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Hassall

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[54] **HYDRAULIC CONTROL VALVES**

[75] Inventor: **Donald Hassall,** Sunderland, England

[73] Assignee: **Coles Cranes Limited,** Grams: Britcranex, Sunderland, England

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[52] **U.S. Cl.**..... **137/491,** 137/625.3, 137/625.37

[51] **Int. Cl.**..... **F16k 31/36**

[58] **Field of Search**..... 137/489, 491, 488, 137/495, 625.3, 625.37; 251/205, 210

[56] **References Cited**

UNITED STATES PATENTS

2,918,087	12/1959	Curran	137/625.3
3,401,605	9/1968	Born	137/491 X
3,595,264	7/1971	Martin	137/495 X
1,712,245	5/1929	Blyston	137/625.37 X
1,802,897	4/1931	Holden et al.	251/210
1,111,244	9/1914	Wilson	137/625.37 X
2,810,259	10/1957	Burdett	137/625.37 X
2,835,266	5/1958	Morte	137/491 UX
3,578,019	5/1971	Turolla	137/491

FOREIGN PATENTS OR APPLICATIONS

399,217	7/1924	Germany	137/625.3
74,653	2/1949	Norway	251/205

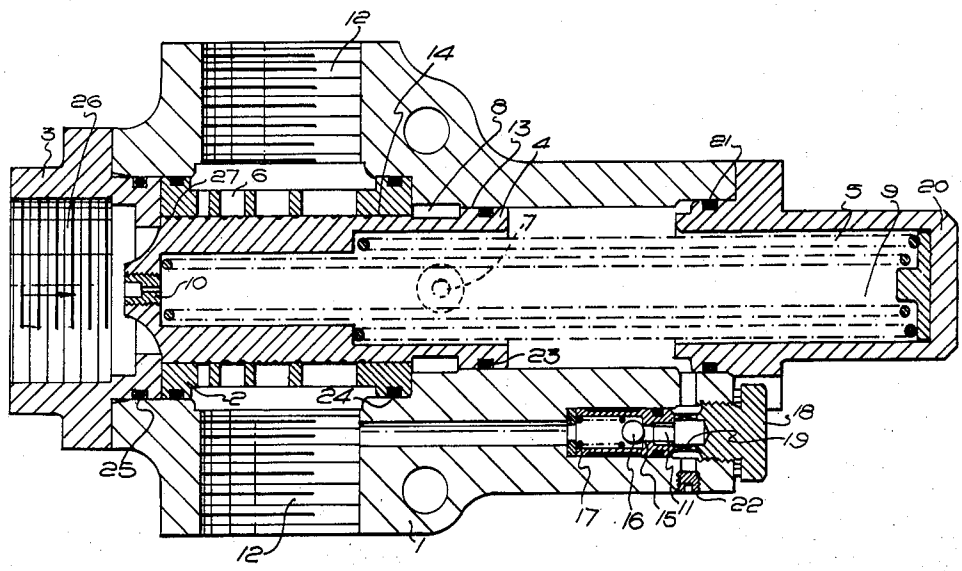
Primary Examiner—Henry T. Klinksiek

Attorney—Sughrue, Rothwell, Mion, Zinn & Macpeak

[57] **ABSTRACT**

An hydraulic control valve has a main body member with feed connections for respective communication with an actuator and a main control valve, the feed connections communicating internally of the body via flow orifice(s) whose effective flow area is governed by a relatively movable control member actuable in response to variation of a pilot pressure and being movable between a fully closed and fully open conditions of the flow orifice(s), the arrangement being such that the rate of increase in effective flow area increases with increased movement of the control member towards the fully open condition of the flow orifices. A spool control member may be slidable in a sleeve and both may be surrounded by an annular feed chamber communicating with a feed connection.

