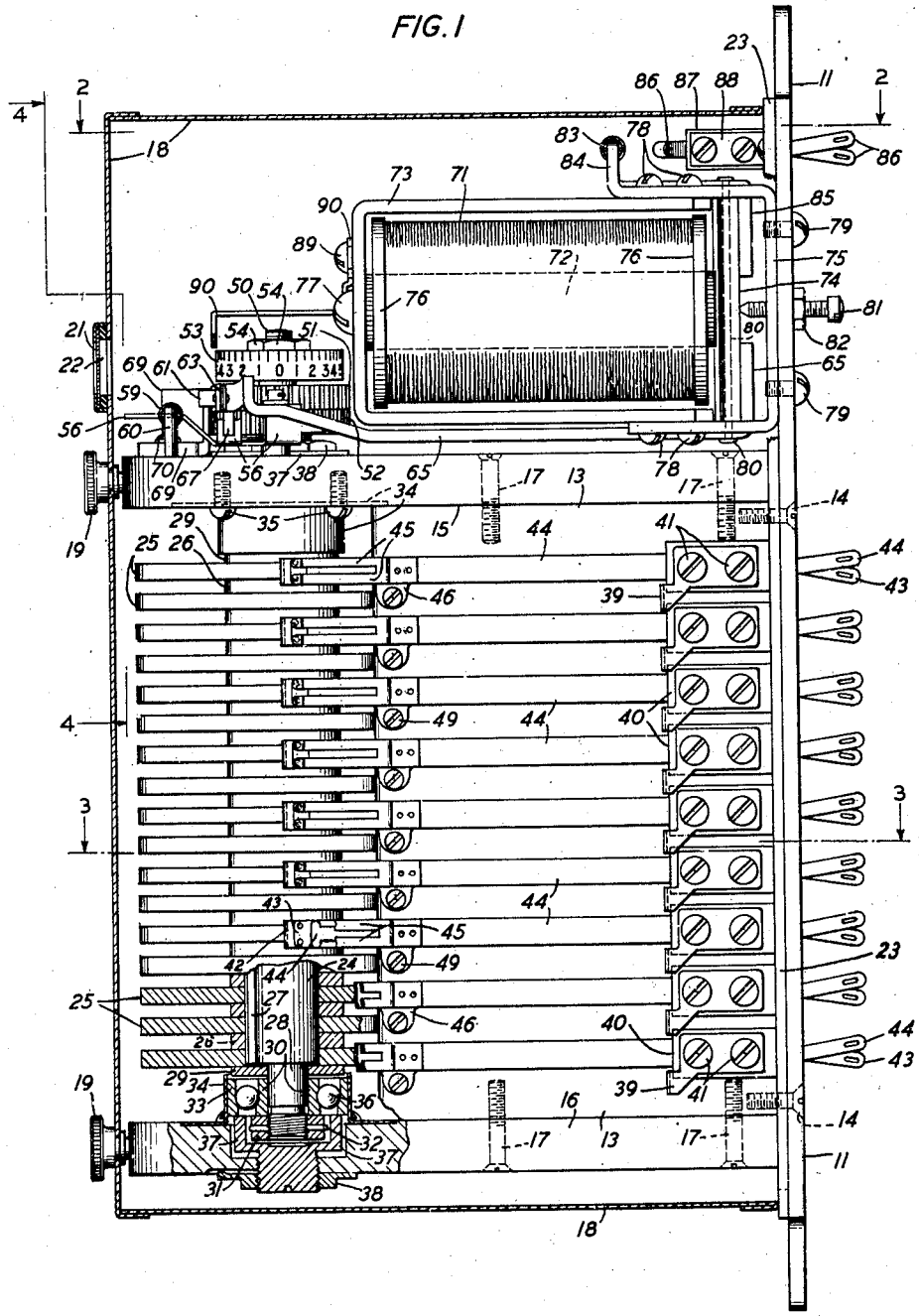
Dec. 13, 1938. H. BROADWELL 2,140,126

ROTARY SWITCH

Filed Dec. 13, 1935 3 Sheets-Sheet 1

FIG. 1



INVENTOR
H. BROADWELL
BY
ATTORNEY

