United States Patent [19]

Ahlstone

[11] **3,924,678**

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

[54] **CASING HANGER AND PACKING RUNNING APPARATUS**

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[73] Assignee: **Vetco Offshore Industries, Inc.,** Ventura, Calif.

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[21] Appl. No.: **488,430**

[52] **U.S. Cl.** **166/120;** 166/87; 166/124; 166/182; 166/208; 285/18; 285/84

[51] **Int. Cl.²** **E21B 23/06;** E21B 33/035

[58] **Field of Search** 166/120, 124, 182, 208, 166/212, 87; 285/18, 84

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Primary Examiner—David H. Brown

Attorney, Agent, or Firm—Bernard Kriegel

[57] **ABSTRACT**

Casing hanger and packing running apparatus is lowered on a tubular running string to locate the casing hanger and packing in a surrounding housing beneath a body of water. The apparatus is responsive to fluid pressure to expand the packing in the annular space between the hanger body and the housing, and to actuate a wedge-type lock which retains the packing in the packed off condition. The apparatus is releasable from the casing hanger and the packing for retrieval.

30 Claims, 11 Drawing Figures

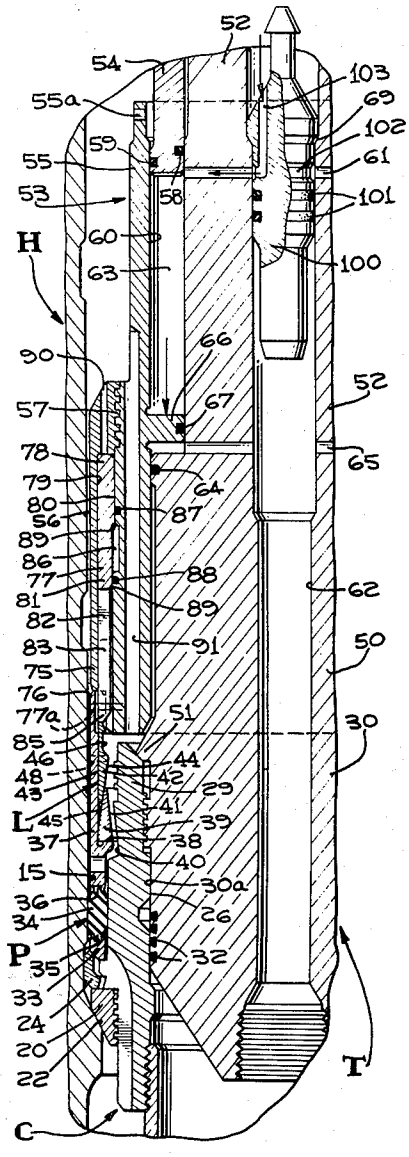

Fig. 1.

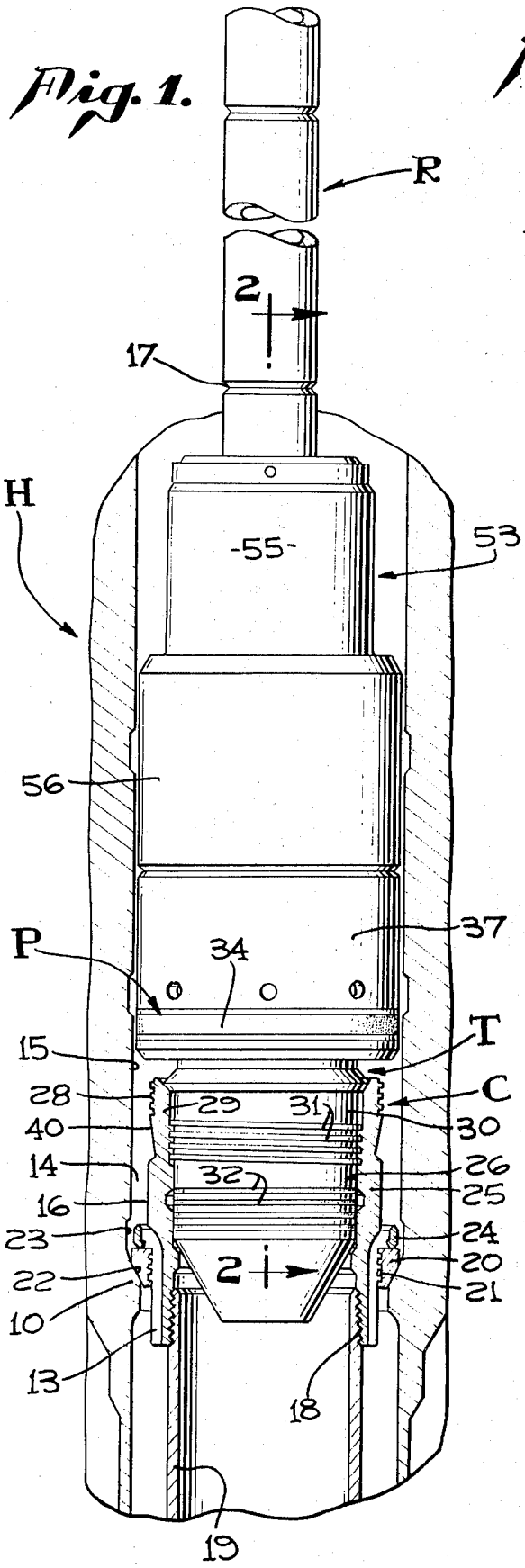
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Fig. 2.

