

[54] **ELECTROMAGNETIC INDICATOR**

[72] Inventor: George E. Pihl, Abington, Mass.

[73] Assignee: Miniature Electronic Components Corp.,
Holbrook, Mass.

[22] Filed: Aug. 27, 1971

[21] Appl. No.: 175,652

[52] U.S. Cl. 335/234, 335/273, 340/373

[51] Int. Cl. H01F 7/08

[58] Field of Search 335/234, 272, 281, 17;
340/373

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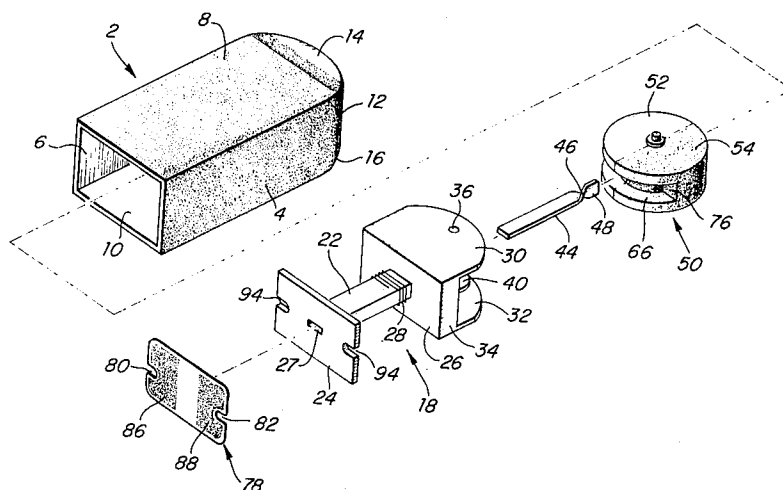
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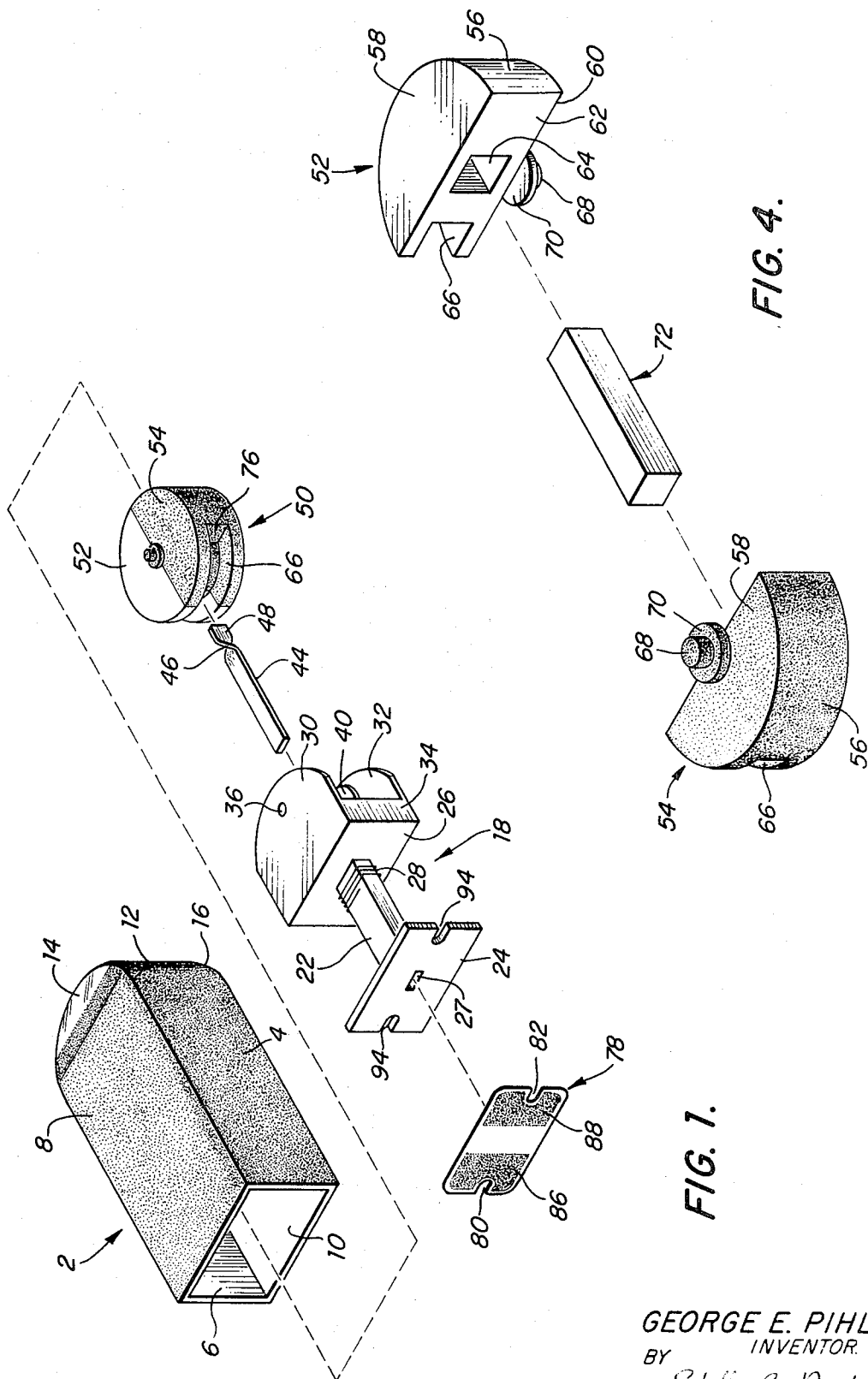
Primary Examiner—Harold Broome
Attorney—Robert J. Schiller et al.

[57] **ABSTRACT**

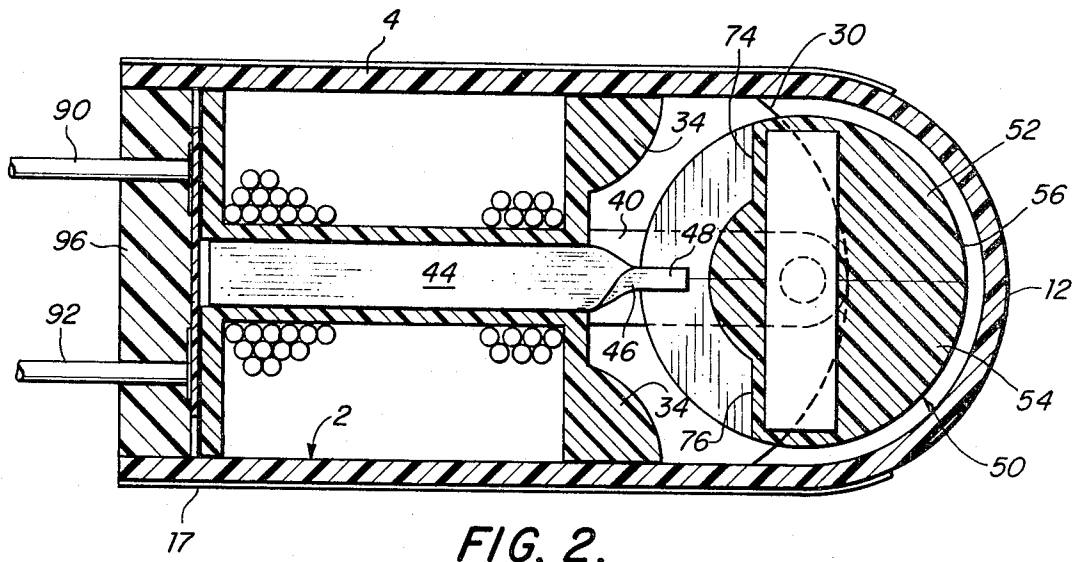
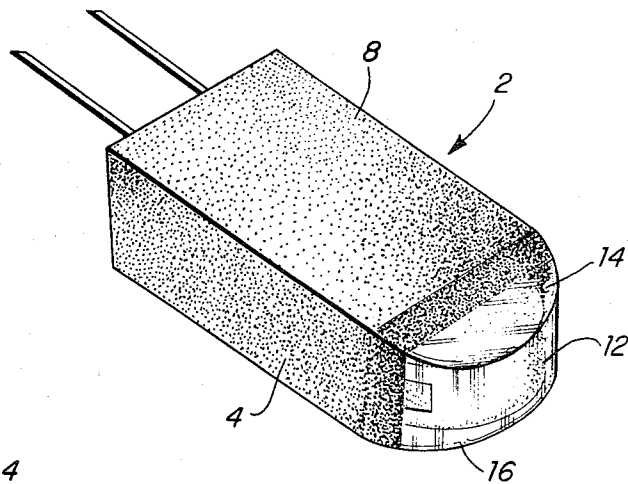
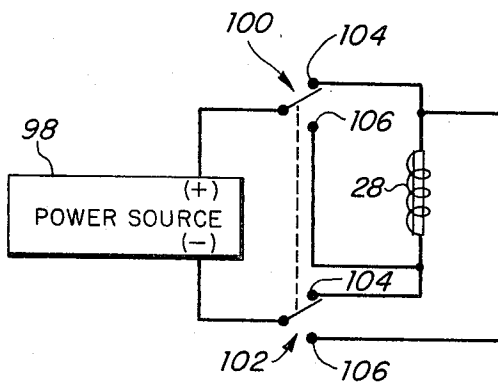
A two position indicating device including an indicator member in the form of a rotor that carries a single permanent magnet and is mounted for rotation between two limit positions which are determined by engagement of spaced-apart portions of the rotor with the end of a pole piece of a stationary electromagnetic structure. The electromagnetic structure comprises a combined bobbin and rotor support, the rotor support having two spaced ears and the rotor being rotatably mounted to the spaced ears by detent means comprising a hole in each ear and two pins carried by the rotor. Attachment and removal of the rotor is achieved by flexing the two ears apart far enough to release the two rotor pins. A coil is wound around the bobbin and terminal means are provided for energizing the coil to selectively establish first and second electromagnetic fields of opposite orientation for effecting movement of the rotor between its two limit positions.

12 Claims, 5 Drawing Figures





GEORGE E. PIHL
 BY INVENTOR
 Schiller & Pandiscio
 ATTORNEYS



GEORGE E. PIHL
INVENTOR.
BY Schiller & Pandiscio
ATTORNEYS.

ELECTROMAGNETIC INDICATOR

This invention relates to miniature electromagnetic indicators and more particularly to provision of low cost indicators capable of indicating two different predetermined conditions.

The present invention is an improvement over electromagnetic indicators of the type set forth in U.S. Pat. No. 3,451,055 and U.S. Pat. Nos. 3,364,481, 2,415,452, and 3,430,170.

OBJECTS AND SUMMARY OF THE INVENTION

The primary object of this invention is to provide a new miniature electromagnetic indicator capable of binary indication that satisfies the myriad of requirements that exist in the commercial and industrial fields by offering reliability combined with low cost.

A further object of the invention is to provide a quick acting miniature bi-stable electromagnetic indicator that is self-latching in both of its two display positions, whereby the indicator may be used as a fault isolation indicator or a condition monitoring device for electrical and electromechanical systems.

Still another object of the invention is to provide a low cost indicator that is moisture sealed, can be made in sizes as small as $0.250 \times 0.375 \times 0.800$ inches, may be pulse operated and will withstand steady state power at elevated temperatures.

