United States Patent [19]

Polk

[11] **3,887,158**

[45] **June 3, 1975**

[54] **BLOW OUT PREVENTERS**

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[73] Assignee: **Otis Engineering Corporation,** Dallas, Tex.

[22] Filed: **Mar. 22, 1973**

[21] Appl. No.: **343,652**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 144,011, May 17, 1971, abandoned.

[52] **U.S. Cl.** **251/1;** 137/462; 137/492.5; 166/53; 251/63.5; 251/212

[51] **Int. Cl.**..... **E21b 33/06; F16k 31/363**

[58] **Field of Search** 166/53; 251/1, 212; 137/456, 462, 488, 489, 492, 492.5

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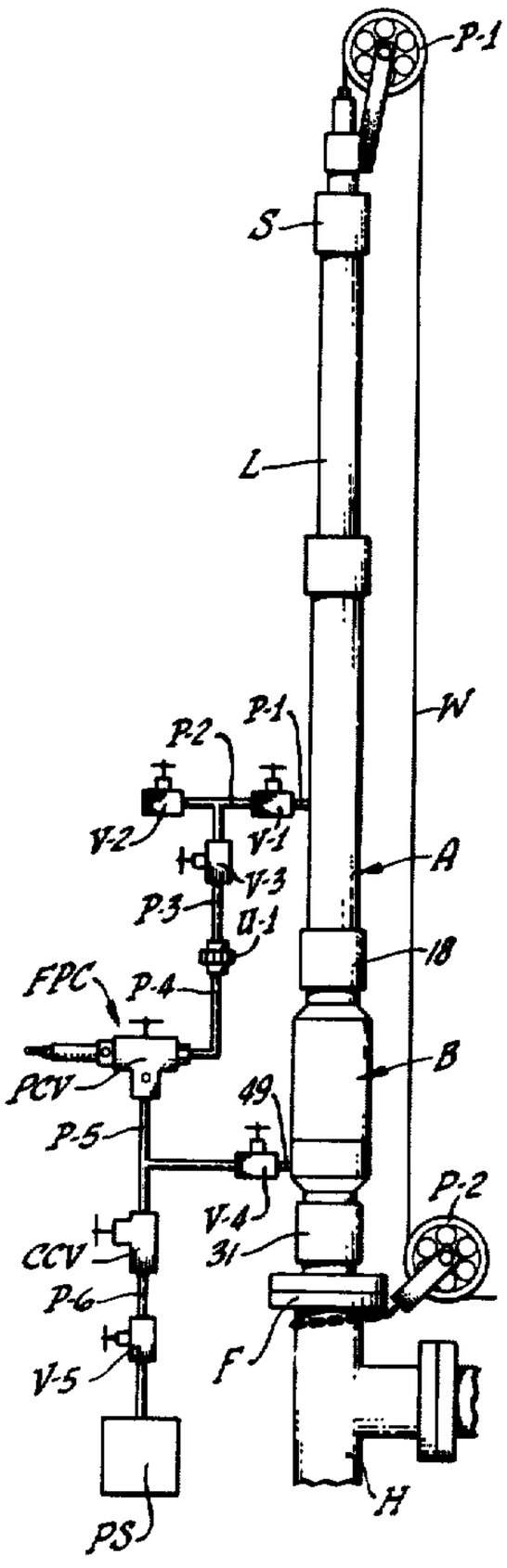
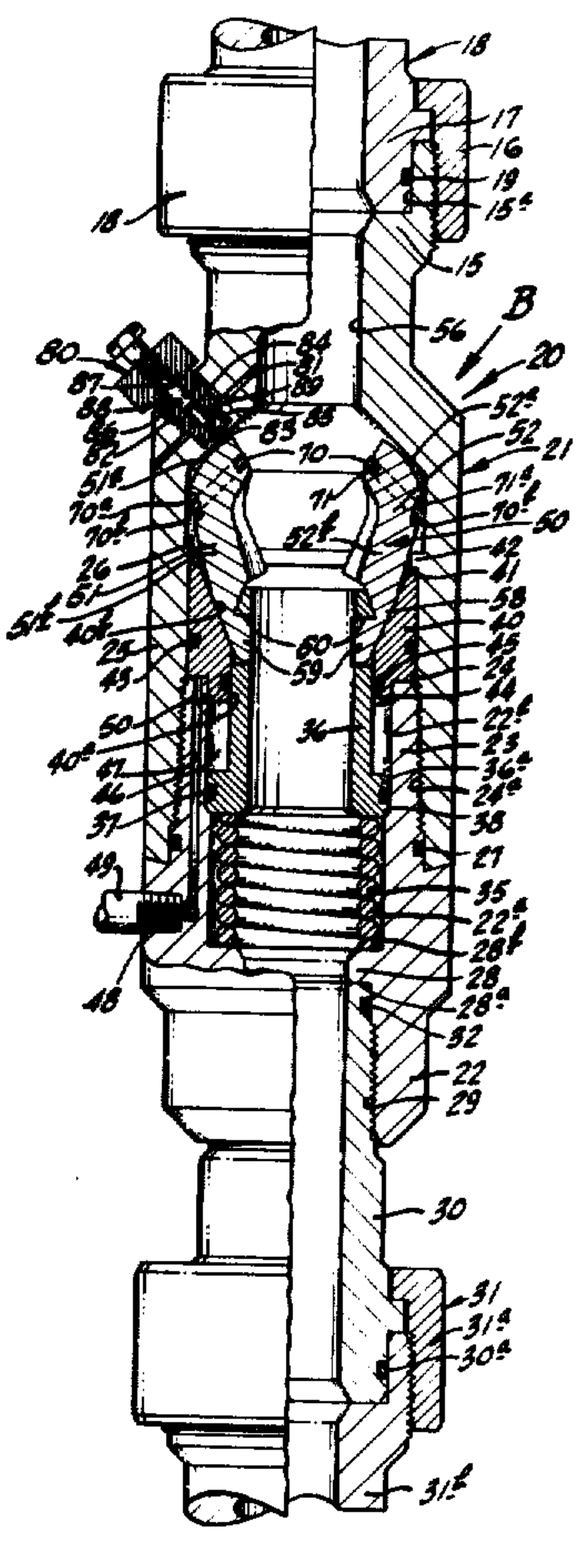
Assistant Examiner—Richard Gerard

[57] **ABSTRACT**

A blowout preventer for sealing off around a flexible line to prevent hazardous leakage of well fluids, which is held in an open position by control fluid pressure actuated means and moved to closed position upon reduction or release of control fluid pressure. A plurality of segmental metallic closure members have resilient seals for engaging the flexible line without damaging it. Fluid pressure control means is provided responsive to fluid pressure conditions within the blowout preventer for controlling application of control fluid pressure to the actuating means for the closure members to control opening and closing of said members.

