Sept. 8, 1964 J. A. HAEBER ETAL 3,147,992

WELLHEAD CONNECTOR

Filed April 27, 1961 6 Sheets-Sheet 1

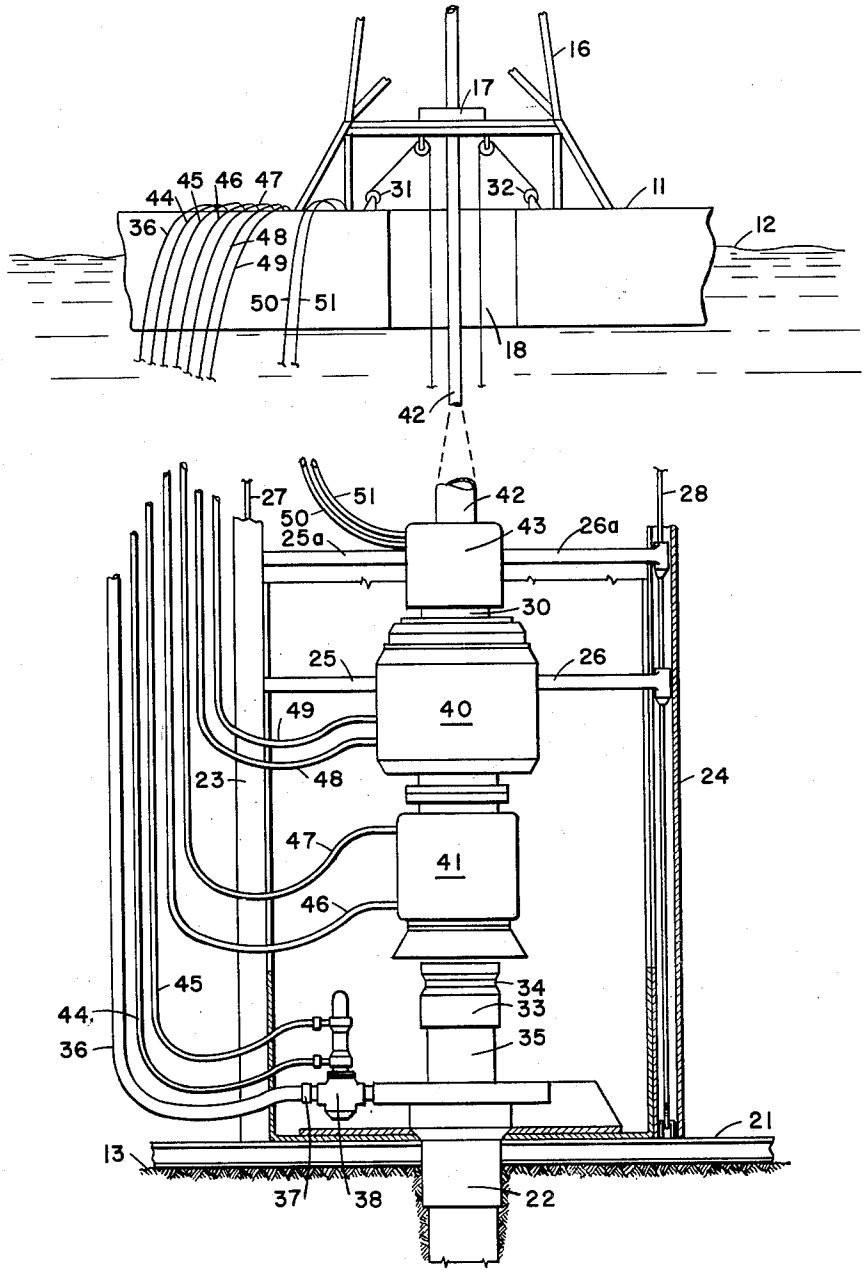

FIG. 1

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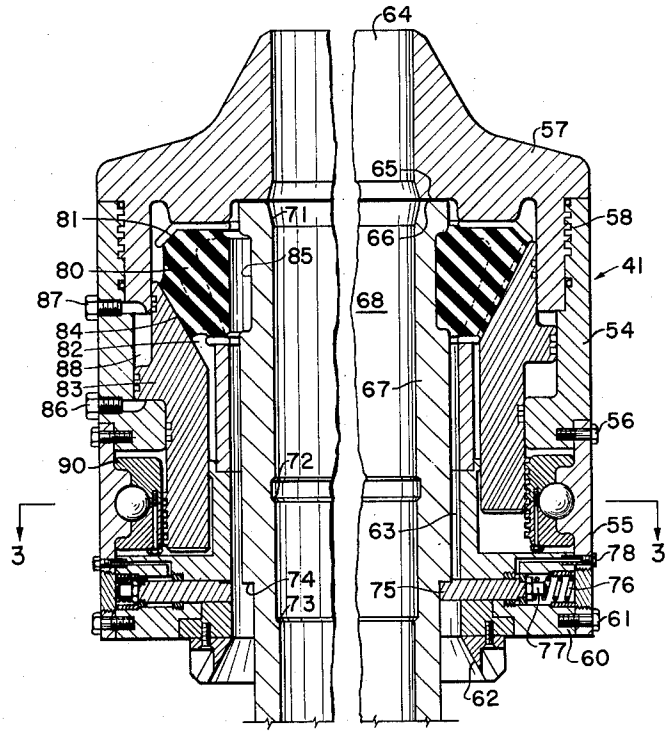

FIG. 2

FIG. 2A

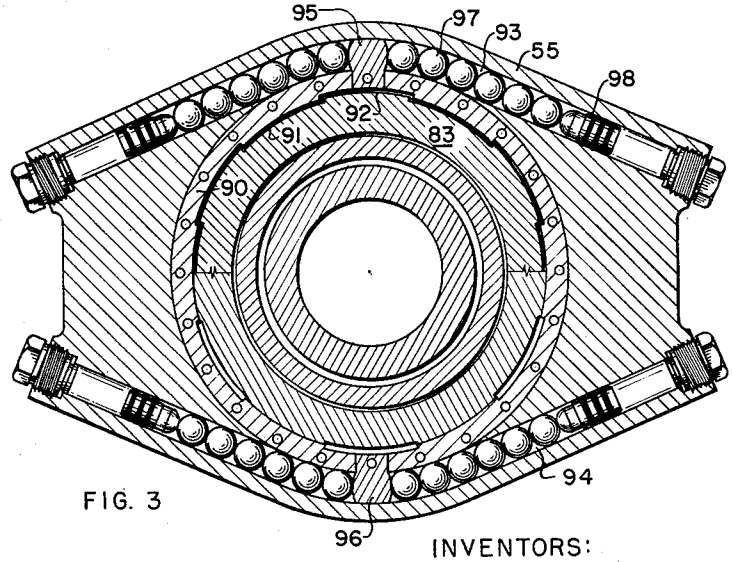

FIG. 3

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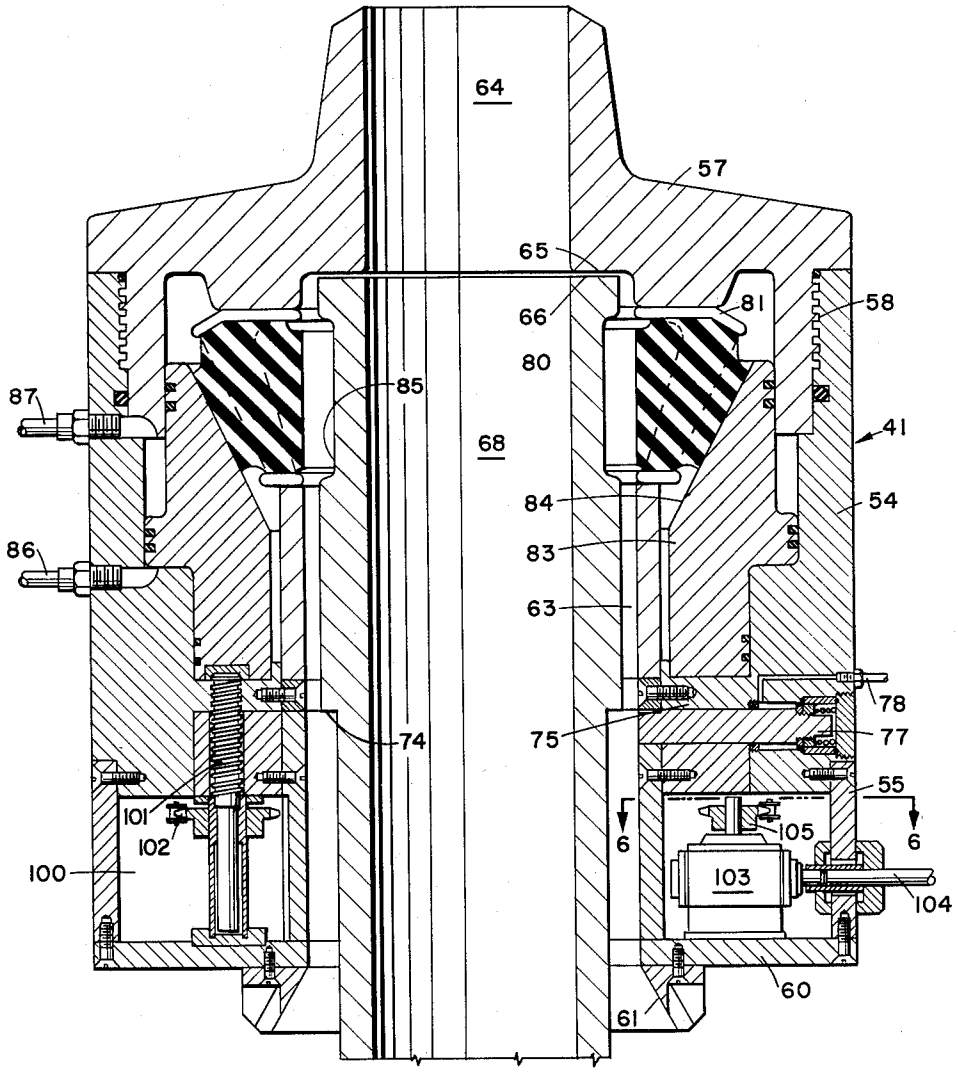

FIG. 4

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WELLHEAD CONNECTOR

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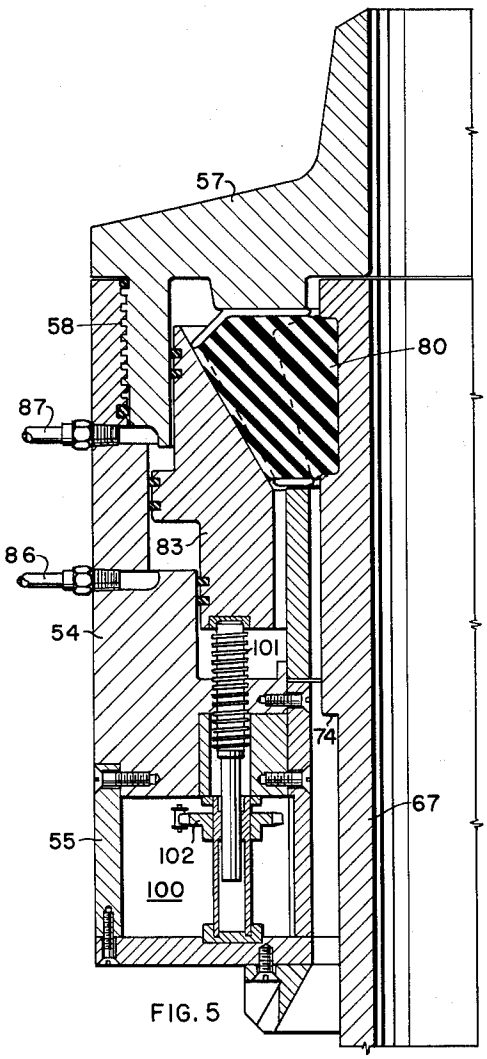

FIG. 5

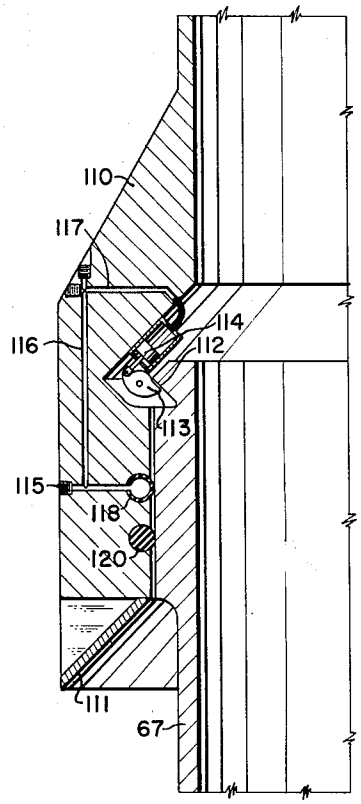

FIG. 10

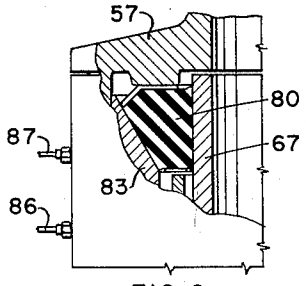

FIG. 9

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WELLHEAD CONNECTOR

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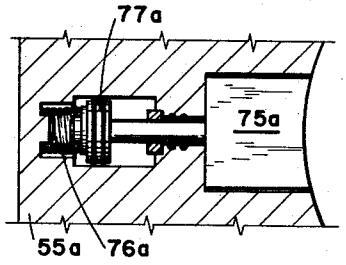

FIG. 7

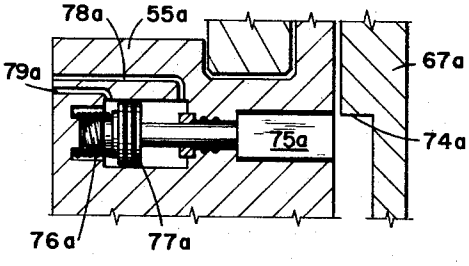

FIG. 8

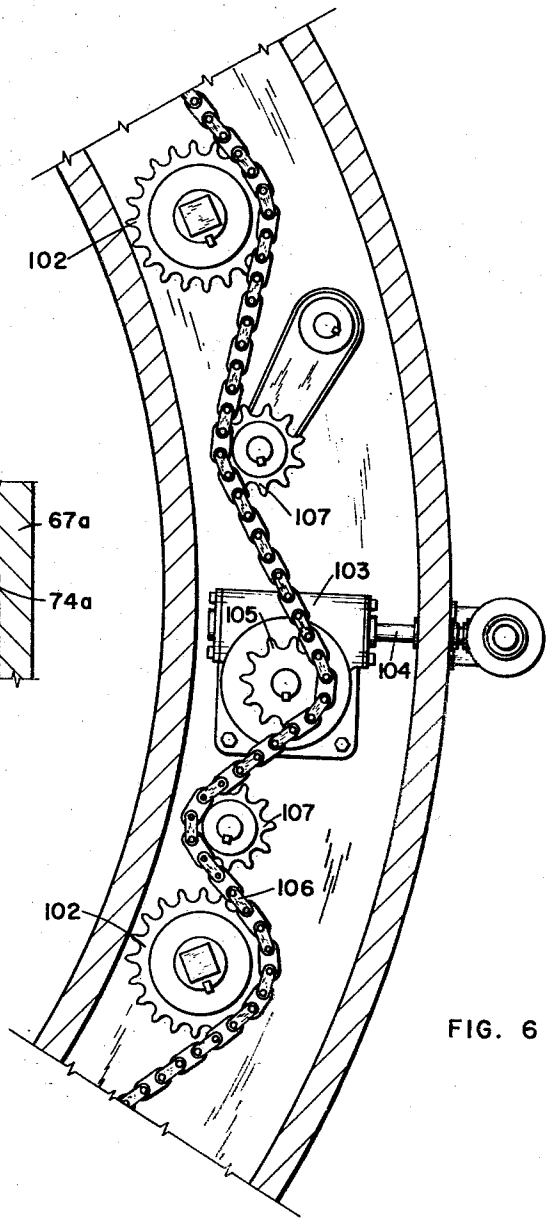

FIG. 6

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WELLHEAD CONNECTOR

Filed April 27, 1961 6 Sheets-Sheet 6

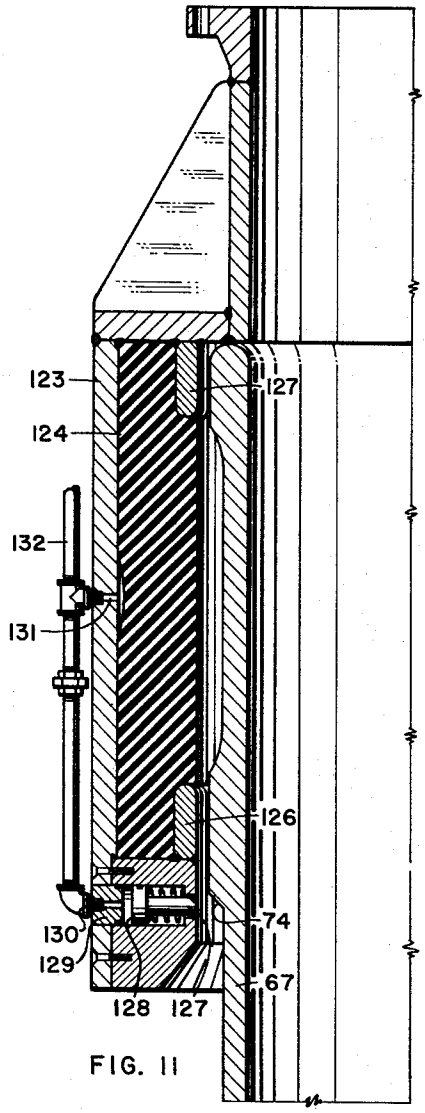

FIG. 11

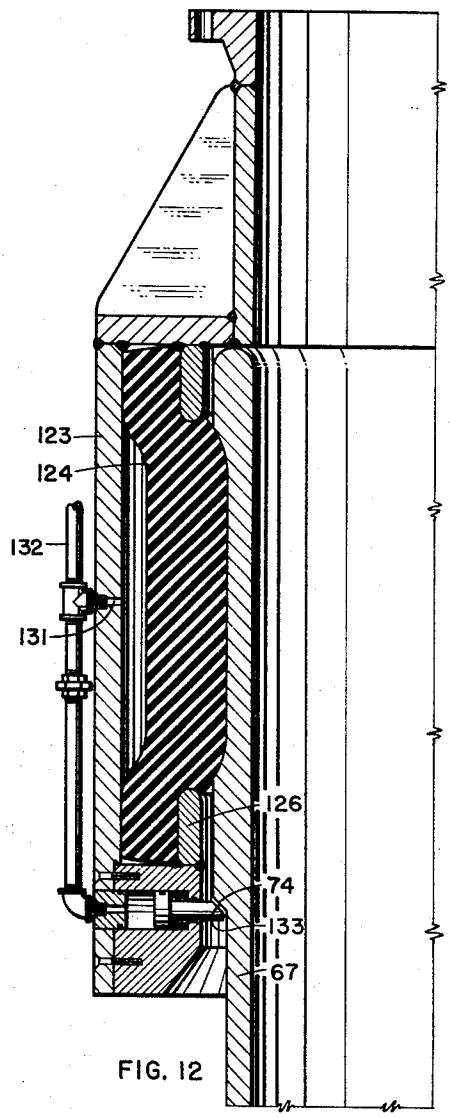

FIG. 12

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United States Patent Office 3,147,992 Patented Sept. 8, 1964

3,147,992

WELLHEAD CONNECTOR

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Filed Apr. 27, 1961, Ser. No. 105,980
5 Claims. (Cl. 285—18)

This invention relates to apparatus for use on offshore wells and pertains more particularly to a wellhead apparatus adapted to be securely locked on a well casinghead positioned under water. The present invention is especially concerned with apparatus for connecting a wellhead component, such for example as a blowout preventer, to a vertically extending wellhead component in a securely locked and fluidtight manner so that the wellhead component could not be accidentally separated from the vertically extending well member.

In an attempt to locate new oil fields an increasing amount of well drilling has been conducted at offshore locations, such for example, as off the coast of Louisiana, Texas, and California. As a general rule, the strings of casing in a well together with the tubing string or strings extend to a point well above the surface of the water where they are closed in the conventional manner that is used on land wells, with a conventional wellhead assembly being attached to the top of the casing. Attempts have been recently made to provide methods and apparatus for drilling and completing a well wherein both the well casinghead and subsequently the wellhead assembly and casinghead closure device are located under water at a depth sufficient to allow ships to pass over them. Preferably, the casinghead and wellhead closure assemblies are located close to the ocean floor. In order to install equipment of this type underwater in depths greater than the shallow depth at which a diver can easily operate, it has been necessary to design entirely new equipment for this purpose. Thus, when drilling and completing an oil or gas well at an offshore location in a manner described in copending patent application, Serial No. 830,538, filed July 30, 1959, and entitled "Underwater Well Completion Method," the well casinghead may have attached thereto various pieces of equipment by means of the apparatus of the present invention.

It is, therefore, a primary object of the present invention to provide apparatus for connecting a wellhead component to an underwater wellhead assembly while operating the apparatus from a remote location.

It is another object of the present invention to provide a wellhead such as a blowout preventer with a connector device so that the blowout preventer may be lowered on guidelines and seated on an underwater well casinghead and securely locked thereto in a fluid-tight manner with the sealing and locking operations being carried out from a remote location.

A further object of the present invention is to provide a remotely operable connector apparatus adapted to lock on to an underwater wellhead and pack off the annulus between the connector device and the wellhead.

Another object of the present invention is to provide a remotely-controlled hydraulically-operated connector device and sealing apparatus for holding a wellhead component on a wellhead against pressures which might be encountered therein at any time, even in the event that the hydraulic pressure lines to said apparatus should break, or otherwise become inoperative.

A still further object of the present invention is to provide a wellhead connector device and sealing apparatus which may readily be unlocked from an underwater wellhead and withdrawn to an operational base at the surface, such for example, to a drilling barge or platform.

Another object of the present invention is to provide a wellhead connector device adapted to seat on an underwater wellhead and be connected to the outside thereof, rather than the inside thereof, so that a well casinghead may be employed which is of a size slightly larger than the largest diameter drill bit which is to be run through the conductor casing.

These and other objects of this invention will be understood from the following description taken with reference to the drawing, wherein:

FIGURE 1 is a diagrammatic view illustrating a floatable drilling barge positioned on the surface of the ocean from which a blowout preventer together with the connector device of the present invention is being lowered to the top of a well casinghead positioned on the ocean floor;

FIGURES 2 and 2A are views taken in longitudinal cross-section of one form of a wellhead connector illustrated as being positioned on a vertically-extending well member, the connector in FIGURE 2 being shown in unlatched and unsealed position while the connector in FIGURE 2A is shown in sealed and latched position;

FIGURE 3 is a plan view taken in horizontal cross-section along line 3 of FIGURE 2 when turned 90° on a vertical axis;

FIGURE 4 is a view in longitudinal cross-section of another form of a wellhead connector shown in its inoperative position on a wellhead;

FIGURE 5 is a partial view taken in longitudinal cross-section of the wellhead connector of FIGURE 4 in its sealed position on a wellhead member;

FIGURE 6 is a plan view taken in horizontal cross-section along the line 6—6 of FIGURE 4;

FIGURE 7 is a plan view taken in horizontal cross-section illustrating another form of latching dogs for a connector device;

FIGURE 8 is a view taken in longitudinal cross-section of a portion of a wellhead connector illustrating latching means of another type;

FIGURE 9 is a view taken in partial longitudinal cross-section of a fragment of a wellhead connector illustrating a sealing member being pressed against a smooth-walled pipe;

FIGURE 10 is a view taken in longitudinal cross-section illustrating another form of a wellhead connector shown as latched and sealed on the outer wall of a smooth-walled well member;

FIGURE 11 is a view taken in longitudinal cross-section of another form of a wellhead connector in its unsealed and unlatched position; and,

FIGURE 12 is a view taken in longitudinal cross-section of the wellhead connector of FIGURE 11 shown in its sealed and latched position.

Referring to FIGURE 1 of the drawing, a drilling barge **11**, of any suitable floatable type is illustrated as floating on the surface of the water **12** and fixedly positioned over a preselected drilling location by being anchored to the ocean floor **13** by suitable anchors (not shown). Equipment of this type may be used when carrying on well drilling operations in water depths varying from about 100 to 1500 feet or more. The drilling barge is equipped with a suitable derrick **16** and a rotary table **17** as well as other auxiliary equipment needed during the drilling of a well. The derrick **16** is positioned over a drilling slot or well **18** which extends vertically through the barge in a conventional manner. When using the equipment of the present invention the slot **18** and the barge **11** may be either centrally located or extend in from one edge. However, drilling operations may be carried out over the side of the barge without the use of a slot. Additionally, it is to be understood that the equipment of the present invention may also be used

while drilling a well from any suitable operational base positioned above the surface of a body of water, such for example, as from a drilling barge having feet extending to the ocean floor, or from a platform permanently positioned on the ocean floor.

A typical underwater wellhead structure is illustrated in FIGURE 1 as comprising a base member **21** which is positioned on the ocean floor **13** and is fixedly secured to a conductor pipe or large-diameter well casing **22** which extends down into a well, which has been previously drilled, and is cemented therein. Thus, the base structure **21** is rigidly secured to the ocean floor in order to support two or more vertically-extending guide columns **23** and **24** adapted to receive and guide therein guide arms **25** and **26** which are arranged to slide along vertically extending guide cables **27** and **28**. The lower ends of the guide cables **27** and **28** are anchored to the base structure **21** within the guide columns **23** and **24** while extending upwardly through the water to the drilling barge **11** where they are preferably secured to constant tension hoists **31** and **32**.

Centrally positioned above the base plate **22** and fixedly secured thereto, or to the conductor pipe **22**, is a well casinghead **33** which may be provided with a sealing groove **34** cut in the outer wall thereof or on the periphery. The casinghead is also provided with a latching shoulder **35**, which may also be in the form of a groove, and extends around the casinghead. The wellhead is also shown as being provided with a cement circulation or kill line **36** which is connected preferably by means of a quick-disconnect coupling **37** to a flow-control valve **38**.

The guide arms **25** and **26** are illustrated as being connected to a blowout preventer **40** which is rigidly flanged to a wellhead connector **41** of the present invention. In FIGURE 1 the wellhead connector **41** is shown as it is being lowered onto the top of the casinghead **33**. The combined blowout preventer and wellhead connector **40** and **41**, respectively, are run into position on the top of the well by being lowered through the water from the barge **11** by means of a pipe string **42**, commonly known as a running string, the blowout preventer **40** being connected to the lower end of the running string **42** by means of a suitable coupling or connector **43** which may take the form of the wellhead connector **41**. The valve **38**, connector **41**, blowout preventer **40** and connector **43** are all hydraulically operated and are provided with hydraulic flowlines **44** and **45**, **46** and **47**, **48** and **49**, and **50** and **51**, respectively. These flowlines **44** through **51** extend upwardly from the wellhead equipment to the barge **11** where they are connected to a suitable source of pressure fluid.

Referring to FIGURE 2 of the drawing, the wellhead connector **41** of FIGURE 1 is shown as comprising a body member having upper and lower portions **54** and **55**, respectively, which are connected together in any suitable manner, as by bolts **56**. The upper end of the upper portion **54** of the body member may be closed by a cap member **57** which may be screw-threaded to the body member **54**, as at **58**. The lower end of the lower portion **55** of the body member may be closed by a plate **60** which is connected thereto by bolts **61**. Preferably, the lower plate **60** of the body member is provided with an outwardly flaring skirt **62** which surrounds the bore or throughbore **63** extending upwardly through the body member **54–55**. The cap **57** has a bore or throughbore **64** of reduced diameter thus forming a seating shoulder **65** which is adapted to seat on a landing surface **66** formed on the outside of a vertically-extending well member **67**, preferably at the upper end thereof, as illustrated.

The well member **67** is provided with a bore **68** therethrough which may vary in diameter at one or more places to form one or more seating shoulders **71**, **72** and **73** on which various well equipment may be seated or latched. Formed on the outer surface of the vertically extending well member **67** is a shoulder **74** which may take the form of a groove similar to that forming shoulder **72** on the inner wall of the well member **67**. The latching shoulder **74** formed on the well member **67** is positioned down from the top of the well member **67** a distance equal to the distance that a plurality of latching dogs **75**, carried by the body member **54–55**, are positioned from the seating shoulder **65** and the cap **57** of the body member.

The shoulder-engaging latching dogs **75** carried by the body member are arranged for substantially lateral movement into and out of engagement with the latching shoulder **74** of the well member **67**. The latching dogs **75** are actuated in any suitable manner. Preferably, a fail-safe type of latching dog **75** is employed. In one such arrangement, a compression spring **76** is mounted in back of each latching dog **75** for urging it inwardly toward the axis of the body member **67**. A piston **77** is formed on the end of the latching dog **75** with a fluid conduit **78** extending through the wall of the body member portion **55**, from the outside thereof, so that a pressure fluid may be applied to one side of the piston **77** to retract the latching dog **75** back into the body member against the action of the compression spring **76**. It will be seen that, upon the failure of pressure fluid to the conduit **78**, the spring **76** would maintain a force on the latching dog **75** urging or maintaining the latching or locking dog in a locked position in engagement with the shoulder **74**, thus preventing relative axial separation of the body member **54–55** from the well member **67**.

Prior or subsequent to the actuation of the latching dogs **75**, the body member **54–55** is sealed to the outer wall of the well member **67** in a fluidtight manner by any suitable annular packing element **80**. The packing element **80** may be reinforced by metal rib sections **81**, if desired. Formed within the body member **54–55** is a chamber **82** in which a piston **83** is slidably mounted for limited vertical movement. The upper end of the piston **83** may be beveled outwardly, as at **84**, so as to facilitate movement of the piston within the chamber **82** of the outside of the annular seal **80**, thus supplying an increasing amount of pressure on the seal **80** as the piston moves upwardly. If desired, the outer surface of the well member **67** may be provided with a peripheral groove **85** near the top thereof for receiving a portion of the packing element **80** therein. However, the packing element **80** may also be employed to seal against a smooth-surfaced outer wall of a well member **67**, as illustrated in FIGURE 9 of the drawing. The vertical width of the shallow groove **85** in the outer wall of the well member **67** is sufficient to receive at least a portion of the packing element **80** therein without permitting the reinforcing rib sections **81** of the packing element **80** from entering the groove **85**, as illustrated. The piston **83** is energized by applying a pressure fluid through a pressure conduit **86** in communication with one side of the piston **83** with fluid above the piston being allowed to discharge through a second conduit **87** in communication with the space **88** above the piston.

In order to insure that a positive seal is maintained by the packing element **80** around the well member **67** at all times, suitable positioning means or locking means are provided for maintaining a piston **83** in its raised position, as shown on the right-hand side of FIGURE 2. In the wellhead connector shown in FIGURES 2 and 3 a rotatable ring **90** is provided in the lower portion of the body member **55** at a point opposite a portion of the piston **83**. The rotatable ring **90** is provided with inwardly extending breach-type locking elements or threads **91** while cooperating breach-type locking elements or threads **92** extend outwardly and are formed on the outer surface of the piston **83**. When the piston is being raised and lowered, the locking thread surface **92**

on the piston 83 is positioned adjacent a smooth surface segment of the rotating ring 90, as shown in the lefthand half of FIGURE 2 when the piston 83 is in its unlocked position. After the piston 83 has been raised to its operative position, as shown in the right-hand half of FIGURE 2, the ring 90 is rotated so that the locking elements thereon engage the locking elements on the piston 83 so as to maintain the piston 83 in a raised position at all times. Thus, in the event of pressure fluid loss to conduit 86, an effective seal would be maintained above the well member 67 as the piston 83 would be maintained in its upper position against the packing element 80.

To actuate the rotatable locking ring within the wellhead connector device 41 of FIGURE 2, the lower portion of the body member 55 is provided with at least one and preferably two conduits 93 and 94 which extend horizontally through the body member. At substantially the midpoint of the conduits, actuating arms 95 and 96 substantially block passage through the conduits. The arms 95 and 96 are rigidly secured to the rotatable ring 90 which is adapted to be rotated in a horizontal plane when pressure is exerted on the arms 95 and 96 in one direction or the other. A flexible piston is provided within the conduits 93 and 94 on either side of the actuating arms 95 and 96. Each flexible piston takes the form of a series of ball bearings or spheres 97 in contact at one end with the actuating arm 95 while a short sealing piston 98 closes the other end of the conduit in a fluidtight manner. Thus, a fluid pressure being supplied to one end of the conduit 93 will force the piston 98, spheres 97 and actuating arm 98 together with rotatable ring 90 in one direction so that the locking surfaces 91 thereon will engage the locking surfaces 92 on the sidewalls of the piston 83. Pressure applied to the other end of the conduit 93 will operate in the opposite manner to move the rotatable ring 90 in the opposite direction until the locking elements become disengaged from the locking elements 92 on the piston. At this time the piston 83 may be again moved up or down.

Another arrangement of the wellhead connector of the present invention is shown in FIGURE 4 wherein the lower portion 55 of the body member is provided with an annular chamber 100 in which a series of jack screws 101 extend and each is provided with a gear or sprocket wheel 102. A drive motor 103, preferably of the hydraulically-actuated type, is positioned in the lower chamber 100 with its shaft 104 extending outwardly through the housing of the body member 55. On rotation of the drive shaft 104 a driving gear or sprocket 105 on the motor 103 is rotated to move a drive chain 106 (FIGURE 6) which interconnects the drive gear 105 on the motor with the various sprocket wheels 102 of the jack screws 101. A series of idler gears 107 may be employed if desired or necessary. The upper ends of the jack screws 101 (FIGURE 4) are in contact with the lower surface of the piston 83 and are employed to force a piston upwardly against the sealing element 80 to force it in sealing engagement with the well member 67 as shown in FIGURE 5. Alternatively, a pressure fluid may be supplied through conduit 86 to force the piston 83 upwardly and extend the sealing member 80 into fluidtight engagement with the well members 67, after which the drive motor 103 may be actuated to rotate the jack screws 101 until they have been raised into contact with the bottom of the piston 83 again so as to hold it in its sealed position. It may be seen that upon failure of pressure fluid to the piston through conduit 86, the piston 83 would be held in its raised position by the jack screws 101.

In FIGURES 7*a* and 8*a* another form of a latching dog is illustrated wherein the body member 55*a* of the well head connector is provided with a pair of conduits 78*a* and 79*a* extending through the wall thereof from the outside into communication with opposite ends of the chamber in which the piston 77*a* is slidably movable. Thus, by applying pressure to conduit 79*a* the piston and its connected latching dog 75*a* will be forced inwardly into latching contact with the shoulder 74*a* on the well member 67*a*. If desired, a spring 76*a* may also be employed but is not necessary. For unlatching the dog 75*a*, pressure fluid would be applied through conduit 78*a*.

Another form of a wellhead connector is illustrated in FIGURE 10 wherein a body member 110 is provided with a stabbing skirt 111 at the lower end thereof which facilitates centering the wellhead connector onto the top of a well member 67 which is provided with a shoulder 112 on the outer surface thereof for receiving a locking cam 113 therein. The locking dog or cam 113 is pivotally mounted within the body member and actuated by piston means 114 carried thereby. The body member 110 is provided with pressure fluid conduits 115, 116 and 117 which interconnect so that a pressure fluid may be applied simultaneously to the actuating piston 114 of the cam 113 and to an inflatable packer or sealing element 118 carried by the body member for sealing off between the adjacent walls of the body member and the well member. Additionally, the body member 110 may be provided with a solid O-ring seal 120.

Another form of a wellhead connector is illustrated in FIGURES 11 and 12 wherein the wellhead connector comprises a body member 123 having a vertically-disposed and inwardly-expansible sealing element 124 carried in a chamber 125 therein. An upwardly-extending retaining element 126 and a downwardly-depending retaining element 127 anchor the ends of the sealing element to the body member 123 while permitting the center portion of the sealing element 124 to expand against a well member 67, as shown in FIGURE 12. The body member 123 is provided in the lower portion thereof with a plurality of locking dogs, each of the dogs 127 having an actuating piston 128 slidably movable within a piston chamber 129 which is supplied with a pressure fluid through conduit 130. The conduit 130, and a conduit 131 extending through the wall of the body member 123 opposite the sealing element 124, are interconnected and served by a common pressure fluid conduit 132. If desired, the upper edge of the locking dogs 127 may be tapered as shown in FIGURE 12 in order to facilitate retraction of the dog when pressure has been released from the locking dog 127 and sealing element 124 and the body element 123 withdrawn from engagement with the well member 67.

In employing the wellhead connector 41 (FIGURE 1) of the present invention, the wellhead connector 41 is rigidly secured coaxially with a suitable wellhead component, such for example, as a blowout preventer 40. The combination of the blowout preventer 40 and its wellhead connector 41 may be lowered from a barge 11 into contact with a well casing head 33 located underwater. Since the blowout preventer 40 and the wellhead connector 41 are fixedly secured together, it is necessary that only one of the components, in this case, the blowout preventer, be provided with guide arms 25 and 26. However, in the event that it is desired to run a wellhead connector alone down through a body of water to contact a wellhead component it is necessary that the wellhead connector 43 be provided with a pair of guide arms 25*a* and 26*a*.

In FIGURE 1 a wellhead connector 43, which may be similar in construction to the wellhead connector 41 described hereinabove, is seated on and locked and sealed to a vertically extending tubular component 30 which may be similar in shape and construction to the casinghead 33. Thus, prior to running the blowout preventer 40 and its wellhead connector 41 to its underwater location on the casinghead 33, the smaller wellhead connector 43 carried at the lower end of the pipe string 42 is set upon and latched to the vertically extending tubular member 30 on the top of the blowout preventer 40 by applying hydraulic pressure through conduit 50. The entire equipment assembly would then be lowered from the barge 11

to the casinghead 33 by means of the pipe string 42. When the blowout preventer 41 is seated within the casinghead 33, fluid pressure would be applied from the barge 11 at the surface to actuate the wellhead connector in a manner described hereinabove.

We claim as our invention:

1. A wellhead connector assembly comprising

(*a*) a body member having a passage extending axially therethrough, said body member being positionable and connectible in axially telescopic relation with a longitudinally projecting well member having an axial passage therethrough forming an unimpeded throughbore passing through said body member and said well member, said well member being of a size to fit within the passage of said body member,

(*b*) cooperating connector means carried in the adjacent walls of said body member and said well member,

(*c*) one portion of said connector means comprising shoulder means formed by a recessed area in the outer wall of said well member,

(*d*) the other portion of said connector means comprising shoulder-engaging locking means carried by said body member in the adjacent wall thereof in a position for registering with said shoulder means, said locking means being substantially laterally movable into and out of engaging relation with said shoulder means,

(*e*) actuating means carried by said body member and being operatively connected to said locking means when urging said locking means to a locked position in engagement with said shoulder means whereby said engaged locking means prevents relative axial separation of said body member and said well member,

(*f*) said body member having conduit means through the wall thereof through which pressure fluid is communicable to said actuating means,

(*g*) annular sealing means carried by said body member and axially displaced from said locking means for sealing off between the adjacent walls of said body member and said well member, and

(*h*) weight - supporting substantially circumferential shoulder means formed on the wall of said body member within the passage thereof for seating on the upper end of said well member when in engagement therewith.

2. The apparatus of claim 1 wherein said body member has a circumferential recessed portion in the inner wall thereof, said annular sealing means being carried in said recessed portion.

3. The apparatus of claim 2 wherein the inside diameter of said annular sealing means is normally no greater than the diameter of the throughbore of said body member.

4. The apparatus of claim 2 wherein said annular sealing means are extendible radially inwardly to seal against said well member and said body member is provided with second conduit means through the wall thereof which is communicable with a source of pressure fluid.

5. The apparatus of claim 2 including second actuating means in operative engagement with said annular sealing means for moving said annular sealing means radially inwardly to seal against said well member upon actuation of said second actuating means.

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