

Sept. 6, 1966

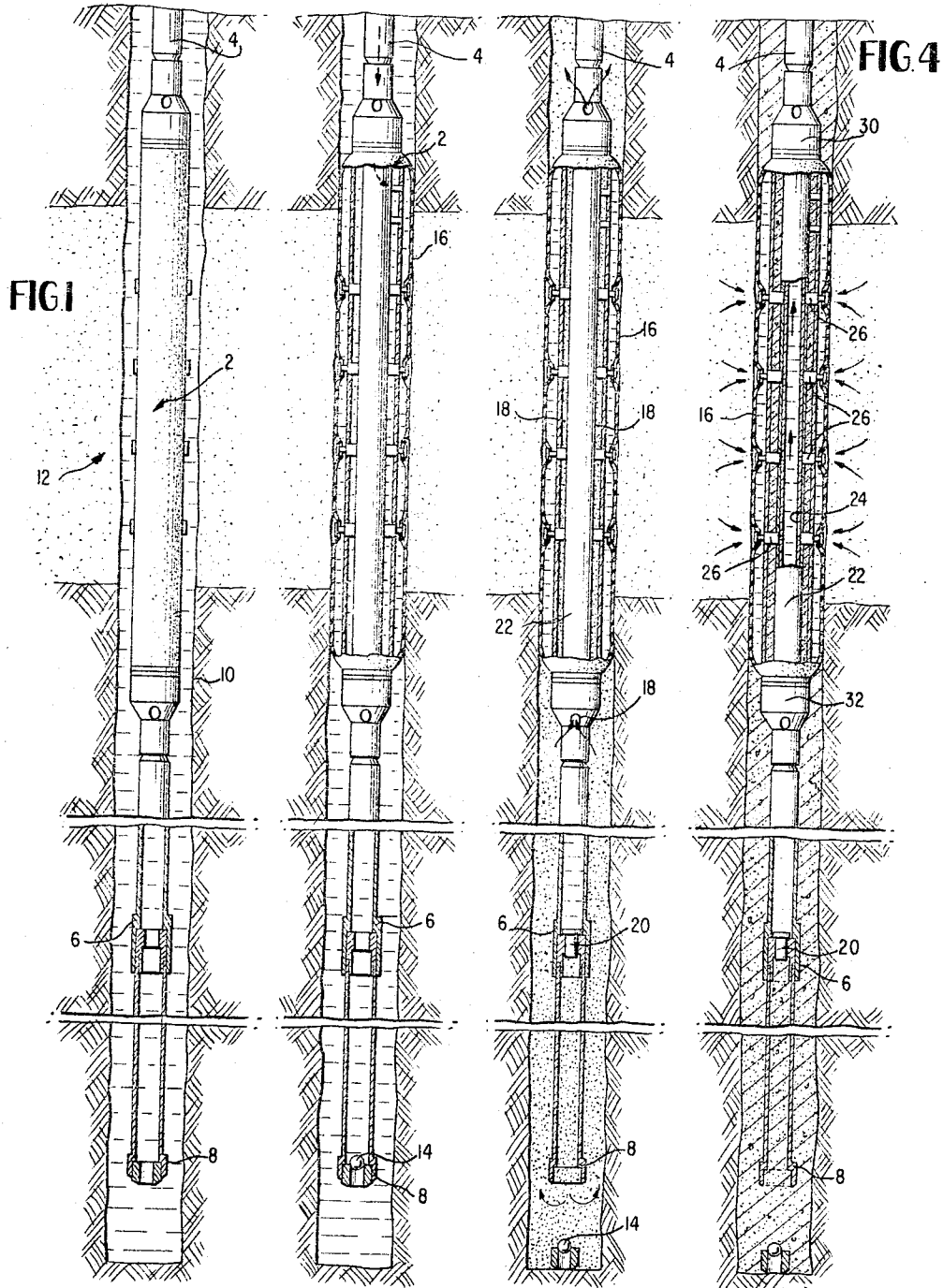
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3,270,814

