May 16, 1944. W. P. ALBERT 2,349,129

DIALING SYSTEM

Filed July 1, 1942 7 Sheets-Sheet 1

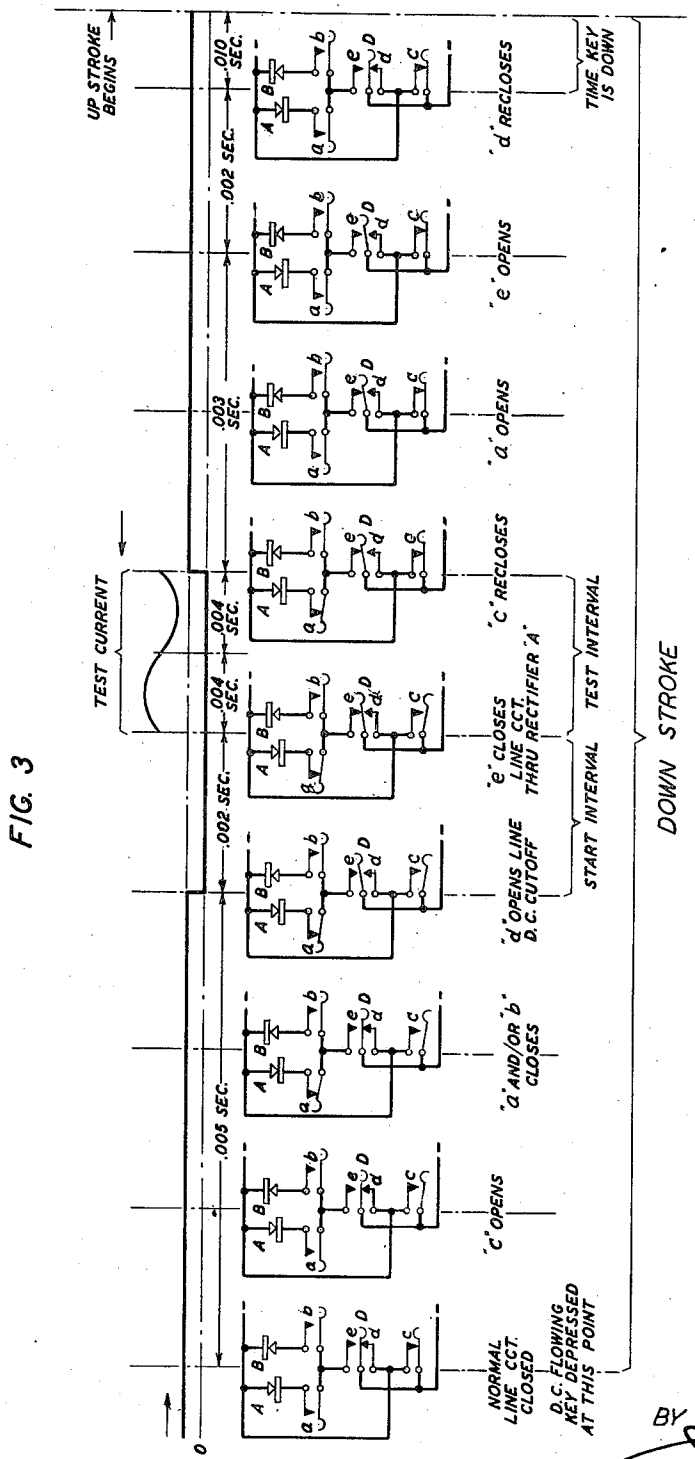

FIG. 3

FIG. 3	FIG. 4	FIG. 5

FIG. 1

FIG. 4	FIG. 6	FIG. 7
FIG. 3		FIG. 8
		FIG. 9

FIG. 2

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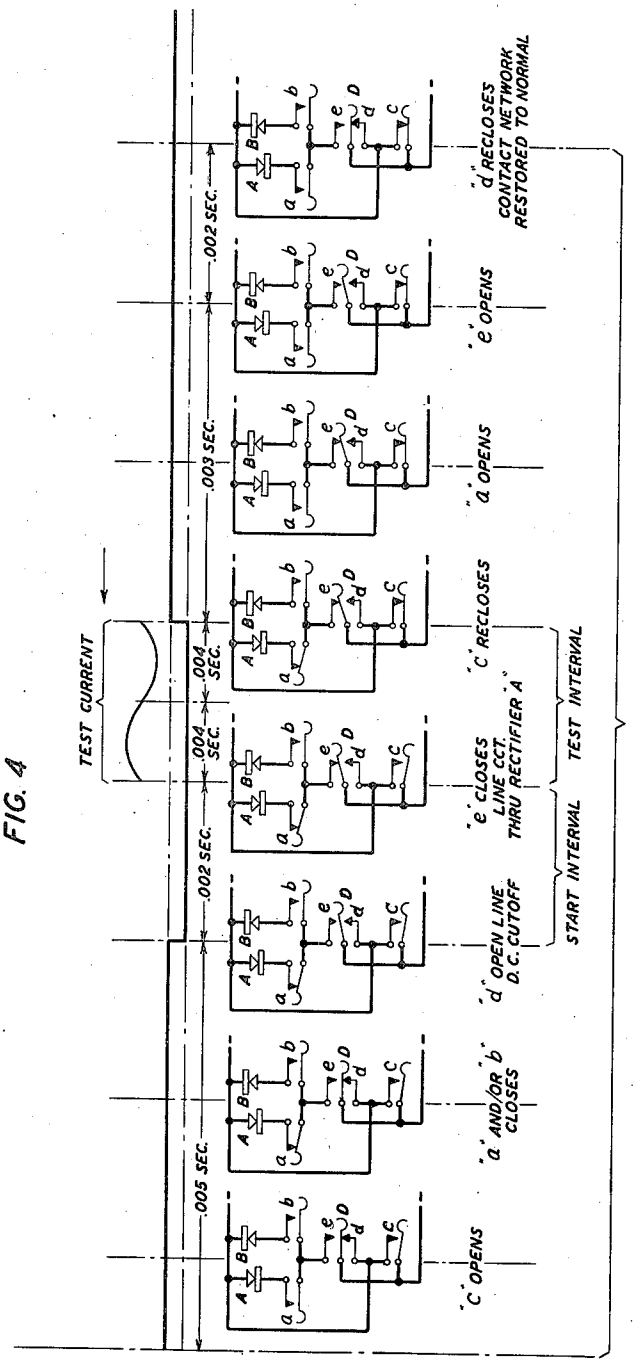

