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SINGLE DUCT, HYDRO-PNEUMATIC, WELL-TOOL ACTUATOR

Filed Nov. 28, 1938

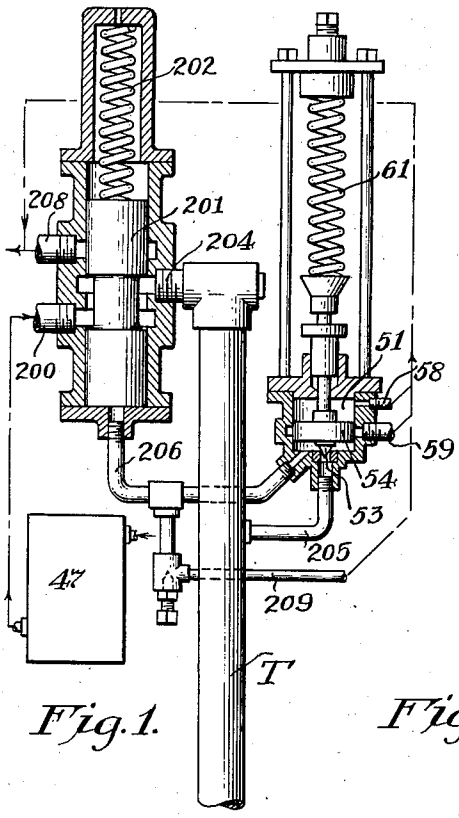


Fig. 1.

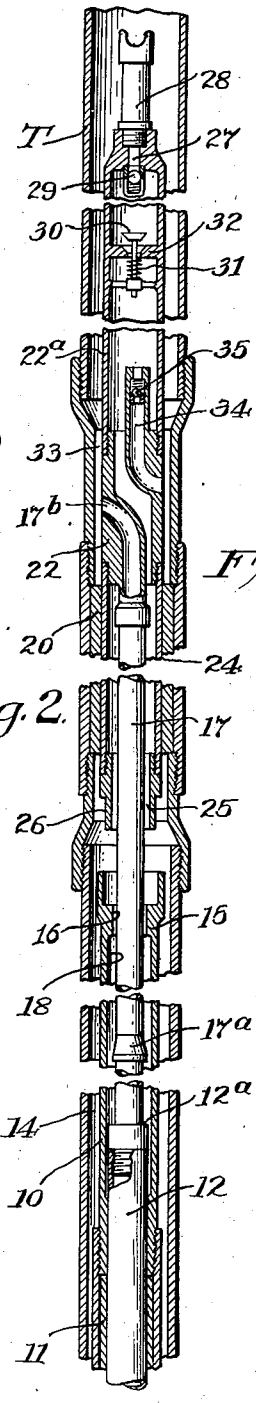


Fig. 2.

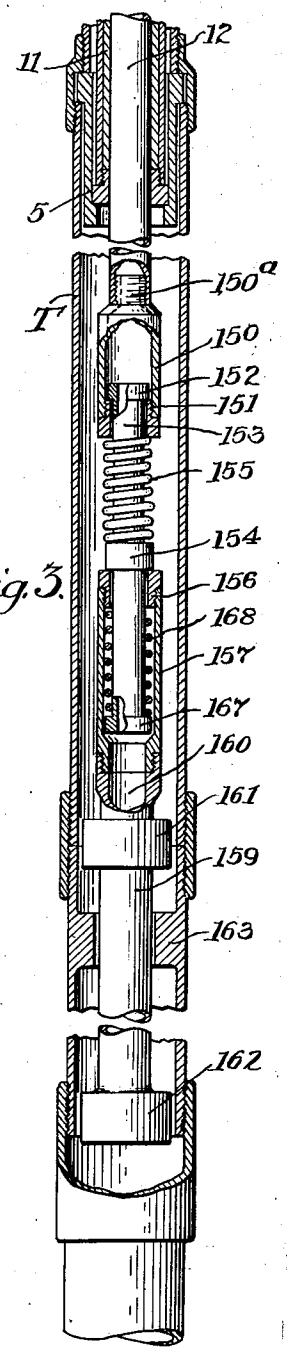


Fig. 3.

