(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 1 809 858 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
26.05.2010 Bulletin 2010/21

(21) Application number: **05804239.1**

(22) Date of filing: **04.11.2005**

(51) Int Cl.:
E21B 33/06 *(2006.01)*

(86) International application number:
PCT/GB2005/004272

(87) International publication number:
WO 2006/048669 (11.05.2006 Gazette 2006/19)

(54) **IMPROVEMENTS IN OR RELATING TO HYDRAULIC RAMS**

VERBESSERUNGEN IN BEZUG AUF HYDRAULISCH BETÄTIGTE KOLBEN-STRANGPRESSEN

AMÉLIORATIONS DES BÉLIERS HYDRAULIQUES OU LES CONCERNANT

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR

(30) Priority: **04.11.2004 GB 0424401**
25.06.2005 GB 0512995

(43) Date of publication of application:
25.07.2007 Bulletin 2007/30

(73) Proprietor: **Hydril USA Manufacturing LLC**
Houston, TX 77032-3411 (US)

(72) Inventor: **Anthony S. Bamford**
Montrose DD10 9JT (GB)

(74) Representative: **Illingworth-Law, William Illingworth**
Global Patent Operation - Europe
GE International Inc.
15 John Adam Street
London WC2N 6LU (GB)

(56) References cited:
EP-A- 0 742 344
GB-A- 2 131 470
US-A- 4 199 131
US-A- 4 934 652
US-B1- 6 244 560

EP 1 809 858 B1

Description

[0001] The present invention relates to hydraulic rams and in particular, though not exclusively, to an actuator for delivering a supplementary force to the piston of a shear ram in a blowout preventer.

[0002] There are a number of applications where hydraulic rams are used. Each ram typically includes a piston which is driven forward by a hydraulic force. In oil well drilling, hydraulic rams are located in blowout preventers. In an emergency procedure when a well is required to be shut in to prevent a blow-out whilst drilling, two opposing rams are brought together to seal the well bore. These rams are typically referred to as shear rams as they include a shear blade on the front face of the piston used to sever drill pipe or casing in the wellbore.

[0003] When the shear rams are actuated by a hydraulic force, the opposing shear blades are brought together to interact, with the blades being driven by the hydraulic pistons. The shear blades first crush and then shear the drill string, casing or other tubular in the well. As wells are drilled to greater depths the tubulars are of increasing diameter, wall thickness and increased steel grades. Consequently shearing the tubular in the well requires more hydraulic force. This calls for a larger actuator piston, hence larger operating fluid volumes and higher closure pressures.

[0004] For shear rams deployed onshore or on fixed offshore installations, the increasing size is inconvenient but can be accommodated. For shear rams that are deployed subsea, the volume of hydraulic fluid that must be stored under pressure in fluid/gas accumulators increases exponentially with water depth. The volume and weight of these accumulators makes the subsea blowout preventer or shut off system much heavier and therefore more difficult to deploy.

[0005] US 4 199 131, entitled "actuator Module for Wireline Cutting Safety valve" is considered the closest prior art and discloses a portable actuator module to provide supplemental energy for closing and simultaneously cutting a wireline in case of emergency. The unit includes a spring loaded locking collet assembly arranged to engage a locking recess within the stem of a surface safety valve.

[0006] It is amongst the objects of embodiments of the present invention to provide a supplementary force actuator for use on a hydraulic ram to increase the applied force without substantially increasing the volume of hydraulic fluid required.

[0007] It is also amongst the objects of embodiments of the present invention to provide a two stage method of operating a hydraulic ram.

[0008] It is also amongst the objects of at least one embodiment of the present invention to provide a blowout preventer having a two stage actuator mechanism for improved shearing of drill pipe, casing or other tubular.

[0009] According to a first aspect of the present invention, there is provided a supplementary force actuator for use on a hydraulic ram, the actuator comprising:

an actuator body including fixation means to connect the body to a hydraulic ram;
first and second chambers located in the body, the chambers isolated from each other by an actuator piston; and,
a rod adapted to be connected to an operating piston of the hydraulic ram, pass through the first chamber and the actuator piston, and extend into at least a portion of the second chamber, characterised by:

(a) gripping means, wherein the gripping means is adapted to grip the rod during movement of the actuator piston in a first direction and to release the rod during movement in a second, opposite direction.

[0010] Thus once the normal operating piston has moved the ram to crush an object, the actuator piston can be released to provide a supplementary force on the ram.

[0011] Preferably the actuator includes a release mechanism to operate the actuator piston. In this way the actuator piston can be released at or near the end of the stroke of the operating piston and thereby provide the supplementary force where it is most required.

[0012] Preferably a separation element is located between the hydraulic ram and the body. More preferably one or more seals are arranged on the separation element to act upon the rod and prevent the release of hydraulic fluid from the body into a hydraulic fluid chamber of the hydraulic ram.

Preferably the actuator includes energy storage means arranged to provide a force to act upon the actuator piston.

[0013] In a first embodiment the energy storage means is a mechanical means. Preferably the mechanical means is one or more springs held in compression. Advantageously the mechanical means is a plurality of Bellville springs as are known in the art.

[0014] In a second embodiment the energy storage means is a hydraulic means. Preferably the hydraulic means is hydraulic fluid held under pressure.

[0015] Preferably also the actuator includes resetting means to move the actuator piston back to its original operating position. Preferably also the actuator includes ram setting means to move the operating piston back to its original position. In this way the hydraulic ram may be reset.

[0016] Preferably, the gripping means comprises a ball-gripping device and may comprise a device of the type disclosed in US Patent No. 2,062,628 (Yannetta) or US Patent No. 2,182,797.

[0017] The ball gripping device may comprise a plurality of balls mounted in a ball mounting element, which may be a ball cage or sleeve, having a plurality of apertures, each aperture associated with a corresponding

ball. The actuator, in particular, the actuator piston may be adapted to urge the balls into engagement with the rod, to grip the rod. This may facilitate application of the supplementary force.

[0018] The actuator piston may define one or more cam surface or ramp for urging one or more of the balls radially into engagement with the rod.

[0019] The device may comprise a ball release mechanism for permitting relative movement between the ball mounting element and the actuator piston. The ball release mechanism may comprise a shoulder or the like which, during return movement of the actuator piston, may be adapted to abut the ball mounting element, to exert a force on the ball element to disengage the balls from the rod. The ball mounting element may comprise a flange or spring plate, and at least one spring may be provided between the flange and the actuator piston. The spring may facilitate operation of the actuator and may prevent the actuator piston from impacting other components of the actuator following disengagement of the balls from the rod. Following release, the rod may move independently of the actuator piston back to a start position.

[0020] According to a second aspect of the present invention there is provided a method of operating a hydraulic ram comprising the steps;

(a) releasing a first piston to act on a ram;
(b) using the movement of the first piston to trigger a release mechanism;
(c) releasing a second piston on operation of the release mechanism, to act upon the ram.

[0021] Preferably the method includes the step of compressing/pressurising hydraulic fluid behind the first piston which is then used to operate the first piston. Preferably the method includes the step of releasably engaging the second piston to the first piston, so that the second piston is stationary when the first piston operates and the second piston also moves the first piston upon operation of the second piston.

[0022] Advantageously the release mechanism is triggered at or near the end of the stroke of the first piston.

[0023] Preferably the method includes the step of resetting the hydraulic ram by moving the first and second pistons back to their original operating positions.

[0024] Further features of the method are defined in relation to the first aspect of the invention.

[0025] According to a third aspect of the present invention there is provided a blow out preventer for use in oil well drilling, the blow out preventer comprising:

a pair of opposing hydraulic rams, each ram having a shear blade on a leading face;
at least one supplementary force actuator according to the first aspect located on at least one of the hydraulic rams.

[0026] Preferably a supplementary force actuator is arranged on each of the hydraulic rams. In this way the rams will initially crush the tubular by action of the operating piston and then the tubular is sheared by operation of the actuator piston.

[0027] Preferably the energy storage means is a hydraulic energy store. In this way the blow out preventer can be kept within the dimensions of 5.7m x 5.7m for deployment through a moon pool.