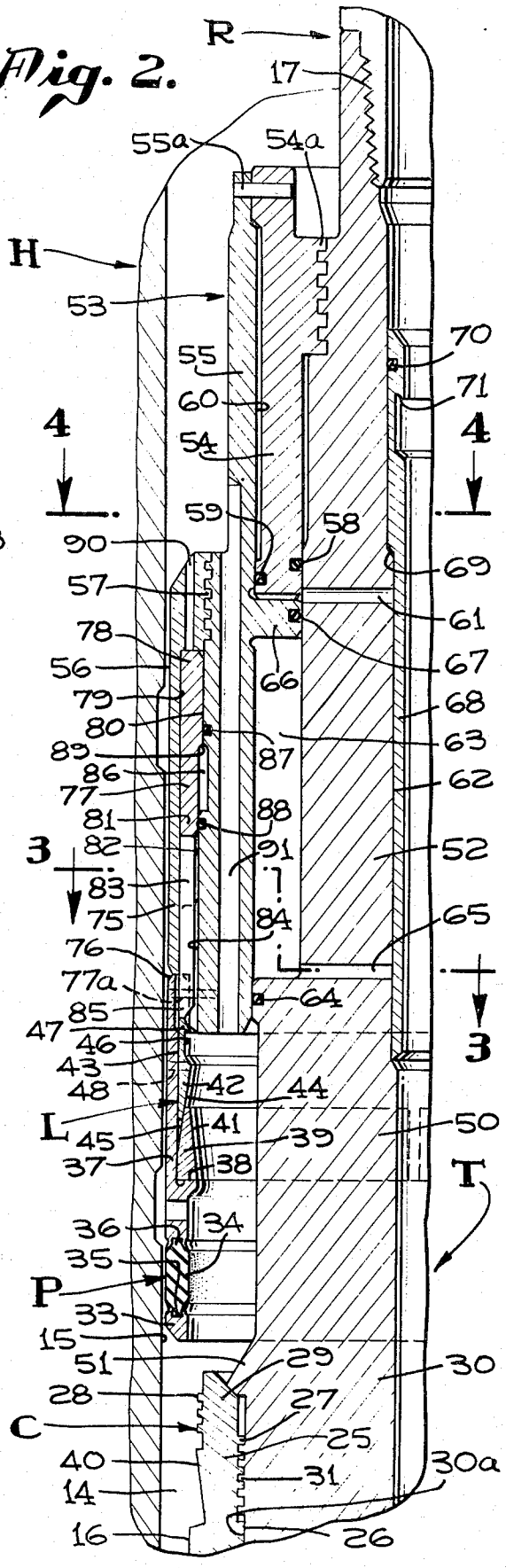
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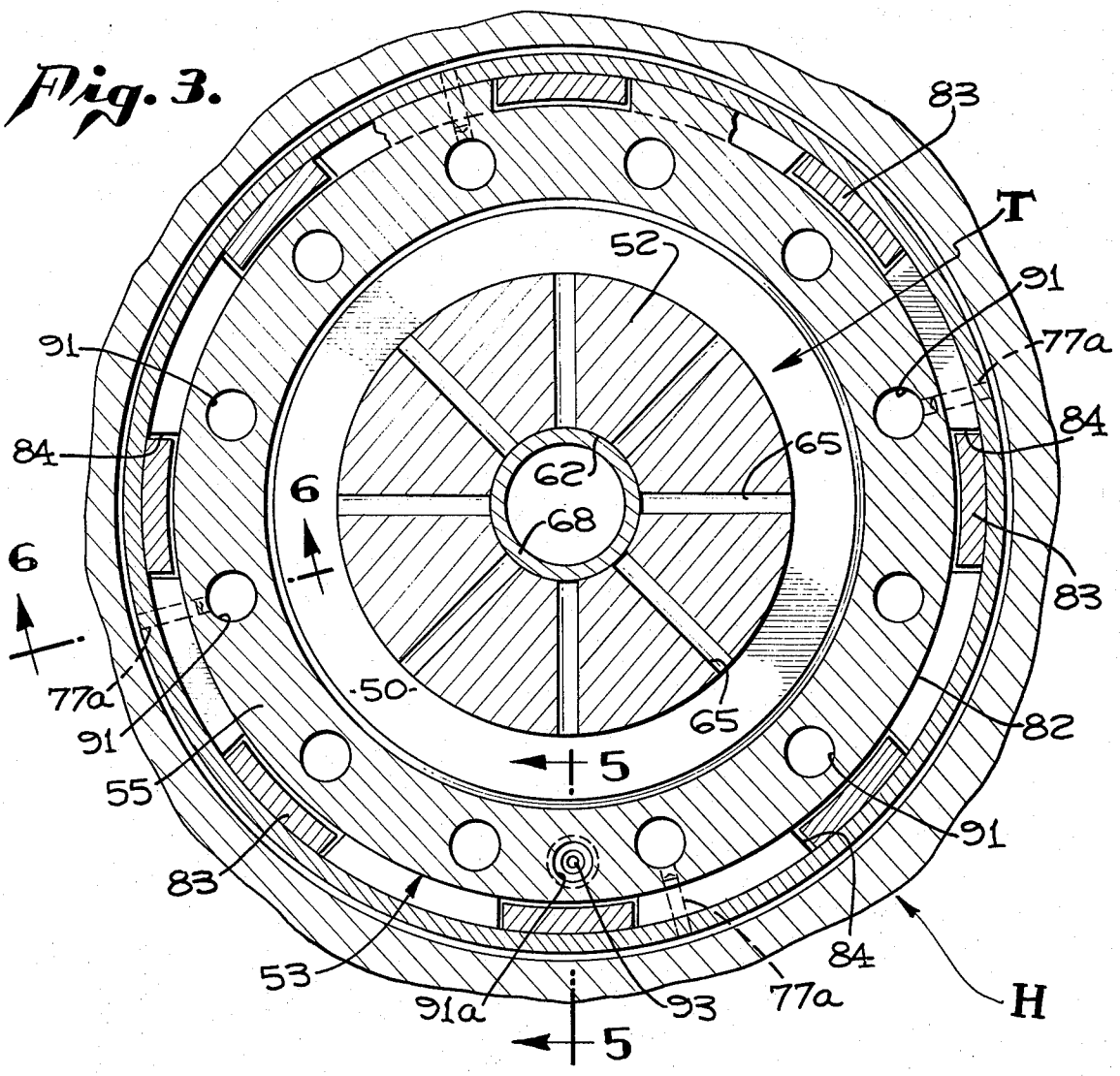
Fig. 3.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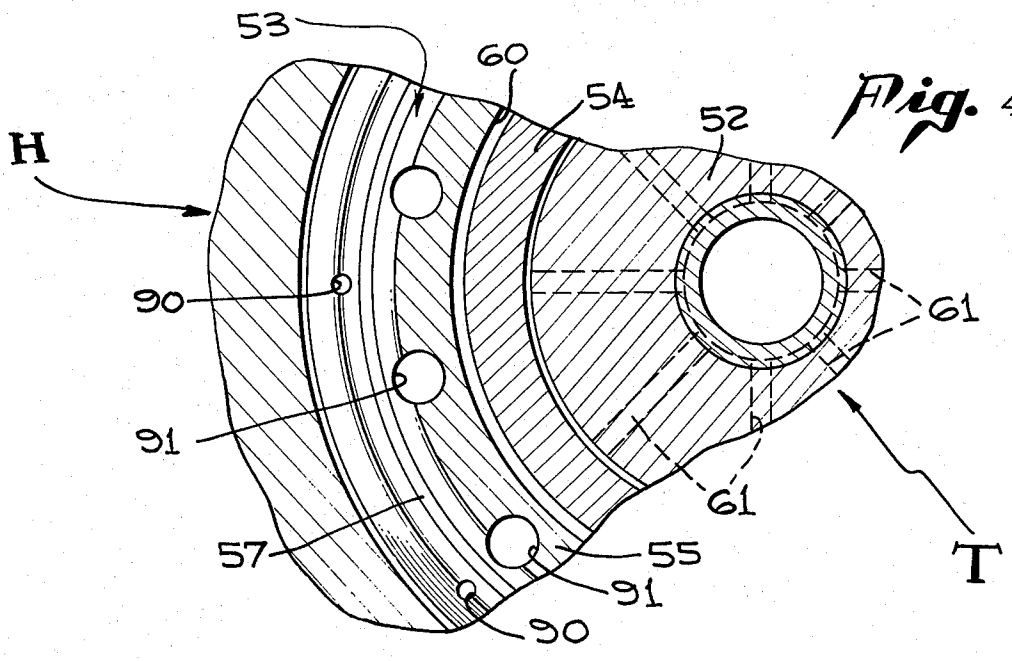
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Fig. 4.

Fig. 5.

