PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
E21B 34/10

A1

(11) International Publication Number: **WO 98/57029**

(43) International Publication Date: 17 December 1998 (17.12.98)

(21) International Application Number: PCT/US98/12121

(22) International Filing Date: 10 June 1998 (10.06.98)

(30) Priority Data:
06/049,171 10 June 1997 (10.06.97) US

(71) Applicant: CAMCO INTERNATIONAL INC. [US/US]; 7030 Ardmore, Houston, TX 77054 (US).

(72) Inventors: HILL, Thomas, G., Jr.; 1426 Losty Maple Trail, Kingwood, TX 77345 (US). MAY, Dwayne, E.; 20119 Atascocita Shores Drive, Humble, TX 77346 (US).

(74) Agent: QUISENBERRY, C., Dale; Tobor & Goldstein, L.L.P., Suite 2300, 1360 Post Oak Boulevard, Houston, TX 77056 (US).

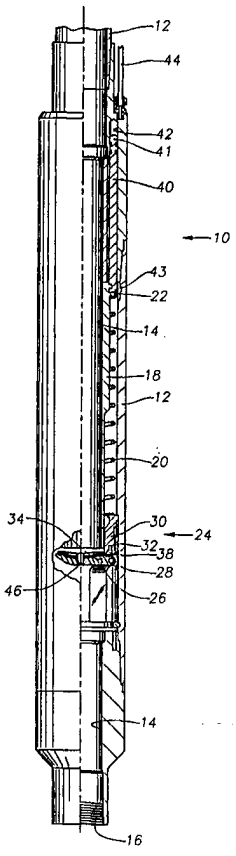
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: PRESSURE EQUALIZING SAFETY VALVE FOR SUBTERRANEAN WELLS

(57) Abstract

A subsurface safety valve (10) having a valve member (26) with a pressure equalizing mechanism is provided. The valve member (26) includes a bore (48) therethrough for receiving an equalizing plug (46). A strike plate (50) is disposed above the valve member and connected to the equalizing plug for transferring downward motion of a flow tube (18) to unseat the equalizing plug, and thereby establish fluid communication through the valve member prior to the opening of the valve member. A spring (54) may be disposed between the lower surface of the strike plate (50) and the upper surface of the valve member to upwardly bias the strike plate away from the valve member, and to thereby upwardly bias the equalizing plug (46) within the plug bore of the valve member.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

PRESSURE EQUALIZING SAFETY VALVE FOR SUBTERRANEAN WELLS

RELATED APPLICATIONS

This application claims the benefit of U. S. Provisional Application No. 60/049,171, filed June 10, 1997.

BACKGROUND OF THE INVENTION

1. Field Of The Invention

The present invention relates to a subsurface safety valve used for controlling fluid flow in a well conduit and, more particularly, to an equalizing subsurface safety valve.

2. Description Of The Related Art

Subsurface safety valves are commonly used in wells to prevent uncontrolled fluid flow through the well in the event of an emergency, such as to prevent a well blowout. Conventional safety valves use a flapper which is biased by a spring to a normally closed position, but is retained in an open position by the application of hydraulic fluid from the earth's surface. A typical subsurface safety valve is shown and described in U.S. Pat. No. 4,161,219, which is commonly assigned hereto.

When the flapper is in the closed position, well fluid pressure below the flapper acting upon a relatively large surface area of the flapper makes opening of the flapper difficult. This difficulty in opening cannot be easily overcome simply by increasing the force exerted against the flapper by an opening piston and cylinder assembly because the relatively small cross-sectional area of the opening piston and cylinder assembly would require a fluid pressure that may burst the control line carrying hydraulic fluid from the earth's surface to the piston and cylinder assembly. Additionally, when the flapper is opened the initial flow of well fluid is relatively rapid which tends to etch, or erode, the primary sealing surface of the flapper. Any

damage to this primary sealing surface is extremely critical because it is this sealing surface which must be intact to prevent uncontrolled flow of well fluids and to prevent a possible well blow out. The present invention solves these difficulties by providing a subsurface safety valve with an equalizing mechanism to allow the pressure above and below the flapper to equalize prior to the complete opening of the flapper.

SUMMARY OF THE INVENTION

The present invention is directed generally to a subsurface safety valve with a pressure equalizing mechanism. In a broad aspect, the equalizing subsurface safety valve of the present invention includes a body member having a longitudinal bore extending therethrough; a valve actuator disposed for axial movement within the longitudinal bore; means for controllably moving the valve actuator within the longitudinal bore; a valve member mounted within the body member to control fluid flow through the longitudinal bore, the valve member having an upper surface, a lower surface, and a bore therethrough; means for biasing the valve member to a normally closed position to prevent fluid flow through the longitudinal bore; means for biasing the valve actuator away from the valve member; an equalizing plug disposed for reciprocal movement within the bore of the valve member for controlling fluid flow through the valve member; a strike plate having a periphery and an actuating member, the strike plate extending into a path of the valve actuator, the actuating member extending downwardly from the strike plate into the bore through the valve member and being connected to the equalizing plug; and a spring disposed between the strike plate and the upper surface of the valve member adjacent the periphery of the strike plate for upwardly biasing the strike plate away from the valve member and for upwardly biasing the equalizing plug within the bore through the valve member, whereby downward movement of the valve actuator is transferred through the strike plate to the equalizing plug to shift the plug

to open a passageway through the valve member and permit fluid pressure above and below the valve member to equalize before the valve member is opened to allow fluid flow through the longitudinal bore of the body.

Another feature of the present invention is that the means for controllably moving the valve actuator within the longitudinal bore includes a piston and cylinder assembly mounted to the body member with one side of the assembly adapted to be in communication with a source of hydraulic fluid for moving the valve member to the open position to permit fluid flow through the longitudinal bore. Another feature of the present invention is that the valve member is a flapper valve. Another feature of the present invention is that the valve member is a curved flapper valve. Another feature of the present invention is that the equalizing plug is a generally cylindrical plug having an upper portion and an enlarged annular sealing surface adjacent a first end thereof for cooperable sealing engagement with a sealing surface formed within the bore of the valve member. Another feature of the present invention is that the enlarged annular sealing surface further includes a metallic annular sealing surface. Another feature of the present invention is that the sealing surface within the bore of the valve member further includes an annular sealing surface. Another feature of the present invention is that the annular sealing surface within the plug bore further includes a metallic portion and a pliable portion. Another feature of the present invention is that the equalizing plug is held in a normally closed position by action of the spring against the strike plate. Another feature of the present invention is that the upper portion of the equalizing plug is disposed below the upper surface of the valve member. Another feature of the present invention is that fluid pressure within the well conduit is equalized through an internal fluid flow passageway formed through the equalizing plug and strike plate.

Another feature of the present invention is that the equalizing plug further includes an upper portion having a generally longitudinal bore, a generally longitudinal passageway, and at least one generally radially disposed opening, the bore extending downwardly from an upper surface of the equalizing plug and having a threaded portion, the passageway extending downwardly from the bore and being disposed in fluid communication with the at least one radially disposed opening, the at least one radially disposed opening exiting the plug at a location between a lower surface of the bore and the sealing surface on the shoulder of the plug; and the actuating member further includes a shank having a threaded portion for mating with the threaded portion of the bore in the upper portion of the plug, and a generally longitudinal passageway extending upwardly from a lower surface on the shank through the actuating member to an upper surface of the strike plate and cooperating with the longitudinal passageway and the at least one radially disposed opening in the equalizing plug to establish an internal fluid flow passageway through the valve member to equalize the fluid pressure above and below the valve member. Another feature of the present invention is that the longitudinal passageway extending through the actuating member further includes a flared portion adjacent the upper surface of the strike plate. Another feature of the present invention is that the upper surface of the valve member further includes a radial lip for receiving the strike plate and forming a groove for receiving the spring. Another feature of the present invention is that the spring is a compression spring. Another feature of the present invention is that the compression spring is a wave spring. Another feature of the present invention is that the compression spring is a Belleville spring.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure **1** is an elevational side view, partially in cross-section, showing a subsurface safety valve of the present invention.

Figure **2** is an elevational side view, in cross-section, showing an equalizing mechanism of the present invention installed in the flapper mechanism of the subsurface safety valve shown in Figure **1,** with both the flapper mechanism and the equalizing mechanism in closed positions.

Figure **3** is a fragmentary elevational view similar to Figure **2**, showing an equalizing mechanism of the present invention installed in the flapper mechanism of the subsurface safety valve shown in Figure **1,** with both the flapper mechanism and the equalizing mechanism in closed positions.

Figure **4** is an exploded elevational view showing the relationship between an equalizing plug of the present invention and a strike plate of the present invention.

Figure **5** is a view similar to Figure **3**, with the flapper mechanism still in a closed position, except that a flow tube has now moved downwardly to displace the equalizing mechanism of the present invention into an equalizing position.

Figure **6** is a fragmentary elevational view showing the flapper mechanism of the present invention in an open position and the equalizing mechanism of the present invention in its closed position.

DETAILED DESCRIPTION OF THE INVENTION

For purposes of the following description, it will be assumed that the present invention is installed within a subsurface safety valve of the type shown in U.S. Pat. No. 4,161,219, which type is commonly referred to as a rod-piston safety valve. However, it should be understood that the present invention can be used in any commercially available safety valve, whether it be tubing conveyed, wireline conveyed, hydraulically operated, or electrically operated.

Referring to the drawings in detail, wherein like numerals denote identical elements throughout the several views, there is shown in Figure **1** a specific embodiment of a subsurface safety valve **10** constructed in accordance with the present invention. With reference to Figure **1**, the subsurface safety valve **10** of this specific embodiment is comprised of a generally tubular body **12** with a longitudinal bore **14** that extends therethrough. Each end of the body **12** includes mechanisms, such as threads **16**, for interconnection with a pipe string (not shown) suspended within a wellbore (not shown). A sleeve member **18**, usually referred to as a flow tube, is disposed within the bore **14** and is adapted for axial movement therein. The flow tube **18** includes a spring **20** disposed therearound that acts upon a shoulder **22** on the flow tube **18** biasing the flow tube **18** away from a flapper mechanism **24**. The present invention is not intended to be limited to any particular means for biasing the flow tube **18** away from the flapper **24**. For example, instead of, or in addition to, the spring **20**, the valve **10** may utilize a balancing gas chamber (not shown), such as those disclosed in U.S. Patent Nos. 4,252,197 (Pringle), 4,660,646 (Blizzard), 4,976,317 (Leismer), and 5,310,004 (Leismer), all of which are commonly assigned hereto and incorporated herein by reference.

Referring to Figures **2** and **3**, the flapper mechanism **24** generally comprises a disc or flapper valve closure member **26** with an arm **28** on a peripheral edge thereof that is hingedly connected to an annular housing **30** mounted within the bore **14**. In a specific embodiment, the annular housing **30** includes a metallic annular sealing surface **32** cooperable with an annular sealing surface **34** on the flapper **26**. In a specific embodiment, the annular housing **30** may further include a secondary annular sealing surface **38** formed from an annular body of pliable material, which is cooperable with the annular sealing surface **34** on the flapper **26**.

The metallic sealing surface **32** is generally referred to as the "hard seat" and the pliable sealing surface **38** is generally referred to as the "soft seat".

As shown in Figure **1**, in a specific embodiment, a rod-piston system may be provided to open the flapper **26**, and may be comprised of a piston **40** sealably mounted for reciprocal movement within a cylinder **42** located within the wall of the tubular body **12**. A first end **41** of the piston **40** is in contact with hydraulic fluid (not shown) provided thereto from the earth's surface through a relatively small diameter control conduit **44**. A second end **43** of the piston **40** is operatively connected, in any suitable manner, to the flow tube **18**. When the pressure of hydraulic fluid in the control conduit **44** exceeds the force needed to compress the spring **20**, the piston **40** is forced downwardly, thereby causing the flow tube **18** to come into contact with, and open, the flapper **26**. In the event that the hydraulic pressure applied to the piston **40** is decreased, as by command from the earth's surface or by the control conduit **44** being damaged, the spring **20** forces the flow tube **18** upwardly away from the flapper **26**. The flapper **26** is then rotated, and biased, into a closed position by action of a hinge spring (not shown) to permit the annular sealing surfaces **32**, **34** and **38** to mate and thereby establish a fluid seal to prevent fluid flow into the flow tube **18**.

As has been described above, when the flapper **26** has been closed, the pressure of fluids within the bore **14** upstream of (i.e., below) the closed flapper **26** increases and the pressure of the wellbore fluids downstream of (i.e., above) the closed flapper **26** decreases as the wellbore fluids remaining above the flapper **26** are recovered to the earth's surface through the pipe string. This creates a large pressure differential across the flapper **26** such that reopening of the flapper **26** becomes difficult. This difficulty in opening the flapper **26** cannot be easily overcome simply by increasing the force exerted against the lower surface of

the flapper **26**, because the relatively small cross-sectional area of the opening piston **40** and cylinder **42** would require a fluid pressure that may burst the control conduit **44** carrying the hydraulic fluid. The present invention solves this difficulty in opening the flapper **26** by providing the flapper mechanism **24** with pressure equalizing mechanism, described below, to allow the pressure above and below the flapper **26** to equalize prior to the complete opening of the flapper **26**, thereby reducing the force necessary to open the flapper **26**.

The equalizing mechanism of the present invention is best shown in Figures **3-5**. Referring to Figure **3**, in a specific embodiment of the present invention, the flapper mechanism **24** is provided with an equalizing mechanism which includes: an equalizing plug **46**; a bore **48** through the flapper **26** for receiving the plug **46**; a circular strike plate **50** having an actuating member **52** extending downwardly from the strike plate into the plug bore and connected to the equalizing plug **46**, the strike plate extending into the path of the flow tube **18** and transferring downward movement of the flow tube **18** to the plug **46** to thereby shift the plug **46** axially downwardly to open a passageway through the flapper **26** and permit the fluid pressure above and below the flapper **26** to equalize; and a spring **54** disposed between the strike plate **50** and the upper surface of the flapper **26** and adjacent the periphery **56** of the strike plate **50** for upwardly biasing (a) the strike plate **50** away from the flapper **26** and (b) the equalizing plug **46** within the bore **48**. In a specific embodiment, the upper surface **27** of the flapper **26** may be provided with a radial lip **84** for receiving the strike plate **50** and forming a groove **86** for receiving the spring **54**. The spring **54** may be any suitable compression spring as known to those having ordinary skill in the art, such as a wave spring or a Belleville spring.

The plug **46** is disposed for reciprocal movement within the plug bore **48**. The plug **46** is held in a normally closed position by action of the spring **54** against the strike plate **50**. The plug **46** includes an enlarged shoulder **58** on a first end thereof and an upper portion **60** on an opposite second end thereof. The upper portion **60** of the plug **46** is disposed below the upper surface **27** of the flapper **26**. The enlarged shoulder **58** includes a metallic annular sealing surface **62** that cooperates with a metallic annular sealing surface **64** (or "hard seat") on the flapper **26** about the plug bore **48**. In a specific embodiment, the bore **48** of the flapper **26** may also include a secondary annular sealing surface (or "soft seat") (not shown) formed from an annular body of pliable material to cooperate with a mating secondary annular sealing surface (not shown) on the enlarged shoulder **58** of the plug **46**. Preferably, a soft seat is used to ensure sealing when operating in low pressure differential applications.

As best shown in Figure **4**, the upper portion **60** of the plug **46** includes a generally longitudinal bore **66** extending from the upper surface **68** of the plug **46** and having a threaded portion **70**. The upper portion **60** of the plug **46** further includes a generally longitudinal passageway **72** which extends from the bore **66** and is in fluid communication with one or more generally radially disposed openings **74** that exit the plug **46** at a location between the lower surface of the bore **66** and the sealing surface **62** on the shoulder **58** of the plug **46**. The purpose of the bore **66**, the passageway **72**, and the openings **74** will be described below.

Still referring to Figure **4**, the actuating member **52**, which extends downwardly from the strike plate **50**, includes a shank **76** having a threaded portion **78** for mating with the threaded portion **70** of the bore **66** in the upper portion **60** of the plug **46**. A generally longitudinal passageway **80** extends from the lower surface **77** of the shank **76** through the

actuating member **52** to the upper surface **51** of the strike plate **50**. The passageway **80** cooperates with the longitudinal passageway **72** and the one or more radially disposed openings **74** in the plug **46** to establish an internal fluid flow passageway through the flapper **26** to equalize the fluid pressure above and below the flapper **26**, as more fully explained elsewhere herein. In a specific embodiment, the longitudinal passageway **80** may be provided with a flared portion **82** adjacent the upper surface **51** of the strike plate **50** to enhance the fluid flow rate through the flapper **26**.

When the flapper **26** is in a closed position, as shown in Figures **1-3**, and it is desired to open the flapper **26**, the flow tube **18** is forced towards the flapper **26** by the application of hydraulic fluid through the control conduit **44** (as has been described previously) or by electrical/mechanical action or simply mechanical action, depending upon the type of safety valve within which the present invention is included. With reference to Figure **3**, as the flow tube **18** is moved downwardly, a lower portion of the flow tube **18** will come into contact with the upper peripheral surface **56** of the strike plate **50**. The lower portion of the flow tube **18** is formed from material sufficiently hard to not be deformed, or galled, by contact with the strike plate **50**, or the lower portion of the flow tube **18** can include a surface hard coating or can be formed as a separate piece joined thereto and formed from harder material than the other portions of the flow tube **18**. As the strike plate **50** is pushed downwardly, it will shift the plug **46** axially downwardly so as to separate the annular sealing surfaces **62** and **64** and expose the one or more radially disposed openings **74**. The relatively high pressure wellbore fluid below the flapper **26** then rapidly flows into the one or more radially disposed openings **74**, through the longitudinal passageway **72** in the plug **46**, through the longitudinal passageway **80** in the strike plate **50**, and into the bore **14** above the flapper **26**. Since the

radially disposed openings **74** are displaced from the annular sealing surfaces **62** and **64**, the relatively rapid flow of wellbore fluids will not damage the sealing surfaces **62** and **64**. In this manner, an internal fluid flow passageway is opened through the flapper **26**, thereby permitting the fluid pressure above and below the flapper **26** to equalize.

In operation, the flow tube **18** travels axially downward, activating the equalizing mechanism and coming to rest against the flapper **26** until pressure equalization has occurred, and then proceeds with the opening of the flapper **26**. In this manner, the pressure differential across the flapper **26** is equalized through the plug **46** prior to the opening of the flapper **26**. As such, the equalizing mechanism of the present invention prevents the initial relatively high velocity flow of fluids past the flapper **26** from damaging the annular sealing surfaces **32**, **34**, and **38**. To complete the opening of the flapper **26**, the flow tube **18** is forced against the flapper **26** with sufficient force to overcome the force exerted by the hinge spring (not shown), the force exerted by the spring **20**, and the force exerted by the pressure in the tubing, and hold the flapper **26** in the open position, as shown in Figure **6**, as long as the hydraulic pressure from the control conduit **44** is applied. When the flapper **26** is in the open position, the plug **46** is maintained by action of the spring **54** in its closed or sealed position. In this manner, excessive exposure of the sealing surfaces **62** and **64** to production fluids is prevented. When the hydraulic pressure from the control conduit **44** is reduced or removed, the spring **20** causes the flow tube **18** to be moved away from the flapper **26**, so that: (a) the flapper **26** rotates to a closed position and the sealing surfaces **32**, **34** and **38** come into operative contact with each other to prevent fluid flow therepast; and (b) the flow tube **18** moves away from the strike plate **50** so that the plug **46** is upwardly biased into the plug bore **48** by the spring **54**, the radially disposed openings **74** are closed, and the sealing surfaces **62**

and **64** come into operative contact with each other to prevent fluid flow therepast. During the closing of the flapper **26**, the equalizing plug **46** may be opened for a very brief time, but will return to the closed position as soon as there ceases to be contact between the strike plate **50** and the flow tube **18**.

In another specific embodiment, the equalizing mechanism of the present invention may be installed within a curved flapper valve of the type disclosed in U.S. Pat. No. 4,926,945, commonly assigned hereto, which is incorporated herein by reference.

It is to be understood that the invention is not limited to the exact details of construction, operation, exact materials or embodiments shown and described, as obvious modifications and equivalents will be apparent to one skilled in the art.

CLAIMS

1. An equalizing subsurface safety valve for controlling fluid flow in a well conduit, comprising:

a body member having a longitudinal bore extending therethrough;

a valve actuator disposed for axial movement within the longitudinal bore;

a piston disposed within the body member and moveable in response to application of hydraulic fluid to move the valve actuator within the longitudinal bore;

a valve member mounted within the body member to control fluid flow through the longitudinal bore, the valve member having an upper surface, a lower surface, and a bore therethrough;

means for biasing the valve member to a normally closed position to prevent fluid flow through the longitudinal bore;

means for biasing the valve actuator away from the valve member;

an equalizing plug disposed for reciprocal movement within the bore of the valve member for controlling fluid flow through the valve member;

a strike plate having a periphery and an actuating member, the strike plate extending into a path of the valve actuator, the actuating member extending downwardly from the strike plate into the bore through the valve member and being connected to the equalizing plug; and

a spring disposed between the strike plate and the upper surface of the valve member adjacent the periphery of the strike plate to upwardly bias the strike plate away from the valve member and to upwardly bias the equalizing plug within the bore through the valve member, whereby downward movement of the valve actuator is transferred through the strike plate to the equalizing plug to shift the plug to open a passageway through the valve member and permit fluid

pressure above and below the valve member to equalize before the valve member is opened to allow fluid flow through the longitudinal bore of the body.

2. The equalizing subsurface safety valve of claim **1**, wherein the means for biasing the valve actuator away from the valve member is a spring.

3. The equalizing subsurface safety valve of claim **1**, wherein the means for biasing the valve actuator away from the valve member is a balancing gas chamber.

4. The equalizing subsurface safety valve of claim **1**, wherein the valve member is a flapper valve.

5. The equalizing subsurface safety valve of claim **1**, wherein the valve member is a curved flapper valve.

6. The equalizing subsurface safety valve of claim **1**, wherein the equalizing plug is a generally cylindrical plug having an internal fluid flow passageway therethrough and an enlarged annular sealing surface adjacent a first end thereof for cooperable sealing engagement with a sealing surface formed within the bore of the valve member.

7. The equalizing subsurface safety valve of claim **6**, wherein the enlarged annular sealing surface on the plug further includes a pliable annular sealing surface.

8. The equalizing subsurface safety valve of claim **6**, wherein the sealing surface formed within the bore of the valve member further includes a pliable annular sealing surface.

9. The equalizing subsurface safety valve of claim 6, wherein the internal fluid flow passageway includes a generally longitudinal passageway and at least one generally radially disposed opening, the generally longitudinal passageway extending from an upper portion of the plug and disposed in fluid communication with the at least one radially disposed opening, the at least one radially disposed opening exiting the plug at a location between the upper portion and the sealing surface of the equalizing plug.

10. The equalizing subsurface safety valve of claim 1, wherein the equalizing plug is held in a normally closed position by action of the spring against the strike plate.

11. The equalizing subsurface safety valve of claim 1, wherein the upper portion of the equalizing plug is disposed below the upper surface of the valve member.

12. The equalizing subsurface safety valve of claim 1, wherein fluid pressure within the well conduit is equalized through an internal fluid flow passageway formed through the equalizing plug and strike plate.

13. The equalizing subsurface safety valve of claim 1, wherein:

the equalizing plug further includes an upper portion having a generally longitudinal bore, a generally longitudinal passageway, and at least one generally radially disposed opening, the bore extending downwardly from an upper surface of the equalizing plug and having a threaded portion, the passageway extending downwardly from the bore and being disposed in fluid communication with the at least one radially disposed opening, the at least one radially disposed opening exiting the

plug at a location between a lower surface of the bore and the sealing surface on the shoulder of the plug; and

the actuating member further includes a shank having a threaded portion for mating with the threaded portion of the bore in the upper portion of the plug, and a generally longitudinal passageway extending upwardly from a lower surface on the shank through the actuating member to an upper surface of the strike plate and cooperating with the longitudinal passageway and the at least one radially disposed opening in the equalizing plug to establish an internal fluid flow passageway through the valve member to equalize the fluid pressure above and below the valve member.

14. The equalizing subsurface safety valve of claim **13**, wherein the longitudinal passageway extending through the actuating member further includes a flared portion adjacent the upper surface of the strike plate.

15. The equalizing subsurface safety valve of claim **1**, wherein the upper surface of the valve member further includes a radial lip for receiving the strike plate and forming a groove for receiving the spring.

16. The equalizing subsurface safety valve of claim **1**, wherein the spring is a compression spring.

17. The equalizing subsurface safety valve of claim **16**, wherein the compression spring is a wave spring.

18. The equalizing subsurface safety valve of claim 16, wherein the compression spring is a Belleville spring.

19. An equalizing subsurface safety valve for controlling fluid flow in a well conduit, comprising:

a body member having a longitudinal bore extending therethrough;

a valve actuator disposed for axial movement within the longitudinal bore;

a piston disposed within the body member and moveable in response to application of hydraulic fluid to move the valve actuator within the longitudinal bore;

a valve member mounted within the body member to control fluid flow through the longitudinal bore, the valve member having an upper surface, a lower surface, and a bore therethrough;

a spring for biasing the valve actuator away from the valve member;

an equalizing plug disposed for reciprocal movement within the bore of the valve member;

a strike plate connected to the equalizing plug and extending into a path of the valve actuator; and

a spring disposed between the strike plate and the upper surface of the valve member adjacent a periphery of the strike plate.

20. The equalizing subsurface safety valve of claim 19, further including a balancing gas chamber to assist the spring in biasing the valve actuator away from the valve member.

21. The equalizing subsurface safety valve of claim 19, wherein the equalizing plug is a generally cylindrical plug having an internal fluid flow passageway therethrough and

an enlarged annular sealing surface adjacent a first end thereof for cooperable sealing engagement with a sealing surface formed within the bore of the valve member.

22. The equalizing subsurface safety valve of claim **21**, wherein the enlarged annular sealing surface on the plug further includes a pliable annular sealing surface.

23. The equalizing subsurface safety valve of claim **21**, wherein the sealing surface formed within the bore of the valve member further includes a pliable annular sealing surface.

24. The equalizing subsurface safety valve of claim **21**, wherein the internal fluid flow passageway includes a generally longitudinal passageway and at least one generally radially disposed opening, the generally longitudinal passageway extending from an upper portion of the plug and disposed in fluid communication with the at least one radially disposed opening, the at least one radially disposed opening exiting the plug at a location between the upper portion and the sealing surface of the equalizing plug.

25. The equalizing subsurface safety valve of claim **21**, wherein the upper surface of the valve member further includes a radial lip for receiving the strike plate and forming a groove for receiving the spring.

26. The equalizing subsurface safety valve of claim **21**, wherein the spring is a compression spring.

27. The equalizing subsurface safety valve of claim **26**, wherein the compression spring is a wave spring.

28. The equalizing subsurface safety valve of claim 26, wherein the compression spring is a Belleville spring.

29. An equalizing subsurface safety valve for controlling fluid flow in a well conduit, comprising:

a body member having a longitudinal bore extending therethrough;

a valve actuator disposed for axial movement within the longitudinal bore;

means for controllably moving the valve actuator within the longitudinal bore;

a valve member having a bore therethrough and mounted within the body member to control fluid flow through the longitudinal bore;

means for biasing the valve member to a normally closed position to prevent fluid flow through the longitudinal bore;

means for biasing the valve actuator away from the valve member;

means for equalizing pressure disposed within the bore of the valve member;

means for transferring downward movement of the valve actuator to the equalizing plug to shift the plug to open a passageway through the valve member and permit fluid pressure above and below the valve member to equalize before the valve member is opened to allow fluid flow through the longitudinal bore; and

means for upwardly biasing the equalizing plug within the bore through the valve member.

30. The equalizing subsurface safety valve of claim 29, wherein the means for biasing the valve actuator away from the valve member is a spring.

31. The equalizing subsurface safety valve of claim **29**, wherein the means for biasing the valve actuator away from the valve member is a balancing gas chamber.

32. The equalizing subsurface safety valve of claim **29**, wherein the biasing means is a wave spring.

33. The equalizing subsurface safety valve of claim **29**, wherein the biasing means is a Belleville spring.

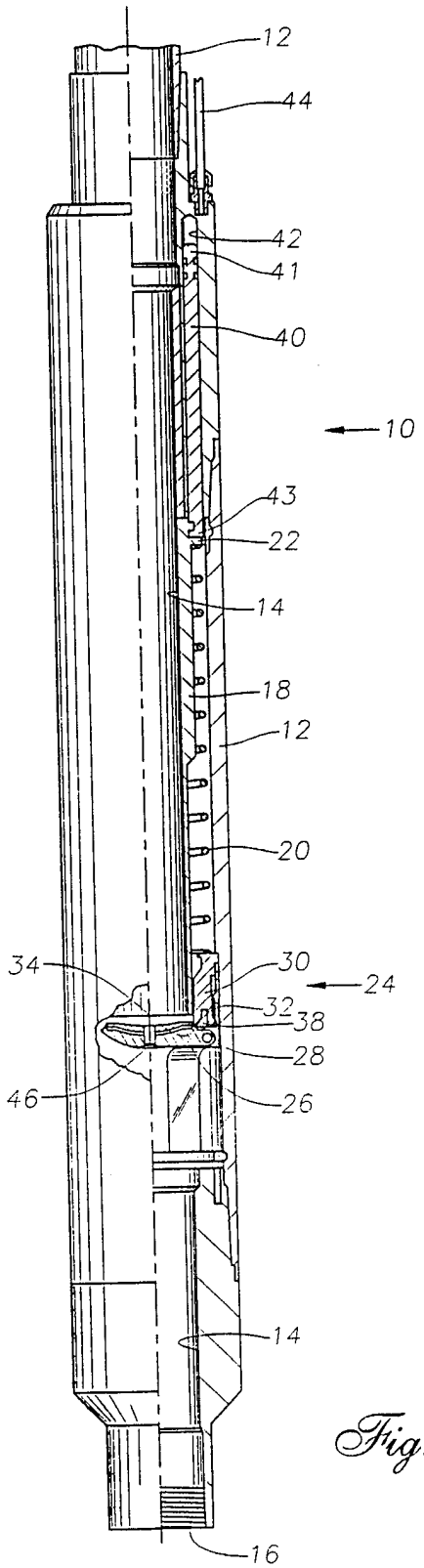


Fig. 1

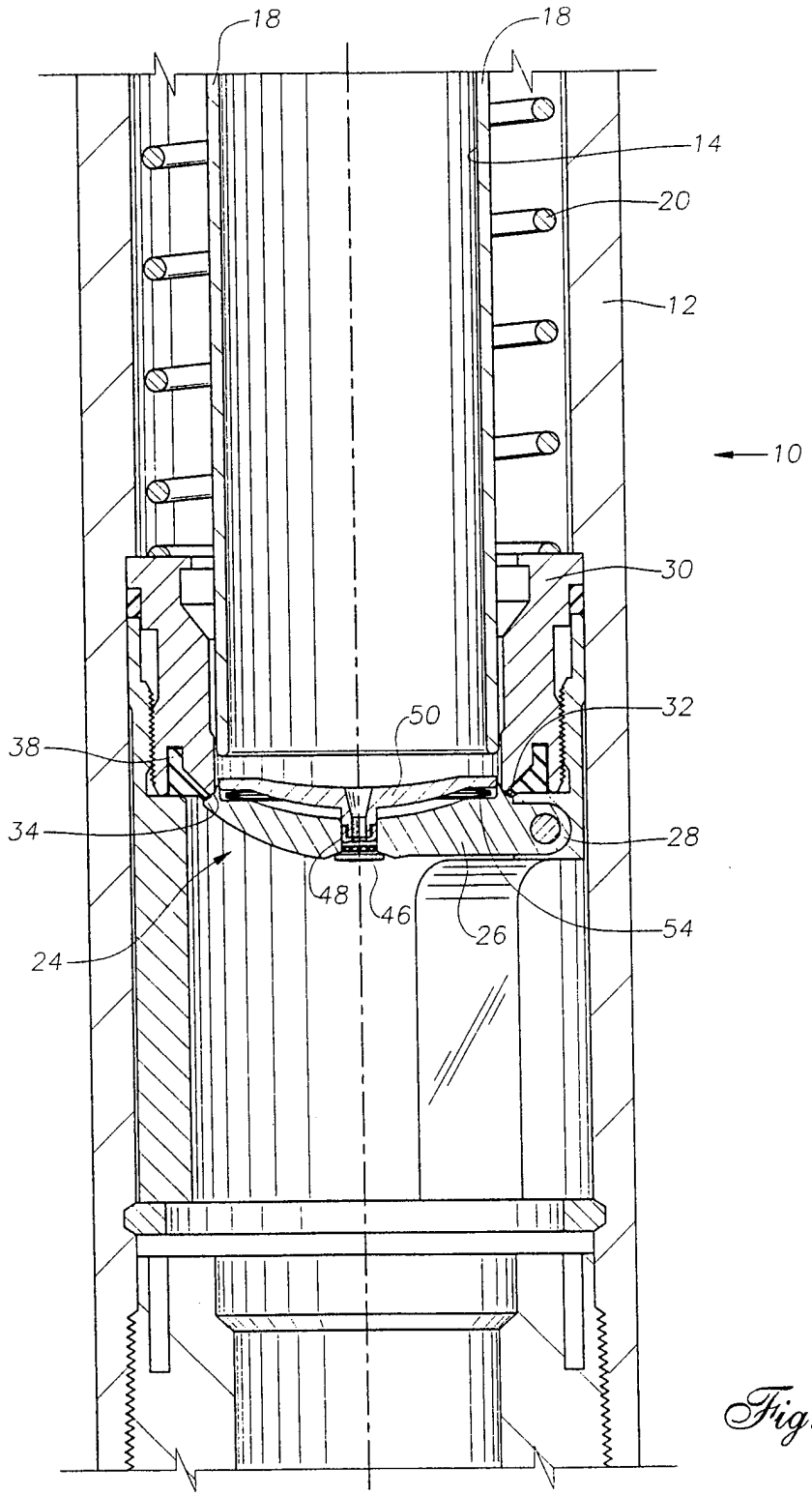


Fig. 2

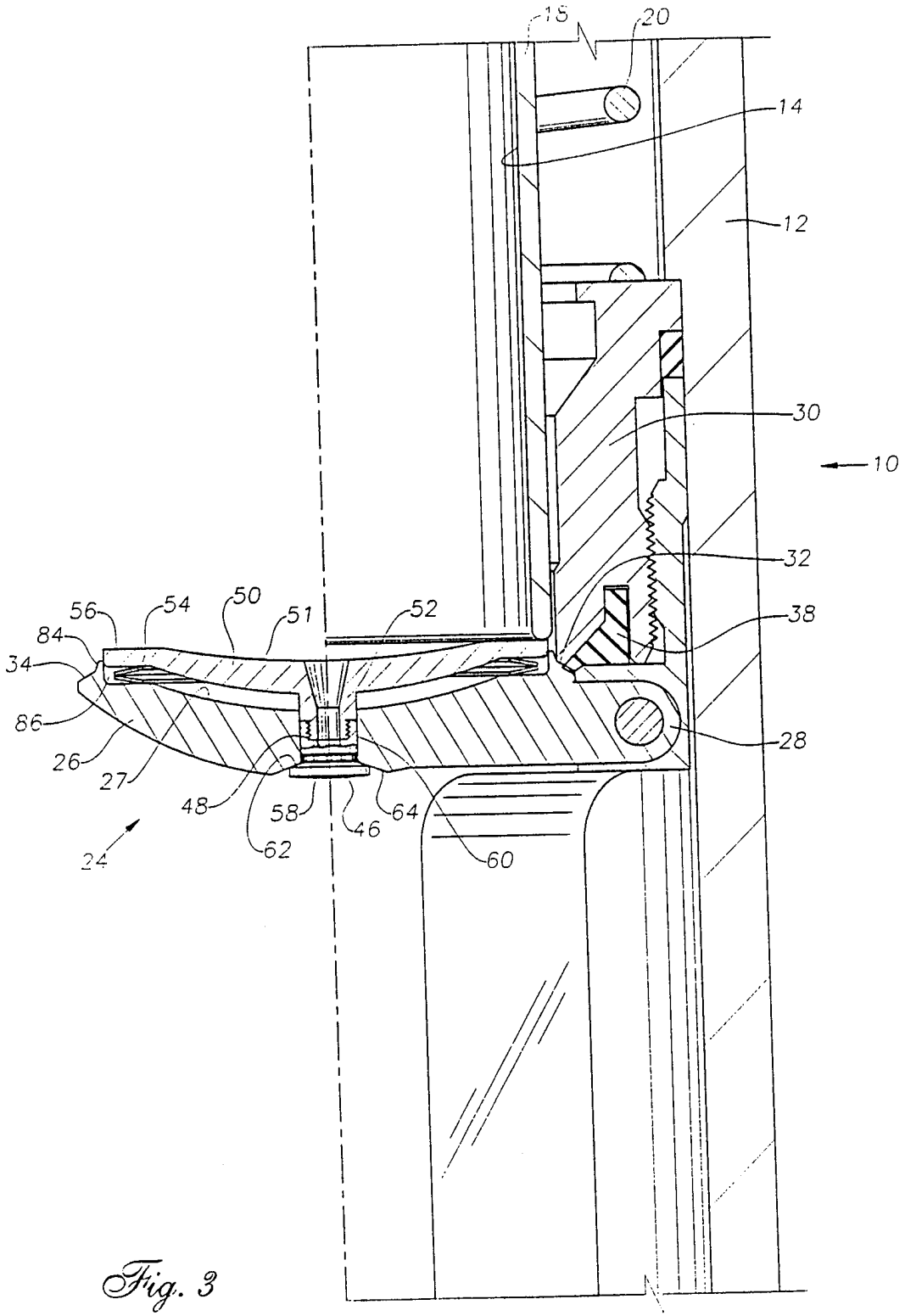

18
20
14
12
30
10
32
38
28
56
54
50
51
52
84
34
86
26
27
48
58
62
46
64
60
24

Fig. 3

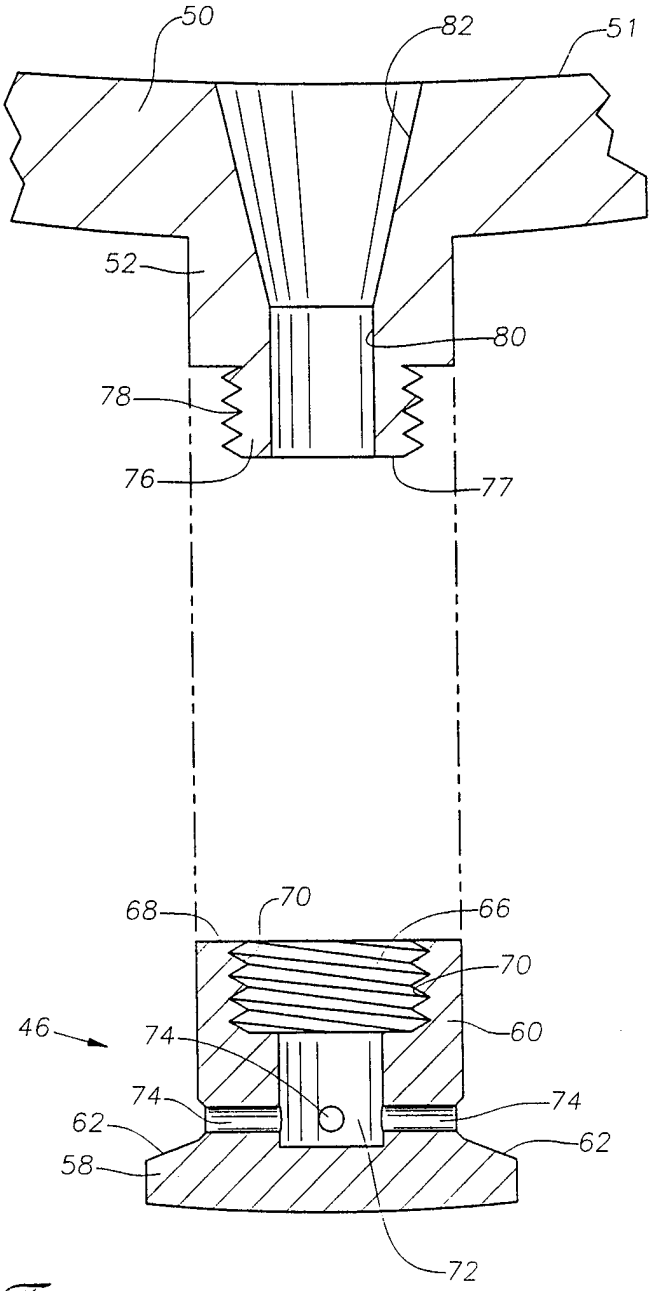


Fig. 4

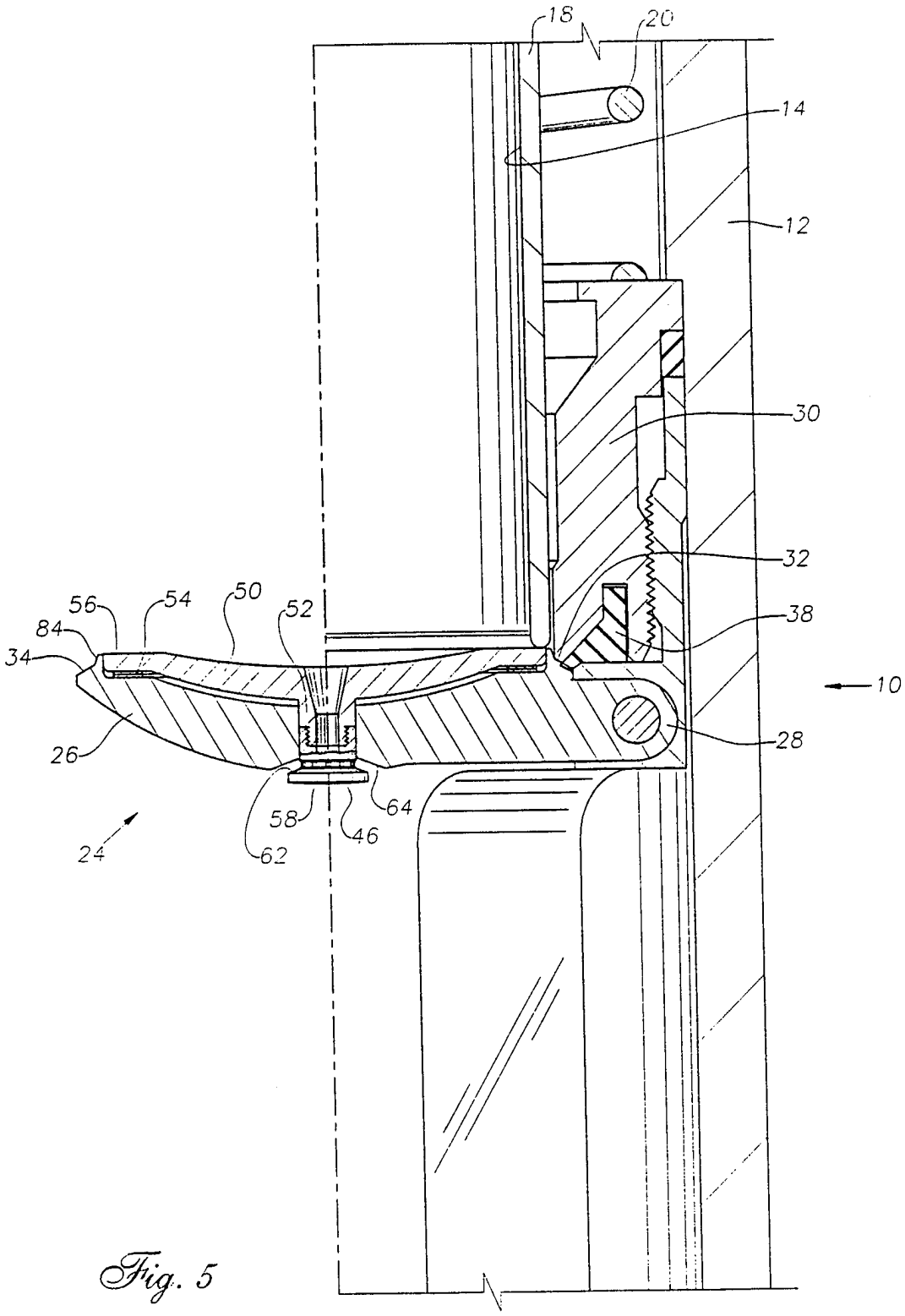


Fig. 5

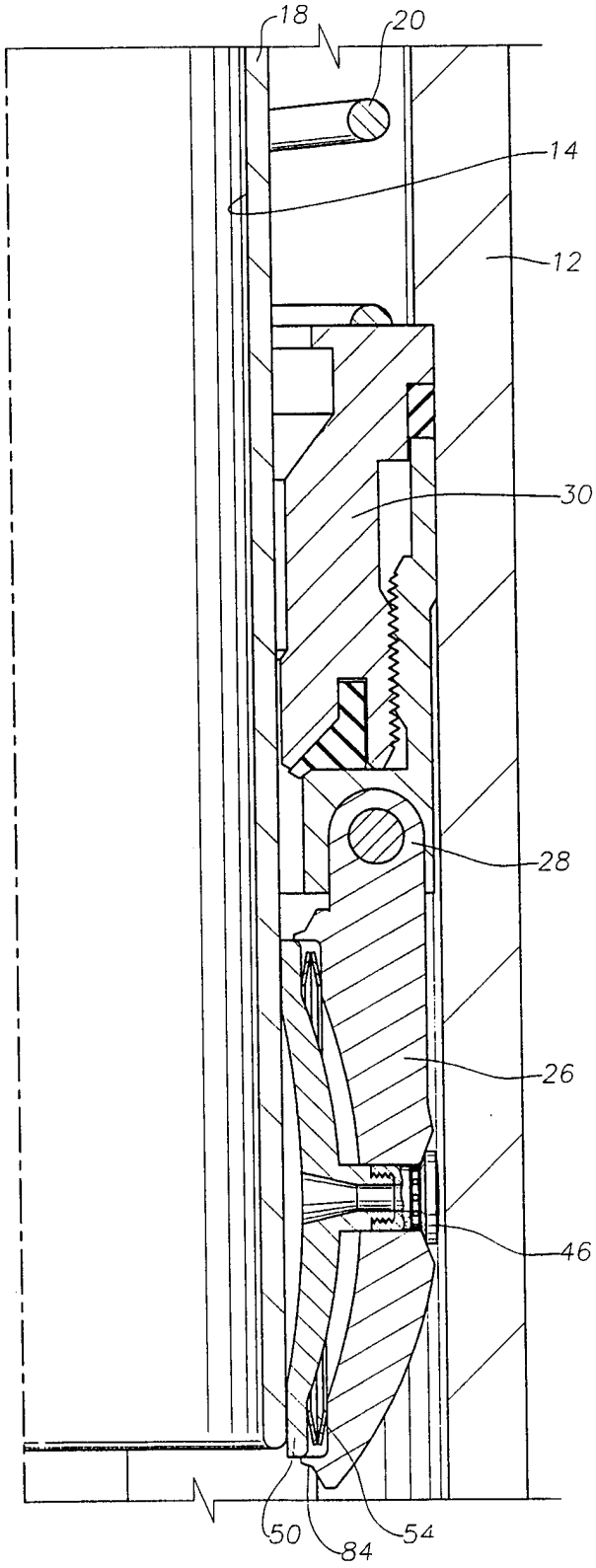


Fig. 6

INTERNATIONAL SEARCH REPORT

Interı nal Application No
PCT/US 98/12121

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 E21B34/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 415 036 A (CARMODY MICHAEL A ET AL) 15 November 1983	1-5, 10-12, 15,16, 19,20, 29-31
Y	see abstract; figures see column 3, line 23 - column 4, line 2 ---	6-9,13, 21-26
X	US 4 478 286 A (FINEBERG DOUGLAS H) 23 October 1984	29-31
Y	see abstract; figures see column 4, line 16 - column 5, line 44 ---	6-9,13, 21-26
A	GB 2 292 959 A (CAMCO INT) 13 March 1996 see abstract; figures --- -/--	1

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 September 1998	22/09/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Weiand, T

1

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Interr. ..nal Application No
PCT/US 98/12121

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	HILL, BHAVSAR: "Development of a self-equalizing surface controlled subsurface safety valve for reliability and design simplification" OTC, no. 8199, 6 - 9 May 1996, pages 471-478, XP002076968 Houston see page 472, right-hand column, last paragraph - page 473, left-hand column, paragraph 1 ---	1-5, 10-12, 15,16, 19,20, 29-31
A	MASON: "Downhole high-pressure equalizing safety valves: a solution-variable labyrinth seals" OTC, no. 5576, 27 - 30 April 1987, pages 217-227, XP002076969 Houston see figure 1 ---	1
A	FR 2 267 501 A (ERAP ENTR RECH ACTIV PETRO) 7 November 1975 see claim 1; figure ---	1
A	US 4 161 219 A (PRINGLE RONALD E) 17 July 1979 cited in the application see abstract; figures ---	1
A,P	US 5 682 921 A (MEGILL MARK S ET AL) 4 November 1997 see abstract; figures -----	1

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter nal Application No
PCT/US 98/12121

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4415036 A	15-11-1983	NONE	
US 4478286 A	23-10-1984	NONE	
GB 2292959 A	13-03-1996	US 5503229 A	02-04-1996
		CA 2157705 A	10-03-1996
		FR 2724410 A	15-03-1996
		NO 953497 A	11-03-1996
		US 5752569 A	19-05-1998
FR 2267501 A	07-11-1975	GB 1487803 A	05-10-1977
US 4161219 A	17-07-1979	GB 2018332 A,B	17-10-1979
US 5682921 A	04-11-1997	NONE	