[0028] Embodiments of the present invention will now be described, by way of example only, with reference to the following drawings in which:

Figure 1 is a schematic cross-sectional view of a hydraulic ram including a supplementary force actuator according to a first embodiment of the present invention, shown in a first operating position;

Figure 2 is an illustration of the release mechanism of the supplementary force actuator of Figure 1;

Figure 3 is a schematic cross-sectional view of the hydraulic ram including a supplementary force actuator of Figure 1, shown in a second operating position;

Figure 4 is a schematic cross-sectional view of the hydraulic ram including a supplementary force actuator of Figure 1, shown in a third operating position;

Figure 5 is a schematic cross-sectional view of a hydraulic ram including a supplementary force actuator according to a second embodiment of the present invention;

Figure 6 is a schematic cross-sectional view of a hydraulic ram including a supplementary force actuator according to a third embodiment of the present invention; and

Figures 7 and 8 are schematic cross-sectional views of part of a supplementary force actuator according to a further embodiment of the present invention, shown in second and third operating positions, respectively.

[0029] Reference is initially made to Figure 1 of the drawings which shows a hydraulic ram, generally indicated by reference numeral 10, upon which is mounted a supplementary force actuator 12, according to a first embodiment of the present invention.

[0030] The hydraulic ram 10 is part of a blow out preventer 14. Blow out preventer 14 comprises a body 16 having an axial bore 18 therethrough and at least one transverse port 20 accessing the bore 18. Mounted at the transverse port 20 is the hydraulic ram 10. The ram 10 comprises cylindrical shaft 22 having a piston 24 at a first end and a shear blade 26 mounted on an opposing end. The piston is operated by the pressurisation of hy-

draulic fluid behind the piston 24, in a ram chamber 36.

[0031] As is conventional, a drill pipe or tubular 28 is located through the bore 18. In the event of a blow out, the piston 24 is actuated to force the shaft 22 towards the bore 18. Typically two opposing hydraulic rams 10 are mounted across the bore so that the shear blades 26 interact. The shear blades first crush and then shear the tubular 28. The shear blades are arranged such that when they meet, the bore 18 is sealed and blow out is prevented.

[0032] The supplementary force actuator 12 is connected to an existing hydraulic ram 10. In this way the actuator 12 may be retrofitted to existing ram systems. An end cap can be removed from the existing ram and the body 30 is then located at this position 32. Body 30 is fixed to the ram, being secured by bolts 34 or other accepted fixation means. A separation plate 40 isolates the ram chamber 36 from the inside of the body 30. '

[0033] Body 30 comprises first and second chambers, 38,37 respectively. In this embodiment these chambers 37,38 have a greater diameter than chamber 36. The chambers are divided by a piston 46.

[0034] The piston 24 of the conventional ram 10 is fitted with an additional connecting rod 42 that extend through seals 44 on the separation plate 40. Said seals 44 contain the full hydraulic pressure that is applied to close the ram 10.

[0035] The connecting rod 42 travels through the first chamber 38 and through the centre of the piston 46. Mounted within the piston 46 is a gripping device 48. In the illustrated embodiment, the gripping device 48 is a ball gripping device of the type described in US 2,062,628, incorporated herein by reference. The ball-gripping device 48 is described hereinafter with reference to Figures 5 and 6. Essentially the device 48 selectively grips the rod 42 such that the piston 46 and rod 42 move together. It will be understood that gripping devices of various different types may be utilised.

[0036] Mounted behind the piston 46 in the second chamber 37 are a stack of Bellville springs 50. These springs 50 can store enormous amounts of energy but the applied force drops off rapidly over a few centimetres of travel. Chamber 38 is arranged to provide only a small distance of possible travel for the piston 46. The purpose of the piston 46 is to compress and retain the Bellville springs 50 arranged in radial fashion around the connecting rod 42. Pressure applied to chamber 38 acting on piston 46 compresses the Bellville springs 50.

[0037] The load in the compressed Bellville springs 50 is retained by a rotating "half pin" 52. This is constructed of high tensile steel capable of supporting or retaining very high loads in excess of 100 metric tons. The movement of the rotating "half pin" is effected by means of a linkage, lever arm or circular plate 54 as illustrated in figure 2. Figure 2 is a schematic diagram of a release mechanism, generally indicated by reference numeral 56. The choice of linkage depends on the provision made for safety of personnel in the release of the stored energy. A circular plate 54 as illustrated in figure 2 has obvious safety advantages.

[0038] A spring loaded linkage arm 58 rotates the "half pin" 52 once the piston 46 has compressed Bellville springs 50. The load is supported on the flattened section of the rotating "half pin" 52 as indicated by the arrow in figure 2. The linkage arm 58 is attached to an adjustable collar 60 fixed to the connecting rod 42 so that when it has moved by a pre-adjusted length, the spring operates the rotation of the circular plate 54 and hence the rotating "half pin".

[0039] By changing the position of the adjustable collar 60, the operator can set at what point in the shear ram closure, the Bellville Springs 50 will discharge their load. This feature would be useful where the properties of steel and other materials to be sheared are changed. Also affecting the optimum discharge point would be the geometry of the pipe or pipes to be sheared. For example pipe in pipe shearing may require an earlier discharge point than single pipe configurations.

[0040] In use, the chambers 36,38 are filled with hydraulic fluid so as to move the pistons 24,46 away from the bore 18. As piston 24 moves it retracts the shear blade 26 of the ram 10. The linkage arm 58 also moves rotating the plate 54 as described above. The piston 46 moves independently of the rod 42 to compress the Bellville springs 50 under the force of the hydraulic fluid supplied to the chambers 36,38. This operating position is as illustrated in Figure 1 and the ram 10 and actuator 12 can remain fixed in this position until movement of the ram is required.

[0041] The operation of the shear ram is illustrated in figure 3. The operator functions the controls of the hydraulic piston 24 and shaft 22 as would occur on a conventional ram 10. By supplying hydraulic fluid between a rear face of the piston 24 and plate 40, the piston 24 is urged forward to advance the shaft 22, so that the shear blades 26 start to crush the pipe 28 to be sheared. At a critical point in the travel of the connecting rod 42, the linkage arm 58 causes the circular plate 54 and "half pin" 42 to rotate and release the stored energy in the Bellville springs 50. This is because the "half pin" cutaway section is flush with the circular section of the actuator wall. On release of the stored energy, the piston 46 moves towards the bore 18. As the piston 46 moves, the gripping device 48 forces balls against the rod 42 and the rod 42 is thus forced towards the bore 18 also. This movement of the rod 42 is passed onto the shaft 22 and the blades 26 are forced further into the bore 18. Thus, the mechanical force from the springs 50 is added to the hydraulic force generated on closure, providing a massive shearing force proportional to the piston area, hydraulic pressure applied and length and configuration of the Bellville springs 50.

Figure 4 shows the configuration when the force of the Bellville Springs 50 has been expended. A second ram, referenced 10a, is illustrated to show that the blades 26,26a interact to seal the bore 18. To re-set the system,

a control system directs hydraulic fluid to chamber 36 on the front face of piston 24. This immediately starts to compress the Bellville springs 50. When the piston 46 with the attached female ball-gripping device 48 makes contact with actuator sleeve 62, the compression of the Bellville springs 50 is complete.

[0042] At this point the spring loaded "half pin" 52 rotates to retain the stored energy. Further movement of the connecting rod 42 causes the female ball-gripping device 48 to contact the actuator sleeve 62. This depresses a ball-cage within the ball-gripping device 48 and allows the connecting rod 42 to continue its travel until the piston 46 has fully stroked back. The actuator sleeve 62 may need to be hydraulically activated to release the ball-cage within the ball-gripping device 48 to ensure immediate contact to the connecting rod 42. Fluid ports 64,66 in chambers 37,38 can be used to apply fluid pressure or vent fluid on either side of the piston 46.

[0043] It will be appreciated by those skilled in the art that the Bellville springs 50 could be replaced by an ordinary coil spring to provide an alternative embodiment. Other types of ball gripping devices may be employed, such as those of the type disclosed in US Patent No 2,182,797 to Dillon, the disclosure of which is incorporated herein by way of reference. Further embodiments could use alternative mechanical gripping devices instead of the ball-gripper system 48, for example, based on tapered slips. Other spring retaining mechanisms could be used based for example on the ball-gripper mechanisms.

