establish the petroleum industry, dispelling doubts
encouraging potential capitalists to invest their funds.

REPORT

ON THE

ROCK OIL, OR PETROLEUM,

FROM

VENANGO CO., PENNSYLVANIA,

WITH SPECIAL REFERENCE TO ITS USE FOR ILLUMINATION AND OTHER PURPOSES.

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NEW HAVEN:

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George H. Bissel and others, the report of which is appended by permission of Professor Silliman to this chapter rather than place it in the chronological order to be observed throughout this work:

MESSRS. EVELETH, BISSELL & REED,

Gentlemen,—

I herewith offer you the results of my somewhat extended researches upon the Rock Oil, or Petroleum, from Venango County, Pennsylvania, which you have requested me to examine with reference to its value for economical purposes.

Numerous localities, well known in different parts of the world, furnish an oily fluid exuding from the surface of the earth, sometimes alone in "tar springs," as they are called in the western United States; frequently it is found floating upon the surface of water in a thin film, with rainbow colors, or in dark globules, that may, by mechanical means, be separated from the fluid on which it swims.

In some places wells are sunk for the purpose of accumulating the product in a situation convenient for collection by pumping the water out. The oil exudes on the shores of lakes and lagoons, or rises from springs beneath the beds of rivers. Such are the springs of Baku, in Persia, and the wells of Amiano, in the duchy of Parma, in Italy. The usual geological position of the rocks furnishing this natural product, is in the coal measures—but it is by no means confined to this group of rocks, since it has been found in deposits much more recent, and also in those that are older—but in whatever deposits it may occur, it is uniformly regarded as a product of vegetable decomposition. Whether this decomposition has been effected by fermentation only, or by the aid of an elevated temperature, and distilled by heated vapor, is perhaps hardly settled.

It is interesting, however, in this connection to remember, that the distillation, at an elevated temperature, of certain black bituminous shales in England and France, has furnished large quantities of an oil having many points of resemblance with Naphtha, the name given to this colorless oil, which is the usual product of distilling Petroleum. The very high boiling point of most of the products of the distillation of the Rock Oil from Venango County, Pa., would seem to indicate that it was a pyrogenic (fire-produced) product.

Bitumen, Asphaltum, Mineral Pitch, Chapapote, &c., &c., are names variously given to the more or less hard, black resinous substance which is produced usually from the exposure of Petroleum to the air, and is found either with or without the fluid Naphtha or Petroleum. The most remarkable examples of the occurrence of these substances, so intimately connected with the history of Rock Oil, are the Lake Asphaltites of the Dead Sea, so memorable in history, the well-known Bitumen Lake of Trinidad, and the deposits of mineral pitch or Chapapote in Cuba. In one of the provinces of India, vast quantities of Petroleum are annually produced, the chief consumption being local, for fuel and lights, but a portion is also exported to Europe for the production of Naphtha. In the United States, many points on the Ohio and its tributaries, are noted as producing this oil; nearly all of them within the coal measures. A detailed history of these various localities can be found recorded in books of science, and their repetition here would be out of place.

General Character of the Crude Product.

The crude oil, as it is gathered on your lands, has a dark brown color, which, by reflected light, is greenish or bluish. It is thick even in warm weather—about as thick as thin molasses. In very cold weather it is somewhat more stiff, but can always be poured from a bottle even at 15° below zero. Its odor is strong and peculiar, and recalls to those who are familiar with it, the smell of Bitumen and Naphtha. Exposed for a long time to the air, it does not thicken or form a skin on its surface, and, in no sense, can it be called a drying oil. The density of the crude oil is .882, water being 1·000. It boils only at a very high temperature, and yet it begins to give off a vapor at a temperature not greatly above that of boiling water. It takes fire with some difficulty, and burns with an abundant smoky flame. It stains paper with the appearance of ordinary fat oils, and feels smooth and greasy between the fingers. It is frequently used in its crude state to lubricate coarse machinery. In chemical characters, it is entirely unlike the fat oils. Most of these characters are common to Petroleum from various places. In one important respect, however, the product of your lands differs from that obtained in other situations, that is, it does not, by continued exposure to the air, become hard and resinous like mineral pitch or bitumen. I have been informed by those who have visited the locality, that on the surface of the earth above the springs which furnish your oil, there is no crust or deposit of this sort such as I have seen in other situations where Petroleum or mineral tar is flowing. This difference will be seen to be of considerable importance, as it is understood and represented that this product exists in great abundance upon your property, that it can be gathered wherever a well is sunk in the soil, over a great number of acres, and that it is unfailing in its yield from year to year. The question naturally arises, of what value is it in the arts, and for what uses can it be employed? These researches answer these inquiries.

