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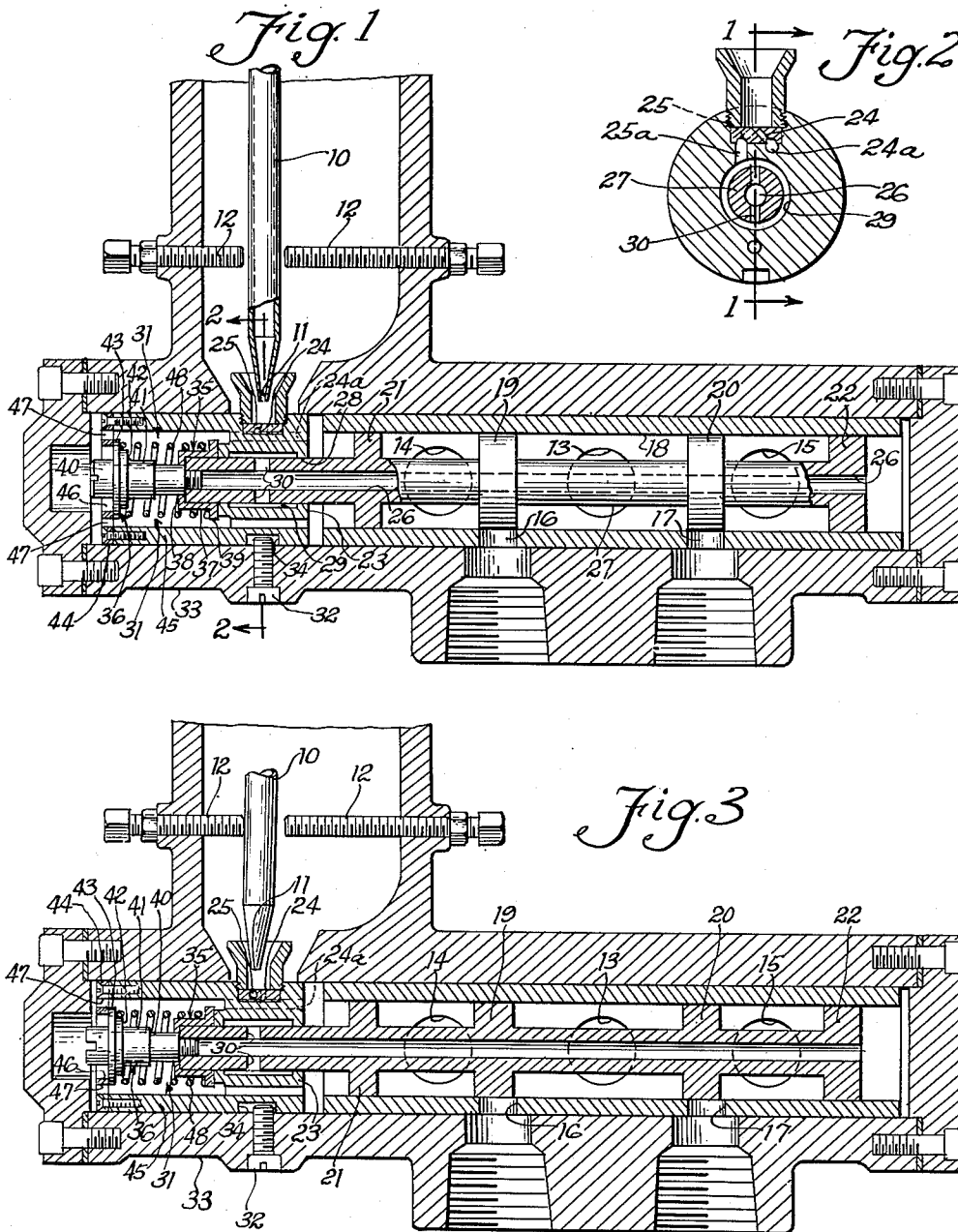
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2,601,207

