May 1, 1956 F. K. LOW 2,744,245

RECTANGULAR COORDINATE REGISTERING CIRCUIT

Original Filed Jan. 7, 1950 4 Sheets-Sheet 1

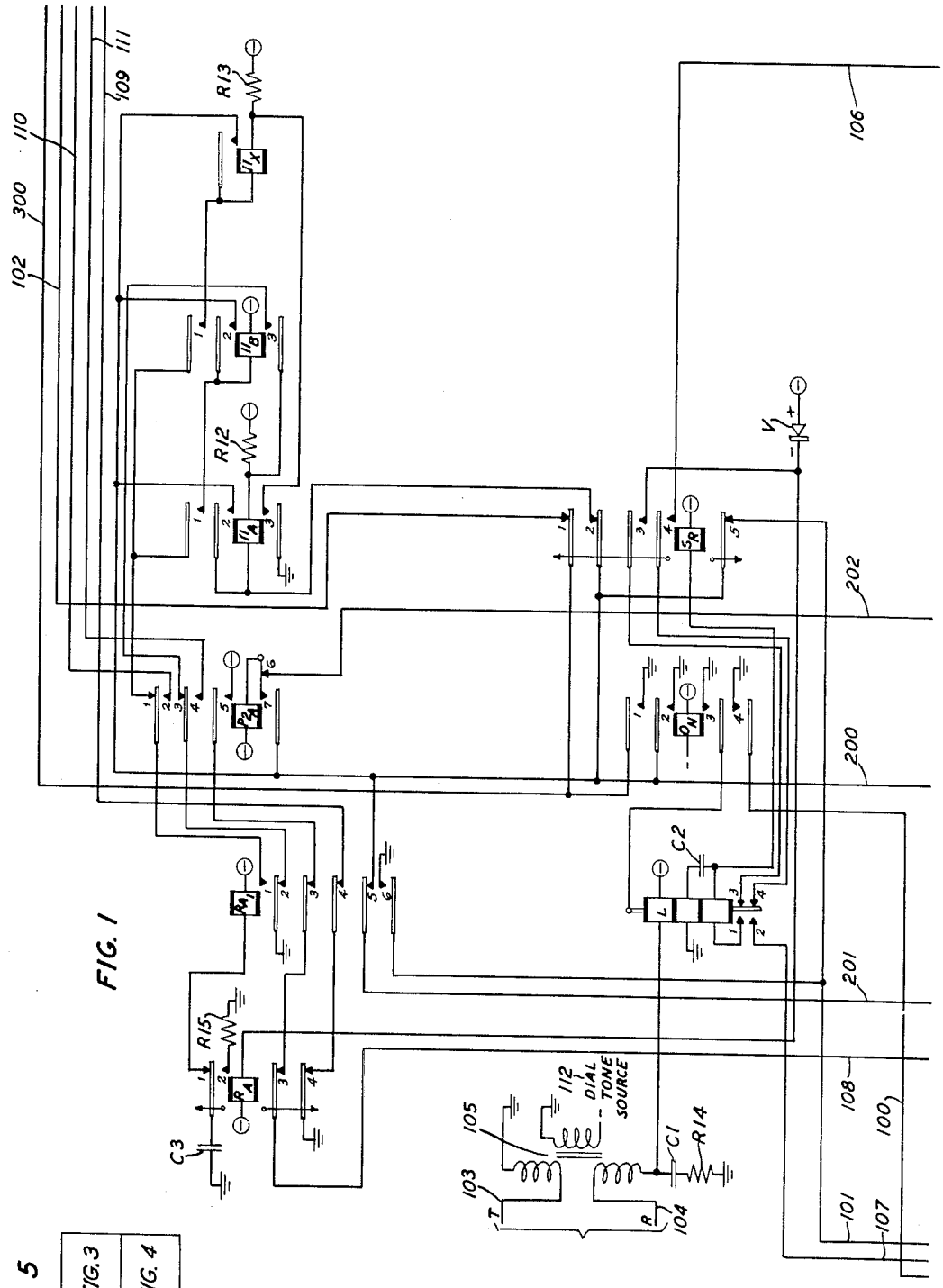

FIG. 1

FIG. 5

FIG. 1	FIG. 3
FIG. 2	FIG. 4

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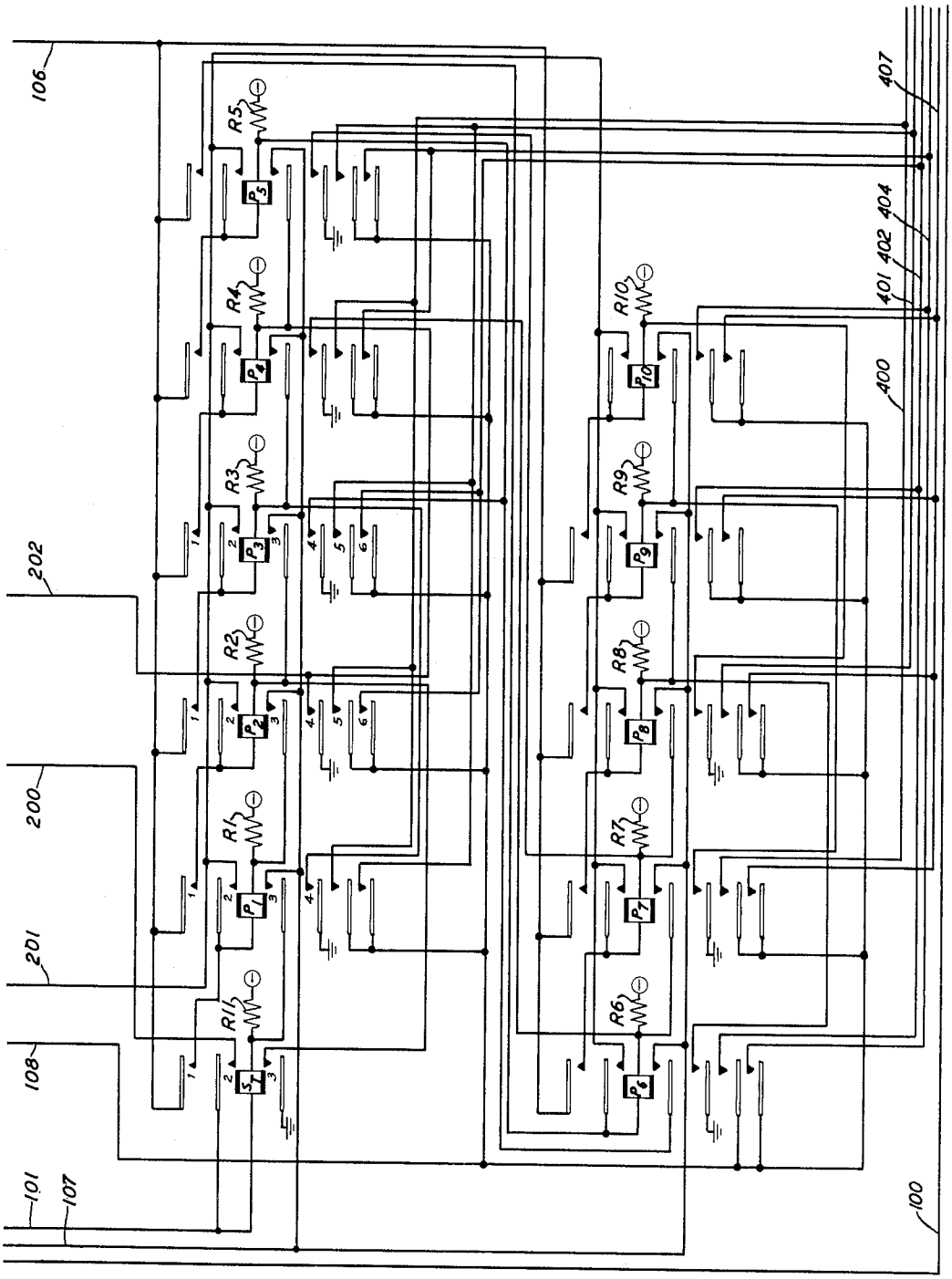

