April 6, 1943. F. W. HOTTENROTH, JR 2,315,960

CIRCUIT CONTROLLER

Filed Oct. 31, 1941

Fig. 1

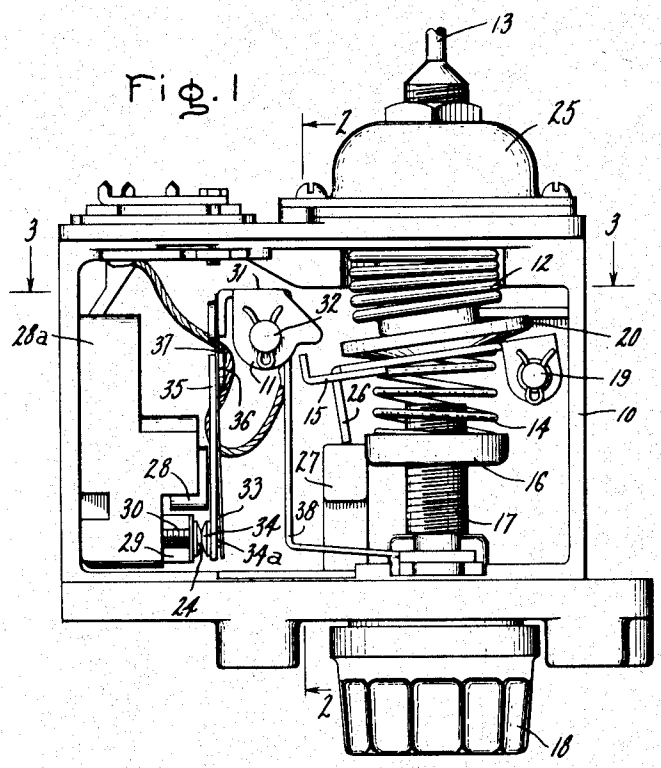


Fig. 2

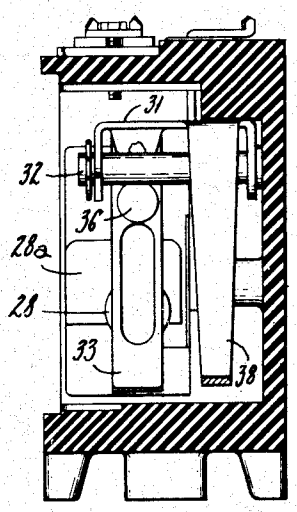


Fig. 3

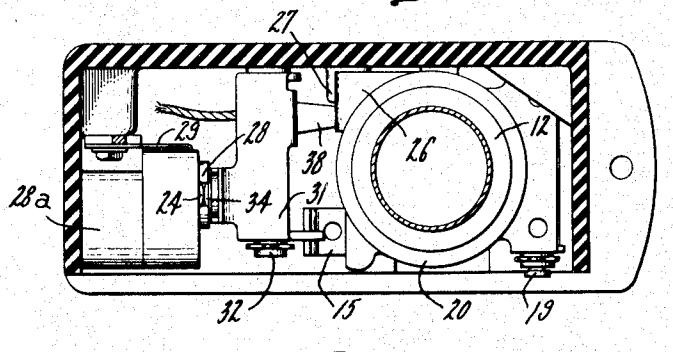


Fig. 4

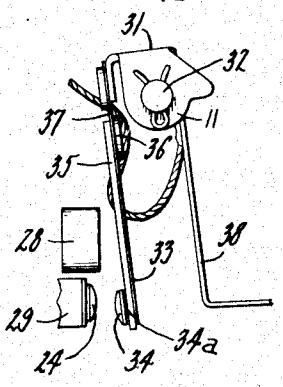
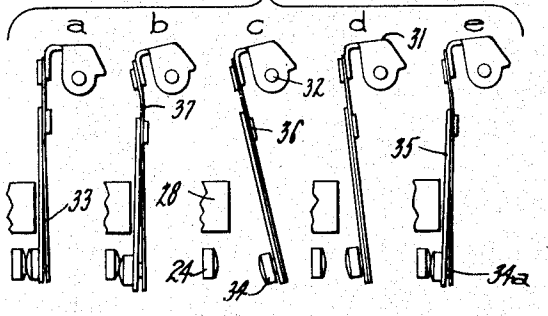


