

Jan. 23, 1962

R. D. ATCHLEY

3,017,864

VALVE

Filed Aug. 18, 1958

3 Sheets-Sheet 2

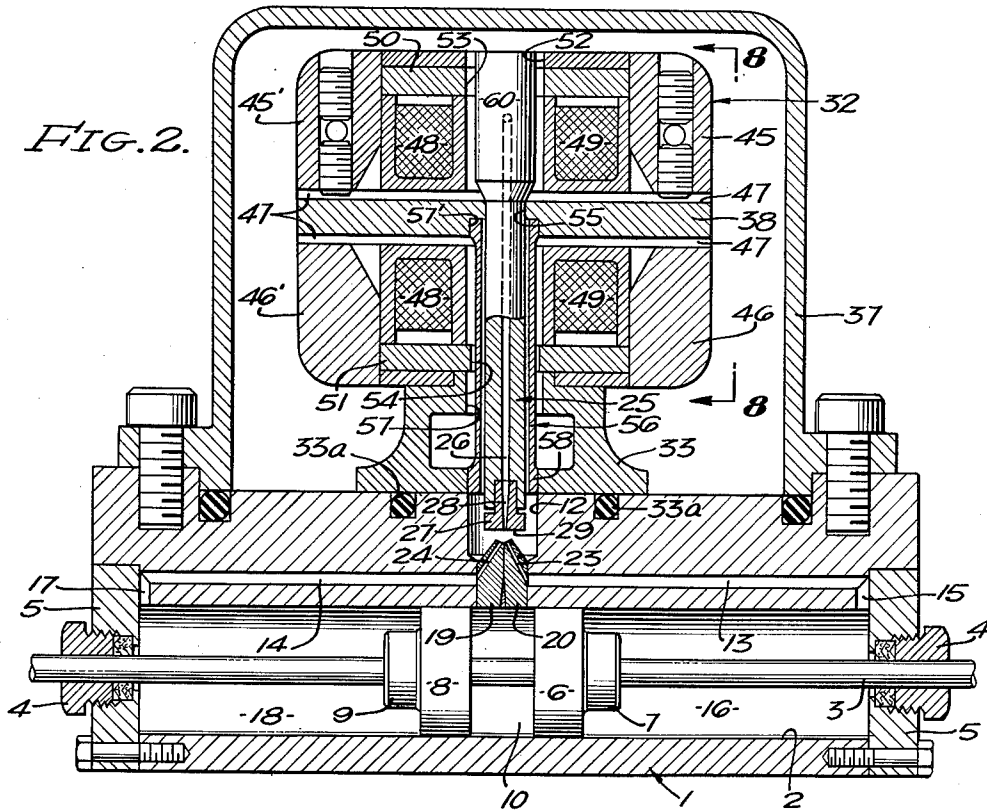
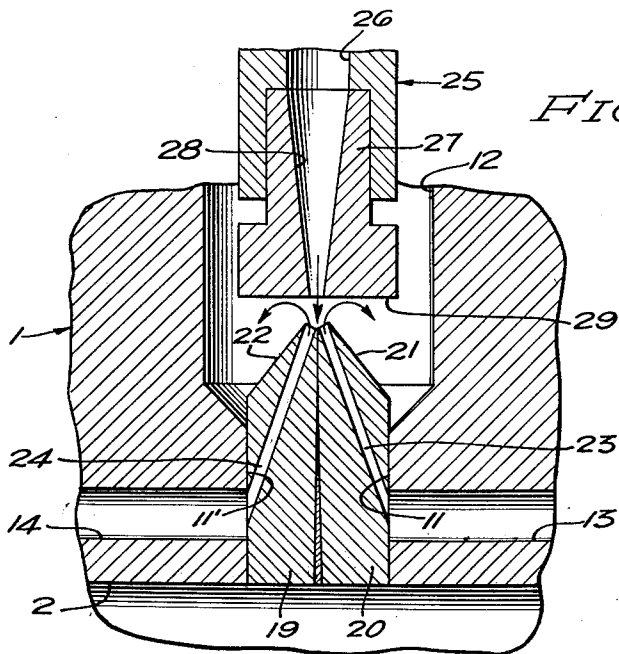
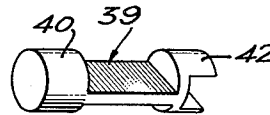


FIG. 6.

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FIG. 9.