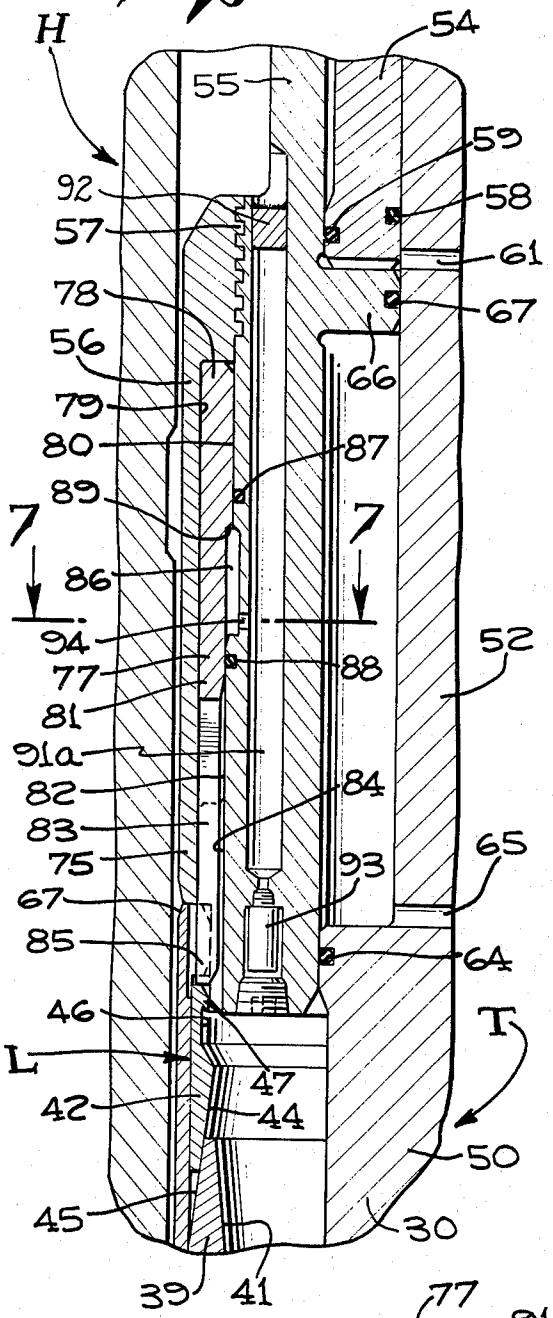
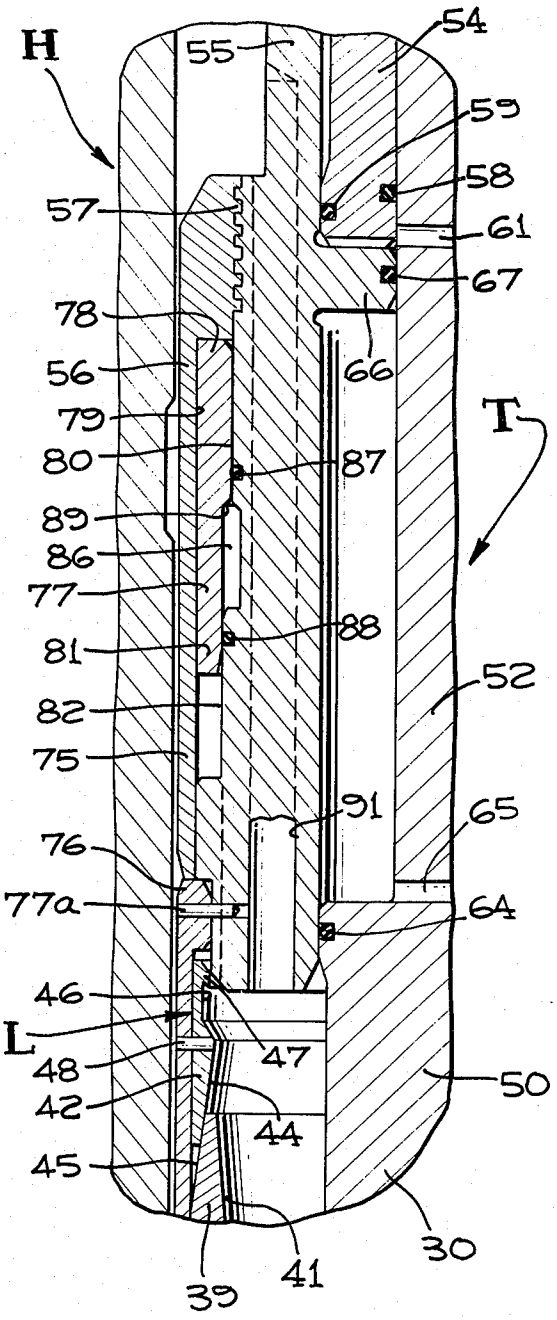


Fig. 6.



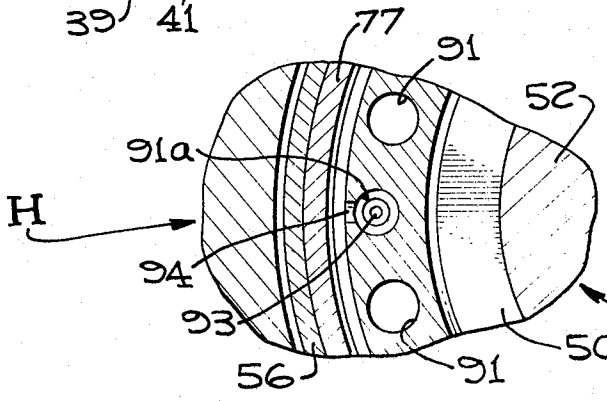


Fig. 7.

Fig. 8.

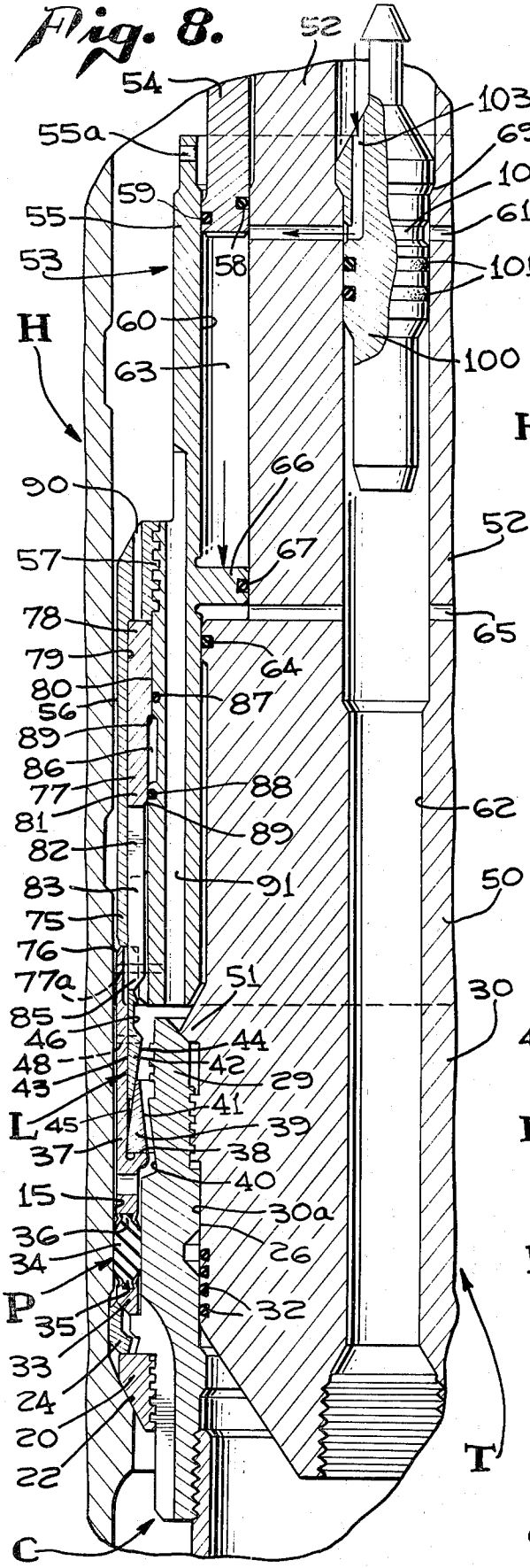

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Fig. 9.