A further object of the invention is to provide an indicator having a movable indicator member that provides an indicia display that is highly visible and which can be seen when viewed at different angles. In a preferred embodiment of the invention the foregoing and other objects are achieved by a construction which comprises a plastic indicator housing that is transparent at one end so as to permit viewing of the displayed indicia of the indicator member. Contained within the case is an electromagnetic structure comprising a combined rotor support and hollow bobbin, a core made of magnetic material disposed within the bobbin, and a coil wound around the bobbin. The rotor support comprises a pair of flexible ears formed integral with one end of the bobbin and having a pair of aligned holes for use in mounting the indicator member. The indicator member is a rotor having salient permanent magnet poles and a pair of aligned pins that are sized to fit within the holes formed in the two ears. The rotor further includes a slot in its periphery, with one end of the pole piece extending into the slot and with the slot having end walls that determine, by engagement with the pole piece, two limit positions for the rotor. The rotor has two distinct indicia, one of which is displayed when the rotor is in one limit position and the other is displayed when the rotor is in its other limit position. Movement of the rotor is effected by energizing the coil so as to magnetize the pole piece with a polarity such that the pole piece will magnetically influence the rotor to rotate on its axis. Attraction of the pole piece to one of the salient permanent magnet poles of the rotor acts to magnetically latch the rotor so as to maintain a steady state indication.

Other features and advantages of the present invention are set forth in or rendered obvious by the following detailed specification which is to be considered together with the accompanying drawings.

THE DRAWINGS

FIG. 1 is an exploded view in perspective of a preferred embodiment of the invention;

FIG. 2 is a longitudinal, partial sectional, view of one embodiment of the invention;

FIG. 3 is a perspective view of the assembled indicator; FIG. 4 is an exploded view of the rotor, i.e. indicator member; and

FIG. 5 schematically illustrates an operating circuit for the indicator.

DESCRIPTION OF PREFERRED EMBODIMENT

Turning now to FIGS. 1 and 2, the preferred embodiment of the invention comprises a case 2 that is made of a strong transparent plastic material, e.g. Lexan. The case is generally rectangular in cross-section, comprising a pair of relatively

narrow side walls 4 and 6 and a pair of relatively broad top and bottom walls 8 and 10. As formed, the case is open at one end and its opposite end is closed. Preferably the closed end of the case comprises a circularly curved end wall 12 with the top and bottom walls being bevelled at that end to form angular faces as shown at 14 and 16 so as to facilitate viewing of the indicator member from the side as well as straight on. Although the case 2 may be transparent from one end to the other, it is preferred that the side walls and the top and bottom walls be rendered opaque and the curved end wall 12 and the bevelled faces 14 and 16 be transparent as illustrated. The case may be made opaque by coating it with a heat-resistant paint 17 or by other methods known to persons skilled in the art. Use of a fully transparent case may be tolerated where the indicator is mounted in a mounting panel so that only the curved surface 12 and the bevelled faces 14 and 16 protrude from the panel and are visible to the observer.

Referring again to FIGS. 1 and 2, the indicator comprises a combined bobbin and rotor support identified generally at 18. This element of the indicator is made of an electrically insulating material, preferably a plastic material such as nylon reinforced with glass fibers. The element 18 comprises a shaft-like portion 22 of rectangular cross section, with a rectangular flange 24 formed at one end and a rectangular end wall or flange 26 formed at its opposite end. The shaft-like section 22 is hollow, having an axial passageway 27 of rectangular cross-section that extends through the flanges 24 and 26 as shown. The flanges 24 and 26 and the shaft-like portion 22 together form a bobbin on which is wound an operating coil 28 as hereinafter described. Additionally, the end wall or flange 26 forms part of the rotor support. In this connection it is to be noted that two like ears 30 and 32 are formed integral with the wall 26 at its broadest sides. The end wall 26 also is enlarged at two sides as shown at 34 so as to provide reinforcement for it and the two ears. The two ears are each provided with round holes 36. These holes are aligned with each other and are located at a point remote from the end wall 26. It is to be noted that end wall 26 and the two ears essentially form a U-shaped yoke. The mutually confronting surfaces of the two ears are formed with like ribs 40 that extend parallel to the shaft-like section 22. The holes 36 extend through these ribs. The ribs provide reinforcement for the two ears and also act as bearing surfaces for the rotor.

An elongate core member 44 is mounted within the combined bobbin and rotor support 18. This core member is made of a magnetic material such as soft iron. A preferred material is that sold commercially under the trademark NIRON. The core member has a rectangular cross section similar to the cross-sectional configuration of the interior of the bobbin and is sized so as to make a snug fit within the passageway 27. As shown in FIG. 2, one end of the core member preferably terminates just short of the outer end surface of the flange 24, while the opposite end of the core member extends between the two ears and stops short of the holes 36. This end of the core member is twisted as shown at 46 so that the broader sides 48 thereof extend parallel to the axes of the two holes 36.

The indicator element of the indicator is a rotor as shown at 50. This rotor is formed of two identical complementary parts 52 and 54 that are made of plastic, e.g. Lexan. Each of the parts is essentially semi-circular, comprising a circularly curved or arcuate surface 56, flat side surfaces 58 and 60, and a flat diametrically extending surface 62. Each of the two rotor parts is provided with a cavity 64 of square cross section, the cavity extending radially and at a right angle to the diametrically extending surface 62. Additionally, each of the rotor parts is provided with an arcuate slot 66 at its periphery, the arcuate slot commencing at the diametrically extending surface 62 and terminating just short of the cavity 64. The width of the slots 66, i.e., the distance between its side walls, is greater than the width of the broad surfaces 48 of the core member. Each of the rotor parts is also formed with a pin unit at one side, the pin unit comprising a short pin 68 and an enlarged round flange 70. The center axis of pin 68 and flange 70

is the center of curvature of surface 56. The two rotor parts fit together so that the slots 66 form one continuous slot and the cavities 64 form one continuous cavity. When the rotor is being assembled, a permanent magnet 72 having salient poles at its opposite ends is disposed within the cavities 64.

The assembled rotor 50 is mounted in the device by flexing the two ears apart just enough to permit the pins 68 to be slipped into the holes 36. The inherent resiliency of the two ears maintains the bearing surface of ribs 40 against the flanges 70 and thereby limits translational movement of the rotor along the axis of the pins while permitting it to rotate. As seen in FIG. 2, the rotor is mounted between the two ears as above described so that the slot 66 faces the core member 44, with the twisted end of the core member extending into the slot 66 but spaced from the sides and base of the slot so as to permit the rotor to rotate freely on its axis. However, the twisted end of the core member can intercept the end surfaces 74 and 76 of the slots 66 when the rotor is rotated. Accordingly, rotation of the rotor is limited between first and second limit positions that are determined by engagement of its slot surfaces with the core member. The assembled rotor is adapted to indicate one state or another according to whether it is in one or the other of its two limit positions. The binary indication may be achieved by means of any suitable indicia. Preferably the binary indication is achieved by making the two rotor parts of contrasting colors. Preferably one of the parts 52 and 54 is black and the other is white. Since these parts are made of plastic, the coloring agents may be embodied in the plastic molding compound. Alternatively, the parts may be colored by painting them.

Completing the indicator is a printed circuit tabbing board 78 made of an electrical insulating material and having a pair of notches 80 and 82 at opposite sides and a pair of conductive lands 86 and 88 on one face. These lands serve as connecting points for the ends of the coil 28 and a pair of terminal leads 90 and 92. The tabbing board is mounted in the case 2 against the flange 24 of the combined bobbin and rotor support 18, with the conductive lands facing away from the flange 24.