11 Claims, 7 Drawing Figures





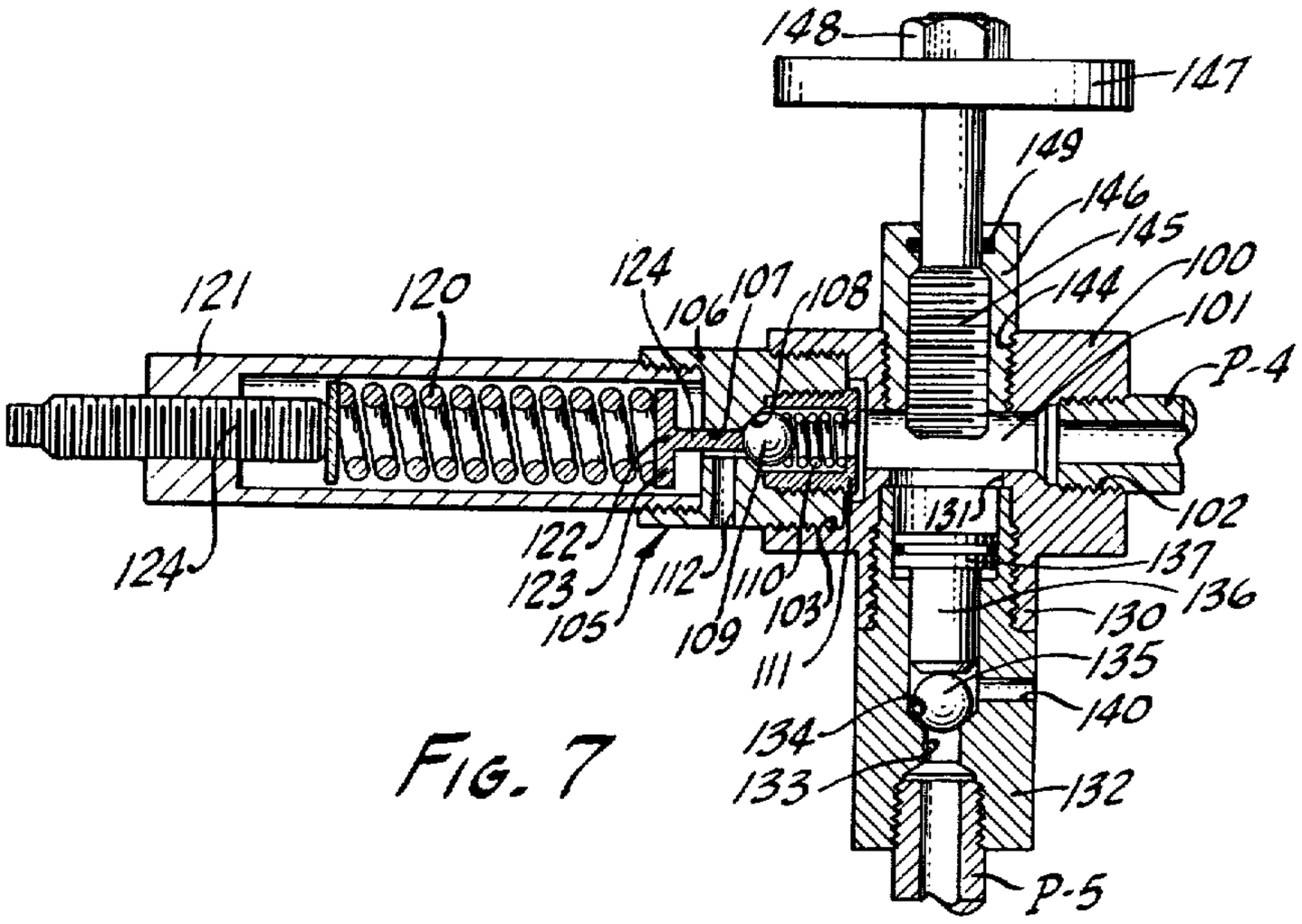


FIG. 7

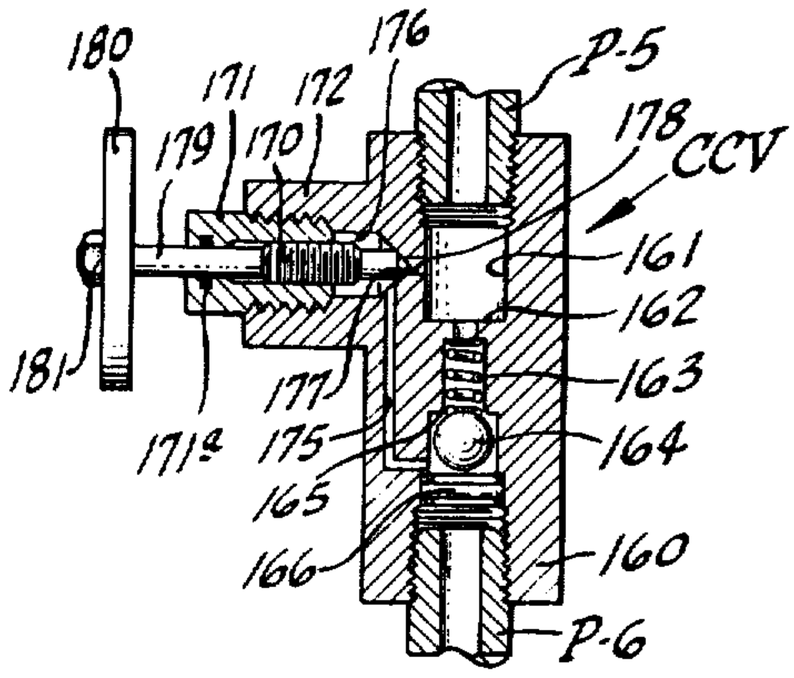


FIG. 6

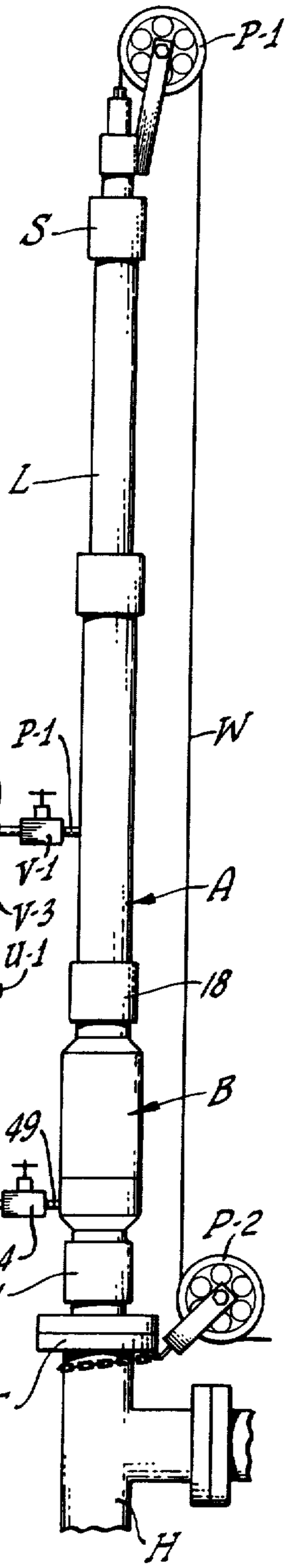


FIG. 1

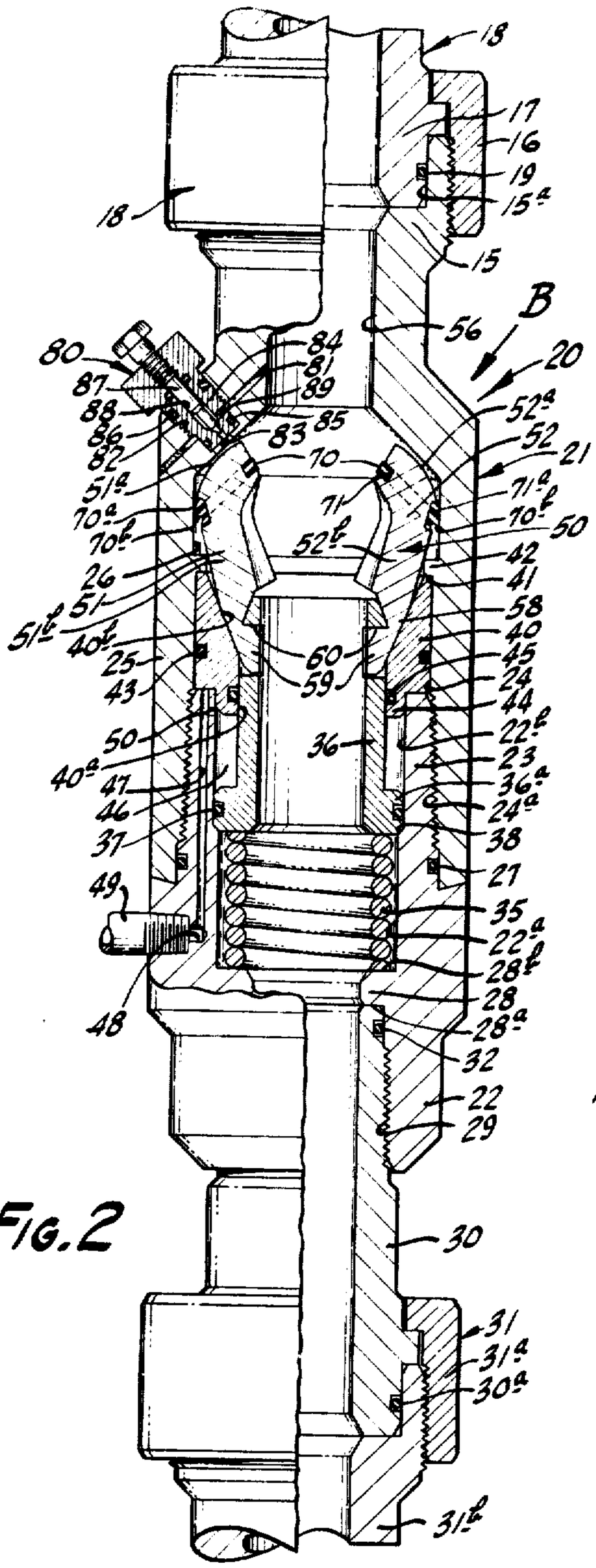


FIG. 2

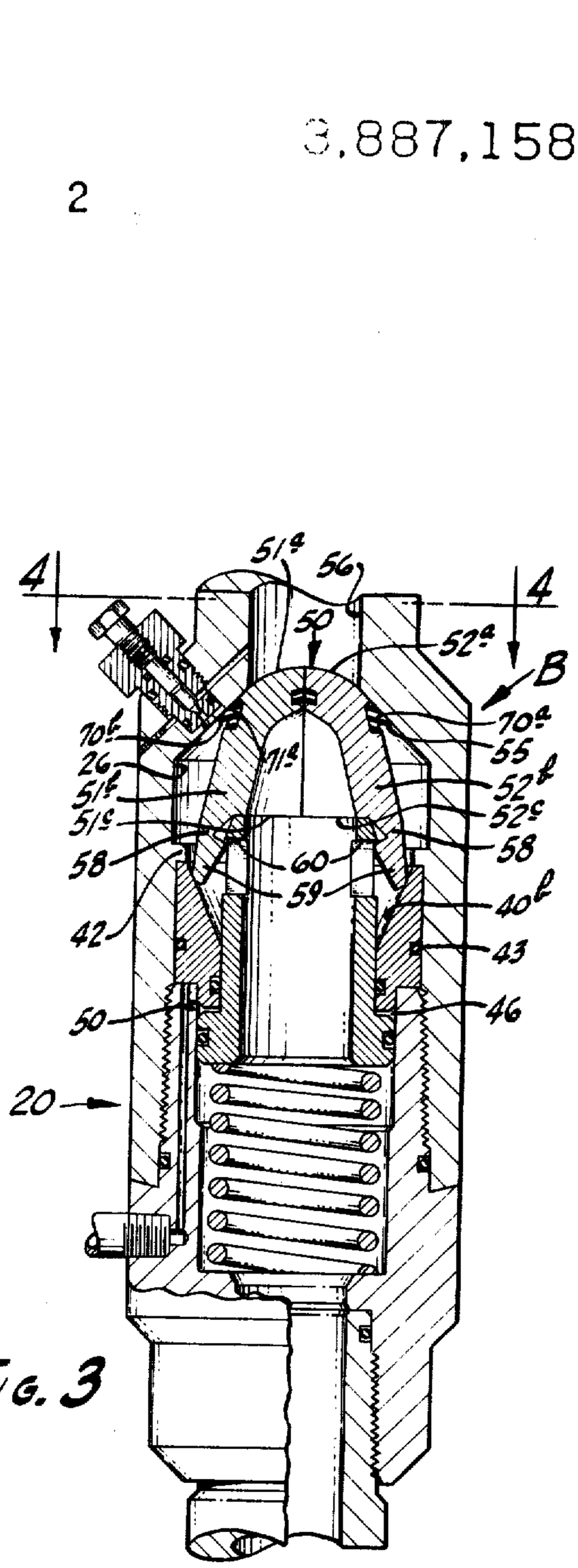


FIG. 3

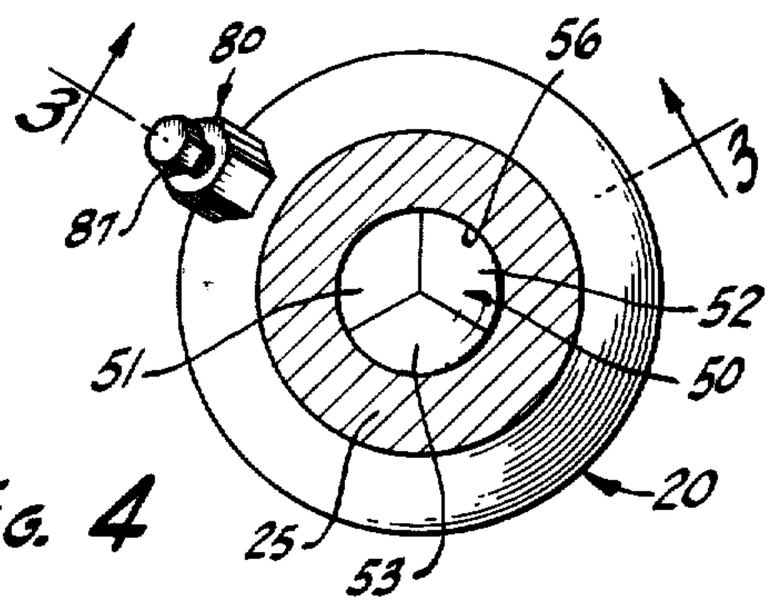


FIG. 4

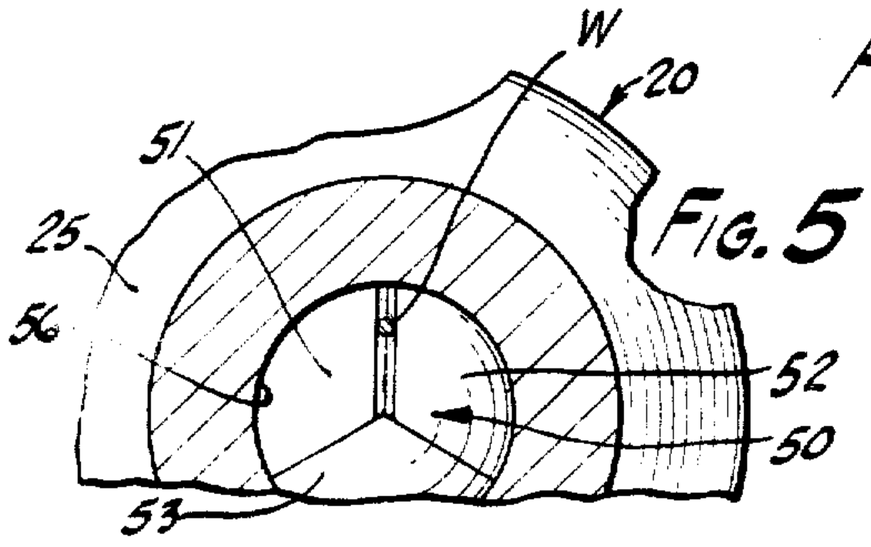


FIG. 5

BLOW OUT PREVENTERS

This is a continuation-in-part of my copending application Ser. No. 144,011, filed May 17, 1971, now abandoned.

This invention relates to blowout preventers and more particularly to blowout preventers adapted to be used with a wireline lubricator.

In conducting wire line operations under pressure in an oil or gas well or the like, it is necessary to enclose and seal around the flexible wire line by means of a lubricator connected to the upper end of the Christmas tree to pass the string of wireline operated well tools through the Christmas tree with the well-head valves open and to permit the master valve to remain open during the operations. After the operations have been concluded the string of wire line tools may be lifted into the lubricator, and the master valve then closed and the lubricator removed.

Without a means for closing off the well conduit in the event of a fluid pressure leak at the lubricator, there is considerable danger in operations of this sort.

For safety purposes, it is desirable to be able to close off around the wire line while the tools are in the well, in the event of such a leak at some point in the lubricator such as at the stuffing box or at the equalizing valve, or at some other fitting. The danger of leakage or uncontrolled well fluid escaping may be minimized or eliminated by the provision of a blowout preventer or closure means movable from an open position to a position closing the wire line between the lubricator and the Christmas tree to shut off flow or escape of well fluids therepast.

