Jan. 14, 1969 R. R. DAVIDSON 3,421,532

FLOW DIVIDER

Filed Oct. 14, 1964 Sheet 1 of 2

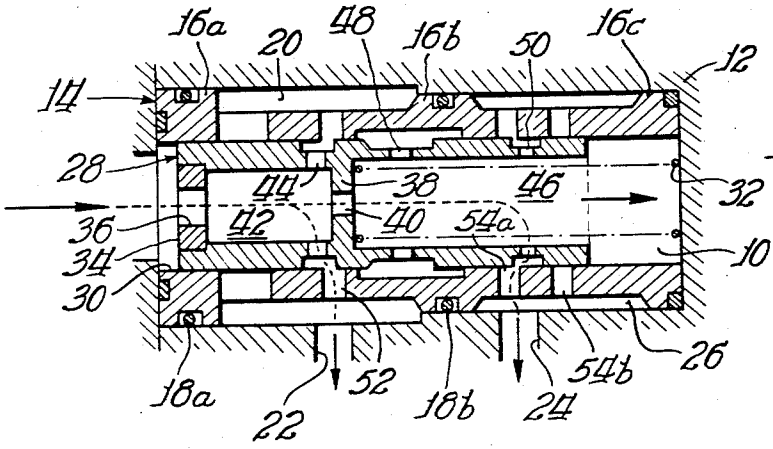


Fig. 1

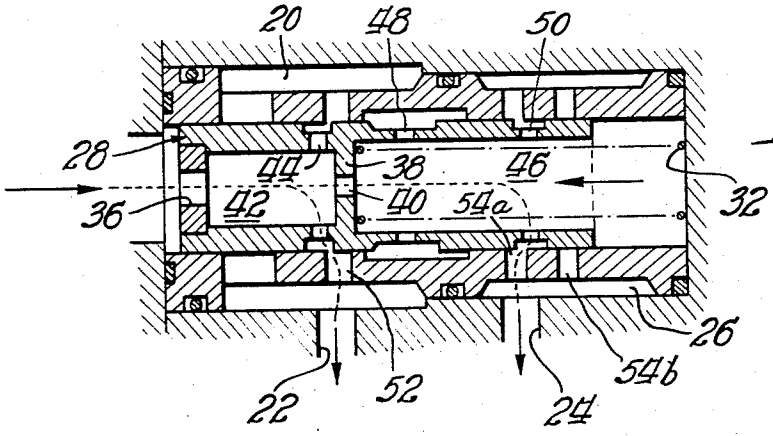


Fig. 2

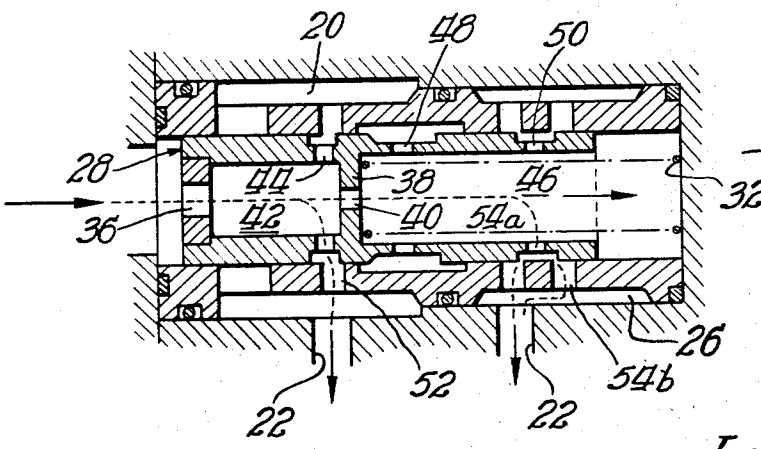


Fig. 3

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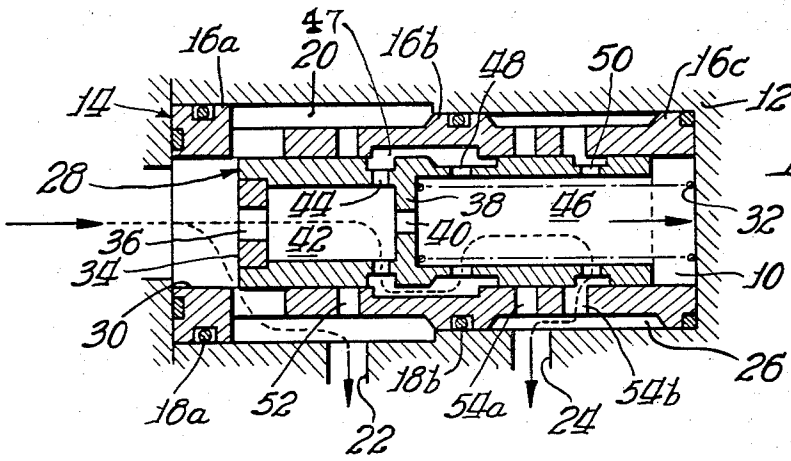


Fig. 4

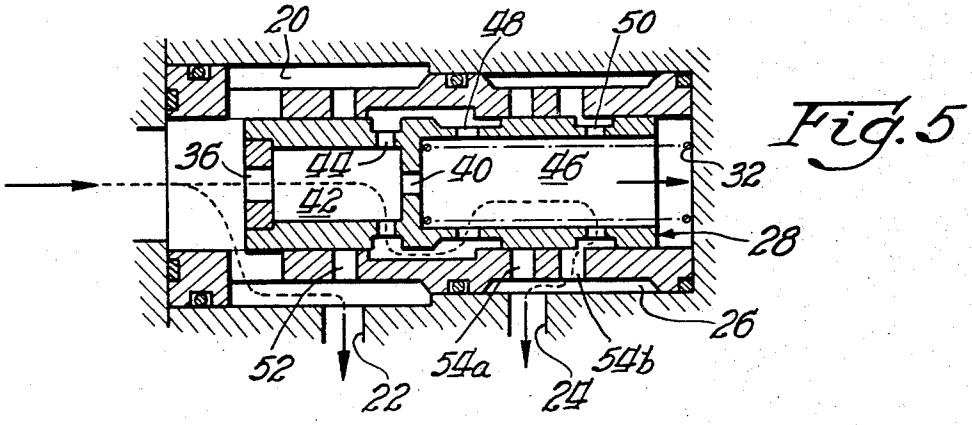


Fig. 5

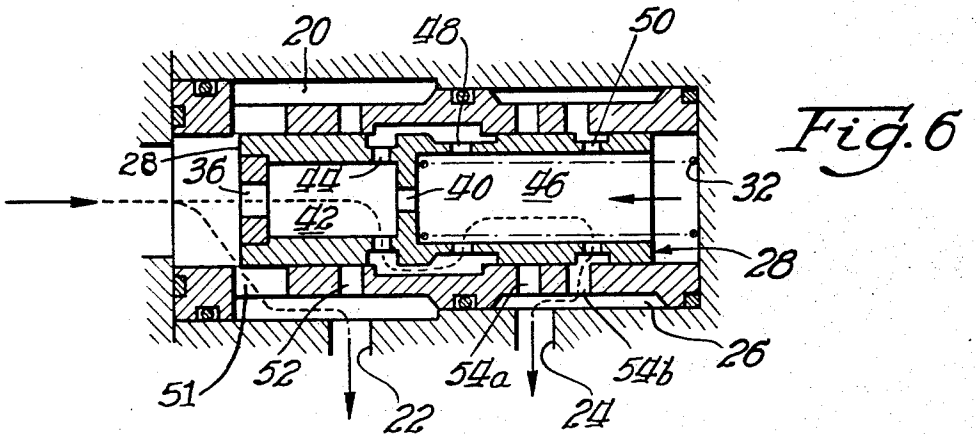


Fig. 6

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FLOW DIVIDER

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Int. Cl. G05d 11/03; F17d 3/00; F01b 25/02

ABSTRACT OF THE DISCLOSURE

A flow divider mechanism having a housing including a bore with a shuttle piston reciprocally mounted with respect to the housing wherein the piston includes two chambers serially in communication with the inlet to the housing and each of which includes a port direct to primary and secondary fluid circuits, respectively, the combination being further characterized as having a flow responsive bypass means interposed between the piston and the housing.

