July 9, 1940. T. A. WETZEL 2,207,082

SOLENOID

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Fig. 1.

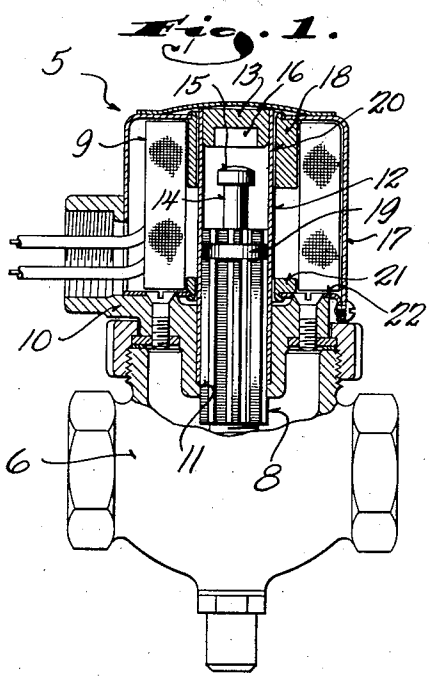



Fig. 2.

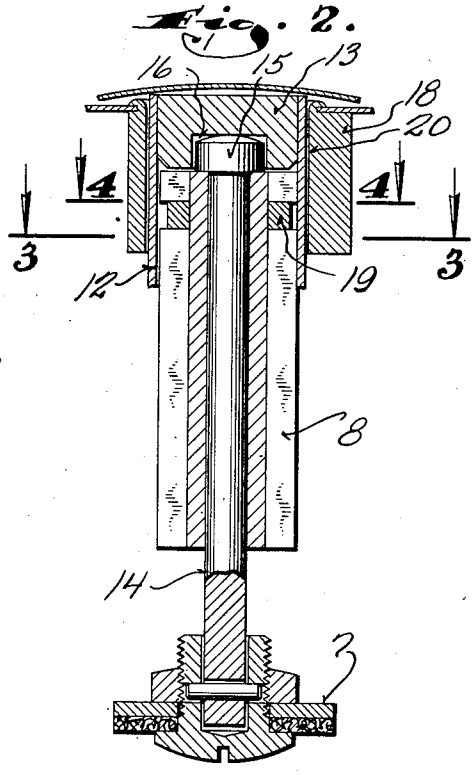



Fig. 4.

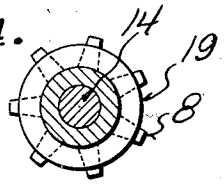



Fig. 3.

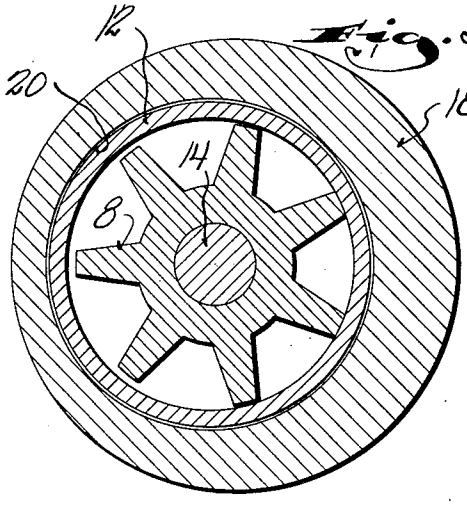
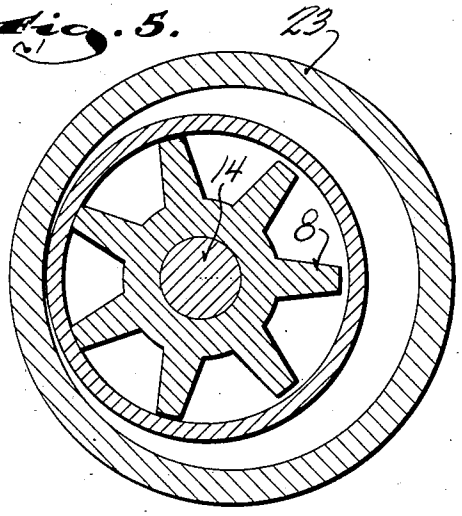



Fig. 5.




