April 17, 1956 D. J. LESLIE 2,742,537

STEP-BY-STEP ELECTRICAL CIRCUIT CONTROLLER

Filed Aug. 26, 1950 2 Sheets-Sheet 1

Fig. 1.

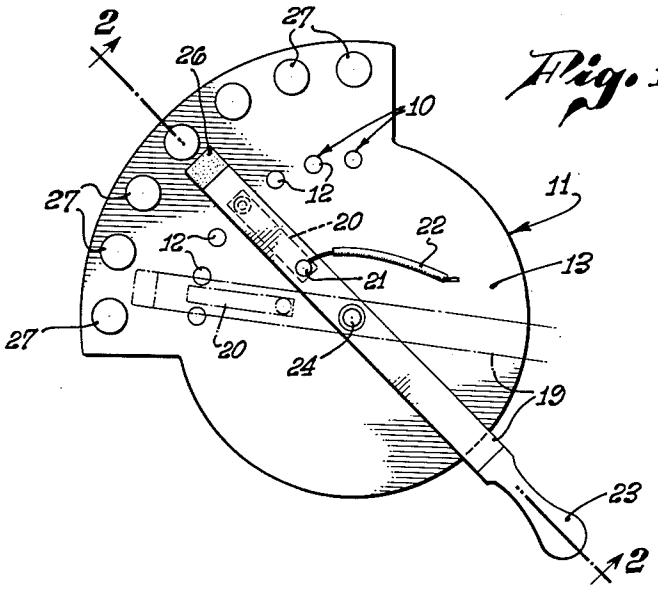

Fig. 2.

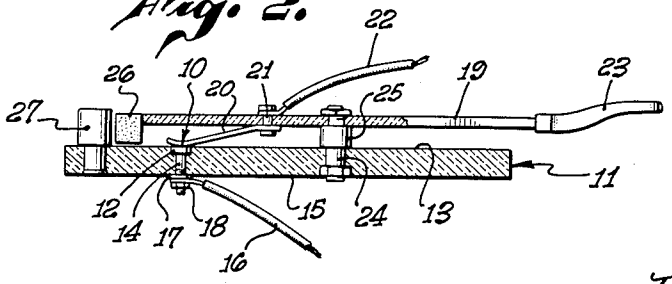

Fig. 3.

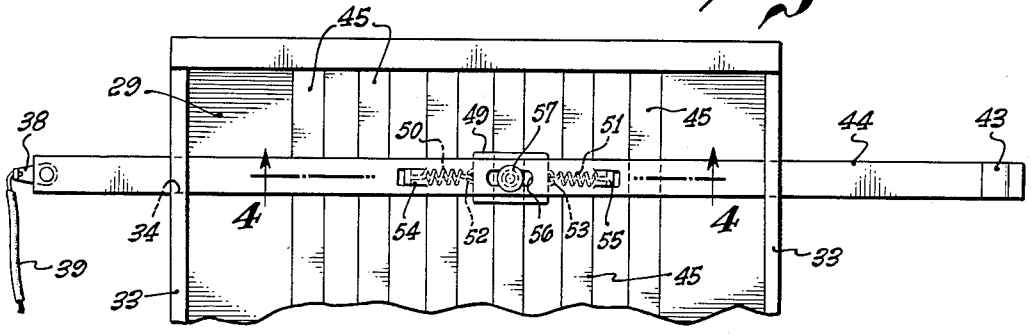

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Fig. 4.

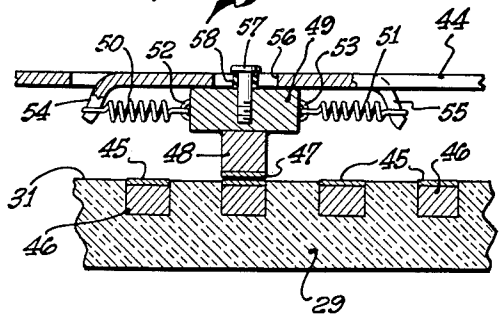


Fig. 5.

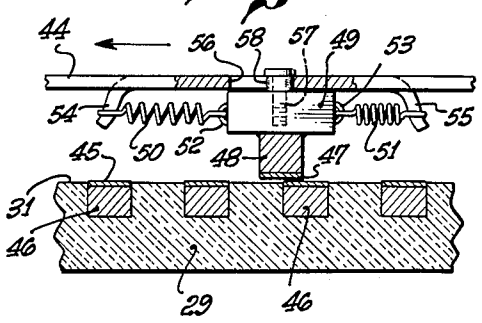


Fig. 6.