FLUID REGULATOR

Filed Feb. 15, 1951

2 SHEETS—SHEET 1



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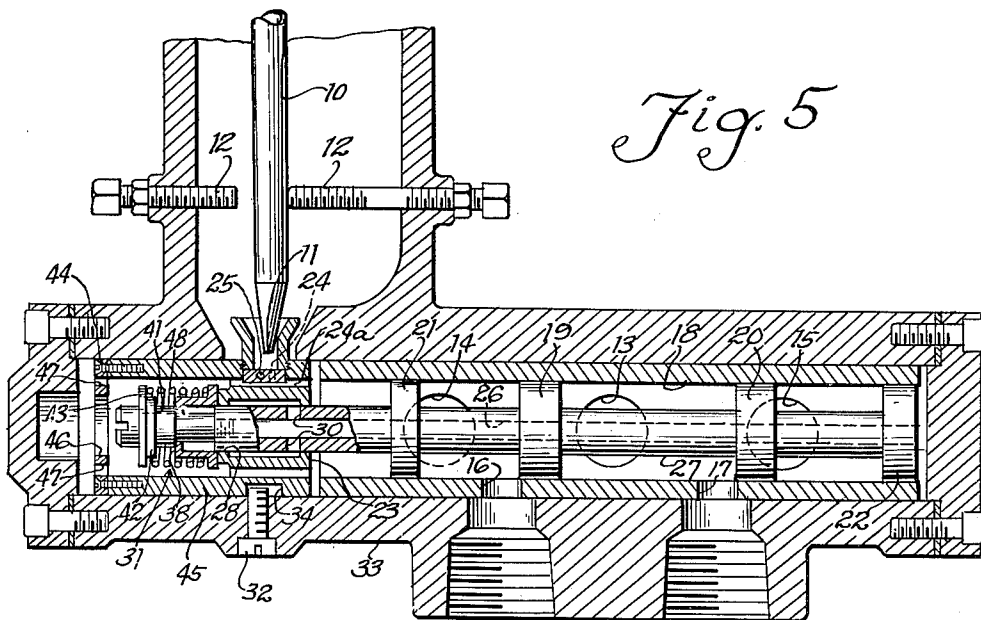
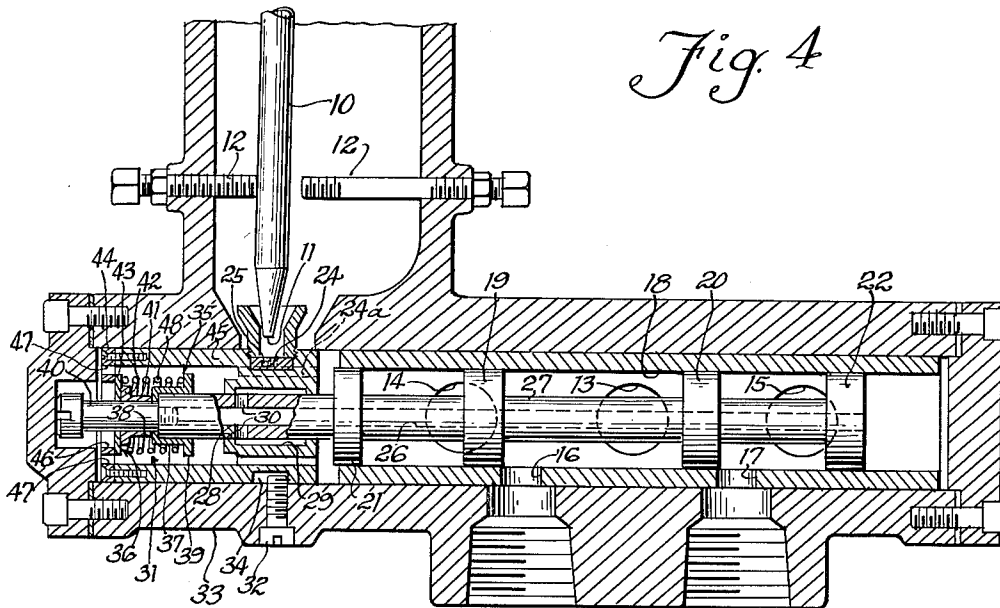
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2 SHEETS--SHEET 2



UNITED STATES PATENT OFFICE

2,601,207

FLUID REGULATOR

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7 Claims. (Cl. 121—46.5)

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This invention relates to jet pipe regulators. A jet pipe regulator is a well-known relay controlling device that includes a nozzle having at its end a discharge orifice and that is pivotally mounted for swinging about an axis in response to magnitude of an applied signal. The regulator also includes a pair of receiver ports that are narrowly spaced in the direction of the path of swing of the discharge orifice, and these receiver ports respectively communicate with a differential pressure responsive device. Movement of the jet pipe and of its orifice serves to deliver fluid in an unequal fashion to the respective receiver ports and thereby develop a pressure differential between them which operates the responsive device. A refinement of the jet pipe regulator is the so-called "auxiliary-piston" arrangement wherein the distributor structure provided with the receiver ports is movable in the direction of the jet pipe swing and is carried by a piston that is movable in a cylinder to opposite ends of which the respective receiver ports are connected so that the differential pressure resulting from movement of the jet pipe is effective, not only to move the piston, but additionally is effective to move the distributor device. The receiver ports are so connected that the piston and the distributor device follow the jet pipe orifice and thus the piston is maintained in positional correspondence with the jet pipe and the receiver ports are maintained in a neutral condition relative to the jet pipe orifice wherein they receive equal amounts of fluid. Any departure from this neutral position results in movement of the piston to reestablish it.

The characteristics of a jet pipe regulator are such that accurate response occurs only in a limited range of jet pipe movement. Additionally, with the signal devices used with jet pipes, particularly in the case that such signal devices are diaphragm-type pressure detectors, normally the distance of swing permitted to the jet pipe is very small, the range of movement of the orifice normally being of the order of $\frac{1}{8}$ of an inch. In certain cases it is desirable that the output member of a jet pipe regulator, and particularly the output of a jet pipe regulator of the auxiliary-piston type, be capable of movement through a range substantially greater than that permitted to the jet pipe orifice. A particular example of a situation wherein it is desirable that the output member of an auxiliary-piston type jet pipe regulator be movable through a travel range substantially greater than that of the jet pipe orifice is that in which the auxiliary-piston moves a pilot valve. In hydraulic power systems, for example, the main pressure fluid lines usually are $\frac{3}{4}$ " or more in diameter. Control of flow through such lines by a jet pipe regulator heretofore has been limited to a valve movement of substantially $\frac{1}{16}$ " in either direction from a fully-closed valve posi-

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tion so that it has not been possible to fully open a valve actuated by a jet pipe regulator of the auxiliary-piston type.

A primary object of the invention is to provide an improved auxiliary-piston type jet pipe regulator assembly wherein the output member driven by the auxiliary-piston may move a substantial distance beyond positions corresponding to the limit positions of the jet pipe orifice. Another object is to provide a novel hydraulic piston assembly for a jet pipe regulator. Still another object is the provision of a novel auxiliary-piston type jet pipe pilot valve operator capable of moving the pilot valve of the assembly between fully-closed and fully-opened positions and requiring a valve body movement of greater length than the movement permitted to the jet pipe orifice.

In the accompanying drawings

Fig. 1 is a longitudinal section through an auxiliary-piston type jet pipe hydraulic booster, showing the pilot valve of the booster in fully-closed position.

Fig. 2 is a section on line 2—2 of Fig. 1.

Figs. 3, 4, and 5 are sections similar to Fig. 1, respectively showing the valve body in a position corresponding to one limit position of the jet pipe orifice, Fig. 4 showing the condition of the assembly with the valve body moved beyond its position corresponding to a limit position of the jet pipe orifice, and Fig. 5 showing the condition of the assembly in the opposite limit position of the valve body.

Describing the drawings in detail, a jet pipe 10 has at its end an axial fluid discharge orifice 11. The jet pipe is assumed to be mounted for swinging movement about a pivot axis by which the orifice 11 is moved along a preselected path. Stops to limit swing of the jet pipe, and thereby determine limit positions of orifice 11, are designated 12. The device that is operated in response to movement of jet pipe 10 is shown to be a pilot valve. This pilot valve comprises an input port 13 of one character such as exhaust or supply, and a pair of ports 14, 15 of common character that is opposite to that of port 13. Herein it is assumed that port 13 is a supply port and ports 14 and 15 are exhaust ports. The valve assembly also includes a pair of controlled ports 16, 17. All of the above-mentioned ports enter into a valve bore 18 wherein is axially movable a valve body that is driven in response to jet pipe movement. This valve body is of spool type and comprises a plug part 19 that is movable in either direction from the position shown in Fig. 1 wherein it blocks output port 16 and a plug part 20 that similarly is movable in opposite directions from the Fig. 1 position wherein it blocks output port 17. By opposite movement of the valve body, ports 16, 17 respectively are connected in opposite sense with port 13, or with ports 14, 15, so that

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fluid is delivered through one of the output ports at a volume flow rate that is proportional to the degree of displacement of the valve body of Fig. 1 to its neutral position. The other of the output ports is connected to exhaust by the same valve body displacement.

The valve body is movable by a piston-like structure that is responsive to pressure differential occurring to opposite sides thereof in response to unbalance of the jet pipe system resulting from jet pipe swinging movement. In the assembly shown, the piston structure is provided by end parts 21, 22 of the valve body, which parts are axially movable as pistons in their reaches of the valve bore 18.

The distributor system of the assembly comprises a structure 23 that is movable in the directions of the travel path of the jet pipe orifice 11 and that is provided with a pair of distributor ports 24, 25 which are both disposed in the path of the orifice and are narrowly spaced in the direction of such path. One of these ports shown as 24 communicates with the reach of valve bore 18 to the left of piston part 21. This communication is provided by a longitudinal passage 24(a) in structure 23 which opens into the valve bore at both ends of structure 23. The other port 25 communicates with the end reach of valve bore 18 to the right of piston structure part 22, such communication being shown as provided by a passage 25 that extends axially through a valve stem 27 to which parts 19, 20, 21, and 22 are attached. Communication from port 25 to passage 26 will be described.

Structure 23 is movable in valve bore 18 and further is movable relative to valve stem 27 which is slidable in an axial bore 28 in structure 23. Referring to Figs 1 and 2 together, it will be seen that port 25 communicates with a transverse passage 25(a) in structure 23 and that opens into an enlarged portion 29 in bore 28. Valve stem 27 is provided with transverse passages 30 that connect with the axial passage 26 of the stem and that open into the bore enlargement 29 throughout the range of relative movement of the valve body in structure 23.

Structure 23 and the piston structure of the assembly are interconnected through a bias spring system 31 that is effective between structure 23 and stem 27 to bias the two structures towards a preselected positional relation and tending to maintain structure 23 in a position that corresponds to that of the piston structure. The travel range of structure 23 is limited to correspond to that of jet pipe orifice 11 by stop means shown as a stop screw 32 mounted in the valve casing 33 and cooperative with the end surfaces of a slot 34 that is axially disposed in the outer part of structure 23. This stop arrangement is so arranged that at the respective limits of travel of structure 23 it occupies limit positions wherein port 24 or port 25 is registered with jet pipe orifice 11 when the latter is in its corresponding limit position as fixed by one of the stop elements 12.

The operation of the structure is as follows: Throughout the range of movement of jet pipe orifice 11 both structures 23, the receiver ports 24, 25, and the piston structure 21, 22, and therefore the valve parts 19, 20 also, will follow movements of the jet pipe orifice 11 since departure of the receiver ports from equal registration with orifice 11 will result in unbalance of pressures at opposite surfaces of piston parts 21, 22, which will result in movement of the piston structure

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and valve body until equal registration is reestablished. During this range of motion the spring bias system is effective to move structure 23 with the piston structure. When the structure 23 has reached one of its limit positions and orifice 11 remains in its corresponding limit position, structure 23 will be maintained against additional movement by the stop system 32, 34, but since valve stem 27 is slidable in structure 23 and since the arrangement of passages 24(a), 25(a) and 26 is such as to continue the unbalance of pressure resulting from registration of only one of receiver ports 24, 25 with orifice 11, the piston structure 21, 22, and therefore the valve body structure 19, 20, continues to move. The range of movement of the latter structures relative to structure 23 may be as great as desired, and in the assembly shown is sufficient to move valve parts 19, 20, sufficiently far to completely clear controlled ports 16, 17.

In the condition shown in Fig. 3, the jet pipe 10 has been swung to the limit of its clockwise rotation, and consequently the valve body and piston structure have moved leftward to a corresponding position. It will be seen that the relatively small movement permitted jet pipe 10 is wholly inadequate to fully open output valve ports 16, 17. However, it will be noted that, due to the registration of port 25 with orifice 11 and the comparative lack of registration of port 24 with orifice 11, pressure fluid discharged through orifice 11 tends to continue to build up pressure in the right hand end of the valve bore while effectively the left hand end of the valve bore is exhausted through port 24. This results in additional leftward movement of the entire valve and piston assembly due to the greater pressure acting on the right end of piston part 22. This movement continues so long as the jet pipe maintains its extreme clockwise position until the valve and piston structure has reached the limit of its leftward movement.

The opposite movement occurs when the jet pipe has swung to its most counter-clockwise position, as shown in Fig. 5, the structure 23 moving to a corresponding limit position and thereafter the piston and valve structure continuing to move as permitted by the sliding relation between valve stem 27 and structure 23.

The biasing system illustrated is a self-centering one that is arranged to move the valve to its normal positional relation to structure 23, shown in Figs. 1 and 3. A pair of spring seats 35, 36 are mounted on the extension portion of valve stem 27 and are slidable thereon for cooperation with a pair of stop surfaces, both of which are fixed relative to structure 23. One of these spring seats 35 is cup-shaped, having a wide wall 37 that surrounds the end portion of stem 27, an end 38 that overlies a marginal portion of the end of the stem, and a terminal flange 39 that butts against the adjacent end surface of structure 23. The second spring seat 36 is tubular and surrounds a stud bolt 40 that is threaded into the end of stem 27 and stop passage 26. This spring seat 36 has a side wall 41 slidably surrounding bolt 40 and an end flange 42 that contacts a washer 43 that is also slidable on bolt 40 and that is movable to contact a spider 44. Spider 44 is mounted at the end of a skirt 45 that extends leftward from structure 23. It is provided with a central opening 46 through which the head of bolt 40 is movable and about the periphery of which washer 43 contacts the spider. It also is provided with axial passages

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47 to permit exertion of pressure against the adjacent end of the valve bore 18. It will be seen that by this arrangement and the passages 24(a), pressure exerted against receiver port 24 will be exerted against the end surface of piston part 21 and the left end of valve bore 18.

When structure 23 moves in either direction to its limit position, continued delivery of fluid to one of the ports 24 or 25 results in sliding of the valve and piston structure relative to distributor structure 23, as described above. If this movement is leftward from the position of Fig. 3, the piston structure in moving farther moves spring seat washer 43 into contact with spider 44 and thereafter continued leftward movement of the structure compresses a compression spring 48 that is engaged between spring seats 35, 36. During this compression the bolt head moves leftward as indicated by its position in Fig. 4. In the opposite direction of movement to the position of Fig. 5 the rightward movement of spring seat 36 compresses spring 48 against spring seat 35.

It will be readily apparent that, although the provision for movement beyond a range corresponding to that of a jet pipe orifice is shown as applied to a hydraulic booster, a great many other devices might be operated from a piston structure movable relative to a distributor device such as structure 23 which has a limited range of travel movement to follow the orifice of the jet pipe.

Consequently, the scope of the invention is to be construed in accordance with the following claims rather than by limitation to the specific disclosures above made.

I claim:

1. A jet pipe regulator assembly comprising a movable jet pipe having a discharge orifice movable along a definite path by movement of the jet pipe and stop means limiting opposite movement of the jet pipe and determining limit positions of its orifice, a distributor element movable in the directions of said path and having a pair of receiver ports disposed in and narrowly spaced in the directions of said path, stop means limiting travel of said distributor element to a range at opposite ends of which respectively the different receiver ports are positioned to substantially register with the orifice in its respective said limit positions, means enclosing a motor chamber and passages connecting the respective receiver ports with opposite ends of said chamber, a wall member movable between said opposite chamber ends by unequal delivery of fluid from said orifice to the two receiver ports and said member being movable relative to said distributor element, and means effective between said distributor element and wall member biasing them to a preselected positional relation.

2. In a jet pipe regulator assembly comprising a movable jet pipe having a discharge orifice movable along a preselected path by movement of the jet pipe and stop means limiting the movement of the jet pipe and determining opposite limit positions of said orifice; a jet pipe movement-responsive device for moving an output element through a travel range greater than that of said orifice and extended beyond positions corresponding to said orifice limit positions, said device comprising means providing a chamber extended in the directions of said orifice path, a wall member in said chamber for moving said output element, distributor means movable in the directions of said orifice path

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and relative to said wall member, said distributor having a pair of receiver ports disposed in and narrowly spaced along said path and respectively communicating with said chamber to opposite sides at said wall member, stop means limiting opposite travel of said distributor means to limit positions wherein respectively the different ones of said receiver ports are disposed to receive fluid from said orifice in a corresponding one of its said limit positions, and spring means effective between said wall member and distributor means and throughout said range of distributor means movement maintaining them in a single preselected positional relation but permitting said wall member to move relative to said distributor means when said orifice and distributor means are in corresponding ones of their said limit positions.

3. In a jet pipe regulator volume flow rate booster that comprises a pilot valve assembly including a valve body having a predetermined range of travel from a fully closed to a fully open position, an expansible chamber motor assembly including structure enclosing a chamber and a wall element mechanically connected to said valve body and movable in said chamber through a full travel path that is effective to move said valve body a preselected distance from its fully closed toward its fully open position, a jet pipe having a discharge orifice and pivotally mounted for swinging said orifice in a definite path, a distributor device movable in the directions of said path and having a pair of receiver ports disposed in said path, narrowly spaced in the directions of its extent and respectively communicating with said chamber to opposite sides of said wall element, stop means arranged relative to the jet pipe for determining limit positions of its orifice, second stop means arranged to limit opposite movement of said distributor device to positions wherein respectively said different receiver ports substantially register with said orifice when the latter is in its different limit positions, and spring means effective between said wall element and distributor device to bias them to a preselected positional relation, but to permit their relative movement while said jet pipe orifice and distributor device are in corresponding ones of their said limit positions.

4. In a jet pipe regulator volume flow rate booster that comprises a pilot valve assembly including a valve body having a predetermined range of axial travel from a fully closed to a fully open position, an operator assembly including structure providing a cylinder and a piston mechanically connected to said valve body and movable axially in said cylinder through a full travel path preselected to move said body a preselected distance from its fully closed position toward its fully open position, a jet pipe having a discharge orifice and pivotally mounted for swinging said orifice alongside said cylinder in the directions of piston movement maintaining said piston in positional correspondence with the jet pipe orifice by delivery of fluid to the cylinder on the side of said piston determined by direction of variance of said piston from such positional correspondence, and stop means limiting swinging of the jet pipe from a position corresponding to said fully closed valve body position to a range less than said full travel path of the piston; means providing for maintenance of said piston in positional correspondence with said jet pipe throughout the swing range of the latter but

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permitting said piston to move through its full travel path, comprising a distributor member movable along said cylinder in the directions of piston movement, relative to said piston and between a portion of the latter and said jet pipe orifice, said member having a surface facing said jet pipe orifice and provided with a pair of receiver ports disposed to receive fluid therefrom, closely spaced in the directions of movement of said member and respectively communicating with the opposite ends of said cylinder, stop means limiting travel of said member to a path corresponding to the path of said jet pipe orifice, and spring means effective between said piston and member to bias the former axially to a pre-selected positional relation to said member throughout the range of movement of the latter, but to permit movement of said piston while said jet pipe and member are held by said stop means, to permit the piston to move said valve body farther toward its fully open position.

