Dec. 16, 1952 H. P. BOSWAU 2,622,143

ELECTROMAGNETIC COUNTING DEVICE

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Fig. 2.

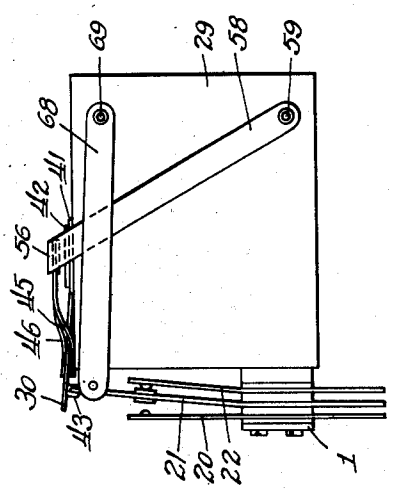


Fig. 4.

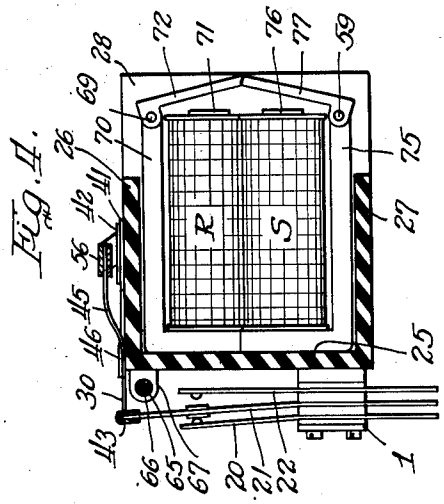


Fig. 1.

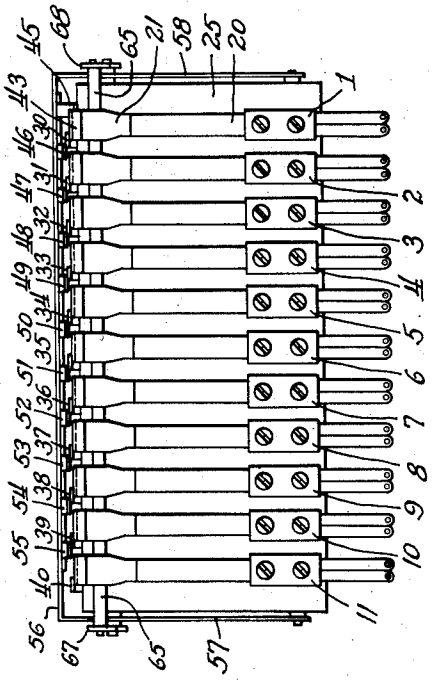
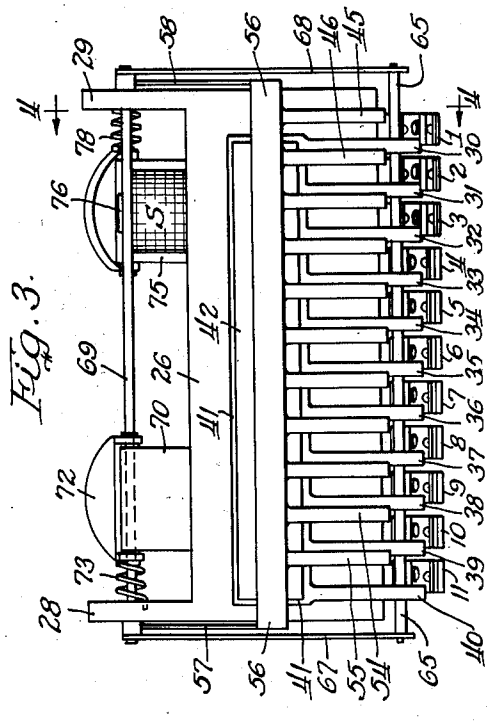


Fig. 3.



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Fig. 5.

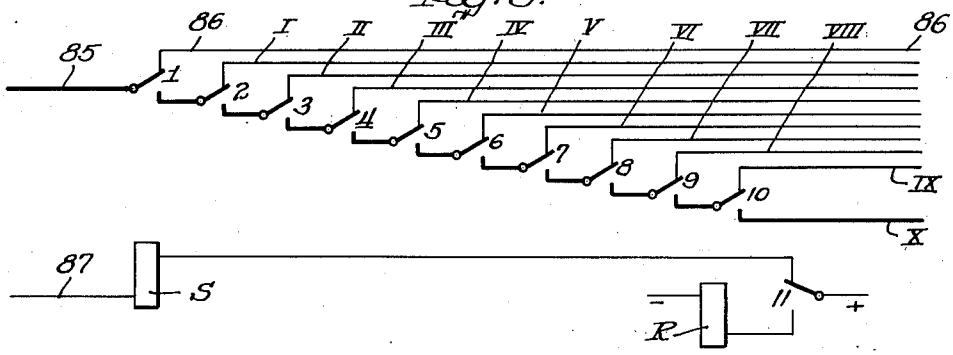


Fig. 6.

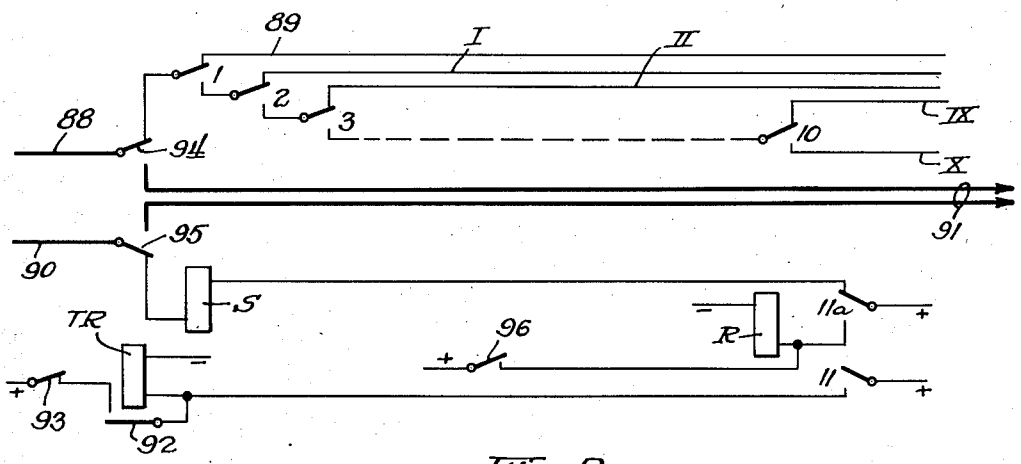
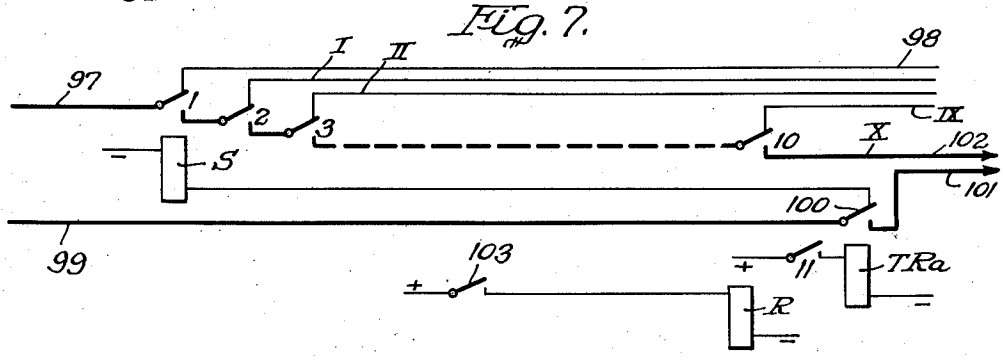


Fig. 7.