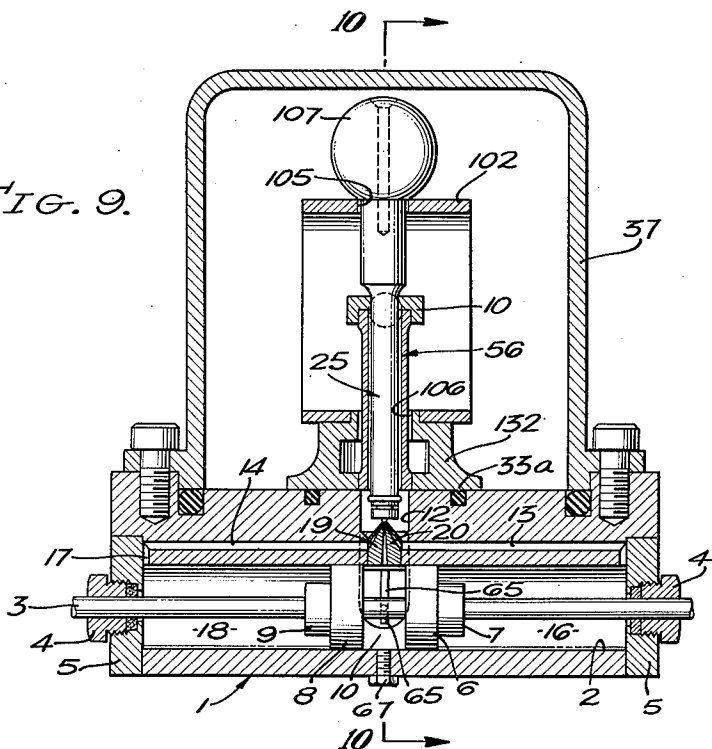


FIG. 10.

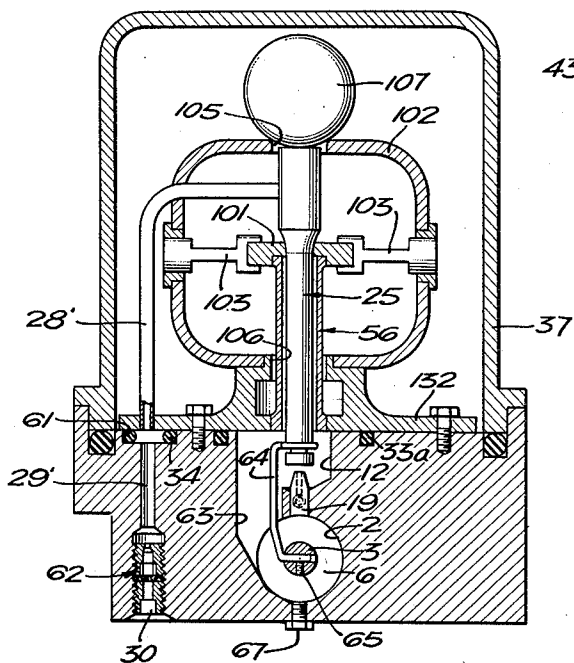
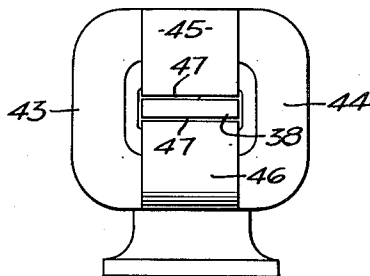


FIG. 8.

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16 Claims. (Cl. 121-41)

This application is a continuation-in-part of application Serial No. 583,487, filed May 8, 1956, now Patent No. 2,891,181; Application Serial No. 586,778, filed May 23, 1956, now Patent No. 2,884,906; and Application Serial No. 681,310, filed August 30, 1957, now Patent No. 2,884,907.

It is related to an hydraulic amplifier for an electrical signal which actuates a motor which moves a fluid motor. The fluid amplifier multiplies the mechanical force exerted by the motor to actuate the fluid motor with a force which may be multiplied by a factor as is desired.

In the further description of my invention I will describe the principle and the application thereof to hydraulic systems intending that the said description shall apply as well to pneumatic or gaseous systems.

I employ as an hydraulic amplifier a movable ejector jet actuated by the motor to move between two stationary receptor jets which are connected by fluid conduits to a movable piston, one to one side of the piston and the other to the other side of the piston. The piston may actuate a valve member or actuate any other member. The pressure delivered to the cylinder in which the piston moves is dependent on the pressure of the fluid supplied to the ejector jet and not on the force applied by the motor. Because the pressure generated in the cylinder in which the piston is moved is not dependent on the force with which the jet is moved, I may obtain any desired degree of amplification of the applied signal and thus exert a large force to the fluid motor on application of a weak signal.

The ejector jet moves from one to the other of the stationary receptor jets and thus applies a different pressure in each receptor jet depending on the degree of overlap of the ends of the respective receptor jets and the ejector jet. Since the ejector jet may be made of small mass a high natural frequency may be obtained of any desired degree and thus the system will respond to signals of desired frequency.

Additionally the single ejector jet and two stationary receptor jets form a four-arm hydraulic bridge and this has twice the sensitivity of a single ejector jet and single receptor jet.

Because the ejector jet may be made to be substantially frictionless in its motion, the system has a high degree of resolution.

It is possible to use relatively large holes for the ejector jet, which allows the passage of large dirt particles such as would disable the jets employed in prior art jet actuated devices.

These and other objects of my invention will be further understood by reference to the drawings, of which

FIG. 1 is a sectional view of the system of my invention;

FIG. 2 is a section on line 2-2 of FIG. 1;

FIG. 3 is an enlarged fragmentary view of FIG. 2;

FIG. 4 is a fragmentary view partially in section and partly in elevation of a modified form of the system of FIG. 1;

FIG. 5 is a section on line 5-5 of FIG. 4;

FIG. 6 is a perspective view of one form of flexure employed in my invention;

FIG. 7 is a perspective view of another form of flexure which may be employed in my invention;

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FIG. 8 is an elevational view of FIG. 2;

FIG. 9 is a section of a modified form of my invention; and

FIG. 10 is a section on line 10-10 of FIG. 9.

