United States Patent

Schultz

[15] **3,663,124**

[45] **May 16, 1972**

[54] DUAL CROSSOVER RELIEF AND CASE SURGE VALVE FOR HYDRAULIC MOTORS AND PUMPS

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[52] **U.S. Cl.** **417/291**, 91/491, 137/493

[51] **Int. Cl.** **F04b 49/00**, F16k 17/26

[58] **Field of Search** 417/291, 282, 308, 507; 137/493; 91/180

[56] **References Cited**

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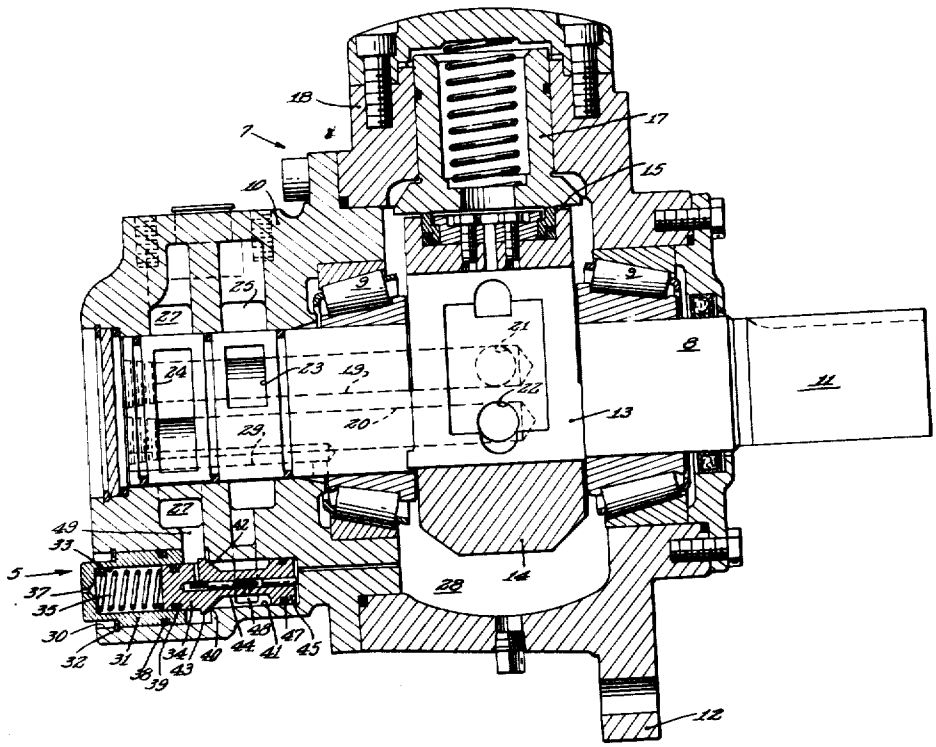
[57] **ABSTRACT**

A valve assembly is provided which will automatically respond to relieve overload hydraulic pressures in a hydraulic operating device such as a motor or pump, being mounted directly in the housing of the device and operatively communicating with the hydraulic operating circuit to bypass hydraulic pressure automatically when an overload in the device is sensed by the valve assembly. This may include reversible line pressure and also case pressure.

9 Claims, 4 Drawing Figures



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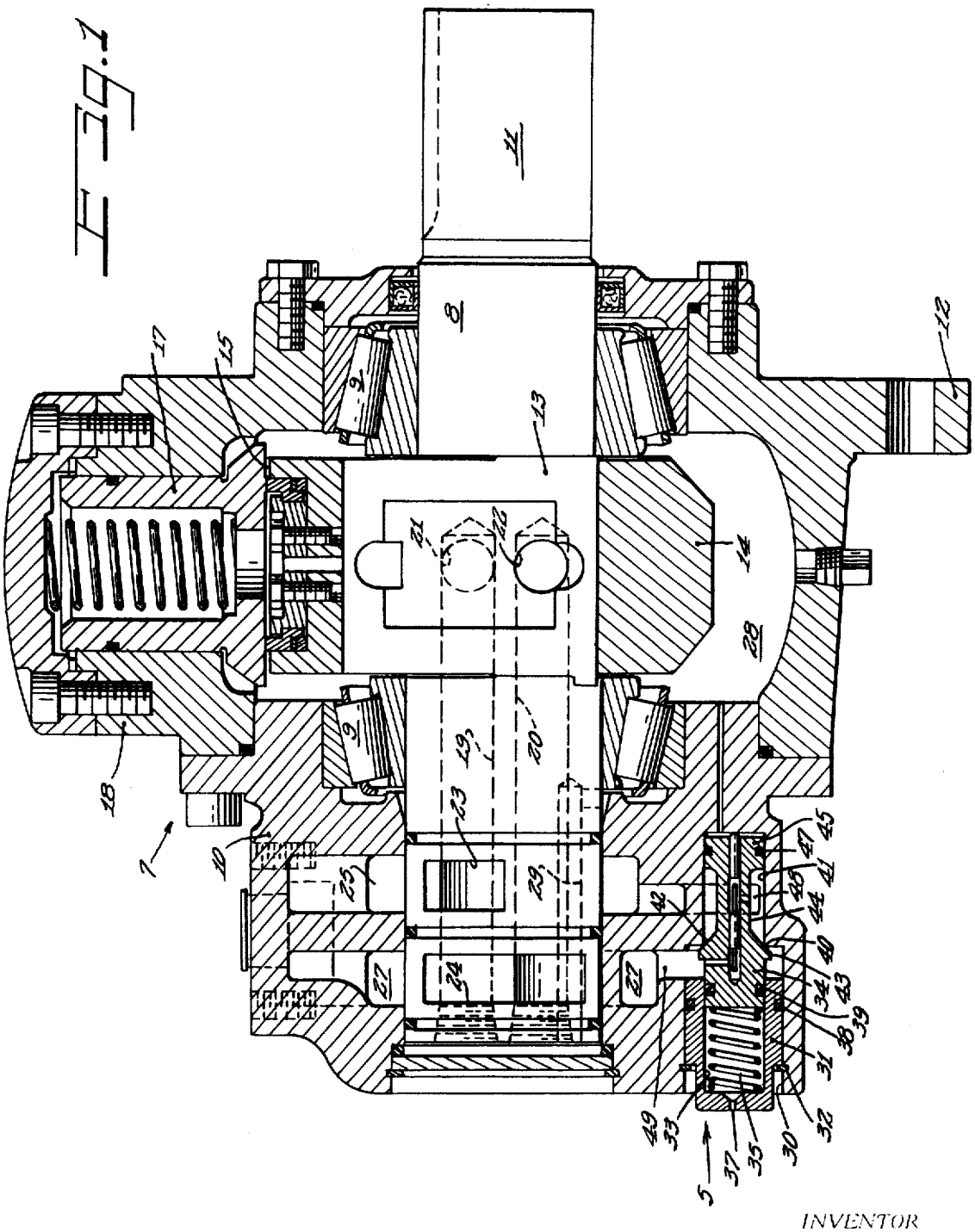
SHEET 1 OF 2

FIG. 1



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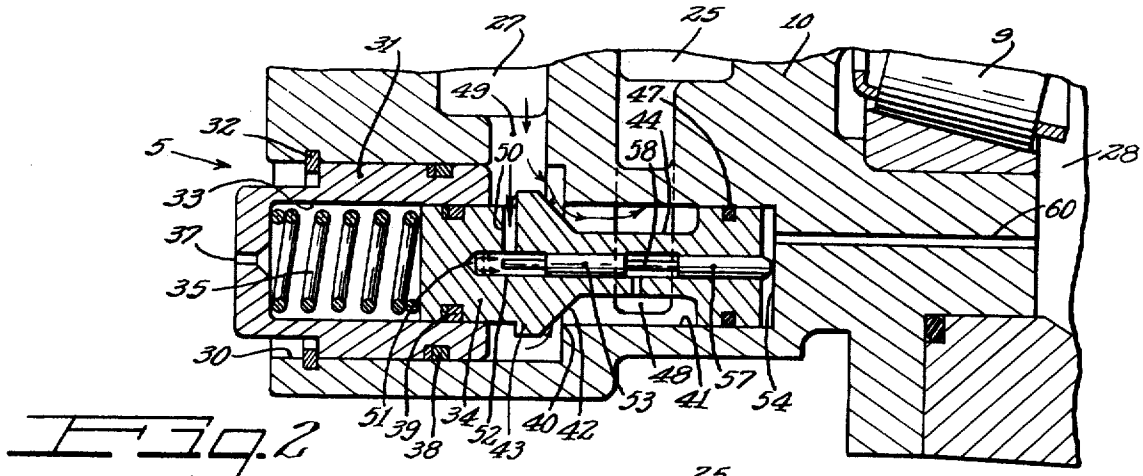

Fig. 2

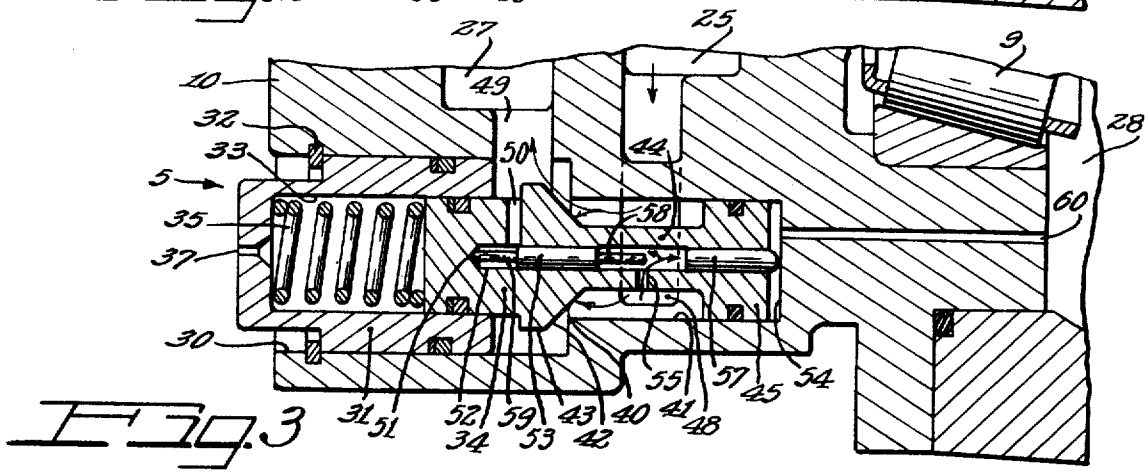

Fig. 3

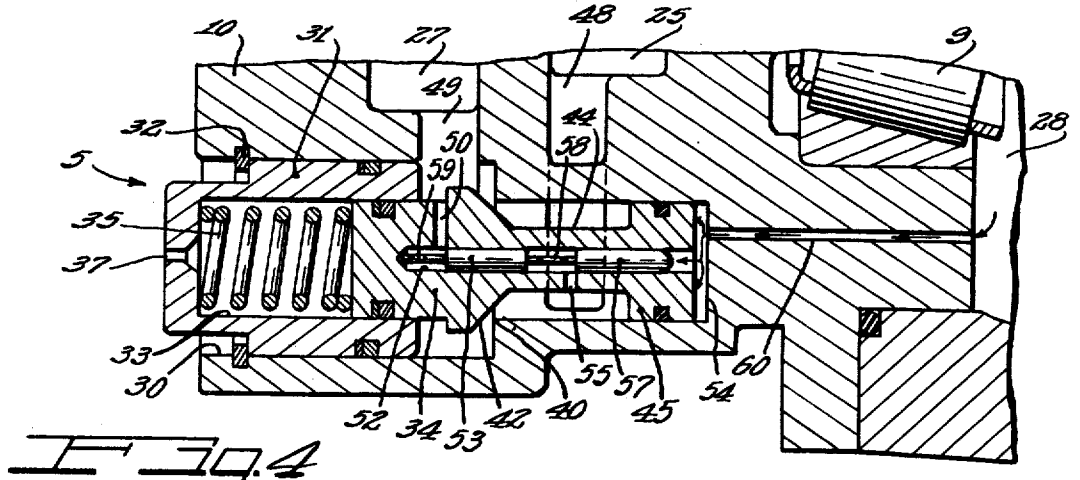

Fig. 4

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DUAL CROSSOVER RELIEF AND CASE SURGE VALVE FOR HYDRAULIC MOTORS AND PUMPS

This invention relates to safety valve structure, and is more particularly concerned with such a valve which is especially useful in association with hydraulic motors or pumps.