The above described indicator is easily assembled. One mode of assembly is as follows. First the rotor is assembled by cementing its two parts 52 and 54 together with the magnet 72 captivated between them as shown. Then the core 44 is inserted in passageway 27. The core is secured in place in the bobbin. This may be done by sizing the core so that it makes a force fit in hole 27. Preferably, however, it is cemented in place. Then the tabbing board 78 is cemented to the flange 24 of the combined bobbin and rotor support 18 and the coil 28 is wound on the bobbin. The two ends of the coil are lead through the notches 80 and 82 and soldered or welded to the lands 86 and 88. It is to be noted that the short sides of flange 24 may be provided with short notches as shown at 94 in FIG. 1 to facilitate leading the ends of the coil through the notches 80 and 82 to the conductive lands. Then the rotor is mounted to the combined bobbin and rotor support 18 by flexing the ears 30 and 32 apart far enough to permit the pins 68 to be inserted in holes 36. Preferably one part of the rotor is white and the other is black. Thereafter the foregoing assembly is inserted in the case 2. The extent to which the assembly can be inserted in the case is limited by engagement of the ears 30 and 32 with the inside surfaces of the bevelled faces 14 and 16. The length of the ears and the angle of inclination of the bevelled faces is such that as seen in FIG. 1, the assembly cannot be inserted far enough for the rotor to engage the inside surfaces of the curved end wall 12 and the bevelled faces 14 and 16. In practice the assembly is insertable far enough to leave about one-sixteenth to one-eighth inch clearance between the rotor and the curved end wall and the sides of the rotor have a minimum clearance of about the same magnitude with respect to the inside surfaces of the bevelled faces of the case. Before the assembly has been inserted, terminal pins 90 and 92 are secured by welding or soldering to the lands 86 and 88 respectively. A potting compound as shown at 96 is applied over the tabbing board to reinforce the terminal pins and lock

the assembly in place. The potting compound may be an epoxy resin and also serves to hermetically seal off the interior of the case 2.

A typical operating circuit for the indicator is shown in FIG. 5. This circuit comprises a DC power source 98 and two reversing switches 100 and 102. The latter may be conventional single-pole, double throw switches with their pole terminals connected to the positive and negative sides of the power source as shown. The two contact terminals of switches 100 and 102 are identified by numerals 104 and 106. Contact 104 of switch 100 and contact 106 of switch 102 are connected to terminal pin 90, while contacts 106 of switch 100 and contacts 104 of switch 102 are connected to terminal pin 92. The moveable contacts of the two switches are ganged together so as to close on contact terminals 104 and 106 of switches 100 and 102 simultaneously or on contact terminals 106 and 104 of switches 100 and 102 simultaneously.

Operation of the indicator is straightforward. Assume that the switches are positioned as shown in FIG. 5 and that the rotor is positioned so that its north pole is nearest to the core 44 and the black surface of the rotor is visible through the front end of the case. If now the switches are reversed, current will flow through the coil in one direction to establish a magnetic field which magnetizes the pole piece so that its twisted end is a north pole. When this occurs the north pole of the rotor magnet is repelled and the rotor is caused to rotate until its south pole is nearest to the pole piece and its white surface is visible through the front end of the case. If subsequently the switches are again reversed, the resulting magnetic field will magnetize the pole piece so that its twisted end becomes a south pole. When this occurs, the south pole of the rotor magnet is repelled and the rotor will return to its original position to again provide a black display. It is not necessary to maintain current through the coil to maintain a current display. If the power source is turned off, the rotor will hold its position due to the attraction of the pole piece for the adjacent pole of the rotor's magnet.

An advantage of the unit is that it may be operated by pulses of current. The current pulses need be of amplitude and duration just sufficient to cause the rotor magnet to reverse its position. Once the pulse has passed, the rotor will hold its new display position until a new pulse of opposite polarity is applied to the coil, whereupon it will rotate to its other display position. Of course, a second oppositely wound coil may be disposed around the core and additional terminal pins provided for energizing this second coil. With two oppositely wound coils, reversal of the rotor may be achieved with pulses of the same polarity.

