ABSTRACT: An electromagnetically operated device is disclosed, the purpose of which is to selectively displace an armature between first and second positions. The solenoid-type device includes a coil member having a pair of energizing leads extending therefrom, a magnetic flux path surrounding the coil member, and a cover member surrounding the magnetic flux path. A portion of the magnetic flux path is defined by a magnetizable sleeve surrounding the coil member and in direct contact therewith so as to concentrate the flux generated by the coil. The sleeve includes an elongated gap along its length to facilitate the passage of the pair of energizing leads from the coil to an external electrical source. The cover member is constructed of nonmagnetic material such as nylon, whereby the cover remains relatively cool and at the same time does not attract extraneous metallic particles. Although the electromagnetically operated device of the instant invention was particularly designed for alternately opening and closing a valve fluid path, a special adapting member makes the electromagnetically operated unit applicable to a variety of other applications which might necessitate the utilization of a selectively displacable member. A unique assembling procedure makes the entire unit easily removable from its functional environment.
SOLENOID VALVE HAVING A SLOTTED FLUX SLEEVE FOR NESTING THE WINDING LEADS

BACKGROUND OF THE INVENTION

This invention relates to electromagnetically operated solenoid-type devices and more particularly relates to simple, multipurpose, easily assembled, electromagnetically operated solenoid devices having improved operating characteristics.

As well known in the art, a typical electromagnetically operated solenoid-type device is essentially a coiled energizable coil having a core magnetizable core within which a magnetizable armature is displaceable between first and second positions in response to the energization of the coil. Conventionally, a magnetic flux path, such as a core of soft iron or other magnetizable material, surrounds the coil to establish a path for the flux generated by the coil. When the coil is deenergized, the armature is drawn against the biasing means toward the center leg of the magnetic flux path to establish its second operative position.

One of the problems which has continually plagued designers of electromagnetically operated devices revolves around the relatively large overall size of these devices which has been dictated in part by the requirement for internal space and storage: provisions for the energizing lead conductors, which extend from the internal coil to an electrical source external to the device. Thus in typical prior art solenoid devices, the coil winding terminates in a pair of energizing leads which extend laterally from the coil toward the cylindrical length thereof. These leads are then turned parallel to the longitudinal axis of the coil and brought out through the cover of the device, normally through an insulating bushing provided in the transversely-located planar rear end portion of the cover.

It will be appreciated that the energizing conductors lying on the external cylindrical surface of the coil have the effect of increasing the effective diameter of the coil. Consequently, in prior art devices, the internal diameter of the surrounding magnetic flux path corresponds to the outermost diameter of the entire coil structure which includes the diameter of the wound coil plus the additional diametric dimension added by the coil leads. Since the coil leads occupy but a small volumetric space, there results a substantial airspace between the major external surface area of the coil structure and the innermost surface of the magnetizable material which establishes the flux path. Such space has the effect, in operation, of diluting the magnetic flux concentration established by the coil and thereby requires a significantly larger coil to establish a given armature pull.

A second problem inherent in prior art solenoid operated devices, and somewhat related to the above described problem, relates to the cover member customarily used by solenoid manufacturers. Typically, such covers are constructed of magnetizable material such as steel or other highly magnetically permeable materials. However, by virtue of the close proximity of such covers to the magnetic flux path established internally thereof, they become inductively heated and are impossible to touch during operation or within a short time thereafter. Additionally, because such cover members are magnetizable, they can attract all extraneous metallic particles within their immediate vicinity. Finally, the fact that such covers are customarily metallic requires the utilization of the aforementioned insulating bushing through which the coil lead conductors must pass as they leave the solenoid device. As a result, should the electromagnetically operated device stems from the manner of assembly and disassembly thereof. Specifically, such devices are customarily constructed as an integral portion of a particular device in which the displaceable armature finds application. For example, in the area of solenoid operated valves to which the instant invention is particularly directed, in the prior art the

Solenoid operating portion of the device is constructed as an integral portion of the valve body through which the regulated fluid path is established. As a result, should the electromagnetically operated portion of the unit or any part thereof require replacement, it is necessary to remove the entire valve body from the fluid path.

SUMMARY OF THE INVENTION

In contradistinction to the prior art, the instant invention provides an electromagnetically operated device which is simple, small, easy to assemble and disassemble, and solves all of the above described problems inherent in similar prior art devices.

