

May 26, 1964

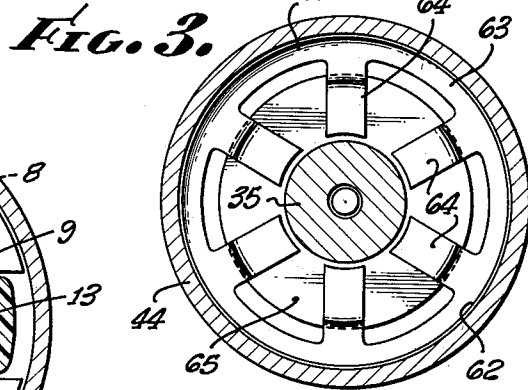
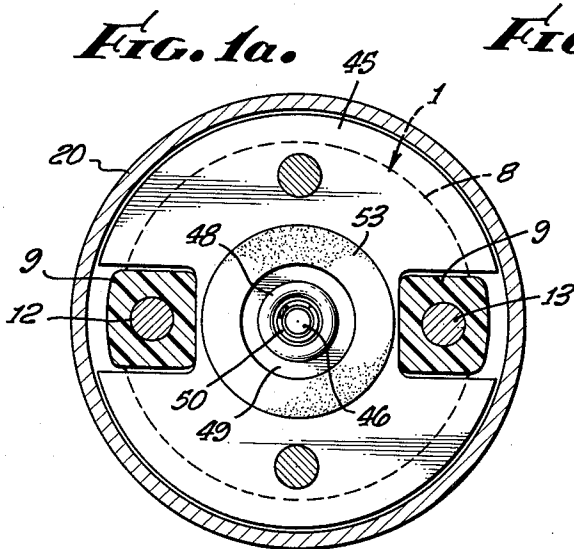
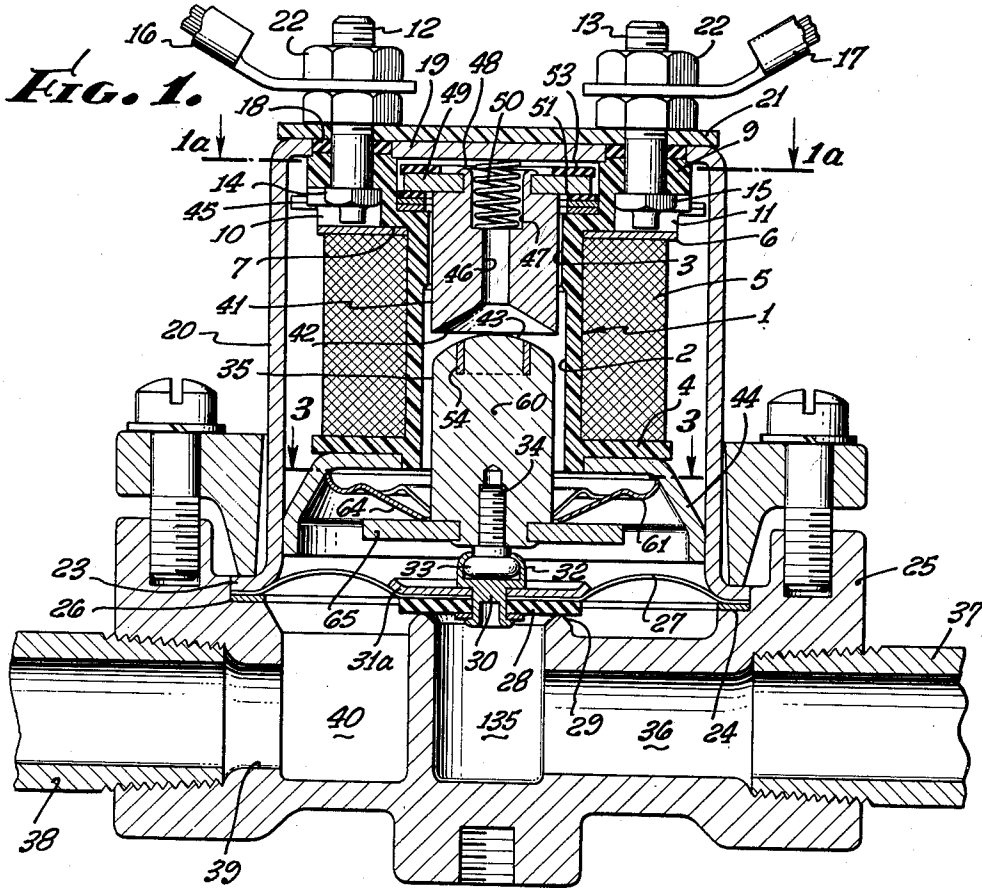
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3,134,932

