BLOWOUT PREVENTER

Filed April 13, 1970 3 Sheets-Sheet 1

Fig. 1

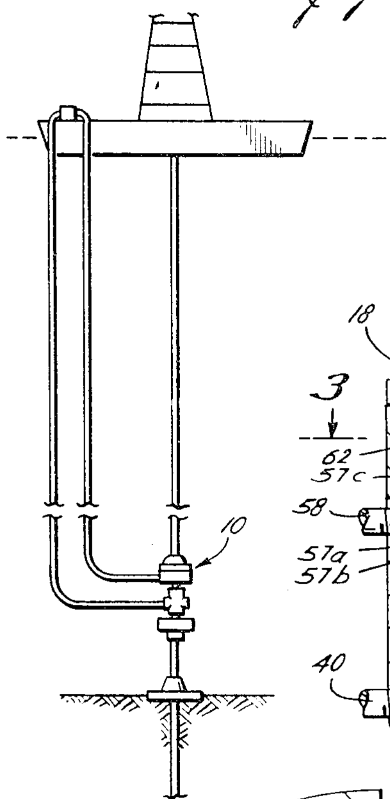


Fig. 2

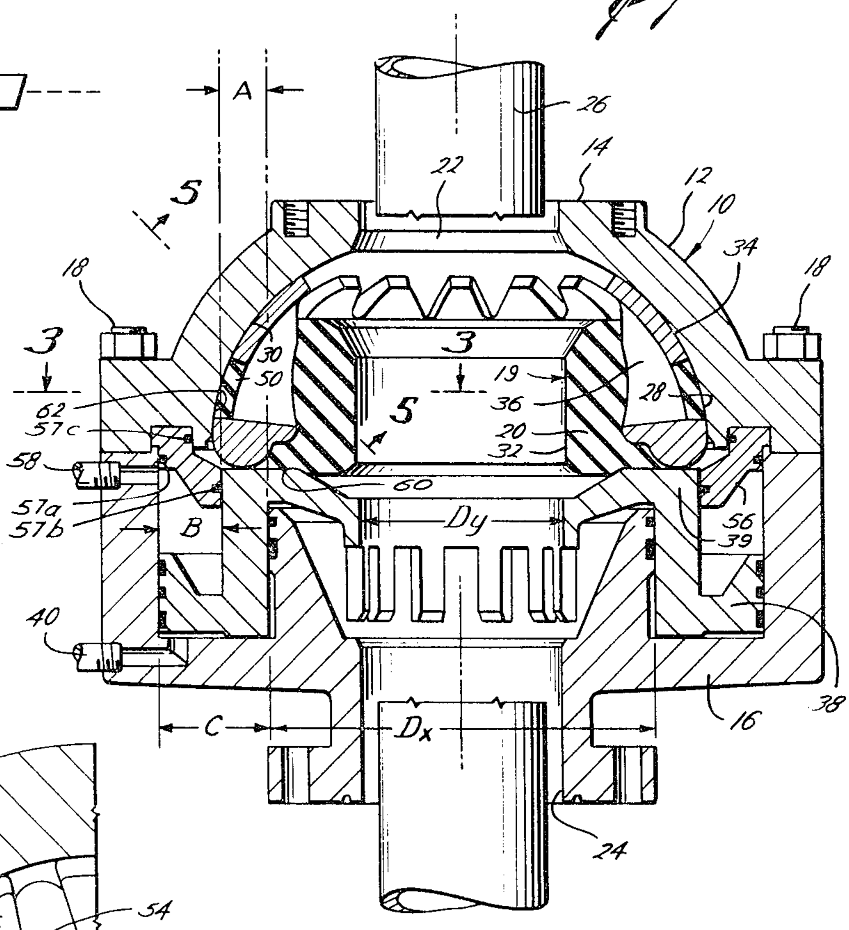
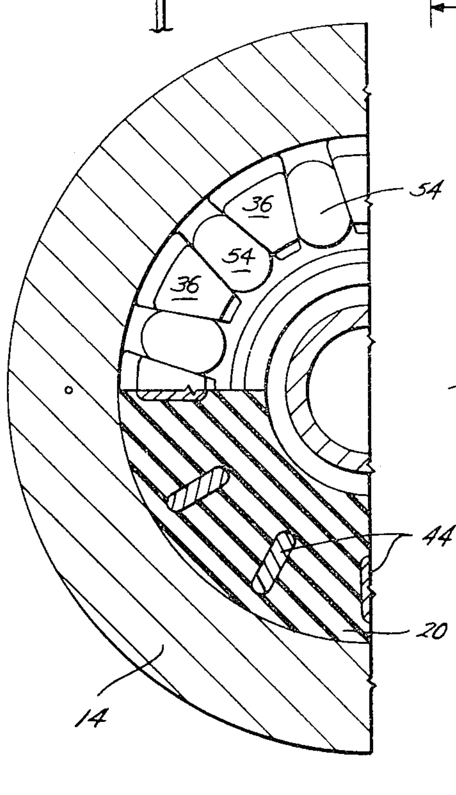


