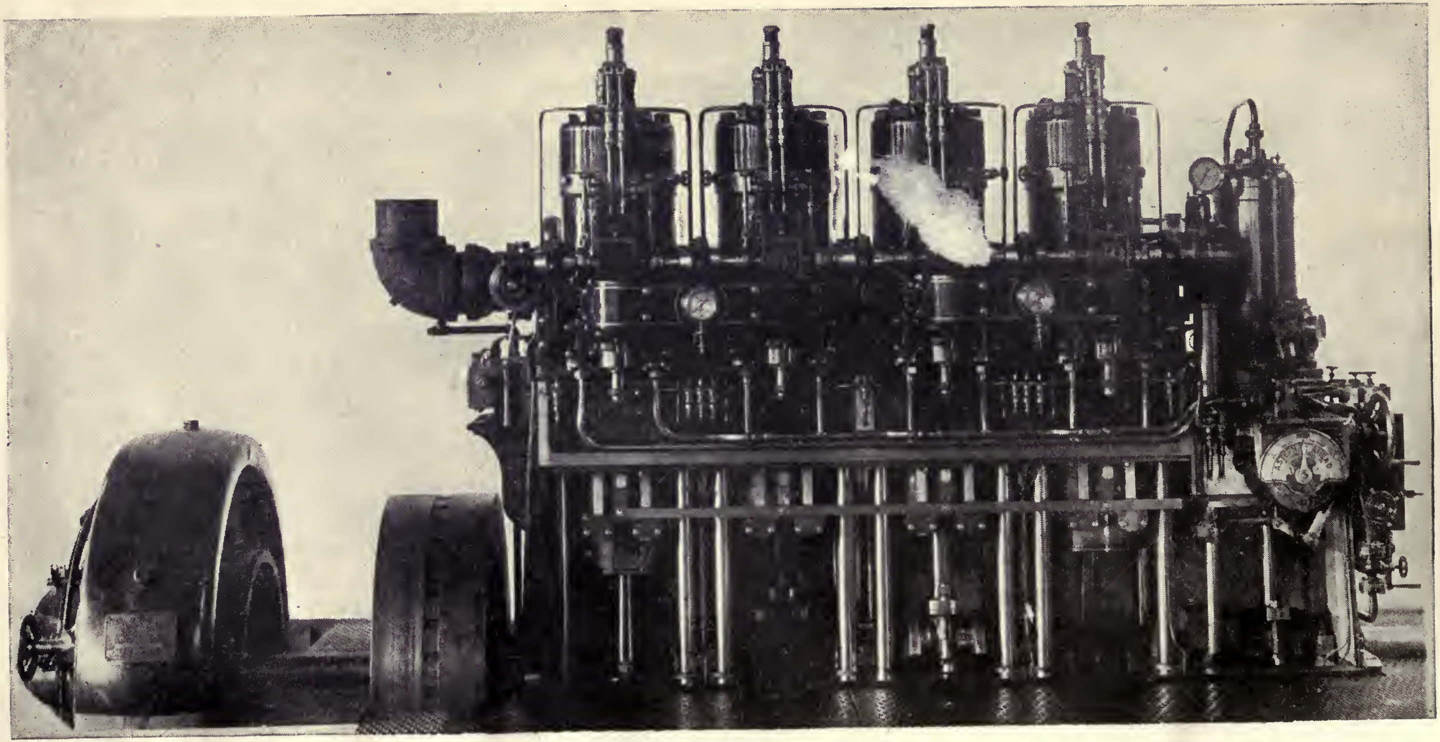
PETRÖLEUM

ITS HISTORY OCCURRENCE PRODUCTION USES AND TESTS

GEORGE THOMPSON WALKER



American Valveless Diesel Engine. Courtesy of the National Petroleum News.

Engines of this class running on crude oil or fuel oil are very largely used for marine purposes. Many sub-marines, both American and foreign are equipped in this way.

PETROLEUM

ITS HISTORY, OCCURRENCE, PRODUCTION, USES *and* TESTS.

By

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PREFACE.

There are few articles so generally used as petroleum, concerning which the general public has so little information. The average man or woman uses some of these products daily—in fact, modern civilization would be almost impossible without them,—but very few know anything about their production and proper uses. How many know why there are different grades of gasolines, or kerosenes, of lubricating oils, etc., and have any idea which grade to buy for their special purpose?

This little book is intended to give real information concerning some of these matters and to give this information within a small compass, so that those who read it will not be discouraged by the prospect of wading through a large volume filled with statistics and tables. It is hoped that the book will be readily understood by young people of high school age, and yet not too childish to prove of value to those of more mature age, who have never known much about the modern petroleum industry.

Those who wish to go further into this interesting subject are referred to the bibliography given at the back of this book.

Great care has been used to prevent errors, but doubtless some have occurred, and the author would greatly appreciate it if his readers would notify him of any errors they may notice, so that they may be corrected in a future edition.

G. T. W.

Minneapolis, December 20, 1915.

INTRODUCTORY.

To realize more fully the importance of petroleum to modern civilization, let us consider for a moment what would happen if we were to remove all petroleum products from the world. Practically all of the rural districts would be left in darkness throughout the night; all the work now done by gasoline engines would cease, nearly all automobiles would be worthless; practically all machinery would stop for lack of lubrication, many of the modern battleships would be without means of propulsion; Rocky Mountain railroads could not operate; the present great war itself would be entirely changed, for the lack of petroleum products would do away with the aeroplane, the Zeppelin, the automobile, and auto truck, the motorcycle, and even the submarine; in fact, temporarily the world would be almost completely paralyzed.

And what would serve as substitutes for these products? Until some better means was found for distributing electricity in thinly settled districts, the average country household would be thrown back on the tallow dips of our grandfathers (the modern candles would disappear for they are made of paraffine wax). Steam engines would replace the larger gasoline engines but could never take the place of the smaller ones, only manual labor could replace them.

For lubricants we would have to fall back on animal and vegetable oils and fats, expensive and unsatisfactory. High pressure steam engines could not be run at all for petroleum furnishes the only satisfactory lubricant for them. True, automobiles, gasoline engines, etc., can be run on denatured alcohol or on coal tar products, but these are high-priced, denatured alcohol depends for its production on agriculture, and coal tar products are merely by-products which are not even now produced in sufficient quantity to meet the demand for use in the manufacture of explosives, dyes and drugs.

All of the possible substitutes for petroleum products are even now two or three times as expensive, they are practically all products of agriculture in one form or another and the necessity of turning so many of these products into other channels would greatly increase the cost of foods. The United States exports annually over 1,000,000,000 gallons of kerosene alone. This enormous quantity represents only the excess produced over requirements for domestic consumption. Imagine the enormous number of cattle required to yield tallow enough to replace this one item. Where would we raise them and what would we feed them? The world would drop back to the old fashioned ways and our promising youths would again have to study by fire light as Lincoln did. It is almost possible to determine the degree of education prevalent in a country by noting the amount of kerosene used per capita, as shown in the table below:

PER CAPITA CONSUMPTION OF KEROSENE DURING 1911.
(Compiled by Sir Boverton Redwood).

	GALLONS		GALLONS
United States	7.3	Roumania	1.8
Canada	4.0	Austria	1.8
*England	3.9	Japan	1.6
*Germany	3.6	Brazil	1.2
Australia	3.4	Italy	1.0
France	2.5	Mexico	.7
Russia	2.0	India	.6
South Africa	2.0	Spain	.5
Egypt	1.9	China	.4

Petroleum ranks second in value of all our mineral products, being exceeded in value by iron alone. The United States produces more than all the other countries of the world combined. Certainly then it behooves each of us to have some general information concerning this product.

*The figures for some of the more thickly populated countries would be considerably increased if the population of all cities having lighting systems were to be deducted before determining per capita consumption.

CHAPTER I.

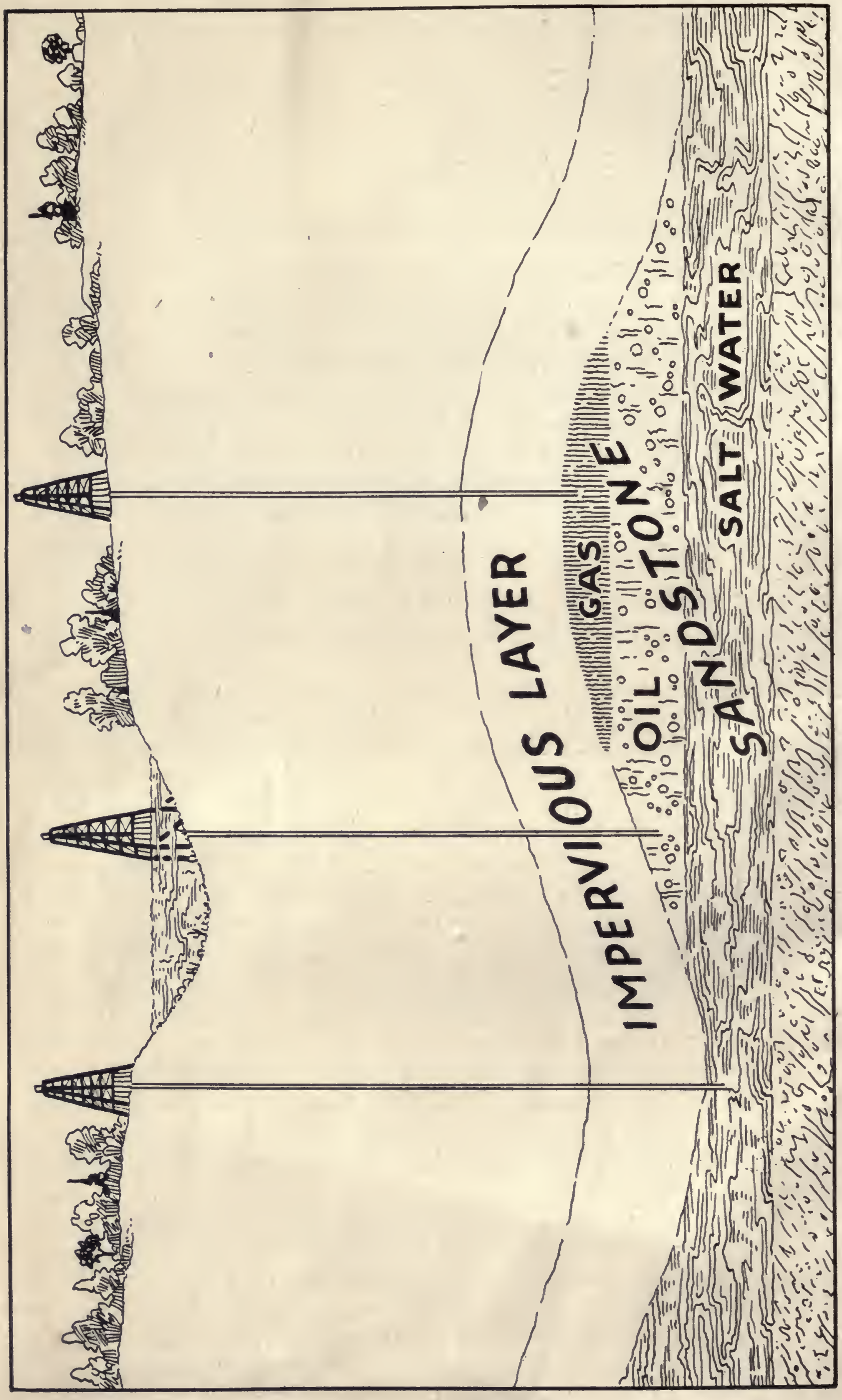
Origin and Occurrence of Petroleum.

Petroleum (from the Greek petros, rock and oleum, oil) also known as rock oil, earth oil, or mineral oil, occurs very widely distributed throughout the world, and is evidently the product of strata of widely separated geological periods.

There has been a great deal of controversy regarding the origin of petroleum. Some of the highest authorities claim that it is produced by the action of water on metallic carbides which they assume to be present in large quantities far below the earth's surface. The simplest illustration of such a reaction is the preparation of acetylene gas from calcium carbide and water. Chemists have actually produced products closely resembling petroleum by the action of water on mixed carbides, but this theory, however attractive, is too fanciful for general acceptance.

