Feb. 25, 1941. H. W. RAMEY ET AL 2,233,227

HYDROPNEUMATIC COUNTERBALANCE

Filed Dec. 27, 1938

Fig. 1.

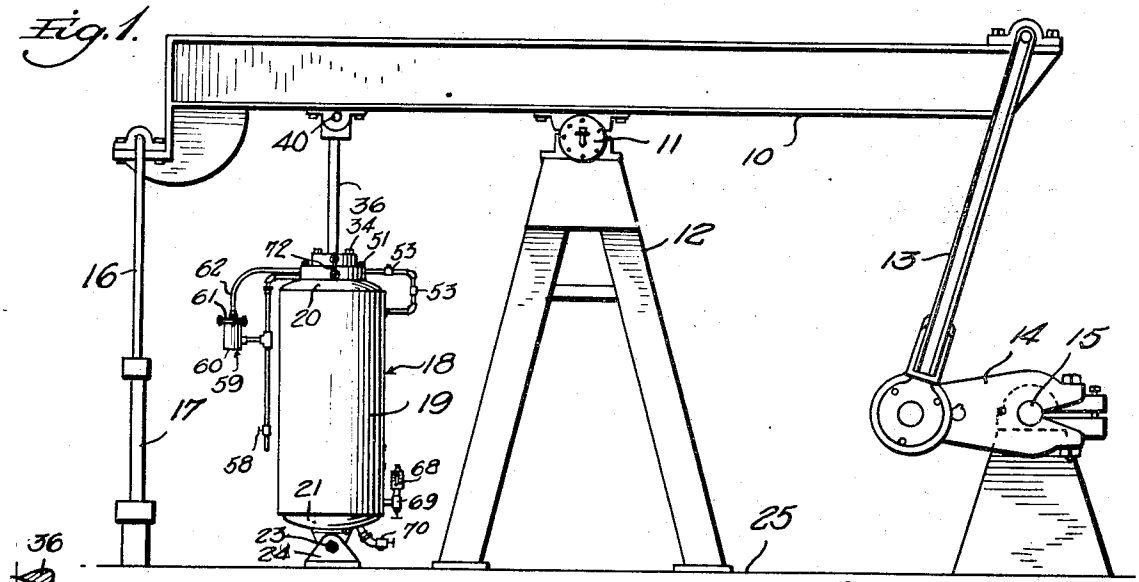


Fig. 4.

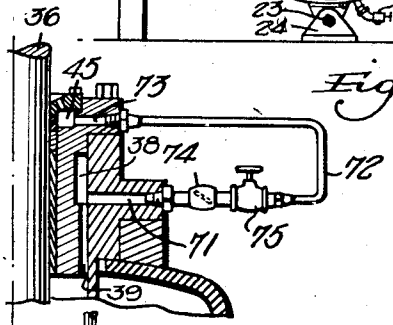


Fig. 2.

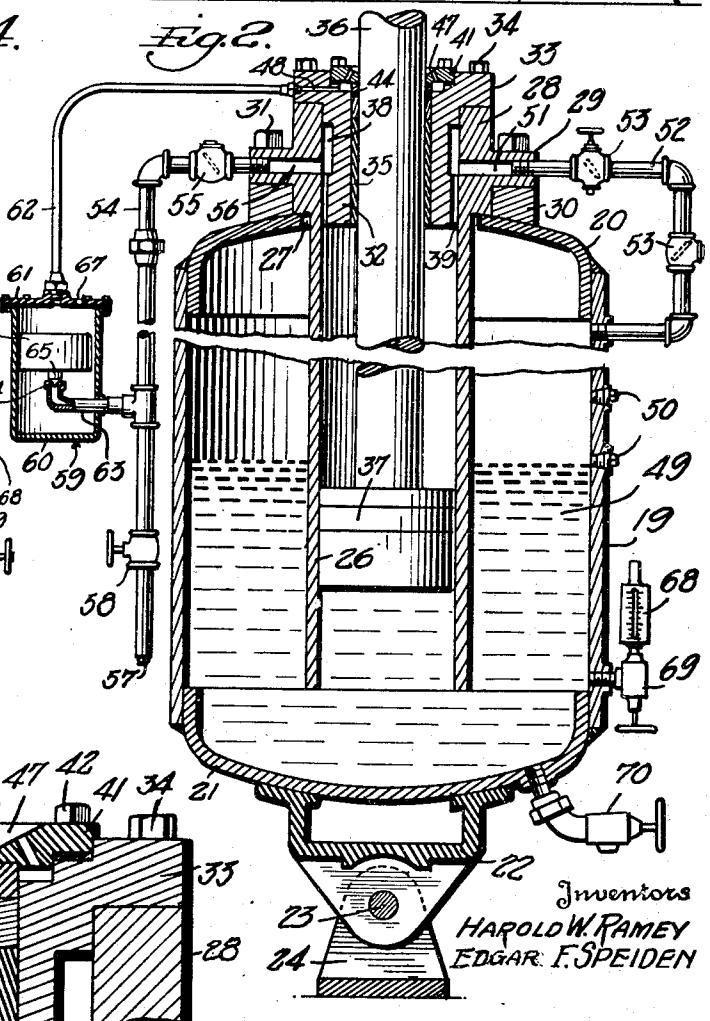


Fig. 5.

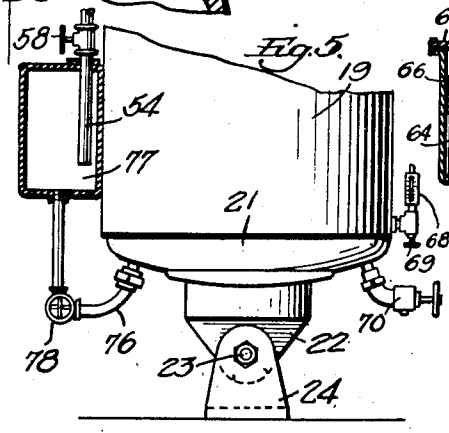
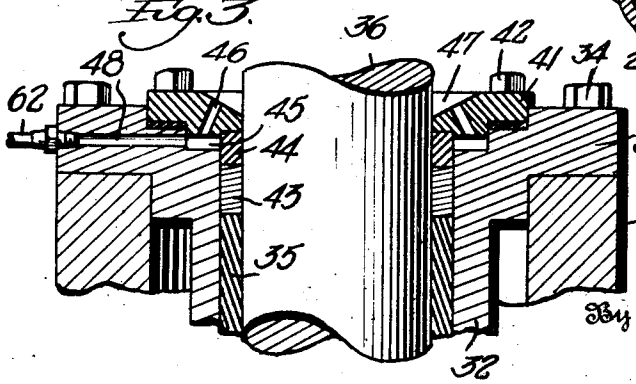


Fig. 3.



Inventors
HAROLD W. RAMEY
EDGAR F. SPEIDEN

By C. P. Parker
Attorney

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HYDROPNEUMATIC COUNTERBALANCE

Harold Williams Ramey, Parkersburg, W. Va., and Edgar French Speiden, Oklahoma City, Okla., assignors to The Parkersburg Rig & Reel Company, Parkersburg, W. Va., a corporation of West Virginia

Application December 27, 1938, Serial No. 247,976

28 Claims. (Cl. 74—589)

This invention relates to counterbalances, and more particularly to hydropneumatic counterbalances for use with oil well pumping rigs.

As is well known, it has been the common practice for a number of years to counterbalance oil well pumping rigs to equalize the power demand during the pumping cycle. This usually has been done either by counter-weighting the walking beam or by counter-weighting the crank shaft from which the pitman is driven. Each method possesses advantages over the other but the advantages of both methods are greatly offset by substantial disadvantages. For example, the use of heavy counterweights on the walking beam requires the use of a very heavy walking beam and the counterweights can be adjusted only with great difficulty. In the case of a pitman failure, the weight of the walking beam obviously will move the walking beam downwardly and may result in wrecking the entire pumping rig and in causing injury to workmen unless the downward movement of the walking beam is stopped by a conventional headache post.

