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Spurlock et al.

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[54] **PREPACKED MULTI-GRADED SAND SCREEN**

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[21] Appl. No.: **136,777**

[52] **U.S. Cl.** **166/228,** 210/497

[51] **Int. Cl.** **E21b 43/08**

[58] **Field of Search** 166/228, 227, 236; 210/282, 290, 497, 483, 484, 487, 496, 503, 504, 510

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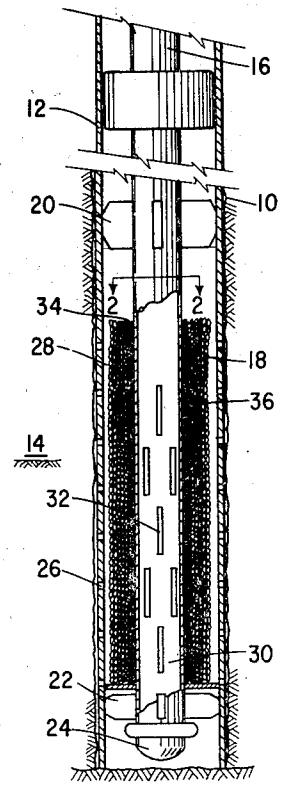
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[57] **ABSTRACT**

This is a special downhole graded mutli-layer prepacked sand filter for oil and other fluids containing sand. The preferred embodiment for the sand filter includes an inner annular consolidated layer of particles placed about a slotted pipe, an intermediate annular layer of consolidated particles adjacent said inner layer and an outer annular layer of consolidated particles next to the intermediate layer of particles. There is an opening or spacing between the particles to permit flow through the prepacked liner. The spacing between the particles of the outer annular layer is such to retain only the coarser sand particles and the spacings or openings in the inner two annular layers are progressively smaller to retain the less coarse sand particles. The coarser sand particles bridge about the larger openings in the outer annular layer and progressively finer sand materials bridge across the openings or spacings between the particles of the intermediate and inner annular layers.

6 Claims, 4 Drawing Figures



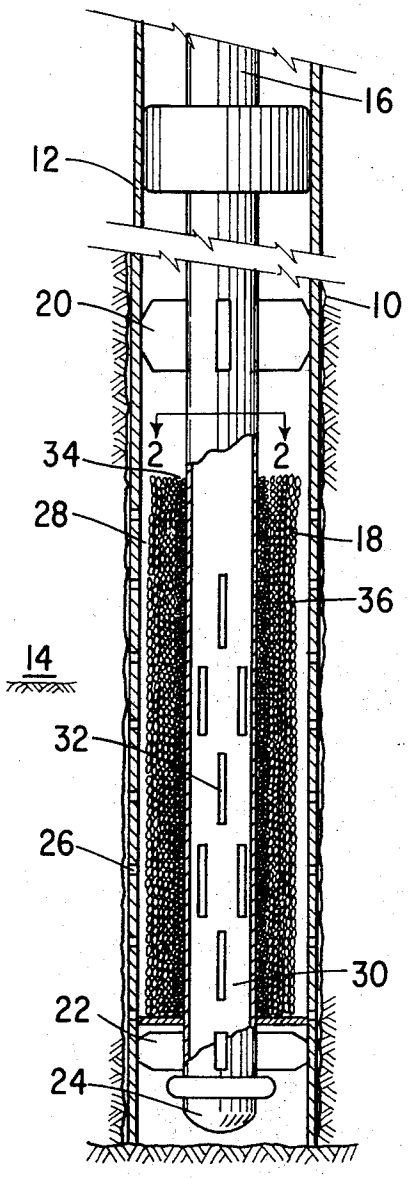


FIG. 1

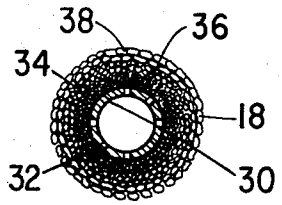


FIG. 2

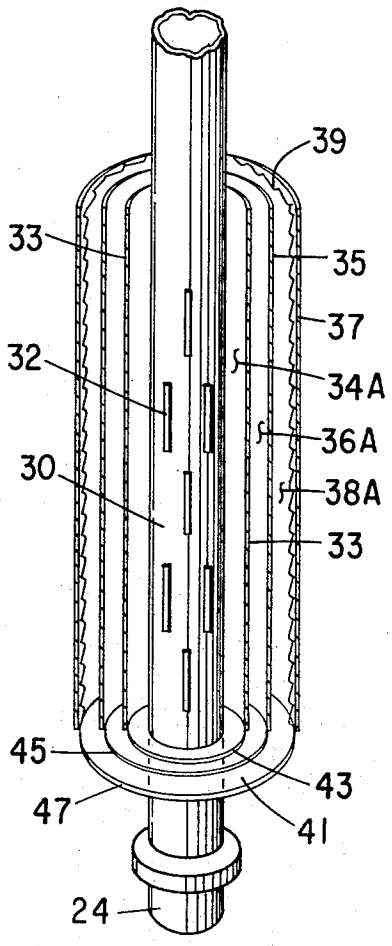


FIG. 4

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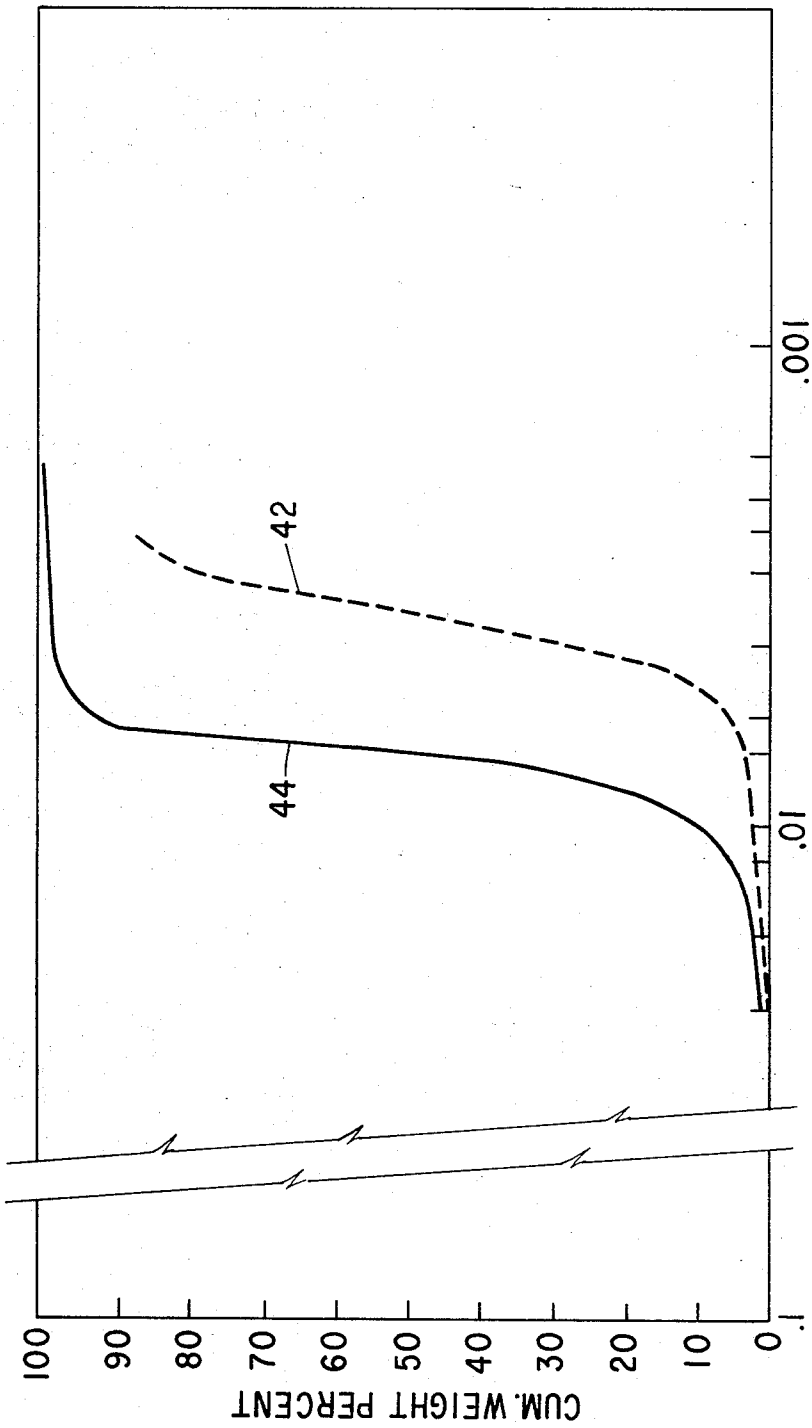


FIG. 3

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PREPACKED MULTI-GRADED SAND SCREEN

RELATED PATENT APPLICATIONS

This application is related to copending application Ser. No. 77,492, filed Oct. 2, 1970, now U.S. Pat. No. 3,412,373, entitled "Multi-Layer Well Screen" for William G. Bearden and George C. Howard.

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to a sand filter for producing fluids containing sand through well bores from subsurface formations. It relates especially to a multi-layer prepacked sand screen for removing the sand before it is produced through the well bore. The prepacked sand filter includes smaller sized clinker or gravel next to a slotted pipe connected to the producing tubing and larger sized clinkers are contained away from the slotted pipe.

Setting of the Invention

Oil and gas are produced from underground formations through well bores drilled from the surface to the formation. Some oil and gas are contained in the pores of consolidated rocks or sand. When this oil is produced through the well bore, it is relatively free of any rock particles or sand. However, many oil and gas wells produce fluid from underground formations which are not consolidated. That is, the various sand particles are not strongly attached to each other and when the fluid is produced, it carries entrained sand with it. This sand causes serious damage to well equipment and greatly restricts production of the fluids. In producing oil and gas from such unconsolidated formations, some method must be provided to restrain the sand inflow into the well. There are four primary methods previously in use for this. These are:

1. Consolidation of the formation with plastic binding agent.

2. Placing a screen in the well with sufficiently small openings to prevent inflow of all undesired material.

3. Use of a gavel pack placed in the annular area between a screen and the formation; the voids between the gavel grains being small enough to prevent inflow of sand particles.

4. Placing a screen in a well consisting of a mechanical screen and a preformed "gravel pack" bonded to the screen.

All of these methods, with the exception of the first one, have one common characteristic; they restrain material all on *one* surface. This provides a perfect environment for plugging, i.e., coarse and fine material are restrained together, permitting progressive plugging of the screen until essentially complete plugging occurs.

Method number 1, while desired, is very difficult and in some instances impossible to perform in the field. Screens as described in number 4 above have been utilized in the Tar Sands project of Northern Canada with success, but they are easily plugged during installation. This plugging again all occurs at essentially the outer surface of the liner.

Thus, there is a need for sand filters which prevent such surface plugging and the tendency to plug during installation.

BRIEF DESCRIPTION OF THE INVENTION

The preferred embodiment of this invention is a graded prepacked sand screen filter having a hollow interior which is connectable to the lower end of a string of tubing. In a preferred embodiment, a slotted pipe forms the hollow portion of the filter. A first or inner annular layer of consolidated particles have a first graded mesh size which is placed or formed about the exterior of the slotted pipe. A second annular layer of consolidated particles is formed around the exterior of the inner annular layer of consolidated particles. A third or outer annular layer of consolidated particles is formed on the exterior of the second or intermediate annular layer. The particles of the first layer have a graded mesh size which is smaller than the particles of the second annular layer. The particles of the second annular layer are smaller than the particles of the third annular layer. The size of the particles is selected so that the openings in the outer or third layer retain a larger sized sand particle produced with the fluid. The smaller produced sand particles pass on to the inner annular layers where they are retained.

BRIEF DESCRIPTION OF THE DRAWINGS

Various objectives and a better understanding can be had of the invention by the following description, taken in conjunction with the drawings in which:

FIG. 1 illustrates a downhole view of a sand filter of this invention connected to the lower end of a string of tubing.

FIG. 2 illustrates a full cross-section along lines 2—2 of FIG. 1.

FIG. 3 illustrates a typical cumulative screen analysis curve of sand samples.

FIG. 4 is useful in describing an apparatus for forming a prepacked filter of this invention.

DETAILED DESCRIPTION OF THE INVENTION

Attention is first directed to FIG. 1. Shown therein is a well bore 10 having a casing 12 therein. Well bore 10 extends through formation 14 which is an unconsolidated formation which produces sand with the produced fluid. Suspended within casing 12 is a tubing string 16 to which is attached a multigraded prepacked sand screen 18 of this invention. Details of this filter 18 will be given later. This prepacked screen can be used in either a cased or uncased hole.

Immediately above filter 18 is a plurality of centralizers 20 mounted on tubing 16. Immediately below sand filter 18 is another centralizer 22. A bull plug 24 closes the lower end of the slotted pipe 30 of sand filter 18. Casing 12 contains a plurality of perforations 26. This permits production of fluid from formation 14 through perforations 26 into annulus 28 between the filter and the casing. There should be some space between the outer surface of filter 18 and the inner surface of casing 12. This should be sufficient to allow washing over the screen, if necessary, when it is removed from the well. Typically, for a 5½ inch O.D. casing 12 (having a wall thickness of 0.304 inch) screen 18 would have a maximum O.D. of about 3¼ inch.

Attention is now directed back to the detailed description of the filter 18. Filter 18 is formed about a pipe section 30 having slots 32 through the walls thereof. An inner annular layer 34 is first formed about slotted pipe 30. The particles which make up this annu-

lar layer have a first graded mesh size. A second annular layer **36** is formed on the exterior of layer **34.** This layer **36** is made up of a second graded mesh size which is larger than the first graded mesh size. A third or outer annular layer **38** is formed on the outer surface of intermediate layer **36.** The particles of layer **38** are graded and have a larger size than the particles of the second annular layer. Stated differently, the average spacing between the particles of layer **38** is greater than the average spacing between the particles of layer **36,** which in turn is greater than the spacing of the particles in layer **34.** In otherwords, the spacing between the particles becomes progressively smaller from the outside layer **38** toward the inner layer **34.** Thus, the sand particles trapped at the outer layer **38** are relatively large and become smaller at each successive layer of particles.

To determine the spacing between the particles of the various layers in the best method we know, one should first prepare a cumulative screen analysis curve of the produced sand which the filter is supposed to retain. It is sometimes difficult to obtain accurate sampling of the sand, which causes a problem. However, if a well is sanded up, the sand must be removed from the well. There are conventional means for washing out such sand. The sand thus removed is collected and a sample taken of such sand. This sample is then analyzed to determine the cumulative screen analysis curve. Two such typical curves are shown in FIG. **3.** The ordinate is cumulative weight percent and the abscissa represents the sand size. Curve **42** represents a sample of a Miocene sand in the High Island Field, Galveston County, Tex. Curve **44** represents a sample of the Miocene sand in the Edgerly Field, Calcasieu Parish, La. The method of obtaining these curves is rather straightforward. The sample is passed through a large screen and the weight of the sample retained is noted. Progressively smaller sized screens are used and the retention of sand on each such screen is recorded. From these data a cumulative screen analysis curve can readily be plotted.

It has been found that the particles of the various layers should be selected so that the spacing (i.e., measure of the opening) between the particles has a relationship to the cumulative screen analysis curve. Typically, the spacing of the particles in the outer layer **38** should be equal to or slightly greater than the diameter of the sand particles or grain size at the **5** percentile point of the cumulative screen analysis curve for the sample of the sand which causes the problems. The spacing of the particles of the intermediate layer **36** should be equal to or slightly greater than the grain size at the **20** percentile point at the cumulative screen analysis curve. The spacing of the particles in the inner layer **34** should be slightly greater than the sand dimension at the **50** percentile point, but less than two times the grain dimension at the **15** percentile point. Using this criteria then for the cumulative screen analysis curve in the Miocene sand in the Edgerly Field in Louisiana, the spacing of the particles in the outer layer **38** is equal to or slightly greater than 0.012 inch, the spacing of the particles in layer **36** should be equal to or slightly greater than 0.0084 inch and the spacing of the particles in the inner layer **34** should be between about 0.007 inch and 0.018 inch. These selected spacings between particles can be easily obtained by proper selecting of particles to have such spacing.

The particles of the various layers of the prepacked filter should be consolidated. If lumnite clinker is used, the consolidation can be effected by merely holding the particles in condition while soaking in water for a day or two.

Attention is next directed to FIG. **4** for an apparatus useful in forming a multi-layer graded prepacked sand filter. Shown thereon is tubing section **30** having slots **32.** Positioned about slotted tubing **30** are three concentric cylindrical-shaped members **33, 35** and **37.** Immediately on the inside of cylinder **37** is a screen **39.** Fixed to the lower end of slotted pipe **30** is plate **41** which has grooves **43, 45** and **47.** These grooves are to retain the lower ends respectively of cylinders **33, 35** and **37.** These concentric metal members form annular spaces **34A, 36A** and **38A** respectively for annular layers **34, 36** and **38.** Particles of the selected size for layer **34** are poured in annular space **34A,** particles of the selected size for layer **36** are poured into annular space **36A** and particles for the layer **38** are poured into annular space **38A.** Screen **39** is fixed to retain the particles in space **38A.** Once the particles are positioned in all annular spaces **34A, 36A** and **38A,** the concentric metal members **33, 35** and **37** are removed. These members are very thin and serve only as spacers while the filter is being packed. Once the filter is packed, the metal spacers can be removed without disturbing the spacing of the graded particles. When these spacers are removed, screen **39** still holds the particles in position together with plate **41.** The next step is to bond the particles together but still retain the spacing between the particles. One convenient way of doing this is to use lumnite clinker as the particles. Then, all that is necessary is to submerge the packed particles in a body of water for a short period of time, e.g., two days and the particles bond themselves together in a fixed permeable mass. They also retain essentially the same particle spacing as when packed. If gravel particles are used, then it may be necessary to use some sort of resin to bond the particles. The excess resin should be removed so as to retain the desired spacing between the particles. After the particles have set lower plate **41** can be removed or, if desired, it can be left fixed to the tubing section **30.**

While the above description of the various embodiments has been made in specific detail, various modifications can be made thereto, without depart-ing from the spirit or the scope of the invention.

We claim:

1. A graded prepacked sand screen filter having a hollow interior which comprises:

an inner annular layer of particles having a first graded mesh size;

a second annular layer surrounding said inner layer of particles, said second annular layer having a second graded mesh size which is larger than the graded mesh size of any annular layer of smaller diameter.

2. A filter as defined in claim **1** in which said particles are lumnite clinker.

3. A filter as defined in claim **1** including a third annular layer of particles surrounding said second layer, the mesh size of the particles of said third layer being larger than the mesh size of said second layer.

4. A screen filter as defined in claim **3** in which said particles are lumnite clinker which have been consolidated by soaking in water.

5. A graded prepacked sand screen filter having a bore for use in a well to filter sand from a fluid being produced from an underground formation which comprises:

consolidated particles having an annular form, the particles near the bore of the annular form having a mesh size smaller than the particles at the outer surface of the annular form.

6. A sand filter as defined in claim 5 in which said annular form of consolidated particles is mounted on a slotted pipe.

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