Feb. 25, 1941. H. W. RAMEY 2,233,225

HYDROPNEUMATIC COUNTERBALANCE

Original Filed Sept. 14, 1937 2 Sheets-Sheet 1

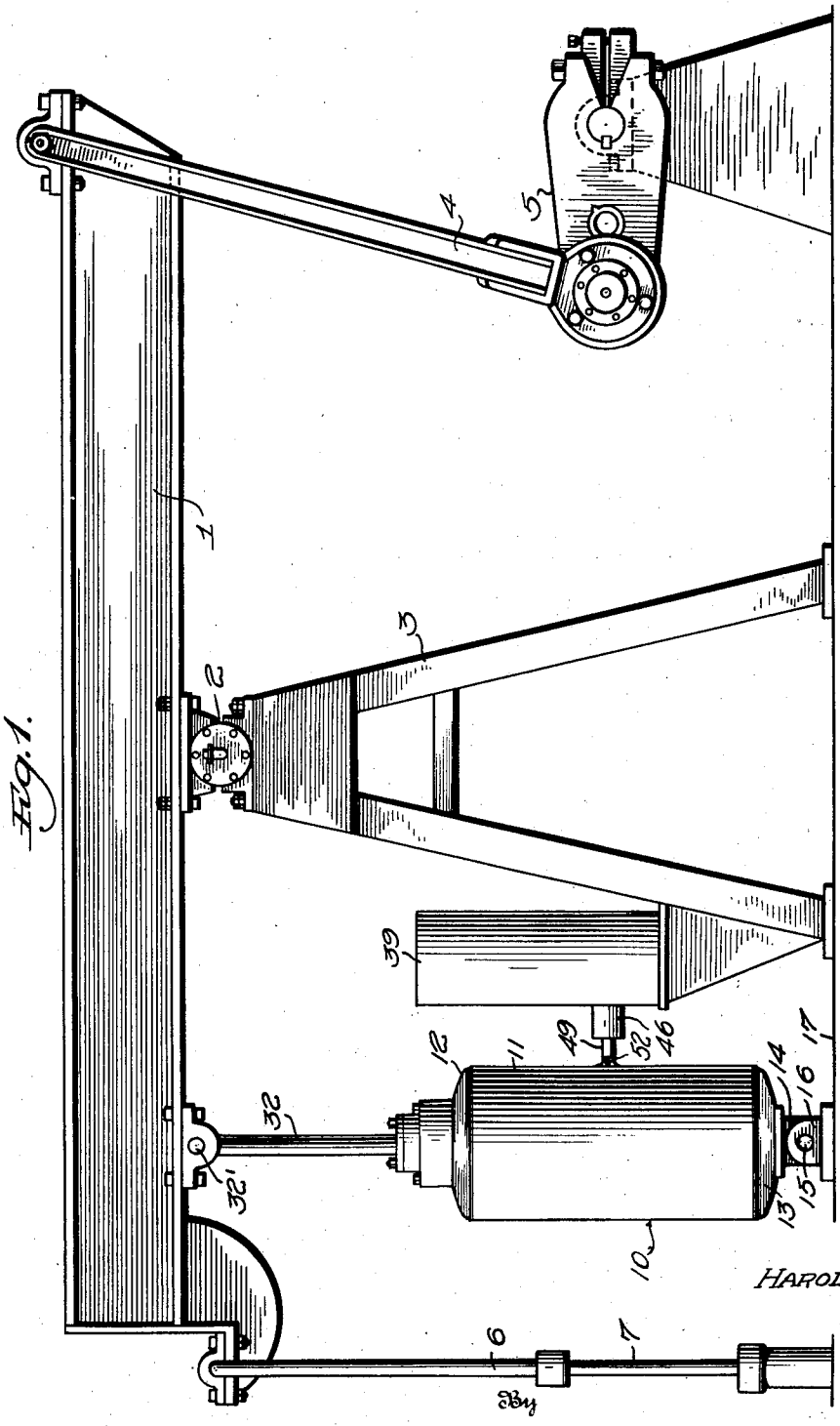


Fig. 1.

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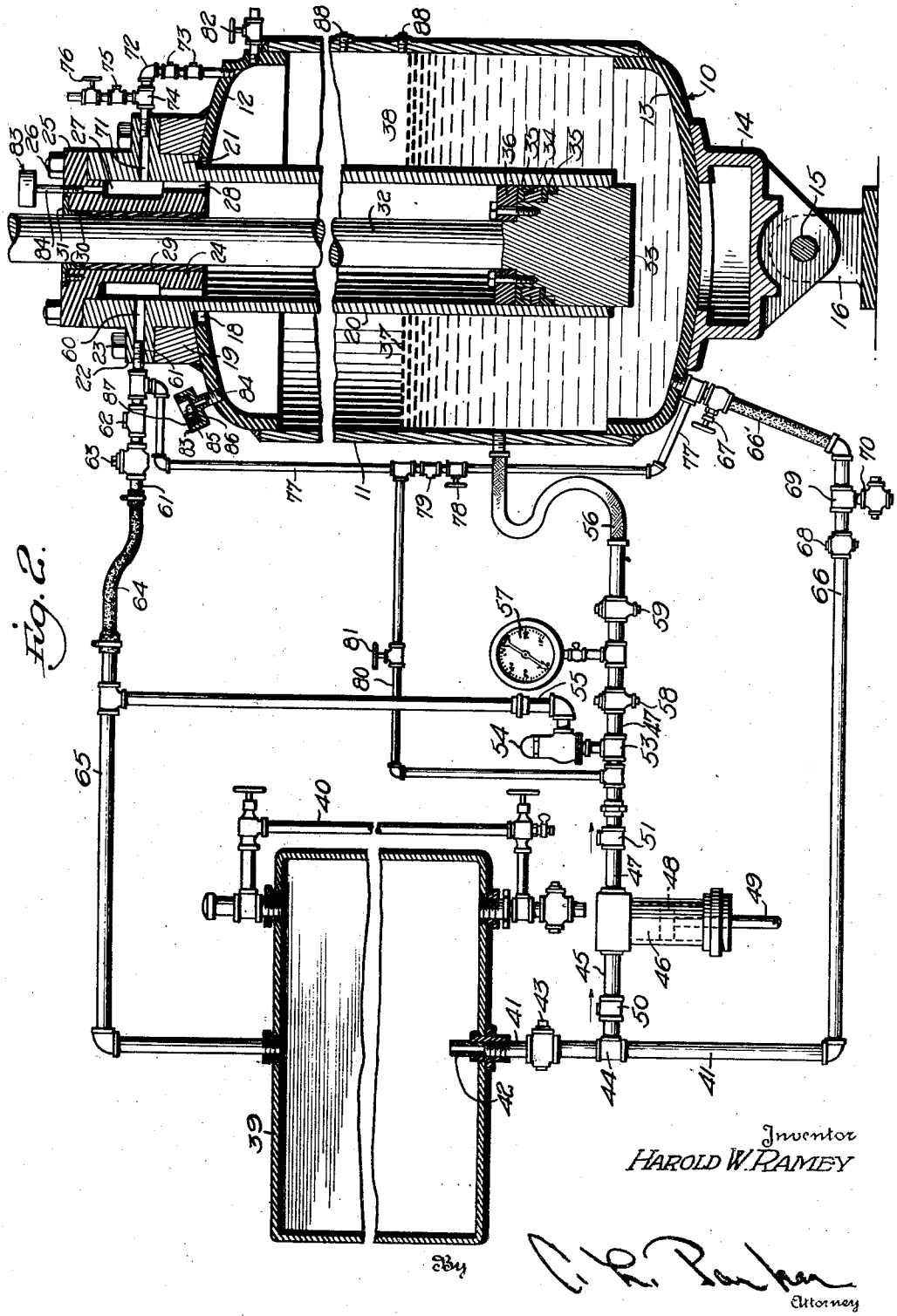


Fig. 2.

