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RETRACTABLE NOZZLE FLAPPER VALVE

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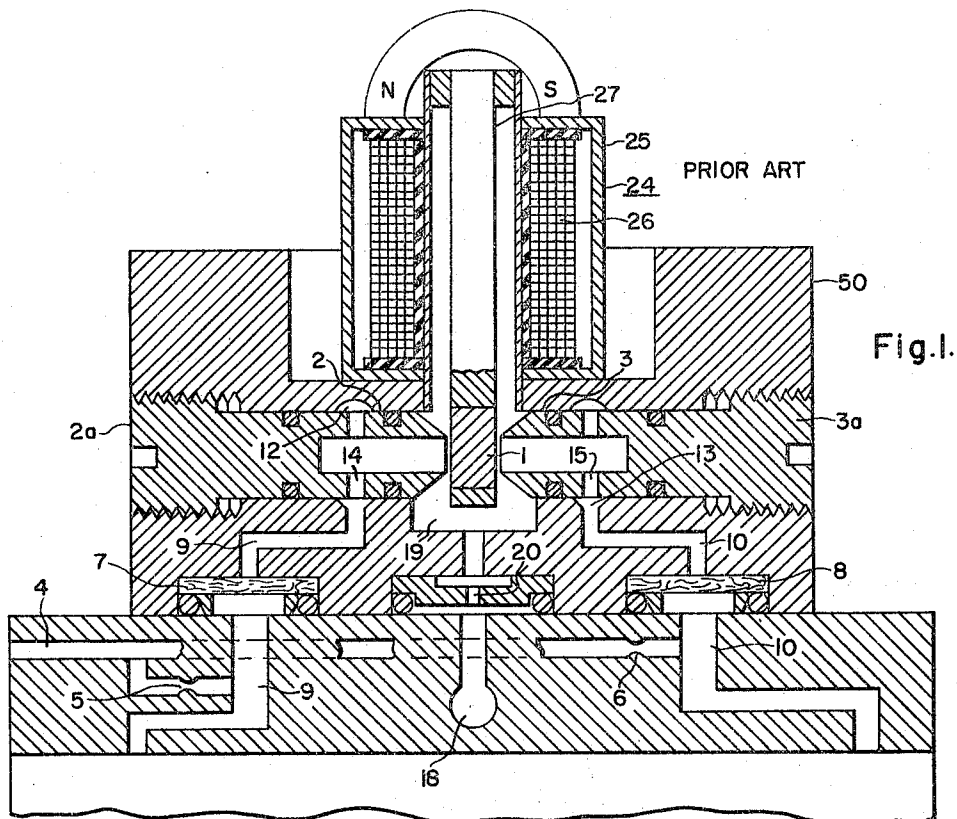


Fig. 1.

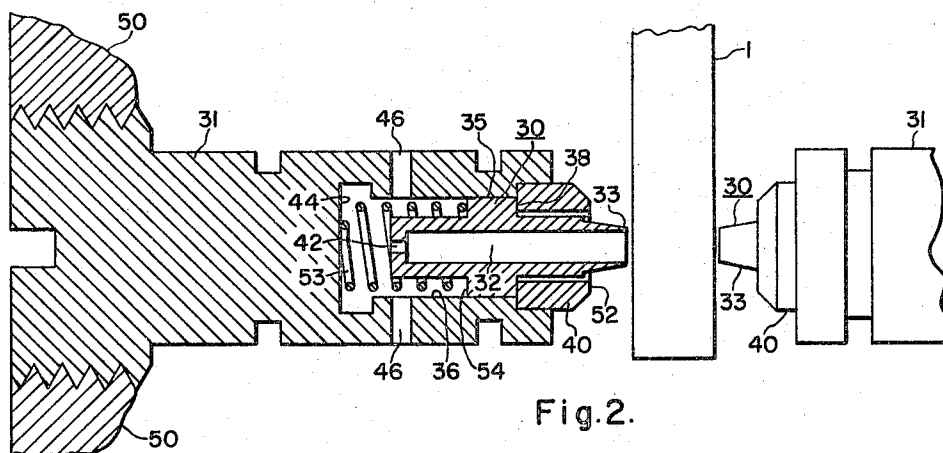


Fig. 2.

