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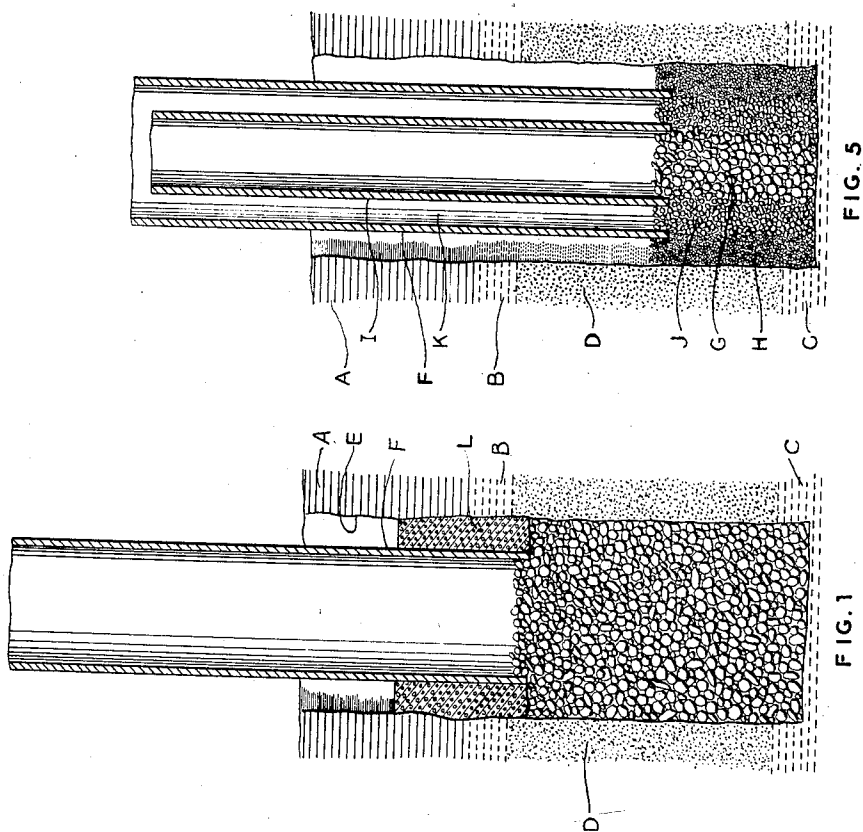
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2,171,884

METHOD OF FINISHING OIL WELLS WITH GRAVEL PACKS

Filed June 10, 1938

2 Sheets-Sheet 1



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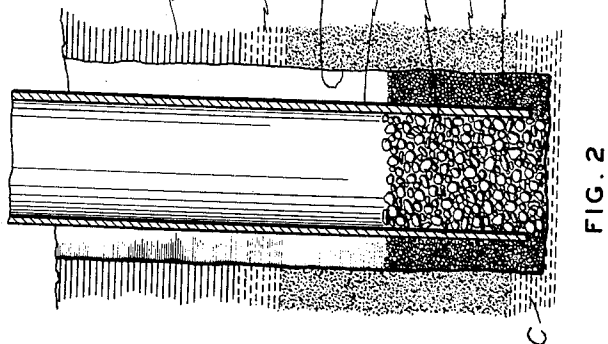
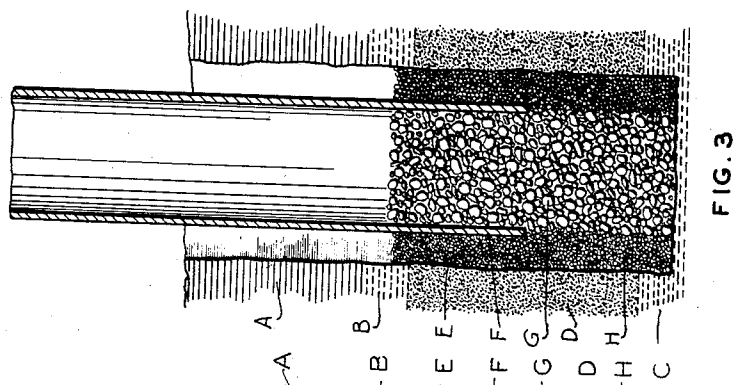
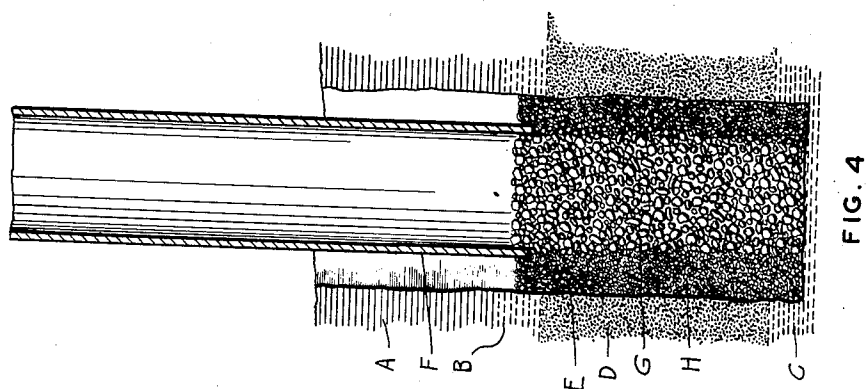
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METHOD OF FINISHING OIL WELLS WITH GRAVEL PACKS

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2 Sheets-Sheet 2



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METHOD OF FINISHING OIL WELLS WITH GRAVEL PACKS

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3 Claims. (Cl. 166—21)

The object of the invention is to provide an inexpensive and highly effective substitute for perforated casing in finishing oil wells and placing them on production.

5 It is established practice in this art to line that portion of the well which passes through productive strata or "oil-sands" with perforated casing. This is casing or pipe provided with numerous holes or slots, sometimes covered with
10 wire mesh or other screen, and is for the purpose of straining the oil and excluding sand or other solid matter from the well while permitting the oil to enter freely.

This perforated pipe is effective for the intended purpose but is subject to several drawbacks. For example, it is structurally weak and liable to collapse under external pressure, often with serious damage to the well. The perforations often choke with sand and the pipe may then be difficult to clean in place or to withdraw from the well for cleaning. The perforated pipe is unduly costly and, particularly where fluid velocities are high, the perforations are subject to cutting and enlargement by which the usefulness of the pipe may rapidly be destroyed.

I have discovered that these disadvantages may be avoided in an inexpensive and effective manner by entirely omitting the use of perforated pipe and filling the productive portion of the hole with
30 gravel, grit, or its equivalent. The casing (the imperforate pipe used for lining the well) may then be set with its lower end above the gravel bed, but preferably it is so set as to enter the gravel bed at least a few inches, thus excluding
35 from the well any solid matter which later may cave from the wall of the hole above the productive strata.

In this practice the oil from the formation enters the periphery of the column of gravel filling
40 the hole and travels upwardly through it into the casing, and thus to the well head if the well be capable of flowing or otherwise to the production pump. The gravel column may be of uniform mesh throughout, or it may consist of one or
45 more concentric layers surrounding a central core, in which case the mesh of the gravel or its equivalent is graded, the finer mesh being placed outside and in contact with the producing formation.

The various manners in which the gravel pack may be arranged are illustrated in the attached drawings, all in full section, showing a fragment of the lower end of an oil well, highly conventionalized. In these drawings—
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Fig. 1 illustrates a well in completed condition with a pack of gravel of uniform mesh;

Figs. 2, 3, and 4 illustrate the progress of placing a gravel pack consisting of a central core of
5 relatively coarse gravel and a surrounding layer of finer gravel, and

Fig. 5 illustrates the placing of a filling having an intermediate layer of gravel of intermediate mesh between the central core and the outer or
10 surrounding layer.

Referring first to Fig. 1, A, B, and C indicate any nonproductive earth strata and D a productive stratum or so-called oil sand. Often this stratum is divided into a plurality of secondary layers by nonproductive partings, but for my purpose these minor layers may be treated in the aggregate as a single continuous layer. E is the wall of the well itself and F is the lower end of the casing with which the well is lined, the so-called "water string" which is shown as cemented
20 to the wall of the hole as at L.

As indicated in this figure, the open hole below the point at which the water string is landed is completely filled with a suitable grade of gravel, no perforated pipe or any equivalent for it being used. This gravel filling may, if desired, extend
25 a short distance into the water string.

The gravel bed may be placed in the hole in any manner which may be convenient. For example, it may be lowered to the bottom of the
30 hole in a bailer and then dumped, or it may be passed into the hole with the circulating fluid, keeping the return velocity low enough to prevent the gravel's being carried out of the hole. In most cases, however, it is preferable merely to
35 introduce the gravel in a slow stream into the upper end of the casing, allowing it to subside through whatever fluid may be in the hole.

The preferred filling consists of hard, clean gravel having rounded particles rather closely
40 graded in size so as to maintain the largest possible relation of free space to solid matter. The mesh of the gravel should be as large as is consistent with excluding sand which may attempt to enter the well along with the oil. As an example, a gravel or grit passing an 8-mesh screen and retained on a 12-mesh screen has been used with good results in an extremely fine oil sand and where the sand is coarser a correspondingly
45 larger mesh may be used for filling. It is preferable to sample the sand of which the producing formation consists, pass the sample through a succession of screens of gradually increasing mesh until only about ten per cent by weight is retained, measure the average particle size of the
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retained ten per cent fraction, and multiply this figure by ten to obtain the average diameter of the grains of which the gravel fillings should be composed.

5 A modification of the above method which may prove advantageous in some cases, particularly in wells in which the producing formation is of considerable thickness and the gravel column correspondingly long, consists in filling the productive portion of the well with two or more grades or kinds of gravel arranged in concentric columns. In this arrangement the central column is of gravel of moderately large grain, offering little obstruction to the upward passage of oil, while the layer or layers surrounding the central column are composed of smaller particles adapted to retain the formation sands in position and exclude them from the well while permitting oil to flow laterally into the central column through which it passes vertically into the lower end of the well casing and thus to the production pump.

20 The method of placing a double column of gravel in this modification of the invention, and the form which it assumes when placed, are illustrated in Figs. 2, 3, and 4 to which reference is now made.

As described in connection with Fig. 1, A, B, and C indicate any nonproductive strata, D the oil sand, E the wall of the well, and F a casing string. In these figures the casing is a special string used in placing the filling and the cemented water-string is not shown.

As indicated in Fig. 2, the casing is first lowered until it nearly or quite touches the bottom of the hole, and relatively coarse gravel G is poured into the upper end of the casing while fine gravel H is introduced into the upper end of the hole outside the casing. It is desirable to maintain the upper surfaces of the two fillings as nearly as possible at the same level as filling proceeds. Care must be taken not to bury the casing so deeply as to risk its sticking. This operation forms the two columns, parted by the wall of the casing, but as the area of the casing wall is only a very small fraction of the area of the hole, the withdrawal of the casing brings the two columns into contact without any material disturbance of their relative positions.

After a few feet of gravel has thus been placed the casing is raised, but not far enough to pass entirely out of the gravel already placed, and further quantities of the two grades of gravel are introduced as before. This sequence of operations is repeated at such intervals as may seem desirable to the operator, until the gravel filling extends at least to the top of the productive formation and preferably somewhat above it. Fig. 3 shows the filling operation in progress and Fig. 4 indicates the form of the filling when the job is completed but before the casing is entirely withdrawn.

A slight further modification of this second form of the invention is illustrated in Fig. 5. In this modification two strings of casing, F and I, are used. Coarse gravel G is introduced into the central string and fine gravel H into the space between the wall E and the outer string I, while an intermediate mesh gravel J is introduced into the annular space K between the two strings. The casing strings are raised simultaneously so as to keep their lower ends at the same level, and should be raised at very short intervals to prevent bridging between the two strings. As shown in the figure, the result of this operation is a central column having relatively large

openings between the constituent particles, an outer envelope consisting of small mesh particles capable of holding back fine oil sands, and an intermediate layer of such mesh as to prevent the outer layer from passing into the voids existing in the central column. This modification is useful particularly in cases where the sand is extremely fine and also exceptionally thick.

Each of these forms of the invention provides at once a strainer to exclude even the finest sands from the well and a central vertical flow channel to conduct the oil up to the pump. It is thus a full substitute for the present perforated, slotted, or screen pipe with none of the disadvantages which attend the use of pipe. Thus it is perfectly rigid and does not permit the producing sands to shift or run and is incapable of collapse; it will maintain its effectiveness for a much longer period than a strainer pipe because of the much greater straining area in contact with the oil sand; it can be placed at a very small cost, and when after long use it may become partially or entirely choked, it may be drilled or circulated out of the hole and replaced with new material having the total original effectiveness.

While for convenience I have used the word "gravel" throughout the above description, it will be understood that the invention is not so limited. The requirement is for small solid bodies so shaped that they afford interspaces and flow channels for liquids when formed into packs by sedimentation. For such purpose almost any inert solid having a generally rounded contour may be used, as well as some which are irregularly angular. For example, rounded particles of vitrified clay, stoneware, or crushed rock may be used, as well as Raschig rings and other filling suitable for fractionation towers, and metals in the form of rings, stars, short rods, etc. Whatever material is used must be heavy enough to subside through the liquid in the hole, must be substantially unaffected by long continued contact with water and oil, and must be of sufficient mechanical strength to avoid crushing by the formation pressure existing in the well.

As illustrative of the advantages obtaining in the application of the first method above described, I may cite its use in a certain well located along the coast of California. This well has its water string cemented at 3036' and is producing from the 3038' to 3117' levels. A pack of gravel ranging from 8-mesh to 12-mesh fills the open hole and extends 53' up the water string. The packing of the well was completed March 15, 1938, at which time the production was 150 barrels of 25 gravity oil per day. This production has been maintained unchanged to the day of writing, May 31, 1938. This well is impractical to produce through perforated screen pipe as the sand is so fine as to pass freely through slots wider than $\frac{1}{30}$ th inch and with a slot of this width only a small proportion of the oil which the well is capable of producing can enter the well and reach the pump.

The term "gravel" is used in the claims to mean any particles of any material larger than the smaller grains of the natural formation.

I claim as my invention:

1. The method of finishing an oil well and forming a filter therein solely of gravel which comprises the steps of successively building up from the bottom of the well hole a column solely of suitably sized gravel to a height slightly above the oil productive area of the well, said column

being contiguous with the well wall and serving to substantially prevent the incursion of sand into the portion of the well thereabove and to permit the free upward flow of oil therethrough.

5 2. The method of finishing an oil well and forming a filter therein solely of gravel which comprises filling the central portion of the well hole with a vertical column solely of suitably sized gravel, said column resting on the bottom of
10 the well hole and rising to a height slightly above the oil productive area and immediately surrounding said column with a layer of relatively smaller suitably sized gravel, said layer being contiguous with the well wall and serving
15 to substantially retain the sand in formation position whereby the free upward flow of the oil is permitted through said central column.

3. The method of finishing an oil well and

forming a filter therein solely of gravel that comprises filling the central portion of the well hole with a vertical column solely of suitably sized gravel, said column resting on the bottom of the well hole and rising to a height slightly above
5 the oil productive area of the well, simultaneously surrounding said column with a contiguous layer of relatively smaller suitably sized gravel, said layer being spaced from the well wall, and simultaneously filling the space between said
10 layer and the well wall with suitably sized gravel, said gravel being relatively smaller than that forming said layer, whereby the incursion of sand into the portion of the well above said groups of
15 said small gravel is prevented and the free upward flow of oil is permitted.

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