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Wilson

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[54] **RETRIEVABLE WELL PACKER**

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[52] **U.S. Cl.** **166/120,** 166/131, 166/134, 166/178, 175/294

[51] **Int. Cl.** **E21b 23/00**

[58] **Field of Search**.....166/120, 121, 134, 131, 178, 166/212; 175/294

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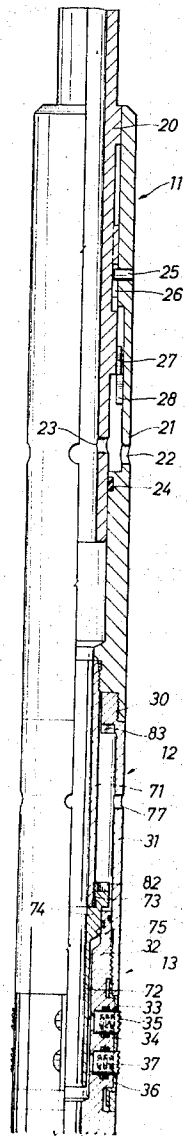
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[57] **ABSTRACT**

In accordance with an illustrative embodiment of the present invention, a retrievable well packer apparatus includes a body structure carrying expansible packing, slip and expander means for anchoring against downward movement, and hydraulically operable gripping means to anchor against upward movement. In the event fluid pressures cannot be equalized in a typical manner to enable release of the packer, the body structure includes a first safety joint means that can be released to enable opening of a pressure equalizing valve means and the operation of tubular telescoping members as a jar or bumper sub. If this fails to release the hydraulically operable gripping means, the body also includes a second safety joint means that can be disconnected to enable release of the pipe string from the packer.

