

Nov. 6, 1945.

W. A. MALTHANER

2,388,488

TELEPHONE SYSTEM

Filed Feb. 18, 1944

14 Sheets-Sheet 1

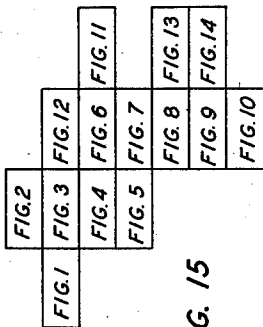
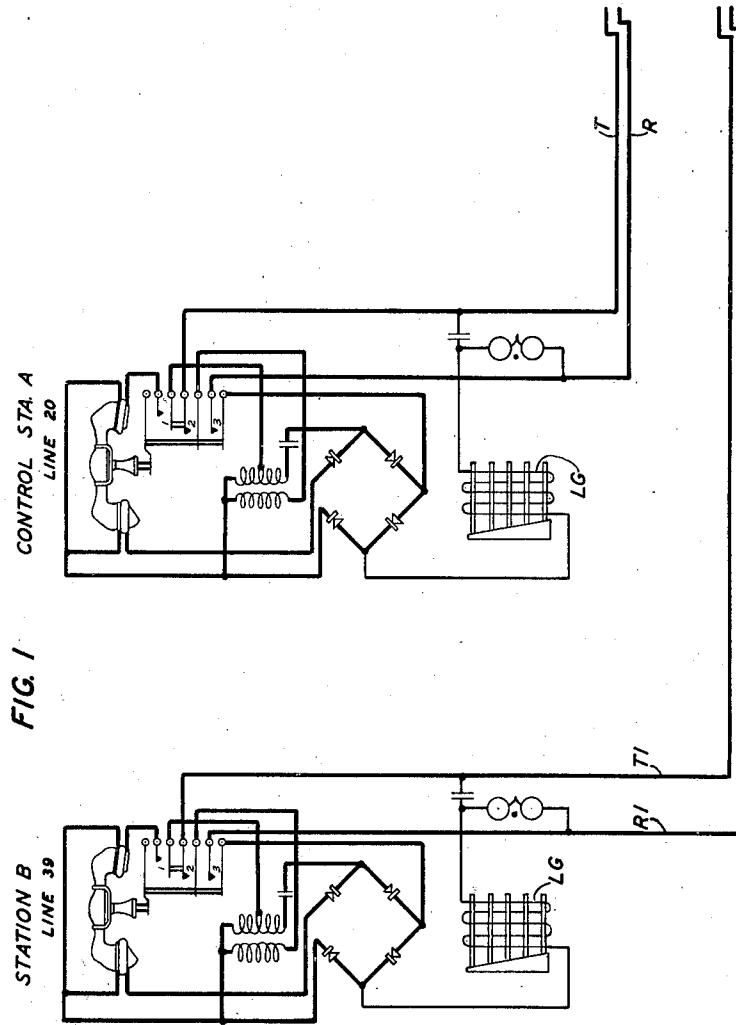


FIG. 15

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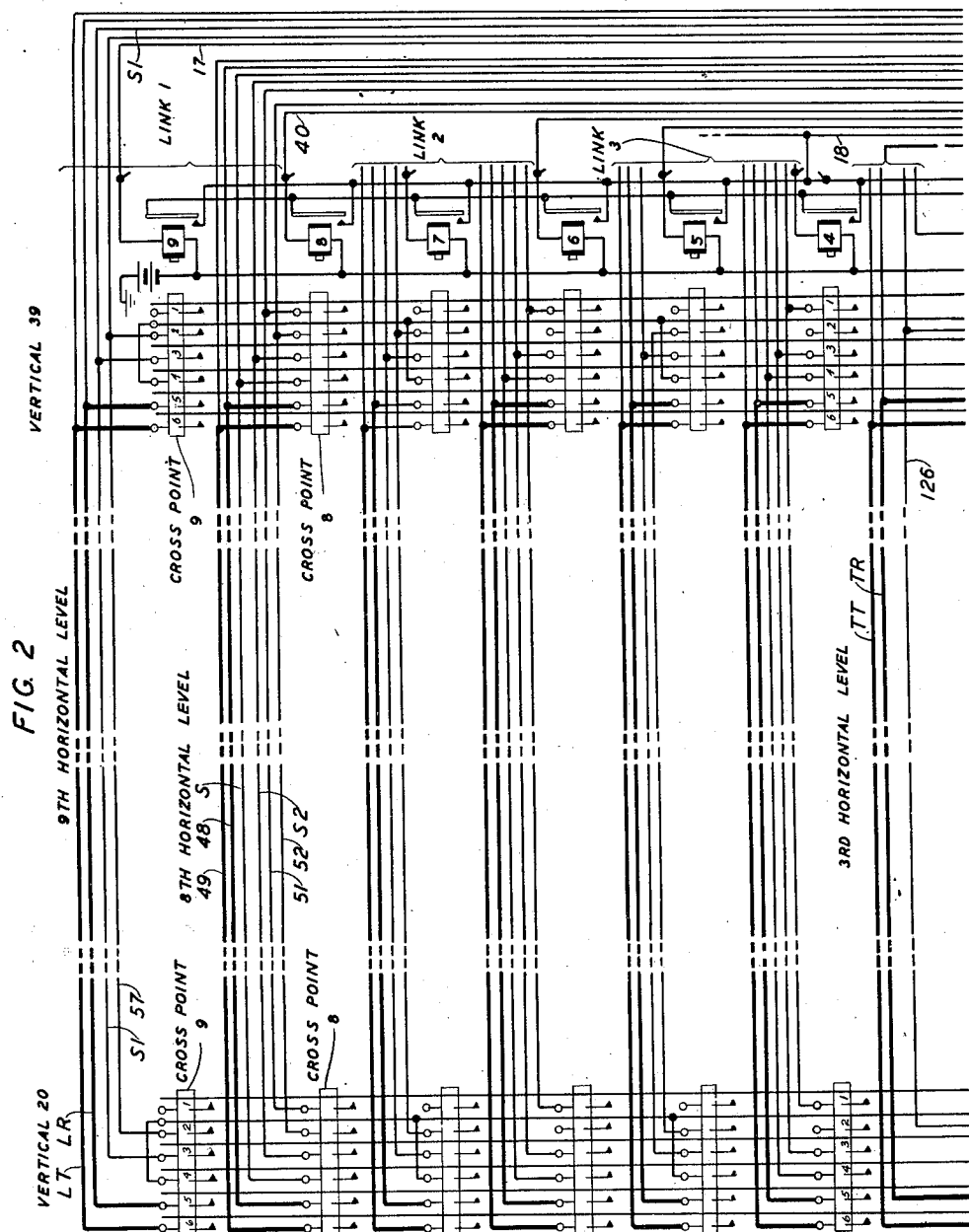
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TELEPHONE SYSTEM

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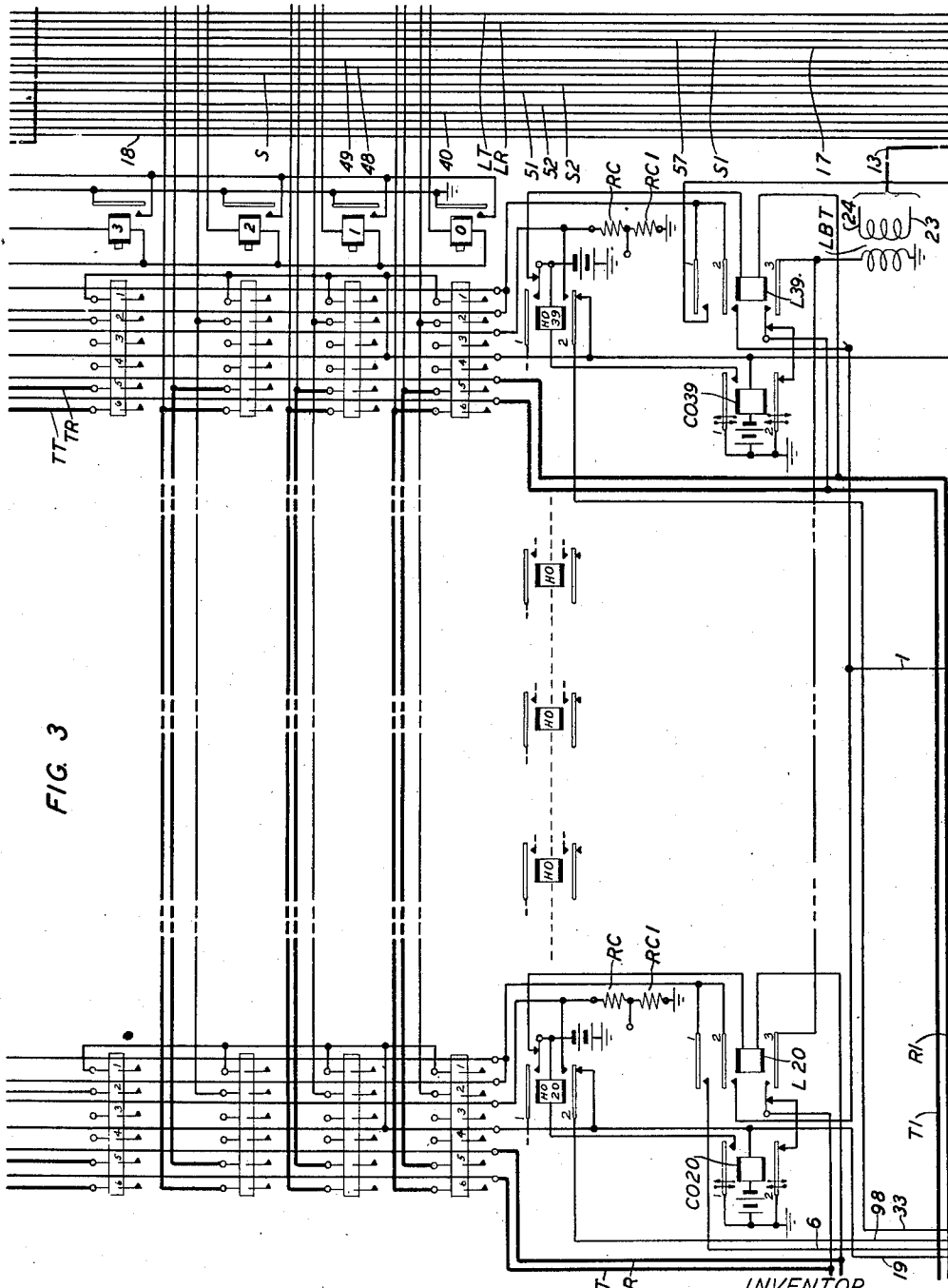
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TELEPHONE SYSTEM

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14 Sheets-Sheet 3



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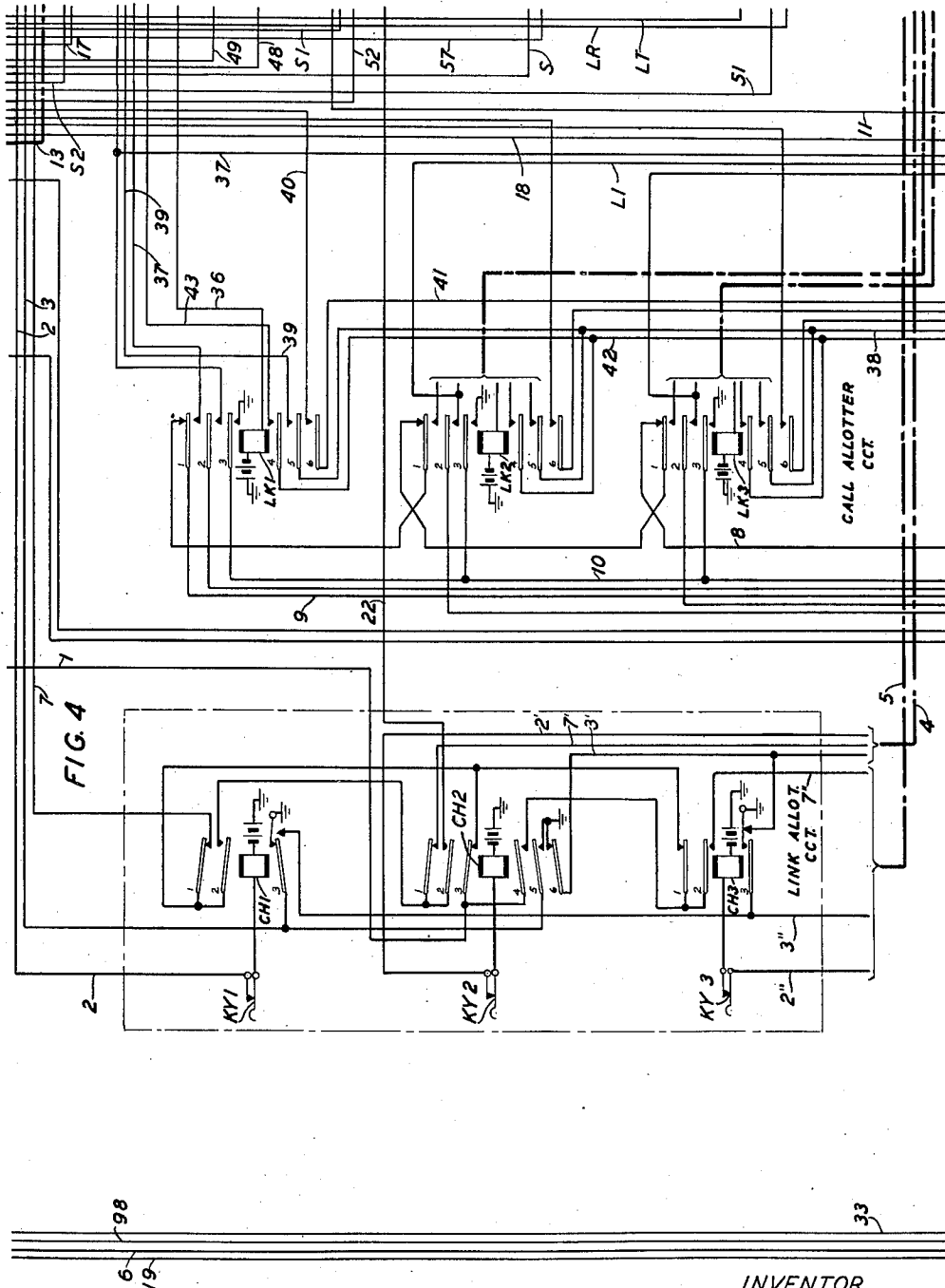
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14 Sheets-Sheet 4



