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Kirkpatrick et al.

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[54] **AUTOMATIC WELL SHUT-OFF APPARATUS**

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[52] **U.S. Cl.** **166/224**

[51] **Int. Cl.** **E21b 33/00**

[58] **Field of Search** 166/224; 251/5; 137/525

[56] **References Cited**

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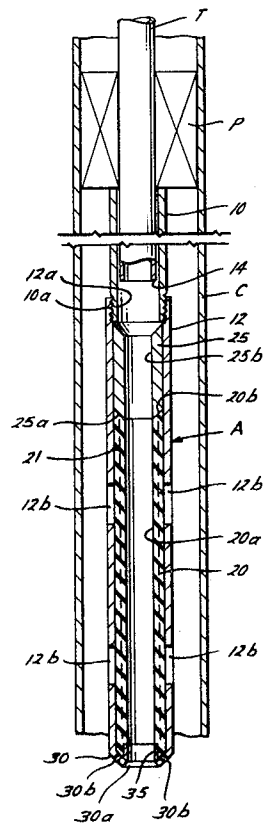
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[57] **ABSTRACT**

An automatic well shut-off apparatus which is adapted to be disposed in a well below a single or multiple string packer for automatically shutting off the flow of fluid upwardly in a well when the pressure differential between the well fluid externally of the apparatus and the pressure in the apparatus reaches a predetermined amount. The apparatus includes a collapsible sleeve which collapses to a closed or shut-off position only when the predetermined pressure is reached and it is sufficient to overcome the collapse resistance of the sleeve.

