Aug. 8, 1961 W. J. HIPP 2,995,141

DUAL VOLUME FLOW DIVIDER

Filed April 8, 1960

Fig. 1

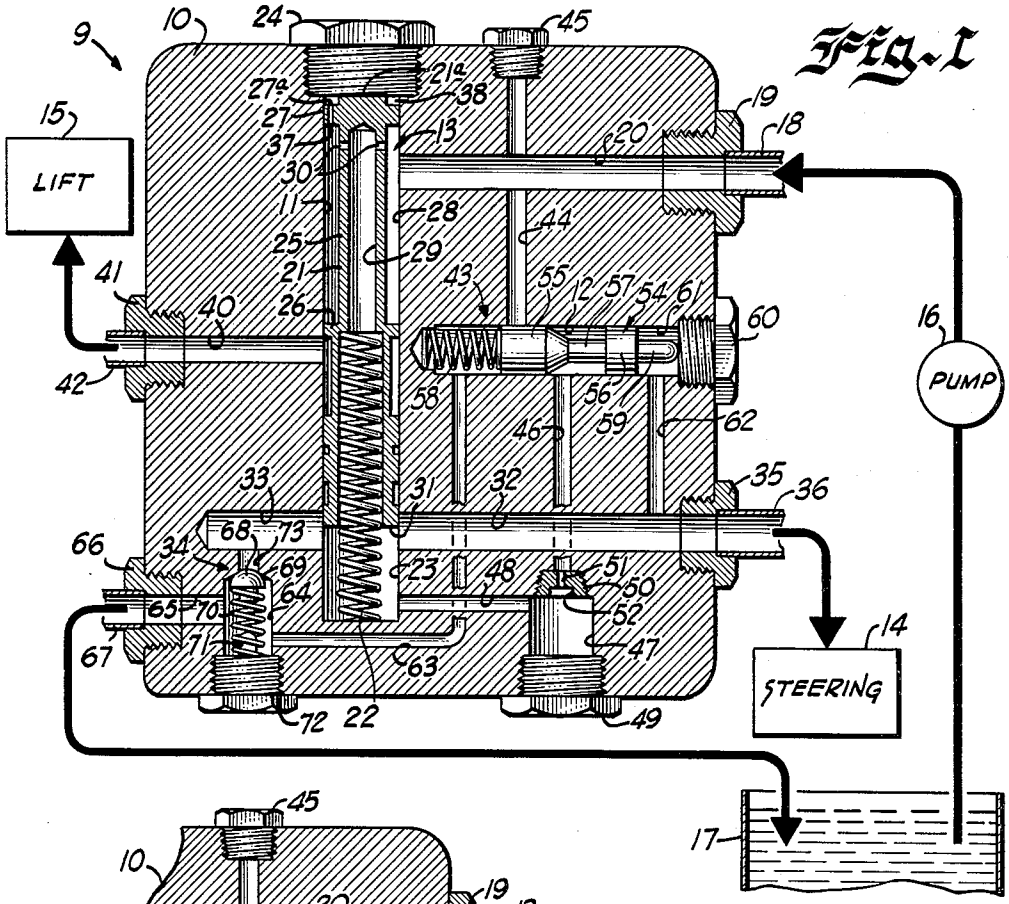


Fig. 2

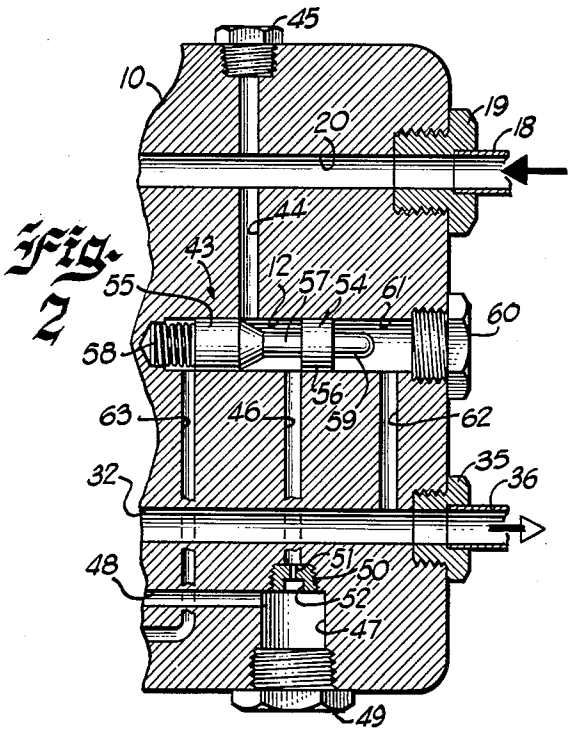
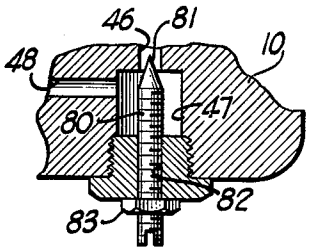


Fig. 3



INVENTOR.
WILLIAM J. HIPP

BY
Mason, Kolehmainen, Rathburn and Wyss
ATTORNEYS.

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DUAL VOLUME FLOW DIVIDER

William J. Hipp, Mount Pleasant Township, Racine County, Wis., assignor to Webster Electric Company, Racine, Wis., a corporation of Delaware

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The present invention relates generally to flow dividing valving for use in hydraulic systems and is more particularly concerned with a new and improved valve for use in hydraulic systems of the type required to supply fluid to different loads one of which must take priority over the other.

While the valve of the present invention may be used in a number of applications, one typical use may be on a vehicle requiring hydraulic fluid for steering and also requiring fluid for performing auxiliary functions. For example, the hydraulic system used on lift trucks is usually called upon to supply fluid for the steering control and auxiliary fluid for operating the lift. In such systems, the steering control circuit must have priority over the auxiliary circuit so that the operator will not lose control of the vehicle in the event that the fluid supply is not capable of meeting the demands of both circuits. However, at all times when the fluid supply is more than adequate to satisfy the requirements of the steering circuit, it is desirable that all excess fluid be made available to the auxiliary or secondary circuit. Therefore, the primary object of the present invention is to provide new and improved valving meeting all of these requirements.

A further object of the invention is to provide valving of the character described which operates completely automatically to afford the desired priority for the primary circuit without requiring intervention by the operator.

Another object of the invention is to provide a valve of the type described above which is effective to permit diversion of a maximum amount of fluid to the auxiliary circuit whenever fluid is not required by the primary circuit.

