Aug. 21, 1945. T. OBSZARNY 2,383,411

SOLENOID CONSTRUCTION

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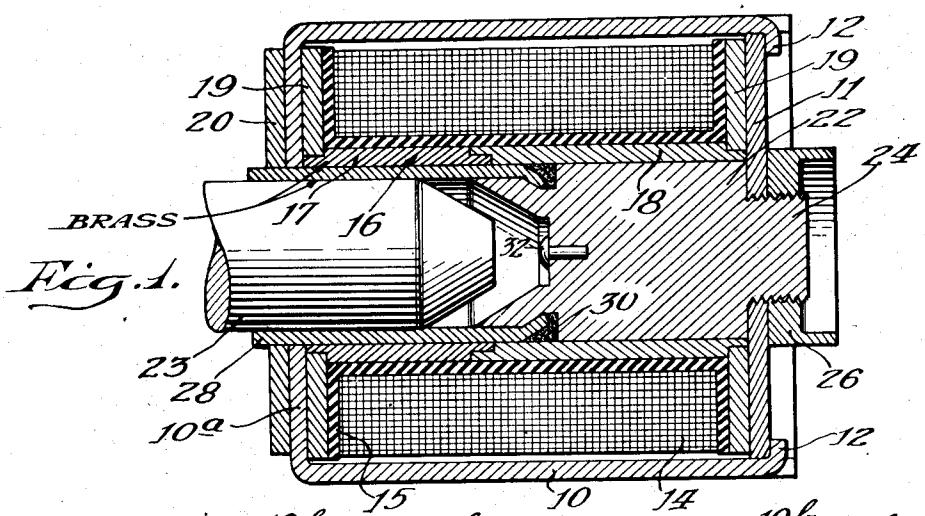


Fig. 1.

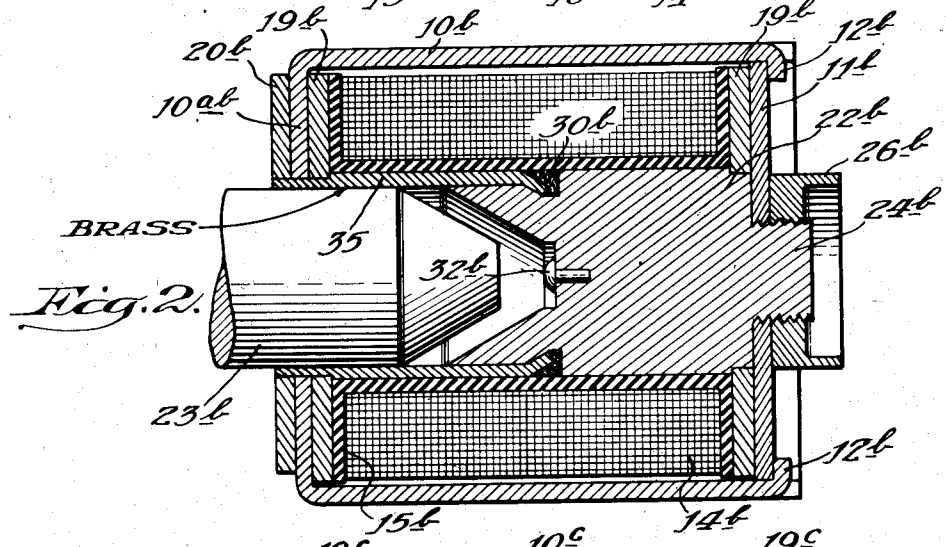


Fig. 2.