Rotary counterweights carried by the crank shafts have been largely used in recent years instead of beam weights because of certain advantages which they possess, but crank counterweights also involve substantial disadvantages. Such counterweights are not easily adjustable; they add substantially to the load on the crank and crank shaft; and they provide the 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 the use of counterweights as counterbalancing means, it has been proposed in recent years to provide pneumatic counterbalancing means which operates to store energy on the down stroke of the pumping rods and to expend energy on the up stroke. Such a mechanism is advantageous over conventional counterweighting for several reasons. For example, the counterbalancing force may be applied substantially at the ideal point and lighter parts may be used through the elimination of heavy counterweights. Thus the use of heavy masses of reciprocating or rotating weights is eliminated and the pumping equipment may be made more portable and easier to install, and much less foundation is required for stability.

Although advantageous over the use of counterweights, pneumatic counterbalancing also involves numerous disadvantages. Many wells are pumped night and day and it is essential that a counterbalance unit be made as trouble free as possible partly because of the fact that one pump attendant will frequently have in his charge a substantial number of pumping wells scattered over a considerable territory. Pneumatic counterbalances provide too many possibilities of failure to render their use practicable or desirable. For example, they require the use of air compressors which may fail in operation, thus resulting in a complete unbalancing of the pumping unit, and the same result may occur through the springing of a leak in the packing of the compressor or in the packing of the counterbalance piston. There are numerous other disadvantages to pneumatic counterbalancing which need not be referred to in detail.

In the copending application of Robert Griffin De La Mater, Serial No. 157,189, filed August 3, 1937, there is disclosed a hydropneumatic counterbalance which is highly efficient, practicable and trouble proof since it overcomes the disadvantages of both the weight and pneumatic types of counterbalances. In the structure of the copending application referred to a vertical receiver is provided with a cylinder therein sealed at its upper end with respect to the receiver and open at its lower end for communication therewith. A plunger is reciprocable in the cylinder and the upper end of the plunger rod and the bottom of the receiver are respectively connected to the walking beam and to a stationary support whereby downward movement of the plunger will displace fluid from the lower end of the cylinder into the receiver. A body of a suitable liquid such as oil is maintained in the bottom of the receiver and the quantity of oil employed is such that its level never reaches the lower end of the cylinder when the plunger reaches its upper limit of movement.

With such a construction, each downward movement of the plunger displaces oil from the cylinder thus causing the level in the oil in the receiver to rise and cause compression of the entrapped air or other compressible gas thereabove, thus storing energy to be expended upon each up stroke of the plunger. With such an apparatus, the entrapped air will remain indefinitely in the top of the receiver since it never reaches the plunger and accordingly cannot leak past the plunger to escape from the apparatus. No air compressor is needed with the apparatus referred to since upward movement of the plunger is utilized to compress air to charge the receiver prior to starting the normal oper-

ation of the apparatus, and any minor leakage of oil which may occur is compensated for by automatic means including a reservoir, a small oil pump for pumping oil from the reservoir to the receiver, and a pressure release by-passing valve connected in the line between the pump and the receiver to by-pass oil from the pump to the reservoir at all pressures above the maximum pressure at which the valve is adjusted.

It will be apparent that the pressure release valve referred to may be adjusted to determine the maximum pressure in the receiver, thus providing a regulating means therefor and preventing the accumulation of excess pressure incident to expansion caused by increased temperatures occurring during the day. Moreover, the valve maintains the desired maximum pressure in the receiver by supplying oil thereto to compensate for any leakage which may occur as well as any drops in pressure which occur incident to decreases in temperature. The system also possesses a degree of flexibility which renders its use highly advantageous over pneumatic counterbalances. For example, by increasing or decreasing the amount of oil in the receiver, pressure differences between minimum and maximum can be predetermined as desired.

In the copending application of Harold W. Ramey, Serial No. 163,862, filed September 14, 1937, there is disclosed a system which is identical in principle to the system disclosed in the copending application referred to above, the differences lying in the provision in the counterbalance of the later filed application of improvements over the system in the earlier filed application. For example, in the application of Harold W. Ramey a manually controllable by-pass is provided between the receiver and the reservoir to permit the drainage of oil from the receiver and to permit the manual controlling of maximum pressure in the receiver in the event of failure of the pressure release valve. The structure of the Ramey application also includes means for supplying oil to the upper end of the cylinder to increase the effective length of the plunger to provide a higher degree of compression of air above the plunger for initially charging the receiver when the apparatus is used with a short stroke pumping unit. The structure of the Ramey application also includes means for creating a partial vacuum above the plunger during the normal operation of the apparatus to increase differential pressures between the fluids above and below the plunger to increase the effective counterbalancing action for a given maximum pressure within the receiver.

The structures of the two copending applications referred to have been found highly advantageous in practice. However, it was found that while such structures would provide a remarkably uniform maximum pressure in the receiver by compensating for leakage of oil and variations in temperature conditions, in most installations the variations in pressure due to temperature changes were not sufficient to noticeably affect the operation of the apparatus. Moreover, the pressure release valve employed with the structures referred to is a relatively expensive piece of equipment which necessarily must operate perfectly to provide the desired results. In the copending application of Harold W. Ramey, Serial No. 223,737, filed August 8, 1938, there is disclosed a similar hydropneumatic counterbalance wherein a pump is employed for supplying oil to the receiver, but instead of using a pressure release valve to supply oil to the receiver in accordance with pressures therein, a reservoir is employed and the apparatus is provided with means for returning to the reservoir all oil which may leak past the plunger. A float in the reservoir admits oil to the pump to be transferred to the receiver under pressure when the level of the oil in the reservoir is above a predetermined point, and the level of the oil in the reservoir rises only because of the returning thereto of oil leaking past the counterbalance plunger. It will be apparent, therefore, that the amount of oil pumped to the receiver will always exactly equal the amount of oil which leaks past the plunger of the receiver. Accordingly the apparatus, after having been provided with the desired quantity of oil, will always operate with the same quantity of oil therein and pressures in the receiver can vary only in accordance with changes in temperature conditions which, for most installations, is unimportant. Therefore, the apparatus of the Ramey application Serial No. 223,737 is advantageous over the structures of the other pending applications referred to in that it eliminates the use of the pressure release by-passing valve.

An important object of the present invention is to provide a hydropneumatic counterbalance which embodies the advantages of the structures of the copending applications referred to but which is advantageous thereover for the reason that it eliminates the use of the pressure release valve, as is true of application Serial No. 223,737, and for the additional reason that it eliminates the use of a separate reservoir and also the pump for supplying oil to the receiver.

More specifically, an important object of the invention is to provide a hydropneumatic counterbalance the structure of which is confined to a single unit and wherein normal parts of the counterbalance structure are employed for returning to the receiver all of the oil which may leak past the plunger.

A further object is to provide an apparatus of the character referred to wherein upward movement of the counterbalance plunger is utilized for creating a pressure effective for returning to the receiver oil which has leaked therefrom.

A further object is to provide means for utilizing the counterbalance plunger and cylinder as a pump for returning to the cylinder oil which has leaked therefrom, wherein downward movement of the plunger creates a partial vacuum to draw some of the leaked oil into the cylinder and wherein upward movement of the plunger returns such oil to the receiver.

A further object is to provide a hydropneumatic counterbalance having means associated therewith for charging the receiver with air under pressure, and for utilizing the same means for returning to the receiver any oil which has leaked therefrom past the plunger.

A further object is to provide such an apparatus wherein the means for returning oil to the receiver may be utilized for increasing the amount of oil in the receiver to increase the differential between minimum and maximum pressures in the receiver.

A further object is to provide an apparatus of the character just referred to wherein additional means is employed for reducing the amount of oil in the receiver to reduce the differential between minimum and maximum pressures in the receiver and wherein the same oil

may be readily returned to the receiver if it is desired to increase the amount of oil therein.

A further object is to provide an apparatus wherein pressure is created in the upper end of the cylinder during the up-stroke of the plunger to return to the receiver oil which leaks past the plunger, and to control and utilize pressures in the upper end of the cylinder to improve the operation of the apparatus.

A further object is to provide such an apparatus wherein the pressures in the upper end of the plunger may be utilized in certain installations and under certain operating conditions for controlling the inertia effects of the pumping apparatus to greatly increase the degree of smoothness of operation of the apparatus.

A further object is to provide an apparatus of the character referred to wherein the tendency of the belt employed for driving the pitman crank shaft to chatter or vibrate excessively on the tight side of the belt may be eliminated by preventing excessive decreases in pressure differentials on opposite sides of the plunger due to the building up of back pressures above the plunger.

A further object is to provide means for bleeding air from the upper end of the cylinder to control back pressures therein.

A further object is to provide a bleeder pipe for the purpose just referred to wherein such pipe is connected to the means for returning leakage oil to the cylinder whereby any oil blowing out of the cylinder through the bleeder pipe may be returned to the cylinder to prevent the loss of such oil.

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

In the drawing we have shown two embodiments of the invention. In this showing:

Figure 1 is a side elevation of a standard well rig showing the invention applied thereto,

Figure 2 is a central vertical sectional view through the counterbalance, parts being broken away and parts being shown in elevation,

Figure 3 is an enlarged detail sectional view of the upper end of the counterbalance cylinder showing the oil collecting means associated therewith,

Figure 4 is a fragmentary central vertical sectional view taken at an angle to Figure 2 showing pressure control means for the upper end of the counterbalance cylinder, parts being shown in elevation, and,

Figure 5 is a fragmentary side elevation of the lower end of the counterbalance showing a slightly modified form of the invention, parts being shown in section.

Referring to Figure 1 the numeral 10 designates a conventional walking beam mounted as at 11 for oscillation on the upper end of a conventional Samson post 12. The walking beam is oscillated in the usual manner by a pitman 13 driven by a crank 14 mounted on the usual crank shaft 15 and driven by any suitable prime mover (not shown). The well end of the beam is connected by the usual polished rod carrier 16 to conventional polished rods 17. The usual "headache post" need not be used in connection with the present apparatus for a reason which will become apparent. While the invention has been illustrated as being applied to a conventional pumping rig, it will become apparent that it can be used in connection with any type of analogous structure.

The present invention comprises a self-contained counterbalance unit indicated as a whole by the numeral 18. This unit comprises a preferably cylindrical receiver 19 having upper and lower heads 20 and 21 preferably welded to the body of the receiver. A supporting member 22 is preferably welded to the bottom head 21 and is pivotally connected as at 23 to a suitable support 24 preferably mounted upon the usual base or foundation 25. While the receiver 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 26 projects downwardly through an axial opening 27 formed in the upper head 20, the cylinder having an annular enlarged portion 28 at its upper end. The latter portion of the cylinder is provided with an outstanding annular flange 29 supported on a ring 30 preferably welded in position on the head 20, the flange 19 being secured in position by suitable bolts 31 passing through the ring 30.

A bearing 32 is mounted in the upper end of the cylinder and is provided at its upper end with a relatively heavy annular flange 33 overlying the upper enlarged end 28 of the cylinder and bolted thereto as at 34. The bearing 32 carries a suitable bushing 35 receiving a vertically reciprocable plunger rod 36 to the lower end of which is connected a plunger 37. Intermediate its ends, the bearing 32 is provided with an annular groove 38 forming a flange for a purpose to be described, and the lower extremity of the bearing is of slightly smaller diameter than the internal diameter of the cylinder to provide a passage 39 communicating between the cylinder and the chamber 38. It will be apparent that the plunger 37 reciprocates in the cylinder, and the upper end of the plunger rod 36 is pivotally connected to the walking beam as at 40 to effect reciprocation of the plunger upon oscillation of the walking beam.

Referring to Figure 3, it will be noted that a cap 41 is bolted as at 42 to the upper end of the bearing 32. Above the bushing 35 a compressible packing ring 43 is arranged and this packing is compressible by a ring 44 engageable against the bottom of the cap 41. An annular chamber or space 45 is defined by the bearing 32, ring 44 and cap 41, and communicates through small passages 46 with a conical recess or basin 47 formed in the top of the cap 41 and surrounding the plunger rod 36. The flange 33 is provided with a radial passage 48 communicating at its inner end with the chamber 45 for a purpose to be described.

The casing contains a body 49 of non-compressible fluid, preferably oil, and plugs 50 may be arranged at different levels in the wall of the receiver to facilitate the initial charging of the receiver with oil and to determine the level of the oil therein. The space above the oil is adapted to be charged with air or other compressible fluid and the apparatus embodies means for pumping air into the top of the receiver. Referring to Figure 2 it will be noted that the flange 29 is provided with a passage 51 communicating with the chamber 38 adjacent the bottom thereof. A piping connection 52 is connected between the outer end of the passage 51 and the top of the receiver, and check valves 53 are arranged in the connection 52 and open outwardly with respect to the passage 51. While two check valves 53 have been shown, only one is necessary.

but two are preferably used to insure against leakage from the top of the receiver.

During initial operation of the apparatus, as will be described, upward movement of the plunger 37 compresses air to be discharged through the connection 52 into the receiver, and upon each down stroke of the plunger, air is drawn into the cylinder through a piping connection 54. The connection 54 is provided with a check valve 55 opening inwardly with respect to the chamber 38, and the connection 54 communicates with such chamber adjacent the bottom thereof through a radial passage 56 formed in the flange 29. The lower end of the pipe connection 54 is preferably normally plugged as at 57, and near its lower end the piping connection 54 is provided with a manually operable cut off valve 58. In charging the receiver with air, it will be obvious that the plug 57 is removed and the valve 58 is opened, whereupon each downward movement of the plunger draws air into the cylinder through the connection 54 and discharges it to the receiver through the piping connection 52. The latter piping connection is also utilized, during normal operation of the apparatus, for returning to the receiver oil which leaks past the plunger 37, and this forms one of the important features of the present invention.

It will be apparent that some slight leakage of oil past the plunger 37 will occur, and some of this oil will be employed in lubricating the plunger rod 36. Slight amounts of oil will be scraped from the plunger rod by the cap 41 during downward movements of the plunger rod, and this oil will be collected in the basin 47 and will flow downwardly into the chamber 45 (Figure 3). Means are provided for automatically returning such oil to the receiver.

Referring to Figure 2 the numeral 59 designates an oil trap as a whole comprising a casing 60 closed by an upper head 61 and a pipe 62 is connected between this head and the radially outer end of the passage 48 to receive oil from the latter. A pipe 63 leads from the piping connection 54 to the interior of the casing 60 and has its inner end turned upwardly and terminating in a valve seat 64 engageable by a valve 65 carried by the bottom of a float 66. Whenever oil collects in the casing 60 to a sufficient extent to move the float 66 upwardly to open the valve 65, oil will be sucked into the pipe 63 when the plunger 37 moves downwardly and the head 61 is vented to the atmosphere as at 67 to permit oil in the casing 60 to flow into the pipe 63. When the valve 65 is closed, it will be obvious that no air from the vent 67 may flow into the pipe 63.

In the copending applications of Robert Griffin De La Mater Serial No. 157,189 and Harold W. Ramey, Serial No. 163,862, referred to above, the level of the oil in the receiver is maintained in accordance with pressure conditions therein, and automatic means is provided for replenishing the oil in the receiver to maintain a fixed maximum pressure therein. Such means has associated therewith a pressure gage arranged in the piping connections associated with the automatic means referred to. No such means need be employed in the present construction but the receiver is preferably provided with a pressure gage 68 normally to cut off from the receiver by a valve 69. The receiver is also provided in the bottom thereof with a valve 70 to permit the receiver to be drained, when desired.

In some installations and under some operating conditions it has been found that a greatly improved operation of the apparatus may be provided by controlling the quantity of air and the back pressures in the upper end of the cylinder 26, and means for this purpose is shown in Figure 4. The upper end of the cylinder may be provided with a passage 71 having a piping connection 72 leading to a passage 73 communicating with the chamber 45. The piping connection 72 is provided with a check valve 74 opening outwardly with respect to the passage 71, and a manually controllable valve 75 also is arranged in the connection 72.

As will be explained, the receiver 19 contains a body of oil 49 to the proper depth according to operating conditions, and the quantity of oil may be changed to adjust the apparatus for changes in working conditions. This may be done by opening the valve 70 to release some of the oil from the receiver, or the amount of oil in the receiver may be increased by introducing oil into the bottom of the piping connection 54 if the valve 58 is opened. If desired, means may be provided, as shown in Figure 5 for maintaining oil in a position to be drawn into the lower end of the pipe 54. As shown, a pipe connection 76 leads from the bottom of the receiver to the bottom of a small container 77, and a manually controllable valve 78 is arranged in the pipe 76. The lower end of the pipe connection 54 extends to a point adjacent the bottom of the container 77.

The operation of the apparatus is as follows:

When the operation of the apparatus is to be started, one of the plugs 50 may be removed and oil or other non-compressible fluid may be piped into the receiver, the level of the oil depending upon the particular installation, and the plunger 37 being maintained in its lower position while oil is piped into the receiver.

