

United States Patent

Maly et al.

[15] 3,637,010

[45] Jan. 25, 1972

[54] APPARATUS FOR GRAVEL-PACKING INCLINED WELLS

[72] Inventors: George P. Maly, Newport Beach; Joel P. Robinson, Santa Ana, both of Calif.

[73] Assignee: Union Oil Company of California, Los Angeles, Calif.

[22] Filed: Mar. 4, 1970

[21] Appl. No.: 16,502

[52] U.S. Cl. 166/51, 166/173

[51] Int. Cl. E21b 43/04

[58] Field of Search 166/51, 173

[56] References Cited

UNITED STATES PATENTS

2,198,573	4/1940	Davis et al.	166/51 X
3,064,731	11/1962	Hall	166/173 X
3,153,451	10/1964	Chancellor et al.	166/51

3,421,586	1/1969	Solum	166/51
3,482,627	12/1969	Nebolsine	166/51

Primary Examiner—David H. Brown

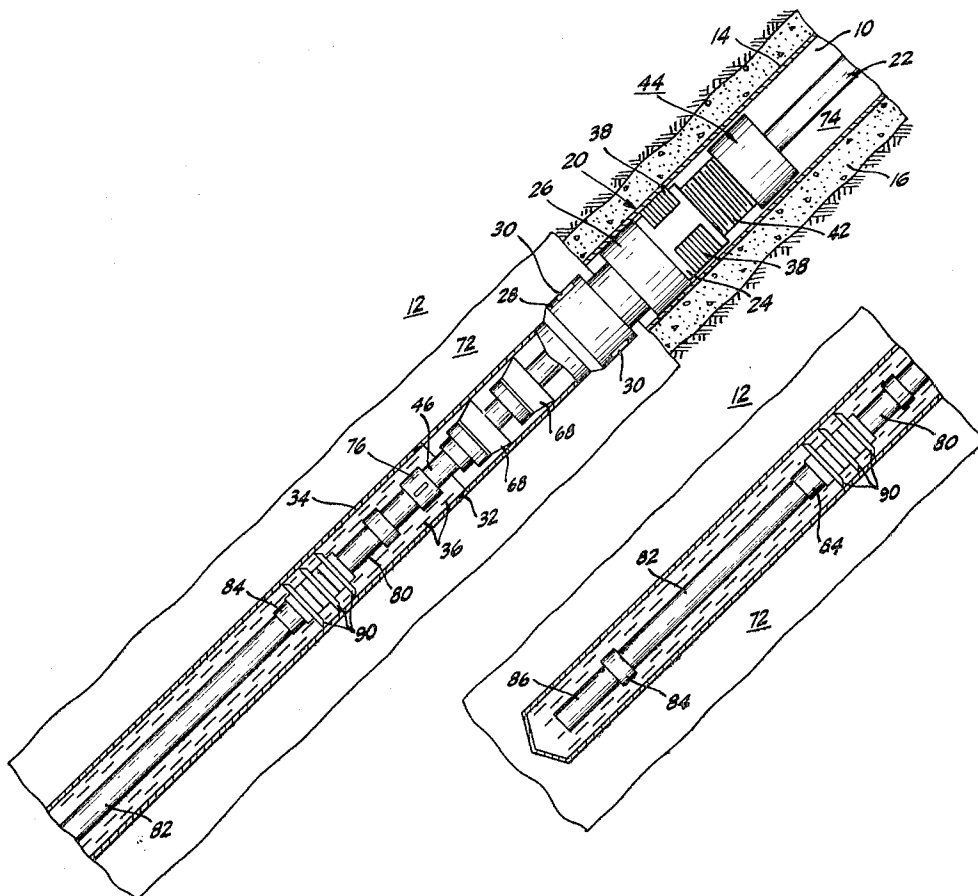
Attorney—Milton W. Lee, Richard C. Hartman, Lannas S. Henderson, Dean Sandford and Robert E. Strauss

