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Jansen, Jr.

[11] **3,924,679**

[45] **Dec. 9, 1975**

[54] **PRESSURE OPERATED APPARATUS FOR RUNNING AND SETTING PACKING ASSEMBLIES IN WELLHEADS**

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[21] Appl. No.: **495,269**

[52] **U.S. Cl.** **166/182;** 285/18; 285/142

[51] **Int. Cl.²** **E21B 23/00**

[58] **Field of Search** 166/182, 120, 121, 87, 166/208, 212, 237; 285/18, 142

[56] **References Cited**

UNITED STATES PATENTS

3,827,488 8/1974 Piazza 166/87

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Attorney, Agent, or Firm—Bernard Kriegel

[57] **ABSTRACT**

Running apparatus is releasably connected to a packing assembly, the combination being lowered on a tubular running string until the packing assembly is disposed between a hanger body and a surrounding wellhead underlying a body of water. The apparatus is operated by pressure fluid supplied through the running string and reaction is taken on the closed blowout preventer rams to effect setting of the packing in the annular space between the hanger body and wellhead. The apparatus is rotated relative to the packing to lock the packing in place, the apparatus then being released from the packing assembly for retrieval to the drilling rig at the water surface.

23 Claims, 8 Drawing Figures

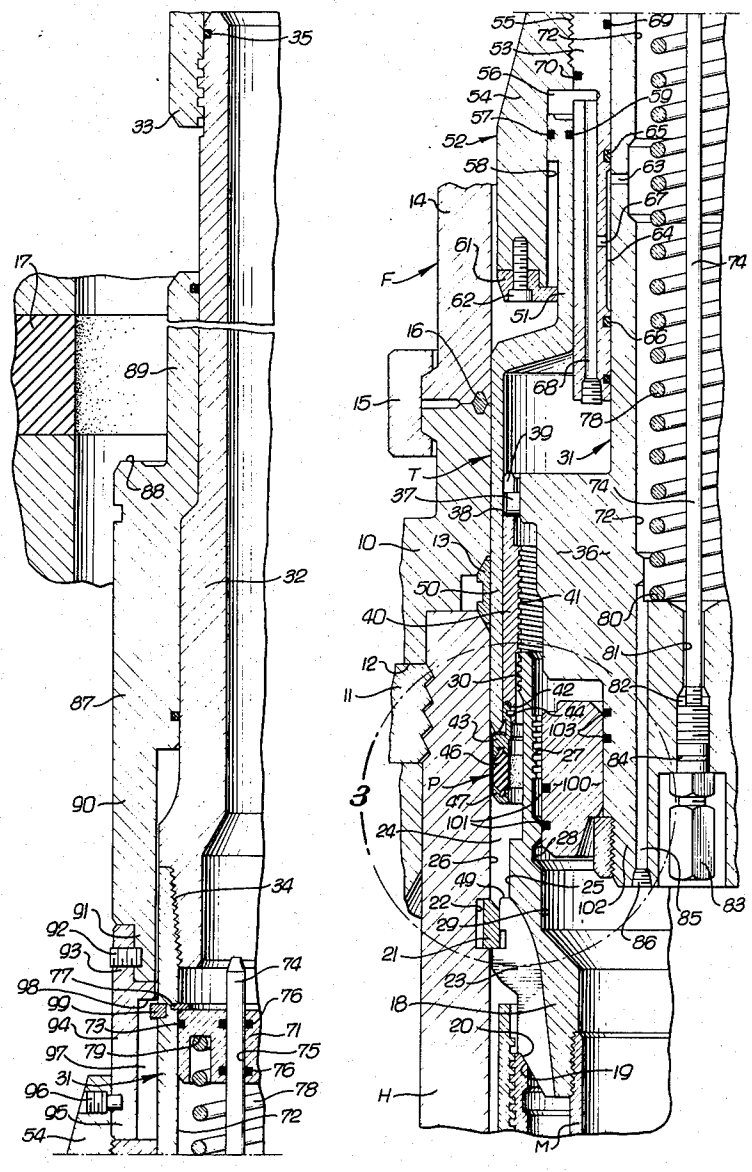


FIG. 1.

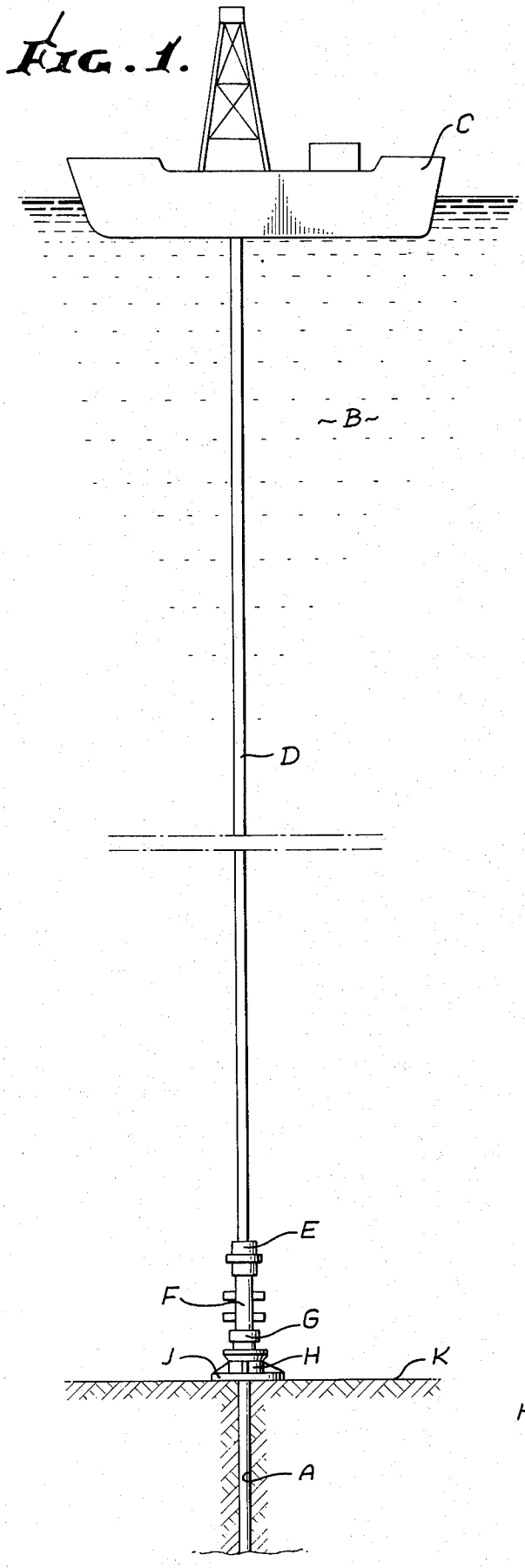

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FIG. 3.