[0044] The automated mechanical linkage of the release mechanism 56 could be changed in subsequent embodiments, for example instead of a conventional spring a small closed hydraulic piston could be used.

[0045] Another embodiment would be to use a proximity switch or some electronic method of pre-determining the point at which the stored mechanical energy in the Bellville spring 58 is discharged. In this case the release mechanism 56 would be operated by solenoid.

[0046] Yet another embodiment would provide for a release mechanism based on a pre-set value of hydraulic pressure. Once this hydraulic pressure threshold is reached communication to the release mechanism 56 could be via a pilot hydraulic line, a solenoid or even a pneumatic line in the event the mechanism is deployed at atmospheric pressure.

[0047] Reference is now made to Figure 5 of the drawings which illustrates a hydraulic ram, generally indicated by reference numeral 110, including a supplementary force actuator 112 according to a second embodiment of the present invention. Like parts to those of Figures 1 to 4 have been given the same reference numeral with the addition of 100.

[0048] The actuator 12 in the first embodiment had a design length of 1.761 metres. When incorporated into a subsea blow out preventer (BOP) stack, the overall design length was 7.61 metres. As the BOP stack must be lowered through a moon pool for sub sea deployment, this size is unacceptable as many moon-pools have dimensions of 6.5 metres by 6.5 metres. The length of the actuator can be reduced by re-designing the Bellville springs 50. So instead of a single stack, there are multiple stacks, typically four in number arranged radially around the rod 42. However for some BOP's the diameter of the resulting actuator 12 impinged on the space of the next ram which was located in series down the well bore.

[0049] Even with the redesign, the overall length of the actuator 12 is 1.18 metres which results in a BOP stack with an overall design length of 5.966 metres, just outside the limit set by certain oil companies of 5.7 metres.

[0050] The second embodiment seeks to achieve the same objectives i.e. to reduce the volume of accumulator bottles required for shearing pipe, especially in deepwater, whilst maintaining or enhancing the available stored shearing force, but with a reduced overall length.

[0051] The ram 110 of Figure 5, has the same arrangement as the ram 10 of Figures 1 to 4. The actuator 112 is similar except that the first chamber 138 is narrower than the second chamber 137 so that the body 130 increases in diameter at one end, typically into an 18" cylinder. The actuator piston 146 is located in the second chamber 137. The piston 146 is connected directly to the ball-gripping device 148, which is of the type described US 2,062,628.

[0052] The ball gripping device 148 comprises a surface of tapered sections forming cam surfaces or ramps 139 in each of which a ball 141 can travel on the tapered edge. A ball mounting element in the form of a ball cage 143 is biased, via springs for example, to constrain the balls 141 within the tapered sections 139. The balls 141 thus travel in the tapers 139, constrained by the ball cage 143. When the balls 141 travel down the tapers 139 they grip the rod 142. To retract them, the ball cage 143 is moved so that the balls can retract into pockets within the tapered sections 141. In the first embodiment it is contact between the cage 143 and the actuator sleeve 62 which causes movement of the cage 143 to retract the balls 141.

[0053] The purpose of the actuator piston 146 is to apply a second stage force, once the primary piston 124 has had fluid pressure applied to it and has moved sufficiently to deform and crush the pipe in the well-bore 18.

[0054] The release of the actuator piston 146 is controlled and actuated by means of a pressure signal from the hydraulic fluid applied to the primary piston 124 or from a position indicator/sensor measuring the desired length of stroke.

[0055] At the appropriate pressure value or position of the stroke sensor, the inlet valve 164 is opened to a separate accumulator bank containing operating fluid, whose pressure is normally stored at 200 bar. Movement of the piston 146 causes the ball-gripping device 148 to engage the rod 142 and apply the full force of the pressure applied over the cross sectional area of the actuator piston 146. At the same time full operating pressure is applied to the piston 124 in the first chamber 136. The shear

blades 126 will thus engage and shear the tubular 128, sealing the bore 118 and shutting in the well.

The small volume of fluid required to operate the actuator piston 146 in chamber 137 means that accumulator pressure will not fall as rapidly as would be the case with a larger volume piston. Furthermore an electric pump operating from a subsea reservoir may be used to ensure maximum applied pressure to the inlet 164 at all times.

[0056] After delivering the combined force applied to the piston 124 and actuator piston 146, the well may be opened by applying a small pressure at port 170 in the second chamber 138. The seal 172 causes the ball-gripper device 148 to move to the right and allows the balls to be retracted and hence the well may be opened by applying pressure to the front face of piston 124.

[0057] The length of stroke of the actuator piston 146 is small, generally about 50mm, which is enough to apply maximum force at the point it is needed to sever the pipe 128 in the well-bore 118. It is expected that the actuator piston 146 and the chamber 141 it occupies will be typically about 270 mm in length and the ball-gripping device 148 about 250mm in length. The total length of the actuator 112 should be about 520 mm in length.

[0058] For very deepwater where the accumulator volumes required are very large an alternate approach to the controls of the system can be implemented. This is illustrated in Figure 6. Like parts to those of Figure 5 have been given the same reference numeral.

[0059] In this embodiment an accumulator 174 of a given volume is filled with nitrogen and kept as close as possible to atmospheric pressure. The accumulator 174 is connected to the inlet 166 by a valve 176. The accumulator lines and valve 176 will be rated for a collapse pressure of at least 300 bar. When the required threshold pressure or position is reached to operate the actuator piston 146, the valve 176 is opened. This allows the fluid on the return side of the actuator piston 146 to vent to the accumulator 174.

[0060] In water depths below 1850 metres the seawater pressure alone may be sufficient to drive the actuator piston 146 to the left and shear the pipe 128. In water depths less than this, accumulator pressure may be required at inlet 166 to shear the pipe 128.

[0061] Turning now to Figure 7, there is shown a schematic cross-sectional view of part of a supplementary force actuator according to a further embodiment of the present invention, the actuator indicated generally by reference numeral 212. Like components of the actuator 212 with the actuator 12 of Figures 1 to 4, and with the actuator 112 of Figures 5 and 6 share the same reference numerals incremented by 200 and 100, respectively.

[0062] The actuator 212 is essentially of similar structure to the actuator 112, and is for use with a ram such as the ram 110. Accordingly, only the substantial differences between the actuator 212 and the actuator 112 of Figure 5 will be described herein in detail.

[0063] In Figure 7, the actuator 212 is shown in a second operating position similar to that of the actuator 12 shown in Figure 3. In this position, an actuator piston 246 is retracted. The actuator 212 includes a ball gripping device 248 of similar structure and operation to the device 148 of Figure 5, except that the device 248 additionally includes a release mechanism 78 which facilitates release of balls 141 from engagement with a rod 242. The release mechanism 78 comprises a flange or spring plate 80 provided on a ball cage 243 and a number of springs 82 provided between the flange 80 and a shoulder 84 on the actuating piston 246. The release mechanism 78 additionally includes a shoulder 86 formed on or in a body housing the actuator piston 246.

[0064] The actuator 212 is operated in a similar fashion to the actuator 112, and is shown in Figure 8 following movement of the actuator piston 246 towards a bore of a blow out preventer such as the BOP 14 shown in Figure 1. As with the actuator 112, this movement causes the balls 141 to be urged radially inwardly to grip the rod 242. When the actuator 212 is returned to the start position, to open the BOP bore, the actuator piston 246, carrying the rod 242, is moved back towards the position of Figure 7. During this movement, the ball cage flange 80 comes into contact with the shoulder 86 before the actuator piston 246 has fully returned to its start position. Accordingly, continued movement of the actuator piston 246 towards the Figure 7 position causes the balls 141 to disengage the rod 242, through abutment between the ball cage flange 80 and the shoulder 86, as the balls 141 are them permitted to move radially outwardly and along the surfaces 239. Further movement of the actuator piston 246 closes the distance between the piston shoulder 84 and the flange 80, compressing the springs 82. In this fashion, the springs 82 prevent the actuator piston 246 from impacting other components of the actuator 212 following release of the balls 141, such as a base 88 on which the shoulder 86 is provided.

[0065] The principal advantage of the present invention is that it provides a supplementary force actuator for use with a hydraulic ram to augment the force supplied by the hydraulic ram without requiring large volumes of hydraulic fluids.

[0066] A further advantage of the present invention is that it provides a supplementary force actuator for use with a hydraulic ram in a two stage application of force to shear an object such as a pipe. An initial force is delivered by the standard hydraulic ram and a secondary force is discharged at a preset point on the stroke to more or less double the applied force.

[0067] A yet further advantage of the present invention is that it provides a supplementary force actuator for use with a hydraulic ram wherein the preset point where the supplementary force is discharged is adjustable to optimise the pipe severance load at the point of hydraulic stroke where the discharged mechanical force is most effective.

[0068] It will be appreciated by those skilled in the art that various modifications may be made to the invention herein described without departing from the scope there-

of. For example, multiple chambers may be arranged transversely to the bore to provide stepped increases in actuator force. As described herein, any release mechanism may be chosen to set and release the actuator piston. Alternative gripper mechanisms may also be incorporated.

Claims

1. A supplementary force actuator (12) for use on a hydraulic ram (10), the actuator comprising;
an actuator body (30) including fixation means (34) to connect the body (30) to a hydraulic ram (10); first (38) and second (37) chambers located in the body (30), the chambers (38,37) isolated from each other by an actuator piston (46);and, a rod (42) adapted to be connected to an operating piston (24) of the hydraulic ram (10), pass through the first chamber (38) and the actuator piston (46), and extend into at least a portion of the second chamber (37), **characterised by**:

(a) gripping means (48), wherein the gripping means (48) is adapted to grip the rod (42) during movement of the actuator piston (46) in a first direction and to release the rod (42) during movement in a second, opposite direction.

2. A supplementary force actuator as claimed in Claim 1 wherein the actuator includes a release mechanism to operate the actuator piston.

3. A supplementary force actuator as claimed in Claim 1 or Claim 2 wherein a separation element is located between the hydraulic ram and the body.

4. A supplementary force actuator as claimed in Claim 3 wherein one or more seals are arranged on the separation element to act upon the rod and prevent the release of hydraulic fluid from the body into a hydraulic chamber of the hydraulic ram.

5. A supplementary force actuator as claimed in any preceding Claim wherein the actuator includes energy storage means arranged to provide a force to act upon the actuator piston.

6. A supplementary force actuator as claimed in Claim 5 wherein the energy storage means is a mechanical means.

7. A supplementary force actuator as claimed in Claim 6 wherein the mechanical means is one or more springs held in compression.

8. A supplementary force actuator as claimed in Claim 6 wherein the mechanical means is a plurality of Belville springs.

9. A supplementary force actuator as claimed in Claim 5 wherein the energy storage means is a hydraulic means.

10. A supplementary force actuator as claimed in Claim 9 wherein the hydraulic means is hydraulic fluid held under pressure.

11. A supplementary force actuator as claimed in any preceding Claim wherein the actuator includes resetting means to move the actuator piston back to its original operating position.

12. A supplementary force actuator as claimed in Claim 11 wherein the actuator includes ram setting means to move the operating piston back to its original position.

13. A supplementary force actuator as claimed in any proceeding claim, wherein the gripping means comprises a ball gripping device.

14. A supplementary force actuator as claimed in Claim 13, wherein the ball gripping device comprises a plurality of balls mounted in a ball mounting element having a plurality of apertures, each aperture associated with a corresponding ball.

15. A supplementary force actuator as claimed in Claim 14, wherein the actuator piston is adapted to urge the balls into engagement with the rod, to grip the rod.

16. A supplementary force actuator as claimed in any one of Claims 14 to 15, wherein the ball gripping device comprises a ball release mechanism for permitting relative movement between the ball mounting element and the actuator piston.

17. A supplementary force actuator as claimed in Claim 16, wherein the ball release mechanism comprises a shoulder adapted to abut the ball mounting element, to exert a force on the ball mounting element to disengage the balls from the rod during movement of the actuator piston in the second direction.

18. A supplementary force actuator as claimed in Claim 17, wherein the ball mounting element comprises a flange and at least one spring provided between the flange and the actuator piston.

19. A method of operating a hydraulic ram comprising the steps of:

a) releasing a first piston to act on a ram;
b) using the movement of the first piston to trigger a release mechanism; and

c) releasing a second piston on operation of the release mechanism, to act upon the ram.

20. A method of operating a hydraulic ram as claimed in Claim 19 wherein the method includes the step of pressurising hydraulic fluid behind the first piston which is then used to operate the first piston.

21. A method of operating a hydraulic ram as claimed in Claim 19 or Claim 20 wherein the method includes the step of releasably engaging the second piston to the first piston, so that the second piston is stationary when the first piston operates and the second piston also moves the first piston upon operation of the second piston.

22. A method of operating a hydraulic ram as claimed in any one of Claims 19 to 21 wherein the release mechanism is triggered at or near the end of the stroke of the first piston.

23. A method of operating a hydraulic ram as claimed in any one of Claims 19 to 22 wherein the method includes the step of resetting the hydraulic ram by moving the first and second pistons back to their original operating positions.

24. A blow out preventer for use in oil well drilling, the blow out preventer comprising:

a pair of opposing hydraulic rams, each ram having a shear blade on a leading face;
at least one supplementary force actuator as claimed in any one of Claims 1 to 19 located on at least one of the hydraulic rams.

25. A blow out preventer as claimed in Claim 24 wherein a supplementary force actuator is arranged on each of the hydraulic rams.

Patentansprüche

1. Hilfskraftbetätigungsvorrichtung (12) zur Verwendung auf einem hydraulischen Stempel (10), wobei die Betätigungsvorrichtung aufweist:

einen Betätigungsvorrichtungskörper (30) mit einer Befestigungseinrichtung (34), um den Körper (30) mit einem hydraulischen Stempel (10) zu verbinden; erste (38) und zweite (37) in dem Körper (30) angeordnete Kammern, wobei die Kammern (38, 37) voneinander durch einen Betätigungsvorrichtungskolben (46) getrennt sind; und eine zur Verbindung mit einem Arbeitskolben (24) des hydraulischen Stempels (10) angepasste Stange (42), die die erste Kammer (38) und den Arbeitskolben (46) passiert und sich wenigstens in einen Abschnitt der zweiten Kammer (37) erstreckt, **gekennzeichnet durch**:

(a) eine Greifeinrichtung (48), wobei die Greifeinrichtung (48) zum Ergreifen der Stange (42) während der Bewegung des Stellvorrichtungskolbens (48) in eine erste Richtung und zum Freigeben der Stange (42) während einer Bewegung in eine zweite entgegengesetzte Richtung angepasst ist.

2. Hilfskraftbetätigungsvorrichtung nach Anspruch 1, wobei die Betätigungsvorrichtung einen Freigabemechanismus zum Betreiben des Betätigungsvorrichtungskolbens enthält.

3. Hilfskraftbetätigungsvorrichtung nach Anspruch 1 oder Anspruch 2, wobei ein Trennungselement zwischen dem hydraulischen Stempel und dem Körper angeordnet ist.

4. Hilfskraftbetätigungsvorrichtung nach Anspruch 3, wobei eine oder mehrere Dichtungen auf dem Trennungselement angeordnet sind, um auf die Stange einzuwirken und die Freigebe von hydraulischem Fluid aus dem Körper in eine Hydraulikkammer des Hydraulikstempels zu verhindern.

5. Hilfskraftbetätigungsvorrichtung nach einem der vorstehenden Ansprüche, wobei die Betätigungsvorrichtung eine Energiespeichereinrichtung enthält, die für die Bereitstellung einer Kraft eingerichtet ist, um auf den Betätigungsvorrichtungskolben einzuwirken.

6. Hilfskraftbetätigungsvorrichtung nach Anspruch 5, wobei die Energiespeichereinrichtung eine mechanische Einrichtung ist.

7. Hilfskraftbetätigungsvorrichtung nach Anspruch 6, wobei die mechanische Einrichtung aus einer oder mehreren unter Druck gehaltenen Federn besteht.

8. Hilfskraftbetätigungsvorrichtung nach Anspruch 6, wobei die mechanische Einrichtung aus mehreren Tellerfedern besteht.

9. Hilfskraftbetätigungsvorrichtung nach Anspruch 5, wobei die Energiespeichereinrichtung eine hydraulische Einrichtung ist.

10. Hilfskraftbetätigungsvorrichtung nach Anspruch 9, wobei die hydraulische Einrichtung ein unter Druck gehaltenes hydraulisches Fluid ist.

11. Hilfskraftbetätigungsvorrichtung nach einem der

vorstehenden Ansprüche, wobei die Betätigungsvorrichtung eine Rückstelleinrichtung enthält, um den Betätigungsvorrichtungskolben in seine Ausgangsbetriebsposition zu bewegen.

12. Hilfskraftbetätigungsvorrichtung nach Anspruch 11, wobei die Betätigungsvorrichtung eine Stempeleinstelleinrichtung enthält, um den Arbeitskolben in seine Ausgangsposition zurückzubewegen.

13. Hilfskraftbetätigungsvorrichtung nach einem der vorstehenden Ansprüche, wobei die Greifeinrichtung eine Kugelgreifvorrichtung aufweist.

14. Hilfskraftbetätigungsvorrichtung nach Anspruch 13, wobei die Kugelgreifvorrichtung mehrere in einem Kugelbefestigungselement mit mehreren Öffnungen befestigte Kugeln aufweist, wobei jede Öffnung einer entsprechenden Kugel zugeordnet ist.

15. Hilfskraftbetätigungsvorrichtung nach Anspruch 14, wobei der Betätigungsvorrichtungskolben dafür angepasst ist, die Kugeln in Eingriff mit der Stange zu drücken, um die Stange zu ergreifen.

16. Hilfskraftbetätigungsvorrichtung nach einem der vorstehenden Ansprüche 14 bis 15, wobei die Kugelgreifvorrichtung einen Kugelfreigabemechanismus aufweist, um eine Relativbewegung zwischen dem Kugelbefestigungselement und dem Betätigungsvorrichtungskolben zuzulassen.

17. Hilfskraftbetätigungsvorrichtung nach Anspruch 16, wobei der Kugelfreigabemechanismus eine Schulter aufweist, die zur Anlage an dem Kugelbefestigungselement angepasst ist, um eine Kraft auf das Kugelbefestigungselement auszuüben, um die Kugeln von der Stange während der Bewegung des Betätigungsvorrichtungskolbens in die zweite Richtung zu lösen.

18. Hilfskraftbetätigungsvorrichtung nach Anspruch 17, wobei das Kugelbefestigungselement einen Flansch aufweist und wenigstens eine zwischen dem Flansch und der Betätigungsvorrichtung vorgesehene Feder.

19. Verfahren zum Betreiben eines hydraulischen Stempels, mit den Schritten:

a) Freigeben eines ersten Kolbens, um auf einen Stempel einzuwirken;
b) Nutzen der Bewegung des ersten Kolbens, um einen Freigabemechanismus auszulösen; und
c) Freigeben eines zweiten Kolbens bei Betrieb des Freigabemechanismus, um auf den Stempel einzuwirken.

20. Verfahren zum Betreiben eines hydraulischen Stempels nach Anspruch 19, wobei das Verfahren die Schritte der Druckbeaufschlagung des hydraulischen Fluids hinter dem ersten Kolben beinhaltet, welches dann zum Betreiben des ersten Kolbens verwendet wird.

21. Verfahren zum Betreiben eines hydraulischen Stempels nach Anspruch 19 oder 20, wobei das Verfahren den Schritt beinhaltet, den zweiten Kolben lösbar mit dem ersten Kolben in Eingriff zu bringen, sodass der zweite Kolben stationär ist, wenn der erste Kolben arbeitet und der zweite Kolben auch den ersten Kolben bei dem Betrieb des zweiten Kolbens bewegt.

22. Verfahren zum Betreiben eines hydraulischen Stempels nach einem der Ansprüche 19 bis 21, wobei der Freigabemechanismus an dem oder in der Nähe des Endes des Hubs des ersten Kolbens ausgelöst wird.

23. Verfahren zum Betreiben eines hydraulischen Stempels nach einem der Ansprüche 19 bis 22, wobei das Verfahren den Schritt der Rückstellung des hydraulischen Stempels beinhaltet, indem die ersten und zweiten Kolben in ihre ursprünglichen Betriebspositionen zurückbewegt werden.

24. Absperrschieber zur Verwendung bei Öllochbohrungen, wobei der Absperrschieber aufweist:

ein Paar gegenüberliegender hydraulischer Stempel, wobei jeder Stempel eine Scherklinge auf einer Vorderseite hat;
wenigstens eine Hilfskraftbetätigungsvorrichtung nach einem der Ansprüche 1 bis 19, die auf wenigstens einem von den hydraulischen Stempeln angeordnet ist.

25. Absperrschieber nach Anspruch 24, wobei eine Hilfskraftbetätigungsvorrichtung auf jedem von den hydraulischen Stempeln angeordnet ist.

Revendications

1. Actionneur à force supplémentaire (12) pour utiliser sur un bélier hydraulique (10), l'actionneur comprenant ;
un corps d'actionneur (30) incluant des moyens de fixation (34) pour connecter le corps (30) à un bélier hydraulique (10) ; des première (38) et seconde (37) chambres situées dans le corps (30), les chambres (38, 37) étant isolées l'une de l'autre par un piston d'actionneur (46) ; et, une tige (42) adaptée pour être connectée à un piston d'actionnement (24) du bélier hydraulique (10), passer à travers la première chambre (38) et le piston d'actionneur (46), et s'étendre dans au moins une partie de la seconde chambre

(37), **caractérisé par** :
des moyens d'accrochage (48), dans lequel les moyens d'accrochage (48) sont adaptés pour accrocher la tige (42) pendant le mouvement du piston d'actionneur (46) dans une première direction et pour libérer la tige (42) pendant le mouvement dans une seconde direction opposée.

2. Actionneur à force supplémentaire selon la revendication 1 dans lequel l'actionneur inclut un mécanisme de libération pour actionner le piston actionneur.

3. Actionneur à force supplémentaire selon la revendication 1 ou la revendication 2 dans lequel un élément de séparation est situé entre le bélier hydraulique et le corps.

4. Actionneur à force supplémentaire selon la revendication 3 dans lequel un ou plusieurs joints sont agencés sur l'élément de séparation pour agir sur la tige et empêcher la libération de fluide hydraulique du corps dans une chambre hydraulique du bélier hydraulique.

5. Actionneur à force supplémentaire selon l'une quelconque des revendications précédentes dans lequel l'actionneur inclut des moyens de stockage d'énergie agencés pour fournir une force pour agir sur le piston actionneur.

6. Actionneur à force supplémentaire selon la revendication 5 dans lequel les moyens de stockage d'énergie sont des moyens mécaniques.

7. Actionneur à force supplémentaire selon la revendication 6 dans lequel les moyens mécaniques sont un ou plusieurs ressorts maintenus en compression.

8. Actionneur à force supplémentaire selon la revendication 6 dans lequel les moyens mécaniques sont une pluralité de rondelles Belleville.

9. Actionneur à force supplémentaire selon la revendication 5 dans lequel les moyens de stockage d'énergie sont des moyens hydrauliques.

10. Actionneur à force supplémentaire selon la revendication 9 dans lequel les moyens hydrauliques sont un fluide hydraulique maintenu sous pression.

11. Actionneur à force supplémentaire selon l'une quelconque des revendications précédentes dans lequel l'actionneur inclut des moyens de réinitialisation pour replacer le piston d'actionneur dans sa position de fonctionnement initiale.

12. Actionneur à force supplémentaire selon la revendication 11 dans lequel l'actionneur inclut des moyens de réglage de bélier pour replacer le piston d'actionneur dans sa position initiale.