Fig. 5



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UNITED STATES PATENT OFFICE

2,315,960

CIRCUIT CONTROLLER

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9 Claims. (Cl. 200—83)

My invention relates to circuit controllers and particularly to electric switches having contacts operable with a snap action.

It is common practice in the control of small motors, such as refrigerator motors and the like, to provide control switch contacts which open and close with a snap action. It is also known to arrange such contacts to open and close with a sliding or wiping action for the purpose of breaking any weld which may occur at the contacts upon the closing thereof. In such arrangements, the action of the movable contact in the opening direction is usually the same as its action in the closing direction with the order of operation simply reversed; that is, if wiping action is present in opening it is also present in closing. However, it has been found that if electric circuit controlling contacts are closed with a simultaneous closing and sliding movement, the sliding movement causes bouncing of the movable contact upon the stationary contact. Such bouncing results in recurring arcing and ultimate welding as the contacts come to rest in pools of molten metal. A gentle closure with minimum slide or no slide generally produces good results, for, while it does not necessarily avoid welding, it does minimize contact bouncing and prolonged arcing. Upon opening of the contacts, however, an entirely different action is necessary in order to ensure the breaking of any weld which may have occurred upon the closing of the contacts. In opening it is desirable that a strong transverse force be available for positively sliding the contacts relative to each other prior to their separation in order to shear a weld.

Accordingly, it is one object of my invention to provide an electric switch which shall have a different contact action in closing than in opening, each action being specifically adapted to the particular condition of operation.

It is a further object of my invention to provide an electric switch having a strong wiping or weld shearing action at the contacts prior to the separation thereof.

It is a still further object of my invention to provide an electric switch contact which shall be separated with a snap action preceded by a strong wiping action.

It is a further object of my invention to provide an electric switch contact which shall have no wiping action upon engagement of the contacts, but which shall have a strong wiping action upon disengagement thereof to shear any weld which may have been formed upon engagement.

In carrying out my invention I provide a movable switch member comprising a pivotally mounted rigid base portion and a relatively long and substantially rigid contact arm flexibly attached thereto. To obtain the desired weld shearing action the contact arm is so arranged that in its contact closing position it is angularly disposed with respect to a line between the pivot and the fixed contact. The free end of the contact arm carries a magnetizable armature and a movable contact member positioned closely adjacent to each other. A snap action magnet is disposed near the contacts for cooperation with the armature. When the rigid base portion of such a switch member is positively rotated in the switch opening direction, as by an expansible thermostatic member, the armature and magnet will prevent disengagement of the contacts during initial rotation of the rigid member, and the contact arm and movable contact will be constrained to slide longitudinally without bowing or other lateral movement, the flexible connection being deformed during this movement. When sufficient force to overcome the magnetic attraction has been built up by deformation of the flexible connection, the armature will be released and the switch arm rotated suddenly about the flexible connection to disengage the contacts. Upon return movement of the rigid base member and the flexibly connected switch arm toward the contact closing position, a point will be reached where the force of magnetic attraction will be sufficient to draw the contacts into engagement with a snap action, the contact arm pivoting about the flexible connection so that the contacts are engaged without sliding movement.

For a more complete understanding of my invention and a further appreciation of its objects and advantages, reference should now be had to the following detailed specification taken in conjunction with the accompanying drawing, in which Fig. 1 is a side view of a thermostatic switch embodying my invention in one form; Fig. 2 is a sectional view taken along the line 2—2 of Fig. 1; Fig. 3 is a sectional view taken along the line 3—3 of Fig. 1; Fig. 4 is a detailed view of my switch member in a circuit opening position; and Fig. 5 is a multiple diagrammatic view of my switch member illustrating sequentially the operating positions of the switch member in circuit opening and circuit closing operation.