In the operation of hydraulic devices such as motors or pumps, conditions of control sometimes occur wherein the hydraulic operating fluid passages to and from the device are abruptly closed. Due to the inertia of the rotating parts of the device and whatever it is driving or by whatever it is driven, rotation tends to continue. Excessive pressures may therefore develop which can result in structural damage to the device and the hydraulic lines. Heretofore in such hydraulic devices intended to operate in both directions of rotation, it has been deemed necessary to provide two relief valves, or a complex arrangement including a system of check valves. Furthermore, there has been some problem with having the relief valve structure located close enough to the hydraulic ports in the system of the device to attain rapid enough response to minimize peak surges.

Where the hydraulic device has a case chamber to which hydraulic fluid leaks, intentionally or otherwise, during operation, a situation may occur wherein the pressure may rise in the case chamber to an excessive and possibly damaging level. Heretofore separate pressure relief means have generally been considered necessary to take care of such case pressure overload.

According to the present invention, the foregoing and other disadvantages, shortcomings, inefficiencies and problems are overcome by providing a new and improved valve means which will, in a single functional assembly, meet all requirements.

An important object of the invention is to provide in one valve assembly means for relieving overload pressures in either direction of rotation of a hydraulic device such as a motor or pump.

Another object of the invention is to provide a new and improved overload relief valve structure which can be simply and efficiently installed directly in association with port cavities in a hydraulic device so as to become a functionally integral part of the device.

Still another object of the invention is to provide new and improved pressure relief means for hydraulic devices such as motors and pumps which will eliminate the need for the usual check valve system.

A still further object of the invention is to provide a pressure relief valve structure which will automatically stop operation of a hydraulic device should a malfunction occur resulting in excessive case pressure.

A yet further object of the invention is to provide a new and improved simplified, highly efficient and reliable pressure relief valve structure for hydraulically operating devices.

Other objects, features and advantages of the invention will be readily apparent from the following description of a preferred embodiment thereof, taken in conjunction with the accompanying drawings, although variations and modifications may be effected without departing from the spirit and scope of the novel concepts embodied in the disclosure, and in which:

FIG. 1 is a vertical longitudinal sectional elevational view through a representative motor embodying features of the invention;

FIG. 2 is a fragmentary vertical longitudinal sectional detail view on an enlarged scale showing the control valve in one of its pressure relief functions;

FIG. 3 is a similar view showing the control valve in another of its pressure relieving functions; and

FIG. 4 is a similar view showing the control valve in a third of its pressure relieving functions.

By way of practical example, a pressure relief valve **5** is illustrated which is especially adapted for relieving excessive hydraulic pressures under a plurality of operating conditions in a hydraulic device **7** such as a motor or pump exemplified in

FIG. 1 as of the low speed high torque reciprocating piston type. Reference may be had to Kimsey U.S. Pat. No. 3,036,557 for a more detailed disclosure of this type of motor or pump. For the present purposes it is believed adequate to point out that in such a hydraulic device a rotary shaft **8** is mounted on roller bearings **9** in a housing **10**. One end portion **11** of the shaft extends from one end of the housing to be keyed to a driven or driving member where the housing is stationarily mounted as by attachment of ears or lugs **12** thereon to a support. On the other hand, the shaft **11** may be held stationary and the housing rotatably driven, as preferred.

Rotary relative movement between the shaft **8** and the housing **10** is effected by hydraulic pressure within the housing acting on the shaft where the device is to operate as a motor, or hydraulic pressure may be created by the device where it is to act as a pump. For this purpose, the shaft **8** has an eccentric **13** intermediate its ends within the housing **10** engaged thereabout by a bearing block **14** which has a plurality such as five outer perimeter substantially flat faces **15** toward the ends of which respective pistons **17** reciprocable in cylinders **18** thrust operatively. Hydraulic pressure fluid such as oil is conveyed to and from the pistons **17** by means of a hydraulic system including a pair of parallel spaced longitudinal ducts **19** and **20** having respective ports **21** and **22** opening through the eccentric **13** to communicate cyclically with the pistons. These ducts extend from an inner end portion of the shaft **8**, that is opposite to the outward extension **11**, and communicate by way of axially spaced ports **23** and **24** respectively with annular transmission grooves **25** and **27**, respectively, in the housing which are suitably connected with hydraulic conduits in the associated hydraulic system. Normal leakage into a case chamber **28** is bled off by way of a scavenging duct **29**.

