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J. N. DEW ET AL
COMBINATION IN SITU COMBUSTION-AQUEOUS
MEDIUM DRIVE OIL RECOVERY METHOD

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2 Sheets-Sheet 1

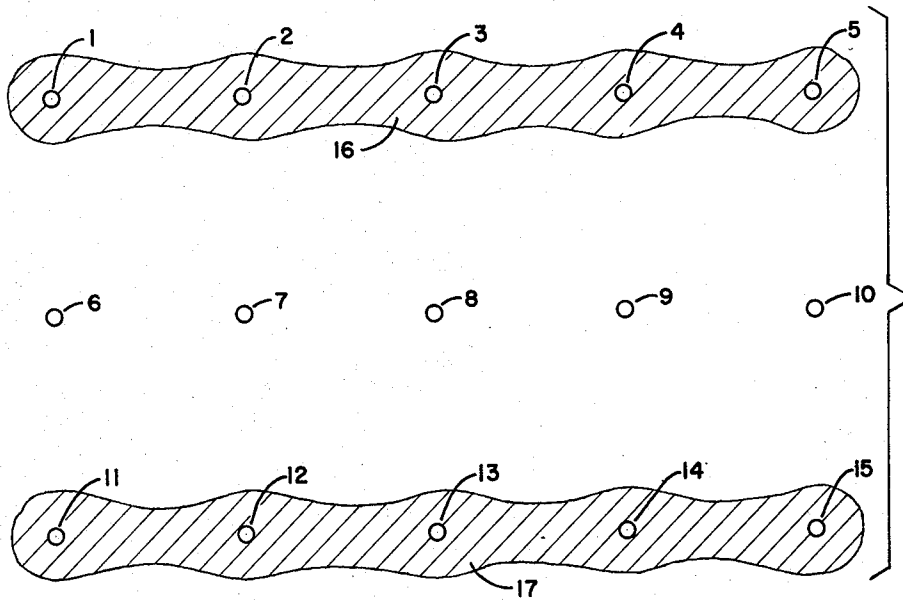


FIG. 1

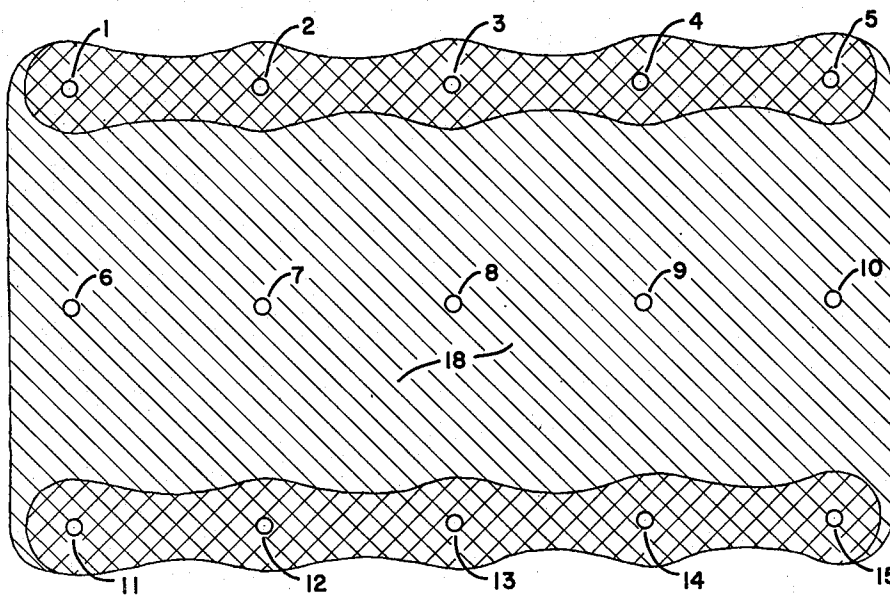


FIG. 2

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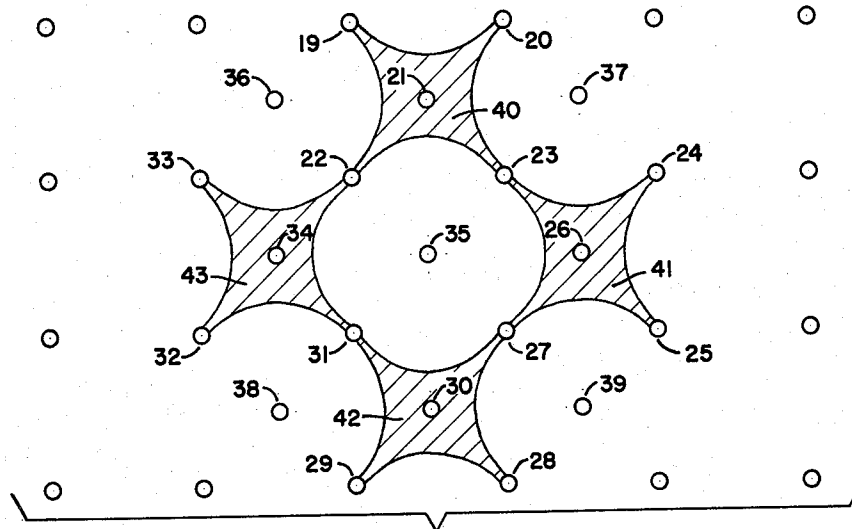


FIG. 3

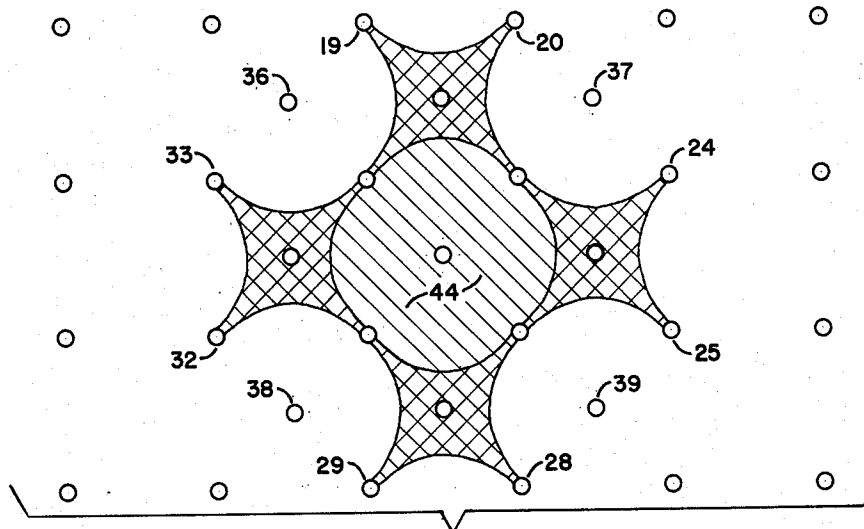


FIG. 4

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COMBINATION IN SITU COMBUSTION-AQUEOUS MEDIUM DRIVE OIL RECOVERY METHOD

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The present invention relates to the recovery of oil from depleted oil fields and pertains more particularly to a new and improved method for applying in situ combustion in a field-wide operation to obtain a secondary recovery of oil.

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

In addition to recovering such free oil by utilizing the pressure of the natural gas present, this free oil can be recovered by creating an artificial fluid or gaseous pressure in the formation and by the more conventional method of pumping. Fixed oil on the other hand cannot be recovered by any of the conventional methods or means used to produce oil and cannot be dislodged economically by either 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 present. Heretofore various methods have been proposed in an attempt to recover part of this residual oil. In one method water is introduced under pressure into a number of wells and oil together with water is produced from other wells by the resultant water drive. As an aid, surface active agents have been added to the water to increase its efficiency. Natural gas and air are frequently used in a similar fashion. Due to various reasons or circumstances these methods of secondary recovery have not been entirely satisfactory.

One of the most recent developments for the secondary recovery of oil is a method which is generally referred to as in situ combustion. In this method, air is injected into the formation through certain injection wells forming a combustible mixture in the formation. The formation is heated near the injection well bore which results in a narrow, cylindrical zone of combustion in the formation immediately surrounding the well bore. Air injection is continued until the thin cylindrical zone of combustion is moved a considerable distance from the injection well. The combustion and concurrent heating of the formation ahead of the combustion front reduces the viscosity of the oil present in the formation and thus facilitates its displacement. The combustion zone moves toward the open production wells surrounding the injection well because the air which is continuously injected moves through the formation toward the point offering the least resistance; i.e., the pressure sink at the production output wells. The resulting thermal drive forces the displaced oil into the producing well. The distance

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through which this thermal drive may be driven is limited by the capacity of the air injection equipment and the pressure which the formation is capable of withstanding without fracturing. It, therefore, follows that the creation of a successful thermal drive by in situ combustion involves consideration of well spacings. Another consideration of this method is the existence of inherent poor sweep efficiencies which cause deposits of oil to be bypassed.

The most recent development in the field of secondary recovery methods is the creation of a thermal drive system based upon a combination of two of the older methods known in the art. This recent method comprises subjecting the formation surrounding the well bore to in situ combustion by conventional means and conducting the combustion front to such a distance from the well bore that the accumulated heat behind the front is sufficient to allow the remaining formation to be heated to a temperature range exceeding the boiling point of water at the pressure conditions throughout the formation. Thereupon the injection of air is terminated causing the combustion to cease. The next stepwise procedure is to convert the air injection well from the in situ combustion process to a water injection well, thereby making it possible to flood the formation with water. Upon entering the formation, the water absorbs the residual heat in the formation behind the front and, due to the nature of the heat capacities and thermal conductivity of water, it becomes a more efficient element for the transfer of this heat to the rest of the formation. The effects of the thermal drive are therein moved a further distance from the well bore of the injection well than the limits of the in situ combustion zone by the subsequent injection of water under pressure. The injected water reaches temperatures exceeding the vaporization point at which the accompanying steam is an effective agent in displacing and forcing the hydrocarbon materials from the formation toward the production wells. This method can offer economic advantages, but it does not allow the recovery of the optimum amount of deposited hydrocarbons of the formation because it is subject to the inherent poor sweep efficiency of the in situ combustion process. Water injected into pre-established channels tends to follow these channels or paths of least resistance, thus bypassing large pockets of unrecoverable oil.

It is therefore a principal object of the present invention to provide a process for the secondary recovery of oil which obviates the disadvantages of the prior art processes. It is another object of our invention to provide a method for the secondary recovery of oil from subterranean formations so as to provide the ultimate 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 by reference to the following description read in conjunction with the accompanying drawings which illustrate our invention.

Broadly, the present invention is a process for the recovery of oil from a subterranean oil-bearing formation in which a plurality of injection wells and producing wells are drilled. These wells are so drilled that the injection wells are adjacent to the producing wells. In operation, air or other gaseous combustion supporting fluid is injected into the oil-bearing formation through the injection wells where it contacts the oil contained in such formation. The oil in the sand and the above gas are then

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ignited at the injection well bore, and the resulting combustion zone is maintained and propagated by air injection until the combustion zone intersects with a similar zone from another injection well or breaks through into offset output wells. This results in the creation of a hot combustion zone or manifold within the oil-bearing formation. Following this controlled amount of combustion an aqueous medium comprising water or water plus an agent which is capable of modifying the surface tension of water is injected as a flooding medium through former air injection wells and output wells in which combustion has broken through. The injection of water or other flooding composition directly into the hot manifold of the formation makes it possible to control the direction of the drive, and improve the volumetric sweep and recovery efficiencies of the process.

Stated somewhat more specifically, the present method comprises a process wherein the formation surrounding the well bore of the injection well is subjected to in situ combustion by conventional means and conducting the combustion to any desired distance from the well bore to include burning into selected fireflood output or producing wells. This procedure provides substantial oil production and simultaneously creates a combusted zone or manifold within the formation which is thereby heated to a temperature which may be well above the boiling point of water at the pressure encountered in the formation. The inherent poor sweep efficiency of the in situ combustion process is utilized and abetted during this step so as to cause the combustion zone or manifold to grow in the direction desired and to minimize the formation of highly permeable channels in the direction of water flood production wells. Injection of air or other combustion supporting gas is terminated when the limits of the manifold are sufficiently established causing combustion to cease.