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Fig. 6.

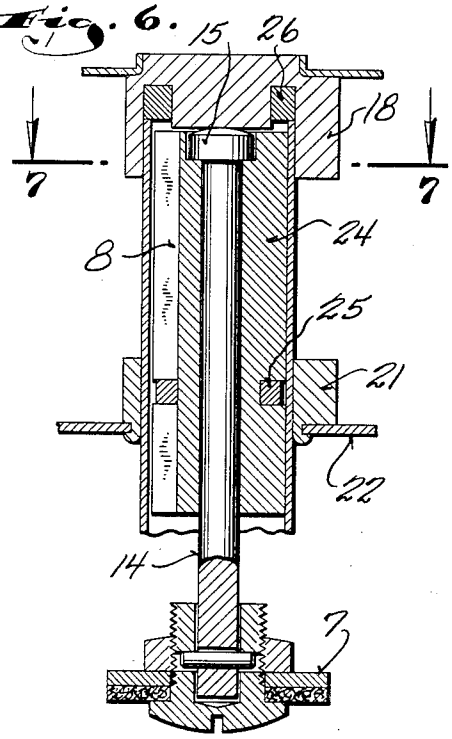
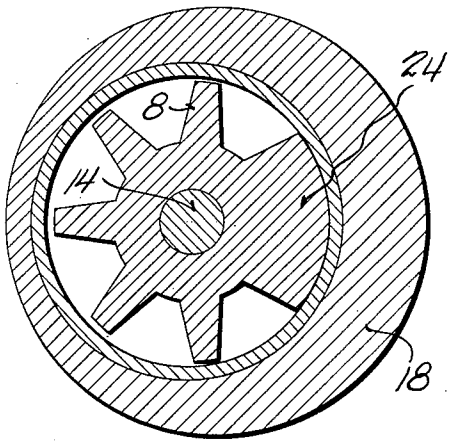



Fig. 7.



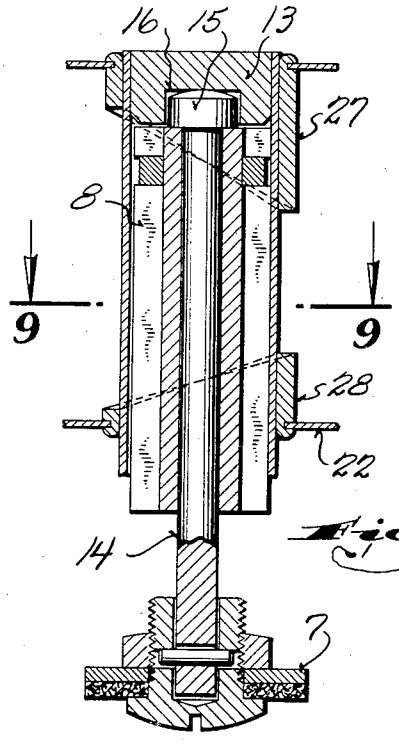
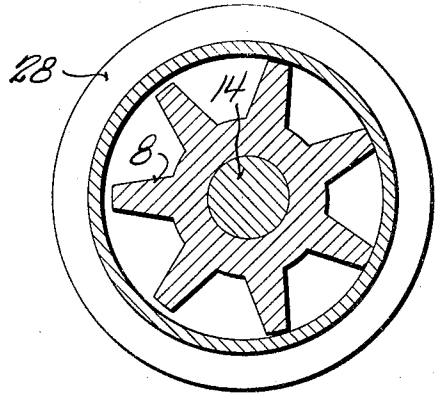




Fig. 8.

Fig. 9.




