

May 10, 1966 E. J. WIGHTMAN ETAL 3,250,878
 ROTARY POLARIZED RELAY HAVING POLE PIECE STOPS
 TO LIMIT ROTATION OF THE ARMATURE
 Filed Aug. 21, 1963 2 Sheets-Sheet 1

E. J. WIGHTMAN ETAL **3**
POLARIZED RELAY HAVING POLE PIECE STOPS
TO LIMIT ROTATION OF THE ARMATURE

3,250,878

Filed Aug. 21, 1963

2 Sheets-Sheet 1

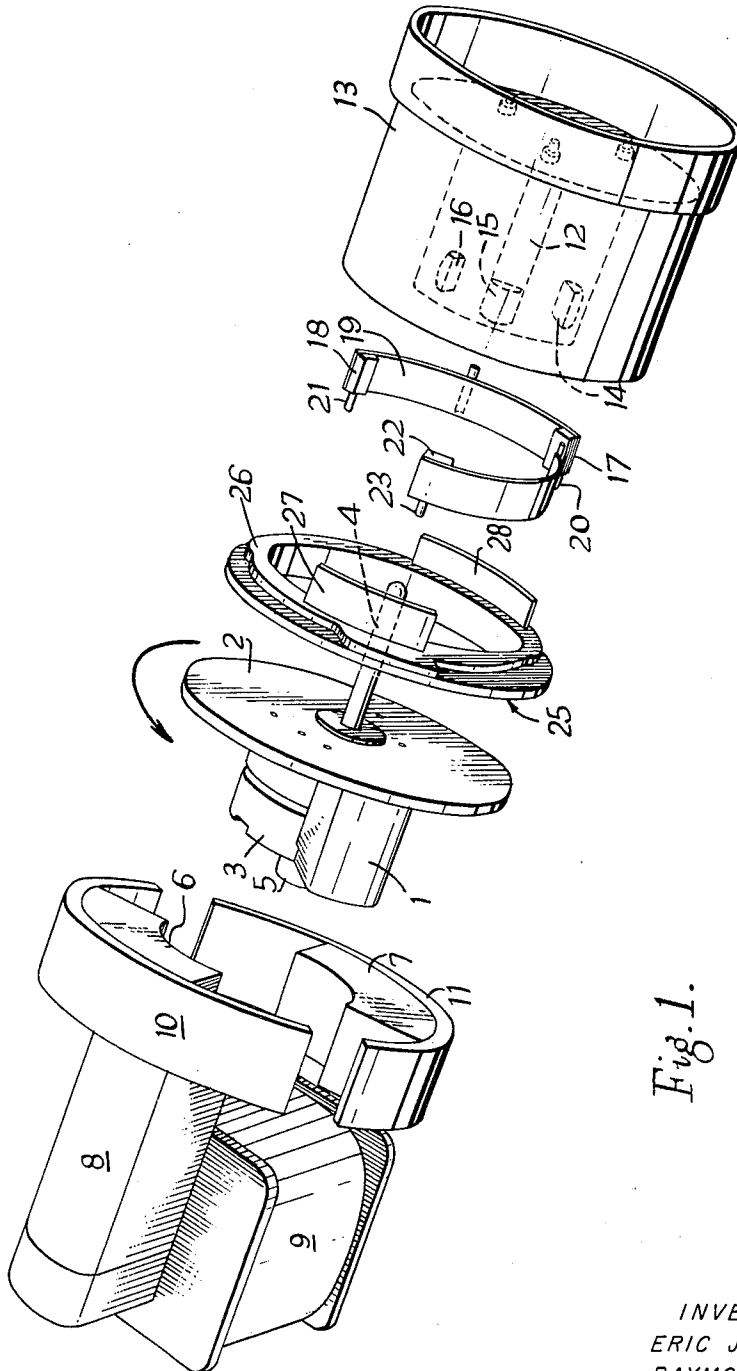


Fig. 1.