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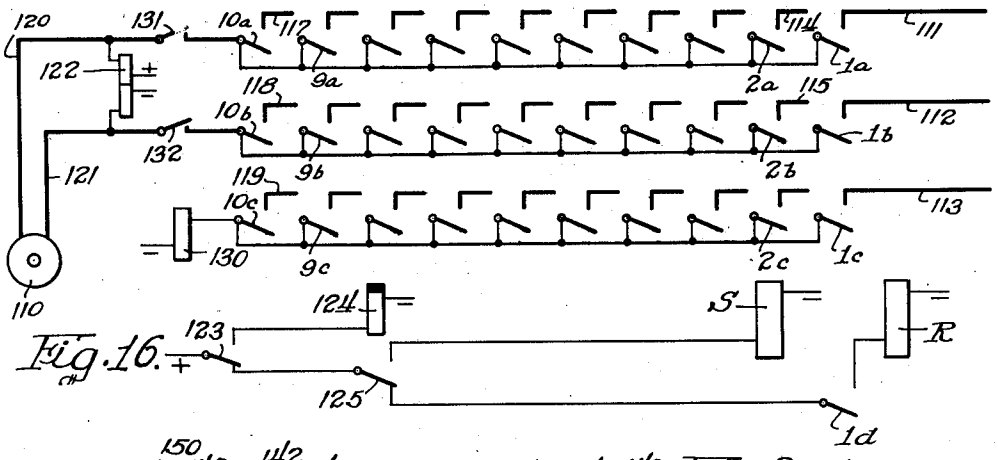


Fig. 16.

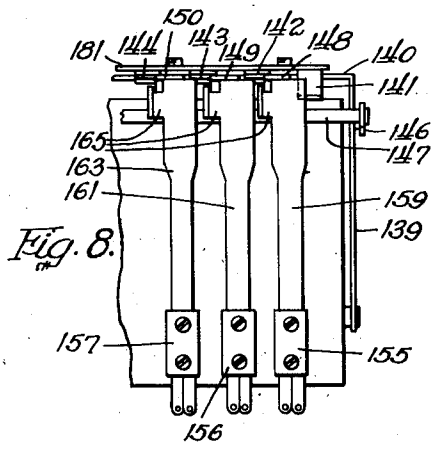


Fig. 8.

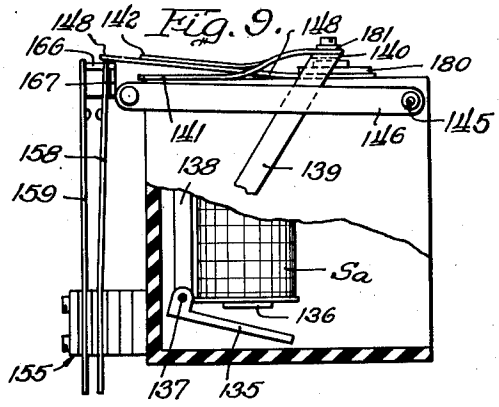


Fig. 9.

Fig. 10.

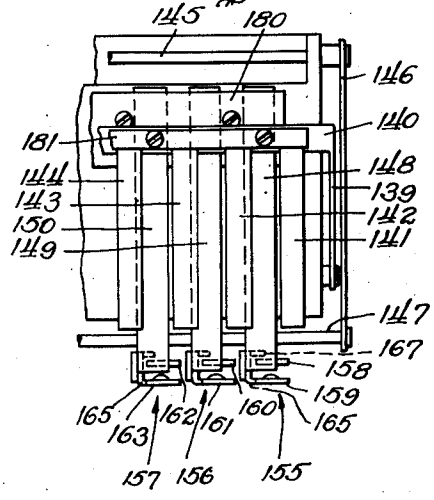
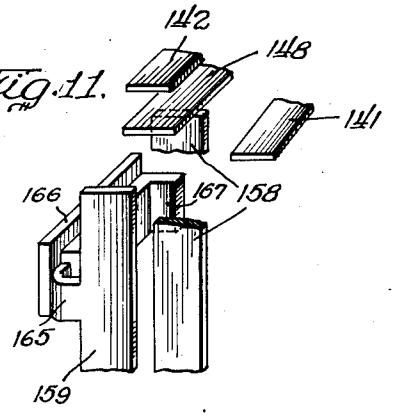


Fig. 11.



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Fig. 12.

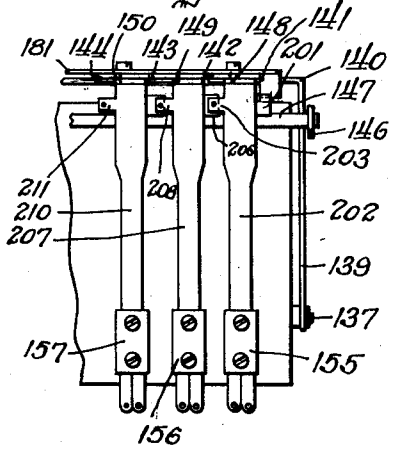


Fig. 13.

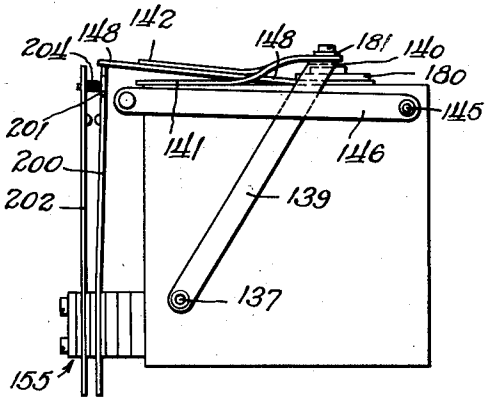


Fig. 14.

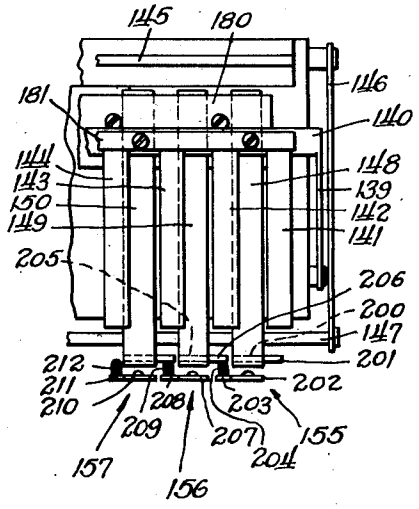
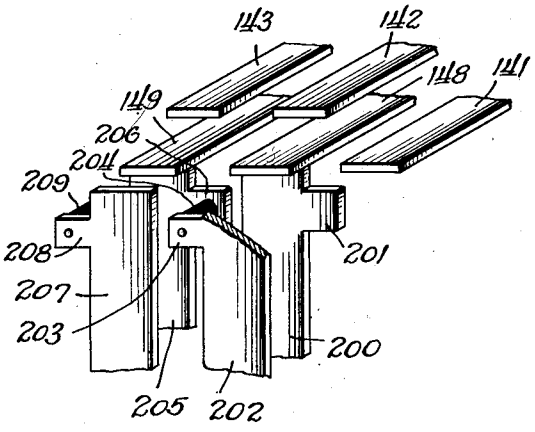


Fig. 15.



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UNITED STATES PATENT OFFICE

2,622,143

ELECTROMAGNETIC COUNTING DEVICE

Hans P. Boswau, Dundee, Ill.

Application October 3, 1947, Serial No. 777,700

13 Claims. (Cl. 177—353)

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This invention is concerned with a new multi-contact switching device and with circuits controlled thereby.

The principal object of the invention is to provide a switching device comprising a plurality of contacts or sets of contacts, a single impulse-responsive driving or stepping magnet, and means controlled by such magnet responsive to impulses delivered thereto for successively individually actuating said contacts or sets of contacts.

Another object is to provide a switching device as indicated in the preceding paragraph, wherein the successively actuated contacts or sets of contacts remain in actuated position, together with means for simultaneously restoring all actuated contacts or sets of contacts to a normal position.

Still another object is to provide in the new switching device coacting control means whereby the operative actuation of each contact or set of contacts causes operatively effective release or opening of the circuit connections established by the actuation of the preceding contact or set of contacts.