WITNESSES

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RETRACTABLE NOZZLE FLAPPER VALVE

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6 Claims. (Cl. 137-82)

The present invention relates to valve apparatus and more particularly to an improved flapper valve assemblage of the general type frequently employed in the first stage of hydraulic servo valves.

A flapper valve assemblage of the type here under consideration comprises a flapper or fluid control vane which is caused to move to relative positions of proximity with respect to an orifice in the end of a flapper nozzle to control the rate of escape of fluid via such nozzle and thereby regulate the inlet pressure to such nozzle for purposes such as controlling pressure dictates to the second stage of a servo valve device, in the first stage of which the flapper valve assemblage may be comprised. Usually there are two such nozzles, with the flapper disposed therebetween, and when the flapper is actuated, it moves toward the one nozzle and away from the other to create a differential pressure effect between the two nozzle inlets. The faces of the flapper which are subjected to direct discharge of fluid from the nozzles are of relatively hard material, metal or ceramic, for example, to resist erosion by such fluid. Actuation of the flapper to positions relative to the nozzle means is usually effected by an electromagnetic means, termed a torque motor, which is so constructed and arranged as to cause pivotal movement of an extension of the flapper against a bias, which is often the resiliency of such extension. A control current supplied to the torque motor dictates the position of the flapper relative to the nozzle means and hence the pressure condition thereof.

The flapper-nozzle type of first stage for hydraulic servo valves is now established as a sound and practicable device which is well suited for converting small electrical signals into large fluid-pressure forces for effectuation of the second or power stage of such valves. Where, however, miniaturization is at a premium, good design practice dictates close proximity of the flapper to the nozzle means and a thin wall at the tip of such nozzle means. Often the flapper valve assemblage is designed to occupy a mid-position between two nozzle tips each of which is only a thousandth of an inch away, and the radial thickness of the wall at the tip of each nozzle may be as little as two thousandths of an inch. Such a thin-walled tip tends to be fragile and susceptible to damage when contacted by the flapper with excessive force, such as might occur during testing, which has led to a practice of providing a nozzle tip of relatively-expensive deformation resistant material such as ruby. At the same time, the maximum clearance between the flapper and a nozzle is only twice that of its mid-position clearance distance, or two thousandths of an inch in the chosen example, and this places a burden on the cleanliness of the hydraulic fluid employed, since any rigid fluid-transported particles larger than two thousandths of an inch cannot pass through the nozzle past the adjacent flapper and would tend to accumulate at this location and cause random and erratic first stage output pressures either as a result of nozzle restriction and/or interference with flapper movement.

In view of the foregoing remarks, it becomes an object of the present invention to provide an improved flapper valve assemblage which is particularly suited for employment in the smaller servo valve devices to overcome the previous problems discussed above in a more practical and economic manner.

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It is another object of the invention to provide an improved nozzle for a flapper valve assemblage, which is suitable for use in miniature servo valve devices as discussed above, but which is immune to damage by the flapper without requiring use of special hard materials such as ruby.

It is another object of the invention to provide an improved flapper nozzle which enables the afore-described close proximity to the flapper, but which enables periodic operation of the valve device employing same in a manner which flushes the nozzle free of any accumulated particles lodged between nozzle and flapper as discussed hereinbefore.

