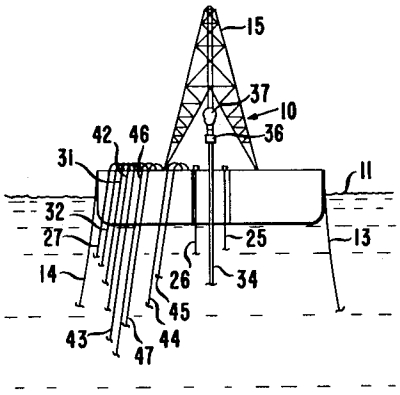
Dec. 14, 1965 L. G. OTTEMAN 3,223,164

METHOD OF ACTUATING FLUID PRESSURE OPERATED MECHANISM OF UNDERWATER WELL INSTALLATION

Original Filed Nov. 9, 1962 5 Sheets-Sheet 1



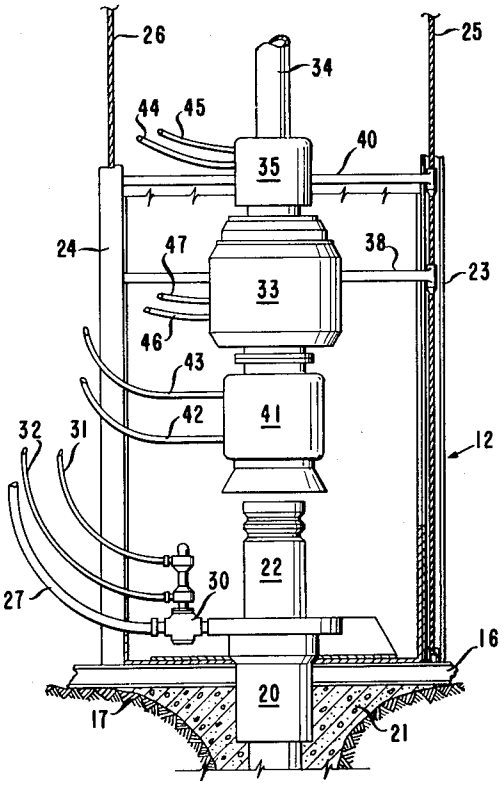


FIG. 1

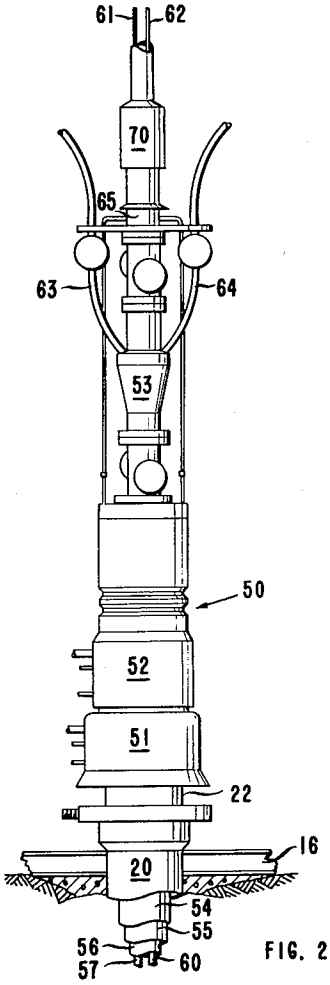


FIG. 2

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METHOD OF ACTUATING FLUID PRESSURE OPERATED MECHANISM OF UNDERWATER WELL INSTALLATION

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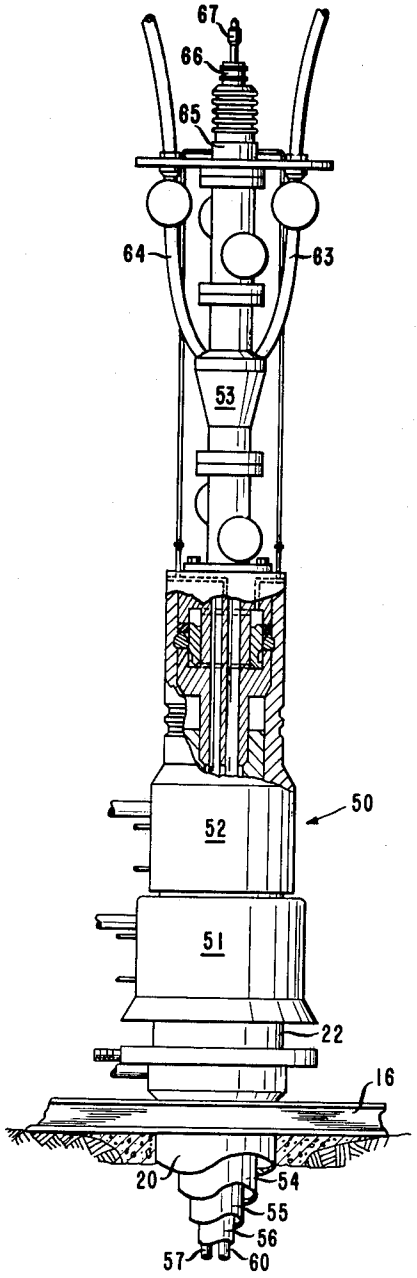


FIG. 3

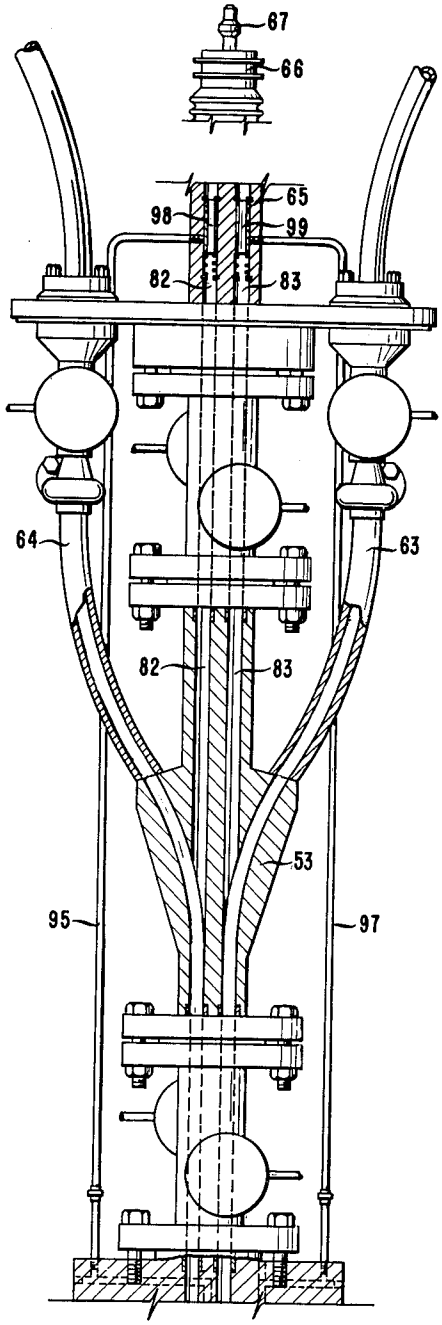


FIG. 4

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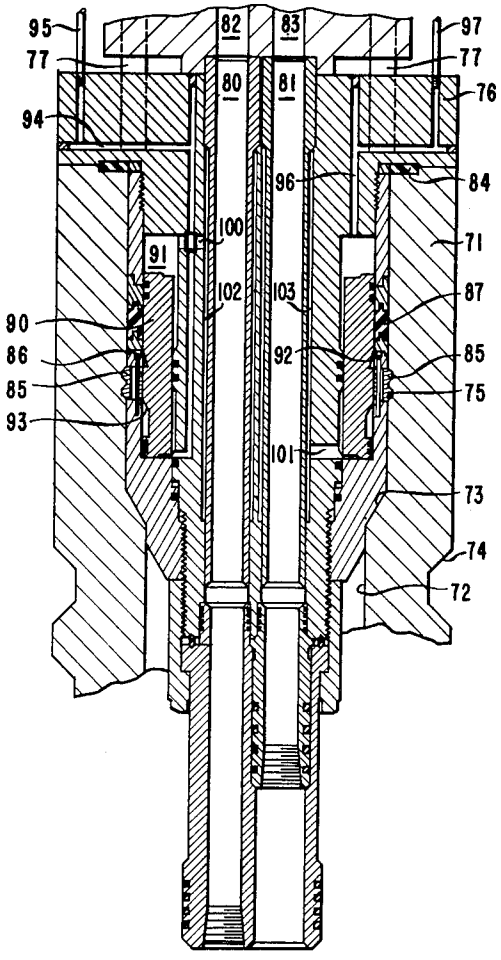


FIG. 5

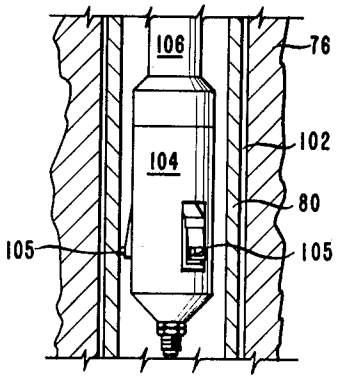


FIG. 6

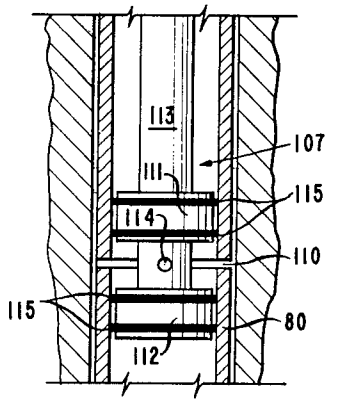


FIG. 7

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METHOD OF ACTUATING FLUID PRESSURE OPERATED MECHANISM OF UNDERWATER WELL INSTALLATION
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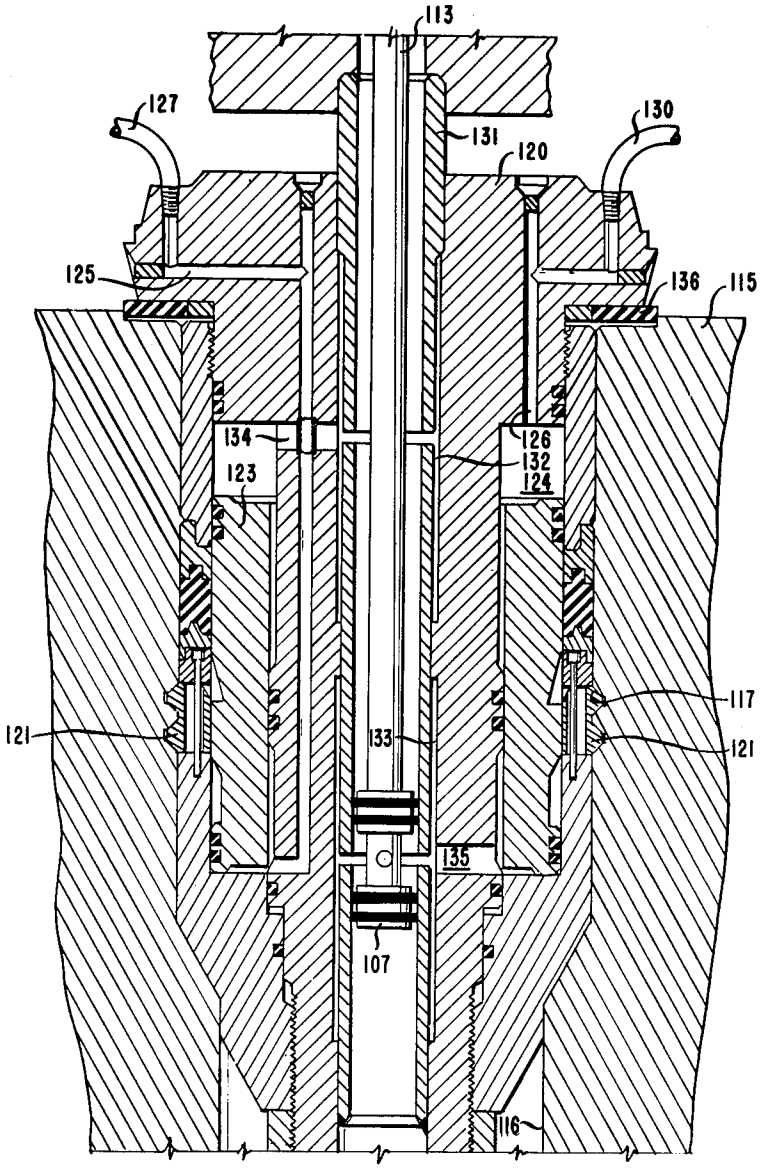


FIG. 8

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Original Filed Nov. 9, 1962 5 Sheets-Sheet 5

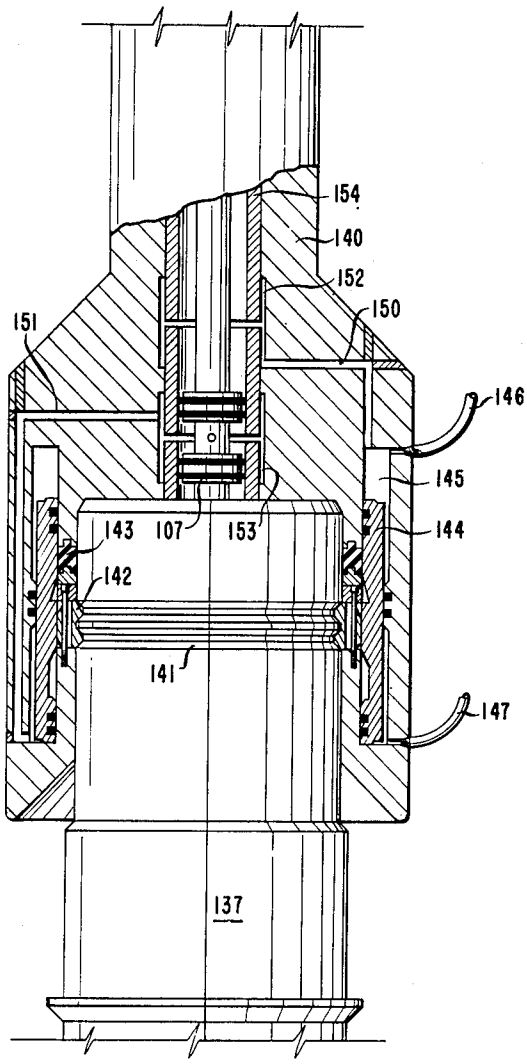


FIG. 9

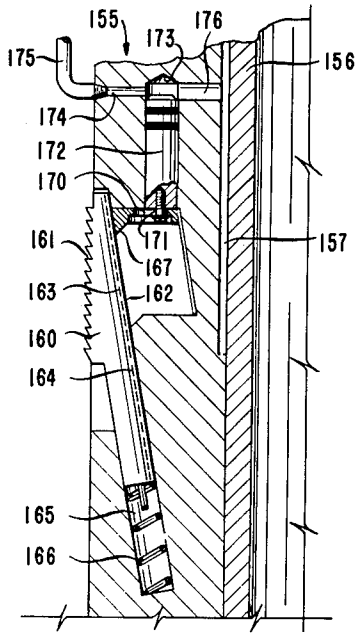


FIG. 10

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United States Patent Office 3,223,164 Patented Dec. 14, 1965

3,223,164

METHOD OF ACTUATING FLUID PRESSURE OPERATED MECHANISM OF UNDERWATER WELL INSTALLATION

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Original application Nov. 9, 1962, Ser. No. 236,645. Divided and this application Dec. 14, 1964, Ser. No. 425,655

6 Claims. (Cl. 166—35)

The present application is a divisional application of copending application Serial No. 236,645, filed November 9, 1962.

This invention relates to a method and apparatus for coupling components used on offshore wells and pertains more particularly to an improved remotely operable coupling apparatus adapted to securely lock conduits used on underwater installations in fluid communication. The invention is especially concerned with an improvement of the apparatus disclosed in copending application Serial No. 127,054, filed July 26, 1961, and entitled "Wellhead Connector," now Patent No. 3,163,223, issued Dec. 29, 1964, wherein there is disclosed a coupling apparatus for connecting a wellhead component, such as a blowout preventor, to a vertically extending wellhead member in a securely locked and fluid tight manner. More specifically, the present invention is directed to a coupling apparatus as disclosed in the latter application wherein the coupling is provided with an alternative operating system to facilitate emergency operation of the apparatus.

Recently, in attempts to locate new oil fields, an increasing amount of well drilling has been conducted at offshore locations, such for example, as off the coasts of Louisiana, Texas and California. As a general rule, in these attempts the wells are provided with strings of casing and tubing which extend to a point above the surface of the water at the offshore location of the well. Extending the casing and tubing strings above the surface of the water has the advantage that the strings may be closed and operated by surface-type operating procedures, with a conventional wellhead assembly being attached to the top of the casing. Extending the well strings and the wellhead assembly secured thereto to the surface of the water at offshore locations has the obvious disadvantage, however, that the extended structure presents a hazard to navigation and is also exposed to the corrosive action of salt water and air. Furthermore, when operating at depths ranging in hundreds of feet, the extension of well strings to the surface of the water often becomes infeasible as a practical matter. In order to avoid these disadvantages, attempts have recently been made to provide methods and apparatuses for drilling and completing offshore wells wherein both the well casinghead and subsequently the wellhead assembly and casinghead closure device are located underwater 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 to avoid all of the disadvantages accompanying the extension of lengths of well string above the floor of the ocean. In locating equipment in this manner, depths are often encountered exceeding the relatively shallow depth at which a diver can safely and easily operate and, thus it has been necessary to design new equipment and procedures for this purpose. Copending application Serial No. 830,538, filed July 30, 1959, and entitled "Underwater Well Completion Method," describes a method of completing offshore wells on the ocean floor. A remotely actuated coupling apparatus well adapted for use in securing components on the underwater well completion method of the latter application is disclosed in aforementioned copending patent application Serial No. 127,054.

In the remote controlled installation and operation of underwater well components there is always the possibility that remote actuators may become damaged or inoperative. This possibility poses a particular hazard in underwater installations located at depths beyond those accessible to human divers, since emergency operations under such circumstances are difficult if not impossible to carry out. The present invention provides a method and apparatus to facilitate emergency operation under such conditions.

It is therefore a primary object of this invention to provide a method and apparatus for coupling and uncoupling underwater wellhead components by remote control under both favorable and adverse conditions.

It is another object of the invention to provide an apparatus to remotely connect conduits to an underwater wellhead assembly wherein the conduits may be lowered to the assembly and secured thereto in a fluid tight manner, with the securing operation being carried out from a remote location.

Another object of the invention is to provide a remotely controlled hydraulically operated coupling device for securing wellhead components in position under any conditions of well pressure.

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

Another object of the invention is to provide an underwater coupling apparatus having operative components which are normally isolated from sea water and marine growth and are thus not subject to fouling due to corrosion or other obstructions.

Yet another object of the invention is to provide a remotely controlled fluid pressure actuated conduit coupling apparatus wherein the fluid pressure is normally supplied from an external source, but wherein fluid pressure may be supplied through the coupled conduits should the external source become inoperative.

These and other objects of the invention will become apparent from the following description and accompanying illustrations.

In its broadest aspect, the present invention provides a method for imparting secondary fluid actuating pressure to the primary fluid pressure system of a fluid pressure actuated mechanism secured to a conduit. Broadly, the method comprises establishing fluid communication between the interior of the conduit and the primary fluid pressure system of the mechanism, and subjecting the primary fluid pressure system to fluid under pressure supplied through the conduit.

Basically, the apparatus of the invention is directed to an arrangement for selectively uncoupling a conduit from an underwater installation. The apparatus includes a lockdown assembly secured to the conduits adjacent a free end thereof and a lockdown receiver fixed to the underwater installation. The receiver is dimensioned to receive the lockdown assembly in seated telescopic engagement therewith, and the lockdown assembly carries locking elements which are moveable with respect thereto into and out of locked engagement with the receiver when the assembly is in telescopic engagement therewith. The apparatus further includes fluid pressure operated actuating means carried by the lockdown assembly and operatively associated with the locking elements to selectively move the locking elements into engagement with the receiver. Fluid pressure is supplied to the actuating means through a manifold system extending through the lockdown assembly into communication with the actuating means. The manifold system communicates with a

primary external source of operating pressure through a passage connected thereto and extending to said source.

In order to provide a secondary source of fluid pressure for the actuating means, rupturable diaphragms are interposed between the manifold system and the interior of the conduit. Through the latter provision, should the external source of fluid pressure become inoperative, the diaphragms may be ruptured to expose the actuating means to fluid pressure supplied through the conduit.

From the foregoing brief description, it is believed apparent that the present invention provides for the selective uncoupling of a conduit from an underwater installation through a primary or an alternative operating system. The operation of the invention will be more definitely understood when viewed in light of the following detailed description and accompanying illustrations, wherein:

FIGURE 1 is a diagrammatic view illustrating an application of the present invention, including a drilling or workover barge positioned at the surface of the water and a well located at the floor of the body of water beneath the barge;

FIGURE 2 is an elevational view of the well shown in FIGURE 1, wherein a production assembly is secured to the well through means of the apparatus of the present invention;

FIGURE 3 is an enlarged view of the production assembly illustrated in FIGURE 2, with the running string removed therefrom;

FIGURE 4 is an enlarged vertical section of the upper end of the production assembly illustrated in FIGURE 3;

FIGURE 5 is a detailed vertical section of a coupling apparatus of the present invention adapted to be used in the wellhead assemblies illustrated in FIGURES 1 to 4;

FIGURES 6 and 7 are vertical sections illustrating a casing cutter and packer assembly, respectively, suited for use in initiating the operation of the present invention;

FIGURE 8 is a detailed sectional view similar to that of FIGURE 5, illustrating another embodiment of the apparatus of the invention adapted to remotely couple a single conduit in communication with an inexcessible receiver;

FIGURE 9 is a detailed vertical section of another embodiment of the apparatus of the present invention wherein the inter-relationship of the engaging components of the coupling has been substantially reversed from the embodiments of FIGURE 5 and FIGURE 8; and,

FIGURE 10 is a detailed vertical section of yet another embodiment of the invention incorporating a coupling or locking structure having a modified locking and actuating structure.

Referring now to FIGURE 1 of the drawings, a drilling workover barge **10** is shown positioned at the surface of a body of water **11** in a location approximately directly above a well station **12**. The barge **10** is preferably of the floating type and is adapted to operate in depths of water of from about 100 to 1500 feet or more. The barge **10** may be maintained at the desired location through means of alternative positioning apparatus, such as the anchor lines **13** and **14** extending from the barge to anchors (not shown) located at the floor of the body of water. As illustrated in FIGURE 1, the barge **10** includes a derrick **15** adapted to be used in lowering equipment to and from the well station **12** and a series of remote control operating lines extending from the barge to the station.

The well station **12** includes a wellhead structure **16** cemented in place at the floor **17** of the body of water **11**. As shown in FIGURE 1, the wellhead structure **16** rests on the floor **17** and has a casing **20** extending into the floor in cemented engagement therewith as illustrated by the cement portion **21**. The wellhead structure **16** further includes a casinghead **22** extending upwardly from the casing **20** and at least one pair of upwardly extending guide columns **23** and **24**. Guide lines **25** and **26** are secured to the wellhead structure **16** and extend through the columns **23** and **24**, respectively, and up to the barge **10**. The guide lines **25** and **26** and the guide columns **23** and **24** cooperating therewith facilitate the raising and lowering of components from the wellhead structure, as will be developed subsequently. The manner in which the well station **12** is initially developed and the wellhead structure **16** is secured thereto is disclosed in aforementioned copending application Serial No. 830,538. The latter application develops the method by which cementing apparatus, such as the cement line **27**, cement valve **30** and valve actuating lines **31** and **32** are utilized to anchor the wellhead structure **16** in place through the cement portion **21**.

After the wellhead structure **16** has been secured in place, it is in condition to receive components, such as workover structure, drilling structure, or production structure, from the barge **10**. FIGURE 1 illustrates a blowout preventor **33** being lowered down the guide lines **25** and **26** to the wellhead structure **16**. In the illustration, the blowout preventor **33** is being lowered on a pipe or running string **34** secured thereto by a running tool **35**. The running string **34** extends upwardly from the running tool **35** and is suspended from the derrick **15** through means of a pair of elevators **36** joined to the traveling block **37** of the derrick by conventional link and hook elements. Thus, the derrick **15** may be utilized to lower the running string **34** and the components secured thereto in the conventional manner. During lowering, the running string **34** and the components secured thereto are guided towards alignment with the wellhead structure **16** through means of guide arms **38** and **40** secured to the blowout preventor **33** and running tool **35**, respectively. The latter guiding operation is clearly disclosed in aforementioned application Serial No. 830,538. In order to secure the blowout preventor **33** to the casinghead **22**, a coupling mechanism **41** of the present invention is secured to the lower surface of the preventor. The coupling mechanism **41**, as will be described subsequently with respect to FIGURE 9, is provided with fluid pressure operated actuating means adapted to secure the mechanism in locked and sealed engagement with the casinghead **22**. The mechanism **41** is adapted to be remotely operated through primary fluid pressure lines **42** and **43** extending to a controlled source of fluid under pressure on the barge **10**. In addition, the coupling mechanism **41** is provided with an alternative operating system which will be developed in detail with reference to the subsequent figures. It is noted that the running tool **35** may be provided with a coupling mechanism corresponding substantially to the mechanism **41** and that fluid pressure may be conveyed to this mechanism through lines **44** and **45**. The lines **46** and **47** are the conventional hydraulic actuating lines necessary for the operating of the blowout preventor **33**.

Although the barge, wellhead structure and the guide and operating structure used therewith are only illustrated in FIGURE 1, it is to be understood that this supporting structure would also be used in combination with the other detailed apparatuses which will be described herein. Furthermore, the coupling structure of the present invention is not intended to be limited to the illustrated applications. For example, in addition to using the coupling apparatus in combination with the illustrated drilling or workover structures and the illustrated production assemblies, it is anticipated that the coupling apparatuses might equally well find use with other underwater installations, such as underwater trap farms utilized in the production and storage of well products.

FIGURES 2 to 5 illustrate a wellhead assembly similar to that described in copending application Serial No. 834,096, filed August 17, 1959, entitled "Wellhead Assembly Lockdown Apparatus." The assembly of FIGURES 2 to 5 differs from the copending application primarily in that it incorporates the lockdown apparatus of the present invention, as shown in detail in FIGURE 5. Referring now to the detailed structure illustrated in the drawings, the numeral **50** designates the production wellhead as-

sembly in its entirety, as positioned on a casinghead **22** corresponding to that described with reference to FIGURE 1. The production wellhead assembly **50** consists of three major elements comprising a wellhead connector **51** received on the casinghead **22**, a landing head **52** received on the upper end of the wellhead connector and a production assembly **53** received within the upper end of the landing head. The connections between the casinghead **22** and the wellhead connector **51** and the above mentioned major elements of the wellhead assembly include the coupling apparatus of the present invention, as will be described in detail subsequently.

In the operative condition illustrated in FIGURES 2 and 3, the wellhead assembly **50** also includes casing strings **54** to **56** extending down from the casinghead **22** from conventional hanging means, such as are disclosed in the aforementioned copending application Serial No. 834,096. As described in the latter application, tubing or production strings **57** and **60** extend through the innermost casing string **56** into communication with tubing extension strings and flowlines connected to the wellhead assembly through the production assembly **53**. The tubing extension strings designated as **61** and **62** are releasible attached to the production assembly and the flowlines designated as **63** and **64** are fixedly attached to the production assembly as illustrated in FIGURE 2. The manner in which the tubing strings **61** and **62** and flowlines **62** and **64** are adapted to communicate with the tubing strings **57** and **60** is illustrated in section in FIGURES 3 and 4 and described in detail in the aforementioned copending application Serial No. 834,096. At this point, it is noted that the tubing extension strings **61** and **62** leading into the wellhead assembly illustrated in FIGURE 2 are not shown in the corresponding assemblies illustrated in FIGURES 3 and 4. This apparent difference is merely the result of illustrating the wellhead assembly in different stages of its operation. In FIGURES 3 and 4, the production assembly **53** is shown as having a closure member body **65** at the upper end thereof, which closure member is capped by a plug **66** having a fishing head **67** extending upwardly therefrom. As shown in FIGURE 2, the closure member body **65** is identical to that of FIGURES 3 and 4, but is illustrated with the plug **66** removed therefrom and with a running head **70**, having the tubing strings **61** and **62** passing therethrough and into the production assembly. A detailed description of the closure member body **65**, plug **66** and running head **70** adapted to cooperate therewith is disclosed in copending application Serial No. 218,482, filed August 16, 1962 and entitled "Wellhead Closure Apparatus."

Referring now to FIGURE 5, therein is illustrated a detailed vertical section of the coupling apparatus shown diagrammatically in the broken-away section of FIGURE 3. The apparatus includes a receiver or socket member **71** in the form of a casing suspension housing fixed to the upper end of the landing head **52**. In actual construction, the receiver **71** may be either formed as an integral part of the landing head **52**, or it may be fixedly attached thereto, as by threads. The receiver **71** has extending therethrough a passage **72**, having a shoulder **73** formed therein and converging into a necked-down portion. The receiver **71** further includes an exterior locking recess **74** formed around the outer periphery thereof and an interior locking recess **75** formed annularly around the passage **72** above the shoulder **73** therein.

In the condition illustrated in FIGURE 5, the production assembly **53** is shown secured to the receiver **71** through a locking assembly **76** fixed to the production assembly and received in locking engagement with the interior of the receiver. Although the receiver **71** is only illustrated with an internal lockdown assembly telescoped therein, it is to be understood that the receiver is also adapted to receive an external lockdown assembly in telescopic engagement therewith, as will be developed subsequently. The lockdown assembly **76** is fixed to the production assembly **53** by bolts **77** extending through the production assembly into threaded engagement with the lockdown assembly. When fixed in this manner, conduits or tubes **80** and **81** secured to and extending through the lockdown assembly communicate in sealed relationship with conduits or passages **82** and **83** extending through the production assembly into communication with the flowlines **63** and **64** and/or the tubing strings **61** and **62**. The conduits **80** and **81** are in turn adapted to communicate with the tubing strings **57** and **60**, respectively, when the lockdown assembly **76** is received in engagement with the receiver **71**, as shown in FIGURE 5. Preferably, in the telescoped relationship illustrated in FIGURE 5, a resilient seal **84** is interposed between the receiver **71** and the lockdown assembly **76**.

Reference will now be made to the locking and sealing mechanism adapted to secure the receiver **71** and lockdown assembly **76** in the relationship illustrated in FIGURE 5. This mechanism includes a plurality of spaced locking dogs **85** positioned around the lockdown assembly **76** for limited radial extension with respect thereto. The dogs **85** are located so as to assume an aligned relationship with the interior locking recess **75** when the lockdown assembly **76** and the receiver **71** are in telescopic engagement. Thus, upon extension as illustrated in FIGURE 5, the dogs **85** lockingly engage the recess **75** and secure the receiver and lockdown assembly in seated engagement. In order to limit the degree to which the dogs **85** may be extended, anchor pins or bolts **86** extend through enlarged axial openings in the dogs into fixed engagement with the body of the lockdown assembly. The locking and sealing mechanism further includes a resilient annular sealing element **87** extending around the lockdown assembly **76** for radial extension with respect thereto.

Extension of the locking dogs **85** and sealing element **87** is accomplished through means of an actuating piston **90** received in an annular recess **91** of the lockdown assembly **76** for reciprocating movement therein. The actuating piston **90** takes the form of a cylinder having cammed surfaces on the outer surface thereof which are adapted to radially extend the locking dogs **85** and sealing element **87** on downward movement of the piston and to permit retraction of the locking dogs and sealing element on upward movement of the piston. Preferably, the outer surface of the actuating piston **90** is provided with a pair of cammed surfaces **92** and **93** adapted to simultaneously extend both the locking dogs and the sealing element. Although a single cammed surface could feasibly extend the locking dogs and sealing element sequentially, the use of a pair of cammed surfaces has the advantage that the piston stroke is minimized. It is noted that the rearmost surfaces of the dogs **85** are provided with beveled edges to facilitate extension of the dogs by the cammed surface **93** of the actuating piston, and that the cammed surface **93** has a recess therebelow of sufficient size to permit the dogs **85** to be retracted thereinto when the piston **90** is in its uppermost position (not shown). In such a retracted position, the outer surfaces of the locking dogs **85** are flush with the outer surface of the lockdown assembly and thus the lockdown assembly may be removed from the receiver **71**. In order to facilitate retraction of the locking dogs **85** and removal of the lockdown assembly **76** from the receiver **71**, the outer upper edges of the locking dogs are preferably beveled so that the dogs are readily retracted upon pulling the lockdown assembly upwardly with respect to the receiver.

In order to reciprocate the actuating piston **90** within the annular recess **91**, a fluid manifold system communicates with the upper and lower ends of the recess. The manifold system includes a first condiut **94** communicating with the lower end of the annular recess **91** and extending through the lockdown assembly **76** to a primary actuating line **95** communicating with a source of controlled fluid under pressure. The manifold system further includes a second conduit **96** communicating with

the upper end of the recess **91** and extending through the lockdown assembly **76** to a primary actuating line **97** communicating with a source of controlled fluid under pressure. In normal operation, the source of controlled fluid under pressure communicating with the lines **95** and **97** preferably is derived from fluid pressure within the conduits **82** and **83**. Referring in detail to FIGURE 4, this pressure is derived by extending the lines **95** and **97** into communication with the conduits **82** and **83** and is controlled through means of apertured sleeve valves **98** and **99** interposed between the lines **95** and **97** and the interior of the conduits **82** and **83**. The sleeve valves **98** and **99** are slidably received in the conduits **82** and **83** and are biased to a normally closed position by springs positioned therebelow. In order to open either one or both of the valves **97** and **98** a valve shifting tool, such as described on page 1976, FIGURES 2 and 3 of the 1957 Composit Catalogue of Oil Field Equipment, may be used. Thus, with this arrangement, when it is desired to subject the lines **95** and **97** to a differential in pressure it is merely necessary to impose a pressure differential across the lines **82** and **83** and open the sleeve valves **98** and **99**. It is to be understood that the external source of fluid under pressure communicating with the lines **95** and **97** is not necessarily limited to that derived from conduits **82** and **83**. For example, the lines **95** and **97** may be fabricated of a flexible material and extended to a source of fluid pressure disposed at a remote operating station, such as barge **10** of FIGURE 1.

The manifold system of FIGURE 5 also includes an alternative operating system comprising auxiliary or secondary actuating passages **100** and **101** communicating with the upper and lower ends, respectively, of the annular recess **91** to provide an alternative source of fluid pressure therefor. The passage **100** communicates with a thin normally closed annular chamber **102** surrounding the conduit **80** and the passage **101** communicates with a thin annular chamber **103** separate from the chamber **102** and surrounding the conduit **81**. During the normal operation of the lockdown assembly **76**, the chambers **102** and **103** and the passages communicating therewith are isolated from the interior of the conduits **80** and **81** and, thus the alternative operating system remains inoperative. It is noted that the walls of the condiuts **80** and **81** serve as diaphragms or barriers to isolate the chambers **102** and **103** from the interior of the conduits, and that these walls are fabricated so as to be rupturable by conventional casing cutters. Therefore, should the primary actuating lines **95** and **97** become inoperative due to damage or fouling, the manifold system of the lockdown assembly may be supplied with fluid pressure by rupturing the walls of the conduits **80** and **81** to expose the annular chambers **102** and **103** to fluid pressure within said conduits. The latter fluid pressure may in turn be controlled and utilized to reciprocate the actuating piston **90** and thus operate the lockdown assembly.

FIGURES 6 and 7 illustrate cutting and packer apparatuses, respectively, suitable for activating and controlling the above described alternative operating system. The cutting apparatus comprises a conventional casing cutter **104** adapted to be lowered into the lockdown assembly **76**, as illustrated in FIGURE 6, to rupture the walls of the conduits **80** and **81** by rotary cutting action. The cutter **104** includes extensible knives **105** adapted to be extended into cutting contact with a tubing string, such as the conduit **80** in which the cutter is positioned. A description of a commercial cutter, such as the cutter **104**, may be found on page 5805 of the 1960–1961, 24th revision, of the Composite Catalogue of Oil Field Equipment. In application to the apparatus of the present invention, the casing cutter **104** would be secured to a drill string **106** and lowered into the position illustrated in FIGURE 6 through the tubing string **62** illustrated in FIGURE 2. After reaching the desired position, the casing cutter would be activated and the drill string rotated to cut an annular opening through the conduit **80** into the annular chamber **102**. Concurrent with this operation, or subsequent thereto, an annular opening would be cut through the conduit **81** into the chamber **103** in a like manner.

After the conduits **80** and **81** have been cut, and the casing cutter has been removed therefrom, the actuating piston **90** may be reciprocated by subjecting one of the conduits to a relatively high pressure with respect to the other. For example, with the piston **90** in the position illustrated in FIGURE 5 and the conduits **80** and **81** in the cut condition, if the conduit **81** is subjected to a relatively high pressure with respect to the conduit **80**, the piston would be forced to the upper extremity of the recess **91**. When the piston **90** is forced to the upper extremity of the recess **91**, the grooves in the piston below the cammed surfaces **92** and **93** are juxtaposed to the sealing element **87** and locking dogs **85** and, thus the sealing element and locking dogs may retract into the lockdown assembly **76** to a position flush with the outer surface thereof. This latter condition is assumed when the lockdown assembly **76** is pulled out of the receiver **71** and the locking dogs **85** are biased inwardly by the cammed surfaces of the recess **75**.

The packer apparatus illustrated in FIGURE 7 comprises a packer assembly adapted to apply fluid pressure to the annular chambers **102** and **103** after the chambers have been ruptured by the cutter **104**. In this figure, the packer assembly is designated by the numeral **107** and is shown located in the conduit **80** in juxtaposition to an annular opening **110** therein which has been formed through means of the cutter **104** illustrated in FIGURE 6. The packer assembly **107** includes a pair of spaced dumbbell type packers **111** and **112** secured to a fluid pressure conduit **113** in sealed engagement therewith. As illustrated, the conduit **113** extends through the packer **111** and is closed at the end extending into the packer **112**. The intermediate portion of the conduit **113** extending between the packers is provided with at least one perforation **114** communicating with the area between the packers. In order to insure sealed engagement between the packers and the conduit in which the packers are being used, each of the packers has secured to the periphery thereof a pair of resilient sealing elements **115**.

In application of the packer **107** to the embodiment of the invention illustrated in FIGURE 5, the packer is lowered to the position illustrated in FIGURE 7 after the conduits **80** and **81** have been ruptured by the cutter of FIGURE 6. Generally, it is sufficient to lower a packer assembly into only the conduit to which it is desired to impart high pressure with respect to the other conduit. However, if desired, a packer assembly may be lowered into each of the conduits and a differential in pressure may be established by imparting a differential in pressure to the conduits **113** communicating with packer assemblies. Locating of the packers in juxtaposition to the opening **110** may be accomplished by adjusting the length of the conduit **113** to a length equal to the length of the drill string **106** used when the openings **110** were cut.

At this point, it is noted that a differential in pressure may be applied between the conduits **80** and **81** through means other than the packer assembly **107** of FIGURE 7. for example, packers may be run into the conduits **80** and **81** to a position below the openings **110** cut therethrough and the closed volumes above the packers may be subjected to a differential in pressure through conventional conduit means, such as the tubing strings **61** and **62**, communicating with the conduits **80** and **81**. It is also noted that in circumstances where it is necessary to activate the alternative operating system of the coupling apparatus of FIGURE 5, and the corresponding alternative operating systems to be described subsequently, the primary actuating lines of the apparatus may have been severed and opened to the relatively low pressure in the environment surrounding the apparatus. Under these circumstances, activating fluid supplied through the secondary

actuating passages will be exhausted into the surrounding environment at the time it is being introduced into actuating mechanism of the coupling apparatus. Therefore, in order for the alternative operating system to be effective it must be capable of supplying a quantity of activating fluid in excess to that which may be exhausted through the primary actuating lines. In order to insure that such a quantity can be supplied, the passages of the alternative operating system (e.g., the passages **100** and **101** of the FIGURE 5 embodiment) and the openings formed by the cutter **104** are sufficiently large to facilitate a flow therethrough exceeding the possible flow through the primary actuating lines.

FIGURE 8 illustrates another embodiment of the coupling apparatus of the present invention, differing from that previously described pirmarily in that it is utilized to couple a single pair of conduits in fluid communication, rather than nested pairs as illustrated in FIGURE 5. In FIGURE 8, the numeral **115** designates a receiver corresponding substantially to the aforedescribed receiver **71**, having a passage **116** extending axially therethrough with an internal locking recess **117** formed around the inner periphery thereof. The receiver **115** is shown with a lockdown assembly **120** telescoped in locked engagement with the passage **116**. The lockdown assembly **120** is similar to the assembly **76** described with reference to FIGURE 5 in that it includes a plurality of locking dogs **121** spaced around the outer periphery thereof for extension into the locking recess **117**. The assembly **120** is also similar to the assembly **76** in that it includes an extensible annular sealing element **122**, an actuating piston **123** and an annular piston receiving recess **124** corresponding, respectively, to the components **87**, **90** and **91** shown in FIGURE 5. The assembly **120** is provided with a manifold system to actuate the piston **123** through fluid pressure including a first conduit **125** communicating with the lower end of the recess **124** and a second conduit **126** communicating with the upper end of the recess. The conduits **125** and **126** communicate with primary actuating lines **127** and **130**, respectively, which extend from the assembly **120** to an external source of controlled fluid under pressure. Thus, the piston **123** may be actuated in a manner corresponding to the actuation of the piston **90** of FIGURE 5 by subjecting the conduits **125** and **126** to a differential in pressure through means of the lines **127** and **130**.

The lockdown assembly illustrated in FIGURE 8 is also similar to that of FIGURE 5 in that it is provided with an alternative operating system to subject the opposed ends of the recess **124** to fluid pressure should the primary actuating lines **127** and **130** become inoperative. This alternative system is included as part of the manifold system for the actuating piston and comprises a rupturable tube or conduit **131** extending axially through the assembly **120**. The conduit **131** is received in the assembly **120** in sealed engagement therewith and is surrounded by an isolated pair of annular chambers **132** and **133** at its upper and lower ends, respectively. The chambers **132** and **133** communicate with the annular recess **124** through an upper actuating passage **134** extending between the recess **124** and the chamber **132** and a lower actuating passage **135** extending between the recess and the annular chamber **133**. It is noted that in FIGURE 8 the apparatus of the invention is shown after the upper and lower sections of the tube **131** have been ruptured through means of a cutter, such as that illustrated in FIGURE 6. In addition to the ruptured condition of the tube **131**, the tube is shown as having a packer assembly **107**, corresponding to that described with reference to FIGURE 7, juxtaposed to the rupture in the lower section of the tube **131**. With the packer assembly so positioned, the piston **123** may be forced to the upper extremity of the recess **124**, thus releasing the lockdown assembly **120** from the receiver **115**, by subjecting the chamber **133** and actuating passage **135** to high fluid pressure with respect to the upper end of the recess **124** through means of the conduit **113** to which the packer assembly is secured. If it is desired to use the alternative operating system to force the piston **123** to the lower end of the recess **124**, it is merely necessary to move the packer assembly **107** to a location juxtaposed to the rupture cut in the upper section of the tube **131** and subject the ruptured section to relatively high fluid pressure through means of the conduit **113**. Thus, it can be seen that the alternative operating system may be used in combination with the packer assembly **107** and conduit **113** to force the actuating piston **123** to either extremity of the recess **124**.

Although the apparatus of FIGURE 8 has been shown with the conduit **131** in the ruptured condition and the packer **107** positioned within the conduit, it is to be understood that during normal operation of the apparatus the conduit is in an unruptured condition, such as the condition of the conduits **80** and **81** of the FIGURE 5 illustration. In the unruptured condition, the conduit **131** acts as a passage for fluid passing therethrough to a conduit that may be secured in fluid communication with the receiver **115**. In this condition, the conduit **131** may be coupled or uncoupled from a conduit secured to the receiver through means of the primary actuating lines **127** and **130**. It is noted, that in the coupled relationship illustrated in FIGURE 8, a seal **136** is interposed between the lockdown assembly **120** and receiver **115** in order to exclude foreign matter from interfering with the operation of the lockdown assembly.

Referring now to FIGURE 9, therein is illustrated another embodiment of the apparatus of the present invention. This apparatus differs from that described with reference to FIGURE 8 primarily in that the receiver **137** takes the form of a male member and the lockdown assembly **140** takes the form of a female member. More specifically, in FIGURE 9, the annular locking recess of the receiver **137** takes the form of an annular groove **141** around the outer periphery of the receiver. Furthermore, the locking dogs **142** and annular sealing element **143** of the lockdown assembly extend inwardly into engagement with the receiver **137**, rather than outwardly into engagement with the receiver. Motion is imparted to the locking dogs and sealing element through means of an annular actuating piston **144** recieved in an annular recess **145** of the lockdown assembly **140** for reciprocating movement therein. The piston **144** differs from the pistons **90** and **123** of the previously described embodiments primarily in that its cammed actuating surfaces are on the inner periphery thereof rather than the outer periphery.

As with the FIGURES 5 and 8 embodiments of the invention, the piston **144** of the FIGURE 9 embodiment is actuated throught a fluid manifolding system communicating with the opposed ends of the recess **145**. This system includes primary actuating lines **146** and **147**, respectively, communicating with the upper and lower ends of the recess **145**. The system further includes an alternative operating system including conduits **150** and **151** extending through the assembly **140** to the upper and lower ends, respectively, of the recess **145**. The conduits **150** and **151** extend to annular normally closed chambers **152** and **153**, respectively, surrounding a conduit **154** extending axially through the assembly **140** in sealed engagement therewith. It is noted, that although the conduit **154** is normally closed to the chambers **152** and **153**, FIGURE 9 illustrates a conduit as being ruptured and in communication with these chambers and also shows a packer assembly **107** juxtaposed to the lower chamber **153**. The operation of the packer **107** illustrated in FIGURE 9 and its application in subjecting the chambers **152** and **153** to pressure in order to reciprocate the piston **144** is identical to that described with reference to the packer illustrated and described in FIGURE 8. Furthermore, during normal operation of the apparatus illustrated in FIGURE 9, the conduit or tube **154** is not in the ruptured condition and the packer **107** is not posi-

tioned within the tube **154**. Thus, normally the coupling apparatus is actuated through the lines **146** and **147**, and the conduit **154** provides a passage whereby fluid may be communicated from a conduit secured to the lockdown assembly **140** into a conduit secured to the receiver **137**.

Referring now to FIGURE 10, therein is illustrated yet another embodiment of the invention adapted to couple a male lockdown assembly within a female receiver in a manner similar to that illustrated in FIGURE 8. In order to simplify the illustration of FIGURE 10, only a vertical section of one-half of the male lockdown assembly is shown. It is to be understood that this male assembly would be received in a female receiver or socket corresponding to the receiver **115** of FIGURE 8. The lockdown assembly **155** illustrated in FIGURE 10 is similar to the assembly **120** of FIGURE 8 in that it includes a rupturable tube or conduit **156** extending axially therethrough. As in the FIGURE 8 embodiment, the lockdown assembly **155** includes an annular chamber **157**, corresponding to the chamber **133**, extending around an intermediate section of the conduit **156**. The lockdown assembly of FIGURE 10 differs materially from those previously described in that the locking elements thereof comprise a plurality of extensible slips **160** positioned around the periphery of the assembly, rather than extensible dogs as described with reference to FIGURES 5, 8 and 9. Although only a single slip **160** is illustrated, it is to be understood that a plurality of such slips are located at spaced intervals around the periphery of the assembly **155**. Each of the slips **160** includes a serrated face **161** adapted to grip a female socket or receiver member into which the assembly is received, and thus lock the assembly within such a receiver without necessity of a locking recess in the receiver.

In order to provide for extension of the slip **160** with respect to the assembly **155**, the rear surface **162** of the slip is formed at an angle with respect to the serrated surface **161**. The rear surface **162** is also provided with a groove **163** adapted to slidably engage a track **164** extending from the surface of a socket **165** in which the finger is slidably received. In order to bias the slip **160** into the extended position shown in FIGURE 10, a compression coil spring **166** is interposed between the lower end of the slip and the socket **165**. Extension of the upper end of the slip **161** is limited by a slotted arm **167** fixedly secured to the surface **162** and extending rearwardly therefrom. The arm **167** includes a stepped slot **170** extending therethrough, which slot is slidably received on the head of a bolt **171** secured to a piston **172** slidably received in a cylindrical recess **173** of the lockdown assembly.

In addition to restricting the outward extension of the slip **160**, the piston **172** acts as a means to force the slip into retracted position within the socket **165**. Thus, it can be seen that the spring **166** acts to normally bias the slip **160** into extended position, and the piston **172** may be utilized to retract the slip. The latter operation is accomplished through means of a fluid pressure manifold system communicating with the cylindrical recess **173** in a manner similar to the manifold system described with reference to FIGURES 5, 8 and 9. The manifold system of the FIGURE 10 embodiment includes a first conduit **174** extending between the upper end of the recess **173** and a primary actuating line **175** extending to an external source of controlled fluid under pressure. Through the line **175**, fluid pressure may be remotely applied to the piston **172** and thus the slip **160** may be retracted to permit the lockdown assembly **155** to be removed from a receiver or socket in which it is engaged.

The manifold system communicating with the upper end of the recess **173** also includes an alternative actuating passage **176** extending into communication with the annular chamber **157** for use therewith should the actuating line **175** become disabled. The alternative actuating passage **176** is utilized by opening the passage to pressure within the conduit **156** in a manner similar to the aforedescribed rupturing of the conduits **131** and **154** of FIGURES 8 and 9 respectively. Specifically, in the latter operation a cutter, such as the cutter **104**, is lowered into the conduit **156** to cut a passage through the conduit into the chamber **157**. After this passage has been cut through the conduit, the chamber **157**, passage **176** and recess **173** may be subjected to fluid pressure to force the piston **172** downwardly. This pressure may be imparted by subjecting the entire conduit **156** to relatively high fluid pressure, or by lowering a packer assembly, such as the assembly **107**, into the conduit **156** in juxtaposition to an opening cut therethrough. Thus, it is seen that the FIGURE 10 embodiment of the invention provides a coupling apparatus with primary and alternative operating means, suitable for use under both ideal and adverse conditions.

To summarize, FIGURES 5, 8, 9 and 10 illustrate embodiments of the present invention suitable for use with underwater installations as shown in FIGURES 1 to 4. During normal operation and application of the invention, components desired to be secured to an underwater installation are lowered to the installation on guide lines, such as the lines **25** and **26** of FIGURE 1. After the receiver and lockdown assemblies assume a telescoped engaged position, the primary actuating lines, such as the lines **42** and **43** of FIGURE 1 are subjected to a differential in pressure from a remote operating location and, thus the extensible locking components of the lockdown assembly are forced into locked engagement with the receiver to which the lockdown assembly is being secured. In specific application, the casing head **22** and coupling mechanism **41** may take the form of the receiver **137** and lockdown assembly **140** of the FIGURE 9 embodiment. In this case, should the primary actuating lines become disabled, the alternative operating system including the chambers **152** and **153** and the passages in communication therewith may be utilized to either couple or uncouple the lockdown assembly from its receiver. It is to be understood that a single wellhead assembly may include a plurality of the lockdown apparatuses of the present invention. For example, in FIGURE 1 both the running tool **35** and coupling mechanism **41** may take the form of the lockdown assembly **140** of FIGURE 9. Furthermore, the wellhead connector **51** and landing head **52** of the FIGURE 2 embodiment may also have internal structures corresponding substantially to the lockdown assembly **140** of FIGURE 9.

From the alternative apparatuses set forth in the above description and accompanying illustrations, it is believed apparent that the generic concept of the present invention is not limited to a particular structure or design. Therefore, various changes in the details of the described methods and illustrated constructions may be made, within the scope of the appended claims, without departing from the spirit of the invention.

I claim as my invention:

1. A method for remotely imparting secondary fluid-actuating pressure to a primary fluid pressure system of a fluid-pressure-actuated mechanism secured to a conduit outwardly thereof and out of fluid communication therewith on an underwater well installation, said method comprising:

lowering a pipe-cutting tool through said conduit to a point adjacent said primary fluid pressure system,

actuating said pipe-cutting tool within said conduit to to form an opening through a section of the conduit to establish fluid communication between the interior of the conduit and at least a portion of the primary fluid pressure system of the mechanism, and

applying an actuating pressure fluid down through said conduit and through the opening cut therein to the primary fluid pressure system.

2. The method of claim **1** including the step of closing the bore of said conduit below the opening cut therein prior to applying pressure fluid through the conduit.

3. The method of claim 1 including the step of sealingly confining the opening cut in the conduit prior to applying pressure fluid through the conduit.

4. The method of claim 1 including the step of originally providing said conduit with a thin-walled section adjacent the primary fluid pressure system and through which the cut can be made.

5. The method of claim 1 including the step of cutting a second opening through the wall of said conduit at a point axially displaced from said original opening, said openings being positioned in communication with independent isolated portions of said primary fluid pressure system.

6. The method of claim 1 including the step of running a pipe string with a dumbbell type packer on the end thereof for isolating said opening cut in said conduit,

and wherein said actuating fluid pressure is applied down said conduit through said pipe string and thence out between said dumbbell packer.

References Cited by the Examiner

UNITED STATES PATENTS

2,582,530	1/1952	Daetwiler	137—68 X
3,115,933	12/1963	Haeber.	

FOREIGN PATENTS

860,914	2/1961	Great Britain.

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