SELECTIVE COMPLETION CEMENTING PACKER

Filed Jan. 23, 1964

3 Sheets-Sheet 1



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FIG 5

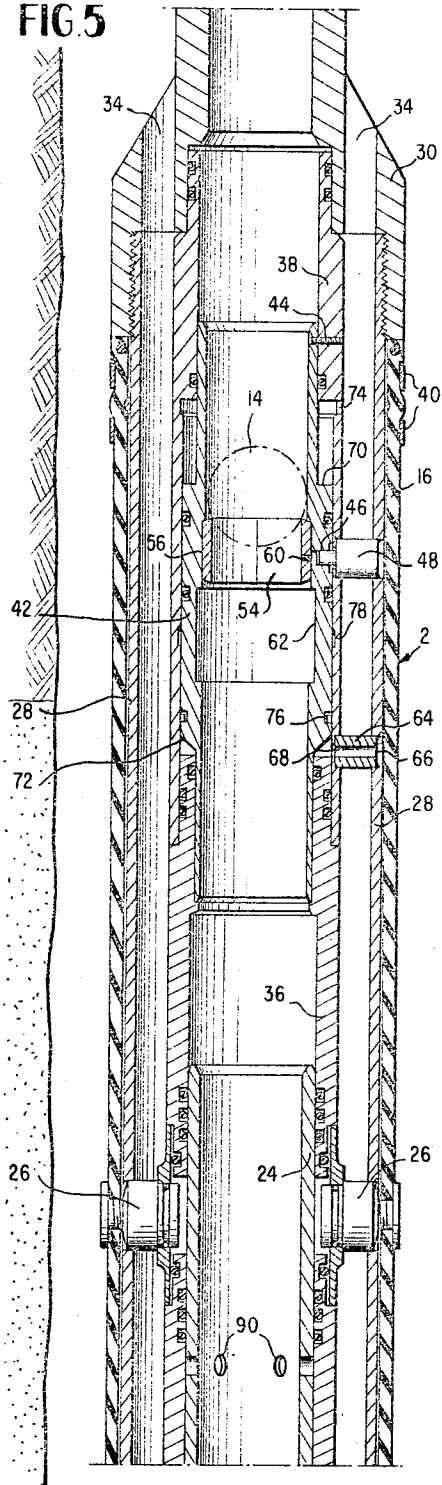


FIG 6

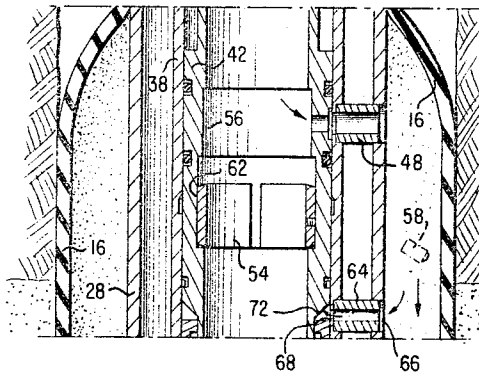
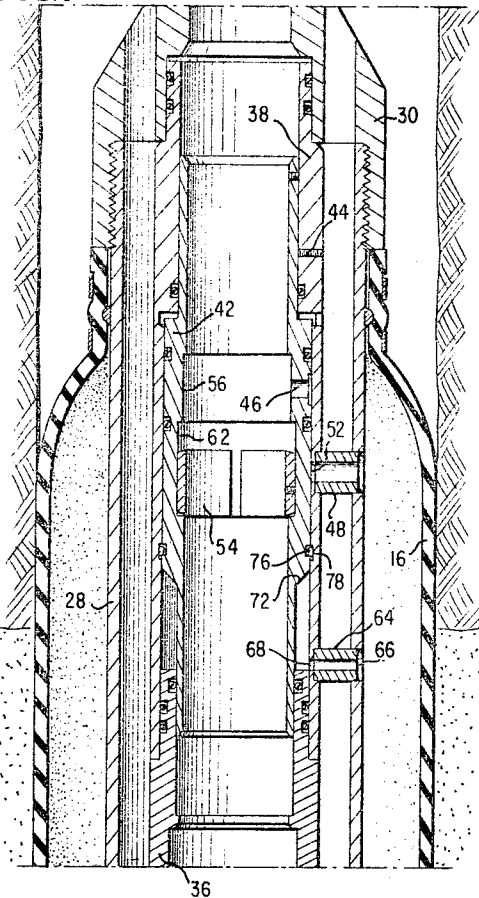


