Nov. 3, 1942. W. A. MALTHANER 2,300,951

TELEPHONE SYSTEM

Filed July 26, 1941 10 Sheets-Sheet 1

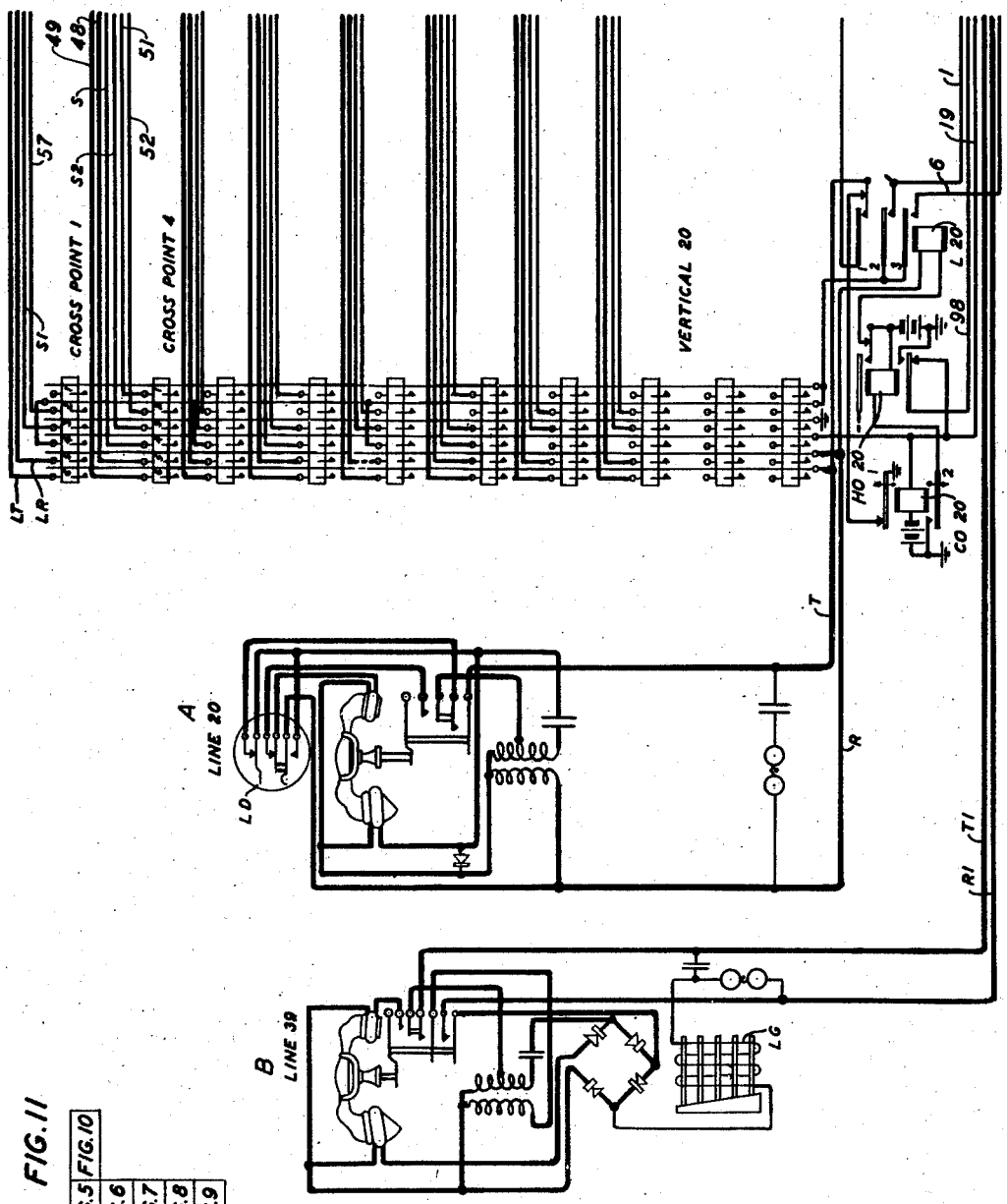

FIG. 1

FIG. 11

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

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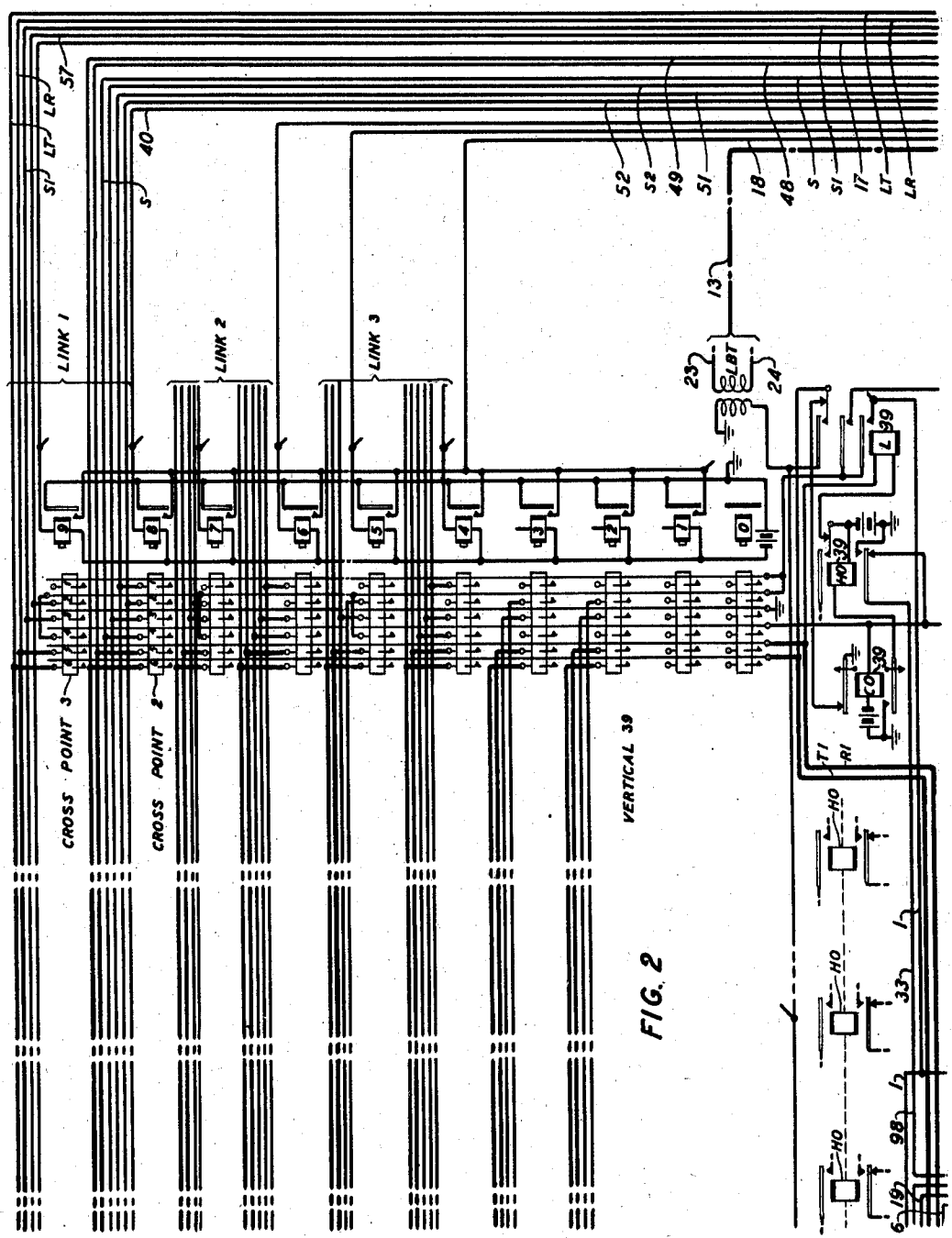

