United States Patent [19]

Holbert, Jr.

[11] **3,726,341**

[45] **Apr. 10, 1973**

[54] **PETROLEUM WELL TUBING SAFETY VALVE**

[75] Inventor: **Marvin L. Holbert, Jr.**, Houston, Tex.

[73] Assignee: **Gray Tool Company**, Houston, Tex.

[22] Filed: **Mar. 12, 1971**

[21] Appl. No.: **123,805**

[52] **U.S. Cl.** **166/224,** 137/466, 137/527, 251/348

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

[58] **Field of Search** 166/224; 137/456, 137/466, 517, 520, 521, 527, 527.2, 527.4; 251/348

[56] **References Cited**

UNITED STATES PATENTS

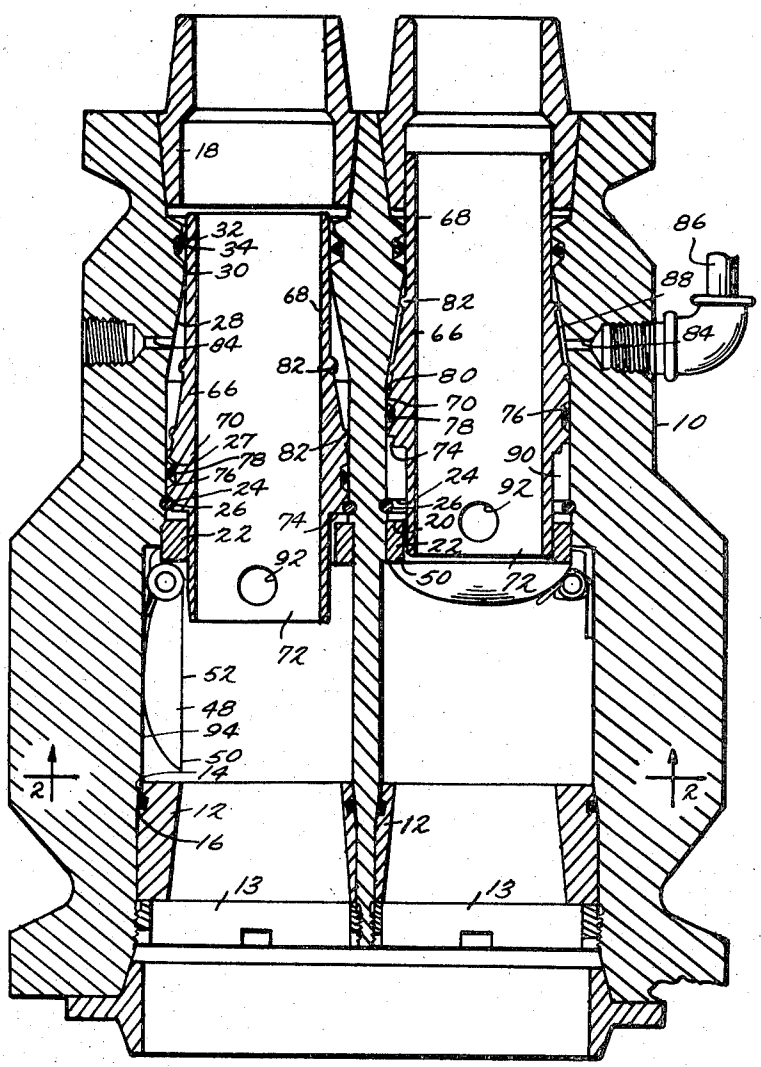
3,375,874	4/1968	Cherry et al.	166/224
3,265,134	8/1966	Tausch	166/224
2,812,821	11/1957	Nelson	166/224
2,921,601	1/1960	Fisher	166/224
2,944,793	7/1960	Conrad	251/348
3,071,151	1/1963	Sizer	166/224
3,078,923	2/1963	Tausch	166/224
3,092,135	6/1963	Brown et al.	166/224

Primary Examiner—James A. Leppink
Attorney—Cushman, Darby & Cushman

[57] **ABSTRACT**

Preferably installed in a socket in the well head, the flapper-type check valve incorporates a differential pressure-operated piston as an opening and closing sleeve. The valve may be economically installed in existing wells e.g. offshore dual wells on multiple well platforms to provide internal blowout and anti-fire protection for wells which presently have no other positive closure than e.g. a storm choke. Even though closed, the flapper-type safety device allows for pumping fluids downward into the well.