FIG 7



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3 Sheets-Sheet 3

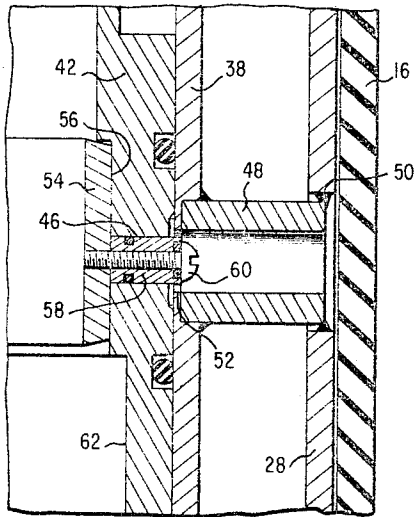


FIG. 8

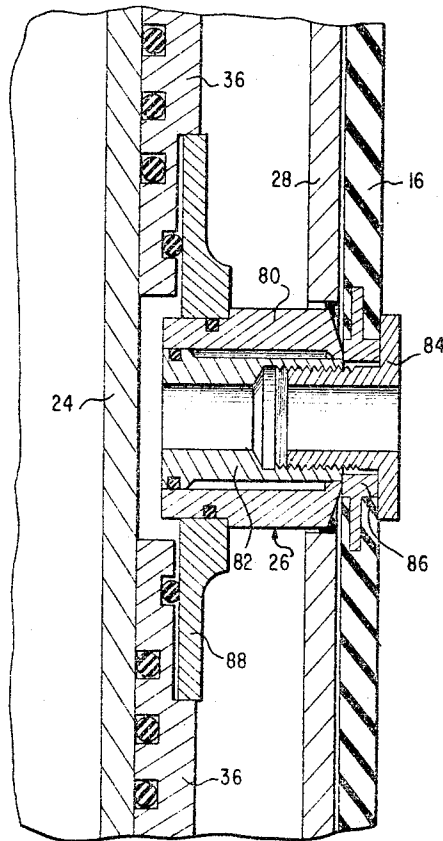


FIG. 9

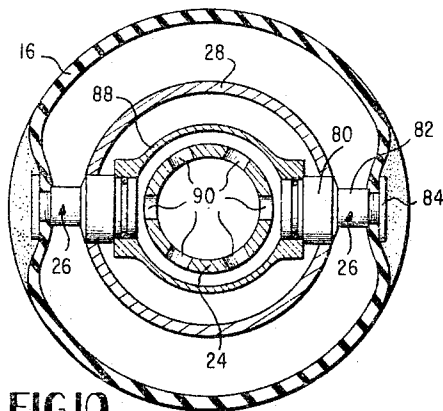
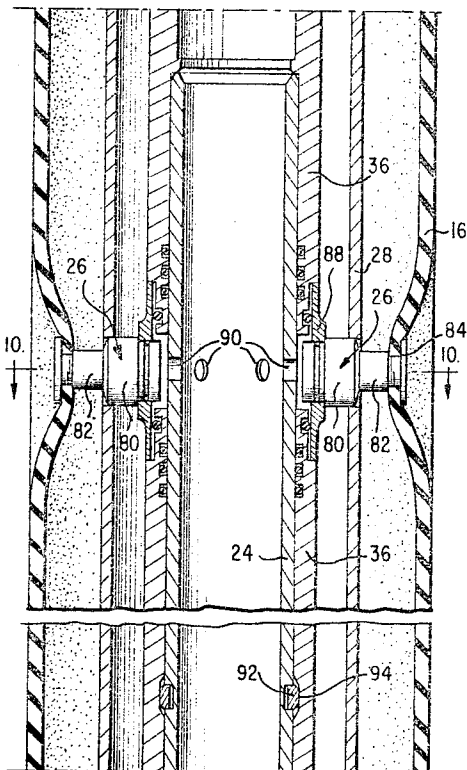


FIG. 10

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SELECTIVE COMPLETION CEMENTING PACKER
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Filed Jan. 23, 1964, Ser. No. 339,744
12 Claims. (Cl. 166-21)

This invention relates to well completion and, more particularly, to a method and apparatus for selectively controlling the inflation of a packer.

Various methods and apparatus have been proposed for controlling the setting of an inflatable packer at a desired depth in a well. The packer may be inflated, for example, by dropping a ball on a valve seat to build up the fluid pressure above the ball. The increased fluid pressure then is applied to the interior of the packer to inflate the packer. When the packer is used in association with cementing apparatus, the valve for controlling the inflation of the packer must operate reliably to ensure that the packer is not accidentally collapsed, particularly during the cementing operation, or that the packer is not unintentionally inflated by hydrostatic pressure on the well, while the packer is in the well.

Accordingly, it is an object of this invention to provide an improved method and apparatus for selectively inflating a packer.

It is a further object of this invention to provide a method and apparatus for automatically trapping fluid in a packer after it is inflated.

It is a still further object of this invention to provide a method and apparatus for sequentially setting a series of packers in a string.

It is another object of this invention to provide an efficient method and apparatus for controlling the inflation of an expandable packer in cementing apparatus.

