

March 2, 1954

C. J. COBERLY
FLUID-OPERATED WELL PUMPING APPARATUS
WITH HYDRAULIC SHOCK ABSORBER

2,670,685

Filed April 20, 1951

2 Sheets-Sheet 1

Fig. 1.

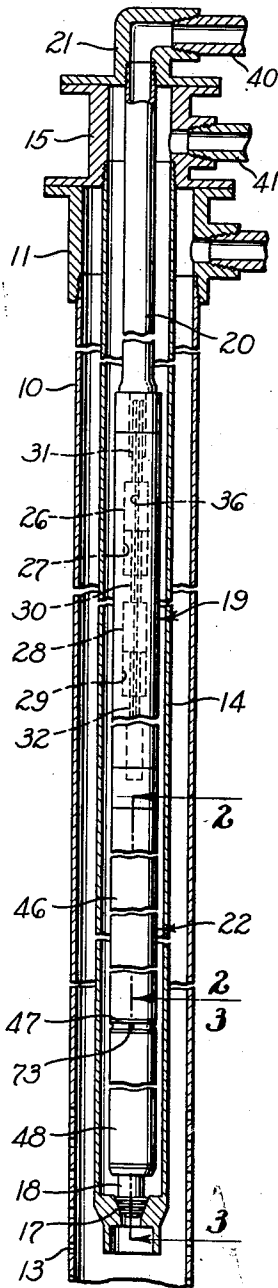


Fig. 2.

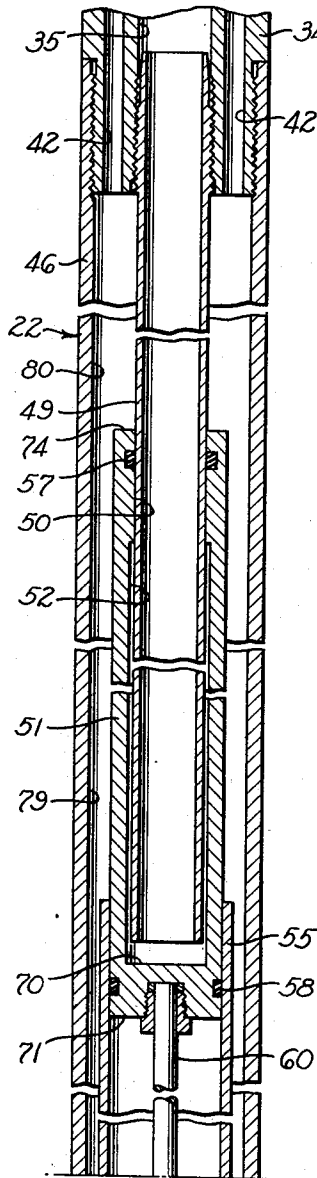
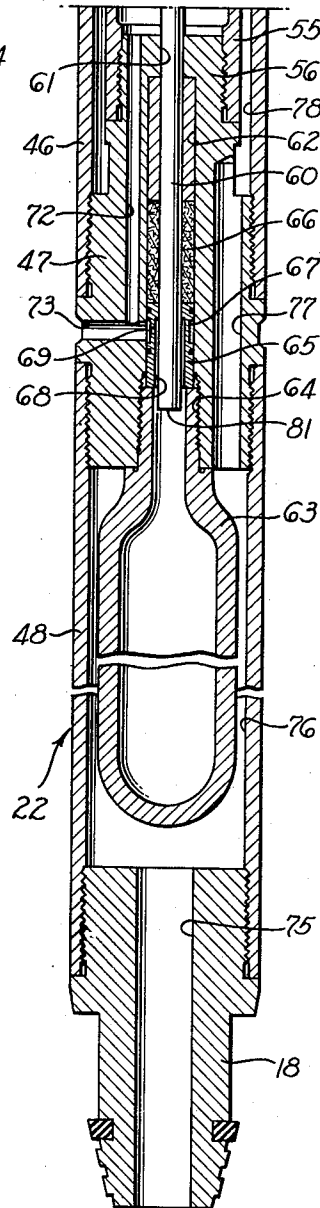
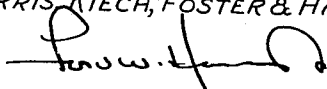


Fig. 3.



