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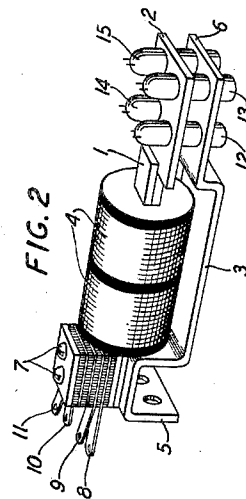
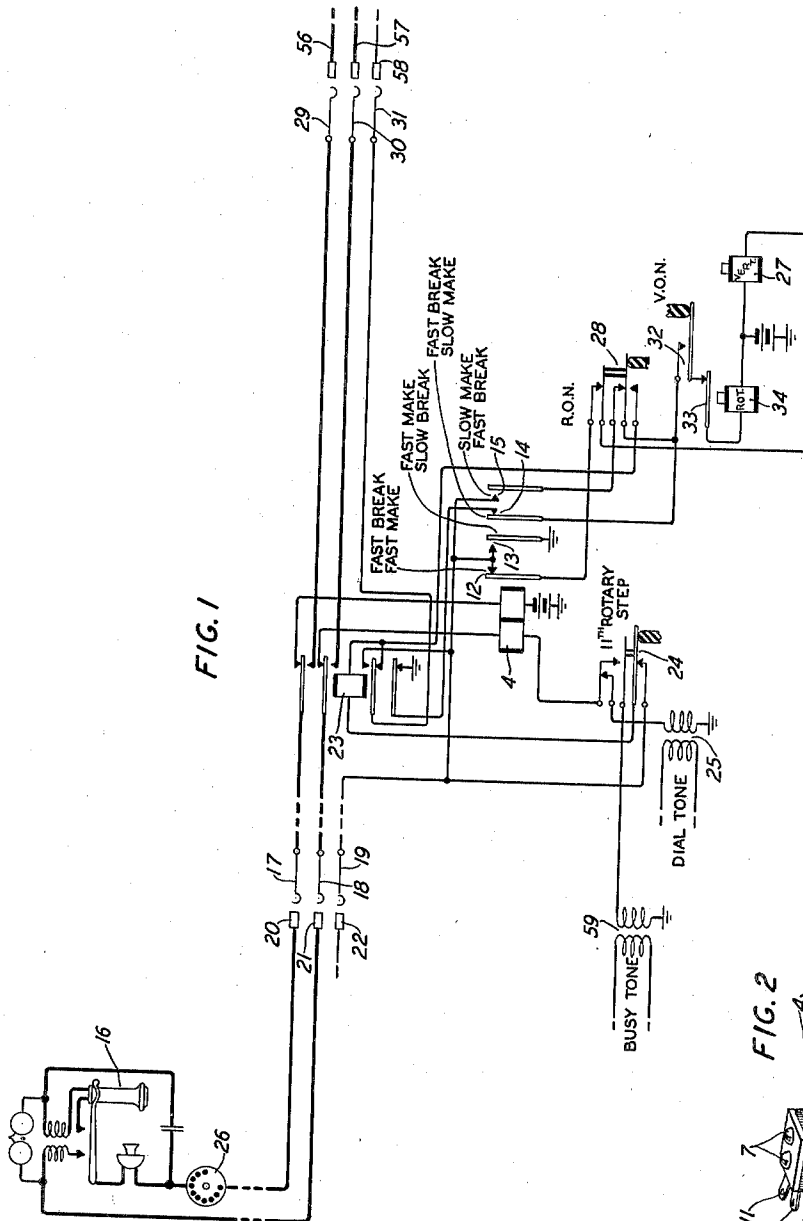
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2,237,419

TELEPHONE SYSTEM

Filed Nov. 2, 1939

2 Sheets-Sheet 1



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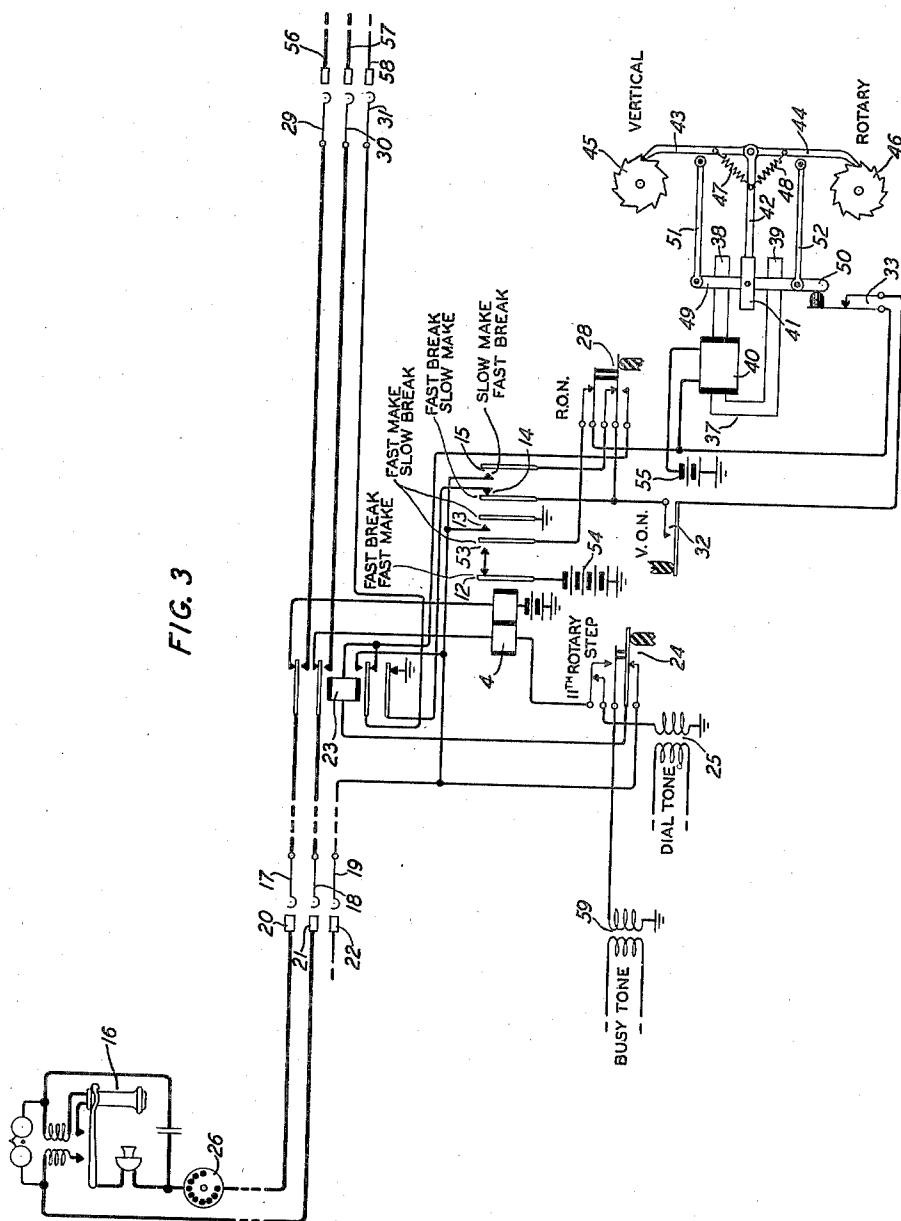
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2,237,419

TELEPHONE SYSTEM

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Application November 2, 1939, Serial No. 302,521

10 Claims. (Cl. 179—18)

This invention relates to telephone systems and more particularly to automatic telephone systems of the step-by-step type.

In systems of this character the selector switch circuits thereof each customarily employs three operating magnets including a vertical stepping magnet with two magnet windings, a rotary stepping magnet with two magnet windings and a single winding release magnet and five control relays including a line or pulsing relay, a cut-through relay, a stepping relay and two slow-to-release relays.

It is the object of the present invention to simplify the structure of a step-by-step selector switch of this character by combining the functions of the pulsing relay and the two slow-to-release relays in a single relay structure; by providing more efficient stepping mechanism which, by the addition of toggle contacts thereto eliminates the usual stepping relay and by providing means to operate the stepping mechanism to restore the switch to normal thereby eliminating the usual release magnet.

