June 25, 1940. G. S. KNOX 2,205,748

WELL PIPE PLUG

Filed June 26, 1937 2 Sheets-Sheet 1

Fig. 1

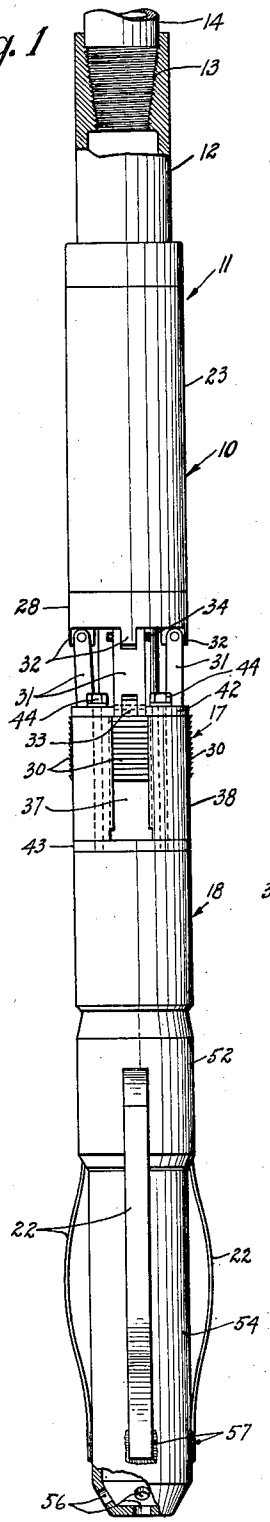


Fig. 2.

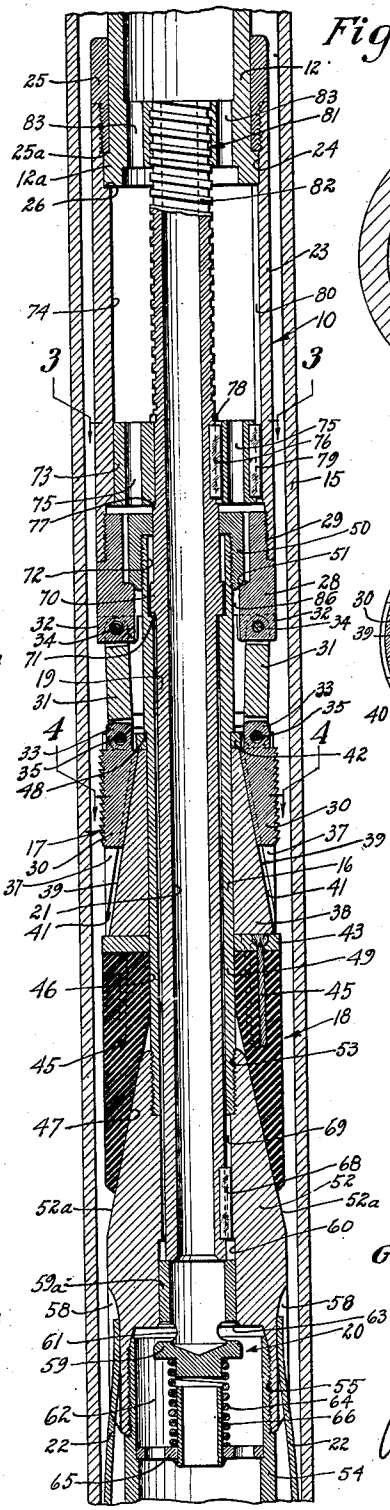


Fig. 3.

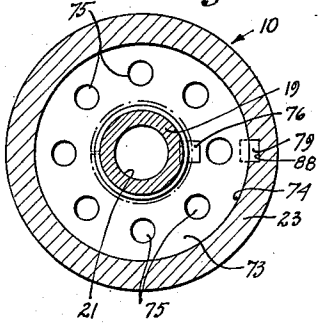
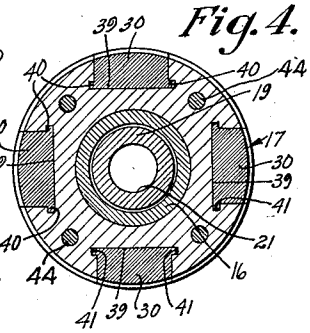


Fig. 4.



Inventor.
Granville S. Knox.

Attorney.

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Fig. 5

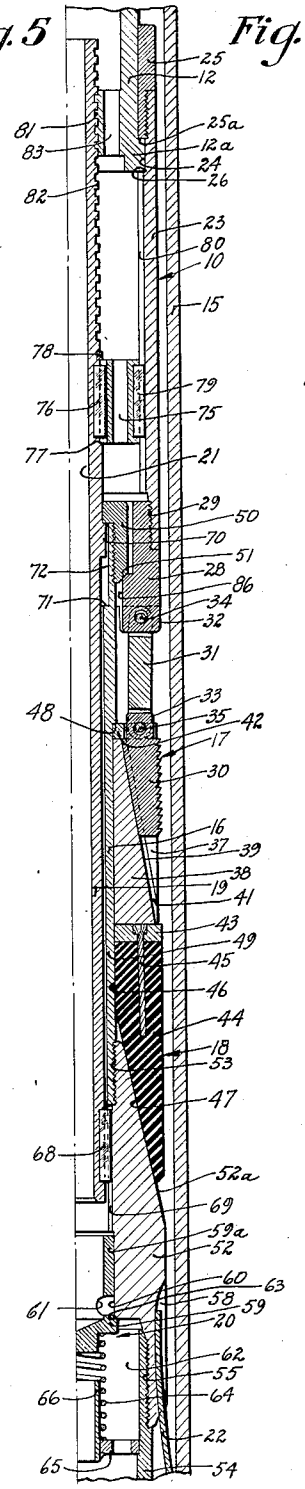


Fig. 6.

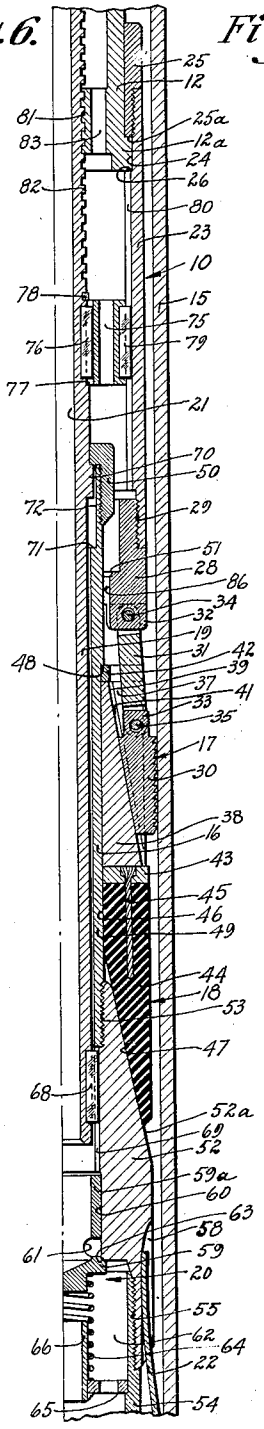
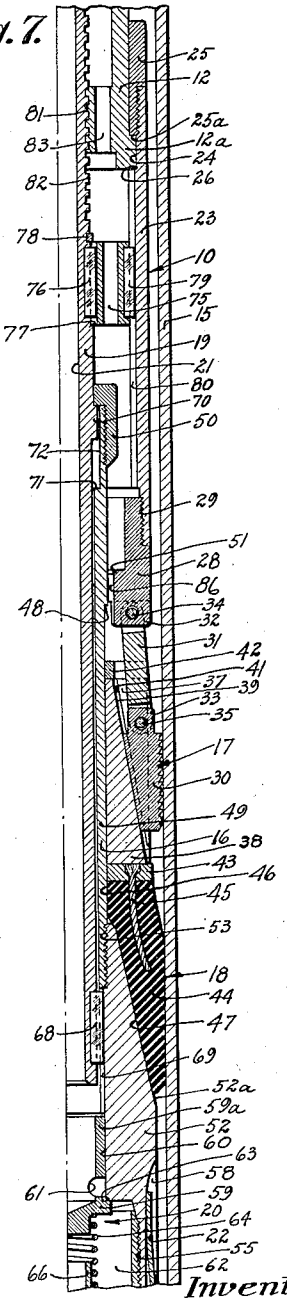


Fig. 7.



Inventor.
Granville S. Knox.

Attorney.

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UNITED STATES PATENT OFFICE

2,205,748

WELL PIPE PLUG

Granville S. Knox, Los Angeles, Calif., assignor to Hydril Company, Los Angeles, Calif., a corporation of California

REISSUE

Application June 26, 1937, Serial No. 150,569

13 Claims. (Cl. 166—13)

This invention pertains generally to well pipe plugs, particularly casing plugs, adapted to be operated and controlled by way of the suspension means on which the plug is lowered in the well. This type of plug is distinguished by its general mode of operation from pump-down plugs, which are forced down ahead of a fluid column and which ordinarily set, independently of any direct actuation from the ground surface, when some predetermined condition is established. The invention may be further characterized as involving, in some of its aspects, improvements on the invention disclosed in United States Letters Patent No. 1,971,514, granted August 28, 1934, to Frederick Stone on Casing plug.

In its preferred form, the invention has in common with the type of plug shown in the Stone patent, three principal operating parts: radially expansible means adapted to be brought into holding engagement with the pipe or casing, a radially expansible packer, and a valve adapted to open or close a fluid passage extending through the plug from one side to the other of the packer. And also, as in the patented plug, these principal operating parts preferably are positively actuated and controlled by way of the suspension means which, ordinarily, will consist of a string of drill pipe. One of my principal objects is to cause and insure the operation of the plug parts in a novel predetermined sequence without conscious effort on the part of the operator to maintain that sequence, and thereby to obviate many of the difficulties commonly encountered in the use of such plugs.

In lowering the plug, the valve ordinarily is kept open to by-pass well fluid through the plug and thereby avoids having to force down the plug against the hydrostatic head of liquid in the well. In accordance with the operating sequence aspect of the invention, the plug setting operation involves, and requires, first, closing the valve, and then expanding the holding means and packer, preferably though not necessarily in the order named, into engagement with the casing. To release the plug from set condition it is necessary first to open the valve, and then to contract the packer and holding means. The required initial opening of the valve is of importance in that sometimes an operator will attempt to release a plug without first relieving the pressure beneath the plug, with the result that either the plug cannot be released because of the applied pressure, or a forced release will result in breaking some of its parts.

A further feature of the invention, and one which is believed to be a broadly novel improvement, is the provision of means whereby any or all of the operating parts mentioned above may repeatedly be actuated, i. e., the valve repeatedly opened and closed, and the pipe engaging means and packer repeatedly expanded and contracted, while the plug is lowered in the casing and while it remains connected to the suspension means. By this means the plug may be set and reset at different locations and as many times as may be necessary without having to withdraw the plug or suspension means, or, leaving the plug in the casing, the suspension means may be run in and out of the casing any number of times to reset and change the position of the plug.

Other objects of the invention have to do with such features as means for maintaining positive control of the operating parts from the ground surface via the suspension means, and, more specifically, a preferred plug structure according to which relatively vertically movable parts of the plug are caused to move relatively in opposite directions as the suspension means is rotated in opposite directions, and the valve, pipe engaging means and packer are actuated in accordance with and in response to movement of the said parts.

All the above mentioned features and objects of the invention, as well as numerous additional aspects unmentioned as yet, can perhaps be explained to best advantage and without necessity for further preliminary discussion by proceeding with a detailed description of a specific form of plug that is illustrative of the invention in one of its typical and preferred forms. Throughout the description reference is had to the accompanying drawings, in which:

Fig. 1 is a general view showing the plug in side elevation;

Fig. 2 is an enlarged sectional view taken longitudinally through the plug and showing the valve open and the pipe engaging means and packer in radially contracted positions;

Figs. 3 and 4 are cross sections taken on lines 3—3, and 4—4, Fig. 2; and

Figs. 5, 6 and 7 are half sections similar to Fig. 2, illustrating the sequential movement of the plug parts beyond their positions in Fig. 2, during a complete plug setting operation.

The illustrated form of plug may be described generally as comprising a tubular body 10 connected by a swivel joint 11 to a sub 12, which in turn is connected by a right-handed screw thread joint 13 with the drill pipe 14 on which the plug

is lowered within the casing 15. Extending within and below the body 10 is a tubular mandrel 16 movable vertically with relation to the body to cause expansion and contraction of the pipe gripping means 17 and the packer 18. An inner tubular mandrel in the form of a pipe 19 operates by virtue of rotation of the sub 12 relative to the body 10 at the swivel 11, to produce relative vertical movement of the body and mandrel 16, thereby controlling the operation of the pipe gripping means 17 and packer 18, and also to operate a valve 20 that controls the passage of well fluid longitudinally through the plug by way of bore 21. The plug is held against rotation within the casing by suitable means, such as bowed springs 22, yieldably engaging the casing and, in effect, carried by the mandrel 16.

Body 10 comprises a tubular section 23 having at its upper end a counterbore 24 which receives the lower flanged end 12a of the sub 12 and a threaded bushing 25. The sub is rotatable within the bushing and body, and its flanged portion 12a is vertically confined between the lower end 25a of the bushing and shoulder 26 at the lower end of counterbore 24. The body also may be regarded as including a supporting ring 28 threaded at 29 into the lower end of section 23. In the position of the parts shown in Fig. 2, ring 28 supports mandrel 16 and certain parts directly connected thereto, and also the pipe engaging means 17 and the packer 18.

In its preferred form, the pipe engaging means 17 comprises a plurality of wedge slips 30, typically four, each of which is connected to the ring 28 by a link 31 having bifurcated ends, as shown in Fig. 1, receiving a depending lug 32 on ring 28, and an upwardly projecting lug 33 on the slip. The link and lugs are interconnected by pins 34 and 35 extending through openings in the lugs with sufficient looseness that a vertical end thrust on the ring, link and slip assembly, is taken by the engagement of the ends of the links with the surfaces of the ring and slips at opposite sides of the lugs, thus relieving the pins from stress. Slips 30 are contained within angularly extending ways 37 in a sleeve 38 movable vertically with relation to the mandrel 16. The slips are vertically movable within ways 37 along inclined wedge surfaces 39, and are radially confined within the ways by the slip flanges 40, see Fig. 4, extending within grooves 41 formed in the side walls of the ways in the bases thereof. One important advantage of mounting the slips on the body by links 31 is that the relative vertical positions of the slips remain the same, so that they expand and contract uniformly and thus evenly engage and disengage the pipe.

Upward movement of the slips relative to the sleeve 38 is limited by their engagement with a ring 42 notched to receive the lower ends of links 31 and connected to the packer supporting ring 43 by bolts 44, see Fig. 1, extending through the sleeve and threaded at their lower ends into ring 43. The packer 18 comprises a rubber sleeve 44 attached by suitable means to ring 43, as by looped wires or cables 45 embedded within the upper portion of the rubber. This type of flexible connection between the packer and its supporting ring is of advantage in that it permits full expansion and flexure of the packer and yet keeps it securely anchored to its support. The upper portion 46 of the packer bore has sliding engagement with the mandrel 16, whereas the lower portion 47 is flared outwardly to receive the mandrel carried expander, as will presently appear. At this point it may be noted that the assembly including ring 42, sleeve 38, ring 43 and the packer sleeve 44, is movable vertically with relation to the mandrel 16, and that upward relative movement of the assembly is limited by the engagement of ring 42 with the mandrel shoulder 48.

The mandrel 16 comprises a tube 49 on the upper end of which is threaded nut 50 which, in the positions of Figs. 2 and 5, seats on annular shoulder 51 within ring 28, to support the mandrel assembly on the body. The packer expander 52, consists of a conically shaped, upwardly tapering tubular member screw-threaded at 53 on the lower end of tube 49. In the illustrative form of the invention shown, a hollow nose member 54 is threaded at 55 into the lower end of the expander 52, although it is to be understood should it be desired to use the plug in combination with any form of tool, such as a bit, the nose member 54 may be replaced by a suitable sub or coupling for connecting the mandrel with such tool. The plug is readily adaptable for use in conjunction with the tool carried below, in that, as will later appear more fully, fluid circulation may be maintained through the plug to the tool during such times as the latter may be in operation.

As shown in Fig. 1, openings 56 are provided in the lower end of the plug nose 54 to permit passage of well fluid through the plug by way of the inner pipe bore 21. The mandrel is held against rotation within the casing by means of spring bows 22 welded at 57 to the nose 54, the upper ends of the springs being received within and slidably engaging the bases of grooves 58 in the expander 52. The valve mechanism 20 at the lower end of the expander comprises the valve proper, denoted at 59, having a tubular guide extension 59a contained within counterbore 60. Ports 61 pass the fluid between space 62 and passage 21 when the valve is open. The valve is yieldably urged toward closed position in which it seats at 63 on the lower end of expander 52, by a coil spring 64 placed about tube 66 and supported on an apertured plate or spider 65.

Pipe 19 moves vertically within the mandrel to operate the valve 59, the pipe in its lower position of Fig. 2 engaging the guide 59a and depressing the valve against the resistance of spring 64 to hold the valve in open position. Relative rotation between pipe 19 and the mandrel is prevented by spline 68 carried by the pipe and received within a vertically extending way 69 in the expander bore. Pipe 19 is vertically movable relative to the mandrel within the limits of engagement of the pipe flange 70 with nut 50 and shoulder 71 at the lower end of counterbore 72 in the upper end of tube 49. The distance of travel permitted pipe 19 as limited by the engagement of flange 70 with nut 50 and shoulder 71, is somewhat greater than the distance through which valve 59 moves in closing from the full open position of Fig. 2. This distance also is sufficient to prevent accidental reopening of the valve in the plug setting operations and to permit movement of the mandrel under the influence of the well pressure to expand the packer, but without injury to the pipe gripping parts as will presently appear. Above nut 50, pipe 19 carries a guide member 73 of circular cross section slidably engaging the bore 74 of body section 23, and provided with circularly spaced passages 75. Guide 73 is held against rotation about pipe 19 by spline 76, and is clamped between shoulder 77 and a

lock washer 78 seated within a groove within the surface of the pipe. The guide is slidable vertically within bore 74, but is prevented from rotating within the body by spline 79 received within a vertically extending way 80 in the body bore.

The upper end portion of pipe 19 has a screw-threaded connection at 81 with the sub 12, the screw threads 82 being left-handed so that as the sub is rotated in a counter-clockwise direction, the pipe is elevated relative to the body 10, through the successive positions shown in Figs. 5, 6, and 7. The lower end of the sub is provided with vertically extending passages 83 through which circulating fluid may be forced downwardly into bore 74, passages 75 and thence outwardly into the well around links 31, as will later appear.

In operation, the plug, with its parts positioned as in Fig. 2, is lowered within the casing 15 on the drill pipe 14 to the location at which the plug is to be set. The right-handed screw-thread joint at 13 between the drill pipe and sub 12 first will have been taken up snugly but not so tight as to prevent the joint from being unscrewed after the plug has been set. While the plug is being lowered within the casing, the valve 59 is held open, permitting the well fluid to pass upwardly through the plug into the drill pipe and thereby balancing the hydrostatic columns inside and outside the drill pipe. With the plug lowered to proper position, the drill pipe 14 and sub 12 are rotated in a counter-clockwise direction, first causing pipe 19 to be raised to the position of Fig. 5 in which the lower end of the pipe is disengaged from the valve, permitting it to seat. Fig. 5 also shows flange 70 to be raised to the point of engagement with the mandrel nut 50. Continued rotation of the drill pipe causes pipe 19 to elevate the mandrel, together with sleeve 38 and packer 44, to the position of Fig. 6 in which the wedge slips 30 are shown to be expanded into engagement with the casing 15. It will be understood that sleeve 38 is supported in its upward slip expanding movement by packer 44, which in turn is supported on the expander 52, and that the packer sleeve has sufficient strength or resistance to distortion, by reason of its resilience, to support sleeve 38 in its slip expanding movement.

With the slips thus set, holding sleeve 38 against further upward movement, continued rotation of the drill pipe causes pipe 19 to raise the mandrel to the position of Fig. 7, in which the expander 52 is thrust upwardly into the packer bore a distance sufficient to expand the packer, by virtue of the wedging engagement between the packer surface 47 and the tapered expander surface 52a, into fluid-tight engagement with the casing. The plug now is fully set, and may be disconnected from the drill string by continuing the left-hand rotation to break the joint at 13, the combined force of springs 22, packer 18 and the pipe engaging means 17, acting to hold the plug against rotation within the casing. Before the plug is disconnected, fluid circulation into the casing above the packer may be effected by forcing the fluid downwardly through passages 83, 75, space 86 between tube 49 and ring 28, and outwardly between rings 28 and 42 and around the links 31.