Dec. 13, 1938. H. BROADWELL 2,140,126

ROTARY SWITCH

Filed Dec. 13, 1935 3 Sheets-Sheet 2

FIG. 2

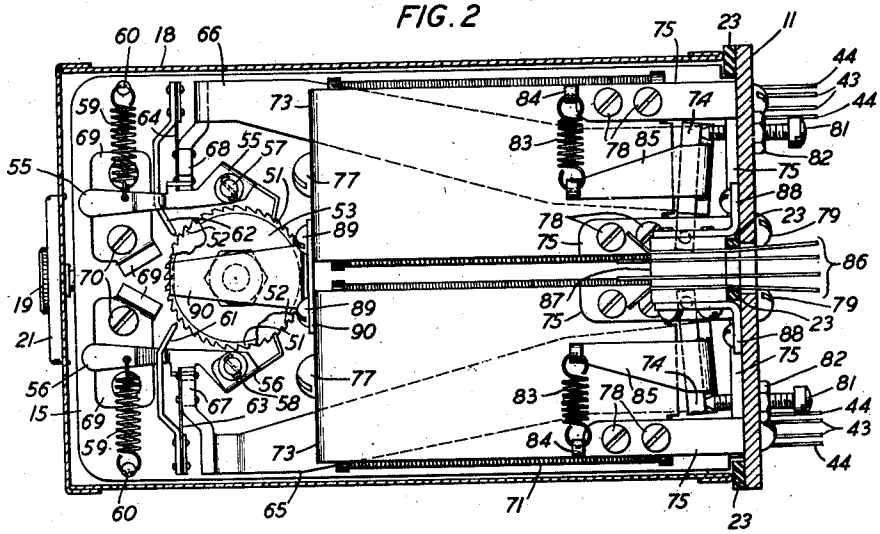
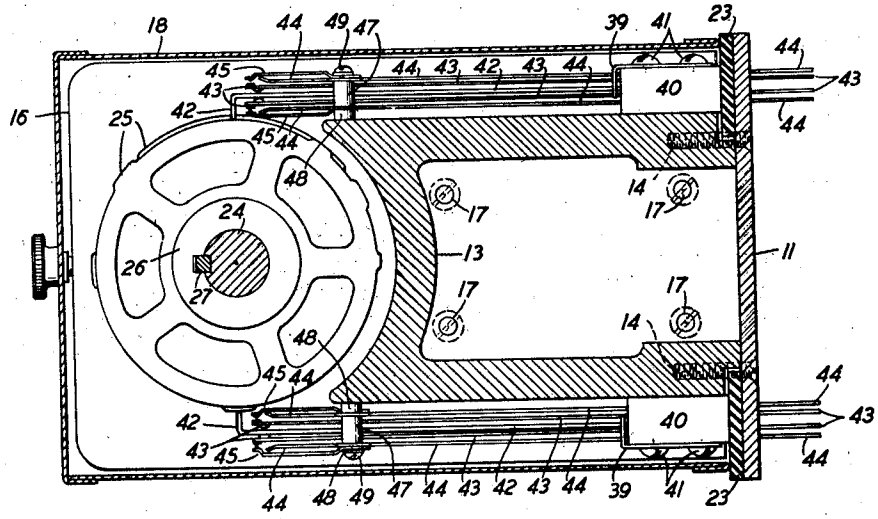


FIG. 3



INVENTOR
H. BROADWELL
BY M. F. McKenney
ATTORNEY

Dec. 13, 1938. H. BROADWELL 2,140,126

ROTARY SWITCH

Filed Dec. 13, 1935 3 Sheets-Sheet 3

FIG. 4

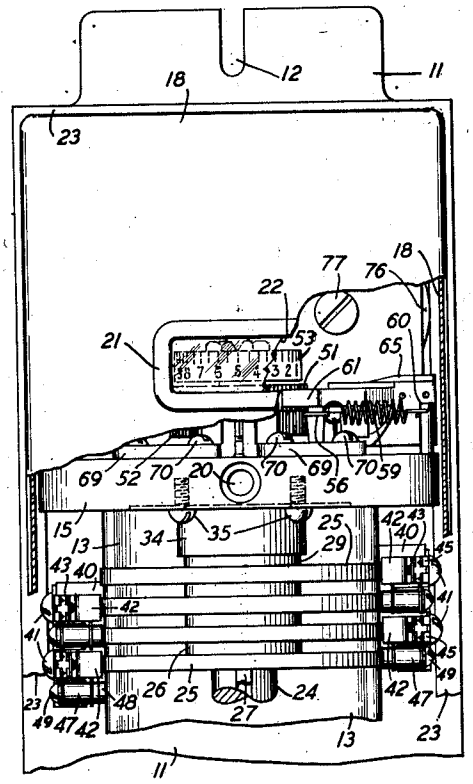


FIG. 5

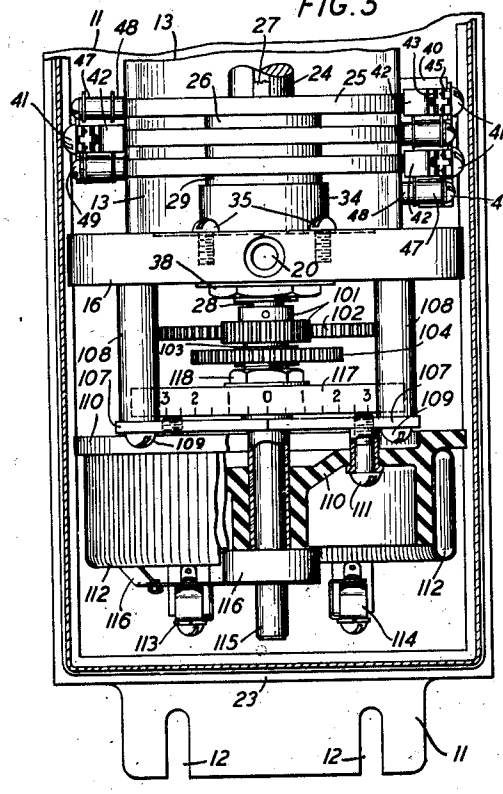
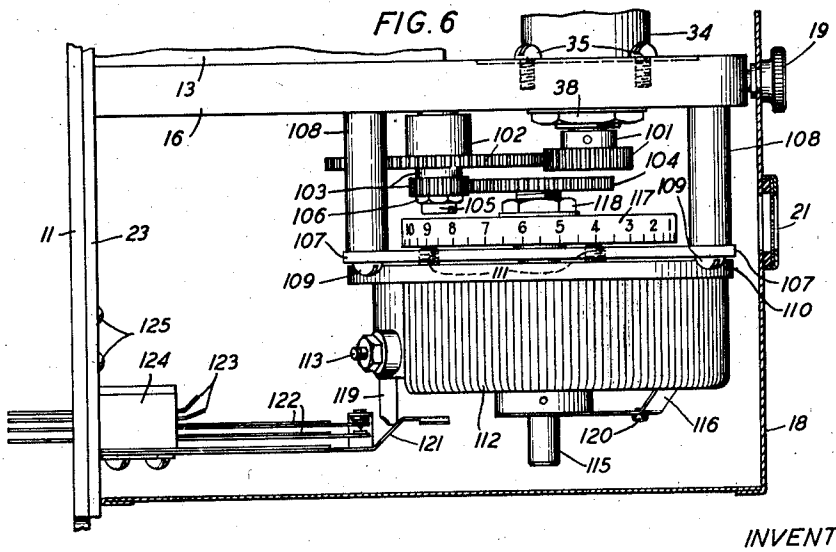


FIG. 6



INVENTOR
H. BROADWELL
BY
ATTORNEY

Patented Dec. 13, 1938 2,140,126

UNITED STATES PATENT OFFICE

2,140,126

ROTARY SWITCH

Howard Broadwell, Ridgewood, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application December 13, 1935, Serial No. 54,197

4 Claims. (Cl. 200—105)

This invention relates to electromagnetic switching devices and particularly to rotary switches which are adapted to be advanced step by step in either direction.

One of the objects of the invention is the provision of a durable and reliable circuit controlling switch mechanism of the rotary two-way step-by-step operated type. Another object is the provision of a compact and efficient rotary two-way step-by-step switch having many positions.

One feature of the invention is a rotary switch having two driving mechanisms, each consisting of an electromagnet, a ratchet, a driving pawl and a holding pawl, each operation of one magnet being effective to advance the shaft of the switch one step in one direction of rotation and each operation of the other magnet being effective to advance the shaft in the opposite direction, the two holding pawls being effective when neither of the electromagnets is energized to lock the shaft and cams in whatever position they are standing. Upon operation of either of the electromagnets and immediately prior to engagement of the associated driving pawl with its ratchet, the holding pawl for the other ratchet is disengaged therefrom.

Another feature of the invention is a rotary switch comprising a shaft, a cam mounted on the shaft for rotation therewith, and a set of contact springs which are particularly designed for operation by a shallow lift cam to make positive and continuous electrical contact at the time and for the interval desired.

A switch, constructed in accordance with this invention, is illustrated in the drawings which form a part of this specification.

Referring to the drawings:

Fig. 1 is a side view of the switch with the near side of the cover cut away;

Fig. 2 is a top view of the switch taken on lines 2—2 of Fig. 1;

Fig. 3 is a top view of the switch taken on lines 3—3 of Fig. 1;

Fig. 4 is a front view of the upper portion of the switch taken on lines 4—4 of Fig. 1;

Fig. 5 is a front view of the lower portion of the switch as modified to include a rheostat; and

Fig. 6 is a side view of the lower portion of the modified switch shown in Fig. 5.

The frame of the switch consists of a metal mounting plate 11, a heavy metal middle frame member 13 fastened to the front of plate 11 by screws 14, and two horizontally disposed heavy metal plates 15 and 16 fastened to the middle frame member 13, one at each end by screws 17. This framework is clearly shown in Figs. 1 and 3. One or more open slots 12 are provided in each end of mounting plate 11 for use in removably fastening the switch to a vertical support, such as an equipment frame. A metal cover 18, which together with mounting plate 11 wholly encloses the switch, is fastened to frame members 15 and 16 by thumb screws 19 in screw holes 20. A soft rubber gasket 23 between the open edge of the cover, the spring pile-up blocks and the mounting plate renders the enclosure dust-proof.

Extending vertically in front of the middle frame member 13 and supported at each end by plates 15 and 16 is a shaft 24 on which are mounted a plurality of circular metal discs 25, herein referred to as cams. The cams are separated by spacers 26 and are fixed to the shaft by a key 27. The end portions 28 of shaft 24, which portions are of reduced diameter, are rotatably supported by ball bearings, each of which comprises an inner ball race 30, an outer ball race 33 and balls 36. Washers 29 separate the inner ball races 30 from the uppermost and lowermost cams, and nuts 31 are screwed onto threaded portions of the shaft 28 outside of the inner ball races 30. A pin 32 fixes the position of the nut to prevent loosening during use. The outer ball races 33 are supported circumferentially by sleeves 34, the horizontal flanges of which are fastened to plates 15 and 16 by screws 35. Rings 37 screwed into the end plate members 15 and 16 serve to position the shaft vertically so that the cams are in alignment with their associated springs. The rings 37 are locked in proper position by flanged nuts 38. The loosening of nuts 38 is prevented by forcing the edge of each into a slot extending radially under the flange in the opposing end plate 15 or 16. The threaded portion of the ring 37 at the lower end of the shaft is solid since the shaft does not need to extend through the plate 16, but the threaded portion of the ring 36 at the upper end of the shaft is drilled to permit the shaft 28 to extend through plate 15, ratchet wheels 51 and 52 being keyed on this end of the shaft above the plate 15. An index wheel 53 is fastened onto the threaded end portion 50 of the shaft, above the ratchets, by a nut 54. The teeth of ratchet 51 are adapted for use in rotating the shaft 24 in one direction and the teeth of ratchet 52 are adapted for use in rotating the shaft in the other direction.

Sets of contact springs are provided, each set being associated with a different one of the cams 25, the spring sets for adjacent cams being