Specifically, and dealing essentially in the order of the problems set out above, the instant invention employs a magnetic flux path including for a portion of its length, a sleeve of magnetizable material which is in direct contact with the coil enclosed thereby. By providing that the magnetic sleeve be in direct contact with the coil, the aforementioned airspace is eliminated and as a result, the flux generated by the coil is more highly concentrated to establish a given armature pull with an overall smaller coil or permit a given coil to develop a greater armature pull than is possible with prior art devices.

In further accordance with the feature of this invention, provision is made for the coil leads by providing such sleeve with an elongated gap along its length which gap together with the internal surface of the cover member, to be described, defines a conductor bearing passageway which facilitates the passage of the coil leads from the coil to the external electrical source.

As a second feature of the instant invention, the cover member thereof is constructed of a nonmagnetizable material such as a plastic i.e., nylon. The provision of the nonmagnetizable cover eliminates the heating problem inherent in the metallic covers of the prior art, prevents the enclosed magnetic flux of the device from attracting extraneous metallic particles, and simultaneously eliminates the necessity of an insulating bushing through which the coil leads must pass to be attached to the energizing source.

Finally, by virtue of a novel construction to be described in greater detail, the unfastening of a single locking member permits the entire electromagnetically operated device of the instant invention to be disassembled without the necessity of either expensive tools or trained personnel. Additionally, such novel assembly construction includes an adapter member by which the solenoid operating portion of the invention can be removably secured to any device, such as the aforementioned valve body member, whereby when replacement is necessary, parts can be removed from the device (i.e., the valve body) without removing the device from its in-line position.

Accordingly, it is an object of the instant invention to provide an electromagnetically operated device which is capable of generating increased armature pull for a given sized coil.

An object of the instant invention is to provide such an electromagnetically operated device which although physically smaller than a similar prior art device provides a greater armature pull.

Another object of the instant invention is to provide such an electromagnetically operated device which includes a magnetic flux path including for a portion of its length a sleeve of magnetizable material which is in direct contact with the external cylindrical surface of an enclosed electromagnetic coil.

Yet another object of the instant invention is to provide such a device wherein the aforementioned sleeve is provided with an elongated gap which receives the leads of the aforementioned electromagnetic coil.

Yet another object of the instant invention is to provide such a device which includes a cover member of nonmagnetizable material, a portion of such cover member and the aforementioned elongated gap defining a conductor bearing passageway to receive the energizing leads of the enclosed coil.
Another object of the instant invention is to provide such an electromagnetically operated device including a nonmagnetizable cover member which remains cool, does not attract extraneous metallic particles, and simultaneously eliminates the necessity of insulating bushings for the passage of coil leads therethrough.

Yet another object of the instant invention is to provide such an electromagnetically operated device, which facilitates the assembly and disassembly thereof with a minimum of tools and without the necessity of skilled personnel.

Yet another object of the instant invention is to provide such a device which includes an adapting member by which the electromagnetically operated portion thereof may be removably secured to any device which requires a displaceable actuating member in its operation.

Still another object of the instant invention is to provide an electromagnetically operated solenoid valve wherein the solenoid portion thereof may be removably secured to the valve port of the flow to which the only region in which the magnetic flux generated by the coil 16 and can be touched even during operation. Additionally, the nonmagnetizable cover member 52 will not attract extraneous metallic articles as do prior art metallic covers. Finally, since the cover 52 is nonmagnetic, the lead conductors 18 may pass directly therethrough without the necessity of an additional insulating bushing which is conventional in prior art devices which employ metallic covers. As desired, however, the cover 52 may be manufactured with an arised embossment 54 thereon to protect the conductors 18 from excessive bending.

Disposed on the opposite side of the second magnetizable end plate 30 is an adapting member 56 constructed of a nonmagnetizable material such as stainless steel. The adapting member 56 includes an externally threaded portion 58 adapted to be threadably received by the internally threaded neck portion 60 of the valve portion 12 with a sealing "O" ring 62 being disposed therebetween. It will be appreciated that although the adapting member 56 is shown in assembled relationship with respect the valve body 12, it is of course within the purview of the instant invention that the adapting member 56 could be received by any other device or body member which requires the utilization of a displaceable armature, such as 38, in its operation.

