United States Patent [19]

Murman et al.

[11] **3,741,295**

[45] **June 26, 1973**

[54] **REPLACEMENT OF SUB-SEA BLOW-OUT PREVENTER PACKING UNITS**

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[73] Assignee: **Hydril Company**, Los Angeles, Calif.

[22] Filed: **June 14, 1971**

[21] Appl. No.: **153,093**

Related U.S. Application Data

[62] Division of Ser. No. 60,066, July 31, 1970, Pat. No. 3,662,823.

[52] **U.S. Cl.** **166/.6**, 251/1, 277/31

[51] **Int. Cl.** **E21b 33/035**

[58] **Field of Search** ..... 166/.5, .6; 251/1; 277/31

[56] **References Cited**

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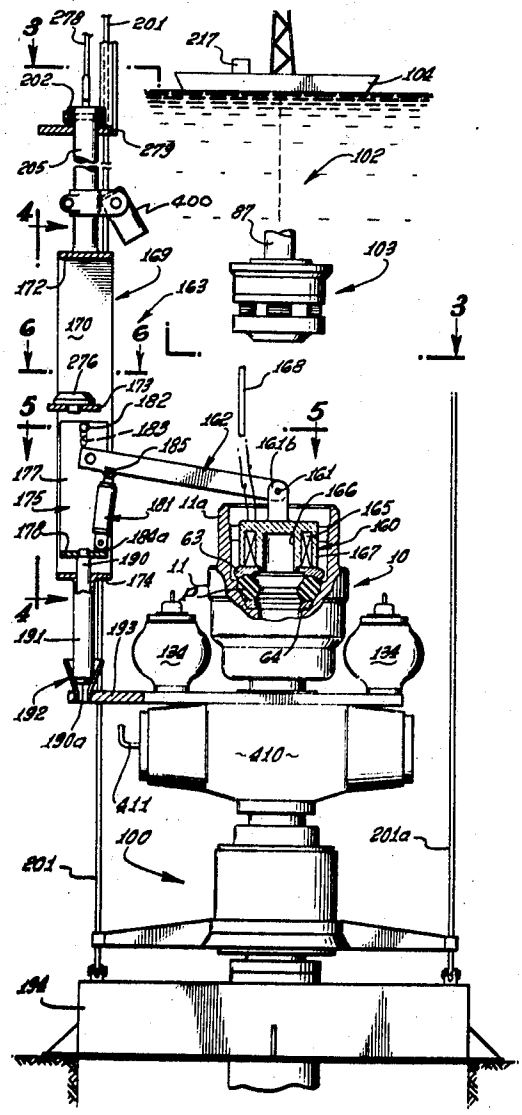
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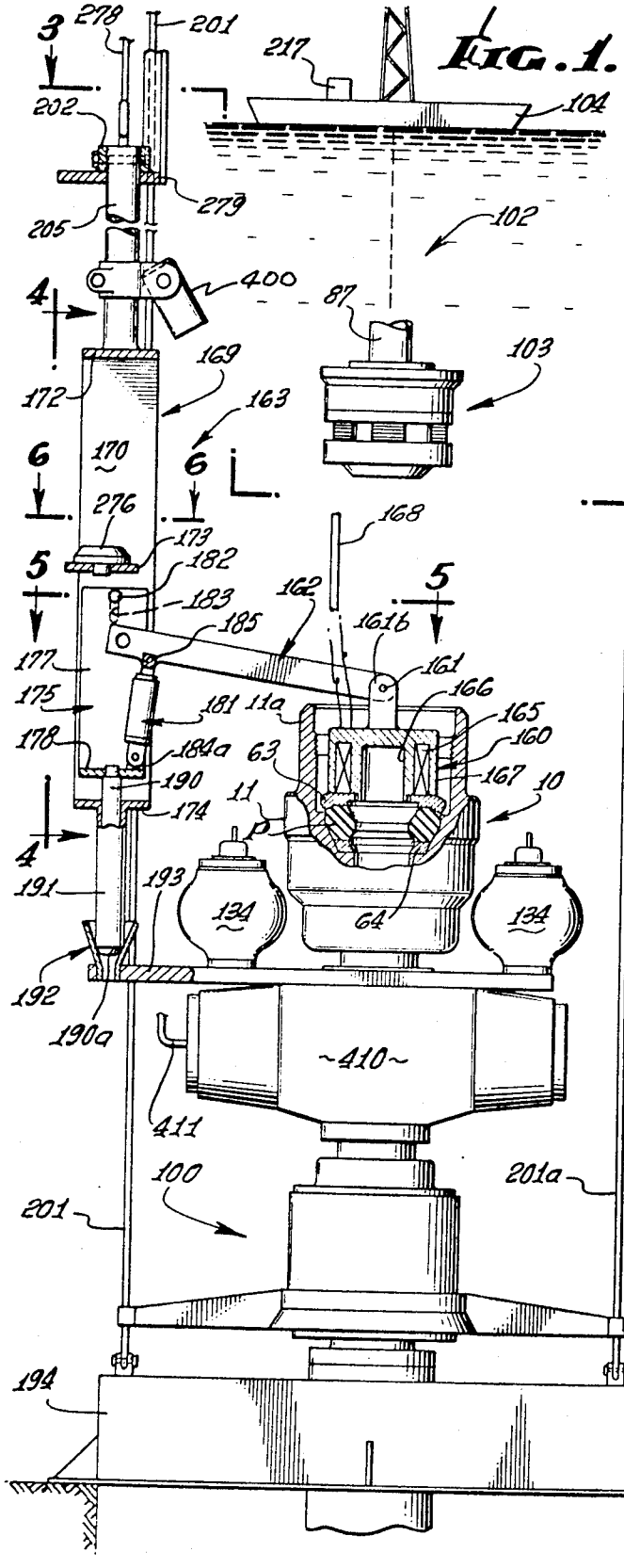
Primary Examiner—James A. Leppink
Attorney—White, Haefliger & Bachand

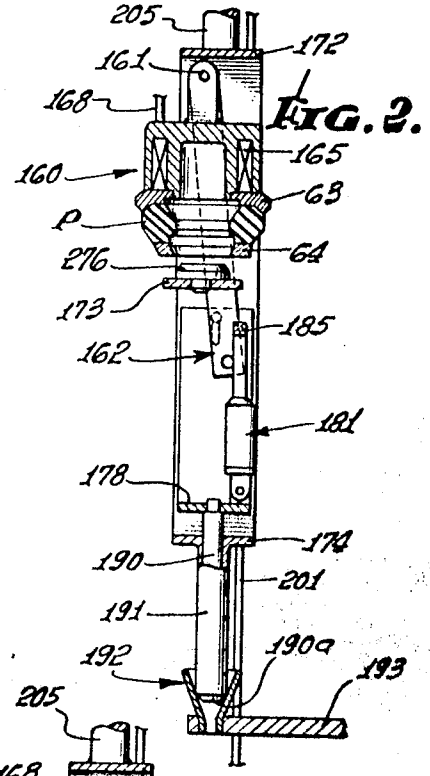
[57] **ABSTRACT**

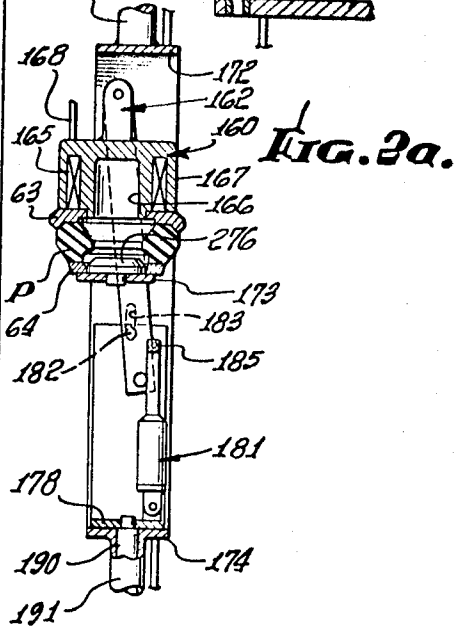
Apparatus and method to enable well blow-out preventer packer replacement at a sub-sea well head location.

