Feb. 1, 1938. W. E. LANG 2,107,006

APPARATUS FOR TREATING DEPLETED OIL SANDS

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Fig. 1.

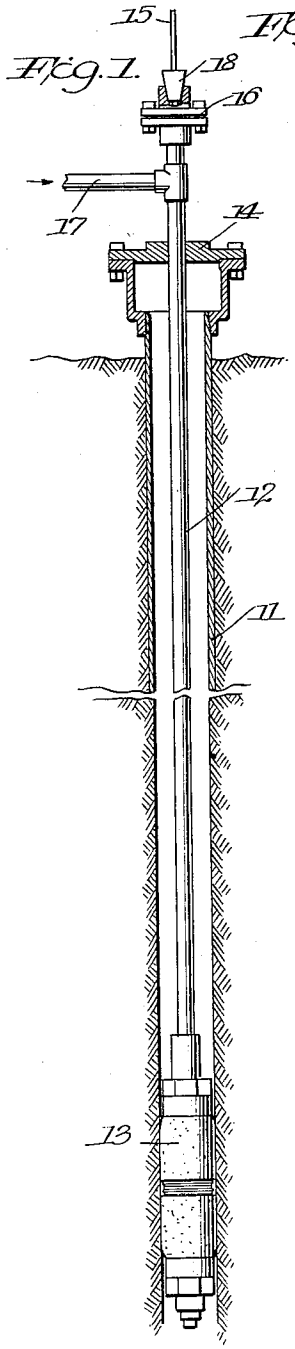


Fig. 2.

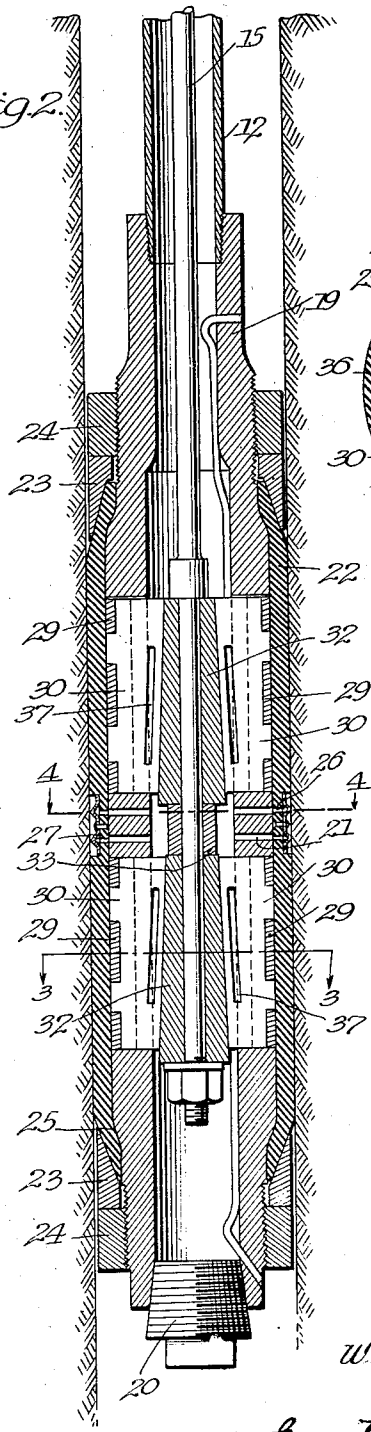
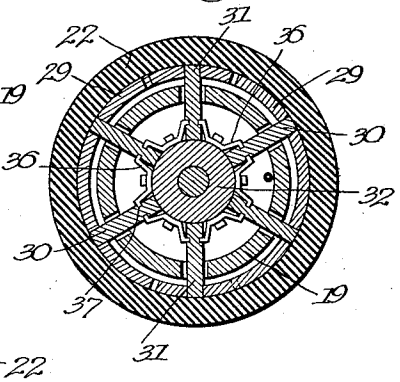


Fig. 3.



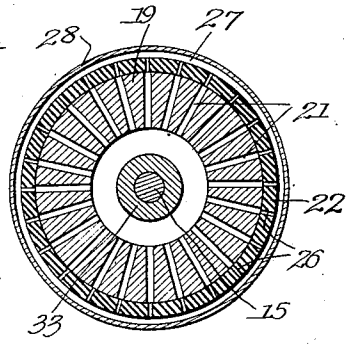


Fig. 4.