8 Claims, 6 Drawing Figures



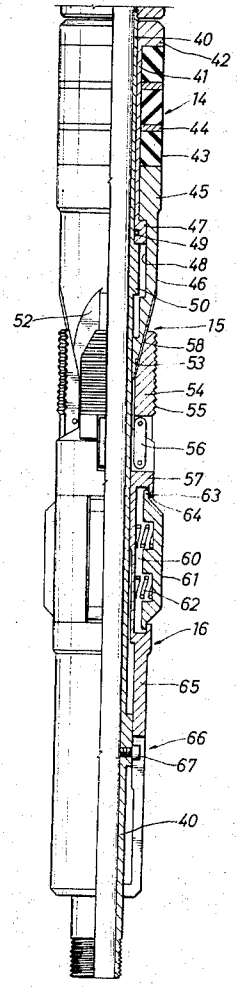


FIG. 1A

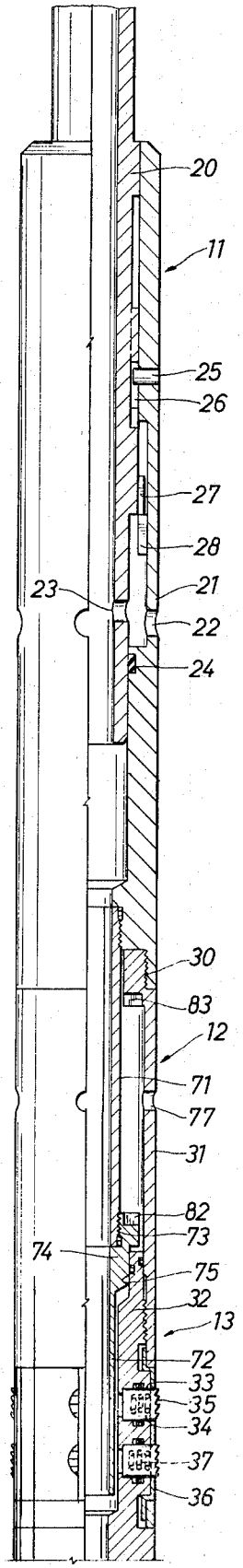
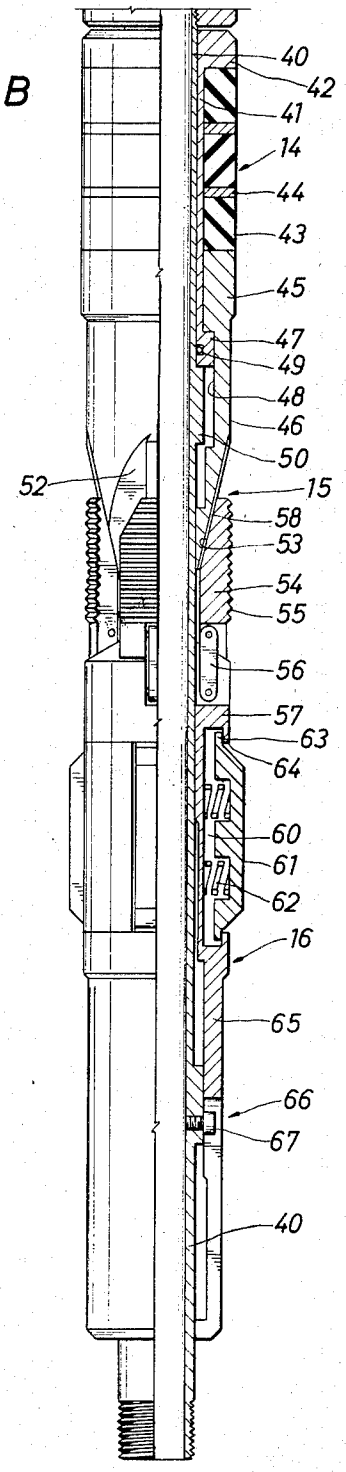


FIG. 1B



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FIG. 2A

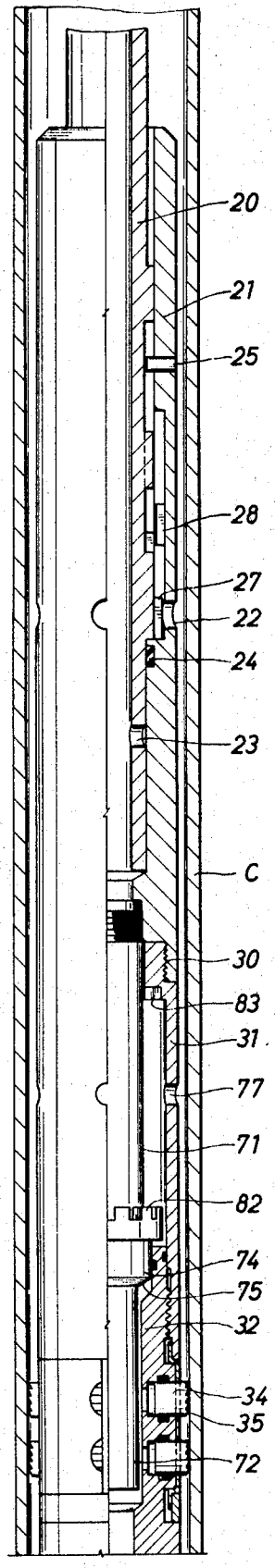
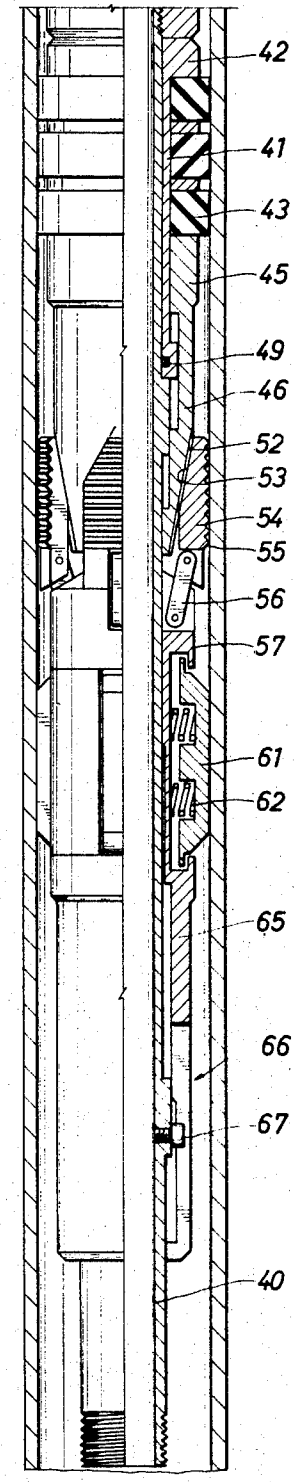


