Dec. 10, 1963 J. N. DEW ETAL 3,113,616

METHOD OF UNIFORM SECONDARY RECOVERY

Filed March 9, 1960 2 Sheets-Sheet 1

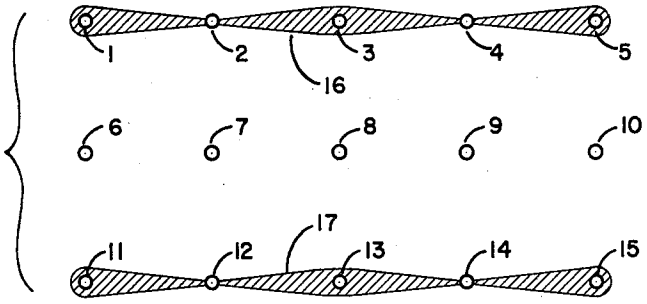


FIG. 1

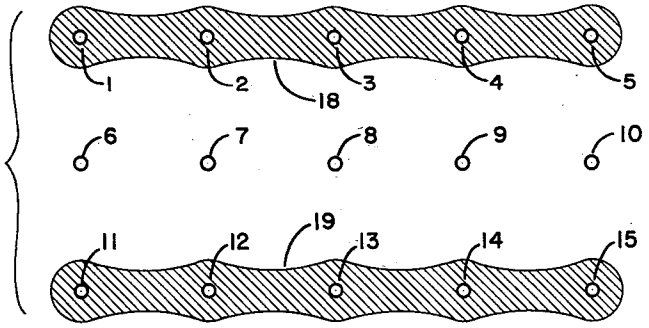


FIG. 2

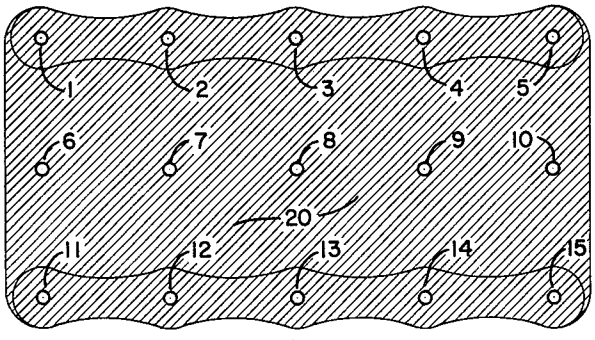


FIG. 3

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Filed March 9, 1960 2 Sheets-Sheet 2