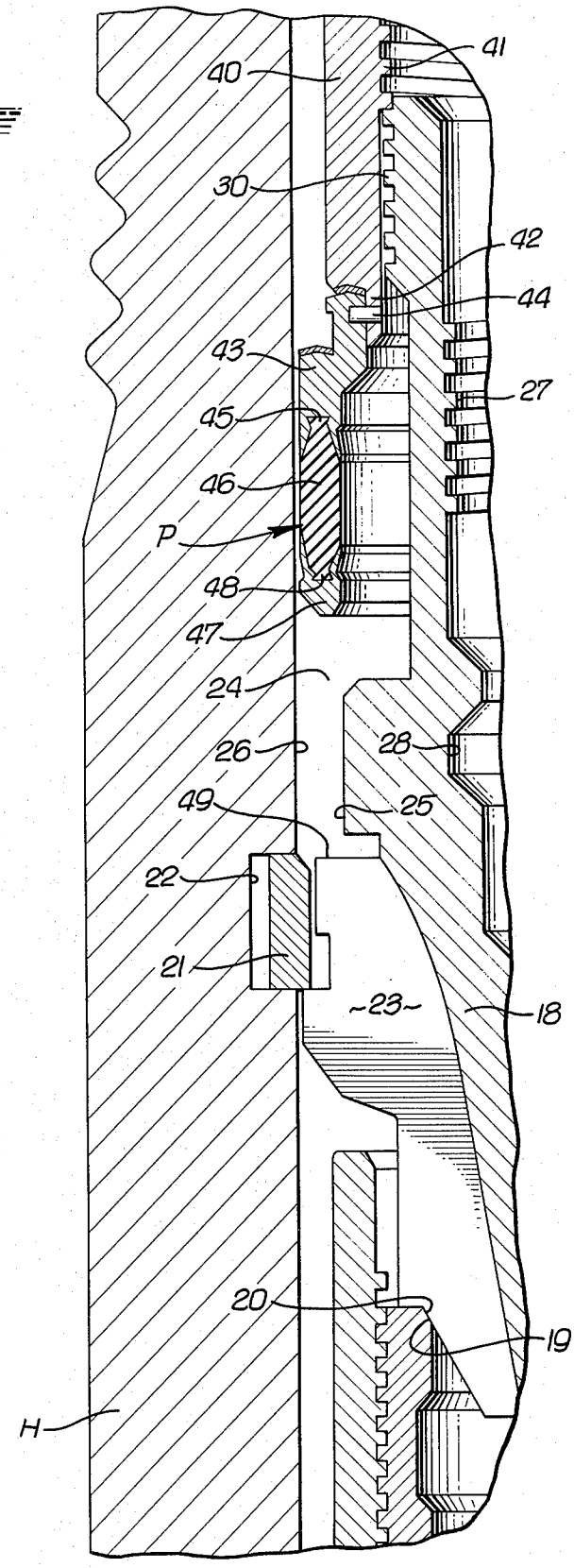

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FIG. 2a.

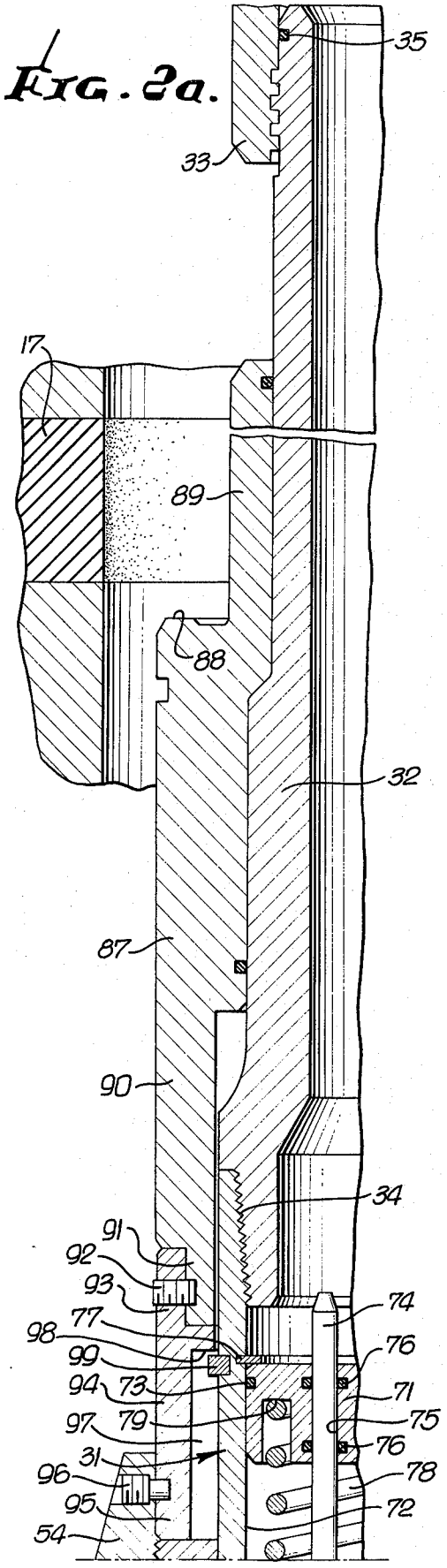

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FIG. 2b.