The invention has for a further object the provision of valving of the type described for permitting a single hydraulic pump to serve both the primary circuit and the auxiliary circuit while at the same time assuring that fluid for the primary circuit will be available upon demand.

The foregoing and other objects are accomplished, in accordance with the present invention by providing valving for controlling the fluid flow from a single pump to a primary circuit and to an auxiliary or secondary circuit. The valving includes a flow dividing valve for supplying a relatively small amount of fluid at all times to the primary circuit and for diverting all excess fluid to the secondary circuit. The latter valve includes a control element having a flow restricting orifice therein producing a pressure drop or difference directly proportional to the rate of flow of fluid to the primary circuit. Whenever this pressure difference exceeds a predetermined value the piston is moved against a biasing spring to a position wherein it directs the major portion of the inlet fluid to the secondary circuit independently of the orifice. A priority control valve is connected to the inlet to supply the major portion of the fluid to the primary circuit via a major flow path in parallel with the path through the flow restricting orifice. The latter valve includes a piston normally biased by a spring to a position wherein it blocks the major flow path and prevents delivery of fluid via said path to the primary circuit. This piston is subjected to the pressure of the fluid in the primary circuit acting in opposition to its biasing spring

and, hence, when the latter circuit demands more fluid than can be supplied through the orifice in the flow dividing valve control element the piston is moved to a position opening the major flow path. As soon as the demand of the primary circuit has been satisfied the priority control valve again becomes effective automatically to block the major flow path, thus making available to the secondary circuit most of the fluid delivered by the pump. A pressure relief valve is provided for relieving any excess pressure of the fluid supplied to the primary circuit.

