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JET PIPE RELAY FOR OPERATION SUBMERGED IN OIL WITH
MINIMUM INERTIA AND FRICTIONAL RESISTANCE

Filed May 1, 1956

3 Sheets-Sheet 1

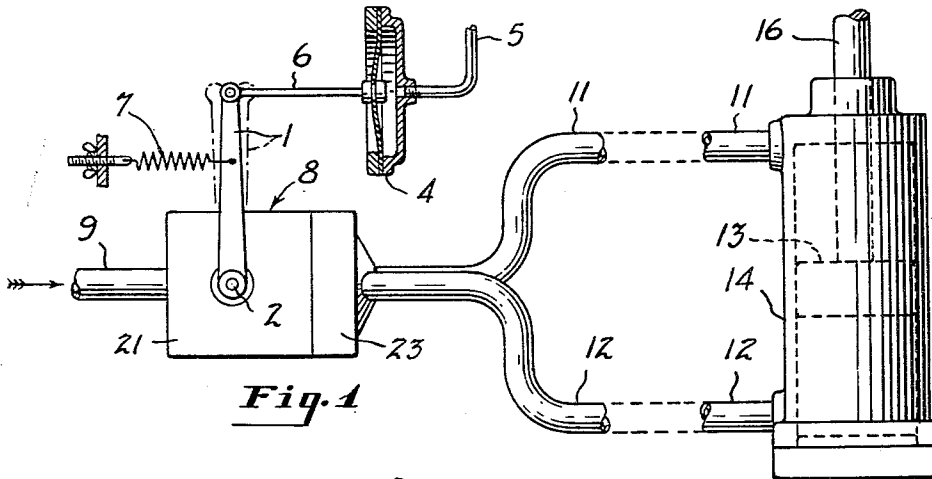


Fig. 1

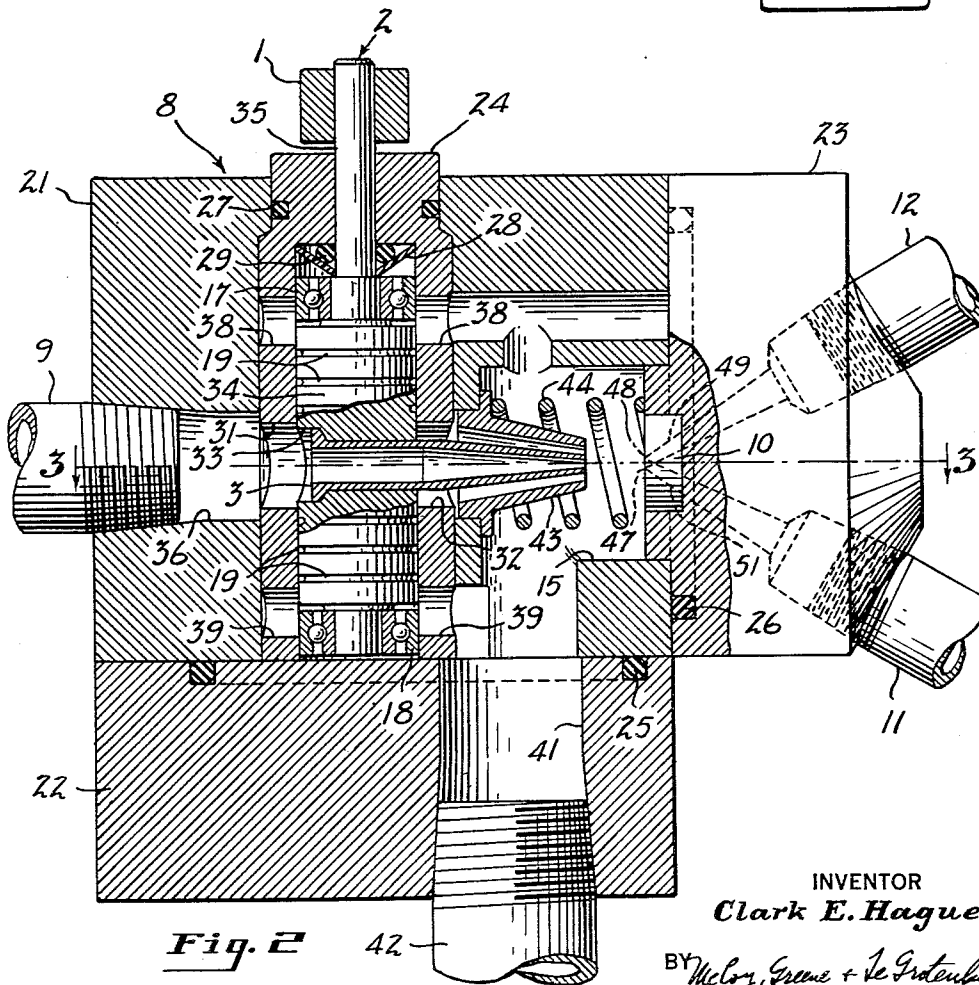


Fig. 2

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3 Sheets-Sheet 2

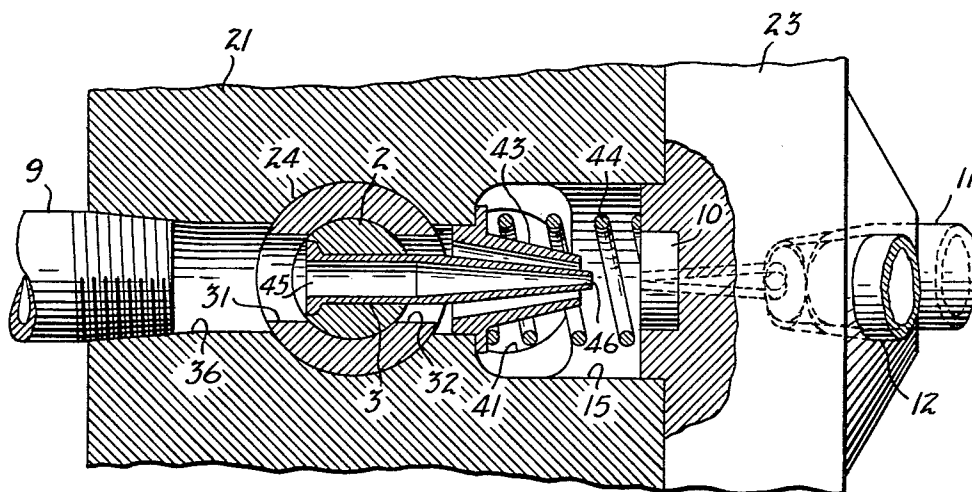


Fig. 3

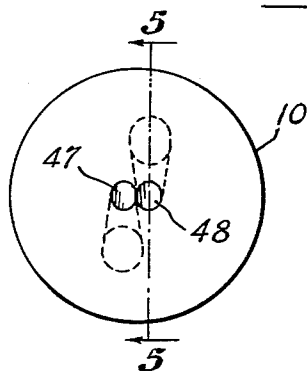


Fig. 4

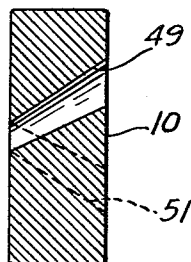


Fig. 5

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3 Sheets-Sheet 3

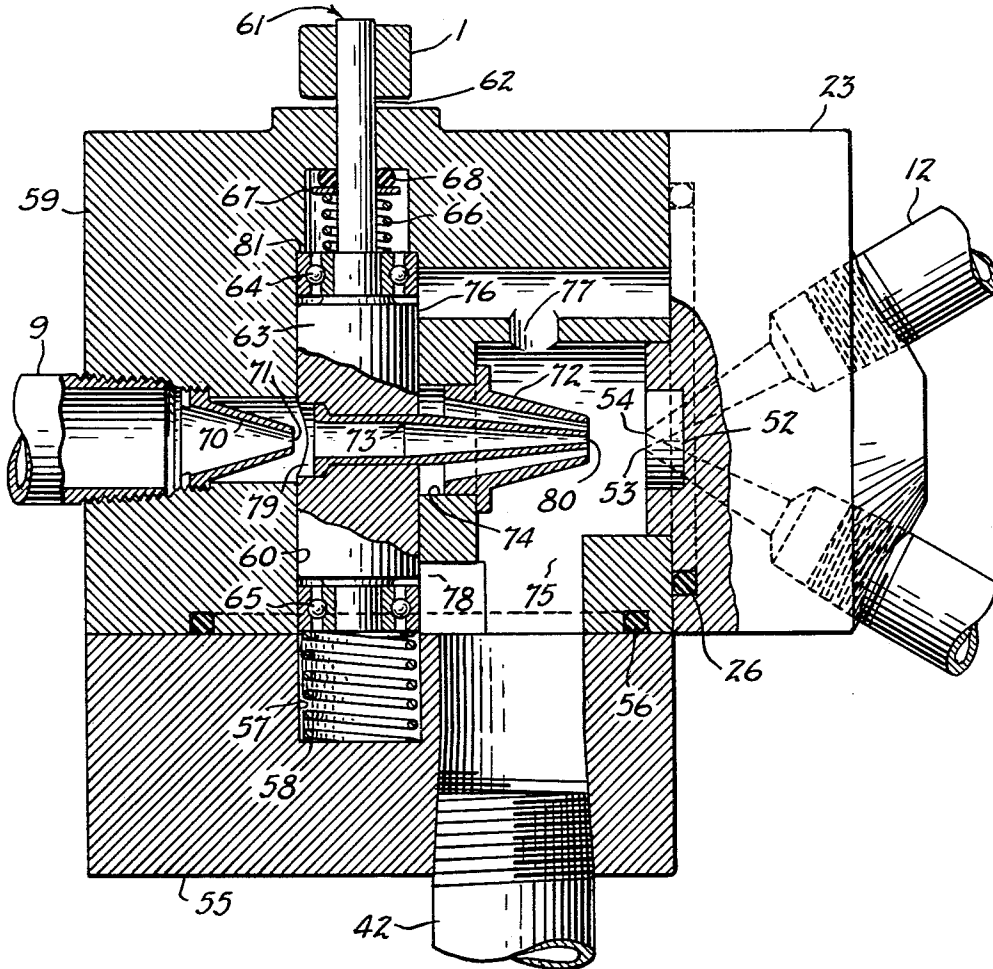


Fig. 6

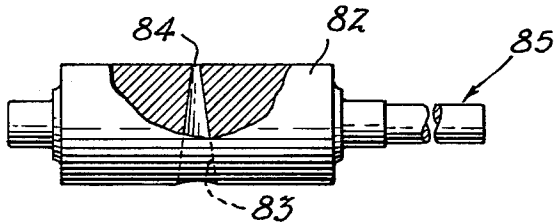


Fig. 7

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**JET PIPE RELAY FOR OPERATION SUBMERGED
IN OIL WITH MINIMUM INERTIA AND FRIC-
TIONAL RESISTANCE**

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7 Claims. (Cl. 137—83)

This invention relates to an improved jet pipe relay and specifically to a jet pipe relay in which the jet pipe is adapted to operate submerged in a bath of oil, under pressure, with minimum inertia and frictional resistance.

In the jet pipe relays proposed prior to the present invention, the chamber within the body was air-filled at atmospheric pressure. Oil spilled into the chamber from the jet and drained, by gravity, from the chamber, through a system of piping, to the sump of the pump supplying oil to the jet. This constitutes a serious limitation in the usefulness of the relay and adds