

[54] SOLENOID VALVE

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[51] **Int. Cl.**..... **F16k 31/06**

[58] **Field of Search**..... 251/129, 139

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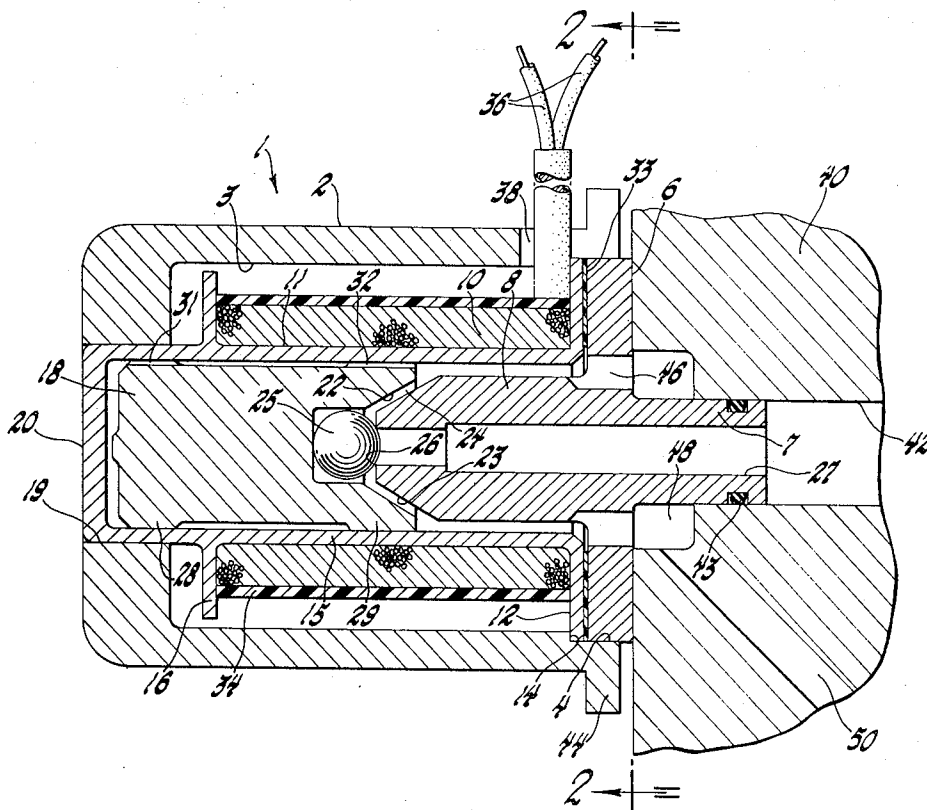
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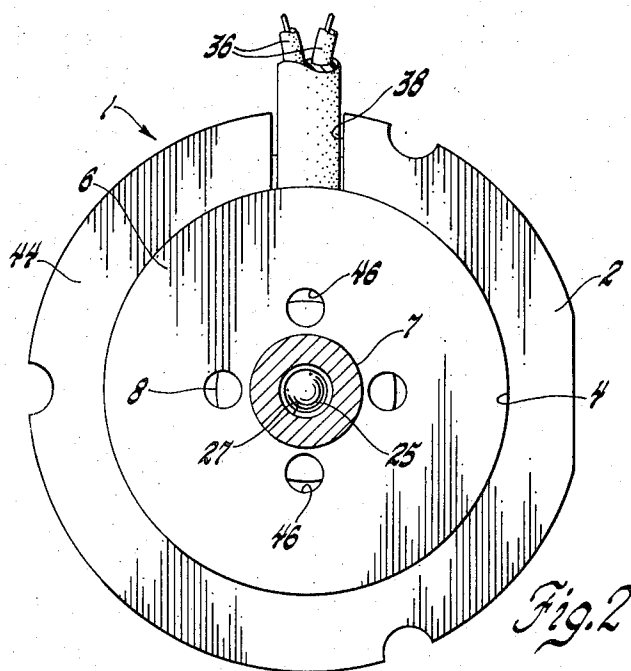
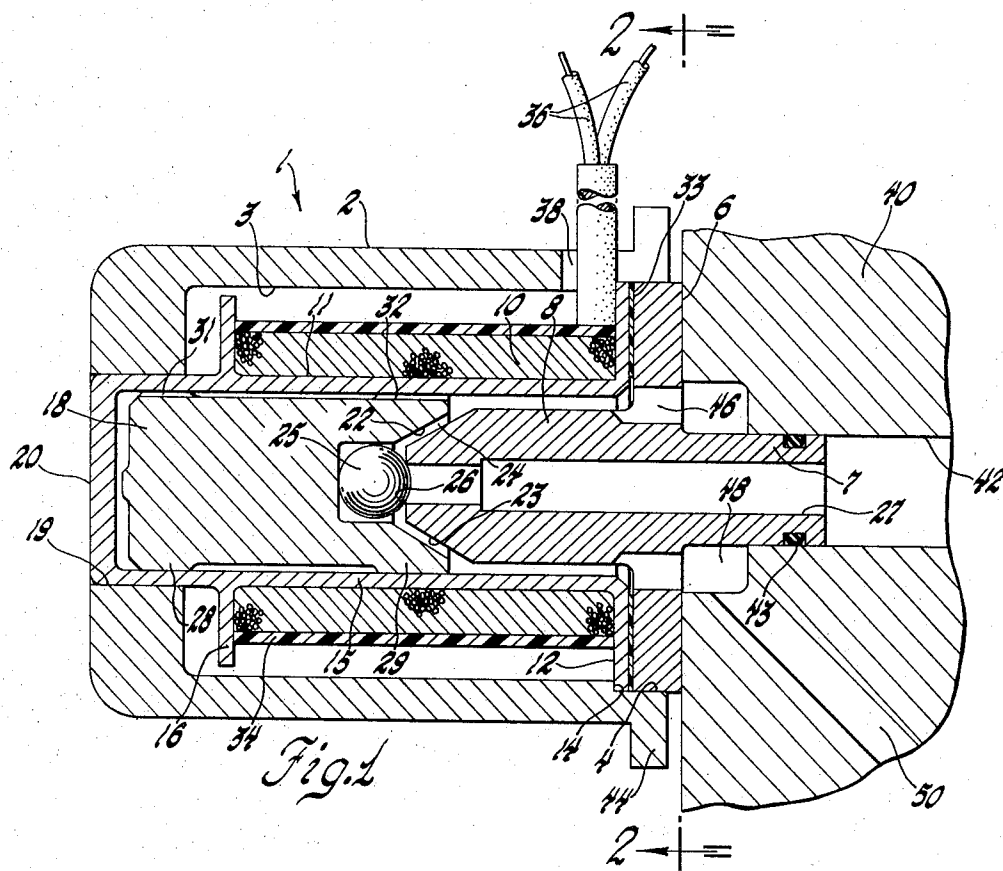
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[57] **ABSTRACT**

