

Dec. 29, 1953

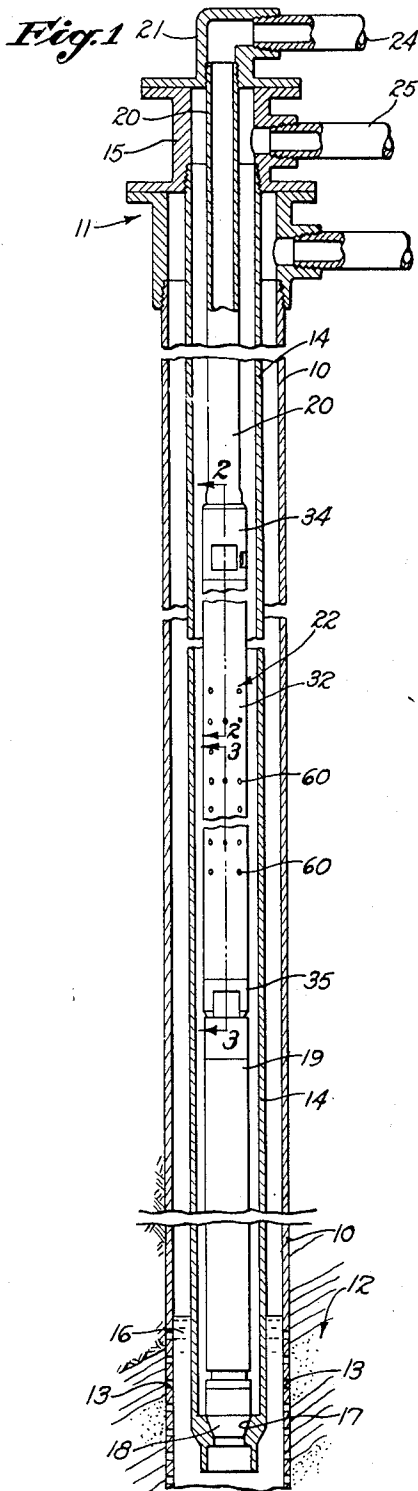
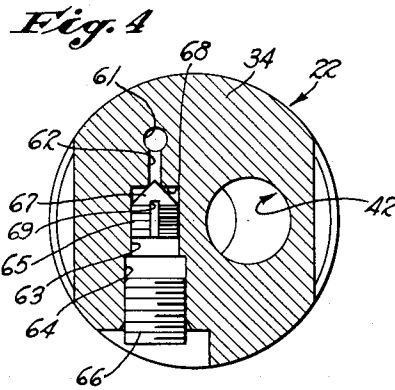
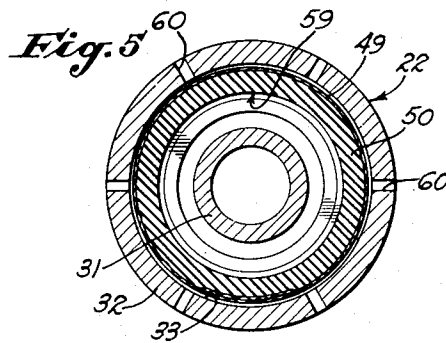
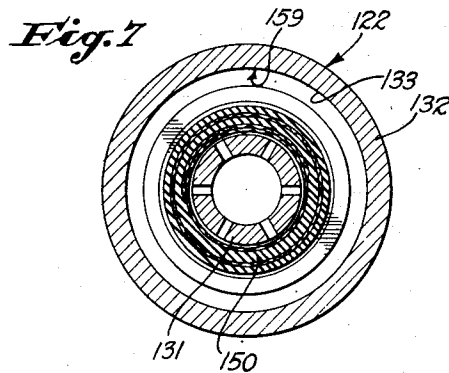
C. J. COBERLY