greatly to the cost of installation because the relay must always be located above the source of oil supply and the gravity return piping system must be disproportionately large, and properly vented, to insure flow of the gravity propelled oil.

Gravity return of oil from the relay to the supply pump sump becomes an absolute limitation when it is desired to supply oil from a single oil pump to a number of relays that may be separated from each other by considerable distance and/or elevation. Also in locations where regulator installations are subjected to wide temperature variations the problems incident to gravity oil return are greatly increased by variations in the oil viscosity and flow characteristics.

This invention eliminates all of the limitations incident to gravity oil return because the hydraulic system through the relay is entirely closed and the hydraulic pressure within the relay body rises to the necessary amount to return the oil to the sump whether the sump be above, below or at a distance from the relay.

Previous jet pipe relay designs have required that means for transmitting the action of signal or impulse systems to the jet pipes extend within the relay body, thus exposing these delicate devices to contamination by contact with the oil or other hydraulic fluid.

In the relay of the present invention, the signal or impulse systems and the means for transmitting their action to the jet pipe are entirely external of the relay body and cannot be contaminated by the hydraulic fluid or its vapors.

A second limitation of relays proposed prior to the present invention has its origin in the design of the jet pipe itself which is made of small tubing as much as seven inches long and mounted in a T-shaped assembly on a vertical column, the upper end of which is hollow and is the conductor through which the oil must pass to reach the jet pipe proper. The bearings on which the jet pipe pivots are at the ends of the vertical column, hence the jet pipe extends as a cantilever arm approximately thirty times its diameter from its pivotal support. As a result of this arrangement, the jet pipe assembly is a delicate, semi-rigid assembly incapable of high frequency response. In other words, as the frequency of impulses to the relay increase from 200 or 300 cycles per minute up to 1000 cycles per second, and more, the relay exhibits an increasing tendency to vibrate widely without relation to the impulse, and otherwise fail. Sometimes adjustable stops are placed on both sides of the

2

jet pipe to limit the vibrating, but this also limits the output range of the relay.

Also with the T-shaped jet pipe design of previous relays it is necessary for the oil to travel through six or seven inches of small tubing and make one right angle bend from the oil inlet at the top of the regulator to the tip of the jet nozzle, resulting in fluid reactions and pressure losses that become limiting factors when the applications require larger nozzle tips and higher fluid pressures.

