May 16, 1967 C. E. GERMANTON 3,320,562

SWITCH ASSEMBLY USING MAGNETICALLY OPERATED SWITCHES

Filed Nov. 30, 1965

3 Sheets-Sheet 1

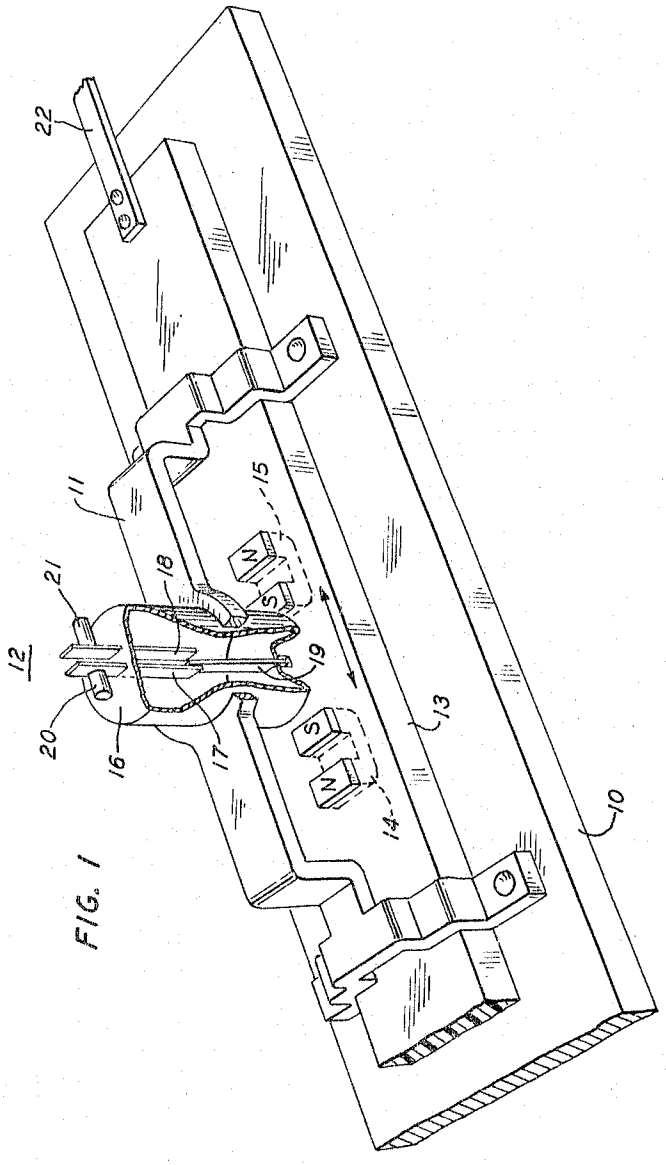



FIG. 1

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May 16, 1967 C. E. GERMANTON 3,320,562