2,664,049

FLUID-OPERATED PUMP WITH PNEUMATIC SHOCK ABSORBER

Filed Feb. 16, 1948

3 Sheets-Sheet 1

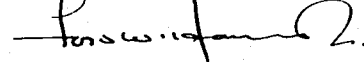


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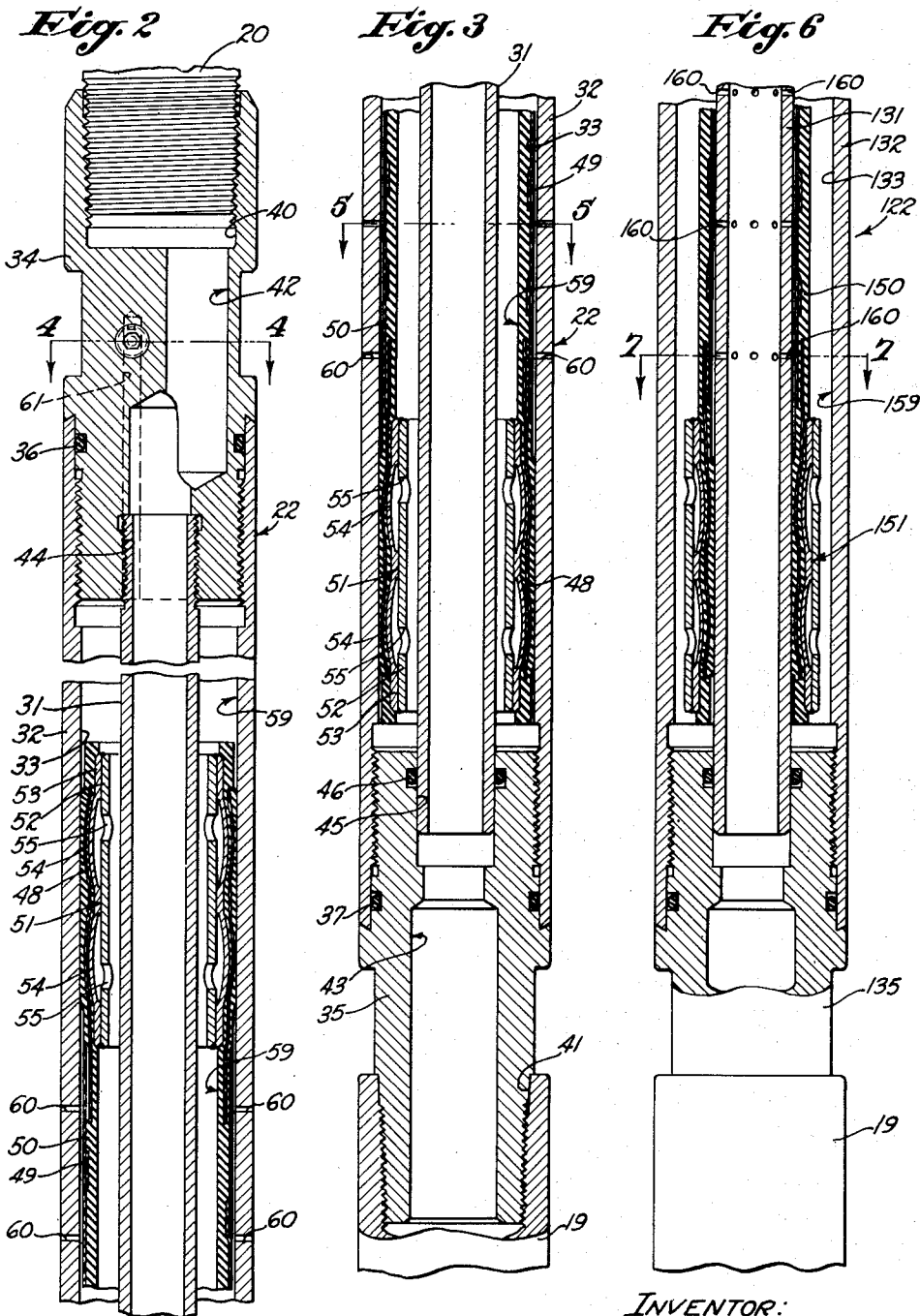
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FLUID-OPERATED PUMP WITH PNEUMATIC SHOCK ABSORBER

