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Abney et al.

[11] **3,860,068**

[45] **Jan. 14, 1975**

[54] **WELL PACKER ZONE ACTIVATED VALVE**

[75] Inventors: **David Lewis Abney**, Stafford; **Robert Carl Williams**, Spring, both of Tex.

[73] Assignee: **Dresser Industries, Inc.**, Dallas, Tex.

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[52] **U.S. Cl.** **166/120**, 166/134, 166/224

[51] **Int. Cl.** **E21b 23/00**, E21b 33/12

[58] **Field of Search** 166/120, 134

[56] **References Cited**

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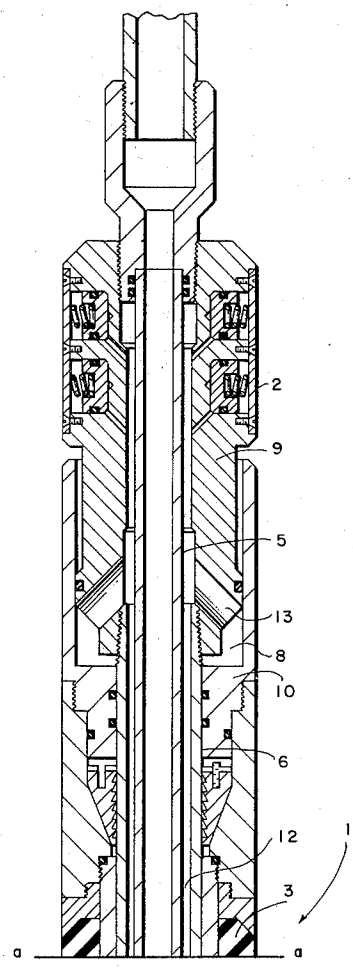
Primary Examiner—David H. Brown

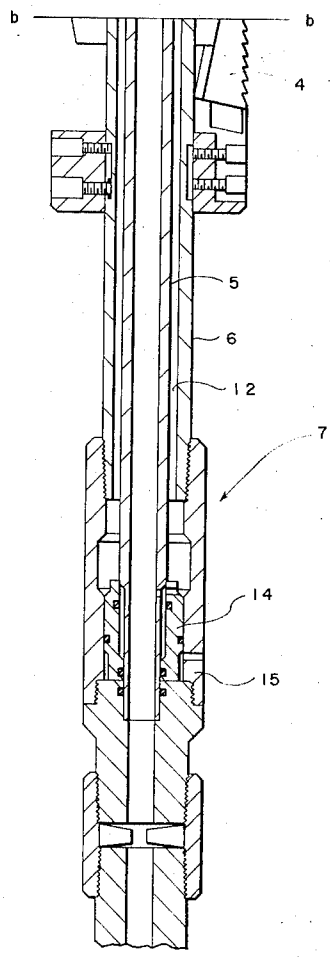
Attorney, Agent, or Firm—Michael J. Caddell

[57] **ABSTRACT**

A sliding valve located in the lower end of a packer assembly utilizes two differential pressure areas for receiving hydraulic pressure from inside the tubing to actuate the packer and then selectively receiving formation pressure when it exceeds the casing pressure and using the higher formation pressure to maintain the packer set in the casing.