INVENTORS
ERIC J. WIGHTMAN
RAYMOND E. PRATT
BY *S.C. Eaton*
ATTORNEY

May 10, 1966

E. J. WIGHTMAN ETAL

3,250,878

ROTARY POLARIZED RELAY HAVING POLE PIECE STOPS
TO LIMIT ROTATION OF THE ARMATURE

Filed Aug. 21, 1963

2 Sheets-Sheet 2

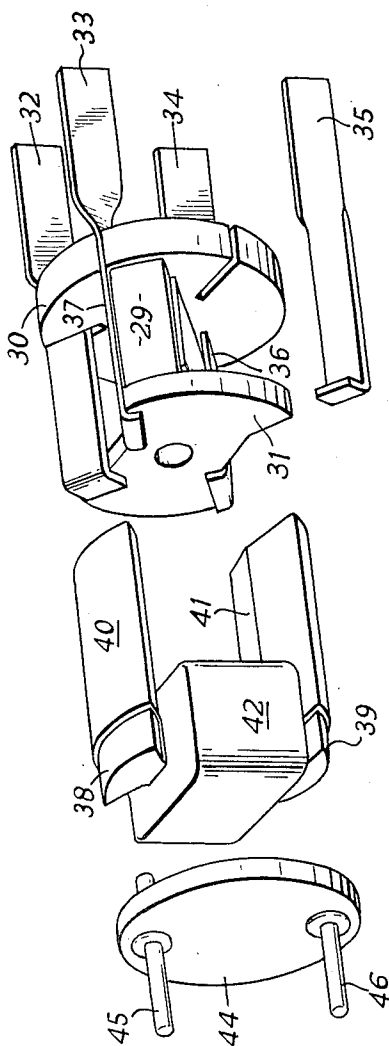


Fig. 2.

INVENTORS
ERIC J. WIGHTMAN
RAYMOND E. PRATT
BY
S. C. Keaton
ATTORNEY

1

3,250,878

ROTARY POLARIZED RELAY HAVING POLE PIECE STOPS TO LIMIT ROTATION OF THE ARMATURE

Eric Jeffrey Wightman, Ascot, Berkshire, and Raymond
Eric Pratt, Bagshot, Surrey, England, assignors to The
Sperry Gyroscope Company Limited, Middlesex, Eng-
land, a company of Great Britain

Filed Aug. 21, 1963, Ser. No. 303,528

Claims priority, application Great Britain, Aug. 31, 1962,
33,488/62

4 Claims. (Cl. 200-93)

The invention relates to an improved electromagnet and make-break switch combination and an object of the invention is to provide a switch of this kind which is of robust construction and not readily affected by shock or vibration.

According to the present invention the mechanism of the combination includes a permanent bar magnet pivoted at its centre between a pair of polar ends on the core of an electromagnet so as to be free to rotate through a substantial angle, the rotation being limited at either extreme by the magnet abutting against the polar ends of the core. The angle may be of the order of 90°, but it should in any case be more than about 30°.

Since the limiting polar ends of the core of the electromagnet are made of magnetically soft ferro-magnetic material, when the bar magnet is rotated to one or other of its extreme positions its poles are attracted to the portion of the core of opposite polarity, so that the bar magnet is locked in its extreme position by polar attraction produced by magnetic poles induced in the core ends by the permanent magnet armature.

In operation a current is passed through the operating coil of the electromagnet in such a sense as to change the polarity of the polar ends of the core of the electromagnet. The bar magnet is then repelled from one of its extreme or limiting positions to rotate to its other extreme or limiting position where it again becomes magnetically locked, even after the current through the operating coil has ceased. The switch is therefore suitable for operation by pulses, or from a flip-flop circuit. The locking torque, and therefore the current required to operate the switch, will depend, as is well known in connection with relays, on the spacing of the magnetic elements. These quantities may be controlled by introducing a thin layer of non-magnetic material between the abutting surfaces, for example by plating the bar magnet with non-magnetic metal.

The core of the electromagnet includes segmental portions having flat surfaces or polar ends extending radially to the axis of the magnet against which the bar magnet lies in one or the other of its extreme positions. The core further includes curved polar end extensions of a crescent shape of greater arcuate dimension than the limiting polar ends of the structure. These extensions provide a second pair of polar ends for the core that are arranged in asymmetrical relation to the limiting polar ends and a third pair of polar ends arranged in asymmetrical relation to the limiting polar ends that are in symmetrical relation to the second pair of polar ends. In the improved combination the core includes second and third pairs of polar ends arranged as described to prevent the bar magnet from being stalled between its limit extremes. Here, the dimensions of the polar ends of the second and third polar ends of the core is greater than the arcuate dimensions of the limiting polar ends with respect to the axis when being less than 180 degrees. The improved structural combination is robust and insensitive to shock, partly because of the magnetic locking effect heretofore described, and also because of the large angular movement of the moving parts between the extreme positions and

2

because the moving magnet is balanced about its pivots.

In one form of the improved structure, the magnet is mounted on a pivoted shaft which rotates with the magnet and carries a cam for operation of the switch contacts.

This cam is in the form of a plate having a rim or slot shaped to provide a surface on which ride projections from the movable contacts of a contact assembly so that rotation of the shaft opens or closes the contacts. In the improved structure, insulative separators are interposed between the contact surfaces as they open to interrupt or prevent arcing. The contacts may be magnetic to ensure that they are not readily separated by shock or vibration from the closed position.

In another form of the invention the cam plate is omitted and a contact leaf overlies at least one of the polar ends of the core against which the bar magnet abuts in one extreme position, so that with the bar magnet abutting against the polar end an electrical circuit is connected through the bar magnet and contact leaf. The contact leaf or leaves may be insulated from the polar end by a closely fitting sleeve of flexible insulating material, for example PTFE, fitted over the core. The contact-making surfaces of the bar magnet are faced with a suitable contact metal having high conductivity and resistance to spark erosion.

In a convenient and compact construction of this kind the magnet pivots in bearings in a pair of end plates between which extend metal strips forming contact leaves and the segmental core of the electromagnet has polar ends of high electrical conductivity that when assembled about the contact strips. Such a construction may be made approximately cylindrical in overall shape so that it may be assembled by placing the components together within an insulating cylindrical sleeve.

The invention will be further described with reference to the accompanying drawings in which

FIG. 1 is a diagrammatic exploded view of an electromagnet and switch combination according to the invention of the kind in which the rotating magnet is coupled to a cam plate to operate the switch contacts, and

FIG. 2 is a diagrammatic exploded view of a further structure according to the invention of the kind in which contact leaves are provided on the limiting polar ends of the core.

Referring first to FIG. 1 the actuating mechanism of the combination includes a permanent bar magnet 1 which is clamped against the face of a non-magnetic disc 2 by a saddle 3. The disc carries an axle 4, and the saddle 3 carries a bearing 5, which enables the disc and magnet to be mounted so that they are free to move about an axis to a limited degree.

This assembly is mounted between two soft segments 6 and 7 of an electromagnet, being joined by a soft iron yoke or core 8 on which is wound an operating coil 9. The segments are so shaped as to allow the bar magnet 1 to rotate through an angle of about 80°, at either limit of which motion its side surfaces near the ends abut against the polar ends of the segments which extend radially of the axis.

Before assembly the ends of the bar magnet 1 are plated with chromium to a thickness of about 0.030", and this is ground to a thickness of 0.020". This plated layer ensures the necessary spacing between the magnet and pole-pieces to enable switching to take place at the operating current.

In the embodiment of the invention shown in FIG. 1, the core 8 includes soft iron extensions 10 and 11. These segmental portions of the core 8 are of greater arcuate dimension than the limiting polar ends while being less than 180 degrees so that when the coil 9 is energised there is a distribution of magnetic pole along the extensions 10 and 11, and the magnetic field is not closely confined to

3

the neighbourhood of the sectors 6 and 7. The segmental portions of the core 8 are also crescent shaped, that is, their radial thickness decreases toward their free ends so as to provide a desired distribution of magnetic field from the neighborhood of the pole pieces 6 and 7.

The axle 4 engages a bearing 12 provided for it in a housing 13, which contains also the fixed make-break switch contacts 14, 15 and 16. Another housing (not shown) is provided for the bearing 5.

The moving contacts of the switch which co-operate with the fixed contacts 14 and 16 to form a change-over switch also lie within the housing 13, and consist of a pair of blocks of contact material 17, 18 mounted on a spring blade 19 anchored in the housing 13. From each of the blocks 17 and 18 projects a small operating pin 20, 21 respectively. There is also a movable switch contact 22 which co-operates with the fixed contact 15 and has projecting from it an operating pin 23. This contact is mounted on a separate spring blade 24, similarly mounted.

The disc 2 carries, attached to its face, a cam plate 25 which has an upstanding rim 26 positioned so as to engage the operating pins 20, 21 and 23 attached to the movable contacts. There are also two separators 27 and 28 provided on the face of the cam plate 25 so positioned that, as the plate rotates, and the rim 26 engages, for example, the pin 23, raising the contact 22, the separator 27 is interposed between the contact 22 and the fixed contact 15 so as to prevent arcing or accidental re-closure. The contacts 14, 15, 16, 17, 18 and 22 each consist of a block of magnetic alloy known under the registered trademark Platinax and are magnetised so that when they are allowed to come into contact they remain locked together by magnetic attraction.

Normally the switch will be in one or the other of the positions in which the ends of the bar magnet 1 are in contact with the polar ends of the segments 6 and 7. In order to operate the switch, current is passed through the operating coil 9 which magnetises the segments 6 and 7 in such a sense that the end of the core which is in contact with the north pole of the permanent magnet 1 acquires a north polarity, and that the end of the core which is in contact with the south pole of the permanent magnet acquires a south polarity. This causes the poles of the bar magnet 1 to be strongly repelled by the core, and so move the rotor, consisting of the disc 2, saddle 3 and cam plate 25, until the permanent magnet comes to rest with its poles against the other of the polar ends of the core. The extensions 10 and 11 extend the magnetic field beyond the intermediate position of the magnet to reduce the risk of its being stalled half-way through its travel.

If, for example, the switch starts to operate from the position in which the contacts 16, 18 and 15, 22 are closed and the contacts 14, 17 are open, the magnet rotates counter-clockwise, in the view shown in the drawing. This rotation of the cam plate 25 causes the rim 26, against which the pins 20, 21 and 23 bear, to allow the pin 20 to move radially and the contacts 14 and 17 to close, and to cause the pins 21 and 23 to move so that the contacts 16 and 18 also open. At the same time, the separator 27 is inserted between the opening contacts 15 and 22 as the separator 28 is withdrawn from between the closing contacts 14 and 17 and inserted between the opening contacts 16 and 18.

Even though the operating current now ceases, the magnetic attraction between the poles of the bar magnet 1 and the field in the segments 6 and 7 keep the rotor in its new position. The contacts 14 and 17 remain locked together because of the magnetic attraction between them, and the contact pairs 16, 18 and 15, 22 remain open because of the interposition of the separators 27 and 28.

In order to change over the contacts to their original mode of connection, current in the reverse sense must be passed through the operating coil 9, so as to cause the

4

rotor assembly to return to its original position. Preferably the extensions 10 and 11 are asymmetrical with respect to the segments 6 and 7. For example, as shown in the drawing the extension 10 provides a second pair of polar ends for the core 8 of greater arcuate dimensions than the limiting polar ends of segments 6 and 7 that are arranged in asymmetrical relation to the limiting polar ends. Likewise, the extension 11 provides a third pair of polar ends for the core 8 of greater arcuate dimensions than the limiting polar ends of segments 6 and 7 that are arranged in asymmetrical relation to the limiting polar ends and in symmetrical relation to the second pair of polar ends.

Referring now to FIG. 2 the mechanism of the switch includes a permanent bar magnet 29 of Alcomax (registered trademark) pivoted on an axis in bearings in a pair of insulated end plates 30 and 31. The end plate 30 is slotted to receive four strips of electrical contact alloy 32, 33, 34, 35 and the surfaces of the magnet 29 are faced with a layer of contact facing material 36, 37 on the pair of opposite sides which come into contact with the contact strips. This layer is of the material known under the registered trademark Silver Elkonite.

The electromagnet is provided with a core having a pair of soft iron pole pieces 38, 39 which are of segmental configuration and each of which is insulated by sliding over it a closely fitting sleeve 40, 41 respectively of PTFE. The electromagnet is provided with a D.C. operating coil 42.

The PTFE sleeve is 0.003" thick and the contact strips 32, 33, 34 and 35, and the facings 36 and 37 are each 0.010" thick, giving a spacing between the magnet and the core against which it abuts of 0.023".

The end plate 30 is circular in outline, its overall diameter corresponding to the diameter of the outer cylindrical surface of the core while the end plate 31 is cut away to contact the pole pieces 38 and 39, so that their insulated faces lie against the backs of the contact strips 32, 33, 34, 35 when assembled.

The improved structure is assembled in a cylindrical insulating sleeve within which it is a sliding fit, the end plate 30 closing one end of the sleeve, the other being closed by a disc 44 carrying a pair of terminal pins 45 and 46 for connection to the ends of the operating coil 42. After assembly the components may be sealed in position by adhesive or by enclosing the whole in a thin metal sleeve, the extremities of which are spun or bent over to grip the plates 30 and 44.

The sleeve 43 may be made of a transparent insulator such as glass or a transparent plastic material, so that the condition of the contacts may be inspected in use.

In operation the bar magnet is retained in position by the magnetism induced in the core with one pair of contact strips on the bar magnet completing the circuit between the strips 33 and 34.

On applying a voltage of suitable magnitude and polarity to the energising coil 42 the polarity of the core is changed to repel the ends of the magnet and cause it to move to its other extreme position where it completes the electrical circuit between the strips 32 and 35.

The improved electromagnet and make break switch combination, is very compact and in one example the overall dimensions of the switch excluding the contact pins and the free ends of the strips was $\frac{3}{4}$ " long and $\frac{1}{2}$ " in diameter. This switch had a continuous current rating of 5 amperes D.C. in a non-inductive circuit, and could handle currents of 20 amperes for short periods.

What is claimed is:

1. An electromagnet and make-break switch combination including a housing having a fixed switch contact, a bar magnet mounted in the housing to move about an axis having opposed magnetic poles extending radially of the axis with respective radially directed stop faces, a soft iron core in the housing having a pair of polar ends, the faces thereof being spaced angularly with respect to

5

the stop faces of the bar magnet to limit its motion about the axis to a range of less than 90 degrees and to lock the magnet magnetically in either of its limit position by poles induced in said core ends by said magnet poles, a pair of segmental portions on each of said polar ends of greater arcuate dimension than the limiting faces thereof but less than 180 degrees, the gaps defined by the terminal ends of said portions being arranged in asymmetrical relation with respect to the limiting polar ends, a switch contact in the housing movable with the bar magnet between a make condition with the fixed switch contact at one lock position and a break condition at the other lock position, and a coil for the soft iron core operable to polarize the core differentially.

2. A combination of the character claimed in claim 1, including a cam plate movable about the axis with the magnet, in which the movable switch contact is connected to the housing by a spring, and a follower for the movable switch contact cooperatively engaging the cam of the plate.

6

3. A combination of the character claimed in claim 2 including an insulative separator for the contact carried by the cam plate.

4. A combination of the character claimed in claim 1 in which the movable contact of the switch is provided on the stop face of the bar magnet by a metal surface of high electrical conductivity and resistance to erosion.

References Cited by the Examiner

UNITED STATES PATENTS

2,574,403	11/1951	Lloyd	200—93
2,635,155	4/1953	Barr	200—93
2,843,696	7/1958	Sturup	200—87
2,895,029	7/1959	Steiner	200—93
3,067,305	12/1962	Stout et al.	200—93

BERNARD A. GILHEANY, *Primary Examiner.*

20 ROBERT K. SCHAEFER, *Examiner.*