Aug. 3, 1965 J. A. JUNCK ETAL 3,198,212

METERING SLOT CONFIGURATION FOR HYDRAULIC CONTROL VALVES

Filed May 22, 1963

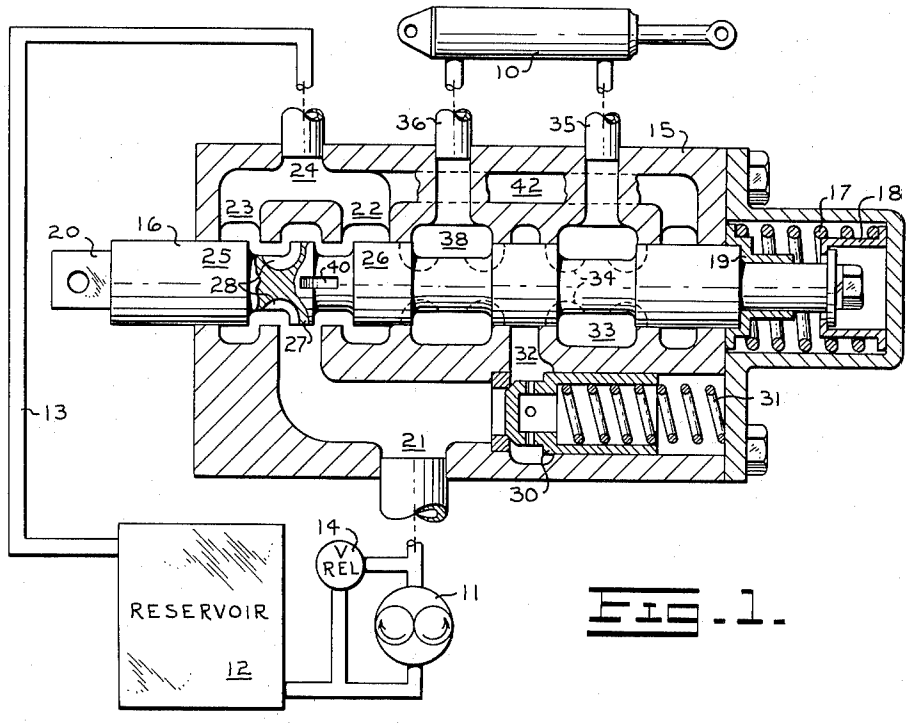

FIG. 1.

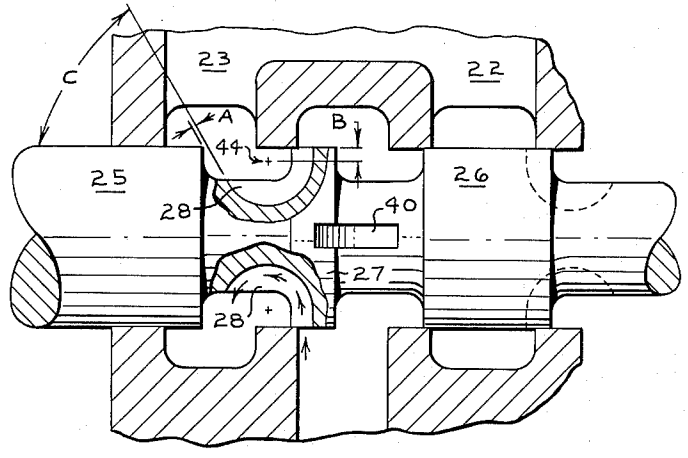

FIG. 2.

INVENTORS.
JOHN A. JUNCK
BY JAMES E. SCHEIDT
Fryer and Timmerd
ATTORNEYS

United States Patent Office 3,198,212
Patented Aug. 3, 1965

3,198,212

METERING SLOT CONFIGURATION FOR HYDRAULIC CONTROL VALVES

John A. Junck and James E. Scheidt, Joliet, Ill., assignors to Caterpillar Tractor Co., Peoria, Ill., a corporation of California

Filed May 22, 1963, Ser. No. 282,418
5 Claims. (Cl. 137—625.37)

This invention relates to hydraulic control valves and particularly to hydraulic control valves of the kind shown in our assignee's Patent No. 2,971,536 in which throttling or metering slots are employed and the invention is particularly concerned with the configuration of metering slots to insure easy operation of a valve unimpeded by reaction forces of fluid under high pressure passing through the slots.