In accordance with other objects and features, the new device may be used for numerous purposes and operations required in communication systems, signalling systems and various control systems and the like. For example, the new device may be used to operate as a counting chain, or as a stepping switch to perform the functions of a selector, or as a position indicator or the like. In short, the new device may be employed wherever it is desired to bring about successive operative actuation of contacts for switching, signalling or desired control operations which heretofore required either a plurality of individual relays or switching mechanism such as pawl and ratchet stepping switches, or both.

The new device is structurally of utmost simplicity and yet adapted to perform complex switching functions. Mechanical elements, which are subject to wear and tear, such as pawls and ratchets and the like, have been eliminated, thus facilitating manufacture, lowering the cost of a unit and contributing to longer, useful life and accurate operation throughout the life of the device. The structural simplifications also contribute toward simplification of circuits in which the device is used.

The objects and features intimated above, as well as additional objects and features, will be brought out in the course of the detailed description which is rendered below with reference to

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the accompanying drawings. In these drawings,

Fig. 1 shows a diagrammatic front elevational view of an embodiment of the new switching device;

Fig. 2 is an elevational end view of the switching device as seen from the right of Fig. 1;

Fig. 3 represents a diagrammatic top elevational view of the switching device;

Fig. 4 shows a section through the frame or housing of the switching device taken approximately along line **4—4** in Fig. 3, looking in the direction of the arrows;

Figs. 5, 6 and 7 are examples of counting chain circuits in which the switching device, Figs. 1–4, may be used;

Figs. 8, 9 and 10 illustrate fractional views of a modification, the representation in these figures being generally analogous to that presented in Figs. 1, 2 and 3, respectively;

Fig. 11 is a diagram to aid in explaining the coaction of certain control means employed in the embodiment illustrated in Figs. 8 to 10 for operatively releasing or opening a contact or set of contacts incident to the operative actuation of the succeeding contact or set of contacts;

Figs. 12, 13 and 14 represent fractional views of a further modification, the showing in these figures being similar to that presented in Figs. 8, 9 and 10, respectively;

Fig. 15 shows in diagrammatic form essential parts of certain contacts and actuating members to aid in explaining the coaction of contact control means employed in the structure illustrated in Figs. 12, 13 and 14; and

Fig. 16 is a circuit diagram showing the use of the new switching device as a selector.

The drawings are not to scale and are intended for illustrative and explanatory purposes only. Like parts are numbered alike throughout the drawings. Known details and elements will be referred to only to the extent required to convey an understanding of the invention.

The embodiment shown in Figs. 1–4 comprises a generally rectangular casing or frame having a front wall **25**, top and bottom walls **26** and **27**, and end walls **28** and **29**. The frame may be made of any desired and suitable material, e. g., of an insulating material, as shown, or of suitable sheet material, if desired. On the front wall **25** are mounted a desired number of contact sets generally indicated by numerals **1—11**.

It will be understood that more or less sets of contacts may be provided, as desired, and that the contact spring combination in each contact

set may be as desired or required. The contact spring combination shown in the drawings has been adopted for convenience and is not intended to indicate any particular limitation.

In the case assumed in Figs. 1–4, each set of contacts 1—11 comprises three springs such as 20—21—22 shown in Figs. 2 and 4 in connection with the first contact set generally indicated at 1, forming a break-make contact combination. The springs are mounted in the form of the usual pile or stack, and spring 21 in each pile is the contact control spring which is operatively displaced relative to springs 21 and 22. Each of the remaining sets or piles of contacts is assumed to form a like combination. The contact springs may be of the well known type used in signalling and switching relays.

On the top wall 26 of the frame are mounted a plurality of resilient members forming control or locking fingers, one for each set of contacts 1—11. Finger 30 is the control or locking finger associated with the set of contacts indicated at 1; finger 31 is the control or locking finger for contact set 2; and the members 32—40 are in like manner associated with and operate as control or locking fingers for the contact sets 3—11, respectively. These control or locking fingers 30—40 extend forwardly from a strip 41 which is suitably secured on the top wall 26 of the casing by means of a member 42. The strip 41 and its fingers 30—40 may be made of suitable resilient material, for example, Phosphor-bronze. Each finger at its free end may be provided with an insulating member or, alternatively, the strip 41 may be dispensed with and the fingers 30—40 may be individual elements mounted on the top wall of the casing, as shown, and, if required, suitably insulated therefrom. It is assumed in the drawings that the locking fingers extend from the common strip 41 and that each contact control spring, such as the spring 21, is provided with an insulating cap or sleeve 43 for coaction with its associated control or locking finger.

Each control or locking finger rests normally on top of the middlemost contact spring or control spring of its associated sets of contacts, as indicated in Fig. 2, showing the finger 30 resting on the insulating member 43 secured to the free end of the spring 21. If it is assumed that the contact spring 21 is flexed or moved forwardly, counter-clockwise as seen in Fig. 2, past the free end of its associated locking finger 30, the locking finger will flex or move into its normal position, in back of the insulating cap 43 secured to the contact spring 21, as indicated in Fig. 4, locking such contact spring in its alternate operative position. The remaining sets of contacts 2—11 are successively locked in actuated position in a similar manner.

The operation intimated in the foregoing paragraph is accomplished by the provision of actuating members or fingers 45—55, one for each set of contacts. These actuating fingers are secured to and extend forwardly from a crosspiece forming a carrier member 56 having arms 57 and 58 which are secured to the free ends of a rotatably mounted shaft 59. The shaft is adapted to be rotated, in counter-clockwise direction, as seen in Figs. 2 and 4, responsive to the energization of a coil associated with the drive or stepping magnet generally indicated by S. The actuating fingers 46 to 55 coact with and normally ride on top of the locking fingers 30 to 39, respectively, when the latter are in normal position in which the finger 30 is indicated in Fig. 2. The actuating finger 45 associated with contact set 1 normally rests on the surface of the top wall 26 of the frame.

It will be seen from the foregoing that, when an impulse is delivered to the coil of the stepping magnet, the shaft 59 is displaced in counter-clockwise direction, as seen in Figs. 2 and 4, thus angularly displacing the arms 57 and 58 and moving the crosspiece or carrier 56, and therewith the actuating fingers 45—55, forwardly in the direction of the sets of associated contacts. The actuating finger 45, resting freely on the top wall 26 of the frame in back of the free end of control spring 21 of contact set 1 becomes operatively effective in response to the current impulse to displace the contact spring 21 to assume its operated position, as shown in Fig. 4. The second to tenth actuating fingers 46—55 ride on the control or locking fingers of the first to tenth sets of contacts, respectively, and are thus ineffective responsive to the energization of the coil of the stepping magnet S incident to the first current impulse delivered thereto. Putting it in other words, the actuating finger for each except the first contact set rides normally on the control or locking finger of the preceding contact set and can become operative only when its coacting control or locking finger is in operative locking position with respect to its associated contact set. The contact control spring 21 of contact set 1 in response to the first current impulse delivered to the stepping or impulse magnet S is thus moved by the actuating member 45 into its operated position (Fig. 4), allowing the locking finger 30 to drop in back of it to maintain it operated, thereby removing the support for the actuating finger 46 which drops into preparatory position, ready to actuate contact set 2 upon delivery of the second current impulse to the coil of the magnet S. The remaining contact sets 3—11 are successively actuated in a similar manner responsive to delivery of the corresponding current impulses to the stepping magnet.

What has been said before with respect to the locking fingers 30—40 is also true with respect to the actuating fingers 45—55; namely, these fingers may extend from a common strip suitably secured to the crossbar 56, and the free end of each finger may be insulated, or these fingers may be individual members secured to the crossbar 56 in insulated relation therewith.

A release bar 65 is provided which may be a tubular insulating member on a rod 66, the opposite ends of which are fastened to arms 67—68, respectively. The other ends of these arms are connected with a shaft 69 which is rotatably journalled in the end walls 28 and 29 and is adapted to be angularly displaced in clockwise direction, as seen in Figs. 2 and 4, responsive to the energization of the coil associated with the restoring magnet R.

The restoring magnet R just like the stepping magnet S, may be structurally similar to the well known type of relay widely used in numerous signalling and switching systems. It comprises a yoke or heel piece 70 from which extends a core 71 surrounded by a suitable coil. The assembly of heel piece, core and coil is in suitable manner attached to the frame inside thereof. The free end of the heel piece 70 is provided with a bore through which extends the shaft 69. The armature 72 is provided with ears, as shown, and these ears are suitably fastened on or keyed to the shaft 69. The shaft is journalled in the side walls 28 and 29, as mentioned before, and a

spring 73 is provided, one end of which is anchored in the side wall 28 and the other in one of the ears of the armature 72. Accordingly, the spring 73 biases the shaft 69 in counter-clockwise direction, as seen in Figs. 2 and 4, thereby holding in normal position the armature 71 and the arms 67 and 68, and therewith the release bar 65. A suitable stop may be provided, if desired, to define the normal position of the armature 72 and associated parts.

If it is assumed that the coil of the restoring magnet R is energized, the armature 72 will be attracted to displace the shaft 69 in clockwise direction, as seen in Figs. 2 and 4, thereby moving the arms 67—68 likewise, lifting the bar 65 for the purpose of engaging and lifting the control or locking fingers such as 30—40 from their operated positions, as shown in Fig. 4, to allow the actuated contact springs to return to normal position, as shown in Fig. 2. The control or locking members 30—40 are then again in normal position, resting on the respective insulating members such as 43 of their associated contact control springs, such as 21, and the actuating fingers 46—55 are again in raised inoperative position, riding on their respective coacting control or locking fingers 30—39.

The drive or stepping magnet S comprises similarly, the heel piece 75 associated with a core 76 which is surrounded by a suitable coil. This assembly is likewise secured within the frame. The free end of the heel piece is provided with a bore through which extends the shaft 59 which is journalled in the side walls 28 and 29. The armature 77 is provided with ears, as shown, which are suitably fastened or keyed to the shaft 59. A spring 78 is provided, one end of which is anchored in the side wall 29, the other end being anchored in one of the ears of the armature 77. The shaft 59 is thus normally biased in clockwise direction, as seen in Figs. 2 and 4, holding in normal position the armature 77 and the arms 57—58, and therewith the crosspiece or carrier 56 and the actuating fingers 45—55 extending therefrom. A suitable stop may be provided for defining the normal position of the armature 77 and its associated parts.

It will be appreciated that the shaft 59, i. e., the pivot point of the arms 57—58 carrying the crosspiece 56 may be differently disposed. For example, it may be shifted to the left from the point at which it is shown in Figs. 2 and 4 by adopting a mounting for the stepping magnet such as shown in connection with the stepping magnet S*a* of the modification illustrated in Fig. 9. If the structure shown in Figs. 1–4 is adopted, the arms 57—58 should be long enough to provide for the desired forward motion of the actuating fingers 45—55.

The actuating fingers 45—55 may also be secured in a separate crosspiece which may be slidably disposed on the top wall of the device and provided with suitable extensions, one at each end, and the free end of each of the arms 57—58 may be forked or provided with a suitable slot for pivotal coaction with an associated extension of the separate slidably disposed crosspiece.

While it is believed that the operation of the device is apparent from the foregoing description of its structure, it may be conveniently separately summarized.

It is assumed for this purpose that the device is in normal position, with all the sets of contacts at normal, as shown in Fig. 2, that is, with the locking fingers 30—40 each associated with a contact control spring such as 21, each resting on top of its associated contact spring such as 21. The actuating fingers 46—55 are in normal position, each riding on its associated control or locking finger. Only the actuating finger 45 is in preparatory position in back of contact control spring of contact set 1. If successive current impulses are now delivered to the coil of the stepping magnet S, we will obtain the following operation:

Upon delivery of the first impulse to the stepping magnet, the armature 77 is attracted to rotate the shaft 59 in counterclockwise direction, as seen in Figs. 2 and 4, thereby moving the arms 57—58 and the crosspiece 56 with its actuating fingers 45—55 forwardly in the direction of the sets of contacts 1—10. The actuating fingers 46—55 remain inactive during the first operative actuation of the stepping magnet, riding on top of their associated control or locking fingers, as described. The actuating finger 45 slides forwardly on the surface of the top wall 26 of the casing until it engages the insulating cap on the free end of the contact control spring 21 of the contact set 1. This contact control spring is moved to the left of its normal position as seen in Fig. 2, until it assumes the position indicated in Fig. 4, when its locking finger 30 moves downwardly to secure it in its operated position. In moving downwardly, the locking finger 30 permits the actuating finger 46 associated with the second contact set 2 to flex downwardly into preparatory position, as shown in Fig. 4, being ready in this position to actuate the contact control spring of the second contact set incident to its forward displacement responsive to delivery of the second impulse to the stepping magnet.

During the energization of the stepping magnet, responsive to delivery of the second impulse, all the actuating fingers 47—55 ride on top of their associated locking fingers, and therefore cannot actuate their contacts; only the actuating finger 46 can become effective to operate the contact control spring of the second set of contacts indicated at 2, permitting the locking finger 31 to assume its locking position to maintain contact set 2 in operated position. Upon moving into locking position, the locking finger 31 permits the actuating finger 47 to move downwardly into preparatory position for the actuation of the third set of contacts responsive to the delivery of the third impulse. The operation is repeated with each successive impulse delivered to the stepping magnet, and the contacts 1—11 are thus successively placed in actuated position, as shown in Fig. 4, and each contact is maintained in this position by its associated locking finger.

A current impulse is delivered to the coil of the restoring magnet R when it is desired to release the actuated contacts to normal. Magnet R attracts its armature 72 which rotates the shaft 69 in clockwise direction, as seen in Figs. 2 and 4, thereby moving the arms 67 and 68 likewise and lifting the release or restoring bar 65 which is thus moved into engagement with the locking fingers 30—40, all or some of which are assumed to be in actuated position, as shown in Fig. 4, lifting these fingers to restore all the actuated contact sets to normal position, as shown in Fig. 2.

Figs. 5–7 illustrate in diagrammatic representation examples of using the mechanism in switching devices such as counting chains. The battery connections are indicated by plus and

minus symbols, plus being referred to as "ground" and minus as "battery."

In the circuit shown in Fig. 5, the object is to extend a conductor 85, which is normally connected with a conductor 86, successively into connection with conductors I—X. Ten make-break contacts, numbered 1—10, corresponding to the sets of contacts shown in Figs. 1–4, serve this purpose. A contact 11, corresponding to the similarly marked eleventh contact set shown in Figs. 1–4, is provided for control functions. Numeral 87 indicates the impulse conductor over which current impulses are delivered to the stepping magnet S which, in the normal position of the device, is connected to ground potential by way of the contact 11 in resting position thereof. Therefore, current impulses delivered to the stepping magnet S will successively energize this magnet, causing successive switching of contacts 1—10 into their alternate positions, and thus extending the line 85 aas described. The eleventh impulse causes displacement of contact 11 into its alternate position to disconnect the stepping magnet S and to energize the restoring magnet R which moves the restoring bar 65 (Figs. 1–4) as described, releasing all actuated contact springs to normal and thus interrupting its own circuit. The device is again in its normal home position. Restoration to normal occurs in this case after all contacts have been operated.

In the circuit shown in Fig. 6, the object is to extend a conductor 88 from connection with a conductor 89 successively into connection with conductors I—X, only conductors I, II, IX and X being indicated in the drawing. The conductor over which the impulses are delivered to the stepping magnet is indicated at 90. The successive actuation of the various contacts 1—11 is accomplished as before, by successive energization of the stepping magnet.

The further object in this particular circuit is to extend both the conductor 88 and the impulse conductor 90 over conductors 91 to another switching device, e. g., to a unit just like the one shown in Fig. 6. The transfer is accomplished upon delivery of the eleventh impulse, causing actuation of a contact set comprising a make contact 11 and a break-make contact 11*a*. The contacts are so adjusted that the make contact 11 operates before the break-make contact 11*a*. Accordingly, when the eleventh impulse is delivered to the stepping magnet S, contact 11 will close a circuit from ground to the transfer relay TR, causing energization of this relay which actuates its make contact 92 to lock itself in operated position over a contact 93 of a suitable restoring relay or the like which is not shown in the drawing. The transfer relay TR actuates its break-make contacts 94—95, transferring conductors 88 and 90 to the conductors 91. Upon actuation of contact 11*a*, the restoring magnet R energizes and restores the various contacts 1—11 and 11*a* to normal.

A make contact 96 is provided which may be a push button, a key, or may be operated by a suitable relay, not shown, for the purpose of energizing the restoring magnet R in any position to which the switching device may have been advanced, that is to say, independent of the operation of its eleventh contact.

The circuit shown in Fig. 7 comprises a line 97 which may be extended from normal connection with a line 98 successively into connection with lines I—X, the last noted line X terminating in another desired switching device, e. g., in a unit just like the one shown in Fig. 7. Impulses are delivered over a conductor 99 by way of the contact 100 of a transfer relay TR*a*, the contact 100 being normally in resting position, as shown, to establish connection with the coil of the stepping magnet S. Upon delivery of the eleventh impulse, contact 11 is actuated, which in this case is a simple make contact, to energize the transfer relay TR*a*. This relay operates and places its contact 100 in alternate position, thus extending the impulse conductor 99 to the next switching device by way of conductor 101. The chain of contacts remains operated, extending the conductor 97 over conductor 102 to the next switching device. Release of the device to normal may be accomplished by actuating the contact 103 by any desired means, e. g., a relay, not shown in the drawing, to cause energization of the restoring magnet R.

It may be desirable in the design of certain circuits to provide operation of a plurality of contacts in such a manner that the operative actuation of each contact set releases or resets to open position the previously actuated contacts. This is possible by employing the structure which is fractionally and schematically indicated in Figs. 8–11.

The device shown in these figures comprises again a suitable generally rectangular frame or housing having a front wall, top, bottom and end walls. Disposed in the frame is a stepping magnet S*a*, as shown in Fig. 9, corresponding to the stepping magnet S provided in the previously described structure. The stepping magnet S*a* is adapted to operate an armature 135, responsive to delivery of an impulse to its coil, the armature being fastened or suitably keyed by means of its ears to a shaft 137 which is rotatably journalled in the end walls of the frame. Attached to the free ends of the shaft 137 are arms such as 139 of a carrier or crosspiece 140 to which are secured the actuating members or fingers such as 141—144, one for each set of contacts of the device. These fingers are assumed to be individual members secured to the crosspiece 140 in insulated relation with respect thereto by means of a striplike member 131.

Also disposed within the frame is a release magnet which is structurally analogous to the release magnet R of the previously described structure. The release magnet is adapted, upon energization, to displace the shaft 145 for the purpose of rotating in clockwise direction (as seen in Fig. 9) the arms 146 carrying the release bar 147.

On the top wall of the frame are mounted the control members or locking fingers such as 148—150, one for each set of contacts, for coaction with the corresponding actuating fingers provided for these sets of contacts. The locking fingers are likewise assumed to be individual members mounted on the frame in insulated relationship by means of a striplike member 130.

On the front wall of the device are secured a desired number of sets of contacts, three of which are shown in Figs. 8 and 10, marked in Fig. 8 generally by numerals 155—157. Each set of contacts is shown as a simple make contact composed of two contact springs. The contact springs of the set of contacts 155 are indicated at 158, 159. Similar springs 160—161, 162—163, respectively, are provided for the remaining sets of contacts 156—157. Each of the contact springs 159, 161, 163 is provided with a rearwardly projecting ear 165, carrying an insulating member

which extends rearwardly therefrom, forming a ledge 166 and a laterally projecting extension 167 which is disposed in parallel with and in back of the associated contact spring, such as spring 158.

In normal position of the device, each of the locking fingers 148—150 rests on the free end of the inner contact spring such as 158 of the associated set of contacts.

The device so far as described in the foregoing is thus similar to the first described embodiment, except for structural modifications having to do with the mounting of the actuating and locking fingers and the manner in which the stepping magnet Sa is secured within the frame. The prominent difference between the former structure and the device shown in Figs. 8–11 resides in the provision of the insulating member associated with each of the contact springs 159, 161 and 163, forming the ledge 166 and the extension 167, and further resides in the coaction of the actuating and locking fingers with the contact springs of their associated and adjacent contact sets.

The object, in this embodiment, as mentioned before, is to obtain successive actuation of the sets of contacts and to release coincident with the operation of each contact set the previously actuated contact set. The operation is briefly described below with reference to Figs. 8–10 taken together with the explanatory diagram Fig. 11.

Assuming that the device is in normal position, with each contact set as shown in Fig. 9, and further assuming that a series of impulses is delivered to the coil of the stepping magnet Sa, we obtain, upon delivery of the first impulse, attraction of the armature 135 and therewith displacement of the shaft 137 in counter-clockwise direction, as seen in Fig. 9, thereby correspondingly moving the arms 139 and therewith the carrier 140, to move the actuating fingers such as 141—144 in the direction of their associated contacts. The actuating finger 141 for the first set of contacts 155, which is in preparatory position, riding freely on the surface of the top wall of the frame, moves the contact spring 158 of the first contact set 155 forward and the free end of such spring slips from underneath its locking finger 148. The remaining actuating fingers ride on top of their coacting locking fingers, as in the previous case, and thus remain inactive. The locking finger 148 drops downwardly into engagement with the shelf formed by the insulating extension 167 carried by the contact spring 159, thus locking contact spring 158 in actuated position. The dropping of the locking finger 148 permits the actuating finger 142, for the second set of contacts 156, to drop downwardly into preparatory position. Upon delivery of the second impulse, all the actuating fingers are again moved forwardly, but only the actuating finger 142 is effective to engage the contact spring 160 of the second contact set so as to move it forwardly into contact-making engagement with its associated spring 161, permitting the locking finger 149 to drop downwardly in back of the spring 160 into engagement with the shelflike extension formed by an insulating member such as 167 associated with the spring 161. The actuating finger 142, in moving forward for the purpose of actuating the contact spring 160, also engages the edge of the insulating member 166 which extends rearwardly from the spring 159, thereby displacing the spring 159 with respect to the spring 158, opening the previously closed contact springs. In moving the insulating member 166—167 forward with its spring 159, the support for the locking finger 148, which rested on the ledge formed by the extension 167, is removed, and this locking finger can drop down a further small amount to lock in back of the extension or projection 167, thus maintaining the contact springs 158—159 in open position. The second set of contacts has thus been operatively actuated, and the previously actuated first set of contacts has been restored to open position. Each successive set of contacts is actuated in a similar manner, and the previously actuated contact set is at the same time restored to open position.

The release to normal is accomplished, as in the first embodiment, by the energization of the restoring magnet which lifts the release bar 147 to engage all locking fingers such as 148 and to allow the associated contact springs to restore to the position shown in Fig. 9.

The embodiment shown in Figs. 12–15 is essentially similar to the one shown in Figs. 8–11, and identical parts are accordingly marked by identical reference numerals. A simplified showing has been adopted for Fig. 13, eliminating the sectional representation of the housing and showing it instead in elevation.

The difference between the embodiment according to Figs. 12–15, and the one shown in Figs. 8–11, resides in the structure of the contact springs and their coaction with the associated actuating and locking fingers. Three sets of contact springs are shown, corresponding to similar sets in the previously described embodiment and correspondingly generally marked by numerals 155, 156, 157. Each contact set comprises again two contact springs. Accordingly, the set of contacts 155 comprises two contact springs 200 and 202; the contact set 156 comprises the contact springs 205 and 207; and the contact set 157 comprises two similar springs, the outer spring being marked by numeral 210.

The rearmost contact spring of each contact set, such as the springs 200 and 205, is provided with a laterally projecting ear such as 201 for spring 200 and 206 for spring 205. The forwardly positioned contact spring in each contact set is provided with a similar ear which projects laterally in opposite direction. Thus contact spring 202 carries the ear 203, contact spring 207 carries the ear 208, and contact spring 210 carries the ear 211. Attached to each of the ears 203, 208 and 211 is a rearwardly extending insulating nipple as indicated at 204, 209 and 212.

The operation is similar to that described in connection with the embodiments Figs. 8–11. The sets of contacts are successively individually actuated and, incident to the actuation of each contact, the contact springs of the previously operated contact set are opened. A cycle of operation is briefly described below:

Upon delivery of the first current impulse to the stepping magnet, the crosspiece 140 with the actuating fingers 141—144 is moved forward toward their associated contact sets. The actuating finger 141 rides freely on top of the housing and engages the ear 201 of the contact spring 200, moving such contact spring forward and allowing the locking finger 148 to drop downwardly, thus placing the actuating finger 142 for the second set of contacts in preparatory position. The contact spring 200 is thus brought into contact-making engagement with the spring 202 and the locking finger 148 flexes downwardly in back of the upper end of the spring 200, lock-

ing the spring in actuated position. Upon delivery of the second current impulse, all the actuating fingers are again moved forward, but only the actuating finger 142 is effective to engage the ear 206 of the contact spring 205, moving such contact spring forward into contact-making engagement with spring 207 and allowing the locking finger 149 to drop in back of it to secure it in operated position. The actuating finger 143 for the third set of contacts is at the same time moved into preparatory position, exactly as in the manner previously described. The ear 206, which is engaged by the actuating finger 142 to move contact spring 205 into operated position, also engages the insulating nipple 204 rearwardly projecting from the ear 203 of the contact spring 202, thus moving this spring away from the spring 200 to open the previously established contact engagement. The actuation of the second set of contacts thus causes opening of the previously actuated first contacts. The remaining sets of contacts are successively operated in a similar manner.

The release of the device to normal is accomplished in accordance with explanations furnished in connection with the description of Figs. 8–11.

The structure shown in Figs. 12–15, inclusive, thus functions in a similar manner as the structure shown in Figs. 8–11, but employs simpler means for accomplishing the intended results.

The successive two-stage contact operation, as described with reference to Figs. 8–15, may also be obtained by the provision of a separate locking finger for each of the two contact springs of each contact set, for example, one locking finger for the spring such as 158 or 200, which locks it in actuated position relative to spring 159 or 202, respectively, and a separate locking finger for spring 159 or 202, which locks it in operated position relative to spring 158 or 200, respectively. Springs such as 159 or 202, respectively, would in this case extend beyond their associated springs such as 158 or 200, and their locking fingers would extend from a separate mounting projecting from the frame of the device.

The contact sets shown in Figs. 8–15 are assumed to be simple make contacts. As remarked before, the contact combinations may be different. For example, there may be a plurality of make contacts in each pile, all of which are simultaneously operated and subsequently released as described. Contact springs such as the springs 158 (Figs. 8–11) or spring 200 (Figs. 12–15) are for this purpose simply mechanically interconnected with like springs of additional contacts, and their operative actuation therefore affects all of them. The simultaneous actuation of several make contacts in each pile is thus accomplished responsive to delivery of the corresponding current impulse to the coil of the stepping magnet. Likewise, the contact springs such as spring 159 (Figs. 8–11) or spring 202 (Figs. 12–15) may be in known manner mechanically interconnected with correspondingly placed contact springs of additional contact sets in the pile, and the displacement of such spring (159 or 202) responsive to actuation of the contacts of the successive pile is thus effective to all and causes opening thereof. There may be an additional off-normal make contact included in the first pile of contacts corresponding to the sets of contacts 155 which remains in actuated position incident to opening of the remaining contacts in the pile responsive to operative actuation of the contacts in the successive pile. This is accomplished by mechanically interconnecting the make spring of each off-normal contact with the make spring such as 153 (Figs. 8–11) or 200 (Figs. 12–15), respectively, but omitting the mechanical interconnection of its resting spring with the resting spring such as 159 or 202, respectively, as previously described.

The above examples have been given for the sake of convenience. Numerous other contact combinations may be devised by employing expedients well known in the relay switching arts.

The modified embodiments shown in Figs. 8–11 and 12–15, respectively, may be employed in many instances. An example is indicated in Fig. 16, showing how such device may be used as a selector. There are ten sets of contacts provided. The first contact set comprises four make contacts indicated by *1a*, *1b*, *1c*, *1d*. Each of the remaining sets of contacts comprises three make contacts such as *2a*, *2b*, *2c*—*9a*, *9b*, *9c*—and *10a*, *10b*, *10c*, respectively. Upon delivery of the first impulse to the stepping magnet S, all make contacts *1a*, *1b*, *1c*, *1d* will be actuated. Upon delivery of the second impulse, all contacts *2a*, *2b*, *2c* will be actuated, and contacts *1a*, *1b*, *1c* will be operatively released; i. e., they will be opened as previously described. Contact *1d* will remain operated, being a special off-normal contact associated with the contact set *1a*, *1b*, *1c* which is not affected by the opening of the other contacts as described before. The successive remaining sets of contacts are successively actuated and subsequently opened. Contacts *1a*, *2a* through to *9a*, *10a* are connected in multiple, as shown. The same is true of contacts *1b*, *2b* through to *9b*, *10b* and to contacts *1c*, *2c* through to *9c*, *10c*. Each set of contacts *1a*, *1b*, *1c*—*2a*, *2b*, *2c* through to *9a*, *9b*, *9c*—*10a*, *10b*, *10c* has access to an outgoing line comprising two line and one test conductor. Contact set *1a*, *1b*, *1c* thus has access to the line comprising conductors 111, 112, 113; contacts *2a*, *2b*, *2c* have access to the line comprising conductors 114, 115, 116; and contacts *10a*, *10b*, *10c* have similarly access to a line comprising conductors 117, 118, 119.

Contacts *10a*, *10b* and *10c* are each connected with a local conductor, contact *10c* connecting with the test relay 130. Numeral 110 may be assumed to be a subscriber's line equipped with a dial for sending out impulses. The circuit is simplified; only elements which are essential for an understanding of the operation are shown. The object is to switch or extend the subscriber's line 110 in response to impulses selectively into connection with any one of ten outgoing lines provided in this case.

The operation is as follows:

When the subscriber removes his receiver, a contact is operated and closes a loop over the conductors 120—121 to energize the line relay 122 which is provided with two windings, as shown. This relay energizes and actuates its contact 123, completing a circuit for the energization of the slow-to-release relay 124. The latter energizes and places its contact 125 in alternate position, thus preparing the impulse circuit for the stepping magnet S. The line relay 122 is successively interrupted by impulses delivered responsive to the actuation of the dial at the subscriber's station 110. Upon deenergizing responsive to the first interruption of the line relay 122, an impulse is delivered to the

stepping magnet S over contact 123 which moves into its resting position, as shown in the drawing. Relay 124 is slow-acting and remains operated. The stepping magnet operates its armature, thus displacing the actuating members carried on a crossbar or carrier such as 140 shown in Figs. 8–15, thereby operating the set of contacts comprising contacts 1*a*, 1*b*, 1*c*, 1*d*. The first two contacts establish connection with the outgoing line conductors 111 and 112, respectively. The third contact 1*c* connects the test relay 130 with the test conductor 113, testing the outgoing line for ground. The third contact 1*d* closes a point in the circuit of the restoring or release magnet R which at this moment is opened at contact 125 of the energized slow-release relay 124. Only one impulse is delivered, if it is desired, to establish connection with the outgoing line comprising the conductors 111, 112, 113. If ground is encountered on the test conductor 113, indicating that the called line is idle, the relay 130 will energize and actuate its contacts 131—132, switching the line conductors of the calling line through to the outgoing line conductors 111—112. The line relay 122 remains energized throughout the call, keeping its contact 123 in alternate operated position, thereby maintaining slow-acting relay 124 energized, and this relay in turn keeps contact 125 in alternate operated position. The restoring circuit is prepared by contact 1*d* which is in actuated position. When the subscriber at station 110 restores the receiver, he interrupts the loop circuit for line relay 122. This relay deenergizes, restoring its contact 123 to normal, thus causing deenergization of slow-acting relay 124. Relay 124 moves its contact 125 to normal, as shown in the drawing, closing a circuit from ground by way of contacts 123, 125, 1*d* to the coil of the restoring magnet R which energizes and restores all contact sets to normal position in the manner already discussed.

The sequence of operations is similar when the subscriber dials any number up to the number "0." The difference resides simply in extension of the calling line to the conductors of the outgoing line which corresponds to the dialed number. For example, if the number "0" is dialed, ten impulses are delivered to the stepping magnet S, causing successive actuation of the sets of contacts until finally contacts 10*a*, 10*b*, 10*c* are in operated position. The test relay 130 is thus extended by way of contact 10*c* to the test conductor 119 of the tenth outgoing line. If the selected outgoing line is idle, ground is encountered and relay 130 operates, closing its contacts 131—132, thus extending the calling subscriber's line by way of contacts 10*a*, 10*b* to the outgoing line conductors 117—118. The remaining operations are identical with those already described.

It will be appreciated that the device may also be used in the manner of a line switch which hunts automatically for an idle line. Known circuit principles are employed in such a case to provide for automatic stepping, automatic successive actuation of the stepping magnet S responsive to the removal of the receiver at the subscriber's line, thus causing successive actuation of the sets of contacts provided on the device and therefore successive automatic testing of the outgoing lines. When an idle line is found, relay 130 energizes and switches the calling subscriber's line through to the line conductors of the seized outgoing line which may terminate in a selector or any other desired switching device. Release of the device is again accomplished upon conclusion of the call, responsive to deenergization of the line relay 122 when the subscriber replaces his receiver.

It will likewise be appreciated that the arrangement shown in Fig. 16 may also be employed for counting chains or the like. The switch structure shown in Figs. 1–4 may also be employed for operation as a selector. Different examples have been given merely to show the flexibility and the adaptability of the new device to meet desired conditions and varying circuit requirements.

The modified embodiment shown in Figs. 8–11 and 12–15, respectively, may be employed in many other instances. A selecting device may be mentioned as an example, which is to be operated in such a manner that only the actually selected circuit elements should operatively respond. Each of the contacts of the modified device may for this purpose be associated with a slow-to-energize relay which does not operatively respond to momentary energization but does operatively energize if its circuit remains closed for a predetermined interval. Current will thus be successively connected to the series of slow-to-energize relays and, inasmuch as each contact is released to inoperated position upon operation actuation of the next successive contacts, the corresponding slow-acting relays will not respond. Only the relay actually selected will respond operatively and execute its assigned functions.

The arrangement shown in Figs. 8–11 or 12–15, respectively, may be modified by associating only predetermined sets of contacts with the rearwardly extending insulating member forming the ledge 166 and the shelf 167 or the rearwardly extending nipple-like insulating members such as 204, 209, 212, respectively. Such arrangement will permit operation in such a manner that selected contact sets remain operated while certain other contact sets restore to normal upon actuation of the next adjacent set of contacts.

The examples given in the foregoing are illustrative only, and it is therefore understood that changes may be made within the scope and spirit of the appended claims which define what is believed to be new and desired to have protected by Letters Patent of the United States.

I claim:

1. In combination, a plurality of sets of contact springs disposed side by side, a resilient control member for each set of contact springs resting normally on a predetermined spring of such set in edgewise engagement with the free end thereof, a movable actuating member for each set of contact spring, the actuating members associated, respectively, with the set of contact springs of the second to last set of springs being superposed on and resting on the control members associated, respectively, with the set of contact springs of the first to one before last set of contact springs, and means for successively displacing said actuating members in common whereby said sets of contact springs are successively individually actuated, the actuation of each set of contact springs causing release of its associated control member from edgewise engagement with its corresponding spring to dispose the actuating member coacting therewith in preparatory operating position relative to its corresponding set of contact springs.

2. The structure and combination defined in claim 1, wherein each control member upon release from edgewise engagement with the corresponding spring of its set is disposed in back of such spring to lock such set of contact springs in operated position.

3. The structure and combination defined in claim 1, wherein each control member upon release from edgewise engagement with the corresponding spring of its set moves in back of such spring to lock such set of contact springs in actuated contact-making position, and means carried directly by and extending from a contact spring of a predetermined set of contact springs for opening the contact-making position of a previously actuated set of contact springs.

4. In a switching device having an impulse magnet and a plurality of sets of contact springs disposed side by side, a mechanism for actuating said sets of contact springs comprising a plurality of elongated control members, one for each set of contact springs, said control members extending from a relatively fixed mounting, each control member being normally supported near its free end on the free end of a spring in its associated set of contact springs and held thereby beyond the free end of such spring, a first actuating finger extending from a movable mounting with its free end normally disposed in operative position relative to a first one of said sets of contact springs and in readiness to actuate such first set of contact springs responsive to initial displacement of said movable mounting, a plurality of additional actuating fingers extending from said movable mounting, one for each one of the remaining sets of contact springs, each of said additional actuating fingers being normally held in inoperative position beyond the free end of its associated set of contact springs in sliding engagement with and supported on the control member associated with the preceding set of contact springs, and means operated by said impulse magnet responsive to current impulses successively delivered thereto for successively displacing said movable mounting and thereby all said actuating fingers, said first set of contact springs being actuated by said first actuating finger responsive to initial displacement of said movable mounting in accordance with the first current impulse delivered to said impulse magnet and the remaining sets of contact springs being successively actuated by their respective actuating fingers each of which is successively placed in operative position relative to its associated set of contact springs by the control member coacting with the preceding set of contact springs incident to the actuation thereof.

5. In a switching device having an impulse magnet and a plurality of sets of contact springs disposed side by side, a mechanism for actuating said sets of contact springs comprising a plurality of elongated control members, one for each set of contact springs, said control members extending from a relatively fixed mounting, each control member being normally supported near its free end on the free end of a spring in its associated set of contact springs and held thereby beyond the free end of such spring, a first actuating finger extending from a movable mounting with its free end normally disposed in operative position relative to a first one of said sets of contact springs and in readiness to actuate such first set of contact springs responsive to initial displacement of said movable mounting, a plurality of additional actuating fingers extending from said movable mounting, one for each one of the remaining sets of contact springs, each of said additional actuating fingers being normally held in inoperative position beyond the free end of its associated set of contact springs in sliding engagement with and supported on the control member associated with the preceding set of contact springs, and means operated by said impulse magnet responsive to current impulses successively delivered thereto for successively displacing said movable mounting and thereby all said actuating fingers, said first set of contact springs being actuated by said first actuating finger responsive to initial displacement of said movable mounting in accordance with the first current impulse delivered to said impulse magnet and the remaining sets of contact springs being successively actuated by their respective actuating fingers each of which is successively placed in operative position relative to its associated set of contact springs by the control member coacting with the preceding set of contact springs incident to the operative actuation thereof, each such control member moving in back of its associated spring upon operative actuation of the corresponding set of contact springs to lock such set in actuated position.