Referring to FIGS. 1 and 2, the block 1 is bored with a cylindrical bore 2 in which is positioned a piston rod 3 passing through packing glands 4 in the recessed end plates 5 which makes a fluid tight joint with the block 1. Pistons 6 and 8 are mounted on the rod 3 and spaced apart to provide an annular space 10 and are provided with bosses 7 and 9. As will appear from the following description, instead of two spaced pistons 6 and 8 one only may be provided with two bosses on the opposite sides of the piston or the two pistons 6 and 8 may be placed side by side.

Positioned in two tapered bores 11 and 11' in the core 1 are two cylindro-conical receptor jets 19 and 20 of identical construction, so positioned that the conical outer ends of the jets are tangent to each other. The bore 24 in the jet 19 and the bore 23 in the jet 20 are positioned at an angle such that the peripheries of the two jets, at the nozzle mouths, are in as close proximity as is permissible by good machining practice. The jets are thus symmetrically positioned.

The lower ends of the ports 23 and 24 are in fluid communication with cross bores 13 and 14 in block 1. Bore 13 is connected to the space 16 through the port 15 and bore 14 is connected to the space 18 through the bore 17.

A counter bore 12 is provided in the block 1. The nozzle 27 of the ejector jet protrudes into the bore 12 and is axially aligned so that its axis is midway between the centers of the bores 23 and 24, as is shown in FIG. 3.

The jet pipe 25 is bored with a bore 26 and counter-bored to receive the nozzle 27 having a downwardly tapered conical bore 28. The axis of the bore 28 bisects the angle between the center lines of the bores 23 and 24 with the adjacent ends of the bores 23 and 24 symmetrically positioned with respect to the axis of the conical bore 28 in the plane of the displacement of the axis of 28 when the nozzle is displaced, as will be described below.

The ejector nozzle tube may be mounted for displacement in the plane including the axis of the bores 23 and 24, see FIG. 3, by any desired means either manual or inertially or by means of a motor such as 32 and supplied with fluid via a cross bore 27' and a connecting tube 28' which communicates with the inlet bore 29' in the block 1.

The configuration of the ejector nozzle 27, as shown, has a flat planar end 29 which is perpendicular to the axis of the bore 28 and is in extent considerably greater than the mouth of the angular bores 23 and 24. The configuration thus has the property that any emitted fluid, particularly if the fluid be liquid of substantial mass, impinging upon the ends of the conical portion of the receptor jets 21 and 22, particularly on the fluid filling the angular bores 23 and 24, will be reflected therefrom to impinge upon the lower end 29 of the nozzle 27 substantially symmetrically about the axis of the bore 28. The fluid will be reflected at a point and in a direction away from the mouth of the receiver jets, discharging into the bore 12, as is schematically illustrated in FIG. 3. Furthermore, it will be observed that the point of reaction resulting from this impingement and reflection from the lower surface of the ejector jet creates a resultant of thrust on each side of the center line of the ejector jet, which is substantially equal and has an equal moment and are each parallel to the axis of the ejector jet. Since the tube 25 may be so mounted as to be rigid in this direction, as will be described below, no displacement of

the ejector jet results from this action. As a result no lateral forces of substantial effect are imposed upon the ejector jet to cause a lateral displacement due to the impingements of the reflected stream of fluid upon the ejector jet surfaces 29. This affords a stability in the jet which is substantially independent of random displacement forces resulting from random variations in the pressure or volume of flow of the fluid from the ejector jet.

The fluid entering the bores 23 and 24 passes through the ports 13, 14, 15 and 17 into the spaces 16 and 18. Due to the symmetry of construction of the receptor jets and communicating ports, the resistance to flow from the outer ends of each of the receptor jets 23 and 24 into the chambers 16 and 18 are the same.

The tube 25 may be actuated by any means, either manually by providing a suitable handle at the upper jet or by means of an inertial member.

While I may also employ any other torque motor assembly, where, however, the fluid pressure employed is high I prefer a mounting which will be substantially rigid in the direction of the axis of the tube for the purposes described above. Such a mounting is provided in the structure described in the aforementioned application Serial No. 681,310, now Patent No. 2,884,907, of which this application is a continuation-in-part. The form of mounting there described has also the advantage of sealing the torque motor case from the fluid so that if the fluid pressures be high the pressure in the case may be low, for example, atmospheric and also if the fluid is liquid, the motor case being sealed off from the liquid, can be kept dry. In both cases also contamination of the torque motor case is prevented.

Carried on the upper face of the case 1 is a torque motor assembly which in the main is described in my co-pending application Serial No. 583,487, filed May 8, 1956, now Patent No. 2,891,181 of which this application is thus a continuation-in-part, the structure being modified, as will be more fully described below.