mounted on opposite sides of the middle frame member 13 as is best shown in Fig. 3. Each set of springs includes an actuating spring 42 and a pair of contact springs 43 and 44 on each side of the actuating spring 42, all of these springs being fixed in a spring pile-up block 40 fastened by screws 41 to the middle frame member 13. The contact springs 43 and 44 of each set extend through the block 40 and through an opposing hole in the mounting plate 11 to form the soldering lugs by which each of the pairs of contact springs is connected in the circuit to be controlled thereby. The rubber gasket 23 surrounds the holes through which the soldering lugs extend, so that each of the blocks 40 engages the gasket and forms a dust-tight joint. The free end of the actuating spring 42 is bent over at right angles to its length to engage the periphery of the associated cam so as to close the contacts of one pair of springs 43 and 44 upon engaging the periphery at or near points of maximum radii and close the contacts of the other pair of springs 43 and 44 upon engaging the periphery at or near points of minimum radii. The cam contour provides for follow in the contact springs to insure good contact. The forward end of each of springs 44 is anchored by its projecting lug 46 and a screw 49 to the middle frame member 13, these two springs of each set being properly spaced at this point by an insulating sleeve 47 through which the screw extends. Washers 48 serve to insulate these springs from the screw 49 and frame member 13. A bifurcated lightweight contact spring 45 is welded to each of the springs 44 at the anchoring point, the portion of each spring 44 which extends forward beyond the anchoring point serving as a stop to limit the follow of its bifurcated contact spring 45 when not in engagement with the free end of its associated spring 43. A clearance between the bifurcated springs 45 and the extending portions of the springs 44 is provided by an offset in the springs 45 near the welding point. The extending portion of each of springs 44 is T-shaped, the width of the spring being reduced between the anchoring point and the end which is bent toward the springs 45 to provide clearance for insertion of an adjusting tool; the reduced width also facilitates bending to adjust the follow of spring 45. Springs 45 are given the desired initial tension and the end of spring 44 provides a definite stop as near as possible to the point of contact between spring 45 and spring 43 so that there is a fast build-up of contact pressure before spring 45 is moved away from engagement with the end of its associated spring 44. The possibility of chatter due to a slow build-up of pressure is thereby eliminated. By the anchoring of springs 44 and the use of the short lightweight bifurcated springs 45, positive and chatterless contact with the long and heavier springs 43 is insured with only a low contact pressure and minimum cam lift. The low cam lift permits cams of smaller diameter and, therefore, smaller electromagnets than would otherwise be necessary. Mechanical vibration is minimized by the heavy frame. To facilitate maintenance, a numbering lug 39 is provided for each set of springs, which lug is held between the heads of screws 41 and the spring pile-up block 40, the cams and associated sets of springs being thereby identified by letter, A, B, C, etc., printed on the front face of the lugs. With the cover removed, these identifying letters are visible upon looking back along each side of the switch.

In addition to the aforementioned ratchets 51 and 52, the mechanism for rotating and controlling the rotation of the shaft and cams step by step in one direction or the other, comprises driving pawls 61 and 62 controlled by the armatures 74 of two electromagnets, the retaining pawls 55 and 56, and overthrow stops 69. Each electromagnet comprises a coil 71, magnetic core 72, U-shaped pole-piece 73, armature 74, and a non-magnetic four-legged bracket 75. The coil of each electromagnet is wound between spool heads 76, the core is fastened within the associated U-shaped pole-piece 73 by a screw 77, the pole-piece is fastened to the four legs of the associated U-shaped bracket 75 by screws 78, and the bracket for each electromagnet in fastened to the mounting plate 11 by screws 79. The armature of each electromagnet is pivoted on a pin 80 which extends vertically through the inner edge of the armature, the ends of the pin being fixed in the inner legs of the associated bracket 75. The rear ends of arms 65 and 66, on the forward ends of which are attached the driving pawls 61 and 62, are bent upward to engage and be respectively fastened by rivets to the rear surface of the armatures 74. For each electromagnet, a back stop pin 81 and lock nut 82 permit adjustment of the gap between the end of core 72 and the face of armature 74, the armature being biased by a spiral spring 83 so that the associated driving pawl is normally disengaged from the teeth of the associated ratchet wheel, one end of spring 83 being fastened to the lug end 84 of the inner upper leg of bracket 75 and the other end to an L-shaped arm 85 screwed to and extending forward from the armature 74. The retaining pawls 55 and 56 are irregularly shaped levers pivoted respectively on pins 57 and 58 fixed in plate 15. The pawls 55 and 56 are identical but are reversely mounted on plate 15 so that pawl 55 engages ratchet 51 and pawl 56 engages ratchet 52. The ends of these pawls remote from the ratchets are fastened by springs 59 to posts 60 fixed in plate 15 so that both pawls are normally in engagement with the ratchets 51 and 52 and the shaft and cams are, therefore, locked in whatever position they happen to be. The ends of these pawls are extended forward beyond the point at which the springs are attached to facilitate hand operation during the testing and adjusting of the switch. Upon energization of the coil of either electromagnet, the armature 74 is actuated, the forward end of the associated arm 65 or 66 being thereby moved toward the ratchet 51 or 52. Before the associated driving pawl engages its ratchet, the retaining pawl must be disengaged from the other ratchet. To this end, a lug 67 projects downward from the end of arm 65 to engage, as soon as arm 65 begins to move toward ratchet 51, an opposing lug of the retaining pawl 56 so that the movement of arm 65 disengages pawl 56 from ratchet 52 before driving pawl 61 engages ratchet 51. A like lug 68 projects upwardly from the end of arm 66 to engage, as soon as arm 66 begins to move toward ratchet 52, an opposing lug of the retaining pawl 55 so that the movement of arm 66 disengages pawl 55 from ratchet 51 before driving pawl 62 engages ratchet 52. The overthrow stops 69, fastened by screws 70 to the plate 15 limit the advance of the ratchets to exactly one step in response to each operation of the associated electromagnet. The ends of coils 71 are connected to the soldering lugs 86 of a pile-up block 87 which is fastened by L brackets 88 and screws to the mounting