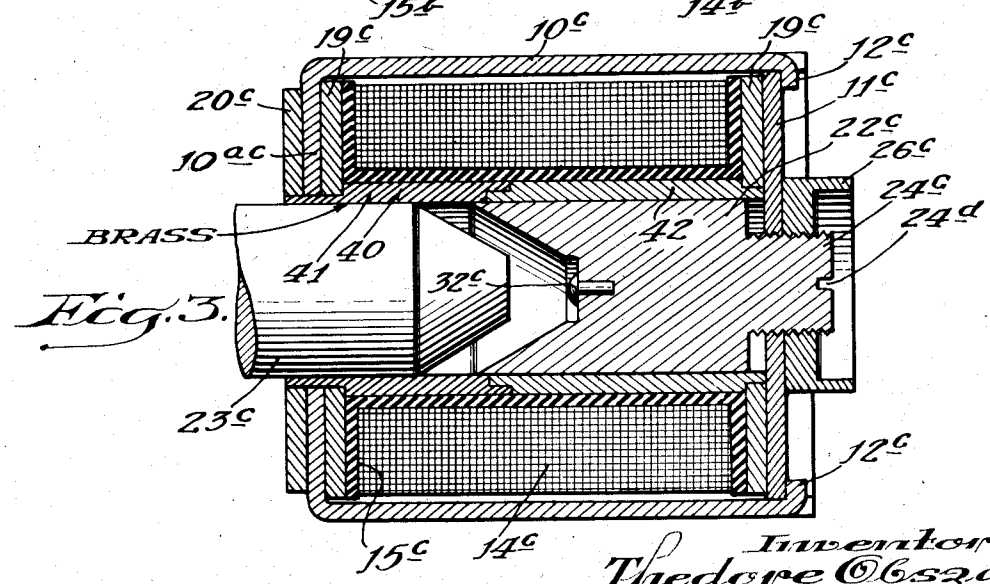


Fig. 3.

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SOLENOID CONSTRUCTION

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2 Claims. (Cl. 175—341)

The present invention relates to improvements in solenoid constructions of the type including an annular coil and a plunger reciprocably movable within the coil upon energizing of the latter.

In present-day manufacture of equipment and apparatus, the matter of space requirements in connection with the use of solenoids is often a critical factor. Frequently, space limitations for accommodating solenoids of certain specifications, as to power input, length of stroke of plunger and pull of plunger, and general external dimensions of the device, present serious problems which give great concern to manufacturers.

One of the objects of the present invention is to provide a novel and improved solenoid construction which permits maintaining general external dimensions of the solenoid for accommodating it to limited space requirements, and obtaining a substantial increase in pull on the plunger when the coil is energized, as compared to equivalent size and specifications for solenoids heretofore available.

Another object is to provide an improved solenoid construction of considerably increased efficiency, and which permits greater utilization of the magnetic flux produced than has heretofore been possible.

A further object is to provide an improved solenoid construction which is efficient in operation, is of durable and sturdy construction, and which is capable of economical manufacture.

Other objects and advantages of this invention will be apparent from the following description, taken in connection with the accompanying drawing, in which:

Figure 1 is an axial section through the solenoid embodying the present invention, and

Figures 2 and 3 are axial sections through solenoid devices embodying modifications of my invention.

Referring now to the structure disclosed in Figure 1 of the drawing, the solenoid includes a ferrous metal, cup-shaped housing 10, the open end of which is adapted to be closed by an end plate or disk 11. When the end plate is placed in position in engagement with the structure mounted within the housing, it is firmly secured in place by staking the outer marginal edge of the housing, as shown, at four equidistantly spaced apart points. In the form shown, the staking consists in severing of tangs 12 from the marginal edge portion of the housing and depressing them inwardly against the outer surface of the end plate or disk 11.

Mounted within the housing is an annular coil 14 wound on a spool 15 of suitable insulating material. Disposed within the spool of the coil is a tube 16 formed of two separate tubular sections. The forward section, designated 17, is formed of suitable non-magnetic material, such as brass, and the rearward section, designated 18, is formed of ferrous metal. For convenience, the adjacent ends of the tubular sections, 17 and 18, are formed to provide a lapped, telescoping connection. The outer ends of the tube 16, project a short distance beyond the end flanges of the spool 15 and are reduced in cross-section for a snug fit in a pair of disks 19 of ferrous metal. Rigidly secured to the outer surface of the closed end wall 10a of the housing, as by spot welding, is a disk 20 of ferrous metal. The purpose of the disks 19 and 20 is to build up the cross-sectional area of ferrous metal, of the housing, for obtaining more efficient utilization of the magnetic flux produced by the coil 14.