FIG. 4

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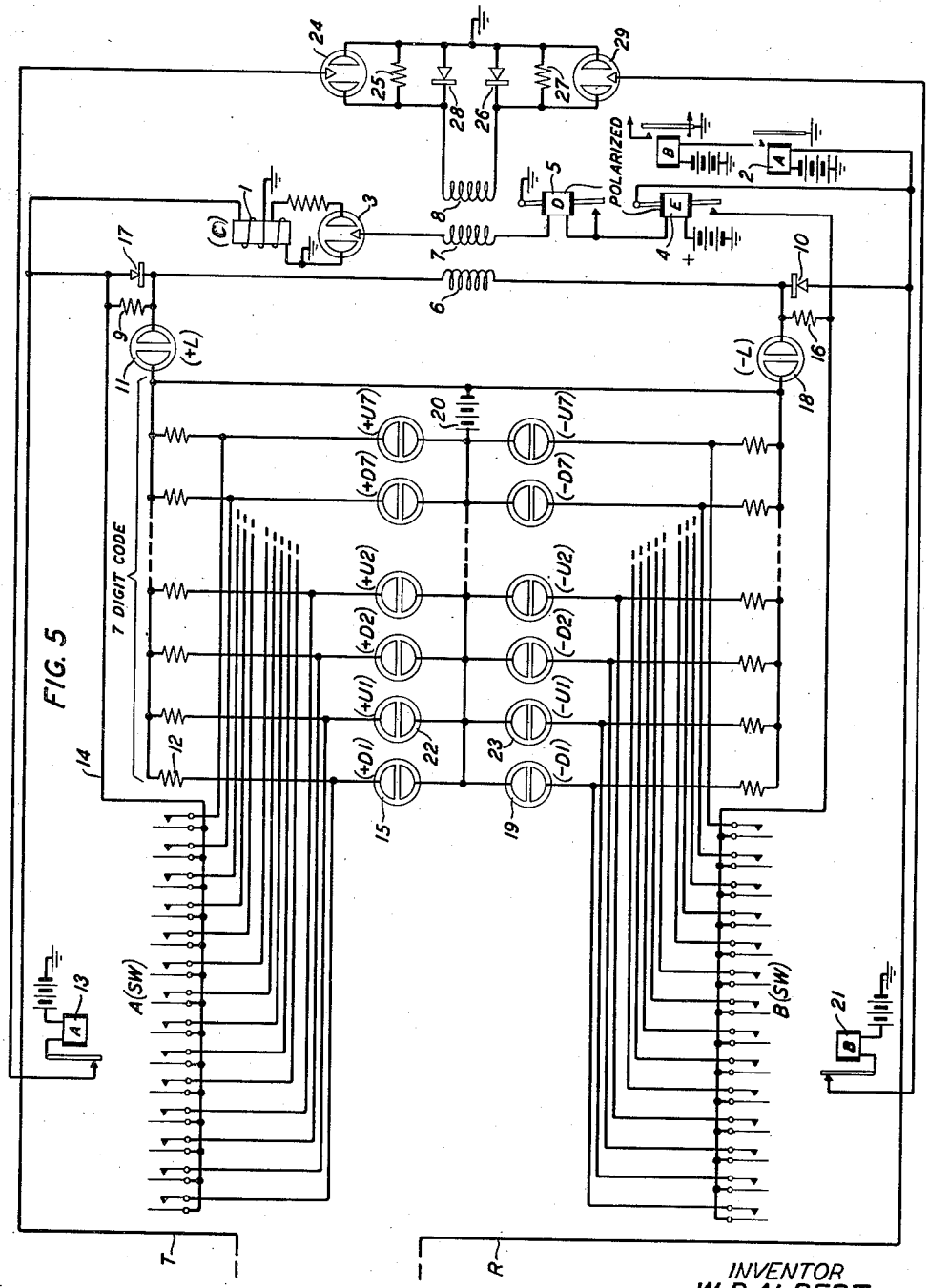

FIG. 5

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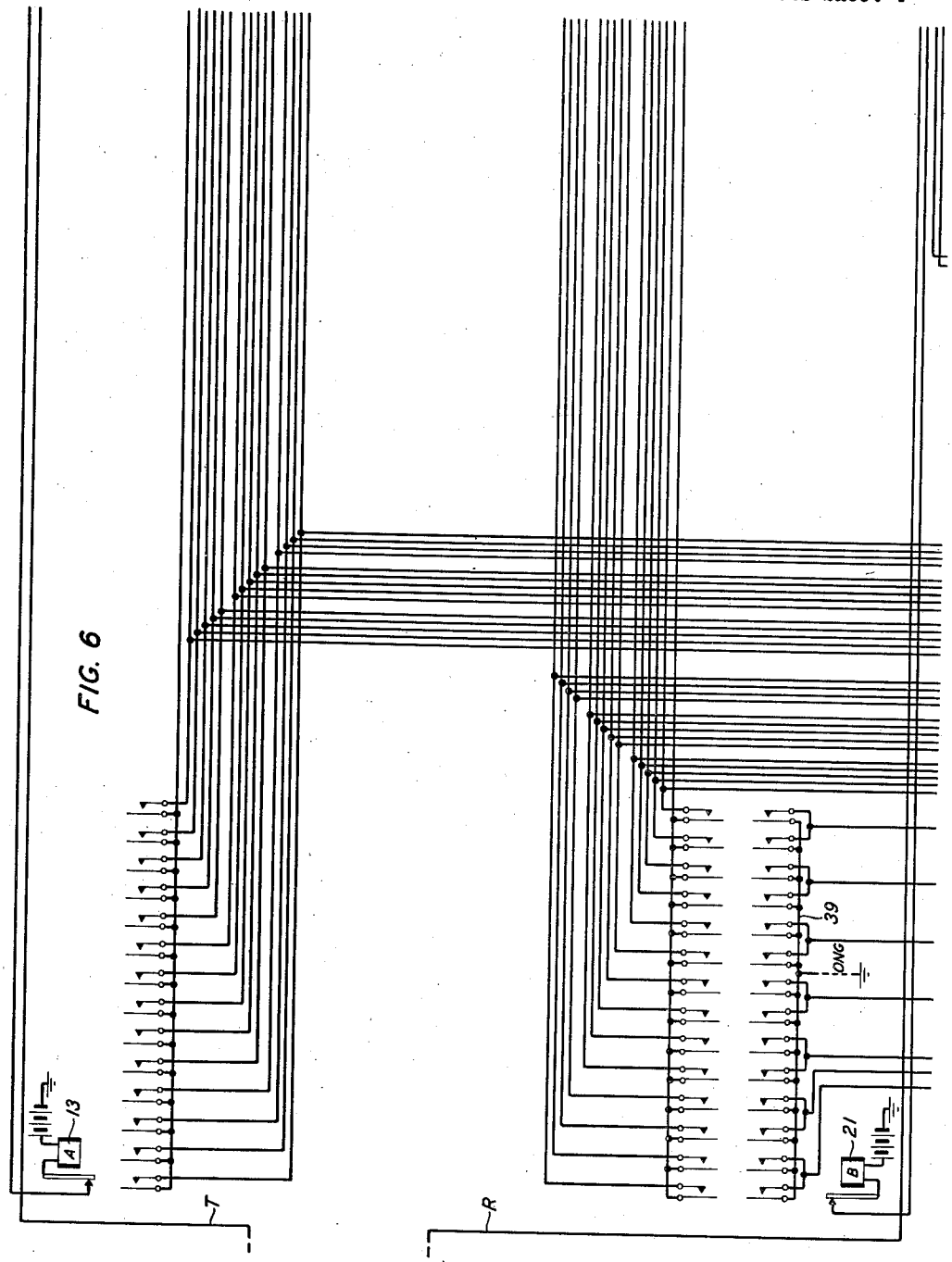

