pressed the opinion that such a system would be highly desirable.

Then followed a long discussion upon the standard of light. It was generally granted that a white light was desirable. Wiedemann remarked, that a fine gauze saturated with the spirit of turpentine, burning in oxygen, gave a very white light. Siemens proposed to employ a current of oxygen passing through a carburetted hydrogen, maintained at some fixed temperature. One could thus obtain a constant mixture which would burn with a white flame. Helmholtz thought that it would be extremely difficult to produce a mixture of air and carburetted hydrogen in constant proportion, and to regulate the temperature. Dumas thought that the late experiments of Violle upon the light emitted by melting platinum might solve the problem. The point of fusion of a body seemed to him to be as good a fixed point as could be wished. He invited the commission to view the experiments of Violle.

After witnessing the experiments of Violle, the members of the commission appeared to think more favorably of Dumas' suggestion. Professor Leblanc, who has had charge for many years of the photometric determinations of the lighting-gas of Paris, was invited to explain his methods; and the members of the commission, in turn, were invited to witness the methods in his laboratory. Professor Leblanc stated his preferences for the employment of a Carcel lamp for photometric determinations. He showed that the personal equation could be practically eliminated, and that differences of tint did not influence the results to the degree supposed. Sir W. Thomson spoke of the advantages of Rumford's photometer. The following resolutions upon this subject were finally adopted: —

a. The conference express their hope that the experiments now in process upon the light emitted by melting platinum will lead to a definite standard of light.

b. They recommend the employment of the Carcel lamp as a secondary standard, this lamp to be employed with the precautions adopted by MM. Dumas and Regnault.

Candles can also be employed as a secondary standard, if sufficient care be taken in regard to their construction and constitution.

c. They call attention also to the necessity of the analysis of the different conditions under which comparisons of light are made, and reiterate the opinions, expressed at the meeting of the electrical congress of 1881, in regard to the necessity of taking into account the amount of light radiated from sources of light in different directions.

At the close of the conference, Sir W. Thomson expressed the opinion that the labors of the conference would stimulate researches during the coming year; and he congratulated the conference upon its important work.

On the 26th of October, President Grévy received the members of the commission at the Palais d'Elysées; and, after a reception by Minister Cochéry, on the afternoon of the same day, the conference was adjourned to the first Monday of October, 1883.

ON THE PHYSICAL CONDITIONS UNDER WHICH COAL WAS FORMED.[1]

THE mode of formation of coal has been much discussed, and various theories have been promulgated in regard to it; but the peat-bog theory, as it is called, has been generally accepted. This is the view, that coal is the residual hydrocarbon of plants which have grown where their remains are found, and that it has been formed precisely as peat accumulates in marshes at the present day.

So great has been the harmony of opinion on this subject, that it would at first sight appear unnecessary to renew discussion on a question that had seemed to be definitely and permanently settled. The calm of geological opinion which has prevailed on the coal-question has, however, been recently disturbed by a very voluminous and painstaking discussion of the mode of formation of coal, by M. Grand'Eury, which occupies nearly 300 pages in the *Annales des mines* for the present year. In this discussion the theory is advocated, that the carbonaceous matter forming beds of coal has been derived from plants, but plants transported from their places of growth, and deposited at a greater or less distance in the bottom of water basins.

[1] Read before the National academy of sciences at its semi-annual meeting in New York, Nov. 14–17, 1882.

We have reports, also, from time to time, of a system of experiments and observations made by M. Fayol, at Commentry, in the department D'Alliers, in Central France, from which he draws the same inference; and it is apparent that a formidable attack has been made all along the line upon the peat-bog theory.

For this reason, and in order that geological truth shall be maintained, I venture to report some facts which I have myself observed in the coal-fields of the Mississippi valley, and which in my judgment are incompatible with the conclusions of MM. Grand'Eury and Fayol.

The opinions presented in the discussions of the chemical and physical history of coal have been based upon two classes of facts: viz., 1°, those gathered from the study *in the field* of the structure and relations of the coal-beds; and, 2°, those obtained from chemical and physical experiments conducted *in the laboratory*. Now, while there is no doubt that such experiments have contributed much to our understanding of the subject, it is obvious that they have misled observers, through the impossibility of imitating by artificial means the grand processes of nature. She has in most instances left a full and faithful record of her work; but the same difficulties attend the disinterment and translation of this buried record that have been encountered by the students of archeology in their efforts to trace the early history of mankind. Necessarily this is a work of time; and much study is required for the acquisition of a full and accurate knowledge of the language in which it is written, and for the gradual accumulation of the large amount of material required. Yet I claim, that so much of nature's record of the processes pursued in the formation of coal has been submitted to our observation, and that this record is so clear that the truth is within our reach; and, further, that this truth is discordant with the results obtained in artificial experimentation, and therefore proves such results fallacious.

In the present communication, nothing like a full discussion of the arguments *pro* and *con* will be attempted; since the space at my command will permit me to cite only a few of many facts, and to very briefly read their meaning.

For the present I will confine myself to some of the phenomena presented by one of the Ohio coal-beds with which I am specially familiar. This is our 'Coal No. 1,' the lowest of the series, sometimes called the Brier-Hill coal. As this has furnished a fuel of exceptional purity, such as could be used in the raw state for the smelting of iron, and lies nearer to the navigable waters of Lake Erie than any other, it has been very extensively worked. The result of this working has been to show, that the coal is confined to a small part of the area it was once supposed to cover, and that it lies in a series of narrow troughs, or basins, which were evidently once peat-marshes, occupying local depressions in the then existing surface. A large number of these detached coal-deposits have been now completely worked out, and the phenomena they present fully exposed to view. Among these phenomena I may cite: —

1. Below the coal a fire-clay, penetrated in every direction with roots and rootlets of Lepidodendron, Sigillaria, etc.

2. A coal-seam having a maximum thickness of six feet in the bottom of the basins, thinning out to feather-edges on the sides, and containing only two to three per cent of ash.

3. The coal on the margins of a basin rising sometimes thirty or forty feet above its place on the bottom.

4. A roof composed of argillaceous shale, of which the lower layers, a few inches in thickness, are crowded with the impressions of plants; among which are interlocked prostrate trunks of Lepidodendra and Sigillaria, traceable from root to summit, often carrying foliage and fruit, the fronds of ferns, — sometimes ten or fifteen feet in length, complete and smoothly spread, — Calamites, Cordaites, etc.

5. In many places the roof marked with circles one to two feet in diameter, called by the miners 'pot-bottoms.' These are sections of the bases of the upright trunks of Sigillaria or Lepidodendron, which rise *perpendicularly*, sometimes many feet, into the overlying shales. They consist of hollow cylinders of coal, perhaps a half-inch in thickness, the interiors of which are filled in with shale, laminated horizontally, and sometimes contain remains of plants and animals which must have been introduced when they were hollow stumps standing where they grew.

6. In certain circumscribed areas, part of the coal-seam is cannel, bituminous shale, or black-band iron-ore; and, as in all cases of this kind, the cannel, shale, and black-band contain the remains of aquatic animals, — crustacea, fishes, or mollusks, — the normal or cubical coal never including any thing of the kind.

7. The boundaries and bottoms of the chan-

nels and basins which hold the coal, composed of the Waverley shales, or the carboniferous conglomerate.

From these facts I translate the following history, which I am sure will be accepted as true by every geologist who has had sufficient experience in field-work to make his judgment of such phenomena trustworthy.

I. At the beginning of the formation of the coal-measures, north-eastern Ohio was a land surface, underlain by the Waverley shales, or beds of gravel, now the conglomerate. This surface was furrowed by the valleys of streams, and pitted by local basins, similar to those which mark the present surface.

II. With a slow subsidence, which continued with interruptions throughout the coal-measure epoch, the drainage was checked, and lakes and marshes were formed in the depressions of the surface. In these basins a fine sediment was deposited, — the 'fire-clay,' — like the clay now found under some of our peat-beds. When overgrown with vegetation the roots of plants penetrating this silt drew out of it iron, potash, soda, etc., leaving it nearly pure silicate of alumina, and specially refractory; whence its uses and name.

III. The marshes and lakes were ultimately filled with peat, which rose to a general level near the water-line, and was sometimes thirty or forty feet deep in the deepest parts of the basins.

IV. In places, water-basins remained such through a considerable portion of the time occupied in the accumulation of the peat; and sluggish streams flowed through the marshes, connecting these basins, and transporting to them fine sand, clay, lime, iron, etc., which, mingling with the completely macerated vegetable tissue, formed cannel coal, black-band iron-ore, and bituminous shale. After a time these basins also were filled with peat growing from the margins, just as our lakelets are now filled, and converted into peat-marshes.

V. After ages had passed with the physical conditions described, a subsidence caused a submergence of the peat-marshes, which first resulted in the destruction of the generation of growing plants that covered them. These dropped, in succession, leaves, twigs, and branches; and, finally, most of the standing trees fell. Some, however, continued longer to maintain an upright position, while the fine argillaceous sediment suspended in the water was slowly deposited around them, to form the roof shale, — of which the lower layers are charged with the *débris* of the plants growing on the marsh; the upper layers, deposited when these were all buried, nearly barren of fossils.

VI. The weight of the superincumbent mass pressed down the bed of peat; which, consolidated by that process, and undergoing internal chemical changes, ultimately became a bed of coal, thickest in the deepest part of each basin, thinning and rising on each side up to its edge, which remains to mark the original level of the surface of the peat-marsh.

Thus, and in no other conceivable way, was the resulting coal-bed made six feet thick in the bottom of the basin, and running out to nothing on the sides, thirty or forty feet higher.

The whole anatomy of the coal-seam shows that it was formed where it is found; the erect trees and plant-bearing shale above, the root-penetrated fire-clay below, the small amount of ash (only the inorganic matter of the plants), with many other features it presents, making the theory that it has been transported untenable. J. S. NEWBERRY.

THE YALE OBSERVATORY HELIOMETER.

FOR the benefit of the non-astronomical reader whose heliometric ideas are vague, the instrument may be defined as a measuring-machine in which the images of two stars, or other celestial objects to be measured, are superposed in the telescopic field by the following method: a telescope object-glass is cut across one of its diameters, and the two halves thus formed can be moved in opposite directions along the line of section by the observer while looking through the eye-piece. If he were examining the sun, for instance, with the two halves of the object-glass together, then he would have an ordinary telescopic view of the sun; but let him separate them, and he has the effect produced in the sextant when the two sun's images are separated by moving the arm. Now, if he brings the two images tangent first on one side and then on the opposite side by passing one over the other, the distance the object-glass halves are moved can evidently be expressed in arc, when the focal length is known, and is a measure of the sun's angular diameter. The advantages of such a method of measurement are only to be fully appreciated from certain considerations in physiological optics, from which it seems to be established that the most accurate measurements by direct vision are to be expected when the measuring-scale and the object measured are precisely similar in appearance and