FIG. 2

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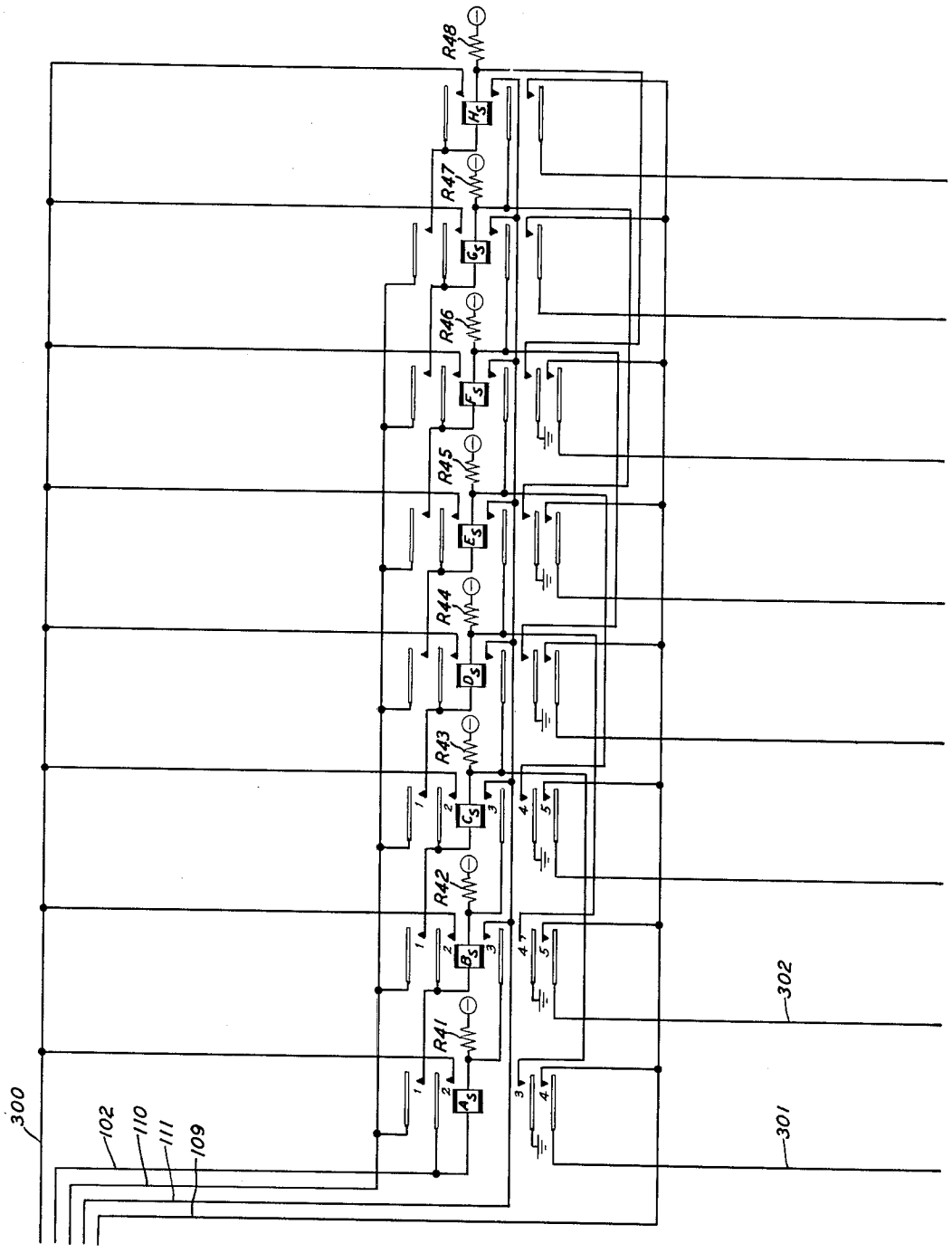

FIG. 3

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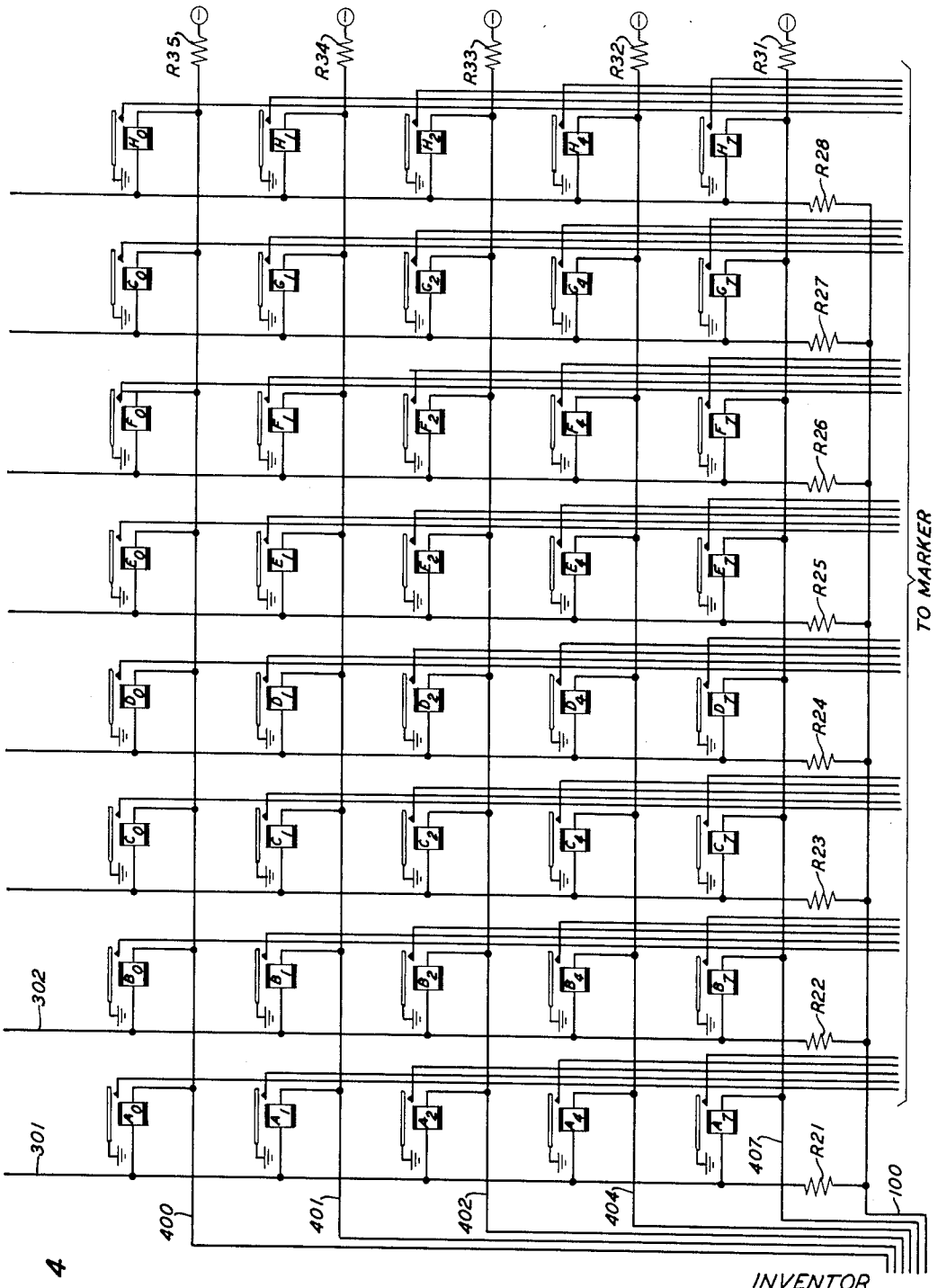

FIG. 4

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2,744,245

RECTANGULAR COORDINATE REGISTERING CIRCUIT

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Original application January 7, 1950, Serial No. 137,323, now Patent No. 2,623,114, dated December 23, 1952. Divided and this application February 16, 1952, Serial No. 271,911

2 Claims. (Cl. 340—166)

This is a division of my application Serial No. 137,323, filed January 7, 1950 for "Pulse Counting and Registering Circuit," which was issued on December 23, 1952 as Patent 2,623,114.

The present invention relates generally to registering systems and more particularly to relay circuits of the registering type.

In the telephone switching art there are numerous applications of relay circuits for counting and registering information such as digits and pulses of a digit. The present invention finds utility in such applications, in addition to others which will be suggested to those skilled in the art of relay circuits.

For a number of reasons, which will be apparent in subsequent description of a preferred embodiment of the invention, the characteristics of enclosed magnetic reed type switching elements, having only make contacts, make such elements particularly desirable as means whereby inexpensive, simple, rapidly responsive counting and registering circuits may be arranged. Such elements comprise at least two normally separated contact elements which are enclosed in an envelope which is in turn enclosed partly or wholly within an energizing coil, whereby upon the energization of the coil at least one contact element will move to make contact with the other element under the influence of the magnetic field set up by the coil and by any polarizing influence which may be used if desired. Such relays include sealed contacts among their advantages.

As a result of the problem presented of devising counting and registering circuits using relays having only make contacts, the present invention provides such circuit arrangements which permit the use of such magnetic reed relays as the preferred means to an end. However, as will be appreciated by those skilled in the art, any relays of which only the front or make contacts are used, may also serve as such means. Furthermore, the present invention is not limited to applications where only front or make contacts are used for it is entirely probable that those skilled in the art, as a result of this disclosure, will infer therefrom similar arrangements which use back contacts of relays as well as front or make contacts without going beyond the scope and spirit of the present invention.

As an exemplary disclosure of the present invention the subsequent detailed description and drawings describe and show a preferred embodiment of the invention as used in a telephone system such as is disclosed in Patent 2,585,904 to A. J. Busch of February 19, 1952 and in Patent 2,616,974 to J. W. Dehn of November 4, 1952. These systems are cross bar automatic systems which use originating register circuits, which are common to calling lines and which are used for transmitting the usual dial tone to a calling subscriber and for receiving, counting, and registering the called number digits dialed by such subscriber.

The drawings comprising a part of this disclosure show a skeletonized originating register circuit the various portions of which may be described generally as follows:

Fig. 1 shows part of the originating register termination of a calling subscriber's line, the relay L(1) of the register which follows line pulses, off-normal relay ON(1), etc.;

Fig. 2 shows a chain of relays arranged for counting the impulses in each digit;

Fig. 4 shows a group of register relays for registering on a two-out-of-five basis as many as eight digits;

Fig. 3 shows a group of steering relays for insuring that successive digits are registered in successive register relay sets, such as the A register, the B register, etc. of Fig. 4; and,

Fig. 5 shows how the other figures may be arranged to disclose the invention.

The counting circuit arrangement embodied in the 11X code prefix detecting and registering circuit in the upper right portion of Fig. 1, in the counting relay circuit of Fig. 2, and in the steering relay circuit of Fig. 3 is disclosed and claimed in my Patent 2,623,114 previously referred to.

A form of the present invention is embodied in the registering circuit of Fig. 4.

The counting circuit provides a chain circuit arrangement of relays actuated and controlled by a pulsing conductor upon which impulses are applied from a source of current, each of said relays being arranged in circuits for accomplishing the following functions when operated by an impulse over said pulsing conductor:

(1) each counting relay when operated is arranged to lock under its own control to a ground common to all;

(2) each counting relay includes contact means arranged upon the operation of said counting relay to connect the next succeeding relay to said pulsing conductor preparatory to the operation of said next succeeding relay by the next pulse on said conductor;

(3) each counting relay includes contact means arranged upon the operation of such counting relay to prepare a shunt circuit for the next preceding relay, which shunt is completed by suitable means at the end of the pulse; and,

(4) each counting relay includes contact means arranged upon the operation of said counting relay to prepare a shunt circuit for the second succeeding relay to prevent the operation of said second succeeding relay while such counting relay is operated.

The counting arrangement further provides means for completing the shunt circuit across said next preceding relay at the end of the pulse, thereby to release said next preceding relay.

The counting arrangement provides, as above outlined, relay circuit means for successively operating one relay at a time along the circuit as an indication of the accumulated count of pulses.

The present invention, as disclosed in an exemplary embodiment, provides a registering relay circuit wherein relays having only make or front contacts may be used. Each register relay has one side of its winding connected through a current limiting impedance to a first source of potential of one magnitude, such as a direct-current voltage, and the other side of its winding connected through another such impedance to a second source of potential of another magnitude, such as ground. Each digit register comprises a plurality of individual relays which are operated on a code combination basis to represent a particular digit, such as a two-out-of-five code where five such relays represent each digit register group. All the relays of a group have their other winding sides connected in the above fashion to the same second source. Each of the first, second, third, etc. relays of all groups have their one winding sides connected to the same first-first source,

second-first source, third-first source, etc. in the above fashion. Thus at all times when such register relays are in use each relay winding carries a current limited by the two impedances in series therewith. This current is of a magnitude which is not sufficient to operate a relay but is sufficient to hold a relay operated once it has been operated. This current is designated the "holding" current. Means is provided for momentarily applying said second source of potential, say ground, directly to the other side of all relays of a particular group and for momentarily applying said first source of potential, say battery, directly to the one side of a combination of first, second, third, etc. relays of all groups. The result is that only that combination of relays will be operated which have applied directly to their windings both sources of potential thereby to increase the current flowing through such windings to the "operate" value. All other relays will carry increased current due to the application to one side or the other, but not both, of their windings the respective sources of potential. These latter relays will carry a current greater than the "holding" value but less than the "operate" value and will not operate. At the end of the momentary selective application of said potential all relays will revert to a condition whereunder they carry only "holding" current, which, of course, retains operated only that combination of relays of a group which were operated as above outlined.

The invention above outlined provides a relay register circuit wherein only relays having make contacts may be used.

The principles of the invention will be understood best from the subsequent detailed description of preferred embodiments thereof.

GENERAL DESCRIPTION

The present invention is herein described as embodied in an originating register circuit of a cross-bar system of the type disclosed in detail in Patent 2,585,904 to A. J. Busch of February 19, 1952. The present disclosure concerns only certain portions of such an originating register, which portions are disclosed in Patent 2,616,974 to J. W. Dehn of November 4, 1952. The Dehn disclosure is considerably simplified and skeletonized, as compared to the complete Busch disclosure, and will afford sufficient information upon which one skilled in the art may rely to appreciate the advantages of the present invention as embodied, by example, in such systems.

A general description of some of the functions of an originating register circuit as employed by Busch or Dehn is considered desirable before going into the details of an exemplary disclosure of the present invention. When a calling subscriber initiates a call, common control equipment, termed a marker, is brought into service to interconnect such subscriber with an originating register circuit. This register circuit is arranged to provide the usual dial tone signal to the subscriber as a directive to commence the dialing of the called number. As the subscriber dials the digit or digits indicative of the desired interconnection the register is arranged to count the pulses in each separate digit, to register each digit separately, and, at the proper time depending upon the type of call indicated by such digit or digits, to seize an idle marker circuit to which the called digit or digits are transferred along with other information required by such marker in performing the switching functions required to effect the desired connection. When the marker has received all of the information registered in the originating register, the marker releases the register circuit to normal and proceeds with subsequent functions of no particular importance in understanding the present invention.

The following detailed description, including the above-described drawings forming a part thereof, is confined to the digit counting, digit steering, and digit registering operations performed by the originating register prior to the seizure of an idle marker for the purpose of completing the desired connection. All circuit operations prior to the seizure of an idle originating register and just prior to the seizure by the register of an idle marker have been omitted as unnecessary, the above Busch and Dehn disclosures providing complete details not shown or described herein.

It has been mentioned above that the present invention permits the use at strategic points in the originating register circuit of relays which have only make contacts; and, whereas it is to be understood that the present invention is not limited to any specific type or types of such relays, nevertheless the preferred types of such relays are those disclosed in Patents 2,187,115 to W. B. Ellwood and W. H. T. Holden of January 16, 1940 and 2,289,830 to W. B. Ellwood of July 14, 1942. These latter types of relays are sealed magnetic reed type relays. Where only one pair of make contacts is required, two magnetic reeds are enclosed in an evacuated glass envelope which is in turn enclosed in an energizing coil. If a plurality of make pairs are required, several such single units may be enclosed in a single coil, etc. These reed type relays are preferred for use according to the present invention because of their desirable characteristics such as sealed contacts, fast response (approaching that of gas tubes), and relatively low cost. The speed of response, both as to operation and release, of these reed type relays, as will be appreciated, will afford, among other advantages, the possibility of realizing much higher dial speeds than would be possible with conventional general purpose relays. It is to be repeated, however, that the present invention is in no way limited to any specific type or types of relays.

DETAILED DESCRIPTION

Seizure of originating register

Upon the seizure of an idle originating register by a marker circuit, the off-normal relay ON(1) in the originating register is operated. Relay ON(1), upon operating, completes a circuit from ground, over its contact 4, and conductor 100 to the digit register relay network in Fig. 4. It will be seen from an inspection of the arrangement shown in Fig. 4 that at this time parallel circuits are completed for permitting current to flow through the windings of all of the register relays A0(4) through H7(4) inclusive. Ground on conductor 100 is applied through resistance R21(4) to the left side of the windings of the A digit register relays A0(4) to A7(4). Ground on conductor 100 is likewise supplied to the windings of the B, C, D, E, F, G and H digit registers through respective resistances R22(4) through R28(4). The right sides of the windings of relays A0(4), B0(4), C0(4), etc. and H0(4) are supplied by battery through resistance R35(4). Likewise, relays A1(4) through H1(4) are supplied by battery through resistance R34(4), etc. The various resistances, windings, and voltages are arranged such that there is insufficient current flowing in any winding to operate the associated register relay. This current will be referred to hereinafter as the "holding" current.

Relay ON(1), upon operating, operates the start relay ST(2) in the pulse counting circuit of Fig. 2 in a circuit extending from ground, over contact 2 of relay ON(1), contact 5 of the slow-releasing relay SR(1), conductor 101, through the winding of relay ST(2), to battery through resistance R11(2). Relay ST(2) operates and locks over its contact 2, conductor 200, to ground over contact 2 of relay ON(1). The relay ST(2) is the start relay of the pulse counting chain shown in Fig. 2 as comprising relays P1(2) to P10(2) in addition to relay ST(2). Relay ST(2) is operated and locked, as above, to prepare the counting chain for the reception of the first pulse of the first digit to be dialed by the calling subscriber.

Relay ON(1), upon operating, operates relay 11A(1) in a circuit extending from ground, over contact 2 of relay ON(1), contact 2 of relay SR(1), winding of relay

11A(1), to battery through resistance R12(1). Relay 11A(1) operates and locks over its contact 2, to ground over contact 2 of relay ON(1). Relay 11A(1) is operated in order to condition the group of relays 11A(1), 11B(1), and 11X(1) preparatory to the recognition of a single initial pulse, which will be absorbed, or of two initial digits of the value of one pulse each, which will indicate that the called number involves an 11X toll directing prefix or special service code where X may be any digit from 2 to 9.

Relay ON(1), upon operating, operates the steering relay AS(3), associated with the register relays A0(4) to A7(4), in a circuit extending from ground, over contact 1 of realy ON(1), contact 1 of relay SR(1), conductor 102, winding of relay AS(3), to battery through the resistance R41(3). Relay AS(3) operates and locks over its contact 2, conductor 300, to ground over contact 1 of relay ON(1). Relay AS(3), upon operating, prepares the register relay network of Fig. 4 for registration of the first digit (unless it be a digit 1 as above) in the A digit register relays A0(4) to A7(4).

Preparation of originating register for counting digits

Subsequent to the seizure by a marker of the originating register and the operation of the off-normal relay ON(1) therein with the results effected thereby, as above described, the marker will effect the necessary switching operations to interconnect the calling subscriber's line circuit with the seized originating register, whereupon the marker will release. The details of such switching functions may be obtained from the above Busch disclosure. Upon the completion of such interconnection a circuit is completed for operating the relay L(1) from battery, through the upper winding of relay L(1), through the lower left winding of the dial tone transformer 105, over the ring conductor 104 of the trunk link frame switch terminating the originating register, through the switch train to the ring conductor of the calling line, over the closed line loop, back over the tip conductor of the calling line, through the switch train, over the tip conductor 103 of the trunk link frame switch, through the upper left winding of the dial tone transformer 105, to ground. Relay L(1) operates in the above-traced circuit.

Relay L(1), upon operating, moves its armature from the normal released position thereof, as shown in contact with contacts 3 and 4 of relay L(1), to the operated position thereof in contact with contacts 1 and 2 of relay L(1). Relay SR(1) is thereupon operated in a circuit extending from ground, over contact 3 of relay ON(1), armature and contact 1 of relay L(1), through the lower low resistance winding of relay L(1), to battery through the winding of relay SR(1).

At this point relays ON(1), L(1), SR(1), ST(2), 11A(1), and AS(3) are operated, the latter three relays remaining operated under the control of the off-normal relay ON(1) upon the abovedescribed operation of relay SR(1).

A dial tone signal is supplied to the calling subscriber from the source 112 thereof through the right primary winding of the dial tone transformer 105, by induction into the upper and lower left secondary windings of transformer 105, and over the subscriber's line by way of the switch train. The subscriber may now dial the digits of the called number.

Absorbing initial digit of one pulse

It is well known that when a subscriber dials, the mechanism at his substation produces a momentary open condition in the line loop followed by a closure thereof for each pulse of each digit and that the line closures between pulses of a digit are much shorter in duration than the closures thereof between digits.

If by accident, or otherwise, an initial digit of one pulse is transmitted, the originating register is arranged to absorb this pulse on the assumption that it is transmitted or created in error. The circuit is arranged, however, as previously indicated, to recognize a first digit of one pulse followed by a second digit of one pulse as a legitimate indication that a special 11X code is to be transmitted, and prepares itself to register successive digits.

The structure of the relay L(1) is preferably, but not necessarily, of the mercury contact type similar to the structure of the mercury contact relay disclosed in Patent 2,577,602 to E. T. Burton of December 4, 1951. The armature of relay L(1) is biased towards its contacts 3 and 4 as has been mentioned. This bias, as in the type of relay disclosed by Burton, may be both partly mechanical due to the usual spring and partly magnetic due to the presence of a permanent magnet, if desired, influencing contacts 3 and 4. When relay L(1) is operated, under closed loop conditions, the current flow through the lower winding in series with relay SR(1) is arranged to counteract partly the effect of the current flowing through the upper winding. This, in effect, increases the total bias tending to release the armature when relay L(1) is operated. This is to improve the releasing response of relay L(1), thereby aiding its performance under line conditions which tend to retard the release of relay L(1). The purpose of the middle winding in series with condenser C2(1) is well known to provide a measure of pulse correction action, as described for instance in Patent 2,029,723 to L. H. Johnson and F. K. Low of February 4, 1936.

Upon the release of relay L(1), during the first open loop period of the first digit, relay RA(1) is operated in a circuit extending from ground, over contact 3 of relay ON(1), armature of relay L(1), contact 3 of relay L(1), contact 3 of relay SR(1), to battery through the winding of relay RA(1). Relay RA(1), upon operating, completes, at its contact 2, an obvious circuit for discharging any charge which may have been accumulated on condenser C3(1), the importance of which function will be evident from subsequent description. The operating ground for relay RA(1) grounds the left side of the unidirectional current carrying element V(1), which is arranged in the circuit to represent a low impedance shunt across the winding of relay RA(1) when the ground is removed, thereby retarding the release of relay RA(1). Relay RA(1) remains operated during the interval between pulses of a digit; but, relay RA(1) will release during the interdigital period. Relay SR(1) remains operated, due to its slow-release characteristic, during open loop periods when relay L(1) is released.

Relay L(1), upon releasing, operates the first counting relay P1(2) in a circuit extending from ground, over contact 3 of relay ON(1), armature of relay L(1), contact 4 of relay L(1), contact 4 of relay SR(1), conductor 106, contact 1 of relay ST(2), winding of relay P1(2), to battery through the resistance R1(2). Relay P1(2) operates and locks over its contact 2, conductor 201, contact 5 of relay RA1(1), to ground over contact 2 of relay ON(1).

When relay P1(1) operates at this time, the following functions are performed:

(1) the operating ground for relay P1(2) on conductor 106 is extended over contact 1 of relay P1(2) to the left side of the winding of relay P2(2), relay P2(2) not being able to operate because the right side of its winding is shunted to ground over contact 3 of relay ST(2);

(2) contact 3 of relay P1(2) is closed to partly establish a shunting ground circuit (which will be completed when relay L(1) reoperates at the end of the pulse from the armature of relay L(1), contact 2 of relay L(1), conductor 107, contacts 3 of relay P1(2), to the right side of the winding of relay ST(2)) for releasing relay ST(2) by shunting it down when relay L(1) reoperates; and,

(3) contact 4 of relay P1(2) is closed to extend ground to the right side of the winding of relay P3(2), thereby to prevent the operation of relay P3(2) when and if relay P2(2) operates during a second pulse.

When relay L(1) reoperates, upon the closure of the line loop at the end of the first pulse, relay SR(1) is re-energized and the operating circuit for relay RA(1) is opened, relay RA(1) remaining operated under the control of element V(1) as above described. Relay L(1), upon reoperating, extends ground over its contact 2, conductor 107, contact 3 of relay P1(2), to the right side of the winding of relay ST(2), thereby shunt releasing relay ST(2). Relay ST(2), upon releasing, removes, at its contact 3, the above-mentioned ground from the right side of the winding of relay P2(2), thereby permitting relay P2(2) to operate upon the next release of relay L(1), if any, representing a second pulse of the first digit.

