Oil[1]

I.—OIL IS WHERE YOU FIND IT.

By A. B. Cox.

THE rapid development of the motor car and the multitudinous uses of petroleum in the industrial world tend to form in the back of our minds the idea that petroleum is something new, when in reality petroleum existed in remotest antiquity, and most of the ancients used it for a variety of purposes. It furnished fuel for the devotion man paid to fire as a sacred element; to him the occurrence of flammable material issuing in streams from the earth must have been a remarkable phenomenon, which he was quick to connect with magic and religion, so that many places where seepages occurred were sites of fire temples where the fire god was worshipped at eternal flames.

As asphalt or bitumen it was known to the ancients, who used the black adhesive material for many purposes, and one may well imagine some savage on the Mesopotamian Plains pitching his canoe with asphalt from the seepages near Kirkuk.

Slime is the biblical word for asphalt, and we are told in Genesis, regarding the Tower of Babel, " . . . and slime had they for morter ".

The American Indians were aware of its existence, skimming the oil from the surface of springs and small streams to use for medicinal purposes.

As early as 1624 the Indians made known to the early settlers an oil spring located near what is now Cuba Lake in the western part of New York State, a spot well known to the writer.

This invaluable gift to man has been so secreted by mother nature in the dark recesses of the earth's great storehouse that no one is really sure whence petroleum came, what its origin, or how extensive its supply.

Geologists have been able to write the history of coal with almost as much accuracy as though they had witnessed its formation, for coal, being solid, has stayed fast in its beds. Petroleum, however, due to its migratory tendencies, has moved from its sources, making the task, therefore, of tracing its history much more difficult.

Petroleum as found is usually termed " crude oil ", and is composed, principally, of hydrocarbons, namely two elements, hydrogen and carbon, and these two elements, by uniting in varying proportions with each other and with a number of other elements, form a multitude of compounds—solid, liquid and gaseous—each having distinct properties. Just as there are many kinds of trees, likewise there are many kinds of petroleum. It is sometimes thick like tar, sometimes oily and heavy like amber-coloured cream, and sometimes light and volatile like the gasoline which it yields. In colour it ranges from almost black, yellow or brown through shades of green to colourless.

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[1] This is the first of a series of three articles by a writer who has had a life-time association with the oil industry, and whose knowledge of oil in general, as recorded in these articles, will prove of interest.

Petroleum is commonly classified as a paraffin-base or asphalt-base, from the nature of the residue left on distillation ; or, if it contains both paraffin and asphalt it is known as mixed-base. The asphalt-base crudes are, possibly, more correctly termed naphthene-base, and are usually so referred to.

Many theories as to the origin of petroleum have been put forward by scientists from their fascinating study into the geological yesterday of the earth's crust. Petroleum and natural gas are almost exclusively found in association with sedimentary rocks. These rocks are mainly shales, limestone and sandstone. Oil shale, which is merely clay or mud more or less compacted, under a microscope reveals remains of algæ, insects, fishes and many other forms of life, besides considerable quantities of formless organic substance, probably a mixture of all.

The sediment from which these rocks take their name was laid down on the earth millions of years of geologic time before the dawn of primitive man. This sediment came from the breaking down of igneous rocks through the action of wind, water and frost. Through the agency of rivers great volumes of mud and sand, vegetable and animal matter was being deposited as silt in great plains along the river courses and upon the ocean bottom.

Through countless ages layer upon layer of compacted mud and sand were built up. Squeezed by the weight of overlying silt, crushed and broken and thrust about, slowly this mud and sand of the geological yesterday became the shales, limestones and sandstone—sedimentary rocks—of the geological today.

Science, tracing the origin of petroleum, regards as extremely important the evidences of plant and animal life found in shales and limestones. It has taken sedimentary rocks which locally contain large quantities of organic material, and has, by heating, produced petroleum.

Weighing the evidence, science assumes that in some manner plant and animal organisms similar to those found in shales and limestones were the origin of oil. It believes that these minute organisms, buried in the sea by new mud deposits, sealed from the air and protected from the ordinary processes of decay by the brine of the ocean itself, were subjected to slow decomposition and yielded, among other products, the petroleum of commerce.

