

[54] **OPEN FLOW PRODUCTION SYSTEM AND METHOD FOR RECOVERY OF SHALLOW OIL RESERVOIRS**

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[51] Int. Cl. **E21b 43/00, E21b 43/20**

[58] Field of Search **166/256, 265, 268, 272, 166/275, 305, 314, 52, 67, 53**

[56] **References Cited**

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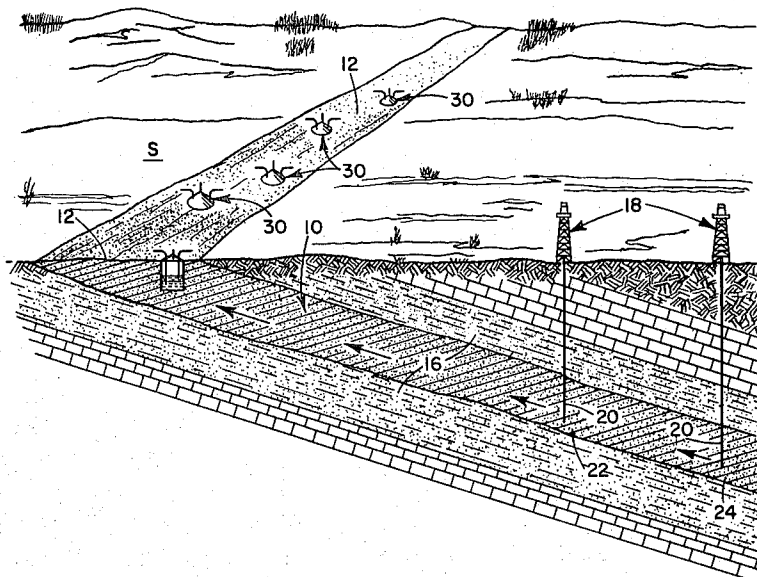
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Attorney, Agent, or Firm—Donald D. Jeffery

[57] **ABSTRACT**

Process and apparatus for recovering flowable oil from relatively shallow, porous oil-bearing formations which outcrop at or near the surface. One or more production systems are located in the outcrop area at the uppermost position of the structure, and oil flows by natural reservoir pressure, or fluid under pressure may be injected in the relatively lower regions of the formation for driving the oil upwardly to the production systems from which the oil is collected. The production systems are open at the bottom in the formation and communicate at their upper ends with the surface. The injection fluid can be supplied through wells formerly used for production purposes, or by new wells specifically provided for that purpose. Said production systems maximize flow capacity by providing an infinite well bore diameter in comparison with conventional producing wells.