INVENTOR.
Jesse E. Hall,
BY R. W. Smith Atty.

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SINGLE DUCT, HYDROPNEUMATIC, WELL-TOOL ACTUATOR

Jesse E. Hall, Long Beach, Calif., assignor, by direct and mesne assignments, to Pacific Pump Works, Huntington Park, Calif., a corporation of California

Application November 28, 1938, Serial No. 242,750

3 Claims. (Cl. 255—4)

This invention is a jar; and has for an object to actuate a jar by alternately exerting and relieving fluid pressure in a well string in which the jar is incorporated.

It is a further object of the invention to control alternate exertion and relief of fluid pressure by means actuated responsive to relief and exertion respectively of said fluid pressure, thereby adapting the jar for automatic operation.

It is a still further object of the invention to position the controlling means at the earth's surface, with the jar at any desired level in the well string, so that the jar may be actuated by alternately exerting and relieving fluid pressure via a column of fluid in the well string between the jar and the surface control.

It is a still further object of the invention to actuate the jar by an operating connection which is adapted to yield when the hammer of the jar strikes the anvil, thereby cushioning the actuating means against the shock of the jarring action.

It is a still further object of the invention to actuate the jar by an actuator of the type described and claimed in my copending application Ser. No. 335,291, filed May 15, 1940.

Further objects of the invention will be readily understood from the following description of the accompanying drawing, in which:

Fig. 1 is a vertical section through control mechanism for the jar.

Fig. 2 is a vertical section through that portion of the well string in which the actuator for the jar is mounted.

Fig. 3 is a vertical section through that portion of the well string in which the jar is incorporated.

The jar is incorporated in a well string at any desired level, with an actuator mounted in the well string above the jar and operatively connected thereto, and with means preferably provided at the earth's surface for alternately exerting and relieving fluid pressure in the well string for operating the actuator. The actuator is preferably of the type described and claimed in my aforementioned copending application.

As an instance, a well string T extends from the earth's surface into a well bore, and an actuator is mounted in the well string, preferably immediately above the jar which it is to operate. The actuator is moved in one direction by pressure in the well string above the actuator, and this movement of the actuator stores energy which upon relief of pressure in the well string moves the actuator in the opposite direction. The stored energy is preferably pressure of an elastic fluid which is compressed by movement of the actuator in the first mentioned direction.

In the illustrated embodiment the upper portion of the actuator is adapted for sealed sliding fit in a liner 20 which is fixed in the bore of the well string, and the lower portion of the actuator is of appreciably smaller diameter and is adapted for sealed sliding fit in a liner 11. The liner 11 is preferably suspended from a barrel 10 which is mounted in the bore of the well string below the liner 20, with the lower end of the liner 11 anchored in the well string, e. g. as shown at 5.

The upper portion of the actuator is a sleeve piston, closed at its upper end and having a concentric tube of appreciably smaller diameter depending from its open lower end. The upper end of this tube opens laterally through the peripheral wall of the sleeve piston above that portion which fits snugly in the liner 20.

As an instance, the piston may comprise a sleeve 22*a*, closed at its upper end and having a depending nipple 22 from which a sleeve 24 is suspended. The sleeve 24 is adapted for sealed sliding fit in the liner 20, and the nipple 22 and the sleeve 22*a* are adapted for reciprocation in the bore of the well string above this liner. An annular space 33 (in the bore of the well string) surrounds the nipple 22 and the sleeve 22*a* above the liner 20, and communicates with that portion of the bore of the well string which extends to the earth's surface. The tube which depends concentrically from the sleeve piston is shown at 17, suspended from the nipple 22 and opening laterally therethrough as shown at 17*b*. A collar 26 at the lower end of the sleeve 24 defines an annular passageway 25 which surrounds the depending tube 17 and forms the open lower end of the sleeve piston.

