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METHODS AND APPARATUS FOR SEALING A BORE HOLE CASING

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2 Sheets-Sheet 1

Fig.1

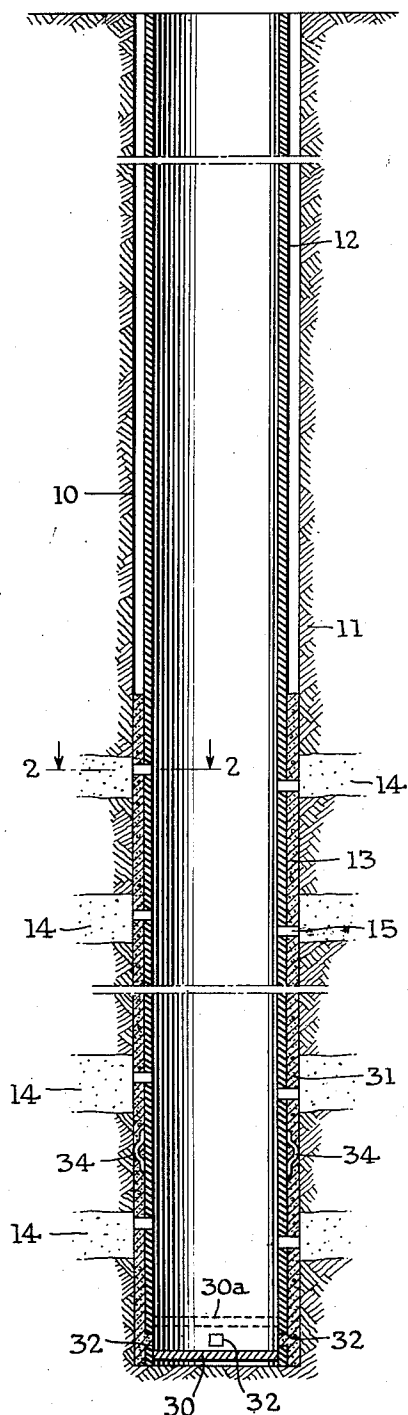
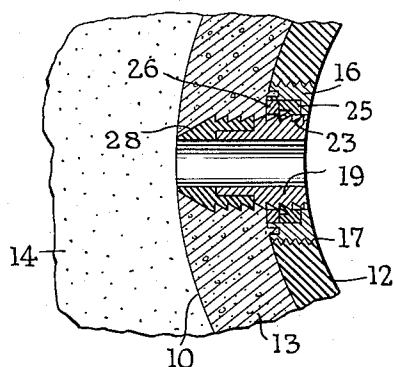


Fig.2



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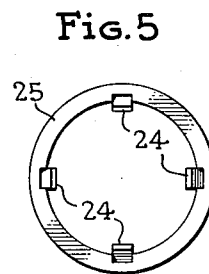
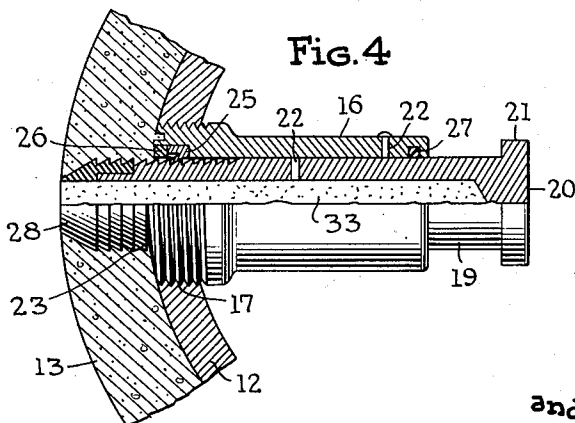
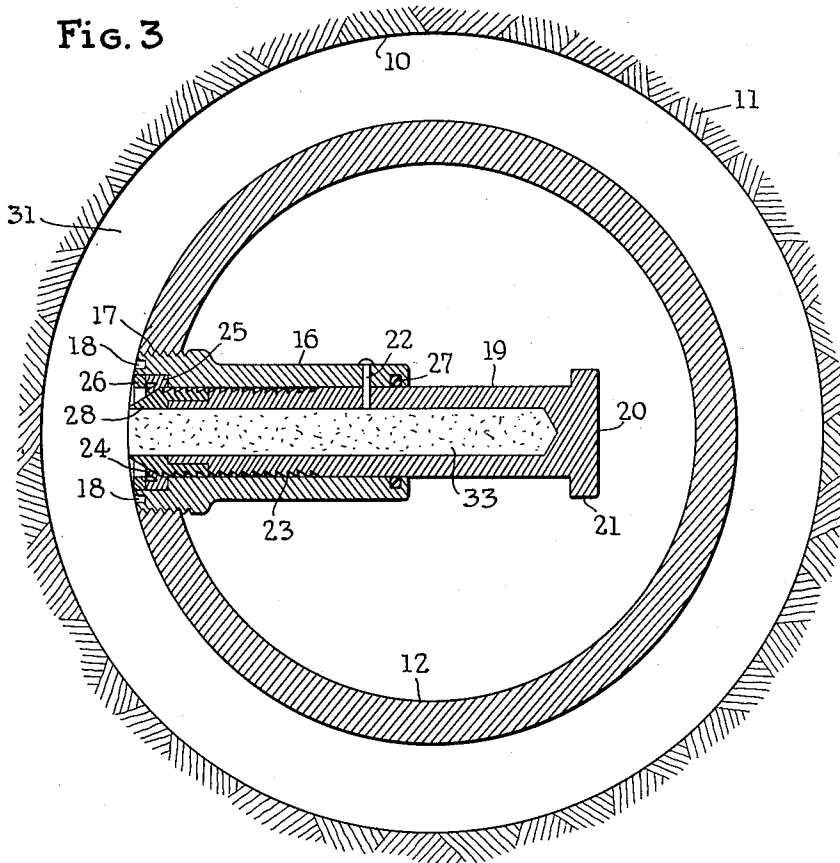
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METHODS AND APPARATUS FOR SEALING A BORE HOLE CASING

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11 Claims. (Cl. 166—46)

This invention relates to improved methods and apparatus for sealing a bore hole casing or liner in a bore hole, and more particularly to novel methods and apparatus for providing ducts for the flow of fluids between selected earth strata and the interior of the bore hole casing or liner.

Heretofore, bore hole casings have been set in drilled bore holes by a cementing process in which fluid cement is forced down through the casing and then upwardly around the outside of the lower portion of the casing to fill the space between the outside of the casing and the surrounding earth. It has then been customary to perforate the casing and the surrounding cement at the levels of producing strata by means of horizontal drilling or by means of gun-type perforators which fire a projectile through the casing and cement to form passageways therethrough. Said known methods and apparatus have created various difficulties such as a shattering of the cement, destruction of the sealing bond between the casing or liner and the cement, and the formation of cracks in the cement making said cement subject to destructive attack by acids subsequently introduced to acidize and improve the flow of fluids from productive strata.

It is an object of this invention to provide an improved method and apparatus for establishing communication between producing strata and the interior of a cemented bore hole casing or liner.

It is another object of this invention to provide ducts between producing strata and a bore hole casing or liner which do not damage in any manner the effectiveness of a cement seal between the casing or liner and the surrounding earth formations.

It is a further object of this invention to provide a novel bore hole casing or liner construction having movable elements provided with passageways, the elements being extendable laterally from the casing or liner into contact with producing strata either before cement is applied around the casing or liner or while such cement is in a fluid condition.

It is a further object of this invention to avoid puncturing or perforating a casing or liner after it has been sealed and hence avoid damaging the sealing cement or the bond between the cement and the bore hole casing or liner and/or the bond between the cement and the bore hole wall.

It is a still further object of this invention to provide a bore hole casing or liner with a plurality of lateral duct-forming devices at various levels operable by hydraulic pressure to establish or position the ducts between the casing or liner and different strata of the surrounding limestone formations without damaging the seal between the casing or liner and the surrounding formation and between the various levels or strata.

Other objects and advantages of this invention will become readily apparent from the following detailed description of a preferred arrangement of apparatus and its method of use. In the accompanying drawings forming a part hereof:

Figure 1 is a vertical section view, partly cut away and partly diagrammatic of a bore hole provided with a casing sealed in accordance with this invention;

Figure 2 is a fragmentary view, on an enlarged scale, taken on line 2—2 of Figure 1;

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Figure 3 is a horizontal sectional view showing one of the duct forming devices of Figure 1 in initial position before projection into contact with a producing stratum;

Figure 4 is a horizontal sectional view showing the device of Figure 3 in its extended position; and,

Figure 5 is a vertical elevation view of the holding spring illustrated in Figures 3 and 4.

Referring to the drawings for the purposes of illustration, a bore hole 10 is drilled in the earth and limestone 11 by any conventional drilling apparatus. In boring wells through limestone formations, for example, the bore hole 10 may be of approximately nine inches in diameter and will have a substantially smooth and regular surface. A bore hole casing or liner 12 is positioned in the bore hole 10, and may be formed of steel or aluminum tubing of about seven inches outside diameter. This leaves a space about one inch across between the outer surface of the casing 12 and the wall of the bore hole 10. The casing 12 may be provided with spaced projecting guides 34 to center the casing in the hole. The casing or liner 12 is sealed or set in the formation 11 by means of cement 13. The cement 13 may be of Portland cement or any other composition or settable plastic material not affected by oil, gas, or bore hole treating chemicals.

Earth formations 11 usually have a plurality of oil or gas producing strata indicated in the drawings by the numerals 14. Some of the strata 14 may be more porous than other adjacent strata. The porosity of the individual stratum may be determined by analysis of specimen cores or by electrical testing apparatus, and such porosities are usually expressed in terms of millidarcies. Where a bore hole traverses several strata of different porosities and the strata are to be treated by acids or other chemicals, it is desirable that the cement seal 13 between various strata be maintained unbroken so that upon application of acids under pressure there will be no leakage outside of the casing 12 from one stratum 14 to another stratum 14 of greater porosity. In actual practice the strata 14 may be found to be of small thickness and possibly spaced only a few feet apart.

The section of well casing or liner 12 adjacent the strata 14 is provided before its introduction into the bore hole with a plurality of duct forming devices 15, shown only diagrammatically in Figure 1, mounted in the wall of the casing 12 at levels to correspond with the indicated levels of the strata 14 to be tapped. One such duct forming device will now be described first with reference to its original position as shown in Figure 3. The device 15 comprises a bushing 16 mounted in an opening in the casing 12 by threads 17. The outer end of bushing 16 may be provided with recesses 18 to permit application of a spanner wrench to screw the bushing into the threaded opening of casing 12. After application of the bushing 16 to the casing 12 any portions of the bushing projecting beyond the outer surface of the casing 12 may be milled away to provide a smooth outer surface. A tubular member 19 is slidably mounted in the bushing 16 and is provided with a closure 20 at its inner end. The closure 20 has a peripheral flange 21 to limit the outward sliding movement of the tubular member 19 in the bushing 16. A shear pin 22 extends through the wall of the bushing 16 into the member 19. A portion of the outer surface of the member 19 is serrated at 23 for cooperation with spring fingers 24 of a detent ring 25 secured in a recess in the outer end of the bore of the bushing 16. The detent ring 25 may be held in the bushing 16 by a locking ring 26. As shown in Figure 5, the detent ring 25 has a plurality of spring fingers 24. The serrations 23 on the member 19 are of triangular shape so that the member 19 may slide

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past the fingers 24 in an outward direction, and the fingers 24 engage the serrations 23 to prevent the member 19 from moving back into the casing 12 once it has been moved outward. A sealing device 27, preferably of the O-ring type, may be provided between the bushing 16 and the smooth surface of the tubular member 19. The outer or nose end of the tubular member 19 may be provided with a hard steel edge ring 28 press-fitted onto a reduced diameter portion of the outer end of member 19.

The tubular member 19 is adapted to be moved from its initial position within the casing 12, as shown in Figure 3, to an extended position, as shown in Figure 4, by the application of fluid pressure within the casing 12. The bottom of the casing or liner 12 being closed by a releasable valve or plate 30, a predetermined fluid pressure applied within the casing 12 acts on the closed inner ends 20 of tubular members 19 to push the members outward into the space 31 between the casing 12 and the surface of strata 14 until the edges 28 of members 19 engage the strata. The pressure required for this action depends on the shearing strength of the shear pin 22 which is sheared to release the member 19 for outward movement. For example, the pin 22 may be of material and size to shear when a net effective outward force of about sixty pounds is applied to the end 20 of the member 19.

The preferred method of operation will now be described. A bore hole 10 drilled in an earth formation, such as limestone 11, is surveyed by conventional methods to determine both the porosity and the actual level of the several porous strata 14 above the bottom of the bore 10. A casing or liner 12 is then prepared with a plurality of duct forming devices 15 secured therein at levels corresponding to the levels of the several strata 14 to be tapped. The casing or liner 12 is then lowered into the bore hole 10 until it engages the bottom and the duct forming devices are opposite the strata 14 to be tapped. Fluid under pressure is then pumped into the casing 12 until the pressure is great enough to cause outward forces to shear the pins 22 and push the tubular members 19 outward so that the outer ends 28 of the members 19 firmly engage the wall of the strata 14. The spring fingers 24 engaging the serrations 23 of the members 19 prevent any subsequent return movement of the members 19 back into the casing 12. Next, sealing cement under a greater fluid pressure is forced into the casing so as to open or force downward the releasable bottom closure 30 of the casing 12 from position 30a to a position below the lateral passages 32, the fluid cement then passing through passages 32 and upwards filling the space 31 between the outer surface of the casing 12 and the wall of the bore hole 10. The duct devices 19 are surrounded by the cement 13 and provide passageways from the casing 12 to the strata 14 before the cement 13 is hardened and set. After the cement 13 has firmly set and become thereby bonded to the outer surface of casing 12, to the wall of the bore hole 10 and to the serrated surface of the duct devices 15, suitable drilling mechanisms, not shown, are lowered and operated within the casing 12 to cut away the portions of the duct forming devices within the casing 12. To facilitate this clearing away operation, the bushings 16 may be made of brass and the tubular members 19 may be made of pot metal. Since the cement 13 has set and securely holds and positions the projecting outer portion of members 19, the inner portion of said members and of bushings 16 may be easily cut away without disturbing the location of the projecting portions and without damaging the cement seal 13.

When the casing 12 and duct forming devices 15 are initially positioned in the bore hole, the hollow portion of members 19 may be filled with filler substance 33 which should be a material which can be dissolved out by the application of acids or other chemicals after the

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inner portion of bushings 16 and members 19 have been drilled away and flushed out of the interior of the casing 12. It is also contemplated that the portions of bushing 16 and member 19 remaining within the casing 12 after the duct members have been extended may also be formed of dissolvable material for removal by chemical action instead of by drilling away.

It will be apparent that the described method and apparatus provides novel means for setting or forming ducts through the casing 12 and cement 13 without in any way damaging the casing 12 or cracking or shattering the cement seal 13. It will also be apparent that the elimination of cutting or perforating set cement eliminates any damage to the sealing bond between the cement 13 and the casing 12 and the bond between the cement 13 and the inner surface of the bore hole 10. This feature is of great importance because it prevents any leakage along the bore outside of the casing 12 of acids applied to treat a given stratum 14 and hence eliminates possible loss of treating chemicals into the more porous strata. The use of packers within the casing 12 to confine the treating chemicals to a desired strata is well known. It will also be apparent that the duct forming devices used with the above-described method may vary in details from the embodiment shown without departing from the scope of this invention as defined in the following claims.

We claim:

1. In apparatus for use in a bore hole traversing a porous stratum to be tapped; a duct-forming device adapted to be supported by and within a bore hole casing, said device comprising tubular supporting means mountable in an opening in the wall of said casing and opening inwardly and outwardly of said casing, a hollow member slidable outwardly in said supporting means to contact the outer end of said hollow member with said porous stratum, said hollow member being initially closed at its inner end, releasable means engaging said supporting means and said member to retain said member within the confines of the outer periphery of said casing as said casing and member are lowered into a bore hole, and locking means engaging said supporting means and said member to retain the outer end of said hollow member in contact with said stratum after said member is moved outwardly in said supporting means with respect to the surface of said casing, said closed inner end of said hollow member being removable to provide a duct from said porous stratum into said casing.

2. In apparatus for use in a bore hole traversing a porous stratum to be tapped; a duct-forming device adapted to be supported by and within a bore hole casing of smaller diameter than the diameter of said hole, said device comprising tubular supporting means mountable in an opening in the wall of said casing and opening inwardly and outwardly of said casing, a tubular member slidable outwardly in said supporting means, the outer end of said tubular member being open and the inner end being closed, releasable means engaging said supporting means and said tubular member to retain said member with its open outer end within the confines of the outer periphery of said casing as said casing and member are lowered into said bore hole, and locking means engaging said supporting means and said member to retain the open outer end of said tubular member in contact with said porous stratum when said member is moved outwardly in said supporting means, the closed inner end of said tubular member being removable by drilling to open a duct through said member from the interior of said casing to said porous stratum.

3. In apparatus for use in a bore hole traversing a porous stratum to be tapped; a casing of smaller diameter than the diameter of said hole, a duct-forming device supported by and within an opening in the wall of said casing, said duct-forming device including a tubular member slidably mounted in the wall of said casing for move-

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ment outwardly, releasable means connected to said casing and engaging said tubular member to retain said member within the confines of the outer periphery of said casing as said casing and member are lowered into said bore hole, and locking means connected to said casing and engaging said member to retain the outer end of said tubular member in contact with said porous stratum when said member is moved outwardly in said casing wall, said tubular member providing a duct from the interior of said casing to said porous stratum adapted to be embedded in sealing material in the space between the exterior surface of said casing and the wall of said bore hole.

4. In apparatus for use in a bore hole traversing a porous stratum to be tapped; a duct-forming device adapted to be supported by and within a bore hole casing, said device comprising a supporting bushing mountable in an aperture in the wall of said casing and opening inwardly and outwardly of said casing, a hollow tubular member slidably mounted in said bushing for movement outwardly to engage the outer end of said member with the wall of said stratum, the end of said member within said casing being closed, a shear pin releasably connecting said hollow member to said bushing to retain said member with its outer end within the outer portion of said bushing during insertion of the casing and member into a bore hole, a portion of the outer cylindrical surface of said hollow tubular member being serrated, a spring finger carried by said bushing and engaging said serrated surface of said member when in its outward position to retain said member against inward movement in said bushing, and a flexible sealing ring mounted in said bushing and engaging the outer cylindrical surface of said member, the closed end of said member being removable after said member is moved outwardly to provide a passage through said member from the interior of said casing to the surface of the stratum to be tapped.

5. In apparatus for use in a bore hole traversing a plurality of porous strata to be tapped; a well casing adapted to be lowered into said bore hole, a plurality of lateral duct-forming devices supported by said casing at spaced intervals corresponding to the distance between strata to be tapped, each of said duct-forming devices comprising a tubular supporting bushing mounted in an opening in the wall of said casing and opening inwardly and outwardly of said casing, and a tubular member slidably mounted in said bushing for lateral movement outward to engage the outer end of said member with the wall of said one of said strata, said tubular member being initially closed at its inner end, and releasable valve means associated with the lower end of said casing defining a passage for the flow of fluid sealing material from within said casing outwards and upwards between said casing and said bore hole and around said duct-forming devices.

6. The method of sealing a casing in a bore hole traversing a porous stratum to be tapped, the steps comprising: lowering into said bore hole a casing; then moving a slidable member laterally outwardly in said casing to engage the outer end of said member with said stratum; next forcing fluid sealing material downward through said casing and then upward between said casing and the wall of said bore hole and around said member; and after said sealing material has set, opening a passage through said member to form a duct extending between the interior of said casing and said porous stratum.

7. The method of sealing a casing in a bore hole traversing a plurality of porous strata to be tapped, the steps comprising: lowering into said bore hole a casing, then applying fluid pressure within said casing to move slidable members laterally outwards in said casing to engage the outer ends of said members with said strata; next forcing fluid sealing material under greater pressure downward through said casing and upward between said casing and

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the wall of said bore hole and around said members to form a seal bonded to said casing, to said members and to said bore hole wall; and after said sealing material has set, cutting away portions of said members within said casing to form ducts between the interior of said casing and said porous strata.

8. The method of sealing a casing to the walls of a bore hole traversing porous strata to be treated and tapped, the steps comprising: lowering into the center of said bore hole a closed casing of smaller diameter than said hole; then applying fluid pressure within said casing to force slidable members laterally outwardly relative to said casing into contact with said strata; next introducing fluid sealing material within said casing under greater pressure to open flow passages at the bottom of said casing and flow upward around the outside of said casing, filling the space between said casing and the walls of said bore hole adjacent to said strata; and meanwhile maintaining said members in stationary contact with said strata while said sealing material hardens.

9. The method of acidizing porous strata traversed by a bore hole, the steps comprising: positioning in said bore hole a casing; then applying fluid under pressure within said casing to push slidable members laterally outwardly in said casing to contact the outer ends of said members with said strata; next introducing fluid sealing material under pressure downward through said casing and into the space between said casing and the wall of said bore hole; after said material has set, opening passages through said members from the interior of said casing to said porous strata; and then introducing an acid solution into selected strata through said members.

10. A method of sealing a casing to the walls of a bore hole traversing porous strata to be treated and tapped, the steps comprising: positioning a casing in the bore hole; then introducing unset fluid sealing material into the space between said casing and the wall of said bore hole; next moving slidable members laterally outwards in the wall of said casing and through said unset sealing material to contact the outer ends of said members with said porous strata before said sealing material sets; and after said sealing material sets, opening passages through said members to provide communication between said strata and the interior of said casing.

11. An apparatus for use in a bore hole traversing a porous stratum to be tapped, comprising: a duct-forming device adapted to be supported by and within a bore hole casing, said device including tubular supporting means mountable in an opening in the wall of said casing and opening inwardly and outwardly of said casing; a hollow member slidably outwardly in said supporting means to contact the outer end of said hollow member with said porous stratum, said hollow member being initially closed at its inner end; releasable means engaging said supporting means and said hollow member to prevent lateral outward movement of said member relative to the casing as said casing and member are lowered into a bore hole; and locking means engaging said supporting means and said hollow member to retain the outer end of said hollow member in contact with said stratum after said member is moved outwardly in said supporting means with respect to the surface of said casing, said closed inner end of said hollow member being removable to provide a duct from said porous stratum into said casing.

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