7 Claims, 5 Drawing Figures





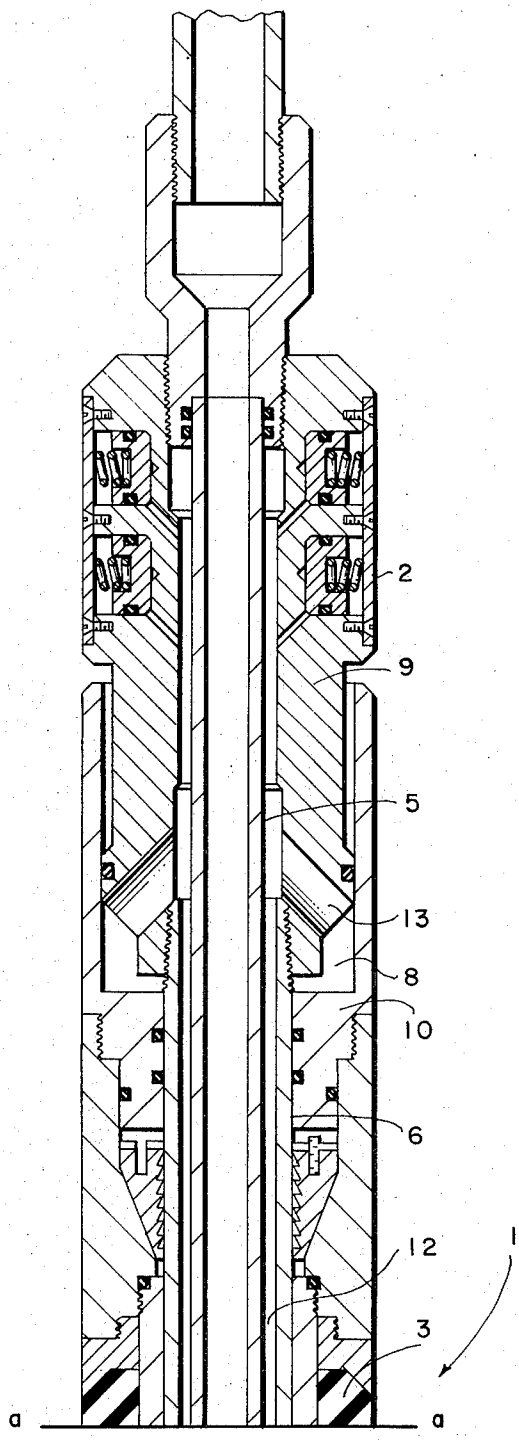


FIG. 1A

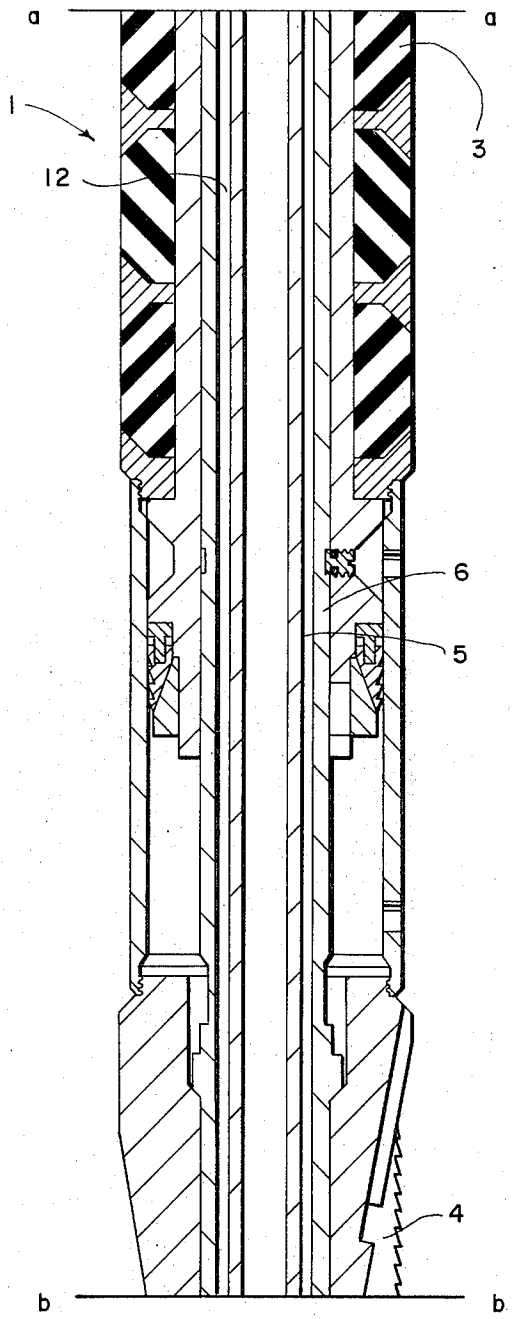


FIG. 1B

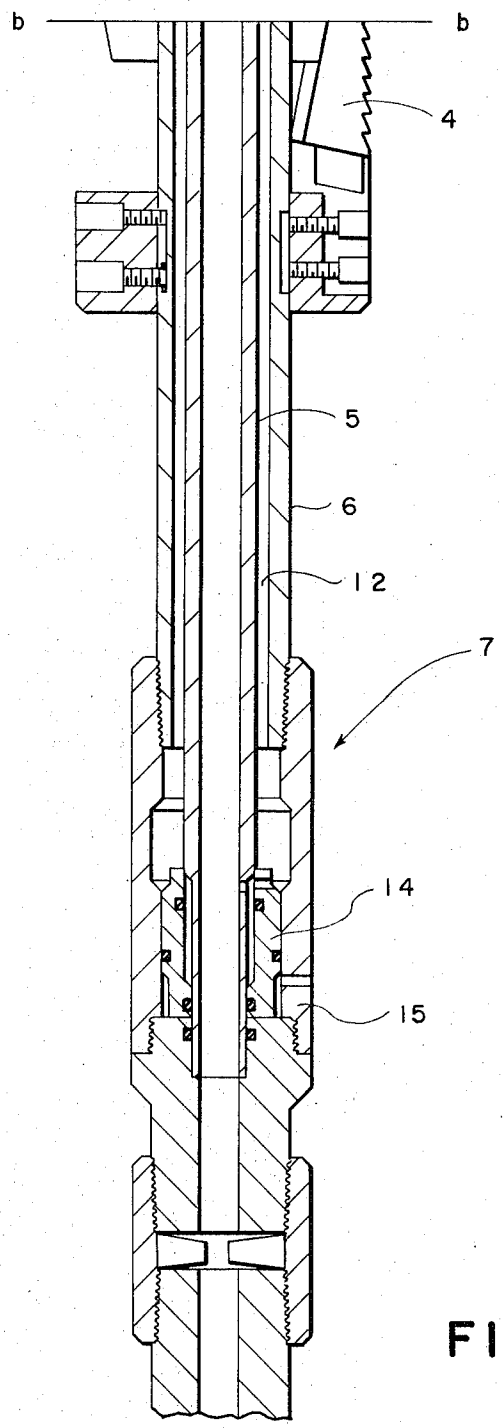


FIG. 1C

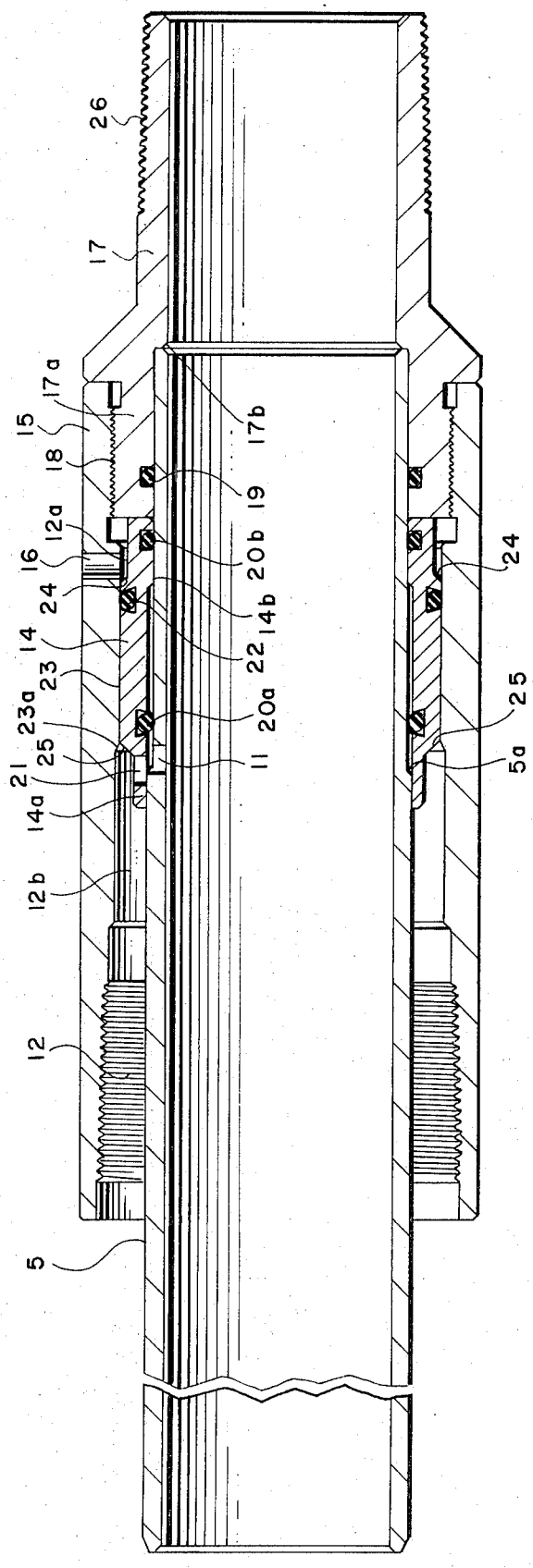

26
17
17a
15
18
12a
16
24
14
23
23a
25
21
14a
12b
12
5
17b
19
20b
14b
22
20a
11
24
25
5a

FIG. 2

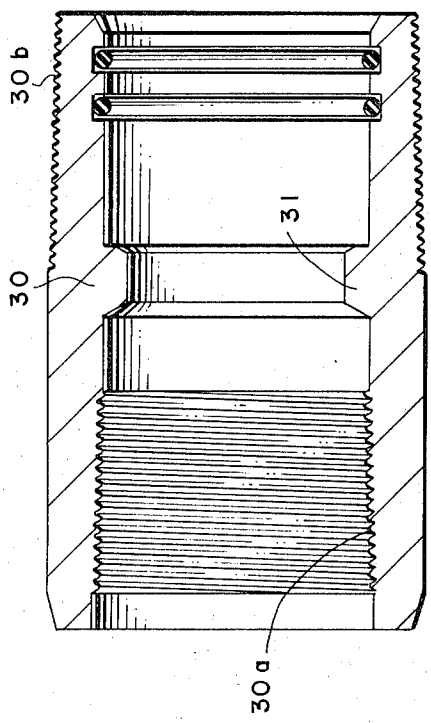

30b
31
30
30a

FIG. 2A

WELL PACKER ZONE ACTIVATED VALVE

BACKGROUND OF THE INVENTION

In the completion and production of multizone wells with two or more producing formations penetrated by the wellbore it is frequently the practice to utilize a number of well packers to isolate the formations.

Often the tool string or production string will be lowered into the hole and all the packers will be set, usually with one or more packers between the formations producing hydrocarbons. Then it is frequently the case that not all the formations will be opened to flow up the production tubing since one or more may be high pressure formations and there may be a low pressure formation also on the production string which, if they are all on production flow, will result in gas and fluid moving from the high pressure zones into the low pressure zone. Thus during production from one zone the others are usually closed off.

This oftentimes results in the problem that if a high pressure zone is closed in, it may build up a pressure below one of its isolating packers greater than the hydraulic actuating pressure in the tubing with the result that the packer and tubing will tend to float up in the casing and destroy the desired zone location.

The present invention solves this problem by providing a packer lower valve mechanism which allows hydraulic actuation of the packer through the tubing string and, when the zone pressure builds up higher than the setting pressure, switches the packer setting mechanism from tubing pressure to formation pressure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1***a*–**1***c* illustrate a cross-sectional side view of a packer assembly containing the invention;

FIG. **2** illustrates a cross-sectional side view of the valve assembly;

FIG. **2***a* shows a cross-sectional side view of the actuating valve seat.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. **1***a* through **1***c*, the packer assembly **1** is shown having hydraulic gripping buttons **2**, resilient packer elements **3** and mechanical anchors **4** mounted on an internal tubular mandrel **5** and a concentric external mandrel **6**.

Secured to the lower ends of mandrels **5** and **6** is the activating valve assembly **7**. It should be noted that the packer assembly is a standard hydraulically actuated packer having radially expanding resilient packer elements and mechanical anchor means for anchoring the assembly in the wellbore.

Normal operation of the packer is accomplished by applying hydraulic pressure to chamber **8** whereupon the pressure acts upward on piston head **9** and downward on cylinder sleeve **10**, compressing packers **3** and wedging anchors **4** outward into engagement with the well casing.

Hydraulic pressure is applied to chamber **8** by closing off the tubing bore below valve assembly **7** by standard valving means such as a dropped plug or ball in the tubing or mechanically actuated sleeve valve means. The tubing is then pressured up and hydraulic pressure acts through mandrel ports **11** up a concentric passage **12** and through channels **13** into actuation chamber **8**.

A ported valve sleeve **14** and valve housing **15** comprise the lower valve assembly **7** and allow pressure from the formation to aid in maintaining the packer set in the well.

Referring now to FIGS. **2** and **2***a* a more detailed description of the zone activation valve assembly **7** is illustrated as having an external tubular cylindrical valve housing **15** with one or more radial ports **16** through the wall thereof. A lower threaded adapter **17** is attached to housing **15** at threaded section **18** and is adapted to be threadedly connected to a valve seating collar therebelow.

The inner mandrel **5** which is an elongated tubular cylindrical member is sealingly and snugly telescoped into the upper portion **17***a* of lower adapter **17** and abuts inner shoulder **17***b* of the adapter. A fluidic seal therebetween is provided by circular seal ring **19** located in an inner annular groove in the wall of section **17***a* of the lower housing.

Annular chamber **12** is formed between the inner mandrel **5** and housing **15** and consists of a lower portion **12***a* and a wider upper portion **12***b*.

A ported sleeve piston **14** is slidably and sealingly telescoped within chamber **12** and is arranged to continuously contact mandrel **5** with seal means **20***a* and **20***b* therein. Piston **14** further has ports **21** passing through an upper skirt **14***a* thereon and communicating with ports **11** when piston **14** is in the lower most position in chamber **12** as shown in the figure.

Sleeve piston **14** has an inner annular shoulder **14***b* arranged upon upward movement to abut a complementary external annular shoulder **5***a* on mandrel **5**, thereby limiting upward movement of piston **14**.

A circular seal **22** on piston **14** provides sealing contact with wall **23** of lower chamber **12***a* until the piston has moved upward sufficiently for seal **22** to clear shoulder **23***a* and enter expanded chamber **12***b*. Piston **14** further has a lower annular differential pressure face **24** and an upper annular differential pressure face **25** formed thereon to receive pressure fluctuations and transmit their force to piston **14**.

FIG. **2***a* illustrates a valve seat collar **30** which may be threadedly attached to the lower threaded end **26** of adapter **17** by threads **30***a* located internally in the upper end. Collar **30** has an inner, annular, bevelled valve seat **31** formed therein to receive an actuating valve member (not shown), as previously mentioned, to close off the tubing bore passage and allow hydraulic actuation of the packer assembly via ports **11** and **21** in assembly **7**. A lower threaded portion **30***b* is adapted for connection into a standard tubing section or another tool or packer assembly.

METHOD OF OPERATION

In typical operation, the valve assembly **7** is attached to the packer assembly **1** as shown in FIGS. **1***a*–**1***c*. This string is then placed in the production string with additional packers in the desired quantity to provide proper isolation of the zones penetrated by the wellbore.

The entire production string is then lowered into the wellbore and the packers situated in the proper location to isolate the producing formations. A valve member such as a ball or plug can then be pumped down the string to seat in valve seat **31** of collar **30** and close off the tubing passage. The fluid in the tubing can then be pressured to the predetermined actuation pressure which acts through the inner bore passage of mandrel

5, through ports 11 and 21, chamber 12, channels 13 and into chamber 8, thereby driving piston 9 out of cylinder 10, moving cylinder 10 downward, compressing packer elements 3 and wedging slips 4 outward into the casing. Usually shear pins are used to temporarily hold cylinder 10 to piston 9 until actuation pressure is reached in the tubing whereupon the pins will shear and the packer will set.

At this time the packer is set and, assuming that the formation below this packer assembly is one of the high pressure formations which it is desirable to maintain closed-in during production of a low pressure formation elsewhere in the string, the pressure will begin to build up below the packer elements 3 and the pressure going beyond the tubing pressure will tend to unset the packer assembly. At this time valve assembly 7 automatically comes into action because of the pressure differential which develops across piston 14 from formation pressure acting through port 16 on differential pressure area 24. This reacts against tubing actuating pressure on upper area 25 and when it exceeds the tubing pressure will move piston 14 upward, closing off ports 11 by straddling them with seals 20*a* and 20*b* and piston 14. Piston 14 will move upward until shoulder 14*b* thereon abuts outer shoulder 5*a* on mandrel 5 which stops upward movement of the piston.

At this upward position of piston 14 ports 11 will be blocked off and ports 16 will now be in communication with enlarged chamber 12*b* and formation pressure will be transmitted via ports 16, chamber 12*b* and chamber 8 to the packer setting mechanism, guaranteeing that the packer remains set.

Should the formation pressure drop below the tubing actuation pressure, for instance if the formation is finally placed on production and its pressure drops considerably, the tubing pressure acting downward on shoulder 14*b* through ports 11 will move the sleeve 14 back downward and once again communicate the tubing fluid with the packer actuating piston and cylinder via ports 11 and 21 and chambers 12 and 8.

Thus it can be seen that valve assembly 7 works automatically to maintain the higher of two pressures, either tubing pressure or formation pressure, on the packer actuating assembly to maintain the packer in the set position.

Although certain preferred embodiments of the present invention have been herein described in order to provide an understanding of the general principles of the invention, it will be appreciated that various changes and innovations can be effected in the described well packer zone activated valve assembly without departing from these principles; for example, it would be possible to utilize the valve assembly as some intermediate point in the packer apparatus rather than at the bottom or the valve assembly could be utilized in other types of pressure actuated packers than the one shown. All modifications and changes of this type are deemed to be embraced by the spirit and scope of the invention except as the same may be necessarily limited by the appended claims or reasonable equivalents thereof.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A well packer for use in an underground formation penetrated by a borehole, said well packer comprising:

an elongated tubular inner mandrel adapted to be connected into a string of well tubing and having an internal bore passage therein;

hydraulic actuation means attached to said mandrel;

external housing means located concentrically on said inner mandrel;

resilient packer means on said housing means arranged to be compressed longitudinally and expanded radially by said hydraulic actuation means;

anchor slip means on said housing means adapted to be urged outward and grip the well casing wall in response to said hydraulic actuation means;

valve assembly means on said well packer adapted to receive pressure from said inner mandrel bore passage and further adapted to receive pressure from the well formation below said resilient packer means; and

said valve assembly means arranged to respond to the higher of said formation pressure and said inner mandrel pressure and to communicate said higher pressure to said hydraulic actuation means.

2. The well packer of claim 1 wherein said hydraulic actuation means comprises a piston head, a cylinder, and annular passage means between said inner mandrel and said external housing means extending from said valve means to said piston and cylinder.

3. The well packer of claim 2 wherein said valve means comprises a telescoping valve sleeve piston located between said inner mandrel and said external housing means; said mandrel, said housing means, and said valve sleeve piston having port means passing therethrough; said valve sleeve piston having a differential pressure area exposed to said mandrel port means and a second differential pressure area exposed to said housing port means, and said valve sleeve piston arranged to move from a position communicating said inner mandrel bore passage with said annular passage means to an opposed position communicating said annular passage means to said port means in said external housing means.

4. The well packer of claim 3 wherein said piston comprises a cylindrical tubular sleeve having seal means thereon and being slidably located between said inner mandrel and said housing means; said annular passage means comprising a first internal bore passage sealingly engaging said piston and a second larger internal bore passage allowing fluid flow past said piston when said piston is in said second internal bore passage.

5. In a hydraulically actuated well packer assembly of the type having an internal bore passage, hyraulic responsive actuating means, resiliently expandable packer elements, and mechanical gripping anchors; the improvement comprising:

valve means below the packer elements having preselective communication between the internal bore passage of said well packer and the hydraulic actuating means in a first valve position, and communicating said hydraulic actuating means with the oil well formation pressure in a second valve position while blocking off communication from said internal bore passage to said hydraulic actuating means; and,

said valve means having differential pressure areas thereon arranged to respond to the higher of either the internal bore pressure or the formation pressure and automatically communicate said higher

pressure to said hydraulic actuation means while blocking said lower pressure therefrom.

6. The well packer assembly of claim **5** wherein said valve means comprises:

hydraulic passage means communicating with said hydraulic actuating means;

first port means communicating between said passage means and the internal bore passage of said well packer assembly;

second port means communicating said passage means with the well formation pressure below the resilient packer elements;

sliding valve means in said passage means arranged in one position to block only second port means and in a second position to block only said first port means; and,

said valve means arranged to slide over said first or second port means in response to a pressure differential between formation pressure and the packer internal bore pressure.

7. The well packer assembly of claim **5** wherein said valve means further comprises:

cylindrical sliding valve means located sealingly and slidably in an annular hydraulic passage means, said cylindrical valve means having bypass ports therethrough and said annular passage means having bypass passage means therein;

said bypass ports allowing fluid communication from said first port means past said cylindrical valve means; and

said bypass passage means arranged to allow fluid communication from said second port means past said cylindrical valve means.

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