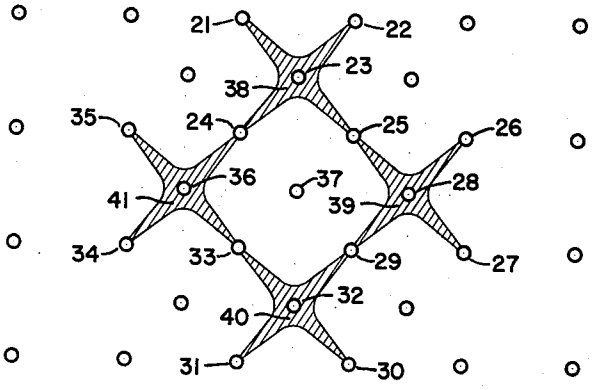


FIG. 4

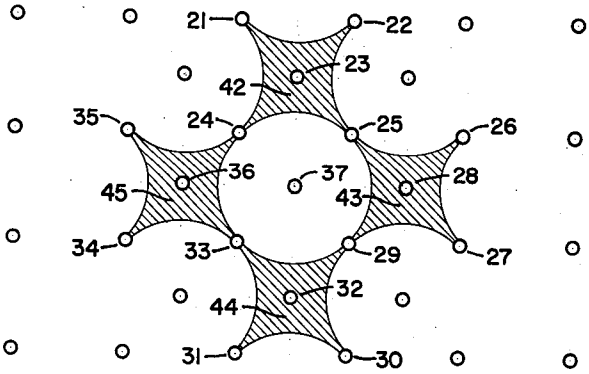


FIG. 5

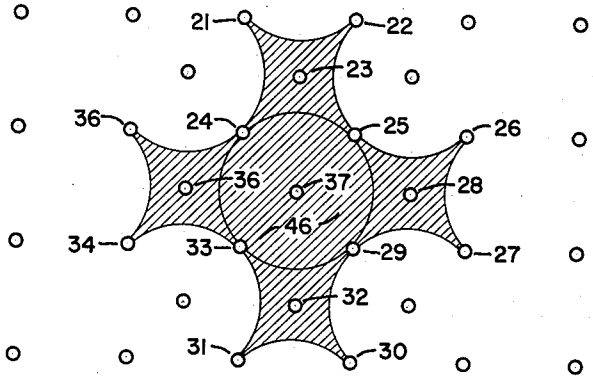


FIG. 6

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3,113,616

METHOD OF UNIFORM SECONDARY RECOVERY

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Filed Mar. 9, 1960, Ser. No. 13,763
11 Claims. (Cl. 166—9)

The present invention relates to the recovery of hydrocarbons from partially depleted oil fields and pertains more particularly to a new and improved method for applying a combination flooding approach to a field-wide operation in order to achieve the ultimate in secondary recovery of hydrocarbons contained therein.

Oil exists in the sands or similar strata within a hydrocarbon-bearing reservoir in two distinct states, i.e., as free oil that is located between the voids of the sands and as fixed oil which is held by absorption and perhaps to some degree by adsorption on the particles of sand which is commonly referred to as the film of oil that adheres to sand or the particles of the oleiferous structure. Such fixed oil referred to above can be said to be held by "sorption." Generally, oil exists in such formations together with the natural gas, and this gas is normally under sufficient pressure to force a portion of the free oil to the surface through a well bore.

In addition to recovering such free oil by utilizing the naturally occurring energy of the gas present within the formation, the free oil can be recovered by creating an artificial fluid or gaseous pressure within the formation or by the more conventional method of pumping. The fixed oil cannot be recovered by the conventional methods used to produce oil, and it becomes economically difficult to recover such oil by fluid or gaseous pressure. In some cases the total amount of oil remaining in the formation after pumping has become unprofitable can equal 60 to 90 percent of the original oil in place. Heretofore, various methods have been proposed in an attempt to recover a portion of the so-called residue oil. In one well known method water is introduced under pressure into a number of well bores, and the oil within the formation is then produced with a portion of the water at other recovery wells by the resultant pressure of the water drive. The use of water as a flooding medium is oftentimes quite limited, and many variations have been attempted in order to convert the water to a more efficient displacing medium, such as the addition of surface-active agents. Natural gas and air have also been used in a similar fashion to the water flood, but due to various reasons or circumstances these methods of secondary recovery have not been as satisfactory as desired.

Another method recently developed for the secondary recovery of oil is generally referred to as in situ combustion. In this method an oxygen containing gas, such as air, is ordinarily injected into the well bore and formation through certain designated wells in order to create a combustible mixture within the reservoir. Thereafter the well bore is subjected to heat treatment, and the formation surrounding the well bore is heated sufficiently to cause the ignition of the hydrocarbons contained therein. The secondary recovery is accomplished by the movement of the displacing heat front through the reservoir, and the hydrocarbons therein are produced at an appropriate recovery well. This method has several disadvantages, such as equipment limitations, formation limitations, geological limitations, and the inherent problems of channeling.

The most recent attempt to recover oil from partially depleted reservoirs has been through the utilization of a method generally referred to as miscible flooding. This approach utilizes the injection of fluid which are miscible with the hydrocarbons within the formation and have a high displacement efficiency. The drawback of this type of flooding operation is that the sweep efficiency, while very good in certain types of formations, is generally considered to be quite poor so that volumetric displacement of oil is economically unfeasible in the normal situation.

Each of these types of approaches to the secondary recovery of oil from partially depleted reservoirs has individual limitations and restrictions, making it quite difficult to develop and apply an economical method of secondary recovery.

The principal object of the present invention is to provide a method for the secondary recovery of oil from partially depleted reservoirs which avoids the disadvantages inherent in the prior art methods.

A further object of our invention is to provide a method for the secondary recovery of oil from a partially depleted reservoir which achieves the ultimate in economic recovery of the oil present therein.

These and additional objects and advantages of the present invention will be apparent to persons skilled in the art on reading the following description and drawings which disclose our invention.

Broadly the present invention is a method for the recovery of oil from a partially depleted oil-bearing reservoir by spacing the wells in order to take advantage of the inherent characteristics of the fluid type of flooding medium and achieve the ultimate recovery possible. The method is to inject successive fluids into the reservoir to be flooded in a predetermined field-wide pattern, the first fluid to be injected will preferably have a low viscosity and therefore have the greatest tendency to finger from the injection well to the recovery well. The overall method disclosed herein anticipates the utilization of the fingering tendency; and to encourage the same, alternately established recovery wells should be opened and the pressure drawn down, thereby causing the acute fingering to occur even more rapidly. Subsequent to the breakthrough at the initial recovery well, the flooding media are then injected into both the initial injection and the initial recovery wells, thereby establishing a uniform zone of displacing fluid within the reservoir. Subsequently, displacing fluids of equal or greater viscosity than the viscosity of the initial displacing fluid are then injected into the alternate well bores, thereby displacing the previously-injected displacing fluid and incorporating into the reservoir a selectively placed zone of efficient displacing fluid having a most uniform front which is then prepared for diversion and displacement throughout the formation. The ultimate recovery fluid which can also be of viscosity greater than that of the initial injected fluid is then injected into all of the injection wells, and the displacing front moves outwardly into the formation displacing the oil therein toward the recovery wells wherein it is withdrawn to the surface and production is accomplished.

In the drawings:

FIGURES 1 through 3 represent the step-wise application of this invention to the well pattern for a straight line drive flood.

FIGURES 4 through 6 represent the application of this invention to a series of five-spot pattern well arrangements.

FIGURE 1 shows a line pattern of 15 wells which is susceptible to the application of the present invention. Reference numerals 1 through 15 are drilled wells, with numerals 1, 3, 5, 11, 13, and 15 being designated as initial injection wells for the initial injection phase of this method and wells represented by numerals 2, 4, 12, and 14 being initial recovery wells for use during initial injection phase. The shaded areas designated by reference

numerals 16 and 17 represent the initial displacement zones created by the initial injection and recovery as developed in compliance with the method disclosed herein.

FIGURE 2 is a representation of the line drive arrangement of 15 wells referred to above with zones of secondary displacement designated as numerals 18 and 19 which include zones 16 and 17. These zones of secondary displacement attain increased size by the conversion of wells represented by numerals 2, 4, 12, and 14 to secondary injection wells so that during the secondary injection stage wells 1 through 5 and 11 through 15 are all secondary injection wells.

FIGURE 3 depicts the application of the present method of secondary recovery to the line pattern of wells for the ultimate displacement from the formation. The wells represented by numerals 6 through 10 are the ultimate recovery wells, and the injection of the displacing fluids of wells 1 through 5 and 11 through 15 is the ultimate phase of recovery. The zones 18 and 19, established by the initial and secondary injection efforts, create a uniform line drive zone which, when displacing fluids are injected in the third or final recovery phase through ultimate injection through wells 1 through 5 and 11 through 15, allows the utilization of a previously formed uniform fluid front. The uniform displacement fronts bounding zones 18 and 19 move inwardly toward the line of ultimate recovery wells designated as numerals 6 through 10. In FIGURE 3, the numeral 20 represents the ultimate displacement zone which is effectively swept during the ultimate injection and recovery step by the method of secondary recovery disclosed in the present application.

FIGURE 4 discloses an overall field layout consisting of groups of wells in patterns generally referred to as inverted five-spot well patterns. Specifically these patterns are represented by numerals 21 through 25; 25 through 29; 29 through 33; 24, and 33 through 36; and 24, 25, 29, 33, and 37. The first phase of initial displacement is accomplished by injecting displacement fluid into initial injection wells represented by numerals 23, 28, 32, and 36, with the initial recovery wells being represented by numerals 21, 22, 24 through 27, 29 through 31, and 33 through 35. The initial displacement zones, represented by numerals 38 through 41, are the zones created by the first phase of displacement in the present method of secondary recovery. This figure could represent also non-inverted five-spot patterns by making the opposite wells injection and recovery wells.

FIGURE 5 represents the second phase of secondary recovery as disclosed in the method herein, and the wells contained therein are identical to those disclosed in FIGURE 4. The secondary displacing fluid is injected into all of the initial injection wells 23, 28, 32 and 36, and all of the initial output wells as set forth in the description of FIGURE 4 are converted to secondary injection wells, which includes wells 21, 22, 24 through 27, 29 through 31, and 33 through 35. The zones represented by numerals 42 through 45 are the zones of secondary displacement which are created by injecting into the secondary injection wells. The secondary displacement zones 42 through 45 include the initial displacement zones and the boundaries of said zones provide the uniform flood front for the ultimate recovery phase of the method.

FIGURES 6 shows the application of the method of secondary recovery as disclosed in the present application as it is applied to the zone surrounding the ultimate output well 37. The shaded zone 46 represents the zone of the formation which is subjected to the uniform displacement front above for the ultimate recovery effort of the present invention and from which all of the oil is displaced through the ultimate output well 37.

A particular embodiment or operation of the present invention as shown in FIGURES 1 through 3, is described in order that the invention will be readily understood. The method disclosed herein is most successful when applied on a field-wide operation utilizing a plurality of wells within the field, but it may be applied to a specific area which contains oil that has eluded previous recovery attempts. The first step of this method is the selection of an initial well pattern to be subjected to this method of secondary recovery, which is based upon the determination that the pattern selected is of the proper size, shape, location, and susceptibility to production. This step requires the wells be spaced, either by utilizing existing wells or drilling others, to affirmatively establish the wells in a pattern in order to flood the formation in a predetermined size, shape, and location. The pattern which is selected can be of any type available within the particular field as the situation allows and can be a line pattern, as in FIGURES 1 through 3, a five-spot pattern, or a special well pattern which is available within a particular field.

The method of the present invention as illustrated in FIGURES 1 through 3 requires that a pattern be selected to include wells which will be adaptable as initial injection wells (1, 3, 5, 11, 13 and 15) and initial recovery wells (2, 4, 12 and 14) during the initial displacement step to create the desired initial displacement zones or manifolds (16 and 17) with the initial recovery wells being convertible to injection wells for the secondary injection step. These wells represent only the initial operational wells in considering the complete pattern, and should be located so that the ensuing arcs of the intersecting lines of the subsequently developed secondary displacement zone or manifold boundaries are opposite the recovery wells to be used during the ultimate recovery phase. The arcs of the lines of intersection, defining the outer limits of the zone or manifold are therefore positioned so that the ultimate recovery wells (6 through 10) are located in the adjacent areas surrounding the initial and secondary injection operational pattern. The positioning of the wells is dependent upon the arcs of the lines of intersection, which are the outer limits of the secondary displacement zones, and the criticality varies according to the degree of acuteness of the arcs. As the arc approaches a straight line, the ultimate recovery wells can be located in any position opposite the zone as shown in FIGURES 1 through 3.

The distance of the ultimate recovery wells from the secondary displacement zones affects the economics of the injection equipment and the amount of energy lost during the displacement, so the wells cannot be too distant and achieve optimum economical production. The initial well pattern selected should preferably be located within the interior area of a field to allow subsequent expansion of the recovery method to similar adjacent patterns in order that the entire volume of the field can be subjected to the secondary recovery efforts. Directional permeabilities should also be taken into consideration in well pattern selection and can be determined by small scale preliminary air or gas injection tests to determine the direction of such flow in the specific reservoir, or through the use of laboratory measurements on cores whose directional orientations have been obtained during the coring operations.

The second step, after selection of the pattern wells, is the initial injection phase which is conducted by conventional means known in the art within the formation immediately surrounding the initial injection wells. The displacement media injected into the hydrocarbon-bearing formation will be governed by the characteristics of the hydrocarbons within the individual formation to which this method of secondary recovery is to be applied and the availability of supply. In operation it is desirable to initially inject into the formation through the initial injection wells, a displacement fluid which has a low viscosity relative to the hydrocarbons within the formation. The viscosity ratio between the hydrocarbon contained within the formation and the initial displacing

fluid should be preferably in the order of a factor of 4 or greater. The actual controlling feature being that the displacing fluid should be of such a viscosity that it will finger or channel directly into the initial recovery wells with rapidity. The fingering which is stimulated by the injection of such a displacement fluid, coupled with the reduction in pressure of the initial output wells, will enable the ordinarily undesirable fingering effect to be utilized in achieving improved displacement zones.

The displacing fluids which can be used during the initial injection are gas, liquid hydrocarbons, or other liquids known in the art, dependent upon the characteristics of the formation hydrocarbons as indicated above. The preferable initial injection fluid is one which would be of the proper viscosity and miscible with the hydrocarbons of the formation, such as liquefied, low-molecular weight, normally gaseous hydrocarbons, generally referred to as liquefied petroleum gases, which include methane, ethane, propane, butane, pentane, hexane, and heptane. The initially injected displacement fluid will displace substantially all of the hydrocarbons within the formation, and will establish an initial displacement zone within the formation which is the basis for the uniform driving mechanism of the overall secondary recovery method. The initial injection is made through wells 1, 3, 5, 11, 13, and 15, in order to displace the hydrocarbons to the initial recovery wells with rapidity.

The initial recovery wells are 2, 4, 12 and 14 and are maintained in a condition of reduced pressure during this second step to stimulate the fingering or channeling effect to the utmost until production is substantially the injected displacement fluid. The ultimate recovery wells, FIG. 1, numerals 6 through 10 are shut-in, back pressured, or drilled later as needed to prevent production of the initial displacing fluid therefrom during the initial injection phase. The initial injection phase is conducted as rapidly as possible until the initial displacement zones, 16 and 17, have progressed through the area surrounding the initial recovery wells, and break through which causes the initial displacement zones to intersect about the initial recovery wells. This initial injection step creates normal recovery drives and oil is produced accordingly from the initial recovery wells to be a part of the production realized from the present invention.

The third step of the present method is to enlarge the initial displacement zones about the initial injection and recovery wells by the secondary injection phase of the method. The initial recovery wells 2, 4, 12 and 14, are converted to secondary injection wells after the displacement fluid has broken into them as initial recovery wells, in order to establish uniform secondary displacement zones 18 and 19. The normally undesirable channeling effect developed by the initial displacement zone is thereby utilized to create the desired manifold of the secondary displacement zone within the limitations of the lines of intersection. These initial and secondary injection phases form the secondary displacement zone of increased permeability due to the recovery therefrom of the fluid containing hydrocarbon deposits which would otherwise impede the movement of fluids therein, and effectively establish an underground manifold system within the formation.

The secondary displacement fluid injected into the formation during the secondary injection phase is injected into the secondary injection wells, and can be any known displacement fluid which is available for utilization. The method disclosed herein anticipates the use of a displacement media in the secondary displacement phase having a viscosity that is equal to or greater than the viscosity of the initial displacement fluid. Any of the liquefied petroleum gases set forth above or more economical liquid fluids, such as water, can be utilized. During the secondary injection phase all of the initial injection and recovery wells are converted to secondary injection wells as the situation necessitates, and the secondary injection

phase is conducted until sufficient amounts of secondary displacement fluid are injected in order that uniform secondary displacement zones, 18 and 19, of sufficient boundaries have been established within the formation.

The ultimate phase of this method is commenced after the termination of the secondary injection phase which creates the limits for the uniform flood fronts. The initial injection wells and the initial output wells, converted to secondary injection wells, or any number thereof, are converted to ultimate injection wells 1 through 5 and 11 through 15, for the ultimate recovery phase of the present method of hydrocarbon recovery. The ultimate recovery wells 6 through 10 can be drilled as needed to serve as recovery wells during the ultimate recovery phase which can be performed using the former injection and recovery wells of the injection steps as ultimate injection wells. The secondary displacement zones or manifolds within the subterranean formation are subjected to the injection of flooding media through all or any portion of the wells within said zones in sufficient amounts to fill the entire zones of the formation with the desired displacing media to the previously developed limits as determined by the foregoing injection phases. The injection of the displacement media is continued after the secondary displacement zones are filled to establish a uniform ultimate displacement drive which thereupon becomes an effective uniform displacement vehicle for the recovery method.

The ultimate step of the recovery method disclosed herein is the injection of a displacement fluid through the secondary injection wells made available by either one of the preceding steps hereinafter referred to as ultimate injection wells. The ultimate recovery phase will normally involve the recovery of the hydrocarbons from the largest zone of the formation, and it therefore becomes necessary to consider the economics of the flooding media to be used in the operation. Although any of the known displacement fluids are satisfactory for the ultimate recovery of oil from the formation, it is economically advantageous to use an efficient medium which is relatively inexpensive per unit volume, due to the large amount necessary. The ultimate fluid injected into the formation to displace the hydrocarbons to the ultimate recovery wells should have a viscosity equal to or greater than the viscosity of the secondary displacement fluid, preferably water, due to the fact that it is inexpensive and normally available. Water is susceptible of being injected into the formation whereupon it displaces substantially all of the hydrocarbons from within the ultimate displacement zones of the formation to the ultimate recovery wells where it is transferred to the surface by means known in the art.

During this phase the secondary displacement zones, 18 and 19, which have been created by this stepwise procedure, act as a vehicle to cause a controlled directional drive to be established in focusing the uniform fluid drive toward the adjacent ultimate recovery wells, 6 through 10, now opened to the ultimate recovery of hydrocarbons. The shaped boundaries of the zones or manifolds in the form of arcs, cause injected media to be directed linearly toward the ultimate recovery wells at a uniform and regular rate in a previously determined direction to create the ultimate recovery zone, 20, as shown in FIGURE 3.

When water is used for the ultimate phase of the method set forth as the present invention, the ultimate recovery zone of the formation which has been finally subjected to water flood is substantially filled with said water. This water is an efficient back-fill from a functional and economic viewpoint, which is favorable because the water is essentially an incompressible medium. It acts as an efficient fill when subjected to subsequent gas, oil or water pressure as would occur when adjacent areas of the field are subjected to subsequent secondary recovery efforts. The water is also an inexpensive medium and can be injected by pumping at less cost than

other materials, such as a gas. The water deposited in the formation during displacement, as a back-fill, precludes the necessity of maintaining air or gas injection units at the site after the secondary recovery is concluded, thereby reducing the amount of investment ordinarily necessary otherwise.

Another embodiment of this invention is set forth in FIGURES 4 through 6 which represent the application of the method to five-spot flooding patterns. The method would be essentially identical to the above detailed description of the operation, but applied to five-spot patterns.

In order to disclose still more clearly the nature of the present invention and the advantages thereof, reference will hereinafter be made to certain specific embodiments which illustrate the flexibility of the process. It should be clearly understood, however, that this is done solely by way of example and not to be construed as a limitation upon the spirit and scope of the appended claims.

Examples

The oil sand formation within a field is at a depth from approximately 1230 feet to approximately 1255 feet, and averaged 16 percent porosity with a horizontal permeability of 95 millidarcies. An average of 50 percent of the pore space is filled with oil, 40 percent with water, and the remainder with gas. The viscosity of the reservoir crude at the formation temperature of 81° F. is 18 centipoises. A portion of the oil sand having a thickness of 25 feet is readily capable of being flooded by means of a straight line drive flood pattern. This would utilize three rows of wells with each row containing five wells, such as illustrated in FIGURE 1 of the drawings. The wells are spaced 660 feet apart on a 10-acre spacing pattern.

The first step of the recovery process is the injection of propane into the alternate wells of the two outside rows of wells. A propane having a viscosity of approximately 0.10 centipoise at the reservoir temperature of 81° F. is injected into the formation through the initial injection wells until an average of 8,000 barrels of propane is injected into each well. The sand face injection pressure average about 900 p.s.i., while the sand face pressure in the alternate initial output wells is essentially 0 p.s.i.

A breakthrough of propane into the other alternate wells, initial recovery wells, occurs after the above amount of propane is injected into each well as above. After propane breakthrough occurs into all initial recovery wells, the initial oil recovery wells are converted into secondary injection wells, and propane injection is continued until a total of 8,000 additional barrels of propane is injected.

At this time water injection is initiated into all of the previous injection wells, and the ultimate output wells are opened to production. Water injection is continued until oil recovery drops below the economic limit, and approximately 80 percent of the oil sand is subjected to displacement by following this procedure whereby an average residual oil saturation of 15 percent of the pore volume is attained.

In another part of the same oil field, a portion of the oil sand is flooded most readily by using a 5-spot well pattern similar to that shown in FIGURE 4 of the drawings. Since the original spacing of the wells is 10-acre spacing, drilling is conducted between the original rows to furnish a row of wells staggered to create the desired 5-spot pattern as above. Into the center wells, initial injection wells, propane is injected until propane breakthrough occurs in the four surrounding wells of each of the five-spot pattern. Approximately 12,000 barrels of propane are injected through each initial injection well in order to achieve the breakthrough. As this point water injection is started into both the initial injection wells and the initial recovery wells, and continued until approximately 10,000 barrels of water are injected to enlarge the displacement zone. Then, the ultimate recovery wells are opened with the injection of water continued, whereby oil recovery is initiated from the ultimate recovery wells. The method disclosed causes displacement of the oil from approximately 80 percent of the oil sand, whereby a residual oil saturation of 15 percent is attained.

While particular embodiments of the invention have been described, it will be understood, of course, that the invention is not limited thereto since many modifications may be made, and it is contemplated to cover by the appended claims any such modifications as fall within the true scope and spirit of the invention.

The invention having thus been described, what is claimed and desired to be secured by Letters Patent is:

1. A method for the recovery of hydrocarbons from a subterranean formation traversed by a plurality of well bores which comprises injecting an initial displacement fluid into a first group of said well bores to displace the hydrocarbons through the formation to a second group of said well bores located with respect to said first group so as to define an elongated pattern; withdrawing said hydrocarbons through said second group of well bores to the surface to define an elongated displacement zone of increased permeability communicating between said first and said second group within the reservoir; injecting a secondary displacement fluid into substantially all of said first and second groups of well bores while maintaining the remaining well bores, located substantially normal to said elongated pattern, substantially at a pressure at least as high as atmospheric pressure to uniformly enlarge said elongated displacement zone around said first and second groups of well bores; injecting into substantially all of said first and second groups of well bores an ultimate displacement fluid outwardly from the thus-produced uniform enlarged elongated zone to displace the hydrocarbons through said formation to said remaining well bores; and withdrawing said hydrocarbons through said remaining well bores to the surface.

2. The method defined in claim 1 wherein the first group of well bores comprises the outer members of a plurality of five spot patterns which are situated around at least one centrally located well bore and wherein the second group of well bores comprises the central well bores of each five spot pattern.

3. The method defined in claim 1 wherein the first group of well bores comprises the central members of a plurality of five spot patterns which are situated around at least one centrally located well bore and wherein the second group of well bores comprises the outer members of each five spot pattern.

4. A method as set forth in claim 1 wherein the initial displacement fluid is liquefied, low-molecular-weight, normally-gaseous hydrocarbons.

5. A method as set forth in claim 4 wherein the secondary displacement fluid is water.

6. A method as set forth in claim 4 wherein the ultimate displacement fluid is water.

7. A method as set forth in claim 1 wherein the initial displacement fluid is miscible with the formation hydrocarbons.

8. A method for the recovery of hydrocarbons from a subterranean formation traversed by a plurality of well bores which comprises injecting an initial displacement fluid of low viscosity into a first group of said well bores to displace the hydrocarbons through the formation to a second group of said well bores located with respect to said first group so as to define an elongated pattern; withdrawing said hydrocarbons through said second well bores to the surface to define an elongated displacement zone of increased permeability communicating between said first and said second group; injecting a secondary displacement fluid of viscosity at least as high as that of said initial fluid into substantially all of said first and second groups of well bores while maintaining the remaining well bores, located substantially normal to said elongated pattern, substantially at a pressure at least as high as atmospheric pressure to uniformly enlarge said elongated displacement zone; injecting into substantially

all of said first and second groups of well bores an ultimate displacement fluid of viscosity at least as high as the viscosity of the secondary displacement fluid outwardly from the thus-produced uniformly enlarged elongated zone to displace the hydrocarbons through said formation to said remaining well bores; and withdrawing said hydrocarbons through said remaining well bores to the surface.

9. A method for the recovery of hydrocarbons from a subterranean formation traversed by a plurality of well bores of injection, initial recovery, and ultimate recovery wells which comprises spacing the injection and initial recovery wells to provide an initial displacement zone of predetermined size, shape and position of elongated pattern; injecting an initial displacement fluid of low viscosity through the injection wells into the formation to displace the formation hydrocarbons toward the initial recovery wells; withdrawing hydrocarbons from the formation through initial recovery wells; terminating the injection of said initial displacement fluid upon substantial breakthrough into the initial recovery wells whereby an initial elongated displacement zone of increased permeability is defined; injecting a secondary displacement fluid of viscosity at least as high as that of said initial displacement fluid through the injection and the initial recovery wells into the initial displacement zone while maintaining the remaining well bores substantially at a pressure at least as high as atmospheric pressure to displace the formation hydrocarbons outwardly from said zone; terminating the injection of said secondary displacement fluid after the initial displacement zone is uniformly enlarged to define a secondary elongated displacement zone; spacing said ultimate recovery wells substantially normal to said secondary elongated displacement zone; injecting an ultimate displacement fluid of viscosity at least as high as that of the secondary displacement fluid through the injection wells and initial recovery wells to displace the formation hydrocarbons outwardly from said secondary displacement zone toward the ultimate recovery wells; withdrawing formation hydrocarbons through ultimate recovery wells to the surface; and terminating the injection of displacing fluid.

10. The method for recovering connate fluid from a subterranean formation traversed by a plurality of well bores which comprises the steps of injecting a fluid into at least a first of said bores while withdrawing connate fluid from at least a second of said bores so as to remove a portion of said connate fluid from said formation in an area around a plurality of the well bores located so as to establish an elongated zone of increased permeability within said area communicating between said plurality of the well bores; injecting a fluid under pressure by way of at least said first and second bores into said area while maintaining pressure in well bores adjacent said area to enlarge said area; and removing connate fluid from an adjacent well bore located substantially normal to said elongated zone while injecting additional fluid by way of at least said first and second bores into said area.

11. The method for recovering connate fluids from a subterranean formation which comprises the steps of drilling a plurality of wells into said formation, said wells being arranged into a first group of rows and a second group of rows the individual rows of which alternate with the individual rows of the first group; injecting a fluid into alternate wells in said first group of rows to displace connate fluid in said formation toward the remaining wells of said first group while withdrawing connate fluid from the wells remaining in said first group so as to establish an elongated zone of increased permeability between said alternate wells and said remaining wells of said first group; stopping injection upon breakthrough of injected fluid in said wells wherein said connate fluid is being withdrawn; injecting fluid in substantially all wells in said first group while maintaining the wells in said second group closed to form an enlarged elongated pressure manifold in said formation; and withdrawing connate fluid from said formation by way of at least a portion of the wells in said second group while injecting a drive fluid into at least a portion of the wells in said first group.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,113,616 December 10, 1963

John N. Dew et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 72, for "fluid" read -- fluids --; column 3, line 64, for "FIGURES" read -- FIGURE --; column 5, line 58, after "the", second occurrence, insert -- initial displacing --; column 7, line 41, for "average" read -- averages --; line 69, for "As" read -- At --.

Signed and sealed this 2nd day of June 1964.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents