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DIGIT REGISTERING MEANS RESPONSIVE TO SELECTIVE FREQUENCIES

Original Filed Jan. 13, 1943

3 Sheets--Sheet 1

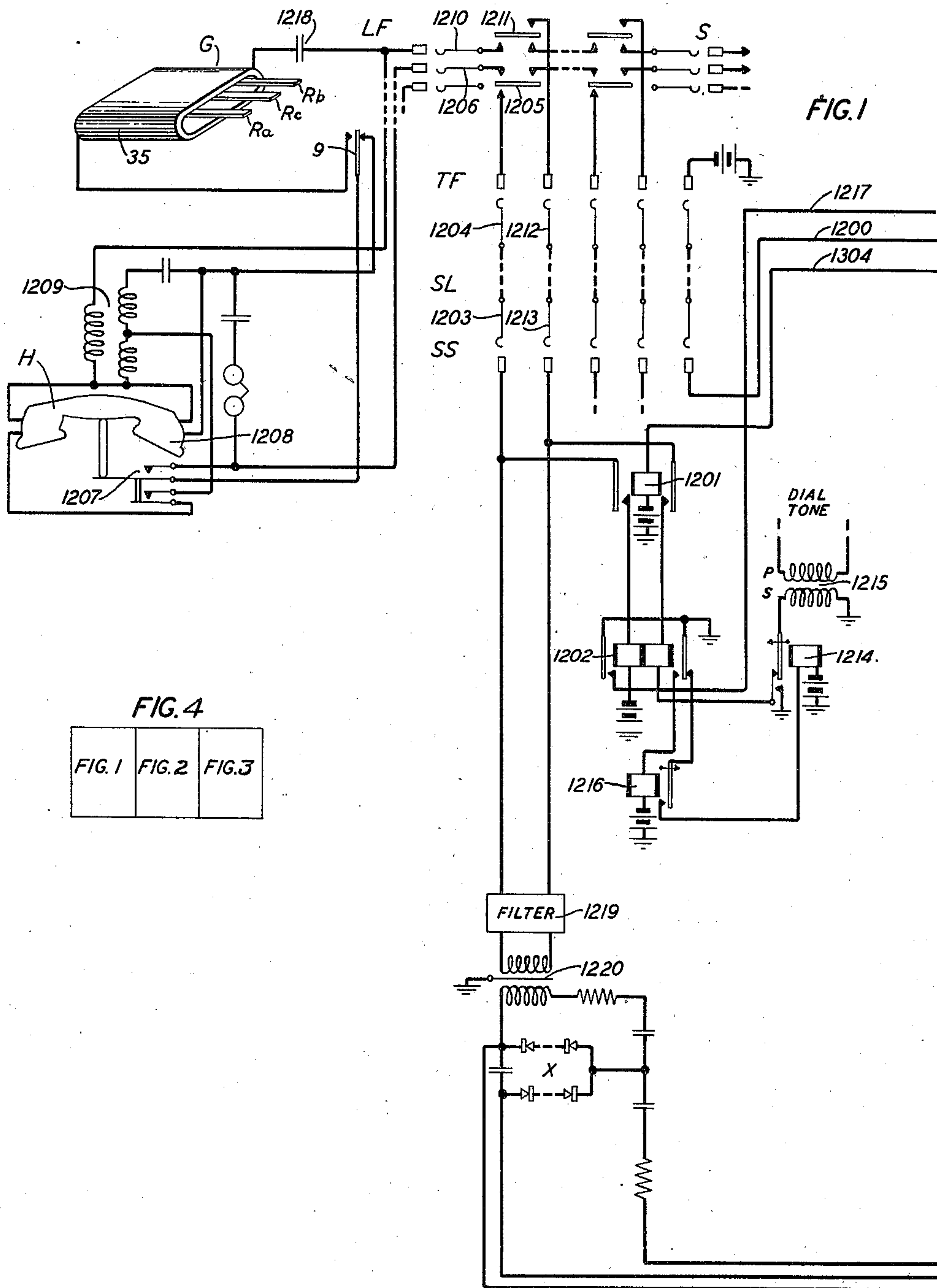


FIG. 4

FIG. 1	FIG. 2	FIG. 3
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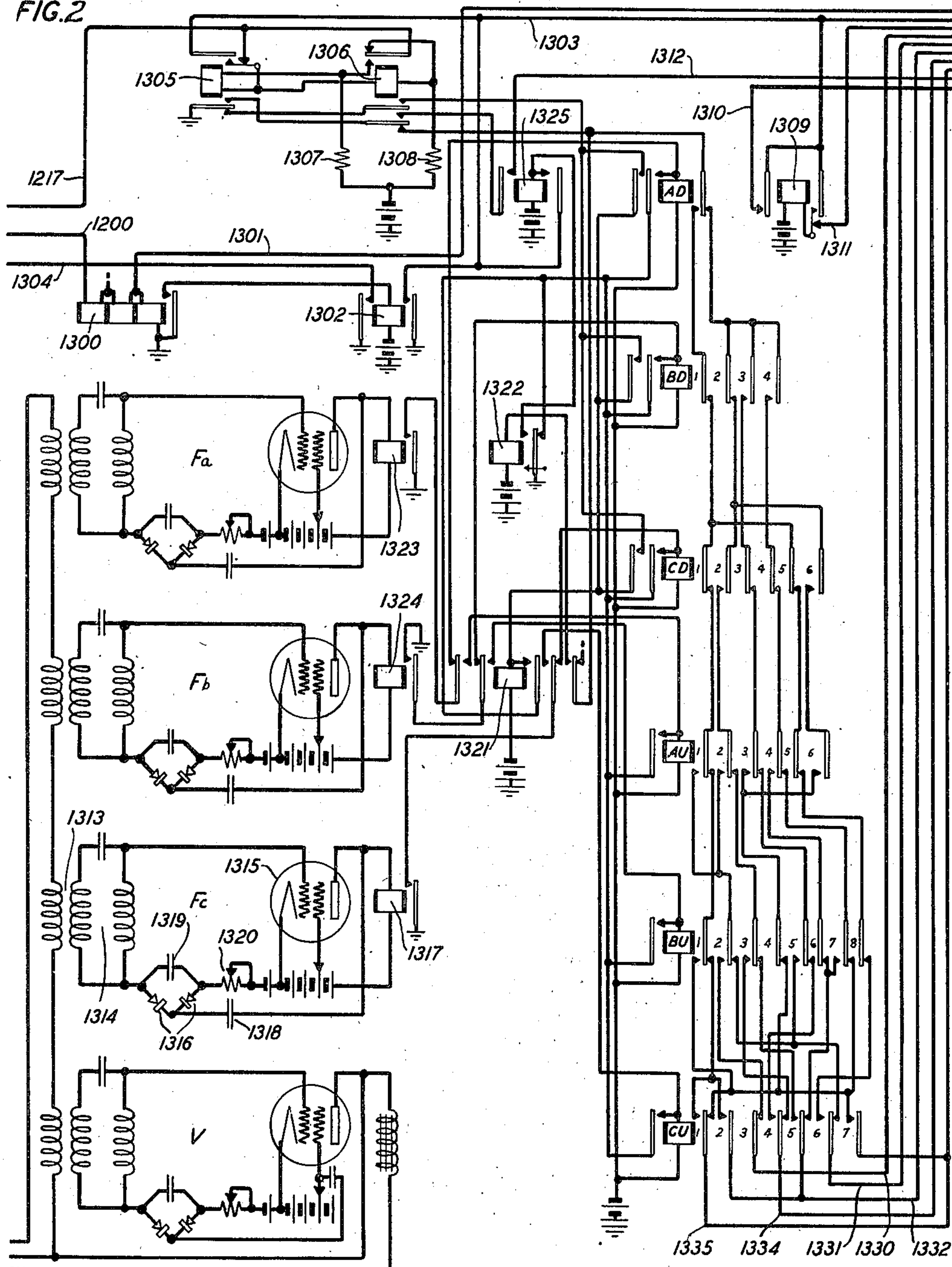
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3 Sheets-Sheet 2

