June 2, 1942. J. R. HARRINGTON ET AL 2,284,816

ROTARY SWITCH

Filed Aug. 3, 1940 5 Sheets-Sheet 1

Fig. 2.

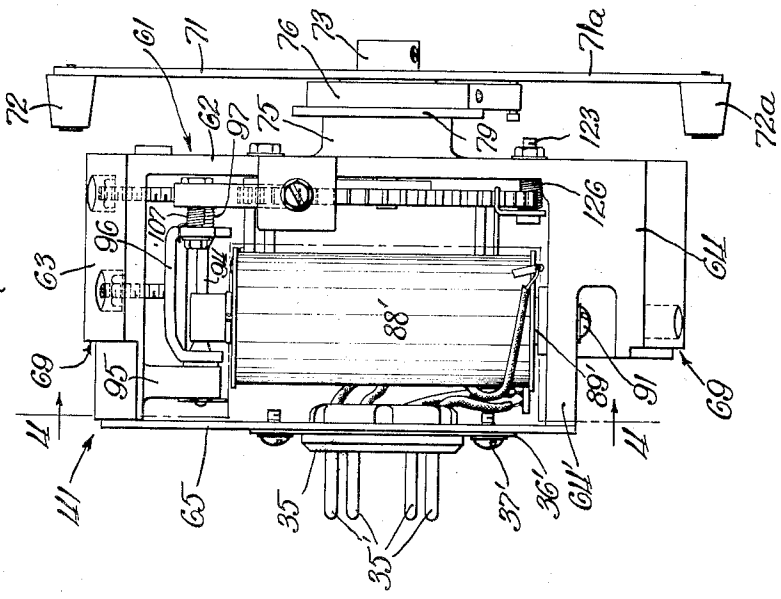
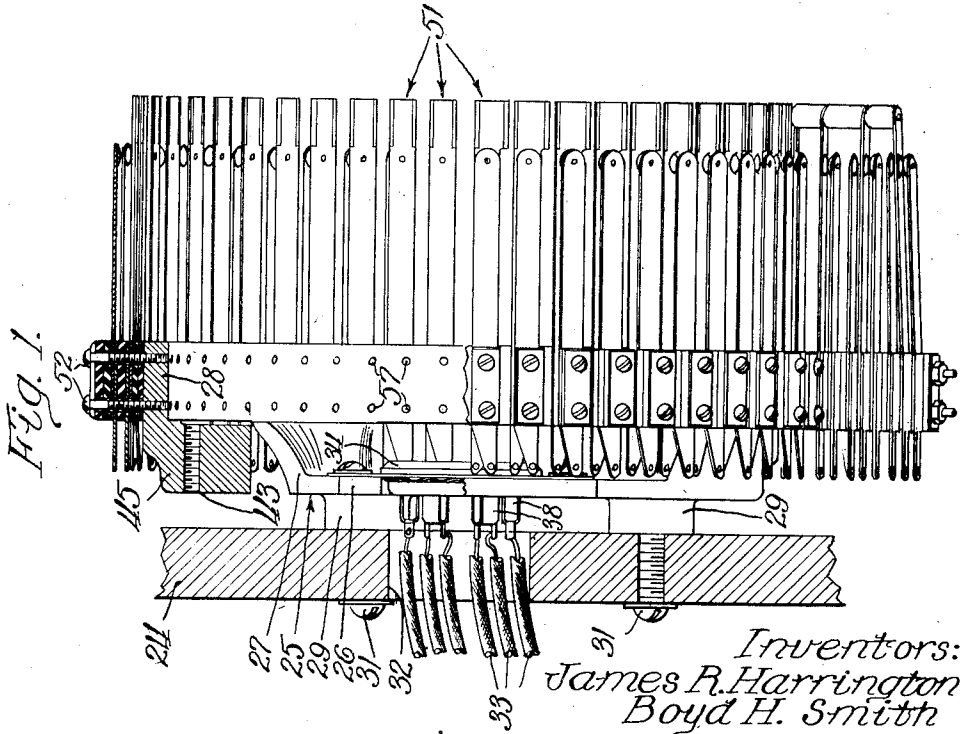


Fig. 1.



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Filed Aug. 3, 1940 5 Sheets-Sheet 2

Fig. 3.

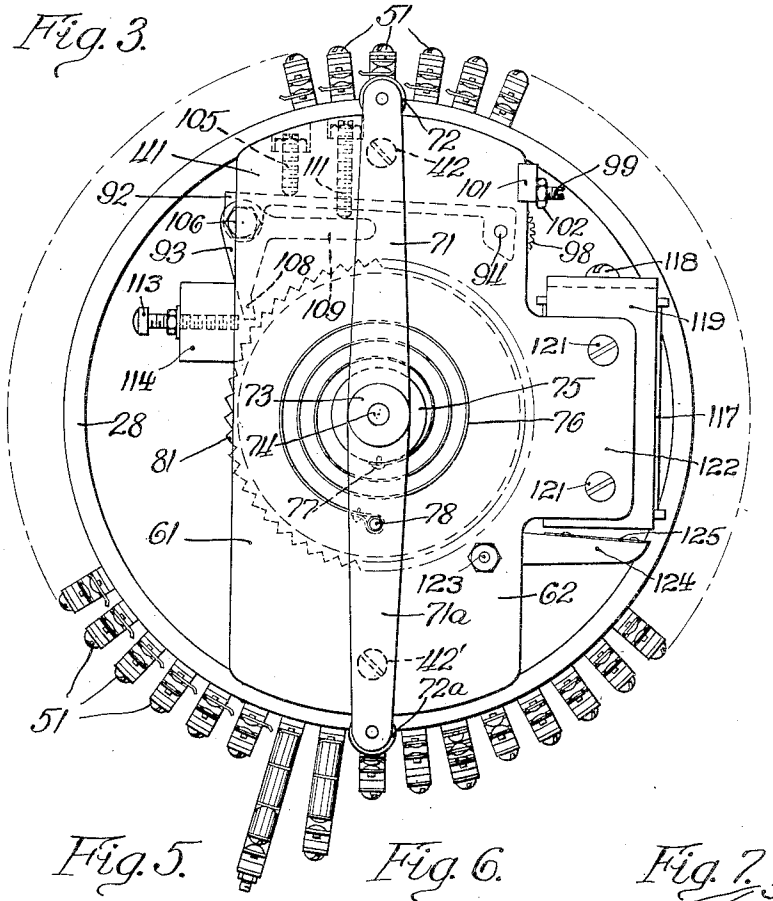


Fig. 5.

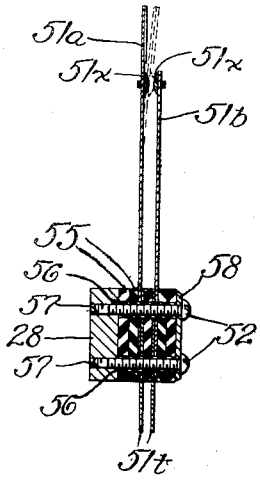


Fig. 6.

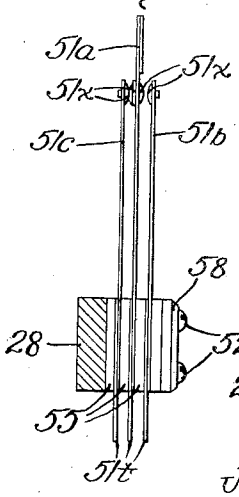
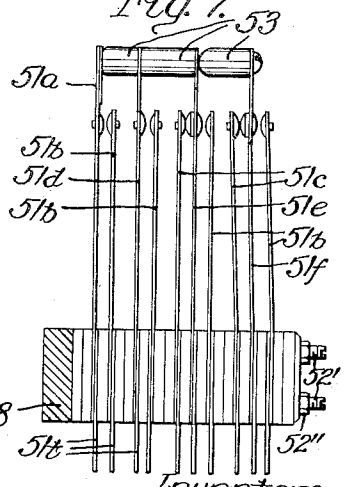


Fig. 7.



