Feb. 17, 1970 B. E. ENSSLE 3,495,544

HYDRAULIC SYSTEM

Filed Aug. 30, 1967 2 Sheets-Sheet 1

Fig. 1.

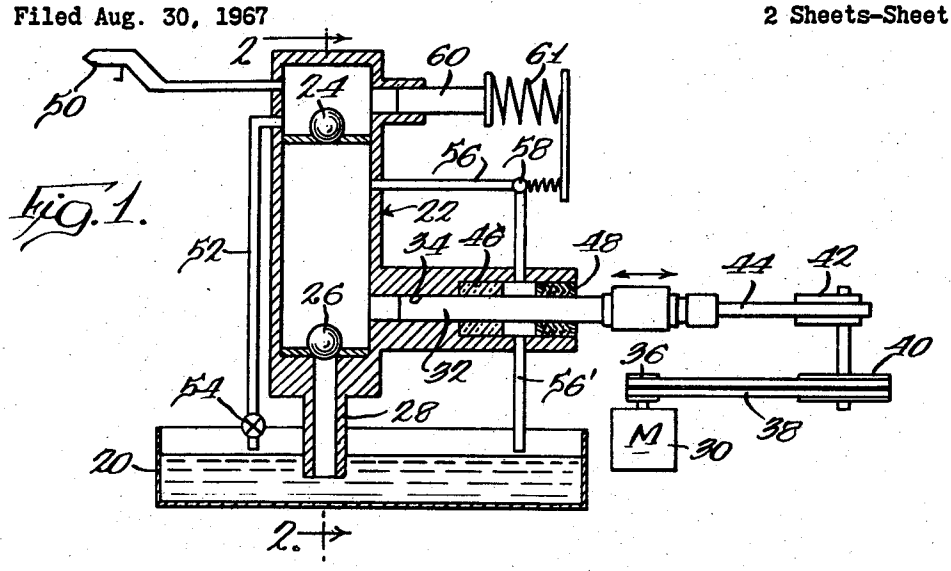


Fig. 2.

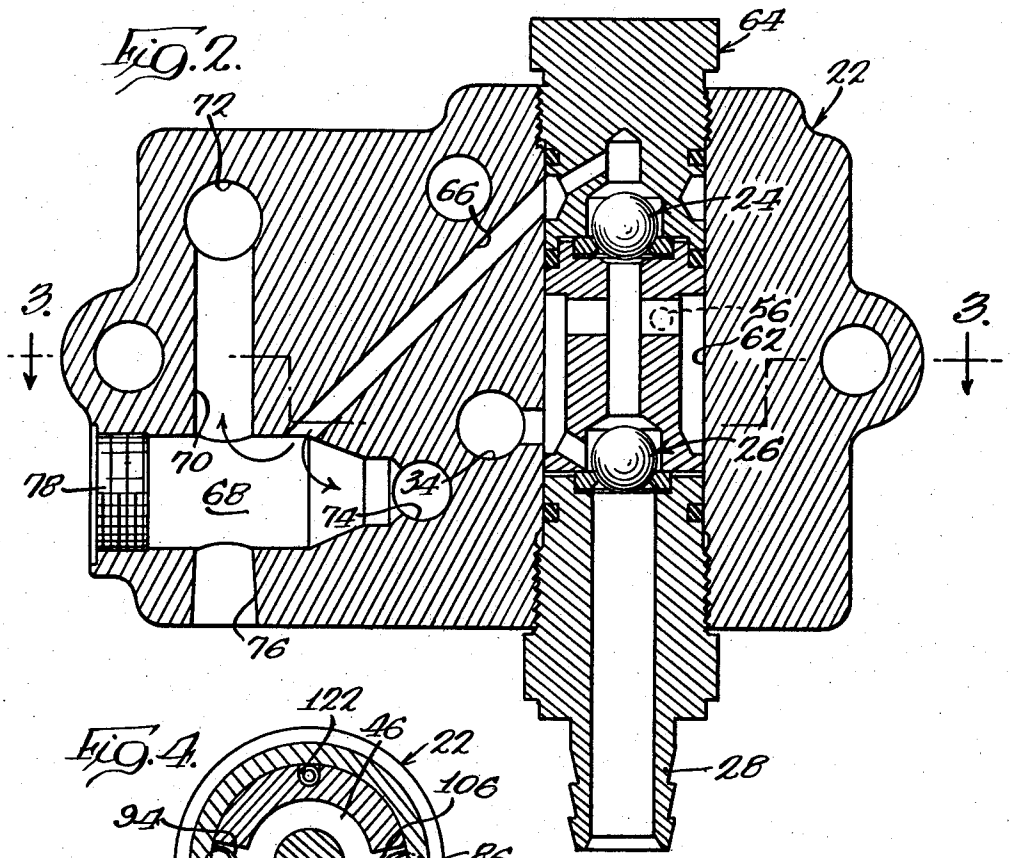
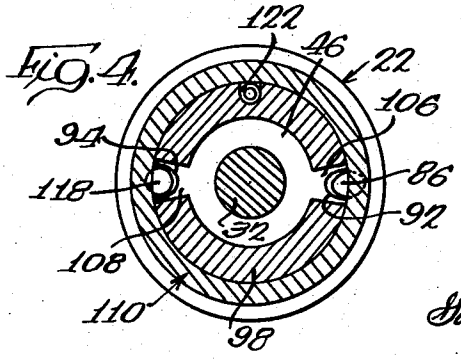


