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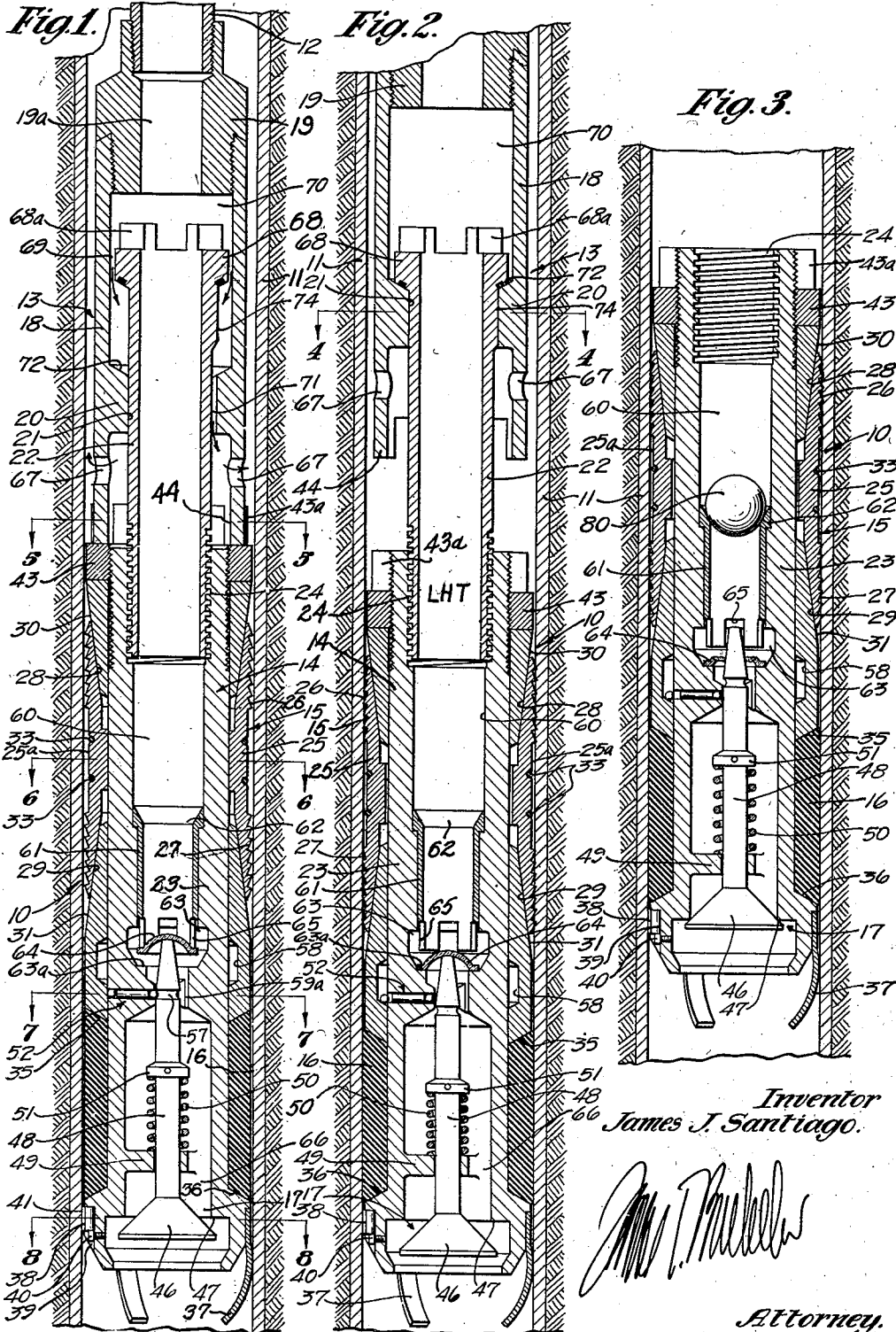
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2,221,204

CEMENTING PLUG

Filed April 25, 1938

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Fig. 8.

UNITED STATES PATENT OFFICE

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CEMENTING PLUG

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9 Claims. (Cl. 166—12)

This invention has to do generally with well cementing plugs (also variously referred to as cement retainers, barriers and bridge forming devices), and relates particularly to an improved type of cementing plug adapted to be set within the casing and controlled in different stages of the cementing process, by operation of the pipe string connected to the plug and extending to the ground surface.

Plugs of the present form may be used in performing various types of well cementing jobs in which cement is pumped down through the pipe string connected to the plug and deposited at a predetermined location either within or outside the well casing. For example, the plug may be used in performing a bottom cementing job, i. e. in depositing cement around the lower end of the casing to shut off a water region above; or in discharging cement into an intermediate section of the casing, to be deposited as a plug within the casing or to be forced through an opening in the casing to form a barrier around its outside. The various situations in which cementing plugs may be used are known to those familiar with the art.

Structurally, plugs of the present type comprise gripping means and a packer adapted to be expanded into tight engagement with the well casing at the depth at which the plug is set, and a normally or initially open valve for controlling passage of fluid through the plug. Means also is provided for maintaining circulation from the pipe string connected to the plug, into the casing above the packer, and for selectively directing the circulation above or through the plug. My major object is to provide a cementing plug in which the gripping means and packer may be set (expanded) mechanically and the valve released for closing, by operation of the pipe string, and in which the circulation controlling means is embodied as a part of the plug itself, as distinguished from connected but otherwise independent devices such as have been used heretofore. Another object of the invention is to provide a closure means for the circulating fluid passage within the plug, that will obstruct the passage against downward flow during circulation into the casing above the plug, and which may thereafter be opened to permit fluid flow through the plug. For this purpose I may use a normally open disc type closure that will seat under the fluid pressure maintained during upward circulation, and which thereafter can be broken simply by increasing the fluid pressure

applied to the disc, to pass the circulation through the plug.

The invention has various additional features and objects which, in addition to those mentioned above, can be explained to best advantage without further preliminary discussion, in the following detailed description of the invention as embodied in certain typical and illustrative forms. Throughout the description reference is had to the accompanying drawings, in which:

Fig. 1 is a longitudinal section showing the positions of the parts as the plug is being lowered within the well;

Fig. 2 is a similar view showing the slips and packer expanded, and the valve holding means released;

Fig. 3 is a view showing the section of the plug remaining in the well after the lowering pipe is disconnected;

Fig. 4 is a section on line 4—4 of Fig. 2;

Figs. 5, 6, 7 and 8 are cross sections on lines 5—5, 6—6, 7—7 and 8—8 of Fig. 1; and

Fig. 9 is a view showing a variational form of the invention.

Referring first to Figs. 1 and 2, the plug, generally indicated at 10, is shown to be lowered within the well casing 11 on the pipe 12 that extends to the ground surface. The plug 10 may be described generally as comprising upper and lower, or body and mandrel sections 13 and 14, respectively, these sections being relatively rotatable and relatively vertically movable by way of the pipe 12, to expand the pipe engaging means 15 and packer 16, and to control the valve, generally indicated at 17, all in the manner to be later explained. The body section 13 comprises a tubular member 18 attached by sub 19 to the pipe 12, and having intermediate its ends a thickened section 20 through which extends a reduced diameter bore 21.

The mandrel 14 comprises upper and lower sections 22 and 23 interconnected by a left-hand threaded joint at 24, so that right-handed rotation of the upper section relative to the lower section will unscrew the joint at 24, enabling the body and upper mandrel section to be disconnected from the lower portion of the plug remaining in the casing (see Fig. 3). The lower mandrel section 23 carries the pipe engaging means 15 and packer 16 which are adapted to be radially expanded into engagement with the casing by upward relative movement of the mandrel. While in the broad aspects of the invention, any suitable form of pipe gripping means

may be used, I preferably employ double-faced wedge slips 25 having toothed gripping surfaces 26 and 27 capable of holding the plug, when set, against upward or downward movement. Wedge surfaces 28 and 29 of the slips bear against correspondingly tapered wedge sleeves 30 and 31 surrounding the mandrel and movable longitudinally thereon. When the plug is assembled the slips 25 are positively held in radially contracted positions by wires 33 encircling the intermediate reduced diameter portions 25a of the slips (see Fig. 6), the ends of each wire being tied or otherwise held together in a suitable manner as indicated at 34.

The packer sleeve 16, made of rubber or other suitable material, is placed about the lower portion of the mandrel between the wedge shaped end 35 of sleeve 31 and an oppositely tapered shoulder 36 on the mandrel. Below the packer, the mandrel carries a plurality of bowed spring elements 37 which frictionally engage the casing 11 with sufficient tightness to support the mandrel and to hold the mandrel against rotation relative to the body during the later described operation of the plug parts. As a further means for holding the mandrel against rotation within the casing, I provide a plurality of gripping elements 38 retained within vertically extending recesses 39 in the outer surface of the mandrel by screws 40. These gripping elements 38 have limited rotation within recesses 39 and are shaped to provide sharply tapered edges 41 projecting beyond the surface of the mandrel. Edges 41 of the gripping elements normally are in engagement with the casing, and due to the shape of the elements, as illustrated, they are caused to bite into the casing as the mandrel tends to rotate right-handedly or in a clockwise direction. While going into the hole, the gripping elements 38 may engage and perhaps lightly score the casing, and later will be forced to resist right-handed rotation of the lower mandrel section.

The slips and packer are expanded by virtue of relative rotation between the body 13 and mandrel 14, through a releasable rotative driving connection between the body and nut 43 threaded on the upper end of the lower mandrel section 23. Formed integrally with nut 43 are a plurality of upstanding lugs or teeth 43a inter-fitting, in the position of the parts shown in Fig. 1, with correspondingly spaced teeth 44 on the lower end of the body. By right-handed rotation of the suspension pipe and body, nut 43 is rotated on the mandrel (with the latter being held against rotation by springs 37 and gripping elements 38), causing the mandrel to become elevated within the nut to a position as illustrated in Fig. 2. This upward movement of the mandrel brings wedge sleeves 30 and 31 relatively together to expand the slips 25 into gripping engagement with the casing, wires 33 being broken as the slips expand so that the lower portion of the plug thereafter remains permanently fixed within the casing. At the same time, upward movement of the mandrel shoulder 36 relative to the lower end 35 of sleeve 31 expands the packer 16 into fluid tight engagement with the casing. Obviously, the slips and packer are retained in their expanded positions by the threaded connection between nut 43 and the mandrel.

The valve assembly, generally indicated at 17, comprises a valve 46 carried on the lower end of a stem 48 extending through a spider or guide

49, and seating upwardly against the mandrel shoulder 47. A coil spring 50 encircling the valve rod between the guide 49 and collar 51, tends to move the valve in a closing direction. Normally the valve is held open by a plurality of detents 52 (see Fig. 7) each consisting of a pin 53 inserted within bore 54, and a pair of steel balls 55 and 56, the latter of which projects within an annular groove 57 in the valve stem, to hold the valve open. Detents 52 are released from holding engagement with the valve stem during the operation of setting the slips and packer, as previously described, by upward movement of the mandrel section 23 to the point at which the detents are brought opposite an annular recess 58 within the wedge ring 31, at which point they are moved out of the valve stem groove 57 by the upward thrust of spring 50.

The bore 60 of lower mandrel section 23 contains a tubular insert or bushing 61, press-fitted within the bore, and having a downwardly tapering ball seat 62. The lower end of the bushing projects downwardly within an annular recess 63 and provides a seat for an upwardly concaved disc 64 at the upper end of the valve stem 48. The bottom projecting end of the bushing is notched at 65 to form openings through which circulating fluid discharged through the mandrel bore 60 may pass around the disc 65 and thence flow downwardly through the spaces 66a (Fig. 7) between lugs 59 and through passage 66 into the casing below the plug. It will be observed that when detents 52 release the valve rod, the valve is prevented from closing due to the engagement of the upper end of the valve rod with disc 64. The particular functions of the disc will be best understood at a later point in considering the operation of the plug.

Provision is made whereby fluid pumped down through the pipe string 12 may be selectively discharged downwardly through the mandrel bore into the casing or well below the packer, or through body openings 67 into the casing above the packer. For this purpose I form on the upper end of mandrel section 22 a head 68, essentially a valve, adapted to engage or seat against body shoulder 72 and annularly spaced at 69 from the body so that with the parts positioned as in Fig. 1, fluid discharged into the body chamber 70 flows downwardly past the head 68 and thence through vertically extending ways 71 to the outlets 67. Circularly spaced lugs 68a on the head prevent the upper mandrel section from at any time closing off the discharge of fluid into the body at times when circulation is to be maintained above the plug. By elevating body 13 to the position of Fig. 2, ways 71 are moved upwardly along splines 74 and shoulder 72 is brought to seat against the mandrel head 68, thus closing off fluid flow through openings 67 and causing the fluid to be discharged downwardly through the mandrel bore. In this same operation, the engagement of ways 71 with splines 74 provides a connection between the body and upper mandrel section whereby the latter may be disconnected from the lower mandrel section by right-handed rotation of the pipe string 12.

As previously indicated, the present form of plug is adaptable for use in a variety of cementing operations; either in cementing around the lower end of the casing, or in operations where cement is to be deposited within or around an intermediate section of casing. In carrying out a cementing operation with any particular ob-

jective, the plug is lowered or forced downwardly through the casing to the proper depth on the pipe string 12, the slips 15 and packer 16 of course being radially retracted and the valve 46 held open as illustrated in Fig. 1. While the plug is being lowered, circulation may be maintained at any depth within the casing above the plug through openings 67, as previously explained. Also, if for any reason it is desired to circulate through the plug into the casing below, the body 18 may be elevated to seat shoulder 72 against mandrel head 68, to require the circulation to pass through the plug. When the plug has been lowered to the position at which it is to be set, the body is rotated in a right-handed direction to set the slips 25 and packer 16, and to release the valve holding detent 52, all in the manner previously explained.

With the plug now in set position, a cementing operation may be performed to deposit cement within the casing or well either below or above the plug. Assume for example that it is desired to place a cement bridge within the casing below the plug and on top of a previously set barrier (not shown). My plug is first lowered to a position in contact with or close to the lower set barrier. With the body and mandrel in the relative positions shown in Fig. 1, cement is pumped down through the pipe string 12 and the circulating mud being displaced ahead of the cement, is discharged outwardly into the casing through openings 67 above the packer. During this time, the fluid pressure within the mandrel bore acts to seat disc 64 against shoulder 63a as shown in Fig. 2, to close off circulation through the plug and require all the fluid to flow out through the openings 67. When the downwardly moving cement column reaches the plug, as may be determined by calculations based on the length of the pipe string in volume of cement pumped into it, the body 18 is raised to the position of Fig. 2, bringing seat 72 against the head 68 to close off circulation above the packer. The full pump pressure then becomes applied to the disc 64, and this pressure breaks the disc, permitting the cement to be discharged down through the mandrel past the valve 46, the latter being held open by the fluid pressure to pass the cement. It is only when circulation through openings 67 is cut off that sufficient pressure is applied to the disk to break it; at all other times the disk will remain unbroken and will function as a check against fluid flow down through the plug. After the disk is broken and while the cement is discharged from the bottom of the plug, the plug is raised until all or substantially all the cement has been discharged to form a cement bridge resting on the lower barrier. The plug is then in a position at the top of the discharged bridge of cement. The parts of the plug are then operated to expand the packer and set the slips.

A suitable object, such as ball 80, has been dropped into the pipe string on top of the cement column and has been forced down, together with the cement, by circulating fluid pressure until the ball engages the tapered seat 62 of bushing 61 as shown in Fig. 3. At this point the cement will have been discharged through the plug, forming the bridge in the casing below. The seating of ball 80 prevents further communication of fluid pressure from the pipe string through the plug to the deposited cement below. At the same time valve 46 seats (disc 64 having been broken) to prevent upward displacement of the cement through the plug and to maintain

the pressure on the cement. It is at this point in the operations that the plug slips are set, as stated above. The body 18 and upper mandrel section 22 now may be disconnected from the lower mandrel section by right-handed rotation of the pipe string to unscrew the threaded joint at 24, leaving the lower section of the plug set within the casing as shown in Fig. 3.

If it is desired to discharge cement above the plug, that may be done, and done either before 10 or after cement has been discharged below. For discharge of cement above the plug it is only necessary that either the disk 64, the ball 80, or the valve 46, close the lower part of the plug passage, and that, the mandrel and body be in the 15 relative positions shown in Fig. 1.

Fig. 9 illustrates a variational form of the invention similar in all respects to the previously described form excepting that the pressure breakable disc is not used. The form of apparatus 20 shown in Fig. 9 may be used for depositing cement either above or below the plug proper. Assume, for example, that it is desired to place a cement bridge within the casing directly above the plug. The plug is lowered and set at prede- 25 termined depth as previously described. Circulation through ports 67 may be maintained at any time before or after the slips or packer are expanded to seat the plug, while the body is lowered to disengage seat 72 from the mandrel head 30 68; or circulation may be maintained through the plug by elevating the body into engagement with the mandrel head and forcing the circulation past the valve 46. In the absence of the disc, the valve of course seats when the valve 35 rod is released from the detents 52, but sufficient pressure may be maintained to force the fluid past the valve. With the parts positioned as in Fig. 9, the ball 80' may be inserted within the pipe string 12 directly ahead of the cement 40 charge. As the cement is pumped into and through the pipe string, the fluid column below the cement is displaced outwardly through openings 67 into the casing above the plug, the valve seating spring 50 preferably being sufficiently 45 strong to keep the valve 46 seated and thus require the fluid to discharge into the casing above the plug. When forced down into the mandrel, the ball 80' seats on the bushing 61, as shown, and the cement charge is displaced outwardly 50 around and above the plug through openings 67. Before the cement takes its initial set, the body and upper mandrel section may be disconnected from the lower mandrel section, as previously described, leaving the lower section of the plug 55 set within the casing below the cement bridge.

If it is desired to use the apparatus of Fig. 9 for placing cement below the plug, the cement may be pumped into the pipe string and the fluid 60 column below the cement discharged through openings 67. When the lower end of the cement column reaches the plug, shoulder 72 may be seated against the mandrel head 68 and the cement forced down through the mandrel bore 65 past valve 46 into the casing below. In this instance, ball 80' may be inserted into the pipe string following the cement and, together with the cement, is forced down through the pipe string by fluid pressure until the ball seats on 70 the mandrel bushing 61. Valve 46 then seats to prevent upward displacement of the deposited cement within the casing. As in the first described operation, after removal of the body and upper mandrel section, the lower section of the 75

plug remains set within the casing above the cement bridge.

I claim:

1. A cementing plug device adapted to be lowered on a suspension pipe within well pipe and adapted to deliver fluid from the suspension pipe selectively into the well either below or above the plug device, said plug device comprising a longitudinally passaged mandrel assembly, well pipe engaging means carried by the mandrel assembly, a tubular connecting member connected to the suspension pipe and the mandrel assembly, means selectively operable for closing the mandrel passage against downward passage of fluid therethrough, said tubular connecting member being movable relative to the mandrel assembly and having a passage therethrough leading from its interior and discharging into the well at a point above the well pipe engaging means, and cooperating valvular means operated by relative movement of the mandrel assembly and the tubular connecting member and adapted in one relative position of said connecting member to open said last mentioned passage and in another relative position to close said last mentioned passage.

2. A cementing plug device adapted to be lowered on a suspension pipe within well pipe and adapted to deliver fluid from the suspension pipe selectively into the well either below or above the plug device, said plug device comprising a longitudinally passaged mandrel assembly, a movable well pipe engager carried by the mandrel assembly, operating means for the engager operable by virtue of rotation relative to said mandrel assembly, a tubular connecting member connected to the suspension pipe and the mandrel assembly, said tubular connecting member being operably connectible with said engager operating means, means selectively operable for closing the mandrel passage against downward passage of fluid therethrough, said tubular connecting member being longitudinally and rotationally movable relative to the mandrel assembly and having a passage therethrough leading from its interior and discharging into the well at a point above the well pipe engager, and cooperating valvular means on the mandrel assembly and on said tubular connecting member adapted upon relative longitudinal movement in one direction to open said last mentioned passage and upon relative longitudinal movement in the other direction to close said last mentioned passage.

3. A cementing plug device adapted to be lowered on a suspension pipe within well pipe and adapted to deliver fluid from the suspension pipe selectively into the well either below or above the plug device, said plug device comprising a longitudinally passaged mandrel assembly, said mandrel assembly including an upper tubular mandrel extension disengageable from the mandrel by rotation relative thereto, a movable well pipe engager carried by the mandrel, operating means for the engager operable by virtue of rotation relative to said mandrel, a tubular connecting member connected to the suspension pipe and the mandrel extension, means selectively operable for closing the mandrel passage against downward passage of fluid therethrough, said tubular connecting member being longitudinally and rotationally movable relative to the mandrel assembly and operatively connectible and disconnectible with the well pipe engager

operating means by relative longitudinal movements in opposite directions, means establishing rotational engagement of said connecting member with said mandrel extension by virtue of the relative longitudinal movement that disengages the well pipe engager operating means, said tubular connecting member having a passage therethrough leading from its interior and discharging into the well at a point above the well pipe engager, and cooperating valvular means on the mandrel extension and on said tubular connecting member adapted upon relative longitudinal movement in one direction to open said last mentioned passage and upon relative longitudinal movement in the other direction to close said last mentioned passage.

4. In a cementing plug adapted to be lowered within well pipe on a suspension pipe and including a mandrel having a longitudinal fluid passage therethrough in communication with the suspension pipe, an upwardly seating back pressure valve adapted to close said passage against fluid flow upwardly through said passage, a pair of vertically spaced seats in the mandrel, the upper seat facing downwardly and the lower seat facing upwardly, and a frangible closure adapted to be moved between upper and lower positions and to seat on either of said pair of seats, said frangible closure engaging the valve to hold it open when seated on the upper seat and adapted to be moved onto the lower seat by fluid pressure applied from above, and adapted to close the passage through the lower seat when seated thereon so that said closure may be broken by application of a predetermined fluid pressure to permit closing of the valve.

5. In a cementing plug adapted to be lowered within well pipe on a suspension pipe and including a mandrel having a longitudinal fluid passage therethrough in communication with the suspension pipe, an upwardly seating back pressure valve adapted to close said passage against fluid flow upwardly through said passage, a pair of vertically spaced seats in the mandrel, the upper seat facing downwardly and the lower seat facing upwardly, and a frangible closure adapted to be moved between upper and lower positions and to seat on either of said pair of seats, said frangible closure engaging the valve to hold it open when seated on the upper seat and adapted to be moved onto the lower seat by fluid pressure applied from above, and adapted to close the passage through the lower seat when seated thereon so that said closure may be broken by application of a predetermined fluid pressure to permit closing of the valve, and means in the body forming a fluid by-pass around the upper seat.