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UNITED STATES PATENT OFFICE

2,233,225

HYDROPNEUMATIC COUNTERBALANCE

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Application September 14, 1937, Serial No. 163,862
Renewed August 2, 1939

29 Claims. (Cl. 74—589)

This invention relates to counterbalances and more particularly to hydropneumatic counterbalances of the type disclosed in the copending application of Robert Griffin De La Mater, Serial No. 157,189, filed August 3, 1937, such counterbalances being particularly adapted for use with oil well pumping rigs.

As is well known, it has been the common practice for a number of years to counterbalance the walking beams of oil well pumping rigs to equalize the power demand during the pumping cycle. It also has been the common practice to effect the counterbalancing action by counterweighting the crank shaft from which the pitman is driven as fully disclosed in the copending application referred to. Each of these systems possesses advantages which are offset by substantial disadvantages. For example, among other disadvantages, the provision of heavy counterweights on the walking beam requires the use of a very heavy walking beam, and such counterweights can be adjusted only with the greatest difficulty. In the case of a pitman failure, the weight on the walking beam obviously will pull the beam downwardly and may result in wrecking the entire pumping rig unless downward movement of the walking beam is stopped by a conventional headache post.

Rotary crank weights have been largely used instead of beam weights because of certain inherent advantages which they possess, but such method of counterweighting also is attended by substantial disadvantages. Rotary counterweights are not easily adjustable and they add substantially to the load on the crank and crank shafts. Moreover, such a system provides counterweighting at a substantial distance from the ideal point, namely, adjacent the connection of the pump rods to the walking beam.

In order to overcome the numerous disadvantages of counterbalancing walking beams by means of counterweights, it has been proposed in recent years to provide the counterbalancing action by pneumatic means which operates to store energy on the down stroke of the pump rods and to expand energy on the up stroke. Such a mechanism involves numerous advantages over conventional counterweighting in that it permits the application of a counterbalancing force substantially at the ideal point, and permits the use of lighter parts through the elimination of the heavy counterweights, as well as eliminating the use of heavy masses of reciprocating or rotating counterweights. Thus the pumping equipment is more portable, easier to install, and requires much less foundation for stability.

However, a pneumatic counterbalance involves numerous disadvantages and leaves much to be desired of an apparatus of this character. For example, a pumper will frequently have in his charge as many as forty pumping wells scattered over a considerable territory and accordingly he will be able to visit each pumping unit only at infrequent intervals. Many wells are pumped night and day and accordingly it is essential that a counterbalance unit be made as trouble free as possible. Pneumatic counterbalances fail to meet this requirement because of numerous possibilities of failure which are always present. For example, the failure of the air compressor may result in a complete unbalancing of the unit, and the same result may occur through the springing of a leak in the packing of the compressor or the packing of the counterbalance piston. It also will be apparent that failure of the lubricator for the counterbalance cylinder or the loss of level of oil in the lubricator will have serious results.

It is possible that a pumping rig may be shut down for hours and even days, and during such period it is essential that there be no material loss of pressure due to leakage, and such loss of pressure cannot be effectively prevented in a pneumatic counterbalance. In such a counterbalance, air is confined at a minimum pressure of approximately 200 lbs. per square inch and such pressure increases to as high as 400 lbs. pressure per square inch. A single stage compressor for supplying and maintaining pressure in a counterbalance of this type must have a relatively long stroke since the air must be compressed to from one-eighth to one-fourteenth of its volume before raising the pressure sufficiently to discharge it into the counterbalance cylinder.

In effecting any appreciable increase in the operating pressure of a pneumatic counterbalance a substantial amount of air must be introduced into the system, and the air compressor will become quite hot unless auxiliary means are provided to cool it. Moreover, the compressor of a pneumatic counterbalance is in continuous operation drawing air from the atmosphere and discharging it into the system, the air being released from the system at a maximum predetermined pressure. Consequently, since the air in an oil field is frequently contaminated with dust or corrosive gases, considerable damage may be done to working parts of

the counterbalance. It will be appreciated that this presents a serious problem when air is being continuously introduced into the system through the compressor, valves, etc., such air, of course coming into constant contact with other working parts of the system such as the piston and cylinder.

From the foregoing, it will be apparent that the provision of an efficient, practicable and trouble-proof counterbalance for oil well pumping rigs presents very serious problems, and the hydropneumatic counterbalance disclosed in the copending application of Robert Griffin De La Mater, referred to above, substantially completely eliminates the disadvantages of prior counterbalancing systems while providing numerous advantages which are not found in prior systems. It is broadly an important object of the present invention to combine with the hydropneumatic counterbalance of the copending application referred to certain additional features which facilitate and materially improve the operation of the apparatus disclosed in such copending application.

More specifically it is an important object of the present invention to provide a hydropneumatic counterbalance of the type disclosed in the pending application referred to wherein the space above the counterbalance plunger is utilized for creating a partial vacuum to increase the differential pressures acting on the plunger, thus increasing the counterbalancing action for a given fluid pressure within the receiver of the counterbalance.

A further object is to provide a hydropneumatic counterbalance wherein each down stroke of the plunger compresses and accordingly stores energy in a body of a compressible fluid, such as air, but wherein a body of a non-compressible fluid such as oil is interposed between the compressible fluid and the counterbalance plunger to positively prevent the leakage of air around the plunger as in the copending application referred to, in combination with means for effecting a partial vacuum above the counterbalance plunger to increase the differential pressures between the upper end of the counterbalance cylinder and the body of compressible fluid referred to.

A further object is to provide a hydropneumatic counterbalance of the character referred to wherein upward movement of the counterbalance plunger may be utilized for charging the receiver with compressible fluid, as in the copending application referred to, together with means for reducing the clearance space above the plunger, when desired, to increase the compression of the compressible fluid which is being supplied to the receiver.

A further object is to provide an apparatus of the character referred to having means for supplying non-compressible fluid to the cylinder above the plunger to increase the effective length of the plunger, when the apparatus is used with a short stroke pumping unit, thus permitting a relatively high compression of compressible fluid to be supplied to the receiver.

A further object is to provide an apparatus of this character having means for transferring some of the non-compressible fluid, which forms a seal between the plunger and the compressible fluid, to the cylinder above the plunger to increase the effective length of the latter for the purpose stated.

A further object is to provide a hydropneumatic counterbalance of the type shown in the copending application referred to wherein pressures in the receiver are maintained by suitable automatically operable means, as in the copending application referred to, in combination with a separate auxiliary means through which pressures may be manually controlled in the event of failure of the automatic means referred to.

A further object is to provide a hydropneumatic counterbalance of the type referred to wherein a reservoir is adapted to supply the non-compressible fluid to the receiver of the counterbalance through the medium of a positively operated pump and wherein the supplying of such fluid to the receiver is automatically controlled to maintain and control pressures in the receiver, and to provide, in conjunction therewith, manually controllable means for by-passing non-compressible fluid from the receiver to the reservoir to control and maintain pressures in the receiver in the event of failure of the means which normally operates to control the supplying of the non-compressible fluid to the receiver.

A further object is to provide manually controllable means of the character referred to which is adapted to function to transfer all or part of the non-compressible fluid from the counterbalance receiver to the reservoir, when desired.

Other objects and advantages of the invention will become apparent during the course of the following description.

In the drawings I have shown one embodiment of the invention. In this showing—

Figure 1 is a side elevation of a standard well rig showing the principal parts of the invention applied thereto, the piping connections, etc., being eliminated for the purpose of simplicity, and,

Figure 2 is a schematic side elevation of the counterbalance system, as a whole, parts being broken away, and parts being shown in section.

Referring to Figure 1, the numeral 1 designates a conventional walking beam mounted as at 2 for oscillation on the upper end of a conventional Samson post 3. The walking beam is oscillated in the usual manner by a pitman 4 driven by a crank 5 operated by the usual prime mover (not shown). The well end of the beam is connected by the usual polished rod carrier 6 to the usual pump or polished rods 7. A conventional apparatus of this character is provided with "headache posts" to prevent damage to the apparatus and injury to the workmen in the event of breakage of any part of the apparatus. It will become apparent, however, that the present apparatus functions to permit the elimination of the usual headache posts by limiting the swinging movement of the walking beam 1.

While the present invention has been illustrated as applied to a conventional type of pumping rig, it will be apparent that it is capable of application to any analogous structure.

The present construction comprises a counterbalance unit indicated as a whole by the numeral 10. This unit comprises a receiver 11 having upper and lower heads 12 and 13 preferably welded in position as indicated in Figure 2. A supporting member 14 is welded to the lower head 13 and is pivoted as at 15 to a suitable support 16 shown in Figure 1 as being mounted upon the foundation 17. The head 12 is provided with an axial opening 18 surrounded by a relatively heavy flange 19 welded in position on the head 12. While the receiver 11 has been shown as an integral part of the counterbalance unit, it will

become apparent that this arrangement is preferred but not essential.

A cylinder 20 projects downwardly through the opening 18 into the receiver and is provided adjacent its upper end with an annular enlarged portion 21 fitting within the flange 19. Such portion of the cylinder is provided with an outstanding annular flange 22 bolted to the flange 19 as at 23. A bearing 24 is mounted in the upper end of the cylinder and is provided at its upper end with an outstanding annular flange 25 seating upon the upper extremity of the cylinder and bolted thereto as at 26. The bearing 24 is provided intermediate its ends with a clearance space 27, for a purpose to be described. Aside from the space 27, the bearing 24 has a sliding fit with the interior of the cylinder 20, and the lower end of the bearing is grooved as at 28 to afford communication between the clearance space 27 and the cylinder 20 below the bearing. The bearing is provided with a suitable bushing 29 at the upper end of which is a packing ring 30 maintained in position by a plate 31.

A plunger rod 32 reciprocates in the bushing 29 and is pivotally connected at its upper end as at 32' to the walking beam adjacent the well end thereof, as shown in Figure 1. The plunger rod 32 carries a plunger 33 at its lower end reciprocable in the cylinder 20 and occupying substantially the position shown in Figure 2 when the pump rods are at the lower limit of their down stroke. Under such conditions, it will be apparent that all fluid will be displaced from the lower end of the cylinder into the receiver upon each down stroke of the plunger. The plunger is provided with a ring 34 above and below which are arranged packing cups 35 preferably having their flanges turned downwardly as shown in Figure 2. A clamping ring 36 retains the ring 34 and packing cups 35 in position.

It will be apparent that reciprocation of the plunger 33 is utilized for compressing fluid in the receiver to store energy therein for use on each up stroke of the pump rods. Instead of using only air or some other compressible gas in the receiver, a feature of the present construction is the provision of two bodies of fluid, one of which is compressible and the other of which is non-compressible. Accordingly the lower end of the receiver is provided with a body of a non-compressible fluid 37, preferably oil, and the space 38 above the body of oil is filled with a compressible fluid, preferably air. Upon each up stroke of the plunger oil will be drawn into the lower end of the cylinder 20 and upon each down stroke of the plunger, this element acts as a displacing member to displace oil from the cylinder into the receiver to raise the level thereof and thus compress the body of air.

Inasmuch as the piston 33 has its lower extremity arranged below the lower extremity of the cylinder 20 when the piston reaches the lower end of its stroke, it will be apparent that any air which may have escaped past the packing rings 35 on the up stroke of the plunger will be discharged from the lower end of the cylinder and will find its way upwardly into the space 38. The quantity of oil in the receiver is such that when the plunger is at its upper limit of movement, the surface of the oil 37 will not be below the lower extremity of the cylinder 20. Thus it will be apparent that the oil, under all conditions, acts as a liquid seal between the plunger and the body of air, and this is highly important as will become apparent.

A reservoir 39 is employed as the source of oil for the receiver, and this reservoir preferably is part of a system which includes the connections for supplying oil to the receiver and connections for returning to the receiver any oil which escapes past the plunger. The reservoir is provided with a sight gauge 40. The reservoir is provided in the bottom thereof with an outlet pipe 41 communicating with the reservoir through an upstanding nipple 42 which tends to prevent any sediment in the oil from flowing into the pipe 41. A stop cock 43 is provided in the pipe 41, and a T 44 connects the pipe 41, below the stop cock 43, to a pipe 45 leading to the intake side of an oil pump 46. The pump is provided with an outlet pipe 47. The oil pump 46 may be of any desired type and is conveniently shown in Figure 2 as having a plunger 48 operated by a plunger rod 49. The pipes 45 and 47 are shown as being provided with check valves 50 and 51 which, of course, may be embodied in the pump structure itself in accordance with conventional practice.

In Figure 1 the pump 46 has been shown as being connected to the reservoir 39 while the plunger rod 49 has been indicated as being pivotally connected as at 52 to one side of the receiver 11. This pivotal connection is provided with a slight amount of play to permit the pin 42 to partake of slight vertical movement incidental to the swinging movement of the receiver about the pivot 15 during oscillating movement of the walking beam. The pump, of course, may be held stationary in any suitable manner, and the arrangement of the pump is such that the oil pump is operated through the medium of the horizontal component of movement of the pivot pin 52 during reciprocation of the plunger rod 32. It will become apparent that the very slight horizontal component of movement referred to is sufficient for maintaining any desired pressure within the receiver. It also will become apparent that even though the pump plunger partakes of a relatively short reciprocatory movement, an ample supply of oil for maintaining a varying pressure may be provided with a pump plunger and cylinder of small diameter. While the particular oil pumping means described is preferred, it is not essential to the operation of the apparatus, and it will be apparent that the invention is not limited to any particular oil pumping means.

A T 53 is connected in the pipe 47 and leads to an adjustable blow-off valve indicated by the numeral 54 and having an outlet connected to a pipe 55. The valve 54 has not been specifically illustrated since a number of commercially available blow-off valves may be employed, it merely being desirable that they be provided with means for adjusting the pressure at which the valve will be released, as will become apparent. A flexible high pressure hose 56 connects the end of the pipe 47 to the receiver, as shown in Figure 2, and the pipe 47 is provided with a pressure gauge 57 between the blow-off valve 54 and the hose 56. Stop cocks 58 and 59 are preferably arranged on opposite sides of the pressure gauge 57, as shown.

The upper end of the cylinder 20 is provided with a lateral passage 60 to the outer end of which is connected a pipe 61. The passage 60 communicates with the clearance space 27 near the bottom thereof, for a purpose to be described. A check valve 62 is connected to this pipe and opens outwardly to discharge oil from the clear-

ance space 27 and a stop cock 63 is provided adjacent and outwardly of the check valve 62. The outer end of the pipe 61 is connected by a flexible hose 64 to a pipe 65 leading to the top of the reservoir 39. The outlet pipe 55 of the blow-off valve is connected to the pipe 65, and accordingly it will be apparent that oil discharged by the opening of the valve 54 will be returned to the reservoir.

It will be apparent that the pump 46 is intended to generate pressure in the oil being pumped at least as great as the maximum pressure present in the counterbalance unit during the normal operation thereof, and the counterbalance pressure is determined by the setting of the valve 54. Means are provided to permit the manual controlling of the pressure within the receiver in the event of failure of the valve 54 to function, such means also permitting oil to be blown under pressure from the receiver to the reservoir 39 if it is desired to empty the receiver for any reason. The means referred to comprises a pipe 66 having a flexible section 66' provided with a manually operable control valve 67 and connected to the bottom of the receiver as shown in Figure 2. A stop cock 68 also is connected in the pipe 66, and this pipe is connected to the pipe 41, as shown. Between the valve 67 and stop cock 68 a T 69 connects the pipe 66 to a valve 70 which may be opened together with the valve 67 if it is desired to drain the oil from the receiver without returning it to the reservoir.

As previously stated, the space 38 normally contains air or other compressible gas under pressure during the normal operation of the counterbalance unit, and reciprocation of the plunger 33 is utilized for charging the space 38. As shown in Figure 2, the upper end portion of the cylinder 20 is provided with a radial passage 71, the inner end of which communicates with the clearance space 27 near the bottom thereof. A pipe 72 has one end connected to the outer end of the passage 71 and its other end connected to the pressure space 38 through the head 12. Two check valves 73 are connected in the pipe 71 and open toward the pressure space 38. While one of the check valves 73 is sufficient, it is preferred that two be employed in order to insure against leakage of pressure from the space 38.

Between the passage 71 and check valves 73, a T 74 is connected in the pipe 72 and leads to an inwardly opening check valve 75 controlled by a valve 76 leading to the atmosphere and being manually controllable. When the valve 76 is open, downward movement of the plunger 33 draws air into the upper end of the cylinder through the check valve 75, whereupon upward movement of the plunger 33 compresses the air of the cylinder to close the valve 75 and discharge the air into the space 38 through the check valves 73. Repeated reciprocation of the plunger 33, while the valve 76 is open, will charge the space 38 with air to the desired pressure, the valve 63 during such period, being closed.

As previously stated, reciprocation of the plunger 33 may be employed for charging the pressure space 38, and the rate of charging, of course, will depend upon the stroke of the plunger 33. For example, in a short stroke pumping rig the plunger 33 obviously will not reduce the volume of air in the cylinder 20 to as great an extent upon upward movement of the plunger as is true in a long stroke pumping unit. With a unit of the latter type, the plunger 33 moves upwardly practically to its limit of movement as defined by the lower end of the bearing 24. Under such conditions the air will be highly compressed and the receiver may be rapidly charged.

Much slower pumping will take place with a short stroke rig, and in fact, the maximum pressure generated in the cylinder 20 may not be sufficient to charge the space 38 to the desired air pressure. Means are provided for reducing the effective clearance above the plunger 33 to provide an efficient pumping action for charging the space 38 when the apparatus is used with a short stroke pumping unit. A pipe 77 is tapped into the pipe 66 between the valve 67 and the head 13, as shown in Figure 2. A manually controllable valve 78 is connected in the ipe 77 and above this valve is arranged an upwardly opening check valve 79. The upper end of the pipe 77 communicates with the pipe 61 between the check valve 62 and passage 60. As reciprocation of the plunger 33 takes place, pressure will increase within the receiver, and such pressure causes oil to be discharged through the pipe 77 into the upper end of the cylinder 20 when the valve 78 is open. The oil discharged into the cylinder 20 collects on the upper face of the plunger 33 to increase the effective length of this plunger and reduce the clearance space in the cylinder so that air may be compressed to a relatively high pressure to be discharged into the space 38.

As an alternative arrangement, a pipe 80 may be connected at one end to the pipe 77 and at its other end to the pipe 47 between the blow-off valve 54 and the check valve 51. A manually controllable valve 81 is arranged in the pipe 80. While the pump 46 is in normal operation the valve 81 may be opened to permit oil to be pumped into the pipe 77 and thence into the upper end of the cylinder 20 to reduce the clearance space above the piston and thus provide for the effective compressing of the air to be discharged into the space 38.

As will become apparent, the combined use of compressible and non-compressible fluids provides a highly desirable degree of flexibility in the adjustment of the counterbalancing action which cannot be obtained with a purely pneumatic counterbalance. As will be described in detail later, the counterbalancing action is subject to variation in accordance with the relative volumes of the oil and air contained in the apparatus. The minimum quantity of oil in the apparatus is indicated by the level of the oil in Figure 2, the minimum quantity of oil being such that when the plunger 33 is at the upper limit of its stroke, the level of the oil will not drop as far as the lower extremity of the cylinder 20. The quantity of the oil may be increased and the volume of the air above the oil decreased in order to vary the counterbalancing action. In order that increased flexibility of adjustment may be obtained, a valve 82 is adapted to release air from the air space 38 when it is desired to reduce the volume of the air and increase the volume of the oil without materially increasing the air pressure, as would occur if the volume of the oil were increased without releasing some of the air pressure from the space 38.

The characteristics of the system are such that the possibility of providing dangerous pressures within the receiver is negligible. In order to guard against any slight possibility of the bursting of the receiver due to excess pressures, it is desired to provide means for releasing the pres-

sures when they accumulate above a predetermined point. This could be done, of course, by the provision of pressure relief valves, but since such valves normally would never operate, their use would not be satisfactory in view of the possibility of the corrosion and sticking of the valves. Accordingly it is desired to employ safety devices of the character shown in Figure 2 and indicated by the numeral 83.

Each of the devices 83 comprises a tubular member 84 having a cup shaped outer portion 85 having a frangible disk 86 therein retained in position by a threaded ring 87. One of the safety devices has its tubular member 84 communicating with the clearance space 27 while the other communicates directly with the air space 38 through the head 12. Upon the accumulation of pressures above the point of safety, the disks 86, or at least one of them, will be ruptured to release pressure from the chamber 38. These disks obviously are easily replaceable.

To facilitate the filling of the receiver with oil, the body of the receiver may be provided with a series of openings normally closed by threaded plugs 88 as shown in Figure 2. For most installations, the oil will be filled to the lowermost plug 88, which determines the level of the oil for the minimum quantity thereof whereby the level of the oil will never drop as low as the lower extremity of the cylinder 20.

The operation of the apparatus is as follows: The upper end of the plunger rod 32 is connected to the walking beam as near as practicable to the well end of the beam, while the bottom of the receiver is pivoted to the foundation 17. Upon operation of the prime mover, power will be transmitted to the walking beam through the crank 5 and pitman 4, thus oscillating the walking beam in the usual manner. The oscillation of the pitman effects the reciprocation of the pump rods in the usual manner.

After the apparatus has been installed and it is desired to place it in operation, one of the plugs 88 is removed and oil is supplied to the receiver until the proper level of the oil is reached as determined from the opening from which the plug 88 has been removed. The oil charging operation is carried out with the walking beam at rest and with the well end of the beam in its lowermost position, the plunger 33 occupying the position shown in Figure 2.

After the receiver has been supplied with the proper volume of oil, the previously removed plug 88 is replaced. It will be apparent that the oil is supplied while atmospheric pressure is present in the receiver, and accordingly the oil need not be pumped against pressure when the receiver is charged. Having provided the desired amount of oil, the space 38 is then charged with air or other gas to the desired pressure, and the plunger 33 and cylinder 20 are adapted to be employed as the air pumping means.

In order to charge the receiver with air, it merely is necessary to open the valve 76 and start the prime mover in operation to oscillate the walking beam. During each downward movement of the plunger 33, air will be drawn into the upper portion of the cylinder 20 through the valve 76 and check valve 75. Upon each upward movement of the plunger 33, the check valve 75 will close and the air compressed in the cylinder 20 will be discharged into the air space 38 through pipe 72 and check valves 73.

It will be apparent that when the air charging operation is initiated atmospheric pressure is present in the space 38, and upward movement of the plunger a slight distance from its lower extremity of movement will compress the air in the cylinder 20 to a sufficient pressure to discharge the air into the receiver. As pressure accumulates in the receiver, it becomes necessary for the plunger 33 to move to progressively higher points in its up stroke before it will build up sufficient pressure in the cylinder 20 to discharge the air into the receiver, it being necessary, of course, to compress the air in the cylinder 20 to a pressure above that in the space 38 before the air will be discharged into the receiver.

It will be apparent that the present apparatus is equally adapted for use with short stroke or long stroke pumping rigs. When employed with a long stroke rig, the plunger 33 moves upwardly upon each reciprocation to a point adjacent the lower end of the bearing 24, and accordingly air will be compressed in the cylinder to a sufficiently high pressure to charge the space 38 to the desired pressure, for example, approximately 200 lbs. per square inch.

However, when the apparatus is employed with a short stroke pumping unit, the clearance space above the piston 33 will be of such volume as to prevent the building up of sufficient pressure in the cylinder 20 to discharge air into the receiver upon each up stroke of the plunger. For this reason, means are provided for reducing the clearance space above the plunger 33 to assist in charging the receiver with air.

In this connection it will be noted that during the air charging operation, the walking beam will be oscillated, and accordingly the pivot 32' (Figure 1) will swing about the axis of oscillation of the walking beam. The horizontal component of movement of the receiver 11 is utilized for operating the oil pump. During the initial charging operation, the valve 58 may be closed to prevent the pumping of oil to the receiver during the air charging operation if the apparatus is being used with a long stroke pumping rig. With a short stroke rig, however, the valve 58 may be permitted to remain open to supply some additional oil to the receiver, and the valve 78 may be opened whereby the pressure accumulated within the receiver will discharge oil through the pipe 77 and passage 60 into the upper end of the cylinder 20. This oil will accumulate above the piston 33 to reduce the clearance space upon each up stroke of the plunger, thus permitting the building up of the necessary pressure to charge the receiver. In this connection it will be noted that the valve 78 may be opened prior to the opening of the valve 76, whereupon the partial vacuum created upon downward movement of the plunger 33 will create differential pressure between the upper end of the cylinder and the top of the receiver whereby atmospheric pressure will force oil through the pipe 77 into the top of the cylinder to reduce the clearance space above the plunger.

It will be obvious that the valve 78 will be closed after the desired quantity of oil has collected above the plunger, whereupon continued operation of the plunger 33 charges the space 38 with the desired air pressure. As an alternative means for supplying oil to the cylinder 20 for the purpose stated, the valve 81 may be opened to supply oil through the pipes 80 and 77 to the cylinder to reduce the clearance space above the plunger 33. If the pipe 80 is to be used for this purpose, the valve 58 may be closed

at least until the desired quantity of oil has collected above the plunger.

The pressures within the receiver are readily determined from the gauge **57**, and after the desired air pressure has been built up in the space **38**, it is preferred that the walking beam be stopped with the plunger **33** in its uppermost position and that the valve **76** be closed while the plunger is in such position. Under such conditions, vacuum will be created in the cylinder **20** upon each downward stroke of the plunger **33**, thus increasing the differential pressures on opposite sides of the plunger **33** to provide a greater counterbalancing action for given pressures within the receiver.

The apparatus is now ready for normal operation. During the rocking movement of the walking beam **1**, the plunger **33** will be reciprocated in the cylinder **20**. During each downward movement of the plunger, this member displaces oil from the lower end of the cylinder **20** into the receiver thus raising the level of the oil in the receiver and compressing the air thereabove. Thus energy is stored by the compression of the air, and this energy is released upon the up stroke of the plunger **33** to assist in lifting the well end of the walking beam. Thus the prime mover is relieved of the greater portion of the work required for each elevation of the pump rods.

The blow-off valve **54** is set for any desired operating pressure and such pressure setting will determine the maximum pressure in the receiver. During any period of operation in which the pressure in the receiver drops below the pressure setting of the valve **54**, oil will be pumped through pipe **47** and hose **56** into the receiver, and thus the pump **46** operates to maintain a predetermined maximum pressure within the receiver. The pump **46** operates continuously, and whenever the pressure in the receiver is above the predetermined maximum, the valve **54** opens to by-pass the oil through pipes **55** and **65** to the reservoir **39**.

It will be apparent that the present system takes care of any accumulation of oil above the plunger **33**. As oil continues to accumulate above the plunger, it will reach the point where its level will be raised to the position of the passage **60** upon upward movement of the plunger **33**. Oil cannot accumulate above such point since it will be discharged through the passage **60** upon upward movement of the plunger **33**, and will pass through pipe **60**, check valve **62**, cut-off valve **63**, hose **64** and pipe **65**, and thence to the reservoir **39**.

In view of the arcuate path of movement of the piston connection **32'**, it will be apparent that the oil pump plunger **49** will partake of two compression strokes for each complete oscillation of the walking beam. This fact, coupled with the inherent characteristics of the apparatus wherein leakage of air pressure in the receiver is completely prevented, permits the retaining or increasing of the pressure in the receiver with the use of an extremely small oil pump.

If changes in pumping conditions render it desirable to increase or decrease the counterbalancing action, it merely is necessary to change the setting of the blow-off valve **54**. If this valve is set for increased pressures, the oil pump will supply additional oil to the receiver to raise the level of the oil and thus reduce the volume of the air while subjecting the air to increased pressures. If the valve **54** is set for a lower pressure, such pressure will be below the maximum pressure previously created within the receiver. Accordingly, the valve **54** will open as the plunger **53** approaches its limit of movement to discharge oil from the receiver back to the reservoir, through hose **56**, pipe **57**, valve **54**, etc.

It will be apparent therefore that the valve **54** not only serves to determine the supplying of oil to the receiver from the pump, but that it also acts to release oil from the receiver to the reservoir. Thus the maximum pressure may be retained in the receiver in accordance with operating conditions. When the plunger **33** moves upwardly from its lowermost limit of movement, a drop in pressure occurs in the receiver, thus permitting the admission of oil into the receiver. Accordingly, downward movement of the plunger **33** will tend to build up the pressure above the predetermined maximum, and under such conditions, the valve **54** will open to release the excess pressure. However, since oil is pumped at a very slow rate, only a very small amount of oil will be released from the receiver as the plunger **33** approaches its lower limit of movement. Accordingly, the maximum pressure is accurately maintained.

It also will be apparent that the valve **54** automatically compensates for variations in pressures in the receiver incident to temperature changes. For example, any lowering of pressures when the apparatus is operating at night or during cool weather will be prevented by the operation of the valve **54**, any tendency for the maximum pressure to drop within the receiver being compensated for by an increased supply of oil to the receiver. Conversely, any tendency for the pressure to increase during warm periods of the day is prevented since the valve **54** functions in the manner stated to prevent any accumulation of pressure above the predetermined maximum.

As previously stated, the present invention presents substantial advantages over purely pneumatic counterbalances, and particular attention is invited to one of such advantages through which a high degree of flexibility in the controlling of the counterbalancing action is possible. In a purely pneumatic counterbalance, the variation between minimum and maximum pressures will always be determined by the relation between the piston displacement and the volume of the receiver. In other words, starting with a given minimum pressure, such a counterbalance will generate a predetermined maximum pressure in accordance with the relation between piston displacement and the volume of the system. This is not true of the present invention for the reason that the volume of the compressible fluid is variable independently of piston displacement.

Assuming that pumping conditions are such as to render desirable a limited differential between minimum and maximum pressures, such result is readily accomplished with the present apparatus by using the minimum quantity of oil, thus providing a maximum air volume in proportion to piston displacement. Thus minimum pressure changes will occur between minimum and maximum pressures, and such pressures may be determined by charging the air space **38** to the desired initial pressure.

Assuming that a greater differential between minimum and maximum pressures is desired, a higher oil level may be provided, thus reducing the volume of air in proportion to the piston dis-

placement. Under such conditions the differential between minimum and maximum pressures may be increased. As a matter of fact, it is possible under such conditions to vary the pressures between atmospheric pressure as a minimum pressure and a very high pressure as a maximum pressure. Thus it will be apparent that the present system not only provides for the increasing or decreasing of minimum or maximum pressures but also provides for any desired differentials between such pressures. Such results are wholly impossible with a purely pneumatic counterbalance.

In connection with the foregoing advantages of the present system, attention is invited to the fact that if operating conditions are such as to require a relatively great differential between minimum and maximum pressures with a relatively low minimum pressure, the valve **82** may be opened to permit the escape of air to provide a lower minimum pressure. Thus a lower minimum pressure may be obtained without discharging oil from the receiver, which action would result in reducing the differential between minimum and maximum pressures.

The foregoing advantages will be obvious when the functioning of the apparatus is considered. As the well end of the walking beam moves downwardly similar movement is transmitted to the plunger **33**, this plunger acting as a displacing element to displace oil from the lower end of the cylinder into the receiver to raise the level of the oil in the receiver and thus compress the air and store energy therein. The progressive increase in pressure as the plunger moves downwardly is important since the maximum pressure is reached at the point where it is necessary to overcome the maximum inertia or load prior to reversing its movement. Moreover, the maximum pressure is present at the point where it is necessary to overcome the great inertia of the load at the beginning of the up stroke of the pump rods.

As the plunger **33** moves upwardly, the pressure in the receiver causes the oil to be displaced therefrom to follow the plunger and exert a lifting force thereagainst. The greatest force is exerted at the bottom of the stroke and progressively decreases toward the top of the stroke. The flexibility of the system is such that any desired maximum pressure can be provided and this pressure can be progressively decreased to any desired minimum pressure, depending upon the characteristics of the particular installation. As stated above, the minimum and maximum pressures will not depend upon each other for the reason that the pressures in the receiver are variable and the relative volumes of the compressible and non-compressible fluids are variable. Accordingly, the counterbalancing characteristics of the apparatus may be accommodated to any installation.

For most installations, it is desirable that the average pressure within the receiver be such as to exert sufficient upward force on the well end of the walking beam to carry the weight of the pump rods plus one-half the weight of the liquid being pumped on each up stroke. Accordingly, the average load on the prime mover, both on the up and down strokes of the pump rods, will be equal to one-half the weight of the liquid being pumped on each up stroke of the pump rods. This fact, together with the fact that the pressures in the receiver vary from a maximum, where the greatest load is to be carried, to a minimum, where the least load is to be carried, greatly smooths out the power demands on the prime mover.

From the foregoing description it will be obvious that the present apparatus possesses numerous distinct advantages over prior counterbalances, both of the weight and pneumatic types. For example, as distinguished from the use of counterweights on the walking beam, it will be apparent that the present apparatus permits the use of a relatively light beam, whereas materially heavier beams must be employed in order to carry the counterweights. Moreover, the present construction permits the application of the counterbalancing force adjacent the well end of the beam, which is impossible with counterweighted crank structures. It also will be apparent that it is unnecessary to take into account the inertia of the weights of a weighted counterbalance, and the difficulties involved in shutting down the pumping rig to change the weights to alter the counterbalancing action are eliminated.

The present construction, weighing only a few thousand pounds, can be employed to provide any desired amount of counterbalancing effect from different minima to different maxima. When the present construction is employed for providing a maximum counterbalancing effect, it accomplishes the elimination of six to seven tons of counterweight. By eliminating the heavy mass of reciprocating or rotating counterweights, the pumping equipment is more portable, more easily installed, and requires very much less foundation for stability.

In addition to the general operation of the apparatus, attention is invited to some of the characteristics of the features of construction. For example, it will be noted that the clearance space **27** extends a substantial distance above the passages **60** and **71**. Accordingly, this clearance space, above the passages referred to, is always filled with air to prevent the generation of excess pressures above the plunger **33**. This is particularly important when the space **38** is being charged with air upon the initial operation of the apparatus. The capacity of the clearance space **27** above the passages **60** and **71** may be designed to determine any maximum pressure which may be generated upon upward movement of the plunger **33**. Accordingly, the clearance space **27** constitutes a safety feature since it prevents the generation of any pressures which might be dangerous to the apparatus upon upward movement of the plunger **33**.

When the receiver is being charged with air by utilizing the plunger **33** as a pump plunger, this plunger moves upwardly from its lowermost position with atmospheric pressure present above the plunger and a greater pressure present below the plunger, depending upon the degree to which the receiver has been charged. During its upstroke, the plunger compresses the air in the cylinder **20** to a pressure equal to that in the receiver, whereupon further upward movement of the plunger increases the pressure of the air in the cylinder to discharge it into the receiver.

A number of the valve connections in the system are provided as a matter of convenience. For example, the cut-off valve **63** is open during normal operation of the apparatus but may be closed for servicing, and the same is true of the valves **59** and **67**. The valve **70** may be opened together with the valve **67** if it is desired for any

reason to drain the oil from the receiver without returning it to the reservoir.

The valve **67** may be opened while the valve **70** remains closed if it is desired to utilize the pressure in the receiver for returning the oil from the receiver to the reservoir. Moreover, in the event of failure of the blow-off valve **54** to function properly, an operator may control the valve **67** to by-pass oil from the receiver to the reservoir while watching the gauge **57** to control pressures in the receiver. The feature of by-passing oil through the pipe **66** under emergency conditions and the feature of utilizing vacuum in the upper end of the cylinder **20** for assisting in the counterbalancing action form important parts of the present invention, both of these features being described but not claimed in the copending application of Robert Griffin De La Mater, previously referred to. The feature of supplying oil through the pipe **77** or the pipe **80** to increase the effective length of the plunger **33** when charging the receiver with air, as for example when the apparatus is employed with a short stroke pumping rig, likewise forms, per se, an important part of the present invention, being described but not claimed in the copending application referred to. The three features referred to in this paragraph form the subject matter of the present invention, all of the remaining features of the construction forming the subject matter of the copending application referred to.

While the two fluids in the receiver have been referred to as being air and oil, it will be apparent that these fluids are used as a matter of convenience and practicability. The invention obviously is not limited to the particular fluids employed but may use any suitable compressible and non-compressible fluids.

It is to be understood that the form of the invention herewith shown and described is to be taken as a preferred example of the same, and that various changes in the shape, size and arrangement of parts may be made without departing from the spirit of the invention or the scope of the subjoined claims.

I claim:

1. A counterbalance comprising a cylinder, a plunger reciprocable in said cylinder, a receiver having a body of a compressible fluid therein and communicating with one end of said cylinder whereby the fluid in said receiver will be compressed upon movement of said plunger in one direction, and means operative for sealing the other end of said cylinder from the atmosphere whereby movement of said plunger in said direction creates a partial vacuum in the last named end of said cylinder.

2. A counterbalance comprising a cylinder, a plunger reciprocable in said cylinder, a receiver having a body of a compressible fluid therein and communicating with one end of said cylinder whereby the fluid in said receiver will be compressed upon movement of said plunger in one direction, the other end of said cylinder being normally closed to the atmosphere, and a manually operable valve controlling communication between the atmosphere and the second named end of said cylinder whereby the latter may be sealed from the atmosphere when said plunger is adjacent the second named end of said cylinder to create a partial vacuum therein upon movement of said plunger in said direction.

3. A counterbalance comprising a cylinder, a plunger reciprocable in said cylinder, a receiver communicating with one end of said cylinder to receive fluid displaced therefrom upon movement of said plunger in one direction, a body of a non-compressible fluid trapping a body of a compressible fluid in the top of said receiver, and means sealing the other end of said cylinder to the atmosphere whereby movement of said plunger in said direction will create a partial vacuum in the second named end of said cylinder.

4. A counterbalance comprising a cylinder, a plunger reciprocable in said cylinder, a receiver communicating with one end of said cylinder to receive fluid displaced therefrom upon movement of said plunger in one direction, a body of a non-compressible fluid trapping a body of a compressible fluid in the top of said receiver, the other end of said cylinder being normally closed to the atmosphere, and a manually controlled valve controlling communication between the atmosphere and the second named end of said cylinder whereby the latter may be closed to the atmosphere when said plunger is adjacent the second named end of said cylinder to create a partial vacuum therein upon each movement of said plunger in said direction.

5. A counterbalance comprising a cylinder, a plunger reciprocable in said cylinder, a receiver communicating with one end of said cylinder and containing compressible fluid adapted to be compressed upon movement of said plunger toward said end of the cylinder, means for utilizing movement of said plunger toward the other end of said cylinder for pumping fluid to said receiver, and means for increasing the effective length of said plunger to reduce clearance in the second named end of said cylinder.

6. A counterbalance comprising a cylinder, a plunger reciprocable in said cylinder, a receiver communicating with one end of said cylinder and containing compressible fluid adapted to be compressed upon movement of said plunger toward said end of the cylinder, means for utilizing movement of said plunger toward the other end of said cylinder for pumping fluid to said receiver, and means for supplying a non-compressible fluid to the second named end of said cylinder to reduce the clearance space therein.

7. A counterbalance comprising a receiver, a cylinder communicating at one end with said receiver and having its other end normally closed to the atmosphere, said receiver containing a body of non-compressible fluid trapping a body of a compressible fluid in said receiver to be compressed upon movement of said plunger toward the first named end of said cylinder, means for utilizing movement of said plunger toward the second named end of said cylinder to pump fluid to said receiver, and means for reducing the clearance between said plunger and the second named end of said cylinder.

8. A counterbalance comprising a receiver, a cylinder communicating at one end with said receiver and having its other end normally closed to the atmosphere, said receiver containing a body of a non-compressible fluid trapping a body of a compressible fluid in said receiver to be compressed upon movement of said plunger toward the first named end of said cylinder, means for utilizing movement of said plunger toward the second named end of said cylinder to pump fluid to said receiver, and means for introducing non-compressible fluid into the second named end of said cylinder to reduce the clearance space between said plunger and the second named end of said cylinder.

9. A counterbalance comprising a receiver, a

cylinder communicating at one end with said receiver and having its other end normally closed to the atmosphere, said receiver containing a body of a non-compressible fluid trapping a body of a compressible fluid in said receiver to be compressed upon movement of said plunger toward the first named end of said cylinder, means for utilizing movement of said plunger toward the second named end of said cylinder to pump fluid to said receiver, a receptacle for non-compressible fluid, and means for transferring non-compressible fluid from said receptable to the second named end of said cylinder to reduce the clearance space therein above said plunger.

10. A counterbalance comprising a receiver, a cylinder communicating at one end with said receiver and having its other end normally closed to the atmosphere, said receiver containing a body of a non-compressible fluid trapping a body of a compressible fluid in said receiver to be compressed upon movement of said plunger toward the first named end of said cylinder, means for utilizing movement of said plunger toward the second named end of said cylinder to pump fluid to said receiver, a receptacle for non-compressible fluid, means for returning to said receptacle at least a portion of the non-compressible fluid leaking past said plunger into the second named end of said cylinder, and means for transferring non-compressible fluid from said receptacle to the second named end of said cylinder to reduce the clearance space therein above said plunger.

11. A counterbalance comprising a receiver, a cylinder communicating at one end with said receiver and having its other end normally closed to the atmosphere, said receiver containing a body of a non-compressible fluid trapping a body of a compressible fluid in said receiver to be compressed upon movement of said plunger toward the first named end of said cylinder, means for utilizing movement of said plunger toward the second named end of said cylinder to pump fluid to said receiver, and means for transferring non-compressible fluid from said receiver to the second named end of said cylinder to reduce the clearance space between said plunger and the second named end of said cylinder.

12. A counterbalance comprising a receiver, a cylinder communicating at one end with said receiver and having its other end normally closed to the atmosphere, said receiver containing a body of a non-compressible fluid trapping a body of a compressible fluid in said receiver to be compressed upon movement of said plunger toward the first named end of said cylinder, means for utilizing movement of said plunger toward the second named end of said cylinder to pump fluid to said receiver, a pipe affording communication between the other end of said cylinder and said receiver below the level of the non-compressible fluid therein to utilize the pressure in the receiver to transfer non-compressible fluid to the second named end of said cylinder to reduce the clearance space between said plunger and the second named end of said cylinder, and a valve controlling said pipe.

13. A counterbalance comprising a cylinder, a plunger reciprocable in said cylinder, a receiver communicating with one end of said cylinder and containing compressible fluid adapted to be compressed upon movement of said plunger toward said end of the cylinder, means for utilizing movement of said plunger toward the other end of said cylinder for pumping fluid to said receiver, means for reducing the clearance between said plunger and said other end of said cylinder, and means for limiting the extent to which the clearance in said other end of said cylinder can be reduced.

14. A counterbalance comprising a cylinder, a plunger reciprocable in said cylinder, a receiver communicating with one end of said cylinder and containing compressible fluid adapted to be compressed upon movement of said plunger toward said end of the cylinder, means for utilizing movement of said plunger toward the other end of said cylinder for pumping fluid to said receiver, means for supplying non-compressible fluid to the second named end of said cylinder to reduce the clearance space between said plunger and the latter end of said cylinder, and means for limiting the extent to which the clearance space in the second named end of said cylinder will be reduced by the introduction of non-compressible fluid thereinto.

15. A counterbalance comprising a cylinder, a plunger reciprocable in said cylinder, a receiver communicating with one end of said cylinder and containing compressible fluid adapted to be compressed upon movement of said plunger toward said end of the cylinder, means for utilizing movement of said plunger toward the other end of said cylinder for pumping fluid to said receiver, means for reducing the clearance in the second named end of said cylinder, a pipe communicating with the clearance space above said plunger at a point spaced from the top of such clearance space, and a check valve in said pipe opening outwardly with respect to said cylinder.

16. A counterbalance comprising a cylinder, a plunger reciprocable in said cylinder, a receiver communicating with one end of said cylinder and containing compressible fluid adapted to be compressed upon movement of said plunger toward said end of the cylinder, means for utilizing movement of said plunger toward the other end of said cylinder for pumping fluid to said receiver, means for supplying non-compressible fluid to the second named end of said cylinder to reduce the clearance space between said plunger and the latter end of said cylinder, a pipe communicating with the clearance space in the second named end of said cylinder at a point spaced from the top of such clearance space to limit the reduction thereof upon introduction of non-compressible fluid into the second named end of said cylinder, and a check valve in said pipe opening outwardly with respect to said cylinder.

17. A counterbalance comprising a receiver, a cylinder communicating at one end with said receiver and having its other end normally closed to the atmosphere, said receiver containing a body of a non-compressible fluid trapping a body of a compressible fluid in said receiver to be compressed upon movement of said plunger toward the first named end of said cylinder, means for utilizing movement of said plunger toward the second named end of said cylinder to pump fluid to said receiver, means for transferring non-compressible fluid from said receiver to the second named end of said cylinder to reduce the clearance space between said plunger and the second named end of said cylinder, and means for limiting the extent to which said clearance space will be reduced by the introduction of non-compressible fluid into the second named end of said cylinder.

18. A counterbalance comprising a receiver, a cylinder communicating at one end with said

receiver and having its other end normally closed to the atmosphere, said receiver containing a body of a non-compressible fluid trapping a body of a compressible fluid in said receiver to be compressed upon movement of said plunger toward the first named end of said cylinder, means for utilizing movement of said plunger toward the second named end of said cylinder to pump fluid to said receiver, means for transferring non-compressible fluid from said receiver to the second named end of said cylinder to reduce the clearance space between said plunger and the second named end of said cylinder, a discharge pipe communicating with the second named end of said cylinder, said clearance space extending above said pipe to limit the reduction in said clearance space, and a check valve in said pipe opening outwardly with respect to said cylinder.

19. A counterbalance comprising a vertical cylinder, a plunger reciprocable in said cylinder, a receiver in which said cylinder is arranged, said receiver communicating with the lower end of said cylinder to receive fluid displaced therefrom by said plunger, and means for sealing the upper end of said cylinder to the atmosphere when said plunger is arranged adjacent such end of the cylinder whereby partial vacuum will be created in the upper end of said cylinder upon each downward movement of said plunger.

20. A counterbalance comprising a vertical cylinder, a plunger reciprocable in said cylinder, a receiver in which said cylinder is arranged, said receiver communicating with the lower end of said cylinder to receive fluid displaced therefrom by said plunger, means for utilizing movement of said plunger toward the upper end of said cylinder for pumping a fluid to said receiver, and means for increasing the effective length of said plunger to decrease the clearance space thereabove.

21. A counterbalance comprising a vertical cylinder, a plunger reciprocable in said cylinder, a receiver in which said cylinder is arranged, said receiver communicating with the lower end of said cylinder to receive fluid displaced therefrom by said plunger, means for utilizing movement of said plunger toward the upper end of said cylinder for pumping a fluid to said receiver, and means for supplying a non-compressible fluid to the upper end of said cylinder to reduce the clearance space above said plunger.

22. A counterbalance comprising a cylinder, a plunger reciprocable in said cylinder, a receiver communicating with one end of said cylinder and containing compressible fluid adapted to be compressed upon movement of said plunger toward said end of the cylinder, means for utilizing movement of said plunger toward the other end of said cylinder for pumping fluid to said receiver, means for increasing the effective length of said plunger to reduce clearance in the second named end of said cylinder during movement of the plunger toward the latter end of said cylinder, and means for sealing the second named end of said cylinder to the atmosphere to create a partial vacuum therein upon each movement of said plunger toward the first named end of said cylinder.

23. A counterbalance comprising a receiver, a cylinder communicating at one end with said receiver and having its other end normally closed to the atmosphere, said receiver containing a body of a non-compressible fluid trapping a body of a compressible fluid in said receiver to be compressed upon movement of said plunger toward the first named end of said cylinder, means for utilizing movement of said plunger toward the second named end of said cylinder to pump fluid to said receiver, means for reducing the clearance between said plunger and the second named end of said cylinder, and means for sealing the second named end of said cylinder to the atmosphere to create partial vacuum therein upon each movement of said plunger toward the first named end of said cylinder.

24. A counterbalance comprising a receiver, a cylinder communicating at one end with said receiver and having its other end normally closed to the atmosphere, said receiver containing a body of a non-compressible fluid trapping a body of a compressible fluid in said receiver to be compressed upon movement of said plunger toward the first named end of said cylinder, means for utilizing movement of said plunger toward the second named end of said cylinder to pump fluid to said receiver, means for transferring non-compressible fluid from said receiver to the second named end of said cylinder to reduce the clearance space between said plunger and the second named end of said cylinder, and means for sealing the second named end of said cylinder to the atmosphere to create a partial vacuum therein upon each movement of said plunger toward the first named end of said cylinder.

25. A counterbalance comprising a vertical cylinder, a plunger reciprocable in said cylinder, a receiver in which said cylinder is arranged, said receiver communicating with the lower end of said cylinder to receive fluid displaced therefrom by said plunger, means for utilizing movement of said plunger toward the upper end of said cylinder for a compressible fluid to said receiver, means for supplying a non-compressible fluid to the upper end of said cylinder to reduce the clearance space above said plunger, and means for sealing the upper end of said cylinder to the atmosphere when said plunger is arranged adjacent such end of the cylinder whereby partial vacuum will be created in the upper end of said cylinder upon each downward movement of said plunger.

26. A counterbalance comprising a receiver, a hollow member, a fluid displacing member movable in said hollow member, said receiver communicating with said hollow member to receive fluid displaced therefrom by said displacing member, a body of a non-compressible fluid trapping a body of a compressible fluid in the top of said receiver, said non-compressible fluid being of a depth sufficient to form a seal between said compressible fluid and said hollow member in any position of said displacing member, means for supplying non-compressible fluid to said receiver including a supply pipe, an adjustable blow-off valve connected to said pipe, and manually controllable means for discharging non-compressible fluid from said receiver.

27. A counterbalance comprising a receiver, a hollow member, a fluid displacing member movable in said hollow member, said receiver communicating with said hollow member to receive fluid displaced therefrom by said displacing member, a body of a non-compressible fluid trapping a body of a compressible fluid in the top of said receiver, said non-compressible fluid being of a depth sufficient to form a seal between said compressible fluid and said hollow member in any position of said displacing member, means for supplying compressible fluid to said receiver to

build up a pressure therein, means for introducing non-compressible fluid into said receiver against the pressure existing therein, means associated with said last named means for automatically controlling pressure in said receiver, and a manually controllable valve for releasing non-compressible fluid from said receiver.

28. A counterbalance comprising a receiver, a hollow member, a fluid displacing member movable in said hollow member, said receiver communicating with said hollow member to receive fluid displaced therefrom by said displacing member, a body of a non-compressible fluid trapping a body of a compressible fluid in the top of said receiver, said non-compressible fluid being of a depth sufficient to form a seal between said compressible fluid and said hollow member in any position of said displacing member, means for supplying compressible fluid to said receiver to build up a pressure therein, a source of supply of non-compressible fluid, means for transferring non-compressible fluid from said source to said receiver against the pressure therein, a blow-off valve connected to said last named means, and means for by-passing non-compressible fluid from said receiver to said source, said by-passing means including a manually controllable valve.

29. A counterbalance comprising a receiver, a hollow vertical member, a fluid displacing member vertically movable in said hollow member, said receiver communicating with the lower end of said hollow member to receive fluid displaced from said hollow member upon downward movement of said displacing member, a body of a non-compressible fluid in said receiver trapping a body of a compressible fluid in the top of said receiver, said non-compressible fluid being of a depth sufficient to form a seal between said compressible fluid and said hollow member in any vertical position of said displacing member, a source of non-compressible fluid, pumping means for transferring non-compressible fluid under pressure from said source to said receiver, a blow-off valve between said pumping means and said receiver, a by-pass connecting the outlet of said blow-off valve to said source, and a second by-pass for returning noncompressible fluid from said receiver to said source, said second by-pass including a manually controllable valve.

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