Nov. 17, 1953 W. L. BUTLER ET AL 2,659,785

SWITCH MECHANISM

Original Filed April 5, 1946

Fig.1.

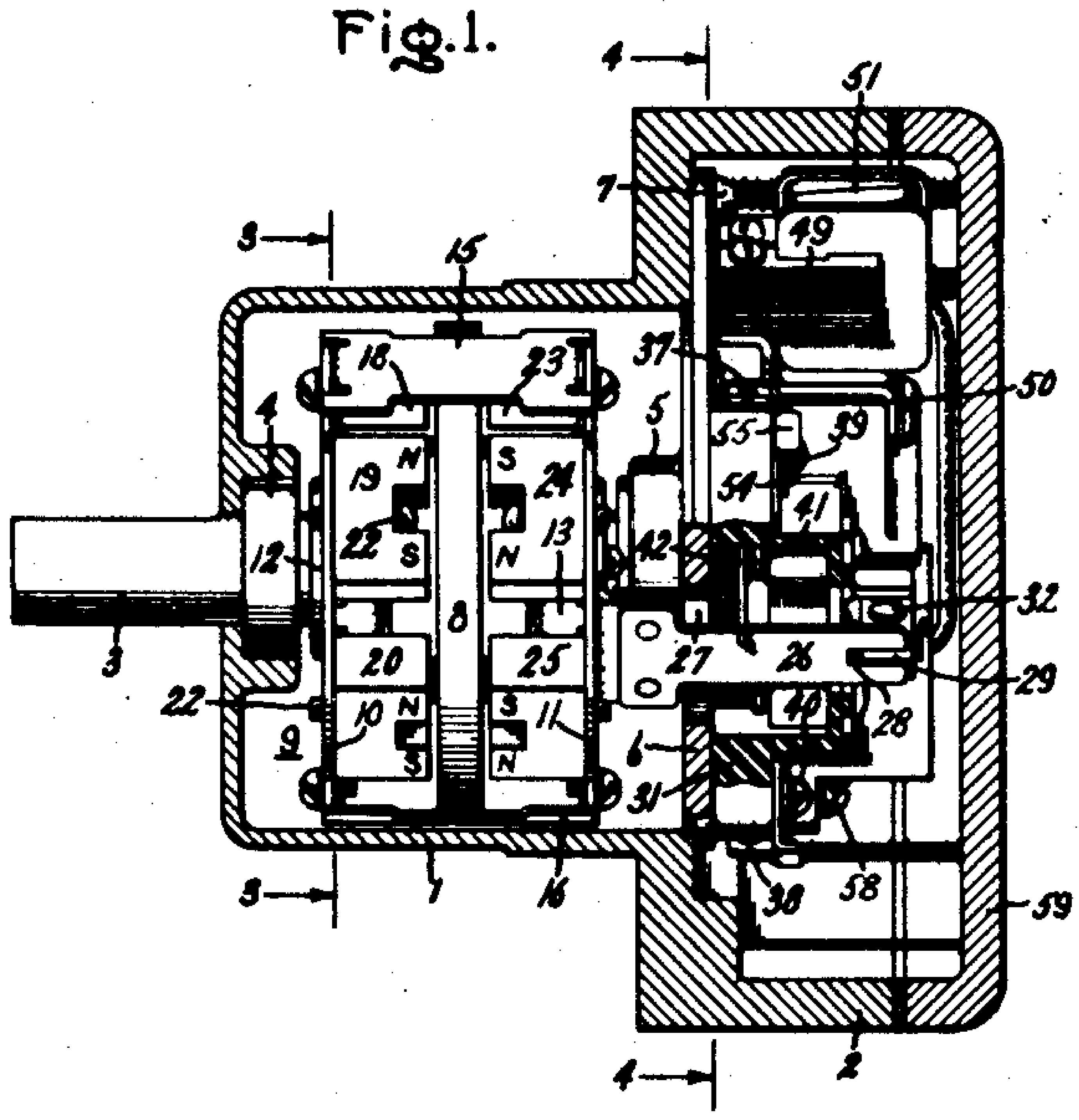


Fig.2.