When the desired amount of oil has been placed in the receiver, the apparatus is operated to charge the top of the receiver with air under pressure. This is accomplished by opening the valve 58 and removing the plug 57 from the bottom of the pipe 54, whereupon each downward movement of the plunger will draw air into the upper end of the cylinder and each upward movement of the plunger will compress the air and discharge it to the receiver through the pipe connection 52. In this connection, it will be noted that the check valve opens inwardly with respect to the cylinder 26, and accordingly the check valve closes immediately upon the beginning of each up stroke of the plunger. The check valves 53 open outwardly with respect to the upper end of the cylinder 26, and accordingly they close upon each down stroke of the plunger while air is being drawn through the pipe 54 into the upper end of the cylinder.

It will be apparent that as pressure is accumulated in the top of the receiver, each up stroke of the plunger must compress the air in the upper end of the cylinder to a pressure above the pressure in the receiver before the check valves 53 will open. Therefore, the check valves 53 open slightly later upon each up stroke of the plunger. This is of no importance when the unit is being operated at its maximum stroking, but in case the stroke is shortened, the pressure in the receiver, before the desired pressure is obtained, will equal the maximum pressure which can be developed upon each upward movement of the plunger 37, and at such time there will be no further charging of the receiver with air. Under such conditions, the operator may remove

the plug 57, hold an open topped container of oil over the bottom of the pipe connection 54, and then open the valve 58. This operation is performed, of course, before the charging operation commences and each down stroke of the plunger will draw oil into the upper end of the cylinder and the oil will lie above the plunger 37 to increase the effective length thereof. In other words, when the apparatus is used at a stroke shorter than the maximum, oil above the plunger will reduce the clearance space above the plunger at the top of its stroke, thus permitting the plunger to compress air in the upper end of the cylinder to the extent necessary to charge the receiver to the desired pressure.

When the desired pressure in the receiver has been attained in the manner described, the system is ready for operation as a counterbalance. Upon each downward stroke of the plunger 37, the oil or other non-compressible fluid will be displaced from the lower end of the cylinder 26 into the receiver 19, thus raising the level of the oil in the receiver against the pressure of the air or other compressible fluid in the top of the receiver. Pressure in the receiver increases progressively upon the downward stroke of the pump rods and reaches its maximum pressure when the pump rods reach their lowermost position.

It will be apparent that energy will be stored in the compressed fluid above the oil on each down stroke of the plunger, and this energy is expended on the up stroke of the pump rods to assume part of the load of the pump rods and the oil being lifted from the well. Thus the prime mover which drives the shaft 15 is required to perform only a portion of the work necessary for moving the pump rods upwardly.

The maximum upward force exterted by the counterbalance is preferably equal to the weight of the pump rods plus half the weight of the column of oil being lifted from the well, and at the beginning of the up stroke, therefore, the force exerted by the prime mover is the force necessary to elevate half the weight of the column of oil being lifted. The energy required for compressing the air in the receiver is theoretically equal to the energy expended by the compressed air in forcing the plunger upwardly during the up stroke of the pump rods. Therefore, the force required to compress the fluid above the oil in the receiver on the down stroke of the pump rods is equal to the weight of the pump rods plus half the weight of the oil which is lifted on each up stroke of the pump rods. Accordingly the prime mover, when the plunger reaches the point of maximum compression of the air in the receiver, exerts a force equal to half the weight of the column of oil which is lifted from the well on each up stroke of the pump rods. It will be apparent therefore, that the prime mover is called upon to exert approximately the same force on the up and down strokes of the plunger 37, thus rendering far more uniform the power demands which are made on the prime mover throughout each cycle of operation.

It will be apparent that variations in the pressures in the receiver at any given point in the movement of the plunger 37 will occur due to expansion and contraction incident to temperature changes and due to the relatively small leakage of oil which occurs past the plunger 37. In the copending applications of Robert Griffin De La Mater Serial No. 157,189 and Harold W. Ramey, Serial No. 163,862, leakage past the plunger of the counterbalance was not directly taken into consideration in maintaining proper pressures in the receiver since in each case the apparatus functioned automatically to maintain pressures regardless of the causes of variations in pressure. As previously stated, such mechanisms required the use of the reservoir, a pump for positively transferring oil from the reservoir to the receiver, and a pressure release valve for determining the operativeness of the pump for supplying oil to the receiver.

While each of the mechanisms referred to is highly efficient in operation, it was found that in most installations changes in pressure due to temperature changes were not sufficiently serious to require that they be compensated for. Accordingly the apparatus disclosed in the copending application of Harold W. Ramey, Serial No. 223,737, referred to above, was developed. Such apparatus eliminates the use of a pressure release valve connected between the pump and the receiver, but employed a pump and a reservoir with means for transferring to the latter any oil which leaked past the plunger of the counterbalance. As oil accumulated in the reservoir, its increased depth above a predetermined level represented the exact amount of leakage of oil from the receiver, and a float in the reservoir would operate to supply to the pump the necessary amount of oil to exactly replenish the receiver with oil to replace the oil which had leaked past the plunger.

The present construction is advantageous over the Ramey application just referred to in that it eliminates the use of a reservoir as a unit separate from the counterbalance and it eliminates the use of a separate pump for pumping to the receiver the necessary amount of oil to compensate for leakage therefrom. The leakage past the plunger 37 takes place at a very slow rate, but a pumping apparatus usually is operated steadily over long periods of time and leakage past the plunger therefore becomes a serious matter. During the normal operation of the present apparatus the valve 58 is maintained closed to prevent any air from being drawn into the top of the cylinder 26. Oil which leaks past the plunger will accumulate thereon, of course, and when this oil reaches the slight depth necessary for it to be forced upwardly as far as the passage 51 (Figure 2) at the upper limit of the stroke of the plunger 37, the pressure generated by the up stroke of the plunger will cause oil to be pumped through the passage 51 and through the pipe 52, to be returned to the receiver 19. Therefore it is unnecessary to drain this oil to a separate reservoir as disclosed in the several copending applications referred to.

Oil leaking past the plunger will lubricate the plunger rod 36 and its bearing bushing 35, and upon each down stroke of the plunger a few drops of oil will be scraped from the plunger rod by the cap 41. This oil is collected by the recess or basin 47 and flows downwardly through the passages 46 into the chamber 45. From this chamber the oil flows by gravity through pipe 62 to the trap 60.

The valve 65 is normally closed, thus preventing the admission of air into the pipe 63. If any air were admitted into this pipe it would be drawn through the pipe connection 54 into the cylinder 26 upon each down stroke of the plunger 37, and each up stroke of the plunger would force more air through the pipe connection 52 into the top of the receiver to increase the pressure therein. When oil accumulates in

the trap 60 to the depth necessary to support the float 66, the valve 65 will slightly open to permit oil to flow into the pipe 63, the valve 65 closing as soon as the oil level in the trap ceases to support the float 66. Oil flowing into the pipe 63 will be drawn through the pipe 54 into the top of the cylinder 26 and will be returned to the receiver, when the plunger 37 is at the top of its stroke, through the pipe connection 52.

From the foregonig it will be apparent that the present apparatus provides a self-contained unit for counterbalancing a walking beam, it being unnecessary to employ an oil pump, a pressure release valve, or an oil reservoir as a separate unit from the counterbalance. The exact amount of oil leaking past the plunger 37 will always be compensated for by the return of such oil to the receiver thus maintaining a constant amount of oil therein. Of course, there will be some slight differences in pressures due to changes in temperature conditions, but in most installations, these differences in pressures need not be compensated for. It is necessary to compensate for leakage of oil past the plunger since such leakage, over a long period of operation of the pumping apparatus, will be quite substantial.

It will be apparent that the greater the quantity of oil in the receiver the greater will be the differential between minimum and maximum pressures at opposite ends of the stroke of the plunger 37. Conversely, a reduction in the quantity of oil in the receiver will reduce the differential between minimum and maximum pressures. The present apparatus provides means whereby the quantity of oil in the receiver readily may be changed to vary the difference between minimum and maximum pressures in accordance with changes in operating conditions. Referring to Figure 2 it will be apparent that if it is desired to reduce the differential between minimum and maximum pressures it merely is necessary to open the valve 70 and drain some of the oil from the receiver. This drainage of oil obviously will reduce the maximum pressure which again may be increased merely by removing the plug 57 and opening the valve 58 to charge the top of the receiver with more air until the desired reading is secured on the gage 68. In this connection, attention is invited to the fact that the use of the plug 57 is wholly unnecessary, but its use is preferred since it provides a positive seal against the leakage of air into the pipe 54 if there should be any leakage past the valve 58.