The torque motor is mounted on block 1 on a mounting base 33 and O-rings 33a. It is composed of a strapped frame 32' which carries the armature 38 mounted on torsion members 39 formed by milling the shaft member 40 to form a thin spring web member, see FIG. 6. One end of the shaft member 40 is rigidly fixed by brazing to a bushing 41 which is rigidly fixed into strap 32 by brazing, and the other end is formed as a fork 42 into which the armature 38 is rigidly fixed by brazing. At each end of the frame 32 is positioned a pole and magnet assembly composed of a C-shaped magnet 43, 44 and a C-shaped magnet oriented with their north poles and south poles opposite each other, each such assembly carrying pole pieces 45 and 45' at the north pole and pole pieces 46 and 46' at the south pole spaced from each other to produce a gap 47. The armature 38 is positioned symmetrically in each of said gaps to give four equal gaps, two at one end of the armature and two at the other end between the adjacent pole pieces. Interiorly of the frame 32 and between the magnet and pole piece assembly are positioned coils 48 and 49 which encompass the armature 38. Each of the coils are wound so as to be in buckling relation and inductively coupled with the armature 38. Interiorly of the frame 32 and abutting the pole pieces 45, 45', and 46 and 46' one at the north pole and one at the south pole, are the magnetically conductive members 50 and 51.

The frame 32 is bored at 52 and the bars 50 and 51 are bored at 53 and 54 and the armature is bored at 55 to receive the jet pipe 25 which is positioned within the bores 52, 53 and 55, and between the coils 48 and 49, pipe 25 being rigidly affixed to the armature 38 and sealed in the bore 55. The flexible pipe 56, axially aligned with the pipe 25, is rigidly connected to and sealed in the armature 38 in a counterbore 57'. The mounting 33 of the torque motor is bored at 57 to permit the passage of the tube 56 and the pipe 25. The tube 56 is rigidly con-

nected and sealed at its end 58 to the mounting fitting 33. The fitting 33 is connected to the top of the block 1 and sealed by means of O-ring 33a as shown.

The upper portion 60 of the pipe 25 is of larger diameter so that the pipe is weight balanced about the center of rotation of the armature 38 on its flexure 39. The pipe 25, which is sufficiently flexible to permit such angular deflection communicates, as described above, with the counterbore 12, in block 1, and fluid sealed by the O-ring 34. The inlet 30 to the bore 29', carries a filter fitting 62 to prevent dirt from entry into the unit. The inlet 30 is connected to a source of fluid pressure. The fluid discharge is provided by a bore 63 connected to the counterbore 12 (see FIG. 1).

Assume that no signal is impressed on the coils 48 and 49 of the torque motor or that the signal is such that equal and opposing flux is generated in the torque motor by coils 48 and 49 so that the armature 38 is in the null position and centered in the gaps 47 between the pole pieces 45, 46 and 45' and 46'. The jet pipe 25 is undeflected and is aligned symmetrically over receptor jets 19 and 20, in the position shown in FIG. 3. The pistons 6 and 8 may be in any position, for example, that shown in FIG. 2.

Fluid under pressure entering through inlet 30 passes through pipe 28' and through the bore 26 exits from the ejector jet 27. It will be seen that with the bores 23 and 24 symmetrically placed, each of the bores 23 and 24 will receive an equal amount of fluid from the jet 28, any excess spilling into the bore 12 being passed into the discharge pipe 63. The fluid through 23 and 24 being thus under equal pressure, exerts equal pressure against the ends of the pistons 8 and 6, which have equal areas, the pressure being exerted through the ports 14, 17, 13 and 15. The total force against both of the pistons being equal, the piston is not displaced from its position. The piston therefore is hydraulically balanced notwithstanding the flow of oil in 30 and out 63, so long as the pressure on the nozzles 24 and 23 is maintained equal.

Should a signal be impressed to coils 48 and 49, so as to unbalance the flux induced by these coils to cause a deflection of the armature 38 in gaps 47, assuming, for example, that the deflection of the armature is clockwise as FIG. 2 is viewed, then the pipe 25 is rotated about an axis of rotation passing centrally through armature 38 and through a line along with axis of the flexure 39. This imposes a twist on the flexible tube 56 and a displacement of the end of the nozzle 27 to the left. It will be seen that more fluid will enter bore 24 of receptor jet 19 than enters bore 23 of receptor jet 20, and the pressure in 18 will become greater than the pressure in 16, and the piston 8 is displaced to the right.

As the pressure is maintained greater in 18 than in 16, the piston will travel to the right until the boss 7 abuts the closure 5. As long as the signal maintains the deflection of the tube to exert this degree of pressure the piston will remain at its attained position and will do so even if the signal is interrupted, whereupon the stress in the tube 56 and in the flexure 39 will act as a restoring force to bring the tube 25 back to center. The pressures in 18 and 16 will then become equal and the piston will remain in the position in which it had been placed previously.

If now an electrical signal is introduced into the coil to displace the tube 25 counterclockwise so that more fluid enters 23 than enters 24, the fluid passing into 16 through 15, the boss 7 having assured fluid entry, the pressure conditions are reversed and the pistons will travel in the opposite direction until the boss 9 abuts the closure 5.

The piston rod 3 may be connected to any device which is to be moved and the device described above is essentially a reciprocable prime mover, i.e., a reversible fluid motor which may be made responsive to an electrical signal.