Fig. 3



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BLOWOUT PREVENTER

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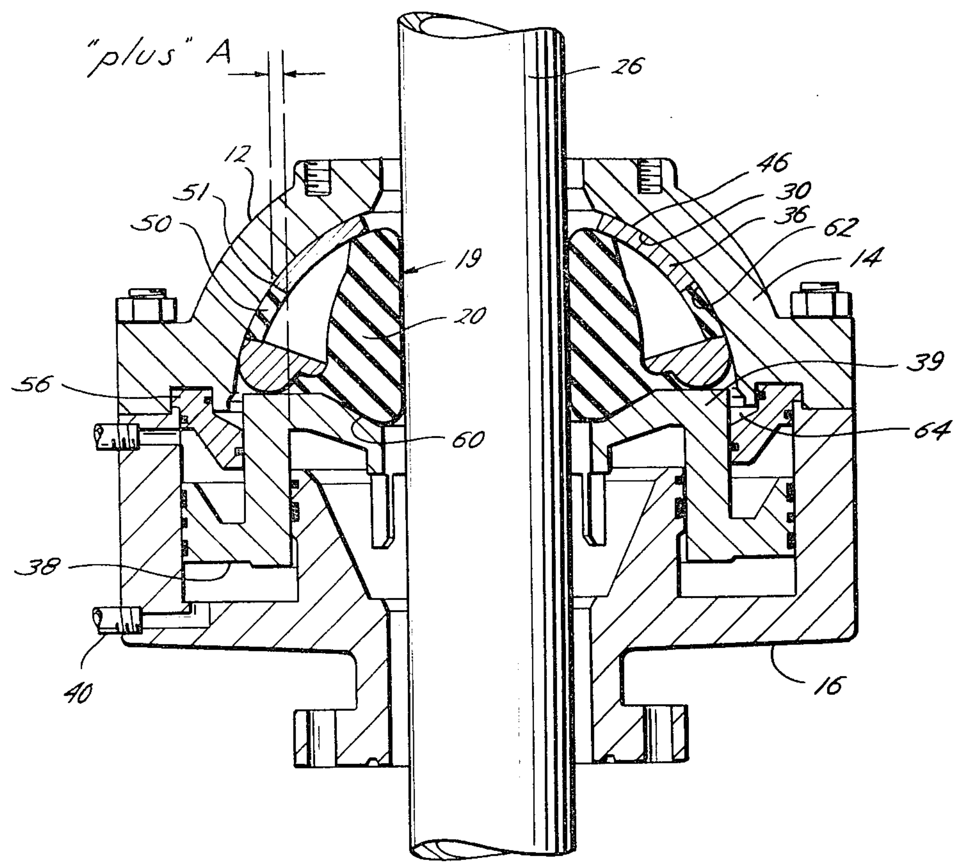