Referring now to the drawing, I have illustrated my invention as applied to a temperature responsive control device having an expansible actuating bellows of the type commonly used

for the control of the domestic and other mechanical refrigeration systems. The control device comprises a housing 10 of suitable insulating material, such as a molded plastic compound, forming a support for mounting a movable switch member 11 and an expansible thermo-responsive actuating bellows 12. The expansible bellows 12 is filled with an expansible fluid and is connected by means of a conduit 13 to a fluid-filled bulb (not shown) which may be disposed as desired in a space to be cooled. Preferably the expansible fluid system including the bellows 12 is of the partial vapor type in which the charge is gaseous at normal room temperature and is condensed to a greater or less degree in accordance with the temperature maintained in the refrigerator, thereby to reduce the pressure within the bellows 12. Methyl chloride is a suitable fluid for such a system. Mounted in opposing relation to the thermostatic bellows 12 is an adjustable compression spring 14 having one end seated against a pivotally mounted switch actuating lever 15 and having its other end seated in a cup 16 which is adjustably mounted upon a manually operable threaded shaft 17. The shaft 17 extends through the front wall of the casing 10 and is secured against longitudinal movement relative thereto. A control knob 18 is provided at the outer end of the shaft 17. The actuating lever 15 is pivotally mounted upon a fixed pivot 19 and carries an annular cup or washer 20 formed of suitable insulating material such as a phenolic condensation product. The cup 20 is shaped to provide a fulcrum for the movable end of the expansible bellows 12, as described and claimed in Patent 2,050,883, issued to John B. Ford on August 11, 1936. The opposite end of the expansible bellows 12 is fixedly mounted within a dome-like casing 25 which is firmly attached to the casing 10. The pivoted actuating lever 15 includes a depending lip 26 arranged for engagement with a boss 27 formed on one side of the casing 10 thereby to provide stop means for limiting the expansion of the bellows 12.

Fixedly mounted upon one side of the casing closely adjacent each other I also provide a stationary contact 24 and a snap action magnet 28. For convenience these elements are shown attached to a block 28*a* of insulating material which is in turn attached to the casing 10. The contact 24 is mounted upon a short cantilever spring strip 29 which may be adjustably positioned by means of a bolt 30 passing through the casing 10 and block 28*a* and having its head portion positioned to be accessible from the outside of the casing.

In order to obtain a strong coercive force while limiting the physical proportions of the magnet 28, I prefer to use for the magnet an alloy comprising six to fifteen per cent aluminum, twelve to thirty per cent nickel, five per cent copper if desired, and the remainder of iron, such as described and claimed in Patents 1,947,274 and 1,968,569, issued on February 13 and July 31, respectively, 1934, to William E. Ruder.

The movable switch member 11 comprises a rigid base portion 31 pivotally mounted upon a fixed pivot 32 and flexibly connected to a substantially rigid contact arm 33, 35. The contact arm comprises a leaf spring 33 and a substantially rigid magnetizable armature 35. The spring 33 is connected at one end to the rigid base portion 31 of the switch member and carries at its other end a movable contact 34 arranged to engage and disengage the fixed contact 24. The contact 34 is mounted upon a pin 34*a*. The armature 35 of magnetic material extends for nearly the full length of the contact arm, and is attached to the spring 33, as by a rivet 36, at a point close to the rigid base member 31. The armature 35 is apertured at its lower end and the pin 34*a* passes loosely therethrough so that the lower end of the armature is loosely embraced between the spring arm 33 and the contact head 34. With this construction the spring arm 33 is maintained relatively inflexible between the rivet 36 and the contact 34, and this portion of the spring acts only as a follow-up spring for the contact. The small length of spring between the rivet 36 and the rigid base member 31 serves as a flexible connection 37 between the rigid base member and the contact arm assembly.