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The ejector jet and receptor jet as described above is essentially a two position valve, which routes fluid in either of two directions.

It will be observed, however, that viewed as a motor, the jet assembly acts as a hydraulic amplifier in that the electrical energy necessary to actuate the pipe 25 may be made very small, dependent only on the flexibility of the pipe 56, 28 and flexure 39, which may be made as small as desired. The power necessary to actuate the pistons 8 and 6 may be as large as desired and is supplied by the fluid pressure at 30 which does not affect the displacement of the pipe 25.

Viewing the jet as a valve, there are substantially no frictional forces present. There is no mechanical connection between the receptor jets and the ejector jet. Thus the proportioning of the flow in the receptor jets in response to the input signal is frictionless. Furthermore, the ejector jet may be made of low mass and of desired mass in relation to the restraint imposed due to the flexibility of the suspension of the pipe 25, and thus the natural frequency of the valve may be made either high or low, as is required by the response which it is desired that the valve have for the signal to which it responds.

It will be observed that because of the seals 33a between the torque motor base 33 and the block 1 and the fact that the tubes 56 and 25 are sealed in and rigidly connected to 38 and tube 56 to base 33, the space inside the torque motor and in the case 37 is completely sealed from the fluid, for example, oil, used to actuate the hydraulic motor, and is therefore dry.

Furthermore, it will be observed that the tube 56 is rigid in an axial direction although flexible in a plane perpendicular to the axis of the tube. However, because of the flat spring-like web 39, the armature structure is rigid except for rotation about a line perpendicular to the axis of the tube 56. The tube 25, due to the mass 60 of the upper end of pipe 25, is balanced so that acceleration in a line perpendicular to the plane of FIG. 2 will cause no substantial displacement of the tube 25 or rotation about the axis of the flexure 39. Consequently, no deflection of the armature resulting from acceleration, impact or other accidental forces will cause any movement of the valve, except only due to the signal imposed by coils 48 and 49, or due to an angular acceleration having a vector perpendicular to the axis of the tube 25 and passing centrally through the armature, due to the flexible web 39. However, because of the low mass of the armature and pipe 25 the permissible selection of flexibility of the web 39 and tube 25, the natural frequency of the structure can be controlled so that such accidental forces may be of no importance in the practical utility of the device.

Additionally, it will be observed that because of the use of the tube 56 and the connection of the tube to the tube 25 at a substantially coincident point with the axis of rotation of the armature 38, the angular displacement of the jet 27 may be made substantially equal to the angular displacement of the armature 38, thus producing a system of high sensitivity.

The construction results in a dry torque motor housing and the magnetic system is secured against accidental contamination by trapped magnetic particles which may occur in the oil and which might otherwise contaminate the air gaps of the torque motor, and as described above the torque motor armature is stabilized against random motions due to random vibrations resulting from acceleration forces.

Furthermore, it will be observed that the ejector jet 27 and the receptor jets 19 and 20 together create a substantially frictionless push-pull hydraulic amplifier to amplify the relatively low power of the torque motor. By valving the high pressure fluid flow and controlling the magnitude of the pressure thus generated by the high pressure fluid flow against the piston ends, the pistons 8 and 6 are moved back and forth within the close fitting

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bore 2. The force necessary to move this piston may be relatively high and would not compare to the power generated by the torque motor, but by the use of the jets of my invention and low power output of the torque motor is amplified by this hydraulic amplifier to move the spool with relatively large force.

Additionally, it will be observed that the displacement of the main valve piston is controlled by the torque motor. Oil leaving the hydro-dynamically ideal ejector jet 28 travels a short distance at high velocities and impinges onto openings in the two receptor jets 23 and 24. If the projected jet oil flows equally into each of receptor jet bores 23 and 24 the recovery pressure in each receptor jet will be equal and approximately equal to one-half the pressure of the fluid exiting the jet 27, and the pressure in the chambers 16 and 18 will be equal.

Additionally, it will be noticed that the receptor nozzles 19 and 20 are rigidly and immovably positioned, and only the ejector jet moves, thus insuring a high accuracy of response and a controlled natural frequency, and a high efficiency of recovery pressure. This permits the pistons 8 and 6 to move a distance different from and independent of the movement of the jet 27. Because the movement of the jet may be made small when the piston movement remains large, the dynamic response and natural frequency of the hydraulic system may be controlled to the desired degree.

Furthermore, the structure may be seen to constitute a four-arm hydraulic bridge which has twice the sensitivity of the previous single ejector jet-single receptor jet two-arm hydraulic bridge. The hydraulic amplifier is frictionless and therefore allows the valve to have a very high degree of resolution. It is possible to use a relatively large hole in the ejector jet and this allows the passage of large dirt particles which would disable conventional valves. If the ejector jet 27 should become partially plugged due to dirt particles the oil emitting from the jet will still control the motor so long as the fluid pressure at the inlet 30 is sufficiently high.

When the motor is used to actuate any movable member such as a damper or any other movable member the rate of movement of the piston will depend on the magnitude of the difference in pressure exerted in the chambers 18 and 16. The magnitude of this difference depends on the angle through which the pipe 25 is displaced. The magnitude of the electrical signal imposed on the bucking coils 48 and 49 will determine this angle of displacement. It will thus be seen that not only will the above device control the direction of movement of the piston but also the rate at which the same will be displaced.

If I employ a fluid seal between the torque motor case 37 and the counterbore 12, I may omit the tube 56, leaving the rest of the structure as described above. If, however, in such construction I desire to add rigidity parallel to the axis of the tube 25, I may employ instead of the flat section 39, a cruciform flexure, shown at FIG. 7, in which there are equally spaced webs shown as 39a, 39b and 39c, the fourth web being planar with 39a and not viewable in FIG. 7. The armature due to the webs 39c and 39b will be restrained from displacement in the plane of the webs 39c and 39b but will rotate about the axis of the shafts 40. The flexure has stiffness and force in the plane of the webs 39a or 39b.

I have above described the application of the jet valve of my invention to a two position reversible fluid motor and which may also, if desired, control the rate at which such piston moves in either direction. The valve is also applicable to servo mechanism whereby the use of a position or force feedback it may function to control not only the movement but also the quantity of motion, i.e., the positioning of the pistons in the piston cylinder and thus the device may be employed to control the position of the piston as well as, if desired, the rate at which the piston attains its position.

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FIGS. 4 and 5 illustrate thus a modification of the structure described above in which a force feedback connection is provided between the jet pipe 25 and the piston rod 3. A slot 63' in block 1 connects the counter-bore 12 and the cylindrical bore 2, and a spring rod 64 is bent at an angle and positioned in a horizontal bore in the rod 3. It is held in place by a set screw 65 which may set by means of a tool passed through the bore 66 closed by the plug 67. The upper end of the spring rod 64 is connected to the end of the jet tube 25. The remaining construction is the same as described in connection with FIGS. 1 to 4, 6 and 7.

It will be observed that as the pistons 6 and 8 are displaced to the right from the position shown in FIG. 4 a spring force is imposed upon the pipe 25 by means of the spring 64, which spring force is proportional to the displacement of the piston so that the spring introduces a restoring force in an amount to balance the torque generated by the torque motor in response to the signal and to restore the pipe 25 to its neutral position, shown in FIGS. 5 and 3, at which place the pressure in nozzles 23 and 24 and the bores 13 and 14 are again equal, and further displacement of the piston cannot occur. The spring 64 thus acts as a force feedback to null out and balance the force of the signal causing the initial displacement. It will be observed that in so doing the initial displacement of the piston occurring upon the reception of the signal is not altered so long as the signal exists in the torque motor at the original strength and direction. In consequence thereof, upon the reception of a signal in the torque motor the ejector jet pipe 25 is displaced an amount proportional to the force of the signal in a direction determined by the direction of a signal, and the piston is displaced an amount proportional to the signal strength in a direction determined by the direction of the signal, and is maintained in such displaced condition so long as the signal remains unchanged in magnitude and direction.

Should the signal increase in strength in the same direction, this additional signal will overcome the spring force of the feedback spring rod 64 and the pipe will again move to the left, as seen in FIGS. 3 and 4. The pressure in 14 will rise and the pressure in 13 will fall, and the piston will move to the right to a new position depending upon the added strength of the signal, the feedback spring thus being further deflected will introduce a negative restoring force to bring the pipe 25 back to the null position shown in FIGS. 3 and 4, thus halting the further movement of the piston spool, holding it in its new position.

Should the signal fall in strength but not reverse in direction, the spring force of 64 will move the jet pipe 25 to the right viewing FIGS. 3 and 4, and now the bore 13 receives more fluid than does the bore 14, and the pressure in 16 is greater than in 18, and the piston moves to the left. However, in so moving the spring 64 is so flexed that the jet 25 is moved to the left, thus bringing it back to the null position and holding the position in the new position.

Should the signal reverse in direction so that now the armature is caused to rotate counter-clockwise, the reverse situation occurs. The pipe 25 is moved to the right, the tube 56 bending for this purpose, and now the bore 13 receives more fluid than the bore 14, and a reverse motion occurs with consequences similar to those described above. Any continued increase or variation in the signal imposed on 48 and 49 will cause the movement of the piston and its control and direction to reverse to that described in connection with the previously mentioned signals.

In FIG. 9 I have illustrated the application of my valve in a system in which the signal which moves the jet valve is entirely mechanical. In this form the signal is an inertial force.

The structures are identical to the structures illustrated

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in FIGS. 1 to 7, except that the torque motor has been removed and the flexible tube 56 and the ejector pipe 25 have been rigidly connected to a collar 101. Mounted upon the base 132 is a frame 102 similar to the frame 32 of the torque motor in which is mounted a flexure 103 similar in construction and function to the flexure 39, one end of the flexure 103 being rigidly connected to the frame 102, the other end of the flexure being rigidly connected to the collar 101, to which is also rigidly connected the flexure tube 56 and the jet tube 25, the end of the jet tube 25 protruding through a hole 105 in the top of the frame, and the jet tube and the flexure tube protruding through a hole 106 in the bottom of the frame similarly to the construction shown in FIGS. 1 to 8, depending on whether the spring 64 is employed. At the top of the tube 25 is a ball 107 with its center positioned axially to the tube 25. It will be observed that the structure is rigid against all vibratory or acceleration forces except in the plane of the drawing of FIG. 9, and that upon any translational acceleration, that is, in a straight line in the plane of the FIG. 9, a moment will be created upon the axis passing through the flexure to cause a rotation or angular displacement of the jet pipe 25. A similar displacement will occur if the structure is caused to be accelerated angularly in the plane of FIG. 9.

