

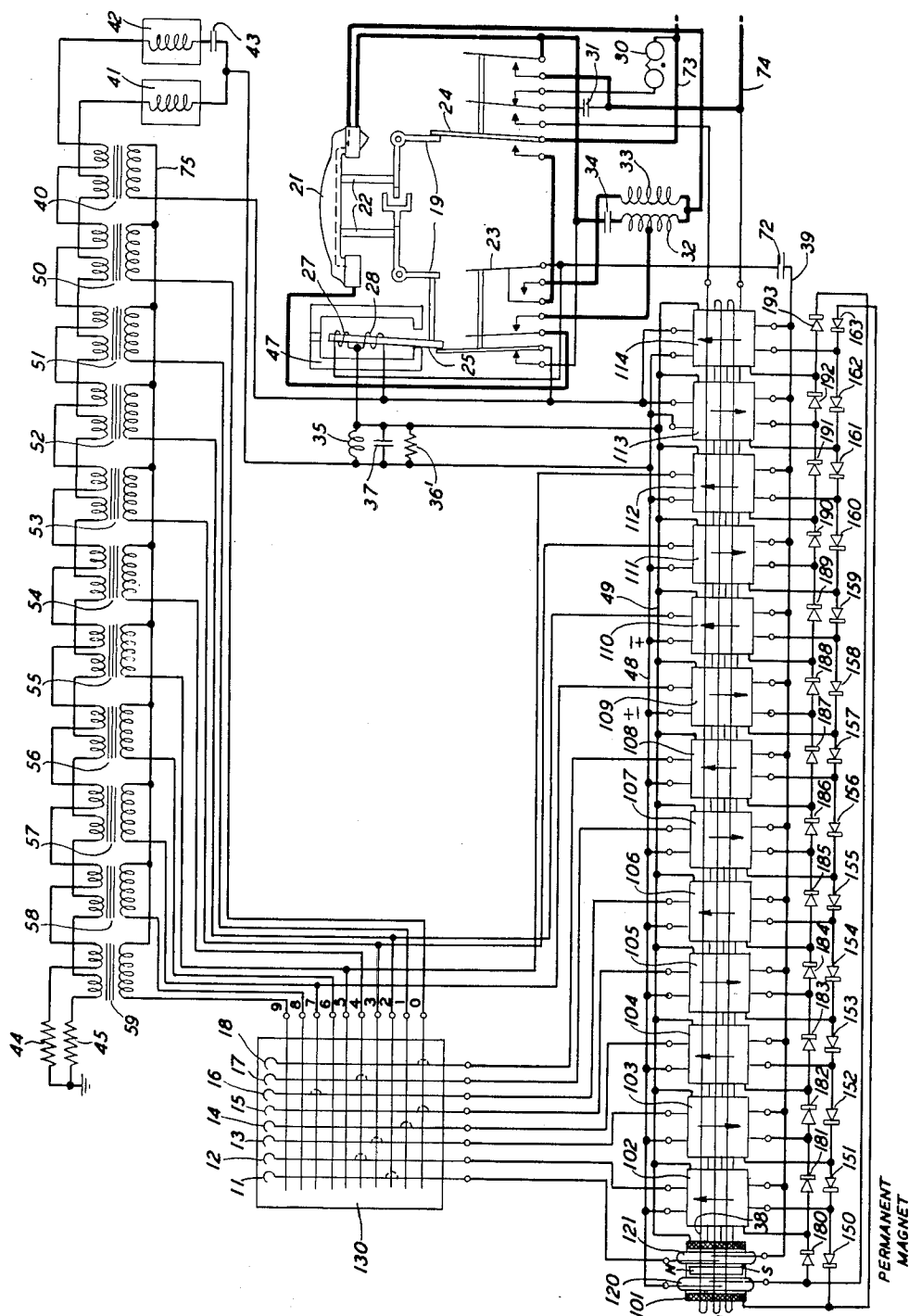
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ALTERNATING-CURRENT OPERATED RELAY DISTRIBUTOR

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ALTERNATING-CURRENT OPERATED RELAY DISTRIBUTOR

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Original application September 10, 1949, Serial No. 115,016, now Patent No. 2,598,695, dated June 3, 1952. Divided and this application March 5, 1952, Serial No. 274,962

6 Claims. (Cl. 317—146)

This invention relates to relay stepping circuits or distributors, methods of control and operation thereof and more particularly to alternating-current operated stepping, commutator, or distributor relay circuits and chains.

This application is a division of our copending application Serial No. 115,016, filed September 10, 1949, now Patent 2,598,695, granted June 3, 1952.

An object of the present invention is to provide an improved stepping or commutator arrangement which is small, lightweight and which may be readily operated. Furthermore, except for certain sealed contacts the stepping arrangement employs no moving parts, thus greatly reducing the maintenance required and at the same time improving the reliability and service.