In accord with general features of the invention, the above objects are realized in a manner which is relatively simple, which thus enhances its value, by providing a nozzle construction which is retractable to a protected position upon exertion of the flapper thereagainst with a force sufficient to overcome a bias force urging such nozzle to a normally projecting position. By this arrangement, the nozzle may be made of a conventional material such as stainless steel or other metal, for example, have the desired thin-walled tip, but yet be immune to damage by an excessive flapper-exerted force. At the same time, where, as is usual, there are two such nozzles at opposite sides of the flapper, a greater-than-normal clearance is provided between the flapper and the other nozzle when the one nozzle is caused to be retracted. This affords opportunity for any particles lodged between flapper and nozzle to be freed by alternate retraction of the two nozzles. By making the bias force which urges the nozzles to their normally projecting positions reducible, such retraction may be effected when desired by application of normal degrees of control force applied to the flapper.

Other objects, advantages, and features of the invention will become apparent from the following detailed description, taken in connection with the accompanying drawings, in which:

FIGURE 1 is a cross-sectional view of the first stage of a typical electrically-controlled hydraulic servo valve device embodying a conventional flapper valve assemblage; and

FIG. 2 is a cross-sectional view of a novel nozzle assemblage for substitution of the conventional nozzle assemblages as employed in the device of FIG. 1.

Referring now to FIG. 1 in the drawings, the typical first stage of an electrohydraulic servo valve device comprises a flapper valve 1 which is normally disposed equidistant between the projecting ends of two alike orifice members in the form of nozzles 2 and 3 through which flows hydraulic fluid from a fluid supply inlet 4 via respective equal-sized flow-restricting orifices 5 and 6, respective filter elements 7 and 8, respective passages 9 and 10, respective annular grooves 12 and 13, and radial ports 14 and 15 into the interior of the nozzles 2 and 3, respectively. Such fluid in flowing through the two nozzles 2 and 3, flows past the flapper 1 to a fluid return outlet 18 via a return chamber 19 and passages including a drain orifice 20. By movement of the flapper valve 1 toward one of the nozzles 2 and 3 and hence away from the other of such nozzles, fluid flow through the one nozzle becomes more restricted while flow through the other nozzle becomes less restricted. This results in creation of a difference in pressures in the two passages 9 and 10, which pressure differential is employed in the second stage (not shown) of the valve device to control an output or power valve therein which in turn effects creation of an output pressure differential used to operate or position an actuator (not shown), for example. The degree of movement of the flapper 1 from its mid-position in one or the other direction, determines the degree

of difference between the two pressures in passages 9 and 10, and the direction of movement determines which of the two pressures is the preponderant one, as in effecting movement of an actuator in one direction and the other. Movement of the flapper is usually effected by a torque motor 24 which includes a magnetic structure 25 including a coil 26 for developing a pulling force on an extended portion 27 of the flapper 1 to cause it to bend according to the degree of current supplied to such coil, thereby carrying its nozzle-proximate end to different positions relative to the nozzles 2 and 3. The direction of such flapper-extension bending or deflecting is determined by the direction of current flow through the coil. Such torque motor is well known and may take other forms than that illustrated herein, and since the specifics of such a motor are of no concern here, it is believed that the present description will suffice.

As discussed hereinbefore, the normal mid-position clearance between flapper and nozzles 2 and 3 is often of the order of a thousandth of an inch and the radial thickness of the nozzle walls at the tips of the nozzles is often of the order of two thousandths of an inch (the dimensions are grossly exaggerated in the drawing for purpose of clarity) it will be apparent that an undue force exerted by the flapper against the nozzle tips will be prone to damage such tips unless made of exceptionally hard material, and that, since the maximum distance between flapper 1 and either of the nozzles 2 and 3 cannot exceed twice the mid-position clearance distance, fluid-borne particles larger than the exemplified two thousandths of an inch, for example, can become lodged between flapper and nozzle to cause erratic and/or undesirable operation of the device.

Referring now to FIG. 2, a novel nozzle assemblage of the present invention comprises a nozzle member 30 of general cylindrical configuration which is mounted in a fitting member 31 in a manner which affords axialwise movement thereof relative to such fitting member. The nozzle member is hollow at its interior to form a central fluid passageway 32 extending axially therethrough and its projecting tip 33 is of reduced wall thickness in accord with a preferred design practice for obtaining optimized valving action between such tip and the flapper with which it cooperates.