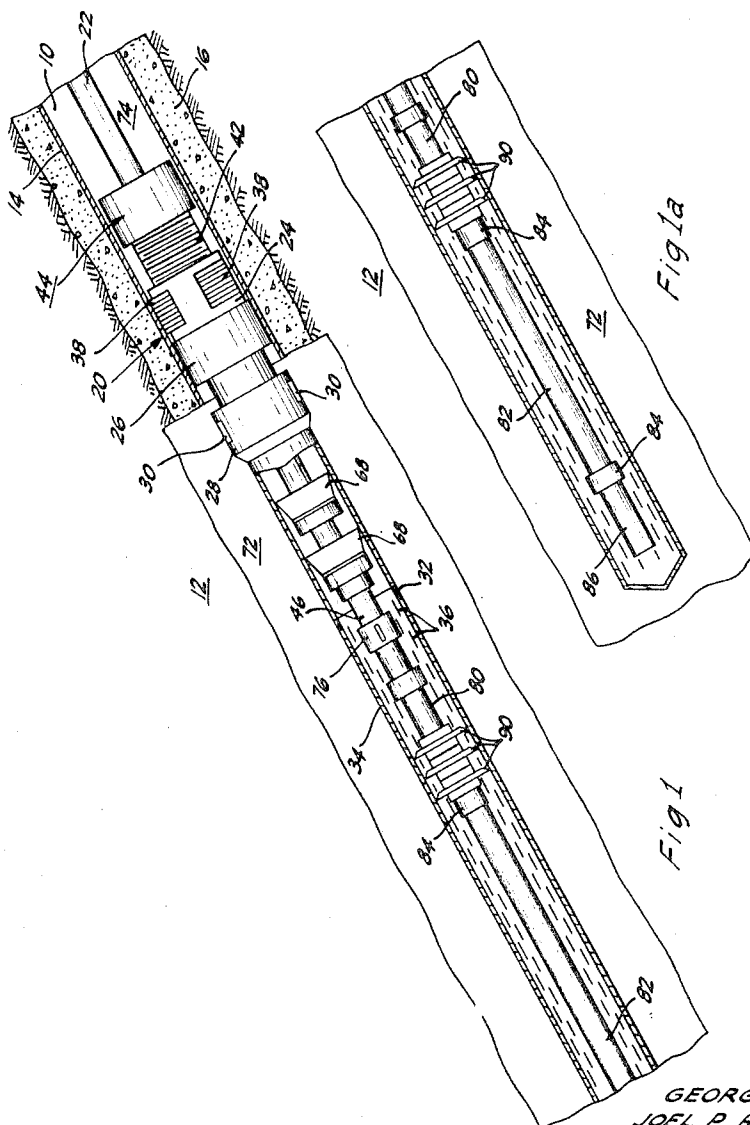
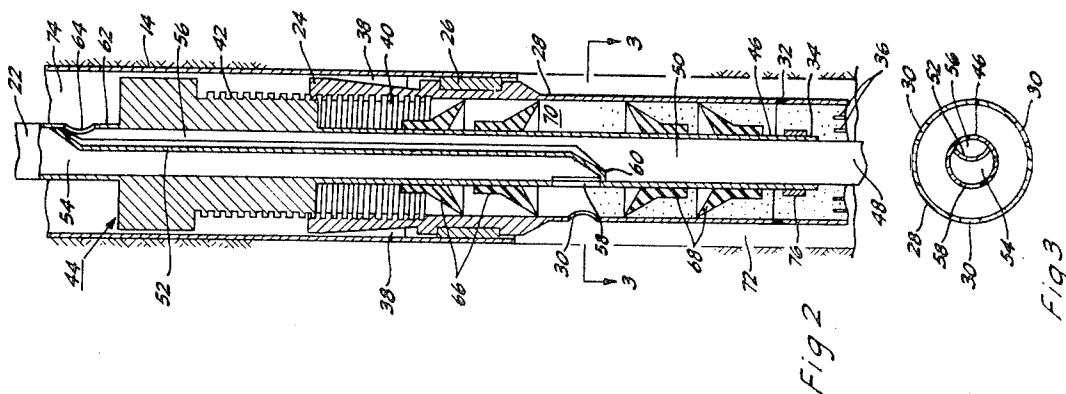
[57]

ABSTRACT

Apparatus is disclosed for hydraulically placing a uniform gravel pack in a well around the exterior of a perforate liner, and especially for forming uniform gravel packs in wells inclined from the vertical. The apparatus is comprised of a number of tubular members that can be axially assembled to form a stinger pipe that is attached to a conventional gravel-packing tool and placed in the interior of the perforate liner during the gravel-packing operation. A plurality of flexible, radial flow control baffles are slidably mounted on the tubular members so that the assembled tool is axially movable within the liner, within a limited travel, and rotatable independent of the baffles.