The lower portion of the actuator comprises a tube 12 suspended from the tube 17 by a coupling which forms a shoulder 12*a*. The bore of the tube 12 communicates with the bore of the tube 17, and the tube 12 is adapted for sealed sliding fit in the liner 11 and projects downwardly therebeyond. A coupling, shown as a threaded connection 150*a*, is provided at the lower end of the tube 12 for detachably suspending the hammer of the jar which is to be operated by the actuator.

With the tube 12 disconnected from the hammer of the jar, the barrel 10 and its liner 11 may be lowered into and withdrawn from the well string along with the actuator. For this

purpose, the bore 18 of the barrel radially clears the tube 17 and has an annular shoulder 15 adjacent its upper end and surrounding the tube 17; and the shoulder 12a is adapted for engagement by the shoulder 15 for suspending the barrel 10 and the liner 11 from the tube 17 while the actuator is being lowered into and withdrawn from the well string.

With a substantially non-compressible fluid in the well string, e. g. a liquid washing medium such as usually employed for circulation while drilling a well, the actuator and the barrel 10 and liner 11 are lowered into the well string. The liquid washing medium rises in an annular space 14 in the bore of the well string and surrounding the barrel 10 and liner 11. This annular space communicates at its upper end with the bore 18 of the barrel 10, and the liquid washing medium thus enters and fills this bore which is sealed at its lower end by the tube 12 sliding snugly in the line 11. The liquid washing medium also enters the bore of the sleeve 24 via the passageway 25, and rises thence via the bore of the nipple 22 into the lower end of the bore of the sleeve 22a.

Consequently, when the liner 11 seats at the anchoring means 5, with the sleeve 24 adapted for reciprocation in the liner 20, the liquid washing medium is trapped in the space 14 and in the bore 18 and in the lower end of the bore of the sleeve piston 24—22—22a. Downward movement of the actuator will thus longitudinally contract the compression chamber which is defined by the annular space 14 and the bore of the sleeve piston, whereby the trapped liquid in this compression chamber will compress an elastic fluid in the upper portion of the bore of the sleeve 22a.

This elastic fluid is preferably precharged. For this purpose a partition 32 in the bore of the sleeve 22a forms a precharge chamber above the partition. A valve 30 controls communication between this precharge chamber and the main portion of the bore of the sleeve 22a, and a spring 31 tends to open this valve but is adapted to yield so that the valve may close against escape of pressure from the precharge chamber.

Prior to mounting the sleeve 22a on the nipple 22, access is had to the stem of the valve 30 via the open lower end of the sleeve 22a, for manually closing the valve against the tension of its spring and until elastic fluid under pressure has been supplied to the precharge chamber so as to provide any desired precharge pressure. This precharge pressure then maintains the valve closed against the tension of its spring so that the manual engagement of the valve stem may be released and the sleeve 22a may be mounted on the nipple 22.

The elastic fluid under pressure may be supplied via a duct 27 in the closed upper end of the sleeve 22a and thence via a check valve 29 to the precharge chamber. The desired precharge pressure having been provided, the duct 27 may be closed by an element 28 which preferably provides a detachable connection whereby the actuator may be engaged by a tool string for lowering it into and withdrawing it from the well string.

As the actuator and the barrel 10 and liner 11 are lowered through the liquid washing medium in the well string, air is trapped in the bore of the sleeve 22a, between the partition 32 and the liquid washing medium which rises in the bore of the sleeve piston 24—22—22a; and this air is compressed by the hydrostatic head of the column of liquid in the well string. The precharge pressure above the partition 32 is such that by the time the actuator reaches its operative position the pressure of the compressed air below the partition 32, plus tension of the spring 31, opens the valve 30 so that precharge pressure is equalized above and below the partition 32, with the spring 31 then retaining the valve in open position throughout the cycle of operation and irrespective of surge of pressure past the open valve. The precharge chamber above the partition 32 thus forms a continuation of the compression chamber which is defined by the annular space 14 and the bore of the sleeve piston, for uniform precharge pressure throughout this entire compression chamber.