These objects are accomplished in accordance with a preferred embodiment of the invention by a packer assembly having a sleeve therein. A port in the sleeve registers with a port communicating with the interior of an inflatable packer. A ball seat is mounted in the sleeve and covers the port in the sleeve. The seat is in the form of a split ring which is radially compressed and inserted into the sleeve. Frangible means temporarily secures the ring in position over the sleeve port and seals the port. Below the ring, a cylindrical recess in the sleeve has an enlarged internal diameter to allow the ring to expand radially when it is displaced downwardly into the recess. Displacement of the ring is accomplished by dropping a ball which becomes lodged on the seat formed by the ring. The fluid pressure above the ball is then increased until the frangible means is broken and the ring is displaced into the recess. In the recess, the ring expands radially outwardly and permits the ball to fall through the ring and to be pumped through the packer tool until it encounters a similar seat on the next lower packer or a seat in a guide shoe for closing off the lower end of the tubing. After the ball seat ring is displaced, fluid flows into the interior of the packer to expand the packer.

As the fluid flows into the interior of the packer, the fluid pressure in the packer rises. One end of the sleeve is in the form of a piston and is in fluid communication with the interior of the packer. Sufficient force is imposed on the piston face of the sleeve to break a second frangible means and to displace the sleeve, so that the port in the sleeve is moved out of registry with the conduit to the interior of the packer, thereby sealing the fluid in the packer and preventing its collapse.

The preferred embodiment of the invention is illustrated in the accompanying drawings in which:

FIG. 1 is an elevational view, partially in section, show-

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ing schematically the packer assembly of this invention in a string suspended in a well bore;

FIG. 2 is an elevational view, partially in section, showing schematically the packer assembly with the packer inflated;

FIG. 3 is an elevational view, partially in section, showing schematically the packer assembly during cementing;

FIG. 4 is an elevational view, partially in section, showing schematically the packer during production;

FIG. 5 is an enlarged cross sectional view of the upper portion of the packer assembly, showing the inflation valve of this invention;

FIG. 6 is an enlarged cross sectional view of the inflation valve while the packer is being expanded;

FIG. 7 is a cross sectional view of the upper portion of the packer after the packer has been inflated.

FIG. 8 is a detail view of a portion of the inflation valve structure;

FIG. 9 is a cross sectional view of the packer assembly, showing the production ports;

FIG. 10 is a cross sectional view of the packer assembly along the line 10-10 in FIG. 9; and

FIG. 11 is a detail cross sectional view of one of the production ports when the port is closed and the packer is not inflated.

In cementing a well, it is often desirable to isolate the productive zone from the cement. This may be accomplished by interposing an inflated packer between the productive zone of the formation and the cement. One suitable apparatus for cementing across a productive zone is illustrated in FIGS. 1 to 4. A string is made up having an inflatable packer assembly 2 secured in the tubing 4. A latch-down baffle 6 is secured in the string below the packer assembly 2 and a pump-out guide shoe 8 is secured to the lower end of the string. This string is shown schematically in FIGS. 1 to 4 as it is suspended in a well bore 10. A production zone is shown at 12.

When the packer assembly 2 is opposite the production zone 12, a ball 14 is dropped in the tubing 4 and after opening the valve for inflating the packer in accordance with this invention, lodges on the guide shoe 8, as shown in FIG. 2. The fluid pressure in the tubing is increased by pumping more fluid into the tubing, and as the fluid flows into the packer 16, it is inflated against the well bore 10. After the packer 16 has been inflated, cement is pumped down the tubing 4 with sufficient pressure to break a retaining device in the shoe 8 and to pump the ball and its seat out of the end of the tubing, as shown in FIG. 3. Cement then flows upwardly in the annulus surrounding the tubing 4 and flows through conduits 18 in the packer assembly 2 to the portion of the well above the packer. A latch-down plug 20 is pumped down the tubing 4 following the cement and lodges on the baffle 6 to serve as a back pressure valve for the cement. The cement is then allowed to set.

As shown in FIG. 4, a central mandrel 22 in the packer assembly 2 has an internal sleeve 24 telescoped therein. The mandrel 22 and the packer 16 have aligned ports cemented by conduits 26 mounted in the packer assembly 2. The sleeve 24 is also provided with ports, which upon upward displacement of the sleeve, are moved into alignment with the mandrel ports. The sleeve 24 is moved longitudinally relative to the mandrel 22 by means of a conventional tool which is run on a wire line and grasps the sleeve 24 to displace it longitudinally upward until the sleeve ports are in alignment with the mandrel ports, thereby opening the mandrel ports, or downward until the sleeve ports are out of alignment, thereby closing the ports selectively.

Several packer assemblies 2 may be provided in a string and spaced apart a distance corresponding to the distance between known productive zones and by opening

the respective sleeves 24, production from the zones may be separately tested and evaluated.

This invention is concerned more specifically with the manner in which the packer 16 is inflated. FIG. 5 is a cross sectional view of the upper portion of the packer assembly 2, which is shown in FIGS. 1 to 4. The packer assembly 2 is shown with the packer 16 in a collapsed condition in FIG. 5 and includes an outer sleeve 28 which is threadably secured at one end to an upper body 30 and at the other end to a lower body 32. The upper and lower bodies 30 and 32 are coupled to the tubing 4 and have a plurality of longitudinal bores 34 which are spaced circumferentially around the respective bodies and communicate with the interior of the outer sleeve 28. The mandrel 22, as shown schematically in FIGS. 3 and 4, includes an inner sleeve 36 and a valve body 38 which are connected together in end-to-end telescoping relation and are clamped between the upper and lower bodies 30 and 32. The annular space between the inner and outer sleeves 36 and 28 forms a conduit through the packer assembly 2 for the cement.

The inflatable packer 16 is secured to the outer sleeve 28 at its opposite ends by a pair of bands 40 which encircle the packer 16. A packer valve sleeve 42 is mounted within the valve body 38 and is secured in the position shown in FIG. 5 by a frangible screw 44. The valve sleeve 42 has a radial port 46 therein and a tube 48 communicates between a port 50 in the outer sleeve 28 and a port 52 in the valve body 38, as shown in FIG. 8. A resilient cylindrical ring 54 having a longitudinal slot therein is mounted in a cylindrical recess 56 in the valve sleeve 42. The slot allows the ring 54 to be radially compressed for insertion in the recess 56. A plug 58 is inserted in the port 46 and a frangible screw 60 extends through the plug 58 and into the ring 54 to prevent displacement of the ring out of the recess 56. The plug 58 prevents the leakage of fluid from the interior of the packer valve sleeve 42 to the interior of the packer 16.

Immediately below the recess 56 is another cylindrical recess 62 in the valve sleeve 42 having a larger internal diameter than that of the recess 56. The recess 62 has approximately the same diameter as the external diameter of the uncompressed ring 54. When the ring 54 is displaced into the recess 62 from the recess 56, the ring expands due to its own resilience until it engages the walls of the recess 62, and is retained in the recess 62 by the shoulders at the opposite ends of the recess.

A conduit 64 communicates between a port 66 in the outer sleeve 28 and a port 68 in the valve body 38, as shown in FIG. 5. The valve sleeve 42 has oppositely facing shoulders 70 and 72 forming pistons within the valve body 38. The pistons 70 and 72 have substantially equal areas, so that a fluid pressure differential on the pistons moves the sleeve 42 in the direction of lower pressure, after the screw 44 is broken. A port 74 in the sleeve 38 provides fluid communication with the annulus above and below the packer assembly. A snap ring 76 is mounted in a groove in the packer valve sleeve 42 and a corresponding groove 78 is provided in the interior of the valve body 38 for permitting the expansion of the ring 76 into the groove 78 when the valve sleeve 42 is displaced upward sufficiently to align the ring 76 with the groove 78.

The operation of the packer inflation valve is initiated by a ball 14, as shown in phantom line in FIG. 5, which is dropped down the tubing 4 and lodges on the ring 54. The fluid pressure in the tubing is then increased until the frangible screw 60 is broken. The ring 54 is then displaced into the cylindrical recess 62 by the fluid pressure above the ball. When the ring 54 moves into the recess 62, the ring expands radially to allow the ball 14 to pass through the center of the ring 54. The ball falls downwardly through the packer assembly 2 to the pump-out guide shoe 8 on the bottom of the string, as shown in FIG. 2. Since the ball 14 closes the lower end of the tubing, pumping additional fluid into the tubing increases

the pressure in the tubing. The increase in fluid pressure in the valve sleeve 42 pumps the plug 58 through the tube 48 and into the interior of the packer 16, as shown in FIG. 6.

Fluid continues to be pumped into the interior of the packer 16 until the packer is inflated against the well bore. Then, since the packer 16 is no longer free to expand, the fluid pressure increases as additional fluid is pumped into the tubing until the fluid pressure in the packer is high enough to impose a sufficient upward force on the piston 72 to break the frangible screw 44. After the screw is broken, the fluid pressure acting on the piston 72 moves the packer valve sleeve 42 upward to close the port 52 in the valve body 38, as shown in FIG. 7. The piston 70 is exposed through the port 74 to the pressure in the annulus surrounding the tubing 4 and the fluid in the space between the valve body 38 and the sleeve 42 is displaced outwardly through the port 74 as the valve sleeve 42 moves upwardly. When the valve sleeve 42 reaches the position shown in FIG. 7, the lock ring 76 expands into the groove 78 to prevent the downward displacement of the sleeve 42. The fluid is confined within the packer 16 by the closing of the port 52 and the packer cannot be collapsed accidentally, since the sleeve 42 is locked in a closed position. O-rings are provided between the valve sleeve 42 and the inner sleeve 38 to prevent the leakage of fluid out of the interior of the packer 16.

Referring to FIGS. 9, 10 and 11, the conduits 26 communicate between the producing formation and the interior of the packer assembly 2. Each of the conduits 26 includes a pair of telescoping tubes 80 and 82. A grommet 84 extends through a ring 86 in the packer 16 and clamps the ring 86 against the tube 82. As the packer 16 expands, the inner tube 82 is pulled outwardly by the grommet 84. The mandrel 22 is formed of a plurality of individual sleeve segments 36 which are coupled together in axial alignment by couplings 88. One end of the outer tube 80 extends through an opening in a coupling 88 and the opposite end is secured in the outer sleeve 28. The sleeve valve 24 is telescoped within the inner sleeve segments 36 and has a plurality of radial ports 90. The sleeve valve 24 is movable longitudinally upward relative to the sleeve 36 and the valve 24 is normally in the position shown in FIGS. 5 and 11, so that the ports 90 are not in communication with the conduits 26. When the sleeve valve 24 is moved upwardly to the position shown in FIGS. 9 and 10, the ports 90 are aligned with the conduits 26 and production from the formation 12 flows into the interior of the sleeve valve. The movement of the sleeve valve 24 is resisted by a drag ring 92 to prevent the accidental displacement of the valve 24. When the valve 24 is in the upward position, the ring 92 engages a groove 94 in the inner sleeve 36, so that the valve 24 will remain in the upward position.

The movement of the valve sleeve 24 is accomplished by a tool which is lowered down the tubing and has means for engaging and moving the sleeve valve 24. An example of a tool that may be used for displacing the sleeve 24 is one having a mandrel on which are mounted drag springs for engaging the interior of the valve sleeve. The mandrel extends through a sleeve on which the drag springs and slips are mounted. The mandrel has inclined surfaces thereon for wedging the slips against the valve sleeve 24 upon axial displacement of the mandrel in either axial direction relative to the sleeve. When the drag springs are in engagement with the valve sleeve 24, they resist relative movement therebetween. The relative movement of the drag spring sleeve and the mandrel is controlled by a J-slot, so that the tool can be retrieved. The valve sleeve 24, therefore, may be moved either up or down by the tool to open or close the ports as desired.

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In carrying out the completion operation, when the packer assembly 2 is opposite a producing formation, the ball 14 is dropped down the tubing and lodges on the split ring 54, as shown in FIG. 5. Sufficient fluid pressure, for example, a gauge pressure of the order of about 200 p.s.i., is applied to break the frangible screw 60, and the ring 54 is displaced downwardly and expands outwardly to the extent permitted by the enlarged recess 62. The ball 14 is pumped through the ring 54 and lodges on the valve seat in the pump-out guide shoe 8. When the screw 60 is broken, the fluid pressure in the valve sleeve 42 propels the plug 58 through the conduit 48 and into the interior of the packer 16. Fluid then flows into the packer 16 to expand the packer outwardly against the well bore. Fluid pressure in the packer communicates with the piston 72 through the tube 64, and when the packer is fully inflated, the pressure in the packer increases sufficiently to break the frangible screw 44. The pressure in the packer 16 might be of the order of 200 p.s.i.g., for example, when it is inflated. The valve sleeve 42 is then propelled upwardly to close the port 52 in the inner sleeve 38, thereby trapping the fluid in the packer 16. If there are several packer assemblies in the tubing string, the ball 14 will be pumped from the ring 54 in the upper packer to a corresponding ring in the next lower packer assembly. Consequently, the packers will be set in sequence. The fluid pressure is then raised to 900 p.s.i.g., for example, to pump the ball out of the guide shoe 8. The cementing operation may then be carried out.

When it is desired to obtain fluid from the producing formation, a tool is lowered through the tubing 4 to engage the valve sleeve 24 to raise the ports 90 into alignment with the conduits 26 for production. The valve sleeve 24 may be moved downwardly to close the ports when desired.

The particular advantage of the packer inflation valve of this invention is that the valve sequentially opens to allow inflation of the packer and then closes in response to a predetermined pressure, after the packer is inflated. The valve then remains closed independently of the pressure in the packer or in the well. Furthermore, since the operation of the packer valve is initiated by dropping a ball, the packer cannot be inflated prematurely by an accidental pressure increase in the tubing. Also, there is no danger of the packer being accidentally collapsed.

While this invention has been illustrated and described in one embodiment, it is recognized that variations and changes may be made therein without departing from the invention as set forth in the claims.

We claim:

1. In an inflatable packer assembly having an annular elastic packer mounted on a sleeve and secured thereto at axially spaced points to form a fluid receiving enclosure between the packer and the sleeve, an inflation valve for the packer comprising a valve body, means for securing said valve body within the sleeve, a valve sleeve mounted within the valve body for axial movement relative thereto, frangible means for preventing said axial movement until a predetermined axial force is applied to the valve sleeve, conduit means communicating between the enclosure and the interior of the valve sleeve, plug means, means for temporarily securing the plug means in the conduit means, and means for applying the fluid pressure in the packer to the valve sleeve for axially displacing the valve sleeve, whereby when the fluid pressure in the packer is sufficiently high, the predetermined axial force displaces the valve sleeve to close the conduit means.

2. In an inflatable packer assembly having an annular elastic packer mounted on a sleeve and secured thereto at axially spaced points to form a fluid receiving enclosure between the packer and the sleeve, an inflation valve for the packer comprising a valve body, means for securing said valve body within the sleeve, a valve sleeve

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mounted within the valve body for axial movement relative thereto, frangible means for preventing said axial movement until a predetermined axial force is applied to the valve sleeve, conduit means communicating between the enclosure and the interior of the valve sleeve, plug means, means for temporarily securing the plug means in the conduit means, means forming a chamber between said valve sleeve and said valve body, said chamber means being expansible upon axial displacement of the valve sleeve in one direction, and means communicating between the packer and the chamber means, whereby fluid in the packer flows into the chamber means until the fluid pressure in the chamber means imposes a force on the valve sleeve which exceeds said predetermined force and the valve sleeve is displaced axially to close the conduit means.

3. In an inflatable packer assembly having an annular elastic packer mounted on a sleeve and secured thereto at axially spaced points to form a fluid receiving enclosure between the packer and the sleeve, an inflation valve for the packer comprising a valve body, means for securing said valve body within the sleeve, conduit means communicating between the enclosure and the interior of the valve body, plug means in the conduit means, means forming a seat in the valve body, and frangible means for securing the plug means to said seat means, whereby when a ball is lodged on the seat means and fluid pressure is applied to break the frangible means the conduit means is opened to allow fluid to flow into the enclosure between the packer and the sleeve.

4. An inflatable packer assembly comprising a tubular means adapted to be inserted in a pipe string, an annular elastic packer mounted on the tubular means and secured thereto at axially spaced points to form a fluid receiving enclosure between said tubular means and said packer, conduit means communicating between the enclosure and the interior of the mandrel, plug means in the conduit means, a ring in the mandrel, and frangible means for securing the plug means to the ring, whereby when a ball is dropped down the tubing string and lodges on the ring, fluid pressure above the ball breaks the frangible means to release the plug and admit fluid to the enclosure for expanding the packer.

5. An inflatable packer assembly comprising a tubular means adapted to be inserted in a pipe string, an annular elastic packer mounted on the tubular means and secured thereto at axially spaced points to form a fluid receiving enclosure between said tubular means and said packer, a valve body mounted in the mandrel, conduit means communicating between the enclosure and the interior of the mandrel, plug means in the conduit means, a ring, means mounting the ring in the mandrel for axial displacement relative thereto, said ring having a seat and being radially compressed, said valve body having a recess portion adjacent the opposite end of the ring, and frangible means for securing the plug means to the ring, whereby when a ball is dropped down the tubing string and lodges on the ring seat, fluid pressure above the ball breaks the frangible means and displaces the ring into the recess where it expands to allow the ball to pass through the ring.

6. An inflatable packer assembly comprising a tubular means adapted to be inserted in a pipe string, an annular elastic packer mounted on the tubular means and secured thereto at axially spaced points to form a fluid receiving enclosure between said tubular means and said packer, a valve body mounted in the mandrel, conduit means communicating between the enclosure and the interior of the mandrel, plug means in the conduit means, a ring, means mounting the ring in the valve body for axial displacement relative thereto, said ring having a seat and having an axial slot therein for being radially compressed and inserted in the mandrel, said valve body having a recess portion adjacent the opposite end of the ring, and frangible means for securing the

plug means to the ring, whereby when a ball is dropped down the tubing string and lodges on the ring, fluid pressure above the ball breaks the frangible means and displaces the ring into the recess where it expands to allow the ball to pass through the ring.