6 Claims, 6 Drawing Figures





INVENTORS
GEORGE P. MALY
JOEL P. ROBINSON
BY

BY *Dean Sanford*
ATTORNEY

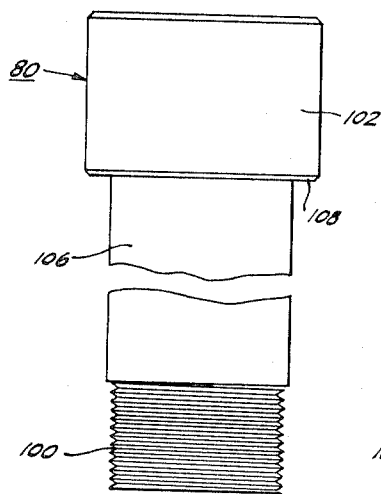


Fig 4

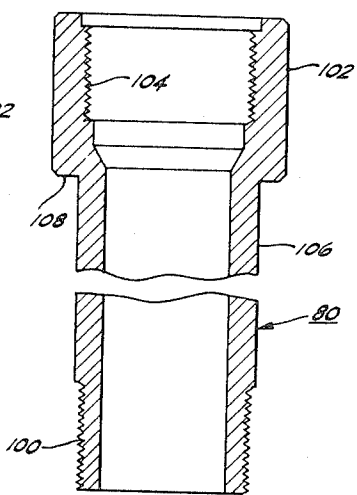


Fig 6

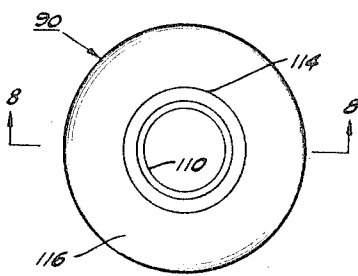


Fig 7

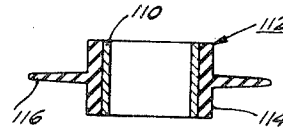


Fig 8

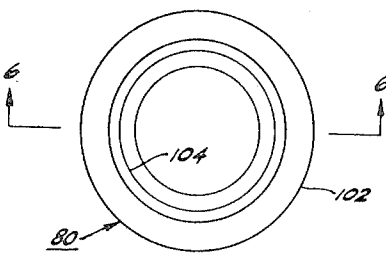


Fig 5

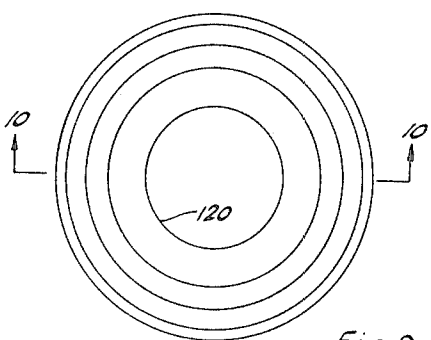


Fig 9

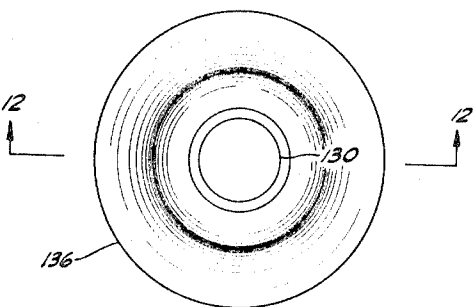


Fig 11

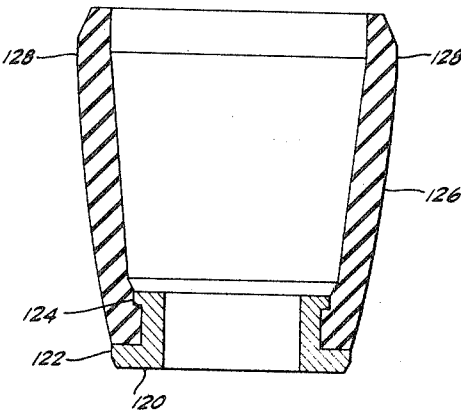


Fig 10

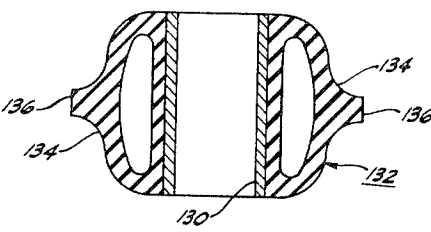


Fig 12

INVENTORS
GEORGE P. MALY
JOEL P. ROBINSON
BY
Dean Sandford
ATTORNEY

APPARATUS FOR GRAVEL-PACKING INCLINED WELLS

This invention relates to the completion of wells in subterranean formations, and more particularly to apparatus for gravel-packing the annulus surrounding a perforate liner installed in a well.

