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REFRIGERATING PACKER

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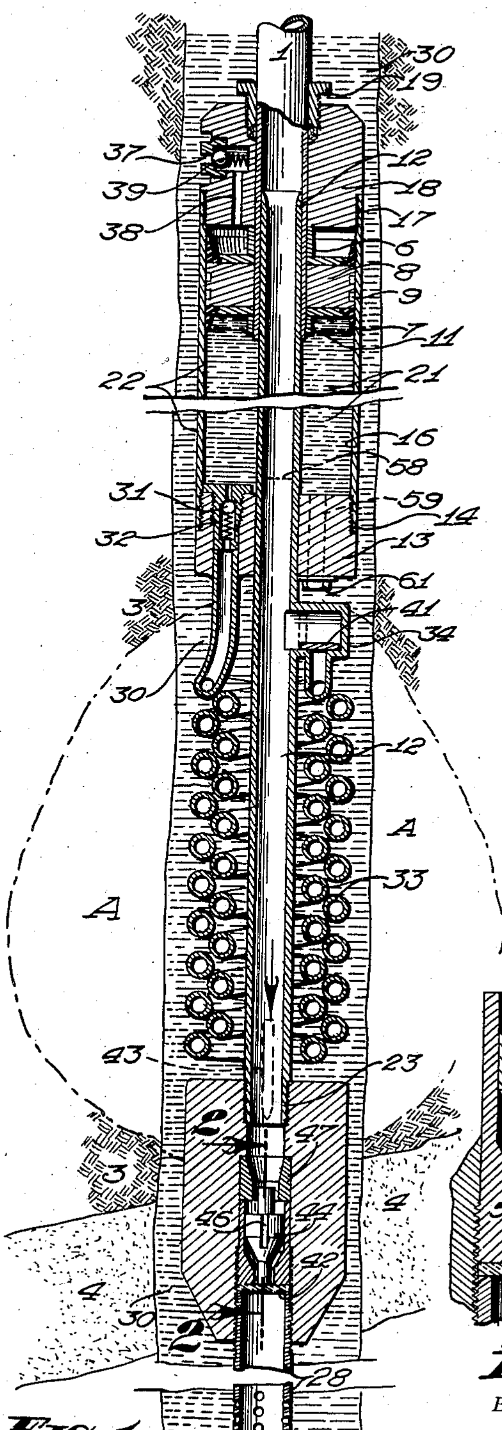

FIG. 1

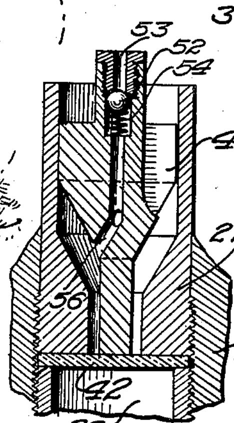

FIG. 2

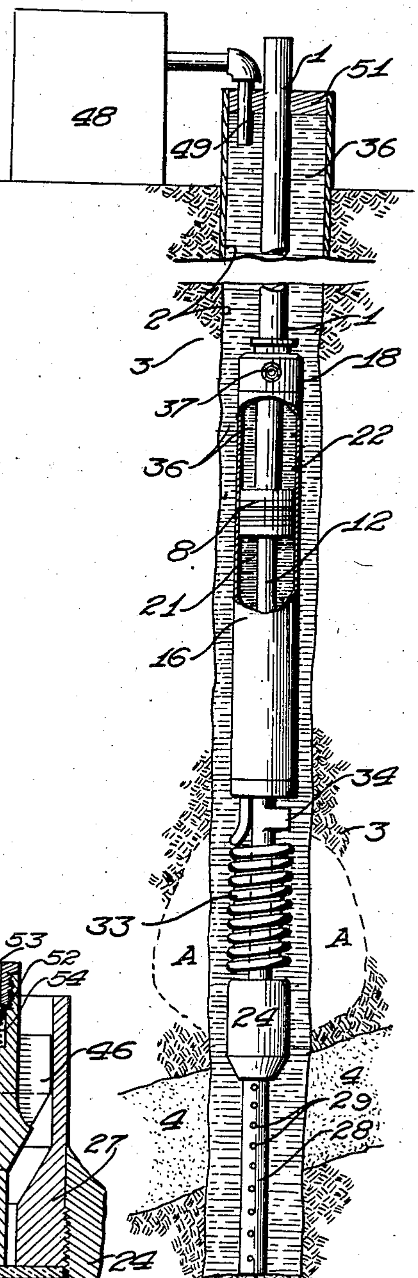

FIG. 3

INVENTOR
WALTER T. WELLS
BY Lloyd Spencer
ATTORNEY

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REFRIGERATING PACKER

Walter T. Wells, Glendale, Calif., assignor to The Technicraft Engineering Corporation, Los Angeles, Calif., a corporation of California

Application November 12, 1932, Serial No. 642,369
Renewed August 20, 1934

11 Claims. (Cl. 166—1)

The present invention relates to refrigerating packers and is a renewal of my previous application entitled: Means for packing oil wells and the like, filed: November 12, 1932, Serial No. 642,369; and from which has been divided subject matter embodied in the following co-pending application: Method of packing wells; filed July 7, 1934; Serial No. 734,170.

The objects of my invention are:

First, to provide a packer 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 packer of this character which provides an adequate and positive seal in open holes, yet may fit quite loosely in the well bore so that danger of hanging up in the well is practically eliminated;

Third, to provide a packer of this character which in no manner damages or interferes with subsequent drilling or other operations in the well bore;

Fourth, to provide a refrigerating packer which incorporates a sampler or formation testing instrumentality; and

Fifth, to provide on the whole a novelly arranged refrigerating packer which is simple of construction proportional to its functions and which will not readily deteriorate or fail in use.

With these and other objects in view as may appear hereinafter, attention is directed to the accompanying drawing in which Figure 1 is a substantially diagrammatical vertical cross sectional view of my refrigerating packer 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 packer wherein hydraulic pressure is utilized.

Referring to the drawing, the number 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 1 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 suitable 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 means of sealing or packing an open hole or formation bore, which has no casing, assures a fluid tight seal between 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 29, 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 co-pending 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 1, 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 opposses 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 or 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, only 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 fractured by expensive force created by freezing the fluid content of the bore extending therethrough.

I claim:

1. As a new article of manufacture, a well tool comprising a refrigeration unit which includes a chamber adapted to hold an isolated body of refrigerant when the tool is lowered into the well, means for operatively connecting said unit with a contractable tubing string, and means, responsive to contraction of said tubing string for operating said refrigeration unit.

2. Apparatus for testing a well comprising a tubing string, means dividing said tubing string into sections connected in a manner providing a limited degree of relative movement, means, associated with said sections, for storing an isolated batch of refrigeration agent while the apparatus including this means is lowered into a well, means, automatically operable in response to relative movement of said sections for circulating around and for liberating said refrigerant through said tubing string, and means excluding pressure, other than atmospheric, from said tubing string.

3. Apparatus for testing a well comprising a tubing string, means dividing said tubing string into sections connected in a manner providing a limited degree of relative movement, means, associated with said sections, for storing an isolated batch of refrigerating agent while the apparatus including this means is lowered into a well, means, automatically operable in response to relative movement of said sections for circulating around and for liberating refrigerant through said tubing string, means for excluding well fluid from said tubing string, and means, operable from the open end of said tubing string, for rendering said exclusion means inoperative.

4. The combination with a tubing string, of means dividing said string into connected sections provided with relative movement, a container for an isolated batch of refrigerating agent adapted to be lowered into position with a batch of refrigerant therein, means responsive to movement of one of said sections for expelling refrigerating agent from said container, closure means for excluding, from said tubing string, fluid in which it is submerged, and means, controlled from the open end of said string, for opening said closure.

5. A well tool comprising tubing string sections connected in a manner providing a degree of relative movement, a cylinder for holding an isolated batch of refrigerant and carrying it into the well, said cylinder being movable with one of said sections, a piston reciprocable in said cylinder and movable with an adjacent section, a refrigeration coil connected at its intake end with said cylinder and at its discharge end with

one of said tubing string sections, valve means, yieldable in response to relative movement of said cylinder and piston, controlling the release of said refrigerating agent, and closure means in the tubing positioned below the discharge orifice of said coil for excluding pressure, other than atmospheric, from said tubing string.

6. A well tool comprising tubing string sections connected in a manner providing a degree of relative movement, a cylinder for holding an isolated batch of refrigerant and carrying it into the well, said cylinder being movable with one of said sections, a piston reciprocable in said cylinder and movable with an adjacent section, a refrigeration coil connected at its intake end with said cylinder and at its discharge end with one of said tubing string sections, valve means, yieldable in response to relative movement of said cylinder and piston, controlling the release of said refrigerating agent, and closure means in the tubing positioned below the discharge orifice of said coil for excluding pressure, other than atmospheric, from said tubing string, said closure constituting a disc of frangible material adapted to shatter under impact of a weight dropped through said tubing string.

7. In a well apparatus for operation in conjunction with a tubing string having telescoping portions, a refrigeration device comprising a refrigerant container for holding an isolated batch of refrigerant and carrying it into the well and a freezing coil, adapted to be lowered in a well with said tubing string, and means, responsive to movement of a portion of said tubing string, for discharging refrigerant from said container through said coil and into said tubing string.

8. A refrigerating means for well bores comprising: a sealed refrigerant container for holding an isolated batch of refrigerant and carrying it into the well, a chilling element connected with said container, an expansion valve interposed between said container and element, said container and element adapted to fit within a well bore, means for lowering said container and element as a unit into a well bore and means for causing discharge of a refrigerant from said container into said element.

9. In an apparatus for producing refrigeration within a well bore, a refrigerator unit shaped to fit within a well bore and including; a receptacle initially containing an isolated quantity of refrigerant and adapted to carry this refrigerant into the well bore, and a chilling element connected with said receptacle to receive refrigerant therefrom; and means tending to cause a pressure drop in said refrigerant as it enters said chilling element from said receptacle; and an arrangement for lowering into a well bore said refrigerator unit in its entirety.

10. In an apparatus for producing refrigeration within a well bore, a refrigerator unit shaped to fit within a well bore and including a receptacle initially containing an isolated quantity of refrigerant and adapted to carry this refrigerant into the well bore, and a chilling element connected with said receptacle to receive refrigerant therefrom and means tending to cause a pressure drop in said refrigerant as it enters said chilling element from said receptacle; an arrangement for lowering into a well bore said refrigerator unit in its entirety; and an instrumentality operative from the mouth of the well to cause operation of said refrigerator unit.

11. An apparatus for producing refrigeration within a well bore, comprising: a refrigerator unit shaped to fit within a well bore and including, a compressor, chilling element and means tending to maintain a pressure difference between said compressor and chilling element upon discharge of a refrigerant from said compressor into said chilling element; and an arrangement for lowering into a well bore said refrigerator unit in its entirety.

WALTER T. WELLS.