Relative movement of the nozzle member 30 in the fitting member 31 to enable retraction of such nozzle member as aforementioned herein, is provided in the illustrative example in FIG. 2 by sliding cooperation between an outer cylindrical surface portion 35 of nozzle member 30 and the inner walls of a bore 36 formed in such fitting member.

For purposes of defining the normally projected position of nozzle member 30 for disposition of its tip portion 33 adjacent to the flapper, as flapper 1 in FIG. 1, the nozzle member 30 is provided with a radially-extending annular shoulder 38 at its forward end which is constructed and arranged to cooperate with a hollow cylindrical stop member 40 mounted in the end of fitting member 31 and encircling the respective end of the nozzle member 30 which extends therethrough.

The central fluid passageway 32 of the nozzle member 30 is availed of fluid under pressure by way of an orifice 42 at the innermost end of the nozzle member 30, a chamber 43 which is defined peripherally by the walls of the bore 36 and at one end by an end wall 44 formed in the fitting member 31. Supply of fluid to the chamber 43 is afforded by a plurality of circumferentially-arranged radial ports 46.

To bias the nozzle member 30 to its normally projecting position beyond the end of stop member 40, the orifice 42 at the inward end of such nozzle member is restricted so that flow of fluid via the inlet ports 46 and chamber 43 to the interior passageway 32 of the nozzle member will create an axially directed force on such

nozzle member urging the same into engagement with the stop member.

In such projecting position of nozzle member 30, the tip end 33 of the nozzle is normally disposed in close proximity to the flapper 1 when the same is in its mid-position such, for example, as that shown in FIG. 2 and in which the right-hand nozzle member 30 shown in outline is disposed. The clearance and other dimensions as shown in FIG. 2, as was the case also in FIG. 1, are exaggerated for purpose of clarity and in some cases the tip end wall thickness may be in the order of two thousandths of an inch and the normal clearance between the tip end 33 and the flapper 1 may be in the order of a thousandth of an inch.

In operation of the novel nozzle assemblage as shown in FIG. 2, assume that each of the nozzles 2 and 3 are formed in the ends of respective fitting members 2a and 3a which are removably mounted in the casing portion 50 of the first stage of an electrohydraulic servo valve device as shown in FIG. 1, and that two fitting members 31 containing the novel nozzle assemblage of FIG. 2 occupy positions, respectively, in substitution for the two removable nozzles 2 and 3 in FIG. 1. Assume also that dimensions are such that the location of the inlet ports 46 in the two fitting members 31 will then be in registry with the annular supply grooves 12 and 13 of FIG. 1, so that hydraulic fluid will flow through the two nozzle members 30, which will be in their extended positions such as shown in FIG. 2, past the flapper valve 1 and into the return chamber 19 to the return outlet 18 in a manner as afordescribed in connection with FIG. 1. In such projected positions of the nozzle members 30, the function of the normal operation of the valve device is as afordescribed in connection with FIG. 1. In accord with features of the invention, however, should the flapper 1 exert a greater than normal force against the projecting end of either of the nozzle members 30, the bias force created by flow of fluid via the orifices 42 in the nozzle members will be overcome by such flapper force and cause retraction of the nozzle member 30 inwardly of the fitting member 31 until the flapper engages a blunt end 52 of stop member 40. Thus, the relatively delicate tip end 33 of the nozzle member is protected from damage due to such excessive force of the flapper. Upon relief of such excessive force by the flapper, the bias force created by fluid flow through the orifice 42 will return the nozzle member to its normal position of projection beyond the end of the stop member 40 and defined by engagement of annular shoulder 38 with the inner end of such stop member.

