May 21, 1963 C. B. COCHRAN ET AL 3,090,442

DEVICE FOR SUPPORTING A CLOSURE WITHIN A WELL PIPE

Filed Oct. 24, 1958 3 Sheets-Sheet 1

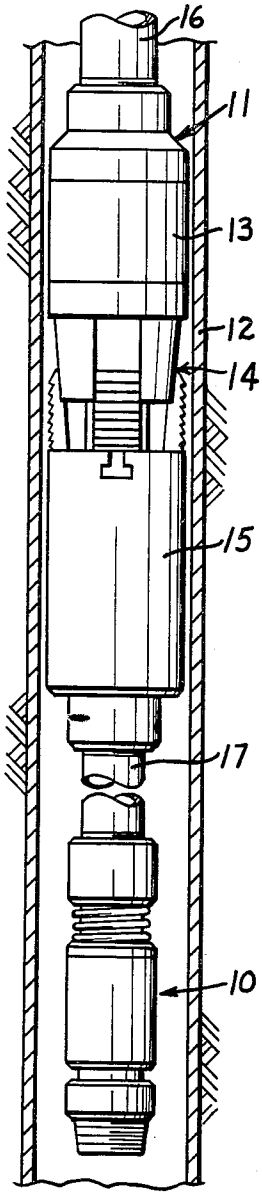


Fig. 1

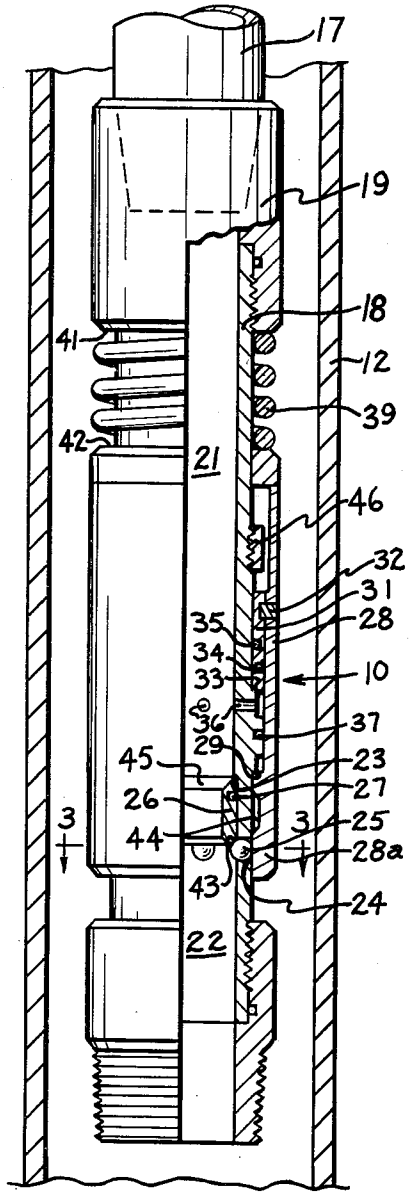


Fig. 2

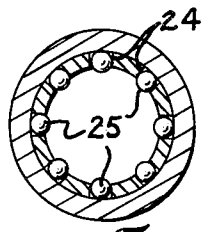


Fig. 3

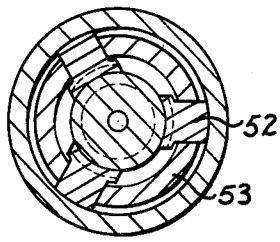


Fig. 7

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DEVICE FOR SUPPORTING A CLOSURE WITHIN A WELL PIPE

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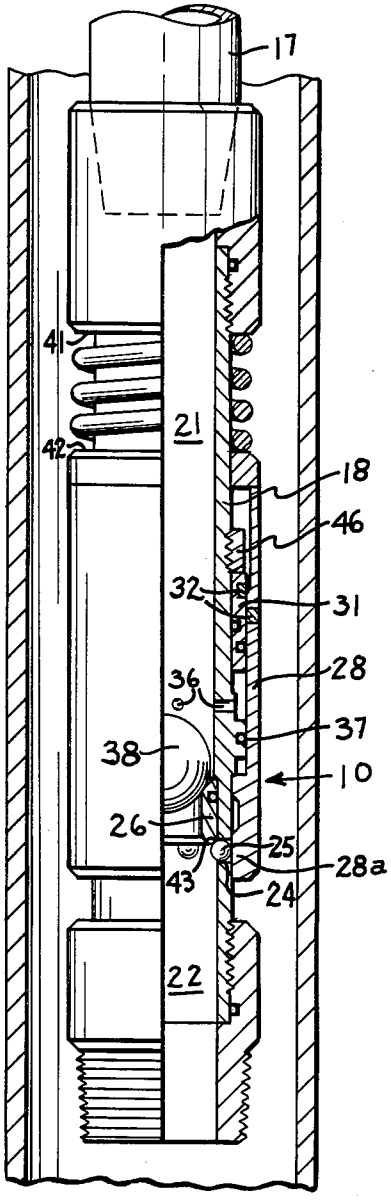


