FLUID PRESSURE AMPLIFIER

Filed Feb. 19, 1968 2 Sheets-Sheet 1

Fig. 1.

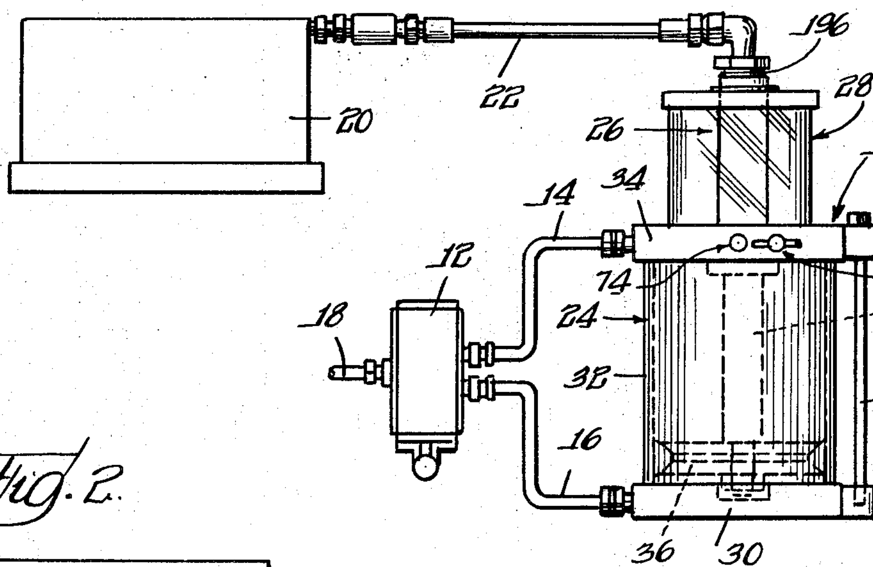


Fig. 2.

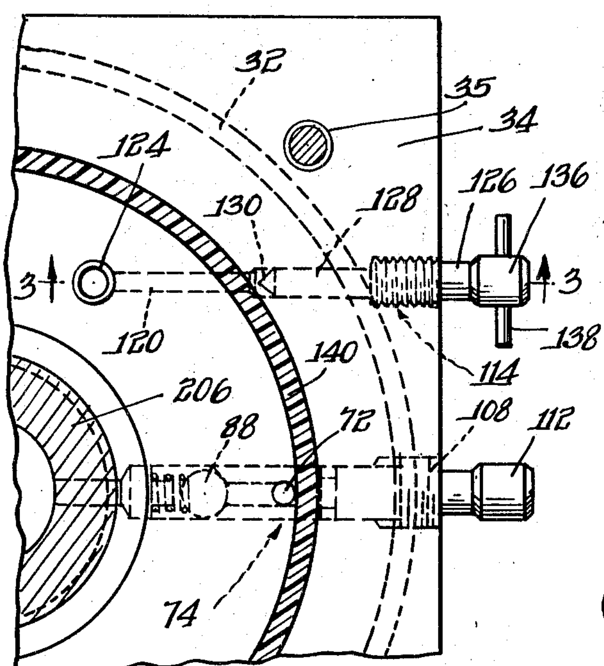


Fig. 3.

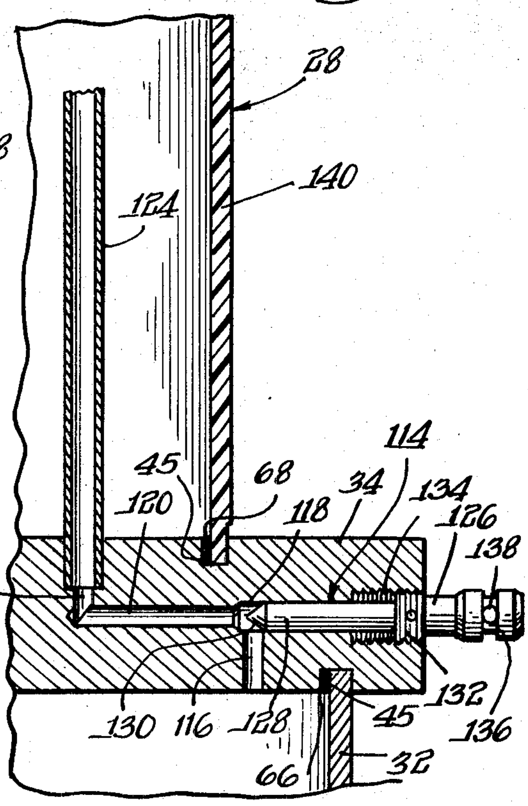
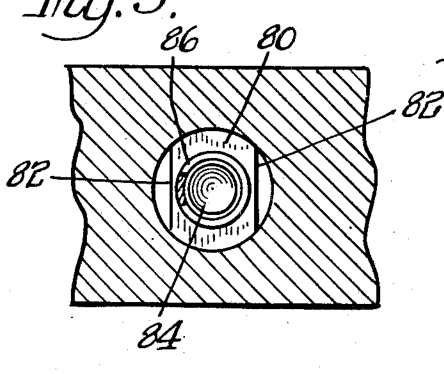


Fig. 5.



Inventor
John T. Ellis, Jr
By: Stone, Zummer & Livingston attys

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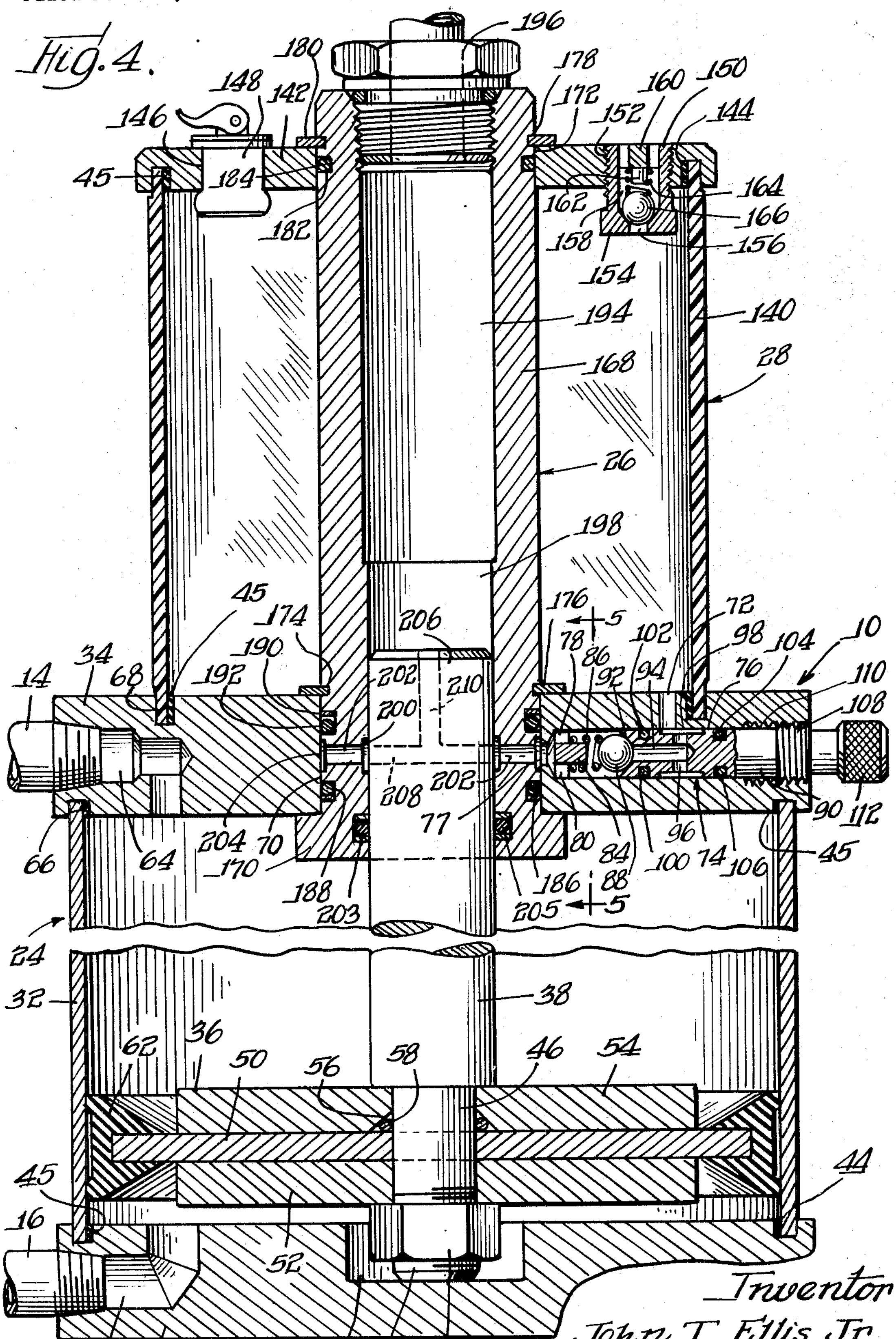
Fig. 4.



Inventor
John T. Ellis, Jr.
By: Stone, Zummer & Livingston attys.

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3,541,792

FLUID PRESSURE AMPLIFIER

John T. Ellis, Jr., Chicago, Ill., assignor to Ellis Engineering, Inc., Chicago, Ill., a corporation of Illinois

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U.S. Cl. 60—54.5 12 Claims

ABSTRACT OF THE DISCLOSURE

This fluid pressure amplifier utilizes air at low pressure to deliver hydraulic fluid at a high pressure. The amplifier includes a relatively large diameter air cylinder, a relatively small diameter hydraulic fluid cylinder, and a piston reciprocally mounted in the air cylinder having a rod which is formed integral with the piston in the hydraulic cylinder. A reservoir is mounted concentric with the hydraulic cylinder, and a hydraulic fluid flow path is provided to deliver hydraulic fluid from the reservoir to the hydraulic cylinder to replenish leaked hydraulic fluid.

BACKGROUND OF THE INVENTION

It is well recognized in machine shops that hydraulically operated work holding devices and other such pieces of equipment may be utilized to increase the efficiency of the overall operation of a machine shop. Many machine-shops, and especially, smaller machine shops, do not have the necessary facilities for providing high pressure hydraulic fluid at a variety of locations so that work holding devices and other such pieces of equipment may not be quickly and readily installed and used in a plurality of positions. Customarily, machine shops have available air compressors, and compressed air lines are usually positioned at convenient locations. Compressed air, as such, is used for numerous applications, from cleaning metal chips from work pieces to operating low pressure devices.

Recognizing the fact that most machine shops have compressed air readily available, and it is desirable to provide hydraulic fluid at a high pressure for specific applications, many conversion devices have been developed wherein the low pressure air is utilized to develop a high pressure hydraulic fluid. Many of these devices have a problem in that the hydraulic devices are customarily used in repetitive activities, and seals, in many instances, are not perfect so that there is a slight leakage of hydraulic fluid. Thereby, some of the hydraulic fluid is lost, which creates inefficiencies in the operation of the hydraulic device. In some instances, the stroke of the device is diminished for lack of hydraulic fluid. A more common problem is that as the hydraulic device is being used, at one portion of the stroke there is insufficient hydraulic fluid to fill the space, thereby creating a partial vacuum which tends to suck air into the system, thereby making the system compressible and seriously limiting the force which may be generated by the hydraulic device.

SUMMARY OF THE INVENTION

The instant fluid amplifier includes a relatively large air cylinder with a piston reciprocally mounted in the cylinder. The cylinder is a double acting cylinder so that there is positive displacement of the piston in both directions. A rod is connected to the cylinder and the rod extends into a small diameter, high pressure hydraulic cylinder. A high pressure piston is formed integral with the rod, which high pressure piston is reciprocally mounted in the hydraulic cylinder. A hydraulic fluid reservoir surrounds the hydaulic cylinder, and a flow path is provided from the reservoir to the hydraulic cylinder with a valve in the flow path to control the flow of hydraulic fluid from the reservoir to the hydraulic cylinder

to replenish leaked hydraulic fluid and to prevent the flow of hydraulic fluid from the cylinder back to the reservoir. The return side of the air cylinder is connected to the reservoir so that air under pressure is delivered to the reservoir to force hydraulic fluid from the reservoir into the high pressure cylinder as the high pressure piston is returned. It is therefore a principal object of this invention to provide a fluid pressure amplifier wherein the hydraulic fluid is self-filling at the end of each stroke to make up any hydraulic fluid which is lost by leakage.

It is a further object of the instant invention to provide an improved fluid pressure amplifier wherein the air pressure utilized to return an air piston is also utilized to force hydraulic fluid into the hydraulic system.

It is another object of the present invention to provide an improved cylinder construction wherein an elastic seal conforms to a tube end and a portion of a head.

It is a still further object of the herein-disclosed invention to provide an improved construction of a fluid pressure amplifier which is economical to manufacture and easy to maintain.

Other objects and uses of the present invention will become readily apparent to those skilled in the art upon a perusal of the following specification in light of the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side-elevational view of a pressure system showing a hydraulically operated work holding device connected to a fluid pressure amplifier embodying the herein-disclosed invention;

FIG. 2 is an enlarged fragmentary cross-sectional view through a reservoir portion of the fluid amplifier shown in FIG. 1;

FIG. 3 is an enlarged cross-sectional view taken on line 3—3 of FIG. 2 showing the construction of an air flow path from the air cylinder to the reservoir and the construction of an air pressure control valve;

FIG. 4 is an enlarged fragmentary cross-sectional view of the fluid pressure amplifier shown in FIG. 1; and

FIG. 5 is an enlarged cross-sectional view taken on line 5—5 of FIG. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, and especially to FIG. 1, FIG. 1 shows a fluid pressure amplifier generally indicated by numeral **10**, which fluid pressure amplifier embodies the instant invention. The fluid pressure amplifier is connected to an air control valve **12** through pipes **14** and **16**. Valve **12** is connected by an air line **18** to a conventional source of air under pressure, which source is not shown herein. The fluid pressure amplifier is connected to a hydraulic work holding device **20** by means of a conventional hydraulic line **22**.

The construction of the fluid pressure amplifier **10** may be best seen in FIG. 4. The fluid pressure amplifier generally includes a large diameter air cylinder **24** connected to an oil pump or a small diameter, high pressure hydraulic cylinder **26**. It may be seen that the longitudinal axis of cylinder **24** is aligned with the longitudinal axis of cylinder **26**. A reservoir **28** is mounted on top of the air cylinder and surrounds the hydraulic cylinder **26** so that the reservoir is concentric with the cylinder **26**.

The low pressure air cylinder **24** generally includes a base head **30**, a tube **32** and a control head **34**, which parts are held together by conventional tie rods **35**. Mounted in the tube **32** is a piston **36** which is connected to a rod **38**. The base head **30** includes an air inlet port **40** to which is connected the pipe **16**. The head includes recess **42** in its center and a groove **44** into which is mounted the tube **32**.

Tube **32** is not sealed to head **30** by a conventional gasket but rather by a room temperature vulcanizing silicone rubber compound **45** which conforms to the end of the tube and a portion of the head. It may be seen that there is no need to provide any additional fine machining of the tube end or the head other than cutting the groove in the head. In this instance, the elastic rubber compound is Silastic caulk manufactured and sold by Dow Corning Corporation of Midland, Mich. However, other manufacturers such as General Electric Company also manufacture and sell like compounds under their own brand names. When the tube is assembled to the head, a quantity of sealing compound in a high viscosity liquid form is layed in the groove. The tube is then placed in the groove and the sealing compound flows around the tube end and conforms to the groove and the tube end. The compound is allowed to cure so that the compound conforms in detail to the head and the tube end and becomes solid having an elastic rubberlike consistency. Any excess sealing compound may be cut away. It may be appreciated that the liquidity of the compound at application allows the material to flow into spaces so that any small errors in machining do not have any effect in the sealing between the head and the tube. Once the sealing compound is cured, the elasticity of the compound creates a seal which improves with sealing ability as fluid pressure is applied to the seal and the composition is held securely in position by its mechanical configuration since it conforms in detail to the groove and the tube end.

The rod **38** has a reduced section **46** with a threaded end **48**. The piston **36** includes a piston plate **50** which is mounted on reduced section **46**. A lower backup plate **52** is also mounted on the section **46** adjacent to piston plate **50**. An upper backup plate **54** is mounted adjacent to piston plate **50** and in engagement with the rod **38**. The piston plate **50** has a chamfer **56**, and an O-ring **58** is mounted between the piston plate **50** and piston backup plate **54** and in engagement with the reduced section **46** to provide a seal between the parts. A conventional nut **60** is threadedly mounted on the threaded section **48** to hold the piston onto the rod **38**. The piston is completed by a piston seal **62** which is molded integrally with the outer periphery of piston plate **50** and in sealing engagement with the interior of tube **32**.

The control head **34** includes an air inlet **64** which is connected to pipe **14**. The head includes a groove **66** into which is mounted the tube **32** and sealing compound **45** provides a seal therebetween. A reservoir groove **68** receives a portion of the reservoir **28**. The control head includes a cylinder aperture **70** wherein the oil pump or high pressure cylinder **26** is mounted. Means is provided in the control head to allow hydraulic fluid to flow from the reservoir **28** to cylinder **26**. The control head includes an axial aperture **72** which is connected to an oil control valve **74**. The oil control valve is mounted in an oil valve aperture **76** in head **34**, and the oil valve aperture terminates in a reduced oil port **77**.

Oil control valve **74** includes a spring guide **78** which has a generally cylindrical head **80** with a pair of opposed flats **82**, so that oil may flow past the spring guide. Formed integral with the head **80** is a spring shank **84**, and a coil spring **86** is mounted on the spring shank. A conventional ball **88** is mounted in the aperture **76** in engagement with spring **86**. The ball also engages a valve body **90**. The valve body **90** includes a ball seat **92** at one end sealingly engageable with ball **88**. A longitudinal port **94** extends through a portion of the valve body and opens into a lateral port **96**. The valve body contains an enlarged oil groove **98** which communicates with both the axial aperture **72** and lateral port **96**. The valve body also includes an inner oil ring groove **100** into which is positioned an O-ring **102** in sealing engagement with the valve body and the head **34**. An outer groove **104** in the valve body has positioned therein an O-ring **106** also in sealing engagement with the valve body and head **34**. An enlarged

threaded portion **108**, which also forms part of the valve body, is in threaded engagement with a female threaded section **110** of the oil valve aperture **76**. A knob **112** is formed integral with the threaded portion to form a convenient means for turning the valve body to adjust the axial position of the valve body relative to the head to control the flow of hydraulic fluid through the valve. By moving the valve body axially until ball **88** is held firmly between ball seat **92** and spring shank **84**, valve **74** is effectively closed so that no hydraulic fluid may flow to cylinder **26**.

Looking now to FIG. 3, means connecting the low pressure cylinder with the hydraulic fluid reservoir and the construction of an air control valve **114** may be seen therein. The valve **114** controls the flow of air from the air cylinder **24** to the reservoir for forcing the hydraulic fluid into cylinder **26**. The head **34** includes an air port **116**, which opens into an air valve aperture **118**. The air valve aperture **118** opens into a radial air port **120**, which in turn opens into an inner air port **122**. The inner air port **122** opens into a riser pipe **124** which extends up into reservoir **28**. The valve **114** includes a body **126** with a stem **128** positioned in air valve aperture **118**. The stem **128** includes a conical valve **130** which is seatable in radial air port **120**. The valve body **126** also includes an enlarged threaded portion **132** which mates with an enlarged female threaded portion **134** of the air valve aperture **118**. A head **136** with a cross-pin **138** fixed therein is fixed to body **126** to provide a convenient means grasping the extending portions of the valve for rotating the valve body and thereby adjusting the rate of flow of air through the radial air port **120**. It is apparent that valve **114** may be selectively closed by seating conical valve **130** in radial air port **122**.

Looking back to FIG. 4, it may be seen that the reservoir **28** includes a transparent cylindrical tube **140** which has one end sealingly mounted in groove **68** of the control head **34**, and sealing compound **45** provides the necessary seal means therebetween as described above. A reservoir head **142** has a groove **144** which receives the upper end of tube **140**, and sealing compound **45** provides a seal therebetween. The reservoir head **142** includes a filling aperture **146** which has a conventional plug **148** sealingly mounted therein. A relief valve **150** is mounted in a threaded relief valve aperture **152** in head **142**. The relief valve **150** includes a relief valve body **154** having a port **156** communicating with a ball aperture **158** which has a ported plug **160** mounted therein. The ported plug **160** includes a stud **162** which has a ball spring **164** positioned thereon and the ball spring engages a conventional ball **166** to hold the ball in engagement with the valve body **154** and thereby close the port **156**.

The high pressure hydraulic cylinder includes a tube or sleeve **168** which has a flange **170** formed integral therewith, and the sleeve has one end positioned in aperture **70** with the flange **170** abutting the interior portion of head **34**. The other end of sleeve **168** is positioned in an aperture **172** of head **142**. The sleeve has an inner lock groove **174** which has mounted therein a lock ring **176** to hold the sleeve in position relative to control head **34**. The sleeve has an outer lock groove **178** which has positioned therein a lock ring **180** to hold the head **142** relative to the sleeve and thereby, relative to the head **34**. The sleeve also has an outer sealing groove **182** with an O-ring **184** positioned therein and in sealing engagement with the head **142** to form a seal therebetween. Sleeve **168** also includes a sealing groove **186** which has an O-ring **188** positioned therein to provide a seal between the sleeve and the head **34**. A reservoir seal groove **190** is formed in the sleeve, and an O-ring **192** is positioned therein to form a second seal between the sleeve and head **34**.

Sleeve or tube **168** is ported and grooved in order to allow oil to flow into the interior section of the sleeve. Sleeve **168** has an enlarged interior section **194** which has mounted in one end a conventional fitting **196**. In the other end of section **194**, there is a reduced high tolerance sliding portion **198** which mates with rod **38**. An inner groove **200** is formed in portion **198**, which groove communicates with a plurality of lateral ports **202**. The lateral ports **202** communicate with an outer groove **204**, a portion of which communicates with port **77**. A seal groove **203** is formed in the interior of tube **168** with an O-ring **205** mounted therein to provide a seal between the tube and rod **38**.

The cylinder **26** includes a piston **206** which is formed integral with rod **38**. The piston **206** includes a radial oil port **208** and an axial oil port **210** which opens into the radial oil port and into the interior of sleeve **168**.

The operation of the instant fluid pressure amplifier is quite simple inasmuch as it is only necessary to operate valve **12** to actuate and deactuate the hydraulic device **20**. The air valve **12** is appropriately positioned so that air under pressure enters pipe **16** and flows through air inlet port **40**, to apply pressure to one side of piston **36**. As the piston moves toward head **34**, the hydraulic fluid in the enlarged interior section **194** is pushed out by virtue of the displacement of the hydraulic fluid by piston **206** and rod **38**. Thereby, the pressure of the hydraulic fluid is increased. When the appropriate pressure of the hydraulic device is attained, the pressure may be maintained by a continuous application of pressure to piston **36**.

In order to relieve the hydraulic pressure from hydraulic device **20**, valve **12** is manipulated so that the air on the side of the piston adjacent to head **30** is dumped through the valve and air under pressure is delivered to the opposite side of piston **36**; that is, in the space between piston **36** and head **34**, thereby retracting piston **206** and rod **38** from space **194**. It is important to note that the air under pressure is also delivered to the reservoir **28** when valve **114** is open inasmuch as the air flows through air port **116**, air valve aperture **118**, radial air port **120**, inner air port **122**, and riser pipe **124**. The level of hydraulic fluid in the reservoir is maintained below the riser pipe so that the air does not flow through the hydraulic fluid to contaminate the fluid. In the event that the air pressure in the reservoir is too great, the air pressure is automatically relieved through the pressure relief valve **150** in view of the fact that excessive air pressure would displace the ball **166** against the force of spring **164** to relieve the pressure in the reservoir and thereby avoid overstressing of transparent tube **140**.

The air pressure on the hydraulic fluid in the reservoir forces the hydraulic fluid to flow to cylinder **26** to replenish any leaked hydraulic fluid when valve **74** is opened. The hydraulic fluid under pressure flows through axial aperture **72** and then to enlarged oil groove **98**, then to lateral port **96** and on into longitudinal port **94**. The hydraulic fluid under pressure displaces ball **88** from seat **92**, then flows past the flats **82** of head **80** and through port **77** to outer groove **204** of the sleeve. The hydraulic fluid flows in groove **204** and into lateral ports **202** of the sleeve and into inner groove **200**. At this point, the hydraulic fluid in the reservoir is under pressure. However, it cannot flow inasmuch as it has no place to go. When the piston **36** reaches near the end of its return stroke, the radial oil port **208** of piston **206** is placed into communication with groove **200** so that the oil may flow through the axial oil port **210** and into the enlarged interior section **194**. It is apparent that in the event that there should be any leakage of hydraulic fluid in any portion of the system, it is automatically replenished at the end of each stroke.

The construction of the instant fluid pressure amplifier is such that the amount of oil flow from the reservoir may be simply and conveniently controlled by an adjustment of the oil control valve **74**. Also, the pressure which is applied to the oil in the reservoir may be controlled by an adjustment of air control valve **114**. Furthermore, there is no danger of an undue amount of pressure being placed on the fluid in view of the fact that the oil reservoir contains the relief valve **150**.

The subject fluid pressure amplifier allows the hydraulic fluid system to be purged simply and conveniently. The system is filled with hydraulic fluid and a bleed part at the top of the system as in the top of device **20** is opened. Air is applied to the return side of piston **36** while valves **74** and **114** are opened so that hydraulic fluid is forced through the system until clear hydraulic fluid flows out of the bleed part. The bleed part is closed and valves **74** and **114** are appropriately adjusted and the system is in condition for normal operation.

It may be appreciated that the instant fluid pressure amplifier may be filled while the device is in operation. It is only necessary to remove the plug **148** and pour additional hydraulic fluid into the reservoir through aperture **146**. It is readily apparent that the plug should not be removed when the oil in the reservoir is under pressure. It is also readily apparent that the instant fluid pressure amplifier may be used over protracted periods of time, even though there may be leaks in the hydraulic system, without stopping the ordinary operation of the device. The fluid may be added as needed by a very simple operation, and if the hydraulic fluid leaks out through the hydraulic device **20** or through leaks in the line **22**, the amount of lost hydraulic fluid is replaced at the end of each stroke, so that at no time is there any substantial partial vacuum in the line which would suck in air to contaminate the hydraulic system.

From the foregoing description, it may be seen that the instant device is economical to manufacture and simple to maintain. The maintenance of an appropriate level of hydraulic fluid in the reservoir is facilitated by virtue of the fact that the reservoir has a transparent outer wall so that the level of the hydraulic fluid may be readily and conveniently observed.

Although a specific embodiment of the instant invention has been shown and described in detail above, it is to be expressly understood that those skilled in the art may make various modifications and changes without departing from the spirit and scope of the invention. It is to be understood that the subject invention is limited only by the appended claims.

What is claimed is:

1. A fluid pressure amplifier comprising, in combination; a large diameter, low pressure pneumatic cylinder; said low pressure cylinder including a reciprocally mounted piston; a rod connected to said piston; a small diameter, high pressure hydraulic cylinder connected to the low pressure pneumatic cylinder; said high pressure cylinder including a reciprocally mounted high pressure piston connected to the rod; a hydraulic fluid reservoir; means connecting the fluid reservoir with the high pressure cylinder; and a valve for controlling the flow of hydraulic fluid from the fluid reservoir to the high pressure cylinder and preventing the flow of hydraulic fluid from the high pressure cylinder to the fluid reservoir.

2. A fluid pressure amplifier as defined in claim **1**, wherein the low pressure pneumatic cylinder and the high pressure hydraulic cylinder have a common head, the longitudinal axis of the low pressure pneumatic cylinder is aligned with the longitudinal axis of the high pressure hydraulic cylinder, the hydraulic fluid reservoir is concentric with the high pressure hydraulic cylinder and has a common longitudinal axis with the high pressure hydraulic cylinder, and one end of the hydraulic reservoir is defined by the common head between the low pressure pneumatic cylinder and the high pressure hydraulic cylinder.

3. A fluid pressure amplifier as defined in claim **2**, wherein the hydraulic fluid reservoir includes a cylindrical transparent wall defining an outer surface of the reservoir.

4. A fluid pressure amplifier as defined in claim 2, wherein the high pressure piston is formed integral with the rod and includes a hydraulic fluid flow path from the face of the piston to the side of the piston, said high pressure hydraulic cylinder includes a groove which communicates with the hydraulic fluid flow path when the high pressure piston is near the end of its return stroke, and said groove is connected to the valve.

5. A fluid pressure amplifier as defined in claim 1, including means connecting the low pressure pneumatic cylinder with the hydraulic fluid reservoir to provide a flow path for a pneumatic fluid from the low pressure pneumatic cylinder to the hydraulic fluid reservoir for forcing by fluid pressure hydraulic fluid from the fluid reservoir into the high pressure cylinder.

6. A fluid pressure amplifier as defined in claim 5, including a pressure relief valve in the fluid reservoir.

7. A fluid pressure amplifier a defined in claim 1, wherein the low pressure pneumatic cylinder includes a head having a circular groove formed in one side thereof, a cylindrical tube mounted in said groove, and an elastic composition positioned in said groove and conforming to the groove in the head and the tube to form an elastic seal therebetween.

8. A fluid pressure amplifier as defined in claim 1, wherein the high pressure piston is formed integral with the rod and includes a hydraulic fluid flow path from the face of the piston to the side of the piston, said high pressure hydraulic cylinder includes a groove which communicates with the hydraulic fluid flow path when the high pressure piston is near the end of its return stroke, said groove is connected to the valve, and including means connecting the low pressure cylinder with the fluid reservoir providing a flow path for a fluid from the low pressure cylinder for forcing hydraulic fluid from the fluid reservoir into the high pressure cylinder through the high pressure piston.

9. A fluid pressure amplifier as defined in claim 1, wherein the low pressure pneumatic cylinder and the high pressure hydraulic cylinder have a common head, and the longitudinal axis of the low pressure pneumatic cylinder is aligned with the longitudinal axis of the high pressure hydraulic cylinder.

10. A fluid pressure amplifier as defined in claim 1, wherein the high pressure piston is formed integral with the rod and includes a hydraulic fluid flow path from the face of the piston to the side of the piston, said high pressure hydraulic cylinder includes a groove which communicates with the hydraulic fluid flow path when the high pressure piston is near the end of its return stroke, and said groove is connected to the valve.

11. In a cylinder construction having a first head, a second head, and a tube between said heads, a piston reciprocally mounted within said tube between said heads, and a rod connected to the piston and extending through one of said heads, the improvement comprising, a groove in one of said heads having one end of the tube positioned in the groove, and a room temperature curing elastic composition positioned in and conforming to a portion of the groove and to the end of the tube to form an elastic seal between the tube and the head.

12. A fluid pressure amplifier comprising, in combination, a base head for a low pressure pneumatic cylinder, a cylindrical tube having one end sealingly connected to the base head, a control head sealingly connected to the other end of the tube, a low pressure pneumatic piston slidably mounted in the tube, a rod connected to the piston and extendable through the control head, a high pressure hydraulic tube sealingly mounted on the control head and having its longitudinal axis aligned with the longitudinal axis of the first-mentioned tube, means connected to the other end of the high pressure hydraulic tube for closing the end of the tube, a transparent cylindrical reservoir tube sealingly mounted on the control head and concentric with the high pressure tube, a reservoir head sealingly mounted in engagement with the reservoir tube and the high pressure tube, a relief valve mounted in the reservoir head, a high pressure piston formed integral with the rod and slidably mounted in the high pressure tube, a flow path in the high pressure piston from the face of the piston to the side wall of the piston, a groove in the interior surface of the high pressure tube, a port extending through the high pressure tube and communicating with the groove, a flow path through the control head from the fluid reservoir to the port in the high pressure tube, a valve mounted in the flow path to regulate the flow of hydraulic fluid from the fluid reservoir to the high pressure cylinder and to restrict the flow of hydraulic fluid from the high pressure cylinder back to the fluid reservoir, a second fluid flow path in the control head from the interior of the low pressure tube to the interior of the fluid reservoir, a riser mounted within the reservoir tube and connected to the second fluid flow path in the control head, and a second valve mounted in the second fluid flow path for controlling the flow of fluid from the interior of the low pressure tube to the interior of the reservoir tube, whereby pneumatic fluid under pressure in the interior of the low pressure tube flows into the interior of the reservoir tube to force hydraulic fluid through the first-mentioned fluid flow path to the interior of the high pressure cylinder through the piston.

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MARTIN P. SCHWADRON, Primary Examiner

R. R. BUNEVICH, Assistant Examiner

U.S. Cl. X.R.

60—54.6; 92—165, 169

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(5/69)

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,541,792 Dated November 24, 1970

Inventor(s) John T. Ellis, Jr.

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

Column 1, Line 69, "hydaulic" should be --hydraulic--

Column 6, Line 69, after "hydraulic" insert --fluid--

Column 7, Line 18, "a" should be --as--

SIGNED AND
SEALED
2 1971

Febuary 2, 1971

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLE
Commissioner of Pa