Recoverable fluids such as petroleum oil, gas and water are frequently found in subterranean formations comprised of unconsolidated or loosely consolidated sand and sandstone. Also, some otherwise consolidated formations become incompetent when certain fluids are produced from or injected into the formation. When such incompetent formations are pierced by a well and the connate fluids therein removed, the loosely or weakly bound sand particles become dislodged and are entrained in the fluid. The dislodged sand is moved into flow channels causing plugging and a reduction in permeability of the formation. Further, sand can accumulate in the well causing plugging, and can be carried to the surface with the withdrawn fluid. These entrained particles cause severe erosion of underground strainers and liners, the producing string, pressure control valves, pumps and flow lines. Oil produced from incompetent formations often requires special treatment to remove entrained sand, and substantial quantities of entrained sand can be deposited in production tanks causing cleaning and disposal problems. In extreme cases, sufficient sand can be removed from the producing formation to cause it to collapse under overburden pressure resulting in loss of the well. Similar problems are encountered in the injection of water, gas and other fluids into unconsolidated or loosely consolidated formations, or into formations which become incompetent upon injection of the fluid.

One conventional technique for completing a well in an incompetent formation so as to substantially prevent entrainment of earth particles into the well involves placing a perforate liner in the well at the lower end of a casing string, and to thereafter pack gravel of selected size around the exterior of the liner in the annular space between the liner and the formation wall. The gravel can be hydraulically placed in the well annulus by circulating a suspension of the gravel in water or other liquid through the annulus so that the gravel is deposited therein. It is conventional practice to run the liner into the well on a special gravel-packing tool suspended on a running-in string. The gravel-packing tool provides a flow crossover from the running-in string to the annulus through gravel ports in a port collar. The tool is suitably packed-off above and below the gravel ports. A stinger pipe extends downwardly from the gravel packing tool to a point just above the lower end of the liner and communicates at its upper end through a bypass passage in the tool with an outlet port at the upper end of the tool opening into the annular space between the running-in string and the well casing. The gravel suspension is pumped down the running-in string and through the tool into the port collar and then outwardly through the ports in the latter into the annulus between the formation wall and the upper end of the perforated liner, whereupon the suspension flows downwardly on the exterior of the liner. The liquid in the well displaced by the inflowing suspension and the water or other gravel carrier liquid flows inwardly through the perforations in the liner and into the lower end of the stinger pipe, causing an upward flow through the stinger pipe which escapes through a bypass in the gravel-packing tool into the annulus surrounding the running-in-string above the packers. This liquid is then returned to the surface through the annulus.

Ideally, the suspension thus pumped into the upper end of the space between the liner and formation wall will gradually move downwardly displacing the liquid already in this space inwardly through the perforations in the liner. As the suspension reaches the bottom of the annulus, the carrier liquid also passes inwardly through the perforations in the liner, leaving the gravel progressively compactly packed in the annulus on the exterior of the liner, from the bottom of the well upward, until no more gravel suspension can be pumped into the upper end of the annulus. Unfortunately, this process often does not operate as desired, even in substantially vertical wells, resulting in the well annulus surrounding the perforate liner being

only partially filled with gravel. One of the theories for such failure is that bridging of the gravel between the liner and the formation wall occurs at a point located a substantial distance above the top of the gravel bed, thus blocking further downward flow of the gravel suspension. After such a bridge occurs, the liquid in the suspension delivered into the annulus above the bridge escapes inwardly through the perforated liner and the annulus is progressively packed with gravel from the bridge upward, but leaving a void in the annulus below the bridge. In practice, a number of such bridges may occur in long liners, leaving a like number of voids in the annulus.

Another problem encountered in the gravel-packing of wells is size segregation of the gravel within the annulus. Since gravity is the primary force causing the gravel to form a uniform pack, the larger and more dense particles settle faster, thus causing particle size segregation in the gravel pack.

To overcome these problems, it has been proposed that flexible, radial baffles be fixedly mounted at each joint of the stinger pipe, i.e., about each 30 feet, so as to divert the downflowing liquid outwardly into the annulus until a compact gravel pack is formed from the bottom of the annulus upwardly. These baffles are slightly larger than the interior of the liner so that they are theoretically cupped upwardly as the stinger pipe is inserted into the previously placed perforated liner, thus providing a liquid seal against the inner surface of the liner. As the annulus is progressively filled with gravel, the carrier liquid is diverted through the perforations in the liner at progressively higher elevations. When the level of gravel in the annulus builds up past a baffle, the differential pressure across the baffle is increased causing it to be cupped downwardly, thus allowing liquid to flow downwardly past the baffle at relatively little pressure drop.

However, while this embodiment of gravel-packing apparatus has been used with some success, it is not universally effective in establishing uniform compact gravel packs, and the use of this tool introduces other problems. Specifically, in the operation of placing the gravel-packing tool in the well it is often necessary that the tool be moved up and down in the well short distances and rotated to perform various operations, such as locating the dogs on the tool that permit opening of the gravel ports. The baffles, particularly with long stinger pipes, introduce sufficient friction that it is difficult to properly perform these necessary operations. Also, as the tool string is moved downwardly and then upwardly in positioning the dogs, the baffles become cupped downwardly and are thus not effective in preventing liquid flow downwardly through the interior of the liner. Further, it is generally found that wells inclined at angles of 45° or more from the vertical cannot be successfully gravel packed, even with the use of the aforementioned gravel-packing tool.

Accordingly, a primary object of the present invention is to provide apparatus that permits a compact, uniform bed of gravel to be hydraulically placed around the exterior of a perforate liner. Another object of the invention is to provide a gravel-packing tool having a baffled stinger pipe that can be readily positioned in the proper vertical location in the well. A further object of the invention is to provide a gravel-packing tool having a baffled stinger pipe that can be moved up and down axially in the well over a limited distance and rotated without effecting the seating of the baffles within the liner. A still further object of the invention is to provide a tool for gravel-packing wells inclined from the vertical, and particularly for gravel-packing wells inclined at angles in excess of 45° from the vertical.

The manner of accomplishing the foregoing objects as well as further objects and advantages of the invention will be apparent from the following description taken in connection with the accompanying drawings, wherein like numerals refer to corresponding parts, and in which:

FIGS. 1 and 1a are diagrammatic vertical sectional views illustrating the assembled gravel-packing tool of this invention in place in an inclined well penetrating an earth formation;

FIG. 2 is an enlarged vertical sectional view of an upper portion of the gravel-packing apparatus shown in FIG. 1;

FIG. 3 is a horizontal sectional view taken along the line 3—3 of FIG. 2 illustrating the gravel suspension ports in the port collar of the liner hanger and similar parts in the gravel-packing tool;

FIG. 4 is a side view of the tubular tool joint of this invention;

FIG. 5 is a top view of the tubular tool joint illustrated in FIG. 4;

FIG. 6 is a sectional view of the tool joint of this invention taken along the line 6—6 of FIG. 5;

FIG. 7 is a top view of one embodiment of the diverting baffle of this invention;

FIG. 8 is a sectional view of this diverting baffle taken along the line 8—8 of FIG. 7;

FIG. 9 is a top view of another embodiment of the diverting baffle of this invention;

FIG. 10 is a sectional view of the diverting baffle illustrated in FIG. 9 taken along the line 10—10 of FIG. 9.

FIG. 11 is a top view of yet another embodiment of the diverting baffle of this invention; and

FIG. 12 is a sectional view of the diverting baffle illustrated in FIG. 11 taken along the line 12—12 of FIG. 11.

Referring specifically to the drawings, FIGS. 1 and 1a show a well 10 penetrating an earth formation 12 at an angle inclined from the vertical. The upper portion of well 10 is cased down to the producing zone with tubular well casing 14, which is cemented in place in the well with cement 16, and the lower portion of well 10 can be underreamed, as illustrated, to provide a larger bore hole in the producing zones to contain the gravel pack. Tool assembly 20 is placed at the lower end of casing 14 by means of running-in string 22. Tool assembly 20 includes a liner hanger 24 having a lead packer 26 on the lower end of which is connected a port collar 28 having gravel suspension ports 30. Suspended from port collar 28 by threaded connection 32 is a perforated liner 34 having perforations, such as the slots 36, throughout its length, the lower end of the liner either resting on the bottom of well 10 or being supported relatively close to the bottom.

The liner hanger 24 is provided with wickered slips 38 which, in FIG. 1, are shown set against the inner surface of casing 14 so as to suspend the liner hanger and liner 34 from the casing. Lead packet 26 is also shown as having been set against the inner surface of well casing 14 to pack off the space between liner hanger 24 and the casing. As more clearly shown in FIGS. 2 and 3, liner hanger 24 is provided with internal threads 40 by which it is adapted to be engaged by an externally threaded head 42 of gravel packing tool 44. This tool is suspended on the lower end of running-in string 22 on which said tool is run into the well and engaged with liner hanger 24. Alternatively, liner hanger 24 and gravel-packing tool 44 can be assembled on the surface and run into the well on running-in string 22. Because of the diagrammatic nature of the drawings, the detailed structure of the various elements of the apparatus which permit slips 38 to be manipulated by manipulation of running-in string 22 so as to set these slips in the casing 14 and cause lead packet 26 to pack off the space between the hanger and the casing are not shown. After these steps have been performed, the running-in string 22 may be set down with the head 42 supported on the upper end of liner hanger 24, thereby firmly setting wickered slips 38 in the metal of casing 14. Head 42 is shown in this position in FIGS. 1, 1a and 2.

Gravel-packing tool 44 has a tubular downward extension 46 which connects at its upper end with the head 42 and at its lower end with a sectionally assembled stinger pipe 48. The downward extension 46 of the tool 44 has an internal bore 50 which extends upwardly through the head 42 and connects with the lower end of the running-in string 22. Tool 44 is provided with a wall 52 extending longitudinally in the bore 50 which divides the space within said bore into a gravel suspension passage 54 and a liquid bypass passage 56. The passage 54 connects at its upper end with the lower end of the running-in string 22, and at its lower end communicates with gravel suspension ports 58, and passage 54 is closed by a wall 60 just

below said ports. The head 42 of tool 44 has a neck or sub 62 which connects with the running-in string 22, the neck 62 having a liquid port 64 with which the upper end of liquid bypass passage 56 connects. The lower end of said bypass passage connects with the bore 50 below wall 60, and thus communicates with the upper end of stinger pipe 48.

The tubular downward extension 46 is provided with upper and lower double packers 66 and 68 which pack off the space between said tool on the one hand, and the liner hanger 24 and port collar 28 on the other hand, just above and below the ports 30 of the port collar and the ports 58 of the gravel-packing tool 44. These packers form a chamber 70 within the port collar 28 which connects the ports 58 of the gravel-packing tool 44 with the ports 30 of the port collar. Thus, when a suspension of gravel in liquid is pumped down the running-in string 22, it is delivered through the passage 54 and ports 58 into the chamber 70 from which it flows outwardly through ports 30 into the space 72 between the formation wall and perforated liner 34. Hexagonal or similarly shaped port collar turning tool 76 is mounted on extension 46 immediately below lower packer 68. Tool 76, when properly positioned in port collar 28, permits the port collar to be rotated by rotation of running-in string 22, thereby opening or closing the ports 30 depending upon the direction of rotation.

Stinger pipe 48 is a jointed assembly of any desired length, and preferably extends substantially the length of perforated liner 34. The stinger pipe is comprised of alternate sections of the special tool joints 80 and short pup joints 82 connected by threaded couplings 84. Baffles 90 are slidably mounted on tool joints 80, and the stinger pipe is provided with a tip piece 86 having an open end. The tip piece is attached to the bottom pup joint by a threaded coupling 84. While the baffled stinger pipe of the present invention has been described in combination with a particular gravel-packing crossover tool and liner hanger, it is to be recognized that this invention can be employed in combination with any tool utilizing a stinger pipe inserted inside the perforated liner as a fluid return means.

FIGS. 4, 5 and 6 more specifically illustrate the tool joints 80. These joints are relatively short tubular members provided at one end with male threads 100 and at the other end with an outwardly protruding, larger diameter receptacle 102 threaded on its interior with female threads 104. The exterior surface 106 of the tubular member is machined to provide a uniform, close-tolerance outside diameter the length of the section extending between the threads 100 and the outwardly protruding shoulder 108 of receptacle 102. Preferably, the surface of the tubular section 106 is machined to an ASA smoothness of 125 or less. Fluid-diverting baffles 90 are adapted to slip fit onto tool joints 80 as illustrated in FIGS. 1 and 1a, and are free to move the length of tubular section 106.

As illustrated in FIGS. 7 and 8, one embodiment of fluid diverting baffles 90 are comprised of a rigid cylindrical inner hub 110 having a uniform, close-tolerance inside diameter slightly larger than the outside diameter of tubular section 106, and an integral molded outer member 112. Outer member 112 is comprised of a hub portion 114 adapted to fit over the cylindrical inner hub 110, and a substantially flat, flexible annular flange portion 116 extending radially from the hub portion. The inner surface of hub 114 is bonded to inner hub 110 to provide a unitary structure. Outer member 112 is formed of resilient material, and is preferably formed of molded rubber exhibiting a Shore hardness of about 40 to 90 on the A scale, although other resilient rubber and plastic materials exhibiting similar properties can be employed. The outer diameter of flange 116 is preferably selected so that it is slightly larger than the inside diameter of the perforated liner in which the baffles are to be employed. In this manner, the baffles will be cupped upwardly on insertion into the liner, thus acting as a seal against downflowing liquid, and will be forced into a downwardly cupped configuration as the differential pressure increases, thus permitting liquid to flow downwardly around the baffles without excessive restriction.