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ROTARY SWITCH

Filed Aug. 3, 1940 5 Sheets-Sheet 3

Fig. 11

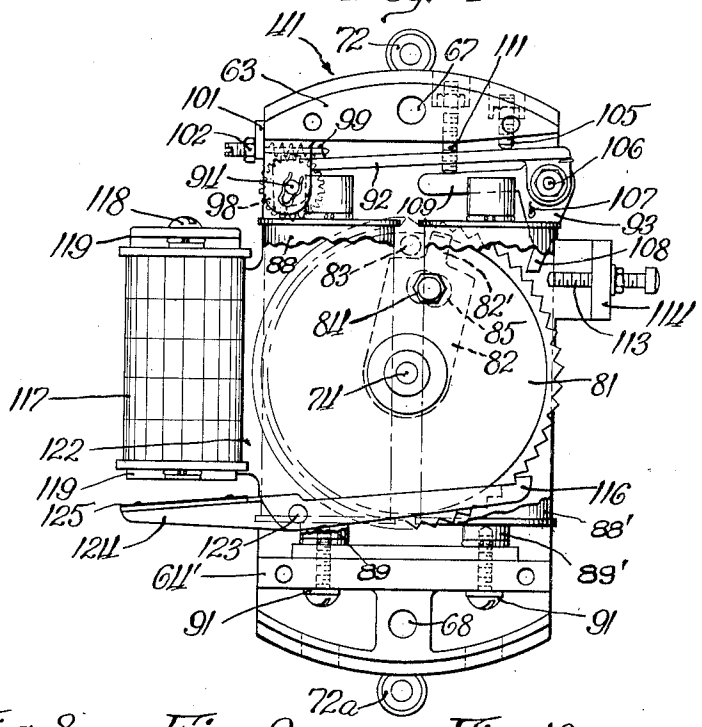


Fig. 8.

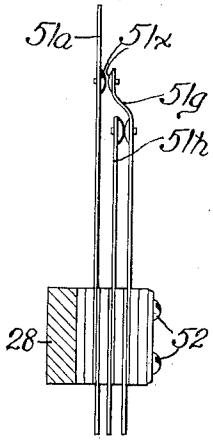


Fig. 9.

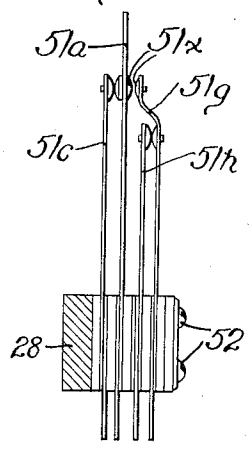


Fig. 10.

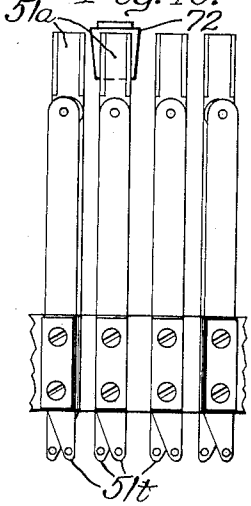
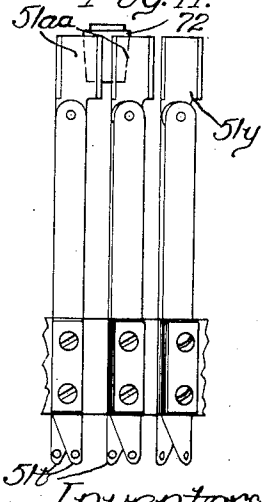


Fig. 11.



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ROTARY SWITCH

Filed Aug. 3, 1940 5 Sheets-Sheet 4

Fig. 12.

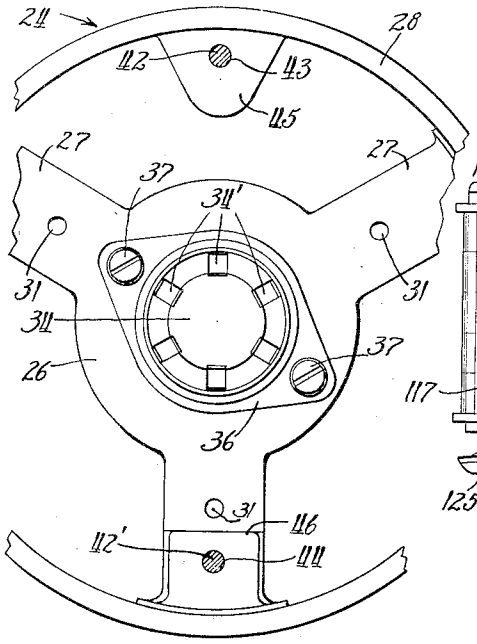
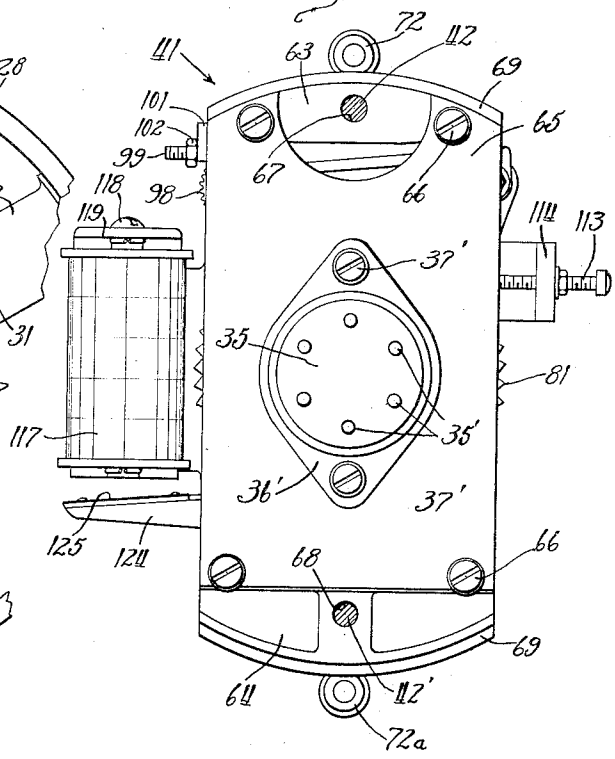


Fig. 13.



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ROTARY SWITCH

Filed Aug. 3, 1940 5 Sheets-Sheet 5

Fig. 14.

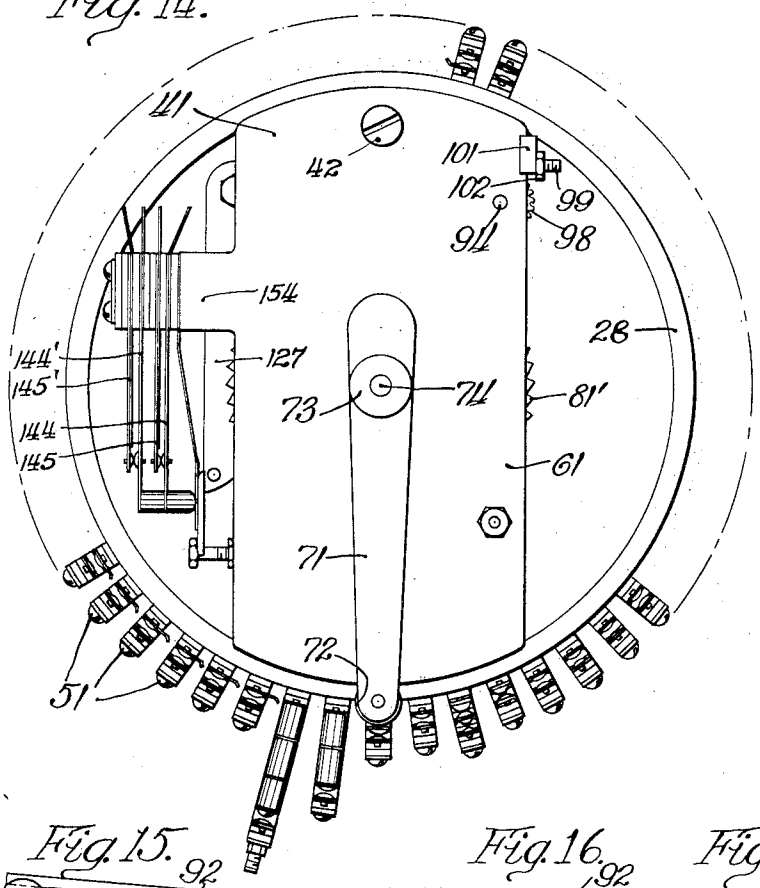


Fig. 15.

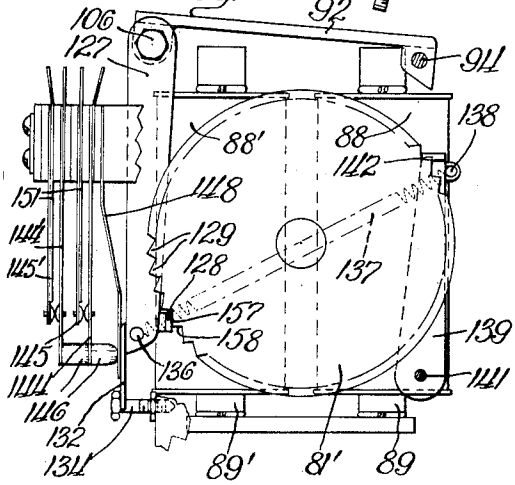


Fig. 16.

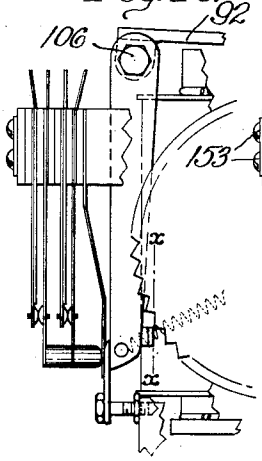
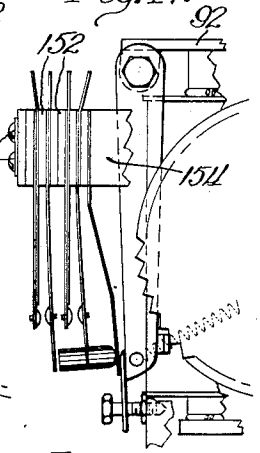


Fig. 17.



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Patented June 2, 1942

2,284,816

UNITED STATES PATENT OFFICE

2,284,816

ROTARY SWITCH

James R. Harrington, Mansfield, and Boyd H. Smith, Shelby, Ohio, assignors to The Autocall Company, Shelby, Ohio, a corporation of Ohio

Application August 3, 1940, Serial No. 350,716

21 Claims. (Cl. 200—105)

The present invention relates to rotary switches of the stepping type in which a rotary member is stepped around to cooperate successively with a circularly arranged series of contacts. Rotary switches of this general description are extensively used for automatic selection, remote control of electrical circuits, hunting of electrical circuits, counting operations, totalizing operations, etc. These switches may be of the remote-controlled pulsing type in which the stepping of the switch is in response to impulses governed or controlled by an outside source, or it may be of the self-interrupted pulsing type in which the stepping of the switch is automatic in response to the interruption of its own energizing circuit.

One of the features of the invention is the provision of an improved rotary switch of the above general description in which the successive switching operations are made to occur between cooperating pairs of contact springs which are flexed into and out of pressure engagement with each other by the successive stepping of a rotary arm or arms, as distinguished from a wiping contact action in which the rotary element carries wipers which depend upon sliding action across the surfaces of successive contacts. The certainty and reliability of contact closure is greatly increased by our improved arrangement using contact springs, and all frictional or sliding wear of contact surfaces is eliminated.

Another feature of our improved rotary switch is an improved operating relation between the stacks or "pile-ups" of contact springs and the stepping arm or arms which actuate the contact springs. The pile-ups of contact springs are arranged in a cylindrical grouping, all extending parallel to the axis of rotation of the actuating arm or arms, and disposed similarly to the elements of a cylinder surrounding the actuating mechanism. This results in a very compact arrangement, with a large number of circuit controlling functions performed in a rotary switch of small size. Each pile-up includes an actuating spring adapted to be flexed outwardly for performing the circuit making or breaking functions of that pile-up. Such actuation is accomplished by the rotary actuating arm or arms being stepped around into engagement with the inner side of the actuating spring, thereby flexing said spring radially outwardly with respect to the cylindrical series of pile-ups. As previously remarked, in the preferred embodiment of our invention there is no wiping contact action between the rotary arm and the contact springs, but, instead, the actuating arm merely exerts a camming or thrusting pressure against the inner side of each actuating spring through the medium of an insulating roller carried on the outer end of the actuating arm. However, a wiping contact action can also be incorporated in our improved construction, if desired.

Another feature of our invention resides in the ready facility of connecting the electrical conductors to the contact springs; and, also, the ease and facility with which any one of the pile-ups can be removed and replaced, as for changing its combination of springs, soldering electrical connections thereto, etc. The series of pile-ups are all detachably secured around the cylindrical outer surface of a stationary supporting ring. This disposes the terminal ends of all of the contact springs in positions readily accessible for soldering conductors thereto. Furthermore, by the mere release of two mounting screws, serving to support each pile-up on said supporting ring, the pile-up can be quickly removed for changing the spring combination thereof, cleaning the contact points, soldering connections to the terminal ends, or for any other purpose.

Another feature of the invention resides in the provision of a readily releasable jack mounting of the movement which carries and drives the actuating arm. This movement comprises the stepping electromagnets, the armature responsive thereto, the pawl and ratchet mechanism actuated by the armature for stepping the actuating arm, and, in some instances, the movement may also include a release electromagnet for resetting the actuating arm, and may include interrupter contact springs for securing the self-interrupting operation. All of the electrical connections for the electromagnets, interrupter springs, etc., are established through this jack mounting. Hence, should any occasion arise to inspect, repair or substitute the movement, the jack mounting thereof enables the movement to be readily withdrawn from the assembly without the necessity of unsoldering and resoldering electrical connections, etc. This jack mounting consists of a receptacle portion carried by the stationary supporting frame, and a plug portion carried by the actuating unit or movement, the receptacle portion comprising a plurality of sockets, and the plug portion comprising a corresponding arrangement of plug pins for engaging in said sockets.

Another feature having particular reference

to the homing or self-interrupting embodiment of our rotary switch is the provision of an improved operating arrangement for the interrupter springs. This arrangement utilizes the pawl and ratchet parts of the stepping mechanism for obtaining a very accurate, reliable timing of the motion of the interrupter springs, i. e., a quick, accurately timed break of the circuit substantially at the instant that the advancing pawl has engaged the next ratchet tooth, and an accurately timed make of the circuit in predetermined relation to the return motion of the advancing pawl and the dropping of the locking dog into the next tooth of the ratchet wheel.

Other features, objects and advantages of the invention will appear in the following detail description of two preferred embodiments of our improved rotary switch. In the accompanying drawings illustrating such embodiments:

Figure 1 is a side view, partly broken away, showing in particular the cylindrically disposed series of contact spring pile-ups mounted on the circular supporting frame;

Figure 2 is a similar side elevational view of the actuating unit or movement, the latter being shown removed from the stationary frame structure and cylindrical series of pile-ups, such illustrating the advantage of the jack mounting of the movement;

Figure 3 is a fragmentary front elevational view showing the movement assembled in its operative position in the stationary frame structure, in position to actuate the cylindrical series of pile-ups;

Figure 4 is a transverse sectional view through the actuating mechanism or movement, taken approximately on the plane of the line 4—4 of Figure 2;

Figures 5 to 11, inclusive, are detail views showing different spring combinations of the pile-ups;

Figure 12 is a fragmentary front elevational view of the receptacle portion of the jack mounting for the movement;

Figure 13 is a rear elevational view illustrating the plug portion of the jack mounting, this plug portion being secured to the rear of the actuating movement;

Figure 14 is a front elevational view of another embodiment of our invention of the self-interrupting or homing type;

Figure 15 illustrates the normal relation between the armature, advancing pawl and interrupter springs in this latter embodiment;

Figure 16 is a similar fragmentary view showing the operating relation while the armature and advancing pawl are moving downwardly and the pawl is just about to snap over the edge of the engaged ratchet tooth; and

Figure 17 shows the interrupter springs moved to open circuit position by the snapping of the advancing pawl over the edge of the engaged ratchet tooth.

Figure 1 illustrates the rotary switch mounted vertically on any suitable supporting panel or the like **24**, it being understood, however, that the switch can also be mounted horizontally or in any angular position. The various elements of the switch are carried by a main frame structure **25** comprising a spider hub **26**, spider arms **27** and a cylindrical ring or annulus **28**, all preferably formed as an integral unit. Tapped bosses **29** project rearwardly from each of the three spider arms **27** and abut against the mounting panel or baseboard **24**, these bosses receiving mounting screws **31** passing through the panel. An aperture **32** in the panel enables the several conductors **33** to be extended forwardly from the back side of the panel for establishing soldered connection with the terminals of the mounting jack. The receptacle portion of this mounting jack is indicated at **34**, and the plug portion is indicated at **35**. The receptacle portion **34** is composed of a cylindrical body of insulation which sets into a central opening in the spider hub **26**, there being a series of sockets **34'** formed around the outer portion of said insulating body **34** (see Figure 12) for receiving the prongs **35'** of the plug portion **35**. The flanged front end of the insulating body portion **34** carries a mounting clip **36** adapted to receive the mounting screws **37**, by which the receptacle portion is secured to the spider hub **26**. The contacts within the sockets **34'** have end terminals **38** (Figure 1) to which the conductors **33** are soldered. The removable actuating unit or movement is indicated in its entirety at **41** in Figure 2, this unit carrying the plug portion **35** of the jack mounting. Said movement is further secured to the stationary frame structure **25** by two diametrically opposite attaching screws **42** and **42'** which pass through the top and bottom portions of the unit **41** and thread into tapped holes **43** and **44** provided in the frame structure. The tapped hole **43** is formed in an attaching lug **45** which projects inwardly and rearwardly from the ring **28**, and the tapped hole **44** is formed in a shouldered step portion **46** projecting from one of the spider arms **27**, at a point diametrically opposite the lug **45**. To withdraw the actuating unit or movement **41** from the rotary switch, it is only necessary to release the two attaching screws **42** and **42'**, and to then withdraw the plug portion from the receptacle portion of the jack mounting. It will be understood that the prongs and sockets of the jack mounting are coded so that the movement **41** can only be reinserted back into the rotary switch in the one proper angular position.

Referring now to the mounting of the stacks or pile-ups of contact springs on the frame **25**, each of these pile-ups is designated **51** in its entirety, and is releasably mounted on the outside of the ring **28** by the mounting screws **52**, as clearly shown in Figures 1 and 5 to 9 inclusive. It will be noted that these pile-ups are arranged in a cylindrical grouping, all extending parallel to the axis of the ring **28** and parallel to the axis of rotation of the actuating arm or arms **71**, **71***a*, whereby the pile-ups are disposed like the elements of a cylinder which surrounds the actuating unit **41**. Each pile-up **51** comprises an actuating spring **51***a* or **51***aa* which is adapted to be flexed outwardly under the camming action of an insulating roller or rollers **72**, **72***a* carried on the ends of the actuating arms. Cooperating with the actuating spring **51***a* of each pile-up are one or more secondary springs **51***b*, **51***c*, **51***d*, etc., which can be assembled in any number of different combinations, as shown in Figures 5, 6, 7, 8 and 9. Figure 5 illustrates a make spring **51***b* disposed on the outer side of the actuating spring **51***a*; Figure 6 illustrates a make spring **51***b* on the outer side, and a break spring **51***c* on the inner side of the actuating spring; Figure 7 illustrates a plurality of concurrently moving actuating springs **51***a*, **51***d*, **51***e* and **51***f*, each cooperating with different make or break secondary springs. In the arrangement shown in Figure 7, all of the actuating springs **51***a*, **51***d*, **51***e*, etc.,

are flexed outwardly concurrently through the medium of the insulating spacers **53** which are disposed between the upper ends of said springs. Figure 8 illustrates a pair of secondary springs **51***g* and **51***h* cooperating with the actuating spring **51***a* in such relation that springs **51***a* and **51***g* make circuit before springs **51***g* and **51***h* break circuit. Figure 9 illustrates a similar combination, with an additional break spring **51***c* on the inner side of the actuating spring **51***a*. The contacts **51***x* carried by each of the springs may be composed of silver or any other desired contact material.

Figure 10 illustrates the use of actuating springs **51***a* which are so proportioned as to be non-bridging in operation, while Figure 11 shows the use of actuating springs **51***aa* which are so proportioned as to be bridging in operation. That is to say, in Figure 10 the upper ends of the actuating springs **51***a* are relatively narrow with regard to the spacing between pile-ups and to the width of the actuating rollers **72** or **72***a*, whereby the roller moves completely out of engagement with one actuating spring, or permits that actuating spring to restore its normal circuit conditions, before the roller engages or flexes the next actuating spring into the position which makes or breaks the circuit connections responding to that spring. Thus, in this non-bridging relation, all of the circuit controlling functions brought about by any one pile-up are restored to normal condition before the circuit controlling functions of the next pile-up are brought into their actuated condition. Figure 11, on the other hand, shows the upper ends of the actuating springs **51***aa* as being formed with lateral wings or extensions **51***y*, which are so proportioned with respect to the spacing between adjacent pile-ups and with respect to the width of the actuating roller **72**, that the motion of the roller from one actuating spring to the other always results in a bridging relation. That is to say, the actuating roller causes all of the circuit controlling functions of each pile-up to be brought into their actuated condition before the circuit controlling functions of the next preceding pile-up have been allowed to return to their normal condition.

It will be seen from the foregoing descriptions of Figures 5 to 11, inclusive, that each of the several pile-ups can be arranged with practically any combination of contact springs, and for either bridging or non-bridging operation. The terminals **51***t* of the contact springs are formed with slanting ends, as best shown in Figures 10 and 11, and each of these terminals is constructed as a separate clip, distinct from the contact spring, so that it can be assembled to dispose the slanting end either to the right or to the left, thereby affording greater facility for soldering conductors thereto when several contact springs are assembled in a pile-up. As shown in Figure 5, the various contact springs of each pile-up are maintained in proper spaced relation by the insulating spacers **55**, and insulating bushings **56** are extended through these insulating spacers and through the contact springs and terminal clips **51***t* for receiving the mounting screws **52** which thread into the tapped holes **57** in the ring **28**. An outer pressure plate **58** composed of metal is assembled over the outer side of each pile-up for receiving the pressure exerted by the heads of the screws **52**. As clearly shown in Figure 1, all of the pile-ups are conveniently accessible around the exterior of the supporting ring **28**, and any pile-up can be quickly and easily removed by the release of the screws **52**, whenever it is desired to change the spring combination, clean the contact points, or perform other operations on the pile-up. This mounting of the pile-ups surrounding the exterior of the ring **28** also greatly facilitates assembly of the rotary switch, and further facilitates the making of the soldered connections between the conductors and the terminals **51***t*. If the pile-up includes a relatively large number of contact springs, as represented in Figure 7, it may be desirable to use stud bolts **52'** and cooperating nuts **52''** instead of the screws **52**. In the two embodiments of rotary switch illustrated in Figures 1 and 15, we have shown a series of fifty pile-ups mounted in equally spaced relation around the supporting ring **28**, but it will of course be understood that a greater or lesser number of pile-ups may be employed in larger or smaller capacity switches.

Referring now to the actuating unit or movement **41**, it will be seen from Figures 2, 3 and 4 that this unit is assembled on a frame casting **61** of substantially C-shaped outline, comprising a front wall **62** and rearwardly extending top and bottom legs **63** and **64**. A detachable rear plate **65** extends downwardly across the rear ends of the frame legs **63** and **64**, to which legs the plate is secured by the screws **66**, as shown in Figure 13. The plug portion **35** of the mounting jack **34—35** is supported on this rear plate **65**, the flanged rear end of the insulating body portion **35** being secured to an attaching clip **36'** which is fastened to the plate **65** by the screws **37'**, similarly to the mounting of the receptacle portion of the jack. As shown in Figure 13, a hole **67** extends longitudinally through the upper frame leg **63** for receiving the upper mounting screw **42**, and a hole **68** extends longitudinally through the lower frame leg for receiving the lower mounting screw **42'**, the upper hole **67** being adapted to align with the upper tapped hole **43** in the stationary supporting frame, and the lower hole **68** being adapted to align with the lower tapped hole **44** in said supporting frame. The hole **67** and its tapped bore **43** are located in closer proximity to the axial center of the actuating unit than the lower hole **68** and its tapped bore **44**, such arrangement preventing the possibility of erroneous mounting of the actuating unit within the stationary part of the switch structure. Arcuate shoulders **69** machined across the top and bottom surfaces of the frame legs **63** and **64** are adapted to abut the forward edge of the supporting ring **28** (Figure 1) when the actuating unit is assembled within the stationary part of the switch structure.

Any desired number of rotary actuating arms **71**, **71***a*, etc. may be employed. Figures 2 and 3 illustrate a construction using two diametrically opposite arms **71**, **71***a*, whereas Figure 14 illustrates a construction using only one arm **71**. It will be noted that the two arm construction of Figures 2 and 3 coacts with the fifty pile-ups to give a twenty-five point switch, and that the single arm construction of Figure 15 coacts with the fifty pile-ups to give a fifty point switch, both embodiments being obtainable on the same switch frame. Furthermore, these actuating arms may be arranged for odd or even multiples, and the pile-ups may be continuous or in groups related to arm movements. The taper of the actuating rollers **72—72***a* conforms approximately to the angle of outward flexure of the contact springs when flexed outwardly by said rollers.

The hub 73 of the actuating arm structure is secured to a drive shaft 74 which has bearing support in a boss 75 projecting forwardly from the front wall 62 of the frame 61. A spirally coiled ribbon spring 76 has one end stationarily anchored at 77 to the boss 75, and has its other end connected with a rivet 78 projecting rearwardly from the actuating arm device. A washer 79 is assembled on the boss 75 to retain the return spring 76 between said washer and the actuating arm. In other embodiments of our invention which do not use a return spring, this washer may be omitted. The torsion of the spring 76 tends constantly to return the actuating arm back to its normal or zero position. This normal position is determined by stop mechanism associated with the driving ratchet wheel, as we shall now describe.

Secured to the inner end of the shaft 74, on the inner side of the frame wall 62, is the driving ratchet wheel 81 through which the step-by-step motion is imparted to the shaft 74 and arm 71. The stop mechanism referred to is mounted between the ratchet wheel 81 and the frame wall 62, and comprises a stop arm 82 carried by the ratchet wheel and adapted to engage a stop pin 83 carried by the frame wall. The stop arm 82 is pivotally mounted for free oscillation on the shaft 74, and is arranged to be driven by the ratchet wheel 81, but in such relation thereto that the stop arm is capable of a limited range of oscillation relatively to the ratchet wheel. This is accomplished by mounting a bolt or stud 84 in the ratchet wheel, with one end projecting forwardly from the wheel and extending into an arcuate slot 85 which is formed in the stop arm 82. A narrow outer extremity 82' on the arm 82 effects the actual contact with the stop pin 83, and the angular length of the slot 85 is so proportioned with respect to the width of the projection 82' that an accurate stop relation is established at a point one step short of a complete revolution. For example, with the actuating arm standing in its normal position in engagement with the No. 1 pile-up, one stop relation will be established, and following this in the operation of the device the arm can swing through engagement with all of the pile-ups up to and including No. 50, at which point the other stop relation will occur. In the spring return of the actuating arm, the latter revolves back into engagement with the No. 1 pile-up, representing the normal position.

The advancing mechanism comprises the two advancing electromagnets 88, 88' which are disposed side by side directly in back of the ratchet wheel 81, and which have their cores 89, 89' anchored to a horizontal shelf portion 64' of the frame by screws 91. Disposed directly above the upper ends of the magnet cores is the armature 92 which carries at one end the advancing pawl 93 adapted to impart advancing movement to the ratchet wheel 81. The other end of the armature is pivotally mounted on a supporting shaft 94 which is supported at its front end in the frame wall 62 and at its rear end in a lug 95 extending downwardly from the frame leg 63, as best shown in Figure 2. This latter portion of the armature 92 is formed with a relatively wide yoke portion 96 so as to establish widely spaced points of bearing support of the armature on the shaft. The armature and pawl are normally retained in their elevated position by a torsion spring 97 which surrounds the shaft 94 in front of the yoke portion 96. One end of this spring is connected to the yoke portion 96, and the other end is connected to a very small pinion 98 which is rotatably mounted on the shaft 94 directly in back of the frame wall 62. The pinion 98 is adapted to be given rotative adjustment through the actuation of a short worm shaft 99 which meshes with the upper side of the pinion. This worm shaft is journaled in a bracket 101 secured to one side of the frame 61, and the outer end of said worm shaft is threaded for receiving a lock nut 102 which serves to lock the worm shaft after the desired adjustment has been given the pinion 98. The rotative adjustment of this pinion in one direction or the other serves to increase or decrease the tension of the torsion spring 97, and relatively fine adjustments can be made whenever it is desired to have the response of the electromagnets 88, 88' marginal. In the illustrated construction, we have shown the armature 92 as being disposed above the electromagnets 88, 88', so that the restoration of the armature to normal position is effected solely by the tension of the spring 97 but, as will be understood, the operating arrangement may be inverted so as to dispose the armature 92 below the electromagnets, in which position restoration of the armature to normal position would be effected by gravity, assisted by the tension of the torsion spring 97. The normal position of the armature is determined by an adjustable stop screw 105 which screws down through the upper frame leg 63, and functions as an adjustable back stop for the armature movement. The advancing pawl 93 is pivotally mounted at 106 on a downturned lug at the end of the armature 92. A torsion spring 107 coiled about the pivot 106 normally tends to urge the nose 108 of the pawl into engagement with the teeth of the ratchet wheel 81. Another arm 109 projecting substantially horizontally from the upper portion of the pawl is adapted to engage a limiting stop in the form of a screw 111 which threads down through the upper frame leg 63. This accurately positions the retracted location of the pawl nose 108 so that the ratchet wheel teeth can just clear the pawl nose at this time, in order that the ratchet wheel can be reversely rotated back to its normal position under the impetus of the return spring 76. The advanced position of the pawl is determined by an adjustable stop screw 113 which threads through an angle arm 114 projecting outwardly from this side of the supporting frame. The outer surface of the advancing pawl 93 is adapted to strike the screw 113 when the pawl has completed the proper one step advancement of the ratchet wheel, the stop function of the screw serving to prevent any overthrow movement being imparted to the ratchet wheel. It will be understood that there are the same number of teeth formed around the ratchet wheel as there are pile-ups 51 disposed around the frame portion of the switch.

In magnetic release embodiments of our invention, such as that shown in Figures 1, 2, 3 and 4, the holding pawl 116, which functions to hold the ratchet wheel 81 in each position of advancement, is made magnetically releasable in response to the energization of a release electromagnet 117. This latter electromagnet is disposed to one side of the advancing electromagnets and ratchet wheel, and has its core secured by a screw 118 to an angle bracket 119 which is fastened by screws 121 to a lug 122 projecting

laterally from the frame casting 61. The holding pawl 116 is rockably mounted on a pivot bolt 123 carried by the front frame wall 62, and the pawl is formed with an armature portion 124 projecting beyond this pivot bolt and disposed directly below the release electromagnet 117. The lateral edge of the armature portion 124 is adapted to abut against the lower edge of the angle shaped magnetic bracket 119 when the armature is attracted, thereby substantially completing a magnetic circuit through the core, armature and angle bracket. A thin strip of brass or other non-magnetic material 125 is secured to the armature in position to abut the lower edge of the bracket 119, and thereby prevent the armature from adhering in its attracted position after the deenergization of the electromagnet 117. A coil spring 126 mounted on the pivot bolt 123 (Figure 2) tends to maintain the holding pawl 116 in the normal position illustrated in Figure 4. Upon the release of this holding pawl by the energization of the electromagnet 117, the ratchet wheel and actuating arm immediately revolve back to their normal position under the return energy of the spring 76. In the above described embodiment, it will be noted that the advancement of the ratchet wheel 81 and switch actuating arm always occurs on the down stroke or attractive movement of the armature 92.