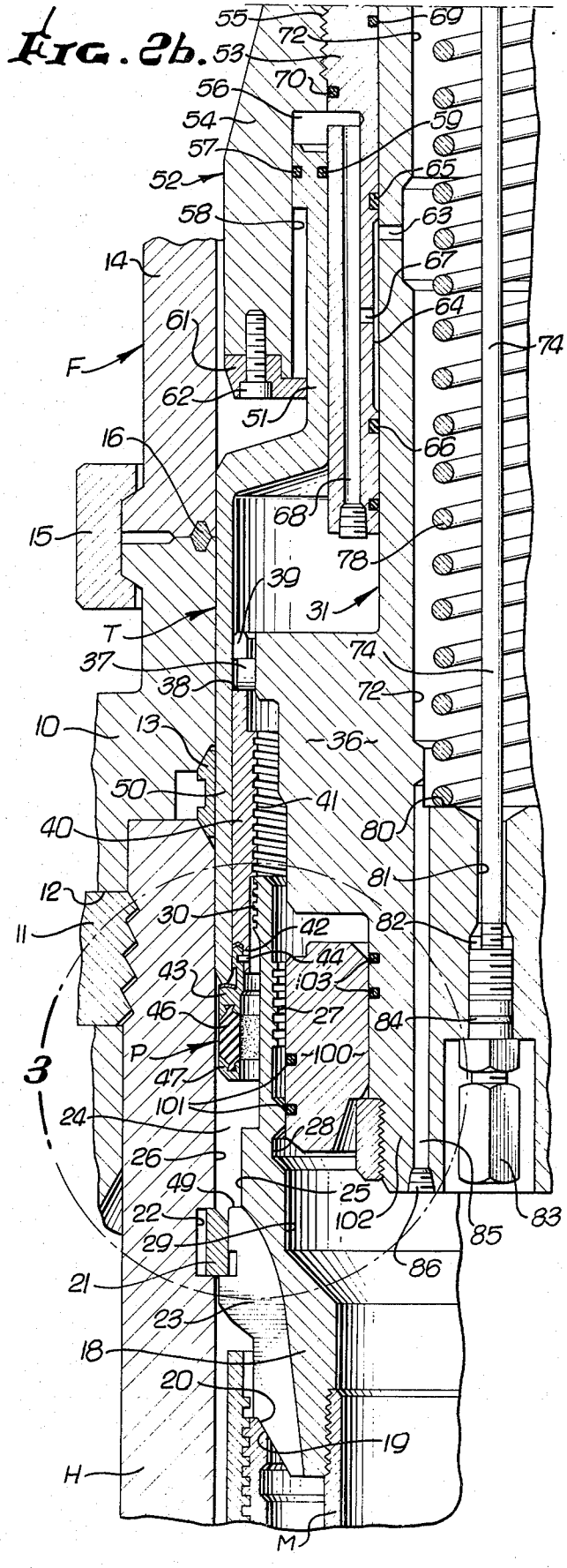

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FIG. 4a.

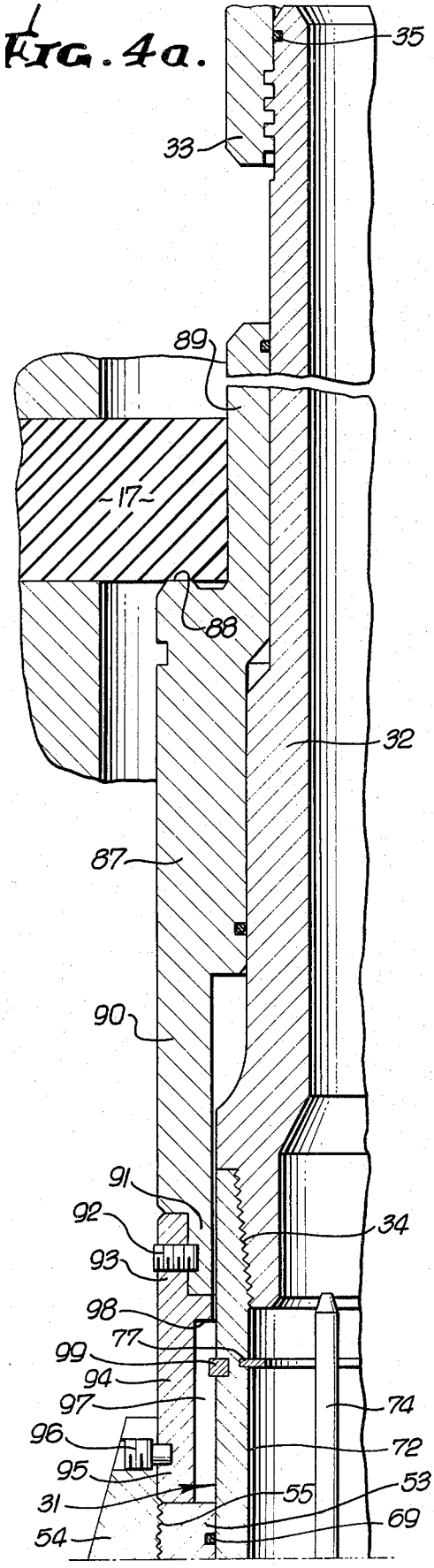

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FIG. 4b.

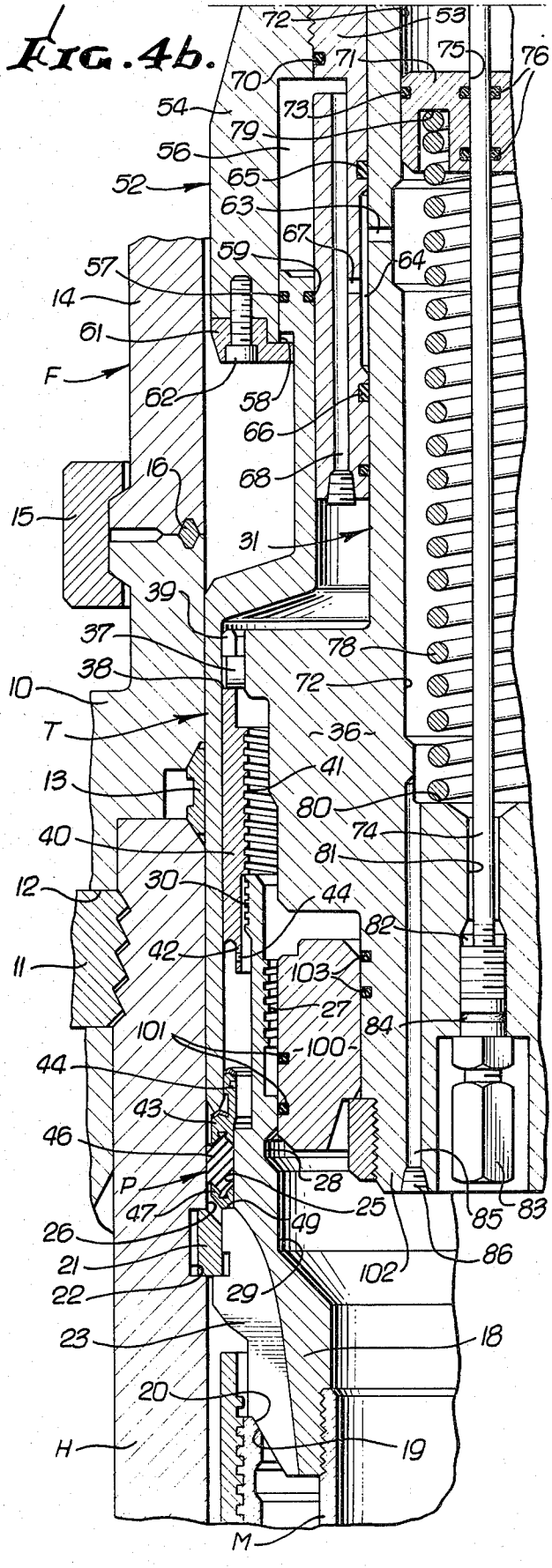

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FIG. 5a.

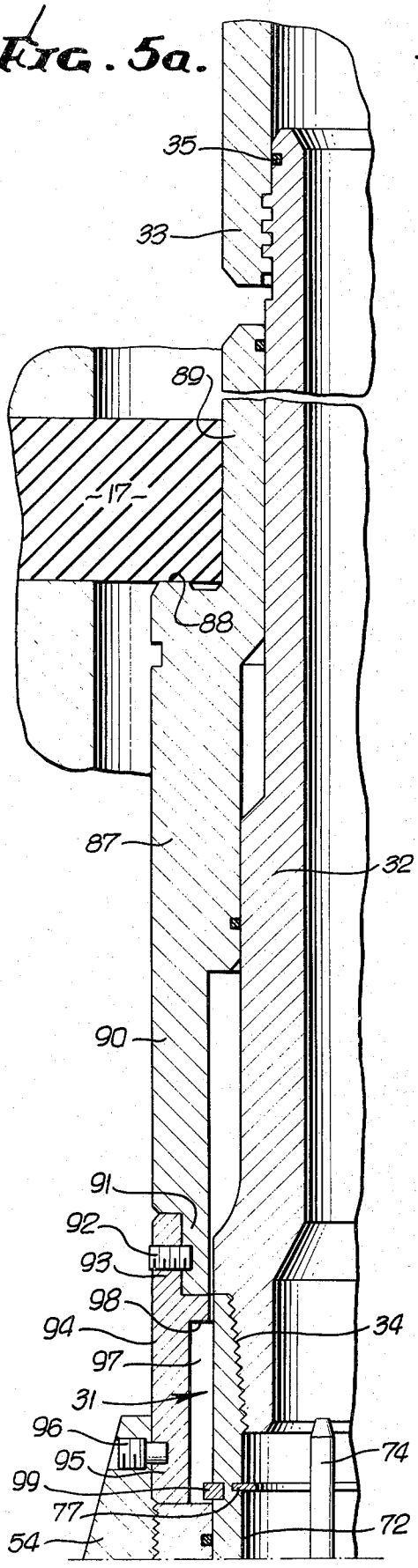
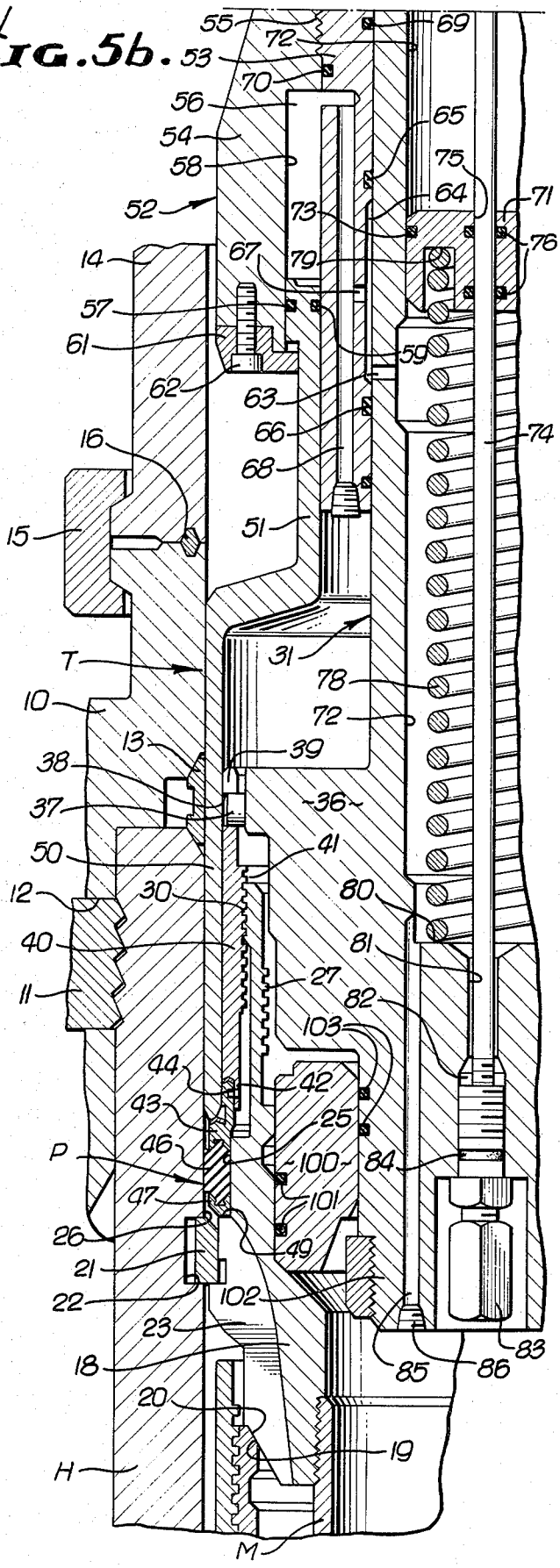

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FIG. 5b.


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PRESSURE OPERATED APPARATUS FOR RUNNING AND SETTING PACKING ASSEMBLIES IN WELLHEADS

The present invention relates to well apparatus, and more particularly to apparatus for effecting a seal in the region between a hanger body and a surrounding wellhead housing disposed at the upper end of the well bore.

In the drilling of oil and gas wells at an underwater location, a casing string is run into a well bore, the casing string being supported on a hanger body resting on a companion seat in a surrounding wellhead. The casing string is cemented in place and a suitable packing or seal assembly actuated to packoff the annular region between the hanger body and wellhead. Apparatus for performing the above method is illustrated in a number of United States patents, including applicant's U.S. Pat. Nos. 3,468,558, 3,468,559, 3,489,436 and 3,492,026.

In general, the packing is supported upon a running and setting tool operable so that the weight of the running pipe string or a downwardly extended weight string beneath the running and setting tool initially effects longitudinal motion of the packing and deforms the packing into sealing engagement in the annular space between the hanger body and the wellhead housing. Thereafter, fluid pressure is applied to the packing via the kill or choke line of the blowout preventer above the wellhead housing to test the efficacy of the seal, and more tightly sets the packing.

The initial packoff weight is generally provided by heavy drill collars which are bulky and difficult to handle as compared with lighter drill pipe, but the drill pipe, in many instances, may not have adequate weight. In other cases, the initial packoff may be effected by rotating the pipe string to drive the packing support rotatively on a threaded connection with the casing hanger body.

In accordance with the present invention, fluid pressure is utilized to initially set the packing in place between the wellhead housing and the casing hanger body by longitudinal motion of the packing assembly and support.

More particularly, in the specific apparatus here involved, fluid pressure is supplied via the running pipe string to the running and setting tool which has piston and cylinder means for shifting the packing into the annular space and applying a force axially thereto to deform the packing element. The reaction is taken against the rams of the blowout preventer which are closed against the running tool. Thereafter, fluid pressure supplied to the wellhead housing via the kill line or choke line of the usual blowout preventer, acts on the packing to more tightly seal the annular space.

With the packing firmly set in place, the running tool is operable to shift a locking sleeve into locking engagement with the packing to hold it in place and then the running tool is retrieved to the drilling rig. In accomplishing this, the running tool is rotatable relative to the packing to drive a locking sleeve rotatively, the locking sleeve being threaded downwardly on a thread on the casing hanger body.

This invention possesses many other advantages, and has other purposes which may be made more clearly apparent from a consideration of the form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. They will now be described in detail for the purpose of illustrating the general principals of the invention; but it is to be understood that such detailed descriptions are not to be taken in a limiting sense.

Referring to the drawings:

FIG. **1** is a diagrammatic view showing an underwater well drilling vessel and associated underwater apparatus located at the floor of a body of water;

FIGS. **2***a* and **2***b*, together, constitute a longitudinal sectional view showing the apparatus of the invention landed in the subsurface wellhead housing, FIG. **2***b* being a downward continuation of FIG. **2***a;*

FIG. **3** is an enlarged fragmentary view in section of the apparatus embraced by the circle **3** of FIG. **2***b;*

FIGS. **4***a* and **4***b*, together, constitute a longitudinal sectional view generally corresponding with FIGS. **2***a* and **2***b*, but showing the apparatus actuated to initially set the packing in place, FIG. **4***b* being a downward continuation of FIG. **4***a;* and

FIGS. **5***a* and **5***b*, together, constitute a further longitudinal sectional view of the apparatus, but showing the packing locked in place.

FIG. **1** is a diagrammatic illustration of a well bore A drilled below a body of water B from a drilling vessel C floating at the surface of the water, a marine riser pipe D extending from the drilling vessel downwardly to a suitable connector E attached to a blowout preventer stack F, which is connected through a suitable connector G to a wellhead housing H disposed within a base J mounted on the floor K of the body of water. The upper end of the wellhead housing H, as seen in FIG. **2***b*, is secured to the connector member **10** by coupling dogs **11** received within circumferential recesses **12** in the wellhead housing. The coupling mechanism or connector is of any suitable type, such as the connector disclosed in U.S. Pat. No. 3,321,217. A suitable seal or gasket ring **13** prevents leakage between the upper end of the wellhead housing H and the connector member **10** thereabove. The housing **14** of the blowout preventer F is connected to the subsea assembly by a collar **15**, a suitable seal **16** being provided. Such blowout preventers include a number of sealing rams **17** adapted to be actuated to and from the blowout preventer housing into and from sealing engagement with a tubular member extending through the blowout preventer, as is well known.

As illustrated in the drawings, a casing hanger body **18** has neen lowered on a suitable running tool (not shown) into the wellhead housing H, this body having a landing surface **19** adapted to rest upon a companion seat **20** in a wellhead housing H, in order that the hanger body can support a string of well casing M threadedly secured thereto and extending downwardly into the well bore. A split lock ring **21** is disposed in a peripheral groove **22** in the housing H and is adapted to contract inwardly over a portion of the body **18** to prevent upward movement of the casing string M and the hanger body **18** with respect to the wellhead housing.

Circumferentially spaced longitudinal flow passages or grooves **23** are provided in the lower portion of the hanger body **18** to permit circulating fluid and cement slurry to flow upwardly through the interior of the landing shoulder **20** and into the annulus **24** between the hanger body and wellhead housing H. The lower portion of this annulus is defined between an external peripheral surface **25** on the hanger body above the flow passages **23** and an opposed internal cylindrical sealing surface **26** in the wellhead housing. A suitable packing

assembly P is shown in FIGS. 2*b* and 3 as having been run into the wellhead housing H on a running and setting tool T and disposed in the upper portion of the annulus **24.**

It is to be noted that the casing hanger body **18** has an internal left-hand thread **27** and an internal groove **28,** either of which can be operatively associated with a running tool (not shown) for lowering the hanger body and casing M in the well bore and wellhead housing. Moreover, a cylindrical internal sealing surface **29** is provided in the hanger body below its threads **27** for a purpose to be described hereinbelow. It should further be noted that the upper external portion of the hanger body is provided with an external right-hand thread **30** which coacts with the packing assembly P in effecting the locking of the packing P in sealing relation against the opposed cylindrical surfaces **25, 26** on the hanger body **18** and wellhead H.

After the well casing M and hanger body **14** attached thereto have been lowered into their appropriate position in the well bore and wellhead, and the circulating and cementing operations have been completed, the annular region between the external and internal sealing surfaces **25** and **26** on the casing hanger body and wellhead are to be engaged by the packing assembly P, which is releasably connected to the running and actuating tool T that includes a body structure **31,** the upper body member **32** of which is threadedly secured by a sub **33** to the lower end of a tubular running string by means of which the running and actuating tool and packing assembly combination are lowered toward the previously set hanger body **18** from the drilling vessel.

The body **31** is an elongated tubular body to which the upper tubular body section **32** is connected by a sealing joint **34,** the upper extremity of the body section **32** having a seal **35** engaged within the lower end of the connector sub **33,** so that operating fluid can be supplied from the drilling vessel to operate the tool T in the manner to be described below.

At the lower end of the body **31** is an enlarged portion **36** having a number of radially projecting pins **37** adapted to support the packing means P. These pins **37** project into a corresponding number of J slots **38** opening upwardly at **39** in a locking sleeve or nut **40** having an internal thread **41** complemental to the external thread **30** on the casing hanger body. At the lower end of the sleeve or nut **40** is a skirt **42** on which the packing unit of the packing means P is supported. The packing unit comprises an upper support ring **43** connected to the nut skirt **42** by a number of shear pins **44.** Depending from the support ring **43** and connected therewith by a dovetailed connection **45** is an elastomeric, resiliently deformable packing sleeve **46** having a lower abutment ring **47** connected thereto by a dovetailed connection **48,** whereby, upon actuation of the tool T, as will be later described, the packing sleeve **46** is deformed into sealing engagement with the hanger wall **25** and the housing wall **26** when the abutment ring seats on an upwardly facing shoulder **49** provided by the casing hanger **18.** Such packings are more particularly disclosed in U.S. Pat. No. 3,797,864, granted Mar. 18, 1974, for COMBINED METAL AND ELASTOMER SEAL.

The packing support ring **43** is adapted to be released from the nut **40** by shearing of the support pins **44** in response to downward movement of an actuator sleeve **50** which is disposed about the nut **40** in abutting engagement with the packing support ring **43.** This actuator sleeve **50** depends from an annular actuator piston sleeve **51** reciprocably supported by reaction means **52,** adapted, as will be later described, to transfer the reaction force of setting the packing means P to the rams **17** of the blowout preventer.

The reaction means **52** comprises a tubular assembly of an inner cylinder sleeve **53** which is slideably disposed about the running tool body **31** and an outer cylinder member **54** threadedly connected at **55** to the inner cylinder sleeve **53.** These cylinder members **53** and **54** define therebetween a piston chamber **56** of annular form in which the actuator piston **51** is disposed, the piston **51** having an outer ring seal **57** slidably engaging the cylinder wall **58** of the outer cylinder member **54** and an inner ring seal **59** slidably engaging the inner cylinder member or sleeve **53.** A retainer ring **61** is secured to the lower end of the outer cylinder member **54** by fastenings **62.**

Operating fluid pressure is applicable to the piston chamber **56** from the tubular body **31** which has a suitable number of radial ports **63** leading to an annular space **64** between the body **31** and the cylinder sleeve **53** which is located between upper and lower sealing rings **65** and **66** engaged between the body and the cylinder sleeve. Communicating with this annular space, via a radial port **67** in the cylinder sleeve **53,** is a passage **68** which leads through the piston sleeve **53** to the piston chamber **56.** Entry of foreign fluid from outside the assembly into the piston chamber **56** is prevented by a seal ring **69** between the cylinder sleeve **53** and the body **31** and another seal ring **70** in the threaded joint **55** between the cylinder members **53** and **54.**

The body **31** is filled with clean operating fluid for actuation of the actuator piston **51** in response to the pressure of fluid supplied to the running pipe string. In this connection, the tool body **31** has an annular piston **71** longitudinally shiftable in the cylindrical bore **72** with which the body port **63** communicates. This piston has a ring seal **73** engaged with the wall of the bore **72.** An elongated rod **74** extends coaxially in the bore **72** and extends through a central bore **75** in the piston **71,** suitable side ring seals **76** forming a seal between the piston and the rod. Upward movement of the piston **71** in the bore **72** is limited by a stop ring **77** engaged in the body **31.** A coiled compression spring **78** in the bore **72** engages a seat **79** in the piston **71** and the base **80** of the bore **72,** to normally bias the piston **71** upwardly. The rod **74** extends downwardly through a passage **81** in the body **31** which establishes communication between the bore **72** and a lower chamber **82** in which a check valve unit **83** is threadedly mounted and sealed by a side ring seal **84.** The piston chamber within the body **71** and the piston chamber **56** are filled with a clean operating fluid through a fill port **85** in the lower end of the body **31** which is then closed by a plug **86.**

Accordingly, it will now be seen that the pressure of operating fluid acting downwardly on the packing actuator piston sleeve **51** is determined by the pressure of fluid supplied to the running pipe string action on the separator piston **71** to displace fluid from the body bore **72** to the actuator piston chamber **56.** The reaction, according to the present invention, is transferred to the blowout preventer rams **17,** as will be later described, and as seen in FIGS. **4***a* and **4***b*.

An upper reaction sleeve **87** is axially shiftably mounted upon the upper tool body section **32** and has an upwardly facing shoulder **88** and an upwardly extended neck **89.** A lower skirt portion **90** of the reac-

tion sleeve **87** has an end flange **91** connected by a number of circumferentially spaced screw pins **92** to the upper end flange **93** of a spacer sleeve **94** which has a lower end flange **95** connected by circumferentially spaced screw pins **96** with the upper end of the reaction member **54.** Within the spacer sleeve **94** is an axial clearance space **97** and a downwardly facing shoulder **98** which shoulders during assembly of the tool on a stop ring **99** installed on the body **31.** This spacer sleeve **94** is of a selected length to adjust the apparatus to varying spacing between casing hangers and blowout preventer rams.

In the operation of the apparatus, the assembled packing means P and running and setting tool T are lowered on the running string through the riser pipe D, blowout preventer stack F, and into the housing H to the position of FIGS. **2***a* and **2***b*, at which the thread **41** in the lock sleeve or nut **40** rests upon the thread **30** of the casing hanger body.

Thereupon, as seen in FIGS. **4***a* and **4***b*, the blowout preventer rams **17** are closed on the neck **89** of the reaction sleeve **87.** Fluid under pressure is supplied through the running pipe string and acts on the piston **71** in the tool body **32,** forcing the piston downwardly, displacing fluid from the bore **72** through the ports and passages **63, 64, 67,** and **68** into the actuator piston chamber **56.** Pressure in the chamber **56** acts upwardly on the exposed cylinder area of the reaction cylinder member **54** and downwardly on the actuator piston sleeve **51.** The reaction sleeve is forced upwardly until the shoulder **88** abuts with the blowout preventer rams **17,** and the skirt **50** of the actuator piston **51** forces the upper packing support ring **43** downwardly, shearing the supporting pins **44** and moving the packing into the packed off condition in the annulus berween the casing hanger body surface **25** and the housing surface **26.**

Next, the running string is rotated, while pressure is held on the packing, so that, as seen in FIGS. **5***a* and **5***b*, the locking nut or sleeve **40** is threaded downwardly on the thread **30** on the casing hanger into locking engagement with the upper ring **43** of the packing means P, to hold the packing in its sealing relation with the casing hanger and the wellhead housing. Actuating pressure in the running string is then released.

As the tool body **31** moves downwardly during rotation of the locking nut **40,** a sealing collar **100** on the lower end of the body **31** is moved downwardly into the sealing bore **29** of the casing hanger. This collar **100** has a number of axially spaced external seal rings **101** engageable in the bore **29,** and a lower end section **102** of the body **31** has seal rings **103** engaged within the collar **100.** With the packing means set to seal the space between the casing hanger and the housing and with the sealing collar **100** sealing the space between the casing hanger and the tool T, test pressure is applicable to the housing above the packing means to test the efficacy of the seal. Such test pressure, as previously indicated, is supplied through the kill line or choke line of the blowout preventer, as is well known.

During the pressure test, if fluid passes either the packing means P or the sealing collar **100,** the check valve **83** at the lower end of the body bore **72** will open to admit fluid into the bore **72** from the casing M, whereby a pressure acting upwardly on fluid in the running string will signify the leak.

Following testing of the seal, the running tool is retrieved to the rig ny backing the running tool pins **37** out of the J slots **39.** If the seal leaks, the running string can be rotated to back off the locking nut **40** and the nut can be retrieved with the running tool and the packing pulled by the usual pulling tool.

I claim:

1. Apparatus for effecting a seal between a wellhead housing below a blowout preventer means and a hanger disposed in said housing for supporting a tubular string extending into a well bore comprising: a running tool having a body structure connectable to a running pipe string, packing means, means releasably connecting said packing means to said body structure, actuator means disposed between and engageable with the blowout preventer means and packing means for setting said packing means between said housing and said hanger, and locking means for holding said packing means in set condition, said actuator means including fluid pressure operated piston and cylinder means for applying a setting force to said packing means and a reactive force to the blowout preventer means with said actuator means in engagement with the blowout preventer means and packing means.

2. Apparatus as defined in claim **1,** said piston and cylinder means defining a piston chamber, said body structure having a chamber containing actuator fluid and having passage means communicating between said piston chamber and said body chamber, and separator piston means in said body chamber for pressurizing said actuator fluid in response to pressure supplied through said running pipe string.

3. Apparatus as defined in claim **1,** said piston and cylinder means being shiftably disposed on said body structure, said locking means including a locking member shiftable by said body structure upon movement of said body structure relative to said piston and cylinder means.

4. Apparatus as defined in claim **1,** said piston and cylinder means being shiftably disposed on said body structure, said locking means including a locking member shiftable by said body structure upon movement of said body structure relative to said piston and cylinder means, and said means releasably connecting said packing means to said body structure including means releasably connecting said locking member to said body structure.

5. Apparatus as defined in claim **1,** said piston and cylinder means being shiftably disposed on said body structure, said locking means including a locking member shiftable by said body structure upon movement of said body structure relative to said piston and cylinder means, said locking member having means cooperable with said hanger to hold said locking member in a locking position.

