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APPARATUS FOR SEALING A BOREHOLE LINER

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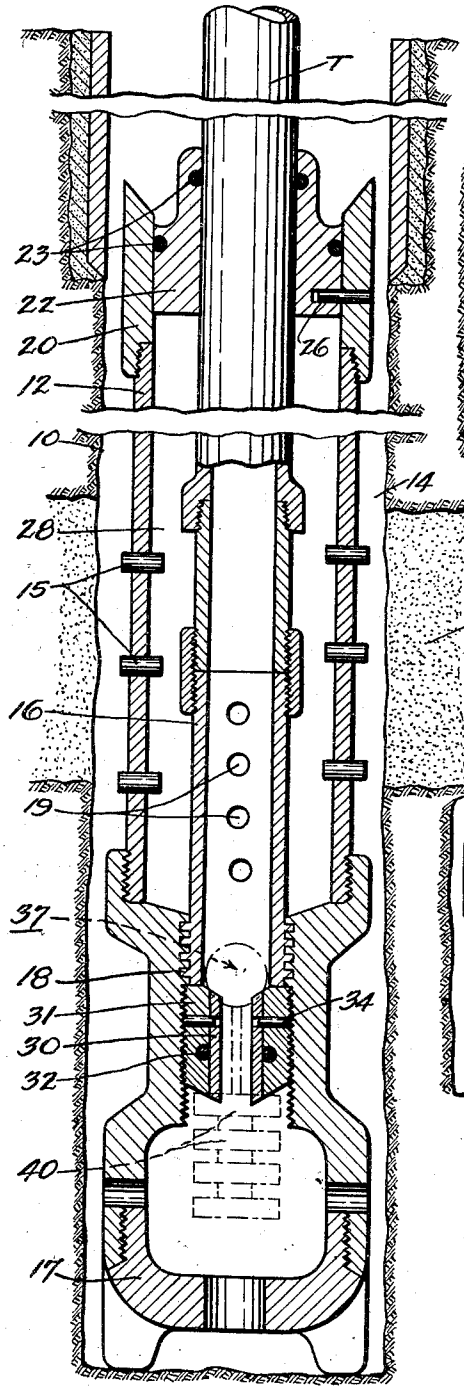


Fig. 1

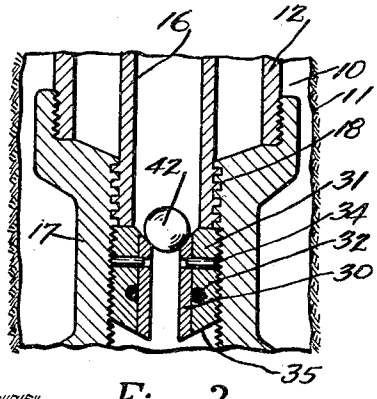


Fig. 2

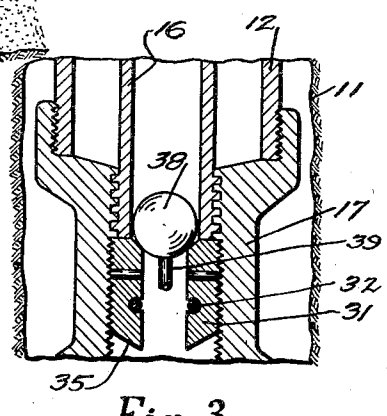


Fig. 3

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APPARATUS FOR SEALING A BOREHOLE LINER

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6 Claims. (Cl. 166—100)

This invention relates to improved apparatus for sealing a bore hole liner in a bore hole.

In lowering a liner into a bore hole traversing productive strata to be tapped, which is subsequently to be sealed by the application of cement in the annular space between the wall of the bore hole and the liner, a string of tubing is screwed at its lower end to the top of the liner bottom shoe. The sections of tubing are connected together by right-hand threaded couplings, and the end of the lowermost tubing is connected to the shoe by coarse left-hand threads so that after the cement has set, the tubing can be disconnected from the liner, more particularly from the shoe, by turning the tubing to the right. It is well known that sometimes the tubing is not easily screwed out of the liner shoe, with the result that the seal between the liner and the wall of the bore hole is damaged or weakened. In some extreme cases, it has been impossible to detach the tubing from the shoe because the threads had become jammed.

In well holes sealed in accordance with the inventions shown in my copending application Serial No. 294,251, filed June 18, 1952, now U. S. Letters Patent 2,708,000, and in my Canadian application Serial No. 639,643, filed December 1, 1952, duct-forming devices are attached to the liner before it is lowered into the bore hole, the pistons or movable parts of the devices are moved outwardly to engage the wall of the bore hole, and portions of the pistons or other parts are dissolved or removed. The present invention concerns methods of using such duct-forming devices and an improved liner construction having a plurality of such duct-forming devices.

Another object of the invention is to provide a novel means by which the string of tubing is easily detached from the liner, more particularly from the bottom shoe of the liner, doing away with the necessity of unscrewing, as obtains under the present day practice, the tubing from the bottom shoe.

Another object of the invention is to provide novel apparatus by means of which any sealing material which has spilled over the adapter of the liner may be flushed or disposed of while the tubing is still attached to the shoe, that is, without having first to detach the tubing from the shoe as obtains under present day practice.

Other objects and advantages of this invention will be readily apparent from examination of the accompanying drawing and the following specification.

In the drawing, wherein is shown the preferred form of the invention,

Figure 1 is a fragmentary longitudinal section of a well hole containing apparatus according to the invention;

Figure 2 is a fragmentary view of Figure 1; and,

Figure 3 is a view similar to that of Figure 2, one of the valve seats having been removed.

As explained in my said copending application and in my Canadian application, into a hole 10 traversing productive horizons or bands 11 to be tapped for oil is lowered a liner 12 having attached thereto a plurality of duct-forming devices 15. For a detailed showing of the duct-forming devices 15, reference may be had to Figures 2–4, inclusive, of my prior U. S. Letters Patent 2,708,000. The annular space 14 between the liner and the wall of the bore hole is filled with a suitable material (not shown) to seal the liner to the wall and thereby isolate one horizon or stratum from all others of varying permeability. The material is intended to bind itself to both the wall and to the liner.

According to the usual practice, the liner 12, more particularly its lowermost section, is attached to a shoe 17, the shoe, in effect, forming a part of the liner. The liner is lowered into the bore hole by means of a string of tubing T, the lowermost end of which is threaded in the bore of the shoe 17.

The tubing, of necessity, is made of aligned sections of pipe, usually 30 feet in length each, connected together by right-hand threaded couplings. The upper end of the bore of the shoe of the liner is threaded with a coarse left-hand thread 18 by which the tubing is effectively attached to the liner.

In accordance with this invention, and as shown, the lower end of the lowermost section of tubing includes a sleeve or coupling 16 of a material readily dissolved in conventional acids, that is, acids such as hydrochloric acid, currently used in acidizing wells. One suitable material for the sleeve 16, for instance, is magnesium. Preferably, the sleeve 16 has a number of holes or ports 19. Threaded to the upper end of the liner 12 is a tubular member or adapter 20 forming the upper portion of the liner. Slidable on the tubing and in the adapter 20 is an annular block or member 22, O rings 23 being used to provide a fluid-tight sliding connection or joint between the block and the cooperating faces of the tubing and of the adapter. The block or closure 22 is releasably secured to the adapter 20 by one or more shear pins 25, only one being shown. The ports 19 afford communication between the interior of the tubing and an annular chamber 28 defined by the block 22 and the shoe 17 and by the tubing T and liner 12. The length of this chamber is at least co-extensive with the length or distance, lengthwise of the liner, within which the duct-forming devices 15 are located.

Secured in the bore of the shoe 17, below the sleeve 16, are valve seats. As shown, the seats are formed of two concentric, telescoped sleeves or rings 30 and 31, the upper edges of which are bevelled to provide the seats. The outer sleeve or ring 31 may be threaded in the bore of the shoe. The inner sleeve 30 is provided with an O seal ring 32 to provide a fluid-tight connection between the two sleeves. The inner sleeve is releasably locked to the outer sleeve by one or more shear pins 34. The lower edge of the outer ring is bevelled as at 35.

The inner sleeve is adapted to support a ball 42, say of aluminum, adapted effectively to seal or close the lower end of the sleeve 16, below the ports 19, when a liquid is pumped into the tubing to fill the chamber 28 to actuate the duct-forming devices 15.

The inside diameter of the outer sleeve 31, on the other hand, is such that the ball 42 may be freed to fall to the bottom of the shoe when the inner sleeve 30 is freed to fall into the bottom of the shoe as when the shear pins 34 have been severed.

After the inner sleeve 30 has been sheared off with outer sleeve 31, as aforesaid, a conventional plug is used to close the bore of the shoe after the layer of sealing material has been pumped up into the annular space 14 to seal the liner to the wall of the bore hole. Such plug, shown in dot and dash as 37, includes a larger metal ball 38 and a depending rod 39 suspending a num-

ber of superposed and oppositely disposed pairs of rubber cups 40.

The ball 38 is of a diameter larger than the inside diameter of the outer sleeve 31, so that, as shown, the ball rests or seats on the upper bevelled edge or seat of the outer sleeve and closes or seals the upper end of the bore of the shoe 17; and the uppermost rubber cup extending under the lower bevelled edge 35 of the outer sleeve 31, not only seals the lower end of the bore of the shoe but locks the conventional plug 37 in operative position, thus holding or supporting the sealing material in the annular space 14, particularly while it is setting.

As already stated, the plungers of the duct-forming devices 15 are first actuated to engage the wall of the bore hole. The inner valve sleeve 30 is then released by the severance of the shear pins 34 so that communication is established between the interior of the tubing and the annular space 14, and after the sealing material has been forced upwardly into the annular space 14 and the plug 37 is in operative position, the shear pin 26 is severed to release the adapter 22. Therefore, it is obvious that the shear value of the shear pin 34 is less than the shear value of the shear pin 26, and also that the shear value of the shear pin 34 is such that the plungers of the duct-forming devices will be actuated before the shear pin 34 is severed.

The present invention, in one of its aspects, is applicable to a conventional liner, that is, one not having duct-forming devices attached thereto. In the case of a blank or conventional liner, the block 22 shown in Figure 1 is eliminated and the sleeve 16 has weakened zones in lieu of the holes 19 of Figure 1. The portions defined by the weakened zones are adapted to shear off at a pressure greater than that required to sever the shear pin 34. Thus, after the sealing material has been forced up into the annular space 14, pressure is increased to shear or blow out the weakened zones, so that liquid may be forced up between the liner and the tubing to wash up the sealing material which has overflown or spilled over the adapter.

The method of operation of the apparatus shown and described is as follows. The liner 12, with duct-forming devices 15 attached thereto, is lowered into the bottom of the bore hole by the tubing T. After free circulation has been established, the ball 42 is dropped into the tubing, seating itself on the seat of the inner sleeve 30. Liquid is pumped into the tubing, thus pushing the plungers of the duct-forming devices 15 outwardly to engage the wall of the bore hole. Increasing the pressure on the liquid pumped into the tubing T severs the shear pin 34 between the inner sleeve and the outer sleeve, and the ball 42 and the inner sleeve 30 fall through the bore to the bottom of the shoe. A charge of sealing material is then poured into the tubing, and a conventional plug 37 placed on top of the charge. Pump pressure is then applied to displace the sealing material downwardly in the tubing, outwardly through the shoe, and upwardly into the annular space 14. The charge is preferably such that it will rise above the upper end of the adapter 20 of the liner. When the ball 38 of the plug 37 seats itself upon the outer sleeve 31, the pump pressure is increased to sever the shear pins 26 and release the block or plunger 22. The block 22 is now free to rise in the adapter, and free circulation is now established between the interior of the tubing and the interior of the liner 12, so that the sealing material which has overflown or spilled over the adapter 20 may now be washed out of the inside of the liner 12.

When it is desired to detach the tubing T from the liner 12, a charge or volume of acid, such as hydrochloric acid, is pumped into the tubing T to immerse the sleeve 16 in the acid so that the sleeve will be dissolved. The dissolving action of the acid may be accelerated by forcing the acid to flow back and forth through the ports 19. When the sleeve 16 has been dissolved, the tubing T may be pulled from the bore without turning or unscrewing, and consequently the bond between the line 12 and the bore wall and the duct-forming devices 15 is not disturbed. The acid also dissolves soluble portions of the duct-forming devices 15, to open the devices for free communication between the stratum 11 and the interior of the liner 12.

What I claim is:

1. In combination with a liner to be sealed in a bore hole, said liner having a plurality of pressure operated duct-forming devices mounted in and movable outwardly through the wall of said liner to engage the wall of the bore hole; tubing removably attached to a lower portion of said liner for lowering said liner into the bore hole and establishing communication between the interior of said tubing and the annular space between said liner and the wall of the bore hole, said tubing including a lower portion within the liner and having ports through its wall, an annular member between an upper portion of said liner and said tubing defining with said liner and tubing an annular pressure chamber in communication with said tubing and said devices, releasable means securing said annular member to said liner and operated by pressure in said chamber against said annular member to release said annular member from said liner, an outer annular valve seat fixed in said liner below said ports, an annular valve seat within said outer valve seat, releasable means securing said inner valve seat within and to said outer valve seat and operated by pressure in said chamber against said inner valve seat to release said inner valve seat, and a valve member engageable with said inner valve seat, said releasable means for said annular member having a release pressure greater than the release pressure of said releasable means for said inner valve seat.

2. In combination with a liner including a bottom shoe, to be sealed in a bore hole, said liner having pressure operated duct-forming devices mounted in and movable outwardly in the wall of said liner to engage the wall of the bore hole; tubing extending into said liner and threaded in the bore of said shoe for lowering said liner into the bore hole and establishing communication between the interior of said tubing and the annular space between said liner and the wall of the bore hole, said tubing having ports through its wall, an annular member between said tubing and an upper portion of said liner defining with said liner and tubing an annular pressure chamber in communication with said ports so that pressure within said tubing is communicated to said annular chamber to actuate said devices, shearable means releasably locking said annular member to said liner and operated by pressure in said chamber against said annular member to release said annular member from said liner, an outer annular valve seat fixedly secured in the bore of said shoe below said ports, and an inner annular valve seat within said outer valve seat, releasable means securing said inner annular valve seat to said outer valve seat and operated by pressure in said chamber against said inner valve seat to release said inner valve seat from said outer valve seat, and a valve member engageable with said inner valve seat, said releasable means for said annular member having a release pressure greater than the release pressure of said releasable means for said inner valve seat.

3. In combination with a liner, including a bottom shoe, to be sealed in bore hole; a section of tubing within said liner and attached at its lower end in the bore of said shoe, tubing attached at its lower end to said section, and forming therewith the means for lowering said liner into the bore hole and establishing communication between the interior of said tubing and the annular space between said liner and the wall of the bore hole, said section being made of a material different than that of which the remainder of said tubing is made and said liner is made and dissolvable in an acid which does not dissolve

the material of which said liner and the remainder of said tubing are made.

4. In combination with a liner, including a bottom shoe, to be sealed in a bore hole; a section of tubing within said liner and threaded at its lower end in the bore of said shoe, tubing attached at its lower end to said section and forming therewith the means for lowering said liner into the bore hole and establishing communication between the interior of said tubing and the annular space between said tubing and the wall of the hole, said section being made of a material different than that of which said liner and the remainder of said tubing are made and dissolvable in acid which does not dissolve the material of which said liner and the remainder of said tubing are made, and said shoe having valve and valve seat means in the bore of said shoe effective to close said bore and retain acid in said section to dissolve the same and thereby detach said tubing from said liner.

5. In combination with a liner to be sealed in a well hole, including a bottom shoe adapted to be supported by the bottom of the bore hole, said shoe having a bore formed with a valve seat; tubing extending into said liner and threaded at its lower end in said bore for establishing communication between the interior of said tubing and the annular space betwen said liner and the wall of the bore hole, a valve to engage said valve seat, said tubing including a section adjacent said shoe and made of a material dissolvable in an acid which does not dissolve the material of the remainder of said tubing and said liner, and said section having weakened areas above said valve seat adapted to be removed, when said valve seat is closed by said valve, by application of fluid pressure within said tubing.

6. In combination with a liner to be sealed in a well hole, including a bottom shoe adapted to be supported by the bottom of the bore hole, said shoe having a bore formed with a valve seat; tubing extending into said liner and threaded at its lower end in said bore for establishing communication between the interior of said tubing and the annular space between said liner and the wall of the bore hole, a valve to engage said valve seat, said tubing including a lower portion having weakened areas above said valve seat adapted to be removed, when said valve seat is closed by said valve, by application of fluid pressure within said tubing.

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