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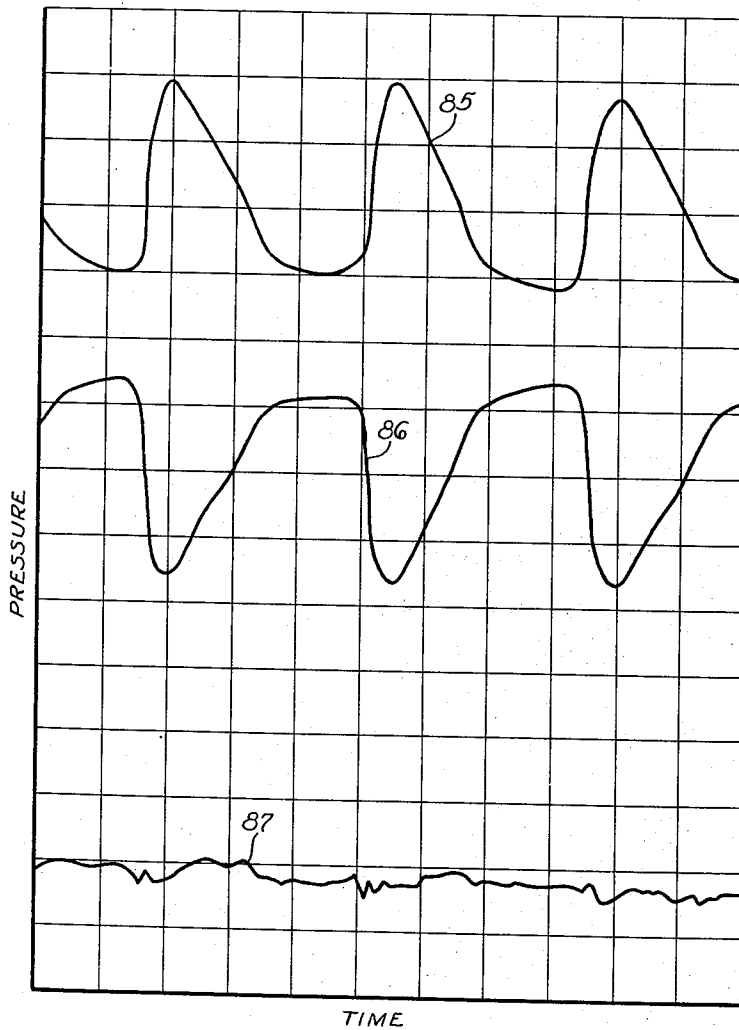
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2 Sheets-Sheet 2

Fig. 4.



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UNITED STATES PATENT OFFICE

2,670,685

FLUID-OPERATED WELL PUMPING APPARATUS WITH HYDRAULIC SHOCK ABSORBER

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of Ohio

Application April 20, 1951, Serial No. 222,045

16 Claims. (Cl. 103-46)

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My invention relates in general to apparatus for pumping fluids from wells and, more particularly, to an apparatus which includes a reciprocating pump of the fluid-operated type, a primary object of the invention being to provide an apparatus of this character having means associated therewith for absorbing fluid pressure variations which may impose hydraulic shock loads on the system.

Reference is hereby made to my copending applications Serial Nos. 18,768 and 26,305, filed April 3, 1948, and May 11, 1948, respectively, now Patents Nos. 2,576,923 and 2,576,924, respectively.

Fluid-operated pumps are used extensively in the oil industry for pumping oil from wells and are well known in the art so that a detailed description thereof herein is unnecessary, an example of such a pump being disclosed in my Patent No. 2,134,174, issued October 25, 1938. Briefly, such a fluid-operated pump comprises a motor section and a pump section and is set in the well at the level from which oil is to be pumped. A power tubing for conveying operating fluid under pressure to the pump and a production tubing for conveying oil and other fluids discharged by the pump to the surface are connected to the motor and pump sections, respectively. The operating fluid is usually clean crude oil and will be referred to hereinafter as the power oil. For convenience, the combination of fluids pumped, which may include oil, water, etc., will be referred to hereinafter as the production fluid. In the event that the spent operating fluid is discharged into the production tubing, the production fluid also includes such spent operating fluid.

The motor section of the pump includes a cylinder having a piston therein and includes an engine valve mechanism for admitting the power oil into at least one end of the motor cylinder periodically so as to reciprocate the motor piston. The pump section includes a cylinder having a piston therein which is connected to the motor piston so that the reciprocating motion of the motor piston is communicated to the pump piston. The latter draws fluid from the well and discharges it into the production tubing through suitable intake and exhaust valve mechanisms. Fluid-operated pumps normally used in the oil industry may be of either the single-acting or double-acting type.

In order to prevent excessive wear and possible breakage of the various parts of such fluid-operated pumps, and in order to prevent possible damage to other components of the installation

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in which the pump is incorporated, it is essential to minimize any shock loads which may originate in the pump, the provision of an apparatus for absorbing such shock loads being the primary object of the present invention. Shock loads may be developed in the pump under various conditions of operation, one of these being the condition resulting when the load on the pump piston decreases suddenly due, for example, to the presence of air or gas in the pump cylinder. The fluid entering the well casing from an adjacent oil producing formation may contain considerable quantities of natural gas, the amounts present depending upon the amount present in the formation and depending upon prevailing conditions of pressure, temperature, etc. Sudden decreases in the load on the pump piston may also result if the well is operated beyond its capacity so that air or gas is drawn into the pump cylinder as a result of recession of the fluid level below the pump inlet. In some instances, the well casing may be connected to a vacuum line so that the pressure on the gas may be less than atmospheric. Also, in fields subjected to partial vacuums, air may be drawn into the well casing if it is left open.

