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AUTOMATIC REFILL AND TEMPERATURE COMPENSATION DEVICE FOR HYDRAULIC SYSTEMS

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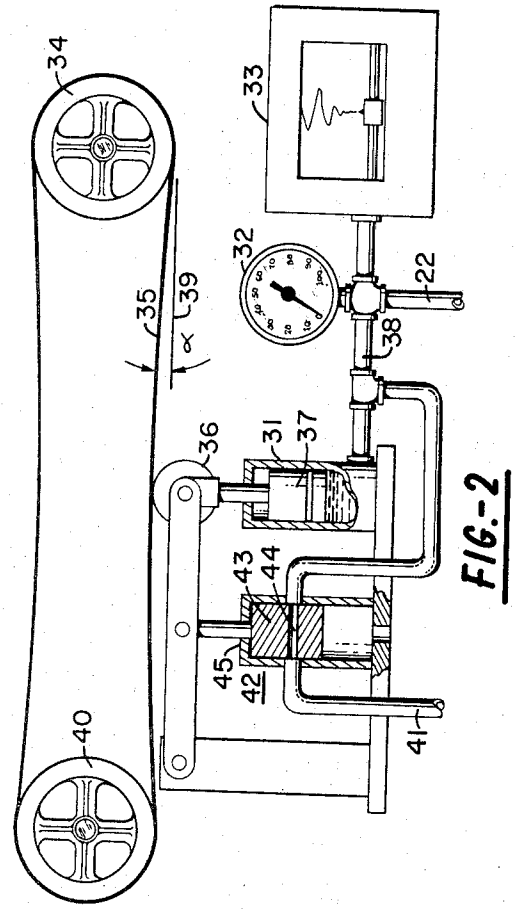