Another embodiment of fluid diverting baffle useful in the practice of this invention is illustrated in FIGS. 9 and 10. In this embodiment, rigid cylindrical hub 120 having a uniform, close-tolerance inside diameter slightly larger than the outside diameter of section 106 of tool joint 80 is provided with outwardly protruding lips 122 and 124 that serve to lock resilient member 126 into hub 120. Outwardly protruding member 126 is adapted at one end to engage hub 120 and flares outwardly therefrom to bear against the inside of the perforate well liner. The flat surface 128 at the most outwardly projecting portion of member 126 is adapted to engage the inner surface of the liner. Hub 120 and resilient member 126, in combination, provides a cuplike assembly adapted for slidable mounting on tool joint 80 so as to inhibit flow through the interior of the liner during the gravel-packing operation. This embodiment of fluid-diverting baffle is mounted on tool joints 80 with the open cuplike end directed downwardly, so as to permit fluid flow past surface 128 when sufficient differential pressure is applied to compress resilient member 126.

FIGS. 11 and 12 illustrate yet another embodiment of fluid-diverting baffle employing a hollow tubular construction. In this embodiment, rigid cylindrical hub 130 having a uniform, close-tolerance inside diameter slightly larger than the outside diameter of section 106 of tool joint 80 is adapted for slidable mounting on the tool joint. Resilient member 132 having a hollow tubular construction is bonded to hub 130 to provide a fluid seal on the inside of the perforate liner. Resilient member 132 is constructed with an outwardly protruding lip 134 having a flat surface 136 adapted to bear against the inner surface of the liner. The void within resilient member 132 can be filled with gas under slight pressure to effect a tighter seal between surface 136 and the inside of the well liner.

The fit of fluid-diverting baffles 90 onto tool joints 80 is critical. If the fit is too tight, the tool joint is not free to move independently of the baffles. With too loose of a fit, sand and other small particles can work between the hub of the baffle 90 and the tool joint, causing the baffle to jam onto the tool and preventing free movement of the tool joint independently of the baffles, or the baffle can cock on the tool joint causing it to jam. For best results, it has been found that the inside diameter of hub 110 should be 0.005 to 0.050 inch larger than the outside diameter of tubular section 106 of tool joint 80, and more preferably, between about 0.020 and 0.030 inch larger.

Usually between 1 and 5 of the fluid-diverting baffles are installed on each tool joint, with 2 or 3 of the baffles per joint being preferred in most applications. Tool joints 80 must be of sufficient length to accommodate the desired number of fluid-diverting baffles and to permit axial movement of the running-in string and tool assembly sufficiently to manipulate the liner hanger and gravel-packing tool. Thus, the length of tool joints 80 depends in part on the particular liner hanger and gravel-packing tool employed, and in part on the driller's preference. However, while tool joints of any desired length can be employed, tools having a constant diameter section 106 between about 3 inches and 3 feet in length are suitable for most applications.

It has been found that the spacing between the various sets of baffles is critical, since at too great of a spacing the carrier liquid will pass into the liner prematurely, which promotes bridging in the annulus and prevents the formation of satisfactory gravel packs. The maximum distance between the various sets of baffles 90 required for satisfactory operation is dependent in part upon the size of the liner perforations, the densities of the gravel and the carrier liquid, the viscosity of the carrier liquid, the gravel size, and the injection rate. However, in most applications it has been found that the baffles should not be placed more than about 10 feet apart, and are more preferably placed between about 2 and 10 feet apart, and even more preferably placed between about 5 and 8 feet apart. The spacing between adjacent baffles is determined by the length of pup joints 82 employed. Thus, it is preferred in most applications that the pup joints be of a length sufficient to maintain

the distance between adjacent sets of baffles between about 5 and 8 feet.

In a typical application of the device of this invention, a well is drilled and cased to the top of a productive zone and the casing cemented in place in the well. The well is then drilled through the productive zone, which may be from a few feet to several hundred feet in thickness. The well can be under-reamed in the productive zone to increase the space available for the gravel pack. Perforated liner of sufficient length to extend through the productive zone is then assembled in the well and the liner hanger installed on the upper section of liner. This assembly is then run into the well on a running-in string and the liner hanger set against the casing. The gravel-packing tool is then installed on the running-in string and run into the well so that the stinger pipe extends substantially the entire length of the liner. When the assembly is in place in the well bore, the gravel ports of the gravel-packing tool are then opened by manipulation of the running-in string. On insertion into the well liner, the baffles bear against the upper protruding shoulder of the tool joint, and are cupped upwardly due to the friction of the baffle against the inside surface of the liner. When in this position, the running-in string, gravel-packing tool, and stinger pipe can be raised the length of travel of the tool joint and rotated independently of the baffles. This permits opening of the gravel ports and other operations by manipulation of the running-in string without affecting the positioning of the baffles in the liner.

After the assembly has been set and the gravel ports opened, slurried gravel is pumped down the running-in string and outwardly through ports 58, chamber 70 and ports 30 into the annular space 72 on the exterior of the perforated liner. The gravel is deposited in the well annulus and the carrier liquid passes through the perforations in the liner and into its interior. The liquid is returned back up the stinger pipe, through the bypass passage in the gravel-packing tool, into well annulus 74 surrounding the running-in string, and is ultimately returned to the surface.

Experimental model studies have shown that with a well inclined from the vertical at an angle of less than about 45°, the well annulus is packed from the bottom upwardly. However, if the well is inclined more than about 45°, the annular space 72 surrounding the liner is filled with gravel from the top downwardly except for a small high-velocity channel along the formation wall at the top of the annulus. Gravel is carried downwardly through this channel and progressively deposited at the lower face of the gravel pack. In this manner, the annular space is filled from the top downwardly, excepting for the high-velocity channel along the uppermost portion of the bore wall. When the annular space has filled from the top to the bottom, the high-velocity channel then quickly fills from the bottom upwardly. When this channel is full, the injection pressure increases substantially and the operation is discontinued. The gravel ports on the liner hanger are then closed by manipulation of the running-in string, and the running-in string, gravel-packing tool and stinger pipe are removed from the well.

Various embodiments and modifications of this invention have been described in the foregoing description and drawings, and further modifications will be apparent to those skilled in the art. Such modifications are included within the scope of this invention as defined by the following claims.

Having now described our invention, we claim:

1. Apparatus for forming a bed of granular material in the annulus of a well surrounding a perforate tubular liner, which comprises:

tool means adapted for connection with a tubing string and placement in said well in sealable engagement with the interior of said liner to separate said well into an upper and lower section and to provide fluid communication between said tubing string and the well annulus exterior of the perforate liner and between the interior of the liner in said lower section of the well and the well annulus in said upper section;

a stinger pipe connected to said tool means and adapted to extend downwardly on the interior of said liner for conducting fluids from the interior of said liner to said tool means; and

a plurality of annular yieldable baffles slidably mounted at spaced intervals on said stinger pipe, each of said baffles being adapted to offer substantial resistance to fluid flowing in said liner past said baffles.

2. The apparatus defined in claim 1 wherein said baffles are mounted on said stinger pipe in groups of about 1 to 5 baffles, and wherein said groups are spaced on said stinger pipe at intervals of about 2 feet to 10 feet.

3. The apparatus defined in claim 1 wherein the longitudinal movement of said baffles on said stinger pipe is constrained to about 3 inches to about 3 feet.

4. Apparatus for forming a bed of granular material in the annulus of a well surrounding a perforate tubular member, which comprises:

tool means adapted for connection with a tubing string and placement in said well in sealable engagement with the interior of said liner to separate said well into an upper and a lower section and to provide fluid communication between said tubing string and the well annulus exterior of the perforate liner and between the interior of the liner in said lower section of the well and the well annulus in said upper section;

a stinger pipe connected to said tool means and adapted to

extend downwardly on the interior of said liner for conducting fluids from the interior of said liner to said tool means, said stinger pipe comprising threadably connected tubular members, alternate of said members having a uniform, close-tolerance outside diameter; and

at least one annular yieldable baffle slidably mounted on each of said tubular members having uniform, close-tolerance outside diameters, said baffles being adapted to make a yieldable sealing engagement with the interior of said liner whereby each baffle offers substantial resistance to fluid flowing in said liner past said baffles.

5. The apparatus defined in claim 4 wherein from about 1 to 5 of said baffles are mounted on each of said alternate tubular members, and wherein the uniform close-tolerance section of said tubular members is from about 3 inches to 3 feet in length.

6. The apparatus of claim 4 wherein said baffles are comprised of a rigid cylindrical inner hub having a uniform, close-tolerance inside diameter slightly larger than the outside diameter of said tubular member, and an outer member molded of resilient material having a hub portion adapted to fit over said cylindrical inner hub and a flexible annular flange extending outwardly from the hub portion, said hub portion being bonded to said cylindrical inner hub so as to provide a unitary structure.

* * * * *

30

35

40

45

50

55

60

65

70

75