This invention relates to a multiple stage flow divider mechanism and, more particularly, to a multiple stage flow divider mechanism having associated therewith a primary and a secondary circuit.

Briefly described, a piston and a cylinder, together with a plurality of ports and a plurality of orifices associated therewith provide a means to divide the flow of fluid from a source of fluid under pressure such as, for example, the output flow from a pump. The flow divider mechanism includes a primary circuit which is a priority flow circuit and a secondary circuit which is an excess flow circuit.

During the first stage of operation, the primary circuit has priority over the secondary circuit and thus, as the flow of fluid to the divider mechanism increases up to the capacity of the primary circuit, all of the fluid passes through the primary circuit. As the flow increases above the capacity of the primary circuit and up to the capacity necessary to switch the divider mechanism into the second stage of operation, all of the additional fluid passes through the secondary circuit. During the second stage of operation, the primary circuit remains effective to function as a priority circuit and the secondary circuit continues to act as an excess flow circuit.

An important feature of the flow divider mechanism is that during operation of the flow divider mechanism, the primary and secondary circuits function independently of each other. During both stages of the operation of the flow divider mechanism, either one or both of the circuits can be subjected to back pressure without adversely affecting the performance of the other circuit.

Other, and more particular, objects and advantages of this invention will be apparent from the following description, taken in connection with the annexed drawings, in which:

FIGURE 1 is a cross-sectional view of the flow divider mechanism illustrating the relative position of the piston in the housing under one set of flow conditions;

FIGURE 2 is a cross-sectional view of the flow divider mechanism illustrating the relative position of the piston in the housing under another set of flow conditions;

FIGURE 3 is a cross-sectional view of the flow divider mechanism illustrating the relative position of the piston in the housing under another set of flow conditions;

FIGURE 4 is a cross-sectional view of the flow divider mechanism illustrating the relative position of the piston in the housing under another set of flow conditions;

FIGURE 5 is a cross-sectional view of the flow divider mechanism illustrating the relative position of the piston in the housing under another set of flow conditions; and

FIGURE 6 is a cross-sectional view of the flow divider mechanism illustrating the relative position of the piston in the housing under still another set of flow conditions.

Referring to the drawing and, more particularly, FIGURE 1, a fluid passage **10** is formed within a body **12**. A housing **14** having spaced apart lands **16***a*, **16***b* and **16***c* is positioned within the body **12**. Seal means **18***a* and **18***b* extend in lands **16***a* and **16***b* respectively to provide a fluid-tight fit between the lands **16***a* and **16***b* and the body **12** to provide an annular secondary circuit chamber **20** between the housing **14** and the body **12**. A secondary circuit passageway **22** provides a means to remove fluid from the annular chamber **20**. A primary circuit passage **24** is in fluid communication with the annular primary circuit chamber **26** which is formed between the housing **14** and the body **12** between lands **16***b* and **16***c*. A piston **28** is slidably positioned within bore **30**. A resilient member **32** is positioned, for example, between the body **12** and the piston **28** to bias the piston **28** to the left with respect to the housing **14** as viewed in FIGURE 1.

The piston **28** includes an end **34** having a first orifice **36** formed therein. The piston includes an inner wall **38** having a second orifice **40** formed therein. The end portion **34** and inner wall **38** together with the wall of the piston **28** form a first chamber **42** in one end of the piston **28**. A plurality of secondary piston ports **44** provide communication between chamber **42** and bore **30** of the housing **14**.