13 Claims, 6 Drawing Figures



PATENTED APR 10 1973

3,726,341

SHEET 1 OF 4

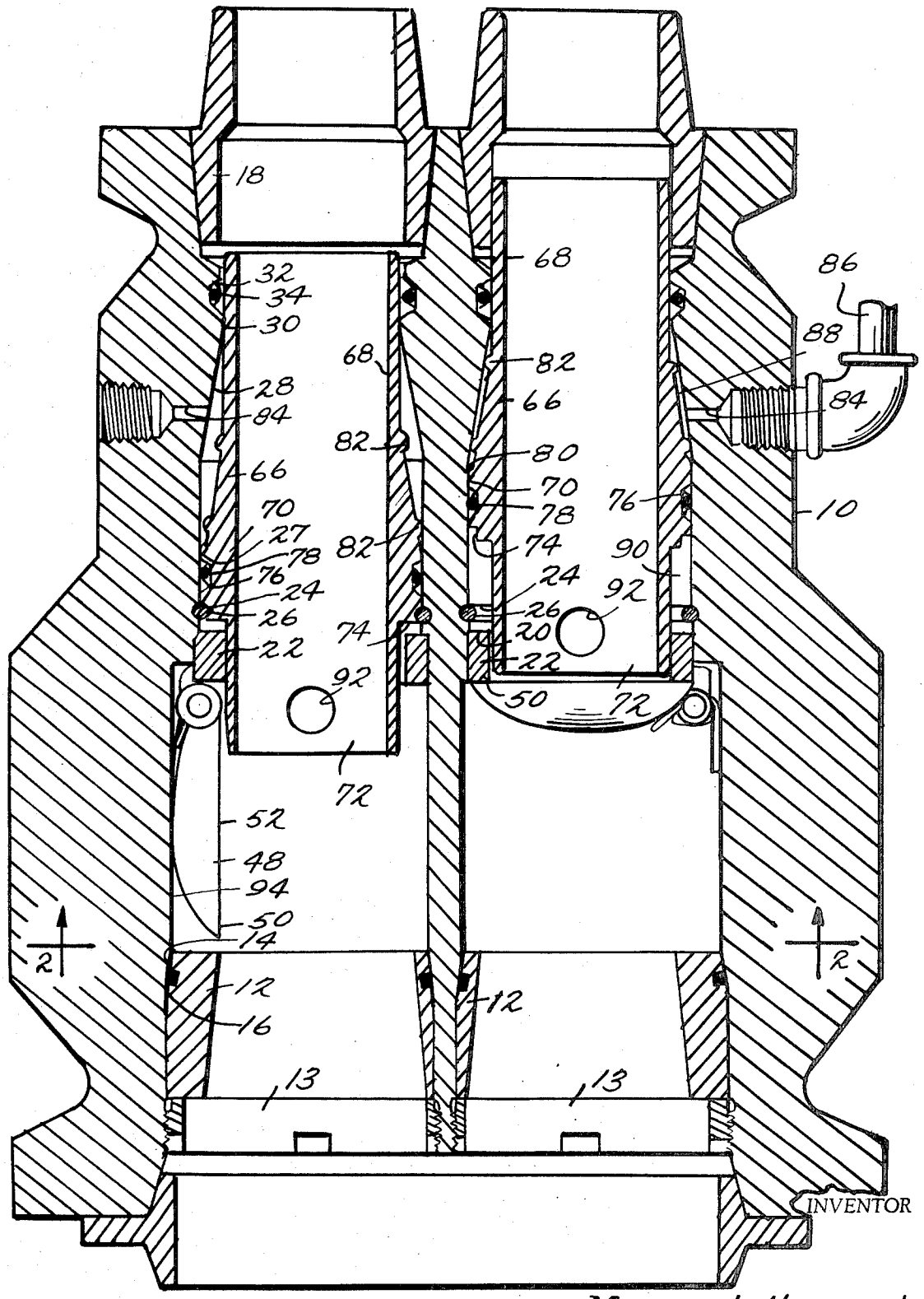


Fig. 1.

INVENTOR
MARVIN L. HOLBERT, JR
BY Cushman, Darby & Cushman
ATTORNEYS

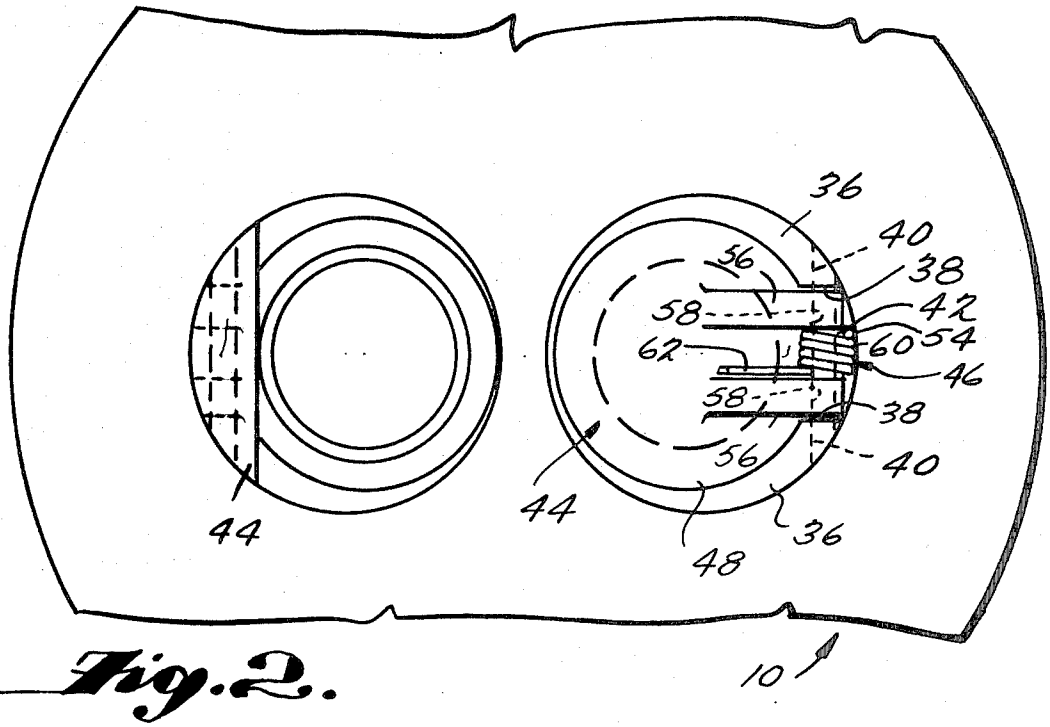


Fig. 2.

