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Boyd

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[54] **MAGNETIC ACTUATOR DEVICE**

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[52] **U.S. Cl.** **335/234,** 335/274, 340/373

[51] **Int. Cl.** **H01t 7/08**

[58] **Field of Search** 340/373, 378; 335/229, 335/230, 234, 274

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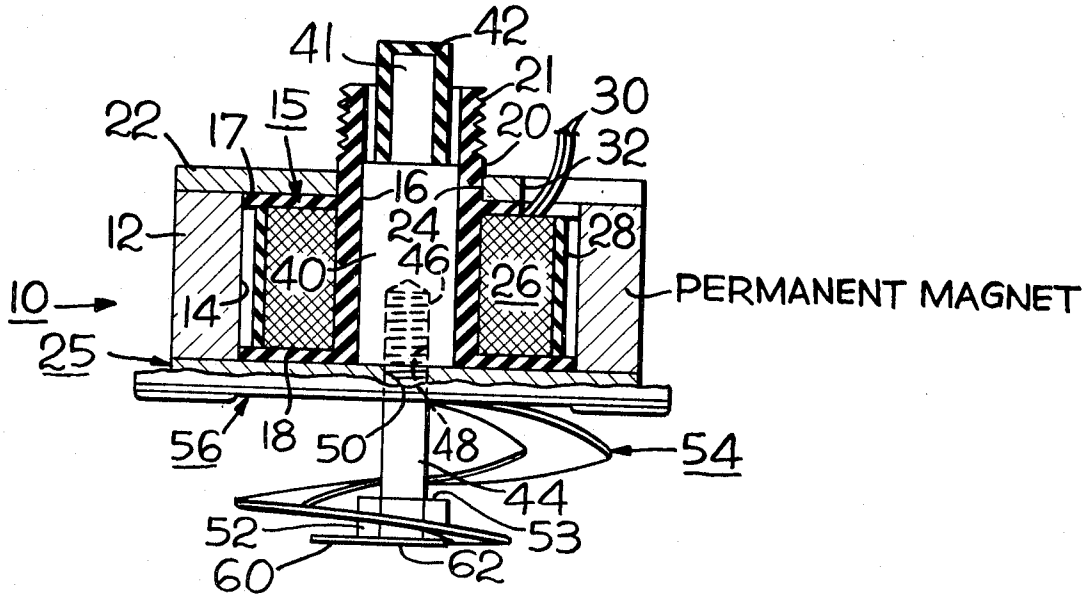
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[57] **ABSTRACT**

There is provided in accordance with an embodiment of the invention a magnetic actuator device comprising an annular-shaped permanent magnet having magnetic pole pieces in contact with the opposite axial ends of the permanent magnet. A bobbin member of a nonmagnetic electrically insulating material such as nylon is coaxially and concentrically positioned within the central opening of the annular permanent magnet. A trip coil connected to an electrical signal source is positioned on the hollow cylindrical hub of the bobbin. A cylindrical plunger or armature of magnetic material is positioned for axial linear sliding movement in the hollow hub of the bobbin. The forward end of the plunger carries a colored stud member which projects forwardly of the front pole piece and serves by its position as an indicator of whether the magnetic actuator device is in tripped or untripped condition. The rearwardly facing end of the magnetic plunger carries a nonmagnetic spindle which projects rearwardly through the rear pole piece and bears against a spiral spring mounted on the rear or outer surface of the rear pole piece. Normally, the magnetic actuator device is in a magnetically latched condition in which the rearwardly facing end of the plunger bears against the inner face of the rear pole piece, with the armature being held in this magnetically latched position against the force of the spring by the magnetic flux from the permanent magnet passing through the magnetic plunger. Upon the receipt of a momentary electrical signal pulse on the coil, a magnetomotive force with resulting magnetic flux is set up by the coil which opposes the magnetic flux of the permanent magnet to a sufficient extent to permit the spring to rapidly move the plunger to its forward or tripped position, thereby causing the signal indicator carried by the plunger to be projected forwardly to a position in which it indicates that the magnetic actuator device has been tripped. The linear movement of the plunger to tripped position upon the receipt of a trip signal on the coil may also be used to actuate a suitable switch, such as a microswitch, positioned contiguous the magnetic actuator device. The magnetic actuator device may be reset after tripping by manually pushing the plunger rearwardly against the spring force until it magnetically latches against the inner surface of the rear pole piece.