The portion of the piston to the right of the inner wall **38**, together with the bore **30** of the housing member **14**, forms a second chamber **46**. A first series of ports **48** provides communication between the second chamber **46** and the bore **30** of the housing **14**. A second series of ports **50** axially spaced from the first series of ports provides communication between the second chamber and the bore **30** of the housing **14**. The housing **14** includes ports **52** which provide communication between bore **30** and the annular chamber **20**. A housing **14** also includes ports **54***a* and **54***b* which provide communication between bore **30** and annular chamber **26**.

In operation, the resilient member **32** provides an initial bias to position the piston **28** adjacent the left end of the bore **30** which is formed in the housing **14**. The operation of the flow divider mechanism will be explained in stepped increments of flow conditions.

Step 1 of Stage 1

This flow condition is from initial flow rate to a flow rate equal to the capacity of the primary circuit under Stage 1 operation. As an initial fluid flow rate is established in the passage **10**, the fluid flows through the orifice **36** located in the end portion **34** of the piston **28**. This initial quantity of fluid passes from chamber **42** through orifice **40** into the second chamber **46** out port **50** in piston **28**, through port **54***a* in housing **14** into annular chamber **26** and thence into the primary circuit passage **24**. Under this set of flow rate conditions, the ports **44** in piston **28** are not aligned with ports **52** in housing **14** and thus all of the fluid passes from passage **10** into the primary circuit.

Step 2 of Stage 1

This flow condition is from a rate above the capacity of the primary circuit to a rate equal to the rate which initiates Stage 2 operation. This step further includes a condition wherein the back pressure, or operating pressure, in the secondary circuit is maintained at a value in excess of the pressure of the fluid in the primary circuit.

As the fluid rate is increased to a value in excess of the capacity of the primary circuit, the fluid flowing through orifice **40** creates a pressure differential thereacross. This differential is of a sufficient magnitude to overcome the resiliency of spring **32**. This, in turn, causes the piston **28** to shift to the right with respect to the housing **14**.

Under this set of flow conditions (see FIGURE 1), the ports **50** in piston **28** are aligned with ports **54***a* in housing **14** and the ports **44** in piston **28** are aligned with ports **52** in the housing **14**. Thus, a portion of the fluid passes from chamber **46** through ports **50**, ports **54***a* into chamber **26**, and thence into the primary circuit passage **24** and the remaining portion passes from chamber **42** through ports **44**, ports **52** into chamber **20**, and thence into the secondary circuit passage **22**. The fluid flowing through orifice **36**, under these conditions, does not create a pressure differential of sufficient magnitude to influence the position of the piston **28**. The controlling orifice under this set of flow conditions is orifice **40**. Metering of fluid to the primary circuit is achieved, in part, by the relative positions of the ports **50** in the piston **28** and the ports **54***a* in the housing **14**. These ports establish and maintain a substantially constant pressure drop thereacross and thus maintain a substantially constant quantity of flow to the primary circuit. All flow in excess of the flow to the primary circuit is diverted to the secondary circuit.

Step 3 of Stage 1

The flow rate for this step is within the same limits as Step 2 of Stage 1; however, the back pressure, or operating pressure, in the primary circuit is at a value in excess of the operating pressure in the secondary circuit (see FIGURE 2).

Under this set of conditions, the orifice **40** and the pressure differential associated therewith is effective to shift the piston **28** against the action of the resilient member **32**, to the right with respect to housing **14**. Metering of the fluid to the primary circuit is accomplished, in part, by the relative positions of the ports **44** and **52** which establish a substantially constant pressure drop thereacross. This pressure drop results in a substantially constant quantity of fluid being diverted to the primary circuit with the exces fluid being directed to the secondary circuit.