This precharge pressure is preferably such that when the liner 11 has seated at its anchoring means 5, and the tube 12 of the actuator has been connected to the hammer of the jar which it is to operate, the actuator and the jar are approximately balanced between the hydrostatic head of the column of liquid in the well string and the precharge pressure in the compression chamber of the actuator.

Means are preferably provided for compensating for leakage from the compression chamber of the actuator, and this means may also be employed for maintaining predetermined precharge pressure in the compression chamber, in lieu of precharging via the duct 27 as previously described. As an instance, a conduit 34 may open at one end through the peripheral wall of the nipple 22, with the opposite end of the conduit opening into the bore of the sleeve 22a via a check valve 35, which closes against escape of pressure from the bore of this sleeve.

By exerting pressure (as hereafter described) upon the column of liquid in the well string, liquid may thus be forced via the conduit 34 into the compression chamber of the actuator for compensating for leakage and for compressing to any desired precharge pressure the air which has been trapped in the upper portion of the compression chamber. When pressure on the column of liquid in the well string is subsequently relieved (as hereafter described), the valve 35 closes against escape of this precharge pressure.

The actuator being in operative position in a well string with its tube 12 connected to the hammer of a jar, it is reciprocated for operating the jar by alternately exerting and relieving pressure via a column of liquid washing medium in the bore of the well string; and this alternate exertion and relief of pressure is preferably controlled at the earth's surface where the washing medium is supplied to the well string.

The washing medium which is supplied to the well string enters the port 17b and flows thence via the bores of the tubes 17—12 for circulation via the suspended jar. When pressure is exerted upon this column of liquid washing medium, it is transmitted and exerted against the effective area of the actuator for downwardly moving the same so as to downwardly shift the hammer of the jar. This effective area of the actuator is the difference between the cross-sectional area of the upper portion of the actuator which has sealed sliding fit in the liner 20, and the appreciably smaller cross-sectional area of the tube 12 which has sealed sliding fit in the liner 11, with the bore of said tube opening through the actuator. Downward movement of the actuator responsive to pressure which is thus exerted at

its effective area, longitudinally contracts the compression chamber of the actuator, thereby compressing the elastic fluid trapped in the upper portion of the compression chamber.

Upon subsequent relief of the pressure which has been exerted via the column of liquid washing medium in the well string, the compressed elastic fluid in the compression chamber of the actuator exerts pressure against the effective area of the actuator, i. e. against that area which is the difference between the cross-sectional areas of the bores of the liners 20—11, thereby elevating the actuator for upwardly shifting the hammer of the suspended jar. Elevation of the actuator expands its compression chamber, so that the parts are again in the position first described, ready for repeating the cycle of operation by again exerting pressure via the column of liquid washing medium in the well string.

Terminal reciprocation of the actuator, beyond that which will cause the hammer of the jar to strike its cooperating anvil, is preferably cushioned.

For thus cushioning terminal upstroke of the actuator an enlargement 17*a* on the tube 17 is adapted for reciprocation in the bore 18 of the barrel 10. This enlargement is clear of the shoulder 15 except at terminal upstroke of the actuator, at which time the enlargement, which is a tapering enlargement, enters the bore 16 of the shoulder. Displacement of liquid via the bore 16 and responsive to movement of the shoulder 12*a* in the bore 18 is thus restricted, thereby cushioning terminal upstroke of the actuator.

For cushioning terminal downstroke of the actuator the collar 26 is clear of the upper end of the barrel 10 except at terminal downstroke of the actuator, at which time the collar telescopes in the upper end of the bore 18. Displacement of liquid via the passageway 25 and responsive to longitudinal contraction of the compression chamber of the actuator is thus restricted, thereby cushioning terminal downstroke of the actuator.

