United States Patent

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[54] SUBSURFACE WELL SAFETY APPARATUS

10 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **166/224,** 137/510
[51] **Int. Cl.** **E21b 33/00**
[50] **Field of Search** 166/224; 137/510

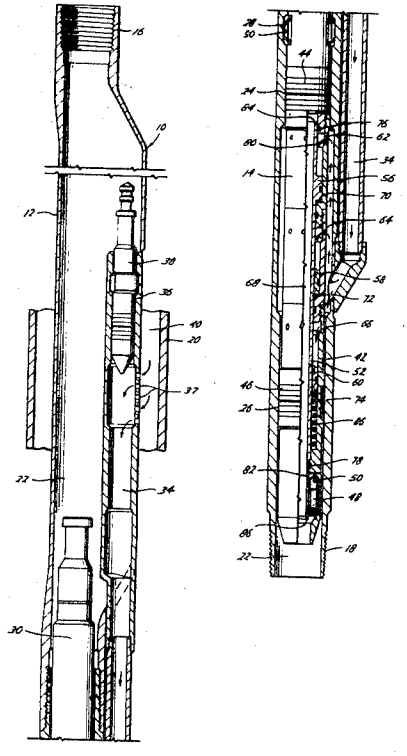
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ABSTRACT: A subsurface well safety apparatus for installation in a well fluid production tubing in a casing which is responsive to the casing pressure. A mandrel having a first open bore passageway and a second passageway laterally offset from the first passageway and a safety valve positioned in the mandrel first passageway. The valve including pressure responsive means acting to control the safety valve and in communication and controlled by pressure in the second mandrel passageway. The first mandrel passageway including first and second spaced apart smooth portions for receiving spaced apart seals on the safety valve and including latch receiving means above the smooth portions for receiving the well lock for supporting the safety valve in the first passageway. A safety valve including an outer valve body having first and second spaced seals with a flap valve pivotally carried at the lower end of the valve body for normally closing the bottom of the valve body and an inner tubular member telescopically movable in the valve body which holds the flap valve in the downward position when the inner member projects out the bottom of the valve body and a plurality of longitudinally spaced pistons connected to the exterior of the inner member, the valve body including an opening leading to the top side of each piston and in communication with the mandrel second passageway for receiving a control fluid acting to keep the valve open.