The device of FIGS. 9 and 10 is insensitive to translational accelerations when the acceleration vector is parallel to the center line of the tube 25 and the tube 56. The device is also insensitive to translational accelerations whose directional vector is in a plane parallel to the central plane of the flexure 103. The device is sensitive to angular accelerations only in the plane of FIG. 9.

It is noted that in the device of FIGS. 9 and 10 the mass of the tube and the ball above the flexure should be greater than the mass of the tube below the flexure 103. However, if it is desired to make the angular accelerometer insensitive to translational acceleration the masses of the structure below and above the flexure point may be made equal, and if it is desired to make the device sensitive to both lateral and angular acceleration at the same time, then as in the case of the translational acceleration the mass of the ball and the tube above the flexure may be made greater than below the flexure.

The structure of the jet valves and the fluid motor is the same as in the other form FIGS. 1 to 7.

It will be observed that in the forms of FIGS. 4 and 10, employing the feed-back spring, the displacement of the fluid motor is made proportional to the input signal while in the forms of FIGS. 1 and 9, without the feed-back spring, the velocity of the fluid motor is made proportional to the input signal. This displacement (see the latter case) is not limited except by the mechanical stops. It will therefore be seen that the device of my invention can control position or velocity and is a highly flexible unit.

While I have described particular embodiments of my invention for the purpose of illustration, it should be understood that various modifications and adaptations thereof may be made within the spirit of the invention as set forth in the appended claims.

I claim:

1. A valve comprising a pair of stationary receptor jets, a fluid connection from each of said jets, means for connecting said fluid connection to a fluid pressure receiving means, a movable ejector jet in fluid communication with said stationary jets, said receptor jets being angularly disposed at an acute angle to each other, and said movable jet being positioned with its axis bisecting the angle of said angularly disposed jets, a fluid communicating passage-way to said movable jet, and means forming an enclosure for the space about said ejector jet and said receptor jets, a fluid motor comprising a cylinder, a piston in said cylinder, one of said stationary jets in fluid communication with said cylinder on one side of said piston and the other of said stationary jets in fluid communication with

said cylinder on the other side of said piston, a force feedback connection between said piston and said movable jet, and means for discharging and recirculating fluid from said enclosure.

2. In the device of claim 1, said feedback connection comprising a spring connected to said movable jet.

3. In the device of claim 2, a signal responsive device operatively connected to said movable jet, and means to move said jet between said fixed receptor jets responsive to said signal, whereby more or less fluid enters each of said receptor jets and said enclosure responsive to said signal.

4. A valve comprising a pair of stationary receptor jets, a fluid connection from each of said jets, means for connecting said fluid connection to a fluid pressure receiving means, a movable ejector jet in fluid communication with said stationary jets, said receptor jets being angularly disposed at an acute angle to each other, and said movable jet being positioned with its axis bisecting the angle of said angularly disposed jets, a fluid communicating passageway to said movable jet, and means forming an enclosure for the space about said ejector jet and said receptor jets, a torque motor including an armature, said ejector jet being mounted on the armature of said torque motor for motion with said armature responsive to a signal received by said torque motor, said ejector jet including a pipe fixedly positioned in the armature of the torque motor, and a flexure tube positioned about said pipe axially thereof, one end of said tube being connected to said armature and the other end of said tube being stationary.

5. In the device of claim 4, said movable jet having a flat end adjacent said receptor jets, a fluid motor comprising a cylinder, a piston in said cylinder, one of said stationary jets in fluid communication with said cylinder on one side of said piston and the other of said stationary jets in fluid communication with the other side of said piston, and a force feedback connection between said piston and said movable jet.

6. A valve comprising a pair of stationary receptor jets, a fluid connection from each of said jets, means for connecting said fluid connection to a fluid pressure receiving means, a movable ejector jet in fluid communication with said stationary jets, said receptor jets being angularly disposed at an acute angle to each other, and said movable jet being positioned with its axis bisecting the angle of said angularly disposed jets, said ejector jet having a flat end extending perpendicular to the axis of said ejector jet adjacent said receptor jets, for a substantially greater distance than the mouth of said receptor jets, a fluid motor comprising a cylinder, a piston in said cylinder, one of said stationary jets in fluid communication with said cylinder on one side of said piston and the other of said stationary jets in fluid communication with said cylinder on the other side of said piston, and a force feedback connection between said piston and said movable jet.