9 Claims, 6 Drawing Figures



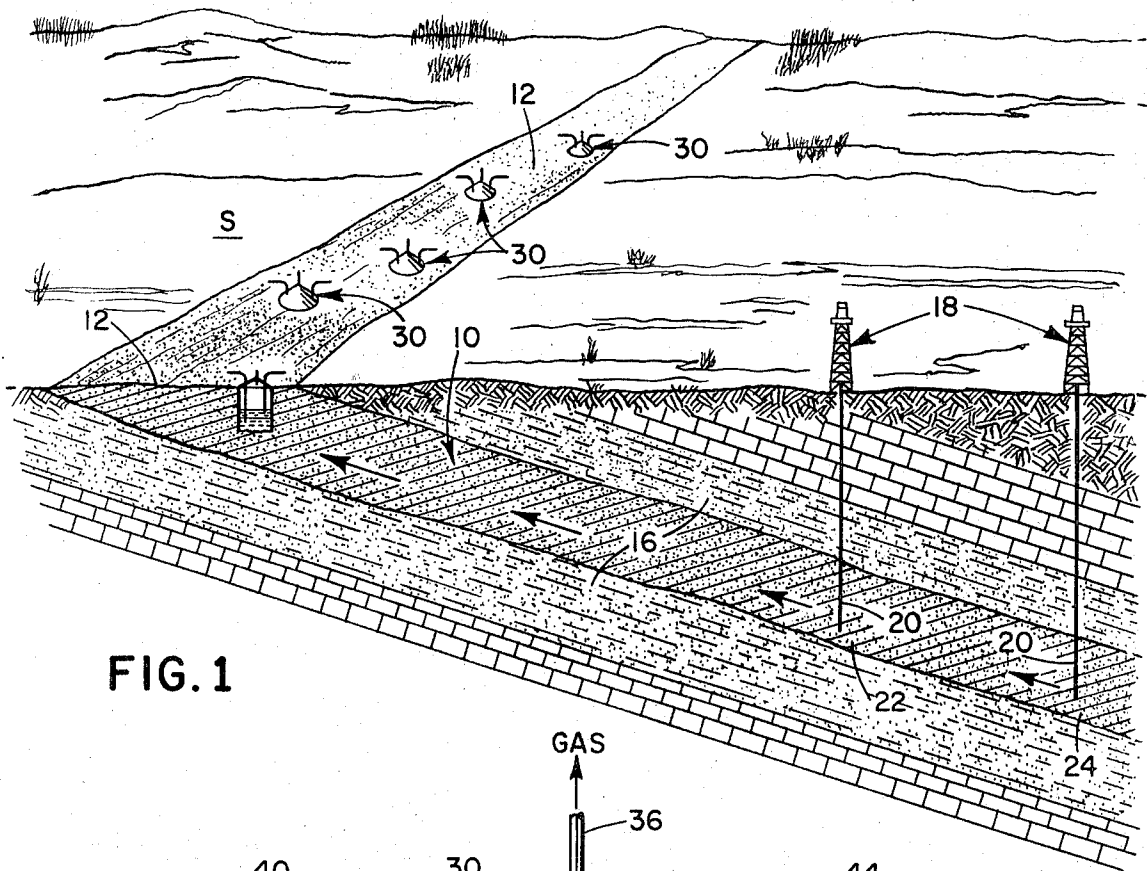


FIG. 1

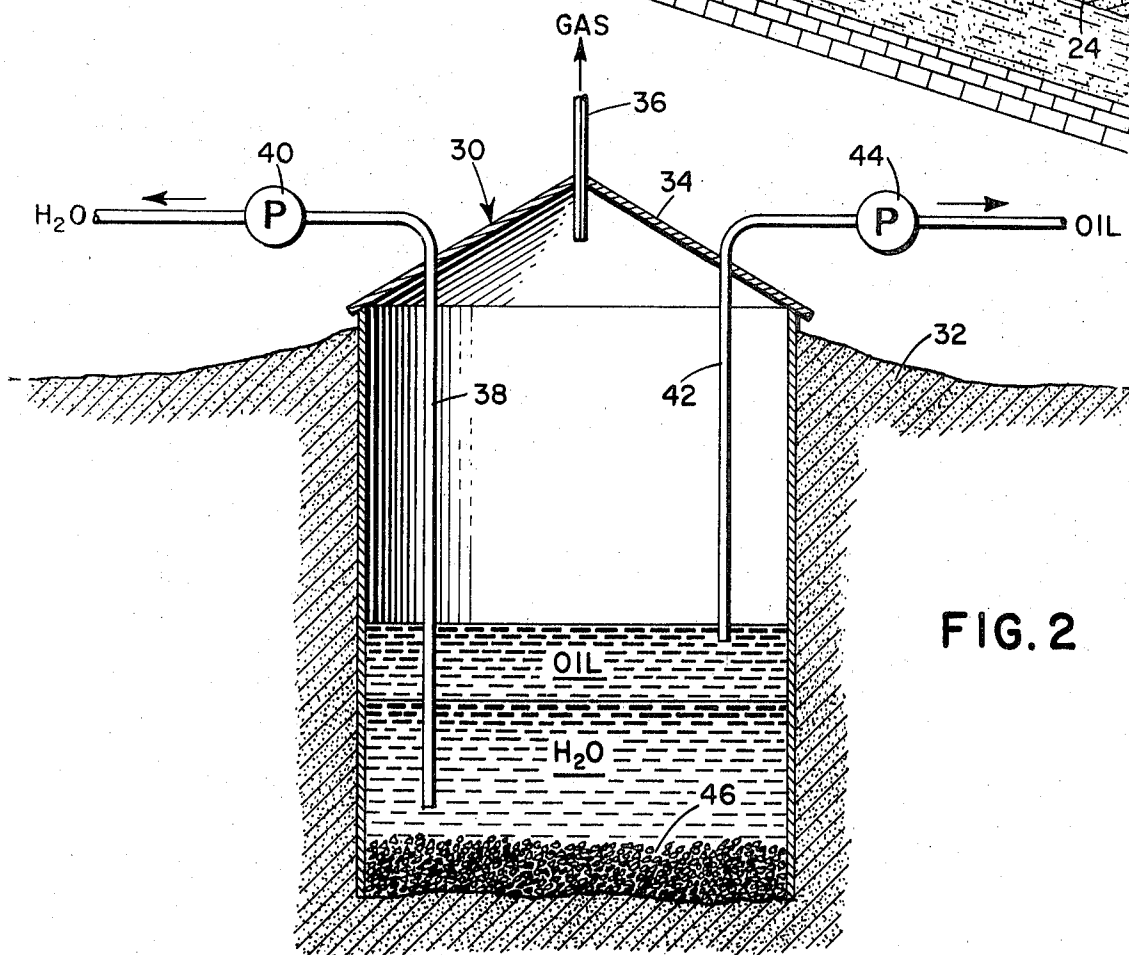


FIG. 2

FIG. 3

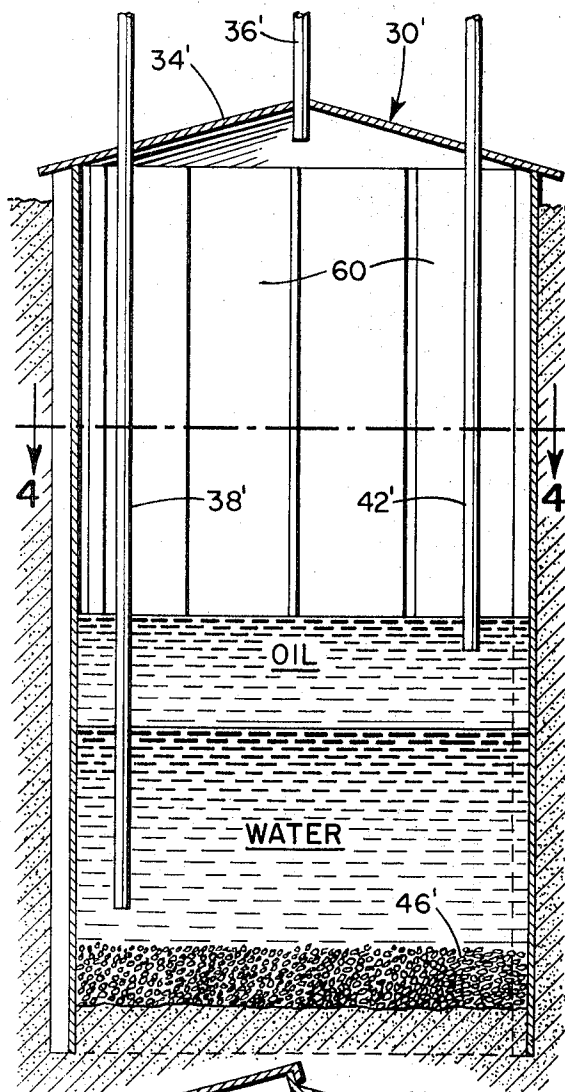


FIG. 5

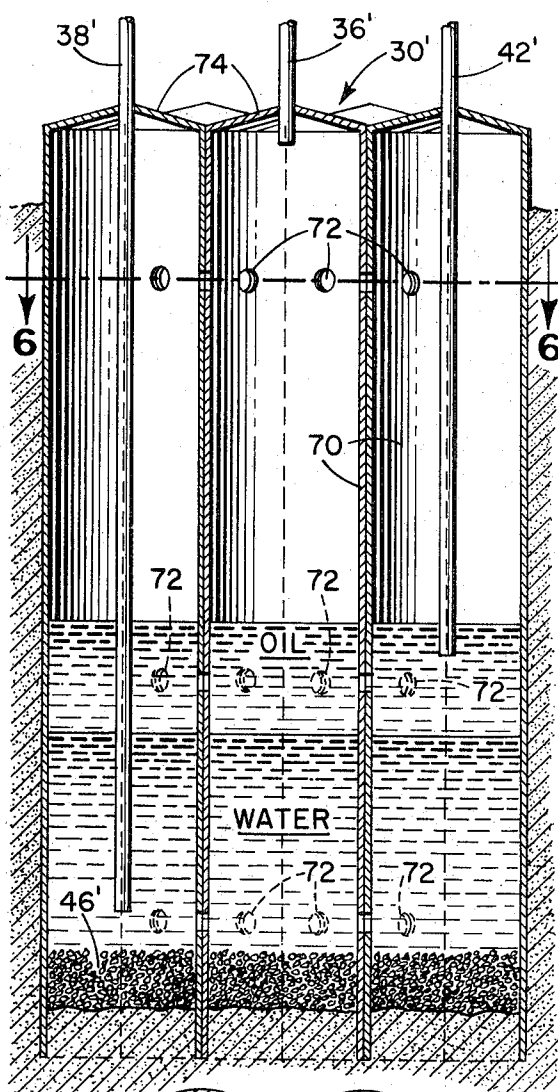
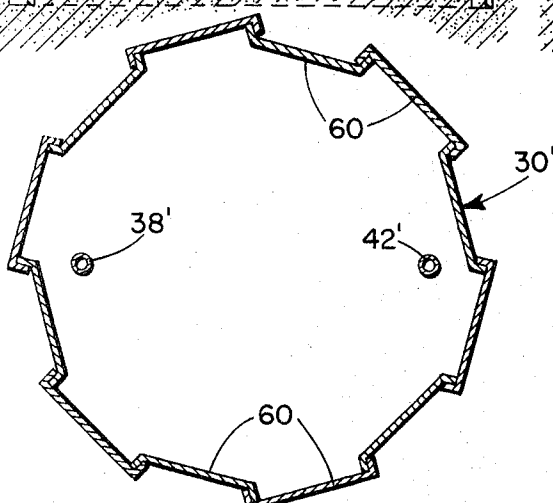


FIG. 4

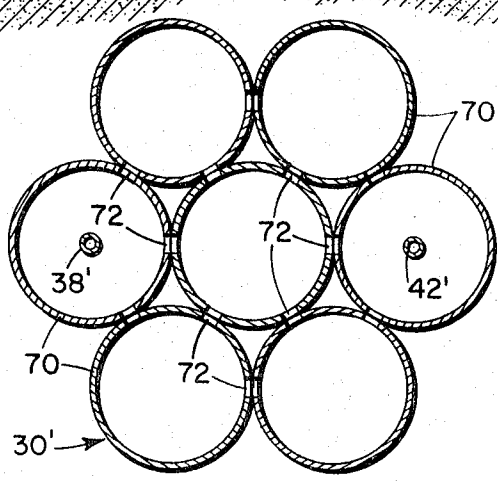


FIG. 6

OPEN FLOW PRODUCTION SYSTEM AND METHOD FOR RECOVERY OF SHALLOW OIL RESERVOIRS

BACKGROUND OF THE INVENTION

The present invention relates as indicated to an open flow production system operating under near atmospheric pressure for oil recovery from shallow oil reservoirs, and relates more particularly to novel method and apparatus for recovering oil from reservoirs or formations which outcrop at or near the surface.

As well understood by those skilled in the art, the recovery of oil from oil-bearing formations by normal production techniques is relatively inefficient, that is, the amount of oil recovered relative to the amount of oil present in the formation is relatively low, with such recovery in the case of viscous heavy petroleum deposits being as low as 8-15 percent of the total amount of oil in place in the formation. This is of course assuming the production of the oil is limited to primary recovery techniques due to the normal gas or water drive naturally occurring in the reservoir, with or without artificial lift means.

In order to improve the recovery, secondary or tertiary recovery techniques of various forms and concepts have been employed, all of which are commonly characterized in a broad sense by the sweeping and repressurization of the formation so as to provide artificial drive to the oil for improved recovery through the production wells. In view of the economic aspects of the problem, secondary or tertiary recovery techniques have reached fairly high levels of sophistication.

Although secondary and tertiary recovery techniques as presently practiced have greatly improved field recovery, there are certain recognized disadvantages. Where the reservoirs are relatively shallow, a condition which the present invention is specifically directed to, the relatively low reservoir pressure requires relatively close well spacing, therefore requiring numerous production and injection wells which rapidly raise field development costs. The additional wells must not only be drilled but operated and maintained as well, and the cost of drilling, maintaining and operating the additional wells necessary to successfully practice primary, secondary or tertiary recovery techniques is oftentimes not economically justified by the increased oil recovery.

It has been recognized that where the oil-bearing formation outcrops at or near the surface, other techniques may be employed for recovering the oil from the reservoir. An article fully exploring the prospects of mining the oil-containing bituminous rock deposits of shallow oil fields appears in the June, 1972 issue of Engineering and Mining Journal, pages 132-138. Although technically feasible, the mining of shallow oil fields by open pit mining techniques inherently meets with certain difficulties, not the least of which is the safety and ecological concern about the tailings produced in the mining operation.

It has also been recognized in the art, reference being made to U.S. Pat. No. 3,157,231, that oil can be recovered from relatively shallow formations by secondary recovery techniques with diluent or solvent, in which the oil is artificially driven from confined extraction areas to a confined recovery area communicating with the surface and from which the accumulated oil can be

pumped. However, the process disclosed therein comprises the pressurizing of the formation at or near the top thereof and the recovery of the oil at or near the down structure position of the formation, with the oil passing through relatively small outlet holes into the recovery area for removal therefrom in a confined area isolated by installing sheet piling. The outlet holes are for the purpose of passing the oil and extracting fluid but preventing the passage of sand in any significant amounts. In this regard, it should be noted that patentee is concerned with the recovery of oil from tar sands, the handling of which presents difficulties well known to those in the art. In the treatment disclosed, a diluent or solvent, such as naphtha, is employed for extracting and carrying the oil through the reservoir. The injection of such an extracting agent into the upper part of the formation as disclosed increases the danger of uplifting the overburden and is conducive to the creation of channeling, not to mention the failure to take advantage of the natural laws of hydraulics. In addition, the patented system does not utilize the natural boundaries of the reservoir, and the cost of installing artificial boundaries for confining operating areas is prohibitive for economical field development.

SUMMARY OF THE INVENTION

With the above in mind, a principal object of the present invention is to provide method and apparatus for recovering oil from shallow reservoirs by normal recovery techniques. In accordance with the present invention, the oil in the reservoir can be driven to the recovery area by natural flow, water flooding, fire flooding, or similar recovery techniques.