7 Claims, 3 Drawing Figures



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Fig. 1

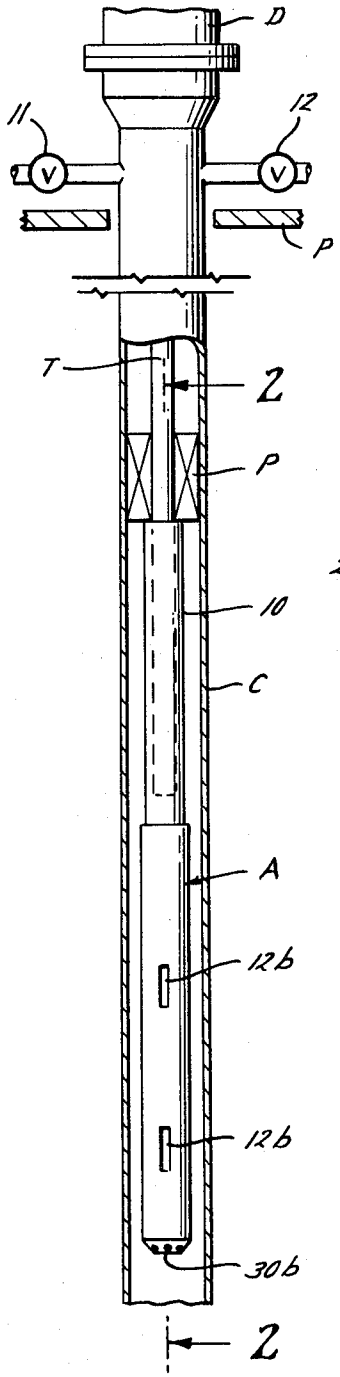


Fig. 2

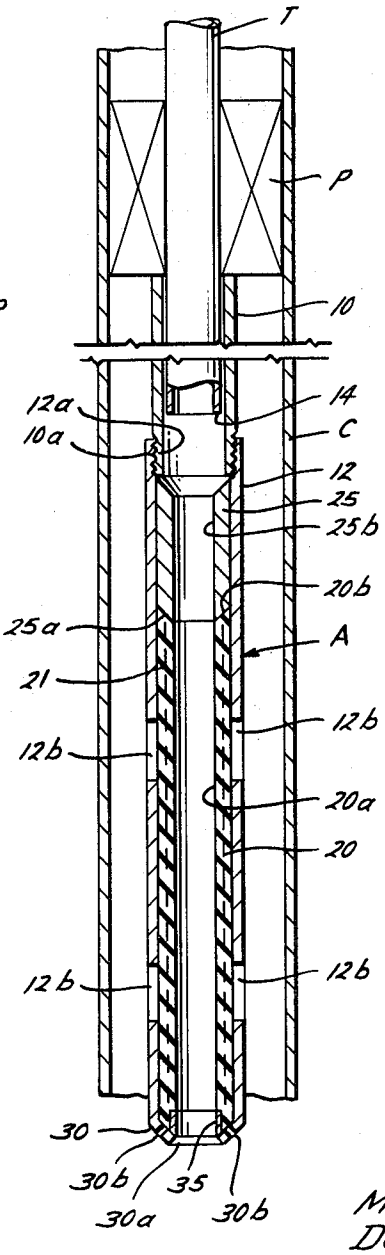
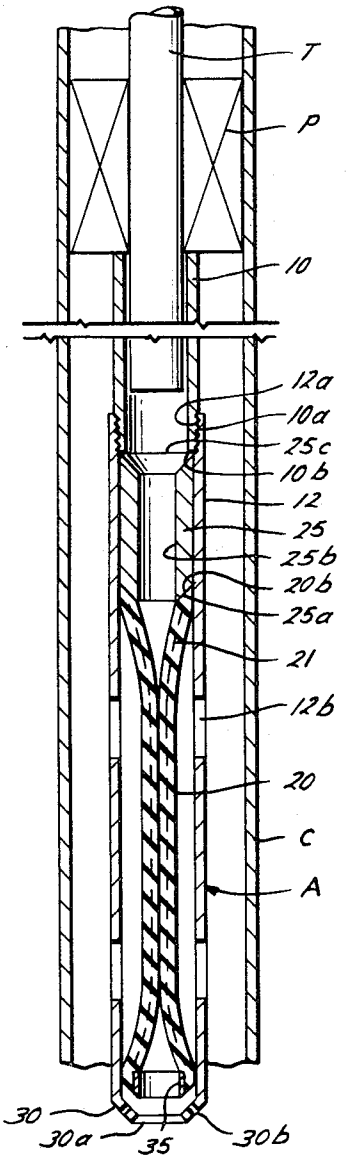


Fig. 3



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AUTOMATIC WELL SHUT-OFF APPARATUS

BACKGROUND OF THE INVENTION

The field of this invention is well control devices for preventing well blowouts.

In recent years, particularly since the advent of offshore drilling for oil, the control of wells blowouts has become even more of a problem than in the past. Well blowouts result in well fires and in pollution of the ocean waters by the oil flowing from the well after the fire is extinguished unless the well is brought under control. Therefore, this problem of bringing wells under control has been of paramount concern.

SUMMARY OF THE INVENTION

The present invention relates to an apparatus which is capable of automatically shutting off well flow in one or more tubing strings so as to bring the well under control in the event the well pressure begins to reach pressures which would otherwise result in a blowout of the well. The apparatus includes a collapsible sleeve which is adapted to automatically collapse so as to close the passage therethrough when the pressure differential acting thereon is sufficient to overcome the collapse resistance of the sleeve.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevation, partly in section, of the apparatus of this invention in position for use in a well casing or pipe;

FIG. 2 is an enlarged vertical sectional view of the apparatus of this invention in the normal open position; and

FIG. 3 is a view similar to FIG. 2, but illustrating the apparatus of this invention in the shut-off or closed position.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the drawings, the letter A designates generally the apparatus of this invention which is particularly adapted for use in a well pipe or casing C wherein oil or other well fluid is being produced from a well formation (not shown). Preferably, the apparatus of this invention is connected to a flow tube **10** which is formed integrally with or is connected to a packer P which is disposed in the well pipe or casing C. Production tubing T extends upwardly to the surface above the level of the platform P or ground level where the usual Christmas tree D is provided for controlling the discharge and inlet of various fluids with respect to the casing and the tubing T. Such control includes valves such as valves **11** and **12** shown in FIG. 1 in the known manner. In offshore rigs, the platform P may be the deck of a floating barge or other similar installation.

This invention is illustrated with a single string of pipe T and a packer P which accommodates just the single string, but is should be understood that the apparatus A may be used with multiple strings of pipe and multiple string packers, as will be more evident hereinafter. The packer P may be a drillable permanent type packer or any other type of packer which is set in the casing C and which is adapted to receive the lower end of the tubing string T in sliding sealing engagement therewith. Since the packer P may have any conventional construction, it is illustrated only schematically in the drawings.

The apparatus A if this invention includes an outer housing **12** which is formed of a rigid material such as stainless steel. The housing **12** is tubular and it has internal threads **12***a* at its upper end for threaded engagement with threads **10***a* on the flow tube **10**. Any other suitable means of connecting the upper end of the housing **12** to the flow tube **10** may of course be provided. The tubing string T extends downwardly into the flow tube **10**, but its lower end **14** terminates above the lower end of the flow tube **10** so that the tubing string T does not extend downwardly into the housing **12**. Preferably, the lower end of the tubing string T fits loosely within the flow tube **10** so that some relative movement therebetween occurs as the tubing expands and contracts under normal changes in temperature occurring during flow conditions. The seal between the tubing string T and the packer P is of course maintained even though the tubing string T moves relative to the packer P.