This invention eliminates these faults in jet pipe design since the jet consists only of a nozzle mounted in a rugged pivotal spool which rotates on, and is held in exact alignment by two large ball bearings. The oil inlet to the regulator body leads directly into and, is in exact alignment with, the jet nozzle, thus eliminating fluid pressure reaction and pressure loss. Also the whole assembly is small so as to fit in with the present miniaturization trend and exceedingly rigid and capable of responding to very high frequencies without distortion or damage.

Still another limitation of relays proposed prior to the present invention was the fact that they had to operate in an upright position and could not operate on their side or upside down. As a result, the relays often had to be installed at quite a distance from the measuring means or regulated part and be provided with a maze of connecting lines, wires, and the like. Because of the small jet design which is essentially balanced in all positions and, because of the pressurized feature of the body design, the relay of the present invention may be installed in any position.

One object of the present invention is to provide a jet pipe mounting in which the jet operates with a minimum of friction and inertia and which responds to impulses with frequencies of 1000 cycles per second or more.

A further and important object of the present invention is to provide a regulator wherein the fluid pressure reaction is substantially eliminated from the bearings so that friction is reduced and greater sensitivity is obtained.

Another object of this invention is to provide a compact relay which will operate in any position.

Other objects and advantages will become apparent from the following description of my invention in which like numerals relate to like parts throughout the several views.

Figure 1 is a schematic diagram of a conventional jet pipe regulator assembly employing a relay of the present invention;

Fig. 2 is a side elevation view of a relay of the present invention, mostly in cross-section;

Fig. 3 is a plan view taken along line 3—3 of Fig. 2, mostly in cross-section;

Fig. 4 is an enlarged front elevation of the distributor of the relay of Fig. 2;

Fig. 5 is a cross-sectional view of the distributor of Fig. 4 taken along line 5—5 of Fig. 4 showing the arrangement of orifices in the distributor;

Fig. 6 is a side elevational view, mostly in cross-section, of a modified form of relay of the present invention; and

Fig. 7 is a side elevational view, partly in cross-section, of a modified form of jet pipe and shaft assembly.

A schematic diagram showing a conventional jet pipe regulator assembly employing a relay of the present invention is shown in Fig. 1. An arm 1 is attached to the top portion of freely rotating jet pipe shaft 2, which shaft is at substantially right angles to arm 1. A jet pipe 3 (Fig. 2) is rigidly attached at substantially right angles to the central portion of the shaft 2. Diaphragm 4 is arranged so as to receive impulses from the con-

3

trolled medium, or medium in which a variable is controlled, through line or tube 5 and communicate them through rod 6 to the arm 1. Thus impulses or signals from the controlled medium act on arm 1 and, in turn, on jet pipe shaft 2. The jet pipe is mounted on shaft 2 so that arm 1, rod 6, diaphragm 4 and line 5 constitute means for transmitting impulses from the controlled medium to the jet pipe. Obviously other suitable means for transmitting impulses from the controlled medium to the jet pipe both electric, hydraulic, pneumatic, mechanical and combinations thereof as is well-known in the art may be substituted for that shown. Spring 7 which may have suitable conventional means (not shown) for adjusting compression or tension acts as a counteracting force to return the arm and jet shaft to the set point or the position which the arm assumes when not subject to variable impulses or charges.

High pressure oil or hydraulic fluid, supplied from a sump (not shown) and by a pump (not shown) enters the relay body 8 through supply pipe 9, passes through the jet nozzle 3 and impinges against the distributor block insert 10 at the horizontal center line of the receiving orifices 47 and 48 shown in Fig. 4. The pivotal action of the jet is limited by conical sleeve 43 so that even at its extremes of travel the oil jet stream will be truly aligned with one of the receiving orifices or the other.

The receiving orifices are connected by tubing or other suitable conduit, to either end of an hydraulic piston, as shown with lines 11 and 12 in Fig. 1. Lines 11 and 12 connect to opposite sides of hydraulic piston 13 in cylinder 14 or other element responsive to fluid pressure so as to actuate the valve or other factor being controlled. The energy of the jet stream is converted into pressure within the receiving orifices and this pressure transmitted to either end of the hydraulic piston 13 in cylinder 14 will cause the piston to move. Swinging the jet nozzle so that the jet stream moves from one receiving orifice to the other will reverse the movement of the piston. When the jet stream strikes both orifices equally, equal pressures will be exerted on both sides of the piston and the piston will stop moving.

As is evident from Figure 1, a piston 13 in power cylinder 14 is positioned by the difference in oil pressure in lines 11 and 12. Rod 16 connects to the piston and in turn operates the final control element such as a valve or the like to compensate for variation from the set point introduced in the original impulse.