FIG. 6

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DIALING SYSTEM

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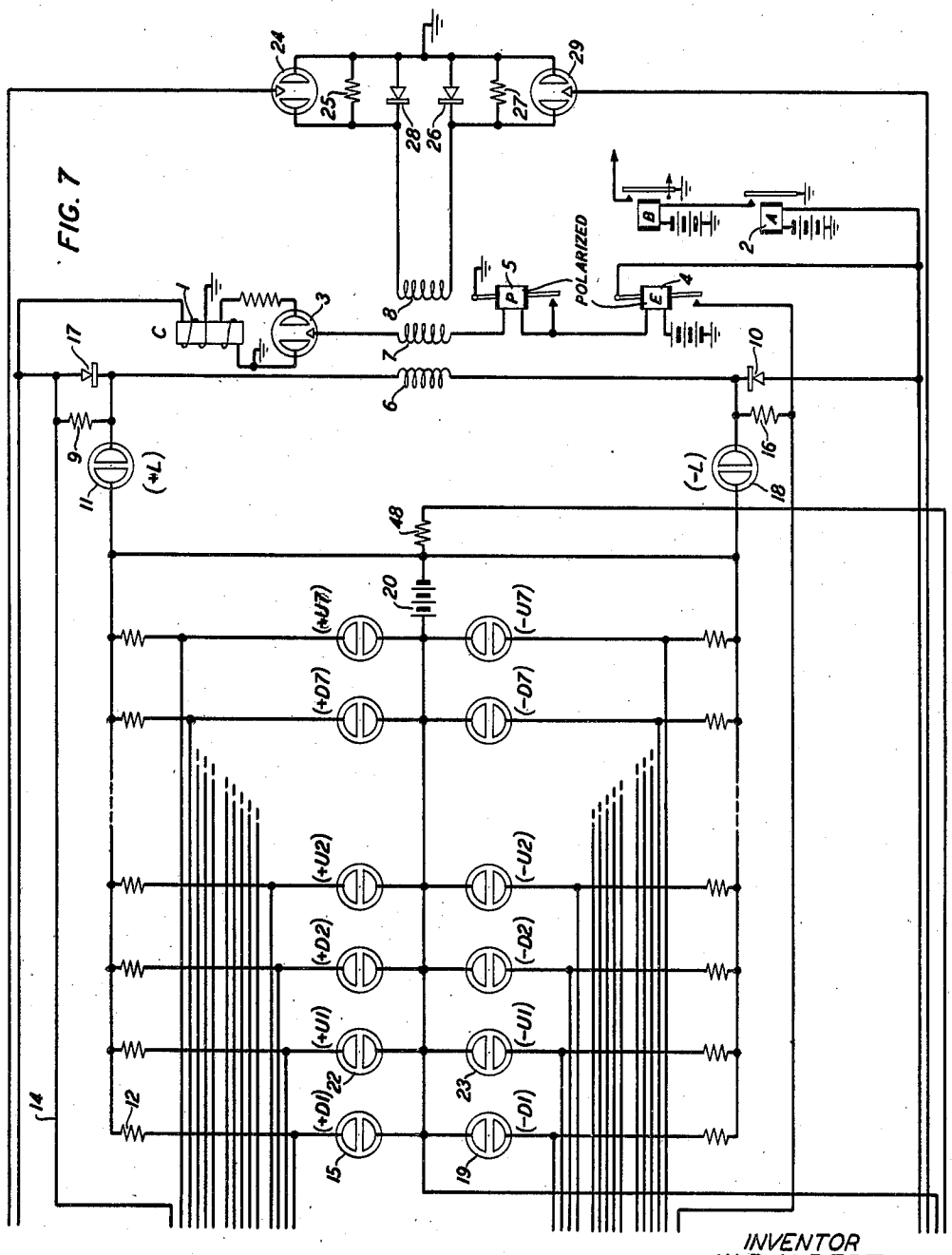
FIG. 7



