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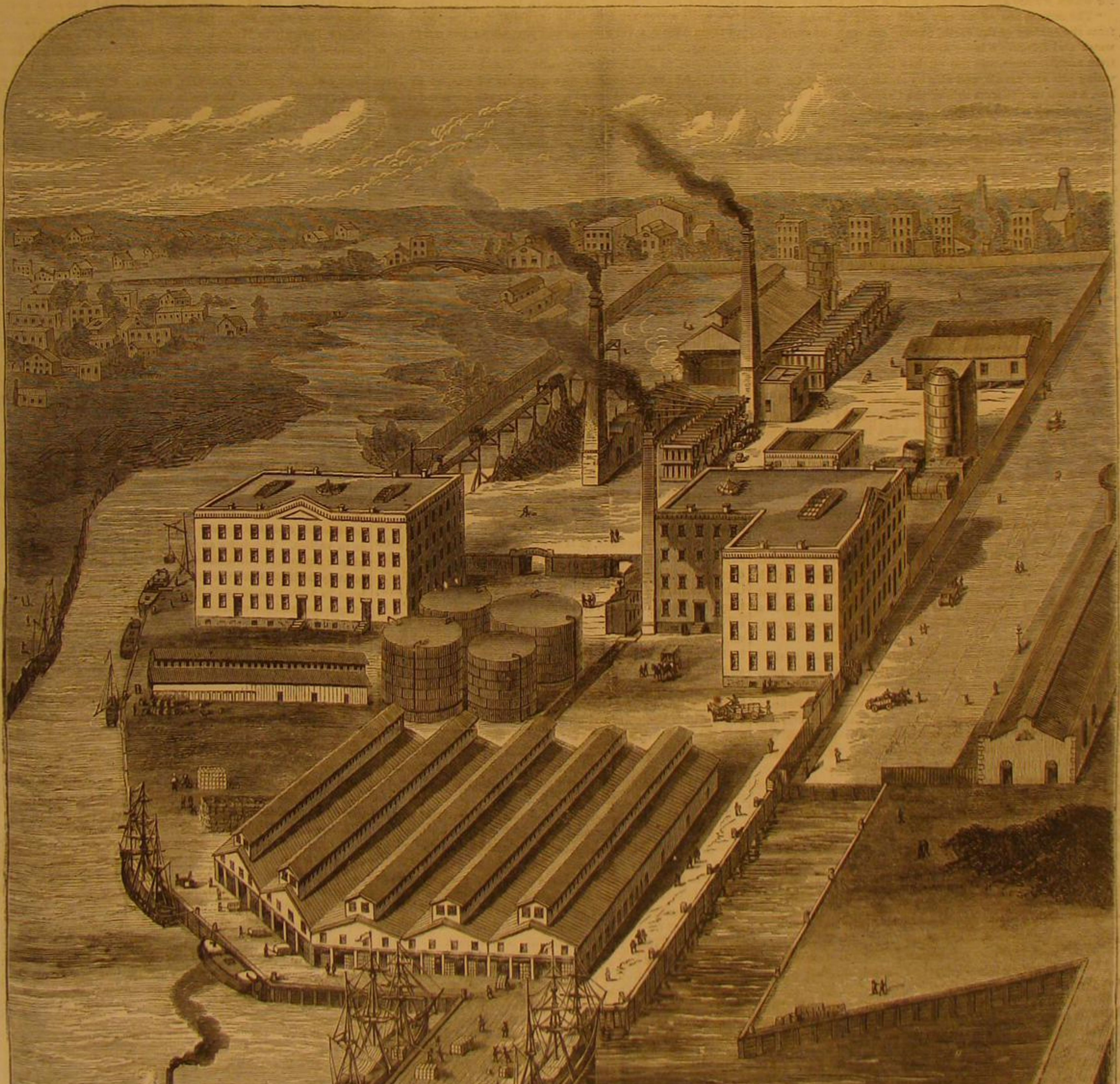
PETROLEUM AND ITS PRODUCTS.

The name of petroleum is derived from the Greek πέτρος a stone, and ἔλαιον oil; Latin, *petri oleum*. The substance to which this name has been given is otherwise called rock oil, and when rectified, mineral naphtha, to distinguish it from analogous compounds distilled from coal and wood, and which are respectively styled coal naphtha and wood naphtha.

Petroleum having, since its manifold uses were discovered, become one of the most important articles of American commerce, it is the purpose of this article to give, so far as space will permit, the leading points in its history, statistics of its production, the method of obtaining and refining it, and the uses to which the various products obtained from it can be applied, together with such other details of interest as may suggest themselves to the writer.

One of the most remarkable oversights that has occurred in the history of American manufactures is the fact that, although petroleum was known to exist in abundance and its analogy to coal oil was well recognized by chemists, the enormous natural supply of this useful material was ignored for years, while the distillation of coal was carried on quite extensively. It may not be amiss, in this connection, to make a brief reference to the coal oil manufacture.



BIRD'S EYE VIEW OF PRATT'S ASTRAL OIL WORKS, BROOKLYN, E.D.

COAL OIL MANUFACTURE.

In a work entitled "Eighty Years of Progress," Mr. James T. Hodge, geologist, writes as follows:

The following is a list of some of the factories which were in operation in 1861:

State.	Town or county.	Name of works.	No. of factories.	Daily capacity in 1860. Galls.
Maine,	Portland	Portland Company	1	4000
Massachusetts,	Boston	Downer Kerosene Company	1	4000
"	"	Page & Co.	1	600
"	"	Suffolk Company	1	300
"	East Cambridge	East Cambridge Company	1	800
"	New Bedford	New Bedford Company	1	300
Connecticut,	Hartford	Hartford Company	1	200
New York,	Newtown Creek, L. I.	Kerosene Oil Company	1	4000
"	Hunter's Point, L. I.	Luther Atwood	1	2000
"	"	Carbon Company	1	300
"	South Brooklyn	Empire State Company	1	300
"	"	Franklin Company	1	500
"	Williamsburgh	Fountain Oil Company	1	400
"	Harlem	Beloni & Co.	1	50
Pennsylvania,	Pittsburgh	Aladdin Company	1	2000 (for the four Pittsburgh works)
"	"	Lucesco Company	1	
"	"	North American Company	1	
"	"	New Galilee	1	
Ohio,	Newark, Licking Co.	Great Western	1	500

Besides these, there were from sixty to a hundred more factories, of greater or less capacity; and the total product of coal oil was estimated as being nearly 10,000,000 gallons per annum at that time.

Petroleum had, however, at this time begun to be produced in large quantities, and to give promise of developing the immense trade that has since grown out of it. The origin of the American trade will be found in the following

HISTORY OF AMERICAN PETROLEUM

for which we are again indebted to the work already quoted:

"The occurrence of an oily fluid oozing in some regions from the surface of the earth, coming out with the springs of water and forming a layer upon its surface, has been noticed from ancient times, and the oil has been collected by excavating pits and canals, and also by sinking deep wells. Bakoo, a town on the west side of the Caspian Sea in Georgia, has long been celebrated for its springs of a very pure variety of petroleum or naphtha, and the annual value of this product, according to M. Abich, is about 3,000,000 francs, and might easily be made as large again. Over a tract about 25 miles long and half a mile wide, the strata, which are chiefly argillaceous sandstones of loose texture, belonging to the medial tertiary formation, are saturated with the oil, and hold it like a sponge. To collect it, large open wells are sunk to the depth of 16 to 20 feet, and in these the oil gathers and is occasionally taken out. That obtained near the center of the tract is clear, slightly yellow, like Sauterne wine, and as pure as distilled oil. Toward the margins of the tract the oil is more colored, first a yellowish green, then reddish brown. In the environs of Bakoo are hills of volcanic rocks through which bituminous springs flow out. Jets of carburetted hydrogen are common in the district, and salt, which is almost always found with petroleum springs, abounds in the neighborhood.

Another famous locality of natural oils is in Burmah, on the banks of the Irrawaddy, near Prome. Fifty years ago, it was reported there were about 520 wells in this region, and the oil from them was used for the supply of the whole empire and many parts of India. The town of Rainanghong is the center of the oil district, and its inhabitants are chiefly employed in manufacturing earthen jars for the oil, immense numbers of which are stacked in pyramids outside the town, like shot in an arsenal. The formation containing the oil consists of sandy clays resting on sandstones and slates. The lowest bed reached by the open wells, which are sometimes 60 feet deep, is a pale blue argillaceous slate. Under this is said to be coal (tertiary?) The oil drips from the slates into the wells, and is collected as at Bakoo. The annual product (1861) is variously stated at 412,000 hogsheads, and at 8,000,000 pounds.

The Burmese petroleum has recently (1861) been imported into Great Britain, and is employed at the great candle manufactory of Messrs. Price & Co., at Belmont and Sherwood. It is described as a semi-fluid naphtha, about the consistence of goose grease, of a greenish brown color, and a peculiar but not disagreeable odor. It is used by the natives, in the condition in which they obtain it, as a lamp fuel, as a preservative of timber against insects, and as a medicine. It is imported in hermetically closed metallic tanks, to prevent the loss of any of its constituents by evaporation. At the works, it is distilled first with steam under ordinary pressure, and then by steam at successively increasing temperatures, with the following results:

Temp. Fahr.	Proportional product.	Character of product.
Below 212°	11	Mixture of fluid hydrocarbons free from paraffin.
230° to 293°	10	" " " containing a little paraffin.
293° to 320°	..	Distillate very small in quantity.
320° to 612°	20	Containing paraffin, but still fluid at 32°.
About 612°	31	Product which solidifies on cooling, and may be submitted to pressure.
Above 612°	21	Fluids with much paraffin.
	3	Pitchy matters.
	4	Residue of coke, and a little earthy matter in the still.

[This is therefore a much heavier petroleum than American.]—Ed.

Nearly all the paraffin may be separated from the distillates by exposing these to freezing mixtures; and the total product of this solid hydrocarbon is estimated at 10 o. 11 per cent.

Many other localities might be named which furnish the natural oils upon a less extensive scale, as in Italy, France, and Switzerland. In Cuba and in South America, impure varieties of bitumen are met with, flowing up through fissures in the rocks and spreading over the surface, in a tarry incrustation which sometimes solidifies on cooling. In the island of Trinidad, three fourths of a mile back from the coast, is a lake called the Tar Lake, a mile and a half in circumference, apparently filled with impure petroleum and asphaltum. The latter, more or less charged in its numerous cavities with liquid bitumen, forms a solid crust around the margin of the lake, and in the center the materials appear to be in a liquid boiling condition. The varieties contain more or less oil, and methods have been devised of extracting this; but the chief useful application of the material seems to be for coating the timbers of ships to protect them from decay. By the patented process of Messrs. Atwood of New York, the crude tar of this locality, having been twice subjected to distillation and treated with sulphuric acid and afterward with an alkali, as in the method of purifying the coal oils, is then further purified by the use of permanganate of soda or of potash. Being again distilled, it yields an oil of specific gravity 0·900, which is fluid at 32° Fahr., and boils at 600° Fahr.

In the United States the existence of petroleum has long been known, and the article has been collected and sold for medicinal purposes, chiefly for an external application, though sometimes administered internally. It was formerly procured by the Seneca Indians in western New York and Pennsylvania, and was hence known as Seneca or Genesee oil. At various places, it was recognized along a belt of country passing from this portion of New York across the northwest part of Pennsylvania into Ohio. In the last named State, it was obtained in such quantity in the year 1819, by means of wells sunk for salt water, that it is a little remarkable the value of the material was not then appreciated, and the means perceived of obtaining it to any amount. The following description of the operations connected with the salt borings then in progress on the Little Muskinguffi, in the southwestern part of the State, written in 1819, was first published in the *American Journal of Science* in 1826: "They have sunk two wells which are now more than 400 feet in depth; one of them affords a very strong and pure water, but not in great quantity. The other discharges such vast quantities of petroleum, or as it is vulgarly called, 'Seneka oil,' and besides is subject to such tremendous explosions of gas, as to force out all the water and afford nothing but gas for several days, that they make but little or no salt. Nevertheless, the petroleum affords considerable profit, and 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." Several coal beds were penetrated in sinking these wells.

In northwestern Pennsylvania, the existence of oil in the soil along the valleys of some of the streams was known to the early settlers. One stream, in consequence of its appearance in the banks, was called Oil Creek. In other localities also it was noticed, and similar occurrences of oil were observed at some places in western Virginia and eastern Kentucky. At Tarentum, above Pittsburgh, oil was obtained by boring about the year 1845. Two springs were opened in boring for salt, and they have continued to yield small quantities of oil, sometimes a barrel a day. This has been used only for medicinal purposes. On Oil Creek, two localities were especially noted, one close to the northern line of Venango county, half a mile below the village of Titusville, and one fourteen miles further down the stream, a mile above its entrance into the Alleghany river. All the way below the upper locality through the narrow valley of the creek are ancient pits covering acres of ground, once dug and used for collecting oil after the method now practised in Asia. Cleared from the mud and rubbish with which they are mostly filled, some of them are found to be supported at the sides with logs notched at the ends, as if done by whites, and it has been supposed by some that this is the work of the French who occupied that region the first half of the last century. Others think the Indians dug the pits, and in proof of this, they cite the account given by Day, in his "History of Pennsylvania," of the use of the oil by the Seneca Indians as an unguent and in their religious worship. They mixed with it their paint with which they anointed themselves for war; and on occasions of their most important assemblages, as was graphically described by the commandant of Fort Duquesne in a letter to General Montcalm, they set fire to the scum of oil which had collected on the surface of the water, and at sight of the flames gave forth triumphant shouts which made the hills re-echo again. In this ceremony, the commandant thought he saw revived the ancient fire worship, such as was once practised in Bakoo, the sacred city of the Guebres or Fire Worshippers.

The old maps of this portion of Pennsylvania indicate several places in Venango and Crawford counties where oil springs had been noted by the early settlers. They made some use of the oil, collecting it by spreading a woolen cloth upon the pools of water below the springs, and, when the cloth was saturated with the oil, wringing it out into vessels. The two springs referred to on Oil Creek furnished small quantities of oil as it was required, and from a third, twelve miles below Titusville, in the middle of the creek, the owner has procured twenty barrels or more of oil in a year.* In 1854, Messrs. Eveleth and Bissel of New York purchased the upper spring and leased mineral rights over a portion of the valley. They then obtained from Professor B. Silliman, Jr., of New Haven, a report upon the qualities of the oil, and in 1855 organized a company in New York, called the "Pennsylvania Rock Oil Company," to engage in its exploration. The same year a new company under the same name, formed in New Haven and organized under the laws of Connecticut, succeeded to the rights of the old company; but for two years they made no progress in developing the resources of the property they had acquired. In December, 1857, they concluded an agreement with Messrs. Bowditch and Drake of New Haven to undertake the search for oil. To the enterprise of Col. E. L. Drake, who removed to Titusville and prosecuted the business in the face of serious obstacles, the region is indebted for the important results which followed. After a well had been sunk and curbed near the spring, ten feet square and sixteen feet deep, boring was commenced in the spring of 1859, and on the 26th of August, at the depth of seventy-one feet, the drill suddenly sunk four inches, and when taken out the oil rose within five inches of the surface. At first a small pump threw up about 400 gallons daily. By introducing a larger one, the flow was increased to 1,000 gallons in the same time. Though the pumping was continued by steam power for months, no diminution was experienced in the flow. The success of this enterprise produced great excitement, and the lands upon the creek were soon leased to parties who undertook to bore for oil for a certain share of the product, sometimes advancing besides a moderate sum to the owner.

The country was overrun by explorers for favorable sites for new wells, and borings were undertaken along the valley of the Alleghany river and up the French Creek above Franklin. The summer of 1860 witnessed unwonted activity and enterprise in this hitherto quiet portion of the State, where the population had before known no other pursuits than farming and lumbering. Every farm along the deep, narrow valleys suddenly acquired an extraordinary value, and in the vicinity of the most successful wells, villages sprung up as in California during the gold excitement, and new branches of manufacture were all at once introduced for supplying to the oil men the barrels required for the oil and the tools employed in boring the wells. From Titusville to the mouth of Oil Creek, about 15 miles, the derricks of the well borers were everywhere seen. On the Alleghany river, the number below Tidioute in Warren county, south into Venango county, seemed to indicate that this portion of the district would be especially productive, and the same might be said of the vicinity of the town of Franklin, both up the Alleghany river and French Creek. The wells had amounted to several hundred, or according to one published statement, to full 2,000 in number before the close of the year; and from an estimate published in the *Venango Spectator* (Franklin), 74 of these on the 21st of November were producing the following daily yield:—

	No. of wells.	Prod. bbls.
On Oil Creek	33	485
" Upper Alleghany river	20	442
Franklin	15	139
Two Mile Run	3	64
French Creek	3	35
Total	74	1165

The last three named places did not, however, fulfil the expectations raised in regard to them.

The capacity of the barrel is 40 gallons. The depth of the wells is in a few instances less than 100 feet. The shallowest one reported, belonging to the Tidioute Island Oil Company, was 67 feet deep, and its product was 30 barrels a day. In general (1861) the depth is from 180 to 280 feet; one well in Franklin is 502 feet in depth, and one on Oil Creek 425 feet. At present from 500 to 1,200 feet are not unusual depths for wells.

LOCALITIES.

The selection of localities for boring was very much a matter of chance. Proximity to productive wells was the first desideratum; but this, when attainable, was not always attended with success. The early notions in regard to location have, however, all been reversed. The oil is now known to lie in belts, and borings are now made through hills as well as in vallies. The belts are in some places wide and in some places narrow, but in general their boundaries are so approximately defined that the element of chance in boring has been in a great measure eliminated. No doubt the system of crevices and pervious strata, through which the oil flows in its subterranean currents, is very irregular and interrupted.

Professor E. W. Evans, of Marietta College, gives in Vol. LII. of "Hunt's Merchant's Magazine," the following in regard to the

PHYSICAL FEATURES OF THE OIL REGIONS.

In what kinds of rock: The best deposits are found in the cavities of loose, brittle, much fractured sandstone or conglomerate. Sometimes the sandstone is quite argillaceous, approaching a shale in character. In some places, the most productive oil rock is a somewhat calciferous sandstone; but in pure limestone rock, the cavities are usually too extensive and afford too free passage to running water to hold good collections of oil imprisoned. The corniferous limestone (which is an ancient coral reef of the lower Devonian) contains petroleum in its minute cellules; but it has not yet, unless in Canada, yielded any in bulk. Strata of shale and slate often contain petroleum; but it is so generally diffused through the small fractures, and through the substance of the rock itself, that it cannot be obtained in large quantities. Indeed, it is a general fact that the rocks through which oil is universally diffused, and in which it may be conceived to have had its origin, are not those which contain it in collections large enough to be profitably pumped. Hard, compact sandstone is usually, for want of cavities, unproductive. This kind of rock, however, often serves as a cover to confine the oil in a looser rock underlying it. It is a common experience among borers to strike oil directly beneath such an impervious layer; for example, under the "third sandrock" of Oil Creek.

It is known that, beneath the oil bearing sandstones, at greater or less depths, there are different strata of bituminous shales containing vegetable impressions. This gives plausibility to the theory that the oil had its origin in the vegetation of the shales, and that by a slow process of distillation, caused by internal heat, it has worked its way up through the cracks and fissures and gradually accumulated in such cavities in the rocks above as do not admit of its escape to the surface. The most general source of petroleum may have been the

*See a pamphlet by Thomas A. Gale, published in Erie, Pa., 1860, entitled "Rock Oil in Pennsylvania and elsewhere."

so-called black slate, which is widely extended over the western States, and is considered identical with the Marcellus shales of New York; but on the western Appalachian slope, there are numerous strata of bituminous or carbonaceous shales above this, included in the carboniferous system.

At what depths: Other circumstances being equal, deep wells, as a class, are more productive than shallow ones. To speak more explicitly, supplies of petroleum found at a depth of two or three hundred feet or more are more copious and lasting than those found at a less depth. Wells not over a hundred feet in depth often give good promise at first; but they are soon exhausted. The best wells are, generally, not less than five hundred feet deep. Many of the most celebrated wells in Pennsylvania derive their supplies from a depth of seven or eight hundred feet, and have been producing for four or five years without complete exhaustion. In shallow wells, it is common to find a heavy lubricating oil, the commercial value of which is greater than that of the light illuminating oil; but what is thus gained in quality is, as a general fact, many times lost in quantity.

The idea of dislocation of the rocks being evidence of oil deposits is subject to a very great limitation. There is an extensive system of lines of upheaval running parallel to the Alleghany mountains, on both sides of them, as if all produced by the same force which slowly raised the mountain folds themselves, acting in a direction nearly at right angles to the Atlantic coast. It is important to observe that those which characterize the most productive oil regions, west of the mountains, are simple flexures. The slopes are curved or polygonal, and the axial lines not sharply defined. Open breaks and wide disruptions are unfavorable signs, since they admit of the free escape of oil to the surface. In places where such signs exist, no considerable deposits have been found. East of the mountains, where there is little or no oil, and even the coal has been debituminized, the dislocations are violent, exhibiting great disruptions and faults.

The somewhat popular idea of an oil basin, except so far as limited to a synclinal axis of disturbance, indicating cavities, is a delusion. It seems to be imagined that petroleum would descend along the strata from the sides of a natural basin toward the center. But being lighter than water, which is always found with it, its tendency is upward, not downward, even through the slight transverse crevices; and we could not conceive of it as running freely along the strata without supposing that it would be rapidly washed to the surface.

Metamorphism as a sign: In the uplifting and folding of the strata which took place in the so called period of the Appalachian revolution, heat (followed by great cooling and contraction) must have been an important agent, as shown by the somewhat metamorphic condition of the rocks in those places where the disturbance was greatest. In the region of great uplifts and faults, east of the mountains, this condition, though not complete, is exhibited in a much more marked degree than in the region of slight and wavy flexures west of the mountains. The absence of petroleum, as, also, the debituminized condition of the coal and shales, east of the mountains, is to be attributed not only to the more open fractures and clefts in that region, admitting to its escape, but in part, also, to the direct expulsive power of the higher degree of heat concerned in causing those fractures. It is certain that scarcely any petroleum has been found in regions where rocks of decidedly metamorphic character are seen. It is certain, also, that, even within the limits of the known oil regions, those places, where the disturbance has been greatest and the rocks approach nearest to that crystaline condition indicating metamorphism, have not been found rich in petroleum. Among the processes of metamorphism, may be enumerated the change of soft and brittle sandstones into those of a hard and crystaline character, and often from a pale color to red,—the change of the compact and colored limestones into bleached and granular ones,—the change of argillaceous shales into firm slates,—also, the partial or total obliteration of fossils. Another evidence of the heat which attended these processes is the frequent occurrence of lodes or transverse veins, of infiltrated metallic ores and other substances not soluble at low temperatures. The oil regions are characterized by loose sandstones and conglomerates, by the soft, shaly condition of the argillaceous rocks, by the absence of regular beds of granular limestone, by the rare occurrence of lodes, by the abundance and perfect condition of the fossils, as well as by the highly bituminous condition of the coal and shales.

Character of surface: Too much stress is often laid on the nature of the surface rocks. Practically, the main question to be determined is: What is the character of the strata at the depths where oil may be expected in remunerative quantities? and in order to determine this, the geologist observes the direction and grade of the dip and seeks the outcrop of the strata at a distance. But there are certain peculiarities in the configuration of the surface which characterize the Pennsylvania districts generally. The hills are abrupt and precipitous, the valleys narrow and deep, exhibiting in a very marked degree the effects of the process of degradation. Originally, the face of the country was higher than the tops of the present hills; but it has been worn down and cut deep by erosion, or the action of water. These effects are more marked than is common elsewhere; partly, because the rocks have been less hardened by metamorphism, and therefore wear away and crumble more easily. The surface rock would be most loosened along the anticlinal lines; hence these have oftenest determined the direction of narrow streams. Indeed, it is not uncommon to see the bottom of an original synclinal valley now crowning the top of a hill, while the original hills on either side of it have been worn down into deep gorges. But the mere fact of a deep valley or gorge is no proof of a line of disturbance of either kind. It is necessary in every case to determine the inclination of the strata in order to form an intelligent judgment. Often, the dip is in the same direction on both sides; but this, if considerable in degree, is of itself an evidence of dislocation and fracturing; for rocks lying in the position in which they were originally deposited are, as a general fact, either horizontal or very nearly so. Many flexures are marked only by a change in the grade of the dip.

Surface oil: In every oil district, there is more or less "surface show," though not always very close to the sites of producing wells. It varies so much in quantity and quality, as as well as in the circumstances under which it appears, that some discrimination is necessary in order to judge of its value as a sign. Considered independently of geological evidence, it affords, at best, no proof that there is oil beneath in collections large enough to be profitably pumped; for it may come up from beds of bituminous shale, or other strata that do not yield it in bulk. In the most productive districts, it is generally seen, on low grounds, in a thin scum on springs and streams, where it comes up with water through slight crevices in the underlying rocks.

Oil coming to the surface in bulk, so often prized as a good sign, is really nothing more than an indication of shallow supplies. In many places where "Seneca oil" used to be collected in gallons, and even in barrels, as it issued from the surface strata or oozed up through the sand, experiments in boring have resulted in finding only small collections at a slight depth. The oil, originally deep in the earth, has gradually worked its way up toward the surface, through the too open cracks and fissures, and is rapidly undergoing the process of exhaustion. If, as on Oil Creek, other oil bearing strata are found upon boring deeper, the kind of surface-show here described afforded, beforehand, no evidence of their existence, but only of that which lies near the surface or perhaps crops out in the hillside.

The thinnest scum of petroleum on water is bluish; a little thicker scum exhibits the colors of the rainbow, especially when agitated. Petroleum may also be distinguished by its dividing, when disturbed, and closing again with a perfectly even margin; while other scums, sometimes mistaken for it, break into pieces which do not perfectly re-unite. That which is oftenest mistaken for oil is a blue and somewhat iridescent scum, seen on waters holding carbonate of iron in solution, and precipitating a red ocherous substance (peroxide of iron) to the bottom. But it is not uncommon to find oil floating on the same pool with it.

Two or three drops of petroleum will cover a spring of ordinary size for half an hour with what would be recognized as fair surface-show. The present production of petroleum must be very slow if it does not exceed the natural drainage through springs, which perhaps would require a geological period to exhaust the supplies now in the earth. Indeed, it is not difficult to suppose that these supplies have mainly come down from a period of much greater heat, perhaps the close of the carboniferous era, when the folds and cavities now containing them were produced.

Connection with mineral waters: In the best oil districts there are numerous oil and gas springs in which the analysis of the water always reveals various minerals, such as common salt, chloride of lime, carbonates of lime, soda and iron, sulphates of soda and potash, and sometimes sulphuretted hydrogen. These are variously called salt licks, chalybeate springs, sulphur springs, oil springs, and so forth, according to the mineral predominating. If, on the common springs of pure water, whose source is usually near the surface, oil is not seen, but only on mineral springs, it affords good evidence that the source of supply is quite deep. It comes up through slight cracks and fissures in the strata, from depths where the water has laid in contact with many substances and gathered its various mineral contents. The high temperature of these oil and mineral springs, as compared with the ordinary springs of pure water, is another fact indicating a deep source. But decidedly thermal springs (in the Pennsylvanian region) are located on the axes of more violent upheavals than those which distinguish the oil districts.

The observed connection of petroleum with various soluble minerals, containing carbon and hydrogen, has led some to suppose that it is directly formed from these minerals, by some chemical interaction not proved or explained. This connection, however, may be satisfactorily accounted for without the aid of such an hypothesis. For aside from the fact, already adverted to, that mineral springs, as a class, come up from a great depth and are thus naturally rendered the common vents of various liquids and gases, it is evident that the same class of cavities, protected from running water, in which petroleum lurks, are also the best adapted to harbor water impregnated with salt and other minerals. The connection of the water in oil cavities with free currents is slight and indirect. The same is true of deposits of salt water and mineral waters generally, for the simple reason that, from cavities exposed to free currents, the minerals must, in the progress of ages, have been washed away. The history of salt wells presents various points of coincidence with that of oil wells. For example, the wells of the great Kanawha salines, in the neighborhood of Burning Spring, are located on a marked uplift. The salt water is found, according to Dr. Hildreth, in a "white calciferous sandstone, full of cavities and fissures." The water is stagnant, and contains, besides salt, various muriates and carbonates. The same wells have yielded large quantities of petroleum with carburetted hydrogen. Indeed, it is a general fact that the water on which collections of petroleum are found is either quite salt or brackish and nauseous with various minerals held in solution. Subterranean currents are almost always fresh, or nearly so; and experience has taught that, in fissures where pure water is found, no large deposits of oil are to be expected.

BORING FOR PETROLEUM.

From Cone and John's "Petrolia," published by D. Appleton & Co., in 1870, the substance of the following description of the process of boring is obtained:

We will suppose that the site for the well has been selected, and a suitable place made ready for the foundations of the derrick, engine house, etc. The first step generally taken, after securing and preparing the location, is to procure an engine, suitable in amount of horse power for the effectual prosecution of the work, and transport it to the location aforesaid. Next in order is the erection of an engine house, derrick, sampson post, working beam, jack frame, and band wheels, and placing them in proper position. The engines in use in the Oil Region are of every conceivable style, portable, stationary, upright, and oscillating. Portable and stationary are the kinds now in general use. These are from eight to thirty horse power, principally the former. In former years it was the custom to operate several wells with one of these large engines, sometimes two; never over three. It is now considered more advantageous to have an engine to each well. The motion required to pump one well is generally different from what is required for another. Arranging motion for one well, where two are operated with one engine, disarranges it for the other, consuming more time and fuel than would pay for the extra one. Engine houses are built of rough boards, and are of sufficient capacity to protect the engine from the weather, contain a forge for dressing tools, bunks for workmen, a small amount of fuel, necessary tools, ropes, etc.

The derrick is a tall frame work, in the shape of a pyramid. They were formerly built of rough poles or hewn timber, the bottom being from ten to twelve feet square, the poles, four in number, being erected one at each corner, thirty feet in hight, converging toward each other, forming a square at the top of two and a half feet, with girths and braces at suitable distances to make the structure sufficiently substantial for the purposes designated. Derricks are now built of sawn lumber or boards, two inches thick and from six to eight wide, the two edges being spiked together, forming a half square on each corner of the foundation, which is from fourteen to sixteen feet square and in some localities more. The derrick is now put up in sections, being braced transversely as it goes up, in order to secure the strength necessary, until it reaches the proper hight, which for deep wells is about fifty-six feet; for shallow ones, less hight and lighter derrick are required, and at the top it forms a square of from two to three feet.

On the top of the derrick is put a strong frame work for the reception of a pulley, over which the drill rope passes. The floor of the derrick is made strong by cross sleepers, covered with plank or boards. A roof, for the protection of the workmen, is laid with boards across the girths, some ten to twelve feet above the floor. In cold weather the sides are boarded up.

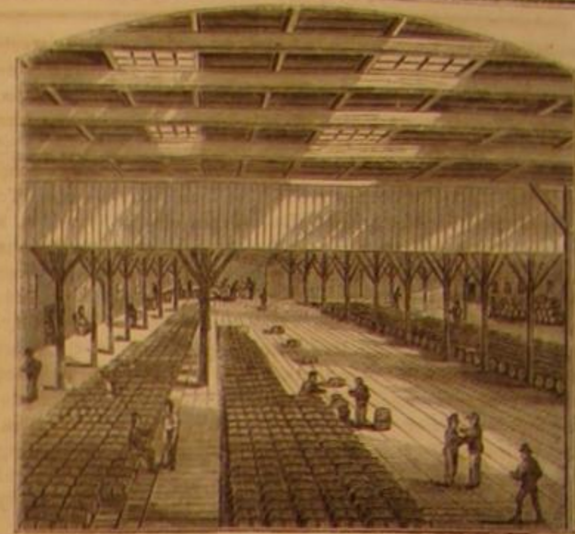
The bull wheel, as it is called, is a shaft of timber, six to eight feet long, fastened like the shaft of a common windlass, and six to eight inches in diameter; the ends of the shaft are banded with iron, and a journal of inch iron is driven into each end for it to revolve upon. Mortices are made through this shaft, eight or ten inches from each end for the arms of the wheel. The wheels are usually made from six to eight inches thick on the face, with strips of plank sunk into and spiked on the outer surface for the double purpose, of receiving the rope belt and connecting it with the band wheel for drawing up tools, tubing, etc. out of the well, and for the workmen to take hold of with their hands when working it without the help of the engine. The bull wheel is placed on the side of the derrick, next to or opposite the band wheel and engine as the workmen may desire. The drill rope is coiled on this shaft, between the wheels, one end passing from it over the pulley on the top of the derrick, and attached to the tools.

The sampson post is of hewn timber, twelve to fifteen inches square and usually twelve feet in height, erected on heavy timbers, framed crossing each other, bedded firmly in the ground with a mortice to receive the tenon on bottom of post; also a brace on each side, reaching nearly to the top of the post. On the top of this are the irons fitted to receive the working beam, which is balanced on the top of the sampson post, admitting of the rock motion required in drilling and pumping. The working beam is a stick of timber, from twenty to twenty-six feet long, eight to ten inches square at each end, eight by fourteen to sixteen inches in the middle, with iron attachment in the center, fitting to a similar one on the sampson post. To the end over the well is an iron joint, for attaching the temper screw when drilling and sucker rods when pumping. On the other end of the working beam is an iron joint for attaching the pitman bar, which connects the same with the crank or band wheel shaft.

The band wheel is usually about six feet in diameter, with a six inch face, built in various styles according to the fancy of the builder, and is placed upon a strong frame, built for its reception, called the jack frame. The jack frame is secured in position by two heavy timbers, bedded into the ground, with gains sunk into them to receive the sills of the jack frame, to which they are keyed fast. The engine is usually placed from eight to twelve feet distant from the band wheel, and connected by rubber or other belting. The belting in general use is six inches in width.

When all this is completed, water supply for the engine procured, etc., we are ready to commence operations. The first thing in order is to drive the iron conductor or driving pipe, as it is generally termed, to the bed rock, which varies from six to seventy-five feet, generally from twenty to fifty feet. The pipe acts as a conductor, and prevents earth and stones from falling into the pit or hole while the drilling is going on. The driving pipe in general use is of cast iron,

COOPER SHOP.



BARREL ROOM.

six to eight inches in diameter, having walls of about one inch in thickness, and is in joints nine or ten feet long. The driving of this pipe is a work of difficulty, requiring the utmost skill, since the pipe must be forced down through all obstructions to a great depth, while it must be perfectly vertical. The slightest deflection, from a straight perpendicular line, ruins the well, as the pipe acts as the conductor for the drilling tools. The process of driving is simple but effective. Two slide ways, made of plank, are erected in the center of the derrick to the hight of twenty or more feet, twelve to fourteen inches apart, with edges in toward each other, and the whole made secure and plumb. Two wooden clamps or followers are made to fit around the pipe and slide up and down on the edges of the ways. The pipe is erected on end between the ways, and held perpendicular by these clamps and a driving cap of iron, fitted to the top. A battering ram is then suspended between the ways, so arranged as to drop perpendicularly upon the end of the pipe. The battering ram is of timber, six to eight feet long, and twelve to fourteen inches square, banded with iron at the lower or battering end, with a hook in the upper end to receive a rope. When the whole is in position, a rope is attached to the hook in the upper end, passed over the pulley of the derrick, down to and around the shaft of the bull wheel. Everything is now in readiness to drive the pipe. The belt connecting the engine and band wheel, and the rope connecting the band wheel and bull wheel, called the bull wheel rope, being adjusted, the machinery is put in motion by the engineer, one man, standing behind the bull wheel shaft, grasping the rope attached to the ram and coiled around the bull wheel shaft, holds it fast and takes it up in his hands, thus raising the ram to its required elevation, when it is let fall upon the pipe, and by repeated blows it is driven to the requisite depth. When one joint of pipe is driven, another is placed upon it and the two ends secured by a strong iron band, and the process continued as before. The pipe has to be cleaned out frequently, both by drilling and sand pumping. Where obstacles, such as boulders, are met with, the centerbit is put in requisition, and a hole, two thirds the diameter of the pipe, is drilled through the same. The pipe is then driven down, the edges of the obstacles being broken by the force applied, the fragments falling into the vacuum created by the passage of the bit. When this cannot be done, the whole machinery and derrick is moved to admit of the driving a new set of pipe, or the well is abandoned. It sometimes happens that the pipe is broken, or diverted from its vertical course by some obstacle; and the whole string of pipe driven has to be drawn up again and the work commenced anew. If this is not possible, a new location is sought.

After the pipe is driven, the work of drilling is commenced. The drilling rope, which is generally one and a quarter inch hawser laid cable, of the required length, from 500 to 1,000 feet, is coiled round the shaft of the bull wheel, the outer end passing over the pulley on the top of the derrick down to the tools, and attached to them by a rope socket. The tools consist of the centerbit, auger stem or drill bar, jars, sinker bar, and rope socket. When connected, these are from thirty to forty feet in length, and sometimes more, weighing from 800 to 1,600 pounds, according to depth required to reach the third sand rock. The process of drilling, until the whole length of the tools is on and suspended by the cable, is slow. When the depth required to suspend the tools is obtained below the surface, the attachment between the working beam and drilling cable is made by means of a temper screw suspended from the end of the working beam, and attached to the rope by a clamp. The temper screw is from two to three feet in length, made with a coarse thread, and works in a thin iron frame, with a wheel at the lower end of the screw for the driller to let out the same as is required. As the drill sinks down into the rock, the screw is let down by a slight turn of the wheel by the driller, some allowing a full revolution every few blows of the bit, others once only in a few minutes, depending upon the hardness of the rock being drilled through.

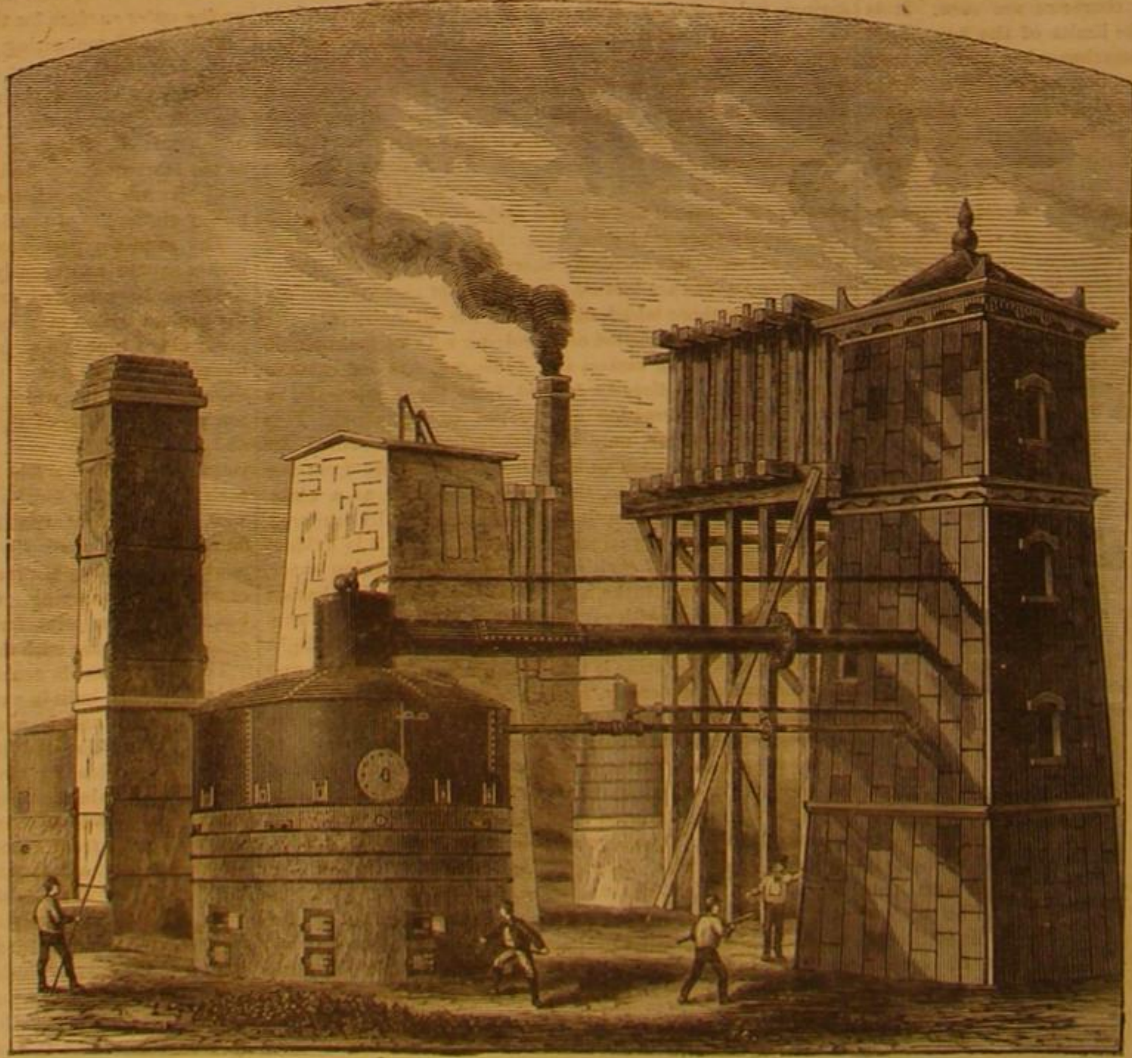
TAP FAUCET SHOP.

What are termed the "jars" by oil miners, attached to the auger stem, play a highly important part in the work of drilling. There are two long links or loops of iron or steel, sliding in each other. Drillers always have about from four to six inches play to the jars, which they call the "jar," and by this they can tell when to let down the temper screw. With the downward motion the upper jar slides several inches into the lower one; on the upward motion this is brought up, bringing the ends of the jars together with a blow as of a heavy hammer on an anvil, making a perceptible jar. Experienced drillers can, as soon as they take hold of the rope, tell how much "jar" they have on.

In drilling, the tools are alternately lifted and dropped by the action of the working beam in its rocking motion. One man is required constantly in the derrick to turn the tools, as they rise and fall, to prevent them from becoming wedged fast, and to let out the temper screw as required. This is one of the most important duties of the work, requiring constant attention to keep the hole round and smooth. The centerbit is run down the full length of the temper screw. The centerbit is about three and a half feet in length, with a shaft two and a half inches in diameter and a cutting edge of steel, three and a half to four inches in width, with a thread on the upper end by which it is screwed on the end of the auger stem. The reamer is about two and a half feet in length, having a blunt instead of cutting edge, with a shank two and a half inches in diameter terminating in a blunt extremity, three and a half to four and a half inches in width by two inches in thickness, faced with steel. The weights of heavy centerbits and reamers average from fifty to seventy-five pounds each. The centerbit is followed by the reamer, to enlarge the hole and make it smooth and round. The sediment, or battered rock, is taken out after each centerbit, and again after each reamer, by means of a sand pump let down in the well for the purpose. The sand pump now in use is a cylinder of wrought iron, six to eight feet in length, with a valve at the bottom and a bail at the top, to which a half inch rope is attached, passing over a pulley suspended in the derrick some twenty feet above the floor, and back to the sand pump reel, attached

REPAIR SHOP.

PUMP ROOM.



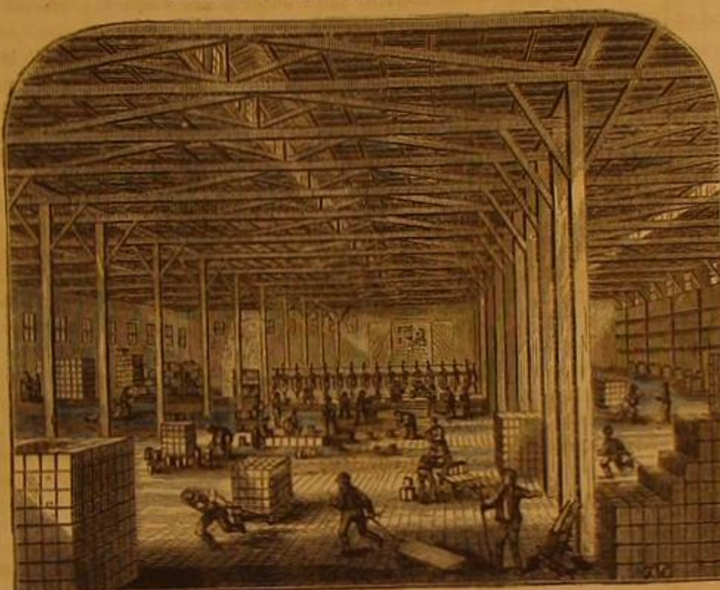
GASOLINE STILL.

to the jack frame, and coiled upon the reel shaft. This shaft is propelled by means of a friction pulley, controlled by the driller in the derrick, by rope attached. The sand pump is usually about three inches in diameter. Some drillers use two, one after the centerbit and a larger one after the reamer, the two being preferable. When the sand pump is lowered to a requisite depth, it is filled by a churning process of the rope in the hand of the driller, and is then drawn up and emptied. This operation is repeated each time the tools are drawn up out of the well, the pump being let down and drawn up a sufficient number of times to remove all the drillings. The fall of the tools is from two to three feet. This labor goes on, first tools and then sand pump, until the well is drilled to the required depth. Abundance of water is found in the wells, both for rope and tools, from the commencement. It flows in from the surface veins, and from the larger ones below.


LOADING VESSELS WITH BARRELS.

After the well is drilled, the process of tubing, to prepare for testing and pumping, is next in order. This is done generally with two inch wrought iron pipe, previously tested by hydraulic power. This tubing is in joints, from twelve to fifteen feet in length, screwed together by means of a thread on each of its ends, with a close fitting thimble.

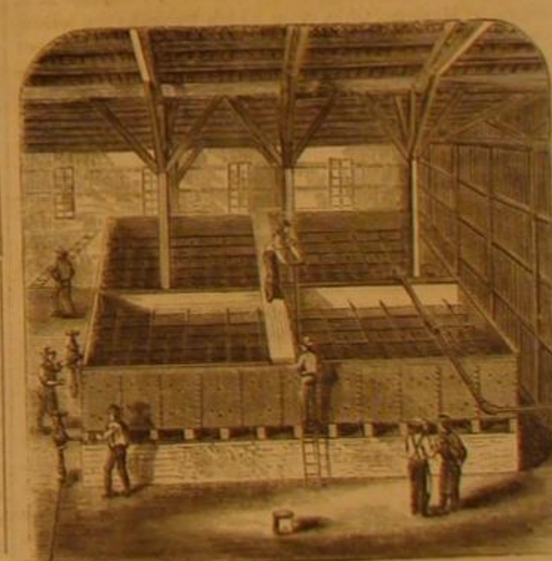
The working or pump barrel is usually from five to six feet in length, made of brass, with a bore of from one and three quarters to one and seven eighth inches, always smaller than the bore of the tubing. In the lower end of this, is placed the lower valve, or standing box, as it is termed. The working barrel is then screwed to the first joint of pipe by means of a sleeve or thimble, such as attaches the sections of tubing together.


PACKING ROOM.

The swivel is now screwed into the other end of the joint of tubing, the tackle blocks being suspended in the derrick. The hook of the lower block is attached to the swivel, and by means of the rope, the whole is suspended over the well and let down into it until the derrick floor is reached. The clamps are placed across the mouth of the driving pipe under the thimble at the end of the joint, fitting closely and secured by a ring at the end of the handles. The swivel is then taken out by the pipe tongs, another joint or section of tubing is attached and lowered as at first. This process is repeated until the amount required is in the well, being held securely by the clamps, as before described. The tubing is put down various depths, usually to or near the bottom of the well. All practical drillers keep a record, of the rock passed through (sand, pebble, or slate) which is done by preserving a portion of each sand-pumping, and of its thickness and relative hardness, shown by the drillings. This record is essentially necessary in order to determine the proper place for fastening the seed bag. The seed bag is placed upon the tubing so as to come at the depth necessary to cut off the surface water, as well as the heavier veins below from the oil veins further down. The depth generally required, being at the first sandrock, averages from 150 to 350 feet. This seed bag is of stout leather, made to about fit the bore of the well, and is from four to six feet in length. The tubing is passed through the seed bag, the lower end of which is fastened at the proper place on the tubing by lashing it with a stout cord. It is then filled with flax seed, pressed in, to a trifle less than the exact bore of the well, lashed fast at the upper end, and lowered into the well to the desired depth with the tubing. The flax seed swells in a few hours, closing the hole effectually when properly arranged, so that water cannot pass down, nor the gas and oil up beyond it. This important appliance is used for the double purpose of shutting off the surface water from the oil veins below, when the well is pumping or flowing, and to force the current of oil and gas up through the tubing to the surface.


CONDENSERS.

In pumping or testing a well, what are called sucker rods are used. These are of wood, about an inch in diameter, and twenty feet in length. Ash and hickory are the kind in general use. The sucker or working valve is attached to the end of one of these, each end of the rod being fitted with a screw thread and thimble alternating, the same fitting on in the form of a socket and lowered into the tubing. The rods are lowered one after another until the valve goes into the working barrel. The attachment is then made to the working beam by means of a rod passing through a stuffing box, fitted on the end of the tubing, above the driving pipe. When these arrangements have been completed, the pump is ready to operate, which is done by the machinery in the same manner as in drilling. The process of "casing" the wells is now in general use. This is done by putting three and one quarter inch artesian tubing in the well to the first sand rock, and placing the seed bag at or near the same. The two inch tubing is then put on the inside of the casing without a seed bag, and can be taken up without danger of flooding out the well with the surface water, as in the old way, by turning the seed bag every time the tubing requires moving.

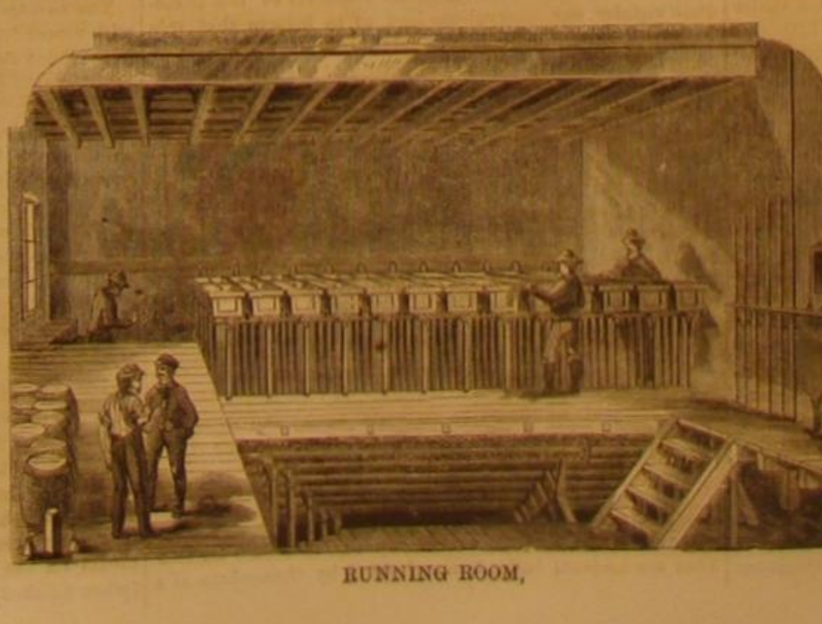

BLEACHING PANS.

In early days, the conductor was made of heavy plank or a log of wood bored out like a pump log, the excavation having been made previously to the rock, or as far as the water would permit, by digging a well hole. The iron driving pipe now used is not only more economical, but insures greater accuracy in drilling. The tools and general machinery now in use are of a heavier description than those formerly used, in consequence of drilling deeper wells, insuring greater rapidity. The drilling of an oil well was formerly a labor of months. Now a well can be drilled and tested in from twenty to thirty days.

Very many improvements have been invented and applied to boring for oil, which have facilitated but have not superseded the old system which is, in its essential features, still retained as described above. Improvements have been made, some of which have proved very successful, in restoring the flow of oil from wells that had ceased to yield or from which the flow had become much reduced. These latter consist mainly of devices whereby powder, nitro-glycerin, or other explosives may be fired after their introduction into the wells, thus re-opening obstructed crevices and forming new fissures.

STRIKING OIL.

In earlier years, when flowing wells were struck, the tools were thrown out of the well to a great hight upon the penetration of the gas and oil crevice below, and a volume of gas and oil, the full size of the aperture, was forced up to a hight of fifty or more feet, creating a shock, with its first escape, similar to an earthquake, bursting forth with a roar like the 'scape pipe of a steamer, covering whole acres with its greasy flood. This frequently continued for several days, and sometimes for weeks, the force of the gas being so great as to prevent the workmen from tubing the well. In such cases, trenches were frequently made for the oil to run into, and the oil dipped out of these into barrels, boats, or other suitable vessels. In many cases, the gas and oil give indication by bubbling up through and out at the end of the conducting pipe; while many others, among which have been some of the best paying wells ever drilled, exhibited no sign until after they were tested. After the tubing is completed, in the manner before described, the pump is put down, a suitable tank or tanks for receiving the oil having been previously built within a convenient distance of the well. The size of these tanks, which are made of pine planks, cylindrical in shape and stoutly hooped with iron, varies, according to the necessity of the case, from 150 to 1,200 barrels. Connection is made with these by means of a pipe attached to the mouth of the stuffing box.


RUNNING ROOM.

The well is generally full of water below the seed bag, from the surface water and veins above or the salt water below. The pump is set to work to pump this off, as also to clear out the well. This operation is called "testing." When the water is thoroughly exhausted, oil generally makes its appearance, in large or small quantities according as fortune has favored the operator The depth to which a well is drilled is generally regulated by the depth of the producing wells in the immediate vicinity, and sometimes by the "show," as it is called, of the oil in the well. It is usual to sink the well several feet below the oil vein, in order to prepare a suitable receptacle for sand, gravel, and particles of earthy matter that fall from the sides of the well, thus preventing the closing up or clogging the oil vein from such causes. The trite old saw, "all signs fail in dry weather," is amply verified by the frequent experience of the operator at this stage of the proceeding. The presence of oil and gas in fair quantity in the well does not necessarily insure a remunerative result. The veins may be small and soon exhausted. The lack of any such indication is not proof that success will not ensue. The oil may be held back by the dense column of water upon it; and when it is freed from this, it may respond liberally to the strokes of the pump, or even flow out abundantly without its aid. The testing process is continued until the water is exhausted, and the oil makes its appearance. Where wells are cased, as before described, and the seed bag perfectly tight, it may be a work of only a few hours or a few days. Where casing is not practised, the duration of the testing generally, though not invariably, occupies weeks and even months of incessant labor, and after all, perhaps, results in abandonment. But few operators continue to test beyond a month, unless the "show" of oil is very good. A few inches of rock, or other trifling obstacle, may intervene between the operator and princely affluence. If the oil gushes forth copiously, after due testing, the operator so fortunate becomes possessed of competence at least, and not unfrequently ample fortune. In case of failure, the reverse, financial loss or even ruin, is equally probable.

TRANSPORTATION OF PETROLEUM.

The crude petroleum is conveyed to the refineries, for the most part in large tanks placed on oil cars. As it reaches the refiners, it consists of a mixture of hydrocarbons, or chemical compounds of hydrogen and carbon, varying greatly in density and volatility, yet having many points of similarity. All are combustible, yet their igniting temperatures vary nearly or quite as much as their boiling points.

Constitution of American petroleum: Pelouze and Cahours have studied the Pennsylvania oil and find that it consists essentially of homologues of marsh gas, the lowest term of the series obtained being hydruret of butyl, C_8H_{10}, which boils at a little above 0° C., while the highest term yet studied is $C_{36}H_{32}$. The authors have obtained from these hydrurets the corresponding chlorids and in many cases the alcohols. They consider it probable that paraffin is a mixture of still higher terms in the series. Similar results have been obtained by Schorlemmer, who, however, finds benzol and toluol in the American oils, while Pelouze and Cahours explicitly deny the presence of these substances.

ORIGIN OF PETROLEUM.

In Silliman's "Journal," for July, 1866, is an article on "Petroleum and its Geological Relations," by Professor E. B. Andrews, of Marietta, Ohio, from which we make the following extracts: "Of the origin of petroleum, there are different opinions. All agree, however, that it must ultimately be traced to vegetable or animal substances, the primary combinations of hydrogen and carbon being the product of vital force. It is the opinion of Dr. J. S. Newberry and others that petroleum in its present form is the product of a slow distillation of bituminous strata. From this theory, Mr. T. S. Hunt, of the Canada Survey, in the 'Geology of Canada,' p. 526, dissents, and quotes approvingly the views of Mr. Wall, who investigated the bitumens of Trinidad, and who writes that the bitumen 'has undergone a special mineralization, producing a bituminous matter instead of coal or lignite. This operation is not attributable to heat nor of the nature of a distillation, but is due to chemical reactions at the ordinary temperature and under the normal conditions of climate.' It would appear to be Mr. Hunt's opinion that the bitumens, of which petroleum is the liquid form, are the product of chemical reactions changing the original organic materials directly into oil and kindred hydrocarbons. * * * There is no doubt that, at the original bitumenization of organic matter, vast quantities of bitumen were formed. The greater portion of this was absorbed by the sediments which now constitute bituminous strata For example, the black shales of the Ohio Devonian rocks are two hundred and fifty feet thick, and in them the bitumen is uniformly distributed throughout the whole mass. This distribution would imply that the bitumen was once in such a state of fluidity as to allow it to diffuse itself. * * * All the oil that I have ever seen, except very insignificant quantities in isolated cavities in fossiliferous limestones, has evidently strayed far from its place of origin. It is seldom, indeed, that we find any oil in juxtaposition with bituminous strata of any kind. It is more often found in fissures in sand rocks, rocks in which no oil could ever have been generated; for whatever organic matter they might have contained was too much exposed to atmospheric oxygen to admit of the possibility of any bitumenization. It is not only impossible that the oil could have originated in these sand rocks, or in the arenaceous shales which underlie them in western Pennsylvania, but it is most probable that the oil ascended from the still lower rocks, in the form of vapor which condensed in the superior cavities. In other words, the oil which, according to the theory, was formed far below in the original bitumenization of organic matter, must have undergone a process of distillation.

"In favor of the other theory, that petroleum, as now generally found, is the product of a distillation of bituminous shales, etc., as suggested by Dr. Newberry and others, the following arguments may be urged: 1. Oil may be artificially produced by distilling such shales and other bituminous materials. * * * 2. The phenomena of oil and gas exhibited in our oil fields greatly resemble those observed in the artificial distillation of oil from bituminous materials. * * * It is believed that some petroleum has been actually produced in the earth by distillation. * * * 4. There is an abundance of oil-making material in the earth. * * * 5. A comparatively low temperature is believed to be adequate to set free the oil vapors. 6. By this theory, there might be produced an almost indefinite quantity of petroleum, since bituminous strata are found widely distributed. * * * Finally, the agency which would volatilize the liquid bitumen, or petroleum formed by direct bitumenization, and bring it up and distribute it through the present oil horizons, would certainly be adequate to distil the bituminous shales, etc., and bring up the oil to the same elevations.

It may, however, be objected that, if this theory of distillation be true, we ought somewhere to find the residuum, or debitumenized shales, etc., remaining after the oil had been extracted. Such discovery could not justly be expected in surface rocks, because, according to the theory, the heat agency would at best be small, and could be scarcely felt near the surface. The question, then, would be reduced to this, namely: Do the borings in deep wells ever show that the deep, bituminous strata have lost any of their original and normal quantity of bitumen?"

After presenting some facts bearing upon this point, he concludes as follows: "Such facts are not conclusive as to any positive loss of bitumen, but they are not without significance. Should I find many similar cases where strata which are highly bituminous at their outcrop are found to contain little bitumen at great depths, and, at the same time, the rocks above these buried strata containing in their fissures much oil, I think the inference, that the oil was derived from the bituminous shales, not unwarranted."

PRODUCTS OF PETROLEUM.

The products of petroleum which can be obtained by fractional distillation, in connection with other processes employed in rectification, are very numerous; but the more important are the heavy lubricating oils and kerosene oil. A lighter product, called gasoline, is used for illumination in various machines devised for the purpose. Naphtha is largely used, for the adulteration of kerosene oils, by unprincipled retailers. A product called chymogene, still lighter and more volatile than gasoline, has been utilized by Professor Vander Weyde in his ice machine. A great variety of names has been originated to characterize the products obtainable from petroleum, some of which are mentioned below, but their discussion in this place would not enlighten the general reader.

REFINING PETROLEUM, AND SEPARATION OF ITS PRODUCTS.

The crude petroleum is first put into stills and, the fires being started, a light product comes over, consisting of a mixture of substances, to which the general name of naphtha is given. The next product is called burning oil. Then follows a small quantity of paraffin oil, leaving a residuum of tar and coke in the stills. The distillates are next treated with sulphuric acid to bleach and deodorize them. The bulk of the acid is then washed out with cold water. What remains is neutralized with caustic soda, supplemented with a little ammonia.

This brief general description of the process of oil refining gives the reader but a meager idea of the magnitude of some of the works engaged in this business, or of the details of the operation. To give a just conception of the vastness of the petroleum industry in this country, we have prepared elaborate engravings of the celebrated

PRATT'S ASTRAL OIL WORKS

located in Williamsburg, N. Y., (Brooklyn, East District,) which is one of the largest of its kind in the United States, and which does an enormous export business in addition to its large domestic trade, in which the article known as Astral Oil figures largely and is justly esteemed as one of the safest and best kinds of kerosene sold in the American market. This establishment is a model in its way. Every appliance that the best engineering skill could supply has been made available to ensure economy, safety and convenience, in the prosecution of the business; and although it has been alleged that the works are obnoxious to the residents of the immediate vicinity, our observations lead us to believe that this allegation has no foundation in fact. Indeed, after a thorough investigation, the Board of Health of the City of Brooklyn dismissed this complaint as unwarranted The odors which are perceptible are not in any way injurious, nor nearly as unpleasant as those emanating from the adjacent gas works; while in point of safety, it is scarcely conceivable that, with the perfect arrangements for the prevention and extinguishing of fires, any disastrous conflagration can take place.

The oil is brought from railroad *termini* in large barges constructed for the purpose, each of which is fitted with a large tank to hold 1,200 barrels. When it arrives at the docks, as shown in the bird's-eye view which is the first of our illustrations, it is pumped through pipes into the receiving tanks.

THE PIPES

are each eight inches internal diameter, and 450 feet in length They are laid, as shown, in an open ditch, the principal reason for which is that, in case any leak should occur, it can be at once discovered and stopped.

THE RECEIVING TANKS,

which form the subject of one of our engravings, are enormous structures having a united capacity of 23,000 barrels. They are made of boiler iron and stand by themselves at a distance from other parts of the works, but are connected with the latter by pipes. In this way, the crude petroleum is kept confined and prevented from giving off its odor, and the danger of ignition is obviated.

THE PUMP ROOM

contains five large steam pumps placed as shown in one of the engravings. There is one for water, one for crude oil, one for distillate and one for refined oil. The fifth is an air pump, used for agitating the oil during treatment. These pumps in their combined capacity are capable of throwing 3,000 barrels an hour. There is also another large pump on the dock for refined oil and general purposes. These pumps are arranged so as to act almost instantly as fire engines, and, through a system of piping, to flood any part of the works in which a fire may originate.

The office of the crude oil receivers is to separate the water from the petroleum before the latter is conveyed to

THE STILLS.

Four of the stills are thirty feet long and fourteen feet in diameter. Six of them are ten feet long and six feet in diameter. The stills convert the oil into vapor which passes into a condensing apparatus, shown in the engraving entitled "Condensers." This apparatus consists of a box eighty feet long, sixteen feet wide and eight feet deep, filled with coiled pipe constantly cooled by running water. The object of this distillation is to separate the volatile constituents from all solid and foreign matters. The distillation is commenced at 120° F. which carries off all the products capable of evaporation at that temperature; the temperature is then steadily raised till it finally reaches about 1,000° F. which drives over all except the solid *residua*. The distillate passes from the condensers to the

RUNNING ROOM

which is also shown in one of our engravings. The distillate, as it runs from the worm, appears by reflected light a beautiful French ultramarine color, but by transmitted light it has a slightly opalescent white tint. The running room is of much importance, as it is here that the progress of the work is noted, the specific gravity of the distillate is determined, and the separations are made.

There are four 500 barrel distillate tanks and two having a capacity of 1,000 barrels, to which the distillate flows from the running room. By proper connections, the stills can be connected with either of these tanks as may be necessary or convenient. From the distillate tanks, the distillate is pumped to the

AGITATOR.

In this apparatus, the oil is treated with one and one half per cent of sulphuric acid, by which it is bleached. It is then washed with a solution of caustic soda, followed by a little ammonia, by which the acid is neutralized; after which it is run into the

BLEACHING AND SETTLING PANS,

shown in one of the engravings, each of which contains 700 barrels. From the settling pans, the oil is pumped to a receiving tank having a capacity of 4,000 barrels. From this tank, it passes to the

PACKING HOUSE,

placed at some distance from the other buildings and near the shipping dock. An interior view of this building has been furnished by our artist. The oil is carried into this building in pipes, where it is measured out, through an ingenious filling apparatus, into the cans which are to receive it, the cans being filled nearly as fast as they can be passed along by the workmen. The filling apparatus is shown in the center of the background of the packing room; and, when fully employed, a dozen or more men can work at it, receiving empty cans from others as they are brought from the tin shop, and, when they are filled, passing them along to other workmen who as quickly seal them hermetically with solder. They are then packed in wooden cases, ordinarily two in a case. In such packages, the cans are passed to the

SHIPPING DOCK,

of which also our artist has provided an excellent view. At the time of our visit to the works, two large vessels lay there, taking in cargoes of oil. One of these vessels was destined to the Mediterranean, and the other was bound first to Odessa and thence to Beyrout.

The various shops connected with the works are supplied with power from two 60 horse power boilers, made at the West Point Foundery. Among these shops, we may mention first the

TIN SHOP

in which the cans are made with a rapidity truly astonishing. All the work, including the soldering, is done with improved machinery and appliances, by which the operation of can making proceeds with the utmost facility, the cans being sent as made on an endless belt directly to the packing room.

The absolute time consumed in making a can, filling it with oil, and sealing, is two minutes, the cost of the labor not exceeding two cents.

There is also the

FAUCET SHOP,

where the patent taps and faucets, one of which is shown in one of our engravings, are made. This tap and faucet is an improvement for which all consumers may be thankful. When the center of the metallic seal is cut into, the consumer finds underneath it a small nozzle, which he adjusts to the tube of the faucet. At the time our artist was there, they were arranging to make a faucet possessing improvements on the one illustrated; which it is claimed will be (when finished) the most perfect appliance for emptying cans ever known. The object aimed at is to produce a faucet that can be attached to the can without exposing it to breakage by rough handling, which will not require an enlarged case (which would increase the cost of transportation), and further to enable the consumer, having once used the can, to refill it with other fluids for use again. All this must, of course, be done at the least possible cost.

They were unwilling to offer it for illustration or description at this time, but, if our opinion is of any value, its efficiency for the use intended is perfect.

TESTING THE OIL.

The safety of illuminating oils and their commercial value are determined by what is called the fire test.

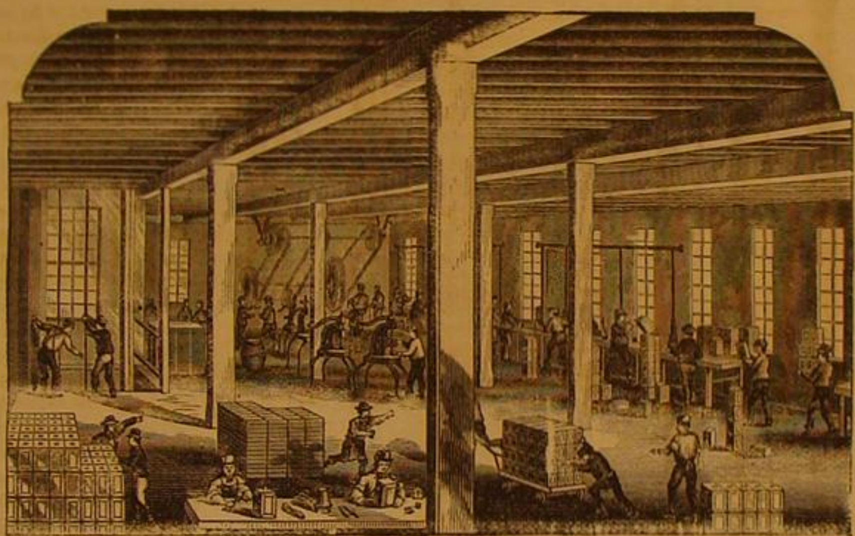
A portion of the oil is put into a glass cup, which is placed in a water bath, heated by a small lamp. From a bent standard a thermometer depends, so that its bulb is placed in the oil to be tested. As the temperature of the specimen rises, a lighted taper is frequently passed over and near to its surface, until vapor d'stils from the liquid and ignites. The temperature at which this takes place is carefully noted, and is termed the fire test. The oil is disposed of to the trader accordingly, and it is obvious that as the flashing point is higher, the safer is the oil. Oils which do not flash below 110° Fah. may, in general, be considered as safe for lighting purposes. The Astral oil, for which these works are celebrated, has a flashing point of about 150°.

LOADING VESSELS WITH CANS.

WHY CANS ARE USED.

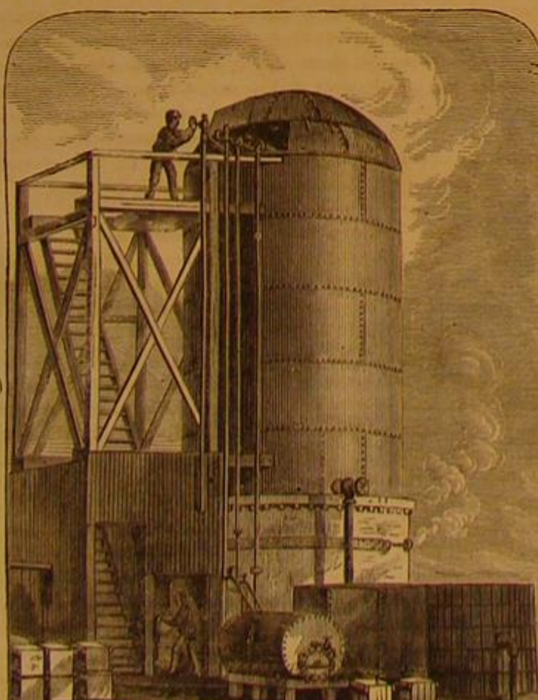
Cans are used to promote convenience in handling, to decrease fire risk in storage and transportation, and to insure the consumer in getting a safe article. The cans being sealed, he is enabled to determine whether the package has been tampered with or not. Every article put in the cans is warranted to be exactly as represented. The Astral oil, being designed for general lighting purposes, may be fully relied on as safe and good whenever the seals show that they have not been meddled with.

FAUCET.



TIN SHOP.

CAN.



AGITATOR.

Each seal has upon it the inscription "Pratt's Astral Oil." The

AMOUNT OF TIN PLATE USED,

in the manufacture of cans at these works, is forty thousand boxes per annum, yet the canned products are less than 50 per cent of the entire production. There is also consumed annually 125 tuns of solder. The other products are put up in barrels prepared in

THE COOPERAGE,

which is shown in one of our engravings. The barrels are not made here, however, the work of the cooperage being to fit them for holding petroleum products. They are painted on the outside, a tun of paint per week being consumed for this purpose. To render the wood impervious, the barrels are coated interiorly with glue. A strong and hot glue size is poured into the barrels, and the bung is inserted. The barrels are then rolled about so as to bring the glue into contact with every portion. The air becoming heated generates pressure, so that, by tapping the bung loose, the latter is projected with considerable force. The barrels are then placed on long frames over troughs which collect the dripping glue. One half a tun of glue is thus weekly consumed.

This is the largest manufactory of gasoline in the world, and it makes a greater specialty of the light products of petroleum than any other. Gasoline is used in gas machines, for extracting oils from linseed cotton seed, and the extractive principle from hops, etc.

OTHER LIGHT PRODUCTS

are chymogene, for use in ice making, and rhigolene, for anæsthetic purposes in surgery. Benzine is prepared for varnish makers, japanners, patent leather and oil cloth manufacturers, special articles in the rubber manufacture, and also a refined deodorized and perfumed benzine for the extraction of grease from clothing, etc.

EXTENT OF THE WORKS, ETC.

The works occupy 110 city lots (2,500 feet in a lot), or from 6 to 7 acres, with about a quarter of a mile of water front.

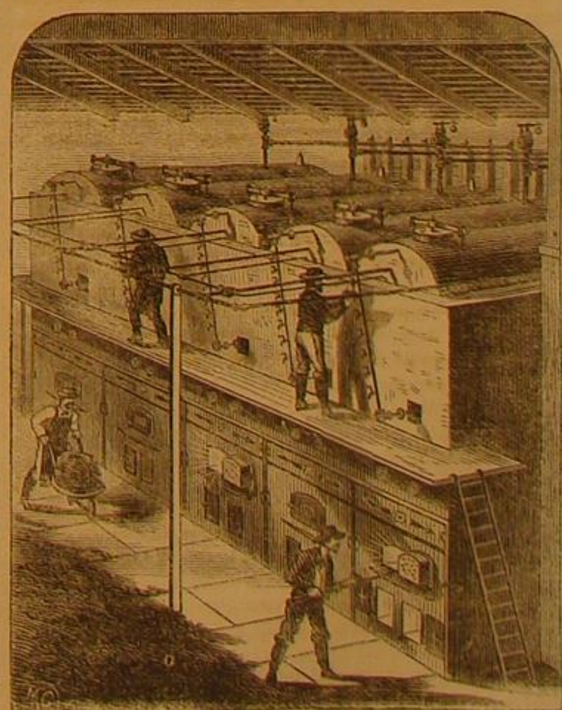
Facilities are possessed for handling 25,000,000 gallons of petroleum products per annum. There are in the works about three miles of pipes. The amount of sulphuric acid employed is from 6,000 to 7,000 lbs. daily. The amount of soda and ammonia consumed is 1,000 pounds of the first and 2,000 of the second weekly. The number of men employed in all departments is between two and three hundred. The establishment constantly employs about ten trucks, ten to twelve lighters, and two steam tugs, in moving goods to and from the works. The export trade is about three fourths the entire business of the works.

Among the safe oils we repeat that Pratt & Co.'s Astral oil ranks as one of the best in market. We have used it and experimented with it, and speak whereof we know. There are also other good oils in market, but the extent to which unsafe illuminating fluids are palmed off on a gullible public is a standing disgrace to the administration of justice in this country.

When we recall that, in 1861, this business had scarcely had its beginning, its enormous extension cannot fail to strike the mind of the reader with astonishment. The supplies being seemingly inexhaustible, a still larger growth may confidently be predicted. As it is, petroleum is one of the greatest sources of our mineral wealth, and its introduction as a lighting material has been an inestimable boon to mankind. Those who would wilfully lessen the benefits of this truly magnificent discovery by fraudulently selling unsafe oils to innocent buyers, ought to have the severest penalties meted out to them, while those who furnish only safe oils should be made known to the public.

THE SCIENTIFIC AMERICAN has frequently, during the last few months, published easily performed experimental tests for ascertaining the inflammability of kerosene oils, and by the adoption of these, every consumer is enabled either to justify the claims of the manufacturer of the oil, or to protect his life and his household from destruction. By using such tests, the dangers of many burning oils will be avoided, and the superiority of a pure safe article, such as the Astral oil, will be made evident, to the satisfaction of the purchaser.

The daily journals are constantly giving accounts of lamentable accidents from the use of low quality oils which ought never to have been sold; and the fact that these fluids are recklessly handled by careless and ignorant people gives additional importance and value to a safe and genuine article,



STILLS.

GENERAL STATISTICS.

To show the importance of the petroleum industry, we append a few statistics of the quantities of the oil shipped from New York, Boston, Philadelphia, Baltimore, Portland, and Cleveland, which are the cities whence foreign shipments are principally made.

FROM	CRUDE.	REFIN'D.	NAPHTHA.	TOTAL. 1870.	1869.	1868.
New York....galls.	7,994,418	74,855,397	4,717,484	87,667,299	65,933,690	52,803,302
Boston...........	25,127	1,559,479	205,665	1,790,271	2,117,939	2,410,114
Philadelphia.......	3,339,795	45,669,838	850,103	49,859,736	33,445,532	40,505,620
Baltimore..........	179,042	1,552,279	....	1,731,321	1,251,423	2,587,707
Portland...........	....	....	....	....	....	205,107
Cleveland..........	....	139,528	....	139,528	....	270,000
Total........galls.	11,538,382	125,996,521	5,773,252	141,208,155	102,748,604	99,281,750
Equal to bbls. of 40 galls..........	288,459	3,097,413	144,331	3,530,204	2,568,715	2,842,044

The following shows, in barrels, the daily average product of the Pennsylvania oil district, during the year:

	1867.	1868.	1869.	1870.
January		9,700	10,192	12,624
February		9,300	9,967	11,917
March		8,621	9,801	12,385
April		8,537	11,067	12,974
May		9,790	10,153	14,165
June		10,102	11,334	14,817
July		10,698	11,607	15,969
August		11,961	12,157	17,777
September	9,700	11,083	12,645	19,489
October	9,600	10,153	13,071	20,158
November	9,800	10,275	13,317	18,012
December	10,400	9,737	12,844	15,214

Total production in December, 31 days, 1870.................471,657
Total production same month, 1869.................398,186

BORING FOR OIL.

The following description of tools and methods employed in boring for oil in Pennsylvania is extracted from Blake's "Notices of Mining Machinery":

The great advance has been in the construction of the tools, and in the adoption of simple apparatus for giving motion to the drill by means of steam power. For prospecting and for sinking to moderate depths, the spring pole, worked by hand, is frequently employed.

The constructions in common use in Pennsylvania at the oil wells, and used for a time during the oil excitement in California, consist of a derrick, bull wheel, band wheel, sampson post, and walking beam, and a portable steam engine.

The derricks are usually constructed of plank and boards, when they can be obtained, or of unhewn poles. They rise to a hight of 50 or 60 feet, and taper upwards from a base about 15 feet square. The standards are of 2 inch plank, 8 inches wide, and the cross braces 8 inches wide and 1 inch thick. The tools are suspended by the cable, which, passing over the pulley at the top, descends at the side and is wound upon the drum of the bull wheel, the shaft of which rests on bearings in the standards. The drum of the bull wheel is about 10 inches in diameter.

The walking beam, of wood, 26 feet long, is supported at the center, upon the top of the sampson post. One end is connected, by a pitman, with a crank of 22 inches radius upon the end of a shaft, receiving motion by a belt from the engine; the other end, projecting within the derrick and directly over the well, carries suspended the temper screw to which is attached a clamp for seizing upon the rope. The rotation of the crank shaft gives a reciprocating motion to the end of the beam, and this is imparted to the rope, carrying the tools at its lower end.

The form of the temper screw is shown by the gure. By this, the drill may be lowered or "fed out" to a certain extent during the progress of boring. The rope is seized and held fast by the clamp, and when the whole length of the screw is fed out, the position of the clamp is changed.

The drilling tools consist of centerbits, reamers, an auger stem, sinker bar, and the "jar," besides a socket for attaching them to the lower end of the rope, and wrenches and other accessories to aid in attaching and unscrewing the bits. There are, besides, a variety of tools for recovering broken bits or other parts of the apparatus lost in the well, and sand pumps for removing the *débris*.

The bits are represented by the annexed cuts. They are 3½ inches broad on the face, and the reamers are 4½ inches. They are made, however, of various sizes, and all have strong, square shanks, so that they may be firmly screwed into the auger stem, made of 2¼ inch iron and 20 feet long.

The "jar" is a contrivance by which the auger stem and bit are, in a measure, detached from the rope. By it a jerk may be given upwards, to loosen the bit in case it is wedged in the hole, while the same device serves to give a blow downwards upon the auger, after the bit strikes the bottom, thus doubling the efficiency of each stroke. It serves, also, to maintain the tension of the rope. These jaws are made of 1½ inch iron on the sides, with 12 inch heads and 18 inch stroke.

The sinker bar, 10 feet long, is attached by a screw to the upper end of the jar, and above this is the rope socket, securely united, by means of rivets, to the end of the rope.

The bits and other parts of the drilling tools are connected and disconnected by means of two large wrenches, 3 feet 9 inches long, with broad flat heads, shaped as shown in the figures.

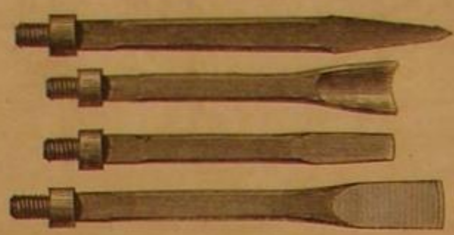
The drilling ropes or cables vary from 1½ inch to 1¾ inch diameter, and weigh from 48 pounds to 86 pounds per 100 feet.

The sand pumps, of sheet or galvanized iron, or of copper, are about five feet long and 3 or 4 inches in diameter, and are fitted with leather valves resting upon iron seats, as indicated at the lower end of the figure.

The steam engines in use are portable, and 8 or 10 horse power. A 900 feet well can be drilled with an 8 horse power engine. Rope for a well 900 feet deep, with the tools, will weigh about 800 pounds.

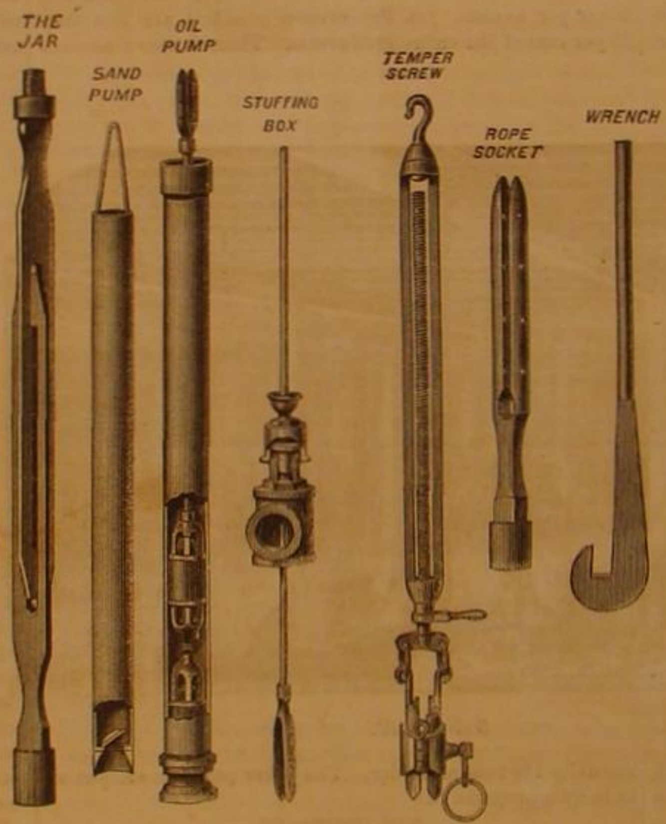
Before commencing to drill, it is usual to drive down a cast iron pipe through the loose soil until the firm bed rock is reached. These pipes are in lengths of 8 feet and 5 or 6 inches in diameter. They are joined together, end to end, by means of wrought iron bands, sized to shrink on to a shoulder turned upon each end of the pipe in a lathe, so that a flush joint is formed by the band. The lower end is made

BITS AND REAMER FOR DRILLING



sharp, and the band is edged with steel. The 5 inch lengths weigh 55 pounds per foot, or 440 pounds in all; and the 6 inch, 69 pounds per foot, or 552 pounds per length. For lining the wells, wrought iron tubing is used, made with screws and sockets, or with flush joints, but always smooth finished inside. The sizes vary for the light kinds from 1½ to 4 inches for the inside diameter, and from 1·66 pounds to 6 pounds per foot. The heavier tubing ranges from 1½ inches in diameter, and 2·70 pounds per foot, to 6 inches, weighing 18·7 pounds per foot. These large sizes are seldom used for oil wells.

Pumps are made of wrought iron pipe, lined with heavy seamless brass tubes bored perfectly true, or of heavy brass



tube alone. One of the last mentioned construction, 5 feet long, is shown by the annexed figure, in which a portion of the interior is seen with the two valves and boxes. These valves are made of gun metal, and are fitted with great care. The packing is made of the best oak-tanned leather. Ball valves are generally used.

At the top of the well a stuffing box and elbow pipe is fitted. The construction of this box and the form of the joint for attaching to the sucker rods is shown in the figure. The stuffing is kept in place, and is pressed firmly upon the plunger rod or piston by means of the follower, made of brass. The plunger rods are 5 feet long, are made of 1 inch diameter cold rolled iron, and are perfectly polished.

One other important adjunct of a complete oil well is the seed bag, the use of which is to form a water tight joint or packing around the tube or lining of the well, and thus shut off all communication between the water of the upper strata and the oil bearing crevices or chambers below.

This bag is made of leather, and is filled with flax seed. It is put around the tube, and is pushed down to the proper place, and soon becomes so much swollen by the absorption of water that it fills the space between the tube and the walls perfectly, and thus shuts off all communication around the tubing, for either water or oil from above or below.

Petroleum yields, by distillation, nine distinct commercial products.

Name.	Specific Gravity.	Beaumé Scale.	Boiling Point.
Rhigolene	625		65° F.
Gasolene	665	85	120°
C. Naphtha	706	70	180°
B. Naphtha	724	67	220°
A. Naphtha	742	65	300°
Kerosene Oil	804	45	350°
Mineral Sperm Oil	847	36	425°
Neutral Lubricating Oil	883	29	575°
Paraffin	848(?)		

Naphtha in Gas Lighting.

Among the novel uses for naphtha, which is so successfully produced at the Pratt Oil Works, is the improvement of common gas light.

The history of this new system of lighting is as follows: About three years ago Dr. Leonard Gale and A. C. Rand, an extensive oil merchant and refiner, invented this process for at once utilizing the otherwise dangerous naphtha and supplying a cheaper and better gas. It has been in use for six months in South Brooklyn by the Citizens' Gas Light Company, who have had two "benches" (series of ovens containing retorts) in use with good success, and are getting more benches ready. The system has also been in operation for six months in Columbus, O., and is now being established in Detroit.

An interesting report concerning this gas has just been made by T. G. Wormley, State Gas Commissioner of Ohio, to the City Council of Columbus, O. The main points of his report are these: Examinations extending over a period of twelve days indicate that during that period the gas had an average illuminating power equal to 20·64 candles: that is, that the gas, when burned at the rate of five cubic feet per hour, gave on an average as much light as 20.64 sperm candles, each consuming 120 grains of sperm per hour. The statute relating to this subject fixes the illuminating power at twelve standard candles. The average of the sulphur found in the gas was 6·12. The averages in London, made at eight stations last year, ranged from 16·21 to 33·30 per 100 cubic feet of gas. The ammonia was scarcely noticeable at the Columbus works—8 100ths of a grain; carbonic acid gas, 60 100ths; vapor of water, 82·100ths; free oxygen gas, 90-100ths. These proportions of carbonic acid gas and vapor of water thus found were about the same or a little below the quantities usually present in illuminating gas, but the proportion of free oxygen was much above.

The works of the New York Mutual Gas Light Company, which gives promise of affecting very much for the better the interests of hundreds of thousands of our citizens, are well worthy of inspection. On the river side of the eight acres covered by the works are the coal sheds, capable of containing 30,000 tuns of coal. On the Eleventh street side are the offices of the company and the coke yard. On the Avenue D side are the four great gas holders, already completed, and capable of containing 265,000 cubic feet each. On Thirteenth street are the foundations of three more gas holders and the naphtha reservoir. The latter is made of half inch boiler iron, fastened with hot rivets, and is steam proof. In the center are the purifying and retort houses.

The process by which naphtha, usually so dangerous, is converted into as harmless an illuminating gas as that produced directly from coal, is as follows: The liquid naphtha flows from the reservoir to the retort house, where it is received in four stills, within which steam pipes are run in all directions. The effect of the heat from the steam pipes is to vaporize the naphtha. These stills are supplied with safety valves. The vaporized naphtha passes next to a row of clay retorts, forty eight in number, similar to those used for making ordinary coal gas, except that they are double. In the same building there are 240 retorts for making the coal gas that is to be mixed with the naphtha gas. The passage of the vaporized naphtha through and over the red hot retorts converts it into a permanent rich illuminating gas, the same as that from the best Australian cannel coal. It passes from the retorts to the building containing the condensers, thence to a large station meter in the office, and thence to the gas holders, where it first comes in contact and mixes with the common coal gas.

The gas contained in the coal has to pass through many more processes than that found in the naphtha; but as these processes have often been described, they need only be enumerated here. The coal is thrown into the retorts. The gas eliminated passes from these through a pipe to the building containing the condensers and a singular series of "scrubbers"—immense reservoirs wherein it comes in contact with falling water; thence to the purifiers—tanks where it is purified by chemical action—and thence to the station meter, preparatory to its mixture with the naphtha gas.

The Generation of Petroleum.

In the usually followed processes of manufacturing refined oil, the crude article yields three separate and different products—naphtha, kerosene, and residuum—a fact which certainly supports the belief that crude oil is the product of three different minerals. So far as concerns the contribution by coal of an integer in the chemical process, by which petroleum is produced in and from certain geological strata, it may be remarked that the "shale" oil produced from bituminous coal in England is very different from American petroleum, in that the American naphtha must be used in order that the latter may be burned in lamps. Another fact that favors the inference that petroleum is mainly produced from or generated through limestone, is that petroleum has been extracted from limestone found in the neighborhoods of Chicago and of Terre Haute, Ind. In regard to the reproductive powers recently developed, in the Pennsylvania territory believed to have been exhausted, it affords two favorable presumptions: First, as a partial assurance that the distillation of petroleum is a continuous process; and next, that the formerly abandoned territory was given up because the machinery for extracting petroleum from the earth exceeded, in its power of exhausting the fluid, the generative powers by which it is produced. These facts will be encouraging to the large number of persons whose livelihood is obtained by this important manufacture.