13. Actionneur à force supplémentaire selon l'une quelconque des revendications précédentes, dans lequel les moyens d'accrochage comprennent un dispositif d'accrochage à billes.

14. Actionneur à force supplémentaire selon la revendication 13, dans lequel le dispositif d'accrochage à billes comprend une pluralité de billes montées dans un élément de montage de billes ayant une pluralité d'ouvertures, chaque ouverture étant associée à une bille correspondante.

15. Actionneur à force supplémentaire selon la revendication 14, dans lequel le piston d'actionneur est adapté pour pousser les billes en prise avec la tige, pour accrocher la tige.

16. Actionneur à force supplémentaire selon l'une quelconque des revendications 14 à 15, dans lequel le dispositif d'accrochage à billes comprend un mécanisme de libération de billes pour permettre un déplacement relatif entre l'élément de montage de billes et le piston d'actionneur.

17. Actionneur à force supplémentaire selon la revendication 16, dans lequel le mécanisme de libération de billes comprend un épaulement adapté pour venir en butée sur l'élément de montage de billes, pour exercer une force sur l'élément de montage de billes pour faire venir hors de prise les billes de la tige pendant le déplacement du piston d'actionneur dans la seconde direction.

18. Actionneur à force supplémentaire selon la revendication 17, dans lequel l'élément de montage de billes comprend un rebord et au moins un ressort placé entre le rebord et le piston d'actionneur.

19. Procédé d'actionnement d'un bélier hydraulique comprenant les étapes consistant à :

a) libérer un premier piston pour agir sur un bélier ;
b) utiliser le déplacement du premier piston pour déclencher un mécanisme de libération ;
c) libérer un second piston lors de l'actionnement du mécanisme de libération, pour agir sur le bélier.

20. Procédé d'actionnement d'un bélier hydraulique selon la revendication 19 dans lequel le procédé inclut l'étape consistant à mettre sous pression un fluide hydraulique derrière le premier piston qui est ensuite utilisé pour actionner le premier piston.

21. Procédé d'actionnement d'un bélier hydraulique selon la revendication 19 ou la revendication 20 dans lequel le procédé inclut l'étape consistant à faire venir en prise de manière amovible le second piston avec le premier piston, de telle manière que le second piston est immobile quand le premier piston fonctionne et le second piston déplace aussi le premier piston lors de l'actionnement du second piston.

22. Procédé d'actionnement d'un bélier hydraulique selon l'une quelconque des revendications 19 à 21 dans lequel le mécanisme de libération est déclenché au niveau de ou près de l'extrémité de la course du premier piston.

23. Procédé d'actionnement d'un bélier hydraulique selon l'une quelconque des revendications 19 à 22 dans lequel le procédé inclut l'étape consistant à réinitialiser le bélier hydraulique en replaçant les premier et second pistons dans leurs positions de fonctionnement initiales.

24. Dispositif anti-éruption utilisé pour le forage de puits de pétrole, le dispositif anti-éruption comprenant :

une paire de béliers hydrauliques opposés, chaque bélier ayant une lame de cisaillement sur une face avant ;
au moins un actionneur à force supplémentaire selon l'une quelconque des revendications 1 à 19 situé sur au moins l'un des béliers hydrauliques.

25. Dispositif anti-éruption selon la revendication 24 dans lequel un actionneur à force supplémentaire est agencé sur chacun des béliers hydrauliques.

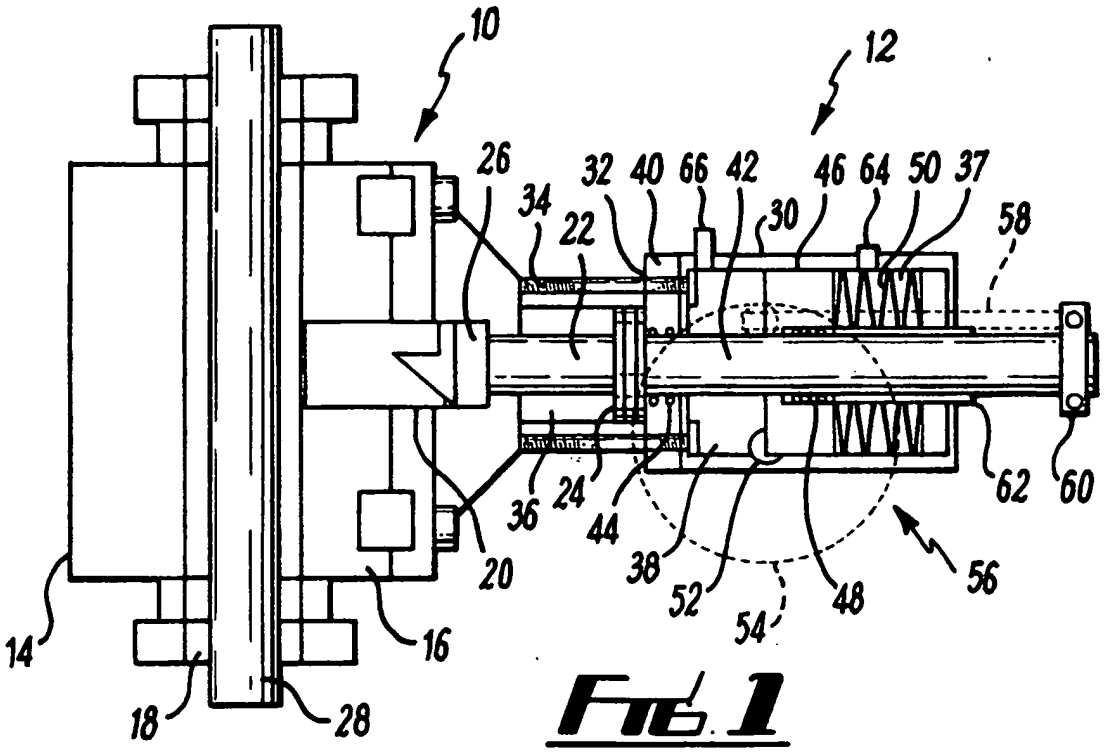
10
12
26
32
40
66
42
46
64
50
37
34
22
30
58
36
24
44
38
52
54
48
56
62
60
20
14
16
18
28