SWITCH ASSEMBLY USING MAGNETICALLY OPERATED SWITCHES

Filed Nov. 30, 1965

3 Sheets-Sheet 2

FIG. 2E

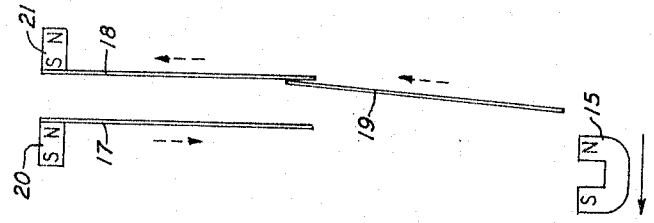



FIG. 2D

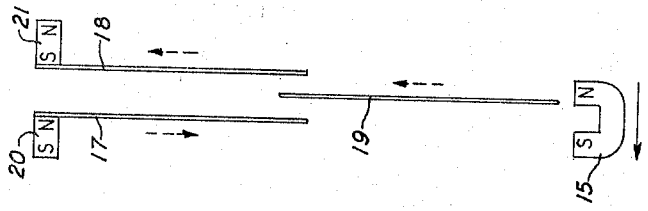



FIG. 2C

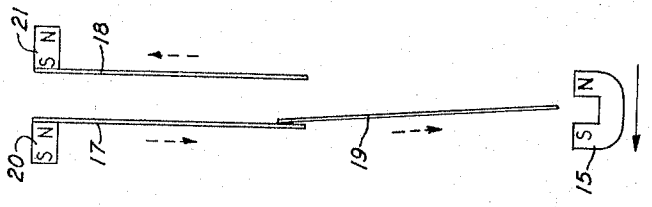



FIG. 2B

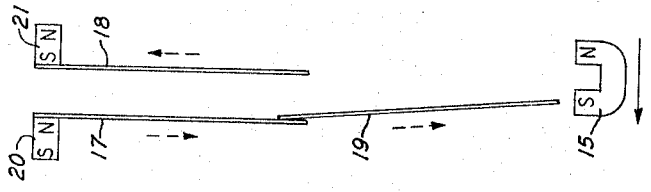
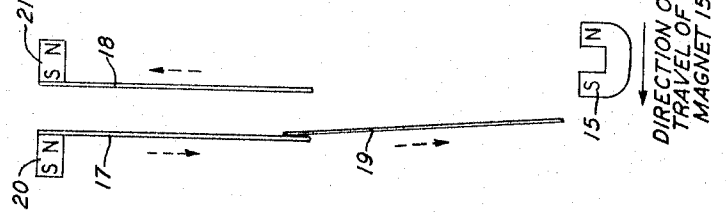



FIG. 2A

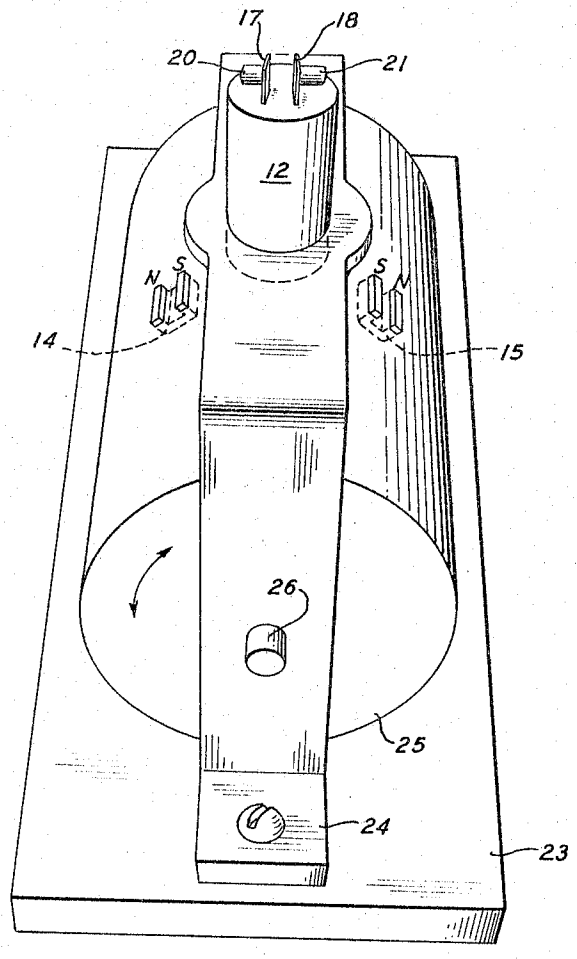


May 16, 1967 C. E. GERMANTON 3,320,562

SWITCH ASSEMBLY USING MAGNETICALLY OPERATED SWITCHES

Filed Nov. 30, 1965 3 Sheets-Sheet 3

FIG. 3



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3,320,562

# SWITCH ASSEMBLY USING MAGNETICALLY OPERATED SWITCHES

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3 Claims. (Cl. 335—207)

This invention relates to switching arrangements that rely upon magnetic rather than mechanical coupling to operate switches in response to positions of mechanical members.