7. An inflatable packer assembly comprising a mandrel, a packer, means mounting the packer on the mandrel and forming an enclosure therebetween, means for connecting the mandrel to a tubing string, a valve sleeve mounted for sliding movement within the mandrel, said valve sleeve having an axial bore therein, conduit means communicating between the enclosure and the interior of the valve sleeve, plug means in the conduit means, a ring having an axial slot, said valve sleeve having a cylindrical recess of a greater diameter than said bore, said ring having a larger diameter than said bore and being radially compressed and mounted in said bore adjacent said recess, frangible means for securing the plug to the ring, whereby when a ball is dropped down the tubing string and lodges on the ring, fluid pressure above the ball breaks the frangible means and displaces the ring into the recess where it expands to allow the ball to pass through the ring.

8. An inflatable packer assembly comprising a mandrel, a packer, means mounting the packer on the mandrel and forming an enclosure therebetween, means for connecting the mandrel to a tubing string, a valve sleeve mounted for sliding movement within the mandrel, said valve sleeve having an axial bore therein, conduit means communicating between the enclosure and the interior of the valve sleeve, plug means in the conduit means, means forming a chamber between said mandrel and said valve sleeve, said chamber means being expandable upon axial displacement of the valve sleeve relative to the mandrel, means communicating between the chamber means and the packer enclosure, means for preventing axial displacement of the valve sleeve until a predetermined force is applied to the valve sleeve by the fluid pressure in the chamber means, and means for selectively removing the plug means from the conduit, whereby fluid flows into the enclosure to expand the packer and to displace the valve sleeve, thereby closing the conduit means to trap the fluid in the expanded packer.

9. An inflatable packer assembly comprising a mandrel, a packer, means mounting the packer on the exterior of the mandrel and forming an enclosure therebetween, means for connecting the mandrel to a tubing string, a valve sleeve mounted for sliding movement within the mandrel, said valve sleeve having an axial bore therein, conduit means communicating between the enclosure and the interior of the valve sleeve, plug means in the conduit means, means forming a chamber between said mandrel and said valve sleeve, said chamber means being expandable upon axial displacement of the valve sleeve relative to the valve body, means communicating between the chamber means and the packer enclosure, means for preventing axial displacement of the valve sleeve until a predetermined force is applied to the valve sleeve by the fluid pressure in the chamber means, means for selectively removing the plug means from the conduit, a ring having an axial slot therein, said valve sleeve having a cylindrical recess of a greater diameter than said bore, said ring having a larger diameter than said bore and being radially compressed and mounted in said bore adjacent said recess,

and frangible means for securing the plug to the ring, whereby when a ball is dropped down the tubing string and lodges on the ring, fluid pressure above the ball breaks the frangible means and displaces the ring into the recess where it expands to allow the ball to pass through the ring.

10. An inflatable packer assembly comprising a mandrel, a packer, means mounting the packer on the mandrel and forming an enclosure therebetween, means for connecting the mandrel to a tubing string, conduit means communicating between the enclosure and the interior of the mandrel, plug means in the conduit means, a ring in the valve body, frangible means for securing the plug means to the ring, means communicating between the exterior of said packer and the interior of the mandrel, and valve means in the mandrel for selectively controlling fluid flow through said communicating means, whereby after the packer is set, the valve means may be selectively operated for controlling production.

11. An inflatable packer assembly comprising a mandrel, a packer, means mounting the packer on the mandrel and forming an enclosure therebetween, means for connecting the mandrel to a tubing string, conduit means communicating between the enclosure and the interior of the mandrel, plug means in the conduit means, a ring in the mandrel, frangible means for securing the plug means to the ring, means communicating between the exterior of said packer and the interior of the mandrel, said communicating means being below said ring, a tube telescoped within the mandrel, said tube having radial ports therein spaced axially from said communicating means whereby upon axial displacement of the tube by a tool extending through the ring, the communicating means are opened for production.

12. A method for isolating and producing from a formation by expanding a packer on a tubing string having a baffle below the packer comprising dropping a ball down the tubing to lodge on a seat in the packer, pumping fluid down the tubing to increase the pressure on the ball, breaking the seat to uncover a filling port for expanding the packer and to allow the ball to drop to the baffle, pumping fluid down the tubing and into the packer through the filling port, closing the filling port in response to fluid pressure in the packer when the packer is expanded, pumping fluid down the tubing to increase the pressure on the ball to break the baffle and pump the ball out of the tubing string, pumping cement down the tubing to cement the packer in the well, and opening production ports in the packer communicating between the formation and the tubing.

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