FIG. 2



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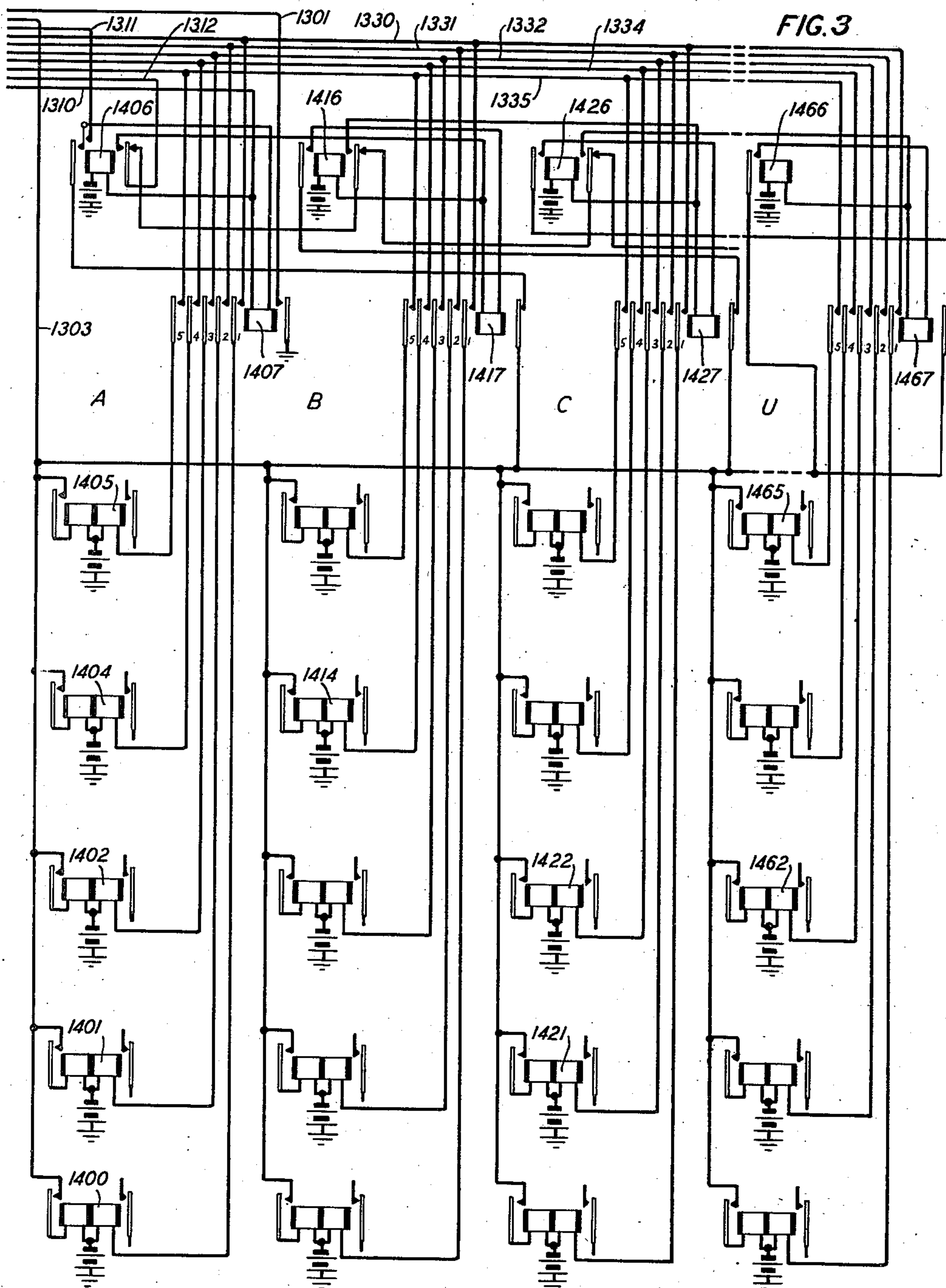
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UNITED STATES PATENT OFFICE

2,434,898

DIGIT REGISTERING MEANS RESPONSIVE
TO SELECTIVE FREQUENCIES

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Original application January 13, 1943, Serial No. 472,202. Divided and this application January 16, 1946, Serial No. 641,592

7 Claims. (Cl. 179—18)

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This invention relates to telephone systems and more particularly to a system employing a call transmitter of the type forming the subject-matter of our application, Serial No. 472,202, filed January 13, 1943, which issued July 9, 1946, as Patent No. 2,403,475, and of which application this application is a division.