Patented Dec. 14, 1971 3,627,042

2 Sheets-Sheet 1

Fig. 1A

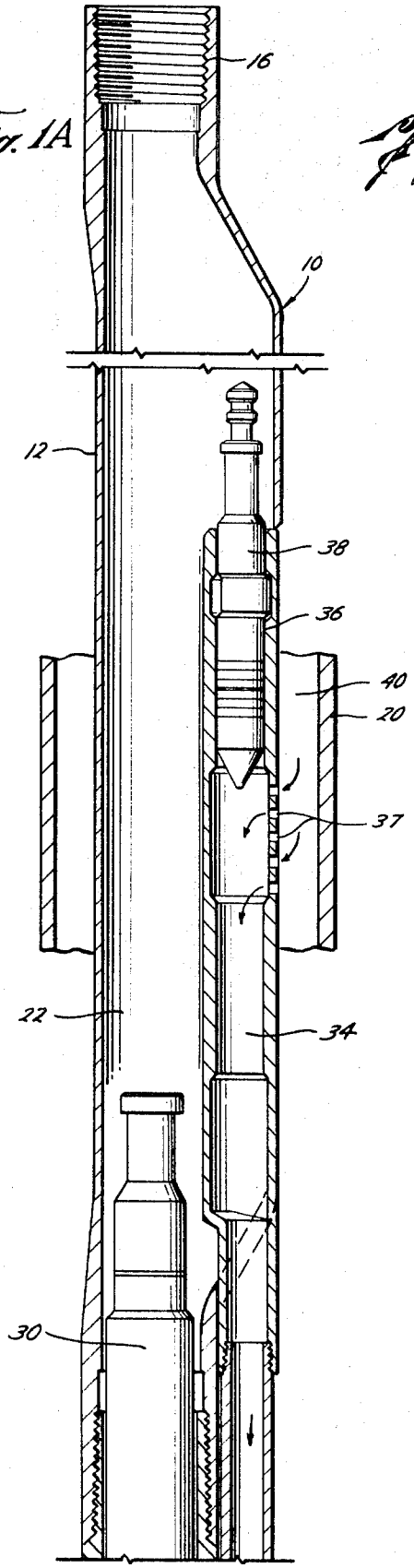
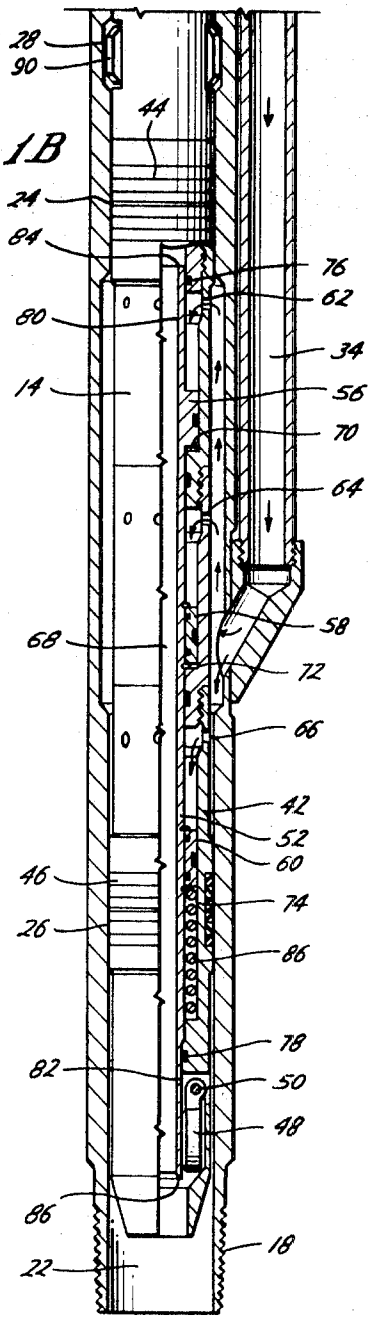


Fig. 1B



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Patented Dec. 14, 1971 3,627,042

