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3,211,227

RELEASE MECHANISM FOR WELL EQUIPMENT

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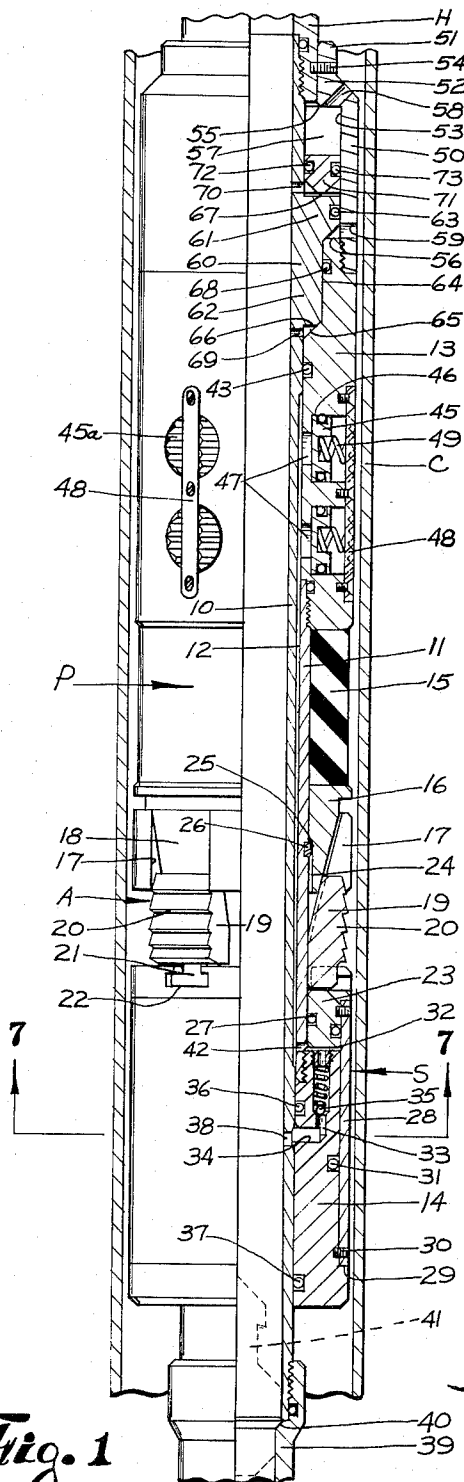