Examination of the Oil.

To determine what products might be obtained in the oil, a portion of it was submitted to fractional distillation.* The temperature of the fluid was constantly regulated by a thermometer, the heat being applied first by a water bath, and then by a bath of linseed oil. This experiment was founded upon the belief that the crude product contained several distinct oils, having different boiling points. The quantity of material used in this experiment, was 304 grammes. The thermometer indicated the degrees of the Centigrade scale, but, for convenience, the corresponding degrees of Fahrenheit's scale are added. The water bath failed to distil any portion of the oil at 100° C. (=212°Fah.) only a small quantity of acid water came over. An oil bath, linseed oil, was then substituted, and the temperature was regularly raised by slow degrees until distillation commenced. From that point the heat was successively raised by stages of ten degrees, allowing full time at each stage for complete distillation of all that would rise at that temperature before advancing to the next stage. The results of this tedious process are given in the annexed table—304 Grammes of crude oil, submitted to fractional distillation, gave :

		Temperature	Quantity.
1st Prod.		at 100° C.=213° Fah. (acid water,)	5 Gms.
2d	"	at 140° C. to 150° C.=284° to 302° Fah.	26 "
3d	"	at 150° C. to 160° C.=302° to 320° Fah.	29 "
4th	"	at 160° C. to 170° C.=320° to 388° Fah.	38 "
5th	"	at 170° C. to 180° C.=338° to 367° Fah.	17 "
6th	"	at 180° C. to 200° C.=356° to 392° Fah.	16 "
7th	"	at 200° C. to 220° C.=392° to 428° Fah.	17 "
8th	"	at 220° C. to 270° C.=428° to 518° Fah.	12 "

Whole quantity distilled by this method . .	160
Leaving residue in the retort	144
Original quantity, ...	304

*Fractional distillation is a process intended to separate various products in mixture, and having unlike boiling points, by keeping the mixture contained in an alembic at regulated successive stages of temperature as long as there is any distillate at a given point, and then raising the heat to another degree, &c.

Product No 1, as above remarked, was almost entirely water, with a few drops of colorless oil, having an odor similar to the original fluid, but less intense.

Product No. 2 was an oil perfectly colorless, very thin and limpid, and having an exceedingly persistent odor, similar to the crude oil, but less intense.

Product No. 3 was tinged slightly yellow, perfectly transparent, and apparently as limpid as the 2d product, with the same odor.

Product No. 4 was more decidedly yellowish than the last, but was in no other respect distinguishable from it.

Product No. 5 was more highly colored, thicker in consistence, and had a decided empyreumatic odor.

Product No. 6. This and the two subsequent products were each more highly colored and denser than the preceding. The last product had the color and consistency of honey, and the odor was less penetrating than that of the preceding oils. The mass of crude product remaining in the retort (equal 47.4 per cent.,) was a dark, thick, resinous-looking varnish, which was so stiff when cold, that it could be inverted without spilling. This showed no disposition to harden or skin over by exposure to the air. The distillation was arrested at this point in glass, by our having reached the limit of temperature for a bath of linseed oil. The *density* of the several products of this distillation, shows a progressive increase, thus:

No. 2	density	.733
No. 3	"	.752
No. 4	"	.766
No. 5	"	.776
No. 6	"	.800
No. 7	"	.848
No. 8	"	.854

To form an idea of the comparative density of these several products, it may be well to state, that Sulphuric Ether, which is one of the lightest fluids known, has a density of .736, and Alcohol, when absolutely pure, .800.