A feature of this invention relates to a plurality of reed-type contact structures enclosed in glass or other suitable envelopes of the type disclosed in United States Patent 2,245,391 granted to Dickten, Jr., June 10, 1941, and United States Patent 2,264,622 granted to Ellwood November 25, 1941.

Another feature of this invention relates to operating a distributor by a plurality of such relays controlled by the same alternating current which controls the impulse coils. The distributor is advanced solely by means of the relays and rectifiers or non-linear elements connected between the windings and contacts of these relays and the source of alternating current provided for operation of equipment at the subscriber's station.

Novel features of the switching arrangement for switching from calling or dialing to talking disclosed herein but not claimed are claimed in a copending application of Dunlap and Malthaner Serial No. 116,068, filed on September 16, 1949, now Patent No. 2,672,523.

Another feature of this invention relates to control networks for controlling the impulse coils and also the distributor relays from the same source of alternating current.

In an exemplary embodiment of this invention set forth herein in detail, specific circuits have been arranged to cooperate with the system set forth in detail in a patent application of Malthaner and Vaughan Serial No. 115,961, filed on September 16, 1949, now Patent No. 2,655,559.

The foregoing and other objects and features of this invention may be more readily understood from the following detailed description of an exemplary embodiment thereof when read with reference to the attached drawing in which the single figure shows a detailed circuit of the various devices and the manner in which they are connected one with another at the subscriber's station.

The figure shows the over-all schematic of the subscriber's station equipment. As shown in the figure the subscriber's station equipment includes a handset 21 which when resting upon the support or cradle depresses the pins 22 and causes the bell cranks 19 to actuate contacts 24 to the right and contacts 23 to the left as shown in the figure. Contacts 24 are controlled solely by the posi-

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tion of the handset 21 while the contacts 23 are controlled jointly by the handset through the pin 22 and bell crank 19 and also a magnetic locking or holding device 47 which includes the windings 27, 28. In addition the usual induction coil having windings 32 and 33 is provided for transmission of the voice currents.

A group of saturable magnetic impulse coils 40 and 50 to 59 are provided for generating a start pulse and ten stop pulses to represent each possible identity or character of each of the digits of the called subscriber's number. The secondary winding of these coils is connected to a manually controlled switching or dialing arrangement 130 which permits the subscriber to select the designation or number of the called subscriber's station. The manual switching or selector device 130 is in turn connected to a plurality of electromagnetic reed-type relays of the type disclosed in the above-identified patents to Ellwood and Dickten. These relays are arranged to successively close their contacts and thus provide a distributor arrangement for transmitting the pulses representing the identity of the various digits of the called subscriber's number in succession. A group of rectifiers or unilateral conducting devices 150 through 163, inclusive, and 180 through 193, inclusive, are provided to control the relays of the distributor as will be described hereinafter. Although any suitable source of alternating current may be employed to actuate the equipment at the subscriber's station, in the specific embodiment described herein the alternating-current power for actuating the subscriber's station apparatus is supplied to the subset equipment over the subscriber's line from a source at a remote or distant point which remote or distant point is usually the central office.

In addition phase-splitting networks comprising inductances 41, 42 and condenser 43 are provided for applying alternating currents in quadrature to the two sets of primary windings of the impulse generating coils 40 and 50 through 59, inclusive. An isolating and phasing network comprising inductance 35 and condenser 37 is provided to isolate the circuits of the distributor comprising relays 101 to 114 and the impulse generating coils 40 and 50 through 59, inclusive. This network suppresses transients due to the operation of the distributor relays 101 through 114 and thus prevents these transients from interfering with the operation of the impulse coils 40 and 50 through 59 or with the operation of the receiving equipment at the central office. In addition, this network is employed to properly phase the controlling currents supplied to the distributor relays and the impulse coils.

In the exemplary embodiment shown, provision is made for the generation of pulses representing eight different digital positions or characters representing the called subscriber's station during each complete cycle of operation of the calling apparatus and these pulses are repeatedly generated as long as the excitation current is applied. In addition in the specific embodiment set forth herein pulses representing four additional digits are transmitted during each cycle of operation of the calling apparatus which additional pulses may be employed to identify the calling station for charging purpose or for other reasons. When these extra digits are not required they will be omitted. Pulses representing any arbitrarily chosen number of digital positions or characters (within reasonable limits) may be generated by properly designed signaling apparatus. Eight digital positions or characters have been selected for this disclosure for representing the called subscriber's station since eight character calling numbers are in common use in telephone systems. It will be understood that these characters may be digits or letters or a combination of the two as commonly used in designating telephone calls. Each of the digits 0 to 9 will be represented by a different combination of two

pulses, the pulse combination representing the digit 2 will also represent the letters A, B and C; the pulse combination representing the digit 3 will also represent the letters D, E and F; and so on. Hereinafter, each combination of eight characters will be referred to as each called number irrespective of whether the combination comprises digits or letters and digits.