In recent years a number of magnetically coupled switching arrangements have been devised. They include at least one magnetically responsive switch and one permanent magnet, with one mounted on a movable member and the other on a fixed member. The relative position of the two members determines the operation of the switch.

Magnetically coupled switching arrangements have been devised because they have advantages over those using mechanical coupling. Friction between members and switches is, for example, eliminated with a resulting reduction in wear and in required force for moving the movable member. Furthermore, the individual switches can be enclosed in glass envelopes, thus permitting their use where arcing may otherwise be dangerous and where dust may otherwise contaminate the switch contacts. The glass enclosures also provide enclosed atmospheres that limit arcing, thus resulting in longer contact life.

Although the prior art discloses a number of magnetically coupled switching arrangements, it does not disclose one that performs an accurate cam type function. In other words, the prior art fails to disclose one that operates a switch in a consistent manner each time a mechanical member changes from one range of positions to another range. This is unfortunate in view of the many advantages inherent in using magnetically operated switches.

An object of the present invention is to perform a cam type switching function through the use of magnetic coupling.

Another object is to provide consistent operation of magnetically operated switches.

The invention in one of its broader forms derives a cam type action from a movable member through the use of at least one pair of permanent magnets and at least one two-position, self-latching, magnetically-operated switch. Either the switch or the pair of magnets may be mounted on the movable member while the other element or elements are mounted on a fixed member. With either combination of mounting, the switch is operated from a first position to a second position by the magnetic field of a first of the magnets and from the second position to the first position by the magnetic field of the second magnet.

The invention has several distinct features. First, the switch has a memory-like characteristic, that is it switches from its first position to its second position only in response to a magnetic field having lines of force in a first direction and from its second position to its first position only in response to a magnetic field having lines of force in the opposite direction. (A magnetic field is generally characterized as comprising lines of force that leave a north pole piece and enter a south pole piece.) Second, the magnets are oriented so that the pole pieces of each magnet pass the switch in a sequential manner with the magnets poled oppositely with respect to one another. These features produced several unique results as described in the following description.



Because of the memory-like characteristic of the switch and orientation of the magnets, the switch changes position in a consistent manner each time the switch and a magnet pass one another. In particular, as the switch and the first half of a magnet pass one another, the switch is subjected to a portion of a magnetic field having lines of force of the same basic direction as those to which it was previously subjected. (This is true even when the direction of travel of the movable member is reversed.) Because the switch responds only to lines of force directed oppositely to those that produced the previous change in position, the switch does not change position. When, however, the midpoints of the switch and a magnet pass one another so that the second half of the magnet is passing the switch, the basic direction of the lines of force reverses and the switch changes position. Because this reverse in direction of the lines of force occurs within a relatively small distance of travel between the switch and a magnet, the switch changes position at substantially the same relative location of each magnet with respect to the switch.

Other objects and features of the invention will become apparent from a study of the following detailed description of two embodiments.

In the drawings:

FIG. 1 shows an embodiment of the invention in which a movable member moves in a straight line;

FIGS. 2A through 2E are diagrams that help to illustrate the operation of the embodiments; and

FIG. 3 shows another embodiment of the invention in which a movable member comprises a rotatable drum.

The embodiment of FIG. 1 includes a fixed assembly comprising a base member **10**, a bracket **11** mounted on base member **10** and a switch assembly **12** mounted in bracket **11**. Slideably mounted on base **10** and passing under bracket **11** is a movable member **13**. This member is movable in either direction along a straight line as indicated by the double arrow-headed line.

Two horseshoe-shaped magnets **14** and **15** are mounted on movable member **13** with the surfaces of their pole pieces slightly above the upper surface of member **13**. Furthermore, these magnets are oriented so that they are poled oppositely with respect to one another with their pole pieces aligned along the direction of travel of member **13**. In other words, when member **13** is first positioned so that magnet **14** is to the right of switch assembly **12** and the member is then moved to the left, the north and south pole pieces of magnet **14** and the south and north pole pieces of magnet **15** pass in that order under the switch assembly.