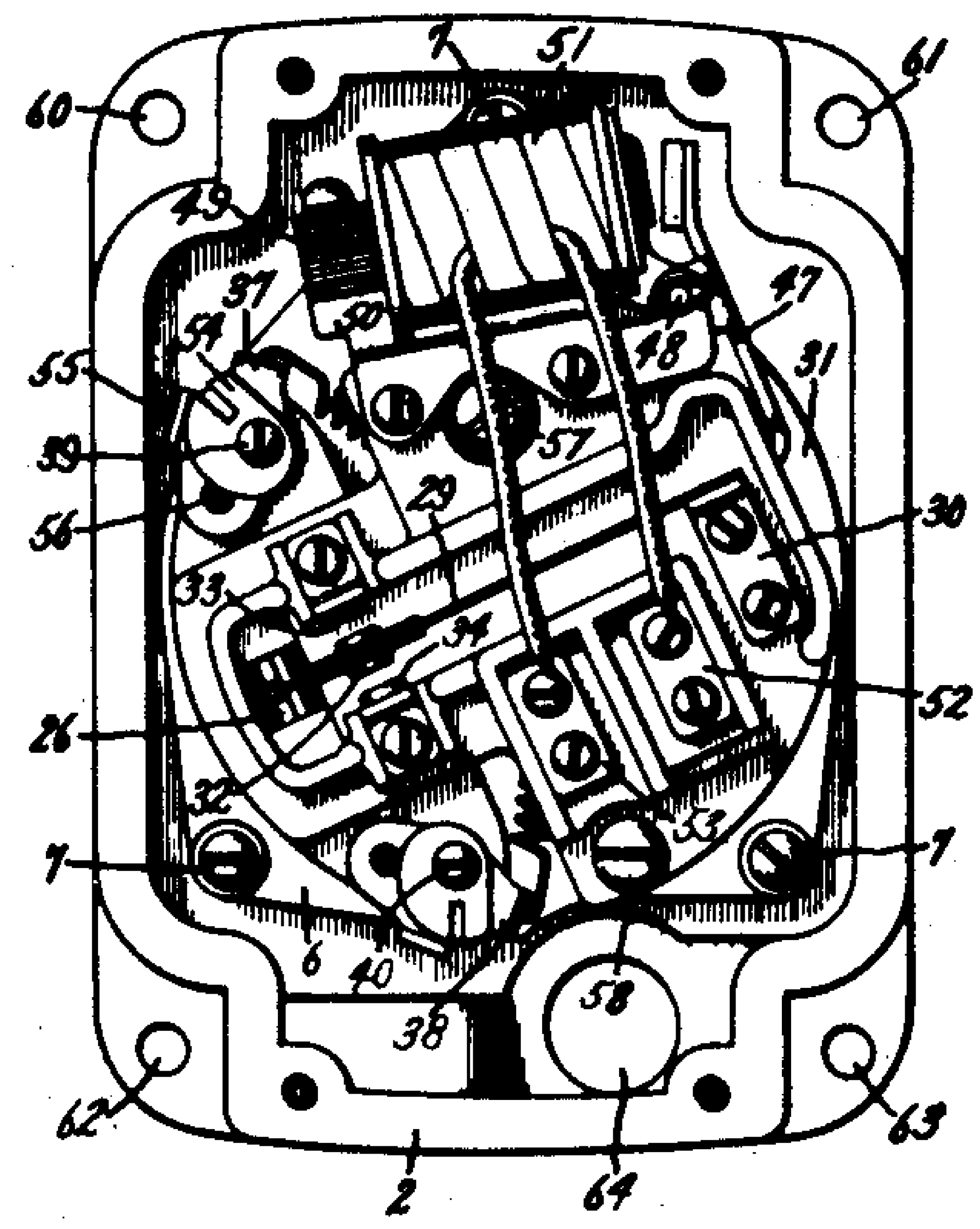


Fig.3.