Fig. 4

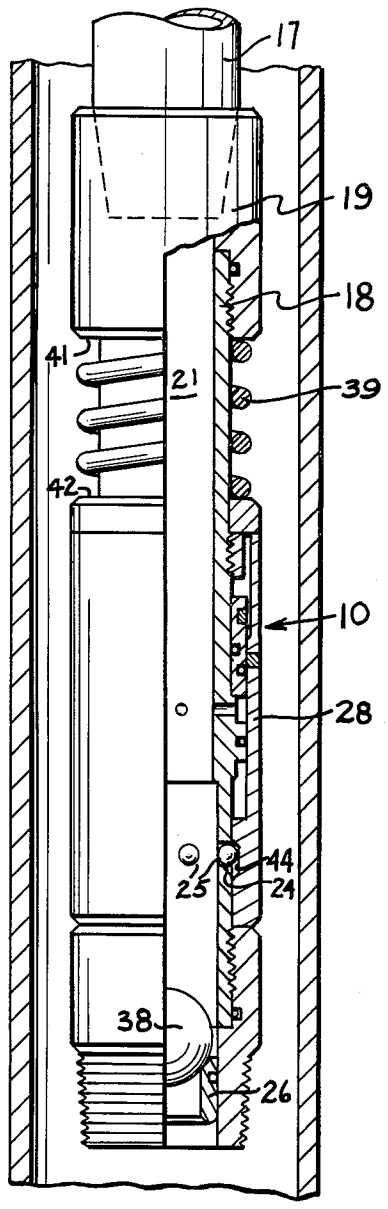


Fig. 5

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DEVICE FOR SUPPORTING A CLOSURE WITHIN A WELL PIPE

Filed Oct. 24, 1958 3 Sheets-Sheet 3

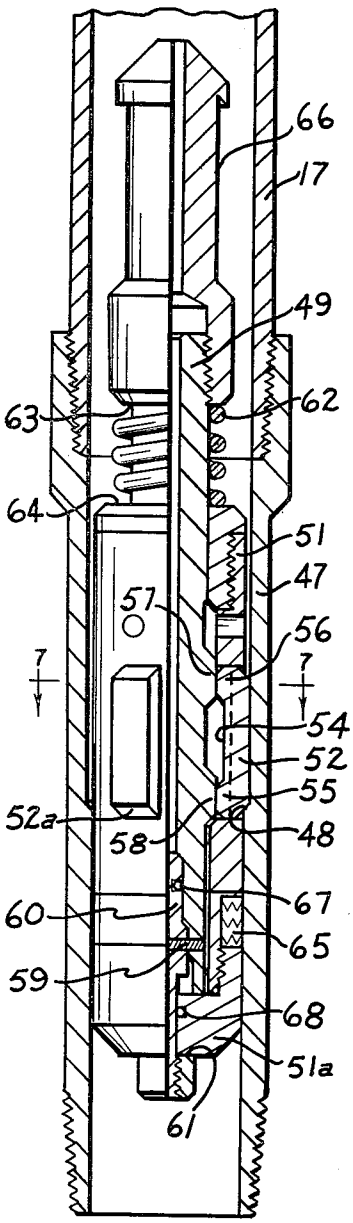


Fig. 6

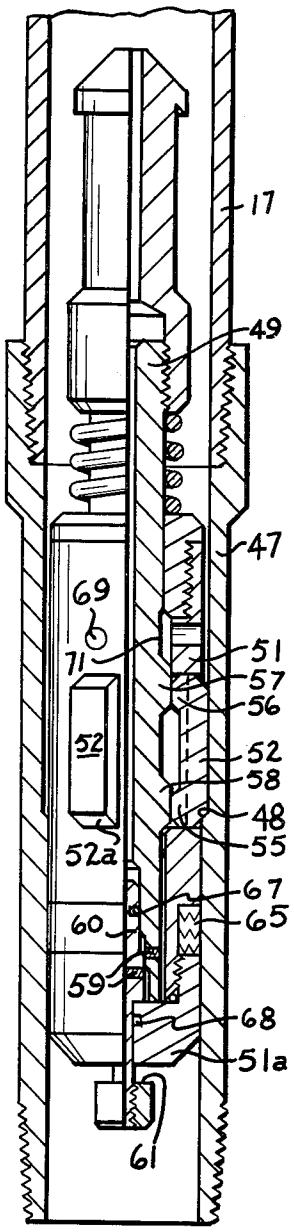


Fig. 8

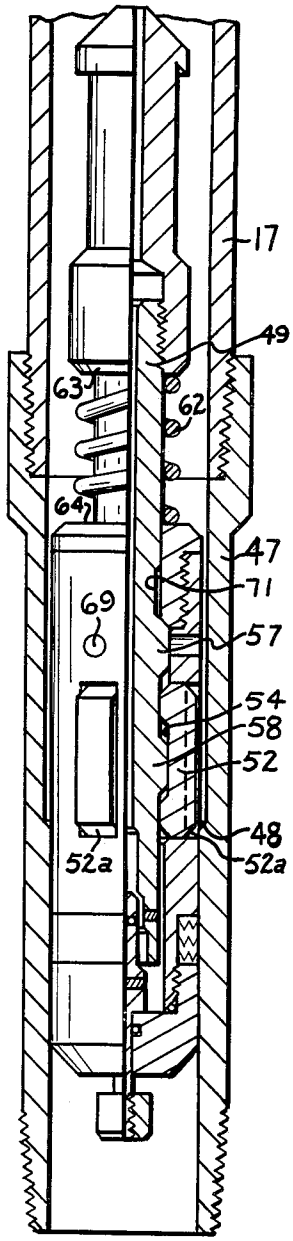


Fig. 9

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DEVICE FOR SUPPORTING A CLOSURE WITHIN A WELL PIPE

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Filed Oct. 24, 1958, Ser. No. 769,435
16 Claims. (Cl. 166—192)

This application relates to well completion tools and more particularly to a device for supporting a closure within a well pipe.

In the completion of wells, packers and other devices are attached to the wall of the casing. There are many different types of actuating mechanisms for these devices. One important type of actuating mechanism employs pressure within the tubing in which the device is run to either partially or completely anchor the device to the casing. An illustrative form of hydraulically set packer is shown in the co-pending application of C. C. Brown, Serial No. 728,967.

When the tubing is run in the hole, it must be open to permit circulating out of drilling mud present in the well bore. After this operation, a plug or some part thereof is usually dropped or run into the tailpipe of the packer. Hydraulic pressure is then built up within the tubing to actuate the packer setting mechanism. The pressure required for setting a packer may be several thousand pounds.

In the past the plug has been designed with shear pins or the like and after the packer had been set the hydraulic pressure was increased to a value which would shear such pins and drive the plug out of the tailpipe to open the tubing for normal production. When this high pressure is suddenly released, the tubing jumps and kinks. This is, of course, hard on the packer.