Switch assembly **12** may comprise the switch assembly shown in Patent No. 3,048,677, issued on Aug. 7, 1962, to E. C. Hellstrom et al. Since the present invention does not require the coil assembly shown in the patent, the coil assembly may be eliminated. As shown in the present FIG. 1, the switch assembly includes a glass housing **16**, two soft iron pole piece extensions **17** and **18** and a soft iron armature **19**. Pole piece extensions **17** and **18** and armature **19** pass through the top and bottom of housing **16**, respectively, so that each has a portion inside of the housing and a portion outside of the housing. Within the housing, armature **19** terminates between pole piece extensions **17** and **18**. The portion of armature **19** that extends outside of housing **16** appears as a pole piece, as described subsequently.

Two permanent magnets **20** and **21** are attached to the external portions of pole piece extensions **17** and **18** so that the extensions are magnetized to opposite polarities. As a result of this opposite magnetization, armature **19** when once placed in contact with either of the extensions **17** and **18** stays in contact with that extension until acted upon by an external magnetic field. In ac-

cordance with the present invention, the external magnetic fields that cause armature **19** to change position are provided by permanent magnets **14** and **15** in a manner which is now discussed in detail.

FIGS. 2A through 2E comprise a sequence of diagrams showing how armature **19** changes position as magnet **15** passes under switch assembly **12**. To help the description, the polarities of the pole pieces of magnets **20** and **21** are identified while the directions of the magnetic lines of force within extensions **17** and **18** and armature **19** are shown by adjacent broken arrows. These lines of force cause the lower extremity of armature **19** (which is external to housing **16** of FIG. 1) to appear as a north pole piece in FIGS. 2A, 2B and 2C and as a south pole pieces in FIGS. 2D and 2E.

In FIG. 2A magnet **15** is sufficiently removed from armature **19** so that the armature is substantially unaffected by the magnetic field of magnet **15**. Magnets **20** and **21** therefore produce substantially all of the lines of force in extensions **17** and **18** and in armature **19**. These lines are directed down extension **17** and armature **19**, across the air gap between armature **19** and extension **18**, and up extension **18**. The strength of the lines is sufficient to cause armature **19** to remain in contact with extension **17**.

Magnet **15** is positioned in FIG. 2B so that its south pole piece is directly under armature **19**. Since lines of force flow into a south pole piece, the lines of force in the vicinity of this pole piece are in the same basic direction as those in armature **19**. Magnet **15** therefore acts in an aiding sense and armature **19** remains in contact with extension **17**.

Magnet **15** is positioned in FIG. 2C with its midpoint directly below armature **19**. The direction of the portion of the external field of magnet **15** in close proximity to the armature is now substantially perpendicular to it. The strength of the lines of force in extensions **17** and **18** and armature **19** is therefore substantially the same as in FIG. 2A and armature **19** remains in contact with extension **17**.

In FIG. 2D a portion of the north pole piece of magnet **15** is directly under armature **19**. The lines of force in the vicinity of this pole piece are in a basically upward direction. Furthermore, the strength of these lines is greater than those in armature **19** as a result of magnets **20** and **21**. Therefore, as the north pole piece of magnet **15** moves under armature **19** the field in armature **19** diminishes, reverses and then increases so that upwardly directed lines of force occur. The upward lines of force in armature **19** cause the armature to be repelled from extension **17** and to be attracted to extension **18**. In this diagram the upward lines have caused armature **19** to move toward extension **18**. Before the north pole piece passes from under armature **19**, the armature is in contact with extension **18**.

The north pole piece of magnet **15** as shown in FIG. 3E has passed from under armature **19**. The armature remains in contact with extension **18** as a result of magnets **20** and **21** producing lines of force in the direction shown by the broken arrows.

