Sept. 15, 1953 H. S. ARENDT ET AL 2,652,117

METHOD AND APPARATUS FOR GRAVEL PACKING WELLS

Filed June 16, 1950 3 Sheets-Sheet 1

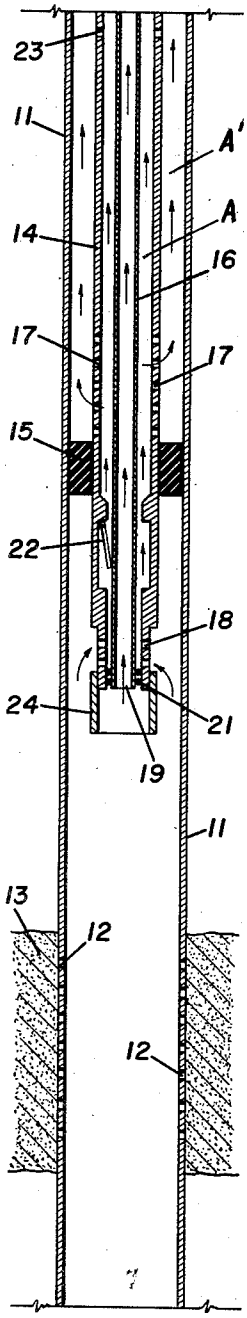


FIG. 1.

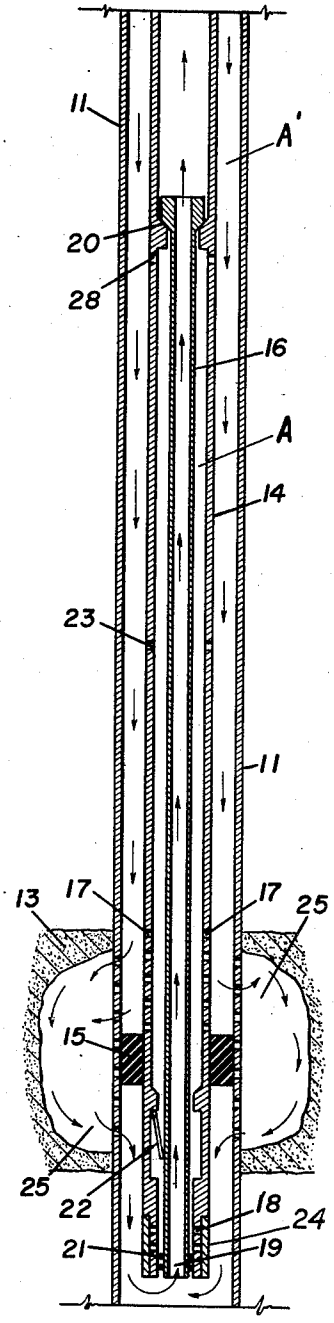


FIG. 2.

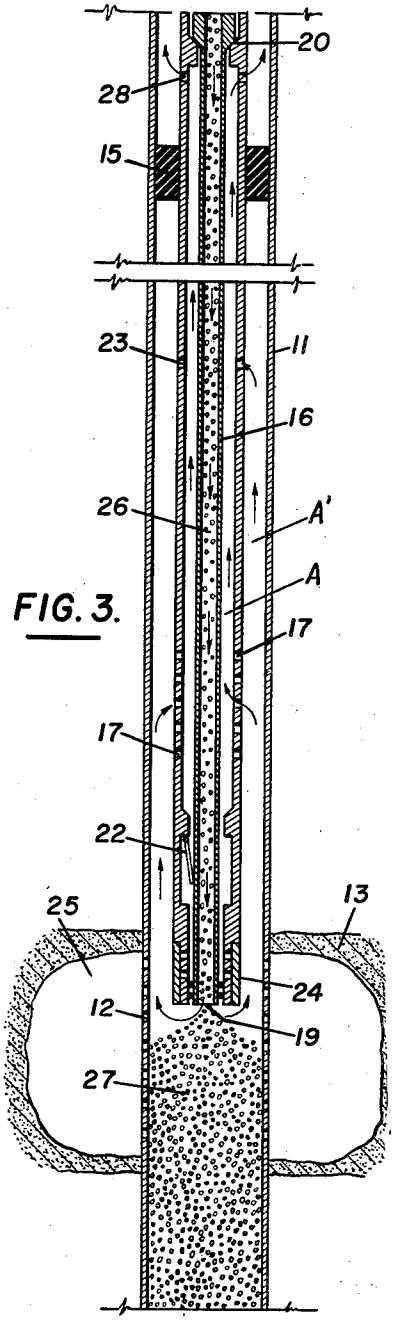


FIG. 3.

INVENTORS.
Harry S. Arendt,
Guss F. Abendroth,
BY
AGENT.

Sept. 15, 1953 H. S. ARENDT ET AL 2,652,117

METHOD AND APPARATUS FOR GRAVEL PACKING WELLS

Filed June 16, 1950 3 Sheets-Sheet 2

FIG. 4.

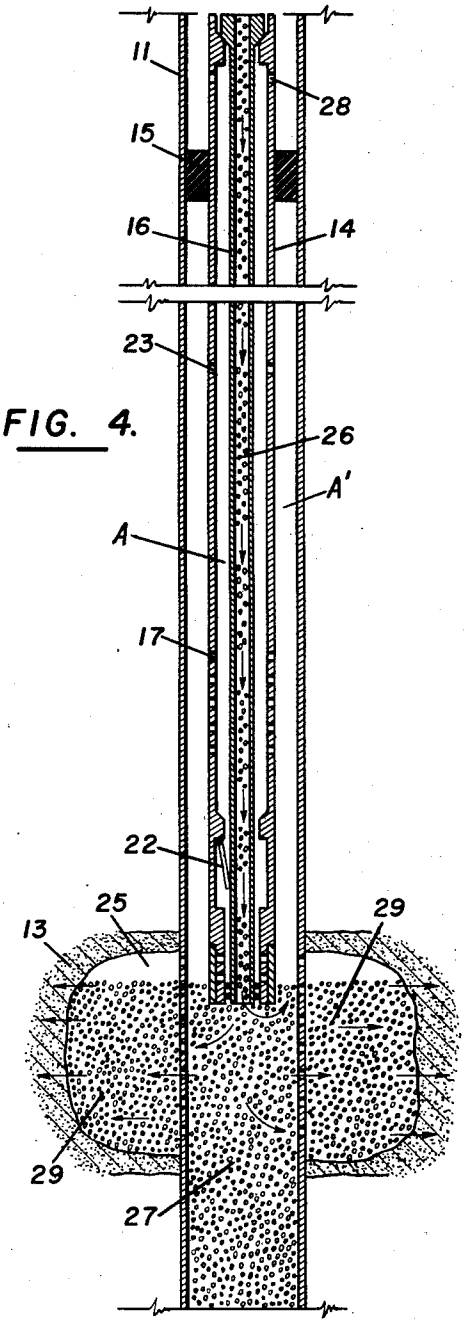
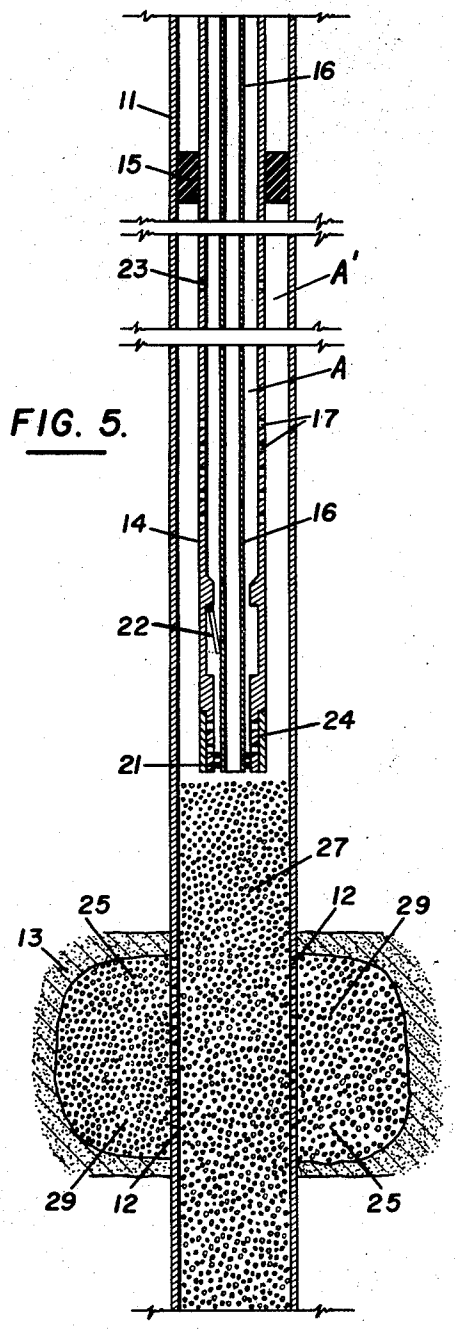


FIG. 5.