2 Sheets-Sheet 2

Fig. 2A

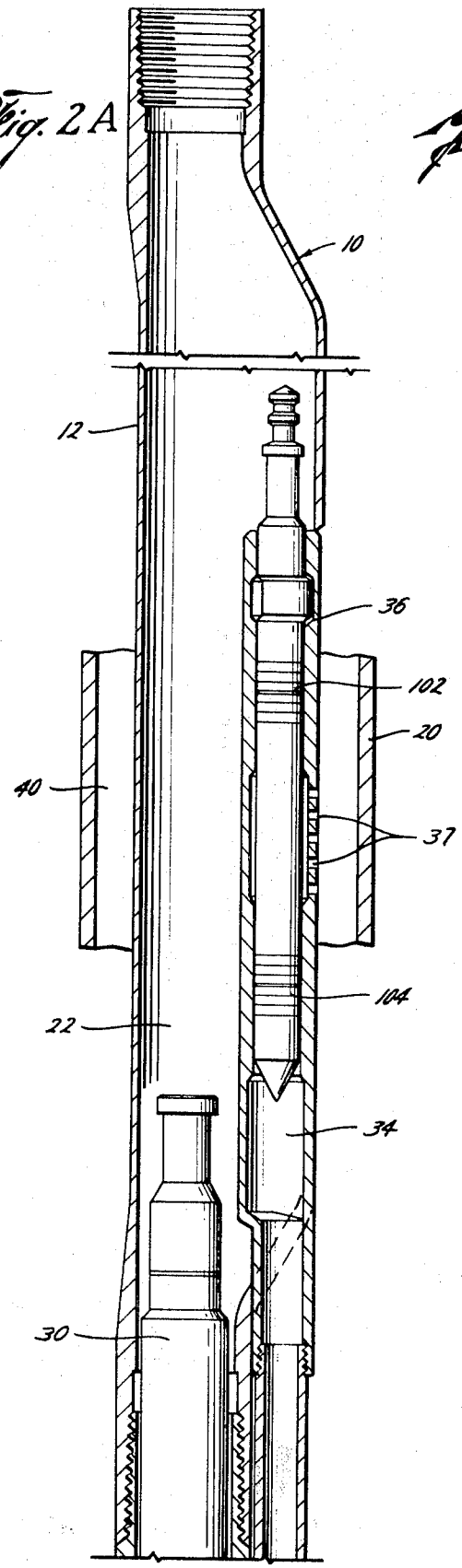
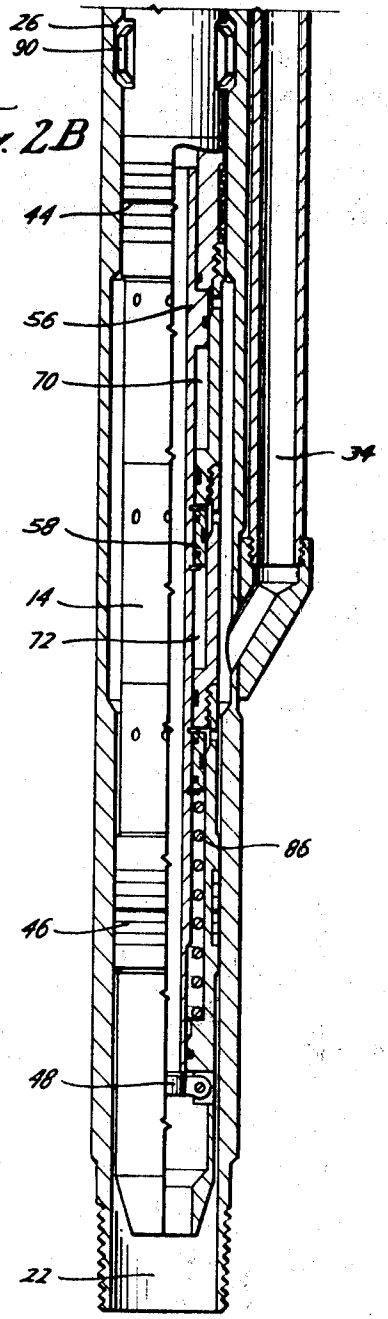


Fig. 2B



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SUBSURFACE WELL SAFETY APPARATUS

BACKGROUND OF THE INVENTION

Various safety valves have been used in the past in a well tubing to shut off production of well fluid from oil or gas well such as shown in U.S. Pat. No. 3,265,134.

The present invention is directed to a subsurface well safety apparatus for installation in a well fluid production tubing positioned in a well casing which is controlled by the pressure in the casing. A mandrel may be provided having a first open bore passageway for alignment with the well tubing in which a safety valve is provided, and including a second elongate passageway laterally offset from the first passageway and which is in communication with the annulus between the well tubing and the casing whereby the mandrel may be used to accomplish other subsurface functions such as gas lift and the casing pressure may be used to control the actuation of the safety valve. Thus under normal flow conditions, the well safety valve is in the open position, but the safety valve is closed in the event failure occurs at the well head causing the casing pressure to drop and the safety valve will close and shut off well production as a result of undesired increase flow through the tubing or a malfunction in the tubing system downstream of the self-acting safety valve.

The pressure between the tubing and the casing or casing pressure may be used to control the safety valve, but by the use of a mandrel the present well safety apparatus may be operated to insure that any high bottom hole pressure in the tubing is not allowed to flow into the and damage the casing.

SUMMARY

The present invention is directed to providing a well safety valve that is controlled by casing pressure. In addition, a mandrel may be provided in a well fluid production tubing positioned in a casing with a safety valve positioned in the mandrel first passageway in alignment with the well tubing and in communication with the pressure in the annulus between the tubing and the casing through the second mandrel passageway which controls the actuation of the safety calve.