To retain the adapting member 56, the magnetizable end plates 38 and 30, the coil 16, the sleeve 22, the end plug 36 and the cover 52 in assembled relationship, there is provided a generally cylindrical tubular retaining member 64 of nonmagnetizable material and within which resides the end plug 36 and the armature 38. One end 66 of the tubular retaining member 64 is flanged outwardly and retained within a recessed cavity 68 provided in the adapting member 56. Additionally, the flanges provided 66 of the tubular member 64 is urged against a sealing "O" ring 70 seated in the aforementioned cavity 68. The opposite planar end surface 72 of the tubular member 64 is sandwiched between the end 74 of the end
plug 36 and the planar end surface 50 of the cover 52, it being appreciated that the first magnetic end plate 28 is centrally apertured at 76 to receive the rightmost extremity of the plug 36 and the end surface 72 of the tubular member 64. Thus, when the internally threaded nut 78 is screwed onto the externally threaded extending neck portion 37 of the end plug 36, all of the aforementioned parts will be firmly retained in assembled relationship with respect to one another. It will also be appreciated that should disassembly be necessary, it is only necessary to unscrew the single nut 78 after which the cover member 52, the end plate 28, the coil body 16, the end plate 30, and the adapting member 56 can be easily removed without even requiring that the body portion 12 be removed from its in-line position about to be described.

As noted, the instant invention is specifically adapted for use in a solenoid operated valve and as such the body member 12 includes an internally threaded entry port 80, and internally threaded exit port 82, and an elongated passageway 84 which establishes fluid communication between the ports 80 and 82 when the armature 38 with a valve member 86 attached thereto is moved to the right against the biasing spring 39 in response to the energization of the coil 16 by the application of current applied to the leads 18 thereof.

One end 88 of a passageway 84 defines a valve seat which sealingly receives the tapered valve member 86 when the coil is deenergized and the spring 39 maintains the armature 38 in the position illustrated in FIG. 2. The valve member 86 is preferably constructed of a plastic material and includes an inverted flanged portion 90 which is somewhat loosely fitted within a similarly shaped but larger dimensioned recess 92 defined in the leftmost extremity of the armature 38. This loose fitting establishes a self-aligning feature which in effect allows the tapered forward surfaces 94 of the valve member 86 to properly seat in the valve seat 88 regardless of slight misalignments of the armature 38 with the tubular member 64.

At the opposite end of the passageway 84 is located the flow orifice 96 which can be selectively made larger (as by drilling) in the event it is desired to increase the gallons per minute rate through the valve body 12. It is to be appreciated that by utilizing a distinct orifice 96 to establish a desired flow rate, the valve seat 88 need never be changed in diameter as is the case in the prior art wherein the valve seat and the flow rate orifice are one in the same.

Thus there has been described an electromagnetically operated solenoid valve which employs a split sleeve in direct contact with the coil enclosed thereby. It may be noted that by placing the sleeve in direct contact with the coil, the increased flux concentration results in a increased armature pull. As an example, it has been found that with a given coil, a prior art valve using 8 watts power was capable of driving its armature against 65 lbs per square inch of oil. Employing the teaching of the instant invention, the same coil required only 5 watts power and generated an armature pull against 140 lbs per square inch of oil. In addition, the solenoid valve of the instant invention had overall smaller dimensions than the prior art device against which it was tested.

Although this invention has been described with respect to its preferred embodiments, it should be understood that many variations and modifications will now be obvious to those skilled in the art, and it is preferred, therefore, that the scope of the invention be limited not by the specific disclosure herein, only by the appended claims.

1. An electromagnetically operated unit for moving an armature between a first and second position; said unit comprising:

a magnetizable coil member having an elongated passageway extending therethrough, said coil member including a pair of conductors extending therefrom;

and further including a cover member surrounding said sleeve;

said gap and said cover member defining a conductor bearing passageway;

and said pair of conductors residing within said conductor bearing passageway for at least a portion of their length;

wherein said cover member includes an integral end portion transversely oriented with respect to said elongated passageway through said coil member; and

wherein said end portion of said cover member includes aperture means through which said pair of conductors passes.

2. The electromagnetically operated unit of claim 1 wherein said cover member is constructed of a nonmagnetizable material.

3. The electromagnetically operated unit of claim 2 wherein said cover member is constructed of a plastic material.

4. The electromagnetically operated unit of claim 3 wherein said plastic material is nylon.

5. The electromagnetically operated unit of claim 1 wherein said end portion of said cover member includes raised embossment means surrounding said aperture means for protecting said pair of conductors.