As pointed out in the patent referred to above, many forms of hydraulic control valves include a shouldered spool reciprocable in a ported cylinder. As the spool is reciprocated in the cylinder, selected ports are opened and closed in order to direct fluid under pressure to desired places such as to a fluid motor or jack. Since the action of opening or closing a port with a simple spool shoulder is relatively abrupt, it is common practice to slot or notch the spool shoulders to obtain a slow throttling or metering effect and thus a desired gradual or smooth action of the fluid motor or jack. Many known designs of such metering slots are found to create a dynamic force from the jet flow which tends to urge the spool in a direction opposing the centering spring force, thus requiring heavy spring pressure to effect return of the spool to a normal or neutral position.

The construction disclosed in the above mentioned patent overcomes the above objectionable feature in a valve designed for metering in. The term "metering in" is employed in describing a valve wherein the metering is accomplished by fluid flow through the metering slots in a direction generally inward with respect to the valve spool whereas metering out is used to describe the condition where metering is accomplished by flow radially outwardly of the valve spool through the metering slots. In the above mentioned patent, a slot is shown which corrects the difficulties encountered in connection with metering out but is ineffective for correcting the same difficulties experienced in valves of the metering in type.

It is the object of the present invention to provide a metering slot configuration for hydraulic control valves which will greatly reduce reactionary force exerted axially on the valve spool so as to permit the return of the spool toward its neutral position with a very light neutralizing spring and particularly in connection with valves where metering is accomplished during flow radially inwardly of the valve spool.

Further and more specific objects and advantages of the invention are made apparent in the following specification wherein the invention is described in detail by reference to the accompanying drawing.

In the drawing:

FIG. 1 is a central sectional view through a spool valve illustrating the metering slot configuration of the present invention and diagrammatically showing a source of fluid under pressure and a hydraulic jack to be actuated by such fluid under control of the valve; and

FIG. 2 is an enlarged fragmentary sectional view of a portion of the valve illustrated in FIG. 1 to illustrate the effect of the improved metering slot.

In the system illustrated in FIG. 1, a double acting hydraulic jack is shown at **10** and is adapted to be actuated in either direction by fluid under pressure from a pump **11** which withdraws fluid from a reservoir **12**.

A return line **13** leads to the reservoir and a relief valve of conventional design illustrated at **14** is employed in the customary manner in such a system. Control of fluid under pressure which is directed to the jack **10** as well as control of the return circuit is accomplished through a valve, the body of which is illustrated at **15**. The valve **15** may be considered as typical of many valves used for this general purpose and the following description of the manner in which it operates will facilitate an understanding of the advantages of the metering slot of the present invention.

The valve **15** has a cylindrical bore for the reception of a reciprocable valve spool **16** having grooves and land portions which cooperate with ports opening into the cylindrical bore to control direction of fluid flow through the valve. FIG. 1 shows the valve spool **16** in a neutral position in which it is balanced as by a spring **17**, exerting pressure against the valve spool in one direction as through a flanged collar **18** and reacting against the valve housing in the opposite direction by means of a shouldered sleeve **19**. With this arrangement, the spool is normally held in the position shown and may be moved in one direction or another through actuating leverage (not shown) which is connected to an end **20** of the spool.

In the neutral position shown in FIG. 1, fluid from the pump **11**, which may be considered as continuously operating, is directed into an inlet port **21** and is free to pass through the valve cylinder to ports **22** and **23** and outwardly through an exhaust port **24** and through the return line **13** without having effected the position of the jack **10**.

When it is desired to retract the rod of the jack **10** by admission of fluid under pressure to its right end as illustrated in FIG. 1, the spool **16** is moved toward the left against resistance of the spring **17** until a land **26** on the spool closes communication to the port **22** as shown in FIG. 2 and a land **27** on the spool closes communication to the port **23** except in the area of metering slots **28** formed in the land **27** and capable of being gradually closed by further movement toward the left for throttling or metering purposes. This restriction of flow causes a buildup of pressure in the inlet chamber **21** which effects opening of a check valve **30** normally urged to a closed position by a spring **31**. Opening of the check valve **30** admits fluid under pressure to a chamber **32** which communicates with the valve cylinder and surrounds the valve spool therein and since the spool has been moved toward the left, fluid under pressure is admitted to a chamber **33** through metering slots illustrated in dotted lines at **34**. The chamber **33** also communicates through a conduit **35** with the right or rod end of the jack **10** as shown. In the same position of the valve fluid necessarily exhausted from the left end of the jack **10** flows through line **36** into a chamber **38**, now in communication through throttling slots with ports **22** and outlet **24**, and returns to the reservoir through conduit **13**.