Referring now to the embodiment illustrated in Figures 14–17, this construction is of the self-interrupted pulsing type in which the stepping of the switch is automatic in response to the interruption of its own energizing circuit. In such construction, the advancement of the ratchet wheel and switch actuating arm occurs on the retracted movement of the armature instead of on the attracted movement. Such modified embodiment has the same cylindrical grouping of the pile-ups around the stationary supporting ring 28, has the same jack mounting of the removable actuating unit or movement 41, and is the same as the previously described embodiment in all respects except that there is no magnetic release and spring return of the switch actuating arm, but instead the arm is pulsed back to a home position by the self-interrupting contacts which are actuated by the advancing pawl. The same identical arrangement of advancing electromagnets 88, 88' actuates the same form of armature 92, and this armature is restored to its normal position by the same arrangement of adjustable torsion spring 97 adapted to be adjusted through the same arrangement of worm shaft 99 etc. The pivot 107 at the opposite end of the armature carries the advancing pawl 127 which extends down substantially vertically alongside the ratchet wheel 81'. The teeth on this ratchet wheel extend reversely to the relation previously described, which may be obtained by simply turning the ratchet wheel 81 over, and the advancing pawl 127 is provided with a nose 128 which imparts advancing movement to the teeth 129 of said ratchet wheel on the upward, retractive movement of the armature 92 instead of on the downward attractive movement thereof. Formed integrally with the lower end of the advancing pawl 127 is a tongue 132 which is bent laterally to lie in a plane at right angles to the advancing pawl. This tongue is slotted or notched to form a vertical guide recess which extends down over the shank of guide screw 134 that threads into a tapped bore in the side of the frame casting 61. This reciprocal guided relation between the forked tongue 132 and the stud 134 prevents the advancing pawl 127 from being accidentally deflected sidewise out of proper operating relation to the teeth of the ratchet wheel. A pin 136 projecting laterally from the advancing pawl 127 has connection with one end of a tension spring 137 which tends to hold the tooth or nose portion 128 of the pawl in constant contact with the ratchet teeth 129. This spring 137 extends approximately diametrically across the rear side of the ratchet wheel 81' and has connection at its opposite end with a pin 138 projecting laterally from a holding pawl 139. This holding pawl is pivotally mounted on a pin 141 carried by the front wall 62 of the frame casting. The upper end of said pawl is formed with a forwardly projecting lug 142 which constitutes the nose or dog portion of the pawl, the latter being held constantly against the ratchet teeth by the spring 137, and preventing any backward motion of the ratchet wheel in the actuation of the switch. As remarked above in connection with the preceding embodiment, the armature 92 and advancing pawl 127 may be reversely disposed with respect to the electromagnets, so that in the restoration of the armature to its normal position the action of the restoring spring 98 will be assisted by gravity.

Referring now to the interrupter springs and their mode of operation, we have shown two duplicate pairs of these springs 144, 145 and 144', 145' arranged for conjoint operation. Both pairs of interrupter springs can be connected together in multiple for controlling the energizing circuit of the advancing electromagnets 88, 88', or only one pair of springs may be employed for interrupting such circuit, and the other pair may be employed for some other purpose. Insulating bushings 146 carried by the contact spring 144 serve to actuate both front springs 144, 144'. The front insulating bushing 146 bears against a slider spring 148 which has sliding contact against the back side of the laterally bent togue portion 132 of the advancing pawl. In the vertical motion of the advancing pawl 127, the spring 148 functions as a slider strip interposed between the advancing pawl and the front bushing 146, whereby the bushing does not have direct contact with the sliding motion of the armature such as would result in rapid wear of the bushing. The three springs 144, 144' and 148 are biased so that they normally tend to flex inwardly to the open circuit position illustrated in Figure 17 whenever the advancing pawl 127 swings inwardly. Stiffener springs 151 may be interposed on the inner sides of the back contact springs 145, 145' so as to stiffen the latter springs against flexing inwardly when the front springs move to the circuit opening position illustrated in Figure 17. The above described pile-up of springs and insulating spacers 152 is secured by screws 153 to an angle lug 154 which projects laterally and rearwardly from the front wall 62 of the frame casting. Each ratchet tooth 129 comprises an idling flank 157 and an advancing flank 158, these two being disposed at approximately a right angle or slightly less than a right angle to each other. The parts of the mechanism are so proportioned and arranged that when the armature 92 is in its retracted position (Figure 15) the pawl nose 128 is then engaging an idling flank 157 which extends substantially parallel to the length of the interrupter springs 144—145'. Thus, in the down stroke idling movement of the armature (Figure 16) the pawl nose

128 slides along the idling flank 157, during which motion the idling flank serves to guide the pawl nose for movement along a path diagrammatically represented by the line x—x in Figure 16. It will be noted that this line extends substantially parallel to the length of the interrupter springs. Hence, during the entire down stroke of the armature while the advancing pawl is moving downwardly preparatory to engaging another advancing shoulder or flank 158, no motion is imparted to the interrupter springs 144, 144', but these springs are held in their normal, closed circuit positions. However, as soon as the pawl nose 128 rides off the extremity of the idling flank 157 and moves inwardly across the actuating flank 158, the interrupter springs 144, 144' both move inwardly to their open circuit positions, as shown in Figure 17. This immediately interrupts the energizing circuit of the electromagnets 88, 88', with the result that the armature 92 is impelled upwardly by the retracting spring, such imparting a one-step advancement to the ratchet wheel 81', and restoring the part to the position illustrated in Figure 15. During the rotative movement of the ratchet wheel in this one-step advancement, the pawl nose 128 and pawl 127 partake of the rotary motion of the ratchet wheel, swinging upwardly and outwardly, and this outward component of motion restores the interrupter springs 144, 144' back to their normal positions in a relatively quick circuit-closing operation near the end of the return motion of the armature. This improved operation of the interrupter springs insures that the motion of the advancing pawl in reaching for the next tooth is completed before the contacts are opened, also that the contacts are not closed until near the end of the actuating motion of the advancing pawl, with the result that a positive reliable control of the contacts is obtained, and a high speed operation of the switch is also secured.

While we have illustrated and described what we regard to be the preferred embodiments of our invention, nevertheless it will be understood that such are merely exemplary and that numerous modifications and rearrangements may be made therein without departing from the essence of the invention.

We claim:

1. In a rotary switch, the combination of an assembly of contact springs grouped cylindrically about a common axis and extending substantially parallel thereto, a movement for actuating the switch comprising electromagnetic stepping mechanism and a rotating arm driven thereby for engaging said contact springs successively, and mounting jack means for said movement enabling said movement to be jack connected and disconnected relatively to said contact spring assembly.

2. In a rotary switch, the combination of a series of contact spring pile-ups grouped cylindrically about a common axis and extending substantially parallel thereto and to each other, an actuating movement for actuating the switch comprising an electromagnet, pawl and ratchet mechanism responsive thereto, and an actuating arm advanced with a step-by-step motion by said pawl and ratchet mechanism, said actuating arm rotating coaxially of the common axis of said pile-ups and flexing the actuating springs of said pile-ups radially outwardly of the series for performing circuit controlling operations in said pile-ups, and mounting jack means for mounting said actuating movement whereby it may be removed axially of said cylindrical series of contact springs without disturbing said springs or their electrical connections.

3. In a rotary switch of the class described, the combination of a supporting frame including a stationary cylindrical ring, a plurality of contact spring pile-ups mounted in a cylindrical series around the exterior of said supporting ring, screw means for detachably securing said pile-ups to the outer surface of said supporting ring, each of said pile-ups comprising at least an actuating spring and a coacting spring adapted to perform a circuit controlling operation when said actuating spring is flexed radially outwardly relatively to its coacting spring, an actuating movement comprising an advancing electromagnet, pawl and ratchet mechanism responsive thereto, a rotatable actuating arm advanced with a step-by-step motion by said pawl and ratchet mechanism, said actuating arm rotating coaxially of said cylindrical supporting ring and operating to flex the actuating springs of said pile-ups radially outwardly of the cylindrical series for performing circuit controlling operations in said pile-ups, and mounting jack means for said actuating movement comprising a receptacle portion carried by said supporting frame and a plug portion carried by said actuating movement, said mounting jack means enabling said actuating movement to be removed and replaced axially of said stationary supporting ring without disturbing said contact spring pile-ups or the electrical connections thereto.

4. In a rotary switch, the combination of a series of contact spring pile-ups grouped cylindrically about a common axis and extending substantially parallel thereto and to each other, a switch actuating arm rotating coaxially of said common axis and flexing the actuating springs of said pile-ups radially outwardly of the series for performing circuit controlling operations in said pile-ups, a ratchet wheel for imparting step-by-step advancing movement to said actuating arm, an advancing pawl for stepping said ratchet wheel in a forward direction, an advancing electromagnet for actuating said advancing pawl, spring means tending to rotate said ratchet wheel and actuating arm back to a normal position, a holding pawl opposing the action of said spring means, and a release electromagnet for releasing said holding pawl, one of said electromagnets being disposed within said cylindrically grouped series of contact spring pile-ups.

5. In a rotary switch, the combination of a series of contact spring pile-ups grouped cylindrically about a common axis and extending substantially parallel thereto and to each other, a switch actuating movement comprising an actuating arm rotating coaxially of said common axis and flexing the actuating springs of said pile-ups radially outwardly of the series for performing circuit controlling operations in said pile-ups, a ratchet wheel for imparting step-by-step advancing movement to said actuating arm, an advancing pawl for stepping said ratchet wheel in a forward direction, an advancing electromagnet for actuating said advancing pawl, spring means tending to rotate said ratchet wheel and actuating arm back to a normal position, a holding pawl opposing the action of said spring means, a release electromagnet for releasing said holding pawl, said advancing and release electromagnets and their respective pawls and ratchet wheel being mounted substantially with-

in said cylindrically grouped series of contact spring pile-ups, and a mounting jack for said switch actuating movement enabling said movement to be mounted and dismounted from the switch assembly in a direction substantially axially of said cylindrical series of contact springs, and to connect and disconnect the electrical connections of said advancing electromagnet and said release electromagnet in such mounting and dismounting of the movement.

6. In a rotary switch, the combination of a series of contact springs grouped cylindrically about a common axis and extending substantially parallel thereto, an actuating arm rotating coaxially of said common axis and affecting flexing motion of a plurality of said contact springs substantially radially of the series for performing circuit controlling operations, a ratchet wheel for imparting step-by-step advancing movement to said actuating arm, a pawl for stepping said ratchet wheel, an electromagnet for actuating said pawl, and stop means for said ratchet wheel and actuating arm comprising a stationary stop pin, a stop arm adapted to move with said ratchet wheel and to engage said stop pin, and lost-motion means comprising a pin and a slot cooperating between said ratchet wheel and said stop arm for permitting said stop arm to have limited lost-motion freedom relatively to said ratchet wheel.

7. In a rotary switch, the combination of a series of contact springs grouped cylindrically about a common axis and extending substantially parallel thereto, an actuating arm rotating coaxially of said common axis and effecting flexing motion of a plurality of said contact springs substantially radially of the series for performing circuit controlling operations, a ratchet wheel for imparting step-by-step movement to said actuating arm, a pawl for stepping said ratchet wheel, an electromagnet for actuating said pawl, and interrupter contacts controlling said electromagnet and arranged to be actuated by the lateral motion of said pawl as the pawl snaps inwardly off the teeth of said ratchet wheel.

8. In a rotary switch, the combination of a series of contact spring pile-ups grouped cylindrically about a common axis and extending substantially parallel thereto and to each other, an actuating arm rotating coaxially of said common axis and flexing the actuating springs of said pile-ups radially outwardly of the series for performing circuit controlling operations in said pile-ups, a ratchet wheel for imparting step-by-step movement to said actuating arm, a pawl for stepping said ratchet wheel, an armature for actuating said pawl, an electromagnet for operating said armature, said armature and pawl imparting advancing movement to said ratchet wheel upon the deenergization of said electromagnet, interrupter contacts governing the energization of said electromagnet, and means actuated directly by the inward and outward movements of said pawl relatively to the teeth of said ratchet wheel for operating said interrupter contacts.

9. In a rotary switch, the combination of a series of contact spring pile-ups grouped cylindrically about a common axis and extending substantially parallel thereto and to each other, an actuating arm rotating coaxially of said common axis and flexing the actuating springs of said pile-ups radially outwardly of the series, advancing mechanism for imparting step-by-step advancing movement to said actuating arm comprising an electromagnet, an armature responsive thereto, a pawl actuated by said armature, a ratchet wheel comprising ratchet teeth actuated by said pawl, interrupter springs governing the energization of said electromagnet and arranged to be actuated by said pawl, said interrupter springs extending substantially parallel to the path of movement of said pawl while the latter is riding along the idling flank of a ratchet tooth, and means actuated solely by the snap motion of said pawl inwardly from the tip of the ratchet tooth into engagement with the advancing flank of the tooth, independently of the motion of said armature, for thereupon separating said interrupter springs to deenergize said electromagnet.

10. In a rotary switch, the combination of a series of contact springs grouped in a cylindrical relation about a common axis, an arm rotating coaxially of said common axis and performing circuit controlling functions at said contact springs, and means on certain of the contact springs of said series for causing said actuating arm to operate certain of said contact springs in a bridging relation, while enabling said arm to operate other contact springs of the series in a non-bridging relation.

11. In a rotary switch, the combination of a supporting ring, a series of contact springs grouped cylindrically about the outside of said supporting ring and extending substantially parallel to the axis thereof, an actuating arm rotating coaxially of said common axis and effecting flexing motion of a plurality of contact springs substantially radially of the series for performing circuit controlling operations, and means for causing said actuating arm to operate a plurality of said contact springs in a bridging relation.

12. In a rotary switch, the combination of a series of contact spring pile-ups grouped cylindrically about a common axis and extending substantially parallel thereto and to each other, an actuating arm rotating coaxially of said common axis and flexing the actuating springs of said pile-ups radially outwardly of the series for performing circuit controlling operations in said pile-ups, and bridging flanges projecting laterally from a plurality of said actuating springs adapted to coact with said actuating arm whereby said arm operates each succeeding pile-up to an actuated position before permitting the preceding pile-up to return to a normal position.

13. In a rotary switch of the class described, the combination of a series of circularly grouped contacts, a rotating arm coacting with said contacts, an advancing electromagnet, an armature responsive thereto, an advancing pawl actuated by said armature through attractive and retractive movements, a ratchet wheel connected with said rotating arm and advanced by said advancing pawl on the retractive movement of said armature, self-interrupting contact springs controlling the circuit of said electromagnet and extending substantially parallel to the path of the attractive movement of said pawl, said contact springs being actuated solely by the sidewise inward snapping motion of said advancing pawl, and means comprising a slider spring positioned between said advancing pawl and said contact springs for causing said contact springs to separate when said pawl snaps inwardly off a tooth of said ratchet wheel whereby the time of separation of said contact springs is dependent solely upon the time of said sidewise inward snapping motion of said advancing pawl rather than

upon any time in the oscillating motion of said armature.

