May 5, 1964 J. R. CURRAN 3,131,601

HYDRAULIC SYSTEM

Filed June 22, 1961

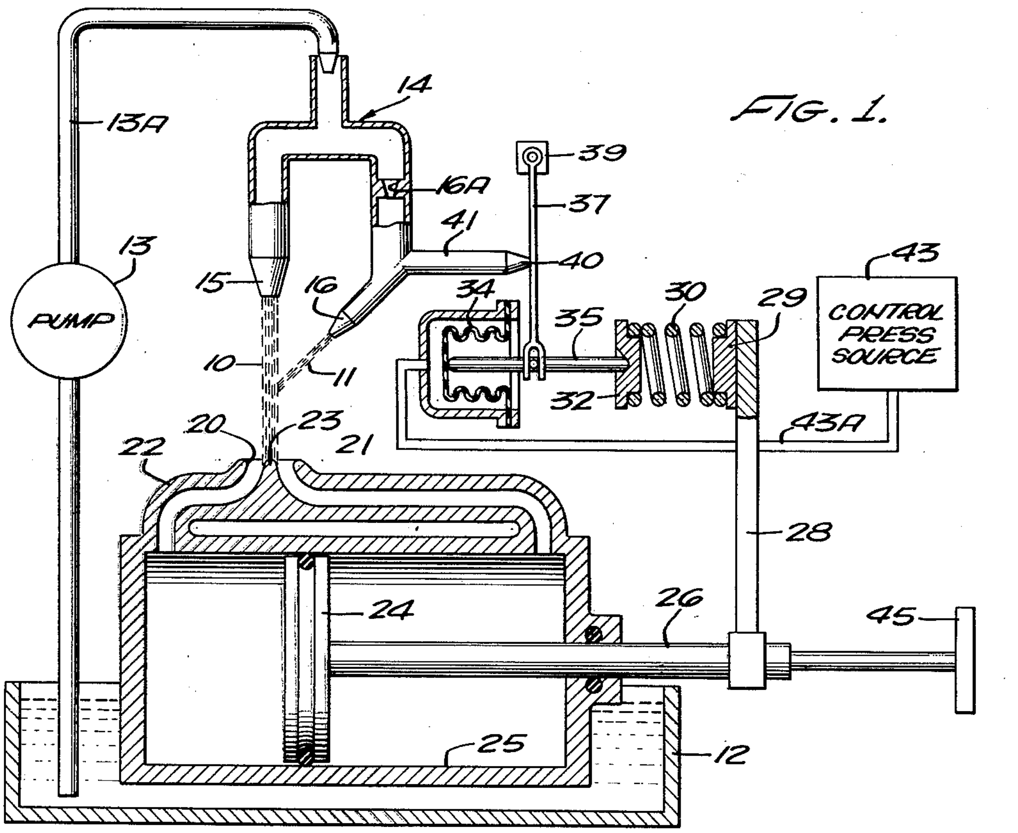

FIG. 1.

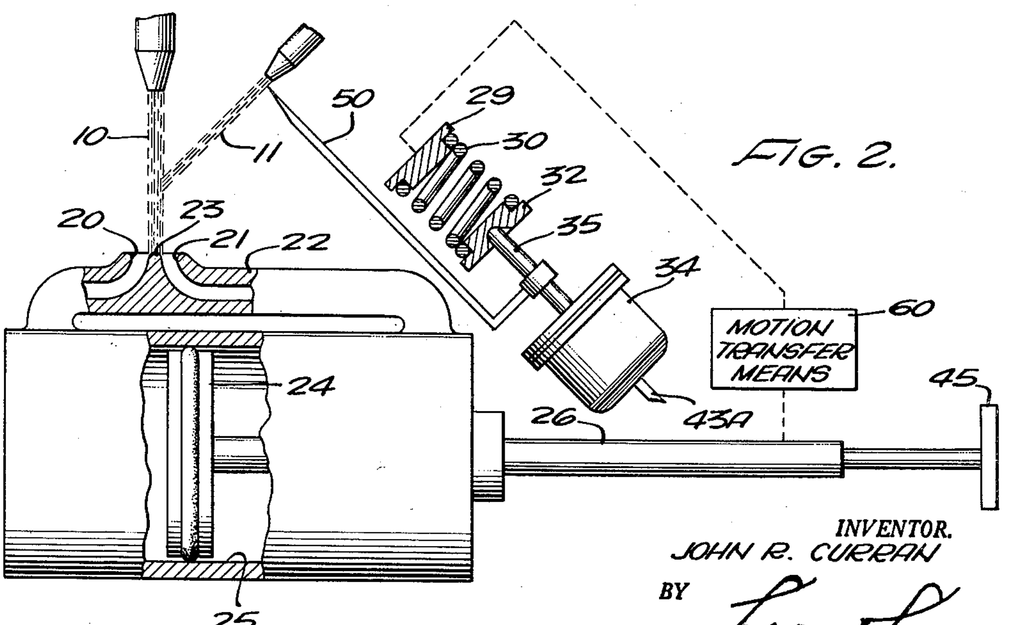

FIG. 2.