FIG. 2B



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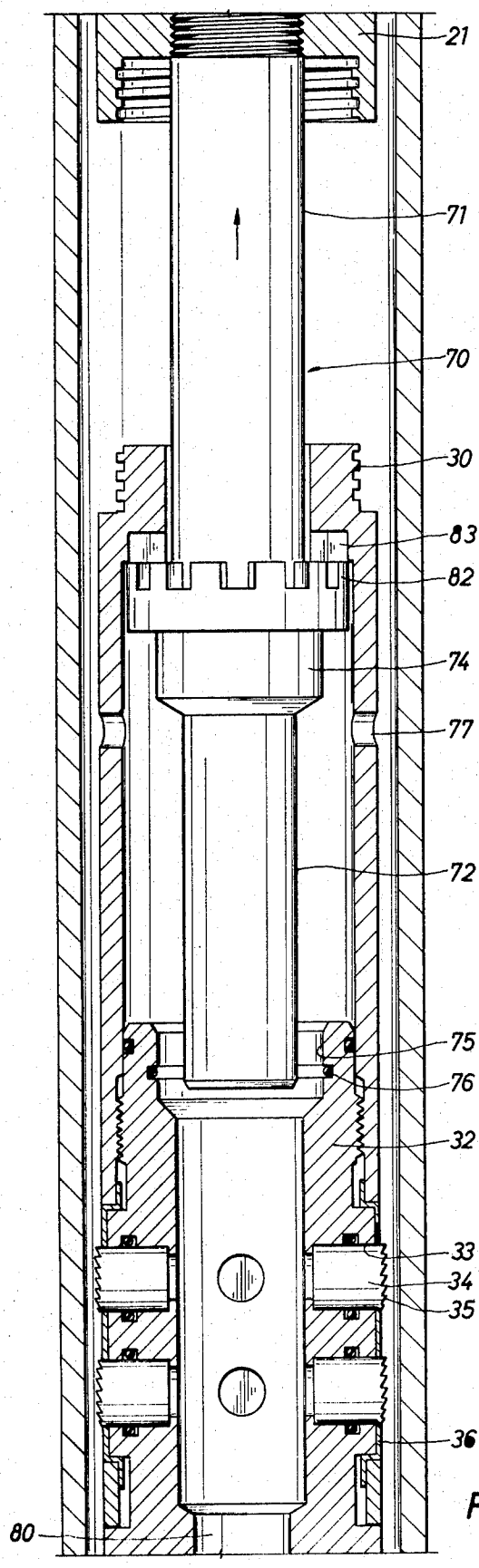