This transmitter is provided with three vibrative elements which may be selectively released for vibration either during the down stroke or the up stroke of an operated key-set key. The studies which have been made of the time interval required for the satisfactory registration of signals transmitted by a substation transmitter of the reed type and observations of the speed with which the keys of the key-set are operated indicate that it would be possible to generate a signal impulse which could be registered accurately on either or both the down stroke and the up stroke of a key-set key. In receiving circuits which have been developed heretofore for use with a call transmitter of the type disclosed in United States Patent 2,315,344 granted March 30, 1943, to R. F. Mallina, a signal duration of 20 to 25 milliseconds is all that is utilized for effecting a registration of such signal the major portion of the signal being consumed in the functioning of the unit of the receiving circuit, which indicates that a signal is present and which activates the receiving channels of the receiving circuit for a period of five to eight milliseconds. Since it appears to be unusual for a key stroke to be completed in less than 100 milliseconds, it is therefore entirely possible to receive two separate signals on each key stroke.

The principal advantage which is gained from this method of operation is that the number of vibrative elements may be reduced from five to three, since the selective release of the three members may be made first during the down stroke of any key to send one signal impulse and again during the up stroke of the key to send a second signal impulse. The reduction of the number of vibrative elements enables a corresponding reduction of the number of receiving channels required in the receiving circuit at the central office. This reduction permits the frequency spacing between channels to be doubled for the same outside frequency range which would reduce the discrimination required between channel surface. For example, the channels could be designed to be responsive to signals of the three frequencies 700, 1,100 and 1,500 and, of course, the vibrative elements of the call transmitter would be selected to cause the generation of such

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frequencies. Alternatively, the outside frequencies could be made smaller so that the difference in attenuation between the highest and lowest frequencies would be less.

It is therefore an object of the present invention to enable the registration of any digit in response to two successive impulses of selected frequencies.

It is a further object of the invention to reduce the number of signal frequency receiving channels necessary to respond to the signal frequencies selectively transmitted in accordance with any keyed digit.

A further object of the invention is to provide a greater discrimination by the receiving channels of a signal receiver which are responsive to codes of impulses of selected frequencies.

These objects are attained by the provision of mechanism in a call transmitter of the type disclosed in our parent application hereinbefore referred to, whereby the operation of any one of the ten keys of the key-set is effective upon the down stroke to selectively release one of three vibrative elements or reeds and is effective upon its up stroke to selectively release one or more of the three vibrative elements. In this transmitter only three vibrative elements or reeds are required.

The selective releasing of the reeds in response to the down strokes and up strokes of the ten key-set keys causes the generation of signals of the three frequencies *a*, *b* and *c* which might, for example, be of 700, 1,100 and 1,500 cycles frequency.

A code may be so selected with respect to the standard arrangement of the keys in the key-set as indicated in a table appearing hereinafter that every key releases a single reed on the down-stroke and that no two adjacent keys arranged either vertically or horizontally release the same reed on the down stroke. Hence, if two keys are depressed at once, two reeds will be released and the receiving circuit can be arranged to recognize this as a false signal.

The transmission of two signal impulses by the call transmitter for each keyed digit requires a modification of the receiving circuit associated with the central office sender whereby three receiving channels are provided to receive the three different frequencies transmitted by the call transmitter with each of which channels two groups of recording relays are associated. Each of these groups of relays comprises a relay corresponding to each of the three frequencies, one group being normally associated with the three

receiving channels so that one of such relays is selectively operable in response to the reception of one of the three frequencies transmitted upon the down stroke of an operated key and the other group being associated with the three receiving channels following the termination of the first impulse of a digit signal so that relays of such group are selectively operable in response to the reception of one or more of the three frequencies transmitted upon the up stroke of the operated key. Thus upon the termination of the two impulses of the digit signal a relay of the first group and one or two relays of the second group will remain operated to control the setting of a digit register of the sender.

For a clearer understanding of the invention, reference may be had to the following detailed description taken in connection with the accompanying drawing in which:

Figs. 1, 2 and 3 taken together, show a telephone system in accordance with the present invention to which the improved call transmitter is applicable; Fig. 1 showing the substation circuit in which the call transmitter is installed, a diagrammatic illustration of a line finder, first selector, a sender link comprising a trunk finder and a sender selector, and a portion of the circuit of a central office sender; Fig. 2 showing the receiving channels of the sender, the recording relay and other control relays; and Fig. 3 showing certain of the sender registers and progress relays associated therewith; and Fig. 4 is a diagram showing how Figs. 1, 2 and 3 should be arranged to fully disclose the invention.

The keys of the key set, which may for reference purposes be designated K1 to K10 inclusive, are so designed that they are effective to control the generation of current of the frequencies *a*, *b* and *c* in the manner indicated in the following table:

Key	K1	K2	K3	K4	K5
Down-stroke Frequency	<i>a</i>	<i>c</i>	<i>b</i>	<i>c</i>	<i>a</i>
Up-stroke Frequency	<i>a</i>	<i>c</i>	<i>b</i>	<i>b</i>	<i>b</i>

Key	K6	K7	K8	K9	K10
Down-stroke Frequency	<i>c</i>	<i>b</i>	<i>a</i>	<i>b</i>	<i>c</i>
Up-stroke Frequency	<i>a</i>	<i>a</i>	<i>c</i>	<i>c</i>	<i>b+a</i>

The call transmitter of our parent patent heretofore referred to, is applicable to a wide variety of types of dial switching systems and, particularly to those of the type in which register mechanisms are employed at the central office for registering the designation transmitted and for controlling the selective operation of automatic switches to complete connections. Accordingly, the system chosen to illustrate the invention is one in which the central office is equipped with automatic switches of the panel type and with register senders for registering the designations transmitted to the central office from subscribers' stations. It will be obvious that other forms of switches may be used for establishing the connections such as switches of the cross bar type and switches of the well-known step-by-step type.