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3 Sheets-Sheet 2



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3 Sheets-Sheet 3

Fig. 8

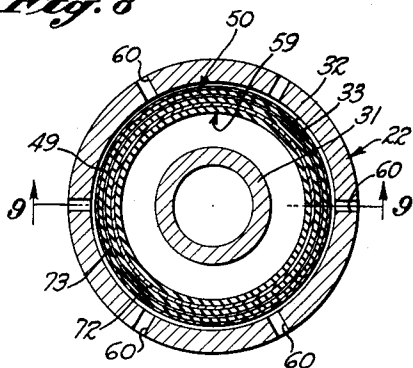


Fig. 9

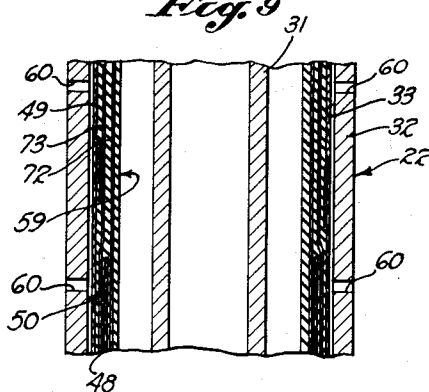


Fig. 10

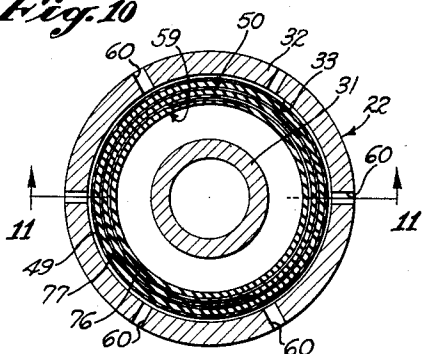


Fig. 11

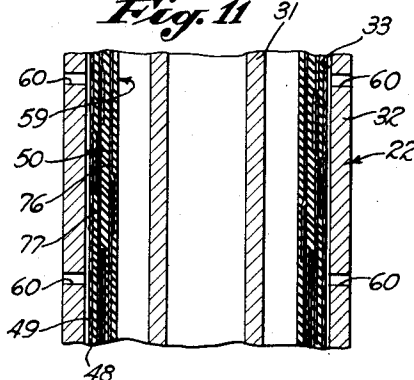


Fig. 12

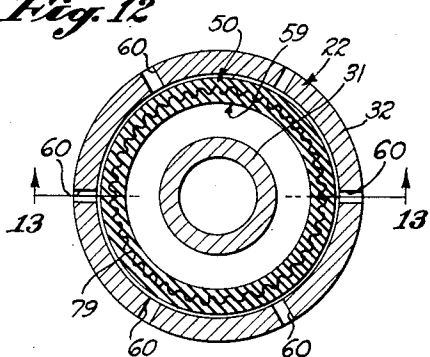
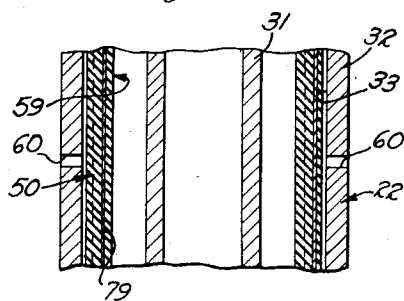


Fig. 13



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UNITED STATES PATENT OFFICE

2,664,049

FLUID-OPERATED PUMP WITH PNEUMATIC
SHOCK ABSORBER

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by mesne assignments, to Dresser Equipment
Company, Cleveland, Ohio, a corporation of
Ohio

Application February 16, 1948, Serial No. 8,524

14 Claims. (Cl. 103—46)

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My invention relates in general to fluid-operated pumping equipment and, more particularly, to an apparatus which includes a fluid-operated pump of the reciprocating type, a primary object of the invention being to provide an apparatus of this character having cushioning means associated therewith for absorbing any shock loads which may be imposed on the system.

Pumps of the fluid-operated type 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 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 to the surface being connected to the motor and pump sections, respectively. The motor section of the pump includes a cylinder having a piston therein and includes a suitable valve mechanism for admitting the pressurized operating fluid in the power tubing alternately into opposite ends of this cylinder so as to reciprocate the piston therein, the operating fluid usually being clean crude oil. The pump section includes a cylinder having a piston therein which is connected to the motor piston, whereby the reciprocatory motion of the motor piston is communicated to the pump piston so that the latter draws oil 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 are ordinarily of the double-acting type so that as oil is drawn into one end of the pump cylinder during a given stroke of the pump piston, oil drawn into the opposite end thereof during the preceding stroke is simultaneously discharged.

In order to prevent excessive wear and possible breakage of the various components of a pump of this type, and in order to prevent damage to other components of the installation in which the pump is incorporated, it is essential to minimize any shock loads which may originate in the pump. Such shock loads may be developed in the pump under various conditions of operation, one of these being the condition

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resulting when the load on the pump piston decreases suddenly due, for example, to the presence of gas in the pump cylinder. The oil entering the well from an adjacent oil producing formation may contain considerable quantities of natural gas in solution or in suspension, or both, the amount of natural gas present in the oil depending upon the amount present in the formation and depending upon prevailing conditions of pressure, temperature, etc.

Since the pump piston reduces the pressure in the pump cylinder below that prevailing in the well as it draws oil into the pump cylinder, the gas present in the oil may be liberated with the result that a quantity of oil sufficient only to partially fill the pump cylinder is drawn thereinto, the balance of the pump cylinder being filled with gas. Consequently, when the direction of movement of the pump piston is reversed and starts its pumping stroke, this piston will act only on the gas in the pump cylinder for at least the first part of its stroke. Since the gas is highly compressible, it offers but little resistance to movement of the pump piston so that the motor and pump pistons, which are 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 energy may be stored in the operating fluid supply system at the operating fluid pressures normally employed because of the compressibility of the column of operating fluid in the power tubing and the expansibility of the power tubing. Such energy is released when the load on the pump piston decreases due to the presence of gas in the pump cylinder, and contributes to the acceleration of the motor and pump pistons.

When the pump piston, traveling at an abnormal, high speed, strikes the oil 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 the parts of the pump. Moreover, pressure surges of considerable magnitude may be produced in the operating fluid and production fluid columns above the pump and may result in abnormal stressing of and possibly damage to other components of the installation. If the fluid mixture being pumped contains a large percentage of water, which occurs frequently in

some oil fields, the compressibility of the production column is substantially less than where the production column is relatively pure oil or a mixture largely of oil and gas, and the present invention is of particular value for use with the former. Also, the present invention has great utility and may be used with particular advantage in a well in which the fluid level in the well is pumped down to a point such that only gas at low pressure is present in the pump cylinder.