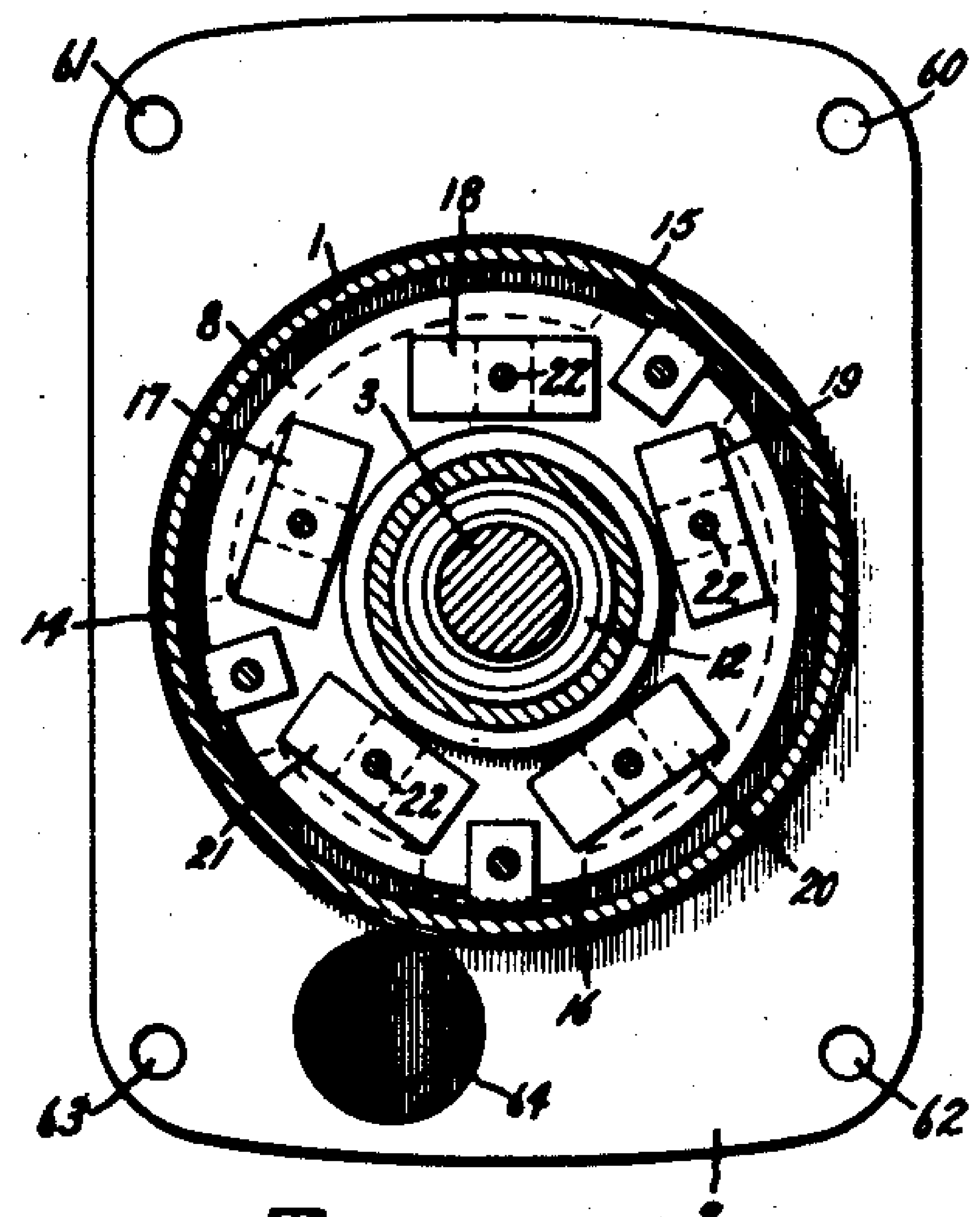


Fig.4.

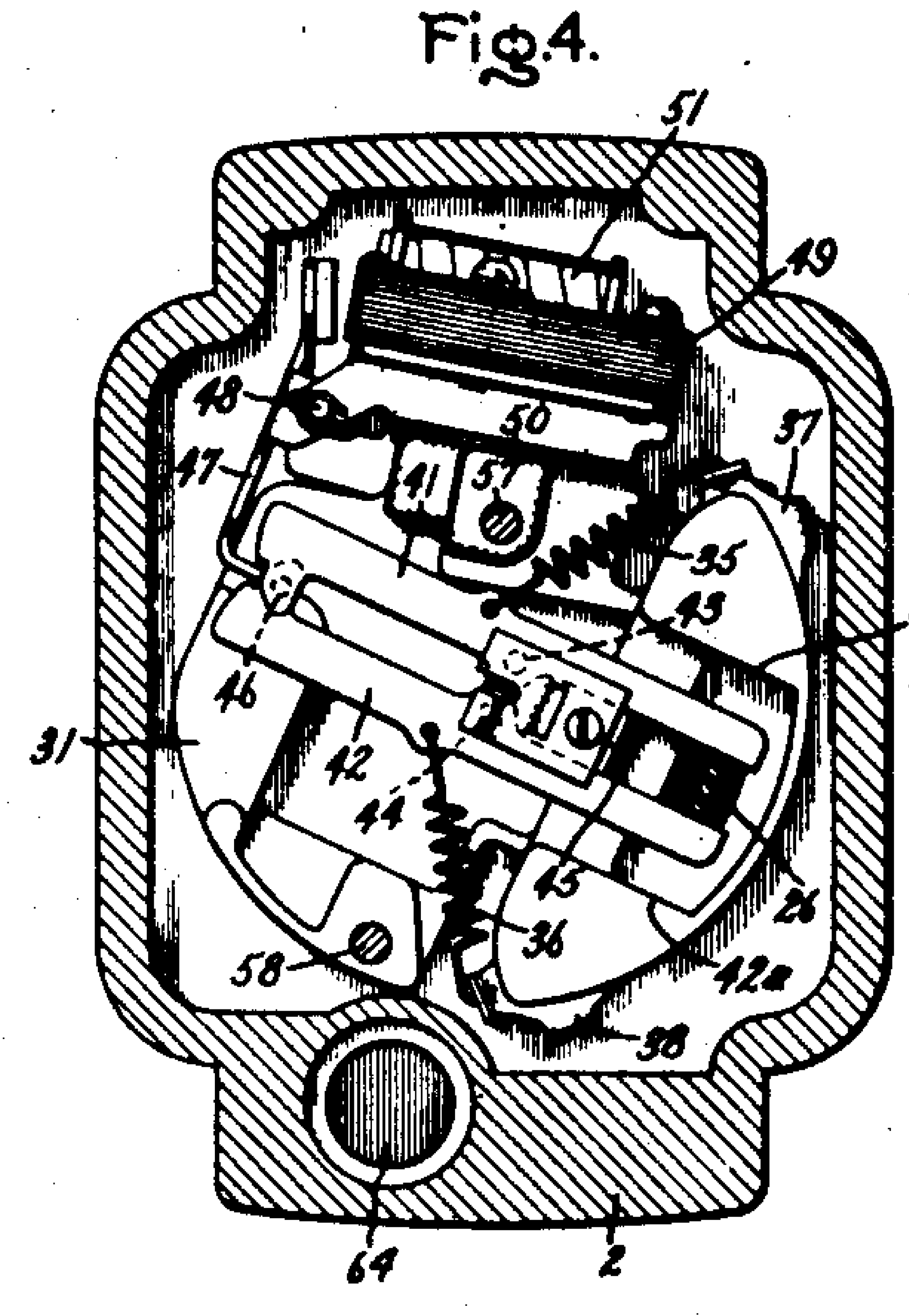
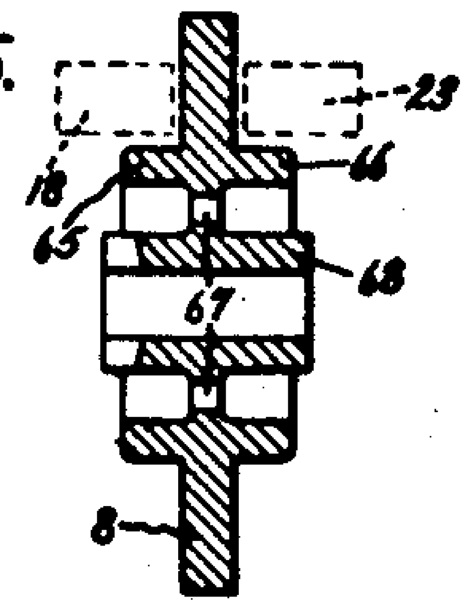


Fig.5.



Inventor:
William Lawrence Butler,
by Claude H. Mott
His Attorney.

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2,659,785

SWITCH MECHANISM

William Lawrence Butler, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

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8 Claims. (Cl. 200—92)

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My invention relates to switch mechanisms, more particularly to direction responsive magnetic clutch operated switch mechanisms, and has for its object a simple and reliable direction responsive switch for use especially in the control of electric motors.

More particularly, my invention relates to switches for controlling the plugging to standstill of alternating current electric motors, i. e., the reversal of the motor connections while the motor is still running thereby to bring the motor quickly to rest. This switch mechanism operates to disconnect the motor from the supply source when the motor comes substantially to rest, thereby to prevent operation of the motor in the opposite direction.

The switch mechanism disclosed herein is particularly useful with the eddy current disc clutch mechanism disclosed in my copending application Serial No. 659,717, now Patent No. 2,596,649, May 13, 1952, which is assigned to the same assignee as the present application, and of which the present application is a division. However, this switch mechanism is also adaptable for use with other clutch mechanisms.

In carrying out my invention in one form I provide a shaft which is arranged to be driven by the motor to be controlled, this shaft having rigidly mounted on it an eddy current disc made of electrically conducting material. Also mounted rotatably on the shaft on opposite sides of the disc are two connected supporting members on which are mounted around their peripheries a plurality of small permanent magnets having their pole faces adjacent the disc, in order to form a yieldable magnetic clutch. Rotation of the shaft and disc between the poles of the magnets produces eddy currents in the disc whereby a magnet torque is applied to the supporting structure for the magnets. The supporting structure is mounted for limited angular movement in each direction and is provided with an operating arm connected to actuate a single pole, double throw switch for controlling the contactors in the motor circuit. Associated with the operating arm is a pair of pivoted arms extending transversely with respect to the shaft, and springs biasing these pivoted arms to substantially parallel positions in which the switch is held in a neutral position. An electromagnetically operated latch member is provided selectively to engage the pivoted arms and hold the switch in the neutral position against the magnetic force applied to the supporting structure upon rotation of the disc.

