dynamic, and a knowledge of it was more a physical than a chemical problem. From the educational view he thought it better to use the theory of valence in connection with the history of the theories concerning atoms and molecules. As a farther step the language and figures of magnetism might be used.

The paper on the optical methods of estimating sugar in milk, by Dr. H. W. Wiley, showed the great importance which must be attached to the influence of albumen on the specific rotary power of milk-sugar. The author prefers to use an acid solution of mercuric nitrate in precipitating albumen, for an excess fails to dissolve the precipitate. Professor Jenkins finds, that on adding sulphate of copper and the potassic hydrate the separation of albumen is very complete.

A discussion on the educational methods in laboratory practice and in the illustration of chemical lectures was opened by Professor Remsen, who remarked that in Germany the student does not go into the laboratory until he understands re-actions, while in England and the United States he is placed there at the beginning of the course. Professor Remsen follows an order of instruction in which the student first becomes acquainted with apparatus and methods of manipulation. He next makes gases, and repeats lecture experiments. He then experiments on oxidation and reduction. Next follows the quantitative analysis of air. Then come alkilimetry and acidimetry, with success. This practical work and the lectures occur simultaneously, and by that time the lecturer has reached the metallic elements the students are ready to take up test-tube re-actions with profit. During the first year the student should only just begin analysis. After the general properties of the metals are known, let the student devise methods of separation. The course of instruction in our colleges, Professor Remsen regards as too short, and superficial. Lecture-experiments should never be made for show. Aesthetics and chemistry are entirely distinct. Professor Atwater said that chemistry is taught now, as a rule, after the student has acquired the methods of the classics and has never been taught to observe facts. Chemists must show that their science will give what is called 'liberal culture,' or it will not find a place in our educational institutions. Present methods are not doing this, as they fail to make the student think for himself.

Prof. W. O. Atwater read a paper on the assimilation of atmospheric nitrogen by plants. Experiments were made on pease grown in washed sea-sand, supplied with proper nutritive solutions. The pease acquired from thirty-eight to fifty per cent more nitrogen than they contained originally, and than had been supplied as nutriment. The above result, Professor Langley remarked, is important, as it is contrary to generally received ideas.

Dr. Springer next read a paper on fermentation without combined nitrogen, in which he showed that the ferment found on the stems of tobacco-plants, and which decomposes nitrates, on being applied to starch and sugar gives rise to butyric acid, and appears to prove that we can have life without protoplasm. After a discussion upon fermentation, a motion was carried that a committee of the section should petition Congress to afford facilities for the study of fermentation. Dr. Springer, Professor Wiley, Mr. Clifford Richardson, Professor Remsen, and Professor Clarke constitute this committee.

Professor Dewar of the Royal institution read a paper on the density of solid carbonic acid. The solid acid was obtained by compressing carbonic acid snow by a hydraulic press. The specific gravity was found to be from 1.58 to 1.60 of the solid acid. Some little discussion resulted, by which it was brought out that the curves obtained from a study of the critical points of gases may explain some facts in regard to dissociation, as there are many cases where the theory of dissociation and experiment do not agree. The pressure necessary to produce the solid carbonic acid is about one and a half tons.

Professor Munroe described some experiments which tended toward the establishing of a law of deliquescence. The temperature and shape of the vessel were not taken into account.

The composition of human milk, by Prof. A. R. Leeds, was found, on using every precaution, to be: albuminoids varying from .5 to 4.25 per cent, lactose from 4.1 to 7.8 per cent, and the fat from 1.7 to 7.6 per cent. The appearance and specific gravity of the milk never indicated its composition. Improvements in apparatus for rapid gas analysis by Dr. Arthur H. Elliott consisted in reducing the length of the tubes by enlarging the upper portion of them into bulbs, and in substituting a solution of bromine in potassic bromide for the liquid element to absorb illuminants. Mr. A. H. Allen, in his communication on oils, said that shark and fish oils are often unsaponifiable, and hence are not fatty ethers. He believes them to contain cholesterine, like cod-liver oil. The fixed oils can be separated into groups, but we know no process for separating a mixture of lard and cotton-seed oil.