Referring to Figs. 1, 2 and 3 of the drawings, in which reference characters corresponding to those designating similar apparatus elements in Figs. 12, 13 and 14 of our parent patent have been applied, a subscriber's line is shown appearing in the contact bank of the line finder LF. The

line finder is joined to a first or district selector S and these two switches together form a link for extending subscribers' lines to trunks extending to other selectors (not shown) by which a connection from a calling subscriber's line may be extended to a wanted subscriber's line. The line finder and district link have access through a sender link SL comprising a trunk finder TF and a sender selector SS to a plurality of common register senders. Figs. 2 and 3 disclose such parts of a sender as are necessary for an understanding of the present invention. The number of registers employed in these senders will vary with the requirements of the exchange areas. In some of the larger areas office codes require two or three office code digit registrations and the numerical part of the designation usually requires four registrations. In the present disclosure three office code digit registers A, B and C are shown in Fig. 3 and the units numerical register U is also shown, it being understood that the thousands, hundreds and tens registers would be provided and inserted between the units register U and the code digit register C. These registers each comprise five register relays which are selectively operated under the control of the six recording relays AD, BD, CD, AU, BU, and CU, and the frequency receiving channels Fa, Fb and Fc of Fig. 2.

It will be assumed that the subscriber at the substation illustrated in Fig. 1 removes the handset H of the subset from the cradle to initiate a call whereupon a circuit is established over the substation line to the central office which is instrumental in causing the line finder LF to hunt for and establish a connection with the calling line, whereafter the line finder first selector link becomes associated over the sender link SL comprising the trunk finder TF and the sender selector SS with an idle sender. Upon the association of the sender with the substation a circuit is established from battery over brushes of the trunk finder TF and sender selector SS, conductor 1200 and windings of relay 1300 to ground. Relay 1300 operates and closes an obvious operating circuit for relay 1302. Relay 1302 upon operating connects ground over its right contacts to the off-normal conductor 1303 to provide locking ground for other relays of the sender and over its left contacts and conductor 1304 establishes the circuit of relay 1201.

With ground connected to conductor 1303 a circuit is established therefrom over the left back contact of relay 1309 and conductor 1310 to battery through the winding of progress relay 1406, whereupon relay 1406 operates and locks in a circuit from battery through its winding and the winding of progress relay 1407, over the inner left front contacts of relay 1406 and over the back contact of progress relay 1417 to ground on conductor 1303. Relay 1407 does not operate in this locking circuit since its winding is shunted so long as ground remains connected to conductor 1310. When relay 1406 operates a circuit is also established from ground on conductor 1303, over the back contact of relay 1417, the outer left contacts of relay 1406, conductor 1311 and to battery through the right normal contacts and winding of relay 1309. Relay 1309 thereupon operates, locks over its right alternate contacts to ground on conductor 1303 and at its back contact removes ground from conductor 1310 whereupon relay 1407 operates in the locking circuit of relay 1406; prepares operating circuits for the relays of the first code digit register A over conductors

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1331, 1332, 1334, 1335 and 1330 and at its right contact connects ground to conductor 1301 to shunt the right winding of relay 1300 whereby the current flowing over the operating circuit of relay 1300 is increased as a signal to the line-finder selector link.

Relay 1201 upon operating connects the windings of battery feed relay 1202 to the calling line substation over a circuit which may be traced from battery through the left winding of relay 1202, the left contacts of relay 1201, brush 1203 of sender selector SS, brush 1204 of the trunk finder TF, contacts of sequence switch cam 1205, brush 1206 of line finder LF, the ring conductor of the calling line, switchhook contacts 1207, the back contact of the off-normal switch assembly 9, through the transmitter 1208, the left winding of repeating coil 1209, the tip conductor of the calling line, brush 1210 of the line-finder LF, sequence switch contacts 1211, brush 1212 of trunk finder TF, brush 1213 of sender selector SS, right contacts of relay 1201, right winding of relay 1202, normal contacts of relay 1214 to ground through the secondary winding of the dial tone coil 1215. Relay 1202 operates over this circuit and dialing tone current is applied thereover to apprise the calling subscriber that he may proceed to key up the digits of the desired telephone number. Relay 1202, upon operating, establishes an obvious circuit for relay 1216 which also operates to prepare an operating circuit for relay 1214, and relay 1202 establishes a circuit from ground over its left contacts, conductor 1217, over the upper normal contacts and through the winding of relay 1305, and through resistance 1307 to battery and in parallel therewith through the winding of relay 1306 and resistance 1308 to battery. Relay 1305 operates and locks over its upper alternate contacts to ground on conductor 1303 but the winding of relay 1306 being shunted so long as ground is applied to conductor 1217, does not operate. The closure of the lower front contact of relay 1305 is without function at this time.

In response to the reception of dial tone the calling subscriber proceeds to key up the digits of the wanted line number, which number it will be assumed is CH3-1067. When the key K2 which, in addition to the digit value 2 has the letter designations ABC, is depressed to transmit signal impulses for the first code letter C, the off-normal switch assembly 9 is momentarily operated and then released during the down stroke of the key and in the interval that the movable contact of such switch assembly is in engagement with the front contact thereof a reed of the generator G is caused to vibrate to generate a current impulse of a predetermined frequency. Again when the depressed key is released, the off-normal switch assembly 9 is momentarily operated and released and during the interval that the movable contact thereof is in engagement with its front contact, a reed will be vibrated to generate a second current impulse of a predetermined frequency. By referring to the preceding table, it will be noted that when key K2 is depressed, the frequency c is generated both upon the down and up strokes thereof. This frequency might, for example, be of 1,100 cycles.

The movement of the movable contact of the off-normal switch assembly 9 from its back or normal contact position disconnects the subset transmitter 1208 from its bridged connection across the substation line and the engagement of the movable contact with the front contact connects the coil 35 of the call transmitter generator

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G across the line through the condenser 1218. There being no direct current bridge across the substation line at the substation so long as the movable contact of the off-normal switch assembly 9 is out of engagement with its back contact, relay 1202 of the sender releases in turn opening the circuit of relay 1216 and removing ground from conductor 1217. Relay 1216, however, being slow to release does not release during the interval that the movable contact of the off-normal switch assembly 9 is disengaged from its back contact. With relay 1202 released and relay 1216 operated an obvious circuit is established for relay 1214 which operates and at its contacts disconnects the secondary winding of the dial tone coil 1215 from the calling line loop to discontinue the application of dial tone current thereover and connects direct ground to the calling line loop. The removal of ground from conductor 1217 removes the shunt from the winding of relay 1306 which now operates in a circuit from ground on conductor 1303, over the upper alternate contacts of relay 1305, through the winding of relay 1306 and resistance 1308 to battery.

When the first impulse of current of the frequency c is transmitted over the line, it passes over the previously traced circuit through the sender link, through the broad band-pass filter 1219 and the primary winding of the transformer 1220 and is impressed through the circuit X and the primary windings of the input transformers associated with the receiving channels Fa, Fb, Fc and V. Associated with each input transformer, such as 1313, is a frequency receiving channel consisting of a secondary winding of such transformer, a series tuned circuit 1314, a single vacuum tube such as 1315 with a feedback through the copper-oxide units, such as 1316, and a relay, such as 1317. Initially, the vacuum tube is biased nearly to cut-off. A small received signal is amplified and fed back through the condenser 1318 and the copper-oxide units 1316 to charge up the condenser 1319. This condenser is poled to reduce the negative bias on the grid of the tube 1315 with the result that the gain of the tube is increased and the amount of voltage on the grid is increased further. The final result is that a relatively small signal is sufficient to produce a sharp rise in plate current through the relay 1317. The sensitivity of each individual channel is adjusted by means of the variable resistance, such as 1320. This method controls the sensitivity by changing the alternating current feedback and does not affect the tuning of the channel.

From the preceding description it will be apparent that each relay, such as relay 1317 in each channel, will respond to a single frequency with a relatively high discrimination against the others. In the present description it has been assumed that the first channel Fa is tuned to the a frequency of 700 cycles; the second channel Fb is tuned to the b frequency of 1,100 cycles; and the third channel Fc is tuned to the c frequency of 1,500 cycles.

Upon the receipt of the first impulse of frequency c the channel Fc responds resulting in the operation of channel relay 1317. Relay 1317 upon operating establishes a circuit from ground over its contacts, the middle right back contact of transfer relay 1321, through the winding of recording relay CD to battery. Relay CD thereupon operates, locks over its inner left contacts to ground over the back contact of release relay 1322 and at its outer left contacts prepares a

circuit for relay 1321. Upon the termination of the signal impulse when the off-normal switch assembly 9 reestablishes the direct current bridge at the substation through the subset transmitter, relay 1202 reoperates to establish the circuit of relay 1216 and to reconnect ground to conductor 1217 whereupon such ground is extended over the upper front contact of relay 1306 to a point between the winding of relay 1305 and resistance 1307. Relay 1305 being now shunted releases. Relay 1306 is, however, maintained operated following the release of relay 1305 over a circuit from ground on conductor 1217, over the upper normal contacts of relay 1305, through the winding of relay 1306, and resistance 1308 to battery. With relay 1305 released and relay 1306 held operated the circuit of relay 1321 is now completed from ground over the lower back contact of relay 1305, the inner lower front contact of relay 1306, the outer left contacts of relay CD to battery through the winding of relay 1321.

Relay 1321 now operates; locks over its inner right front contact to ground over the back contact of relay 1322; at its back contacts disconnects the windings of recording relays AD, BD and CD from the contacts of the channel relays 1323, 1324 and 1317, respectively; connects the windings of recording relays AU, BU and CU with the contacts of the channel relays, all of which are at this time released, and at its outer right front contact prepares a circuit for relay 1322.

During the transmission of the second signal impulse, assumed to be also of the frequency c, the off-normal spring assembly 9 being again operated momentarily, relay 1202 again releases to remove ground from conductor 1217 thereby releasing relay 1306. Channel circuit Fc again responds to the receipt of the frequency c and the channel relay 1317 upon operating and with transfer relay 1321 operated establishes a circuit from ground over the contacts of relay 1317, the middle right front contact of relay 1321 to battery through the winding of recording relay CU. Relay CU upon operating locks over its left front contact to ground over the back contact of relay 1322.

When the off-normal spring assembly 9 again releases to terminate the second frequency impulse the reoperation of relay 1305 over the circuit previously traced is effected by the reoperation of relay 1202. With relay 1305 operated and relay 1306 unoperated a circuit is established from ground over the lower front contact of relay 1305, the lower back contact of relay 1306, the right back contact of relay AD, the No. 2 right back contact of relay BD, the No. 2 right front contact of operated relay CD, the No. 2 right back contact of relay AU, the No. 3 right back contact of relay BU, the No. 5 right front contact of operated relay CU, conductor 1332, the No. 3 left contacts of progress relay 1407, to battery through the right winding of relay 1402 of the A code digit register. Relay 1402 thereupon operates and locks over its left winding and left contacts to ground on conductor 1303 and with the remaining relays 1401, 1404, 1405 and 1400 of the A register unoperated, serves to register the first office code letter C.

A circuit is also established upon the operation of relay 1305 over its lower front contact, the lower back contact of relay 1306, over the outer right front contact of relay 1321 to battery through the winding of relay 1322, which operates after an interval sufficient to insure that

the digit signals recorded through the operation of recording relays have been effective to cause the registration thereof in a digit register of the sender; at its back contact opens the locking circuits of the operated recording relays, in the case assumed relays CD and CU, which thereupon release; opens the locking circuit of transfer relay 1321 which releases and at its front contact establishes an obvious circuit for relay 1325. Relay 1325 operates, locks over its right contacts to off-normal ground on conductor 1303 and at its left contacts prepares a circuit for operating the progress relay 1416. When relay 1321 releases, relay 1322 also releases.

When the subscriber depresses the key K4 to transmit impulses for the second office code letter H which has a numerical value of 4, the off-normal switch assembly 9 is operated momentarily to open the direct current loop at the substation and to connect the generator G to the substation line. During the interval that the switch is thus operated the reed R_c is released to transmit an impulse of the frequency c which, upon being received in the receiving channel F_c of the sender results in the operation of channel relay 1317 and, with transfer relays 1321 now released, in the operation of recording relay CD over the circuit previously traced. Relay CD upon operating locks under the control of relay 1322 and prepares the circuit of relay 1321 as previously described. When the line loop is opened at the substation by the off-normal switch assembly, relay 1202 releases and by removing ground from conductor 1217 permits relay 1306 to operate in the manner previously described. With relays 1305 and 1306 now both operated and relay 1325 operated, a circuit is established from ground over the lower front contact of relay 1305, the lower front contact of relay 1306, the left contacts of relay 1325, conductor 1312, the right front contact of progress relay 1406 to battery through the winding of progress relay 1416 which operates and locks through its winding and the winding of progress relay 1417 over the left contacts of relay 1416 and the back contact of progress relay 1427 to ground on conductor 1303. Relay 1417 being shunted so long as ground remains connected to conductor 1312, does not operate.

At the end of the first impulse for the second code digit, with the off-normal switch assembly 9 restored, the transmission of the frequency c ceases; channel relay 1317 releases, and the direct current loop is reestablished at the substation resulting in the reoperation of relay 1202 and the reconnection of ground to conductor 1217. As before described relay 1306 is now held operated to this ground and relay 1305 is shunted and releases. With relay 1305 released and relay 1306 operated, the circuit for transfer relay 1321, previously prepared through the operation of recording relay CD, is completed and relay 1321 operates and locks as previously described under the control of relay 1322. Relay 1305 upon releasing also removes ground from conductor 1312 whereupon progress relay 1417 operates in the locking circuit of relay 1416; connects the windings of the relays of the B code digit register to conductors 1331, 1332, 1334, 1335 and 1330, extending to contacts of the recording relays and at its right back contacts opens the locking circuit of relays 1406 and 1407 which now release since their operating circuit was opened upon the previous operation of relay 1309.

Upon the up stroke of the depressed key K4

the off-normal switch assembly 9 is again operated momentarily to open the direct current loop at the substation and to connect the generator G to the substation line. During the interval that the switch is thus operated the reed Rb is released to transmit the frequency b which upon being received in the receiving channel Fb of the sender results in the operation of channel relay 1324 and, with transfer relay 1321 now operated, in the operation of the recording relay BU over a circuit extending from ground over the contacts of relay 1324, the inner left front contact of relay 1321 to battery through the winding of relay BU. Relay BU upon operating locks over its left contacts under the control of relay 1322. With the direct current loop now open at the substation, relay 1202 releases followed by the release of relay 1306 as previously described.

When the off-normal switch assembly 9 again releases to terminate the second frequency impulse, relay 1202 again operates thereby causing the reoperation of relay 1305 over the circuit previously traced. With relay 1305 operated and relay 1306 unoperated, a circuit is established from ground over the lower front contact of relay 1305, the lower back contact of relay 1306, the right back contact of relay AD, the No. 2 back contact of relay BD, the No. 2 front contact of relay CD, the No. 2 back contact of relay AU, the No. 3 front contact of relay BU, the No. 4 back contact of relay CU, conductor 1334, the No. 4 front contacts of progress relay 1417 to battery through the right winding of relay 1414 of the office code register B. Relay 1414 upon operating in this circuit locks over its left winding and left contacts to ground on conductor 1303 and with the remaining relays of the B register unoperated serves to register the second office code letter H.

The operation of relay 1305 with relay 1306 unoperated also establishes the previously traced circuit for relay 1322 which operates after an interval to cause the release of the operated recording relays CD and BU and the release of the transfer relay 1321. When relay 1321 releases, relay 1322 also releases.

When the subscriber depresses the key K3 to transmit impulses for the third code digit 3, the off-normal switch assembly 9 is operated momentarily to open the direct current loop at the substation and to connect the generator G to the substation line. During the interval that the switch is thus operated the reed Rb is released to transmit an impulse of the frequency b which upon being received in the receiving channel Fb of the sender results in the operation of the channel relay 1324 and, with transfer relay 1321 not operated, in the operation of recording relay BD over a circuit extending from ground over the contacts of relay 1324, the inner left back contact of relay 1321 to battery through the winding of relay BD. Relay BD upon operating locks under the control of relay 1322 and prepares the circuit of relay 1321 as previously described. When the line loop is opened at the substation by the off-normal switch, assembly relay 1202 releases and by removing ground from conductor 1217 permits relay 1306 to operate in the manner previously described. With relays 1305 and 1306 now both operated and relay 1325 operated, a circuit is established from ground over the lower front contact of relay 1305, the lower front contact of relay 1306, the left contacts of relay 1325, conductor 1312, the right back contact of relay 1406, the right front contact of

relay 1416, to battery through the winding of progress relay 1426. Relay 1426 operates and locks through its winding and the winding of progress relay 1427, over the left contacts of relay 1426 and over the back contact of the progress relay (not shown) associated with the thousands digit register and corresponding to progress relay 1427 to ground on conductor 1303. Progress relay 1427 being shunted does not operate so long as ground remains connected to conductor 1312.

At the end of the first impulse for the third code digit with the off-normal switch assembly 9 restored, the transmission of the frequency b ceases, channel relay 1324 releases and the direct current loop is reestablished at the substation resulting in the reoperation of relay 1202 and reconnection of ground to conductor 1217. As before described, relay 1306 is now held operated to this ground and relay 1305 is shunted and releases. With relay 1305 released and relay 1306 operated a circuit for transfer relay 1321, previously prepared through the operation of recording relay BD, is completed and relay 1321 operates and locks as previously described under the control of relay 1322. Relay 1305 upon releasing also removes ground from conductor 1312 whereupon progress relay 1427 operates in the locking circuit of relay 1426; connects the windings of the relays of the C code digit register to conductors 1331, 1332, 1334, 1335 and 1330 extending to contacts of the recording relays and at its right back contact opens the locking circuit of relays 1416 and 1417 which now release since their operating circuit was opened upon the removal of ground from conductor 1312.

Upon the up stroke of the depressed key K3 the off-normal switch assembly 9 is again operated momentarily to open the direct current loop at the substation and to connect the generator G to the substation line. During the interval that the switch is thus operated the reed Rb is released to transmit the frequency b which upon being received in the receiving channel Fb of the sender results in the operation of the channel relay 1324 and, with transfer relay 1321 operated, in the operation of recording relay BU. Relay BU upon operating locks over its left contacts under the control of relay 1322.

When the off-normal switch assembly 9 again releases to terminate the second frequency impulse, relay 1202 again operates thereby causing the reoperation of relay 1305 over the circuit previously traced. With relay 1305 operated and relay 1306 unoperated, a first circuit is established from ground over the lower front contact of relay 1305, the lower back contact of relay 1306, the right back contact of relay AD, the No. 3 right front contact of relay BD, the No. 3 right back contact of relay CD, the No. 3 right back contact of relay AU, the No. 5 right front contact of relay BU, the No. 6 right back contact of relay CU, conductor 1331, the No. 2 left contacts of progress relay 1427 to battery through the right winding of relay 1421 of the code digit register C, and a second circuit is established from ground applied over the right back contact of relay AD, the No. 4 right front contact of relay BD, the No. 4 right back contact of relay CD, the No. 4 right back contact of relay AU, the No. 7 right front contact of relay BU, the No. 5 right back contact of relay CU, conductor 1332, the No. 3 left contacts of progress relay 1427 to battery through the right winding of relay 1422 of the code digit register C. Relays 1421 and

1422 upon operating lock over their left windings and left contacts to ground on conductor 1303 and with the other relays of the C code digit register unoperated serve to register the third office code digit 3.