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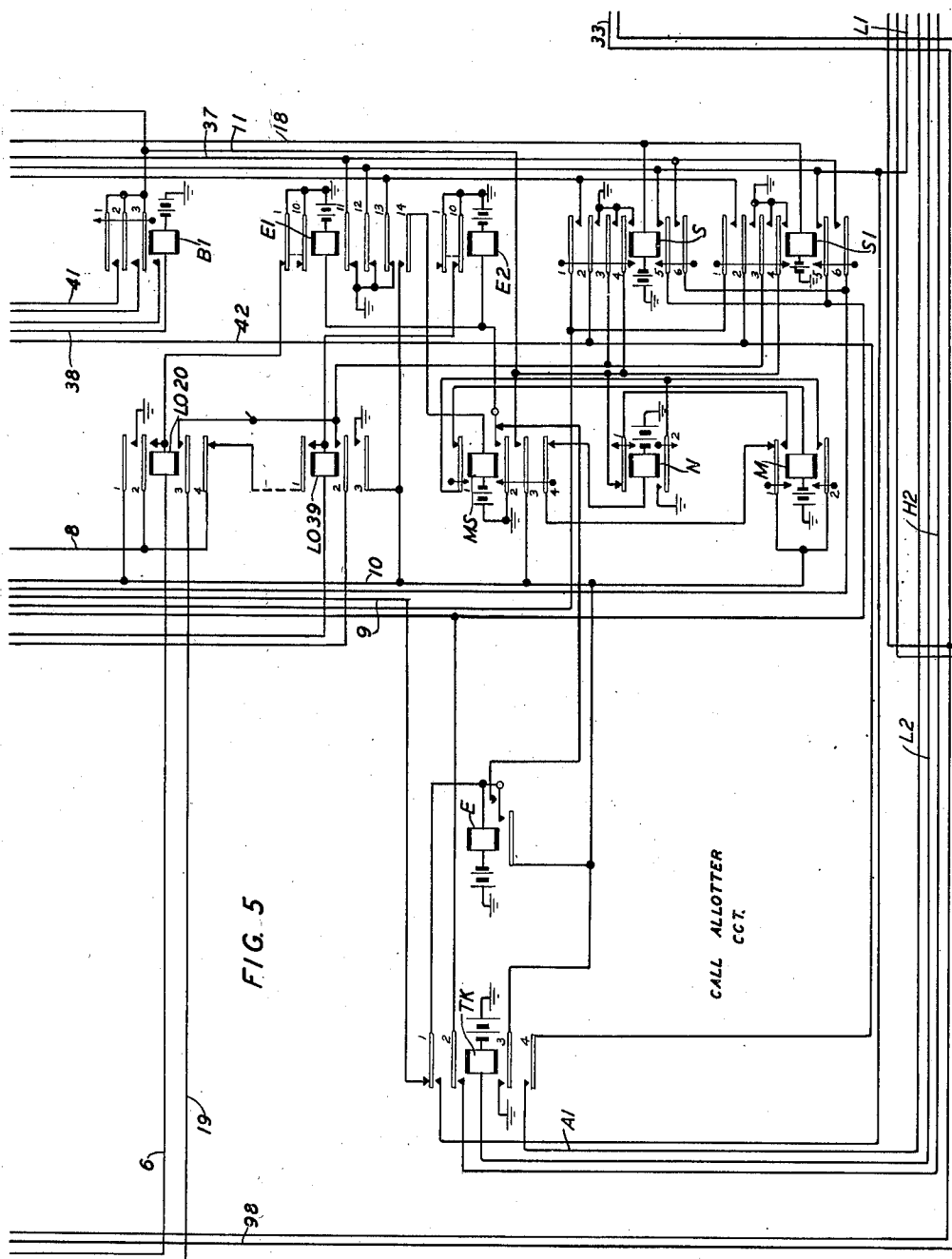


FIG. 5

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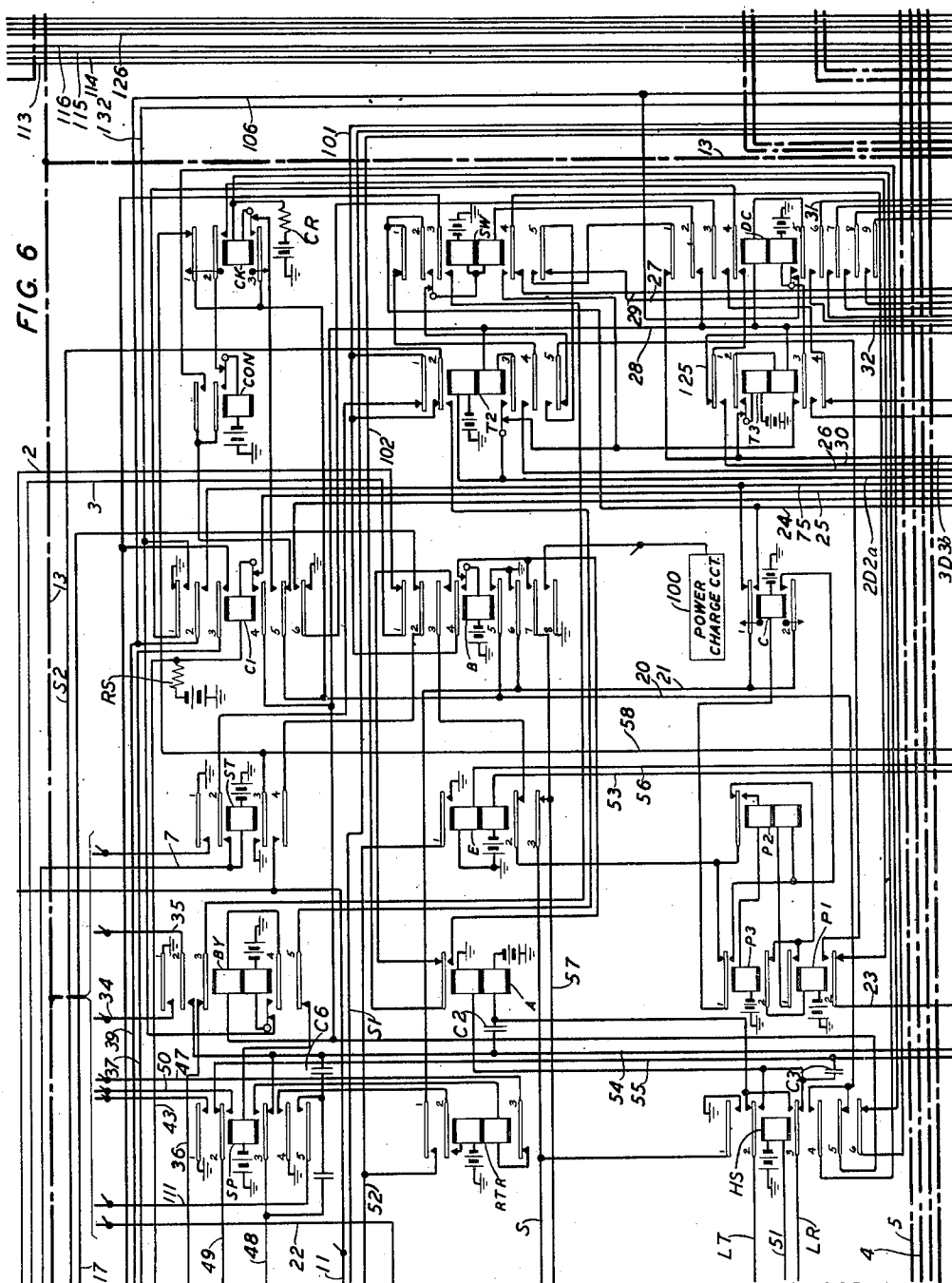
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TELEPHONE SYSTEM

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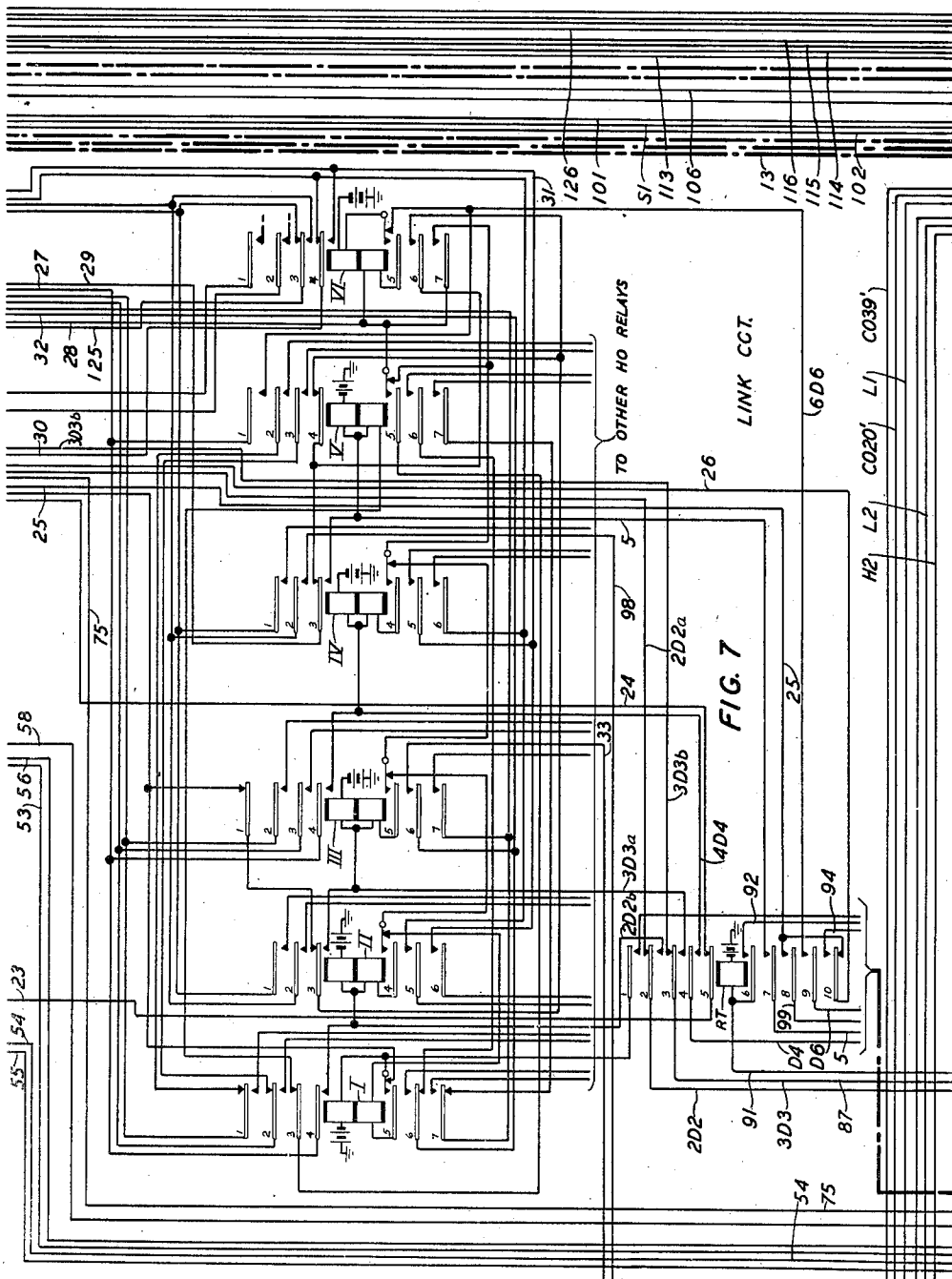
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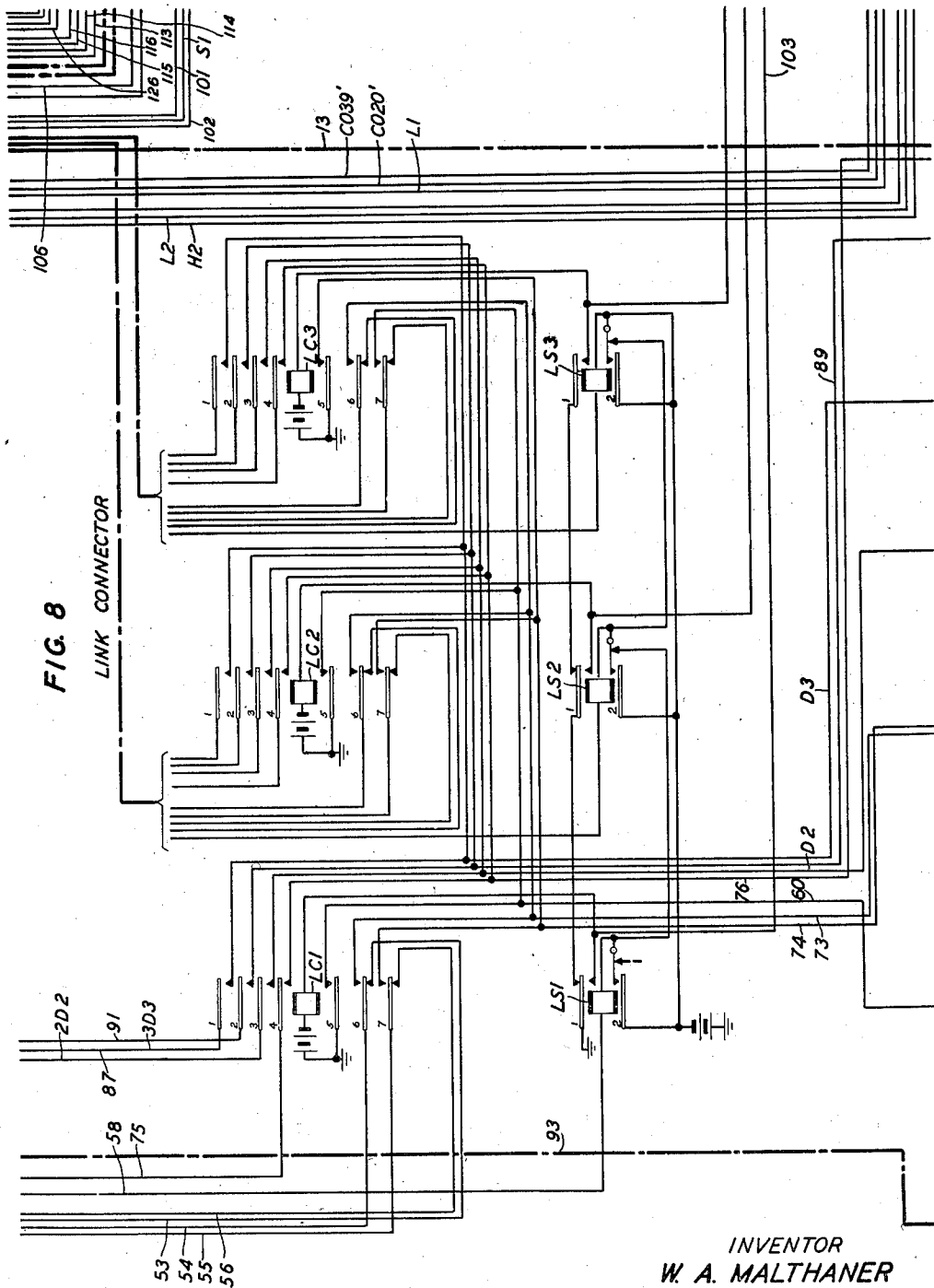
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TELEPHONE SYSTEM