This object is attained by the improved construction of the stepping mechanism as previously outlined and by the substitution of a relay of the type disclosed in the application of H. C. Harrison and C. E. Pollard, Serial No. 302,526 filed concurrently herewith for the pulsing relay and the two slow-to-release relays. This relay has a single magnetic circuit including two parallelly disposed pole-pieces having sets of aligned openings therein in which switch elements of the mercury contact type are positioned. Each of these switch elements is provided with a pair of contact terminals. Normally the terminals of one element are bridged by a globule of mercury and the circuit across the terminals is quickly opened and quickly closed upon the energization and deenergization of the relay windings. The terminals of a second of the switch elements are normally open but are closed quickly by a mercury globule upon the energization of the relay windings and are opened slowly upon the deenergization of the windings. The terminals of a third switch element are normally closed by a mercury globule but are opened quickly upon the energization of the relay windings and are closed slowly upon the deenergization of the windings. The terminals of a fourth switch element are normally open but are closed slowly by a globule of mercury upon the energization of the relay windings and are opened quickly upon the deenergization of the windings.

For a more complete understanding of the in-

vention reference may be had to the following detailed description taken in connection with the accompanying drawings in which:

Fig. 1 diagrammatically represents a portion of a telephone system embodying the present invention, only so much of the system being disclosed as is considered necessary for a clear understanding of the invention;

Fig. 2 shows a mercury contact relay of the type employed as the combined relay structure of Fig. 1; and

Fig. 3 shows a modification of the circuit of Fig. 1 by which both the vertical and rotary stepping of the switch shaft are accomplished by a single magnet winding.

The relay of Fig. 2, and indicated by the reference numeral 4 in Figs. 1 and 3, is of the mercury contact type disclosed in the application of H. C. Harrison and C. E. Pollard hereinbefore referred to and comprises a core 1 to the forward end of which is suitably secured a pole-piece plate 2 and to the rear end of which is secured a forwardly extending return pole-piece 3. The return pole-piece is offset at its middle portion to furnish clearance for the two operating windings 4 surrounding the core 1, is bent at right angles at its rear end to form a mounting bracket 5 by which the relay may be secured to the switch frame and has its forward end 6 positioned parallel to and suitably spaced from the pole-piece plate 2. Secured by screws 7 and insulatedly supported upon the rear of core 1 are terminal lugs 8, 9, 10 and 11 to which the terminals of the two windings 4 are connected. Other terminal lugs may also be provided if desired for connection with the terminals of the mercury contact switch elements 12, 13, 14 and 15 positioned in aligned openings in the pole-pieces 2 and 6.

As fully disclosed in the application hereinbefore referred to, each of these switch elements comprises an envelope of glass or other suitable material, two electrode or contact terminals sealed through the upper end thereof and extending downwardly into the inside of the envelope, a plunger armature freely slidable within the envelope and a globule of mercury supported on the plunger. The switch elements 12, 13, 14 and 15 may be of the respective types disclosed in Figs. 8, 6 and 7 of the aforementioned application, the element 12 being arranged for a fast break-fast make of its normally closed contacts, the element 13 being arranged for a fast make-slow break of its normally open contacts, the element 14 being arranged for a fast break-slow make of its normally closed contacts and the ele-

ment 15 being arranged for a slow make-fast break of its normally open contacts.

The switch operating mechanism may be of the general type disclosed in Patent 2,028,689 granted June 21, 1936, to R. N. Saxby, the rotary magnet of which is rendered self-interrupting by toggle contacts of the type disclosed in British Patent 433,877 granted to R. N. Saxby. The switch is provided with no release magnet, the switch brushes being restored by being stepped in a rotary direction by the rotary magnet to the end of their rotary travel from which position they drop to their lowermost position below the terminal bank and are then restored by a spring in a rotary direction back to their normal position.

