It should be mentioned, that in this essay its author indicates by the word oxyanthraflavone the material isolated by Perkin's method, but which, through oversight of the earlier publications, he credits to Auerbach, and names isopurpurine in consequence of this mistake. We have recently repeated, with a portion of the flavopurpurine separated by us in 1875, by repeated solutions in alcohol, all the tests given by Schunck and Roemer, including the examination of its absorption spectrum, and these tests show it to have been perfectly pure flavopurpurine.

The swatches of dyed test cloth accompanying this paper, as illustrations, speak for themselves. The peculiar slaty-blue of the iron mordant noticed by Perkin, is strongly contrasted with the "brownish-violet" of the corresponding part of the swatch dyed with flavopurpurine. The characteristic differences elsewhere are also readily seen. The materials with which these swatches are dyed, are essentially pure, or as pure as it was practicable to make so large a quantity as was required within a moderate time.

STEVENS INSTITUTE OF TECHNOLOGY, HOBOKEN, N. J.

XX.—PETROLEUM AND ITS EXAMINATION.

BY A. BOURGOUGNON.

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In this communication to the American Chemical Society, I will describe the mode of examination which I have adopted in examining the different kinds of petroleum and its products. This method of analysis is the result of several years' experiments.

Before entering directly upon my subject, I think that a brief description of the general process employed in obtaining crude oil will be acceptable, and I will therefore relate some observations made during a recent trip through the oil-bearing territory.

I here take occasion to tender my thanks to Mr. J. Labouret, for his valuable information, and to A. J. Pouch, Esq., of the firm of J. A. Bostwick & Co., who has favored me with several samples very useful in my investigations.

Petroleum is found in several parts of the world, but the most abundant field of production is situated in Pennsylvania. It is also met with in several other States of the Union, but the Pennsylvania oil is justly considered the best in quality for illuminating purposes.

Contrarily to the rule governing the occurrence of most mineral substances, which are confined to well determined geological formations, petroleum occurs in rocks of nearly all ages, from the Lower Silurian up ; most abundantly in shales and sandstones ; also, to some extent, in limestones. In the Rangoon and Caspian regions, the oil occurs near the surface in clayey soil, and collects in shallow pits. A noted locality is Ye-nan-gyoung, in Burmah, where the wells are narrow shafts, 180 to 300 feet deep, and large enough for a man to work in. In Persia, the oil is largely found at Baku, on the west shore of the Caspian ; China yields a small amount of oil ; Japan has small and undeveloped districts ; New Zealand, also, shows indications. In the Caucasus, Russia, surface wells have long been worked, and lately wells have been sunk with success. In Gallicia, Austria, are wells yielding largely ; and Alsace and Hanover have produced some oil. Petroleum has likewise been found in Peru, Ecuador, Southern Mexico, San Domingo, Trinidad and Nova Scotia, in small quantities. In Canada, petroleum occurs mainly in the corniferous limestone of the Lower Devonian, but is also found in greater or less quantity in the bird's-eye limestone of the Lower Silurian, and the Lower Helderberg limestone of the Upper Silurian.

In the United States, oil is very abundant in Western Pennsylvania, and has been found in considerable quantity in West Virginia, Ohio, Kentucky and Tennessee. It has also been found in New York State, in Michigan, Indiana, Colorado and California. The oil of Southern California comes from tertiary shales. The upper oil-region of Pennsylvania begins in the vicinity of Tidioute, on the Alleghany, in Warren Co., and runs southwest of Titusville, thence nearly south, along Oil Creek, into Venango Co., to Oil City, and thence southwest to Franklin.

The lower oil belt begins at Triangle City, Beaver Creek, Clarion Co., and runs southwest twenty-one miles to St. Joe, in Butler Co. In 1866, rock with some oil was struck at Brady's Bend, at a depth of 1,100 feet, giving rise to further investigation of the river above, which resulted in the discovery of a sand rock of 57 feet thickness at a depth of 960 feet, on the Alleghany River at Parker's Landing. The oil-bearing rock of Pennsylvania is a sand-rock, of which different strata are struck at different depths.

Various opinions have been advanced upon the origin of the formation of petroleum. It was almost generally admitted that petroleum was derived from vegetable or animal matter. Another explanation was that petroleum was of a similar formation to coal, but under a different condensation. Amongst the more recent explanations upon the formation of petroleum, it has been suggested that this hydrocarbon was produced by natural distillation of coals and bituminous shales. Lesquereux attributes its origin to the partial decomposition of low form of marine vegetation, while Berthelot has advanced the theory that by complex chemical changes at present taking place in the interior of the earth, petroleum is continually set free.

Petroleum has been known for ages. The spring of Zante, one of the Ionian Islands, was mentioned by Herodotus more than two thousand years ago ; and Pliny says that the oil of a spring at Agrigentum, Sicily. was used in lamps. The city of Genoa was formerly lighted from the wells of Amiano, in Parma, Italy.

Prof. A. E. Foote (AM. CHEM., Nov., 1872) states that Peter Kahn, in his *Travels in North America*, published in 1772, gives a map of the Pennsylvania oil springs in 1771 ; but, according to H. E. Wringley, the earliest mention of petroleum in that State occurred in the report of the commander of Fort Duquesne, 1750, when he witnessed the ceremonies of the Seneca Indians on Oil Creek. A prominent feature of the ceremonies was the burning of the oil as it oozed from the ground.

In 1819, Dr. S. P. Hildreth, in the *American Journal of Science*, alluded to the discovery of petroleum in Ohio, on the little Muskingum River, and wrote : "It is beginning to be in demand for lamps in workshops and manufactories. It affords a clear, bright light when burnt in this way, and will be a valuable article for lighting the street lamps in the future cities of Ohio."

The oil spring of Cuba, Alleghany Co., N. Y., called the Seneca Oil Spring, was described by B. Silliman, in 1833, as a dirty pool, about 18 feet in diameter, covered with a film of oil, which was skimmed off from time to time for medicinal purposes.

In 1854, the Rock-oil Company was formed for the purpose of gathering oil in the vicinity of Oil Creek. The process employed by this company was to collect all the surface oil they could by means of cloths, which were subsequently squeezed into tanks. In 1858, Col. E. L. Drake, the superintendent of the Rock-oil Co., conceived the idea of boring an artesian well near Oil Creek. After several experiments conducted with the persistency and enthusiasm of discoverers, he, at last, in 1859, struck oil. A wild excitement prevailed throughout the country and almost every body was stricken with the "oil fever ;" companies were formed to bore for petroleum, and in New York alone, 317 of these companies were formed, representing a capital of more than two hundred millions of dollars.

Petroleum is extracted from bored wells of a variable depth, and about 7 inches diameter. Wells can be classified as follows: Flowing wells, pumping wells, gas wells, salt-water wells and dry holes.

The commercial history of petroleum begins with the Drake well, bored in 1859, near Titusville. At a depth of 60 feet only, oil was struck, and the daily production was 25 barrels.

The first flowing well was situated on the McEllenny or Funk farm. Oil flowed in June, 1861, at the rate of 250 barrels a day for fifteen months and then stopped. Other flowing wells were bored, and amongst them the following are remembered: The Phillips well, on the Tar farm, with a daily production of 2,000 barrels; the Empire well, daily production 4,000 barrels for nearly a year, and then dropped to a pumping well, yielding 100 barrels a day; the Sherman well flowed 1,500 barrels daily for several months, when it declined to 700 barrels, and continued flowing for twenty-three months; the Coquette, well known as the "glory of the oil region," manifested a surprising peculiarity—after flowing 600 barrels a day for several months, it suddenly increased its yield with great rapidity, and reached 2,000 barrels per day.

Flowing wells, like the above, are not now to be found through the oil region, but intermittent wells are sometimes bored. They flow at regular intervals, between which they are pumped.

Pumping wells are worked by steam engines, and the crude oil is received in a wooden tank. When this tank is full, it is gauged, and its contents are transferred by means of iron pipes into large iron tanks. These large tanks are the property of the pipe companies, who buy all the production of the country. From their tanks the pipe companies send the oil to their stations on the railroads through iron pipes, 2 or 3 inches in diameter, and from these stations petroleum is delivered into iron cars of a cylindrical form, holding about 85 barrels.

Throughout the oil district, 42 gallons are equivalent to 1 barrel, but the pipe companies take 43 gallons for the barrel, this extra gallon covering their charges for removing the oil from the tanks of the producer into their own.

The market oil delivered for a cargo is, therefore, not produced from a single well, but is the production of a whole district. Before the establishment of the pipe companies, the producers were obliged to send the oil to the railroad stations; now they are relieved of their trouble, since the pipe companies take oil directly from their wells, and pay for it prices fixed at the Petroleum Exchanges. Wells are bored by contract for so much a foot, but there is no external indication to prefer one place to another, although experiment has shown that the petroliferous zone follows a line having an inclination of 22° from north to south. This indication is not always correct. since producing wells have been bored out of the 22° line, some time as far as 16° inclination, and other wells bored in the neighborhood, or even upon the 22° line, have proved to be dry holes. The yield of a well decreases sometimes very rapidly, and the general belief is that the well is obstructed by solid hydrocarbons, such as paraffine. In order to remove this obstruction, a torpedo of dynamite is generally exploded in the well, which is intended to break the walls of the natural petroleum reservoir, thus connecting the shaft with it. The cost of such a torpedo is very high, and some producers try to dissolve the solid hydrocarbons by means of benzine. About 50 barrels of benzine are poured into the well, and after a lapse of twelve hours they are removed by pumping. In several instances, the benzine only dissolved paraffine, and the produce pumped as crude oil was merely a solution of paraffine in benzine. The use of the torpedo is not always followed by success. I was shown a well at Summit, the daily production of which had been 60 barrels, but its owner not being satisfied (a neighboring well yielding 100 barrels daily). resolved to have a torpedo exploded in his well. The result was that the daily production was reduced to 16 barrels. The average depth of producing wells is about 1,200 feet, and petroleum is designated under the name of third or fourth sand, according to the stratum where it comes from. This denomination is derived from the fact that before reaching the rocks bearing oil, the following layers are to be bored. 1st—The earth surface; 2d—First layers of slate rock: 3d—First sand rock; 4th—Second slate rock; 5th—Second sand rock; 6th—Third slate rock; 7th—Third sand rock; 8th—Fourth slate rock; 9th—Fourth sand rock. The color of the third sand oil is darker than that of the fourth, and the specific gravity heavier by about one degree Baume. At Butler, crude oil is amber colored. and comes from the fourth sand. The cost of a derrick and the boring of a well is about twelve hundred dollars.

In these last years, the oil known under the name of Parker's oil has been in general demand abroad, as furnishing, when refined, a better quality burning oil than other crude oils. The fact, however. is, that other oils may yield just as good products as Parker's oil, but their treatment is more expensive.

It is estimated that the Parker District covers about 750 square miles.

Parker's oil is pumped to the following stations :

HARRISVILLE,
FULLERTON STATION,
FOXBURG "
PARKER "
MONTEREY STATION,
SARAH FURNACE,
BRADY'S BEND,
SLIGO.

Parker's oil is generally clear. At Butler, it is amber colored, but the color is darker in Millerstown ; darker yet in Petrolia, Karns and Parker ; and the oil from Foxburg has no longer the reddish tinge of the oil from the above-mentioned localities.

Although the denomination of Parker's Landing oil is generally adopted, we must remark that in the revised rules of the N. Y. Produce Exchange, the word Parker does not appear ; it is, however, understood that when a contract calls for Parker's oil, the oil delivered must be of the first quality.

The examination of American petroleum by Pelouze and Cahours has established the existence of a series of hydrocarbons homologous to marsh-gas. All these hydrocarbons are acted upon by chlorine, which produces a successive elimination of hydrogen, under the form of hydrochloric acid, and the substitution of an equivalent quantity of chlorine. The first term of the substitution for each of these hydrocarbons, is represented by the chlorhydric ether of the corresponding alcohol. All these chlorhydric ethers, heated with sodium, give sodium chloride and an hydrocarbon, containing two atoms less of hydrogen than the primitive hydrocarbon, thus converting the original marsh-gas series into the corresponding olefines. The hydrocarbons isolated and studied by Pelouze and Cahours are the following :

HYDROCARBONS.	FORMULA	BOILING POINT	SPECIFIC GRAVITY.	
			LIQUID.	VAPOR.
Butyl hydride....	C_4H_{10}	0° C.	0.600	
Amyl "	C_5H_{12}	30°	0.628	2.557
Caproyl "	C_6H_{14}	68°	0.669	3.055
Oenanthyl " ...	C_7H_{16}	92°–94°	0.699	3.600
Capryl "	C_8H_{18}	116°–118°	0.726	4.010
Pelargyl "	C_9H_{20}	136°–138°	0.741	4.541
Rutyl "	$C_{10}H_{22}$	158°–162°	0.757	5.040
Undecyl "	$C_{11}H_{24}$	180°–182°	0.766	5.458
Lauryl "	$C_{12}H_{26}$	198°–200°	0.778	5.972
Conicyl "	$C_{13}H_{28}$	218°–220°	0.796	6.569
Myristyl "	$C_{14}H_{30}$	236°–240°	0.809	7.019
Benyl "	$C_{15}H_{32}$	258°–262°	0.825	7.526
Palmityl "	$C_{16}H_{34}$	280°		8.078

It seems probable, that, when petroleum is dissociated by heat, the products of the distillation must belong to another series than the marsh-gas. I have already begun the examination of the products of dissociation of petroleum, and I hope I will be able, before long, to bring my results before the American Chemical Society. For the present I will only state that I have observed the phenomena of fluorescence in several liquid hydrocarbons, resulting from the destructive distillation of petroleum.

I let here follow a table containing valuable information about petroleum from different localities, taken from A. Wurtz's *Dictionnaire de Chimie* :

ORIGIN.	Heavy oil Virginia	Light oil Pennsylvania.	Heavy oil Penn.	Parma.	Java.	Pechelleon.	Gabian.	Hanover.	Gallicia.	Circassia.	Bernstania	China.	Caucasus.	Heavy oil of coal.
Volatile products at 100°C.	1.0	4.3	.....	1.1	1.0	......	......	0.5	2.1	3.3	....	....	.. ...	......
" 140°	1.3	16.0	......	33.3	....	....	....	5.0	8.7	15.7	4.9	1.0	2.7	....
" 180°	12.0	28.7	......	60.5	7.7	7.8	....	... ...	14.3	24.0	5.8	20.0	13.3	. .....
" 200°	. ....	31.0	... .	69.3	15.0	15.2	....	11.0	21.7	27.7	... ...	35.0	....	12.5
" 220°	... ..	... ..	......	.....	22.3	25.7	....	14.0	25.3	32.7	8.0	45.0	19.0	....
" 200°	......	......	. ....	......	30.0	40.6	....	20.0	33.0	35.0	14.0	70.0	29.3	.....
" 280°	......	......	12.0	......	... ...	....	0.5	....	... ...	....	....	....	36.0	....
Specific gravity at 0°C.	0.873	0.816	0.886	0.786	0.923	0.892	0.894	0.892	0.870	0.887	....	0.680	0.884	1.044
" 50°C.	0.853	0.784	0.853	0.747	0.888	0.857	0.831	0.860	0.836	0.850	......	0.622	0.854	1.007
Co-efficient of expansion	0.00072	0.00084	0.00072	0.00106	0.000769	0.000793	0.000867	0.000772	0.000813	0.000750	0.000774	0.000824	0.000724	0.000743
Composition Carbon	85.3	82.0	84.9	84.0	86.2	85.7	86.1	80.4	82.2	84.2	83.8	83.5	86.3	82.0
Hydrogen	13.9	14.8	13.7	13.4	12.2	12.0	12.7	12.7	12.1	12.4	12.7	12.9	13.6	7.6
Oxygen	0.8	3.2	1.4	1.8	1.6	2.3	1.2	6.9	5.7	3.4	3.5	3.6	0.1	10.4
Heat of Combustion	10180	9963	10672	10121	10831	*10020*	....	....	10005	.... ..	......	.... ..	*11460*	*8916*

Important information is derived from this table, as it furnishes the coefficient of expansion of petroleum, and the knowledge of this coefficient determines the empty space which must be allowed in the vessel containing the oil. This space will be:

V. K. 50.

V represents the volume of the oil; K, the coefficient of expansion; and, at the same time, we base our calculation on the assumption that the oil is to be submitted to a change of temperature of 50° C.

The coefficient of expansion of Pennsylvania crude oil varies from 0.00072 to 0.00086, according to the amount of naphtha contained in the oil. These coefficients, therefore, bear a certain relation to the gravity of the crude oil, and for the products of distillation the following numbers can be generally adopted with satisfactory results:

Under 0.700,	gravity	at 15° C.	= 0.00090
Above 0.700 to 0.750,	"	"	= 0.00085
" 0.750 " 0.800,	"	"	= 0.00080
" 0.800 " 0.815,	"	"	= 0.00070
" 0.815,	"	"	= 0.00065

In the above table of Wurtz, the numbers representing the percentage of oxygen in the composition of petroleum, are apparently too large, since the fact that crude oil generally contains sulphur is not taken into consideration. In Canada oil the amount of sulphur is large, but in Pennsylvania petroleum I have detected only traces of this substance.

PETROLEUM OR CRUDE OIL.

Petroleum has been classified as follows, according to quality:

First Class. The production of Butler, Clarion, Armstrong and Venango Counties, Pennsylvania (excepting Bullion District).

Second Class. The production of Warren, Tidioute, Fagundas and Garland Districts, Pennsylvania.

Third Class. The production of Bullion District, of Venango County, the Bradford District, of McKean County, Pennsylvania, and the Limestone District, of Cattaraugus County, New York.

Inspectors appointed to examine petroleum, must employ all the means they possess for the determination whether an oil really is within the contract of sale.

A *fractional distillation in ten parts* is generally considered an examination of petroleum. This process is short, but the results are far from being satisfactory, and it is for this reason that we have entirely rejected it, and have adopted instead the *fractional distillation in one hundred parts.* The advantages gained are the following: 1. Exact determination in volumes and weights of the different products, as naphtha, benzine, burning oil and residuum. 2. The determination of the presence of paraffine oil as soon as it appears in the products of distillation. Paraffine oil is always present in the distillate when the first products of decomposition are observed.

When petroleum is heated, one part of it will distill, and if the distillation is fractioned into one hundred parts, the specific gravity of each hundredth is always increasing until the hydrocarbons remaining in the retort reach a temperature at which they cannot exist; at this moment, therefore, decomposition occurs, and the result is a deposit of carbon and paraffine in the retort; also, gases escape, and a decrease in the specific gravity of the distilled liquid is observed.

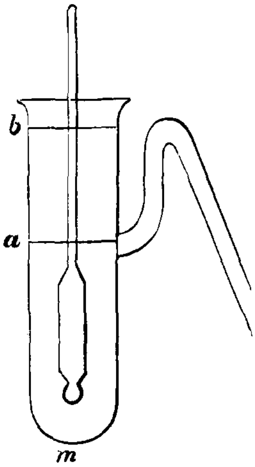
This phenomenon of decomposition can be explained in the following way: According to the hypothesis of R. Pictet, temperature is the measure of the amplitude of calorific motion, *i.e.*, the amplitude of motion increases directly with the temperature. At first, the amplitude of motion produces merely distillation; but, in continuing the distillation, a point is reached where the hydrocarbons remaining in the retort reach a temperature at which they cannot exist without undergoing a partial decomposition, although this temperature is not high enough to produce ebullition. In short, the hydrocarbons $C_{2n}H_{2n+2}$, are decomposed before reaching their point of ebullition. The products of decomposition are substances of lower gravity and boiling point; therefore, instead of an increase, a decrease of specific gravity, as well as temperature, is observed. The decrease in the temperature also shows that the dissociation has been accompanied by an absorption of heat.

The point where dissociation occurs during the distillation of petroleum, is of importance for the refiner, for, from this point until the end of the distillation, paraffine is deposited in the retort, and the last portions of the distillation give only paraffine oil, which is not fit for illuminating purposes. Burning oil need not, however, be entirely free from paraffine. It is, to the contrary, in the interest of the refiner to employ as much as he can of this product, but he must always bear in mind that paraffine oil decreases the illuminating power of the burning oil.

During the distillation, a thermometer must be placed in the retort to show at any moment the temperature of the vapors, as this observation of temperature is very important. A certain relation exists between the temperature at which a product distills and its specific gravity. When a sample of pure petroleum is distilled in one hundred parts, the temperature at which each hundredth distills follows an arithmetical progression, as also do the densities of each hundredth. The temperature, when distillation commences, varies; but, with an increase of 2° C., we also note an increase of specific gravity of $\frac{2}{1000}$. This increase of temperature and specific gravity begins only, when the lighter products have distilled, and ceases with the appearance of the first products of decomposition.

One of the greatest advantages of the fractional distillation in one hundred parts, is a positive knowledge acquired upon the purity of the sample submitted to examination. If, during the distillation, before the appearance of the products of destructive distillation, when the temperature has reached about 320° C., the distillation is stopped, the specific gravity of the remaining oil in the retort must agree with its theoretical specific gravity. If, between the observed specific gravity and the theoretical specific gravity, there should exist a noted difference, and, on the other hand, if, during the first part of the distillation, the densities and temperatures had not followed a regular progression, the conclusion is, that the petroleum under examination is not pure and will interfere seriously with the interest of the refiner. I should observe, however, that even for a pure sample of petroleum, the theoretical and observed specific gravities always differ slightly, since, during the first part of the distillation, a certain amount of uncondensable gas escapes and cannot be taken into consideration for the calculation of the theoretical specific gravity.

During the distillation, the appearance of the distillate must be carefully noted, the most important being the color of the products distilled, and also the temperature when paraffine oil commences to solidify, by cooling with cold water. But not only the point of solidification need be observed, but also the temperature at which the oil loses its transparency. The fluorescent appearance of the distillates should likewise be noted. The last products of distillation show generally a blue fluorescence; should, however, a green fluorescence be observed, the sample of petroleum is suspicious, as I observed that this is found in petroleum to which residuum of former distillation had been added.



In order to save time during the distillation, I use the following apparatus, in which the product of the whole distillation is allowed to pass into or through the same vessel. This glass vessel contains exactly 20 cc from *m* to *a* and 10 cc from *a* to *b* ; this part is connected with a syphon of a special form, which, when in action, each time removes 10 cc, or 1 volume. *a m* is filled with two volumes, having a density, *d*, giving a weight, 2*d*. 1 volume, or 10 cc, is received from the worm, having a weight or density, δ_1, which is found from the whole specific gravity, D, by the use of the following calculation. The glass contains $2d + \delta_1$, having a density $\frac{2d + \delta_1}{3} = D$. The density, D, is given by a densimeter plunging in the glass vessel. The density, δ_1, is evidently $\delta_1 = 3D - 2d$; it remains in the glass, 2 volumes having a weight, 2D; another volume, δ_2, is received, and when the syphon is filled it contains 3 volumes, having a density $\frac{2D + \delta_2}{3} = D_1$, whence $\delta_2 = 3D_1 - 2D$. The densities, $\delta_3\delta_4 - \delta_n$, are obtained in the same way. The syphon discharges the liquid in a vessel containing a densimeter, indicating the specific gravity of the distillate. For a receiver divided in 10 cc, as described above, the quantity of petroleum to be distilled is 1 kilogramme.

An analysis of petroleum, conducted as above described, is not yet complete for the purposes of a refiner, it being necessary to add a lamp assay to determine the hourly consumption, and a photometric assay to determine the illuminating power of the burning oil. In order to make these two determinations, the distillate forming the burning oil is refined, as in the factories, by means of sulphuric acid, caustic soda and washing with cold water. When the water is separated from the oil, it is now ready for the determination of its flashing and burning point, and also for the lamp and photometric assay. The results of the analysis may be tabulated, as we have done in a former communication to the American Chemical Society, but it is more convenient to adopt a graphical method to represent the results. Upon the line of the abscisses the volumes are inscribed, and on the ordinates the specific gravities and corresponding temperatures, from which the curve of temperature and the curve of specific gravity are obtained.

Before distilling the sample of petroleum, it must be submitted to preliminary examinations ; the first thing to ascertain is its specific gravity ; the color and smell are noted. A thin layer of about two millimeter thickness is poured on a plate and left undisturbed for twelve hours, when it must not have any trace of soft or solid matter, but must remain fluid. A small quantity, about 100 cc. of the sample is placed in a platinum dish and ignited. Pure petroleum treated in this way will burn almost entirely, leaving a residue having a weight not exceeding 1 per cent. of the crude oil used. This residue is composed partly of oxide of iron. Before, however, weighing the platinum dish, it must be heated to completely burn the carbon deposited on its sides during the burning of the petroleum. For the distillation of petroleum I have adopted a copper retort, holding 2½ liters. A glass retort can be employed, but as crude oil contains generally some water, the glass is in danger, and severe accidents may result. It has been claimed that a glass retort offered the advantage that the distillation of paraffine oil could be observed. This assertion I doubt, and maintain that to make a distillation of petroleum in a copper still furnished with a thermometer, is more accurate to indicate the presence of paraffine oil, and is, at the same time, perfectly safe for the operator.

NAPHTHA.

In THE PROCEEDINGS OF THE AMERICAN CHEMICAL SOCIETY, Vol. I, p. 119, I have described a process for the determination of naphtha in crude oil. Two kinds of naphtha are in the market : crude naphtha or "distillate," and deodorized naphtha. Deodorized naphtha is generally asked for. Naphtha shall be colorless and sweet (deodorized), and of gravity of from 68° to 73° Baumé.

Naphtha must not contain any oil ; placed upon white paper, it must entirely evaporate, without leaving any greasy stain. A small quantity rubbed between the hands must evaporate quickly and leave the hands dry. To see if naphtha has been well washed, a small quantity is treated by diluted sulphuric acid in a bottle, and agitated ; the acid and naphtha must remain colorless. If naphtha of a very light gravity, is asked for, it is important to ascertain that it does not contain relatively heavy products ; the only way to prove this is distillation, where, however, only the specific gravities of the last products are observed.

REFINED PETROLEUM.

According to the rules regulating the petroleum trade, refined petroleum shall be standard white, or better, with a fire test of 110° Fahrenheit, or upwards. After having verified these points, the inspector must satisfy himself that the oil is not acid, and does not contain too large a proportion of heavy oil.

Recently complaints were received from Germany about the quality of the kerosene received. It was stated that the burning oil received at Bremen was not well refined, and was often acid. During the discussion of the reclamations of the German merchants, it has been advanced that kerosene could not be acid, for if sulphuric acid had been present, the kerosene should have shown a dark color.

That sulphuric acid produces a dark color with burning oil, is a well-known fact; but it must be remembered that in the action of sulphuric acid upon kerosene, when the sludge acid is produced, sulphuric acid is decomposed and produces sulphurous acid. Besides, the acid used for refining is not chemically pure, and generally contains oxides of nitrogen. From these remarks it follows, that if sulphuric acid is not present in burning oil, this substance may contain either sulphurous acid or oxides of nitrogen, if the acid treatment has not been followed by washing with alkalie, and finally water.

To examine for these acids, we treat the kerosene with an alcoholic solution of caustic soda. After separating this solution, it is evaporated, and the residue examined.

To ascertain if the kerosene contains too large proportions of heavy or paraffine oil, it is cooled down and the temperature at which the paraffine begins to solidify, is observed. It is evident that kerosene must remain fluid at the winter temperature of the place where it is stored.

A very good way of ascertaining if kerosene has been well refined, is to submit it to a photometric assay.

First, a sample of about two liters is obtained and divided into two parts. The first sample is submitted to the lamp assay and to the photometric assay, then the second sample is refined by treatment with sulphuric acid, caustic soda and water. If the result given by the photometric assay of the second sample corresponds with the result obtained by the first sample, the kerosene examined was well refined. Heavy oils in kerosene decrease its illuminating power. If a sample of kerosene, after being well refined, has an illuminating power below a standard admitted, it will be safe to conclude that the decrease of brilliancy in the light is due to the presence of heavy oils. If, during the lamp assay, which furnishes the hourly consumption of kerosene and enables us to compare the price of kerosene with the price of other kinds of lights, the wick of the lamp gives off fumes and turns black by carbonization during the burning of the last parts of oil, this is an indication that the kerosene was not well refined, and was, perhaps, acid.

I have lately examined several samples of kerosene of the largest refineries of New York, and I did not meet with a single sample containing acids. The process of washing kerosene with water and testing the washings with litmus paper, must not be relied upon, as often blue litmus paper is too alkaline to indicate small quantities of acid.

Kerosene must stand a fire test of 110° Fahrenheit. It has been often pointed out, that the fire test of kerosene is of little importance, for the real danger in the handling of oil is at the point where it gives off an explosive vapor. The French law requires that kerosene must not give off an inflammable vapor at a temperature of 35° C.

Several kinds of apparatus have been devised for the determination of the flash test and fire test of burning oil. The most reliable is an open vessel containing the oil to be tested ; the inflammation is produced by an electric spark.

RESIDUUM.

The residuum must be free from coke, liquid at ordinary temperature, and must not contain any burning oil. In foreign countries the residue is free of duty, provided it does not contain any burning oil, otherwise the duty will be the same as for crude oil. The instrument used in America for ascertaining the gravity of petroleum and its products, is the hydrominor areometer of Baumé. On the continent densimeters are generally substituted, and very often discussions arise about the gravity of petroleum, for the tables comparing degrees Baumé and the density are not alike. I think that the areometer of Baumé must not be entirely discarded, because the numbers indicating the gravity are smaller and more readily remembered than the numbers given by the densimeter. The construction of the densimeter is far more difficult than that of the hydrometer ; their stems may be divided as to indicate specific gravities directly : for this purpose, if we denote by w the weight of the densimeter, by v the volume of the liquid displaced, and by d its density, we shall have

$$w = d.\ v,$$

as the equation which will enable us to calculate the volume displaced for any corresponding density, and allow us to graduate the stem accordingly. This equation is that of the hyperbola ; if, therefore, the specific gravities be supposed to vary by equal differences, the corresponding volumes will vary unequally, or the stem must not be divided into equal parts, but into intervals proportionate to the difference of consecutive ordinates of the hyperbola. Such densimeters are consequently of rather difficult construction, and require skill and intelligence on the part of the manufacturer. In a former communication to the American Chemical Society, I have given the formula to be employed to transform the degrees of Baumé's hydrominor areometer into corresponding specific gravities (PROCEEDINGS OF THE AMERICAN CHEMICAL SOCIETY, Vol. I, p. 45).

The formula referred to is

$$\frac{144{,}329}{134{,}329 + N} = D,$$

in which N = degree Baumé, and D = sp. gr.

N	D	N	D	N	D	N	D	N	D
10	1.000	24	.911	38	.837	52	.774	66	.720
11	0.993	25	.905	39	.832	53	.770	67	.716
12	.986	26	.900	40	.827	54	.766	68	.713
13	.979	27	.894	41	.823	55	.762	69	.709
14	.973	28	.889	42	.818	56	.758	70	.706
15	.966	29	.883	43	.813	57	.754	71	.702
16	.960	30	.878	44	.809	58	.750	72	.699
17	.953	31	.872	45	.804	59	.746	73	.696
18	.947	32	.867	46	.800	60	.742	74	.692
19	.941	33	.862	47	.795	61	.738	75	.689
20	.935	34	.857	48	.791	62	.735	76	.686
21	.929	35	.852	49	.787	63	.731	77	.682
22	.923	36	.847	50	.783	64	.727	78	.679
23	.917	37	.842	51	.778	65	.724	79	.676

Volume of the areometer at + 15°C. = 144,329.

A fractional distillation of a sample of petroleum, taken by myself, from a well at Millerstown, Pa., gave the following results.

This well, called the "Great Leather," is 1430 feet deep; once in an hour it flows during ten minutes, and is then pumped. Daily production 200 barrels. Temperature of the oil taken directly from the well = 10° C., specific gravity at + 15° C. = 0.790.

DISTILLATION.

	Gravity.		Gravity.		Gravity.				Gravity.
1	.662	21	.730	41	.768	61	.807	81	.807
2	.665	22	.733	42	.770	62	.809	82	.812
3	.668	23	.735	43	.772	63	.810	83	.812
4	.670	24	.737	44	.774	64	.812	84	.812
5	.676	25	.739	45	.775	65	.815	85	.813
6	.681	26	.741	46	.777	66	.817	86	.811
7	.686	27	.744	47	.779	67	.817	87	.810
8	.690	28	.746	48	.782	68	.814	88	.809
9	.695	29	.748	49	.784	69	.819	89	.809
10	.699	30	.749	50	.787	70	.822	90	.810
11	.703	31	.750	51	.788	71	.822	91	Residuum.
12	.706	32	.752	52	.790	72	.819	92	
13	.710	33	.754	53	.792	73	.814	93	
14	.713	34	.756	54	.794	74	.806	94	
15	.716	35	.758	55	.795	75	.803	95	
16	.718	36	.760	56	.797	76	.810	96	
17	.721	37	.761	57	.799	77	.810	97	
18	.723	38	.763	58	.801	78	.811	98	
19	.726	39	.764	59	.803	79	.810	99	
20	.728	40	.766	60	.805	80	.805	100	

In concluding this communication, I must state that I have obtained valuable information from A. Wurtz's *Dictionnaire de Chimie;* also from a paper published by H. Cornwall, in the *Scientific Monthly;* from *Dana's Geology;* and from THE PROCEEDINGS OF THE AMERICAN CHEMICAL SOCIETY.