Filed Feb. 18, 1944

14 Sheets-Sheet 8



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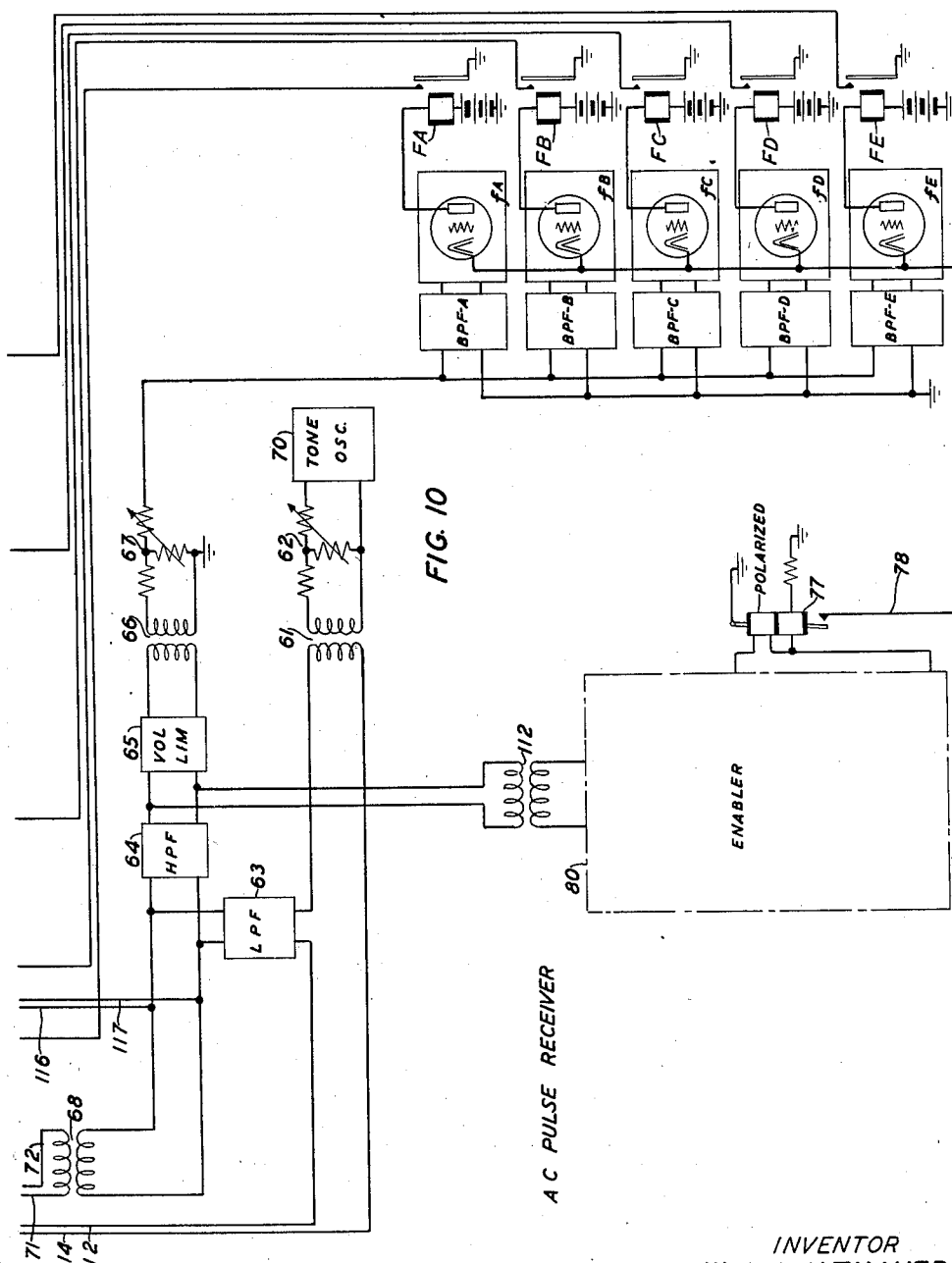
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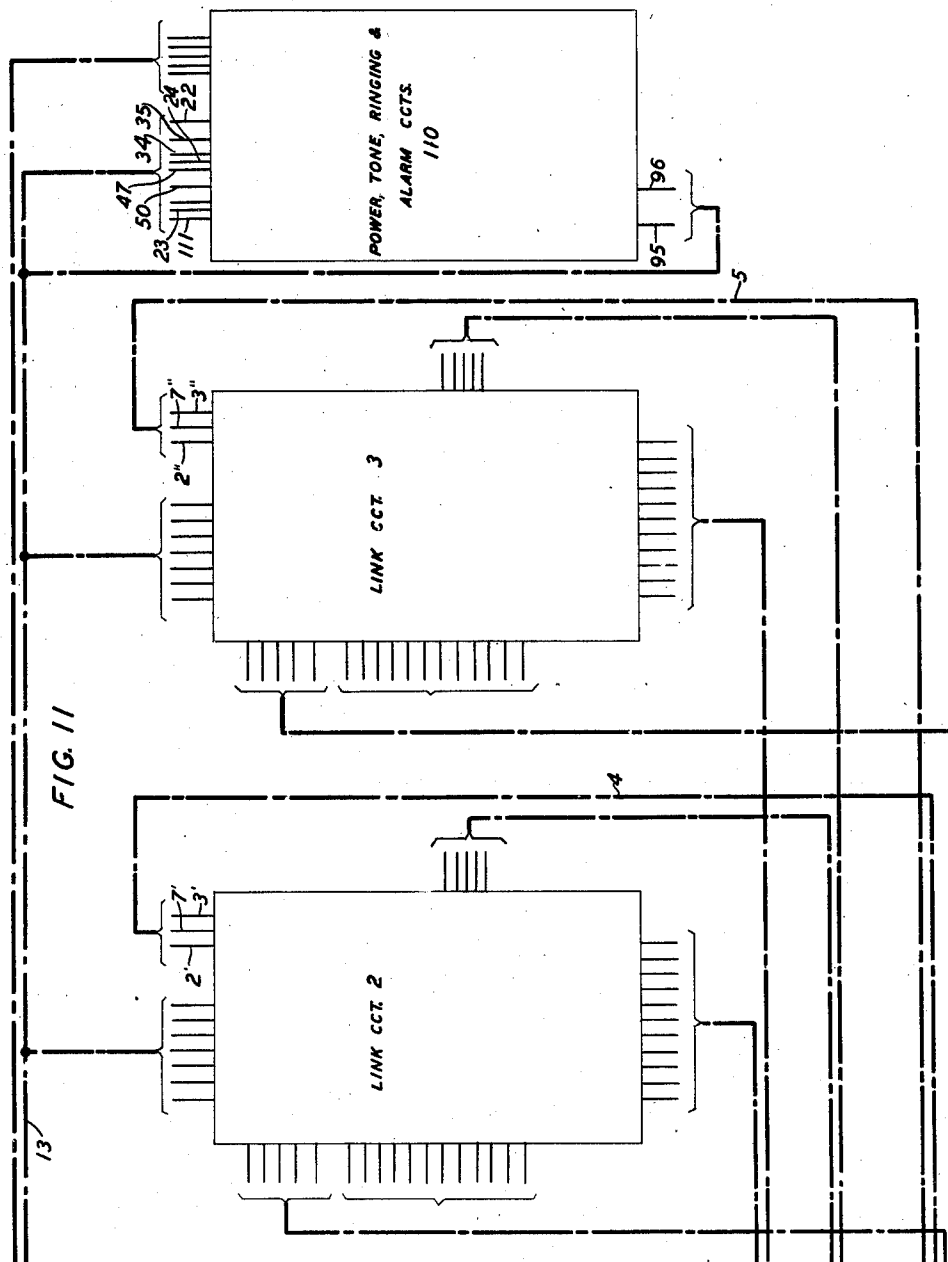
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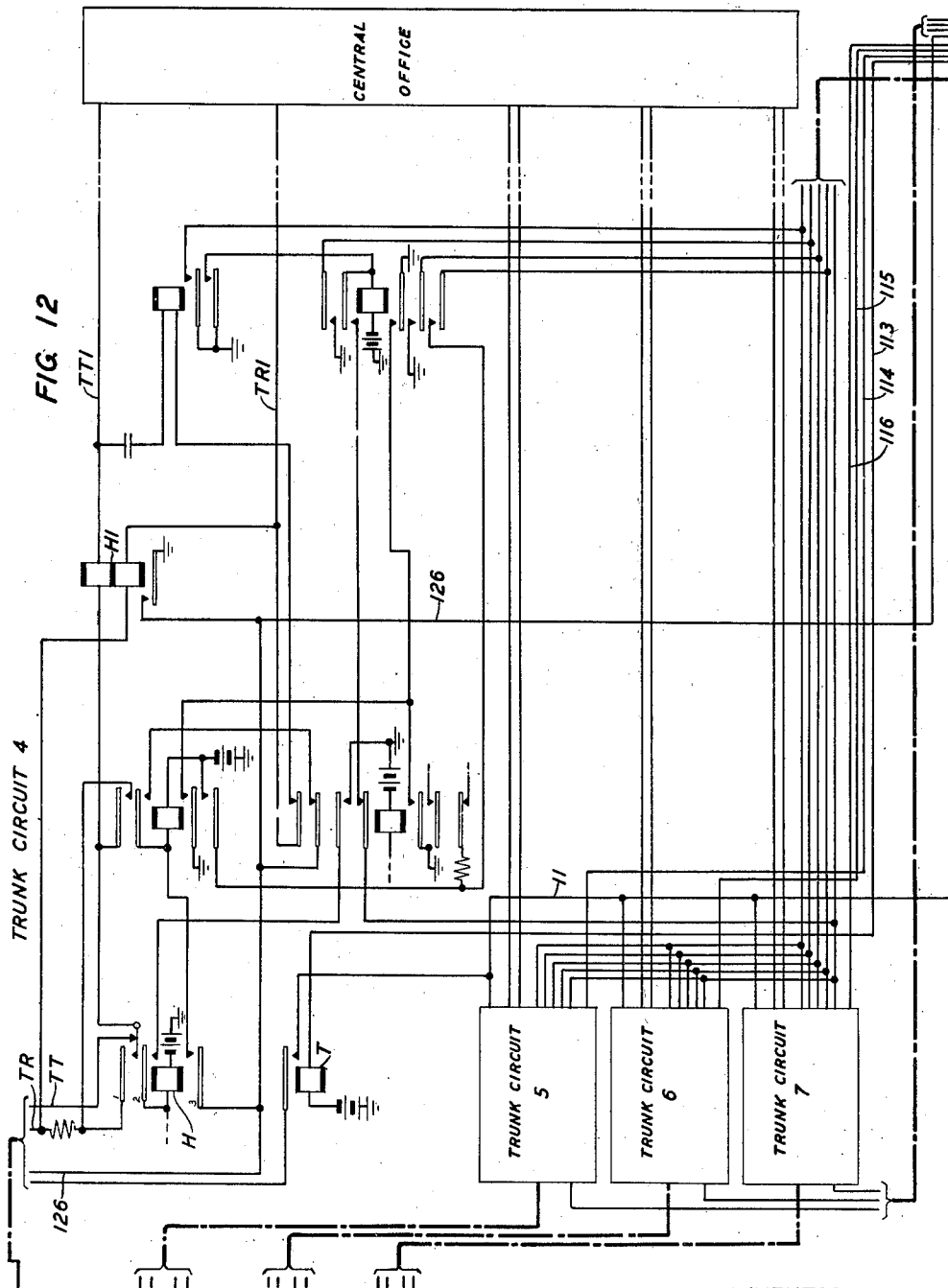
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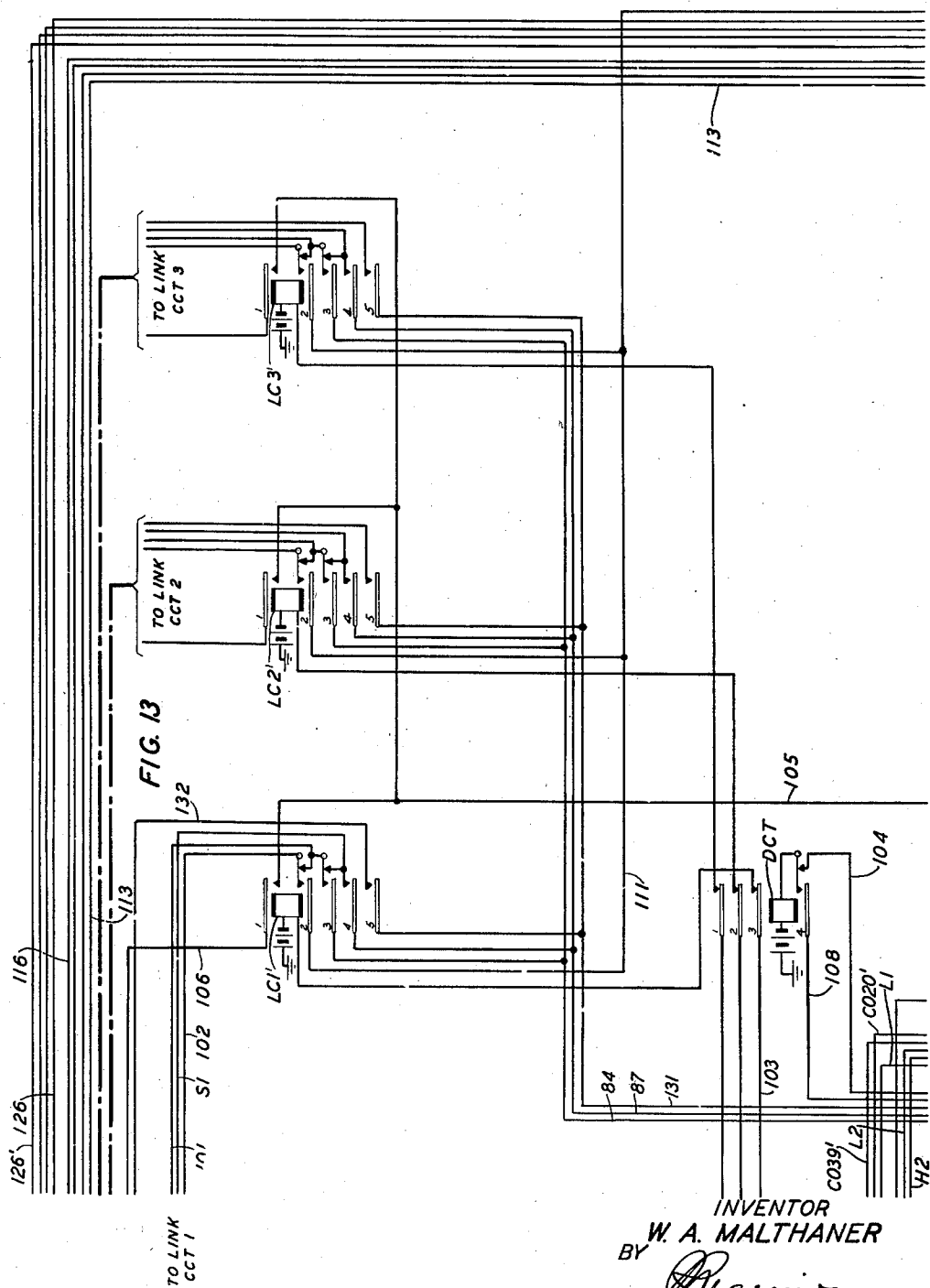
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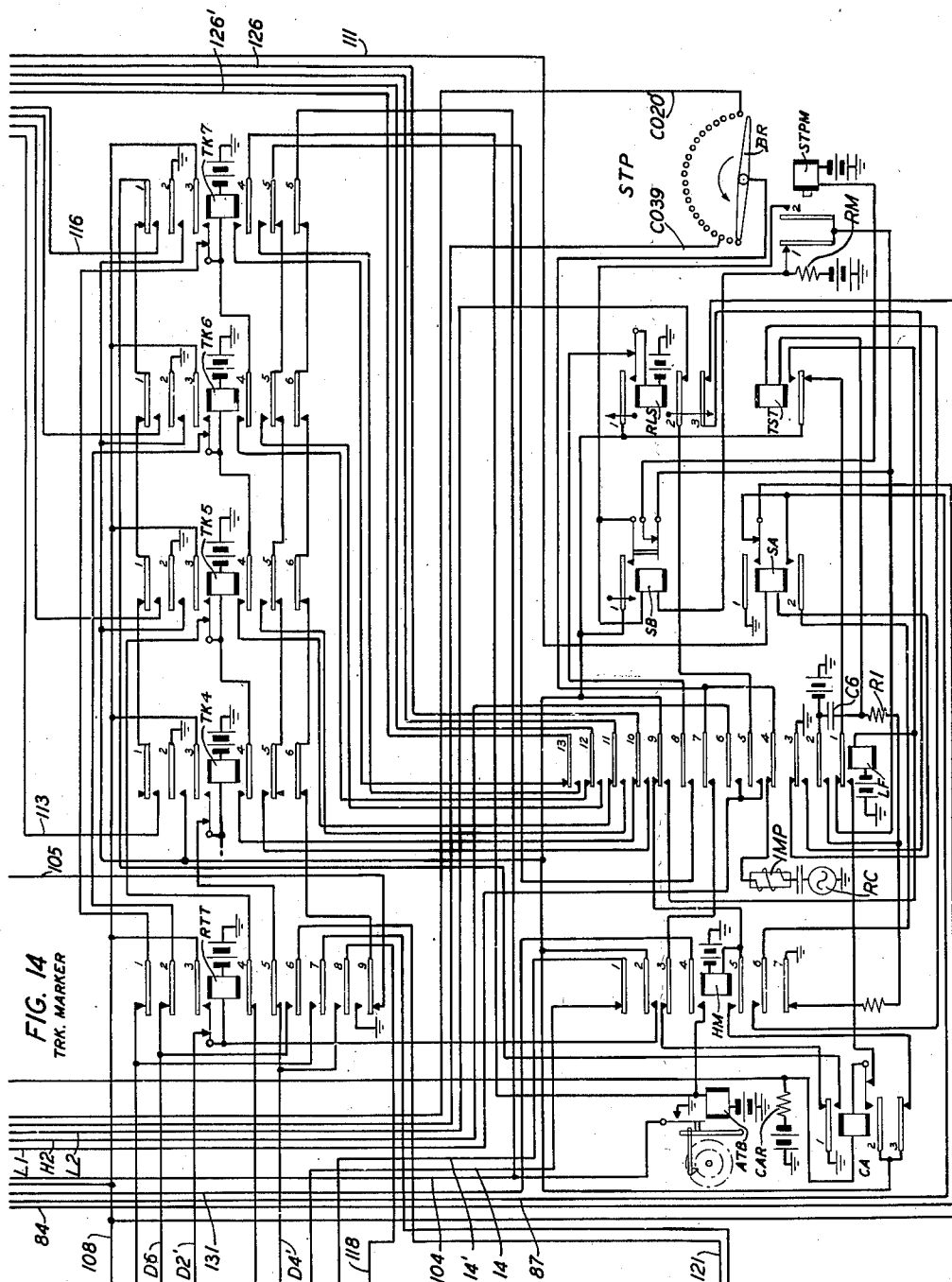
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2,388,488