Referring to Fig. 2, the relay housing 8 comprises a main body block 21, a base block 22, and distributor block 23, all preferably made of brass, aluminum, or other suitable material. The base block 22 and distributor block 23 are attached to the main body block 21 by screws or other suitable attaching means. Inasmuch as the base block is merely a means for closing off the bottom of the unit, it may be omitted if desired and the main block 21 screwed or otherwise attached to other suitable support such as a machine frame or the like. Of course, a drain hole 41 or other fluid exhaust means must be provided to drain oil from the jet chamber 15. Sealing means such as O-rings 25 and 26 provide a seal between the base block and distributor block respectively. In the main body block, the jet pipe shaft 2 is mounted on ball bearings 17 and 18 located on each end portion or spindle 35 of the jet pipe shaft 2, which ball bearings are press-fitted onto the shaft. Other bearings or substantially frictionless shaft-supporting means, such as graphite-bronze bearings or the like may also be used, but ball bearings or certain roller bearings are preferred because they offer the least frictional resistance and support limited end thrust.

The shaft is relatively small in diameter at the end portions or spindle 35 and is relatively large in diameter in the central portion or spool 34 intermediate the end portions. A series of grooves such as grooves 19 may

4

be formed in the outer surface of the spool 34 of the shaft to act as labyrinth seals. They are not necessary, however, and a plain spool may be used so long as it has a relatively close fit and limits bleeding of the hydraulic fluid. By having controlled bleeding, the high pressure oil flow to the end portions of the shaft is restricted so that the oil flow is easily drained away through drain ports 38 and 39 into the low pressure oil return cavity or jet chamber 15. In this way, all end thrust on the shaft is eliminated and the overall sensitivity of the unit is increased.

Surrounding the shaft and fitted into the main body block 21 is sleeve 24. This sleeve is sealed against oil leakage at the top portion or end opposite base block 22 with sealing means such as O-ring 27 mounted in a groove in the sleeve. At the bottom portion of the sleeve adjacent base block 22, sealing means is provided by an O-ring 25 mounted in a groove in the base block 22. This seals both the sleeve and juncture between the base block and body block. The sleeve is preferably a steel, machined part and is press-fitted into main body block 21.

Adjacent the bearing on the top portion end of the shaft, is sealing means between the shaft and sleeve such as a rubber O-ring 29 backed up by a ring seal 28 of resilient plastic with a low coefficient of friction such as nylon, tetrafluoroethylene or the like to hold it against the shaft.

The shaft and shaft sleeve are machined so as to have a relatively loose fit in the grooved center portion of the shaft, a press fitting at the supporting bearings, and relatively loose fit in the top portion between bearings 17 and arm 1. Thus the only appreciable frictional contact is at the bearings and at ring seal 28. As a result, the shaft turns with a minimum of friction.

The central portion of the generally cylindrical, hollow shaft sleeve 24 is bored or drilled out to provide for clearance and free movement of the jet pipe by clearance holes or relieved portions 31 and 32. The central portion of the shaft is correspondingly provided with a hole 33 aligned with the clearance holes 31 and 32 and adapted to receive the jet pipe. In other words, the shaft sleeve is provided with means defining jet pipe clearance apertures 31 and 32 and the shaft is provided with means defining a jet pipe receiving hole 33. The jet pipe thus fits into hole 33 in the shaft and projects through clearance hole 32 in the sleeve and is thus rigidly attached to the shaft.

The jet pipe or nozzle is a generally tubular, tapered member of greatest diameter at the supply end 45 and of smallest diameter at the nozzle or discharge end 46. The bore intermediate the supply and discharge ends is tapered as shown. The central portion of the jet pipe is thus provided with means defining a longitudinal, hollow, tapered fluid-conducting portion. The entrance end is open to an oil supply opening or chamber 36 defined by the body block 21 but is free of any rigid connection with it. The shaft and jet pipe rotate freely without interference with the shaft sleeve. Oil supply line or tube 9 is screwed into chamber 36 and chamber 36 and line 9 comprise oil supply means for the jet pipe. The nozzle or discharge end is directed at but spaced from the distributor block 10.

Adjacent and surrounding the output end of the jet pipe, the main body block is provided with means defining a central jet chamber or jet pocket 15. Oil relief holes 38 and 39 are drilled or otherwise formed in the shaft sleeve and lead into the jet chamber. A drain hole or opening 41 is provided in base block 22 and connects to oil return line 42, which line returns oil to a sump. The size of the opening or orifice 41 is such that the oil does not drain out of the jet chamber faster than it is being supplied to it so that the jet chamber is kept full of oil. In other words, opening 41 acts as an orifice to maintain a small back pressure in the jet

5

chamber. Surrounding the jet pipe or nozzle is a conical shield or splash guard 43 held in place by retaining means such as compression spring 44. Spring 44 is placed in compression between the distributor block and main body block in assembly. If desired, the splash guard may also be screwed or otherwise rigidly attached to the main body block.