5. A jet regulator volume flow rate booster comprising casing structure provided with a bore; a valve body and operator unit comprising a valve body movable in a valve portion of said bore and through a predetermined travel range between fully closed and fully open positions, and piston means also movable in said bore as a cylinder; a jet pipe having a discharge orifice and pivotally mounted for swinging said orifice alongside a part of said bore in a path extended in the directions of piston movement, a distributor structure slidable in said bore and slidably surrounding a part of said valve body and operator unit, said structure having a surface facing said jet pipe orifice and provided with a pair of receiver ports disposed to receive fluid from said orifice, said ports being closely spaced in the direction of said orifice path and respectively communicating with said bore to opposite ends of said piston means; stop means associated respectively with said jet pipe and with said distributor structure and arranged to limit their travel to corresponding ranges of less length than said travel range of said valve body, and to limit positions wherein respectively the different said receiver ports are disposed to receive fluid from said orifice; and spring means effective between said distributor and unit to maintain them in a predetermined positional relation throughout the said travel range of the former but to permit the latter to move relative to the former when in one of its said limit positions, and toward the fully open valve body position.

6. A jet pipe volume flow rate booster according to claim 5, wherein said valve body and operator unit comprises a spool body having axially spaced end parts forming said piston means and having outer end surfaces, valve body structure between and spaced axially from said end parts, and a stem interconnecting said valve body structure and end parts, and a stem extension projecting beyond the end surface of one of the latter and comprising said part that is slidably surrounded by said distributor structure; said distributor structure having a chamber, a bore extending through said chamber, and wherein said stem extension is slidable, and a passage connecting said chamber with one of said receiver ports, and said stem and extension having an axial passage opening into said chamber and through the end surface of the end part that is spaced beyond said valve body structure from said stem extension, and said distributor structure

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being arranged to connect the second said receiver port with said bore between itself and both the end surface of the other said end part and the adjacent end of said bore.

7. A jet pipe volume flow rate booster comprising casing structure provided with a bore; a valve body and operator unit in said bore and comprising a pair of axially spaced piston parts having outer end surfaces respectively disposed toward the opposite bore ends, valve body structure comprising a pair of valve elements axially spaced apart and axially spaced from and between said piston parts, and stem structure interconnecting said parts and elements and projecting beyond one of said piston part end surfaces toward the adjacent bore end, said unit being axially movable in said bore in opposite directions from a neutral position wherein said valve elements respectively block the different ones of a pair of controlled ports, and said unit having travel ranges along said bore in both directions from said neutral position sufficient to move said valve elements completely clear of said ports; a jet pipe having a discharge orifice and pivotally mounted to swing said orifice in a path extended in the directions of travel of said unit, and stop means for said jet pipe limiting the travel path of its orifice and determining opposite limit positions thereof; a distributor structure slidable in said valve bore between said piston end surface beyond which said stem structure extension projects, said distributor structure having a configuration providing communication between bore reaches at its opposite ends, an internal bore extended axially therethrough and wherein said stem structure extension is slidable, an internal chamber constituting an enlargement of said internal bore, a pair of receiver ports disposed to receive fluid from said discharge orifice and narrowly spaced in the direction of movement thereof, and passageways connecting one of said receiver ports with the bore between said piston end part from which said stem structure extension projects and the other with said internal chamber; said stem structure and its extension having an internal passage opening at opposite ends into said internal chamber and through the piston part end surface opposite that from which said extension projects; and biasing means effective between said unit and distributor structure and comprising members respectively carried by the stem extension and distributor structure and path extending beyond the latter toward the adjacent bore end, a stop mounted on said distributor structure-carried member, a first spring seat secured to the end of said stem structure extension-carried member and that is movable into and out of contact with said stop by opposite axial relative movement of said unit and distributor structure, a second spring seat slidably surrounding said stem extension and bearing against the adjacent end of the distributor structure, and a compression spring interposed between said spring seats; and stop means limiting the travel range of said distributor structure to a distance equal to length of said orifice path and defining limit positions wherein the different receiver ports respectively are located to receive fluid from said orifice.

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No references cited.