The *boiling points* of these several fluids present some anomalies, but are usually progressive, thus, No. 2 gave signs of boiling at 115° C. (=239° Fah.) and boiled vigorously and remained constant at 225° C. to 228° C., (=437° to 442° Fah.) No. 3 began to boil 120°, (=248° Fah.,) rose to 270° (=518° Fah.,) where it remained constant. No. 4 began to vaporize at 140°, (=284° Fah.,) rose to 290°, (=554° Fah.,) where it remained constant. On a second heating the temperature continued to rise, and passed 305°, (=581° Fah.) No. 5 gave appearance of boiling at 160°, (=320° Fah.,) boiling more vigorously as the heat was raised, and was still rising at 308°, (=581° Fah.) No. 6 commenced boiling at 135°, (=275° Fah.), boiled violently at 160°, (=320° Fah.,) and continued rising above the range of the mercurial thermometer. No. 7 commenced ebullition at the same temperature as No. 6, and rose to 305°, (=581° Fah.,) where the ebullition was not very active. Much time was consumed in obtaining these results. We infer from them that the Rock Oil is a mixture of numerous compounds, all having essentially the same chemical constitution, but differing in density and boiling points, and capable of separation from each other, by a well-regulated heat.

The uncertainty of the boiling points indicates that the products obtained at the temperatures named above, were still mixtures of others, and the question forces itself upon us, whether these several oils are to be regarded as *educts* (*i. e.*, bodies previously existing, and simply separated in the process of distillation,) or whether they are not rather produced by the heat and chemical change in the process of distillation. The continued application of an elevated temperature alone is sufficient to effect changes in the constitution of many organic products, evolving new bodies not before existing in the original substance.

Properties of the Distilled Oils.

Exposed to the severest cold of the past winter, all the oils obtained in this distillation remained fluid. Only the last two or three appeared at all stiffened by a cold of 15° below zero, while the first three or four products of distillation retained a perfect degree of fluidity. Exposed to air, as I have said, they suffer no change. The chemical examination of these oils showed that they were all composed of Carbon and Hydrogen, and probably have these elements in the same numerical relation. When first distilled, they all had an acid reaction, due to the presence of a small quantity of free sulphuric acid, derived from the crude oil. This was entirely removed by a weak alkaline water, and even by boiling on pure water. Clean copper remained untarnished in the oil which had thus been prepared, showing its fitness for lubrication, so far as absence of corrosive quality is concerned. The oils contain no oxygen, as is clearly shown by the fact that clean potassium remains bright in them. Strong *Sulphuric Acid* decomposes and destroys the oil entirely. *Nitric Acid* changes it to a yellow, oily fluid, similar to the changes produced by Nitric Acid on other oils. *Hydrochloric, Chromic* and *Acetic Acids,* do not affect it. *Litharge* and other metallic oxyds do not change it, or convert it in any degree to a drying oil. *Potassium* remains in it unaffected, even at a high temperature. *Hydrates of Potash, Soda,* and *Lime,* are also without action upon it. *Chloride of Calcium* and many other salts manifest an equal indifference to it. Distilled with *Bleaching Powders* (chloride of lime) and water, in the manner of producing chloroform, the oil is changed into a product having an odor and taste resembling chloroform. Exposed for many days in an open vessel, at a regulated heat below 212°, the oil gradually rises in vapor, as may be seen by its staining the paper used to cover the vessel from dust, and also by its sensible diminution. Six or eight fluid ounces, exposed in this manner in a metallic vessel for six weeks or more, the heat never exceeding 200°, gradully and slowly diminished, grew yellow, and finally left a small residue of dark brown lustrous-looking resin, or pitchy substance, which in the cold was hard and brittle. The samples of oil employed were very nearly colorless. This is remarkable when we remember that the temperature of the distillation was above 500° Fah. The oil is nearly insoluble in pure alcohol, not more than 4 or 5 per centum being dissolved by this agent. In ether the oil dissolves completely, and on gentle heating is left unchanged by the evaporization of the ether. India Rubber is dissolved by the distilled oil to a pasty mass, forming a thick black fluid which, after a short time, deposits the india rubber. It dissolved a little amber, but only sufficient to color the oil red. It also dissolves a small portion of copal in its natural state, but after roasting, the copal dissolves in it as it does in other oils.

Use for Gas Making.

The Crude Oil was tried as a means of illumination. For this purpose, a weighed quantity was decomposed, by passing it through a wrought iron retort filled with carbon, and ignited to full redness. The products of this decomposition were received in a suitable apparatus. It produced nearly pure carburetted hydrogen gas, the most highly illuminating of all the carbon gases. In fact, the oil may be regarded as chemically identical with illuminating gas in a liquid form. The gas produced equalled ten cubic feet to the pound of oil. It burned with an intense flame, smoking in the ordinary gas jet, but furnishing the most perfect flame with the Argand burner.

