June 25, 1957 S. G. WOODRUFF 2,796,939

WELL LINER

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FIG. 1. FIG. 2. FIG. 4.

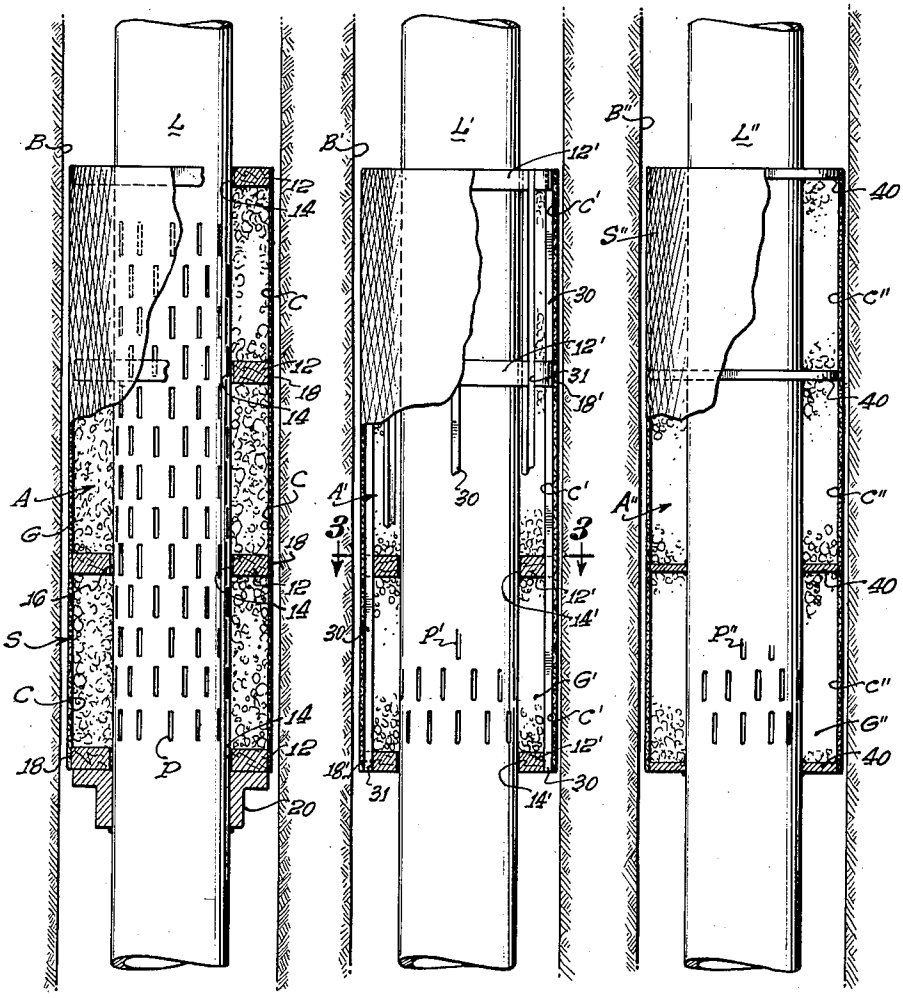
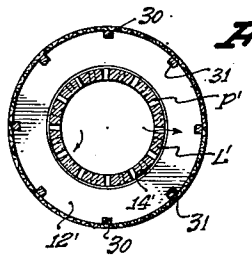


FIG. 3.



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WELL LINER

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4 Claims. (Cl. 166—228)

The present invention relates generally to the field of oil well equipment, and more particularly to a pre-packed gravel liner that may be lowered into a well bore as an integral unit, and the method of using same in the production of fluid therefrom.

As is well known, oil production is effected by drilling a well bore into a fluid communicating position relative to a producing sand. Fluid flows from an area or zone of high pressure to an area or zone of lower pressure. Therefore, the production of fluid from a well bore is dependent upon maintaining a differential in pressure between that within the well bore and that existing on the fluid in the fluid containing sand or geological formation in which the fluid is situated. This differential in pressure is most critical, and has a definite bearing on the use of the present invention.

In most oil fields there is a critical range for this differential in pressure, which range if it can be maintained permits fluid to be produced without appreciable quantities of sand, silt and other foreign material being carried into the bore hole during the process of producing fluid therefrom.

The lower limit of this critical range is when the differential in pressure between that in the bore and the pressure on the fluid in the geological formation containing same is so small, that the pressure on the fluid is not sufficient to overcome the resistance offered by the sand or geological formation that is necessary for the fluid to traverse in reaching the bore hole. A well of this type will have little or no commercial value, as either no fluid enters the bore hole from the fluid containing sand, or the fluid will flow into the bore hole at such a slow rate that the well literally has no production.

The upper limit of the critical range is of primary importance in the present invention, for here the differential in pressure between that existing in the bore hole at the level that fluid enters same and that on the fluid in the formation in which the fluid is situated is sufficiently great that not only does a flow of fluid take place towards the bore hole, but at a sufficiently rapid rate that sand and finely divided solid material is carried along therewith. Sand and foreign material carried into the bore hole in this manner are highly detrimental, in that, they ultimately fill up a portion of the bore hole, as well as clog the pump and tubing when such equipment is used in the well. Ultimately, when such a sanding condition exists the pump will have to be pulled to clean same, and a bailing operation conducted to remove the deposited sand and foreign material from the bore hole. Both of these operations are not only expensive but time consuming.

Many devices and apparatus have been proposed and used in the past, the only purpose of which has been to permit fluid to enter a bore hole and be brought to the surface, and which tend to prevent solids moving or carried by the fluid as it flows toward the bore hole from entering the confines thereof. One of the most common solutions of the problem of preventing sanding is the

use of an elongate perforated liner surrounded by a screen or perforated shield that is somewhat larger in horizontal cross section than the liner, through which fluid may flow. The annulus-shaped confined space between the liner and screen is packed with gravel of the desired size through which passage of solid particles is prevented. Theoretically the gravel provides a barrier that permits fluid flow therethrough but prevents passage of particles into the bore hole to such an extent that they become detrimental to normal well production. In practice, however, no perfect barrier has as yet been developed that completely prevents inward movement of solid material into the confines of the well bore, yet at the same time permits fluid to flow thereinto.

Therefore it will be seen that gravel packing does not completely solve the problem as above outlined, but merely serves to prolong the period of time between necessary bailing operations during which the sanded up condition is temporarily rectified. However, even though gravel packing restricts the movement of sand into a well bore, it gives rise to another problem of serious consequence from an operational standpoint in that as fluid flows into the well bore, solid particles borne therewith are deposited on the outer surface of the gravel pack or screen and eventually build up to form a substantially impervious film or layer thereon whereby the flow of fluid is restricted to such an extent that the well production becomes commercially impractical. The procedure most commonly employed in overcoming this condition is to backwash the well in order to dislodge the deposited solids from the gravel pack or screen.

For backwashing to successfully remove deposited material from the outer surface of the gravel pack or screen, the direction of flow of the washing liquid must be substantially normal to that of the longitudinal axis of the liner, and outwardly through the screen or shield. However, on many occasions it is not possible to place a pressure on the backwashed liquid sufficient for the liquid to break portions of the deposited film loose to permit increased fluid flow into the bore hole and liner. When this situation prevails the screen and gravel pack simply serve to define a cylindrical side wall of hard deposit and the backwashed liquid is directed upwardly and downwardly to the open ends of the deposit side wall without accomplishing any useful results relative to dislodging it or breaking it up sufficiently to reopen the screen and permit fluid flow therethrough.

The applicant has devised the present invention which eliminates the possibility that backwashed fluid would flow substantially parallel to the liner, rather than in a direction normal to the gravel pack whereby the deposited material may be removed from the gravel or screen.

A major object of the present invention is to provide a pre-packed gravel liner of novel design in which fluid backwashed downwardly therethrough is directed outwardly through the gravel to remove flow-obstructing deposit from the exterior surface thereof and the associated retaining screen, and by means of which all possibility that backwashed fluid will flow axially relative to the liner is completely eliminated.

Yet another object of the invention is to supply a novel method of backwashing a gravel-packed liner to remove deposited flow-obstructing material from the exterior surface thereof, as well as a method of fabricating said liner.

Yet another object of the invention is to furnish a pre-packed liner construction that may be applied equally well to any one of the presently commercially available liners when used with either a screen or perforated shield to hold the gravel or filtering material in the desired position.

These and other objects and advantages of the inven-

tion will become apparent from the following description of a preferred and certain alternate forms thereof, and from the drawing illustrating those forms in which:

Figure 1 is a combined elevational and vertical cross-sectional view of a portion of a compartmented pre-packed gravel liner as installed in a bore hole;

Figure 2 is a combined elevational and vertical cross-sectional view of a portion of a first alternate form of the present invention;

Figure 3 is a horizontal cross-sectional view of the first alternate form of the invention, taken on line 3—3 of Figure 2; and,

Figure 4 is a combined elevational and vertical cross-sectional view of a portion of a second alternate form of the invention.

Referring now to the drawing for the general arrangement of the preferred and alternate forms of the invention, it will be seen that a tubular liner L is provided in which perforations P are formed. The liner is surrounded by a screen or shield S of somewhat larger cross-sectional area, but that is sufficiently small as to permit lowering of the liner assembly into a well bore B. The exterior surface of liner L and the interior surface of screen S define an elongate space A of annulus cross section, a portion of which is filled with gravel G, or other suitable material through which fluids may flow, yet which tends to prevent inward passage of solid material into the confines of the liner.

Liner L is normally a metallic tubular member, and the member of perforations P therein, and the relative positions thereof being determined by such factors as the capacity and fluid discharge rate of the pump associated with the liner, the rate at which fluid enters the bore hole when the fluid standing in the bore hole is subjected to a predetermined hydrostatic head, the physical characteristics of the fluid produced, and the like.

The perforations P, as shown in Figures 1, 2 and 4, may take the form of elongate slots **10**, or other desired shapes. The total area of perforations P per unit length of liner L is of importance in that it determines the maximum pressure to which screen S will be subjected during backwashing, as will hereinafter be described in detail. Obviously the screen S selected for use with the liner must incorporate the necessary physical strength to withstand the maximum fluid backwashing pressure, which is determined by both the maximum pressure of the fluid received by the liner and the total area of the perforations therein per unit length thereof.

In the preferred form of the invention seen in Figure 1, the annulus-shaped space A is subdivided into a number of compartments C defined by vertically spaced rings **12**. Rings **12** are preferably fabricated from redwood or the like, that expands when wet but does not appreciably deteriorate under such conditions. Each ring **12** is provided with an inner annular opening **14** through which the liner L passes. This opening is defined by a circumferentially extending face **16**, the diameter of which permits the ring to be slidably mounted on the exterior surface of the liner. The outer circumferential face **18** of ring **12** is of such size that it snugly engages the interior surface of screen S.

Each compartment C is filled with gravel G or other comminuted material adapted to allow fluid flow therethrough. Downward movement of screen S, gravel G, and rings **12** relative to liner L is prevented by means of a suitable rigid member such as a plate, collar or outwardly extending legs **20** which may be rigidly affixed to the exterior of liner L and positioned directly below the lowermost ring **12** to support same.

It will be seen in Figure 1 that compartments C are arranged in vertical sequence one above the other, and that substantially the entire weight of these gravel-filled compartments is borne by supporting member **20**. When the redwood rings **12** are subjected to water, expansion thereof is uniform in all directions, with the result that the diameter of openings **14** shrink as the circumferential ring faces **16** are brought into fluid-tight gripping contact with the exterior surface of liner L. It will therefore be seen that this construction provides a preformed liner in which axial fluid flow along the exterior face of the liner is virtually impossible due to the multiple fluid-tight seals created by rings **12**.

When the present invention is backwashed to remove flow-obstructing material therefrom, it will be apparent that sufficient pumping capacity must be provided at the ground surface to allow flow of backwashing fluid through open portions of the screen without permitting the hydrostatic head exerted on other of the obstructed openings in screen S to drop appreciably. Obviously, unless such pumping capacity is adequate to supply fluid to liner L faster than it can escape through the opened screen, there will not be sufficient fluid pressure to remove the deposited material.

At the time of fabricating the pre-packed liner of the present invention the gravel G is preferably subjected to a predetermined pressure as each succeeding ring **12** is positioned on liner L. However, this predetermined pressure is usually increased somewhat when the liner is disposed in the bore hole B, for there normally is some water contained in the fluid entering the bore hole. When this water contacts the redwood rings **12** it causes them to expand both longitudinally and radially. Radial expansion of the redwood acts in both directions whereby the diameter of opening **14** tends to shrink, and the circumferential edges **16** of the rings expand and engage the interior surface of the screen, whereby each pair of rings **12** cooperate with the liner and screen S to define a compartment C which limits the direction of fluid flow discharged therefrom. By use of a pre-packed liner as above described, fluid production from a well which tends to sand up may be materially increased for appreciably longer intervals before back washing is required.

In addition to the preferred form of pre-packed gravel liner of the present invention, several alternate forms thereof may also be used with equal success as described hereinafter.

A first alternate form of the invention is shown in Figures 2 and 3, wherein it will be seen to include the same components embodied in the preferred form, which components are identified by the same letters and numerals employed with the preferred form but to which a prime has been added. This alternate form is particularly characterized by a number of vertical, circumferentially spaced ribs **30** that fit into notches **31** formed in rings **12'**. Ribs **30** extend substantially the length of liner L' and are affixed to the rings by conventional fastening means such as nails, or the like. These ribs serve to maintain rings **12'** in the desired relative vertical position. The use and operation of the invention is the same as that of the preferred form thereof.

A second alternate form of pre-packed gravel liner may be seen in Figure 4 wherein a number of vertically spaced rings **40** fabricated of steel plate, or a similar metal, are welded or otherwise affixed to the exterior surface of liner L''. The screen S'' encircles the outer circumferential edges **41** of the rings, and is affixed thereto by tack welding. Liner L'', screen S'', and rings **40** cooperatively provide a number of vertically disposed compartments C'', each of which is filled with gravel G''. This gravel is subjected to a predetermined pressure at the time the rings **40** are affixed to the liner L''.

This second form of the invention operates in precisely the same manner as the other two forms thereof, and merely constitutes another structural variation that accomplishes the same result. Gravel G'' remains under substantially the same pressure at all times, for the rings **40** have no tendency to expand when wet and the weight of gravel G'' in each compartment C'' is carried by the lowermost ring **40** defining same.

The method of using the present invention in producing fluid from a well may best be described as fol-

lows. After a series of vertically disposed compartments are formed around the liner, these compartments are then filled with gravel under the desired pressure. As previously mentioned, the gravel selected is of a size to permit radial flow of fluid therethrough by means of the perforations P, P' or P'' formed in the liner and the openings formed in the screen S, S' or S''. However, it will be apparent that fluid cannot flow longitudinally from one compartment to the other due to the fluid-tight seals effected by rings 12, 12', 40 at their junction with the liner.

After assembly, the pre-packed liner is lowered into the bore hole for use in the production of fluid therefrom in the manner commonly employed with the conventional liner. Production is continued until such time as solids carried by the fluid in traveling into the well bore are deposited on the screen exterior to such an extent that the fluid production is reduced to an undesirable low level. Liquid under pressure is then pumped to the liner L, L' or L'' from the ground surface, which liquid is discharged into one of the compartments C, C' or C'' through which it flows radially to exert sufficient force on the deposited material to remove it from the screen or gravel.

It will be apparent that the greatest internal liquid pressure can be applied to the deposited material when the minimum amount of liquid is presented as a column in the annulus shaped space between the liner assembly and bore hole in which it is disposed. For that reason, the maximum pressure to be used on the liquid in the backwashing operation should be applied at the very start thereof. Pressure applied to the deposited material in this manner will cause some of it to separate from the screen or gravel. Those portions of the screen or gravel from which the flow-obstructing material is separated will permit the outward flow of backwashing liquid into the annulus-shaped space X. Therefore, it is of the utmost important that pump facilities be provided at the ground surface capable of maintaining a predetermined maximum pressure on the backwashing liquid as the rate of flow thereof increases when pieces of the flow-obstructing material are separated from the gravel or screen. Relatively high fluid pressure may be exerted on the interior of the liner L, L' without causing expansion of screen S, S', to the extent gravel would drop downwardly from one compartment to that positioned therebelow. A fluid pressure of 2000 to 3000 pounds of the liner interior actually exerts but a small fraction of this pressure on the layer of deposited solids. The reason for this lower pressure is due to the fact that in each unit length of liner there are only a certain number of perforations P, P' or P'' of fixed area. Thus, if perforations of two square inches in area are present in one unit length of liner, and the screen associated with the liner has an internal diameter of six inches, backwashing liquid at 2000 pounds pressure in the tubing will be discharged from the perforations to flow radially through the gravel and exert a uniform pressure of

$$\frac{4000}{3.1416\times 6}=200.5 \text{ pounds per square inch}$$

on the deposited solids to displace them from the exterior surface of the gravel. Actually the pressure on the deposited material is somewhat less than this figure, due to the resistance offered the backwashing liquid by the gravel during the flow therethrough.

The operation of the present invention is extremely simple. In the field, the above-described gravel packed liners are used in the same manner as other conventional liners, but due to the novel construction thereof, the fluid flow-obstructing material may be removed from the gravel or screen by a backwashing operation.

Although the pre-packed gravel liner and method of using same of the present invention are capable of providing the advantages and achieving the objects hereinabove described, it is to be understood that they are merely illustrative of the presently preferred embodiments of the invention and that there is no intention to limit the scope thereof other than as defined in the appended claims.

I claim:

1. A liner surrounded by a gravel retaining screen from which deposited flow-obstructing material on the external surface of said gravel may be removed by application of not over a predetermined maximum pressure per unit area exerted by liquid backwashed through tubing supporting said liner on the lower end thereof, including: an elongate cylindrical screen capable of withstanding a maximum pressure per unit area when exerted on the interior surface thereof; a tubular member centrally disposed within the confines of said screen and extending substantially the length thereof, said member having a plurality of spaced perforations formed throughout the length thereof, the open area of said perforations being so limited that said maximum pressure on said screen will not be exceeded when liquid is backwashed downwardly through said tubular member at the maximum pressure used for said backwashing operation; a plurality of longitudinally spaced radially expandible solid rings mounted on said screen and extending inwardly to effect fluid-tight seals with said tubular member, with each two adjoining rings defining a compartment wherein a separate stream of fluid may be directed outwardly toward said screen from said perforations communicating with that particular compartment; and gravel disposed in each of said compartments, which gravel serves to filter fluid entering the confines of said compartments and uniformly distributes backwashed fluid to the interior surface of said screen to cause removal of said flow-obstructing material therefrom at a pressure not in excess of said maximum pressure said screen is capable of withstanding.

2. A liner as defined in claim 1 in which said rings are fabricated of a wood which will expandingly react when subjected to water to bring said rings into fluid-sealing contact with the exterior surface of said liner.

3. A liner as defined in claim 1 in which said rings are held in predetermined spaced relationship by means of a plurality of elongate circumferentially disposed rigid ribs that rigidly engage same, which ribs are outwardly spaced from said liner and substantially parallel thereto.

4. A pre-packed gravel liner as defined in claim 1 in which said rings are fabricated of redwood that expands when subjected to water and will effect a fluid-tight seal with said liner to subject the gravel in said compartments to a compacting action as said expansion occurs.

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