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DIALING SYSTEM

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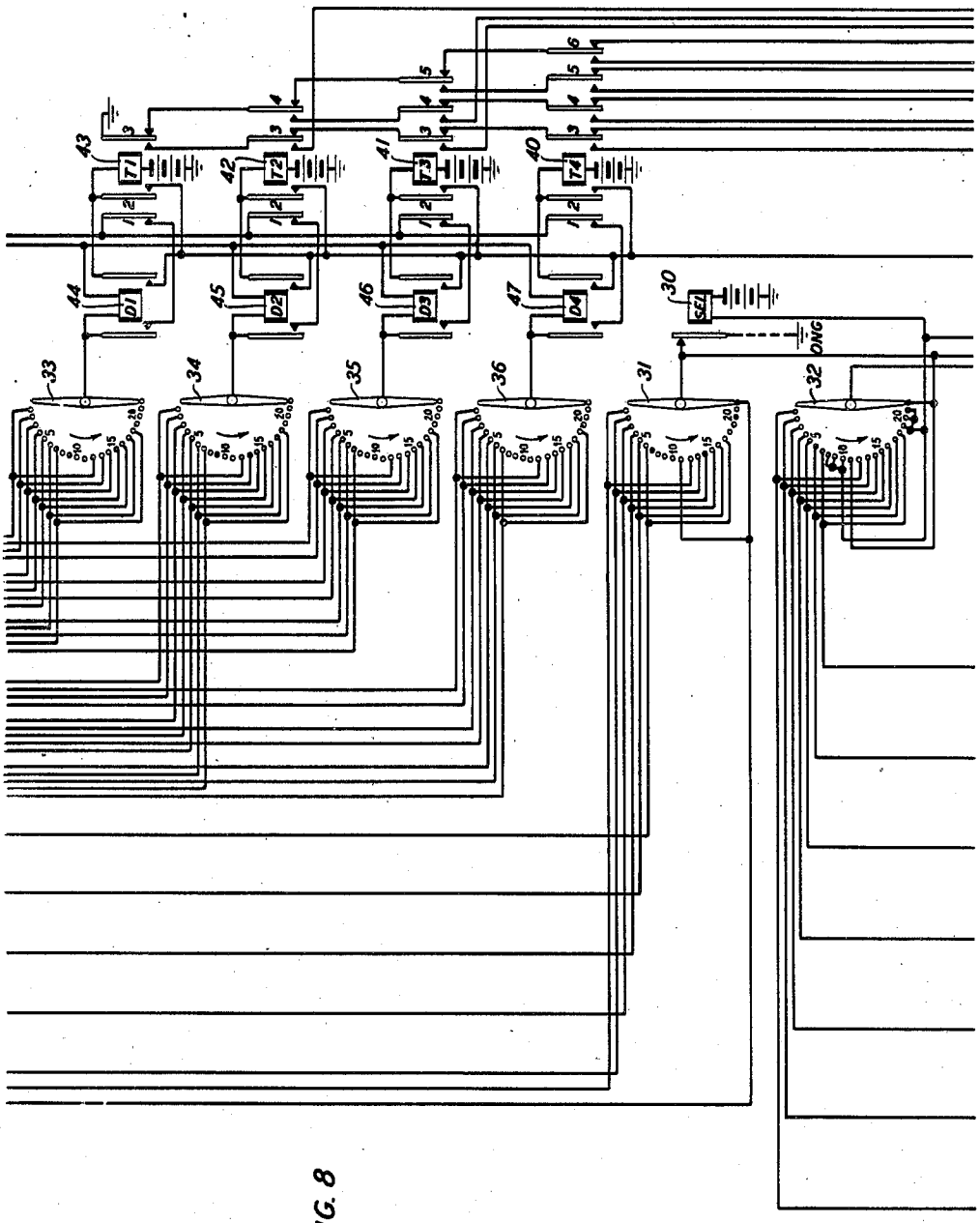

FIG. 8

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DIALING SYSTEM

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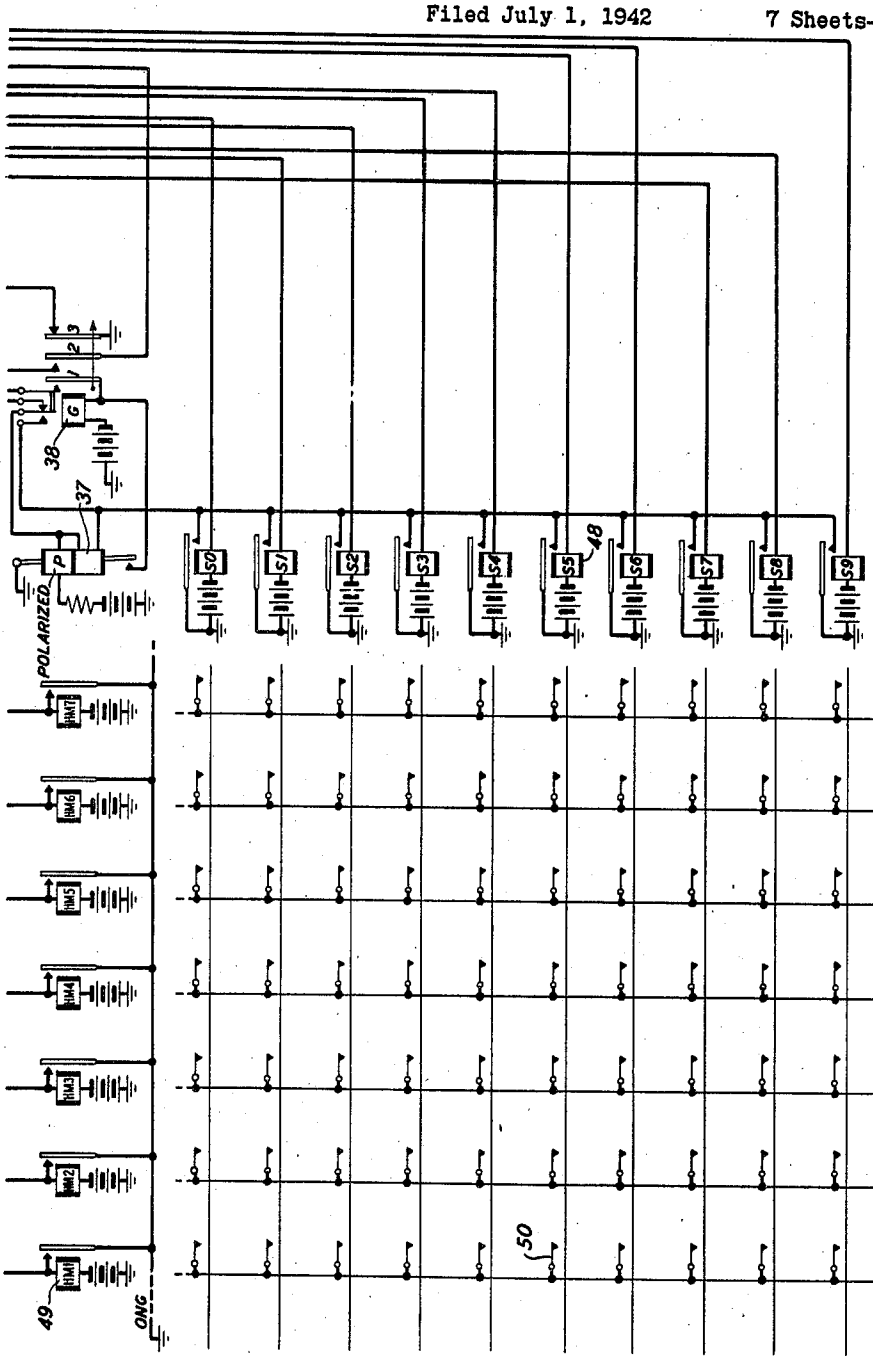

FIG. 9

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Patented May 16, 1944 2,349,129

UNITED STATES PATENT OFFICE

2,349,129

DIALING SYSTEM

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Application July 1, 1942, Serial No. 449,257

4 Claims. (Cl. 177—353)

This invention relates to communication systems and particularly to signaling means therein.