These experiments were not prosecuted further, because it was assumed that other products, now known and in use, for gas making, might be employed at less expense for this purpose, than your oil. Nevertheless, this branch of inquiry may be worthy of further attention.

Distillation at a higher Temperature.

The results of the distillation at a regulated temperature in glass led us to believe, that in a metallic vessel, capable of enduring a high degree of heat, we might obtain a much larger proportion of valuable products. A copper still, holding five or six gallons, was therefore provided, and furnished with an opening, through which a thermometer could be introduced into the interior of the vessel. Fourteen imperial quarts (or, by weight, 560 ounces) of the crude product were placed in this vessel, and the heat raised rapidly to about 280° C. (=536° Fah.), somewhat higher than the last temperature reached in the first distillation. At this high temperature, the distillation was somewhat rapid, and the product was easily condensed without a worm. The product of the first stage was 130 ounces (or over 28 per cent.), of a very light-colored thin oil, having a density of .792. This product was also acid, and, as before, the acid was easily removed by boiling with fresh water. The temperature was now raised to somewhat above 300° C. (=572° Fah.), and 123 ounces more distilled, of a more viscid and yellowish oil, having a density of .865. This accounts for over 43 per cent. of the whole quantity taken. The temperature being raised now above the boiling point of mercury, was continued at that until 170 ounces, or over 31 per cent., of a dark brown oil had been distilled, having a strong empyreumatic odor. Upon standing still for some time, a dark blackish sediment was seen to settle from this portion, and on boiling it with water, the unpleasant odor was in a great degree removed, and the fluid became more light-colored and perfectly bright. (It was on a sample of this that the photometric experiments were made.) The next portion, distilled at about 700° Fah., gave but about 17 ounces, and this product was both lighter in color and more fluid than the last. It now became necessary to employ dry hickory wood as a fuel, to obtain flame and sufficient heat to drive over any further portions of the residue remaining in the alembic.

It will be seen that we have already accounted for over 75 per cent. of the whole quantity taken. There was a loss on the whole process of about 10 per cent., made up, in part, of a coaly residue that remained in the alembic, and partly of the unavoidable loss resulting from the necessity of removing the oil twice from the alembic, during the process of distillation, in order to change the arrangements of the thermometer, and provide means of measuring a heat higher than that originally contemplated.

About 15 per cent. of a very thick, dark oil completed this experiment. This last product, which came off slowly at about 750° Fah., is thicker and darker than the original oil, and when cold is filled with a dense mass of pearly crystals. These are Paraffine, a peculiar product of the destructive distillation of many bodies in the organic kingdom. This substance may be separated, and obtained as a white body, resembling fine spermaceti, and from it beautiful candles have been made. The oil in which the crystals float is of a very dark color, and by reflected light is blackish green, like the original crude product. Although it distills at so high a temperature, it boils at a point not very different from the denser products of the first distillation. The Paraffine, with which this portion of the oil abounds, does not exist ready-formed in the original crude product; but it is a result of the high temperature employed in the process of distillation, by which the elements are newly arranged.

I am not prepared to say, without further investigation, that it would be desirable for the Company to manufacture this product in a pure state, fit for producing candles (a somewhat elaborate chemical process); but I may add that, should it be desirable to do so, the quantity of this substance produced may probably be very largely increased by means which it is now unnecessary to mention.

Paraffine derives its name from the unalterable nature of the substance, under the most powerful chemical agents. It is white, in brilliant scales of a greasy lustre; it melts at about 116°, and boils at over 700° Fah.; it dissolves in boiling alcohol and ether, and burns in the air with a brilliant flame. Associated with Paraffine are portions of a very volatile oil, *Eupione*, which boils at a lower temperature, and by its presence renders the boiling point of the mixture difficult to determine. I consider this point worthy of further examination than I have been able at present to give it, *i. e.* whether the last third, and possibly the last half, of the Petroleum, may not be advantageously so treated as to produce from it the largest amount of Paraffine which it is able to produce.

The result of this graduated distillation, at a high temperature, is that we have obtained over 90 per cent. of the whole crude product in a series of oils, having valuable properties, although not all equally fitted for illumination and lubrication.

A second distillation of a portion of the product which came over in the latter stages of the process, (a portion distilled at about 650° Fah., and having a high color), gave us a thin oil of density about .750, of light yellow color and faint odor.