The invention, both as to its organization and manner of operation, together with further objects and advantages will best be understood by reference to the following description taken in conjunction with the accompanying drawing wherein:

FIG. 1 is a somewhat cross sectional view illustrating flow dividing valving characterized by the features of the present invention although it should be understood that the view is not a true cross section since the passages in the valve body have been illustrated as though they lie in a single plane while, in actual practice, it is necessary to offset these passages to establish the desired flow paths;

FIG. 2 is a fragmentary view somewhat similar to FIG. 1 but illustrating the priority valve in a position wherein it is effective to deliver a major portion of the fluid from the inlet to the primary circuit; and

FIG. 3 is a fragmentary view illustrating a modification of the valving shown in FIGS. 1 and 2.

Referring now to the drawing and first to FIG. 1, the valve of the present invention is there indicated generally by the reference numeral **9** and includes a valve body **10** having defined therein a main valve bore **11**, a secondary valve bore **12** and a plurality of drillings forming flow passages to be described hereinafter. The main valve bore **11** contains a flow dividing valve **13** for distributing to a primary circuit **14** and a secondary circuit **15** inlet fluid supplied from a single hydraulic pump **16**. The latter pump has its inlet connected to draw a suitable fluid such as oil from a tank or reservoir **17** and has its outlet connected through a pipe or conduit **18** to an inlet fitting **19** threaded into the valve body **10**. The fitting **19** is connected to supply inlet fluid to the valve bore **11** through a passage **20** drilled into the valve body. The primary circuit **14**, as was indicated previously, may comprise the steering control for a vehicle while the secondary circuit **15** may comprise equipment for performing auxiliary functions such as the lift on a power operated lift truck.

The flow dividing valve **13** includes a piston **21** mounted for sliding movement within the valve bore **11** and biased upwardly as viewed in FIG. 1 by means of a coiled spring **22**, the upward movement of the piston being limited by engagement of its end **21***a* with a plug **24** threaded into the valve body. The piston **21** is generally in the form of an open ended, hollow cylinder and cooperates with the bore **11** to define a spring chamber **23** containing the spring **22** which is seated at one end against the blind end of the bore **11** and at its other end is nested within the hollow **29** of the piston.

The piston **21** includes a reduced diameter portion **25** bounded by lands **26** and **27** and cooperating with the valve bore **11** to define an inlet chamber **28** receiving fluid from the inlet passage **20**. The inlet chamber **28** is connected continuously to the spring chamber **23** through one or more flow restricting orifices **30** formed in the valve piston **21**. These orifices provide a restricted flow path extending from the inlet passage **20** through the spring chamber **23** and around the extreme lower end **31** of the valve piston to an outlet passage **32** leading to the primary circuit **14**. The passage **32** is drilled through the valve body **10** to intersect the valve bore **11** and includes a

drilled portion 33 leading to a pressure relief valve 34 which will be described more fully hereinafter. An outlet fitting 35 threaded into the valve body 10 connects the passage 32 to a conduit or pipe 36 leading to the primary circuit.