Construction and arrangement of the relief valve **5** is such that it will respond to and relieve excessive pressure build up reflected in either of the transmission passages or grooves **25** and **27** or the case chamber **28**. To this end, the valve assembly is mounted in a bore **30** provided in what may be referred to as the rear end portion of the housing **10** on an axis parallel to the shaft **8** but spaced therefrom and opening rearwardly from the housing. Within the bore **30** is received a generally cup-shaped valve retainer **31** retained against outward displacement by means comprising a snap ring **32**. Within a blind end inwardly opening bore **33** of the retainer is slidably mounted an outer end portion of a spool valve member **34** normally thrust inwardly but in a direction out of the bore **33** by biasing means comprising a coiled compression spring **35**, there being a free air relief port **37** opening to atmosphere through the outer blind end of the retainer. Leakage past the retainer is prevented by a static ring seal **38**, and leakage past the valve member in the bore **33** is prevented by a dynamic ring seal **39**.

Normally, under the bias of the spring **35**, the valve member **34** closes a crossover port between the transmission groove passages **25** and **27** and defined by an annular valve seat **40** which is provided on a stepped juncture with an inwardly extending reduced diameter portion **41** of the bore **30** into which the valve member extends and which is desirably of the same diameter as the bore **33** of the retainer **31** so that both opposite end portions of the valve member **34** are of the same diameter. In normal sealing engagement with the seat **40** is a poppet shoulder **42** located intermediately on the spool valve member **34** and comprising a frusto-conical area extending from an annular flange **43**, of larger diameter than the remainder of the valve member, into an annular groove **44** of substantial length providing a reduced diameter on the member between the shoulder **42** and an inner end head portion **45** of the valve member carrying a peripheral dynamic ring seal **47** engaging the bore portion **41**. Communication between the bore portion **41** and the groove **44** and the transmission passage groove **25** of the housing is effected through a passage extension **48**. At the outer side of the crossover port valve seat **40** communication is effected between the transmission passage **27** and the larger diameter portion of the bore **30**

between the seat 40 and the inner end of the retainer 31 by way of a branch passage 49.

While the pressure in the operating circuit of the device 7 is within a safe range as reflected in either of the passages 25 and 27 and as reference to the valve assembly 5 by way of the normally non-communicating branch passages 48 and 49, respectively, the biasing spring 35 retains the valve member 34 in the crossover port blocking, sealing position as shown in FIG. 1. Should excessive pressure develop in either of the passages 25 or 27, the valve member 34 will respond in opposition to the bias of the spring 35 and open the crossover port to bypass the excessive pressure to the low pressure side of the circuit represented by the other of the passages. To effect this with a minimum size biasing spring, the valve member 34 is provided with hydraulic fluid thrust surfaces which are nearly in balance on both sides of the crossover port seat 40, but sufficiently out of balance in the outward direction of the valve to be responsive to the overload or excessive hydraulic pressure at either side of the crossover port to shift the valve member and effect hydraulic pressure relief.

Assuming that the hydraulic device 7 is operating in a fashion wherein the transmission passage 27 is on the high pressure side of the system and the transmission passage 25 is on the low pressure side, the pressure on the opposite sides of the annular flange 43 is substantially balanced. Should there be an overload pressure referenced to the valve from the passage 27, this will be felt internally within the valve member 34, as indicated in FIG. 2 through a port 50 extending radially inwardly adjacent to the outer side of the flange 43 and whereby the overload pressure is referenced to a thrust surface 51 at the blind end of a bore extending through the valve member from the blind end and opening through the inner end of the valve member. To contain the pressure on the thrust surface 51, means comprising a plunger 53 are provided closing the bore 52 inwardly from the reference port 50 and slidable in the bore 52 so that the pressure thrusts the plunger inwardly toward an inner blind end shoulder 54 of the bore portion 41. Since the valve member 34 and the plunger 53 are relatively reciprocable, the combined pressure area provided by the shoulder 42 and the thrust surface 51 overbalances pressure on the outer side of the flange 43 and overcomes the bias of the spring 35 to shift the valve member 34 outwardly, thus opening the crossover port defined by the valve seat 40 thereby dumping the overload pressure through the crossover port into the passage 25 by way of the passage extension 48.

Similarly, where the transmission passage 25 is in the high pressure side of the hydraulic system and the passage 27 is in the low pressure or exhaust side of the system, should a pressure overload develop in the passage 25, such overload is referenced by way of the passage extension 48 and through a radial reference port 55 (FIG. 3) in the small diameter portion 44 of the valve member to the thrust surface bore 52, as indicated by directional arrows. Thereby, the overload pressure thrusts outwardly relative to the valve member 34 onto the adjacent end of the plunger 53 which thereby thrusts against the thrust surface 51 to add the area of such thrust surface to the area of the shoulder 42 exposed to the overload pressure, overbalancing the pressure against the shoulder of the valve head 45 and overcoming bias of the spring 35 to move the valve shoulder from the seat 40 thereby to open the crossover port and thus dump the overload pressure into the low pressure side of the system by way of the branch passage 49 and the transmission passage 27. During such an occurrence, a plunger 57 reciprocable in the bore 52 inwardly relative to the reference port 55 contains the pressure between the inner end of the plunger 57 and the plunger 53 while remaining stationary relative to the valve member 34 by thrusting against the dead-end shoulder 54 as a stop. In order to maintain the adjacent ends of the plungers 53 and 57 normally separated and at all times clear of the reference port 55, one of the plungers, herein the plunger 53, is provided with a reduced diameter spacing extension 58. Similarly to maintain the opposite end of the plunger 53 clear of the reference port 50, a reduced diameter spacing extension 59 is provided thereon which in the outward pressure relief thrusting of the plunger 53 makes the actual engagement with the thrust surface 51.

In yet another pressure relieving response, the valve member 34 is adapted to be shifted outwardly against the bias of the spring 35 to move the valve shoulder 42 from the seat 40 to open the bypass port when an overload hydraulic pressure develops in the case chamber 28, as depicted in FIG. 4. When this occurs, the case overload pressure is referenced through a port or passage 60 through the stop surface 54 onto the inner end of the valve member 34, and more particularly the inner end of the head 45 whereby to thrust the valve member in an outward direction, the entire area of the valve head end, including the area of the bore 52 being responsive to the pressure by virtue of the plunger 57 blocking the inner end portion of the bore as shown. Opening of the crossover port by action of the case pressure overload causes bypassing of pressure from whichever of the passages 25 or 27 is on the high pressure side to the other of the passages which is on the low pressure side at the particular occurrence, thus relieving the hydraulic device of internal pressure until the case pressure has resumed a safe pressure level.

From the foregoing, it will be appreciated that in the one relatively simple, possitively acting valve unit 5, anyone of the plurality of hydraulic overload hazards that may occur in the hydraulic device 7 are avoided efficiently by direct, short range communication with the areas in which the overload pressures may develop.

It will be understood that variations and modifications may be effected without departing from the scope of the novel concepts of the present invention.

I claim as my invention:

1. In a hydraulic device including operating means in a hydraulic circuit having respective passages communicating with the operating means and each passage liable to overload pressure, and an overload bypass having means defining a port communicating at one end with one of said passages and communicating at its opposite end with the other of said passages, the improvement comprising:

a valve having means normally biasing it into closing relation to said port and the valve being movable in one direction only for opening the port;

different hydraulic fluid thrust-receiving surfaces of said valve exposed respectively to hydraulic fluid pressure from said passages to effect movement of the valve in said one opening direction in opposition to said biasing means when either of said passages experiences pressure overload;

said valve comprising a generally spool configuration carrying said surfaces intermediately along its length and at one end thereof opposite to the end toward which said biasing means thrusts;

a longitudinal blind end bore in the spool valve opening through said end opposite to the end against which the biasing means thrusts;

the blind end of said bore presenting a thrust surface comprising part of said surfaces; and

a reciprocable plunger in said bore and longitudinally spaced hydraulic pressure ports in said valve respectively communicating with said bore between said blind end surface and said plunger and with said bore and a surface on said plunger facing in the same direction as said blind end surface and providing pressure responsive surface alternative to said blind end surface.

2. In a hydraulic device including operating means in a hydraulic circuit having respective passages communicating with the operating means and each passage liable to overload pressure, and an overload bypass having means defining a port communicating at one end with one of said passages and communicating at its opposite end with the other of said passages, the improvement comprising:

a valve having means normally biasing it into closing relation to said port and the valve being movable in one direction only for opening the port;

different hydraulic fluid thrust-receiving surfaces of said valve exposed respectively to hydraulic fluid pressure from said passages to effect movement of the valve in said one opening direction in opposition to said biasing means when either of said passages experiences pressure overload;

a case chamber liable to hydraulic pressure overload; and

means connecting said case chamber operatively with said valve to drive the valve into open position relative to said port in opposition to said biasing means in response to said case chamber overload pressure.

3. In a hydraulic device including operating means in a hydraulic circuit having respective high/low pressure passages communicating with the operating means and each passage liable to overload pressure, and an overload bypass having means defining a port communicating at one end with one of said passages and having a generally axially facing annular valve seat about this end of the port and the port communicating at its opposite end with the other of said passages, the improvement comprising:

a valve member having an annular shoulder facing generally axially toward and engageable with said seat for closing the port;

means normally biasing the valve member into the closing relation to said valve seat;

the valve member being movable in one direction only from said seat for opening the port;

first reactive surfaces adjacent to said shoulder, each responding to respectively one of the pressures of the operating means; and

second reactive surfaces each responding to respectively one of the pressures of the operating means;

said second surfaces being alternately active in cooperation with one of the respective first reactive surfaces to shift the valve against said biasing means when either of said passages experiences pressure overload.

4. In a hydraulic device according to claim 3, said second surfaces being located internally of the valve member, and respective openings in the valve member effecting communication between said second surfaces and said passages respectively.

5. In a hydraulic device according to claim 3, said valve member comprising a body having a bore extending in the axial direction of movement of the valve member, said second surfaces being within said bore.

6. In a hydraulic device according to claim 3, said valve member comprising a generally spool configuration carrying aid first surfaces intermediately along its length and a valve retainer having a bore within which the biased end portion of the valve member is slidably reciprocably engaged, said biasing means being located within said bore.

7. In a hydraulic device according to claim 3, said valve member comprising a generally spool configuration carrying said first reactive surfaces intermediately along its length, a longitudinal bore in the valve member, a reciprocable plunger in said bore, said valve member and said plunger having within said bore said second reactive surfaces, and said valve member having longitudinally spaced ports respectively communicating with said bore at opposite ends of said plunger.

8. In a hydraulic device according to claim 3, a chamber liable to hydraulic pressure overload, and means connecting said chamber operatively with said valve member to drive the valve member into open position relative to said port and in opposition to said biasing means in response to overload pressure in said chamber.

9. In a hydraulic device according to claim 8, said valve member comprising a spool configuration, said device having a bore including said port, said biasing means being active on one end of said valve member, said device having a passage from said chamber into said bore at the opposite end of said valve member.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,663,124 Dated January 6, 1973

Inventor(s) John Clayson Schultz

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 6, after line 35 add:

10. In a hydraulic device comprising a housing and operating means within said housing with a hydraulic system connected therewith having a high pressure side and a low pressure side:

said housing having a recess therein with a bypass port intermediately in said recess;

passage means connecting one of said hydraulic system sides in communication with said recess relative to one end of said port and separate passage means connecting the other side of said hydraulic system with said recess relative to the opposite end of said port;

a valve assembly in said recess including a valve member and means normally biasing said valve member into closing relation to said port;

pressure responsive surface means on said valve member against which overload hydraulic pressure from one of said passage means is adapted to oppose said biasing means to move said valve member into opening relation to said port for crossover flow of hydraulic fluid between said sides of the system through said passage means and said port;

a case chamber liable to hydraulic pressure overload; and

means connecting said case chamber operatively with said valve member to drive the valve member into open position relative to said port in opposition to said biasing means in response to said case chamber overload pressure.

Signed and sealed this 22nd day of May 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

USCOMM-DC 60376-P69