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3,348,178

SOLENOID ACTUATED DEVICE

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Fig. 1

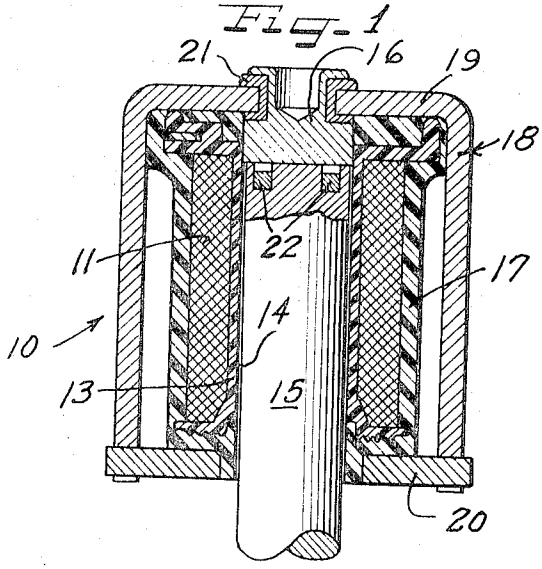
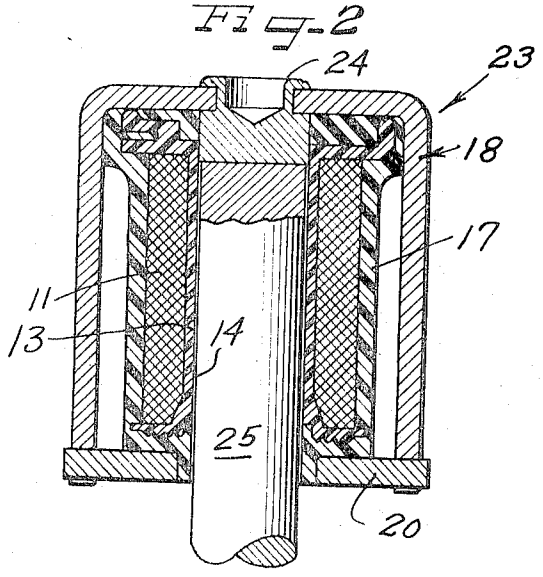


Fig. 2



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SOLENOID ACTUATED DEVICE

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Continuation of application Ser. No. 417,375, Dec. 10, 1964. This application Sept. 20, 1966, Ser. No. 587,359
4 Claims. (Cl. 335—251)

This is a continuation of application Ser. No. 417,375, filed Dec. 10, 1964, now abandoned.

This invention relates to solenoid actuated devices and more particularly to novel structural improvements therein which greatly reduce residual magnetism in the magnetically permeable relatively movable parts.

One common form of solenoid actuated device is one which employs a solenoid having a tubular center portion in which a magnetically permeable armature is disposed for movement axially thereof. The armature is so dimensioned that it extends part way into the solenoid but has its remaining portion projecting out of the solenoid. Such an armature is biased either by gravity or by spring means in a direction tending to move the armature out of the solenoid. Electric energization of the solenoid sets up a magnetic field which attracts the magnetically permeable armature against the action of its biasing force and tries to pull it further into the solenoid. Stop means are provided to limit the inward movement. It is also common to provide a yoke or frame of magnetically permeable material to afford an exterior return flux path from one end of the solenoid to the other. Such a yoke has what might be termed pole portions, one of which forms the stop means at one end of the solenoid and the other of which extends across the other end of the solenoid and is apertured to permit the armature to freely slide therethrough.

Devices of this character have had several disadvantages, one of which is that residual magnetism in the pole piece and yoke assembly and armature tend to hold the armature in its inward position after the solenoid has been deenergized. This has necessitated, in many cases, the use of a relatively strong biasing force which in turn requires a greater expenditure of energy to overcome.

Any residual magnetism which remains in soft ferromagnetic parts which have relative movement with respect to each other in a solenoid actuated device can create objectionable characteristics. This is particularly true with respect to the plunger or armature and the associated yoke structure of the solenoid. Here the plunger or armature might be held by residual magnetism in its normal energized position even though the solenoid is deenergized. A common method used in compensating for the residual magnetic attracting force is the application of a biasing spring, which applies a force slightly greater than the residual magnetizing force and in the opposite direction. However, this method may subject various parts of the assembly to deterioration as the parts wear, and the opposing force applied by such a spring may eventually become ineffective after repeated stretchings of the spring under normal operation.