FIG.-2

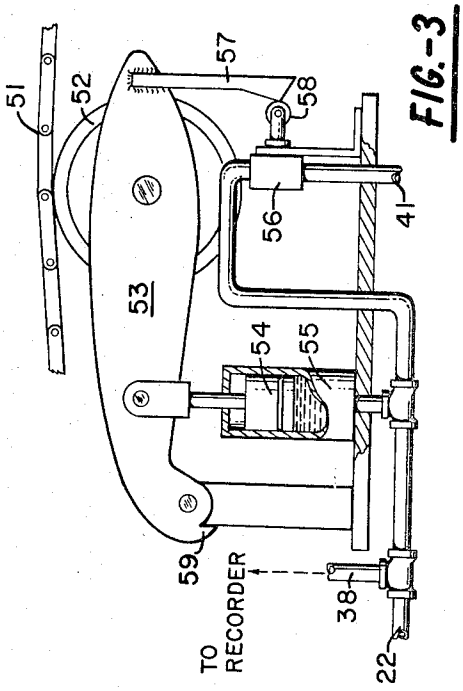


FIG.-3

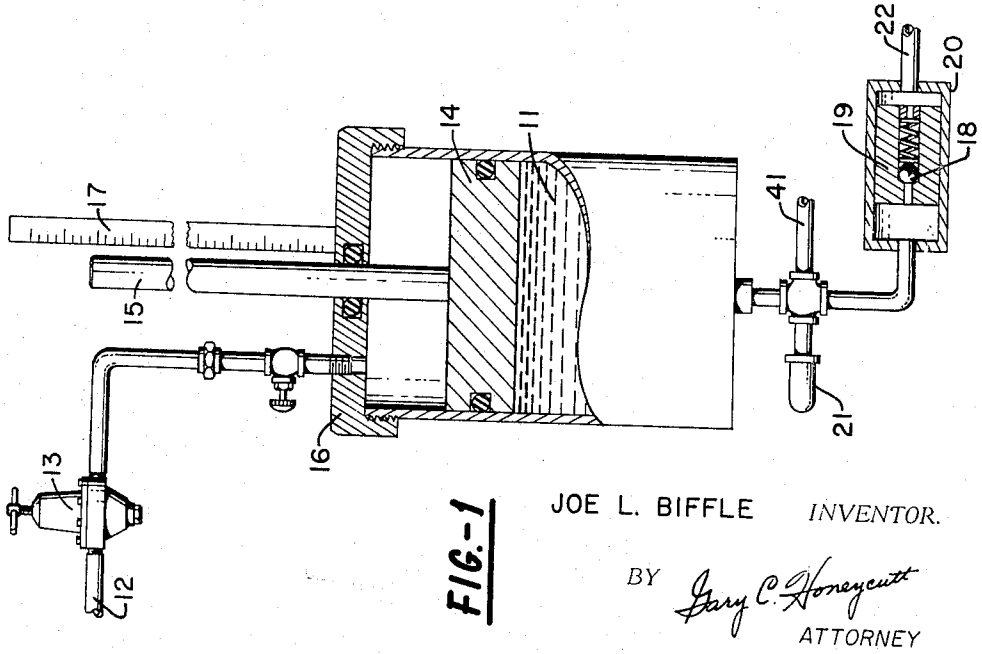


FIG.-1

JOE L. BIFFLE *INVENTOR.*

BY Gary C. Honeycutt

ATTORNEY

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Joe L. Biffle, Tia Juana, Zulia, Venezuela, assignor to Esso Production Research Company, a corporation of Delaware

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ABSTRACT OF THE DISCLOSURE

A combination automatic refill-temperature compensation device for a hydraulic load sensing system. The refill device is a pressurized fluid reservoir and check valve assembly which passes hydraulic fluid into the load sensing system when the volume of hydraulic fluid in the system decreases. The temperature compensating device is a valved conduit which bypasses the check valve and returns hydraulic fluid to the fluid reservoir when increases in temperature cause expansion of the hydraulic fluid in the system. When the temperature in the system drops, the refill device functions as a low temperature compensating device.

This invention relates to an improved method and apparatus for the operation of hydraulic pressure-sensing devices. In one aspect, the invention is directed to an automatic refill device for continually adjusting the volume of hydraulic fluid contained in hydraulic pressure-sensitive devices, in order to compensate for volume changes normally caused by variations in ambient temperature and pressure, and to replace any fluid which may be lost from the system due to minor leakage.

Hydraulic load-sensing or weight-sensing devices have found widespread use in a great variety of industrial applications. For example, in the petroleum industry, hydraulic load-sensing devices are used in several capacities on rotary drilling rigs. These include torque-sensing devices to measure the rotational force applied to the drill column, hook load-sensing devices from which a measure of the weight imposed on the drill bit is determined, and pump pressure-recording devices used in connection with the circulation of a drilling fluid.

When a hydraulic load-sensing device is subjected to intermittent service over a prolonged period of time—for example, several hours or several days—it is usually desirable that the records obtained be consistently related to the same base pressure or "zero" reading. However, substantial errors are typically introduced into the record when a hydraulic sensing device is kept in service over a prolonged period, due to variations in the atmospheric temperature and pressure. Of course, any leakage of hydraulic fluid from the system may also introduce substantial error.

Accordingly, it is an object of the present invention to stabilize hydraulic load-sensing devices against gradual drift or departure from their initial calibration. Particularly, it is an object of the invention to provide hydraulic load-sensing devices with a constant volume supply of hydraulic fluid during prolonged service, despite the influence of changes in temperature and pressure, and despite the occurrence of minor leakage.

FIGURE 1 is an elevational view, partly in cross-section, of the automatic refill device.

FIGURE 2 is a schematic elevational view, partly in cross-section, showing a specific hydraulic load-sensing system adapted for use in combination with the refill device of FIGURE 1.

FIGURE 3 is a schematic elevational view, partly in

cross-section, showing a specific torque-sensing assembly for a rotary drilling rig, to be used in combination with the refill device of FIGURE 1.

In FIGURE 1, the automatic refill device is seen to include fluid reservoir **11**, which is maintained at a predetermined constant pressure by means of pressurized air or other gas supplied through line **12** and maintained at a constant pressure by regulator **13**. A free piston **14** separates the pressurized air from the hydraulic fluid. Rod **15**, attached to piston **14**, extends through the top of vessel **16** and serves in combination with scale **17** as a fluid level indicator.

The assembly further includes check valve **18** mounted inside piston **19**, the latter being free to move back and forth between the ends of expansion chamber **20**. A pressure relief valve **21** is provided as a safety measure in the event of check valve failure. Conduit **22** is connected to a hydraulic load-sensing device (not shown), the operation of which is to be improved in accordance with the present invention. Conduit **41** is not an essential feature of the refill device, as such, but is shown in FIGURE 1 because of its relationship to the embodiments of FIGURES 2 and 3.

In the calibration of a hydraulic load-sensing device, a "zero" output normally corresponds to the existence of a small positive pressure in the hydraulic system, due to the weight imposed thereon by certain elements of the device itself, such as the piston which receives the applied load, together with any associated lever arms or linkage members. Regulator **13** is set to provide a constant pressure within the gas-filled volume above piston **14**, corresponding to that pressure within the hydraulic system of a load-sensing device required to generate a suitable "zero" output.

Initially, therefore, the hydraulic pressure in line **22** is exactly equal to the pressure of reservoir **11**. When the first increments of additional load are applied to the hydraulic system, check valve **18** prevents a return of hydraulic fluid into reservoir **11**, except for the small volume of fluid displaced by piston **19** as it moves to the left-hand end of expansion chamber **20**. Thus, during periods of continuous loading of the hydraulic system, there is no significant transfer of fluid between the hydraulic system and reservoir **11**.

The refill device again becomes operative whenever the hydraulic system is reduced at least momentarily to a zero signal, or to a very small signal which approaches zero. At such times, if the volume of hydraulic fluid in the system has remained constant, no pressure difference will be developed across check valve **18**. However, in the event leakage or shrinkage has occurred in the hydraulic system, check valve **18** will permit the transfer of fluid from reservoir **11** to replenish the supply of hydraulic fluid by way of line **22**.

On the other hand, in the event an expansion of fluid within the hydraulic system has occurred, the position of piston **19** which corresponds to a "zero" output from the system will have shifted from the extreme right within chamber **20**, to a more centralized position, which corresponds to the displacement of fluid from chamber **20** into reservoir **11**, in an amount sufficient to restore equal pressures on the opposite sides of piston **19**.

In those systems where a periodic return to a zero signal does not occur as a matter of course, it will be necessary to provide an arbitrary removal of the load from the system in order to accomplish an intermittent return to its zero base pressure.

In FIGURE 2, a hydraulic load-sensing system is shown which comprises pressure transmitter **31**, gauge **32**, and recording means **33**. As torque is applied to pulley **34** in a counterclockwise direction, belt member **35** is forced downward against roller **36**, which causes a pressure to

be developed in transmitter 31 by means of piston 37. The hydraulic pressure developed is transmitted through line 38 to gauge 32 and recorder 33. The force acting on roller 36 which corresponds to a given torque in pulley 34 depends upon the angle α formed between belt 35 and line 39, the latter being drawn tangent to each of pulleys 34 and 40. Accordingly, it is an additional function of the automatic refill device, when used in combination with the system of FIGURE 2, to restore angle α to a fixed, predetermined value whenever torque is removed from pulley 34.

In this embodiment, fluid communication between reservoir 11 and the hydraulic system is established through two separate paths. One path is established by connecting conduit 22 of FIGURE 2 with conduit 22 (including check valve 18) of the embodiment of FIGURE 1. The second path is provided by connecting line 41 of FIGURE 1 with conduit 41 and valve assembly 42 of FIGURE 2. During periods of normal loading, roller 36 and piston 37 are displaced slightly downward, whereby the pressure generated in the hydraulic system causes check valve 18 to remain closed. Also, piston 43 is displaced slightly downward, thereby interrupting fluid communication through port 44 and conduit 41.

Suppose, during some period of continuous loading, that a small volume of hydraulic fluid is lost from the system due to inadvertent leakage. Then, whenever torque is at least momentarily removed from pulley 34, the hydraulic pressure acting on piston 37 is no longer sufficient to return roller 36 to its initial position. Similarly, piston 43 is not returned to a position capable of restoring fluid communication through port 44 and conduit 41. In this event, a pressure difference is developed across check valve 18 because of the constant pressure maintained in reservoir 11 by the regulated air supply acting on piston 14. Check valve 18 opens, thereby permitting the hydraulic system to refill, which in turn restores roller 36 to its initial position, thereby correcting angle α to its proper value. Cylinder head 45 acts as a mechanical stop to prevent piston 43 from being lifted too far.

An additional feature of the invention is its ability to correct for the gradual wearing out of roller 36. As the radius of the roller grows smaller, the application of a given pressure to the fluid in cylinder 31 lifts piston 37 to a gradually increased height, thereby compensating for the wear, and maintaining angle α at its original size.

In the embodiment of FIGURE 3, a hydraulic load-sensing device and the automatic refill system of FIGURE 1 are functionally interrelated in essentially the same manner as in the embodiment of FIGURE 2. Torque imparted to a drive member (not shown) causes a downward thrust of chain 51, which acts upon roller 52 of the load-sensing device. The force acting on roller 52 is transferred by means of lever arm 53 to hydraulic piston 54. The pressure developed within hydraulic cylinder 55 is transmitted by way of line 38 to recording means not shown.

As in the embodiment of FIGURE 2, fluid communication between reservoir 11 of FIGURE 1 and the hydraulic system of FIGURE 3 is established through two separate paths. One of these is through check valve 18, and the other is through line 41 and valve 56. The application of a significant load to the system displaces roller 52 and lever arm 53 slightly downward. Cam 57 attached to lever arm 53 is also displaced downward, thereby releasing follower 58 which closes valve 56.

So long as the volume of hydraulic fluid contained in cylinder 55, line 38, and the recording means remains constant, then a removal of load from the system permits an immediate return of roller 52 to the position shown in FIGURE 3, whereby cam 57 again holds valve 56 open. In the event of leakage or shrinkage in the volume of hydraulic fluid during some period of continuous loading, then roller 52 would be returned to its original position only by virtue of the automatic refill device of the invention. In this event, the hydraulic pressure within cylinder 55 falls below the hydraulic pressure supplied to line 22. As a result, check valve 18 opens, permitting refill of cylinder 55 whereby arm 53 and roller 52 are returned to their original positions, as shown in FIGURE 3. Valve 56 is now held open whereby any thermal expansion of hydraulic fluid contained in cylinder 55 will cause a return of the excess fluid volume to reservoir 11 through line 41. Mechanical stop 59 prevents arm 53 and cam 57 from being lifted too far.

In the embodiments of FIGURES 2 and 3, expansion chamber 20 and piston 19 are not necessary; that is, an ordinary check valve in line 22 is sufficient. The function of chamber 20 and piston 19, as described in connection with FIGURE 1, is replaced in the embodiments of FIGURES 2 and 3 by the operation of valves 42 and 56, respectively.

While certain embodiments have been specifically disclosed, it will be apparent that many variations thereof fall within the scope of the claims.

What is claimed is:

1. A hydraulic load sensing device comprising a cylinder filled with hydraulic fluid, means for applying a load to said fluid, means for measuring the pressure developed in said cylinder, an auxiliary reservoir of hydraulic fluid, means for applying a fixed, predetermined pressure to said auxiliary reservoir, a check valve which prevents flow of hydraulic fluid from said cylinder to said reservoir, conduit means bypassing said check valve and including valve means operative to permit fluid communication between said cylinder and said reservoir when hydraulic pressure within said cylinder is substantially equal to the hydraulic pressure within said reservoir and operative to prevent the bypassing of said check valve whenever the hydraulic pressure within said cylinder differs significantly from the hydraulic pressure of said reservoir.

2. An improved load sensing device having a pressure transmitter in fluid communication with a hydraulic system, an auxiliary reservoir adapted to contain hydraulic fluid, a conduit interconnecting the auxiliary reservoir and the hydraulic system, a check valve within the conduit to permit the flow of hydraulic fluid from the auxiliary reservoir to the hydraulic system when the pressure in the hydraulic system falls below a predetermined amount and to prevent the flow of hydraulic fluid from the hydraulic system to the auxiliary reservoir wherein the improvement comprises an expansion chamber within the conduit, a free piston within the expansion chamber and adapted to contain the check valve which permits the flow of hydraulic fluid from the auxiliary reservoir to the hydraulic system and prevents the flow of hydraulic fluid from the hydraulic system to the auxiliary reservoir, wherein the expansion chamber and free piston provide a means for compensating increases in pressure of the hydraulic fluid in the hydraulic system due to thermal increase.

3. An improved load sensing device having a pressure transmitter in fluid communication with a hydraulic system, an auxiliary reservoir adapted to contain hydraulic fluid, a conduit interconnecting the auxiliary reservoir and the hydraulic system, a check valve within the conduit to permit the flow of hydraulic fluid from the auxiliary reservoir to the hydraulic system when the pressure in the hydraulic system falls below a predetermined amount and to prevent the flow of hydraulic fluid from the hydraulic system to the auxiliary reservoir wherein the improvement comprises a bypass conduit intreconnecting the hydraulic system and the conduit between the auxiliary reservoir and the check valve, a shut-off valve within the bypass conduit to interrupt the flow of hydraulic fluid within the bypass conduit and means interconnecting the shut-off valve and pressure transmitter to permit the flow of fluid from the hydraulic system to the auxiliary reservoir during periods of zero load to adjust for thermal expansion of the hydraulic fluid in the hy-

draulic system and to prevent the flow of fluid within the bypass conduit when load is imposed upon the pressure transmitter.

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RICHARD C. QUEISSER, *Primary Examiner.*

JAMES GILL, *Examiner.*

C. A. RUEHL, *Assistant Examiner.*