TELEPHONE SYSTEM

Filed Feb. 18, 1944

14 Sheets-Sheet 14



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UNITED STATES PATENT OFFICE

2,388,488

TELEPHONE SYSTEM

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Application February 18, 1944, Serial No. 522,860

13 Claims. (Cl. 179—22)

This invention relates to telephone systems and more particularly to small capacity telephone systems of the private branch exchange type (P. B. X.), in which cross bar switches are employed having telephone lines, links and trunks terminating thereon, each of said telephone lines being equipped with an alternating current generating device for producing pulses composed of combinations of different frequencies to designate wanted lines or trunks.

A feature of the present invention is a trunk marker available to each of the links upon connection of any one of the latter to a calling line, which marker, in response to a trunk designation registered therein, causes the line to be disconnected from the link and connected to a trunk.

Another feature of the present invention is a calling line checking circuit operable to set a switch in the marker by means of which a "memory" of the calling line is retained by the marker in order that, after the release of the line from the link, the holding mechanism in the cross bar switch individual to the line may be reoperated to extend said line to the selected trunk.

These and other features of the invention will be better understood from the following detailed description and accompanying drawings in which:

Fig. 1 shows two of the twenty stations in the private branch exchange, station A having a line designation of 20 and station B having a line designation of 39;

Figs. 2 and 3 show, diagrammatically, a cross bar switch frame of known construction having twenty verticals and ten horizontal outlets. To each of the vertical outlets a station is connected, station A being connected to vertical 20, station B to vertical 39 and the other intermediate eighteen stations, in the order of their respective numerical designations, being connected to verticals 21 to 38, inclusive. Of the ten horizontal outlets, the uppermost six are reserved for three links and the lowermost four are reserved for four trunks, the latter extending either to one main central office (as shown in Fig. 12) or to different central offices;

Fig. 4 in the left portion thereof, shows a link allotter circuit, while the rest of this figure, together with Fig. 5, shows the call allotter circuit;

Figs. 6 and 7 show the details of the link circuit;

Figs. 8 and 13 show the link connector and trunk marker connector, respectively;

Figs. 9 and 10 show the common translator and alternating current receiver, respectively;

Fig. 11 shows, in diagrammatic form, two other links and a power generating, tone and alarm circuit;

Fig. 12 shows in detail one of the four trunks extending between the private branch exchange and the central office, the other three trunks extending to the same central office being conventionally indicated;

Fig. 14 shows the trunk marker; while

Fig. 15 shows the manner in which Figs. 1 to 14, inclusive, are to be arranged with respect to each other to completely disclose the invention.

Before describing the detailed operation of the invention it is desirable to call attention to the fact that the invention has been illustrated in connection with the circuits and equipment completely disclosed and described in Patent 2,300,951 issued to me on November 3, 1941, the equipment and circuits shown in said patent having been modified and adapted to carry out the new functions and features constituting the essence of the present invention, including their adaptation for cooperative action with circuits and equipment not shown therein. Reference, therefore, is made to said patent for an understanding of such operations as are not described herein; for example, the establishment of local connections, that is, connections between the different stations within the private branch exchange itself.

Referring, now, to Fig. 4, there are shown therein three relays, namely, relays CH1, CH2 and CH3, which form a link allotter circuit. Relays CH1 and CH2 are shown in the operated position, while relay CH3 is shown in the unoperated position. These three relays control the sequential allotment of an available link to a calling line, and the function of the relays CH1 and CH2 in the positions shown is to route the start conductor 1 to the first available link in the office. As stated before, in the present embodiment of the invention it is assumed that the volume of traffic from and between the various stations of the office, including trunk service to the central manual office, may be adequately handled by the use of only three links so that the relays CH1, CH2 and CH3 serve to route a calling line to one of the three links furnished depending upon which one of them is free in the order of allotment at the time the line initiates the call. The operated condition of relay CH1 indicates that the link to which it provides access is in the idle condition, the relay remaining locked until said link is taken into use, the locking circuit of said relay extending from battery, through the winding thereof, contacts of key KY1, conductor

2, No. 1 back contacts of relay B of link No. 1 (Fig. 6), conductor 3, No. 3 front contacts of relay CH1 to ground. The locking circuit of relay CH2, which controls access to link No. 2, is traced over a path that extends from battery through the winding of said relay, contacts of key KY2, conductor 2' in the bracket line 4, the No. 1 back contacts of relay B in link No. 2 (said link being conventionally indicated in Fig. 11), conductor 3' in the bracket line 4, No. 6 contacts of relay CH2 to ground.

On the other hand, the operating circuit of relay CH3, which provides access to link No. 3, while traceable over the contacts of its associated key KY3, conductor 2'' within the bracket line 5, through the No. 1 back contact of relay B of link No. 3 (said link being conventionally indicated in Fig. 11), and conductor 3'' within the bracket line 5, terminates in the No. 3 normal contacts of relay CH3 and, also, in the No. 3 open contacts of relay CH1.

In other words, for a calling line to have accessibility to link No. 1, relays CH1 and CH2 must be operated and relay CH3 must be normal. It will be shown that as each link is allotted in rotation, the circuits of relays CH1, CH2 and CH3 are changed to provide for the advancement of start conductor 1 from one link to the next in the order designated by the numerical indication of each of the three links.

Bearing in mind that relays CH1, CH2 are assumed to be operated and that relay CH3 is assumed to be normal, it may now be further assumed that a call is originated at station A (line 20) for a trunk connection to the manual central office. As before stated, the present invention is in the nature of an improvement over the small capacity office disclosed in my above-mentioned Patent 2,300,951, in which the stations thereof are equipped either with a dial device or an alternating current generating device, and in which links are provided whereby local connections between the several lines may be established over said links by dialing or keying the number of the wanted station. In the present invention, each of the stations is assumed to be provided with an alternating current device LG and that local connections between the several stations in the office may be established over the links in the manner described in said patent. Although the link circuit herein shown and used has been modified in some respects over the link in said patent to provide for the performance of functions essential to the present invention, its structure, in so far as it pertains to the establishment of local connections, remains substantially unaltered. With respect to the establishment of local connections, therefore, the operations of the link are not described herein, reference being made to the above-mentioned patent for a description of said operations.

We may now assume that it is desired to establish a connection from station A to the manual central office. To do so, the attendant at station A removes the telephone instrument from its cradle and then waits for "key" tone, upon receiving which he keys an arbitrarily assigned digit indicative of the trunk to which connection is desired, say the digit 4. The removal of the telephone instrument from the cradle completes a circuit for line relay L20 which extends from ground and battery, over the No. 1 normal contacts of the hold magnet HO20 associated with vertical 20, winding of relay L20, ring conductor R, over the station loop, tip conductor T,

No. 3 normally made contacts of relay L20 to ground on the No. 2 contacts of cut-off relay CO20. Relay L20 operates. Over its No. 3 front contacts, the ground terminal of its circuit is switched from ground on the No. 2 contacts of relay CO20 to ground through the secondary winding of transformer LBT to the primary winding of which is connected a source of distinctive tone which, as will be shortly described, is transmitted to the calling line in the event that no link is available.