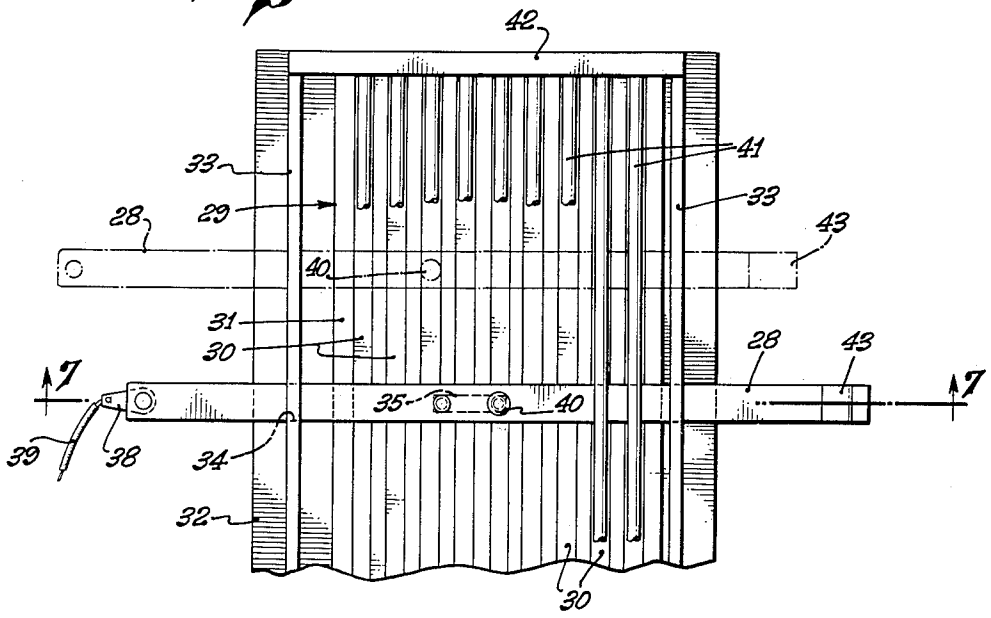
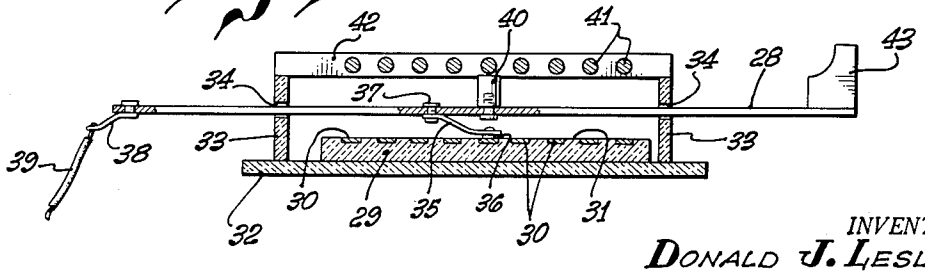


Fig. 7.



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STEP-BY-STEP ELECTRICAL CIRCUIT CONTROLLER

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11 Claims. (Cl. 200—6)

This invention relates to a sliding contact switching mechanism that is multipositionable.

Generally, such switches find application in widely divergent fields of electrical engineering. However, this invention has for its primary object the provision of a switch of this character that is particularly adapted for use in connection with electric organs, such as for selective control of harmonic components.

To avoid shorting of adjacent contacts in multipositionable switches, the bank of contact points is usually arranged in spaced relation, the cooperating, relatively movable contact having a width less than such spacing. It is however, important that the relatively movable contact never occupies an intermediate position to ensure that a circuit of some kind is effected. It is apparent, therefore, that some means must be provided to render such intermediate position relatively unstable, and the contacting positions relatively stable.

In many fields of electrical engineering, a mechanical detent arrangement has been provided. However, such systems are unsuited for use in connection with electric organs, for such systems produce considerable noise that should be avoided in the playing of music. It is, accordingly, an object of this invention to provide a multipositionable switch that ensures stable contacting position in a noiseless manner.