These communications closed the sessions of by far the most successful meeting of section C for many years.

PROCEEDINGS OF THE SECTION OF MECHANICAL SCIENCE.

OWING to previous unfavorable conditions, this was practically the first meeting of the new section (D) of mechanical science. Notwithstanding the great heat, the small and inconvenient auditorium, and the fact that the electrical exhibition deprived the section of much local support, the meeting was a greater success than had been expected, and warrants the anticipation that this will shortly become one of the leading sections of the association as it is in the British association. The attendance was large, and included many prominent English visitors, who furnished papers, and took part in the discussions. In order to indicate more definitely the scope of the section, it has been proposed to extend its title to 'mechanical science and engineering;' and it is hoped that our leading engineers and architects will give it their active support by presenting before it papers embodying the progress of their work from scientific standpoints. Besides appointing a committee of invitation to increase the interest and attendance for the next meeting, two special committees were appointed to work up the subjects, 'The best method of teaching mechanical engineering,' and 'The use and value of accurate standards, screws, surfaces, gauges, etc., and of systematic drawings, in the modern machine-shop.'

On Friday, Mr. J. C. Hoadley read by request his excellent *résumé* of steam-engine practice in the United States; reviewing the different classes of engines, and giving figures to show their economy, with other important facts. Mr. Hoadley classifies engines as follows: large compound engines for pumping, etc., rolling-mill engines, saw-mill engines, marine engines, locomotives, hoisting-engines, steam-cranes, steam-pumps, portable engines, etc., and engines for electric lighting. This would seem to be an enumeration, rather than a classification, of different types of engines. The paper contains, in compact form, information as to all the prominent engines, and forms a valuable addition to steam-engine literature. It will be printed in full in the Transactions.

The subject for the day was then introduced by a paper on the training for mechanical engineers, by Prof. G. I. Alden of Worcester, Mass., in which one phase of the subject was presented. Professor Alden urged the importance of practical as well as scientific attainments, and claimed that the shop for manual instruction should not be such an institution as would be developed by or out of the school, but should bring with it not only the methods but the business of an actual productive machine-shop, the work being done for the market. It is to be regretted that other prominent gentlemen expected to furnish papers were prevented from attending.

The discussion commenced with so much interest, that an extra session was devoted to it, when the various phases of the question were brought out. A starting-point was thus formed which should enable the committee to secure a more complete, important, and decisive discussion next year. Messrs. Rigg, Kent, etc., and Professors Woodward, Robinson, Wood, Thompson, Higgins, Carr, etc., and Webb, joined in the discussion; and the latter called attention to the necessity of distinguishing between machine-shop practice and experiments in the mechanical laboratory, and pointed out three existing and natural kinds of schools: 1°. manual training schools, where the manual exercises are for discipline only; 2°. schools for master-machinists, superintendents, etc., as at Châlons-sur-Marne, where the course is seven hours daily, for three years, in the shop, with such instruction in mathematics, draughting, etc., as can be added thereto; 3°. schools for mechanical engineers (as the École centrale), where theoretical training predominates, and where there is either no shop-practice, or only such as is specialized and organized so as to give, in the limited time available, the maximum intellectual and manual grasp of machine-shop methods.