Over its No. 1 and No. 2 contacts, relay L20 causes a circuit to be completed for relay LO20 in the call allotter circuit (there being one relay LO—therein for each line) and relay ST of link No. 1 which, since relays CH1 and CH2 of the link allotter are assumed to be operated and relay CH3 is assumed to be normal, is the preferred link in the order of selection. The circuit for the relays ST and LO20 is traced as follows: ground through the No. 1 contacts of relay E1, winding of relay LO20, conductor 6, No. 1 and No. 2 contacts of relay L20, start conductor 1, No. 3 contacts of relay CH2, No. 1 contacts of relay CH1, conductor 7, winding of relay ST to battery. Both relays LO20 and ST operate in this circuit. Relay LO20, upon operating, completes a circuit for relay N, the path of which may be traced from ground on the No. 1 contacts of relay LO20, conductor 10, No. 1 back contacts of relay M, No. 4 contacts of relay MS, winding of relay N to battery. Relay N operates and completes a circuit for relay M which extends from ground on the No. 2 contacts of relay N, No. 1 contacts of relay MS, winding of relay M to battery. Relay M operates, opens the circuit of relay N at its No. 1 back contacts and causes the latter relay to release. The release of relay N opens the operating circuit of relay M but this latter relay, however, remains locked to ground on conductor 10 under the control of the No. 1 contacts of relay MS and its own No. 2 contacts. When relay MS operates, as described below, relay M releases. This cycle for operating relays M and N ordinarily performs no useful function, but does perform an emergency function which will be explained in due course. At the same time, relay LO20 completes a circuit for relay E which may be traced from ground on the No. 1 contact of relay E1, No. 2 contacts of relay LO20, conductor 8, serially through the No. 1 back contacts of the individual link relays LK3, LK2 and LK1 in the call allotter, conductor 9, No. 1 back contacts of relay TK, winding of relay E to battery. Upon operating, relay E locks to ground on the No. 1 contacts of relay LO20 and, at the same time, closes a circuit for relays E1 and E2 extending from ground on its contacts traced thereto from the No. 1 contacts of relay LO20, No. 2 normally made contacts of relay MS, the windings of relays E1 and E2 in parallel to battery and ground. Relays E1 and E2 operate but relay LO20, which operated from ground on the No. 1 contacts of relay E1, now holds locked to ground over its own No. 1 contacts from ground and battery through relay ST of the selected links (as previously traced to conductor 6), winding of relay LO20 and its No. 2 contacts, conductor 8 as traced to conductor 9, No. 1 back contacts of relay TK, contacts of relay E, conductor 10, to ground on the No. 1 contacts of relay LO20. Hence, with the operation and locking of relay LO20 individual to the calling station A, and with the operation of relays E1 and E2, all other lines

may not receive service if calls are initiated thereat during the time when station A is having a link assigned to it since, with relays E1 and E2 operated, no ground is available for completing the circuit of any other relay LO—individual to a calling line.

When relay E1 operates, it completes a circuit for relay MS, said circuit being traced from ground on conductor 10, No. 14 contacts of relay E1, winding of relay MS to battery and ground. Since relay MS has slow-operating characteristics, it operates after an interval, at which time it opens the locking path of relay M, supplies holding ground over its No. 2 contacts for relays E1 and E2 and, over its No. 3 contacts, applies ground on conductor 10 to conductor 11. Ground on conductor 11 is used to complete the circuit of the link select magnet 9 by virtue of operations which will be shortly described and which have been taking place in the link as the result of the operation of relay ST therein.

In the event that, due to some trouble condition, relay E of the call allotter fails to operate, relay MS cannot operate and ground will not be applied to conductor 11 over its No. 3 contacts. If possible under these circumstances, it is desirable to complete the connection, and so emergency means are provided for applying ground to conductor 11 when relay MS fails to operate. It will be remembered that upon the operation of relay LO20, a circuit was completed for relay N, and that prior to the operation of relay MS, relay N caused the operation of relay M. Now when relay M operates, it opens the circuit of relay N, but relay M remains locked over its No. 2 contacts and the No. 1 contacts of relay MS to ground on conductor 10, and it will be observed that, with relay N normal and relay M operated, ground on conductor 10 is applied to conductor 11 via the No. 1 front contacts of relay M and the No. 1 contacts of relay N.

Returning, now, to the operation of relay ST of the allotted link No. 1, a circuit is completed for select magnet 9, the path of which may be traced from battery, through the winding of said magnet, conductor 17, No. 2 contacts of relay B, No. 4 contacts of relay ST, conductor 11, to the aforetraced ground thereon. Select magnet 9 operates and conditions the group of cross-points in the ninth horizontal level for selection, including cross-point 9 on vertical 20 through which the calling loop will be extended into the link, as shown hereinafter. Select magnet 9, upon operating, completes a circuit from ground over its contact and common conductor 18, to the paralleled windings of relays S and S1, causing said relays to operate and complete a circuit for cut-off relay CO20, the circuit of said relay being traced from ground on the No. 3 contacts of relays S and S1, No. 3 contacts of relay LO20, conductor 19, winding of relay CO20 to grounded battery. Relay CO20, upon operating, closes an obvious circuit for hold magnet HO20 of the vertical 20 to which line 20 (station A) is connected, and because select magnet 9 is operated, cross-point 9 on vertical 20 is also operated, said cross-point 9 remaining operated after the circuit of select magnet 9 has been opened, all in accordance with standard cross bar switch operation. When hold magnet HO20 operates, it releases line relay L20 which, in turn, releases relay LO20 and the latter, upon releasing, opens the circuit of relay CO20 and further disconnects ground from start conductor 1 which

caused the operation of relay ST. Relay CO20 (as well as every other relay CO—) is slow-release and slow-operate and will hold up for the nonce until a holding circuit therefor will have been completed in the link as described hereinafter. Also, while conductor 1 is now opened, the fact that cross-point 9 on vertical 20 is closed, relay ST will not release, it having a locking circuit through a cross-point contact, said circuit being traced over the No. 2 contacts of said relay, No. 1 contacts of relay T2, conductor 101, No. 3 normally made contacts of relay LC1', conductor S1, No. 3 contacts of cross-point 9 on vertical 20, resistors RC and RC1 to ground.

Since cross-point 9 on vertical 20 is closed, the line tip and ring conductors T and R, respectively, are joined to the link tip and ring conductors LT and LR, respectively, over the No. 6 and No. 5 contacts, respectively, of the operated cross-point 9, and this joining of conductors completes an operating path for relay A of the link, which circuit may be traced from ground and battery, through the lower winding of said relay, No. 2 back contacts of relay HS, conductor LT, No. 6 contacts of cross-point 9 on vertical 20, line conductor T, over the calling line loop, ring conductor R, No. 5 contacts of cross-point 9 on vertical 20, conductor LR of the link, No. 3 back contacts of relay HS, upper winding of relay A to ground. Relay A operates and completes a circuit for relay B which extends from ground on conductor S1, No. 3 and No. 2 normally made continuity contacts on relay LC1', conductor 102, front contacts of relay A, No. 4 normally made continuity contacts of relay B, winding of relay B to grounded battery. Relay B operates and locks over its No. 4 front contacts, conductor 101, No. 3 normally made continuity contacts on relay LC1', to ground on conductor S1. At its No. 7 contacts, relay B now completes a holding circuit for CO20 which traces from battery through the winding of said relay CO20, No. 4 and No. 2 contacts in series of cross-point 9 on vertical 20, conductor 57, No. 7 contacts of relay B, front contacts of relay A, conductor 102 and thence as traced to ground on conductor S1. Relay CO20 thus holds operated, in turn holding magnet HO20 which keeps cross-point 9 closed. At its No. 2 contacts, relay B opens conductor 17, thereby causing the release of select magnet 9. However, since the hold magnet HO20 is being held, cross-point 9 on vertical 20 will likewise be held. Relay B further completes a circuit from ground over its No. 8 contacts to a relay (not shown) in the power charge circuit 100 by means of which, when the relay is operated, circuits are closed that will increase the charging rate to the link power supply during the time that the link is being used and, over its No. 5 and No. 6 contacts, relay B further applied ground to hold conductors 20 and 21, respectively, for holding and operating certain other relays as noted below. Over its No. 1 contacts, relay B opens the locking circuit of relay CH1 in the allotter circuit which, upon releasing, advances the common start conductor 1 over the No. 3 contacts of relay CH2, No. 2 contacts of relay CH1, No. 1 contacts of relay CH2 to conductor 1' which further extends to relay ST of link No. 2 (conventionally indicated in Fig. 11).

It is now evident that if link 1 is busy or is otherwise made unavailable at the time a call is initiated at station A (or any other station), relay CH1 in the link allotter circuit will be normal and the start conductor 1, with ground applied

thereto, will be connected to conductor 7' of link 2 to cause the operation therein of relay ST in the manner described for relay ST of link 1. On the other hand, if both links 1 and 2 are busy or are otherwise unavailable, relay CH2 as well as relay CH1 will be normal since their respective locking circuits will be opened at the No. 1 contacts of relay B of their respective links. However, as soon as these relays are both normal, a circuit is completed for relay CH3 which extends from battery through its winding, contacts of XY3, conductor 2'' within bracket line 5, No. 1 contacts of relay B of link 3, (conveniently indicated in Fig. 11) conductor 3'' to ground over the No. 1 normally made contacts of relay CH1. Relay CH3 operates and, with relays CH1 and CH2 normal, represents the condition in which links 1 and 2 are unavailable but link 3 is available. If, now, a call is initiated at a line station, as for example station A, ground on start conductor 1 is extended to conductor 7'' which is connected to the winding of relay ST of link 3, the path being from ground on conductor 1 as applied thereto from conductor 6 through the No. 2 and No. 3 contacts of relay L20, No. 4 contacts of relay CH2, No. 2 contacts of relay CH3, conductor 7'', to the winding of relay ST of said link, causing the operation of said relay and the connection of the associated link 3 to the calling line.

If all three links are unavailable, relay CH3 will be normal along with relays CH1 and CH2. The initiation of a call under these circumstances will cause ground on the start conductor 1 to be applied to conductor 22 via the No. 4 contacts of relay CH2, No. 1 contacts of relay CH3, No. 2 contacts of relay CH1, No. 2 contacts of relay CH2, to conductor 22. This conductor extends (within bracket line 13) to the power tone and alarm circuit 110 and completes a circuit therein which causes a distinct "link busy tone" to be applied to conductors 23 and 24 which are connected to primary winding terminals of busy tone transformer LBT. Since the lower terminal of the secondary winding of this transformer is connected to ground and its upper terminal is completed into a circuit over the winding of the operated line relay L— to battery on the upper normally made contacts of the hold magnet HO—, the subscriber at the calling station will hear the tone as an indication that, due to an unavailable link, the connection cannot be established.

As soon as a link becomes available, say link 1, a circuit is completed for relay CH1 which extends from grounded battery through its winding, thence as traced to conductor 3 No. 5 contacts of relay CH2 to ground. Relay CH1 operates and locks to ground over its No. 3 front contacts to reestablish the path of start conductor 1 to the winding of relay ST of link 1 in readiness for seizure on a call. If link 2 becomes available, relay CH2 operates over a circuit traceable from grounded battery, through its winding, thence as traced to conductor 3', to ground on the No. 3 normally made contacts of relay CH3.

Returning, now, to the operation of relay ST of link 1, assumed to have been taken into use as a result of a call having been initiated at station A, ground on the No. 3 contacts of said relay completes a circuit for relay LS1 of its private link connector, and this circuit is traced from ground on said contacts, conductor 58, winding of relay LS1, serially through the No. 2 normally made continuity contacts of relays LS2 and LS3 (the former relay being individual to link 2 and the

latter relay individual to link 3), to grounded battery. Relay LS1 operates, connects operating battery to its winding through its own No. 2 front contacts and, over its No. 1 front contacts, closes two circuits, the first extending from ground, winding of relay LC1 to grounded battery, and the second extending from the same ground, conductor 103, No. 3 contacts of relay DCT, winding of relay LC1' to battery. Both relays LC1 and LC1' operate, the former to connect the translator and alternating current receiver shown in Figs. 9 and 10, respectively, to the link and the latter to connect the trunk marker shown in Fig. 14 to the link.

In connection with the circuit for operating relay LC1' (or LC2' or LC3'), it should be observed that the link is designed to control the setting up of two types of connections, namely, a local connection between two local stations as, for instance, between stations A and B, and a trunk connection between a local station as, for instance, station A and a trunk extending to the central office. In the case of a local connection, no trunk is required and, therefore, the services of the trunk marker (Fig. 14) may be dispensed with whereas, on a trunk connection, its services are required and, therefore, connection of the trunk marker to the link is necessary. Discrimination between the two types of connections is made with the first digit keyed by the calling subscriber. Since in the present embodiment of the invention the private branch exchange is limited to twenty stations with each station having a numerical designation from 20 to 39 depending upon the cross bar vertical in the cross bar switch to which the designated station is connected, and since for the establishment of a local connection the calling subscriber merely keys the two digits of the wanted local number as set forth in my above-mentioned patent and whereas for a trunk connection he keys the trunk digit only, it is obvious that if the first digit keyed by a subscriber is a 2 or 3 and such numerals are not used for trunk digit designations, said numerals 2 and 3 may be used to apprise the link that the connection will be a local one and, therefore, does not require the use of the trunk marker. As described in my above-mentioned patent, the keying of a digit 2 or 3 as the first digit will cause the operation of relay T2 of the link (if digit 2 is keyed) or relays T2 and T3 simultaneously (if digit 3 is keyed), for registering therein the digit 2 or 3, respectively. Relay T2 completes a circuit for relay C1 (as set forth in said patent) and the latter, upon operation, completes a circuit for relay DCT of the trunk marker connector. This circuit may be traced as follows: Ground and battery through the winding of relay DCT, No. 4 normally made continuity contacts of said relay, conductor 104, serially through the No. 6 contacts of the individual trunk relays TK7, TK6, TK5, and TK4 (assuming that four trunks are provided between the private branch exchange and the central office), No. 9 back contacts of relay RTT, conductor 105, No. 1 contacts of relay LC1' conductor 106, No. 2 contacts of relay C1, No. 1 back contacts of relay C, conductor 21, to ground on No. 6 contacts of relay B. Relay DCT operates over the above circuit, locks over its No. 4 front contacts, conductor 108, to ground on the No. 5 contacts of relay ON which is operated at this time as will be shown, and opens the circuit of relay LC1' which releases and, in so doing, disconnects the trunk marker from the link. In the event of a trunk connection, however,

the subscriber merely keys the trunk digit designation 4. Under these circumstances, relay T2 will not be operated and neither will relays C1 and DCT. Accordingly, the trunk marker remains connected to the link. The operation of relay LC1' transfers the holding circuit of relay B from ground on conductor S1 and conductor 101 as traced thereto over the normally made continuity contacts of relay LC1', to the same conductor S1 as traced thereto from conductor 101, No. 3 front contacts of relay LC1', conductor 84, No. 1 normally made contacts of relay SA, conductor 87, No. 4 front contacts of relay LC1' to conductor S1. It also transfers, over its No. 2 front contacts, the holding ground for cut-off relay CO20 which now holds over conductor 111 in series with the winding of relay SA to ground on the No. 3 back contacts of relay LF. Relay SA now operates over the holding circuit of the cut-off relay CO20. Over its No. 1 front contacts, relay SA applies ground to conductor 84 to hold relay B and initiates the operation of the trunk marker to check the calling station as more particularly described hereinafter. Relay LC1' (or relay LC2' or relay LC3' depending upon which of the relays LS1, LS2 or LS3 is operated) also performs certain other functions in the progressive establishment of the connection which are best described when these functions come into play.

Relay LC1 closes a circuit from ground on its No. 5 contacts over conductor 60 to the winding of relay ON which operates to complete a circuit over its No. 1 contacts to a relay (not shown) in the "time out" circuit 120, and applies ground over its Nos. 3 to 5 contacts, inclusive, to the connected conductors for controlling certain relays of the circuit as described hereinafter. With the operation of relay ON, a circuit is also completed for relay ONA extending from grounded battery through the winding of said relay, No. 1 contacts of relay HR, No. 3 normally made continuity contacts of relay ONA, conductor 76, No. 4 contacts of relay LC1, conductor 75, No. 1 back contacts of relay C, conductor 21 to ground on the No. 6 contacts of relay B. Relay ONA operates, locks over its No. 3 front contacts under the control of the No. 1 contacts of relay HR to ground on conductor 60 and, at the appropriate time performs certain functions which are noted below. The operation of the relay in the "time out" circuit 120 initiates the operation of an appropriate means for measuring a predetermined time interval, which is allowed the calling subscriber to complete keying the wanted number which, in this case, is the trunk digit. When that interval is terminated, a circuit is completed for relay HR which operates to perform certain functions best described in connection with the keying of the assigned trunk digit, in this case 4.

The object of operating relay LS1 and, locally therefrom relays LC1 and LC1' is, as before stated, to connect the link when taken into use with the common alternating current pulse receiver and translator shown in Figs. 9 and 10 and with the trunk marker shown in Fig. 14. When these circuits are connected to the link (the signal for which is the operation of relay LS1), the receiver and the trunk marker must be made unavailable to the other two links. This is done by removing the operating ground for relays LC2, LC3, LC2' and LC3' at the No. 1 back contacts of relay LS1 so that if either relay LS2 or LS3 should have its operating circuit established by relay ST of link 2 or relay ST of link

3, respectively, the circuits of relays LC2 and LC2' or LC3 and LC3' will be cut off at the No. 1 back contacts of relay LS1. On the other hand, if the link taken into use happens to be link 2 or 3, then the corresponding operation of relay LS2 or LS3 respectively, will cut off the operating circuit of relay LS1 at their respective No. 2 normally made continuity contacts so that if link 1 is seized thereafter, the failure of relay LS1 to operate will prevent the operation of relays LC1 and LC1' and thereby prevent the connection of the common alternating current receiver, translator and trunk marker simultaneously to two calling links.

The alternating current receiver of Fig. 10 is adapted to receive alternating current impulses from a calling station which, as said before, is equipped with an alternating current generating device LG, and this receiver as well as the translator and trunk marker must be connected to the link before the calling subscriber can be advised, by an appropriate warning tone, to transmit the called line or trunk designation. Accordingly, when relay ONA operates, it closes the primary circuit of a low frequency tone derived from the tone oscillator 70 through adjustable resistance pad 62 and transformer 61. The path is traced as follows: from the lower terminal of the secondary (left) winding of transformer 61, conductor 14, No. 1 contacts of relay HM, conductor 14', No. 3 contacts of relay RR, No. 2 contacts of relay RA, No. 2 contacts of relay ON, No. 2 contacts of relay ONA, conductor 12, through the low-pass filter 63 to the upper terminal of the secondary (left) winding of transformer 61. The tone frequencies produced by the oscillator 70 are thus induced over the circuit above traced.

Through a transformer arrangement (not shown) in the low-pass filter 63, the low frequencies are induced in the closed circuit comprising the transformer 68, a transformer in said low-pass filter 63 and a transformer in high-pass filter 64. Beyond the secondary winding of the transformer (not shown) in the filter 64 are connected suitable filter networks (not shown) which are designed to pass only frequencies within the signal frequency band of the frequencies that are produced by the station generator LG when operated. Hence the tone frequencies produced by oscillator 70 will not pass into the volume limiter 65 or into the enabler 80. They will, however, be induced into the secondary (upper) winding of transformer 68 if said secondary winding forms a part of a closed electrical system, which it does because conductors 71 and 72 are but extensions of the line conductors T and R into the link and alternating current receiver connected thereto. The path of this circuit is traced as follows: From the left terminal of the secondary (upper) winding of transformer 68, conductor 71, No. 2 back contacts of relay HR, conductor 73, No. 6 front contacts of relay LC1, conductor 54, condenser C2, No. 2 back contacts of relay HS, conductor LT, No. 6 contacts of cross-point 9 on vertical 20, conductor T, over the loop of station A, conductor R, No. 5 contacts of cross-point 9 on vertical 20, conductor LR, No. 3 back contacts of relay HS, condenser C3, conductor 55, No. 7 front contacts of relay LC1, conductor 74, No. 3 back contacts of relay HR, conductor 72 to the right terminal of the secondary (upper) winding of transformer 68. Inasmuch as the receiver of the telephone instrument of station A is included in the above-closed circuit, the tone induced thereover is heard by the subscriber, which he understands

as a signal to proceed with keying the number of the wanted local subscriber or of the trunk digit.

If the subscriber fails to key the wanted number or the trunk digit in the time taken for relay HR to operate as above set forth, it is presumed that the connection so far set up was due to an accidental removal of the telephone instrument at station A. In any event, the fact that but three links are provided to serve twenty lines and the fact that a link, tied up with presumably a calling line, prevents any other line from getting through due to the use of one common alternating current receiver by all three links, makes it imperative that no link be kept unduly out of service after key tone is transmitted to the calling line, without said link performing the necessary connection-completing functions that follow the transmission of the wanted number designation. Hence if the subscriber fails to transmit the local number or trunk digit by the time relay HR operates, relay ONA is unlocked, a circuit is completed from ground over the No. 4 contacts of relay HR, No. 4 contacts of relay ONA to a relay (not shown) in the howler circuit 130 which operates to complete a sharp howler tone which is applied over the No. 2 and No. 3 front contacts of relay HR to conductors 73 and 74, both of said conductors extending over the calling loop (as previously traced) including the station telephone instrument. The tone is sufficiently loud to be heard at a distance from the receiver and is intended to apprise the subscriber that the telephone instrument should be restored, an occurrence that will cause the link to be disconnected and restored to normal as described hereinafter.

Assuming, however, that relay HR has not operated, the subscriber, upon hearing key tone, operates the device LG to transmit the wanted designation which, since the connection desired is to a trunk extending to the manual central office, will consist of the arbitrary digit "4" indicating a trunk to said central office. The subscriber transmits the digit by operating the digit key 4 of the device LG. Now the depression of any key in the device LG causes two out of five reeds therein to be plucked according to a code combination individual to the numeral indicated by the key depressed, and the reeds are set into vibration to produce two alternating currents of specific frequencies which are then transmitted over a circuit which may be traced as previously to conductors 73 and 74 at the No. 2 and No. 3 back contacts, respectively, of relay HR and, thereafter, to conductors 71 and 72, respectively, connecting with the secondary winding of transformer 68. These frequencies are induced into the circuit comprising the primary winding of said transformer and the high-pass filter 64.

The alternating current pulse receiver shown in Fig. 10 is a conventional disclosure of the receiver shown in Patent 2,269,022 issued to G. Hecht and A. A. Lundstrom on January 6, 1942. It comprises the channel composed of transformer 68, the high-pass filter 64, the volume limiter 65, the transformer 66, the adjustable pad 67, five detector amplifiers $fA-fE$ with relays $FA-FE$ in the respective anode circuits thereof, and a suitable filter BPF—intermediate the pad 67 and each one of the detector amplifier tubes $fA-fE$, each of said filters being designed to pass only the frequency intended for the particular channel in which the filter is included. Between the high-pass filter 64 and the

volume limiter 65 is bridged the primary winding of transformer 112 to the secondary winding of which is connected the enabler 80. This enabler is identical to the one disclosed and described in the above-mentioned patent to G. Hecht and A. A. Lundstrom and is shown only conventionally in Fig. 10 except for polarized relay 77. The enabler responds to a portion of the energy in each of the signal pulses that pass through the high-pass filter 64 and functions to operate polarized relay 77 after a predetermined interval. Relay 77 grounds conductor 78 which is connected to the cathode of each of the detector tubes $fA-fE$ thereby activating them to respond to the portion of the signal energy which passes through the volume limiter 65. Since the operation of the enabler 80 is completely described in the above-mentioned patent to G. Hecht and A. A. Lundstrom, reference is made to said patent for a complete description thereof, only so much of said description being supplied herein as will be necessary to an understanding of the present invention.

It will further be noted that the No. 1 contacts of relay ONA are bridged across the high-pass filter 64 (through conductors 116 and 117) to short-circuit said filter when the relay is normal. This is a safety measure to insure that if, at the time the subscriber initiates the call, the Nos. 5 and 6 contacts of cross-point 9 on vertical 20 close last, and should close after the alternating current receiver is connected to the link, the impulse produced over the line loop will not find a passage into the high-pass filter. For if it should and the pulse were to contain frequency components within the signal frequency band, these frequencies would falsely operate one or more of the signal channels. By the time relay ONA has operated, however, such a pulse will have been dissipated, the short-circuit will have been removed and the receiver will have been connected to the line as above described.

As stated before, each detector amplifier tube $fA-fE$ is preceded by a filter BPF— which passes only the frequency intended for the channel in which the tube therein is to operate on the energy carried by said frequency. It is assumed that the device LG is capable of producing five different frequencies which, for convenience, may be designated A—E, inclusive, and that, in accordance with the operation of the receiver as described in the above-mentioned patent to G. Hecht and A. A. Lundstrom, frequency A will cause the operation of tube fA , frequency B will cause the operation of tube fB and so on up to and including frequency E which will cause the operation of tube fE .

As already mentioned, each detector amplifier tube has a relay F — connected in its anode circuit, and a front contact of this relay is further connected to the winding of one of the five relays TA—TE in the translator circuit shown in Fig. 9. Relay FA in the anode circuit of the first channel which responds to frequency A has its front contact connected to the winding of relay TA, while relay FB of the second channel, responding to frequency B, is connected to the winding of relay TB and so on up to and including relay FE in the anode circuit of the fifth channel which responds to frequency E, the front contact of which relay is connected to relay TE. Hence the operation of any combination of detector amplifier tubes $fA-fE$ will cause the operation of a corresponding combination of the register relays in the translator circuit of Fig. 9.

The combination of frequencies for each of the digits which may be keyed from the calling station, the operation of the channels and translator relays operated thereby are as follows:

Digit keyed	Channels operated	Translator relays operated
1.....	/A, /D	TA, TD
2.....	/B, /D	TB, TD
3.....	/D, /E	TD, TE
4.....	/B, /E	TB, TE
5.....	/C, /D	TC, TD
6.....	/A, /C	TA, TC
7.....	/B, /C	TB, TC
8.....	/C, /E	TC, TE
9.....	/A, /E	TA, TE
0.....	/A, /B	TA, TB

When, therefore, the subscriber keys the trunks digit 4, frequencies B and E are generated and these frequencies are transmitted over the previously described loop, including a winding of transformer 68, whence they pass through high-pass filter 64 from the output of which the signal energy divides, part of it passing through transformer 112 to operate the enabler 80 and part of it passing through the volume limiter 65, transformer 66, resistance pad 67, the filters preceding the tubes /B and /E to the grids of said tubes. Since the operation of the receiver has been amply described in the above-mentioned patent to G. Hecht and A. A. Lundstrom and to which reference is made for a complete description thereof, it may be stated that a definite time interval is consumed in the operation of enabler 80 subsequent to which relay 77 operates to apply ground to conductor 78. Since this conductor is connected to the cathode of each of the tubes /A—/E, those detectors will respond through whose channels the filters will have caused the passage of the frequencies in the signal to be passed. Hence for the digit 4 for which the frequencies B and E are produced to cause the response of channel tubes /B and /E, relays FB and FE will be operated and they, in turn, will close obvious circuits for relays TB and TE which, upon operating, lock over conductor 81 under the control of polarized relay TL to ground on the No. 3 contacts of relay ON, relay TL having operated in the meanwhile (before the operation of relays TB and TE) over a circuit which may be traced from battery, the No. 2 contacts of relay TLT, upper winding of relay TL, No. 3 contacts of relay TLT, serially through the No. 3 contacts of relays TE, TD, TB, TC and TA, No. 1 contacts of relays BK1, BK3 and KBD, conductor 76 and ground previously traced thereto. Relay TL also has a circuit through its lower winding, which may be traced from ground on the No. 3 contacts of relay ON, No. 4 contacts of relay TLT, lower winding of relay TL, No. 1 contacts of relay TLT to resistance battery and ground. Now the current flowing through the upper winding of relay TLT is in a direction to cause its armature to engage the stationary contact while that flowing through the lower winding is in a direction to do the opposite. The strength of the current through the lower winding, however, is not sufficient, by itself, to overcome the effect of the current flowing through the upper winding so that when both windings are energized, the armature will engage its contact and provide locking ground for relays TB and TE (or any other combination of relays TA—TE) as above described.

It will be noted that the ground which forms a part of the circuit of the upper winding of relay

TL also keeps condenser C5 short-circuited. However, the operation of any one of the register relays TA—TE removes this ground, and a charging circuit is established for the condenser through the circuit of the upper winding of relay TL. Relay TL continues to hold for a short interval until the charging current through the condenser dies down after which, being then solely responsive to the current through its lower winding, the relay will release and unlock the register relays TB and TE. However, the interval in which relays TB and TE (or other register relays in the translator) are locked is sufficient to operate or release relay RA as described in my above-mentioned patent, and to cause the number designated by relays TB and TE to be transferred to the direct current pulse register of the link (Fig. 7) if said number is a digit of a local station number, or to the trunk marker if it is the code of a trunk to the central office. Since those operations of the link which have to do with the establishment of local connections are not involved in the present invention, reference being made to my above-mentioned patent for a description of the same, the digit 4 registered by the operation of relays TB and TE is immediately transferred to the register of the trunk marker. In other words, during the time that relays TB and TE are locked to the contacts of relay TL, a circuit is completed for relay TK4 over the following path: Ground and battery through the winding of relay TK4, No. 3 normally made continuity contacts of said relay, No. 5 contacts of relay RTT, conductor D4' (which is in parallel with conductor D4), No. 11 contacts of relay TE, No. 10 contacts of relay TB, No. 6 contacts of relay TE, No. 5 contacts of relay TD, No. 4 contacts of relay TB, No. 3 contacts of relay TC, No. 3 contacts of relay TA, No. 1 contacts of relay BK1, No. 1 contacts of relay BK3, No. 1 contacts of relay KBD, to aforetraced ground on conductor 76. Relay TK4 operates over this circuit, locks over its No. 3 front contacts and conductor 108 to ground on the No. 5 contacts of relay ON, and completes a circuit for relay HM over a circuit which may be traced from ground on the No. 2 contacts of relay TK4, No. 9 back contacts of relay LF, winding of relay HM to battery and ground. This relay operates, locks to operating ground over its own No. 5 contacts and the No. 3 back contacts of relay CA and, by breaking its No. 1 contacts, opens the secondary path of the circuit of oscillator 70, thereby causing key tone to cut off from the calling line.

After the trunk digit "4" has been registered in the trunk marker by the operation of relay TK4 therein, the trunk marker, in combination with the link, operates to set a switch therein to a position which is individual to the calling line. After the switch is set, the link is dismissed. Thereafter the trunk marker reoperates the cross bar switch to extend the calling line to an available trunk.

As previously mentioned, the operation of relay TK4 completes a circuit for relay HM which then locks over its No. 5 contacts, No. 3 contacts of relay CA to ground on the No. 2 contacts of relay TK4. Relay HM now completes a circuit for relay RTT from ground on said No. 2 contacts of relay TK4 No. 2 contacts of relay HM, winding of relay RTT to ground and battery. Relay RTT operates, locks over its No. 3 front contacts to off-normal ground on conductor 108 and opens the operating paths to relay TK4—TK7 (each of said relays being arranged for operation by the translator upon the keying of the digits 4 to 7, respectively, if desired), thereby leaving only relay TK4

in an operated condition. The operation of relay RTT causes changes to be made in the translator (Fig. 9) network which, however, do not affect this type of connection.

Relay HM, when operated, starts the line hunting cycle. Considering Fig. 14, it will be noted that a rotary stepping switch STP of a well-known type is provided which has a driving magnet STPM and a terminal arc of twenty-two terminals, each of which can be engaged by either end of the rotary brush BR. To each of twenty consecutive terminals of the terminal arc, beginning with the first terminal on the right, is connected a conductor which extends directly to the lower armature of a hold magnet HO— of one of the lines in consecutive order. Thus, to the first or terminal 20 of the arc is connected conductor CO20' which, joining conductor 98 in Fig. 5, extends to the lower armature of magnet HO20 of station A (20). Consecutively after terminal 20 are connected the conductors CO21'—CO39' extending, respectively, to each of the lower armatures of the hold magnet HO— indicated by the conductor designation. Hence, each of the twenty lines in the private branch exchange is represented on a terminal of the terminal arc of switch STP by a conductor which extends to the lower armature of its hold magnet. If this hold magnet is normal, the terminal on the arc is connected to battery through the winding of the associated cut-off relay CO— via the No. 2 back contacts of the magnet; if the magnet is operated, then the terminal is connected to ground through resistors RC and RC1 via the No. 2 front contacts of the magnet. In checking to determine the line which has keyed the trunk connection, brush BR is driven to the terminal on the arc which is reserved to the line, whence a check circuit is completed that will provide the desired information as described below.

When relay HM operates, and remembering that relay SA was previously operated in the locking circuit of relay CO20, said relay HM extends conductor 87 (which is joined to conductor S1 of the link at the No. 4 front contacts of relay LC1') over the No. 2 contacts of relay SA, No. 6 contacts of relay HM, winding of relay TST, condenser C6, battery and ground. At the same time an operating circuit is closed for the stepping magnet STPM which extends from ground and battery through the winding of said magnet, No. 2 contacts of relay SB, No. 1 back contacts of relay LF, back contacts of relay TST, to ground as previously traced on the No. 2 contacts of relay TK4. Magnet STPM operates, prepares to advance brush BR one terminal on its release, opens its No. 1 contacts and closes its No. 2 contacts. The closure of the latter then completes a circuit for relay SB extending from ground and battery, resistor RM winding of relay SB, No. 2 contacts of magnet STPM, No. 1 back contacts of relay LF, back contacts of relay TST, and thence to ground as previously traced. Relay SB operates and closes its No. 1 contacts before opening its No. 2 contacts. By opening the latter contacts, the operating circuit of magnet STPM is opened causing said magnet to release and advance the switch brush BR to the next terminal, said magnet, upon releasing, opening its No. 2 front contacts and closing its No. 1 back contacts. The circuit of relay SB, however, is not opened by the opening of the No. 2 contacts of magnet STPM inasmuch as the No. 1 contacts of relay SB cause ground on the No. 2 contacts of relay TK4 to be applied to the winding of said relay, causing the latter to be locked

against release when its operating circuit is interrupted by the opening of the No. 2 contacts of magnet STPM. The closure of the No. 1 contacts of this magnet, however, causes ground previously traced to the No. 1 back contacts of relay LF to be applied to the other terminal of relay SB so that this relay, upon the closure of the No. 1 contacts of magnet STPM following its release, is shunted and released.

The release of relay SB reestablishes the circuit of the motor magnet STPM whereupon the latter operates, opens the circuit of relay SB and then releases to advance the brush BR to the next terminal. This cycle of operations between magnet STPM and relay SB continues until the brush BR has been advanced to the terminal in the arc which is connected to the conductor CO—' of the calling line, at which time a circuit will be completed for relay TST in the manner shortly to be described.

It will be observed that the brush BR is connected to a source of ringing current RC through the impedance network IMP and the No. 4 contacts of relay LF. Now when the brush BR engages the terminal of an idle line, its conductor CO—' will be connected to the winding of its cut-off relay CO— via the No. 2 back contacts of the associated hold magnet HO—. Since the cut-off relay CO— is connected to battery and ground, a circuit will be completed from the ringing current source RC to battery and ground through the winding of the cut-off relay over the path indicated. This circuit, however, will not be effective to operate the cut-off relay CO because the slow-operate feature of the relay will cause said relay to be effectively unresponsive to the ringing current.

On the other hand, if the brush BR engages the terminal of a busy line, its relay CO— and its hold magnet HO— will both be operated and the path of the ringing circuit will be completed over the associated test conductor CO—', No. 2 front contacts of the hold magnet HO—, resistors RC and RC1 to ground. This circuit is, of course, effective to draw ringing current through the path but inasmuch as there is no electroresponsive device included in the path, the closure of this circuit will have no effect.

It will further be recalled that the upper terminal of the winding of the test relay TST is extended to conductor S1 via conductor 87 and the No. 4 contacts of relay LC1', and that its lower terminal is connected in series with condenser C6 and grounded battery so long as relay HM remains operated. Now conductor S1 is individual to the link taken into use by the calling station A and is joined to the upper terminal of relay TST by virtue of the operated condition of relay LC1' which is also individual to the link taken into use, that is to say, link 1. Since this link is connected to the line of the calling station A by virtue of the operated condition of cross-point 9 on vertical 20, conductor S1 is extended to resistors RC and RC1 in series to ground. Moreover, since hold magnet HO20 is operated, the same terminal of resistor RC which is connected to conductor S1 is also connected by way of the No. 2 front contacts of magnet HO20, conductor 98, conductor CO20' to the brush BR and thence to the source of ringing current RC when the brush BR engages the terminal to which conductor CO20' is connected. Consequently, when the brush is advanced to this terminal (which will be the first in the order of brush travel), the ground through resistors RC and

RCI establishes two parallel paths, one through conductor S1, No. 4 contacts of relay LCI, conductor 81, No. 2 contacts of relay SA, No. 6 contacts of relay HM, winding of relay TST, condenser C6 to battery and ground; the other path from ground through resistors RC and RCI, No. 2 front contacts of hold magnet HO20, conductor 98, conductor CO20', brush BR and the terminal engaged thereby, No. 4 contacts of relay LF, impedance IMP, ringing source RC to ground. The part of the ringing current which flows through the winding of relay TST will cause said relay to operate. Note, however, that unless the ringing current path is established through the resistors RC and RCI as above traced, relay TST will not be able to operate on its own path to these resistors inasmuch as condenser C6 in series with the battery, will prevent the flow of direct current.

Hence when the brush BR of the stepping switch STP engages the terminal on the arc which is allocated to the calling line (or station A), relay TST operates, opens the circuit of magnet STPM and completes a circuit for relay LF, which circuit extends from ground and battery through the winding of said relay, front contacts of relay TST, No. 2 contacts of relay TK4 to ground. Relay LF, upon operating, locks through its No. 9 front contacts to ground on the No. 2 contacts of relay TK4. At its No. 2 front contacts it shunts condenser C6 thereby causing relay TST to hold over a direct current path which extends from ground and battery, No. 2 front contacts of relay LF, resistor R1, winding of relay TST, and thence as traced to ground through resistors RC and RCI; at its No. 4 contacts relay LF disconnects the ringing source RC from the brush BR; at its No. 3 back contacts it disconnects ground from the winding of relay SA and, therethrough, from conductor 102 which, through the front contacts of relay A of the link and No. 7 contacts of relay B, holds relay CO20 operated which, in turn, locally holds the hold magnet HO20 and, therefore, keeps the cross-point 9 on vertical 20 closed. The removal of ground from conductor 102, therefore, results in the release of relay CO20, magnet HO20 and the disconnection of the link from vertical 20. Relay L20 now reoperates over the calling station loop, but due to operations in the call allotter following the operation of relay LF in the trunk marker as described below, start conductor 1 is not grounded to cause the assignment of another link to said station. The release of relay B further causes the release of all relays holding thereto including relay LSI. Relay LSI releases relay LCI and LCI' the former causing the disconnection of the translator and pulse receiver from the link and the latter the disconnection of the trunk marker. When the translator releases, relay ON releases and thereby disconnects ground from conductor 108. This, however, will not disturb the operated relays in the trunk marker which are held to ground on said conductor over the No. 3 front contacts of relay LF through the No. 3 contacts of relay RLS to conductor 108.

In the meanwhile, a circuit is further completed for relay TK in the call allotter, said circuit extending from ground on the No. 12 contacts of relay E1, conductor L1, No. 5 contacts of relay LF, No. 2 contacts of relay RLS, conductor L2, winding of relay TK to battery and ground. Relay TK operates and completes a circuit for relay E in said call allotter over its No. 1

front contacts to aforesaid ground on conductor L1.

Relay E completes a circuit for relays E1 and E2 extending from ground on the No. 3 contacts of relay TK, contacts of relay E, No. 2 normally made continuity contacts of relay MS, winding of relays E1 and E2 in parallel to battery and ground connected, respectively, to the other side of each of these relays. Relay E1, upon operating, opens the locking circuit of relay LO20 which now releases and further completes the circuit of relay MS, which circuit extends from ground and battery through the winding of said relay, No. 14 contacts of relay E1, conductor 10, to ground on the No. 3 contacts of relay TK. Relay MS applies local ground over its No. 2 front contacts to hold relays E1 and E2 operated and further applies ground on the No. 3 contacts of relay TK over its No. 3 contacts to conductor 11 which, as will be shown, is used to complete the circuit of the trunk select magnet. It is now evident that, with relays E1 and E2 operated, no ground can be furnished to conductor 6 and over the No. 1 and No. 2 contacts of relay L20, to start conductor 1 whereby to seize another link. So long, therefore, as the calling station remains unsatisfied without the connection of a trunk thereto, neither it nor any other calling station can initiate the operation of a link.

With the disconnection of the link from the calling station, the holding circuit of relay TST is opened, whereupon a circuit is completed for relay CA extending from ground and battery through resistor CAR, winding of relay CA, No. 2 normally made continuity contacts of relay CA, No. 1 front contacts of relay LF, back contacts of relay TST, to ground in the No. 2 contacts of relay TK4. Relay CA releases relay HM and completes the circuit of relay T of trunk 4 (Fig. 12), said circuit extending from ground on the No. 1 front contacts of relay CA, serially through the No. 1 back contacts of relays TK7-TK5, No. 1 front contacts of relay TK4, conductor 113, winding of relay T to battery. Relay T operates to complete a circuit to the trunk select magnet as explained hereinafter. Moreover, since relay LF remains operated, relay TK of the call allotter also remains operated over conductor L1 and its No. 1 front contacts, contacts of relay E to ground on the No. 3 contacts of relay TK. Thus after the test of the calling line, the link originally connected thereto is restored, but by virtue of the fact that the brush BR of the trunk marker switch STP when engaged to conductor CO20' caused the operation of relay LF, the trunk marker retains the memory, as it were, of the calling line.

Relay T when operated, extends ground on conductor 11 over its contacts to complete the circuit of selector magnet 3 which operates to condition the cross-points on the third horizontal level for selection and locking in order now to connect the calling line to the trunk. The operation of selector magnet 3 closes the circuit of relays S and S1 in the call allotter (the circuit of these relays being closed by the operation of any selector magnet) and, upon their operation, ground is applied to No. 4 contacts of relay TK and thence to conductor A1 thereby shunting and releasing relay CA in the trunk marker. Since relay HM is also released while relay LF is still operated, a circuit is completed for relay CO20 of the calling station, said circuit being completed from ground on the No. 1 back contacts of relay CA, No. 3 contacts of relay HM, No. 7 contacts of relay LF,

brush BR and terminal 20 engaged thereby, conductor CO20', conductor 98, No. 2 back contacts of hold magnet HO20, winding of relay CO20 to battery and ground. Relay CO20 operates and closes the circuit of hold magnet HO20 which, upon operating and in view of the fact that selector magnet 3 is still operated, closes cross-point 3 on vertical 20 and thereby extends the calling line to the trunk. The closure of contacts 6 and 5 on said cross-point effects a juncture of the line conductors T and R with the trunk conductors TT and TR, respectively, the latter two conductors extending to the central office over the following path: Conductor TT, No. 1 normally made contacts of relay H, upper winding of relay H1, conductor TT1 which extends to the central office and is in series thereof with a signal responsive device and a battery, conductor TR1, lower winding of relay H1, to conductor TR. Since the line loop beyond conductors TR and TT is closed by the calling station as previously traced, the signal device at the central office operates to indicate to the operator that service is requested over the trunk. Relay H1 operates to provide locking ground for various relays that function on incoming calls with which this invention is not involved and, therefore, not described and, also, to provide holding ground for the cut-off relay CO20 over conductor 126, No. 2 contacts on cross-point 3 of vertical 20, the common vertical wire, No. 1 contacts on said cross-point, the common vertical wire winding of relay CO20 to battery. Relay CO20 is thus maintained operated, in turn maintaining the hold magnet HO20 operated and the cross-point 3 closed. A branch of conductor 126 completes a circuit for relay RLS in the trunk marker, said circuit tracing from ground on conductor 126, No. 10 front contacts of relay LF, No. 5 contacts of relay TK4, serially through the No. 5 back contacts of relays TK5-TK7 inclusive, No. 8 contacts of relay LF, No. 1 normally made continuity contacts of relay RLS, winding of said relay to battery and ground. Relay RLS operates, locks over its No. 1 front contacts to ground on the No. 2 contacts of relay TK4 and opens conductor L2 which causes relay TK in the call allotter circuit to release, in turn opening the circuit of relay MS which releases, in turn releasing relays E and E1, relay MS further removing ground from conductor 11 thereby causing the release of the selector magnet 3. The cross-point 3 in vertical 20 is then held closed so long as the trunk connection is held. Relay RLS, by opening its No. 3 contacts, disconnects ground on the No. 2 contacts of relay TK4 from conductor 108. Since all relays in the trunk marker are held to ground on this conductor, the removal of ground therefrom will cause all relays in said trunk marker to restore to normal, the brush BR of the stepping switch STP remaining in engagement with the terminal last used; that is, with the terminal allocated to station A. The trunk marker is now ready to be resized to establish another trunk call.

The trunk connection is now held over cross-point 3 on vertical 20 under the control of ground from the trunk relay H1. When the calling station disconnects, relay H1 is released, relay CO20 releases in consequence thereof and hold magnet HO20 also releases and opens the cross-point. Both line and trunk are thus restored to normal.

The number of trunks which may interconnect the private branch exchange with the central office will, of course, vary with the needs of the

traffic and the capacity of the switch. In the present embodiment of the invention wherein a twenty line switch with ten horizontal outlets is utilized, the needs of three links for local traffic leaves four horizontal outlets which may be used for as many trunks. Assuming, therefore, that a maximum of four trunks is provided between the private branch exchange and the central office, each trunk is marked by its own relay TK— in the trunk marker. Thus, relay TK4 marks the trunk whose circuit is shown in detail in Fig. 12, while relays TK5, TK6 and TK7 mark the trunks designated trunks 5, 6 and 7, respectively in said figure. When the subscriber keys the trunk digit 4, the trunk marker immediately assigns a trunk, if one is available. The trunks are arranged in a numerical order of preference so that trunk 4, marked by relay TK4, will be first choice. Should this trunk be busy, the next idle trunk in the order of preference will be selected. This is accomplished in the following manner:

It will be recalled that as soon as a trunk is taken into use and relay H1 operates, ground is applied to conductor 126 individual to the trunk. Now when a subscriber keys the trunk digit 4 and the trunk marker is connected to the link, relay TK4 operates in the manner described. However, if the trunk marked by this relay is busy, ground will be present in its conductor 126 and a circuit will be closed thereby for relay TK5 if the trunk marked by this relay is free. The circuit of said relay TK5 traces from afore-traced ground on conductor 126, No. 10 back contacts of relay LF, No. 5 contacts of relay TK4, winding of relay TK5 to battery. Relay TK5 operates and then functions, at the proper time, to complete the circuit of relay T of trunk 5, operations thereafter proceeding as already described in connection with trunk 4. Should trunk 5 also be busy, ground will be present on its own conductor corresponding to conductor 126 of trunk 4 and connected to the stationary spring of the No. 5 contacts of relay TK5, so that, with relay TK4 operated by the trunk marker and relay TK5 operated by ground on conductor 126, a circuit will be completed for relay TK6 from ground extended from trunk 5 to the No. 4 contacts of relay TK5, winding of relay TK6 to battery. Relay TK6 now assigns the idle trunk and performs and controls the same operations which have been described for trunk 4.

If all the four trunks are busy, relays TK4-TK7, inclusive, will all be operated by the ground on the private conductors individual to the trunks (similar to conductor 126 individual to trunk 4), and a circuit will be closed for all the all-trunks-busy meter ATB, extending from battery through the winding of the meter coil ATB, No. 4 contacts of relay TK7, No. 13 back contacts of relay LF to ground on the private conductor 126' of trunk 7. The operating ground for the meter ATB is further applied through the No. 4 contacts of relay HM, conductor 131, No. 5 contacts of relay LC1', conductor 132, No. 4 normally made contacts of relay BY, lower winding of relay BY to battery. Relay BY operates, locks through its No. 4 front contacts in series with its upper winding, No. 5 contacts of relay HS to ground on conductor 20. Relay BY applies ground through its No. 1 contacts to conductor 34, extending to the power, tone and alarm circuit 110 whereby circuits are closed therein to apply a "busy" tone source to conductor 35. This

conductor extends over the No. 2 contacts of relay BY to one side of condenser C2, through which the tone current passes over the No. 2 back contacts of relay HS; conductor LT, over the calling loop to conductor LR, No. 3 back contacts of relay HS, upper winding of relay A to ground. The busy tone thus furnished the calling line indicates to the subscriber thereat that no trunk is available.

While I have described my invention in connection with one specific embodiment thereof and demonstrated one of its applications, it is to be understood that various other embodiments and applications thereof may be made by those skilled in the art without departing from the spirit of the invention as defined within the scope of the appended claims. Thus, for example, the four outgoing trunks may, if desired, be grouped to extend to two or more different central offices and a separate trunk digit—other than 2 and 3—assigned to each office. The relays TK—in the trunk marker may then be similarly grouped to operate, upon the keying of the appropriate digit, in the serial order herein described, so that when all trunks in that particular group are busy, meter ATB will operate.

What is claimed is:

1. In a telephone system, the combination with a calling line, a link connected to said line and a trunk having an identifying designation, of a trunk marker responsive to said designation for controlling the extension of said line to said trunk after said link has been disconnected from said line.

2. In a telephone system, the combination with a calling line, a link connected to said line and a plurality of trunks each having an identifying designation, of a trunk marker settable in response to the designation of one of said trunks for controlling the extension of said line to said one of said trunks after said link has been disconnected from said line.

3. In a telephone system, the combination with a number of lines, a link connected to one of said lines when calling and a plurality of trunks each having an identifying designation, of a trunk marker connectable to said link comprising means settable in response to the designation of one of said trunks, means settable in response to a condition on said calling line, means responsive to said settable means for disconnecting said link from said calling line and from said trunk marker, and means responsive to said means settable in response to the designation of said one of said trunks for controlling the extension of said calling line to said trunk.

4. In a telephone system, the combination with a calling line, a link connected to said line and a trunk having an identifying designation, of a trunk marker having means responsive to said calling line, means responsive to said trunk designation and means responsive to both of said previously mentioned means for controlling the extension of said calling line to said trunk after said link has been disconnected from said line.

5. In a telephone system, the combination with a calling line, a link connected to said line and a trunk having an identifying designation, of a trunk marker having means responsive to said calling line, means responsive to the designation of one of said trunks, means responsive to said first-mentioned means for disconnecting said link from said line and means responsive to said second-mentioned means for controlling the ex-

tension of said line to an idle one of said trunks.

6. In a telephone system, the combination with a calling line, a link connected to said line and a trunk group having an identifying designation, of a trunk marker having means responsive to said calling line, means responsive to the designation of said trunk group, means responsive to said first-mentioned means for disconnecting said link from said line, and means operative in response to said last-mentioned means for controlling the extension of said line to one of the trunks in said group of trunks.

7. In a telephone system, a cross bar switch, lines connected to the vertical elements of said switch, links and trunks connected to the horizontal elements of said switch, each of said trunks having individual designations, means responsive to a line when calling for operating said switch to connect the vertical element of said line to the horizontal element of one of said links, a trunk marker common to said links and connectable to any of said links when one of the latter is taken into use by a calling line, means in said trunk marker responsive to a signal transmitted from said calling line indicative of the designation of one of said trunks, means in said trunk marker, settable to indicate said calling line, means responsive to said last-mentioned means for releasing the connection between said calling line, said link and said trunk marker, and means responsive to said signal-operated means in said marker for causing the reoperation of said cross bar switch to connect the vertical element of said calling line to the horizontal element of the trunk whose designation was registered in said marker.

8. In a telephone system, a cross bar switch, lines connected to the vertical elements of said switch, link and trunks connected to the horizontal elements of said switch, all of said trunks having a common designation, means responsive to a line when calling for operating said switch to connect the vertical element of said line to the horizontal element of one of said links, a trunk marker common to said links and connectable to any one of said links when taken into use by a calling line, means in said trunk marker responsive to a signal transmitted from said calling line indicative of said common trunk designation, means in said trunk marker settable to indicate said calling line, means responsive to said last-mentioned means for releasing the connection between said calling line, said link and said trunk marker, and means responsive to said signal-operated means in said marker for causing the reoperation of said cross bar switch to connect the vertical element of said calling line to the horizontal element of one of said trunks.

9. A telephone system comprising a plurality of stations each having an individual terminal, a plurality of links available to said stations, a plurality of trunks for connection to said stations, means responsive to one of said lines initiating a call for connecting one of said links thereto, means in said link for registering the designation of a trunk connection, means responsive to the registration of said trunk designation for connecting a source of alternating current to the terminal individual to the calling line, and a signal responsive device connected to said terminal through the link extension of said calling line whereby said signal responsive device is operated by the current supplied through said source of alternating current.

10. A telephone system comprising a plurality

of stations each having an individual terminal, a plurality of links available to said stations, a plurality of trunks for connection to said stations, means responsive to one of said stations initiating a call for connecting one of said links thereto, means in said link for registering the designation of a trunk connection, a stepping switch in said link having a terminal for each line connected to the corresponding individual terminal of said line, means responsive to said trunk designation registering means for advancing said stepping switch to the terminal thereof which is allocated to the calling line, means for connecting a source of alternating current to the terminal individual to said calling line, and a signal responsive device connected to said terminal through the terminal of said switch whereby said signal responsive device is operated by the current supplied from said source of alternating current.

11. A telephone system comprising a cross bar switch, lines connected to the verticals of said switch, each of said lines including a terminal individual thereto, a plurality of links connected to a plurality of horizontals of said switch for access to all of said lines, a plurality of trunks connected to another plurality of the horizontals of said switch for connection to all of said lines, means responsive to one of said lines initiating a call for connecting one of said links to said line through the common cross-point of said line and said link on said switch, means in said link for registering the designation of a trunk connection, means responsive to the registration of said trunk designations for connecting a source of alternating current to the terminal individual to the calling line, a signal responsive device connected to said terminal through the cross-point connecting said line with the link whereby said signal responsive device is operated by the current supplied from said source of alternating current, means responsive to the operation of said signal responsive device for disconnecting said link from said line, and means operative after the disconnection of said link for connecting one

of said trunks to said line through a cross-point common to said line and said trunk.

12. A telephone system comprising a plurality of lines, a resistance element individual to each line, a plurality of links available to said lines, a plurality of trunks for connection to said lines, means responsive to one of said lines initiating a call for connecting one of said links thereto, means in said link for registering the designation of a trunk connection, means responsive to the registration of said trunk designation for connecting a source of alternating current to a terminal of the resistance element individual to said calling line, a signal responsive device connected to said terminal through the link extension of said line whereby said signal responsive device operates on current supplied through said source of alternating current, means responsive to the operation of said signal responsive device for disconnecting said calling line from said link and means thereafter operative to extend said calling line to one of said plurality of trunks.

13. A telephone system comprising a plurality of lines, a resistance element for each line, a plurality of links available to said lines, a plurality of trunks for connection to said lines, means responsive to one of said lines when calling for connecting one of said links thereto, means in said link for registering the designation of a trunk connection, means responsive to the registration of said trunk designation, means settable to the resistance element of said calling line in response to said trunk registration means, means for connecting a source of alternating current to a terminal of the resistance element individual to said calling line, a signal responsive device connected through said settable means to said terminal of said line, whereby said signal responsive device operates on current supplied through said source of alternating current, means responsive to the operation of said signal responsive device for disconnecting said link from said line, and other means operative thereafter for extending said calling line to one of said trunks.

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