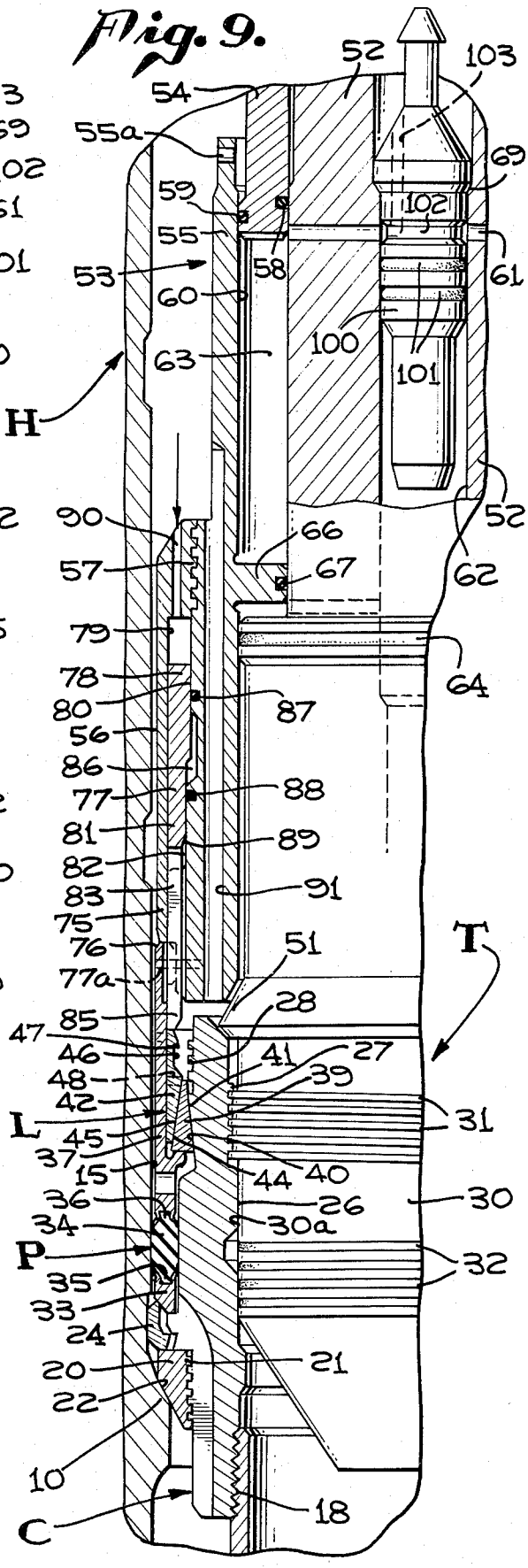
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Fig. 10.

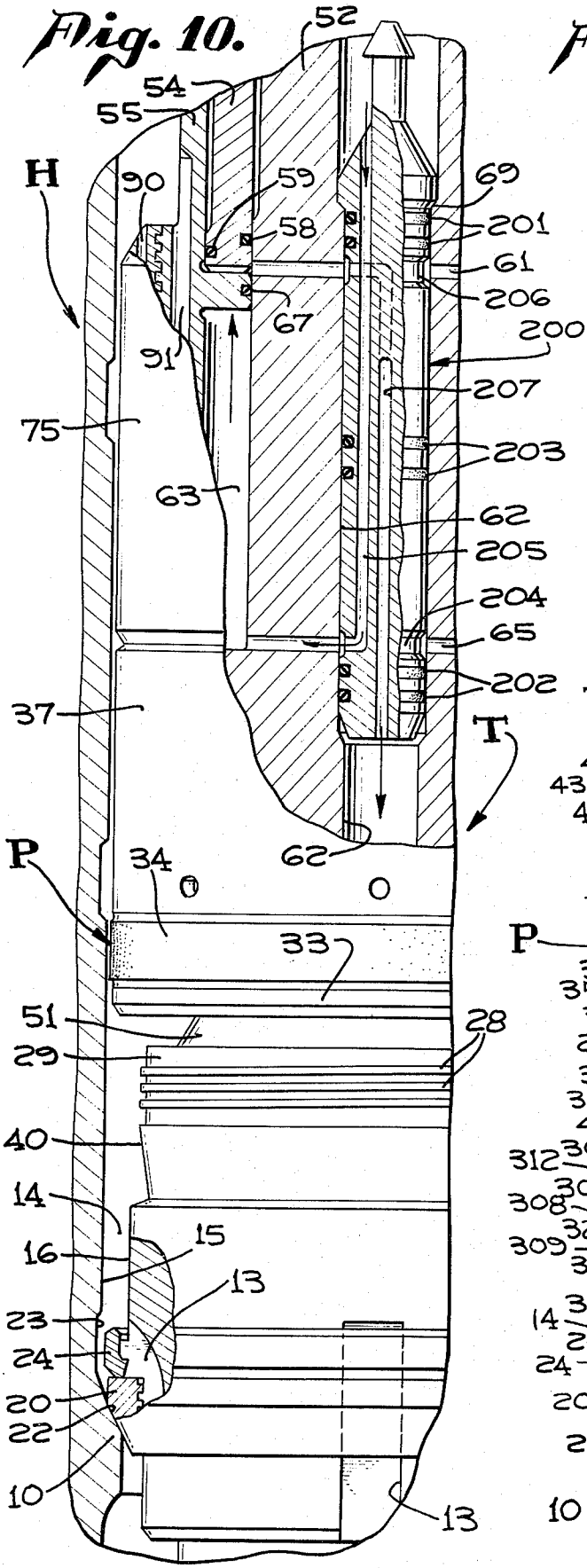
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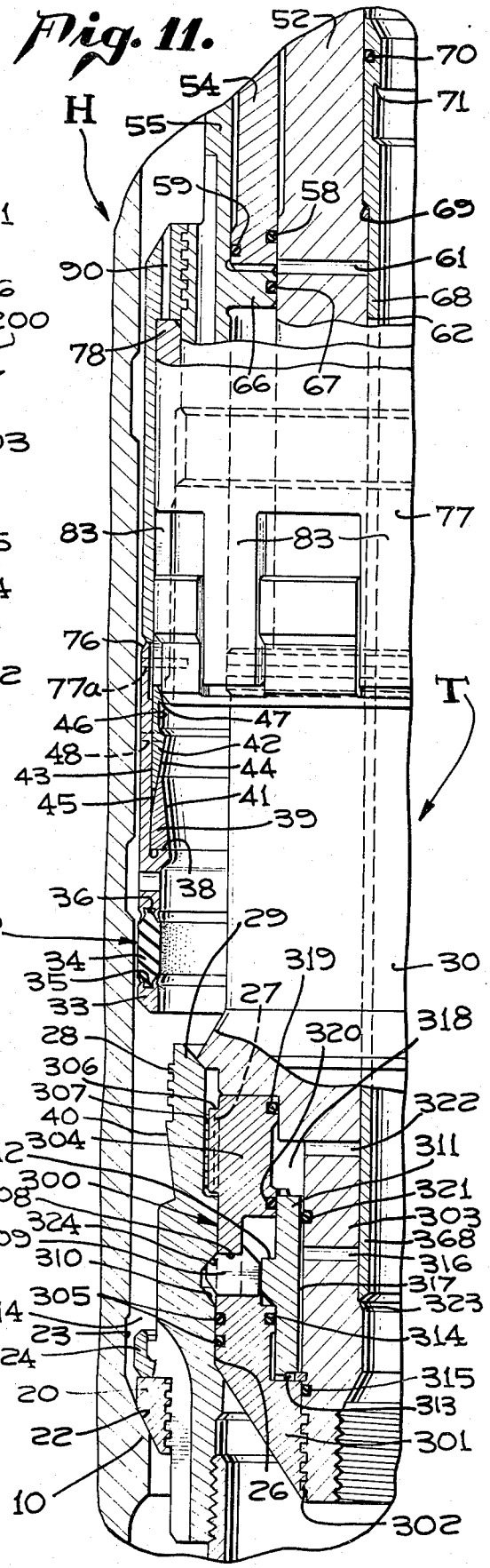
Fig. 11.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CASING HANGER AND PACKING RUNNING APPARATUS

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

In the drilling and completion of subaqueous or subsea well bores extending downwardly from the floor of a body of water, apparatus has been provided for lowering a casing string through a wellhead housing at the top of the well and into the well bore, and for landing a hanger body secured to the upper end of the casing string in the wellhead housing. A sealing region or space is present between the hanger body and housing. The casing string is cemented in place and a suitable seal structure is then disposed in the sealing region to provide an effective seal between the hanger body and the surrounding wellhead. An apparatus employed in the performance of the above operations is illustrated and described in U.S. Pat. No. 3,492,026.

In the present invention, the casing hanger and the packing assembly are lowered from a drilling barge or platform into position within the wellhead through use of a running string secured to a running and setting tool apparatus releasably connected to the casing hanger and to the packing assembly. Fluid pressure is operable on the setting and running tool to effect deformation of the packing to form a seal between the housing and the casing hanger and the locking of a wedge-lock device which prevents the packing from recovering and breaking the seal. Thereafter, the running and setting tool is released from the casing hanger and from the packing and wedge-lock for recovery or retrieval to the drilling rig.