Since it has been assumed that the first digit contains one pulse, relay L(1) will remain operated long enough to permit relay RA(1) to release. Relay RA(1), upon releasing, connects the discharged condenser C3(1) in series, over contact 1 of relay RA(1), with battery through the winding of relay RA1(1). Relay RA1(1) will be operated by the transient charging current and will release when the charging current has been reduced below the releasing current value for relay RA1(1), even though relay RA(1) may remain released.

Relay RA1(1), while operated, releases relay P1(2) by removing ground from conductor 201 and reoperates relay ST(2) by applying ground to conductor 101 over contact 6 of relay RA1(1). Relay ST(2), as before, locks to off-normal ground on conductor 200. Relay RA1(1), while operated, completes a circuit for operating relay 11B(1) from ground, over contact 1 of relay RA1(1), contact 1 of relay P2A(1), contact 1 of relay 11A(1), to battery through the winding of relay 11B(1). Relay 11B(1) operates and locks over its contact 2, to off-normal ground over contact 2 of relay ON(1). The operating ground for relay 11B(1) is extended over contact 1 of relay 11B(1) to the left side of the winding of relay 11X(1) but the latter relay cannot operate because the right side of its winding is shunted to ground over contact 3 of relay 11A(1).

When relay RA1(1) releases, relay 11A(1) is shunt-released by ground, over contact 2 of relay RA1(1), contact 3 of relay P2A(1), contact 3 of relay 11B(1), to the right side of the winding of relay 11A(1). Relay 11A(1), upon releasing, removes at its contact 3 the shunting ground on the right side of the winding of relay 11X(1) so that the latter may operate if the second digit is also composed of only one pulse. During the interval following the release of relay RA(1) and ending with the subsequent operation of relay RA1(1), ground is applied over contact 4 of relay RA(1), contact 4 of relay RA1(1), conductor 109, contact 4 of relay AS(3), conductor 301 to the left sides of the windings of relays A0(4Q to A7(4). While this ground increases the current flowing in their windings, such current is not increased to the "operate" value for such relays and none of their relays operate. Thus it will be appreciated that the counting of the digit 1 as an initial digit has not affected the digit registers of Fig. 4 and has in fact been absorbed.

An 11X code

If the second digit is also merely composed of one pulse, this is assumed not to be an accident but is assumed to be the second of two initial digits preceding a third digit of from 2 to 9 which is a legitimate called code. Upon the release of relay L(1), in response to the first open loop period of the second digit, relays RA(1) and P1(2) are reoperated as before. When relay RA(1) reoperates it discharges condenser C3(1). When relay L(1) reoperates at the end of the pulse relay ST(2) is again released. If, as assumed, relay L(1) remains reoperated for a length of time indicative of an interdigital pause, relay RA(1) again releases to reoperate momentarily relay RA1(1) as above described. Relay RA1(1), upon reoperating momentarily, again releases relay P1(2), reoperates and locks relay ST(2), and operates relay 11X(1) in a circuit extending from ground, over contact 1 of relay RA1(1), contact 1 of relay P2A(1), contact 1 of relay 11B(1), through the winding of relay 11X(1), to battery through the resistance R13(1). Relay 11X(1) operates and locks over its contact to off-normal ground over contact 2 of relay ON(1). Relays 11B(1) and 11X(1) remain operated to inform the marker at a later time, through the medium of other contacts (not shown) on relay 11X(1), that this is an 11X code call.

When relay RA1(1) releases the circuits will be prepared to receive the X digit of 2 to 9 which will be handled by the counting and registering circuits as though it were an initial digit. As will be shown hereinafter, when a digit of two pulses or greater is counted, relay P2A(1) will be operated and locked to off-normal ground thereby disabling, at its contacts 1 and 3, the above-described initial one-pulse digit absorption and 11X features.

Counting, steering and registering first digit (exclusive of a 1 or an 11 prefix

It will be recalled that when relay L(1) reoperated at the end of the first pulse of the first digit, relays RA(1), L(1), SR(1), P1(2), and 11A(1) were operated.

It will be assumed that the first digit, exclusive of a 1 or an 11 prefix, is one containing two pulses and that therefore the second pulse will be received by relay L(1) before relay RA(1) can release.

When relay L(1) releases in response to the second open loop period of the second pulse, relay RA(1) is reenergized as before to insure its remaining operated. Relay L(1), upon releasing, operates counting relay P2(2) in a circuit extending from ground, over contact 3 of relay ON(1), armature of relay L(1), contact 4 of relay L(1), contact 4 of relay SR(1), pulsing conductor 106, contact 1 of relay P1(2), winding of relay P2(2), to battery through the resistance R2(2). Relay P2(2) operates and locks over its contact 2, conductor 201, contact 5 of relay RA1(1), to ground over contact 2 of relay ON(1).

When relay P2(2) operates the following functions are performed:

(1) the operating ground for relay P2(2) on conductor 106 is extended over contact 1 of relay P2(2) to the left side of the winding of relay P3(2), relay P3(2) not being able to operate because the right side of its winding is shunted to ground over contact 4 of relay P1(2);

(2) Contact 3 of relay P2(2) is closed to partly establish a shunting ground circuit (which will be completed over conductor 107 when relay L(1) reoperates at the end of the pulse) for shunt-releasing relay P1(2) when relay L(1) reoperates;

(3) Contact 4 of relay P2(2) is closed to extend ground to the right side of the winding of relay P4(2), thereby to prevent the operation of relay P4(2) when and if relay P3(2) operates during a third pulse; and,

(4) Contact 4 of relay P2(2) grounds a circuit for operating relay P2A(1) extending from ground, over contact 4 of relay P2(2), conductor 202, contact 6 of relay P2A(1), to battery through the winding of relay P2A(1), whereupon relay P2A(1) operates and locks over its contact 7 to off-normal ground over contact 2 of relay ON(1).

When relay L(1) reoperates at the end of the second pulse, relay P1(2) is shunt-released by ground, over contact 2 of relay L(1), conductor 107, contact 3 of relay P2(2), to the right side of relay P1(2).

At the end of the digit, relay RA(1) releases as above described to operate relay RA1(1) momentarily as also described previously. During the interval of time inherently necessary for any relay to operate there will be a short period of time when the back contacts 3 and 4 of relay RA (1) are closed and the back contacts 3 and 4 of relay RA1(1) are also closed, due to the inherent operating time of relay RA1(1). During this interval the digit

2 which has been counted by the counting chain of Fig. 2 must be steered to and registered in the A digit register relays A0(4) to A7(4). As will be appreciated, the digit value as counted is represented by one operated relay, such as relay P2(2), out of ten such relays; whereas, the digit registers of Fig. 4 are arranged to register digits on a two-out-of-five code basis, which code is illustrated by the table below, taking the A digit register as an example:

Digit	Relays Operated	Digit	Relays Operated
1	A0(4)—A1(4)	6	A2(4)—A4(4)
2	A0(4)—A2(4)	7	A3(4)—A4(4)
3	A1(4)—A2(4)	8	A1(4)—A7(4)
4	A0(4)—A4(4)	9	A2(4)—A7(4)
5	A1(4)—A4(4)	0	A4(4)—A7(4)

From an inspection of Fig. 4 it will be appreciated that the relays A0(4) to H0(4) can be operated over conductor 400, relays A1(4) to H1(4) over conductor 401, relays such as A2(4) over conductor 402, relay A4(4) over conductor 404, and relay A7(4) over conductor 407. These five conductors are connected to contacts of the counting relays such that upon the operation of one of such relays, say relay P2(2), only two conductors of the five will be arranged to have battery applied thereto as will be explained. Needless to say the two conductors energized will conform to the above code according to the digit represented by the counting relay operated. Battery is supplied over contact 5 of relay P2A(1), contact 3 of relay RA1(1), contact 3 of relay RA(1), conductor 108, contacts 5 and 6 of relay P2(2), to conductors 400 and 402. Battery on conductors 400 and 402 is extended to the right sides of all relays A0(4) to H0(4) and A2(4) to H2(4). At the same time ground is supplied over contact 4 of relay RA(1), contact 4 of relay RA1(1), conductor 109, contact 4 of the A digit steering relay AS(3), conductor 301 to the left sides of all of the A digit register relays A0(4) to A7(4). Thus the only register relays of Fig. 4 which are supplied by both solid ground and solid battery are relays A0(4) and A2(4). These relays thereupon operate to register the first digit, exclusive of a 1 or an 11 prefix, the current through these relays being referred to as the "operate" current. The increases of current through the relays A1(4), A4(4), A7(4), B0(4) to H0(4) and B2(4) to H2(4) are not sufficient to operate these others and such current is referred to as the "non-operate" current.

When relay RA1(1) operates momentarily, as a result of the previously described charging of condenser C3(1), the above-described solid battery and solid ground supplies for the register relays of Fig. 4 are opened at contacts 3 and 4 of relay RA1(1). The current flowing in the windings of relays A0(4) and A2(4) therefore drops to the previously described "holding" current value as limited by resistance R21(4) in the ground supply over conductor 100 and by resistances R35(4) and R33(4) in the battery supplies. This current is insufficient to operate a relay of Fig. 4 but is sufficient to hold operated any such relays, such as relays A0(4) and A2(4), which have been operated.

Relay RA1(1), upon operating as previously described, releases relay P2(2) and reoperates and locks relay ST(2) preparatory to counting the next digit.

Relay RA1(1), upon operating, advances the steering circuit of Fig. 3 to permit the operation of the B register relays according to the next digit. Relay BS(3) is operated in a circuit extending from ground, over contact 1 of relay RA1(1), contact 2 of relay P2A(1), conductor 110, contact 1 of relay AS(3), winding of relay BS(3), to battery through resistance R42(3), and relay BS(3) locks over its contact 2 to off-normal ground on conductor 300. As was the above-described case with the operating of counting relays of Fig. 2, the operation of relay BS(3) accomplishes the following functions:

(1) prepares at its contact 1 a circuit for operating relay CS(3) at the end of the second digit registration, relays CS(3) not being able to operate at this time because of the ground shunt on the right side of its winding from contact 3 of relay AS(3);

(2) prepares at its contact 3 a circuit for shunt-releasing relay AS(3) upon the release of relay RA1(1);

(3) grounds at its contact 4 the right side of the winding of relay DS(3) to prevent the operation of relay DS(3) when and if relay CS(3) operates later; and,

(4) prepares at its contact 5 a circuit for operating the B digit register relays B0(4) to B7(4) according to the pulse count registered in the counting relays of Fig. 2 at the end of the second digit.

Upon the eventual release of relay RA1(1), at the end of the transient period above described, relay AS(3) is shunt-released by ground, over contact 2 of relay RA1(1), contact 4 of relay P2A(1), conductor 111, over contact 3 of relay BS(3) to the right side of the winding of relay AS(3). Relay AS(3), upon releasing, removes at its contact 3 the previous ground shunt on the right side of the winding of relay CS(3), thereby enabling relay CS(3) to operate over contact 1 of relay BS(3) at the end of the second digit. Relay AS(3), upon releasing, opens, at its contact 4, the circuit including conductor 301 to prevent any undesired effects upon relays A0(4) to A7(4) upon subsequent grounding of conductor 109 for registering purposes.

The A digit, assumed to be 2, has now been registered in relays A0(4) and A2(4), the digit-steering circuit of Fig. 3 has been advanced preparatory to registering the second digit, the pulse counting circuit of Fig. 2 has been restored to normal, and the interdigital timing relay RA(1) and auxiliary relay RA1(1) have been released so that the entire circuit is prepared to receive, count, steer, and register the second digit.

Counting, steering and registering the second digit

Let it be assumed that the second digit is composed of three pulses. In the manner described above regarding the first digit of two impulses, relay L(1) will release and reoperate in response to each pulse.

Upon the release of relay L(1), responsive to the open loop period of the first pulse, relay RA(1) reoperated as above described thereby opening the operating circuits for the register relays of Fig. 4 and discharging condenser C3(1). The first release of relay L(1) operates and locks operated relay P1(2) as aboved described. Upon the reoperation of relay L(1), at the end of the first pulse, relay ST(2) is shunt-released.

Upon the release of relay L(1), responsive to the open loop period of the second pulse, relay P2(2), is operated and locked, the operated relay P1(2) preventing relay P3(2) from also operating as above described. At the end of the second pulse, when relay L(1) reoperates, relay P1(2) is shunt-released thereby conditioning relay P3(2) for operation during the third pulse, if any.

When relay L(1) releases during the third pulse, relay P3(2) is operated in a circuit extending from ground, over contact 3 of relay ON(1), armature of relay L(1), contact 4 of relay L(1), contact 4 of relay SR(1), conductor 105, contact 1 of relay P2(2), winding of relay P3(2), to battery through resistance R3(2). Relay P3(2) operates and locks over its contact 2 to off-normal ground on conductor 201. Relay P4(2) cannot operate at this time due to the ground shunt on the right side of its winding from contact 4 of relay P2(2). Relay P3(2), upon operating, applies ground over its contact 4 to the right side of the winding of relay P5(2) to prevent the operation of the latter should relay P4(2) be operated in response to a fourth pulse. Relay P3(2), upon operating, also prepares at its contact 3 a shunt circuit for shunt-releasing relay P2(2) upon the reoperation of relay L(1) at the end of the third pulse.