14. In a rotary step-by-step switch of the class described, the combination of a supporting frame including a stationary cylindrical ring, a plurality of contact spring pile-ups mounted in a cylindrical relation around the exterior of said ring, the contact springs of said pile-ups extending substantially parallel to the axis of said ring and to each other, screw means for detachably securing said pile-ups to the outer surface of said supporting ring whereby any pile-up can be readily removed from the exterior of said ring without disturbing other pile-ups, each of said pile-ups comprising at least an actuating spring and a coacting spring disposed in radially spaced relation and adapted to perform a circuit controlling operation when said actuating spring is flexed radially outwardly relatively to its coacting spring, a rotatable actuating arm revolving concentrically of the axis of said cylindrical series of pile-ups, a roller carried by said actuating arm adapted to directly engage said actuating springs successively for flexing the latter outwardly, bridging flanges projecting laterally from a plurality of said actuating springs adapted to be engaged directly by said roller so as to cause said latter springs to be operated in bridging relation, a ratchet wheel for imparting step-by-step advancing movement to said actuating arm, an advancing pawl for stepping said ratchet wheel in a forward direction, an advancing electromagnet for actuating said advancing pawl, spring means tending to rotate said ratchet wheel and actuating arm back to a normal position, a holding pawl opposing the action of said spring means, and a release electromagnet for releasing said holding pawl, one of said electromagnets being disposed substantially within said cylindrically grouped series of contact spring pile-ups.

15. In a rotary step-by-step switch of the class described, the combination of a supporting frame including a stationary cylindrical ring, a plurality of contact spring pile-ups mounted in a cylindrical relation around the exterior of said ring, the contact springs of said pile-ups extending substantially parallel to the axis of said ring and to each other, screw means for detachably securing said pile-ups to the outer surface of said supporting ring whereby any pile-up can be readily removed from the exterior of said ring without disturbing other pile-ups, each of said pile-ups comprising at least an actuating spring and a coacting spring disposed in radially spaced relation and adapted to perform a circuit controlling operation when said actuating spring is flexed radially outwardly relatively to its coacting spring, a rotatable actuating arm revolving concentrically of the axis of said cylindrical series of pile-ups, said actuating arm being adapted to engage said actuating springs successively for flexing the latter outwardly, a ratchet wheel for imparting step-by-step advancing movement to said actuating arm, an advancing pawl for stepping said ratchet wheel in a forward direction, an advancing electromagnet for actuating said advancing pawl, spring means tending to rotate said ratchet wheel and actuating arm back to a normal position, a holding pawl opposing the action of said spring means, and a release electromagnet for releasing said holding pawl, one of said electromagnets being disposed substantially within said cylindrically grouped series of contact spring pile-ups.

16. In a rotary step-by-step switch of the class described, the combination of a supporting frame comprising a stationary cylindrical ring, a plurality of contact spring pile-ups mounted in a cylindrical relation around the exterior of said ring and extending parallel to the axis of said ring and parallel to each other, each of said pile-ups comprising at least an actuating spring and a coacting spring disposed in radially spaced relation, cooperating contacts carried by said springs and adapted to perform a circuit controlling function when said actuating spring is flexed radially outwardly relatively to its coacting spring, each actuating spring comprising a projecting end portion extending longitudinally outwardly beyond the plane of said contacts, bridging flanges projecting laterally from said end portions of a plurality of the actuating springs, a rotatable actuating arm revolving concentrically of the axis of said cylindrical series of said pile-ups, a roller carried by said actuating arm adapted to flex said actuating springs radially outwardly, said roller engaging said projecting end portions and said bridging flanges directly whereby those actuating springs provided with bridging flanges are actuated in bridging relation while still permitting non-bridging actuation of other actuating springs in the series not provided with bridging flanges, a ratchet wheel for advancing said actuating arm from one of said contact spring pile-ups to another with a step-by-step motion, an advancing pawl for stepping said ratchet wheel, and an electromagnet for actuating said advancing pawl, said actuating arm, ratchet wheel, pawl and electromagnet being confined substantially within said cylindrical series of pile-ups.

17. In a rotary step-by-step switch of the class described, the combination of a supporting frame comprising a stationary cylindrical ring, a plurality of contact spring pile-ups mounted in a cylindrical relation around the exterior of said ring and extending parallel to the axis of said ring and parallel to each other, each of said pile-ups comprising at least an actuating spring and a coacting spring disposed in radially spaced relation, cooperating contacts carried by said springs and adapted to perform a circuit controlling function when said actuating spring is flexed radially outwardly relatively to its coacting spring, each actuating spring comprising a projecting end portion extending longitudinally outwardly beyond the plane of said contacts, bridging flanges projecting laterally from said end portions of a plurality of the actuating springs, a rotatable actuating arm revolving concentrically of the axis of said cylindrical series of said pile-ups, a roller carried by said actuating arm adapted to flex said actuating springs radially outwardly, said roller engaging said projecting end portions and said bridging flanges directly whereby those actuating springs provided with bridging flanges are actuated in bridging relation while still permitting non-bridging actuation of other actuating springs in the series not provided with bridging flanges, and electromagnetic stepping mechanism enclosed substantially within said cylindrical series of contact spring pile-ups for advancing said actuating arm with a step-by-step motion.

18. In a rotary step-by-step switch of the class described, the combination of a supporting frame comprising a stationary cylindrical ring, a plurality of contact spring pile-ups mounted in a cylindrical relation around the exterior of said

ring and extending parallel to the axis of said ring and parallel to each other, each of said pile-ups comprising at least an actuating spring and a coacting spring disposed in radially spaced relation, cooperating contacts carried by said springs and adapted to perform a circuit controlling function when said actuating spring is flexed radially outwardly relatively to its coacting spring, each actuating spring comprising a projecting end portion extending longitudinally outwardly beyond the plane of said contacts, a rotatable actuating arm revolving concentrically of the axis of said cylindrical series of pile-ups, a roller carried by said actuating arm, said roller engaging said projecting end portions of the actuating springs directly at points beyond the radial plane of said contacts, and electromagnetic stepping mechanism enclosed substantially within said cylindrical series of contact spring pile-ups for advancing said actuating arm from one of said pile-ups to another with a step-by-step motion.

19. In a rotary step-by-step switch of the class described, the combination of a substantially circular supporting member, a plurality of contact spring pile-ups mounted on said supporting member and grouped cylindrically about a common axis and extending substantially parallel thereto and to each other, each of said pile-ups comprising at least an actuating spring and a coacting spring disposed in radially spaced relation and adapted to perform a circuit controlling function when said actuating spring is flexed radially outwardly relatively to its coacting spring, a rotatable actuating arm revolving concentrically of the axis of said cylindrical series of pile-ups and adapted to flex said actuating springs of the pile-ups radially outwardly, and means carried by one of said actuating springs for causing the operation of its pile-up and the next succeeding pile-up to be in bridging relation.

20. In combination, an electromagnet, an armature responsive thereto, a pawl actuated by said armature, a rotary member having ratchet teeth successively actuated by said pawl, said pawl being oscillated substantially endwise in one direction along the idling flank of each ratchet tooth and thence snapping laterally off the tip of the tooth to take an inward position where it is operative to impart motion to the advancing flank of said tooth on the reverse endwise oscillation of the pawl, and a pair of cooperating contacts arranged to be actuated by such lateral snapping motion of said pawl, whereby the circuit controlling function of said contacts is dependent upon the pawl snapping off the tip of the ratchet tooth, independently of the position of said armature.

21. In a rotary stepping switch of the class described, the combination of a series of contact spring pile-ups grouped cylindrically about a common axis and extending substantially parallel thereto and to each other, each of said pile-ups comprising at least an actuating spring and a coacting spring disposed in radially spaced relation and adapted to perform a circuit controlling operation when said actuating spring is flexed radially outwardly relatively to its coacting spring, an actuating arm rotating coaxially of said common axis and adapted to have progressive stepping motion imparted thereto to engage successive pile-ups for flexing the actuating springs of said pile-ups radially outwardly, and electromagnetic stepping mechanism substantially enclosed within said cylindrical group of contact spring pile-ups and operative to impart stepping motion to said actuating arm.

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