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# UNITED STATES PATENT OFFICE

2,207,082

## SOLENOID

Theodore A. Wetzel, Milwaukee, Wis., assignor to Milwaukee Gas Specialty Company, Milwaukee, Wis., a corporation of Wisconsin

Application April 4, 1938, Serial No. 199,820

6 Claims. (Cl. 175—338)

This invention relates to improvements in solenoids of the type forming the subject matter of Patent No. 2,111,232, issued to Theodore A. Wetzel March 15, 1938.

Like the aforesaid patent, the present invention is directed primarily to solenoids designed to operate valves and kindred appliances, and likewise has as a general object the provision of a solenoid which will be quiet and free from hum during use.

In general, the solenoid to which this invention appertains, comprises a coil and an armature movable in the coil and constrained to move in a fixed path by suitable guide means. In the aforesaid patent quietness is obtained by constructing the armature with its magnetic mass so distributed on a cross sectional plane that the armature will be drawn laterally against its guide means upon energization of the coil.

The present invention contemplates the same manner of assuring quietness, i. e., by causing the armature to be drawn to one side, but attains this object without the necessity for unbalanced mass distribution in the armature.

To this end, the present invention has as a more specific object the provision of novel means for so defining the flux paths from the coil to the armature that the armature will be drawn sidewise against its guide means upon energization of the coil.

With the above and other objects in view which will appear as the description proceeds, this invention resides in the novel construction, combination and arrangement of parts substantially as hereinafter described, and more particularly defined by the appended claims, it being understood that such changes in the precise embodiment of the hereindisclosed invention may be made as come within the scope of the claims.

The accompanying drawings illustrate several complete examples of the physical embodiment of the invention constructed in accordance with the best modes so far devised for the practical application of the principles thereof, and in which:

Figure 1 is a view partially in side elevation and partially in vertical section, showing the application of this invention to a valve;

Figure 2 is an enlarged vertical sectional view through the armature per se and its associated elements;

Figure 3 is an enlarged cross sectional view taken through Figure 2 on the plane of the line 3—3;

Figure 4 is a cross sectional view through the armature per se taken on the plane of the line 4—4 in Figure 2;

Figure 5 is a cross sectional view similar to Figure 3, but showing a slightly modified embodiment of the invention;

Figure 6 is a longitudinal sectional view through the armature and its associated elements, illustrating another modified embodiment of the invention;

Figure 7 is a cross sectional view taken through Figure 6 on the plane of the line 7—7; and

Figures 8 and 9 are respectively views similar to Figures 6 and 7, illustrating another modified embodiment of the invention.

Referring now particularly to the accompanying drawings in which like numerals indicate like parts throughout the several views, the numeral 5 designates generally the solenoid of this invention which in the present invention is shown mounted on a valve body 6, the valve 7 of which is liftable from its seat (not shown) by the response of the armature 8 to energization of the coil 9.

Inasmuch as the specific construction of the valve and also the manner in which the solenoid is mounted on the valve body forms no part of this invention and is illustrated in the aforesaid patent, no description thereof is necessary here. It is sufficient to note that the solenoid per se is mounted on a base 10 which in turn is secured to the valve body 6.

The base 10 has a bore 11 through which the armature 8 slides and carries a fixed guide tube 12 of non-magnetic material which projects upwardly from the base and extends through the entire length of the coil. The upper end of this guide tube is closed by a magnetic plug 13 which limits the rise of the armature and provides a seat against which the armature is securely held upon energization of the coil.

The armature preferably has a ribbed cross sectional shape, as shown, so that its area of contact with the bore of the guide tube is small. A bore extending longitudinally through the armature receives a stem 14 of nonmagnetic material, to the lower end of which the valve 7 is secured. The upper end of this stem has a head 15 by which the upward motion of the armature is imparted to the valve stem 14. When the armature rises and carries the stem up, the head 15 enters a recess 16 in the magnetic plug to allow the armature to approach closely to the plug, but freezing of the armature onto the plug is prevented inasmuch as the height of the head 15 is

slightly greater than the depth of the recess, as clearly shown in Figure 2.