When relay L(1) reoperates at the end of the third

pulse, relay P2(2) is shunt-released. When relay L(1) remains operated for a length of time which indicates an interdigital pause, relay RA(1) releases as above described.

Upon the release of relay RA(1), and prior to the momentary operation of relay RA1(1), ground is applied over contact 4 of relay RA(1), contact 4 of relay RA1(1), conductor 109, contact 5 of relay BS(3), conductor 302, to the left sides of relay B0(4) to B7(4), and battery is applied over contact 5 of relay P2A(1), contact 3 of relay RA1(1), contact 3 of relay RA(1), conductor 103, contacts 5 and 6 of relay P3(2), conductors 401 and 402, to the right sides of relays A1(4) to H1(4) and A2(4) to H2(4). As previously explained, all of the relays B0(4) to B7(4) will carry increased current due to the solid ground applied to the left sides of their windings over conductor 302 and all of the relays A1(4) to H1(4) and A2(4) to H2(4) will carry increased current due to the solid battery applied to the right sides of their windings over conductors 401 and 402. Only relays B1(4) and B2(4) have the benefit of both increases, thereby increasing the current flowing therethrough to the "operate" value, whereupon relays B1(4) and B2(4) operate. The remaining relays, such as B0(4), B4(4), B7(4), A1(4), C1(4) to H1(4), and C2(4) to H2(4), carry increases of current only of the "non-operate" value and will not operate. Relay A2(4) is already operated responsive to the registration of the first digit 2, and will remain operated.

As soon as relay RA1(1) operates momentarily, relay P3(2) is released and relay ST(2) is reoperated and locked as before to return the counting chain of Fig. 2 to normal preparatory to registering the third digit.

Relay RA1(1), upon operating, removes the solid ground and battery from the operating circuits of the register relays of Fig. 4 whereupon relays A0(4), A1(4), B1(4) and B2(4) remain operated due to the "holding" current flowing therethrough as limited by resistances R35(4), R34(4), R33(4), R21(4), and R22(4).

Relay RA1(1), upon operating, advances the steering relays of Fig. 3. Relay CS(3) operates in a circuit extending from ground, over contact 1 of relay RA1(1), contact 2 of relay P2A(1), conductor 110, contact 1 of relay BS(3), winding of relay CS(3), to battery through resistance R43(3). Relay CS(3) locks over its contact 2 to off-normal ground on conductor 300. Relay DS(3) cannot operate at this time because the right side of its winding is shunted to ground over contact 4 of relay BS(3).

Relay CS(3), upon operating, performs the following functions:

(1) at its contact 1 prepares the operating circuit for relay DS(3) to be completed at the end of the third digit;

(2) at its contact 3 prepares the releasing shunt for relay BS(3) to be completed when relay RA1(1) releases;

(3) at its contact 4 applies ground to the right side of the winding of relay ES(3) to prevent the operation thereof when relay DS(3) operates at the end of the third digit; and,

(4) at its contact 5 prepares the circuit whereby the C digit will be registered in the relay group C0(4) to C7(4).

Upon the release of relay RA1(1), at the end of the transient period of operation, relay BS(3) is shunt-released in an manner similar to that previously described in connection with the release of relay AS(3).

All of the circuits are now in condition for receiving, counting, steering, and registering the next digit. It is not considered necessary to repeat the above description for the succeeding digits, since the operation of the circuits is the same. Any number of digits may be counted, steered, and registered in this manner, provision for eight such digits (exclusive of a 1 or 11 prefix) having been shown.

Release of originating register

When sufficient digits have been registered to warrant the seizure of a marker for completing the desired connection, a marker start-seizure circuit (not shown) is completed in a manner similar to that described by Dehn or Busch, previously identified. As will be appreciated, one of the steering relays AS(3) to HS(3) operates as an indication that the preceding digit has been registered. For instance, relay BS(3) operates after the first digit has been registered, relay CS(3) operates after the second digit has been registered, etc., and relay HS(3) operates to indicate that the seventh digit has been registered. As described by Dehn or Busch, the marker seizure may be effected under the control of such steering relays, for instance upon the operation of relay HS(3) as an indication that a full seven-digit number has been registered.

If the marker seizure start circuit should need to be completed at an earlier stage for 11X codes, it is of course obvious that the operation of relay 11X(1) can close such a circuit in cooperation with relay BS(3), the latter relay operating as an indication that the X digit is registered in the A digit register of Fig. 4. Numerous other combinations of such start signal may be produced as will be apparent from Dehn and Busch.

When the marker is seized, the information registered in Fig. 4, along with other information of no particular importance to the present invention, is transferred to register relays in the marker circuit as indicated at the bottom of Fig. 4, "To Marker."

When the seized marker is satisfied, by suitable well-known check circuits, that it has received all of the necessary information from the originating register circuit, the off-normal relay ON(1) in the latter circuit is released, thereby releasing the entire originating register circuit to normal.

It is to be understood that the above-described arrangements are merely illustrative of the application of the principles of the invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the present invention.

What is claimed is:

1. In a register circuit, a plurality of relay windings arranged into first groups each including a number of different windings and arranged into second groups each including a number of windings each one from a different first group, a first resistance for each first group, a second resistance for each second group, one side of each winding of each first group connected through its associated first resistance to a potential of one magnitude, the other side of each winding of each second group connected through its associated second resistance to a potential of a different magnitude, whereby each winding carries a holding current limited by both a first and a second resistance, said holding current being insufficient to operate a relay but sufficient to hold a relay operated, means for selectively and momentarily applying said one potential directly to the said one side of all windings of any one first group and for selectively and momentarily and concurrently applying said different potential directly to said other sides of all windings of one or more second groups, whereby only windings common to said latter mentioned first group and second group or groups carry increased current sufficient to operate the relays associated with said common windings, said operated relays remaining operated due to said holding current after the lapse of said momentary period.

2. In a register circuit, a plurality of relay windings arranged into first groups each including the same number of different windings and arranged into second groups each including one different winding from each first group, a first resistance for each first group, a second resistance for each second group, one side of each winding of each first group connected through its associated first resistance

to a potential of one magnitude, the other side of each winding of each second group connected through its associated second resistance to a potential of a different magnitude, whereby each winding carries a holding current limited by both a first and a second resistance, said holding current being insufficient to operate a relay but sufficient to hold a relay operated, means for selectively and momentarily applying said one potential directly to the said one side of all windings of any one first group and for selectively and momentarily and concurrently applying said different potential directly to said other sides of all windings of a combination of second groups, whereby only said combination of windings of said one

first group carry increased current sufficient to operate the associated combination of relays, said operated relays remaining operated due to said holding current after the lapse of said momentary period.

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