FIG. 2

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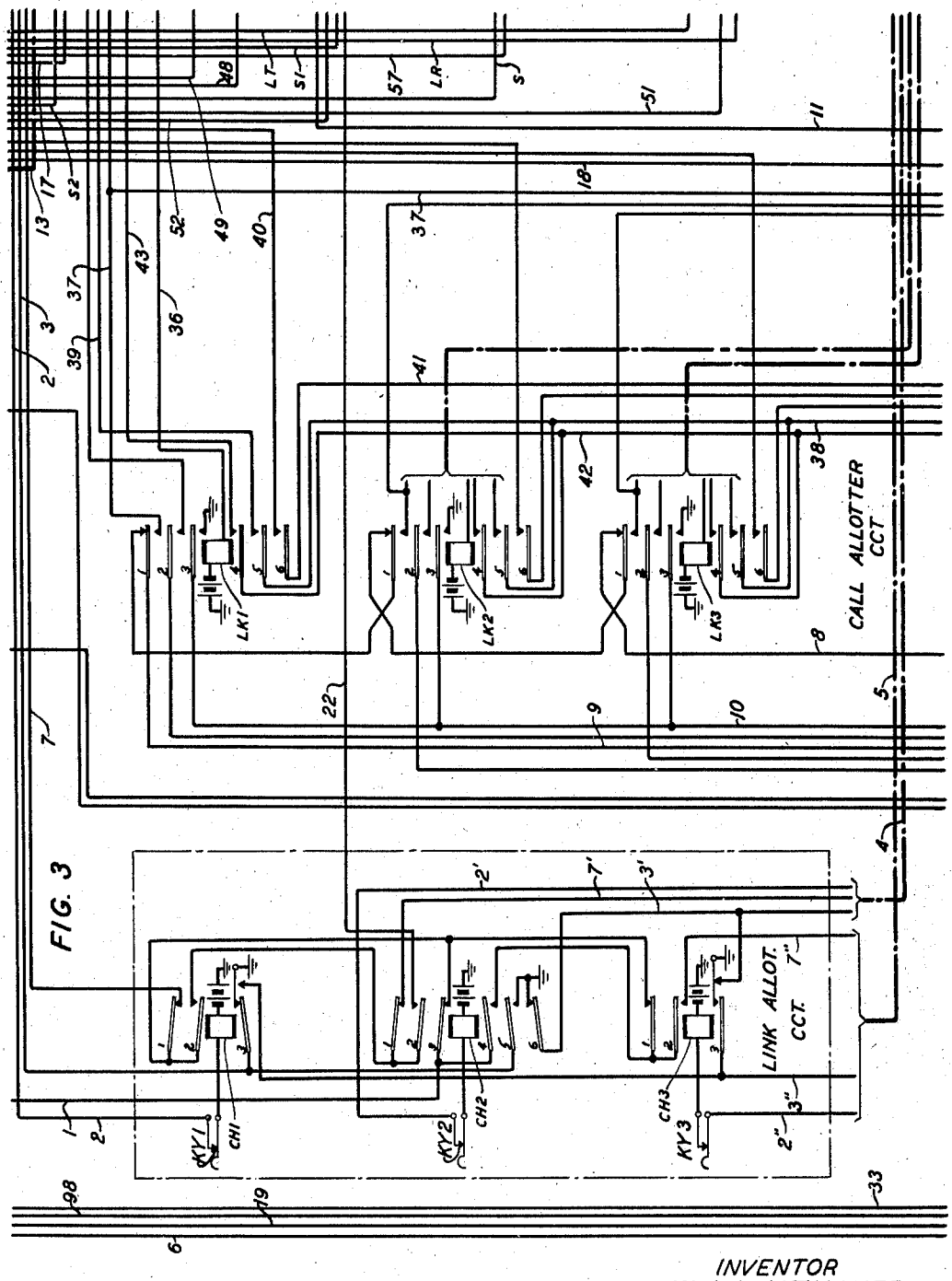

FIG. 3

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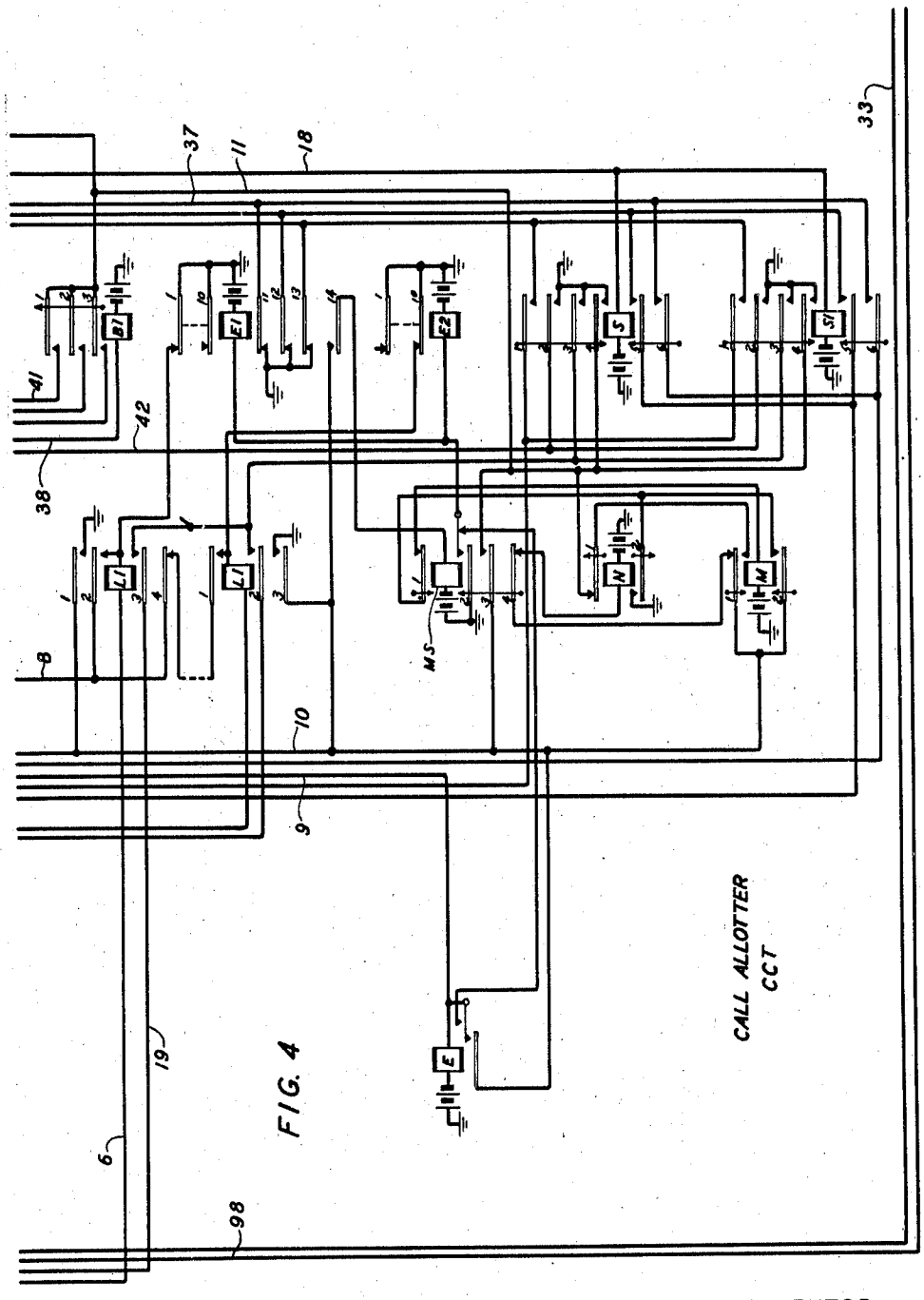

FIG. 4

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TELEPHONE SYSTEM

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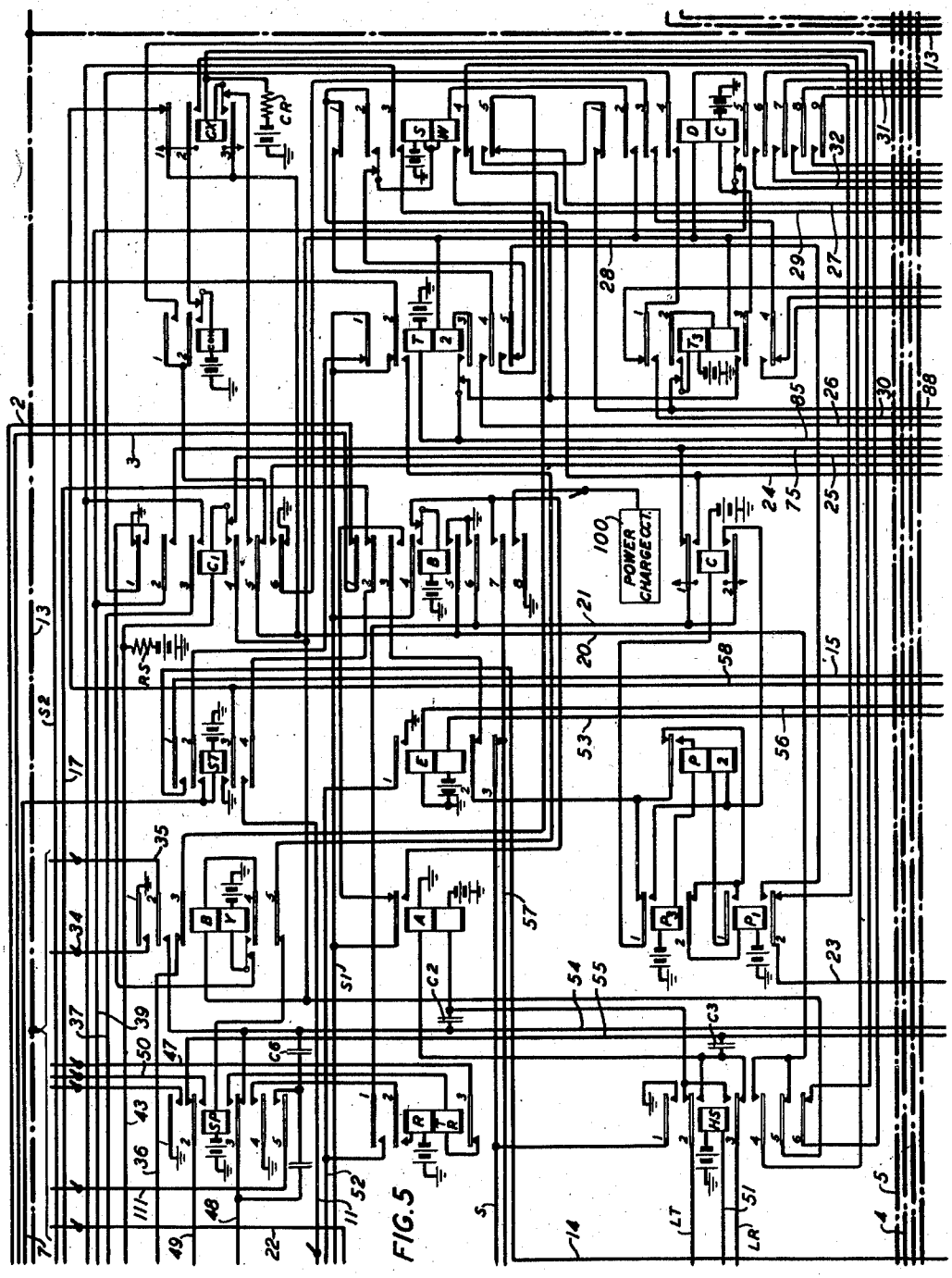

FIG. 5

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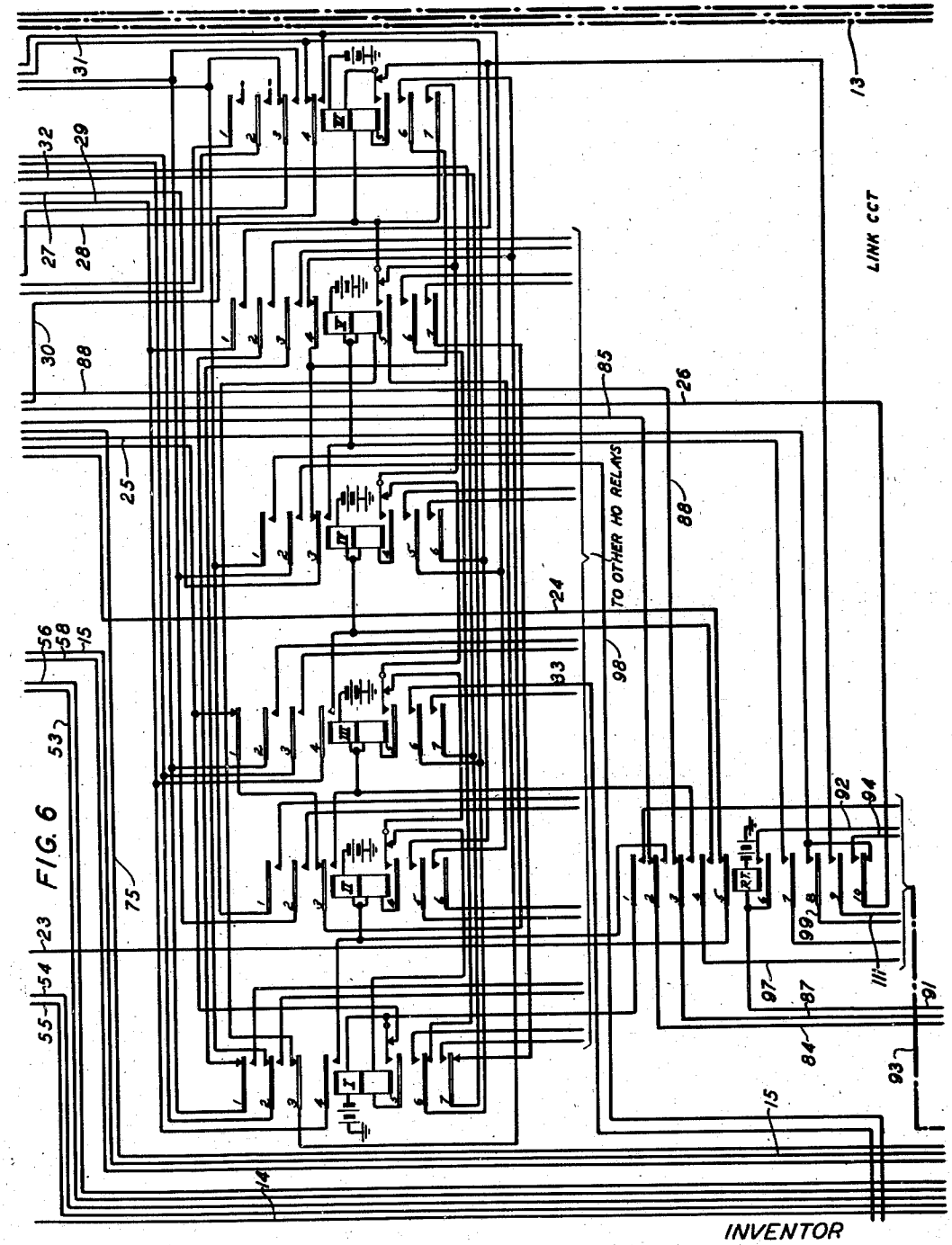

FIG. 6

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TELEPHONE SYSTEM

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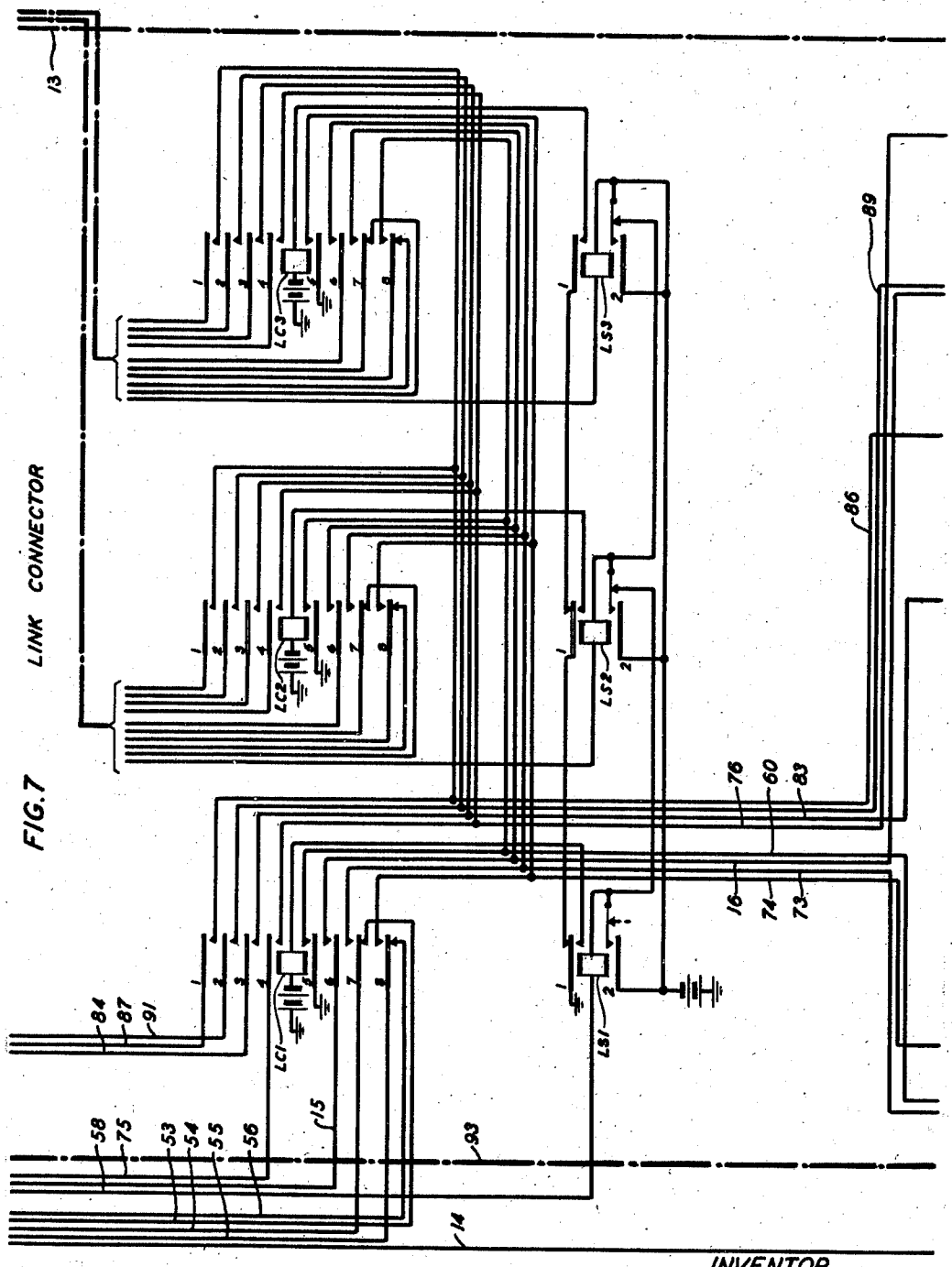