If it is desired to increase the differential between minimum and maximum pressures, the operator may remove the plug 57, hold a container of oil at the bottom of the pipe 54 with the lower end of the pipe immersed in the oil, and then open the valve 58 until the desired amount of oil has been drawn through the pipe 54. Oil will be drawn through the pipe 54 into the upper end of the cylinder 26 upon each down stroke of the plunger 37 and will be discharged upon the up stroke of the plunger through the pipe connection 52 into the receiver. When the desired amount of oil has been supplied to the receiver, the valve 58 may be closed. Accordingly it will be apparent that the pipe connections 52 and 54 and associated elements form means for charging the receiver with air; means for returning to the receiver all of the oil which leaks past the plunger 37; and means for increasing the amount of oil in the receiver when it is desired to increase the differential between minimum and maximum pressures.

If desired, the arrangement shown in Figure 5 may be employed for reducing the amount of oil in the receiver or for increasing it. When it is desired to decrease the amount of oil in the receiver, the valve 78 may be opened to permit oil to flow from the receiver into the container 77, the valve 78 being closed after the quantity of oil in the receiver has been reduced to the desired extent. Oil in the container 77 provides a ready source of oil when it is desired to increase the amount of oil in the receiver, it merely being necessary to open the valve 58 whereupon oil will be drawn through the pipe 54 to be pumped into the receiver as described in connection with the structure in Figure 2.

As is true of the structures of the copending applications referred to, the present invention adds nothing to the weight of the walking beam, and thus permits the use of a much lighter walking beam, and the counterbalance applies the counterbalancing force at a point close to the point where work is performed. It also will be apparent that downward movement of the plunger is limited, and accordingly the apparatus acts as a headache post to limit the downward movement of the adjacent end of the walking beam, thus eliminating the necessity for using conventional headache posts.

Particular attention is invited to the importance of the use of the bleed line 72 and its control valve 75, this means being useful under certain conditions, particularly during the normal operation of the apparatus. It has been found that regardless of the type of oil used in the apparatus, the subjection of the oil to substantial pressures causes the aeration of the oil, thus causing the oil to assume a foamy consistency when the pressure is released. This characteristic of the oil does not affect the functioning of the oil in the receiver to any noticeable extent for the reason that this oil is always maintained under sufficient pressure to prevent substantial expansion of the oil under the influence of the air entrained therein. The aeration of the oil must be given serious consideration, however, in the functioning of the compression chamber, that is, the space above the plunger 37.

In the preferred practice of charging the receiver, the walking beam is oscillated before being connected to the polished rods, the valve 58 being opened and the plug 57 removed to admit air into the compression chamber on each downstroke of the plunger. Upon each up-stroke of the plunger air is compressed and discharged over into the receiver to build up pressure therein. It will be apparent that the clearance space above the plunger 37 determines the maximum pressure which can be built up in the compression chamber and this pressure under any conditions obviously is sufficient to discharge air over into the receiver when the charging operation is started. It is desired to reduce the clearance space above the plunger when the latter is at the upper limit of its stroke, during the charging operation, for two reasons, namely, in order to increase maximum pressures in the compression chamber to reduce the time required for charging the receiver, and to insure the development of sufficient pressure in the compression chamber to fully charge the receiver to its minimum pressure.

For this reason oil is introduced into the compression chamber in an amount sufficient to

raise the level of the oil approximately to the level of the passages 51 and 56 when the plunger is at the upper limit of its stroke, in which case maximum pressures in the compression chamber can be developed upon each up-stroke of the plunger. As previously stated, each down-stroke of the plunger during the charging operation, draws air into the compression chamber, and it is this air which is compressed to be discharged over into the receiver. Due to the characteristics of the oil as explained above, a certain amount of the air upon each up-stroke of the plunger will be entrained in the oil and when the plunger moves downwardly to create a partial vacuum and draw more air into the compression chamber, the oil in such chamber will expand. It is believed that the up-stroke of the plunger does not completely reduce the oil to its normal volume at the upper limit of the plunger stroke, and accordingly some little oil will pass over into the receiver during each reciprocation of the plunger.

As a result, oil is gradually lost from the compression chamber by being pumped over into the receiver and while this action increases the quantity of oil in the receiver, the increase is proportionately so small as to cause no noticeable difference in the normal operation of the counterbalance. The loss of the oil from the compression chamber, however, sometimes seriously affects the charging operation since the loss of oil from the compression chamber obviously increases the clearance space therein and the maximum pressure which can be developed in the compression chamber obviously is dependent upon the clearance space therein at the top of each plunger stroke.

This matter may be more clearly understood from consideration of a typical installation and the conditions existing thereunder. For example, in a given installation, the desired maximum receiver pressure may be 400 lb. per square inch and the minimum pressure 300 lb. per square inch. This minimum pressure may be easily and quickly built up in the receiver if the clearance space in the compression chamber is maintained relatively small. Assuming that 3 quarts of oil are added to the compression chamber to reduce the clearance space therein to zero (except for the fixed clearance space 38) this quantity of oil soon may be reduced one-half by the loss of oil due to the aeration and expansion of the oil and the pumping thereof to the receiver with the air. Under such conditions, the increase in the clearance space in the compression chamber will be such that air will not be compressed upon each up-stroke of the plunger to a pressure in excess of 300 lb. per square inch, which is necessary in order to fully charge the receiver in the particular installation being considered.

Assuming that this condition occurs, the operator will close the valve 58 to prevent the admission of more air into the compression chamber, and will open the bleeder valve 75. Upon each up-stroke of the plunger 37, therefore, some air will be discharged from the compression space through the pipe 72 until approximately atmospheric pressure will exist in the compression chamber at the top of the plunger stroke. The operator then may close the valve 75 (although this is not wholly necessary as will become apparent) and will open the valve 58 while holding a container of oil at the bottom of the pipe 54, whereupon each down-stroke of the plunger will create a partial vacuum to draw oil into the compression chamber and thus reduce the clearance space therein to the point where the pressure built up in the compression chamber will be sufficient to discharge air over into the receiver to establish the desired minimum pressure therein. It will be obvious that in the form of the invention shown in Figure 5, oil may be maintained in the receptacle 77 to supply the desired amount of oil under the conditions just described.

The foregoing charging operation is assumed to have been carried out with the walking beam disconnected from the polished rod. It is not necessary that the charging operation to be completed to establish the desired minimum receiver pressure before connecting the walking beam to the polished rods. As soon as the counterbalance pressure reaches a point where its reaction is approximately equal to the weight of the polished rods, which may be at about 275 lb. per square inch minimum, the unit may be shut down and the walking beam connected to the polished rods. With the valve 58 left open, the operation of the unit is continued until the minimum counterbalance pressure is built up, which pressure may be 300 lb. per square inch in the particular installation being considered. When such minimum counterbalance pressure has been established, the air intake valve 58 will be closed and the counterbalance will operate in its normal and intended manner.

Assuming that normal operation of the apparatus is started with a relatively small clearance space existing in the compression chamber, it will be apparent that some air in most cases will leak into the compression chamber. Such leakage occurs past the bearing 35 and it also will be apparent that some air may leak past the valve 58, particularly if this valve is carelessly closed. It is also possible that a lag in the closing of the float valve 65 may result in a slight leakage of air into the pipe 63. Assuming that such leakage occurs, and it actually does occur in many installations, there will be a gradual increase in the quantity of air present in the compression chamber.

