

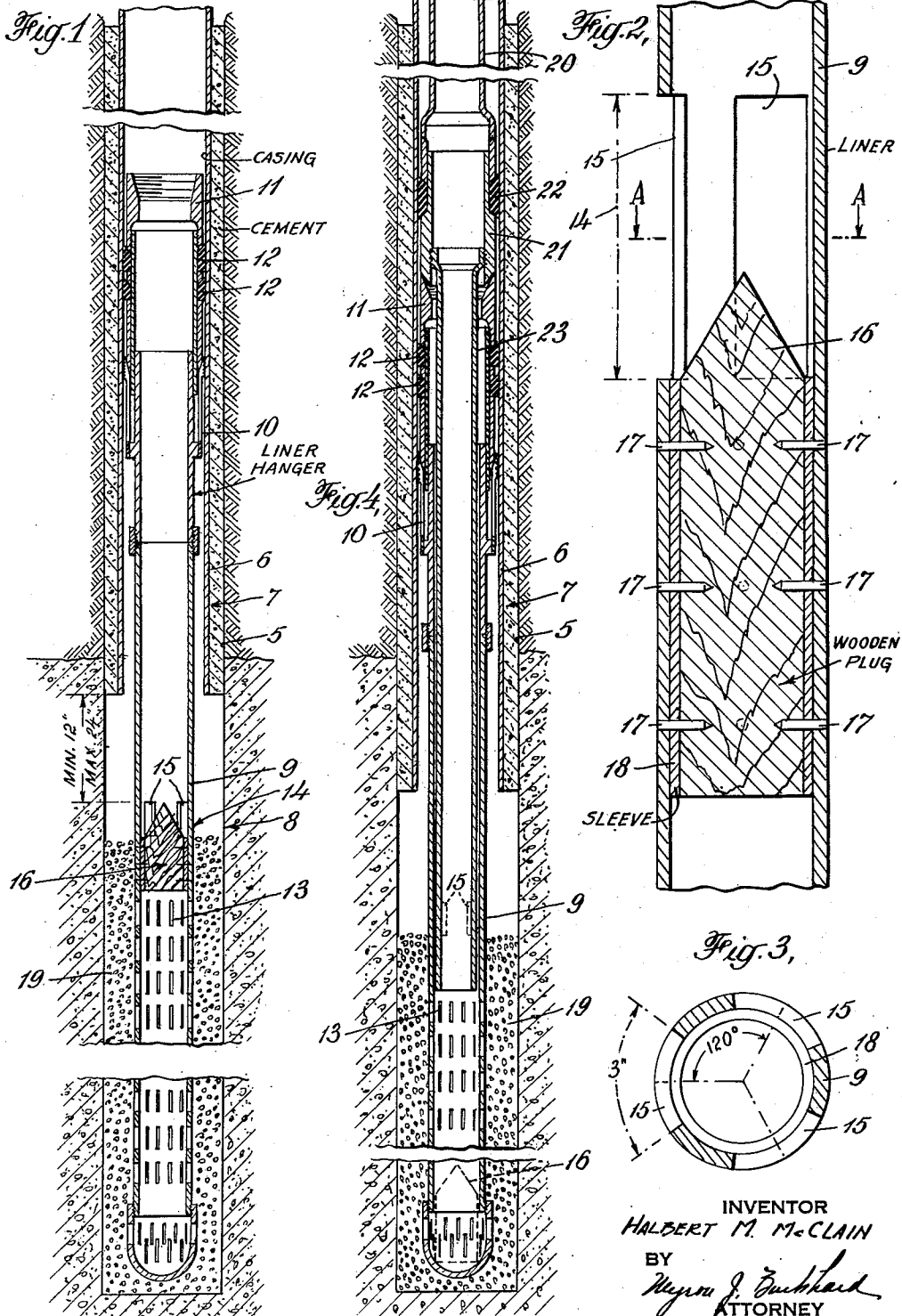
Oct. 13, 1942.

H. M. McCLAIN

2,299,057

APPARATUS FOR GRAVEL PACKING WELLS

Filed Sept. 19, 1940



INVENTOR
 HALBERT M. McCLAIN
 BY
Wm. J. Embick
 ATTORNEY

UNITED STATES PATENT OFFICE

2,299,057

APPARATUS FOR GRAVEL PACKING WELLS

Halbert M. McClain, Oklahoma City, Okla., assignor to Socony-Vacuum Oil Company, Incorporated, New York, N. Y., a corporation of New York

Application September 19, 1940, Serial No. 357,370

3 Claims. (Cl. 166—1)

This invention is directed to apparatus for gravel packing a well to be used for the production of petroleum or gas therefrom or for use as a channel for the introduction of gas or water into a subterranean formation.

Gravel packing is the operation of filling the space between the formation walls and the liners, at the bottom of a well, with screened gravel particles of desired size. The packing so placed serves several functions, among the chief of which are to prevent the formation walls from sloughing off and stopping use of the hole, to prevent plugging of the liner with sand, and to permit of proper flow conditions between the formation and the liner.

In general, the present methods of gravel packing, either a water well or an oil well, vary only in detail and may be classified as: (1) Reverse circulation method, in which the gravel is injected between the casing and the tubing on which the liner is run and through which the circulating fluid returns to the surface; and (2) Normal circulation method, in which the gravel is pumped down the hole inside the tubing, and the circulating fluid returning between the tubing and casing.

When considering the reverse circulation method, the procedure usually includes underreaming the open hole below the casing seat, to provide ample annular space outside the liner to permit free passageway for the gravel without bridging at any point up the hole below the casing seat. Also since the space between the casing and liner will always be smaller than any enlarged hole below the casing seat, the size of casing and liner become important and should provide the largest space possible when the gravel is injected by the reverse circulation method. When using the normal circulation method the size of the casing and liner are not so important. The liner is usually run on a string of tubing, with suitable setting tools or connections whereby the tubing can be backed off from the liner after the gravel has been placed back of the liner.

After the liner is placed in position on the bottom of the hole for the reverse circulation method and before backing tubing off from liner, the circulating fluid (either a drilling mud or oil) is pumped into the hole between the tubing and casing, down back of the liner through the perforations in the liner shoe, and up through the inside of the tubing to establish circulation. A thin cement lining is usually run on the inside of the perforated liner to close the perforation so the fluid will circulate down back of the liner to the perforated shoe on the bottom of the liner.

With free circulation the gravel is introduced into the circulating fluid stream at the casing head by means of suitable gravel pumps and/or a pressure gravel lubricator. As the gravel is deposited back of the liner the circulating fluid is pumped to the surface through the tubing.

While gravel packing with the reverse circulation method the greatest hazard is the bridging of the gravel in the restricted space between the tubing and casing above the liner, resulting in sticking the tubing, which usually results in an expensive fishing job to recover the tubing. Also, while gravel packing with the reverse circulation method there is always the possibility of the hole caving. This caving would be partially due to agitation while circulating an improper drilling fluid in and out of the hole across the face of the enlarged open hole below the casing seat. This would usually result in the bridging of the gravel back of the liner before the entire space back of the liner has been filled with gravel, and thereby necessitate pulling the tubing and liner and cleaning the hole out before attempting another gravel pack.

The normal circulation method includes underreaming of the hole below the casing seat, and the setting of the liner in place in the hole with tubing. Instead of circulating the fluid and gravel into the hole through the annular space between the casing and tubing, it is pumped into the hole through the tubing, down through the liner and check valve in the bottom of the liner and up the hole back of the liner. The check valve prevents the gravel from flowing back and entering the liner after the circulating pumps are shut down. As the gravel is placed in the annular space back of the liner the fluid is circulated up to the surface through the annular space between the tubing and casing.

The normal circulation method reduces the possibility of the gravel bridging due to caving back of the liner, because the fluid, as it circulates back of the liner, lifts the cavings and carries them up back of the liner as the gravel comes in from the bottom through the liner check valve. However, the possibility of the gravel bridging in the tubing and/or liner above the check valve is still prevalent in this method of gravel packing.

The principal object of this invention is the provision of a method and apparatus, useful in gravel packing, whereby the difficulties of present methods may be avoided to a large degree. A further object is the provision of a method of gravel packing capable of eliminating the use

of tubing and utilizing the full interior area of the casing for passage of gravel.

A major object is the provision of a method of gravel packing whereby the washing action of circulated fluids upon the formation being packed is minimized.

An important object is the provision of a method of gravel packing involving a minimum of operative steps.

These objects are obtained by use of the method here disclosed which will be most readily understood by reference to the drawing attached hereto.

Fig. 1 is a sectional elevational view of the apparatus in the well hole during gravel packing.

Fig. 2 is an enlarged view of the portion of tube 9 of Fig. 1 that contains plug 16 and ports 15 showing details of construction.

Fig. 3 is a cross section of Fig. 2 taken along line A—A looking in the direction indicated.

Fig. 4 is a similar view after the gravel packing is completed, plug 16 displaced, and the well is producing through tubing 20.

In Figure 1, 5 denotes the bore hole, in which there has been seated a casing 6, which is cemented at 7. The well, after casing, has been underreamed to increase its diameter below the casing seat at shown at 8. A suitable liner 9 has been placed within the underreamed hole 8 and positioned by means of liner hanger 10, terminating at its upper end in a coupling 11, the whole being supported in and packed to the casing by a conventional liner hanging packer 12.

The liner is provided with slots 13, as is usual, for production, these slots extending throughout a desired portion of the length of the liner. At a point 14, above the production slots, but at a point below the bottom of the casing 6, there is provided in liner 9 a construction best understood by referring to Figures 2 and 3, wherein the liner 9 is shown to be equipped at level 14 with three large slots or "windows" 15, distributed as shown in Figure 3 which is a section of the liner at A—A. Below these windows and within liner 9 is a cone topped plug 16, supported within the liner by pins 17. This plug may be made, as shown, of wood, or it may be of soft metal, or concrete, or Bakelite, or any frangible material which may later be broken or removed by drilling, or which may be pushed to the bottom of the liner. If desired, the plug may be encased in a metal sleeve 18. The cone shaped top of plug 16 is so placed relative to the slots 15 that it forms a directive slope whereby material such as gravel, will be forced to pass entirely out through said slots.

With the liner and packer set, and the tubing entirely removed, all as shown in Figure 1, a mixture of gravel and a small amount of fluid is dropped into the casing at the surface. In a non-flowing oil well, the fluid may be oil or a petroleum fraction. In a salt water disposal well the fluid may be water. In an oil well under pressure, the fluid may be oil and the mixture may be introduced at the surface through a proper lubricator as is well known. Other appropriate modifications are obvious and well known. The gravel falls to the bottom of the casing and passes out through the slots 15, to collect around the liner as shown at 19. This procedure is followed until

a sufficient amount of gravel is in place. Excess gravel inside the liner, above the plug, after filling the annular space back of the liner, is removed with a suitable bailer. After this, the plug 16 and sleeve 18, if such sleeve is used, are drilled out or driven to the bottom of the liner 9.

To complete the well for service, as shown in Figure 4, a string of tubing 20 is run into the well. This tubing 20 ends in an adaptor 21, carrying an adaptor packing 22, which is set down on the coupling 11 of the liner hanger 10. Depending from the adaptor 21 is a tubing 23 which is of slightly smaller external diameter than the internal diameter of liner 9 and which extends into liner 9 to a sufficient distance to extend beyond and blank off the slots 15 in liner 9.

The advantages of this method of gravel packing are as follows:

Elimination of the possibility of sticking a string of tubing by gravel bridging above the liner.

Elimination of the possibility of gravel bridging due to restricted space between casing and liner. Restricted space is eliminated because line is hung in hole with a packer. The three slots in top end of liner above wooden plug provide larger cross sectional area to gravel pack through.

In case gravel does bridge above the wooden plug in top of liner, it can be removed readily with suitable bailer, eliminating necessity of pulling tubing as in the case of both the reverse and normal circulation methods.

Possibility of gravel bridging back of liner due to caving conditions is reduced because the fluid used to inject gravel back of liner is pumped into the surrounding formation and thereby maintains a constant pressure on the face of the open hole and partially eliminates the washing action of the circulating fluids.

I claim:

1. An apparatus for completing and gravel packing a well comprising a liner equipped with a liner hanging packer, in the wall of said liner a plurality of slots of large cross-sectional area for the passage of gravel, said slots being so located longitudinally as to be just below the casing bottom when the lining is set, and within said liner a frangible plug placed just below said slots.

2. An apparatus for completing and gravel packing a well comprising a liner equipped with a liner hanging packer, in the wall of said liner a plurality of slots of large cross-sectional area for the passage of gravel, said slots being so located longitudinally as to be just below the casing bottom when the liner is set, and within said liner a conical topped frangible plug so placed as to plug the liner below said slots and divert gravel through said slots.

3. An apparatus for completing and gravel packing a well comprising a liner equipped with a liner hanging packer, in the wall of said liner a plurality of slots of large cross-sectional area for the passage of gravel, said slots being so located longitudinally as to be just below the casing bottom when the liner is set, within said liner a frangible plug placed just below said slots, and a liner tube adapted to be inserted in said liner after gravel packing and to extend thereinto sufficiently to seal off said slots.

HALBERT M. McCLAIN.