

Sept. 12, 1944.

B. F. LEWIS ET AL

2,358,237

TELEPHONE SYSTEM

Filed Dec. 22, 1942

12 Sheets-Sheet 1

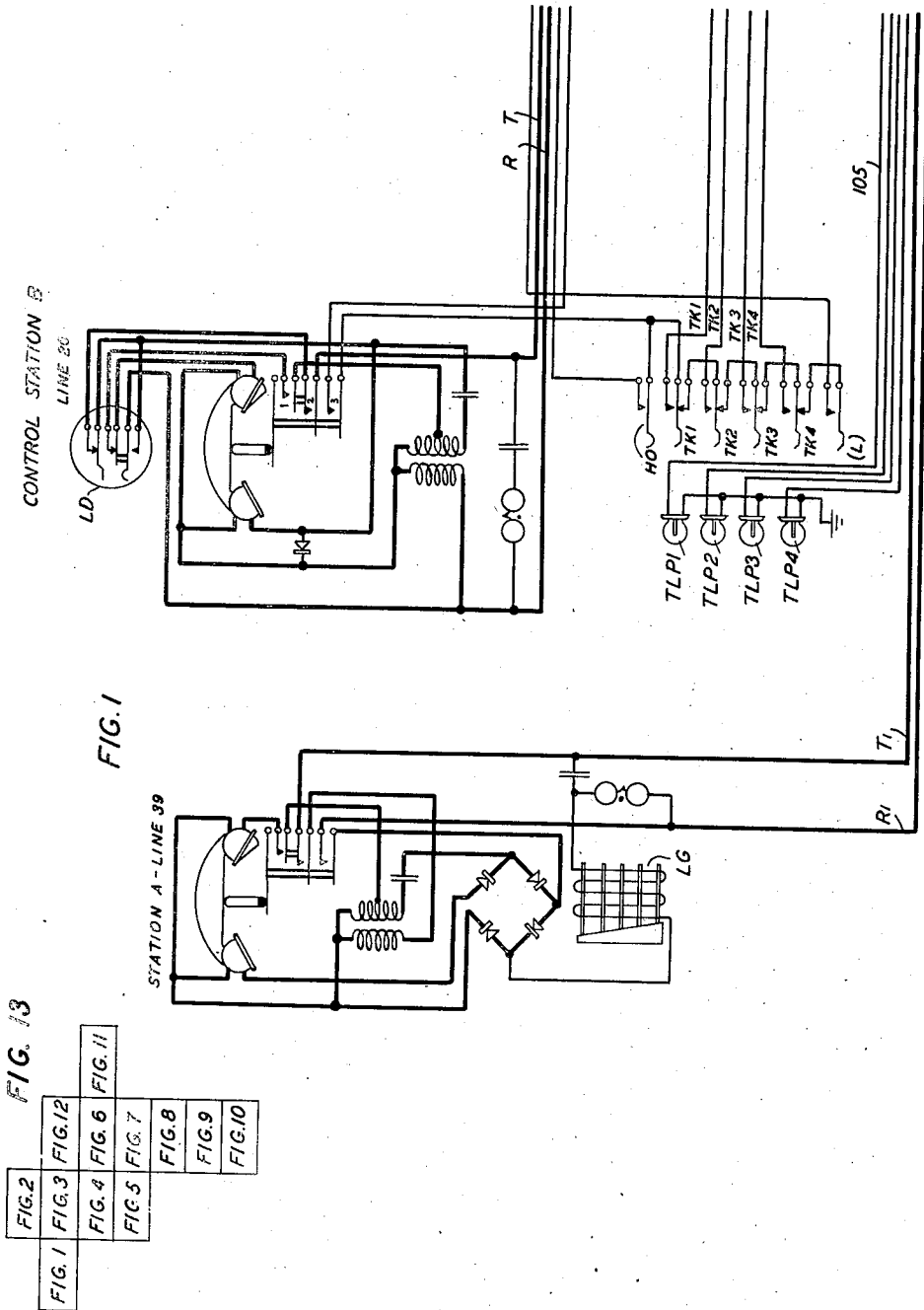


FIG. 13

FIG. 1	FIG. 2	FIG. 3	FIG. 4	FIG. 5	FIG. 6	FIG. 7	FIG. 8	FIG. 9	FIG. 10	FIG. 11	FIG. 12
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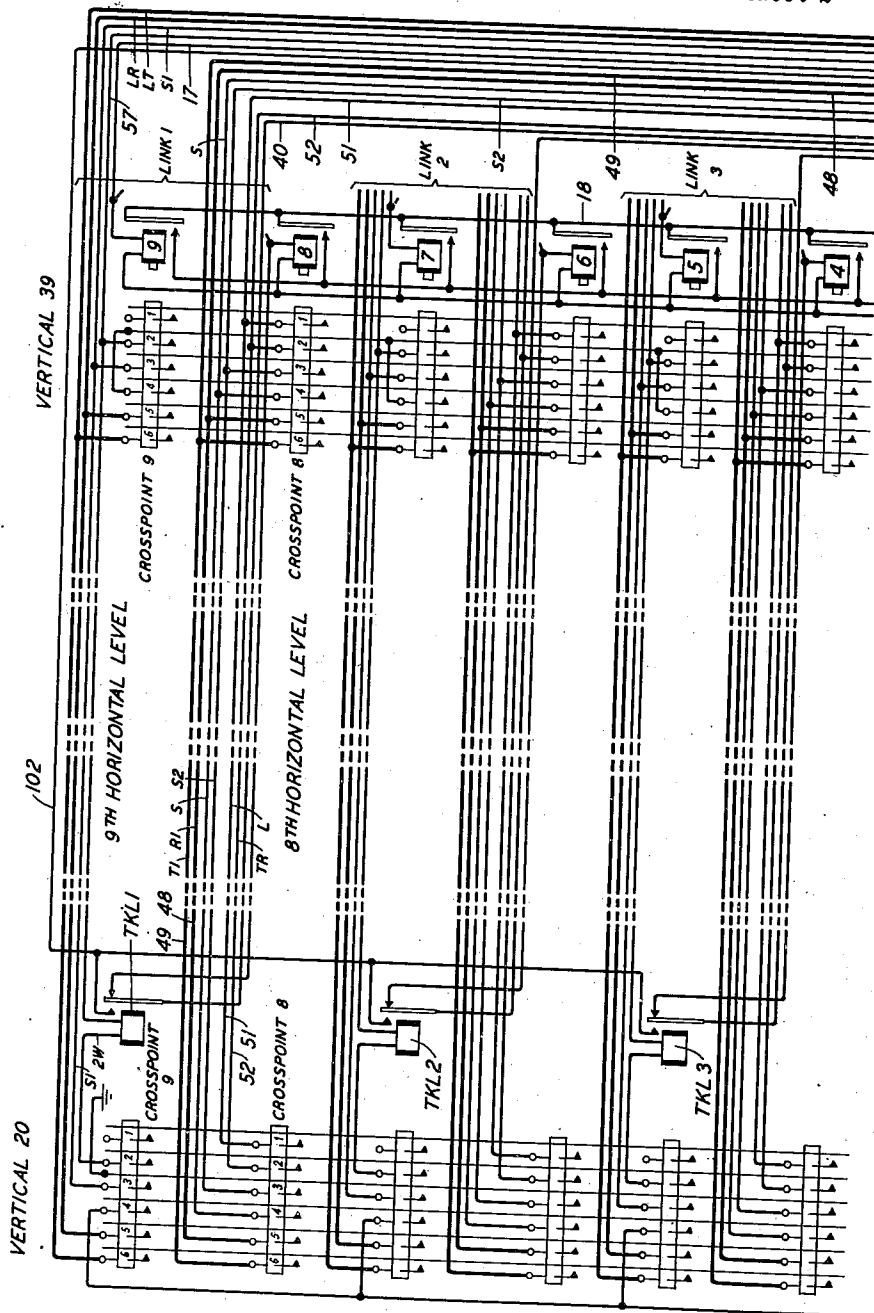
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FIG. 2



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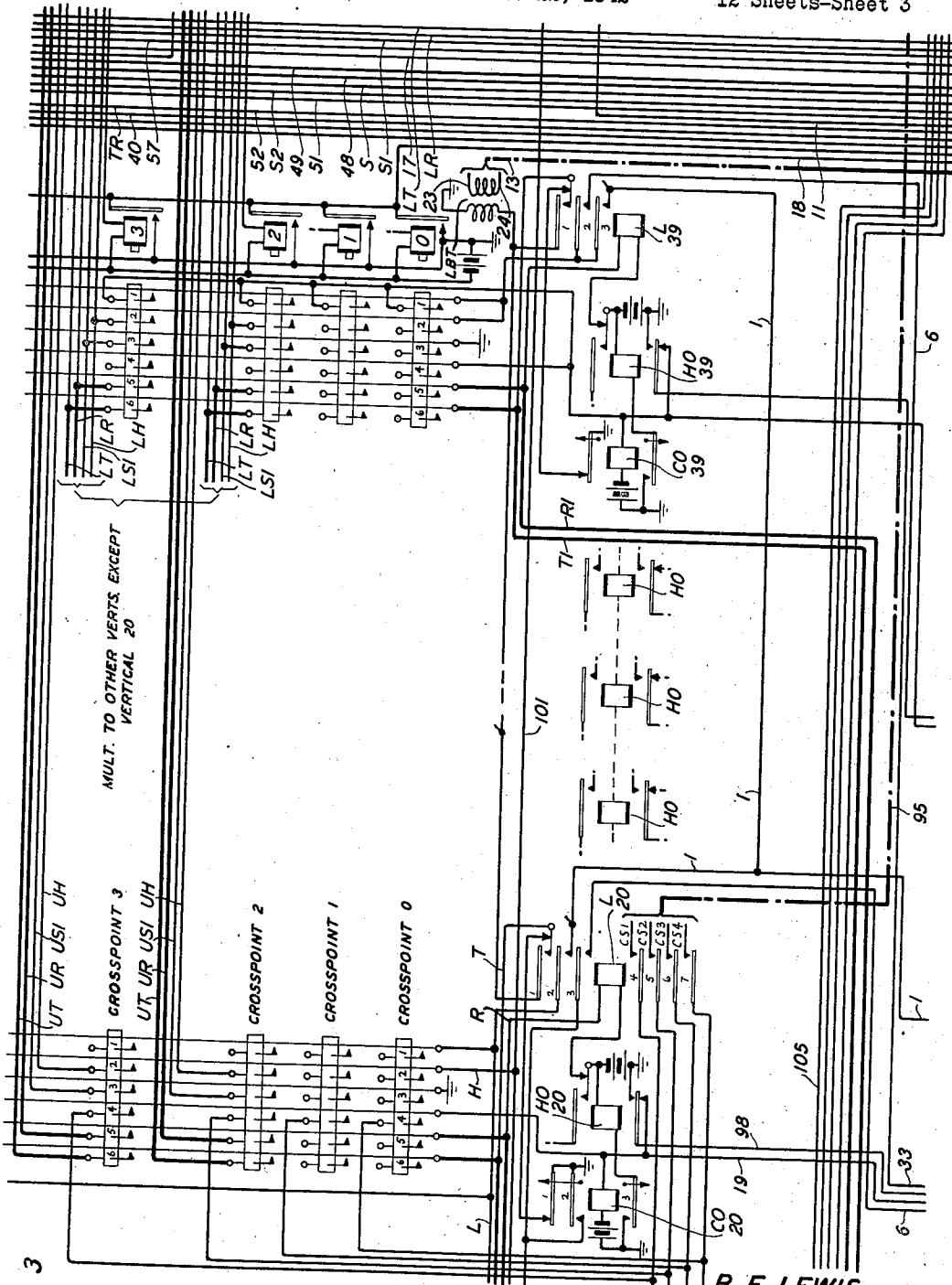


FIG. 3

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12 Sheets-Sheet 4

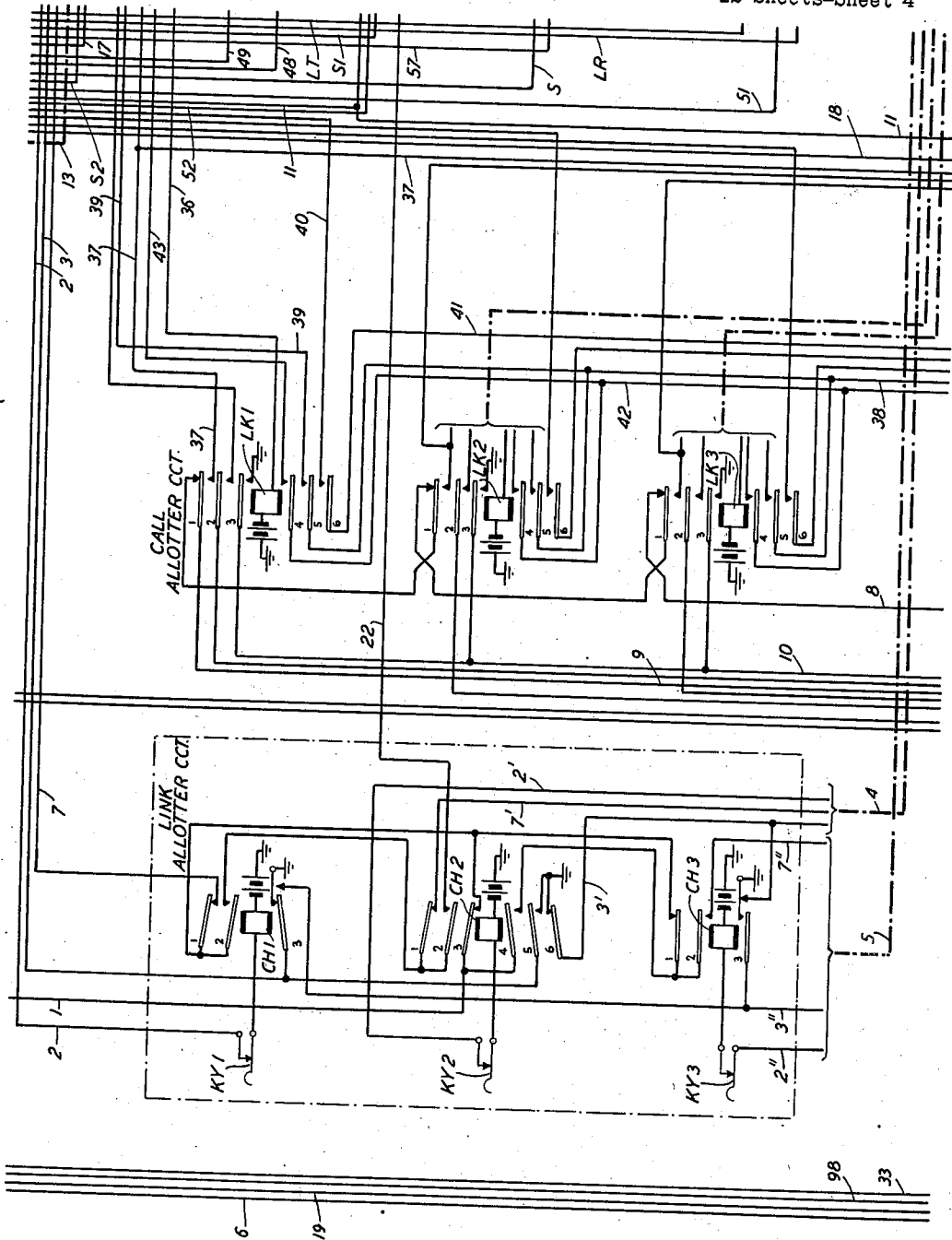


FIG. 4

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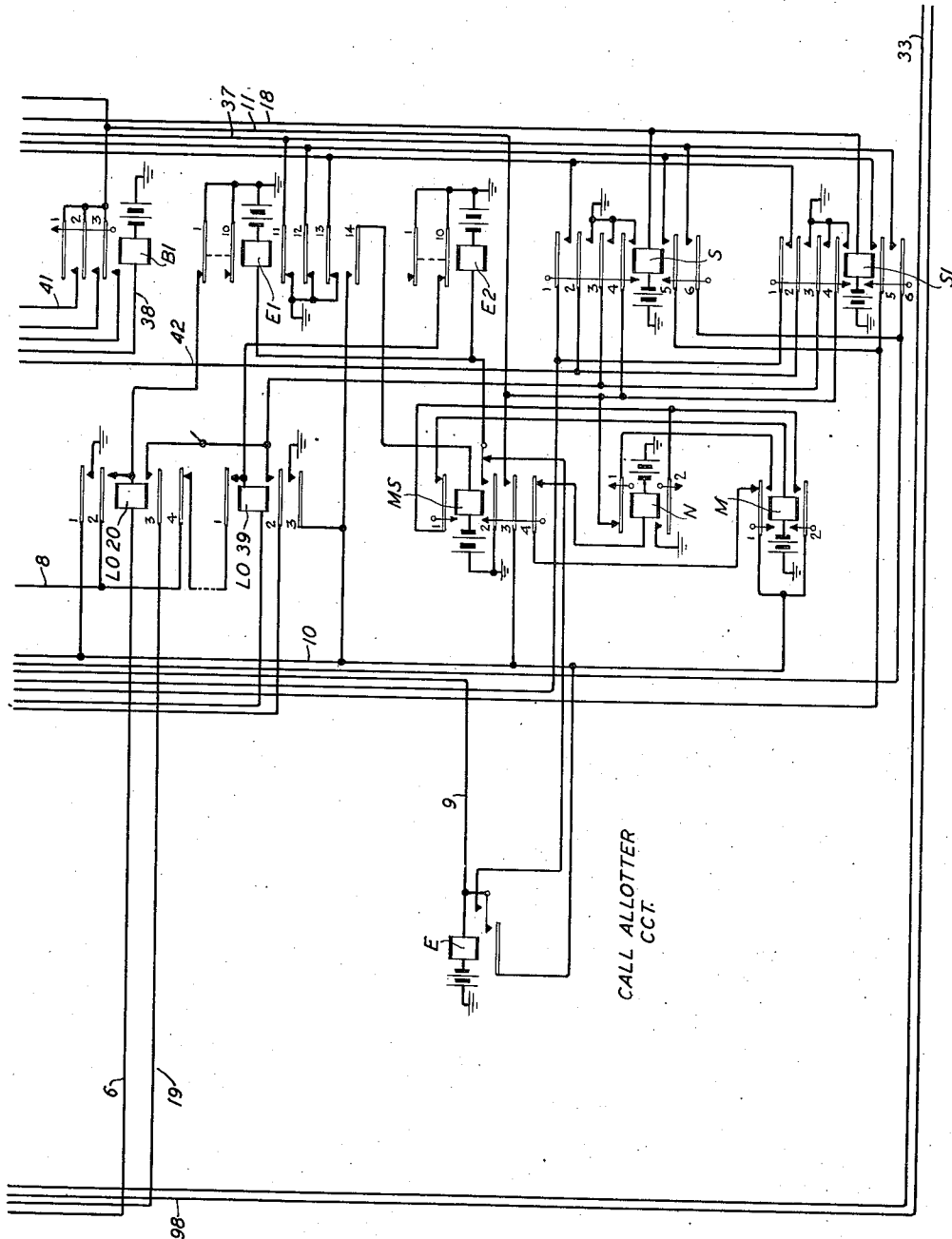


FIG. 5

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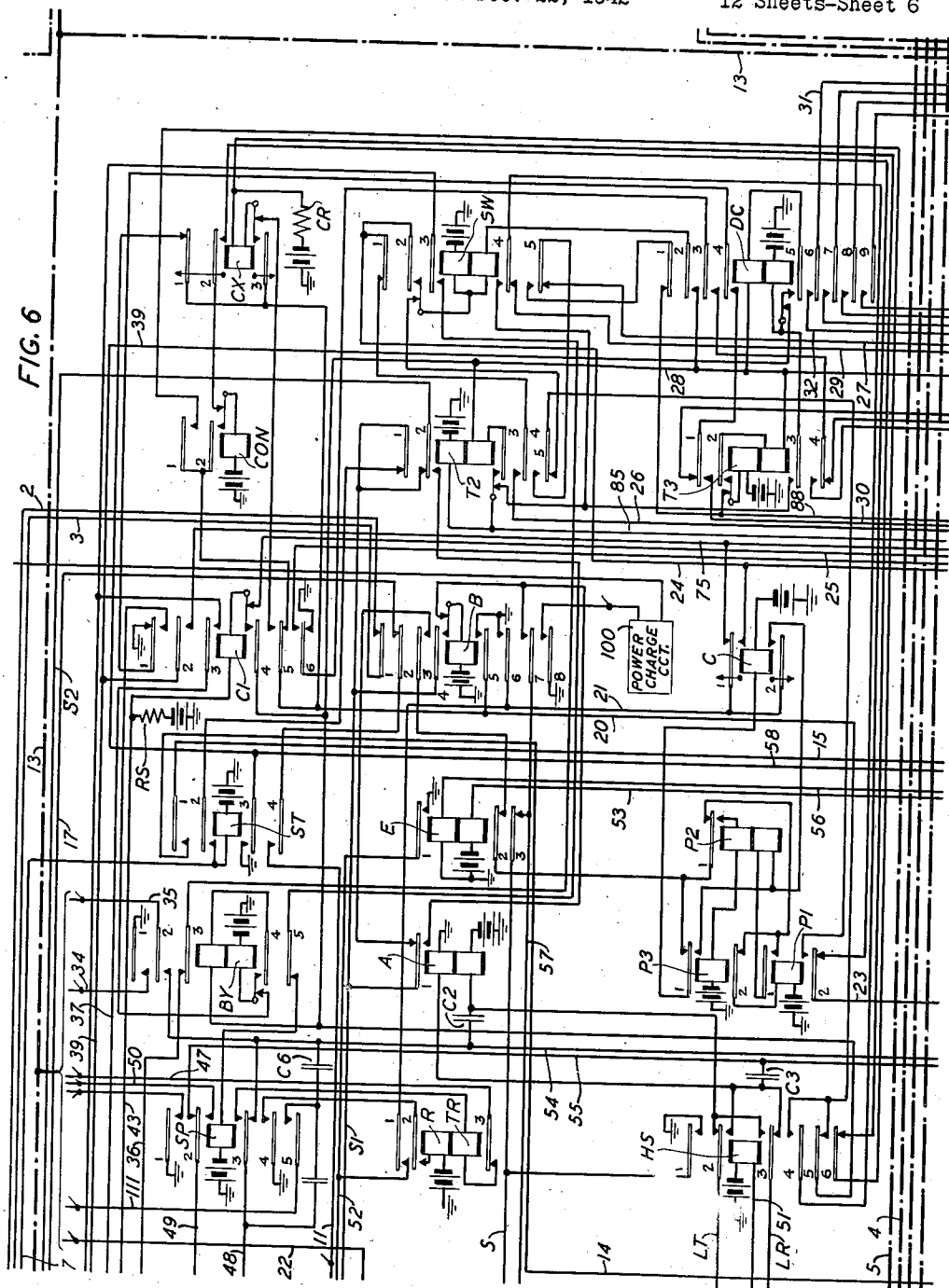
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TELEPHONE SYSTEM

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12 Sheets-Sheet 6



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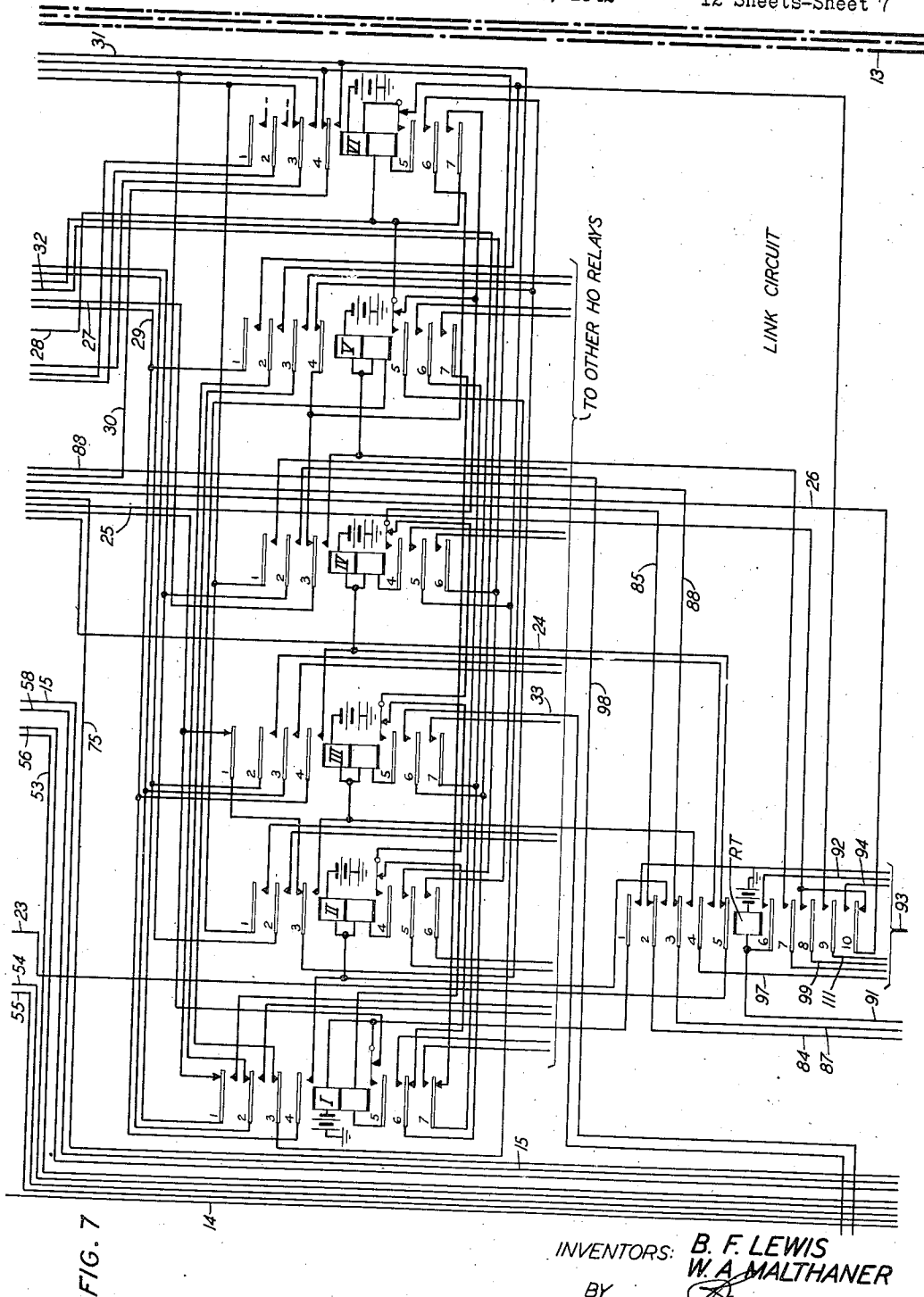
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TELEPHONE SYSTEM

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12 Sheets-Sheet 7



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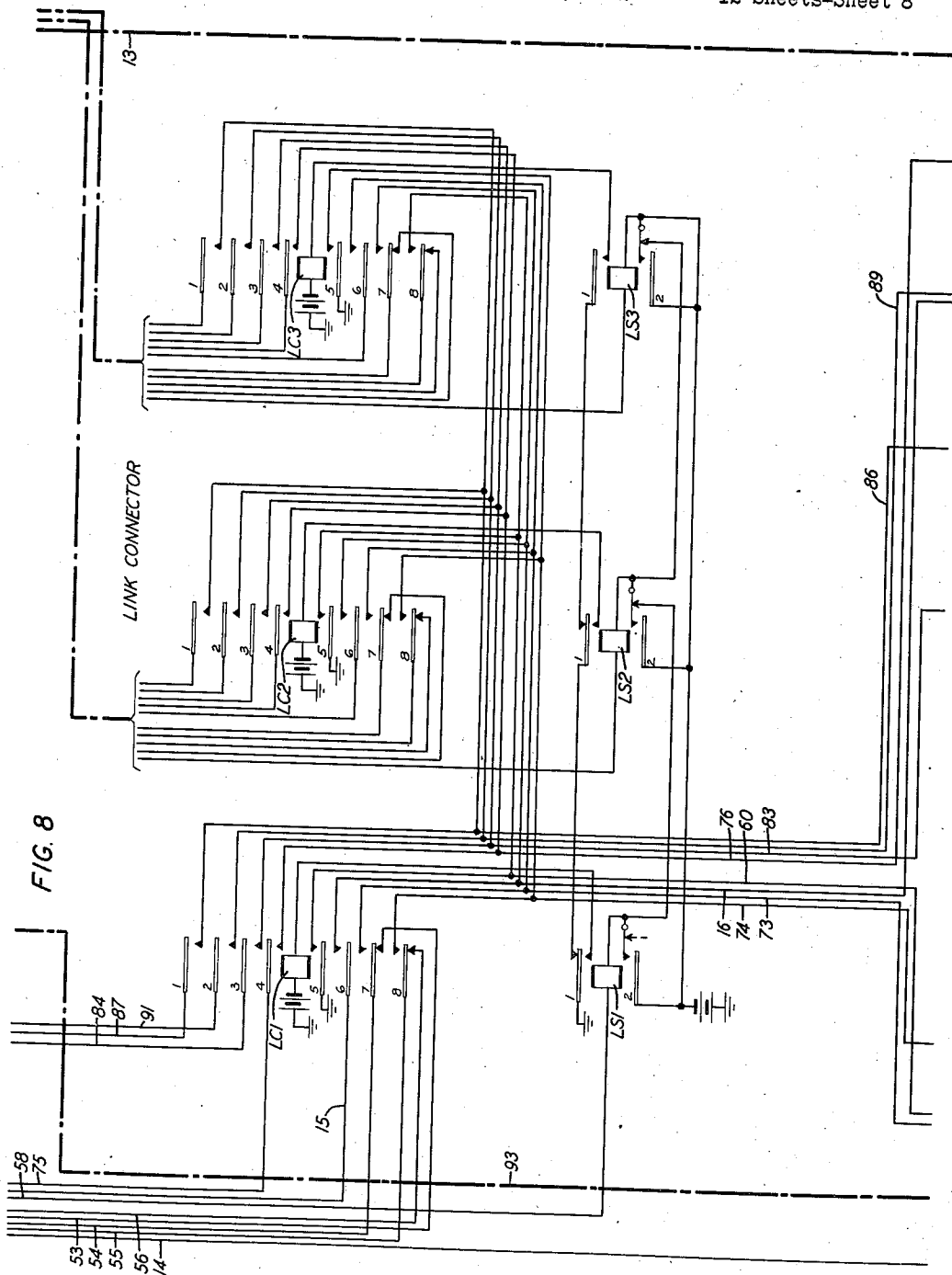
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TELEPHONE SYSTEM

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12 Sheets-Sheet 8



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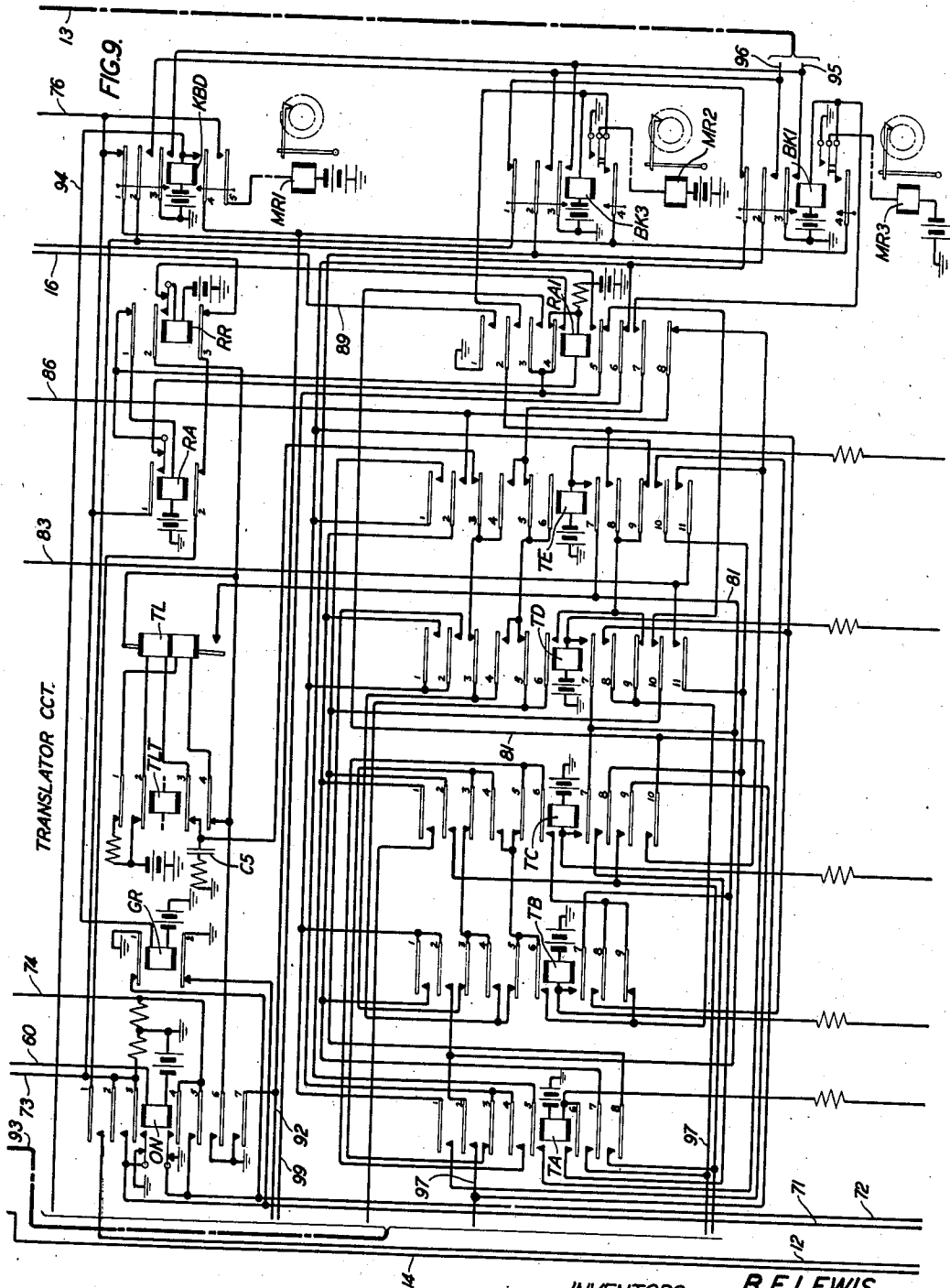
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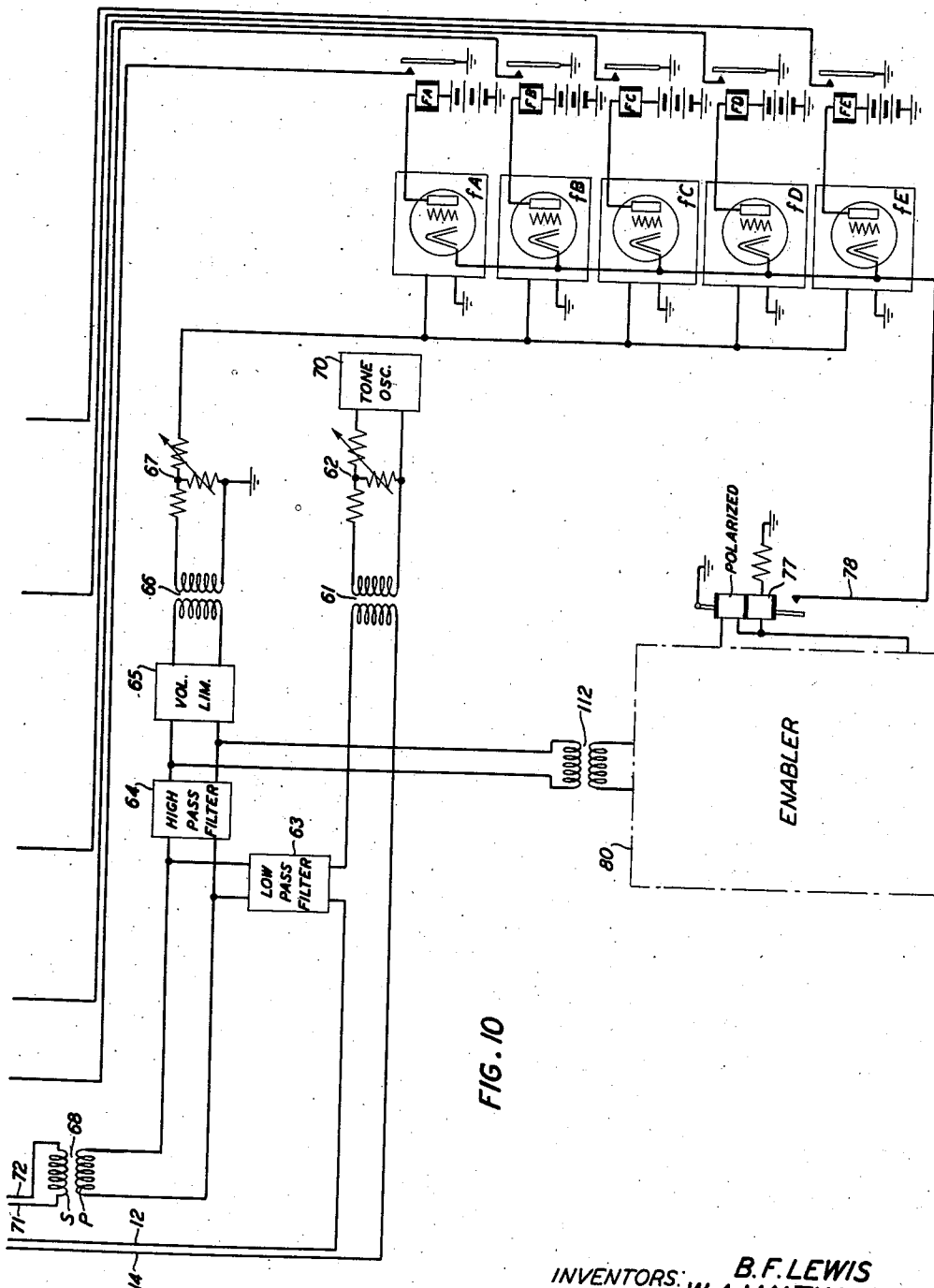


FIG. 10

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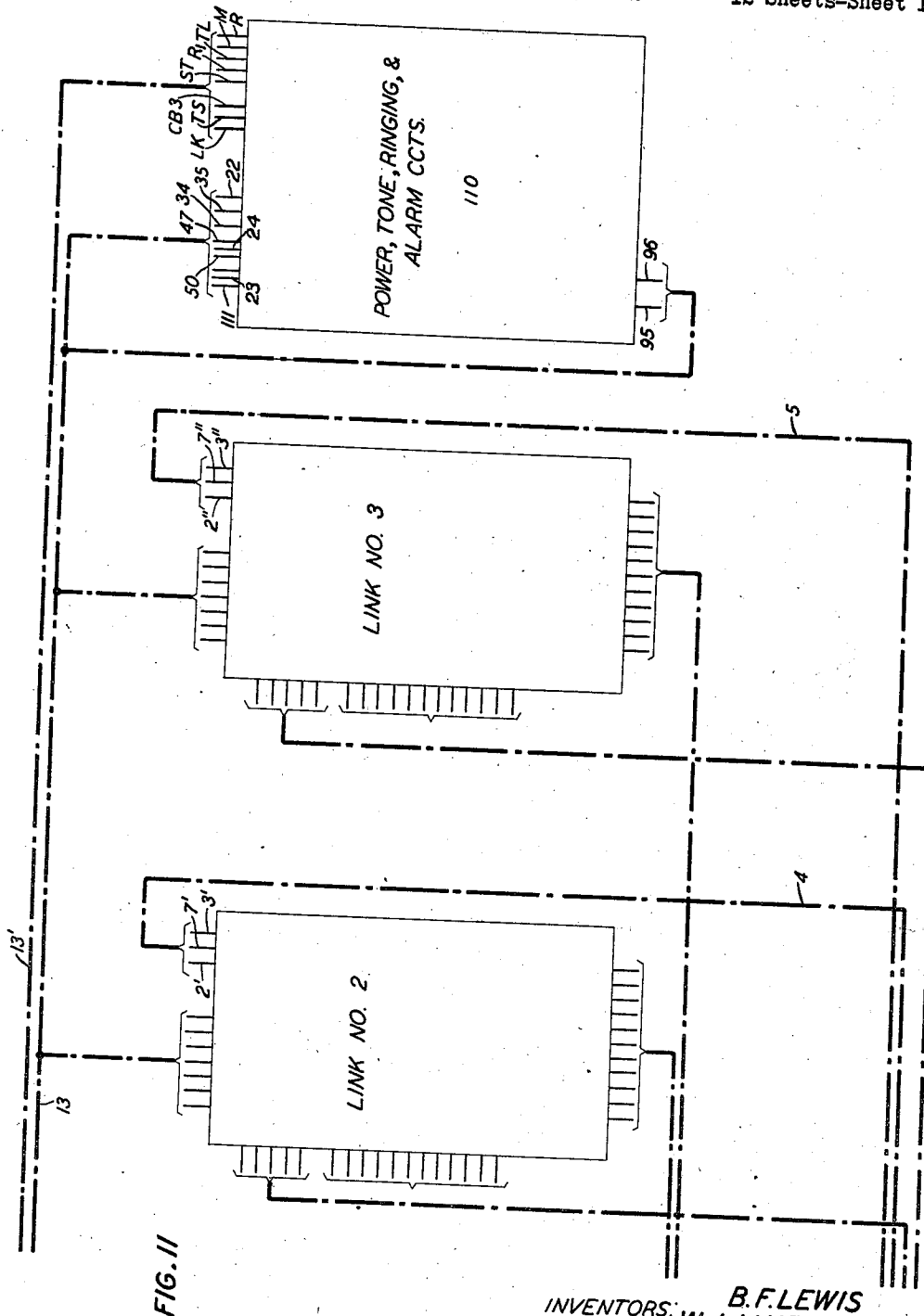


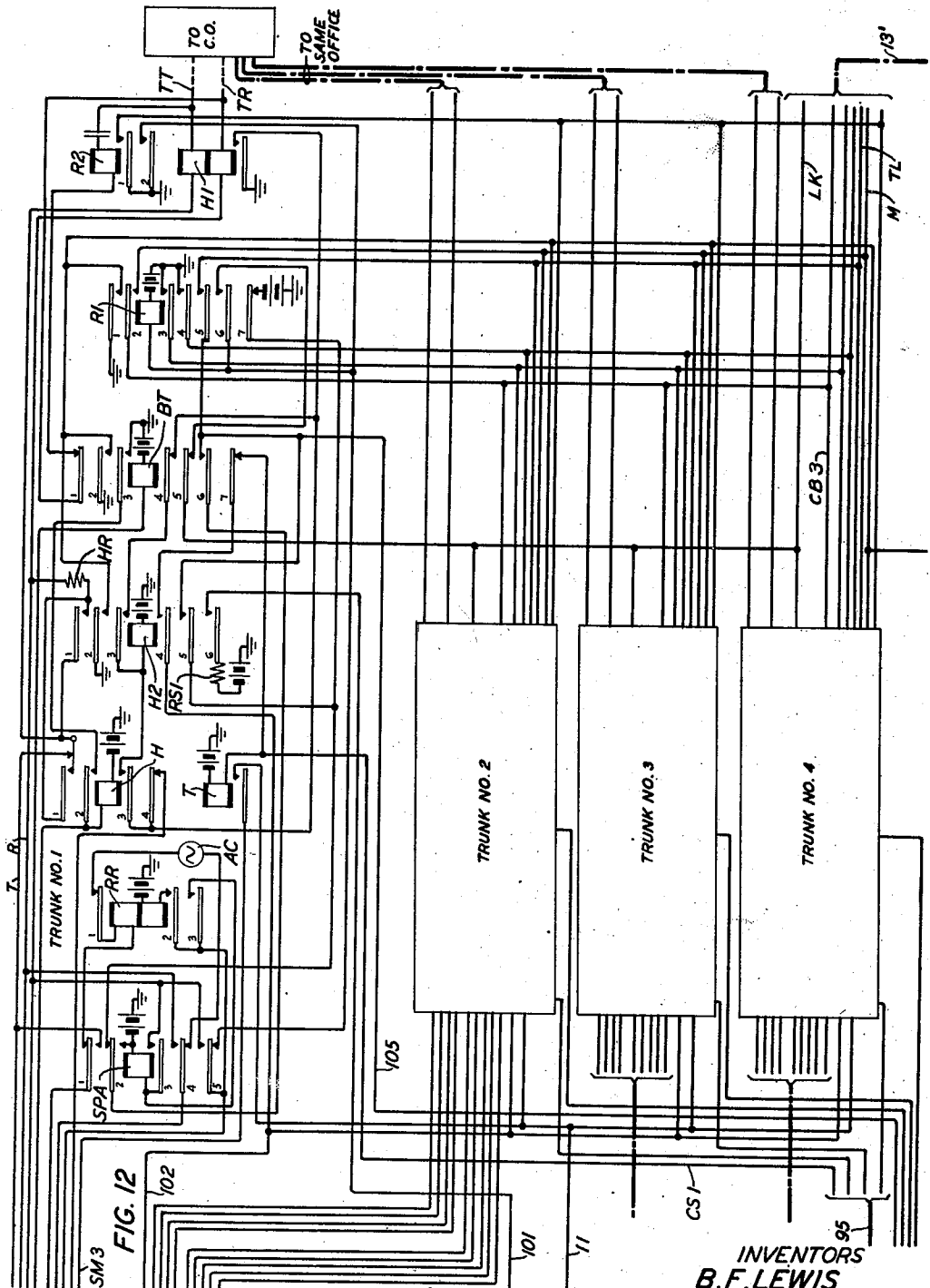
FIG. II

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12 Sheets-Sheet 12



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UNITED STATES PATENT OFFICE

2,358,237

TELEPHONE SYSTEM

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Application December 22, 1942, Serial No. 469,778

5 Claims. (Cl. 179—27)

This invention relates to telephone systems and particularly to small capacity telephone systems of the private branch exchange type (P. B. X) in which cross bar switches are employed. More particularly, the invention is in the nature of an improvement over the small capacity telephone system disclosed in Patent 2,300,951, issued to W. A. Malthaner on November 3, 1941, in which means are provided whereby the telephone lines or stations equipped with different types of call sending devices may operate common apparatus by which to set up desired connections such as, for instance, between a station that utilizes a dial sender to transmit a series of impulses designating a called number and a station that utilizes an alternating current generating device to operate and transmit combinations of different frequencies to designate the called number.

In some P. B. X exchanges of the above type in which the P. B. X subscribers are also provided with facilities for establishing direct connections to the main central office over trunks interconnecting the office and the switching element of the P. B. X, the lines privileged to establish trunk connections are provided with a key for each trunk which must be operated to connect the associated trunk with the line upon the initiation of a call. When the branch exchange contains both privileged and non-privileged lines, the non-privileged lines being restricted to local branch service only, circuit complications arise to distinguish and keep separate the two classes of lines.

According to the present invention the privileged lines are not provided with trunk keys, and a feature of the invention is the provision of an arrangement whereby all outgoing and incoming trunk calls clear through what may be called a "control" station at which the trunk keys and other necessary equipment are concentrated, all lines desiring trunk connections being required to dial or key the control station and request the desired connection of the attendant thereat. The control station attendant then asks the calling party to restore, dials the outside number over an available trunk and, when the wanted outside party answers, dials the number of the station originating the request. The trunk is then automatically extended back to this party without any further assistance on the part of the control station operator. A trunk lamp associated with the engaged trunk apprises the control station operator that the call is established and the control operator thereupon restores his receiver to

effect a breakdown of the local connection between the control station and party originating the call. The trunk is thereafter under the direct control of the originating party and when he restores, the trunk is restored to normal, proper signal facilities being provided to apprise the control station operator that the trunk is then again available for service.

A more specific feature of the invention is, therefore, a circuit arrangement in a P. B. X of the class described in which, on an outgoing trunk connection between the control station and the trunk and the subsequent dialing of the calling line by the control operator, the trunk is automatically caused to be extended back to said line to establish thereby a talking connection thereover.

The invention is illustrated in connection with the following drawings in which:

Fig. 1 shows two of the twenty stations in the P. B. X, station A having a line designation of 39 and provided with an alternating current or "key pulsing" generating device LG, and station B having a line designation 20 and provided with a dialing device LD. In the present embodiment of the invention, station B is utilized as the "control station" through which all outside connections to and from any other station in the P. B. X may be established, said control station being always provided with a dialing device LD, while the other nineteen stations in the P. B. X may be provided with either a dialing device LD or a key pulsing device LG;

Figs. 2 and 3 show diagrammatically a cross bar switch frame of known construction having ten horizontal outlets and twenty verticals to each of which vertical is connected a subscriber's line. The first vertical is designated as vertical 20 and is assigned to control station line 20 (station B), the last vertical is designated as vertical 39 and is assigned to line 39 (station A), while the intermediate verticals 21 to 38 are each respectively assigned to a similarly designated line;

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

Figs. 6, 7, 8, 9 and 10 show the details of the link circuit;

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

Fig. 12 shows one two-way trunk in detail, said trunk interconnecting the P. B. X with the central office, and three other trunks, conven-

tionally shown, extending to the same or some other central office; while

Fig. 13 shows the manner in which Figs. 1 to 12, inclusive, should be arranged with respect to each other to completely disclose the invention.

The invention will now be described in detail, first in respect to the operations necessary to set up a local connection from the control station B to another station such as, for example, station A; secondly, in respect to the operations necessary to set up an outside call to the central office from station A, and, thirdly, in respect to the operations necessary to establish an incoming connection from the central office to station A.

Before describing the detailed operation of the invention, however, it is desirable to call attention to the fact that the illustrative embodiment of the invention is being shown in connection with a small office having a maximum capacity of twenty lines, each station of which, with the exception of the control station B, is equipped either with a dial LD or a generator LG for transmitting called line designations, said control station B being always provided with a dial LD. Each line appears on one of the twenty verticals of the cross bar switch, conventionally shown in Figs. 2 and 3, and each line, for simplicity, has been given a numerical designation corresponding to the vertical to which it is assigned.

The dial LD is the ordinary impulse dial well known in automatic telephony, and its manipulation interrupts the line to produce a series of pulses the number of which, in a series, corresponds to the digit from which the dial is pulled over to the "stop" attachment prior to releasing it for its return to normal, in the course of which the train or series of impulses is produced. The device LG, on the other hand, is an alternating current generator which, for example, may be of the type shown in Patent No. 2,147,710 granted to R. F. Mallina on February 21, 1939. It comprises a number of reeds which may be plucked in pairs to produce vibrations within a magnetic field and thereby cause the production of currents having frequencies determined by their respective physical periodicities. These currents are transmitted over the link into registers therein for use in causing the link to complete the connection to the desired line.

For the quantity of internal traffic which may arise within the twenty lines of the system, only three links are provided each occupying two horizontal outlets of the cross bar switch, link 1 (the circuit structure of which is shown in detail in Figs. 6 to 10, inclusive) occupying the two uppermost outlets controlled, for selective purposes, by select magnets 8 and 9; link 2 occupying the two horizontal outlets immediately below those of link 1 and controlled by select magnets 6 and 7, while link 3 occupies the two horizontal outlets immediately below those of link 2 and controlled by select magnets 4 and 5. The remaining four outlets of the switch are reserved for four inter-office trunks, trunk 1 (Fig. 12) being wired to the third horizontal outlet controllable for selective purposes by select magnet 3, while trunks 2, 3 and 4 are each wired to horizontal outlets 2, 1 and 0, respectively. It is to be observed that the horizontal outlets for the links extend straight across the frame, thereby giving each vertical access to each link. The horizontal outlets for the four trunks, on the other hand, are not continuous. The upper group of trunk conductors designated UT, UR, US and UH are connected only to the cross-point of vertical 20 on the third horizontal

level reserved for the trunk while the lower group of conductors LT, LR, LS and LH are multipled to each of the remaining cross-points in said horizontal level. In other words, the horizontal multiple of the switch is split, for the trunks, between the control station vertical and the other station verticals.

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 an operated position while relay CH3 is shown in an 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 condition 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 quantity of traffic from and between the various lines of the office, including the control station B, may be properly 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 depending upon which one is free in the order of allotment. The operated condition of relay CH1 indicates that the link to which it provides access is in an idle condition, 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. 5), 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 which extends from battery through its winding, contacts of key KY2, conductor 2' in the bracket line 4, through the No. 1 back contacts of relay B in link No. 2 (said link being diagrammatically indicated in Fig. 10), 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 bracket line 5, through the No. 1 back contacts of relay B in link No. 3 (said link being diagrammatically shown in Fig. 10) and conductor 3'' within 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 indicated by the numerical indication of each of the three links.

Bearing in mind that relays CH1, CH2 are operated and that relay CH3 is normal, it may now be assumed that a call is originated at control station B (line 20). The telephone instrument is removed from its cradle at said station and key L is operated. A circuit is now completed for relay L20 of said line which extends from battery over the upper 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. 1 normally made contacts of relay L20 to ground on the No. 1 contacts of cut-off relay CO20. Relay L20 operates. Over its No. 1 front contacts, the ground terminal of its circuit is switched from solid ground on the No. 1 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 described shortly, is transmitted to the calling line in the event that no link is available for completing the connection.

Over its No. 2 and No. 3 contacts, relay L20 causes a circuit to be completed for relay LO20 of the call allotter circuit (there being one relay LO— for each line) and relay ST of link No. 1 which, since relays CH1 and CH2 of the 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 L20 is traced as follows: Ground through the No. 1 contacts of relay E1, winding of relay LO20, conductor 6, No. 3 contacts of relay L20, the No. 3 set of contacts closed by the telephone instrument cradle, serially through normal contacts of the trunk keys TK1, TK2, TK3 and TK4, contacts of key L, 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 ground. Relay N operates and completes a circuit for relay M which extends from ground on the No. 2 contacts of relay N, No. 1 back 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 circuit of relay M but this 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 will perform an emergency function that 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 contacts 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 allotter, conductor 9, 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 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. Relays E1 and E2 operate but relay LO20, which operated from ground on the No. 1 contacts of relay E1, now holds locked to battery through relay ST of the selected link, as previously traced, to conductor 6, winding of relay LO20 and its No. 1 contacts, conductor 8 as traced to conductor 9, contacts of relay E to ground on the No. 1 contacts of relay LO20. Hence with the operation and locking of relay LO20 individual to control station B, 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 B is having a link assigned to it since, with relays E1 and E2 operated, no ground is

available for completing the circuit of the relays LO— of the respective calling lines.

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. Since relay MS has slow-operating characteristics, it operates after an interval, opens thereby the locking path of relay N, 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 in virtue of operations which will be shortly described and which have been taking place in the link as a result of the operation of relay ST therein.

In the event that, due to some trouble condition, relay E of the link allotter fails to operate, relay MS cannot operate and ground will not be applied to conductor 11 over its No. 3 contacts. Under these circumstances it is desirable, if possible, 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 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 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 afore-traced ground thereon. Select magnet 9 operates and conditions the group of cross-points on 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 contacts and common conductor 18 to the common 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 battery. Relay CO20 upon operating closes an obvious circuit for hold magnet HO20 of the vertical 20 to which line 20 (station B) is connected and, because select magnet 9 is operated, operates cross-point 9 on vertical 20. This cross-point 9 remains operated after the circuit of select magnet 9 has been opened, and since this is standard cross bar switch operation it will not be amplified any further. When hold magnet HO20 operates, it releases line relay L20 which, in turn, releases relay LO20 and the latter, upon releasing, disconnects ground from start conductor 1 which caused the operation of relay ST. However, since cross-point 9 on vertical 20 is closed, relay ST will not release, it having a locking circuit through a cross-point contact which may be traced over the No. 2 contacts of said relay, No. 1 contacts of re-

lay T2, conductor S1, No. 3 contacts of cross-point 9 on vertical 20 to ground.

Furthermore, although the release of relay LO20 opened the original operating circuit of cut-off relay CO20, said relay now remains locked under the control of the No. 3 contacts of the station telephone instrument and the contacts of key L, said locking circuit being traced from ground on the No. 2 contacts of relay CO20, No. 3 switchhook contacts, serially through the normal contacts of the trunk keys TK1 to TK4, contacts of key L, No. 4 contacts of cross-point 9 on vertical 20, winding of relay CO20 to battery. Thus relay CO20 is maintained in an operated position, in turn holding operated magnet HO20 which keeps cross-point 9 closed.

Since cross-point 9 is operated, the line tip and ring conductors T and R are joined to the link tip and ring conductors LT and LR, respectively, over the No. 6 and No. 5 contacts of the operated cross-point 9, respectively, and this joining of conductors completes an operating path for relay A of the link which may be traced from battery through the lower winding of said relay, No. 2 back contacts of relay HS, conductor LT, No. 6 contacts of cross-point 9, line conductor T, over the calling line loop, line conductor R, No. 5 contacts of cross-point 9, 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, front contacts of relay A, No. 4 normally made continuity contacts of relay B, winding of relay B to battery. Relay B operates and locks over its No. 4 front contacts to ground on conductor S1. Relay B, at its No. 2 contacts, opens conductor 17 thereby causing the release of the select magnet 9. However, since the hold magnet HO20 is operated, cross-point 9 on vertical 20 remains closed. 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 thereby 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, connects ground to holding conductors 20 and 21 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 7' which further extends to relay ST of link No. 2.

It is now evident that if, at the time the call was initiated at station B, link No. 1 is busy or otherwise unavailable, relay CH1 individual to the link in the link allotter circuit would have been normal, and the start wire 1 with ground applied thereto would have been joined to conductor 7' of link No. 2 to cause the operation therein of relay ST in the same manner as that of relay ST in link No. 1 as already described. On the other hand, if both links No. 1 and No. 2 are busy or otherwise unavailable, relay CH2, as well as relay CH1, would be normal since their respective locking circuits would be opened at the No. 1 contacts of relay B of their respective links. However, as soon as relays CH1 and CH2 are both normal, a circuit is completed for relay CH3 which extends from battery through its winding, contacts of key KY3, conductor 2'', No. 1 contacts of relay B of link No. 3, conductor 3'', to

ground over the No. 1 normally made contacts of relay CH1. Relay CH3 operates and, with relays CH1 and CH2 normal, indicates that links No. 1 and No. 2 are unavailable but that link No. 3 is. If a call is now initiated at a line station as, for example, station B, ground on start conductor 1 is extended to conductor 7' which is connected to the winding of relay ST of link No. 3, the path being from ground on conductor 1, No. 4 contacts of relay CH2, No. 2 contacts of relay CH3, conductor 7', to the winding of relay ST of said link causing its operation and the connection of link No. 3 to the calling line.

If all three links are unavailable, relay CH3 will be normal as well as relays CH1 and CH2. Under these circumstances, the initiation of a call 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 (through bracket line 13) to the power, tone and alarm circuit 110 and closes a circuit therein which causes a distinct "link busy tone" to be applied to the conductors 23 and 24 extending to the primary winding of the link busy tone transformer LBT. Since the secondary winding of this transformer is connected to ground and is completed into a circuit over the line loop to battery through the upper normally made contacts of the hold magnet HO— and through the winding of the line relay L—, the subscriber at the calling station will hear the tone as an indication that, due to unavailable links, the connection cannot be established.

As soon as a link becomes available, say link No. 1, then a circuit is completed for relay CH1 which extends from 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 contacts to reestablish the path of start conductor 1 to the winding of relay ST in readiness for seizure on the next call. If link No. 2 becomes available, relay CH2 operates over a circuit traceable from 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 No. 1 assumed to have been taken into use, 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 being individual to link No. 2 and the latter to link No. 3) to battery. Relay LS1 operates, connects operating battery to its winding through its own No. 2 front contacts and, over its No. 1 front contacts, completes an obvious circuit for cut-in relay LC1 which operates in consequence thereof.

The object in operating relays LS1 and LC1 at this time is to connect the common alternating current pulse receiver and translator shown in Figs. 10 and 9, respectively, to the link taken into use and, when the former circuit is so connected to the latter, the signal for the consummation of the connection being the operation of relay LS1, said receiver must be made unavailable to other links. This is done by removing the operating ground for relays 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 its correlated link, the circuit of relay LC2 or LC3 will be cut off at the No. 1 back contacts of relay LS1. On the other hand, if the first calling link happens to be either link No. 2 or link No. 3, then the corresponding operation of either relay LS2 or LS3 will cut off the operating circuit of relay LS1 at its respective No. 2 normally made continuity contacts. Under these conditions, if link No. 1 is seized in the meanwhile, the failure of relay LS1 to operate will prevent the operation of relay LC1 and thereby prevent the simultaneous connection of the common alternating current receiver and translator to two calling links.

The alternating current receiver of Fig. 10 is adapted to receive alternating current impulses from a calling station equipped with an alternating current generating device such as, for example, the device LG at station A (line 39). Since the P. B. X exchange will contain telephone stations equipped with either a device LG, as at station A, for producing alternating frequency pulses designating the wanted line, or with the usual dial LD, as at station B, for producing a series of direct current pulses indicative of the wanted line, the link must be equipped to serve both types of stations although at the time it is connected to a calling line the seized link has no way of telling which type of station is making the call. Hence the link must be prepared, initially, to receive either direct current pulses from a dial LD or alternating current pulses from a generating device LG. Since the link itself is normally arranged with a register to receive direct current pulses, as will be shown shortly, the alternating current receiver common to all links must be connected to a calling link before the calling subscriber can be advised, by an appropriate warning tone, to transmit the called line designation. Accordingly, when relay LC1 operates, a circuit is completed for relay GR in the translator which extends from ground on conductor 21, No. 1 back contacts of relay C, conductor 75, No. 4 contacts of relay LC1, conductor 76, winding of relay GR to battery. Relay GR operates and disconnects ground from conductors 71 and 72 which, as will be shown, are connected to the calling loop by the operation of relay ON. A circuit is also completed for relay ON which may be traced from ground on the No. 5 contacts of relay LC1, conductor 60, winding of relay ON to battery. Relay ON operates and, over its No. 1 contacts, closes through a circuit for a low frequency tone derived from the tone oscillator 70 through adjustable resistance pad 62 and transformer 61. The path of this circuit is traced as follows: From the lower terminal of the secondary winding of transformer 61, conductor 14, No. 1 contacts of relay ST, conductor 15, No. 6 contacts of relay LC1, conductor 16, No. 3 contacts of relay RR, No. 2 contacts of relay RA, No. 1 contacts of relay ON, conductor 12, through the low-pass filter 63 to the upper terminal of the secondary winding of transformer 61. The tone frequencies produced by the oscillator 70 are thus induced over the secondary 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 and a transformer in high-pass filter 64. Beyond the secondary winding of the transformer in the filter 64 are connected suit-

able filter networks which are designed to pass only frequencies within the signal frequency band of the frequencies that are produced by the station generator LG when the same is 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 winding of transformer 68, if said secondary winding is closed into an electrical system, which it is, because conductors 71 and 72 are but extensions of the line conductors T and R into the link and the alternating current receiver connected thereto. The path is traced as follows: From the left side of the secondary winding of transformer 68, conductor 71, No. 2 contacts of relay ON, conductor 73, No. 7 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 B, 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. 8 front contacts of relay LC1, conductor 74, No. 5 contacts of relay ON, conductor 72 to the right terminal of the secondary winding of transformer 68. Inasmuch as the receiver of the telephone instrument of station B is included in the above closed circuit, the tone induced thereover is heard by the attendant at station B, which he understands as a signal to proceed with dialing the wanted number.

The control station attendant, upon receiving a tone, operates the dial LD to transmit the called line designation. In the present embodiment of the invention, it is assumed, as said before, that the capacity of the office is twenty lines and that the numerical designation of each of said lines extends from 20 to 39, inclusive, it being further assumed that the control station B has a numerical designation of 20 and that station A has a numerical designation of 39, the intermediate stations, equipped either with the dial LD or the device LG, bearing the numbers 21 to 38, inclusive. The calling subscriber therefore dials a wanted designation by dialing two digits, the first of which may be a 2 or a 3 and the second of which may be any digit from 0 to 9. Since it has been assumed that control station B is to be connected to the called line A, the attendant at station B will first operate his dial to transmit three pulses for the tens digit and thereafter nine pulses for the units digit.

As is well known, the operation of the dial LD makes and breaks the calling line loop as many times as required to produce the impulses called for by the digits. Hence, upon dialing the digit "3," three impulses are produced and the same will cause three successive releases of relay A. When relay A releases on the first pulse it completes a circuit for relay P1 which extends from ground on conductor S1, the back contacts of relay A, No. 3 contacts of relay B, No. 2 contacts of relay E, back contacts of relay P2, No. 2 back contacts of relay P3, winding of relay P1 to battery. Through the No. 1 back contacts of relay P3, the circuit further extends to the winding of slow-release relay C. Both relays P1 and C operate and short-circuit the lower winding of relay P2, ground to one side of this winding being supplied over the No. 2 contacts of relay C and ground on the other side being supplied over the No. 1 contacts of relay P1 to the back contacts of relay A. With the operation of relay P1, a circuit is completed for relay SW which extends

from battery through its upper winding and the No. 2 normally made contacts, No. 5 back contacts of relay T2, No. 2 front contacts of relay P1, conductor 23, No. 5 contacts of relay RT, conductor 24, No. 1 front contacts of relay C to ground on conductor 21. Relay SW operates and locks over its upper winding and No. 2 front contacts to ground on the No. 1 front contacts of relay C. When relay A operates at the termination of the first pulse, the short-circuit around the lower winding of relay P2 is removed and this relay operates in series with relay P1 over a circuit path which may be traced from ground on the No. 2 contacts of relay C, lower winding of relay P2, No. 1 contacts of relay P1, No. 2 contacts of relay P3, winding of relay P1 to battery. Hence, after the first pulse is terminated, relays P1, P2 and SW are operated, the latter being locked, as said before, to ground on conductor 21 through the No. 1 front contacts of relay C which, being slow releasing, remains in an operated condition between pulses.

On the beginning of the second pulse, relay A releases again and completes a circuit path for relay P3 which extends from ground on the back contacts of relay A, No. 3 contacts of relay B, No. 2 contacts of relay E, front contacts and upper winding of relay P2, winding of relay P3 to battery. Relay P3 operates and releases relay P1 subsequent to which a circuit is completed for relay T2 which extends from battery through the upper winding of said relay and its No. 3 normally made contacts, No. 4 front contacts of relay SW, No. 2 back contacts of relay P1, conductor 23, and thence, as previously traced, to ground on the No. 1 front contacts of relay C. Relay T2 operates, locks over both of its windings in series through its No. 3 front contacts, conductor 28, No. 5 contacts of relay HS, conductor 20 to ground on the No. 5 contacts of relay B and opens the locking circuit of relay ST which releases. The release of relay ST at this time, however, results in no other function.

At the termination of the second pulse, relay A reoperates and relays P2 and P3 release so that, at the termination of the second pulse, relays P1, P2 and P3 are normal, relay C is in an operated position due to its slow-releasing characteristics, while relays SW and T2 are locked.

At the beginning of the third pulse, the release of relay A again causes the operation of relay P1 and relay P2 is again short-circuited but, in this case, a circuit is also completed for relay T3 which extends from battery through its upper winding and No. 2 normally made continuity contacts, No. 1 contacts of relay DC, No. 5 front contacts of relay SW, No. 5 front contacts of relay T2, No. 2 front contacts of relay P1, conductor 23, and thence, as already traced, to ground on the No. 1 front contacts of relay C. Relay T3 operates and, through its No. 2 front contacts, locks serially over both windings to previously traced ground on conductor 28 from the No. 5 contacts of relay B. At the end of the pulse, relay A reoperates and relay P2 operates in series with relay P1, as previously described. However, since this is the third and last pulse of the tens digit, there will be a relatively long interval before the transmission of the first pulse of the units digit, an interval which is sufficient to cause the release of relay C, followed by the release of relay SW and the release of relays P1 and P2 which hold to ground over the No. 2 contacts of relay C.

It will be observed that the dialing of the nu-

meral 3 as the tens digit of the called number has resulted in the operation and locking of relays T2 and T3. If the tens digit had been a 2 instead of a 3, the result would have been the operation and locking of relay T2 only. No provision has been made in the link for registering any tens digit other than a 2 or a 3 since the capacity of the exchange is assumed to be limited to twenty lines each having a numerical designation from 20 to 39. However, it is evident that if other numerical designations were to be used, or if the capacity of the exchange were to be increased to include more than twenty lines, the link circuit could easily be changed by any one skilled in the art to cause the registration therein of any or all other values of the tens digit.

Prior to the dialing of the second or units digit, relay A is operated and relays P1, P2 and P3 are normal. Upon the first interruption of the line loop for the series of pulses of the second or units digit, relay A will release followed by the operation of relays P1 and C as previously described, while a circuit is now completed for relay C1 which extends from battery through resistance RS, the winding of said relay, No. 4 normally made continuity contacts thereof, conductor 25, No. 10 back contacts of relay RT, conductor 26, No. 4 contacts of relay T2, No. 1 contacts of relay SW, conductor 24, to ground on the No. 1 front contacts of relay C. Relay C1 operates in this circuit and locks over its No. 4 front contacts, No. 5 contacts of relay HS to ground on conductor 20. A circuit is now completed for relay CX, which extends from battery, resistance CR, the winding of said relay and its No. 3 normally made continuity contacts, No. 5 front contacts of relay C1, to ground on the No. 5 contacts of relay B. Relay CX operates, locks to operating ground over its No. 3 front contacts and, at its No. 1 contacts, opens the circuit of relay LS1 which releases to release relay LC1, the latter relay disconnecting the translator and alternating current receiver from the link, thus causing them to be available for service with some other link.

A circuit is also closed for relay I which extends from battery through its upper winding and No. 5 normally made continuity contacts, No. 1 contacts of relay III, No. 3 back contacts of relay II, No. 4 back contacts of relay V, No. 3 back contacts of relay IV, conductor 27, No. 5 back contacts of relay SW, No. 5 front contacts of relay T2, No. 2 front contacts of relay P1 and thence as traced to ground on the No. 1 front contacts of relay C. Relay I operates and locks with both of its windings in series through its No. 5 front contacts, serially through the No. 4 continuity contacts of relay II, No. 5 continuity contacts of relay III, No. 4 continuity contacts of relay IV, No. 5 continuity contacts of relay V, conductor 28, No. 5 contacts of relay HS to ground on conductor 20. Upon the termination of the pulse, relay A reoperates and relay P2 is operated serially with relay P1.

On the second pulse, relay A releases, relay P3 operates in series with relay P2 in consequence thereof, while relay P1 releases as previously described. A circuit is now completed for relay II extending from battery through its upper winding, No. 4 contacts of relay I, conductor 29, No. 4 back contacts of relay SW, No. 2 back contacts of relay P1 to ground, as previously traced, to the No. 2 front contacts of relay C. Relay II operates and then locks serially through both of its windings and No. 4 front contacts to

a previously traced ground through the continuity contacts of relays III, IV and V. On the break of its own No. 4 continuity contacts, relay II releases relay I which thereby restores to normal. At the termination of the second pulse, relay A reoperates and relays P2 and P3 release as previously described.

At the beginning of the third pulse, relay P1 reoperates and a circuit is completed for relay III which extends from battery through its upper winding, No. 3 front contacts of relay II, No. 4 contacts of relay V, No. 3 contacts of relay IV, conductor 27, No. 5 back contacts of relay SW, No. 5 front contacts of relay T2, No. 2 front contacts of relay P1, conductor 23 to ground as previously traced. Relay III operates on its upper winding, locks serially with its lower winding and No. 5 front contacts to a previously traced ground through the No. 4 and No. 5 continuity contacts of relays IV and V, respectively, while, upon the break of its own No. 5 continuity contacts, it releases relay II which thereby restores to normal.

On the fourth pulse, relay P1 will be in a non-operated position and, therefore, a circuit will be closed for relay IV which extends from battery through its upper winding, No. 4 contacts of relay III, conductor 29, No. 4 back contacts of relay SW, No. 2 back contacts of relay P1 to ground as previously traced. Relay IV operates on its upper winding and then locks in series with its lower winding and No. 4 front contacts, through the No. 5 continuity contacts of relay V, to ground as previously traced. Upon the break of its No. 4 continuity contacts, relay III releases and restores to normal.

On the fifth pulse, relay P1 will be operated and a circuit will be closed for relay V which extends from battery through its upper winding, No. 3 front contacts of relay IV, conductor 27, No. 5 back contacts of relay SW, No. 5 front contacts of relay T2, No. 2 front contacts of relay P1 to ground. Relay V operates on its upper winding and locks in series with its lower winding through the No. 3 contacts of relay I, its own No. 5 front contacts to ground as previously traced on the No. 1 front contacts of relay C. When it breaks its own No. 5 continuity contacts it releases relay IV which thereby restores to normal.

On the sixth pulse, relay P1 will be in a non-operated position whereupon a circuit will be completed for relay VI which extends from battery through its upper winding and No. 5 continuity contacts, No. 1 contacts of relay V, conductor 29, No. 4 back contacts of relay SW, No. 2 back contacts of relay P1 to ground. Relay VI operates on its upper winding and locks serially through its lower winding and No. 5 front contacts to ground as previously traced on conductor 28. Relay V, however, will remain locked since its own locking circuit is independent of the operated condition of relay VI.

On the seventh pulse, relay P1 will be in an operated position whereupon the previously traced circuit for relay I will be established and relay I will operate in said circuit, locking thereafter in series with its lower winding and No. 5 contacts and through the previously identified contacts of relays II, III and IV, and the No. 7 contacts of relay VI to ground on conductor 28. Relay V is released upon the operation of relay I.

On the eighth pulse, relay P1 will be unoperated and a previously traced circuit for relay II will be established, which relay, upon operating,

locks serially through its lower winding and No. 4 front contacts, serially through the previously designated continuity contacts of relays III, IV and V to ground on conductor 28. Upon the operation of relay II, the locking circuit of relay I is opened at the No. 4 continuity contacts of relay II and relay I thereby restores to normal. Relay VI remains locked to ground on conductor 28.

On the ninth pulse, relay P1 will be operated and a previously traced circuit for relay III is established causing said relay to operate on its upper winding and then lock in series with its lower winding and No. 5 contacts, No. 4 continuity contacts of relay IV, No. 5 contacts of relay V to ground on conductor 28. Upon the operation of relay III, relay II restores. Relay VI remains locked to ground on conductor 28.

On the last or zero pulse, relay P1 will be normal and a previously traced circuit will be established for relay IV which operates thereover on its upper winding and then locks serially through its lower winding and No. 4 continuity contacts, No. 5 continuity contacts of relay V, to ground on conductor 28.

On the last or zero pulse, relay P1 will be normal and a previously traced circuit will be established for relay IV which operates thereover on its upper winding and then locks serially through its lower winding and No. 4 continuity contacts, No. 5 continuity contacts of relay V, to ground on conductor 28. Relay VI is still locked to ground on conductor 28.

Thus the pulses of the second or units digit are registered in the relays I-VI of Fig. 7, the relay, or relays, operated depending upon the number of pulses received. The relationship between the number of pulses and the relays operated to correspond thereto is shown in the following table:

40	Pulses	Relay operated
1	-----	(I)
2	-----	(II)
3	-----	(III)
4	-----	(IV)
5	-----	(V)
6	-----	(V, VI)
7	-----	(I, VI)
8	-----	(II, VI)
9	-----	(III, VI)
50	-----	(IV, VI)

It has been assumed that the called subscriber's number is 39 and therefore in respect to the units digit, relays III and VI will have been operated.

At the end of the last pulse of the second digit with relay A reoperated, relay C will release and a circuit is then closed for relay DC which extends from battery through its lower winding and No. 5 continuity contacts, conductor 39, No. 2 contacts of relay C1, conductor 75, No. 1 back contacts of relay C to ground on conductor 21. Relay DC operates on its lower winding and locks through its No. 5 front contacts in series with its upper winding to ground as previously traced on conductor 28. Relay DC, upon operating, completes a path for relay SW extending from battery through its upper and lower windings in series, No. 2 front contacts of relay DC to ground on conductor 28. Relay DC also connects battery through the lower winding of relay BY to a conductor which, depending upon the numerical register relays in Fig. 7 which have been operated in response to the units digit, extends to an armature of the hold magnet of the vertical associated with the called line which, in this case,

will be hold magnet HO39. This path is traced as follows: Battery through the lower winding of relay BY, No. 4 continuity contacts of said relay, No. 1 front contacts of relay C1, No. 4 contacts of relay DC, No. 1 front contacts of relay T3, conductor 30, No. 4 front contacts of relay VI, conductor 31, No. 6 contacts of relay DC, conductor 32, No. 6 contacts of relay III, conductor 33, lower armature and contact of hold magnet HO39 to the winding of relay CO39. The object of this circuit is to test for the idle or busy condition of the called line. Should this line be busy, hold magnet HO39 will be operated, whereupon it will apply ground to conductor 33 through its lower front contacts and cause thereby the operation of relay BY which then locks through its No. 4 front contacts serially through 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 loop previously traced to conductor LR, No. 3 back contacts of relay HS, upper winding of relay A to ground. The busy tone thus furnished the calling station 20 indicates to the attendant thereat that the called line is busy, whereupon he restores the telephone instrument upon the cradle and thereby opens the circuit of relay A, the release of which initiates the restoration of the apparatus as described hereinafter.

Assuming, however, that the called line is not busy, then hold magnet HO39 will be normal and relay BY will not be caused to operate. In this case a circuit is closed for relay LK1 of the link in the call allotter, which circuit extends from battery through the winding of said relay, conductor 36, No. 3 contacts of relay BY, No. 3 contacts of relay SW, No. 3 contacts of relay C1, conductor 37 to ground on the No. 11 contacts of relay E1. Relay LK1 operates, completes a circuit for relay B1 in the call allotter, which circuit extends from battery through the winding of relay B1, conductor 38, No. 5 contacts of relay LK1, conductor 39, No. 2 contacts of relay C1, conductor 15, No. 1 back contacts of relay C to ground on conductor 21, and opens the serial locking path of all relays LO— which, should any of them operate in response to the initiation of a call during the time that a link is setting up the terminating end of a connection, will be prevented from locking at the time relays E1 and E2 operate in the manner previously described. The failure of a relay LO— to lock will then prevent ground from being applied to conductor 11 over the contacts of relay MS. In this manner, a line which calls during the setting up of a connection will be prevented from interfering and, of course, will also be denied service until the previous connection has been set up. Relay LK1 also completes a circuit for relay E of the call allotter which traces from battery through its winding, conductor 9, No. 1 front contacts of relay LK1, conductor 37, to ground on the No. 11 contacts of relay E1. Relay E now operates relays E1, E2 and MS as previously described and, when relay MS operates, a circuit is completed for select magnet 8 which extends from battery through the winding of said magnet, back contacts of relay TKL1, conductor 40, No. 6 contacts

of relay LK1, conductor 41, No. 1 contacts of relay B1, conductor 11, No. 3 contacts of relay MS, conductor 10, to ground on the No. 3 contacts of relay LK1. Select magnet 8 operates, conditions the horizontal cross-points on the eighth level for selection and completes a circuit from ground through the contacts of said magnet, conductor 18, windings of relays S and S1 in parallel, to battery, causing said relays to operate. The operation of relay S connects ground through its No. 2 contacts, conductor 42, the No. 4 contacts of relay LK1, conductor 43 to the common terminal of resistance RS and the winding of relay C1 causing the release of the latter. Upon the release of relay C1, ground is applied to conductor 33 which, as previously traced, is connected to the winding of relay CO39 of the called line A. Relay CO39 operates and completes an obvious circuit for hold magnet HO39 which operates to close cross-point 8 on vertical 39. The operation of the hold magnet HO39 disconnects operating ground for relay CO39, but this relay now holds over the No. 4 contacts of cross-point 8 of vertical 39, conductor S, No. 3 back contacts of relay E, No. 7 contacts of relay B, front contacts of relay A (which is being held over the calling line loop from station B) to ground on conductor S1 as previously traced thereto. Operated cross-points 8 and 9 on verticals 39 and 20, respectively, effect the connection between the calling control station B and the called station A.

Ground on conductor S2 applied thereto by the closure of the No. 3 contacts of cross-point 8 on vertical 39 completes a circuit for relay SP, the path of which may be traced from ground on said conductor, No. 2 front contacts of relay T2, No. 5 contacts of relay BY, winding of relay SP to battery. Relay SP operates and connects ringing current applied to conductor 47 within the bracket line 13 from the power and ringing circuit 110, through the No. 3 contacts of relay RTR and lower winding thereof, No. 3 front contacts of relay SP, conductor 48, No. 5 contact of cross-point 8 of vertical 39, ring conductor R1 of the called station A, over the loop of said station, tip conductor T1, No. 6 contacts of said cross-point 8, conductor 49, No. 2 front contacts of relay SP, conductor 50 within the bracket line 13 to ground applied thereto in the power and ringing circuit 110. Ringing current is thus applied to the called subscriber's line and an audible ringing tone is provided for the calling station, the circuit of said tone extending from one side of ringing tone circuit (not shown) in the power and ringing circuit 110, conductor 111 within bracket line 13, No. 5 contacts of relay SP, condenser C6, condenser C2, and thence as traced over the calling loop to ground through the upper winding of relay A. The control operator at station B thus hears the ringing tone. When the call is answered, relay RTR operates and locks over its upper winding and No. 2 contacts to ground on the No. 4 front contacts of relay SP, and further completes a circuit for relay HS which extends from battery through its winding, conductor 51, contacts 1 and 2 in cross-point 8 of vertical 39, conductor 52, No. 1 contacts of relay RTR to ground on conductor 21. Relay HS operates and, by opening its No. 5 contacts, disconnects the ground which holds relays SW, T2, T3, DC and the register relays III and VI operated. The release of relay T2 releases relay SP which, in turn, releases relay RTR and connects the supervisory relay E to the called line. The circuit of relay E is as follows: Battery through

its lower winding, conductor 53, No. 7 back contacts of relay LC1, conductor 54, No. 3 back contacts of relay SP, conductor 48 thence as previously traced over the called loop back to conductor 49, No. 2 back contacts of relay SP, conductor 55, No. 8 back contacts of relay LC1, conductor 56, upper winding of relay E to ground. Relay E operates and connects ground on its No. 1 contacts and therefrom to conductor 52 which, over the No. 1 and No. 2 contacts of cross-point 8 in vertical 39, joins conductor 51 which further extends to the winding of relay HS, thereby holding said relay operated. Over its No. 1 contacts, relay HS applies ground to conductor S which, through the No. 4 contacts of cross-point 8 in vertical 39, extends to the winding of relay CO39 to hold said relay which, in turn holds hold magnet HO39 and cross-point 8 in vertical 39 closed. Relay HS also establishes a circuit from ground on conductor 20, over its No. 4 contacts, the No. 2 contacts of relay CX to battery through the No. 2 normal contacts and winding of relay CON whereupon relay CON operates and locks over its No. 2 contacts and the No. 5 contacts of relay C1 to ground on conductor 20.

The control station operator releases his part of the connection by restoring the telephone instrument. The restoration of the telephone instrument opens the calling line loop in consequence of which relay A releases and disconnects ground on conductor S1 from conductor 51. However, since this last-mentioned conductor is open at the contacts of the non-locking holding key HO, the release of relay A performs no useful function. On the other hand, the opening of the No. 3 contacts of the telephone switchhook opens the holding circuit of cut-off relay CO20, causing said relay to release and release hold magnet HO20 which opens cross-point 9 in vertical 20 and disconnects the control station from the link.

The disconnection of the calling line from the link does not release the called line from the link if the line is still looped through the called station. For, under these circumstances, relay E remains operated to maintain ground on conductor 52 which holds relay HS and the latter then maintains ground on conductor S to hold cut-off relay CO39 which, in turn, holds magnet HO39 to maintain cross-point 8 on vertical 39 closed, thereby maintaining the connection between the called line and the link. When the called line restores, relay E releases, in turn causing the release of relay HS, the disconnection of ground from conductor S and the release of relay CO39, which latter then causes the release of magnet HO39 to open cross-point 8. The link, therefore, is held until the called line restores in order to prevent the same line from seizing another link and receiving key tone in consequence thereof. When the called station restores, relay E releases, disconnecting ground from conductor 52 to release relay HS. Relay HS, on releasing, disconnects ground from conductor S which releases relay CO39 in turn releasing hold magnet HO39 and opening cross-point 8 on vertical 39.

In case the attendant at station 20 desires to add a third station to the connection, that is, a so-called "conference" connection, the called subscriber will replace the receiver on the switchhook. As a result of this, relay E releases, disconnecting ground from conductor 52 and thereby causing the release of relay HS. The release of relay HS closes a circuit extending from ground on conductor 20, No. 5 back contacts of relay C1,

No. 1 contacts of relay CON, No. 6 contacts of relay HS, to the common terminal of resistance CR and the winding of relay CX, causing the latter to release. The release of relay CX causes ground to be applied from conductor 20, No. 1 contacts of relay CX to conductor 53, thereby causing the reoperation of relay LS1 and the reconnection of the translator and alternating current receiver to the line. As already described, key tone is now supplied to the control or calling station, the attendant at which will thereafter proceed to dial the number of the third party. When the first digit is dialed, relay T2 will operate as described, in turn operating relay SP over a circuit that traces from battery through the winding of said relay, No. 5 contacts of relay BY, No. 2 front contacts of relay T2 to ground on conductor S2 via the No. 3 contacts of cross-point 8 of vertical 39. Relay SP, in operating, reconnects the ringing circuit to the first called station, that is, station A, and causes thereby the operation of the ringer thereat. Now, when the second called station is connected to the line in the same manner as called station A, the bells at the two called stations will ring, and when the second called station answers, the bell at station A will cease to ring, which furnishes an indication that the second called station has answered. This acts as a signal to the first called station A to answer also. In case the second station is busy, then relay BY will operate as described when the station line is tested for a busy condition and this will cause the release of relay SP since its circuit is controlled through the No. 5 contacts of relay BY, in consequence of which the ringer at station A will cease to operate and the calling station will receive a busy tone. The subscriber at the first called station A will then answer since the cessation of ringing is due to the third party either answering or being busy. Relay HS operates as before described, releasing relay BY and all the register relays. It is to be noted that, on a conference connection, the stations connected to the terminating end, that is, station A and the second called station, cannot release until all called stations disconnect since relay HS, which can be operated from any station, will hold to the cut-off relay of any one of the called stations.

Having described the establishment of a connection from the control station B equipped with a dial LD to called station A, we will now describe the establishment of a connection from station A equipped with the alternating current generating device LG to the control station B.

When the subscriber at A removes the receiver from the switchhook, the line relay L39 will operate in the same manner as already described for line relay L20 and a link will be caused to be connected to the line of the calling station A, over cross-point 9 of vertical 39. When relay ST of the link operates, relays LS1 and LC1 are operated and the alternating current translator and receiver are connected to the link, relays ON and GR of the translator being operated to transmit a tone to the calling station A, all in the manner previously described for station B.

It will be remembered that relay GR, in its unoperated condition, normally applies ground to the unoperated No. 2 and No. 5 contacts of relay ON which, when operated, connects these contacts to conductors 73 and 74 which further extend, in this case, to the ring and tip conductors R1 and T1 of the calling station A instead of, as previously, to the ring and tip conductors R and

T of calling station B. Relay GR operates subsequent to the operation of relay B while relay ON operates following relay ST. Now inasmuch as the circuit of relay A is completed as soon as cross-point 9 of vertical 39 is closed and relay ON may be operated at the time, the current build-up in relay A will cause a change in the charge on condensers C2 and C3 over one path completed from one side of condenser C2, conductor 54, No. 7 contacts of relay LC1, conductor 73, No. 2 and 3 contacts of relay ON, to ground on the No. 2 contacts of relay GR; and another path from one side of condenser C3, conductor 55, No. 8 front contacts of relay LC1, conductor 74, Nos. 4 and 5 contacts of relay ON to ground on No. 1 contacts of relay GR. This charging current, if allowed to flow into the winding of transformer 68, would produce a false pulse which might have frequency components within the frequency signal band and thereby produce a false operation of the receiver. Therefore, in order to prevent such an occurrence, conductors 73 and 74 are kept grounded through the contacts of relay GR to short-circuit the winding of transformer 68 until relay GR operates, which occurs after the operation of relay B and, therefore, after the current in relay A will have reached its steady state.

Upon hearing tone, the calling subscriber at station A depresses a key (not shown) of the device LG which designates the first digit of the called number, thereby plucking two of its set of five reeds. The reeds are set into vibration and produce two alternating currents of specific frequencies within the signal frequency band, which frequencies are transmitted over a circuit path that may be traced as previously to conductors 73 and 74 at the Nos. 2 and 5 contacts, respectively, of relay ON and, thereafter, completed through the secondary winding of transformer 68 whence they are induced into the circuit comprising the primary winding of said transformer and the high-pass filter 64.

The receiver circuit 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 limiting device 65, the transformer 66, the adjustable pad 67, five detector-amplifiers *fA* to *fE* with relays FA to FE, respectively, in each of the anode circuits thereof, and a suitable filter (not shown) intermediate the pad 67 and each one of the detector-amplifiers, each of said filters being designed to pass only the frequency intended to operate the particular channel which includes the filter. Between the high-pass filter 64 and the volume limiter 65 is bridged the primary winding of transformer 112 to the secondary of which is connected the enabler 80. The enabler is identical in construction to that completely disclosed and described in the above-mentioned patent to G. Hecht and A. A. Lundstrom and is herein shown only in conventional form except for relay 77. The enabler responds to a portion of the signal impulses which 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* to *fE* thereby activating them to respond to 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, reference is made

thereto for a complete description thereof, only so much of said description as is necessary to an understanding of the present invention being incorporated herein.

Each detector-amplifier tube is preceded by a filter (not shown) which passes only the frequency to which that tube is assigned to respond. It is assumed that the device LG is capable of producing five different frequencies which, for convenience, may be designated A to E, inclusive and that, in accordance with the operation of the receiver as described in the above-mentioned patent, frequency A will cause the operation of tube *fA*, frequency B will cause the operation of tube *fB* and so on to frequency E which will cause the operation of tube *fE*.

As already mentioned, each detector-amplifier tube *f*— has a relay connected to the anode terminal thereof, and a front contact of this relay is further connected to the winding of one of the five relays TA to TE in the translator circuit shown in Fig. 9. Thus 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 relay FE being connected to relay TE. Hence, the operation of any combination of detector-amplifiers *fA* to *fE* inclusive will cause a corresponding operation of the register relays in the translator of Fig. 9.

The combination of frequencies for each of the digits which may be dialed from the calling station A or any other station equipped with an alternating current sending device LG and the operation of channel and translator relays operated thereby are as follows:

Digit keyed	Channels operated	Translator relays operated
1.....	<i>fA, fD</i>	TA, TD
2.....	<i>fB, fD</i>	TB, TD
3.....	<i>fD, fE</i>	TD, TE
4.....	<i>fB, fE</i>	TB, TE
5.....	<i>fC, fD</i>	TC, TD
6.....	<i>fA, fC</i>	TA, TC
7.....	<i>fB, fC</i>	TB, TC
8.....	<i>fC, fE</i>	TC, TE
9.....	<i>fA, fE</i>	TA, TE
0.....	<i>fA, fB</i>	TA, TB

When, therefore, the subscriber at station A keys the first digit, which may be a 2 or a 3, but, in the assumed illustration, will be a 2, frequencies B and D are generated, and these frequencies are transmitted over a previously described loop including a winding of transformer 68, whence they pass through high-pass filter 64 from the output of which energy thereof 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 (not shown) preceding the tubes *fB* and *fD* to operate said tubes. Since the operation of the receiver has been amply described in the above-mentioned patent to which reference has already been made, it may be stated that a definite time interval is consumed in the operation of enabler 80 in consequence of which relay 77 operates to apply ground to conductor 78. Since this conductor is connected to the cathodes of the various detector tubes *fA* to *fE*, those tubes will respond

through whose channels the filters have permitted the passage of the frequencies in the signal. Hence for the digit 2, the two frequencies of whose pulse cause the response of channels /B and /D, relays FB and FD are operated and they, in turn, close obvious circuits for relays TB and TD, respectively, which, upon operating, lock over conductor 81 under the control of polarized relay TL to ground on the No. 6 contacts of relay ON, relay TL having been previously operated 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, No. 3 contacts of relays TE and TD, No. 3 contacts of relays TB and TC, No. 3 contacts of relay 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 traces from ground on the No. 6 contacts of relay ON, No. 4 contacts of relay TLT, lower winding of relay TL, No. 1 contacts of relay TLT to resistance battery. Now the current flowing through the upper winding of relay TL is in a direction to cause the armature to engage the contact, while the current flowing through the lower winding is in a direction to do the opposite. The strength of the current through the lower winding, however, is insufficient 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 TD 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 to TE removes this ground, and a charging circuit is established for said 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, relay TL will release and unlock the register relays TB and TD. However, the interval during which relays TB and TD are locked is sufficient to permit the slowest of the register relays T2, T3I—VI in the link circuit to operate, and relay RA to operate or release as described hereunder. In other words, during the time or immediately upon the operation of relays TB and TD and during the interval that the same are locked to the contacts of relay TL, a circuit is completed in the link to operate relay T2 which is the relay that registers the tens digit 2 in the link as previously described. This circuit is completed from ground on conductor 76, No. 1 contacts of relays KBD, BK3 and BK1, No. 3 contacts of relay TA, No. 3 contacts of relay TC, No. 4 contacts of relay TB, No. 6 contacts of relay TD, No. 9 contacts of relay TE, No. 2 contacts of relay TB, No. 11 contacts of relay TD, conductor 83, No. 3 contacts of relay LC1, conductor 84, No. 2 back contacts of relay RT, conductor 85, upper winding of relay T2 to battery. Relay T2 operates and then locks as previously described to register the first digit 2. If the first or tens digit of the called number has been a 3 instead of a 2, then, according to the above table, relays TD and TE would have been operated in consequence of the operation of channel relays FD and FE in which event, in addition to closing a circuit for relay T2, a circuit would also have been closed for relay T3,

said circuit tracing from ground on conductor 76, No. 1 contacts of relays KBD, BK3 and BK1, No. 3 contacts of relay TA, No. 3 contacts of relay TC, No. 3 contacts of relay TB, No. 4 contacts of relay TD, No. 6 contacts of relay TE, No. 1 contacts of relay TD, No. 2 contacts of relay TE, conductor 86, No. 1 contacts of relay LC1, conductor 87, No. 3 back contacts of relay RT, conductor 88, No. 2 normally made continuity contacts of relay T3, upper winding of said relay T3 to battery. Relay T3 operates and then locks as previously described to register the digit 3.

Simultaneously with the operation of the translator relays TB and TD in response to the keying of the tens digit 2, or relays TD and TE in response to the keying of digit 3 (the latter not being considered), a circuit is completed for relay RA. For either digit, however, the ground on conductor 76 may be traced to the common conductor joining the No. 6 and No. 9 contacts of relay TE. These paths are through a network of contacts which extends over the contacts of relays TA to TE in order to insure that exactly two of these relays are operated before grounding any of the link register relays. From the common terminal of this network at the Nos. 6 and 9 contacts of relay TE, the circuit for relay RA may further be traced through either No. 1 contacts of relay TE or No. 1 contacts of relay TB, thence through the No. 10 contacts of relay TD, No. 5 back contacts of relay RA1, No. 1 normally made continuity contacts of relay RA, No. 1 contacts of relay RR, winding of relay RA to battery. Relay RA operates and, by the closure of its No. 1 front contacts, applies ground on conductor 76 to one terminal of the winding of the relay RA1, the other terminal being grounded over the No. 4 back contacts of said relay by the aforetraced ground for operating relay RA. Relay RA, in operating, opens the tone circuit at its No. 2 contacts thereby removing "dial" or key tone from the line.

When the translator relays TB and TD release in consequence of the release of relay TL, ground is removed from the conductor which completed the circuit for relay RA and ground is also removed from the battery side of the winding of relay RA1 causing said relay to operate over the circuit completed to an aforetraced ground on the No. 1 front contacts of relay RA. Relay RA1, in operating, closes a circuit for relay RT the path of said circuit extending from ground on the No. 1 contacts of relay RA1, conductor 89, No. 2 contacts of relay LC1, conductor 91, winding of relay RT to battery. Relay RT operates, locks over its No. 6 contacts, conductor 92 within bracket line 93 to ground on the No. 7 contacts of relay ON, connects the winding of the link units register relays I to VI with the contact network of the translator relays TA to TE so that the operation of any two of the latter in accordance with the digit code for the alternating current transmission of the units designation of the called number will result in the operation of the appropriate two relays of the units register of the link in accordance with the dial impulse code for the registration of said digit. Relay RT further completes a partial path for relay KBD which may be traced from battery through the winding of relay KBD, conductor 94 within bracket line 93, No. 10 front contacts of relay RT, conductor 26, No. 4 contacts of relay T2, No. 1 contacts of relay SW to the No. 1 front contact of relay C. Now if the subscriber should flash the switchhook after hav-

ing keyed the tens digit, the release of relay A in consequence of the momentary opening of the line will cause the operation of relay C to operate relay KBD which locks over its No. 2 contacts to ground on the No. 7 contacts of relay ON. Relay KBD applies ground over its No. 3 contacts to conductor 95 within bracket line 13 which extends to a relay (not shown) in the power, tone and alarm circuit 119 that controls a distinctive source of tone. This tone is applied to conductor 96 which, over the No. 2 contacts of relay KBD, connects with conductor 73 and thence as previously traced over the subscriber's loop, back on conductor 74 to resistance ground. This tone warns the subscriber that the connection will not be completed, that he should restore the telephone instrument and try again to reestablish the connection. In the event that the subscriber ignores the signal and proceeds to key the units digit, the same will not be registered since, with relay KBD operated, the ground on conductor 76 normally available for completing the circuit of the units register relays will be cut off at the No. 1 contacts of relay KBD. Relay KBD further completes a circuit for message register MR1 over its No. 5 contacts to ground on conductor 76. The operation of the message register furnishes the traffic division of the operating company with information as to how often a subscriber flashes.

When the calling subscriber depresses a key of the device LG for the second or units digit, the receiver of Fig. 10 responds to the two frequencies transmitted, to operate whichever two of the five channels are adapted to respond to said frequencies. Thus, if the units digit is 0, as assumed, channels /A and /B are operated, in turn causing the operation of channel relays A and B, followed by the operation of translator relays TA and TB, respectively, which lock to ground on the contacts of relay TL, as before. Since relay RA1 is operated, a circuit path is completed for relay RR which extends from battery through the winding of said relay and the No. 2 normally made continuity contacts thereof, No. 4 and No. 5 front contacts of relay RA1, No. 9 contacts of relay TE, No. 9 contacts of relay TD, No. 6 contacts of relay TB, No. 5 contacts of relay TC, No. 4 contacts of relay TA, No. 1 contacts of relays BK1, BK3 and BKD to ground on conductor 76. Relay RR operates, locks to ground on the No. 6 contacts of relay ON and releases relay RA. Relay RA1, however, will not release upon the release of relay RA, it being held over the No. 1 continuity contacts of said relay RA to the same ground which caused the operation of relay RR, said ground tracing, in part, through the No. 4 front contacts of relay RA1. Relays RR and RA1 now remain locked during the interval in which translator relays TA and TB remain operated.

Since the units digit 0 requires the operation of relays IV and VI in the units register, the operation of relays TA and TB completes the following two circuit paths for relays IV and VI: (1) Ground on conductor 76, No. 1 contacts of relays KBD, BK3 and BK1, No. 4 contacts of relay TA, No. 5 contacts of relay TC, No. 6 contacts of relay TB, No. 9 contacts of relay TD, No. 9 contacts of relay TE, No. 2 contacts of relay TB, No. 2 contacts of relay TA, conductor 97 within bracket line 93, No. 4 contacts of relay RT, upper winding of relay IV to battery. Relay IV operates and locks to ground on conductor

28. (2) The circuit path for relay VI may be traced from ground on conductor 76 through the No. 1 contacts of relays KBD, BK3, and BK1, No. 4 contacts of relay TA, No. 5 contacts of relay TC, No. 6 contacts of relay TB, No. 9 contacts of relay TD, No. 9 contacts of relay TE, No. 1 contacts of relay TB, No. 7 contacts of relay TA, conductor 97 within bracket line 93, No. 9 contacts of relay RT, No. 5 normally made continuity contacts of relay VI, upper winding of relay VI to battery. Relay VI operates and locks to ground on conductor 28. Relays IV and VI connect ground to conductor 98, which, over the lower back contacts of hold magnet HO20, connects with the winding of cut-off relay CO20. The operation of relay CO20 closes an obvious circuit for hold magnet HO20 which insures the holding of cross-point 8 on vertical 20 after select magnet 8 has released, said magnet having operated as a result of the link operation. Cut-off relay CO20, after its circuit is cut off by the operation of the horizontal magnet HO20, holds to ground over the following path: Battery, winding of relay CO20, No. 4 contacts of cross-point 8 in vertical 20, conductor S, No. 3 contacts of relay E, No. 7 contacts of relay B, front contacts of relay A, conductor S1, No. 3 contacts of cross-point 9 in vertical 39, to ground. When relay TL releases, translator relays TA and TB release, followed by the release of relays RR and RA1.

In the event that the subscriber keys any digit other than a 2 or a 3 for the tens digit, the digit will not be registered in the link. The reason for this is because conductors 84 and 87 (the former being used for the registration of the digit 2 and the latter for the digit 3) alone are connected between the translator relays TA to TE and the link tens register relays T2 and T3 through the back contacts of relay RT. If any other digits were to be keyed in which these conductors are used, they would be ineffective since no ground is applied to these conductors for any digit other than 2 or 3 until relay RA1 has operated, which occurs after the registration of the tens digit.

On keying the second digit if, through improper manipulation of device LG, a single frequency is generated, the same will result in the operation of a single translator relay and in the operation of relay BK1 in consequence thereof. Thus, if frequency E is produced and transmitted and, as a result, relay TE operates, a circuit path is completed for relay BK1 which traces from battery through the winding of said relay, No. 7 contacts of relay RA1, No. 4 contacts of relay TE, No. 3 contact of relay TD, No. 3 contacts of relays TB, TC and TA, No. 1 contacts of relays BK1, BK3 and KBD to ground on conductor 76. Relay BK1 operates, closes its No. 4 locking contacts before opening its No. 1 contacts, closes an obvious circuit for message register MR3 and applies ground to conductor 95 which, as before described, operates a tone circuit which is applied to conductor 96, No. 2 contacts of relay BK1, and thence over the subscriber's loop, to signal the subscriber to restore the instrument and restart the call.

If three or more frequencies are transmitted for the second or units digit, a circuit is completed for relay BK3 over one of a plurality of paths traceable through the contacts of the translator relays TA to TE to ground on conductor 76. Relay BK3 operates, closes its locking No. 4 contacts before opening its No. 1 contacts, completes an obvious circuit for register MR2, grounds conductor 95 and completes the tone cir-

cuit on conductor 96 to the tip side of the calling loop via conductor 13.

Returning, now, to the operation of the link, when relay T2 operates in response to the first or tens digit, relay ST is released but the link still holds because relay B is still operated and the translator is still held connected to the link by relay LSI which holds to ground on conductor 58, furnished through the No. 1 front contacts of relay B, via the No. 1 contacts of relay CX.

When, after the registration of the second digit, relays RR and RA1 have both released, a circuit is completed for relays C1 and CX in the link, which circuit extends from ground on conductor 76, No. 1 contacts of relay KBD, No. 1 contacts of relay BK3, No. 1 contacts of relay BK1, No. 6 contacts of relay RA1, conductor 99 within bracket line 93, No. 8 front contacts of relay RT, conductor 25, No. 4 continuity contacts of relay C1, winding of relay C1, resistances RS to battery. Relay C1 operates and completes a circuit for relay CX which extends from battery through its winding and No. 3 continuity contacts, No. 5 front contacts of relay C1 to ground on the No. 5 contacts of relay B. The operation of relay CX removes ground from conductor 58 thus releasing relay LSI followed by the release of relay LC1 and relay RT by which the translator and receiver are disconnected from the link. Relay CX further prepares a path for operating relay CON through its No. 2 contacts and the No. 4 contacts of relay HS when the called subscriber answers in case the calling subscriber should desire to set up a conference connection as described hereunder. The operation of relay C1 also starts the sequence of operations by which the link is connected to the called station B and for ringing the bell of said station if idle, or for returning busy tone if busy, as previously described. The release of the link connector relay LC1 reconnects relay E to the outgoing ends of conductors T and R of the link for supplying talking battery and supervision to the called subscriber when connected.

When the called station answers, relay HS operates to perform the functions already described, including the application of ground to conductor S to hold relay CO20 after relay E has operated over the called loop, the reversal of the connections between relay A and the calling line conductors to condition the calling station set for talking since the previous polarity of the voltage from relay A has kept the transmitter of the calling station set disabled to prevent speech frequencies from interfering with the reed frequency signals and, in addition, the completion of the circuit of relay CON to ground on the No. 5 contacts of relay B, which operates and then locks through the No. 5 back contacts of relay C1 (which releases when relay S of the call allotter operates as previously described) to ground on the No. 5 front contacts of relay B.

If the called party now replaces his receiver on the switchhook, relay HS will release, closing the following path to short-circuit relay CX: Ground on the No. 5 contacts of relay B, No. 5 back contacts of relay C1, No. 1 contacts of relay CON, No. 6 contacts of relay HS, to the resistance side of the battery supply for relay CX. Relay CX releases, recloses ground to conductor 58 in consequence of which relay LSI again operates, to connect the alternating current receiver to the link whereby tone is again transmitted to the calling station, consequence of which the subscriber thereat is thus apprised to key a second

station in the same manner as for the original call. When relay C1 operates on the second call, relay CON will be released. The original called party, that is, station B, must wait until ringing has been tripped by the second called party before reanswering. Relay CX is slow in releasing and thereby prevents the translator from being reseized if the called party flashes his switchhook.

We will now describe the establishment of a call from a station in the P. B. X (say station A) to some subscriber located in a central office. For such a call, a trunk interconnecting the P. B. X with the central office is, of course, necessary, and since such a trunk will have to provide for both outgoing and incoming traffic, "two-way" trunks are used. Such trunks are connected to the horizontal outlets of the P. B. X cross bar switch in much the same manner as the links are connected, the number of trunks provided being determined, of course, by the total outgoing and incoming traffic to flow thereover. In Fig. 2 the connection of trunk No. 1 in Fig. 12 is shown in detail, it being evident that as many trunks may be furnished as is consistent with the requirements of the traffic and available horizontal outlets, making due allowance for the horizontal outlets occupied by the three links. Since the cross bar switch unit indicated in Figs. 2 and 3 provides a maximum of ten horizontal outlets, and each link wired thereto requires two horizontal levels, the provision of three links for local exchange service leaves four levels which can be utilized for trunks. Since each trunk requires but one level, a maximum of four trunks may thus be provided for the full capacity of the switch, each of said trunks all extending to the same central office or to different central offices as the case may be.

With respect to the connection of the different trunks to the horizontal outlets of the switch, it should be noted that a distinction exists between the connection of the links and that of the trunks. Whereas each of the links extends across the switch for accessibility to each of the lines connected to the several verticals of the switch, including the control line 20, the "inward" portion of each trunk (the lower group of conductors LT, LR, LSI and LH) extends across the switch for accessibility to all the line verticals except line vertical 20. On the other hand, the "outward" portion of each trunk (the upper group of conductors UT, UR, USI and UH) is connected to one cross-point on vertical 20 in the horizontal outlet reserved for the particular trunk, so as to make the outward portion of the trunk accessible only to line vertical 20; that is, to station B. In other words, the horizontal multiple of the switch is split between vertical 20 and vertical 21 for the horizontal levels to which the trunks are connected, thereby giving line 20 access to the outward portion of each trunk and lines 21 to 39 inclusive, access only to the inward portion of each trunk.

Fig. 12 shows one of the two-way trunks (trunk 1) in detail, said trunk being assumed to extend between the central office and the third horizontal level of the cross bar switch. The other three trunks, namely, trunks 2, 3 and 4, which are identical with trunk 4, are conventionally indicated, are wired to switch horizontal levels 2, 1 and 0 respectively, and may extend to the same central office as trunk 4, as is indicated in Fig. 12 or to different central offices as previously stated.

Now let it be assumed that station A (line 39)

desires an outside connection. The party thereat dials the control station number (20) and a connection is established therebetween over one of the links as previously described. The control station attendant receives the requested outside number and the number of the calling station (39), and thereafter, requests the calling station to restore the receiver.

The control station now operates the key of an idle trunk. Assuming that trunk 1 is idle and is the one to be used for the connection, the control station attendant operates key TK1 associated with said trunk, there being one such key for each trunk. Now the trunk keys TK1 to TK4 and key L constitute a key unit in which the operation of any one key in the unit immediately causes the release of any other key. It will be remembered that in the establishment of a local connection from station B to station A, the attendant at station B, in initiating the connection, not only removed his receiver from the hook but also operated key L. When the connection terminated, station B is disconnected from the link merely by restoring the receiver thereat even though the key L is left in an operated position. But in establishing a local connection from any station to the control station, as for example, from station A to station B preliminary to the establishment of an outside connection, the release of the link from station B is controlled by the contacts of key L rather than the opening of the line loop since, in establishing the outside connection, the attendant at station B will not restore the receiver as a preliminary step, but merely operates the trunk key. The reason for this is because the locking circuit of relay CO20 previously traced, includes the contacts of key L. When the station A restores, ground is disconnected from conductor 57 as applied thereto from conductor 5 through the No. 7 contacts of relay B. Conductor 57 extends to the winding of relay CO39 via the Nos. 2 and 4 contacts of cross-point 9 on vertical 39. Consequently, when ground is removed from conductor 57, relay CO39 releases, in turn releasing magnet HO39 which opens cross-point 9 on vertical 39 and disconnects station A from the link. Now the fact that relay E remains operated does not necessarily cause, for station B as the called station, the continued operation of relay HS as would be the case for any other station as the called station. At vertical 20, conductor 52 is joined to conductor 51 to complete the holding circuit of relay HS only through the contacts of holding key HO which is non-locking and the contacts thereof normally opened. Hence relay HS is not under the control of the control station loop as it would be for any other station as the called station. In the case of the control station as the called station, relay HS is maintained operated by ground on the No. 2 contacts of relay CO20, No. 3 switchhook contacts of the central station telephone instrument, serially through the normal contacts of the trunk keys TK1 to TK4, contacts of key L, No. 1 contacts of cross-point 8 on vertical 20, conductor 51, winding of relay HS to battery. Relay HS applies ground to conductor S, holding relay CO20 operated thereby and cross-point 8 on vertical 20 closed.

Hence when the called station initiates the trunk connection by operating the trunk key TK1, the above holding circuit for relay HS is opened, key L is released, relay CO20 released, in turn releasing magnet HO20 and opening cross-point 8 on vertical 20, thereby disconnecting the link from the called station. However, since the loop

of the called station is still closed, relay L20 immediately reoperates and since trunk key TK1 is also operated, a circuit is completed for relay T of trunk 1 (after the operation of relay L20) which extends from battery through the winding of relay T, conductor CS1, No. 4 contacts of relay L20, operated contacts of key TK1, No. 3 switch-hook contacts of station B, No. 3 contacts of relay L20, conductor 6, winding of relay LO20 to ground on the No. 1 contacts of relay E1. Also, due to the fact the key L is now released, previously described circuit operations result in the application of ground to conductor 11 and the former applies ground on said conductor to a circuit for select magnet 3 for horizontal level 3 of the cross bar switch, said circuit tracing from ground on said conductor 11, contacts of relay T, conductor SM3, winding of select magnet 3, to battery. This magnet operates and prepares the cross-points on level 3 for operation, depending upon the particular hold magnet operated. The operation of relay LO20 now closes, over conductor 19, a previously traced circuit for cut-off relay CO20 which operates to complete the circuit of hold magnet HO20. This magnet, upon operating, causes cross-point 3 in vertical 20 to be closed and thereby causes the extension of the trunk conductor UT and UR to the control station, conductors UT and UR being extended to the control line loop conductor T and R over cross-points 6 and 5, respectively. It is to be noted as previously stated that these conductors, as well as corresponding conductors on trunks 2, 3 and 4 terminating on cross-points 2, 1 and 0, respectively, are not paralleled to the cross-points of the other verticals of the switch but extend directly to the named cross-point on vertical 20 and only on vertical 20.

The closure of the cross-point 3 on vertical 20 and the closure of the No. 4 contacts therein complete a locking circuit for cut-off relay CO20 which extends from ground on the No. 2 contacts of said relay, No. 3 switchhook contacts, front contacts of trunk key TK1, No. 4 contacts of cross-point 3, winding of relay CO20 to battery. This relay now holds under the control of the trunk key TK1 independent of its operating circuit and, in so doing, holds magnet HO20 operated so that, upon the release of select magnet 3 in the same manner as previously described for select magnet 9, cross-point 3 will remain closed to maintain the connection of the control station to the trunk.

Cutting through the tip and ring conductors T and R of the station with conductors UT and UR, respectively, serves to extend the connection to the central office, the terminating end of the trunk thereat including the usual double-wound relay (not shown) with battery and ground applied to said windings for application to complete a circuit for said relay over the line loop. In the present invention, the loop also includes the double-wound relay H1, and the loop may be traced from battery through the one winding of the trunk relay in the central office, conductor TT, upper winding of relay H1, No. 1 normally made continuity contacts of relay H, conductor UT and thence as traced over the control station loop, conductor UR, lower winding of relay H1, the second winding of the trunk relay in the central office, to ground. Both the trunk relay and relay H1 operate in this circuit, the former to initiate well-known switching operations at the central office whereby, depending upon the type of central office, impulse responding facilities are

connected to the trunk conductors TT and RT in consequence of which dial tone is then transmitted over the calling loop to apprise the control operator to dial the wanted number. The latter relay, that is, relay H1, operates to apply ground to the No. 3 contacts of relay H2 via the No. 4 contacts of relay BT in order to lock relay H1 when it operates, and to supply ground to other parts of the trunk circuit, as described hereinafter.

The control station attendant, upon hearing dial tone, dials the wanted number by operating the dial device LD. The impulses produced thereby cause the impulse responding facilities at the central office to selectively position one or more selectors to reach the terminals of the wanted line, after which the called subscriber is rung in the usual way and ringing stopped when he answers the call. Since all of these operations at the central office are standard automatic telephone switching and ringing operations which are well established in the telephone art, no description of the central office facilities or their mode of operation is given herein. The transmission of dial impulses over the trunk loop will, of course, cause relay H1 to respond to each impulse, but since the stationary contact of the relay controls nothing at this time, the release and reoperation of the relay following each pulse will be without effect.

When the called subscriber answers he is, of course, connected over the loop with the control station attendant who then advises the called subscriber to wait for the answer of calling subscriber A. The attendant then momentarily operates the non-locking key HO which thereupon establishes a circuit for relay H of the trunk over the following path: Ground on the No. 2 contacts of cut-off relay CO20, No. 3 switchhook contacts, contacts of key HO, No. 2 contacts of cross-point 3 in vertical 20, conductor UH, winding of relay H to battery. Relay H operates and, over its No. 3 contacts, completes a circuit for relay H2 extending from ground on the contacts of relay H1, No. 3 contacts of relay H, winding of relay H2 to battery. Relay H2, upon operating, locks over its No. 3 contacts to previously traced ground on the contacts of relay H1 and, over its No. 1 front contacts, interposes resistance HR across both windings of relay H1 in order to hold the central office end of the trunk at the time that the control station loop is disconnected from the windings of relay H1 by the opening of cross-point 3 in vertical 20 as described hereinafter. When, therefore, the control station attendant releases key HO and relay H releases in consequence thereof, relay H2 remains locked under the control of relay BT and relay H1. The resistance RS interposed between battery and the armature of the No. 6 contacts of relay H2 when the latter operates, is for the purpose of avoiding a battery short-circuit at the time these contacts are closed and key HO is still operated, as it will be. Ground applied to the contacts of the key HO is applied to conductor 101 which extends to the stationary contact of the No. 6 contacts of relay H2. When key HO is released, resistance RS performs another function as noted below.

The attendant then depresses key L which, among other things, causes trunk key TK1 to be automatically released. The previously traced locking circuit of cut-off relay CO20 is now opened, causing said relay to release and, in turn, release relay T and hold magnet HO20, the

former opening the circuit of select magnet 3 and the latter opening cross-point 3 on vertical 20. Since the control station line loop is still closed, line relay L20 reoperates thereover, and the closure of key L now establishes a previously traced circuit for relay LO20 and relay ST of an available link for connecting the control station to the link, which, for convenience, may again be assumed to be link 1, and, therefore, said connection being established through cross-point 9 on vertical 20. The closure of cross-point 9 on vertical 20 establishes a circuit for relay TKL1 in the link, which circuit extends from battery through resistance RS1, No. 6 contacts of relay H2, conductor 101, No. 2 contacts on cross-point 9 on vertical 20, winding of relay TKL1, conductor 57, No. 7 contacts of relay B, front contacts of relay A, conductor S1, No. 3 contacts of said cross-point 9, to ground. Relay TKL1 operates but performs no function at this time.

Upon the connection of the link to line 20, key tone is transmitted to the control station in the manner described and the attendant thereat then dials the number 39, the line which requested the outside call. The link now functions as before in response to the called line digit impulses to connect the link to the called line via cross-point 8 on vertical 39, and if the line is idle as it should be since the party was requested to restore the telephone instrument, relay LK1 in the allotter operates over a previously traced circuit and, among its other functions, completes another circuit for relay T in the trunk which extends from ground on the No. 3 contacts of relay LK1, No. 3 contacts of relay MS, conductor 11, No. 1 contacts of relay B1, conductor 41, No. 6 contacts of relay LK1, conductor 40, front contacts of relay TKL1, conductor 102, No. 4 contacts of relay H2, No. 7 contacts of relay BT, winding of relay T to battery. Relay T operates and once again completes the circuit of select magnet 3, which, upon operating, again prepares the cross-points on horizontal level 3 for closure and further completes the circuit of relays S and S1, the former shunting relay C1 which, since the units digit 9 is registered in the register relays of Fig. 7, causes ground to be applied to conductor 33 for the operation of cut-off relay CO39 as previously described. Relay CO39 operates and closes the circuit of hold magnet HO39 which operates to close cross-point 3 in vertical 39 and thereby extend the tip and ring conductors T1 and R1 of the station to the inward trunk conductors LT and LR over the No. 6 and No. 5 contacts respectively of cross-point 3. With the closure of cross-point 3, the No. 2 contacts thereon provide a holding circuit for relay CO39 from ground on relay H1, No. 4 contacts of relay H, conductor LH, No. 2 contacts of cross-point 3, the common vertical conductor, No. 1 contacts of cross-point 3, winding of relay CO39 to battery. Relay CO39 is thus held under the control of the trunk independent of its original operating circuit, it, in turn, holding magnet HO39 operated to maintain cross-point 3 closed.

When the trunk cross-point 3 is closed on vertical 39, a circuit is completed for relay R1 which extends from battery through the winding of said relay, No. 5 back contacts of relay SPA, conductor LS1, No. 3 contacts of cross-point 39, to ground. Relay R1 operates to close a lamp signal circuit as noted hereinafter and locks over its No. 6 contacts, No. 5 contacts of relay BT, conductor LK to ground thereon (not shown) as applied to said conductor by equipment in the

power circuit 110. A ringing circuit is also completed between the calling station A (line 39) and the trunk which extends from one side of the source of interrupted ringing current AC, No. 1 contacts of relay RR, upper winding of relay RR, No. 1 back contacts of relay SPA, conductor LT, No. 6 contacts of cross-point 3, conductor T1, over the calling line loop, conductor R1, No. 5 contacts of cross-point 3, No. 4 back contacts of relay SPA, to the other side of the ringing current source AC. An interrupted lamp circuit is also completed for trunk lamp TLP1 to indicate to the control station attendant that the calling station A is being rung, said circuit being traced from ground through the filament of said lamp, conductor 105, No. 5 contacts of relay R1, conductor TL within bracket line 13' to a source of interrupted battery (not shown) in the power circuit 110.

When station A answers, relay RR operates, disconnects ringing source AC from the line, locks through its lower winding and No. 2 contacts to ground on conductor LS1, and further applies this ground through its own No. 3 contacts to the winding of relay SPA which operates and then locks to said ground over its No. 3 and No. 5 front contacts. Relay SPA, over its No. 1 and No. 4 front contacts, extends the tip and ring conductors LT and LR to trunk conductors TT and TR extending to the central office and thereby extending the loop of station A to said office, said connection being traced in part from conductor T1, No. 6 contacts of cross-point 3 in vertical 39, conductor LT, No. 1 front contacts of relay SPA, No. 1 normally made continuity contacts of relay H, upper winding of relay H1, conductor TT extending to the central office, battery supply and signaling devices in series therewith at the central office, ring conductor TR, lower winding of relay H1, No. 3 front contacts of relay SPA, conductor LR, No. 5 contacts of cross-point 3 on vertical 39, conductor R1 and thence over the loop of station B back to conductor T1.

Relay SPA further completes a circuit for relay BT extending from battery through the winding of said relay, No. 5 front contacts of relay SPA to aforetraced ground on conductor LS1. Relay BT operates, unlocks relay H2 which, in releasing, removes the holding condition in the trunk by disconnecting resistance HR across conductors TT and TR thereby causing the trunk now to hold over the calling loop, unlocks relay R1 and, in conjunction with the operated condition of relay BT, causes the circuit of trunk lamp TLP1 to be changed from an interrupted to a steady signal, the latter being supplied from battery through No. 2 front contacts of relay SPA, and the No. 6 contacts of relay BT to conductor 105. The steady lighting of trunk lamp TLP1 tells the control station attendant that the calling station A is now connected to the trunk. The attendant now restores his receiver whereupon the circuit of relay CO20 is opened to cause said relay to release, in turn releasing magnet HO20 which opens cross-point 9 in vertical 20. The line now releases in the manner previously described and the calling station A remains connected to the trunk over cross-point 3 in vertical 39.

When talking is terminated and station A restores the receiver, the trunk loop is opened to cause the disconnection of the selectors at the central office and, also, the release of relay H1. This relay, in releasing, opens the holding circuit of relay CO39 which releases. Hold magnet HO39 now releases and opens cross-point 3 on

vertical 39 in consequence of which ground is removed from conductor S1 and relays SPA, BT and RR holding thereto are released. With the release of relays SPA and BT, the lighting circuit for trunk lamp TLP1 is opened. The non-lighted condition of this lamp apprises the control station attendant that trunk 1 is now normal and may again be taken for service.

On an incoming trunk call for any station in the P. B. X, the establishment of the trunk connection in the usual manner causes ringing current to be applied thereover. Since ringing relay R2 is connected across the trunk via the No. 1 contacts of relay BT, relay R2 operates on the ringing current and completes an obvious circuit for relay R1 which operates and then locks over its No. 6 contacts and No. 5 contacts of relay BT to ground on conductor LK. Relay R1 completes a previously traced interrupted circuit for trunk lamp TLP1 as an indication that service is being awaited on the trunk, and further completes an audible circuit common to all trunks extending from one side of a source of tone connected to a buzzer (not shown) in the power circuit 110, conductor M, No. 2 contacts of relay R1, conductor CB3, to the other side of the source of tone in said power circuit. The attendant, upon hearing the buzzer or seeing the trunk lamp TLP1 flashing, proceeds to answer the call by removing the telephone instrument from its cradle and by operating the trunk key TK1. The closure of the line loop operates relay L20 which, in turn, completes the circuit of relay T in the trunk and relay LO20 in the allotter. Relay T now closes a previously traced circuit for select magnet 3 which operates to condition the cross-points on horizontal level 3 for selection, cross-point 3 in vertical 20 being so selected following the operation of hold magnet HO20 subsequent to the operation of relay CO20 in the manner previously described. The closure of cross-point 3 on vertical 20 extends the control station line to the trunk thereby closing the trunk loop including relay H1, and causing thereby the cutting off of ringing current at the central office and the application of talking battery to the trunk conductors, relay H1 operating to provide holding ground to various parts of the trunk as in the previous type of connection.

The control station attendant now inquires of the calling party (in this case the party at the remote end of the trunk) the number desired which, we may say, is station A (line 39). Before dialing the wanted station number, the attendant momentarily operates key HO that serves to complete a previously traced circuit for relay H which operates to operate in turn relay H2, said relay H2 locking and placing resistance HR across the trunk to hold the same subsequent to the opening of the cross-point 3 in vertical 20. Thereafter the attendant operates key L which automatically unlocks trunk key TK1 and causes thereby the release of relay CO20, the release of magnet HO20 and the opening of cross-point 3 on vertical 20, thereby disconnecting the trunk from the control station. Relay L20 is now re-operated to initiate the connection of a link to the control station line. Assuming that link 1 is once again taken into use, cross-point 9 in vertical 20 is closed to effect the connection of the control station to the link whereupon, after receiving key tone, the attendant dials 39. In this case, however, and since relay TKL1 is operated, the circuit of select magnet 8 is not closed to effect a connection of the called station to the

link since the circuit of said magnet traces through the back contacts of said relay. On the other hand, relay TKL1 completes a previously traced circuit for relay T which, upon operating, completes the circuit of select magnet 3. Since the units digit dialed is 9, ground is applied to conductor 33 to complete the circuit of cut-off relay CO39 which then operates magnet HO39 to close cross-point 3 on vertical 39. Had the connection been local from station B to station A, relay TKL1 would have been normal and cross-point 8 on vertical 39 would have been selected to join the called station to the link. Since it is a trunk which is to be extended to the called station A, relay TKL1 is operated and cross-point 3 on vertical 39 is closed instead.

Upon the closure of cross-point 3, the trunk rings the line as previously described for line 20. When station A answers, relay RR operates to operate relay SPA, the trunk lamp TLP1 illumination is turned from an intermittent flash to a steady light as an indication to the control attendant that station A has answered. The attendant then restores his receiver with results already noted. Upon the termination of the call, the disconnection of the trunk from the cross bar switch takes place in the same manner already described.

What is claimed is:

1. A telephone system comprising a cross bar switch, lines including a control line connected to the verticals of said switch, a plurality of links connected to a number of the horizontals of said switch for access to all of said lines, a plurality of trunks connected to another number of the horizontals of said switch for connection to all of said lines except the control line and for another connection to said control line only, means responsive to an operation at said control line for connecting said control line to one of said trunks through the cross-point connection thereof at the control line vertical, means for establishing a connection between said control line, and one of said other lines through one of said links, said means including other means for holding said trunk independently of the control line loop during the establishment of said connection, means responsive to the establishment of said connection for extending the trunk to said other line through the cross-point connection of said trunk at said line vertical whereby said trunk is held over the loop of said line, means responsive to the establishment of the connection to said line for removing the holding condition in the trunk, and means responsive to the restoration of said control line for restoring said link to normal.

2. In a telephone system, a cross bar switch, subscribers' lines including a control line arranged vertically in said switch, links arranged horizontally in said switch, trunks arranged horizontally in said switch, means for establishing a connection from any calling line to any other line through a link, a key for each trunk at said control line, means operated in response to the initiation of a call at said control line and the actuating of a trunk key thereat for establishing a connection from said control line to the trunk corresponding to the key actuated, means responsive to the establishment of a connection between said control line and another line through one of said links for automatically extending said trunk to said other line whereby said trunk is

held by said other line, and means responsive to said control line restoring for restoring said link to normal.

3. In a telephone system, a cross bar switch, subscribers' lines including a control line arranged vertically in said switch, links arranged horizontally in said switch, trunks arranged horizontally in said switch, means for establishing a connection from any calling line to any other line through an idle link, a key for each trunk at said control line, a trunk holding key at said control line, means operated in response to the initiation of a call at said control line and the actuation of a trunk key thereat for establishing a connection from said control line to the trunk corresponding to the key actuated, means thereafter responsive to the operation of the trunk holding key for establishing a holding condition on the engaged trunk, means for releasing said control line from said trunk, and means thereafter operative in response to the establishment of a local connection between said control line and another line for holding said trunk over said other line and for removing said holding condition.

4. In a telephone system, a cross bar switch, telephone lines including a control line terminating in said switch, trunks terminating in said switch, a key for each trunk at said control line, a trunk holding key for all trunks at said control line, means responsive to the initiation of a call at said control line and the operation of a trunk key thereat for establishing a connection between said control line and the trunk corresponding to said operated key, means thereafter responsive to the operation of the trunk holding key for establishing a holding condition on said trunk, means under the control of said control line for extending said trunk to said other line, means responsive to said other line answering the connection for placing said trunk under the control thereof and for removing said holding condition, and means responsive to said control line restoring for breaking down said local connection between said control line and said other line.

5. In a telephone system, a cross bar switch, telephone lines including a control line terminating in said switch, links terminating in said switch, trunks terminating in said switch, a key for each trunk at said control line, another key at said control line, means responsive to a call initiated at said control line and the operation of a trunk key thereat for establishing a connection between said control line and the trunk corresponding to the trunk key actuated, means responsive to the establishment of said connection for placing a holding condition on said trunk, means responsive to the operation of said other key at said control line for establishing a connection between said control line and a link, means in said link responsive to digits represented by series of impulses from said control line for connecting said trunk to the one of said lines corresponding to the digits transmitted, means responsive to said line answering the connection for holding the trunk thereover and for removing the holding condition on said trunk, and means responsive to the disconnection of said control line for restoring said link to normal.

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