Fig. 4.



Inventor:
Bruno E. Enssle
By
Gary, Parker, Juettner & Cullinan
Atty's

Feb. 17, 1970 B. E. ENSSLE 3,495,544

HYDRAULIC SYSTEM

Filed Aug. 30, 1967 2 Sheets-Sheet 2

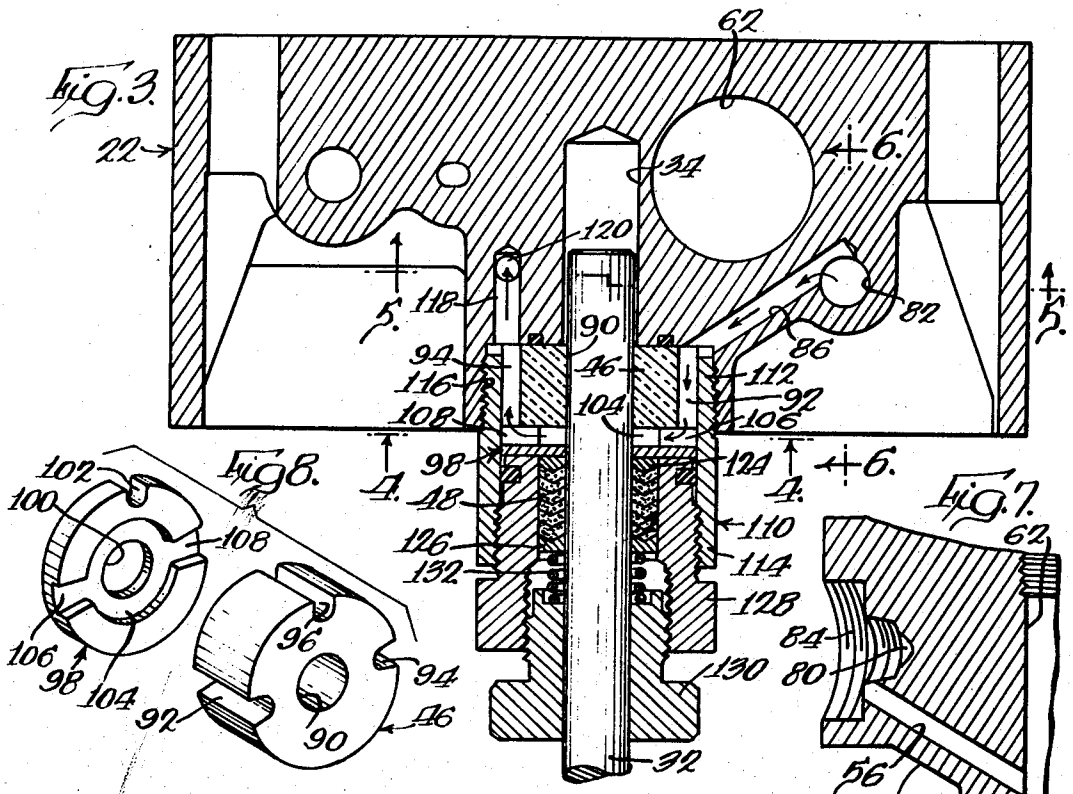


Fig. 3.