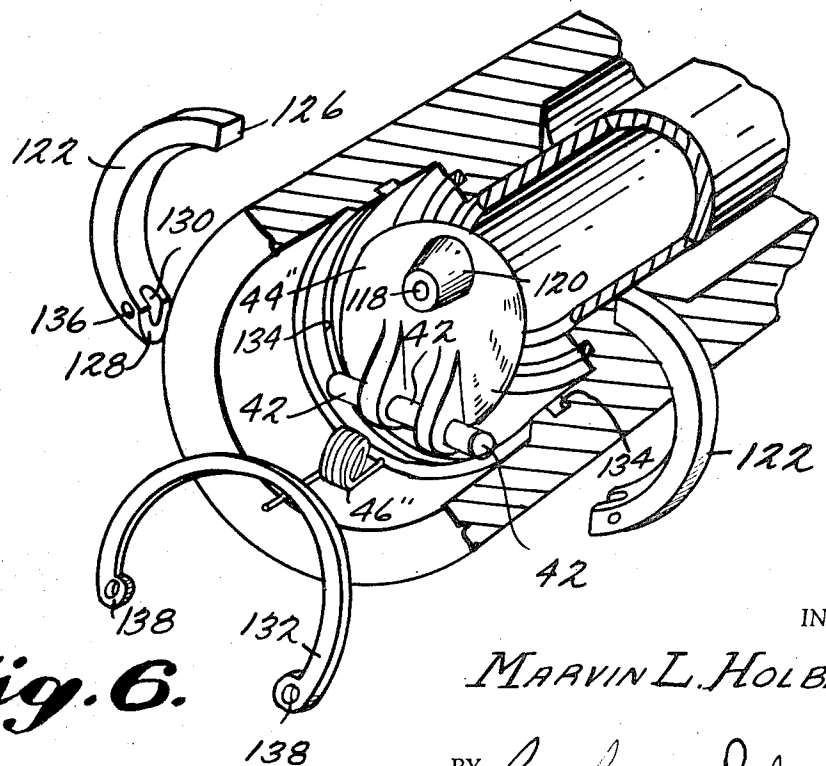


Fig. 6.

INVENTOR

MARVIN L. HOLBERT, JR.

BY Cushman, Darby & Cushman

ATTORNEYS

Fig. 3.

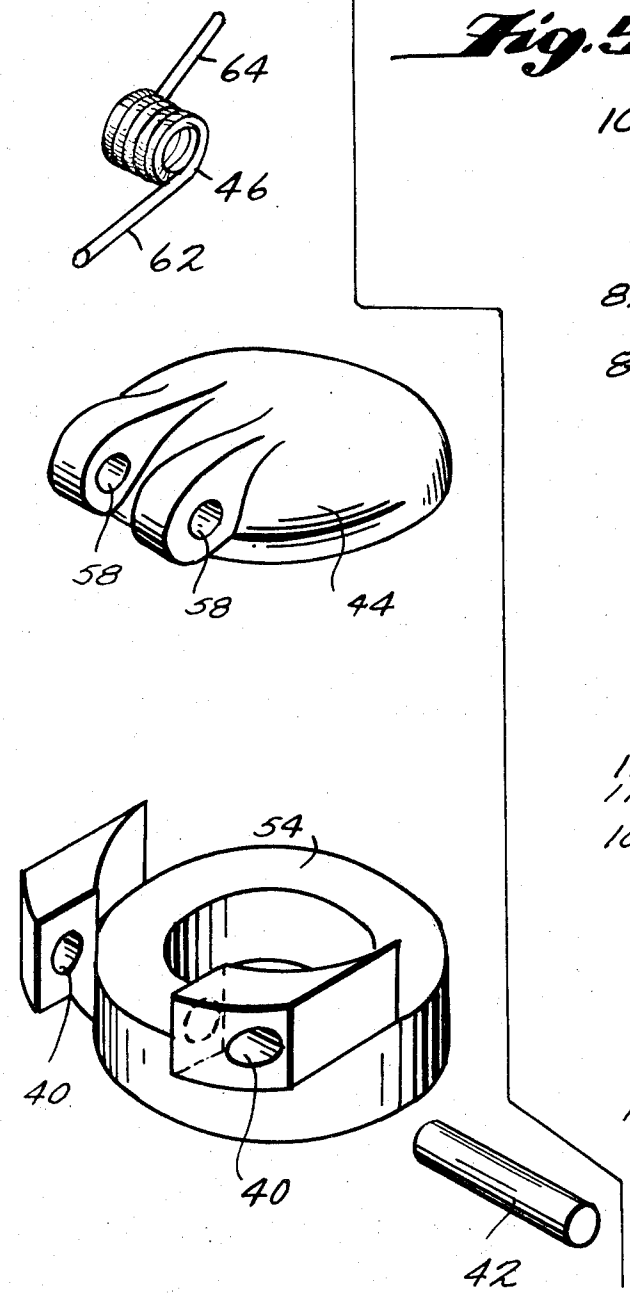
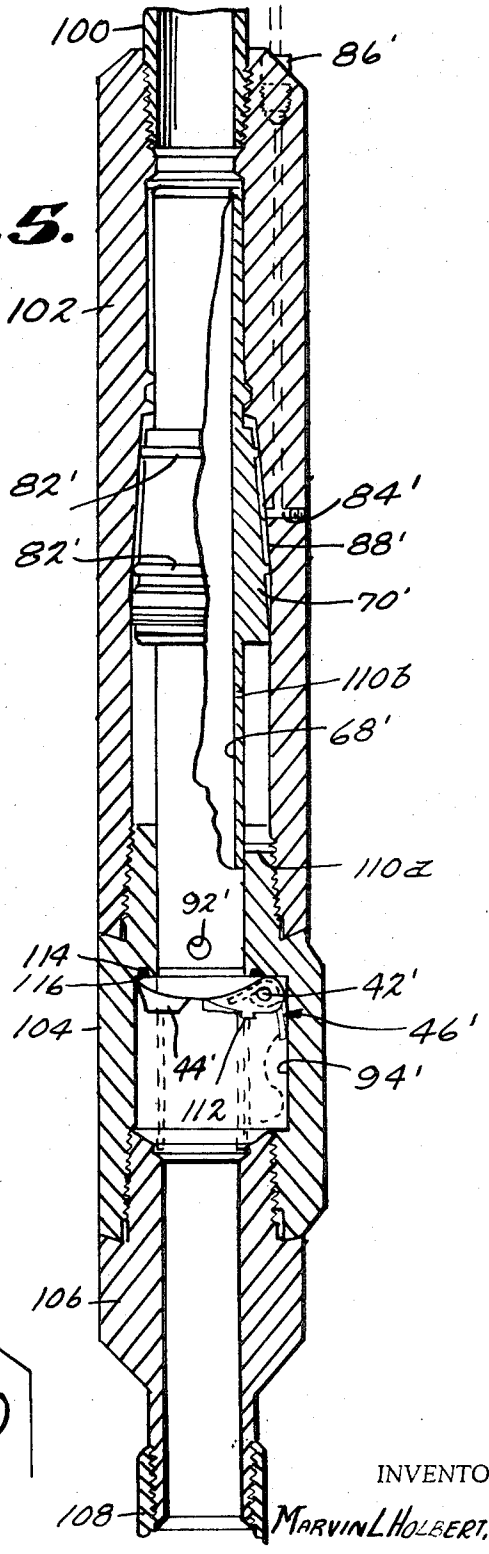


Fig. 5.