Inasmuch as the pulse generating coils and their manner of operation and the selector switch are described in detail in the above-identified parent application now Patent 2,598,695, to which reference is made, a detailed description of the structure and mode of operation of this apparatus is canceled from this application.

In order to indicate the starting point of the transmission of a called number, a time interval of approximately 22 milliseconds during which no pulses are transmitted is provided at the beginning of or between groups of pulses representing a called number.

As shown in the figure, each pulsing transformer is connected to lines 73 and 74 through condenser 72. This condenser is proportioned to the iterative impedance of the line and to the impedances of the secondary windings of coils 40 and 50 through 59, inclusive, so that each half-cycle pulse as generated by a transformer is applied through condenser 72 to the line as a complete cycle of alternating current of sinusoidal wave form, and the period of each complete cycle of alternating current is equal to the time required for each half-cycle pulse as generated by the transformers.

A selector switch 130 serves to interconnect the pulsing transformers with the line through the distributor. Thus, pulses representing any of the digits 0 to 9 may be impressed across the telephone line in accordance with the setting of the selector switch.

The distributor arrangement comprises 14 relays 101 to 114, of the type disclosed in the above-identified patents to Ellwood and to Dickten and each of the relays in the specific embodiment set forth herein comprises an individual coil 101 surrounding two normally open reed relay contacts. These reeds are made of magnetic material and sealed in a container which may be of glass or other suitable material. The reeds are polarized by means of one or more permanent magnets so that reeds normally remain open. However, when a current of one polarity within the operating range flows in the winding the contacts will not close but when a current of the same or smaller magnitude of the opposite polarity flows through the winding surrounding these contacts the contacts will close. When the current through the winding is then reduced to zero, the contacts remain closed until current of a predetermined substantial magnitude flows in the reverse direction through the windings at which time the contacts open and remain open until the current again flows through the winding in the operating direction. In addition a common winding 38 is provided for all of the relays and surrounds all of the reeds and their associated polarizing magnets in such a manner that, when a current of sufficient magnitude is passed through the winding, the reeds of a predetermined one of the relays will be actuated in the opposite manner to that which the reeds of all the other relays are actuated. This behavior may be accomplished by reversing the sense of polarity of the polarizing magnet and of the operating winding of the one relay from the sense of the polarity of the polarizing magnet and operating winding of all the other relays.

It is to be noted that the right-hand reed in each of the relays is employed to interconnect successive ones of the digit selectors 11 through 18 of the selector switch 130 with the common conductor 39, whereas the left-hand reeds are employed to control the operation of the relays of the distributor.

Assume now that the relays are positioned with the reed contacts in relay 109 closed while the reed contacts of all the other relays are open. Further assume that

controlling frequency for controlling the reeds is applied between conductors 48 and 49. If the alternating current between the conductors 48 and 49 is in such a direction that the upper conductor 48 is negative with respect to 49 at the time the contacts of the relay 109 are closed then a path is completed by the closure of the left-hand contacts of the relay 109 from conductor 48 through the left-hand contacts of relay 109, rectifier 187, winding of relay 108 to conductor 49. Current flows in the above path in such a direction as to maintain the reed contacts of relay 108 open. This is indicated diagrammatically by the arrow shown within the relay 108 which indicates the direction which the current must flow between the windings of this relay to cause its contacts to close. When the current flows in the opposite direction the relay will open the contacts as described above. When the alternating current changes polarity so that the upper conductor 48 becomes positive and the lower conductor 49 negative then current ceases to flow through the winding of relay 108 and flows from the upper conductor 48 through the left-hand reed of relay 109 and through the rectifier 188 at this time and through the winding of relay 110 in such a direction as to close its contacts. Upon closure of the left-hand contacts of relay 110, current also flows from the upper conductor 48 through the left-hand contacts of relay 110 through rectifier 158 and the winding of relay 109 to the lower conductor 49. This current flows in such a direction as to open contacts of the relay 109 and interrupt the current flowing through the winding of relay 110. The contacts of relay 110 however remain closed at this time so that current continues to flow through the winding of relay 109 in such a direction as to maintain the contacts of this relay open. When the upper conductor 48 again becomes negative current flowing through the left-hand contacts of relay 110 reverses and flows through the winding of relay 111 and rectifier 159 instead of through the winding of relay 109 and rectifier 158. The direction of flow of current through this winding is such as to cause the reed contacts of this relay to close and complete a circuit through the left-hand contacts of relay 111 and rectifier 189 through the winding of relay 110 in the reverse direction thus causing this relay to release. In this manner the contacts of each of the relays are closed for one-half cycle of the alternating current between conductors 48 and 49.

Furthermore, upon each reversal of the voltage between these conductors 48 and 49 the reed contacts of the succeeding relays are closed and the reed contacts of the previous relays are opened. Consequently, the contacts of reeds close in succession, each one being closed for approximately one-half cycle of the applied controlling alternating current.

The manners in which the various devices and circuits cooperate with each other to form a subscriber's subset capable of cooperating with a switching system to provide improved service will now be described.

The circuits as shown in the figure are in their normal or idle condition. At this time the ringer 30 is connected in series with condenser 31 across the tip and ring conductors 73 and 74 extending to the central office. At the central office battery is normally connected to one of these conductors and ground to the other conductor thus placing a charge upon the condenser 31.

If the subscriber is called, ringing current will be applied to these conductors at the central office and cause the ringer 30 to ring and call the subscriber. When a subscriber answers, he will pick up the handset 21 and allow pins 22 to rise. As a result, the contacts 24 will be moved to their left-hand position as shown in the figure. The pins 22 in rising cause the bell cranks 19 to rotate in a clockwise direction. As a result, the contacts 24 close and the member 71 is rotated in a counter-clockwise direction away from the armature 25 of

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the magnetic lock or relay 47. The polarity of the voltage applied to the tip and ring conductors 73 and 74 at the central office is in such a direction at this time as to move the armature 25 to the right as viewed in the figure with the result that the contacts 23 are also switched to their opposite or right-hand position.

With both contacts 23 and 24 actuated to their operated positions, the signalling equipment at the subscriber's station comprising the impulse coils 40 and 50 through 59, the selector switch 130 and the distributor relays 101 through 114 inclusive are disconnected from line conductors 73 and 74 and the transmission apparatus and circuits including the transmitter and receiver of the handset 21 and windings 32 and 33 of the induction coil and condenser 34 are connected to the tip and ring conductors 73 and 74 extending to the central office to provide the usual subscriber's transmission circuit and to supply necessary battery to the transmitter of the handset 21.

The circuits then remain in this condition so long as the subscribers are talking over the established circuits. It should be noted that throughout this time a direct-current path exists between the conductors 73 and 74 extending from conductor 73 through the left-hand operated set of contacts 24, the right-hand operated set of contacts 23, induction coil 33, the transmitter of the handset 21 and the right-hand set of operated contacts of the group of contacts 24 to conductor 74 extending to the central office. Variations in the transmitter resistance produced by the voice waves are thus transmitted in the above-described circuit to the central office. In addition they induce currents in the secondary winding 32 of the induction coil which currents flow in a circuit which extend from the common connection between the transmitter and receiver through the left-hand winding 32 of the induction coil, through the central set of operated contacts of a group of contacts 23, and through the receiver and back to the common points between the receiver and transmitter.

Voice currents arriving over conductors 73 and 74 transmitted over the above-described circuit, including the winding 33 of induction coil and the transmitter of the handset induce currents in the left-hand winding 32 connected to the receiver in the manner described above. The condenser 34 is connected between the upper terminal of winding 32 and the transmitter and increases the transmission efficiency of the handset in the usual manner.

At the termination of the call, the subscriber will replace the handset 21 upon the cradle or supporting members and cause pins 22 to be depressed. As a result, the group of contacts designated 24 will be actuated to the right as shown in the figure, while the contacts 23 will be actuated to the left. In addition the armature 25 of the switching relay 47 is also actuated to the left. At this time the direct-current path between conductors 73 and 74 is interrupted and the ringer 30 and condenser 31 reconnected between the tip and ring and the normal battery potential applied to the conductor at the central office thus restoring the charge on condenser 31 to its normal value.

When a subscriber at the substation described herein in detail desires to make a call, he will first ascertain the number or designation of the subscriber with which he wishes to communicate. The subscriber will then set the selector switch 130 of the figure by placing his finger over the desired letter or numeral for each digit in the ratchet wheels 11 to 18 and then moving these wheels downward to the guide or stop member, which may form a part of the front of the case of the subset.

After the subscriber has moved each one of these dials or wheels in this manner, he may check the setting of the instruments to be sure that it is set in accordance with the designation of the desired subscri-

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er's station. At this time this designation appears in the first line above the stop or guide member.

After having set these discs, the subscriber will then pick up the handset 21 which will allow the pins 22 to rise. The bell crank 19 then rotates and permits both groups of contacts 23 and 24 to be actuated to their operated position. Contacts 24 do so move and are actuated to their left-hand position as shown in the figure. However, the armature 25 of the relay or magnetic holding device 47 maintains the set of contacts 23 in their normal or operated position at this time due to residual magnetic attraction between the armature and left-hand pole-piece as shown in the figure.

The contacts 24 in being operated to their left-hand position connect the condenser 31 across the terminals of the common winding 38 surrounding all of the reeds of the reed relays 101 through 114. The condenser 31 discharges in this circuit and in discharging closes the reed contacts of one of the relays and opens the reed contacts of all of the other relays which may be closed. Assume, for example, the contacts of 110 are closed and the contacts of all of the other relays are opened.

As described hereinabove, the permanent magnet associated with the reeds of relay 110 will then maintain these contacts closed until opened by the reversed magnetic field due to a reverse current flowing through its winding.

Contacts 24 in moving to their left-hand position also connect conductor 73 through the left-hand operated contacts 24 and right-hand normal contacts 23 to the upper terminal of winding 27, and connect conductor 74 through the right-hand operated contacts 24 and the left-hand normal set of contacts 23 to the lower winding terminal of winding 28. The other terminals of windings 27 and 28 are connected together and to the network comprising inductor 35 and condenser 37. Thus, the windings of relay 27 provide a direct-current path between conductors 73 and 74 at this time and provide a path from each of these conductors to the network comprising the elements 35 and 37.

At this time, a circuit also extends from conductor 74 through the right-hand operated contacts 24 and the left-hand normal contacts 23 to the left-hand terminal of the secondary winding of the impulse coil 40. This circuit may be also traced through this winding of coil 40 to the common conductor 75 extending to a terminal of a secondary winding of each of the saturable pulse coils 50 through 59. The circuit will later extend then through various ones of these coils and the selector switch 130 to the right-hand set of reed contacts of the respective relays 101 through 108 or to the corresponding contacts of relays 109 through 112, independent of the selector switch 130. The circuits then extend from the contacts of relays 101 through 112 to common conductor 39 and then through condenser 72, the right-hand break contacts of contacts 23, the left-hand operated contacts 24 to conductor 73 extending to the central office.

The connection of the windings 27 and 28 between conductors 73 and 74 extending to the central office, as described above, causes current to flow from a central office over these conductors through a relay or other responsive device in the central office and also through the windings 27 and 28. The polarity of current flowing through these windings at this time is such that it maintains armature 25 in its left-hand position as shown in the figure.

The equipment at the central office responds to the current flowing over conductors 73 and 74 and through the windings 27 and 28 and causes the line at the central office to be connected to a receiving and registering circuit. Upon connection of the line to this circuit at the central office, the central office equipment will be conditioned to respond to the calling signals transmitted from the subscriber's station. In addition, the equipment at the central office interrupts the supply of direct-

current to the conductors 73 and 74 and applies alternating current between both of these conductors and ground. The armature of relay 25, however, still remains in the position shown due to the residual magnetic induction of the permanent magnets employed in this device. The alternating current applied to both conductors 73 and 74 at the central office flows over these conductors and through the two windings 27 and 28 in opposition so that it does not produce any appreciable magnetic effect upon the magnetic locking device 47. The alternating current then flows to the network comprising elements 35, 36 and 37. This network is provided to suppress switching transients which may arise due to the operation of the distributor relays and thus prevents these transients from adversely affecting the operation of the pulse coils 40 and 50 through 59. The suppression of these transients also prevents said transients from interfering with the operation of the equipment at the central exchange. This network also controls the magnitude and phase of the alternating voltage between conductors 48 and 49 so that a voltage sufficient to operate the relays at the required speed is provided across these conductors, which voltage has a phase such that the distributor relays advance on each half cycle before the pulses from coil 40 are generated during each half cycle. This current consequently flows from the conductor 49 through the winding of relay 109, rectifier or unilateral conducting device 158 and left-hand reed contacts of relay 110 to conductor 48, assuming that the first half cycle of the alternating current applied to conductors 60 and 70 is of the negative polarity. From the conductor 48, the alternating current flows through the phase shift networks comprising inductors 41 and 42 and condenser 43 and then through the two sets of primary windings of the saturable impulse coils 40 and 50 through 59, inclusive. Thereafter the alternating currents flow through the resistors 44 and 45 to ground. As described hereinbefore, the two phase shifting networks 41 and 42 and condenser 43 cause the alternating currents flowing through the two primary windings of the impulse coils to be displaced substantially 90 degrees in phase. As described above, during each half cycle of this alternating current, a pulse is generated in output or secondary windings of each of these impulse coils. These pulses are generated at different times in the manner described above. The pulses are first generated in the secondary or output windings of the start coil 40 and thereafter in the output windings of each of the successive saturable magnetic coils 50 through 59, inclusive. Such a pulse is generated by each of the coils for each half cycle of the applied alternating current. Thus, if the first half cycle is substantially complete, such a pulse is generated by each of these coils. However, in the usual case, the phase of this pulse and frequently the pulses generated for the next two or three half cycles will not be accurate so that these pulses usually are not employed at the central office because the circuits of the central office will not have had time to become properly conditioned to receiving these pulses. Furthermore, there may be some transient currents which will interfere with the proper generation of these pulses at this time so that these first pulses are generally ignored. However, when the alternating current reverses, after the first half cycle, which as assumed above is negative, or if the first half cycle applied to the specific subset described herein in detail is positive then current flows from the conductors 73 and 74 and through the windings 27 and 28 in opposition to conductor 49 and then through the winding of relay 111, rectifier 159, left-hand operated reed contacts of relay 110 to conductor 48, and then through the impulse coils and phase shift networks to ground as described above. The direction of flow of current through the winding of relay 111 at this time causes its reed contacts to close and in closing, the left-hand reed contacts complete a circuit from conductor

49 through the winding of relay 110, rectifier or unilateral conducting device 189 to conductor 48, through the left-hand operated reed contacts of relay 111 and then to ground in the manner described above. The direction of flow of current through the winding of relay 110 at this time is in such a direction as to cause its contacts to open. Thereafter the contacts of this relay remain open until the relay is again actuated. During this half cycle the pulses will be generated by each of the impulse coils as described above.

During the next succeeding half cycle of the alternating current, a circuit is completed from conductor 49 through the winding of relay 112 and unilateral conducting device 190 to conductor 48 through the left-hand operated reed contacts of relay 111 and then to ground as described above. Current is flowing through the winding of relay 112 at this time in such a direction as to close its contacts. When the contacts of relay 112 close, a circuit is completed through the winding of relay 111 from conductor 49 through the rectifier 160 and closed left-hand contacts of relay 112 to conductor 48 and thus to ground. The direction of the flow of current at this time through relay 111 is in the reverse direction and causes this relay to open its contacts.

During each of these half cycles, certain of the impulse coils are connected to the transmission circuit as will be described hereinafter. However, as pointed out above, the equipment at the central office will usually be designed to employ these first few pulses for conditioning the equipment to accurately respond to the succeeding pulses.

Under the assumed conditions, at the beginning of the next half cycle the contacts of relay 113 will close and cause the contacts of relay 112 to open. The closure of the right-hand contacts of relay 113 at this time connects conductors 73 and 74 together in a circuit which extends from conductor 74 through the right-hand operated contacts 24, through the left-hand break contacts 23 and the operated right-hand contacts of relay 113 to conductor 39, and then through condenser 72 and through the right-hand break contacts 23 and the left-hand operated contacts 24 to conductor 73, thus in effect short-circuiting the line through the condenser 72 and the operated contacts 113. As a result, the output of the impulse coils are in effect disconnected or short-circuited at this time. Consequently, no pulses will be transmitted over lines 73 and 74 even though such pulses are generated during this half cycle by the various coils 40 and 50 through 59, inclusive; likewise, at the beginning of the next half cycle of the alternating current, the contacts of relay 114 close in a manner similar to the operation of the previous relays, and the contacts of relay 113 open. During this half cycle, the right-hand contacts of relay 114 similarly short-circuit or connect the conductors 73 and 74 together through condenser 72 and prevent the transmission of pulses to the central office.

These two half cycles during which no pulses are transmitted constitute a blank interval and are recognized at the central office as indicating the termination of pulses representing a subscriber's designation has been transmitted and that pulses representing the succeeding transmission or repetition of the designation is about to be started. The central office circuits respond to the blank interval by conditioning the received circuits so that they will respond to the next succeeding pulses and record these signals if they are properly received as described in the above-identified application of Malthaner and Vaughan filed on an even date herewith.

During the next half cycle of the applied alternating current, contacts of relay 101 are closed and the contacts of relay 114 open. At this time the brush 11 of the selector switch 130 has been positioned in contact with one of the conductor bars. Assume for a purpose of illustration that it has been moved to engage the No. 2 or third conductor bar from the bottom of the figure as shown by the dotted half circle. In other words, the brush arm attached to

the first selector disc engages a conductor indicating that the first letter designation of the called subscriber's station is an A, B or C. Assume, for example, that it is a C. During this half cycle, the right-hand contacts 121 of relay 101 are closed and connect the brush arm 11 to the common conductor 39. Consequently, when the start pulse coil 40 generates a pulse, this pulse is transmitted over the following path to conductors 73 and 74 to the central office. This path may be traced from conductor 73 through the left-hand operated contacts 24, the right-hand break contacts 23, condenser 72, common conductor 39, right-hand contacts 121 of relay 101, brush arm 11, the No. 2 horizontal conductor of the selector switch 130, the secondary winding of the impulse coil 52 and the secondary winding of the start pulse coil 40 and through the left-hand break contacts 23 and the right-hand operated contacts 24 to conductor 74.

It is noted that the windings 27 and 28 of the polarized relay or locking device 47 are also shunted across these conductors as described above. However, these windings offer high impedance to the pulses transmitted to the central office and thus do not materially interfere with the transmission of these pulses.

A short time later during the same half cycle and in the position for the No. 2 or C character of the digit or symbol of the called subscriber's number, a pulse is generated in the secondary winding of the impulse coil 52 which pulse is likewise transmitted over the conductors 73 and 74 to the central office over the same circuits described above with reference to the start pulse generated in the secondary winding of coil 40. These two pulses as explained above, identify the character of the first digit or symbol of the called subscriber's number. The condenser 72, together with the secondary winding of coil 52, for the start pulse and condenser 72, together with the secondary winding of the coil 40 for the stop pulse, comprise a pulse-shaping or filter element which tend to eliminate the high frequency components of these pulses and cause the pulses transmitted over the line to the central office to have a wave form approximating a single cycle of a sine wave.

During the next half cycle the reed contacts of relay 102 will close and cause the contacts of relay 101 to open. Closure of the contacts of relay 102 and the opening of the contacts of relay 101 occur very near the beginning of the half cycle. Consequently when the start pulse is generated by coil 40 it is transmitted over a circuit extending from conductor 74, the right-hand operated contacts 24, the left-hand break contacts 23, through the secondary winding of coil 54, the selector disc brush 12 which is assumed to be positioned in contact with No. 4 segment as shown in the figure, the left-hand closed reed contacts of relay 102 to common conductor 39 and then through condenser 72 and through the right-hand contacts of contacts 23 and the left-hand operated set of contacts of contacts 24 to the conductor 73, extending to the central office.

A short time later the stop or digit pulse is generated in coil 54 which is likewise transmitted through the same circuit to conductors 73 and 74 extending to the central office. It is to be noted that the pair of pulses transmitted during the time the contacts of relay 101 are closed has one given polarity while the pair of pulses transmitted during the time the contacts of relay 102 are closed has the opposite polarity.

As shown in the figure by the dotted lines the selector switch 130 has been set to transmit a number assumed to be CH3-10740. Consequently, during the second half cycle after the blank interval, pulses will be transmitted from coils 40 and 54 designating G, H or I which we have assumed to be H. During the third half cycle pulses will be transmitted from coils 40 and 53; during the fourth half cycle pulses will be transmitted by coils 40 and 51 and will be transmitted through the contacts of relay 104. Thus during each half cycle following the blank interval a pair of pulses is transmitted under control of one of the brush

arms 11 through 18, inclusive as positioned by the selector discs designating the number of the called subscriber's station. Consequently, during each half cycle a pair of pulses is transmitted designating each one of the digits or symbols of the designation.

Each pair of pulses is transmitted during the time successive ones of the distributor relays 101 through 108 is operated. During the ninth half cycle and the succeeding three additional half cycles the relays 109 through 112 operate and transmit four additional pairs of pulses. These pulses are transmitted to identify the calling subscriber's station. As shown in the drawing the left-hand reed contacts of these relays are connected to output windings of coils 57, 55, 53 and 52, thus indicating that the last four or any other specified group of digits of the calling subscriber's designation comprise the number 7532. Consequently this information is also available to the equipment at the central office for switching purposes as well as charging purposes if and when it is desired. Thus during the ninth half cycle the pair of digits identifies the numeral 7 while the pair during the tenth half cycle identifies the numeral 5, etc.

At the end of the twelfth half cycle and at the beginning of the thirteenth half cycle, relay 113 will again be operated and effectively short-circuit the line conductors 73 and 74 to the pulses so that no pulses will be transmitted during this half cycle. During the fourteenth half cycle relay 114 likewise operates and causes relay 113 to release. Relay 114 as described above also prevents transmission of any pulses to the central office. These two intervals during which no pulses are transmitted comprise a blank interval as described above to indicate that a complete designation or calling code has been transmitted and that a succeeding one will start following this blank interval. Thereafter the above cycle of operation of the calling equipment at the subscriber's station is repeated until the circuits at the central office function to change the connections of the subscriber's station.

The equipment at the central office in responding to one or more complete sets of signals or portions thereof will establish switching paths through the switches from the calling subscriber's line towards the called subscriber's line.

When the connection has been extended to the called subscriber's line the central office equipment is arranged to interrupt the alternating current applied between both of the line conductors 73 and 74 and ground and apply a direct-current voltage between these conductors of reversed polarity.

The details of the operation of the central office equipment in response to the calling signals transmitted from the subscriber's station and also the details of the arrangement for interrupting the application of the alternating current to the line conductors 73 and 74 at the central office and the application of a direct-current voltage of the reverse polarity between them at this time is described in detail in the above-identified application of Malhaner and Vaughan which application is made a part of this application to the same extent as if fully set forth and repeated herein.

Interruption of the alternating current stops the operation of the impulse coils 40 and 59 through 59 and also stops the operation of the distributor relays 101 through 114.

The application of the direct-current voltage between conductors 73 and 74 in the reverse direction causes the armature of the magnetic relay or holding device 25 to operate to its right-hand position and thus permit contacts 23 to be operated. At this time both contacts 23 and 24 are operated and thus as described above the transmitter and receiver of the handset 21 are connected to the windings 32 and 33 of the induction coil and to the line conductors 73 and 74 extending to the central office. At this time the impulse coils as well as the distributor relays and the selector switch 130 are disconnected from the line

so that they do not in any way interfere with the transmission and reception of the voice currents. Thereafter the circuits at the subscriber's station remain in the position described so long as communication takes place between the subscribers and so long as the handset 21 is removed from its supporting yoke or cradle and pins 22 are elevated.

Upon the completion of the call the handset 21 will be placed upon its supports and the pins 22 depressed whereupon both sets of contacts 23 and 24 are actuated to the positions shown in the drawing. Likewise the armature 25 of the magnetic holding device 47 is moved to its left-hand position as shown in the drawing where the circuits to the subscriber's station are returned to their normal or idle condition ready to respond to a call from the central office or to be utilized in making a call to another subscriber in the manner described above.

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

What is claimed is:

1. A relay stepping circuit comprising a plurality of two-position relays arranged in succession, each having a winding and a control set of contacts, magnetic bias means for each of said relays whereby said contacts remain in either position to which they are actuated until said relays are actuated to the other position, a pair of rectifiers individual to and oppositely connected to one of said contacts of each of said relays, connections from one of said rectifiers to a winding terminal of the preceding relay in said succession, another connection from said other rectifier to a winding terminal of the succeeding relay in said succession of relays, means for supplying an alternating current voltage between one of the winding terminals of all of said relays, and one of the contact members of each of said contacts of each of said relays.

2. A relay distributor comprising in combination a plurality of multiposition relays arranged in succession, each having at least one winding and one set of contacts, means for maintaining the contacts of each of said relays in the position set by current flowing through the windings of said relay, a pair of rectifiers individual to a contact of each of said relays, one of said rectifiers being connected between one of the contacts of each of said relays and a winding terminal of a preceding relay and the other of said rectifiers being connected to a winding terminal of a succeeding relay for transmitting currents of opposite polarity to the windings of said relays, means for applying alternating-current voltage to said contacts and windings of said relays for advancing said relays one relay for each half cycle of the alternating current.

3. A relay distributor comprising a plurality of electromagnetic relays each having an individual winding and a set of contacts individual thereto, means for maintaining the contacts of each of said relays in the position set by current flowing through the windings of said relays, means including a pair of rectifiers individual to and connected to contacts of each of said relays for applying electrical conditions to said relays for actuating one of said relays and immediately thereafter restoring the previously actuated relay, a winding common to all of said relays, means for applying an electrical condition to said common winding for setting all of said relays in a predetermined condition.

4. A relay distributor comprising in combination, a plurality of electromagnetic relays each including a winding and a contact, means for maintaining the contacts of each of said relays in the position set by current flowing through the windings of said relay, a pair of electrical conductors supplied with alternating current, a series circuit including a winding of a preceding relay and a unilateral conducting device individual to said winding completed between said alternating-current conductors by the operation of each of said relays for deenergizing said preceding relay, a second circuit completed between said alternating-current conductors by each of said relays including a winding of a succeeding relay and another unilateral conducting device individual to said winding for operating said succeeding relay on the next succeeding half cycle of the alternating current supplied to said conductors.

5. A relay chain circuit comprising in combination, a plurality of two-position electromagnetic relays each including a winding and a contact, means for maintaining the contacts of each of said relays in the position set by current flowing through the windings of each of said relays, a pair of electrical conductors supplied with alternating current, a series circuit including a winding of a preceding relay and a unilateral conducting device individual to said winding completed between said alternating-current conductors by the operation of each of said relays for deenergizing said preceding relay, a second circuit completed by the operation of each of said relays between said alternating-current conductors including a winding of a succeeding relay and another unilateral conducting device individual to said winding for operating said succeeding relay on the next succeeding half cycle of the alternating current supplied to said conductors, a winding common to all of said relays and a control circuit for energizing said common winding to actuate each of said relays to a predetermined condition.

6. A relay distributor comprising in combination, a plurality of electromagnetic relays each including a winding and a contact, a means for maintaining the contacts of each of said relays in the position set by current flowing through the windings of each of said relays, a pair of electrical conductors supplied with alternating current, a series circuit including a winding of a preceding relay and a unilateral conducting device individual to said winding completed between said alternating-current conductors by the operation of each of said relays for deenergizing said preceding relay, a second circuit between said alternating-current conductors including a winding of a succeeding relay and another unilateral conducting device individual to said winding completed by the operation of each of said relays for operating said succeeding relay on the next succeeding half cycle of the alternating current supplied to said conductors, and a control circuit including windings interlinking all of said relays for selectively actuating each of said relays to a predetermined one of its two conditions of operation or release.

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