A further object of the present invention is the provision of an improved subsurface well safety valve having an outer tubular body with first and second spaced seals around the exterior with a flap valve pivotally carried at the lower end of the body for normally closing the bottom of the body and an inner tubular member telescopically movable in the body and which holds the flap valve in the downward and open position when the inner member projects below the bottom of the body. A plurality of longitudinally spaced pistons may be connected to the exterior of the inner member and slidable on the interior of the valve body with the inner member and the valve body forming a closed chamber below each of the pistons with the body having an opening leading to the top side of each piston for supplying a control fluid thereto acting to keep the valve open. Further control of the actuation of the valve may be provided by providing spring means between the body and the inner member tending to move the inner member upwardly and close the valve and upper and lower seals may be provided between the valve body and the inner member with the upper wall portion of the inner member being thicker than the lower wall portion of the inner member thereby providing a greater downwardly facing area on the inner member whereby pressure in the inner member acts to move the member downwardly and open the valve.

A further object of the present invention is the provision of an improved mandrel for installation in a subsurface well safety apparatus in which the mandrel has a first open bore passageway for alignment with the well tubing and includes first and second spaced apart smooth portions for receiving spaced apart seals on a safety valve and the first passageway includes latch-receiving means above the smooth portions for receiving a well lock for supporting a safety valve in the first passageway with the mandrel body including a second passageway laterally offset from the first passageway and including a flow control unit housing at the upper end of the second passageway for receiving a flow control unit with the second passageway including an opening communicating exteriorly of the mandrel body for receiving causing pressure with the second passageway being in communication with the first passageway at a position between the first and second smooth portions for supplying casing pressure to a safety valve positioned in such first passageway.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a fragmentary elevational view, partly in cross section, illustrating the upper portion of the preferred embodiment of the subsurface well safety apparatus of the present invention in use with the casing pressure regulating a safety valve,

FIG. 1B is a continuation of FIG. 1A showing the lower portion of the present apparatus showing the safety valve in the open position,

FIG. 2A is a fragmentary elevational view, partly in cross section, showing the upper portion of the present invention in use with the safety valve closed and the casing pressure blocked off whereby the safety valve may be removed without allowing tubing pressure to flow to the casing, and

FIG. 2B is a continuation of FIG. 2A showing the lower portion of the apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings and particularly FIGS. 1A and 1B, the reference numeral 10 generally indicates subsurface well safety apparatus of the present invention and may generally include a mandrel 12 and a well safety valve 14. The mandrel 12 includes suitable connections, such as threads 16 at the top and 18 at the bottom, for connection to conventional well tubing (not shown) in a well bore, and is generally positioned in a casing 20 for conducting fluid production such as oil or gas from a production zone and up the tubing to the surface.

The mandrel 12 includes a first passageway 22 having an open bore in alignment with the well tubing for passage of well tools. The mandrel 12 of the present invention includes in the first passageway 22, as best seen in FIG. 1B, first and second spaced-apart smooth portions 24 and 26 for receiving and coacting with spaced-apart seals for sealing about the safety valve 14, which will be more fully described hereinafter. In addition, the first passageway may include suitable holding means such as latch-receiving means such as notch 28 positioned above the smooth portions 24 and 26 for receipt of holding means such as a well lock 30 for supporting the safety valve 14 in the first passageway 22 at the desired location.

The mandrel 12 also includes a second passageway or side pocket 24 which is laterally offset from but in communication with the first passageway 22 at the op thereof as is conventional. The second passageway 34 includes a housing 36 at its upper end for receipt of suitable flow control units 38 which may be inserted into and removed from the flow control housing 36 by conventional setting and retrieving tools (not shown). Openings 37 are provided in the mandrel 12 between the second passageway 34 and the exterior of the mandrel 12 whereby fluid such as gas pressure in the annulus 40 between the tubing and the casing 20 is admitted into the second passageway 34. It is to be particularly noted that the lower end of the second passageway 34 is in communication with the first passageway 22 (FIG. 1B) at a location between the first and second spaced smooth portions 24 and 26 thereby supplying gas under pressure from the annulus 40 between the tubing and the casing 20 to the safety valve 14 for controlling the actuation of the safety valve 14 as will be more fully described hereinafter.

One of the functions of the safety valve 14 is to prevent the well from over producing or blowing wild should surface controls fail or become damaged. Thus the safety valve 14 is positioned in the first passageway 22 in the mandrel 12 and

remains open to allow flow therethrough under proper operating conditions, but closes at a predetermined pressure drop across the valve **14** or a decrease in control pressure.

