

Oct. 7, 1958

S. M. ZANDMER
DUCT-FORMING DEVICES

2,855,049

Filed Nov. 12, 1954

Fig. 1

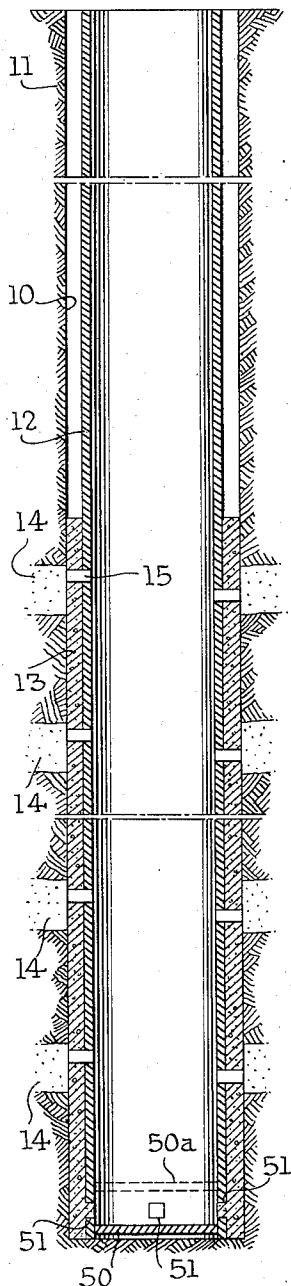


Fig. 2

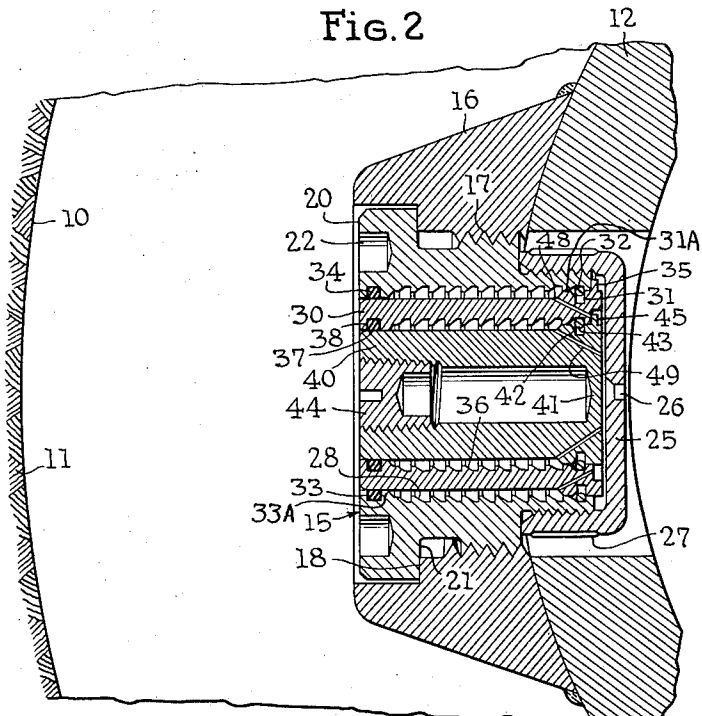
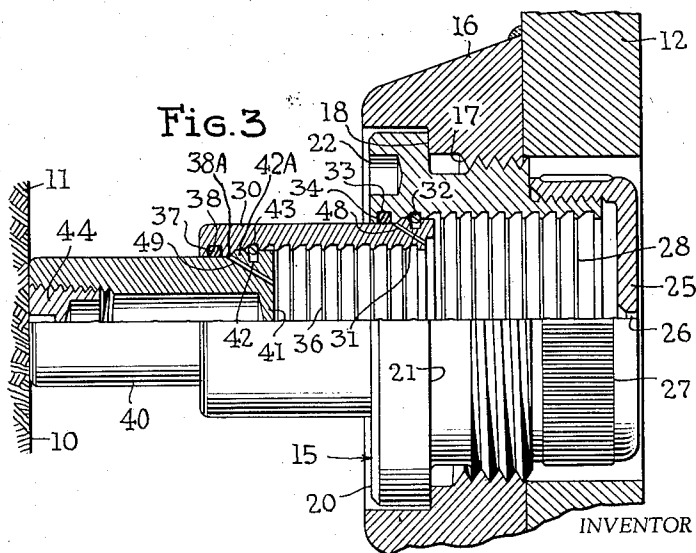


Fig. 3



Solis Myron Zandmer

BY *Lee B. Kemmer*

ATTORNEY

1

2,855,049

DUCT-FORMING DEVICES

Solis Myron Zandmer, Calgary, Alberta, Canada

Application November 12, 1954, Serial No. 468,470

5 Claims. (Cl. 166—100)

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

Heretofore, borehole casings or liners have been set in drilled boreholes 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 or liner. The cement fills the space between the outside of the casing or liner and the surrounding earth or formation through which the borehole extends. It has then been customary to perforate the casing or liner and the surrounding cement at the level or levels of producing strata by means of horizontal drilling or by means of gun-type perforators which force a projectile through the casing or liner and the cement to form passageways or ducts therethrough. Said known methods and apparatus have produced various difficulties such as a shattering of the cement seal, the destruction of the sealing bond between the casing or liner and the cement, and the formation of vertical cracks in the cement which make the cement subject to destructive attack by acids subsequently used to acidize and improve the flow of fluids from productive strata. Cracks in the cementitious seal also may permit acids or other production stimulating materials to leak from a less permeable stratum to a more permeable stratum while attempting to apply pressure selectively at other given bands or areas of perforations.

It is an object of the present invention to provide improved apparatus for forming a duct or passageway through the borehole casing or liner and the surrounding cement seal to establish communication between a selected producing stratum and the interior of the casing or liner.

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

It is another object of this invention to provide duct-forming devices which are extendable laterally from a borehole casing or liner into contact with earth strata either before or after sealing cement is applied around the casing or liner, the extended devices being locked in the extended position while the sealing cement sets around the devices.

A still further object of the invention is to provide an extendable duct-forming device adapted to be extended by the application of definite fluid pressures thereto, and also which can be adapted to be dissolved by the application of an acid thereto.

Other objects and advantages of this invention will be readily apparent from the following detailed description of a preferred embodiment of the improved duct-forming device and its method of use. In the accompanying drawings forming a part hereof:

2

Figure 1 is a vertical section view, partly cut away and partly diagrammatic, of a borehole provided with a casing sealed in a formation and indicating diagrammatically the location of duct-forming devices.

Figure 2 is an enlarged horizontal section view showing one of the duct-forming devices in initial position before being extended to contact a producing stratum, and before the seal cement is placed in position.

Figure 3 is an enlarged section view of the duct-forming device in its fully extended position.

Referring to the drawings for the purpose of illustration, a borehole 10 is drilled in the earth 11 by any conventional drilling apparatus. In drilling a bore through limestone formations, for example, the borehole 10 may be of approximately nine inches in diameter and will have a relatively smooth regular surface. A borehole casing or liner 12 is positioned in the borehole 10, and may be formed of steel or aluminum casing of about seven inches outside diameter. Thus, an annular space about one inch across is provided between the outer surface of the casing or liner 12 and the wall of the borehole 10. The casing or liner 12 is sealed to or set in the formation 11 by means of cement 13. The cement 13 may be Portland cement or any other composition or settable plastic material not adversely affected by oil, gas, or borehole treating chemicals.

Earth formations 11 usually have a plurality of oil or gas producing strata indicated in the drawing by numeral 14. Some of the strata 14 may be more permeable than other adjacent strata. The permeability and porosity of the individual strata may be determined by analysis of specimen cores and porosity by electrical testing apparatus, and such porosities and permeabilities are usually expressed in terms of percentages and millidarcies, respectively. Where a borehole traverses several strata of different permeabilities 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 the 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 permeability. In actual practice some strata 14 may be found to be of small thickness and possibly spaced only a few feet apart vertically.

The section of well casing or liner 12 adjacent to strata 14 is provided before its introduction into the borehole with a plurality of duct-forming devices 15 mounted in the wall of the casing or liner 12 at levels to correspond with the indicated levels of the strata 14 to be treated and tapped. One such duct-forming device will now be described first with reference to its original position shown in Figure 2. As shown in Figure 2, the duct-forming device comprises a mounting ring 16 having a curved surface welded to the outer surface of the casing or liner 12, and a series of telescoping sleeves mounted in the ring 16. The rings are provided with sloping sides to facilitate the insertion of the casing or liner 12 into a borehole. The mounting rings 16 serve to prevent contact between the casing or liner 12 and the wall of the borehole so that seal cement may later be run into the annular space. The ring 16 has a central bore aligned with an opening in the casing or liner 12, and is provided with internal threads 17 and a shoulder 18 engaged by the duct-forming device 15.

The duct-forming device 15 includes an outer sleeve or bushing 20 threaded in the mounting ring 16 and having a shoulder 21 engaging the shoulder 18. The bushing 20 has recesses 22 for the application of a wrench to tighten the duct-forming device in the mounting ring. The bushing 20 is provided with a threaded cap 25 at its inner end, the cap 25 being threaded onto the bushing and having a central aperture 26. The cap 25 may have

3

a knurled edge 27. The inner bore of the bushing 20 is provided with a plurality of annular grooves 28 forming a serrated inner surface. The grooves 28 have forward frusto-conical surfaces inclined toward the outer end of the device, and have rearward surfaces substantially perpendicular to the axis of the device. The sleeve 30 is slidably mounted within the bushing 20, and has an annular groove 31 in its outer surface near its inner end. A spring ring 32 is carried in the groove 31 and tends to expand and engage the grooves 28 of the bushing member 20 when the sleeve 30 moves outward in the bushing. The spring ring 32 serves as a locking member to prevent movement of the sleeve 30 back into the bushing 20 once the sleeve has been moved outward in the bushing. The bushing 20 is provided with a groove 33 containing an O-ring 34 engaging the outer surface of the sleeve 30 to form a pressure seal between the bushing and the sleeve. The sleeve 30 has at its inner end a projecting flange 35 which engages the inner end of the bushing 20 to prevent movement of the sleeve outward in the bushing until a predetermined fluid pressure is applied to the inner end of the device. When the proper pressure is applied, the flange 35 is sheared away permitting the sleeve 30 to move outward in the bushing 20. An inner sleeve 40 is slidably mounted within the sleeve 30 and has a relatively thin closure 41 at its inner end. The sleeve 30 has its inner bore provided with a plurality of annular grooves 36 forming a serrated inner surface. The grooves 36 have frusto-conical forward surfaces inclined toward the outer end of the sleeve and have rearward surfaces substantially perpendicular to the axis of the device. The sleeve 40 is slidably mounted in the sleeve 30 and likewise has an annular groove 42 on the outer surface of its inner end to contain an expandable spring ring 43. The outer end of the bore of the sleeve 40 is threaded to receive a threaded plug 44. The inner end of sleeve 40 is provided with a flange or flanges 45 engaging the inner end of sleeve 30 in the original position of the device. The flange 45 is adapted to be sheared away when a desired predetermined pressure is applied to the inner end of the device to allow the sleeve 40 to move outwardly within the sleeve 30. The sleeve 30 is provided with an O-ring 37 in a groove 38 to engage the outer surface of the sleeve 40.

Referring to Figure 3, the duct-forming device is shown in its fully-extended position. A small passage 48 is provided in the inner end of the sleeve 30 to form an exit for grease or the like packed in the space between bushing 20 and sleeve 30. As the sleeve 30 is forced outward in the bushing 20, any grease in the space and grooves 28 may exit through the passage 48. A similar passage 49 is provided in the inner end of the sleeve 40 to form an exit for grease in the space between the sleeves 30 and 40. The shearable flange 35 shown in Figure 2 may be continuous or segmental, and may be of a size and thickness such as to be sheared away upon the application of a fluid pressure of the order of two thousand, four hundred pounds per square inch, or less if desired, to the inside of the casing or liner 12. The shearable flange 45 on the inner end of sleeve 40 may also be continuous or segmental, and may be of a size and thickness such as to be sheared away upon the application of a fluid pressure of the order of two thousand, six hundred pounds per square inch, or less if desired, to the inside of the casing or liner 12. The duct-forming device is thus designed to extend in two steps or phases, sleeves 30 and 40 moving outward together at one time under one pressure, and then sleeve 40 moving outward in sleeve 30 under the application of a larger pressure. It is desirable that the larger outer sleeves contact the wall of the bore hole so that the openings through the casing to the producing strata be as large as possible. Due to irregularities in the annular interval between the casing and the bore hole, however, the inner sleeves are provided and will be released at a higher pressure in or-

4

der that each duct forming device will in fact contact the wall of the bore hole since a small opening is better than no opening at all. As shown diagrammatically in Figure 1, the lower end of the casing or liner 12 may be closed by a releasable valve or plate 50. The application of a predetermined fluid pressure within the casing or liner 12 acts upon the plate 50 to force the plate downward from the initial position 50a shown in dotted lines to a position 50 below the lateral openings 51 in the casing or liner 12. The openings 51 permit sealing cement in a fluid state to be pumped downward in the casing or liner 12 and thence outward through the openings 51, and thence upwardly in the annular space between the casing or liner 12 and the borehole wall, such cement being illustrated by the numeral 13 in Figure 1. The entire duct-forming device is preferably formed from magnesium or aluminum metal, excepting the O-rings and the spring rings, in order that the device may be dissolved by the application of hydrochloric acid solutions thereto.

The preferred method of operation will now be described. A borehole 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 borehole 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 exerted through the aperture 26 against the inner ends of the sleeves 30 and 40 is great enough to shear the flange 35. The sleeves 30 and 40 then move outward together until their outer ends engage the borehole wall or until the flange 31A adjacent the groove 31 on the outer surface of sleeve 30 engages the flange 33A adjacent the groove 33 of bushing 20 thereby stopping further relative movement. After the sleeves 30 and 40 have been moved outward to the limit of travel without engaging the wall of the borehole, the application of an increased fluid pressure within the casing or liner 12 will be effective to shear the flange 45 on sleeve 40 to allow the sleeve 40 to be moved outward with respect to the sleeve 30. Once the end of sleeve 40 engages the borehole wall, further extension of the duct-forming device is unnecessary. Relative outward movement of sleeve 40 with respect to sleeve 30 is limited by means of the flanges 42A and 38A on 40 and 30 respectively, which are in engagement at the outer limit of travel of sleeve 40 with respect to sleeve 30. The action of the expandable locking rings 32 and 43 prevents any inward movement of the sleeves 30 and 40 in the bushing 20. Next, sealing cement under a greater fluid pressure is forced into the casing 12 so as to open or force downward the releasable bottom closure 50 of the casing 12 from position 50a to the position illustrated below the lateral passages 51, the fluid cement then passing through passages 51 and upwards, filling the space between the outer surface of the casing 12 and the wall of the borehole 10. The duct devices 15 are surrounded by the cement 13 and extend 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 borehole 10, an acid solution is introduced into the casing or liner 12 and pressure is applied to force the acid through the aperture 26 and against the closed end 41 of the sleeve 40. The acid solution dissolves the cap 25, the bushing 20, the sleeve 30, the sleeve 40, and also the plug 44. Clear ducts are thus provided through the seal cement 13 from the interior of the casing or liner 12 to the wall of the porous formation strata 14 without the application of any shattering

5

forces to the seal cement 13, as by explosive perforating methods, or the like. By the use of a cement having a known and definite setting time, it is possible to first cement the casing or liner in position and to then force the sleeves of the duct-forming devices outward through the seal cement before the latter sets.

It will be apparent that the described 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 the cutting or the perforating of 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 borehole 10. This feature is of great importance because it prevents any leakage along the bore outside of the casing 12 of acids or fluids applied to treat a given strata 14 and hence eliminates possible loss of treating chemicals into the more permeable strata. The use of packers or straddle tools 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.

I claim:

1. In apparatus for use in a borehole traversing a porous stratum to be tapped, a duct-forming device adapted to be supported by a borehole casing having an opening through the wall thereof, said duct-forming device comprising: a supporting bushing mountable on the wall of said casing with the bore of the bushing in alignment with the casing opening, a hollow member mounted in and movable outwardly in said supporting bushing, a second hollow member mounted in and movable outwardly in said first-mentioned hollow member to contact the outer end of said second member with the wall of a porous stratum, locking means between said bushing and said first hollow member operable when said member has been moved outwardly of said bushing to secure said member against movement inwardly in said bushing, additional locking means between said first hollow member and said second hollow member operable when said second member has been moved outwardly of said first member

6

to secure said second hollow member against movement inwardly in said first hollow member, and shearable means between said bushing and said first member and between said first member and said second member, said shearable means being operable to release said members for movement outwardly upon the application of a predetermined fluid pressure within said casing, said shearable means between said bushing and said first member being shearable at a lower fluid pressure applied within the casing than said shearable means between said first and second hollow members.

2. Apparatus as defined by claim 1 in which said locking means comprise a pair of expansible spring rings, one mounted on each of said hollow members, and serrated surfaces on the inner surface of said bushing and said hollow member with which said rings are engaged.

3. Apparatus as defined by claim 1 and in which each of said hollow members include radially outwardly projecting shoulders at their inner ends, and said bushing and said outer hollow member each include radially inwardly projecting shoulders at their outer ends, said shoulders on said bushing and said outer hollow member and said outer and said inner hollow member being engageable to limit outward travel of said hollow members.

4. Apparatus as defined by claim 1 in which said shearable means comprise radially outwardly projecting lugs on said hollow members, the lugs on the outer hollow member engaging a portion of said bushing and the lugs on the inner hollow member engaging a portion of said outer hollow member.

5. A duct forming device of the character defined in claim 1 in which said bushing and said hollow members are formed of a metal dissolvable in the ordinary well acidizing solution.

References Cited in the file of this patent

UNITED STATES PATENTS

1,928,533	Goss	Sept. 26, 1933
2,201,290	Greene	May 21, 1940
2,381,929	Schlumberger	Aug. 24, 1945
2,707,997	Zandmer	May 10, 1955
2,708,000	Zandmer	May 10, 1955