7. In the device of claim 6, said feedback connection comprising a spring connected to said movable jet.

8. A valve comprising a pair of stationary receptor jets, a fluid connection from each of said jets, means for connecting such fluid connection to a fluid pressure receiving means, an ejector jet in fluid communication with said stationary jets, means for moving said ejector jet, said ejector jet including a pipe connected at one end to said moving means, and a flexure tube positioned about said pipe axially thereof, one end of said tube being connected to said moving means and the other end of said tube being stationary, said receptor jets being angularly disposed at an acute angle to each other, and said movable jet being positioned with its axis bisecting the angle of said angularly disposed jets, and means forming an enclosure for the space about said ejector jet and said receptor jets.

9. In the device of claim 8, said movable jet having a flat end adjacent said receptor jets, a fluid motor comprising a cylinder, a piston in said cylinder, one of said stationary jets in fluid communication with said cylinder on

one side of said piston and the other of said stationary jets in fluid communication with the other side of said piston, and a force feedback connection between said piston and said movable jet.

10. A valve comprising a pair of stationary receptor jets, a fluid connection from each of said jets, means for connecting said fluid connection to a fluid pressure receiving means, a movable ejector jet in fluid communication with said stationary jets, said receptor jets being angularly disposed at an acute angle to each other, and said movable jet being positioned with its axis bisecting the angle of said angularly disposed jets, a fluid communicating passageway to said movable jet, a jet tube in fluid communication with said ejector jet, a frame, a flexible connection between said jet tube and said frame, a flexure tube positioned about said jet tube axially thereof, one end of said flexure tube being connected to said flexible connection and the other end of said tube being stationary.

11. In the device of claim 10, said movable jet having a flat end adjacent said receptor jets, a fluid motor comprising a cylinder, a piston in said cylinder, one of said stationary jets in fluid communication with said cylinder on one side of said piston and the other of said stationary jets in fluid communication with the other side of said piston, and a force feedback connection between said piston and said movable jet.

12. A valve comprising a pair of stationary conically shaped receptor jets, and jets being angularly disposed at an acute angle to each other, the outer ends of said jets being substantially tangent to each other, said jets being positioned at an angle such that the peripheries of said jets at the mouths thereof are in close proximity, a fluid connection from each of said jets, a movable ejector jet in fluid communication with said stationary jets, said movable jet being positioned with its axis bisecting the angle of said angularly disposed jets, said movable ejector jet overlapping the peripheries of said stationary jets at the mouths thereof when said ejector jet is in position bisecting said angle, and a fluid communicating passageway to said movable jet.

13. A valve comprising a pair of stationary receptor jets, a fluid connection from each of said jets, an ejector jet in fluid communication with said stationary jets, means for moving said ejector jet, said receptor jets being angularly disposed at an acute angle to each other, said movable jet having a flat end adjacent said receptor jets and being positioned with its axis bisecting the angle of said angularly disposed jets, said movable ejector jet overlapping the outer ends of said stationary receptor jets when said ejector jet is in position bisecting said angle, fluid pressure receiving means connected to said fluid connection, and a feedback means from said fluid pressure receiving means, for applying a feedback force to said movable ejector jet.

14. A valve comprising a pair of stationary receptor jets, said jets each having a jet bore, said jet bores being angularly disposed at an acute angle to each other, said jet bores being positioned at an angle such that the peripheries of said jets at the mouths of said jet bores are in close proximity, a fluid connection from each of said jets, a movable ejector jet in fluid communication with said stationary jets, said movable jet having a bore and being positioned with the axis of said bore bisecting the angle between said angularly disposed jet bores, said movable ejector jet having a flat end perpendicular to the axis of the bore of said movable ejector jet, said end of said movable ejector jet overlapping the peripheries of said stationary jets at the mouths thereof when said ejector jet is in position with the bore thereof bisecting said angle, and a fluid communicating passageway to said movable jet.

15. A valve comprising a pair of stationary receptor jets, said jets each having a jet bore, said jet bores being angularly disposed at an acute angle to each other, said jet bores being positioned at an angle such that the pe-

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ripheries of said jets at the mouths of said jet bores are in close proximity, a fluid connection from each of said jets, a movable ejector jet in fluid communication with said stationary jets, said movable jet having a bore and being positioned with the axis of said bore bisecting the angle between said angularly disposed jet bores, said movable ejector jet having a flat end perpendicular to the axis of the bore of said movable ejector jet, said end of said movable ejector jet overlapping the peripheries of said stationary jets at the mouths thereof when said ejector jet is in position with the bore thereof bisecting said angle, a space about the end of said ejector jet and the ends of said receptor jets, means forming an enclosure for said space, and a fluid communicating passageway to said movable jet.

16. A valve comprising a pair of stationary receptor jets, each having a receptor jet bore with an outer end adapted to receive fluid, a fluid connection from each of said jets, a movable ejector jet including a jet pipe having an ejector jet bore in fluid communication with the outer ends of said stationary receptor jet bores, means for moving said ejector jet, said receptor jet bores being disposed with their outer ends closely adjacent to each

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other, said ejector jet pipe of said movable jet having a flat end adjacent said receptor jet bores and being positioned with the axis of said ejector jet bore midway between said receptor jet bores, said flat end overlapping the outer ends of said receptor jet bores when said ejector jet bore is in said midway position, fluid pressure receiving means connected to said fluid connection, and a feedback means from said fluid pressure receiving means, for applying a feedback force to said movable ejector jet.

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