A solenoid-operated valve intended primarily to exert a force closely proportional to energizing current and particularly adapted for use in fluid pressure and flow controlling systems. The device includes an annular housing of magnetic material enclosing a nonmagnetic bobbin on which a coil is wound. An armature reciprocable within the bobbin in proximity to a pole piece of the housing exerts a force on a ball which seats at the end of an axial bore extending through the pole piece. The controlled fluid may communicate with the interior of the bobbin; one end of the bobbin is closed and the other end is sealed to the housing so that the fluid may not escape from the device. The fluid circuit through the valve is completed through holes in the pole piece.

3 Claims, 2 Drawing Figures





SOLENOID VALVE

My invention is directed to electromagnetic valves which are intended to exert a closing or pressure-resisting force which is a function, preferably a substantially linear function, of the energization of a coil or solenoid which is a part of the device. Valves according to my invention are particularly adapted for use in engine controlling systems and in general in systems in which the force exerted may be a means for providing an interface between an electrical control system and a fluid flow or pressure regulating system. Solenoid devices according to my invention are of structure which is particularly adapted to leakproof operation, to linearity of response, to economical fabrication and compact dimensions, and to convenient association with valve bodies and the like.

My invention provides in some respects an improvement on that described in Deckard U.S. Pat. application Ser. No. 327,958 filed Jan. 30, 1973 [U.S. Pat. No. 3,805,203]. It represents a structure more adapted to large-scale production and use, and may serve the same fluid-controlling function as the Deckard device. It is more completely self-contained.

Generally speaking, in its preferred embodiment, the valve comprises a cup-shaped housing having an annular pole piece closing one end of the housing, and having a bobbin mounted within the housing defining a guide for an armature reciprocable within the bobbin. The armature is attracted to the pole piece upon energization of a solenoid wound around the bobbin. The fluid may be displaced past the armature in case of its movement, and the bobbin is sealed to the pole piece to contain fluid within the enclosure defined by the bobbin. The armature biases a spherical valve member which cooperates with a seat at the end of a bore extending through the pole piece.

The nature of my invention and its advantages will be more fully apparent from the succeeding detailed description of preferred embodiments of the invention and the accompanying drawings.

FIG. 1 is a longitudinal sectional view of a valve device embodying the invention as installed.

FIG. 2 is a sectional view taken on the plane indicated by the line 2—2 in FIG. 1.

Referring first to FIG. 1, the electromagnetic valve device 1 comprises a cup-shaped housing 2 defining a generally cylindrical internal chamber 3 recessed as indicated at 4 at the open end of the housing. An annular pole piece 6 fitted in the recess 4 substantially closes the open end of the housing. The pole piece includes an external boss 7 and an internal boss or pole 8 extending into the housing along its axis. The housing and pole piece are made of a suitable magnetic material, preferably SAE type 1020 steel. The solenoid or coil 10 which generates the magnetic force is wound on a bobbin or spool 11 made of a suitable nonmagnetic material. The preferred material is an aluminum alloy identified as SAE 6061-T6. The bobbin includes a flange 12 which abuts the inner surface of the pole piece 6 and is impinged between it and a shoulder 14 at the bottom of recess 4. It includes a central hollow cylindrical portion 15 and a second flange 16.

The cylindrical portion defines internally a guideway for a magnetic reciprocable armature 18, also preferably of SAE 1020 steel. The end of the bobbin remote from pole piece 6 extends into and is located radially

by a bore 19 in the closed end of the housing. This end of the bobbin is closed by an integral wall 20. The portion of the bobbin adjacent the pole piece 6 extends over the pole 8 with radial clearance. The bobbin is located radially by its piloted fit of flange 12 in the housing and of cylindrical portion 15 with the interior of bore 19, and is located axially between the pole piece 6 and the housing 2.

The armature 18 is approximately of cylindrical shape, with a concave conical forward end 22 which is disposed adjacent to a corresponding conical nose 23 on the pole, the device defining an air gap between the surfaces of portions 22 and 23. Armature 18 is recessed to receive a spherical valve member 25 which may engage a seat 26 at the inner end of a bore 27 along the axis of the pole piece 6. Preferably, the armature has two shallow flanges 28 and 29 which bear against the interior of the bobbin cylinder 15. These flanges are partially cut away to define flats or slots indicated at 31 and 32 to permit fluid to flow freely past the armature when it moves. The fluid may enter the device through the bore 27 and fill the space around the armature. It is prevented from leaking by a gasket or sealant 33 disposed between the forward face of the bobbin and the pole piece. It is essential to fast transient displacement response that no significant fluid pressure differential be generated by shifts of the armature. If slow movement is acceptable, some fluid damping of armature movement by fluid in the cylinder 15 may be desirable.

The coil 10 wound on bobbin 11 is enclosed by a coating 34 of epoxy resin. Electrical lead-in wires 36 extend through an opening 38 in the housing 2.

As will be understood, if magnetizing current is passed through leads 36 to the solenoid 10, the resulting magnetic flux flows through the housing 2, armature 18, and pole piece 6, and tends to draw the armature to the right, as illustrated, into contact with the pole piece. For any given position of the armature, the force exerted is substantially proportional to the magnetomotive force, which again is substantially proportional to current as long as the saturation of the iron does not significantly vary the reluctance of the magnetic circuit. If the armature moves, the force increases as the surfaces 22 and 23 approach each other.

The device is intended primarily, however, for use in a substantially stationary condition in which force is modulated rather than position. This modulation may be accomplished by varying the magnitude of a constant current or by varying the average current as, for example, by duty cycle control of current flowing through the solenoid.

The housing 2 is illustrated as mounted so that the pole piece 6 abuts a body or valve block 40 which defines a bore or passage 42 into which the external boss 7 of the pole piece is piloted. An O-ring 43 prevents leakage around the boss 7. The housing 2 has a flange 44 adjacent the block 40 which is engaged by suitable clamping means (not illustrated) to hold the valve device in position on the block 40. Passage 42 thus communicates through bore 27 with valve 25, 26. Fluid which passes through the valve may discharge through the gap 24 between the armature and the pole 8, between pole 8 and cylinder 15, and through holes 46 in the web of pole piece 6 into a recess 48 in block 40 surrounding boss 7. This recess may discharge through a drain or other exit passage 50. If this passage is under pressure, a gasket or other seal may be provided be-

tween the pole piece 6 and block 40 around recess 48.