6. A cementing plug device adapted to be lowered on a suspension pipe within well pipe and adapted to deliver fluid from the suspension pipe selectively into the well either below or above the plug device, said plug device comprising a longitudinally passaged mandrel assembly, well pipe engaging means carried by the mandrel assembly, a tubular connecting member connected to the suspension pipe and the mandrel assembly, said tubular connecting member being movable relative to the mandrel assembly and having a passage therethrough leading from its interior and discharging into the well at a point above the well pipe engaging means, and cooperating valvular means operated by relative movement of the mandrel assembly and the tubular con-

necting member and adapted in one relative position of said connecting member to open said last mentioned passage and in another relative position to close said last mentioned passage.

5 7. A cementing plug device adapted to be lowered on a suspension pipe within well pipe and adapted to deliver fluid from the suspension pipe selectively into the well either below or above the plug device, said plug device comprising a
10 longitudinally passaged mandrel assembly, said mandrel assembly including an upper tubular mandrel extension disengageable from the mandrel by rotation relative thereto, a movable well pipe engager carried by the mandrel, operating
15 means for the engager operable by virtue of rotation relative to said mandrel, a tubular connecting member connected to the suspension pipe and the mandrel extension, said tubular connecting member being longitudinally and rotationally
20 movable relative to the mandrel assembly and operatively connectible and disconnectible with the well pipe engager operating means by relative longitudinal movements in opposite directions, means establishing rotational engagement of said
25 connecting member with said mandrel extension by virtue of the relative longitudinal movement that disengages the well pipe engager operating means, said tubular connecting member having a passage therethrough leading from its interior and discharging into the well at a point above the
30 well pipe engager, and cooperating valvular means on the mandrel extension and on said tubular connecting member adapted upon relative longitudinal movement in one direction to open
35 said last mentioned passage and upon relative longitudinal movement in the other direction to close said last mentioned passage.

8. A cementing plug device adapted to be lowered on a suspension pipe within well pipe and
40 adapted to deliver fluid from the suspension pipe into the well either below or above the plug device, said plug device comprising a longitudinally passaged mandrel assembly, an expansible well pipe engager carried by the mandrel assembly,
45 an upwardly closing valve controlling the longitudinal mandrel passage, means holding said

valve open and releasable by virtue of pipe engager expansion to allow the valve to close, a tubular connecting member connected to the suspension pipe and the mandrel assembly, said tubular connecting member being movable relative
5 to the mandrel assembly and being, in association with the mandrel assembly, provided with passage and valvular means for discharging cement at a point above the well pipe engager when the tubular connecting member is in a predetermined
10 position relative to the mandrel assembly, said valvular means being closed when the tubular connecting member is in another predetermined position relative to the mandrel assembly to discharge cement through the mandrel assembly below the plug device.
15

9. A cementing plug device adapted to be lowered on a suspension pipe within well pipe and adapted to deliver fluid from the suspension pipe into the well either below or above the plug device, said plug device comprising a longitudinally
20 passaged mandrel assembly, an expansible well pipe engager carried by the mandrel assembly, rotary operating means for said engager, an upwardly closing valve controlling the longitudinal mandrel passage, means holding said valve open and releasable by virtue of pipe engager expansion to allow the valve to close, a tubular connecting member connected to the suspension pipe and the mandrel assembly, said tubular connecting
30 member being movable both rotatively and longitudinally with reference to the mandrel assembly and drivingly connectible with the engager operating means by longitudinal movement in one direction, and the mandrel assembly and tubular connector having passage and valvular
35 means for discharging cement at a point above the well pipe engager, said valvular means controlled by relative longitudinal movement of the connector to open the connector passage to discharge cement above the engager or to close the connector passage to direct cement downwardly through the mandrel assembly to discharge below the plug device.

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