In accordance with the present invention the setting and running tool enables the use of fluid pressure applied through the usual kill line or choke of the subsurface blowout preventer to test the efficacy of the packing. Fluid pressure applied through the running string acts on the setting and running tool to set the packing, and the test pressure releases the locking wedge ring from its support and actuates the wedge-lock mechanism.

More particularly, the wedge-lock device for holding the packing packed off comprises a normally expanded resiliently contractable locking ring engageable with a tapered shoulder externally of the casing hanger body and a wedge ring normally held in a position allowing the lock ring to be in its expanded position, but releasable to be moved axially to circumferentially deform the lock ring inwardly into locking co-engagement with a locking recess or tapered shoulder of the casing hanger. The wedge ring and the lock ring have cooperative locking wedge surfaces whereby the locking action is maintained to hold the packing in a packed off condition.

In the event it becomes necessary to release the packing the locking wedge ring can be pulled from its locking position, for example, by the pulling tool which is the subject of my copending application for Pat. Ser. No. 475,586, filed June 3, 1974, for "RETRIEVING TOOL FOR WELLHEAD PACKING."

Among the objectives of the invention is the provision of a tool or apparatus for running a casing hanger

and a packing and a locking wedge device for holding the packing in a packed off condition in the annular space between a casing hanger and the surrounding wellhead or housing. Another objective of the invention is to provide a running and setting tool operable in response to the pressure of fluid supplied through the running string to initially deform the packing and pack-off the annular space and thereafter in response to applied test pressure to actuate the wedge lock to the locked position prior to removal of the setting and running tool from the casing hanger.

This invention possesses many other advantages, and has other purposes which may be made more clearly apparent from a consideration of the forms in which it may be embodied. These forms are 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 view partly in longitudinal section and partly in elevation showing one form of the running tool and packing apparatus connected to the casing hanger which has been lowered into a subaqueous wellhead housing on a running pipe string, but prior to operation of the running tool;

FIG. **2** is an enlarged fragmentary detail view in longitudinal section, as taken on the line **2—2** of FIG. **1**;

FIG. **3** is a detail transverse section, as taken on the line **3—3** of FIG. **2**;

FIG. **4** is a detail transverse section, as taken on the line **4—4** of FIG. **2**;

FIG. **5** is a fragmentary view in vertical section, as taken on the line **5—5** of FIG. **3**;

FIG. **6** is a fragmentary view in vertical section, as taken on the line **6—6** of FIG. **3**;

FIG. **7** is a fragmentary view in trasverse section, as taken on the line **7—7** of FIG. **5**;

FIG. **8** is a view in longitudinal section, generally corresponding with FIG. **2**, but showing the packing packed off by fluid pressure applied to the running tool through the running string;

FIG. **9** is a view generally corresponding with FIG. **8**, but showing the packing locking means actuated to the locking condition in response to test pressure applied to the housing;

FIG. **10** is a view in longitudinal section, generally corresponding with FIG. **2**, showing the packing setting means held in an upper position by fluid pressure; and

FIG. **11** is a view partly in elevation and partly in longitudinal section, showing another form of the running tool.

In the drilling and completion of wells, such as oil and gas wells, form vessels on a body of water, the blowout preventer equipment and casing hanger equipment are located and supported on in a base mounted on the floor of a body of water. The well casing is supported by a wellhead housing, and a marine riser pipe extends downwardly from the vessel to the blowout preventer which is connected to the wellhead housing, all as is well known.

As seen in the drawings, referring first to the embodiment of FIGS. **1** through **7**, the wellhead housing H has a casing hanger body C landed therein and supported upon an upwardly facing seat or shoulder **10**. The casing hanger C has suitable passages **13** whereby circulating and cementing operations can be conducted in the

usual manner by the displacement of cement downwardly through the casing, fluid in the well being displaced upwardly through the passages **13** and through an annular space **14** defined between the cylindrical inner wall **15** of the housing H and the opposing cylindrical wall **16** of the casing hanger C.

A seal is provided between the opposing cylindrical walls **15** and **16** after the cementing operation is completed by setting a packing P in the annular space **14** in sealing engagement between the opposing cylindrical walls **15** and **16** and securely locking the packing in packed off condition by locking means L. The casing hanger C, the packing means P, and the locking means L are lowered from the drilling vessel on a running and setting tool T which is connected at **17** to a running pipe string R.

The casing hanger C supports at **18** a string of casing **19** which is adapted to extend downwardly into the well and be supported by the casing hanger on a support collar **20** threadedly connected at **21** to the casing hanger body and engageable with an upwardly facing tapered seat **22** in the wellhead housing H. Above the seat **22** the wellhead housing H has a circumferentially extended locking groove **23** adapted, as will be later described, to receive a locking ring **24** above the seating collar **20,** whereby the casing hanger is locked against upward movement in the housing H. Typically, the casing hanger C comprises a main body **25** provided with an internal cylindrical bore **26** above which is a left hand thread **27.** Another thread **28** extends about the upper end of the upper body section **29** of the casing hanger C. Either of the threads **27** or **28** is adapted for engagement by suitable running tools. In the present case, the running tool T has a lower body section **30** provided with a thread **31** engaged with the internal left hand thread **27** within the casing hanger C, whereby, as will be later described, the casing hanger with the casing **19** depending therefrom can be lowered into the well and seated in the wellhead housing H on the running tool T. The body section **30** of the tool T also has a cylindrical section **30*a*** provided with side ring seals **32** engageable in the bore **26** of the casing hanger C.

The running tool T not only supports the casing hanger C, but also the packing means P and the locking means L as more particularly shown in FIG. **2.**

The packing P includes a lower abutment ring or collar **33** and an annular body **34** of resiliently deformable elastomeric sealing material connected by a dove-tailed connection **35** to the lower ring **33,** and by a corresponding upper dove-tailed connection **36** with a packing support sleeve **37.** The packing body **34** is deformable outwardly and inwardly into sealing engagement with the opposed cylindrical walls **15** and **16,** respectively, of the housing H and the casing hanger C upon axial deformation of the packing body. Such a packing is more fully disclosed in U.S. Pat. No. 3,797,864, granted Mar. 18, 1974, for COMBINED METAL AND ELASTOMER SEAL.

The packing support sleeve **37,** at a location above the packing **34,** has an internal upwardly facing shoulder or seat **38** on which rests a split resilient lock ring **39** which is normally of such diameter as to pass downwardly over the upwardly extended annular section **29** of the casing hanger C. This casing hanger section **29** is undercut on its outer periphery at **40** to provide a groove, or, as shown in this specific embodiment, a downwardly and inwardly tapered annular surface adapted to receive the correspondingly downwardly and inwardly tapered side **41** of the lock ring **39,** when the latter is deformed inwardly from its normally expanded condition of FIG. **2** to its contracted or locking position of FIG. **9.** In order to effect locking contraction of the lock ring **39** a lock ring actuator **42** is provided. This lock ring actuator is in the form of an annular wedge having an outer cylindrical wall **43** slidably disposed within the packing support sleeve **37** and an inner downwardly and outwardly tapered wedge surface **44** opposed to and engageable with the outer downwardly and outwardly tapered surface **45** of the lock ring **39,** whereby upon downward movement of the actuator **42** within the support sleeve **37** the lock ring **39** will be wedged or cammed circumferentially inwardly to the locking position with the locking surface **40** of the casing hanger C. The angles of the surfaces **44** and **45** of the actuator ring **42** and the lock ring **39,** respectively, are selected to be locking wedge angles, so that once the wedge action has deformed and locked the lock ring in place, the actuator **42** must be forcefully retracted before the lock ring can be released. Accordingly, the actuator **42** has an internally undercut neck **46** at its upper extremity and an internal fishing or retrieving shoulder **47** adapted to be engaged by a pulling tool, such as the wedge lock pulling tool of my copending application Ser. No. 475,586, filed June 3, 1974, for RETRIEVING TOOL FOR WELLHEAD PACKING.