INVENTOR.
JOHN R. CURRAN
BY Lyon & Lyon
ATTORNEYS

United States Patent Office

3,131,601
Patented May 5, 1964

3,131,601
HYDRAULIC SYSTEM

John R. Curran, North Scituate, R.I., assignor to International Telephone and Telegraph Corporation, a corporation of Maryland

Filed June 22, 1961, Ser. No. 118,356
10 Claims. (Cl. 91—3)

The present invention relates to an improved hydraulic system and in particular to a servo system wherein an element is automatically positioned by hydraulic means in accordance with a controlling influence or condition.

Briefly the arrangement described herein involves a stream movable with respect to a port for delivering a fluid jet to opposite sides of a double-acting piston, such stream being thus movable by a controlled fluid jet impinging thereon, the last-mentioned fluid jet being controlled by the joint action of a controlling influence (signal) and the piston.

The system as disclosed involves a plurality of jet streams, one of which may be termed the main jet stream and the second of which may be termed a control jet stream which orients the main jet stream with respect to a port.

Using these techniques, there is produced in effect a pilot-operated four-way valve having only one moving part.

It is therefore an object of the present invention to provide an improved system of the character indicated above.

A specific object of the present invention is to provide an improved hydraulic servo system wherein a main jet is oriented by a control jet.

Another specific object of the present invention is to provide a system as set forth in the preceding paragraph in which the force exerted by the control jet on the stream producing the main jet is controlled jointly in accordance with an element positioned by the main jet and a controlling influence, the intensity of which ultimately establishes the rest position of such element.

Another specific object of the present invention is to provide a system of this character wherein kinetic energy of a control jet stream is used in positioning of a main jet stream.

Another specific object of the present invention is to provide an improved servo system of this character wherein all controls are effected solely by the use of fluid pressures.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. This invention itself, both as to its organization and manner of operation, together with further objects and advantages thereof, may be best understood by reference to the following description taken in connection with the accompanying drawings in which:

FIGURE 1 illustrates a system embodying features of the present invention.

FIGURE 2 illustrates a modification in the system shown in FIGURE 1.

In the system shown herein a suitable fluid such as oil, water, gas or air is used in providing a main jet stream 10 and a control jet stream 11. For exemplary purposes the systems are described using oil as the fluid.

In FIGURE 1 there is illustrated an oil sump or reservoir 12 which collects the oil and from which such oil is pumped by pump 13 to deliver such oil at a substantially constant pressure through conduit 13A and a T-type connection 14 to the main stream nozzle 15 from which the jet stream 10 emerges and also through the restriction 16A to the control nozzle 16 from which the jet stream 11 emerges to impinge on stream 10 for moving and positioning the same.

The nozzle 15 is in communication with the T-connection 14 and the jet stream produced thereby is moved and positioned as described later.

The main nozzle 15 cooperates with two ports 20 and 21 in cylinder casing 22, the ports being separated by a thin wall 23 and being in communication with opposite sides of a double-acting piston 24 in cylinder 25 for moving the piston 24 either to the left or right, depending upon the position of jet stream 10, i.e. in response to unbalanced pressures acting on opposite sides of piston 24.

Piston 24 has a rod 26 which extends sealingly through the cylinder casing 22 and has mounted thereon an arm 28 carrying a spring seat 29 against which one end of coil-compression spring 30 bears, the other end of spring 30 bearing against the seat 32 for exerting a variable biasing force on bellows 34 through rod 35.

This rod 35 has secured thereto the free end of a flapper valve element 37 which is supported as a cantilever in the fixed support 39 and which cooperates with the port 40 in bleeder nozzle 41 for controlling the oil pressure in control nozzle 16, the nozzle 41 being on the downstream side of restriction 16A.