Since the pump piston reduces the pressure in the pump cylinder below that prevailing in the well as it draws well fluid into the pump cylinder, any gas present in the well fluid in solution or in suspension may be liberated in the pump cylinder with the result that a quantity of liquid sufficient only to partially fill the pump cylinder is drawn thereinto, the balance of the pump cylinder being filled with gas. Similarly, the pump cylinder may be partially filled with air or gas at a low pressure if the well is pumped beyond its capacity. Consequently, when the direction of movement of the pump piston is reversed, the pump piston acts only on the air or gas in the pump cylinder for at least a portion of the stroke. Since the air or gas is highly compressible, it offers but little resistance to movement of the pump piston so that the motor and pump pistons, being directly connected, may accelerate to an extremely high speed. In many instances, the speed attained by the pistons may greatly exceed their normal operating speed, the reason for this being that a considerable amount of potential energy is normally stored in the power oil supply system at the pressures usually employed because of the compressibility of the column of power oil in the power tubing and the expansibility of the power tubing. Such a potential energy is released when the load on the pump

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piston decreases and may accelerate the motor and pump pistons to a speed far in excess of their normal operating speed.

When the pump piston, moving at an abnormally high speed, strikes liquid in the pump cylinder, severe shock loads are developed which may cause extensive damage to the pump in the form of excessive wear, scoring, seizing and even breakage of parts. Moreover, pressure surges of considerable magnitude may be produced in the power oil and production fluid columns above the pump and may result in abnormal stressing of and possible damage to other components of the system. Also, if the well fluid being pumped contains a large percentage of water, which is frequently the case, shock loads originating in the pump may be particularly severe, the reason for this being that the compressibility of water is less than that of crude oil. Consequently, when water is present, the compressibility of the production fluid column above the pump is materially reduced, as compared to the compressibility of a production fluid column consisting of relatively pure crude oil, or a mixture of crude oil and gas, so that the amount of energy which it is capable of absorbing is materially decreased. Also, if air is drawn into the pump under shock loading conditions with water present, both mechanical failure and corrosion are greatly accelerated for two reasons: first, the presence of oxygen reduces the fatigue strength of the material; and, second, the high stresses produced by shock loads increase the chemical action at points of maximum stress.

A governor located in close proximity to the pump may be employed to reduce the rate of flow of power oil to the motor section of the pump in response to decreases in the load on the pump piston so as to reduce the piston speed which would otherwise be attained, an example of such a governor being disclosed in my Patent No. 2,311,157, issued February 16, 1943. However, due to the fact that such a governor tends to operate only after the conditions which result in acceleration of the motor and pump pistons have already developed, there may be some lag in its operation. Consequently, even if a governor is employed, shock loads of undesirably large magnitude may be produced, although such shock loads are, of course, greatly reduced as a result of the use of the governor.

Even when a fluid-operated pump of the type disclosed in my Patent No. 2,134,174, for example, is operating under normal conditions, i. e., when little or no gas or air is present in the well fluid being pumped, pressure pulsations are produced in both the power oil and the production fluid columns due to the fact that the motor and pump pistons stop momentarily at the ends of their strokes. This results in an increase in the pressure of the power oil and a decrease in the pressure of the production fluid. The amount of dwell at the ends of the strokes may be controlled with an engine valve of the type disclosed in my Patent No. 2,134,174, it being desirable to have sufficient dwell to allow time for the pump valves to seat. If the time allowed for the pump valves to seat is too great, excessive pressure pulsations in both the power oil and production fluid columns result, and, if the time allowed is too small, serious pressure pulsations in the production fluid columns result. It is impractical and, in many instances, impossible to eliminate such pressure pulsations by regulating the time allowed for the pump valves to seat. Although the magnitude of

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such pressure pulsations is small when the pump is operated at moderate speeds and when the pump cylinder fills properly, such pressure pulsations may be sufficiently large to cause serious difficulties at high pump speeds. Severe stresses may be developed in various components of the installation by the pulsations if the frequency of the reciprocating motion of the motor and pump pistons coincides with either the natural frequency of oscillation or one of the harmonics of either the power oil or the production fluid columns above the pump, i. e., if the frequency of the pressure pulsations developed in the columns as a result of the reciprocating motion of the motor and pump pistons coincides with either the natural frequency or one of the harmonics of one of the columns. These columns are only moderately damped so that standing pressure waves of a magnitude sufficient to develop abnormal stresses in various components of the installation may be produced under such resonant operating conditions.

Since the natural frequencies of the power oil and production fluid columns are usually relatively low as compared to the frequency of reciprocation of the motor and pump pistons during normal operation, it is usually possible to avoid operating the pump in phase with the natural frequencies of the columns. However, it is virtually impossible to select an operating speed for the pump which avoids both the natural frequencies of the power oil and production fluid columns and all of the harmonics thereof due to the fact that the intervals between the natural frequencies and the first harmonics and the intervals between harmonics are relatively small.

Another factor which makes it difficult to avoid both the natural frequency and all of the harmonics of the production fluid column in particular is that the natural frequency of this column varies with variations in the proportions of gas, oil and water in the production fluid. Consequently, since resonant operating conditions cannot be avoided readily by a selection of a suitable operating speed for the pump, it is desirable to reduce the magnitude of the pressure surges resulting from the reciprocatory nature of the operation of the pump so as to avoid producing standing pressure waves of excessive magnitude, the provision of an apparatus capable of absorbing such pressure surges being an important object of the present invention.

In fluid-operated pump installations of the type under consideration, the power oil and production fluid columns are semi-closed systems and do not communicate with each other freely in both directions because the fluid-operated pump is interposed between them, the direction and amount of communication possible depending upon the positions of the engine and pump valves. With closed columns each terminating in a valve, serious "water hammer" may result from sudden closing of the valves with high fluid velocities therethrough. In all cases of normal operation and in many cases of shock resulting from malfunctioning of the pump valves or improper filling of the pump cylinder, the pressure surges in the two columns are out of phase and may be cancelled out or greatly reduced by balancing the two columns against each other, which is another important object of my invention.

More specifically, an object is to provide a shock absorber which includes a movable fluid separating means, such as a piston, having opposed first and second surfaces which are exposed to

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the fluid pressures obtaining in the power and production tubings, respectively, the areas being so related to each other and to the fluid pressures in said tubings that the piston is substantially balanced hydraulically.

Another object is to provide such a shock absorber having a piston, or other fluid separating means, which includes a third surface disposed on the same side thereof as said first surface and exposed to the fluid pressure obtaining in the well substantially at the level of the pump so that the power oil and well fluid pressures act in the same direction on the piston, the three areas being so related in size that the piston is hydraulically balanced.

Another object is to provide a shock absorber of the foregoing character wherein the piston is provided with a stem projecting therefrom into a substantially closed chamber filled with liquid which is adapted to absorb or dampen sudden fluid pressure surges in one or both of the tubings. A further object is to provide such a device in which the interior of the closed chamber is connected by a small restricted orifice to one of the tubings so that the fluid pressure normally existing in the chamber is the same as the fluid pressure in one of the tubings. I prefer to make this orifice connection to the production tubing.

Other objects of the invention are to provide a shock absorber which may be connected directly to a pump with which it is to be used so that the piston therein may be exposed to the fluid pressures obtaining in the power tubing, the production tubing and the well at points in close proximity to the pump, whereby pressure surges originating in the pump are absorbed substantially instantaneously, and to provide a compact device which occupies a minimum of space in a well.

The foregoing objects of my invention and the advantages suggested thereby, together with various other objects and advantages which will become apparent, may be attained with the exemplary embodiment which is illustrated in the accompanying drawings and which is described in detail hereinafter. Referring to the drawings:

Fig. 1 is a vertical sectional view illustrating a pumping installation which embodies the invention as installed in a well;

Fig. 2 is an enlarged, vertical sectional view taken along the broken line 2—2 of Fig. 1 and showing an upper portion of a shock absorber of the invention connected to a lower portion of a fluid-operated pump;

Fig. 3 is an enlarged, vertical sectional view taken along the broken line 3—3 of Fig. 1 and showing the lower portion of the shock absorber, Fig. 3 being a downward extension of Fig. 2; and

Fig. 4 is a graph illustrating the operation of the shock absorber.

Referring particularly to Fig. 1, I show a well casing 10 which extends downwardly from a casing head 11 into an oil producing formation of a well, the lower end of the casing being provided with perforations 13 through which well fluid, i. e., oil, water, gas, etc., from the oil producing formation may flow into the casing. A production tubing 14 is suspended from a tubing head 15 which forms an intermediate part of the casing head 11 and extends downwardly through the casing 10 into the well fluid in the lower portion thereof. The lower end of the produc-

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tion tubing 14 is equipped with a tapered seat 17 which is adapted to receive and support an inlet fitting 18. A fluid-operated pump 19 is disposed in the production tubing 14 and is connected to the lower end of a power tubing 20 for conveying power oil to the pump, the power tubing being suspended from a cap member 21 of the tubing head 15 and extending downwardly through the production tubing. A shock absorber 22 of the invention is interposed between the inlet fitting 18 and the pump 19 in the particular construction illustrated in the drawings, the shock absorber being connected to the inlet fitting at its lower end and to the pump at its upper end.

The fluid-operated pump 19 per se forms no part of the present invention and is not shown in complete detail in the drawings. The pump 19 may, for example, be of the type disclosed in my aforesaid Patent No. 2,134,174, or may be of any other suitable type, as is well known in the art. As best shown in Fig. 1 of the drawings, the pump 19 includes, in general, an engine or motor piston 25 which is reciprocable in a motor cylinder 27, and includes a pump piston 28 which is reciprocable in a pump cylinder 29, the two pistons being directly connected by a rod 30. Connected to and extending upwardly from the motor piston 26 is a pilot rod 31, and connected to and extending downwardly from the pump piston 28 is a lower rod 32. As best shown in Fig. 2, the pump 19 is provided at its lower end with a fitting 34 having a bore 35 therein, and is provided with a continuous passage 36, Fig. 1, which communicates at its upper end with the power tubing 20 and which communicates at its lower end with the bore 35 and with the shock absorber 20 as will be discussed in more detail hereinafter, the passage 36 extending through the pilot rod 31, the motor piston 26, the intermediate rod 30, the pump piston 28 and the lower rod 32.