A governor located in close proximity to the pump may be employed to reduce the rate of flow of operating fluid to the motor section of the pump in response to decreases in the load on the pump piston so as to reduce the piston speeds 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 begins to operate only after the condition which results in acceleration of the motor and pump pistons has already developed, there may be considerable lag in its operation. Consequently, even if a governor is employed, shock loads of undesirably large magnitudes may be produced, although such shock loads are, of course, greatly reduced as a result of the use of the governor.

Severe stresses may be developed in various components of the installation even under normal conditions of operation if the frequency of the reciprocatory motion of the motor and pump pistons coincides with either the natural frequency of oscillation or one of the harmonics of either the operating fluid or the production fluid column above the pump, i. e., if the frequency of the pressure pulsations developed in the fluid columns as a result of the reciprocatory motion of the motor and pump pistons coincides with either the natural frequency or one of the harmonics of one of the columns. These fluid 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 such 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 operating fluid 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 piston speed, 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.

In view of the foregoing considerations, an object of the present invention is to provide a cushioning or shock absorbing device for use

with pumps of the character described which is adapted to absorb shock loads and pressure surges originating in the pump under various conditions of operation.

More specifically, an object of the invention is to provide a pneumatic shock absorber which may be exposed to the fluid pressure obtaining in either the power tubing or the production tubing at a point in close proximity to the pump so that shock loads originating in the pump are absorbed substantially instantaneously.

Another object is to provide a shock absorber which includes a variable volume chamber having a gas, such as air or nitrogen, for example, therein and which includes means for exposing the exterior of the chamber to fluid pressure obtaining in the power tubing or the production tubing at a point in close proximity to the pump.

Another important object of the invention is to provide a chamber which is capable of retaining the gas contained therein for long periods of time in order to eliminate any necessity for repairing or replacing the shock absorber at frequent intervals.

A further object is to provide a shock absorber having a flexible member which forms one wall of the gas chamber and having means for preventing diffusion of the gas through this wall.

Still another object is to provide a cushioning device wherein the flexible wall of the chamber includes a layer of rubber-like material to provide flexibility and includes a layer of reinforcing material which is capable of resisting diffusion of the gas in the chamber therethrough.

A further object is to provide a shock absorber wherein the gas chamber is filled with a liquid to a depth sufficient to substantially submerge the flexible wall thereof so as to provide a liquid seal of considerable length between the gas in the chamber and this wall.

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, and to provide a compact shock absorber which occupies a minimum of space in a well.

The foregoing objects of the invention and the advantages suggested thereby, together with various other objects and advantages which will become evident, may be attained through the employment of the exemplary embodiments are illustrated in the accompanying drawings and which are described in detail hereinafter. Referring to the drawings:

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

Fig. 2 is an enlarged vertical sectional view which is taken along the broken line 2—2 of Fig. 1 and which shows an upper portion of a shock absorber embodying the invention;

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

Figs. 4 and 5 are transverse sectional views taken along the broken lines 4—4 and 5—5, respectively, of Figs. 2 and 3, respectively;

Fig. 6 is a vertical sectional view which is similar to Fig. 3 but which shows another embodiment of the invention;

Fig. 7 is a transverse sectional view taken along the broken line 7—7 of Fig. 6;

Fig. 8 is a cross-sectional view, similar to Fig.

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5, but showing an alternative type of resilient sleeve;

Fig. 9 is a fragmentary longitudinal sectional view taken along the broken line 9—9 of Fig. 8;

Fig. 10 is a view similar to Fig. 8, but showing a further alternative type of resilient sleeve;

Fig. 11 is a fragmentary longitudinal sectional view taken along the broken line 11—11 of Fig. 10;

Fig. 12 is a view also similar to Fig. 8, but showing still another alternative type of resilient sleeve; and

Fig. 13 is a fragmentary longitudinal sectional view taken along the broken line 13—13 of Fig. 12.

Referring particularly to Fig. 1 of the drawings, I show a well casing 10 which extends downwardly from a casing head 11 into an oil producing formation 12 of a well, the lower end of the casing being provided with perforations 13 through which fluid 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 a body 16 of production fluid in the lower portion thereof. The lower end of the production tubing 14 is equipped with a pump seat 17 which is adapted to receive and support the inlet end 18 of a fluid-operated pump 19. A power tubing 20 for conveying operating fluid to the pump 19 is suspended from a cap member 21 of the tubing head 15 and extends downwardly through the production tubing 14. In the particular construction illustrated in the drawings, the power tubing 20 is connected to the pump 19 through a shock absorber or cushioning device of the invention which is indicated generally by the numeral 22 and is described in detail hereinafter.

The fluid operated pump 19 per se forms no part of the present invention and is not shown in 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 the type disclosed in my aforesaid Patent No. 2,311,157. As previously mentioned, the pump disclosed in the latter patent is provided with a governor and the shock absorber 22 may be employed in connection with a pump of this type advantageously in many instances, particularly in wells where large quantities of gas are liberated from the production fluid during pumping operations.