Fig. 1

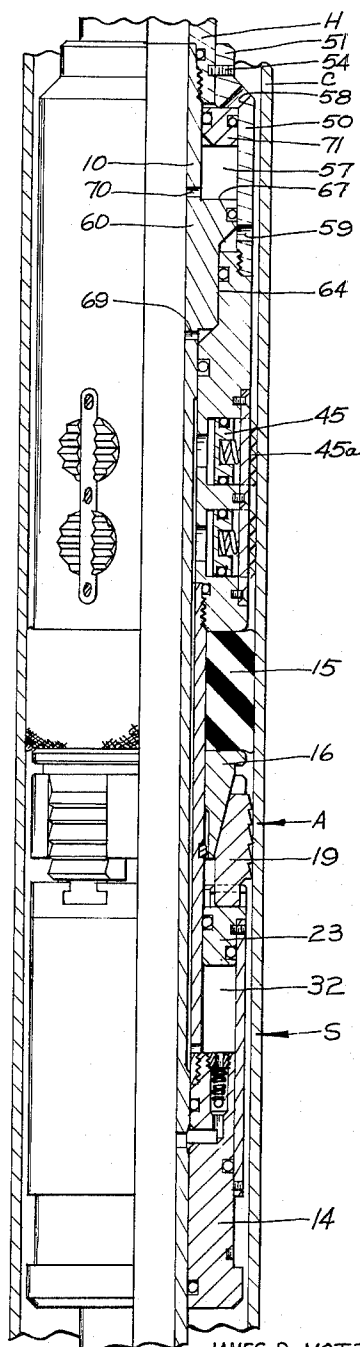


Fig. 2

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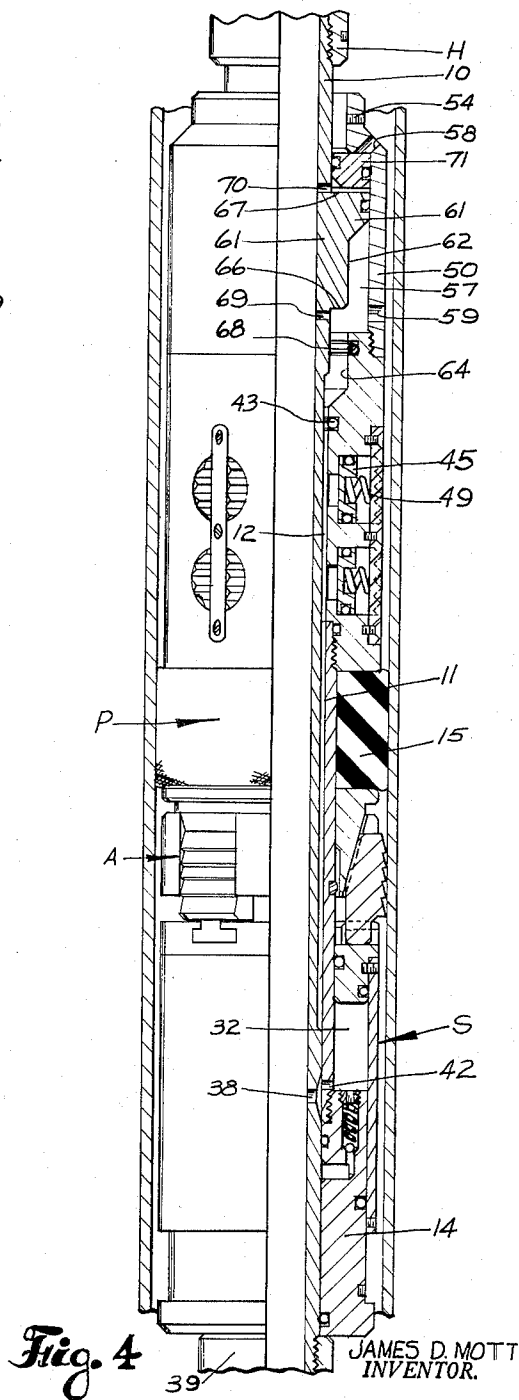
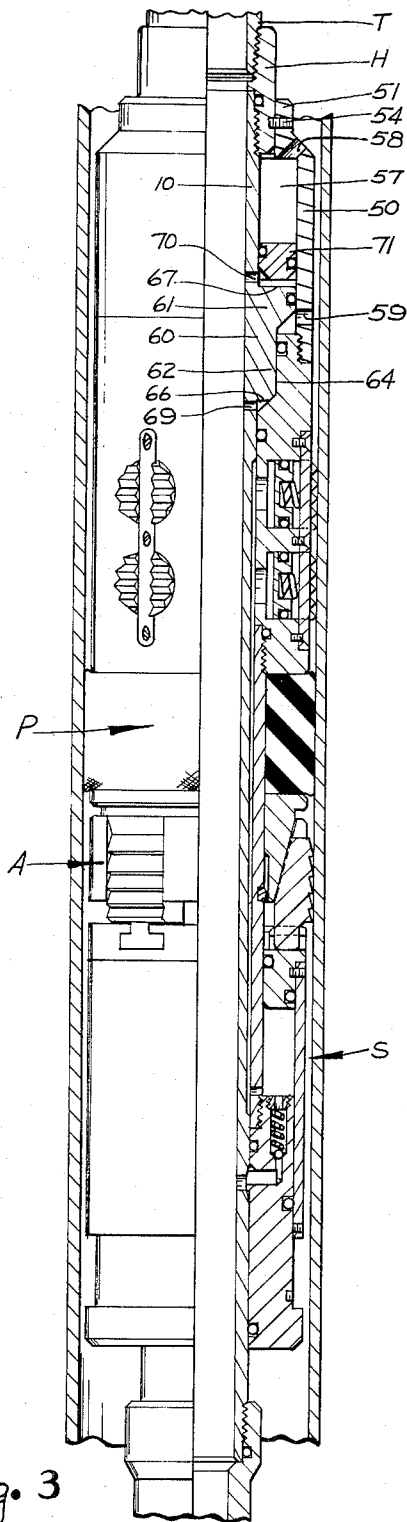
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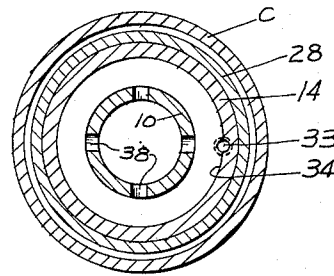
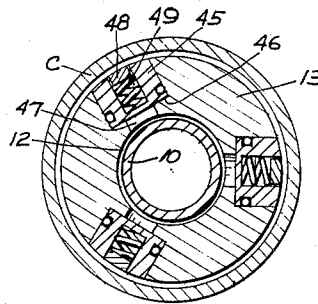
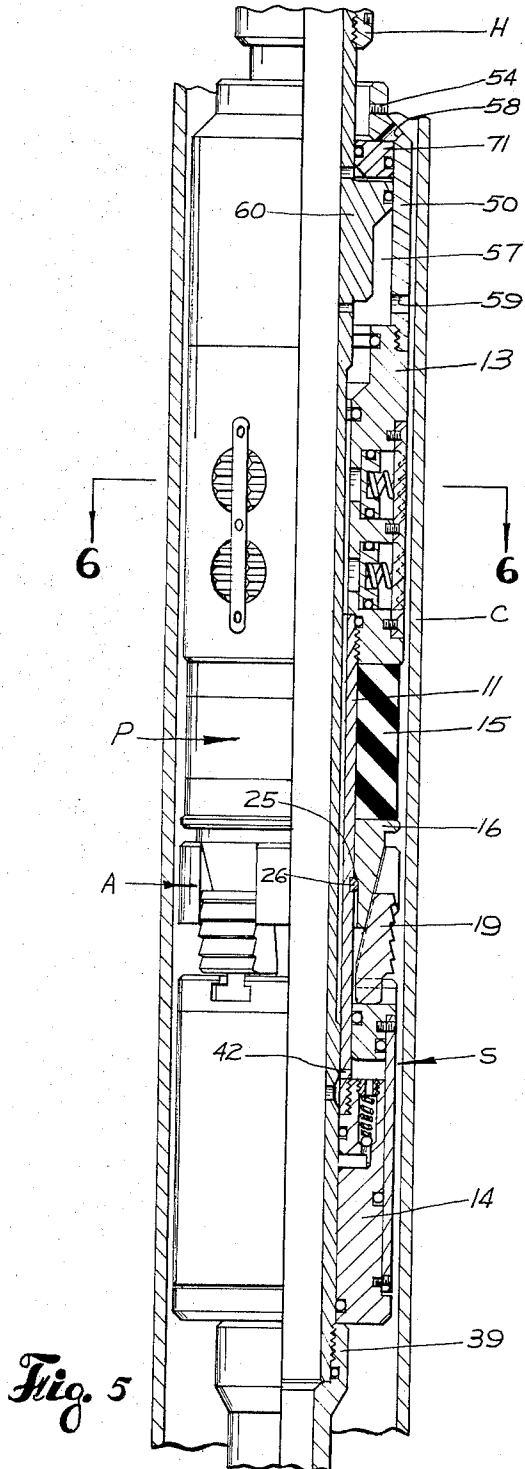
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RELEASE MECHANISM FOR WELL EQUIPMENT