The processes by which nature transformed these mother substances into the rich and bountiful liquid found in the crust of the earth is one of the great unsolved problems of petroleum geology. Whether oil was formed through the action of bacteria and the various chemical reactions associated with that action soon after they were buried in the silt, or whether through subjection to high pressures and temperatures a part of the organic material was changed to petroleum, are purely theories.

What makes the problem more difficult of solution is the early migration of petroleum. Shales and limestones containing the source material are relatively compact and impervious rocks. Oil in some way has left them and gone into more porous ones. Thus it is found that while the shales and limestones contributed most of the source material for petroleum, sandstones are the most common reservoirs.

In the early days of petroleum discovery surface indications such as seepages, oil springs, and so forth were the clues which led early drillers in their search, and while scientific methods have largely supplanted the earlier ones, oil industry men still resort to actual trial: for example, in 1930, aided by the best geological brains, more than 20,000 wells were drilled in the United States, at a cost of about £100,000,000, and one-third of these wells were dry.

The geologist does not locate oil; he attempts to locate the position of formations which he believes favourable to oil accumulation. By a study of earth and rock formations geologists are able to predict with increasingly greater accuracy the probable location of oil.

The geologist necessarily studies the questions of oil migration and employs all the scientific means at his disposal to define the structural pattern formed by the layers of sandstone, limestone, shale and other rocks which make up the crust of the earth.

Accurate logs of thousands of drilled wells with samples of the formations found at every foot of its depth have enabled the geologist to construct the formations to depths of up to two miles under various areas. Co-ordinating these contours of strata with actual results of drilling produces valuable information for predicting the possible productivity of other untried areas.

Special wells of small diameter have been drilled and "cores" (cylindrical segment of the rocks) secured to furnish the geologist with information. Thus has arisen the associated activity of what is sometimes termed "sub-surface geology", assisted by core drilling and by the science of palæontology (the study of fossil remains in the rocks). In order better to meet the need of exploring the sub-surface in certain areas, new fact-finding technique and instruments have been developed under the name of geophysics (earth physics). Delicate instruments of the most refined precision measure variations and differences from point to point in gravity, density, conductivity, magnetic susceptibility, etc., of the rocks which compose the crust of the earth. From such data the slope of deeply buried beds of rock is computed—a picture of the structural pattern at such depths is deduced.

There are several instruments employed in geophysical work, the most widely used at the present time being the torsion balance, the seismograph, and the magnetometer.

Having determined that after oil entered the more porous rocks it travelled, either alone or with water, through pores of sandstone or through larger openings (such as systems of fissures or through cavernous beds of limestone), influenced by rock, by water, and by gas pressure and by the force of gravity, working its way upward from one bed to another, we then find it has tended to gather along the roof of its porous carrier bed, and has stopped wherever the roof of the bed was arched or domed in such a way as to form a closed trap.

The folded or arched earth structures which commonly contain oil may be generally classified into four groups: anticlines, synclines, faults and domes. Figures 1, 2, 3 and 4 illustrate these structures and show the location of the pools.

The modern search for oil conducted along scientific lines is helping to remove many uncertainties by assisting in locating the most likely place to drill in order to tap the reservoirs secluded under the cap rock of a dome or anticline or held in leash by a fault.

Surface indications are not always reliable guides, as will be noted from the photographs of various fields ranging from the almost inaccessible mountain heights of California (Fig. 6) to the flat prairie lands and swamp lands of Texas (Fig. 7) and Louisiana.

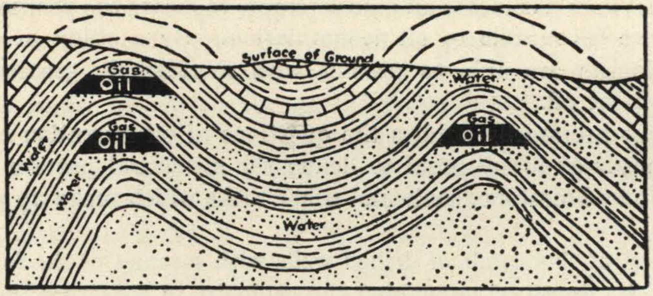

Fig. 1.
Diagram showing accumulation of oil and gas in anticlines.

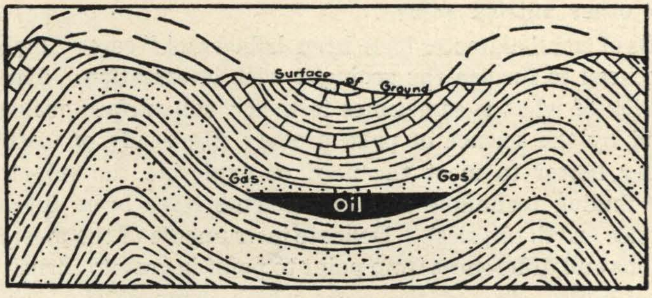

Fig. 2.
Diagram showing accumulation of oil in synclines.

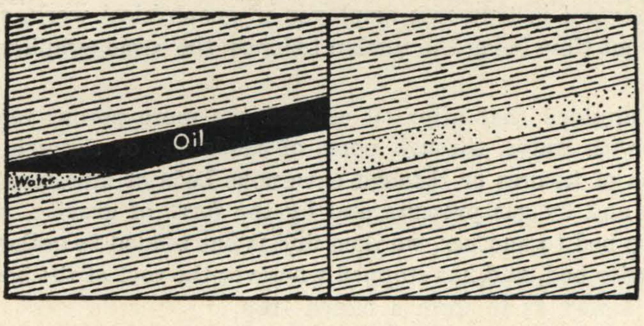

Fig. 3.
Diagram showing accumulation of oil in faults.

While petroleum has been found on every continent, and in more than twenty-three countries of the world, eight of these contribute 96% of all the oil that is being produced. In the United States of America oil is produced in nineteen States, the principal States being Texas, which accounts for 37% of the total production, Oklahoma, 25%, and California, 24%. The oil produced in the State of Texas almost equals in quantity that produced in all other countries of the world combined.

Whether nature, who has so richly endowed that country with oil resources, has been more bountiful in her gift than to certain other countries only the future can say ; but under American laws of property ownership, giving, in most cases, the surface owner title to the sub-soil, oil development has been free and little handicapped as compared with other countries where the Government has retained sub-soil rights, enacted highly restrictive laws, and exacted royalty obligations which have been regarded as prohibitive by prospective developers.

The term " wildcat " drilling as used in the oil industry means test operations in areas where the discovery of oil will probably mean the opening of a new field. The drilling of " wildcat " wells is always attended by a great deal of suspense, anxiety and excitement, particularly the latter if any real showing is found.

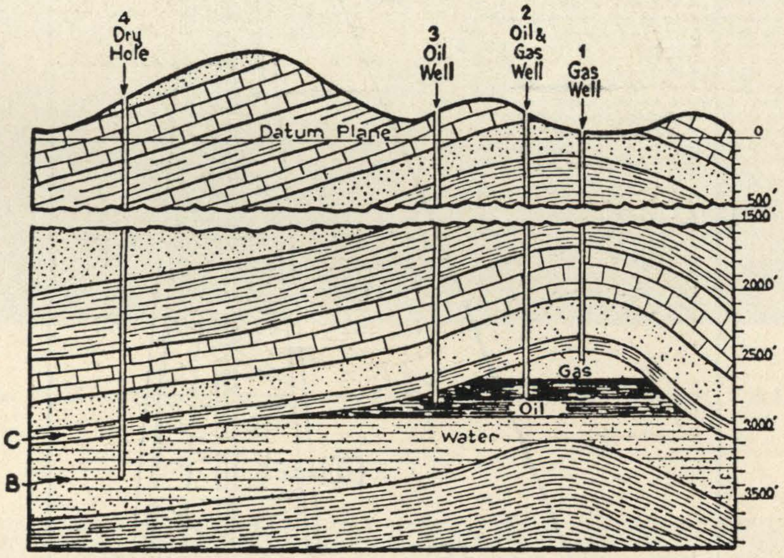

Fig. 4.
Diagram of a cross-section through a dome.

Before a well can be drilled on a lease, roads must be built, water lines laid, equipment hauled to the location, and the derrick or rig erected. The accessibility of a good water supply and fuel are primary considerations. A good water supply is absolutely essential, for without it drilling operations cannot be carried on.

The drill, the final authority on the presence of oil, has been classified into two general types : cable tool or percussion drilling, and rotary drilling.

The cable tool method is the one originally developed from the drilling tools employed by Drake and which were, to a large extent, suggested by the methods used in drilling salt wells in that period (1857). This method, developing rapidly in efficiency, was used exclusively in the earlier days of the production of petroleum where hard rock formations were encountered. This equipment (Fig. 5) consisted of a wooden or steel derrick, approximately 84 feet in height. By means of the walking beam in the derrick a " string of tools " is raised and dropped at regular intervals ; the great weight of the tools giving them a stroke of considerable energy, thus making the hole by pulverizing the rock. The motion of the walking beam is regulated to the speed that will snap the tools against the hard rock in the bottom of the hole, by the spring of the rope. At intervals during the process it is necessary to remove crushed rock and sand from the hole. It is also necessary to line the hole with

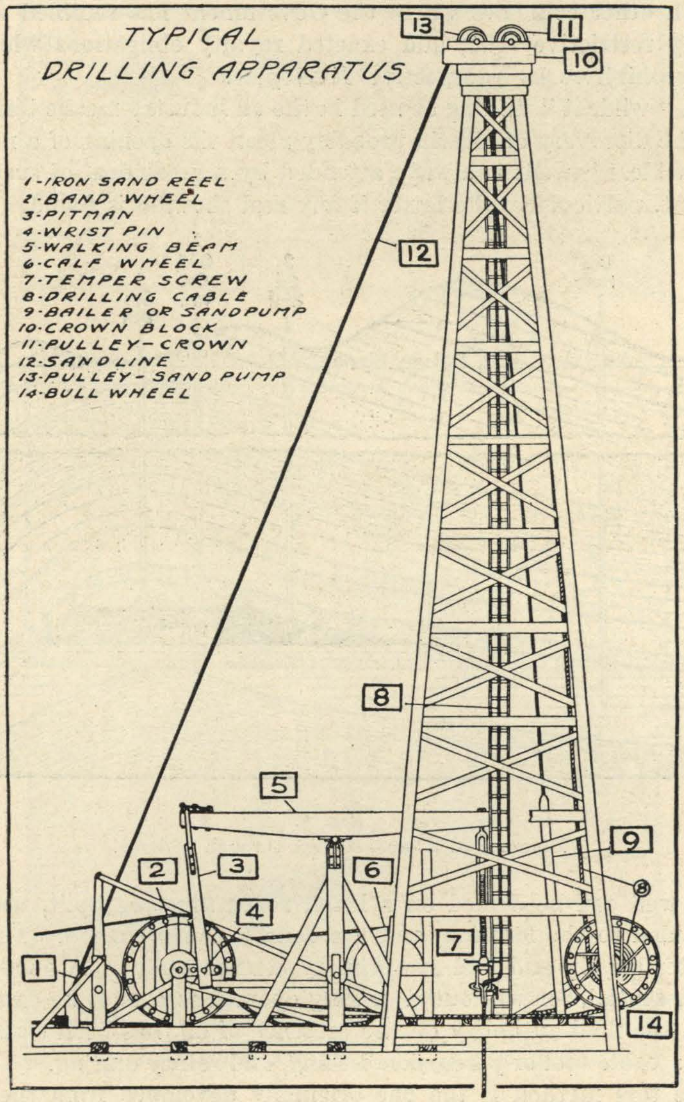

Fig. 5.
A cable or percussion drilling outfit, rigged for drilling.

casing of steel pipe so as to prevent caving strata and water from blocking the hole. As the depth of the well increases, the hole becomes narrower, and successive lengths of casing must be smaller in diameter.