INVENTOR
MARVIN L. HOLBERT, JR.

BY Cushman, Darby & Cushman
ATTORNEYS

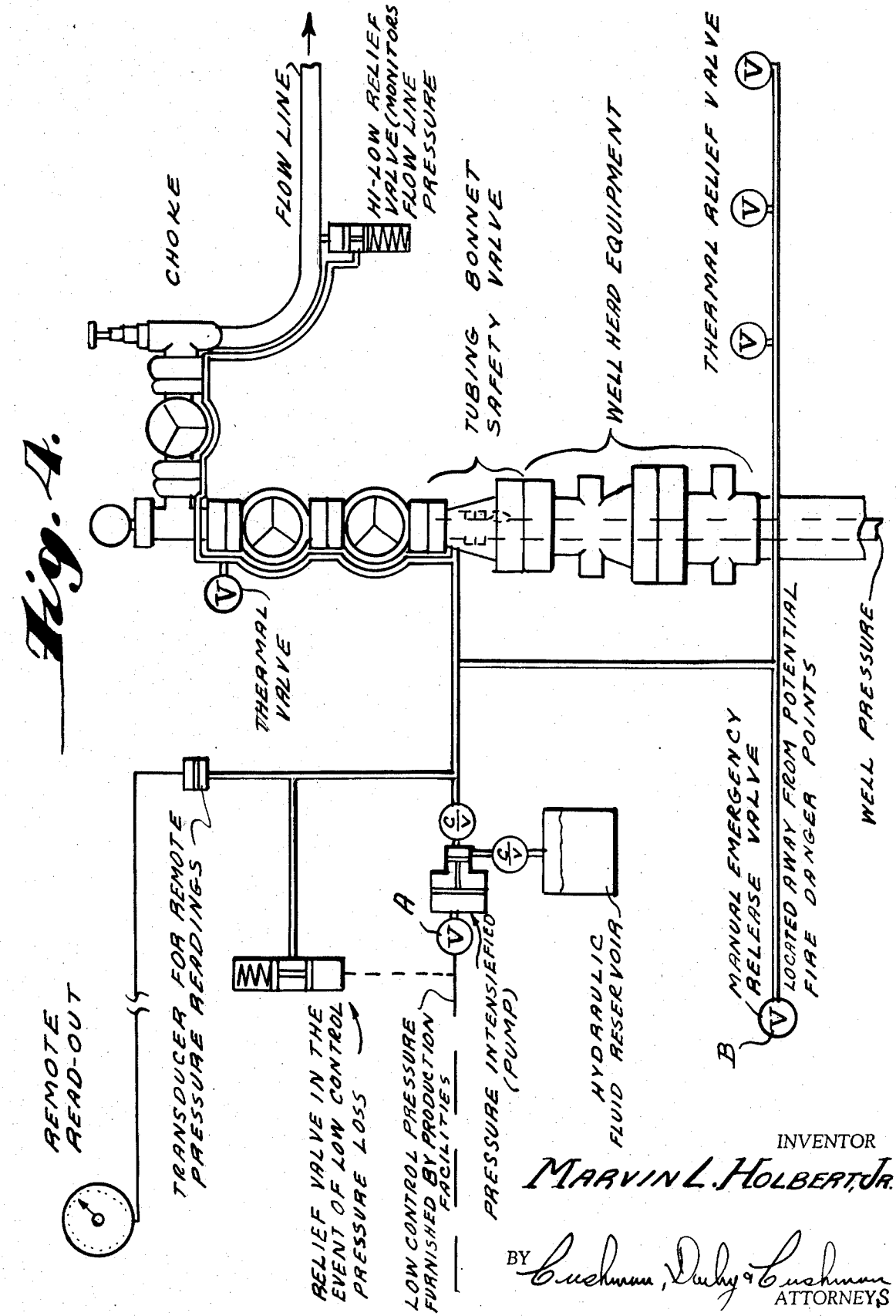


Fig. 4.

INVENTOR
MARVIN L. HOLBERT, JR.

BY Cushman, Darby & Cushman
ATTORNEYS

PETROLEUM WELL TUBING SAFETY VALVE

BACKGROUND OF THE INVENTION

Recent highly publicized offshore petroleum well fires and other mishaps have broght to increasing scrutinization the measures taken to minimize the potentials for disasters of various well-connected mishaps such as fires, subterranean pressure surges, platform disturbances due to storms, shifting submarine foundations and the like. Some wells which were completed when the potential hazards were not as fully understood could be better equipped than they are to prevent surprises from turning to disasters. However, the disassembly of wells to make safety-related modifications is not without risk-taking. Some disassembly procedures needed for installation of conventional safety equipment call for dewelding, cutting of pipes, and other procedures which can make not-normally-timid workers edgy until their task has been completed, owing to their respect for the dangers.