FIG. 4

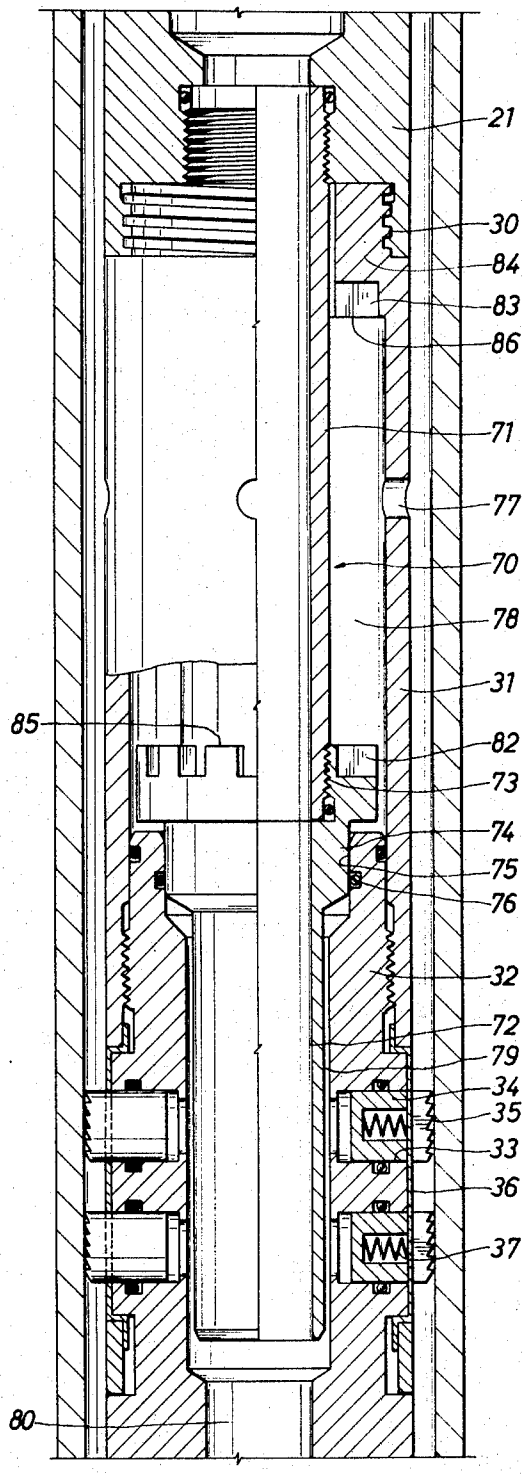


FIG. 3

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RETRIEVABLE WELL PACKER

This invention relates generally to subsurface well tools and more specifically to a retrievable well packer having a hydraulically operable hold down device and with provision for releasing the well packer so that it can be retrieved even in the event of certain adverse conditions that can arise during a well pressuring operation.

Well packers for performing well bore pressuring operations such as squeeze cementing or hydraulic fracturing often incorporate hydraulically operated hold down systems that include gripping pistons adapted to bite into the casing to anchor against upward sliding of the packer. Cement slurry or fracturing fluid is displaced under pressure through a pipe string attached to the packer and into a formation zone below the packer. The pressure difference between the squeeze or fracture pressures and the hydrostatic pressure in the annulus above the packer is effective as a force urging the gripping pistons against the casing walls. When the pressure operation is completed, the pressures are equalized and the gripping pistons returned to their retracted positions so that the packer can be retrieved from the well.

Under certain circumstances, the anomaly of "flash" setting of cement slurry can occur in the pipe string and within the packer bore. That is to say, the cement slurry ingredients are improperly mixed at the surface and will prematurely set up or become hardened when subjected to high temperatures and pressures normally encountered in a well bore. When the cement slurry hardens, squeeze pressures can be trapped behind the gripping pistons so that they will not retract for release of the packer. Moreover, in hydraulic fracturing operations where proping agents such as sand grains are suspended within a gel, the gel can loose viscosity under high temperatures and pressures to the extent that the sand grains can settle within the tubing string and packer bore so as to form a solid plug therein. This anomaly is called "sanding out," and the fracture fluid pressures can be trapped within the hold down system to prevent its release when sanding out occurs.

If the hold down system will not release, the packer must be removed from the well by forcing it upwardly by pulling on the pipe string at the earth's surface until the wickers or teeth on the gripping piston are stripped or torn off, or by removing the pipe string and attempting to wash over the packer, or by drilling the packer away. Obviously, any of these remedial measures involves loss of valuable rig time and/or damage to valuable equipment.

One object of the present invention is to provide a new and improved hydraulic hold down system in a well packer wherein fluid pressures can be equalized that have been trapped in the system and are preventing its release.

Yet another object of the present invention is to provide a new and improved well packer having telescoping mandrels with transverse surfaces that can be utilized in a manner similar to a bumper sub or jar to facilitate release of the packer under adverse conditions.

Another object of the present invention is to provide a new and improved well packer of the type mentioned above and including a safety joint that enables releasing the lower end of the pipe string from the well packer.

These and other objects are attained in accordance with the concepts of the present invention by the provision of a well packer apparatus comprising an anchor body that carries settable packing elements for sealing off a well bore. Slip and expander means are mounted below the packing elements and function to anchor the packer against downward movement. The anchor body has hydraulically operable gripping elements that respond to greater fluid pressure in well bore below the packing than in the annulus above the packing and grip the casing to prevent upward movement. The anchor body includes an inner tubular member disposed in laterally spaced relation to an outer member and coupled thereto by a releasable threaded connection. The inner tubular member has a valve head that normally engages a valve seat located on the outer member above the gripping elements. The outer member is provided with ports so that the annular cavity between the members above the valve elements is in fluid communication with the well annulus. In the event that the pressure of fluids behind the gripping elements cannot be relieved to enable retraction thereof, it is possible to unthread the connection between the inner and the outer members and to unseat the valve head, thereby communicating the area behind the gripping elements with the cavity between the members and with the well annulus via the ports. This should equalize pressures so that the gripping element can retract.

If further difficulties are encountered in retracting the gripping elements, a bumping or jarring action can be applied inasmuch as the inner member has an outwardly directed shoulder that is vertically aligned with an inwardly directed shoulder on the outer member. These shoulders can be repeatedly engaged by working the running-in string upwardly and downwardly to apply a jarring action to the anchor body to the view of loosening and releasing the engagement of the gripping elements. If the foregoing procedures fail to enable release of the packer, a safety joint structure is provided for releasing the lower end of the pipe string from the packer. This structure takes the form of having the inner member constituted by upper and lower sections coupled together by a left-hand thread. The outwardly directed shoulder mentioned above is on the lower section, and is provided with upwardly facing clutch teeth that can mesh with downwardly facing clutch teeth on the inwardly directed shoulder. Thus, by elevating the inner member with respect to the outer member, the clutch teeth are engaged so that relative rotation will unthread the two sections and release the lower end of the pipe string from the packer.

The present invention has other features and advantages that will be made apparent in the following detailed description of a preferred embodiment, taken in conjunction with the appended drawings, in which:

FIGS. 1A and 1B are longitudinal sectional views, with portions in side elevation, of a well packer in accordance with this invention with parts shown in relative positions for lowering into a well bore, FIG. 1B forming a lower continuation of FIG. 1A;

FIGS. 2A and 2B are views similar to FIGS. 1A and 1B except with parts in their relative positions upon setting of the packer in a well bore;

FIG. 3 is an enlarged cross-sectional view to illustrate further detail of the pressure release and safety joint apparatus of this invention; and

FIG. 4 is a view to show the structure of FIG. 3 in certain positions during operation thereof.

Referring initially to FIGS. 1A and 1B, a well packer apparatus 10 in accordance with the principles of the present invention includes by way of general description a bypass assembly 11, a pressure release and safety joint section 12, a hydraulic hold down assembly 13, a packing structure 14, and a slip and expander assembly 15. A drag block control section 16 forms the lower part of the tool. The slip and expander assembly 15 functions to anchor the tool in a well casing against downward movement from a desired setting point, and the packing structure 14 is of the weight-set variety and includes elastomeric packing elements that when expanded function to pack off the casing. The hydraulic hold down assembly 13 has gripping elements that move outwardly in response to a greater fluid pressure in the well casing below the packer and grip the casing to prevent upward movement of the tool. The bypass assembly 11 enables fluids in the well bore to pass through the tool and into the annulus above the packing assembly 14 to facilitate descent of the tool into the well, and is closed during a well pressuring operation. At the completion of the operation, the bypass can be opened to equalize pressures and enable the tool to be unseated for retrieval from the well.

Referring particularly to FIG. 1A, the bypass assembly 11 includes a mandrel 20 that has its upper end adapted for connection to a running-in string of tubing or drill pipe by a suitable collar or the like (not shown). The mandrel 20 is telescopically disposed within a tubular housing 21 having lateral ports 22 for communication with the well annulus. The lower end portion of the mandrel 20 has lateral ports 23 that register with the ports 22 to permit fluid flow in the upper position of the mandrel, and the mandrel can be moved downwardly to a lower position where a seal 24 engages the mandrel above the ports 23 to close off the bypass. The housing 21 has an index pin 25 that extends into a "jay" slot 26 on the mandrel 20 to provide for a required sequence of relative rotational and longitudinal movements in order to place the mandrel in the upper or the lower position. In the upper position, circumferentially spaced lugs 27 and 28 on the mandrel 20 and the housing 21, respectively, are aligned for engagement to prevent the application of shear force to the pin 25. However, when the mandrel 20 is rotated with respect to the housing 21 by an amount controlled by the configuration of the jay-slot 26, the lugs 27 are positioned to pass through the lugs 28 and enable closing movement of the mandrel.

The lower end of the bypass housing 21 may be connected by a thread 30 to a tubular housing member 31 that is in turn connected to the upper end of a tubular anchor body 32. The anchor body 32 has a series of circumferentially spaced, radially extending bores 33, each of which receives a gripping piston 34 having upwardly facing wickers or teeth 35 on its outer face. Each piston 34 has a diametrically extending slot that receives a retainer bar or strap 36 extending across the face of each piston and attached to the anchor body 32 by appropriate means. Springs 37 are positioned between each gripping piston and the retainer bars to urge the pistons inwardly. The details of the hydraulic hold down assembly 13 are well known to those skilled in the art and need not be further elaborated since reference may be had to U.S. Pat. No. 2,792,063, to Jones, issued May 14, 1967, and assigned to the assignee of the present invention.

The anchor body 32 includes a reduced diameter mandrel section 40 that extends downwardly to the bottom end of the tool. The mandrel section 40 carries the packing assembly 14 which includes a compression sleeve 41 having an upper abutment 42. Elastomeric packing rings 43 separated by spacer rings 44 are mounted on the compression sleeve 41 which the lowermost ring resting on a lower abutment 45 that constitutes the upper portion of an expander member 46. The lower end portion of the compression sleeve 41 may be provided with an enlargement 47 that is slidably received within an internal annular recess 48 so that the parts are relatively movable within limits. An O-ring seal 49 is used to prevent fluid leakage between the compression sleeve 41 and the mandrel section 40, and an annular shoulder 50 functions in conjunction with the enlargement 47 to limit downward movement of the expander member 46 relatively along the mandrel section 40.

The expander member 46 has downwardly and inwardly inclined surfaces 52 that coact with mating surfaces 53 on the slip elements 54 to expand the slip elements outwardly. Each slip element 54 has wickers or teeth 55 on its outer face that are arranged to bite into and grip a well casing wall to anchor against downward movement. The slip elements 54 are pivotally coupled by reins 56 to the upper end of a cage member 57 that is movably mounted on the lower portion of the mandrel section 40. Each slip element 54 is also slidably coupled to the expander member 46 through the use of "dove-tail" spline and groove connections 58 so that the slips are moved to retracted positions in the upper position of the expander member 46.

The cage member 57 has a plurality of circumferentially spaced, radially directed recesses 60, each of which receives a drag block 61. Each drag block 61 is urged outwardly by coil springs 62, with outward movement being limited by shoulder 63 and 64 at each end thereof. A depending section 65 of the cage member 57 has a typical jay-slot 66 which receives an outwardly projecting index pin 67 on the mandrel section 40. When the pin 67 is in the closed transverse pocket of the jay-slot 67, the tool is conditioned for longitudinal movement in a well casing, whereas by appropriate manipulation of the mandrel section 40 the pin 67 can be moved into the elongated vertical portion of the jay-slot 67 to enable setting the slip elements 54 and expanding the packing rings 43.