ALTERNATING CURRENT SOLENOID HAVING YIELDINGLY MOUNTED STOP

Filed March 28, 1960

2 Sheets-Sheet 1



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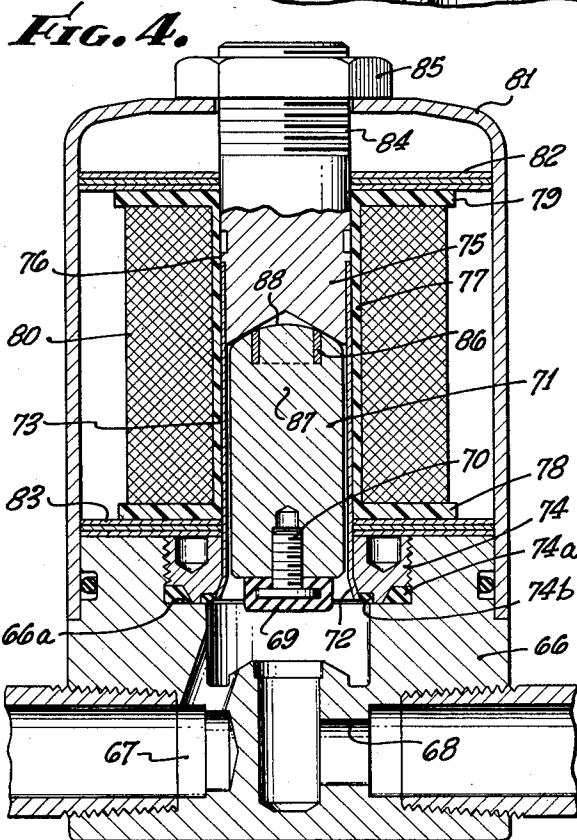
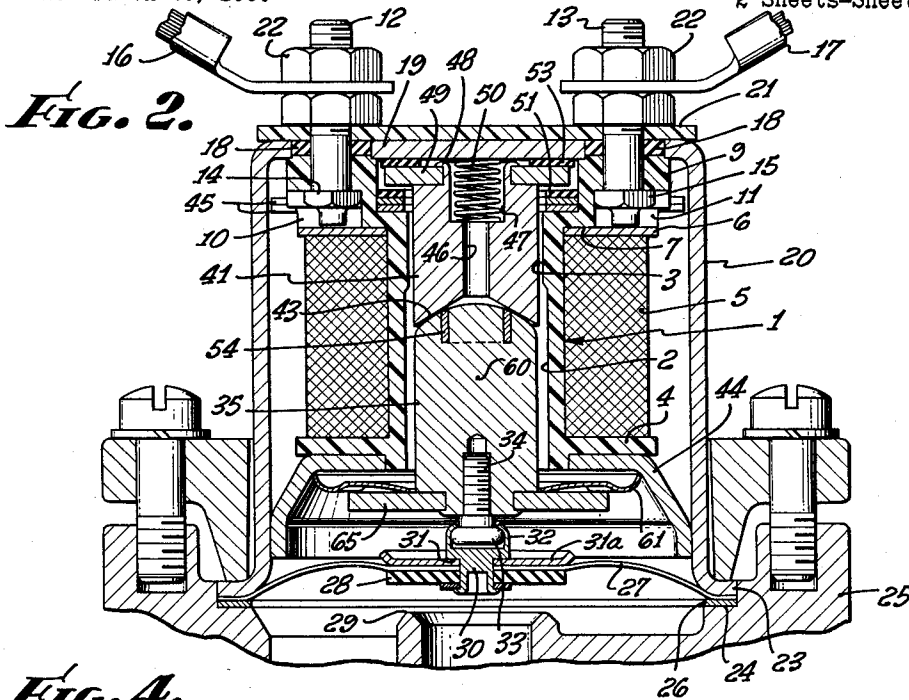


FIG. 5.

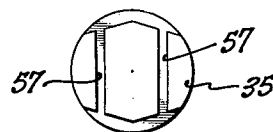
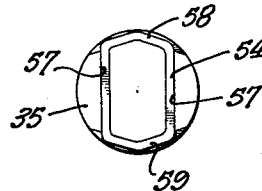


FIG. 6.



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1

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ALTERNATING CURRENT SOLENOID HAVING YIELDINGLY MOUNTED STOP

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2 Claims. (Cl. 317-185)

This invention relates to electromagnets, and more particularly to such electromagnets adapted to be operated by alternating current.

The cyclic variation of the current through an electromagnetic coil, from zero to a maximum and through zero to a negative maximum, causes the magnetic force of the electromagnetic to vary at the same rate. When the electromagnet is used to pull a plunger against a stop, these variations usually cause a persistent hum while the electromagnetic coil is energized.

While in many installations such noise is unobjectionable, it becomes a source of annoyance when the electromagnet is used to operate apparatus such as a fuel valve located in dwelling quarters such as a home or apartment. To limit or reduce this noise, various expedients have been used, such for example as described in Patent No. 2,096,763, issued October 26, 1937, and Patent No. 2,098,195, issued November 2, 1937.

Both of these patents describe the use of an alternating current solenoid for operating a fuel valve. While these prior devices were successful to a certain extent, they nevertheless were at times noisy; the power consumption was quite large; and the structure was such that, after continued use, the plunger would become tight in its tube, with the likelihood of "sticking."

It is one of the objects of this invention to overcome these objections in a simple and effective manner.

One of the features of the prior constructions is the use of a specially shaped stop for the plunger, the shape being convex, and cooperating with a tapered concave surface of the plunger. A shading coil of cylindrical form divided the effective area of the plunger into a band or ring surrounding an inner circle, thereby introducing a substantial air gap into the magnetic circuit including the stop and the plunger. Such a gap made it necessary to provide sufficient ampere turns to enable the electromagnet to operate its load.

It is another object of this invention to arrange the shading coil in such manner as to introduce little or no reluctance into the magnetic circuit for the electromagnet.

In said prior devices, the stop being convex, the tapered concave surface of the plunger was pounded by the impact of the plunger upon the stop. This pounding, often repeated during the life of the electromagnet, inevitably caused enlargement of the plunger at its contacting end, ultimately causing binding of the plunger in its guide.

It is another object of this invention to obviate such occurrences.

It is still another object of this invention to provide assurance of proper seating and substantial contact over a relatively large area between the stop and the plunger. In this way, a substantial reduction of reluctance in the magnetic circuit is effected.

When the plunger is in its attracted position, that end thereof which is opposite the contacting end provides an annular polar area radially spaced from the stationary part of the magnetic structure. An incipient misalignment of the plunger in its guide would cause an accumulative effect upon an unbalance of the magnetic forces acting to aggravate the misalignment and to cause a chattering contact between the lower end of the plunger and its guide.

2

It is accordingly still another object of this invention to reduce substantially any material misalignment.

In order to accomplish this result, the magnetic force existing between the plunger and stop is effective over an area spaced at a substantial distance from the axis of the plunger, and thus produces a magnetic moment that resists angular movement of the plunger; and the plunger itself constitutes but a relatively small lever arm upon which the radial flux can act.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of several embodiments of the invention. For this purpose, there are shown a few forms in the drawings accompanying and forming part of the present specification. These forms will now be described in detail, illustrating the general principles of the invention; but it is to be understood that this detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

FIGURE 1 is a longitudinal sectional view of an electromagnet structure embodying this invention, shown as applied to a valve structure, the electromagnet being shown in unenergized position;

FIG. 1a is a detail plan view of the coil frame, taken on line 1a-1a of FIG. 1, and showing the bosses that accommodate the terminals for the electromagnet;

FIG. 2 is a view similar to FIG. 1, but illustrating the electromagnet in its attracted position;

FIG. 3 is a sectional view, taken along a plane corresponding to line 3-3 of FIG. 1;

FIG. 4 is a view similar to FIG. 1, but illustrating a modified form of the invention;

FIG. 5 is a plan view showing the grooved end of a plunger before installation of the shading coil; and

FIG. 6 is a similar plan view showing the shading coil installed.

In the form shown in FIGS. 1, 2 and 3, the electromagnet includes a coil form 1 molded from insulating material, such as nylon. This coil form has a cylindrical inner guiding surface 2. This inner surface has an upper portion 3 of smaller diameter than the surface 2.

Adjacent the lower end of the coil form 1 is an integral flange 4. This serves as a lower support for the accommodation of an electromagnet coil 5. A flange 6, conveniently made in two halves so that it may be installed over the main body of the coil form 1, defines, with flange 4 and form 1, a spool for the coil 5. Flange 6 is placed immediately below a shoulder 7 defined by flange 8 of form 1. Rising from flange 8 adjacent the edge thereof are the integral upwardly extending bosses 9. These bosses are of rectangular form, as shown in FIG. 1a. Recesses 10 and 11 below bosses 9 provide for the accommodation of binding posts 12 and 13. These binding posts are each provided with a square or hexagonal head 14 and 15.

The binding posts 12 connect to appropriate terminals 16 and 17 controlled by any conventional switch for energizing and deenergizing the coil 5. These terminals are held in place by the aid of the nuts 22.

The binding posts 12 and 13 pass through insulation washers 18 placed in appropriate apertures in the top wall 19 of a cylindrical casing member 20 made from magnetic material. Disposed over the top wall 19 is a strip 21 of insulation material, through which pass the binding posts 12 and 13.

The lower end of the casing 20 is provided with a flange 23 adapted to overlie a shoulder 24 formed on a valve body 25. A gasket 26 is disposed below the flange 23. Between this gasket 26 and the flange 24 is clamped the edge of a flexible diaphragm 27. This diaphragm carries

at its center portion a yielding closure member 28 adapted to cooperate with a valve seat 29 formed in valve body 25.

In order to attach the closure member 28 to the diaphragm 27, use is made of a center post 30 having a hollow end operating as a rivet for clamping the closure 28 against the shoulder 31 formed around the upper end of the post 30 and against a disc 31a. This disc serves to reinforce the center portion of the diaphragm 27.

The upper end of the post 30 is enlarged, and has a hollow recess formed by the thin walls 32. These thin walls may be swaged inwardly for attaching the closure structure to the rounded head 33 of a machine screw 34. This machine screw 34 is threaded into the lower end of an operating plunger 35, constructed in a manner to be hereinafter described.

The valve seat 29 surrounds a port 135 communicating, as by way of a port 36, with the interior of a conduit 37 having its end threaded into the body 25.

Another conduit 38 is similarly threaded into the left-hand end of the body 25. It communicates with a port 39 leading to a chamber 40. This chamber surrounds the seat 29. It can be placed in communication with the port 135 when the valve closure 29 is lifted from its seat, for example as viewed in FIG. 2. In that case, there is communication between the conduits 37 and 38. Either one of these two conduits may be chosen as the inlet or the outlet for the valve.

The plunger 35 extends into the form 1 from the lower end of that form and is adapted to be pulled inwardly when the coil 5 is energized, so as to seat against a stop structure 41.

In the present instance, this stop structure 41, made of magnetic material, is shown as having a concave recess 42 at its inner end. This recess is formed as a conical surface and having an included angle of about ninety degrees or somewhat greater.

This conical surface is adapted to cooperate with a spherical surface 43 extending substantially over the entire end on the plunger 35. As shown most clearly in FIG. 2, in the energized position the conical surface 42 has an outer boundary corresponding to the outer boundary of the spherical surface 43. Furthermore, this spherical surface 43 has a periphery corresponding to the outer boundary surface or periphery of the plunger 35.

The magnetic circuit partially formed by the stop 41 and cooperating plunger 35 includes a cup member 44 of magnetic material fastened to the flange 4. A plurality of discs 45 of magnetic material are attached to the top of flange 8. They are appropriately slotted, as shown in FIG. 1a, to accommodate the terminal bosses 9. These discs fit into the casing 20.

The stop structure 41 is provided with an aperture 46 communicating with a counterbore 47. This counterbore 47 has a lip 48 which may be riveted over a magnetic washer 49 engaging the upper surface of stop 41.

The recess 47 houses a compression spring 50. The upper end of this spring abuts the lower surface of the wall 19. Its lower end is accommodated on the shoulder formed between the aperture 46 and the counterbore 47.

In the unenergized position, the washer 49 rests on a resilient rubber disc 51 disposed over the discs 45. The washer 49 serves to support another resilient disc 53 which is urged upwardly into engagement with the wall 19 of the casing 20 whenever the coil 5 is energized.

There is thus a resilient or yielding cushion provided by discs 51 and 53 for the attracted and unattracted position of the stop 41. This cushion softens the impact of the plunger 35 upon the stop 41. By this means, even repeated blows will not distort the upper end of plunger 35 as to impede its free movement in frame 1.

In order to minimize chatter and hum, the plunger 35 carries a shading coil 54 which may take the form illustrated in FIG. 6. The plunger 35 is provided with parallel slots 57 into which the legs of the coil 54 may extend,

and the crests 58 and 59 form the coil ends. The grooves 57 do not interfere with the path of the magnetic flux between the stop member 41 and the plunger 35. There is substantially no air gap between these two elements.

FIG. 5 illustrates the symmetrical grooves in the plunger end before the coil 54 is installed.

Due to the symmetrical arrangement of the coil 54 with respect to the axis of the plunger 35, there is no asymmetrical distribution of the flux over the contacting areas of the plunger 35 and stop 41.

The radius of the spherical surface 43 is quite large, bringing the center 60 quite close to the lower end of the plunger 35. There are radial magnetic lines of force extending between the lower end of plunger 35 and cup 44. The distance between the effective center of these lines and the center 60 of spherical surface 43 corresponds to a lever arm. Thus, the leverage upon an incipient asymmetry of the radial flux would tend to move the plunger 35 about center 60 as a pivot. Since, by the specific proportions shown, this lever arm is small, there is a materially reduced likelihood of causing the plunger 35 to become misaligned. This is enhanced by the provision of a relatively large diameter of the circle of contact between the conical surface 42 and the spherical surface 43. The air gap on each side of the point of contact increases very gradually due to the large radius of the surface 43. Therefore, there is a relatively wide zone adjacent the point of tangency that produces a magnetic moment opposing misalignment of the plunger 35. This is of considerable importance in eliminating or minimizing the hum.

In order to urge the plunger 35 downwardly when the electromagnet coil 5 is deenergized, use is made of a spring member 61, shown most clearly in FIG. 3. This spring member 61 has an upturned edge 62 adapted to contact the inner surface of the cup 44. The annular outer portion 63 of the spring member is provided with integral inwardly directed arms 64 that extend downwardly and inwardly to contact the upper surface of a collar 65 connected to the lower end of the plunger 35. This collar is thus urged downwardly by spring pressure.

In the modification of FIG. 4, a valve body 66 is provided with ports 67 and 68 controlled by a yielding closure member 69. This closure member is hollow to accommodate the head of a screw 70 threaded into the bottom of a magnetic plunger 71. This magnetic plunger is guided by a guide tube 73 of brass or the like, split longitudinally and having its lower end 72 flared outwardly and welded or otherwise attached to an insert 74. This insert 74 is threaded into the valve body 66, and serves with sleeve 73 as a unit capable of being assembled or removed from the valve body 66. Appropriate sealing means 74a and 74b may be provided between this insert and the shoulder 66a formed at the bottom of the tapped aperture accommodating the insert 74.

The upper end of guide sleeve 73 is similarly welded to the outer periphery of a magnetic stop 75, and is seated on a shoulder 76 formed on the stop.

This magnetic stop 75 and the guide tube 73 are telescoped within a coil form 77 having flanges 78 and 79, serving to support the winding 80.

In this form, the stop 75 extends through the magnetic casing member 81. This casing member 81 telescopes over the valve body 66 and is appropriately attached thereto.

Extending between the inner periphery of the casing 81 and the stop member 75 are a plurality of magnetic discs 82. Similar discs 83 complete the magnetic circuit around the lower end of the plunger 71.

The upper end of the stop 75 is threaded, as indicated at 84, for the accommodation of a nut 85. This nut holds the casing 81 tightly in place.

A shading coil 86, of the same general character as illustrated in FIG. 6, is utilized in connection with the plunger 71. Furthermore, the axis 87 of the upper spherical

surface 88 of the plunger 71 is substantially below the spherical surface 88, thereby rendering it unlikely that the plunger 71 will be materially laterally displaced.

The inventor claims:

1. In an electromagnet structure having a non-magnetic coil frame, a coil mounted on the frame, a movable plunger of magnetic material, and a stop for the plunger also made of magnetic material, characterized by the provision of a mounting for the stop to permit the stop to have limited movement relative to the plunger for absorbing at least partially the impact of the plunger on the stop upon energization of the coil, comprising: a yielding disc surrounding the stop and supported on the frame; means attached to the stop for providing a lower surface above the disc; a second yielding disc in contact with the upper surface of said means; and means limiting the upward movement of the second disc; said second disc having substantial clearance with respect to the limiting means when the electromagnet structure is deenergized.

2. In an electromagnet structure having a nonmagnetic coil frame, a coil mounted on the frame, a movable plunger of magnetic material, and a stop for the plunger also made of magnetic material, characterized by the provision of a mounting for the stop to permit the stop to

have limited movement relative to the plunger for absorbing at least partially the impact of the plunger on the stop upon energization of the coil, comprising: a yielding disc surrounding the stop and supported on the frame; means attached to the stop for providing a lower surface above the disc; a second yielding disc above said means; means limiting the upward movement of the second disc; and a spring for urging the stop downwardly.

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