of gas lighting. For instance, a 4 ft. gas burner would be held to be ample for lighting a small bed-room, and such a burner is frequently permitted to remain burning all night in a room of, not to exceed, 800 cubic feet capacity. This burner, by the computation, would produce 2488 units of heat each hour. In moderate weather no considerable loss of heat from the surfaces enclosing the room is supposable, and the figures give 7200 cubic feet of air per hour (or 120 feet per minute) as the indispensable necessity to keep down the temperature to 19° above the normal one. To be sure, the current of gases ascending from the burner will reach the ceiling of the room at a greatly elevated temperature, perhaps 140° even, and a stratum of hot air next the ceiling be formed (unless some arrangement of ventilation removes the hot air at once), and then the conductivity of the ceiling will be brought into action, but yet it is hard to feel satisfied that this means is sufficient to account for all the loss of heat apparently demanded.

It must be admitted that further inquiry and experiment are wanted to elucidate the subject of the dispersal of heat of gas lights, and perhaps to review the entire subject of the quantity of heat produced by them.

THE OIL SANDS OF PENNSYLVANIA.¹

By CHAS. A. ASHBURNER, M. S., Asst. Second Geological Survey
of Pennsylvania.

The recent discussion among the producers, shippers and refiners of the petroleum of Pennsylvania, as to the advisability of the State Legislature passing a free pipe line law, which will permit the laying of pipes for the running of the crude material from the producing regions to the seaboard, has brought many points of interest, connected with one of the greatest industries of our State, before unnoticed, to the attention of the public.

One of the most important questions to the petroleum miner, and one which even the more enlightened of our oil men can answer only

¹ Paper read before the Engineers' Club of Philadelphia, Feb. 16th, 1878.

in a very vague and uncertain way, is, where is petroleum found? The question is an exceedingly broad one, and involves many considerations which cannot reasonably be noticed within the limits of a brief paper. The origin of petroleum, its connection with the sand in which it is found, the influence of the character of the oil sands on their productiveness, the relation of the surface rocks to the oil sands, and the bearing of surface indications upon the position of underlying oil belts, the connection between petroleum and natural gas, etc., are all vital questions which must be met before we can say where petroleum is found and where we may locate profitable wells.

I do not wish to anticipate any of the conclusions which our present Geological Survey may advance, to meet any or all of these questions which suggest themselves so pertinently to those interested in the petroleum industry, or express any views on the more important and practical question as to the position of producing territory, and the location of profitable wells. I have thought it would be of interest to the members of the Engineers' Club to give, in a general way, a vertical section of the rock formations, showing the relative position of all the oil horizons of Western Pennsylvania, together with an estimate of the daily production of each horizon.

That portion of the State in which petroleum has been found, lies entirely west of a line drawn across the State, from the State line at the southeastern corner of Greene County to the State line at the northeastern corner of McKean County.

For convenience of description, the oil regions may be divided into three groups or districts—the southwestern, the western and the northern.

The southwestern district may be said to include that part of the state south of the Ohio River, and west of the Monongahela River; the western, better known among the producers as the "lower country," lies in the water-basin of the Alleghany River, between Pittsburg, on the south, and the Philadelphia and Erie Railroad, on the north; and the third or northern district lies entirely north of the Philadelphia and Erie Railroad, in the counties of Warren and McKean, and extends ten miles into the State of New York.

The strata of Western Pennsylvania lie comparatively horizontal. The average dip of the rock from Bradford, near the State line, to Pittsburg, is about 18 ft. to the mile; that is, a rock which occurs at

water level at Bradford, at an elevation of 1450 ft. above ocean level, would be found at Pittsburg about 750 ft. below the same datum, or 1500 ft. below water level. Three thousand feet of the stratified rocks of the Carboniferous and Devonian Ages in Pennsylvania, have been found to contain petroleum. The highest stratum in which oil is found, occurs in the coal measures, 165 ft. below the Pittsburg coal seam, in Greene County; while the lowest occurs about 3200 ft. below the geological position of the Pittsburg coal seam in McKean County.