It will be observed that the contact arm 33, 35 is connected to the rigid base member 31 in such a manner that the contact arm in its contact closing position is disposed in non-parallel relation with respect to a line drawn between the fixed contact 24 and the fixed pivot 32. In the particular form illustrated the contact arm 33, 35 is relatively long and, when in contact closing position, lies in a plane substantially perpendicular to a line normal to the contact surfaces at their point of engagement, while the distance from the pivot pin 32 to the point of attachment of the spring 33 to the member 31 is relatively short, the contact arm being substantially perpendicular to a line from the pivot pin to the point of attachment. With this disposition of parts the initial movement of that portion of the rigid base member 31 to which the contact arm 33, 35 is attached is in a direction perpendicular to the normal through the contact surfaces at this point of engagement. By this means in combination with the magnet and armature a strong and positive sliding movement of the contacts is insured prior to their disengagement. By the term "substantially rigid" when used in connection with the contact arm 33, 35 I mean an arm which is sufficiently rigid to prevent bowing before it is released by the snap action magnet 28. Thus, since the armature 35 will not bow away from the magnet 28 during the initial opening movement, a predetermined air gap and hence the desired snap action may be maintained despite a slight bowing of the follow-up portion of the spring 33. While the portion of the spring 33 between the rivet 36 and the contact 34 may, if desired, be sufficiently strong to break a weld without the assistance of the more rigid armature 35, its bowing action is strictly limited by the pin connection 34*a* even if the spring itself does not resist bowing. Furthermore any bowing of the spring 33 does not affect the air gap between the armature 35, and the magnet 28. The principal function of the follow-up spring is to preclude reduction of the contact pressure to zero at any time even though opposing forces on the armature 35 be exactly balanced. With such an arrangement, fluttering of the contacts and arcing during opening are prevented. The armature 35 is so arranged that it never engages the magnet 28.

The rigid base portion 31 of the switch member 11 also includes a rigid arm 38 which extends toward the control knob 18 and has a depending portion (not shown) arranged to engage a stop formed integrally with the knob 18, thereby to limit the rotation of the knob to one complete revolution and to provide means for positively

separating the contacts 24 and 34 in one position of the control knob.

The movable switch member 11 is shown at Fig. 1 and at position *a* of Fig. 5 in the completely relaxed position which it assumes when there is no weld formed at the contacts 24, 34 and when the actuating lever 15 is moved entirely out of engagement with the rigid base portion 31 of the switch member, as by full expansion of the bellows 12 until the lip 26 engages the stop 27. The biasing force exerted by the magnet 28 upon its armature 35 is sufficient to bring the switch member to this position whenever the lever 15 becomes disengaged therefrom. Since the contacts are engaged in this position, the refrigerating system to which the controller is connected will be operating to cool the fluid in the bellows 12. Cooling and contraction of the fluid will permit the spring 14 to rotate the actuating lever 15 in a clockwise direction, as viewed in the drawing, until its end engages the rigid base portion 31 of the switch member. Further contraction of the bellows will produce rotation of the rigid base portion 31 of the switch member about the pivot pin 32. Due to the arrangement of parts as previously described, the contact arm 33 being angularly disposed with respect to a line drawn between the fixed pivot 32 and the fixed contact 24, the initial movement of that portion of the rigid base member 31 to which the contact arm 33, 35 is attached is in a direction substantially transverse to the contact surfaces, so that the contact arm 33, 35 and the movable contact 34 are initially moved longitudinally and downward as viewed in the drawing. During this initial movement, as between the positions *a* and *b* of Fig. 5, the attraction between the permanent magnet 28 and its armature 35 is sufficient to maintain the contacts 24 and 34 in engagement. This initial movement is also carried out without any bowing or lateral displacement of the contact arm, since the contact arm is rigid for the greater portion of its length. Since the armature 35 is not displaced laterally from the magnet 28 during sliding movement, there is no diminution in the force of magnetic attraction during such movement. For the purpose of illustration, it may be assumed that when the rigid member 31 reaches position *b* of Fig. 5 sufficient force has built up by deformation of the flexible connection 37 to overcome the magnetic attraction between the permanent magnet 28 and its armature 35. At this instant the magnet will release its armature and the contact arm 33, 35 will spring suddenly from position *b* of Fig. 5 to position *c* of Fig. 5. During this snapping movement the rigid portion 31 of the switch member experiences no substantial change in position, so that the contact arm 33, 35 pivots about a point in the region of the flexible connection 37. Since the flexible connection 37 is substantially in a plane drawn perpendicular to the normal to the contact surfaces at their point of engagement, the contacts are disengaged by movement of the movable contact substantially along the normal, thereby to avoid sliding movement in the actual contact disengaging motion.

With the contacts 24 and 34 disengaged the refrigerating system will be out of operation and the temperature of the conditioned space will increase. The resulting increase in the temperature of the fluid contained in the bellows 12 will cause the bellows to expand and rotate the actuating lever 15 in a counter-clockwise direction as viewed in Fig. 1. The magnetic biasing force exerted upon the switch member 11 constrains the switch member to clockwise following movement while engaging the lever 15. If such clockwise rotation is begun from the position *c* of Fig. 5, the switch member 11 will move as a unit to a predetermined position such as position *d* of Fig. 5. Let it now be assumed that when the switch member reaches the position *d* of Fig. 5 the attractive force between the snap action magnet 28 and the armature 35 is sufficient to attract the armature and contact arm despite the bias of the flexible connection 37. Thus by magnetic attraction the armature 35 and spring 33 will be moved almost instantaneously from the position *d* to the position *e* of Fig. 5 while the rigid base portion 31 of the switch member experiences no substantial change in position. It will now be observed that the contact engaging movement of the switch arm is carried out by rotation of the switch arm about the flexible connection 37 and consequent deformation of the flexible connection. Since the connection 37 lies substantially in the plane of the switch arm, the contacts are engaged without sliding movement.

If no weld is formed at the contacts at the instant of closure indicated at position *e* of Fig. 5, continued clockwise rotation of the rigid base member 31 by the magnet 28 will cause the movable contact to slide longitudinally upward as viewed in the drawing to position *a* of Fig. 5. For the purpose of illustration, however, let it be assumed that as soon as the movable contact 34 arrives at position *e* of Fig. 5 a weld is formed between the contacts. Such a weld will hold the movable switch member 11 in position *e* of Fig. 5 even though the bellows 12 continues to expand and disengages the rigid portion 31 of the switch member because the attractive force of the magnet is ordinarily insufficient to break a weld. Since the contacts are now engaged, however, the refrigerating system will be in operation to cool the conditioned space and the bellows 12 will eventually contract until the actuating lever 15 again engages the rigid base portion 31 of the switch member.

Continued contraction of the bellows will permit the spring 14 to move the lever 15 and to rotate the rigid base portion 31 of the switch member about the fixed pivot 32. As previously described in connection with an initial switch opening operation, the rigid member 31 will be rotated to the position *b* of Fig. 5 before the force exerted by the flexible connection 37 is sufficient to overcome the attraction between the magnet 28 for its armature 35. Comparison of positions *b* and *e* of Fig. 5 will show that in position *b* the rigid base member 31 is displaced in a counterclockwise direction with respect to its position *e* and the movable contact 34 is displaced downwardly with respect to its location at position *e*. This difference between the contact engaging and contact disengaging positions of the movable switch member results from the fact that the holding force of magnetic attraction in the armature 35 is considerably greater when the contact arm is in its circuit closing position and the armature in its fully attracted position than the magnetic pickup force when the contact arm is in its circuit opening position. It will be evident that as a result of this condition a strong and positive sliding movement of the contacts from position *e* to position *b* prior to their separation is insured even though the contacts may have welded upon closure and prevented complete re-

laxation of the flexible connection 37 by the magnet.

While I have shown and described but one preferred embodiment of my invention by way of illustration many other modifications will occur to those skilled in the art, and I therefore wish to have it understood that I intend by the appended claims to cover all such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A circuit controller comprising a fixed contact, a switch member having a rigid base portion rotatably mounted upon a fixed pivot and movable between circuit opening and circuit closing positions, a substantially rigid contact arm carrying at one end a movable contact and having its other end flexibly connected to said rigid base portion, said contact arm in the circuit closing position of said switch member being disposed in non-parallel relation with respect to a line passing through said fixed pivot and said fixed contact, means for rotating said rigid base portion of said switch member to said circuit opening position, and snap action means for releasably retaining said contacts in engagement during a predetermined initial rotation of said rigid base portion and for re-engaging said contacts with a snap action, whereby disengagement of said contacts is necessarily preceded by relative sliding movement and said contacts are re-engaged without substantial wiping action.

2. A circuit controller comprising a fixed contact, a switch member having a rigid base portion rotatably mounted upon a fixed pivot and movable between circuit opening and circuit closing positions, a substantially rigid contact arm carrying at one end a movable contact and having its other end resiliently connected to said rigid base portion, said contact arm in the circuit closing position of said switch member being disposed in non-parallel relation with respect to a line passing through said fixed pivot and said fixed contact, means for rotating said rigid base portion of said switch member to said circuit opening position, and snap action means for releasably retaining said contacts in engagement during a predetermined initial rotation of said switch member to ensure relative sliding movement of said contacts prior to disengagement and for re-engaging said contacts without substantial wiping action.

3. A circuit controller comprising a fixed contact and a movable contact having engaging surfaces, a movable switch member comprising a rigid base portion and a substantially rigid contact arm flexibly connected at one end to said rigid base portion, said contact arm carrying at its other end said movable contact and being so disposed when said contacts are engaged that it lies in a plane substantially perpendicular to the normal to said surfaces at their point of engagement, said rigid base portion being pivotally mounted upon an axis substantially parallel to and displaced from said plane, means for rotating said rigid base portion to disengage said contacts, and magnetic means for releasably retaining said contacts in engagement during a predetermined initial rotation of said rigid base portion and for reengaging said contacts with a snap action, whereby disengagement of said contacts is necessarily preceded by relative sliding movement along a line parallel to said plane and said contacts are reengaged without sliding movement.

4. A circuit controller comprising a fixed contact and a movable contact having engaging surfaces, a movable switch member comprising a rigid base member and a substantially rigid contact arm carrying said movable contact at one end thereof, said contact arm being so disposed when said contacts are in engagement that it lies in a plane substantially perpendicular to the normal to said surfaces at their point of engagement, said rigid base member being rotatably mounted upon a fixed pivot and having a portion movable in a direction substantially parallel to said plane, flexible means for connecting said contact arm to said portion of said rigid base member, magnetic means operable in conjunction with said contact arm to bias said contacts into engagement, and actuating means arranged to move said rigid base member to engage and disengage said contacts, whereby rotation of said rigid base member to disengage said contacts will slide said movable contact relative to said fixed contact and deform said flexible means until said magnetic means releases said contact arm with a snap action thereby to disengage said contacts by rotation of said movable contact about said flexible means and rotation of said rigid base member to reengage said contacts will permit said magnetic means to attract said contact arm with a snap action and reengage said contacts without sliding movement.

5. A circuit controller comprising a support, a fixed contact mounted upon said support, a permanent magnet mounted upon said support adjacent said fixed contact, a movable switch member comprising a rigid base portion rotatably mounted upon a fixed pivot and a substantially rigid contact arm carrying at one end a movable contact arranged to engage said fixed contact, spring means for connecting the other end of said contact arm to said rigid base portion of said switch member, said contact arm being disposed in nonparallel relation with respect to a line passing through said fixed pivot and said fixed contact when said contacts are in engagement, an armature of magnetic material mounted upon said contact arm adjacent said movable contact and operable in conjunction with said permanent magnet to bias said contacts into engagement, and actuating means for rotating said rigid base portion in a direction to place said rigid contact arm under longitudinal compression and to disengage said contacts.

6. A pressure responsive switch comprising a support, a fixed contact mounted upon said support, a permanent magnet mounted upon said support adjacent said fixed contact, a movable switch member comprising a rigid base rotatably mounted upon a fixed pivot, a substantially rigid contact arm carrying at one end a movable contact having a contact surface arranged to engage and disengage said fixed contact, said contact arm being so disposed when said contacts are in engagement that it lies in a plane substantially perpendicular to the normal to said surface at its point of engagement with said fixed contact, said rigid base having a portion lying substantially within said plane and said fixed pivot being disposed substantially parallel to and displaced from said plane, deformable spring means for connecting said contact arm to said portion of said rigid base, an armature of magnetic material mounted upon said contact arm adjacent said movable contact and arranged in combination with said per-

manent magnet to bias said contacts into engagement, an actuating element arranged to engage said rigid base, adjustable spring means for moving said actuating member to rotate said rigid base in a direction to disengage said contacts thereby to move said contact arm longitudinally in said plane while said magnet prevents disengagement of said contacts and simultaneously to deform said spring means, said magnet being arranged to release said armature after a predetermined deformation of said spring means thereby to disengage said contacts by rotational movement of said contact arm about said spring means, and pressure responsive means opposing the action of said adjustable spring and arranged upon increase in pressure to disengage said actuating element from said rigid base member.

7. A circuit controller comprising a pivoted operating arm, an elongated rigid member including an armature, a flexible spring member connecting one end of said rigid member to said arm so that said rigid member extends substantially at right angles to said arm, a movable contact operated by the other end of said rigid member, a stationary contact, a magnet cooperating with said armature so as to snap said movable contact into and out of engagement with said stationary contact, said spring member being flexed by the force of said magnet to provide for engagement of said contacts without substantial wiping action between them and upon opening movement of said operating arm said spring member flexing to provide for a wiping action between said contacts prior to separation of said contacts.

8. A circuit controller comprising a pivoted operating arm, a flexible spring member connected at one end to said arm so as to extend substantially at right angles to said arm, a movable contact on the other end of said spring member, a stationary contact, an armature member extending in lengthwise engagement with said spring member having one end connected to said spring member at a point adjacent said arm so as to provide a portion of said spring member between said point and said arm, a magnet cooperating with said armature so as to snap said movable contact into and out of engagement with said stationary contact, said portion of said spring member being flexed by the force of the magnet to provide for engagement of said contacts without substantial wiping action between them and upon opening movement of said operating arm said portion of said spring member flexing to provide for a wiping action between said contacts prior to separation of said contacts.

9. A circuit controller comprising a pivoted operating arm, a flexible spring member connected at one end to said arm at a point spaced from the pivot of said arm so as to extend substantially at right angles to said arm, a movable contact on the other end of said spring member, a stationary contact, an armature member extending in lengthwise engagement with said spring member having one end connected to said spring member at a point adjacent said arm so as to provide a portion of said spring member between said point and said arm, a loose connection between the end of said armature member and said movable contact providing for limited movement of said armature member into engagement with said movable contact after said movable contact engages said stationary contact, a magnet cooperating with said armature so as to snap said movable contact into and out of engagement with said stationary contact, said portion of said spring member being flexed by the force of said magnet to provide for engagement of said contacts without substantial wiping action between them and upon opening movement of said operating arm said portion of said spring member flexing to provide for a wiping action between said contacts prior to separation of said contacts.

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