Supported from an outer enclosing shell 17 of magnetic material is a magnetic sleeve 18 which extends downwardly into the upper portion of the coil and encircles the guide tube 12. The sleeve 18 is of sufficient length to encompass a shading ring 19 carried by and encircling the upper end portion of the armature. The magnetic sleeve 18, as will be readily apparent, provides a concentrated flux path and by having the shading ring 19 enter the sleeve, insures more economical operation.

The sleeve 18, as best shown in Figure 3, has its bore 20 disposed eccentrically to the outside surface of the sleeve and is so mounted that the bore of the sleeve is substantially concentric or coaxial to the longitudinal central axis of the armature while its outer surface is concentric to the axis of the coil. As a consequence, when the armature is drawn upwardly upon energization of the coil, the flux being greater through the thick walled portion of the sleeve than at the thin walled diametrically opposite portion thereof, causes the armature to be drawn sidewise against the wall of its guide tube and securely held against vibration. This condition is clearly illustrated in Figure 3.

While in most instances the provision of a single magnetic sleeve 18 is sufficient to assure quietness, if desired, an additional magnetic ring 21 may be provided adjacent to the lower end of the coil. This ring 21 has the same cross sectional dimensions as the sleeve 18 and is mounted in the same angular relationship so that its presence in the flux path has the same effect upon the armature as the sleeve 18.

The armature is thus not only drawn against the tube at its upper end portion, but also at the bottom. The ring 21, as stated, is part of the magnetic path or circuit, and to this end is carried by a plate 22 of magnetic material which closes the bottom of the cup-shaped casing 17, and, as clearly shown, is fastened to the base 10.

As a modified construction, a magnetic sleeve of uniform wall thickness, as shown in Figure 5, may be employed. In this instance, the bore and the outside diameter of the magnetic sleeve 23 are concentric, but the sleeve is eccentrically positioned with respect to the guide tube and consequently the path of the armature. Hence, the lines of flux are shorter on one side of the armature than at the diametrically opposite side thereof so that the armature is drawn laterally into firm engagement with the bore of the tube, as clearly shown in Figure 5.

If desired, the effect of the eccentric sleeve shown in Figures 1, 2 and 3 may be accentuated by use of an armature which has its magnetic mass unequally distributed on a cross sectional plane in the manner defined in the aforementioned patent. Such a construction is illustrated in Figures 6 and 7. As here shown, the unbalanced magnetic mass of the armature is produced by filling in the spaces between two of the ribs which results in a wide longitudinally extending portion 24.

The construction shown in Figures 6 and 7 also distinguishes from those already described in that the shading ring 25 carried by the armature encircles its lower portion to enter the ring 21 when the armature rises in response to energization of the coil. A second shading ring 26 is also provided, which, however, is mounted in the eccentric sleeve 18, the construction of which is slightly altered to accommodate the ring 26.

Another manner of obtaining the desired differential in magnetic mass on opposite sides of a plane coincident with the central longitudinal axis of the armature is illustrated in Figures 8 and 9. This construction follows very closely that illustrated in Figures 1, 2 and 3, but the magnetic sleeve 27 and the magnetic ring 28 are both concentric to the central longitudinal axis of the armature. These elements are mounted in the same manner from the closed top of the outer shell 17 and from the bottom plate 22 which closes the shell. However, their lower and upper edges, respectively, instead of lying on planes normal to the central longitudinal axis of the armature, are inclined in opposite directions so that the sleeve and the ring both have a major length on one side of a plane passing through and coinciding with the central longitudinal axis of the armature and a minor length at the opposite side of said plane.

Hence, it will be seen that although the armature has a uniform magnetic mass distribution on a transverse plane, and although the magnetic sleeve and the magnetic ring are concentric to the path of the armature, the flux at one side of the armature is greater than on the opposite side thereof so that upon energization of the coil, the armature is drawn sidewise against its guide tube.

From the foregoing description taken in connection with the accompanying drawings, it will be readily apparent to those skilled in the art, that this invention provides a construction for solenoids which insures quietness of operation without the necessity for complicated or costly mechanical expedients.