The general object of the invention is to provide fast acting reliable dialing means of the push-button type for transmitting number signals for the purpose of controlling switching apparatus in central office installations.

Another object of the invention is to place under subscriber control only the most simple and rugged apparatus in a metallic line circuit arrangement.

In accordance with these objects a dialing means at a substation is provided in the form of a plurality of push-buttons and a pair of varistors which may thereby be selectively cut into the substation loop in various sequences. A responsive means at the central office end of the line will register the permutations of the various conditions thus set up and act as a switching control means.

The substation means consists generally of a plurality of digital keys for writing up the number of a wanted line in the usual manner. Each key is arranged to open the substation loop and to then insert in the open circuit a non-linear resistance element spoken of hereafter as a varistor pointed in one or the other direction. This action is repeated on the upstroke of the key so that upon each actuation of a key there are four conditions which may be detected and these set in a permutation code will give sixteen selective possibilities. In some respects the actuation of the key is analogous to the operation of a teletypewriter key for upon the downstroke it first produces a start signal in the form of an open circuit, follows this with a connection which may be interpreted four ways and finally produces a stop signal in the form of a closed circuit. Upon the upstroke of the key another start signal in the form of an open circuit is produced followed by a circuit condition which may be interpreted four ways and finally produces a stop signal in the form of a closed circuit.

At the other end of the line there are provided a plurality of sets of detecting devices, preferably in the form of cold cathode tubes. Upon the receipt of the said start signal responsive apparatus will produce a simulated single full cycle of alternating current which is used to detect the conditions produced by the actuation of the key at the substation. The result of the test made by the transmission of this single cycle is recorded on cold cathode tubes and is later used to control the desired switching operations.

A feature of the invention is the use of a pair of varistors at the controlling point which may be included in the line circuit thereat sequentially and selectively.

Another feature is the method of signaling which consists in sending a start signal from one end of the line to the other and then selectively presenting a predetermined circuit condition at said one end to be tested from the said other end by currents generated at said other end in response to the receipt of said start signal.

Still another feature of the invention is a means for generating a single simulated cycle of alternating current for testing purposes with means responsive to the strength of each half wave to indicate selectively established circuit conditions at the point to which said current is transmitted.

Another feature is a circuit arrangement including a set of cold cathode tubes for registering the sequential and selective imposition of certain circuit conditions at a distant point.

Another feature is the use of a push-button signaling device which will set up different circuit conditions on the forward and return strokes thereof.

Another feature is the means for starting two trains of operations one on the forward stroke of the signaling device and one on the return stroke thereof, which trains may be separated in time. Regardless of such separation in time, such two trains of operations will produce a single result at the receiving end which may be used to register a single item of intelligence as a single digit of a telephone number.

Another feature is signaling by transient currents. The receipt of the start signal results in the generation of, first, a positive transient and, second, a negative transient both aperiodic in character but of sufficient magnitude to operate as a testing current which will operate or fail to operate a local medium in response to a condition established or not established at the far end of a line.

Other features will appear in the following description.

The drawings consist of seven sheets which may be combined as shown in Figs. 1 and 2. Figs. 3, 4 and 5 in combination serve to explain a single digital key operation and the reaction at the other end of a line caused thereby. Figs. 3, 4 and 6 to 9 serve to explain the registration of a designation consisting of a plurality of digits. Figs. 3 and 4 are schematic circuit diagrams showing the sequential operations of a

dialing key, Fig. 3 representing the down stroke and Fig. 4 representing the return or up stroke of the key. Each of these figures consists of a plurality of circuit diagrams of the key contacts placed in order from the left to the right with an indication of the timing and the creation of a start signal sent from the substation and the test current returned from the other end of the line. The remainder of the figures are circuit diagrams.

The key arrangement is such that a particular key will set up two independent circuit conditions, one on the down stroke and another on the up stroke. These circuit conditions may be alike or they may be different. The mechanical arrangement of the spring contacts may be similar to the arrangement shown and described in the application Serial No. 444,772, filed May 28, 1942 by Bascom and Hubbard.

Each of the separate circuit diagrams of Figs. 3 and 4 shows a path through the key contacts from one line wire to another and each at the time of its consideration is to be connected to the line wires at the extreme left in Fig. 5. The first diagram of Fig. 3 is the normal condition before the key is depressed and the last is the normal condition at the extreme end of the down stroke. This diagram may also be considered the normal condition before the start of the up stroke since the subscriber may hold the key in this condition for an indefinite period. The last diagram in Fig. 4 is also a duplicate of the first diagram in Fig. 3 and represents the normal condition attained at the extreme end of the upstroke. The intermediate diagrams represent various stages in the sequential operation of the springs, and it is believed that with the help of the notations the operation will be abundantly clear.

At the top of these diagrams there is a line which represents the direct current flowing in the line circuit. This flows at a value fixed by the various circuit factors and remains at a fixed point until the fourth stage is reached when it drops to zero as the circuit is effectively opened at this point. This condition exists through the fifth stage and until the sixth stage is reached whereupon the circuit for the direct line current is again closed. During this interval a test current consisting of a single cycle of alternating current is sent from the distant end to detect the circuit condition established at the substation. Similar operations take place on the up stroke of the key.

The essential operation is to selectively connect a pair of varistors in the circuit and to then test from and register at the other end of the line which of these varistors have been introduced into the circuit. The two varistors in the circuit diagrams of Figs. 3 and 4 are marked A and B, respectively. If the A varistor has been included in the circuit, then the positive impulse or the positive half wave of the single cycle of alternating current will find a path of low resistance at the substation and consequently the current flow will rise to the point where it will act as a signal. Similarly if the B varistor is included in the circuit the negative impulse or negative half wave will find a path of low resistance at the substation and the resulting current will act as a signal. By the selective connection of these varistors the transmission of the single cycle of alternating current from the other end of the line will result in the registering of four different conditions: first, no response showing that neither varistor has been connected in the circuit; second, a positive signal, showing that the A varistor has been connected in the circuit; third, a negative signal, showing that the B varistor has been connected in the circuit, and fourth, both a positive and a negative signal showing that both varistors have been connected in the circuit. Since one selective connection may be made from the down stroke and a different one for the up stroke of the key it follows that there are, theoretically, sixteen different available permutations which may be used for signals. Since that one where there is no response in either the down stroke or the up stroke could not be used for certain practical reasons it follows that there are fifteen codes which may be used for digital designations. Ten of these may be used in regular service and the other five may be used for certain special service features, such as for calling long distance or for making certain emergency calls, such as to the police or the fire services. The following table shows the combinations which may be used.

Digit	Down stroke		Up stroke	
	Positive	Negative	Positive	Negative
1	√			
2		√		
3			√	
4				√
5	√		√	
6		√	√	
7	√			√
8		√		√
9	√	√		
10			√	√
11	√	√	√	
12	√	√		√
13	√		√	√
14		√	√	√
15	√	√	√	√

By way of example the diagrams of Figs. 3 and 4 show the key contact operations for the sending of digit 5 according to the above table.

The essential operations of a key are then to select the varistor to be used, to open the line as a start signal to the apparatus at the other end of the line and then to connect in the selected varistor to expose it to the single cycle of alternating current which will be sent from the other end of the line in response to the said start signal. These operations both for the down stroke and for the up stroke are shown in step-by-step detail in Figs. 3 and 4. The time values indicated are by way of example and are not necessarily controlling.

The various contacts of the keys at the substation are designated *a*, *b*, *c*, *d* and *e*. The two varistors A and B are cut into the loop circuit by closure of key contacts *a* and *b*, respectively, followed by the transfer of the key from contact *d* to *e*. All key contacts are common to all keys but contacts *a* and *b* are controlled by mechanical cams on the individual keys so that various combinations may be obtained on the down stroke and different combinations on the up stroke of the keys. Contacts *c*, *d* and *e* function on each down stroke and again on each up stroke of any key. The order of operation of contacts on the down stroke is: *c* opens, *a* and/or *b* close if required, *d* transfers to *e* with a definite open interval, then, near the end of the down stroke, *c* reclosed, *a* and *b* open followed by transfer from *e* to *d*. On the up stroke the same order is required, namely, *c* opens, *a* and/or *b* close, *d* transfers to *e* and near the end of the up stroke *c*

recloses, *a* and *b* open and *e* transfers back to *d*. The transfer from contact *d* to *e* on both strokes of any key may be warranted to open the loop by a toggle switch arrangement for a definite interval independent of the speed of operation of the key.

The momentary opening of the loop caused by the transfer from contact *d* to contact *e* in the subset is the signal for the sender to send out a pulse of positive and negative current to determine the polarity condition existing by virtue of the closed or opened *a* and *b* contacts. When the line has been taken for use a circuit is established from ground through the winding of relay 1, the tip of the line T through the loop closed at the substation, the ring of the line R and thence through the winding of relay 2 to battery. The momentary opening of the loop induces in the secondary coil of relay 1 a potential which is sufficient to energize the tube 3 which thereupon locks in its anode circuit to positive battery through the windings of relays 4 and 5 and in series with the primary winding of a transformer having the windings 6, 7 and 8. The build up of flux in the transformer due to current flowing in its primary winding induces a potential in its secondary winding 6 and this is connected so that the terminal which is positive on the build up of flux is connected to the tip of the line through the resistance 9. This positive potential is therefore applied to the tip of the line and finds the path over the loop through varistors A or B, over the ring of the line through varistor 10, back to the other terminal of the secondary winding 6. Since varistors A and B are designed with very low resistance in one direction and very high resistance in the opposite direction, there will be a very great difference in the amount of current which will flow in the resistance 9.

If varistor A is connected in the circuit then a relatively large current will flow and the drop in potential across resistance 9 will cause tube 11 to fire. The circuit of tube 11 includes a resistance 12 and a contact on progress switch controlled by magnet 13 and leading to conductor 14. The drop in potential across the resistance 12 due to current flowing through tube 11 is added to the voltage supplied to the other terminal of tube 15 to bring the total potential above the firing point and tube 15 will fire and thereafter remain in an ionized condition by the sustaining battery voltage until a subsequent registering operation extinguishes it. Tube 11, however, is operated only while the positive current is flowing in the resistance 9.

The progress switch which is under control of the magnet 13 may be of the type shown in the application of Frank H. Hibbard, Serial No. 411,105, filed September 17, 1941.

As previously noted, the positive half of the test cycle is induced in the secondary winding 6 of the transformer by the build up of flux due to current flowing in the primary winding of the transformer by the firing of tube 3. The value of the voltage induced is dependent upon the time rate of change of flux acting upon the total turns of the secondary winding. The length of the positive pulse is largely dependent upon the design of the transformer but is also influenced by the load on the secondary and tertiary windings as well as the external inductive elements in series with the primary winding, namely, relays 4 and 5. It may be assumed that the flux in this transformer is almost fully built up and that relays 4 and 5 will operate in approximately .004 second. Relay 5, in operating, closes its contact and short circuits itself in series with the primary winding of the transformer and tube 3. This causes the flux in the transformer to decrease at a rate dependent upon the design of the transformer and loads on all three windings. During the collapse of the flux a negative voltage is produced at the terminal of the secondary winding 6 which is connected at the tip side of the line and a positive potential at the terminal which is connected to the ring side of the line, through resistance 16 and the make contact of relay 4. This negative half wave of the cycle of test current will be designed to be approximately the same value in potential and of about the same duration as the positive half cycle. If the B varistor at the subset is closed across the loop by contact *b* then a relatively large positive current will flow from the secondary winding 6 of the transformer through resistance 16, make contact of relay 4, over the ring of the line through varistor B, thence over the tip of the line through the tip varistor 17, back to the other terminal of the secondary winding 6 of the transformer. This produces a drop in voltage across the resistance 16 sufficient to momentarily fire tube 18. This, in turn, increases the potential across tube 19 sufficient to fire it. This latter tube is sustained in an operated condition by the battery 20. As soon as the voltage of the anode of tube 18 drops below the sustaining value it will extinguish and open the circuit for relay 5. This relay requires approximately .004 second to release during which the relay 4 is held operated. As soon as relay 5 opens its contact relay 4 will release and the circuit is again normal except that the progress switches controlled by the magnets 13 and 21 have progressed to terminals associated with tubes 22 and 23, as will be described hereinafter. The key at the subset will now reach the end of the down stroke and contact *c* will reclose the loop circuit. The key may be kept depressed for as long or as short a time as desired.

The return stroke of the digit key at the subscriber's station will repeat the same order of operation of key contacts but the contacts *a* and *b* are now actuated by different mechanical cams than on the down stroke. The opening of the loop on the return stroke again fires tube 3 and repeats the generation of the test current as described for the down stroke. This test current is always positive at the tip first followed by positive at the ring, resulting in the generation of a simulated full cycle of alternating current. On the up stroke tube 22 will be fired if contact *a* is closed and tube 23 will be fired if contact *b* is closed. When the varistors at the subset are connected so they oppose the flow of the positive or negative current, then the drop of potential across resistances 9 or 16 is of low value and tubes 11 or 18 will not fire. Hence tubes 15, 19, 22 or 23 will not fire.

In the example given in the drawings of Figs. 3 and 4, tube 15 will fire on the down stroke of the key and tube 19 will fail to fire. On the up stroke tube 22 will fire but tube 23 will fail to fire.

The means for progressing the registration from down stroke to up stroke of the same digit and for progressing from digit to digit is shown in Fig. 5. Four tubes are required to register a digit, although with the ten-digit code used, not more than two out of the four will be energized

for any given digit. The contacts of the progress switches are normally set to render the circuit for tubes 15 and 19 effective when the sender is seized for an incoming call. When the first digit key is operated it opens the loop on the down stroke and causes the transformer to induce a cycle of alternating test current in its secondary winding 6, as previously described. At the same time a corresponding cycle of alternating current is induced in the tertiary winding 8 of this transformer for the purpose of advancing the progress switches controlled by the magnets 13 and 21. These switches are arranged to have the required number of positions for the total number of digits to be keyed and are capable of high-speed operation. When the positive half cycle of the line test current is about at its maximum and ready to fire tubes 11 and 15 (assuming they are to be actuated) the voltage across the tertiary winding 8 of the transformer has reached a point where tube 24 will fire on its cathode circuit from the potential drop across resistance 25. The tertiary winding 8 is connected so that the terminal which is positive when the flux is building up is connected to tube 24. Varistor 26 short circuits resistance 27 for this positive current but varistor 28 compels the current to flow through resistance 25, causing tube 24 to operate. Tube 24 being fired, locks in its anode circuit from positive battery through magnet 13 and its self-interrupting contact. The magnet of this selector therefore starts to energize at almost the same instant that the registration of the test current is being made by tube 15. By the time the selector magnet 13 has energized to the point of breaking its contact with the terminal connected to tube 15, the register tube will have been actuated and the test with the negative half cycle will be in progress. When the selector magnet 13 is fully energized it breaks its interrupter contact, thus opening the circuit for tube 24 which is extinguished and selector magnet 13 releases to render the circuit for tube 22 now effective. Since this tube is not actuated until the positive test on the up stroke of the key there is ample time for the operation of the selector magnet 13. Likewise, while tube 19 is taking the registration of the negative half wave of the test current, the corresponding negative voltage across the tertiary winding 8 of the transformer will fire tube 29 which locks in its anode circuit through selector magnet 21. Selector magnet 21 operates and releases in a manner similar to the selector magnet 13 and advances its contact to the terminal associated with tube 23. It should be noted that with the proper design of the transformer there can be practically no variation between the tube registration resulting from voltage induced in the secondary winding and the energizing of the selectors for advancing resulting from a corresponding voltage induced in the tertiary winding of the same transformer. Because of this close timing it is possible to start energizing the selector magnet while the registration is still in progress. This cycle of operation is completed for the down and up stroke of each digit key. For a seven-digit number there must be fourteen steps of both selectors.

The drawings arranged as indicated in Fig. 2 show the translation and registration transfer circuit which functions to test the four tubes for each digit simultaneously and to operate corresponding detector and translating relays which convert the code to a decimal system for final registration (by way of example) on a crossbar register switch. It should be noted that the various elements in Figs. 6 and 7 which correspond to similar elements in Fig. 5 are numbered in the same manner. Thus the two progress switching magnets of Figs. 6 and 7 are designated 13 and 21, respectively, to correspond to the same magnets in Fig. 5. Each digit is tested, translated and registered, one at a time, following the temporary registration on the tubes. The progress switch controlled by the magnet 30 has six brushes 31 to 36, inclusive. The selector has a normal position with the following seven terminals of the banks controlled by brushes 33, 34, 35 and 36 wired to the tube register circuit. Means is provided so that this progress switch cannot advance to a tube to register a digit until the progress switch controlled by the magnet 21 has advanced from that digit. The transfer of the registration starts as soon as the first digit is completely registered on the tubes. Off-normal ground is connected to the armature of magnet 30 as soon as the circuit is seized for use and at the same time the same off-normal ground is connected to the lower seven contacts controlled by magnet 21. This off-normal ground, which is indicated by a dotted line, causes relay 37 to operate through the normal contact of the selector switch brush 32 in a circuit which may be traced from the off-normal ground armature and break contact of magnet 30, normal brush contact of the bank operating with brush 32, through brush 32, the normally closed contacts controlled by armature 1 of relay 38, through the upper winding of relay 37 to battery. Another circuit may also be traced from the off-normal ground to conductor 39, through the first or second pair of contacts controlled by magnet 21, through the normal contact of the bank controlled by wiper 31 to supply ground to the same point as the armature and back contact of magnet 30. Relay 37, in operating, energizes relay 38 which locks to the double source of off-normal ground just traced and by a mechanical sequence of contacts opens the circuit for relay 37 which immediately releases since no select magnet is energized. Relay 38, operated, energizes magnet 30 in a circuit which may be traced from battery winding of magnet 30, front contact and armature 2 of relay 38 and thence in a series circuit through the back contact and armature 6 of relay 40, back contact and armature 5 of relay 41, back contact and armature 4 of relay 42, back contact and armatures 3 of relay 43 to ground. This checks the fact that the four translation relays 40 to 43, inclusive are released. If this circuit is complete the magnet 30 will operate and open one path of off-normal ground which is holding relay 38 locked. But the other off-normal ground over the contacts controlled by stepping magnet 21 is not removed until this switch has left the terminal associated with the tube 23 which indicates final tube registration of the first digit.

Relay 38 is slightly slow to release so it will not release on the short opening of the off-normal ground when the selector switch controlled by magnet 21 advances from tube 19 to tube 23. Therefore, as soon as tube registration of the first key digit is completed relay 38 is released which releases the magnet 30, allowing it to advance its brushes to position 1. In this position brushes 33, 34, 35 and 36 are connected through the bank to the four tubes representing digit 1, namely, tubes

15, 19, 22 and 23. Four detector relays 44 to 47 are connected simultaneously to the tube register circuit in such an arrangement as will determine which tubes are fired. There will be a drop in potential across the associated resistance sufficient to operate the detector relay connected across it through a common resistance 48 which will prevent excessive current flowing in the register tube circuit. The operation of the detector relay will cause it to lock to the positive side of the sustaining battery 20, thus short circuiting the register tube and extinguishing it. The detector relay or relays (normally not more than 2) will operate the corresponding translation relay or relays 40 to 43 which in turn unlocks the associated detector relay. The translation relays lock to ground at the back contact and armature 3 of relay 38. The operation of the translation relays will connect ground to the proper select magnet representing the decimal of the digit key according to the code shown in a previous paragraph. The operation of a translation relay 40 to 43 will release the associated detector relay. The operation of a select magnet closes ground through the primary winding of relay 37, closed contact of relay 38, brush 32 to the hold magnet for the first digit.

Since it was assumed that the digit 5 was being registered which would mean that tubes 15 and 22 were fired, then detector relays 44 and 46 would have operated, resulting in the operation of translator relays 43 and 41. Therefore a circuit can be traced from ground, armature 3 and front contact of relay 43, armature 3 and back contact of relay 42, armature 3 and front contact of relay 41, winding of select magnet 48 to battery. Select magnet 48 prepares the contacts in its horizontal row for operation and at the same time closes a circuit through its armature and front contact to extend ground over the lower winding of relay 37, thence through the normally closed contacts controlled by armature 1 of relay 38, wiper now on its first position contact to the winding of hold magnet 49 and thence to battery. Hold magnet 49 now causes the contacts at 50 to operate to register 5 as the first digit. Relay 37 is differential and will not operate until locking ground is returned by the operation of the hold magnet. The operation of relay 37 then causes relay 38 to operate and lock to the off-normal ground through the back contact of magnet 30 and to the off-normal ground through the next pair of contacts controlled by the magnet 21 and associated with the tubes for the second digit if this switch has not advanced from digit 2. Assuming digit 2 has been keyed and the latter path is open, the operation of relay 38 opens the ground at the back contact of its armature 3 which releases the translation relays. The release of the translation relays opens the circuit for the select magnet 48 and closes a back contact circuit through armature 2 of realy 38 to operate the magnet 30 of the selector switch. Relay 38 will release when the select magnet 48 has released, thus releasing relay 37, when the selector magnet 30 operates to break its back contact and when the selector switch controlled by magnet 21 has advanced from the registration of the second digit. The lead through the armature 2 and front contact of relay 38 again checks that all translation relays are released. Relay 38 releases and causes selector magnet 30 to release, which advances the registration transfer circuit to the tube register circuit for digit 2 and connects to the second hold magnet. This operation is repeated for each digit. If at any time the transfer circuit represented by the selector of Fig. 8 catches up to the next preceding tube register circuit connected to by the switch controlled by magnet 21, relay 38 will be held operated, preventing the advance of the selector of Fig. 8 until the switch controlled by magnet 21 indicates by advancing that the succeeding digit has been registered on the tubes. All register tubes are extinguished as the transfer circuit advances. The registration on the crossbar switch is then used in conjunction with a marker to set up the call in the usual manner.

Party line identification may be obtained by the addition to the central office of four register tubes preceding the first digit and the requirement that party-line subscribers operate an added "start" key at the subset before keying the called number. This added key can be arranged to use digits 11, 12, 13 or 14 of the code table hereinbefore set forth, dependent upon which party originates the call. These particular four codes are the only ones requiring the operation of three register tubes for each code so that an identifying check can be made of the party codes. In a similar manner digit 15 of the code table can be used by an added key to send a special code for use on long-distance calls.

What is claimed is:

1. In a signaling system, a line, a plurality of differently poled varistors at one end of said line, a plurality of keys thereat, each said key having means constructed and arranged on its operating stroke to transiently open said line circuit and to then selectively insert therein said varistors in one combination and on its return stroke to transiently open said line circuit and to then selectively insert therein said varistors in the same or another combination, and means at the other end of said line responsive to an open circuit condition established at said one end to transmit testing current to said one end for determining the presence and polarity of said selectively inserted varistors and to register at said other end the nature of the connection established by the said selective insertion of said varistors in said line, said means responding to both the operating and return stroke operations of said keys.

2. In a signaling system, a line, a plurality of differently poled varistors at one end of said line, a plurality of keys thereat, each said key having means constructed and arranged on its operating stroke to transiently open said line circuit and to then selectively insert therein said varistors in one combination and on its return stroke to transiently open said line circuit and to then selectively insert therein said varistors in the same or another combination, and means at the other end of said line responsive to an open circuit condition established at said one end to transmit testing current to said one end for determining the presence and polarity of said selectively inserted varistors and to register at said other end the nature of the connection established by the said selective insertion of said varistors in said line, said means responding to both the operating and return stroke operations of said keys, said means comprising a set of four cold cathode tubes for each complete key operation, whereby information may be recorded in a four place permutation code.

3. In a signaling system, a line, a plurality of differently poled varistors at one end of said line, a plurality of keys thereat, each said key having means constructed and arranged on its operating stroke to transiently open said line circuit and to then selectively insert therein said varistors in one combination and on its return stroke to tran-

siently open said line circuit and to then selectively insert therein said varistors in the same or another combination, means at the other end of said line responsive to an open circuit condition established at said one end to transmit testing current to said one end and to register at said other end the nature of the connection established by the said selective insertion of said varistors in said line, said means responding to both the operating and return stroke operation of said key, registering means for each stroke operation of said key, and distributing means for effectively and sequentially introducing said registering means in circuit controlled by said test current transmitting means.

4. In a signaling system, a line, a plurality of differently poled varistors at one end of said line, means at said one end of said line for transiently opening said line and then selectively closing said open circuit through said varistors, means at the other end of said line comprising an inductance coil having a first winding in series with a source of direct current and a second winding coupled with a transient current responsive means responsive to said transient opening of said line for generating a test current comprising a simulated full cycle of alternating current, said transient current responsive means comprising a cold cathode tube responsive to the transient current generated in said second winding of said inductance coil by the transient opening of the circuit of said first winding, a transformer having a first winding energized by said cold cathode tube, a second winding for transmitting said test current and a third winding for generating a control current, a plurality of registers responsive to the reaction of said test currents to said different line conditions established at said one end of said line and a progress switch operated by said control currents for sequentially rendering said registers effective.

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