The more commonly accepted theory attributes petroleum to large deposits of organic matter which have been subjected to the action of water, or steam under tremendous pressure, at an elevated temperature, through long periods of time. Whether this organic-matter was of animal or vegetable origin is still a question. However, one of the most plausible theories would have us believe that the petroleum found in the Eastern part of the United States is of vegetable origin while the crude oils found in the central and western portions are almost certainly of animal, or mixed animal and vegetable origin. It is almost necessary to adopt some such theory to account for the presence of considerable amounts of sulphur and large amounts of nitrogen compounds in some of these oils. These sulphur and nitrogen compounds closely resemble compounds which can actually be produced in the laboratory by destructive distillation of various kinds of animal matter but could scarcely be accounted for by any theory which attributes all petroleum to a purely vegetable origin.

In the early days of the petroleum industry, it was generally considered that the oil occurred in crevices and cavities in the rocks, so that there were actual rivers and lakes of oil. This theory was supposed to explain the fact that an abundant supply of oil might be struck in one well and little or none in another one only a short distance away. It is, however, very well



ANTICLINE AND SYNCLINE.

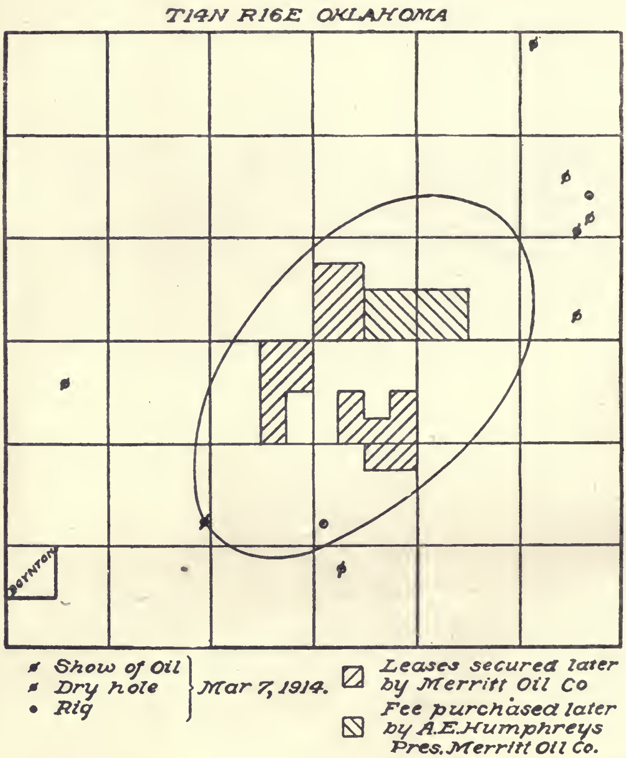
The well to the left struck the oil-sand at a syncline and so missed the oil and struck salt water. The well in the center is on the slope of an anticline and struck oil.

known that under the tremendous pressure which would exist at a depth of several hundred feet, there could be no large cavities, for the rock under these conditions would gradually fill in any crevices which might be formed. So tremendous is the pressure that most rocks are in a plastic form and could a large cavity be produced, it would very shortly be filled in by the rock surrounding it.

Petroleum and natural gas deposits always occur below an impervious layer which is generally a shale. Wherever a porous limestone, sandstone or conglommerate occur, just below such a layer of shale, gas or oil or both are very apt to be found. These rocks are sufficiently porous to hold anywhere from one-tenth to one-fifth of their volume of oil, and even if they held only one-tenth, this would account for even the very largest yields of petroleum without any necessity of imagining enormous lakes of oil. Even though at present we do not believe that the oil exists in cavities, oil fields are still frequently spoken of as "pools."

Courtesy of the National Petroleum News
A 55,000 Barrel Tank on Fire

Of course, when they were originally deposited, the layers of sandstone or other porous rock were horizontal, but as the earth's crust has cooled and contracted, this horizontal layer has formed folds more or less pronounced. These folds in places have given rise to mountain ranges, but throughout the greater part of the world, there may be only a few feet between the top and bottom of one of these rises. The top of the fold is called an anticline and the trough between is called a syncline. As the oil rises through the porous rock, it naturally accumulates in the anticline. Generally salt water occurs in connection with petroleum deposits and, of course, the petroleum, being lighter, accumulates in a layer above the water. Whenever gas is present, it will be found under great pressure in a layer above the oil. By referring to the accompanying diagram, it is easy to see how wells comparatively close together may strike either oil, gas, or water. It is also easy to see why wells drilled even in streams or lakes, may strike oil just as well as those drilled on the tops of the hills, for it would be very seldom that the valleys on the surface would follow the same lines as these valleys or troughs several hundred feet below the surface.

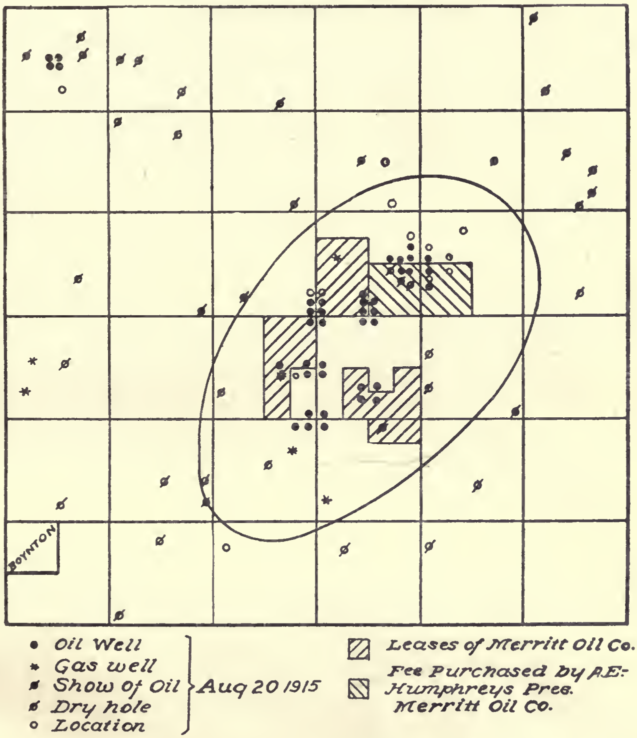


Courtesy of the Fuel Oil Journal.

The early drillers did not understand this and thought that it was necessary always to drill in the valleys. They also had many other peculiar notions regarding the best places to drill. Very few, if any of these notions, were based on actual facts. Some would depend on people who claimed special ability to detect oil by the means of twigs or by second sight. Others would always drill in a certain direction from a well which was already producing oil, as they believed that the "veins" of oil all ran in the same direction. Or, perhaps, they might select a place on account of some special character of the soil or vegetation, not considering the fact that conditions several hundred feet below the surface would probably be entirely different in the two places.

Since the anticline theory has been proved correct, it is possible to select sites for wells much more intelligently. The anticline may be in the form of a dome underlying only a few square miles of surface, or it may take the form of a long fold, perhaps only a mile or two wide, but many miles in length. Of course, these domes or folds are not perfectly uniform and they are often crossed by other smaller folds at other angles so that even though a well may be drilled over an anticline, it may not strike oil.

T14N R16E OKLAHOMA



Courtesy of the Fuel Oil Journal

The two illustrations of a portion of the Boynton field in Oklahoma before and after development, give a very good example of what can be done by geologists at the present time toward locating a profitable territory. The oval on these two diagrams represents the outside limit where it would be possible to secure oil, according to the geologists' theory before any wells had been drilled. The second diagram shows how nearly correct he was. Of course, not every well was profitable, but the majority of those within this territory produced oil or gas, while practically all of those outside of the territory are failures. In spite of geology, it is still very common, whenever one well strikes oil, for others to rush in and lease any property possible within several miles and immediately commence to drill. This "wild catting" generally means a dry well but occasionally oil will be found where its presence had not been suspected before. Other wells will immediately be drilled around this one, and after a few have been finished, the geologist can mark out very definitely what should be profitable territory.

The diagram shown on page 4, of course, represents only a typical anticline. In many cases there is no salt water below the oil. In other cases there will be no gas in any part of a pool, although this is not often true. When the wells are first drilled, the pressure of the gas is sometimes tremendous, amounting to several hundred and even a thousand pounds per square inch, a pressure sufficient to blow all the tools and sometimes the casing also, out of the hole. This gas pressure also produces the pressure in the oil wells, causing them to flow more or less violently and very frequently a well which first produces gas, later produces oil, and finally after the oil is exhausted, may yield only brine. The appearance of brine in wells, generally indicates an early exhaustion of the field.

There have been a number of theories as to the cause of this tremendous pressure. In some fields, at any rate, it seems probable that the pressure is merely artesian, being due to the head of water which has penetrated the porous rock from some higher point. It has been discovered in Ohio and Indiana that the brine will rise in an exhausted well to practically the same level as that of the water in the Great Lakes, where the same limestone, in which the oil occurs, out-crops just below water level. Of course, the water in flowing through the earth, takes up salt and other soluble matter and thus becomes a strong brine. However, in general, the pressure is much stronger than could be produced by this cause, and it seems more likely that both the oil and water are confined so that they cannot escape, while the gas is produced by decomposition of the oil and thus accumulates under tremendous pressure, and wherever the well is drilled, either gas, oil, or water, according to which is struck first, will be driven out under the full gas pressure. As the flow continues, the pressure will gradually decrease until in time the flow will cease.

At first it was believed that the oil and gas were being constantly formed so that the supply would be indefinite. On the contrary, every field has proved that the supply is limited and although there may be parts of the world where petroleum and gas are now being formed, these parts evidently are not located in the fields which are being drilled and it is only a matter of time, in some cases a year or so, in others a quarter of a century, before this supply is completely exhausted and a field must be abondoned.

Chemically crude petroleum consists chiefly of compounds of carbon and hydrogen, known as hydro-carbons. Pennsylvania crude oils are nearly pure hydro-carbons. Ohio crudes contain compounds of carbon, hydrogen and sulphur, in addition to the pure hydro-carbons. California crude oils contain some hydro-carbons of a different series, the same as some of those which are produced by distilling coal tar. In addition, they contain various compounds of carbon, hydrogen and nitrogen, with or without oxygen. Russian crude oils consist largely of the coal tar series of hydro-carbons.

Petroleum occurs very widely distributed throughout the whole world. In 1913 the United States alone produced over 248,000,000 barrels, or over 65% out of a total production for the entire world of over 381,000,000 barrels. The other countries credited with production were in order as follows: Russia, Mexico, Roumania, Dutch East Indies, Galicia, India, Japan, Peru, Germany, Canada and Italy, with a half million barrels credited to "other countries."

In the United States, we find California in the lead, producing about 40% of the entire amount produced by the country. Then follow in order,—

Oklahoma, Illinois, Texas, Louisiana, West Virginia, Ohio, Pennsylvania, Wyoming, Indiana, Kansas, New York, Kentucky, Colorado and "other states," producing only .004% of the entire amount.

However, there is scarcely a state in the Union where indications of petroleum have not been found and it is entirely possible that a few years may entirely change the rank of the states in petroleum production.

Pennsylvania and New York held the lead until 1895, when Ohio was first and remained so until 1903, when California came to the front, only to lose first place to Oklahoma in 1907. But California came back strong in 1909 and has ever since been the greatest producing state in the nation, producing more petroleum in 1913 than the entire country had produced in any year previous to 1903. In fact, California alone in 1913, produced more petroleum than Russia and Mexico together, although they are the second and third greatest petroleum producing countries in the world.

CHAPTER II.

History of Petroleum.

Probably the oldest reference to a petroleum product is that in Genesis IX, 3, where we learn that "slime" was used for mortar in building the tower of Babel—this "slime" was evidently a bitumen or asphalt naturally produced from petroleum and occurring in those regions. A number of other references are also found in the Bible, while a number of Greek historians also mention bitumen. Herodotus describes a well which yielded petroleum and water, while Strabo, Pliny, and others mention its use as an illuminant. Natural gas was used as a fuel and illuminant in China, long before the Christian era.