At the beginning of the normal operation of the apparatus and before the leakage of air into the compression chamber has progressed to a noticeable extent, it will be apparent that the minimum counterbalance action will be provided when the plunger 37 is at the top of its stroke and during most of the stroke of the plunger the pressure in the compression chamber will be at atmospheric or sub-atmospheric pressure. The fact that sub-atmospheric pressure exists during a greater portion of the stroke of the plunger obviously will tend to cause leakage of air into the compression chamber. As this leakage progresses, it will be apparent that pressures in the compression chamber at the upper limits of the plunger stroke will gradually increase, thus gradually decreasing differential pressures affecting opposite faces of the plunger 37. Depending upon the amount of oil remaining in the compression chamber, the pressure therein, as the leakage of air continues, will approach a maximum equal to the minimum receiver pressure and above such pressure it will be obvious that air will be discharged over into the receiver. Assuming that this occurs, it has been found that the quantity of air pumped into the receiver, except in extreme cases, will be so slight as to cause no noticeable difference in the coun-

terbalancing effect. If the pumping of additional air to the receiver tends to cause an objectionable increase in the minimum pressure in the receiver, the operator may "crack" the bleed valve 75 to release air from the compression chamber approximately at a rate equal to the rate of leakage of air into the compression chamber, in which case no air will be pumped over into the receiver.

If this procedure is followed, it will be apparent that substantial back pressure will exist in the compression chamber and this back pressure may be advantageous or disadvantageous depending upon the particular installation, and in any event, it can be properly controlled by the bleeder valve 75. It will be apparent that upon each down stroke of the plunger, pressure will be built up in the receiver and the increasing pressures will offer increasing resistance to the movement of the plunger, thus cushioning the movement of the walking beam to assist in deceleration thereof and tending to overcome the inertia of the parts when the walking beam reaches the limit of its stroke. The compression of the air in the receiver during downward movement of the plunger stores energy which is expended during the up-stroke of the plunger to provide the desired counterbalancing action. If the clearance in the compression chamber is negligible, the energy stored in the receiver will exert a force tending to lift the plunger throughout its upward stroke, substantially to the top limit thereof, although the force exerted will progressively diminish as the pressure in the receiver approaches minimum.

However, if the compression chamber is "air locked," that is, if the quantity of air above the plunger is such that it will not be raised to a pressure sufficient to be discharged into the receiver at the upper limit of the plunger stroke, it will be apparent that the effective counterbalancing action will be greatly reduced. In other words, during the upward movement of the plunger the pressure in the receiver will be progressively reduced as previously described, but on the other hand, substantial back pressures will be present in the compression chamber throughout the greater portion of the plunger stroke. For example, assuming that the minimum receiver pressure is 300 lb. per square inch, the compression chamber may contain so much air that the pressure therein will vary from 10 lb. below atmosphere for example, at the bottom of the plunger stroke to a little less than 300 lb. per square inch at the top of the plunger stroke. Accordingly it will be apparent that throughout most of the up-stroke of the plunger super-atmospheric pressure will be present and it necessarily follows that differential pressures on opposite sides of the plunger will be very rapidly reduced as the plunger approaches its upper limit of movement.

This back pressure is highly advantageous in some installations. For example, if the unit is operating at a speed faster than 10 strokes per minute, the back pressure not only may be permitted to remain in the compression chamber but will be quite advantageous in overcoming the inertia of the parts. As pointed out, the building up of pressure in the receiver on the down-stroke of the plunger tends to overcome the inertia of the parts at the lowermost limit of movement of the polished rods, and in a similar manner, the building up of pressure in the compression chamber as the polished rods approach their upper limit of movement likewise advantageously provides a decelerating effect overcoming inertia and improving the smoothness of operation of the apparatus.

At the top of the stroke of the reciprocating parts, such parts tend to continue to move upwardly by inertia. Ordinarily, this throws a shock load on the pitman assembly at the extreme end of the stroke, as the load on the pitman changes from tension to compression. Under high speeds, at the top of the stroke, the upward force due to inertia may be even greater than the weight of the parts themselves plus the reaction of the counterbalance and the resulting shock load may be materially reduced if the counterbalance reaction is reduced. The back pressure in the compression chamber, as previously stated, will act as a decelerant during the last half of the up-stroke, and after the cranks have crossed center and the beam begins its downward travel the expanding air in the compression chamber will act as an accelerant. Therefore, during the last half of the up-stroke the beam will be decelerated and during the first half of the down-stroke the beam will be accelerated, and accordingly it will be apparent that back pressure in the counterbalance materially assists in stabilizing the action of the unit.

In other installations, however, for example, in a unit operated at 10 strokes or less per minute, the inertia of the parts is not a serious question and the reaction provided by back pressure in the compression chamber against the receiver pressures may be wholly disadvantageous. Under such conditions, the operator may "crack" the valve 75 in which case air will gradually escape from the compression chamber until a pressure only slightly above that of the atmosphere will exist in the compression chamber at the top of each stroke of the plunger 37. During the greater portion of the downward travel of the plunger, therefore, sub-atmospheric pressure will exist in the compression chamber to increase the counterbalancing action, pressures in the receiver under such conditions being effective throughout substantially the entire upward stroke of the plunger for assisting such movement. Any intermediate conditions may be obtained by properly controlling the valve 75. This valve may be adjusted so that the leakage therethrough approximates the leakage of air into the compression chamber, in which case air pumped through the valve 75 upon each upward movement of the plunger will be approximately equal to the air leaking into the compression chamber upon each downward movement of the plunger, thus maintaining the same conditions in the apparatus. It also will be apparent that the valve 75 may bleed air from the compression chamber even during the charging operation, in which case the operation of charging the receiver will not be materially affected since approximately 95 per cent. of the air drawn into the compression chamber will be discharged over into the receiver, with only approximately 5 per cent. of the air escaping through the valve 75.

Infinitely variable loadings are encountered in pumping oil from different wells and the loadings which will be encountered on a well of given depth cannot be definitely forecast. The provision of a single type of counterbalance capable of taking care of variable conditions encountered therefore constitutes quite a serious problem. The present apparatus very effectively solves such problems because of its versatility not only with

respect to wells of different depths but with respect to varying conditions in wells of the same depth.

In a great many installations it is wholly unnecessary to use the bleeder arrangement at all since the presence of back pressures in the compression chamber is advantageous. On the other hand there are many installations in which the use of the bleeder means renders the operation of the unit materially smoother and more satisfactory. This fact, together with the fact that the counterbalance pressure differential may be varied between wide limits by varying the oil level in the receiver renders the present construction highly advantageous for use regardless of the depth of any particular well or the operating conditions encountered therein.

The controlling of the back pressure in the compression chamber also is useful for another reason. When a unit is running under maximum load conditions at the longest stroke and at a speed of 6 to 8 strokes per minute, the decrease in pressure differentials between the upper and lower faces of the plunger 37 due to substantial back pressure in the compression chamber may throw an excess loading on the driving mechanism for the crank shaft 15 during the latter part of the up-stroke, thereby causing the drive belts to chatter, or rather vibrate excessively on the tight side of the belts. Under such conditions, it is advisable to relieve the back pressure, and this obviously can be readily accomplished with the present apparatus by opening the bleed valve 75.

It will be apparent that some oil will flow out through the port 71, and this is particularly true when the receiver is being charged with air in the manner previously described. As stated, if sufficient oil is present above the plunger 37 to substantially reduce the clearance space at the upper limit of the plunger stroke, the oil will become aerated and will expand on the down stroke of the plunger. On each up-stroke of the plunger slight amounts of oil will be blown through the port 71 due to the fact that the increasing pressures occurring during upward movement of the plunger 37 will not fully restore the oil to its normal volume. Of course, some oil also will be blown through the passage 71 during the normal operation of the apparatus, particularly when it is being operated without substantial back pressure. It is highly desirable to prevent the loss of oil through the passage 71, and accordingly the pipe 72 is employed for conducting the escaping oil to the chamber 45 (Figure 3) the air blowing through the pipe 72 escaping through the drain openings 46. Any oil which escapes through such openings with the air will collect in the recess 47 and will subsequently drain back into the system in the manner previously described.

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

We claim:

1. A counterbalance for parts having uniform relative movement, comprising a receiver, a cylinder, a plunger reciprocable therein, said receiver being adapted to contain a non-compressible fluid extending into one end of said cylinder to be displaced therefrom upon movement of said plunger in one direction, and means for utilizing reciprocating movement of said plunger for supplying non-compressible fluid directly to said receiver.

2. A counterbalance for parts having uniform relative movement, comprising a receiver, a vertical cylinder, a plunger reciprocable therein, said receiver being adapted to contain a non-compressible fluid extending into the lower end of said cylinder to be displaced therefrom upon downward movement of said plunger, and means for utilizing upward movement of said plunger for supplying non-compressible fluid to said receiver.

