June 21, 1938. T. M. RAGAN ET AL 2,121,051

CEMENT RETAINER

Filed July 14, 1937 3 Sheets-Sheet 1

Fig. 1.

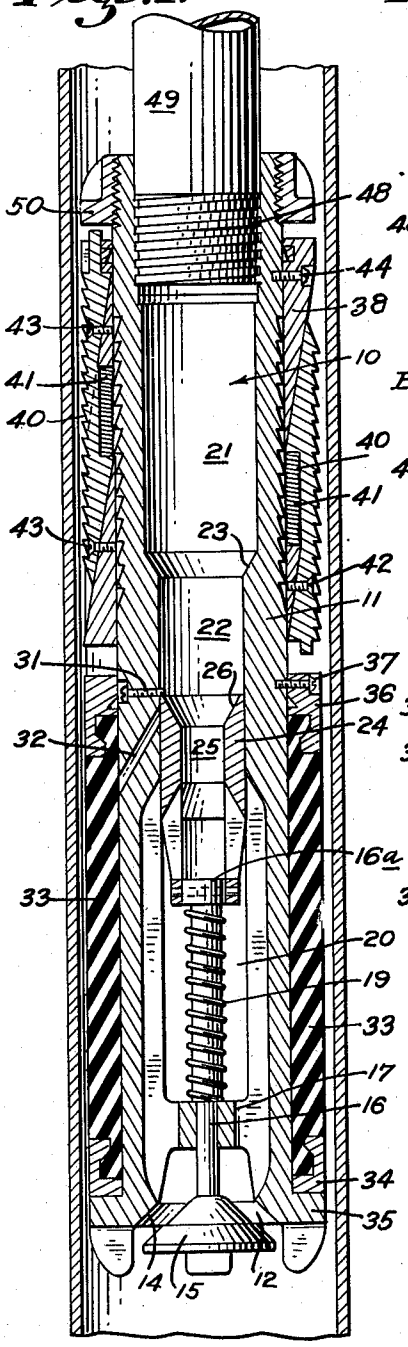


Fig. 2.

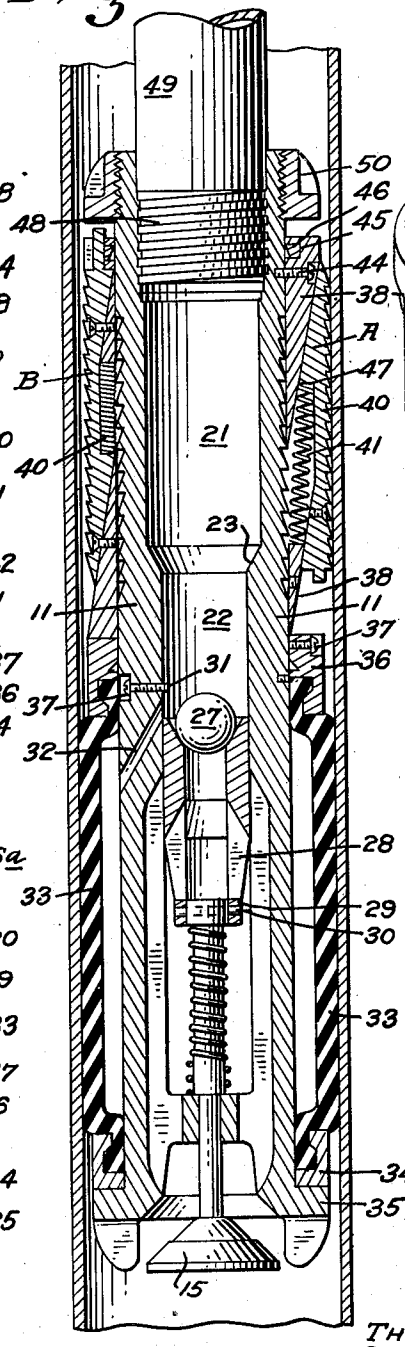


Fig. 3.

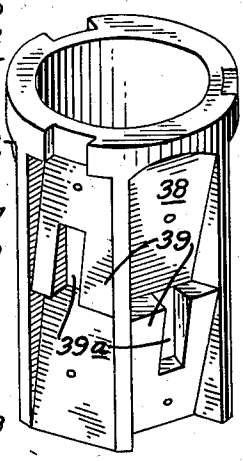
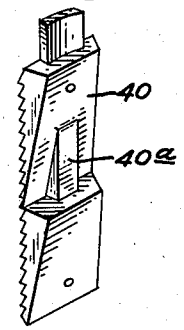


Fig. 4.



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Filed July 14, 1937 3 Sheets-Sheet 2

Fig. 5.

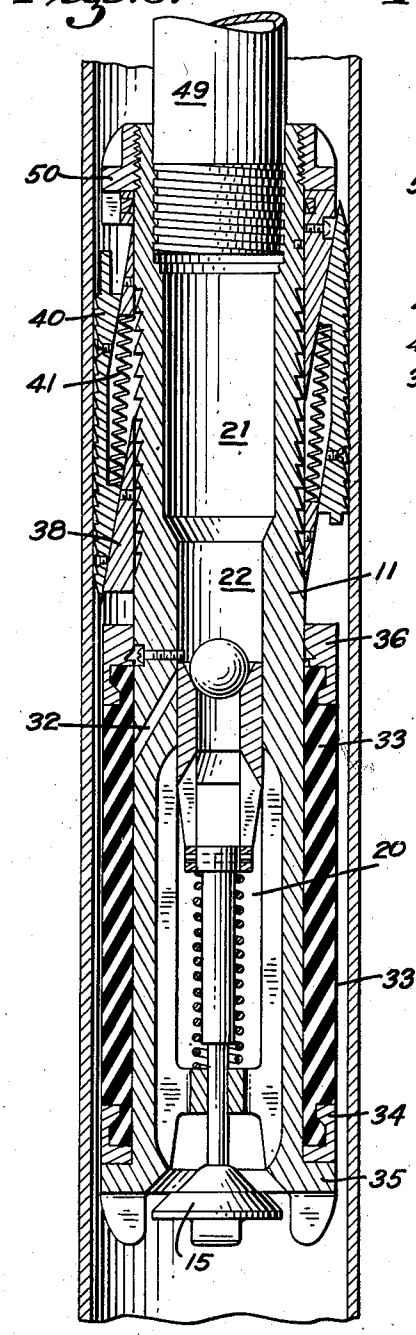


Fig. 6.

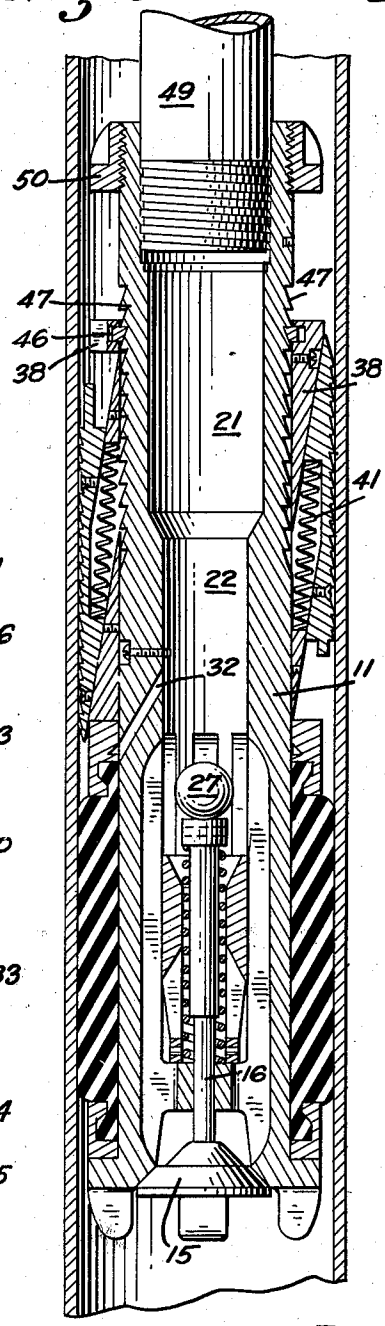
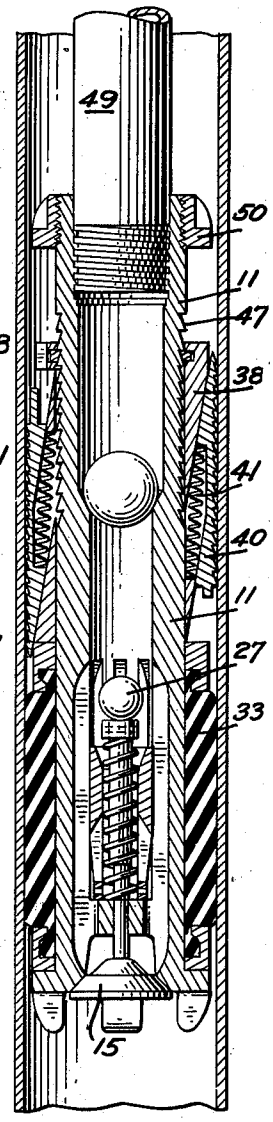


Fig. 7.



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Filed July 14, 1937 3 Sheets-Sheet 3

Fig. 8.

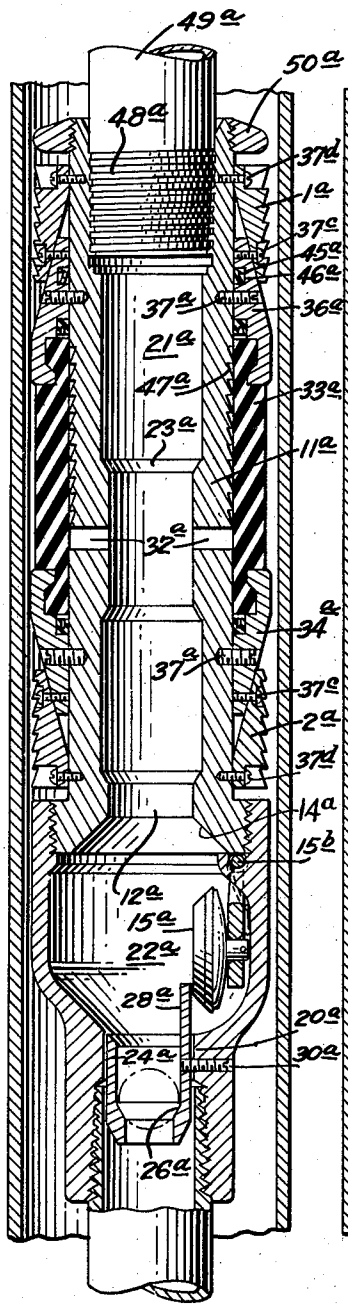
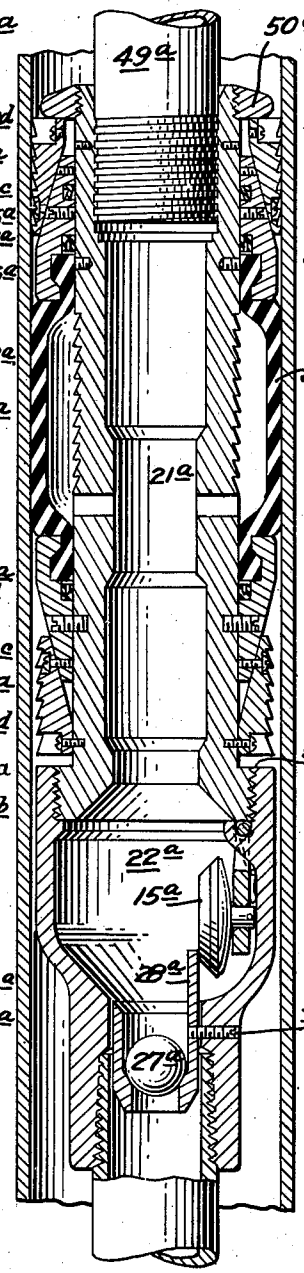


Fig. 9.