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RELEASE MECHANISM FOR WELL EQUIPMENT

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10 Claims. (Cl. 166—120)

This invention relates to well equipment and more particularly to well equipment such as well packers, anchors, and the like.

Various types of well equipment, such as well packers, including hydraulic and weight set packers, anchors and other devices, are normally run on a release mandrel or so-called "stinger" connected to an operating string and releasably secured to the well equipment by means of frangible devices, such as shear pins, enabling the equipment to be released, when desired, by a straight pull on the operating string sufficient to break the shear pins.

While this simple type of straight pull release is often most desirable for well equipment of the kind mentioned, it is subject to the difficulty that the equipment, when in place in the well, may be subjected to high pressures from below which may apply a sufficient force to the mandrel exceeding the breaking strength of the shear pins, and thereby cause premature release of the release mandrel. On the other hand, if the shear pins are made strong enough to withstand the maximum pressures which might thus be encountered, they become too strong to be broken by any reasonable pull which can be effectively applied to the operating string to which the mandrel is secured.

To overcome the difficulties mentioned above to which shear pins release mechanisms are subjected, while still retaining the advantages of the simple straight-pull release arrangement provided by shear pins, this invention has for its primary object the provision of an auxiliary mechanism arranged between the mandrel and the well equipment with which it is run, which is operable in response to pressure differentials in either direction across the well equipment to counter-balance or offset any upward force which would otherwise tend to break the shear pins.