An object of this invention is to provide a hydraulically operated mechanism for attachment to the wall of a well with a plug which is set up for release by high pressure but which is not released until the pressure is reduced to such an extent that when the plug is pumped out of the tubing, the resulting forces will not cause the tubing to kick or kink.

Another object is to provide a hydraulically controlled plug in which a pin is sheared by high pressure in setting the packer or the like and in which the plug is held against being pumped through the tubing until the tubing pressure has been reduced to a value at which sudden release of this pressure will not cause the tubing to kink or kick.

Another object is to provide a hydraulically set mechanism adapted to be secured to the wall of a well with a plug for closing the lower end of the mechanism in which a landing ring and ball are employed to close the lower end of the tubing and in which a pin preventing release of the landing ring is sheared during setting of the packer and the landing ring is held in position by the hydraulic pressure until this pressure has reduced to a predetermined value at which sudden release of the pressure will not cause the tubing to kick or kink.

Another object is to provide a hydraulically operated mechanism to be secured to the wall of a well with a plug which may be dropped into the tubing to permit building up of hydraulic pressure in which a pin is sheared during setting of the mechanism to release the plug from the tubing, but the release is prevented by hydraulic pressure in the tubing until the tubing pressure has been reduced to a value at which the sudden release of pressure will not cause the tubing to kick or kink.