The safety valve **14** includes an outer valve body **42** adapted to be movable in the well tubing and set and retracted from the first passageway **22** of the mandrel **12** and includes seals **44** and **46** (the upper of which may be made a part of well lock **30** for convenience), which coact with the smooth portions **24** and **26**, respectively, in the first passageway **22** thereby isolating the pressure in annulus **40** or the casing pressure flowing into the second passageway **34** to a point between the two seals **44** and **46**. In addition, seals **44** and **46** prevent the well pressure in the tubing and first passageway **22** from communicating with the lower end of the second passageway **34**. Thus, the seals **44** and **46** prevent fluid pressure in the tubing and first passageway **22** from entering the lower end of passageway **34** and possibly damaging the casing **20**. A flap valve **48** is pivotally carried about pivot **50** and includes spring means (not shown) for normally pivoting the flap valve **48** upwardly to close off the bottom of the valve body **42** and block the flow of fluids upwardly through the first passageway **22** and through the well tubing to the surface. An inner tubular member **52** is telescopically movable in the valve body **42** and when the inner member **52** projects out of the bottom of the valve body **42** the member holds the flap valve **48** in the downward and open position thereby permitting fluid flow through the safety valve **14** and the first passageway **22**.

In order to provide a control to maintain the inner tubular member **52** in a downward position to keep the flap valve **48** open, one or more pistons, here shown as pistons **56**, **58** and **60**, are provided connected to the exterior of the inner member **52** and slidable on the interior of the valve body **42**. The valve body **42** is provided with openings **62**, **64** and **66** above the pistons **56**, **58** and **60**, respectively, and the openings are in communication with the lower end of the second passageway **34** of the mandrel **12** to receive a control fluid such as casing pressure from the casing annulus which acts on the top of the pistons **56**, **58** and **60** to keep the safety valve **14** in the open position. While a single piston may be sufficient, depending upon the pressures and conditions involved, the pressure in the annulus **40** between the tubing and the casing **20** would generally be considerably lower than the well-tubing pressure and the multiple longitudinally spaced and stacked pistons **56**, **58** and **60** may be desirable to provide a sufficient force to keep the safety valve in the open position while still maintaining a sufficient flow through the safety valve **14**. It is to be noted that closed chambers **70**, **72** and **74** are formed below the pistons **56**, **58** and **60**, respectively, by the exterior of the inner tubular member **52** and the interior of the valve body **42** which are preferably at atmospheric pressure and thus do not provide any obstacle against which the pistons are required to operate. Thus the pressure in the annulus **40** may be controlled conveniently from the surface to control the opening and closing of the safety valve **14**.

It is also noted that the inner tubular member **52** and the outer valve body **42** have an upper seal **76** and a lower seal **78** therebetween and that the upper section **80** of the tubular member **52** may be thicker than the lower section **82** of the tubular member **52** whereby the upwardly facing shoulder **84** has a greater area than the lower or downwardly directed shoulder **86** at the bottom of the member **52**. Thus, because of the differential difference in area between the surfaces of the shoulders **84** and **86**, a normal static pressure force may be provided acting to hold the inner tubular member **52** in the downward position to also aid in holding the flap valve **48** in the open position. However, upon over production or blowing wild of the fluid in the tubing, the pressure drop across the inner tubular member **52** would rise to a predetermined value, overcoming the force of the control fluid acting on the pistons **56**, **58** and **60**, and automatically move the inner tubular member **52** upwardly allowing the flap valve **48** to close and shut off the upper flow of fluid through the first passageway **22** and the well tubing. In addition, a spring **88** may be provided between shoulders on the outer valve body **42** and the inner valve body **52** yieldably urging the inner tubular member **52** in the upper direction to provide a more positive closing action when the predetermined pressure drop occurs across the valve **14**.

While the well safety valve **14** may be held in position in the first passageway **22** of the mandrel **12** by any suitable means, a conventional well lock **30** such as type-M sold by Camco, Incorporated, is satisfactory and includes latching dogs **90** which coact with the latch-receiving means **28** in the first passageway **22** of the mandrel **12** for retrievably holding the safety valve **14** in position.

While the preferred embodiment of the present invention includes the mandrel **12** whereby the mandrel may be used to accomplish other surface functions and for the purpose of allowing the safety valve to be removed without subjecting the casing **20** to tubing pressure, the mandrel **12** may be omitted and the safety valve **14** inserted in the well tubing and controlled by the casing pressure. That is, the second passageway **34** may be omitted and the safety valve **14** would be in direct communication with the annulus **40** through one or more the ports **62**, **64** and **66**.

In use, as shown in FIGS. **1A** and **1B**, the casing pressure from the annulus **40** between the tubing and the casing **20** enters the openings **36** and flows into the second passageway **34** and as best seen in FIG. **1B** flows through the openings **62**, **64** and **66** of the valve body **42** of the safety valve **14** and acts on the pistons **56**, **58** and **60** to hold the safety valve **14** and member **52** in a downward position holding the flap valve **48** open to allow fluid production to flow through the tubing and the first passageway **22** and to the surface. As shown in FIG. **1A**, the flow control unit **38** which is positioned in the flow control housing **36** is shown as a dummy plug such as type-E as manufactured by Camco, Incorporated, wherein the entire casing pressure is used solely to regulate the safety valve **14**. However, by using the mandrel **12**, other normal well functions may be provided such as gas lift operations by replacing the dummy plug **38** with any suitable conventional and desired flow control unit. In any event, the actuation of the safety valve **14** is suitably controlled by the casing pressure. It is also to be noted that if an equipment failure occurs at the well head at the surface which would cause casing pressure in the annulus **40** to drop, the control force on top of the pistons **56**, **58** and **60** would be removed and the spring **86** would act to close the safety valve **14**. Or in the event that the production through the well tubing and first passageway **22** is over producing or flowing wild and the surface controls fail or become damaged, the differential pressure across the safety valve **14** will increase to a predetermined value and overcome the control force on the pistons to move the inner tubular member **52** upwardly and allow the spring loaded valve flap **48** to close thereby closing the safety valve **14**.

However, the well casing **20** is not generally designed to withstand the well pressure to which the tubing and mandrel **12** may be subjected. The present well safety apparatus **10** may be operated to use the pressure in the casing annulus to control the safety valve **14**, but yet prevents the tubing pressure in the tubing and first passageway **22** in the mandrel **12** from flowing into the annulus **40** between the mandrel **12** and the casing **20**. That is, assuming that the safety valve **14** has moved to a closed position, as best seen in FIG. **2B**, due to high-flow conditions in the tubing and first passageway **22** or loss of casing pressure, the safety valve **14** could not be removed from the apparatus **10**, even assuming that the surface controls were acting satisfactorily in the installation shown in FIGS. **1A** and **1B** without subjecting the casing **20** to the undesirable high pressures in the tubing and fluid passageway **22**. Therefore, prior to pulling the well lock **30** and safety valve **14**, the dummy plug **38** shown in FIG. **1A** would be removed by conventional wireline retrieving tools and replaced, as best seen in FIG. **2A** with a blanking plug **100** having seals **102** and **104**. Thus, when the blanking plug **100** is placed in the housing **36**, the seals **102** and **104** strattle the

openings 36 closing off both ends of the second passageway 34 from the first passageway 22, after which the well lock 30 and safety valve 14 may be safely removed without subjecting the casing 20 to undesired high pressures.

The present invention, therefore, is well adapted to carry out the objects and attain the ends and advantages mentioned as well as others inherent therein.

What is claimed is:

1. A subsurface well safety apparatus for installation in a well fluid production tubing comprising,
- a mandrel having a first elongate passageway adapted to be aligned with the well tubing and a second elongate passageway laterally offset from the first passageway, said second passageway including a flow control unit housing at the upper end for receiving a flow control unit, said mandrel including an opening communicating from the outside of the mandrel to said second passageway,
- a safety valve positioned in the first passageway, said valve including pressure responsive means acting in a direction to open said valve, and
- said second passageway in communication with the valve pressure-responsive means for actuating said pressure-responsive means.

2. The apparatus of claim 1 wherein said valve pressure-responsive means includes a plurality of pistons one side of which are in communication with the second passageway and a closed chamber in contact with the second side of each piston.