Transition from Stage 1 to Stage 2

As the flow rate exceeds the upper limit of Stage 1, mentioned hereinabove, the orifice **36** becomes the controlling orifice. The pressure differential created across orifice **36** tends to shift the piston **28** with respect to the housing **14** to a new control position as illustrated in FIGURES 3 and 4. As the piston **28** tends to complete its movement with respect to the housing **14** into the second stage control position (FIGURE 4), the ports **44** become aligned with the intermediate chamber **47** which chamber **47** is in communication with ports **48**. This flow path, i.e., from chamber **42** through ports **44**, into chamber **47**, and thence to chamber **46** by way of ports **48** functions as a bypass which is in parallel wtih orifice **40**. The effect of the aforementioned bypass is to increase the capacity of the primary circuit.

Step 1 of Stage 2

The flow rate condition for this step is above the maximum Stage 1 rate with the back pressure, or operating pressure, in the secondary circuit maintained at a pressure above the operating pressure of the primary circuit (FIGURE 5). Under this set of conditions, the fluid flowing through the orifice **40** and the bypass means (ports **44**, chamber **47** and ports **48**) is effective to shift the piston **28** against the action of the resilient member **32** to the right with respect to the housing **14** as illustrated in FIGURE 5. Metering of the fluid to the primary circuit is accomplished, in part, by the relative position of ports **50** and **54***b* which function to establish a substantially constant pressure drop thereacross. This results in a substantially constant quantity of fluid being diverted to the primary circuit with the excess fluid being directed to the secondary circuit.

Step 2 of Stage 2

The flow rate for this step is within the same limits as Step 1 of Stage 2 hereinabove set forth; however, the back pressure or operating pressure in the primary circuit is maintained above the operating pressure of the secondary circuit. Under this set of conditions, the fluid flowing through the orifice **40** and the bypass means is effective to shift the piston **28** against the action of the resilient member **32** to the right with respect to the housing **14** (FIGURE 6). Metering of the fluid to the primary circuit is accomplished, in part, by the relative position of the end of the piston **28** with respect to the passage **51** in the housing **14** (see FIGURE 6). Thus, a substantially constant quantity of fluid is directed to the primary circuit with the remaining quantity being diverted to the secondary circuit.

The foregoing description of a preferred embodiment of the invention has been shown and described for the purpose of illustrating the principles of the invention and is subject to change without departure from the spirit and the intent of the invention. The invention is to be limited only by the scope of the following claims.

What is claimed is:

1. A flow divider mechanism comprising a housing having a bore therein, an inlet passage in communication with said bore, housing primary port means in said housing, housing secondary port means in said housing, a piston having a first chamber and having a second chamber, said piston being slidably positioned within said bore, a first orifice providing communication between said bore and said first chamber, a second orifice providing communication between said first chamber and said second chamber, piston primary port means in said second chamber operatively associated with said housing primary port means, piston secondary port means in said first chamber operatively associated with said housing secondary port means, bypass flow means responsive to the position of the piston with respect to said housing to allow passage of fluid between said first chamber and said second chamber, and means to bias said piston with respect to said housing.

2. A flow divider mechanism comprising a housing having a bore therein, an inlet passage in communication with said bore, housing primary port means in said housing, housing secondary port means in said housing, a piston having a first chamber and having a second chamber, said piston being slidably positioned within said bore, a first orifice providing communication between said bore and said first chamber, a second orifice providing communication between said first chamber and said second chamber, piston primary port means in said second chamber operatively associated with said housing primary port means, piston secondary port means in said first chamber operatively associated with said housing secondary port means, flow sensitive bypass flow means effective in response to the position of said piston with respect to said housing to permit fluid to flow from said first chamber to said second chamber, and means to bias said piston with respect to said housing.

3. A flow divider mechanism comprising a housing having a bore therein, a piston slidably positioned within the bore, said housing including an inlet passage, a primary circuit passage and a secondary circuit passage, a flow path between said inlet passage and said primary and secondary circuit passages including primary circuit ports, and secondary circuit ports, defined by said piston and said housing in combination, a pair of spaced apart orifice means in said piston arranged with the first of said orifice means disposed intermediate said inlet passage and said secondary circuit ports and the second of said orifice means disposed intermediate said first orifice means and said primary circuit ports, said housing and said piston in combination further defining by-pass flow means disposed intermediate said primary circuit ports and said

secondary circuit ports sensitive to flow into said inlet passage to by-pass said second of said orifice means in response to a predetermined flow and means to provide an initial bias to shift said piston in a first direction with respect to said housing.