The internal portion of bellows 34 is supplied with a control pressure from an adjustable or variable pressure source 43, the magnitude of which establishes the position of piston rod 26 and thereby the position of a control element 45 carried thereon, the control element 45 being exemplified as a slide valve element but, of course, such control element may take other forms for other different purposes and uses.

Typical operating conditions may be as follows. The pressure in supply conduit 13A may be a substantially constant pressure in the range of 50 to 100 pounds per square inch. The main jet nozzle 15 delivers approximately fifteen (15) times as much energy as the control jet 16. For these purposes the internal bores of nozzles 15 and 16 may have a diameter of fifty-five thousandths of an inch (.055″) and thirteen thousandths of an inch (.013″), respectively.

When flapper valve element 37 covers the port 40 of nozzle 41, the jet stream from nozzle 16 is a maximum and deflects stream 10 such that the jet stream 10 enters port 20 to force the piston 24 to the right. Similarly, when flapper valve element 37 is moved to uncover port 40, the momentum in jet stream 11 is reduced, allowing jet stream 10 to enter port 21 to force the piston 24 to the left.

Various mechanical, electrical and/or pneumatic means may be used to modulate flapper valve element 37, i.e. to move it so as to position piston 24. As illustrated, a pneumatic signal pressure is applied to the bellows assembly 34 through tube 43A.

It will be observed that feedback of piston rod position is obtained using the spring 30. The arrangement is such that the piston rod 26 assumes a position proportional to or dependent upon the air pressure supplied to bellows assembly 34.

In operation of the system, an increase in pneumatic pressure in source 43 causes the bellows 34 to expand to move the flapper valve element 37 in a direction away from port 40, thereby decreasing the pressure supplied to nozzle 16 and allowing the jet stream 10 to move to the right to, in turn, increase the pressure on the right-hand side of piston 24 and move the piston rod 26 and spring seat 29 to the left, compressing spring 30 further to equalize the increased pressure which is assumed to have been applied to bellows 34.

Conversely, it will be seen that when the control pressure in control line 43A is reduced, the spring 30 causes the flapper valve 37 to move closer to bleeder port 40 to increase the pressure in nozzle 16 and deflect the jet stream 10 to the left to apply an unbalanced force acting on the left side of piston 24 to move it and the spring seat 29 to the right to minimize the force exerted by spring 30.

The bellows 34 and spring 30 thus act as part of a force-balancing system, the functioning of which results in automatic positioning of piston 24 and the control element 41 attached thereto.

In the system illustrated in FIGURE 2, the jet stream 11 is modulated or controlled in a more direct manner than as illustrated in FIGURE 1 in that a needle or blade 50 is positionable in the jet stream 11 itself. This needle or blade 50 is moved by the bellows 34 provided with its appropriate feedback spring 30 connected to the piston rod in such a manner as to interfere to a greater or lesser degree with the main jet 10. When the blade is not in contact with jet 11, it allows jet 11 to deflect jet 10 a maximum amount to the left. Similarly, when the needle or blade 50 is at its maximum contact with jet 11, the effect of jet 11 on jet 10 is minimized and jet 10 moves to enter the right-hand port 21 of the piston cylinder assembly.

In the operation of the system shown in FIGURE 2, an increase in control pressure in line 43A results in movement of the blade or needle 50 into the jet stream 11, thereby minimizing its effect on jet stream 10 such that jet stream 10 moves to the right and enters further port 21 to cause piston 24 to move to the left and causing spring 30, which is connected to piston rod 26 through suitable motion transfer means 60, to be compressed further, producing a force in spring 30 which balances the force developed in bellows 34. Conversely, when the control pressure in line 43A is decreased, the then unbalanced force of spring 30 moves the connecting stem 35 to retract the needle or blade 50 from the jet stream 11 to allow it to have greater effect on jet stream 10, causing it to be deflected to the left to further enter port 20, in which case the piston 24 is moved to the right to relieve some of the forces in spring 30 to restore the system again to a balanced condition during which time the control element is automatically repositioned to a different position as in FIGURE 1 corresponding to a particular pressure in control bellows 34.

Thus, in the systems illustrated in both FIGURES 1 and 2 it will be seen that a valving action is obtained using one main jet stream 10 controlled by a control jet stream 11 as a result of impingement of the control jet stream on the main jet stream. Due to such impingement, kinetic energy or momentum of the control jet is transferred from the control to the main jet stream to deflect the main jet stream. The amount of such energy or momentum transfer is effectively controlled by modulating or controlling the control jet either as shown in FIGURE 1 by control of pressure or as shown in FIGURE 2 by spoiling or reducing the effective cross-sectional area of the control jet. While this action takes place in a servo system, the same may be accomplished without feedback signals from a servo system. Thus, the flapper valve in FIGURE 1 and the needle or blade in FIGURE 2 may be controlled by means other than those illustrated in the practice of broader aspects of the present invention.

While the particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from this invention in its broader aspects and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

I claim:

1. In a fluid control system, condition responsive means, a fluid cylinder, a double-acting piston in said cylinder, a pair of ports each communicating respectively with a different side of said double-acting piston, means producing an unrestricted fluid stream normally oriented to enter one of said ports, means producing an unrestricted control fluid stream impinging on the first-mentioned stream for deflecting the same in the direction of the other one of said ports, and means modulating said fluid control stream in accordance with positioning of said piston by the first-mentioned stream after interaction with the second-mentioned stream and jointly in accordance with the condition of said condition responsive means to automatically statically position said piston.

2. A system as set forth in claim 1 in which said modulating means includes means for changing the pressure of said fluid control stream.

3. A system as set forth in claim 1 in which said modulating means includes means engageable with said control fluid stream for modifying its effect on the first-mentioned fluid stream.

4. In a system as set forth in claim 1 in which a member is connected to said piston for movement thereby and means responsive to movement of said member for controlling said modulating means.

5. A hydraulic servo system including force balancing means; said force balancing means including a control bellows, a movable member, spring means between said movable member and said bellows, said bellows being stressed in accordance with forces developed in said bellows and forces developed by said spring means; means producing a first unrestricted jet stream; means producing a second unrestricted jet stream impinging on said first jet stream; means responsive to the position of said first jet stream for positioning said member; and an element controlled by said force balancing means for modulating said second jet stream.

6. In a system of the character described comprising condition responsive means, means producing a first unrestricted jet stream, means producing a second unrestricted constantly oriented jet stream of variable intensity and impinging on said first jet stream for deflecting said first jet stream to different positions depending upon the intensity of said second jet stream, means movable in response to the position of said first jet stream, and means responsive both to said condition responsive means and to the position of said movable means for varying the intensity of said second jet stream.

7. In a system of the character described comprising first means producing two interacting unrestricted jet streams, second means moved and pressured by the interaction of said jet streams for developing a variable force on said second means which varies depending upon the ultimate static position to which said second means is moved by said interacting jet streams, and force balancing means responsive to said variable force developed on said second means for controlling the interaction between said jet streams.

8. In a system of the character described, a fluid cylinder, a double-acting piston in said cylinder, a pair of ports each communicating respectively to a different side of said double-acting piston, means producing a first unrestricted jet stream directed generally towards one of said ports for moving said piston in one direction, means producing a second unrestricted jet stream impinging on the first jet stream for deflecting the first jet stream from said one port to the other port to produce movement of the piston in the direction opposite to said one direction, a member attached to and movable with said piston, an expansible bellows having a movable wall, spring means acting between said movable wall and said member, said bellows including means for introducing fluid under pressure thereto to change the stressing of said spring means, the particular position of the piston also affecting stressing of said spring means, and means responsive to the position of said movable wall for modulating said second fluid jet stream.

9. A system as set forth in claim 8 in which said means for producing said first jet stream comprises a source of fluid, a first nozzle and pump means for pumping fluid from said source to said nozzle, said means for producing

said second jet stream comprising a second nozzle in communication with the delivery side of said pump means, a restricted orifice between said second nozzle and the delivery side of said pump means, a flapper valve in communication with said pump means located on the downstream side of said restricted orifice and the upstream side of said second nozzle, and said movable wall controlling said flapper valve.

10. A system as set forth in claim 8 in which said modulating means comprises an element connected to the movable wall of said bellows and enterable into said second jet stream.

References Cited in the file of this patent

UNITED STATES PATENTS

2,408,603	Braithwaite et al.	Oct. 1, 1946
2,408,705	Todd	Oct. 1, 1946
3,024,805	Horton	Mar. 13, 1962

FOREIGN PATENTS

706,257	Germany	May 22, 1941
730,577	France	May 17, 1932
897,046	France	May 15, 1944

OTHER REFERENCES

Electromechanical Design Magazine, Benwill Publishing Corp., June 1960, pp. 60, 61.

Science and Mechanics magazine, pub. by B. G. Davis, Chicago, Ill., June 1960, pp. 81–84.