Other objects, features and advantages of this invention will be apparent from the specification, claims and drawings.

In carrying out this invention the plug may be of the type in which a mechanism controls release of a ball or the like landed in a tubular member. In the alternative, the complete plug may be run in a well and landed on a shoulder in the tubular member. In either case dogs are provided which are held in extended position to either engage the shoulder in the tubular member or to engage the landing ring and permit tubing pressure to be increased to set a mechanism such as a hydraulically operated packer. Before pressuring up of the tubing the dogs are held in extended position by a mechanical arrangement which is controlled by a releasable connection. This connection is released by hydraulic pressure during setting of the packer or the like.

To prevent retraction of the dogs and sudden reduction in the tubing pressure, a hydraulically operated means is provided to maintain the dogs in extended position so long as high pressure is present within the tubing. Preferably this hydraulic retaining means prevents release of the dogs by a frictional engagement so that the friction will reduce as the tubing pressure is reduced. It is preferred that the design be such that when the tubing pressure has been reduced to a value at which the pressure may be released without causing the tubing to kick or kink, the friction means is insufficient to prevent release of the dogs and clearing of the tubing to provide for full open flow therethrough.

Referring now to the drawings, wherein there are shown by way of illustration two embodiments of this invention and wherein like reference numerals indicate like parts:

FIGURE 1 is an elevational view of a hydraulically set packer equipped with a plug constructed in accordance with this invention and shown being run into a well casing;

FIGURE 2 is a view partially in elevation and partially in vertical cross-section through the preferred form of plug showing the parts in their position before the packer is set;

FIGURE 3 is a view along the lines 3—3 of FIGURE 2;

FIGURE 4 is a view similar to FIGURE 2 showing the parts of the plug in the position they assume during setting of the packer;

FIGURE 5 is a view similar to FIGURE 4 after the packer setting pressure has been reduced to a predetermined low value showing the ball and retainer ring being pumped out of the tubing;

FIGURE 6 is a modified form of plug shown partly in elevation and partly in section with the parts in the position they assume just prior to setting of the packer;

FIGURE 7 is a view along the lines 7—7 of FIGURE 6;

FIGURE 8 is a view similar to FIGURE 6 showing the position of the parts during setting of the packer; and

FIGURE 9 is a view similar to FIGURE 8 showing the position of the parts upon reduction of the packer setting pressure to a predetermined value to permit clearing of the tubing.

Referring first to FIGURE 1, the plug of this invention is shown generally at **10** in combination with a hydrau-

lically operated packer indicated generally at 11 which is to be anchored to the casing 12.

The packer 11 includes a packer rubber 13, a slip expander assembly 14 and a hydraulic actuator 15 for setting the packer in response to fluid pressure within tubing 16. The tubing 16 extends through the packer to a tailpipe 17. While the particular manner in which the packer 11 is set by hydraulic fluid is unimportant as any hydraulically set packer or other hydraulically operated apparatus for engaging the wall of a well may be substituted for packer 11, reference is made to the application of Cicero C. Brown, Serial No. 728,967 filed April 16, 1958, for a more complete description of the particular packer shown in FIGURE 1.

Referring now to FIGURE 2, in which the preferred form of plug is shown, the plug includes a tubular mandrel 18 which depends from tailpipe 17 and is connected thereto by coupling 19. The bore 21 through mandrel 18 has an enlarged section 22 at its lower end to provide a downwardly facing shoulder 23. Spaced slightly below shoulder 23 are a plurality of circumferentially spaced holes 24 for mounting dogs 25. As shown in FIGURE 3, eight dogs are employed, but more or less could be utilized if desired.

A tubular landing member 26 is supported in bore 22 and held against the shoulder 23 by dogs 25. A suitable seal may be provided between bore 22 and landing member 26 in any desired manner as by O-ring 27.

A sleeve 28 is telescoped over mandrel 18 and maintains the dogs 25 in extended position as shown in FIGURE 2 to support the landing ring 26. It will be noted that the inner diameter of the sleeve 28 at 28*a* is such as to provide a sliding fit with mandrel 18 and prevent radial outward movement of dogs 25. Of course the dogs 25 are provided by balls whose diameter is slightly greater than the thickness of mandrel 18 at the holes 24.