In that type of switch in which adjacent contacts of a bank of contacts are necessarily shorted during shifting of the relatively movable contact, it is often important that the time in which such adjacent contacts are shorted is minimized, as well as to ensure that the shorting condition is relatively unstable, as compared with the condition in which the relatively movable contact cooperates only with one of the bank of relatively stationary contacts. The object of this invention is to provide a multipositionable switch adapted for use in such type of switch, and that ensures stable contacting position in a noiseless manner.

For accomplishing the above mentioned objects, use is made of magnetic means for securing the stable positioning of the contacting elements.

It is another object of this invention to proivde novel means for reducing friction in a multipositionable switch.

It is another object of this invention to provide a multipositionable switch of this character that has a snap action between adjacent contacting position, and that is particularly adapted for use in the shorting type of switch. For this purpose, novel mounting is provided for magnetic contacting means, so that the switch arm is, to a limited extent, movable indepednently of the magnetic contacting means, sufficient motion of the switch arm finally initiating the snap motion of the magnetic contacting means.

It is another object of this invention to provide a multipositionable switch of this character that is simple in structure, but yet efficient in operation.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of several embodiments of the invention. For this purpose, there are shown a few forms in the drawings accompanying and forming part of the present specification. These forms will now be described in detail, illustrating the general principles of the invention; but it is to be understood that this detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

Figure 1 is a plan view of one embodiment of this invention;

Fig. 2 is a sectional view, taken along the plane indicated by line 2—2 Fig. 1;

Fig. 3 is a plan view of another embodiment of this invention;

Fig. 4 is a sectional view, taken along the plane indicated by line 4—4 of Fig. 3;

Fig. 5 is a view, similar to Fig. 4, illustrating the apparatus in the process of causing a switching from one contacting position to another;

Fig. 6 is a plan view of yet another embodiment of this invention;

Fig. 7 is a sectional view, taken along the plane indicated by line 7—7 of Fig. 6.

In the form illustrated in Figs. 1 and 2, a plurality of stationary contacts **10** are mounted arcuately and substantially equiangularly on an insulation base **11**. The contacts **10**, in this instance, comprise a contact button **12** having a surface flush with the upper surface **13** of the base **11**. A threaded shank portion **14** of the contact **10** extends through the base **11** and beyond the lower surface **15** thereof. A connection **16** for each contact **10** may be secured to the contact by the aid of a washer **17** and a nut **18**. Each of the connections **16** may lead to various circuits, such as electric organ circuits having differing harmonic characteristics.

A pivotally mounted, manually operable lever or arm **19** carries an arcuately sliding spring contacting arm **20**, cooperable selectively with any of the contacts **10** to complete one of the circuits of which a connection **16** forms a part. The arm **20** is secured to the lever **19**, as by the aid of a bolt assembly **21**, the arm **20** being in electrical contacting relation to the bolt assembly. The single connection **22**, secured to the bolt assembly **21** in electrical contacting relation, is therefore adapted to cooperate with any of the connections **16** to control the harmonic characteristics of an electric organ.

The lever **19** may be of insulation material. Secured thereto is an operating handle **23**. Conventional bolt assembly **24** supports the lever **19** for pivotal movement on a bearing **25**. Thus far described, the apparatus constitutes a conventional multipositionable switch. While the spacing of the contacts **10** is such, with respect to the width of the spring arm **20**, that no shorting of adjacent contacts **10** can occur, it is yet necessary, in normal operation, to ensure that there be one contacting position, and that the switch arm **19** cannot be left in an intermediate position.

Accordingly, means are provided to render any intermediate position of the lever **19** relatively unstable as compared with any adjacent contacting position. For this purpose, the lever **19** carries a permanent magnet **26** at one end thereof. A plurality of arcuately arranged, and substantially equiangularly spaced, magnetic slugs **27** are carried by the base **11**, and are cooperable with magnet **26**. As the lever **19** is mounted for minimum friction on bearing **25**, several stable positions of the lever arm **19** are accordingly provided, as the magnet **26** is drawn nearest to one of the slugs **27** to reduce the energy integral of the magnetic field to a minimum. Such position is indicated in full lines in Fig. 1.

The angular spacing of the slugs **27** is correlated to

the angular spacing of the several contacts 10, so that, for a stable condition of the magnet 26 and a slug 27, the spring contact arm 20 is in full engagement with one of the contacts 10.

Should the operator inadvertently leave the arm 19 in an intermediate position, such as is illustrated by the dot-and-dash lines in Fig. 1, the arm 19 will be attracted to one of the adjacent slugs 27 to return the spring contact arm 20 to either one or the other contacting position. Equilibrium at such an intermediate position would be unlikely to occur. Even if such condition should occur, the equilibrium condition would be unstable; and minor vibrations, such as would be encountered in operation of an electric organ, would ensure against continuation of such unstable equilibrium condition, the lever 19 being mounted for minimum friction. Accordingly, the arm 19 assumes a stable position wherein the magnet 26 is nearest to a slug 27, ensuring contacting relation of the contact 10 and the spring arm 20.

It is clear that, even if the spacing between adjacent contacts 10 were such that shorting thereof would occur, the magnet 26 would yet have definite equilibrium positions to ensure against continued shorting of adjacent contacts.

In the form illustrated in Figs. 1 and 2, the magnet 26 and the slugs 27 are so arranged that the magnet attraction between the magnet 26 and a slug 27 is directed substantially radially of the pivotally mounted lever 19, ensuring against binding of the lever 19 on the pivotal mounting provided by the assembly 24 and bearing 25. The magnet 26 and slugs 27 are out of mechanical engagement, ensuring noiseless operation of the mechanism.

In the form illustrated in Figs. 6 and 7, a linearly movable contact carrying slide arm 28 is provided that is similar to the form illustrated in Figs. 1 and 2.

An insulation base 29 carries a plurality of spaced contact bars 30 having contact surfaces flush with the upper surface 31 of the base 29. Suitable connections for each bar 30 (not shown) may provide connections to a plurality of circuits designed to be effective upon the completion of a connection thereto by the switch device.

The base 29 is carried by a support 32. A pair of slide arm supporting members 33 extend from the support 32. Appropriate through apertures 34 are provided for supporting the slide arm 28 for longitudinal movement transverse to the bars 30, the supporting members 33 being of small width in order to minimize the frictional contact area between the arm 28 and the supporting member 33. More elaborate forms of anti-friction support may, however, be provided.

In this instance, the arm 28 carries a spring arm 35 carrying a contact 36 cooperable with the several contact bars 30. The spring arm 35 is in electrical conducting relation to the slide arm 28, and is secured thereto by the aid of a rivet 37. A terminal 38, carried by the slide arm 28, has secured thereto a connection 39. It is thereby provided that the connection 39 may be in electrical conducting relation to any of the several contact bars 30 in order to control the harmonic characteristics of the system, similar to that set forth in connection with the form illustrated in Figs. 1 and 2.

To ensure that the several contacting positions of the slide arm 28 are stable, and that any intermediate position thereof is relatively unstable, the slide arm 28 carries a permanent magnet 40, cooperable with spaced magnetic rods 41. The rods 41 are carried by a frame 42 that is, in turn, carried by the supporting members 33. The center-to-center spacing of the rods 41 corresponds to the spacing of the contact bars 30. The bars 41 are so mounted that, upon cooperation of the magnet 40 with any one of such bars, contacting relation between the contact 36 and one of the bars 30 is achieved. Accordingly, contacting position is rendered stable, and any intermediate position of the slide 28 is accordingly relatively unstable, ensuring that contacting position is achieved, similar to the operation set forth in connection with the form illustrated in Figs. 1 and 2.

A suitable operating handle 43 for the slide arm 28 is provided for movement of the slide 28 by the operator.

In the form illustrated in Figs. 6 and 7, any number of slide arms 28 could be provided, the rods 41 and contact bars 30 being made as long as is thereby needed. Accordingly, several circuits can be made to cooperate with any of the contact bars 30, all depending upon the needs of the installation.

In the form illustrated in Figs. 3, 4, and 5, the basic arrangement is similar to that of the form illustrated in Figs. 6 and 7. In the present form, however, novel combinations of elements achieve a positive contact, and provide a snap action for the movable contact between adjacent bars.

As shown most clearly in Fig. 4, the contact bars in this instance each comprise a silver strip 45, providing the contacting surface flush with the upper surface 31 of base 29, and a bar 46 of magnetic material beneath the strip 45.