FIG. 1

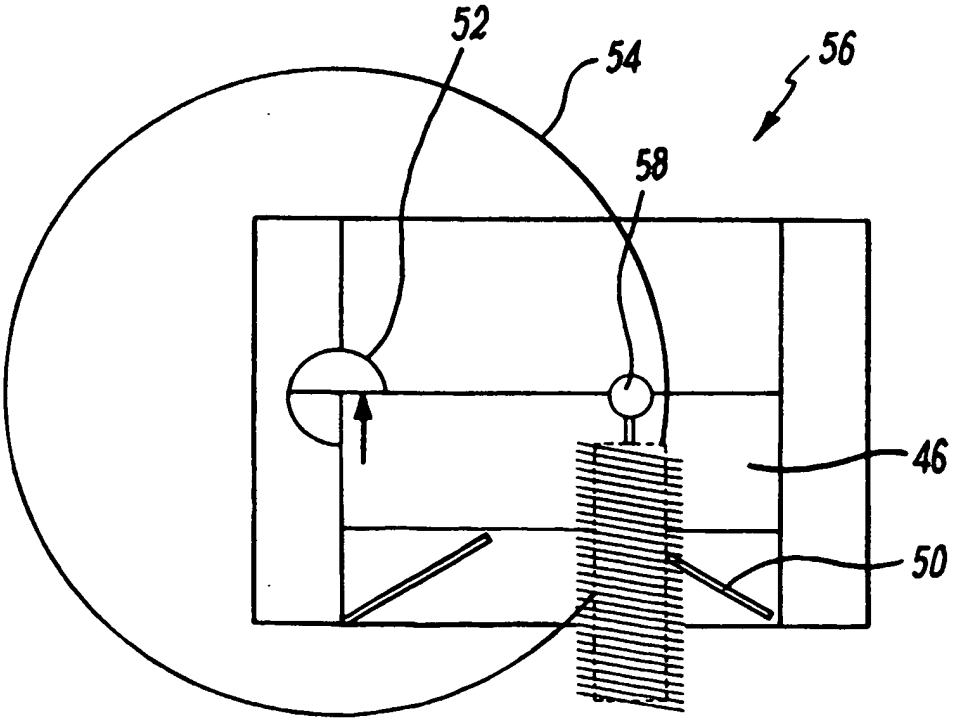
52
54
56
58
46
50

FIG. 2

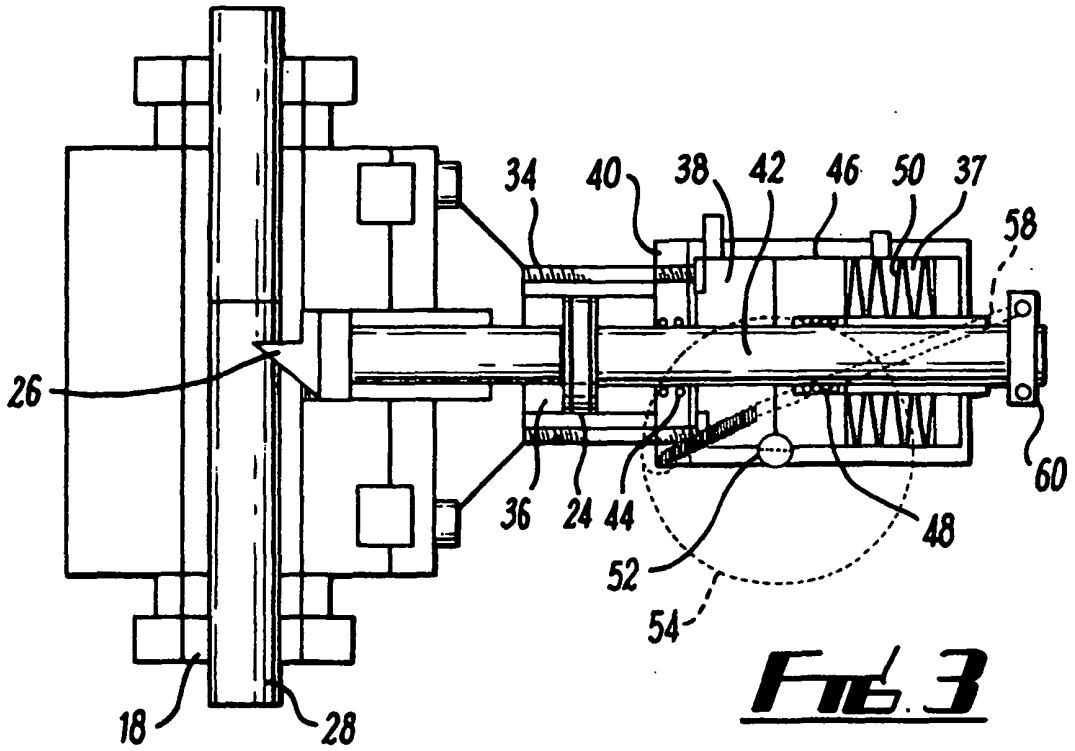
34
40
38
42
46
50
37
58
26
60
36
24
44
48
52
54
18
28

FIG. 3

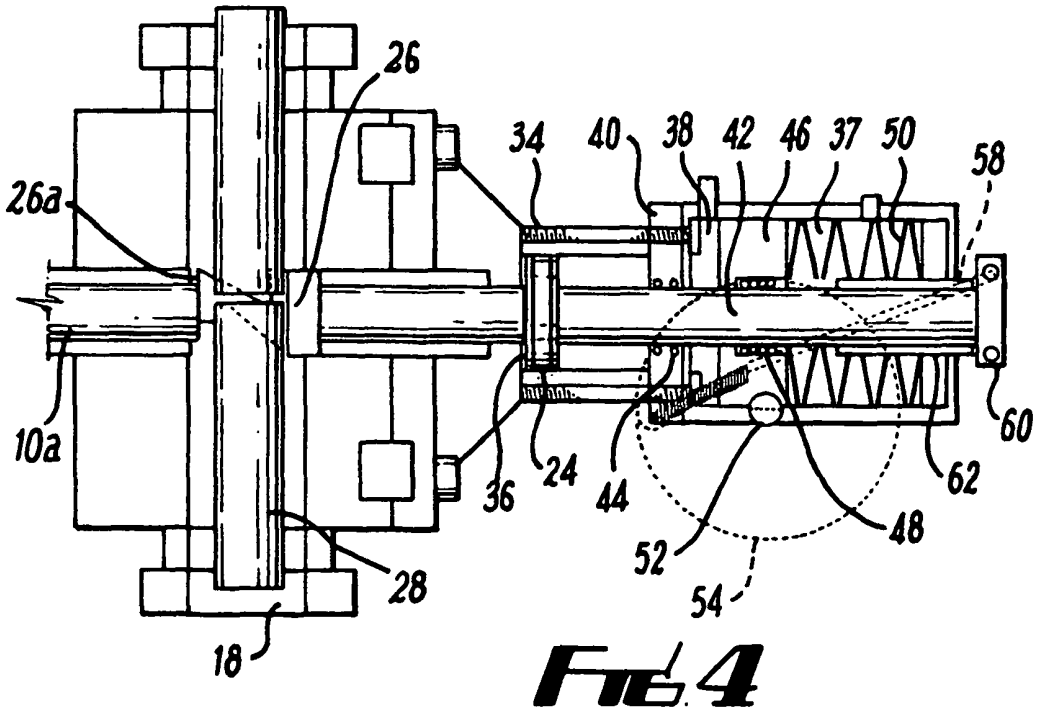
26
34
40
38
42
46
37
50
58
26a
10a
60
36
24
44
62
48
52
54
28
18

FIG. 4

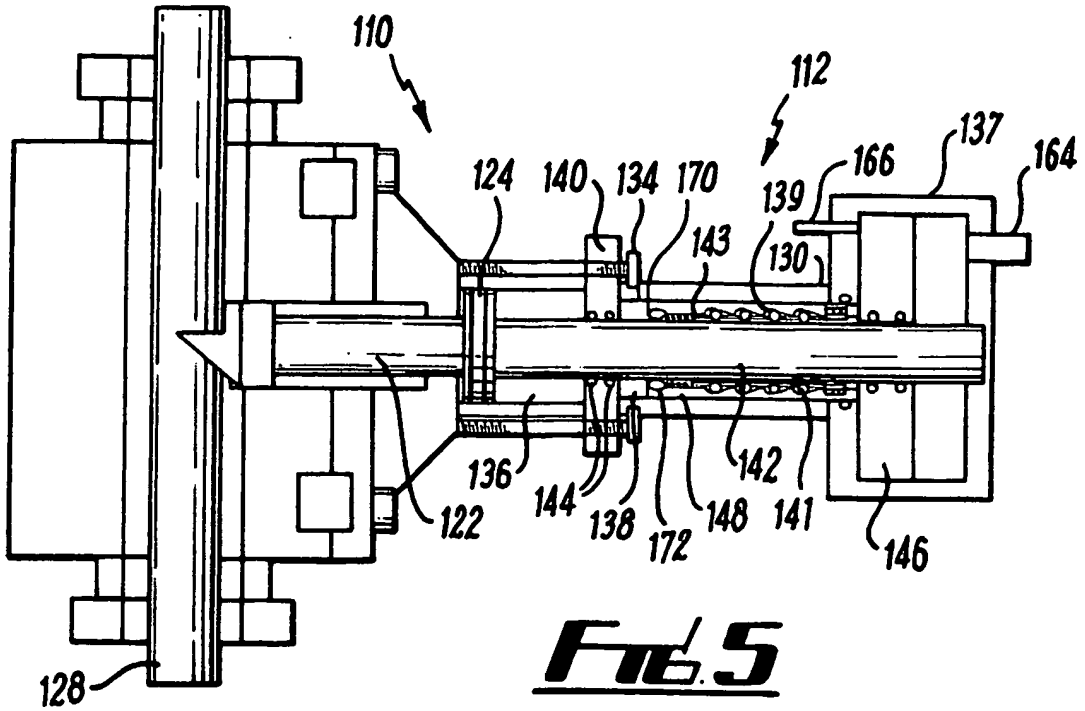
110
112
124
140
134
170
139
166
137
164
143
130
136
144
138
172
148
142
141
122
146
128

FIG. 5

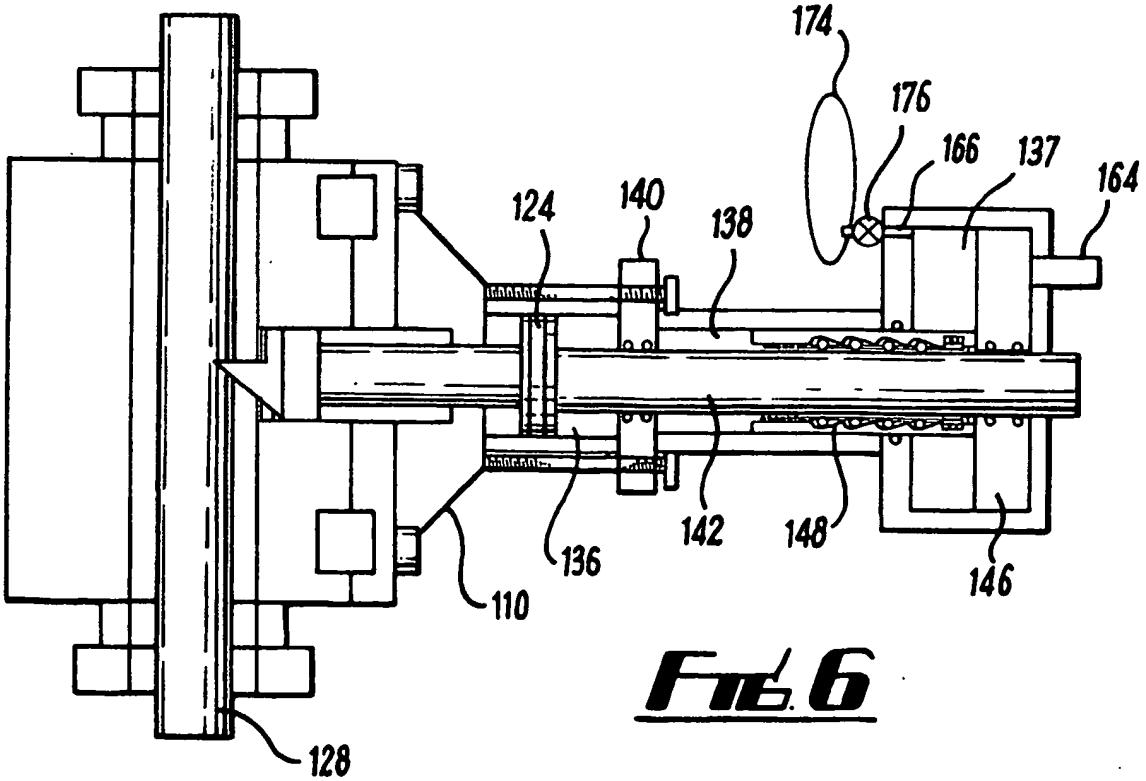
174
176
166
137
164
124
140
138
136
142
148
146
110
128

FIG. 6

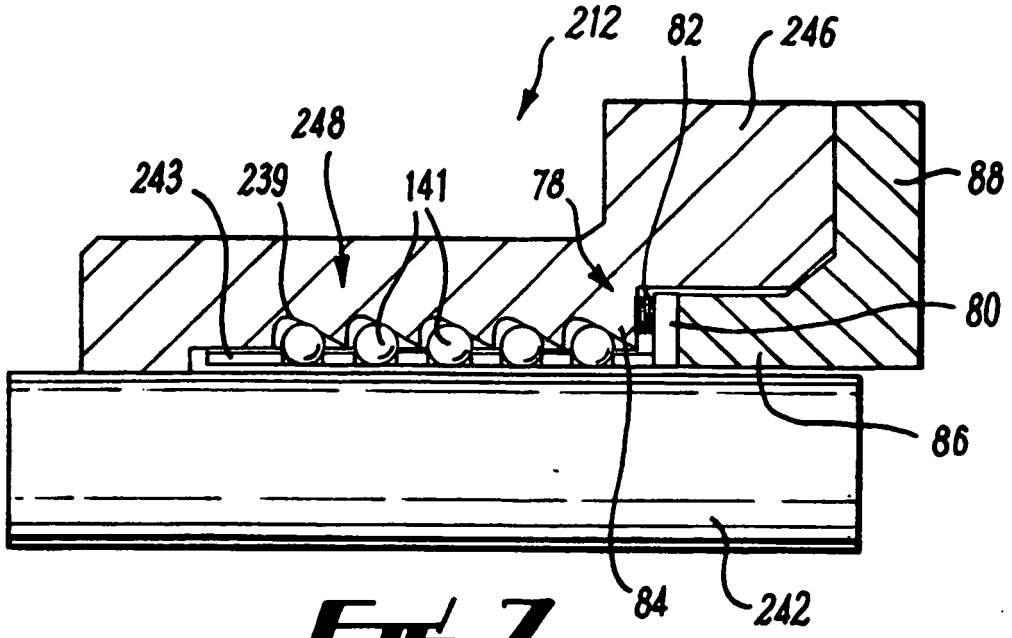
212
82
246
248
243
239
141
78
88
80
86
84
242

FIG. 7

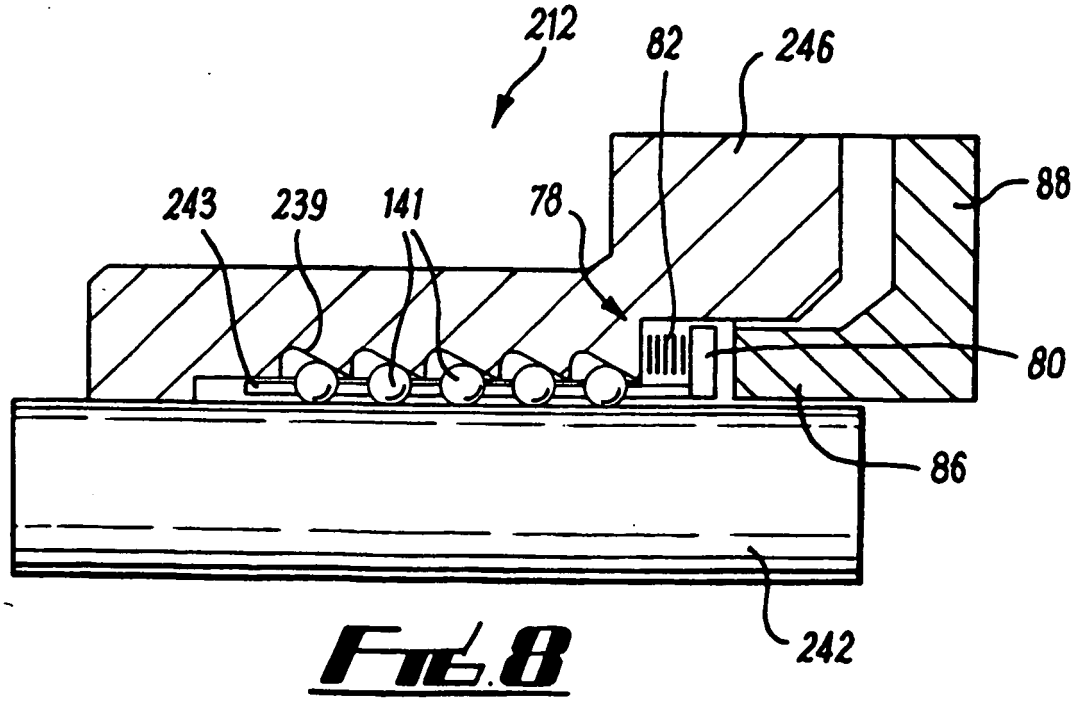
212
82
246
243
239
141
78
88
80
86
242

FIG. 8

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 4199131 A **[0005]**
- US 2062628 A, Yannetta **[0016] [0035] [0051]**
- US 2182797 A **[0016] [0043]**