On Monday Prof. W. A. Rogers read a paper on a new method of producing screws of standard length and uniform pitch; and Mr. J. A. Brashear, a paper on the production of optical surfaces: the subject for the day being the value of accurate screws, surfaces, etc., in the machine-shop. Professor Rogers has developed a method by which practically perfect screws can be cheaply made, and Mr. Brashear has succeeded in making perfectly flat surfaces of larger size than usual. Professor Rogers's method of making a screw presupposes a correctly graduated scale over which a microscope attached to the lathe-carriage moves. The error in the movement of the carriage is thus made visible, and can be neutralized by means of a stout micrometer screw, which varies slightly the position of the cutting-tool on the carriage. By this means the screw is cut so nearly true that the remaining inequalities are easily ground out by means of a long nut cut into four pieces, which can be put together in different ways so as to make the errors in the nut oppose those of the screw. Professor Rogers pointed out the way for further improvements, and hoped that some way would be found for the detection of errors extending over long distances, by means of gratings ruled by the screw. The subject of the proper use and preservation of such perfect screws in the machine-shop was also touched upon by Mr. Pickering, who has found means in his own practice of distributing the work as equally as possible over the where leading screw of a lathe in order to keep it from wearing unequally. This whole subject will come up next year for discussion, and the paper was deemed of such importance as to warrant its publication in full in the Transactions. Mr. Brashear's paper is also to appear in full. The discussion of these papers, engaged in by many prominent physicists and engineers, was highly interesting. It opened by a criticism from one of our English friends, who expected to find every thing in the United States done by machinery, and was disappointed to find that these flat surfaces (or slightly curved, when needed so for lenses, etc.) were produced by polishing, much in the old manner; and it was claimed that the correct form should first be produced by machinery, and the polish put on subsequently. The telescope of Mr. Bessemer was alluded to as an instance where such work would be done by machinery. Several gentlemen followed, and spoke of the difference between ordinary work which might thus be produced, and the extremely accurate forms required for astronomical purposes produced by Mr. Bessemer. Professor Harkness described his measurements of the 'transit of Venus' plane mirrors down to hundred-thousandths of an inch, and showed that work was done in the United States to a degree of accuracy not perhaps appreciated in Europe. Mr. Brashear closed the discussion by a complete defence of his methods. He claimed that the degree of accuracy of his work was such, that, after a surface was polished, he could, by a few suitably lengthened strokes of the polisher, make it parabolic, elliptic, or any thing he wished, and that his principal difficulty was that the finest polishing powders cut too fast, so that to shape first and polish afterward was meaningless: then, growing eloquent, he ventured, for reasons which he explained, to predict that Mr.

Bessemer's telescope never would be completed in the intended manner, and this opinion was evidently shared by many gentlemen present.

On Tuesday Sir Frederick Bramwell explained the method employed to warm the Third Middlesex-county lunatic-asylum at Banstead, Eng., where a circulation of warm water is produced by centrifugal pumps, which maintain two parallel mains in a relatively plus and minus condition. The discussion was a comparison of warm water and steam for heating purposes; and the former was shown to have various advantages over steam, where the expense of the plant is not considered.

Mr. J. C. Hoadley's paper on driven wells followed, and was a description of a series of experiments to determine the way in which water moves toward a well from which it is pumped. Driven were shown to obey the same law as open wells; which is, that the water simply runs down hill, toward the well, its flow being more or less obstructed by its percolation through the soil, so that its surface forms a slope more or less steep, i.e., an 'obstructed hydraulic slope.' This is only what was to have been expected, but it is interesting to have it proved experimentally. In the discussion, a fresh-water well was instanced, bored on the sea-beach, in which the water rose and fell with the tide; the weight of the latter depressing the underlying and seperating strata.