4. A flow divider mechanism comprising a housing having a bore therein, a piston reciprocally positioned within said bore, said housing including an inlet passage, a primary circuit passage, and a secondary circuit passage, a flow path between said inlet passage and said primary and secondary circuit passages including primary circuit ports, and secondary circuit ports, formed by said housing and piston in combination, said piston including a first chamber and a second chamber, and a first orifice and a second orifice, said first chamber being in communication with said second chamber through said second orifice, and in communication with said primary circuit passage through said primary circuit ports, said second chamber being in communication with said inlet passage through said first orifice and communicating with said secondary circuit passage through said secondary circuit ports, said housing and said piston in combination further defining by-pass flow means disposed intermediate said primary circuit ports and said secondary circuit ports sensitive to flow into said inlet passage to by-pass said second of said orifices in response to a predetermined flow and resilient means to bias said piston with respect to said housing.

5. A flow divider mechanism comprising a housing having a bore therein, a piston reciprocally positioned in said bore, said housing including an inlet passage, a primary circuit passage, a secondary circuit passage, a flow path between said inlet passage and said primary and secondary circuit passages including first ports in said housing communicating with said primary circuit passage and second ports in said housing communicating with said secondary circuit passage, a first orifice in said piston intermediate said inlet passage and said secondary circuit passage, a second orifice in said piston intermediate said first orifice and said primary circuit passage, first ports in said piston adapted to communicate with said first ports of said housing and second ports in said piston adapted to communicate with said second ports of said housing, and by-pass flow means responsive to the position of said piston with respect to said housing to allow flow of fluid from said inlet passage to said secondary circuit passage, said piston being shiftable with respect to said housing in a first stage of operation to align said ports in said piston and said ports in said housing to establish a first predetermined flow into said primary circuit passage, with the excess above said first predetermined flow flowing to said secondary circuit passage through said second ports and further being shiftable in a second stage of operation to align said ports in said piston and said ports in said housing to establish a second predetermined flow into said primary

circuit passage with the excess above said predetermined flow flowing into said secondary circuit passage, resilient means to bias said piston with respect to said housing.

6. A flow divider mechanism comprising a housing having a bore therein, a piston reciprocally positioned in said bore, said housing including an inlet passage, a primary circuit passage, a secondary circuit passage, a flow path between said inlet passage and said primary and secondary circuit passages including, first ports in said housing communicating with said primary circuit passage, and second ports in said housing communicating with said secondary circuit passage, a first chamber, a second chamber, a first orifice, a second orifice, each formed in said piston, first ports in said piston adapted to communicate with said first ports of said housing and second ports in said piston adapted to communicate with said second ports of said housing, said first chamber being in communication with said second chamber through said second orifice and communicating with said primary circuit passage through said first ports, said second chamber being in communication with said inlet passage through said first orifice and communicating with said secondary circuit passage through said second ports, and by-pass flow means responsive to the position of said piston with respect to said housing including means to allow flow of fluid to by-pass said second orifice and further means to allow flow of fluid from said inlet passage to said secondary circuit passage in response to predetermined flow, said piston being shiftable with respect to said housing in a first stage of operation to align said first ports in said piston with said first ports of said housing to establish a first predetermined flow into said primary circuit passage and to align said second ports of said piston with said second ports of said housing to allow excess flow above said first predetermined flow to flow to said secondary circuit passage and further being shiftable in a second stage of operation to align said first ports of said piston with said first ports in said housing to establish a second predetermined flow to said primary circuit passage and to align said second ports of said piston with said second ports of said housing to allow excess flow above said second predetermined flow to flow to said secondary circuit passage, resilient means to bias said piston with respect to said housing.

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91—6, 412; 60—52