In accord with the self-clearing feature of the invention, it will be seen that while the one nozzle member 30 is thus depressed inwardly of the fitting member 31, a greater-than-normal clearance will exist between the flapper 1 and the other nozzle member 30, so that any particles that had been lodged between the projecting end of the nozzle member 30 and the flapper 1 during normal clearance conditions will now have an opportunity to be flushed out by the flow of fluid through such nozzle. By causing alternate depression, or retraction, of the nozzle members, each may be so flushed out in turn. To facilitate such periodic flushing out as may be desired from time to time, the pressure of the supply fluid availed to the nozzles may be reduced to reduce the bias force created by a flow of fluid through the orifices 42 in the nozzle members and thus enable the retraction of such nozzle members with less force from the flapper 1. It will be appreciated, however, that such restricted-flow type of bias may be abetted by or substituted by a light bias spring 53 acting on one end of the movable nozzle member 30. Such spring may be helical and of the compression type as shown, disposed, for example, in chamber 43 for abutment at its one end with the wall 44 and at its opposite end with such as an annular shoulder 54 formed on such nozzle member.

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While there has been shown and described what are at present considered to be the preferred embodiments of the invention, modifications thereto will readily occur to those skilled in the art. It is not desired, therefore, that the invention be limited to the specific arrangement shown and described and it is intended to cover in the appended claims all such modifications that fall within the true spirit and scope of the invention.

I claim as my invention:

1. An improved flapper valve construction comprising a flapper valve, and a retractable tapered-thin-wall-tip nozzle means biased to a particular projecting position proximate to said flapper valve for the influencing of flow of fluid through said nozzle means and displaceable to a retracted protected position by a non-tip-damaging force delivered by said flapper valve.

2. An improved flapper valve construction comprising a flapper valve, a retractable tapered-thin-wall-tip nozzle means biased to a particular projecting position proximate to said flapper valve for the influencing of flow of fluid through said nozzle means according to proximate flapper valve position during valving action and displaceable in the opposite direction by a non-tip-damaging force delivered by said flapper valve, first stop means engageable by said nozzle means to define its said particular projecting position, and second stop means engageable by said flapper valve during its displacement of said nozzle means to limit maximum travel of the flapper valve to a distance less than the available travel of said nozzle means.

3. The improved flapper valve construction of claim 1, wherein the nozzle means is constructed and arranged to be biased to said particular projecting position at least partially by flow of fluid therethrough.

4. The improved flapper valve construction of claim 2, wherein the nozzle means is constructed and arranged to be biased to said particular projecting position at least partially by flow of fluid therethrough.

5. An improved flapper valve assemblage comprising a flapper valve, and a pair of tapered-thin-wall-tip retractable nozzles biased to normal projecting proximate

positions at opposite sides of said flapper valve for influencing relative flow of fluid through said nozzles according to flapper valve positioning therebetween, said nozzles being separately displaceable by said flapper valve to retracted protected positions whereby clearance between such valve and the non-displaced one of said nozzles may be increased above that prevailing during normal valving action.

6. An improved flapper valve assemblage comprising a flapper valve having a neutral position and movable respective fixed travel distances in opposite directions from such neutral position, a pair of tapered-thin-wall-tip nozzles arranged at opposite sides of said flapper valve, respectively, in a manner directing flow of fluid under pressure theretoward, said nozzles having freedom for movement by said flapper valve to the full extent of flapper valve travel, means biasing each of said nozzles in the direction of said flapper valve, and stop means engaged by said nozzles to define projecting positions thereof relative to which said flapper valve is moved distances less than its full travel capability for normal valving action on the fluid passing through the nozzles, wherein movement of said flapper valve beyond its normal valving excursions can be effected without nozzle-tip damage to cause alternate displacement of each of said nozzles during flow of liquid therethrough, thereby alternately increasing the clearance between said flapper valve and the non-displaced nozzles whereby flushing of particle accumulation from the nozzles may be realized.

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