What is claimed is:

1. An electromagnetic indicator comprising:
 - a rotor support having a pair of spaced ears;
 - a rotor having oppositely polarized permanent magnet poles, said rotor being disposed between said ears;
 - said ears and rotor having cooperating means for releasably and rotatably mounting said rotor to said ears so that said permanent magnet poles reside in a common plane that extends transversely of the axis of rotation of said rotor;
 - first and second stop means on said rotor;
 - a magnetic pole piece extending along said common plane and transversely of said axis of rotation, said pole piece extending close enough to said rotor to intercept (a) said first stop means when said rotor is rotated in a first direction and (b) said second stop means when said rotor is rotated in a second opposite direction, whereby to establish first and second limit positions respectively for said rotor; and
 - electromagnetic field generating means for magnetizing said pole piece so as to magnetically influence said rotor to rotate to one or the other of said limit positions.
2. An indicator according to claim 1 wherein said electromagnetic field generating means comprises:
 - a hollow bobbin surrounding a portion of said pole piece;
 - a coil of electrically conductive wire wound around said bobbin; and

terminal leads connected to the ends of said coil for coupling said coil to a source of electrical current, said ears being integral with said bobbin.

3. An indicator according to claim 1 wherein said ears are resilient and said cooperating means are adapted to provide a detent connection between said rotor and said ears. 5

4. An indicator according to claim 3 wherein said cooperating means comprises a pair of aligned pins on said rotor and a pair of aligned holes in said ears, said ears being spaced from one another so that they must be spread apart by flexing in order to insert said pins in said holes. 10

5. An indicator according to claim 3 wherein said pins are integral parts of said rotor.

6. An indicator according to claim 5 wherein said rotor comprises two parts secured together, with one of said pins formed integral with one of said parts and the other of said pins formed integral with the other of said parts. 15

7. An indicator according to claim 5 wherein said rotor has a circumferentially extending slot in its periphery, and further wherein said first and second stop means are surfaces at the opposite ends of said slot and said pole piece extends into said slot. 20

8. An indicator according to claim 1 further including:

a plastic case enclosing said rotor, said ears, said pole piece and said electromagnetic field generating means; 25
said rotor having indicia and at least a portion of said plastic housing being transparent so as to render one portion of said rotor visible when said rotor is in said first limit position and a second portion of said rotor visible when said rotor is in said second limit position. 30

9. An electromagnetic indicator comprising:

a one-piece plastic case open at one end and closed at its opposite end, said case being transparent at least at said opposite end;

a combined coil and rotor support means comprising a hollow bobbin with a pair of spaced ears at one end of said bobbin, said coil and support means being disposed within said case with said ears located at said opposite end of said case, 35

an elongate magnetic core member disposed within said bobbin, one end of said core member projecting between said ears; 40

a rotor disposed between said ears, said rotor having two distinct indicia for indicating two different states of said 45

indicator and a permanent magnet with salient magnetic poles at opposite sides of the axis of rotation of said rotor; means rotatably mounting said rotor to said ears;

means for limiting rotation of said rotor between first and second limit positions;

a coil of electrically conductive wire wound on said bobbin about said core member for producing when energized by an electric current a magnetic field that magnetizes said core member with a polarity determined by the direction of said current through said coil;

terminal leads connected to the ends of said coil for energizing said coil with current from a selected source of current, said terminal leads projecting out of said one end of said case; and

means sealing off said one end of said case.

10. An indicator according to claim 9 wherein said rotor mounting means comprises cooperating relatively rotatable detent means on said ears and said rotor, said detent means being adapted to permit removal of said rotor by flexing said ears.

11. An electromagnetic indicator comprising in combination:

a member comprising a hollow bobbin and a rotor support;

a core of magnetic material within said bobbin;

a coil wound on said bobbin and surrounding at least part of said core;

a rotor rotatably mounted to said rotor support, said rotor being distinctively finished for visual indications of position and comprising a permanent magnet, said permanent magnet being magnetically coupled to said core so as to produce rotation of said rotor upon a change in the polarity of said core induced by energization of said coil; and

a housing in which said member and rotor are disposed, said housing having end and side windows for viewing the presented distinctive surface of the rotor.

12. An indicator according to claim 11 wherein:

said rotor support comprises a pair of spaced resilient ears formed integral with one end of said bobbin, and a hole in each ear; and further wherein

said rotor comprises two identical halves secured together, each of said halves being formed with a pin at one side, said pins being mounted in the said holes in said ears.

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