Mr. W. A. Traill not being present, Dr. Fitzgerald of Trinity college, Dublin, described the Giants' Causeway and Portrush electric tramway. A working model of the same is to be placed in the electrical exhibition. Water-power is used for this line, which is six miles long, the American turbine used being a mile beyond the end; so that the maximum distance over which the electricity is carried is seven miles. The rails carry only the return current; there being a third rail, on two-feet-high posts at the side of the track, for the direct current. Two springs rub along on this rail to connect it with the dynamo in the car: these being placed as far apart as possible, an opening less than their distance apart can be passed without breaking the current. The railway, however, runs along a cliff by the sea, so that there are but few openings. The road, though new, is represented as a complete success. The line is quite hilly, the maximum incline being one in twenty-eight; crossing-places are all arranged on an incline, so that the car running down can give up the third rail to the other, and go on by gravity. The electrical arrangements were planned by William Siemens, his death occurring just as he had seen the whole thing in successful operation. It is interesting to note, that the current itself has been used to telegraph to the next car, ordering it to stop. The current is governed by a man in charge of the turbine, who regulates the water to the work: this reminds us of the suggestion of Professor Thompson at the Montreal meeting, that the fireman should be able to completely regulate an electric-light plant by his firing. Running expenses by horse-power, steam-power, and by the turbines, are found to be in the proportion 10:7:3; so that, where water-power can be obtained, an immense saving can be effected by the arrangements here used. Dr. Preece followed, and described Mr. Holroyd Smith's improvements in electric railways. Mr. Smith employs much the same arrangement as on our cable lines, using, however, in place of the cable, a pair of fixed electrical conductors, between which runs a shuttle; the current is taken off by it, and brought up to the car through the groove, thus placing the electric conductors under ground, as they evidently should be. Other minor details were described, otherwise the line is essentially the same as that previously described.

Mr. A. Stirling then followed with a paper in which the economy of the electric light was made the subject of calculations based on the author's experience. It was stated, that at present, for lighting a compact block, the incandescent light could be considered as no more expensive than gas at $1.69 per thousand. Mr. Preece opened the discussion by a criticism on the theoretical character of the calculations given, claiming that no dependence could be placed on such statements, and went on to give his own experience, which, however, appeared to fairly sustain Mr. Stirling's figures. He stated that he had experimentally lighted three miles of streets in London (Wimbledon), and that it was not a success; the turning-point seeming to be the price of gas, $2.25 in New-York city, but only one-third that price in London. Mr. Preece described his own establishment, where, by means of a gas-engine in the garden, the house is lighted in the most convenient fashion (including a doll's house of four rooms). He stated also, that the same quantity of gas gave more light when thus indirectly used, than could be got from it by burning it in the best gas-burners: this is readily to be believed, the gas furnished by gas-companies being much better adapted for producing heat than light. It is to be hoped that the time will soon come when the present gas mains and pipes will be employed to distribute gas for heating-purposes alone. Instances were given where the amount manufactured had been increased, or the quality of the goods improved, over ten per cent, by the introduction of electric lighting. Mr. Preece explained the superiority of this light, by saying that while in the arc light a candle-power was obtained by the expenditure of but one watt of energy, or by the incandescent light two and a half watts, gas required the equivalent of sixty-two, and candles of ninety-seven watts, for every candle-power produced. The great stumbling-block in universal electric lighting was shown to be the enormous cost of the mains for conveying the electricity over long distances. At the afternoon session, Mr. Crampton exhibited a piece recently cut out in repairing the first submarine cable ever constructed, and which he laid under the English Channel over thirty years ago. The model was then sent to the historical collection of the electrical exhibition as a donation to the Franklin institute. Mr. J. Dillon read two papers describing his method of regulating floods and an automatic method of sounding the bottoms of shallow rivers. The first depends on sluices which are automatically opened and shut by large floats; and the second consists principally of an arm dragging along on the bottom, and taking various angles according to the depth of the river. Prof. J. B. Johnson's paper on Three problems in river physics was devoted to a discussion of the transportation of sediment, and the formation and removal of sandbars; the flow of water in natural channels; and the relation of levees to great floods, and to the low-water navigation of rivers. Sediment was distinguished as either continuously or discontinuously in suspension, or as rolled along the bottom; and the action of the second sort in the formation of bars was discussed. It was also shown, that the third kind produces sand-reefs on the bottom which move along perhaps ten to thirty feet per day: they are sometimes fifteen feet high, and succeed each other at intervals of some three hundred feet. For the flow of water, the old formulae were shown to be worthless; but the author did not make the mistake of giving new ones. Levees were discussed, and their use discountenanced; waste weirs into side outlets being recommended. This paper will be printed in full. Mr. O. Smith's paper on topography of machines referred to more exact and systematic methods in drawing and speaking of machines and parts thereof, and should have been discussed on Monday. On Thursday, Mr. Arthur Rigg discussed the advantages of trip and eccentric gears, and a somewhat lengthy discussion ensued. It appeared that the American practice of employing simple valve-gearing in small quick-speed engines was approved of, though giving a somewhat inferior card to that of a trip-gear engine. Three other papers — 'The strength of cast iron,' W. J. Millar; 'Experiments on belting,' G. Lanza; 'Steam-engine tests,' C. H. Peabody — were, in the absence of the authors, presented by Professors Wood and Webb; and the session concluded with an interesting talk by vice-president R. H. Thurston, on the development of the philosophy of heat-engines.