A similar action is produced when magnet **15** is moved from the position shown in FIG. 2E back to the position shown in FIG. 2A. In other words, armature **19** changes position when the midpoint of magnet **15** has moved past armature **19**.

From the above discussion, it is believed apparent that switch assembly **12** has a memory-like characteristic, that is it changes position only in response to a pole polarity opposite to the last to which it was subjected. This, of course, is accomplished as a result of the lower extremity of armature **19** functioning as a pole piece that acquires a polarity related to the position of the switch. Furthermore, it is believed apparent that the switch changes position each time at substantially the same relative position of magnet **15** and armature **19** because the lines of force of the field of magnet **15** change direction within a relatively small distance.



Referring again to FIG. 1, it is believed apparent in view of the discussion with respect to FIGS. 2A through 2E that armature **19** remains in the illustrated position until it is subjected to the north pole piece of either magnet **14** or **15**. Once subjected to either of these north pole pieces, the switch changes position and remains in the new position until armature **19** is subjected to one of the south pole pieces of magnets **14** and **15**, at which time it reverts to the illustrated position. The embodiment may therefore be connected by a member **22** to a piece of apparatus to produce a warning signal or to terminate power when the apparatus is within predetermined ranges of operation. Furthermore, additional switching ranges may be provided by providing one or more additional magnets in line with magnets **14** and **15**. In accordance with the invention, the additional magnets must be poled so that each magnet is of the opposite polarity to that of its neighbors.

FIG. 3 discloses another embodiment of the invention which may also be used for limit control purposes. This embodiment includes a fixed base member **23**, a bracket **24** mounted on base member **23**, and a switch assembly **12** mounted in the bracket. A drum **25** is mounted on a shaft **26** within bracket **24**. A pair of magnets **14** and **15** are embedded in drum **25** so that the surfaces of their pole pieces are slightly above the surface of the drum. These magnets are oriented so that they are poled oppositely with respect to one another with their poles aligned so that each pole passes under switch assembly **12** as drum **25** is rotated.

The operation of switch assembly **12** in FIG. 3 is the same as that discussed with respect to FIGS. 2A through 2E. The angular displacements of magnets **14** and **15** of course determine the percent of rotation of shaft **26** during which the switch assembly remains in one or the other of its two positions.

Additional pairs of magnets may be placed around drum **25** so that switch assembly **12** may be operated more than twice per revolution of shaft **26**. The polarities of these additional magnets, in accordance with the invention, are arranged so that each magnet has a polarity opposite to that of its neighbors. It should be noted that whereas the embodiment shown in FIG. 1 may have one or more individual magnets added to the structure, the embodiment shown in FIG. 3 must have pairs of magnets when the drum is permitted to rotate continuously in either direction. On the other hand, when the rotation of the drum is restricted to less than 360°, magnets need not be added in pairs but may be added in an individual sense.

Although the invention has been discussed with respect to two specific embodiments, various other embodiments may be devised by those skilled in the art without departing from the spirit and scope of the invention. The use of bar magnets instead of horseshoe magnets is, for example, fully within the scope of the invention.

What is claimed is:

1. A switch arrangement comprising:
   - switch means comprising a pair of oppositely polarized fixed contacts and a movable contact wherein the movable contact is latched to either one of the fixed contacts when placed in contact therewith and assumes the polarity of the fixed contact,
   - at least two magnetic means each having a pole piece of a first magnetic polarity and a pole piece of a second magnetic polarity,
   - a member mounting said means with their pole pieces in line and with the polarity of each means opposite with respect to its immediate neighbors, and
   - means for moving said switch and said member relative to one another with said switch remaining in close proximity to the line of pole pieces,
   - said magnetic means causing the movable contact to

move from one fixed contact to the other fixed contact when the polarity of the magnetic means in close proximity to the movable contact is the same as the polarity of the movable contact.

2. A combination in accordance with claim 1 in which said member is movable in a straight line and said switch is fixed in position.

3. A combination in accordance with claim 1 in which said member is rotatable and said switch is fixed in position.


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