plate 11. The soldering lugs 86 extend out through a hole in the mounting plate and the block 87 fits down onto the rubber gasket 23 to exclude dust.

A pointer 90 is fastened by screws 89 to the pole piece 73 to mark on the index wheel 53 the position in which the shaft and cams are resting. A glass index window 22 fastened in the cover 18 by a frame 21 opposite the index wheel enables the reading of the position in which the switch is standing without removing the cover. This window is made dust tight by a rubber gasket around the frame 21.

The above described switch is particularly adapted for use in gain control for toll telephone lines. A switch is provided for each line, the cutting in or cutting out of resistance pads being controlled by the cams in the various positions of the switch. Switches having forty-one positions, that is, a zero or normal position and adapted to take twenty steps in either direction from the normal position meet present commercial requirements. To prevent excessive drain in case all of the individual switches were moved simultaneously, a master switch may be provided to control the individual switches in groups, the various groups being operated successively. The master switch may be controlled by a Wheatstone bridge circuit, one arm of which includes a pilot line similar to those whose gain is to be controlled. Changes in the resistance of the pilot line due to temperature variation cause an unbalance of the bridge thereby causing the master switch to be stepped in one direction or the other as the case requires. One such Wheatstone bridge control circuit is disclosed in Patent 2,017,654 issued to J. A. Coy et al., October 15, 1935. The master switch may have a number of normal positions and once started in either direction continues to rotate automatically until the next normal position is reached, all of the groups of individual switches being thereby successively moved as required. Thus, a master switch having forty-two positions might be used without waste of positions and with equally timed cycles of advance, for either six or for seven groups of individual switches. It is, of course, necessary that the balance of the control circuit for the master switch be automatically restored by the movement of the switch. To this end, the switch of Figs. 1, 2, 3 and 4 may be modified as shown in Figs. 5 and 6 by extending the mounting plate, adding a rheostat below the plate 16, and by extending and coupling the shaft of the switch by a reduction gearing to the shaft of the rheostat to secure the required movement of the rheostat brush for each advance of the master switch from one normal position to the next and the resulting advance of each of the individual gain control switches from one position to the next.