It is therefore one object of this invention to provide a fail-safe wireline blowout preventer.

Another object is to provide a fail-safe wireline blowout preventer operable automatically or from a remote control point for positively closing off a well around a wireline in lubricator.

An important object of the invention is to provide a wireline blowout preventer which is designed to function automatically in response to well fluid pressure for closing off flow around the wire line; which may be controlled from a remote point; and which is constantly resiliently biased toward closed position.

Another object is to provide a blowout preventer having closure means normally resiliently biased to closed position and having fluid pressure responsive actuating means connected therewith adapted to have control fluid pressure applied thereto to move said closure means to an open position, and wherein well fluid pressure acting on said actuating means assists the resilient means to move the closure means to closed position upon the occurrence of predetermined conditions of pressure differential across said actuating means applied thereto as a result of leakage from the lubricator at elevated pressures or reduction of control fluid pressure.

A particular object of the invention is to provide a blowout preventer having fluid pressure control means sensing and responsive to fluid pressure conditions within the blowout preventer for controlling application of control fluid pressure to the actuating means for the closure means for causing actuation of the closure means upon the occurrence of predetermined conditions of fluid pressure within the blowout preventer or the control means.

Still another object is to provide a substantially metal to metal seal at the closure means except around the wire line, and wherein a deformable seal is provided to reduce or obviate damage to the wire line when the closure means of the blowout preventer is closed.

Additional objects and advantages of the invention will be readily apparent from the reading of the following description of a device constructed in accordance with the invention, and reference to the accompanying drawings thereof, wherein:

FIG. 1 is a schematic view, in elevation, of a wire line lubricator installation for a well, having a blowout preventer incorporated therein;

FIG. 2 is a longitudinal sectional view of the wireline blowout preventer showing the closure members in fully open position;

FIG. 3 is a view similar to FIG. 2, showing the closure members in closed position;

FIG. 4 is a horizontal cross-sectional view taken along the line 4 — 4 of FIG. 3;

FIG. 5 is an enlarged fragmentary view similar to FIG. 4 showing a wire line sealed off by the closure members;

FIG. 6 is an enlarged vertical sectional view of one of the valves of the fluid pressure control means of the blowout preventer; and

FIG. 7 is an enlarged vertical sectional view of a pilot control valve used in the fluid pressure control means assembly.

In the drawings, in FIG. 1, is shown a schematic representation of a wire line lubricator assembly A for use on well heads H for controlling fluid pressures during the insertion and removal of a wire line W during wire line operations performed in the well. The lubricator assembly A includes a stuffing box S at the upper end of an elongate tubular high pressure chamber of lubricator L which may be formed of several lengths of high pressure pipe or the like connected to the upper end of the well head H by usual flanged connection means F. The wire line is directed to the stuffing box S over a pulley P-1 forming a part of the stuffing box assembly at the upper end of the lubricator, and around a second pulley P-2 secured near the upper end of the well head H and the lower end of the lubricator assembly A to a pulling unit (not shown). Incorporated in the lubricator assembly A is a blowout preventer B constructed in accordance with this invention.

For controlling the actuation of the blowout preventer a fluid pressure control system FPC is connected in flow communication with the lubricator L on the downstream side of the blowout preventer B by means of a pipe or conduit *p*–1 and a cutoff valve *v*–1 which may be used to control fluid pressure flow into or out of the lubricator from the fluid pressure control system. A T-shaped pipe *p*–2 has one arm connected to the cut-off valve *v*–1 and its other arm connected to a vent valve *v*–2, while its vertical stem portion is connected to a valve *v*–3 which is in turn connected by a pipe *p*–3 to a union *u*–1. An L-shaped pipe *p*–4 has one end connected to the union *u*–1 and its other end connected to a pilot control valve PCV by means of which the actuation of the blowout preventer B is controlled. A T-shaped pipe *p*–5 has one arm connected to the pilot control valve and its other arm connected to a check control valve CCV, and has its stem portion connected to a cut-off valve *v*–4 which is also connected to a pipe 49 which communicates with the interior of the blow-

out preventer B on the upstream side thereof. The check control valve CCV is connected opposite the pipe *p*–**5** with a conductor or pipe *p*–**6** which leads to the check control valve CCV from a pump or other sources PS of control fluid under pressure, which is used to control actuation of the blowout preventer B. A cut-off valve *v*–**5** is connected in the pipe *p*–**6** for controlling flow of control fluid under pressure from the source PS to the fluid pressure control system. The fluid pressure control system FPC is utilized to sense the fluid pressure conditions within the lubricator L and within the blowout preventer B and to control the admission of control fluid pressure from the pressure source PS to the blowout preventer for controlling actuation thereof, as will be hereinafter more fully explained.

The blowout preventer B, also numbered **20,** has a body **21** formed of a lower tubular body section **22** having an upstanding, threaded reduced upper pin portion **23** threaded into the enlarged lower internally threaded pocket end **24***a* of the bore **24** of an upper section **25** to provide a valve chamber **26** in the body. An O-ring seal member **27** is disposed in an external annular groove formed in the lower end of the reduced upper portion **23** of the lower section **22** of the body for sealing between the lower section and the lower end of the upper section **25** of the body.

An externally threaded connecting flange pin **15** is formed on the upper end of the upper housing section **25** and receives a union coupling **16** which is threaded onto such upper end and secures a flanged connector sub **17** of a union **18** at the lower end of the lubricator L in tight sealing engagement with the upper end of the housing **21.** An O-ring seal member **19** is disposed in an external annular groove on the lower end of the sub or lower end of the connector sub **17** of the union at the lower end of the lubricator and seals between the sub and the enlarged bore **15***a* formed in the upper end of the threaded flange pin of the upper housing section to prevent fluid escape therebetween in the usual manner.

An internal annular flange and stop shoulder member **28** is formed in the lower portion of the bore **22***a* of the lower body section, and the bore below sand flange is enlarged and threaded as at **29** to receive the threaded pin sub section **30** of a union **31** having a coupling member **31***a* thereon for connecting the pin sub **30** to a mating complementary union box member **31***b*, which is also connected to the flange connection F to the well head H. A seal ring **30***a* on the lower end of the pin sub seals between the pin sub and box member. An O-ring seal member **32** is disposed in an external annular groove at the upper end of the pin section for sealing between the pin section of the union and the lower section **23** of the body. The upper end of the pin engages the downwardly facing shoulder **28***a* of the stop flange **28.** The upwardly facing shoulder **28***b* of the stop flange supports the lower end of a helical coil spring **35,** the upper end of which engages the lower end of an operating or actuating sleeve **36** having an enlarged piston head **36***a* thereon slidable in the enlarged upper portion **22***b* of the bore of the lower section of the body. A seal ring **37** seals between the piston head and the bore wall **22***a* of the body. An internal annular upwardly facing stop shoulder **38** at the lower end of such enlarged bore limits downward movement of the actuating sleeve and piston in the body, while the spring biases the piston and sleeve upwardly in such enlarged upper portion of the bore of the lower body section.

An internal annular supporting sleeve **40** is supported on the upper end of the reduced upper section **23** of the lower body and held tightly in engagement therewith by a downwardly facing shoulder **41** on the lower side of an internal annular flange **42** in the mid-portion of the bore **24** of the upper body section **25,** and an external O-ring seal member **43** disposed in an external annular groove in the supporting sleeve **40** seals between said supporting sleeve and the upper body section. A depending annular flange **44** formed on the lower end of the supporting sleeve projects downwardly into the upper end of the bore **22***b* of the lower body section, and an internal annular seal ring or O-ring seal **45** disposed in an internal annular groove formed in the lower portion of the bore **40***a* of the supporting sleeve seals between the supporting sleeve and the upper portion of the actuating sleeve **36.**

An operating fluid chamber **46** is formed in the bore **22***b* of the lower body member between the piston head **36***a* and the lower end of the reduced depending annular flange **44** of the supporting member. A longitudinal control fluid passage **47** is formed in the reduced upper portion of the lower body section extending downwardly from the upper end thereof to a laterally extending inlet opening **48** which is enlarged and provided with screw threads for receiving a control fluid conductor or pipe *p*–**10** for conducting control fluid from a source of supply PS of such control fluid under pressure inwardly of said lateral opening into the longitudinal passage **47** and outwardly through a lateral port **50** communicating with the chamber **46** below the lower end of the depending flange **44** of the support member **40.** Control fluid under pressure introduced into the chamber will therefore act on the piston head **36***a* to move the actuating sleeve **36** downwardly against the force of the spring **35** and will hold the sleeve in such downward position until the control fluid pressure is reduced or released or until fluid pressure in the bore **22***a* of the lower body section acting on the lower end of the piston head **36***a* will move the same upwardly as a result of the differential area between the O-ring seal member **45** in the bore of the supporting sleeve and the O-ring seal member **37** on the piston head.

A closure assembly **50** formed of a plurality of segmental arcuate sections **51, 52** and **53,** respectively, is supported on the upper end of the actuator sleeve **36,** and the segmented sections move between an open position, shown in FIG. **2,** and a closed position, shown in FIG. **3.** Each of the segments comprises approximately 120° of a circle when in the closed position shown in FIGS. **3** and **4,** and the edges thereof abut to provide a complete metal-to-metal sealing closure for the inclined seat **55** at the lower end of the upper reduced bore **56** of the upper housing section **25** above the valve chamber **26.** The upper end of each of the sections is curved inwardly and upwardly to provide a substantially concavo-convex or hemispherical upper end portions **51***a*, **52***a* and **53***a* above the frusto-conical segmental lower portions **51***b* and **52***b* of the closure segments, and the concavo-convex portions, when the segments are in the closed position of FIG. **3** engage the downwardly facing inclined seat **55** at the upper end of the chamber **26** of the upper housing section **25.**

The segments **51, 52** and **53** of the closure assembly **50** are swingably mounted on the upper end of the ac-

tuator sleeve **36** by depending hook members **58** having hook fingers **59** which extend inwardly through radially extending complementary apertures **60** provided at circumferentially spaced positions in the upper end portion of the actuating sleeve. The hook members **58** have inwardly and upwardly inclined inner faces **61** which engage exteriorly the beveled surfaces **62** at the upper end of the sleeve and the hooks **59** extend into the openings **60** for swingably connecting or securing the segments to the actuating sleeve. When the segments are in the open position, they provide an open bore through the body **21** and the actuating sleeve. The lower ends **51***c* of the frusto-conical portions **51***b* and **52***b* and **53***b* of each of the segments **51, 52** and **53,** engage and rest on the upper end of the actuating sleeve when the closure segments are in the closed position as shown in FIG. **3.**

The inclined upwardly flared bore **40***b* of the supporting member **40** engages the lower outer edges of the depending hook members to restrain outward movement thereof when the actuating sleeve is moved upwardly to move the segments into engagement with the seat **55** in the upper body section. When the actuating sleeve is moved downwardly, as shown in FIG. **2,** by the control fluid pressure in the chamber **46** acting on the piston head **36***a*, the upwardly facing surfaces of the hooks **59** of the segments engage the downwardly facing shoulders at the upper end of the lateral apertures **60** in the actuating sleeve, and the segments are moved downwardly by the actuating sleeve toward the position shown in FIG. **2,** the flared surface **40***b* of the supporting member camming the lower ends of the segments inwardly to the position shown in FIG. **2,** wherein the upper concavo-convex portions of the segments are swung outwardly to provide an open uninterrupted bore through the blowout preventer.

A compressible or deformable sealing member **70** is disposed in an external recess **71** on the abutting upper end surfaces of each of the setments of the closure. The portion of the groove in the V-shaped abutting faces of the segments is substantially rectangular in cross-section and the packing or sealing member projects therefrom so that when the segments are moved to the closed position shown in FIG. **3** the sealing material of the sealing member will be compressed or deformed into tight sealing engagement with the corresponding complementary sections of the seal member on the adjacent abutting surfaces of the other segments of the closure. The arcuate outer section **71***a* of the recess in the convex outer face of each segment, in which the seal member is disposed is enlarged in longitudinal dimension and the seal member section **70***a* disposed therein is provided with a flexible lip **70***b* which is adapted to engage the seating surface **55** at the upper end of the chamber **26** in the upper body section to assure a positive seal therewith and to further urge the segments upwardly into metal-to-metal sealing engagement with each other on the seat.

The actuating member and segments of the closure illustrated are similar to those found in the patent to Schramm et al., 2,911,997, issued Nov. 10, 1959, and function in much the same manner as the segments of that device. However, the actuation of the device is substantially different, and the engagement of the seal members with the wire line extending therethrough, as shown in FIG. **5,** differs from that of the Schramm et al. device. When the closure segments are closed, as shown in FIGS. **3, 4** and **5,** fluid is prevented from moving upwardly through the bore of the housing or body **21** to the bore **56** thereabove and through the union **18** to the lubricator L connected therewith thereabove.

To equalize pressures on opposite sides of the closure to permit opening the same without damage to the wire line or tools and utilizing minimum control fluid pressure, an equalizing valve assembly **80** is connected in the upper body section **25.** An equalizing port **81** extends from the reduced upper bore **56** of the upper body section above the seat **55,** and a transverse enlarged bore **82** having a reduced port **83** opening through the seat to the chamber **26** below the closure assembly **50** communicates with the equalizing port and is provided with internal screw threads. A valve body or bushing **84** is mounted in such enlarged bore, and has an inner seal ring **85** disposed in an external annular groove formed thereon sealing between the inner end portion of the body and the enlarged transverse bore **82** between the port **83** and the equalizing passage **81.** An external annular outer seal ring **86** disposed in an annular groove or recess on the outer portion of the valve body **84** seals between the body and the enlarged transverse bore on the outer side of the equalizing passage **81.** A needle valve closure member **87** is threadedly disposed in the bore **88** of the valve body **84** and has a needle closure point engaging a seat at the reduced lower end of the bore in the body for closing off flow from a lateral port **89** communicating with the equalizing passage. A seal ring **90** is disposed in the valve body for sealing between the needle valve closure member and the valve body. When the valve is closed the bypass equalizing passage is closed, and when the valve is moved to the open position fluids may pass through the equalizing passage into the chamber **26** in the upper body section **25** below the seal provided by the closure **50** so that the fluid pressures on the opposite sides of the seal may be equalized to permit easy opening of the closure.

In use, the blowout preventer **20** or B is connected at its upper end to the lubricator L, as has been described, by means of the union **18.** The coupling pin sub **30** at the lower end of the housing or body **21** of the blowout preventer is connected by means of the union coupling **31***a* to the threaded upper end of the mating complementary union box sub **31***b* which is in turn connected to the upper end of the Christmas tree or well head H of the well. The seal ring **30***a* on the lower end of the pin sub seals between the pin sub and the box sub to prevent escape of fluids therebetween when the device is coupled to the Christmas tree of the well.

The well tools (not shown) to be operated in the well are connected to the wire line W and located in the lubricator L above the blowout preventer B, also numbered **20,** in the usual manner. At this time the bypass valve **80** on the housing of the blowout preventer is closed, as is the vent valve *v*–**2** of the fluid pressure control system FPC. The well fluid cut-off valves *v*–**1** and *v*–**3** of the fluid pressure control system are opened, as are the control fluid cut-off valves *v*–**4** and *v*–**5.** Therefore, control fluid pressure from the pressure source PS may be introduced through the pipe *p*–**6,** the check control valve CCV, the pipe *p*–**5** and the valve *v*–**4,** through the pipe conductor **49** and control fluid passage **47** into the chamber **46** between the piston head **36***a* of the actuating sleeve **36** and the lower end of the support and guide member **40** in the body

21 of the lubricator to hold the closure member 50 of the blowout preventer in the open position shown in FIG. 2.

The gate valve (not shown) on the Christmas tree is then opened and the lubricator pressurized, whereupon the pressure of the well fluids in the lubricator acting upon the pilot control valve PCV, as will be hereinafter more fully explained, will cause the pilot control valve to move to the closed position shown in FIG. 7 to confine the well fluid pressures in the lubricator, the blowout preventer, the Christmas tree and the well flow conductor, so that the well tools may then be lowered from the lubricator through the blowout preventer and Christmas tree into the well flow conductor in the usual manner for operation therein.

The pilot control valve PCV utilizes the pressure of the well fluids in the lubricator directed thereto from the lubricator through the pipe *p*–1, the pipe *p*–2 and the pipe *p*–3 and *p*–4 to control application of control fluid from the pressure source PS through the pipe *p*–6, the pipe *p*–5 and the conductor 49 to the piston head of the actuating sleeve of the blowout preventer, as will be hereinafter more fully explained. Should a condition be created or exist in the lubricator or in the flow lines of the fluid pressure control system FPC which would require or make desirable the closing of the blowout preventer closure 50, with or without the wire line extending through the blowout preventer, the fluid pressure control system will automatically relieve the pressure of the control fluid applied to the piston head of the actuating sleeve of the blowout preventer. When such pressure is reduced or relieved, the spring 35 automatically moves the actuating sleeve upwardly and biases the closure segments 51, 52 and 53 of the closure 50 to the closed position shown in FIG. 3 and in FIG. 4. When such a condition exists or occurs, the check control valve CCV automatically closes to prevent waste or loss of control fluid pressure from the pressure source PS.

The pilot control valve PCV has a housing or body 100 with a cross-flow bore or passage 101 therein. The pipe *p*–4 is threadedly connected to one inlet opening 102 of the cross-flow passage and a low pressure pilot valve 105 such as the well known Type B pilot valve manufactured and sold by Otis Engineering Corporation is threadedly connected in the opening 103 at the opposite end of the cross-flow bore or passage 101. The pilot valve 105 includes a body 106 having a longitudinal flow passage 107 therein which is enlarged at its inner end to provide a valve seat 108 on which a ball valve 109 is held seated by a spring 110 confined between the ball valve and a cage 111 threaded into the enlarged inner end of the bore in the body. A lateral vent passage 112 is provided in the body 106 outwardly of the seat 108, and when the ball valve is moved off the seat, fluid pressure from within the passage 101 of the housing of the pilot control valve may pass outwardly through the opening 112 to the atmosphere. Fluid pressure from within the lubricator L acts on the ball valve, with the spring 110, to hold the ball seated on the seat 108 during normal operations. However, a pilot pressure control spring 120 confined in a cage 121 between a plunger 122 having a disc head 123 and an actuating pin 124 extending through the bore 107 of the pilot valve body into engagement with the ball valve 109 controls movement of the ball valve off the seat 108 when pressure within the bore or passage 101 of the pilot control valve housing becomes sufficiently low. The pilot pressure control spring 120 is compressed by an adjusting screw 124 threaded through a threaded opening in the outer end of the cage 121 and having a head or bearing disc 125 on its inner end engaging the outer end of the spring, whereby the adjusting screw may be turned to increase or reduce the compression of the spring 120. Thus, the force exerted by the spring 120 acting on the plunger 122 and the pin 124 projecting through the bore 107 to engage the ball valve 109 may be varied to vary the conditions of pressure under which the ball valve 109 will be unseated. When the pressure exerted by the spring on the ball valve is sufficient to overcome the pressure of the well fluid present in the passage 101 of the housing 100 plus the force of the spring 110, the ball valve will be moved off its seat and well fluid pressure in the cross flow bore passage 101 will be exhausted through the vent 112. This exhausting of the well fluid pressure from the passage 101 also exhausts the pressure from within the lubricator through the pipes and valves connected between the lubricator and the pilot control valve.

The housing 100 also has a lateral wing 130 with a bore 131 therein communicating with the bore or cross-flow passage 101, and a control fluid vent valve housing 132 is threaded in the bore 131 of the wing. The control fluid vent valve housing has a longitudinal passage 133 reduced medially to provide a seat 134 against which a ball valve 135 seats. The ball valve 135 is held on the seat 134 by a plunger 136 having an enlarged piston head 137 slidable in sealing engagement in the enlarged bore 138 in the inner end of the vent valve housing 132. The well fluid pressure in the cross-flow passage 101 acts on the piston head 137 to force the same in a direction to hold the ball 135 in engagement with the seat 134. The outer end of the bore 133 of the vent valve housing 132 is connected to the pipe *p*–5 which leads to the control fluid pressure source PS and to the chamber 46 in the blow-out preventer. A lateral vent passage 140 in the wall of the housing or body 132 on the opposite side of the seat from the pipe *p*–5 permits control fluid to be vented from the pipe *p*–5 when the ball valve 135 is unseated. Therefore, when pressure in the passage 101 is relieved or vented through the vent passage 112 by unseating the pilot ball valve 109, the pressure in the passage 101 holding the plunger 136 downwardly to hold the control ball valve 135 against the seat 134 is reduced and the pressure of the control fluid in the pipe *p*–5 may move the valve and plunger 136 upwardly to permit the control fluid in the pipe *p*–5 to be vented through the lateral vent 140 in the body 132.

A manual closing screw 145 is threaded into a bushing 146 and has a handle 147 held on its outer end by a nut 148. When rotated, the end of the screw 145 may be moved toward the plunger 136 to mechanically force the plunger to a position holding the control fluid ball valve 135 in engagement with the seat 134 to prevent further escape of control fluid pressure from the pipe *p*–5. The bushing 146 is threaded into a lateral opening 144 in the body 100 of the pilot control valve opposite the control fluid vent valve housing 132, and a seal ring 149 seals between the shaft of the screw and the cage 146 to prevent fluid leakage from the bore or passage 101.

It will be seen, therefore, that when well fluid pressure in the lubricator is reduced to such a value that the

pilot spring **120** of the pilot control valve may move the ball valve **109** off its seat **109** and vent the fluid pressure in the cross-flow passage **101** of the pilot control valve to atmosphere through the vent **112,** the plunger **136** will be moved off its seat by the control fluid pressure in the pipe *p*–**5** acting on the ball valve **135.** When this occurs, the control fluid pressure in the pipe *p*–**5** will escape through the vent **140** to relieve the pressure acting on the piston head **36***a* of the actuating sleeve **36** holding the segments of the closure **50** of the blowout preventer in the open position. Releasing the control fluid pressure from within the chamber **47** permits the spring **35** to move the actuating sleeve to cause the closure segments **51, 52** and **53** of the closure to be moved automatically to the closed position shown in FIG. **3.**

When the control fluid pressure in the pipe *p*–**5** is reduced or released by operation of the pilot control valve PCV, the check control valve CCV, which is a velocity check valve, automatically moves to a closed position to cut off escape of control fluid pressure from the pressure source PS through the pipe *p*–**6.**

The check control valve comprises a housing **160** having a longitudinal bore **161** which is enlarged at its opposite ends to receive the pipe *p*–**5** and the pipe *p*–**6** threaded into such opposite ends. The central portion of the bore is reduced to provide an internal annular spring supporting shoulder **162,** and a spring **163** is confined between said shoulder and ball check valve **164** in the upstream end of the flow passage **161** from a check valve seat **165.** The spring **163** normally biases the ball valve **164** off the seat **165,** and a cross pin **166** in the upstream portion of the bore of the housing prevents the ball from moving into engagement with the end of the pipe *p*–**6,** so that the ball remains off its seat and control fluid pressure may pass the ball from the pipe *p*–**6** into the pipe *p*–**5,** from whence it is directed through the conductor **49** and the passage **47** into the chamber **46** to act on the piston head **36***a* of the actuating sleeve **36** to move the closure segments of the blowout preventer to open position.

When the control fluid pressure in the pipe *p*–**5** is vented through the vent **140** of the pilot control valve PCV, as has already been explained, the pressure in the pipe *p*–**5** and in the downstream end of the passage **161** is reduced or relieved and the ball check valve will, as a result of the velocity flow of the control fluid from the pressure source through the pipe *p*–**6,** be moved into engagement with the seat **165** to close off automatically further escape of such fluids.

An equalizing by-pass needle valve member **170** is threaded into a bushing **171** which is in turn threaded into a lateral boss **172** in the housing **160** of the velocity check valve. A by-pass passage **175** extends from upstream of the valve seat **165** to the opening **176** in the lateral wing **172** in which the equalizing needle valve member **170** is adjustably movable toward and away from a seat **177.** A lateral passage **178** in the housing communicates the seat with the bore **161** of the body **160** downstream of the ball valve seat **165.** Therefore, when the equalizing needle valve **170** is rotated to move the end thereof out of engagement with the seat **177,** control fluid pressure from the pipe *p*–**6** may pass to the downstream side of the ball valve **164** and the pipe *p*–**5** to equalize pressures across the ball valve and permit the spring **163** to move the ball valve to the normal open position shown in FIG. **6.** The stem **179** of the needle valve member **170** extends outwardly from the bushing **171** through a seal **171***a* and has a handle **180** held on its outer end by a nut **181** in the usual manner. The handle is rotated to move the needle valve **170** into and out of engagement with the seat **177** to open and close the bypass passage for equalizing pressures on opposite sides of the velocity check ball valve **164.**

As has been explained the ball check valve will move to the closed position, closing off escape of control fluid pressure from the pressure source through the pipe *p*–**5,** when the pilot control valve PCV is operated to vent the control fluid from the pipe *p*–**5** upon the occurrence of a condition of low pressure in the lubricator or upon fracturing or rupturing of any of the lines downstream of the check control valve. Upon rupture or loss of pressure in any of the pipes *p*–**5,** *p*–**3,** *p*–**4,** *p*–**2** or *p*–**1,** the pressure in the chamber **46** of the blowout preventer will be reduced permitting the spring acting on the actuating sleeve **36,** and the well fluid pressure upstream piston head **36***a* on the actuating sleeve, to move the closure segments **51, 52** and **53** of the closure **50** of the blowout preventer to the closed position to close off escape of well fluids from the well through the lubricator or any of the flow connections.

Obviously, the pipe *p*–**4** and the stem of the T-shaped pipe *p*–**5** may extend to a remote point a distance from the well head, so that the pilot control valve PCV, the check control valve CCV, and the pressure source PS may be located at such remote point, and yet provide for actuation of the blowout preventer in the manner described from such remote point.

Should any situation producing a hazardous condition arise, such as for example the gland packing of the stuffing box, through which the wire line enters the lubricator, blow out or become sufficiently worn as to cause a leak, it may be desirable to close the blowout preventer B around the wire line without damaging the same while the leak in the gland packing is repaired. Similarly, should any other type of leak occur in the lubricator connections or fittings, or in the fluid pressure control system, the blowout preventer may be closed to permit the repair thereof to close off the leak while the line is still in place in the well. This may be urgently necessary because of the danger of fire or the like.

In such event, the cut-off valve *v*–**1** may be closed and the vent valve *v*–**2** opened to reduce the well fluid pressure in the passage **101** of the pilot control valve PCV acting on the plunger **136** therein to vent the control fluid pressure in the pipe *p*–**5** and the pressure of the control fluid in the chamber **46** so that the well pressure acting on the differential area of the piston head **36***a* between the O-ring **37** of the piston head and the smaller O-ring seal **45** engaging the actuating sleeve **36,** together with the force of the spring **35,** will move the actuating sleeve upwardly to lift the segments **51, 52** and **53** of the closure **50** into the closed position shown in FIG. **3.** In this closed position the flexible wire line W, shown in FIG. **5,** will be engaged between the adjacent abutting faces of two adjacent segments of the closure assembly **50** and the sealing members **70** on the abutting faces of the adjacent segments will seal around the line, as shown in FIG. **5.**

The metal of the adjacent faces of the segments engages the metal of the wire line to limit further movement of the segments toward abutting position, but the sealing members **70** disposed in the recesses **71** in such faces are deformed into sealing engagement around the wire to prevent leakage of fluid pressure therepast. The

other faces of the segments of the closure will engage each other to provide the usual metal-to-metal seal therebetween and cause the seals **70** to further extrude to seating engagement with the wire line.

After the leak or condition producing the hazardous condition has been cured, the pressure within the lubricator above the blowout preventer may be equalized with that below the closure **50** by closing the vent valve *v*–**2** and then opening the equalizing valve **80,** permitting fluid pressure from below the lubricator closure **50** to pass through the equalizing valve and the passage **81** into the reduced upper bore **56** of the upper body section **25** above the seat **55,** and thence upwardly into the lubricator to produce conditions of equal pressure in the lubricator and the blowout preventer on opposite sides of the closure therein. This pressure will close the ball valve **109** against the force of the spring **120** and will then act on the plunger **136** in the pilot control valve PCV to hold the ball valve **135** on its seat, and permit the equalizing needle valve **170** to be opened to bypass control fluid pressure past the ball check valve **164** to cause it to open and permit control fluid pressure to flow through the pipe *p*–**5** and the control fluid conduit **49** and the passage **47** into the chamber **46** to act on the piston head **36***a* to move the actuator sleeve **36** downwardly and draw the segments of the closure **50** downwardly along the inclined cam surface **40***b* of the guide and support member **40** to the open position. The well servicing operations or wire line operations may then be continued to conclusion, after which the tools may be raised through the blowout preventer and into the lubricator and the master valve of the Christmas tree closed, after which pressure may be released from within the lubricator in the usual manner, as by closing the cut-off valve *v*–**3** and opening the vent valve *v*–**2,** to permit the wire line tools and the lubricator and the blowout preventer to be thereafter removed from the upper end of the Christmas tree.

It will be seen that should the pressure within the control fluid chamber **46** be reduced for any reason, as by intentionally lowering the control fluid pressure, by breakage of the fluid pressure control fluid conductors, or similar reasons, the blowout preventer closure segments will be automatically moved to the closed position, since the spring **35** will bias the actuating sleeve **36** upwardly, as will the pressure of the well fluids acting on the unbalanced area of the piston head **36***a* between the seals **45** and **37.**

It is also believed readily apparent that, should a leak occur in the system of the lubricator or the associated parts thereof, or in the fluid pressure control system FPC, which would produce a reduction in pressure in the lubricator downstream of the blowout preventer, the control fluid pressure acting on the piston head **36***a* would be vented as has been explained and the well pressure acting on the unbalanced area of the piston, together with the spring, would move the actuator sleeve **36** upwardly to move the closure segments to the closed position. Similarly, a sudden increase in pressure in the bore of the blowout preventer creating a differential across the unbalanced area of the piston in excess of the pressure of the control fluid in the chamber **46,** acting with the spring **35,** would likewise move the actuating sleeve upwardly to move the closure segments to closed position.

It is believed readily apparent that the blowout preventer and the fluid pressure control system provides means for operation, from a remote point, of a closure below a lubricator for sealing around a wire line extending through the Christmas tree or well head downwardly into a well flow conductor, which may be actuated immediately in the event of the occurrence of a hazardous condition of any kind to prevent escape of well fluids and the attendant dangers of fire, blowout and the like. In view of the fact that the closure member may be moved to closed position by fluid pressure acting on the unbalanced area of the piston connected with the actuating sleeve, together with the biasing force of the spring, the closure means may be moved to closed position on any occasion in which the pressure of the control fluid is not sufficient to hold the actuating sleeve in the lower position in which the segments of the closure are open. The device is therefore fail-safe and will close off around the wire line, or merely close off the passage through the blowout preventer, upon the occurrence of any such condition.

The foregoing description of the invention is explanatory only, and changes in the details of the construction illustrated may be made by those skilled in the art, within the scope of the appended claims, without departing from the spirit of the invention.

What is claimed and desired to be secured by Letters Patent is:

1. A blowout preventer comprising: a body having a flow passage therethrough; a seat in the body surrounding the passage; closure means in the body movable between open and closed positions; tubular operating means in the flow passage of said housing connected with said closure means and movable in said housing for moving said closure means between open and closed positions; means biasing said operating means for moving said closure means to closed position; fluid pressure actuating means on said operating means and said body operable by control fluid pressure applied thereto for moving said closure means to open position, said biasing means moving said operating means to move said closure means to closed position automatically when control fluid pressure is relieved from said fluid pressure actuating means; means conducting control fluid pressure from a remote separate source of control fluid under pressure to said actuating means for causing movement of said closure means to open position; pilot control valve means communicating with the flow passage of said body on the downstream side of said closure means and with said means conducting control fluid to said actuating means and actuated responsive to a predetermined decrease in pressure in said housing on said downstream side of said closure means to relieve control fluid pressure from application to said actuating means to permit said biasing means to move the operating means to move the closure means to closed position; and check valve means in said means conducting control fluid pressure from said remote source to said actuating means between said remote source and said actuating means operable to cut off escape of control fluid pressure from said remote source when said pilot valve is actuated to relieve application of control fluid pressure to said actuating means.

2. A blowout preventer as set forth in claim **1,** wherein said means for biasing said closure means to closed position includes resilient biasing means in said body flow passage engaging said operating means.

3. A blowout preventer of the character set forth in claim **1** including: means on said operating means ex-

posed to the fluid pressure in the body flow passage upstream of the closure means acting in response to such fluid pressure in cooperation with said resilient biasing means to move said closure means to closed position.

4. A blowout preventer as set forth in claim **1,** wherein said fluid pressure actuating means for moving said operating means for moving said closure means to open position includes piston means on said operating means sealingly slidable longitudinally axially in the flow passage of said body to provide a variable capacity pressure chamber in said body between said body and said piston means, said piston means having a pressure responsive face thereon exposed in said variable capacity pressure chamber of said fluid pressure actuating means; and wherein fluid pressure directed into said variable capacity chamber causes expansion of said chamber and movement of said piston and said operating means axially of the body passage to unseat the closure means upon such expansion of the variable capacity chamber.

5. A blowout preventer comprising: a body having a flow passage therethrough; a seat on the body surrounding the passage; closure means including a plurality of closure segments cooperatively moving together and against said seat to close the passage; said closure segments being also movable apart to an unseated open position in which the segments are disposed laterally of the passage out of engagement with each other and said seat in the passage of the body; a bored tubular operating member connected at one end of said closure segments movable in the body member axially of the body passage for moving said closure segments between open and closed positions and having its bore in communication with the body flow passage; pressure responsive piston means on the other end of said tubular member sealably slidable within the body flow passage to provide a variable capacity control fluid pressure chamber between said body and said piston means; said pressure responsive piston means being operable in response to fluid pressure directed within the variable capacity chamber for moving said tubular operating member and the closure segments to open position; vent port means on the body for venting the variable capacity chamber; spring means in said body passage engaging the piston means end of said tubular operating member biasing said operating member toward position moving said closure segments to closed position upon venting of pressure in said variable capacity chamber; pressure responsive pilot valve means communicating with the vent port means on the body for controlling venting of said chamber; and means for conducting fluid pressure from downstream of the closure means in the body flow passage to said pressure responsive pilot valve means for controlling operation of said pilot valve means, said pilot valve means being moved to a condition venting said chamber in response to a predetermined reduction in pressure from downstream of said closure means; conductor means communicating a remote source of control fluid pressure with said variable capacity chamber in said housing; said pilot valve being connected in flow communication with said conductor means and operable to vent control fluid pressure from said variable capacity chamber; and check valve means connected in said conductor means between said remote source of control fluid pressure and said pilot valve means to cut off flow of control fluid under pressure from said source when said variable capacity chamber is vented by said pilot valve means.

6. A blowout preventer comprising: a body having a longitudinal rectilinear flow passage therethrough; a seat on said body surrounding said passage; valve closure means movable to extend across said seat to close said flow passage through said body when said closure means is in seated position and movable to an unseated position displaced laterally of the passage of the body a sufficient distance to permit longitudinal rectilinear axial flow through the body corresponding to the minimum diameter of the passage therethrough; a variable capacity pressure chamber in said body formed of a cylinder closed at one end and a pressure responsive member having piston means thereon movable in said cylinder in said body and also having means connected with said valve closure means for moving said closure means in said body between seated and unseated position; resilient means in said body flow passage engaging said pressure responsive member biasing said pressure responsive member to a position moving said valve closure means to seated position; conductor means for conducting control fluid pressure from a separate source of such control fluid pressure to said variable capacity pressure chamber to act on said piston means for controlling movement of said pressure responsive member between a position in which said valve closure means are disposed in closed seated position and a position in which said valve closure means are disposed in open unseated position; pressure responsive pilot valve means connected to said conductor means between said source and said pressure chamber for venting control fluid pressure from said chamber; means communicating said pressure responsive pilot valve means with fluid pressure in said body flow passage downstream of said closure means for conducting such fluid pressure to said pilot valve means for actuating said valve means to vent said pressure chamber of control fluid pressure upon the occurrence of a predetermined decrease of fluid pressure downstream of said closure means; said resilient means normally automatically biasing said valve closure means to seated position when said control fluid pressure in said pressure chamber is so vented; and check valve means in said conductor means between said source of control fluid and said pilot valve means operable to prevent loss of control fluid pressure from said source.

7. A blowout preventer comprising: a body having a longitudinal flow passage threrthrough; a downstream tapered valve seat in said body surrounding said passage; a tubular actuator member slidable longitudinally in said body passage upstream of said valve seat and having a longitudinal bore therein aligned with and forming a part of said flow passage; a plurality of equally circumferentially spaced lateral openings in the downstream end of said actuator member; a plurality of valve closure segments equal in number to the lateral openings in the actuator member and each having a connector member projecting from the upstream end thereof and engaged in one of said lateral openings of said actuator member whereby each valve closure segment is swingably connected to the downstream end of said actuator member and movable longitudinally of the body therewith axially and laterally within the body passage in a downstream direction to engage and be cammed laterally by said valve seat into seating engagement therewith to close off the passage through said

body, and movable longitudinally with said actuator member in an upstream direction to an unseated position out of said flow passage to permit unrestricted flow through said flow passage; an annular support member in said body passage and projecting inwardly annularly into said passage into slidable sealing engagement with the exterior of said actuator member; means providing a variable capacity pressure chamber in said body comprising an annular shoulder on said support member facing upstream of said body passage and an external annular piston member on the upstream end of said actuator member projecting into slidable sealing engagement with the wall of said body passage upstream of said supporting member for enclosing therebetween said variable capacity pressure chamber for controlling movement of said actuator member to control opening and closing movement of said valve closure segments thereby; means for conducting control fluid pressure from a separate source of control fluid pressure to said variable chamber to act on said piston member to move said actuator member for moving said closure segments to open position; resilient means in said body passage surrounding said flow passage engaging said actuator member for biasing said actuator member longitudinally of said body toward said tapered valve seat to a position engaging said seat and moving said valve closure segments to closed position; means comprising the upstream ends of said actuator member and said piston member exposed to fluid pressure upstream thereof in said body passage for acting on said actuator member in cooperation with said resilient means for moving said actuator member to move said valve closure segments toward closed seated position in said body; pressure responsive valve means between said source of control fluid pressure and said variable capacity pressure chamber operable to relieve control fluid pressure from said variable capacity pressure chamber and prevent flow of control fluid from said source to said chamber; means communicating with said pressure responsive valve means and with fluid pressure in said body flow passage downstream of said valve closure segments for conducting such fluid pressure to said pressure responsive valve means; said pressure responsive valve means having means responsive to a predetermined decrease in pressure conducted thereto from downstream of said closure means in said body flow passage or to reduction in pressure of control fluid pressure conducted to said variable capacity chamber or a loss of pressure in said means communicating said pressure responsive valve means with fluid pressure in said body flow passage downstream of said valve closure segments to relieve control fluid pressure from said variable capacity chamber to permit said resilient biasing means to move said actuator member to move the valve closure segments to closed position automatically when said control fluid pressure is relieved from said variable capacity pressure chamber.

8. A device of the character set forth in claim **7** including: equalizing bypass passage means communicating with the opposite upstream and downstream sides of said valve closure segments when in closed seated engagement with said valve seat in said body for equalizing pressures on opposite sides thereof; and valve means in said passage means for controlling the flow of pressure fluid through said passage means.

9. A blowout preventer of the character set forth in claim **7**; wherein said valve closure segments each have cooperating abutting surfaces thereon movable to sealing engagement with the cooperating surfaces of each adjacent segment; resilient seal means on the abutting surfaces of each of said segments disposed to engage the seal means on the adjacent abutting surface of the adjacent segments to seal therewith; said abutting surfaces of said segments being disposed to engage a flexible line extending through said blowout preventer passage to limit movement of the segments toward each other to prevent cutting the line; the sealing members on the abutting surfaces engaging each other to seal between the segments around the line to prevent fluid leakage between the segments around the line.

10. A blowout preventer comprising: an elongate body having a longitudinal flow passage therethrough enlarged intermediate its ends to provide a valve and actuator cylinder therein; a seat in said body passage surrounding said passage at one end of said cylinder; actuator means slidable longitudinally in said cylinder of said body passage and comprising: an elongate tubular operating sleeve having a plurality of equally circumferentially spaced openings therein adjacent one end an an external annular piston on its opposite end slidably engageable with the wall of the cylinder, seal means between said piston and said wall of said cylinder; supporting means in said cylinder providing an internal annular head shoulder in said cylinder slidably engageable with the exterior of the tubular operating sleeve of said actuator means; seal means sealing between said internal annular head shoulder and said tubular operating sleeve and forming an expansible and contractable pressure chamber in said valve and actuator cylinder exteriorly of said operating sleeve between the external piston thereon and said internal annular head shoulder; closure means movable in said cylinder in said body passage comprising a plurality of closure segments of identical configuration each having hook means at one of its ends adjacent the operating sleeve and engageable in the openings adjacent said one end of said operator sleeve for hingedly connecting each of said segments to said operator sleeve for movement by said sleeve toward and away from said seat in said body passage; each closure segment also having cooperating complementary abutting surfaces thereon movable to engage and seal with the abutting complementary surfaces of adjacent segments when in closed position; resilient seal means on the abutting complementary surfaces of each of said segments disposed to engage the seal means of adjacent segments and the seat in the body passage when said segments are moved to closed position; helical coil spring means in said actuator cylinder engaging the piston end of said operating sleeve and acting to bias said sleeve for movement thereof in a first direction moving said closure segments into engagement with said seat in said passage; means for conducting control fluid pressure into said expansible and contractible pressure chamber between said external annular piston on said operating sleeve and the internal annular head shoulder of said supporting means for moving said operating sleeve in a second direction against the force of said spring biasing means for moving said operating sleeve to move the closure segments out of engagement with said seat to open the flow passage, said inwardly projecting supporting means in said chamber having cam means thereon engageable with the hook ends of said closure segments to force the same in a direction swinging the hooks into the open-

ings in said operating sleeve and simultaneously swinging the opposite ends of the segments in a direction away from each other to provide unrestricted flow through the passage of the body when control fluid pressure is directed into said pressure chamber between said piston on said operating sleeve and the internal head shoulder in said cylinder; said spring biasing means acting to automatically move said operating sleeve in said first direction toward said seat to move said closure segments to closed position when control fluid pressure is vented from said pressure chamber between the piston and head shoulder; said abutting complementary surfaces of said segments being disposed to engage a flexible line extending through the body flow passage to limit closing movement of the segments engaging said line when said segments are moved to closed position; said resilient seal means on the adjacent surfaces of the segments between which the flexible line is engaged being displaced into sealing engagement with each other to seal between said adjacent surfaces of the segments around the flexible line therebetween and to seal with the seat in the body to close off flow through the body around the flexible line when the closure segments are moved to closed position.

11. A blowout preventer of the character set forth in claim **10** including: means conducting control fluid pressure from a separate source of control fluid under pressure to said expansible and contractible pressure chamber for actuating the operating sleeve to move the closure segments to open position; pressure responsive valve means between said source of control fluid pressure and said pressure chamber operable to relieve control fluid pressure from said pressure chamber and prevent flow of control fluid from said source to said chamber; means communicating with said pressure responsive valve means and with fluid pressure in said body flow passage downstream of said closure segments for conducting such fluid pressure to said pressure responsive valve means; said pressure responsive valve means having means responsive to a predetermined decrease in pressure conducted thereto from downstream of said closure segments in said body flow passage or to reduction in pressure of control fluid pressure conducted to said chamber or a loss of pressure in said means communicating said pressure responsive valve means with fluid pressure in said body flow passage downstream of said closure segments to relieve control fluid pressure from said chamber to permit said resilient spring biasing means to move said operating sleeve to move the closure segments to closed position automatically when said control fluid pressure is relieved from said chamber.

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