During the lowering of the packing and the locking assembly through the riser pipe and into the wellhead housing H, and during the initial packing off of the packing P, the actuating wedge **42** is held in an upper inoperative position by releasable means such as one or more shear pins **48** which interconnect the actuator **42** to the packing support sleeve **37.** These shear pins are selected so that they will retain the actuator **42** in the initial position until the packing is fully set, and a downward force is applied to the actuating wedge **42** to shear the pins **48** enabling downward locking movement of the actuator wedge **42.**

Referring more particularly to the running tool T, it has a tubular neck **50** extending upwardly from a make-up shoulder **51** above the lower body section **30.** An inner body section or cylinder **52** extends upwardly from the neck **50** and has the threaded connection **17** with the running string R. An outer body assembly **53** is carried by the inner body section **52** and includes a supporting sleeve and cylinder head **54** fixedly or threadedly connected at **54*a*** to the inner body **52,** and an external cylinder sleeve **55** which carries a packing actuator sleeve **56** threaded at **57** to the outer cylinder sleeve **55.**

The cylinder head **54** has an inner side ring seal **58** engaged with the inner body **52** and an outer side ring seal **59** engaged within an upper bore **60** of the outer cylinder sleeve **55** above a number of circumferentially spaced upper ports **61** which extend from the bore **62** in the tool inner body into the space or piston chamber **63** defined between the inner body section **52** and the outer cylinder sleeve **55.** At the lower end of the chamber **63** the body section **52** has a side ring seal **64** slidably engaged with the inner cylindrical wall of the cylinder sleeve **55** below a number of circumferentially spaced lower ports **65** which also extend between the body bore **62** and the chamber **63.** Reciprocable in the chamber **63** is an annular piston **66** carried by the cylinder sleeve **55** and having a side ring seal **67** slidably engaging the body section **52.**

As previously indicated, fluid circulation and casing cementing operations are performed by displacing fluid and cement downwardly through the running string R and the tool T. In order to protect the piston chamber **63** from dirty or cementitious fluids, a protector sleeve **68** is disposed in the body bore **62** and spans the ports **61** and **64** to normally close the ports. This protector sleeve has an external seating shoulder **69** engageable with an internal shoulder in the bore **62** and an upper seal ring **70** engageable in the bore **62.** When it is desired to operate the tool T, as will be later described, the protector sleeve **68** is pulled by the usual wireline fishing tool (not shown) having gripping means engageable with an internal fishing shoulder **71** adjacent to the upper end of the sleeve **68.**

As previously indicated, the outer body assembly **53** includes the packing actuator sleeve **56** which has a cylindrical skirt portion **75** extending downwardly and disposed in abutting engagement with the upper end **76** of the packing supporting sleeve **37.** This upper end **76** of the sleeve **37** is releasably connected to the lower end of the cylinder sleeve **55** by a number of circumferentially spaced shear pins **77***a* which normally connect the packing supporting sleeve **37** to the cylinder sleeve **55** for simultaneous movement as the cylinder sleeve **55** moves downwardly in response to the application of fluid under pressure to the piston chamber **63** above the piston **66,** as will be later described. Disposed between the packing actuator sleeve **56** and the outer periphery of the outer cylinder sleeve **55** is a differential actuator piston **77** of annular form, this piston having an upper section **78** of major diameter disposed between the inner cylindrical wall **79** of the sleeve **56** and the outer cylindrical wall **80** of the cylinder sleeve **55** and a lower minor diameter section **81** disposed between the actuator sleeve wall **79** and an enlarged diameter section **82** of the cylinder sleeve **55.** Depending from the differential piston **77,** as best seen in FIGS. **2, 3** and **11,** is a plurality of circumferentially spaced fingers **83** which extend downwardly through correspondingly circumferentially spaced and longitudinally extended slots **84** formed on the outer periphery of the cylinder sleeve **55.** The lower ends **85** of the fingers **83** extend into abutting engagement with the upper end of the locking wedge ring **42** so that upon downward actuation of the piston **77** the fingers **83** will be forced downwardly, forcing the wedge ring **42** downwardly, to lock the packing in sealing condition, as will be later described.

A pressure chamber **86** is defined between the actuator piston **77** and the cylinder sleeve **55** between an upper seal ring **87** and a lower seal ring **88,** respectively, disposed between the upper large end section **78** of the piston **77** and the smaller diameter lower section **81** of the piston **77** and the cylinder sleeve **55,** whereby a differential area **89** is provided on the piston **77,** facing downardly and exposed to pressure in the chamber **86** to normally hold the piston **77** in its upper position. The piston **77** is adapted to be actuated downwardly under the influence of pressure fluid action on its larger upper end area which is exposed through a suitable number of apertures **90** in the upper end of the actuator sleeve **56.** Such pressure fluid is applied to the upper end of the piston **77,** as will be later described.

As previously indicated, the casing hanger C and the packing P are landed in the wellhead housing H in the initial condition as seen in FIGS. **1** through **7,** and thereafter fluid is circulated downwardly through the running string R, the casing **19,** and thence upwardly through the passages **13,** bypassing the running tool T. To facilitate such fluid bypass the running tool T is provided with a number of circumferentially spaced bypass flow passages. In the present form, such flow passages are formed at **91** through the cylindrical sleeve **55.** One of such flow passages **91***a* as seen in FIG. **3, 5** and **7** is plugged by a suitable plug **92** at its upper end and has a filler valve **93** at its lower end, whereby the passage **91***a* is adapted, while the apparatus is on the drilling rig platform, to be filled with a compressible fluid, such as air, such pressurized air finding access through a radial port **94** in the cylinder sleeve **55** to the previously described chamber **86,** so as to act upwardly on the differential area **89** of the actuator piston **77** to hold the latter in its upper position. It is apparent that the air in the chamber **86** acts as an air spring which must be overcome before the actuator piston **77** can be moved downwardly.

In operation, when it is desired to set the packing P, as shown in FIG. **8,** and lock the packing in place as shown in FIG. **9,** the apparatus functions as follows. Initially, the cylinder sleeve **55** is held in the upper position of FIG. **2** by a suitable number of shear pins **55***a* which releasably interconnect the cylinder sleeve **55** with the cylinder head **54.** Following the conduct of the cementing operations, the protector sleeve **68** is pulled, and a dart **100,** as seen in FIG. **8,** is dropped into the running string R and lands upon the shoulder **69** formed within the body shore **62.** The dart has suitable side ring seals **101** sealingly engageable in the bore **62** below an annular groove **102** formed in the body of the dart and communicating with a flow passage **103** which opens at the top of the dart. When the dart **100** is seated the groove **102** communicates with the ports **61** through the body section **52** above the actuator piston **66.** Thus, with the dart seated fluid pressure supplied through the running string R is applied to the piston **66** in the piston chamber **63** to force the cylinder sleeve **55** downwardly after shearing the upper shear pins **55***a.* The cylinder sleeve **55** and the actuating sleeve **56,** together with the packing supporting sleeve **37** move downwardly simultaneously to the position of FIG. **8,** at which the packing sleeve **34** is deformed into sealing engagement between the opposing housing and hanger walls **15** and **16.** As the packing sleeve **34** is being deformed, the lower ring **33** thereon engages and cams the casing hanger locking ring **24** outwardly into the locking groove **23.**

With the apparatus in this condition a preliminary pressure check can be made by closing the blowout preventer on the running string R and supplying test pressure fluid to the wellhead housing H through the usual kill or choke line of the blowout preventer. This test pressure is applied to the packing while the initial pre-load which deformed the packing is maintained by holding the pressure in the running string which is applicable to the packing actuator piston **66.**

As the test pressure is increased, the pressure acts on the differential area of the locking actuator sleeve or piston **78** overcoming the pressure in chamber **86** acting upwardly on the piston area **89,** and overcoming the shear pins **48** which connect the locking wedge or actuator ring **42** to the packing support sleeve **37.** When the pins **48** are sheared, the locking wedge ring **42** is shifted downwardly to the position of FIG. **9,** from the position of FIG. **8.** The opposed wedge surfaces **44** and **45** on the wedge ring and the lock ring **39** deform the split

lock ring circumferentially inwardly into the locking position in engagement with the locking shoulder or surface **40** on the casing hanger C, whereby the packing means P is securely locked in place by the locking means L.