A distributor or receiver plate 10 is mounted in distributor block 23. As shown in Figs. 4 and 5, it has two orifices 47 and 48 leading through passages 49 and 51 to lines 11 and 12 (Fig. 1), tapped into distributor block 23. An O-ring 26 mounted in the receiver block provides sealing means between the receiver block and body block 21.

Fig. 3 is a top plan view in section showing the jet pipe or nozzle mounted in the shaft 2. The view also shows the shaft sleeve 24, nozzle shield 43, shield retaining spring 44 and the distributor block 10.

Oil under pressure enters through supply line 9, passes through opening 36 in the main block, opening 31 in the shaft sleeve, and into the receiving end of nozzle 3. It emerges as a jet and strikes receiving orifices 47 and 48 in the distributor. Although oil is generally supplied to the relay at pressures of 100-400 p.s.i., because of the inherently strong construction of my relay, the pressure can be increased up to 1000 p.s.i. if desired. A higher pressure in the jet causes a correspondingly higher pressure in the power cylinder so that it in turn can deliver more power without an auxiliary relay or booster. It will be seen that by having a straight flow jet pipe with relatively small inner, oil-containing surface area, the thrust on the jet pipe due to the reaction from the oil jet as it emerges from the nozzle is minimized. The major portion of the jet reaction is taken in the oil supply line 9 and chamber 36. Furthermore, there is no change of direction in the oil supply line so as to react on the nozzle or shaft and increases the frictional and inertia forces.

It should be noted that in the relay of Figs. 2-5, the receiving orifices 47 and 48 in the distributor block have diameters which are approximately forty percent larger than the diameter of the discharge orifice 46 of the jet pipe. By having the diameters and obviously the cross-sectional area of the orifices greater than the cross-sectional area of the discharge orifice of the jet pipe, greater fluid flow is available for activating the cylinder, in other words there is greater pressure flow, and the cylinder is capable of doing more work. The need for a hydraulic booster valve and cylinder or other device to increase the work capacity of the unit is thus often avoided. As the diameters of the receiving orifices are increased over that of the discharge orifice of the jet pipe, however, there is a loss in rigidity of the relay so that the requirements of each specific installation must be taken into consideration. The diameters of the receiving orifices are usually 10-15 percent larger than that of the discharge orifice of the jet pipe. In accordance with my invention, they may be from 25 percent up to 50 or 55 percent larger than that of the discharge orifice of the jet pipe depending upon the requirements of the specific installation. Only in a relay in which the jet pipe chamber is filled with oil with no air being present, however, is it possible to have receiving orifices with diameters appreciably larger than the diameter of the discharge end of the jet pipe. For my purposes, receiving orifices with diameters from 25% to 50% larger than the diameter of the discharge end of the jet pipe are preferable. Putting it in another way, the cross-sectional area of the receiving orifices may preferably be from 50% up to 225% larger than that of the inside of the discharge end of the jet pipe.

A modified form of relay of the present invention is shown in Fig. 6. This relay is similar to the relay of Fig. 2 except that it has a booster nozzle or cone 70 mounted in the housing or body block 59 directed at the

6

intake end of the jet pipe 73 but is not connected with it. The longitudinal axes of the nozzle 70 and jet pipe 73 are coextensive or, in other words, the nozzle and jet pipe have a common longitudinal axis. The cross-sectional area of the discharge end or orifice 71 of the booster nozzle is greater than that of the discharge end 80 of the jet pipe but is appreciably smaller than the diameter of the intake end 79 of the jet pipe. Generally, the diameter of the discharge end of the booster nozzle is $\frac{1}{2}$ to 2 and up to 4 and 5 times the diameter of the discharge end of the jet pipe. The length of the booster nozzle is preferably at least three times the diameter of its discharge orifice.

I have found surprisingly when a nozzle, such as inlet nozzle 70, is provided in the fluid supply means opposite the intake end of the jet pipe, that the turbulence and friction loss between the fluid supply means and discharge end of the jet pipe is greatly reduced and that there is appreciably greater flow in the actuating cylinder to which lines 11 and 12 connect.

The inlet or booster nozzle 70 of the present invention can be screwed into the main body block 59 as shown or pressure fitted into the block or otherwise attached to the block. The term nozzle as used herein refers to a conical unit with a tapered inner bore as shown. If desired, the housing opposite the inlet end 79 of the jet pipe and intermediate the fluid supply line 9 may be formed so as to define a conical hollow or shape similar to nozzle 70 and accomplish the same result. In other words, a conical, tapered nozzle portion is formed in the housing instead of being a separate unit mounted therein.

A second feature of the modification of Fig. 6 is the fact that the jet pipe shaft is mounted and accurately positioned against a shoulder 81 in the body block by spring 58. In this modification, the shaft-receiving bore or recess 60 defined by the body block is provided with a shoulder portion 81 formed by a counter-bore of smaller diameter than the shaft spool 63 and shaft-spool receiving bore. The top portion of shoulder bearing 64 is positioned against this shoulder 81 by compression spring 58 mounted in spring-receiving recess 57 in bottom block 55 of the jet pipe housing. The spring 58 holds the spring bearing 65 and jet pipe shaft in position against shoulder or shaft positioning means 81 so that location of the jet pipe is determined by the distance from the shoulder to the center of the jet pipe and is not necessary to accurately hold other dimensions in the assembly. When other type bearings are employed, the shaft spool itself may be positioned against a shoulder defined in the shaft-receiving recess of the housing. Expansion of parts from heat, wear, and other changes in the size of the moving parts is thus automatically compensated for and the jet pipe is properly positioned.

In the modification of Fig. 6, the spool 63 of the jet shaft 61 is smooth and without grooves. The fit between the spool and walls of the housing is relatively close but allows certain oil leakage past the spool and out openings 76 and 78 into the jet pipe chamber 75. An additional opening 77 is provided in the jet pipe chamber to drain oil leakage through opening 76 as is apparent from inspection of Fig. 6.

The sealing means between the housing and spindle 62 of the shaft attached to arm 1 comprises a relatively weak spring 66 resting on a shoulder of bearing 64 which holds spring washer 67 against O-ring 68 so as to effect a seal.

The conical splash guard 72 is press-fitted into bore 74 in the housing and it is not necessary to retain it with a spring as in the modification of Fig. 2. In other respects the modifications of Fig. 6 are similar to that of Fig. 2. The impulse-receiving arm 1 is rigidly mounted on spindle 62 of jet pipe shaft 61. Jet pipe 73 is mounted at right angles to the spool portion 63 of the jet pipe shaft. Top bearing 64 and bottom bearing 65 are press-

7

fitted onto the respective spindle portions 62 of the shaft and support the shaft in the housing with a minimum of friction. Oil is supplied from fluid supply line 9, passes through booster nozzle 70 and into the receiving end of the jet pipe 79. It emerges from the discharge end of the jet pipe 80 and strikes orifices 53 and 54 in the distributor block 52 and is then lead to the cylinder from lines 11 and 12 as shown.

The housing for the jet pipe comprises a main body block 59, base block 55 and a distributor block 23. The distributor block is substantially the same as that of the modification of Fig. 2. The base block is substantially the same as that of the modification of Fig. 2 except that it is a bored-out, spring-receiving cylindrical recess portion 57. Also, O-ring seal 56 is mounted in a groove in the main body block instead of in the base block. If desired, the spool of the jet shaft may be shortened and the spring positioned against the face of the block 55 so as to avoid the necessity of boring it out to form portion 59. In the main body block 59, there is no sleeve surrounding the shaft and the body block is bored and counter-bored to provide a shaft-receiving bore 60 and jet chamber 75 with suitable oil drainage ports into the jet chambers 76 and 78 adjacent bearings 64 and 65.

Fig. 7 shows a combination jet pipe and shaft unit in which the center portion of the spool 82 of the shaft 85 is hollowed out to define a conically-shaped cavity 83 provided with a discharge nozzle 84 directed at the distributor block similar to the discharge nozzle 80 of jet pipe 73 of Fig. 6. In other words, the shaft and jet pipe are combined in a single element, the spool or central portion of the shaft being hollowed out similarly to the inner portions of a jet pipe nozzle. This eliminates the need for fitting a separate jet pipe nozzle into the spool. This combination unit is readily substituted for the shaft 61 and jet pipe 73 of Fig. 6. One advantage of the unit is the fact that a splash guard is not required. While there is some loss in the overall efficiency of the relay with this construction, it also lends itself to further miniaturization of the relay.

In the modification of Fig. 6, the diameters of the orifices 53 and 54 are approximately 10% larger than the inside diameter 30 of the discharge end of the jet pipe. In other respects, they are the same as the orifices of the modification of Figs. 2-5 as particularly shown in Figs. 4 and 5. The diameters of relays of the Fig. 6 modification, of course, may be increased up to 50% larger than that of the discharge end of the jet pipe for specific installations. The relay of Fig. 6 operates similar to that of Figs. 2-5 as is apparent.

Fluids other than oil such as ethylene glycol, diethylene glycol and propylene glycol mixtures, water and even gases such as air may be used in the relay of the present invention in place of oil. However, oil, glycol mixtures, and other hydraulic fluids are generally preferable.

The moving parts of my relay thus consist only of the nozzle, arm, and shaft, all of which are relatively light in weight. All of the reaction forces from the jet are taken on the shaft or in the high pressure oil line 9 and the jet chamber operates filled with oil. The frictional forces are thus reduced to a minimum and finally the regulator is found to respond to impulses with frequencies of 1000 cycles per second or more.

It is understood that in accordance with the provisions of the patent statutes, variations and modifications of the invention shown and described may be made without departing from the spirit of the invention.

What I claim is:

1. A jet pipe relay comprising, in combination, a housing, a cylindrical recess in said housing, a first chamber in said housing communicating with portions of said recess, a second chamber in said housing communicating with separate portions of said recess, a cylindrical shaft rotatably supported in said recess and substantially in sealing engagement with the sidewalls thereof and seal-

8

ing said first chamber from said second chamber, a jet passage in said shaft having a discharge orifice opening into said second chamber and an inlet orifice opening into said first chamber, means defining an inlet passage into said first chamber through said housing for supplying fluid under pressure to said first chamber whereby fluid is discharged in a jet into said second chamber, said inlet passage and said first chamber each having a cross-sectional diameter greater than the diameter of said jet passage throughout the latter's length to maintain continuous fluid pressure at the inlet end of the jet passage, and a distributor plate positioned in the line of discharge of said jet.

2. A jet pipe relay comprising, in combination, an integral housing member, a cylindrical recess in said housing member, a cylindrical shaft rotatable in said recess and having a diameter such that the surfaces of said shaft sealingly engage the surfaces of said recess, said cylindrical recess having a cylindrical opening of the same diameter at one end of the housing member for the insertion of said shaft endwise into said recess through said opening, an end plate closing said end of the cylindrical recess, first and second chambers each communicating with diametrically opposite sides of said recess with the width of each chamber at its connection to said recess having a dimension transverse to the axis of the recess which is less than the diameter of the recess whereby the shaft seals one chamber from the other, means defining an inlet passage to said first chamber for supplying fluid thereto under pressure, a separately formed jet nozzle member carried by said shaft and defining a jet passage transversely through said shaft opening at one end to said first chamber and at the opposite end into said second chamber whereby fluid under pressure flows from said first chamber in a jet into said second chamber, said inlet passage and said first chamber each having a cross-sectional diameter larger than that of said jet passage to maintain continuous fluid pressure at the inlet end of the jet passage, said jet nozzle member having its discharge end disposed laterally beyond said cylindrical recess, and a distributor plate in said second chamber in the line of discharge of said jet.

3. The combination of claim 2 wherein said chambers communicate with said recess at points spaced from the axial ends thereof and said shaft surfaces have a slight clearance from said recess surfaces whereby fluid from said first chamber will flow axially along said shaft toward the ends thereof, and wherein there are provided means establishing fluid communication between the ends of said shaft remote from said first chamber and said second chamber.

4. The jet pipe relay of claim 1 wherein said jet passage has its smallest diameter at its discharge end and has a continuous inward taper leading to its discharge end.

5. The jet pipe relay of claim 2 wherein said jet passage has its smallest diameter at its discharge end and has a continuous inward taper leading to its discharge end.

6. The jet pipe relay of claim 2 wherein there are provided cylindrical anti-friction bearings at each end of said cylindrical recess which have an outer diameter equal to the diameter of said cylindrical recess and which rotatably support the shaft in said recess.

7. A jet pipe relay comprising, in combination, a housing, a cylindrical recess in said housing, a first chamber in said housing communicating with portions of said recess, a second chamber in said housing communicating with separate portions of said recess, a cylindrical shaft rotatably supported in said recess and substantially in sealing engagement with the sidewalls thereof and sealing said first chamber from said second chamber, a jet passage in said shaft having a discharge orifice opening into said second chamber and an inlet orifice opening into said first chamber, means defining an inlet passage into said first chamber through said housing for supplying

fluid under pressure to said first chamber whereby fluid is discharged in a jet into said second chamber, said inlet passage and said first chamber each having a cross-sectional diameter greater than the diameter of said jet passage throughout the latter's length to maintain continuous fluid pressure at the inlet end of the jet passage, a distributor plate positioned in the line of discharge of said jet, there being a slight clearance between the sides of said shaft and the walls of said recess whereby a small amount of fluid will flow axially along said shaft from said first chamber, and means establishing fluid communication between the opposite ends of said shaft remote from said first chamber and said second chamber.

15

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