Although residual magnetic characteristics between a solenoid plunger and a stop piece within the solenoid is somewhat troublesome, it is not wholly undesirable in solenoids operating from an AC power source. That is, by providing a predetermined amount of residual magnetism between the solenoid plunger and the stop piece, sufficiently strong to insure that the plunger will not be disengaged from the stop piece during low current intervals of the applied AC current, and yet sufficiently weak to insure that the solenoid plunger will not stick to the stop piece after the solenoid has been deenergized, will improve the operating characteristics of the solenoid.

Another disadvantage of solenoid actuated devices heretofore, is that the configuration of the end of the solenoid plunger which engages the stop piece is such that a relatively large pressure per unit area is transmitted to the stop piece. Therefore, after repeated operation of the solenoid actuated device, either the end of the plunger or the stop piece become deformed to such an extent as to change the operating characteristics of the solenoid.

It is therefore an object of this invention to provide a solenoid actuated device wherein residual magnetism is greatly reduced but not completely eliminated.

Another object of the present invention is to provide a solenoid actuated device wherein the force per unit area transmitted to a stop piece by a plunger is greatly reduced, thereby substantially eliminating deforming of either the plunger or the stop piece.

Another object of the present invention is to provide a solenoid actuated device which is simple in design, inexpensive to manufacture and easy to assemble.

One of the principal features of the present invention is to introduce a discontinuity at a particular location in the flux path of the yoke assembly and armature. It has been found that the amount of residual magnetism between the armature and the upper pole piece of the yoke assembly will be reduced 50% or more.

Another important feature of the present invention is the provision of a solenoid plunger and a stop piece which have continuous mating surfaces so as to distribute the force of the plunger over a relatively large area.

Another feature of the present invention is to provide a novel manner of locating and mounting a shading ring in an AC actuated solenoid device.

The term "soft ferromagnetic" material as used herein is intended to refer to any magnetic material having a permeability greater than 1 and having relatively low magnetic retentivity.

FIGURE 1 of the drawing is a sectional view of a preferred form of solenoid actuated device which is constructed in accordance with the teaching of this invention.

FIGURE 2 of the drawing is a sectional view of a modified form of solenoid actuated device.

The solenoid actuated device 10 as shown in FIGURE 1 includes an electric coil 11 which is arranged to be selectively energized from time to time by current from a suitable source of magnetizing current. The coil 11 may be of cylindrical shape and specifically may be formed on an insulating spool 13 having a central bore 14 in which is slidably disposed a movable plunger 15. The plunger 15 is dimensioned to project out of one end of the bore 14. The opposite end of the bore 14 is closed by a pole piece 16 which acts as a stop or bumper (pole piece) to prevent the plunger 15 from passing a predetermined upper position within the solenoid coil 11. The stop or pole piece 16 is provided with a continuous flat surface at the interior of the solenoid so as to engage a substantial amount of surface area of the end of the plunger 15, thereby reducing the pressure per unit area exerted by the plunger as it is drawn into the solenoid by the magnetic field. The coil 11 is preferably encapsulated with an insulating material 17 which forms an outer shell therefor. The entire assembly is intended for use with the plug end of the solenoid disposed at the top. The plunger 15 is thus normally biased by gravity in a direction tending to move it out of the solenoid.

The encapsulated coil in turn is mounted in a ferrous metal frame 18 formed of a material having relative high permeability and low coercive force, such as soft iron. The frame 18 comprises a U-shape upper member 19 and a base strip 20 which provide a return magnetic flux path from one end of the solenoid 11 to the other.

An important feature of this invention is to reduce the amount of residual magnetism between the ferrous metal plunger **15**, and the ferrous metal frame or yoke assembly **18** and the pole piece **16** without detrimentally affecting the return flux path of the assembly which is provided by the frame **18**. That is, the present invention provides means within the magnetic circuit of the solenoid to reduce the residual magnetism between the plunger **15** and the stop **16** sufficient so as to prevent sticking of the plunger, while maintaining a sufficient amount of residual magnetism so as to insure proper and efficient operation of the solenoid during the low current intervals of the AC current applied to the coil **11**.

In the embodiment of the invention illustrated in FIGURE 1, this is accomplished by providing a brass eyelet **21** between the stop **16** and the frame **18** to effectively reduce the residual magnetism between the top rivet **16** and the plunger **15** by approximately one-half. Although the eyelet **21** is shown as brass in this instance, it can be seen that copper, aluminum or other non-ferrous materials can be used in place of brass to obtain generally the same effect. It is important to note the position of the eyelet **21** with respect to the magnetic path of the solenoid **10**. By positioning the eyelet **21** between the stop member **16** and the upper member **19** of the frame **18**, the magentic flux path of the solenoid is impeded in this area and not between the stop member **16** and the plunger **15**, where it is important to maintain a certain amount of residual magnetism.

A copper shading ring **22** is circumferentially located in the upper end of the plunger **15**. If the shading ring **22** extends beyond the upper surface of the plunger **15**, thereby acting as a non-ferrous spacer to further reduce the residual magnetism, it has the disadvantage in that a considerable amount of hum usually results. It is another feature of this invention to mount the copper shading ring **22** in a recess in the end of the plunger **15** which is sufficiently deep that the upper surface of the shading ring **22** lies below the end surface of the plunger **15**. It has been found that this greatly reduces if not eliminates hum and yet performs its usual function as a shading ring.

The solenoid actuated device **23** shown in FIGURE 2, generally is a modified form of that shown in FIGURE 1, but is designed for operation from a source of direct current.

The coil **11**, mounted on a spool **13**, is provided with a non-ferrous stop **24** in the upper end of the spool bore **14**. An axially slidable plunger **25** is disposed in the bore **14** and extends below the lower end as shown. Although the magnetic circuit, provided by the frame assembly **18** and the plunger **25**, is slightly impeded by the non-ferrous stop **24** during the energized state, the residual magnetism is greately reduced between the ferrous frame assembly **18** and the ferrous plunger **25** by the interruption in the magnetic flux path afforded by the non-ferrous stop **24**. Furthermore, the stop member **24** is provided with a continuous flat surface at the interior of the solenoid to engage a corresponding continuous flat surface at the end of the plunger **25**. This feature distributes the pressure per unit area exerted by the solenoid **25** which would otherwise deform the stop member **24**, of non-ferrous material, and which materials are generally soft and malleable. In the preferred embodiment of the present invention the stop members **16** and **24** extend into the bore of the solenoid a distance equal to approximately one-half the distance measured across the flat surface thereof.

Furthermore, it will be noted that the shaft portion of the stop members **16** and **24** are fashioned similar to the shaft portion of a rivet. Therefore, the stop members are merely inserted through the aperture of the frame assembly **18** and fastened thereto by a suitable riveting tool, thereby greatly simplifying the construction of the solenoid device of the present invention.

It will be understood that modifications and variations may be made without departing from the spirit and scope of the novel concepts of this invention.

We claim as our invention:

1. A solenoid actuated device comprising:
a solenoid having an axial bore therethrough;
a soft ferromagnetic frame extending from across one end of said solenoid externally to a position across the other end of said solenoid;
said frame member being apertured opposite said one end of said solenoid;
a soft ferromagnetic plunger having a flat end thereof slidably mounted in said bore of said solenoid and extending through said aperture;
the improvement therein comprising:
a stop member of non-magnetic material disposed in said bore of said solenoid at its said other end,
said stop member having a flat surface so as to provide a continuous mating surface with the flat end of said plunger when said solenoid is energized.

2. A solenoid actuating device according to claim **1** wherein said stop member extends into said bore a distance of approximately ½ the distance across said flat surface.

3. A solenoid actuated device comprising:
a solenoid having an axial bore therethrough;
a ferromagnetic frame extending from across one end of said solenoid exteriorly to a position across the other end of said solenoid,
said frame being apertured at said one end and at said other end of said solenoid in alignment with the bore therethrough;
a stop member having a first diameter portion extending into said bore at said other end of said solenoid, and
a second diameter portion extending through the aperture in said frame at said other end of said solenoid, the portion of said second diameter portion being folded over the exterior peripheral surface of the aperture to secure said stop member to said frame,
said stop member being constructed of non-magnetic material,
said stop member further having a continuous flat surface interiorly of said bore and perpendicular to the axis thereof;
a ferromagnetic plunger slidably mounted in the bore of said solenoid and extending through the aperture at said one end thereof.

4. A solenoid actuated device comprising:
a solenoid having an axial bore therethrough;
a ferromagnetic frame extending from across one end of said solenoid exteriorly to a position across the other end of said solenoid,
said frame being apertured at said one end and at said other end of said solenoid in alignment with the bore therethrough;
a stop member constructed of a non-magnetic material having a first diameter portion extending into said bore at said other end of said solenoid, and a second diameter portion extending through the aperture in said frame at said other end of said solenoid, the portion of said second diameter portion being folded over the exterior peripheral surface of the aperture to secured said stop member to said frame,
said stop member further having a continuous flat surface interiorly of said bore and perpendicular to the axis thereof;
a ferromagnetic plunger slidably mounted in the bore of said solenoid and extending through the aperture at said one end thereof, and
said plunger is provided with a continuous flat surface at one end thereof for engagement with

the continuous flat surface of said stop member when said solenoid is energized.

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