The slide arm 44 carries a silver contact 47 that is positionable to cooperate with any of the strips 45. The contact 47 is movable, not only with respect to the strips 45 and bars 46, but also, to a limited extent, with respect to the slide arm 44 on which it is carried, for purposes that will hereinafter be described. The contact 47 is secured to the face of a permanent magnet 48, the permanent magnet 48 being, in turn, secured to a supporting block 49 of conducting material. The block 49 is resiliently mounted on the slide arm 44 for relative movement with respect to the arm 44 in a longitudinal direction thereof. For this purpose, a pair of coil springs 50 and 51 are secured at one end to the block 49 at opposite sides thereof, as by the aid of eyes 52 and 53 formed on, or carried by, the block 49. The other ends of the springs 50 and 51 are secured to depending posts 54 and 55 that may be formed by striking away a portion of the slide arm 44.

The springs 50 and 51 are preferably soldered to the posts 54 and 55, respectively, as well as soldered to the eyes 52 and 53, to ensure proper electrical conducting path between the contact 47 and the connection 39, the bar 28 and the magnet 48 forming a part of such electrical conduction path.

Substantially centrally of the posts 54 and 55, the sliding arm 44 is slotted, as at 56. Through the slot 56 extends a threaded bolt or pin 57, carried by the supporting block 49. This pin and slot connection limits relative movement of the contact 47 and slide arm 44. A silencing sleeve 58 is carried by the pin 57, and it may be of suitable resilient material.

In operation, it is clear that magnetic attraction between the magnet 48 and the bars 46 defines a plurality of stable conditions, such stable conditions corresponding to contacting relation between contact 47 and the silver strips 45, since the magnet 48 is immediately behind the contact 47 and the bars 46 of magnetic material are directly behind the silver contacting strips 45. Such a stable condition is illustrated in Fig. 4. In such stable condition, the springs 50 and 51 tend to centralize the slot 56 about the pin 57, since the posts 54 and 55, to which the springs 50 and 51 are fastened, are spaced substantially equally from the center of the slot 56. An electrical conducting path is established from the strip 45, contact 47, magnet 48, supporting block 49, eyes 52 and 53, springs 50 and 51, arm 44, post 38 (Fig. 3), and lead 39.

As the slide arm 44 is moved by the handle 43, magnetic attraction between the magnet 48 and the bars 46 causes the contact 47 to lag behind the movement of the slide arm 44, as facilitated by the resilient mounting of the magnet 48 and contact 47. Accordingly, contacting relation is prolonged during movement of the slide arm 44. Thus, in Fig. 5, the slide arm 44 is being moved to

the left, but the contacting relation remains. Spring 50 is tensioned, and spring 51 is compressed. Finally, the silencing sleeve 58 of the pin 57 abuts the edge of the slot 56, and the contact is then moved with the slide arm 44. Magnetic attraction is then decreased as the magnet 48 moves from the bar 46; and, suddenly, as the spring force overpowers the now decreased magnetic attraction, the magnet assembly shifts the supporting block 49 and the magnet 48 to the adjacent contact. A snap action is thereby achieved, and the switch mechanism will then assume a stable position as long as is desired. The spring constants are so designed, with respect to the size of the magnet 48 and the geometry of the system, that the snap-over action is ensured, providing against the contact 47 remaining in an intermediate position.

Such form as is illustrated in Figs. 3, 4, and 5 is particularly adapted for use in connection with that type of switch in which adjacent contacts are shorted during shifting of the switch arm, as the snap action ensures against continued shorting of the contacts.

The several forms of switches shown are all substantially noiseless, the only metal-to-metal relatively movable surfaces being the contacts themselves. Accordingly, the switch mechanisms are particularly adapted for use in electric organs.

What is claimed is:

1. In a multipositional switch: a plurality of spaced electrical conducting members, said members being of magnetic material; a manually movable switch arm having a contact, the contact including magnetic means cooperable with the magnetic material of said spaced members; and means supporting said arm for movement so that said contact is slidably engageable with said conducting members in succession upon movement of said arm in one direction; said supporting means being so constructed and arranged that said magnetic material exerts a force upon said magnetic means sufficient to move said arm to a stable position from any intermediate position; the stable positions corresponding only to contacting position.

2. In a multipositional switch: a plurality of electrical conducting contacting strips; a plurality of bars of magnetic material adjacent each of said strips respectively; a switch arm movable transversely of said strips; a magnetic contact adapted to be carried by said arm; and means resiliently mounting said magnetic contact on said switch arm for relative movement with respect to said arm in the direction of movement of said arm.

3. In a multipositional switch: a plurality of electrical conducting contacting strips; a plurality of bars of magnetic material adjacent each of said strips respectively; a switch arm movable transversely of said strips; a magnetic contact adapted to be carried by said arm; means resiliently mounting said magnetic contact on said switch arm for relative movement with respect to said arm in the direction of said arm; and means limiting the relative movement of said magnetic contact with respect to said switch arm.

4. In a multipositional switch: a plurality of electrical conducting contacting strips; a plurality of bars of magnetic material adjacent each of said strips respectively; a switch arm movable transversely of said strips; a magnetic contact adapted to be carried by said arm; means resiliently mounting said magnetic contact on said switch arm for relative movement with respect to said arm in the direction of said arm; and means limiting the relative movement of said magnetic contact with respect to said switch arm, comprising a pin and slot connection between the magnetic contact and said switch arm.

5. In a multipositional switch: a plurality of electrical conducting magnetic contacting members; a switch arm movable transversely of said contacting members; a magnetic contact adapted to cooperate with said magnetic contacting members; and means mounting said magnetic contact on said switch arm for limited relative movement therewith in the direction of movement of said switch arm.

6. In a multipositional switch: a plurality of electrical conducting magnetic contacting members; a switch arm movable transversely of said contacting members; a magnetic contact adapted to cooperate with said magnetic contacting members; and means mounting said magnetic contacting member on said switch arm for snap-over movement between adjacent contacting members.

7. In a multipositional switch mechanism: a base; a manually movable switch arm having a contact thereon; a pivotal mounting for said switch arm for movement about an axis transverse to said base; a plurality of contacts spaced on said base substantially arcuately about said axis; said contact of said switch arm being engageable with said spaced contacts in succession upon angular movement of said arm in one direction; a plurality of members of magnetic material, said members being arcuately arranged about said axis; and magnetic means carried by said switch arm and cooperable with said magnetic members, said magnetic means and said magnetic members being at all times out of mechanical engagement; said pivotal mounting being so constructed and arranged that said magnetic members exert forces upon said magnetic means sufficient to move said arm to a stable contacting position from any intermediate position.

8. In a multipositional switch: a base; a series of spaced contact strips on said base; a plurality of magnetic members underlying said strips respectively; a plurality of independently movable switch arms; a plurality of contacts each slidably engageable with said strips in succession upon movement thereof in one direction; a plurality of magnetic means carrying said contacts respectively; and means mounting said magnetic means on said switch arms respectively.

9. In a multipositional switch: a plurality of spaced electrical conducting contacting members, at least a portion of said members being of magnetic material; a manually movable switch arm movable with respect to said spaced members; and a contact carried by said arm, said contact being engageable with said members in succession upon movement of said arm in one direction, said contact including magnetic means cooperable with said magnetic material of said spaced members to provide alternate stable and unstable conditions as said switch arm is moved with respect to said spaced members, the stable conditions corresponding only to contacting relationship between said contact and said members, the interaction between the magnetic means and said magnetic material being sufficient to move said arm from any intermediate position to an adjacent stable position.

10. In a step-by-step electrical circuit controller: a support; a plurality of spaced electrical contacting members mounted on said support; a switch arm movable transversely of said contacting members; a plurality of similarly spaced magnetic means mounted on the support; a contact element; a magnetic element cooperable with said magnetic means; and means mounting said contact element and said magnetic element together for limited relative movement on said arm in the direction of movement of said switch arm.

11. In a multipositional switch: a plurality of spaced electrical conducting members; a plurality of magnetic members respectively associated with the conducting members; a manually movable switch arm having a contact; magnetic means carried by the arm and cooperable with the magnetic members; and means supporting said arm for movement so that said contact is slidably engageable with said conducting members in succession and so that said magnetic means is cooperable with said magnetic members in corresponding succession upon movement of said arm in one direction; said supporting means being so constructed and arranged that said magnetic members exert forces upon said magnetic means sufficient to move said

arm to a stable position from any intermediate position; the stable position corresponding only to contacting position.

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