6. In a switching device having an impulse magnet and a plurality of sets of contact springs disposed side by side, a mechanism for actuating said sets of contact springs comprising a plurality of elongated control members, one for each set of contact springs, said control members extending from a relatively fixed mounting, each control member being normally supported near its free end on the free end of a spring in its associated set of contact springs and held thereby beyond the free end of such spring, a first actuating finger extending from a movable mounting with its free end normally disposed in operative position relative to a first one of said sets of contact springs and in readiness to actuate such first set of contact springs responsive to initial displacement of said movable mounting, a plurality of additional actuating fingers extending from said movable mounting, one for each one of the remaining sets of contact springs, each of said additional actuating fingers being normally held in inoperative position beyond the free end of its associated set of contact springs in sliding engagement with and supported on the control member associated with the preceding set of contact springs, means for delivering current impulses to said impulse magnet, means operated by said impulse magnet responsive to current impulses successively delivered thereto for successively displacing said movable mounting and thereby all said actuating fingers, said first set of contact springs being actuated by said first actuating finger responsive to initial displacement of said movable mounting in accordance with the first current impulse delivered to said impulse magnet and the remaining sets of contact springs being successively actuated by their respective actuating fingers each of which is successively placed in operative position relative to its associated set of contact springs by the control member coacting with the preceding set of contact springs incident to the operative actuation thereof, each such control member moving in back of its associated spring upon operative actuation of the corresponding set of contact springs to lock such set in actuated position, a release magnet, means for delivering a current

impulse to said release magnet, and a rodlike member operated by said release magnet for flexing all control members which are in locking position in back of their associated springs so as to move such control members out of engagement with their associated springs to allow the corresponding sets of contacts to restore to normal and the corresponding control members to assume their normal positions relative thereto.

7. In a switching device having an impulse magnet and a plurality of sets of contact springs disposed side by side, a mechanism for actuating said sets of contact springs comprising a plurality of elongated control members, one for each set of contact springs, said control members extending from a relatively fixed mounting, each control member being normally supported near its free end on the free end of a spring in its associated set of contact springs and held thereby beyond the free end of such spring, a first actuating finger extending from a movable mounting with its free end normally disposed in operative position relative to a first one of said sets of contact springs and in readiness to actuate such first set of contact springs responsive to initial displacement of said movable mounting, a plurality of additional actuating fingers extending from said movable mounting, one for each one of the remaining sets of contact springs, each of said additional actuating fingers being normally held in inoperative position beyond the free end of its associated set of contact springs in sliding engagement with and supported on the control member associated with the preceding set of contact springs, means operated by said impulse magnet responsive to current impulses successively delivered thereto for successively displacing said movable mounting and thereby all said actuating fingers, said first set of contact springs being actuated by said first actuating finger responsive to initial displacement of said movable mounting in accordance with the first current impulse delivered to said impulse magnet and the remaining sets of contact springs being successively operatively actuated by their respective actuating fingers each of which is successively placed in operative position relative to its associated set of contact springs by the control member coacting with the preceding set of contact springs incident to the actuation thereof, each such control member moving in back of its associated spring upon operative actuation of the corresponding set of contact springs to lock such set in actuated position, and means carried directly by a spring of a predetermined set of contact springs for restoring to normal a predetermined previously actuated set of contact springs.

8. In a switching device having an impulse magnet and a plurality of sets of contact springs disposed side by side, a mechanism for actuating said sets of contact springs comprising a plurality of elongated control members, one for each set of contact springs, said control members extending from a relatively fixed mounting, each control member being normally supported near its free end on the free end of a spring in its associated set of contact springs and held thereby beyond the free end of such spring, a first actuating finger extending from a movable mounting with its free end normally disposed in operative position relative to a first one of said sets of contact springs and in readiness to actuate such first set of contact springs responsive to initial displacement of said movable mounting, a plurality of additional actuating fingers extending from said movable mounting, one for each one of the remaining sets of contact springs, each of said additional actuating fingers being normally held in inoperative position beyond the free end of its associated set of contact springs in sliding engagement with and supported on the control member associated with the preceding set of contact springs, means operated by said impulse magnet responsive to current impulses successively delivered thereto for successively displacing said movable mounting and thereby all said actuating fingers, said first set of contact springs being actuated by said first actuating finger responsive to initial displacement of said movable mounting in accordance with the first current impulse delivered to said impulse magnet and the remaining sets of contact springs being successively actuated by their respective actuating fingers each of which is successively placed in operative position relative to its associated set of contact springs by the control member coacting with the preceding set of contact springs incident to the operative actuation thereof, each such control member moving in back of its associated spring upon operative actuation of the corresponding set of contact springs to lock such set in actuated position, and means carried directly by a spring of a predetermined set of contact springs for restoring to normal predetermined contact springs of a previously actuated set of contact springs.

9. A switching device of the class described comprising a plurality of sets of contact springs disposed side by side, a plurality of control members in the general form of leaf springs, one for each of said sets of contact springs, means for relatively fixedly mounting said control members at one end thereof, each control member resting normally near its free end on the free end of a spring in its associated set of contact springs and being held thereby in resilient edgewise engagement therewith, a plurality of actuating fingers in the general form of leaf springs, one for each set of contact springs, a movable operating member to which said actuating fingers are secured at one end thereof, each actuating finger resting normally on the control member associated with a preceding set of contact springs, in sliding engagement with such control member and with its free end in inoperative position relative to its associated set of contact springs, an impulse magnet, means for delivering a series of current impulses to said impulse magnet, means actuated by said magnet in response to the first current impulse delivered thereto for operating the first one of said sets of contact springs whereby the control member thereof is caused to place the actuating finger associated with the next succeeding set of contact springs in operative position relative to said next succeeding set, and means actuated by said magnet in response to succeeding impulses delivered thereto for moving said movable member to displace successively said actuating fingers secured thereto whereby the remaining sets of contact springs are successively actuated by their respective actuating fingers each of which is successively placed in operative position relative to its associated set of contact springs by the control member coacting with the preceding set of contact springs incident to the operative actuation thereof.

10. A switching device of the class described comprising a series of sets of contact springs,

a control member for each set of contact springs, an actuating member for each set of contact springs, all but the actuating member for the first set of contact springs in said series being normally in inoperative position relative to associated sets of contact springs, and electromagnetic means for simultaneously actuating all of said actuating members responsive to each current impulse successively delivered thereto to cause successive actuation of said sets of contact springs and coincident therewith successive displacement of the control members respectively associated therewith to place said actuating members successively in operative position relative to the respective sets of contact springs.

11. A switching device of the class described comprising a series of sets of contact springs, a control member for each set of contact springs to lock its associated set mechanically in actuated position responsive to actuation thereof, an actuating member for each set of contact springs, all but the actuating member for the first set of contact springs in said series being normally in inoperative position relative to associated sets of contact springs, and electromagnetic means for simultaneously actuating all of said actuating members responsive to each current impulse successively delivered thereto to cause successive actuation of said sets of contact springs and to cause coincident with the actuation of each set of contact springs displacement of the control member associated therewith to lock such actuated set of contact springs in actuated position, the displacement of each control member causing displacement of the next successive actuating member in operative position relative to its associated set of contact springs.

12. A switching device of the class described comprising a series of sets of contact springs, a control member for each set of contact springs to lock its associated set mechanically in actuated position responsive to actuation thereof, an actuating member for each set of contact springs, all but the actuating member for the first set of contact springs in said series being normally in inoperative position relative to associated sets of contact springs, electromagnetic means for simultaneously actuating all of said actuating members responsive to each current impulse successively delivered thereto to cause successive actuation of said sets of contact springs and to cause coincident with the actuation of each set of contact springs displacement of the control member associated therewith to lock such actuated set of contact springs in actuated position, the displacement of each control member causing displacement of the next successive actuating member in operative position relative to its associated set of contact springs, and means for simultaneously moving all said displaced control members to restore said actuated sets of contacts to normal position.

13. A switching device of the class described comprising a series of sets of contact springs, a control member for each set of contact springs to lock its associated set mechanically in actuated position responsive to actuation thereof, an actuating member for each set of contact springs, all but the actuating member for the first set of contact springs in said series being normally in inoperative position relative to associated sets of contact springs, electromagnetic means for simultaneously actuating all of said actuating members responsive to each current impulse successively delivered thereto to cause successive actuation of said sets of contact springs and to cause coincident with the actuation of each set of contact springs displacement of the control member associated therewith to lock such actuated set of contact springs in actuated position, the displacement of each control member causing displacement of the next successive actuating member in operative position relative to its associated set of contact springs, and means actuated by a predetermined set of contact springs upon actuation thereof for cancelling the locked actuated condition of a previously actuated set of contact springs.

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