Of coures, safety valves, basically, are not a new development. The following U.S. patents depict flapper valves in the context of petroleum wells:

Patentee	U.S. Pat. No.	Issue date
R.L. Fletcher	1,255,147	Feb. 5, 1918
J.C. Fortune	1,814,549	July 14, 1931
B.H. Scott	1,818,508	Aug. 11, 1931
M.L. Hacker	2,162,578	June 13, 1939
C.E. Burt et al	2,189,703	Feb. 6, 1940
L.O. Goodwin	2,354,310	July 25, 1944
T.M. Ragan	2,624,412	Jan. 6, 1953
J.R. Baker	2,630,865	Mar. 10, 1953
J.R. Baker et al.	2,841,171	July 1, 1958
H.H. Fisher, Jr.	2,921,601	Jan. 19, 1960
M.B. Conrad	2,944,793	July 12, 1960
J.R. Baker	2,984,303	May 16, 1961
C.C. Brown	2,994,381	Aug. 1, 1961
J.D. Keithahn	3,016,914	Jan. 16, 1962
R.H. Magill et al.	3,016,955	Jan. 16, 1962
J.S. Page	3,035,641	May 22, 1962
P.S. Sizer	3,071,151	Jan. 1, 1963
G.H. Tausch	3,078,923	Feb. 26, 1963
J.R. Brown et al.	3,092,135	June 4, 1963
G.H. Tausch	3,265,134	Aug. 9, 1966

Note, e.g. from Tausch U.S. Pat. No. 3,078,923, that differential fluid pressure has been employed to keep such flapper valves open. A pressure equalizer is provided in Tausch at **43**. Shear pins are sometimes used to keep various parts "cocked" until their actuation is desired, e.g. see the pin 53 in Brown U.S. Pat. No. 2,994,381 for one context where a shear pin is employed.

The present inventor and his coworkers have been active in the design of flapper-type check valves as evidence by the U. S. patent of Latham and Holbert, Jr. No. 3,509,908, issued May 5, 1970 and the copending U. S. patent application of Boitnott, Ser. No. 869,160, filed Oct. 24, 1969.

SUMMARY OF THE INVENTION

Preferably installed in a socket in the well head, the flapper-type check valve incorporates a differential pressure-operated piston as an opening and closing sleeve. The valve may be economically installed in existing wells, e.g. offshore dual wells on multiple well platforms to provide internal blowout and anti-fire protection for wells which presently have no other positive closure than e.g. a storm choke.

Pressure is supplied to the piston through a control port in the head via a control line.

To actuate the safety valve to the open position, hydraulic fluid, under pressure, is forced down control line through the control port, into a cylinder cavity and brought to bear on the piston.

As the pressure against the piston is increased in an amount slightly greater than present in the well tubing bore, the piston will be forced downward.

As piston rod stinger engages the valve's flapper during the opening operation, pressure trapped in the annulus is allowed to be displaced by virtue of an equalizing port.

As the piston causes the piston rod to move downwardly through the bore, the flapper is forced back into an eccentric recess allowing the piston rod end to cover the flapper and seal surface.

The safety valve is now in its operating, or open, position.

To close the safety valve, the unbalanced pressure in cavity is reduced. Pressure in the annulus will move piston and rod back to its uppermost position.

As the upward movement of the piston draws the piston rod end past the flapper and the flapper seat, the flapper return spring will rotate the flapper about its pviot point and come to rest on the seal surface.

Upon reaching its uppermost position, tapered seals are forcedly seated against a seal surface forming a secondary metal-on-metal pressure barrier.

When it is desirable to run the safety valve in its open position an optional shear pin holds the piston at approximately **90** per cent of its downward travel. This holds the flapper in its open position. To put the valve into operation, pressure sufficient to shear the pin is applied through the control line. Upon shearing of the pin, the piston completes the remaining 10 per cent of its downward stroke.

As an added feature, should the well "kick" or tend to blow out while running the tubing, pressure buildup in the bore serves to shear the pin causing the piston to move upward, thereby closing the valve. This feature offers internal blowout protection.

Control of the piston through the control port can be effected by pump pressure, a thermal actuated device, an electronic device, or well pressure, and such control may be adjacent to the christmas tree or at some remote place. Multiple well platforms, as are found in offshore producing areas, can have a monitoring arrangement whereby, if a problem occurs at one well, all wells can be immediately shut in.

The safety valve device is full opening; tubing can be plugged below it; it is completely enclosed; and its opening and closing capabilities can be checked at any time. The internal parts can be made out of stainless steel and can be hard faced, if required.

The principles of the invention will be further hereinafter discussed with reference to the drawings wherein a preferred embodiments are shown. The specifics illustrated in the drawings are intended to exemplify, rather than limit, aspects of the invention as defined in the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a fragmentary longitudinal perspective view of a dual well wellhead equipped with two safety valves in accordance with the present invention. One valve is

shown in an open, operating condition, the other is shown closed;

FIG. 2 is a sectional view taken upwardly from the line 2—2 in FIG. 1;

FIG. 3 is an exploded perspective of the valve flapper and associated parts;

FIG. 4 is a schematic view of several wells equipped with valves in accordance with the present invention and tied to a common monitoring and control system;

FIG. 5 is a longitudinal sectional view of one modified form of the safety valve;

FIG. 6 is a fragmentary exploded perspective view of another modified form of the safety valve.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIGS. 1 and 2, the element 10 is a tubing bonnet, which forms part of a well head, e.g. being mounted between the tubing head and the christmas tree master valve. An example of the location of tubing head bonnet in a well head is shown on page 2,245 of the 1970–71 Edition of the Composite Catalog of Oilfield Equipment and Services, Gulf Publishing Company, Houston, Texas. Other tubing head bonnets for use on single or multiple zone oil or gas wells are shown on pages 2,238, 2,239, 2,248 and 2,249 of the same catalog.

In the instance depicted, the bonnet is for a dual, side-by-side completion wherein two tubing strings are hung in the well and terminate in respective production zones. Tubing hanger (not shown) for suspending tubing strings have tapered upper ends which seat and seal in the internal tapered bores of the adapters 12. The adapters 12 seal with the tapered seats 14 in the tubing bonnet. The adapters 12 are secured in place by threaded rings 13.

The upper ends of the bores 16 are also tapered, to receive double tapered annular sealing cones 18 which project upwardly therefrom the seal with corresponding bores in the master valve.

Intermediate the sealing provisions at the ends of the tubing bonnet, the through bores 16 each have the following features of interest, starting nearer their lower ends: The bore 16 undergoes a reduction in cross-sectional area at 20 to provide a site for an annular valve seat, which, in the instance depicted, is constituted by an annular ring 22 fixed in the bore adjacent the shoulder 20 produced by the reduction. Above the shoulder 20 a circumferential, radially inwardly opening groove 24 is located for mounting a snap ring 26 which serves as a positive stop for the control piston. Above the groove 24, the bore 16 is cylindrical for a distance at 27 then has a frustoconically tapering portion at 28, followed by a return to cylindricity at 30. The latter portion leads up to the sealing cone seat at the upper end of the bore 16. Intermediate its axial extent, the portion 30 is provided with a circumferential, radially inwardly opening groove 32 which receives an 0-ring seal 34.

Returning to the valve seat, it should be noticed that the annular ring 22, on its downwardly facing side, includes two arcuate, ramp-like enlargements 36 which terminate with ends 38 squarely facing one another. An opening 40 is formed in each enlargement 36; the two openings 40 are in axial alingment and receive an axle or trunnion 42 which also mounts the valve flapper 44 and a return spring 46. The valve flapper 44 is a disk 48 having an annular peripheral portion 50 of its front face 52 configured to sealingly seat against the downwardly facing annular seating surface 54 of the valve seat.

The back of the valve flapper disk has two, laterally spaced ribs 56 with aligned openings 58 through them via which the valve flapper is mounted on the trunnion 42.

The return spring 46 is a torsion spring which in the instance depicted includes a central coil 60 of several turns, and opposite end legs 62, 64. Th coil 60 is received between the ribs 56 with the trunnion 42 passing through the coil. The spring leg 62 gets leverage against the back of the valve disk between the ribs 56 and the spring leg 64 gets leverage against the wall of the througbore 16 of the tubing bonnet, below the valve seat.

The equipment depicted in FIGS. 1 and 2 further includes a control piston 66 received in each throughbore 16. Each control piston 66 is tubular, with a generally smooth throughbore 68. Each piston 66 includes an enlarged central body 70 having a stinger 72 extending axially downwardly therefrom and a tail extending axially upwardly therefrom. The body 70, from its outer, lower extent, includes a circumferentially extending, downwardly facing shoulder 74 configured and positioned to abut the stop 26 to a limit downward travel of the piston. Above the shoulder 74 the piston is exteriorly generally cylinderically curved and of a diameter to be disposed adjacent the portion 27 of the bore 16, and includes a circumferentially extending, radially outwardly opening groove 76 which receives an 0-ring 78. The latter seals against the bore portion 27. A short way above the groove 76, the piston body exterior begins a generally furstoconically curved reduction in diameter at 80 complementarily to the surface portion 28 of the bore 16. The curved surfacd 80 is punctuated at two, vertically spaced locations by integral, circumferentially extending beads 82.

It should now be noticed that the piston member is sufficiently long that, when it is all the way down against the stop ring, the stinger has pushed the flapper to a fully open condition (FIGS. 1 and 2, left side) yet the exterior of the upper end region of the piston tail remains in sealing contact with the 0-ring 34. It should further be noticed that when the piston member is all the way up, with both the beads 82 in metal-to-metal sealing contact with the bore 16 frustoconically curved surface portion 28, the lower end of the stinger lies slightly above the valve seat surface 54 so the flapper can fully close.

In the instance depicted, in order to make the bonnet as longitudinally compact as possible, the tapered seats at the upper ends of the bores 16 have been made larger and the double tapered sealing cones are of the transitional type (i.e. the lower frustoconical surface of each is of larger diameter throughout than is the upper frustoconical surface thereof). Thus, when the control piston is in its uppermost condition (as depicted at the right in FIGS. 1 and 2) the upper end portion of the tail of the control piston is received within the bore of the lower half of the respective double tapered sealing cone.

It should now be further noticed that two control ports **84** are provided in the bonnet which respectively communicate with the two bores **16** through the surface portions **28** at a level that is intermediate the two beads **82** (when the pistons are in their respectively uppermost conditions).

Tubular control lines **86** are connected to the respective control ports **84**; the control lines are also communicated to a source of fluid pressure.

To actuate either safety valve to the open position, hydraulic fluid, under pressure, is forced down its control line **86** through the control **84**, into the cylinder cavity **88** and brought to bear on the piston.

As the pressure against the piston is increased in an amount slightly greater than present in the tubing bonnet bore **16**, the piston will be forced downward.

As piston rod stinger engages the valve's flapper during the opening operation, pressure trapped in the annulus **90** is allowed to be displaced by virtue of an equalizing port **92** in the stinger.

As the piston moved downwardly through the bore, the flapper is forced back into an eccentric recess **94**, allowing the piston stinger to cover the flapper and valve seat surface.

The safety valve is now in its operating, or open, position.

To close the safety valve, the unbalanced pressure in cavity **88** is reduced. Pressure in the annulus **90** will move piston and rod back to its uppermost position.

As the upward movement of the piston draws the piston stinger past the flapper and the flapper seat, flapper return spring will rotate the flapper about its pivot point and come to rest on the seal surface.

Upon reaching its uppermost position, tapered seals are forcedly seated against a seal surface **28** forming a secondary metal-on-metal pressure barrier.

When it is desirable to run the safety valve in its open position, an optional shear pin holds the piston at approximately 90 per cent of its downward travel. This holds the flapper in its open position. To put the valve into operation, pressure sufficient to shear the pin is applied through the control line. Upon shearing of the pin, the piston completes the remaining 10 per cent of its downward stroke.

As an added feature, should the well "kick" or tend to blow-out while running the tubing, pressure buildup in the bore serves to shear the pin causing the piston to move upward, thereby closing the valve. This feature offers internal blow-out protection.

Control of the piston through the control port can be effected by pump pressure, a thermal actuated device, an electronic device, or well pressure, and such control may be adjacent to the christmas tree or at some remote place. Multiple well platforms as are found in offshore producing areas, can have a monitoring arrangement (FIG. **4**) whereby, if a problem occurs at one well, all wells can be immediately shut in.

Referring to FIG. **4**, the safety valve may be installed with the flapper in the open or closed position. The low pressure control line leads to the pressure intensifier, i.e., pump. As the pump charges the high pressure line, valves installed in the closed position would open, allowing access to the tubing bore. To subsequently test the closing or opening capability of the devices, valve "A" would be closed, and valve "B" opened, thereby releasing pressure that had been holding the closure means in an open position; well pressure would then actuate the closing means of each device. The safety valves would be opened by closing valve "B" and opening valve "A", allowing pressures to actuate the pump. Pressure would build to a point greater than the well pressure, thereby opening the safety valves. The pressure intensifier and valves "A" and "B" can be electrically or hydraulically operated from a remote source.

The safety valve device is full opening; tubing can be plugged below it; it is completely enclosed; and its opening and closing capabilities can be checked at any time. The internal parts can be made out of stainless steel and can be hard faced, if required.

A real advantage of the safety valve design depicted in FIGS. **1–3** is that it can be installed in existing wells with a very minimum of disturbance and disassembly. What is involved is: plugging the tubing, removing the main control valve and old tubing bonnet, mounting the control valve on a bonnet equipped with safety valve means as shown in FIG. **2**, reinstalling this assembly on the remaining lower part of the wellhead, removing the tubing plugs and pressurizing the control lines to open the well to production.

Due to the relative ease with which such installations can be made, the safety valve structure of FIGS. **1–3** is preferred. The well depicted is a dual-completed well, partly in order to illustrate the valve in an open and a closed relationship in close juxtaposition; the tubing head bonnets of singly, triply or other multiply completed wells can be similarly provided with safety valves in accordance with the present invention. Although "tubing bonnet" is a well-known term in the oil and gas well equipmemt field, there is far from uniformity among well equipment manufacturers in structuring and naming the various parts of a well head, especially one for offshore use. For that reason it should be appreciated that the apparatus of the invention may be installed in a functionally comparable part of a well head, even if that part is not called a tubing head, and yet not depart from the underlying principles of the present invention.

Another safety valve installation is shown in FIG. **5**. In this instance the valve is mounted directly within a short section of the tubing string whose bore is to be controlled by the valve. Apparatus parts which have equivalents in FIGS. **1–4** are correspondingly numbered, but primed.

The conduit members shown in FIG. **5** are: an upper portion **100** of the tubing string, an upper sub **102**, a valve housing **104**, a lower sub **106** and a lower portion **108** of the tubing string. Structly speaking, the parts **102** and **106** can also be referred to as parts of the housing. They are separated from the part **104** for manufacturing, supply and servicing convenience.

As generally discussed in respect to the preferred embodiment, the tubing string containing the safety valve may be run into the well with the control piston of the valve temporarily pinned in a lower position, for instance **90** percent down, using a shear pin **110** (shown sheared into fragments a and b). Then, to shear the pin, the piston is pressurized through the control line in a sense to drive it down the remainder of the distance to its stop.

The flapper retainer is shown being partially instead of fully circumferentially extending; it is bolted to the valve housing at **112**. A full annular metal seal is provided for seating the flapper, recessed into a groove **114** in the housing at **116**.

In the embodiment shown in FIG. **6**, wherein the comparable parts are doubly primed, the extent to which the flapper may open is adjustable by virtue of an exteriorly threaded bumper plug **118** threadably received in a socket **120** in the lower side of the flapper.

Two somewhat arcuately less than semicircular flapper retainer segments **122** are received in the circumferential recess **124** adjoining the shoulder which contains the valve seat. The segments **122** each have one end **126** abutting the corresponding end of the other. The opposite ends **128** of the segments **122** are provided with sockets **130** which receive and journal the two outer ends of the valve flapper trunnion.

The assembly which includes the flapper retainer segments, the flapper, its axle and the torsion spring is maintained in a mounted condition in the valve housing, by an internal snap ring **132** removably fixed in the groove **134**. Bosses **136** are shown formed on the downstream faces of the flapper retainer segments near their ends. These lie adjacent the ends **138** of the snap ring to prevent rotation of the flapper retainer segments with respect to the snap ring. The valve embodiment of FIG. **6** may be installed in either the tubing string of FIG. **5** or the tubing head of FIG. **1**.

It should now be apparent that the Petroleum Well Tubing Safety Valve as described hereinabove posseses each of the attributes set forth in the specification under the heading "Summary of the Invention" hereinbefore. Because the Petroleum Well Tubing Safety Valve of the invention can be modified to some extent without departing from the principles of the invention as they have been outlined and explained in this specification, the present invention should be understood as encompassing all such modifications as are within the spirit and scope of the following claims.

What is claimed is:

1. A safety valve for incorporation in the flow path of petroleum issuing from a petroleum well through a tubing string comprising: a tubular housing forming a part of a petroleum well completion; means defining a circumferentially extending, annular seat in the throughbore of the housing, facing downwardly; a flapper; axle means on said flapper laterally offset from a diameter of the flapper; means mounting the axle means with respect to the housing so the flapper is movable between an open condition wherein the flapper is disposed generally parallel to the petroleum flow path, below the annular seat and a closed condition wherein the flapper is seated against the annular seat, interrupting the petroleum flow path; spring means mounted in the housing, said spring means disposed to urge the flapper toward the seat; a tubular piston vertically slidably disposed in the throughbore of the housing so as to be disposed above the valve seat when the flapper is in a closed condition; means defining an upwardly facing surface on said piston; two circumferentially extending seal means disposed between and sealing with the housing and the piston, one above and one below said upwardly facing surface; fluid conduit means communicating through the housing to the ambit of the upwardly facing surface so that pressurized fluid may be admitted to bear against said upwardly facing surface to drive said piston downwardly; stop means in said housing and stop shoulder means on said piston abuttable with one another to limit downward travel of the piston; said piston including downwardly projecting stinger means engageable with the flapper as the piston is driven downwardly for forcing the flapper to an open condition; and downwardly facing surface means on the piston subject to pressure in the petroleum flow path for causing upward movement of the piston, withdrawing the stinger from forceable opening of the flapper so that the spring may close the flapper the upwardly facing surface being generally frustoconically curved; the throughbore radially adjacent the upwardly facing surface when the piston is uppermost being complementarily frustoconically curved; the fluid conduit means communicating with the throughbore intermediate the frustoconically curved portion of the throughbore and the valve further including a metal seal ring above and another below the communication of the fluid conduit means with the throughbore for sealing between the complementarily frustoconically curved surfaces of the piston and the housing.