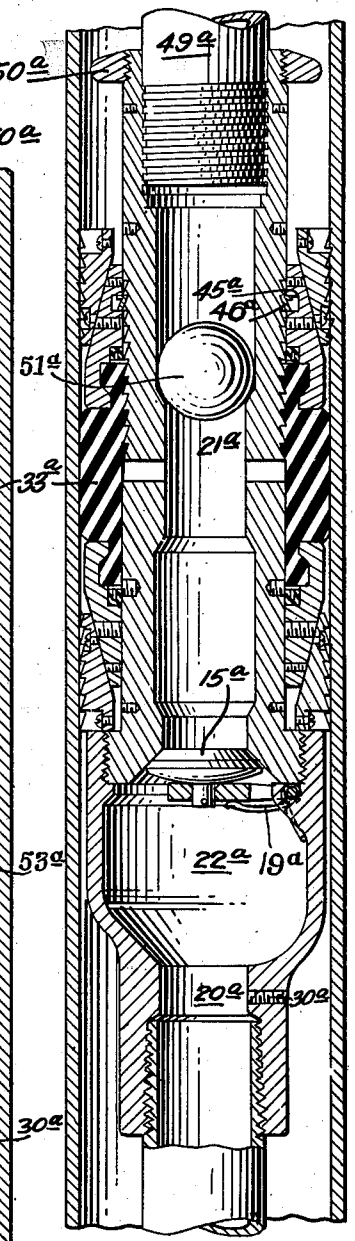


Fig. 10.

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Patented June 21, 1938 2,121,051

UNITED STATES PATENT OFFICE

2,121,051

CEMENT RETAINER

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Application July 14, 1937, Serial No. 153,522

19 Claims. (Cl. 166—13)

This application is a continuation in part of our pending application entitled "Cement retainer" filed March 26, 1935, and bearing Serial No. 13,063.

The invention relates to appliances commonly known as cement retainers which are utilized in packing off, cementing and repressuring operations in deep oil wells.

It is the principal object of the present invention to provide an improved tool of the character referred to which may be safely and properly run-in and set at any desired point in the casing of a deep well and resist dislodgment by pressures either above or below it; the apparatus being utilized in cementing operations to cement off a water formation at a predetermined level or form a cement seal and reinforcement between the well casing and the bore throughout the entire length of the casing. The tool is also capable of efficient use in packing off or bridging the well casing at any desired point thereabove for purposes such as packing-off high pressure gas sands below the oil strata.

In general, the device consists of a valved hollow packer which may be run in the hole at the lower end of a string of tubing. This packer is fitted with operative slips for firmly anchoring it to the surrounding casing so that it will resist dislodgement either from pressures above or pressures below. The packer is fitted with an expansible packing or sealing element for sealing off the space between the exterior of the device and the casing wall. The slips or anchoring means and the packing element are operated by fluid pressure and by manipulation of the running-in tubing at the derrick floor.

In cementing operations, the tubing method may be practiced, that is, the cement slurry is pumped downwardly through the running-in tubing and the packer into the space below the packer and back up around the casing to form a seal. The cement slurry is prevented from returning into the packer and casing above the same by a back pressure valve carried by the packer. As this packer or cement retainer can be set at any desired point in the casing after the latter is in place, the tool is capable of use in shutting off water at any point along the well. The device may also be used as a bridge plug to bridge off the interior of the casing at any desired point. This permits cementing operations to be carried on above the device as is desirable in some instances. The device likewise may be used purely as a packer to seal off the interior of the casing at any predetermined point above bottom. This enables it to be employed to shut off high pressure gas below the producing sands.

The invention is exemplified in the following description and illustrated by way of example in the accompanying drawings in which:

Fig. 1 is a longitudinal sectional view through a portion of a well casing and disclosing one form of our improved device positioned therein with the parts in the positions they assume when the device is being run-in in the casing.

Fig. 2 is a view similar to Fig. 1 but disclosing one set of slips in tripped position.

Fig. 3 is a perspective view of the slip sleeve.

Fig. 4 is a perspective view of one of the slips.

Fig. 5 is a view similar to Fig. 2 with the exception that all of the slips are shown in tripped position.

Fig. 6 is a view similar to Fig. 5 showing the parts of the packer in the position they assume when the packer is fully set in the casing.

Fig. 7 is a view the same as Fig. 6 except the bridging ball valve is shown in position so that the device will act as a bridge plug.

Fig. 8 is a longitudinal sectional view through a portion of a well casing and disclosing a second embodiment of our invention positioned therein with the parts in the position they assume when the device is being run-in in the casing.

Fig. 9 is a view similar to Fig. 8 but disclosing one set of slips in tripped position.

Fig. 10 is a view similar to Fig. 9 but disclosing the device as it appears when completely set in position.

Referring to the accompanying drawings, (particularly to Figs. 1 to 7 inclusive), 10 indicates a packer or what is commonly known as a cement retainer. This device is generally cylindrical in cross section and of an overall external diameter just slightly less, when its parts are in unset position, than the internal diameter of the well casing into which it is to be run and set.

The packer or cement retainer 10 includes an elongated hollow cylindrical body 11, the lower end of which is formed with a concentric main circulating port 12 surrounded by a valve seat 14. Cooperating with this valve seat to control the flow of fluid upwardly into the body 11 from below the same is a downwardly opening back pressure valve 15 of the poppet type. This valve is fitted with a valve stem 16 which extends vertically upward into the body 11 and is reciprocably mounted in a guide 17 centrally of a spider 18 formed integrally with or secured within the body 11. An expansion spring 19 is arranged be-

tween the guide 17 and an enlarged head 16a formed on the upper extremity of the valve stem 16. The spring 19 normally tends to maintain the valve 15 seated on the seat 14, thereby closing the main circulating port 12. It is obvious, however, that the valve 15 may be opened by fluid pressure from within the body when the same exceeds the pressure in the casing below the packer 10.

It will be noticed that the body 11 is hollow and is formed with a lower bore 20 and an upper bore 21. These two are connected by an intermediate bore 22 which is reduced in diameter with respect to the upper and lower bores 21 and 20. A bridging valve seat 23 is formed at the junction between the upper bore 21 and the intermediate bore 22, the purpose of this seat will be hereinafter described.

Reciprocably mounted in the intermediate bore 22 is a sleeve valve 24 which has a passageway 25 formed co-axially therethrough. At its upper end the sleeve valve 24 is formed with a trip valve seat 26 to receive a ball trip valve 27 as shown in Fig. 2. Depending from the lower end of the sleeve valve 24 are spaced legs 28 which connect the sleeve valve to a circular trunnion 29 which is connected to the head 16a by means of a shear pin 30.

Due to the connection between the sleeve valve 24 and the valve stem 16, the valve spring 19 constantly tends to maintain the sleeve valve 24 in its uppermost position. When the packer is assembled for running-in, it is desirable to hold the valve 15 open so that fluid may pass freely upwardly through the body 11. To maintain the valve in this open position we provide a stop pin 31 which is secured in the body 11 and against which the upper end of the sleeve valve 24 abuts. Such engagement prevents the valve 15 from entirely closing so that when the plug is run-in in the casing, it may be moved up and down therein without causing a swabbing action.

In the running-in position the sleeve valve 24 covers a port 32 formed through the wall of the body 11 and which extends from the intermediate bore 22 to a point between the exterior of the body 11 and a surrounding packer sleeve 33. This packer sleeve 33 is formed of rubber or any other suitable pliable material and is anchored at its lower end to a fixed ring 34 which is bolted or otherwise secured to an annular flange 35 circumscribing the lower end of the body 11. The upper end of the packer sleeve 33 is anchored to a sliding ring 36 slidably fitting the exterior of the body 11. In running-in condition, the sliding ring 36 is connected to the body 11 by shear pin 37.

In operation it is intended that when the sleeve valve 24 uncovers the port 32, as will be described, that fluid under presure be directed through the port 32 to between the exterior of the body 11 and the interior of the packer sleeve 33, causing expansion of the latter. We have found in actual practice that by creating this pressure between the packer sleeve and the body, that the packer sleeve will first expand into contact with the well casing and then, due to compression, it will elongate. This elongating movement is sufficient to shear the pin 37 and cause the sliding ring 36 to move upwardly. We use this movement of this sliding ring 36 to operate a portion of the setting mechanism of the tool, as will be described.

Referring particularly to Figs. 1 to 4 inclusive, it will be seen that above the packer sleeve 33 the body 11 is provided with a slip sleeve 38. This slip sleeve is bored so that it is capable of reciprocation on the exterior surface of the body 11. The exterior of the slip sleeve 38 is formed with a plurality of vertically arranged slip sockets 39 which are spaced equal distances apart about the periphery of the slip sleeve 38. There are two sets of these sockets, one set to receive what we prefer to term "down-pressure slips", which are provided to resist dislodgement of the plug from pressures above it, the other set of slips we prefer to term "up-pressure slips" which are provided to resist dislodgement of the device from pressures below the packer.

The inner surface of each socket 39 is formed with two parallel surfaces arranged one above the other and which are inclined with respect to the vertical axis of the slip sleeve. The inner surfaces of adjacent sockets are oppositely inclined so that the "up-pressure" and "down-pressure" slips will be arranged alternately about the slip sleeve 38. Each socket 39 is fitted with a slip 40. In the present instance there are three up-pressure slips and three down-pressure slips, there being six sockets formed in the slip sleeve 38. It is to be understood, however, that we may provide a greater or lesser number of slips if we so desire.

The inner surface of each slip 40 is formed with parallel inclined surfaces which coincide with and are complemental to the inner surface of its socket so that relative vertical movement between the slips and the slip sleeve 38 will result in radial movement of the slips.

It will be noticed that at the junctions between the inclined surfaces of the slip socket, there is a lateral shoulder which coincides with a similar lateral shoulder between the inclined surfaces of the slip fitting the socket. Each socket is formed with a keyway 39a which is engaged by a key 40a formed on the slip. An expansion spring 41 is arranged in each socket and it abuts against the end of the keyway 39a at one end and against the lateral shoulder on the slip 40 at the other end so that when the slip is detached from the slip sleeve 38, the spring 41 will move the slip relative to the slip sleeve 38 and consequently cause the slip to move radially outward.

In the case of the down-pressure slips which we have indicated at A, the springs 41 will move the slips upwardly relative to the slip sleeve 38 and in the case of the up-pressure slips B, the springs 41 will move the slips downwardly relative to the slip sleeve 38. This movement of the slips causes them to move radially outward and into engagement with the casing.

Referring to Fig. 1 where the parts are shown in the position which they assume when the device is run-in to the casing, it will be noticed that the slips are arranged in their innermost position and that the down-pressure slips are secured to the slip sleeve 38 by a shear pin 42 while the up-pressure slips B are secured to the slip sleeve 38 by shear pins 43. It will be noticed that the up-pressure slips B are each secured by two shear pins 43, while each down-pressure slip is secured to the slip sleeve by a single shear pin 42. It will also be noticed from Fig. 1 that when the parts are in run-in condition of an assembly, that the springs 41 are under full compression.

When the slip sleeve 38 is assembled on the body 11 prior to running the tool into the casing, it is secured to the body 11 by a shear pin 44. It will also be noticed that within its upper end, the slip sleeve 38 is formed with an annular groove

45 which receives a spring latch ring 46. This latch ring is adapted to engage annular serrations 47 formed about the exterior surface of the body 11 to latch the sleeve 38 in position on the body 11 when the tool has been run in the casing and set.

For the purpose of running the tool into the casing, the upper end of the upper bore 21 is formed with a left-hand female thread to receive the left-hand male thread 48 formed on the lower end of running-in tubing 49. The purpose of the left-hand thread is to enable the tubing 49 to be unscrewed from the body 11 after the tool has been tripped and set in the casing.

In operation of the device, it is constructed and assembled as shown in Fig. 1. In this condition the valve 15 will be unseated, the two sets of slips A and B will be in their innermost position, and the packer sleeve 33 will be fully contracted. The tool is then threaded on the lower end of the running-in tubing 49 and lowered into the casing. It is obvious that due to the fact that the valve 15 is open, the device can be moved up and down in the casing without causing a swabbing action.

When the device has been positioned at the desired point, the trip ball valve 27 is dropped through the tubing 49 and it will find its seat on the seat 26 on the sleeve valve 24. Fluid pressure is then created in the tubing 49 and in the interior of the body of body 11 above the sleeve valve 24. This pump pressure is sufficient to move the trip ball valve 27 and the sleeve valve 24 downwardly against the action of the spring 19 until the port 32 is uncovered by the sleeve valve 24. This fluid pressure, however, is insufficient to shear the pin 30 which connects the sleeve valve 24 to the enlarged head 16a of the valve stem 16.

The fluid pressure passing through the port 32 causes the packer sleeve 33 to expand, as illustrated in Fig. 2, and thereafter compresses the sleeve, which causes it to elongate and, in so doing, it shears the pin 37 which connects the sliding collar 36 to the body 11 and moves the sliding collar 36 upwardly. The sliding collar 36 is moved upwardly a sufficient distance and with sufficient force to engage the lower ends of the down slips A and shear the pins 42. The minute that these pins 42 are sheared, the springs 41 of the down slips A move the slips upwardly with respect to the slip sleeve 38. This movement of the slips causes them to move radially outward into engagement with the casing.

The pump pressure above the valve 27 is then relieved and a portion of the weight of the running-in tubing 49 is permitted to bear on the upper end of the body 11. This moves the body 11 and slip sleeve 38 downwardly relative to the down slips A, consequently moving the slips A outwardly into a firm gripping contact with the casing, when the slip A stops moving downwardly, relative to the slip sleeve 38. During this movement, an upper annular flange 50 which circumscribes the upper end of the body 11 will engage the upper ends of the up-pressure slips B. This engagement will tend to move the up-pressure slips B downwardly relative to the slip sleeve 38 shearing the pins 43. The moment that these pins are sheared, the springs 41 act to move the up-pressure slips downwardly relative to the slip sleeve 38 which causes them to move radially outward into engagement with the casing.

As soon as the set of up-pressure slips B are tripped, a strain is taken on the running-in string of tubing 49, moving the body 11 upwardly relative to the slip sleeve 38 and the slips. This movement is continued until the upper end of the sliding ring 36 abuts against the lower end of the slip sleeve 38 and is further continued so as to compress the packer sleeve 33 into the condition shown in Fig. 6, forming a complete watertight seal between the body 11 and the casing. This upward pull will likewise to some extent force the up-pressure slips into firm gripping contact with the wall of the casing.

After the packer sleeve 33 has been fully compressed, the latch ring 46 of the slip sleeve 38 will engage one of the latch grooves in the body 11 and maintain the parts in set condition, as illustrated in Fig. 6. Thereafter pump pressure is again built up in the interior of the body 11 through the running-in tubing 49. This fluid pressure is built up sufficiently to shear the pin 30 which connects the sleeve valve to the head of the valve stem 16a. In so shearing this pin, the sleeve valve 24 drops to an ineffective position, as illustrated in Fig. 6, within the lower bore 20 of the body 11 and the valve 15 is then free to seat.

The ball 27 is then, of course, ineffective to prevent fluid under pressure from being pumped downwardly through the body 11 through the port 12 after opening the valve 15. It will be noticed that a series of radial ribs are provided in the lower bore 20 of the body 11 to maintain the sleeve valve 24 in an ineffective position.

It is obvious from the previous description and from the drawings that any up-pressure built up in the casing below the retainer or packer will tend to more tightly press the up-pressure slips into contact with the casing due to the inclined surfaces of the slip sockets. It is likewise apparent that any considerable pressures built up in the casing above the packer or retainer will tend to more tightly press the down-pressure slips into contact with the casing. Therefore, the packer will resist dislodgement either from pressures above or pressures below. It will be noticed that the down-pressure slips are provided with downwardly extending wickers and that the up-pressure slips are provided with upwardly directed wickers for gripping purposes.

The device is then ready for cementing operations and cement may then be pumped downwardly through the running-in tubing 49, thence through the body 11, opening the valve 15 and discharging into the casing below the packer 10. In most instances the casing is perforated below the packer 10 so that the cement may discharge outwardly through these perforations and upwardly through the casing to effect a seal between it and the wall of the hole. After the cementing operations have been completed, the back pressure of the cement will close the valve 15 to prevent the cement from passing upwardly into the body 11 and into the casing above the body.

After the cementing operation has been completed, the running-in tubing 49 may be disconnected from the body 11 due to the left-hand screw connection between the two. The running-in tubing may then be pulled from the hole.

We may prefer to use in connection with this packer a circulating jar or joint of any preferred type.

If for any reason it is desired to make the device a bridge plug so as to prevent the passage of fluid either upwardly through the packer or downwardly therethrough, a bridging ball 51 is

provided. This ball may be dropped through the running-in tubing 49 and it will seat on the bridging valve seat 23. This will prevent fluid from being pumped downwardly through the body 11 and the back pressure valve 15 will prevent fluid from passing upwardly through the body 11.

Referring to the second embodiment of our invention and particularly to Figs. 8 to 10 inclusive of the drawings, the device there disclosed includes an elongated hollow cylindrical body 11*a*, the lower end of which is formed with a concentric main circulating port 12*a* surrounded by a valve seat 14*a*. Cooperating with this valve seat to control the flow of fluid upwardly into the body 11*a* from below the same is a downwardly opening back pressure valve 15*a* of the flapper type. This valve is hinged as at 15*b* within the body 11*a*. A spring 19*a* is arranged between the valve 15*a* and the body and normally tends to seat the valve 15*a* on the seat 14*a*, thereby closing the main circulating port 12*a*. It is obvious, however, that the valve 15*a* when seated, may be opened by fluid pressure from within the body when the same exceeds the pressure in the casing below the valve.

It will be noticed that the body 11*a* is hollow and is formed with a lower bore 20*a* and an upper bore 21*a*. These two bores are connected by an intermediate chamber 22*a*. A bridging valve seat 23*a* is formed in the upper bore 21*a*, the purpose of which seat is the same as described in connection with the form of the device shown in Figs. 1 to 7 inclusive.

Mounted in the bore 20*a* is a hollow sleeve 24*a* which has a trip valve seat 26*a* formed interiorly thereof to receive a ball trip valve 27*a* as shown in Fig. 9. Extending upwardly from the upper end of the sleeve 24*a* is a lug 28*a* which engages the valve 15*a* to hold the same in open position as shown in Fig. 8. The sleeve 24*a* is held in position by a shear pin 30*a*. When the packer is assembled for running in, it is desirable to hold the valve 15*a* open so that fluid may pass freely upwardly through the body 11*a*. It is to maintain the valve in this open position that we provide the sleeve 24*a* which is secured in the body 11*a* by the shear pin 30*a* so that the lug 28*a* will prevent the valve 15*a* from closing so that when the plug is run-in in the casing, it may be moved up and down therein without causing a swabbing action.

A packer sleeve 33*a* is provided and is formed of rubber or any other suitable pliable material and is connected at its lower end to a lower cone 34*a* which slidably fits the body 11*a*. The upper end of the packer sleeve 33*a* is anchored to an upper cone 36*a* slidably fitting the exterior of the body 11*a*. In running-in condition, both cones 34*a* and 36*a* are connected to the body 11 by shear pins 37*a*. There are more shear pins 37*a* connecting the lower cone 34*a* to the body than connecting the upper cone 36*a* to the body so that a lesser pressure is required to release the upper cone than the lower one.

In operation it is intended that fluid under pressure be directed through ports 32*a* to between the exterior of the body 11*a* and the interior of the packer sleeve 33*a*, causing expansion of the latter. As before stated, we have found in actual practice that by creating this pressure between the packer sleeve and the body, that the packer sleeve will first expand into contact with the casing whereupon its elongating movement is sufficient to shear the pins of the upper cone 37 and cause the same to move upwardly. We use this movement of this upper cone 36*a* to release an upper set of segmented slips 1*a* and move them into contact with the well casing. The set of slips 1*a* are the "up-pressure" slips.

The co-acting surfaces of the slips 1*a* and the cone 36*a* are such that upward movement of the latter relative to the slips will move the same outwardly. It will be noticed that the slips are connected to the cone by shear pins 37*c* and to the body 11*a* by shear pins 37*d*. When the cone 36*a* commences to move upwardly along the body due to elongation of the packer sleeve 33*a* the pins 37*a*, 37*c* and 37*d* are sheared so that the cone will move the slips to set position.

Mounted in a similar manner on the lower cone 34*a* is a set of "down-pressure" slips 2*a*. These slips and cone have co-acting cone faces disposed so that upward movement at the body 11*a* and slips 2*a* relative to the cone 34*a* will disrupt the shear pin connections and set the slips 2*a*.

Referring to Fig. 8 where the parts are shown in the position which they assume when the device is run-in to the casing, it will be noticed that the slips are arranged in their innermost position so that ample clearance in the casing will be provided.

It will be noticed that the upper cone 36*a* is formed with an interior annular groove 45*a* which receives a spring latch 46*a*. This latch is adapted to engage annular serrations 47*a* formed about the exterior surface of the body 11*a* to latch the cone 36*a* in position on the body 11*a* when the tool has been run in the casing and set.

For the purpose of running the tool into the casing, the upper end of the upper bore 21*a* is formed with a left-hand female thread to receive the left-hand male thread 48*a* formed on the lower end of running-in tubing 49*a*. The purpose of the left-hand thread is to enable the tubing 49*a* to be unscrewed from the body 11*a* after the tool has been tripped and set in the casing.

In operation of the device shown in Figs. 8 to 10 inclusive, it is constructed and assembled as shown in Fig. 8. In this condition the valve 15*a* will be unseated, the two sets of slips 1*a* and 2*a* will be in their innermost position, and the packer sleeve 33*a* will be fully contracted. The tool is then threaded on the lower end of the running-in tubing 49*a* and lowered into the casing. It is obvious that due to the fact that the valve 15*a* is open, the device can be moved up and down in the casing without causing a swabbing action.

When the device has been positioned at the desired point, a trip ball valve 27*a* is dropped through the tubing 49*a* and it will find its seat on the seat 26*a* on the sleeve 24*a*. Fluid pressure is then created in the tubing 49*a* and in the interior of the body of body 11*a* above the sleeve 24*a*. This fluid pressure, however, is insufficient to shear the pin 30*a* which connects the sleeve 24*a* to the body 11*a*.

The fluid pressure passing through the ports 32*a* causes the packer sleeve 33*a* to expand, as illustrated in Fig. 9, and thereafter compresses the sleeve, which causes it to elongate and, in so doing, it shears the pins 37*a* which connect the sliding cone 36*a* to the body 11*a* and tends to move the cone 36*a* upwardly with sufficient force to shear the pins 37*a*, 37*c* and 37*d*. The moment that these pins are sheared, the slips 1*a* are caused to move longitudinally into contact with an enlargement 50*a* carried by the body and

radially outward into engagement with the casing.

The pump pressure above the valve 27a is then relieved and a strain is taken on the running-in tubing 49a which moves the body 11a and cone 36a upwardly relative to the up slips 1a, consequently moving the slips 1a outwardly into a firm gripping contact with the casing.

During this movement of the body the lower cone 34a and slips 2a will move upwardly with the body compressing the packer sleeve 33a into sealing condition against the casing until it will compress no further, then the pin 37a will shear and an annular shoulder 53a which circumscribes the body 11a will engage the lower ends of the down-pressure slips 2a. This engagement will move the slips 2a upwardly shearing the pins 37c and 37d. When these pins are sheared, continued upward movement of the body 11a will move the slips radially outward into set engagement with the casing.

After the packer sleeve 33a has been fully compressed and the slips firmly set, the latch ring 46a of the cone 34a will engage one of the latch grooves in the body 11a and maintain the parts in set condition, as illustrated in Fig. 10. Thereafter pump pressure is again built up in the interior of the body 11a through the running-in tubing 49a. This fluid pressure is built up sufficiently to shear the pin 30a which connects the sleeve to the body 11a. In so shearing this pin, the sleeve 24a drops from the body 11a and the valve 15a is free to seat.

It is obvious from the previous description and from the drawings that any up-pressure built up in the casing below the retainer or packer will tend to more tightly press the up-pressure slips into contact with the casing due to the inclined surfaces of the slip sockets. It is likewise apparent that any considerable pressures built up in the casing above the packer or retainer will tend to more tightly press the down-pressure slips into contact with the casing. Therefore, the packer will resist dislodgement either from pressures above or pressures below. It will be noticed that the down-pressure slips are provided with downwardly extending wickers and that the up-pressure slips are provided with upwardly directed wickers for gripping purposes.

The device is then ready for cementing operations and cement may then be pumped downwardly through the running-in tubing 49a, thence through the body 11a, opening the valve 15a and discharging into the casing below the packer 10a. After the cementing operations have been completed, the back pressure of the cement will close the valve 15a to prevent the cement from pasing upwardly into the body 11a and into the casing above the body.

After the cementing operation has been completed, the running-in tubing 49a may be disconnected from the body 11a due to the left-hand screw connection between the two. The running-in tubing may then be pulled from the hole.

We prefer to use in connection with this packer a circulating jar or joint of any preferred type.

If for any reason it is desired to make the device a bridge plug so as to prevent the passage of fluid either upwardly through the packer or downwardly therethrough, a bridging ball 51a is provided. This ball may be dropped through the running-in tubing 49a and it will seat on the bridging valve seat 23a. This will prevent fluid from being pumped downwardly through the body 11a and the back pressure valve 15a will prevent fluid from pasing upwardly through the body 11a.

From the foregoing it is obvious that we have provided a cement retainer which will resist dislodgement either by pressures above it or by pressures below it. It is further pointed out that the device may not only be used in various kinds of cementing operations but may likewise be used as a bridge plug.

It should be pointed out that the device may also be used in repressuring oil sands. This is brought about by selecting an exhausted well which taps the oil sands to be repressured. Our tool is then run into the casing of this well and set in the same manner as previously described herein in connection with the cementing operation. The packer is positioned just above the perforated section of the casing. Gas under high pressure is then forced downwardly through the running-in tubing so that it will discharge through the port by opening the back pressure valve. This will raise the pressure in the oil sands and drive out additional oil into adjacent wells from whence it may be pumped to the surface.

While we have disclosed the preferred form of our invention, it is to be understood that various changes may be made therein by those skilled in the art without departing from the spirit of the invention as defined in the appended claims.

Having thus described our invention, what we claim and desire to secure by Letters Patent is:

1. An apparatus of the character described comprising a hollow member adapted to be secured to the lower end of a string of tubing and lowered into a well casing, slips mounted on said member, means capable of being released connecting said slips to said member and maintaining them in an ineffective position, a packing sleeve mounted on said member and capable of being hydraulically actuated to release said means and thereby release said slips so that they may move to an effective position.

2. An apparatus of the character described comprising a hollow member to be secured to the lower end of a string of tubing and slips mounted on said member, cooperating means on the slips and member whereby relative axial movement between the slips and said member will cause said slips to move radially outward, means capable of being released connecting said slips to said member and maintaining them in an ineffective position, a packer member mounted on said member and capable of being hydraulically actuated to release said means and release said slips to permit them to move axially relative to said member to an effective position.

3. An apparatus of the character described comprising a hollow member to be secured to the lower end of a string of tubing, slips mounted on said member, cooperative means on the slips and member whereby relative axial movement between the slips and said member will move said slips radially outward, shearing means capable of being sheared connecting said slips to said member and maintaining them in an ineffective position, spring means constantly tending to move said slips to an effective position, a packing sleeve mounted on said member and capable of being elongated by hydraulic pressure, said sleeve being so associated with said slips that elongation thereof will act to shear said shear means and release said slips so that said spring means may move said slips axially relative to said member.

4. A device of the character described com-

prising a member to be detachably connected to the lower end of a string of tubing, means carried by said member and operative to secure said member to a well casing, a packing sleeve surrounding said member and capable of elongation when fluid pressure is created between it and said member, said member being hollow whereby fluid discharged therein through said tube may pass downwardly through said member, said member having a port formed therein to direct fluid between it and said sleeve, valve means normally preventing the flow of fluid through said port, and fluid pressure actuated means to move said valve to uncover said port.

5. An apparatus of the character described comprising a hollow member to be connected to the lower end of a string of tubing, a first set of slips mounted on said member, a second set of slips mounted on said member, cooperative means between said slips and on said member whereby relative axial movement between said member and said slips will move said slips radially outward, shear means connecting said slips to said member in ineffective positions, a hydraulically actuated packing sleeve on said member operative to shear said means of the first set of slips so that they may move to an effective position, and means operative upon subsequent endwise movement of said member to shear the shear means of the second named slips to release the same.

6. An apparatus of the character described comprising a hollow member adapted to be detachably connected to the lower end of a string of tubing, a first set of slips mounted on said member and a second set of slips mounted on said member, spring means associated with said means and said member and constantly tending to move said slips axially relative to said member, cooperative means on said slips and said member causing said slips to move radially outward upon relative movement between the same and said member, shear means connecting said slips to said member, a packing sleeve mounted on said member capable of being hydraulically actuated to shear said shear means of the first set of slips, and means on said member and operative upon endwise movement of said member subsequent to the shearing of the shear means on the first set of slips to engage the second set of slips and shear the shear means thereof to release the same.

7. An apparatus of the character described comprising a hollow member to be connected to the lower end of a string of tubing, a first set of slips mounted on said member, a second set of slips mounted on said member, cooperative means between said slips and on said member whereby relative axial movement between said member and said slips will move said slips radially outward, shear means connecting said slips to said member in ineffective positions, a packing member adapted to be elongated by hydraulic pressure and thereby operative to shear said means of the first set of slips so that they may move to an effective position and means operative upon subsequent movement of said member downwardly to shear the shear means of the second named slips to release the same, the lower end of said member being formed with a valve port, a valve cooperating with said port to close the same, means normally maintaining said valve in open position and hydraulically actuated means for rendering said means ineffective.

8. An apparatus of the character described comprising a hollow cylindrical member adapted to be connected at its upper end to the lower end of a string of tubing and lowered thereby into a string of well casing, a set of slips at the exterior of said member, coinciding angular faces on said slips and member whereby relative axial movement between said member and slips will move said slips radially outward into engagement with the casing, means for detachably connecting said slips to the member to maintain the slips in ineffective position, a hydraulically actuated packing sleeve for detaching said slips from the member, spring means associated with the slips and member constantly tending to cause relative axial movement between the slips and said member thereby moving said slips radially outward into engagement with the casing, and means for subsequently expanding said packing means to packing position and latching it in such position.

9. An apparatus of the character described comprising a hollow cylindrical member adapted to be connected to the lower end of a string of tubing and lowered thereby into a string of well casing, a set of slips at the exterior of said member, coinciding angular faces on said slips and member whereby relative axial movement between said member and slips will move said slips radially outward into engagement with the casing, means for detachably connecting said slips to the member to maintain the slips in ineffective position, a hydraulically actuated packing sleeve for detaching said slips from the member, spring means associated with the slips and member constantly tending to cause relative axial movement between the slips and said member thereby moving said slips radially outward into engagement with the casing, and means for subsequently expanding said packing means to packing position and latching it in such position, said packing means being expanded into packing engagement with the interior of the well casing by upward movement of said member subsequent to the releasing of said slips.

10. A device of the character described comprising a body adapted to be connected to the lower end of a string of tubing and lowered thereby into a well casing, a slip sleeve carried by said body and normally secured against movement coaxially therealong, slips carried by said sleeve and detachably secured thereto in their innermost positions, cooperative means on the sleeve and slips for moving the latter outwardly when they are detached from the sleeve, a packer sleeve surrounding the body and adapted to expand and elongate when the fluid pressure is built up between it and the body, said packer sleeve and slips being so relatively associated that upon elongation of the packer sleeve it will detach said slips from the slip sleeve, said packer sleeve being capable of thereafter being axially compressed by upward movement of the body, said upward movement also detaching said slip sleeve from the body and forcing said slips into gripping engagement with the casing.

11. An apparatus of the character described comprising a hollow body adapted to be detachably secured to the lower end of a string of tubing and lowered into a well casing, segmental slips mounted on said body and detachably connected thereto in an ineffective position, a longitudinally expansible member mounted on said body and capable of being expanded by fluid pressure built up in said body to engage said slips and move them longitudinally of the body.

12. An apparatus of the character described

comprising a hollow body to be secured to the lower end of a string of tubing, segmental slips mounted on said body, a cone on said body, cooperating cone faces on the slips and cone whereby relative axial movement between the same will cause said slips to move radially outward, a longitudinally expansible member mounted on said body and capable of being expanded by fluid pressure built up in the body to cause relative axial movement between the slips and the cone.

13. An apparatus of the character described comprising a hollow body to be detachably secured to the lower end of a string of tubing, segmental slips mounted on said body, a cone mounted on the body, cooperative cone faces on the slips and cone whereby relative axial movement between the slips and said cone will move said slips radially outward, shearing means capable of being sheared connecting said slips to said body and maintaining them in an ineffective position, a sleeve mounted on said body and capable of being elongated by hydraulic pressure built up in said body, said sleeve being so associated with said slips and cone that elongation thereof will act to cause relative axial movement between the slips and cone and shear said shear means.

14. An apparatus of the character described comprising a hollow body to be detachably connected to the lower end of a string of tubing, a first set of slips mounted on said body, a second set of slips mounted on said body, two cones on the body and associated with said sets of slips whereby relative axial movement between said cones and said slips will move said slips radially outward, shear means connecting said slips to said body in ineffective positions, a hydraulically actuated packing sleeve on said body and connected with one of said cones and operative upon fluid pressure being built up therein to move the said cone relative to the first set of slips and shear said means of the first set of slips and move the same to an effective position, and means operative upon subsequent endwise movement of said body to move the second set of slips axially relative to the other cone to shear the shear means of the second named slips and move them to an effective position.

15. An apparatus of the character described comprising a hollow body adapted to be detachably connected to the lower end of a string of tubing, a first set of slips mounted on said body and a second set of slips mounted on said body, a first and a second cone on said body and associated with said slips to move the same radially outward upon relative movement between the cones and said slips, shear means connecting said cones to said body, shear means detachably connecting said slips to said cones and body, a packing sleeve mounted on said body and connected with said cones and capable of being hydraulically actuated to shear said shear means of the first cone, and means on said body and operative upon endwise movement of said body subsequent to the shearing of the shear means on the first cone to engage the second set of slips and move the same longitudinally relative to the second cone.

16. An apparatus of the character described comprising a hollow cylindrical member adapted to be connected at its upper end to the lower end of a string of tubing and lowered thereby into a string of well casing, a set of slips at the exterior of said member, a cone on said member, coinciding conical faces on said slips and cone whereby relative axial movement between said cone and slips will move said slips radially outward into engagement with the casing, means for detachably connecting said slips to the member and cone to maintain the slips in an ineffective position, a hydraulically actuated packing sleeve for detaching said slips from the member and cone and causing relative axial movement between the slips and said cone thereby moving said slips radially outward into engagement with the casing, and means for subsequently expanding said packing sleeve to packing position and latching it in such position.

17. An apparatus of the character described comprising a hollow cylindrical member adapted to be connected to the lower end of a string of tubing and lowered thereby into a string of well casing, a set of slips at the exterior of said member, a cone on the member, coinciding conical faces on said slips and cone whereby relative axial movement between said cone and slips will move said slips radially outward into engagement with the casing, means for detachably connecting said slips to the member to maintain the slips in ineffective position, a hydraulically actuated packing sleeve for detaching said slips from the member and for causing relative axial movement between the slips and said member thereby moving said slips radially outward into engagement with the casing, and means for subsequently expanding said packing sleeve to packing position and latching it in such position, said packing sleeve being expanded into packing engagement with the interior of the well casing by upward movement of said member subsequent to the releasing of said slips.

18. A device of the character described comprising a body adapted to be connected to the lower end of a string of tubing and lowered thereby into a well casing, a pair of cones carried by said body and normally secured against movement coaxially therealong, two sets of slips detachably secured thereto in their innermost positions, cooperative conical faces on the cones and slips for moving the latter outwardly when the cones are detached from the body by relative axial movement therebetween, a packer sleeve surrounding the body and adapted to expand and elongate when the fluid pressure is built up between it and the body, said packer sleeve and cones being so relatively associated that upon elongation of the packer sleeve it will operate one cone and set one set of said slips, said packer sleeve being capable of thereafter being axially compressed by upward movement of the body, said upward movement also setting the second set of slips by moving the same relative to the second cone.

19. An apparatus of the character described comprising a hollow body adapted to be secured to the lower end of a string of tubing and lowered into a well casing, slips mounted on said body adapted for radial movement, an inflatable member carried by said body in cooperative relationship with said slips for imparting radial movement thereto and means for applying fluid pressure to said member to inflate the same and actuate said slips.

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