6. Apparatus as defined in claim **1,** said piston and cylinder means being shiftably disposed on said body structure, said locking means including a locking member shiftable by said body structure upon movement of said body structure relative to said piston and cylinder means, said locking member having a thread cooperable with a thread on said hanger to hold said locking member in a locking position.

7. Apparatus as defined in claim **1,** said piston and cylinder means being shiftably disposed on said body structure, said locking means including a locking member shiftable by said body structure upon movement of said body structure relative to said piston and cylinder means, and said means releasably connecting said packing means to said body structure including means releasably connecting said locking member to said

body structure, and means releasably connecting said packing means to said locking member.

8. Apparatus as defined in claim **1**, said piston and cylinder means being shiftably disposed on said body structure, said locking means including a locking member shiftable by said body structure upon movement of said body structure relative to said piston and cylinder means, and said means releasably connecting said packing means to said body structure including means releasably connecting said locking member to said body structure, and shear pins releasably connecting said packing means to said locking member.

9. Apparatus as defined in claim **1**, said piston and cylinder means being shiftably disposed on said body structure, said locking means including a locking member shiftable by said body structure upon movement of said body structure relative to said piston and cylinder means, and said means releasably connecting said packing means to said body structure including J slots and pin means engageable between said body structure and said locking member.

10. Apparatus as defined in claim **1**, said piston and cylinder means defining a piston chamber, said body structure having a chamber containing actuator fluid and having passage means communicating between said piston chamber and said body chamber, and separator piston means in said body chamber for pressurizing said actuator fluid in response to pressure supplied through said running pipe string, said body structure having means cooperable with said hanger to form a seal therebetween.

11. Apparatus as defined in claim **1**, wherein said body structure includes means for forming a seal with said hanger.

12. Apparatus as defined in claim **1**, wherein said piston and cylinder means includes a cylinder sleeve longitudinally shiftably carried by said body structure and having a piston chamber, a piston shiftable with respect to said body structure and having a portion in said piston chamber, one of said cylinder sleeve and piston being engageable with said blowout preventer means and the other supporting said packing means.

13. Apparatus as defined in claim **1**, wherein said piston and cylinder means includes a cylinder sleeve longitudinally slidable along said body structure and having a piston chamber, a piston shiftable with respect to said body structure and having a portion in said piston chamber, one of said cylinder sleeve and piston being engageable with said blowout preventer means and the other supporting said packing means, said body structure having a body chamber communicating with said piston chamber for transmitting the pressure of fluid from said running pipe string to said piston chamber.

14. Apparatus as defined in claim **1**, wherein said piston and cylinder means includes a cylinder sleeve longitudinally slidable along said body structure and having a piston chamber, a piston shiftable with respect to said body structure and having a portion in said piston chamber, one of said cylinder sleeve and piston being engageable with said blowout preventer means and the other supporting said packing means, said body structure having a body chamber communicating with said piston chamber, pressure transmitting fluid in said body chamber and said piston chamber, and a piston shiftable in said body chamber by the pressure of fluid in said running pipe string to apply pressure to said pressure transmitting fluid.

15. Apparatus as defined in claim **1**, wherein said piston and cylinder means includes a cylinder sleeve slidable on said body structure and having an upwardly facing shoulder engageable with a ram of said blowout preventer means upon upward sliding of said cylinder sleeve on said body structure, and a piston reciprocable with respect to said body structure and connected with said packing means.

16. Apparatus as defined in claim **1**, wherein said piston and cylinder means includes a cylinder sleeve slidable on said body structure and having an upwardly facing shoulder engageable with a ram of said blowout preventer means upon upward sliding of said cylinder sleeve on said body structure, and a piston reciprocable with respect to said body structure and connected with said packing means, said cylinder sleeve having a tubular neck above said shoulder sealingly engageable by said blowout preventer ram.

17. In subsqueous well equipment: a blowout preventer having sealing ram means actuatable into sealing engagement with a tubular member disposed therein, a wellhead housing beneath said blowout preventer, a pipe string extending through said blowout preventer means into said housing, and tool means connected with said pipe string and disposed in said housing, said tool means including pressure operated piston and cylinder means for actuating a device carried by said tool means, said piston and cylinder means being slidable longitudinally on said pipe string and having means engageable with said blowout preventer means upon the application of fluid pressure to said piston and cylinder means and upward sliding of said piston and cylinder means on said pipe string.

18. In subaqueous well equipment as defined in claim **17**, said piston and cylinder means including a cylinder sleeve, said tool having a body supporting said cylinder sleeve for movement thereon, said cylinder sleeve having an upwardly facing shoulder engageable with said blowout preventer ram means upon actuation of the latter to sealing position.

19. In subaqueous well equipment as defined in claim **17**, said piston and cylinder means including a cylinder sleeve, said tool having a body supporting said cylinder sleeve for movement thereon, said cylinder sleeve having an upwardly facing shoulder engageable with said blowout preventer ram means upon actuation of the latter to sealing position, said cylinder sleeve having a tubular neck extending upwardly from said shoulder and sealingly engageable by said ram means.

20. In subaqueous well equipment as defined in claim **17**, said piston and cylinder means defining a piston chamber, and including pressure transfer piston means for applying the pressure of fluid in said running pipe string to said piston chamber.

21. A running tool adapted to be lowered on a running pipe string through a blowout preventer mounted on a wellhead housing beneath a body of water said tool comprising: a body structure having means connectable with the running pipe string, pressure operated means slidable along said body structure and including relatively reciprocable piston and cylinder means for actuating a device in said wellhead housing, said body structure having means for transmitting the pressure of fluid in said running string to said piston and cylinder means to effect relative reciprocation thereof, one of said piston and cylinder means having a shoulder for reacting against the blowout preventer and the other being connectable with said device.

22. A running tool as defined in claim 21, means mounting said body structure rotatable with respect to said piston and cylinder means.

23. A running tool as defined in claim 21, means mounting said body structure rotatably with respect to said piston and cylinder means, said body structure having means releasably connectable with said device.

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