Nov. 29, 1966 D. E. YOUNG ETAL 3,288,219

WELL PACKING APPARATUS

Filed June 11, 1964

Fig. 2B

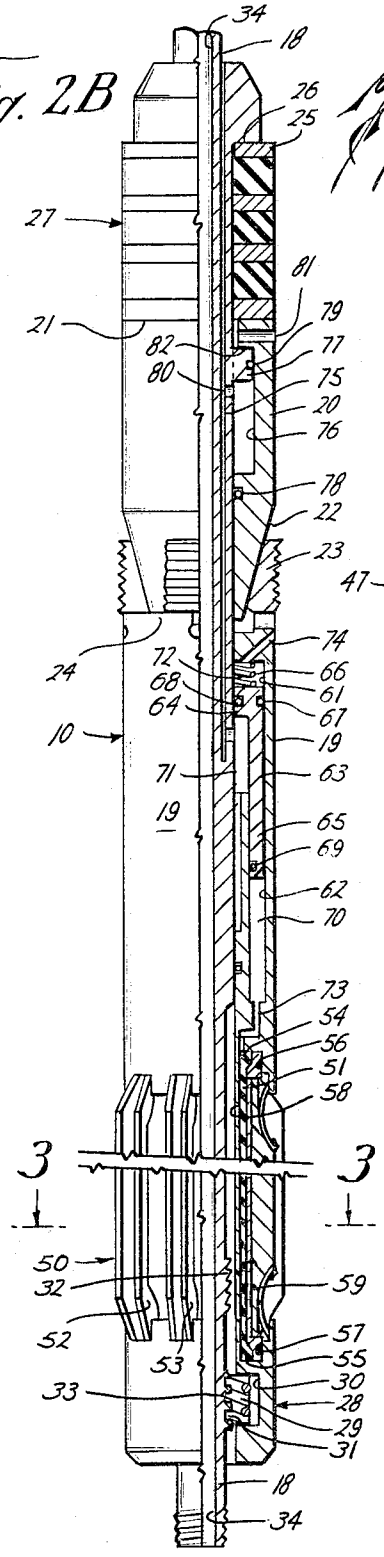


Fig. 2A

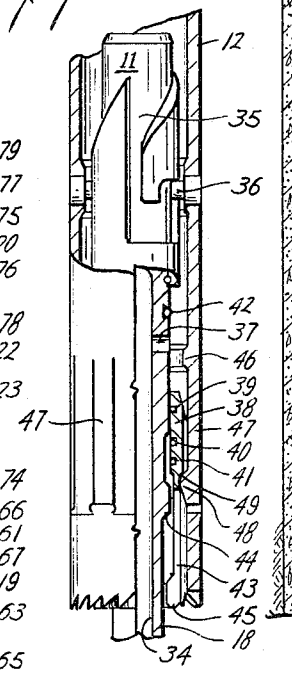


Fig. 1

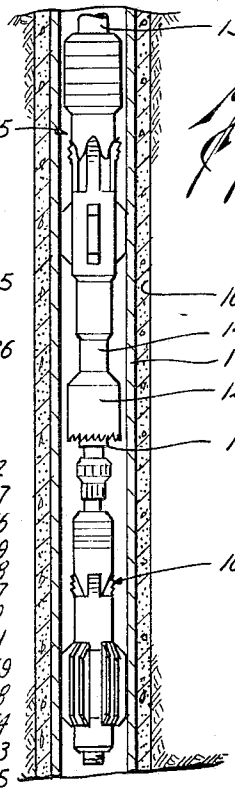
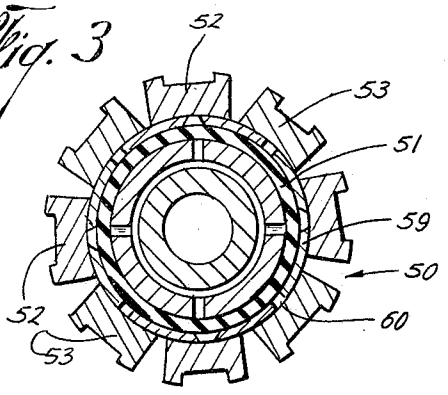


Fig. 3



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WELL PACKING APPARATUS

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This invention relates to apparatus adapted for packing-off a well bore; and, more particularly, to packers or bridge plugs which, when set in place, will be anchored against hydraulic pressures acting from either direction thereon by an anchoring force proportionately related to the acting pressure.

In conducting such well-completion operations as acidizing, cementing, or fracturing, a full-opening well packer dependently coupled from a tubing string is positioned at a particular depth in a cased well and the packer set to isolate the formation interval to be treated from the remainder of the well bore thereabove. Treating fluids are then pumped downwardly at high pressure through the tubing and introduced into the formation being treated beneath the packer through perforations appropriately located in the casing. In those instances where a well having several producing formations is being completed, a selectively operable bridge plug can be dependently coupled beneath a full-opening packer. Such a bridge plug permits formation zones of selected length to be packed-off for selective treatment of different formation intervals with only a single trip into the well.

It will be appreciated that the packers and bridge plugs must be capable of withstanding high fluid pressures acting on them from either direction. Furthermore, during the course of typical completion operations, such packers and bridge plugs are usually subjected to high fluid pressures acting alternately from both above and below them. Thus, it is necessary that the packers and bridge plugs be securely anchored against movement in either longitudinal direction.

Heretofore, mechanically actuated slip members have been typically employed to anchor packing apparatus from movement in at least one direction. Extendible anchoring members have also been developed which are hydraulically actuated by the fluid being pumped through the tubing for securing the apparatus from shifting.

Accordingly, it is an object of the present invention to provide new and improved packing apparatus having hydraulically actuated wall-engaging members including extendible slip members, which members are pressed into anchoring engagement with a force proportionately related to the pressure differential across the apparatus of the fluid in the well.

It is a further object of the present invention to provide new and improved well-packing apparatus capable of being releasably anchored in a packed-off condition and resist extreme pressure differentials acting from either longitudinal direction.

Packing apparatus arranged in accordance with the present invention includes selectively operable, hydraulically actuated, wall-engaging means which, in response to a fluid pressure differential acting across the apparatus from one longitudinal direction, presses the wall engaging means into anchoring engagement with a force proportionately related to this differential. Whenever a fluid pressure differential acts across the apparatus from the opposite direction, appropriately arranged extendible slip members are further pressed into anchoring engagement with an added force proportionately related to this latter pressure differential. Thus regardless of which direction a pressure differential acts across the apparatus, the apparatus will be anchoringly secured with an anchoring force that is proportionately related to this pressure differential.

The novel features of the present invention are set forth with particularity in the appended claims. The present invention, both as to its organization and manner of operation together with further objects and advantages thereof, may best be understood by way of illustration and example of certain embodiments when taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a view of a typical full-bore packer and a bridge plug employing principles of the present invention and depicted as they would appear in a well bore;

FIGS. 2A and 2B are detailed cross-sectional views of an embodiment of the bridge plug shown in FIG. 1; and

FIG. 3 is a cross-sectional view taken along the lines 3—3 of FIG. 2.

As seen in FIG. 1, a retrievable bridge plug **10** having a fishing neck **11** at its upper end is releasably connected thereby to an overshot **12** which may be dependently coupled as desired from either a tubing string **13** directly or a tubing sub **14** suspended beneath a typical full-bore packer **15**. This releasable coupling of course allows the bridge plug **10** to be set and left at a particular depth in a well bore **16** having a casing **17**. Where used, the packer **15** of course may be subsequently set at any point thereabove irrespective of the length of the tubing sub **14** connecting the bridge plug **10** to the packer.

Turning now to FIG. 2, the retrievable bridge plug **10** constructed in accordance with the principles of the present invention includes a rotatable tubular mandrel or body member **18** having its lower portion telescopically arranged within and slidably engaged with a tubular housing member **19**. An annular expander member **20** having an upwardly directed shoulder **21** at its upper end and a downwardly converging, conically shaped, surface **22** at its lower end is slidably mounted around the central portion of the mandrel **18**. A plurality of conventional slip members **23** are slidably connected to the upper end **24** of the housing **19** and operatively arranged and engaged around the tapered surface **22** of the expander member **20**. A freely swiveling annular ring **25** is loosely mounted around the mandrel **18** and engaged against a downwardly directed shoulder **26** around the upper portion of the mandrel. Elastomeric packing means **27** mounted around the mandrel **18** between the annular ring **25** and the upper shoulder **21** of the expander **20** are arranged to be foreshortened and expanded outwardly whenever the mandrel **18** is shifted downwardly into the housing to one of its operative positions. Upward shifting of the mandrel **18** to its other operative position will, of course, allow the elastomeric packing means **27** to relax and return to their normal position.

Normally engaged latch means **28** are provided to releasably latch the mandrel **18** to the housing **19** and secure the mandrel from shifting from either of its two operative positions until the mandrel is first rotated a predetermined amount. This latch means **28** includes a conventional, normally contracted, split or expansible "dizzy" nut **29** disposed around the mandrel **18** and arranged within an inwardly facing annular recess **30** in the lower end of the housing **19**. The "dizzy" nut **29** has internal, right-hand, square threads **31** operatively arranged to threadedly engage spaced-apart sets of complementarily formed, right-hand, buttress threads **32**, **33** around the lower portion of the mandrel **18**. The flat faces of the lowermost mandrel threads **33** are directed downwardly whereas the uppermost mandrel threads **32** have their flat faces directed upwardly in the opposite direction.