What I claim as my invention is:

1. A solenoid comprising: a coil; a nonmagnetic guide tube within the coil disposed eccentrically with respect to the axis of the coil so as to leave a space of varying dimensions between its outer surface and the coil of such proportions that the inside diameter of the tube is greater than twice the average distance of the exterior of the tube from the coil; an armature snugly slidable in said guide tube and constrained thereby to movement in a fixed path; and a magnetic sleeve in said space between the outer surface of the tube and the coil, the outer side wall of the sleeve being concentric with the coil so that the flux path from the coil to the armature has less reluctance at one side of the guide tube than on the other to cause the armature to be drawn sidewise against the guide tube upon energization of the coil.

2. A solenoid comprising: a coil; a nonmagnetic guide tube within the coil disposed eccentrically with respect to but surrounding the axis of the coil; an armature slidable in said guide tube and constrained thereby to movement in a fixed path; and a magnetic sleeve encircling the guide tube, said magnetic sleeve having substantially cylindrical internal and external surfaces disposed eccentrically to each other to an extent substantially equal to the eccentricity of the guide tube and the coil and having a wall substantially filling the space between the guide tube and the coil whereby the flux path defined by the sleeve is so distributed as to cause the armature to be drawn sidewise against its guide tube upon energization of the coil, said sleeve having an external diameter less than twice the diameter of the armature.

3. A solenoid comprising: a coil; a nonmagnetic guide tube within the coil disposed eccentrically with respect to the axis of the coil; an

armature slidable in said guide tube and constrained thereby to movement in a fixed path; and a magnetic sleeve encircling the guide tube, said magnetic sleeve having substantially cylindrical internal and external surfaces disposed eccentrically to each other to an extent substantially equal to the eccentricity of the guide tube and the coil and having a wall substantially filling the space between the guide tube and the coil and an average wall thickness less than half the diameter of the armature, whereby the flux path defined by the sleeve is so distributed as to cause the armature to be drawn sidewise against its guide tube upon energization of the coil.

4. A solenoid comprising: a coil; a nonmagnetic guide tube within the coil disposed eccentrically with respect to the axis of the coil; an armature slidable in said guide tube and constrained thereby to movement in a fixed path; and a magnetic sleeve encircling the guide tube, said magnetic sleeve having substantially cylindrical internal and external surfaces disposed eccentrically to each other to an extent substantially equal to the eccentricity of the guide tube and the coil and having a wall substantially filling the space between the guide tube and the coil and an average wall thickness substantially less than the diameter of the armature, whereby the flux path defined by the sleeve is so distributed as to cause the armature to be drawn sidewise against its guide tube upon energization of the coil.

5. A solenoid comprising: a coil; a nonmagnetic guide tube within the coil disposed eccentrically with respect to but surrounding the axis of the coil; an armature snugly slidable in said guide tube and constrained thereby to movement in a fixed path; and a magnetic sleeve encircling the guide tube, said magnetic sleeve having substantially cylindrical internal and external surfaces disposed eccentrically to each other to an extent substantially equal to the eccentricity of the guide tube and coil and having a wall substantially filling the space between the guide tube and the coil and an average wall thickness less than half the diameter of the armature, whereby the flux path defined by the sleeve is so distributed as to cause the armature to be drawn sidewise against its guide tube upon energization of the coil.

6. A solenoid comprising: a coil; a nonmagnetic guide tube within the coil disposed eccentrically with respect to the axis of the coil; an armature concentric to and slidable in said guide tube and constrained thereby to movement in a fixed path; and a magnetic sleeve having substantially cylindrical inner and outer surfaces, said sleeve encircling the guide tube with its outside surface eccentric thereto and consequently the armature and being substantially concentric to the coil, whereby the armature is drawn sidewise firmly against its guide tube upon energization of the coil, said armature having a diameter greater than the major portion of the outer diameter of the magnetic sleeve.

THEODORE A. WETZEL.