Rotary drilling, as the name implies, is a method of drilling wells by rotating a bit or cutting tool in the hole, the bit being at the end of a continuous column of twenty

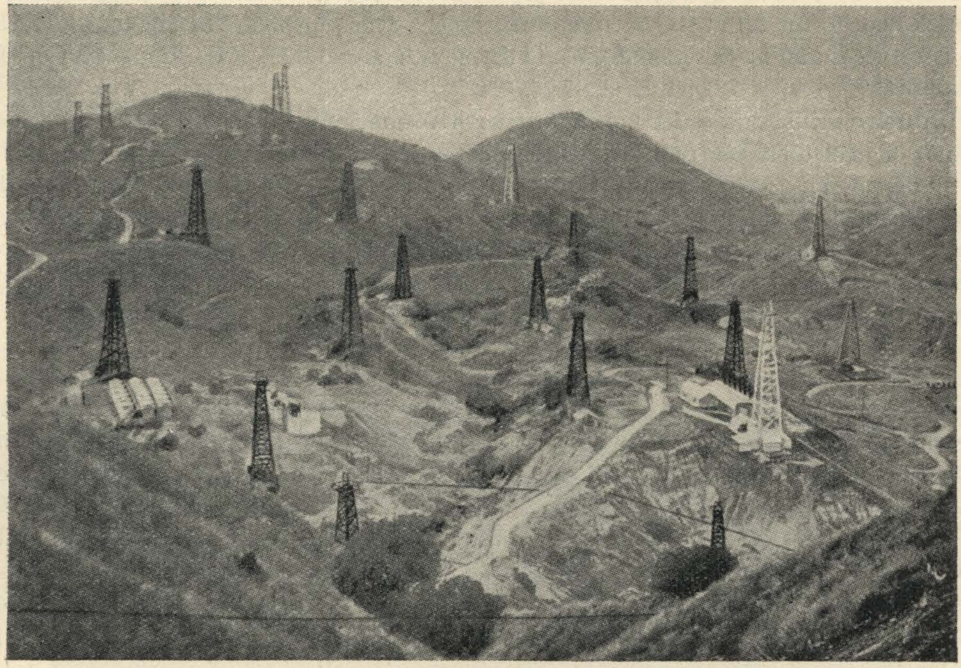

Fig. 6.
The Texas Company's Harvey Lease, South Mountain Field, California, U.S.A.

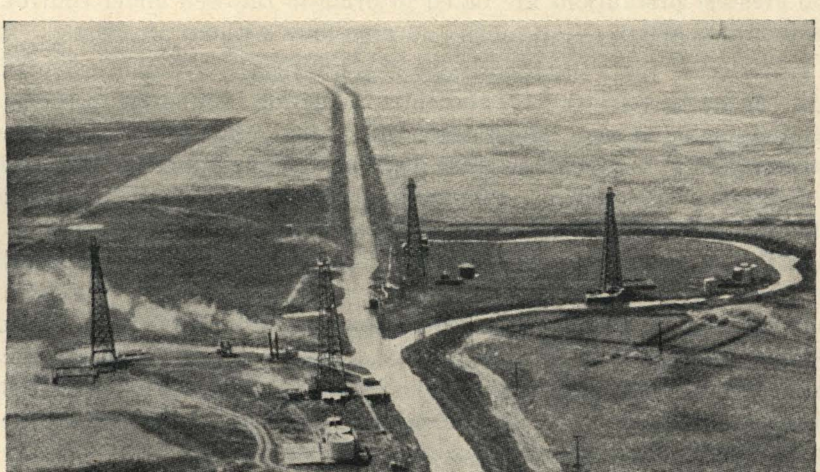

Fig. 7.
The Texas Company's Port Neches oil field in Texas, U.S.A., showing canal connecting with Neches River and Discovery Well in the centre.

to thirty feet sections of round steel pipe screwed together, and extending from the derrick floor to the bit at the bottom of the hole. This pipe is the means by which the bit is rotated, and as the hole deepens other joints are added to the upper end of the column.