It is safe to add that, by the original distillation, about

50 per cent. of the crude oil is obtained in a state fit for use as an illuminator without further preparation than simple clarification by boiling a short time with water.

Distillation by high Steam.

Bearing in mind that by aid of high steam, at an elevated temperature, many distillations in the arts are effected which cannot be so well accomplished by dry heat, I thought to apply this method in case of the present research. Instances of this mode of distillation are in the new process for Stearine candles, and in the preparation of Rosin Oil. I accordingly arranged my retort in such a manner that I could admit a jet of high steam into the boiler, and almost at the bottom of the contained Petroleum. I was, however, unable to command a jet of steam above 275° to 290° Fah., and, although this produced abundant distillation, it did not effect a separation of the several products, and the fluid distilled had much the same appearance as the Petroleum itself, thick and turbid. As this trial was made late in the investigation, I have been unable to give it a satisfactory issue, chiefly for want of steam of a proper temperature. But I suggest, for the consideration of the Company, the propriety of availing themselves of the experience already existing on this subject, and particularly among those who are concerned in the distillation of Rosin Oil—a product having many analogies with Petroleum in respect to its manufacture.

Use of the Naphtha for Illumination.

Many fruitless experiments have been made in the course of this investigation which it is needless to recount. I will, therefore, only state those results which are of value.

1. I have found that the only lamp in which this oil can be successfully burned, is the Camphene lamp, or one

having a button to form the flame, and an external cone to direct the current of air, as is now usual in all lamps designed to burn either Camphene, Rosin Oil, Sylvic Oil, or any other similar product.

2. As the distilled products of Petroleum are nearly or quite insoluble in alcohol, burning fluid (*i. e.*, a solution of the oil in alcohol) cannot be manufactured from it.

3. As a consequence, the oil cannot be burned in a hand lamp, since, with an unprotected wick, it smokes badly. Neither can it be burned in a Carcel's mechanical lamp, because a portion of the oil being more volatile than the rest, rises in vapor on the elevated wick required in that lamp, and so causes it to smoke.

I have found all the products of distillation from the copper still capable of burning well in the Camphene lamp, except the last third or fourth part (*i. e.*, that portion which came off at 700° Fah. and rising, and which was thick with the crystals of Paraffine). Freed from acidity by boiling on water, the oils of this distillation burned for twelve hours without injuriously coating the wick, and without smoke. The wick may be elevated considerably above the level required for Camphene, without any danger of smoking, and the oil shows no signs of crusting the wick tubes with a coating of Rosin, such as happens in the case of Camphene, and occasions so much inconvenience. The light from the rectified Naphtha is pure and white without odor. The rate of consumption is less than half that of Camphene, or Rosin Oil. The Imperial pint, of 20 fluid ounces, was the one employed —a gallon contains 160 such ounces. A Camphene lamp, with a wick one inch thick, consumed of rectified Naphtha in one hour 1¾ ounces of fluid. A Carcel's mechanical lamp of ⅞ inch wick, consumed of best Sperm Oil, per hour 2 ounces. A "Diamond Light" lamp, with "Sylvic Oil," and a wick 1½ inch diameter consumed, per hour, 4 ounces.

I have submitted the lamp burning Petroleum to the inspection of the most experienced lampists who were accessible to me, and their testimony was, that the lamp burning this fluid gave as much light as any which they had seen, that the oil spent more economically, and the uniformity of the light was greater than in Camphene, burning for twelve hours without a sensible diminution, and without smoke. I was, however, anxious to test the amount of light given, more accurately than could be done by a comparison of opinions. With your approbation I proceeded therefore to have constructed a *photometer*, or apparatus for the measurement of light, upon an improved plan. Messrs. Grunow, scientific artists of this city, undertook to construct this apparatus, and have done so to my entire satisfaction. This apparatus I shall describe elsewhere—its results only are interesting here. By its means I have brought the Petroleum light into rigid comparison with the most important means of artificial illumination. Let us briefly recapitulate the results of these

Photometric Experiments.

The *unit* adopted for comparison of intensities of illumination is Judd's Patent Sixes Sperm Candle.

The Sperm Oil used was from Edward Mott Robinson, of New Bedford—the best winter Sperm remaining fluid at 32° Fah. The Colza Oil and Carcel's lamps were furnished by Dardonville, lampist, Broadway, New York. The Gas used was that of the New Haven Gas Light Co., made from best Newcastle coal, and of fair average quality.