19 Claims, 15 Drawing Figures




FIG. 1.
278
201
217
202
104
279
205
102
400
87
103
4
169
172
163
6
170
276
173
182
183
185
177
175
181
178
184a
190
174
191
193
192
190a
410
411
100
201a
194
3
5
162
161b
168
161
166
165
160
11a
63
167
10
11
P
64
134


FIG. 2.
205
161
172
168
165
160
63
P
276
64
173
185
162
181
178
174
190
201
191
192
190a
193


FIG. 2a.
205
168
172
162
165
160
167
63
166
276
P
173
64
183
182
185
181
178
190
174
191

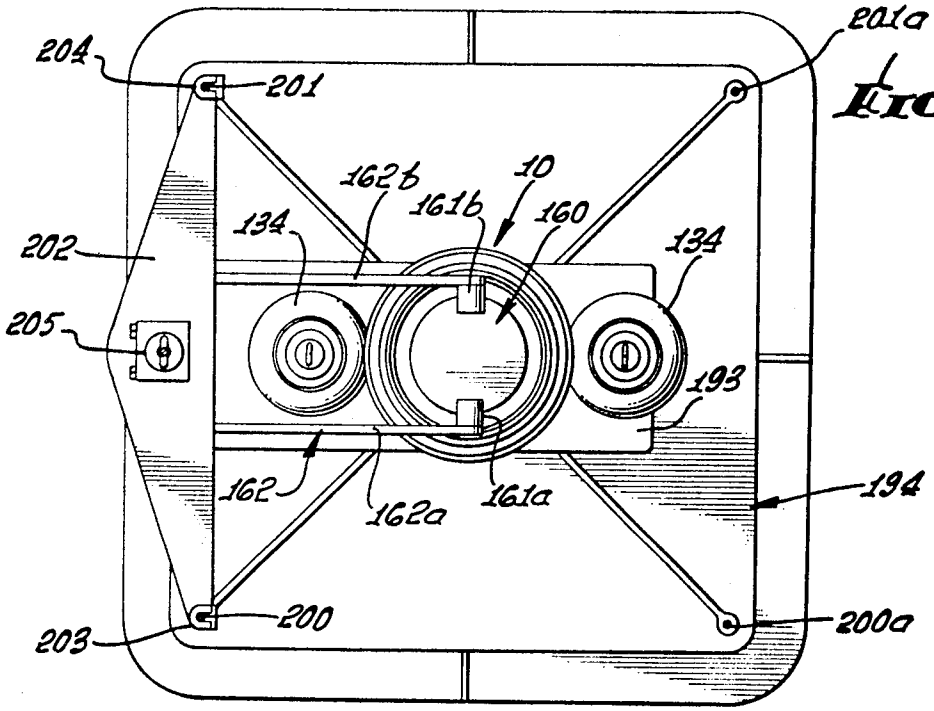


FIG. 3.

FIG. 11.

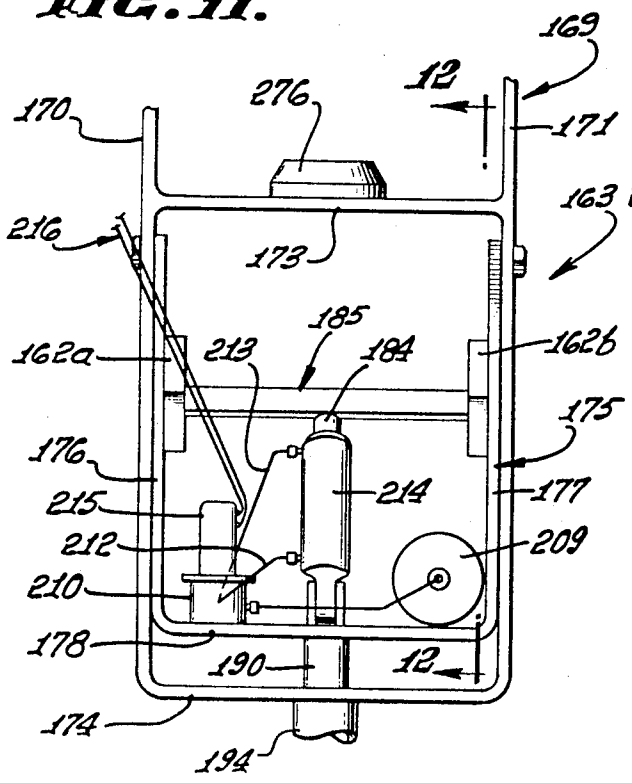


FIG. 12.

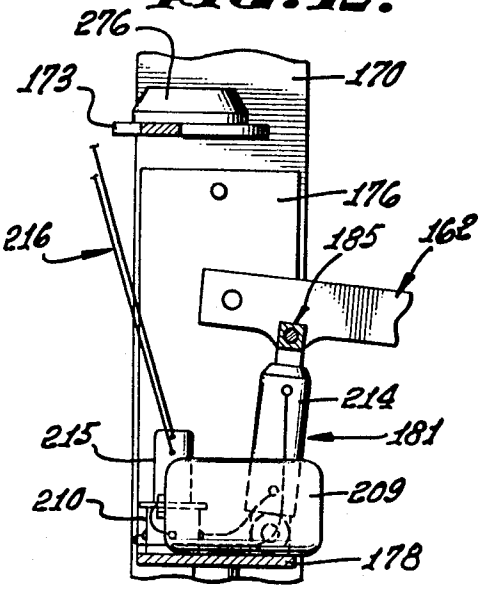


FIG. 5.

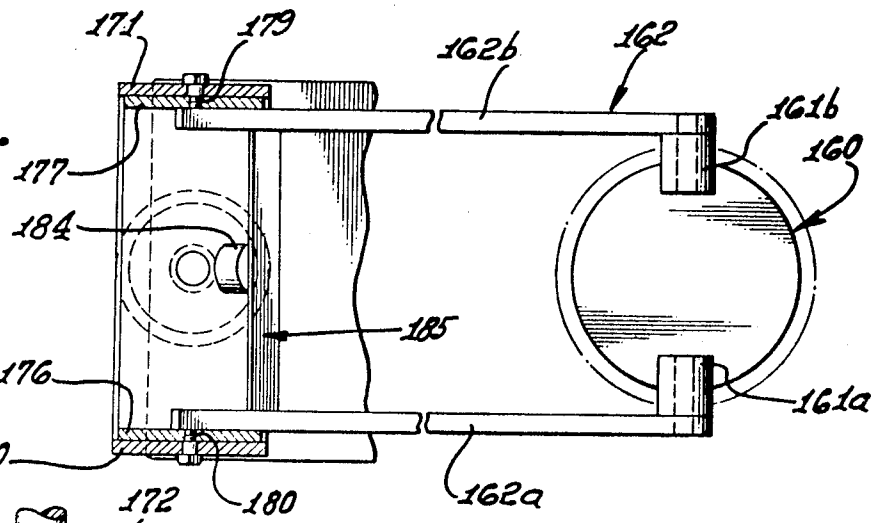


FIG. 4.

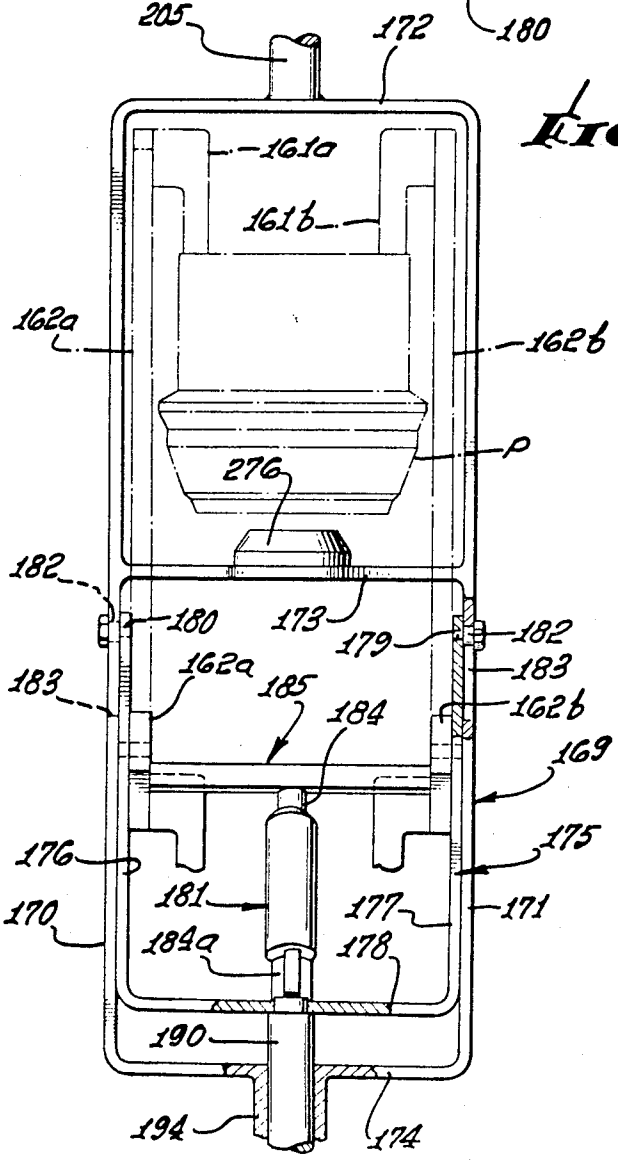


FIG. 6.

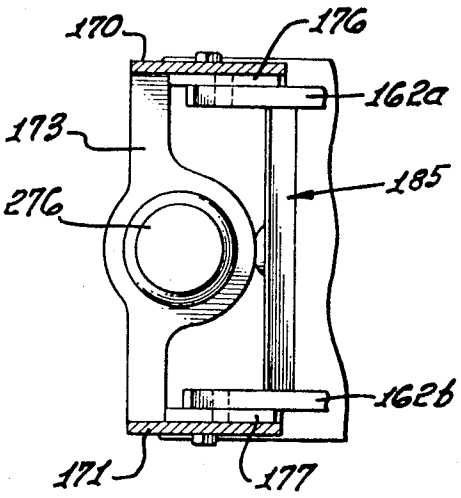


FIG. 1.

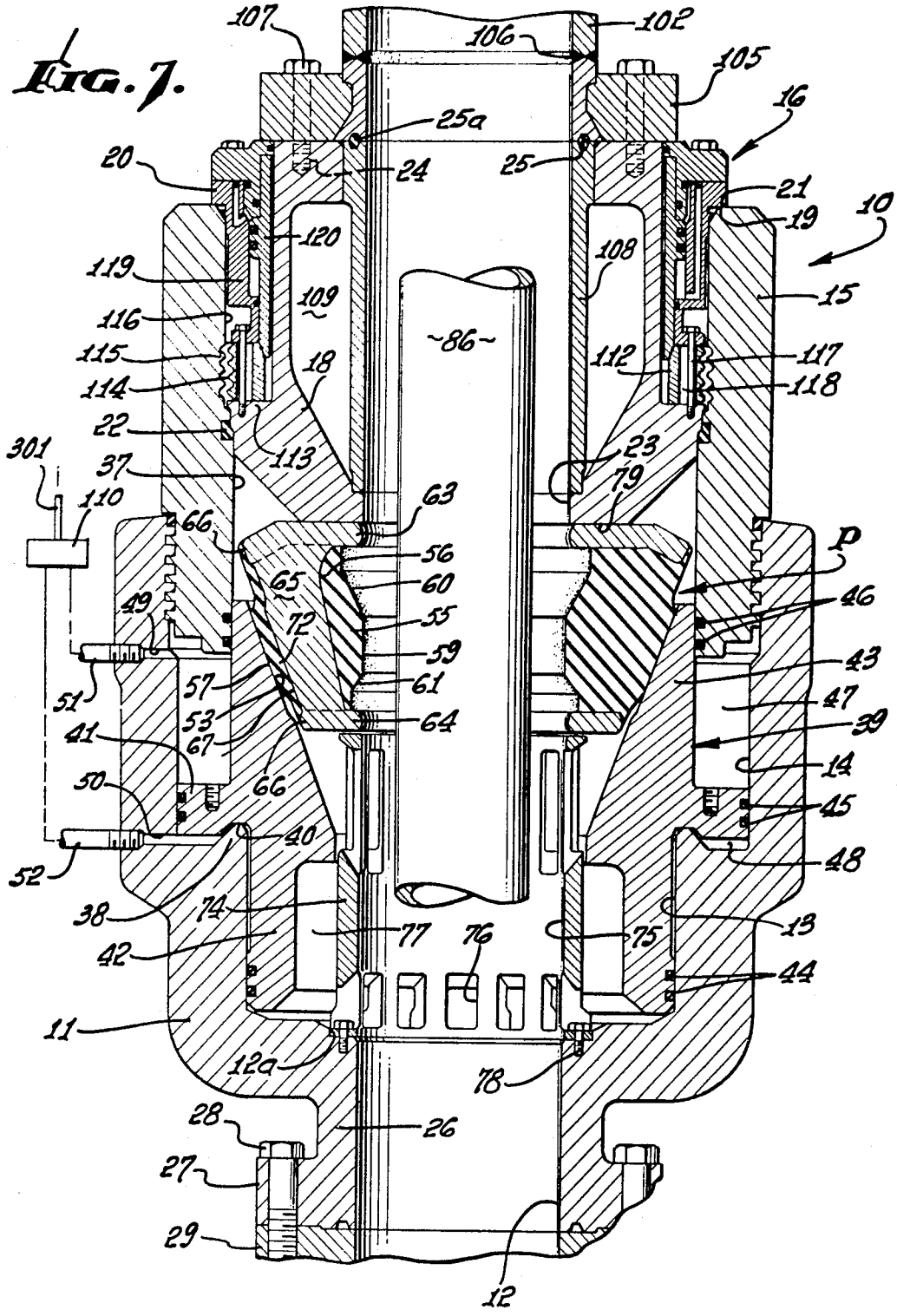

107
106
102
105
16
25a
20
24
25
21
19
10
120
108
119
109
15
116
~86~
112
117
115
18
118
114
22
113
23
301
37
79
63
110
66
56
P
65
60
46
49
55
72
59
43
51
57
61
47
53
64
39
41
67
14
66
50
45
40
48
52
38
74
77
76
75
13
42
44
11
12a
78
28
26
27
29
12

FIG. 10.

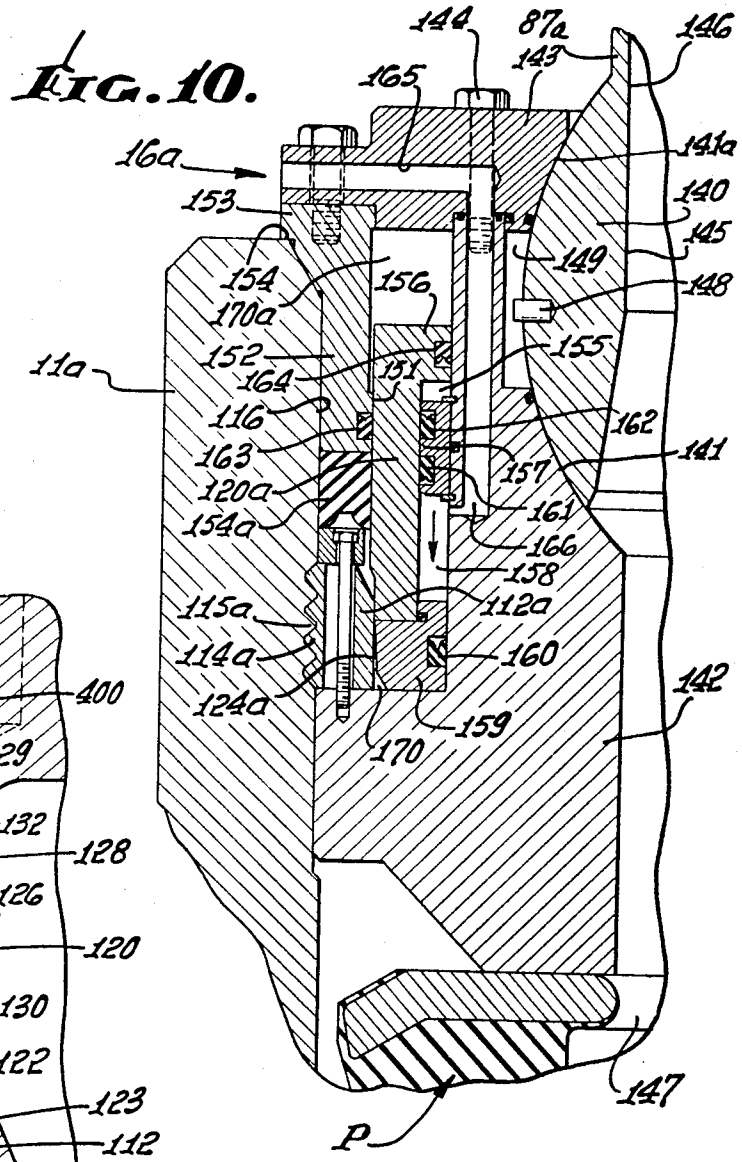

144
87a
146
143
165
16a
141a
153
140
145
154
149
170a
156
148
152
155
164
151
11a
116
162
163
157
141
120a
161
154a
166
158
115a
112a
114a
160
142
124a
159
170
147
P

FIG. 8.

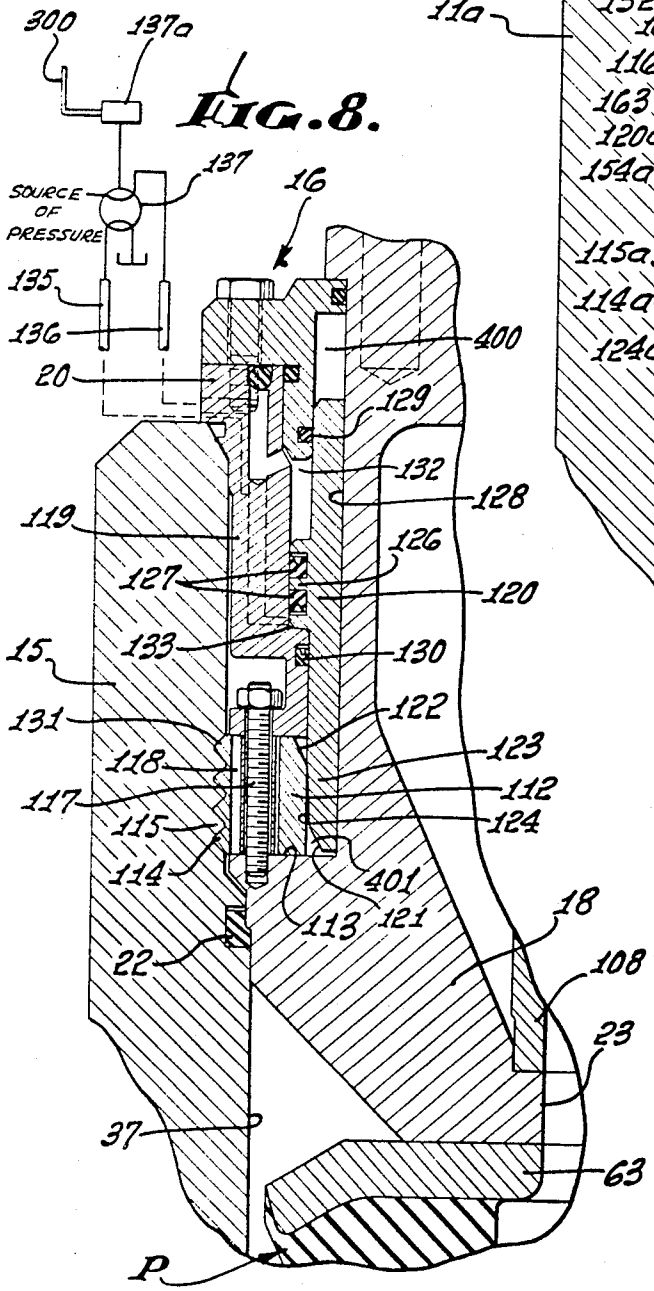
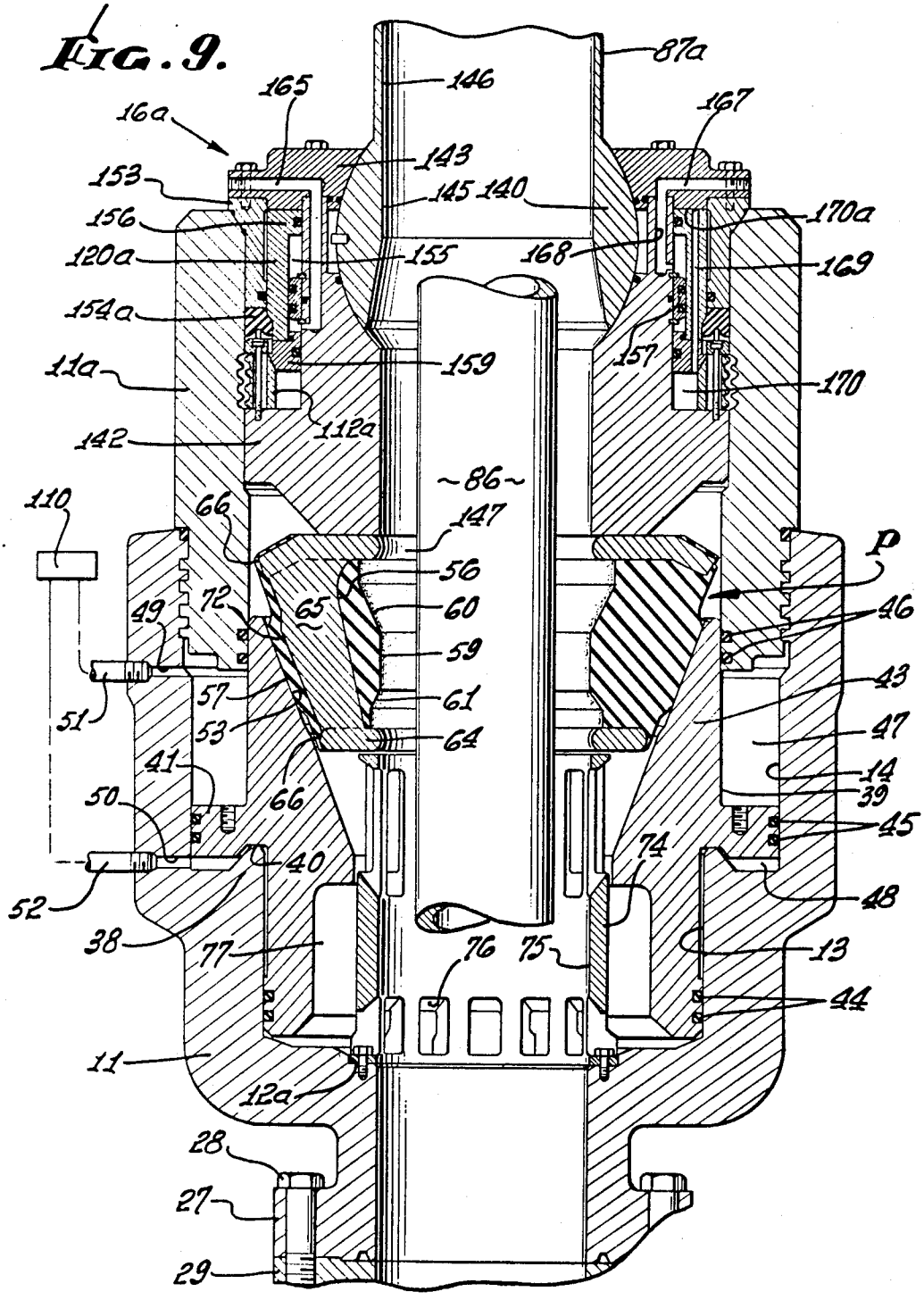

300
137a
137
SOURCE OF PRESSURE
16
135
136
400
20
129
132
128
119
126
127
120
133
130
15
122
131
123
118
112
117
124
115
401
114
113
121
18
22
108
23
37
63
P

FIG. 9.


87a
146
165
167
16a
143
153
145
140
156
170a
120a
155
168
169
154a
157
11a
159
170
112a
142
86
110
66
147
P
56
72
65
60
46
49
59
43
57
61
47
51
53
64
41
14
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76
75
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44
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12a
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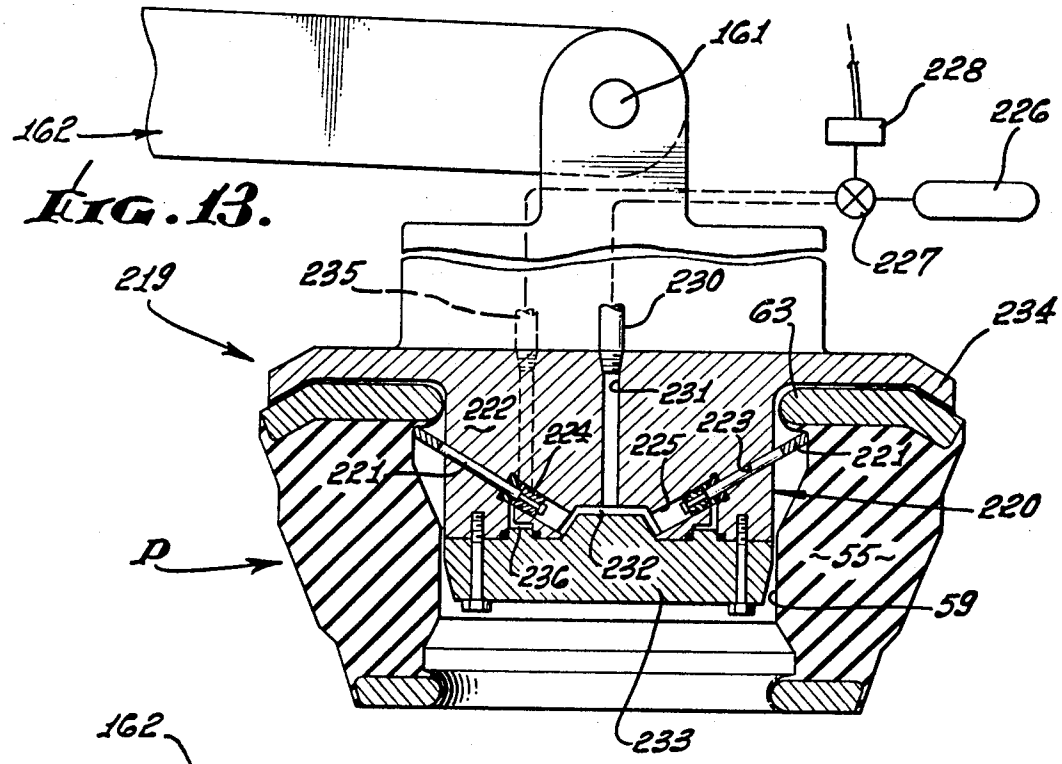

161
228
226
162
227
219
235
230
63
234
231
222
224
225
223
221
221
220
P
236
232
55
59
233

FIG. 13.

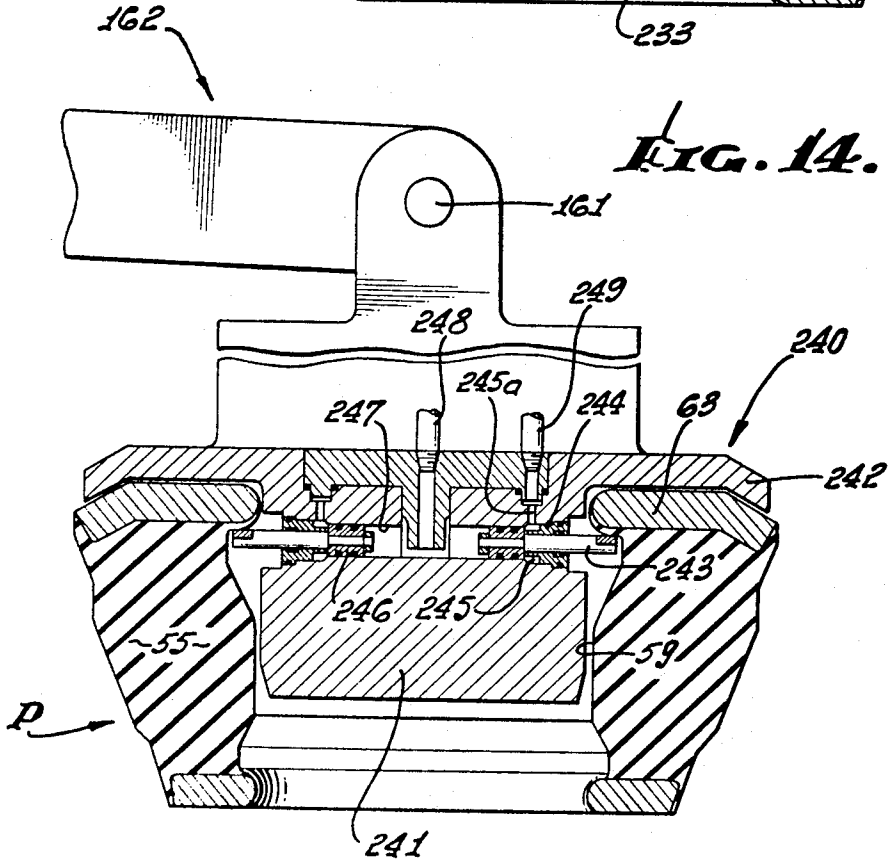

162
161
249
248
240
245a
247
244
63
242
243
246
245
55
59
P
241

FIG. 14.

REPLACEMENT OF SUB-SEA BLOW-OUT PREVENTER PACKING UNITS

This application is a division of Ser. No. 60,066 filed July 31, 1970, now U.S. Pat. No. 3,662,823.

BACKGROUND OF THE INVENTION

This invention relates generally to replacing blow-out preventer packers in housings therefor, and more particularly concerns such replacement carried out at sub-sea well head locations.

The replacement of blow-out preventer packers located at off-shore sub-sea installations is presently extremely expensive due to the relatively great amount of time involved in carrying out such replacement. For example, up to twenty hours and more time is consumed in pulling to the surface the entire stack of equipment at the well head, replacing the preventer packer, and lowering and re-installing the stack at the ocean floor. Accordingly, there is a great need for method and apparatus for carrying out a packer replacement operation without requiring such elevation and lowering of the entire stack.

SUMMARY OF THE INVENTION

It is a major object of the invention to provide a solution to the above problem, enabling blow-out preventer packer replacement at the sub-sea well head location and at greatly reduced expense. Basically, and in its method aspects, the invention contemplates the retrieval of the packer from an annular body to which packer hold-down means is releasably attached. The method includes the steps of elevating the hold-down means relative to the body to expose the packer for removal; advancing a packer retrieval tool laterally and downwardly to penetrate the body, and effecting lifting attachment of the tool to the packer; and retracting the tool, with packer attached, upwardly and laterally to lift the packer out of vertical alignment with the body, enabling its subsequent elevation to the surface. As will be seen, the lifting tool may become magnetically attached, or mechanically attached to the packer to lift it from the body or housing at sub-sea locations, and the hold-down means may be preliminarily elevated as by lifting a tubular riser to which the hold-down means is attached. Additional steps may include the lowering of a replacement packer to a location proximate the preventer body from which the original packer has been retrieved; advancing the tool, with replacement packer attached, laterally and downwardly to penetrate the body; detaching the tool from the packer; retracting the tool upwardly and laterally from the body; and lowering the hold-down means for attachment to the body.

In one important apparatus aspect, the invention comprises an annular body and a fluid pressure responsive packer actuator movable vertically in the body; an annular packer received downwardly in the body and supported by the actuator for radial construction and expansion; hold-down means carried to block upward displacement of the packer in response to upward movement of the actuator; and other means for effecting locking of the hold-down means to the body and unlocking thereof to permit upward removal of the hold-down means from the body, followed by upward withdrawal of the packer. Typically, the hold-down means may have telescopic interfit with the body, and referred

to other means may include latch structure carried by the hold-down means for movement into and out of locking position relative to the body. Also, a fluid pressure responsive member may be carried by the hold-down means for movement in one direction to urge the latch structure into locking position, and for opposite direction movement to allow lateral movement of the latch structure out of said locking position. In this regard, the body is typically mounted in a sub-sea well head stack and a tubular riser is connected to the hold-down means for elevating same to a position in which the packer becomes upwardly exposed for removal from the body. The riser connection may advantageously comprise a ball and socket joint allowing for some misalignment and preventing excessive moment exertion on the body and stack.

Another important apparatus aspect of the invention concerns the provision of packer retrieval means located generally laterally of the body and riser and having a part bodily movable laterally and downwardly into the body for lifting the packer from the body. Such retrieval means may include a carrier that is vertically movable relative to the stack, as for example to and from the surface, and an arm operatively connected to the carrier and supporting the part for bodily movement between lowered position in which the retrieval part projects within the annular body for operative connection to the packer, and raised position in which the part and packer are laterally offset from the stack for elevation by the carrier to the sea surface. As will be seen, the arm may have pivotal connection to the carrier, and locating means may be provided for locating the carrier in predetermined offset relation to the stack in response to lowering of the carrier laterally of the stack.

Further, retention means may be provided on the carrier to interfit the packer in raised position thereof and in response to carrier elevation, thereby to positively retain the packer on the carrier during elevation to the surface. Such functioning is facilitated with unusual advantage by means of a retention plug sized to upwardly penetrate the packer central passage, and by pivotally suspending the packer lifting part from the arm, as will be seen. In addition, the carrier may comprise a first section connected to the retention means, and a second section to which the arm has pivotal connection, the second section being movable vertically relative to the first section to effect the interfit of the retention means with the packer in response to initial elevation of the carrier relative to a portion of the locating means attached to the stack.

These and other objects and advantages of the invention, as well as the details of illustrative embodiments, will be more fully understood from the following description and drawings, in which:

DRAWING DESCRIPTION

FIG. 1 is a vertical side elevation showing a sub-sea well head assembly;

FIG. 2 is an elevation showing a retrieved packer in its carrier;

FIG. 2*a* is a view similar to FIG. 2, showng the retrieved packer retained on the carrier;

FIG. 3 is an enlarged section taken on line 3—3 of FIG. 1;

FIG. 4 is an enlarged elevation taken in section on lines 4—4 of FIG. 1;

FIG. 5 is an enlarged plan view taken on lines 5—5 of FIG. 1;

FIG. 6 is an enlarged fragmentary section taken on lines 6—6 of FIG. 1;

FIG. 7 is a vertical elevation taken in section showing a complete blow-out preventer assembly constructed in accordance with the invention;

FIG. 8 is an enlarged fragmentary showing of the hold-down means illustrated in FIG. 7;

FIG. 9 is a vertical elevation taken in section showing another modified hold-down means;

FIG. 10 is an enlarged fragmentary showing of the hold-down means of FIG. 9;

FIG. 11 is an enlarged front elevation of the FIG. 1 carrier for retrieving and installing a blow-out preventer packing unit;

FIG. 12 is a vertical elevation taken on line 12—12 of FIG. 11; and

FIGS. 13 and 14 are vertical elevations taken in section to show other methods of retrieving (or installation) attachment to a packer.

DETAILED DESCRIPTION

Referring first to FIG. 1, the new type blow-out preventer assembly 90 is shown connected in a sub-sea stack 100. A riser system 102 extends above the stack and is connectible thereto by a connector 103 which also serves as a packer hold-down means as will be described. Riser pipe 87 extends into the sea surface, and typically to a drilling barge 104 or other installation, for conducting production fluid to the surface, as within production tubing installable within pipe 87 by known techniques, and better indicated at 86 in FIG. 7.

Turning to FIG. 7, the control head or preventer assembly, generally indicated at 10, includes a body member 11, having concentric bores 12, 13 and 14, which are of progressively increased diameters. Releasable hold-down means 16 is releasably held to the body member in telescopically interfitting relation and in such a position that the face 19 of flange 20 engages the upper end 21 of the body member 15, the latter and hold-down annulus 18 being packed off at 22. Annulus 18 has a bore 23 which may be of the same diameter as, and concentric with, body bore 12. Sunk in the upper face of annulus 18 are bolt holes 24 for the attachment of a flange 105 to which the riser 87 is fastened as by welding at 106, the bolts being shown at 107. An annular groove 25, in the upper face of a sleeve 108 is adapted to receive a sealing ring 25*a* for sealing engagement with the riser. Sleeve 108 interfits the annulus 18 to define a hollow 109, reducing the weight of the hold-down means 16.

The lower neck 26 of body member 11 has an attachment flange 27 whereby connection is made through bolts 28 to the flange 29 or any other suitable fitting.

The body 11 has an annular, upstanding flange 38 which engages the packer actuating member 39 at 40 to limit the extent of downward movement of said member. The actuator 39 has a piston portion 41, having piston-fit in bore 14, and the actuator is extended upwardly at 43, extension 43 having piston fit in the bore 37 of member 15. Sealing rings 44, 45 and 46 are provided between actuator portions 42, 41 and 43, respectively, and the respective cylinder defining walls which receive those portions.

Piston 41 divides body bore 14 into upper and lower cylinders or pressure chambers 47 and 48, ports 49 and 50 opening, respectively, from those chambers. External pipes 51 and 52 open to ports 49 and 50, respectively. Note that the outer diameters 14 of chambers 47 and 48 are equal, and the inner diameters 13 and 37 of these chambers may be equal, for balancing purposes. Means to controllably deliver fluid pressure to chambers 47 and 48 is indicated generally at 110.

The actuator 39 has a downwardly and inwardly tapering conical bore 53, and the actuator portion 43 which defines this bore may be considered broadly as an internal, conical wedge, or as a packer-constricting element.

Packer P includes a massive annulus or sleeve 55 of an elastomer and, preferably, resilient material such as rubber or Neoprene. In most instances, it is intended that a single packer be adapted for repeated opening and closing operations, and therefore it is preferable that it have relatively high resilient characteristics, so it may be self-restoring to open position when the constricting force is removed. From this point on in the description, it will be assumed that the packer has such resilient characteristics, but this assumption is not considered as limitative on my broader claims. It has been found that rubber having a durometer hardness of about 75 is suitable for general use in my packer but, again, this specification of relative hardness is not to be considered as limitative. The packer is shown as an unsplit, continuous annulus, but it will be understood that the disclosure is not limited to a packer wherein there is no split, so long as there is no angularly extending gap interrupting the continuity of the packer at times when it is inwardly contracted into sealing engagement with members positioned within its bore.

Included in the make-up of the packer is a series of rigid, rubber-flow-control elements 56. These elements may take different forms, and they are individually movable bodily with the rubber in its movement of contraction and expansion and also, to a limited extent, movable individually with respect to the rubber as will later appear. Taken together, the rigid control elements may be considered as a radially expansible and contractible armature embedded and bonded within annulus 55.

Molded annulus 55 has an outer conical face 57 which is complementary to actuator bore 53, and a bore which has a central, substantially cylindrical portion 59 and oppositely inclining upper and lower portions 60 and 61, respectively; the outward flare, in each case being toward the associated end of the annulus.

It will be seen that each element 56 comprises top and bottom plates 63 and 64, respectively, rigidly connected by vertical rib 65, the outer faces 66 of the plates and the outer face 67 of the rib having substantially the same degree of taper as bore 53 and annulus face 57. Or plates 63, 64 may be considered as transverse flanges on rib 65. Elements 56, which may be of steel, bronze, or any other suitable rigid material, are preferably positioned in the rubber at the time of molding and, preferably, the rubber and the elements are bonded together by the use of suitable adhesive during the molding process. The plates of the control elements are sectorial in shape, as viewed in plan, and are arranged in a circular series, with spaces left between the opposing side edges of the plates, both top and bottom. The plates are so sized that the two opposed side edges of adjacent elements are spaced apart, if following that as the elements move radially inward, the spaces be-

tween these, will diminish to form a line contact from end to end of the plates. This will prevent the rubber which will flow during the constriction of the annulus from being pinched off at the radially inward ends of the plates.

The annulus **55** is molded so its outer annular portion **72** projects radially outward beyond the outer faces **66** of the plates, it following that these metallic faces do not engage the wall of actuator bore **53.** For purposes of later description, annular portion **72** is considered as being that portion which extends radially from face **57** to the outer faces **67** of ribs **65.**

The packer is lowered, while hold-down means **16** is elevated, into the position of FIGS. **1** and **7,** the annulus **55** nicely fitting the upper portion of bore **53** without requiring appreciable radial constriction of the annulus. For positively limiting the downward movement of the annulus, a stop is provided in the form of tube **74** which is retained in housing bore **12***a*. The upper end of the tube provides the packer stop. The bore **75** of this tube is of the same diameter as bores **12** and **23,** and the tube is annularly spaced from both piston portion **42** and the lower end of actuator wedge-portion **43.** Ports **76** open from bore **75** to chamber **77,** which latter is annularly defined by the tube and the actuator portion **42** while it is retained endwise by bolts **78.**

When means **16** is subsequently secured in place, its horizontal under-surface **79** provides a stop for limiting upward movement of the packer, the upper plates **63** of control elements **56** sliding over this surface as the packer is radially constricted or expanded. The under-surface **79** and the upper end of tube **74** thus form vertically spaced stops which prevent appreciable vertical movement of the packer with relation to the body member **11.**

It will be seen that the radial constriction of the packer is accomplished by virtue of relative vertical movement between the packer and the actuator. While the illustrated embodiments show this relative movement as brought about by holding the packer against vertical movement with respect to the body member and then moving the actuator vertically with respect to the housing and packer, it will be understood the arrangement and operation may be reversed, and indeed may vary depending upon the type of blow-out preventer to be used.

An important aspect of the invention concerns the construction of the hold-down means **16** to permit its upward removal as by the riser **87,** and at the sub-sea stack location, thereby to permit retrieval of a thus exposed packer and installation of a new packer in the body **11.** In this regard, other means on the hold-down means **16** is operable to effect locking of the hold-down means to the body and unlocking thereof, such other means typically including latch structure carried by the hold-down annulus **18** for movement into and out of locking position relative to the body, as for example member **11** and **15.**

In the FIG. **7** and **8** example of such latch structure, a series of latch dogs **112** may be circularly supported on the shoulder **113** of the hold-down annular insert **18,** for radial movement bringing the latch dog teeth **114** into meshing engagement with the annular teeth **115** formed in the bore **116** of member **15.** Vertical pins **117** fit in slots **118** in the dogs to accommodate such movement of the dogs, while retaining them to the insert annulus **18,** the pins being carried by cylinder member **119.**

The referred to other means for effecting locking of the hold-down means to the body may also include a fluid pressure responsive member carried by the hold-down means for movement in one direction (as for example downwardly) to urge the latch dogs into the described meshing or locking condition, and for movement in the opposite direction to allow lateral movement of the dogs out of locking position. In the FIG. **7** and **8** example, the fluid pressure responsive member is shown to comprise the annular actuator **120,** the lower terminal of which includes a cam surface **121** to engage cam surfaces **122** of the dogs upon down-stroking of the actuator, thereby to effect interlocking of the teeth **114** and **115.** Lower terminal **123** also includes a slight downward and inward taper **124** to engage the dogs upon continued down-stroking, thereby to effect final forcible tightening of the interlock of the teeth, and to frictionally lock the actuator to the dogs during normal sub-sea operation of the blow-out preventer.

Actuator **120** includes a piston **126** working in the cylinder, with seals **127** sealing off there between. Also, the actuator has a slide fit on the surface **128** of the annular insert **18,** and seals **129** and **130** seal off between the actuator and the cap **20,** and the actuator and the cylinder, as shown. Accordingly, pressure chambers are formed at **132** and **133,** at opposite vertical sides of the piston **126,** to receive pressure from one of the pressure bottles **134** in FIG. **1,** or from the surface, and via appropriate piping **135** and **136,** and four-way valving **137** controllable from the surface as via electrical line **300** and actuator **137***a*. Pressure admitted to chamber **132** urges the actuator **120** downwardly to effect the interlock, as described; at which time fluid from chamber **133** may be exhausted to the sea; and pressure admitted to chamber **133** urges the actuator upwardly to release the interlock, at which time fluid from chamber **132** may be exhausted to the sea. The latter movement of the actuator allows the dogs **112** to be cammed inwardly by engagement with the member **15** at **131** as the hold-down means is lifted out of the body **11** as by the riser, when replacement of the packer is to be effected.

FIGS. **9** and **10** show a connection of the riser **87***a* to the hold-down means **16***a* in the form of a ball **140** attached to the riser, and socket **141** and **141***a* formed by the annulus **142** and cap **143,** the latter two elements being integrally connected as by bolts **144.** The ball contains a through passage **145** in registration with the bore **146** of the riser and the opening **147** defined by the packer P. Pivoting of the ball in the socket allows for limited vertical misalignment as between the riser and the housing or body **11** of the preventer, whereby transmission of bending moments to or from the stack **100** are relieved, and the bolted interconnections of the elements of the stack and in the riser are not overstressed. Engagement of a lug **148** on the ball with the sides of a slot **149** is to limit relative rotation of the riser and the hold-down means.

Also, the structure operable to displace the latch dogs **112***a* is somewhat modified. As illustrated, the actuator **120***a* now works up and down within the bore **151** defined by the cylinder **152,** the upper flange **153** of which seats on the shoulder **154** of the body member **11***a*. A compressible elastomer annulus **154***a* seals off

between the actuator and the bore 116 of member 11*a*, whereby sea water cannot continue to gain access to the latch dogs from the exterior once the hold-down means is assembled in place. Upper pressure chamber 155 is formed between the actuator piston 156 and the ring 157, and lower pressure chamber 158 is formed between the actuator piston 159 and that ring, there being suitable seals as at 160 – 164. Down-stroking pressure is provided via porting 165 and 166, whereas up-stroking pressure is supplied via porting 167 and 168. A bleed port 169 communicates between the chamber 170 at the lower end of the piston 159 and the chamber 170*a* at the upper end of piston 156 to prevent differential pressure build-up in these chambers as the piston moves. The lack of a gasket at surface 128 in FIG. 8 allows pressure balance between chambers 400 and 401. (Elements 114*a*, 115*a* and 124*a* in FIG. 10 correspond to 114, 115 and 124 in FIG. 8).

Turning now to FIGS. 1 – 6, 11 and 12, a further aspect of the invention concerns the provision of packer retrieval means located generally laterally of the blow-out preventer assembly 10, and riser 87, and having a part bodily movable generally laterally and downwardly into the body 11 for lifting the packer therefrom after preliminary elevation of the hold-down means by the riser. Such elevation may be accomplished from the derrick on the barge or vessel 104, after the hold-down means is pressurized to relieve the latch dogs for inward movement, as described.

The referred to lifting part is exemplified in FIG. 1 by an electromagnet 160 pivotally suspended at 161 from a lifting arm 162 operatively connected to a carrier 163, the latter being vertically movable relative to the stack. As illustrated, the electromagnet 160 is supported for bodily movement between lowered position (FIG. 1) in which it projects downwardly within the annular body 11 for operative connection to the packer, and raised position in which the electromagnet (or other part) and the packer are laterally offset from the stack for elevation by the carrier to the sea surface, FIG. 2*a* showing the stowed position of the packer during vertical travel with the carrier, either up or down. Electromagnet 160 typically may include a coil 165 extending between annular north and south pole elements 166 and 167, the lower terminals of which are magnetically attachable to the top plates 63 of the packer, where such plates consist of steel or other magnetizable material. An electrical control cable from the surface is indicated at 168. Note that the positioning of the carrier 163 and arm 162 are such that the electromagnet 160 is approximately centered over the packer in lowered position, at which time the coil 165 may be electrically energized. During vertical travel of the packer in the carrier, the electromagnet need not be electrically energized due to the stowed condition of the packer, as will be explained.

The carrier in FIGS. 1, 2, 2*a*, 4 – 6, 11 and 12 comprises a first frame section 169 including laterally spaced vertical members 170 and 171, and cross members 172, 173 and 174; the carrier also includes a second frame section 175 which is U-shaped and has vertical and horizontal members 176, 177 and 178. The arm 162 has laterally spaced members 162*a* and 162*b* pivotally connected at 179 and 180 to the second frame members 176 and 177, as better seen in FIG. 5. An actuator 181 on the carrier is connected at 184 to the arm and is operable to displace the arm between lowered position as seen in FIG. 1 and raised position as seen in FIG. 2.

The carrier carries what may be referred to as retention means operable to interfit the packer in its raised position and in response to elevation of the carrier, for retaining (i.e. stowing) the packer during its elevation to the surface, and likewise to stow a replacement packer being lowered from the surface to the sub-sea stack site. In this regard, FIG. 2 *a* shows one unusually advantageous retention means on which the packer is stowed during vertical travel of the carrier. As there shown, the retention means comprises a plug 276 mounted on carrier cross members 173 and sized for upwardly penetrating the central passage formed by the packer lower plates 64, with loose interfit of such plates. Such penetration is effected in response to initial raising of the carrier section 169 as by lifting cable 278 attached to the carrier via coupling structure 279 seen in FIG. 1. Such raising lifts the section 169 relative to the second section 175, as afforded by the lost-motion tongue and groove connection between the sections, thereby to take up the spacing between the horizontal members 174 and 178 as is clear from comparison of FIGS. 2 and 2*a*. Note in FIG. 4 the typical tongues 182 on members 176 and 177 received in the vertical slots or grooves 183 in members 170 and 171; the pivotal mounting 184*a* of the actuator 181 to the cross member 178, and the pivotal connection at 184 of the actuator to yoke 185 connected to the arm sections 162*a* and 162*b*.

Upon lowering of the carrier 163 to position seen in FIG. 2, the second frame section 175 is elevated relative to the first frame section 169 in response to centered engagement of a lifting element with a locating element, assuming the operating position shown in FIG. 2. In this regard, the lifting element may comprise a rod 190 connected to the second frame section 175 as shown and projecting downwardly through a guide tube 191 to protrude at 190*a* for centered engagement with the downwardly tapering centering receptacle 192 mounted on the stack arm 193. That arm is fixed relative to the stack 100 and base 194, as shown. The first frame section 169 continues to lower, following such engagement, until the tube 191 bottoms on the receptacle, as shown. Accordingly, the second section 175 is lifted by a predetermined amount relative to the first section 163, thereby to free a replacement packer from the retention means 276 during the replacement operation, and also the carrier is precisely located in lateral relation to the housing 11, enabling desired extension and lowering of arm 162 to enter the part 160, and a replacement packer, into the open-topped housing, as shown on FIG. 1.

Azimuthal centering of the carrier relative to the housing is assured by the guiding of the carrier on the vertical guide cables 200 and 201 as seen in FIG. 3. For this purpose, the cross-arm 202 integral with the carrier 163 has cable passing sleeves 203 and 204, as shown, a vertical rod 205 connecting the arm 202 with the carrier first frame section 169. Coupling 279 slides vertically on rod 205, and lifts upwardly against cross-arm 202, upon raising of the carrier. The connection 161 of the arm to the packer lifting part 160 may be effected by trunnions 161*a* and 161*b*, respectively, on the arm sections 162*a* and 162*b*, as seen in FIG. 5. Other guide cables attached to base 194 are shown at 200*a* and 201*a*.

FIGS. 11 and 12 show the provision of an actuator fluid pressure reservoir 209 and valve 210 mounted on the carrier 163, with a line 211 connecting the reservoir and valve, and lines 212 and 213 connecting the valve with opposite ends of the actuator cylinder 214. The valve motor 215 is controlled from the surface, as by control means 216. Note surface control means 217 which is connected with cables 168 and 216, and also to control cables 300 and 301 to controls 137*a* and 110 as shown on FIG. 7 and 8.

FIGS. 13 and 14 illustrate alternate forms of parts operable to lift and lower packers while suspended from the arm 162. In FIG. 13, the part 219 comprises a plug 220 downwardly insertible into a central opening or bore 59 formed by the packer elastomer body 55. One or more lifting elements 221 are carried by the plug body 222 to be extensible therefrom in under-fitting relation to the inner terminals of the upper plates 63, as shown, for mechanically coupling the plug to the packer. Such elements 221 may comprise plungers working in upwardly and outwardly angled bores 223, with pistons 224 integral with the plungers and working in cylinders 225. Fluid pressure delivery to the latter from a reservoir 226 is controlled by a valve 227, with valve motor 228 operated from surface control at 217 in FIG. 1. Elements 226 – 228 may be mounted on the carrier, in a manner similar to elements shown in FIGS. 11 and 12. Ducts and porting between the valve and cylinders 225 are shown at 230 – 232. A closure plate 233 attached to the plug 220 seals the porting 232 and cylinders 225, and the plug 220 carries an upper flange 234 which overlaps and interfits the upper plates 63 of the packer unit.

Similarly, fluid may be delivered from valve 227 via line 235 to the chamber 236 communicating with the opposite sides of the pistons 224, for retracting the filters.

The packer lifting part 240 in FIG. 14 likewise comprises a plug 241 fitting downwardly into central opening or bore 59 formed by packer body 55, an upper flange 242 integral with the plug fitting over the packer unit plates 63. The lifting elements 243 in this case are horizontally slidable within glands 244 sealing off between lifter retraction chambers 245 and the plug exterior. Pistons 246 carried by the lifters work in cylinders 247 to which fluid pressure may be supplied via line 248 for extending the lifters into the positions shown. Fluid for retracting the lifters is supplied via line 249 to chambers 245, with which the opposite sides of the pistons communicate via ports 245*a*.

In operation, the basic method of the invention includes the steps of elevating the packer hold-down means relative to the packer housing or body to vertically expose the packer for removal; moving a packer retrieval element laterally and downwardly to penetrate the body and effecting lifting attachment of the element to the packer; and moving the element with packer attached thereto upwardly and laterally to lift the packer out of vertical alignment with the body, for subsequent elevation of the packer to the surface, all of these steps being carried out underwater. As described, the attachment of the lifting element or part to the packer may be magnetically or mechanically effected. Further, a replacement packer may be lowered to predetermined location proximate the preventer body, the packer may then be lowered into the open-topped body followed by detachment of the lowering or lifting part from the packer and return of the tool out of alignment with the body, and the hold-down means may be replaced. Preliminarily, the well may be closed off at a level below the packer to block communication with the sea. Conventional blind rams 410 are operable to effect such closure, as via control cables 411.

In FIG. 1, the item 400 is a television camera in a circuit having a surface viewing screen to enable viewing of the packer replacement operation.

We claim:

1. In well blow-out preventer apparatus, the combination comprising

a. an annular body adapted to pass well equipment,

b. a fluid pressure responsive packer actuator movable in the body,

c. an annular packer received downwardly in the body and supported for generally radial construction and expansion in response to said actuator movement,

d. hold-down means carried to block upward displacement of the packer in response to movement of the actuator,

e. other means for effecting locking of the hold-down means to the body and unlocking thereof to permit upward removal of the hold-down means from the body followed by withdrawal of the packer therefrom,

f. said hold-down means having telescopic interfit with said body, and said other means including latch structure carried by the hold-down means for movement into and out of locking position relative to said body, and

g. said other means including a fluid pressure responsive member carried by said hold-down means for movement in one direction to urge said latch structure into said locking position, and for movement in the opposite direction to allow lateral movement of the latch structure out of said locking position.

2. The combination of claim 1 wherein said latch structure includes a circular series of latch dogs received downwardly within said body on an annular insert portion of said hold-down means.

3. The combination of claim 2 wherein the lower terminal of said annular insert portion of said hold-down means provides a stop against which the upper surface of the packer is engageable, said packer including an elastomeric body and metallic inserts carried thereby and having upper plates defining said upper surface.

4. The combination of claim 1 including a sub-sea well head stack mounting said body, and a tubular riser extending upwardly from said hold-down means.

5. The combination of claim 4 wherein said riser has connection to said hold-down means for elevating said hold-down means relative to said body and to a position in which said packer is upwardly openly exposed for removal from the body.

6. In well blow-out preventer apparatus, the combination comprising

a. an annular body adapted to pass well equipment,

b. a fluid pressure responsive packer actuator movable in the body,

c. an annular packer received downwardly in the body and supported for generally radial constriction and expansion in response to actuator movement,

d. hold-down means carried to block upward displacement of the packer in response to movement of the actuator,

e. other means for effecting locking of the hold-down means to the body and unlocking thereof to permit upward removal of the hold-down means from the body followed by withdrawal of the packer therefrom, and

f. a sub-sea well head stack mounting said body, and a tubular riser extending upwardly from said hold-down means, said riser having connection to said hold-down means for elevating said hold-down means relative to said body and to a position in which said packer is upwardly openly exposed for removal from the body, and said riser connection to the hold-down means comprising a ball and socket, the ball defining a vertical passage above an opening defined by the packer.

7. The combination of claim **6** wherein said hold-down means has telescopic interfit with said body, and said other means includes latch structure carried by the hold-down means for movement into and out of locking position relative to said body.

8. The combination of claim **7** wherein said other means includes a fluid pressure responsive member carried by said hold-down means for movement in one direction to urge said latch structure into said locking position, and for movement in the opposite direction to allow lateral movement of the latch structure out of said locking position.

9. The combination of claim **6** including packer retrieval means located generally laterally of said body and riser and having a part bodily movable laterally and downwardly into said body for lifting the packer therefrom after preliminary elevation of the hold-down means by said riser.

10. The combination of claim **9** wherein said part comprises an electromagnet.

11. The combination of claim **9** wherein said part comprises a plug downwardly insertible into a central opening defined by the packer, and including a lifting element carried by the plug for movement into packer lifting position.

12. The combination of claim **9** including vertically extending guy wires to which the packer retrieval means has guided connection for elevation and lowering thereof relative to the stack.

13. The combination of claim **9** wherein said packer retrieval means includes a carrier that is vertically movable relative to the stack, and an arm operatively connected to the carrier and supporting said part for said bodily movement between lowered position in which said part projects within said annular body for operative connection to the packer, and raised position in which said part and the packer are laterally offset from the stack for elevation by the carrier to the sea surface.

14. The combination of claim **13** wherein said arm has pivotal connection to the carrier, and including locating means for locating the carrier in predetermined relation to the stack in response to lowering of the carrier laterally of the stack.

15. The combination of claim **14** including retention means on the carrier to interfit the packer in raised position thereof and in response to elevation of the carrier, for positive retention of the packer on the carrier during elevation to the surface.

16. The combination of claim **15** wherein said retention means comprises a plug sized to upwardly penetrate the central passage formed by the packer in said raised position.

17. The combination of claim **15** wherein said carrier comprises a first section connected to said retention means, and a second section to which the arm has said pivotal connection, the second section being movable vertically relative to said first section to effect said interfit of the retention means with the packer in response to initial elevation of the carrier relative to a portion of said locating means attached to the stack.

18. The combination of claim **13** wherein said part is pivotally suspended from said arm.

19. The combination of claim **13** including an actuator on the carrier and operable to displace said arm between positions corresponding to said raised and lowered positions of said part.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,741,295 Dated June 26, 1973

Inventor(s) Fernando Murman, George E.Lewis, Allen I. Dunn and Charles E. O'Brien

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

Column 10, line 17; "body and supported for generally radial construc- " should read -- body and supported for generally radial constric- --

Signed and sealed this 6th day of August 1974.

(SEAL)
Attest:

McCOY M. GIBSON, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents