This invention relates to the development of oil fields and more particularly to a method of treating an oil body in the oil sands so that a maximum recovery of oil may be recovered from the sands.

The sand or formation in which the oil is found is seldom of the same degree of porosity throughout its thickness. Sometimes the upper portions of the sands are more porous than the lower portions, or vice versa, or there may be fissures or crevices in the sands which extend in lateral directions. Unless the oil body occupies the more porous parts of the sand the amount of oil recovered will be but a very small percentage of what might be recovered if the oil saturated sands were those sands of greatest porosity. Furthermore, if the more porous stratum of the sands are above the general level of the oil saturated sands, the free gas which usually accompanies an oil body will find its way through the upper sands to the wells without carrying or forcing any oil from the oil body or from the oil saturated sands to the wells. Moreover, even if the oil saturated sands comprise the more porous portions of the sands, the drainage of the oil, which occurs from the top of the sands, will leave an upper stratum of porous sands through which the free gas may readily find its way toward the wells. As a consequence, the gas-oil ratio will gradually increase as the life of the well increases. To put the matter in another way, the more oil that is drained from the top of the oil sands the greater the thickness of the channel or path through which the free gas may flow on its way toward the wells.

It is a well known fact that oil under pressure contains a very considerable volume of dissolved gas and that it is the expansion of the gases in the oil that is primarily responsible for the movement of the oil through the sands, the gas expanding and coming out of solution as the pressure decreases. If the free gas which is usually found above the oil body in cavities or domes, is allowed to escape through the sands which have been drained of their oil or through other paths such as channels, crevices or fissures in the sands above the oil body, the pressure on the field will fall very rapidly and thus seriously interfere with the drainage of the oil sands. As the pressure falls the gas which is dissolved in the oil will naturally seek the nearest point of low pressure. The upper portions of the sands from which the oil has been drained and through which the free gas is finding its way toward the wells will obviously be the nearest region of reduced pressure, and consequently the dissolved gas, in expanding, will flow toward this region. Some of the oil will be carried up by the expanding gas into this region of reduced pressure and be carried along by the gas which is flowing therethrough toward the wells. However, the top portion of the drained sands will continue to offer a comparatively free path to the flow of gas and consequently the production of oil will gradually decrease while the production of gas will increase.

It is an object of the invention to provide a method of treating the oil body which will prevent the free escape of gas through the more porous portions of the sands and thus to increase the amount of oil which may be recovered from the sands.

Another object is to provide a method of adjusting the position of the oil body within the sands so that the oil may flow through the more porous portions of the sands.

Oil bodies are usually found associated with underlying bodies of water. If the body of water happens to occupy the more porous portions of the sands, the production of oil is very materially retarded or interfered with.

It is therefore a still further object of the invention to provide a method of adjusting the oil body downwardly so as to allow the oil to flow through the more porous stratum therebelow.

The features of the invention will be more fully described in connection with the accompanying drawings in which:

Fig. 1 is a plan view of an oil field in which the oil wells are represented by small circles and the approximate upper and lower boundaries of the oil pool underlying the field are respectively the inner and outer dotted contour lines;

Fig. 2 is a vertical sectional view taken on
the line 2—2 of Fig. 1 and which shows a

typical strata formation and oil pool;

Fig. 3 is a view similar to that of Fig. 2

showing the oil pool after elevation in

accordance with the process of the invention;

Fig. 4 is a view similar to Fig. 3 showing a

modified strata formation with the oil pool

lowered.

In practicing the present invention oil

wells shown as small circles in Fig. 1 are to

be projected into the oil sands according to

a more or less geometric pattern. While the

wells are being drilled, cores will be taken

from the oil sands and a careful study made

to ascertain the relative degrees of porosity

of the sands at different levels. A study of

the cores will also reveal the relative posi-

tion of the oil body 12 with respect to the

more porous parts 14 of the sands 16.

When conditions indicate that the more

porous portions of the sands are above the

main body of the oil saturated sands as shown

in Fig. 2, the oil body will be elevated so as
to bring the level of the oil body above the

upper portion or level of the more porous

stratum of sand. The elevation of the oil

body will be accomplished by pumping water

into the sands 16 below the oil body. The

water will be pumped through water wells

20 located around the edge-water line and

also preferably through wells 22 which pro-

ject through the oil sands into the water

sands therebelow. It is preferred to pump

water into the water sands by way of wells

extending through the oil sands as well as

through wells located at the edge-water line,

so that the water level 24 may be raised as

rapidly as possible and as uniformly as pos-

sible beneath the entire oil body.

By raising the level of the oil body in the

manner indicated and until the upper level 28

of the oil body is on a level with or above

the more porous stratum 14 (as shown in

Fig. 3), the free gas 28 in the upper portion

of the sands will not be able to escape with-

out doing useful work, namely, in forcing or

carrying the oil toward the wells. By elevat-

ing the body of oil until the upper part of the

porous stratum is completely saturated, it is

obvious that the gas pressure on the oil body

may be maintained more or less nearly ap-

proximately the original rock pressure and,
in any event, will not be enabled to fall be-

low the pressure in the region of the wells.

As a consequence, the gas, in coming out

of solution in the oil, will be obliged to move

laterally toward the wells or, in other words,
towards the region of reduced pressure. The

ratio of gas to oil will therefore approximate

more or less closely the ideal ratio, which is

that the volume of gas produced per barrel

of oil should not materially exceed the

amount of gas which is dissolved in the oil

at the pressure existing on the field.