The next step is to convert the gas injection well and the producers experiencing breakthrough to water injection wells, thereby making it possible to flood the formation with water. The water, upon entering the formation, is heated and becomes an efficient element for the transfer of heat throughout the formation. The thermal drive effects are moved from the well bore of the injection well to a distance greater than the limits of the in situ combustion. The flowing water, under such conditions, is an efficient agent for displacing and forcing the oil from the formation toward preselected water flood production wells and undesirable channeling effects have been minimized. Because of these factors the water injection phase requires that a reduced quantity of heat be generated by combustion which concurrently reduces the power requirement and operating expense for air compressors and the time required for recovery. The water injected into such a system of highly permeable combusted zones also provides an effective means to prevent resaturation of these zones when adjacent area are subsequently produced by in situ combustion, and no "back-fill" maintenance expense is incurred.

In the drawings:

FIGURES 1 and 2 represent the stepwise application of our invention to the well pattern for a straight line drive flood.

FIGURES 3 and 4 represent the application of our invention to a series of 5-spot pattern well arrangements.

FIGURE 1 shows a line pattern of 15 wells which is susceptible to being subject to the present invention. The reference numbers 1-15 are drilled wells with numbers 1, 3, 5, 11, 13 and 15 being designated as injection wells for the in situ combustion step of the method and wells represented by numbers 2, 4, 12, and 14 being output wells for the combustion. The shaded areas designated by reference numbers 16 and 17 represent the zones wherein in situ combustion was conducted to establish the manifolds or combustion zones in compliance with the method disclosed herein.

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FIGURE 2 shows the application of water flood to the line pattern combustion zone or manifold system developed by the invention and the area swept by the hot fluid drive. The wells represented by reference numbers 1-5 and 11-15 are potentially convertible to fluid injection wells and the wells represented by numbers 6-10 are the ultimate recovery wells. The large shaded zone designated 18, which also includes the zone represented by number 17 of FIGURE 1, is the zone effectively subjected to the heated fluid drive as disclosed herein.

FIGURE 3 shows a field layout consisting of groups of wells in groupings normally referred to as five-spot well patterns, specifically these patterns are represented by numbers 19-23; 23-27; 27-31; 22, 31-34; and 22, 23, 27, 31, and 35. The shaded areas 40-43 represent the combustion zones or manifolds as created by the in situ combustion conducted in compliance with the method disclosed herein.

FIGURE 4 shows the application of water flood to the five-spot pattern combustion or manifold system developed by this invention and the area swept by the hot fluid drive. The wells represented by reference numbers 19-34 are potentially convertible to fluid injection wells and the well represented by number 35 is an ultimate recovery well with the wells represented by numbers 36-39 being potential ultimate recovery wells. The large shaded zone designated as 44, which also includes the zones represented by numbers 40-43 of FIGURE 3, is the zone effectively subjected to the heated fluid drive as disclosed herein.

The method of the present invention 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 pattern to be subjected to this method of secondary recovery and 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 combust the formation in a predetermined size, shape, and location. The pattern which is selected may be of any type available within the particular field as the situation demands and can be a line pattern, as in FIGURES 1 and 2; a five-spot pattern, as in FIGURES 3 and 4; or a special well pattern which is available within a particular field. The method of the present invention requires that a pattern be selected to include wells which will be adaptable as injection and output wells during the in situ combustion step to create the desired combustion zone or manifold, and convertible to water injection wells for the water injection step. These wells represent only the fireflood operational wells in considering the complete pattern, and should be located so that the ensuing arcs of the intersecting lines of the subsequently developed manifold boundaries are opposite the production wells to be used during the hot water drive phase. The arcs of the lines of intersection, defining the outer limits of the combustion zone or manifold are therefore positioned so that the hot water drive production wells are located in the adjacent area surrounding the initial fireflood operational pattern. The positioning of the wells is dependent upon the arcs of the lines of intersection, which are the outer limits of the manifold zone, and the criticality varies according to the degree of acuteness of the arcs. When the arc approaches a straight line, the production wells can be located in any position opposite the manifold as shown in FIGURES 1 and 2 and as the angle of the arc becomes more pronounced, the water flood production well should be located on a line extending from the in situ combustion injection well of the pattern to the output wells, said line bisecting the angle of the arc as shown in FIGURES 3 and 4. The distance of the production wells from the

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manifold zone affects the economics of the water injection equipment and the amount of heat lost during the hot water drive, so the wells cannot be too distant and achieve optimum production. The initial pattern selected should preferably be located within the interior area of the field to allow subsequent expansion of the recovery method to similar adjacent patterns in order that the entire area of the field can be subjected to the treatment and produced. Directional permeabilities should also be taken into consideration in well 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.

The second step, after selection of the pattern wells, is the in situ combustion phase which is conducted by conventional means known in the art within the formation surrounding the well bore or bores. The combustion phase should utilize the inherent fingering effect which accompanies in situ combustion to cause the combustion zones or manifolds (17 and 40-43) to be extended from the injection wells for the combustion supporting gas, FIGURE 1, numbers 1, 3, 5, 11, 13, 15, and FIGURE 3, numbers 19, 20, 22, 23, 24, 25, 27, 28, 29, 31, 32, and 33; to the fireflood output wells, FIGURE 1, numbers 2, 4, 12, 14, and FIGURE 3, numbers 21, 26, 30, and 34; which are maintained in an open condition to stimulate this fingering effect. The water flood recovery wells, FIGURE 1, numbers 6-10 and FIGURE 3, numbers 35-39, are shut-in, back pressured, or drilled later as needed to prevent air or combustion gas production therefrom during the combustion phase. The combustion phase is conducted until the combustion zone has progressed to the area actually surrounding the initial output wells which causes the combustion zones to intersect about the output wells, as specified in FIGURES 1 and 3 above. The zone of intersection may be enlarged about the fireflood output wells by converting these wells to air injectors for a short time as desired after combustion has broken into the well bore. The normally undesirable channeling effect occurring in the combustion zone is thereby utilized to create the desired manifold volume within the limitations of these lines of intersection. The in situ combustion step creates a normal thermal drive and oil is produced accordingly from these initial output wells, and this is a significant part of the production realized from the present invention. Another purpose of the in situ combustion is the creation of a hot combusted zone extending between the air injection and initial output wells of this phase. This combustion step forms a zone of high permeability which has been voided of all liquid deposits which would impede the movement of fluids therein and effectively establishes an underground manifold system within the above designated combustion zone portion of the formation. The in situ combustion is also effective in creating an increase in the temperatures existent within the formation to a higher degree of heat which allows the next stepwise procedure of this method of secondary recovery to be initiated.

The third step of this method commences upon the termination of the in situ combustion thermal drive process. The air injection and initial output wells, or any number thereof, which were utilized during the in situ combustion step, are converted to water injection wells for the waterflood phase of the present method of recovery. The manifold area within the subterranean formation is subjected to water injection through all or any portion of the wells terminated within said manifold, in sufficient amounts to fill the entire manifold of the formation with water and steam to the previously developed limits of the manifold as determined by the foregoing in situ combustion. The injection of water is continued after the manifold zone has been filled to establish a thermal drive which thereupon becomes an effective hot fluid drive recovery method by the utilization of the heat

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capacity and transfer properties of the water. At this point the manifold or combustion zone which has been created by this stepwise procedure acts as a vehicle to cause a controlled directional drive to be established in focusing the hot fluid drive toward the adjacent water flood production wells, now opened for ultimate production. The shaped boundaries of the manifold in the form of arcs, cause the injected water to be directed linearly or radially toward the production wells at a uniform and regular rate in a previously focused direction, as shown in FIGURES 3 and 4.

FIGURE 4 would also represent the situation in which a normal, non-inverted five-spot combustion pattern will be conducted. In this case in situ combustion is carried out by utilizing wells represented by numbers 21, 26, 30 and 34 as injection wells simultaneously until breakthrough into the wells represented by numbers 19, 20, 22-25, 27-29, and 31-33 designated herein as fireflood output wells. The end result will remain as set forth in FIGURE 4 regardless of which type of five-spot pattern is utilized.

The ultimate production wells may be drilled as needed to serve as oil recovery wells during the water flooding phase which can be performed using the former injection and output wells of the fireflood step as water injection wells.

The ultimate step of the method set forth in the present invention is the utilization of the resultant water filled area which occurs within the formation which has been finally subjected to water flood. The filling with water of that portion previously voided by operation of an in situ combustion process provides an efficient back-fill from a functional and economic viewpoint. The functional aspects are favorable because the water is essentially an incompressible medium which is capable of acting as an efficient fill when subjected to subsequent gas, oil, or water pressure as would occur when adjacent areas were subjected to secondary recovery processes. Economically, the water is an inexpensive medium and can be injected by pumping at less cost than other materials, such as a gas. The water as a back-fill precludes the necessity of maintaining air or gas injection units at the site once the water flood portion is underway, so the compressors and other equipment are free for use at other sites. This reduces the amount of investment which must be made in equipment and allows a more effective usage, whereas the use of a gaseous phase to perpetuate the pressure for an effective back-fill requires that surface gas injection equipment be maintained in operation. Our invention has, therefore, new aspects of function and economy which are achieved by water injection into a hot manifold system which have not been previously accomplished or disclosed.

Since after the initial combustion phase the water flooding and back-fill phase can be carried out concurrently with the subsequent in situ combustion phases, the rate at which the ignition wells are developed will control the rate of development of the entire field. In situ combustion can be carried out from one or more ignition wells simultaneously depending on the rate of development desired. The minimum investment required would result from conducting combustion from one ignition well at a time. However, the optimum development for an entire field will be conducted so that the number of ignition wells at a given time is such that the entire field will be exploited in a specified number of years. In general, in situ combustion will be carried out so that the average rate of advance of the combustion zone will range between $\frac{1}{2}$ to 3 feet per day. Therefore, for an average spacing of 300 to 1200 feet between ignition and production wells, the individual combustion phases could range between 3 months to 6 years. The air injection schedule and the well spacing would be selected to complete the combustion phase at the desired rate of development.

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.

Example I

A portion of a Wyoming field in which our invention is being practiced is presented by FIGURES 3 and 4 of the drawings. The field was developed on 10-acre spacing, 660 feet between wells and rows. The formation is 900 feet deep and 45 feet thick and the crude oil is 21° API. An inverted 5-spot pattern was selected for application of the subject invention in this field by drilling an injection well in the center of an existing group of 4 wells; thus creating a 10-acre 5-spot with 467 feet between injection well and producer. Compressor capacity of 880 H.P. was installed for the recovery process, and after a six-month air injection period the formation was ignited using an electric heater. The in situ combustion process was carried out with an air injection rate of 2.5 MM s.c.f.d. for approximately 600 days, at which time the combusted zone reached the offset fireflood output wells. Air injection was then stopped at the well and water was injected into the injection well at a rate of approximately 500 b.w.p.d. to provide a back-fill in the burned out area and thereafter positive pressure was maintained to prevent any resaturation of the combusted manifold. Additional ignition wells were scheduled for drilling prior to the completion of the combustion phase in the first or pilot pattern. In situ combustion and water back-filling were subsequently initiated and completed successively in the injection wells until breakthrough of the combustion zone into the fireflood output wells. Water flooding was simultaneously initiated in the fireflood injection and output wells by injecting 300 b.w.p.d. into each well. Flush oil production was obtained from the ultimate recovery well and at the same time production can be continued from additional manifold patterns created by in situ combustion from other injection wells. Oil amounting to approximately 70% of the oil in place was recovered by the combination process, 50% of which was recovered through the ultimate production wells of the hot fluid drives.

Example II

A field in Arkansas produces 15° API crude oil from a depth of 1250 feet. There are approximately 15 feet of net pay which has a porosity of 28%. The fluid saturations of the field after primary recovery are 50% oil, 40% water, and 10% gas. The field is developed on 10-acre spacing and a line drive thermal recovery process is selected for the development of the field. Sufficient new infield wells are drilled to give three rows of five wells each in line flood pattern as shown in FIGURE 1. The rows of wells are 660 feet apart, and the individual wells are spaced 330 feet apart in the rows. Preliminary air injection tests show that injected air in this field has a tendency to flow in the east-west direction, so a complementary pattern orientation is selected to utilize this flow. The two most exterior wells and the middle well of the exterior rows are continued as injection wells for the in situ combustion step and the two remaining wells in the exterior rows are completed as fireflood output wells. The remaining wells in the interior row are closed or back-pressured during the combustion step. The in situ combustion process is conducted between wells in the exterior rows until the combusted zones intersect as desired at the output wells. Air is injected at a rate of about 800 m.c.f.d. into each injection well with breakthroughs being observed at the output wells in approximately 400 days. The output wells can be converted to

air injectors and the former injectors made producers for a short period to smooth out and enlarge the manifold system. Air is injected at a rate of 500,000 s.c.f. for 60 days into each of the injection wells in the exterior rows before cumulative gas analysis data indicate that a manifold of the desired volume of 3,000,000 cubic feet is established. Upon termination of the in situ combustion all of the wells in the exterior rows are converted for water injection. Two hundred fifty barrels per day of water are injected into each of the wells, until the manifold is filled. After fill-up the injection rates are restricted by pressure limitations to 70 barrels of water per day per well. The hot fluid drive is directed to each of the wells in the interior row of five wells now opened to flush production. The resulting depletion of the area between the rows of the pattern is complete with the minimum amount of undesirable bypassing of oil. Approximately 60% of the oil in the depleted formation is produced by the combination in situ combustion-water drive process as compared to only 20% recovery estimated by water flooding alone. The entire field is produced as in FIGURE 2 by repeating these sequences of operations at the next adjacent row or rows of wells. Thus, by proper scheduling of the field development, continuous usage of surface equipment is obtainable.

While particular embodiments of this invention have been described, it will be understood 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 scope of the invention.

We claim:

1. The method of recovering hydrocarbons from a subterranean formation traversed by bores of a plurality of injection wells and at least one output well which comprises the steps of positioning at least two injection wells adjacent each output well; conducting direct in situ combustion in the formation surrounding said injection and output wells while recovering hydrocarbons from the output wells; terminating said combustion to define a predetermined combustion zone; substantially filling said combustion zone with an aqueous medium introduced by way of at least one of said injection and output wells; positioning a recovery well adjacent to and outside of said zone; and injecting additional aqueous medium into the combusted zone through said injection and output wells to drive hydrocarbons from the formation adjacent said zone while removing hydrocarbons from the formation through said recovery well.
2. The method defined in claim 1 wherein combustion within the formation is terminated before breakthrough of the combustion at the output well.
3. The method defined in claim 1 wherein combustion within the formation is terminated after breakthrough of the combustion at the output well.
4. The method defined in claim 3 wherein a quantity of fuel is placed in the formation through said injection wells prior to combustion.
5. The method defined in claim 4 wherein a combustion supporting gas is injected through at least one output well subsequent to the combustion breakthrough thereat to combust a portion of the hydrocarbons within the formation adjacent the output well.
6. The method defined in claim 1 wherein the initial output well is shut in prior to the termination of combustion to combust said zone in a more uniform manner.
7. The method of recovering hydrocarbons from a subterranean formation traversed by bores of a plurality of output wells and at least one injection well which comprises the steps of positioning at least two output wells adjacent each injection well; conducting direct in situ combustion in the formation surrounding said injection and output wells while recovering hydrocarbons from the output wells; terminating said combustion to

define a predetermined combustion zone; substantially filling said combustion zone with an aqueous medium introduced by way of at least one of said injection and output wells; positioning a recovery well adjacent to and outside of said zone; and injecting additional aqueous medium into the combusted zone through said injection and output wells to drive hydrocarbons from the formation adjacent said zone while removing hydrocarbons from the formation through said recovery well.

8. The method defined in claim 7 wherein combustion within the formation is terminated before breakthrough of the combustion at the output well.

9. The method defined in claim 7 wherein combustion within the formation is terminated after breakthrough of the combustion at the output well.

10. The method defined in claim 9 wherein a combustion supporting gas is injected through at least one output well subsequent to the combustion breakthrough thereat and prior to said filling with an aqueous medium to combust a portion of the hydrocarbons within the formation adjacent the output well.

11. The method of recovering hydrocarbons from a subterranean formation traversed by a plurality of well bores of injection, output, and recovery wells which comprises the steps of spacing the wells in three adjacent, substantially parallel rows wherein the injection and output wells are positioned alternately in the outer two of said three rows and wherein said recovery wells are positioned within the inner one of said rows; conducting direct in situ combustion in the formation surrounding the outer rows of wells while recovering hydrocarbons from output wells within said outer rows; preventing egress of fluid from said recovery wells during said direct in situ combustion; substantially filling the combusted portion of the formation with an aqueous medium introduced by way of at least one of said injection and output wells; and injecting additional amounts of aqueous medium by way of at least one of said injection and output wells in each of said outer two rows into the combusted portion of the formation to drive hydrocarbons from the formation adjacent said combusted portion while withdrawing hydrocarbons through said recovery wells.

12. The method defined in claim 11 wherein combustion is initiated in the formation from the injection wells and wherein a combustion supporting gas is injected into the formation to propagate a combustion zone toward said output wells.

13. The method defined in claim 11 wherein the propagation of said combustion zone is terminated after breakthrough thereof at the output wells.

14. The method defined in claim 12 wherein a combustion supporting gas is injected into said output wells after breakthrough of said combustion zone to said output wells and prior to said filling with an aqueous medium to enlarge said zone adjacent said output wells.

15. The method of recovering hydrocarbons from a subterranean formation traversed by a plurality of well bores of injection, output and recovery wells which comprises the steps of spacing adjacent a recovery well the injection and output wells in a series of five-spot patterns wherein each injection well is substantially equidistant from each output well within the individual five-spot pattern; conducting direct in situ combustion within at least a portion of the formation within the boundaries of said five-spot patterns to form a predetermined combustion zone while recovering hydrocarbons from the output wells; preventing egress of fluid from said recovery wells during said direct in situ combustion; substantially filling said combustion zone with an aqueous medium introduced by way of at least one of said injection and output wells; and injecting additional fluid material by way of at least one of said injection and output wells in each of said patterns into said zone to drive hydrocarbons

from the formation adjacent said zone toward the recovery well; and removing hydrocarbons from the formation through said recovery well.

16. The method defined in claim 15 wherein combustion is terminated after breakthrough of the combustion zone at the output wells.

17. The method defined in claim 16 wherein combustion supporting gas is injected into said formation through said output wells after breakthrough of the combustion zone at the output well and prior to said filling with an aqueous medium.

18. The method defined in claim 16 wherein the outer positions of each five-spot pattern are occupied by injection wells and the inner position is occupied by an output well.

19. The method defined in claim 16 wherein the outer positions of each five-spot pattern are occupied by output wells and the inner position is occupied by an injection well.

20. The method of recovering hydrocarbons from a subterranean formation traversed by a plurality of well bores of injection, output, and recovery wells which comprises the steps of spacing adjacent a recovery well the injection and output wells in a series of four five-spot patterns wherein each injection well is substantially equidistant from each output well within the individual five-spot pattern; passing a combustion supporting gas into the formation through the injection wells while conducting direct in situ combustion in the formation within at least a portion of the areas bounded by the five-spot patterns to define a predetermined combustion zone; recovering hydrocarbons from the output wells in said patterns; preventing egress of fluid from said recovery wells during said direct in situ combustion; substantially filling the combustion zone with an aqueous medium introduced by way of at least one of said injection and output wells; injecting additional fluid by way of at least one of said injection and output wells in each of said patterns into said zone to drive hydrocarbons from the formation adjacent the zone toward the recovery well; and removing hydrocarbons from the formation through said recovery wells.

21. The method defined in claim 20 wherein combustion is terminated after breakthrough of the combustion zone at the output wells.

22. The method defined in claim 21 wherein combustion supporting gas is injected into said formation through said output wells after breakthrough of the combustion zone at the output well and prior to said filling with an aqueous medium.

23. The method defined in claim 21 wherein the outer positions of each five-spot pattern are occupied by injection wells and the inner position is occupied by an output well.

24. The method defined in claim 21 wherein the outer positions of each five-spot pattern are occupied by output wells and the inner position is occupied by an injection well.

25. A method of recovering hydrocarbons from a subterranean formation which comprises the steps of establishing an injection well and an adjacent output well in communication with said formation; initiating combustion in the formation immediately adjacent said injection well; injecting a combustion supporting gas through said injection well to propagate a combustion front from said injection well toward said output well while recovering hydrocarbons from said output well; terminating said combustion upon breakthrough of the combustion front at the output well; filling the combusted zone within the formation with an aqueous medium introduced by way of at least one of said injection and output wells; establishing a recovery well in communication with said formation at a point outside and adjacent to the combusted zone; and injecting additional amounts of aqueous me-

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dium by way of at least one of said injection and output wells into said zone while withdrawing hydrocarbons from the recovery well.

26. The method defined in claim 25 wherein a combustion supporting gas is injected in said output well after breakthrough of the combustion zone and before filling said zone with the aqueous medium.

27. The method defined in claim 26 wherein the medium is injected into the formation through the output and injection wells.

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