For a more complete understanding of my invention reference should be had to the accompanying drawing, Fig. 1 of which is a side elevation view with the enclosing casing in section showing a switch mechanism embodying my invention; Fig. 2 is an end view of Fig. 1 with

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the cover removed; Fig. 3 is a sectional view taken along line 3—3 of Fig. 1 looking in the direction of the arrows, Fig. 4 is a sectional view taken along the line 4—4 of Fig. 1 looking in the direction of the arrows, while Fig. 5 is a sectional view of the eddy current disc.

Referring to the drawing, in one form of my invention I provide a metal enclosure or casing comprising a cylindrical portion 1 to the right-hand end of which is integrally joined a rectangular portion 2. Mounted in the cylindrical portion 1 is a shaft 3 having its left-hand end as seen in Fig. 1 projecting from the casing for connection through a suitable coupling to the shaft of the electric motor to be controlled, the shaft being mounted in a ball bearing 4 mounted in the left-hand end wall of the enclosure portion 1, and a ball bearing 5 which is mounted on a supporting plate 6 secured by suitable screws 7 to the left-hand wall of the enclosure portion 2. Preferably, as shown, the shaft is supported by the bearings 4 and 5 with its axis of rotation coaxial with the center line of the enclosure 1.

The shaft 3 drives an eddy current disc 8, which is rigidly secured to the shaft, between axially disposed permanent magnets carried by a supporting structure 9 rotatably mounted on the shaft. As shown, this supporting structure for the permanent magnets consists of supporting discs 10 and 11 mounted on central bearings 12 and 13 secured to the shaft 3. At their peripheries the two discs 10 and 11 are rigidly connected together by axially extending straps 14, 15, and 16 which extend across the periphery of the disc 8 in spaced relation therewith. It will be understood that the two discs 10 and 11 and the connecting members 14, 15 and 16 are made of a suitable non-magnetic and preferably light material such as aluminum.

As shown in Fig. 3, five small bipolar permanent magnets 17 to 21, inclusive, are mounted on the disc 10 on the side adjacent the eddy current disc 8 and with the two poles of each magnet in closely spaced relation with the eddy current disc. The magnets are conveniently secured in place each by a screw 22 extending centrally through it and into a tapped hole in the disc 10. Preferably as shown, the magnets are equally spaced apart around the periphery of the disc 10 with unlike poles of adjacent magnets adjacent each other. An identical set of five magnets, only three of which are shown and indicated by reference numerals 23, 24 and 25, are mounted on the disc 11 in the same equally spaced relation with each other and with each magnet directly opposite axially a magnet on the disc 10. As shown, the magnet 24 is directly opposite the magnet 19 thereby to form a pair of axially oppositely disposed magnets. Moreover, the magnets of each oppositely disposed pair are arranged with their north poles axially opposite their south poles, as indicated by the letters N and S on the magnets 19 and 24. This relative pole positional arrangement of the magnets provides for the maximum generation of eddy currents and the maximum torque.

As the disk 8 is rotated in the magnet field produced by the permanent magnets, eddy currents are set up in the disc whereby a torque is produced tending to rotate the magnet supporting structure 9 in the same direction as the disc 8 is being driven. This rotation of the structure 9 is limited to a small angle by means of an operating member 26 made of electrically insulating material having one end secured to the disc 11 and extending parallel with the shaft 3 through a rotation limiting aperture 27 in the supporting plate 6. At its opposite end the member 26 is provided with a slot 28 through which extends the end of a flexible switch arm 29 the other end of which is secured to a bracket 30 mounted on a supporting block 31 made of a molded electrically insulating material. A switch contact 32 on the movable end of the arm 29 cooperates with stationary contacts 33 and 34 on the opposite sides of the switch arm so as to engage one or the other of the stationary contacts in dependence upon the direction of the rotation of the magnet supporting structure 9. It will be observed that the switch arm and two stationary contacts form a single pole double throw switch.

The magnet supporting structure 9 and the switch arm are biased to an intermediate position with the switch arm midway between the two stationary contacts by means of two helical springs 35 and 36, as shown in Fig. 4, on the side of said support 31 opposite the switch arm. The springs are secured each at one end respectively to spring tension adjusting members 37 and 38 which are in turn secured by screws 39 and 40 to the insulating support 31. The opposite ends of the springs are secured respectively to arms 41 and 42 mounted on pivots 43 and 44 secured to the molded support 31. As shown in Fig. 4, the arms 41 and 42 are biased by the springs against a projection 45 extending between them and formed integrally with the support 31. Extending between the right-hand ends of these arms as seen in Fig. 4 is the operating member 26 whereby the springs bias the operating member, the magnet supporting structure and the switch arm in their intermediate positions shown. The right ends of the arms 41 and 42, as seen in Fig. 4, move between the walls 41*a* and 42*a* of the recess in the support 31 into which the ends extend.

In order that the left-hand ends of the arms as seen in Fig. 4 may overlap, the arm 42 is somewhat lower than the other arm so that its left end is free to move under the left-hand end of the other arm. A protuberance 46 is provided on the lower side of the arm 41 which rubs on the arm 42 thereby providing a minimum of friction between them. A similar protuberance, not shown, is provided on the upper side of the arm 42 which engages the lower side of the arm 41.

For the purpose of immobilizing the movable parts in their intermediate position shown when the motor is deenergized, a pivoted latch 47 is provided having its lower end as seen in Fig. 4 bent toward the right and extending between the arms 41 and 42 whereby pivotal movement of the arms is prevented. When the motor is energized the latch 47 is moved about its pivot 48 in a clockwise direction by a magnet 49 mounted on a bracket 50 which in turn is mounted on the support 31, the pivot 48 being mounted on the bracket. The coil 51 of the magnet has its terminals connected to connectors 52 and 53 on the front side of the support 31 as seen in Fig. 2.

To facilitate adjustment of the force applied by the spring 35, a cam 54 is provided having an aperture through which extends the screw 39. This cam engages a projection 55 on the member 37 which has a slot (not shown) for the screw 39. After loosening the screw 39, the member 37 may be moved about a pivot 56 at its lower end to adjust the tension of the spring 35, after which the cam is turned to a position to contact the member 37 and the screw 39 is then tightened. A similar adjustment is provided for the member 38 and spring 36. The pivot 56 is conveniently formed by extruding a hole in the lower end of the member 37 whereby a circular flange (not shown) is provided on its lower side, which flange seats in an aperture in the support 31. It will be understood that adjustment of the springs adjusts the device for opening of the switch at a predetermined low speed of the shaft 3 whereby the motor is deenergized and coasts to a standstill.

The support 31 is secured to the plate 6 by means of screws 57 and 58 and by removing these screws the support with all of the parts mounted on it may be removed. In a similar manner the plate 6 may then be removed by removing the screws 7 after which the shafts 3 and the support structure 9 can be removed. A cover 59 is provided for the enclosure portion 2. The device may be mounted on a suitable support by means of screws or bolts passing through the apertures 60 to 63 inclusive.

Electric conductors for connecting the coil 51, the two stationary contacts, and the contact arm 29 in their control circuits are led in through an aperture 64 in the rectangular enclosure portion 2. The electric connections for connecting the switch for the control of a three-phase motor may be as shown in Fig. 3 of U. S. Patent No. 2,141,278 issued to Joseph W. Owens on December 27, 1938 for Switch Mechanism. In addition, the terminals of the coil 51 are connected directly across two terminals of the motor so that the coil is energized and the latch 47 moved to release the arms 41 and 42 only when the motor is energized. The latch is provided for the purpose of preventing the closure of the switch inadvertently when the shaft of the driving motor is turned manually, which is sometimes done for the purpose of adjusting the apparatus driven by the motor while the motor is deenergized. It will be understood that closure of the switch by movement of the contact arm 29 into engagement with either one of the stationary contacts effects the closure of one or the other of the starting contactors and energization of the motor.

The permanent magnets mounted on the supporting structure 5 preferably are made of a material having a high coercive force and high resistance to change in magnetic properties. One such material is an alloy of 12 percent aluminum, 25 percent nickel and 5 percent copper, the balance being mainly iron, such as described and claimed in Patent 1,947,274, issued on February 13, 1934 to William E. Ruder and Patent 2,027,997, issued on January 1, 1936 to Tokushichi Mishima.

As shown in Fig. 5, for the purpose of increasing the torque I provide tubular flanges 65 and 66 on opposite sides of the eddy current disc 8 and concentric with the axis of rotation of the disc. These flanges are each inside of its series of magnets, two of which, such as 18 and 23, are indicated in dotted lines. The flanges serve the purpose of providing a conducting path for eddy currents of increased cross section, and therefore, decreased resistance, whereby the flow of eddy currents and hence torque is increased. In a typical device I found that these flanges on the disc increased the torque applied to the magnet supporting structure from ten to twenty percent.