Turning now to a consideration on the structural detail of the pressure release and safety joint section 12 as shown in FIGS. 1A and 3, an inner tubular member 70 is threadedly connected at its upper end to the bypass housing 21 and is disposed in laterally spaced relation to the tubular housing 31 that connects the bypass housing to the upper end of the anchor body 32. The inner member 70 is comprised of an upper section 71 and a lower section 72 joined by a thread 73 and with the lower section providing an annular valve head 74. The valve head 74 normally engages a valve seat 75 located above the gripping pistons 34. A seal that may take the form of an O-ring 76 prevents fluid leakage between the valve head 74 and the seat 76. The housing

member 31 is provided with one or more radial ports 77 through the wall thereof for communicating the cavity 78 with the well annulus outside. The lower section 72 is sized to provide a fluid passage space 79 leading from the bore 80 of the anchor body 32 to regions behind the gripping pistons 34 to enable fluid pressures to act on the rear faces thereof. As shown in FIG. 3, it will be noted that the thread 30 which connects the upper end of the housing member 31 to the lower end of the bypass housing 21 is a relatively large pitch stub thread which is formed on a left-hand helix. Also, it will be noted that the upper end of the valve head 74 is provided with clutch teeth 82 that are aligned with downwardly facing clutch teeth 83 on the thickened section 84 at the upper end of the housing member 31. Moreover, the thread 73 which joins the upper and lower sections 71 and 72 of the inner member is also formed on a left-hand helix for purposes to be fully described below in connection with a description of the operation of the device.

In operation, the well packer 10 is assembled as shown in FIGS. 1A and 1B with the parts in the relative positions for lowering into a well casing. During lowering, the drag blocks 61 slide along in frictional engagement with the well casing wall, and the index pin 67 is in the upper closed portion of the jay-slot 66. Since in this condition the slip elements 54 cannot move relatively upwardly with respect to the expander member 46, the slip elements will remain in retracted positions along with the packing rings 43. Fluids in the well bore can pass upwardly through the mandrel 40 and exit via the bypass ports 23 and 22 to the well annulus, as well as between the packing rings 43 and the well casing wall, to facilitate rapid decent to a desired setting point.

When it is desired to set the well packer 10, the tool is halted and the pipe string is manipulated to cause the lugs 27 and 28 to be appropriately aligned for movement past one another, and the index pin 67 to be aligned with the downwardly opening vertical portion of the jay-slot 66. Then the pipe string is lowered. Since the drag blocks 61 will resist downward movement of the cage member 57 and the slip elements 54, the expander member 46 will be moved downwardly relative to the slip elements and expand the slip elements into gripping contact with the well casing wall as shown in FIG. 2B. With the slip elements 54 set, the lower abutment 45 cannot be moved any further downwardly, so that pipe weight applied to the anchor body 32 and to the compression sleeve 41 will cause the upper abutment 42 to be advanced relatively toward the lower abutment 45 to compress and expand the packing rings 43 into sealing engagement with the well casing wall. The bypass mandrel 20 will have been shifted downwardly relative to the housing 21 so that the bypass seal 24 engages the mandrel above the ports 23 to close off fluid communication to the well annulus. In this condition of parts, the well packer is set and well pressuring operation can be conducted with the developed pressures confined to the well bore region below the packer. A greater fluid pressure in the bore 80 of the mandrel 40 than in the annulus above the packing elements 43 will cause the gripping pistons to move outwardly until their teeth 35 grip the casing, such engagement functioning to anchor the packer against upward movement due to such pressure.

When it is desired to remove the well packer 10 from the well bore, or to move it to another setting location therein, it is normally only necessary to elevate the pipe string to shift the bypass mandrel 20 upwardly. This results in opening the bypass ports 22 and 23 to equalize any pressure differentials that may exist across the packing elements 43. Continued upward movement will enable the packing elements 43 to relax, and will serve to draw the expander member 46 upwardly with respect to the slip elements 54, causing the slips to retract. A partial turn of the pipe string to the left will rejay the bypass assembly 11 and the drag block control 16.

In the event of flash setting of cement or sanding out as previously described, however, opening the bypass may not result in a retraction of the gripping pistons 34. If this occurs, the structure of the present invention can be operated as follows. Inasmuch as the extended gripping pistons 34 will prevent rotation of the anchor body 32 and the tubular member 31, it is possible to release the safety joint thread 30 by rotating the pipe string to the right, such rotation being transmitted through the bypass mandrel 20 and housing 21. With the thread 30 released, the inner tubular member 70 can be elevated as shown in FIG. 4 to disengage the valve head 74 from the seat 75. Since the region behind the gripping pistons 34 is thus communicated with the well annulus via the ports 77, this should result in equalization of pressures across the pistons 34 so that the springs 37 can cause them to retract. If any difficulty is encountered in accomplishing such retraction, however, the pipe string can be worked up and down at the surface, bring the opposed surfaces 85 and 86 of the clutch teeth 82 and 83 together to effect a repeated jarring action. Such jarring action should aid in releasing the teeth of the hold down pistons from engagement with the casing.

If the foregoing procedure fails to release the packer 10, then it will become necessary to disconnect from the packer and leave it for later drilling or wash-over operations. This is accomplished by placing the pipe string in tension and then rotating to the right. The clutch teeth 82 and 83 will engage to co-rotatively couple the lower section 72 of the inner tubular member 70 to the outer housing member 31, so that right-hand rotation will unthread the connection 73. Then the pipe string can be withdrawn from the well with the bypass assembly 11 and the upper mandrel section 71 attached to its lower end.

It will now be apparent that a new and improved well packer apparatus has been disclosed having provision for release of the hydraulic hold down under a number of adverse conditions. Since certain changes or modifications may be made in the disclosed embodiment without departing from the inventive concepts involved, it is the aim of the appended claims to cover all such changes or modifications falling within the true spirit and scope of the present invention.

I claim:

1. A retrievable well packer apparatus comprising: a body structure carrying packing means for sealing off a well bore and hydraulic means operable in response to a pressure differential for anchoring said body structure against upward movement in a well bore, said body structure including tubular telescoping members cou-

pled together by a selectively releasable connection, said body structure further including normally closed valve means that can be opened in response to release of said releasable connection and longitudinal relative movement of said tubular members to equalize said pressure differential and enable retraction of said hydraulic means.

2. The well packer apparatus of claim 1 further including safety joint means in one of said tubular telescoping members adapted to be released in response to relative rotation of said members.

3. The well packer apparatus of claim 1 wherein said tubular members have opposed shoulder surfaces adapted to be brought together by said longitudinal relative movement to impart a jarring action to said body structure.

4. The well packer apparatus of claim 3 further including safety joint means between upper and lower sections of one of said tubular members and clutch means for corotatively coupling said lower section to the other of said members so that said safety joint means can be disconnected in response to relative rotation.

5. A retrievable well packer apparatus comprising: a body structure carrying packing means for sealing off a well bore and hydraulic means operable in response to a pressure differential for anchoring said body structure against upward movement in a well bore, said body structure including an outer member and an inner member defining an annular cavity therebetween in communication with the well annulus above said packing means, said inner member extending downwardly within said outer member to a point below said hydraulic means; coengageable valve means on said members located above said hydraulic means, said valve means being normally closed to enable the development of a pressure differential across said hydraulic means; and a connection between said members that is releasable in response to relative rotation to enable longitudinal relative movement opening said valve means to equalize a pressure differential across said hydraulic means.

6. The well packer apparatus of claim 5 wherein said valve means on said inner member is provided by an annular valve head having an upwardly facing shoulder surface aligned for engagement with a downwardly facing shoulder surface on said outer member so that upon release of said connection and opening of said valve means said shoulder surfaces can be brought together by longitudinal relative movement to impart jarring force to said outer member.

7. The well packer apparatus of claim 6 wherein said inner member has upper and lower sections connected together by safety joint means, and further including means for preventing relative rotation between said lower section and said outer member so that rotation of said upper section with respect thereto can effect release of said safety joint means.

8. The well packer apparatus of claim 7 wherein said means for preventing relative rotation comprises coengageable clutch means on said lower section and said outer member adapted to be engaged by longitudinal relative movement.

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