The general operation of the pump 19 is well known in the art, being described in detail in my Patent No. 2,134,174, and needs be described only briefly herein. The power oil, which is preferably clean crude oil, is delivered under pressure to the tubing head 15 through a supply pipe 40 and flows downwardly through the power tubing 20 to the pump 19. Such power oil is introduced alternately into opposite ends of the motor cylinder 27 in the case of a double-acting pump by a suitable valve mechanism, not shown, so as to reciprocate the motor piston 26, the reciprocatory motion of the motor piston being communicated to the pump piston 28 by the intermediate rod 30. Well fluid is introduced alternately into opposite ends of the pump cylinder 29 by a suitable valve mechanism, not shown, and is discharged into the production tubing 14 as production fluid by the pump piston 28, the production fluid subsequently flowing upwardly through the tubing 14 to the surface and into a discharge pipe 41. As will be discussed in more detail hereinafter, the well fluid enters the pump 19 by way of the inlet fitting 18 and the shock absorber 22, the fitting 34 at the lower end of the pump being provided with a plurality of passages 42 through which the well fluid may flow from the shock absorber into the pump, as best shown in Fig. 2.

Referring particularly to Figs. 2 and 3, the shock absorber 22 includes a tubular housing section 46 which is threaded at its upper end onto the fitting 34 and which is threaded at its lower end onto a fitting 47, another tubular housing section 48 being threaded at its upper end onto

the lower end of the fitting 47. The inlet fitting 18, which is adapted to seat on the tapered seat 17, is threaded into the lower end of the lower housing section 48. Extending downwardly into the upper housing section 46 and threaded at its upper end into the bore 35 in the fitting 34 is a tube 49 the lower end of which extends into a bore 50 in a shock absorber piston 51, the bore 50 being enlarged within the piston, as indicated by the numeral 52, throughout a substantial portion of the length of the piston to minimize friction between the piston and the tube. The piston 51 is reciprocable in a cylinder 55 which extends upwardly into the upper housing section 46 and which is threaded at its lower end onto a cylindrical boss 56 on the upper end of the fitting 47. Fluid-tight seals between the piston 51 and the tube 49 and between the piston 51 and the cylinder 55 are maintained by annular sealing elements 57 and 58, respectively, which are carried in grooves in the piston. Extending downwardly from and carried by the piston 51 is a stem 60 which extends through a bore 61 and a counterbore 62 in the fitting 47 into a chamber 63 disposed in the lower housing section 48 and threaded at its upper end into a second counterbore 64 in the fitting 47, movement of the stem 60 into and out of the chamber 63 varying the volume of the chamber. Retained in the counterbore 62 is a tubular member 65 above which is provided suitable packing 66. The periphery of the tubular member 65 has an annular groove 67 therein which communicates with a radial passage 73 in the fitting 47 communicating at its outer end with the production tubing, suitable O-ring-sealing members being provided above and below the groove. The tubular member 65 has a counterbore 68 which is connected to the groove 67 by a small restricted orifice 69, so that the production fluid may fill the chamber 63 and equalize the fluid pressures between the chamber and the production tubing. Although I prefer to provide such restricted fluid communication between the interior of the chamber 63 and the production tubing, I do not intend to be limited thereto.

The shock absorber piston 51 is provided with a first transverse area or surface 70 which is exposed to the pressure of the power oil in the power tubing 20 by way of the longitudinal passage 36 through the fluid-operated pump 19, the bore 35 in the fitting 34, and the tube 49. It will be noted that the effective area of the first transverse surface 70 is equal to the cross-sectional area of the bore 50 in the piston 51. The shock absorber piston 51 is also provided with a second transverse area or surface 71 which is exposed to the pressure of the production fluid in the production tubing 14 by way of a longitudinal passage 72 in the fitting 47 which communicates at its upper end with the interior of a cylinder 55 and which communicates at its lower end with the radial passage 73. Preferably, a plurality of the longitudinal and radial passages 72 and 73 is provided in the fitting 47, only one of each being shown in the drawings. As will be apparent, the effective area of the second transverse surface 71 is equal to the cross-sectional area of the shock absorber piston 51 minus the cross-sectional area of the stem 60. The shock absorber piston 51 is provided on its upper end with a third transverse area or surface 74 which is exposed to the pressure of the well fluid in the casing 10 by way of a bore 75 through the inlet fitting 18, an annular passage 76 between the lower housing