In order to maintain the upper level 28 of

the oil body substantially constant, it is con-
templated in accordance with the invention

that water will be supplied continuously to

the water sands below the oil body in about

the same volume that the oil is drained from

the sands. If there is no leakage or migra-
tion of the water to remote points or to the

surface, the volume of water supplied through

wells 20 and 22 should equal the amount of

oil recovered from the sands through wells

10 after the oil body has once been raised to

the proper level.

If conditions indicate that the more porous

portions 14 of the sands are below the oil

saturated portions of the sands, the invent-
don contemplates that water shall be pumped

from below the oil body through wells 20

sufficiently to enable the oil to sink or be

forced by the gas pressure thereabove into

the more porous stratum 14 therebelow as

shown in Fig. 4. If the gas pressure on the

field is comparatively high, the oil will sink

more or less readily through the water-

wetted sands and gradually find its way to-
toward the wells 10. However, if the pressure

on the field is not very high, the pressure

should be increased by pumping gas from an

extraneous source or by pumping air into the

field through wells 30 to assist the oil in pen-

etrating through the water-wetted sands.

Once a channel has been established by the

oil through the water-wetted sands, the drain-
age of oil will proceed very rapidly and the

efficiency of the oil recovery will be unusually

high.

While it is preferred to obtain cores from

the oil sands while the wells are being drilled

so that the operator may be in a position

to adjust the position of the oil both with re-

tect to the more porous stratum or portions

of the oil sands, nevertheless the invention

may be practiced without this preliminary

study of the oil sands. The wells may be

opened to the flow of oil and gas in the usual

manner, the ratio of gas to oil being care-

fully noted. If the wells flow an excessive

amount of gas the operator may justifiably

assume that free gas is finding its way

through an upper stratum. The operator

will then proceed to elevate the oil body until

the upper level of the latter is sufficiently

high to prevent the free gas from freely flow-
ing through such stratum. On the other

hand, if the ratio of gas to oil is compara-

tively low but the wells tend to flow a mix-
ture of oil and water, the operator may justifi-
ably assume that this stratum of the sands

from which the mixture is drawn is occupied

at least in part by the body of water and

he may therefore proceed to pump out suffi-
cient water to enable the oil body to sink or

penetrate into said stratum.

It is preferable that the wells be operated

under a back-pressure in order to prevent as

far as possible the tendency of the free gas
from channeling through the oil body. The maintenance of a back-pressure on the wells is particularly desirable where the gas pressure on the field is high. Due to the fact that gas will flow through the sands more readily than oil, it will tend to channel its way through the oil sands toward the wells when the pressure is high.

The invention is particularly adapted to the treatment of an oil body or field as a whole. It also offers a method of recovering oil from oil sands which cannot be satisfactorily drained of their oil by ordinary methods of production. In addition, it offers a method which will enable a more complete extraction of oil from any given oil bearing sands.

What is claimed is:

1. The method of developing oil fields which consists in ascertaining the location of the most porous stratum of the sands in which the oil body is found, bringing the oil body into such position with respect to said stratum that the oil will flow through the same toward oil wells projected into the sands, and maintaining said oil body in line with said porous stratum while removing oil through said wells.

2. The method of developing oil fields which consists in projecting wells into the field in accordance with a given geometric pattern, obtaining cores of the oil sands as the wells are being drilled, ascertaining from a study of the cores the relative degrees of porosity of the oil sands at different levels and the relative position of the oil body with respect to the more porous strata of the oil sands, changing the relative position of the oil body in the sands to bring the oil body in line with the more porous strata of the sands, and maintaining said oil body in line with said porous strata while recovering oil from said body.

3. The method of reducing flow of fluids other than oil along paths in oil sands which are more porous than the main body of the sands which consists in adjusting the position of the oil body into line with the more porous paths in preference to said other fluids and holding the oil body in said new position while flowing oil along said paths.

4. The method of reducing flow of fluids other than oil from a region of high pressure toward a region of low pressure through paths in oil sands offering relatively low resistance to the flow of fluids in the sands which consists in shifting the oil body into a position which will permit the oil to flow along the paths of least resistance in preference to the other fluids, and holding said oil body in said position while removing oil therefrom.

5. The method of preventing gas from flowing from a region of high pressure toward a region of low pressure along paths in oil sands offering less resistance to the flow of fluids than the main portion of the sands which consists in elevating the oil body into such position that oil will tend to flow along said paths in preference to the gas, and maintaining the oil body in line with said paths while recovering oil therefrom.

6. The method of developing an oil body contained within sands in the earth which consists in so adjusting the position of the oil body as a whole that oil may flow along the most permeable sand stratum toward the oil wells in preference to water and gas, the position of the oil body being adjusted by varying the pressure from beneath the same, and flowing oil from said body along said permeable stratum.

7. The method of developing an oil field which consists in projecting wells into the oil sands, flowing oil and gas from the wells as long as a predetermined ratio of gas to oil is maintained, elevating the oil body in the sands when more gas flows than should flow according to said ratio, and maintaining the oil body at that level which will cause the predetermined ratio of gas to oil to be maintained.

8. The method of reducing the water-oil production ratio of an oil well draining porous sands, which consists in removing the water from said porous sands and in shifting the underground oil body as a unit downwardly into line with said porous sands through which the underlying water tends to flow toward the oil well to thereby cut off such water flow and substitute a flow of oil therefor.

9. The method of developing an oil body contained within sub-surface earth strata which consists in shifting the position of the oil body as a unit into line with the most permeable stratum directly communicating with the oil well to thereby increase the flow of oil and proportionately reduce the flow of water and gas.

In testimony whereof I affix my signature.

HENRY L. DOHERTY.