Fig. 8.

Fig. 7.

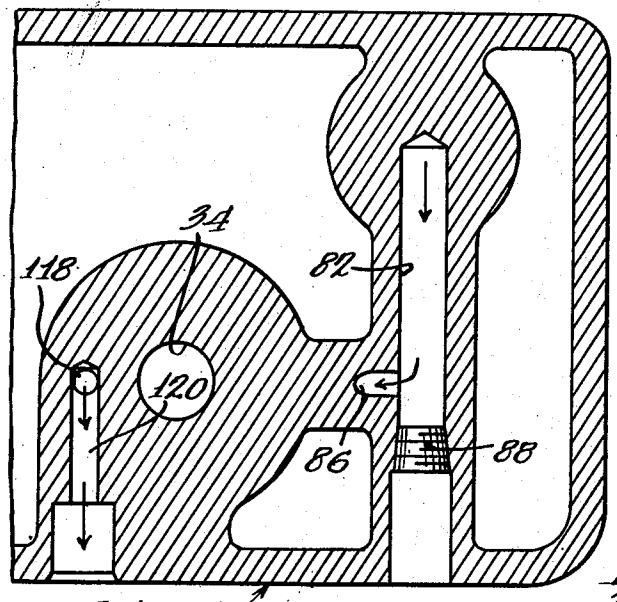


Fig. 5.

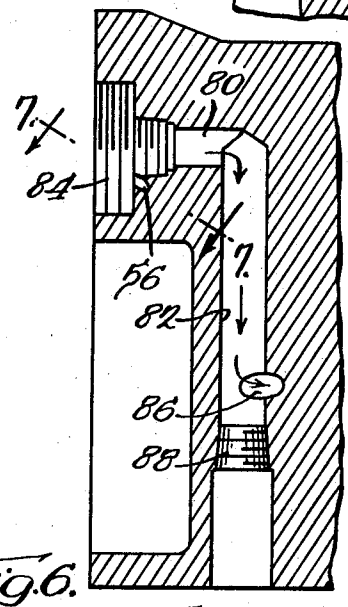


Fig. 6.

Inventor
Bruno E. Enssle
By
Gary, Parker, Juettner & Cullinan
Attys

United States Patent Office 3,495,544
Patented Feb. 17, 1970

3,495,544

HYDRAULIC SYSTEM

Bruno Eugen Enssle, Boulder, Colo., assignor to Binks Research and Development Corporation, Boulder, Colo., a corporation of Colorado

Continuation-in-part of application Ser. No. 535,424, Mar. 18, 1966. This application Aug. 30, 1967, Ser. No. 664,325

Int. Cl. F04b *21/02, 49/00, 21/00*

U.S. Cl. 103—204 7 Claims

ABSTRACT OF THE DISCLOSURE

A reciprocating piston hydraulic pump having controlled leakage around the piston, said leakage accumulating in a low pressure collection chamber and then being flushed therefrom by low pressure by-pass fluid from the pumping chamber.

RELATED APPLICATION

This application is a continuation-in-part of my copending application Ser. No. 535,424, filed Mar. 18, 1966.

BRIEF SUMMARY OF THE DISCLOSURE

In my copending application, Ser. No. 535,424, filed Mar. 18, 1966, I have described a hydraulic system including a fluid source for supplying fluid under pressure, a pressure chamber, a one-way valve interposed between the fluid source and the pressure chamber and arranged to permit fluid flow from the fluid source to the pressure chamber, a low pressure by-pass disposed between the fluid source and the one-way valve for diverting fluid from the source away from the pressure chamber, and a pressure control member located downstream of the valve in conjunction with the pressure chamber for sensing the fluid pressure thereat and for automatically rendering the by-pass operative when the pressure attains a predetermined value.