PROCEEDINGS OF THE SECTION OF GEOLOGY AND GEOGRAPHY.

IT will be readily admitted by all who were in attendance upon any of its proceedings, that the sessions of section E of the Philadelphia meeting of the American association possessed, both as regards the numbers present and the character of the papers presented, a very unusual interest. As a special feature, might perhaps be mentioned the large amount of attention devoted to those most difficult of geological problems relating to prefossiliferous strata and the origin of the crystalline schists, — questions which not only in the meetings of the association, but in the world generally, seem year by year to be claiming an ever-increasing share of geologists' thought and study.

This tendency was well marked by the opening address of the vice-president of the section, Prof. N. H. Winchell, on the crystalline rocks of the northwest, a paper which needs no notice here, as we have already printed an abstract, and which according to the usages of the section admitted of no discussion.

The real business of the section was commenced on Friday morning, the day succeeding its organization, by the reading of a paper, by Prof. S. G. Williams of Cornell university, on the gypsum deposits of Cayuga county, N.Y. He maintained, on paleontological evidence, that these beds were members of the lower Helderberg formation, instead of belonging, as might have been expected, to the Salina period. A section illustrating their occurrence was discussed, and four distinct reasons given for considering their origin to be due to the action of sulphur-springs on beds of impure limestone.

A paper by Prof. E. Orton of Columbus followed, in which he showed how the remarkable symmetry and order pervading the lower coal measures in western Pennsylvania and Ohio extend across the Ohio River into Kentucky. Sections in both Pennsylvania and Ohio were carefully analyzed, and especial stress laid upon the importance of certain thin limestone beds accompanying the coal measures as reliable geological guides. Credit was given to Professor Crandall for having first shown that the sequence of beds was the same on the Kentucky side of the Ohio River as it was in Ohio. An interesting discussion followed this paper, between Professors Lesley and Orton; the former affirming that no traces can now be found of what were the shores of the original coal basin, and that no elevations or depressions accompanied the deposits of coal-seams, while the latter maintained that the evidences of the old shore-line, especially in Ohio, were very manifest.

Prof. F. D. Chester read an account of the geological survey of the state of Delaware, upon which he has for some time been engaged. He exhibited an unpublished map defining the small areas occupied by Laurentian and Cambro-silurian rocks in the northern part of the state; but naturally devoted most of his attention to the more important clays, sands, and marls, which represent the cretaceous, tertiary, and quaternary formations.

The vice-president of the section, Professor Winchell, followed with a description of a salt-well situated at Humboldt, Minn. The brine, although now to be found principally in rocks of Devonian or Silurian age, he considers to have originated in overlying strata, probably carboniferous.

Professor Orton, in a paper on the distribution of petroleum and inflammable gas in Ohio, showed that while scarcely a formation in the whole state was altogether free from them, their presence in really valuable quantities was confined to the subcarboniferous, and even here to two members of this series, — the Waverly conglomerate and Berea grit. These strata alone satisfy the necessary conditions of productive 'oil sands,' i.e., porous layers of sandstone or conglomerate sealed up between impervious layers of shale. As closely connected with the petroleum deposits of Ohio were mentioned the salt-wells, which yield an abundance of brine derived from the same 'oil sands.' This brine is remarkable for the amount of bromine it contains, the production here — one