2. The safety valve of claim **1** wherein said tubular housing is constituted by a well head part.

3. The safety valve of claim **1** wherein said tubular housing is constituted by a tubing bonnet.

4. The safety valve of claim **3** wherein the tubing bonnet is equipped for a multiple completion by having a plurality of side-by-side longitudinal throughbores, including said throughbore, provided at their upper ends with means for establishing a sealed relationship with respective bores of a christmas tree master valve and at their lower ends with means for establishing a sealed relationship with individual strings of tubing.

5. The safety valve of claim **1** wherein the tubular housing is constituted by tubular sub means incorporated in a tubing string between the ends of the tubing string.

6. The safety valve of claim **1** further including frangible a shear pin initially pinning the piston to the housing with the piston at such a lowered condition that the stinger holds the flapper nearly open, but the stop means on the piston and housing are not in abutment.

7. The safety valve of claim **1** wherein the stop means on the housing is constituted by a circumferentially extending, radially inwardly opening recess in the housing; and a snap ring received in the housing and projecting radially inwardly from the groove.

8. The safety valve of claim **1** wherein the spring means is constituted by a torsion spring including at least one leg disposed to bear against the flapper in such sense as to urge the flapper toward the seat and at least another leg disposed against the housing.

9. The safety valve of claim **8** wherein said torsion spring includes a curved intermediate portion looped around said axle means for retention.

10. A safety valve for incorporation in the flow path of petroleum issuing from a petroleum well through a tubing string comprising: a tubular housing forming a part of a petroleum well completion; means defining a

circumferentially extending, annular seat in the throughbore of the housing, facing downwardly; a flapper; axle means on said flapper laterally offset from a diameter of the flapper; means mounting the axle means with respect to the housing so the flapper is movable between an open condition wherein the flapper is disposed generally parallel to the petroleum flow path, below the annular seat and a closed condition wherein the flapper is seated against the annular seat; interrupting the petroleum flow path; spring means mounted in the housing, said spring means disposed to urge the flapper toward the seat; a tubular piston vertically slidably disposed in the throughbore of the housing so as to be disposed above the valve seat when the flapper is in a closed condition; means defining an upwardly facing surface on said piston; two circumferentially extending seal means disposed between and sealing with the housing and the piston, one above and one below said upwardly facing surface; fluid conduit means communicating through the housing to the ambit of the upwardly facing surface so that pressurized fluid may be admitted to bear against said upwardly facing surface to drive said piston downwardly; stop means in said housing and stop shoulder means on said piston abuttable with one another to limit downward travel of the piston; said piston including downwardly projecting stinger means engageable with the flapper as the piston is driven downwardly for forcing the flapper to an open condition; and downwardly facing surface means on the piston subject to pressure in the petroleum flow path for causing upward movement of the piston, withdrawing the stinger from forceable opening of the flapper so that the spring may close the flapper; said housing including means defining a circumferential downwardly facing ledge in said throughbore and means defining a circumferentially extending, radially inwardly opening groove subjacent the ledge; two arcuate retainers being received in the throughbore, against the ledge, the retainers each having one end engaging the corresponding end of the other; the opposite ends of the retainers having means defining recesses therein which open facing one another; the opposite ends of the axle means being received in the recesses; and a snap ring received in the inwardly open groove to hold the arcuate retainers in place, so that the ledge, groove, retainers and snap ring constitute said mounting means for the axle means.

11. A safety valve for incorporation in the flow path of petroleum issuing from a petroleum well through a tubing string comprising: a tubular housing forming a part of a petroleum well completion; means defining a circumferentially extending, annular seat in the throughbore of the housing, facing downwardly; a flapper; axle means on said flapper laterally offset from a diameter of the flapper; means mounting the axle means with respect to the housing so the flapper is movable between an open condition wherein the flapper is disposed generally parallel to the petroleum flow path, below the annular seat and a closed condition wherein the flapper is seated against the annular seat, interrupting the petroleum flow path; spring means mounted in the housing, said spring means disposed to urge the flapper toward the seat; a tubular piston vertically slidably disposed in the throughbore of the housing so as to be disposed above the valve seat when the flapper is in a closed condition; means defining an upwardly facing surface on said piston; two circumferentially extending seal means disposed between and sealing with the housing and the piston, one above and one below said upwardly facing surface; fluid conduit means communicating through the housing to the ambit of the upwardly facing surface so that pressurized fluid may be admitted to bear against said upwardly facing surface to drive said piston downwardly; stop means in said housing and stop shoulder means on said piston abuttable with one another to limit downward travel of the piston; said piston including downwardly projecting stinger means engageable with the flapper as the piston is driven downwardly for forcing the flapper to an open condition; and downwardly facing surface means on the piston subject to pressure in the petroleum flow path for causing upward movement of the piston, withdrawing the stinger from forceable opening of the flapper so that the spring may close the flapper; said stinger being tubular and including means defining a lateral port for venting pressure from the region of the throughbore lying exteriorly of the piston between the stop shoulder means on the piston and on the housing.

12. The safety valve of claim 11 further including eccentric recess means in said throughbore below said valve seat, adjacent said axle means, for receiving the flapper when the flapper is in an open condition.

13. The safety valve of claim 11 wherein the valve seat is formed on the lower side of an annular member further provided with arcuate ribs along the outer periphery of the lower side thereof, which ribs extend toward one another sufficiently to receive the opposite ends of said axle means to provide said means for mounting said axle means.

* * * * *