The sleeve is fixed against upward movement relative to the mandrel by abutting shoulder 29 on mandrel 18. The sleeve is held against downward movement relative to the mandrel by being pinned to a pressure responsive member such as piston 31 by shear pin 32. The piston 31 in turn rests on an upwardly facing shoulder 33. The piston 31 is preferably an annular piston arranged exteriorly of the mandrel 18 and interiorly of the sleeve 28 and is provided with a sliding seal with each of these members as by O-rings 34 and 35.

The O-rings 34 and 35 confine the fluid from the tubing which reaches the underside of piston 31 through a plurality of ports 36. Fluid against the piston 31 is confined against flow in a downwardly direction by a suitable sliding seal such as O-ring 37.

From the description as it has thus far proceeded, it will be appreciated that there has been provided a mandrel and sleeve and a third concentric, landing ring 26, with one of the members, the mandrel, secured to the tail pipe of the packer and one of the members, landing ring 26, adapted to receive a ball and block flow through the plug. Such a ball is shown at 38 in FIGURE 4.

As will be explained in more below, pressure acting on piston 31 shears pin 32 to release the mechanical connection between the mandrel 18 and sleeve 28. This will free the sleeve for downward movement relative to mandrel 18. To make certain that such downward movement occurs at the proper time, a spring 39 is compressed between shoulders 41 and 42 on the mandrel and sleeve, respectively.

As has been previously explained, it is desirable to prevent the release of the dogs 25 until after the pressure within the tubing has been reduced. For this purpose, means are provided which prevent relative movement between the mandrel 18 and sleeve 28 until the pressure within the tubing has been reduced. This means, of course, is actuated by the pressure within the tubing 17. In the form of invention shown in FIGURE 2, the means for preventing relative movement between the mandrel and sleeve is a friction means provided by the engagement of dogs 25 and section 28*a* of the sleeve. The fluid pressure acting downwardly across the landing ring 26 and through the rounded lower section 43 of landing ring 26 drives the dogs 25 into firm frictional engagement with the sleeve 28. So long as high pressures are present within the bore 21, this frictional engagement prevents movement of the sleeve relative to the mandrel under the force of compression spring 39. Of course after the pressure has been reduced within bore 21 to a predetermined low value, spring 39 drives sleeve 28 downwardly to where the interior groove 44 in sleeve 28 registers with holes 24 and permits the dogs 25 to be moved radially outward by ring 26.

In operation, the plug is made up on tailpipe 17 and run in the hole with the packer 11. The mud in the hole is washed out by circulation through tubing 16 in the usual manner. Then the ball 38 is dropped through the tubing and lands on the beveled seat 45 of landing ring 26. When this occurs, the lower end of tubing 16 is effectively blocked and conventional means may be employed at the surface for pressurizing tubing 16. Pressure in the tubing may be increased to a value of several thousand pounds to set packer 13.

This increase in pressure will be exerted through ports 36 on piston 31. The pin 32 may be designed to shear at any desired pressure, preferably at about 1,000 pounds, for a packer to be set with several thousand pounds of pressure. When pin 32 shears, the piston will move upwardly and strike stop 46 as shown in FIGURE 4. This stop prevents movement of piston 31 to a position at which fluid could escape about the upper end of the sleeve 28. At this time the tubing pressure is acting downwardly on landing ring 26 which in turn is wedging dogs 25 against sleeve 28 to prevent relative movement between the mandrel and the sleeve. Thus the parts will remain in their position shown in FIGURE 4 during completion of setting of the packer. After the packer is set, tubing pressure is reduced at the surface and when it reduces to a predetermined low value, the force of spring 39 becomes greater than the frictional resistance of dogs 25, and the sleeve 28 is moved downwardly relative to mandrel 18 until the annular groove 44 is in register with holes 24 to permit radial outward movement of dogs 25. There will still remain some pressure within the tubing and this pressure is sufficient to pump the landing ring 26 and ball 38 downwardly and out of the plug to fall free in the well as junk. After this occurs, the well may be produced in the usual manner through mandrel 18 and tubing 16.

Referring now to FIGURES 6 through 9, an alternative form of this invention is shown in which the parts, that is the sleeve, mandrel and concentric landing ring, are reversed. In this instance an annular member which may be a length of tubing 47, is secured to the lower end of tailpipe 17. This tubular member has an inwardly and downwardly inclined shoulder 48 on which the remainder of the tool, to be hereinafter described, is landed. Of course the remainder of the tool will not be landed until after the hole has been washed and the packer is ready to be set.

The remainder of the tool includes a mandrel 49 about which there is telescoped a sleeve 51. A plurality of dogs 52 having bat wings 53 to prevent their escape from the sleeve are provided. There is an elongate groove 54 in the interior face of each dog. These grooves extend laterally across the dogs resulting in effect in spaced lands 55 and 56 on the inner face of each dog.

The dogs are held in extended position by a pair of annular spaced lands 57 and 58 on mandrel 49. With the parts positioned to be dropped into tubing 47, land 57 underlays dog land 56 and land 58 underlays dog land 55.

The sleeve and mandrel are held in the above-defined relationship with each other by a frangible pin 59 which

secures a pressure responsive member, such as piston 60, to the mandrel. The piston 60 is provided with a shoulder 61 which abuts the lower end 51*a* of sleeve 51.

As in the case of the preferred embodiment, a spring 62 is compressed between opposing shoulders 63 on the mandrel and shoulders 64 on the sleeve. This spring is, however, ineffective due to shear pin 59 holding the mandrel and sleeve in the position shown in FIGURE 6.

In order to seal between the sleeve and tubing 47, a suitable packing, such as the W packing 65, is provided in an exterior groove in the lower section of sleeve 51.

In the event the tool hangs up or it is desired to withdraw it from the well for any reason, a wireline retrieving gooseneck 66 is provided at the upper end of mandrel 49.

In operation, the tubular member 47 is made up on tailpipe 17, the well is washed and readied for setting of packer 11 in the usual manner. The remainder of the plug is then dropped through the tubing to land on shelf 48. It should be noted that the lower end of each dog is provided with a downwardly and inwardly inclined surface 52*a* which conforms to the inclined ledge 48 on the tubular member 47.

Pressure in the tubing is now increased for the purpose of setting packer 11. At a predetermined pressure, preferably around 1,000 pounds, pin 59 is sheared, and piston 60 moves downwardly to the position shown in FIGURE 8. The tubing pressure is confined due to suitable seals on the piston, such as O-ring 67 and O-ring 68.

Due to the O-rings 67 and 68 and packing 65, the mandrel and sleeve will be subjected to a downward force by pressure within tubing 17. This downward force will tend to drive dogs 52 inwardly due to the coaction of surfaces 52*a* on the bottom of the dogs and ledge 48 in tubing 47. This action will induce a frictional engagement between the lands 56 and 57 and between lands 55 and 58, respectively.

After the packer has been set and pressure within tubing 47 reduced to a predetermined value, the frictional restraint shown in FIGURE 8 will be removed and the mandrel and sleeve will move relative to each other under the force of spring 62. This will permit the annular land 58 on mandrel 49 to move into the grooves 54 in the dogs and permit the dogs to retract as shown in FIGURE 9. After this occurs, the mandrel and sleeve may be pumped through the tubing 47 and out the bottom thereof. To insure that the mandrel and sleeve will move relative to each other due to the action of spring 62, a plurality of ports 69 are provided in the sleeve and a gathering ring 71 underlays these ports. This will permit free exit of any mud or fluid in the upper portion of the sleeve which might tend to interfere with downward movement of the sleeve relative to the mandrel.

From the above it will be seen that there has been provided an apparatus for use in setting hydraulically set packers which may be pumped from the tailpipe of the packer without suddenly releasing the setting fluid. The means for restraining the release of the dogs until the pressure has been reduced in both of the illustrated embodiments employs a frictional drag. This form is preferred, as it will withstand very high pressures without placing relatively small parts in shear, but it will be understood that other pressure responsive restraining means might be used to prevent release of the dogs.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction, may be made within the scope of the appended claims without departing from the spirit of the invention.

What is claimed is:

1. A plug for closing the lower end of a tubing comprising, a mandrel, movable dog means carried by the mandrel, means mounted on the mandrel holding the dog means in extended position, a releasable connection between said holding means and said mandrel, means including pressure responsive means releasing said releasable connection upon being subjected to a predetermined pressure, and pressure operated means preventing the holding means from releasing the dog means until said predetermined pressure has been reduced to a second predetermined pressure.

2. A plug for closing the lower end of a tubing comprising, a mandrel, movable dog means carried by the mandrel, means mounted on the mandrel holding the dog means in extended position, a releasable connection between said holding means and said mandrel, means including pressure responsive means releasing said releasable connection upon being subjected to a predetermined pressure, and pressure operated friction means preventing the holding means from releasing the dog means until said predetermined pressure has been reduced to a second predetermined pressure.

3. A plug for closing the lower end of a tubing comprising, a mandrel, movable dog means carried by the mandrel, means including a frangible member holding the dog means in extended position, means including pressure responsive means for rupturing said frangible means, and pressure responsive friction means maintaining the holding means effective to hold the dog means in extended position after the frangible means has been ruptured and until the pressure on the plug has been reduced to a predetermined value.

4. A plug for closing the lower end of a tubing comprising, a mandrel, movable dog means carried by the mandrel, means movable between a first position in which the dog means are maintained in extended position and a second position in which the dog means are permitted to retract, means urging said movable means toward said second position, releasable means holding said movable means in said first position, pressure responsive means releasing said releasable means upon being subjected to a predetermined pressure, and pressure operated friction means holding said movable means in said first position until said pressure has been reduced to a predetermined value.

5. A plug for closing the lower end of a tubing comprising, a mandrel, movable dog means carried by the mandrel, a sleeve telescoped with the mandrel and holding the dog means in extended position, pressure releasable mechanical means holding the sleeve and mandrel against relative movement, pressure operated means for selectively holding the sleeve and mandrel against relative movement, said pressure operated means and pressure releasable mechanical means subject to the same pressure fluid, and means urging the sleeve toward a position to release the dog means whereby subjecting the plug to a pressure fluid will release the pressure releasable mechanical means and the pressure operated holding means will prevent relative movement of the mandrel and sleeve until the pressure has been reduced to a predetermined value.

6. A plug for closing the lower end of a tubing comprising, a mandrel, a sleeve slidable thereon, a seal between said sleeve and tubing, means including a frangible pin preventing relative movement of the mandrel and sleeve in one direction, resilient means compressed between opposing shoulders on the mandrel and sleeve urging relative movement thereof in said one direction, movable dogs carried by said sleeve and when extended, adapted to hang on a shoulder in said tubing, said mandrel having means for maintaining the dogs extended while the mandrel and sleeve are held in said one position, said first mentioned means including a piston exposed to the pressure in the tubing above the mandrel and coacting with said pin whereby said piston when subjected to a predetermined pressure effects shearing of said pin to release the mandrel and sleeve for relative movement in said one direction to release the dogs and permit them

to move into retracted position and the plug to be pumped through said tubing, and pressure responsive means including said dogs and said means for maintaining the dogs extended maintaining the dogs in extended position until pressure within the mandrel has been substantially reduced below said predetermined pressure.

7. A plug for closing the lower end of a tubing comprising, a mandrel, an annular piston slidable on the mandrel and engageable with a shoulder thereon to limit movement of the piston in one direction, port means establishing fluid communication between the interior of the mandrel and said piston, a sleeve telescoped over the mandrel and piston, a shear pin connecting the sleeve and piston, opposing shoulders on the mandrel and sleeve, a spring compressed between said opposing shoulders holding the piston on said first mentioned shoulder, movable dogs carried by the mandrel and held in extended position by said sleeve, a landing ring concentric with said mandrel and supported on said dogs, a ball landable on said ring to obstruct flow of fluid through said mandrel, said sleeve movable by expansion of said spring to a position permitting said dogs to retract, said landing ring having means engaging said dogs and preventing movement of said sleeve after said pin has been sheared to maintain the dogs in extended position until the pressure within the mandrel has been substantially reduced.

8. The plug of claim 7 wherein the dogs are a plurality of balls movable radially in holes in the mandrel.

9. A plug for closing the lower end of a tubing comprising, a sleeve telescoped with the mandrel, a tubular member having a shoulder thereon arranged concentrically with the mandrel and sleeve, one of said mandrel, sleeve and member adapted to be secured to the tubing to be closed, resilient means compressed between confronting shoulders on the sleeve and mandrel, a first pressure responsive means secured to one of the mandrel and sleeve with shear pin means and engaging a shoulder on the other of the mandrel and sleeve to prevent relative movement between the mandrel and sleeve by said resilient means, movable dogs carried by one of the mandrel and sleeve and held in extended position by the other of the mandrel and sleeve to engage the shoulder on the tubular member to limit relative movement therebetween in one direction, said resilient means moving the mandrel and sleeve into a second position in which the dogs are not held in extended position, and a second pressure responsive means preventing movement of said sleeve after said pin has been sheared to maintain the dogs in extended position until the pressure within the mandrel has been substantially reduced.

10. In combination, apparatus adapted to be run in a well on a string of tubing and anchored in the well be fluid pressure exerted through the tubing, and means for closing the lower end of the tubing comprising, a mandrel, movable dog means carried by the mandrel, means mounted on the mandrel holding the dog means in extended position, a releasable connection between said holding means and said mandrel, means including pressure responsive means releasing said releasable connection upon being subjected to a predetermined pressure, and pressure operated means preventing the holding means from releasing the dog means until said predetermined pressure has been reduced to a second predetermined pressure.

11. A plug for closing the lower end of a tubing comprising, a mandrel, movable dog means carried by the mandrel, means mounted on the mandrel holding the dog means in extended position, a mechanical connection between said holding means and said mandrel, pressure operated means holding the dog means in extended position while subjected to a predetermined pressure, and a second pressure operated means for rendering said mechanical connection ineffective whereby subjecting the plug to fluid pressure will render the mechanical connection ineffective and the dog means will be held in extended position until the fluid pressure is reduced.

12. In combination, apparatus adapted to be run in a well on a string of tubing and anchored in the well by fluid pressure exerted through the tubing, and means for closing the lower end of the tubing comprising, a mandrel, movable dog means carried by the mandrel, means including a frangible member holding the dog means in extended position, means including pressure responsive means for rupturing said frangible means, and pressure responsive friction means maintaining the holding means effective to hold the dog means in extended position after the frangible means has been ruptured and until the pressure on the plug has been reduced to a predetermined value.

13. In combination, apparatus adapted to be run in a well on a string of tubing and anchored in the well by fluid pressure exerted through the tubing, and means for closing the lower end of the tubing comprising, a mandrel, a sleeve telescoped with the mandrel, a tubular member having a shoulder thereon arranged concentrically with the mandrel and sleeve, one of said mandrel, sleeve and member adapted to be secured to the tubing to be closed, resilient means compressed between confronting shoulders on the sleeve and mandrel, a first pressure responsive means secured to one of the mandrel and sleeve with shear pin means and engaging a shoulder on the other of the mandrel and sleeve to prevent relative movement between the mandrel and sleeve by said resilient means, movable dogs carried by one of the mandrel and sleeve and held in extended position by the other of the mandrel and sleeve to engage the shoulder on the tubular member to limit relative movement therebetween in one direction, said resilient means moving the mandrel and sleeve into a second position in which the dogs are not held in extended position, and a second pressure responsive means preventing movement of said sleeve after said pin has been sheared to maintain the dogs in extended position until the pressure within the mandrel has been substantially reduced.

14. In combination, a well packer of the type which is set at least in part by pressure and means for closing the lower end of the tubing comprising, a mandrel, movable dog means carried by the mandrel, means mounted on the mandrel holding the dog means in extended position, a releasable connection between said holding means and said mandrel, means including pressure responsive means releasing said releasable connection upon being subjected to a predetermined pressure, and pressure operated means preventing the holding means from releasing the dog means until said predetermined pressure has been reduced to a second predetermined pressure.

15. In combination, a well packer of the type which is set at least in part by pressure and means for closing the lower end of the tubing comprising, a mandrel, movable dog means carried by the mandrel, means including a frangible member holding the dog means in extended position, means including pressure responsive means for rupturing said frangible means, and pressure responsive friction means maintaining the holding means effective to hold the dog means in extended position after the frangible means has been ruptured and until the pressure on the plug has been reduced to a predetermined value.

16. In combination, a well packer of the type which is set at least in part by pressure and means for closing the lower end of the tubing comprising, a mandrel, a sleeve telescoped with the mandrel, a tubular member having a shoulder thereon arranged concentrically with the mandrel and sleeve, one of said mandrel, sleeve and member adapted to be secured to the tubing to be closed, resilient means compressed between confronting shoulders on the sleeve and mandrel, a first pressure responsive means secured to one of the mandrel and sleeve with shear pin means and engaging a shoulder on the other of the mandrel and sleeve to prevent relative movement between

the mandrel and sleeve by said resilient means, movable dogs carried by one of the mandrel and sleeve and held in extended position by the other mandrel and sleeve to engage the shoulder on the tubular member to limit relative movement therebetween in one direction, said resilient means moving the mandrel and sleeve into a second position in which the dogs are not held in extended position, and a second pressure responsive means preventing movement of said sleeve after said pin has been sheared to maintain the dogs in extended position until the pressure within the mandrel has been substantially reduced.

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