3. The apparatus of claim 1 wherein said valve includes means responsive to flow through the valve acting to close said valve.

4. A subsurface well safety mandrel for installation in a well fluid-production tubing comprising,
- a mandrel body having a first open bore passageway for alignment with the well tubing,
- said first passageway including first and second spaced apart smooth portions for receiving spaced-apart seals on a safety valve,
- said first passageway including latch receiving means above said smooth portions for receiving a well lock for supporting a safety valve in said first passageway,
- said mandrel body including a second passageway laterally offset from the first passageway, said second passageway including a flow control unit housing at the upper end in communication with said first passageway above said first and second smooth portions for inserting and removing a flow control unit and including an opening in the housing communicating exteriorly of the mandrel body, and said second passageway being in communication with the first passageway at a position between the first and second smooth portions.

5. In combination with the mandrel of claim 6 of a well safety valve comprising,
- an outer tubular valve body having first and second spaced seals around the exterior of the valve body for sealing in the first passageway at said first and second smooth portions,
- a valve carried on the lower end of the valve body for normally closing the bottom of the valve body,
- an inner tubular member telescopically movable in the valve body and which holds the valve in the open position when the inner member projects out of the bottom of the valve body,
- piston means connected to the exterior of the inner member and slidable on the interior of the valve body,
- the valve body having an opening leading to the top side of said piston means and in communication with the mandrel second passageway for receiving a control fluid thereto tending to keep the valve open,
- a closed chamber formed between the member and valve body below said piston means, and
- a well lock connected to the safety valve and including latch means for locking in the mandrel latch-receiving means.

6. The apparatus of claim 4 including,
- a first flow control unit adapted to be positioned in the flow control unit housing for blocking the upper end of the second passageway from the first passageway but allowing communication from the opening in the housing to the first passageway between the first and second smooth portions.

7. The apparatus of claim 6 including,
- a second flow control unit adapted to replace the first flow control unit and close the opening in the housing.

8. A subsurface well safety valve comprising,
- an outer tubular body having first and second spaced seals around the exterior for sealing in a well tubing,
- a flap valve pivotally carried on the lower end of the body for normally closing the bottom of the body,
- an inner tubular member telescopically movable in the body and which holds the flap valve in the downward open position when the inner member projects below the bottom of the body,
- a plurality of longitudinally spaced pistons connected to the exterior of the inner member and slidable on the interior of the body,
- the body having an opening leading to the top side of each piston for supplying a control fluid thereto tending to keep the valve open,
- a closed chamber formed between the member and the body below each of the pistons,
- spring means between the body and the inner member tending to move the inner member upwardly and close the valve,
- upper and lower seal means between the body and the inner member and the upper wall portion of the inner member being thicker than the lower wall portion of the inner member thereby providing a greater downwardly facing area whereby pressure in the inner member acts to move the tubular member downwardly for holding the valve open.

9. A subsurface well safety apparatus for installation in a well fluid-production tubing positioned in a casing comprising,
- a mandrel body having a first open bore passageway for alignment with the well tubing, and a second elongate passageway laterally offset from the first passageway, said second passageway including a flow control unit housing at the upper end for receiving a flow control unit, said mandrel including an opening communicating from the outside of the mandrel body to the second passageway for admitting pressure in the annulus between the tubing and the casing into the second passageway, said second passageway in communication with the first passageway,
- a safety valve positioned in the first passageway including,
  - an outer tubular valve body having first and second spaced seals around the exterior for sealing in the first passageway,
  - a valve carried on the valve body for normally closing the body,
  - an inner tubular member telescopically movable in the valve body and which holds the valve in the open position when the inner member projects downwardly,
  - at least one piston connected to the exterior of the inner member and slidable on the interior of the valve body,
  - said valve body and member forming a closed chamber against the bottom of the piston,
  - the valve body having an opening leading to the top side of the piston for supplying a control fluid thereto tending to keep the valve open, and positioned to be in communication with the second passageway of the mandrel.

10. The apparatus of claim 10 including,
- the first passageway of the mandrel including latch-receiving means, and
- a well lock connected to the safety valve and including latch means for locking in the mandrel latch-receiving means for supporting the safety valve.

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