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APPARATUS FOR TREATING DEPLETED OIL SANDS

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Fig. 5.

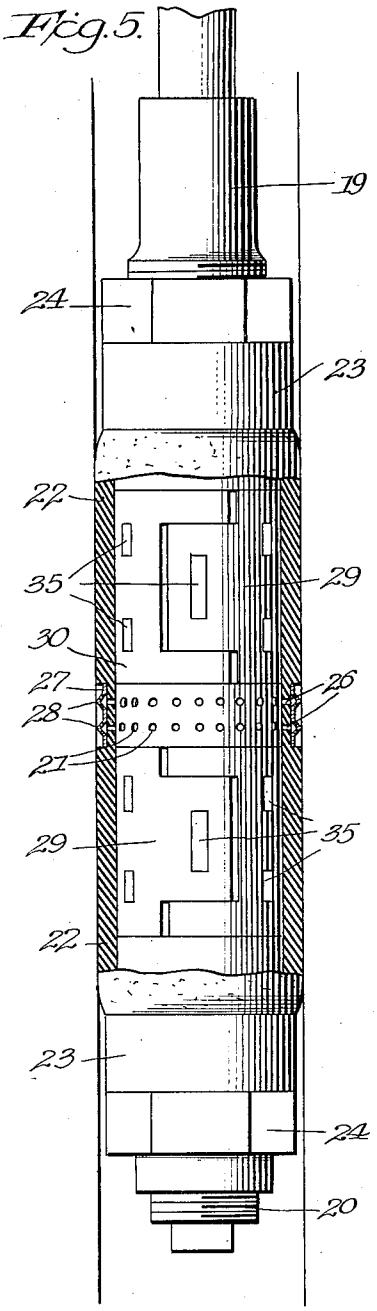


Fig. 6.

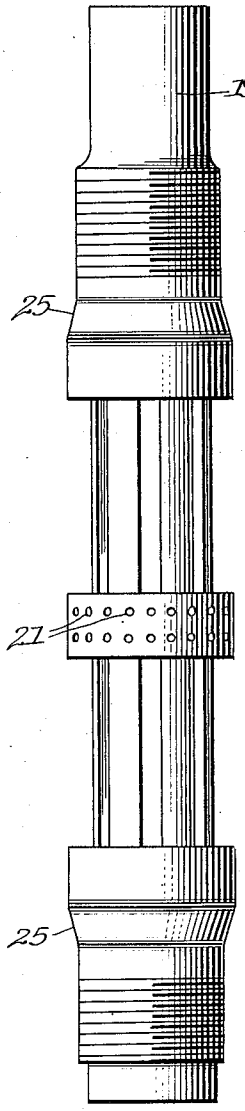


Fig. 7.

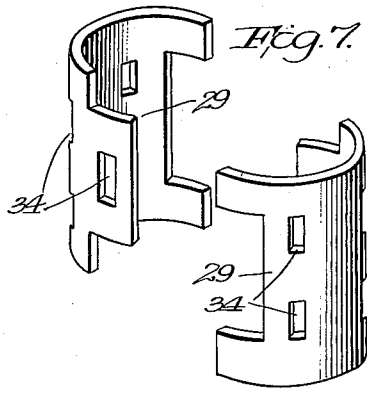


Fig. 8.

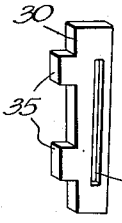


Fig. 10.

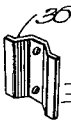
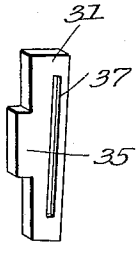


Fig. 9.



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William E. Lang.

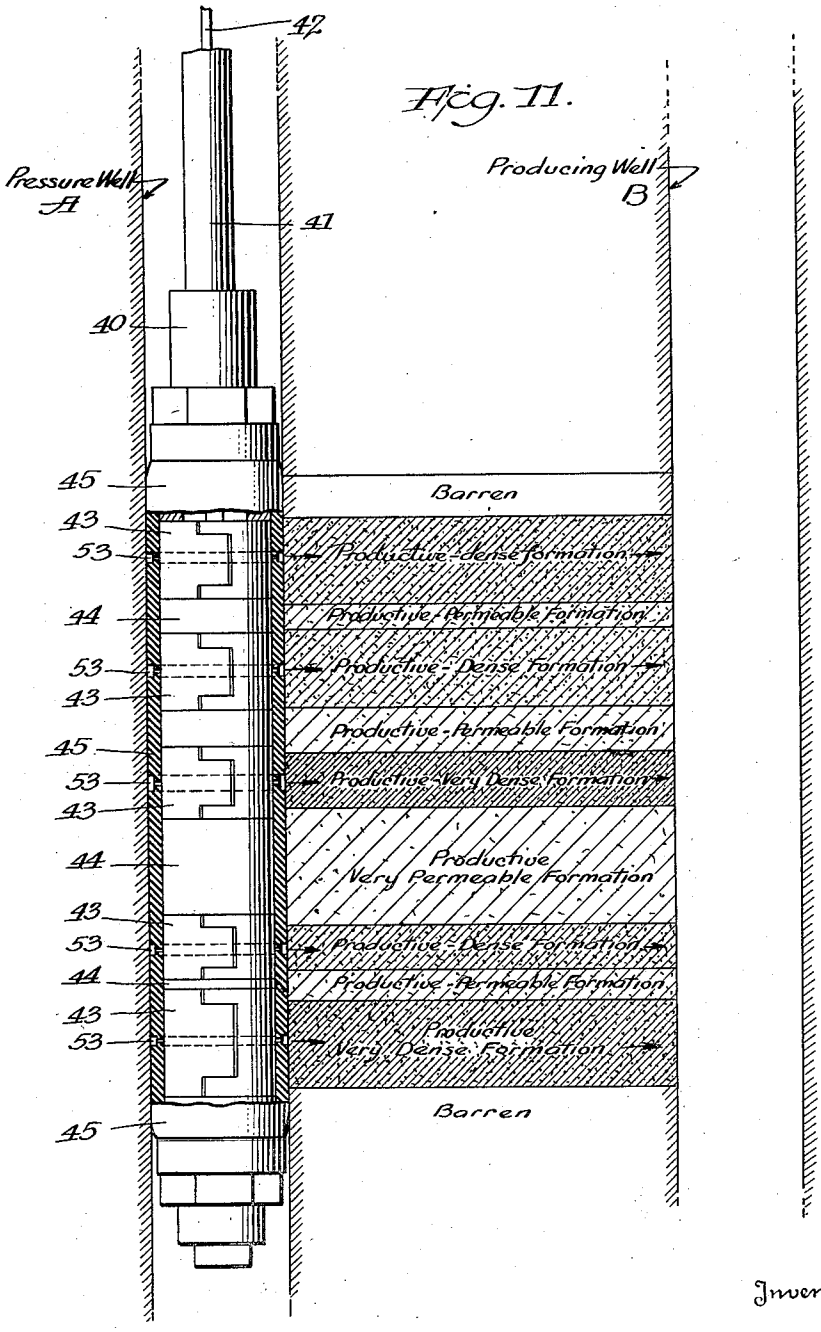
By Emery, Booth, Holcombe & Miller

Its Attorneys

Feb. 1, 1938. W. E. LANG 2,107,006

APPARATUS FOR TREATING DEPLETED OIL SANDS

Filed May 1, 1936 4 Sheets-Sheet 3



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APPARATUS FOR TREATING DEPLETED OIL SANDS

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Fig. 12.

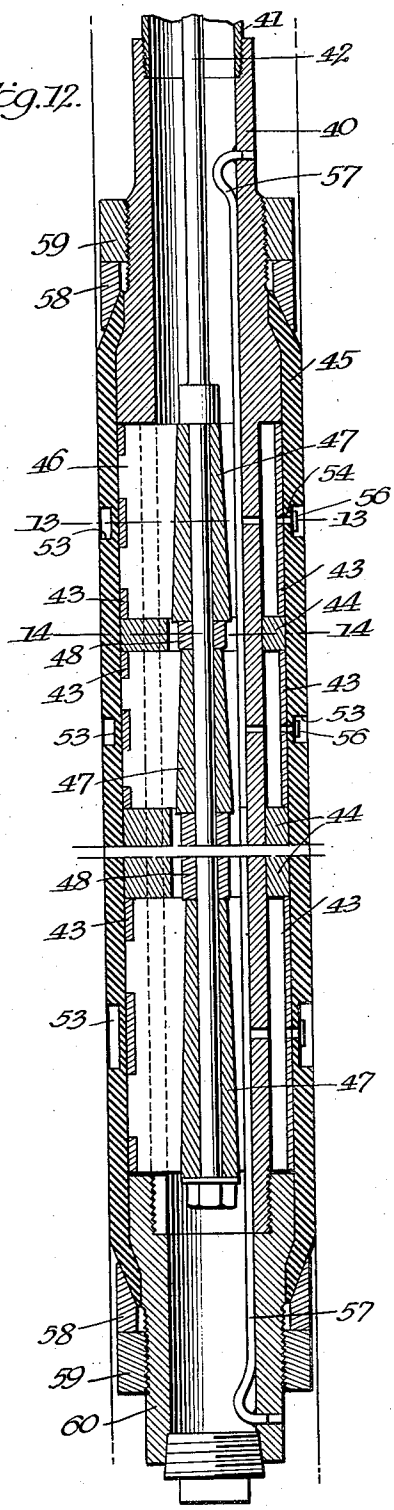


Fig. 13.

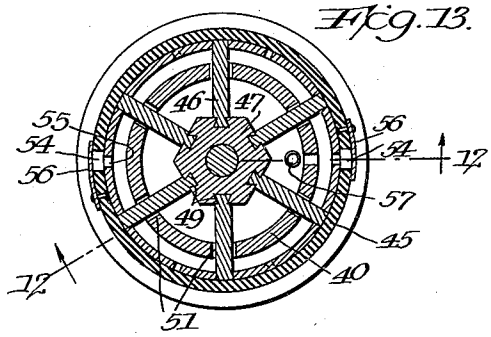


Fig. 14.

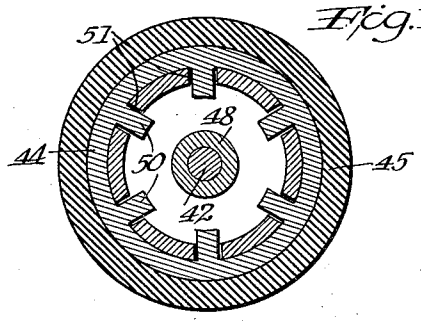


Fig. 15.

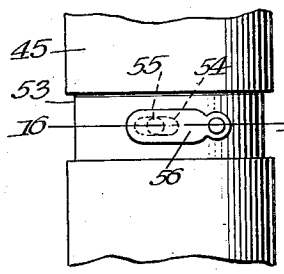
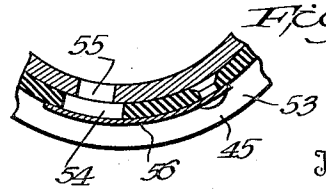


Fig. 16.



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Patented Feb. 1, 1938 2,107,006

UNITED STATES PATENT OFFICE

2,107,006

APPARATUS FOR TREATING DEPLETED OIL SANDS

William E. Lang, Lexington, Ky.

Application May 1, 1936, Serial No. 77,413

7 Claims. (Cl. 166—1)

My invention aims to provide a method for more effectively pressuring or repressuring oil-bearing sands to secure a greater efficiency in the recovery of oil therefrom, and thereby recover a greater portion of the oil contained in the entire thickness of the sand.

My present invention is an improvement on that covered by my Patent No. 2,019,418, issued October 29, 1935, and may be used with said patented invention or separately as desired.

In my Patent No. 2,019,418 I have discussed in some detail the problem of securing a more nearly uniform recovery from the various oil-containing or productive strata making up a single sand or horizon which is subjected to pressuring or repressuring at a pressure well to increase recovery therefrom at one or more recovery wells. Great differences in permeability may and usually do exist between different oil-containing strata in the same sand, and a potentially highly productive strata may be relatively impermeable, while in the same sand a neighboring strata containing a relatively smaller amount of oil may be highly permeable and hence more readily drained than the relatively impermeable strata by re-pressuring methods heretofore used which have left a large portion of the original oil still in the ground.

A problem arises from the fact that analyses of the cores taken in drilling are frequently inadequate from which to determine the distribution of pressure between the various strata in a producing sand, and thus the recovery of the oil contained therein is largely a matter of guess work as heretofore conducted.

Objects of the invention are to provide an improved method, and apparatus for use therein, for treating the exposed strata of a sand in a pressure well to facilitate injection of a pressuring fluid into the relatively impermeable oil-bearing strata thereof; to increase the permeability of certain oil-bearing strata; and to more nearly equalize the permeability of the respective strata.

Another object is to provide improved apparatus for injecting pressuring fluid into the more impermeable oil bearing strata in adequate volume to move the oil therein while controlling the admission of pressuring fluid into the more permeable strata to prevent too rapid depletion thereof.

A further object is to provide means for injecting pressuring or treatment fluids into a single stratum or localized regions only of a stratified sand or horizon, and to measure the pressure and flow in a single stratum of the sand individually; said means being also adapted for use in treating and testing a single stratum of a sand in various ways as desired.

Other objects and features of the invention will be made evident as the description progresses.

Apparatus illustrating the invention is shown in the accompanying drawings, wherein

Fig. 1 is a vertical cross-sectional view of a typical oil well, showing my apparatus in place;

Fig. 2 is an enlarged cross-section of the packer unit in working position;

Figs. 3 and 4 are horizontal cross-sections on the lines 3—3 and 4—4, respectively, in Fig. 2, looking in the direction of the arrows;

Fig. 5 is a side elevation of the packer unit shown in Fig. 2 with the expansible outer tube partly broken away to disclose the parts within;

Fig. 6 is a side elevation of the tubular steel body or frame with all other parts removed;

Fig. 7 is a perspective view of the two expanding ring sections;

Figs. 8 and 9 are perspective views of the operating wedges used for expanding the ring sections;

Fig. 10 shows a wedge guide bracket, Figs. 6 to 10 being details of the packer shown in Fig. 2.

Fig. 11 is a vertical cross-section through the bottom of the well bore indicating diagrammatically an oil sand comprising typical oil-bearing formations and illustrating an improved type of packer for simultaneously introducing fluid pressure in controlled volume under pressure into the respective strata; the packer being partly sectionalized to disclose its construction;

Fig. 12 is a longitudinal axial section of the packer shown in Fig. 11, drawn to a larger scale;

Figs. 13 and 14 are cross-sections thereof on the lines 13—13 and 14—14, respectively, in Fig. 12;

Fig. 15 is a side view of a portion thereof showing an anti-back pressure valve; and

Fig. 16 is an enlarged cross-section of the valve on the line 16—16 in Fig. 15.

The invention is primarily (but not exclusively) concerned with improved methods of repressuring oil wells after the natural gas pressure has been reduced in the field to the point that only a small production can be made from each well, and may be carried on with the aid of an old well or series of old wells spaced advantageously between adjacent groups of old producing wells, but preferably a series of new wells will be drilled for repressuring at uniform distances from the old wells.

In order that the novel methods may be better understood and applied, suitable apparatus for carrying out the preliminary treatment and for

controlling the repressuring of the different formations will next be described.

The apparatus shown in Fig. 1 includes the well casing 11, which extends from the surface of the ground to the pay-sand, and a string of tubing 12 reaching to about the level of the stratum of pay-sand to be investigated or treated, the improved packer 13 being supported on its lower end. At its upper end the tubing 12 passes through a stuffing box 14, and is suspended from the drillrig by any suitable means, such as the sectional rod 15 passing through a stuffing box 16, and to which the tubing 12 is adjustably secured by a clamp 18 so that it may be raised and lowered as desired. A lateral pipe 17 is connected to the upper end of the tubing 12 for supplying gas, air or other fluid under pressure to the packer.

The packer 13 has a hollow steel body 19 closed at its lower end by means of a plug 20, and one or more rows of orifices 21 around its middle, as shown in Figs. 2 to 6, inclusive. The packer is surrounded with a heavy rubber tube 22, secured thereto at its ends by slip rings 23 and nuts 24, which clamp the ends of the tube against the shoulders 25, as shown in Figs. 2 and 5. This tube has one or more rows of lateral holes or openings 26 which register approximately with the similarly spaced holes 21 in the body. These openings 26 are preferably protected by a metal shield 27 let into a groove in the circumference of the rubber tube near its middle and provided with raised perforated ribs or beads 28 covering the openings 26 for preventing the shield from contacting flat against the tube within or against the well wall without.

The tube 22 may be expanded to hug the well wall on each side of the rows of perforations 26 by means of semi-circular bands or split sleeves 29 arranged above and below the rows of perforations, and between the tube and the hollow body 19, which latter has groups of slotted openings through its wall on each side of the center, these openings being shaped to receive and guide the follower wedge plates 30, 31, which expand the split sleeves 29 against the inner wall of the rubber tube 22 to force the latter outwards against the rock or sand wall of the well. These wedges 30, 31 are engaged by one or the other of two expanding cones 32 spaced lengthwise on the lower end of the operating rod 15 by the bushing 33 so that when the rod is raised slightly, they will be forced out and in turn expand the split sleeves 29 and rubber tube 22 against the well wall.

In order to secure the wedges and sleeves in place in the grooved parts of the body 19, the sleeves are provided with spaced slots 34, into which short lugs 35 on the outer edges of the wedges project, and the lugs may be riveted over or welded to the sleeves after the parts are assembled in position on the body with the expanding cones 32. The wedges are slidably connected to the cones 32 by means of brackets 36 bolted to the latter and sliding in grooves 37 cut in the sides of the wedges, as shown in Figs. 3, 8, and 9.

The operation of the device to measure the flow into or out of a particular stratum of the well is simple. The packer section 13 is lowered into the well to the desired spot by adding sections of tubing 12 and rod 15 as the lowering progresses, in a well known manner. Where the right spot has been reached, the sectional rod 15, which is connected to the drillrig to be raised and lowered in any suitable manner, is raised with respect to the tubing 12 until the cones 32 spread the wedges 30, 31 sufficiently to expand the tube 22 tightly against the well wall, whereupon the clamp 18 is set to lock the rod 15 to the tubing 12 and suspended parts in the raised position to retain the packer and tube 22 in position in the well.

Thereupon gas may be admitted through the pipe 17 and blown through the holes 21, 26 into the well stratum opposite the groove in the rubber tube 22, the gas pressure serving to expand the tube more firmly against the well wall. Or, if the purpose be to measure the pressure and flow of gas from the particular stratum, the tube 17 will be connected to suitable instruments for this purpose and the gas permitted to flow out from the well through the orifices in the tube and packer and through the tube 12.

For repressuring oil sands containing formations of different permeability, after ascertaining the permeability of the respective strata, my invention contemplates introducing into the less permeable strata hydrofluoric acid or other acid or fluid having a disintegrating effect on the sand stone or other material comprised in the less permeable formations to make it more permeable in the region immediately surrounding the pressure well, and thereafter proceeding in accordance with the method of my Patent No. 2,019,418. The acid or other fluid may readily be introduced into the desired formation (or series of formations) by means of the apparatus herein described, proceeding to treat one stratum at a time, the amount of acid or other fluid used being regulated to suit the permeability desired for each formation treated. For calcareous formations hydrochloric acid is preferred.

The effect of the acid treatment is to enlarge the well bore opposite each stratum treated and to honeycomb and disintegrate the adjacent formation making it more permeable to pressuring fluid applied thereto and thereby enlarging the radial injection zone, whether applied generally to the entire wall or in controlled volume to particular strata as hereinafter described. Following this acid treatment, my invention contemplates measuring the increased permeability of each stratum so treated as above described with a view to determining the relative permeability of the strata to be subjected to the action of the repressuring fluid, and adjusting the distribution thereof accordingly.

In the apparatus illustrated in Figs. 11 to 16, inclusive, the packer consists in a number of sections spaced to correspond to the respective strata to be supplied with pressuring fluid, each such section having a circumferential delivery channel of a width proportional to the area of well wall that it is desired to expose to the action of the pressuring fluid, thereby controlling the volume of fluid forced into each stratum in a given time.

Referring to Fig. 11, the pressure well A and the producing or recovery well B, shown diagrammatically, may be old or new wells suitably spaced so that the pressuring fluid introduced into the formations from which it is desired to produce oil (marked "productive" in the diagram), the more dense of which heretofore have been considered barren, will have an opportunity to spread radially and vertically to drive out the oil from all of the productive formations into one or another of surrounding recovery wells.

The packer 40 (the details of which are shown in Figs. 12 to 16) is suspended in the well by means of the string of tubing 41 and is clamped in proper working position by lifting the sectional rod 42, like the packer 19 shown in Figs.

1 to 10. The packer 40, however, has a plurality of sectional expanding sleeves 43, separated by spacer rings 44, of suitable lengths and spacings to position them opposite the several productive strata, and the outer flexible sheath or barrel 45 is provided with a series of circumferential grooves 53 or channels in register with the expanders 43 and adapted to be pressed tightly against the rock surface of the well wall, the widths of the respective grooves being proportional to the area of rock surface of each strata that it is desired to expose to the action of pressuring fluid.

The sectional sleeves 43 are expanded by means of follower plates 46 engaged by their respective wedge blocks 47 which are suitably spaced on the sectional rod 42 by means of bushings 48, as illustrated in Fig. 12. The wedge blocks are provided with dovetail grooves 49 to receive the dovetail shape inner edges of the follower plates, so that the follower plates and sectional sleeves may be withdrawn from contact with the barrel 45 by dropping the sectional rod. The spacing collars 44 are provided with lugs 50 projecting into the longitudinal grooves 51 in the body of the packer and which may be welded thereto to space and guide the follower plates, which slide in and out of these same grooves.

The barrel 45 has openings 54 through it in the bottom of the grooves 53, alining with holes 55 in the expanders 43, to permit pressuring fluid to enter the grooves from the interior of the packer, and flexible valve members 56 are advantageously secured in the grooves to cover these holes and prevent back pressure in the well from entering the packer when the pressuring fluid is not being supplied, although such may not be required in all installations. A duct 57 connects the space below the packer with that above it to relieve pressure in the bottom of the well.

The barrel 45 is removable by loosening the clamp rings 58 which are secured by the ring nuts 59, and the lower end 60 of the packer is removable to permit replacement of the expanding wedges and followers when it is desired to change the width and spacing of the grooves 53 or to add injection channels to suit changes in the well formations as the recovery of the oil progresses, or for use in other wells.

In the preferred mode of operation of my invention, after the relative permeabilities of the more dense strata have been determined, I adjust the widths of the supply channels 53 of the repressuring packer (of the type shown in Figs. 11 to 16) to suit the density of the zones to which pressure is to be admitted, starting with the more dense strata and either blocking off the highly or relatively highly permeable strata entirely or admitting only a very little pressuring fluid thereto, and set the packer at the proper height in the well. Thereupon pressuring fluid is supplied until the more dense strata have been completely filled and the pressuring fluid works into the adjacent more permeable strata through intervening portions of the formation, and the oil in the entire formation is caused to flow radially and vertically from the dense portions into the more permeable portions and into the recovery wells.

By my method of injecting the repressuring fluid into the more dense strata to the exclusion of the more highly permeable strata I reestablish approximately the natural distribution of pressure originally existing in the sand before depletion thereof by the first recovery operations, and maintain the pressure in the entire area while moving the oil out of the more dense formations. The natural tendency of the oil to follow the lines of least resistance in response to the higher pressure thus maintained in the dense formations will drive it into the depleted more permeable formations and so into the recovery wells along with any oil remaining in these formations, thus automatically maintaining uniform or balanced pressure and flow conditions throughout the entire productive formation.

If as the result of changes in distribution of oil during repressuring, or changes in the resistance offered by different strata, unsatisfactory recovery is obtained, the packer can be withdrawn and the permeabilities of the respective strata redetermined under the changed conditions, whereupon another packer adapted to the changed conditions may be placed in the well and the repressuring operation resumed with renewed effectiveness.

The invention is not restricted to the apparatus illustrated nor to the entire series of steps described in the process, as obviously certain features of the apparatus and process are useful independently of the others.

Attention is called to my copending application Ser. No. 115,996, filed December 15, 1936, as a continuation in part hereof, and which relates to repressuring methods described herein.

I claim the following as my invention:

1. A pressure packer, adapted for use in oil wells, having a chamber therein and means for connecting the chamber to a well tubing, passage means for conducting fluid under pressure between the chamber and the exterior of the packer at a short intermediate portion only thereof, mechanical means adapted to releasably press and seal the packer against a well wall at each side of said intermediate portion to prevent flow of fluid under pressure lengthwise along the exterior of the packer and restrict flow of fluid to that passing between said intermediate portion of the packer and the directly surrounding well wall, thereby permitting fluid to be forced into or withdrawn under pressure from a portion only of an oil sand exposed in a well.

2. A packer for use in oil wells comprising a tubular body adapted for connection to a well tubing, an expansible sleeve concentrically disposed about the body and secured thereto at the ends to prevent outflow of fluid therebetween, a passageway within the body to permit flow of fluid between a midportion of the sleeve and the well pipe, openings in said midportion of the sleeve to permit flow of fluid to or from a sand, and positive mechanical means within the body adapted to press the sleeve against a well wall at each side of and adjacent said openings to afford sealing action.

3. A packer for use in oil wells comprising a tubular body adapted for connection to a well tubing, an expansible sleeve concentrically disposed about the body and secured thereto at the ends to prevent outflow of fluid therebetween, a passageway within the body to permit flow of fluid between a midportion of the sleeve and the well pipe, openings in said midportion of the sleeve to permit flow of fluid to or from a localized region of a single stratum, and positive mechanical means within the body adapted to expand and press the sleeve against a well wall at each side of

and adjacent said openings to afford sealing action.

4. A packer for use in oil wells comprising a tubular body adapted for connection to a well tubing, an expansible sleeve concentrically disposed about the body and secured thereto at the ends to prevent outflow of fluid therebetween, a plurality of spaced guide slots in the side walls of said body, a series of expanders in said guide slots, circumferential channels in the outer face of said expansible sleeve in axial alinement with said expanders, openings from said tubular body through said expanders and expansible sleeve into said channels, and positive mechanical means within the body adapted to expand and press the sleeve against a well wall at each side of and adjacent said openings to afford sealing action.

5. A packer for use in oil wells comprising a tubular body adapted for connection to a well tubing, an expansible sleeve concentrically disposed about the body and secured thereto at the ends to prevent outflow of fluid therebetween, a plurality of spaced guide slots in the side walls of said body, a series of expanders in said guide slots, circumferential channels in the outer face of said expansible sleeve in axial alinement with the expanders, openings from said tubular body through said expanders and expansible sleeve into said channels, back pressure valves covering said openings, and positive mechanical means within the body adapted to expand and press the sleeve against a well wall at each side of and adjacent said openings to afford sealing action.

6. A pressure packer for use in oil wells having a plurality of neighboring strata differing in permeability, comprising a tubular sleeve having a length coextensive with the productive strata to be subjected to fluid pressure and adapted to be expanded into contact with the well wall, a flow pipe communicating with the interior of said sleeve, and channels of different widths in the outer surface of said sleeve spaced to register with said productive strata, the widths of said channels respectively corresponding to the resistance to desired volumetric rate of flow of oil through said strata, said channels being in communication with said flow pipe through passages communicating with the interior of said sleeve.

7. Apparatus for introducing fluid under pressure to several associated productive strata in the same sand each of different permeability to oil, which comprises fluid pressure supply means adapted to be located within the sand for simultaneously supplying fluid to all or any part of the several strata in the sand from a common supply, and means for selectively controlling the fluid supply to the several individual strata of the sand independently of each other, said controlling means comprising a plurality of spaced annular packings mounted on said fluid pressure supply means and adapted to be clamped against the interior of the well bore to expose between them a greater or smaller surface of the respective productive strata, depending on the degree of density thereof, whereby greater uniformity of treatment is secured.

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