If we should drill a well in Greene County 3200 ft. deep, starting on the Pittsburg coal, we would pass through the horizon of all the sands and sandstones in which the petroleum of our State has been found.

This estimate is made on the assumption, that if the coal measures up to the Pittsburg seam should be restored in McKean County, the lowest oil-bearing rock in the northern district would be found the same depth below the Pittsburg coal, as the geological horizon of the same sand would be found below the same coal-bed in Greene County.

From observations in the western part of the State, we know that the rocks are subject to very marked and rapid changes in their thicknesses, in comparatively short distances. What the change in rock thickness may prove to be, between McKean and Greene Counties, we have not sufficient facts at hand to assert. Whether the total thickness of the stratified rocks between the Pittsburg coal and the "Sartwell" or lowest oil horizon, at localities between the two counties, shall be found to be a variable quantity, or much greater or much less than the above estimate, the fact, in itself, will not defeat the object of this paper, which is intended to point out the relative, and not the absolute, position of the oil sands one to another.

The petroleum, in the southwestern district, comes from the highest rocks; that in the northern, comes from the lowest; while the producing sands of the western district are found intermediate between the other two groups of rocks.

The southwestern district "oil-sand group" is about 800 feet thick, and is composed of three sandstone members, separated by intervals containing coal seams, slate and shale. The following is a general section of the group, by Prof. Stevenson:

1. Morgantown Sandstone, Dunkard Creek ; thickness, 66 ft.
Lower Barren Coal Measures, shales and slates ; thickness, 194 ft.
2. Mahoning Sandstone, Dunkard, Whiteley and Dunlap's Creeks ;
thickness, 50 ft.
Lower Productive Coal Measures ; thickness, 85 ft.
3. Piedmont Sandstone and Coal Conglomerate, Dunkard Creek ;
thickness, 400 ft.

The first or upper oil sandstone shows considerable variation, and is oftentimes replaced by shale. It is a noticeable fact that in this case the shale contains no oil.

The Mahoning or second sandstone is quite constant in thickness, and is the principal repository of petroleum in the southwestern district. It frequently contains conglomerate layers.

The third or lower sandstone is made up of three members, an upper and lower sandstone member, separated by about 30 to 40 ft. of shale and coal. The upper member is regarded as the oil-bearing rock. The lower member, or Piedmont Sandstone, is the representative of the coal conglomerate or millstone grit.

Some of the characteristics of this district are quite different from those of the western or northern districts. In drilling, small crevices in the oil sands are of frequent occurrence ; and it is a striking fact that the oil is said never to have been found except where a crevice was struck. The producers in this field have considered this fact necessary to the original production of oil itself.

According to Prof. Stevenson, the oil in nowise owes its origin to disturbance of strata, and the only effect of the disturbance has been to provide reservoirs for the oil in the rock already oil-bearing.

Between the bottom of the coal conglomerate, which is the lowest member of the lowest oil-producing sandstone of the southwestern district, and the "first oil sand," which is the highest producing sandstone of the western district, there is an interval of from 650 to 700 ft. of shales and sandstones, forming the Barren Oil Measures, or Mountain Sand group. These rocks are perfectly barren of any economical strata ; they contain no coal, iron or oil. In Butler County this group often contains gas.

The Greene County "oil sand group," and the upper part of the Barren Oil Measures, belong to the Carboniferous Age, while

the oil sands of the western and northern districts are Devonian rocks.

The following is a general section of the oil sands of the western district :

First sand,		40 ft. thick.
Interval,		105 ft.
Second sand,		25 ft. thick.
Interval,		110 ft.
Third sand,		35 ft. thick.
Total thickness of the group, . . .		<hr/> 315 ft.

All the oil from Clarion, Butler and Venango Counties, which comprise our most productive field, comes from this group, and from one of the representatives of the three sands. These sands are sometimes split up into several members, giving rise to what are known as the "fourth," "fifth," and "sixth" sands of Oil Creek.

The first sand produces a heavy lubricating oil from 30° to 35° gravity ; the second, an oil of about 40° gravity ; and the third sand, the usual light oil, from 45° to 50° gravity.

The third sand of this district is the most productive, and supplies most of the oil of commerce. According to Mr. Carll, assistant in the Oil Regions, "the well records along the 'green oil belt' in Venango County, show a great uniformity in the arrangement of the sand rocks. They are sharply defined, massive, and lie at regular intervals. Going southeast from this belt, they gradually split into several members, fine down in their composition, and shade away into shales. Going to the northwest, the third sand terminates rather abruptly—the second sand overlaps it, and continues a mile or two farther ; the first sand overlaps the second, and extends, in some places, a long distance beyond. The majority of the wells producing from the first and second sands, are located along these overlapping edges of the sand rocks.

"Wherever the third or lowest sand is adapted to the production of oil, the main deposit is found in it, and not in the sands above. The first and second sands, although of good quality, do not produce oil along the centre of the belt. In some wells, it is true, oil has

been obtained from all three of the sands. These wells are not on the axis, but near the edge of the third sand; and but a short distance further from the centre, no third sand can be found."

These are very suggestive facts, and seem to point to the conclusion that the oil sands are merely reservoirs, which have acted as sponges in absorbing the oil which has ascended from a much greater depth. The oil in this case would not be indigenous to the rock in which it is found.

If indigenous, why is the bulk of the "first sand oil" found in the edges of the first sand which overlap or extend beyond the edges of the second and third sands? The same question suggests itself in regard to the most productive portions of the second sand.

Between the "third oil sand" of the western district and the Warren sand of the northern district, there is an interval of about 600 ft. of shale, which is entirely barren. The Warren oil sand is very irregular in character, and the oil is found at horizons varying from 600 to 800 ft. below the Venango third sand.

The oil obtained from the Warren horizon resembles very much the "third sand oil."

Among many of the producers the oil is known as "slush oil," on account of the irregular and poor quality of the sand, and the rapid diminution in the production of the wells, which are large producers when first struck.

The productive horizon of the Bradford oil belt in McKean County and Cattaraugus County, New York, occurs probably 300 ft., more or less, below the Warren horizon. The sand in the Bradford belt is finer and closer in texture than that of any other producing belt in Pennsylvania; it is also more constant in character over a wide area. These facts have much to do with the small percentage of risk which the producer experiences in obtaining "dry holes," or non-producing wells. The Bradford belt is the surest and safest territory in which to operate.

Of the wells completed in November in the Butler, Parker and Clarion districts, 14.8 per cent. were "dry holes;" while in the Bradford district only 6.6 per cent. were "dry holes." This is more than the usual monthly average of "dry holes" in Bradford, on account of the great number of "wild cat" or test wells which were drilled.

The oil is of about the same gravity as the "third sand oil," but somewhat different in character. On account of the difference in the sand and in the oil, the Bradford wells are never pumped continuously, but "by heads," or at regular intervals. This is found necessary, in order to keep the sand open and porous. When the interstices of the sand become "choked" by the heavier parts of the oil, the sand is broken up and loosened by nitro-glycerine torpedoes, which are lowered to the depth of the producing sand and exploded.

A great deal of the oil obtained from the Bradford belt, along the State line, is found several hundred feet above the regular producing sand. The horizon of this oil may prove to be the same as the horizon of the Warren oil.

The lowest oil found in the northern district, and, in fact, in Pennsylvania, comes from what I have called the "Sartwell oil sand," which has but recently been discovered in Liberty Township, McKean County. This horizon is, probably, 400 ft. below the Bradford sand; it has not as yet been thoroughly tested; at present it is non-productive.

Petroleum has never been found in the three groups of oil measures in the same locality. As the oil sands of the southwestern and western district outcrop, or come to the surface, in the northern district, we may never expect to find oil in them north of the Philadelphia and Erie Railroad. The question as to whether we will ever find the northern district oil in the western district, and the oil of both of these districts in the southwestern district, is a very suggestive one. If our future explorations shall prove such to be the case, we are safe in the assertion that, at the present price of crude oil, the wells would be too deep and too expensive to warrant the development.

PRODUCTION.

I am unable to state how much petroleum is produced in the southwestern district. Quite extensive developments were made in Greene County last fall, and I am informed, on good authority, that one of the new wells was producing 50 barrels a day. No oil territory has yet been found in Washington County.

The following table shows the production in the western district, in November last:

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Name of Districts.	No. of bbls. of oil produced in the month.	Average per day for the month of 30 days.	No. of wells producing.	No. of wells drilling.	No. of wells completed in November.	Aggregate daily production of new wells.	Daily Average of new wells.	No. of Rigs building.	Dry holes in Nov.
Butler, . . . }	709170	23639	4470	275	209	2617	12½	159	31
Parker, . . . }									
Clarion, . . . }									
Scrubgrass, . .	120000	4000	275	10	12	162	13½	9	2
Franklin, . .	12000	400	370	10	6	42	7	7	2
Reno, . . .	3000	100	31	.....	.....	.....	.....	.....	.....
Oil City, . .	24000	800	365	10	5	32	6½	8	2
Rouseville, . .	12000	400	200	3	3	21	7	2	1
Rynd Farm, . .	12000	400	125	2	2	14	7	2	.....
Columbia, . .	3750	125	31	.....	.....	.....	.....	.....	.....
Petroleum Cr. .	3000	100	50	1	2	10	5	1	1
Shamburg, . .	6000	200	96	1	2	12	6	1	.....
Titusville, . .	45000	1500	768	10	10	80	8	9	3
Pithole, . . .	6000	200	78	2	2	6	3	2	1
Fagundas, . .	6000	200	150	1	4	16	4	1	2
Tidioute, . .	12000	400	83	5	6	42	7	4	2
Beaver, . . .	7500	250	144	12	4	20	5	3	1
Totals, . . .	981420	32714	7236	342	267	.....	.....	208	48

The following is the production, for the same month, in the northern district:

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Warren, . .	12000	400	122	5	4	28	7	3	1
Bradford, . .	180000	6000	965	218	120	1200	10	152	8
Totals, . .	192000	6400	1087	223	124	.....	.....	155	9

The total daily production for November, in the western and northern districts, was 39,114 barrels; in the month of October the same districts produced 40,946 barrels per day. This does not

necessarily show a decrease in the actual production; it is probably an error in the estimates.

The above figures were taken from the *Petroleum Reporter*. From reports made to me during the past week, the Warren district is said to be producing nearly 500 barrels, while the Bradford daily production approaches 8500 barrels. Of the Bradford production, about four-fifths come from the regular Bradford sand, and one-fifth from the higher horizons in the "slush oil" wells.

CRANK PINS AND JOURNALS.¹

By WILLIAM D. MARKS, Whitney Professor of Dynamical Engineering, University of Pennsylvania.

(15) THE CRANK PIN.—The crank pin has ever been one of the most troublesome parts of the steam engine to the mechanical engineer. The mere determination of its proportions, so that it will not break under the strain put upon it by the pressure of the steam upon the piston head, does not suffice, and often results in trouble from heating when the engine is at work. It therefore becomes a first consideration to so proportion crank pins as to prevent heating, their strength being a matter of secondary importance to be afterwards investigated, if it is deemed necessary to do it.

Before taking up the mathematical part of our consideration, it will be of practical value to quote, from the writings of General Morin, the following remarks:

"But it is proper to observe, that from the form itself of the rubbing body (cylindrical), the pressure is exerted upon a less extent of surface, according to the smallness of the diameter of the journal, and that unguents are more easily expelled with small than with large journals. This circumstance has a great influence upon the intensity of friction, and upon the value of its ratio to the pressure.

"The motion of rotation tends of itself to expel certain unguents, and to bring the surfaces to a simply unctuous state. The old mode of greasing, still used in many cases, consisted simply in turning on

¹ An extract from a course of lectures on "The Relative Proportions of the Steam Engine."