The distance between the standard candle, and the illuminator sought to be determined, was constantly 150 inches—the Photometer traversed the graduated bar in such a manner as to read, at any point where equality of illumination was produced, the ratio between the two lights. I quote only single examples of the average results, and with as little detail as possible, but I should state that the operation of the Photometer was so satisfactory that we obtained constantly the same figures when operating in the same way, evening after evening, and the sensitiveness of the instrument was such that a difference of one half inch in its position was immediately detected in the comparative illumination of the two equal discs of light in the dark chamber. This is, I believe, a degree of accuracy not before obtained by a Photometer.

Table of illuminating power of various artificial lights compared with Judd's patent candles as a unit.

Source of Light.	Ratio to Candle.—1.
Gas burning in Scotch fish-tail tips, 4 feet to the hour	1 : 5.4
" " " " " 6 " "	1 : 7.55
" " Cornelius " " 6 " "	1 : 6.3
" " English Argand burner 10 " "	1 : 16.
Rock Oil, burning in 1 inch wick Camphene Lamp, consuming 1 3-4 ounces of fluid to the hour	1 : 8 1
Carcel's Mechanical Lamp, burning best Sperm Oil, 2 ounces of fluid to the hour, wick 7-8 of an inch	1 : 7.5
Carcel's " " " " " " Colza Oil,	1 : 7.5
Camphene Lamp, (same size as Rock Oil above,) burning best Camphene, 4 fluid ounces per hour	1 : 11.
"Diamond Light" by "Sylvic Oil," in 1 1-2 inch wick, 4 ounces per hour	1 : 8.1

From this table it will be seen that the Rock Oil Lamp was somewhat superior in illuminating power to Carcel's Lamp of the same size, burning the most costly of all oils. It was also equal to the "Diamond Light" from a lamp of one half greater power, and consequently is superior to it in the same ratio in lamps of equal power. The camphene lamp appears to be about one-fifth superior to it, but, on the other hand, the Rock Oil surpasses the Camphene by more than one half in economy of consumption, (*i. e.*, it does not consume one half so much fluid by measure), and it burns more constantly. Compared with the Sylvic Oil and the Sperm, the Rock Oil gave on the ground glass diaphragm, the whitest disc of illumination, while in turn the Camphene was whiter than the Rock Oil light. By the use of screens of different colored glass, all inequalities of *color* were compensated in the use of the photometer, so that the intensity of light could be more accurately compared. Compared with Gas, the Rock Oil gave more light than any burner used except the costly Argand consuming ten feet of gas per hour. To compare the *cost* of these several fluids with each other, we know the price of the several articles, and this varies very much in different places. Thus, gas in New Haven costs $4 per 1,000 feet, and in New York $3.50 per 1,000, in Philadelphia $2.00 per 1,000 and in Boston about the same amount.

Such Sperm Oil as was used costs $2.50 per gallon, the Colza about $2, the Sylvic Oil 50 cents, and the Camphene 68 cents—no price has been fixed upon for the rectified Rock Oil.

I cannot refrain from expressing my satisfaction at the results of these photometric experiments, since they have given the Oil of your Company a much higher value as an illuminator than I had dared to hope.

Use of the Rock Oil as a Lubricator for Machinery.

A portion of the rectified oil was sent to Boston to be tested upon a trial apparatus there, but I regret to say that the results have not been communicated to me yet. As this oil does not gum or become acid or rancid by exposure, it possesses in that, as well as in its wonderful resistance to extreme cold, important qualities for a lubricator.

Conclusion.

In conclusion, gentlemen, it appears to me that there is much ground for encouragement in the belief that your

Company have in their possession a raw material from which, by simple and not expensive process, they may manufacture very valuable products.

It is worthy of note that my experiments prove that nearly the *whole* of the raw product may be manufactured without waste, and this solely by a well directed process which is in practice one of the most simple of all chemical processes.

There are suggestions of a practical nature, as to the economy of your manufacture, when you are ready to begin operations, which I shall be happy to make, should the company require it—meanwhile, I remain, gentlemen,

Your obedient servant,

B. SILLIMAN, Jr.,

Professor of Chemistry in Yale College.

New Haven, April 16, 1855.