6 Claims, 4 Drawing Figures



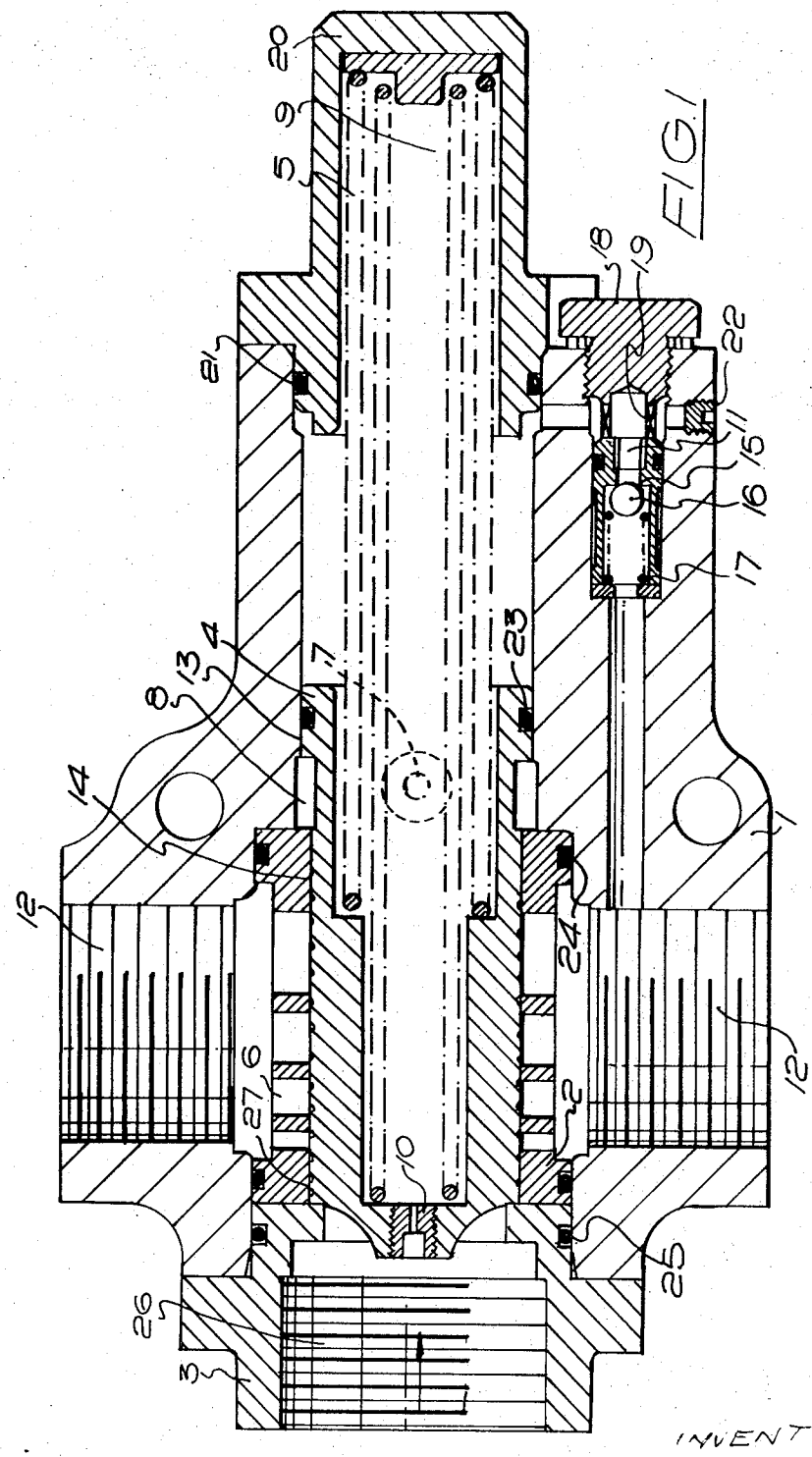


FIG. 1

INVENTOR
DONALD HASSALL
3rd Sughrue, Rothwell, Mion,
Zinn & Macpeak
ATTORNEYS

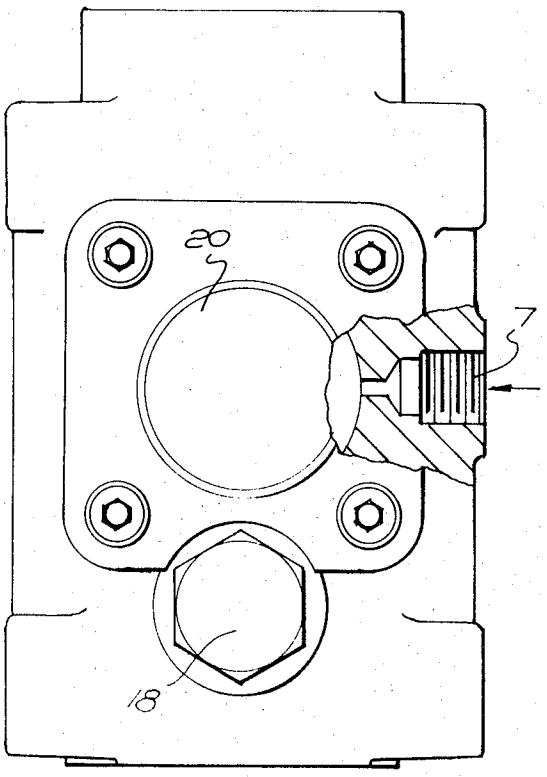


FIG. 2

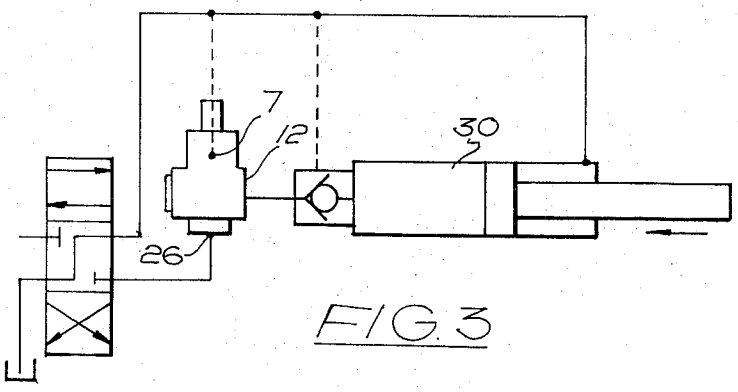


FIG. 3

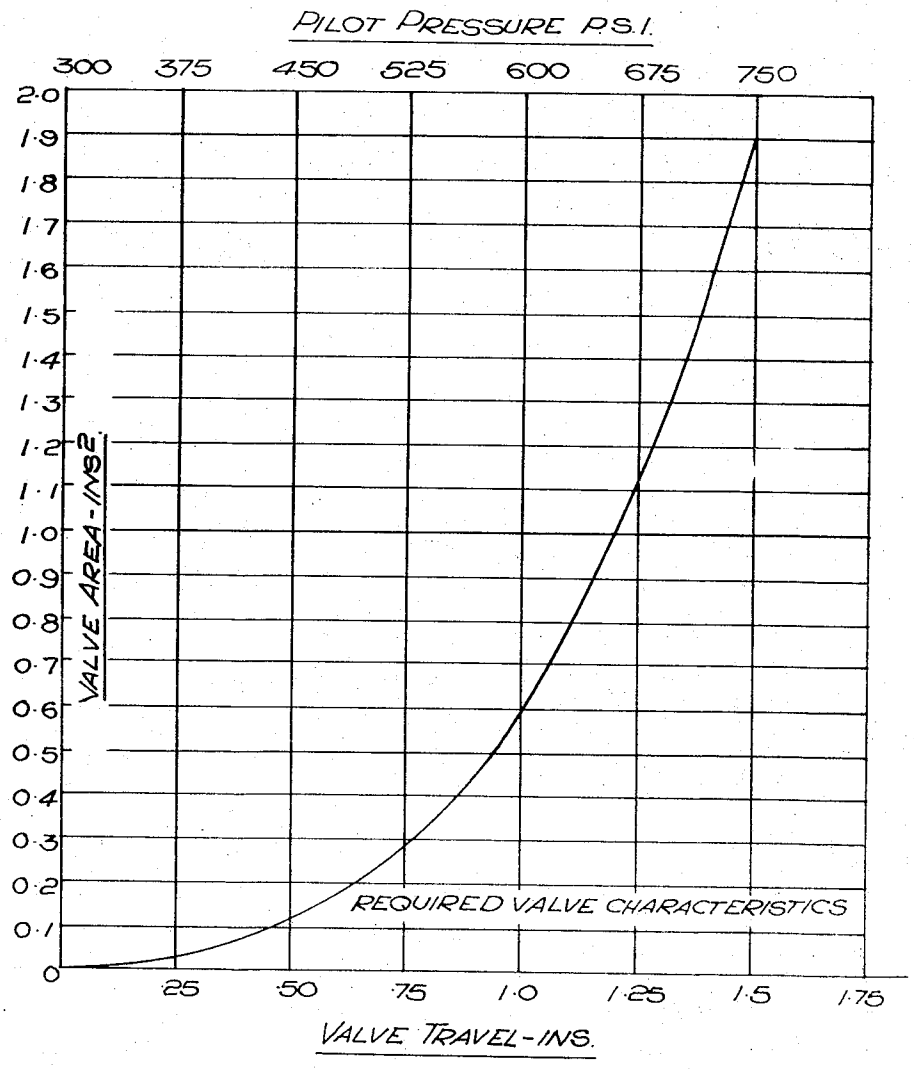

PILOT PRESSURE P.S.I.
300
375
450
525
600
675
750
2·0
1·9
1·8
1·7
1·6
1·5
1·4
1·3
1·2
1·1
1·0
0·9
0·8
0·7
0·6
0·5
0·4
0·3
0·2
0·1
0
VALVE AREA-INS2
REQUIRED VALVE CHARACTERISTICS
·25
·50
·75
1·0
1·25
1·5
1·75
VALVE TRAVEL-INS.

FIG. 4

HYDRAULIC CONTROL VALVES

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to hydraulic control valves.

2. Description of the Prior Art

When controlling hydraulic actuators with a following load it is usual to include a braking valve to prevent running away of the actuator under the influence of the load. The braking valve can be in the form of a relief or counterbalance valve situated in the return feed line from the actuator and can be either direct-operated or piloted from a remote source.

Direct-operated relief or counterbalance valves suffer from the disadvantage that they have to be set to a sufficiently high pressure to prevent running away of the actuator under conditions of maximum load which, in turn, results in high pressures required to drive an unloaded actuator.

Remote piloted counterbalance valves, for safety reasons, are usually piloted from the feed line to the actuator in the relevant direction of movement. This ensures that a pressure is always required to drive the actuator in the direction of the load and removal of this pilot pressure would prevent actuation. The pilot pressure can be a small compared with the pressure generated by the load and depends on the design of the valve. Frequently means are also provided whereby the pilot pressure required may be automatically increased or decreased with the magnitude of the following load to suit a particular application.

For certain applications, such as on cantilevered jib crane derrick cylinders, safety requirements dictate that the pilot pressure to a counterbalance valve situated in a feed line is taken from the opposite feed line, as indicated above, such that loss of pressure would prevent the load from running away.

One of the disadvantages of this arrangement is that when the valve is being controlled in the manner described above, the build up of the pilot pressure required to open the valve suddenly drops as the actuator commences moving under the application of the load; this causes the valve to close until pressure again builds up to release it. This opening and closing of the counterbalance valve is commonly termed "hunting" and means are sometimes incorporated into the valve to minimise this phenomena, for example by providing a restricting orifice for damping of the pilot piston movement.

Also certain applications require valves capable of accepting substantial fluid flows and yet still be capable of accurately controlling very small flows without hunting.

It is when controlling small flows that the problem is greatest, as movement of the pilot piston is quite small and the flow to and from this piston is also small, making damping of the movement difficult.

SUMMARY OF THE INVENTION

The object of the present invention is to provide a pilot operated valve for controlling flow from an actuator with following load, such as on crane derricking, hoisting and telescoping motions, whereby the main valve is piloted open and is constructed generally to minimize the aforesaid problem.

An hydraulic control valve according to the present invention comprises a main body member having a first feed connection for communication with an actuator and a second feed connector for communication with a main control valve, said first and second feed connections communicating internally of the body member via at least one flow orifice whose effective flow area is governed by a relatively movable control member actuable in response to variation of a pilot pressure, said control member being movable between a fully closed and a fully open condition of the flow orifice(s) and the arrangement being such that the rate of increase in effective flow area increases with increased movement of the control member towards the fully open condition of the flow orifice(s).

The control member may consist of a spool sliding within a sleeve. The spool is normally biassed to its closed position under the action of a spring and controlling flow orifices are situated in the sleeve, the design of which is such that a substantial part of the total spool movement relative to the sleeve is required for small controlled flows through the vlave whilst still permitting large flows without excessive spool movement. The valve is arranged such that the rate of increase in the area of the flow passage revealed by the spool movement is small during initial spool movement and increases with increased spool movement. Flow orifice area can be arranged to increase with valve movement such that it follows a square or cube rule or any desired characteristic.

The effective flow area of the flow orifices is controlled by the form of drilled holes and/or shaped ports in the sleeve, progressively increasing in size as they are uncovered by the spool. It is also or alternatively possible to arrange the holes or ports in the spool if so required.

A portion of increased diameter may be provided at one end of the spool control member, said portion defining an annular chamber extending around the control member within the main body of the valve and a pilot feed connection provided in the main body member communicating with said annular chamber.

This large initial spool movement required to reveal a comparatively small flow area makes it easier to damp out the tendency to hunt. The damping orifice can either be in the pilot feed line or situated such that the fluid behind the valve is forced through it on opening.

The spool control member and the sleeve may be surrounded by an annular feed chamber in the main body of the valve, one of said first and second feed connections communicating with said annular feed chamber and the other communicating with the spool control member.

A further requirement of this type of valve frequently is the provision of free flow in the opposite direction. This is sometimes achieved using a separate bypass valve, but it is difficult to accommodate this within known valve constructions and yet maintain low pressure loss within compact dimentions. With the valve disclosed in this invention, it is possible to arrange for the main valve to be opened wide through the action of a small one way valve which opens in the free flow direction. The interior of the main body and the spool may define a bypass chamber which is connected through a one-way valve with the feed chamber, the one way valve closing passage of fluid from the feed chamber to the bypass chamber.

The damping orifice may be provided in the bore of the spool.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is an axial section through a valve in accordance with the invention;

FIG. 2 is an end view of the valve, partly in section;

FIG. 3 is a circuit diagram illustrating an example of the use of a valve according to the invention; and

FIG. 4 is a graph showing an example of valve characteristics obtainable with a valve in accordance with the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The main body of the valve contains a main feed connection **12** from an actuator, also a feed connection **26** to the main circuit control valve. A sleeve **2** is held in a body **1** by an end cap **3**, with a control member in the form of a spool **4** constrained to slide within the sleeve **2**, the spool being biassed into a closed position by a spring **5** and the spool and the sleeve being surrounded by an annular feed chamber from feed connector **12**. Controlling flow orifices **6**, contained in the sleeve **2**, are arranged such that rate of increase in area uncovered by the spool is small initially and increases with spool movement towards a fully open position. The diameters of the spool **4** are arranged so that diameter **13** is greater than **14** providing an annular chamber **8** for actuation by pilot pressure from a port **7**.

A small one way valve **11** comprises a seat **15** normally closed by a ball or poppet **16** and a spring **17**. This one way valve assembly is held in position by a plug **18**. Passages **19** allow flow of oil from a bypass chamber **9** inside the body **1** to pass through the one way valve **11** to the feed connection **12** whilst the one way valve prevents flow in the reverse direction.

An end cap **20** and a seal **21** prevent fluid from escaping to atmosphere, the end cap **20** also acting as a location for a spring **5**. A plug **22** is provided for sealing from atmosphere the passage-way between the chamber **9** and the one way valve **11**. The chamber **9** is sealed at one end by a seal **23** and at the other end by the seal **21** in the end cap **20**.

The annular chamber **8** is sealed at one end by the seal **23** in the spool **4** and at the other end by a close fit of diameter **14** in sleeve **2**. A seal **24** prevents leakage from the annular chamber **8** to the feed connection **12** while a seal **25** prevents leakage from the feed connections **12** and **26** to atmosphere. Leakage from the feed connection **12** to feed connection **26** is prevented by the close fit of spool **4** in sleeve **2** at **27**.

Operation of the valve is as follows:

Control Direction

The valve is connected generally as shown in FIG. **3** to an actuator which can be in the form of an hydraulic ram **30** or motor or any other device where the control of speed of a following load is by restriction of the fluid passing out of the actuator.

The pressure generated by the load is transmitted from the actuator to the feed connector **12** and is prevented from escaping by virtue of the controlling flow orifices **6** being covered by spool **4**. When it is required to move the actuator in the direction of the applied external load, pressure is applied to the top side of the actuator tending to assist the load, at the same time pressure is fed to the pilot connection **7** and thence to the annular chamber **8**. This pressure acts on the spool **4** tending to move it against the action of spring **5**.

As the spool moves it progressively uncovers orifices **6** in sleeve **2** allowing flow of fluid to take place from the feed connection **12** to the feed connection **26** and thence to the control valve. The orifices **6** in sleeve **2** are arranged to give the desired feature of a small increase in area for considerable initial spool movement.

The braking pressure in the feed connection **12** also acts on the poppet or ball **16** of the one way valve **11** to hold the valve closed. Therefore, when the spool **4** moves to the open position, fluid trapped behind the spool in chamber **9** has to pass through a damping orifice **10** which is sized to give the required response time and damping characteristic.

In the construction shown, the pilot pressure acts on the differential area between the diameters **13** and **14** of the spool **4** but it will be appreciated that the piloting could be in the form of a separate pilot piston acting on the main spool **4**.

The pilot pressure can be arranged to suit a particular application by varying the pilot chamber area **8** and/or the strength of spring **5**.

If pilot-operated lock valves are included in the circuit, they are usually positioned between the actuator and the braking valve and arrangements would then normally be made to pilot the brake valve open at a pressure higher than that to pilot the lock valves, thus keeping control of the load on the braking valve.

Reverse or Free Flow Direction

When operating the valve in the reverse direction, low pressure in the feed connection **26** passes through the damping orifice **10** and thence through the one way valve **11**. In this case the one way valve must open as the pressure in the feed connection **26** must of necessity be slightly higher than in the feed connection **12**. The flow through the damping orifice **10** results in a pressure drop across the orifice which acts on the full area of spool **4** moving the spool fully open against the action of spring **5**. As the ratio of areas of the spool **4** and pilot chamber **8** is usually large, the pressure required to overcome spring **5** in the free flow direction will be small compared with the pilot pressure required to open the valve in the controlled direction.

When the pressure in the feed connections **12** and **26** is high, for example when there is a heavy load on the actuator, this pressure load acts on the chamber **8** in the direction tending to add to the load from spring **5**, thus increasing the pressure difference required between feed connections **26** and **12** to open the valve in the free flow direction. This increase in pressure difference can be overcome by arranging a conduit between the pilot connection **7** and the feed connection **26**, including a one-way valve which opens in the direction towards the pilot connection **7**. A restricting orifice is provided in the line to pilot connection **7** on the pilots control side of the connection with said conduit, in order to build up pressure from the feed connection **26** for the free flow condition.

The embodiments in which an exclusive property or privilege as claimed are defined as follows:

1. A hydraulic control valve assembly, comprising:

a. a main body member having a first feed connector for communication with an actuator, and a second feed connector for communication with a main control valve,

b. a spool slidable longitudinally with respect to said second feed connector,

c. a chamber bounded on one side by the spool, cooperative sliding surfaces of the spool and body member extending on opposed sides of said chamber,

d. said first and second feed connectors communicating internally of the body member via at least one orifice flow means whose effective flow area is governed by movement of said spool in response to variation of a pilot pressure in said chamber,

e. said spool being movably between a fully closed and a fully open position with respect to the orifice flow means such that the rate of increase in effective flow area increases with increased movement of the spool towards the fully opened position, and

f. biasing means for urging said spool into the closed position, a portion of increased diameter being provided at one end of the spool, said portion defining an annular chamber extending around the spool within the main body of the valve and a pilot feed connector being provided in the main body member communicating with said annular chamber.

2. A hydraulic control valve as claimed in claim **1** in which a sleeve is carried in the body member, the spool being slidable in the sleeve, the orifice flow means are provided in the sleeve and progressively increase in size in the direction in which they are uncovered by the spool, and the spool and the sleeve are surrounded by an annular feed chamber in the body of the valve, the bore of the spool being provided with a dampening orifice, a bypass chamber defined by the interior of the main body and the spool and being connected through a one way valve with the first feed connector, the one way valve closing the passage of fluid from the first feed connector to the bypass chamber.

3. An hydraulic control valve as claimed in claim **1** in which a sleeve is carried in the body member, the spool being slidable in the sleeve, the spool and the sleeve are surrounded by an annular feed chamber in the main body of the valve, said first feed connector communicating with said annular feed chamber and said second feed connector communicating with the spool.

4. An hydraulic control valve as claimed in claim **3** in which the bore of the spool is provided with a damping orifice.

5. An hydraulic control valve as claimed in claim **4** in which the interior of the main body and the spool define a bypass chamber which is connected through a one-way valve with the first feed connector, the one way valve closing passage of fluid from the first feed connector to the bypass chamber.

6. An hydraulic control valve as claimed in claim **3** in which the orifice flow means are provided in the sleeve.

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