15 Claims, 3 Drawing Figures



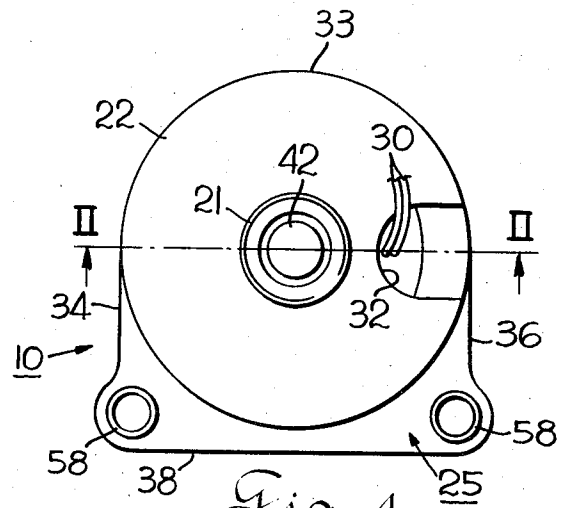


Fig. 1

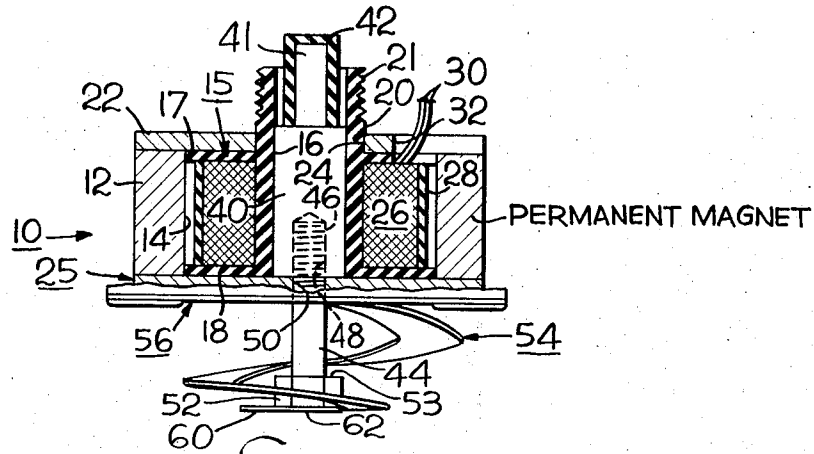


Fig. 2

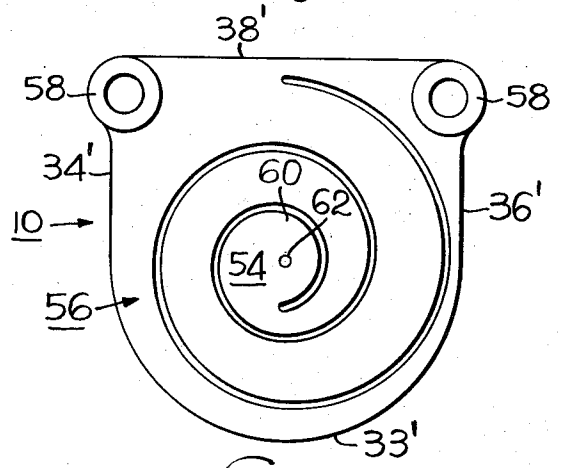


Fig. 3

MAGNETIC ACTUATOR DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to magnetically operated actuator devices such as a magnetic flux cancelling device which may be used, for example, as an indicating device to indicate the occurrence of a fault current such as a ground fault or a phase-to-phase fault, for example. However, the linear mechanical movement produced during the operation of the device of the present invention may be utilized in other ways although it will be described as embodied as used in an indicating device.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a magnetically operated actuator device such as a flux cancelling device which can be manufactured and sold at relatively low cost.

It is a further object of the invention to provide a magnetically operated actuator device which is useful in indicating that a fault has occurred (i.e., a ground fault or phase-to-phase fault) which has caused a circuit breaker to trip.

BRIEF DESCRIPTION OF THE DRAWING

Further objects and advantages of the invention will become apparent from the following description taken in conjunction with the accompanying drawing in which:

FIG. 1 is a front elevation view of the magnetic actuator device of the invention;

FIG. 2 is a view partially in section along line II—II of FIG. 1, and also partially in elevation, showing the plunger or armature of device **10** in magnetically latched position; and

FIG. 3 is a rear elevation view of the device of FIGS. 1 and 2.