The operation of relay 1305 with relay 1306 unoperated also establishes the previously traced circuit of relay 1322 which operates after an interval to cause the release of the operated recording relays BD and BU and the release of transfer relay 1321 followed by the release of relay 1322.

In a similar manner in response to the keying of the thousands numerical digit 1 two impulses of frequency *a* are sent resulting in the operation of recording relays AD and AU. In response to the keying of the hundreds digit 0 an impulse of frequency *c* followed by an impulse of frequencies *a* and *b* are sent resulting in the operation of recording relays CD, AU and BU. In response to the keying of the tens digit 6 an impulse of frequency *c* followed by an impulse of frequency *a* are sent resulting in the operation of recording relays CD and AU and in response to the keying of the units digit 7 an impulse of frequency *b* followed by an impulse of frequency *a* are sent resulting in the operation of recording relays BD and AU.

With recording relays AD and AU operated to record the receipt of signal impulses for the thousands digit 1, then when ground is applied to the right armature of relay AD, a circuit is established over the right front contact of relay AD, the No. 1 right back contact of relay BD, the No. 1 right back contact of relay CD, the No. 1 right front contact of relay AU, the No. 2 right back contact of relay BU, the No. 6 right back contact of relay CU to conductor 1331 and thence over the No. 2 left contacts of an operated progress relay, similar to relay 1407 but associated with the thousands digit register, to battery through the winding of a relay of that register corresponding to relay 1401 whereby such relay operates and locks and with the other relays of such register unoperated registers the thousands digit 1.

With the recording relays CD, AU and BU operated to record the receipt of signal impulses for the hundreds digit 0 then when ground is applied to the right armature of relay AD, a circuit is established over the right back contact of relay AD, the No. 2 right back contact of relay BD, the No. 2 right front contact of relay CD, the No. 2 right front contact of relay AU, the No. 2 right front contact of relay BU, the No. 3 right back contact of relay CU to conductor 1339 and thence over the No. 1 left contacts of an operated progress relay, similar to relay 1407 but associated with the hundreds digit register, to battery through the winding of a relay of that register corresponding to relay 1400 whereupon such relay operates and locks to register the hundreds digit 0.

With recording relays CD and AU operated to record the receipt of signal impulses for the tens digit 6, then when ground is applied to the right armature of relay AD a first circuit is completed over the right back contact of relay AD, the No. 2 right back contact of relay BD, the No. 2 right front contact of relay CD, the No. 2 right front contact of relay AU, No. 2 right back contact of relay BU, the No. 6 right back contact of relay CU, conductor 1331 and thence over the No. 2 left contacts of an operated progress relay, similar to relay 1407 but associated with the tens digit

register, to battery through the winding of a relay of such register corresponding to relay 1401 whereupon such relay operates and locks. A second circuit is also established from ground applied over the right back contact of relay AD, the No. 2 right back contact of relay BD, the No. 6 right front contact of relay CD, the No. 6 right front contact of relay AU, the No. 4 right back contact of relay BU, the No. 1 right back contact of relay CU, conductor 1335 and thence over the No. 5 left contacts of an operated progress relay, similar to relay 1407 but associated with the tens digit register, to battery through the winding of a relay of that register corresponding to relay 1405 which thereupon operates and locks. With these two register relays operated and the other relays of the tens digit register unoperated, the tens digit 6 is registered.

With recording relays BD and AU operated to record the receipt of signal impulses for the units digit 7, then when ground is applied to the right armature of relay AD, a first circuit is completed over the right back contact of relay AD, the No. 4 right front contact of relay BD, the No. 4 right back contact of relay CD, the No. 4 right front contact of relay AU, the No. 6 right back contact of relay BU, the No. 5 right back contact of relay CU, over conductor 1332 and thence over the No. 3 contacts of the operated progress relay 1467, to battery through the right winding of relay 1462 of the units digit register U. A second circuit is also completed over the right back contact of relay AD, the No. 3 right front contact of relay BD, the No. 3 right back contact of relay CD, the No. 3 right front contact of relay AU, the No. 4 right back contact of relay BU, the No. 1 right back contact of relay CU, conductor 1335 and thence over the No. 5 contacts of relay 1467 to battery through the right winding of relay 1465 of the units digit register U. Relays 1462 and 1465 upon operating lock over their left windings and left contacts to ground on conductor 1303 and with the other relays of this register unoperated serve to register the units digit 7.

All of the digits of the wanted line number keyed by the subscriber are now registered in the sender and the sender may proceed to control selector switches to extend a connection over the district selector S and over other selectors, not shown, in accordance therewith, after which the sender link SL is released to release the sender to make it available for other calls.

In the preceding discussion the keying and registration of letters or digits having the digit values 1, 2, 3, 4, 6, 7 and 0 have been described. If the digit 5 is keyed by the operation of key K5 then an impulse of frequency *a* would be sent followed by an impulse of frequency *b* resulting in the operation of recording relays AD and BU. With these relays operated then when ground is applied to the right armature of relay AD, a circuit is completed over the right front contact of relay AD, the No. 1 right back contact of relay BD, the No. 1 right back contact of relay CD, the No. 1 right back contact of relay AU, the No. 1 right front contact of relay BU, the No. 1 right back contact of relay CU to conductor 1335 to cause the operation of a relay of a register, such as relay 1405 of the first code digit register A.

If the digit 8 is keyed by the operation of key K8, then an impulse of frequency *a* is sent followed by an impulse of frequency *c* resulting in the operation of recording relays AD and CU. With these relays operated then when ground is applied to the right armature of relay AD, a first

circuit is completed over the right front contact of relay AD, the No. 1 right back contact of relay BD, the No. 5 right back contact of relay CD, the No. 5 right back contact of relay AU, the No. 8 right back contact of relay BU and the No. 6 right front contact of relay CU to conductor 1331; a second circuit is completed over the right front contact of relay AD, the No. 1 right back contact of relay BD, the No. 1 right back contact of relay CD, the No. 1 right back contact of relay AU, the No. 1 right back contact of relay BU and the No. 2 right front contact of relay CU to conductor 1332 and a third circuit is established over the right back contact of relay AD, the No. 1 right back contact of relay BD, the No. 1 right back contact of relay CD, the No. 1 right back contact of relay AU, the No. 1 right back contact of relay BU and the No. 1 right front contact of relay CU to conductor 1335. With ground applied to conductors 1331, 1332 and 1335 relays of a digit register, such as relays 1401, 1402, 1405 of the first code digit register A are operated to register the digit 8.

If the digit 9 is keyed by the operation of key K9, then an impulse of frequency b is sent followed by an impulse of frequency c resulting in the operation of recording relays BD and CU. With these relays operated, then when ground is supplied to the right armature of relay AD, a first circuit is completed over the right back contact of relay AD, the No. 3 right front contact of relay BD, the No. 3 right back contact of relay CD, the No. 3 right back contact of relay AU, the No. 5 right back contact of relay BU and the No. 4 right front contact of relay CU to conductor 1334 and a second circuit is established from ground over the right back contact of relay AD, the No. 4 right front contact of relay BD, the No. 4 right back contact of relay CD, the No. 4 right back contact of relay AU, the No. 7 right back contact of relay BU and the No. 7 right front contact of relay CU to conductor 1335. With ground applied to conductors 1334 and 1335, relays of a digit register such as relays 1404 and 1405 of the first code digit register A are operated to register the digit 9.

What is claimed is:

1. In a telephone system, a central office, a line incoming thereto, means for generating current of a plurality of different frequencies, means for transmitting over said line two impulses of selected frequencies in accordance with any of a plurality of signal values, means at said central office responsive respectively to said different frequencies, two groups of relays, each group comprising as many relays as there are frequency responsive means, means for rendering one of said groups of relays responsive to said responsive means to register the first impulse of a transmitted signal, and means controlled over said line for rendering the other of said groups of relays responsive to said responsive means to register the other impulse of the same signal.

2. In a telephone system, a central office, a line incoming thereto, means for generating current of a plurality of different frequencies, means for transmitting over said line two impulses of selected frequencies in accordance with any of a plurality of signal values, means at said central office responsive respectively to said different frequencies, two groups of relays, each group comprising as many relays as there are frequency responsive means, means for rendering one of said groups of relays responsive to said respon-

sive means to register the first impulse of a transmitted signal, and a transfer relay operable following the operation of any relay of said first group for rendering the other of said groups of relays responsive to said responsive means to register the other impulse of the same signal.

3. In a telephone system, a central office, a line incoming thereto, means for generating current of a plurality of different frequencies, means for transmitting over said line two impulses of selected frequencies in accordance with any of a plurality of signal values, means at said central office responsive respectively to said different frequencies, two groups of relays, each group comprising as many relays as there are frequency responsive means, means for rendering one of said groups of relays responsive to said responsive means to register the first impulse of a transmitted signal, a transfer relay for rendering said one group of relays unresponsive to said responsive means and for rendering the other of said groups of relays responsive to said responsive means to register the other impulse of the same signal, and relay means operative upon the termination of the transmission of the first impulse of a signal to cause the operation of said transfer relays.

4. In a telephone system, a calling line, a central office, means for extending a connection from said line to said office, means at the substation of said calling line for generating current of a plurality of different frequencies, means for transmitting over said line two impulses of selected frequencies in accordance with any of the ten digit values, means at said central office responsive respectively to said different frequencies, two groups of relays, each group comprising as many relays as there are frequency responsive means, means for rendering one of said groups of relays responsive to said responsive means to register the first impulse of a transmitted digit signal, and means controlled over said calling line for thereafter rendering the other of said groups of relays responsive to said responsive means to register the other impulse of the same digit signal.

5. In a telephone system, a calling line, a central office, means for extending a connection from said line to said office, means at the substation of said calling line for generating current of a plurality of different frequencies, a plurality of digit keys associated with said generating means, means selectively responsive to the operation of said keys in accordance with the ten digit values to transmit an impulse of selected frequency during the down stroke of the operated key and to transmit a second impulse of one or more of said frequencies during the up stroke of the operated key, means at said central office responsive respectively to said different frequencies, two groups of relays, each group comprising as many relays as there are responsive means, means for rendering one of said groups of relays responsive to said responsive means to register the first impulse of a transmitted digit signal, and means controlled over said calling line for thereafter rendering the other of said groups of relays responsive to said responsive means to register the other impulse of the same digit signal.

6. In a telephone system, a calling line, a central office, means for extending a connection from said line to said office, means at the substation of the calling line for generating current of a plurality of different frequencies, means for trans-

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mitting over said line two impulses of selected frequency in accordance with any of the ten digit values, means at said central office responsive respectively to said different frequencies, two groups of relays, each group comprising as many relays as there are frequency responsive means, means for rendering one of said groups of relays responsive to said responsive means to register the first impulse of a transmitted digit signal, means controlled over said calling line for there-
 5 after rendering the other of said groups of relays responsive to said responsive means to register the other impulse of the same digit signal, a plurality of registers for registering digits of wanted line numbers, and means for successively setting said registers in accordance with successive joint setting of the groups of relays responsive to the successive transmission of digit impulses in accordance with the digits of a wanted line number.

7. In a telephone system a central office, a line incoming thereto, means for generating current of a plurality of different frequencies, means for transmitting over said line two impulses of selected frequencies in accordance with any of a plurality of signal values, means at said central office responsive respectively to said different frequencies, two groups of relays, each group comprising as many relays as there are frequency

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responsive means, means for rendering one of said groups of relays responsive to said responsive means to register the first impulse of a transmitted signal, a transfer relay for rendering said one group of relays unresponsive to said responsive means and for rendering the other of said groups of relays responsive to said responsive means to register the other impulse of said signal, a register, and relay means controlled over said line and operative upon the termination of the transmission of the first impulse of a signal to cause the operation of said transfer relay and operative upon the termination of the transmission of the second impulse of a signal to render
 10 said register selectively operable under the joint control of said groups of relays.

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The following references are of record in the file of this patent:

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