Thus, whenever the bridge plug **10** is retracted, the mandrel **18** is in its uppermost operative position with the lower mandrel threads **33** being threadedly engaged by the

dizzy nut 29. The mandrel 18 is of course released only by a concerted application of right-hand torque and a downwardly directed force which screws the lowermost threads 33 downwardly and out of engagement with the dizzy nut threads 31. Continued application of this downward force on the mandrel 18 will subsequently bring the upper mandrel threads 32 into engagement with the threads 31 of the dizzy nut 29. As the downwardly facing tapered surfaces of the upper mandrel threads 32 come into contact with the square threads 31 of the dizzy nut 29, however, the tapered thread surfaces 32 act as cams to expand the dizzy nut and allow the threads 32 to ratchet freely downwardly through the dizzy nut. Whenever the mandrel 18 has reached its lowermost operative position, the dizzy nut 29 then contracts and threadedly engages the upper mandrel threads 32. The engagement of the upwardly directed flat faces of the upper mandrel threads 32 with the lower faces of the dizzy nut threads 31 will of course prevent the mandrel 18 from shifting upwardly relative to the housing until the mandrel has been rotatively released.

Whenever it is desired to release the mandrel 18 from its lowermost operative position, the mandrel is simultaneously rotated to the left as it is pulled upwardly. This concerted action will screw the upper mandrel threads 32 upwardly through the dizzy nut 29. Then, whenever the upper mandrel threads 32 have been disengaged from the dizzy nut threads 31, the tapered upper faces of the lower mandrel threads 33 allow these threads to ratchet freely upwardly through the dizzy nut 29 in a manner similar to that of the previously described downward ratcheting action of the upper threads 32. Whenever the mandrel 18 has reached its upper operative position, the dizzy nut 29 again contracts to re-engage the dizzy nut threads 31 with the upper mandrel threads 32 to resecure the mandrel and prevent it from shifting downwardly.

A central axial bore 34 extending the full length of the mandrel 18 is capped at its upper end by the conventional fishing neck 11. This fishing neck 11 is arranged to cooperatively receive a conventional tubular overshot 12 which may be dependently coupled from either a full-bore packer or a tubing string 13. Matched J-slots 35 on opposite sides of the fishing neck 11 are arranged to receive cooperatively arranged J-pins 36 projecting radially inwardly from the overshot 12 whenever the overshot is lowered over the fishing neck. After the J-pins 36 enter the open upper end of the slots 35, the pins are lockingly engaged in the closed portion of the slots by a concerted application of left-hand torque and a slight upward pull on the tubing 13. Conversely, the overshot 12 is selectively disengaged from the fishing neck 11 by lowering the tubing 13 slightly, torquing it to the right, and then pulling the tubing upwardly.

Radial equalizing ports 37 are provided in the upper end of the mandrel 18 to allow fluid to flow through the axial bore 34 and bypass the bridge plug 10 as it is being shifted within a fluid-filled well bore. Fluid communication through the equalizing ports 37 is selectively controlled by an annular valve member 38 which is slidably disposed around the mandrel 18 immediately below the ports. O-rings 39–42 around the inner surface of the valve 38 and outer surface of the mandrel 18 fluidly seal the ports 37 whenever the equalizing valve member 38 is shifted upwardly to its closed position.

This slidable valve member 38 is cooperatively arranged to be longitudinally shifted by the running overshot 12 so that the equalizing ports 37 are uncovered whenever the overshot is engaged with the fishing neck 11 and covered whenever the overshot is removed.

Whenever the valve member 38 is pulled upwardly, depending resilient fingers 43 around the lower end of the valve member are cammed outwardly as they pass over an annular shoulder 44 around the index mandrel 18 and then retracted after clearing the shoulder. The lower ends 45 of these fingers 43 will then engage the upwardly facing portions of the annular shoulder 44 and hold the slidable valve member 38 in its uppermost or port-closed position after the overshot 12 has been removed.

A shoulder 46 projecting inwardly from the central portion of the overshot 12 is arranged to engage the upper end of valve member 38 and shift it downwardly to its open position as the overshot is being coupled to the fishing neck 11. Whenever the overshot 12 is removed by torquing it to the right and picking up, a group of resilient fingers 47 spaced around the lower portion of the overshot 12 have inwardly projecting shoulders 48 which engage a shoulder 49 on the sliding valve member 38 to pull it upwardly and close the equalizing ports 37.

Whenever it is desired to move the bridge plug 10, the overshot 12 is dropped over and re-engaged with the fishing neck 11. Once the overshot 12 reaches its engaging position, J-pins 36 will reenter the open upper end of the J-slots 35 on the fishing neck 11. As the J-pins 36 reenter the closed portion of the slots, the slidable valve member 38 is again shifted downwardly to reopen the equalizing ports 37.

A hydraulically actuated, radially expansible, friction anchor 50 is mounted around the housing 19 and adapted to be pressed outwardly against the casing to initially secure the housing relatively fixed against rotation of the mandrel 18 as well as to subsequently anchor the bridge plug 10 against a pressure differential acting upwardly against the bridge plug.

This anchor assembly 50 includes an elastomeric sleeve 51 encircling the housing 19 with a plurality of elongated casing-contacting members 52, 53 being uniformly mounted around the periphery of this sleeve. The upper 54 and lower 55 ends of the elastomeric sleeve 51 are enlarged and sealingly secured within opposed annular recesses 56, 57 around the housing 19 to provide an annular fluid-tight space 58 between the sleeve and housing.

Each of the casing-engaging members 52, 53 are elongated and have a thick, arcuate, cross-section (FIG. 3). Alternate ones 52 of these casing-engaging members are centrally aligned and mounted along the outer convex surface of relatively thin, elongated, arcuate backing members 59. These mounted members 52 are arranged uniformly around the periphery of the elastomeric sleeve 51 so that the backing members 59 substantially encompass the sleeve. The unmounted casing-engaging members 53 are alternately disposed between the mounted casing-engaging members 52 in such a manner that the unmounted members 53 straddle adjacent backing members 59 and cover the gap 60 therebetween. The ends of the casing-engaging members 52, 53 are loosely disposed within the opposed annular recesses 56, 57 around the housing 19 at opposite ends of the members.

Turning now to the hydraulic system of the present invention, an elongated annular space having an enlarged cross-sectional upper portion 61 and a reduced cross-sectional lower portion 62 is formed in the housing 19 above the anchor 50. An annular piston member 63 is slidably disposed within the annular space with an enlarged upper portion 64 and a smaller portion 65 thereof, respectively, being complementarily fitted within the upper 61 and lower 62 annular spaces. A compression spring 66 engaged between the housing 19 and the enlarged portion 64 of the piston member 63 biases the piston downwardly into the lower annular space 62.

O-rings 67, 68 around the outer and inner surfaces of the enlarged piston portion 64 and an O-ring 69 around the inner surface of the reduced piston portion 65 fluidly seal the annular piston member 63 relative to the housing 19. The O-rings 67–69 accordingly form and separate a lower fluid-tight chamber 70 beneath the reduced piston portion 65; an intermediate fluid-tight chamber 71 between the enlarged piston portion 64 and the lower O-ring 69; and an upper fluid-tight chamber 72 above the enlarged piston portion 64.

A fluid passage **73** leading from the lower chamber **70** provides fluid communication therefrom to the annular fluid-tight space **58** beneath the elastomeric sleeve **51** of the anchor **50**. The fluid-tight space **58**, fluid passage **73** and the lower chamber **70** are filled with a suitable hydraulic fluid. It will be appreciated, of course, that whenever the annular piston member **63** is shifted downwardly into the lower fluid-tight chamber **70**, a hydraulic pressure will be accordingly developed to expand the elastomeric sleeve **51** and press the casing-engaging members **52, 53** against the casing. Thus, the downwardly directed biasing force of the compression spring **66** against the piston **63** will develop a slight hydraulic pressure sufficient to maintain the casing-engaging members **52, 53** against the casing. The members **52, 53** are pressed with only sufficient force to secure the housing **19** against moving relative to the mandrel **18** but not so great as to retard shifting of the bridge plug **10**.

It will be realized that annular piston member **63** will be shifted either downwardly or upwardly relative to the housing **19** in response to differences between the fluid pressures in the upper **72** and intermediate **71** fluid-tight chambers and the cross-sectional areas of the upper surface and the lower surface of the enlarged piston portion **64**. The direction that the piston member **63** shifts will of course be determined by the relative difference between the arithmetical product of the fluid pressure in each chamber and the effective area of the piston surface in that chamber. Accordingly, to actuate the piston member **63** a fluid passage **74** is formed through the housing **19** at a point beneath the packing means **27** to provide fluid communication therefrom to the upper fluid-tight chamber **72**. An elongated fluid passage **75** through the mandrel **18** provides fluid communication from a point above the packing means **27** to the intermediate fluid-tight chamber. Thus, whenever the packing means **27** is sealingly engaged within a fluid-filled well bore, the pressure of the fluids above the bridge plug **10** will be directed through the fluid passage **75** into the intermediate chamber **71** to act against the lower surface of the enlarged piston portion **64**. At the same time, the fluid pressure in the well below the bridge plug **10** will be applied against the upper surface of the enlarged piston portion **64** through fluid passage **74**.

The hydraulic system of the present invention further includes an elongated, inwardly facing, annular space **76** wtihin the expander member **20** into which an annular shoulder **77** around the central portion of the mandrel **18** is received. An O-ring **78** fluidly seals the lower portion of the expander **20** below the annular space **76** to the mandrel **18**. Similarly, an O-ring **79** around the mandrel shoulder **77** fluidly seals the mandrel **18** relative to the upper portion of the expander member **20** above the annular space **76** to make it a fluid-tight chamber. A radial port **80** extending through the mandrel **18** into the elongated fluid passage **75** provides fluid communication from a point above the packing means **27** to the fluid-tight chamber **76**. A second port **81** through the expander member **20** above the O-ring **79** around the mandrel shoulder **77** provides fluid communication from the exterior of the bridge plug **10** below the packing means **27** to the upper face **82** of the shoulder **77**.

It will be appreciated, therefore, that with the bridge plug **10** in position within a fluid-filled well bore, whenever the packing means **27** is sealingly engaged therein, the well bore pressure above the packing means will be simultaneously directed into both the fluid-tight chamber **76** within the expander member **20** and the intermediate fluid-tight chamber **71** within the housing **19**. At the same time, whatever fluid pressure there is in the well bore below the sealingly engaged packing means **27** will be imposed into the upper fluid-tight chamber **72** in the housing **19** above the annular piston member **63** as well as through the port **81** against the upper face of mandrel shoulder **77**.

As previously described, whenever the bridge plug **10** has been positioned in the well bore, the casing-engaging members **52, 53** act as drag blocks to secure the housing **19** from moving as the mandrel **18** is manipulated to set the bridge plug. The tubing string **13** is lowered slightly as it is rotated to the right. This action successively rotates the J-pins **36** of the overshot **12** into the bottom of the open portion of the fishing neck J-slots **35** and screws the lower mandrel threads **33** out of the dizzy nut **29**. As the mandrel **18** travels downwardly, force is transmitted from the upper mandrel shoulder **26** through the packing means **27** and against the upper face **21** of the expander **20** to shift the expander downwardly relative to the housing **19**.

As the expander member **20** moves downwardly relative to the housing **19**, the tapered expander surface **22** of course forces the slip members **23** outwardly into engagement with the casing. Once the slip members **23** are engaged, the expander **20** cannot move further downwardly; and the continued downward travel of the upper mandrel shoulder **26** will then begin foreshortening the packing means **27** into sealing engagement.

The mandrel **18** will of course continue to travel downwardly until the packing means **27** are sealingly engaged and the slip members **23** set. The upper mandrel threads **32** will ratchet through the dizzy nut **29** until the mandrel **18** reaches its lower operative position. Then, the dizzy nut **29** will contract to engage the mandrel threads **32** and secure the mandrel **18** as previously described.

Once the mandrel **18** is secured, the overshot **12** may then be pulled upwardly and released from the fishing neck **11**. As the overshot **12** is pulled upwardly, the sliding valve member **38** is shifted upwardly to close the equalizing ports **37** as previously described. Accordingly, as soon as the overshot **12** has been removed and the equalizing ports **37** closed, whatever pressure differential there is across the packing means **27** will be imposed against the anchoringly and sealingly engaged bridge plug **10**.

It will be realized that should the pressure in the well bore above the bridge plug **10** be greater than that below, the resulting pressure differential across the bridge plug will impose a downwardly directed force against the mandrel **18**. Since, however, the annular ring **25** above the packing means **27** is not fluidly sealed against the uppermost mandrel shoulder **26**, the same pressure will act on both faces of the shoulder. Thus, the pressure on the mandrel **18** will in effect be acting downwardly only against the cross-sectional area of that portion of the mandrel that is encompassed by and extends through the packing means **27**.

This resultant downward pressure force on the mandrel **18** is substantially counteracted, however, inasmuch as the same higher pressure that is acting downwardly is also transmitted through the elongated fluid passage **75** in the mandrel and acts upwardly against the lower face of the mandrel shoulder **77** within the fluid tight chamber **76** in the expander **20**. It will be appreciated, therefore, that by appropriately dimensioning the shoulder **77**, its effective annular cross-sectional area can be made substantially equal to, or even slightly greater than the above-mentioned effective cross-sectional area of the mandrel **18**. Thus, no significant pressure forces will be applied downwardly on the mandrel **18**, which forces would otherwise be transmitted from the upper mandrel threads **32** into the dizzy nut threads **31**.

This same higher pressure above the packing means **27** is of course imposed against the full cross-sectional area of the upper end of the packing means **27** to aid in maintaining the packing means sealingly engaged with the casing. This downwardly directed force is also transmitted through the elastomeric packing means **27** against the upper end **21** of the expander **20**. In addition to this force being applied through the packing means **27**, the higher pressure acting on the lower surface

of the chamber **76** within the expander **20** will impose an additional downwardly acting force on the expander. Thus, a substantial additional downwardly acting force will be directed against the expander **20** to maintain the slip members **23** anchoringly engaged with the casing whenever there is a greater pressure above the bridge plug **10** than that below it.

It will be realized, of course, that with the well bore pressure being greater above the packing means **27** than that therebelow, annular piston member **63** will be shifted upwardly against the spring **66** in the upper end of the upper housing chamber **72**. Thus, there will be little or no hydraulic pressure in the hydraulic system of the anchor **50**.

Should, perchance, the pressure in the well bore below the sealingly engaged packing means **27** be or become greater than that thereabove, the mandrel **18** will of course be restrained from moving relative to the housing **19** by the engagement of the upper mandrel threads **32** with those of the dizzy nut **29**. It will be appreciated, of course, that with a higher pressure below the bridge plug **10**, the slip members **23** will not effectively secure the bridge plug **10** against shifting upwardly and the anchor **50** must now act to secure the bridge plug.

Accordingly, the higher pressure beneath the sealingly engaged packing means **27** will now be imposed against the upper face of the enlarged portion **64** of the annular piston member **63** by way of fluid passage **74**. The annular piston member **63** will now be forced downwardly to develop a hydraulic pressure within the lower fluid-tight chamber **70**. It will be recognized that this developed hydraulic pressure will be proportionately greater than the pressure in the well bore beneath the packing means **27** by a ratio equal to the effective cross-sectional area of the enlarged piston portion **64** divided by the effective cross-sectional area of the reduced piston portion **65**. Thus, since the same pressure is acting on the outside of the elastomeric sleeve **51** as that acting on the upper end of the annular piston member **63**, the increased hydraulic pressure within the fluid-tight chamber **70** will expand the elastomeric sleeve outwardly to press the casing-engaging members **52**, **53** tightly against the casing and secure the bridge plug **10** against shifting with a force proportionately related to the pressure differential across the bridge plug.

The mandrel **18** is still effectively balanced inasmuch as the higher pressure now enters the fluid port **81** and imposes a downwardly directed force on the upper face of mandrel shoulder **77**. The resulting downward force will of course oppose the upwardly directed pressure force against the effective cross-sectional area of the mandrel **18** in the same manner as previously described.

Thus, it will be realized that the bridge plug **10** will be securely anchored against longitudinal shifting in either direction inasmuch as the slip members **23** secure the bridge plug from shifting downwardly when there is a higher pressure thereabove. Correspondingly, the anchor **50** secures the bridge plug **10** from upward shifting whenever the pressure beneath the bridge plug is greater than that above.

Accordingly, it will be appreciated that the present invention provides new and improved packing apparatus having hydraulically actuated wall-engaging members. These members are arranged to be pressed into anchoring engagement with the well casing with a force proportionately related to a pressure differential acting across the packing apparatus. Furthermore, this new and improved well-packing apparatus is capable of being releasably anchored in a packed-off condition to resist extreme pressure differentials acting from either longitudinal direction.

While particular embodiments of the present invention have been shown and described, it is apparent that changes and modifications may be made without departing from this invention in its broader aspects and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed is:

1. A well packer sized and adapted for reception in a well bore for packing-off the well bore comprising:
- a housing having a longitudinal bore;
- a body member slidably disposed within said housing bore;
- packaging means operatively mounted on said body member and arranged for expansion thereby into sealing engagement with the well bore;
- first anchoring means selectively operable for securing said packer against longitudinal movement in one direction within the well bore;
- second anchoring means for securing said packer against longitudinal movement in the opposite direction relative to the well bore including outwardly-extendible wall-engaging means mounted on said housing and fluidly sealed relative thereto to provide a fluid-tight space therebetween, said wall-engaging means being adapted for extension into engagement with the well bore upon application of hydraulic pressure in said fluid-tight space; and
- hydraulic means responsive to a pressure differential acting in said opposite direction across said packing means when expanded for applying a hydraulic pressure in said fluid-tight space to press said wall-engaging means into anchoring engagement with a force proportionately related to this pressure differential.

2. A well packer sized and adapted for reception in a well bore for packing-off the well bore comprising:
- a housing having a longitudinal bore;
- a body member having a fixed shoulder, said body member being slidably disposed within said housing bore and adapted for travel therein from a first position to a second position;
- first anchoring means responsive to travel of said body member for securing said packer against longitudinal movement in one direction relative to the well bore whenever said body member is in said second position including outwardly-extendible wall-engaging slip members and expander means operatively engaged with said slip members;
- packing means mounted around said body member intermediate said fixed shoulder and first anchoring means and operatively arranged for expansion into sealing engagement with the well bore whenever said body member is shifted into said second position;
- means for securing said body member to said housing whenever said body member is in said second position;
- second anchoring means for securing said packer against longitudinal movement in the opposite direction relative to the well bore including outwardly-extendible wall-engaging means mounted on said housing and fluidly sealed relative thereto to provide a fluid-tight space therebetween, said wall-engaging means being adapted for extension into engagement with the well bore upon application of hydraulic pressure in said fluid-tight space; and
- hydraulic means responsive to a pressure differential acting in said opposite direction across said packing means when expanded for applying a hydraulic pressure in said fluid-tight space to press said wall-engaging means into anchoring engagement with a force proportionately related to this pressure differential.

3. A well packer sized and adapted for reception in a well bore for packing-off the well bore comprising:
- a housing having a longitudinal bore and a chamber therein;
- a body member having a fixed shoulder, said body member being slidably disposed within said housing bore and adapted for travel therein from a first position to a second position;
- first anchoring means responsive to travel of said body

member for securing said packer against longitudinal movement in one direction relative to the well bore whenever said body member is in said second position including outwardly-extendible wall-engaging slip members and expander means operatively engaged with said slip members;

packing means mounted around said body member intermediate said fixed shoulder and first anchoring means and operatively arranged for expansion into sealing engagement with the well bore whenever said body member is shifted into said second position;

means for securing said body member to said housing whenever said body member is in said second position;

second anchoring means for securing said packer against longitudinal movement in the opposite direction relative to the well bore including outwardly-extendible wall-engaging means mounted on said said housing and fluidly sealed relative thereto to provide a fluid-tight space therebetween, said wall-engaging means being adapted for extension into engagement with the well bore upon application of hydraulic pressure in said fluid-tight space; and

hydraulic means responsive to a pressure differential acting in said opposite direction across said packing means when expanded for applying a hydraulic pressure in said fluid-tight space to pressure said wall-engaging means into anchoring engagement with a force proportionately related to this pressure differential including a piston member slidably disposed within said housing chamber and adapted to shift therein in response to this pressure differential;

means fluidly sealing said piston member within said chamber for fluidly isolating a portion of said chamber;

first passage means providing fluid communication between said isolated chamber portion and said fluid-tight space, all being filled with a hydraulic fluid; and second passage means providing fluid communication between the well bore and the other portion of said chamber.

4. A well packer sized and adapted for reception in a well bore comprising:

a housing having a longitudinal bore and a cylindrical chamber therein, said chamber having a first portion of a greater cross-sectional area than the remaining portion of said chamber;

a body member having a fixed shoulder, said body member being slidably disposed within said housing bore and adapted for travel therein from a first position to a second position;

first anchoring means responsive to travel of said body member securing said packer against longitudinal movement in one direction relative to the well bore whenever said body member is in said second position including outwardly-extendible wall-engaging slip members mounted on said housing and expander means slidably mounted on said body member and operatively engaged with said slip members;

packing means mounted around said body member intermediate said fixed shoulder and expander means and operatively arranged for expansion into sealing engagement with the well bore whenever said body member is shifted into said second position;

means for securing said body member to said housing whenever said body member is in said second position;

second anchoring means for securing said packer against longitudinal movement in the opposite direction relative to the well bore including outwardly-extendible wall-engaging means mounted on said housing and fluidly sealed relative thereto to provide a fluid-tight space therebetween, said wall-engaging means being adapted for extension into engagement with the well bore upon application of hydraulic pressure in said fluid-tight space; and

hydraulic means responsive to a pressure differential acting in said opposite direction across said packing means when expanded for applying a hydraulic pressure in said fluid-tight space to press said wall-engaging means into anchoring engagement with a force proportionately related to this pressure differential including a piston member having an enlarged portion and a reduced portion complementarily fitted and slidably disposed within said housing chamber and adapted to shift therein in response to this pressure differential;

first and second sealing means respectively fluidly sealing said piston portions for dividing said first chamber portion and isolating said remaining chamber portion from said divided portions;

first passage means providing fluid communication between said isolated chamber portion and said fluid-tight space, all being filled with a hydraulic fluid;

second passage means providing fluid communication from the well bore above said packing means to one of said divided chamber portions; and

third passage means providing fluid communication from the well bore below said packing means to the other of said divided chamber portions.

5. A well packer sized and adapted for reception in a well bore for packing-off the well bore comprising:

a housing having a longitudinal bore;

a body member slidably disposed within said housing bore;

packing means operatively mounted on said body member and arranged for expansion into sealing engagement with the well bore;

first anchoring means responsive to a pressure differential acting in one direction across said packing means when expanded for securing said packer against longitudinal movement in said one direction within the well bore;

second anchoring means for securing said packer against longitudinal movement in the opposite direction relative to the well bore including outwardly-extendible wall-engaging means mounted on said housing and fluidly sealed relative thereto to provide a fluid-tight space therebetween, said wall-engaging means being adapted for extension into engagement with the well bore upon application of hydraulic pressure in said fluid-tight space; and

hydraulic means responsive to a pressure differential acting in said opposite direction across said packing means when expanded for applying a hydraulic pressure in said fluid-tight space to press said wall-engaging means into anchoring engagement with a force proportionately related to this pressure differential.

6. A well packer sized and adapted for reception in a well bore for packing-off the well bore comprising:

a housing having a longitudinal bore;

a body member having a fixed shoulder and an enlarged diameter portion longitudinally spaced from said shoulder, said body member being slidably disposed within said housing bore and adapted for travel therein from a first position to a second position;

first anchoring means responsive to travel of said body member for securing said packer against longitudinal movement in one direction relative to the well bore whenever said body member is in said second position including outwardly-extendible wall-engaging slip members movably mounted on said housing and an annular slip cone having an enlarged bore portion slidably mounted around said enlarged body portion and operatively engaged with said slip members;

packing means mounted around said body member in-

termediate said fixed shoulder and slip cone and operatively arranged for expansion into sealing engagement with the well bore whenever said body member is shifted into said second position;

means for securing said body member to said housing whenever said body member is in said second position;

first hydraulic means responsive to a pressure differential acting in said one direction across said packing means when expanded for urging said slip cone against said slip members with an additional force proportionately related to this pressure differential;

second anchoring means for securing said packer against longitudinal movement in the opposite direction relative to the well bore including outwardly-extendible wall-engaging means mounted on said housing and fluidly sealed relative thereto to provide a fluid-tight space therebetween, said wall-engaging means being adapted for extension into engagement with the well bore upon application of hydraulic pressure in said fluid-tight space; and

second hydraulic means responsive to a pressure differential acting in said opposite direction across said packing means when expanded for applying a hydraulic pressure in said fluid-tight space to press said wall-engaging means into anchoring engagement with a force proportionately related to this pressure differential.

