March 17, 1959 H. ALLEN 2,877,977

WELL CONTROL EQUIPMENT

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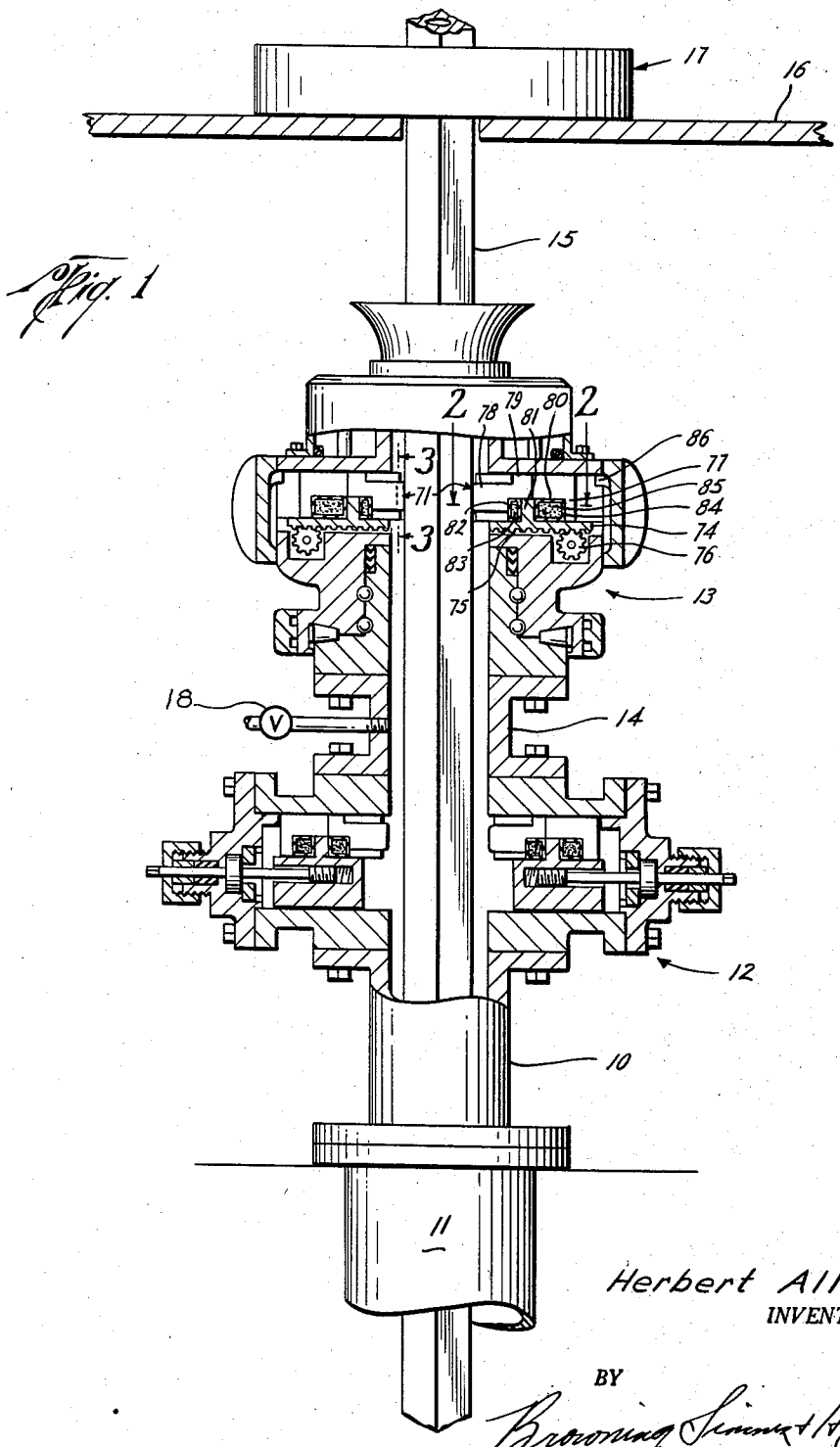


Fig. 1

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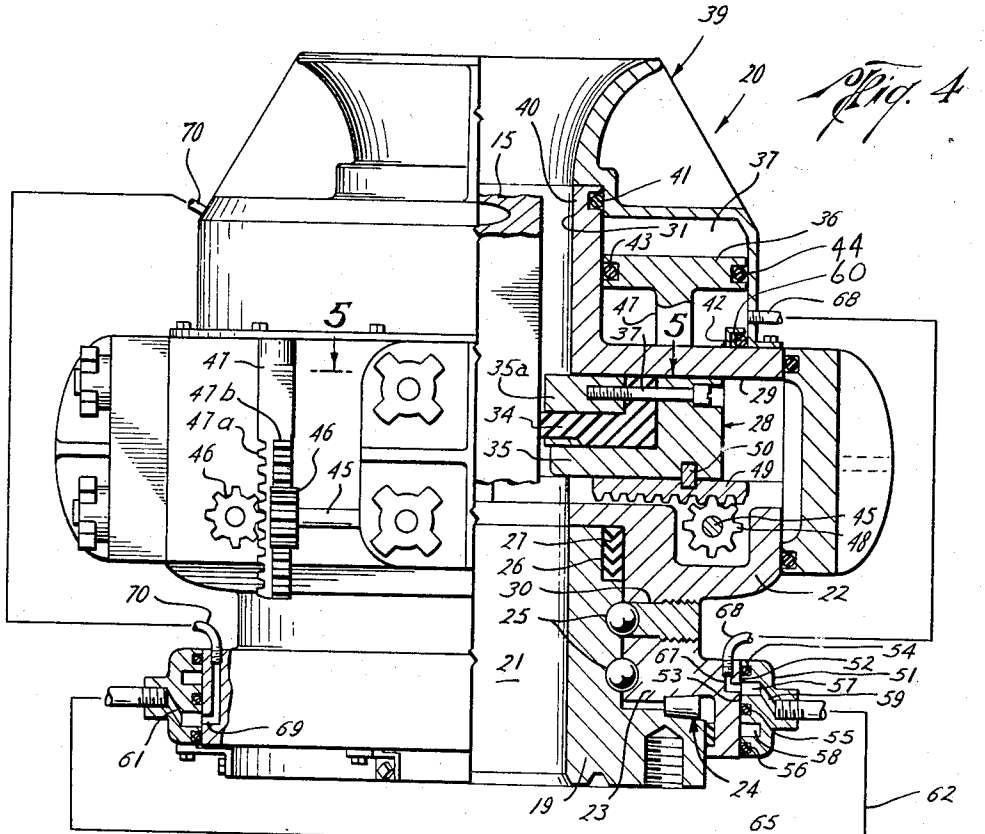


Fig. 4

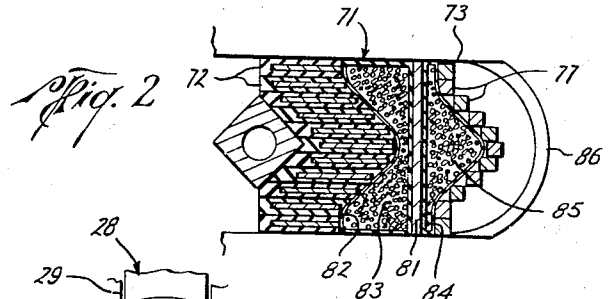


Fig. 2

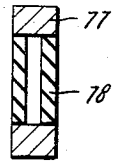


Fig. 3

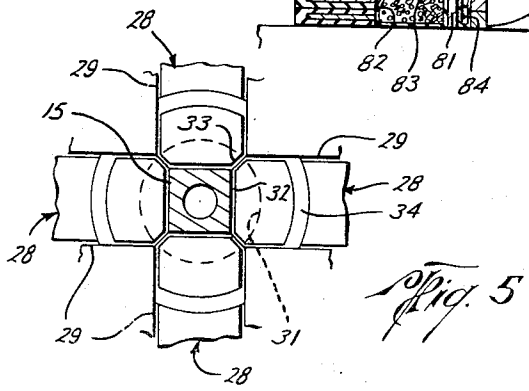


Fig. 5

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Fig. 6

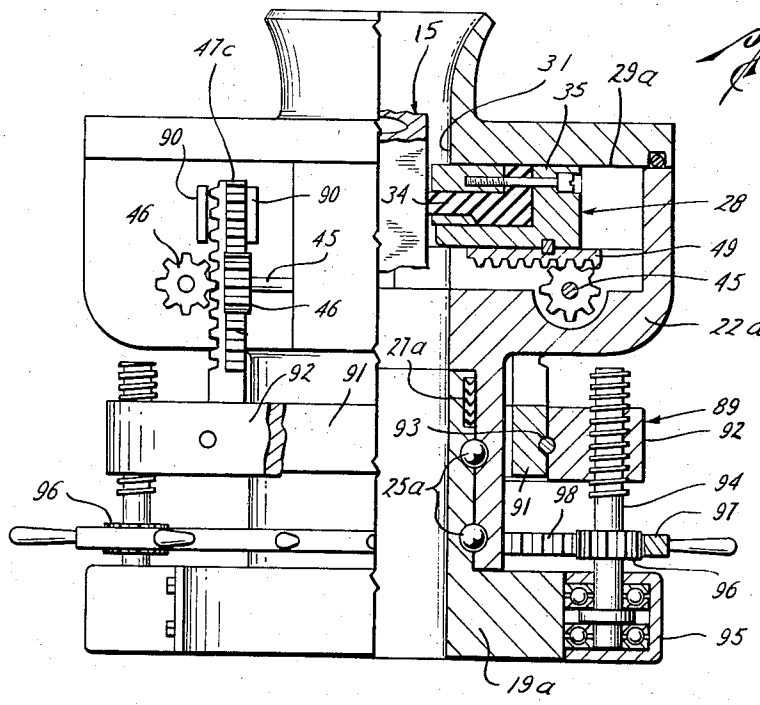
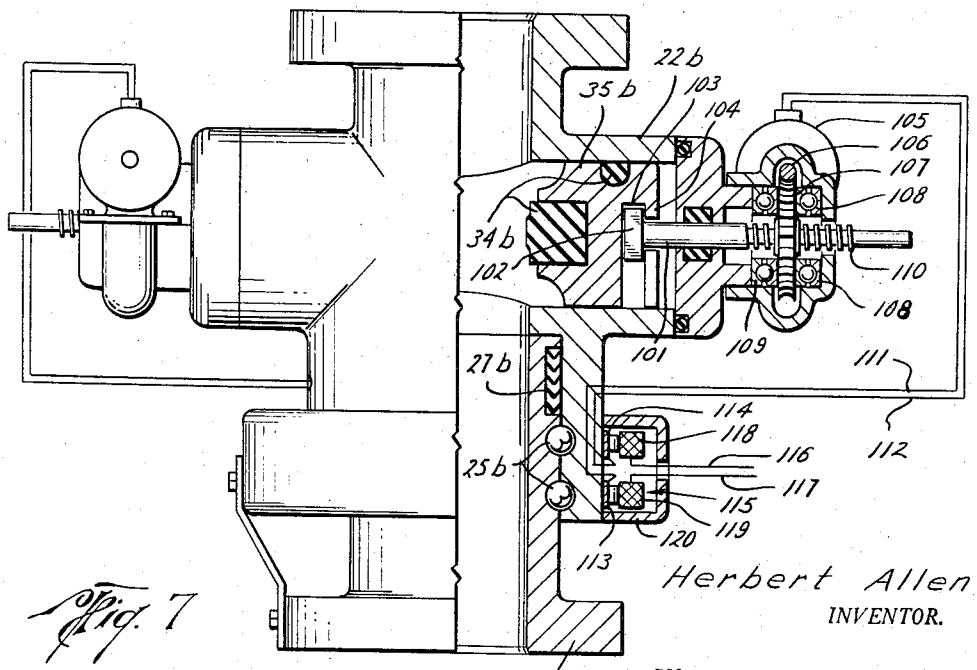


Fig. 7



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WELL CONTROL EQUIPMENT

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Application April 6, 1956, Serial No. 576,629

3 Claims. (Cl. 251—1)

This invention relates to control equipment adapted to be made up as a part of a wellhead to provide positive control of the well, and more particularly to control equipment which will not interefere with normal drilling operations, but may be instantly activated when dangerous well conditions occur and which will permit continued drilling with the well bore closed at the surface.

It is considered to be good drilling practice, especially where high well pressures are expected to be encountered, to employ a bank of three blowout preventers to control the well. The blowout preventers are arranged in tandem with the intermediate preventor employing blanking rams which will seal the blowout preventer bore when empty. The function of the intermediate preventer may be accomplished by a master valve. The upper and lower blowout preventers employ drill pipe rams which will seal about the cylindrical drill pipe portion of a drill string. The two drill pipe rams provide, in effect, a pressure compartment which may function in the manner of a pressure lock to insert or withdraw the drill string from the well while maintaining complete pressure control.

The above arrangement will not in itself permit drilling under pressure and where it is desired to be able to drill under pressure, a fourth pressure seal must be provided which will provide a seal with the non-circular kelly. Several Kelly seals are available. One form is a device which is permanently secured to the wellhead and provided with a stripper seal through which the kelly and drill pipe may be run and withdrawn. The stripper seal rotates with the kelly. A rotating seal is provided between relatively rotatable parts of the device. This form of device is constantly subject to wear when it is in position, whether being used or not. Another form of such equipment employs a stripper seal which may be landed in an uppermost blowout preventer of a particular design, and provide with the uppermost blowout preventer the rotating seal desired. This form of Kelly seal may be left in position continuously, and when so used, is subject to the objection of constant wear. When it is desired to use this type of Kelly seal, it is necessary to pull the drill string and remove the rotary master bushing before the Kelly seal can be landed in the blowout preventer.

In each of the forms of Kelly seal referred to above, the height of the wellhead equipment, and hence, the necessary height of the derrick floor is substantially increased. To be immediately available, each form of presently available Kelly packer must be installed so as to be subject to continuous wear even though not being used to contain the well. It is difficult and inconvenient to strip drill pipe through the stripper seal. As the stripper seals are continuously distorted in normal drilling operations an operator can never be quite sure that the packers have not been torn or damaged so that they will not hold pressure when they are suddenly needed.

It is an object of this invention to provide wellhead equipment for drilling with the well bore closed at the surface which is made up as a part of the wellhead and is always ready for immediate use, but which is not subject to wear except while being used to drill with the well bore closed.

Another object is to provide a rotatable means for sealing about a kelly which is always in position and ready for immediate use and which does not interfere with normal drilling operations.

Another object is to provide a means for sealing about a kelly which does not substantially increase the overall height of the wellhead.

Another object is to provide a power-operated blowout preventer for sealing about a kelly which rotates with the kelly when being used.

Another object is to provide a rotatable blowout preventer in which the lateral or horizontal dimensions of the apparatus are held to a minimum to minimize inertia problems.

Another object is to provide with a single blowout preventer means for sealing an open hole, for sealing about a section of tubing of a drill string or the kelly of a drill string, and for drilling with the well under positive and complete control.

Another object is to provide for complete control of a well with a battery of two blowout preventers which will form a seal with a kelly for drilling under pressure, which will close off the open hole when the drill string is entirely removed, and which will strip the drill string into and out of the well under pressure.

Another object is to provide a rotating blowout preventer with a single hand or power operator for four rams.

Other objects, features and advantages of this invention will be apparent from a consideration of the specification, the drawings and the appended claims.

In the drawings wherein there is shown by way of illustration several forms of the invention and wherein like reference numerals indicate like parts:

Fig. 1 is a view in elevation of a wellhead including the control means of this invention with portions of the wellhead shown in section for purposes of illustration;

Fig. 2 is a fragmentary view on an enlarged scale taken along the line 2—2 of Fig. 1 illustrating a universal type of blowout preventer preferably used with this invention;

Fig. 3 is a fragmentary view on an enlarged scale taken along the lines 3—3 of Fig. 1 further illustrating the preferred blowout preventer rams;

Fig. 4 is a view partly in elevation and partly in cross-section illustrating a fluid operated form of this invention;

Fig. 5 is a fragmentary view in horizontal cross-section illustrating the manner in which the several rams seal about the kelly and to the transverse bores of the blowout preventer of Fig. 4;

Fig. 6 is a view partly in elevation and partly in cross-section illustrating a manually operated form of this invention; and

Fig. 7 is a view partly in elevation and partly in section illustrating and electrically operated form of this invention.

Referring to Fig. 1, there is shown a typical application of this invention to a wellhead. A casing head **10** is secured to surface casing **11**. It will be understood that as the well deepens, the casing head **10** may have additional sections added thereto from which several strings of casing may be suspended in the well. A blowout preventer indicated generally at **12** is rigidly secured to the casing head **10** and is of conventional construction except that it preferably employs a novel type of ram which will seal about either a kelly, a length of tubing, or will seal the blowout preventer bore. A second blowout preventer indicated generally at **13** is spaced above and secured to the lowermost blowout pre-

venter by a spool 14. The blowout preventer 13 is so constructed that it will rotate with the drill string when its rams are in engagement with the drill string and permit drilling while the well is held under pressure by the rams of this blowout preventer. These rams are again preferably of the universal type. The kelly 15 which forms the upper end of the drill string and extends through both blowout preventers is driven from the derrick platform 16 by a conventional rotary table indicated generally at 17.

The above pressure control system gives complete control of the well at all times as well as permitting drilling under pressure while utilizing only two blowout preventers. The universal type of rams permit the drill string to be stripped out of the hole while pressure control is maintained. By way of example the kelly 15 can be raised until the first joint of the drill string is above the lower blowout preventer 12. The rams of the lower blowout preventer 12 may then be closed and pressure within the chambers between the two blowout preventers bled off through fitting 18. The rams of the upper blowout preventer can then be opened and the string raised. The first section of tubing may be supported in the turntable and the kelly removed. This operation may be repeated and the several sections of the string of tubing broken out. After the bit has been stripped through the lower blowout preventer, the lowermost blowout preventer is closed and the universal type rams seal the bore in the blowout preventer to act as a master valve and close in the well.

If while drilling the density of the returns begin to decrease and the mud weight reduces to a value which the operator fears is not sufficient to contain the well, the rotary table may be stopped and the rams of the upper rotatable preventer advanced to engage and seal with the kelly. Rotation may then be resumed and the mud return line choked so that the mud pumps will build up a pressure within the well to compensate for the reduced weight of the drilling fluid. This condition may be maintained and additional sections of tubing added through the two blowout preventers in the customary manner to permit continued drilling under pressure. Meanwhile steps can be taken to add weight to the mud or correct the formation condition which is causing loss of mud weight. Drilling under pressure with the top blowout preventer containing the well may continue for hours or days as is necessary to correct the condition which is causing loss of mud weight.

There are certain conditions under which it is desirable to drill with the well under pressure and this system may also be utilized for such service as the two blowout preventers permit the stripping in and out of the drill string and continued making of hole while the well is under pressure.

It will be appreciated that the uppermost rotatable blowout preventer 13 may be added to a conventional bank of blowout preventers and will serve as a Kelly packer to permit drilling under pressure. When this sort of system is used, the conventional bank of blowout preventers is used for stripping the drill string into and out of the well and the rotatable blowout preventer utilized for drilling under pressure.

Referring now to Fig. 4, the rotatable blowout preventer 20 employs four rams which are contoured to fit a square kelly. The unit includes a base 19 which may be rigidly secured to the spool 14. The base 19 has a central bore 21 which forms a continuation of the well bore and is adapted to pass the drill string and other tools into the well.

Rotation of the body 22 of the blowout preventer about the axis of bore 21 is provided by a tubular extension 23 depending from body 22 and telescoped over the upper portion of base 19. The body is supported on the base for rotation relative to the base by suitable ball and roller bearing assemblies indicated generally at 24 and 25. The anti-friction rollers and balls may be provided in any desired manner which will hold the body 22 and base 19 in the desired telescoped relationship and permit relative rotation between the body and base. For instance, the ball bearing assembly may be provided by confronting races in the body and base and the balls fed into the races through radial holes, plugged as at 30.

A rotating seal between the base 19 and body 22 is provided to seal between these two parts while the body of the blowout preventer is rotating. This seal may be conveniently provided by forming an annular recess 26 in the upper outer periphery of base 19 and packing the annular groove so provided with V packing 27.

To seal about a square kelly, the body 22 is provided with four rams indicated generally at 28 which reciprocate in lateral or horizontally extending bores 29. The bores 29 are spaced equally about and extend radially from the bore 31.

The several rams when extended into engagement with kelly 15 form a seal with the kelly, with each other and with the body of the blowout preventer to seal in the well. The coaction of these several elements can best be seen in Fig. 5. Each of the rams 28 has a square or blunt nose 32 having a horizontal dimension substantially equal to a side of the square kelly. The ram tapers from this point to the full width of the ram at approximately the intersection of the ram bores 29 with the rams extended. This tapered wall or side 33 is formed on approximately a 45° angle. The seal element 34 of each ram extends back from the ram front to the mid section of the ram and upwardly into engagement with the roof of ram bore 29. As is customary, the seal elements 34 also extend to the sides of the ram about its upper half and engage the side walls of the ram. The seal material is also exposed in the face of tapered walls 33 of the rams so that the seal material of adjacent rams will be in abutment and seal between adjacent rams. As best shown in Fig. 4, this ram construction is provided by a base 35 to which the flexible portion 34 of the ram is secured and held by a floating retainer 35*a*. Retainer 35*a* is secured to ram base 35 by a bolt 37 which will permit relative movement between the retainer 35*a* and ram base 35 along the axis of the lateral bore 29. This construction will permit the retainer 35*a* to abut or be in close proximity with the kelly to provide a dam for the sealing material without limiting movement of the ram.

This preventer has four rams. It is desirable to operate the several rams from a single motor to simplify the structure and reduce inertia problems. This may be accomplished by providing a single large fluid motor operably connected to each of the rams. Such a fluid motor is provided by the annular pressure responsive member or piston 36 mounted for vertical reciprocation within pressure chamber 37. Pressure chamber 37 surrounds the bore through the blowout preventer and is provided by a bell housing indicated generally at 39 which fits over a reduced diameter tubular extension 40 on the top of the blowout preventer. The bell housing is sealed to the body of the blowout preventer by an O-ring 41 carried in a groove in the upper extremity of the reduced diameter section 40 and by an O-ring 60 at the outer lip of the bell. A groove for the O-ring 60 is provided by the body 22 and a retainer 42 which is welded to the body. The O-ring retainer 42 is generally angular in cross-section having one leg extending horizontally and one vertically. The vertical leg is welded to the body 22 and the free end of the horizontal leg has a sliding fit with the lip of the bell housing 39.

This piston 36 is annular in configuration and has a central bore dimensioned to receive the upstanding tubular member 40. An O-ring 43 is carried by the piston and forms a seal with the tubular member 40. A second O-ring 44 carried at the outer periphery of the piston forms a seal with the bell housing 39.

A suitable force transmitting means is provided between the pressure responsive member **36** and each of rams **28**. Preferably, the force transmitting means is provided by double racks and pinions for each ram to translate the vertical movement of the piston into horizontal movement of the rams. For this purpose, pinion shafts **45** are journaled for rotation in housing **22** and carry an exterior pinion **46** engageable with a rack **47** carried by piston **36** and an interior pinion **48** engageable with a rack **49** which drives a ram. The drive between rack **49** and the ram is provided by a key **50** which locks the rack **49** and the ram body **35** so that they will reciprocate with each other. To simplify the structure it is preferred that a single rack **47** drive the pinions of two rams and for this purpose the pinion shafts **45** of two adjacent rams are so disposed as to engage their exterior pinions **46** with toothed sections **47***a* and **47***b* of rack **47** as shown on the left hand side of Fig. 4.

In addition to the advantage of simplifying the structure and simplifying inertia problems, this form of force transmitting means does not employ a shaft which must be forced into the blowout preventer under pressure. The transmission of force between the exterior and interior of body **22** is through a rotating shaft **45** instead of a reciprocating shaft as is commonly employed. Thus, the motor does not have to overcome the pressure of the well acting over the area of the several shafts.

Power may be applied to the motor **36** through a swivel ring indicated generally at **51**. This ring is carried by base **19** and has an inner annular surface **52** which fits closely about a complementary surface **53** on the depending portion **23** of body **22** and rotates relative thereto. Surface **52** has three spaced annular grooves therein and O-rings **54**, **55** and **56** are positioned in these grooves to form a sliding seal between surfaces **52** and **53**. The ring **51** has an annular groove **57** opening into surface **52** between O-rings **54** and **55**. Likewise, a groove **58** is provided which opens into surface **52** between O-rings **55** and **56**. The O-rings **54**, **55** and **56** and the surface **53** of body **22** cooperate to confine fluid within the grooves **57** and **58**. A fluid inlet **59** is provided into groove **57** and similar inlet **61** provides entrance into groove **58**. Suitable piping indicated diagrammatically at **62** and **63** interconnect the inlets **59** and **61** to a four-way valve **64** which is in turn connected to a pump **65**. Preferably pump **65** delivers air to piston **36**, but if desired, the operating fluid may be a liquid. If a liquid is used, a reservoir may be provided to collect liquid from chamber **37** and supply it to pump **65** in the usual manner. This system will alternately pressurize one of grooves **57** and **58** and relieve the pressure from the other groove by the expedient of reversing the four-way valve **64**.

Fluid from the grooves **57** and **58** is supplied to the two sides of the pressure responsive member **36** to reciprocate the rams **28**. A passageway **67** communicates with surface **53** between O-rings **54** and **55** and a conduit **68** connects passageway **67** to the chamber **37** below the piston **36**. A like passageway **69** connects surface **53** between O-rings **55** and **56** to the top side of piston **36** through a conduit **70**.

The operation of the Fig. 4 form of blowout preventer will now be explained. It will be assumed that it is secured to the top of a bank of blowout preventers of conventional form and the rams **28** are retracted. Now let it be supposed that a condition suddenly arises which renders it improvident to continue drilling in an open hole and it is desired to maintain a pressure on the hole. The rotary table will be stopped and four-way valve **64** turned to provide pressure to the top of piston **36** and to remove pressure from the bottom of piston **36**, this being the position shown in Fig. 4. The pressure supplied by pump **65** will begin moving piston **36** downwardly which will cause rams **28** to begin moving inwardly toward kelly **15**. If the flats of the kelly are not parallel with the blunt noses of the rams, the engagement between the kelly and rams will act as a couple to rotate the blowout preventer to position the Kelly flats parallel to the blunt faces of the rams—the position shown in Fig. 5. At this time the well will be under complete control and the operator may resume drilling while holding the rams under pressure with pump **65**. The body **22** which carries the rams **28** will rotate about base **19** and the V packing **27** will provide a rotating seal between the body and base to contain well pressure. Drilling may be continued in this manner until the condition which made it deisrable to drill under pressure has been corrected.

Referring again to Fig. 1 and Fig. 2, it will be noted that the principal difference between blowout preventer **13** of Fig. 1 and blowout preventer **20** of Fig. 4 lies in the type of ram utilized. In Fig. 1 only two rams are utilized. The rams of Figs. 1 and 2 are designed to seal an open hole or to seal about a kelly or a tubing. Any rams which will seal an open hole, seal about a kelly or about a tubing, as will ram **71**, will be referred to in this application as a universal type of ram. Rams **71** are made up of a plurality of thin ram segments **72** arranged side-by-side in ram bore **73** and mounted on a carrier **74**. The under surface of carrier **74** is provided with a rack **75** which meshes with pinion **76**. Pinion **76** is driven in the same manner as corresponding pinion **48** of the Fig. 4 form of blowout preventer. Each ram segment **72** includes a metal base **77** and carries on its forward section packing **78**. The body **77** at its front end is formed in the general configuration of an I-beam with the web terminating short of the flanges as best seen in Fig. 3. Packing **78** is carried between the upper and lower cross-heads at the I-beam. The body **77** is notched at its top at a point spaced from the forward edge of the ram segment and the packing material **78** fills this notch as at **79**. The width dimension of the ram segments is such that the ram segments slide relative to each other within bore **73**. When the packing **78** is stressed by being forced into engagement with an opposite ram, a kelly or tubing, the packing of each ram segment will engage the packing of an adjacent ram segment and the roof of ram bore **73**. The end ram segments will engage the side wall of ram bore **73**. In this manner, the several ram segments will cooperate to seal the blowout preventer bore.

The ram segments are moved into and out of the blowout preventer bore by a unique compensator arrangement which permits them to assume the desired contour to seal the open blowout preventer bore or about different shaped objects in the blowout preventer bore. Referring to Fig. 1, it will be noted that the body **77** of each ram segment is notched as at **80**. A pusher **81** on carrier **74** extends the width of the carrier and is received in notches **80** to cause reciprocation of the ram segments upon movement of carrier **74**. A flexible bag **82** of smooth wall granular elements **83**, preferably cylindrical balls, extends through notch **80** in front of pusher **81** and from side wall to side wall of ram bore **73**. A similar bag **84** of granular elements **85** is positioned to the rear of pusher **81**. As pusher **81** exerts force on the ram segments to move them toward the center of the blowout preventer bore, balls **83** and **85** will flow in hydraulic manner to equalize the force on the several ram segments **72**. Thus, as a resistance to movement is encountered in the blowout preventer bore, the front of the ram segments will assume the contour of the portion of the drill string within the bore of the blowout preventer.

It is desirable to design the throw of each ram for minimum possible movement and for this purpose, the front of each ram **71** should assume the general contour of the blowout preventer bore when the ram is retracted. For this purpose, a backstop **86** having the general contour of the blowout preventer bore may be provided to contact the rear of each ram segment as the ram is retracted to cause the ram front to assume the general

contour of the blowout preventer bore. For further illustration and description of the rams shown in Figs. 1 and 2, see my co-pending application filed on even date herewith, Serial No. 576,696, filed April 6, 1956, and entitled, "Blowout Preventer and Ram Therefor."

It will be noted that the lower blowout preventer of Fig. 1 is also equipped with universal type rams and when both blowout preventers **12** and **13** are so equipped, only two blowout preventers are required to provide absolute control of well pressure at all times and to permit drilling under pressure as heretofore explained.

Referring now to Fig. 6, there is illustrated a rotatable blowout preventer constructed in accordance with this invention which is manually operable. The blowout preventer body **22***a* is mounted for rotation about a central bore through base **19***a* with anti-friction bearings **25***a* between the body and base. The rotating seal between the body and the base is provided by V packing **27***a*. Four rams **28** are reciprocal in ram bores **29***a* in the manner of the Fig. 4 form of blowout preventer with the ram driven by pinion **48** and rack **49**. The drive pinions **48** are rotated by an exterior rack and pinion **47***c* and **46** respectively. The racks **47***c* are mounted for vertical reciprocation in guides **90** and carried by a crosshead indicated generally at **89**. The crosshead **89** includes an inner ring **91** and an outer ring **92** which rotate relative to each other. A ball race **93** is disposed between the two rings **91** and **92** and forces the inner ring to reciprocate vertically with the outer ring.

The crosshead **89** is reciprocated by a simple hand-operated device which is carried by base **19***a*. This hand operator includes a plurality of vertical screws **94** which are threadedly received in outer ring **92** and which are journaled for rotation in journal boxes **95**. The journal boxes **95** are secured to base **19***a* to hold the screws **94** against reciprocation. Each screw **94** carries a pinion **96** and a ring wheel **97** extends circumferentially about all of the screws **94**. Wheel **97** has a spur gear **98** on its inner periphery which meshes with pinions **96**. Rotation of the ring wheel **97** will rotate screws **94** and reciprocate crosshead **89** which will in turn drive the rams in or out depending upon the direction of rotation. The threaded connection between crosshead **89** and screws **94** is self locking and holds the rams in position until wheel **97** is rotated.

Referring now to Fig. 7, there is shown a rotatable blowout preventer in which the rams are reciprocated by electric motors. The blowout preventer body **22***b* is mounted for rotation about a base **19***b* with bearings **25***b* providing for relative rotation between the body and base while preventing relative longitudinal movement of these elements. A rotating seal **27***b* confines fluid to the interior of the blowout preventer while permitting rotation of the body. A pair of rams **35***b* employing ram packing **34***b* with a V-shaped notch in the ram front may be employed or the universal type of ram may be employed.

Reciprocation of the rams may be provided by a rod **101** which has a square head **102** received within a square slot **103** in the rear of the ram. Slot **103** extends to the bottom of the ram to permit the ram to be moved downwardly over the head **102** of the rod and overhanging flange members **104** prevent withdrawal of the head **102** from the ram during reciprocation of the rod by electric motor **105**. The arbor **106** of the electric motor drives a worm wheel **107** which is mounted for rotation in ball races **108** and **109**. Wheel **107** is provided with a threaded bore which engages threads **110** of rod **101** and upon rotation of wheel **107** cause reciprocation of rod **101**. The motor **105** may be provided with suitable limit stops as by overload switches to protect the motor. The gear train between the ram and motor is of the self-locking type and ram **35***b* is movable only by rotation of arbor **106**.

Electric current is fed to motor **105** through leads **111** and **112** connected to contact rings **113** and **114** respectively of a slip ring indicated generally at **115**. Current is fed to the slip ring through lines **116** and **117** which are connected to contact rings **118** and **119** respectively of the slip ring. These contact rings **118** and **119** are carried in a suitable housing **120**, preferably explosion proof, which is mounted for rotation about body **22***b*.

Suitable reversing switch means, now shown, is utilized to reverse flow of a D. C. current through wires **116** and **117** to operate motor **105**. By employing a D. C. motor the direction of rotation of arbor **106** may be easily controlled by controlling the incoming signal.

From the above, it will be seen that all of the objects of this invention have been attained. There has been provided a rotatable blowout preventer which is always in position for immediate use and yet does not interfere with normal drilling operations. The preventer permits drilling under pressure. This blowout preventer has been combined with a universal type of ram so that only two blowout preventers need be used to give full control of a well and to permit drilling under pressure. The rotatable blowout preventer may be operated manually or by a fluid or electric motor as desired. The rotating seal is long lasting because it is not subject to wear except when the blowout preventer is actually being used to drill under pressure.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the apparatus.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

The invention having been described, what is claimed is:

1. Well control equipment comprising, a base adapted to be secured to a casing head, a central bore through the base for passing a drill string, a blowout preventer having a plurality of circumferentially arranged sealing rams movable toward and away from the central axis of said bore, means mounted for reciprocating in a direction parallel to the axis of the bore through the base and connected to the rams to move them toward and away from the central axis of said bore, means for reciprocating said first named means, means mounting the blowout preventer on the base for relative rotation therewith about the axis of the bore through the base, and means providing a rotating seal between the base and blowout preventer.

2. Well control equipment comprising, a base adapted to be secured to a casing head, a central bore through the base for passing a drill string, a blowout preventer having a plurality of circumferentially arranged sealing rams movable toward and away from the central axis of said bore, means mounted for reciprocating in a direction parallel to the axis of the bore through the base and connected to the rams to move them toward and away from the central axis of said bore, a single wheel for operating the reciprocating means and simultaneously moving the rams toward and away from the central axis of said bore, means mounting the blowout preventer on the base for relative rotation therewith about the axis of the bore through the base, and means providing a rotating seal between the base and blowout preventer.

3. Well control equipment comprising, a base adapted to be secured to a casing head, a central bore through the base for passing a drill string, a blowout preventer

having a plurality of circumferentially arranged sealing rams movable toward and away from the central axis of said bore, a single pressure responsive means mounted for movement in a direction parallel to the axis of the bore through the base, force transmitting means between the pressure responsive means and the rams for reciprocating the rams, means mounting the blowout preventer on the base for relative rotation therewith about the axis of the bore through the base, and means providing a rotating seal between the base and blowout preventer.

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