As will be apparent, if fluid is introduced through the passage 42, the resistance to its escape will be a function of the force exerted by the armature 18 and, therefore, the average current going through the solenoid 10 of the valve device may maintain the pressure communicating with the inlet 42 at a particular desired value as a function of this current. If the supply of fluid through passage 42 is limited, this regulation may be accomplished with slight travel of valve member 25. The valve is thus well-adapted to regulate a pressure to control further hydraulic devices as a function of solenoid current.

The valve ball 25 may be of various materials. Both steel and firm rubber balls have worked successfully. The rubber tends to seal somewhat better.

Among the advantages of the valve device as illustrated herein are the substantially constant or consistent relation of force to current, a fast response to transients, and negligible hysteresis; that is, variation of the force exerted between increasing and decreasing current flows. It is self-contained, and mounts easily on a recessed opening in a valve block or other device to be controlled.

The particular devices illustrated are shown to scale and have a housing about 1½ inches in diameter.

The detailed description of the preferred embodiment of the invention for the purpose of explaining the principles thereof is not to be considered as limiting or restricting the invention, since many modifications may be made by the exercise of skill in the art.

I claim:

1. An electromagnetic valve device comprising, in combination, a housing; a pole piece abutting the housing including a first hollow boss extending into the housing and a second hollow boss extending from the housing; an annular bobbin fixed in the housing; a solenoid on the bobbin; an armature reciprocally guided within the bobbin, the armature and the first boss having confronting portions defining an air gap; means providing a fluid seal between the bobbin and the pole piece; the housing, pole piece, and armature being of a magnetic material and the bobbin being nonmagnetic; the bosses defining a fluid inlet passage terminating in an annular seat at the inner end of the first boss; and a movable valve closure member disposed adjacent the seat and biasable against the seat by energization of the solenoid; a fluid outlet passage extending along the exterior of the first boss bounded by the first boss and the bobbin; the pole piece defining an outlet from the outlet passage.

2. An electromagnetic valve device comprising, in combination, a housing; a pole piece abutting the housing including a first hollow boss extending into the housing and a second hollow boss extending from the housing; an annular bobbin fixed in the housing; a solenoid on the bobbin; an armature reciprocally guided within the bobbin; the armature and the first boss having confronting portions defining an air gap; and means providing a fluid seal between one end of the bobbin and the pole piece; means closing the other end of the bobbin; the armature having sufficient clearance from the pole piece and bobbin for displacement of fluid upon reciprocation thereof; the housing, pole piece, and armature being of a magnetic material and the bobbin being nonmagnetic; the bosses defining a fluid inlet passage terminating in an annular seat at the inner end of the first boss; and a movable spherical valve closure member disposed adjacent the seat between the armature and first boss and biasable against the seat by energization of the solenoid; a fluid outlet passage extending along the exterior of the first boss bounded by the first boss and the bobbin; the pole piece defining an outlet from the outlet passage.

3. An electromagnetic valve device comprising, in combination, a housing; a pole piece abutting the housing including a first hollow boss extending into the housing and a second hollow boss extending from the housing; an annular bobbin in the housing piloted at the end of the bobbin adjacent the pole piece on the housing, the bobbin including a portion providing a pilot connection between the other end of the bobbin and the housing; means closing the said other end of the bobbin against escape of fluid; a solenoid on the bobbin; an armature reciprocally guided within the bobbin, the armature and the first boss having confronting portions defining an air gap; means providing a fluid seal between the bobbin and the pole piece; the armature having sufficient clearance from the pole piece and bobbin for flow of fluid upon reciprocation thereof; the housing, pole piece, and armature being of a magnetic material and the bobbin being nonmagnetic; the bosses defining a fluid inlet passage terminating in an annular seat at the inner end of the first boss; and a movable valve closure member disposed adjacent the seat and biasable against the seat by energization of the solenoid; a fluid outlet passage extending along the exterior of the first boss bounded by the first boss and the bobbin; the pole piece defining an outlet from the outlet passage.

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