Thereafter, the running tool T is disconnected from the casing hanger by right hand rotation of the running string R which will break left hand threaded connection **27, 31** between the casing hanger and the body of the tool. The running string and tool are then lifted. When the inner body neck **50** shoulders against and picks up the actuator piston **66,** the outer cylinder sleeve **55** will be pulled free from the packing support sleeve **37,** as the shear pins **77***a* are sheared.

It may occur that, due to cement or other material being present in the annular space **14** between the casing hanger and the wellhead housing, the packing does not properly seal and resist pressure testing. Under these circumstances, it may be desirable to pull the packing means free from the annulus **14,** and possibly retrieve the running tool T with the packing thereon to allow remedial washing or cleaning operations.

To accomplish this a release dart **200** is provided, as shown in FIG. **10.** The dart **200,** like the dart **100,** has a retrieving head adapted to land on the shoulder **69** in the bore of the tool body section **52.** The release dart **200** is elongated so as to span the ports **61** and **65** in the body section **52.** Above the ports **61,** the dart **200** has upper side ring seals **201** sealingly engageable in the body in the body bore **62.** Below the lower ports **65,** the dart **200** has side ring seals **202** sealingly engaged in the body bore **62.** Between the ports **61** and **65,** the dart **200** has intermediate side ring seals **203** which sealingly engage in the body bore **62.** An annulus **204** in the dart **200** communicates with the lower body ports **65,** and a passage **205** leads from the annulus **204** to the top of the dart, whereby pressure fluid supplied through the running string is applicable to the piston chamber **63** below the actuator piston **66** of the cylinder sleeve **55.** To enable the exhaust of fluid from the chamber **63** above the piston **66,** the dart **200** has another annulus **206** communicating with the upper body ports **61,** and a discharge passage **207** leads from the annulus **206** downwardly to the bottom of the dart.

Upon completion of remedial or washing work, the tool T is again operable, upon removal of the dart **200** and seating of the dart **100,** to set and lock the packing means in place in the annulus **14,** after pressure testing.

It will be recognized that the threaded joint **27, 31** between the running tool lower body **30** and the casing hanger C is a connection which is easily released by rotation of the running string R. In FIG. **11** a modified connector means **300** is shown for connecting the tool T with the casing hanger C. This connection means **300** is releasable without requiring rotation of the running string R.

In FIG. **11** the casing hanger C is landed in the wellhead housing. The connector means **300** includes a lower conical nose **301** threadedly connected at **302** to a reduced section **303** extending downwardly from the setting tool body. The lower nose **301** has an upstanding hollow body **34** which carries the side ring seals **305** sealingly engageable in the bore **26** of the casing hanger C. At its upper end, the body section **304** has one or more longitudinally extended keys **306** engageable in a key way **307** extending through the internal threads **27** of the casing hanger. Above the seals **305** the body section **304** has a number of circumferentially spaced radial windows or openings **308** in which are reciprocable a corresponding number of latching dogs **309.** These latching dogs are adapted, upon outward movement, to engage in a locking groove **310** formed in the casing hanger body. The locking groove **310** would be used for the locking ring or lockdown dogs of a tubing hanger, as is well known, to lock it to the casing hanger or such groove may be used when running the hanger on the running tools. A piston sleeve **311** is disposed about the tool body section **303** and has a central flange **312** engageable with the dogs **309** to hold them outwardly in the locking position of FIG. **11.**

A lower piston chamber **313** is formed below the piston sleeve **311** by a side ring seal **314,** engaged between the outer periphery of the piston sleeve and the body **304** of the connector, and a seal **315** in the threaded connection **302.** The tool body section **303** has a lower plurality of circumferentially spaced ports **316** leading from the tool body bore **62** to the annular clearance **317** between the piston sleeve **311** and the tool body section **303.** An upper piston chamber **318** is formed by an upper seal ring **319** between the bodies **303** and **304,** a lower seal ring **320,** between the body **304** and the piston sleeve **311,** and another seal ring **321** between the body **303** and the inside diameter of the piston sleeve **311.** An upper plurality of circumferentially spaced ports **322** lead from the body bore **62** to the upper chamber **318.**

During the running and cementing operations previously described, the ports **316** and **322** are closed by a downward extension **368** of the protector sleeve **68.** When the protector sleeve **68** is pulled, the ports **316** and **322** are open. Since the piston sleeve **311** is a balanced piston, its position is not affected by fluid entering both piston chambers **313** and **318.**

As is apparent, without requiring further description or illustration, when it is desired that the running tool T be released from the casing hanger c following setting and locking of the packing P in the annulus **14,** a dart (not shown) can be landed on a seating shoulder **323,** such dart having suitable seals and porting to allow discharge from the upper piston chamber **318** and to enable the application of operating fluid pressure to the lower chamber **313,** so that the piston sleeve **311** will be shifted to an upper position at which the dogs **309** are free to be shifted inwardly by camming surface **324** when the tool is pulled upwardly.

I claim:

1. Apparatus for effecting a seal between a wellhead and a hanger disposed in the wellhead for supporting a tubular pipe string extending into the well bore comprising; a running tool having a body structure connectable to a running pipe string; means for releasably connecting said body structure to said hanger; packing means; means releasably connecting said packing means to said body structure to enable said packing means to be set in sealing relation to said hanger; locking means for locking said packing means in sealing relation to said hanger including a locking member actuatable longitudinally to lock said locking means; said body structure having means responsive to fluid pressure supplied through said running pipe string to set said packing means in sealing relation to said hanger; and said body structure having means responsive to fluid pressure outside of said running pipe string for actuating said locking member longitudinally.

2. Apparatus as defined in claim **1,** wherein said means for releasably connecting said body structure to

said hanger includes a threaded connection.

3. Apparatus as defined in claim 1, wherein said means for releasably connecting said body structure to said hanger includes latch means carried by said body structure including latch elements engageable with said hanger, and means for releasing said latch elements.

4. Apparatus as defined in claim 1, wherein said means for relaeasably connecting said body structure to said hanger includes latch means carried by said body structure including latch elements engage latch elements engageable with said hanger, and means for releasing said latch elements in response to fluid pressure supplied through said running pipe string.

5. Apparatus as defined in claim 1, wherein said locking means comprises a resiliently deformable locking ring engageable with a downwardly facing surface of said hanger upon deformation of said locking ring to lock said packing means to place.

6. Apparatus as defined in claim 1, wherein said locking means comprises a resiliently deformable locking ring engageable with a downwardly facing surface of said hanger upon deformation of said locking ring to lock said packing means in place, said locking member and said locking ring having means for deforming said locking ring upon longitudinal movement of said locking member.

7. Apparatus as defined in claim 1, wherein said locking means comprises a resiliently deformable locking ring engageable with a downwardly facing surface of said hanger upon deformation of said locking ring to lock said packing means in place, said locking member being in the form of a wedge shaped ring for deforming said locking ring upon longitudinal movement of said locking member.

8. Apparatus as defined in claim 1, wherein said locking means comprises a resiliently deformable locking ring engageable with a downwardly facing surface of said hanger upon deformation of said locking ring to lock said packing means in place, said locking member being in the form of a wedge shaped ring for deforming said locking ring upon longitudinal movement of said locking member, said locking ring and said locking member having coengageable locking wedge surfaces.

9. Apparatus as defined in claim 1, said packing means comprising a support sleeve, a resilient elastomeric packing element supported on said support sleeve, means releasably connecting said locking member to said support sleeve, and said locking means including a resiliently deformable lock ring carried by said support sleeve and engageable by said locking member to be deformed thereby.

10. Apparatus as defined in claim 1, said packing means comprising a support sleeve, a resilient elastomeric packing element supported on said support sleeve, means releasably connecting said locking member to said support sleeve, and said locking means including a resiliently deformable lock ring carried by said support sleeve and engageable by said locking member to be deformed thereby, said locking member and said lock ring having companion wedge surfaces formed on locking wedge angles for deforming said lock ring upon longitudinal movement of said locking member.

11. Apparatus as defined in claim 1, wherein said means responsive to fluid pressure supplied through said running pipe string to set said packing means in sealing relation to said hanger includes piston means longitudinally shiftable in said body structure.

12. Apparatus as defined in claim 1, wherein said means responsive to fluid pressure supplied through said running pipe string to set said packing means in sealing relation to said hanger includes piston means longitudinally shiftable in said body structure, and means initially holding said piston means against movement relative to said body structure.

13. Apparatus as defined in claim 1, wherein said means responsive to fluid pressure supplied through said running pipe string to set said packing means in sealing relation to said hanger includes a cylinder sleeve carried by said body structure, said cylinder sleeve and said body structure having means defining a piston chamber, a piston on said cylinder sleeve exposed to the pressure of fluid in said piston chamber, and passage means for establishing communication between said piston chamber and said running pipe string.

14. Apparatus as defined in claim 1, wherein said means responsive to fluid pressure supplied through said running pipe string to set said packing means in sealing relation to said hanger includes a cylinder sleeve carried by said body structure, said cylinder sleeve and said body structure having means defining a piston chamber, a piston on said cylinder sleeve exposed to the pressure of fluid in said piston chamber, and passage means for establishing communication between said piston chamber and said running pipe string, said means responsive to fluid pressure outside said running pipe string for actuating said locking member longitudinally including an actuator piston engageable with said locking member.

15. Apparatus as defined in claim 1, wherein said means responsive to fluid pressure supplied through said running pipe string to set said packing means in sealing relation to said hanger includes a cylinder sleeve carried by said body structure, said cylinder sleeve and said body structure having means defining a piston chamber, a piston on said cylinder sleeve exposed to the pressure of fluid in said piston chamber, and passage means for establishing communication between said piston chamber and said running pipe string said means responsive to fluid pressure outside said running pipe string for actuating said locking member longitudinally including an actuator piston engageable with said locking member, said cylinder sleeve having means supporting said actuator piston for longitudinal movement relative to said cylinder sleeve.

16. Apparatus as defined in claim 1, wherein said means responsive to fluid pressure supplied through said running pipe string to set said packing means in sealing relation to said hanger includes a cylinder sleeve carried by said body structure, said cylinder sleeve and said body structure having means defining a piston chamber, a piston on said cylinder sleeve exposed to the pressure of fluid in said piston chamber, and passage means for establishing communication between said piston chamber and said running pipe string, said means responsive to fluid pressure outside said running pipe string for actuating said locking member longitudinally including an actuator piston engageable with said locking member, said cylinder sleeve having means supporting said actuator piston for longitudinal movement relative to said cylinder sleeve, and means for normally holding said actuator piston against such longitudinal movement.

17. Apparatus as defined in claim 1, wherein said means responsive to fluid pressure supplied through said running pipe string to set said packing means in

sealing relation to said hanger includes a cylinder sleeve carried by said body structure, said cylinder sleeve and said body structure having means defining a piston chamber, a piston on said cylinder sleeve exposed to the pressure of fluid in said piston chamber, and passage means for establishing communication between said piston chamber and said running pipe string, said means responsive to fluid pressure outside said running pipe string for actuating said locking member longitudinally including an actuator piston engageable with said locking member, said cylinder sleeve having means supporting said actuator piston for longitudinal movement relative to said cylinder sleeve, said cylinder sleeve and said actuator piston having means defining a chamber containing a compressible fluid for normally holding said actuator piston against such longitudinal movement.

18. Apparatus as defined in claim **1,** wherein said means responsive to fluid pressure outside said running pipe string for actuating said locking member longitudinally including an actuator piston engageable with said locking member.

19. Apparatus as defined in claim **1,** wherein said means responsive to fluid pressure supplied through said running pipe string to set said packing in sealing relation to said hanger including piston means carried by said body structure, said body structure having passage means for controlling the application of fluid pressure to said piston means.

20. Apparatus as defined in claim **1,** said means responsive to fluid pressure in said running pipe string to set said packing in sealing relation to said hanger including a cylinder sleeve shiftably carried by said body structure, said packing means including a support sleeve, said means releasably connecting said packing means to said body structure connecting said support sleeve to said cylinder sleeve.

21. Apparatus as defined in claim **1,** said means responsive to fluid pressure in said running pipe string to set said packing in sealing relation to said hanger including a cylinder sleeve shiftably carried by said body structure, said packing means including a support sleeve, said means releasably connecting said packing means to said body structure connecting said support sleeve to said cylinder sleeve annd including shear pins shearable upon removal of said body structure from said hanger.

22. Apparatus as defined in claim **1,** wherein said body structure comprises an inner body having seal means engageable in said casing hanger.

23. Apparatus as defined in claim **1,** wherein said means responsive to fluid pressure supplied through said running pipe string to set said packing means in sealing relation to said hanger includes means responsive to pressure fluid supplied through said running pipe string to pull said packing means from sealing relation to said hanger.

24. A running and operating tool for setting a packing and locking assembly between a wellhead housing and a hanger for a tubular well conduit comprising: a body having means at its upper end connectable to a running pipe string; means at the lower end of said body; means adapted to releasably connect said last-mentioned means to the hanger; a cylinder sleeve reciprocable relative to said body; said cylinder sleeve and said body having means defining a piston chamber; a piston on said cylinder sleeve and in said piston chamber; passage means for admitting fluid under pressure to said piston chamber; said cylinder sleeve having means enabling releasable connection with said packing means; and actuator means responsive to fluid pressure outside of said tool including an actuator member shiftable longitudinally of said cylinder sleeve.

25. A running and operating tool as defined in claim **24,** including means for initially holding said actuator member against movement relative to said cylinder sleeve.

26. A running and operating tool as defined in claim **24,** including means for initially holding said actuator member against movement relative to said cylinder sleeve including means on said actuator member and said cylinder sleeve providing a pressure chamber, said actuator member having an area in said pressure chamber exposed to the pressure therein.

27. A running and operating tool as defined in claim **24,** including means for initially holding said actuator member against movement relative to said cylinder sleeve including means on said actuator member and said cylinder sleeve providing a pressure chamber, said actuator member having an area in said pressure chamber exposed to the pressure therein, said cylinder sleeve having inlet means for supplying pressure to said pressure chamber.

28. A running and operating tool as defined in claim **24,** wherein said body has inlet passages at both sides of said piston.

29. A running and operating tool as defined in claim **24,** including shearable means releasably connecting said cylinder sleeve to said body.

30. A running and operating tool as defined in claim **29,** wherein said means defining said piston chamber comprises a cylinder head threaded on said body, said cylinder sleeve and said body and cylinder being sealingly and slidably engaged at opposite sides of said piston, said actuator member including a differential area piston sleeve disposed about said cylinder sleeve, and an outer sleeve disposed about said cylinder sleeve and threaded thereon.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,924,678

DATED : December 9, 1975

INVENTOR(S) : ARTHUR G. AHLSTONE

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 43: change "applied" to --supplied--.

Column 2, line 55: change "form" to --from--.

line 57: cancel "in".

Column 5, line 7: change "64" to --65--.

Column 6, line 30: change "shore" to --bore--.

Column 7, line 62: change "34" to --304--.

Signed and Sealed this

Thirteenth Day of July 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks