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R. H. DEITRICKSON
AIR PRESSURE CONTROL APPARATUS
FOR SURFACE HYDRAULIC PUMPS

2,726,512

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2 Sheets-Sheet 1

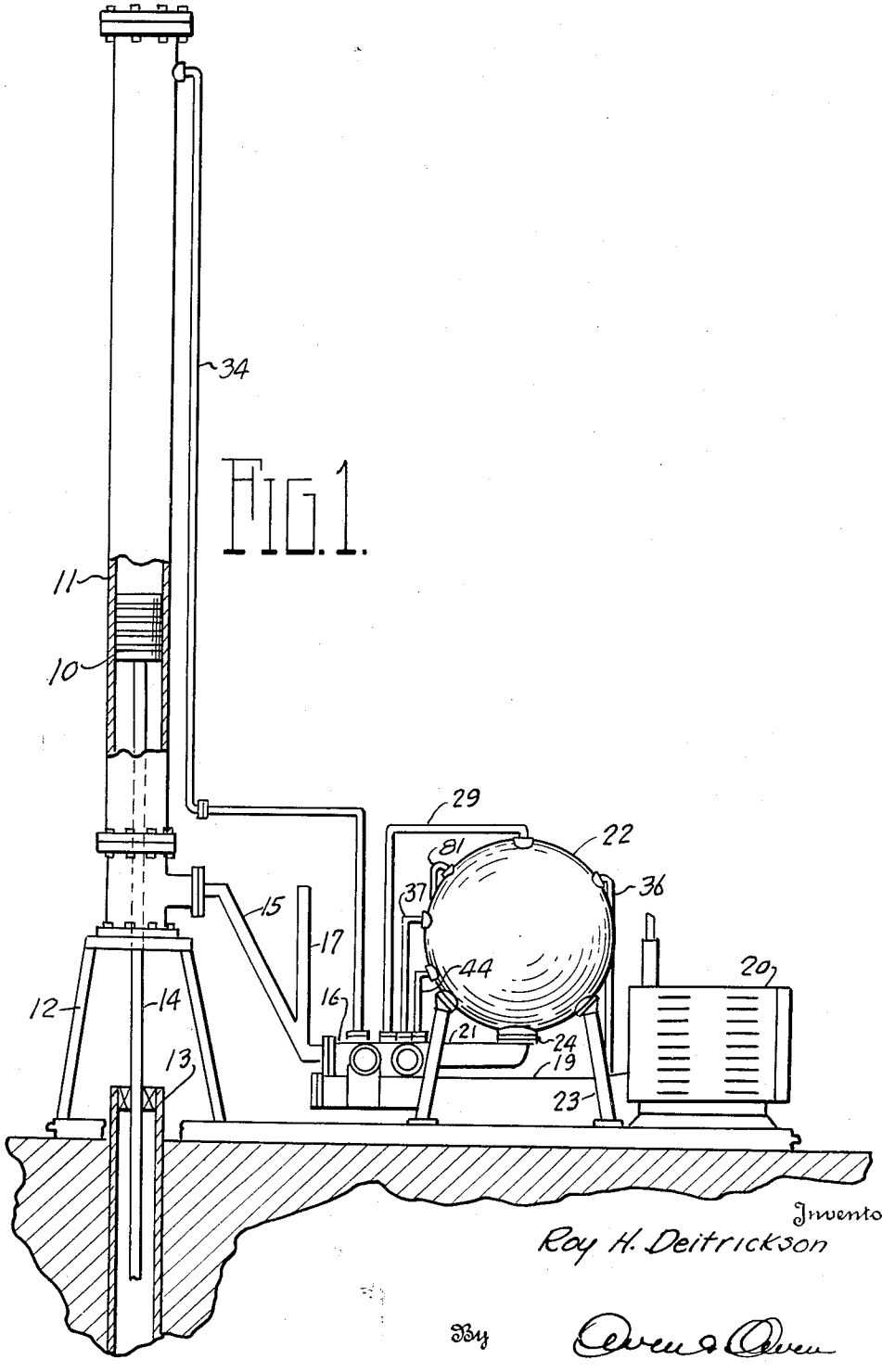


FIG. 1.

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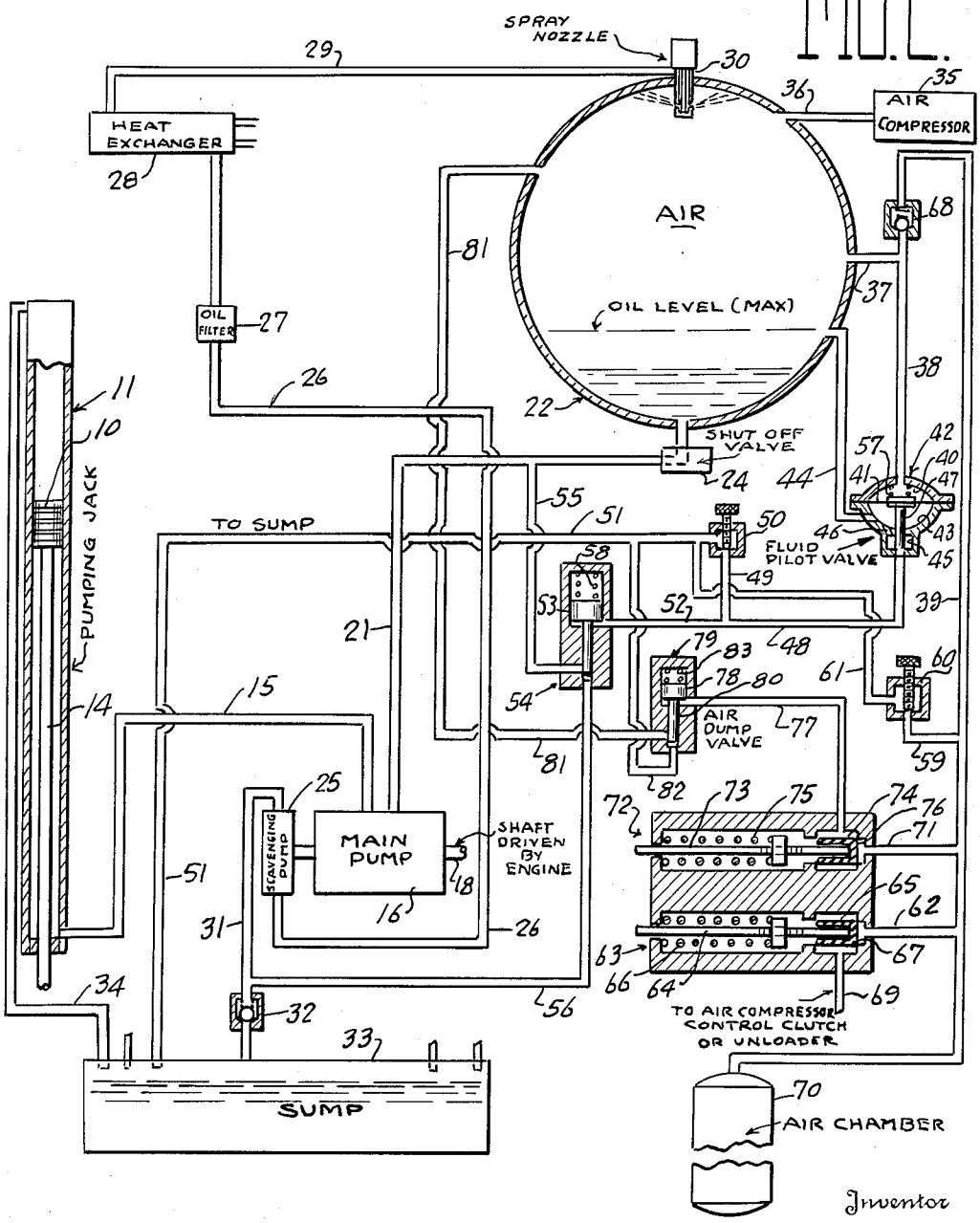
Attorneys

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FIG. 2.



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2,726,512

AIR PRESSURE CONTROL APPARATUS FOR SURFACE HYDRAULIC PUMPS

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Application May 13, 1953, Serial No. 354,689

9 Claims. (Cl. 60—51)

This invention relates to hydraulically actuated surface equipment for well pumps of the type frequently used in oil wells and, more particularly, to a hydraulic system by which a surface jack is activated for the vertical reciprocation of a pumping rod extending into a deep well, for example, an oil well.

A surface hydraulic apparatus includes a fluid motor or "jack" in which there is located a piston that is connected to a pump rod which usually extends downwardly from the pumping jack and is operatively linked to the sucker rod string extending down to the pump itself at the production area level. A hydraulic system for the introduction of working fluid under high pressure into the pumping jack to force the piston upwardly usually includes a main pump and an engine for driving the pump, a sump for providing a supply of working fluid, a so-called "counterbalancing tank" in which a volume of working fluid is kept under pressure for the storage of energy so that the load on the pump engine can be kept relatively constant during both up and down strokes and the necessary controls, valves and hydraulic lines properly to connect one part of the apparatus with the others.

In a system of this general type various control means must be provided for automatically controlling the connections between the various elements, the operation of the pump, and the proper pressures and volumes of both the working fluid and air within the system.

The instant invention has as its principal object the provision of automatic air pressure control means for controlling the pressure within the counterbalancing tank to compensate for the variations in such pressure resulting from variations in the volume of fluid in the tank and the temperature of the tank due to atmospheric temperature changes.

It is another object of this invention to provide air pressure control means for the counterbalancing tank of a surface hydraulic system having pressure actuated control means normally operative to control an air compressor employed to maintain the air pressure within the tank and provided with auxiliary means for bleeding air from the tank when the pressure therein rises above the normal operating level, said auxiliary means operating only after the air compressor control means has operated.

It is still another object of this invention to provide air pressure control means for the counterbalancing tank of a surface hydraulic system incorporating a relatively stable source of air pressure which follows the maximum pressure in the tank and not rapid fluctuations in tank pressure whereby "fluttering" of the air pressure control mechanisms is prevented.

Other and more specific objects and advantages of the invention will be better understood from the specification which follows and from the drawings, in which—

Fig. 1 is a simplified view, in elevation and on a very small scale, of a surface hydraulic apparatus for actuating the sucker rod of a down well pump, certain parts being shown in section.

Fig. 2 is a schematic hydraulic diagram of the main apparatus and lines constituting a surface hydraulic system and in particular illustrating the portion of the apparatus embodying the instant invention for automatic air pressure control.

A surface hydraulic system embodying the invention includes a number of conventional structures, the operation of which the invention is designed to facilitate. A surface hydraulic apparatus is designed for the purpose of actuating a piston **10** of a fluid motor in its elongated motor cylinder **11** which may be erected upon suitable framework **12** extending vertically above a casing **13** of a well. A sucker rod **14** is attached to the piston **10** of the fluid motor and extends down the casing **13** where it is connected to the plunger of a pump (not shown) in the production area of the well. The pumping jack or fluid motor **11** is connected by a main pump line **15** to a main pump **16**. The line **15** may be provided with an accumulator pipe **17** (see Fig. 1—not shown in Fig. 2) for the purpose of reducing the peak sucker rod stresses by absorbing pulsations in the power oil beneath the piston **10**.

The pump **16** is driven by a shaft **18** (Fig. 2) extending through a shaft tunnel **19** (Fig. 1) and connected by suitable clutch means (not shown) to an engine **20**.

The pump **16** also is connected by a main tank line **21** to the bottom of a counterbalancing tank generally indicated at **22**. The counterbalancing tank **22** is mounted upon legs **23** and provided with a shut off valve **24**.

In addition to the main pump **16** the present system includes a constantly driven scavenging pump **25** which is connected by a scavenging pump output line **26** through an oil filter **27** and heat exchanger **28** to a tank return line **29**. The tank return line **29** is attached to a spray nozzle **30** located at the top of the tank **22** and through which working fluid returned to the tank by the scavenging pump **25** is sprayed onto the interior surface of the tank **22**. Spraying the working fluid onto the interior surface of the tank **22** at its top provides for thorough washing over the surface of the tank **22** so that the rust and oxidization inhibitors introduced into the working fluid may prevent corrosion and condensation on the inner surfaces of the tank **22**.

The scavenging pump **25** has an input line **31** which is connected through an upwardly openable check valve **32** to a main sump **33**. The top of the pumping jack **11** also is connected by a line **34** to the sump **33** so that leakage past the jack piston is returned to the sump. Since the hydraulic system operates under a substantial pressure as hereinafter described, leakage is bound to occur at various points, and it is the function of the scavenging pump to make up for these losses.

An air compressor **35** is connected by a line **36** to the upper portion of the tank **22** and functions to maintain pressure within the tank **22**.

In general, the apparatus operates as follows: During an up stroke the pressure maintained within the tank **22** forces working fluid through the line **21** to the main pump **16**. The pump **16** raises the pressure on the fluid and pumps it through the main line **15** into the pumping jack **11**. The high pressure working fluid thus introduced into the pumping jack **11** beneath the piston **10** forces the piston **10** upwardly lifting the sucker rod **14** and the column of production fluid located in the casing **13** or in the tubing (not shown) within the casing **13** and delivering a quantity of the production fluid to the top of the well and to the production fluid manifold (not shown) whence it is led to storage or further treatment.

Upon the completion of an up stroke caused by the introduction of high pressure working fluid beneath the pumping jack piston **10**, suitable reversing valves are actuated and the fluid within the pumping jack **11** flows

back through the main line **15** to the main pump **16** and then with higher pressure added by the main pump **16** is pumped back into the counterbalancing tank **22**.

The pressure to be maintained within the counterbalancing tank **22** is calculated by the equation set forth below according to the work to be performed. If P_r is the unit pressure beneath the piston **10** created by the weight of the sucker rod **14**, P_s is the unit pressure exerted on the piston **10** by the static head of the column of production fluid in the well tubing and P_c is the counterbalancing pressure to be applied by the counterbalancing tank **22**, then

$$P_r+\frac{P_s}{2}=P_c$$

For example, if the weight of the sucker rod **14** creates a pressure of 200 p. s. i. beneath the piston **10** and the weight of the column of production fluid creates a similar pressure of 400 p. s. i., then

$$200+\frac{400}{2}=400 \text{ p. s. i.}$$

the average pressure to be maintained within the counterbalancing tank **22**.

The pressure within the tank **22** is controlled by controlling the air pressure within the tank and such control is divided into two phases. First, the instant invention provides means for controlling the operation of the air compressor **35** so that it pumps air into the tank **22** only when necessary to build up the air pressure therein. Second, the instant invention includes automatically actuated means for dumping or venting the tank **22** for direct reduction of air pressure within the tank **22** when necessary, said last means being operated only when the tank pressure continues to rise even though air compressor **35** has been shut off.

An air pressure sensing line **37** is connected to the tank **22** and then divided into an air pressure delivery line **38** and an air pressure control line **39**.

Since air pressure in the tank affects in some measure the fluid level control devices, such devices will be described briefly herein, although claims thereto are made only in my copending application Serial No. 354,167, filed May 11, 1953. The line **38** is connected to a chamber **40** located above a diaphragm **41** in a fluid level control pilot valve **42**. A chamber **43** beneath the diaphragm **41** is connected by a fluid level sensing line **44** to the counterbalancing tank **22** at the height of the maximum fluid level desired in the tank **22**. A pocket **45** in the pliot valve **42** located beneath the chamber **43** is connected to the chamber **43** by a passageway **46**. A diaphragm plunger **47** extends downwardly from the diaphragm **41** into the pocket **45** and its end acts as a valve for the connection of a fluid pressure line **48**.

The fluid pressure line **48** is branched with one branch **49** leading to a fluid bleeder valve **50** and thence to a sump line **51** and the other branch **52** leading beneath a piston **53** in a fluid dump valve **54**. The dump valve **54** controls the connection between a fluid branch line **55** that is connected to the main fluid tank line **21** and a scavenging pump input branch line **56** which is connected into the scavenging pump input line **31** above the check valve **32**.

When the working fluid in the tank **22** reaches the height of the connection of the fluid sensing line **44**, line **44** fills and the head of fluid therein flexes the diaphragm **41** upwardly against the air pressure in the chamber **40** and compressing a small spring **57** which is located above a diaphragm **41**. This pulls the plunger **47** upwardly and connects the fluid sensing line **44** to the line **48**. Pressure of the fluid in the line **48** lifts the piston **53** opening the fluid dump valve **54** and placing the lines **55** and **56** in direct communication. Thus when the level of working fluid in the tank **22** rises above its desired maximum the scavenging pump **25** is connected between the output side of the tank **22** and the input side thereof to directly recirculate the working fluid within the tank **22** without adding fluid from the sump **33**.

When the level of working fluid in the tank **22** drops below the connection point of the vertical fluid sensing line **44**, the fluid in the line **44**, chamber **43**, pocket **45** and line **48** is bled away through the bleeder valve **50** until its pressure lowers to a point where it first allows the diaphragm **41** to be moved downwardly by the combined air pressure in the chamber **40** and spring **57** and, second, where it allows a spring **58** to move the piston **53** downwardly cutting off communication between the scavenging pump **25** and the main tank line **21** so that the scavenging pump once again pumps fluid from the sump **33** through the check valve **32** and into the tank **22**.

As previously noted the fluid level control above described is claimed in my said copending application Serial No. 354,167. The present invention relates particularly to the air pressure control for the counterbalancing tank **22**.

Because of the fact that the air pressure in the counterbalancing tank fluctuates rapidly as liquid rushes in and out during the operation of the pumping jack, provision must be made for operation of the air compressor **35** in response to some much more stable pressure. For this purpose the present invention provides an air chamber **70** connected to the counterbalancing tank through the control line **39** and an outwardly opening check valve **68**. Thus the air chamber will reach a pressure corresponding to the maximum pressure in the tank. However, a bleed valve **60** is connected to the line **39** on the chamber side of the check valve **68** so that the pressure in the air chamber is reduced at a controlled rate, and will thus follow a reduction in maximum tank pressure if one occurs. The air chamber **70** will be supplied with air from the counterbalancing tank each time the pressure in the tank exceeds the existing pressure in the air chamber so that check valve **68** opens. During the remainder of the time check valve **68** is held closed by the pressure in the air chamber.

The air pressure control line **39** connects to two spring loaded air pressure sensing valves through branch lines. The first sensing valve is designated generally **63** and connects to a branch line **62**. The sensing valve **63** has a plunger **64**, a valve head **65** and a biasing spring **66** which normally urges the valve head into engagement with a valve seat **67** so that branch line **62** is closed, and no air pressure can be communicated from line **62** to an outlet line **69**.

When the pressure in the counterbalancing tank exceeds a predetermined maximum, which is, of course reflected promptly in air chamber **70**, valve **63** is opened and line **62** brought into communication with line **69** which disables the supplying compressor **35**, either by unloading the compressor or by declutching it from its driving means in a manner well understood in the art. If the maximum pressure in the tank **22** at repeated cycles of operation of the jack falls below the pressure in air chamber **70**, the bleed valve **60** will soon reduce the pressure in the air chamber to the point where it is insufficient to hold valve **65** open and the compressor will resume supplying air to the tank. Thus the present invention controls the operation of the compressor not by the rapidly fluctuating air pressure in the tank, but by the relatively steady pressure of the air chamber **70**, reflecting the maximum pressure in the counterbalancing tank reached in successive cycles of operation of the system.

A second branch line **71** connects the air control line **39** to a second air pressure sensing valve **72**, in construction very much like the valve **63** and placed to connect the branch line **71** to the cylinder of an air dump valve **79** when open. The valve **72** has a plunger **73**, a valve head **74** and a coil spring **75** biasing the valve against a seat **76** to close air line **71**. The biasing spring of this second valve is adjusted to a somewhat greater force than the spring of the first valve **63**, so that a higher pressure

(by for example 20 p. s. i.) is required to open it than is required to open the first valve. Thus, if shutting off the supply of air to the tank is not effective to reduce the maximum pressure therein so that the pressure keeps on increasing, the pressure in the air chamber **70** and thus on valve **72** will likewise increase. Valve **72** is thus opened, and communication established between line **39**, line **71**, a line **77** to dump valve **79**.

The dump valve **79** comprises a piston **78** having a valve extension **80** controlling an opening between a line **81** leading directly to the counterbalancing tank **22** and a vent line **82** leading back to the sump. A spring **83** biases the piston and valve to closed position.

When the dump valve is opened by the admission of air past sensing valve head **74**, air from the tank can flow directly from the tank **22** to the sump. The maximum tank pressure is thus reduced rather quickly, more rapidly of course than can be expected from normal dissipation and leakage. As the air chamber pressure bleeds down through bleed valve **60** it soon reaches a point where sensing valve **72** closes, permitting the dump valve stem **30** to seat and stopping the rapid venting of air from the tank. It will be seen that the time required for the air chamber to bleed down, and thus the duration of the open period of the dump valve, is adjustable by the setting of the bleed valve **60** and may be so arranged that air from the tank is dumped in large or small increments.

To recapitulate the operation of the parts described, air pressure is built up in tank **22** by compressor **35** which may be driven by any conventional means. During operation of the pumping system, the air pressure in the tank varies at each stroke of the jack **11** because of the withdrawal and replacement of working fluid. This pressure therefore fluctuates between a minimum and a maximum at each stroke.

Whenever the pressure in the tank **22** exceeds the pressure in the air chamber **70**, air passes check valve **68** and flows to the chamber. Thus only the maximum pressure of the tank has any significant effect on the air chamber pressure.

When the air chamber pressure reaches a predetermined value, valve **63** first opens to stop or unload the compressor. This expedient may not be enough to cause the maximum tank pressure to drop. For example, if the system has been operating during a cool night, the air pressure will rise as the day becomes warmer and the rays of the sun strike the tank. If the maximum pressure continues to rise even with the compressor effectively stopped, the pressure in air chamber **70** will also rise to the point where the second sensing valve **72** opens, thus opening dump valve **79** and discharging air from the tank directly through lines **81** and **82** to the sump. Discharge is made to the sump because it is not desired simply to vent the tank to atmosphere since the entrained oil in the air would dissipate over all of the surrounding equipment and might also create a fire hazard.

While the invention has been disclosed in conjunction with a specific installation it should be expressly understood that it is capable of numerous embodiments without departing from the scope of the appended claims.

What I claim is:

1. In a hydraulic system for operating a fluid motor piston, a counterbalancing tank containing liquid under air pressure which fluctuates between a minimum and maximum at each piston stroke, an air compressor connected to supply air to said tank, means to control the maximum tank air pressure comprising, an air chamber, means to charge said air chamber from said tank to a relatively stable pressure corresponding substantially to the maximum air pressure in said tank, means responsive to a predetermined pressure in said air chamber to disable said air compressor, and means to reduce the pressure in said air chamber at a controlled rate.

2. In a hydraulic system for operating a fluid motor piston, a counterbalancing tank containing liquid under air pressure which fluctuates between a minimum and maximum at each piston stroke, an air compressor connected to supply air to said tank, means to control the maximum tank air pressure comprising, an air chamber, means to charge said air chamber from said tank to a relatively stable pressure corresponding substantially to the maximum air pressure in said tank, first means responsive to a predetermined pressure in said air chamber to disable said air compressor, second means responsive to a higher air pressure in said air chamber to vent said tank, and means to reduce the pressure in said air chamber at a controlled rate.

3. In a hydraulic system for operating a fluid motor piston, a counterbalancing tank containing liquid under air pressure which fluctuates between a minimum and maximum at each piston stroke, an air compressor connected to supply air to said tank, means to control the maximum tank air pressure comprising, an air chamber, means to charge said air chamber from said tank to a relatively stable pressure reflecting the maximum air pressure in said tank, means responsive to a predetermined pressure in said air chamber to disable said air compressor, and means to reduce the pressure in said air chamber at a controlled rate.

4. In a hydraulic system for operating a fluid motor piston, a counterbalancing tank containing liquid under air pressure which fluctuates between a minimum and maximum at each piston stroke, an air compressor connected to supply air to said tank, means to control the maximum tank air pressure comprising, an air chamber, a connection from said tank to said air chamber, a check valve in said connection whereby said air chamber is charged to a relatively stable pressure corresponding substantially to the maximum air pressure in said tank, means responsive to a predetermined pressure in said air chamber to disable said air compressor, and means to reduce the pressure in said air chamber at a controlled rate.

5. In a hydraulic system for operating a fluid motor piston, a counterbalancing tank containing liquid under air pressure which fluctuates between a minimum and maximum at each piston stroke, an air compressor connected to supply air to said tank, means to control the maximum tank air pressure comprising an air chamber, means to charge said air chamber from said tank to a relatively stable pressure corresponding substantially to the maximum air pressure in said tank, first means responsive to a predetermined pressure in said air chamber to disable said air compressor, a pneumatically actuated vent valve connected to said tank, second means responsive to a higher air pressure in said chamber to cause actuation of said vent valve, and means to reduce the pressure in said air chamber at a controlled rate.

6. In a hydraulic system for operating a fluid motor piston, a counterbalancing tank containing liquid under air pressure which fluctuates between a minimum and maximum at each piston stroke, an air compressor connected to supply air to said tank, means to control the maximum tank air pressure comprising, an air chamber, a first pressure responsive means, a second pressure responsive means, a check valve, a connection from said tank to said check valve, parallel connections from said check valve to said air chamber and said first and second pressure responsive means, means controlled by said first pressure responsive means for disabling said air compressor when said air chamber pressure reaches a predetermined value, other means controlled by said second pressure responsive means to vent said tank, and a bleed valve connected to reduce the pressure in said air chamber at a controlled rate.

7. Apparatus to control air pressure in a tank in which the air pressure fluctuates relatively rapidly comprising, an air compressor connected to supply air to said tank, an air chamber, means to charge said air chamber from said tank to a relatively stable pressure corresponding substantially to the maximum air pressure in said tank,

means responsive to a predetermined pressure in said air chamber to disable said air compressor, and means to reduce the pressure in said air chamber at a controlled rate.

8. Apparatus to control air pressure in a tank in which the air pressure fluctuates relatively rapidly comprising, an air compressor connected to supply air to said tank, an air chamber, means to charge said air chamber from said tank to a relatively stable pressure reflecting the maximum air pressure in said tank, means responsive to a predetermined pressure in said air chamber to disable said air compressor, and means to reduce the pressure in said air chamber at a controlled rate.

9. Apparatus to control air pressure in a tank in which the air pressure fluctuates relatively rapidly comprising, an air compressor connected to supply air to said tank, an air chamber, a connection from said tank to said air chamber, a check valve in said connection whereby said air chamber is charged to a relatively stable pressure corresponding substantially to the maximum air pressure in said tank, means responsive to a predetermined pressure in said air chamber to disable said air compressor, and means to reduce the pressure in said air chamber at a controlled rate.

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