The foregoing system is especially advantageous for use with an airless system for spraying paint or other coating material where the paint is supplied to an atomizing nozzle at high pressure, e.g. 1000 to 3000 p.s.i., the paint being atomized hydraulically into a fan-shaped spray as it passes through a small elliptically shaped orifice. While airless spraying of paint or other coating material affords numerous advantages, particularly when carried out in accordance with the teachings of my above-identified copending application, it will be recognized that the high pressures which must be used present problems relative to the need for providing an effective seal for the pump which supplies the paint or other coating material at the desired high pressure. The present invention is concerned with a pump of the general type described in the aforesaid copending application, including a reciprocating piston rod. By way of example, the particular pump described in such application comprises a piston rod having one end which extends into a bore formed in a manifold body, and as the piston rod is reciprocated it acts directly on the fluid material to be pumped and supplies such fluid material to a spray gun or the like at the desired high pressure.

Heretofore, problems have been encountered in providing an effective seal for use with a high pressure pump of the type described above where a reciprocating piston rod acts directly on the material to be sprayed, particularly in connection with the spraying of paint and other like coating materials. It is extremely difficult to provide a seal which is completely effective that no paint whatsoever will leak from the high pressure side past the seal. Thus, as the piston rod reciprocates in a bushing which

functions as a seal, at least a very small amount of paint will work its way through the bushing.

I have found that where the clearance between the piston rod and the seal bushing is made substantially as small as possible so as to minimize leakage, a freezing problem will often result due to the small amount of material which nevertheless does work its way through the bushing. That is, the paint pigments will break down and will be ground up due to the action of the piston rod and the bushing, and the resultant leakage material will tend to cause the piston rod to freeze within the bushing. Moreover, as the coating material such as paint is squeezed past the piston and bushing the solvent is lost and it tends to become gummy and to harden, and as it accumulates its presence within the pump apparatus will interfere with the normal operation thereof.

It is therefore an object of the present invention to provide an improved fluid seal system which substantially eliminates the foregoing problems without causing any significant reduction in the efficiency of the pump.

A more specific object of the invention is to provide a fluid seal system as last above-mentioned where the pump is designed to purposely permit a small controlled amount of fluid material to leak past the piston and bushing thereby lubricating the latter, and where fluid material which is recirculated through a by-pass by the pump back to a supply vessel or the like is first directed through the area where such leakage material tends to accumulate in order to mix such leakage material with the by-pass fluid and return the same to the supply vessel.

The foregoing and other objects and advantages of the invention will be apparent from the following description of a preferred embodiment thereof, taken in conjunction with the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a schematic elevational view, partly in section, showing a hydraulic system embodying a high pressure fluid seal system constructed in accordance with the present invention;

FIGURE 2 is an enlarged vertical sectional view, taken substantially along the line **2—2** of FIGURE 1, showing a manifold body and ball check assembly which comprise components of the apparatus of FIGURE 1;

FIGURE 3 is a horizontal sectional view taken substantially along the line **3—3** of FIGURE 2;

FIGURE 4 is a vertical sectional view taken substantially along the line **4—4** of FIGURE 3;

FIGURE 5 is a fragmentary vertical sectional view taken substantially along the line **5—5** of FIGURE 3;

FIGURE 6 is a fragmentary vertical sectional view taken substantially along the line **6—6** of FIGURE 3;

FIGURE 7 is a fragmentary sectional view taken substantially along the line **7—7** of FIGURE 6; and

FIGURE 8 is an exploded perspective view showing a bushing member and a spacer member which comprise components of the apparatus of FIGURE 3 and which cooperate to define passages for conducting by-pass fluid to be recirculated to a supply container.

Now, in order to acquaint those skilled in the art with the manner of making and using my invention, I shall describe, in conjunction with the accompanying drawings, certain preferred embodiments of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings, FIGURE 1 is a schematic view showing a supply vessel **20** for containing a supply of paint or other fluid coating material, a manifold body **22** having a pair of check valves **24** and **26** therein, a suction tube **28** extending from the manifold body **22** into the supply vessel **20**, an electric pump motor

30, and a pump piston rod 32 which reciprocates in a bore 34 formed in the manifold body 22. It will be understood that the electric motor 30 acts through a pulley 36, belt 38, pulley 40, crank hub 42 and connecting rod 44 to reciprocate the piston 32 back and forth in the bore 34.

The piston rod 32 rides in a bushing 46, and the low pressure area to the right of the bushing as shown in FIGURE 1 is sealed from atmosphere by means of a packing 48. The system shown in FIGURE 1 further includes a spray gun 50, a return line 52 which extends from the manifold body 22 back to the supply vessel 20, a manual pressure relief valve 54 in the return line 52, a by-pass line 56 which leads from the manifold body 22 through an area between the bushing 46 and the packing 48 and then by means of an extension 56' returns to the supply vessel 20, a by-pass valve 58, and an accumulator piston 60 which controls the by-pass valve 58 in response to the pressure developed at the piston 60 and spray gun 50.

In a hydraulic system of the foregoing type, the apparatus may be operated by first opening the pressure relief valve 54, and then starting the pump motor 30 so as to reciprocate the piston rod 32. Fluid material to be sprayed such as paint or the like will then be drawn up through the suction tube 28 past the inlet check valve 26 on the rearward or suction stroke of the piston, and on the forward or compression stroke of the piston the fluid material will be forced past the upper check valve 24 and through the return conduit 52 back to the supply vessel 20. The pressure relief valve 54 is then manually closed thereby causing the fluid material delivered by the pump to pass to the spray gun 50 and also to act against the accumulator piston 60.

When the spray gun 50 is not operating, i.e., the valve thereof is closed, the pressure will build up at the gun and at the accumulator piston 60 until the resultant movement of the latter is of a predetermined magnitude sufficient to open the by-pass valve 58. It will be understood that the pressure at which the by-pass valve 58 will open is determined by adjustable control means not described herein. Thus, when a desired predetermined pressure is developed at the spray gun 50, the by-pass valve 58 will be opened automatically, whereupon fluid material discharged by the pump piston 32 will be circulated through the low pressure by-pass line 56 and will thus be returned to the supply vessel 20.

When the by-pass valve 58 is opened, the by-pass line 56 establishes communication between the ball valve 24 and a location which is at a very low or approximately atmospheric pressure, and thus the fluid under high pressure, e.g. 2000 p.s.i., at the spray gun 50 and accumulator piston 60 will cause the valve 24 to close thereby preventing loss of pressure at the piston 60 and at the spray gun 50 until such time as the gun is triggered. Thus, a desired predetermined high pressure will be maintained at the gun 50, and yet the pump operates simply to circulate fluid material at substantially no pressure head through the unrestricted by-pass line 56, whereby the motor 30 will simply idle. When the spray gun 50 is operated, the pressure and volume accumulated at the gun and at the accumulator piston 60 are immediately available for supplying the spray gun requirements, and as the accumulator piston 60 is gradually returned toward its original position by spring means 61, the by-pass valve 58 is closed, whereupon the pump 32 will build up pressure at the upper ball valve 24 and again deliver fluid material directly to the spray gun at the desired pressure.

It will be understood that the by-pass system is operative not only when the spray gun 50 is shut off, but also during a spraying operation at any time the pressure at the gun and at the accumulator shaft 60 reaches a predetermined desired pressure in accordance with adjustable control means (not shown) which determines the amount of movement of the accumulator shaft 60 required to actuate the by-pass valve 58. Thus, where the capacity of the pump 32 exceeds the capacity of the spray gun nozzle (not shown), the excess capacity of the pump is diverted through the by-pass 56 while maintaining the approximate desired discharge pressure at the spray gun 50 at all times. A hydraulic system of the foregoing type is described in greater detail in my copending application, Ser. No. 535,424, although the number and arrangement of the inlet check valves, the path of travel of the by-pass line, and certain other specific features as described in the copending application do not correspond with the apparatus of the present invention.

FIGURE 2 illustrates the manifold body 22 in greater detail and there is shown a vertical bore 62 in which a check valve assembly 64 including the valves 24 and 26 is removably positioned. A passage 66 communicates with the bore 62 above the position of the upper ball valve 24 and extends downwardly to a chamber 68. The chamber 68 is connected by a passage 70 to a bore 72 in which the accumulator piston 60 is disposed, and the chamber 68 is also in communication with a conduit 74 to which the spray gun 50 is connected. A further conduit 76 in communication with the chamber 68 is for connection with the return hose 52, while the outer end of the chamber 68 is closed by means of a plug 78.

It will now be understood that when the pump delivers fluid material under pressure past the upper check valve 24, the fluid will pass through the conduit 66 to the chamber 68 and will be supplied to the spray gun 50, the accumulator piston 60 and the return hose 52. It will further be seen that the by-pass line 56 communicates with the bore 62 between the inlet valves 24 and 26, and fluid will be pumped through the by-pass line by the pump piston 32 whenever the by-pass valve 58 is open. FIGURE 7 shows the manner in which the by-pass conduit 56 extends along an upwardly inclined path from the bore 62 to a generally horizontal passage 80, and as shown in FIGURE 6 the horizontal passage 80 communicates with a generally vertical passage 82. At the outer end of the horizontal passage 80 there is provided a seat 84 to accommodate the by-pass valve 58, and thus when the by-pass valve is closed it seals the upper end of the by-pass conduit 58 and prevents the same from communicating with the passage 80.

FIGURE 3 shows that the vertical passage 82 communicates with a passage 86 which extends generally toward the bushing 46 in which the pump piston 32 reciprocates, and FIGURE 6 shows that the lower end of the passage 82 beyond the end of the passage 86 is closed by a plug 88. Referring now to FIGURES 3 and 8, the bushing 46 is a generally cylindrical member preferably made of a ceramic material and having a bore 90 therein to receive the piston rod member 32. The bushing 46 is also provided at its periphery with a pair of oppositely disposed generally semicircular grooves 92 and 94 which as will be seen more fully hereinafter constitute fluid passageways. In addition, a further groove 96 is formed at the top of the periphery of the bushing 46 to receive a roll pin or the like to be described later herein.

In association with the bushing 46 there is provided a spacer member 98 which is a relatively thin generally disc-shaped member having a central bore 100 to accommodate the piston rod 32 and having a groove 102 formed in its periphery for alignment with the groove 96 in the bushing 46. In addition, the spacer 98 has a circular recess 104 formed in the face thereof facing the bushing 46, the recess being generally concentric with the bore 100 and being substantially larger in diameter than the latter. A pair of generally radial recessed slots 106 and 108 are formed in the face of the spacer 98 and extend from the circular recess 104 to the periphery of the spacer.

Referring again to FIGURE 3, a sleeve 110 is externally threaded at one end 112 and internally threaded at its opposite end 114. The sleeve end 112 is mounted in a threaded counterbore 116 formed in the manifold body 22 concentric with the piston bore 34. The bushing 46 is positioned in the sleeve 110 so as to rest against the base

of the counterbore **116**, and the spacer **98** which also fits over the piston rod **32** is located so that the face having the recess **104** and the slots **106** and **108** is abutted against the low pressure side of the bushing. The bushing **46** is oriented so that the peripheral groove **92** therein is aligned with the end of the fluid passage **86** formed in the manifold body **22**, whereby the oppositely disposed peripheral groove **94** will be aligned with a fluid passage **118** which is formed in the manifold body **22** and as shown in FIGURE 5 communicates with a vertical passage **120**. The passage **120** is connected to suitable hose means, such as shown at **56'** in FIGURE 1, which leads back to the supply vessel **20**. The bushing **46** and spacer **98** are held in the foregoing positions by a roll pin or the like **122** (see FIGURE 4) which fits in the grooves **96** and **102** in the bushing and spacer respectively and extends into a suitable bore (not shown) formed in the manifold body **22** at the base of the counterbore **116**.

Outwardly of the spacer **98** an adapter **124** is positioned over the piston rod **32**, and the packing **48** and a second adapter **126** are also mounted over the piston rod, the two adapters and the packing all being disposed within the inner diameter of a retainer **128**. The retainer **128** is threaded into the outer end **114** of the sleeve **110** so as to hold the spacer **98** in position, and a screw **130** is threaded into the end of the retainer **128** so as to hold a compression spring **132** in engagement with the adapter **126**. Consequently, the spring **132** compresses the packing **48** between the adapters **124** and **126**, and the packing serves to seal the low pressure side of the bushing **46** from atmosphere.

As previously stated, the piston rod **32** reciprocates in the bore **34** formed in the manifold body **22**, and as described in conjunction with FIGURE 1 it supplies paint or other fluid coating material to the spray gun **50** at a relatively high pressure, i.e., between 1000 p.s.i. and 3000 p.s.i. An important feature of the present invention relates to provision of a sealing system so as to maintain such high pressures while at the same time maintaining the efficiency of the pump piston **32**. In accordance with the present invention, the dimensions of the piston rod **32** and the bushing **46** are determined so as to permit a controlled leakage of fluid material which serves to lubricate the bushing.

As stated earlier herein, I have found that if the clearance between the piston rod and the bushing is too small, certain spray materials such as paint pigment when it works its way through the piston rod and bushing will break down and be ground up which can result in the piston rod freezing in the bushing. In accordance with the present invention, a clearance is provided between the bushing and the piston rod which is purposely made large enough so that any paint pigment which works its way through the clearance will not be ground up or otherwise caused to deteriorate. On the other hand, it is not desirable to make the clearance substantially larger than necessary since an unduly large clearance will reduce the efficiency of the pump.

One example of a preferred embodiment of the present invention comprises the combination of a ceramic bushing having an inner diameter of 0.5000 inch and a ceramic piston rod having an outer diameter of 0.4992 inch, thereby providing a total diametral clearance of 0.0008 inch. In accordance with the invention, it is preferred that the total diametral clearance be maintained in the approximate range of 0.0005 inch to 0.0015 inch. These values represent the initial diametral clearance or the difference between the outer diameter of the piston rod and the inner diameter of the bushing as manufactured. During usage the clearance between the piston rod and the bushing will gradually increase due to wear, and these components will ultimately have to be replaced.

Because a controlled leakage of paint or other fluid coating material past the piston rod **32** and bushing **46** is purposely permitted, it is a further feature of the invention to provide means for carrying such leakage material back to the supply vessel **20**. As previously described in conjunction with FIGURE 1, the by-pass valve **58** will open whenever the pressure at the spray gun **50** and accumulator piston **60** reaches a predetermined value. Thus, the by-pass valve **58** will open whenever the spray gun **50** is shut off, and it will normally be opened intermittently during operation of the spray gun.

As also described earlier herein, when the by-pass valve **58** is open, fluid which is delivered to the by-pass passage **56** will flow up to the horizontal passage **80** and then down the passage **82** (see FIGURE 6) to the passageway **86**. Referring again to FIGURE 3, it will now be understood from FIGURES 3 and 8 that the by-pass fluid flows from the passage **86** into the groove **92** formed in the side of the bushing **46** and then through the radial slot **106** into the recess **104** formed in the spacer **98**. The fluid thus flows through the recess **104** and around the piston rod **32**, through the radial slot **108** and into the groove **94** formed in the opposite side of the bushing **46**. Thereafter, the by-pass fluid passes into the passageway **118** and then through the passage **120** to a return hose or the like such as shown at **56'** in FIGURE 1 whereby the by-pass fluid is returned to the supply vessel **20**.

It is important to note that the fluid such as paint or other coating material which is permitted to leak from the high pressure area between the piston rod **32** and bushing **46** will pass into the recess **104** which is formed in the spacer **98** and is located immediately adjacent the face of the bushing **46**. Thus, the recess **104** defines a low pressure area which is sealed from atmosphere by the packing **48** and which receives the fluid which leaks through the piston rod and bushing. Accordingly, it will be seen that the by-pass fluid passes directly through the recess **104** where the leakage material tends to accumulate and thus mixes with such leakage material and returns the same to the supply vessel **20**.

It will be understood that even though the by-pass valve **58** is not always open so as to permit continuous flow of fluid through the by-pass circuit, such valve will in normal operation be open frequently and will permit more than enough fluid to flow through the by-pass line so as to flush out any leakage material from the area **104** adjacent the bushing **46**. It will of course further be understood that the amount of leakage material which works its way between the piston rod **32** and bushing **46** for a given diametral clearance will depend upon the type of fluid material being utilized. For example, where the fluid is a relatively viscous outside house paint, the volume of leakage material will be substantially less than where the apparatus is being used with a clear lacquer or stain. Due to the controlled leakage, the high pressure seal, i.e., the ceramic bushing **46**, is continuously lubricated by the paint or other coating material being sprayed.

In the preferred embodiment of the present invention, the piston rod **32** and the bushing **46** are made of ceramic material. However, various other materials can be used within the scope of the invention. Such other materials should be harder than the pigments in any paint which is used in such apparatus and preferably should have a hardness in excess of Rockwell C65.

While I have described my invention in certain preferred forms, I do not intend to be limited to such forms, except insofar as the appended claims are so limited, since modifications within the scope of my invention will readily occur to those skilled in the art, particularly with my disclosure before them.

I claim:

1. In a hydraulic system of the type including reciprocating piston rod means made of ceramic material which functions as a pump to draw fluid from a supply vessel and deliver the fluid at a high pressure to manifold means,

the improvement comprising, in combination, bushing means made of ceramic material in which said piston rod means reciprocates, said bushing means defining a high pressure area on one side thereof and a low pressure area on the other side thereof whereby fluid which leaks past said bushing means from said high pressure area will tend to accumulate in said low pressure area, and a low pressure by-pass conduit connected to said manifold means for diverting a portion of the fluid delivered by said pump and returning the same to said supply vessel, said by-pass conduit being connected with said low pressure area whereby fluid material which leaks past said bushing means into said low pressure area will be flushed away by the fluid flowing through said by-pass conduit and returned to said supply vessel.

2. The invention of claim 1 including sealing means for sealing said low pressure area from atmosphere.

3. The invention of claim 1 where the diametral clearance between said piston rod means and said bushing means is at least 0.0005 inch so as to provide for a controlled leakage of fluid material past said bushing means into said low pressure area.

4. The invention of claim 1 where the diametral clearance between said piston rod means and said bushing means is in the approximate range of 0.0005 inch to 0.0015 inch.

5. The invention of claim 1 including means disposed at the low pressure side of said bushing means which together with said bushing means defines said low pressure area, said low pressure area being immediately adjacent a face of said bushing means and extending around the entire circumference of said piston rod means.

6. In a hydraulic system of the type including reciprocating piston rod means made of ceramic material which functions as a pump to draw fluid from a supply vessel and deliver the fluid at high pressure to manifold means, the improvement comprising, in combination, bushing means made of ceramic material defining a high pressure area on one side thereof and a low pressure area on the other side thereof whereby fluid which leaks past said bushing means from said high pressure area will tend to accumulate in said low pressure area, the diametral clearance between said piston rod means and said bushing means being in the approximate range of 0.0005 inch to 0.0015 inch so as to provide for a controlled leakage of fluid material past said bushing means into said low pressure area, sealing means for sealing said low pressure area from atmosphere, means disposed at the low pressure side of said bushing means which together with said bushing means defines said low pressure area, said low pressure area being immediately adjacent a face of said bushing means and extending around the entire circumference of said piston rod means, and a low pressure by-pass conduit connected to said manifold means for diverting a portion of the fluid delivered by said pump and returning the same to said supply vessel, said by-pass conduit being connected with said low pressure area whereby fluid material which leaks past said bushing means into said low pressure area will be flushed away by the fluid flowing through said by-pass conduit and returned to said supply vessel.

7. In a hydraulic system of the type including pump means which draws fluid from a supply vessel and acts directly on such fluid to deliver the same at high pressure, the improvement comprising, in combination, reciprocating piston rod means made of ceramic material, manifold means having a bore therein for receiving one end of said piston rod means, and a bushing made of ceramic material having a bore therein for receiving said piston rod means, said bushing defining a high pressure area on one side thereof and a low pressure area on the other side thereof and serving substantially as a seal therebetween, the diametral clearance between said piston rod means and said bushing being in the approximate range of 0.0005 inch and 0.0015 inch so as to provide a small controlled leakage of fluid from said high pressure area past said bushing to lubricate the latter.

References Cited

UNITED STATES PATENTS

2,330,781	9/1943	Langmyhr et al.	103—204
2,410,947	11/1946	Johnson	103—41
2,485,208	10/1949	Longenecker	103—204
2,500,719	3/1950	Ungar	103—204 X
2,672,014	3/1954	Yarger	103—41 X
2,768,587	10/1956	Corneil	103—204 X
2,931,314	4/1960	Erikson et al.	103—41 X
3,091,186	5/1963	Hofmeister et al.	103—204
3,104,619	9/1963	Swarthout	103—204
3,143,969	8/1964	Eames et al.	103—202 X
3,253,882	5/1966	Deackoff	103—204 X

DONLEY J. STOCKING, Primary Examiner

WARREN J. KRAUSS, Assistant Examiner

U.S. Cl. X.R.

103—41