with slightly rotary motion 200 times, the marbles removed, and the char sifted as before. The increased weight of dust is calculated to per cent. of the char used. These tests are pretty constant for different portions of the same sample of char.

The dust formed thus from a good new char was in three cases 1.72 per cent., 1.46 per cent., and 1.76 per cent. From another new char 2.68 per cent. and 2.44 per cent. Two grades made by one firm gave 2.16 per cent. and 2.16 per cent. in one case, and 2.86 per cent. and 2.87 per cent. in the other. Char which had been in use ten months and whose softer parts had already been separated by use gave 0.92 per cent. and 0.94 per cent., showing that it was then in a better wearing condition than when it first entered into use.

THE ASPHALT QUESTION.

By S. F. Peckham.

THERE has lately been published some very interesting reading concerning this question. To go back a few months, in October, 1892, Consul Pierce made a report that seemed to leave very little to be said in reference to Trinidad asphaltum from any standpoint. A few months later, Mr. Clifford Richardson published in the *Journal of Analytical and Applied Chemistry*, for Dec. *1892*, and Jan. *1893*, a paper in which he embodied the results of a most elaborate series of technical analyses of Trinidad asphalts. Within the last twelve months there has been published a voluminous report on Trinidad asphalt by Mr. Richardson, in the "Mineral Resources of the United States." In several late numbers of *Paving*, Mr. D. Torrey has shown that a method of analysis of asphalts may be based on successive solutions in alcohol; and he has also discussed in a very suggestive and intelligent manner, the general subject. In the July number of *Paving*, Messrs. Richardson and Bowen pay their respects to the report of Messrs. Leffman and Sadtler, made to the Citizens' Municipal Association and Trades League, of Philadelphia. In the August number of the same journal Messrs. Leffman and Sadtler reply to their critics. In the December number of this JOURNAL Miss Laura Linton publishes a paper, in which she gives the result of a very careful

research upon the methods heretofore employed in the technical analysis of asphalts. I am also just in receipt of a report upon "The Gas and Petroleum Yielding Formations of the Central Valley of California," by W. L. Watts, of the State Mining Bureau.

I propose, by a general review of these papers, to ascertain where a chemist, who is occasionally consulted in reference to asphalt, might reasonably take his stand.

It is now about fifty years since I first noticed, in a number of the *Penny Magazine*, an illustrated article on the "Pitch Lake of Trinidad." My interest in this wonderful phenomenon has never abated. Somewhere late in the fifties, when the Downer Kerosene Oil Co., was ransacking everywhere, but in Pennsylvania, for crude material for illuminating oil that was cheaper than Boghead Mineral, or Albertite, the late William Attwood was sent to Trinidad, where he remained two or three years. Several years after his return it was my good fortune to meet him, and I listened with eager interest to his description of the so-called lake, which he represented as a mass of asphaltum of unknown depth, floating upon a veritable lake of water. His experiments in the line of preparing illuminating oil from the asphalt were so far from a success that the late Samuel Downer once facetiously remarked, that the Trinidad pitch was, without doubt, derived from right-whales, black-fish, etc., while Pennsylvania petroleum was certainly nearly pure sperm oil. Later investigations have shown that both Mr. Attwood and Mr. Downer were considerably mistaken in their conclusions.

The report of Consul Pierce shows that the so-called pitch lake has no definite boundaries, but overflows towards the sea, over the rim of its irregularly circular basin, on one side. His report also shows that the sources from which the bitumen rises to the surface, are not confined to the strata beneath the so-called pitch lake, but are also found in the strata that underlie that portion of the island of Trinidad adjacent to the lake, to such an extent that unknown areas are covered with masses of asphalt, of unknown thickness. This asphalt, from both inside and outside the lake, was mined and sold, but that from outside the lake was finally distinguished as "land asphalt" by those who chose to

do so. Consul Pierce shows conclusively that the same cosmical forces that bring asphaltum to the surface in large quantity at the lake, bring it to the surface at many other points upon the island in smaller quantity, and, that other things being equal, the asphaltum is the same thing in both instances.

In Mr. Richardson's elaborate paper above referred to,[1] he gives results of analyses of a number of specimens that were taken from the lake, and compares them with corresponding results of analyses of a number of specimens taken from the land. He admits that no practical difference can be shown to exist between good commercial samples from either source; but he insists on introducing analyses of lake asphalt that are too soft for commercial purposes, and also of a lot of land specimens that, so far as serving any useful purposes are concerned, are neither more nor less than rubbish. No one familiar with deposits of surface asphalt in Southern California, would visit an asphalt bed and dignify the refuse from the numerous fires that, from immemorial periods, have swept over its surface, with the names of "iron-pitch," etc., and think an argument necessary to prove that the ashes, cinders, coke, and half-burned asphaltum, are unfit for street pavement. I have seen masses of coke, from fifteen to eighteen inches thick, taken from burnt asphalt beds, and thousands of tons of melted and half-burned asphaltum, in streams miles in length, the analysis of which would afford most convincing proof that they were unsuitable for street pavement. Setting aside the soft pitch on the one hand, and the rubbish on the other, it appears to me, that any unprejudiced person must admit, that Mr. Richardson's paper proves either too little or too much; either that the methods and material he used proves nothing, as is really the case, or that the results he has obtained prove the practical identity of "lake" and "land" asphalt of good commercial quality.

In the report by Mr. Richardson in "Mineral Resources of the United States for 1893," he goes into the history of the paving industry, and gives some very interesting details, both political and commercial, the argument of which appears to be that while there are other asphalt paving materials to be had in the

1. *J. Anal. Appl. Chem.*, Dec. *1892*, and Jan. *1893*.

world, the only material worth considering is that laid by the Barber Asphalt Paving Co., that use and practically own the "lake" deposit, which, after all, is not a lake at all, but fills "the crater of an old mud volcano." He says, "in times past it appears that the continued welling up of pitch at the center of the lake filled the crater and caused it to overflow towards the sea." Here again, he either proves that the whole of the pitch is worthless, or that the whole deposit outside and inside the crater is practically one and the same thing.

He starts into the discussion of the Technology of Trinidad asphalt pavements, with the important information that "The crude pitch is shipped from La Brea in Trinidad in both sailing vessels and steamers." Farther on, he shows by a sort of historical résumé, that a little more care has lately been taken in refining the pitch than formerly, by which the damage resulting from prolonged overheating is avoided to some extent. He then grapples with the cement problem. He says of the fluxing oil, "it should not contain large amounts of hard paraffins, for in this case, while it may be of suitable nature for making cement at ordinary temperatures, it is susceptible to changes and makes the resulting cement too brittle at low temperature and too soft in heat of hot summer sun. The more the oil is of a vaseline nature the better it is. While the oil now in use is a great advance over that of some years ago, there still seems to be room for improvement. "The character of an oil may be learned by determining—

1. Specific gravity.
2. Flash-point.
3. Percentage volatile in seven hours at 400° F.
4. Susceptibility to changes in temperature as revealed in changes in viscosity.
5. Presence of crystals of paraffin scale.

Before mixing, the asphalt is raised to a temperature of 300° F., or thereabout, and to produce rapidly a smooth mixture, the oil should be heated as hot as is convenient. The oil is then pumped or in other ways added to the still, and the mixture agitated for several hours with a current of air until it is quite homogeneous. This agitation must be done with great thor-

oughness to insure a uniform cement, and must be continued whenever the material is in a melted condition, as a certain amount of separation takes place when the melted cement stands at rest. It is, therefore, customary to agitate it constantly with an air-blast when in use as well as in its preparation."[1]

Then he goes on to describe the ingenious toy with which Prof. Bowen, of Columbia College, amuses himself. This instrument is so delicate that, "as the needle (a cambric needle) is not at a normal temperature an allowance must be made." Comment is unnecessary.

In a paper that I read at the Congress of Chemists,[2] held at the Columbian Exposition, I took the position that the residuum in use for softening asphalt that is made from petroleums consisting of paraffins, and that consequently contains paraffins, is not a solvent for asphaltum, and therefore is not a suitable material for an asphaltic flux; as when an attempt is made to incorporate the two materials, the result is a mechanical mixture and not a chemical union as it should be. I based my argument on the results of laboratory experiments, and I now gladly welcome Mr. Richardson to my side, as his very emphatic statements are based upon the much stronger proof of practical experience. In the paper above referred to I further maintained that the custom of "blowing" asphalt, or mixing it by the use of a current of air injected into the molten mass while heated to a high temperature, is all wrong.

Mr. Richardson writes well, and he uses the word "scientific" in a way that sounds well; but I hazard the opinion, that if he read more and wrote less, his opinions would have more weight. The first "scientific" paper in which the effect of the prolonged heating of bitumens was discussed, was published by Boussingault in 1837. He says,[3] "after different experiments, the means that I have finally employed in order to free the bitumen of its volatile principles, consists in exposing it at a temperature of about 250° (C. = 480° F.?) in a Gay-Lussac oil-bath until it no longer loses weight. This method is prolonged, as it is necessary to heat during forty-five to fifty hours, even when operating

[1] Mineral Resources of the United States, *1893*, 651.

[2] *Am. J. Sci.*, Jan., *1894*; *Paving and Municipal Engineering*, Aug., *1894*.

[3] *Ann. chim. phys.*, 64, 141.

on only two grams of material." In a note he adds, "By this method it is impossible to determine the two principles of the bitumen, as at that temperature a part of the petrolene is oxidized and passes to the solid state or asphaltene." Technologists in petroleum have known for years that prolonged heating will convert paraffin petroleums into a solid residuum. It has also been known for years that California petroleums can be so manipulated by heat as to convert a large percentage of them into an asphaltic residuum, that will contain varying proportions of material soluble in petroleum ether, carbon disulphide, and chloroform, leaving a residue of coke, according to the temperature to which it has been heated. The percentage of material soluble only in chloroform increases also in proportion to the time during which it has been heated. A patent has lately been issued from the U. S. Patent Office for a method or process for preparing these residues.

It seems incredible, that the scientific adviser of a great corporation, that has the reputation of seeking to control the asphalt paving business of the United States, should be ignorant of these facts. Why then this space occupied in the Mineral Resources of the United States, with descriptions of technological processes, that all of the knowledge possessed by the scientific world for the last sixty years, condemns as unscientific?

Mr. Richardson has taken great pains to show that he found a good quality of "land asphalt," that contained, if I remember his figures, two per cent. less of matter soluble in petroleum ether than a fair quality of "lake asphalt." This difference he regards as absolutely exclusive of "land asphalt" for paving purposes. He then describes how this "lake asphalt" is refined. He does not say whether refined lake and land alsphalt differ by two per cent. of matter soluble in petroleum ether or not. He then shows how the refined lake asphalt is softened with a material that, according to his own showing, will not form even a mechanical mixture with the melted asphalt except by constant agitation with a current of air, and that, up to the point when the so-called cement is put into its final resting place upon the street. It is a fair question, whether lake asphalt after this wholly unscientific treatment does not contain a larger percentage of matter insolu-

ble in petroleum ether than would land asphalt, when properly manipulated.

Mr. Richardson says, "Washington has had more experience with sheet asphalt pavements and more time and attention have been devoted to both the scientific and practical sides of the industry there than in any other city in the country."[1] If Mr. Richardson has faithfully represented the state of the art in this highly favored city, in what condition must the rest of the country be found where scientific principles have not been introduced into the industry?

Mr. Richardson has been giving his attention to the scientific principles underlying this industry for a number of years. I think it may be safely said that he has had a better opportunity to become an acknowledged scientific authority upon this subject than any chemist living. After what manner has he used this opportunity? He has published a large number of so-called analyses of asphaltum. When making these analyses he either found a method already in use, which his experience proved to be satisfactory, or he invented a better one. In either case, by long continued use, he made the method his own. I am not aware that he has anywhere described his method of analysis, but the terms in which he has stated the results of his analyses, indicate his method with sufficient clearness. He states the amount of water, the percentage soluble in petroleum ether, the percentage soluble in carbon disulphide, the percentage of organic matter not bitumen, and the percentage of inorganic or mineral matter. It is a fair assumption that with Mr. Richardson's opportunities, he thoroughly investigated every step in this process of analysis, and is prepared to show that water, and not volatile oils or gases, are determined as water; that either petroleum ether of any sp. gr., *e. g.*, any light distillate of petroleum can be used in place of any other, with the same results, or that a distillate of a particular sp. gr., obtained from a particular petroleum should be used. It is further to be presumed, that he is able to show that petroleum ether is the best liquid that can be used for this purpose, and that the separation made by its use is sharp and clearly defined. It is further to be

[1] Mineral Resources of the United States, 1893, 653.

presumed, that when this residue from which petroleum ether has made a complete solution, is subjected to the action of carbon disulphide, that setting aside the difficulty of obtaining the reagent pure, its action is attended with no serious objections and is complete; that is, it dissolves every trace of bitumen remaining in the residue. All of this should have been proved beyond question years ago. But Mr. Richardson has apparently allowed that two per cent. of difference between lake and land asphalt to so obscure his mental vision that he has left it to the careful and painstaking accuracy of Miss Linton to show that carbon disulphide will not dissolve completely the bitumen from asphaltum, and that boiling spirits of turpentine is an equivalent for carbon disulphide, and is a much more convenient and satisfactory reagent to use.[1]

There are mistakes to which every one is liable and that are properly to be excused; there are others that are absolutely without excuse. I confess, that to my mind, there is no excuse for a man, who, occupying the position or responsibility that Mr. Richardson has occupied, publishes the results of analyses year after year, upon which, as a basis, it has been sought to influence the expenditure of millions of public money, when, in reality, he has made no proper investigation of his processes, and knows nothing respecting the accuracy or proper significance of his results. Mr. Richardson has no right to complain if his constituency hereafter repudiate all of the dicta that he has with, I had almost said, unpardonable arrogance thrust upon the public, in reference to the "Asphalt Question."

I have read the articles of Mr. Torrey with a great deal of interest.[2] They are suggestive. I have not found, by experience, that his method of analysis by solution in alcohol, promises any superiority over that proposed by Miss Linton. The test of a method of analysis is, other things being equal, the parallelism shown in the results when duplicate analyses are made, side by side. In one instance, with her process, I have obtained results parallel to the third place of decimals. Such close correspondence in work of this kind is not generally to be expected;

[1] This JOURNAL, 16, 809.

[2] *Paving and Municipal Engineering*, Nov., *1893*; April, May, and September, *1894*.

but the process, on the whole, has given me very satisfactory results, and the possibility of rejecting altogether the use of carbon disulphide is a great gain.

Messrs. Sadtler and Whitfield, remark in their article in *Paving*, "While some of the European asphaltic limestones are capable of being used for paving without addition of fluxing material, they have not been found to make as satisfactory pavement as those containing a siliceous base."[1] Why should they? Is not any form of calcium carbonate easily dissolved by rainwater or decomposed by weak acids, such as abound in the street gutters? Will Mr. Richardson please explain why pulverized limestone is required as an ingredient of the asphalt surface used in Washington? Why is it any better than the same amount of fine quartz sand? The reasons given above are sufficient reasons why it is not as good. In California, infusorial earth occurs in many localities in close proximity to deposits of asphalt. It is found to be a very superior material with which to temper asphalt.

On page 52 of the Report of the California State Mining Bureau, above referred to, an extract appears from the Records of the Standard Asphalt Co. There an attempt is made to compare some of Mr. Richardson's analyses of Trinidad asphalt, made with petroleum ether, with other analyses made by G. Q. Simmons, who analyzed California asphalt by using common ether. Other tests are given, made by H. Stillman, who used presumably petroleum ether from California petroleum. Miss Linton has shown that the solvent powers of these three reagents, when applied to the same asphaltum, vary widely; hence they can not be used interchangeably, and results based upon their use can not be compared. The material used should be petroleum ether of sp. gr. 700 equal to 70° B., obtained from petroleum consisting of hydrocarbons of the marsh-gas series—in other words "paraffins."

These criticisms have not been made at the suggestion of, or in the interest of any party to the asphalt question.

UNIVERSITY OF MICHIGAN, ANN ARBOR, MICH.,
October 30, 1894.

[1] Ibid, September, *1894*, 120.