6. The electromagnetically operated unit of claim 1 further including first and second magnetic end members disposed at opposite ends of said coil member in abutting relationship with the opposite end surfaces of said coil member and the opposite end surface of said sleeve respectively.

said first magnetic end member being disposed between said integral end portion of said cover and one of said end surfaces of said coil member.

7. The electromagnetically operated unit of claim 6 wherein said first magnetic end member includes a cutout section through which said pair of conductors passes.

8. The electromagnetically operated unit of claim 6 and further including a magnetizable end plug disposed in said elongated passageway at one end thereof;

said end plug being spaced from said armature by a predetermined distance to define an airgap when said armature is in its first position.

said sleeve, said first and second end members, said end plug and said armature defining a magnetic path for the flux generated by said coil member.

9. The electromagnetically operated unit of claim 8 wherein said airgap is located substantially in the center of said elongated passageway.

10. The electromagnetically operated unit of claim 8 wherein said armature includes an arcuate elongated slot therein for reducing undesirable eddy currents.

11. The electromagnetically operated unit of claim 10 wherein one end surface of said end plug includes a shading ring therein.

12. The electromagnetically operated unit of claim 8 and further including a centrally apertured nonmagnetizable adapting member disposed adjacent said second magnetizable end member on a side opposite thereof from said coil member;

said adapting member including means by which said adapting member can be secured to a valve body.

13. The electromagnetically operated unit of claim 12 and further including a tubular, nonmagnetizable retaining member surrounding said armature and said end plug, said retaining member having laterally projecting flange means at one end thereof for maintaining said adapting member adjacent said second magnetizable end member.

14. The electromagnetically operated unit of claim 13 wherein a second end of said retaining member includes an integral centrally apertured planar end surface which resides between one end of said end plug and the end portion of said cover member; and
3,593,241

wherein said one end of said end plug includes an outstanding neck portion extending through said planar end surface, said first magnetizable end member, and said end portion of said cover member;

and further including locking means removably securable to said neck portion for maintaining said adapting member, said first and second end members, said sleeve, said coil member, said end plug and said cover member in assembled relationship with respect to one another.

15. The electromagnetically operated unit of claim 12 and 10 further including a valve body removably secured to said adapting member;

said valve body including an entry port, an exit port, and a passageway for interconnecting said entry and exit ports;

one end of said passageway terminating in a seat which is to sealingly receive a valve member when it is desired to interrupt communication between said entry and exit ports; and

further including a valve member secured to said armature, said valve member being sealingly received by said valve seat when said armature is in its first position.

16. The electromagnetically operated unit of claim 15 wherein said valve member is loosely secured to said armature.

17. The electromagnetically operated unit of claim 15 wherein said valve body further includes a flow rate control orifice interconnecting said passageway and one of said entry and exit ports.

18. An electromagnetically operated unit for moving an armature between a first and second position; said unit comprising:

an energizable coil member having an elongated passageway extending therethrough;

an armature slidably disposed within said elongated passageway and movable between first and second position in response to the energization of said coil member;

a magnetic flux path surrounding said coil member;

a nonmagnetizable cover member surrounding said magnetic flux path, said cover member including one centrally apertured end portion which abuts one end surface of said magnetic flux path;

a magnetizable end plug disposed in said elongated passageway at one end thereof, said end plug being spaced from said armature by a predetermined distance to define an airgap when said armature is in its first position;

a centrally apertured nonmagnetizable adapting member disposed adjacent a second end of said passageway, said adapting member having means by which said adapting member can be secured to any device which uses the slidable action of said armature in its operation, said adapting member having a recessed cavity therein;

retaining means having restraining means at one end thereof for restricting said adapting member from longitudinal movement and having planar end means at a second end thereof sandwiched between said end plug and said cover member for restricting said retaining means from longitudinal movement;

said restraining means comprising on outwardly projecting flange portion of said retaining means received within said recessed cavity of said adapting member, and further including an “O” ring disposed within said cavity between the seat of said cavity and said flange portion;

said end plug having an outstanding neck portion which passes through said planar end means, said magnetic flux path and said end portion of said cover member; and

locking means removably secured to said neck portion for maintaining said adapting member, said magnetic flux path, said coil member, said end plug, and said cover member in assembled relationship with respect to one another.

19. The electromagnetically operated unit of claim 18 wherein said magnetic flux path is in direct contact with said coil member.

20. The electromagnetically operated unit of claim 13 wherein said adapting member includes a recessed cavity within which said laterally projecting flange means is received, and further including an “O” ring disposed within said cavity between the seat of said cavity and said flange means.