INVENTORS.
Harry S. Arendt,
Guss F. Abendroth,
BY
AGENT.

Sept. 15, 1953 H. S. ARENDT ET AL 2,652,117

METHOD AND APPARATUS FOR GRAVEL PACKING WELLS

Filed June 16, 1950 3 Sheets-Sheet 3

FIG. 6.

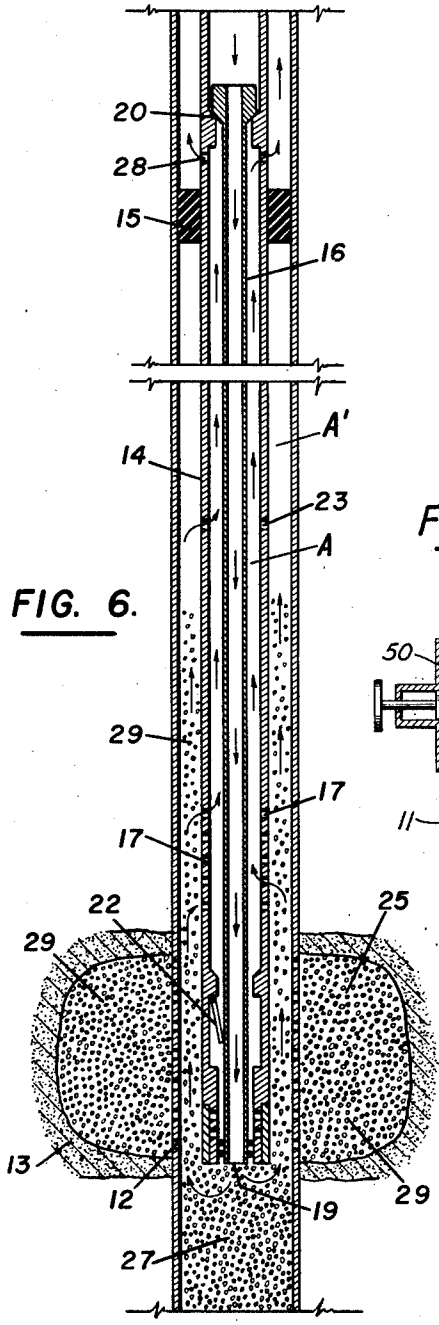


FIG. 8.

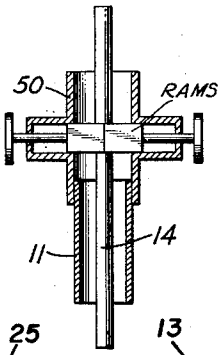
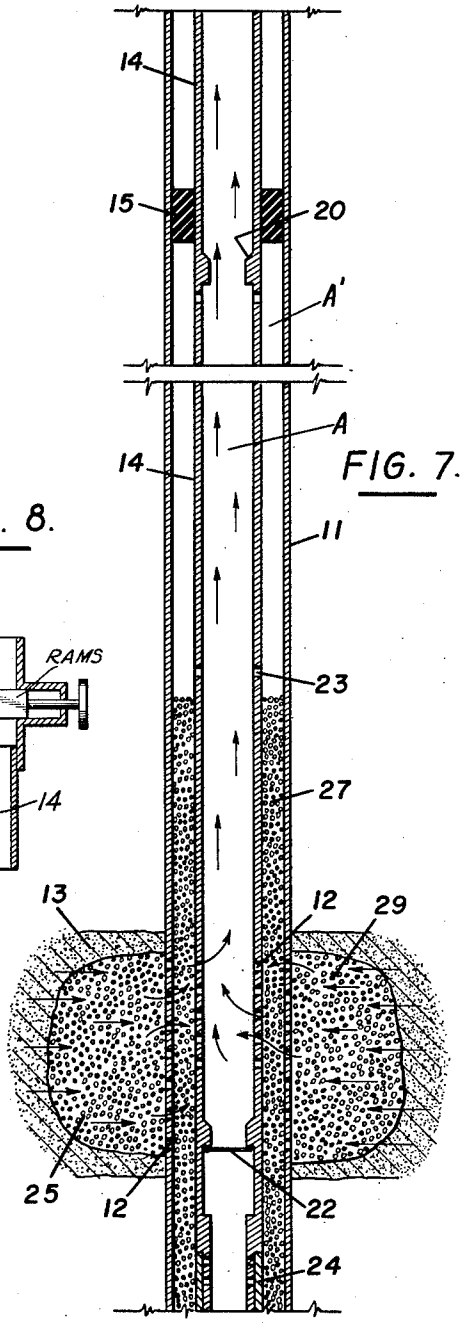


FIG. 7.



INVENTORS.
Harry S. Arendt,
Guss F. Abendroth,
BY
Thomas B. McCulloch
AGENT.

Patented Sept. 15, 1953 2,652,117

UNITED STATES PATENT OFFICE

2,652,117

METHOD AND APPARATUS FOR GRAVEL PACKING WELLS

Harry S. Arendt and Guss F. Abendroth, Houston, Tex., assignors, by mesne assignments, to Standard Oil Development Company, Elizabeth, N. J., a corporation of Delaware

Application June 16, 1950, Serial No. 168,496

6 Claims. (Cl. 166—1)

1

The present invention is directed to a method and apparatus for depositing gravel or other similar granular material in either a cased or open borehole. In the present invention a well, in which a cased borehole having perforations arranged adjacent a producing formation of an incompetent material, such as sand, which is susceptible to being washed out, is packed with a bed of gravel or other granular discrete particles. The well is packed by running a producing string defining a screen section including a wash pipe downwardly into the cased borehole to provide an annulus between the producing string and the casing. In such wells, the normal circulation is upwardly through said string to recover the fluid produced from the producing formation. In our invention the normal circulation is reversed downwardly through the annulus and outwardly into the producing formation and then upwardly through a bottom opening in the wash pipe under such conditions that the producing formation and sand or other incompetent material is washed out to form a cavity outside the casing. The flow of washing fluid is directed outwardly into the producing formation by arranging a packer at a point inside the casing adjacent the producing formation such that the reversed flow must pass out into the producing formation and thence back into the annulus to find its way up the tubing string. After the cavity has been washed out the annulus is isolated from upward circulation of fluid by shutting in the casing annulus at the surface. Granular material, such as gravel, in a carrier vehicle, such as water or oil, if desired, is then flowed downwardly into the cased borehole through the wash pipe to deposit in the casing adjacent the producing formation a bed of granular material. The flow of granular material is continued until the cavity has been filled by the granular material squeezing through the perforations in the casing. After the cavity has been filled, the wash pipe and the screen and liner assembly is raised in the cased borehole to a point substantially above the filled cavity while the flow of granular material is continued to extend the height of said bed in the casing. After the bed of granular material has been extended the flow of suspended granular material is discontinued and replaced by an aqueous or oily medium which causes the producing string with the wash pipe assembly to be washed downwardly into the bed to a point adjacent the producing formation. The wash pipe is then retrieved by a wire line attached thereto and the well is put on production with normal flow from the producing sand to the cavity filled with granular particles, thence into the casing through the bed of granular particles therein and upwardly through the perforations in the strainer of the producing string and thence to the earth's surface.

2

The apparatus of the present invention includes, in combination, a screen and liner adapted to be connected to a producing string. Slidably mounted on the screen and liner is a packer structure, to produce a shut-off between the casing and the screen and liner and to isolate an annulus between the screen and liner and the well bore. Arranged inside the screen and liner is a retrievable wash pipe which is provided at its upper end and its lower end with separate means for packing off the top and bottom thereof to prevent circulation between the wash pipe and screen and liner at those points. Adjacent a bottom outlet of the screen and liner is a closure means, such as a flapper-type back pressure valve, which is retracted into an open position by running therein the wash pipe and which assumes a closed position when the wash pipe is retrieved therefrom. The lower end of the screen and liner is offset inwardly to define a recessed portion which defines radial ports. Embracing this recessed portion is a slidable annular sleeve which is adapted to close the radial ports on said recessed portion of said screen and liner when said sleeve is in a retracted position. The screen and liner is provided with perforations or ports which are adapted to be arranged adjacent the producing formation and is further provided with ports medially therein and in the upper end thereof to allow circulation to be continued while the well is being packed in a manner which will be described further.

The invention will be described in more detail by reference to the drawing in which

Fig. 1 is a sectional view, showing the assembly being run into a cased borehole;

Fig. 2 is a sectional view of the assembly in position during the washing out operation;

Fig. 3 shows the position of the apparatus of the present invention while gravel or other discrete particulate material is being pumped therein;

Fig. 4 is a further sectional view of the apparatus of the present invention showing the squeezing operation wherein gravel is being squeezed through the perforations of the casing into the cavity;

Fig. 5 is a similar sectional view showing the position of the assembly when the strainer and liner and the wash pipe therein is in raised position to extend the height of the bed;

Fig. 6 is an illustration of the wash down operation;

Fig. 7 is a further showing of the apparatus of the present invention with the wash pipe removed from the well and the well on production; and

Fig. 8 is a view illustrating means to close off the annulus between the casing and the producing string at the top of the well.

In the several figures of the drawing, identical parts will be designated by identical numerals.

Referring now to Figs. 1 to 7, numeral 11 designates casing in a borehole in which the casing 11 is provided with perforations 12 arranged adjacent a producing formation 13. In the showing in Fig. 2 an internal flush joint screen and liner 14 is provided with packer 15 to provide a shut-off between the casing and screen and liner. A wire line retrievable wash pipe 16 is arranged within the screen and liner 14 and blanks off the screen and ports 17 of the producing section and the ports 18 adjacent the outlet 19. The wash pipe 16 is packed off at the top by a ground seat 20 and at the bottom adjacent the outlet 19 by a double O-ring seal 21. Other known packing or sealing means may be used. For example, it may be desired to use ground seats at both top and bottom or sealing rings, cups, packing, and the like materials available commercially. The wash pipe extends below a flapper-type back pressure valve 22 which is arranged below the producing section or ports 17 of the screen and liner 14. The wash pipe 16 holds the flapper-type back pressure valve 22 in an open position while the wash pipe 16 is in the screen and liner 14 but allows it to assume a closed position when the wash pipe 16 is retrieved.

In Fig. 1 the assembly is being run into the hole and has not been landed with the producing section 17 adjacent the producing formation 13.

Referring again to Figs. 1 to 7, the operation of the present invention will be described in more detail in which fluid movement is described while the assembly is being run into the hole. In this operation the fluid in the hole is free to pass through the open wash pipe continually filling the tubing, the direction of flow being shown in Fig. 1 as upwardly through the opening 19 into the wash pipe to the earth's surface and through the ports 18 into the annulus A between the wash pipe and the screen and liner 14 and then outwardly into the annulus A' between the casing 11 and the screen and liner 14 by the producing section 17 and ports 23 and upwardly to the earth's surface through the annulus A' between the screen and liner 14 and the casing 11.

In Fig. 2 when the screen and liner 14 reaches the bottom, weight is placed on the sleeve 24 forcing it upwardly to shut off circulation through the ports 18. Sleeve 24 is then in the position shown in Fig. 2 and may be held either by spring actuated dogs, by rubber seal rings or by metal to metal friction. In the drawing, metal to metal friction is employed but other means as illustrated above may be used. It will be clear that in Fig. 2 the packer 15 is adjusted so its position is adjacent the producing formation 13. Circulation is then reversed with the flow indicated by the arrows downwardly through the annulus A' between the casing 11 and the screen and liner 14. By virtue of the position of the packer 15 which is slidably mounted on the screen and liner 14, the flow is caused to go into the producing formation 13 and thence around the packer into the annulus A' and upwardly through the wash pipe 16 and thence to the earth's surface. The packer 15 which is slidably mounted on the screen and liner 14 may be a packer, such as described in the Composite Catalog of Oil Field and Pipeline Equipment, 18th edition, 1951, vol. 1, page 898. On page 898 of the Composite Catalog supra, the Brown Oil Tools, Inc. Duo-Pak all purpose packer is described. This packer may be moved with respect to the screen and liner 14 in the following manner: Referring to

Fig. 1, it will be seen that the packer 15 on the screen and liner 14 is being lowered in the casing 11 until it reaches a point, as is shown in Fig. 2, for washing out the cavity 25 as will be described in more detail hereinafter. The packer 15 is not set but it affords a sufficient seal to allow the cavity to be washed out as indicated by the arrows showing the flow. Thus, after the cavity 25 is washed out, as shown in Fig. 3, the assembly including the packer 15 is then raised in the casing 11 by lifting up on the screen and liner 14 until the packer 15 has reached the position shown in Fig. 3 at which point the latching means holding the packer 15 to the screen and liner 14 is released by rotating the pipe string or by other means and the packer 15 set against the interior wall of the casing 11. After the packer 15 is set against the wall of the casing 11, such as by setting down weight on the pipe string, the screen and liner 14 may be moved freely through the packer 15; thus the screen and liner 14 serves as a packer mandrel and is freely movable through the packer so that the screen and liner 14 may be lowered to the point shown in Fig. 3 to deposit the finely divided materials, such as gravel, in the casing 11. Thereafter, the packer 15 remains in position until the cavity 25 has been filled. It is only necessary to move the screen and liner 14 through the packer, such as shown in Fig. 5, wherein the screen and liner 14 is raised upwardly in the casing 11 to allow the gravel to be deposited in the casing.

As shown in Figs. 6 and 7, since the packer 15 has been set against the casing 11 the screen and liner 14 may be moved freely through the packer to allow the screen and liner 14 to be washed downwardly to set the apparatus of the present invention on bottom.

It may be desirable after setting the device of the present invention to latch the packer 15 against the screen and liner to obtain a permanent installation. However, employment of packers such as illustrated in the Composite Catalog supra do not require latching of the packer against the screen and liner 14 since an effective seal may be obtained without a permanent latch.

A more detailed description of the gravel packing operation follows: By virtue of the flow conditions which are suitably adjusted, the sand in producing formation 13, being of an incompetent nature, is washed out and back into the annulus A' and up into the wash pipe causing the formation of a cavity 25. After the cavity has been suitably washed out the assembly including the screen and liner 14, the wash pipe 16, and the packer 15 is raised by raising up on the producing string. The packer, which is slidably mounted on screen and liner 14 and which may be latched thereto by means not shown, is adjusted to a position as indicated in Fig. 3. A suspension or mixture 26 of gravel or other granular particles is then flowed downwardly through the wash pipe 16 into the bottom of the cased borehole 11 to cause the formation therein of a bed of granular particles 27. The suspension after depositing the granular particles therefrom allows the liquid vehicle or carrier fluid to proceed upwardly through the annulus A' between the screen and liner 14 and casing 11 and thence through the ports or producing section 17 into the annulus A between the wash pipe 16 and the screen and liner 14 and upwardly therethrough to a point above the packer 15 where the flow then

proceeds as indicated by the arrows through the ports 28 back into the annulus A' between the screen and liner 14 and the casing 11. After the bed 27 of granular material has been deposited into casing 11 to a suitable height as indicated in Fig. 3, blow-out preventers 50, such as shown in Fig. 8, and/or other means are closed, directing the flow through the perforations 12 into the formation 13 with the velocity of flow carrying the gravel through the perforations to fill the cavity 25 as shown in Fig. 4, the liquid vehicle being forced into the earth formation as indicated by the arrows designating the flow thereof. This operation is continued until gravel from the bed 27 completely fills the cavity 25 forming a bed 29 therein. Thereafter the flow is continued while raising the assembly to a point substantially above the cavity 25 in producing formation 13, as shown in Fig. 5. The addition of granular material to the fluid stream is then terminated. The blow-out preventers 50 are opened and flow as indicated in Fig. 6 is begun, which causes the assembly including the screen and liner 14 and the wash pipe 16 to be washed back downwardly through the bed 27, the flow being indicated by the arrows with the fluid passing outwardly into the bed 27 through the outlet 19 and back into the annulus A between the screen and liner 14 and the wash pipe 16 through ports 17 and upwardly therethrough and outwardly through ports 28 into the annulus A' between the casing 11 and the screen and liner 14 and thence to the earth's surface. Some of the flow will be from the outer annulus A' into the inner annulus A by ports 23. After port 28 enters the packer 15, the lower portion of the outer annulus A' is isolated with the assembly including the screen and liner 14 being in the desired position. The wash pipe 16 is then retrieved by a suitable wire line (not shown). The packer had been previously set in the predetermined position before placement of gravel was started and serves as a tubing packer. In Fig. 7 the wash pipe has been retrieved and the flapper-type back pressure valve 22 is shown in a closed position causing the oil or other medium to be produced from producing formation 13 to flow through cavity 25 containing the granular materials 29 and thence through bed 27, through the perforations 17 and upwardly through the producing string to the earth's surface, the flow being shown by the arrows.

After the screen has been washed to the bottom, as indicated in Fig. 7, and the wash pipe 16 removed, the Christmas tree may then be placed on the well and the well placed in operation, as shown in Fig. 7.

The method of the present invention increases the safety of operations and reduces rig time. The method and apparatus of the present invention allows a well to be packed with gravel or other granular materials with a half round trip as contrasted to two and one-half to four and one-half round trips with the pipe when employing the methods and apparatus heretofore available to the industry, one round trip including running the pipe in the hole and removing it from the hole. Furthermore, the apparatus and method of the present invention eliminate the necessity of pulling the cavity washing packer or tool assembly and also eliminates the attendant danger of swabbing the well in. The absence of round trips also avoids objections to having salt or fresh water or oil in the hole during a trip and thus eliminates the several changes from drilling mud to salt water or other liquid media and back. The employment of salt water or other liquid throughout the operation also avoids contamination of the gravel pack and sand face with mud filter cake. Experience has indicated that contamination of the gravel pack and sand face results in partial plugging of the sand face and/or gravel pack with consequent reduction in well potential. The method of the present invention also avoids the danger of gravel sticking the wash tool which currently exists when the gravel is placed with the wash tool in the hole. The method is also usable in gravel packing shaly sections and gravel packing in open holes using salt or fresh water or oil.

In employing the present invention in an open hole, the circulation is reversed as has been described with respect to Fig. 2 to clean out the hole and to remove any filter cake which may have deposited on the face of the producing formation. Reversal of circulation may also result in washing out a cavity if none existed before or enlarging an existing cavity. Thereafter a mixture or suspension of gravel or other granular, particulate material is flowed downwardly into the open hole to fill the cavity or borehole with the granular material, the liquid vehicle or carrier fluid being forced into the earth formations as has been described. The remaining steps of raising the assembly and washing back down are as has been described previously.

In some formations where the structure is of such an incompetent nature that it tends to slough even when a pressure differential is applied against the formation, it is possible to wash out the sand while depositing granular material in the formation. In effect because of the different settling rates of the incompetent material and the granular particles, it is possible to conduct the washing out and depositing operations practically simultaneously, the velocity of flow of the carrier medium to the surface being adjusted to deposit the granular material and carry out the material washed from the formation.

The nature and objects of the present invention having been fully described and illustrated, what we desire to claim as new and useful and to secure by Letters Patent is:

1. A method for packing a borehole in a producing formation susceptible to being washed out in which a pipe string defining a screen section has been run including a wash pipe arranged therein wherein the normal circulation from the producing formation is upwardly through said string, which comprises flowing a washing fluid downwardly through an annulus between the pipe string and the borehole and upwardly through said pipe string, directing said flow of washing fluid into said producing formation and outwardly therefrom to wash a cavity in said formation and to wash and clean a portion of said borehole adjacent said producing formation, flowing a mixture of granular material in a liquid carrier vehicle downwardly in said borehole through said wash pipe to deposit a bed of granular material in said borehole adjacent said producing formation, isolating the borehole from upward circulation, continuing the flow of granular material until said washed portion of said borehole adjacent said producing formation has been filled with granular material, raising said pipe string and wash pipe in said borehole to a point substantially above said filled portion of said borehole while continuing the flow of granular material to extend the height of said bed,

discontinuing the flow of granular material, flowing a liquid medium downwardly in said borehole through said wash pipe to wash said pipe string and wash pipe downwardly into said bed adjacent said producing formation, and removing said wash pipe from said borehole.

2. A method for packing a well in a cased borehole having perforations arranged adjacent a producing formation susceptible to being washed out and in which a producing string defining a screen section has been run including a wash pipe arranged therein to provide an annulus between said producing string and said casing wherein the normal circulation from the producing formation is upwardly through said string, which comprises flowing a washing fluid downwardly through said annulus and outwardly into said producing formation and thence upwardly through a bottom opening in said wash pipe to wash out said producing formation to form a cavity outside said casing in said producing formation, flowing a mixture of granular material in a liquid carrier vehicle downwardly into said cased borehole to deposit therein a bed of granular material adjacent said producing formation, isolating the annulus from upward circulation, continuing the flow of granular material until said cavity has been filled with granular material squeezing through said perforations from said bed, raising said producing string and wash pipe in said cased borehole to a point substantially above said filled cavity while continuing the flow of granular material to extend the height of said bed in said cased borehole, discontinuing the flow of granular material, flowing a liquid medium downwardly through said wash pipe to wash said producing string and wash pipe downwardly into said bed to a point adjacent said producing formation, and removing said wash pipe from said well.

3. A method for packing a well in a cased borehole having perforations arranged adjacent a producing formation susceptible to being washed out which comprises running a producing string having a screen section including a wash pipe arranged therein into said cased borehole to provide an annulus between said producing string and said casing wherein the normal circulation from the producing formation is upwardly through said string, flowing a washing fluid in said well downwardly through said annulus and outwardly into said producing formation and thence upwardly through a bottom opening in said wash pipe to wash out said producing formation to form a cavity outside said casing in said producing formation, flowing a mixture of granular material in a liquid carrier vehicle downwardly into said cased borehole to deposit therein a bed of granular material adjacent said producing formation, isolating the annulus from upward circulation, continuing the flow of granular material until said cavity has been filled with granular material squeezing through said perforations from said bed, raising said producing string and wash pipe in said cased borehole to a point substantially above said filled cavity while continuing the flow of granular material to extend the height of said bed in said cased borehole, discontinuing the flow of granular material, flowing a liquid medium downwardly through said wash pipe to wash said producing string and wash pipe downwardly into said bed to a point adjacent said producing formation, removing said wash pipe from said well and producing said well.

4. Apparatus for packing a well with granular material which comprises, in combination, a screen and liner provided with spaced apart ports arranged at an intermediate point and adjacent an upper end thereof and said screen and liner defining a lower outlet with a lower end thereof, said screen and liner being adapted to be connected to a producing string, a packer slidably mounted on said screen and liner adapted to direct flow into and out of said screen and liner on positioning said packer between the spaced apart ports, a retrievable wash pipe adapted to be retrieved by a wire line attached thereto arranged with said screen and liner, separate means for packing off the top and the bottom of said wash pipe to prevent circulation between said wash pipe and said screen and liner, closure means arranged in said screen and liner adjacent said lower outlet which is adapted to be held in an open position when said wash pipe is in said screen and liner and adapted to close said lower outlet of said screen and liner when said wash pipe is retrieved to allow flow from said producing formation upwardly through said screen and liner and through said producing string on positioning said packer above the ports adjacent the upper end of said screen and liner.

5. Apparatus in accordance with claim 4 in which the screen and liner defines radial ports immediately above the lower outlet, and in which a slidable annular sleeve is arranged on said screen and liner adapted to close said radial ports when said sleeve is in a retracted position.

6. Apparatus for packing a well with granular material which comprises, in combination, a screen and liner provided with spaced apart ports arranged at an intermediate point and adjacent an upper end thereof defining with a lower end thereof a recessed shoulder having radial ports communicating the exterior with the interior thereof and defining a lower outlet with said lower end, said screen and liner being adapted to be connected to a producing string, a packer slidably mounted on said screen and liner adapted to direct flow into and out of said screen and liner on positioning said packer between the spaced apart ports, a retrievable wash pipe adapted to be retrieved by a wire line attached thereto mounted within said screen and liner, separate means for packing off the top and bottom of said wash pipe to prevent circulation between said wash pipe and said screen and liner, closure means arranged in said screen and liner adjacent said lower outlet which is adapted to be held in an open position when said wash pipe is in said screen and liner and adapted to close said lower outlet when said wash pipe is retrieved to allow flow from said producing formation upwardly through said screen and liner and through said pipe string on positioning said packer above the ports adjacent the upper end of said screen and liner, and a slidable annular sleeve embraceably mounted on said recessed shoulder adapted to close said radial ports when said sleeve is in a retracted position.

HARRY S. ARENDT.
GUSS F. ABENDROTH.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,207,334	Reynolds et al.	July 9, 1940
2,229,493	Croft et al.	Jan. 21, 1941
2,310,397	Coberly	Feb. 9, 1943
2,349,062	Vren	May 16, 1944