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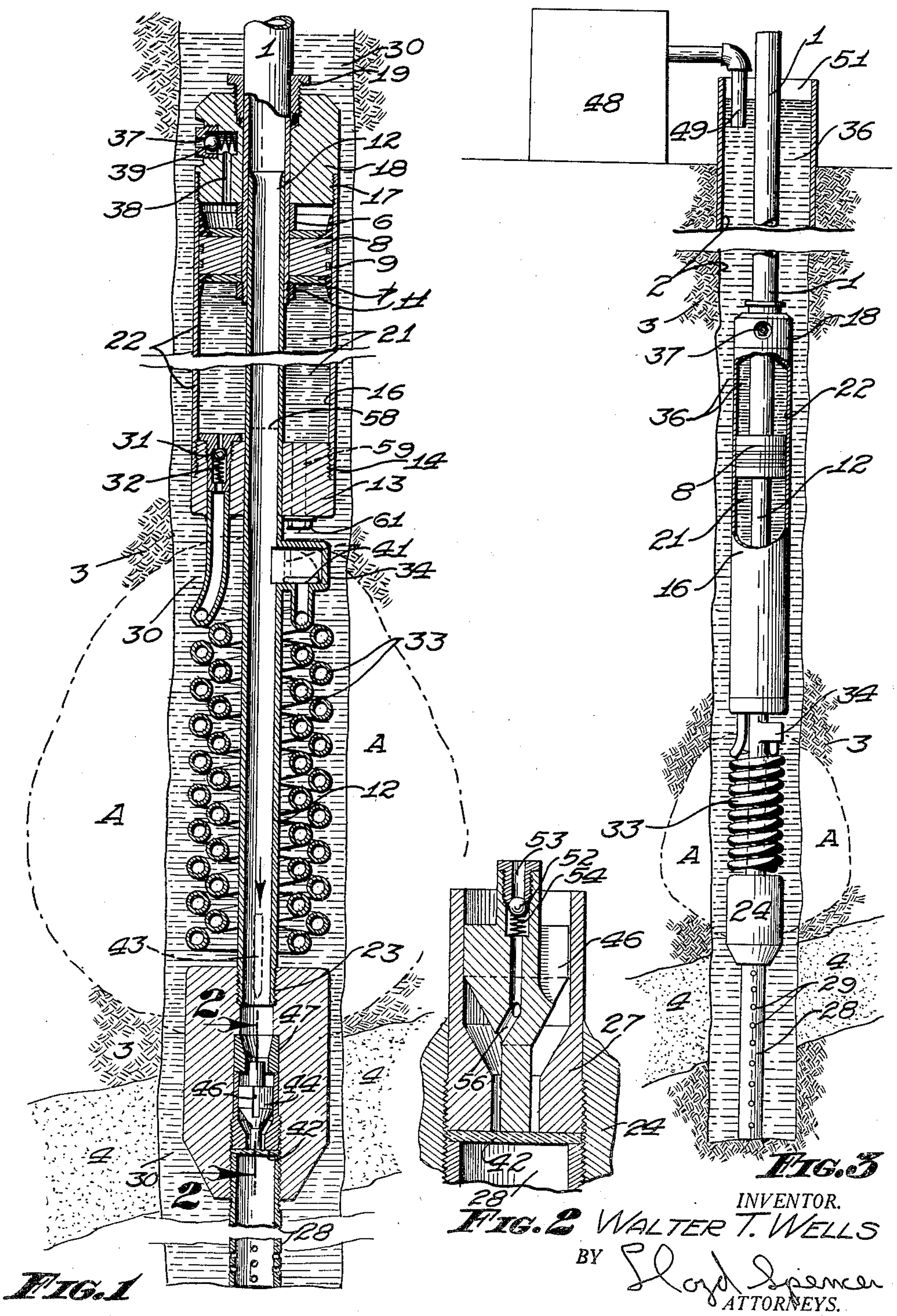

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METHOD OF PACKING WELLS

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9 Claims. (Cl. 166—21)

The present invention relates to a method of packing wells and is a division of my co-pending application entitled: Means for packing oil wells and the like; filed: November 12, 1932, Serial No. 642,369.

The objects of my present invention are:

First, to provide a method of this character which has a wide range of application, it being useful in performing for such operations as formation testing or testing for shoe leaks, location of water intrusion in oil or gas wells, fractures in cement jobs, and segregation or orientation of oil or water producing zones in bores of great depth, breaking up cement that has been set to facilitate its removal, cleaning the well bore of mud accumulations, and many other uses;

Second, to provide a method of this character which is readily adaptable to and usable in conjunction with present-day oil well practice and requires a minimum of special equipment for its execution; and

Third, to provide a method of this character which may be easily and quickly executed.

With these and other objects in view as may appear hereinafter, attention is directed to the accompanying drawing in which Figure 1 is a vertical cross sectional view of an apparatus designed to execute my method, showing the apparatus in position within a well bore; Figure 2 is an enlarged sectional view thereof taken through 2—2 of Figure 1 illustrating particularly the check valve incorporated in the sampler means; and Figure 3 is a diagrammatical view illustrating a modification of my method wherein hydraulic pressure is utilized.

Referring to the drawing, the numeral 1 indicates a tubing string lowered into a well bore 2, here shown as open formation, filled with drilling fluid 3, and terminating below an oil producing stratum 4.

The device hereinafter described is operated in association with a divided tubing string wherein two sections of said tubing are provided with means permitting relative movement of the sections and said movement is utilized to expel a refrigerating agent for the purpose of solidifying all water bearing matter cognate to said tubing string.

But one string of tubing is employed and it serves several purposes. Said string is run into the well "dry", that is to say, closed at the bottom to keep it empty of fluid as it is lowered into drilling fluid or the like.

It thus provides a conduit for the discharge refrigerating agent at substantially atmospheric pressure. When subsequently opened, it affords a means of communication with the producing zone below the frozen area for the recovery of a sample of fluid therefrom, and for circulating, from the mouth of the well, a stream of liquid to expedite thawing or to create hydraulic pressure in the zone below the frozen core.

The lower end of tubing 1, (upper section) is threaded to receive collars 6 and 7. Between said collars is a piston 8, provided with rings 9 and cup leathers 11.

Slidable within the tubing is the upper end member 12 of the lower section of tubing string 1. Welded or suitably secured to member 12 is a cylinder head 13 to which is threaded, at 14, one end of a cylinder 16, the opposite end of which is threaded at 17 to a cylinder head 18, provided with a packing gland 19 through which slides the tubing 1.

The structure so far described provides a cylindrical chamber 21 which is loaded, before the device is lowered into the well 2, with a refrigerant 22, which may be anhydrous ammonia, carbon dioxide, sulphur dioxide or other suitably equivalent.

The member 12 is threaded into a bore 23 in a connector 24. Said bore is enlarged from below and tapped to admit therein a threaded collar 26, a valve cage 27, and one end of a pipe 28 provided with perforations 29.

A rigid connection is thus formed between perforated pipe 28 and member 12 and it results from this that, when pipe 28 encounters the bottom of well 2, cylinder 16 is held stationary and the weight of the entire upper section of the tubing string 1 is effective to move piston 8 through said cylinder and expel the refrigerant 22 through an expansion valve 31 which, under urge of a spring 32, normally closes one end of a pipe coil 33, here shown as a double coil surrounding the member 12 and terminating in a valve cage 34.

As the weight of tubing string 1 moves piston 8 downwardly the space behind said piston is filled with drilling fluid 36, from well bore 2, which enters through passages 37 and 38 normally closed by a spring actuated check valve 39.

The refrigerant 22, under pressure, unseats expansion valve 31, passes through coil 33, lifts a flapper valve 41 (in valve cage 34) to its dotted line position and exhausts into member 12 of the dry tubing string.

The rapid expansion of the refrigerant, thus released, congeals the liquid surrounding the coil 33 and solidifies an area of considerable size in the adjacent formation as indicated by the broken line shaded area A in Figure 1.

This method of sealing or packing an open hole or formation bore, which has no casing, assures a fluid tight seal betwen the tubing string and a surrounding wall which is completely effective, irrespective of inequalities or irregularities of surface, or formation characteristics, which so often defeat mechanically operated packers.

The tubing string 1 has been kept dry up to this point by a membrane or disc 42 compressed between collar 26 and pipe 28 in a manner obstructing passage of liquid into member 12.

When the refrigerating action has taken place, a go-devil indicated in dotted lines at 43 is dropped through tubing string 1, from the mouth of the well, and it strikes the top of a piston valve 44, which rests on said disc 42 and is thereby prevented from seating in its cage 27 until said disc is broken out as described.

As soon as said disc is broken, fluid in the zone below the frozen area is released at substantially atmospheric pressure, and it rushes into member 12 of the tubing string, lifting piston 44 until it abuts collar 26. Said piston is provided with quadrilaterally disposed channels 46, Figures 2 and 3, which communicate with a bore 47 in collar 26.

Fluid continues to rise in the tubing string until it reaches its normal head, being relieved of hydrostatic pressure of drilling fluid in the well by the frozen area 33.

When the pack thaws 33 sufficiently to permit raising of the tubing string, piston valve 44 acts as a foot valve, entrapping the fluid content of the tubing, as the lower tapered end of said valve seats in cage 27 and closes channels 46.

Check valve 37 prevents escape of drilling fluid from cylinder 16 and said fluid, being entrapped, forms a connecting link between the upper and lower sections of tubing string 1, automatically responsive to the first lifting strain.

Said check valve 37 also provides a means for applying pump pressure to piston 8 as shown in Figure 3. Should it be desirable to augment the pressure provided by the weight of tubing string 1, a pump 48 is connected, by a pipe line 49, to the well 2 which is closed at the mouth as indicated at 51. As the pump increases the pressure in the well valve 31 is unseated and piston 8 moved downwardly to discharge refrigerant 22.

It is of course recognized that heat resulting from compressing of the refrigerant before opening of valve 31 must be dissipated to obtain an efficient refrigerating action in coil 33. This may be accomplished in several ways. First, the refrigerant may be introduced in the cylinder 21 under pressure; but such pressure being lower than that necessary to open valve 31. Then upon applying additional pressure either through tubing string 1 or hydraulically through valve 37 the valve 31 is caused to open. The additional pressure need not be such as to heat the refrigerant materially; furthermore, the chamber 21 is quite elongated and the pressure therein may be maintained fairly uniform after the valve 31 is open so that a large percentage of such additional heat will be dissipated through the walls of the cylinder. Very little of this heat will be absorbed by the chilling coil as heat tends to be dissipated upwardly.

Second, as the refrigerator is lowered, the liquid in the well bore tends to maintain an equality of pressure between the exterior of the refrigerator and the upper end of the piston 8, providing valve 37 does not offer too much resistance. This pressure increase lifts the refrigerator structure relative to the tubing string moving the piston relatively downwardly and compressing the refrigerant. In this case as in the first, valve 31 is designed to withstand this pressure. The movement of the piston is gradual and the heat of compression is dissipated to the well fluid as fast as it is generated so that the temperature of the refrigerant does not increase materially. When the refrigerator is in position, additional pressure either hydraulically or by gravity is applied to open valve 31.

Third, valve 37 may be designed to remain closed against the pressure of the well fluid. After the refrigerator is in position the tubing string is moved downwardly shifting the piston a predetermined distance calculated to compress the refrigerant but not open valve 31, and is then held until the resulting heat is dissipated; whereupon the additional pressure is applied.

Pump pressure can also be applied to tubing string 1 to flush the formation below the frozen zone, or to increase pressure at that point.

A check valve 52 is provided in the piston valve 44 and said valve normally closes a port 53 under urge of a spring 54. However when said check valve is unseated fluid enters the port 53 and finds its way through passages 56 which open into a bore 57 in valve cage 27, when the piston valve is seated in said cage.

The piston valve 44, check 52, and cage 27 are also shown and described in my co-pending application for patents, filed September 6, 1932, Serial Number 631,781.

In order to prevent accumulation of frost around expansion valve 31 and its orifice I load coil 33 with an inert fluid containing no moisture. Said fluid is also placed in the lower portion of pipe 12 to a level indicated by the dotted line 58, Figure 1. Said fluid is driven out of coil 32 by the release of refrigerant 22 ahead of piston 8.

It will be seen that pipe 28 can be removed from the foot member 24 and other anchoring means substituted therefor.

I employ a standard thread which makes possible the interchangeable use of either a rat-hole packer of the type illustrated in my copending application Serial Number 634,599, filed September 23, 1932, or a hook-wall packer such as is described in my application Serial Number 614,731, filed June 1st, 1932.

The operation of my invention is as follows:

Formation test.—During the drilling of an oil well, the bit progresses into the ground or formation, passing through various strata. The object is to terminate the well when a formation has been reached containing a supply of oil or gas in quantity sufficient for practical production. While the well is being drilled it contains a quantity of mud laden fluid, known as drilling fluid.

This fluid exerts pressure, dependent upon the height of the fluid, which opposes the natural pressure of the oil or gas contained in the formation through which the well is being drilled.

Oil is usually encountered in formations at considerable depth and at pressures insufficient to overcome the pressure of the fluid in the well.

As the driller does not know the depth at which oil may be present, and to prevent drilling on past an oil bearing stratum of formation without knowledge of its existence, a formation test is made to determine the productivity at a given depth.

My apparatus is assembled as shown in Figure 1 and lowered into the well 2 on the lower end of tubing string 1, the lower section of which is movable with respect to the upper section, said movement being limited to the degree of travel of piston 8 in cylinder 16.

When the lower end member 28 of the bottom section encounters the bottom of the well, the weight of the upper section moves piston 8 and displaces the refrigerant 22, the rapid dissipation of which lowers the temperature in the zone surrounding the coil 33 until a pack or seal A is solidified and seals off the drilling fluid 3 from formation below.

When the well has been packed in this manner, go-devil 43 is dropped through tubing string 1 and its impact shatters the frangible disc 42, opening the tubing string 1 to the influx of fluid from the formation 4. Said fluid, being now opposed by no pressure other than atmospheric, rises within the tubing string 1 to its natural head or level.

The frozen pack A is allowed to thaw and the tubing string 1 is raised. Foot valve 44 seats under pressure of the entrapped fluid sample in the tubing and said sample is lifted within the string.

Water shut off test.—Before a well is placed on a production basis, a string of casing is set and said casing is cemented around its shoe, or bottom end, and measures must be taken to ascertain the efficacy of said cement seal in excluding extrusion of water from upper levels into oil producing formation. Laws, enacted in the interest of the field as a whole, require a test furnishing proof that this water shut off is complete.

A cementitious material is introduced through the casing and allowed to set around the casing and below its lower end for a considerable distance. The cement plug so formed is then drilled through, the bore extending beyond the casing and into formation below. As it is impracticable to bail out the casing at great depths owing to danger of collapse of casing under external pressure it is necessary to pack within the casing and near the shoe and thereafter recover a sample of the content of formation below.

In this instance, the relatively small volume of fluid between the casing and the drill stem need be solidified to effect a pack.

A quantity of refrigerant 22 is injected through a loading bore 59, Figure 1, through the cylinder head 13, and said bore is closed by a plug 61.

The device is lowered as before and the drilling fluid solidified at a point above the shoe of the casing, go-devil 43 is dropped to open the tubing string 1 to admit a sample of fluid through pipe 28. The seal is allowed to thaw and the entrapped sample recovered as previously described.

Removing coated accumulations from formation wall.—Formation walls become plastered or encrusted with drilling fluid which impedes filtration of oil into the bore. The weight of the column of dense fluid and the action of the boring tool combine to produce this effect.

As the accumulation contains water it can be removed by submitting it to alternate freezing and thawing and the solid content of the encrustation will gravitate to the bottom of the well, leaving the formation wall in a better condition to exude oil.

Disintegration of cement bodies.—It sometimes happens, in a cementing operation, that cement introduced in plastic state sets prematurely, or improperly, leaving an obstruction to re-cementing efforts, and not effectively preventing infiltration of water from above.

Such bodies can be fractures by expansive force created by freezing the fluid content of the bore extending therethrough.

I claim:

1. The method of extracting heat from a predetermined section of a well bore characterized by: introducing opposite the section to undergo treatment a batch of refrigerant isolated from the surface, restrained in an inert condition but capable upon being released to absorb a predetermined quantity of heat; and then releasing said refrigerant charge to cause it to undergo a single refrigerating cycle.

2. The method of extracting heat from a predetermined section of a well bore characterized by: introducing opposite the section to undergo treatment a batch of refrigerant isolated from the surface; then influencing the refrigerant body to cause it to undergo a refrigerating cycle.

3. The method of extracting heat from a predetermined section of a well bore characterized by: introducing opposite the section to undergo treatment a batch of compressed refrigerant isolated from the surface; then reducing the effective pressure against the refrigerant body.

4. The method of forming a congelation plug in a well bore characterized by: introducing opposite a predetermined point in the well bore a batch of refrigerating material isolated from the surface and calculated to absorb sufficient heat from the surrounding formation while being dissipated to divide temporarily by congelation said well bore into upper and lower zones.

5. The method of obtaining fluid samples from liquid filled well bores characterized by: causing a refrigerating charge to undergo a single refrigerating cycle while being dissipated and temporarily divide the well bore by congelation into an upper and a lower zone; and then collecting a sample from the lower zone while the well bore is so divided.

6. The method of obtaining fluid samples from liquid filled well bores characterized by: introducing above the region from which the sample is desired an isolated refrigerant charge restrained in an inert condition but capable of being released to absorb a sufficient quantity of heat to divide by congelation the well bore into an upper and a lower zone; then collecting a sample from the lower zone.

7. The method of obtaining fluid samples from liquid filled well bores characterized by: introducing above the region from which the sample is desired, a compressed refrigerant body isolated from the mouth of the well bore; then reducing the effective pressure against the refrigerant body whereby the refrigerant body is caused to absorb heat, the refrigerating capacity of said refrigerant body being calculated to provide upon completing its refrigerating action a congelation plug dividing the well bore into an upper and a lower zone; then collecting a sample from the lower zone.

8. In the art of obtaining fluid samples from well bores wherein the well bores are divided into upper and lower zones and the fluid samples are collected from the lower zones, the method of

producing such division of a well bore characterized by: introducing at the point of division a refrigerant charge calculated to absorb sufficient heat from the surrounding formation while the charge is being dissipated to divide temporarily said well bore into an upper and a lower zone.

9. A method of dividing into an upper and lower zone a well bore in which a sampling device has been positioned for the purpose of obtaining a fluid sample from the lower zone without displacement of fluid from the upper zone, characterized by: causing a refrigerant to form by congelation a plug dividing the well bore exteriorly of the sampling device and above its inlet; and discharging the dissipated refrigerant into the sampling device.

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