May 4, 1954 W. A. CLARK 2,677,428

GRAVEL PACK WASHING ASSEMBLY

Filed Jan. 29, 1948 2 Sheets-Sheet 1

Fig. 1.

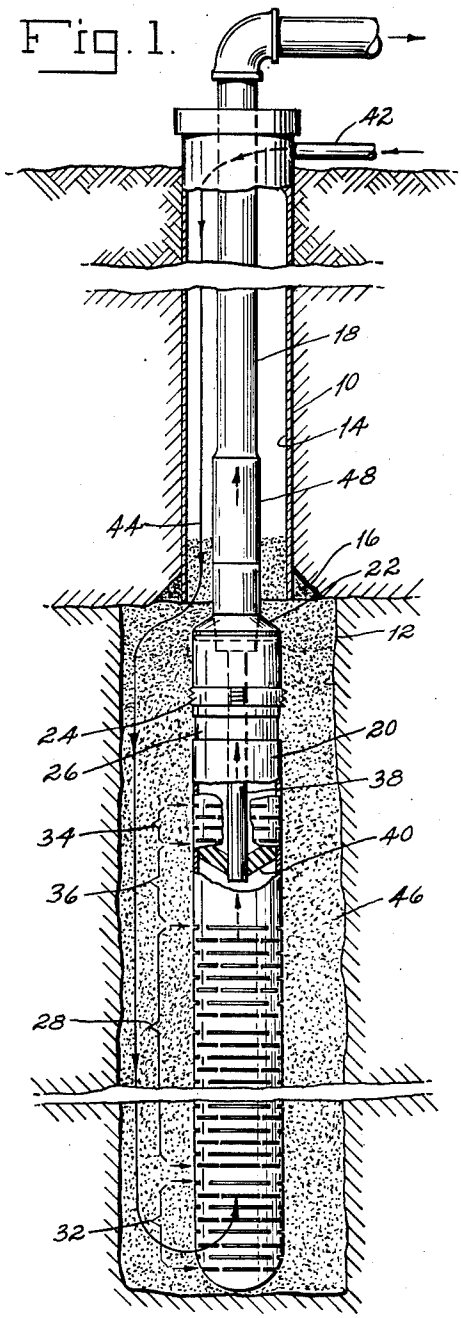
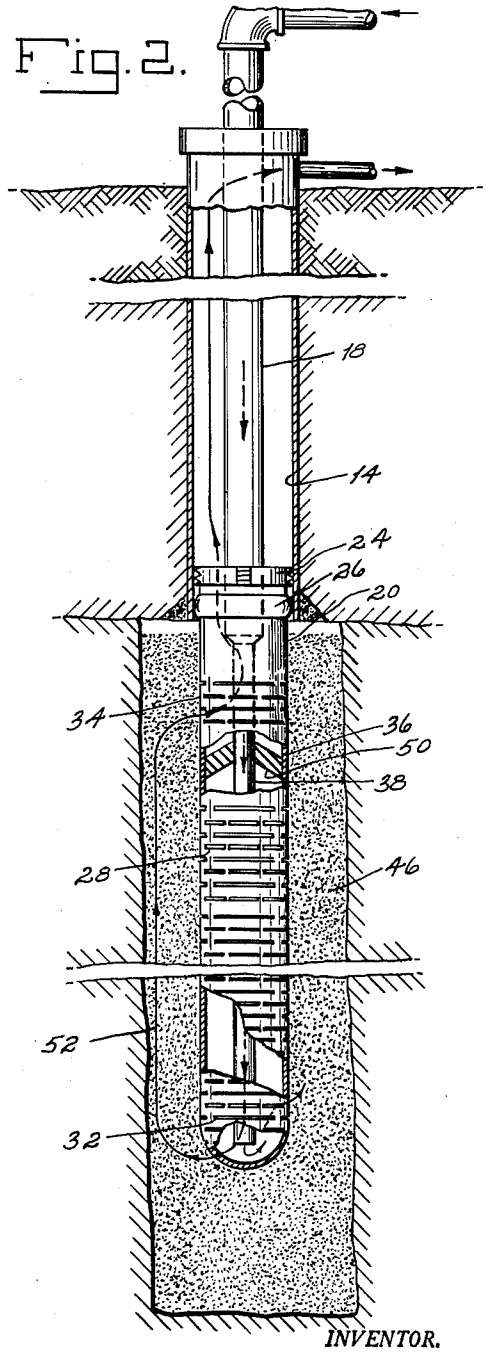


Fig. 2.



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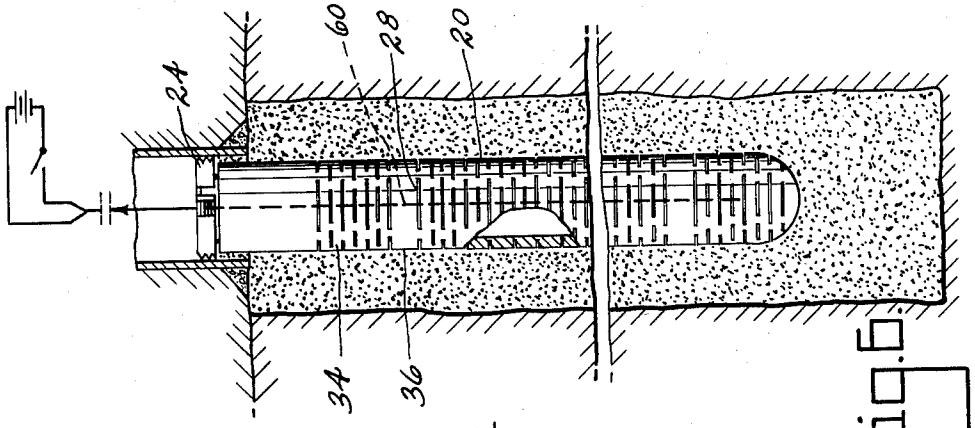


Fig. 6.

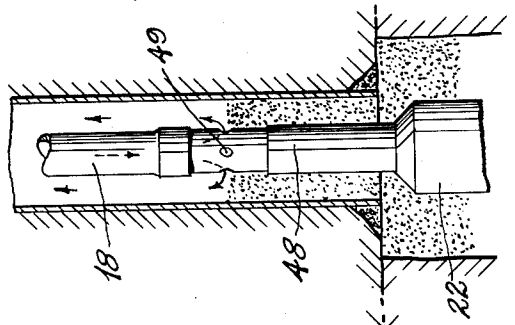


Fig. 5.

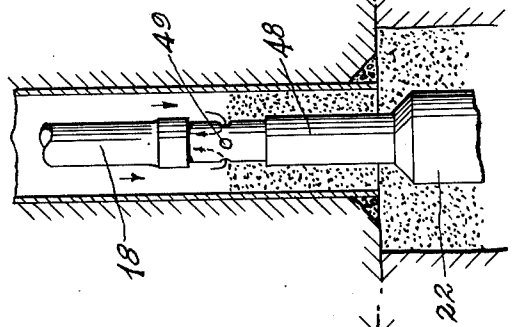


Fig. 4.

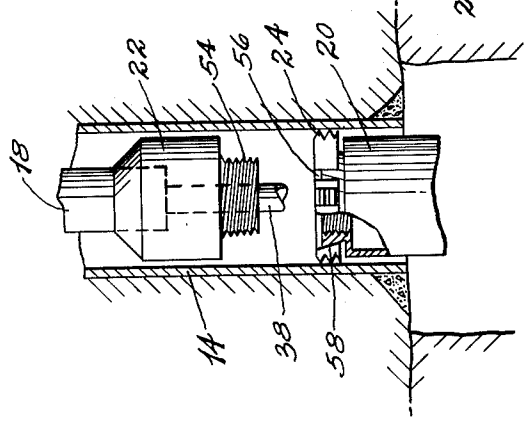


Fig. 3.

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UNITED STATES PATENT OFFICE

2,677,428

GRAVEL PACK WASHING ASSEMBLY

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Application January 29, 1948, Serial No. 5,164

1 Claim. (Cl. 166—26)

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This invention relates to the cleaning or washing of gravel packs used for filling the cavity in the producing formation of a well, and more particularly to an apparatus or assembly which can be used during the graveling operation and subsequently for the gravel washing operation. The principal object of the invention is the provision of an apparatus of this type by means of which the gravel washing operation can be conducted immediately after the gravel has been placed in the cavity and without the use of apparatus additional to that used in the graveling operation.

The uses and advantages of gravel packs in wells are now well known. The gravel may be placed in a well cavity in the annular space between the well screen or strainer and the walls of the formation in several different ways, such as for example, by merely dumping the gravel into the well between the casing and tubing string whereby it will follow by gravity into the cavity; by direct circulation in which the gravel particles in a carrier fluid are forced downwardly to the cavity through the tubing string or by employing reverse circulation whereby the gravel is circulated in a carrier fluid downwardly between the casing and tubing strings, the gravel accumulating in a pack in the well cavity and the carrier fluid entering the lower end of the well screen through passages sufficiently restricted as to hold back the gravel particles. The last mentioned, i. e. the reverse circulation method of gravel packing, is being used more and more frequently since with this method a uniform pack is obtained without appreciable danger of the gravel bridging or clogging in restricted passages and without the occurrence of voids in the pack. Since the gravel is frequently circulated into the cavity with a drilling mud as a carrier fluid, it is usually desirable to clean the mud, sand or silt from the formation walls and from the pore spaces of the gravel pack so that the oil or other fluid to be produced from the well can pass freely through the pack to the well screen. Various methods have been tried for cleaning the gravel pack but most of these have not been too successful. It has been found, however, that when gravel packs are washed by a positive circulation of wash fluid by downward, i. e. reverse, or preferably by upward or direct circulation, the mud and other clogging materials are quite thoroughly removed from the gravel pack. This invention comprises an apparatus whereby the gravel may be placed in the cavity by reverse circulation with a carrier fluid and the washing operation conducted by

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direct circulation soon after the gravel pack has been completed.

In carrying out the invention a temporarily blanked perforated liner or screen having open perforations at the bottom and top, is used in the well cavity, the lower open perforations serving to permit the gravel carrier fluid to enter the screen and to pass upwardly to the surface through the tubing string. After the gravel pack has been completed, and the screen suspended from the lower end of the casing, wash fluid such as water, passing downwardly through the tubing string passes outwardly into the lower part of the gravel pack through the lower perforations in the screen whereupon the fluid passes upwardly through the gravel to enter the upper open screen perforations and then to pass upwardly to the surface through the annular space between the tubing and casing. After the washing operation the temporarily blanked screen perforations are opened and the well is ready for production.

For a better understanding of the invention reference may be had to the accompanying drawing in which:

Fig. 1 is a vertical sectional elevation through a well showing the apparatus in position for the graveling operation,

Fig. 2 is a view similar to Fig. 1 showing the apparatus in position for the gravel washing operation,

Fig. 3 is a sectional elevation through the lower end of the casing showing one manner in which the screen may be attached to the casing,

Fig. 4 is a vertical elevation through the lower end of the casing showing the "tell-tale" valve in its open position,

Fig. 5 is a view similar to Fig. 4, but showing the washing of the surplus gravel from around the tubing, and

Fig. 6 is a vertical elevation partly in section showing a line fuse within the screen.

Referring to the drawing and particularly to Fig. 1 thereof, a well 10 is shown as provided with an enlarged cavity 12 in a producing formation. A casing 14 is shown as lining the upper portion of the well and cemented in place above the producing cavity as at 16, care being taken that the shoe of casing 14 is located above the sand or zone to be produced. A string of tubing 18 extends downwardly through the cased portion of the well and has attached at its lower end a perforated liner or screen member 20. The tubing string is attached to the screen by means of an adapter 22 which serves to cover the upper

end of the screen and which can subsequently be removed from the screen in any suitable manner such as is disclosed, for example, in the U. S. Letters Patent to Davis et al., No. 2,198,573, granted April 23, 1940. Also attached to the screen near its upper end is a liner hanger 24 of any suitable type preferably provided with slips which can subsequently be set or expanded by means of a suitable hanger setting tool to engage the inner surface of the lower end of the casing 14. An expansible packer 26 is also provided below the hanger member and is adapted to be subsequently expanded, if desired, as shown in Fig. 2, to seal the space between the upper end of the screen member 20 and the casing 14.

The main section of the screen member 20 is provided with a group 28 of temporarily blanked perforations, the vertical length of this group depending, of course, upon the height of the cavity 12. These perforations may be temporarily sealed for the period of the graveling and washing operations in any suitable manner such as by filling them with a substance which can be subsequently removed by physical or chemical action or they may be formed by milling them almost but not quite all the way through the screen pipe as shown in Fig. 6, thus leaving a thin layer of metal which can later on be removed by pressure produced within the screen by the exploding of a line fuse as is disclosed in the U. S. Letters Patent to J. E. Garol, 2,418,343, granted April 1, 1947. At its lower end the screen member 20 is provided with a group 32 of open perforations and in its upper portion with another group 34 of open perforations, the vertical length of this latter group being approximately six inches to one foot and the group being separated from the group 28 by a two to three foot blank section 36 of the screen pipe. A short pipe member 38 attached to the bottom end of the tubing string 18 projects downwardly into the screen 20 and is provided at its lower end with a packer member shown as a swab 40, this swab sealing the space between the lower end of the pipe 38 and the blank section 36 of screen pipe.

With the apparatus in the position shown in Fig. 1 a mixture of gravel particles and a carrier fluid enters the casing through the pipe 42 and passes downwardly in the direction of the arrows 44, the gravel 46 being deposited in the cavity 12 and the carrier fluid entering the screen member 20 through the perforations 32 and passing upwardly to the surface through the pipe member 38 and tubing string 18. A "tell-tale" device 48 is preferably disposed in the tubing string 18 above the top of the screen member 20 for providing an indication at the surface when the deposited gravel reaches the elevation at which the device is disposed. This "tell-tale" device may be of any suitable type but it is preferred to use a device of the nature of that disclosed in the U. S. Letters Patent to L. E. Tomlinson, No. 2,337,429, granted December 21, 1944. As is described in that patent, the device comprises valved openings 49 which when opened by raising the tubing string slightly as in Figs 4 and 5 for testing purposes will permit some of the gravel to enter the tubing and to pass upwardly to the surface as shown in Fig. 4, providing the gravel has reached the height of the device. When such an indication is given that sufficient gravel has been placed in the well the flow of gravel and carrier fluid into the well is stopped.

During the graveling operation the swab 40 prevents the carrier fluid from passing through perforations 34 and then upwardly through the pipe 38 and tubing string 18, thereby by-passing the gravel accumulated in the cavity below the level of the perforations 34.

When the graveling operation is completed and the tubing string 18 still slightly raised to open the tell-tale device 48 liquid is forced downwardly through the tubing string and outwardly through the device 48 so as to wash excess gravel upwardly out of the annular space between the tubing and the casing 14 as shown in Fig. 5. The tubing string is then raised another few feet and the screen 20 is thereby pulled upwardly so that its upper end will be within the lower portion of the casing as is shown in Fig. 2. The hanger slips 24 are then set by operation of the setting device in a manner well known in the art and the packer 26 may be expanded to seal the space between the upper end of the member 20 and the casing 14. The weight of the screen member is thus transferred to the casing.

After the screen member 20 is hung from the casing the tubing string 18 is disengaged by disconnecting the screen cover member 22 from the top of the screen member in any suitable manner such as is disclosed in the aforementioned Davis et al. Patent, No. 2,198,573. If desired, the liner or screen may be hung from the casing in the same operation in which the cover member 22 is disconnected from the screen. Thus, as shown in Fig. 3, after the screen has been pulled upwardly with its upper end within the lower portion of the casing 14, the tubing 18 and the cover member 22 may be unscrewed from the screen by rotating the tubing to unscrew the left hand threads 54, the screen being prevented from turning by the friction of the surrounding granular material 46. In this manner of hanging the screen from the casing, the liner hanger 24 will be in the form of a split ring normally tending to expand outwardly as indicated by the small gap 56 in the expanded position of Fig. 3. In the position shown in Fig. 1, the split ring is squeezed together to close the gap 56 and the ring is held in this closed position by compression between the upper end of the screen 20 and the member 22. As soon as the upper end of the screen is pulled up into the lower end of the casing and the tubing 18 rotated to loosen the threaded connection 54, the split ring of the liner hanger will automatically expand and the teeth on the outer surface of the ring will engage the inner surface of the casing. The upper end of the screen 20 is provided with the annular outwardly flaring surface 58 engaging a corresponding inner surface on the liner hanger ring as shown clearly in Fig. 3. As soon as the cover member 22 has become disconnected from the screen 20, the weight of the screen will cause the clearing outwardly slopping surface 58 to force the ring outwardly into tight engagement with the casing and the screen will thereafter be securely attached to or suspended from the casing, as is also shown in Figs. 2 and 6. The tubing string and the pipe member 38 are then removed from the well and an inverted swab 50 is substituted for the swab 40 after which the tubing string is run back in the hole to the position shown in Fig. 2. If desired, a longer pipe extension may be substituted for the pipe member 38, as shown in Fig. 2. The inverted swab 50 is positioned opposite the blank screen section 36 and seals the space between the pipe 38 and the inner surface of the screen member 20. The washing of the gravel pack is then begun by forc-

ing the washing fluid in direct circulation in the direction of the arrows 52 downwardly through the tubing string 18 and through the pipe member 38 the fluid, being prevented by the aforementioned swab 50 for by-passing through the inner part of the screen 20, passing outwardly into the gravel through the lower open perforations 32, upwardly through the gravel pack 46, inwardly through the open perforations 34 and upwardly to the surface through the space between the tubing string 18 and the casing 14, the washing-out of the gravel being prevented by the screen 34. Since the main body of screen perforations comprising the group 28 is still sealed the wash liquid cannot pass outwardly through these perforations but is forced to enter the lower portion of the gravel pack, as above explained, through the lower perforations 32. In its upward flow the wash fluid causes some agitation of the gravel particles and the mud, sand, and silt, which might otherwise adhere to these particles, is thoroughly washed from the pack and is carried upwardly to the surface with the washing fluid.

After the gravel pack has been sufficiently washed the tubing 18, the pipe extension 38, and the inverted swab 50 are removed from the hole after which the main screen perforations 28 are opened by any suitable means such, for example, as by lowering and exploding a line fuse 60 within the screen, as is described in the aforementioned Garol patent, No. 2,418,343. The well is then in condition to be placed on production.

Obviously many modifications and variations of the invention, as hereinbefore set forth, may be made without departing from the spirit and scope thereof, and therefore only such limitations should be imposed as are indicated in the appended claim.

I claim:

The method of completing a well provided with a casing and a well screen suspended from a tubing string below the bottom of the casing and entirely within a cavity in a producing formation which comprises circulating a mixture of gravel and a carrier liquid downwardly through the annular space around said tubing string and into said cavity above the well screen, the gravel collecting and building up in the cavity around the screen while the carrier liquid enters the screen at its lower end and passes upwardly to the surface through said tubing string, raising and attaching said screen to the lower end of said casing, circulating gravel washing fluid downwardly through said tubing and out of the bottom of said screen, then upwardly through the deposited gravel and to the surface through the annular space between the tubing and the casing.

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