Rotary drilling was developed for earth formations which are soft and which cannot be drilled efficiently by the cable tool method. While the bit or cutting tool is revolving in the earth, a steady stream of mud and water is circulated through the pipe which holds the bit into the bottom of the hole. In this manner the drillings, such as earth, shale and pulverized rock, are brought to the surface, and the walls of the hole are mudded, thus preventing caving in the hole. This method also requires the use of casing to protect the hole, although mudding of the walls often results in a satisfactory wall.

At the beginning of the industry almost all of the wells were comparatively shallow, seldom exceeding 2,000 feet, and the cost per well rarely was in excess of £200. In the present day wells, however, the drilling is a long and costly procedure. One thousand feet may be drilled in ten to twenty days, while the drilling of a 10,000 feet well may extend over a period of a year or more. The cost may range from £200 to £800 for 1,000 feet, to from £5,000 to £8,000 for a well 4,000 feet in depth, extending up to £31,000 to £50,000 for 8,000 feet wells.

The deepest producing well up to 1932 was located in the Ventura Avenue field at Ventura, California, and was 9,710 feet deep. The deepest non-producing well in the world is in the Mexican oil field. It was drilled by the rotary method to a total depth of 10,585 feet.

A common misconception of oil wells is that many of them are fountains or "gushers", from which the oil spouts in great volume. Actually this is not so. The oil man considers a "gusher" a most undesirable occurrence, and in preparing for the oil greatest precautions are taken to bring in the well under control, that is, to turn the oil immediately into tanks and pipe lines without any loss.

The majority of the wells produce at a low rate, the average production being about eight to ten barrels per day, and this production is brought to the surface by means of pumping equipment which raises the oil found at the bottom of the hole to the surface, where it is run into small receiving tanks, from there into pipe lines called "gathering" lines, which take it to large tank farms located at pumping stations. From these pumping stations it is forced through trunk pipe lines ranging from two inches to twelve inches in diameter and thousands of miles in length, to the refineries.

A map showing the pipe line system of the central and south central portion of the United States would have the appearance of a spider web or a tangled skein of yarn. These trunk line systems consist of pumping stations placed at average intervals of about 45 miles, depending upon the character of the country through which the line passes, and of independent telegraph or telephone systems.

The first step in the building of a pipe line is a survey of the country through which it has to pass, these surveys being carried out in latter years by aerial photography, and then by ground survey. The rights-of-way must next be purchased, and pipe transported and stored at intervals along the right-of-way. Automatic ditch-digging machines dig the trench into which the pipe line is lowered and covered after it has been laid and tested (Fig. 8).

The pipe is either welded or screwed length by length, and bent to conform to the contour of the country. It is then doped with asphalt and wrapped with asphalt-saturated felt to protect it from corrosion. Automatic welding and wrapping machines, aided by tractors, carry on this work in a modern way at unbelievable speed compared with the old hand-power methods.

Fig. 8.
Laying section of the Texas Company's West Texas pipe line, a part of their 6,000 mile pipe line system, using present-day methods as compared with the old man-power methods in the earlier days.

Six inch pipe lines, under pressure of about 800 pounds per square inch, can deliver about 10,000 barrels (of 35 imperial gallons) per day of twenty-four hours.

Storage tanks located at pipe line stations are constructed of steel, capacities ranging from 55,000 to 80,000 and 120,000 barrels each. In California, and to an extent in Texas, concrete reservoirs are used, the largest having a capacity of four million barrels.

The pipe line system is, in many respects, similar to that of a railway system, with its trunk lines, feeders, terminals, storage yards, switch systems, stations, dispatchers, telegraph and telephone systems, which are called upon to carry and control daily all the crude oil produced, amounting to about two and a half million barrels per day. This enormous flow of "black gold" is swallowed up by the refineries in their efforts to supply the ever-increasing demands of the nation's industries, great and small, and of ships that ply the seven seas, and to provide transportation for man and materials, whether by car or truck, by rail or plane.

(Part II will appear in the June issue.)