Mounted in the rear end of the tube 16 is a plug 22 of ferrous metal, which, as may be seen in the drawing, is of a length substantially coextensive with the length of the ferrous metal tube section 18. As is well understood in the art, said plug, in addition to providing a concentrated area for the magnetic flux, also serves as the means for limiting movement in one direction of the ferrous metal reciprocable plunger, indicated at 23. The rear end portion of the plug 22 is of reduced cross-section to form a threaded shank 24, which is threaded through the end plate or disk 11. The outer end of said shank 24 is projected beyond said end plate 11 and is provided with a nut 26 for securely fixing said plug 22 in position in the tube 16.

Disposed within the forward portion of the tube 16 is a second tube 28 of non-magnetic material, such as brass, the inner end of which telescopes over the adjacent inner reduced end of the plug 22. The inner or rear end marginal portion of said tube 28 is deformed inwardly, into a groove 30 in the body of the plug so as to connect said second tube 28 and plug 22 together as a unit. If desired, the deformed rear end portion of the second tube 28 may be permanently connected to the plug by brazing. The forward or opposite end of the second tube 28 projects through the closed end wall 10a of the housing and the outer disk 20 so as to provide an air gap between the ferrous metal housing and disk 20 with respect to the plunger 23, which is guided for reciprocable movement in said tube 28. This constructional arrangement tends to eliminate and reduce the effect of the magnetic flux acting directly on

the plunger 23 from impeding movement of said plunger when the coil 14 is energized.

The adjacent ends of the plunger 23 and the plug 22 are cooperatively formed in frusto-conical contour, and mounted in the bottom of the recess in the inner end of the plug is a rivet or pin 32 of non-magnetic material, such as brass, the purpose of which is to preclude what is termed "freezing" of the plunger to the plug, and which is caused by the residual magnetism of the plug when the coil 14 is de-energized.

By virtue of the construction described, it will be apparent that the ferrous metal tube section 18 and the ferrous metal plug 22 being substantially coextensive in length, in effect provides a cross-sectional area of ferrous metal within the coil 14, considerably greater than the cross-sectional area of the ferrous metal plunger 23. It will thus be manifest that due to this relationship of the cross-sectional areas of the plug 22 and tube section 18 with the plunger 23, it is possible to obtain a relatively great increase in efficiency in the utilization of the magnetic flux produced incident to energizing of the coil 14. It likewise has been found that provision of the ferrous metal disks 19 and 20 in the arrangement disclosed also adds considerably to the efficiency of operation of the solenoid.

As an illustration of the extent of increase in efficiency of this construction over constructions heretofore employed, when adhering to the same over-all dimensions of devices heretofore employed and with the same coil specifications and length of stroke of the plunger, it was found that it was possible to reduce the current input in the coil approximately fifty per cent, while at the same time increasing the pull on the plunger upwardly of forty per cent. It will therefore be apparent that the present construction of solenoid will lend itself to adaptation to a relatively small, compact size device when it is desired or necessary to adhere to definite power input for the coil and where a definite length of stroke and a desired pull of the plunger are required.

The construction represented in Figure 2 of the drawing will now be described. The parts of the device shown in Figure 2 which are identical with the parts of the structure disclosed in Figure 1 will be designated by the same reference characters, together with the exponent "b."

Mounted within the forward end of the spool 15^b is a tube 35 of non-magnetic material, such as brass, the outer end of which is of reduced cross-section and extends through the closed end wall 10^{ab} of the housing 10^b and the disks 19^b and 20^b, respectively. Mounted in the other end of the spool 15^b for the coil 14^b, is the plug 22^b which, as may be seen in the drawing, is of the same cross-sectional area as the area defined by the tube 35.

The tube 35 is connected to the plug 22^b in the same manner as above disclosed in connection with the structure of Figure 1 of the drawing, so that the tube 35 and plug 22^b, in effect, become a single unitary structure. In this construction, however, the disk 19^b adjacent the end plate 11^b is mounted directly upon the rearward portion of the plug 22^b.

It will thus be seen that the construction disclosed in Figure 2 of the drawing permits dispensing with the tube 16 of Figure 1, while still obtaining the desired relationship of increased cross-sectional area of the ferrous metal plug 22^b to the ferrous metal plunger 23^b.

In the construction disclosed in Figure 3 of the drawing, the parts which are identical with the parts of the structure disclosed in Figure 1 will be designated by the same reference characters, together with the exponent "c."