The selector switch disclosed in Fig. 1 functions in the following manner: When the calling subscriber removes the receiver from the switchhook at the substation 16, the line-finder brushes 17, 18 and 19 are operated in the well-known manner in search of the terminals 20, 21 and 22 of the calling line. As soon as the calling line is found, the movement of the brushes is arrested and a circuit is established from battery through the right winding of relay 4, upper back contact of cut-through relay 23, brush 17, terminal 20, over the line loop through substation 16, terminal 21, brush 18, inner upper back contact of relay 23, left winding of relay 4, upper normal contacts of the eleventh rotary step off-normal switch 24, through the right winding of dial tone coil 25 to ground. Dial tone is now impressed by the left winding of tone coil 25 upon the calling line as a signal to the calling subscriber that he may commence dialing the directory number of the wanted line and the windings of relay 4 are energized thereby actuating the plunger armatures of the switch elements 12, 13, 14 and 15 positioned in the magnetic circuit of the relay.

Switch elements 12, 13 and 14 being fast to operate, elements 12 and 14 immediately open their associated contacts and element 13 immediately closes its associated contacts and after an interval determined by its slow-to-operate characteristic switch element 15 closes its contacts. Upon the closure of the contacts of element 13 ground is applied thereto to the sleeve brush 19 of the line finder and thence to the sleeve terminal 22 of the calling line to mark the line as busy and to operate the cut-off relay (not shown) of the calling line.

In response to the first opening of the line loop upon the return of the dial 26 when the subscriber dials the first digit of the wanted line number, the windings of relay 4 become deenergized and as a consequence the plunger armatures of all the switch elements associated therewith immediately start to restore. The switch element 15 being of the type which opens its contacts quickly following the release of its armature, its contacts now open and remain open until after the termination of the impulses for the first digit series. The switch element 14 being of the type which closes its contacts slowly following the release of its armature, its contacts remain open until after an idle trunk has been found and the windings of relay 4 remain deenergized. Switch element 13 being of the type which opens its contacts slowly following the release of its armature, its contacts remain closed until after the windings 4 remain deenergized following the operation of cut-through relay 23 as hereinafter described. Since, however, the switch element 12 is of the type which opens and closes its contacts quickly upon each restoration

and operation of its armature and thus follows the impulses dialed by the calling subscriber the deenergization of the windings of relay 4 in response to the first impulse will close a circuit from ground and battery through the winding of the vertical magnet 27, upper normally closed contacts of the rotary off-normal switch 28, closed contacts of elements 12 and 13 to ground and magnet 27 will operate to step the selector switch shaft one step vertically. When the windings of relay 4 reenergize following the termination of the first dial impulse the contacts of element 12 again open to deenergize the vertical magnet 27. Similarly, in response to succeeding dial impulses for the first digit, relay 4 controls the operation of the vertical magnet 27 to further advance the switch brushes step by step. The switch shaft has now been stepped vertically to position the brushes 29, 30 and 31 carried thereby opposite the bank level corresponding to the numerical value of the first digit dialed.

Upon the termination of the first series of dial impulses the windings of relay 4 remain energized for a sufficient interval to permit the contacts of switch element 15 to close and since upon the first vertical step of the switch shaft the vertical off-normal switch 32 was operated, a circuit is now established from ground over the contacts of switch elements 13 and 15, lower normal contacts of rotary off-normal switch 28, contacts of vertical off-normal switch 32, the contacts of toggle switch 33 operable by the rotary stepping magnet 34, winding of magnet 34 to battery and ground. Magnet 34 now operates interrupting its own circuit at the toggle contacts 33 and operating the rotary off-normal switch 28 to its alternate position. The rotary magnet has now advanced the switch brushes 29, 30 and 31 into engagement with the terminals of the first trunk in the selected bank level.

If the first trunk is busy, low resistance ground will be encountered by the test brush 31 upon the sleeve terminal of such trunk and a circuit for reoperating rotary magnet 34 will be established from such ground over brush 31, the inner lower back contact of relay 23, the lower alternate contacts of rotary off-normal switch 28, contacts of the vertical off-normal switch 32, contacts of the toggle switch 33 through the winding of magnet 34 to battery and ground. At this time the winding of cut-through relay 23 is shunted since one terminal thereof is connected to ground over the lower contacts of the eleventh rotary step off-normal switch 24 and the contacts of switch element 13 and the other terminal thereof is connected over its own inner lower back contact to ground over brush 31. Magnet 34 upon operating opens its own circuit at the contacts 33 and thereby advances the switch brushes into engagement with the terminals of the next trunk in the bank level. This operation will continue until the terminals of an idle trunk are encountered, upon the test terminal of which there is no busy ground whereupon relay 23 will operate in a circuit from ground over the contacts of switch element 13, the lower normal contact of the eleventh rotary step off-normal switch 24, winding of relay 23, lower alternate contacts of rotary off-normal switch 28, contacts of vertical off-normal switch 32, toggle contacts 33, winding of magnet 34 to battery and ground. Due to the resistance of the winding of relay 23 the magnet 34 does not receive sufficient current to operate at this time.

Had all trunks of the group been found busy,

magnet 34 would have advanced the selector brushes to the end of the bank level in which position the switch shaft would have operated the eleventh rotary step off-normal switch 24 to its alternate position thereby disconnecting the right winding of tone coil 25 from the left winding of relay 4 and connecting the right winding of busy tone coil 59 thereto whereby a busy tone is impressed upon the calling line loop from ground through the right winding of tone coil 59, upper alternate contacts of switch 24, thence over the circuit previously traced through the winding of relay 4.

Assuming that an idle trunk is found and that relay 23 operated as previously described, relay 23 at its upper and inner upper back contacts disconnects the windings of relay 4 from the calling line loop and at its upper and inner upper front contacts connects the calling line loop over the tip and ring brushes 29 and 30 to the tip and ring conductors 56 and 57 of the selected trunk terminating in a second selector switch. The control relay of the second selector, corresponding to relay 4, thereupon operates and at its switch element, corresponding to element 13, applies busy ground to the test terminal 58 to mark the trunk as busy to other first selector switches having access thereto. This busy ground is now connected over brush 31 and the inner lower front contact of relay 23 to the sleeve brush 19 of the line finder to mark the calling line as busy and over the lower normal contacts of switch 24 through the winding of relay 23 thence as traced to battery and ground through the winding of magnet 34 to hold relay 23 operated. Following the operation of relay 23, relay 4 releases restoring all of its switch elements to their normal condition.

When following the termination of the conversation the calling subscriber restores his receiver to the switchhook, ground is removed in the usual manner from the sleeve terminal 58 of the trunk extending to the second selector and relay 23 thereupon releases and closes a circuit from ground over its lower back contacts, the contacts of switch element 14, which closed following the release of relay 4 as previously described, contacts of vertical off-normal switch 32, toggle contacts 33, to battery and ground through the winding of rotary stepping magnet 34. Magnet 34 now intermittently operates and releases under the control of the toggle switch 33 operated thereby and steps the switch brushes to the end of the bank level or to their twelfth rotary step position, from which position the brushes are dropped by gravity to a position below the bank and are restored to normal by spring action in the manner disclosed in Patent 2,028,589 to Saxby hereinbefore referred to. In the normal position of the switch shaft the rotary and vertical off-normal switches are restored. The line finder is restored in the usual manner.

In accordance with the modified circuit of Fig. 3 the selector switch may be further simplified whereby but a single operating magnet is required for stepping the switch shaft in its vertical selecting movement, in its rotary hunting movement and in its restoring movement. For this purpose, a polarized magnet structure is provided comprising a field core 37 having two parallelly disposed pole-pieces 38 and 39 on one of which a single field winding 40 is mounted and between which a permanent magnet armature 41 is mounted for oscillation. Connected to the armature is an arm 42 to the outer end of which

two stepping pawls 43 and 44 are pivoted for cooperation respectively with the vertical ratchet wheel 45 and with the rotary ratchet wheel 46. In the normal position of the armature the pawls are held in engagement with the teeth of the ratchet wheels by the springs 47 and 48. The armature is also provided with two laterally extending arms 49 and 50 to which are pivoted the sliding rods 51 and 52, the ends of which are in normal engagement with the pawls 43 and 44, respectively. The end of arm 50 is also effective to operate the toggle switch 33 in response to the oscillation of the armature in one direction from its normal position.

For controlling the stepping mechanism the relay 4 is provided with four switch elements 12, 13, 14 and 15 of the type previously described and with an additional switch element 53 similar to element 13 which is fast to close its contacts upon the energization of the windings of relay 4 and slow to open them upon the deenergization of the windings.

The modified selector switch circuit of Fig. 3 functions in the manner previously described until vertical stepping is initiated by the release of relay 4 in response to dial impulses. In response to dial impulses, each time that the windings of relay 4 become deenergized, a circuit for magnet winding 40 is established from battery 54 over the contacts of switch element 12 which are fast to make, over the contacts of switch element 53 which are slow to break, the upper normal contacts of the rotary off-normal switch 28, through the winding of magnet 40 to battery 55. Since battery 54 is of higher potential than battery 55 current will flow in such a direction through the magnet winding 40 as to oscillate the armature 41 to move the outer end of its arm 42 upwardly thereby stepping the vertical ratchet wheel one step to raise the switch shaft one step. At the same time the end of rod 52 will be moved toward the right thereby disengaging the pawl 44 from the teeth of the rotary ratchet wheel 46 to render it ineffective to rotate such ratchet wheel upon the return of the armature 41 to its normal position. The movement of the arm 50 to the right is ineffective to operate the toggle switch 33.

When the windings of relay 4 remain energized for a prolonged interval following the termination of the impulse series at which time the contacts of vertical off-normal switch 32 are closed and the contacts of switch elements 13 and 15 are closed as previously described, a circuit is established from ground over the contacts of elements 13 and 15, the lower normal contacts of rotary off-normal switch 28, contacts of vertical off-normal switch 32, contacts of the toggle switch 33 through the winding of magnet 40 to battery 55 and ground. Current now flows through the winding of magnet 40 in such a direction as to oscillate the armature 41 to move the outer end of the arm 42 downwardly thereby stepping the rotary ratchet wheel 46 one step to rotate the switch shaft one step in a rotary direction. At the same time the end of rod 51 will be moved to the right thereby disengaging the pawl 43 from the teeth of the vertical ratchet wheel 45 to render it ineffective to rotate such ratchet wheel upon the release of the armature 41 to its normal position. The movement of the end of arm 50 to the left operates the toggle switch 33 to open its contacts thereby interrupting the circuit of magnet 40. The further operation of magnet 40 to rotate the brush shaft step by step

then proceeds in the manner previously described in connection with the operation of the circuit of Fig. 2. For returning the switch shaft to its normal position the magnet 40 is controlled in a similar manner to step the rotary ratchet wheel 46 upon the release of cut-through relay 23.

It will be obvious to those skilled in the art that the circuits of other switches, such as connector switches, of repeaters and so forth; of step-by-step systems employing combinations of fast and slow-operating relays could be simplified in the manner previously described.

What is claimed is:

1. In a selector switch having vertical and rotary stepping mechanisms, a cut-through relay and circuits therefor, a single control relay, said control relay having a contact element fast to operate and fast to release, contact elements fast to operate and slow to release and a contact element slow to operate and fast to release for controlling the circuits of said mechanisms and of said cut-through relay.
2. In a selector switch having vertical and rotary stepping mechanisms, a cut-through relay and circuits therefor, a single control relay, said control relay having a magnetic circuit and a plurality of mercury contact elements associated with said magnetic circuit, one of said contact elements being fast to operate and fast to release, others of said contact elements being fast to operate and slow to release and a further one of said contact elements being slow to operate and fast to release for controlling the circuits of said mechanisms and of said cut-through relay.
3. In a selector switch having vertical and rotary stepping mechanisms, a cut-through relay and circuits therefor, a single control relay, said control relay having a magnetic circuit and a plurality of mercury contact elements associated with said magnetic circuit, one of said elements having normally closed contacts which are fast to open and fast to close, a second of said elements having normally open contacts which are fast to close and slow to open, a third of said elements having normally closed contacts which are fast to open and slow to close and a fourth of said elements having normally open contacts which are slow to close and fast to open for controlling the circuits of said mechanisms and of said cut-through relay.
4. In a selector switch having a vertical stepping magnet, a rotary stepping magnet, a cut-through relay and circuits therefor, a single control relay, said control relay having a contact element fast to operate and fast to release, a contact element fast to operate and slow to release and contact elements slow to operate and fast to release for controlling the circuits of said magnets and of said cut-through relay.
5. In a selector switch having a vertical stepping magnet, a rotary stepping magnet, a cut-through relay and circuits therefor, a single control relay having a magnetic circuit and a plurality of mercury contact elements associated with said magnetic circuit, one of said control contact elements being fast to operate and fast to release, others of said contact elements being fast to operate and slow to release and a further one of said contact elements being slow to operate and fast to release for controlling the circuits of said magnets and of said cut-through relay.
6. In a selector switch having a vertical stepping magnet, a rotary stepping magnet, a cut-through relay and circuits therefor, a single control relay, said relay having a magnetic circuit and a plurality of mercury contact elements associated with said magnetic circuit, one of said elements having normally closed contacts which are fast to open and fast to close, others of said elements having normally open contacts which are fast to close and slow to open, another of said elements having normally closed contacts which are fast to open
7. In a telephone system, a subscriber's line having a calling device, outgoing lines and a selector switch associable with said calling line for extending a connection therefrom to any one of said outgoing lines, said switch having a vertical stepping magnet, a rotary stepping magnet, a cut-through relay and a single control relay having a first contact element fast to open and fast to close, a second contact element fast to close and slow to open, a third contact element fast to open and slow to close and a fourth contact element slow to close and fast to open, a circuit established over said second contact element by the energization of said control relay upon the connection of said switch to said calling line for marking said switch and line as busy, an operating circuit for said vertical magnet controlled over said first and second contact elements by the intermittent release of said control relay in response to the operation of said dialing device, an operating circuit for said rotary magnet controlled over said second and fourth contact elements upon the prolonged energization of said control relay following the termination of the dialed impulses, an operating circuit for said cut-through relay established over said second contact element when said switch in response to the operation of said rotary magnet finds an idle outgoing line, said cut-through relay upon operating causing the release of said control relay, and an operating circuit for said rotary magnet for causing the restoration of said switch controlled over said third contact element upon the release of said cut-through relay.
8. In a selector switch having a polarized stepping magnet operable when energized by current of one polarity for stepping the brushes of said switch in a vertical direction and operable when energized by current of the opposite polarity for stepping said brushes in a horizontal direction, a cut-through relay and circuits therefor, a single control relay, said control relay having a contact element fast to operate and fast to release, contact elements fast to operate and slow to release, and a contact element slow to operate and fast to release for controlling the circuits of said magnet and of said cut-through relay.
9. In a selector switch having a polarized stepping magnet operable when energized by current of one polarity for stepping the brushes of said switch in a vertical direction and operable when energized by current of the opposite polarity for stepping said brushes in a horizontal direction, a cut-through relay and circuits therefor, a single control relay, said control relay having a magnetic circuit and a plurality of mercury contact elements associated with said magnetic circuit, one of said elements having normally closed contacts which are fast to open and fast to close, others of said elements having normally open contacts which are fast to close and slow to open, another of said elements having normally closed contacts which are fast to open

and slow to close and a further contact element having normally open contacts which are slow to close and fast to open for controlling the circuits of said magnet and of said cut-through relay.

10. In a telephone system a subscriber's line having a calling device, outgoing lines and a selector switch associable with said calling line for extending a connection therefrom to any one of said outgoing lines, said switch having a polarized stepping magnet operable when energized by current of one polarity for stepping the brushes of said switch in a vertical direction and operable when energized by current of the opposite polarity for stepping said brushes in a horizontal direction, a cut-through relay and a single control relay having a first contact element fast to open and fast to close, second and third contact elements fast to close and slow to open, a fourth contact element fast to open and slow to close and a fifth contact element slow to close and fast to open, a circuit established over said third contact element by the energization of said control relay upon the connection of said switch to said calling line for marking said switch and

line as busy, a circuit controlled over said first and second contact elements by the intermittent release of said control relay in response to the operation of said dialing device for applying impulses of one polarity to said stepping magnet for stepping said switch brushes in a vertical direction, a circuit controlled over said third and fifth contact elements upon the prolonged energization of said control relay following the termination of the dial impulses for applying impulses of the opposite polarity to said stepping magnet for stepping said switch brushes in a horizontal direction, an operating circuit for said cut-through relay established over said third contact element when said switch in response to the stepping of said brushes in a horizontal direction finds an idle outgoing line, said cut-through relay upon operating causing the release of said control relay, and an operating circuit for said stepping magnet for causing the restoration of said switch controlled over said fourth contact element upon the release of said cut-through relay.

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