In achievement of these objectives, there is provided in accordance with an embodiment of the invention a magnetic actuator device comprising an annular shaped permanent magnet having magnetic pole pieces in contact with the opposite axial ends of the permanent magnet. A bobbin member of a nonmagnetic electrically insulating material such as nylon is coaxially and concentrically positioned within the central opening of the annular permanent magnet. A trip coil connected to an electrical signal source is positioned on the hollow cylindrical hub of the bobbin. A cylindrical plunger or armature of magnetic material is positioned for axial linear sliding movement in the hollow hub of the bobbin. The forward end of the plunger carries a colored stud member which projects forwardly of the front pole piece and serves by its position as the indication of whether the magnetic actuator device is in tripped or untripped condition. The rearwardly facing end of the magnetic plunger carries a nonmagnetic spindle which projects rearwardly through the rear pole piece and bears against a spiral spring mounted on the rear or outer surface of the rear pole piece. Normally, the magnetic actuator device is in a magnetically latched condition in which the rearwardly facing end of the plunger bears against the inner face of the rear pole piece, with the plunger or armature being held in this magnetically latched position against the force of the spring by the magnetic flux from the permanent magnet

passing through the magnetic plunger. Upon the receipt of a momentary electrical signal pulse on the coil, a magnetomotive force with resulting magnetic flux is set up by the coil which opposes the magnetic flux of the permanent magnet to a sufficient extent to permit the spring to rapidly move the plunger to its forward or tripped position, thereby causing the signal indicator carried by the plunger to be projected forwardly to a position in which it indicates that the magnetic actuator device has been tripped. The linear movement of the plunger to tripped position upon the receipt of a trip signal on the coil may also be used to actuate a suitable switch, such as a microswitch, positioned contiguous the magnetic actuator device. The magnetic actuator device may be reset after tripping by manually pushing the plunger rearwardly against the spring force until it magnetically latches against the inner surface of the rear pole piece.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawing, the magnetic actuator device of the invention is generally indicated at **10** and comprises an annular-shaped permanent magnet **12** which may, for example, be a ceramic compound of barium ferrite mixed with ferric oxide. Such ceramic permanent magnet materials are well known in the art under the general name "ferrite" and are manufactured under the trade name "Arnox" by Arnold Engineering Company and under the trade name "Indox" by Indiana General Corporation. The annular shape of permanent magnet **12** defines a central opening **14.**

A bobbin of a nonmagnetic, electrically insulating material such as nylon generally indicated at **15,** is positioned within the central opening **14** of the annular-shaped permanent magnet **12** in coaxial and concentric relation to permanent magnet **12.** Bobbin **15** includes an axially extending hollow cylindrical hub portion **16** and radially extending front and rear flanges **17** and **18.** The outer diameter of the radially extending flanges **17** and **18** is just slightly less than the inner diameter of the annular permanent magnet **12.** Hollow hub portion **16** of bobbin **15** also includes a hollow axial extension **20** which projects axially beyond the front flange **17** of the bobbin relative to the view of FIG. **2** and through a passage **24** in the generally disc-shaped front pole piece **22** of the device **10.** Axial extension **20** of bobbin hub **16** is threaded as indicated at **21** to permit mounting of device **10** on a panel or the like.

Front pole piece **22** has the same outer diameter as annular permanent magnet **12** and is suitably adhesively attached to the axially front end annular surface of annular permanent magnet **12.** The disc-shaped pole piece **22** is made of a suitable magnetic material such as soft iron or soft steel.

An electrical winding or coil **26** is mounted on hub **16** of bobbin **15** and a wrapping of a suitable insulating material **28** is positioned on the outer periphery of the winding **26.** Electrical leads or conductors **30** connected to winding **26** extend through a suitable opening or slot **32** in front pole piece **22** to permit connection of winding **26** to the electrical signal source.

A back magnetic pole piece generally indicated at **25** formed of the same magnetic material such as soft iron or soft steel as the front magnetic pole piece **22** is adhesively secured to the back annular surface (or lower surface relative to FIG. **2**) of permanent magnet **12.**

As viewed in FIG. 1, back pole piece 25 has a semicircular peripheral edge 33 having the same radius as front pole piece 22 for 180 degrees of its periphery (the upper 180 degrees as viewed in FIG. 1). For the lower half of its periphery, back pole piece 25 is of generally rectangular shape, as bounded by the straight or flat edges 34, 36, 38. Straight or flat edge 38 might be considered the "base edge" of device 10.