3. A counterbalance comprising a receiver, a plunger reciprocable therein, said receiver being adapted to contain a non-compressible fluid extending into one end of said cylinder to be displaced therefrom upon movement of said plunger in one direction, a source of non-compressible fluid, and means including flow connections between said source and said receiver for utilizing reciprocation of said plunger for transferring non-compressible fluid from said source to said receiver.

4. A counterbalance for parts having uniform relative movement, comprising a receiver, a cylinder having one end communicating with said receiver, a plunger reciprocable in said cylinder, said receiver being adapted to contain a body of a non-compressible fluid at least partially filling said receiver and extending into said end of said cylinder to be displaced therefrom by said plunger, said non-compressible fluid trapping a body of a compressible fluid in the top of said receiver, and means for utilizing variations in pressure in the other end of said cylinder incident to reciprocating movement of said plunger for supplying non-compressible fluid to said receiver.

5. A counterbalance comprising a receiver, a cylinder having one end communicating with said receiver, a plunger reciprocable in said cylinder, said receiver being adapted to contain a body of a non-compressible fluid at least partially filling said receiver and extending into said end of said cylinder to be displaced therefrom by said plunger, said non-compressible fluid trapping a body of a compressible fluid in the top of said receiver, a source of non-compressible fluid, means for conducting such fluid from said source to the other end of said cylinder, and a single means for conducting non-compressible fluid from said other end of said cylinder, said last named means being connected directly to said receiver.

6. A counterbalance comprising a receiver, a cylinder having one end communicating with said receiver, a plunger reciprocable in said cylinder, said receiver being adapted to contain a body of a non-compressible fluid at least partially filling said receiver and extending into said end of said cylinder to be displaced therefrom by said plunger, said non-compressible fluid trapping a body of a compressible fluid in the top of said receiver, a single means for conducting fluid from the other end of said cylinder, said means being connected to said receiver, and means independent of said last named means for supplying non-compressible fluid to the last named end of said cylinder.

7. A counterbalance comprising a receiver, a cylinder having one end communicating with said receiver, a plunger reciprocable in said cylinder, said receiver being adapted to contain a body of a non-compressible fluid at least partially filling said receiver and extending into said end

of said cylinder to be displaced therefrom by said plunger, said non-compressible fluid trapping a body of a compressible fluid in the top of said receiver, a connection for supplying non-compressible fluid to the other end of said cylinder, a check valve in said connection opening inwardly with respect to said cylinder, and a connection between the second named end of said cylinder and said receiver, said last named connection having a check valve therein opening outwardly with respect to said cylinder.

8. A counterbalance comprising a receiver, a cylinder having one end communicating with said receiver, a plunger reciprocable in said cylinder, said receiver being adapted to contain a body of a non-compressible fluid at least partially filling said receiver and extending into said end of said cylinder to be displaced therefrom by said plunger, said non-compressible fluid trapping a body of a compressible fluid in the top of said receiver, a connection for supplying non-compressible fluid to the other end of said cylinder, a check valve in said connection opening inwardly with respect to said cylinder, a connection between the second named end of said cylinder and said receiver, said last named connection having a check valve therein opening outwardly with respect to said cylinder, and a manually operable valve normally closing said first named connection to the atmosphere.

9. A counterbalance comprising a receiver, a cylinder having one end communicating with said receiver, a plunger reciprocable in said cylinder, said receiver being adapted to contain a body of a non-compressible fluid extending into said end of said cylinder to be displaced therefrom by said plunger, an inlet connection communicating with the other end of said cylinder, a manually operable valve controlling communication between said inlet connection and the atmosphere, means for delivering non-compressible fluid to said inlet connection between said valve and the second named end of said cylinder, and an outlet connection communicating between the second named end of said cylinder and said receiver.

10. A counterbalance comprising a receiver, a cylinder having one end communicating with said receiver, a plunger reciprocable in said cylinder, said receiver being adapted to contain a body of a non-compressible fluid extending into said end of said cylinder to be displaced therefrom by said plunger, an inlet connection communicating with the other end of said cylinder, a manually operable valve controlling communication between said inlet connection and the atmosphere, a branch pipe leading to said connection and having a valve seat, a container for non-compressible fluid in which said valve seat is arranged, a float in said container, a valve carried by said float and engageable with said seat, and an outlet connection communicating between the second named end of said cylinder and said receiver.

11. A counterbalance comprising a receiver, a substantially vertical cylinder having a bearing at its upper end and having its lower end communicating with said receiver, a plunger reciprocable in said cylinder and having a plunger rod mounted in said bearing, said receiver being adapted to contain a body of a non-compressible fluid extending into the bottom of said cylinder and trapping a body of a compressible fluid in the top of said receiver, means for collecting non-compressible fluid from said plunger rod above said bearing, means for delivering the collected fluid to the upper end of said cylinder, and means for delivering non-compressible fluid from the upper end of said cylinder to said receiver.

12. A counterbalance comprising a receiver, a substantially vertical cylinder having a bearing at its upper end and having its lower end communicating with said receiver, a plunger reciprocable in said cylinder and having a plunger rod mounted in said bearing, said receiver being adapted to contain a body of a non-compressible fluid extending into the bottom of said cylinder and trapping a body of a compressible fluid in the top of said receiver, an annular receptacle surrounding said plunger rod above said bearing for collecting non-compressible fluid from said plunger rod, a pipe connection leading to the upper end of said cylinder and having a check valve opening inwardly with respect to said cylinder, said pipe connection being normally closed to the atmosphere, means for delivering non-compressible fluid from said receptacle to said pipe connection, and a conduit connected between the upper end of said cylinder and said receiver and provided with a check valve opening outwardly with respect to said cylinder.

13. A counterbalance comprising a receiver, a substantially vertical cylinder having a bearing at its upper end and having its lower end communicating with said receiver, a plunger reciprocable in said cylinder and having a plunger rod mounted in said bearing, said receiver being adapted to contain a body of a non-compressible fluid extending into the bottom of said cylinder and trapping a body of a compressible fluid in the top of said receiver, an annular receptacle surrounding said plunger rod above said bearing for collecting non-compressible fluid from said plunger rod, a pipe connection leading to the upper end of said cylinder and having a check valve opening inwardly with respect to said cylinder, a manually operable valve controlling communication between said pipe connection and the atmosphere, a container communicating with said pipe connection between the valves therein, means for delivering non-compressible fluid from said receptacle to said container, a float controlled valve mechanism in said container, a conduit communicating between the upper end of said cylinder and said receiver, and a check valve in said conduit opening outwardly with respect to said cylinder.

14. A counterbalance comprising a vertical receiver, a vertical cylinder projecting into said receiver from the upper end thereof and having its lower end open for communication with said receiver, a plunger reciprocable in said cylinder, said receiver being adapted to contain a body of a non-compressible fluid extending into the bottom of said cylinder to be displaced therefrom upon downward movement of said plunger, a conduit leading to the upper end of said cylinder and having a depending end provided with a manual valve controlling communication between said conduit and the atmosphere, said conduit having a check valve between said manual valve and the upper end of said cylinder opening inwardly with respect to said cylinder, and means for utilizing pressure generated by upward movement of said plunger for transferring non-compressible fluid from the upper end of said cylinder to said receiver.

15. A counterbalance comprising a vertical receiver, a vertical cylinder projecting into said

receiver from the upper end thereof and having its lower end open for communication with said receiver, a plunger reciprocable in said cylinder, said receiver being adapted to contain a body of a non-compressible fluid extending into the bottom of said cylinder to be displaced therefrom upon downward movement of said plunger, a conduit leading into the upper end of said cylinder, a check valve in said conduit opening inwardly with respect to said cylinder, a manually controllable valve for controlling communication between said conduit and the atmosphere outwardly of said check valve, a conduit having one end arranged with respect to the upper end of said cylinder to receive non-compressible fluid therefrom and having its other end communicating with said receiver, and a check valve in said last named conduit opening outwardly with respect to said cylinder.

16. A counterbalance comprising a vertical receiver, a vertical cylinder projecting into said receiver from the upper end thereof and having its lower end open for communication with said receiver, a plunger reciprocable in said cylinder, said receiver being adapted to contain a body of a non-compressible fluid extending into the bottom of said cylinder to be displaced therefrom upon downward movement of said plunger, a conduit leading into the upper end of said cylinder, a check valve in said conduit opening inwardly with respect to said cylinder, a manually controllable valve for controlling communication between said conduit and the atmosphere outwardly of said check valve, means for introducing non-compressible fluid into said first named conduit between said valves, a conduit having one end arranged with respect to the upper end of said cylinder to receive non-compressible fluid therefrom and having its other end communicating with said receiver, and a check valve in said last named conduit opening outwardly with respect to said cylinder.

17. A counterbalance comprising a vertical receiver, a vertical cylinder projecting into said receiver from the upper end thereof and having its lower end open for communication with said receiver, a plunger reciprocable in said cylinder, said receiver being adapted to contain a body of a non-compressible fluid extending into the bottom of said cylinder to be displaced therefrom upon downward movement of said plunger, a conduit leading into the upper end of said cylinder, a check valve in said conduit opening inwardly with respect to said cylinder, a manually controllable valve for controlling communication between said conduit and the atmosphere outwardly of said check valve, a container for non-compressible fluid having a pipe connection leading to said first named conduit between said valves, a float in said container controlling the admission of non-compressible fluid from said container to said pipe connection, a conduit having one end arranged with respect to the upper end of said cylinder to receive non-compressible fluid therefrom and having its other end communicating with said receiver, and a check valve in said last named conduit opening outwardly with respect to said cylinder.

18. A counterbalance comprising a substantially vertical receiver, a cylinder projecting into the upper end of said receiver and having its lower end open for communication therewith, a bearing carried by the upper end of said cylinder, a plunger reciprocable in said cylinder and having a plunger rod extending upwardly through said bearing, said receiver being adapted to contain a body of non-compressible fluid extending into the bottom of said cylinder to be displaced therefrom upon downward movement of said plunger, said non-compressible fluid being adapted to trap a body of a compressible fluid in the top of said receiver, a conduit communicating between the top of said cylinder and said receiver and having a check valve therein opening outwardly with respect to said cylinder, means for collecting non-compressible fluid from said plunger rod above said bearing, and means for delivering non-compressible fluid from said last named means to the upper end of said cylinder.

19. A counterbalance comprising a substantially vertical receiver, a cylinder projecting into the upper end of said receiver and having its lower end open for communication therewith, a bearing carried by the upper end of said cylinder, a plunger reciprocable in said cylinder and having a plunger rod extending upwardly through said bearing, said receiver being adapted to contain a body of non-compressible fluid extending into the bottom of said cylinder to be displaced therefrom upon downward movement of said plunger, said non-compressible fluid being adapted to trap a body of a compressible fluid in the top of said receiver, a conduit communicating between the top of said cylinder and said receiver and having a check valve therein opening outwardly with respect to said cylinder, an inlet conduit leading into the upper end of said cylinder and provided with a check valve opening inwardly with respect to said cylinder, means for collecting non-compressible fluid from said plunger rod above said bearing, and float controlled means for delivering non-compressible fluid from said last named means to said inlet conduit.

20. A counterbalance comprising a substantially vertical receiver, a cylinder projecting into the upper end of said receiver and having its lower end open for communication therewith, a bearing carried by the upper end of said cylinder, a plunger reciprocable in said cylinder and having a plunger rod extending upwardly through said bearing, said receiver being adapted to contain a body of non-compressible fluid extending into the bottom of said cylinder to be displaced therefrom upon downward movement of said plunger, said non-compressible fluid being adapted to trap a body of a compressible fluid in the top of said receiver, a conduit communicating between the top of said cylinder and said receiver and having a check valve therein opening outwardly with respect to said cylinder, an inlet conduit leading into the upper end of said cylinder and provided with a check valve opening inwardly with respect to said cylinder, a container into which the end of said inlet conduit projects, a drain conduit connected between the bottom of said receiver and said container and having a manually controllable valve therein, and a manually controllable valve in said inlet conduit between said container and said check valve.

21. A counterbalance comprising a substantially vertical receiver, a cylinder projecting into the upper end of said receiver and having its lower end open for communication therewith, a bearing carried by the upper end of said cylinder, a plunger reciprocable in said cylinder and having a plunger rod extending upwardly through said bearing, said receiver being adapted to contain a

body of non-compressible fluid extending into the bottom of said cylinder to be displaced therefrom upon downward movement of said plunger, said non-compressible fluid being adapted to trap a body of a compressible fluid in the top of said receiver, a conduit communicating between the top of said cylinder and said receiver and having a check valve therein opening outwardly with respect to said cylinder, an inlet conduit leading into the upper end of said cylinder and provided with a check valve opening inwardly with respect to said cylinder, a container into which the end of said inlet conduit projects, a drain conduit connected between the bottom of said receiver and said container and having a manually controllable valve therein, a manually controllable valve in said inlet conduit between said container and said check valve, means for collecting non-compressible fluid from said plunger rod, and float controlled means for delivering non-compressible fluid from said last named means to said inlet conduit between the valves therein.

22. A counterbalance for parts having uniform relative movement, comprising a receiver, a cylinder having one end communicating with said receiver, a plunger reciprocable in said cylinder, said plunger being movable in one direction to compress and store energy in fluid in said receiver, a head on the other end of said cylinder, and means for controlling maximum pressures in the last named end of said cylinder.

23. A counterbalance comprising a receiver, a cylinder having one end communicating with said receiver, a plunger reciprocable in said cylinder, said plunger being movable in one direction to compress and store energy in fluid in said receiver, a head on the other end of said cylinder, means for supplying a non-compressible fluid to the second named end of said cylinder to reduce the clearance space therein, and means including a conduit leading from the last named end of said cylinder for controlling pressures therein.

24. A counterbalance comprising a receiver, a substantially vertical cylinder having its lower end communicating with said receiver, a plunger reciprocable in said cylinder, said plunger being movable toward the lower end thereof to compress and store energy in fluid in said receiver, and means connected to the upper end of said cylinder and operative independently of pressures in said receiver for governing differential pressures above and below said plunger.

25. A counterbalance comprising a receiver, a substantially vertical cylinder having its lower end communicating with said receiver, a plunger reciprocable in said cylinder, said plunger being movable toward the lower end thereof to compress and store energy in fluid in said receiver, means for introducing a non-compressible fluid into the upper end of said cylinder to reduce the clearance space therein, and means connected to the upper end of said cylinder and operative independently of pressures in said receiver for governing differential pressures above and below said plunger.

26. A counterbalance comprising a receiver, a cylinder having one end communicating with said receiver, a plunger reciprocable in said cylinder, said plunger being movable to said end of said cylinder to compress and store energy in fluid in said receiver, a head on the other end of said cylinder, a bearing in said head, a plunger rod reciprocating in said bearing and connected to said plunger, a conduit communicating at one end with the second named end of said cylinder and at its other end with the atmosphere, a check valve in said conduit opening outwardly with respect to said cylinder, and a manually controllable valve in said conduit between said check valve and the second named end of said pipe, said valve being adapted to be opened to relieve pressure from the second named end of said cylinder.

27. A counterbalance comprising a receiver, a cylinder having one end communicating with said receiver, a plunger reciprocable in said cylinder, said receiver being adapted to contain a body of a non-compressible fluid at least partially filling said receiver and extending into said end of said cylinder to be displaced therefrom by said plunger, said non-compressible fluid trapping a body of a compressible fluid in the top of said receiver, means connected for utilizing variations in pressure in the other end of said cylinder incident to reciprocating movement of said plunger for supplying non-compressible fluid to said receiver, and manually controllable means for relieving maximum pressures in said other end of said cylinder.

28. A counterbalance comprising a receiver, a substantially vertical cylinder having a bearing at its upper end and having its lower end communicating with said receiver, a plunger reciprocable in said cylinder and having a plunger rod mounted in said bearing, said receiver being adapted to contain a body of a non-compressible fluid extending into the bottom of said cylinder and trapping a body of a compressible fluid in the top of said receiver, an annular receptacle surrounding said plunger rod above said bearing for collecting non-compressible fluid from said plunger rod, a pipe connection leading to the upper end of said cylinder and having a check valve opening inwardly with respect to said cylinder, said pipe connection being normally closed to the atmosphere, means for delivering non-compressible fluid from said receptacle to said pipe connection, a conduit connected between the upper end of said cylinder and said receiver and provided with a check valve opening outwardly with respect to said cylinder, a pressure relieving pipe connected between the upper end of said cylinder and said annular receptacle, and a manually controllable valve in said pressure relieving pipe.

HAROLD WILLIAMS RAMEY.
EDGAR FRENCH SPEIDEN.