To permit extension of the lower end 28 of shaft 24, there is a hole through the screw-end of lower ring 37, and the shaft extends through this hole far enough below plate 16 to permit spur gear 101 to be keyed onto the end of the shaft. The added rheostat comprises a rectangular metal mounting plate 107 fastened parallel to the frame plate 16 by metal sleeves 108 and the screws 109, a frame 110 of insulating material, such as Bakelite or hard rubber, fastened to the mounting plate 107 by screws 111, a winding 112 of high resistance wire, binding post terminals 113 and 114, a shaft 15 extending through the center of frame 110, and a brush 116, the hub part of which is keyed on the lower end of shaft 115. The shaft is enlarged to form a collar which rests on the upper surface of the plate 107. On the shaft 115 above the collar is an index wheel adjustably held by a nut 118 screwed onto a threaded portion of the shaft. The spur gear 104 which is staked onto the upper end of the shaft 115 is coupled to the spur gear 101 on the end 28 of shaft 24 by the spur gears 102 and 103. The hub of gear 102 fits tightly over the hub of gear 103 and both rotate together on the sleeve 106 which is fixed by pin 105 to plate 16. The hole through sleeve 106 is eccentrically placed and the end is of hexagonal shape so that the sleeve may be turned to adjust the position of gears 102 and 103 and thereby limit the backlash. A set of soldering lugs 123, a pair of contact springs 122, and an actuating spring 121 are fixed in a pile-up block 124, which block is fastened by screws 125 to the mounting plate 11. The free end of the actuating spring normally engages a stud 119 projecting downward from the binding post 113 so that the contacts of springs 122 are closed. The brush 16 carries a stud 120 which, when the brush has reached the limit of its motion in either direction, engages the end of spring 121 to open the contacts of springs 122.

What is claimed is:

1. In a switching mechanism, a base plate, a shaft rotatably mounted thereon, a disc cam on said shaft for rotation therewith, means for rotating said shaft and cam from any one of a plurality of positions of rest into any other of said positions, a spring pile-up comprising an insulating block fastened to said mounting plate and a pair of flat contact springs fixed near one end in said block in spaced and parallel relation and extending forward from said block toward said cam, a spring actuating member, one end of said member engaging the periphery of said cam, a flat spring extension of the other end of said member being fixed in said block so as to maintain the engagement between the free end of said member and said cam, the forward end of a first one of said contact springs being free and tensioned toward said actuating member, the second of said contact springs being further fixed at a point near its forward end, and a more flexible contact spring welded to the second contact spring at said point and extending forward to engage the free end of said first contact spring.

2. In a switching mechanism, a base plate, a shaft rotatably mounted thereon, a disc cam on said shaft for rotation therewith, means for rotating said shaft and cam from any one of a plurality of positions of rest into any other of said positions, a spring pile-up comprising an insulating block fastened to said mounting plate and a pair of flat contact springs fixed near one end in said block in spaced and parallel relation and extending forward from said block toward said cam, a spring actuating member, one end of said member engaging the periphery of said cam, a flat spring extension of the other end of said member being fixed in said block so as to maintain the engagement between the free end of said member and said cam, the forward end of a first one of said contact springs being free and tensioned toward said actuating member, the second of said contact springs being further fixed at a point near its forward end, and a more flexible contact spring welded to the second contact spring at said point and extending forward to

engage the free end of said first contact spring, the portion of said second contact spring which extends forward beyond said point being curved toward the free end of said more flexible contact spring to form a stop for limiting the follow of the free end of said more flexible spring.

3. In a switching mechanism, a base plate, a shaft rotatably mounted thereon, a disc cam on said shaft for rotation therewith, means for rotating said shaft and cam from any one of a plurality of positions of rest into any other of said positions, a spring pile-up comprising an insulating block fastened to said mounting plate and a pair of flat contact springs fixed near one end in said block in spaced and parallel relation and extending forward from said block toward said cam a spring actuating member, one end of said member engaging the periphery of said cam, a flat spring extension of the other end of said member being fixed in said block so as to maintain the engagement between the free end of said member and said cam, the forward end of a first one of said contact springs being free and tensioned toward said actuating member, the second of said contact springs being further fixed at a point near its forward end, and a more flexible contact spring welded to the second contact spring at said point and extending forward to engage the free end of said first contact spring, the portion of said second contact spring which extends forward beyond said point being bent toward the free end of said more flexible contact spring to form a stop for limiting the follow of the free end of said more flexible spring, the extending portion of said second contact spring being of reduced width intermediate said point and its free end.

4. In a rotary circuit controlling device, a shaft, driving means comprising an electromagnet, a ratchet and a driving pawl for rotating said shaft in one direction, driving means comprising another electromagnet, ratchet and driving pawl for rotating said shaft in the other direction, a holding pawl normally engaging one of said ratchets for preventing rotation in one direction, and a like holding pawl normally engaging the other of said ratchets for preventing rotation in the other direction, each of said driving pawls having a projection effective just before the driving pawl engages its associated ratchet for disengaging the holding pawl from the other ratchet.

HOWARD BROADWELL.