The internal periphery of hollow cylindrical hub member 16 of bobbin 15 serves as a bearing for a linearly movable cylindrical plunger or armature member 40 of a suitable magnetic material such as soft iron or soft steel.

The outer diameter of the cylindrical plunger member 40 is just sufficiently less than the inner diameter of the hollow cylindrical bobbin hub 16 (and of the hollow cylindrical axial extension 20 of hub 16) to permit easy linear sliding movement of the plunger as will be described. The axial length of plunger or armature 40 is such that in the magnetically latched position of armature 40, as seen in FIG. 2 the axially innermost or rear end surface of armature 40 abuts against the inner surface of rear pole piece 25 while the opposite axial end or forward end of the armature 40 projects slightly beyond the forward surface or axially outer surface of front pole piece 22.

The forward end of magnetic plunger 40 has a sleeve-like stud member 42 of a colored (such as red), preferably nonmagnetic and preferably electrically insulating plastic material or the like suitably pressed onto an integral reduced diameter extension 41 which forms part of and is carried by plunger or armature 40. A spindle member 44 of a suitable nonmagnetic preferably electrically insulating material such as a suitable plastic material such as nylon has a threaded end 46 which is in threaded engagement with a threaded bore 48 in the rearwardly facing surface of plunger 40. Spindle 44 extends through a passage 50 in back pole piece 25 and projects, in the magnetically latched position shown in FIG. 2, for a distance, for example, approximately one-half inch rearwardly of back pole piece 25, in the illustrated embodiment. Spindle 44 is provided with an enlarged head portion 52 at the axially rearmost end thereof which cooperates with the spring generally indicated at 54 to be hereinafter described.

A thin sheet of a spring-like material such as beryllium cooper or the like, generally indicated at 56 (FIG. 3) is mounted on back pole piece 25. Sheet 56 has substantially the same contour as back pole piece 25 as previously described, including a semicircular edge portion 33' which substantially coincides with semicircular edge portion 33 of back pole piece 25, and straight or flat edge portions 34', 36', 38' which respectively coincide with edge portions 34, 36, 38 of back pole piece 25. Edge 38' of beryllium copper sheet 56 is secured to corresponding edge 38 of back pole piece 25 by rivets 58 or other suitable fasteners. With the exception of the rivets 58 which secure bottom edge 38' of beryllium copper sheet 56 to the corresponding edge 38 of pole piece 25, the beryllium copper sheet 56 is otherwise free or unsecured to the rear surface of the rear pole piece 25.

Prior to being secured to the surface of the pole piece 25, the beryllium cooper sheet 56 is subjected to a photographic etching process whereby to cut from the sheet 56 the spiral spring member generally indicated at 54 which is extendable in spring-like fashion from the remaining portions of sheet 56, while still remaining attached to sheet 56, as best seen in the magnetically latched position of FIG. 2 in which spring 54 is in its extreme tensioned position. During the outer axial movement of spiral spring 54 to its tensioned position as seen in FIG. 2, when armature 40 is moved to its magnetically latched position, the peripheral edges 33', 34', 36', 38' of the beryllium copper sheet 56 remain in substantially a common plane substantially parallel to the flat rear surface of rear pole piece 25. Spring 54 includes a central nub 60 having a point 62 which lies substantially in alignment with the central longitudinal axis of spindle 44. The enlarged head portion 52 at the outer or rearmost end of spindle 44 is adapted to engage and be engaged by the nub portion 60 of spring 54.

DESCRIPTION OF OPERATION

The device 10 is placed into magnetically latched position as seen in FIG. 2 of the drawing by manually pushing inwardly on stud portion 42 at the forward or front end of the magnetic plunger or armature 40, causing the rearward end of the plunger 40 to move against the force of spring 54 until the axially rearmost end of plunger 40 moves into engagement with the inner surface of rear pole piece 25. In this position of the armature, the armature is held in magnetically latched position by the magnetic flux which passes from the annular permanent magnet 12 into the rear pole piece 25 and thence forwardly through the magnetic armature 40 in its magnetically latched position, the magnetic flux returning from forward end of armature 40 to the forward or front pole piece 22. It should also be noted that the magnetic circuit of the magnetic flux from the forward end of the plunger 40 to the front pole piece 22 includes a annular nonmagnetic gap defined by the radial thickness of the hub portion 16 of bobbin 15. In the magnetically latched position of the device 10 as seen in FIG. 2, the head portion 52 on the rearmost end of the plastic spindle 44 engages the central nub 60 of spring 54 and holds the spiral spring 54 in the extended position shown in the magnetic latched position of FIG. 2 in which the spring 54 is tensioned and exerts a force on armature or plunger 40 through spindle 44 trying to return plunger 40 to its unlatched position.

The coil 26 on the bobbin 15 is wound in such direction that when a signal, such as a fault signal, for example, is received through the conductors 30 which connect the signal source to coil 26, a magnetomotive force (MMF) is set up by the coil during the brief moment of a pulse signal which might last, for example, for 12 milliseconds, that will oppose the magnetic field of the permanent magnet 12 in such manner as to reduce the magnetic force holding the armature 40 in it magnetically latched position against the inner surface of rear pole piece 25 to such an extent as to permit the force of the tensioned spring 54 to return the plunger to its unlatched position. When the inner end 53 of the head portion 52 of spindle 44 abuts against the rear surface of rear pole piece 25, the plunger 40 will have reached the limit of its forward travel in the unlatching direction. The unlatching movement of plunger 40 under the influence of the spring 54 upon the receipt of a signal pulse on the coil 26 will, of course, advance the colored plastic stud 42 to a position forwardly of that shown in the view of FIG. 2 by distance equal to the stroke of the plunger 40 during the unlatching mo-

tion just described. This advanced position of the colored stud portion **42** attached to plunger **40** will serve as indication to an observer that the device **10** has been moved to its tripped position by the receipt of a signal pulse on coil **26**, thereby advising the observer that a predetermined condition has occurred such as a ground fault or a phase-to-phase fault which may have caused an associated circuit breaker to trip. Of course, the particular signal which is used to energize the coil **26** may be derived from any suitable source and may indicate any desired condition. It should also be noted that during the tripping operation of device **10** the linear movement of the stud portion **42** at the forward end of the device **10** or the corresponding linear movement of the nub portion **60** of spring **54** at the rear of device **10** may be utilized to actuate a suitable switch device such as a microswitch, for example, to thereby perform some desired switching operation such as the actuation of an alarm signal or the like.

When plunger **40** moves to its advanced forward position upon the receipt of a trip signal on coil **26** as previously described, plunger **40** will remain in the tripped position until it is manually reset by manually pushing on stub **42** at the forward end of the device **10** to axially push the plunger toward the rear pole piece **25** to the position in which the plunger is held in its magnetically latched position as previously explained.

From the foregoing detailed description of the invention, it has been shown how the objects of the invention have been obtained in a preferred manner. However, modifications and equivalents of the disclosed concepts, such as readily occur to those skilled in the art are intended to be included within the scope of this invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A magnetic actuator device comprising a permanent magnet, said magnet having a central opening therein, a bobbin of nonmagnetic material positioned within said central opening in concentric coaxial relation to said permanent magnet, an electrical winding positioned on said bobbin, said winding being adapted to be connected to an electric signal source, a first magnetic pole piece in contact with one axial end of said permanent magnet, a second magnetic pole piece in contact with the opposite axial end of said permanent magnet, said bobbin having a hollow hub lying substantially along the central longitudinal axis of said actuator device, a magnetic armature positioned in said hollow hub of said bobbin and being axially movable along said hub, means carried by said armature at one end of said armature contiguous said first magnetic pole piece, said means being movable by movement of said armature to an extended position forwardly of said first magnetic pole piece, a spindle member carried by the opposite end of said armature and movable with said armature, said spindle member extending through a passage in said second magnetic pole piece, a spring mounted on the outer surface of said second magnetic pole piece, said spindle member engaging said spring, said armature being movable against the force of said spring to a position in which it is magnetically latched by magnetic flux from said permanent magnet against the inner surface of said second magnetic pole piece, a signal on said electrical winding being effective to counteract the magnetic effect of said permanent magnet of said armature sufficiently to permit said spring to move said armature axially away from said second pole piece, whereby to cause said means carried by said armature to be projected to an extended position forwardly of said first pole piece.

2. A magnetic actuator device as defined in claim **1** in which said means carried by said armature at said one end of said armature is an indicating device to indicate whether said actuator device has been moved to tripped position.

3. A magnetic actuator device as defined in claim **1** in which said means carried by said armature comprises a sleeve-like stud member mounted on an integral extension of said armature.

4. A magnetic actuator device as defined in claim **1** comprising a sheet of spring-like metal secured to said outer surface of said second pole piece, and a spiral spring etched from said sheet of metal but remaining connected to said sheet of metal, said spindle engaging and being engaged by said spiral spring.

5. A magnetic actuator device as defined in claim **4** in which said first pole piece has a circular outer periphery having a diameter substantially the same as the outer diameter of said annular permanent magnet, said second pole piece having a semicircular outer periphery having substantially the same radius as the outer radius of said annular permanent magnet, the remaining portion of the periphery of said second pole piece being of generally rectangular-shape and formed of straight edges, the outer peripheral contour of said sheet of spring-like metal being substantially the same as the peripheral contour of the outer face of said second pole piece.

6. A magnetic actuator device as defined in claim **1** in which said permanent magnet is of annular shape, and said central opening is defined by said annular shape.

7. A magnetic actuator device as defined in claim **1** in which the axial end of said armature which magnetically latches against the inner surface of said second magnetic pole piece lies substantially entirely radially inwardly of said permanent magnet and has a substantially smaller area than the area of said inner surface of said second magnetic pole piece.

8. A magnetic actuator device as defined in claim **1** in which said spindle is made of nonmagnetic material.

9. A magnetic actuator device as defined in claim **1** in which said means carried by said armature remains projected in said extended position until said armature is reset by a force external of said device against the force of said spring to a position in which said armature is again magnetically latched against the inner surface of said second magnetic pole piece.

10. A magnetic actuator device as defined in claim **1** in which said spindle includes an enlarged head portion engaging said spring, said head portion serving as a stop which engages the outer surface of said second pole piece to limit the tripping movement of said armature, the distance of the axial tripping movement of said armature as determined by the position of said head portion being such that upon completion of said tripping movement said armature has moved a sufficient axial distance away from the inner surface of said magnetic pole piece that said armature must be reset by a force external of said magnetic actuator device against the force of said spring to a position in which said armature

is again magnetically latched against the inner surface of said second magnetic pole piece.

11. A magnetic actuator device comprising a permanent magnet, said magnet having a central opening therein, a bobbin of nonmagnetic material positioned within said central opening in coaxial relation to said permanent magnet, an electrical winding positioned on said bobbin, said winding being adapted to be connected to an electric signal source, a first magnetic pole piece in contact with one axial end of said permanent magnet, a second magnetic pole piece in contact with the opposite axial end of said permanent magnet, said bobbin having a hollow hub lying substantially along the central longitudinal axis of said actuator device, a magnetic armature positioned in said hollow hub of said bobbin and being axially movable along said hub, an indicator device carried by said armature at one end of said armature contiguous said first magnetic pole piece, said indicator device being movable by movement of said armature to an extended position forwardly of said first magnetic pole piece, a spindle member carried by the opposite end of said armature and movable with said armature, said spindle member extending through a passage in said second magnetic pole piece, a spring mounted on the outer surface of said second magnetic pole piece, said spindle member engaging said spring, said armature being movable against the force of said spring to a position in which it is magnetically latched by magnetic flux from said permanent magnet against the inner surface of said second magnetic pole piece, a signal on said electrical winding being effective to counteract the magnetic effect of said permanent magnet on said armature sufficiently to permit said spring to move said armature axially away from said second pole piece, whereby to cause said indicator device carried by said armature to be projected to said extended position forwardly of said first pole piece, said indicator device remaining projected in said extended position until said armature is reset by a force external of said magnetic actuator device against the force of said spring to a position in which said armature is again magnetically latched against the inner surface of said second magnetic pole piece.

12. A magnetic actuator device as defined in claim **11** in which said permanent magnet is of annular shape, and said central opening is defined by said annular shape.

13. A magnetic actuator device as defined in claim **11** in which said spindle is made of nonmagnetic material.

14. A magnetic actuator device as defined in claim **11** in which said spindle includes an enlarged head portion engaging said spring, said head portion serving as a stop which engages the outer surface of said second pole piece to limit the tripping movement of said armature, the distance of the axial tripping movement of said armature as determined by the position of said head portion being such that upon completion of said tripping movement said armature has moved a sufficient axial distance away from the inner surface of said magnetic pole piece that said armature must be reset by a force external of said magnetic actuator device against the force of said spring to a position in which said armature is again magnetically latched against the inner surface of said second magnetic pole piece.

15. A magnetic actuator device as defined in claim **11** comprising a sheet of spring-like metal secured to said outer surface of said second pole piece, and a spiral spring etched from said sheet of metal but remaining connected to said sheet of metal, said spindle engaging and being engaged by said spiral spring.

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