Sept. 8, 1970 B. C. MALONE 3,527,296

INFLATABLE SAFETY SHUT-OFF FOR WELL BORES OR OTHER OPENINGS

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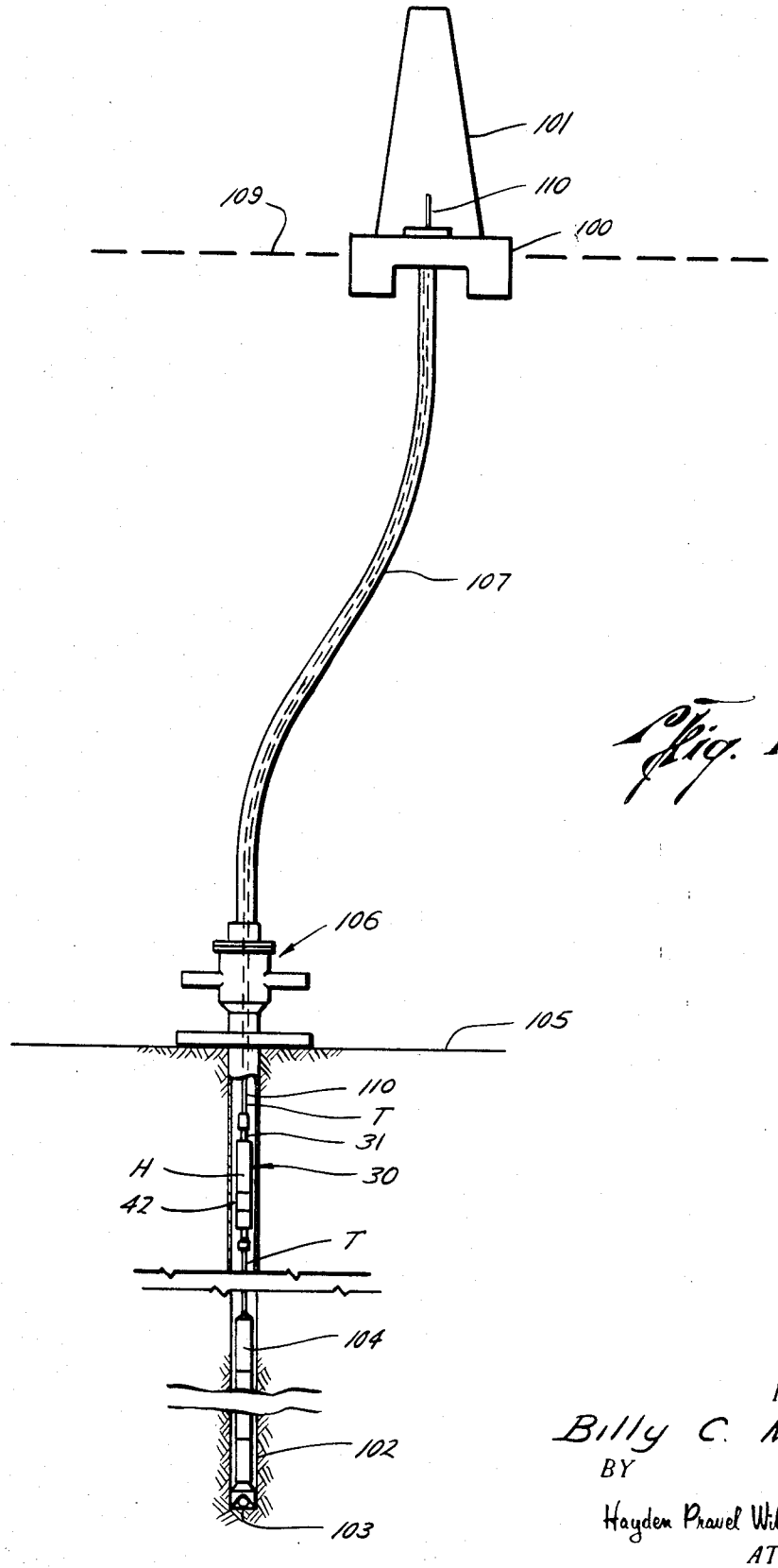

Fig. 1

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Fig. 2

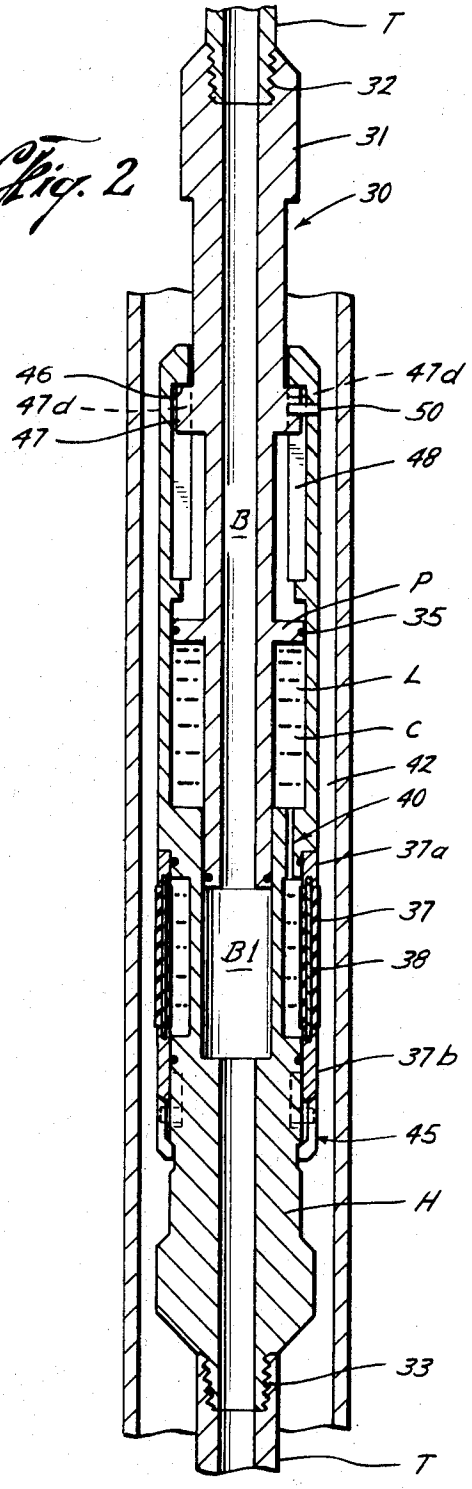

Fig. 3

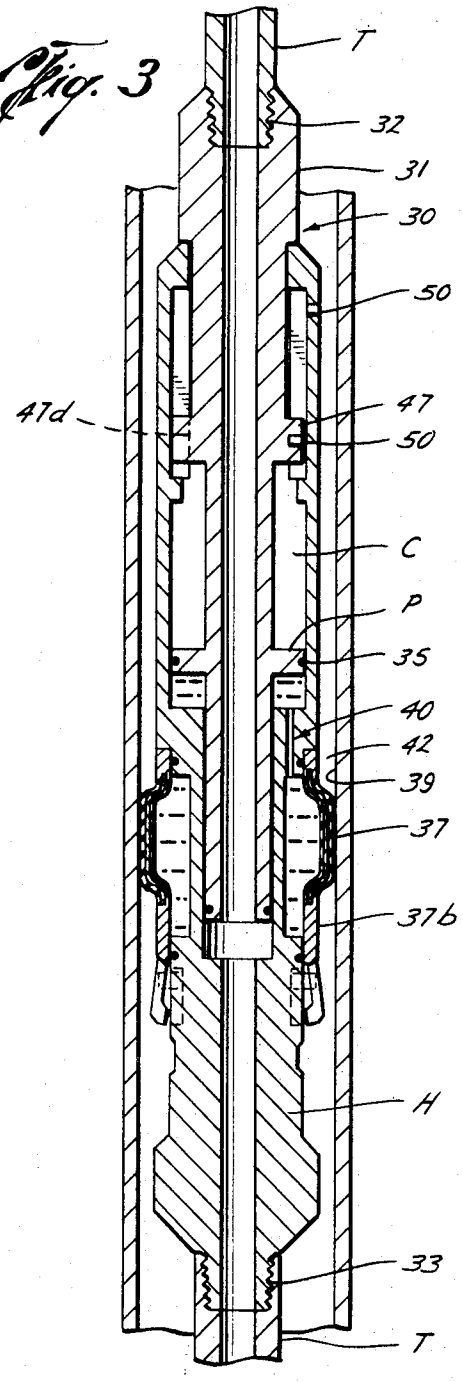

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Fig. 4

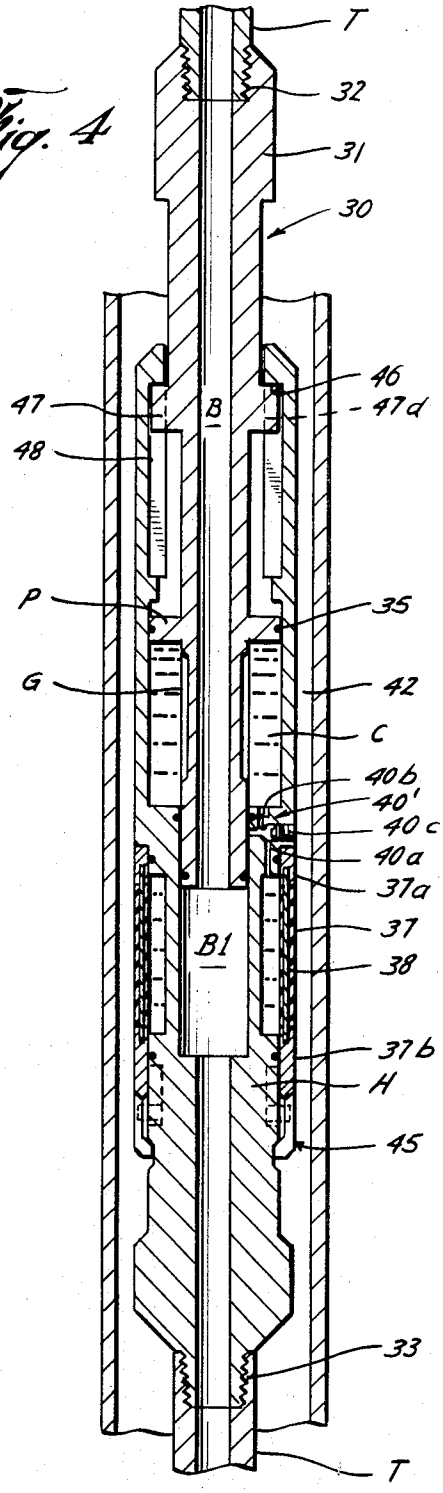

Fig. 5

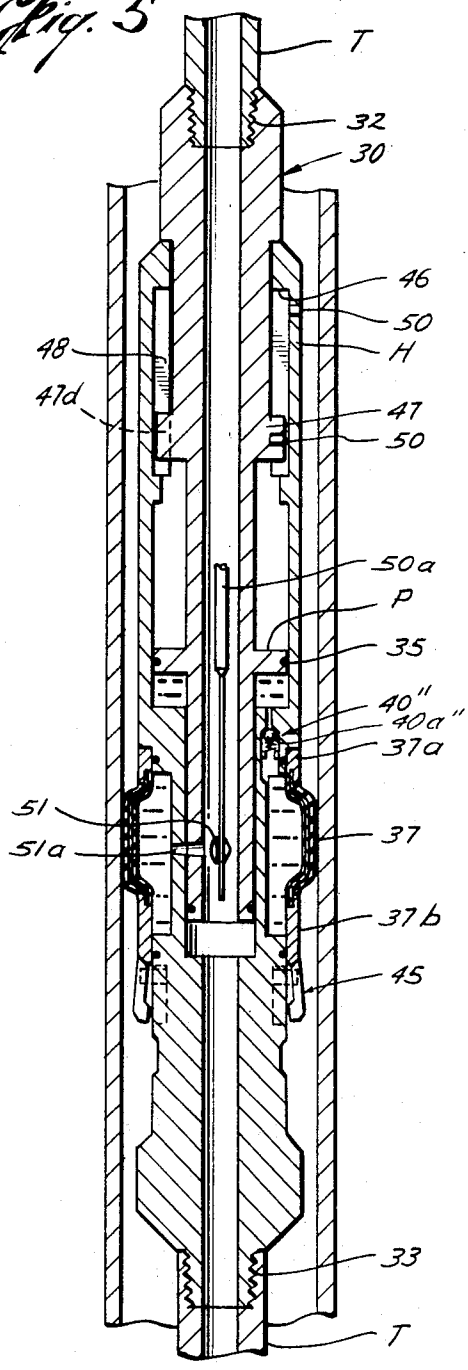

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Fig. 6

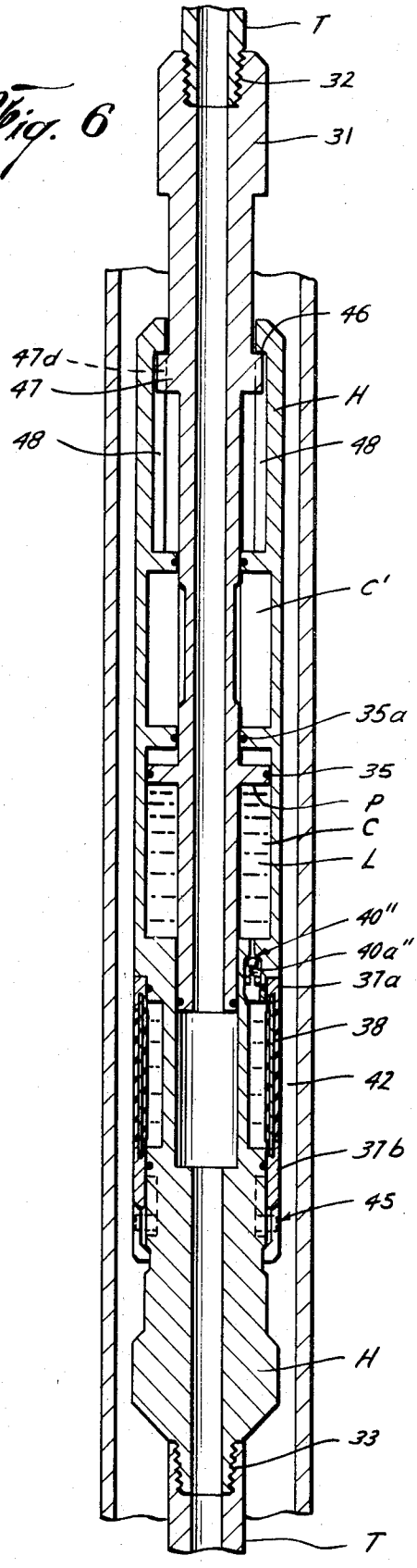


Fig. 9

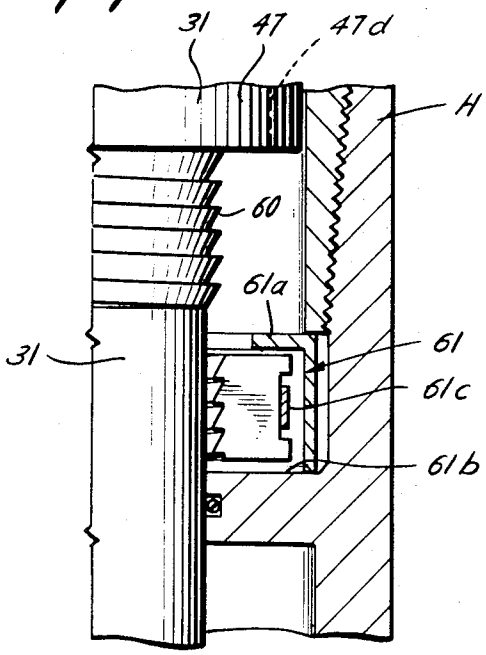
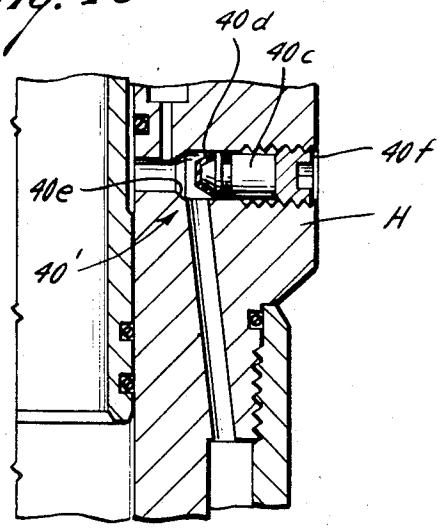


Fig. 10



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INFLATABLE SAFETY SHUT-OFF FOR WELL BORES OR OTHER OPENINGS

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Fig. 7

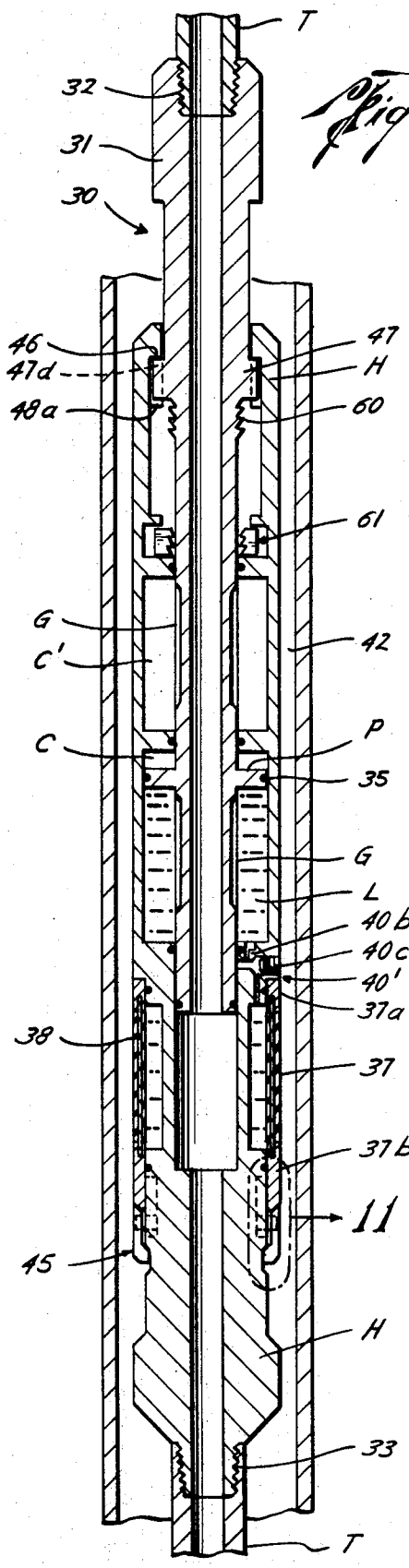
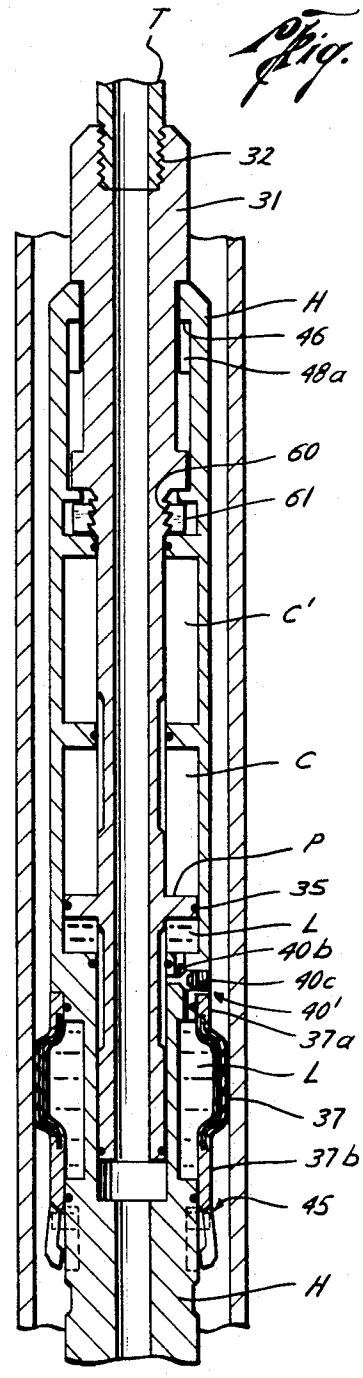


Fig. 8



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INFLATABLE SAFETY SHUT-OFF FOR WELL BORES OR OTHER OPENINGS

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Fig. 11

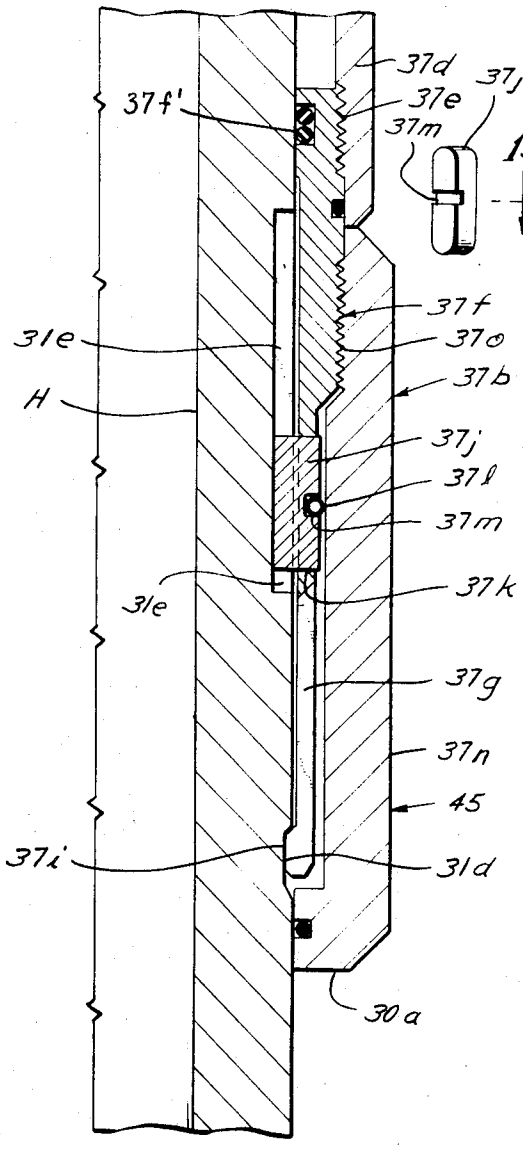
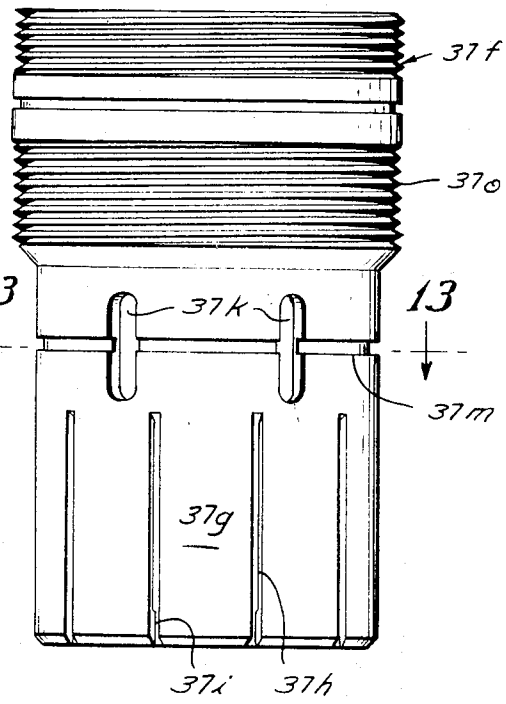


Fig. 12



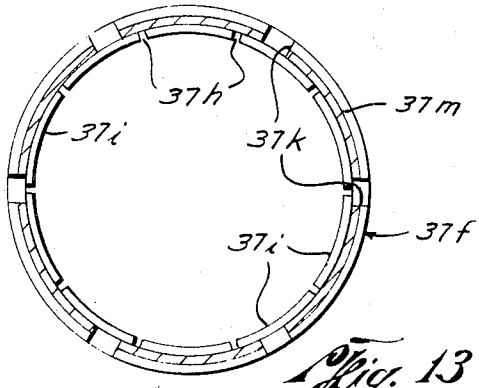


Fig. 13

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INFLATABLE SAFETY SHUT-OFF FOR WELL BORES OR OTHER OPENINGS

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Fig. 14

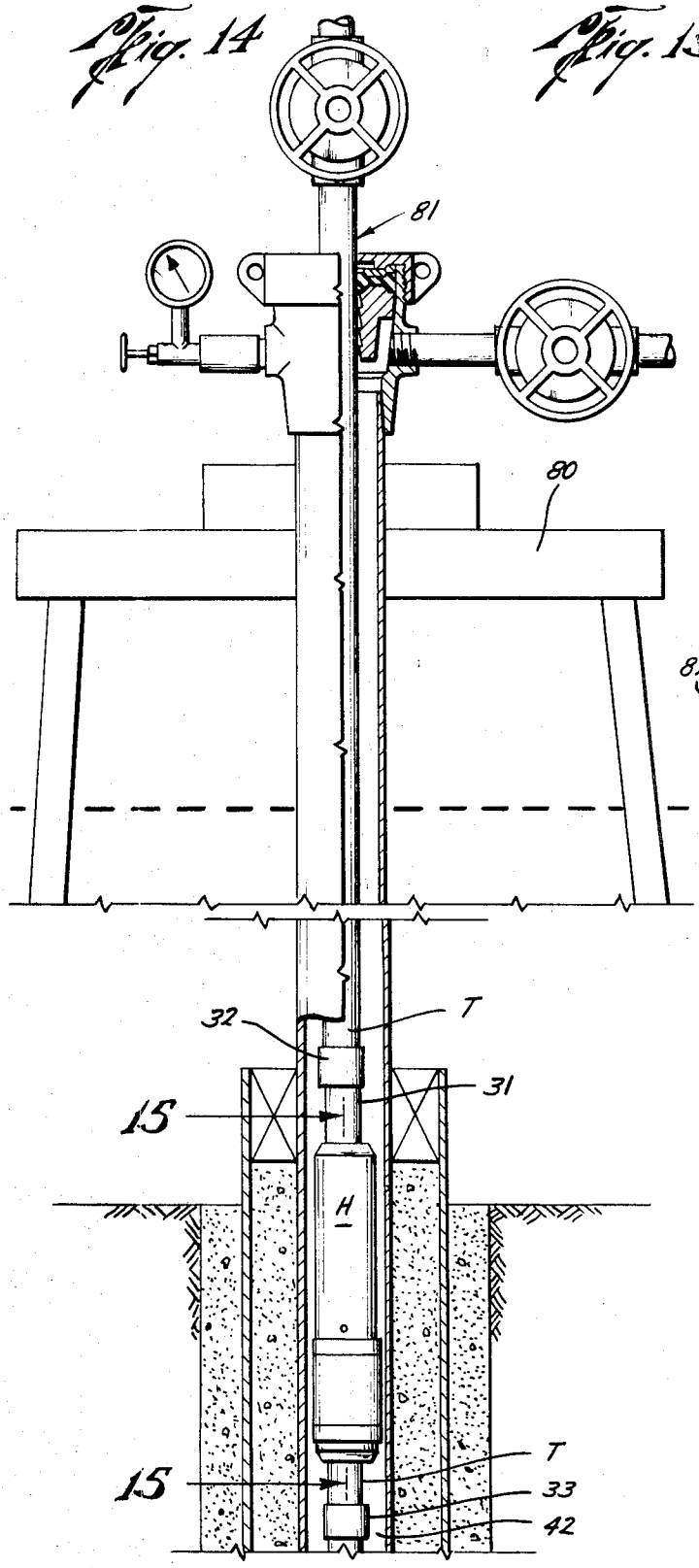
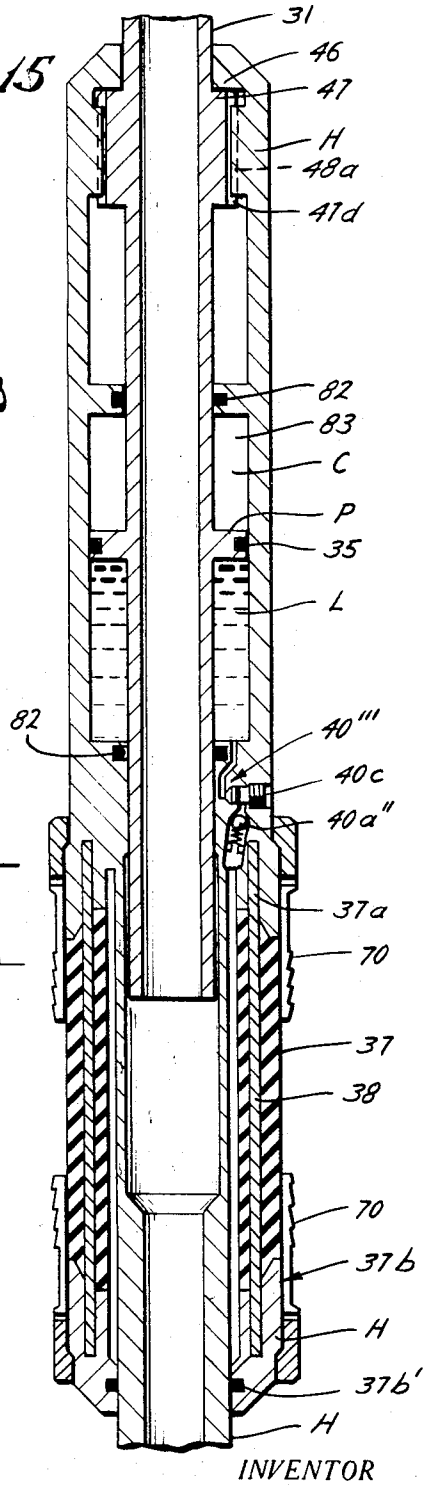


Fig. 15



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INFLATABLE SAFETY SHUT-OFF FOR WELL BORES OR OTHER OPENINGS

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Fig. 16

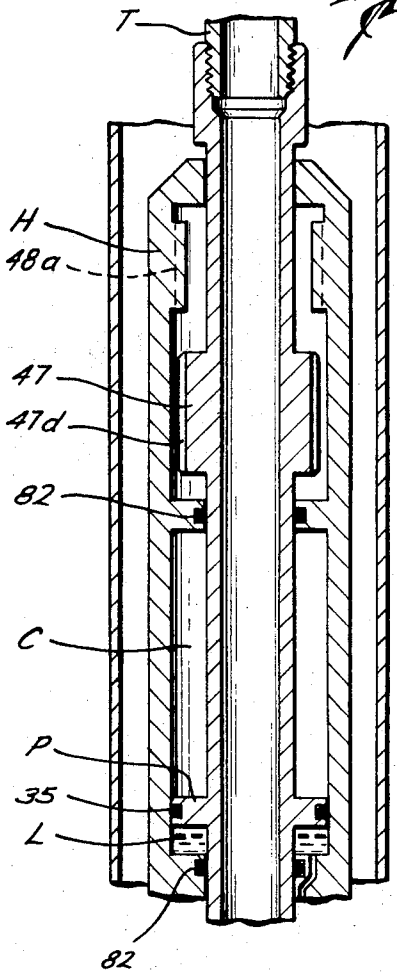
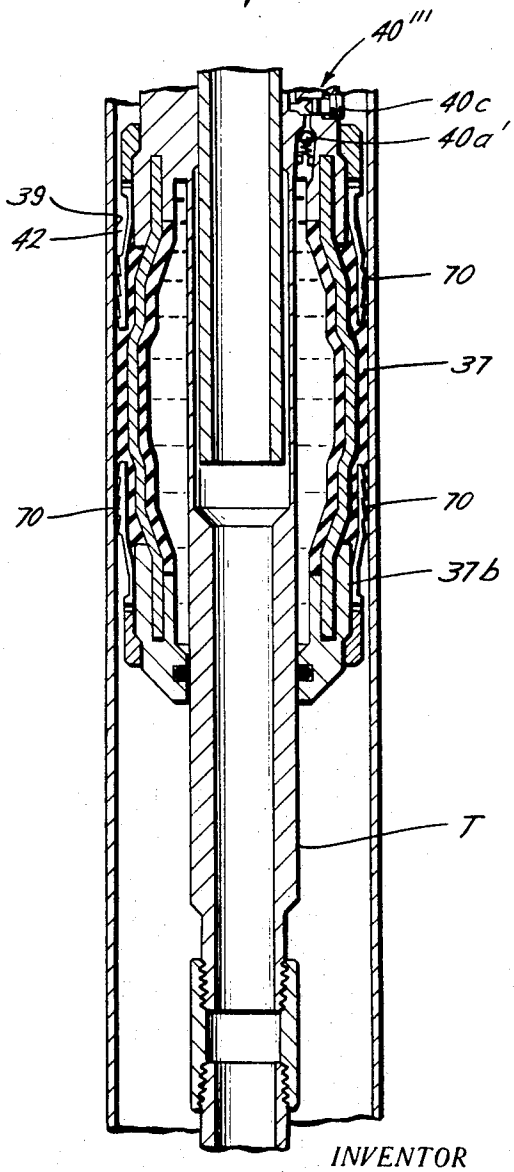


Fig. 17



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United States Patent Office 3,527,296 Patented Sept. 8, 1970

3,527,296

INFLATABLE SAFETY SHUT-OFF FOR WELL BORES OR OTHER OPENINGS

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Filed Sept. 20, 1968, Ser. No. 761,150
Int. Cl. E21b 33/127, 33/129
U.S. Cl. 166—122 27 Claims

ABSTRACT OF THE DISCLOSURE

A tool incorporating a reinforced inflatable element to be carried on a tubular member within a well bore or other opening whereby the reinforced inflatable element can be expanded within the surrounding opening and seal off the opening when either tension is relieved from the tubular member or weight applied to the tubular member to place it under compression.

BACKGROUND OF THE INVENTION

Field of the invention

The present invention relates to a tool for sealing off an opening surrounding a tubular member when tension is relieved from the tubular member or when the tubular member is placed under compression. It may be used in earth-boring operations such as in mining, drilling of oil, gas or water wells, or where an opening is being drilled in the earth. It also has application to a tubular member which is positioned in a previously drilled or bored opening in the earth for sealing off the opening with a reinforced inflatable element. The invention includes a mandrel having means at one end for connection with the tubular member. A reinforced inflatable element is carried by a housing, which housing is, in turn, supported by the mandrel and has means at one end for connection with the tubular member. A piston is formed on the mandrel and carried in a chamber formed in the housing. The chamber is adapted to be filled with liquid and the tool incorporates passage means for conducting liquid from the chamber to the inflatable element when the piston moves within the chamber upon relative longitudinal movement between the mandrel and housing to force liquid from the chamber and into the reinforced inflatable element to expand it and seal off an opening.

Description of the prior art

Although there may be prior art, applicant is not aware of any device as contemplated by the present invention for sealing off an opening.

SUMMARY OF THE INVENTION

The present invention has many applications, several of which are described herein. For example, while drilling a well, particularly in a water-covered area, it can be appreciated that the platform or barge or other support means for the drilling means may be located several hundred or several thousand feet above the surface of the earth in which the hole is being drilled or bored. In some situations it may be desirable to temporarily disconnect the drill pipe which extends from the surface of the water-covered area from the drilling barge without retrieving or removing all of the drill string from the opening in the earth. The present invention enables this to be accomplished in that when the pipe is so disconnected, the inflatable element will expand and seal off with the surrounding wall of the opening to prevent entry of water into the well bore and at the same time prevent egress of fluids from the well bore. Also, the element can be constructed to retain and support that portion of the drill string or other tubular member which is within

the opening, thus eliminating the removal of the drill string or tubular member from the opening in the earth.

In other situations the drilling platform structure, or vessel may be unintentionally moved by wave action, by contact with moving vessels, or by reason of storms. In such event, the drill pipe and the conductor or riser pipe extending from the support structure to the earth's surface in the water-covered area may become severed and the present invention upon such occurrence seals the opening in the earth. It may also serve to retain and support the pipe in the opening in the earth so that it can be reconnected after such disruption has occurred.

Similarly, in producing oil, gas or water wells, the anchor or support at the wellhead and the production tubular member or members carried thereby may become separated, or, the tubular members may corkscrew or move upwardly under pressure. In such event, the present invention will seal off between the well bore and the tubular member or members. Also, the inflatable element can be provided with means such as slips to catch and hold the tubular member within the casing or well bore in which it extends.

It can be appreciated that in like manner the invention has application in other fields such as mining, or in any situation where an opening is bored, or is being bored, or drilled in the earth's surface and a tubular member positioned therein either during or after the opening has been formed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic representation illustrating the present invention being used in connection with an off-shore drilling operation;

FIG. 2 is a diagrammatic, sectional view, partly in elevation, showing one form of the tool and showing it connected in a tubular member that is positioned in a cased opening;

FIG. 3 is a view similar to FIG. 2 but illustrating the form of the invention shown in FIG. 2 after it has been actuated so that the reinforced inflatable element is expanded to seal off the opening;

FIG. 4 is a diagrammatic, sectional view illustrating another form of the invention connected in a tubular member that is positioned in a cased opening;

FIG. 5 is a diagrammatic, sectional view of another form of the invention and showing the relationship of the components of the tool after it has been actuated to seal off an opening and diagrammatically illustrating one means for releasing liquid from the reinforced inflatable element so that the inflatable element may disengage from the wall of the opening;

FIG. 6 is a diagrammatic, sectional view illustrating still another form of the invention;

FIG. 7 is a diagrammatic, sectional view illustrating still another embodiment of the present invention;

FIG. 8 is a diagrammatic, sectional view illustrating the relationship of the components of the present invention shown in FIG. 7 after it has been actuated;

FIG. 9 is an enlarged sectional view partly in elevation to illustrate the lock means on the mandrel and housing shown in FIGS. 7 and 8 just prior to their engagement;

FIG. 10 is an enlarged sectional view showing one form of the passage means in the tool and the plug valve which is externally accessible;

FIG. 11 is an enlarged sectional view showing an arrangement for accommodating realtive longitudinal movement between one end of the reinforced inflatable element and the housing as well as a form of releasable latch means to prevent premature movement or wadding of the inflatable element, such figure being an enlargement of the means which is circled in FIG. 7 and identified by FIG. 11;

FIG. 12 is an eleavtion of a part of the releasable latch means as well as showing an exploded view of the lug means which is carried between one end of the reinforced inflatable element and housing. The lug means which fits within keyways formed in the housing accommodates relative longitudinal movement therebetween while preventing realtive rotational movement therebetween;

FIG. 13 is a sectional view on the line **13—13** of FIG. 12 illustrating further details of the means which accommodates relative longitudinal movement between one end of the packer and the housing while preventing realtive rotation therebetween;

FIG. **14** diagrammatically illustrates the present invention positioned in a production string;

FIG. 15 is a diagrammatic, sectional view illustrating a form of the inevntion when it is used with a production string as illustrated in FIG. 14;

FIG. 16 is an enlarged sectional view illustrating the relationship of the components of the upper portion of the tool of FIG. 15 after it has been actuated; and,

FIG. 17 is an enlarged section view which is a continuation of the tool shown in FIG. 16 and illustrates the reinforced inflatable element of FIG. 15 in expanded and locked position with the surrounding casing.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 2, the tool is represented generally by the numeral **30** and is shown in this form as including the mandrel **31** which is provided at its upper end with threads **32** or other suitable means for connection with the tubular member T. It will be noted that the tubular member T as well as the mandrel **31** is provided with an internal, longitudinal bore which communicate with each other.

A housing H is carried by the mandrel **31** and in cooperation with a portion of the mandrel **31** which is telescopically received within the housing forms a chamber C therein for receiving liquid designated by the letter L.

The lower end of the housing H is provided with suitable means such as threads **33** for connection with the portion of the tubular member T which extends therebeneath. Thus, the invention **30** is connected in and forms a part of the tubular member T. It will be noted that the internal bore which extends through the mandrel **31** designated by the letter B also communicates with the internal bore B_1 extending through the housing H. A piston P is formed or carried on the mandrel **31** and is provided with a suitable seal as illustrated at **35** for sealingly engaging the outer wall of the chamber C.

The housing H supports and carries a reinforced inflabable element **37**, the reinforcing being diagrammatically represented at **38** and comprises an annular sheath which is suitably impregnated with an elastomeric compound that is yieldable when the piston P moves downwardly within the chamber C to force the liquid designated at L therein through the passage **40** formed in the tool and into the reinforced inflatable element **37** to expand it to engage the wall **39** of the well bore or opening **42** which surrounds the tool and the reinforced inflatable element as illustrated in FIG. 3.

It will be noted that the upper end **37***a* of the reinforced inflatable element is secured to the housing H while the lower end thereof represented generally by the number **37***b* is arranged so that it may move longitudinally realtive to the housing H to accommodate radial expansion of the reinforced element **37** and the element **37** is also mounted on the housing H to prevent relative rotational movement therebetween, should the tubular member T be rotated during boring or drilling opeartions. However, the lower end **37***b* and the housing H may move longitudinally realtive to each other to accommodate the expansion of the infiatable element **37**.

Additionally, releasable latch means represented generally by the numeral **45** inhibit premature release or

wadding of the inflatable element **37** should any portion of the lower end **37***b* of the reinforced element **37** strike a ledge or projection as it is moved downwardly within the opening **42** either during drilling or boring operations, or as it is being positioned within the opening **42**.

In the form of the invention shown in FIGS. 2 and 3, the housing H is provided with a shoulder as shown at **46** which rests on the upper end of the annular enlarged potrion **47** formed on the tubular member T. The portion **47** is provided with grooves longitudinally thereof, shown at **47***d* in dotted line. Longitudinally extending keys **48** formed on the housing H as shown fit within the grooves **47***d*. This arrangement accommodates relative longitudinal movement between the mandrel **31** and housing H while preventing relative rotation therebetween.

The housing H and the tubular member T may be rotated and will retain the relationship shown in FIG. 2 of the drawings until something occurs which either applies compression to the tubular member T or relieves tension on the tubular member T so that the means which connect and lock the tubular member T and housing H together are released. In the form of the invention shown in FIGS. 2 and 3 a locking means is shown as being in the form of a shear pin **50**, and when tension is relieved from the tubular member T or compression applied thereto to overcome the shear strength of the pin **50**, it will shear, thus enabling the tubular member T to move downwardly and assume the position as shown in FIG. 3 of the drawings. When this occurs, relative longitudinal movement between the housing H and mandrel **31** will move piston **35** in chamber C to force liquid L through passage means **40** in the tool which communicates chamber C with inflatable element **37**. Also relative longitudinal movement between the lower end **37***b* of the reinforced inflatable element **37** and the housing H will occur to accommodate expansion of the reinforced inflatable element **37** and sealing of the annulus, or opening **42**.

The construction of the invention as shown in FIGS. 4 and 5 is generally similar to that shown in FIGS. 2 and 3 with several modifications. Again, the tubular member is represented by the letter T and the mandrel of the tool **30** by the numeral **31**. The tubular member T is connected with the mandrel **31** at its upper end by suitable means such as threads **32** or the like and the bore of the tubular member communicates with mandrel bore B and also communicates with the bore B_1 extending through the housing H. As in FIGS. 2 and 3, the bore B communicates with the bore in the housing H and in tubular member T below the tool **30**. The housing H is connected by suitable means such as the threads **33** at the lower end of the housing to the tubular member T. The piston P on mandrel **31** is arranged within the chamber C formed between the housing H and a portion of the mandrel which extends into the housing H, and as in FIGS. 2 and 3, the housing H and mandrel **31** cooperate to define an annular, ring-shaped chamber C for receiving a liquid designated at L therein. A seal **35** is provided on the piston P for sealingly engaging with the outer periphery of the chamber C as the piston P moves downwardly therein.

It will be noted that the shoulder **46** is again formed on the housing which engages the annular enlarged portion **47** formed on the mandrel **31**. Grooves **47***d* extend longitudinally of portion **47** and are circumferentially spaced thereabout. Engaged within the grooves **47***d* are longitudinally extending keys **48** that are, in turn, circumferentially arranged and circumferentially spaced within a portion of the housing to thereby accommodate relative longitudinal movement between the mandrel **31** and housing H and at the same time preventing relative rotational movement therebetween. Again, releasable latch means **45** is provided adjacent the lower movable end **37***b* of the reinforced inflatable element **37** which is secured at its upper end **37***a* to the housing H as previously described with regard to the FIGS. 2 and 3 modification.

The passage means in the tool in the FIGS. 4 and 5 modification is referred to by the numerals **40'** and **40''** respectively. The passage means **40'** includes the generally T-shaped passage **40*a***. One side of the T extends outwardly through the housing to receive a plug valve **40*c***, as will be described. The other side of the T extends inwardly through the housing H. The restricted passage **40*b*** communicates passage **40*a*** at the top of the T with the liquid filled chamber C when valve **40*c*** is unseated. The restricted passage **40*b*** functions as a dash pot and restricts movement of liquid L from chamber C when the tool is actuated so as to delay expansion of the reinforced inflatable element **37**.

In the FIG. 4 form of the invention, it will be noted that there is no shear pin restraining or locking the housing H and the mandrel **31** together and when tension is released from the tubular member, or compression applied thereto, the piston P begins to move downwardly within the chamber C, but the restricted passage **40*b*** will restrict the flow of liquid from the chamber C so there will be some delaying action insofar as radial expansion of the reinforced inflatable element **37** is concerned until the longitudinally extending and circumferentially spaced grooves designated by G formed in the mandrel wall and which extend within the chamber C, but are spaced from each end of the chamber as shown in FIG. 4 of the drawings, communicate with the passage **40*a***. After the mandrel **31** has moved down so that the grooves G therein are in communication with the passage **40*a***, the liquid from the chamber C is supplied in a greater quantity so that the reinforced inflatable element then moves outwardly to seal the opening **42**.

In the form of the invention shown in FIG. 5, it is similar to that shown in FIG. 4 with the exception that a shear pin **50** is provided to initially lock the housing H and tubular member T together against movement and passage means **40''** is provided with a check valve means **40*a''***. Thus, when tension is relieved from the tubular member T or compression applied thereto, so as to move the piston P downwardly within the chamber C, the liquid is locked within the reinforced inflatable element **37** and the tool cannot be released until some means for egress of the liquid L from the reinforced inflatable element can be accomplished.

This may be accomplished by any suitable means such as lowering a cable designated at **50*a*** into the tool and positioning an explosive charge designated at **51** adjacent the reinforced inflatable element **37** to perforate the mandrel wall and the wall of the housing as shown at **51*a*** whereupon the liquid L which is trapped within the reinforced inflatable element **37** may escape through the mandrel bore, housing bore and tubular member T.

Attention is now directed to FIG. 6 of the drawings wherein the tubular member is again represented by the letter T and the mandrel by the numeral **31** and the housing by the letter H. The shoulder **46** on the housing H rests on the annular enlarged portion **47** on the mandrel **31**. Grooves **47*d*** extend longitudinally of and are circumferentially spaced, in which fit the radially projecting and circumferentially spaced longitudinal keys of **48** on the housing H. The mandrel **31** is again connected at its upper end by suitable means such as threads **32** to the tubular member T and the housing H is connected at its lower end by any suitable means such as threads **33** to the portion of the tubular member T which extends beneath the tool.

A chamber C for receiving liquid L is formed between the housing and the mandrel, as previously described, and a piston P having a seal means **35** is mounted on the mandrel and positioned within the liquid chamber C as shown in the drawings.

An additional chamber formed between the housing H and the mandrel **31** is referred to as C'. The chamber C' is adapted to receive a gas under pressure, preferably an inert gas such as nitrogen. The passage means in the tool from the liquid chamber C to the inflatable element **37** is designated by the number **40''** and is similar in construction to that shown in FIG. 5 in that it includes a one-way check valve **40*a''***. The reinforced inflatable element **37** is secured at its upper end **37*a*** to the housing H and its lower end **37*b*** is constructed and arranged so that longitudinal movement between the housing H and the lower end of the reinforced inflatable element will accommodate radial expansion of the reinforced inflatable element.

In the modification shown in FIG. 6 when tension is relieved from the tubular member T or compression applied thereto, the piston P is moved down within the chamber C. It will be noted that seal means **35*a*** are provided for sealing off around the mandrel **31** and between the chambers C and C' and that grooves G are formed on the mandrel **31** portion which extends longitudinally within the chamber C' but are spaced from each end thereof. This serves as a delaying action in communicating the nitrogen gas from chamber C' to one side of the piston P and thereby force it down; however, after the grooves G have moved beyond the seal **35*a*** nitrogen gas from chamber C' is communicated freely to chamber C to act against one side of the piston P and force the liquid on the other side thereof through the passage means **40''** and into the interior of the reinforced inflatable element **37** carried by the housing.

When it is desired to release the seal between the reinforced inflatable element **37** and the wall of the opening **42**, a charge may be lowered through the tool as described with regard to FIG. 5 and an opening formed in the mandrel and in a portion of the housing adjacent the reinforced inflatable element to enable the liquid to escape from the element **37** into the mandrel **31**. Each of the forms shown in FIGS. 4, 5 and 6 employ a releasable latch means **45** and each form provides an arrangement as will be described, to enable the lower end of the inflatable element **37** and housing H to move longitudinally relative to each other while preventing relative rotational movement.

In the modification of the invention shown in FIGS. 7 and 8, the mandrel **31** is again connected at its upper end to the tubular member T by suitable means such as threads **32**. The housing H is connected at its lower end by suitable means such as threads **33** to the tubular member T. However, in this form of the invention, it will be noted that the arrangement of the longitudinal keys in the upper end of the housing H is somewhat different and also a different means for holding the tubular member T and housing H in locked position after the reinforced inflatable element has expanded is provided. For example, the radially projecting enlarged portion **47** abuts the shoulder **46** of the housing, and circumferentially arranged keys **48*a*** are provided on the housing which interfit with grooves **47*d*** in portion **47**, it being noted that the keys **48*a*** extend for only a relatively short distance within the housing H as compared with the previous forms of keys in the housing H. Thus, when the mandrel **31** and housing H are in the position shown in FIG. 7, relative longitudinal movement may occur therebetween, but no relative rotational movement. When the keys **48*a*** and grooves **47*d*** are disengaged, as shown in FIG. 8, they may be rotated relative to each other as the element **37** holds housing H stationary as mandrel **31** is rotated.

In order to lock the mandrel **31** and housing H together after the piston P has moved within the chamber C to force the liquid therein into the reinforced inflatable element **37** and expand it as shown in FIG. 8, a buttress threaded area referred to at **60** is provided on the mandrel which is adapted to engage with the segmented nut **61** carried by the housing H and lock the mandrel **31** and the housing H together until rotation is applied to the tubular member T and connected mandrel **31** to disengage them, as previously described.

It will be noted in this form of the invention that the chamber C' and the chamber C are both again provided

as described with regard to the FIG. 6 modification; however, in the FIG. 7 modification grooves G are formed on the mandrel within each of the chambers C and C' and extend longitudinally thereof, but are spaced from the end of the chambers to aid in delaying the passage of nitrogen from the end of chamber C' to act on one side of the piston P and to initially delay full flow of liquid to the inflatable element **37**. Also, a restriction **40***b* is provided in the passage means **40'** in the tool between the liquid chamber C and the interior of the reinforced inflatable element to further aid in initially retarding the radial expansion of the reinforced inflatable element, or to act as a "dash pot" so that release of liquid from chamber C to the reinforced inflatable element **37** will not be instantaneous when tension is removed from the tubular member T or when compression is applied thereto. This form of passage means is similar to that shown in FIG. 4. In the form of the invention shown in FIGS. 7 and 8, the upper end **37***a* of the reinforced inflatable element **37** is secured to the housing H and the lower end **37***b* is movable relative to the housing. The releasable latch means **45**, as previously described is also provided, as is an arrangement to accommodate relative longitudinal movement between the one end of the element **37** and housing H, while preventing relative rotation therebetween.

Attention is directed to FIG. 9 wherein further details of the buttress thread **60** are shown. The mandrel is again represented by the numeral **31** and the buttress thread arrangement is shown in enlarged detail at **60**. The segmented nut **61** is retained within the housing by the shoulders **61***a* and **61***b* and is urged radially inwardly by the spring **61***c* which surrounds the segmented nut **61** so that when the threaded surface **60** on the mandrel **31** moves downwardly into engagement with the segmented buttress-threaded nut **61**, it will be locked together.

In FIG. 10 reference is directed to the enlarged detail of the passage means referred to by the numeral **40'** of FIGS. 4, 7 and 8, the housing being represented by the letter H and an externally accessible plug valve by the numeral **40***c* which is threadedly connected in a passage which is part of the passage means **40'**.

The plug valve **40***c* is provided with suitable means such as rubber or the like at **40***d* on its nose for seating on the seat **40***e* formed within the passage means **40'** to close off the passage means.

Additionally, suitable means such as the Allen locknut **40***f* may be positioned rearwardly of the plug **40***c* and formed integrally therewith so that the plug valve **40***c* may be moved towards and away from the seat **40***e*. The plug valve **40***c* will normally be positioned inwardly on the seat **40***e* until shortly prior to the time that the tool is positioned within the tubular member. If desired, the plug valve arrangement may be incorporated in the other forms of passage means shown in the drawings.

Attention is now directed to FIGS. 11, 12 and 13 which illustrate the details of one form of the lower end of the reinforced inflatable element heretofore referred to by the numeral **37***b*, and the releasable latch means **45**. A skirt **37***d* is connected to, and extends downwardly from the reinforced inflatable element **37** (not shown), and is internally threaded as illustrated at **37***e*. Threadedly engaged with the threads **37***e* is the collar **37***f*, the lower end of which forms the spring fingers **37***g*. Suitable seal means **37***f'* are provided for sealing between the housing H and collar **37***f* of the lower packer end which surrounds the housing. The spring fingers **37***g* are provided in the collar **37***f* by forming longitudinally extending and radially spaced slots **37***h* therein and providing an enlargement **37***i* which fits within the annular recess **31***d* formed on the surounding housing. This arrangement provides releasable latch means between the lower end **37***b* of the reinforced inflatable element **37** and the housing H until a predetermined amount of pressure is exerted to spring the fingers **37***g* out of the annular recess **31***d* to enable the reinforced inflatable element **37** to radially expand and seal with the wall of the surounding opening.

Additional means are provided to accommodate relative longitudinal movement of the lower end **37***b* of the inflatable element **37** and the housing H, while preventing relative rotation between the housing H and lower end **37***b* of the element, such means being shown as lugs **37***j* which are received within the openings **37***k* formed in the collar **37***f*. A plurality of longitudinally extending keyways **31***e* are provided at circumferentially spaced intervals within the housing H within which the lugs **37***j* slide, and the lugs **37***j* move upwardly as the inflatable element **37** radially expands. It can be appreciated that since the skirt **37***d* is connected to the collar **37***f* and that the lugs are, in turn, carried in the openings **37***k* of the collar **37***f*, when the inflatable element radially expands, the lugs **37***j* move upwardly.

In assembling the skirt **37***d*, collar **37***f* and lugs **37***j*, the collar **37***f* and skirt **37***d* will be threadedly engaged by means of threads **37***e*. Thereafter slight relative rotation of the collar **37***f* can be effected so as to align at least several of the openings **37***k* with the keyways **31***e* in the housing H to enable the lugs **37***j* to be dropped therein. Thereafter, suitable spring means as illustrated at **371** can be positioned in the recess **37***m* formed in the collar and in the lugs to aid in retaining them in position.

Thereafter the retaining collar **37***n* can be threadedly secured by means of the threads **37***o* on the collar **37***f*. Suitable seals are provided as illustrated to prevent leakage of fluid from the element **37**.

From the above description, it can be appreciated that this arrangement enables the lower end **37***b* of the reinforced inflatable element **37** and the housing H to move relative to each other longitudinally while preventing relative rotation. Similarly, the arrangement of the projections **37***i* and cooperating recess **31***d* prevent premature actuation or radial movement of the reinforced inflatable element **37** should the lower radially projecting portion of the tool **30***a* strike a ledge or some other projection which might tend to wad the lower end of the packer.

Attention is now directed to FIGS. 15, 16 and 17 of the drawings wherein a form of the invention is illustrated that may be used, for example, with a production string in an oil, gas or water well. In this form of the invention, the tubular member T is again shown as connected to the mandrel **31** in FIG. 14 by suitable means such as the threaded coupling **32**. The mandrel **31** is again telescopically received within the housing H and the shoulder **46** of the housing H rests on enlarged portion **47** of the mandrel. Grooves **47***d* in the portion **47** and keys **48***a* on housing H prevent relative rotation when they are engaged in the position shown in FIG. 15, as is true with the form shown in FIG. 7. The housing H and the mandrel **31** form a chamber C for receiving liquid L therein as previously described with regard to the other forms of the invention. A piston P is formed on the mandrel **31** within the chamber C and is provided with seal means **35** as previously described for engaging the annular wall of the chamber C as it moves downwardly to force liquid through the passage means designated generally by the numeral **40'''**. Again, the bore of the tubular member above the tool or invention **30** communicates with the bore of the mandrel within the housing and with the bore of the housing. The bore of the housing in turn communicates with the bore of the tubular member T connected thereto by suitable means such as the threaded coupling **33** shown in FIG. 14. The passage conducting means between the chamber C includes the plug valve **40C** previously described in detail with regard to FIG. 10 as well as the one-way check valve **40***a''* so that when liquid has been conducted from the chamber C into the reinforced inflatable element **37**, the mandrel **31** and housing H will be retained in locked position, and the inflatable element expanded to seal against the wall of the surounding opening.

If desired, the buttress thread arrangement described with regard to FIGS. 8 and 9 may be used in lieu of the one-way check valve in this modification of the invention.

The annular reinforcing sheath **38** is shown in the inflatable element **37**, and it will be noted that the lower end **37***b* of the reinforced inflatable element does not incorporate the releasable latch means **45** or the means to prevent relative rotation between the housing H and lower element end **37***b* described with regard to the other forms of the invention. The upper end **37***a* of the inflatable element is secured to the housing and lower end **37***b* is movable relative thereto, to accommodate expansion of the inflatable element **37**. A seal **37***b'* between the lower end **37***b* of the element and housing H prevents the escape of liquid as the element expands.

In this form of the invention gas under pressure is placed in the portion of the chamber C represented at **83** on the top side of the piston P. Seals **82** between the mandrel **31** and housing H prevent escape of the gas and liquid from the chamber C.

FIGS. 16 and 17 show the upper part of the tool shown in FIG. 15 and the lower part respectively after it has been actuated.

It will be noted that in this form of the invention the annular reinforced inflatable element **37** is provided with a plurality of circumferentially arranged slip segments **70** at each end of the reinforced inflatable element which are adapted to expand as the element expands and where the reinforced inflatable element and tool are used within a pipe or other conduit, they will serve to grip or engage the walls thereof and aid in retaining or locking it in position.

The form of the invention described in FIGS. 15 through 17 can be employed quite satisfactorily in connection with a tubular member T where the tubular member T is a production string of an oil, gas or water well. For example, a platform **80** is represented as being positioned in a water-covered area, and the wellhead, or Christmas tree as it is commonly referred to, designated generally by the numeral **81**. The tubular member T is anchored in the wellhead by any suitable means and it can be appreciated that in some instances the wellhead might be knocked off or otherwise disconnected from the production string, in which event the weight of the tubular member T above the invention **30** would be relieved, thereby enabling the compressed gas in the portion **83** of chamber C to expand and to act on the upper end of the piston P to move it down in chamber C and thereby force the liquid L through the passage means **40'''** to radially expand the inflatable element **37**. Of course, as previously mentioned, the plug valve **40***c* is normally retained in closed position until the tool is inserted in the well string at which time it is opened to open the passage means **40'''** to enable communication of liquid L to the interior of the inflatable element **37** when tension is relieved from or compression applied to the tubular member T. In some instances, the pressure in the annulus **42** below the tool **30** connected in the production string or strings T may be subjected to pressure to cause it to corkscrew, or move upwardly. When this occurs, the tool **30** would be actuated, if sufficient force were involved to disconnect the wellhead and production string and thereby relieve the tension in the production string to actuate the tool as previously described.

The one-way check valve will lock the liquid within the inflatable element **37** and at the same time the slips **70** will set against the surrounding pipe, normally referred to as casing in oil or gas well terminology.

It can be appreciated that this arrangement seals off the annulus or opening of the well bore to inhibit the passage of any liquids in a water-covered area into the annulus and at the same time prevent escape of fluids from the annulus and into the surrounding water.

By suitable means well known in the art, the tubular member T could again be located, and a charge as described with regard to the modification shown in FIG. 5 be lowered thereinto to enable the liquid to escape from the inflatable element **37**, or where the buttress-threaded arrangement is employed, as described with regard to the FIGS. 7, 8 and 9 form, the tubular member T could be rotated and the mandrel **31** then elevated to enable the fluid to escape back into the chamber C. Thereupon repairs could be made to the wellhead **81** and further operations as may then be necessary can then be conducted to continue production of the well.

In FIG. 1 a floating vessel **100** is illustrated supporting a drilling rig **101** for drilling an opening or well bore **102** in the earth. A drill bit **103** is supported on the lower end of a drill string, and immediately thereabove there are arranged a plurality of drill collars **104** to aid in maintaining the desired amount of weight on the drill bit. In this situation the wellhead arrangement **106** is positioned adjacent the submerged surface **105** in the water-covered area. It is not uncommon for the drilling platform or vessel as shown in FIG. 1 to be anywhere from several hundred to several thousand feet above the wellhead **106** and a conductor or riser pipe **107** extends between the wellhead **106** and the drilling vessel **100** where the normal drilling equipment is supported.

The riser pipe or conductor pipe **107** receives the drill string referred to at the surface of the water **109** by the numeral **110**. The drill string extends down through the conductor or riser pipe **107** and into the well bore, and for purposes of illustration only, forms the tubular member T referred to herein. The present invention is again referred to as the numeral **30**, and generally speaking, surface pipe is set in the earth's surface and may extend anywhere from 500 to 2500 feet or more downwardly into the earth. The drill string **110** is rotated by means well known which is positioned on the drilling vessel **100** and is maintained in tension throughout its drilling operation except for the drill collar portion **104** which places the drill bit in compression to accomplish the drilling function.

It can be appreciated that in some instances it may be desirable to disconnect the riser pipe **107** and drill string **110** and leave the drill string **110** in the well bore **102** and move the drilling vessel. For example, if a storm or hurricane or other unusual weather disturbance arises, it may be desirable to move the vessel temporarily and then relocate it over the well bore. The present invention enables this to be accomplished in that when the drill pipe is disconnected at any point above the invention **30**, the tension therein is relieved and the mandrel **31** will move in the manner described in the various embodiments. Reinforced inflatable element **37** will expand to close off and seal the opening or well bore **42**. This prevents entry of water into the well bore **42** and at the same time prevents egress of any fluids from the well bore. After the disturbance has passed, the vessel may then be relocated relative to the well bore and anchored by means well known in the art and the drill string **110** and riser pipe **107** relocated and reconnected so that drilling operations can continue.

Also, if the riser pipe **107** and/or drill string **110** shears above the wellhead **106** due to any circumstance, this would actuate the tool **30** and cause the element **37** to expand and seal off the well bore **42**. By means well known in the art, the sheared drill string **110** and riser pipe **107** could be relocated, the vessel **100** positioned properly, and drilling operations continued.

In some instances it may be desirable to use the form shown in FIG. 2 wherein compression may be applied to the tubular member T above the tool to shear the pin **50**, or the weight of the tubular member T, when tension is relieved therefrom may be used to shear the pin **50**. In other inistaces it may be desirable to use one of the other forms.

Since the mandrel **31** and housing H are constructed and arranged at their upper end so that no relative rotational movement can occur therebetween, and since the

lower end of the inflatable element **37** is arranged so that no relative rotational movement can occur therebetween and the housing H, it can be appreciated that when the present invention is used in connection with boring or drilling operations, the entire tool **30** will rotate with the rotating drill string, or tubular member T.

The present invention has been described in detail in connection with its use in drilling operations where the well bore may be provided with a casing or conductor pipe; however, it will function in uncased or "open-hole" in the same manner to seal it off. Of course, the slip arrangement of FIGS. 15–17 functions primarily in a cased hole.

Similarly, the tool can be used in many operations such as mining, trenching, boring or in any situation where it may be desired to seal off the annulus surrounding a tubular member.

The foregoing disclosure and description of the invention are 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.

What is claimed is:

1. A tool for connection between two tubular members to seal off an opening surrounding the tubular members comprising:

(a) a mandrel having means for connection with one of the tubular members;

(b) a housing carried by said mandrel, said housing in cooperation with said mandrel forming a chamber for receiving liquid therein;

(c) means on said housing for connection with the other of the tubular members;

(d) an inflatable element including an annular reinforcing sheath having an end secured to said housing;

(e) means surrounding said housing with the other end of said reinforcing sheath secured thereto and movable upon inflation of said element;

(f) seal means sealing between said housing and said means surrounding said housing;

(g) piston means on said mandrel and positioned within said chamber;

(h) there being passage means in the tool for conducting liquid from said chamber to said inflatable element; and

(i) said piston movable within said chamber upon relative longitudinal movement between said mandrel and housing to force liquid from said chamber into said reinforced inflatable element to expand said reinforced inflatable element and seal off the opening.

2. The invention of claim **1**, including means for locking said mandrel and housing in a predetermined position against relative longitudinal movement, said locking means releasing when a predetermined tension or compression is applied to said one tubular member.

3. The invention of claim **1** including cooperating means on said mandrel and housing to accommodate relative longitudinal movement between said housing and mandrel while preventing relative rotation therebetween.

4. The invention of claim **1** wherein a restriction is formed in said passage means which restricts flow of liquid from said chamber to said inflatable element and thereby functions as a delaying means for inflation of said element.

5. The invention of claim **4** including longitudinally extending grooves in said mandrel which terminate at points spaced from the end of said chamber and which serve to communicate liquid from said chamber to said inflatable element upon a predetermined amount of relative movement between said mandrel and housing.

6. The invention of claim **1** including lock means for retaining said inflatable element inflated.

7. The invention of claim **6** wherein said lock means includes check-valve means in said passage means for preventing escape of liquid from said inflated element.

8. The invention of claim **6** wherein said lock means includes a buttress threaded surface on said mandrel, a segmented nut carried by said housing, spring means normally urging said segmented nut radially inwardly and said segmented nut having buttress threads formed thereon for engaging with the buttress threaded surface on said mandrel to retain said mandrel and housing in a predetermined relative longitudinal position.

9. The invention of claim **1** including externally accessible valve means carried by said housing for preventing flow through said passage means in the tool.

10. The invention of claim **1** including means carried by said housing and inflatable element to accommodate relative longitudinal movement between one end of said element and said housing while preventing relative rotation therebetween.

11. The invention of claim **10** wherein said means include cooperating keys and longitudinally extending keyways acting between one end of said inflatable element and said housing.

12. The invention of claim **1** including releasable latch means formed on said housing and one end of said inflatable element to restrain relative longitudinal movement of said element and housing until a predetermined amount of inflating force is exerted by said inflating liquid within said element.

13. The invention of claim **12** wherein said releasable latch means includes spring fingers carried by said inflatable element and a groove formed in said housing within which said spring fingers are received.

14. The invention of claim **1** wherein said chamber on one side of said piston is provided with a gas under pressure which acts against said piston to move said piston and thereby inflate said inflatable element when tension is relieved from the tubular member.

15. The invention of claim **14** including lock means for retaining said inflatable element inflated.

16. The invention of claim **15** wherein said lock means includes check-valve means in said passage means for preventing escape of liquid from said inflated element.

17. The invention of claim **15** wherein said lock means includes a buttress threaded surface on said mandrel, a segmented nut carried by said housing, spring means normally urging said segmented nut radially inwardly and said segmented nut having buttress threads formed thereon for engaging with the buttress threaded surface on said mandrel to retain said mandrel and housing in a predetermined relative longitudinal position.

18. The invention of claim **14** including externally accessible valve means carried by said housing for closing said passage means in the tool.

19. The invention of claim **1** including slip means carried by said inflatable element for engaging an adjacent surface as said element expands.

20. The invention of claim **1** including an additional chamber formed in said housing with gas under pressure therein, means for communicating said gas under pressure to said piston and thereby force said piston to move liquid from said chamber into said inflatable element.

21. The invention of claim **20** including cooperating means on said mandrel and housing to accommodate relative longitudinal movement between said housing and mandrel while preventing relative rotation therebetween.

22. The invention of claim **20** wherein a restriction is formed in said passage means which restricts flow of liquid from said chamber to said inflatable element and thereby functions as a delaying means for inflation of said element.

23. The invention of claim **20** including longitudinally extending grooves in said mandrel which terminate at points spaced from the end of said chamber and which serve to communicate liquid from said chamber to said

inflatable element upon a predetermined amount of relative movement between said mandrel and housing.

24. The invention of claim **20** including lock means for retaining said inflatable element inflated.

25. The invention of claim **24** wherein said lock means includes check-valve means in said passage means for preventing escape of liquid from said inflated element.

26. The invention of claim **24** wherein said lock means includes a buttress threaded surface on said mandrel, a segmented nut carried by said housing, spring means normally urging said segmented nut radially inwardly and said segmented nut having buttress threads formed thereon for engaging with the buttress threaded surface on said mandrel to retain said mandrel and housing in a predetermined relative longitudinal position.

27. The invention of claim **20** including externally accessible valve means carried by said housing for closing said passage means in the tool.

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