United States Patent [19]

Brown

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[45] **Aug. 20, 1974**

[54] **WELL CONTROL MEANS**

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[52] **U.S. Cl.** **166/315,** 166/53, 166/73, 166/78, 166/95, 166/226

[51] **Int. Cl.** **E21b 43/01,** E21b 33/035

[58] **Field of Search** 166/53, 72, 73, 226, 95, 166/78, 315

[56] **References Cited**

UNITED STATES PATENTS

2,831,539	4/1958	En Dean et al.	166/73
3,094,170	6/1963	Bourne	166/72 X
3,219,107	11/1965	Brown et al.	166/53 X
3,313,350	4/1967	Page	166/72 X
3,351,133	11/1967	Clark et al.	166/53
3,411,585	11/1968	Page	166/73
3,419,076	12/1968	Sizer et al.	166/72 X
3,459,260	8/1969	Dollison	166/73
3,494,417	2/1970	Fredd	166/73
3,696,868	10/1972	Taylor	166/315
3,731,742	5/1973	Sizer et al.	166/72 X

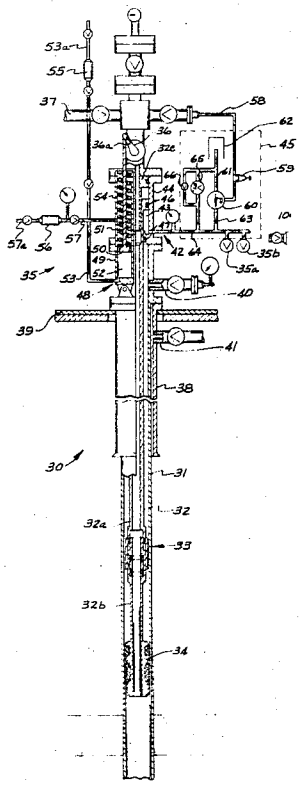
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[57] **ABSTRACT**

Opening and closing of a subsurface safety valve in a well conduit is regulated by predetermined movement of a well conduit supported from an offshore production platform. In one form of the invention, release of support means employed to suspend the conduit in the well permits the conduit to move longitudinally to close the valve and in another embodiment, release of support permits the conduit to rotate to close the valve. Slip joints and/or hydraulic or mechanical tensioning means are employed for accommodating normal conduit movement to prevent such movement from operating the subsurface valve. Closing of the valves is regulated by heat sensitive, frangible sensors which release the conduit support upon the occurrence of fire, explosion, impact with a vessel, or other damaging occurrence. A master control system is employed for closing subsurface and/or surface valves in all of the wells supported by the platform in the event of closure of any one of the wells. Means may also be provided for closing or opening the subsurface and/or surface valves in one or all of the wells with equipment responsive to a remotely generated command signal.

The subsurface valves may be retrievable and in one embodiment of the invention, dual valves are employed with retrieval of one of the valves closing the remaining valve and replacement of the valve automatically reopening the closed valve. In another embodiment, closure of the subsurface valve also closes the annular area between the conduit and the well casing to provide a packer back-up valve.

50 Claims, 21 Drawing Figures



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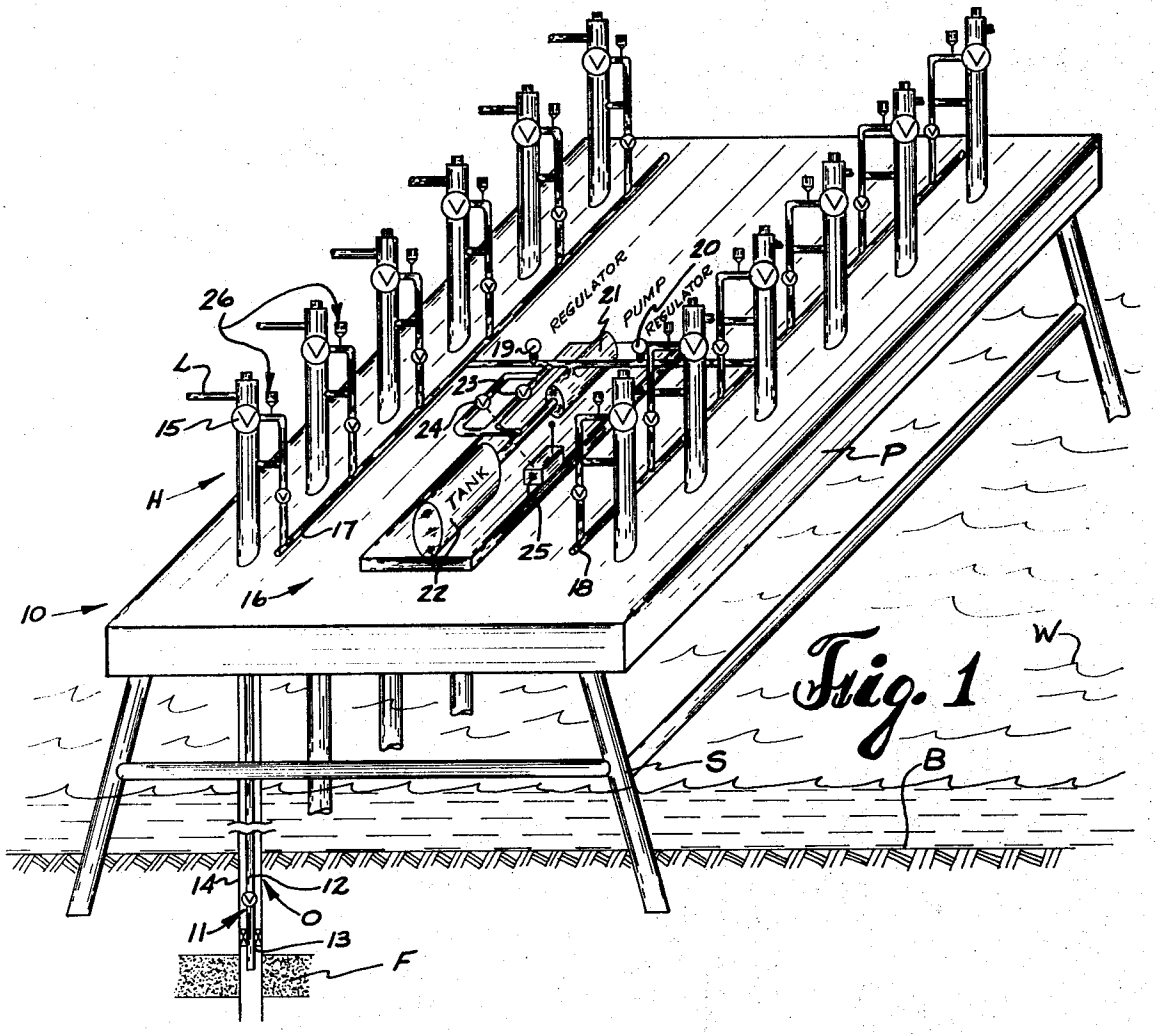


Fig. 1

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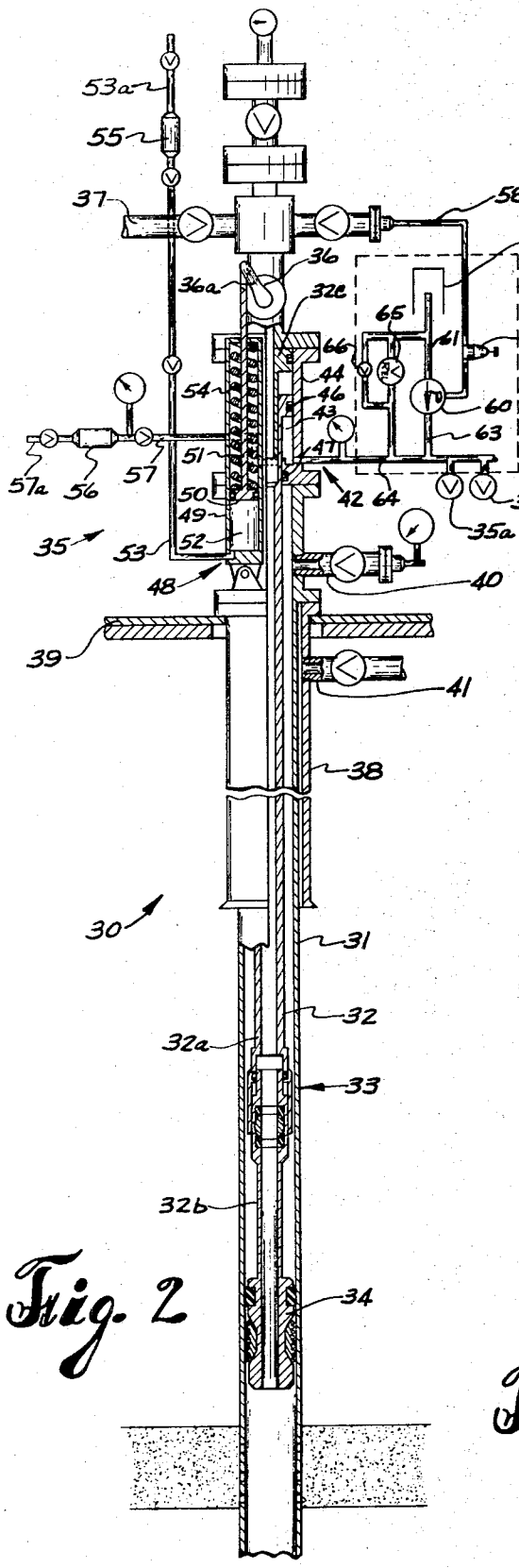


Fig. 2

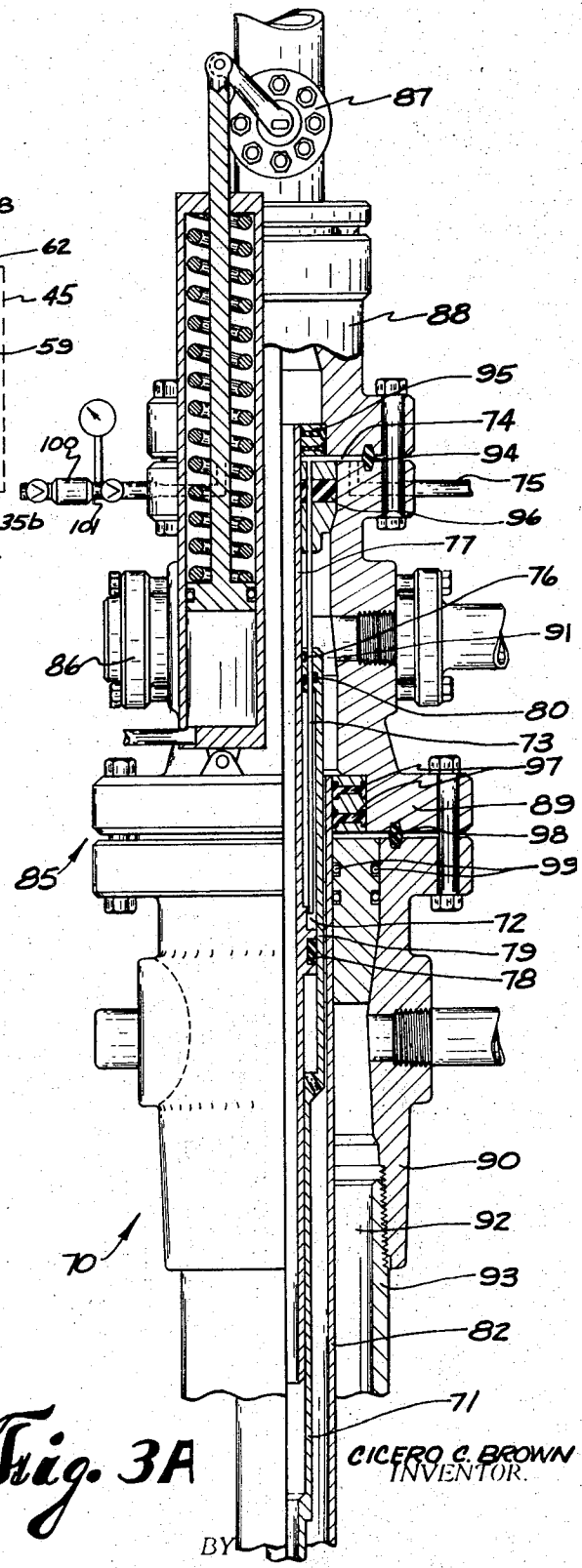


Fig. 3A

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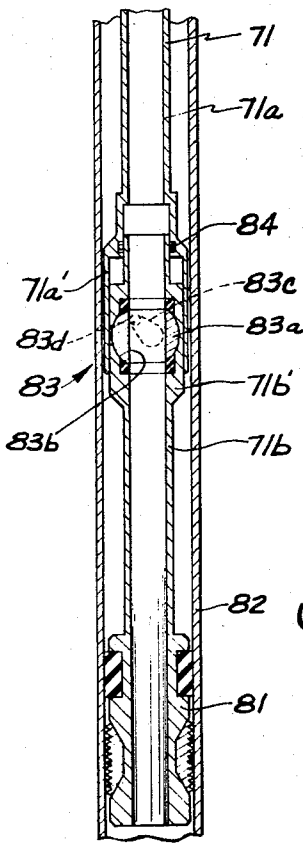


Fig. 3B

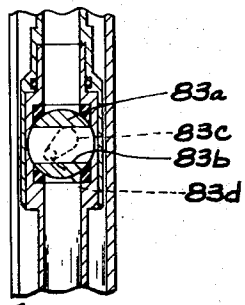


Fig. 3D

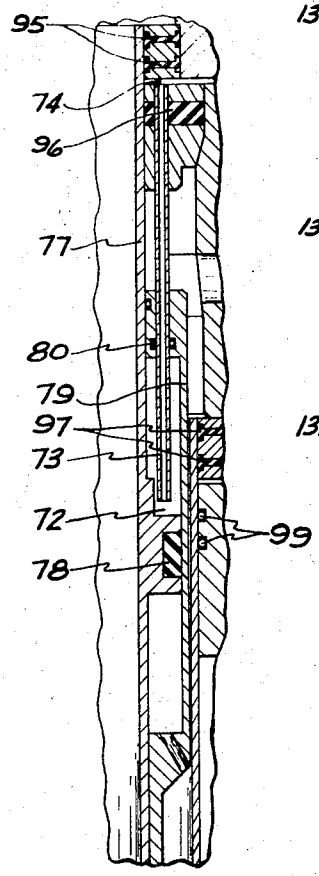


Fig. 3C

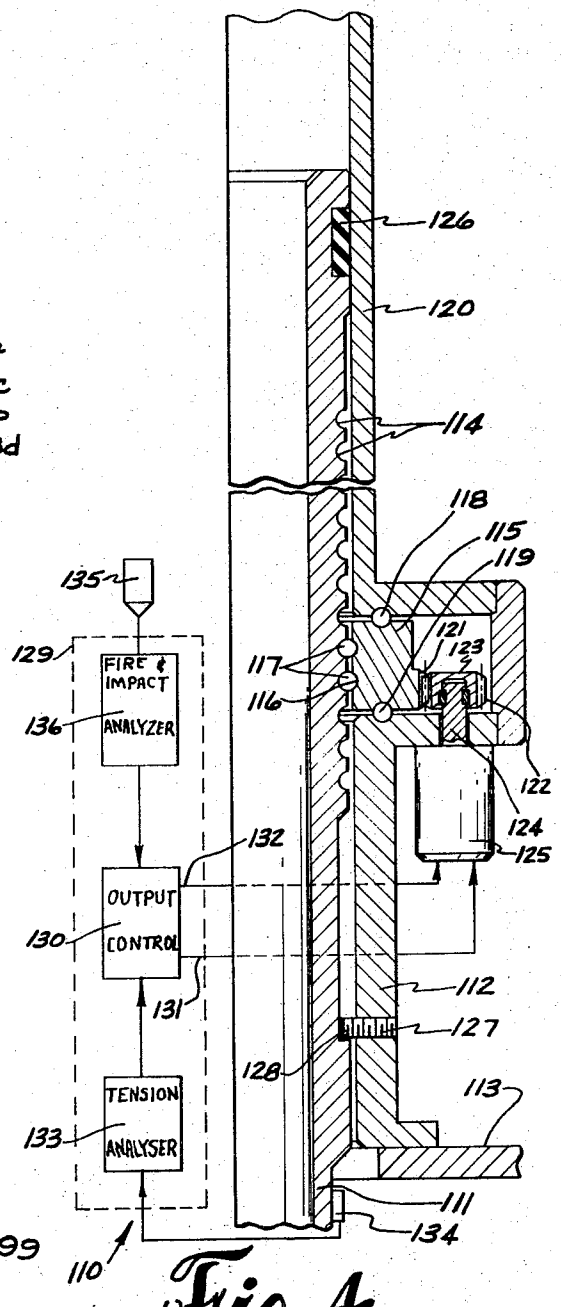


Fig. 4

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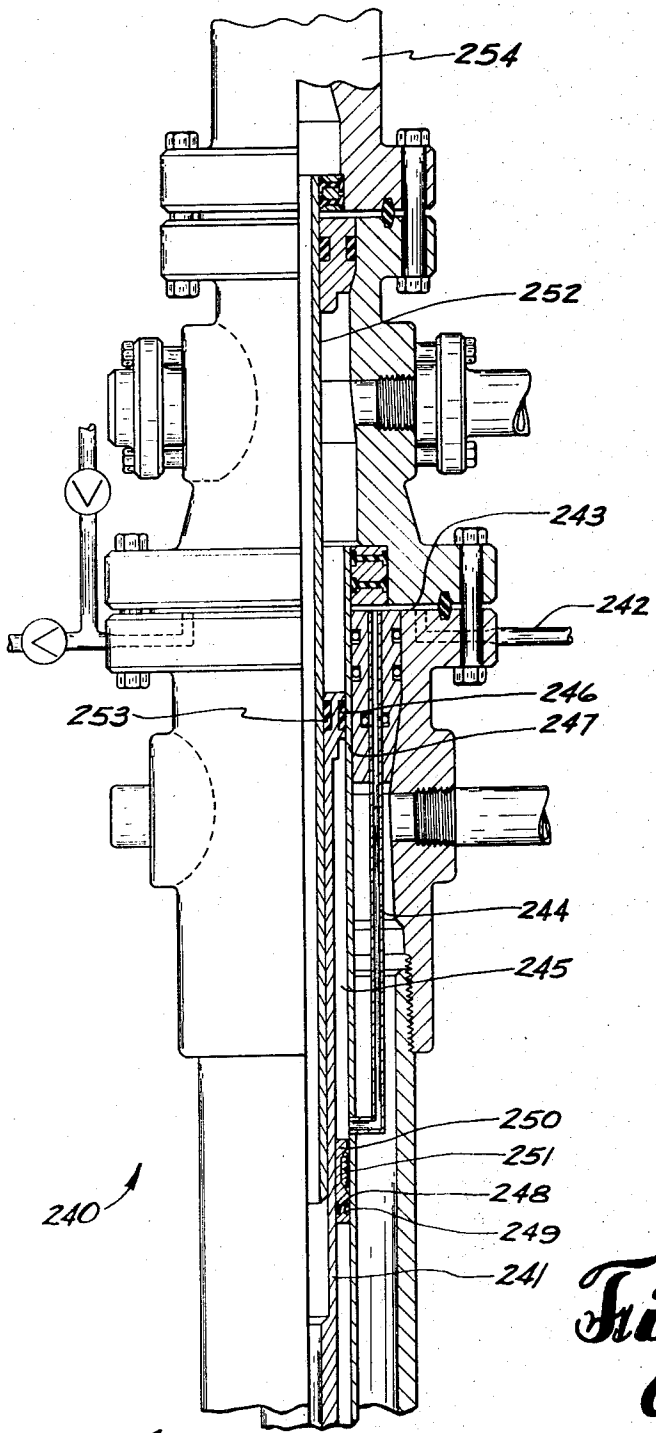


Fig. 6

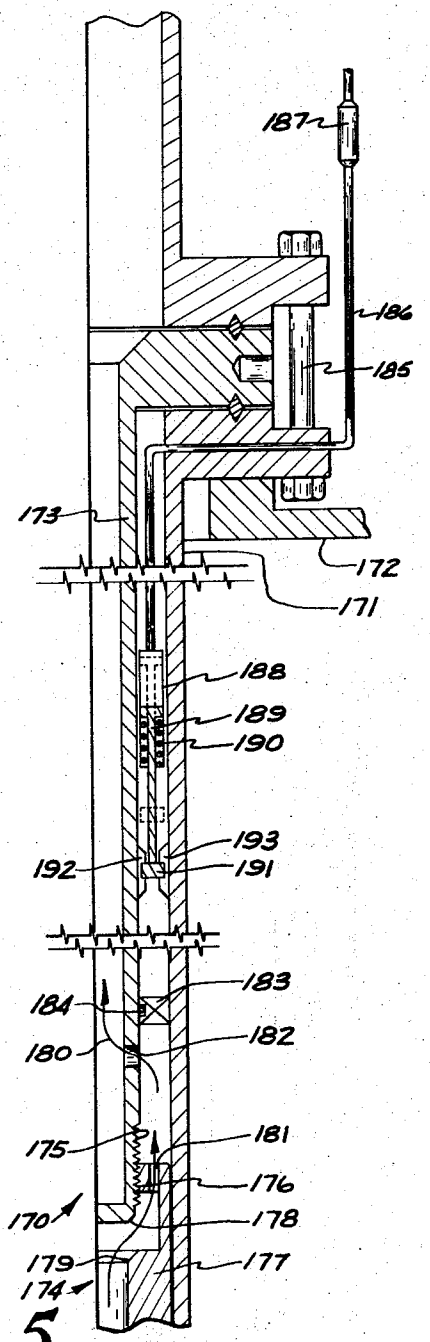


Fig. 5

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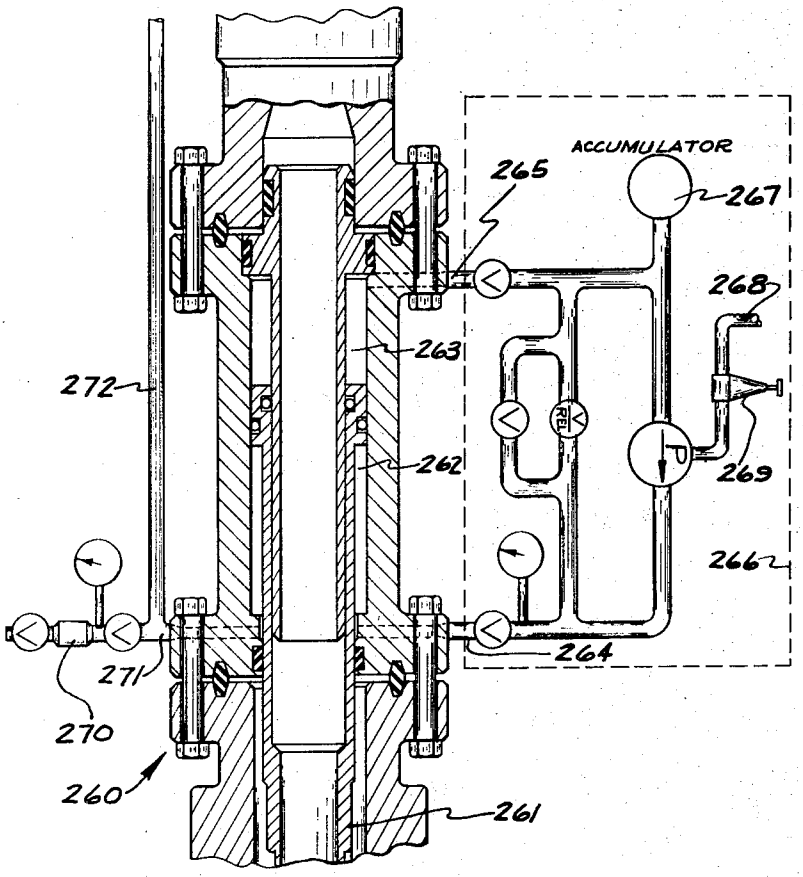


Fig. 7

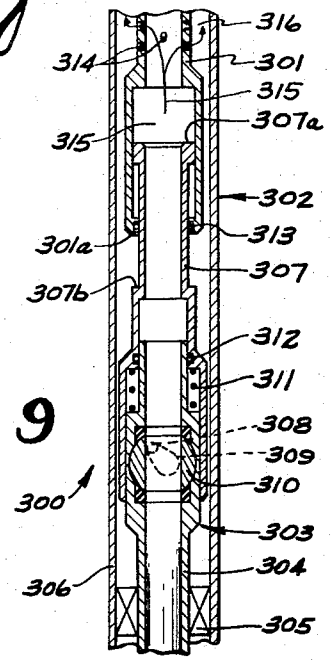


Fig. 9

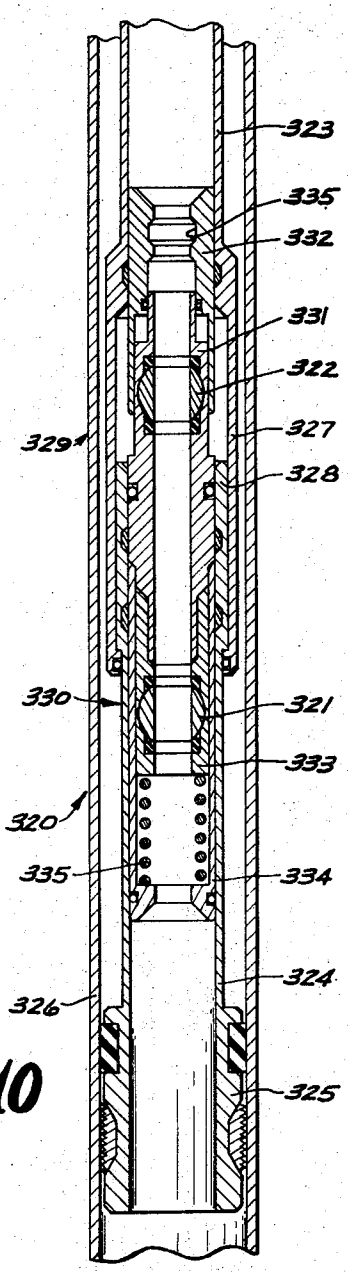


Fig. 10

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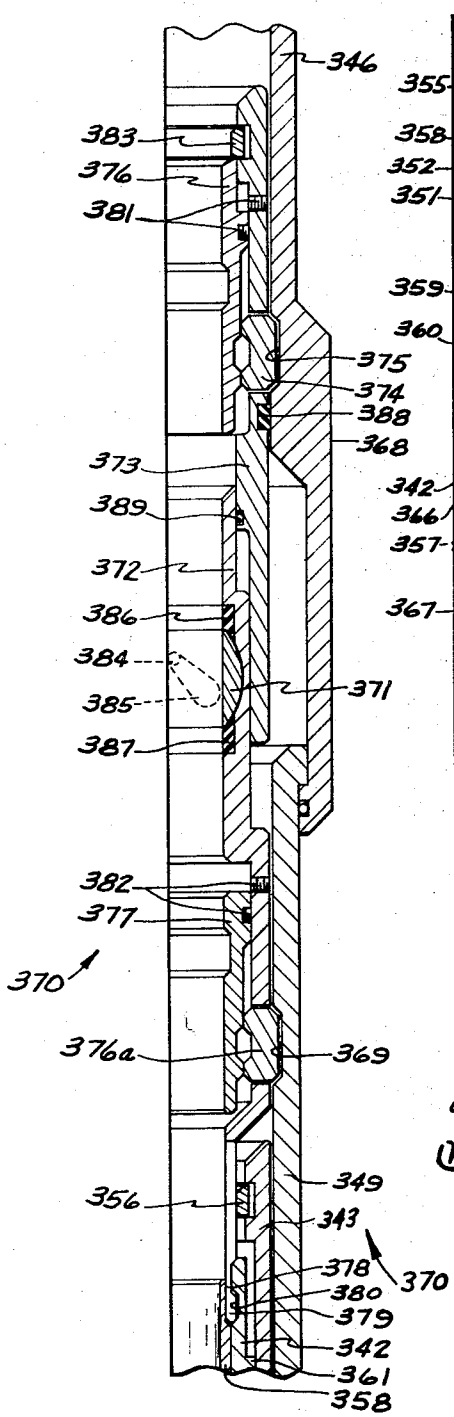


Fig. 11A

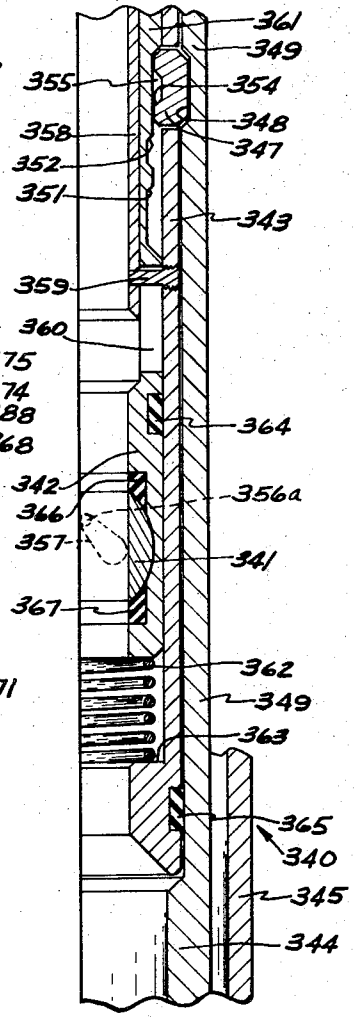


Fig. 11B

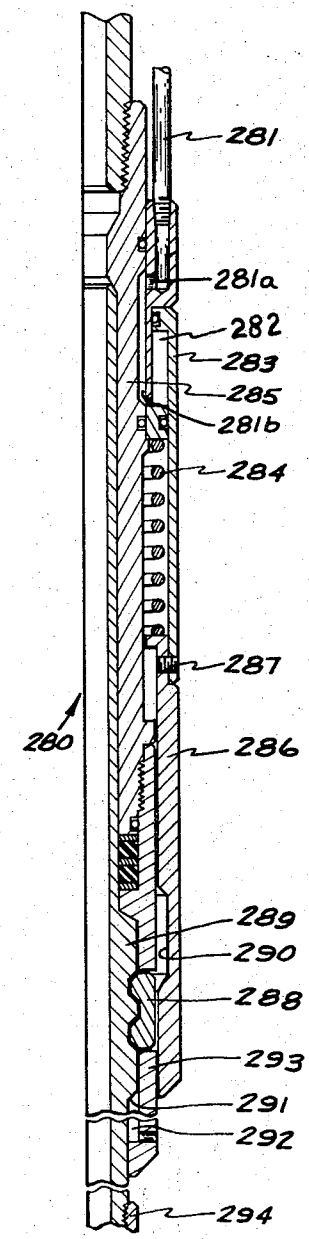


Fig. 8

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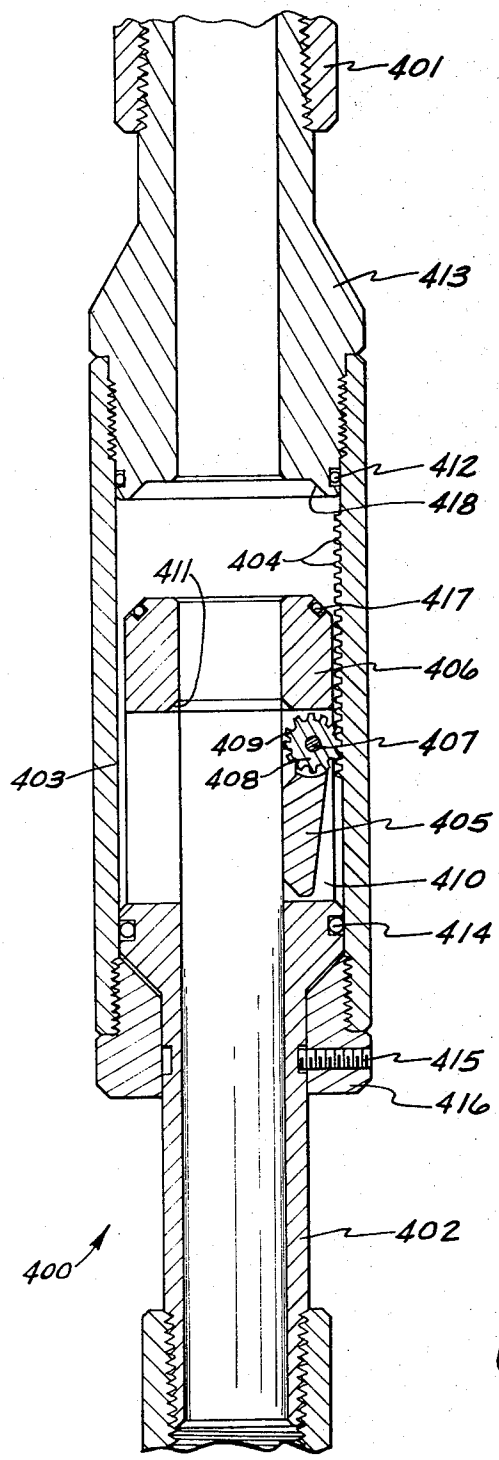


Fig. 12

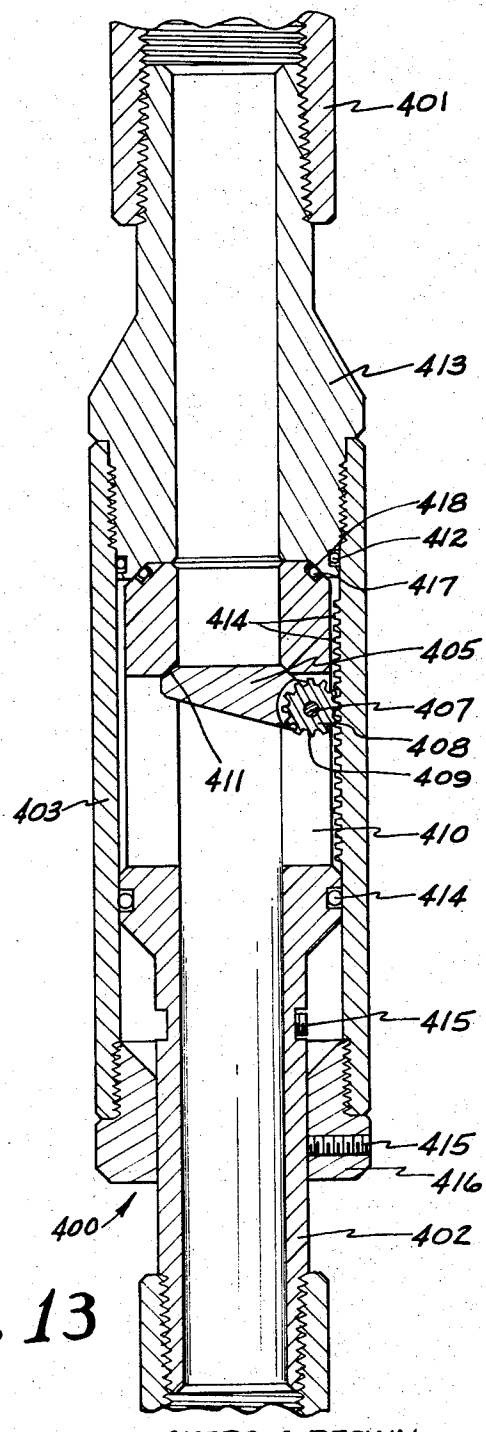


Fig. 13

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Fig. 14

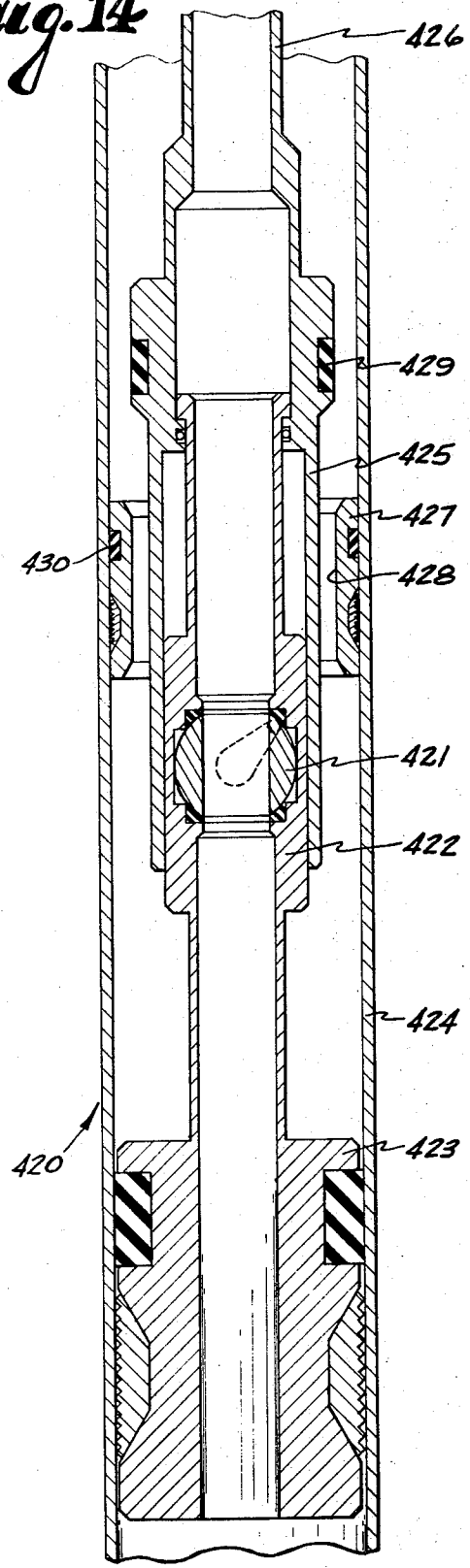
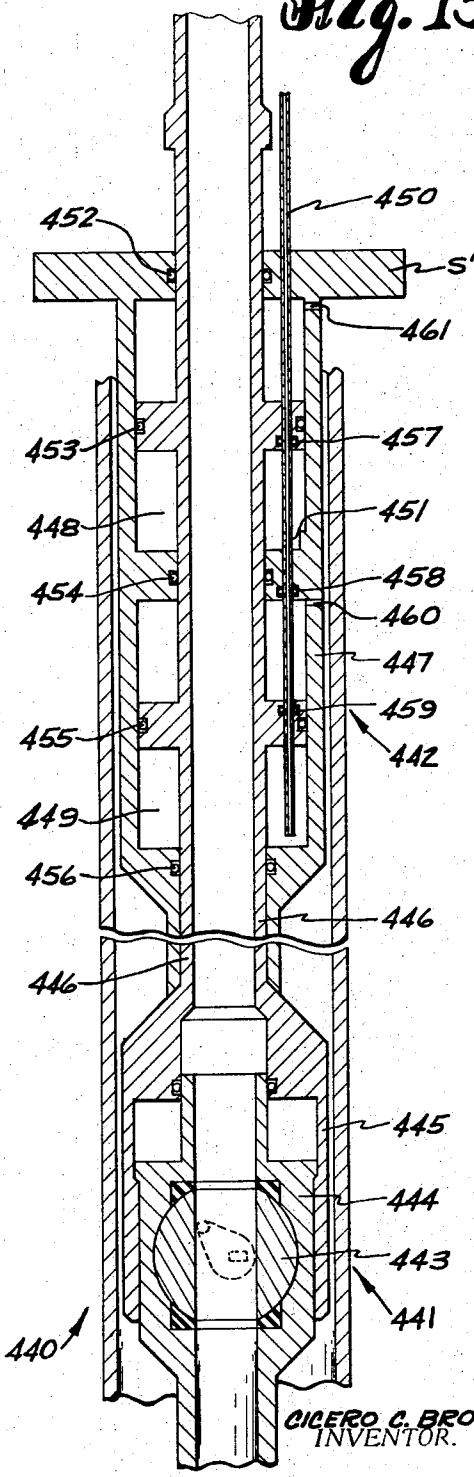


Fig. 15



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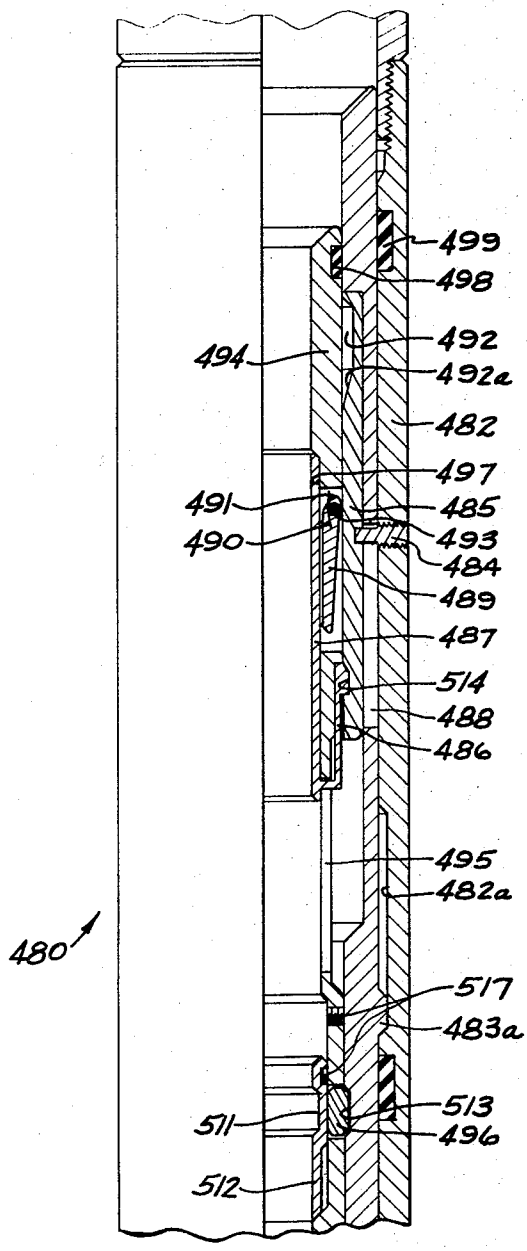


Fig. 16A

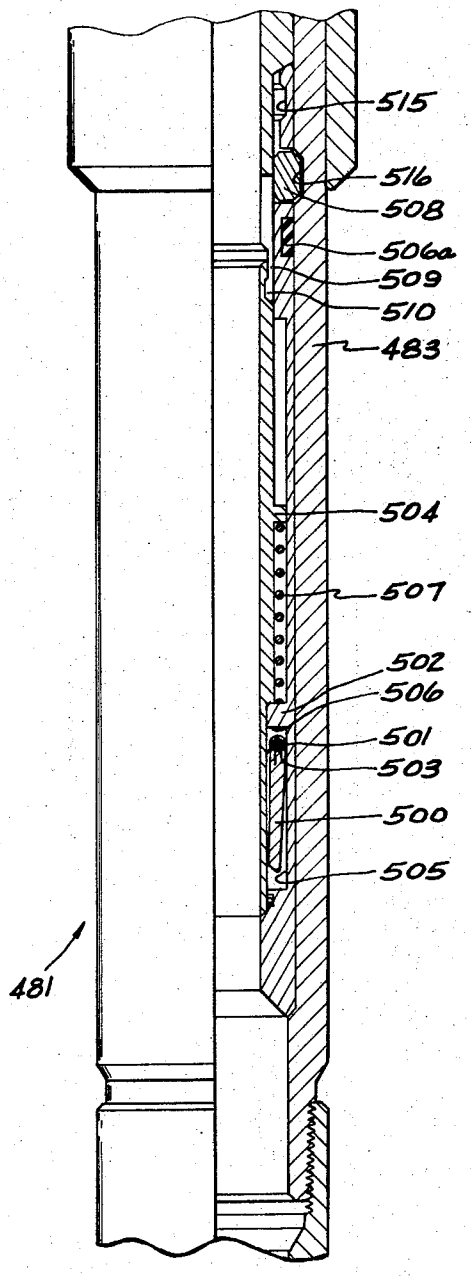


Fig. 16B

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WELL CONTROL MEANS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the control of effluent flow through well structures. More specifically, the present invention relates to an assembly, system, and method for automatically and/or remotely terminating the flow of effluents through one or more well conduits supported from an offshore production platform in the event of fire, explosion, damage to or inoperability of the restraining structures at the wellheads.

2. Brief Description of the Prior Art

Many of the prior art safety valves employed in offshore well installations are the self-contained type which close automatically in response to either a drop in pressure of the well effluents or to an increase in rate of fluid flow through the well. As used herein, the term "fluids" includes both liquids and gases. Valves are positioned at a subsurface location within the well where they are protected from surface damage. The valves are intended to function as safety devices to prevent a "blowout" in which the well fluids flowing uncontrollably from a damaged well may cause injury to personnel, environmental damage or may ignite and destroy the supporting well structures.

Those conventional, self-contained safety valves which close only on the occurrence of either low effluent pressure or an increased rate of effluent flow are impractical to test since it is difficult to simulate the necessary high flow or low pressure conditions within the well. Such self contained valves may also present problems when it is desired to close-in the subsurface valve and a wellhead valve simulataneously in anticipation of threatened damage to the wellhead structure, for example, when a hurricane is eminent. Self-contained pressure or flow rate responsive valves are not closed simply by closing the wellhead valves since the pressure and flow rate values of the effluent with the surface valve closed are inadequate to cause closing of the subsurface valve.

One prior art safety valve which overcomes many of the disadvantages associated with self-contained flow responsive or pressure responsive safety valves employs small diameter macaroni conduit which extends from a subsurface valve to the well's surface. The macaroni conduit string contains a pressurized, incompressible hydraulic fluid which maintains the valve open. The valve is positively controlled from the wellhead in that loss of pressure in the line automatically releases the closure elements of the subsurface valve to permit the valve to close thereby terminating all flow through the tubing string. The system is disadvantageous in that macaroni conduit strings must be accommodated between the tubing string and surrounding well casing. The requirement for an additional conduit in addition to the casing and tubing string is undesirable in many applications, and a macaroni conduit string, because of its small size, is subject to breakage and crimping which may prevent proper operation of the valve. In addition, the macaroni line and the tubing string must be installed in the well simultaneously and special equipment is required for handling the dual string assembly.

SUMMARY OF THE INVENTION

In the preferred embodiment of the well control means of the present invention, movement in the conduit which conveys effluents from a subsurface formation to the wellhead is employed to regulate opening and closing of a subsurface safety valve which permits or terminates effluent flow through the well conduit. The conduit is supported at the well surface by a structure which is designed to release the conduit in the event of fire or severe physical impact sensed by heat fusible, frangible detectors positioned at the wellhead. In one form of the invention, release of the support following fire or impact permits the conduit to fall longitudinally under the influence of gravity to the extent necessary to close the subsurface valve. In another embodiment, release of the support means permits the release of torque forces in the conduit which rotate the conduit to close the subsurface valve.

In the longitudinally movable forms of the invention, compensating means are provided for preventing axial conduit movement induced by normal well conditions, such as changes in the temperature or pressure of the well effluent, from opening or closing the subsurface valve. Telescoping slip joints may be employed to compensate for such normal well condition induced longitudinal elongation and foreshortening of the conduit to prevent such induced movement from operating the subsurface valve. In one form of the invention, compensation for induced movement is provided by automatically maintaining a substantially constant tension in the conduit.

In the preferred form of the invention, the support structure includes an hydraulic system which provides longitudinal support for the well conduit and also maintains a constant tension in the conduit. Loss of the hydraulic fluid in the system or a predetermined reduction in pressure of the fluid permits the well conduit to move longitudinally under the influence of gravity which produces the movement required to close the subsurface valve. The valve may be reopened by repressuring the system to elevate the well conduit. During normal operation, the pressure of the hydraulic fluid in the system is automatically held at a fixed value to maintain a substantially constant tension in the conduit which prevents normal movement of the conduit from operating the subsurface valve. In a modified form, a releasable mechanical support is employed to suspend the conduit from the wellhead and to maintain a constant tension in the conduit.

One form of the invention includes first and second cooperating subsurface valves which are retrievable through the well conduit. Retrieval of the first valve automatically closes the second valve which remains in place. Replacement of the first valve automatically reopens the second valve to reinitiate effluent flow through the well.

In another embodiment of the invention, the movement of the well conduit which closes the subsurface safety valve also closes a second valve which seals the annular area between the well conduit and the surrounding casing to provide a back-up seal for the well packer.

Where a plurality of wells are mounted on the same platform, all of the wells are linked together by a master control system so that closure of one of the subsurface valves due to fire or impact automatically closes

the subsurface valves in all of the other linked wells. Surface control valves are included in each well and are tied in with the master control system so that the surface valves in each of the wells are closed when fire or impact causes the closing of any one of the valves in any single well. The master control system may also be operated by a command signal generated from a remote point to cause opening or closing of the surface and/or subsurface valves in all or any one of the wells even in the absence of fire or impact.

The well control means of the present invention provides a failsafe method for closing a subsurface valve without the need for an auxiliary control line extending from the wellhead to the subsurface valve. The valves employed in the well conduit are retrievable so that they may be repaired and replaced without requiring the removal of the entire tubing string. Since the subsurface valves are surfaced operated, they may be quickly and easily tested or closed when exposed to dangerous conditions. When connected into a master system, closure of all of the wells upon closure of any one of the wells in the system prevents explosion or fire in one well from spreading to the other wells in the system. The remote control provision permits the wells to be closed in by a remotely generated signal, coming from a land base, or otherwise, in anticipation of storm damage or other damage. The remote control may also be employed to reopen the wells after the danger has passed.

The foregoing as well as other features and advantages of the present invention will be more readily apparent from the following specification, drawings and the related claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic representation of an offshore oil platform supporting a plurality of separate well structures;

FIG. 2 is a partial vertical elevation, partially in section schematically illustrating an hydraulically supported, longitudinally movable form of the well control means of the present invention;

FIGS. 3A and 3B are partial vertical sections of the upper and lower portions, respectively, of a modified hydraulically supported, longitudinally movable form of the control means of the present invention;

FIG. 3C is an enlarged vertical section illustrating details in the construction of the means illustrated in FIG. 3A;

FIG. 3D is a partial vertical section of the valve in FIG. 3B illustrated in closed position;

FIG. 4 is a partial vertical elevation, partially in section, schematically illustrating a mechanically supported, longitudinally movable form of the well control means of the present invention;

FIG. 5 is a partial vertical elevation, partially in section, schematically illustrating a torque operated, rotatably movable form of the present invention;

FIG. 6 is a partial elevation, partially in section, illustrating a modified, hydraulically supported form of the present invention adapted to close on longitudinal movement of the conduit;

FIG. 7 is a partial vertical section illustrating a modified hydraulic support structure which may be employed in the present invention;

FIG. 8 is a partial vertical quarter section illustrating an hydraulically controlled mechanical support structure which may be employed in the present invention;

FIG. 9 is a partial vertical section illustrating a modified form of the present invention for compensating for well condition induced movement of the well conduit and for production through the well annulus;

FIG. 10 is a vertical section schematically illustrating dual, retrievable subsurface safety ball valves employed in the present invention;

FIGS. 11A and 11B are vertical quarter sections illustrating respectively details in the construction of the upper and lower ball valve assemblies schematically illustrated in FIG. 10;

FIG. 12 is a vertical section illustrating an open flapper valve employed for use as a subsurface safety valve in the well control means of the present invention;

FIG. 13 is a vertical section of the valve of FIG. 12 illustrated in closed position;

FIG. 14 is a vertical section illustrating a dual closure assembly which forms a back-up seal for the packer and closes a subsurface safety valve in the well conduit upon longitudinal movement of the conduit;

FIG. 15 is a vertical section illustrating a plural chamber hydraulic support system which may be employed with the present invention; and

FIGS. 16A and 16B are partial vertical sections illustrating the upper and lower portions respectively of a retrievable, dual flapper valve assembly employed as the subsurface safety valve in the well control means of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 of the drawings schematically illustrate an exemplary form of the well control system of the present invention, indicated generally at **10** mounted on an offshore well platform P. The platform P is supported over the surface of the body of water W by a support structure S which extends through the water and into the water bottom B. A plurality of separate well structures such as the structure indicated generally at O extend between the well platform P and a subsurface oil or gas bearing formation F. Each of the well structures O is suspended from a wellhead indicated generally at H supported on the surface of the platform P. Oil and gas in the formation F flows upwardly through the well structure O and enters the wellhead H where it is carried by a pipeline L to storage tanks (not illustrated) or to a main pipeline (not illustrated) connecting the platform with the mainland.

Each of the well structures O in the system **10** is equipped with a subsurface safety valve indicated generally at **11** which is employed to regulate the flow of well effluents through a production tubing string **12**. A packer **13** provides a fluid-tight seal between the production string **12** and a surrounding casing string **14**. At the wellhead H, a surface valve **15** is employed to regulate the flow of effluents from the production tubing **12** into the line L.

In the preferred form of the present invention, an incompressible, hydraulic fluid is employed to regulate opening and closing of the subsurface valve **11** and the surface valve **15** in a manner to be described. The hydraulic fluid is supplied to each of the wellheads from a pressurizing system indicated generally at **16** which automatically maintains a constant control pressure on the hydraulic fluid for a purpose to be explained. The

system 16 includes dual, manifolded fluid supply lines 17 and 18 connected through regulators 19 and 20, respectively, to pressurizing means including a pump 21, a reservoir tank 22, a pressure relief valve 23 and a bypass valve 24. A remotely operated, radio controlled servomechanism 25 is employed in the system 16 to regulate opening and closing of the bypass valve 24.

In the preferred form of the present invention, loss of pressure in the system 16 automatically causes the valves 11 and 15 to close. Such pressure loss may be caused by manually or remotely opening the pressure bypass valve 24, or through leakage caused by damage to or destruction of a sensor indicated generally at 26 located in the vicinity of the wellhead H. Preferably, all of the wellheads on the platform P are in pressure communication to form a master system so that loss of pressure in the system 16 causes automatic closing of the subsurface and surface valves corresponding to the valves 11 and 15 in each of the separate well structures. The pump 21, tank 22, regulators 19 and 20 and the pressure relief valve 23 in the system 16 function in a conventional manner to maintain a substantially constant pressure in the lines 17 and 18 for a purpose to be described. It will be appreciated that any other suitable system for maintaining constant pressure in the lines 17 and 18 may be substituted for the pressurizing means in the system 16.

In operation, fire or impact damage to any one of the sensors corresponding to the sensor 26 releases pressure in the hydraulic system 16 to permit automatic closure of the subsurface and surface valves in each of the well structures. In addition, all surface and subsurface valves may be closed by opening the bypass valve 24 to release the pressure in the system 16. Opening of the valve 24 may be done manually or by sending a command signal from a remote location to the radio controlled servomechanism 25 which also releases the pressure in the system 16. In the latter situation, the valves may be reopened by manually closing the valve 24 or by sending a second command signal which causes the servo 25 to close the bypass valve 24. With the valve 24 closed, the pressurizing means in the system 16 reestablish the hydraulic pressure required to open the surface and subsurface valves.

It will be appreciated that while a specific exemplary system 16 for maintaining a constant pressure in line 17 and 18 has been described in FIG. 1, any conventional or well known means for automatically maintaining a predetermined pressure value in the line 17 and 18 may be employed. Moreover, while a specific method for remotely releasing pressure in the hydraulic system has been shown, any suitable means for automatically releasing or reinitiating pressure in the system by command signals generated from a remote location may be employed.

Referring to FIG. 2, a specific well structure of the type employed in the system 10 is indicated generally at 30. The well structure 30 includes a casing string 31 surrounding a smaller production conduit 32. A subsurface safety valve indicated generally at 33 is included within the conduit 32. The lower end of the conduit 32 is engaged with a conventional packer 34 anchored to the surrounding casing 33. The conduit 32 includes two separate components or lengths comprising an upper length 32*a* and a lower length 32*b*. The lower length 32*b* is fixed with respect to the packer 34 whereas the upper conduit length 32*a* is movable longitudinally with respect to the packer and the surrounding casing 31. The valve 33 is designed to close when the upper conduit length 32*a* moves longitudinally downwardly with respect to the lower component 32*b*, and to reopen when the upper length is raised The packer 34 provides a fluid-tight seal whereby effluents in the well formation are forced to flow through the conduit 32 and valve 33 to a wellhead indicated generally at 35, and into a valved pipeline 37 which may connect with storage tanks or a main pipeline. The well structure 30 is supported by the wellhead 35 from a stationary, above-water platform 39. A connecting line 40 communicates with the annular space formed between casing 31 and conduit 32 and a second line 41 communicates with the annular passage between the conductor casing 38 and the casing 31. The lines 40 and 41 function in a conventional manner to supply fluids to or remove fluids from the respective annular passages with which they are connected.

An hydraulic suspension system indicated generally at 42 is employed to releasably support the production conduit 32 longitudinally within the wellhead 35. The system 42 includes an annular, expansible hydraulic chamber 43 formed between the conduit 32 and an overlying tubular chamber housing 44. A control system 45 supplies the chamber 43 with pressurized hydraulic fluid. The chamber 43 is sealed at its upper and lower ends by annular O-rings 46 and 47 which form pressure-tight sliding seals permitting the chamber to expand and contract longitudinally with longitudinal movement of the conduit 32 through the stationary housing 44. A guide sleeve 32*c* telescopes into the top of the conduit section 32*a* and seals with the upper end of the housing 44.

Under normal operating conditions with the subsurface valve 33 opened, the chamber 43 is pressurized by the system 45 to hold the upper end of the conduit 32 above the base of the chamber 43 to keep the valve 33 open. Loss of pressure in the chamber 43 permits the conduit 32 to drop longitudinally downwardly through the wellhead 35 automatically closing the valve 33. A shoulder formed at the top of conduit length 32a engages an inwardly formed shoulder at the lower end of the chamber 43 to prevent complete release of the conduit 32. In addition to providing a releasable support for the conduit 32, the system 42 also functions to prevent normal longitudinal movement in the conduit 32, induced for example by temperature changes or pressure changes in the well structure, from operating the valve 33. To this end, constant pressure is maintained in the chamber 43 by the system 45 to maintain constant tension in the conduit 32. Thus, as the top of conduit 32 rises due to elongation, the volume of chamber 43 increases tending to decrease the pressure of the fluid in the chamber which in turn tends to permit the conduit to move downwardly. This latter movement which could cause closure of the valve 33 is prevented by maintaining the pressure in chamber 43 constant. The housing 44 is of sufficient longitudinal development to accommodate normal, induced elongation and foreshortening of the well conduit 32 so that only a predetermined longitudinal movement, produced by a reduction of pressure in the chamber 43, is effective to close the valve 33.

At the wellhead 35, a surface valve control indicated generally at 48 is employed to regulate opening and closing of the surface valve 36. The control 48 includes

a tubular housing **49** through which a piston **50** and piston rod **51** are moved axially by hydraulic pressure introduced into a chamber **52** by a supply line **53.** A coil spring **54** urges the piston **50** and **51** downwardly which turns a valve handle **36a** connected to the rod **51** causing closure of the surface valve **36.** The supply line **53** includes a heat and impact responsive sensor **55** which is adapted to release the pressure in the chamber **52** when fire or severe impact destroy or rupture the sensor **55.** The end **53***a* of the line **53** may connect with the hydraulic pressurizing system **45** or may be connected with a separate pressurizing system (not illustrated). If connected with the system **45,** it will be appreciated that the surface valve **36** will be closed and opened as the subsurface valve **33** is closed and opened. Where a separate pressurizing system is connected to the line **53,** operation of the surface valve **36** may be controlled independently of operation of the subsurface valve **33.**

A second sensor **56** similar to the sensor **55** is included in a line **57** which is in pressure communication with the chamber **43.** Upon rupture or destruction of the sensor **56,** the pressure in chamber **43** is released to permit the conduit **32** to drop longitudinally downwardly closing the valve **33.** The free end **57***a* of line **57** may communicate with a second wellhead as may the free end **53***a* of line **53** to form a master system so that loss of pressure in any wellhead support structure or surface control valve would cause closure of all valves in pressure communication with each other.

The hydraulic pressurizing system **45** is similar to the system **16** illustrated in FIG. **1** but is designed to employ the well pressure to help pressurize the hydraulic pressure fluid. To this end, the well pressure is communicated through a conduit **58** to a regulator **59** to a pump **60.** An input line **61** connects the pump with a reservoir tank **62** containing hydraulic fluid. The pump **60** provides pressurized hydraulic fluid at its output **63** which connects with a manifolded supply line **64** adapted to be connected into the wellhead **35** and into one or more of the wellheads indicated schematically at **35**a and **35**b. A pressure relief valve **65** in a line between the input **61** and the output **64** opens to release pressure occurring in the line **64** when such pressure exceeds a predetermined maximum value. Such excessive pressure may occur for example when the conduit **32** foreshortens tending to reduce the volume of chamber **43.** A bypass valve **66** is employed to release the pressure in the line **64.** The valve **66** may be manually operated, or as previously described, may be connected with a servo-mechanism governed by remotely generated command signals. The regulator **59** functions to maintain a given pressure input to pump **60.** It will be appreciated that the system **49** affords increased efficiency in that the pressure of the well fluid is employed to assist in pressurizing the hydraulic control fluid in the manifolded line. In the illustration of FIG. **2,** the valves and pressure gauges which have not been specifically described function in a conventional manner to respectively regulate fluid flow and to indicate fluid pressures.

FIGS. **3**A and **3**B illustrate upper and lower portions, respectively, of a modified well structure indicated generally at **70.** With joint reference to FIGS. **3**A and **3**C, it may be seen that the structure **70** includes an hydraulic suspension system which regulates longitudinal movement of a central production tubing string **71.** Pressurized hydraulic fluid is supplied to an annular chamber **72** to provide the desired longitudinal support for the conduit **71.** The fluid is supplied to chamber **72** by means of a longitudinally extending supply line **73** which communicates with an annular flow passage **74** which in turn is in fluid communication with an external supply line **75.** The supply line **75** connects to an external pressure fluid control system (not illustrated) such as the system **16** or the system **45** previously described. Suitable sealing means are provided to ensure pressure-tight, fluid communication through the supply line **75,** annular connecting passage **74** and vertically extending tubular conduit **73.** The upper end of the chamber **72** is sealed by an annular O-ring seal **76** which forms a sliding, sealing engagement with a central tubular guide member **77.** The guide member **77** is supported in the wellhead by any suitable means. A second annular seal **78** forms a sliding sealing engagement with a surrounding, tubular chamber housing **79.** A small annular O-ring seal **80** carried in an upper end shoulder **79***a* of the housing **79** encircles the conduit **73** to provide a sliding, leakproof seal between the conduit and the housing.

From the described construction, it will be appreciated that the housing **79** is moved longitudinally with respect to the guide member **77** as the pressure in the chamber **72** is varied. The conduit **73** is of sufficient length to communicate with the chamber when the housing **79** is at its lowest longitudinal position. Longitudinal movement of the housing **79** produces a corresponding movement in the well conduit **71** carried at the lower end of the housing. With reference to FIG. **3**B, the lower end of the tubing **71** is secured to a conventional packer **81** anchored within a stationary well casing **82.** Longitudinal movement of the conduit **71** functions to open and close a subsurface valve indicated generally at **83** which regulates the flow of well effluents flowing within the conduit **71.**

The conduit **71** includes an upper section **71***a* and a lower section **71***b* and the base of section **71***a* forms an enlarged tubular housing section **71***a'* which encircles the upper end **71***b'* of the lower tubing section **71***b.* A ball closure member **83***a*, rotatably carried in the end **71***b'*, is equipped with a central flow passage **83***b* which, in FIG. **3**B, is aligned with the central opening of the conduit **71** to permit effluent flow through the valve. The external surface of the ball **83***a* is equipped with a cam recess (indicated in dotted line) **83***c.* A pin (indicated in dotted line) **83***d* carried by the outer body **71***a'* extends through a suitable opening (not illustrated) in the end **71***b'* and projects into the cam recess **83***c.* As the upper conduit section **71***a* is shifted longitudinally downwardly with respect to the stationary conduit section **71***b*, the pin **83***d* rides against the lower surface of the recess **83***c* to rotate the ball into the position illustrated in FIG. **3**D. The reverse movement of the conduit **71***a* draws the pin **83***d* against the upper surface of the recess **83***c* to return the ball into the position illustrated in FIG. **3**B. When the ball member **83***a* has been rotated into position as illustrated in FIG. **3**D, upper and lower packings carried in the conduit end **71***b'* cooperate with the ball to prevent fluid flow through the conduit **71.** An annular seal ring **84** forms a sliding seal between the conduit member **71***a* and **71***b* to permit sealing, longitudinal movement between the two conduit members.

Referring to FIG. 3A, the structure 70 includes a wellhead indicated generally at 85 equipped with an automatic surface control system indicated generally at 86 employed to regulate opening and closing of a surface valve 87 in the manner previously described with reference to the surface valve control 48 of FIG. 2. The wellhead structure 85 is supported in any conventional manner from a stationary surface support structure. The wellhead 85 includes upper, intermediate and lower connecting structures 88, 89 and 90, respectively, employed, respectively, to permit fluid communication with the conduit 71, an annular passage 91 between the connector 89 and the external surface of the tubular guide member 77, and an annular passage 92 formed between the lower connector 90 and the external surface of the casing 82. As may be necessary or desirable, a second string of casing 93 may be connected to the connector 90 for providing additional flow passages in the well structure. The annular passage 74 is maintained fluid-tight by the cooperation of an annular seal 94 secured between the base of upper connector 88 and the top of intermediate connector 89. Suitable seals such as the seals 95, 96, 97, 98 and 99 provide fluid-tight, pressure-proof seals between adjoining components. A heat sensitive, frangible sensor 100 is included in a line 101 which is in pressure communication with the fluid in the line 75.

In operation, hydraulic pressure is supplied to the chamber 72 to longitudinally support or lift the tubing conduit string 71. By maintaining the pressure in the chamber 72 constant, a relatively constant tension is maintained in the conduit 71 in the manner and for the purpose previously described. The design of the wellhead support structure 85 accommodates well condition induced movement in the conduit 71 below the support structure which permits a reduction in the height of the wellhead above the platform. When the pressure in chamber 72 falls below a predetermined minimum value, caused for example, by rupture or destruction of the sensor 100, the housing 79 slides longitudinally downwardly over the guide member 77 permitting the conduit 71 to move longitudinally under the influence of gravity. During the downward movement of the housing 79, continuous sliding sealing engagement is maintained between relatively movable, engaging components by annular seal rings 76, 80 and 78. The downward movement of conduit 71 functions to close the valve 83 in the manner previously described. Repressuring the chamber 72 elevates the housing 79 and conduit 71 longitudinally to reopen the valve 83. As with the embodiment described in FIG. 2, operation of the surface control assembly 86 may be combined with or may be independent of the operation of the subsurface valve 83.

FIG. 4 of the drawings schematically depicts a mechanical tensioning and support system constructed in accordance with the teachings of the present invention. The mechanical system indicated generally at 110 is designed to release longitudinal support of a production well conduit 111 to permit the conduit to move longitudinally downwardly causing a subsurface valve (not illustrated) to close. The system 110 includes a tubular wellhead support structure 112 mounted on a stationary surface structure 113. The upper external surface of the conduit 111 is equipped with helical threads 114 and is surrounded by an annular threaded collar 115 equipped with internal threads 116. Metal ball members 117 engage the threads 114 and 116 and upper and lower ball bearings 118 and 119, respectively, support the collar 115 for rotary motion about the upper end of the well conduit 111.

A second tubular wellhead support structure 120 encircles the uppermost end of the well conduit 111 and provides an upper mounting member for the collar 115. The outer external surface of the collar 115 is equipped with gear teeth 121 which extend circumferentially about the collar. The gear teeth 121 meshed with teeth 122 on spur gear 123 which is rotated by a drive shaft 124 extending from an electric motor and drive assembly 125. Assembly 125 is a conventional, reversible electric motor which acts through a reduction gear to rotate the output shaft 124 in either direction. An annular resilient seal ring 126 encircling the upper end of the well conduit 111 maintains a continuous, longitudinally slidable seal with the surrounding support structure 120 to confine well effluents in the wellhead. A radially projecting pin 127 extends from the support structure 112 and is adapted to engage a shoulder 128 formed on the well conduit 111 to limit the upper axial movement of the conduit.

In operation, rotation of the drive shaft 124 causes rotation of the collar 115 which acts through the engaging balls 117 and threads 114 and 116 to raise the well conduit 111 upwardly. Rotation of the shaft 124 is regulated by a control system schematically indicated at 129. The system 129 may be formed by any conventional circuitry or automatic control equipment and includes output control means 130 for providing an electrical control signal on a line 131 to regulate the direction of rotation of the assembly 125 and shaft 124. The control 130 also provides an electrical control signal over a line 132 to cause disengagement of the shaft 124 from the drive assembly 125 whereby the shaft may rotate freely.

A tension analyzer 133 is employed to monitor the output from a strain gauge 134 connected to the conduit 111 to determine the tension existing in the conduit 111. When the tension falls below a predetermined minimum value as determined by the means 133, a suitable output signal is formed by the analyzer 133 and transmitted to the control 130 to form a suitable control signal on the line 131 which causes the motor 125 to rotate in a direction which will cause the threads 114 to advance upwardly through the collar 115 thereby increasing the tension in the conduit 111. When the conduit tension exceeds a predetermined maximum value as determined by the analyzer 133, a suitable output command signal is formed on the line 131 to cause rotation of the shaft 124 in a direction which will permit the conduit to be moved longitudinally downwardly to the point required to reestablish the desired tension in the conduit.

A heat sensitive, frangible sensor 135 provides an input to an analyzer means 136 which monitors the sensor 135 to determine the presence of fire or impact. When fire or impact occurs, a suitable signal is generated by the analyzer 136 to form an output on the line 132 which causes release of the shaft 124 from the assembly 125 which permits the shaft to rotate freely. With the shaft 124 released, the weight of the well conduit 111 acting through the balls 117 causes the collar 115 to rotate in a direction which permits the conduit to move longitudinally downwardly to close the subsurface valve. The control system 129 and the assembly

125 are conventional and any suitable means which provides the described functions may be employed.

A system which closes a subsurface valve upon rotation of the production tubing string is indicated generally at 170 in FIG. 5. The system 170 which is depicted schematically includes a casing string 171 supported from a surface structure 172. A production string 173 extends downwardly through the casing 171 where it is in fluid communication with a subsurface formation. At the lower end of the system 170, a subsurface safety valve indicated generally at 174 is provided to automatically terminate the flow of well effluents from the formation through the tubing 171 in the event of fire or impact occurring at the well surface. The valve 174 is closed by rotating the tubing string 174 which advances threads 175 formed at the base of the tubing string downwardly through engaged threads 176 provided in a valve structure 177 which is suitably secured to the surrounding casing 171. As the tubing 173 rotates, the threads 175 advance downwardly through the threads 176 bringing a beveled valve surface 178 into sealing engagement with a tapered seating surface 179 to terminate effluent flow through the well.

With the valve 174 in the open position illustrated in FIG. 5, effluent flowing in the direction of arrow 180 enters the base of the structure 177, flows upwardly between the base of the conduit 173 and the seat 179 and upwardly through longitudinally extending openings 181 formed in the member 177 and into the conduit 173 through radial openings 182 formed in the conduit wall. A suitable packer 183 with an O-ring seal 184 permits the conduit 173 to be rotated and moved longitudinally while a continuous seal is maintained between the conduit and the surrounding casing 171. The upper end of the well conduit 173 is locked in position by clamp means 185 which prevents the top portion of the conduit from rotating within the casing 171.

A hydraulic fluid control line 186 which connects with a sensor 187 extends to a cylinder 188 and is employed to depress a piston 189 against a spring 190. A locking wedge 191 connected to the lower end of the piston 189 functions to lock projections 192 and 193 together to prevent relative rotation between the production conduit 173 and the surrounding well casing 171.

In operation, the well conduit 173 is rotated or twisted at the wellhead with the cam wedge 191 in the position illustrated in FIG. 5 to develop a torque force in the conduit between the wedge and the wellhead. Thereafter, the well conduit is clamped by the clamping means 185 to prevent the conduit from unwinding and releasing the torque force. Under normal conditions, hydraulic pressure in the line 186 keeps the piston 189 at its lower position whereby the member 191 locks with the projections 192 and 193. When fluid pressure in the line 186 is lost, by rupture or damage to the sensor 187, pressure in chamber 188 is released permitting the piston 189 to move upwardly under the influence of the spring 190. With the piston 189 moved into the dotted line position, the well conduit 173 is permitted to rotate to release the torsional forces in the conduit. Rotation of the conduit advances the threads 175 through the threads 176 to move the well conduit downwardly terminating flow through the well.

FIG. 6 illustrates a modified support structure indicated generally at 240 which provides hydraulic support for a longitudinally movable well conduit 241. Pressure fluid is supplied to the structure from an external pressure line 242 through an annular passage 243 and through a vertically extending tubular connecting line 244 which communicates with the lower end of an expansible, annular chamber 245. The upper end of the chamber is sealed by an annular seal 246 which forms a sliding, sealing engagement with a surrounding well conduit 247. The lower end of the chamber 245 is sealed by dual annular O-ring seals 248 and 249 carried in an annular anchor member 250. The seal 248 forms a sliding seal with the outer surface of well conduit 241 and the seal 249 provides a seal between the member 250 and the surrounding well conduit 247. Friction producing slip members such as the slip teeth 251 anchor the member 250 within the surrounding conduit 247. A central, tubular guide member 252 extends through the upper end of the well conduit 241 and an annular seal 253 provides a sliding, sealing engagement between the well conduit 241 and the member 252. The upper end of member 252 is mounted in the structure 240 in any suitable manner and provides continuous fluid communication between the well conduit 241 and an external removal point connected to an upper connector member 254.

It will be appreciated that the wellhead structure 240 may be equipped with various sensors, pressurizing systems and other components described in connection with other forms of the invention. In operation, the structure 240 functions to maintain the well conduit 241 in an elevated position by maintaining a predetermined pressure on hydraulic fluid in the chamber 245. Although not illustrated, it will be appreciated that the well conduit 241 extends downwardly through the well structure and connects with a subsurface valve operable by longitudinal movement of the conduit as previously described. The sliding surfaces engaged by the seals 246, 248 and 253 are of sufficient longitudinal development to accommodate all normally anticipated, well condition induced longitudinal movement of the well conduit 241. The wellhead structure 240 differs in part from the structure 85 illustrated in FIG. 3A in eliminating the need for sliding seals along the pressure supply line 244. It will also be appreciated that the structure 240 may accommodate the induced axial movement by permitting the lost motion to occur below the mounting structure which supports the wellhead, thereby eliminating the need for a tall structure extending above the floor of the platform.

FIG. 7 illustrates a modified form 260 of the hydraulic support structure of the present invention. The assembly 260 is similar to the systems previously described to the extent that longitudinal movement of a tubing conduit 261 regulates opening and closing of a subsurface valve. Dual expansion chambers 262 and 263 are included in the embodiment 260 and are connected by lines 264 and 265, respectively, to a pressure control system indicated generally at 266. Variations in the pressure of fluid in the chamber 262 regulate longitudinal movement of the conduit 261 in the manner described with reference to previous embodiments. The chamber 263 acts as a storage chamber for fluids employed to pressurize the chamber 262. Fluid not contained within the chambers 263 and 262 and in the pressurizing system 266 is stored in an accumulator 267. Wellhead pressure may be supplied to the system 266 through a conduit 268 acting through a regulator 269. In other respects, the system 266 is similar or anal-

ogous to the pressurizing systems described for use with previous embodiments.

Operation of the assembly **260** may be controlled by loss of pressure through a sensor **270** which is in a line **271** in fluid communication with the system **266.** If desired, the line **271** may also be in fluid communication through a line **272** with a surface valve control or with a master control system.

Referring to FIG. **8,** a mechanically locking, hydraulically regulated support system is indicated generally at **280.** Pressurized hydraulic fluid supplied from a supply line **281** is introduced through a radial port **281***a* and an annular passage **281***b* into the base of an expansible chamber **282** to maintain a release sleeve **283** in the upper axial position illustrated in FIG. **8.** A coil spring **284** mounted concentrically about a supporting mandrel **285** acts against the top of a sleeve segment **286** and through connecting pins **287** to bias the sleeve **283** downwardly. In the upper axial position illustrated in FIG. **8,** the sleeve **286** retains one or more locking dogs such as locking dog **288** in a radially inner position where it locks with an annular recess in a central sleeve **289** fixed at an upper axial position in the structure **280.** Release or reduction of the pressure in the annular chamber **282** permits the spring **284** to shift the sleeve **286** downwardly bringing an annular recess **290** into registry with the dog **288.** Inclined engaging surfaces formed on the dog **288** and on the inner sleeve **289** push the dog **288** radially outwardly into the recess **290** as the sleeve **289** is urged downwardly. With the dog **288** in recess **290,** the sleeve **289** is freed and moves longitudinally downwardly under the influence of gravity until a lower shoulder **291** formed on the sleeve **289** engages a shoulder **292** formed at the lower end of a dog mounting cage **293.**

In operation, a tubular well conduit **294** is connected to the lower end of the sleeve **289** and extends downwardly through the well where it connects with a subsurface valve (not illustrated) operable by longitudinal movement of the conduit as previously described. The longitudinal downward movement of the sleeve **289** is transmitted through the conduit **294** to the subsurface valve to effect closure of the valve. It will be appreciated that the structure **280** does not accommodate induced movement of the conduit **294** and that suitable provision should be made for accommodating such movement. Throughout the assembly **280,** suitable seals are employed to maintain fluid-tight engagement between connecting components in an obvious manner. If desired, the line **281** may be connected to a pressurizing system and to sensors in the manner previously described.

FIG. **9** illustrates a modified system indicated generally at **300** wherein induced longitudinal movement of a tubing conduit section **301** is accommodated in a slip joint indicated generally at **302.** The compensating means **302** works in combination with a subsurface valve indicated generally at **303.** The valve assembly **303** includes a relatively fixed tubular mounting section **304** which is secured to a conventional packer **305** anchored within a fixed well casing **306.** An enlarged tubular activating section **307** carried at the base of section **301** extends over the mounting section **304** and is movable longitudinally with respect thereto. An activating pin **308** carried in the section **307** extends through suitable openings formed in the section **304** and projects into a cam recess **309** formed in a ball closure member **310.** A coil spring **311** positioned between the mounting section **304** and the activating section **307** biases the two connecting members longitudinally apart from each other to maintain ball member **310** in a normally open position. The upper end of the activating member **307** is equipped with an external shoulder **307***a* which is adapted to meet and engage with an inwardly directed shoulder **301***a* formed at the base of the tubing section **301.** Annular sealer rings **312** and **313** provide a continuous sliding seal between the activating member **307** and the mounting member **304** and the lower end of the tubing section **301,** respectively.

In operation, normal well condition induced longitudinal movement of the tubing conduit **301** causes the shoulder **301***a* to move longitudinally over the reduced diameter, central body of the activating member **307.** When the tubing string **301** is released from its surface support, it falls longitudinally downwardly bringing the shoulder **301***a* into engagement with a shoulder **307***b* formed on the activating member **307** causing the activating member to shift longitudinally downwardly. Downward movement of the member **307** moves the pin **308** against the lower surface of cam recess **309** to shift the ball into closed position. When surface support of the conduit **301** is reestablished, the spring **311** raises the actuating member **307** to reopen the ball valve member **310.** It will be appreciated that the central body of the actuating member **307** is of sufficient length to accommodate all normally expected, well induced longitudinal movement of the conduit **301** and that release of the support of the tubing **301** permits a longitudinal downward movement to a position which is lower than that produced by the maximum well condition induced elongation of the conduit.

The conduit **301** is equipped with ports **314** whereby well effluents may flow in the direction of the arrow **315** into the annular space **316** formed between the tubing conduit **301** and the external casing **306.** Suitable provision is made at the well surface to remove the well effluents from the annular flow passage in a conventional manner. It will be appreciated that the provision for producing through the casing rather than the conduit string may be incorporated in the various embodiments described herein.

FIG. **10** schematically illustrates a dual, retrievable subsurface valve assembly indicated generally at **320** designed to be employed with the present invention. Dual ball closure members **321** and **322** are included in the assembly **320** and the valve **322** is designed to be rotated between open and closed positions by longitudinal movement of a well conduit section **323** extending to a support structure at the well surface (not illustrated). The lower end of the conduit **324** is connected to a conventional packer **325** which is anchored to a stationary well casing **326.** In the schematic representation of FIG. **10,** the lower end of the conduit section **323** carries an enlarged, tubular activator housing **327** which surrounds a tubular mount assembly **328** formed at the upper end of the conduit section **324.** The valve assembly of **320** includes an upper valve means indicated generally at **329** and a lower, separable valve means indicated generally at **330.** The upper valve means includes a tubular valve housing **331** partially surrounded by a tubular actuator sleeve **332.** The lower valve means **330** includes a tubular valve housing **333** and a tubular actuating overbody **334.**

In operation, the composite assembly **320**, upon longitudinal lowering of the well conduit **323**, shifts the actuator sleeve **332** downwardly causing the ball member **322** to rotate to closed position in the manner described with reference to the ball valve closure member of FIG. **9** and in other embodiments of the present invention. In the event the valving assembly **329** is to be repaired or replaced, a suitable retrieving mechanism is lowered through the well conduit **323** and locked with an annular latching recess **335** formed in the upper end of the actuating sleeve **332.** Suitable mechanisms, to be described more fully with reference to FIGS. **11**A and **11**B, are actuated by the retrieving tool whereby the upper valve means **329** may be separated from the valve means **330** and withdrawn to the surface of the well. As the housing member **331** moves upwardly with the upper valve assembly **329** during this procedure, the valve housing **333** is shifted upwardly by an expanding coil spring **335** to rotate the ball **321** into closed position. By this means, it will be appreciated that the flow of effluents from the well is terminated when the upper valve means **329** is removed. When the valve means **329** is replaced, the ball **321** is automatically rotated back into open position. Where retrieval of the entire assembly **320** is desired, the valve means **330** is retrieved following retrieval of the valve means **329.**

FIGS. **11**A and **11**B are detailed illustrations of upper and lower portions, respectively, of a dual retrievable ball valve closure assembly similar to the assembly **320** described with reference to the schematic illustration of FIG. **10.** Referring first to FIG. **11**B, a lower valve assembly is indicated generally at **340** and includes a ball closure member **341** rotatably carried in a tubular, axially movable ball mount body **342.** The mount body **342** is slidably carried within a surrounding tubular housing **343.** The external dimensions of the housing **343** are such that the assembly **340** may be moved longitudinally through a production tubing conduit which is fixed at its lower end by a conduit section **344** to a conventional packer (not illustrated) anchored in a surrounding well casing **345.** An upper conduit section **346** (illustrated in FIG. **11**A) extends to the well surface and is supported by a releasable, longitudinal support (not illustrated) such as that illustrated in FIGS. **2, 3, 4, 6** or **7.** The internal dimensions of the conduit section **346** are sufficiently large to permit the assembly **340** to be moved therethrough to permit surface placement and retrieval of the assembly.

The assembly **340** is equipped with one or more radially movable locking dogs such as the dog **347** designed to be moved radially outwardly into locking engagement with an annular recess **348** formed along the internal surface of an upper end section **349** of the conduit **344.** While the assembly **340** is to be moved longitudinally through the well conduit **346,** the dog **347** is permitted to freely move to a radially retracted position so that the assembly may be accommodated within the conduit. When the desired subsurface location has been reached, a running tool (not illustrated) moves the mount body **342** downwardly through the surrounding housing **343** which urges tapered shoulders **351** and **352** on the body against oppositely tapered shoulders **354** and **355,** respectively, on the dog **347** to move the dog radially outwardly into the position illustrated in FIG. **11**B. Downward shifting of the body **342** permits a resilient, split snap ring **356** to close radially inwardly to prevent return upward movement of the body **342.** In the position illustrated in FIG. **11**B, radial projections on the body **342** contact radial projections on the dog **347** to lock the dog radially outwardly. The engagement of the dog with the recess **348** locks the entire assembly **340** in position within the conduit section **344.**

An activating pin **356***a* carried by the housing **343** extends radially inwardly through appropriate openings formed in the mount body **342** and projects into a cam recess **357** formed along the external surface of the ball closure member **341.** A retaining sleeve **358** is secured to the housing **343** by pin **359** and functions to align and retain the body **342** in the desired position and to lock the composite assembly together in a manner to be described. The sleeve is slotted at **360** to permit axial movement of the body **342** with respect to the housing **343.** The mounting body **342** may be shifted downwardly from the position illustrated in FIG. **11**B until a shoulder **361** engages the top of the dog **347.** Downward shifting of the body **342** from the position illustrated in FIG. **11**B slides the cam recess **347** along the stationary pin **356** causing the ball member **341** to rotate to open position. A compressed coil spring **362** extending between a shoulder **363** formed internally of the housing **343** and the base of mounting member **342** urges the mounting member upwardly through the housing **343** so that the ball **341** tends to remain in a normally closed position.

Upper and lower annular seals **364** and **365,** respectively, cooperate with upper and lower ball packing seals **366** and **367,** respectively to prevent effluent flow through the valve assembly **340** when the ball **341** is rotated to closed position.

Referring to FIG. **11**A, the lower end of tubing section **346** is equipped with an enlarged tubular actuating housing **368** which telescopes over the upper end section **349** of the conduit **344.** The section **349** is equipped with an annular recess **369** which is employed to lock an upper valve assembly, indicated generally at **370,** with the lower assembly **340.**

The assembly **370** includes a ball valve closure member **371** carried within a tubular ball mount body **372.** A tubular actuating sleeve **373** encircles the upper end of the mount body **372.** The sleeve **373** is anchored to the housing **368** by a radially movable dog **374** which extends through the sleeve **373** and locks within an annular recess **375** formed along the internal surface of the housing **368.** The dog **374** is held in its radially outer locking position by a locking sleeve **376** and the mount body **372** is locked in position within the section **349** by a similar dog **376***a* engaging the recess **369** and held in its outer locking position by a locking sleeve **377.** The lower end of mount body **372** includes a plurality of depending, circumferentially spaced resilient collet fingers **378** which tend to bias enlarged locking heads **379** formed at the lower end of each of the fingers to a radially outer position into engagement within a receiving annular recess **380** formed along the internal surface of the mount body **342.**

The upper assembly **370** is inserted into the well conduit **346** after the lower assembly **340** has been locked into position within the section **349.** Assembly **370** is lowered through the conduit **346** by a suitable running tool (not illustrated) which keeps the ball **371** in open position. When the collet fingers **378** engage the upper end of housing **343,** the fingers are urged radially in-

wardly permitting the assembly **340** to be lowered until the collet heads **379** snap into the annular recess **380.** The upper axial end surfaces of housing **343,** split ring **356,** and mount body **342** are tapered and cooperate with tapered surfaces on the collet heads to urge the collet members **378** radially inwardly as they are being lowered through the top of the assembly **340.** Once in position within the annular recess **380,** the collet heads **379** expand radially outwardly to lock with the mount body **342** and subsequent lowering of the upper assembly **370** shifts the body **342** downwardly to rotate the lower ball **341** to open position. When the assembly **370** is in the latter position, the running tool is manipulated to sever shear pins **381** and **382** which frees locking sleeves **376** and **377,** respectively and permits the sleeves to be moved axially downwardly. Downward movement of the sleeves **376** and **377** urges the dogs **374** and **376,** respectively, outwardly into locking engagement with recesses **375** and **369,** respectively. When the sleeve **376** has been lowered into the position illustrated in FIG. **11A,** a resilient metal split ring **383** is freed to spring radially inwardly to prevent return upward movement of the locking sleeve **376.**

As the conduit structure **346** is moved longitudinally downwardly due to a loss of surface support, the lower section **368** telescopes downwardly over the section **349** causing the actuating sleeve **373** to move downwardly over the valve mount body **372.** A pin **384** carried by the actuating sleeve **373** projects radially inwardly through appropriate openings formed in the mount body **372** and projects into a cam recess **385** formed along the external surface of the ball **371.** Downward movement of the pin **384** forces the pin along the lower surface of the cam recess **385** to rotate the stationary ball **374** into closed position. When the surface support is reestablished and the tubing conduit **346** is moved longitudinally upwardly, the pin **384** acts against the upper edge of cam recess **385** to return the ball **371** to its open position. Upper and lower packing rings **386** and **387,** respectively, cooperate with annular seal rings **388** and **389** to maintain a leakproof closure when the valve element **371** is rotated to closed position.

In the event it becomes necessary to retrieve the valve **370,** a suitable running tool is lowered through the well conduit **346** and engaged with the assembly **370.** Manipulation of the retrieving tool pushes the snap ring **383** radially outwardly and shifts sleeves **376** and **377** to their upper axial positions where the dogs **374** and **376***a* may be moved to their radially inner positions. Subsequent upward motion of the assembly **370** acts through the collet fingers **378** and engaged collet heads **379** to shift the valve mount body **342** upwardly until the upper end of the body engages the retaining ring **356.** During the initial upward pull exerted by the collet fingers, the sleeve **378** overlies the collet heads to keep the heads latched in the recess **380** so that the upper and lower assemblies cannot be separated until the ball **341** closes. The coil spring **362** also cooperates with the positive pull exerted by the collet fingers to rotate the ball **341** to closed position. Subsequent upward movement of the assembly **370** engages tapered surfaces formed between the collet heads **379** and the recess **380** to bias the collet fingers **378** radially inwardly whereby the assembly **370** is released from the assembly **340** and the former may be retrieved to the surface.

If retrieval of the assembly **340** is desired, a running tool is lowered through the assembly after the assembly **370** is removed and the snap ring **356** is moved outwardly to permit the mount body **342** to be moved upwardly so that the dog **347** may move radially inwardly against a reduced diameter portion of the body **342.** Inward radial movement of the dog **347** from the position illustrated in FIG. **11B** releases the assembly **340** so that it may be retrieved to the well surface.

FIG. **12** illustrates a flapper type subsurface valve indicated generally at **400** designed to be closed upon longitudinal movement of a surface connected tubing string **401.** The lower end of the valve includes a tubing conduit section **402** secured to a subsurface packer (not illustrated) anchored in a stationary well casing as previously described.

The valve **400** includes a tubular valve housing **403** which is equipped with a vertically extending rack provided by gear teeth **404** formed along the internal housing surface. A flapper closure member **405** is pivotably mounted about a pin **407** carried in an enlarged tubular mounting body **406** formed at the upper end of the tubing conduit **402.** A pinion gear wheel **408** is rigidly secured to the flapper member **405** and includes teeth **409** which mesh with the rack teeth **404.** The flapper valve member **405** is received in a recess **410** formed in the wall of the tubular body **406.**

When the valve assembly **400** is in the open position illustrated in FIG. **12,** well effluents within the conduit **402** flow through the conduit and through a valve seat **411** into the conduit **401** where they travel to the well's surface. An O-ring seal **412** between the tubular housing **403** and a connector sub **413** provides leakproof engagement between the two components. A second O-ring seal **414** encircling the upper end of tubing section **402** provides a vertically movable sliding seal with the surrounding cylindrical surface of the housing **403.** A shear pin **415** secures an end bushing **416** threadedly engaged to the housing **403** to the conduit section **402** to prevent premature relative axial movement between the section **402** and the housing **403.** Annular packing **417** carried at the upper end of body **406** is adapted to seat against and seal with an annular seat **418** formed along the base of sub **413.**

In operation, longitudinal lowering of the conduit section **401** severs the shear pin **415** which permits the housing section **403** to move longitudinally downwardly over the fixed tubing section **402.** The shear pin **415** prevents premature closure of the valve assembly **400** and is designed to permit closure of the valve only when a predetermined longitudinal downward force is exerted by the conduit **401.** Downward movement of the housing section **403** and integrally formed rack teeth **404** acts against the pinion teeth **409** on the gear wheel **408** to rotate the flapper valve closure member **405** into the closed position illustrated in FIG. **13.** Downward movement of the housing **403** over the conduit section **402** also brings annular packing **417** into engagement with the seat **418** to completely terminate effluent flow through the well. Subsequent raising of the conduit **401** functions in a reverse manner to reopen the flapper valve member **405.**

FIG. **14** illustrates a modified assembly **420** designed to provide both a subsurface safety valve for terminating effluent flow through the production tubing and a back-up valve to prevent surface flow of well fluids which may leak through the anchored packer. The as-

sembly 420 includes a ball valve closure member 421 mounted within a mount body 422 which in turn is secured to a packer 423 anchored in a stationary casing 424. An actuating sleeve 425 extends over the mount body 422 and connects at its upper end with a tubing conduit 426 which extends to the well surface. An annular seal ring structure 427 anchored within the casing string 424 provides a smooth cylindrical seal surface 428 which is adapted to engage an annular resilient seal 429 carried on the actuating sleeve 425.

Operation of the ball closure member 421 is similar to that previously described with reference to the ball member 83 illustrated in FIGS. 3B and 3D. Lowering of the conduit 426 also brings the annular seal 429 into sealing engagement with the cylindrical seal surface 428 which cooperates with an annular seal 430 carried in the seal ring structure 426 to prevent fluid flow through the annular space between the actuating sleeve 425 and the surrounding casing 424.

A modified support structure and valve arrangement is indicated generally at 440 in FIG. 15. The assembly 440 includes a subsurface closure valve indicated generally at 441 and a surface support system indicated generally at 442. The subsurface valve 441 includes a ball valve closure member 443, a ball mount body 444 and an actuating sleeve 445 which are operable as previously described upon longitudinal movement of a tubing conduit 446 to terminate effluent flow through the assembly.

The upper end of well conduit 446 is slidably carried within a cylindrical housing 447 which cooperates with the upper conduit end to form dual hydraulic lift chambers 448 and 449. The housing 447 is secured by flanges S' to a stationary surface support in any suitable manner. A small macaroni conduit string 450 extends longitudinally through the support assembly 442 and is equipped with ports 451 which are in pressure communication with the chamber 448. The lower end of the conduit is in pressure communication with the chamber 449. Suitable annular seals 452–456 positioned between the upper end of conduit 446 and the surrounding housing 447 cooperate to produce sliding seals between the two components. Smaller O-ring seals 457–459 encircle the vertically extending, stationary conduit 450 to provide a sliding seal between the conduit and the movable tubing section 446. The conduit 450 communicates with a pressurizing system (not illustrated) similar to those described previously which supplies a pressurized hydraulic fluid to the chamber 448 and 449 to longitudinally elevate and support the conduit 446. Radial ports 460 and 461 eliminate pressure locks in the enclosed areas to which they are connected to permit the desired longitudinal movement of the well conduit 446 through the surrounding, vertically stationary housing 447. Release of the pressure in chambers 449 and 448 permits the conduit 446 to move longitudinally downwardly closing the ball valve assembly 441 in the manner previously described. Use of a plurality of separate pressurizing chambers increases the lifting force exerted by the hydraulic fluid.

FIGS. 16A and 16B illustrate the upper and lower portions, indicated generally at 480 and 481, respectively, of a retrievable, subsurface flapper valve closure member for use as part of the present invention. With joint reference to both figures, the assemblies 480 and 481 are carried in an upper tubing section 482 and a lower tubing section 483, respectively. The section 483 is connected at its lower end to a packer (not illustrated) in the conventional manner. The upper end of section 482 extends to the well surface where it is supported longitudinally by any suitable structure of the type previously described herein. When the tubing section 482 is shifted downwardly by release of surface support of the conduit, the downward motion is transmitted through a pin 484 to an actuating sleeve 485 which in turn transmits the downward movement through a collet finger 486 to an inner sleeve 487. A slot 488 formed through the wall of lower tubing section 483 permits downward movement of the pin 484 and attached sleeve 485 and 487 to the extent required to clear the lower end of a flapper valve closure member 489 which permits the closure member to pivot into closed position. A spring 490 biases the flapper closure member 489 toward its closed position. The flapper member 489 is equipped with an activating projection 491 which is designed to rotate into an annular recess 492 formed along the upper internal surface of the actuating sleeve 485 when the member pivots to closed position. A radial projection 483*a* extends into a longitudinal slot 482*a* to limit the longitudinal movement between conduit sections 482 and 483.

The flapper element 489 is mounted for pivotal motion by means of a hinge pin 493 carried within a tubular mount body 494. Until the upper end of the inner sleeve 487 has been lowered below the lowermost point of the flapper element 489, the flapper is retained in its open position. The collet finger 486 is connected to the inner sleeve 487 through a vertically extending slot 495 formed in the valve mount 494. A radially movable locking dog 496 anchors the mount body 494 within the upper end of the tubing section 483.

After the flapper element 489 has snapped to closed position, the valve is reopened by reestablishing the surface support which raises the conduit 482 longitudinally. Upward movement of the conduit 482 is transferred to the actuating sleeve 485 which urges a tapered camming surface 492*a* formed in the recess 492 against the activating projection 491 which rotates the flapper element 489 in a counterclockwise direction around the pin 493 into its open position. With the valve element 489 thus opened, the sleeve 487 is free to move upwardly into the position illustrated in FIG. 16A where it functions to shield the flapper element from well effluents. It will be appreciated that the external surface of the projection 491 is configured to maintain the flapper element 489 in its fully opened position when the internal walls of the actuator sleeve 485 engage the projection in the manner illustrated in FIG. 16A. When the projection registers with the recess 492, the spring loading of the flapper element 489 permits it to rotate in a clockwise direction about the pin 493 into its closed position where it seats against a valve seat 497 formed along the internal surface of the mount body 494. In its closed position, the closure element 489 cooperates with annular seals 498 and 499 to prevent effluent flow through the valve assembly 480.

The lower assembly 481 includes a second closure element 500 pivoted about a hinged pin 501 carried in a tubular mount body 502. A spring 503 biases the flapper element 500 in a clockwise direction about the pin 501 toward closed position. An operating sleeve 504 carried internally of the mount body 502 retains the flapper element 500 in its open position where it is re-

ceived in a protected recess **505** formed along the internal wall of the mount body **502.** In the position illustrated in FIG. **16B**, it will be appreciated that the flapper valve element **500** and an annular seating surface **506** formed along the internal wall of the mount body **502** are protected from the corrosive effect of effluents flowing through the well. A coil spring **507** encircling the operator sleeve **504** and mounted between radial shoulders formed on the control sleeve and the mount body acts to urge operator sleeve **504** upwardly with respect to the mount body **502.** The mount body is secured within the conduit section **483** by radially movable locking dogs **508.** The assembly **481** is secured to the lower end of the upper mount body **494** by means of resilient collet fingers **509** which latch into an annular recess **510** formed along the outer surface of the operator sleeve **504.** An annular seal **506***a* cooperates with the flapper valve element **500** and the seating seal **506** to prevent effluent flow through the valve when the assembly **481** is in closed position.

When it becomes necessary or desirable to remove the upper assembly **480** from the well, a suitable retrieving tool (not illustrated) is lowered through the conduit **482** and latched into an annular recess **511** formed on a tubular retaining sleeve **512.** Subsequent upward movement of the running tool shifts the sleeve **512** upwardly to free the dog **496** permitting the dog to retract radially out of an annular recess **513** formed along an internal surface of the conduit section **483.** Subsequent upward movement of the running tool draws the mount body **494** upwardly through the surrounding conduit section **483.** The latching engagement between collet finger **509** and recess **510** draws the operator sleeve **504** upwardly. When the lower end of the sleeve **504** has cleared the upper end of recess **505,** the flapper element **500** is permitted to spring into closed position to prevent effluent flow through the well. Upward movement of the mount body **494** draws the sleeve **504** upwardly until the recess **510** is above the dog **508** which permits the collet fingers **509** to spread radially outwardly and release the sleeve **504.**

The upward movement of the mount body **494** during the foregoing operation draws the slot **495** into registry with the upper enlarged head of collet finger **486.** The upper end of the collet head is beveled and cooperates with beveled surfaces formed along the upper edge of a recess **514** to push the finger **486** radially inwardly which then permits the inner sleeve **487** to move upwardly with the mount body **494.** The upper end of recess **492** is similarly beveled to prevent the collet finger **486** from locking in the recess so that the entire assembly **480** may be withdrawn to the well surface.

From the foregoing, it will be appreciated that retrieval of the assembly **480** causes the flapper element **500** to close and that the engagement between the upper and lower assemblies **480** and **481,** respectively, prevents separation of the two assemblies until the flapper **500** has been freed to move to closed position.

If retrieval of the assembly **481** is also desired, a suitable retrieving tool (not illustrated) is lowered into the tubing following removal of the assembly **480.** The retrieving tool depresses the actuator sleeve **504** against the biasing force exerted by the spring **507** to return the valve element **500** to the open position illustrated in FIG. **16B.** Suitable locking dogs on the retrieving mechanism anchor within an annular recess **515** formed along the upper internal surface of the mount body **502.** With the sleeve **504** depressed, the dog **508** is free to retract radially to release the assembly **481** from anchored engagement with the conduit **483** to permit complete extraction of the assembly from the well.

Positioning of the assembly in the well is effected by first lowering the assembly **481** into position with a suitable running mechanism (not illustrated), moving the dog **508** radially outwardly into locking engagement with an annular recess **516** and shifting the operator sleeve **504** axially upwardly to hold the dog in place. Subsequently, the assembly **480** is run into position with a suitable running tool which maintains the closure element **489** in open position and retains the sleeve **512** in its upper axial position so that the dog **496** may move radially inwardly as the assembly is being lowered through the well conduit. When the collet fingers **509** engage the upper end of the operator sleeve **507,** the tapered end surfaces on the fingers **509** force the fingers to spread radially outwardly permitting the enlarged heads on the collet fingers to snap into the recess **510.** Subsequent lowering of the running tool shifts the sleeve **504** downwardly into the position illustrated in FIG. **16B.** Thereafter, the running tool is manipulated to sever a shear pin **517** which permits the sleeve **512** to be shifted downwardly into the position illustrated in FIG. **16A** to lock the dog **496** in its outer radial position.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof, and various changes in the size, shape and materials as well as in the details of the illustrated construction may be made within the scope of the appended claims without departing from the spirit of the invention.

I claim:

1. An assembly for regulating the flow of effluents through a well comprising:

a. releasable support means for supporting a conduit in said well;

b. sensor means connected to said support means and responsive to one or more predetermined conditions at said well to automatically release said support means;

c. flow control means connected with said conduit and operable upon predetermined movement of said conduit following release of said support means to regulate the flow of effluents through the well; and

d. compensating means associated with said conduit accommodating normal well condition induced movement of said conduit for preventing said induced movement from operating said flow control means.

2. An assembly as defined in claim **1** further including remotely operable control means for releasing said support means by a remotely generated command signal to release support of said conduit and close said flow control means.

3. An assembly as defined in claim **1** wherein said sensor means includes heat fusible means and frangible means disposed adjacent the well surface for permitting said conduit to move longitudinally upon the occurrence of a predetermined temperature which ruptures said heat fusible means or a predetermined physical movement which ruptures said frangible means.

4. An assembly as defined in claim **1** further including:

a. mounting means for retrievably placing valve means in operating position within said conduit whereby said valve means may be retrieved to the well surface through said conduit;
b. first and second valves in said valve means; and
c. means for closing said first valve to terminate flow through said conduit when said second valve is removed from operative position and means for opening said first valve when said second valve is placed in operative position within said conduit.

5. An assembly as defined in claim **1** wherein:
a. said conduit extends between said support means and an anchoring means disposed in said well;
b. said anchoring means is operable to secure said conduit to a substantially fixed part of said well; and
c. said compensating means includes tensioning means connected with said conduit for maintaining substantially constant tension in said conduit between said support means and said anchoring means.

6. An assembly as defined in claim **5** wherein:
a. said anchoring means including packer means for isolating a portion of said well;
b. said conduit includes a surface extending flow passage in fluid flow communication through said flow control means with said isolated portion of said well; and
c. said flow control means includes valve means for opening or closing said flow passage to permit or terminate the flow of fluids from said isolated well portion, through said flow passage to the surface of said well.

7. An assembly as defined in claim **1** wherein said compensating means includes telescoping joint means between two connecting sections of said conduit whereby said conduit may elongate and foreshorten longitudinally at said joint means without operating said flow control means.

8. An assembly as defined in claim **7** wherein:
a. one of said connecting sections is fixed vertically relative to said support means;
b. said telescoping joint means forms sealed chamber means enclosing a chamber which varies in volume as said conduit moves longitudinally relative to said support means;
c. said sealed chamber is equipped with a pressurized fluid for supporting said conduit above a predetermined vertical position in said telescoping joint means;
d. said compensating means includes means for maintaining a substantially constant pressure on said pressurizing fluid; and
e. said sensor means includes pressure release means for causing a pressure reduction in said chamber upon the occurrence of said one or more predetermined conditions whereby said conduit is permitted to move longitudinally through said well below said predetermined vertical position to close said flow control means.

9. An assembly as defined in claim **1** in which said compensating means includes tensioning means connected with said conduit for maintaining a predetermined minimum tension in said conduit.

10. An assembly as defined in claim **9** wherein said tensioning means includes mechanical suspension means for supporting said conduit in said well and tension detecting means for detecting the tension in said conduit and means responsive to said tension detecting means for moving said conduit longitudinally to maintain a substantially constant tension in said conduit.

11. An assembly as defined in claim **5** wherein:
a. said conduit includes a confined, longitudinal flow passage extending between an isolated well zone and the surface of said well; and
b. said flow control means includes valve means operable upon predetermined movement of said conduit to open or close said flow passage to respectively permit or terminate flow of effluents from said isolated well zone through said confined flow passage to said well surface.

12. An assembly as defined in claim **11** in which said valve means includes mounting means for retrievably placing said valve means in operating position within said conduit whereby said valve means may be retrieved to the well surface through said conduit.

13. An assembly as defined in claim **1** wherein:
a. said flow control means includes valve means operable for opening or closing said conduit to regulate effluent flow through said conduit; and
b. said valve means is operable to open or close said conduit by predetermined movement of said conduit.

14. An assembly as defined in claim **13** wherein said valve means is operable to open and close said conduit by longitudinal movement of said conduit.

15. An assembly as defined in claim **14** wherein said support means includes release means operable for releasing support of said conduit to permit said conduit to move longitudinally under the influence of gravity for closing said valve means.

16. An assembly as defined in claim **15** in which said valve means includes mounting means for retrievably placing said valve means in operating position within said conduit whereby said valve means may be retrieved to the well surface through said conduit.

17. An assembly as defined in claim **15** further including remotely operable control means for operating said release means by a remotely generated command signal to release support of said conduit and close said valve means.

18. An assembly as defined in claim **15** wherein:
a. said valve means includes biasing means tending to maintain said valve in normally open position; and
b. longitudinal movement of said conduit overcomes said biasing means to close said valve.

19. An assembly as defined in claim **15** wherein:
a. said valve means includes biasing means tending to maintain said valve in normally open position;
b. said biasing means includes spring means;
c. longitudinal lowering of said conduit beyond a predetermined amount compresses said spring means to close said valve; and
d. longitudinal raising of said conduit permits said valve to open under the influence of said spring.

20. An assembly as defined in claim **15** wherein:
a. said compensating means includes hydraulic suspension means for supporting said conduit in said well and means for maintaining a substantially constant hydraulic pressure in said suspension means; and
b. said suspension means includes means for accommodating longitudinal movement of said conduit

and said conduit is connected with an expansion chamber whereby longitudinal movement of said conduit changes the volume confined within said chamber.

21. An assembly as defined in claim **20** wherein:

a. said conduit cooperates with a second relatively fixed concentric conduit to form an annular expansion chamber having a variable volume which changes upon longitudinal movement of said conduit with respect to said fixed conduit, and

b. pressure line means communicate with said annular chamber for regulating the pressure within said chamber.

22. An assembly as defined in claim **21** wherein said pressure line means extends longitudinally into said annular chamber and said conduit telescopes over and is movable longitudinally with respect to said pressure line whereby pressure communication is maintained between said line and said chamber as said conduit moves longitudinally.

23. An assembly as defined in claim **21** further including a plurality of longitudinally spaced annular chambers communicating with said pressure line for increasing the support force exerted by said hydraulic fluid acting in said chambers.

24. An assembly as defined in claim **15** wherein:

a. said conduit includes a confined, longitudinal flow passage extending between an isolated well zone and the surface of said well; and

b. said valve means is operable upon said predetermined longitudinal movement of said conduit to open or close said flow passage to respectively permit or terminate flow of effluents from said isolated well zone through said confined flow passage to said well surface.

25. An assembly as defined in claim **24** wherein:

a. said first mentioned conduit extends longitudinally through a second well conduit;

b. an annular flow passage extends longitudinally between said first mentioned conduit and said second conduit; and

c. said first mentioned conduit and said second conduit carry second valving means operable when said first mentioned conduit is moved longitudinally through said second conduit to open and close said annular flow passage.

26. An assembly as defined in claim **24** wherein:

a. said first mentioned conduit extends longitudinally through a second well conduit;

b. an annular flow passage extends longitudinally between said first mentioned conduit and said second conduit; and

c. flow passage openings extend through the wall of said first mentioned conduit into communication with said annular flow passage at a point above said valve means whereby effluents flow from said isolated zone into said confined longitudinal passage, through said valve means and through said annular passage to the well surface.

27. An assembly as defined in claim **24** wherein said compensating means includes hydraulic suspension means for supporting said conduit in said well and means for maintaining a substantially constant hydraulic pressure in said suspension means.

28. An assembly as defined in claim **27** in which said sensor means comprises pressure release means for causing a pressure reduction in said suspension means upon the occurrence of said one or more predetermined conditions whereby said conduit is permitted to move longitudinally through said well to close said valve means.

29. An assembly as defined in claim **28** further including:

a. surface valve means connected with said conduit for permitting or terminating effluent flow from said conduit; and

b. condition responsive control means connected to said surface valve means for closing said surface valve means in response to the occurrence of said one or more predetermined conditions.

30. An assembly as defined in claim **29** wherein said condition responsive control means includes hydraulic pressure means in pressure communication with said hydraulic suspension means for permitting said surface valve means to close when the hydraulic pressure acting in said hydraulic suspension means or said hydraulic pressure means falls below a predetermined minimum value.

31. An assembly as defined in claim **28** wherein said pressure release means includes heat sensitive means connected with said suspension means and operable when exposed to a predetermined temperature to release said hydraulic pressure in said suspension means.

32. An assembly as defined in claim **31** wherein said valve means includes ball type valve means.

33. An assembly as defined in claim **31** wherein said valve means include flapper type valve means.

34. An assembly as defined in claim **18** wherein:

a. said conduit extends between said support means and an anchoring means disposed in said well;

b. said anchoring means is operable to secure said conduit to a substantially fixed part of said well;

c. said flow control means includes a first length of conduit fixed with respect to said anchoring means and extending toward the well surface;

d. said flow control means includes a second length of conduit connected with said first length and movable longitudinally with respect to said first length; and

e. said valve means may be operably connected with said first and second conduit lengths whereby longitudinal movement of said first length opens and closes said valve means.

35. An assembly as defined in claim **34** wherein said valve means includes first and second valves and means for closing said first valve to terminate flow through said conduit when said second valve is removed from operative position within said conduit and means for opening said first valve when said second valve is placed in operative position within said conduit.

36. An assembly as defined in claim **35** wherein said first and second valves include ball type valve means.

37. An assembly as defined in claim **35** wherein said first and second valves include flapper type valve means.

38. An assembly for regulating the flow of effluents through a well comprising:

a. releasable support means for supporting a conduit in said well;

b. sensor means connected to said support means and responsive to one or more predetermined condi-

tions at said well to automatically release said support means; and

c. flow control means connected with said conduit and operable upon predetermined movement of said conduit following release of said support means to regulate the flow of effluents through the well;

d. said control means being operable to open and close said conduit by rotary movement of said conduit;

e. said support means including release means operable for releasing torque forces in said conduit to permit said conduit to rotate and close said flow control means.

39. An assembly as defined in claim **38** further including compensating means for maintaining a substantially constant torque in said conduit to accommodate normal well condition induced movement of said conduit whereby said induced movement is prevented from operating said flow control means.

40. A well control system for regulating the flow of effluents through a plurality of wells comprising:

a. support means for supporting a conduit in each of said wells;

b. flow control means connected with each of said conduits and operable upon predetermined movement of said conduits to regulate the flow of effluents through each of said wells;

c. release means included in each of said support means operable for releasing support of said conduit to permit said predetermined movement;

d. control means connecting said release means in each of said support means for releasing support of all of said conduits when support of one of said conduits is released;

e. surface valve means connected with each of said conduits for permitting or terminating effluent flow from said conduit; and

f. second condition responsive control means for closing said surface valve means in response to the occurrence of one or more predetermined conditions.

41. A system as defined in claim **40** further including remotely operable actuating means for operating said release means by a remotely generated command signal to release support of said conduits for terminating effluent flow through said conduits.

42. A well control system as defined in claim **40** wherein said support means includes hydraulic suspension means containing an hydraulic fluid and actuable in response to a predetermined reduction in pressure of said hydraulic fluid to release said conduits for longitudinal movement under the influence of gravity to thereby close said conduits to effluent flow.

43. A well control system as defined in claim **42** wherein said release means includes heat fusible and frangible sensing means connected with said hydraulic suspension means for permitting said predetermined reduction in the pressure of said hydraulic fluid upon subjecting said sensing means to a temperature or a physical movement which ruptures said sensing means.

44. A well control system as defined in claim **40** wherein each of said conduits includes compensating means accommodating normal well condition induced movement of said conduits for preventing said induced movement from operating said flow control means.

45. A well control system as defined in claim **44** wherein each of said flow control means includes valve means having means for retrievably placing said valve means in operating position within said conduit whereby said valve means may be retrieved and positioned through said conduit.

46. A subsurface safety valve for use with a well structure on an offshore platform comprising:

a support means supporting a well conduit from said platform for conducting effluents from said well through said conduit to a wellhead on said platform;

b subsurface valve means included in said conduit and movable between opened and closed positions to regulate the flow of well effluents through said conduit;

c valve operating means included with said valve means and said conduit means for moving said valve means between open and closed positions by predetermined longitudinal movement of said conduit; and

d compensating means for accommodating normal well condition induced movement of said conduit for preventing said induced movement from moving said valve means between opened and closed positions.

47. A safety valve as defined in claim **46** wherein:

a said conduit connects to a packer anchored at a subsurface location within said well;

b said valve operating means includes a relatively fixed conduit section connected with said packer and a relatively movable conduit section suspended from said platform; and

c said compensating means includes telescoping joint means between first and second connecting sections of said conduit for accommodating normal, well condition induced longitudinal movement in said conduit to prevent such induced movement from operating said valve means.

48. A safety valve as defined in claim **47** wherein:

a said telescoping joint means forms sealed chamber means enclosing a chamber which varies in volume as said connecting sections telescope longitudinally relative to each other;

b said chamber is equipped with a pressurized fluid for controlling the longitudinal telescoping overlap between said two connecting sections by regulating the pressure of said fluid; and

c said first connecting section is supported by said platform whereby a predetermined reduction of the pressure of said fluid permits said second section to move longitudinally under the influence of gravity to the extent required to operate said valve means.

49. A safety valve as defined in claim **48** further including pressure control means for maintaining a substantially constant pressure in said fluid for maintaining substantially constant tension forces in said conduit as said conduit elongates and foreshortens longitudinally under the influence of normal well conditions.

50. A safety valve as defined in claim **48** further including sensing means connected with said pressurizing fluid and operative upon the occurrence of a predetermined temperature or physical movement to cause a reduction in the pressure of said fluid whereby said valve means is operated to terminate effluent flow through said conduit.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,830,306 Dated August 20, 1974

Inventor(s) Cicero C. Brown

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

Column 1, line 37, "simulataneously" should be
-- simultaneously --;

Column 23, line 23, "including" should be -- includes --;

Column 24, line 5, "5" should be -- 9 --;

Column 26, line 32, "18" should be -- 31 --;

Column 27, line 8, after "said", insert -- flow --.

Signed and Sealed this

Twenty-fifth Day of *August 1981*

[SEAL]

Attest:

GERALD J. MOSSINGHOFF

Attesting Officer *Commissioner of Patents and Trademarks*