A further, more specific object of the present invention is to provide an oil production system of the type described in which a relatively shallow field is developed or redeveloped by forming and locating a production system excavated in the formation at or near the outcrop and to which the oil is driven for collection and removal. In accordance with the invention, the production system is excavated and open at the bottom and maintained at essentially atmospheric pressure, and has a large diameter and open area which is exposed to the formation thereby providing in effect a large well bore thereby increasing fluid flow by virtue of reducing the friction losses inherent in present recovery techniques where the oil to be recovered is driven to relatively small conventional well bores.

A still further object of the present invention is to provide an open flow production system particularly suited for shallow oil reservoirs and which is capable of recovering substantial quantities of oil in an economical manner, thereby permitting extraction of oil from low production or abandoned fields and extending the useful lives thereof.

A still further object of the present invention is to provide an open flow production system with a maximum producing capacity by eliminating producing wells by virtue of the surface production systems, thereby not only eliminating the otherwise high drilling costs but also significantly reducing the operating and maintenance costs associated with the conventional producing wells.

These and other objects will become apparent as the following description proceeds in specific reference to the application drawings.

BRIEF DESCRIPTION OF THE APPLICATION DRAWINGS

FIG. 1 is a partially sectioned perspective view through a shallow, oil-bearing formation, with one or more injection wells being illustrated in the relatively down structure portions of the formation, and several oil production systems being shown where the formation outcrops at the surface;

FIG. 2 is a cross-sectional view through an oil production system employing a standard cylindrical tank;

FIG. 3 is a vertical cross-sectional view through a modified oil production system;

FIG. 4 is a cross-sectional view taken on line 4—4 of FIG. 3;

FIG. 5 is a vertical cross-sectional view of a further modified form of oil production system, and

FIG. 6 is a cross-sectional view taken on line 6—6 of FIG. 5.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the application drawings, and initially to FIGS. 1 and 2, there is illustrated in FIG. 1 an oil bearing formation generally indicated at 10 which outcrops at or near the surface S at 12, with the outcrop as shown extending substantially along the surface. As above explained, the present invention is particularly well suited for shallow, oil-bearing formations which outcrop at or near the surface, and it will be understood that the top of the formation could terminate slightly below the surface and the concepts of the invention nevertheless applied for recovering the oil.

As shown, the formation 10 is bounded at its upper surface by an impermeable barrier and other strata which form the overburden 14 which varies in thickness due to the inclination of the formation 10, with the bottom of the formation 10 being defined by the impermeable formation 16, which impermeable formations represent the boundaries of the oil bearing formation of the type typically found with oil-bearing reservoirs. The impermeability of both the upper and lower formations is of course of major importance for oil accumulations and implementing recovery techniques which are employed so as to confine the injection fluids to the oil-bearing formation.

With respect to the formation 10 itself, this is normally of a porous rock through which the mobile oil can pass as a result of reservoir pressure differential. The porous reservoir rock desired in accordance with the present invention should not be confused with tar sands, the viscosity of which makes very difficult the driving of the tar oil along the formation unless the tar oil is previously extracted from the sand by a suitable reagent or solvent. In accordance with the present invention, the oil entrapped in the formation 10 can be driven from the formation to the production system through natural flow, water injection, thermal drive or other means.

It should further be noted that the formation 10 may represent either a new field or a shallow field of current low production capacity, or an abandoned field whose production has terminated. In either event, the situation is typically one in which the further production of oil by present recovery techniques is not economically justified in view of the low well productivity and the

high field development costs, primarily due to the development drilling and operation of injection and producing wells. Ideally, in accordance with the present invention, wells, generally indicated at 18, are present on the premises so as to minimize field development costs. The wells 18, whose well bores are indicated at 20, are at a down structure position and can be quickly converted from production to injection wells when required so as to permit fluid injection into the areas of the formation indicated at 22 and at 24. If the wells 18 remain from a prior or current production operation, the well bores can still be utilized as production or injection wells thereby making more efficient the recovery process.

It should also be noted that if the oil-bearing formation 10 is sufficiently extensive and the outcrop accessible, the drilling of injection wells of the type shown at 18 may be economically justified. In drilling, the well bores extend into the down structure portion of the formation 10, as shown in FIG. 1, whereby the liquid hydrocarbons following the injection process are driven upwardly through the formation by the driving fluid thereby taking advantages of the principles of hydraulics. When the injection fluid is injected at the upper part of the formation, there is greater change of breakthrough, channeling of the injection fluid at formation interface, and uplift of the overburden.

A series of production systems commonly designated at 30 are positioned along the outcrop 12 or near the surface, with a typical system being shown in cross-section in FIG. 2. As shown, the system is in the form of a cylinder that can be constructed either of plate steel or concrete, and is open at the bottom and installed by excavating a hole to the desired depth into the formation. The system can also be constructed by installing sheet piling as shown in FIG. 3 and excavating inside to the desired depth. Alternatively, a cluster of pipes can be driven and excavated or drilled into the formation with communicating perforations if desired as shown in FIGS. 5 and 6. Excavating increases fluid flow by virtue of producing the head on the reservoir fluids. Although not shown, the system 30 can be diametrically braced interiorly of the vessel so as to withstand the lateral forces resulting from the overburden 32 and formation.

A head 34 is preferably provided over the system 30 for venting the gas through pipe 36, and to provide protection to the environment.

Disposed within the system 30 is a pipe 38 for withdrawing any water collecting in the bottom portion of the system, with a pump 40 being disposed in the line. A similar pipe 42 and pump 44 are provided for withdrawing the oil and/or emulsion collected in the system above the oil-water interface. Although not shown, it will be understood that suitable control equipment, such as oil and/or water level indicators may be employed to effect automatic, periodic withdrawal of the oil and water from the system. The oil can with little or no treatment be transported directly to a production storage area, and the water may be treated for reinjection.

As described, the cylinder which forms part of the system 30 illustrated in FIGS. 1 and 2 is open at the bottom, and if necessary or desirable a layer of packed gravel indicated generally at 46 can be provided at the bottom of the cylinder.

As mentioned above, the production system can also be constructed from sheet piling or by assembling a cluster of pipes, and these alternative constructions are shown in FIGS. 3-6. In these figures, parts previously described have been given the same reference numeral with an attached prime.

Referring to the modification illustrated in FIGS. 3-4, the system 30' is comprised of a series of sheet pilings commonly designated at 60 the edges of which are flanged and mated as shown in FIG. 4. The abutting flanges can be connected to form a sealed joint by any suitable means such as mechanical interlocks, welding or the like. As shown in FIG. 4, the individual pilings are located or positioned so as to form a generally circular structure. The earth inside the pilings can be excavated after the pilings are driven to the desired depth or, if desired, the pilings can be installed after excavation.

The system illustrated in FIGS. 3-4 is otherwise similar to the FIGS. 1-2 form of the invention as indicated by the primed reference numerals.

Referring to the modification shown in FIGS. 5-6, the production system 30' in this form comprises a cluster of pipes commonly designated at 70 which are in abutting relationship as shown in FIG. 6. At their areas of tangency, the cylinders are intercommunicated at vertically spaced regions by means of perforations commonly designated at 72 formed in the pipes 70. As shown in FIG. 5, the perforations 72 are generally located in the oil, water and upper regions of the pipes to permit level build-up of the liquids to facilitate removal of the same from the system.

As shown in FIG. 5, each pipe is provided with a head 74 for closing the same, and the liquids and vented gas are removed from the system in the same manner as previously described.

Development of shallow oil reservoirs should be apparent from the above description. The selection of a field for development is based on several factors such as the thickness of the formation and the potential oil recovery, the location and extent of the formation outcrop, and the existence of wells communicating with the formation. As above mentioned, the invention is ideally suited for economically developing shallow fields in which production by conventional techniques is uneconomical and has terminated for other reasons.

When the formation is selected, one or several production systems are installed, with the number of such systems depending upon the extent of the outcrop and the potential recovery. Where production wells exist, they may be modified to permit the injecting of fluids down the well bores 20 into the formation 10. The formations selected will preferably contain flowable oil deposits recoverable by primary, secondary or other tertiary recovery techniques. Injection takes place in the lower regions of the structure, with the oil flowing in the path of least resistance upwardly toward the outcrop and the production systems. The delay between initial injection and migration of the oil into the production system will vary depending upon the injection pressure and the length, porosity and permeability of the formation, viscosity of the oil, and the fluid previously produced. The movement and producing capacity of the oil are of course greatly influenced and expedited by the provision of a large excavation well bore opening or openings such as provided by the produc-

tion systems 30, as contrasted with the substantial frictional losses occurring in typical recovery techniques where the oil is driven to relatively small bore conventional wells.

With respect to the production systems 30 and 30', these have been shown rather simplified in the application drawings, and it will be understood that the systems may include additional equipment such as heaters, separators, compressors, as the specific nature and quantity of the oil produced may dictate.

As above indicated, the concept of the present invention may also be employed for new field development. Where geological exploration indicates the existence of a shallow, outcropping oil formation, the reservoir may be developed by providing one or more injection wells and production systems rather than numerous production wells to produce the oil from the reservoir in accordance with standard techniques. The field development costs are thereby greatly reduced where the geology permits production of the oil in accordance with the invention concepts.

We claim:

1. A process of recovering flowable oil from a relatively shallow, porous oil-bearing formation which outcrops at or near the surface, comprising the steps of:

a. locating, excavating and installing an oil production system at the uppermost portion of the formation at the outcrop or near the surface thereof, said system communicating at its upper end with the surface and being entirely open at its bottom end in said formation;

b. injecting a fluid underpressure into the down structure position of said formation in a region thereof spaced from said production system, said fluid driving said oil upwardly through said formation to said production system, the latter by virtue of its size operating at essentially atmospheric pressure, the reduction of hydrostatic head and said open bottom providing in effect a large, open well bore thereby greatly increasing production capacity and reducing friction losses resulting from movement of the oil upwardly through the formation, and

c. removing the thus collected oil from said production system.

2. The process of claim 1 further including the injecting of fluid into several locations in the down structure position of said formation in suitably spaced relation, and collecting the oil in a plurality of spaced production systems.

3. The process of claim 1 further including separately collecting and removing gas and oil produced from the production system and venting from said production system gas produced with said oil, thereby establishing predetermined pressure conditions in said system which approximates atmospheric pressure.

4. The process of claim 1 wherein said pressurized fluid comprises water in a liquid or vapor state.

5. Apparatus for recovering flowable oil from a relatively shallow, porous oil-bearing formation which outcrops at or near the surface, comprising:

a. means for injecting a fluid into the down structure position of said formation so as to drive said oil toward said surface;

b. means in the form of at least one production system excavated and installed in the uppermost portion of the formation at the outcrop or near the surface thereof, with said system communicating at its

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upper end with the surface and operated at essentially atmospheric pressure, and being entirely open at its bottom end in said formation, and
c. means for removing from the production system the oil produced thereto from the reservoir under pressure.

6. The apparatus of claim 5 wherein said injection means comprises a plurality of injection wells having well bores penetrating the down structure portion of said formation in suitably spaced relation, and further including a plurality of suitably spaced production systems.

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7. The apparatus of claim 5 wherein said production system comprises a tank.

8. The apparatus of claim 5 wherein said production system comprises a plurality of sheet pilings interconnected at their adjoining edges to provide an enclosure for receiving the produced oil.

9. The apparatus of claim 5 wherein said production system comprises a plurality of cylindrical pipes arranged in a clustered, abutting relation, and means providing communication between adjoining pipes in the regions of water, oil and gas collection.

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