Fig. 4

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Fig. 4A

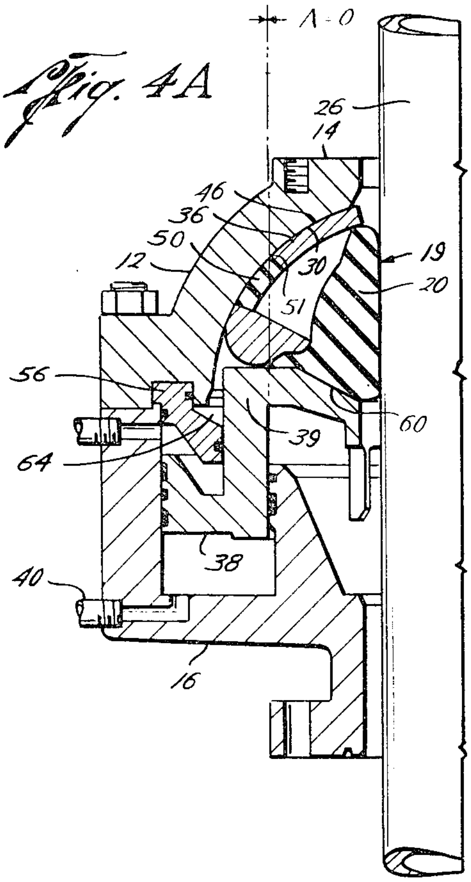


Fig. 4B

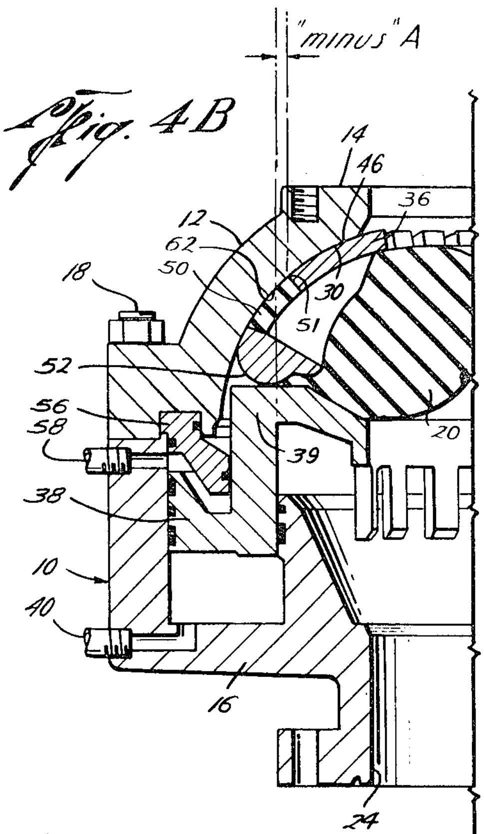


Fig. 5

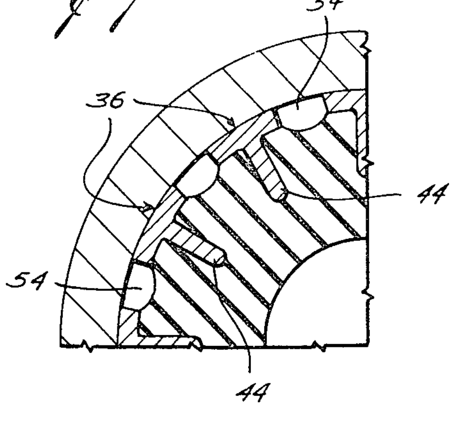
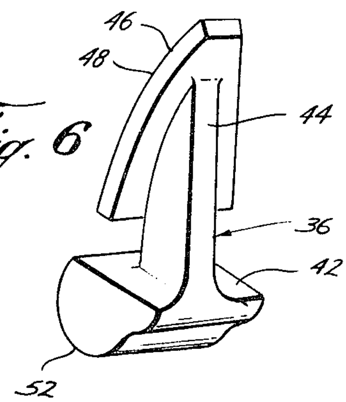


Fig. 6



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BLOWOUT PREVENTER

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Int. Cl. E21b 33/06
U.S. Cl. 251—1 8 Claims

ABSTRACT OF THE DISCLOSURE

An improved blowout preventer in which a packing element having a resilient sealing means and a plurality of metallic translating means slidably moves against a curved inner surface of a housing for moving into a sealed position in which the packing element is positioned against but not connected to an actuating piston for increased sealing performance, freedom of movement, and for ease of replacement and in which the axial extent of the curved portion of the translating means is less than the curved outer surface of the packing element whereby the sealing means may circumferentially contact the curved inner surface of the housing to form a seal to provide an improved closing characteristic, and the bases of the translating means are further away from the bore whereby the sealing means on the bottom of the packing element is only slightly compressed allowing a fast response and quick adjustment of the packing element to changes in diameter and configuration of moved-through components of the drilling string.

BACKGROUND OF THE INVENTION

Pat. No. 3,323,773 generally describes a spherical blowout preventer having a resilient sealing means and metallic translating means for converting the axial movement of the actuating means into a rolling inward motion of the sealing means to completely seal the well hole with or without a drilling string therein. The present invention is directed to various improvements to a blowout preventer such as providing a packing element which has no connection with the actuating piston thereby providing an easy replacement of a worn packing element, providing a blowout preventer with an improved closing characteristic, one which is self-opening, and an improved packing element which provides an improved sealing action and stripping performance and in which the translating means does not interfere with the sealed-off objects when these are vertically moved through the closed packing element.

SUMMARY

The present invention is directed to an improved blowout preventer one feature of which is providing a housing with a curved inner surface, preferably spherical, extending to a receiving port in which the resilient sealing means and metallic translating means slidably cooperate with the curved inner surface of the housing to move into a sealing position in which the translating means has an outer curved surface mating with the curved inner surface of the housing but of an axial extent less than the curved outer surface of the packing element and the resilient sealing means circumferentially extends below said outer curved surface of the translating means and contacts the curved inner surface of the housing to form a circumferential seal to provide an improved sealing action and to provide an improved closing characteristic especially on subsea applications.

In connection with the improved closing characteristic, a further object of the present invention is the provision of an annular space between the outer circumference of the lower portion of the sealing means and the housing

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in a spherical blowout preventer and outside of the actuating piston whereby the annular space increases in size as the seal is moved to a closing position thereby avoiding a fluid trap.

A further object of the present invention is the provision of a resilient sealing means bonded to a plurality of radially spaced metallic translating segments to form a packing element in a spherical blowout preventer wherein the resilient sealing means includes on its exterior a recess between adjacent segments thereby preventing interference with the metal-to-metal action of the segments on the housing as the blowout preventer closes.

A further object of the present invention is the provision of a resilient sealing means bonded to a plurality of metallic translating means having a curved portion slidably cooperating with a curved inner surface of the housing of the blowout preventer in which the translating means and resilient sealing means of the packing element are positioned against but free of a connection to an actuating piston thereby providing a structure in which the packing element may be easily replaced and the piston does not restrict the movement of the seal and in which the lower end of the translating means are arcuate thereby providing a free rocking movement of the translating means on the piston during opening and closing of the blowout preventer.

The present invention is also directed to provide a blowout preventer with an improved stripping characteristic of the packing element by allowing the resilient seal to easily and flexibly adjust to changes in the configuration of the drilling string during stripping operations while still maintaining the desired seal, all with least possible damage to the packing element.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatical view of a subsea drilling rig in which the blowout preventer of the present invention may be used,

FIG. 2 is an elevational view in cross section of the preferred embodiment of the present invention in the open and nonsealing position with a drilling string within the apparatus,

FIG. 3 is a fragmentary elevational view, partly taken in cross section along the line 3—3 of FIG. 2,

FIG. 4 is an elevational view, in cross section, illustrating the blowout preventer of the present invention in an intermediate position closing around the drilling string,

FIG. 4A is a fragmentary elevational view in cross section, illustrating the blowout preventer of the present invention in a closed position around the drilling string,

FIG. 4B is a fragmentary elevational view, in cross section, illustrating the blowout preventer of the present invention in a closed position with no drilling string therein,

FIG. 5 is a fragmentary cross-sectional view taken along the line 5—5 of FIG. 2, and

FIG. 6 is an enlarged perspective view of the metallic translating segments of the packing element.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The blowout preventer apparatus of the present invention is generally indicated by the reference numeral **10** and is shown in FIG. 1, for example only, as used in an offshore subsea drilling operation, although of course the present apparatus **10** may be used in all types of drilling rigs whether they are underwater or not.

The blowout preventer **10**, as best seen in FIG. 2, may include a housing **12** including an upper portion **14** and a lower portion **16** which are releasably fastened together by a plurality of bolts **18**. The bolts **18** may be easily disassembled to remove the upper housing **14** for easily replacing the packing element which is generally indicated by the reference numeral **19**.

Axially aligned well tool receiving ports **22** and **24** are provided in the upper housing **14** and the lower housing **16**, respectively, for receiving a well tool or drilling string **16** adapted to be axially moved within the apparatus **10**. The housing **12** and preferably the upper housing **14** includes an enlarged cylindrical bore **28** which includes a curved inner surface **30**, preferably spherical, extending from the port **22**.

The packing element **19** includes a resilient sealing means **20** positioned within the enlarged cylindrical bore **28** and adapted to be selectively moved between nonsealing position as shown in FIG. 2 to a sealing position as shown in FIGS. 4A and 4B. The sealing means **20** may include a continuous ring of resilient material such as natural or synthetic rubber. The seal **20** includes an inner bore **32** and an outer surface **34** with the diameter of the inner bore **32** being approximately equal to the diameter of the bores **22** and **24** and the outer surface **34** including a curved portion.

The packing element **19** also includes a plurality of radially spaced translating means **36** which are provided for slidably cooperating with the curved inner housing surface **30** for converting axial movement of an actuating means such as piston **38** into a rolling inward motion of the sealing means **20** to provide a seal adjacent the well receiving port **22**. Preferably, the translating means **36** are a plurality of radially spaced steel segments bonded to the resilient sealing ring **20**.

Suitable actuating means are positioned in the bore **28** adjacent the lower end of the packing element **19** for applying an axial movement thereto for moving the sealing means **20** and translating means **36** toward the curved inner housing surface **30** to a closed position, and may include a piston **38**. A fluid actuating line **40** is provided through the lower housing **16** to the underside of the piston **38** having an actuating head **39** and may be connected to remotely controlled fluid sources and controls (not shown) for actuating the piston **38**.

Referring now to FIGS. 2, 3, 4, 4A, 4B, 5 and 6, the metallic translating means **36** generally includes a base **42**, a web **44** and a curved plate **46**. The outer surface **48** of the curved plate **46** is preferably a portion of a sphere and coacts with the curved inner surface **30** of the upper housing **14** to provide a low friction, metal-to-metal sliding surface during the inward closing action of the packing element **19**. It is to be noted from FIGS. 2, 4, 4A and 4B that the curved plate **46** does not extend continuously from top to the base **42** of the translating means **36** but is spaced from the base **42** thereby allowing the provision of a continuous circumferential surface **50** of resilient sealing means between the bottom of the curved plate **46** and the top of the base **42** of the translating means **36**. This continuous strip of resilient material **50** forms a circumferential seal contacting the curved inner surface **30** of the upper housing **14** to form a seal therewith and is of particular importance in providing an improved closing action of the blowout preventer as will be more fully described hereinafter.

The bases **42** of the translating means **36** translate the vertical motion of the piston **38** into the inward rolling motion of the whole packing element **19** by transmitting the piston force through the web **44** and the curved plates **46**. It is to be noted that the translating means **36** and sealing means **20** have no positive connection with the piston **38** but merely rest thereon thereby providing ease of replacement of the packing element **19** merely by removal of the upper housing **14** and replacement therein. It has also to be noted that the bottom **52** of the base **42** of the translating means **36** is arcuately shaped, such as cylindrically, thus allowing for the rocking movement of the translating means **36** on the head **39** of the piston **38** during the closing and opening operation. The improved stripping action of the packing element **19** results

from the inward spherical motion of the translating means **36** and their location with reference to the sealing means **20**. Thus a metal supported sealing is generated on the top side of the packing element **19**. The bottom side of the packing element **19** is free of rigid metal and since the packing element **19** is not connected to the piston **38** the bottom side of the sealing means **20** can seal and easily and flexibly adjust to changes in the configuration of the drilling string during stripping operations.

Referring now to FIGS. 3 and 5, it is noted that a plurality of spaced recesses **54** are positioned around the exterior **34** of the sealing means **20** and positioned above the circumferential seal **50** and between the curved plates **46** of the translating means **36**. Thus, during the closing process, when the translating means **36** move inwardly and the space or recess **54** between the curved plates **46** is diminishing in width. the resilient material does not flow between the plates **46** to become pinched off or interfere with the closing operations, but may flow inwardly between the vertical webs **44**.

The packing element **19** has a self-opening capability. The force resulting from the potential energy stored in the compressed resilient sealing means **20** exerts sufficient downward pressure on the piston **38** to provide a complete return of the packing element **19** into the open relaxed position of FIG. 1 after the control pressure in line **40** has been relieved. Thus, only a single hydraulic line **40** is required to actuate the piston **38** on land based operations. For subsea application two hydraulic lines are required in order to balance the forces which act on the piston **38** and result from the static fluid head in the control lines. For this purpose a sealing insert **56** (FIGS. 2, 4, 4A and 4B) carrying the seals ***57a***, ***57b*** and ***57c*** is provided. Seals ***57a*** and ***57b*** seal-off the space above the piston and allow fluid pressure to be applied on the back side of the piston **38** through a hydraulic line **58**. Seal ***57c*** prevents sea water from entering the housing **12**.

In addition to the main sealing action of the resilient sealing means **20** against the pipe **26**, or open hole, as best seen in FIGS. 4A and 4B, two additional sealing actions are automatically obtained during the closing process as the force of the piston **38** is applied to close the packing element **19**. One additional sealing action takes place between the resilient sealing means **20** and the top of the piston head **39** along the surface **60** and another sealing action occurs between the circumferential seal **50** and the inner curved surface **30** of the upper housing **14** along surface **62**. Thus, the resilient sealing means **20** performs all of the internal sealing functions of the blowout preventer and thus the replacement of a worn-out packing element **19** does not require a disengagement or a replacement of any additional seal.

In subsea applications, the sealing area **62** formed by the upper housing **14** and the circumferential seal **50** of the resilient seal **20** determines the balance of forces which results from the static fluid head of the drilling mud within a riser pipe and the static fluid head in both control lines. The hydraulic balance of the submerged spherical blowout preventor **10** can best be seen from FIG. 2. In the open position of the apparatus **10**, when the packing element **19** is exerting no sealing action the forces acting on the piston **38** in the direction opposing closing are the head of the drilling mud acting on the area A, and the head of the control fluid in the control line **58** acting on the piston area B of the piston **38**. The force acting in the direction of closing the blowout preventer is the head of the control fluid in the control line **40** acting upon the area C of the piston **38**.

When the apparatus head is opened, as shown in FIG. 2, the forces acting upon the piston **38** are unbalanced since the drilling mud acting upon the area A is usually heavier than the control fluid acting on the opposite side C of the piston **38**. Thus in order to start closing the packing element **19**, more control pressure than on a comparable land based operation must be applied through line **40** to the area C of the piston **38** to overcome this unbalance. However, as the piston **38** moves upwardly, the circumferential seal **50** on the sealing element **19** which forms the seal with the inner curve surface **30** along the area **62** also moves upwardly along the curved inner surface **30** and, as best seen in FIG. 4, progressively decreases the area A thus gradually changing the hydraulic balance in favor of the forces which act in the direction of closing the preventer. When, at a certain stroke, the seal **50** moves in the position indicated in FIG. 4A, where the upper outer edge **51** of the circumferential seal **50** coincides axially with the diameter Dx, the area A has entirely disappeared and the forces resulting from the static head of drilling mud do not affect the piston balance any more since they are equally distributed on both sides of the piston head **60**, on an area confined by the inside diameter of the piston Dx and the diameter of the piston bore Dx. At this point, however, the balance has already shifted in favor of the forces acting in the direction of closing the blowout preventer as the area B is smaller than the area C. An additional balance shift in the same direction takes effect if the piston can be further stroked as shown in FIG. 4B, thus further reducing the upper piston head area exposed to the static head of the drilling mud. This effectively allows the hydrostatic pressure of the drilling mud column to support the closing action of the blowout preventer.

The result of this closing feature is that less control pressure has to be applied for closing the blowout preventer in a submerged condition than on a comparable land based operation without fluid heads within the riser and in the control lines. The unbalance condition at initial stroke, which is in favor of the forces acting in the direction opposite to closing, is of little practical importance, since almost all of the sealing action takes place at piston strokes when the area A becomes zero as in FIG. 4A or "negative" as in FIG. 4B.

In connection with the improved closing performance, another important feature of the present invention is the provision of an annular space **64** between the packing element **19**, the sealing insert **56** and the upper housing **14** exteriorly of the actuating head **39** of the piston **38** which increases in volume with progressive stroking of the piston **38** thus avoiding a fluid trap therein which might otherwise break the sealing action along the area **62**.

In operation, hydraulic fluid is introduced in the line **40** and applied against the area C of the piston **38** causing upward movement of the piston **38** against the metallic translating means **36** and the resilient sealing means **20** causing the curved plates **46** of the translating means **36** to slidably engage and move along the inner curved housing surface **30** and inwardly to translate the axial motion of the actuating means **38** into an inward rolling motion of the sealing means forcing the sealing means into a sealing position to completely seal off a well hole with or without a drill string **26**. For opening the apparatus **10** in a land rig, the pressure in the line **40** is relieved and the "spring force" of the compressed resilient sealing element **20** exerts sufficient downward pressure on the piston **38** to provide a complete return of the packing element **19** into its open relaxed position. For subsea applications where two control lines are required to balance the forces resulting from the fluid heads, the piston **38** may be retracted by application of fluid pressures through line **58** acting upon the area B of the piston.

The present invention, therefore, is well adapted to carry out the objects and attain the ends and advantages mentioned as well as others inherent therein.

What is claimed is:

1. In a blowout preventer adapted for use on an oil well rig, and having a housing provided with a well tool receiving port and a curved inner surface extending from the receiving port, a resilient sealing means within said housing having a curved outer surface and adapted to move between a nonsealing and a sealing position, and translating means slidably cooperating with said curved inner surface of said housing and cooperating with said sealing means for converting axial movement of an actuating means into an inward motion of said sealing means, the improvement comprising,

said translating means having an outer surface mating with the curved inner surface of said housing, said outer surface being of an axial extent less than the curved outer surface of the sealing means and being of an axial extent less than the curved inner surface of the housing and

said resilient sealing means circumferentially extends below said outer surface of the translating means and contacting the curved inner surface of the housing to form a circumferential seal with the inner surface which decreases the effective fluid pressure area of the sealing means responsive to the fluid pressure at the receiving port as the sealing means moves to the sealing position.

2. The apparatus of claim **1** wherein said translating means including a plurality of radially spaced metallic segments, and the resilient sealing means includes an exterior recess between adjacent segments positioned above said circumferential seal and of sufficient dimension to prevent flow of the resilient material between the curved outer surface of adjacent segments to interfere with closing of same.

3. In a blowout preventer adapted for use on an oil well rig, and having a housing provided with a well tool receiving port and a curved inner surface extending from the receiving port, resilient sealing means within said housing having a curved outer surface and adapted to move between a nonsealing and a sealing position, a plurality of curved metallic translating means slidably cooperating with said curved inner surface of said housing, axial movable actuating means in said housing for moving said translating means and said sealing means toward said curved inner surface of said housing, the improvement comprising,

said translating means including a curved outer surface mating with the curved inner surface of the housing, said curved outer surface of the translating means is of an axial extent less than the axial extent of the curved outer surface of the sealing means and of an axial extent less than the axial extent of the housing curved inner surface,

said resilient sealing means circumferentially extending below said outer curved surface of the translating means to form a circumferential seal in contact with the inner surface of the housing which decreases the effective fluid pressure area of the sealing means responsive to the fluid pressure at the receiving port as the sealing means moves to the sealing position,

said translating means having a base, and

said base and the resilient sealing means positioned against but free of said actuating means whereby the sealing means may flexibly adjust to changes in the configuration of equipment passing through the receiving port.

4. The apparatus of claim **3** wherein said translating means including a plurality of radially spaced metallic segments, and the resilient sealing means includes an exterior recess between adjacent segments positioned above said circumferential seal and of sufficient dimension to prevent flow of the resilient material between the curved outer surface of adjacent segments to interfere with closing of same.

5. In a blowout preventer adapted for use on an oil well rig, and having a housing provided with a well tool receiving port and a curved inner surface extending from the receiving port, resilient sealing means within said housing having a curved outer surface and adapted to move between a nonsealing and a sealing position and a plurality of radially spaced metallic translating means slidably cooperating with said curved inner surface of the housing and the sealing means for sealing, axially movable actuating means in the housing for moving the translating means and sealing means toward said curved inner surface to provide an inward motion of the sealing means, the improvement comprising,

said translating means including a base, a rib extending upward therefrom, and a curved plate having an outer surface for mating with the curved inner surface of said housing, said curved plate being spaced from the base and the extent of the curved plate being less than the extent of the curved outer surface of the sealing means and being less than the extent of the curved inner surface of said housing, and

said resilient sealing means circumferentially extending between the curved plate and the base and contacting the curved inner surface of the housing for forming a circumferential seal therewith which decreases the effective fluid pressure area of the sealing means responsive to the fluid pressure of the receiving port as the sealing means moves to the sealing position.

6. The apparatus of claim **5** wherein the base includes an arcuate surface in contact with but disconnected from the said actuating means.

7. The apparatus of claim **5** wherein the resilient sealing means includes an exterior recess between adjacent segments positioned above said circumferential seal and of sufficient dimension to prevent flow of the resilient material between the curved outer surface of adjacent segments to interfere with closing of same.

8. The apparatus of claim **5** including,

an annular space defined by the outer circumference of the lower portion of the seal, the actuating means, the housing, the translating means, and the sealing means which increases in size as the actuating means moves the seal toward a closed position to avoid a fluid trap.

References Cited

UNITED STATES PATENTS

3,323,773	6/1967	Walker	251—1
2,731,281	1/1956	Knox	277—73 X
2,846,178	8/1958	Minor	251—1
3,561,723	2/1971	Cugini	251—1

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U.S. Cl. X.R.

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