In accordance with this invention, a floating piston arrangement is employed in conjunction with a differential area piston member fixedly mounted on the mandrel connected by shear pins to a well equipment to counter any high pressure forces tending to break the shear pins and prematurely release the mandrel.

It is a principal object, therefore, of this invention to provide a straight-pull release mechanism for use with well equipment adapted to be anchored in a well bore, including means for counter-balancing any upward forces caused by pressure below the equipment to prevent premature release of the release mechanism.

A more specific object is the provision of a straight-pull release mechanism employing shear pins between a release mandrel and a well equipment anchored in a well bore in combination with a piston member carried by the mandrel and having differential pressure-responsive areas and a floating piston positioned between the differential area piston member and the well equipment operable in response to differential pressures across the well equipment to prevent premature breaking of the shear pins.

Other more specific objects and advantages of this invention will become more readily apparent from the following detailed description when read in conjunction with the accompanying drawing which illustrates a useful embodiment in accordance with this invention.

In the drawing:

FIG. 1 is a longitudinal quarter-sectional view of a

well packer employing a release mechanism in accordance with this invention disposed in un-set position in a well bore;

FIG. 2 is a view similar to FIG. 1, showing the packer in set position, the parts of the release mechanism being in the position responsive to an upwardly directed pressure differential across the packer;

FIG. 3 is a view similar to FIG. 2 showing the parts of the release mechanism in the position responsive to a downwardly directed differential pressure across the packer;

FIGS. 4 and 5 are views similar to the preceding views showing the positions of the parts at successive stages in the release of the release mechanism and the packer; and

FIGS. 6 and 7 are cross-sectional views taken respectively along line 6—6 of FIG. 5 and line 7—7 of FIG. 1.

Although the details of the well equipment with which this invention is employed do not form a part of this invention, for purposes of illustration, the invention is shown in conjunction with a hydraulic pressure actuatable well packer of a known form which may be quite similar to that described in Cicero C. Brown's U.S. application, Serial No. 745,550, filed June 30, 1958, now Patent No. 3,080,923. It will be understood, however, that the invention, as will appear subsequently, may be applied to other types of hydraulic pressure-set packers, weight-set packers, and other well equipment adapted to be anchored in a well bore, especially equipment of this general character which is run on a tubular mandrel or stinger to which the equipment is releasably secured by means of frangible release elements, such as conventional shear pins. As seen in the illustrative embodiment of the drawing the well packer, designated generally by the letter P, is shown run into a well bore on a tubular mandrel or stinger 10 having its upper end threadedly secured to a coupling H, which, it will be understood, is connected to an operating string of tubing T (FIG. 3).

Packer P includes a tubular body 11 having a bore 12 through which mandrel 10 extends. The upper end of body 11 is threadedly received in the bore of an upper anchor head 13 and the lower end of body 11 is threadedly secured to lower cylinder head 14. A conventional flexible resilient seal element 15 is slidably mounted on body 11 in abutting relation to the lower end of upper head 13 and an anchor assembly A is slidably disposed about body 11 in abutting relation to the lower end of seal element 15. Anchor assembly A comprises an expander element 16 provided with a plurality of angularly spaced longitudinal slots 17 having downwardly and inwardly tapering wedge surfaces 18 over which are slidably disposed wedge slips 19 having toothed outer faces 20 adapted to grip the wall of a well casing C. The lower ends of slips 19 are provided with conventional T-heads 21 receivable in correspondingly shaped slots 22 carried by the upper end of an annular piston 23 slidably mounted about the exterior of body 11. Piston 23 forms a movable abutment engageable with the lower end of anchor assembly A and forms part of a hydraulic pressure actuating assembly S which is adapted, in response to actuation by hydraulic pressure, to urge slips 19 longitudinally and radially over wedging surfaces 18 on the expander element into anchoring engagement with the wall of casing C and which, at the same time, will axially compress seal element 15 against upper head 13 and radially expand the sealing element into sealing engagement with the wall of casing C. The bore of expander element 16 is counterbored from its lower end at 24 to provide a downwardly facing shoulder 25 cooperable with a snap ring 26 mounted in the exterior of body 11 to form an externally projecting

shoulder which will be abutable with shoulder 25 in a stage of operation of the device as will appear hereinafter.

A seal ring 27 is mounted in the bore of piston 23 to provide a fluid-tight slidable seal between the piston and the exterior of body 11. A cylindrical skirt 28 is secured to the exterior of piston 23 and extends slidably over the exterior of cylinder head 14. When piston 23 is in its lowermost position relative to the upper end of cylinder head 14, skirt 28 will abut a stop shoulder 29 formed on the exterior of cylinder head 14. Shear screws 30 releasably secure the lower end of skirt 28 to the cylinder head. A seal ring 31 is mounted in the exterior of cylinder head 14 to provide a slidable seal between skirt 28 and the cylinder head. The space between piston 23 and the upper end of cylinder head 14 defines an expandible chamber 32 which is in communication with an inlet passageway 33 which extends downwardly through cylinder head 14 into communication with an annular groove 34 formed in the inner periphery of cylinder head 14 and defines the inlet end of the inlet passageway. A back-check valve 35 of conventional form is mounted in passageway 33 to prevent reverse flow of fluid from chamber 32 through passageway 33. Upper and lower seals 36 and 37, respectively, are mounted in the bore of cylinder head 14 in slidable sealing relation to the exterior of mandrel 10 at points above and below groove 34. Ports 38 are provided through the wall of mandrel 10 to register with groove 34 when the mandrel is fully inserted in the bore of the packer, as shown in FIG. 1. The lower end of mandrel 10 extends below cylinder head 14 and is connected to a landing collar 39 having an internal seat 40 to be closed by means of a conventional form of a retrievable plug 41 or other device suitable for plugging the bore of the mandrel when necessary to develop fluid pressure in the bore of the mandrel, as will appear subsequently. Ports 42 are provided through the wall of body 11 communicating chamber 32 with annular space 12. The latter is closed at a point between the mandrel and upper head 13 by means of a seal ring 43.

Upper anchor head 13 carries auxiliary anchoring elements comprising a plurality of cylindrical so-called "button" anchor slips 45 slidably disposed in radial cylinders 46 in head 13, the bottoms of the cylinders communicating with annular space 12 through passages 47. The toothed end faces 45a of slips 45 are bifurcated to receive a keeper bar 48 which will retain these slips against falling outwardly from cylinders 46, while permitting limited outward movement sufficient to engage the wall of casing C. A biasing spring 49 is mounted in the base of each slip 45 in compression against keeper bar 48 to normally urge the slips inwardly. With the packer structure assembled on the mandrel, as shown in FIG. 1, it will be evident that when plug 41 or other plugging device is dropped on to seat 40 and fluid pressure developed in the bore of the mandrel, this pressure will act against piston 23 forcing the latter upwardly, breaking shear pins 30 and actuating the anchor assembly, so as to move slips 19 upwardly over expander element 16. This upward movement will, in turn, compress and radially expand seal element 15 to set the packer. At the same time, fluid pressure entering chamber 32 will also flow through ports 42 into annular space 12 and thence through passages 47 to actuate holddown slips 45, thereby finally and effectively setting the packer, as illustrated particularly in FIG. 2.

Returning now to the mandrel and the release connection between the mandrel and the packer, a tubular housing 50 is threadedly secured to the upper end of upper head 13 to form an extension thereof, the exterior of which is substantially flush with the exterior of upper head 13. The upper end of extension housing 50 is secured to, or integrally formed with, an adapter collar 51 having a bore 52 smaller in diameter than bore 53 of

housing 50. Bore 52 of the adapter collar is adapted to slidably receive coupling H by which the mandrel is secured to the operating tubing string T and collar 51 is releasably secured to coupling H by means of shear pins 54, these being the primary releasable connections between the mandrel and the packer. The difference in diameters between bores 52 and 53 provides the downwardly facing shoulder 55 vertically spaced from the upper end 56 of upper head 13. The annular space thus provided between the exterior of mandrel 10 and the inner wall of housing 50 and defined at its ends by shoulder 55 and the upper end 56 of upper head 13 comprises a pressure cylinder 57 which is in communication at its upper end by means of ports 58 through the wall of adapter collar 51 with the exterior of the housing, thereby placing cylinder 57 in communication with the interior of casing C. Additional ports 59 are provided through the wall of housing 50 spaced below ports 58 immediately adjacent upper end 56 of the upper head. An annular enlargement 60, herein termed a differential area piston, is formed on, or affixedly secured to, mandrel 10 generally opposite cylinder 57. Piston 60 has upper and lower pressure-actuable area sections 61 and 62, respectively, upper area section 61 being of the greater area and projecting radially into chamber 57. The diameter of section 61 is such as to form a sliding fit with the bore wall of housing 50 and is provided with a peripheral packing 63 slidably sealing with the bore wall of housing 50. Upper head 13 is counterbored from its upper end to provide an extension 64 of cylinder 57 terminating at a shoulder 65. Cylinder extension 64 is adapted to slidably receive the smaller pressure actuable area section 62 of the differential area piston which defines the downwardly facing annular shoulder 66. Upper section 61 defines the upwardly facing annular shoulder 67. A packing ring 68 is mounted in the wall of cylinder extension 64 to provide a slidable seal between smaller piston section 62 and the wall of cylinder extension 64 at a point below upper end 56 of the upper head. Ports 69 are provided through the wall of mandrel 10 immediately below shoulder 66 to provide fluid communication between the bore of mandrel 10 and the lower end of cylinder extension 64. Ports 70 are provided through the wall of mandrel 10 immediately above upper shoulder 67 of the piston and communicate the bore of the mandrel with the interior of cylinder 57 above shoulder 67. It will be seen that cylinder 57 with cylinder extension 64 defines a differential area cylinder for receiving the corresponding portions of the differential area piston 60.

A floating seal or piston 71 is slidably disposed about mandrel 10 in the portion of cylinder 57 between housing shoulder 55 and upper shoulder 67 of the differential area piston. Piston 71 carries internal and external packings 72 and 73, respectively, for slidable sealing engagement with the opposite walls of cylinder 57. The downward movement of piston 71 will, therefore, be limited by engagement with shoulder 67 and its upward movement by shoulder 55, packings 72 and 73 sealing with the walls of the cylinder to provide continuous sealing-off of cylinder 57 between ports 58 and 70.

Operation of the device is as follows: The packer, assembled as shown in FIG. 1, is run through the bore of casing C to the point in the well at which it is to be set. At that point plug 41 will be inserted into the tubing string and pumped down until it lands on plug seat 40, closing off the bore of the mandrel. By the use of the usual pumps at the surface, the column of hydraulic fluid which will normally be present in the bore of the tubing string will be pressurized and this pressure will be transmitted through ports 38 and groove 34 into inlet passageway 33 and thence into pressure chamber 32 where it will act upwardly against setting piston 23, urging the latter upwardly and under sufficient force to break shear pins 30, to thereby release the setting piston. The latter, under the applied pressure, will then urge

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slips 19 upwardly over expander element 16 and both will move upwardly compressing seal element 15 until the latter is in sealing engagement with the wall of casing C and slips 19 have been effectively set in the wall of the casing. At the same time, the pressurized fluid will flow through ports 42 into annular space 12 and thence through passages 47 of the upper anchor head to actuate slips 45 and set them in gripping engagement with the wall of casing C. The packer will thus be set and plug 41 may be fished out and the tubing string opened to production, as required.

When the packer has been set, a high pressure below the packer will act against the cross-section of the tubing string and mandrel and will tend to break shear pins 54, if not otherwise counter-balanced. With the present construction this pressure will be exerted through ports 69 and 70 against the differential areas of piston 60. The pressure entering through ports 70 will move piston 71 upwardly to the position shown in FIG. 2 and will, at the same time, act downwardly against shoulder 67 while the pressure entering through ports 69 will act upwardly against shoulder 66. By virtue of the difference in areas of piston sections 61 and 62, the downwardly exerted pressure will, of course, be greater than the upwardly exerted pressure on the opposite end of the piston. As a consequence, a resultant force will be applied in the downward direction tending to hold the mandrel downwardly in opposition to the upwardly directed pressure, thereby counter-balancing the upward force on shear pins 54 and protecting them against this unbalanced pressure.

Should the pressure above the packer be greater than that from below and produce a pressure differential in the downward direction, this pressure, acting through ports 58, will move piston 71 to its downward position as shown in FIG. 3, and will thereupon act against upper shoulder 67 of the differential area piston. The same pressure will be exerted through ports 59 against the difference in areas between piston sections 61 and 62, but since this difference in area is less than the pressure-actuable area of shoulder 67, the resultant force will be in the downward direction against the latter and will act to hold the mandrel in its downward position, relieving shear pins 54 of any excessive breaking force. By selection of an appropriate ratio for the areas of piston sections 61 and 62, any desired hold-down pressure may be generated on piston 60.

Of course, where the pressures are equalized, the release mechanism will be inactive, although it is obvious that in most instances some pressure differential across the packer will normally exist sufficient to actuate the hold-down elements of the release mechanism.

When it is desired to release the packer, an upward pull will be taken on tubing T sufficient to break shear pins 54, as shown in FIG. 4. As the mandrel is then pulled upwardly, the seal formed by packing ring 43 with the mandrel will be broken, allowing the pressure fluid in annular space 12 to escape through cylinder extension 64 and thence through ports 59, relieving the fluid pressure upon slips 45, so that they become free to retract under the action of springs 49. At the same time, the pressure in chamber 32 will be relieved through ports 42 and 38 into the bore of the mandrel. As upward movement of the mandrel is continued by drawing the tubing string upwardly, the upward force will be applied through pistons 60 and 71 to housing 50 and thence to the upper head of the packer, which will pull packer body 11 upwardly until snap ring 26 engages shoulder 25 (FIG. 5), and thereby pull expander 16 out from under slips 19, retracting the latter from engagement with the wall of casing C. Further upward movement of the tubing string will finally pull landing collar 39 against the lower end of cylinder head 14 and enable the upwardly moving tubing string to pull the entire packer out of the well.

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In cases where an excessive differential in pressure exists between the tubing and the casing annulus, it may be necessary to equalize these pressures before attempting to release the packer. This may be done in any suitable manner as by pumping fluid into the tubing or into the casing annulus as may be required.

It will be understood that various changes and alterations may be made in the details of the illustrative embodiment within the scope of the appended claims, but without departing from the spirit of this invention.

What I claim and desire to secure by Letters Patent is:

1. For use with a well equipment positioned in a well bore and adapted to be anchored therein, said equipment including a tubular body having an axial bore, means mounted on the body for anchoring said body to the wall of the well bore, and a tubular release mandrel slidably disposed in said axial bore, a straight-pull release mechanism for releasing said mandrel from said body, comprising, frangible means securing the mandrel to the body and releasable therefrom by upward force on the mandrel, and means for counterbalancing fluid pressures internally and externally of said body which tend to exert upward force on the mandrel, said last mentioned means comprising cooperating differential pressure-actuable areas carried by the mandrel and body exposed to differentials in said fluid pressures across said body and constructed and arranged to direct the force of said fluid pressure differentials downwardly on said mandrel.

2. Apparatus according to claim 1, wherein said well equipment is a well packer.

3. Apparatus according to claim 1, wherein said well equipment is a hydraulic pressure-settable well packer.

4. For use with a well equipment positioned in a well bore and adapted to be anchored therein, said equipment including a tubular body having an axial bore, means mounted on the body for anchoring said body to the wall of the well bore, and a tubular release mandrel slidably disposed in said axial bore, a straight-pull release mechanism for releasing said mandrel from said body, comprising, frangible means securing the mandrel to the body and releasable therefrom by upward force on the mandrel, and means for counterbalancing fluid pressures internally and externally of said body which tend to exert said upward force on the mandrel, said last-mentioned means comprising cooperating differential pressure-actuable areas carried by the mandrel and body exposed to differentials in said fluid pressures across said body and constructed and arranged to direct the force of said fluid pressure differentials downwardly on said mandrel, said last-mentioned means including a differential area cylinder carried by the body, a cooperating differential area fixed piston carried by the mandrel having larger and smaller pressure-actuable areas disposed in the corresponding portions of said cylinder, the larger pressure-actuable area being uppermost, and port means in the body and mandrel arranged to direct fluid pressure in the mandrel against said pressure-actuable areas.

5. For use with a well equipment positioned in a well bore and adapted to be anchored therein, said equipment including a tubular body having an axial bore, means mounted on the body for anchoring said body to the wall of the well bore, and a tubular release mandrel slidably disposed in said axial bore, a straight-pull release mechanism for releasing said mandrel from said body, comprising, frangible means securing the mandrel to the body and releasable therefrom by upward force on the mandrel, and means for counterbalancing fluid pressures internally and externally of said body which tend to exert said upward force on the mandrel, said last-mentioned means comprising means defining a differential area cylinder at the upper end of said body, a differential area fixed piston mounted on the mandrel having relatively larger and smaller pressure-actuable areas disposed in the corresponding portions of said cylinder, the larger pressure-actuable area being uppermost, first port means

communicating the upper end portion of said cylinder with the well bore, second port means communicating the interior of the mandrel with said cylinder at a point above the larger pressure-actuable area of said fixed piston, an annular piston slidably disposed in said cylinder about the mandrel for slidable sealing movement between said first and second port means, third port means communicating said cylinder at a point between said larger and smaller pressure-actuable areas with the well bore, fourth port means communicating the bore of the mandrel with the cylinder below said smaller pressure-actuable area, and means sealing-off between the smaller pressure-actuable area and the cylinder at a point between said third and fourth port means.

6. Apparatus according to claim 5, wherein said well equipment is a hydraulic pressure-settable well packer.

7. For use with a well equipment positioned in a well bore and adapted to be anchored therein, said equipment including a tubular body having an axial bore, means mounted on the body for anchoring said body to the wall of the well bore, and a tubular release mandrel slidably disposed in said axial bore, a straight-pull release mechanism for releasing said mandrel from said body comprising, a tubular housing coaxially secured about the upper end of said body to define a piston chamber surrounding an upper portion of the mandrel, a collar member carried by the upper end of the housing surrounding the mandrel, frangible means initially securing said collar member to said mandrel, an annular enlargement disposed on the mandrel generally opposite said chamber, said enlargement defining annular shoulder portions at its upper and lower ends, the upper shoulder portion having a larger pressure-actuable area than the lower shoulder portion, the lower shoulder portion being receivable in the bore of said body and the upper shoulder portion being receivable in said housing, upper and lower seals between the respective shoulder portions and the cooperating portions of said housing and said body, first port means through the wall of said housing communicating the interior of said chamber between said seals with the well bore exteriorly of said housing, second port means through the wall of the housing communicating the interior of said chamber above the upper one of said seals with the well bore exteriorly of said housing, third port means through the wall of the mandrel communicating the bore thereof with the chamber at a point closely above said upper shoulder portion, fourth port means communicating the bore of said mandrel with the bore of said body below said smaller shoulder portion, and an annular sealed piston slidably disposed in said chamber about the mandrel for movement longitudinally of the chamber between said first and third port means.

8. Apparatus according to claim 7, wherein said well

equipment is a well packer settable by hydraulic pressure supplied through said mandrel.

9. For use with a well equipment positioned in a well bore and adapted to be anchored therein, said equipment including a tubular body having an axial bore, means mounted on the body for anchoring said body to the wall of the well bore, and a tubular release mandrel slidably disposed in said axial bore, a straight-pull release mechanism for releasing said mandrel from said body, comprising, a tubular housing coaxially secured about the upper end of said body to define therewith a differential area cylinder surrounding the mandrel and comprising an upper larger diameter section and a lower smaller diameter section, an annular cylinder head carried by the upper section of said housing surrounding said mandrel, frangible means initially securing said cylinder head to said mandrel, an annular differential area piston fixedly mounted on the mandrel and having relatively larger and smaller diameter portions slidably receivable in the corresponding sections of said cylinder and having sealing engagement therewith, longitudinally spaced first port means through the wall of the mandrel communicating the bore of said mandrel with said chamber at points respectively above and below the larger and smaller diameter portions of said piston, upper and lower longitudinally spaced second port means through the wall of the housing communicating the exterior of the housing with the interior thereof, the upper of said second port means communicating with the interior of said cylinder above the upper of said first port means, and the lower of said second port means communicating with the interior of the cylinder at points between said cylinder portions, and an annular floating piston in the cylinder slidably disposed about the mandrel for movement longitudinally thereof between the upper ones of said first and second port means, said floating piston having slidable sealing engagement with said mandrel and said cylinder.

10. Apparatus according to claim 9, wherein said well equipment is a well packer comprising radially expandible seal-and-anchor assemblies, hydraulic pressure-actuated means mounted on the body cooperating with said seal-and-anchor assemblies to expand the same in response to hydraulic pressure supplied to said pressure-actuated means through said mandrel, and passage means communicating hydraulic pressure fluid from the interior of said mandrel to said pressure-actuated means.

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