A similar pair of flanges on the outer periphery of the disc outside of the magnets would serve to give a still greater increase in torque but, for manufacturing reasons, I prefer not to use such flanges on the periphery of the disc. Instead, I mount the permanent magnets in such positions that they are inside the periphery of the disc, as shown clearly in Fig. 3, i. e., the space from the periphery. The metal of the disc outside of the magnets serves to some extent to provide a path for eddy currents of decreased resistance whereby the torque is increased.

It will be noted that the disc 8 is of substantial thickness which also is for the purpose of providing a low resistance path for the flow of eddy currents. In a typical device the disc was one-quarter inch thick, while the distance between the two poles of each magnet, i. e., the width of the air gap between the two poles was also one-quarter inch. The disc is preferably made of good copper having a conductivity ninety-five percent of the conductivity of pure silver. It will be understood that the thickness of the disc for maximum torque is a compromise between the air gaps between the poles of each magnet and between the poles of oppositely disposed magnets. If the thickness of the disc is decreased, oppositely disposed magnets will be closer together and, therefore, produce more magnetic flux through the disc but, on the other hand, the decreased thickness of the disc gives increased resistance to the flow of eddy current. On the other hand, if the disc, and therefore the air gap between oppositely disposed magnets, is too great, the magnetic flux will tend to pass between the two poles of each magnet without passing through the disc, with resulting decrease in torque.

It will be noted that, because of the spacing between the magnets and the disc, the distance between the poles of oppositely disposed magnets is somewhat greater than the width of the slot between the two poles of each magnet, although the distance between oppositely disposed poles is very considerably less than the distance from center to center of the pole faces of each magnet. The efficient distribution of the magnetic field for the generation of eddy current is further increased by spacing the magnets apart, as seen in Fig. 3, at such distances that the effective distance between the adjacent poles of separate magnets is substantially the same as the distance between the two poles of a single magnet.

As shown in Fig. 5, I have provided a series of holes 67 in the web of the disc joining the flanges 65 and 66 with the web 68. Preferably, six equally spaced holes are provided in this web. These holes serve the purpose of reducing the cross section of the disc thereby to reduce the loss by conduction of heat from the outer portion of the disc in which eddy currents are generated, whereby that portion is heated more quickly to a stable operating temperature providing the ultimate operating torque for which the switching device is calibrated. This rapid heating of the disc is desirable to prevent non-uniform operation in the event that the motor is plugged before the disc is heated to its calibrated temperature. In such case the contacts would open later because of the increased torque at the lower disc temperature with undesirable control of the motor. It will be understood that the copper disc has a positive temperature coefficient of resistance with higher resistance and decreased torque at the higher temperatures.

I have also found that increased torque is provided by arranging each magnet as seen in Fig. 3 with both of its poles lying on a circle whose center is the axis of rotation of the disc, i. e. equidistant from the shaft. This arrangement gives the greatest possible torque about the axis of rotation. At high speeds the torque is limited by the leakage of flux directly between the two poles of each magnet.

While I have shown a particular embodiment of my invention, it will be understood, of course, that I do not wish to be limited thereto since many modifications may be made and I therefore contemplate by the appended claims to cover any 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 direction responsive switch mechanism comprising, a shaft mounted for continuous rotation in either of two directions, an eddy current disc secured to said shaft, a magnet supporting structure rotatably mounted adjacent said disc, a plurality of magnets mounted on said supporting structure for producing eddy currents in said discs, a switch operating member secured to said supporting structure, a switch member actuated by said operating member between two circuit controlling positions, a pair of pivoted arms extending in approximately parallel relation on opposite sides of and engaging said operating member, spring means biasing said arms to predetermined positions in which said switch member is held by said operating member in a neutral position between said two circuit controlling positions, and releasable latching means arranged to engage said pivoted arms for selectively preventing and permitting the movement of said arms whereby the actuation of said switch member is respectively prevented and permitted upon rotation of said disc.

2. A switch mechanism comprising, a shaft mounted for continuous rotation in either of two directions, a yieldable clutch mechanism operated responsively to the rotation of said shaft, a switch operating member operated by said clutch mechanism, a switch member actuated by said operating member between two circuit controlling positions, a pair of pivoted arms extending in approximately parallel relation on opposite sides of and engaging said operating member, spring means biasing said arms to predetermined positions in which said switch member is held in a neutral position between said two circuit controlling positions, and releasable latching means arranged to engage said pivoted arms for selectively preventing and permitting the movement of said arms whereby the actuation of said switch arm is respectively prevented and permitted upon rotation of said shaft.

3. A switch mechanism comprising, a contact carrying member movable between two circuit controlling positions, an operating member arranged to move said contact carrying member to either of said two positions, a pair of pivoted

arms extending in approximately parallel relation on opposite sides of and engaging said operating member, spring means biasing said arms to predetermined positions in which said operating member holds said contact carrying member in a neutral position between said two circuit controlling positions, and releasable latching means arranged to engage said pivoted arms for selectively preventing and permitting the movement of said arms whereby the actuation of the switch mechanism is respectively prevented and permitted.

4. A direction responsive switch mechanism comprising, a shaft mounted for continuous rotation in either of two directions, an eddy current disc secured to said shaft, a magnet supporting structure rotatably mounted adjacent said disc, a plurality of magnets mounted on said supporting structure for producing eddy currents in said disc, a switch operating member secured to said supporting structure, a switch member actuated by said operating member between two circuit controlling positions, a pair of pivoted arms extending in substantially parallel relation on opposite sides of and engaging said operating member, spring means biasing said arms to predetermined positions in which said switch member is held in a neutral position approximately midway between said two operating positions, a latch member biased to engage said pivot arms to secure them in said predetermined positions against the magnetic driving force applied to said supporting structure upon rotation of said disc, and electromagnetic means for moving said latch member to release said arms thereby to provide for movement of said structure upon rotation of said disc.

5. A direction responsive switch mechanism comprising, a shaft mounted for continuous rotation in either of two directions, an eddy current disc secured to said shaft, a magnet supporting structure rotatably mounted on said shaft, a plurality of bipolar permanent magnets mounted on said supporting structure in equally spaced relation with each other on each side of said disc around its periphery with their pole faces in closely spaced relation with said disc, said magnets being arranged with their unlike poles directly opposite each other on opposite sides of said disc, a switch operating member secured to said supporting structure, a switch actuated by said operating member, and releasable latching means arranged to immobilize the said supporting structure whereby the actuation of said switch is selectively prevented and permitted upon rotation of said disc.

6. A direction responsive switch mechanism comprising a shaft mounted for continuous rotation in either of two directions, an eddy current disc secured to said shaft, a magnet supporting structure rotatably mounted on said shaft, a plurality of permanent magnets mounted on said supporting structure in equally spaced relation with each other adjacent the periphery of said disc with their pole faces in closely spaced relation with said disc, said magnets being arranged directly opposite each other in a direction parallel with the axis of said shaft with unlike poles of the magnets opposite each other and the magnets on each of said supporting members having unlike poles adjacent each other, a switch operating member secured to said supporting structure, a switch member arranged for actuation by said operating member to either of two circuit controlling positions, and electromagnetically operated latching means arranged to immobilize said supporting structure whereby the actuation of said switch member is selectively prevented and permitted.

7. A direction responsive switch mechanism comprising, a shaft mounted for continuous rotation in either of two directions, an eddy current disc secured to said shaft, a magnet supporting structure rotatably mounted on said shaft, a plurality of bipolar permanent magnets mounted on said supporting structure in equally spaced relation with each other on each side of said disc around its periphery with their pole faces in closed spaced relation with said disc, said magnets being arranged with their unlike poles directly opposite each other, a switch operating member secured to said supporting structure, a switch actuated by said operating member between two circuit controlling positions, a pair of pivoted arms on opposite sides of and engaging said operating member, spring means biasing said arms to predetermined substantially parallel positions in which said switch is held in a neutral position approximately midway between said two operating positions, and releasable latch means arranged to engage said pivoted arms for selectively preventing and permitting the movement of said pivoted arms whereby the actuation of said switch is respectively prevented and permitted.

8. A direction responsive switch mechanism comprising a shaft mounted for continuous rotation in either of two directions, an eddy current disc secured to said shaft, a magnet supporting structure rotatably mounted on said shaft, a plurality of bipolar permanent magnets mounted on said supporting structure in equally spaced relation with each other on each side of said disc around its periphery with their pole faces in closely spaced relation with said disc, said magnets being arranged with their unlike poles directly opposite each other, a switch operating member secured to said supporting structure extending in a direction parallel with the axis of said shaft, a switch member actuated by said member between two circuit controlling positions, a pair of pivoted arms extending at right angles with the axis of said shaft on opposite sides of and engaging said operating member, spring means biasing said arms to predetermined substantilly parallel positions in which said switch member is held in a position midway between said two positions, a latch member biased to engage said arms to secure them in said predetermined positions against the magnetic driving force applied to said supporting structure upon rotation of said disc, and a magnet for moving said latch member to release said arms thereby to provide for movement of said structure upon rotation of said disc.

WILLIAM LAWRENCE BUTLER.

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