The general operation of the pump 19 is well-known in the art, being described in detail in my aforesaid Patent No. 2,134,174, and needs be described only briefly herein. Operating fluid, such as clean crude oil, for example, is delivered under relatively high pressure to the casing head 11 through a supply pipe 24 and flows downwardly through the power tubing 20 and the shock absorber 22 to the pump 19 to operate same. Such operating fluid is alternately supplied to opposite ends of a motor piston (not shown) which forms part of the pump 19 to reciprocate same, the reciprocatory movement of the motor piston being communicated to a pump piston (not shown) through a suitable connection between the two pistons. The pump piston draws production fluid from the body 16 through the inlet end 18 of the pump 19 and discharges it into the production tubing 14. The oil discharged by the pump flows upwardly through the production tubing 14 into the casing head 11 and is discharged therefrom into a discharge pipe 25 which may lead to a point of use or storage.

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Referring particularly to Figs. 2 and 3 of the drawings, the shock absorber 22 includes concentric inner and outer tubes 31 and 32 having an annular space 33 therebetween, and includes fittings 34 and 35 which close the upper and lower ends, respectively, of this space. The upper fitting 34 is threaded into the upper end of the outer tube 32 and the lower fitting 35 is threaded into the lower end thereof, fluid-tight seals between the outer tube and the fittings 34 and 35 being provided by sealing rings 36 and 37 disposed in annular grooves in the respective fittings. The lower end of the power tubing 20 is threaded into a bore 40 in the upper fitting 34 to connect the shock absorber 22 to the power tubing, and the lower fitting 35 is threaded into a bore 41 in the upper end of the pump 19 to connect the shock absorber to the pump.

The upper fitting 34 is provided with a passage 42 therethrough which communicates with the power tubing 20 and the inner tube 31, and the lower fitting 35 is provided with a passage 43 therethrough which communicates with the inner tube and the pump 19, whereby operating fluid from the power tubing may flow through the shock absorber 22 to the pump by way of the passage 42, the inner tube 31 and the passage 43. The passages 42 and 43, and the inner tube 31, are of relatively large cross-sectional area, and thereby afford very little resistance to the flow of operating fluid therethrough. The upper end of the inner tube is threaded into a central bore 44 which forms part of the passage 42 through the upper fitting 34, and the lower end of this tube is disposed in a bore 45 which forms part of the passage 43 through the lower fitting 35. In order to facilitate assembly and disassembly of the shock absorber 22 and in order to avoid close tolerances in the relative lengths of the inner and outer tubes 31 and 32, the lower end of the inner tube is preferably merely telescoped into the bore 45 in the lower fitting 35, a fluid-tight seal between the inner tube and the lower fitting being provided by a sealing ring 46 which encircles the lower end of the inner tube and is disposed in an annular groove in the lower fitting.

A flexible sleeve 50 of oil-resistant rubber, or other suitable material of a similar nature, is disposed in the annular space 33 between the inner and outer tubes 31 and 32 adjacent the lower end of this space, layers 48 and 49 of reinforcing material, e. g., a fabric having a close weave, such as duck, preferably being embedded in the rubber. The layers 48 and 49 are preferably formed of loosely wound spiral strips of fabric to avoid undue stiffening of the sleeve. The ends of the flexible sleeve 50 are sealed with respect to the inner wall of the outer tube 32 in the embodiment illustrated in Figs. 2 to 5 of the drawings, the ends of the sleeve being held in fluid-tight engagement with the outer tube 32 by ferrules 51 inserted in the ends of the sleeve. Each ferrule 51 comprises an inner sleeve 52 and an outer shell 53, annular portions 54 of the shell being expanded to hold the flexible sleeve 50 in fluid-tight engagement with the outer tube 32. The sleeves 52 of the ferrules 51 are provided with apertures 55 therein to provide fluid communication between the inner surfaces of the expanded portions 54 of the shell 53 and the annular space 33 between the inner and outer tubes 31 and 32 so that the fluid pressure obtaining in this space is applied to the expanded portions of the shells to assist in pressing the ends of the

flexible sleeve 50 into engagement with the outer tube.

The internal diameter of the flexible sleeve 50 is greater than the external diameter of the inner tube 31 so as to provide an annular space therebetween which communicates with that portion of the annular space 33 above the flexible sleeve, thus providing a chamber 59 having a volume which is variable due to the flexibility of the sleeve 50. The outer tube 32 is provided with a plurality of apertures 60 therein intermediate the ends of the flexible sleeve 50 so that the outer surface of this sleeve is exposed to fluid pressure obtaining in the production tubing 14. The chamber 59 is filled with gas, such as air, for example, at a pressure substantially equal to the pressure normally prevailing in the production tubing 14 immediately above the pump 19 so that the flexible sleeve 50 is normally in the position shown in Figs. 2 and 3 of the drawings, the upper fitting 34 being provided with a passage 61 for introducing air into the chamber 59. As best shown in Fig. 4, the passage 61 terminates at its upper end in a bore 62 and counterbores 63 and 64, plugs 65 and 66 being threaded into the counterbores 63 and 64, respectively. The plug 65 is provided with a conical portion 67 which is adapted to seat against a shoulder 68 formed at the junction of the bore 62 and the counterbore 63 and is also provided with a longitudinal slot 69 therein. With this construction, in order to fill the chamber 59 with air to the required pressure, it is necessary to remove the plug 65 and to rotate the plug 65 until the conical portion 67 thereof is unseated. Air may then be introduced into the chamber 59 through the slot 69 in the plug 65 and, after the proper pressure within the chamber 59 has been attained, the plug 65 may be rotated until the conical portion 67 thereof seats on the shoulder 68. Subsequently, the outer plug 66 may be reinserted to provide a further seal.

Considering the operation of the shock absorber 22, it will be assumed that the pump 19 is operating under conditions such that the pump cylinder thereof is only partially filled with liquid. Consequently, as hereinbefore discussed, racing of the pump piston may occur so that it strikes the liquid in the pump cylinder while traveling at an abnormally high speed. Such impact of the pump piston against the liquid in the pump cylinder produces a pressure surge which is transmitted upwardly through the fluid in production tubing 14 and, since the exterior of the flexible sleeve 50 is exposed to the pressure in the production tubing, through the apertures 60, this pressure surge compresses the flexible sleeve and the gas in the chamber 59.

Thus, as the column of production liquid in the production tubing 14 above the shock absorber 22 is relatively incompressible as compared with the gas in the chamber 59, the fluid pressure surge in the production column is absorbed substantially at the level of the fluid-operated pump 19, and is not transmitted upwardly through the production column as a shock wave of a magnitude sufficient to cause damage. Also, the liquid in the cylinder of the fluid-operated pump 19 can more readily be displaced therefrom, lessening the reactive force of impact on the pump piston and, consequently, reducing the tendency to damage thereof. It will thus be noted that by connecting the shock absorber 22 directly to the pump 19, the gas chamber 59 responds to pressure surges originating in the pump substantially instantaneously, which is an important feature of the inven-

tion. The maximum pressure in the gas chamber 59 is normally low relative to the peak pressure built up by a shock wave in the production column. It is also to be noted that the apertures 60, communicating between the air chamber 59 and the production column in the production tubing 14, are quite small in diameter to dampen any oscillation of fluid between the air chamber and the production column by a throttling action and to prevent the formation of standing waves in the production column of sufficient amplitude to be detrimental, and this is a further important feature of the invention.

Similarly, under normal conditions of operation of the pump 19, i. e., when no gas is present in the pump cylinder, the pressure pulsations in the production fluid column above the pump which result from the reciprocatory motion of the pump piston are absorbed by the gas chamber 59 so that such pulsations are not transmitted through the production fluid column to produce standing pressure waves of damaging magnitude therein.

The volume of the gas chamber 59 required to produce the desired shock absorbing action may vary to some extent from one installation to another, although I have found that a gas chamber having a volume of approximately ten times the displacement of the pump piston per stroke is adequate for most installations. In some instances, smaller gas chambers may suffice, or at least will have beneficial effects.

The chamber 59 must be capable of retaining gas for long periods of time so that frequent removal of the apparatus from the well to replenish the gas in the chamber will not be necessary. I have found that if oil-resistant rubber alone is employed for the flexible sleeve 50, the gas will be retained for reasonable periods of time. However, in some instances, the use of such a material by itself may not be completely satisfactory, particularly in extremely deep wells where pulling the shock absorber 22 to replenish the gas in the chamber 59 may be quite expensive. Air and other gases suitable for filling the gas chamber 59 have a tendency to be dissolved by the rubber, or other similar material, forming the flexible sleeve 50 and a solution pressure gradient is established tending to cause the rubber to take up gas on one side and give it up to the oil on the other side. This represents a leakage of gas through the flexible sleeve 50, but it is a function of the solubility of the gas in the rubber rather than diffusion through pores or capillary passages in the rubber.

I have found that such gas losses through the flexible sleeve 50 may be decreased materially by embedding one or more thin metallic layers in the rubber or other material forming the sleeve. Such a construction substantially prevents leakage if the metallic layers are imperforate and greatly reduces leakage even if small holes in the metallic layers are present since the gas can leak through such small holes only by convergent flow from the interior of the gas chamber 59 to the holes and by divergent flow from the holes to the oil outside the sleeve 50.

In Figs. 8 and 9 of the drawings, I show an embodiment of the invention wherein spaced, thin metallic layers 72 and 73 are embedded in the material forming the flexible sleeve 50, such layers being provided in addition to the fabric layers 43 and 49 for mechanically reinforcing the sleeve. The metallic layers 72 and 73 may be continuous sheets of metal foil, tin foil being well suited for the purpose.

In Figs. 10 and 11 of the drawings, I show another embodiment wherein spaced metallic layers 76 and 77 in the form of spirally wound metal tapes are embedded in the rubber or other similar material forming the flexible sleeve 50, such tapes being formed of thin strips of a metal such as copper, for example. Alternatively, as shown in Figs. 12 and 13 of the drawings, the flexible sleeve 50 may have embedded therein a metallic layer 78 in the form of a thin walled, longitudinally corrugated metal sleeve which may be formed of copper or stainless steel, for example.

The metallic layers employed in the embodiments shown in Figs. 8 to 13 are preferably formed of very thin material so as to avoid undue stiffening of the flexible sleeve 50.

Another and preferred way of avoiding gas losses through the flexible sleeve 50 is to fill the chamber 59 with a liquid, such as oil, to a point such that the sleeve is submerged and has a column of liquid above it. Thus, the liquid provides a seal of considerable length between the flexible sleeve 50 and the gas in the chamber 59 so that the gas in the chamber does not contact the sleeve. There will, of course, be some vertical movement of the liquid in the chamber 59 during operation of the shock absorber 22, but such movement is small and is not accompanied by sufficient agitation to produce mixing of the gas saturated liquid at the gas liquid interface to any appreciable extent with the liquid in contact with the flexible sleeve. Therefore the liquid in contact with the sleeve will have a very low concentration of solution gas and will lose this gas at a very low rate to the rubber type material of the sleeve. As a result the loss of gas from the shock absorber will be at a very low rate and it has been found that it will retain sufficient gas to be effective after a year or more.

In the embodiment of the invention which is illustrated in Figs. 2 to 5 of the drawings, the shock absorbing action is attained by exposing the exterior of the gas chamber 59 to the pressure obtaining in the production tubing 14. However, similar results may be obtained by exposing the exterior of the gas chamber to the pressure obtaining in the power tubing 20 since any pressure surges originating in the pump are transmitted to both the operating fluid column and the production fluid column.

An embodiment of the invention wherein the gas chamber is exposed to fluid pressure in the power tubing 20 is shown in Figs. 6 and 7 of the drawings. Referring thereto, I show a shock absorber 122 which is generally of the same construction as the shock absorber 22, the various components of the shock absorber 122 being identified by numerals which are greater by one hundred than the numerals used to identify the corresponding components of the shock absorber 22. Thus, the shock absorber 122 includes concentric inner and outer tubes 131 and 132 having an annular space 133 therebetween, and includes a flexible sleeve 150 which is sealed with respect to the inner tube 131 by ferrules 151, the sleeve 150 cooperating with the tubes 131 and 132 to provide a gas chamber 159 corresponding to the gas chamber 59. In the shock absorber 122, the gas chamber 159 is exposed to the fluid pressure obtaining in the power tubing 20 through apertures 160 in the inner tube 131. Gas losses through the flexible sleeve 150 may be reduced by embedding metallic layers therein corresponding to the layers embedded in the flexible sleeve 50. Also, the gas chamber 159 may be filled with

liquid to a point such that the flexible sleeve 150 is submerged so as to further reduce gas losses. The operation of the shock absorber 122 is similar to that of the shock absorber 22 and will not be described in detail.

In actual operation of my invention, as shown in Figs. 1 to 6, inclusive, I have found that the life of the pumping equipment is greatly prolonged over its normal life with the invention. For example, in several oil wells having severe pumping conditions, conventional fluid-operated pumps had to be removed approximately every forty-five days for the repair or replacement of parts, but when the pumps were equipped with the present invention they operated successfully in the same wells and under the same pumping conditions for a continuous period of from four to five months without the repair or replacement of any of the pump parts.

Although I have disclosed exemplary embodiments of the invention herein and have disclosed a specific application of such embodiments for purposes of illustration, I do not intend to be limited specifically thereto since the embodiments disclosed may be used for other purposes and since various changes, modifications and substitutions may be incorporated therein all without necessarily departing from the spirit of the invention. Consequently, I hereby reserve the right to the protection afforded by the full scope of the appended claims.

I claim as my invention:

1. In a shock absorber for use in a well pumping apparatus comprising 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 production fluid discharged thereby, the combination of: yieldable chamber means adjacent the pump; and means for exposing said yieldable chamber means to fluid pressure obtaining in said first tubing at a point in close proximity to the pump.

2. In a shock absorber for use in a well pumping apparatus comprising 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 production fluid discharged thereby, the combination of: a variable volume chamber having a gas therein and connected to the pump, and means for exposing the exterior of said chamber to fluid pressure obtaining in said first tubing at a point in close proximity to the pump.

3. In an apparatus for pumping production 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 production fluid discharged thereby; and cushioning means connected to said pump for absorbing fluid pressure surges produced thereby, said cushioning means including a variable volume chamber having a gas therein, and including means for exposing the exterior of said chamber to fluid pressure obtaining in said first tubing at a point in close proximity to said pump.

4. In a shock absorber for use in a well pump-

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ing apparatus which includes a fluid-operated pump having first and second tubings connected thereto, the first tubing being disposed within and spaced from the second tubing and being adapted to convey operating fluid to the pump to operate same, and the second tubing being adapted to convey from the pump production fluid discharged thereby, the combination of: a variable volume chamber adapted to be positioned in the second tubing in close proximity to the pump and having a gas therein; and means for exposing the exterior of said chamber to fluid pressure obtaining in one of the tubings.

5. A shock absorber as set forth in claim 2 wherein said means for exposing the exterior of said chamber to fluid pressure comprises a plurality of small openings tending to throttle flow therethrough.

6. In a fluid-operated pumping apparatus for a well, the combination of: a fluid-operated pump set in the well; a variable-volume chamber containing a gas under pressure, said chamber having a longitudinal passage therethrough and being connected to said pump with one end of said passage in fluid communication with said pump, said passage being adapted to convey an operating fluid under pressure through said chamber to said pump to operate said pump; a first tubing extending into the well and connected to said chamber in fluid communication with the other end of said passage for conveying the operating fluid to said passage; a second tubing extending into the well and connected to said pump for conveying from said pump fluid discharged thereby; and means for exposing said chamber to the fluid pressure obtaining in one of said tubings at a point in close proximity to said chamber.

7. In a fluid-operated pumping apparatus for a well, the combination of: a fluid-operated pump set in the well; a variable-volume chamber containing a gas under pressure and having a flexible wall, said chamber being of annular cross section to provide a central longitudinal passage therethrough and being connected to said pump with one end of said passage in fluid communication with said pump, said passage being adapted to convey an operating fluid under pressure through said chamber to said pump to operate said pump; a first tubing extending into the well and connected to said chamber in fluid communication with the other end of said passage for conveying the operating fluid to said passage; a second tubing extending into the well and connected to said pump for conveying from said pump fluid discharged thereby; and passage means for exposing said flexible wall of said chamber to the fluid pressure obtaining in one of said tubings at a point in close proximity to said chamber.

8. A pumping apparatus according to claim 7 wherein said chamber comprises concentric inner and outer tubes having an annular space therebetween, and wherein said flexible wall comprises a sleeve sealed at its ends with respect to one of said tubes, said passage means comprising a plurality of apertures in said one tube between the ends of said sleeve.

9. In an apparatus for pumping production 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 con-

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nected to said pump, said second tubing being adapted to convey from said pump production fluid discharged thereby; and shock-absorbing means connected to said pump for absorbing fluid pressure surges in the operating fluid conveyed to said pump through said first tubing so as to minimize any tendency of pressure surges in the operating fluid to produce racing of said pump, said shock-absorbing means including yieldable means, and including passage means for exposing said yieldable means to the operating fluid pressure obtaining in said first tubing at a point in close proximity to said pump, said passage means connecting said first tubing to said yieldable means.

10. In a fluid-operated pumping apparatus for a well, the combination of: a fluid-operated pump in the well; a shock-absorber connected to said pump, said shock absorber having a longitudinal passage therethrough which is connected at its lower end to said pump in fluid communication therewith and which is adapted to convey an operating fluid under pressure through said shock absorber to said pump to operate said pump, said shock absorber including yieldable means; a first tubing extending into the well and connected to said shock absorber in fluid communication with the upper end of said passage for conveying the operating fluid to the upper end of said passage; a second tubing extending into the well and connected to said pump for conveying from said pump fluid discharged thereby; and passage means connecting said passage to said yieldable means for exposing said yieldable means to the pressure of the operating fluid.

11. In a shock absorber, the combination of: an elongated chamber having an axis and having a flexible wall portion at one end thereof, said wall portion extending along said axis, the length of said flexible wall portion being less than the overall length of said chamber, said chamber containing a liquid in an amount sufficient to substantially submerge said flexible wall portion but insufficient to fill said chamber when said chamber is vertical with said one end lowermost, the balance of said chamber containing a gas under pressure.

12. In a shock absorber, the combination of: a pair of concentric tubes, a first of said tubes having apertures intermediate its ends, a flexible sleeve concentric with said tubes and covering said apertures, means for sealing the ends of said flexible sleeve with respect to the first of said tubes, the walls of a second of said tubes cooperating with said flexible sleeve and said first of said tubes to provide a closed chamber, the length of said flexible sleeve being less than the overall length of said chamber, said chamber containing a liquid in an amount sufficient to substantially submerge said flexible sleeve when said chamber is vertical, the balance of said chamber containing a gas.

13. A shock absorber according to claim 12 wherein the first of said tubes is the innermost of said tubes.

14. A shock absorber according to claim 12 wherein the first of said tubes is the outermost of said tubes.

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