The control at the earth's surface for alternately exerting and relieving pressure is preferably automatically operated so as to inaugurate exertion of pressure responsive to predetermined relief of pressure upon the column of liquid washing medium in the well string, and then inaugurate relief of pressure responsive to predetermined exertion of pressure upon the column of liquid washing medium.

As an instance, a valve 201 when shifted in one direction by a spring 202 supplies liquid washing medium under pressure from a source of supply 47 and thence via conduit 200 and the valve 201, to the well string T via conduit 204; and when shifted against the tension of its spring by pressure in a conduit 206 the valve shuts off the liquid supply via the conduit 200 and relieves pressure in the well string via the conduit 204 and the valve 201, and thence via a discharge conduit 208.

The valve 201 is controlled by means which operates responsive to alternate exertion and relief of pressure in the well string. As an instance, a cylinder 51 has a piston 54, one face of which has a pilot valve 53 of appreciably smaller area than the piston; and the pilot valve controls a conduit 205 which leads from the well string T. A spring 61 tends to shift the piston so that its pilot valve closes the conduit 205, thereby shutting off communication with the conduit 206, which leads from the cylinder 51 to the valve 201 and which is provided with a needle-valve controlled discharge line 209.

The cylinder 51 is preferably provided with discharge lines 58 and 59. The line 58 bleeds that end of the cylinder 51 which is remote from the conduits 205—206. The line 59 is closed by the piston 54 while the pilot valve 53 closes the conduit 205, but bleeds that end of the cylinder which is proximate the conduits 205—206, when the piston 54 has been shifted so as to open the pilot valve 53. The discharge lines 58—59—209 may be connected to the discharge conduit 208.

The springs 61—202 are adjusted so that with the pilot valve 53 closing the conduit 205 and pressure in the conduit 206 relieved via the line 209, the valve 201 is shifted by its spring 202 for supplying liquid washing medium to the bore of the well string T. The liquid washing medium circulates via the bores of the tubes 17—12 and thence via the hammer of the suspended jar, and transmits pressure for downwardly moving the actuator so as to downwardly shift the hammer of the jar as previously described. When the actuator has completed its downstroke, for desired compression of the elastic fluid in its compression chamber, pressure of the column of liquid in the well string, exerted via the conduit 205, opens the valve 53 against the tension of its spring 61. The pressure in the conduit 205 is then exerted against the larger area of the piston 54 for maintaining the piston in elevated position so that the valve 53 remains open. Pressure from conduit 205 is thus exerted via the conduit 206 for shifting the valve 201 against the tension of its spring 202 so as to close the conduit 200 and open the discharge conduit 208.

The pressure transmitted via the column of liquid in the well string is thus relieved. Responsive to predetermined relief of pressure the actuator is moved upwardly by expansion of the compressed elastic fluid in the compression chamber of the actuator, thereby upwardly shifting the hammer of the jar as previously described, and the spring 61 shifts the piston 54 so as to close the valve 53, whereupon relief of pressure in the conduit 206, via its discharge line 209, permits the spring 202 to shift the valve 201 to position opening the conduit 200 and closing the conduit 208, for repeating the cycle of operation.

The jar which is operated by the actuator for jarring action just prior to terminal stroke of the actuator, is preferably adapted for jarring action at both upstroke and downstroke.

As an instance, an anvil 163 is fixed in the well string T below the actuator and above a depending portion of the well string from which a fishing tool (not shown) may be suspended. The hammer of the jar comprises a mandrel 159 which is adapted for reciprocation through the anvil, and hammer elements 161—162 on the mandrel are adapted to respectively strike the anvil at terminal downward and upward movement of the mandrel. The mandrel is suspended from the tube 12 of the actuator by a connection hereafter described, and has a bore 160 communicating with the bore of the tube 12 so that the liquid washing medium in the bore of this tube flows thence via the bore of the mandrel and the depending portion of the well string for usual circulation.

Cushioning means are preferably provided between the mandrel 159 and the tube 12, to pre-

vent the jarring blow being transmitted to the actuator and to permit the actuator continuing its movement to terminal stroke after one or the other of the hammers have struck the anvil.

As an instance, a socket **150** is suspended from the tube **12** by the detachable coupling **150***a*, and a socket **157** projects upwardly from the mandrel **159**. The upper end of a tube **153** is adapted for telescopic play in the socket **150**, with telescopic expansion limited by a collar **152** at the upper end of the tube engaging a bushing **151** at the lower end of the socket; and the lower end of the tube **153** is adapted for telescopic play in the socket **157**, with telescopic contraction and expansion respectively limited by collars **154**—**167** on the tube engaging a bushing **156** at the upper end of the socket. A spring **155** surrounds the tube **153** between the bushing **151** and the collar **154**, and a spring **168** surrounds the tube **153** between the bushing **156** and the collar **167**.

During downstroke of the actuator the springs **155**—**168** expand the telescopic connection at the socket **150** and contract the telescopic connection at the socket **157**, with the collar **154** abutting the bushing **156** so that the mandrel **159** is moved downwardly for striking the hammer **161** against the upper face of the anvil **163**. When this jarring blow is struck, the spring **155** yields for telescopic contraction of the upper end of the tube **153** in the socket **150**, thereby cushioning the actuator against the jarring blow.

During upstroke of the actuator the spring **155** reexpands the telescopic connection at the socket **150** and the spring **168** maintains telescopic contraction at the socket **157**, thereby elevating the mandrel **159** for striking the hammer **162** against the lower face of the anvil **163**. When this jarring blow is struck, the spring **168** yields for telescopic expansion of the lower end of the tube **153** relative to the socket **157**, thereby cushioning the actuator against the jarring blow.

What is claimed is:

1. In a jar, a well string, a control communicating with the well string for alternately inaugurating supply of pressure fluid to and relief of pressure in the well string responsive to respective relief and exertion of pressure in the well string, an anvil fixed in the well string remote from the control, a hammer adapted for reciprocation through the anvil for striking the anvil at respective terminal shifting of the hammer in opposite directions, the hammer having a bore communicating at its respective ends with the well string, an actuator adapted for reciprocation in the well string, an operating connection for shifting the hammer by and in the same direction as the reciprocating actuator, the operating connection including spring tensional lost-motion means adapted for respective cushioning yielding when the hammer strikes the anvil at respective terminal shifting of the anvil in opposite directions, the actuator being adapted for shifting in one direction in the well string responsive to pressure in the well string, said shifting of the actuator being in direction away from the control, and means associated with the actuator for compressing an elastic fluid and storing energy responsive to said shifting of the actuator, the actuator being adapted for shifting in the opposite direction upon relief of pressure in the well string and responsive to said stored energy.

2. In a jar, a well string, means for alternately exerting and relieving pressure in the well string, an anvil fixed in the well string, a hammer adapted for reciprocation in the well string for striking the anvil, an actuator adapted for reciprocation in the well string by alternately exerting and relieving pressure in the well string, and an operating connection for shifting the hammer by the reciprocating actuator, the operating connection including means adapted for cushioning yielding when the hammer strikes the anvil.

3. In a jar, a well string, means for alternately exerting and relieving pressure in the well string, an anvil fixed in the well string, a hammer adapted for reciprocation in the well string for striking the anvil, an actuator adapted for reciprocation in the well string, means for shifting the actuator in one direction responsive to pressure in the well string, means associated with the actuator for storing energy responsive to said shifting of the actuator, the actuator being adapted for shifting in the opposite direction upon relief of pressure in the well string and responsive to said stored energy, and an operating connection for shifting the hammer by the reciprocating actuator so that the hammer strikes the anvil when the actuator is shifted in said opposite direction, the operating connection including means adapted for cushioning yielding when the hammer strikes the anvil.

JESSE E. HALL.