The upper end of the piston 21 cooperates with the valve bore 11 to define a damping dashpot of conventional construction for inhibiting oscillation of the piston. More specifically, the land 27 is provided with one or more passages 37 therein providing communication between the inlet chamber 28 and a dashpot chamber 38 formed within the valve bore 11 adjacent the upper end 21*a* of the piston. The high pressure fluid in the inlet chamber 28 acts against the upper face 27*a* of the land 27 to develop a relatively large force urging the piston downwardly against the action of the biasing spring 22. It will also be understood that the fluid flowing through the orifices 30 is sufficient to establish a pressure difference between the chambers 28 and 23. The force of the high pressure fluid acting against the upper end of the piston is opposed by the relatively low pressure fluid in the spring chamber 23, but when the rate of flow through the orifices 30 increases sufficiently to cause a pressure drop of predetermined value, the piston 21 is moved downwardly until the land 26 uncovers a passage 40 leading to the secondary circuit 15. The latter passage is connected through a fitting 41 and through a conduit or pipe 42 to the secondary circuit. When the land 26 uncovers the passage 40, the secondary circuit 15 is connected directly to the inlet chamber 28 and, hence, receives the major portion of the fluid from the pump 16, while the flow restriction orifices 30 limit the flow to the primary circuit to a very low level. The flow dividing valve 13 thus far described is of conventional construction and, hence, need not be considered in further detail.

In accordance with an important feature of the present invention, the major portion of the fluid for the primary circuit is supplied through a major flow path including a priority control valve 43 mounted within the secondary bore 12. The major flow path includes a passage 44 drilled through the valve body to intersect the inlet passage 20 and to connect with the bore 12. The drilling is made from the upper edge of the valve body and hence the extreme outer end is sealed by a plug 45. The major flow path further includes a passage 46 leading from the bore 12 to a chamber 47 and a further passage 48 connecting the latter chamber to the spring chamber 23 in the valve bore 11. The chamber 47 is closed by a removable plug 49 threaded into the valve body which plug may be removed to permit insertion of a flow restricting element 50 in the form of a small plug having a small central orifice 51 therethrough. The latter plug may have an Allen socket 52 therein for receiving a head of an Allen wrench by means of which the plug may be threaded into or out of its seat in the valve body. The orifice 51 in the plug 50 provides a restriction in the major flow path leading from the inlet passage 20 to the passage 32 for supplying fluid to the primary circuit.

As was previously indicated, the fluid flow through the major flow path just described is controlled by the priority valve 43 which includes a valve piston 54 mounted for sliding movement within the secondary bore 12. The latter piston includes a pair of lands 55 and 56 separated by a reduced diameter portion 57. A biasing spring 58 having one end seated in the blind end of the bore 12 and having its other end resting against the inner end of the piston urges the piston 54 to the right as viewed in FIG. 1 with the rightward movement being limited by engagement of an axially extending stem 59 on the piston with a plug 60 threaded into the outer end of the bore 12. The stem 59 cooperates with the bore 12, with the plug 60, and with the land 56 to define a pressure chamber 61 which communicates with the primary circuit outlet passage 32 through a passage 62 in the valve body. When the pressure in the chamber 61 is at a relatively low value, the spring 58 is effective to maintain the piston 54 at the right so that the land 55 covers the passage 44 in order to interrupt or block the major flow path. In the event that the primary or steering control circuit 14 is operated, the pressure of the fluid in the passage 32 and in the chamber 61 builds up to a value sufficient to move the piston 54 to the left against the biasing spring 58 to the position shown in FIG. 2 whereupon the passage 44 is connected to the passage 46 through the reduced diameter portion 57 thus opening the major flow path. When the priority valve is opened fluid is supplied in parallel with the flow through the orifices 30 in order to meet increased demands of the primary circuit.

To prevent leakage fluid entering the spring chamber at the blind end of the bore 12 from blocking the leftward movement of the piston 54, this spring chamber is connected through a passage 63 to the tank or reservoir 17. More specifically, the passage 63 opens to a chamber 64 containing the pressure relief valve 34. The latter chamber is connected to the reservoir 17 through a drilled passage 65 in the valve body 11, through a bypass fitting 66, and through a pipe or conduit 67. The relief valve 34 is a conventional poppet type valve having a valve element 68 seated against a tapered valve seat 69 formed at one end of the chamber 64. The valve element 68 is biased into engagement with the valve seat by a spring 70 having one end encircling the stem on the valve element and having its other end telescoping over an inwardly extending projection 71 on a plug 72 threaded into the outer end of the chamber 64. A passage 73 connects the valve seat to the drilling 33 so that the valve element 68 is subjected to the pressure of the fluid in the primary circuit. Thus when the latter pressure exceeds a predetermined value, the valve element 68 is unseated to provide a bypass to the reservoir 17 through the chamber 64 and through the passage 65.

Considering next the operation of the valving shown in FIGS. 1 and 2 and assuming first the condition where the primary circuit 14 requires no fluid, it will be observed that a very small amount of the fluid entering the inlet passage 20 is passed through the orifices 30 and through the passage 32 to the primary circuit. Under these conditions, the major portion of the inlet fluid from the passage 20 is directed to the secondary circuit 15 through the passage 40. Since the primary or steering circuit 14 is not being operated at this time, the pressure of the fluid in the passage 32 is very low and, hence, the valve piston 54 of the priority valve 43 is in the position shown in FIG. 1 wherein it blocks the major flow path. Thus, only the fluid passing through the orifices 30 is supplied to the primary circuit or steering control.

Assuming next that the operator has moved the steering control or primary circuit to steer the vehicle, it will be recognized that the pressure builds up in the passage 32. This pressure also exists in the chamber 61 and acts to move the piston 54 to the position shown in FIG. 2 against the spring 58 thus connecting the passages 44 and 46 and opening the major flow path. Fluid from the inlet passage 20 then flows through the open priority valve 43 and through the orifice 51 to the passage 32. Thus, the fluid flowing through the orifice 51 is in parallel with that flowing through the orifices 30 and, as a result, an increased amout of fluid is supplied through the passage 32 to the primary circuit 14. As long as the pressure of the fluid in the passage 32 remains above the predetermined value determined by the spring 58, the increased fluid flow through the major flow path will be available for the primary circuit. As soon as the demands of the latter circuit have been satisfied, the pressure of the fluid in the passage 32 and in the chamber 61 falls to a value where the spring 58 is again effective to move the piston 54 to the position shown in FIG. 1 thus again blocking or interrupting the major flow path. The fluid that had been required for the primary circuit is thus made immediately available for the secondary circuit 15.

Any excess pressure of the fluid in the primary circuit passage **32** is relieved through the valve **34** in conventional manner.

Both the orifice **51** and the orifices **30** are pressure compensated to insure constant flow of fluid regardless of changes in the inlet fluid pressure. The amount of fluid flowing through the major flow path to the primary circuit passage **32** is controlled by the size of the orifice **51** and, hence, different rates of flow can be established by selection of a plug **50** having the proper orifice size. Preferably, the size of the orifice **51** is such that the fluid flow via the major flow path is greater than that through the orifices **30** so that the major portion of the fluid required by the primary circuit is supplied by the priority valve.

The fluid flow through the major flow path may also be controlled by the arrangement shown in FIG. 3 wherein the orifice size is adjusted from the exterior of the valve body by turning a control element **80**. The latter element includes a conically shaped inner end **81** forming a needle cooperating with the lower end of the passage **46** to form the variable orifice. The stem of the control element is threaded into a tapped axial bore **82** in the plug sealing the lower end of the chamber **47** to permit the adjustment. A lock nut **83** is preferably provided for the purpose of locking the control element **80** in position after it has been properly adjusted.

In view of the foregoing discussion, it will be observed that the valving illustrated and described is effective to accomplish all of the enumerated objects of the invention. Thus, this valving provides priority for the fluid flowing to the primary circuit and at the same time makes available for the secondary circuit a maximum amount of fluid whenever the demands of the primary circuit are satisfied. All of this is accomplished automatically and without intervention by the operator. Moreover, the mechanism required is very simple in construction employing a minimum number of compactly arranged parts.

While particular embodiments of the invention have been illustrated and described, it will be understood by those skilled in this art that many modifications and changes may be made without departing from the true spirit and scope of the invention as set forth in the appended claims.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. Valving for controlling the flow of fluid from a source to a primary circuit and to a secondary circuit, said valving including valve body means having first and second valve bores defined therein, inlet passage means delivering inlet fluid from the source to both of said bores, a first valve piston mounted for reciprocation in said first bore and carrying means defining at least one flow restricting orifice, a chamber in said first bore receiving fluid flowing from the inlet passage means through said orifice, an outlet passage in said valve body means spaced from the inlet passage means and leading from said chamber to the primary circuit, said chamber being connected at all times to the inlet passage means through the orifice in the first valve piston, a spring disposed at least partly within said chamber and acting against the first piston to bias it towards one end of the first valve bore, a secondary passage in said valve body means connected to said bore at a position intermediate the inlet passage means and the outlet passage and leading to the secondary circuit, the pressure drop across said orifice caused by the flow of fluid from the inlet passage means to the outlet passage through the orifice being effective to move said first piston within said bore against the action of said spring whenever the rate of such flow exceeds a predetermined value, said first piston including means for connecting the inlet passage means to the secondary passage independently of the orifice when the first piston is moved a predetermined distance against said spring by the pressure drop across the orifice, a primary flow passage in said valve body means connecting said second bore to said chamber, a second valve piston mounted for sliding movement within said second bore, spring means in said second bore normally biasing said second piston to a position wherein it blocks flow of inlet fluid from the inlet passage means to the primary flow passage, a passage in said valve body means connecting the outlet passage to the second bore in order to supply fluid pressure acting against said second piston in opposition to said spring means so that increase in pressure of the fluid in the outlet passage above a predetermined level causes said second piston to move within said second bore against said spring means, said second piston including means for connecting said inlet passage means to said primary flow passage when the second piston is moved against the spring means, thereby to deliver fluid from the inlet passage means through the chamber to the outlet passage in parallel with the flow through said orifice, and means in said primary flow passage for restricting the flow therethrough.

2. The apparatus defined by claim 1 wherein the flow restricting means in the primary flow passage comprises a plug detachably secured to the valve body means and having a flow restricting orifice therein.

3. The apparatus defined by claim 1 wherein the flow restricting means in the primary flow passage comprises an adjustable valve element cooperating with a fixed valve element to form an adjustable flow restricting orifice in the primary flow passage, said adjustable element being adjustable from the exterior of the valve body means to vary the size of the latter orifice.

4. Valving for controlling the flow of fluid from a source to a primary circuit and to a secondary circuit, said valving including valve body means having first and second valve bores defined therein, inlet passage means delivering inlet fluid from the source to both of said bores, a first valve piston mounted for reciprocation in said first bore and carrying means defining at least one flow restricting orifice, an outlet passage in said valve body means spaced from the inlet passage means and leading from said chamber to the primary circuit, said outlet passage being connected to the inlet passage means through the orifice in the first valve piston, a spring acting against the first piston to bias it towards one end of the first valve bore, a secondary passage in said valve body means opening to said bore at a position intermediate the inlet passage means and the outlet passage and connected to the secondary circuit, the pressure drop across said orifice caused by the flow of fluid from the inlet passage means to the outlet passage through the orifice being effective to move said first piston within said bore against the action of said spring whenever the rate of such flow exceeds a predetermined value, said first piston including means for connecting the inlet passage means to the secondary passage independently of the orifice when the first piston is moved a predetermined distance against said spring, a primary flow passage in said valve body means connecting said second bore to said outlet passage, a second valve piston mounted for sliding movement within said second bore, spring means in said second bore normally biasing said second piston to a position whenever it blocks flow of inlet fluid from the inlet passage means to the primary flow passage, a passage in said valve body means connecting the outlet passage to the second bore in order to supply fluid pressure acting against said second piston in opposition to said spring means so that increase in pressure of the fluid in the outlet passage above a predetermined level causes said second piston to move within said second bore against said spring means, said second piston including means for connecting said inlet passage means to said primary flow passage when the second piston is moved against the spring means, thereby to deliver fluid from the inlet passage means to the outlet passage in parallel with the flow through said orifice.

5. The valving defined by claim 4 wherein means are provided in said primary flow passage for restricting the fluid flow therethrough.

6. The apparatus defined by claim 5 wherein the flow restricting means in the primary flow passage comprises an adjustable valve element cooperating with a fixed valve element to form an adjustable flow restricting orifice in the primary flow passage, said adjustable element being adjustable from the exterior of the valve body means to vary the size of the latter orifice.

7. The apparatus defined by claim 5 wherein the flow restricting means in the primary flow passage comprises a plug detachably secured to the valve body means and having a flow restricting orifice therein.

8. Valving for controlling the flow of fluid from a source to a primary circuit and to a secondary circuit, said valving including valve body means having first and second valve bores defined therein, inlet passage means delivering inlet fluid from the source to both of said bores, a first valve piston mounted for reciprocation in said first bore and carrying means defining at least one flow restricting orifice, an outlet passage in said valve body means spaced from the inlet passage means and leading from said chamber to the primary circuit, said outlet passage being connected to the inlet passage means through the orifice in the first valve piston, a spring acting against the first piston to bias it towards one end of the first valve bore, a secondary passage in said valve body means opening to said bore at a position intermediate the inlet passage means and the outlet passage and connected to the secondary circuit, the pressure drop across said orifice caused by the flow of fluid from the inlet passage means to the outlet passage through the orifice being effective to move said first piston within said bore against the action of said spring whenever the rate of such flow exceeds a predetermined value, said first piston including means for connecting the inlet passage means to the secondary passage independently of the orifice when the first piston is moved a predetermined distance against said spring, a primary flow passage in said valve body means connecting said second bore to said outlet passage, and a priority valve element mounted for movement within said second bore and normally effective to prevent fluid flow from the inlet passage means to the primary flow passage, said valve element being movable in response to the pressure in said outlet passage to connect said inlet passage means to said primary flow passage.

9. The valving defined by claim 8 wherein means are provided in said primary flow passage for restricting the fluid flow therethrough.

10. The apparatus defined by claim 9 wherein the flow restricting means in the primary flow passage comprises a plug detachably secured to the valve body means and having a flow restricting orifice therein.

11. The apparatus defined by claim 9 wherein the flow restricting means in the primary flow passage comprises an adjustable valve element cooperating with a fixed valve element to form an adjustable flow restricting orifice in the primary flow passage, said adjustable element being adjustable from the exterior of the valve body means to vary the size of the latter orifice.

12. Valving for controlling the flow of fluid from a source to a primary load circuit and to a secondary load circuit, said valving comprising a flow dividing valve receiving inlet fluid from said source and constructed and arranged to continuously supply to said primary circuit a portion of the inlet fluid and automatically operated in response to the continuous flow to divert to said secondary circuit inlet fluid not required by the primary circuit, and means for supplying fluid from the inlet to the primary circuit independently of the flow dividing valve, the last named means including a priority valve having a movable valve element normally effective to prevent said last named means from supplying fluid to the primary circuit, said movable valve element being automatically moved from its normal position in response to an increase in pressure of the fluid delivered to the primary circuit from the flow dividing valve to render the last named means effective to supply inlet fluid to the primary circuit in parallel with the continuous flow to the latter circuit through the flow dividing valve.

13. Valving for controlling the flow of fluid from a source to a primary circuit and to a secondary circuit, said valving comprising a flow dividing valve receiving inlet fluid from said source and constructed and arranged to supply continuously to said primary circuit a portion of the inlet fluid and operated in response to the continuous flow of fluid to the primary circuit to divert to said secondary circuit inlet fluid not required by the primary circuit, and means for supplying fluid from the inlet to the primary circuit independently of the flow dividing valve, the last named means including a priority valve normally effective to prevent said last named means from supplying fluid to the primary circuit and operated in response to pressure of the fluid delivered continuously to the primary circuit from the flow dividing valve to render the last named means effective to supply inlet fluid to the primary circuit in parallel with the continuous flow through said flow dividing valve.

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