FIG. 7

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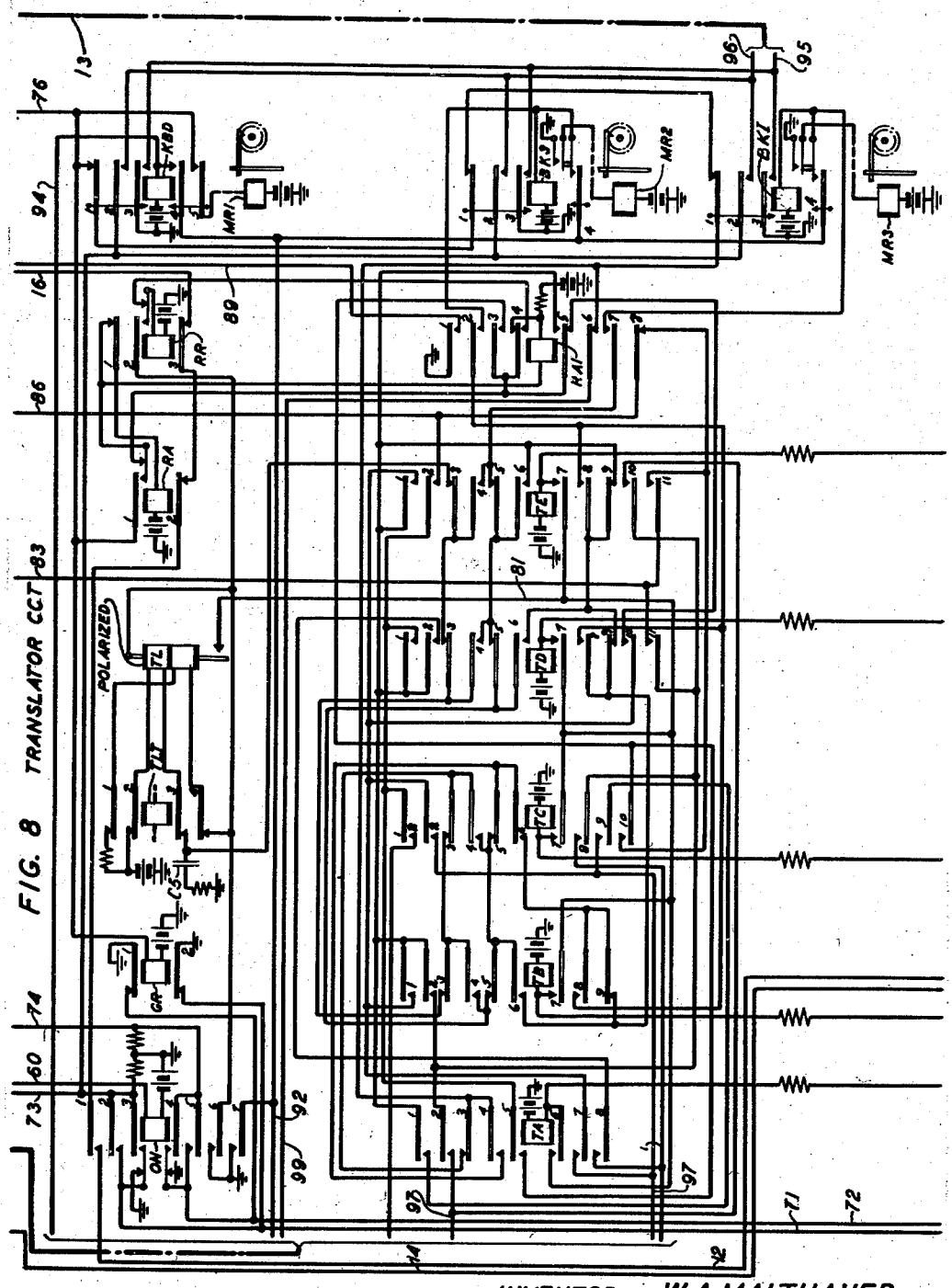

FIG. 8

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TELEPHONE SYSTEM

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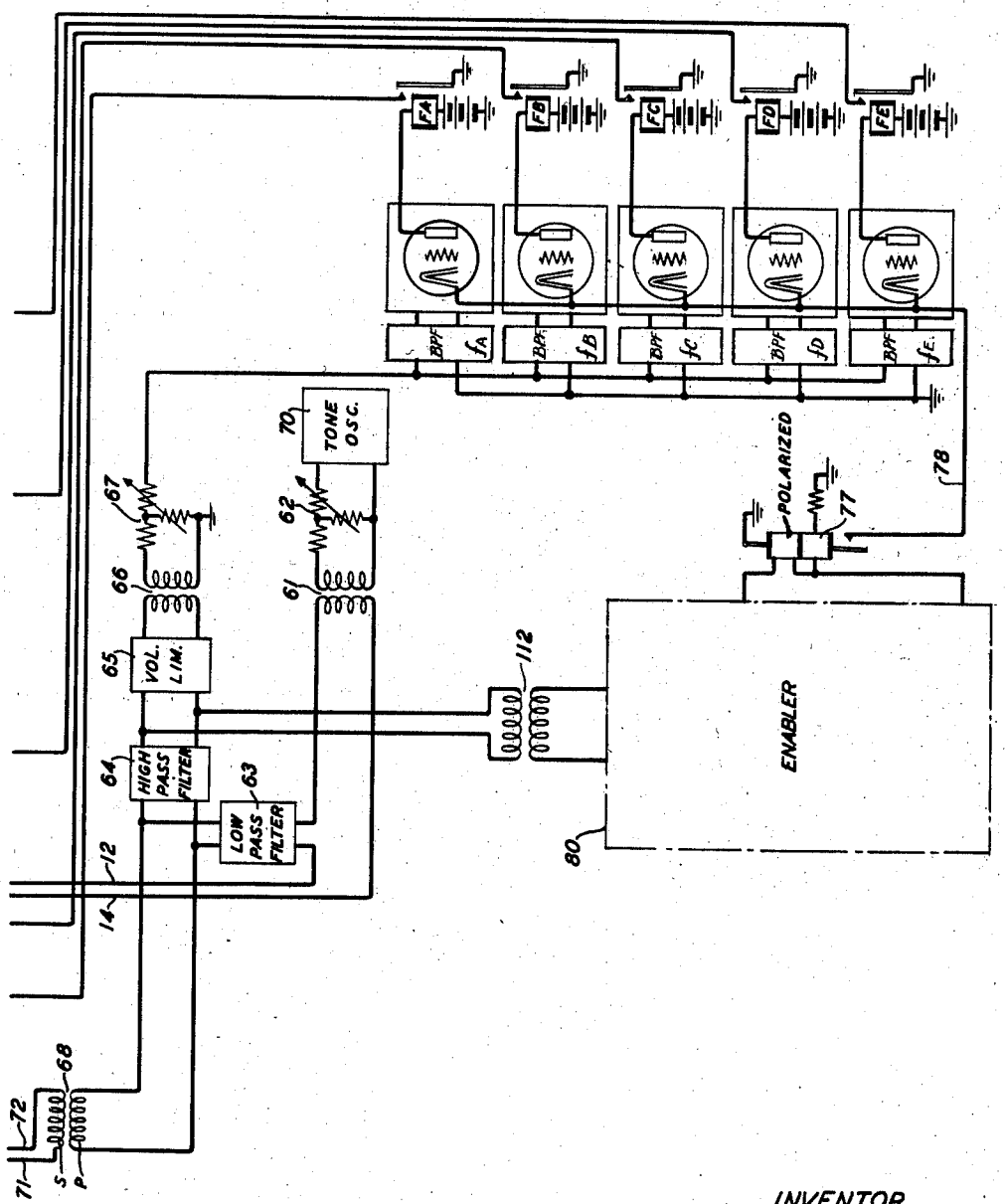
FIG. 9



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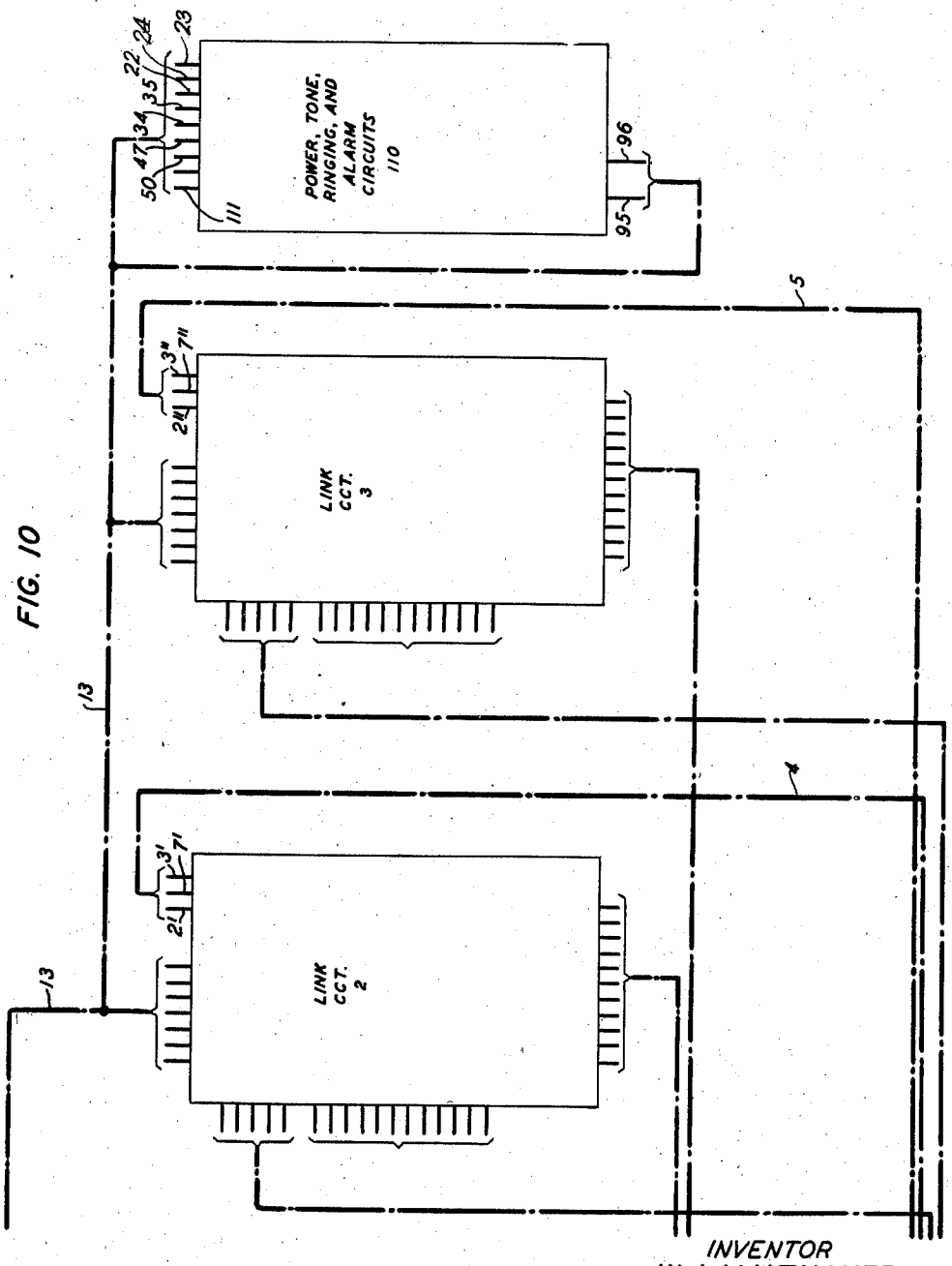

FIG. 10

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Patented Nov. 3, 1942 2,300,951

UNITED STATES PATENT OFFICE

2,300,951

TELEPHONE SYSTEM

William A. Malthaner, New York, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application July 26, 1941, Serial No. 404,109

9 Claims. (Cl. 179—25)

This invention relates to telephone systems and particularly to small capacity telephone systems in which crossbar switches are employed. An object of the invention is to provide means whereby line stations equipped with different types of call devices may operate common apparatus with which to set up desired connections as, for instance, between a station equipped with a dial sender to transmit a series of impulses designating a called number and a station that utilizes an alternating current generating device to generate and transmit combinations of different frequencies to designate the called line number.