In this construction the tube 40, mounted within the spool 15^c of the coil 14^c, is formed of two sections, the outer section designated at 41 being formed of non-magnetic material, such as brass, and the other section designated at 42 being formed of ferrous metal. The abutting ends of the respective tube sections 41 and 42 are lapped and telescoped together to form a single unitary tube 40. The forward or outer end of the tube section 41 is of reduced cross-section and extends through the disks 19^c and 20^c, and the end wall 10^{ac} of the housing 10^c. The rear end of the ferrous metal tube section 42 is of reduced cross-section for a snug fit in the adjacent ferrous metal disk 19^c.

Reciprocably mounted within the non-magnetic tube section 41 is the plunger 23^c of ferrous metal, which cooperates with the ferrous metal plug indicated at 22^c. Said plug 22^c is substantially coextensive in length with the ferrous metal tube section 42, and is adjustable axially therein by reason of its reduced shank 24^c being threaded through the end plate or disk 11^c, and has its outer end provided with a slot 24^d for accommodating a screwdriver or other suitable instrument so as to permit convenient axial adjustment of the plug within the tube 40. The nut 26^c, threaded on the outer end of the shank 24^c, thus serves to lock the plug in a desired position of axial adjustment within the coil 14^c. The purpose of providing for axial adjustment of the plug is to obtain maximum efficiency in operation of the plunger 23^c. Such arrangement also permits accommodation for variations in the manufacture and assembly, not only of the solenoid itself but of parts of apparatus which may be connected to the plunger for operation thereby.

As is well known, certain devices which are operated by plungers of solenoids desirably must move within a relatively exact or predetermined range, and it will be apparent that variations in such movements may result from inaccuracy of fabrication or assembly of parts. Hence, by providing for adjustment of the plug, it is possible to readily accommodate such variations by providing a nicety of adjustment of said plug. It is also known that in certain instances where a solenoid is constructed to certain specifications for operation by a definite electrical current, it is possible that a variation of voltage will impair the efficient operation of the plunger of the solenoid, and this condition may be partially or wholly compensated for by such adjustment of the plug.

It will be apparent that by reason of the fact that the plug 22^c is substantially coextensive with the length of the tube section 42, the effective cross-sectional area for the passage of magnetic flux is the combined area of the plug 22^c and tube section 42, which is of considerably greater cross-sectional area than the cross-sectional area of the plunger 23^c. This will, as above stated, in connection with the other two structures described, result in greatly increased efficiency in the utilization of the magnetic flux produced upon energizing of the coil 14^c for obtaining increased pull on the plunger.

Although I have shown and described certain preferred embodiments of my invention, manifestly it is capable of further modification and rearrangement of parts without departing from

the spirit and scope thereof. I do not, therefore, wish to be understood as limiting this invention to the precise forms herein disclosed, except as I may be so limited by the appended claims.

I claim:

1. In a solenoid, a housing comprising a cup-shaped body and a disc for enclosing the open end thereof, an annular coil mounted in the housing, a tube mounted within and extending the length of the coil, one end portion of said tube being formed of non-magnetic material and the other end portion being formed of magnetic material, a second tube of non-magnetic material mounted within said first mentioned tube in lapped relation to said non-magnetic portion of said first mentioned tube and extending beyond the juncture of the portions of said first mentioned tube, a ferrous metal plunger reciprocably mounted in said second tube, and a ferrous metal plug mounted in said tubes in alignment in axial direction with substantially the entire length of said magnetic portion of the first mentioned tube.

2. In a solenoid, a housing comprising a cup-shaped body and a disc for enclosing the open end thereof, an annular coil mounted in the housing, a tube mounted within and extending the length of the coil, one end portion of said tube being formed of non-magnetic material and the other end portion being formed of magnetic material, a second tube of non-magnetic material mounted within said first mentioned tube in lapped relation to said non-magnetic portion of said first mentioned tube and extending beyond the juncture of the portions of said first mentioned tube, a ferrous metal plunger reciprocably mounted in said second tube, and a ferrous metal plug mounted in said tubes in alignment in axial direction with substantially the entire length of said magnetic portion of the first mentioned tube, the inner end of said second tube being telescoped over the reduced adjacent end of the plug and being rigidly connected thereto as a unit.

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