A collapsible sleeve **20** which is formed of rubber or a rubber like material so that it is resilient is disposed in the housing **12**, preferably so that its outer external surface engages the internal surface of the housing **12** so that it is fully supported against outward extrusion or expansion during the normal flow of fluid through the bore **20***a* of the sleeve **20**. To provide a predetermined collapse resistance for the sleeve **20** it is preferable to have a flexible metallic screen **21**, usually of stainless steel, embedded within the rubber or other material forming the collapsible sleeve **20**.

The external surface of the sleeve **20** is exposed to the fluid pressure in the well by reason of a plurality of slots or openings **12***b* which are formed in the wall of the housing **12** so as to provide a sufficient area of exposure for the external surface of the sleeve **20** to accomplish a collapse and a closing of at least a portion of such sleeve **20** when a predetermined pressure differential exists across the sleeve **20**.

In the preferred embodiment of the invention, the upper end of the sleeve **20** is secured so that it does not collapse when a portion of the sleeve **20** therebelow collapses to the closed position (FIG. 3). By reason of the upper end of the collapsible sleeve **20** remaining substantially uncollapsed while the portion therebelow is in the collapsed condition, the return of the sleeve **20** from the collapsed condition of FIG. 3 to the normal open position of FIG. 2 may be more readily effected by fluid pressure from the tubing string T moving downwardly when it is desired to open the sleeve **20** again. In the preferred form of the invention, the securing of the upper end of the sleeve **20** is accomplished by bonding or vulcanizing the upper edge **20***b* of the sleeve **20** to the lower annular edge or shoulder **25***a* of a sleeve **25** which is welded or is otherwise secured in the upper end of the housing **12**. The sleeve **25** is thus a retainer tube and it may be integral with the housing **12** if desired. The bore **25***b* of the retainer tube **25** is preferably of the same size and in alignment with the bore **20***a* of the collapsible sleeve **20**. The sleeve **25** may be separate from the casing **12** and may be insertable along with the sleeve **20** since it is confined in its seated position as shown in FIGS. **2** and **3** by reason of the engagement of the upper edge **25***c* thereof with the lower end **10***b* of the flow tube **10**.

The lower end of the housing **12** is preferably formed with an annular lip **30** which terminates in an opening **30***a* which is of substantially the same size as the bore **20***a* of the sleeve **20**. One or more ports or openings **30***b* are provided so that fluid pressure externally of the housing **12** acts upon the lower end of the sleeve **20** to urge same upwardly to assist in an effective seal between the walls of the sleeve **20** when they are collapsed as shown in FIG. **3**.

To reduce or minimize wear on the rubber or other material of the sleeve **20** as a result of the flowing fluid through the bore **20***a* thereof, it is preferable to provide a wear sleeve **35** on the inside lower portion of the bore **20***a*. Such sleeve **25** is formed of ceramic or other hard material which normally does not collapse and therefore the lower end of the sleeve **20** retains its approximate diameter even though the portion thereabove collapses as shown in FIG. **3**. If such wear ring **35** is omitted, the lower portion of the sleeve **20** collapses to the same extent as the portion thereabove, except for the very upper end which remains open as previously explained because of the securing thereof to the retainer tube **25**.

In the use of the apparatus A of this invention, the apparatus A is mounted on the lower end of a packer flow tube **10** which may extend downwardly from a single string or multiple string packer in the known manner. Under normal operating conditions the oil or other well fluid flowing from the well formation would flow upwardly in the casing C and through the bore **20***a* of the sleeve **20** and then upwardly through the tubing T to the conventional equipment D at the platform P or other surface location.

In the event the well pressure increased considerably and the pressure was great enough to cause a blowout condition which might result in a blowing out of the oil in an uncontrolled manner or even a fire at the surface, the rapidly flowing oil creates a pressure drop through the inside of the sleeve **20** so that there is a pressure differential created across the wall of the sleeve **20** which is sufficient to collapse the sleeve **20** from the position shown in FIG. **2** to the position shown in FIG. **3**. As soon as the sleeve **20** begins to collapse to some extent, the pressure drop internally of the sleeve **20** increases so that there is a very rapid closing of the sleeve **20** once it starts to close. Also, since the pressure from below the sleeve **20** acts upwardly thereon after the sleeve **20** has closed, it tends to compress the rubber or other resilient material forming the collapsible sleeve to obtain a more effective seal between the walls of the portion of the sleeve **20** which are engaged.

Since the upper end of the sleeve **20** remains open, fluid may be pumped downwardly through the tubing string T to reopen the sleeve **20** and return it to its normal open position when well conditions dictate such action.

As a modification of the sleeve **20** illustrated and described above, it is possible to provide only a section or portion of the length of the sleeve **20** which actually collapses by having such section made of a more yieldable collapsible material than the rest of the sleeve **20**. For example, the central portion of the sleeve **20** may be made of a softer rubber than the rest of the sleeve **20** so that collapse is initiated at the central portion of the sleeve **20** by a predetermined fluid pressure differential acting across the sleeve **20**.

It will be appreciated that under normal flow conditions, the well pressure inside of the sleeve **20** will be substantially equal to the well pressure externally thereof and below the sleeve **20**. However, when there is a sudden surge of well pressure as a result of a blowout condition in the well, then the size of the bore **20***a* serves as a sufficient restriction to flow so that a pressure drop occurs and there is a reduced pressure inside of such bore **20***a* as compared to the pressure externally thereof. The collapse resistance of the sleeve **20** is thus determined to cause a collapse of such sleeve **20** when the pressure differential acting on the sleeve **20** is such that a blowout of the well fluid would occur if the well fluid were not shut off. With this invention, the well fluid is automatically cut off when such blowout condition occurs, thus preventing pollution by oil spillage at the surface by reason of a blowout and also preventing a well fire.

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 without departing from the spirit of the invention.

We claim:

1. An automatic well shut-off apparatus connected below a well packer and to a packer flow tube extending downwardly from the well packer for automatically closing off a well to prevent a blowout thereof, comprising:

a tubular housing having means at its upper end connected to a packer flow tube and having its lower end open to well pressure;

a resilient collapsible sleeve disposed in said tubular housing and having a bore therethrough which is normally open for the flow of fluid through said sleeve; and

said housing having a plurality of openings through the wall thereof and with a substantially smooth external surface surrounding and in proximity to said openings communicating fluid pressure in the well externally of said housing to the external area of said sleeve.

2. The structure set forth in claim **1**, including:

a non-resilient retainer tube secured in said housing near the upper end thereof to prevent collapse of the upper end of said sleeve;

said retainer tube having a lower shoulder engageable by the upper end of said collapsible sleeve; and

means securing the upper end of said collapsible sleeve to said retainer tube to prevent its collapse so that it will be open for receiving fluid from above the sleeve to return it to its normal open condition after the pressure differential falls below said predetermined amount.

3. The apparatus set forth in claim **1**, wherein:

said resilient collapsible sleeve is formed of rubber or rubber-like material having a flexible metallic screen embedded therein to provide predetermined collapse resistance.

4. The apparatus set forth in claim **1**, wherein:

said sleeve has a lower annular edge which is free to move upwardly relative to said housing; and

the lower end of said housing has an outer annular lip substantially coextensive with the lower annular

edge of said sleeve when said sleeve is in the normally open position for supporting same to prevent extrusion thereof during normal flow conditions.

5. An automatic well shut-off apparatus for automatically closing off a well to prevent a blowout thereof, comprising:

a tubular housing having means at its upper end for connection to a packer flow tube;

a resilient collapsible sleeve disposed in said tubular housing and having a bore therethrough which is normally open for the flow of fluid through said sleeve;

support means in said housing attached to only the upper end of said collapsible sleeve, leaving the lower end of said sleeve unattached to both said housing and said support means and free to move upwardly in said housing upon the application of well pressure to said sleeve from externally thereof; and

said housing having a plurality of openings through the wall thereof for communicating fluid pressure in the well externally of said housing to the external area of said sleeve for effecting a collapse of at least a portion of said sleeve to close off fluid flow through said sleeve when a predetermined pressure differential develops across the sleeve.

6. The apparatus set forth in claim 5, wherein:

the lower end of said housing has an annular lip substantially coextensive with the lower edge of said sleeve; and

said lip has port means for establishing fluid communication with the lower end of said sleeve for urging said sleeve upwardly to increase the effective sealing contact of the walls of the collapsed portion of the sleeve in the closed position.

7. The apparatus set forth in claim 5, including:

a wear ring secured in the inside lower end of said sleeve for minimizing wear on said sleeve during normal flow through said sleeve when it is in the open position.

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