Heretofore, systems have been provided for establishing connections between two subscribers' lines in single crossbar units wherein all of the calling stations were equipped with dial sending devices as, for instance, the system disclosed in Patent No. 2,071,075 issued to Charles D. Koechling on February 16, 1937.

A feature of the present invention is an arrangement in a system of the above kind in which a connection may be established between two subscribers' lines by means of a link which, on the one hand, is adapted to respond to dial pulses produced at an originating station equipped with a dial to set up a connection to the station indicated by the pulses and, on the other, is also adapted to respond to combinations of currents of different frequencies generated at an originating station, to set up the connection to the station indicated by such combinations of frequencies. The link is provided with suitable registers for response to either type of pulses, the direct current register, however, being the one which, in all cases, operates the hold magnet of the called line in the crossbar switch. A translator is provided whereby, in response to the setting of the register that responds to the alternating current pulses designating the digits of the called line, the direct current register is set for those digits, which then controls means for operating the hold magnet of the called line.

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

Figs. 1 and 2 show, diagrammatically, a crossbar switch frame of known construction having ten horizontal outlets and twenty verticals to each of which a subscriber's station is connected. The first vertical, assigned to station A, has a line number designation 20, and the last vertical, assigned to station B, has a number designation 39, station A being provided with a dialing device LD and station B being provided with an alternating current or "key pulsing" generating device LG;

Fig. 3 in the left portion thereof, shows a link allotter circuit, while the rest of this figure, together with Fig. 4 show the call allotter circuit;

Figs. 5, 6, 7, 8 and 9 show the details of the link circuit;

Fig. 10 shows, in diagrammatic form, two other links and a power generating, tone and alarm circuit; while

Fig. 11 shows the manner in which Figs. 1 to 10, inclusive, should be arranged with respect to each other to completely disclose the invention.

The invention will now be described in detail by describing the operations necessary to set up two different types of connections; namely, a connection originating at station A for station B, in which the number designation 39 of station B will be dialed at station A through the manipulation of dialing device LD thereat, and a connection originating at station B for station A in which the number designation 20 of station A will be set up on device LG by the depression thereon of keys (not shown) corresponding to the digits of the designated station.

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 is equipped with either a dial LD or a generator LG for transmitting called line designations. Each line appears on one of the twenty verticals of the crossbar switch, conventionally shown in Figs. 1 and 2, and each, for simplicity, has been given a numerical designation corresponding to the vertical to which it is connected. Thus line A is connected to vertical 20 and, therefore, has been given a numerical designation 20 while line B which is connected to vertical 39 has been given a numerical designation of 39, the intermediate eighteen lines (each of which is provided either with a dial LD or a generator LG) being given numerical designations corresponding to the different verticals of the frame to which they are severally connected.

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 corresponds to the digit to 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

LD, 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 generation of currents having frequencies determined by their several physical constants. 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 of which occupies two horizontal outlets of the crossbar switch, link 1 (the circuit of which is shown in detail in Figs. 5 to 9, 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 may, if desired, be used as outgoing trunks or links. However, since the invention is not concerned with outgoing connections, these outlets are not shown connected either to links or trunks.

Referring, now, to Fig. 3, there are shown three relays, namely, relays CH1, CH2 and CH3, which form a link allotter circuit, the first two relays being shown in an operated position while the last 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 first two relays in the position shown is to route the start conductor 1 to the first idle link available to the office. As said before, in the present embodiment of the invention it is assumed that the traffic between the various lines of the office may be properly satisfied by the use of but three links so that the relays CH1, CH2 and CH3 serve to route a calling line to one of said three links depending upon which one of them 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, its locking circuit (that is, the locking circuit of relay CH1) extending from battery through the winding thereof, contacts of KY1, conductor 2, No. 1 contacts of relay B of link 1, conductor 3, No. 3 front contacts of relay CH1 to ground. The locking circuit of relay CH2 which controls access to the second link is traced over a path which extends from battery through its winding, key KY2, conductor 2' in the bracket line 4, through the No. 1 back contacts of relay B in link No. 2 (diagrammatically indicated in Fig. 10) conductor 3' in the bracket line 4, No. 5 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 its associated key KY3, conductor 2'' within bracket line 5, through the No. 1 contact of relay B in link 3 (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, a calling line, to have accessibility to link 1, relays CH1 and CH2 must be operated while 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 advance of start conductor 1 from one link to the next in the order named.

Bearing in mind the condition of relays CH1, CH2 and CH3 of the allotter circuit as described above, it may now be assumed that a call is originated at station A for station B by the removal, at the former station, of the telephone instrument from its cradle, whereupon a circuit is 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 contacts, the ground terminal of its circuit is switched from solid ground on the No. 1 contacts of relay CO to ground through the secondary winding of transformer LBT to the primary of which a source of distinctive tone is connected for transmission to the calling line in the event that no link is available for completing the connection, as will be described shortly.

Over its No. 2 and No. 3 contacts, relay L20 causes a circuit to be completed for relay L1 of the call allotter circuit (there being one L1 relay for each line) and relay ST of link 1 which, since relays CH1 and CH2 of the allotter are assumed to be locked and relay CH3 is assumed to be normal, is the preferred link in the order of selection. The circuit for the relays ST and L1 is traced as follows: Ground through the No. 1 contacts of relay E1, winding of relay L1, conductor 6, No. 2 and No. 3 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 L1 and ST operate in this circuit. Relay L1, upon operating, opens the locking circuit of all other nineteen L1 relays at its No. 4 contacts and completes a circuit for relay N, which circuit may be traced from ground on the No. 1 contacts of relay L1, 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 from ground on its No. 2 contacts, No. 1 back contacts of relay MS, winding of relay M to battery. Relay M operates and opens the circuit of relay N at its No. 1 back contact causing it to release while the release of relay N opens the circuit of relay M which, however, remains locked under the control of the No. 1 contacts of relay MS and its own No. 2 contacts to ground on conductor 10. 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 its proper sequence. At the same time, relay L1 completes another circuit for relay E which may be traced from ground on the No. 1 contacts of relay E1, No. 2 contacts of relay L, conductor 8, serially through the No. 1 back contacts of the individual link relays LK3, LK2 and LK1, conductor 9, winding of relay E to battery. Relay E upon operating, locks to ground on the No. 1 contacts of relay L1 and at the same time closes a circuit for relays E1 and E2 from ground on its contacts, No. 2 normally made contacts of relay MS to the windings of relays E1 and E2 to the other respective

terminals of which battery is connected. Relays E1 and E2 operate but relay L1, which operated from ground on the No. 1 contacts of relay E1, now holds locked on battery through relay ST of the selected link as previously traced to conductor 6, winding of relay L1 and its No. 2 contacts, conductor 8 as traced to conductor 9, contacts of relay E to ground on the No. 1 contacts of relay L1. Hence with the operation and locking of relay L1 individual to station A, and with the operation of relays E1 and E2, all other lines may not receive service if calls are initiated thereat while station A is in the process of having a link assigned since, with relays E1 and E2 operated, no ground is available for completing the circuit of the relays L1 of the respective calling lines.

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

In the event that, due to some trouble condition, relay E of the call allotter fails to operate, relay MS cannot operate and ground will not be applied to conductor 11 over its No. 3 contacts. Under these circumstances it is desirable to complete the connection if possible and so emergency means are provided for applying ground to conductor 11 in the event that relay MS fails to operate. It will be remembered that upon the operation of relay L1, 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 No. 1 contacts of relay N.

Returning, now, to the operation of relay ST, a circuit is completed for select magnet 9, which circuit traces from battery through the winding of said magnet, conductor 17, No. 2 contacts of relay B, No. 4 contacts of relay ST, conductor 11, to the aforetraced ground thereon. Select magnet 9 operates and preselects the group of crosspoints on its horizontal level, including crosspoint 1 through which the calling loop is extended into the link as shown hereinafter. Magnet 9, upon operating, completes a circuit from ground, over its contacts and common conductor 18 to the windings of relays S and S1 in parallel causing said relays to operate and complete a circuit for cut-off relay CO20, said circuit tracing from ground on the No. 3 contacts of said relays, No. 3 contacts of relay L1, 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 A is connected and, in so doing, operates crosspoint 1. This crosspoint remains operated after the circuit of select magnet 9 has been opened, is standard crossbar switch operation and need not be amplified any further. When hold magnet HO20 operates, it releases line relay L20 in turn releasing relay L1 and those relays controlled thereby. Relay L20 further disconnects ground from start conductor 1 which caused the operation of relay ST. However, since crosspoint 1 is closed, this relay will not release, having a locking circuit through a crosspoint contact, which may be traced over the No. 2 contacts of said relay, No. 1 contacts of relay T2, conductor S1, No. 3 contacts of crosspoint 1, to ground.

Since line crosspoint 1 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 crosspoint 1, respectively, and this connection completes an operating path for relay A which may be traced from battery through its lower winding, No. 2 back contacts of relay HS, conductor LT, contact 6 of crosspoint 1, line conductor T, over the loop, ring conductor R, contact 5 of crosspoint 1, conductor LR of the link, No. 3 back contact of relay HS, upper winding of relay A, to ground. Relay A, upon operating, completes a circuit for relay B, which circuit extends from ground on conductor S1, front contacts of relay A, No. 4 normally made contacts of relay B, winding of relay B to battery, causing said relay to operate and lock 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. Since however, the hold magnet HO20 is operated, crosspoint 1 remains operated. Relay B further completes a circuit from ground over its No. 8 contacts to a relay (not shown) in the power charge circuit 100 to operate circuits thereby that will increase the charging rate to the link power supply while 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 described hereinafter. Over its No. 1 contacts it 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 2.

It is now evident that if, at the time the call was initiated at station A, link 1 was busy or was otherwise unavailable, its relay CH1 in the link allotter circuit would have been normal, and the start wire 1, with ground applied thereto, would have been connected to conductor 7' of link 2 to cause the operation therein of relay ST in the same manner as that of relay ST in link 1 as already described. On the other hand, if both links 1 and 2 were busy or otherwise unavailable, relay CH2 as well as relay CH1 would have been 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 these relays are both normal, a circuit is completed for relay CH3 which extends from battery through its winding, conductor 2'', No. 1 contacts of relay B of link 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, represents the condition in which links 1 and 2 are unavailable but link 3 is available. Now if a call is initiated at a line station as, for instance, station A, ground on start conductor 1 is extended to conductor 7'' which is connected to the winding of relay ST of link 3, the path being from ground on con-

ductor 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 the link to the calling line.

If all three links are unavailable, relay CH3 will be normal along with relays CH1 and CH2. The initiation of a call under these circumstances will cause ground on the start conductor 1 to be applied to conductor 22 via the No. 4 contacts of relay CH2, No. 1 contacts of relay CH3, No. 2 contacts of relay CH1, No. 2 contacts of relay CH2, to conductor 22. This conductor extends (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 connecting with the primary winding of 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 on the upper normally made contacts of the hold magnet HO– through the winding of 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 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 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 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 2 and the latter individual to link 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 as a result thereof.

The object of operating relays LS1 and LC1 is to connect the common alternating current pulse receiver and translator shown in Figs. 8 and 9 to the link taken into use, and when this circuit is so connected, the signal for which is 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 respective link, the circuit of relay LC2 or LC3 is cut off at the No. 1 back contacts of relay LS1. On the other hand, if the first calling link happens to be link 2 or 3, then the corresponding operation of relays LS2 or LS3 will cut off the operating circuit of relay LS1 at their respective No. 2 normally made continuity contacts so that if link 1 is seized 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. 9 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 B. At the time a call is initiated, however, the seized link has no knowledge of which type of station is making the call. Hence it must be prepared, at first, 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 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 through the operation of relay ON. A circuit is also completed for relay ON which is traced from ground on the No. 5 contacts of relay LC1, conductor 69, winding of relay ON to battery. Relay ON operates and, over its No. 1 contacts, closes through a low frequency tone circuit derived from the tone oscillator 79 through adjustable resistance pad 62 and transformer 61. The path 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 79 are thus induced over the secondary circuit above traced.

Through a transformer arrangement 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 suitable 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 operated. Hence the tone frequencies produced by oscillator 79 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 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 crosspoint 1, conductor T, over the loop of station A, conductor R, No. 5 contacts of crosspoint 1, conductor LR, No. 3 back contacts of relay HS, condenser C3, conductor 55, No. 8 front contacts of 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 A is included in the above closed circuit, the tone induced thereover is heard by the subscriber, which he understands as a signal to proceed with dialing the number of the wanted subscriber.

The subscriber, 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 number of designations of said line extends from twenty to thirty-nine, inclusive, it being further assumed that station A has a designation of 20 and that station B has a designation of 39. 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 the connection is to be established between the calling line A and called line B, the subscriber at A will first manipulate 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 pulses required for the digit. Hence upon dialing the digit "three," three pulses are produced that 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, a branch 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 while ground on the other side of the winding is 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 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 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 said relay operates in series with relay P1 over a circuit path which traces 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 contacts of relay C which, being slow releasing, remains in an operated position 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 its back contacts, 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 after which a circuit is completed for relay T2 which extends from battery through the upper winding of relay T2 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 through both of its windings in series through its No. 3 front contacts, No. 5 contacts of relay HS, conductor 29 to ground on the No. 5 contacts of relay B and opens the locking circuit of relay ST which releases but its release results in no other function at this time.

At the termination of second pulse relay A reoperates and relays P2 and P3 release. Hence at the termination of the second pulse, the pulsing 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 the short-circuiting of relay P2 but, in this case, a circuit is 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 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 on both windings, to previously traced ground on 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, which interval is sufficient to cause the release of relay C followed by the release of relay SW and the release of relays P1 and P2, the latter two holding to ground over the No. 2 contacts of relay C.

It will be observed that the dialing of the numeral 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 numeral had been a 2 instead of a 3, the result would have been the operation and locking of only relay T2. No provision has been made in the link for registering any digit other than a 2 or a 3 as a tens digit since the capacity of the office is assumed to be limited to twenty lines, each having a numerical designation from 20 to 39. However, it is evident that if any other numerical designations were to be used, or if the capacity of the office 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 register therein any other digit for the tens digit.

Prior to the dialing of the second or units digit, relay A is operated while 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, resistance RS, the winding of said relay, No. 4 normally made continuity contacts thereof, conductor 25, No. 1 back contacts of relay RT, conductor 26, No. 4 contacts of relay T2, No. 1 contacts of relay SW to ground on the No. 1 front contacts of re-

lay 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, through the winding of said relay, No. 3 normally made continuity contacts of said relay, No. 5 contacts of relay C1, to ground on the No. 5 contacts of relay B. Relay CX operates and locks to operating ground over its No. 3 front contacts and, at its No. 1 contacts, opens the circuit of relay LS1 causing it to release and, in turn, release relay LC1 which disconnects the translator and alternating current receiver from the link, thus causing them to be available for service with other links.

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 operated 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. 6 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 and, in consequence, relay P3 operates in series with relay P2 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 serially 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 serially with its lower winding through the No. 3 contacts of relay I, its own No. 5 front contacts to ground as previously traced to 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 serially through its lower winding and No. 5 contacts and through the previously identified contacts of relays II, III and IV, 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 serially through 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 (which will not be dialed by the subscriber since it has been assumed that the units digit will be the digit 9) relay P1 will be normal and a previously traced circuit will be established for relay IV which will operate thereover on its upper winding and then lock 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 digit are registered in the relays I—VI of Fig. 6, the relay or relays operated depending upon the number of

pulses transmitted. The relationship between the number of pulses and the relays operated is shown in the following table:

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)
0	(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, No. 2 contacts of relay C1, No. 1 back contacts of relay C to ground on conductor 21. Relay DC operates on its lower winding and locks in series with its upper winding and No. 5 front contacts 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, 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 extends to an armature of the hold magnet of the vertical associated with the called line which, in this case, is hold magnet H039. 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 H039 to the winding of relay C039. The object of this circuit is to test for the idle or busy condition of the line. Should the line be busy, hold magnet H039 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 calling 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 subscriber indicates to him that the 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 H039 will be normal and relay BY will not 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, No. 1 back contacts of relay C to ground on conductor 21, and opens the serial locking path of all relays L1 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, the same will be prevented from locking at the time relays E1 and E2 operate in the manner previously described. The failure of relay L1 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 the latter relay operates, a circuit is completed for select magnet 8 which extends from battery through the winding of said magnet, 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 and preselects the horizontal crosspoints controlled by it and completes a circuit from ground through the contacts of said magnet, conductor 18, windings of S and S1 relays 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 C039 of the called line 39. The path is as follows: Ground on the No. 1 back 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 and thence as traced to the winding of relay C039 to battery. Relay C039 operates and completes an obvious circuit for hold magnet H039 which operates to close crosspoint 2. The operation of the hold magnet H039 disconnects operating ground for relay C039, but this relay now holds over the No. 4 contacts of crosspoint 2, 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 A) to ground on conductor S1 as previously traced thereto. Operated cross points 1 and 2 effect the connection between the calling line A and the called line B. Ground on conductor S2 applied thereto by

the closure of the No. 3 contacts of crosspoint 2 completes a circuit for relay SP, which circuit 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 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 crosspoint 2, ring conductor R1 of the called line, over the loop of station B, tip conductor T1 of the called line, No. 6 contacts of crosspoint 2, conductor 49, No. 2 front contacts of relay SP, conductor 50 within the bracket line 13 to ground connected thereto in the power circuit 110. Ringing current is thus applied to the called subscriber's line and an audible ringing tone is provided for the calling subscriber A over a circuit which extends from one side of ringing tone circuit (not shown) in the Power, etc., circuit 110, conductor 111 within bracket line 13, No. 5 contacts of relay SP, condenser C3, condenser C2, and thence as traced over the calling loop to ground through the upper winding of relay A. The calling subscriber thus hears the ringing tone. When the call is answered, relay RTR will operate and lock 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 of crosspoint 2, 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. The release of relay T2 releases relay SP which, in turn, releases relay RTR, the former relay connecting 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 2 contacts of crosspoint 2, joins the conductor 51 which further extends to the winding of relay HS, thereby holding said relay operated. Over its No. 1 front contacts, relay HS applies ground to conductor S which, through contact 4 of crosspoint 2, extends to the winding of the cut-off relay CO39 of line B to hold said relay in an operated condition. 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 to battery, whereupon relay CON operates and locks over its No. 2 contacts and the No. 5 back contacts of relay C1 to ground on conductor 20.

When the calling line A releases, relay A of the link releases and disconnects ground on conductor S1 from conductor 51 but relay HS holds, as said before, to ground on conductor 52. Relay A also disconnects ground from conductor 57 which holds the cut-off relay CO20 operated, thereby causing this relay to release, in turn releasing hold magnet HO20 and opening crosspoint 1. The calling line A is now disconnected from the link. Hence if the calling station should restore first, the release of relay A merely removes one of the grounds which holds relay HS operated, but the latter, holding to ground on conductor 52 applied thereto by relay E which holds over the called loop, prevents the link from being disconnected from the called line. The link, therefore, is held until the called line restores in order to prevent the same from seizing another link and receiving dial tone in consequence thereof. When the called station restores, relay E releases, disconnects ground from conductor 52 releasing relay HS. Relay HS, on releasing, disconnects ground from conductor 52 which releases relay CO39 in turn releasing hold magnet HO39 and opening crosspoint 2.

In case it is desired to add a third station to the connection for a conference, the called subscriber will replace the receiver on the switchhook. As a result of this, relay E releases, disconnects ground from conductor 52 and thereby causes 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 58, thereby causing the reoperation of relay LS1 and the reconnection of the translator and alternating current receiver to the link. Key tone is now supplied to the calling subscriber as originally described and thereafter he will 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 crosspoint 2. Relay SP, in operating, reconnects the ringing circuit to the first called station and causes thereby the operation of the ringer thereat. Now, when the second called station is connected to the link in the same manner as called station B, the bells of the two subscribers will ring, and when the second called subscriber answers, the bell at station B will cease to ring and this furnishes an indication that the second called subscriber has answered. This acts as a signal to the called subscriber at B to answer also. In case the second line is busy, relay BY will operate as described when the 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 B will cease to operate and the calling subscriber will receive a busy tone. The subscriber at station B will then answer since the cessation of ringing is either due to the third party answering or to the third party 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 of the type described, the stations connected to the terminating end, that is, station B, 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 con-

nection between an originating dial station, such as station A, for a terminating station, such as station B, I will now describe the establishment of a connection from a calling station B equipped with an alternating current generating device LG for a called station A. When the subscriber at B removes the receiver from the switchhook, the line relay L39 will operate in the same manner as the line relay L20 operated for station A, in consequence of which a link will be connected to the calling station B in the same manner as previously described for station A but, in this case, over crosspoint 3, and when relay ST of the link operates, relays LSI and LCI are operated to connect the alternating current translator and receiver to the link, relays ON and GR therein being operated and tone being to the calling station in the manner previously described for station A.

It will be observed 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 to the ring RI and tip TI conductors of the calling line. 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 crosspoint 3 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 LCI, conductor 73, Nos. 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 3, conductor 55, No. 8 front contacts of relay LCI, conductor 74, Nos. 4 and 5 contacts of relay ON to ground on No. 1 contacts of relay GR. This charging current, if allowed into the winding of transformer 68, would be productive of a false pulse that might contain frequency components within the signal band and thereby produce a false operation of the receiver. In order to prevent the possibility of such an occurrence, conductors 73 and 74 are kept grounded through the contacts of relay GR thereby short-circuiting 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 has reached its steady state.

Upon hearing tone, the calling subscriber at station B 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 which are now transmitted over a circuit which may be traced as previously to conductors 73 and 74 at the Nos. 2 and 5 contacts, respectively, of relay ON and, thereafter, to conductors 71 and 72, respectively, connecting with the secondary winding of transformer 68. These frequencies are induced into the circuit comprising the primary winding of said transformer and the high-pass filter 64.

The receiver circuit in Fig. 9 is a conventional disclosure of the receiver shown in Patent 2,269,022 issued to G. Hecht and A. A. Lundstrom on Jan. 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 *f*A—*f*E with relays FA—FE respectively in each of the anode circuits thereof and a suitable filter intermediate the pad 67 and each one of the detector amplifiers, each of said filters being designed to pass only the frequency intended for the particular channel. Between the high-pass filter 64 and the volume limiter 65 is bridged the primary of transformer 112 to the secondary of which is connected the enabler 80. This 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 shown only in conventional form except for relay 77. The enabler responds to a portion of the signal pulses 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 *f*A—*f*E 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 to said patent 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 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—E inclusive and that, in accordance with the operation of the receiver as described in the above-mentioned copending application, frequency A will cause the operation of tube *f*A, frequency B will cause the operation of tube *f*B and so on to frequency E which will cause the operation of tube *f*E.

As already mentioned, each detector amplifier tube 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—TE in the translator circuit shown in Fig. 8. Relay FA in the anode circuit of the first channel which responds to frequency A has its front contact connected to the winding of relay TA, while relay FB of the second channel, responding to frequency B, is connected to the winding of relay TB and so on up to and including relay FE in the anode circuit of the fifth channel which responds to frequency E, the front contact of which relay is connected to relay TE. Hence, the operation of any combination of detector amplifiers *f*A—*f*E will cause a corresponding operation of the register relays in the translator of Fig. 8.

The combination of frequencies for each of the digits which may be dialed from the calling station B, the operation of channel and translator relays operated thereby is as follows:

	Digit keyed	Channels operated	Translator relays operated
First digit	2	*f*B, *f*D	TB, TD
Second digit	3	*f*D, *f*E	TD, TE
	1	*f*A, *f*D	TA, TD
	2	*f*B, *f*D	TB, TD
	3	*f*D, *f*E	TD, TE
	4	*f*B, *f*E	TB, TE
	5	*f*C, *f*D	TC, TD
	6	*f*A, *f*C	TA, TC
	7	*f*B, *f*C	TB, TC
	8	*f*C, *f*E	TC, TE
	9	*f*A, *f*E	TA, TE
	0	*f*A, *f*B	TA, TB

When, therefore, the subscriber keys the first digit, which may be a 2 or a 3 but which, 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 the 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 preceding the tubes *f*B and *f*D to operate said tubes. Since the operation of the receiver has been amply described in the above-mentioned patent to G. Hecht and A. A. Lundstrom and to which reference is made for a complete description thereof, it may be stated that a definite time interval is consumed in the operation of enabler 80, in consequence of which relay 77 operates to apply ground to conductor 78. Since this conductor is connected to the cathodes of the various detectors, those detectors will respond through whose channels the filters have permitted the passage of the frequencies in the signal. Hence for the digit 2 for which the frequencies B and D are produced to cause the response of channels *f*B and *f*D, relays FB and FD will be operated and they, in turn, close obvious circuits whereby relays TB and TD are operated and, 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 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 TLT is in a direction to cause the armature to engage the contact, while that through the lower winding is in a direction to do the opposite. The strength of the current through the lower winding, however, is not sufficient by itself to overcome the effect of the current flowing through the upper winding so that, when both windings are energized, the armature will engage its contact and provide locking ground for relays TB and 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—TE removes this ground and a charging circuit is established for the condenser through the circuit of the upper winding of relay TL. Relay TL continues to hold for a short interval until the charging current through the condenser dies down after which, being solely responsive to the current through its lower winding, it will release and unlock the register relays TB and TD. However, the interval in which relays TB and TD are locked is sufficient to permit the slowest register relay 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 in the link that registers the digit 2 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 digit of the called number had 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 will also be closed for relay T3 and this circuit may be traced 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 register relays TB and TD in response to the keying of the tens digit 2, or with the operation of relays TD and TE for the digit 3, a circuit is completed for relay RA. For either digit, 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—TE in order to insure that exactly two of these relays are operated before grounding any of the link registers. 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, 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 afore-traced 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 register 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, ground is removed from the battery side of the winding of relay RA1 causing said relay to operate by the circuit completed to an afore-traced ground on the No. 1 front contacts of relay RA. Relay RA1, in operating, closes a circuit for relay RT the path of which extends 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 register relays I—VI with the contact network of the translator relays TA—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 relay, or relays, of the former in accordance with the dial impulse code for the registration of said digit. Relay RT further completes a partial path for relay KBD that traces 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 having keyed the tens digit, the release of relay A in consequence of the momentary opening the line will cause the operation of relay C, whereupon the circuit of relay KBD is completed and said relay operates. Relay KBD applies ground over its No. 3 contacts to conductor 95 within bracket line 13 which extends to a relay in the power, tone and alarm circuit 110 that controls a distinctive source of tone. This tone is applied to conductor 96 which connects with conductor 73 and thence as previously traced over the calling 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 once more 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 used for operating the register relays of the link from the setting of the translator relays will not be available. Relay KBD further completes a circuit for message register MR1 over its No. 5 contacts. 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 digit, the receiver of Fig. 9 responds on the two frequencies supplied to operate whichever two channels are tuned to said frequencies. Thus, if the units digit is 0, as assumed, channel relays A and B are operated, followed by 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 its No. 2 normally made continuity contacts, No. 4 front contacts of relay RA1, No. 5 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. But relay RA1 will not release on the release of relay RA, it being held over the No. 1 continuity contacts 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 digit 0 requires the operation of relays IV and VI, the operation of relays TA and TB completes the following two circuits for relays IV and VI: 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. The circuit path for relay VI traces 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 magnet HO20 which insures the holding of crosspoint 4 after select magnet 8 has released, said magnet having operated as a result of the link operations. 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 for the reason that only conductors 84 and 87 (the former being used for the registration of the digit 2 and the latter for the digit 3) are connected between the translator relays TA—TE and the link register relays T2 and T3 through the back contacts of relays RT. If any other digit were to be keyed in which these conductors are used, they would be ineffective because no ground is applied to these conductors 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 the operation of relay BK1 in consequence thereof. Thus, if frequency E is generated 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 contacts 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, closing its No. 4 locking contact before opening its No. 1 contacts, closes an obvious circuit for message register MR3, applies ground to conductor 95 which, as before described, operates a tone circuit which is applied to conductor 95, No. 2 contacts and thence over the subscriber's loop to signal the subscriber to restore the instrument and reinitiate 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—TE to ground on conductor 76. Relay BK3 operates, closes its locking No. 4 contact before opening its No. 1 contact, completes

an obvious circuit for register MR2, grounds conductor 95 and completes the tone circuit on conductor 96 to the tip side of the calling loop via conductor 73.

Returning, now, to the operation of the link, when relay T2 operates for the first digit, it releases relay ST, but the link still holds, however, by virtue of the operation of relay B, while the translator is held 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 relays RR and RAI have both released after the registration of the second digit, a circuit is completed for relays CI 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 BKI, No. 6 contacts of relay RAI, conductor 99 within bracket line 93, No. 8 front contacts of relay RT, conductor 25, No. 4 continuity contacts of relay CI, winding of relay CI, resistances RS to battery. Relay CI 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 CI to ground on the No. 1 contacts of relay B. The operation of relay CX removes ground from conductor 58 thus releasing relay LSI followed by the release of relay LCI 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 CI also starts the sequence of operations by which the link is connected to the called subscriber B and for ringing his bell if idle, or for returning busy tone if busy, as previously described. The release of the link connector relay LCI 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 subscriber answers, relay HS operates to perform the functions already described and, in addition, completes 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 CI (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 CI, 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, the subscriber at which may now key a second station in the same manner as for the original call. When relay CI operates on the second call, relay CON will be released. The original called party, that is, station A, 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.

While I have described my invention in connection with a specific application thereof, it is understood that various other applications and embodiments thereof may be made by those skilled in the art without departing from the spirit of the invention as defined within the scope of the appended claims.

What is claimed is:

1. A telephone system comprising a plurality of lines, each of said lines being provided either with a calling device adapted to produce line interruptions indicative of a wanted designation or a calling device adapted to produce combinations of alternating currents of different frequencies indicative of a wanted designation, link circuits for interconnecting said lines, a crossbar switch having each of its vertical elements connected to one of said lines and each two of its horizontal elements connected to one of said link circuits, means responsive to one of said lines initiating a call for taking one of said links into use whereby the vertical element of said calling line is closed to one of the horizontal elements of said link circuit, and means in said link circuit responsive to the transmission of a wanted line designation from either calling device with which said calling line may be equipped for closing the vertical element of said called line to the other horizontal element of said link circuit.

2. A telephone system comprising a plurality of lines, each of said lines being provided either with a first calling device adapted to produce line interruptions indicative of a wanted designation or a second calling device adapted to produce combinations of alternating currents of different frequencies indicative of the same wanted designation, link circuits for interconnecting said lines, a crossbar switch having each of its vertical elements connected to one of said lines and each two of its horizontal elements connected to one of said link circuits, a register in each of said link circuits adapted to be set in response to line interruptions produced by said first calling device, means available in common to all of said link circuits adapted to be set in response to alternating currents of different frequencies produced by said second calling device, means responsive to one of said lines initiating a call for taking one of said links into use whereby the vertical element of said calling line is connected to one of the horizontal elements of said link circuit, means responsive to the seizure of said link for connecting said common means to said link, a source of tone in said common means, and means responsive to the connection of said common means to said link for applying said source of tone to said calling line.

3. A telephone system comprising a plurality of lines, each of said lines being provided either with a first calling device adapted to produce line interruptions indicating a wanted designation or a second calling device adapted to produce combinations of alternating currents of different frequencies indicative of the same wanted designation, link circuits for interconnecting said lines, a crossbar switch having each of its vertical elements connected to one of said lines and each two of its horizontal elements connected to one of said link circuits, a register in each of said link circuits adapted to be set in response to line interruptions produced by said first calling device, means available in common

to all of said link circuits adapted to be set in response to alternating currents of different frequencies produced by said second calling device, means responsive to one of said lines having a first calling device initiating a call for taking one of said link circuits into use whereby the vertical element of said calling line is closed to one of the horizontal elements of said link circuit, means responsive to the seizure of said link circuit for connecting said common means to said link circuit, and means responsive to the setting of the register in the seized link in response to the transmission of line interruptions indicative of the first digit of the wanted designation for disconnecting said common means from said seized link circuit.

4. In a telephone system, a first telephone line, a transmitter for said line for sending series of direct current impulses indicative of a telephone designation, a second telephone line and a transmitter therefor for sending over the line combinations of alternating currents of different frequencies representative of a telephone designation, a link accessible to either of said lines for extending a connection therefrom, switching selectors for interconnecting said link with said lines, a register in said link responsive to direct current pulses transmitted from said first telephone line for controlling the setting of said switching selectors, an alternating current register connectable to said link and settable in response to said alternating currents of different frequencies transmitted from said second telephone line, means responsive to the setting of said alternating current register in accordance with a designation when said link is connected to said second telephone line for setting the link register in accordance with the setting thereof for the same designation when responsive to direct current pulses from said first telephone line, and means responsive to a series of direct current pulses indicative of the connection of said link to said first telephone line for disconnecting said alternating current register from said link.

5. A link circuit for interconnecting automatic telephone lines each provided with a dial or an alternating current generator for producing pulses indicating the digits of a wanted designation, comprising a settable register responsive to direct current pulses produced by said dial to take a setting according to the digit indicated by said pulses, an alternating current receiver responsive to alternating current pulses produced by said generator to take a setting according to the digit indicated by said alternating current pulses, and a translator intermediate said register and said receiver and responsive to said receiver for operating said register to the setting said register would take when operating in response to direct current pulses indicating the same digit indicated by the alternating current impulses in response to which said alternating current receiver was set.

6. A telephone system comprising a plurality of lines, each of said lines being provided either with a first calling device adapted to produce line pulses indicative of a wanted designation or a second calling device adapted to produce combinations of alternating current pulses of different frequencies indicative of the same wanted designation, a link circuit for interconnecting any two of said lines, a crossbar switch having each of its vertical elements connected to one of said lines and two of its horizontal elements connected to said link circuit, means responsive to one of said lines initiating a call for connecting said line to said link at one of the crosspoints of said crossbar switch where the line vertical elements cross one of the link horizontal elements, and means in said link for connecting the other of said link horizontal elements to the vertical elements of one of said lines, comprising an alternating current receiver adapted to be set in response to the alternating current impulses of different frequencies produced by said second calling device if the calling line is provided therewith, and a register settable in response to direct current pulses produced by said first calling device if the calling line is provided therewith, said register being identically settable by said alternating current receiver for the same wanted designation.

7. In a telephone system, a first register settable in response to dial pulses to denote digits or characters in accordance with a predetermined code, a second register settable in response to combinations of pulses of different alternating current frequencies to denote the same digits or characters in accordance with another predetermined code, a translator intermediate said first and second register responsive to a setting of said second register for a digit or character for operating said translator to register said digit or character in accordance with a third predetermined code, and means in said translator responsive to its setting for said digit or character for operating said first register to register said digit or character therein in accordance with said first predetermined code.

8. In a telephone system, a switch, a first plurality of telephone lines terminating in said switch, each of said lines being equipped with a transmitter for sending series of direct current pulses representing telephone designations, a second plurality of telephone lines terminating in said switch, each of said lines in said second plurality of lines being equipped with a transmitter for sending alternating current pulses of different frequencies representing telephone designations, a common receiving mechanism responsive to alternating current impulses generated from a calling line in said second plurality of lines, a common translator arranged for operative connection with said receiving mechanism, and links terminating in said switch for establishing connections between lines in either of said plurality of lines with lines in the other of said plurality of lines, each of said links comprising a register responsive to direct current pulses and means for connecting said common receiving mechanism and said common translator to any one of said links when taken into use by a calling line.

9. In a telephone system, a switch, a first plurality of telephone lines terminating in said switch, each of said lines being equipped with a transmitter for sending series of direct current pulses representing telephone designations, a second plurality of telephone lines terminating in said switch, each of said lines in said second plurality of lines being equipped with a transmitter for sending alternating current pulses of different frequencies representing telephone designations, a common receiving mechanism responsive to alternating current impulses generated from calling lines in said second plurality of lines, a common translator arranged for operative connection with said receiving mechanism, and links terminating in said switch for estab-

lishing connections between lines in either of said plurality of lines with lines in the other of said plurality of lines, each of said links comprising a register responsive to direct current pulses, means for connecting said common receiving mechanism with said common translator and both to any one of said links when taken into use by a calling line, and means in said common translator responsive to said common receiving mechanism when set by alternating current pulses representing a called line designation for operating the register of the link taken into use to the same setting that said register would take when operated by direct current pulses representing the same called line designation.

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