The Apsheron Penninsula on the Caspian Sea in Russia, probably gave more natural indications of petroleum than any spot in the world. This field has been worked for an unknown length of time and oil was already being exported in the tenth century. Marco Polo describes a large fountain of oil here and mentions that people came for great distances to get the oil which they used for fuel and as an ointment for camels which had the mange. It was in this vicinity that the fire-worshippers held sway for centuries. Temples were built and lighted by the "Eternal fires" from natural gas escaping from the ground.

Hanway, writing in the middle of the 18th century says that, by removing a little of the surface soil and applying a flame to the exposed surface, the ground would catch fire and burn for a long time. When a tube was thrust into the ground the gas could be lighted at its upper end and this property was utilized by the natives in lighting their homes, also for cooking. He also mentions the transportation of petroleum in bulk on the Caspian Sea. One variety was used medicinally, both internally and externally and was also used for removing spots from woolen goods.

All of the early wells were hand-dug pits and it was not until some time after wells were drilled for oil in large numbers in the United States, that the Russian oil was produced in notable quantities.

In Galicia a form of petroleum known as "earth balsam" was known as far back as 1506. In the early part of the 19th century small amounts of petroleum were refined for illuminating purposes and by 1853 it was replacing candles in Vienna. This distillate was purified by treating with sulphuric acid and caustic soda in a manner similar to that used in modern refineries.

The earliest mention of petroleum in the U. S. A. is found in a letter written by a Frenchman, dated 1629, in which he refers to the oil-springs in what is now New York State. In the early part of the 18th century petroleum, obtained near Lake Seneca, New York, was known as "Seneca Oil" on account of its use by the Indian tribe of that name. It oozed up with water in springs and was skimmed off the surface by means of broad wooden paddles. It was then refined by heating and straining and used as a remedy for rheumatism, burns, coughs, strains, etc., "for man or beast."

Petroleum was obtained quite extensively in drilling for brine on the banks of the Kanawha River, West Virginia. In some cases it was such a nuisance that the wells had to be abandoned. The bottled oil sold for medicinal purposes at 40 or 50 cents for a few ounces.

The first rock-bored brine-well was sunk in 1806 and this method was soon used for other brine-wells, some of which proved to be flowing wells yielding several barrels daily of oil, and in one case "many thousands of gallons per day." The latter well yielded for thirty years and the oil was sold as "The American Medicinal Oil, Burkesville, Ky." Much of the oil from these wells was turned into the rivers and became a menace to those down-stream.

In some parts of the country efforts had been made to utilize crude petroleum as an illuminant, but the smoke and odor were so bad that it could not be used for household purposes. About 1832 the manufacture of illuminating oils from coal and shale was commenced in France. In 1846 Abraham Gesner commenced the manufacture of such a product in Prince Edward Island and commenced selling it in the U. S. under the name of "kerosene." Refineries for its manufacture were soon established in this country. At first they used the coal from Prince Edward Island, but soon commenced to use domestic shale and coal. The use of the product increased until there were 50 or 60 of these refineries scattered from Portland, Maine, to St. Louis.

About the year 1849, S. M. Kier, a Pittsburgh druggist, commenced selling the oil from the salt wells in small bottles labeled as follows:

KIER'S
PETROLEUM OR ROCK OIL,
Celebrated for its wonderful curing power.
A NATURAL MEDICINE.
Pumped from a well in Allegheny county,
Pennsylvania, 400 feet below the
surface of the ground.

The sale of the product was pushed by various means, in a manner very similar to that used by patent medicines at the present day, until it reached three barrels per day. But the taste and odor were so disagreeable that this outlet for the oil did not take care of the supply. Kier then attempted to sell it as an illuminant, but had very little success since the oil burned very badly and had such a disagreeable odor.

In a further effort to develop a market, Kier tried distillation, probably following the practice in shale oil plants, and produced an oil which was quite satisfactory. This "Carbon Oil" was first used in Pittsburgh and the demand soon exceeded the supply, so much so that the price went as high as $2.00 per gallon.

The high price and scarcity of the oil led to the formation of the "Pennsylvania Rock Oil Company" with a capitalization of $25,000.00. This Company acquired some land on Oil Creek, Venango County, Penn. This site was selected because oil springs had been known here for a long time. Great difficulty was experienced in selling the stock, for fraudulent companies were common then as now, and money was scarce. Finally the company was reorganized with a capitalization of $300,000.00. This company, too, found that the springs did not yield a sufficient supply of oil, so it was finally decided to drill a well in order to secure a more abundant supply. The company secured a railroad conductor, Edwin L. Drake, to manage the work, giving him the title of "Colonel."

Repeated attempts were made to dig down to rock in order to start drilling but the soil caved so badly that this could not be accomplished. As a last resort an iron pipe was driven 50 feet to bed-rock and the boring and drilling tools were operated inside of this pipe without special difficulty. Progress was slow,—only two or three feet per day. But on returning to work the next morning after reaching a depth of 69 feet, the well was found nearly full of oil, August 29th, 1859.

Thus was completed the first well ever drilled in the United States for oil. At first the well yielded 25 barrels per day, but by the close of the year had dropped to 15 barrels and the total yield for the year was about 2,000 barrels.

As soon as the news of this wonderful discovery of petroleum spread, people came in great numbers out of curiosity, to see it for themselves. Within a very short time all the surrounding land was taken up, either by purchase or lease and many other wells were started. As no one had any idea where oil might be found, and everyone felt that if they were lucky they could make a fortune in a few days, many sacrificed everything in order to secure a lease on even the smallest piece of property and associations of those who could not raise enough capital alone were formed to put in wells even when most exorbitant royalties were demanded. In many cases they were not able to afford the necessary machinery and the wells were drilled by means of spring poles or other primitive methods. Of course, only shallow wells could be drilled by these means, so that a great many were unable to reach oil and lost everything they had invested.

On the other hand, wages were high and many a man who started as a day laborer, by good fortune soon found himself a rich man. Within two years' time an enormous number of wells had been drilled extending up and down the Valley of Oil Creek for about 10 miles, and Oil City at the mouth of the Creek, where it entered the Allegheny River, boasted a population of about 10,000 people. Extremely high prices were paid for land and leases, as at first it was thought necessary to be close to the original wells. In one instance, two acres were sold for half a million dollars. In another case, $4,000,000.00 was refused for a 50-acre farm.

For the first two or three years, all the wells put down were comparatively shallow and produced only a few barrels of oil per day. None of them were flowing wells. However, in June, 1861, the first flowing well was secured at a depth of 460 feet. This well yielded 300 barrels per day. Soon after another one was drilled which yielded 2,500 barrels per day and in 1863 a well was brought in which yielded 3,000 barrels per day. It is estimated that this well produced $3,000,000.00 worth of oil.

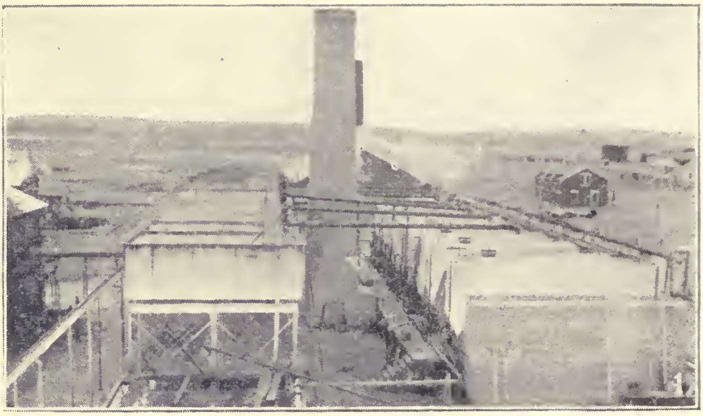
This sudden and tremendous increase in production, lowered prices very rapidly. The first oil had brought as high as $1.00 per gallon. Soon the price dropped to 10c per barrel and even less, but in 1861 several refineries were started along Oil Creek and soon the shale oil refineries changed over to petroleum refineries, since they found otherwise they would be forced out of business.

The first shipment to Europe consisting of 27,000 barrels, was made at about this time. Although this shipment proved a loss, it was only the first and many others later were more profitable, so that export trade was soon established.

On account of low prices and hard times, excitement soon died down on Oil Creek and by 1865 the production had greatly decreased. Then in January, 1865, the first well was finished on Pit Hole Creek. This proved to be a flowing well and a new boom was started. While it lasted, there was as much excitement as occurs when a new gold field is discovered. By September, Pit Hole, which had only been platted in March, had a population of 12,000 or 15,000 people and town lots were bringing as high as $10,000.00 each. Fortunes were made and lost so suddenly that speculation rather than slow profits in safe business became the rule. A great many speculative concerns were organized and stock put on the market. One of these was capitalized at $5,000,000.00, divided into 1,000,000 shares. In most cases the stock was sold at only a fraction of its value in order to secure a little money and enormous dividends were promised even though the Company did not own any land which had proved to be oil bearing property.

The fall of the Pit Hole boom was almost as rapid as its rise. Within two years the town was almost deserted. This was caused by the rapid decrease in production of the wells together with hard times, low prices and a number of disastrous fires. All of these results combined resulted in the failure of most of the speculative companies and by 1868 the oil producing business had reached a very low stage.

No better example of the usual result can be given than the fact that Drake who produced the first well, after accumulating quite a sum of money went to New York City and lost it all in speculating on petroleum stock, so that he became practically a pauper. His friends then took up a collection of several thousands of dollars to help him out and the State of Pennsylvania



Courtesy of the National Petroleum News.
A Set of 1,000 Barrel Crude Oil Stills and Condensers.

gave him a pension of $1,500.00 per year. This, however, was the only permanent benefit he obtained and this was the case with very many others, for a man who had once struck oil was very seldom willing to stop there, but had to try again and again until he had lost all he had made.

However, the demand for petroleum at home and abroad rapidly increased and with better means of transportation and refining conditions rapidly improved and production was constantly increased until the Pennsylvania field reached a maximum in 1891 of 33,000,000 barrels, this being 3/5 of the entire production of the United States for that year.

The next field to be developed was Ohio, which first appears in statistics in 1876 and reached its maximum production of about 24,000,000 barrels in 1896. West Virginia commencing with the same year, reached a maximum of 16,000,000 barrels in 1900. Indiana commencing in 1889 reached a maximum of

11,000,000 barrels in 1904. Kentucky commencing in 1883 reached its maximum of one and one-quarter million barrels in 1905. Texas commencing in 1896 reached a production of 28,-000,000 barrels in 1905, but in 1906 the production was only 12,000,000 and dropped still lower, although at the present time it is increasing again. Illinois commencing production in 1905 reached its maximum of 33,000,000 barrels in 1910. It will be noted that all of these fields have passed their maximum production and most of them are falling off rapidly, Pennsylvania producing less than one-quarter of its maximum, in 1913.

On the other hand, California which commenced to produce in 1876 had reached 98,000,000 barrels in 1913 and the 1914 production was estimated to be 104,000,000 barrels. Oklahoma commencing production in 1900, reached 63½ million in 1913 with a still larger production in 1914. The only other producing states of any importance are Louisiana, which commencing in 1902 reached 12½ million in 1913 and Wyoming which commencing in 1894, reached 2½ million in 1913

Undoubtedly some, if not all, of the latter states will yield even larger amounts in the future but there is no question that within a few years time their production will begin to decline unless new fields are discovered. New pools are being constantly opened up but in many cases their production is not sufficient to offset the decrease in production of the older wells and it must be borne in mind that in the latter part of 1914 and early part of 1915, production was greatly stimulated by the unusually high market price for crude petroleum and every effort possible was made to increase production in order to take advantage of this high price.

The United States has furnished practically 60% of the entire amount of petroleum produced from oil fields throughout the whole world. Russia ranks second, with 30%. No other country has produced more than a small fraction of this amount. The total production of the United States for 1913 alone was almost one-quarter billion barrels or 10½ billion gallons, enough to fill 1 1/3 million tank cars of standard size. This amount equals the total production of the United States for the first 25 years and is more than the world's entire production in 1906.

It is needless to say that this rapid increase cannot be kept up indefinitely although it is useless to attempt to state how long it will be before production will commence to decrease. Every year it has been a question whether the country would produce as much as the year before, yet the estimated increase of 1914 over 1913 was double that of 1913 over 1912. At any rate, we are rapidly using up the supply of a valuable resource, which once exhausted can never be replaced and it is certainly very important that all petroleum products should be used so as to produce the best possible results and do away with all possible waste.

CHAPTER III.

Production and Transportation of Petroleum.

The earliest method of producing petroleum, as mentioned before, was that of skimming it off the surface of water where it had accumulated from springs. In China, Japan and India, from earliest times wells have been dug by hand for petroleum. These wells have reached depths as great as 900 feet, although ordinarily not more than one or two hundred feet deep. It would seem that the cost would be prohibitive, but in the eastern countries where time is of no value and wages extremely low, the cost of such wells is not very great. Even in the latter half of the 19th century, oil was still secured from ancient hand dug wells in Burma.

Not even a windlass was used for raising the oil, but the rope was drawn over a timber at the top of the well and 2 or 3 men would seize it and run over to one side far enough to bring up the jar of oil. By this primitive method a few gallons of oil per day would be secured from each well. Undoubtedly the same method was used for raising the earth when the wells were dug. When rock was struck which was too hard for digging, a large angular lump of iron would be suspended at the mouth of the well by a rope. The rope would be cut and the fall of the iron would crush a little of the rock in the bottom of the well. Then a man would climb down, attach the rope again, the iron would be raised and this method repeated indefinitely. All of this was accomplished where the vapor of oil was so strong that a man could work only a few minutes at a time.

In China, drilling was early developed. This method was used particularly in securing brine and is really very similar to the American method of drilling oil wells, showing again that there is nothing new under the sun. The Chinese would dig down by hand until they struck rock and case the hole with bamboo tubing. Then they would arrange a heavy plank pivoted at the center and supported so that one end was directly over the opening. To this end would be attached a cable which supported the heavy drilling tools. Small platforms were arranged at each side of the plank and for each stroke, a man would jump from one of the platforms onto the end of the plank and back again. Sometimes two men would jump together, then two from the other side. By means of this primitive walking-beam, wells were put down to considerable depths and it will be noted that the modern method simply substitutes the steam engine for man power. Otherwise we have only improved the scheme by making everything heavier, larger and stronger.

The first drilled well of which we have record in this country, was put down a little over one hundred years ago in order to secure brine. This was drilled with a spring pole, a flexible sapling about 50 feet long, inclined at an angle of 30° so that the top was just over the well. The drill was attached to a rope which was attached to the end of the spring pole. By pulling on this rope the necessary motion was given to the drill. Before drilling, a hollow tree trunk was sunk through the quicksand to bed rock and by means of thin wedges the surface water was cut off so that it would not flow in and dilute the brine. When the well was finished it was cased with a long wooden tube which was tightly wrapped at the bottom, in order to cut off any water which might flow through the rock above the vein of brine which it was desired to reach. This crude outfit embodied most of the principles used later in drilling for oil. A great many of the early oil wells were put down with spring poles, others by the method known as "kicking down," which was very similar to the Chinese method referred to above except that the walking beam was weighted sufficiently to raise the drill above the bottom of the well. A stirrup was fastened to the cable and the driller imparted the necessary motion by kicking down with his foot in this stirrup.

Under the more modern system of drilling, a derrick is always used. This is a heavy frame-work which was formerly built of wood, but is now built of steel and is very similar to a windmill tower. This derrick is erected over the spot which has been selected for the well. It is generally necessary first to dig down a few feet to rock or to a firm layer of soil. This opening is cased with a wooden conductor somewhat larger than the diameter of the well which is to be drilled and great care is taken to secure a close joint between the bottom of the conductor and the surface of the rock. When the surface soil is too deep to admit of digging, a steel shod pipe is driven down sometimes to the depth of 200 or 300 feet. When the rock is nearer the surface than 60 feet, the full string of tools can not be used in the ordinary way. In this case, a special outfit called "spudding tools" is used. (See Plate 1 f. The derrick is here shown erected and the spudding tools in use). The cable supporting the tools is rolled up on the bull wheel (b) and just enough is let out so that the spudding tools will reach the bottom of the well. Then by means of the short cable (e) connected to the crank of the band wheel (c) the tools are lifted and dropped so that they gradually work down until a depth is reached where the regular tools can be used.

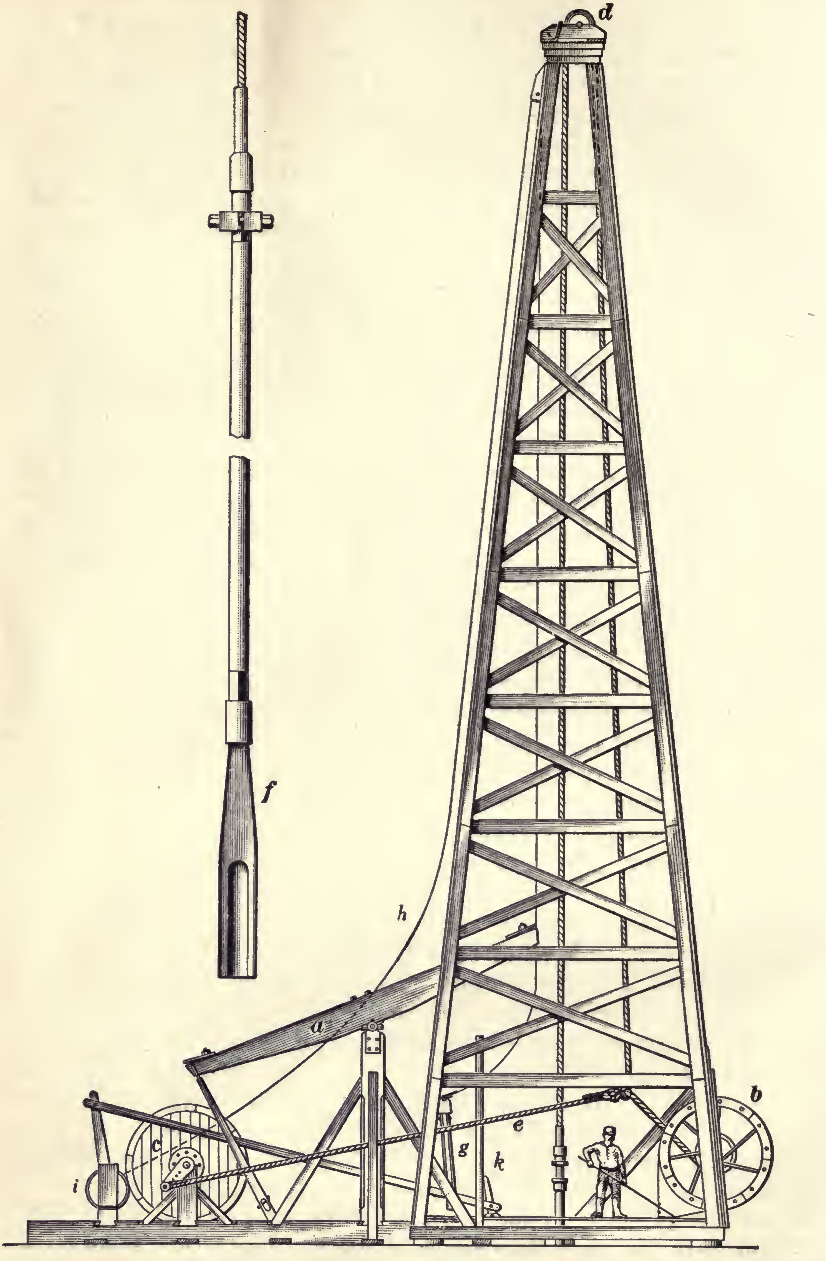


Diagram of Oil Derrick

(a) Walking-beam
(b) Bull Wheel
(c) Band Wheel
(e) Cable to operate Spudding Tools

(f) Spudding Tools
(g) Sand Pump
(h) Sand Pump Line
(i) Sand Pump Reel
(k) Lever which controls Sand Pump Ree

The regular string of tools consists of the rope socket which is attached to the end of the cable; then a heavy sinker bar; then the jars, which are like a long flat pair of chain links, allowing about 13 inches play; then the auger stem and finally the bit. The entire string is about 60 feet long and will weigh about a ton. When the tools have been lowered into the well, the cable (e) is disconnected and the walking beam (a) is connected with the crank of the band wheel (c). The cable is then lowered just enough to allow a little slack in the jars and attached to the end of the walking beam by means of a clamp with a long threaded screw known as the "temper screw." Then a few feet of cable are slacked off from the bull wheel and everything is ready to commence drilling. Of course, the power is furnished by a steam engine which drives the band wheel. The boiler is located at a considerable distance, in order to minimize the danger of fire.

As the band wheel revolves, the walking-beam goes up and down, raising and lowering the tools. It is usual to adjust the cable so that there will be about 4 inches rise before the jars strike. Then the tools are raised about 20 inches and dropped again. By this means the heavy sinker bar gives a strong upward stroke to loosen the drill, instead of putting all the strain on the cable. This is the object of the jars. The driller constantly walks around the mouth of the well, first one way and then the other, in order to rotate the drill by means of a lever in the temper screw, and thus produce a perfectly round hole. He also lets out the temper screw from time to time as drilling progresses. When it has been run out nearly to the top of the well or when the progress becomes slow, showing that the drill is dull, the cable is tightened up on the bull wheel, the temper screw is disconnected, and the tools are drawn up. Then the sand pump (g) is raised by means of the line (h) and the sand pump reel (i) which is operated through the lever (k). The sand pump consists of a hollow tube about 10 or 12 feet long with a valve at the bottom. This valve has a projecting plunger which is pushed up as soon as it strikes the bottom of the well. Then the pump is pulled up and let down on the dump pile when the plunger again rises, allowing the water and sand to flow out. If the well is dry, a little water is added from time to time to aid in the removal of sand. While the sand pump is being used, a sharp drill is attached to the tools and as soon as the sand pump has been withdrawn, the tools are again run down and drilling continues. This is kept up day and night without interruption unless an accident occurs.

When gas begins to issue from the well, it is piped to the boiler to furnish fuel. In many cases, oil will also flow out and the pipe is arranged so that the cable runs through a stuffing box and the oil flows off into a tank. As soon as the well has reached sufficient depth to penetrate the last water bearing stratum, the tools are removed and the hole is cased with iron pipe, which is screwed together in sections. Formerly it was customary to fasten a buckskin sack full of flax seed near the bottom of this pipe. When this was forced down into the hole, the water soon swelled the flax seed and was thus effectually cut off from entering the well. At present it is generally customary to make a beveled shoulder in the rock and the pipe is beveled to fit this. Any slight leakage will soon be stopped by the sand and mud which the water carries. The drilling can then be continued with only the necessary amount of water. This is much more effective since the tools then act under full weight instead of being buoyed up by the water. The rate of drilling depends entirely upon the condition of the strata to be penetrated and varies all the way from a few feet to two or three hundred feet, per day. One well at Corsicana, Texas, was put down to a depth of 1,000 feet in 32 hours. The first productive well in the Spindle top field, Texas, was drilled to a depth of 1,139 feet in 75 days. At this depth the pressure of the oil was so great as to blow the casing out of the well.

In deep wells, it is often necessary from time to time to put in another string of casing, which, of course, must be small enough to fit inside of the casing previously set. Sometimes several different sizes are used. In the Russian fields the strata are so broken up that caving is very apt to occur and only comparatively short distances can be drilled before a casing must be inserted, so that these wells are often started with a diameter as great as 2 feet. The deepest well in the Spindletop field which reached a depth of 4,720 feet, was commenced Nov. 16th, 1914, and finished June 5th, 1915. For the first thousand feet a 14⅞″ bit was used; then a 10″ casing was set. For the next 1,000 feet a 9⅞″ bit was used, when an 8″ casing was set. Then a 7⅞″ bit for 1,370 feet and a 6″ casing was set. The well was finished with a 5⅞″ bit. Sometimes it is necessary to reduce the size of the casing so many times that the finished well does not yield very rapidly, since the final casing is too small.

If it were not for accidents the well driller's life would be quite monotonous but at any time a drill may break or the cable may wear out and the whole string of tools and cable be left in the hole. It is cases such as this that all the driller's ingenuity is called upon. There are a great number of so-called "fishing" tools, which are used in an endeavor to remove the cable and drill, and it has even been found possible to cut a new thread on the end of a broken drill and pull it out. Sometimes these "fishing" jobs require weeks, and occasionally a well must actually be abandoned on this account.

The cost of wells increases very rapidly with the depth. The first Pennsylvania wells cost only a few hundred dollars, but in other fields where deep wells are necessary and drilling is difficult, the cost runs up rapidly. The deep well referred to, in the Spindletop field, cost from $25,000.00 to $30,000.00 and then did not yield any oil. Some of the California wells cost even more, for boring is very difficult there and it may take a year or more to put down one well. In Galicia there are reported to be over 250 wells over 4,000 feet deep and one is 5,400 feet or a little over a mile.

There are many other methods of drilling used in different fields. Many of them are based on some form of rotary drilling. This is the same in principle as the common well boring outfits which are used where rock is not encountered. For hard strata, the diamond core drill may be used. In some systems, a continuous stream of water passes down through the hollow auger stem and up through the casing so that the sand is constantly washed out of the well. This method is especially favored where the strata are loose and caving is apt to occur, for the water pressure helps a great deal in preventing caving.

When it is known that the drill should soon strike oil, preparations are made and every effort is used to close or cap the well at once, so that all of the oil may be saved. However, the oil often comes in with a tremendous flow which is sufficient to throw all of the tools and even sometimes the casing out of the well. Even this may not do a great deal of harm provided the oil does not catch fire. This may happen and then it is very difficult to extinguish the fire where the flow of oil is great. In some cases it has been necessary to tunnel underground on a slant for over 100 feet and bore into the pipe by means of a special tool, so that the flow of oil was shut off and diverted through the tunnel away from the fire. In some cases the top of the pipe is shot off with a cannon and the flame is thus put out, or a large pipe may be erected over the opening and suddenly jerked away. The last two methods, of course, apply to gas wells and can be very easily demonstrated on a small scale by means of a Bunsen burner.

In 1913 a well in the Caddo field, Louisiana, gave an initial production of 18,000 barrels per day. One in the Sunset Midway field, California, finished in April, 1913, was a 20,000 barrel well. One well in Mexico is estimated to have yielded over 30,000,000 barrels during its flow. However, the greatest gushers ever produced were some of those in Russia. Probably the most famous was the Droojba Fountain which commenced flowing at a rate of about 50,000 barrels valued at over $55,000.00 daily. This had all the appearance of a geyser in action. The oil rose in a solid stream 18 inches thick to a height of from two to three hundred feet. Enormous amounts of sand were brought up and formed a mound 6 or 7 feet high. The oil flowed out in a whole series of lakes, some deep enough to float a boat and finally ran out into the Caspian Sea, where it was wasted.

An even more remarkable well was struck at a depth of only 714 feet in 1886 and was described as follows:

*"From the town the fountain had the appearance of a colossal pillar of smoke, from the crest of which clouds of oil-sand detached themselves and floated away a great distance without touching the ground. Owing to the prevalence of southerly winds, the oil was blowing in the direction of Bailoff Point, covering hill and dale with sand and oil and drenching the houses of Bailoff, a mile and a half away. * * * The whole district of Bibi-Eibat was covered with oil, which filled up the cavities,

Courtesy of the National Petroleum News

Big Gusher in the Caddo, La. Field.

formed a lake, and on the fifth day began flowing into the sea. The outflow during three days was estimated at 5,000 or 6,000 tons daily. * * * On the eighth day the maximum was reached, the oil then spouting at the rate of 11,000 tons, or 2,750,000 gallons (65,000 bbls.) a day. After the tenth day it began to diminish and by the fifteenth day the engineers had so far got it under control that the outflow was only 250,000 gallons a day. Altogether over 10,000,000 gallons of oil came to the surface, and most of this was lost for want of storage accommodation."

* Redwood's Petroleum; 2nd Edition, page 8.

Even larger flows than this have been recorded, running up a maximum of 190,000 barrels per day. However, such enormous gushers are a misfortune rather than a benefit for they frequently cannot be controlled and a great deal of the oil goes to waste. Then fires are very apt to result and destroy many of the surrounding derricks and the oil which is in storage. A

Courtesy of the National Petroleum News

Vendor of Oil Cans in Constantinople.

flowing well is desirable but one which is more moderate and can be controlled is of more value.

In contrast with these wells, we find that in the Pennsylvania field out of over 4,000 wells drilled in 1913, over 500 were dry wells and the average initial yield of the producing wells was only 2.6 barrels per day. However, as we go on to the newer fields, the average yield of new wells increases, Illinois showing an average of 35 barrels, Oklahoma, 48 barrels,—the Gulf Field, 312 barrels and Louisiana 475 barrels, while in California wells yielding anywhere from 1 to 20,000 barrels per day are not at all uncommon. In California alone there are nearly 7,000 producing wells.

It is generally customary to drill first near the edge of the property in order to secure as much oil as possible before those on adjoining property put down wells. On account of this desire to increase production, more wells are drilled than would be really necessary to remove all of the oil within a reasonable length of time. For the same reason the oil is generally allowed to flow or is pumped from the wells just as rapidly as possible, regardless of selling price, since those who do not remove the oil now, may find very little left if they allow others to get ahead of them. It would be extremely desirable if some means could be arranged so that wells would be handled in a more scientific manner.

No matter how rapidly a well may flow at first, as the pressure decreases, the flow ceases. When this occurs it is generally customary to torpedo the well. This is done by means of nitro-glycerine which is put up in long tubes. These are carefully lowered into the well one above the other. Sometimes as much as 200 quarts of nitro-glycerine are used for one charge. A priming cap is inserted in the top of the last cylinder and the nitro-glycerine is exploded by dropping a weight called the "go devil." When the explosion occurs, very little sound is heard but within a few minutes, if successful, there will be a great rush of water and oil which may rise far above the top of the derrick. There is generally time between the explosion and the rise of the oil to connect the well with a tank, so that the oil may be saved. Sometimes a well is torpedoed three or four times at intervals, with less effect each time. Torpedoing is also frequently tried on wells which would otherwise be dry and sometimes they yield oil after this treatment.

But whatever means may be adopted, sooner or later it becomes necessary to resort to pumping. This is done by means of a sucker-rod which fits inside the casing and is supplied with several cup-shaped valves of leather or rubber. The weight of the oil causes these to fit snugly against the side of the pipe on the up stroke. In order to economize, it is customary to connect several wells with one engine by means of a pumping jack, similar to that often used on farms for operating pumps. In some cases, as many as 15 wells are operated by one engine and the rod lines connecting the engine with the pump may be over 2,000 feet long. By this means, wells in Pennsylvania which yield as little as half a barrel per day, can be pumped profitably and it is only by pumping large numbers of these small wells that the yield of Pennsylvania oil is kept up to the present figure.

When a well no longer yields oil, it is customary to pull out the casing for use in a new well. The hole is then plugged up with concrete so that water may not enter the oil bearing strata and damage other wells.

In ancient times, earthenware baskets daubed with clay, or earthenware jars were used for transporting and storing oil. In the early days on Oil Creek, wooden barrels were used entirely and these had to be hauled a good many miles to the nearest railway. As the country was practically unsettled, there were no decent roads and such as there were soon became almost impassable. Then a great many boats and barges were built to transport the oil down the Creek to Oil City and from there down the Allegheny River to Pittsburgh. The water was very shallow in Oil Creek and at many times of the year was not sufficient to float the barges. Therefore, it became customary to arrange with the mill owners to open their dams and form a small freshet. Sometimes as much as 20,000 barrels went down the Creek on a single freshet. However, jams often occurred and many boats were damaged with the loss of a great deal of oil. At one time at least 1,000 boats were used for this form of transportation, but even at the best it was objectionable since the barrels leaked badly and the loss was heavy. Efforts were made to carry the oil in bulk in open barges, but these were readily capsized and the scheme did not prove satisfactory until the barges were divided into compartments and covered over.

After a few years railroads were built in to the oil fields. At first rail shipments were made in wooden tanks fastened on an ordinary flat car. From this evolved the modern all steel tank car holding from 6,000 to 12,000 gallons. However, most of the oil had to be hauled from the wells to the railway in barrels and this hauling often cost more than the rail freight.

Various parties planned to put in pipe lines and in 1865 the first successful line was built from the United States well at Pit Hole to the railroad. This line, which was 5 miles long, consisted of 2″ pipe and had three pumping stations. The teamsters greatly objected to this innovation and it was necessary to station armed guards to protect the pipe line. Gradually the pipe lines were increased until now they connect nearly all of the oil fields east of the Rocky Mountains with either the Gulf or the Atlantic Coast and it is now possible to pump crude oil from the Oklahoma fields direct to the great refineries along the Atlantic Coast. In order to handle oil through the pipe lines, it is necessary to have large storage tanks at the wells, where the oil is accumulated until the pipe line is ready to take it. Where the pipe lines go through mountainous districts, it is necessary to have pumping stations at frequent intervals. It is by this means that practically all of the crude oil produced in the United States is transported to the refineries. From the refinery the product goes out on land by tank cars,—on water in tank steamers.

It was not until about 1880 that bulk transportation across the ocean really became successful, but now large numbers of steamers built especially for this purpose are constantly engaged in transporting petroleum and its products to all parts

Courtesy of the National Petroleum News

Oil Wells in a Bayou, Louisiana.

of the world. However, for distribution in uncivilized countries which lack railroad facilities, kerosene is generally exported in boxed cans and in this form it is transported over mountains and deserts on the backs of men, camels, donkeys or elephants to the remotest parts of the world.

CHAPTER IV.

Testing Petroleum Products.

The tests commonly made on petroleum products are chiefly physical and actual chemical analysis would only show that carbon and hydrogen were present in certain proportions and possibly small percentages of sulphur, nitrogen, oxygen and other elements. An analysis of this sort would be of no value in determining the quality and lubricating properties of an oil.

The color of a lubricating oil is ordinarily stated in terms of standard colors which have been arbitrarily selected. Sometimes these standards are kept as actual bottles of oil; sometimes as colored glasses. The latter are preferable, since most oils will change in color in time. (To give an idea of the colors, No. 20 in the cabinet is No. 2 color. No. 19 is No. 3, while No. 22 is No. 5). For oils prepared from the same source and by the same method, for equal viscosities the lighter colored oil will give less carbon than the darker colored one. It will also be more expensive and will run somewhat lower in viscosity than the darker oil, from which it was made, for filtering removes viscosity as well as color.

The gravity of petroleum products is generally determined by means of hydrometers, which consist of an elongated glass bulb with a weight at the bottom and a slender stem at the top. This stem is arbitrarily divided into degrees on the Baume scale. This scale commences at 10, for liquids as heavy as water and goes up as the liquid is lighter. Of course, the lighter the liquid, the further the hydrometer sinks into it, so the higher figures are toward the top. As the gravity of oils is nearly always referred to in terms of the Baume scale, it is for this reason that heavy oils are spoken of as low gravity oils and light products as high gravity products, although, of course, in actual specific gravity, those showing a low Baume figure, run higher than those showing a high Baume gravity. The specific gravity of water is 1, which is represented by 10 on the Baume scale. The specific gravity of .75, corresponds to 57 on the Baume scale.

For accurate work it is necessary to correct the reading of the hydrometer to the reading which would be shown at 60° F. Petroleum products expand decidedly on heating. The average amount is about 1% for every 20° change in temperature, so that 50 gallons at a temperature of 60° would measure 51 gallons at a temperature of 100° F. For the same reason, the approximate correction to the hydrometer reading is 1° Baume for every 10° F. The neglect to use this correction, very often decidedly misleads those who have a small hydrometer and feel that they can tell all about the quality of the goods they are purchasing by this means.

The viscosity of an oil, as commonly referred to, is a measure of the cohesion of the molecules to one another and the adhesion of the oil to the surface of the container. When the user refers to the body of an oil, he really means the viscosity in this sense. It is the property which causes an oil to string and drop slowly from the bottom of the sample bottle when it is inverted, and some slight notion of the comparative viscosity can be obtained by this rough method. However, viscosity is ordinarily determined by noting the length of time required for a definite amount of oil under a definite head to flow through an opening of definite size at a definite temperature. There are various instruments for this purpose, but either the Saybolt or Tagliabue viscosimeters are ordinarily used. It is customary to use a temperature of 70° for all oils except steam cylinder stocks. These are tested at 212° F.

In the case of the Tagliabue Viscosimeter, the actual number of seconds required for the oil to run through, is multiplied by two and this figure represents the viscosity of the oil. (By referring to the cabinet, some idea of comparative viscosities can be obtained. No. 16 is of about 110 viscosity; Nos. 18 and 19, about 210; No. 22 about 300 and No. 24 about 3,000,—all at 70° F., while Nos. 25 and 26 will run from 150 to 175 at 212° F.).

The Cold Test of an oil is determined by freezing it and then stirring with a thermometer and warming it up until the point is reached where it will just commence to flow. This point is somewhat lower than the temperature at which the oil would flow through a faucet from a barrel, but yet it gives a comparative measure of the amount of cold oils will stand and still serve as lubricants.

The Flash Test is determined by heating the oil, using a thermometer to determine the temperature. When the point is reached where a small flame passed over the surface will cause a slight puff due to the explosion of the vapors produced, the temperature shown on the thermometer is known as the flash point. The heating is continued until the point is reached where the oil will catch fire and continue to burn. This is known as the fire point. Many people have very erroneous ideas regarding the inflammability of petroleum products. Of course, gasoline and benzine are inflammable at practically any ordinary temperature. However, a lighted match thrown into kerosene will be extinguished. In fact, it would prove very difficult to light kerosene, by means of a match, when exposed in any considerable volume. If a large amount of kerosene is suddenly poured on a small fire, it will put it out just as water would do. Lubricating oils have fire tests of from 400 to 500° F., while steam cylinder stocks may have fire tests up to 700° F., meaning that they must be raised to this very high temperature before they can be ignited. Of course, the condition is changed when the oils are distributed over the surface of paper, cloth or wood. Here we have a very small amount of the product so placed that the heat cannot be carried away when a match is applied and combustion takes place readily.

Distillation on a small scale is an important test when applied to gasoline, benzine or kerosene. It is usually carried out in a small glass flask to which a thermometer is fitted. The flask is connected with a water cooled condenser and distillation is carried out on a small scale, very much as it is on the large scale in a refinery. It will give the average person a rather strange feeling at first to step into a laboratory and learn that the liquid which is boiling so briskly in a thin glass flask, is gasoline, and to note that the chemist seems to feel no fear. But when we consider that a vessel completely filled with vapors of petroleum products will extinguish a flame just as quickly as it would if filled with carbon dioxide gas, it is easy to see that there is no danger of an explosion connected with the process. It is only when the vapors are mixed with a large excess of air that combustion assumes explosive violence and it is the kerosene can which is practically empty and which has been allowed to stand near the stove so that vapors have formed, which usually produces the terrible accidents so commonly reported. On general principles, no one but an expert should ever undertake to handle such products near a flame. Nine times out of ten or perhaps 99 times out of 100, there will be no accident, but with circumstances slightly altered, trouble may occur.

To determine the amount of carbon which a lubricating oil will give in an automobile or gas engine cylinder, a weighed amount of oil is distilled in a weighed flask. The distillation is carried to dryness, so that only coke remains. The coke is heated red hot to drive off all oil, and then weighed.

In testing cylinder-stocks, the tar test is frequently referred to. This consists in mixing 5 parts of the stock with 95 parts of high gravity gasoline. The mixture is allowed to stand and any products insoluble in gasoline, such as asphalt, water or dirt, will settle out. The test is carried out in a graduated tube so that the percentage can be stated in terms of volume.

CHAPTER V.

Refining Crude Petroleum.

The various crude oils from different sources have very different compositions. A method that is very satisfactory for refining one grade of crude oil, has to be decidedly modified to produce good results with another grade. However, whatever process is used, distillation generally comes first. This is carried out in horizontal cylindrical tanks with a capacity of about 600 barrels. For the first distillation, these "stills" as they are called, are heated by fire. Very frequently natural gas or gas produced during the refining is used for fuel. At the top of the still is a dome, very similar to that on an ordinary steam boiler. From this an outlet pipe passes to a coil of pipe surrounded by cold water. This coil is known as the condenser. The principle is exactly the same as that adopted in steam heating. The oil is boiled in the still just as water is boiled in the boiler. The vapors of oil pass through the condenser, and are condensed to a liquid just as the steam is condensed in the heating coils or radiators. Near the end of the coil there is a U-shaped trap similar to that used in plumbing. The condenser is fitted with a small vertical pipe just above the trap. This pipe serves to carry off any uncondensed gases. These are generally fed to the burners under the boiler and used as fuel.

Just beyond the trap there is a triangular box with a glass front so that the still-man can observe the rate of flow and the color of the distillate. There is also a valve so that he can draw out a sample at any time in order to determine the gravity. Beyond this "sight box" there is a series of valves connected with pipes leading to the different tanks. As the distillate changes in color and gravity, the still-man cuts off from one tank and turns the distillate into another, in accordance with rules which have been set. The following description applies to the distillation and refining of Pennsylvania Crude Oil, using the method which is called "running to cylinder stock." This is the process which is used on the highest grade of crude oils.

When the still has been filled about three-quarters full, the fire is started. At first gas is driven out which cannot be condensed unless the condenser coil is surrounded by a freezing mixture. In most cases this gas is used as fuel. At the same time, water distills off if any is present. As soon as the oil commences to distill regularly, the distillate is run into the benzine tank. In some cases all of the benzine distillate is run into one tank. In other cases it is divided into two cuts, light and heavy. When the gravity has dropped to a point which has been determined by experiment, the distillate is switched to the kerosene tank. At this point high pressure steam is generally blown into the oil in the still by means of perforated pipes. This prevents overheating and produces a sweeter oil. The kerosene distillate is generally divided into two or three cuts. The next fraction is the gas oil distillate which of course is run into a separate tank. Wax distillate follows this and it is the still-man's effort to drive out all of the paraffine wax possible in this distillate in order that there may be as little as possible in the residue left in the still. This residue is the source of cylinder stock to be used in the manufacture of steam cylinder oils. Each of these distillates must be refined by appropriate processes in order to produce satisfactory products.

The benzine distillate is pumped into a still similar to the crude oil still except that it is heated by steam instead of fire. Here it is carefully re-distilled, being divided into several cuts, the first of which will be high test gasoline of about 76 gravity. This fraction must be cooled by means of a freezing mixture. Then follow the 68° and 65° gasolines. The next cut furnishes naptha or benzine. The residue together with the light product first produced from the kerosene distillate furnishes turpentine substitute. Each of these distillates is placed in an agitator which is simply a tall lead-lined tank furnished with perforated pipes. The agitating is done by means of compressed air blown through these pipes. Here the distillate is treated first with sulphuric acid and then with caustic soda solution. The distillate is finally washed with water and allowed to settle, when it is pumped off into the storage tanks ready for shipment.

The kerosene distillates are re-distilled in a fire heated still. The distillates from this process are further treated in steam stills to remove the light products which would give the kerosene a low flash and fire test. Then the oil is treated with acid and lye in agitators just as with the gasoline and benzine distillates. These treatments remove most of the impurities which were so objectionable in the first illuminating oils produced by distillation. It is these impurities which cause the oil to turn yellow and to crust and clog the wick. The refining process requires great care and skill and when properly conducted yields a very high grade of kerosene. By this means kerosenes of different fire tests are produced; also mineral seal oil, which has a 300° fire test. The final residue goes into gas oil distillate. This distillate may be sold untreated or it may also be re-distilled.

The wax distillate consists of a solution of paraffine wax in lubricating oils. When this is cooled it forms a mushy mixture but the wax does not crystalize so that it can be filtered out successfully. It is necessary to re-distill this oil in a fire heated still in order to "crack" the wax so that it will crystalize. This distillate is then chilled by means of liquid ammonia and pressed in filter presses. The paraffine wax is removed and the oil passes on into another tank. The filtrate is reduced (as the process of removing light oil is called) by live steam. This also removes most of the odor produced by high temperature during distillation and sweetens the oil. This light distillate, which is very thin, is again slightly reduced by live steam and filtered through bone black or fuller's earth. At present fuller's earth is generally used. That which is best for this purpose comes from Florida. It is used in a finely powdered form. The filters are simply tall conical tanks which are filled with the earth to a depth of 20 or 30 feet. The oil is allowed to filter through this earth which removes most of the color and at the same time decreases the viscosity and increases the gravity. The filtered product is known as a non-viscous neutral oil. Where an especially fine grade is required, this oil is exposed to sunlight in shallow tanks. This treatment still further bleaches the oil and also removes the fluorescence or "bloom" which can ordinarily be observed on looking at a sample of mineral oil, whereas, the color which is ordinarily referred to is that shown by looking through the oil toward a light. The heavier oil left after the removal of the non-viscous neutrals, after similar treatment furnishes the oil known as viscous neutrals. The crude paraffine wax which was removed by the filter press is filtered hot through bone black and pressed again. This gives crude scale wax which is used for many purposes. When it is to be further refined, the scale wax is dissolved in benzine. This solution is chilled and put through the filter press again. This gives a refined wax, but in order to raise the melting point, the product must be "sweated." This sweating consists in submitting the cakes of wax, for several hours, to a temperature about equal to the desired melting point. All of the oil and lower melting products run off and the cakes become honeycombed. This refined wax is again melted and poured in cakes of various sizes, yielding the paraffine wax so well known to every one. The melting point of the finished product will depend somewhat upon the crude oil used.

The residue which was left in the still after the wax distillate was run off, is reduced with high pressure or superheated steam in order to raise the fire test. The exact fire test of the finished oil, of course, depends on the point to which the original distillation was carried. Cylinder stocks are made in various tests such as 500, 550, 600, 650 and 700° F. The lower fire test stocks are often filtered, yielding oils which are very heavy and viscous but yet perfectly transparent. The higher fire test oils are not filtered. Filtering lowers the viscosity and raises the gravity and cold test.

Another process which is largely used on poorer qualities of crude oil, is known as "running to tar." This process is practically the same as the other until the regular kerosene distillate has all come off. Then instead of increasing the fire, the heat is lowered so that the vapors will condense in the top of the still and drop back into the heated oil. By this means decomposition occurs and a considerable amount of light distillate can be obtained in place of gas oils and light lubricating oils. However, this "cracked" distillate does not yield high grade illuminating oils such as that which is produced by the previous process. It requires more extensive treatment with acid and lye and even then yields a product which will crust and clog the wick. The tar left from this process is transferred to small heavily built "tar stills." The wax is distilled off in the form of a paraffine distillate by fire heat. Toward the end of the process the bottom of the still will be at a bright red heat. The residue is petroleum coke. The paraffine distillate is treated just as the wax distillate is, in the other process. The oil pressed from the wax, furnishes the product commonly known as paraffine oil.

In the case of illuminating oil distillation, from Ohio crude oils, special treatment is required, since so much sulphur is present. One process consists in using granular copper oxide in the still or re-distilling with this compound. The sulphur unites with this to form a sulphide. The copper oxide can be recovered by roasting which drives off the sulphur again. Another process consists in agitating the oil with lye and lead oxide or litharge. This removes the sulphur in the form of lead sulphide. Until these processes were devised, the Ohio crudes could scarcely be used for producing illuminating oils.

Black Oil is produced by practically the same process as cylinder stocks but from a cheaper grade of crude oil and with a good deal less care. Mid-Continent crude oils which come from the Kansas and Oklahoma fields, generally contain asphaltum, with or without paraffine wax. These oils with an asphaltum base do not yield satisfactory cylinder stocks since asphaltum is not a good lubricant. The residue left in the still after driving off lubricating oil and wax is a thick tarry liquid which is largely used in the manufacture of paving materials and oils for treating roads. When this asphaltum is oxidized by blowing air through it, it forms a rubbery substance or when the oxidation is pushed further, we get a brittle solid resmbling coal tar pitch.

The Texas Crude Oil does not contain paraffine wax and does not furnish cylinder stock. However, the general distilling processes are similar for all grades of crude oil. The gravities of the different distillates vary with the crude oil used.

Petrolatum, commonly sold under the trade name of "vaseline", is produced by filtering cylinder stocks from carefully selected crude oils. This filtering can be carried to a point which will yield a perfectly white product. The melting points are raised by adding refined paraffine wax. The white mineral oils which have become so popular lately for medicinal use are simply viscous neutrals which have been filtered until all color and odor is removed.

In the early days of oil refining, kerosene was the most valuable product and every effort was made to increase the yield. It was for this reason that the cracking process referred to, was used so extensively. However, with the introduction of the gasoline engine, gasoline became more valuable and a great

Courtesy of Robert B. Moran.
Oil Wells Drilled in the Bed of the Ocean in the Summerland Field California.

many processes were patented for increasing the yield of gasoline. Most of these are based on distillation at a high temperature and considerable pressure. The process used by The Standard Oil Company for producing their motor spirits, is based on this principle. Another somewhat similar process is the new Rittman method which has been worked out by government scientists and is now being tried out on a large scale. It is claimed that this process can be arranged either to produce considerable percentages of hydro-carbons of the coal tar series, or the regular paraffine hydro-carbons such as occur in the light distillates of Pennsylvania kerosene. In either case these hydro-carbons are produced by some decomposition of the higher boiling constituents of the oil.

Still another process consists in the addition of aluminum chloride to the contents of the still. It is claimed that by this process hydrogen is abstracted from the higher boiling constituents and caused to combine with hydro-carbons containining a smaller percentage of hydrogen thus producing paraffine hydro-carbons and leaving a deposit of coke. Hundreds of other processes have been patented, for this purpose, but have not proved practical.

There are certain characteristics of the different crude oils which appear throughout all their products and make it possible generally to determine from what crude any particular oil was produced. Starting in the eastern part of the United States, we find that the products of Pennsylvania crude are characterized by their high gravity, high flash and fire test, and high cold test, with only a moderate viscosity. The best Pennsylvania lubricating oils will have a viscosity of from 200 to 240. The gravities will run from 30 to 32° B, decreasing as the viscosity increases. The flash test would be about 415, fire test about 480, cold test 20° F. above zero. These oils can be readily produced in No. 2 and No. 3 colors.

The oils from the central states run much lower in gravity, from 23 to 25° B, the viscosities running from 200 to 400° F. The colors are much darker, these being the popular "red oils." The oils from the Mid-Continent field (Kansas and Oklahoma) have gravities of from 25 to 26° B.; viscosities from 200 to 325; flash test is about 410, fire test 470. The colors will vary from No. 2 for the thinner oils to No. 5 for the thick oils, cold test is about 10° above zero.

The Texas oils are characterized by their high viscosities, running up as high as 3,000. At the same time, they have a low cold test, about 5° below zero, gravity 19 to 20° B, flash about 390, fire test about 450.

Another distinction lies in the difference in the bloom or fluoresence of the oil. The Pennsylvania and other central state oils, have a greenish bloom. Those from the Mid-Continent field are slightly bluish while the Texas oils have a decidedly blue bloom. The Russian oils, as has already been mentioned, are of a decidedly different character from the American oils. They are characterized by very low cold tests and high viscosities. These high viscosity oils can be produced in very light colors. Some of the best are perfectly colorless and tasteless and yet almost as thick as glycerine.

Of course the gasolines and kerosenes do not show differences in color, nor can they be judged by the viscosity, but it is a fact that a 70 to 72 Pennsylvania gasoline has practically the same distilling temperature and the same rate of evaporation as a 68° Mid-Continent gasoline and the high grade 49° Pennsylvania kerosene is equaled if not exceeded in quality by the 46° Mid-Continent kerosene. In the same manner, an eastern benzine or naptha has a gravity of 58 to 60, while the Mid-Continent product of the same quality has a gravity of 53 to 55.

CHAPTER VI.

Petroleum Products and Their Uses.

Natural gas furnishes one of the most desirable fuels known. It is largely used in melting iron and manufacturing steel; also in burning cement and for all purposes where a clean ashless fuel is desired. It can be piped for long distances so that whenever a good natural gas field is discovered, arrangements are soon made to carry it to some large manufacturing city where there will be plenty of use for it. In many places it is piped throughout the cities and used for illuminating and domestic purposes also.

In the early days of the petroleum industry, enormous amounts of gas were wasted. In many cases street lights were allowed to burn all of the time since it was considered cheaper to do this than to pay someone to turn them off. A great deal of gas is still wasted at times in new fields for lack of pipe lines, to carry the gas to market. In some cases after giving gas for some time, wells will yield oil, so the gas may be allowed to escape in the hope that this will occur.

Crude petroleum from some sources is used as a natural lubricant, but very few wells yield a crude oil which is satisfactory for this purpose without refining. Beaumont crude oil from Texas has been largely used in dipping cattle for Texas fever. Crude oil is also considerably used as a hog dip. Many people have a strong belief that it is valuable as a preventative of baldness and many efforts have been made to put it up in a popular form by disguising the odor, but no very great market has been developed. In fact, Kier probably had more success in selling crude petroleum for medicinal purposes, than any of his successors.

Until recent years 86° gasoline was commonly sold as lamp gasoline. This product was produced from Pennsylvania petroleum, but only obtained in small amounts. It is extremely volatile and when properly distilled leaves no oily residue. Some of it when re-distilled and carefully refined is put out as petroleum spirit or petroleum ether which is used as a solvent in place of ether or chloroform, also in the extraction of some perfume oils. Petroleum ether is valuable for these purposes because it can be completely evaporated at a low temperature and does not leave a trace of odor. At one time it was customary to prepare an even more volatile product which was used for cooling purposes since it produced a low temperature by evaporation, very much as can be done with ether. Within the past few years it has been found possible to produce, from natural gas, a product similar to this 86° gasoline. This is accomplished by subjecting the gas to great pressure and low temperature. At first this process was applied particularly to the gas produced from wells which were pumped, since the gas produced under several inches of vacuum would naturally contain some of the low boiling ingredients of the petroleum from which the gas was evolved. It is very natural, as gas escapes from petroleum, that it should carry with it a small amount of all of the volatile ingredients. Of course, those most volatile will be present in large amounts and the higher boiling ingredients in smaller proportions. The gasoline produced by this process may have a gravity as high as 100° B. and when placed in a closed container will develop a great deal of pressure, since the process liquifies substances which are naturally gaseous at the ordinary temperature.

For this reason when poured out in an open vessel, a violent effervescence occurs, very much the same as that produced when a bottle of pop is poured out into a glass. Gasoline having this characteristic is said to be "wild." Effervescence, of course, is due to the escape of the gas produced from these low boiling ingredients; also to the fact that pressure has charged the liquid with uncondensable gases which escape as soon as the pressure is removed. In order to make the product safe to ship, it is necessary to let it stand for some time in tanks, so that the gas may escape. This process is known as "weathering." The weathered product is sold as "casing head" or "natural gas" gasoline. While this is very volatile, at the same time it contains some higher boiling ingredients, so that when equal amounts of this product and of a gasoline distilled from crude petroleum are allowed to stand in open dishes, it will be found that although the natural gas gasoline evaporates faster at first, it will leave an oily residue which will not evaporate, until long after the straight run product has entirely disappeared. The product is generally used for mixing with lower gravity gasolines, and of course imparts to them some of this oiliness, so that they are no longer "dry." (This term does not refer to the absence of moisture, but to the fact that a gasoline evaporates rapidly and leaves no oily stain). At first a great deal of dissatisfaction and many complaints were produced by efforts to use the product, but recently it has become customary to re-distill it and by this means a product of about 75 gravity can be produced from western gas, which is equally as satisfactory for lamp gasoline as the 86° eastern straight run gasoline. Distillation gives the only satisfactory means of testing these products. It will be found that a high grade re-distilled article will have an end point of about 275° F.

The gasoline ordinarily sold as a high grade automobile gasoline, will have a gravity of 70 to 72 if produced from Pennsylvania crude, or 68 to 70, if produced from Mid-Continent crude. Distillation will show that the western product is really more readily volatilized than the eastern, since it will have an end point of about 325 while the eastern will often leave 2 or 3% of residue at 350° F. A product of similar gravity, of course, can be produced by mixing naptha or benzine with natural gas gasoline. These mixed products are known as "blended gasoline." They yield gas more readily than the straight run of the same gravity but will not entirely evaporate so quickly. When stored in tanks where the gas can evaporate, there will be a greater percentage of evaporation from the blended product in warm weather. Otherwise it is equally as satisfactory and in cold weather perhaps more satisfactory for automobile use than the straight run goods, provided the products used in blending are dry.

The ordinary stove gasoline will have a gravity of anywhere from 60 to 65, when produced from Pennsylvania crude, or 58 to 60 from Mid-Continent crude. On distillation, these products, when well made, will leave about 3½% residue above 350° F. The uses of gasoline are so well known, that it is scarcely necessary to enumerate them. A few of the uses are, for automobiles, gasoline engines of all kinds, aeroplanes, gasoline launches and boats,—in fact, for running nearly any kind of small machinery where electric power is not available. It is also used for cooking and lighting purposes.

Benzine or naptha from Pennsylvania crude, has a gravity of 58 to 60, from Mid-Continent, 53 to 55. On distillation these products will leave about the same amount of residue above 350 as that from stove gasoline, but it will be found that the greater part of the distillate is between 200 and 300° whereas, the lighter gravity products give a much larger percentage below 200. Benzine is the product commonly used by dry cleaners and is also largely used in the manufacture of varnishes and paints, when it is more commonly referred to as "painters' naptha." It is also used as a solvent for extracting various kinds of oils from waste products or from crushed seeds. For instance, a low grade olive oil is produced by extracting the crushed seeds with naptha after as much oil as possible has been removed by pressure. The same thing is done in the case of cocoanut oil, corn oil and many others. The naptha is removed by heat and blowing air or steam through the oil. Naptha is also used in some processes for extracting rosin and turpentine from sawdust and other wood waste.

Turpentine substitute may be considered to be either a very high boiling benzine or a very volatile kerosene. It has a flash test at least as high as 105 and yet will evaporate completely leaving no oily residue. As its name indicates, it is largely used as a substitute for turpentine in the manufacture of paints, varnishes, shoe polish, etc.; also as a general solvent wherever its high boiling point is not objectionable.

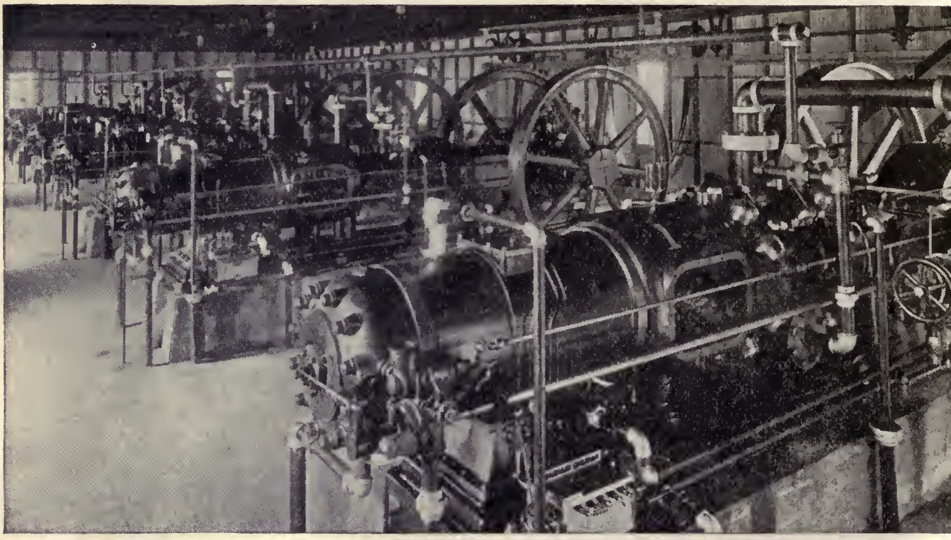
From Pennsylvania crude, it is customary to produce kerosenes of about 49 and 45 gravities. The high gravity product has generally been considered the best grade of kerosene it is possible to produce. However, the 46 gravity kerosene, manufactured from Mid-Continent Crude, will generally prove at least as good and oftentimes better, although it is slightly cheaper.* From the Mid-Continent Crude, one or two lower grades are produced also; the second grade will have about 42 gravity and the third, 40 to 41 gravity. Just as we have found to be the case with gasolines from different crudes, it will be found that the 46 western kerosene is more volatile than the 49 eastern. This can be shown by distillation tests. It will be found that the 49 eastern kerosene will give perhaps 5% of distillate below 280 and leave a 4 or 5% residue above 570, while the range of the 46 western will be between 300 and 500.

It has been the custom to judge kerosene by gravity just as has been done with gasoline. It will readily be seen from the conditions mentioned, that the method is no more reliable for kerosene than for gasoline, for a 46 western kerosene would be far superior to the same gravity from eastern crude and at least equal to the 49 gravity. For this reason state inspection laws which require the inspector to determine the gravity, furnish very little protection to the consumer. The only correct way to determine the quality of kerosene is to actually burn it, using a clean lamp, new wick, and clean chimney. By applying this test, it does not take an expert to tell the difference. High grade kerosene whether eastern or western, will leave the chimney practically clean, and the wick will show only a slight charring even if the kerosene is allowed to burn out dry, whereas, with poor grades of kerosene, the chimney will be badly fogged or frosted and the wick will be found heavily crusted. These tests can be brought out even more strongly by repeating the tests several times with the same wick. It will soon be found that in using poor kerosene it is impossible to get satisfactory results unless the wick is changed very frequently. As this is not the common custom, it is easy to see why so much kerosene gives such unsatisfactory results. Many states require inspection to determine either the flash or fire point of kerosene. This requirement dates from the time when gasoline was practically unsaleable and every effort was made to increase the yield of kerosene. It was natural enough that some manufacturers in doing this would put in enough gasoline or benzine to

* References to comparative cost of production frpm Pennsylvania and Mid-Continent Crudes are of course based on costs at the refinery. For eastern localities, the great difference in freight rates may reverse the figures.

produce a very low flash test and it was necessary then to have the goods tested in order to determine whether or not they had a safe flash or fire point, but for many years gasoline has been far more expensive than kerosene and the refiners efforts are devoted to increasing the yield of gasoline at the expense of kerosene, so that it would be practically impossible to buy any kerosene which would show an unsafe flash or fire test. On account of the emphasis which has been placed on the fire test, many make the mistake of judging the quality of the kerosene by the fire test, considering that the higher the fire test the better the goods. The reverse is the truth, that is, the higher gravity kerosenes have the lower flash tests, while the low gravity, poor products, have high fire and flash tests.

Mineral Seal Oil, also known as Mineral Colza or Mineral



Courtesy of the National Petroleum

Machinery Used in Producing Casing Head Gasoline at Glenpool, Oklahoma.

Sperm, has a fire test of 300° and is used in some cases for manufacturing signal oil, or wherever a very high test illuminating oil is required.

Engine distillate largely used in kerosene tractors, is practically, a very low grade of unrefined kerosene. Gas oil, as its name implies, is largely used by gas plants to impart illuminating qualities to gas. This is accomplished by spraying the oil on very highly heated brick work, so that it is decomposed into gases of high illuminating power. Gas oil is also used in internal combustion engines and sometimes as a fuel oil for burning purposes.

Soap Stock Oil is a very thin light colored non-viscous neutral oil. Oils of this class are used as adulterants in soaps, for burning in miners' lamps, for lubricating presses in brick plants and in compounding oils for many different purposes.

The Non-Viscous Neutral oils in various viscosities and colors are used for lubricating hand separators, sewing machines and other light, fast running machinery. The highly refined grades are used for greasing the slabs on which candy is poured to cool, in candy factories. Non-viscous neutrals which have been bleached to a very light color, are especially useful for lubrication of machinery in woolen mills, since these oils do not produce stains if they get on the goods.

Paraffine Oil, which runs a little higher in viscosity, is used in the manufacture of sweeping compound, floor oils, as a lubricant for light machinery, and as an insulating medium for transformers.

The Viscous Neutral Oils furnish the lubricating oils which are most commonly used for automobiles, gas engines, aeroplanes, dynamos, turbines and air compressers. It must be borne in mind that oils very similar in appearance can be produced either from Pennsylvania or Mid-Continent crudes. These oils will have equal viscosities and provided they are properly manufactured, it is very difficult, if not impossible, to distinguish them in actual use. There has been considerable prejudice against western oils, for automobiles especially. Undoubtedly there was ground for this at first for refiners had not learned how to produce high grade lubricants from these new crudes. In many cases, the oils were refined with acid and alkali, instead of being filtered, in order to produce light colors. Oils so refined, generally contain a little acid and corrode bearings. They also give much more carbon in gas engines and automobile cylinders, than are produced by oils which are filtered to a light color, but at the same time, high grade filtered oils are produced from crudes from either source, and are practically equivalent for all practical purposes.

As the Pennsylvania crude oil is becoming very scarce and in some cases people will only use Pennsylvania oil, these products bring a higher price than those from western crudes. Undoubtedly several times as much Pennsylvania lubricating oil is sold as is produced in a year, the case being very similar to that of "pure Vermont Maple Syrup." The average consumer is absolutely unable to tell the difference and must depend entirely upon the reliability of the company from whom he buys. This same statement applies to most of the petroleum products, for only the large buyers purchasing in tank car lots can afford to have all of the tests made which would be necessary to determine whether they are securing just what they pay for. Reliable jobbers have their own laboratories completely equipped for this purpose and therefore are in position to know absolutely what they are selling. They will not misinform dealers who purchase from them and if the dealers are also honest, the consumer will be certain that he is getting what he is paying for. It is a fact that a great many automobiles and other high

Courtesy of the Fuel Oil Journal

Oil Wells in the River Bed and along the Banks of the Cimarron River, Cushing Pool, Oklahoma grade machines have been successfully lubricated for a good many years from oils produced from western crudes and there seems absolutely no reason for believing that an oil must be made from Pennsylvania crude to be satisfactory. Poor oils are produced from either source and are expensive at any price.

Red oils in viscosities of from 200 to 300 are produced from Ohio or Indiana crudes. These are very largely used for engine oils and general purpose machine oil. Oils very similar and of similar viscosities are also produced from Mid-Continent crudes but are not as red in color for the same viscosity. The Texas oils, as mentioned before, are especially notable for their low cold test. For this reason they are especially used for lubricating windmills, ice machines and other machinery exposed to low temperatures. In addition, these oils can be produced in much higher viscosities than those from other crudes. Therefore, they are largely used for harvester oil, and for lubricating other heavy slow running machinery. These oils can be produced ranging as high as 3,000 viscosity.

Filtered Cylinder Stocks are not ordinarily used for steam cylinder oils except those of the highest grade. They are considerably used for compounding with viscous neutrals to produce oils of higher viscosity than can be produced by distillation. By this means, of course, it is possible to make oils of almost any required viscosity. These stocks, also make fine motorcycle oils.

The Steam Refined Cylinder Stocks which are commonly used for steam cylinder oils, range from 600 to 700 fire test. Those of lower fire test are particularly used for low pressure engines and are usually compounded with from 6 to 12% of acideless tallow oil, lard oil, or neatsfoot oil. As the pressure of the steam to be used increases, the amount of animal oil is decreased and for very high pressure or superheated steam, only straight mineral stocks of high fire test, are used. Until the introduction of petroleum cylinder stocks, it was practically impossible to run steam engines with high pressure steam on account of the difficulty in properly lubricating the cylinders. If animal or vegetable oils are used for this purpose, they will be decomposed by the high temperature, forming fatty acids which corrode the metal of the cylinders, uniting with it to form soaps, which will greatly increase the friction and in the course of time, ruin the cylinders. High grade cylinder stocks are of a greenish, not a brownish color. It is necessary in applying this test to compare stocks of the same fire test, for those of high fire test, even though of the best quality, are more brownish than those of low fire test. It is also important that they should be free from tar or other matter insoluble in gasoline. The best stocks are as free from odor and taste as vaseline.

Fuel oil consists of the residue left after distillation of gasoline and kerosene from the crude. This, of course, will be of various gravities and consistencies, depending on the source of the crude. In a good many cases, light oils which are not especially valuable for other purposes may be added to the fuel oil, so that it is very apt to represent a mixture of various products and residues, which can be more profitably sold this way than as refined products.

Road Oils are very similar to fuel oils, but usually of higher viscosity and containing a considerable amount of asphalt, which may all have been present in the crude oil, or part of it may have been added to produce the necessary consistency.

Petroleum Coke furnishes a very high grade fuel, since it is practically pure carbon and contains very little ash. It is

Courtesy of the National Petroleum News

Oil Well at Katalla, Alaska.

sometimes used in the manufacture of artists' crayons, etc., or wherever a practically pure form of carbon is desired. Petroleum asphalts of various consistencies are very largely used in the manufacture of paving compounds, roofing paper, paint and cement; also in rubber substitutes.

Paraffine Wax in various melting points is used for forming an air and water tight coating for cheese, meats, sausages and other food products; also for coating the inside of barrels, cheese boxes and butter tubs; for polishing wooden handles, spokes and other wooden ware, and in the manufacture of water proof paper from which signs, ice cream pails, milk bottle caps and sanitary drinking cups are produced. As is well known it is also largely used for various household purposes, especially for sealing fruits and jellies.

Petrolatum ("vaseline") in various colors both with and without medication, is largely used as an ointment, and in the manufacture of salves and other medicinal products.

White Mineral Oil, produced from either Russian or Pennsylvania crude, is largely used in the manufacture of cold creams; also for various medicinal purposes. The chief requirement is that it shall be absolutely tasteless, odorless and colorless and that it shall not turn yellow on exposure to light.

Mineral Castor Oil is used as a cheap lubricant wherever an oil of a very high viscosity is required. It is manufactured from cheap non-viscous oils to which is added aluminum soap. This is not a soap in the ordinary sense of the word, for it is not soluble in water, but it is referred to chemically as a soap, since it is a compound of a metal with fatty acids. When the metal is sodium or potassium, we have ordinary soap. When it is aluminum, calcium, lead, or some other metal, we have an insoluble soap. The lead plaster frequently used in pharmacy is a lead soap of this class. The particular soap, used in the production of mineral castor oil, is an aluminum soap which is generally manufactured from cotton seed oil. This oil is very stringy and appears to have a very high viscosity, but actually its lubricating value is very slight and it is not at all to be recommended for any lubricating purposes. In a great many cases part of the soap separates from the oil, especially in the presence of moisture, and it is then of even less value.

Ordinary Cup Grease and Transmission Grease are similar products made with calcium or lime soaps. Their manufacture requires a great deal of skill and care, but essentially they are composed of mineral oil and the insoluble lime soap. The grease is made by boiling the animal fat with milk of lime until it is all changed into lime soap and the moisture has practically all been driven out. This soap is then thinned down with mineral oil to the consistency desired. The lubricating value of the grease depends chiefly on the quality of the mineral oil used. So-called fibre greases are produced from mineral oil and soda soap. The ordinary soda soap, which is common hard soap, when thoroughly dry will dissolve to a small amount in mineral oils. These mixtures furnish the fibre greases.

All of the greases referred to above are known as "made" greases since they have to be produced by the aid of heat and long continued stirring and cooking. Axle Greases, on the other hand, are known as "set" greases. They consist of mineral oil and lime rosin soap and are made without heat. The ingredients are made up in two separate mixtures. These mixtures when stirred together in the proper proportion form the grease, which "sets" in a few minutes.

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