Obviously, the plug may be released while the drill pipe 14 remains connected to the sub 12, or, otherwise, by again lowering the drill pipe and by right-hand rotation making the joint at 13. Continued right-hand rotation first moves pipe 19 downward to the point of engaging the valve guide 59a and unseating the valve 59, thus opening passage 21 for the relief of well pressure below the plug, so that the pressures above and below the packer 44 will be equalized. Further right-handed rotation of the drill pipe brings flange 70 into engagement with the mandrel shoulder 71 and withdraws the expander 52 from the packer to the extent that the packer assumes its normal contracted form. Further downward movement of pipe 19 brings the mandrel shoulder 48 into engagement with ring 42, forcing sleeve 38 downward to slip releasing position, in which all the parts will have returned to the position shown in Fig. 2.

It is to be noted that all the described sequences involving the operation of the valve, pipe engaging means and packer, are predetermined and insured against any variation by the operator. All that is required to be done by the operator is to rotate the drill pipe in one direction or the other as required for setting or releasing the plug. The automatic characteristics of the tool predetermine the operating sequence of its parts. No injury can occur to the plug by reason of excessive rotation of the drill pipe in one direction or the other, since in the setting operation, the joint at 13 will unscrew when the plug parts are properly positioned, while in the releasing operation, rotation beyond the point of releasing the packer and slips will merely rotate the plug freely within the casing.

Another important feature of the invention that lends indestructibility to the plug, and particularly to the parts directly associated with the pipe engaging means, is the fact that after the wedge slips are set against the casing and the packer is expanded, excessive well pressure tending to force the plug upwardly within the casing, will not impose strains on the slip actuating parts. After the slips are set, increased well pressure acting against the mandrel will merely expand the packer more tightly into engagement with the casing and cause the mandrel to move upward within sleeve 38 without affecting either the sleeve or the slips.

It will be understood that in the claims, such terms as "upward," "downward," "lowered," "vertical," and "vertically" are to be regarded as relative only; that is, these terms are employed merely for convenience of terminology in defining direction or position with relation to a vertically extending well pipe.

I claim:

1. In a plug adapted to be lowered within a well pipe on a suspension means, the combination comprising a body, means connecting said body with the suspension means and adapted to allow relative movement therebetween, a valve normally held open while the plug is being lowered to permit fluid to pass upwardly through said body, means for holding the valve open, pipe engaging means adapted to be radially expanded into engagement with said pipe to hold the body against upward movement therein, a packer adapted to be radially expanded into fluid tight engagement with the pipe, control mechanism operable by movement of the suspension means in one direction with respect to the body to close said valve and to radially expand said pipe engaging means and packer into engagement with the pipe, said mechanism also being operable by movement of the suspension means in an opposite direction with respect to the body to open the valve and to radially contract the pipe engaging means and

packer, and yielding means carried by the plug and engaging the well pipe, said yielding means holding said body against movement relative to the well pipe during operation of said control mechanism

2. In a plug adapted to be lowered within a well pipe on a suspension means, the combination comprising a body, means connecting said body with the suspension means and adapted to allow relative rotation therebetween, a valve normally held open while the plug is being lowered to permit fluid to pass upwardly through said body, means for holding the valve open, pipe engaging means adapted to be radially expanded into engagement with said pipe to hold the body against upward movement therein, a packer adapted to be radially expanded into fluid tight engagement with the pipe, control mechanism operable by rotation of the suspension means in one direction with respect to the body to close said valve and to radially expand said pipe engaging means and packer into engagement with the pipe, said mechanism also being operable by rotation of the suspension means in an opposite direction with respect to the body to open the valve and to radially contract the pipe engaging means and packer, and yielding means carried by the plug and engaging the well pipe, said yielding means holding said body against rotation relative to the well pipe during operation of said control mechanism.

3. In a plug adapted to be lowered within a well pipe on a suspension means, the combination comprising a body, means connecting the plug with said suspension means, yielding means carried by said plug and engaging the pipe, a valve controlling the flow of fluid through a passage extending through the plug, radially expansible pipe engaging means, a radially expansible packer, control mechanism actuated by the suspension means whereby repeated rotation of the suspension means in opposite directions while the plug remains in the pipe, causes said valve to repeatedly close and open and said expansible pipe engaging means and packer to repeatedly expand and contract, said yielding means engaging the well pipe to hold said body against movement relative to the well pipe during the said operations of the valve, expansible pipe engaging means and packer.

4. In a plug adapted to be lowered within a well pipe on a suspension means, the combination comprising a tubular body, a relatively vertically movable tubular mandrel within the body, a plurality of radially expansible wedge slips, links having their opposite ends pivotally connected to said body and slips so that the slips are movable with the body in its vertical movement relative to the mandrel, an annular slip actuating wedge ring slidable longitudinally on the mandrel, a radially expansible packer mounted on the mandrel and connected to said ring, and upwardly movable packer expanding means carried by the mandrel, said slips and packer being expansible by upward movement of the mandrel within the body.

5. In a plug adapted to be lowered within a well pipe on a suspension means, the combination comprising a tubular body, a mandrel within the body and movable vertically relative thereto, radially expansible pipe engaging members, a plurality of links connecting the lower end of said body with said pipe engaging members, a wedge ring movable vertically on the mandrel and operable upon upward movement of the mandrel within the body to radially expand the pipe engaging means, a packer connected to the wedge ring, and upwardly movable means for radially expanding the packer by upward movement of the mandrel relative to the body, said packer, when acted upon by said last mentioned means, acting on said wedge ring so to operate it.

6. In a plug adapted to be lowered within a well pipe on a suspension means, the combination comprising a tubular body, a mandrel within the body and movable vertically relative thereto, radially expansible pipe engaging members, means connecting the lower end of said body with said pipe engaging members, wedge means movable vertically on the mandrel and operable upon upward movement of the mandrel within the body to radially expand the pipe engaging means, a packer surrounding the mandrel below said upwardly movable wedge means and connected thereto, and wedge means for radially expanding the packer by upward movement of the mandrel relative to the body.

7. In a plug adapted to be lowered within a well pipe on a suspension means, the combination comprising a tubular body, a mandrel within the body and movable vertically relative thereto, radially expansible pipe engaging members, means connecting the lower end of said body with said pipe engaging members, a wedge ring surrounding the mandrel and movable vertically relative thereto, said ring being operable to expand said pipe engaging members upon upward movement relative thereto, a packer below said wedge ring and connected thereto, and an annular upwardly movable packer expanding wedge carried by the mandrel within the packer, said packer and pipe engaging members being radially expansible by upward movement of the mandrel within the body.

8. In combination, a plug adapted to be lowered within a well pipe on a suspension means, said plug including a body, a swivel joint between the body and suspension means whereby said body and suspension means are capable of relative rotation, pipe engaging means adapted to be radially expanded into engagement with said pipe to hold the body against upward movement therein, a packer adapted to be radially expanded into fluid tight engagement with the pipe, a valve adapted to be open while the plug is being moved longitudinally through the pipe to permit well-fluid to by-pass the packer, releasable means for holding the valve open, and control mechanism operable by rotation of the suspension means with respect to the body member at said swivel joint first to close said valve and then, after the valve is closed, to expand said pipe engaging means and packer into engagement with said pipe.

9. In a plug adapted to be lowered within a well pipe on a suspension means, the combination comprising a body, means connecting said body with the suspension means and adapted to allow relative movement therebetween, a valve normally held open while the plug is being lowered to permit fluid to pass upwardly through said body, means for holding the valve open, pipe engaging means adapted to be radially expanded into engagement with said pipe to hold the body against upward movement therein, a packer adapted to be radially expanded into fluid tight engagement with the pipe, control mechanism operable by movement of the suspension means in one direction with respect to

the body to close said valve and to radially expand said pipe engaging means and packer into engagement with the pipe, said mechanism also being operable by movement of the suspension means exclusively in an opposite direction with respect to the body to open the valve and to radially contract the pipe engaging means and packer, and yielding means carried by the plug and engaging the well pipe, said yielding means holding said body against movement relative to the well pipe during operation of said control mechanism.

10. In a plug adapted to be lowered within a well pipe on a suspension means, the combination comprising relatively vertically movable body and mandrel sections, radially expansible pipe engaging means supported by and suspended from the body section, an annular packer normally suspended from the pipe engaging means, said pipe engaging means and packer both being movable vertically with the body section in its said relative vertical movement, and means whereby relative movement of the sections in one direction causes the pipe engaging means and packer to radially expand, and whereby relative movement of the sections in an opposite direction causes the pipe engaging means and packer to contract.

11. In a plug adapted to be lowered within a well pipe on a suspension means, the combination comprising a body, means connecting said body with the suspension means and adapted to allow relative rotation therebetween, said connection including a joint breakagle by selective relative rotation of its parts upon the imposition of pre-determined torque, a valve normally held open while the plug is being lowered to permit fluid to pass upwardly through said body, means for holding the valve open, pipe engaging means adapted to be radially expanded into engagement with said pipe to hold the body against upward movement therein, a packer adapted to be radially expanded into fluid tight engagement with the pipe, control mechanism operable by sustained rotation of the suspension means in one direction with respect to the body to close said valve, radially expand the pipe engaging means and packer into engagement with the pipe and break said joint to free the suspension means from the plug; and yielding means carried by the plug and engaging the well pipe and thereby holding said body against rotation with respect to the pipe during operation of said control means prior to the effective engagement of the first mentioned pipe engaging means with the well pipe.

12. In combination, a plug adapted to be lowered within a well pipe on suspension means, said plug including a tubular body, a sleeve supported by the body and mounted for vertical movement with respect thereto, an upwardly facing packer expander near the lower end of the sleeve, an annular packer supported in coaxial relation to the sleeve and positioned above the expander, a tubular, upwardly pointing wedge member slidably mounted on the sleeve above the packer expander, expansible wedge slips suspended from the body and cooperatively engaging the wedge member, an operating mandrel mounted within the sleeve bore and adapted, during upward movement thereof, to move the sleeve and the packer-expanding member vertically with respect to the body, means holding the mandrel, body member and sleeve against relative rotation, casing-engaging means connected to said sleeve, a swivel joint between the suspension means and the body near its upper end, and a screw-thread connection between said operating mandrel and the body at a point, in effect, above said swivel joint.

13. In combination, a plug adapted to be lowered within a well pipe on suspension means, said plug including a tubular body, a sleeve supported by the body and mounted for vertical movement with respect thereto, an upwardly facing packer expander near the lower end of the sleeve, an annular packer supported in coaxial relation to the sleeve and positioned above the expander, said plug having a passage adapted to by-pass well fluid around the packer, a spring-pressed valve for controlling said passage and carried by said sleeve, a tubular, upwardly pointing wedge member slidably mounted on the sleeve above the packer expander, expansible wedge slips suspended from the body and cooperatively engaging the wedge member, an operating mandrel non-rotatably mounted within the sleeve bore and capable of limited vertical movement with relation to the sleeve, said mandrel, in one of its positions of vertical adjustment with respect to the sleeve, engaging the valve to hold it open, said mandrel freeing the valve for opening movement when the mandrel is moved upwardly from that position, and nhoulders on the sleeve and mandrel engaging one another upon continuation of such upward movement to move the sleeve and the packer-expanding member vertically with respect to the body, means holding the mandrel, body member and sleeve against relative rotation, casing-engaging means connected to said sleeve, a swivel joint between the suspension means and the body near its upper end, and a screw-thread connection between said operating mandrel and the body at a point, in effect, above said swivel joint.

GRANVILLE S. KNOX.

5

CERTIFICATE OF CORRECTION.

Patent No. 2,205,748. June 25, 1940.

GRANVILLE S. KNOX.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, second column, line 20, claim 6, strike out the words "upwardly movable" and insert the same before "wedge" in line 21, same claim; page 5, first column, line 34, claim 11, for "breakagle" read --breakable--; and second column, line 46, claim 13, for "nhoulders" read --shoulders--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 24th day of September, A. D. 1940.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.