7. A well packer sized and adapted for reception in a well bore for packing-off the well bore comprising:

a housing having a longitudinal bore and a chamber therein;

a body member having a fixed shoulder and an enlarged diameter portion longitudinally spaced from said shoulder, said body member being slidably disposed within said housing bore and adapted for travel therein from a first position to a second position;

first anchoring means responsive to travel of said body member for securing said packer against longitudinal movement in one direction relative to the well bore whenever said body member is in said second position including outwardly-extendible wall-engaging slip members movably mounted on said housing and an annular slip cone having an enlarged bore portion slidably mounted around said enlarged body portion and operatively engaged with said slip members;

packing means mounted around said body member intermediate said fixed shoulder and slip cone and operatively arranged for expansion into sealing engagement with the well bore whenever said body member is shifted into said second position;

means for securing said body member to said housing whenever said body member is in said second position;

first hydraulic means responsive to a pressure differential acting in said one direction across said packing means when expanded for urging said slip cone against said slip members with an additional force proportionately related to this pressure differential including first and second means respectively fluidly sealing said enlarged body portion within said enlarged bore portion and said body member to said slip cone to provide a fluid-tight chamber in said enlarged bore portion between said sealing means, and first passage means providing fluid communication between said fluid-tight chamber and the well bore at a point longitudinally displaced in the opposite direction from said packing means;

second anchoring means for securing said packer against longitudinal movement in said opposite direction relative to the well bore including outwardly-extendible wall-engaging means mounted on said housing and fluidly sealed relative thereto to provide a fluid-tight space therebetween, said wall-engaging means being adapted for extension into engagement with the well bore upon application of hydraulic pressure in said fluid-tight space; and

second hydraulic means responsive to a pressure differential acting in said opposite direction across said packing means when expanded for applying a hydraulic pressure in said fluid-tight space to press said wall-engaging means into anchoring engagement with a force proportionately related to this pressure differential including a piston member slidably disposed within said housing chamber and adapted to shift therein in response to this pressure differential;

third means fluidly sealing said piston member within said chamber for fluidly isolating a portion of said chamber;

second passage means providing fluid communication between said isolated chamber portion and said fluid-tight space, all being filled with a hydraulic fluid; and

third passage means providing fluid communication between the well bore at a point longitudinally displaced in said one direction from said packing means and the other portion of said chamber.

8. A well packer sized and adapted for reception in a well bore comprising:

a housing having a longitudinal bore and a cylindrical chamber therein, said chamber having a first portion of a greater cross-sectional area than the remaining portion of said chamber;

a body member having a fixed shoulder and an enlarged diameter portion longitudinally spaced from said shoulder, said body member being slidably disposed within said housing bore and adapted for travel therein from a first position to a second position;

first anchoring means responsive to travel of said body member for securing said packer against longitudinal movement in one direction relative to the well bore whenever said body member is in said second position including outwardly-extendible wall-engaging slip members movably mounted on said housing and an annular slip cone having an enlarged bore portion slidably mounted around said enlarged body portion and operatively engaged with said slip members;

packing means mounted around said body member intermediate said fixed shoulder and slip cone and operatively arranged for expansion into sealing engagement with the well bore whenever said body member is shifted into said second position;

means for securing said body member to said housing whenever said body member is in said second position;

first hydraulic means responsive to a pressure differential acting in said one direction across said packing means when expanded for urging said slip cone against said slip members with an additional force proportionately related to this pressure differential;

including first and second means respectively fluidly sealing said enlarged body portion within said enlarged bore portion and said body member to said slip cone to provide a fluid-tight chamber in said enlarged bore portion between said sealing means, and first passage means providing fluid communication between said fluid-tight chamber and the well bore at a point longitudinally displaced in the opposite direction from said packing means;

second anchoring means for securing said packer against longitudinal movement in the opposite direction relative to the well bore including outwardly-extendible wall-engaging means mounted on said housing and fluidly sealed relative thereto to provide a fluid-tight space therebetween, said wall-engaging means being adapted for extension into engagement with the well bore upon application of hydraulic pressure in said fluid-tight space;

second hydraulic means responsive to a pressure differential acting in said opposite direction across said packing means when expanded for applying a hy-

draulic pressure in said fluid-tight space to press said wall-engaging means into anchoring engagement with a force proportionately related to this pressure differential including a piston member having an enlarged portion and a reduced portion complementarily fitted and slidably disposed within said housing chamber and adapted to shift therein in response to this pressure differential;

third and fourth sealing means respectively fluidly sealing said piston portions for dividing said first chamber portion and isolating said remaining chamber portion from said divided portions;

second passage means providing fluid communication between said isolated chamber portion and said fluid-tight space, all being filled with a hydraulic fluid;

third passage means providing fluid communication from the well bore above said packing means to one of said divided chamber portions; and

fourth passage means providing fluid communication from the well bore below said packing means to the other of said divided chamber portions.

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