Actuation of the jack in the opposite direction is effected by movement of the spool **16** oppositely or to the right where throttling slots **40**, one of which is shown, control the flow of fluid through port **22** to outlet **24**. The course of fluid flowing to and returning from the jack is a reverse of that hereinbefore described, the exhaust from the right hand end of the jack flowing through conduit **35**, chamber **33** and toward the exhaust port **24** through a passage **42**.

In accordance with the present invention, the configuration and arrangement of the metering slots **28** and **40** is such as to impose a minimum of axial thrust on the valve spool so that the centering spring **17** thereof need exert a

relatively low force in performing its function and a minimum operator effort is required to actuate the spool in either direction. The manner in which this is accomplished is best understood by reference to FIG. 2 wherein the main body of the spool is shown as having a large diameter as represented by the lands **26** and **27** and a smaller diameter as represented by the grooves or spaces between the land and the metering slots **28** are shown as bridging these two diameters. The metering slots of the present invention are formed as by a cylindrical milling cutter moved radially inwardly with respect to the spool until the center thereof reaches a point 44 well within the greater diameter of the spool as indicated by the space B. The distance B and the diameter of the cutter should be such that a line tangent to the portion of the slot terminating in the groove between lands should form an angle C with the greater diameter of the spool which is approximately 59° to 65° and should be spaced a short distance represented by dimension A from the end of the land, A representing a minimum clearance of approximately .032".

Any material variation from the configuration and disposition of the metering slots illustrated in FIG. 2 results in unbalance of axial flow forces acting on the spool requiring the use of a heavier centering spring and increased operator effort. For example if the point 44 is disposed at or outside of the greater spool diameter, the slot enters the spool at the greater diameter at less than 90° to the axis of the spool and axial flow forces tend to shift the spool further in the direction of its movement which was to the left as shown in FIG. 2. This tends to prevent free return of the spool to its neutral position when the operator's lever is released unless an excessively heavy centering spring is employed. With the present construction, inward movement of a milling cutter until its center reaches the point **44** forms a flat or plane surface tangent to the curved portion of the slot and normal to the axis of the spool at the end of the slot which terminates at the land. If either the dimension A or the angle C is reduced, the outward flow of fluid reacts against the end of the adjacent land again urging the spool toward the direction in which it has been moved. On the other hand, increasing the value of the angle C results in overcompensation or unbalance of flow forces in a direction

which tends to return the spool toward its neutral position. Unbalance in this direction requires increased operator effort.

In practice, valves provided with metering slots of the present invention have been found to reduce the operator effort required to shift the spool from 20 pounds, in comparable valves with known types of metering slots and the same advantage afforded by leverage, to approximately 6 pounds with dependable operation of a centering spring exerting considerably less force than those previously used.

We claim:

1. In a control valve having a ported bore and a spool with lands separated by grooves reciprocable in the bore for controlling fluid flow through the ports, metering slots bridging said lands and grooves and having a substantially semi-cylindrical configuration originating from a center disposed within a groove and spaced inwardly from the outer diameter of the lands.

2. The combination of claim **1** in which a line tangent to the terminal end of a slot in the groove is spaced from the shoulder of an adjacent land.

3. The combination of claim **2** in which the tangent line is spaced at least .03 inch from the shoulder of the adjacent land.

4. The combination of claim **1** in which a line tangent to the terminal end of a slot in the groove forms an angle of approximately 59° to 65° with the outer surface of the lands.

5. The combination of claim **1** in which the end of the slot terminating in a land is a plane surface normal to the axis of the spool and tangent to the semi-cylindrical surface of the slot.

References Cited by the Examiner

UNITED STATES PATENTS

2,391,531	12/45	Warren	251—282
2,747,612	5/56	Lee	251—282 X
2,812,775	11/57	Hodgson	137—625.34 X
2,971,536	2/61	Junck et al.	251—282
3,009,480	11/61	Miller	251—282 X

M. CARY NELSON, *Primary Examiner.*