section 48 and the chamber 63, one or more longitudinal passages 77 through the fitting 47, an annular passage 78 between the upper housing section 46 and the cylinder 55, and an annular passage 79 between the upper housing section and that portion of the piston 51 which projects from the cylinder 55. It will be noted that the area of the third transverse surface 74 exposed to the pressure of the well fluid in this manner is equal to the cross-sectional area of the piston 51 minus the cross-sectional area of the tube 49. It will also be noted that the annular passage 79 between the exposed projecting portion of the piston 51 and the upper housing section 46 communicates with an annular passage 80 between the upper housing section and the tube 49, the annular passage 80 communicating with the passages 42 through the fitting 34 so that well fluid may enter the pump 19 by way of the system of passages just described. The shock absorber piston 51 is further provided with a fourth transverse area or surface 81 which is exposed to the pressure of the liquid in the chamber 63, the area of the transverse surface 81 being equal to the cross-sectional area of the stem 60. The areas 70 and 71 are proportioned so that the hydraulic forces on the piston 51 are substantially balanced, and the areas 70, 71, 74 and 81 are so proportioned that the hydraulic forces on the piston 51 are fully balanced.

Considering the operation of the shock absorber 22, it will be apparent that the pressure forces applied to the piston 51 by the application of the power oil and well fluid pressures to the first and third transverse surfaces 70 and 74, respectively, tend to move the piston downwardly in its cylinder 55, whereas the pressure force applied to the piston by the application of the production column pressure to the second transverse surface 71 tends to move the piston upwardly in its cylinder. Preferably, the areas of the surfaces 70, 71 and 74 are so selected with reference to the pressures applied thereto that the net pressure force differential applied to the piston 51, i. e., the algebraic sum of the pressure forces applied to the piston by the pressures applied to the surfaces 70, 71 and 74, is normally equal to zero so that the piston is normally balanced. Consequently, if any pressure surges occur in the power oil or production fluid columns, they are absorbed by the liquid in the chamber 63 acting on the fourth transverse area 81.

It will be apparent that if a pressure surge occurs in the power oil column for any reason, the energy producing the surge is absorbed by compression of the oil or other liquid in the chamber 63 and by compression of the production fluid. Conversely, if a pressure surge occurs in the production fluid column, the energy producing the pressure is absorbed by compression of the power oil and, to a slight extent, by any compression of the well fluid which may occur. Such pressure surges may arise from various sources. For example, if air or gas is present in the pump cylinder 29, the motor piston 26 and the pump piston 28 may, as previously discussed, accelerate to an excessive speed so that a pressure surge in the production tubing 14 may result when the pump piston strikes solid fluid in the pump cylinder. Also, pressure pulsations may be produced in the fluids in the production tubing 14 and the power tubing 20 as a result of the reciprocatory nature of the operation of the fluid-operated pump 19, the manner in which

such pressure pulsations are absorbed being considered in detail in the following paragraph.

Referring particularly to Fig. 4 of the drawings, the numerals 85 and 86 indicate oscillograph curves showing, respectively, typical pressure pulsations encountered in the power oil and production fluid columns when a pump such as the pump 19 is used without the shock absorber 22. It will be noted that the power oil pressure rises at the ends of the strokes of the motor and pump pistons 26 and 28, see curve 85, and that the pump discharge pressure or production fluid pressure drops at the same time, see curve 86, the pressure pulsations in the two columns being of approximately the same magnitude and of opposite sign. The rise in pressure in the power tubing 20 and the drop in pressure in the production tubing 14 cause the shock absorber piston 51 to move downwardly against the pressure of the oil in the chamber 63 so that the energy producing such movement is absorbed by compression of the oil in this chamber, and also by compression to some extent of the production fluid. The net result is that the pressure in the power tubing 20 is decreased and the pressure in the production tubing 14 is increased, the resultant pressure in the two columns being approximately as indicated by the oscillograph curve 87 in Fig. 4. Thus, it will be apparent that, in effect, the shock absorber 22 causes the rise in power oil pressure and the drop in production fluid pressure to cancel out, which is an important feature of the invention.

By designing the device so that the area of the fourth surface 81 is small relative to the volume of the chamber 63, the amount of surge energy which the liquid in the chamber will absorb is relatively great.

Although I have disclosed an exemplary embodiment of my invention herein for purposes of illustration, I do not intend to be limited specifically thereto since various changes, modifications and substitutions may be incorporated in the embodiment disclosed without necessarily departing from the spirit of the invention. Various other changes may also be made without departing from the spirit of the invention. Consequently, I hereby reserve the right to all changes, modifications and substitutions as properly come within the scope of the invention as set forth in the appended claims.

I claim as my invention:

1. In an apparatus for pumping fluid from a well, the combination of: a fluid-operated pump in the well; a first tubing extending into the well and connected to said pump, said first tubing being adapted to convey operating fluid to said pump to operate same; a second tubing extending into the well and connected to said pump, said second tubing being adapted to convey from said pump fluid discharged thereby; and a shock absorber connected to said pump, said shock absorber including movable fluid separating means having four transverse areas at least one of which is on one side thereof and at least one other of which is on the opposite side thereof, including means for exposing one of said areas to fluid pressure obtaining in said first tubing, including means for exposing another of said areas to fluid pressure obtaining in said second tubing, including means for exposing still another of said areas to fluid pressure obtaining in the well substantially at the level of said pump, and including means for applying a fourth fluid pressure to the fourth of said areas.

2. In a shock absorber for use in a well pumping apparatus which includes a fluid-operated pump adapted to be set in a well and having first and second tubings thereto, the first tubing being adapted to convey operating fluid to the pump to operate same and the second tubing being adapted to convey from the pump fluid discharged thereby, the combination of: movable fluid separating means having four effective areas at least one of which is on one side thereof and at least one other of which is on the opposite side thereof, means for exposing one of said areas to fluid pressure obtaining in the first tubing; means for exposing another of said areas to fluid pressure obtaining in the second tubing; means for exposing still another of said areas to fluid pressure obtaining in the well substantially at the level of the pump; and means for applying to the fourth of said areas a fluid pressure sufficient to balance any net pressure force differential resulting from the pressures applied to the other three areas.

3. A shock absorber according to claim 2 wherein the means last defined includes a chamber of variable volume one wall of which is defined by said fourth of said areas, said chamber being adapted to confine a liquid the pressure of which is adapted to be applied to said fourth of said areas so as to resiliently balance said net pressure force differential.

4. In a shock absorber for use in a pumping apparatus which is adapted to be set in a well and which includes a fluid-operated pump having first and second tubings connected thereto, the first tubing being adapted to convey operating fluid to the pump to operate same and the second tubing being adapted to convey from the pump fluid discharged thereby, the combination of: a cylinder; a piston disposed in and reciprocable longitudinally of said cylinder, said piston having first and third transverse areas on one side thereof and having second and fourth transverse areas on the opposite side thereof; means including a passage adapted to communicate with the first tubing for exposing said first area of said piston to fluid pressure obtaining in the first tubing; means including a passage adapted to communicate with the second tubing for exposing said second area of said piston to fluid pressure obtaining in the second tubing; means for exposing said third area of said piston to fluid pressure obtaining in the well, including a passage communicating with the well substantially at the level of the pump; and a chamber which is adapted to contain a liquid and one wall of which is defined by said fourth area of said piston so that the pressure force applied to said fourth area of said piston by a liquid in said chamber resiliently balances any net pressure force differential applied to said piston by the pressures applied to said first, second and third areas.

5. A shock absorber as defined in claim 4 wherein said fourth area is small as compared to said first, second and third areas.

6. A fluid-operated pumping unit, comprising: a pump adapted to be operated by a fluid at a first pressure to discharge at a second pressure fluid entering said pump at a third pressure; a cylinder; a piston in said cylinder; means for exposing at least a portion of one end of said piston to the first pressure; means for exposing at least a portion of the opposite end of said piston to the second pressure; means for exposing at least a portion of one of said ends of said piston to the third pressure; and means for applying to at least

a portion of one of said ends of said piston a fourth pressure balancing any net pressure force differential resulting from the application of the first, second and third pressures to said piston.

7. In a device for absorbing pressure variations, the combination of: movable fluid separating means having first and third areas on one side thereof and having second and fourth areas on the opposite side thereof; means for applying a first fluid pressure to said first area of said fluid separating means; means for applying a second fluid pressure to said second area of said fluid separating means; means for applying a third fluid pressure to said third area of said fluid separating means; and means for applying to said fourth area of said fluid separating means a fourth fluid pressure providing a pressure force sufficient to balance the algebraic sum of the products of said first, second and third areas and the first, second and third fluid pressures, respectively.

8. A device as defined in claim 7 wherein the means last defined includes a chamber which is adapted to contain a liquid and one wall of which is defined by said fourth area of said fluid separating means.

9. In a shock absorber for use in a well pumping apparatus which includes a pump operable by an operating fluid to pump well fluid from the well to the surface as production fluid, the combination of: movable fluid separating means having a first pair of areas on one side thereof which are adapted to be exposed to the operating and well fluid pressures, respectively, and having a second pair of areas on the opposite side thereof one of which is adapted to be exposed to the production fluid pressure; and a chamber which is adapted to contain a liquid and one wall of which is defined by the other area of said second pair.

10. In a shock absorber, the combination of: a cylinder having first and second ends; a tube axially aligned with said second end of said cylinder; means rigidly connecting said cylinder and said tube; a generally cup-shaped piston disposed in said cylinder and telescoped over said tube, said piston having a first surface exposed to fluid pressure in said tube so that fluid pressure in said tube tends to move said piston toward said first end of said cylinder, and said piston having a second surface exposed to fluid pressure in said cylinder so that fluid pressure in said cylinder tends to move said piston toward said second end of said cylinder; and fluid means for resiliently biasing said piston toward said second end of said cylinder, including a chamber which is adapted to contain a fluid and one wall of which is defined by a third surface of said piston so that fluid pressure in said chamber tends to move said piston toward said second end of said cylinder.

11. In a shock absorber for use in connection with a hydraulically-actuated deep well pump having a column of operating liquid at relatively high pressure and a column of pumped fluid at a relatively lower pressure, the combination of: cylinder means; piston means in said cylinder means, having a first relatively small area facing in one direction, a second relatively large area facing in the other direction, and a third area of intermediate size facing in the same direction as said first area, said first area being adapted to be constantly exposed to the fluid pressure of said operating fluid column, said second area being adapted to be constantly exposed to the fluid pressure of said pumped fluid column, and said third area being adapted to be constantly exposed

to the fluid pressure in the well adjacent the pump, said areas being so related in size that said piston is substantially hydraulically balanced; and resilient means engaging said piston means and adapted to dampen sudden fluid pressure surges in one of said columns.

12. In a shock absorber for use in connection with a hydraulically-actuated deep well pump having a column of operating liquid at relatively high pressure and a column of pumped fluid at a relatively lower pressure, the combination of: cylinder means; piston means in said cylinder means, having a first relatively small area facing in one direction, a second relatively large area facing in the other direction, and a third area of intermediate size facing in the same direction as said first area, said first area being adapted to be constantly exposed to the fluid pressure of said operating fluid column, said second area being adapted to be constantly exposed to the fluid pressure of said pumped fluid column, and said third area being adapted to be constantly exposed to the fluid pressure in the well adjacent the pump, said areas being so related in size that said piston is substantially hydraulically balanced; and hydraulic means engaging said piston means and adapted to dampen sudden fluid pressure surges in one of said columns.

13. In a shock absorber for use in connection with a hydraulically-actuated deep well pump having a column of operating liquid at relatively high pressure and a column of pumped fluid at a relatively lower pressure, the combination of: cylinder means; piston means in said cylinder means having a first relatively small area facing in one direction, a second relatively large area facing in the other direction, and a third area of intermediate size facing in the same direction as said first area, said first area being adapted to be constantly exposed to the fluid pressure of said operating fluid column, said second area being adapted to be constantly exposed to the fluid pressure of said pumped fluid column, and said third area being adapted to be constantly exposed to the fluid pressure in the well adjacent the pump, said areas being so related in size that said piston is substantially hydraulically balanced; a stem connected to said piston means extending therefrom; and a substantially closed chamber filled with liquid into which said stem projects.

14. In a shock absorber for use in connection with a hydraulically-actuated deep well pump having a column of operating liquid at relatively high pressure and a column of pumped fluid at a relatively lower pressure, the combination of: cylinder means; piston means in said cylinder means having a first relatively small area facing in one direction, a second relatively large area facing the other direction, and a third area of intermediate size facing in the same direction as said first area, said first area being adapted to be constantly exposed to the fluid pressure of said operating fluid column, said second area being adapted to be constantly exposed to the fluid pressure of said pumped fluid column, and said third area being adapted to be constantly exposed to the fluid pressure in the well adjacent the pump, said areas being so related in size that said piston is substantially hydraulically balanced; a stem of relatively small cross-sectional area compared with said first area and connected to said piston means and extending therefrom; and a substantially

closed chamber filled with liquid into which said stem projects, the liquid in said chamber dumping sudden fluid pressure surges in one of said columns.

15. In a shock absorber for use in connection with a hydraulically-actuated deep well pump having a column of operating liquid at relatively high pressure and a column of pumped fluid at a relatively lower pressure, the combination of: cylinder means, piston means in said cylinder means having a first relatively small area facing in one direction, a second relatively large area facing the other direction, and a third area of intermediate size facing in the same direction as said first area, said first area being adapted to be constantly exposed to the fluid pressure of said operating fluid column, said second area being adapted to be constantly exposed to the fluid pressure of said pumped fluid column, and said third area being adapted to be constantly exposed to the fluid pressure in the well adjacent the pump, said areas being so related in size that said piston is substantially hydraulically balanced; a stem connected to said piston means and extending therefrom on the same side of said piston means as said second area; and a substantially closed chamber filled with liquid into which said stem projects.

16. In a shock absorber for use in connection with a hydraulically-actuated deep well pump

having a column of operating liquid at relatively high pressure and a column of pumped fluid at a relatively lower pressure, the combination of: cylinder means; piston means in said cylinder means having a first relatively small area facing in one direction, a second relatively large area facing the other direction, and a third area of intermediate size facing in the same direction as said first area, said first area being adapted to be constantly exposed to the fluid pressure of said operating fluid column, said second area being adapted to be constantly exposed to the fluid pressure of said pumped fluid column, and said third area being adapted to be constantly exposed to the fluid pressure in the well adjacent the pump, said areas being so related in size that said piston is substantially hydraulically balanced; a stem connected to said piston means and extending therefrom; a substantially closed chamber filled with liquid into which said stem projects; and restricted orifice means communicating between the interior of said chamber and said pumped fluid column.

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