lery is due to the presence and growth of the yeast-fungus. At the time of the publication of Schloesing and Muntz's memoir, it was remarked in corroboration of their view, that tradition has taught, that in the days when 'saltpetre plantations' or 'saltpetre yards' were worked in Europe, in order to obtain a supply of the nitrate for making gunpowder, pains were taken to use the earth of a yard over and over again, after the nitrate had been leached from it; and that, in order to insure success, when a new yard was to be started, some earth had to be brought from an old yard, and mixed with the new earth, — all of which went to show a recognition of the truth, that something useful for the process of nitrification was contained in the old earth. But the wisdom of the fathers is expressed even more emphatically in the following citation from the 'Diary of Samuel Sewall,' recently published by the Massachusetts historical society (see 'Sewall papers,' vol. 2, p. 10, of the preliminary 'Miscellaneous items'). It appears that in the year 1686 Judge Sewall copied upon the cover of his journal this receipt: —

"To make a salt-petre bed. All the sward of the ground is to be taken off or trenched in, and the stones to be taken clean out as deep as the trench. Then get the best and richest mould you can, and fill up the trench according as you will make it in greatness — length or depth as you see cause. When the ground is made clean and fitting, turn over the ground and trench it in again, and as you trench it in mix it with strong lime about a tenth or sixth part; and the Seed-Petre, or Mother of Petre, and hen or pigeon's dung as much as you can get, the more the better. And after 'tis trenched in as above, let all the butcher's blood and lees of wine be mixed often with the upper part of the mould about half a foot down, that it be not lost or run away from the bed or bank. Let the bank be made upon rising ground, and a ditch about it, that the water rest not, nor run into the petre-bed; with a dry house over it, to keep it from rain."

Surely it is something more than a curious coincidence that our forefathers should have thus spoken of the 'mother of petre' as they did habitually of the 'mother of vinegar.' In the face of expressions so distinct as these, it is impossible, as a matter of history, to deny that just conceptions of nitrification and acetification were current long ago. It is, perhaps, the fault of their descendants, rather than of themselves, that this knowledge of our ancestors was not more firmly grasped or sooner formulated with precision. F. H. STORER.

Archeological frauds.

As an illustration of the demand and supply of archeological material, I will call attention to a carved stone representing a naked child about two feet in length, which was said to have been dug up near the Hot Springs in Arkansas. The carving was partly enclosed by a cement, which, it was said, covered the stone when it was found. This was received at the Peabody museum, with its history, apparently well authenticated, describing it as an antique. This piece of carving proved to be a child of the 'Cardiff giant' family. The fraud was unquestionable; and the image was returned to its owner with a full statement of the evidence against it, and the request that in the interest of science the object should be destroyed. Since then I have heard nothing more of it, and in case it has not been destroyed this notice will serve to put others on their guard. This is, however, but one of the many fraudulent specimens offered for sale; and we have received a number of pipes, tubes, dishes, ceremonial and other objects, made in Philadelphia, and sold as having been found in such or such a locality. The variety of these articles made by the Philadelphia manufacturer, and the character of the work, are such that many have found their way into collections in this country, and not a few have supplied the foreign demand for American antiquities. A manufacturer in Indiana confines his attention chiefly to 'mound-builders' pipes,' which are carved from stone, and offered in a systematic method to collectors. In Ohio a large business has been done in the so-called gorgets, cut from blue slate, and in hematite celts. In southern Illinois, a few years ago, many specimens of pottery were made, until the demand fell off so that one manufacturer acknowledged that he was no longer paid for his trouble by their sale. Another man who made this pottery is, I believe, no longer living; but much of his work is still extant. This list might be lengthened; but it is already sufficient to show that the demand for 'antiquities' is considerable in this country, and that we are not behind the old world in keeping up the supply. F. W. PUTNAM.

Cambridge, Feb. 19.

AMERICAN INSTITUTE OF MINING ENGINEERS.

THE American institute of mining engineers, organized in 1871, and consisting at that time of mining and mechanical engineers, metallurgists, and chemists, held its second February meeting in Boston, in 1873, with a membership of about two hundred and fifty. Since that time the American chemical society and the Society of mechanical engineers have been formed, in a measure limiting the field of the institute to the mining engineers proper, the metallurgists, those chemists who are engaged on the problems connected with the profitable extraction and working of metals, and those geologists whose work lies in the same direction. But, even with this specialization of the aims of the institute, it has just held its twelfth annual meeting in Boston, Feb. 20–23; and the membership at present numbers over twelve hundred.

The decade which has elapsed between these two meetings has witnessed a most marvellous growth of mining and metallurgical enterprises. It is now very generally recognized that our mineral resources in extent and richness rival those of any other country. It is, on the other hand, true that the mining-lands of America present obstacles to the extraction and transportation of their mineral wealth such as no other country has to contend with. The ores, too, are of much more refractory nature, and the laws of the deposits very different from those that govern the veins and beds of the eastern continent.

The novelty and the difficulty have attracted to this field of research a number of Americans of liberal education fitted in the schools at home and abroad. The magnitude of the obstacles and the difficulty of the problems encountered in the field have only served to stimulate their mental energies, and have drawn hither a goodly number of foreign scientific and practical men, who have sought in this untried field an opportunity to win greater laurels than was offered by the better-known regions of Europe. All these causes have brought together a body of men of a degree of keenness of intellect, versatility of powers, and acquired skill in overcoming difficulty, which is rarely found in any association at home or abroad.

To the meetings they bring the freshest thought on the newest problems; and those of kindred pursuits have the means of informing themselves as to the progress in their several departments.

Besides the February meeting, which has always been held in some eastern city, one or two expeditions are taken each year to mining regions, where methods and processes are carefully examined and criticised. This close contact of the laboratory and the office with the field results in a union of theoretical and practical science which cannot fail to effect a great development in the metallurgical art.

The Boston meeting, which has just closed, was attended by about seventy-five members. Twenty-eight papers were presented, of which thirteen were read and discussed. Abstracts of these appear in the following pages. Some idea of the range of thought at one of these meetings may be gained from the following classification of the papers: In metallurgical subjects, ten papers were offered; in mining and ore-dressing, six; in geology, five; in analytical chemistry, three; in characters of iron and steel, two; and two unclassified.

Besides the five sessions for the reading of papers, there were three excursions to works of engineering interest. The first was to the pumping-station of the new sewerage system at Old-Harbor Point. The chief objects of interest were the two great pumping-engines, each with two plungers, four feet in diameter, and nine feet stroke. One of the engines was started for the benefit of the visitors, and they were informed that it was pumping about thirty-seven million gallons per day. One of these pumps would be able to pump the Charles River dry if its outlet to the sea were stopped by a dam. The sewage is here lifted forty-three feet in order to gain column enough to carry it out to Moon Island. On the way home the party visited the Norway iron-works, and inspected the new petroleum furnaces, which are said to replace one ton of coal with two barrels of crude petroleum; and also the Billings cold-drawn shafting apparatus. Later the Carson trenching apparatus was inspected, whereby a sewer may be constructed through the crowded streets without stopping the travel.

The second excursion was to see the celebrated testing-machine at the Watertown arsenal. No European nation has a testing-machine of equal capacity and precision of measurement; a piece of steel tested was a flat bar of the manufacture of the Norway iron-works, of twelve-hundredths carbon. Its length was 80 inches; width, 5.85 inches; thickness, one inch. Under tension it stretched eighteen inches, and broke when a force of 288,300 pounds had been applied, which is 49,282 pounds to the square inch. In the afternoon several of the buildings of Harvard university were visited, including the Museum of comparative zoölogy, the Peabody museum of American archeology, the gymnasium, and the chemical laboratory and museum of minerals in Boylston Hall. A lunch was served in Memorial Hall.

The third excursion, was made to Lowell; and the party visited a cotton-mill and print-works, besides a carpet- and a hosiery-mill, all of which proved of great interest to the members living out of New England.

Microscopic analysis of the structure of iron and steel.

BY J. C. BAYLES OF NEW YORK.

After briefly reviewing the work of A. Martens of Berlin and Dr. H. C. Sorby of Sheffield in this field of research, Mr. Bayles considered the methods of preparing specimens for microscopic study which in practice he had found to give the best results, and continued: The first step to be taken in practical microscopy is the training of the eye to observe what may be seen without the aid of a lens. This is accomplished by the patient examination of characteristic fractures, and noting similarities and differences. After the naked eye has become familiarized with all it can see, the student should continue his investigations assisted by a hand-lens with a power of from two to three diameters, and absolutely achromatic. Specimens to be studied with a view to determining their internal structures should be surfaced in a planer, and smoothed by draw-filing in the direction of the fibre. The surface thus obtained is treated with slightly diluted nitric acid, which gives a rapid and wide development of the structure, which may be studied with advantage while it lasts, and will prepare the student for finer work. For fine development more care and time are needed. After planing, the surface of the metal is ground with fine emery, or under a metallic mirror-grinder. It is then treated with acid, Mr. Bayles describing the manner in great detail. A thorough development with weak acid requires from twenty-four hours to six days, according to the composition of the metal. Small specimens are prepared by planing down from the back to a thickness of $\frac{1}{32}$ to $\frac{1}{16}$ of an inch. The planed face is then ground and surfaced on a fine whetstone, developed with weak acid, and mounted between glasses with Canada balsam. In selecting a microscope, care should be taken that the lenses give a good definition, that there is no 'shake' or lateral motion in the adjustments for focus, and then the table should admit of inclination at any angle found most convenient for observation. Concerning the results to be expected from the microscopic analysis of metals, Mr. Bayles expressed the belief that it opens a vast field of knowledge not yet reached by either chemical analysis or physical test. There are many conditions, the result of changes produced by mechanical treatment, to which chemical analysis gives no clew, and which are detected, but not explained, by the tests of the physical laboratory. The microscope will, no doubt, explain many of the mysterious changes which occur in metals of given chemical composition under different conditions, and will give the metallurgist an opportunity of studying the anatomy and physiology of iron and steel, which, in a most important sense, will supplement analysis and mechanical test, which have thus far, to some extent, run in parallel lines. When, between the report of analysis and the fracture of the broken test-piece, we can place a polished longitudinal or cross-section of the material, its internal structure developed by acid, and admitting of careful microscopic study, we are furnished with the missing link in the chain of evidence required for a correct conclusion as to the nature of the material under investigation.

Coal and iron of Alabama.

BY DR. T. STERRY HUNT OF MONTREAL.

After referring to the researches of Profs. R. P. Rothwell and Eugene Smith, and complimenting them in high terms on the results of their labors in that section, Dr. Hunt said that the existence of coal in Alabama had been known for half a century: it forms a part of the great Appalachian coal-basins, which lie principally upon the waters of the Ohio, and has an extent of 58,000 □ miles, including eastern Tennessee, the north-western corner of Georgia, and a large part of the state of Alabama. The principal part of these measures has an area of 5,000 □ miles; but on the east side are two small detached basins, — the Cahawba, 230 □ miles in extent, and the Coosa, 100 □ miles. They are separated from the main basin by narrow belts of older rocks a few miles in width; and there is no doubt that they are detached portions separated, — the one by a fault pure and simple, the other by an undulation which has overturned the folds, and has faulted them in some places. To the east of these, stretches the Coosa valley, a geographical feature of the greatest importance, being a continuation of the great limestone valley which runs up to Lake Champlain. On the eastern border of the valley is a great belt of crystalline rocks, of which the Blue Ridge, Hoosac Mountain, etc., are a part, and forming the great Atlantic belt from the hills of New England to Alabama. Next is a limestone valley forty or fifty miles in width. Then we have the North Mountain, which is the beginning of the great series of folds which make up the Alleghany Ridge, and formed of paleozoic rock which underlies the coal. To the west are the great coal-measures, essentially the same in character as those of Pennsylvania and Virginia. A peculiarity of the underlying bed of sedimental rock is its varying thickness, from 18,000 feet in Huntington County, Penn., and diminishing toward the south, until in some places in Alabama it has thinned down to 1,800 or even 1,000 feet of soft rock, sandstone, and shale.

The ores in the limestone valley are limonite, and the brown hematites found in Berkshire County, Mass., enormously developed; furnishing a large part of all the ore which is smelted, and practically inexhaustible for generations to come. In the mountain belt is another set of iron-ores, also important, — the red hematites of the Clinton group. Beyond that are coal and occasional clay ironstones, of secondary importance as regards amount. In the northern portion of these beds, especially in Pennsylvania, the North Mountains separate the coal and iron by distances of 100 miles or more, offering serious drawbacks, and increasing the cost of production; at the same time the Atlantic belt renders it impossible to reach the region by navigation. But a remarkable fact is the almost complete disappearance in Alabama of the two great mountain barriers before reaching the sea, being thinned out and worn and ground away. The southern rim of the basin is broken down, and the coal and iron are on a level with the navigable waters of the gulf at Mobile; bringing up the question of the importance of rendering the rivers navigable so as to reach the heart of the coal-region. The coal-measures to the south suffer no diminution in quantity or quality; but the bed-rocks are so upturned and folded and faulted, that within three or four miles the coal and iron are found together. A curious fact of the enormous fault — this great break in the stratification of nearly 10,000 feet — is, that it has brought up the hematite ores directly beside the coal in the Cahawba valley, so near that by the simple means of gravity they may be brought to a common point, reducing the cost of production to the lowest. To these geographical and geological conditions the region owes its future importance. It is the part of the country which is growing most rapidly in population, showing an increase in ten years of 41.6% against 30% for the nation; it includes the states where agriculture and the carrying trade are to be built up, requiring coal and iron; and they can be obtained under the most favorable conditions. Its significance was long ago noted by Isaac Lothian Bell, who found its ores richer and its fluxes much nearer than in Yorkshire; and he said that the region matched and more than matched anything in Great Britain. Abram Hewitt regarded it as important, reckoning not by the wages paid, but by the number of days of labor necessary to produce a given quantity. Dr. Hunt predicted a most remarkable future for the coal and iron regions of Alabama.

President Rothwell stated that he must disclaim any credit for original investigations, his first knowledge coming from a careful survey and plan made by Joseph Squires.

Dr. Hunt replied, that, had he been aware of it, he would have been glad to give due recognition to the labors of Mr. Squires.

Changes in the structure of block-tin.

BY PROF. R. H. RICHARDS OF BOSTON.

The speaker exhibited a pig of the metal, which in December last appeared to be perfectly good malleable block-tin; Feb. 15, the pig was found to be brittle, and had undergone a change in its molecular condition which involved about half of the mass. It made itself apparent by enlargement in spots which took on a darker color, and which revealed a crystalline structure very like that of stibnite. It was surmised that the change was due to imperfect retorting, leaving in the tin a small percentage of the mercury with which the metal was originally treated; and an analysis of a portion of the pig, using a current of hydrogen at a bright red heat, showed by the direct method the presence of 2.62 parts of mercury to 97.24 of tin; or, by difference, 2.76% of mercury and 97.24% of tin.

Dr. T. Sterry Hunt said that such changes had been previously noted in tin supposed to be in a state of purity, the metal becoming so crystalline that it was almost ready to fall in pieces. Under certain conditions, very like those stated by Prof. Richards, it had been ascertained that block-tin would undergo these changes.

A suggested cure for blast-furnace chills.

BY H. M. HOWE OF BOSTON.

These chills, as well known, are the results of a falling of the temperature below that needed for the fusion of the slag, from 1,800° C. to 1,900° C. The common remedies are the injection through the tuyeres of liquid petroleum, or of air-gas, and the increase in the temperature of the blast, rather than hastening the latter; since this tends to lower the temperature at the tuyeres, just as, up to a certain point, blowing a match, or fire, or candle, will increase its combustion, but beyond that point will decrease it. The difficulty with the use of liquid petroleum is, that it is not generated at a sufficiently high temperature, and the process of vaporizing it within the furnace also requires additional heat. He suggested, that instead there should be used vapor of petroleum or coal-gas, heated externally, so that the energy needed for that operation would not be taken out of the furnace. When cold liquid petroleum is used, there is not enough margin in temperature to avoid chills. The results of his observations were expressed by the following figures, the temperature being in centigrade degrees: —

	Initial Temperature.	Final Temperature.	
		Complete combustion.	Incomplete combustion.
Air-gas	482	2383	1323
Liquid petroleum . .	15	2885	1698
Vapor of petroleum .	482	3967	2117

In discussing the paper, Dr. Raymond of Cambridge said, that, at the Durham furnace, a chill had caused a large scaffolding, which had fallen suddenly, and had choked up the hearth. Liquid petroleum introduced through the tuyeres, with the blast at 900° Fahr., had burned a large hole in the mass, although it was not thoroughly successful in doing away with the obstruction; but a very high temperature was produced within a few inches of the tuyeres. He questioned whether the petroleum in the form of a fine mist, or spray, would not give a higher result than the vapor.

A member said that the chills were produced by the formation of scaffoldings, which prevented the descent of the fuel, and the proper reducing atmosphere could not be maintained. He was of opinion that the petroleum vapor would not remedy this unless carbon were introduced with it. Mr. Howe replied that he would introduce an excess of the gas.

President Rothwell asked if the combination of carbonic oxide and hydrogen, known as water-gas, had been tried. In recent experiments in Germany, in pipe-making and for welding purposes, introduced with air it had given a very high temperature.

Mr. C. Constable, of Constableville, N.Y., thought that 'chilling,' as here used, was a misnomer; that the air of the blast was only capable of burning so much, and, when in excess, a portion of it was driven up in the furnace, and caused the scaffolding. His remedy was a reduction of the blast.

The metallurgy of nickel in the United States.

BY PROF. W. P. BLAKE OF NEW HAVEN.

Nickel has for a long time, and until within a few years, been a compound rather than a simple element, so far as it was known commercially. It was extracted as a secondary product from cobalt spia, and of necessity was a very impure result, being contaminated with a great many other substances, especially arsenic, iron, and sulphur, which were present in small quantities, but sufficient to destroy, to a great extent, the true properties of the metal. In this respect nickel is essentially the same as iron, and these metals and steel offer many analogies when in a state of alloy or combination. For a long time cobalt was the principal object sought, and nickel was a by-product; but the production of artificial ultramarine diminished the demand for cobalt, and at the same time the introduction of nickel-plating and kindred industries increased the call for nickel, until now the conditions are reversed, and the latter metal is in the greater demand. But to the scientific chemists, who prepared nickel in a state of purity, its properties were not wholly unknown; yet between them there was a great diversity of opinion, — one declaring it to be malleable, and another the reverse. Its malleability was diminished by the presence of carbon or manganese; and, reduced by carbon, its ductility was less than that of zinc. These results, however, were confined to chemists and laboratories, and were not known to the arts; and the production of nickel continued as an alloy, with 2% or 3% of foreign matter, sufficient to destroy its malleability and ductility, and prevent its usefulness in the arts. The first demand for the metal was for nickel-plate, and next for making coins; being first used for the latter purpose in Switzerland in 1850, and in the United States in 1857, although as early as 1853 Booth of Philadelphia had made sample coins, and submitted them to the mint, but they were not accepted. The alloy varied from 5 parts of nickel and 95 of copper to 30 of nickel and 70 of copper. This country first adopted the ratio of 12 to 88; and at present, in the five-cent nickel coins, uses 25 parts of nickel to 75 of copper. Of these five-cent pieces there were issued up to June 30, 1876, the value of $7,000,000. Another large demand for the metal was occasioned by the discovery of the possibility of depositing it by the action of electricity.

Nickel ores are extensively distributed through the United States, more generally than is usually supposed. It is found with chrome ores in serpentine rocks which have a coating of nickel-oxide or emerald nickel, and is also commonly associated with magnetic pyrites; particularly in Connecticut, by the Hudson River, in New Jersey, and at Lancaster Gap, Penn., which is the chief source of the metal in this country. The general diffusion of nickel is pointed out by Dr. Hunt in the magnesian rock at Quebec; at Silver Harbor, on the shores of Lake Superior, is another supply; and a valuable deposit has been found in Nevada, whence last year there were shipped ten tons of the ore to Swansea. Another deposit, closely resembling that of New Caledonia, a hydrated silicate of nickel oxide, and carrying as high as 10% of the metal, has been discovered in Douglas County, in southern Oregon; the Lancaster-Gap ore contains only 1½% to 2% of nickel, with magnetic pyrites. A few years ago the discovery of the hydrated silicate at New Caledonia attracted a great deal of attention. It was at first thought that the deposit was small, and would rapidly be exhausted; but it has proved to be of sufficient extent to supply now nearly all the works of Europe, and is very pure.

In 1876 a remarkable series of objects was exhibited at Philadelphia by Professor Wharton, being nothing more nor less than a number of articles made by that gentleman of pure wrought nickel. They did not attract by any means the attention to which they were entitled; and the same fate befell them at Paris in 1878, where they seemed insignificant beside the splendid cases of alloyed products exhibited by the French workmen, these cases containing, however, not one piece of the pure metal of over three or four grains weight. Professor Blake called the attention of the chairman of the board of judges to these wrought-nickel goods. That official was inclined to be incredulous, but cut a small piece off a square bar, and took it to his laboratory. The next day he informed his associates, that this exhibit of Professor Wharton was beyond comparison, and that they were in the presence of one of the most important results of the age in this direction. This step paved the way to greater advances; and experiments were begun in Westphalia on the mechanical combination, or welding, of nickel with iron and steel. As a result there have been produced sheets of iron and steel coated with nickel on one or both sides, this end being accomplished by securing plates of the baser metal of proper surface, on which are laid the plates of nickel: these are then heated, and passed through rolls under high pressure. The thickness of the nickel is a tenth by weight on each side. The applications of this coated metal will suggest themselves. It is chiefly used in the manufacture of hollow-ware, being readily spun and pressed; and its advantages of lightness, strength, and infusibility, are apparent. These results have also been obtained by Professor Wharton at Camden, N.J.; who has also succeeded in making objects of cast-nickel, the door-knobs in his residence being of this material. There is a great future in this industry, which gives additional importance to all localities where nickel is found; and it is also of interest scientifically. A proposition has been made to use pure nickel for the magnetic needle, and one was exhibited at Paris in 1878. It was afterward presented to the French government, and a commission was appointed to test it: their report has not yet been made.

Professor Blake exhibited to the members of the institute several of the articles shown by Professor Wharton at Philadelphia and Paris. They included a knife, a bent bar, a horse-bit, etc. The bit, it was explained, had not been rubbed or polished since it was sent to Paris in 1878; yet it had not the slightest appearance of tarnish about it. There were also shown specimens of the hollow-ware made in Westphalia. In reply to questions, Professor Blake stated that these vessels were presumably harmless, as the nickel is not easily attacked by vegetable acids; and, further, that the experiment had been tried of feeding a dog on nickel-salts, on which the animal seemed to thrive. It is more economic and more rapid to coat the plates by rolling than by electrolysis.

The Bower-Barff process.

BY MR. BOWER OF ENGLAND.

Mr. G. W. Maynard was announced to read a paper on the 'Bower-Barff process;' but he stated that Mr. Bower of England, one of the discoverers of the process, was present, and could do better justice to the subject. Mr. Bower said, that any process which has for its object the preservation of iron and steel from rust, and which will make these metals more applicable than they now are to the requirements of mankind, will be sure to meet with attention from all those who are either engaged in the extraction of the ore, its reduction to metal, or the subsequent application of the metal itself. With iron and steel rendered secure against corrosion, they will be used to an infinitely greater extent than they now are. The whole realm of science has therefore been explored in the attempt to discover some method by which the formed article may be preserved, leaving its strength undiminished by the action of rust. Paints, oils, varnishes, glazes, enamels, galvanizing, electro-depositing, and what is called 'inoxidizing,' are among the many systems now in vogue to effect the preservation of iron and steel from the corrosive action of air and water. The object of this paper is to show what may be done in protecting iron and steel from rust by forming upon their surface a film of magnetic oxide by an inexpensive process. Russian sheet-iron is less affected by exposure than the ordinary material because of this formation, but this was not known until Dr. Percy discovered it. That such a coating is produced is quite certain, but it is only an accident of manufacture. To Professor Barff is due the credit of being the first to deliberately undertake to coat iron and steel with magnetic oxide produced designedly for the purpose of protecting their surfaces from rust. Some sixteen or seventeen years ago my father was making a series of experiments in the production of heating gases, one set of them being on the decomposition of water by passing superheated steam through masses of red-hot iron. He noticed that the iron became less and less active, until it ceased to decompose at all; when, on examining it, he noticed that it was coated with a kind of enamel. It at once occurred to him that the process in question might be used to obtain such a coating; but he found, after a few days' exposure of the iron to the atmosphere, that the coating scaled off, and he pursued the matter no farther. The iron employed in this case was rusty; but if it had been new, my father would in all probability have been the accidental author of the process which Professor Barff discovered ten years later. That consists in subjecting iron or steel articles to the action of superheated steam; and, when they are at a temperature sufficiently high, the following chemical change takes place: $3\ Fe + 4\ (H_2 O) = Fe_3 O_4 + 8\ H$. My father thought that what Professor Barff could effect with steam, he might also effect with air; and experiments were made varied both in character and results. On considering the fact that air is oxygen and nitrogen in mechanical combination only, I came to the conclusion, that, to form the lower or magnetic oxide, the quantity of free oxygen, and so of the air employed, must bear some proportion to the surface of the articles exposed to its action, more especially when a comparatively low heat is employed; and it has been found that the quantity of air passed through the retort during most of the unsuccessful experiments was three hundred or four hundred times more than was actually necessary. The mode of action I adopted was to admit a few cubic feet of air into the retort at the commencement of every half-hour, and then leave the iron and air to their own devices; the retort, of course, being tightly closed. During each half-hour a coating of magnetic oxide was formed, and the operation was repeated as often as was considered necessary. This was effective, but costly; both this and the Barff process requiring the external heating of the chamber. Successful experiments were made with air, but open to the same objection in regard to cost. Experiments with carbonic acid, produced by the decomposition of chalk, which should give $3\ Fe + 4\ (C O_2) = Fe_3 O_4 + 4\ (C O)$, gave a coating of light color and easily removed; the film probably being a mixture of $Fe O$ and $Fe_3 O_4$, or something nearer the metallic state than is magnetic oxide. But, even if successful, the cost of this method would still be too high. I therefore proposed to use a fuel gas-producer, similar in principle to the Siemens generator, but altered to suit other requirements; to burn the combustible gases thus produced, with a slight excess of air over and above that actually required for perfect combustion, and to heat and oxidize the iron articles placed in a suitable brick chamber by these products of combustion. I also arranged a continuous regenerator of fire-clay tubes underneath the furnace; so that the products of combustion, leaving the oxidizing chamber, passed outside the tubes, imparting a portion of the waste heat to them, which was taken up by the in-going cold air passing through their interior on its way to the combustion-chamber. I had hoped in this way to be able to so regulate the excess of air over that required for complete combustion, as to be able to produce magnetic oxide direct, instead of the lower and useless oxide or combination of oxides. I obtained some beautiful results, and some again were unaccountably bad; and I soon found that it was as difficult to regulate the precise amount of oxidation as it first was in the Bessemer process. But I was fortunate enough to hit upon an almost parallel remedy; that is to say, I increased the quantity of free oxygen mixed with the products of combustion, and oxidized the iron articles to excess during a fixed period of generally forty minutes, when magnetic oxide was found close to the iron, and sesquioxide over all. Then for twenty minutes I closed the air-inlet entirely, leaving the gas-valve open, and so reduced the outside coating of sesquioxide to magnetic oxide by the reducing action of the combustible gases alone.

The Barff patents have been purchased by my father. His process is better than ours for wrought iron, and perhaps for polished work of all kinds, as iron commences to decompose steam at a very low temperature, — in fact, much below visible redness. For ordinary cast iron, and especially that quality which contains much carbon, the Barff process is much too slow in its action; and some specimens that I have treated in England have taken as many as thirty-six hours to coat effectually, which could readily have been finished off in five hours by the Bower process. The main distinction between the two is, that the Bower is much more energetic in its action. The objection to the use of a closed muffle externally heated in the Barff process has been almost entirely overcome by simply putting wrought iron into a Bower furnace previously well heated, then shutting off both the gas and air supplies, and admitting steam into the regenerator tubes. Steel, I consider, can be equally well treated by both processes; except polished steel, which is better treated in a low-temperature Barff furnace. Of the fuel burnt in the gas-producers, a non-caking coal is the best. Virginian splint has suited very well in this country; and of this about one ton every three days is required for a furnace with an oxidizing chamber 13 feet long and 4 feet 3 inches wide and high. When a gas-coal is employed, it should be fed through the charging hoppers just before each deoxidizing operation, when a smoky flame is of great advantage. I have, however, discovered that anthracite coal can be used as well as a gas-coal by simply allowing petroleum to drop, at the rate of one gallon per hour, upon the red-hot surface of the coal in one of the producers. This method has been exclusively used in this country.

These magnetic-oxide processes not only protect from rust, but the coating is of such a beautiful color as to render articles ready for the market directly they are out of the furnace and cooled. One remarkable feature of these is, that there is no more cost (except in the labor of handling them) in treating 2,240 articles each weighing a pound than in coating a cube of the metal weighing a ton; and so penetrating is the process, that every crevice, no matter how intricate the pattern may be, is as effectively coated as the plainest surface. There is absolute certainty that paint used on iron so coated will adhere as well as on wood or stone; and thus iron may be used for construction work in a thousand directions in which it has not up to the present time been possible on account of its liability to rust, no matter what the coating used to protect it has been. Manufacturers appear far more ready to apply the processes here and on the continent of Europe than, up to now, they have been in England; but perhaps the reason has been, that, so far as Professor Barff's process is concerned, it has only just been shown how large masses can be dealt with by the use of the Bower furnace. For ordinary hollow-ware for kitchen or table use, whether of cast or wrought iron, the process is admirably adapted. It is intended to apply the process to cast-iron gas and water pipes; and, as the former have comparatively little pressure to bear, they may be made much lighter if rendered incorrodable: while, for water, there is no reason now why wrought-iron or mild steel pipes should not be used. In the case of railwaysleepers in iron and steel, which are now almost wholly used in Germany, the process is likely to prove of much advantage. For fountains, railings, and all architectural work, the process is invaluable; and iron may now be used in many instances instead of bronze. The cost has been carefully estimated at two dollars per ton; and this may be reduced by giving several furnaces in charge of one workman, and by a better system of taking the articles out than that in use when the estimate was made. Tests have been made as to the effect of the process on the strength of the metals, with the result that no alteration was detected in the strength. Theoretically one would suppose that iron and steel would be somewhat toughened, as the tendency of the process is to anneal, and would, no doubt, if continued long enough, render some classes of cast-iron malleable. A very thin article, if excessively coated, might probably be weakened, due to the fact that the coat of magnetic oxide would form an appreciable percentage of the bulk of the article; but that, of course, is a very extreme case, and one which is not likely to ever occur in practice.

Note on the jacketing of roasting cylinders at Deloro, Canada.

BY PROF. R. P. ROTHWELL OF NEW YORK.

The speaker said, that he merely desired to place on record the fact that he had been using roasting cylinders jacketed, to prevent any one from taking out a patent on the idea. He did not wish to deprive any one of the privilege of using it, but he also did not wish to be deprived of that privilege himself. In the roasting of arsenical sulphurets he had employed what is commonly known as the White and Howell cylinders, of plain boiler-iron, with fire-brick lining and shelves. He used two of them; the ore passing from one to the other through a pipe, without losing its heat. The first cylinder is 30 feet long and 5 feet in diameter, and takes out a large part of the arsenic and sulphur. The second is 24 feet long and a little less than 4 feet in diameter, in which the roast is finished. The two make a complete roast for chlorinating, and give from 94% to 98% of the gold. But these cylinders radiated an immense amount of heat, too much to allow the temperature to be kept sufficiently high to obtain a complete roast. This loss by radiation has been avoided by jacketing. A sheet-iron jacket is placed around the cylinder, leaving an air-space of two inches; outside of this is another jacket with a space of two and a half inches, which is filled with mineral or slag wool; this is mixed with plaster of paris, and further covered with roofing-paper bound on with wire. Immediately upon the use of this apparatus there was noticeable a tremendous reduction in the consumption of fuel required, and a remarkable increase in the amount of ore roasted. As thus made, it even resulted in heating the upper portion of the first cylinder too much, and roasting too quickly, not leaving in the ore the sulphur necessary for the treatment in the second cylinder. The trouble was remedied by removing eight feet of the jacket around the upper part of the cylinder.

Geological relations of the topography of the South Appalachian plateau.

BY PROF. W. C. KERR OF WASHINGTON.

By aid of a rough black-board sketch of the Blue Ridge and Smoky Mountains, the backbone of the system, the speaker showed from a study of the rivers, that the plateau has been gradually travelling westward. A series of spurs are thrown out by the Blue Ridge on the east, making a drainage system of cross valleys; here are the head-waters of the Tennessee river, which force their way through the great escarpment of the plateau, and through the Smoky Mountains, which in some places attain an altitude of 6,000 feet. This is a very remarkable and curious fact. The cañon through which the waters break is 4,000 feet deep, and has rocky sides not easily removed or eroded. A study of the situation shows, that since the establishment of the water-system there has been slow and steady rise of the mountain chain, the waters at the same time cutting their way down. There is another curious feature in this connection: the Tennessee river runs between this chain and the Cumberland ridge, and it would naturally be supposed that there is a rise from the west side of the river to the Cumberland. But observations with the barometer show, that there is really a continuous descent from the top of the Smoky Mountains to the base of the Cumberland chain, and here we have a river running at a higher level than its tributaries. The explanation is simply, that the Cumberland ridge has been gradually sinking since the establishment of the water-system.

The collection of flue-dust at Ems.

BY DR. T. EGLESTON OF NEW YORK.

In the treatment of silver from lead-ores, this subject is a matter of growing importance in Ems at the works under the charge of Herr Freidenbach, and of some importance here. In 1874 it was found at Ems that there was a considerable loss of product by the dry method, and the wet method was substituted; and still the loss of dust was much greater than had been supposed. There were three difficulties to overcome: to arrest the material carried off by mechanical means, to collect the material which is volatilized, — these two problems being comparatively easy of solution; but, when the collection was made, it was another thing to keep the material collected where it was, and prevent its further loss. The works are located on a plateau and hill. They run first down the valley, and then, turning on themselves, up the hill, continuing in a straight line to the top, where there is a chimney. In 1874 the length of the flue was 460 m., and it was furnished with the old style of condensing-chambers. The canal was then lengthened to 2,000 m., and carried to the flue 200 m. above the bed of the river. It was noted at once, that there was an immediate precipitation of flue-dust, much larger than had been anticipated, but still not effecting a sufficient reduction of the loss. An examination of the pipes led to the adoption of iron pipes, with the lower part terminating in zigzags 75 cm. deep, through which, by means of a door and close-fitting tube, the dust could be drawn out of the flue. This dust was rich, and the results of the method were satisfactory until the assays showed that much matter was lost by volatilization. Freidenbach soon found that the old-style arched flue was the worst that could be used; for, while its form gave strength to resist pressure from without, it also rendered it weak against pressure from within, and the gases found a comparatively easy means of exit through it. The flues were then made rectangular, bound together with iron, and made as tight as possible to prevent the escape of vapors. This form is now adopted everywhere. In the length of the flue was a series of condensation-chambers, but these were found to give no great results. The flue was now 2,600 m. in length, with an area of 42,650 □ m., and had cost 255,000 marks. A series of condensation-houses was built beyond the chimney, and still the results were unsatisfactory. It gradually became apparent that what was wanted was surface, and not volume. The iron pipes before described not having been affected, there were introduced into the flue sheet-iron plates hung vertically. Four of these plates were at first put in; but the results were so immediate and so gratifying, that the number was increased to six, with still better effect. The conclusion was at once jumped at, that the flue would stand all the plates that could be put into it; and accordingly seventeen plates were introduced, having a space of 10 cm. between them. It was then discovered, that nearly all of the material carried off mechanically was thrown down near the furnace, and that volatilized was deposited a little farther on. These results having been reached, the difficulty was to keep these deposits where they were, and to prevent them from being carried off by the immense draught in so long a flue. This last obstacle was surmounted by placing transverse sheets of iron in the bottom. When the deposits reached a certain amount on the vertical plates, they dropped off from their own weight, and fell to the bottom, where the transverse plates retained them. Experiments were made as to the distance from the works at which the deposits were made; and at a short distance away was found nearly all the mechanical dust, that from volatilization being a little farther on. There was no material diminution in the draught occasioned by the introduction of the plates. The dust collected so quickly and to such an extent that it became a serious question as to how to remove it. The flues were constructed with manholes at the top, and the dust was in such fine state that the men would be subjected to the danger of suffocation. The problem was solved by setting fire to the flue and burning the dust, which was found in agglomerations easy to remove, and in just the condition to be put into the furnace. The removal was a matter of little difficulty, the manholes having been changed to the sides of the flue. Next arose the question of temperature, and whether or not the lowering of it had any effect on the collection of the dust. It varied from 300° C. near the chimney to 64° C. at some distance from it; and it was found that the degree of heat made little difference. This led to important conclusions; and the substitution was begun, near the chimney, of pasteboard for the iron plates. They answered the purpose just as well, provided they were of sufficient thickness to sustain themselves, and were also much cheaper. After the success of these experiments, the method of cleansing flues by water will probably be abandoned. They have demonstrated the importance of surface over volume, and of the rectangular against the arched flue. It is doubtful if any method can save the whole of the material carried off by mechanical means or volatilization; but it is proved that there can be saved two or three times more than was believed possible.

President Rothwell said that he had visited these works, and had taken much interest in going over them. By the process, a saving of about four per cent is effected over the old way; and Freidenbach charges a royalty of two per cent, or one-half of what he saves. Since the collection of the dust by burning, the pasteboard surfaces had been dispensed with, as they would be destroyed. He had closely observed the iron plates, and found that they were little affected. The first plates used were those which had been discarded from the screens, and had been lying about the yard, being as likely to be acted upon as any; but they showed no signs of deterioration. He had observed the same effect of surface in the collection of arsenic dust in the works at Deloro, although at times he had been obliged to use a fan to secure a draught in long flues. The fan, however, needs frequent cleaning. His observations in regard to the ability of the iron to withstand action by the vapors led him to believe that arsenical chambers might be constructed of the same material with advantage. In regard to the flues at Ems, he had the fault to find, that they were built partly beneath the ground, and were apt to become too warm. He was in favor of building them above ground, and on arched supports, which would give the additional advantage that they could be opened without stopping the run.

Lines of weakness in cylinders.

BY PROF. R. H. RICHARDS OF BOSTON.

It has long been known to boiler-makers and to the users of cylindrical pipes of many kinds, that, when a tube is exposed to internal fluid pressure, the resolution of forces is such that the material of the walls of the tube is exposed to twice the stress in the direction tending to produce longitudinal rupture, that it is in the direction to produce circumferential fracture. By longitudinal fracture is meant the fracture by a rent parallel to the axis; by circumferential fracture, fracture by rents running round the cylinder. In consequence of this, makers of boilers always lay the fibre of their metal around the boiler; and the same is true with the makers of gun-barrels. I have never seen any good and simple illustration of this law until I met it in blowing glass. If a thin bubble of glass be blown out in a spherical form, and then exploded, it will be found that the particles tumble into totally irregular shapes, showing no special direction in the molecular structure of the material. If, now, a bubble of glass be blown out, and so manipulated that it will take a cylindrical form, and then be exploded, it will drop into ribbon-shaped pieces from end to end; and the only parts that will be found to differ from this form will be the two hemispherical ends, which will remain whole, having a fringe of ribbons representing the lines of fracture from the cylinder. The main point of difference between this experiment and the accidental explosion of large boilers appears to be, that in a boiler the shell goes at its weakest point, and once the rent is started it tears the boiler to pieces without much regularity of lines: while in the glass cylinder the walls are so nearly of the same strength that it can hardly be said to have a weakest point; when, therefore, it gets to its limit of strength, and is on the verge of exploding, there is no one place to initiate the explosion, and the glass explodes everywhere. This it does as it should do, by tearing into innumerable ribbons parallel to the axis of the cylinder. If $P =$ the pressure, and $D =$ the diameter of the cylinder, then $\frac{PD}{2} =$ stress tending to longitudinal rupture, and $\frac{PD}{4} =$ stress tending to circumferential rupture.

Professor Richards illustrated his statements by experiments with glass tubing and a blast, with the most complete success.

The shop-treatment of structural steels.

BY MR. A. F. HILL OF NEW YORK.

The speaker urged the importance in the manufacturing-arts of a knowledge of the effects on iron and steel of the various processes to which those metals are subjected. He took up these processes in their order, and gave the results of a close and careful study into the matter. In the operations of punching and shearing, it is conceded that the effect is to harden the metal to a local extent only; and also that enlargement of the area punched by reaming restores the plate to its original state. But Mr. Hill did not agree with Lieut. Barber, who has announced, as the result of his researches, that the amount of enlargement is a fixed quantity: on the contrary, the amount is dependent upon the carbon percentage and the thickness of the plate. The experiments were made with plates 18 inches wide, ¼, ⅜, and ½ inches in thickness, and .30, .40, and .50% carbon. They were cut in the planer, crosswise to the direction of the fibre; and three pieces from each plate were taken — one from the centre, and one from each end — for examination. The result of the experiments led to the conclusion, that the heavier the plate, or the lower the carbon percentage, the greater the effect of punching. Here is a clear indication of the direction which must be given to this line of investigation; but the conclusion is evident, that a restoration of strength is effected by reaming, although the enlargement is not a fixed quantity. In the cases of sheared and hammered open-hearth steel plates, annealing always restores the plate to its original strength. The capacity for welding is in inverse ratio to the carbon percentage, and the metal must not be heated any higher than is absolutely necessary to effect the weld. Annealing should immediately follow the welding, and the metal must be carried to a higher temperature than when it was last worked. It is a most important operation, and its effect varies directly with the carbon percentage. A metal bath gives unsatisfactory results: the best are obtained by annealing with oil. There is no more danger to be apprehended in annealing steel than in performing the same operation on iron; and nearly all trouble can be traced to poor workmanship.

The strength of American woods.

BY PROF. S. P. SHARPLES OF CAMBRIDGE.

When Gen. Walker was put in charge of the Census department, he was authorized to appoint experts to inquire into special industries. Under this act Prof. Charles S. Sargent of Brookline was appointed to gather statistics in relation to forest industries. Soon after his appointment, in 1869, he became convinced that it would be desirable to make an examination of the fuel-value of the various woods of the United States; and this work was placed in my hands. At the same time I made the suggestion, that, while we had the opportunity, it would be well to test also the strength of these woods: the suggestion was at once adopted, and Professor Sargent immediately set his agents at work in various parts of the country to collect specimens of all the trees growing in their localities; employing, as a rule, botanists who were familiar with the flora of the region in which they were at work. The result was the collection of over 1,300 specimens of wood, comprising more than 400 species and varieties, nearly 100 of which had not before been described as trees growing in the United States. The ash and specific gravity of every specimen in this collection have been determined, in most cases in duplicate: there have been about 2,600 ash and 2,800 specific-gravity determinations. About 325 species were further tested for transverse strength and resistance to crushing. In these series about 1,300 specimens were tested; and, as each was tried in three different ways, it made in all about 3,900 tests. There was a total of about 10,600 tests made on the specimens, many of them being of a series that required at least ten entries on the final report. In addition, seventy tests were made of the carbon and hydrogen in a number of the specimens. These tests have already, so far as the results of the ash and specific gravity of the dry wood are concerned, been published (*Forestry bull.*, No. 32); and a bulletin is soon to be published giving the deflections under various loads.

After the wood had become thoroughly seasoned, it was dressed out into rods 4 centimetres square and 11 decimetres long. These were tested on the Watertown machine, the stick being placed in a perpendicular postion, resting on supports that were exactly one metre apart; the deflection being measured by an ordinary Brown and Sharp's scale graduated to millimetres. The force was applied at the centre of the length, by means of an iron bearing with a diameter of 12.5 millimetres. The loads were applied 50 kilogrammes at a time, and the deflection read on the scale after each weight was added. When the weight equalled 200 kilos, the load was taken off, and the set was measured; the load was again put on, the reading taken at 200 kilos, and again at every 50 kilos until the stick was broken, the breaking-weight being also noted. In entering the test, a record was made of the direction of the fibre in each piece, — i.e., whether the pressure was applied parallel with, or perpendicular to, the annual rings, or quartering them, — but this portion of the test resulted in a failure, the wood seeming to have equal strength in all directions of application of pressure. The stick was also weighed to about half a gramme, from which was calculated the specific gravity. To determine the specific gravity exactly, blocks were taken, carefully dressed out to precisely 11 centimetres in length and 35 millimetres square. They were carefully dried at the temperature of boiling water for a week, and were then measured with a micrometer caliper, and weighed; the specific gravity being calculated from the measurement and weight.

The ash was determined by igniting small blocks, thirty-five millimetres square and a centimetre long, dried in the same way, in a platinum dish in a muffle furnace heated by gas, the heat being applied so carefully that in most cases the ash retained the exact shape of the block: by taking care not to melt the ash, there was avoided a common error resulting from the non-combustion of a portion of the carbon. The ash was perfectly white, except where manganese or iron was present in the wood. It was judged best to report the ash exactly as found, and not to attempt any correction on account of carbon dioxide that might have been lost from the calcic carbonate present. From the results of the specific gravity and ash, the approximate full value was calculated. Count Rumford made experiments from which he came to the conclusion that the same weight of all woods will give the same amount of heat when burned under the same conditions; and Marcus Bull of Philadelphia, in 1826, reached the same result. These are the only attempts known to determine the fuel-value of wood. It is evident, that, if the cellulose in all woods is of equal value, that with the most ash is of the least value for fuel.

In 1848 Liebig made determinations of the carbon and hydrogen in the average composition of European woods; and, singularly enough, all of his experiments were made on hard wood, with one exception, that of fir. I determined the carbon and hydrogen in forty specimens of hard, and twenty-nine specimens of soft, wood. The average results agreed within one-tenth of one per cent with those of Liebig: in soft woods the hydrogen is almost the same as in hard, but the carbon is from 4 to 5% greater, giving pine a higher fuel-value than hard wood. In these values we find mountain mahogany at the top (on account of its weight); the southern long-leaved pine is next, and at the bottom is poplar; shell-bark hickory is third on the list, these three having 49 to 54% of carbon. The pines are very close together, with over 52% of carbon, while the hard woods average a little under 49% of the average fuel-value by weight for soft wood: burning one kilo gives 4,488 units of heat; hard wood, 3,993.9: by volume, soft, 2,524; hard, 2,776.

In the tests for breaking-strength, the coefficient of elasticity was calculated for all sticks for the first two deflections, i.e., at loads of 50 and 100 kilos, and that at 100 kilos was found in many cases to be larger than that at the lesser load; but the explanation is found in the fact that there is more or less twist in the stick, no matter how carefully it is dressed; and this twist is increased by seasoning. The first load of 50 kilos is just about sufficient to take out the twist, and the second represents the true deflection. The results have shown, that it is by no means necessary to break two sticks to show which is the stronger, provided they are of the same kind of wood: the weak stick will show the largest deflection from the start. The strongest stick found was a piece of common yellow locust, the average of eight or nine specimens giving a breaking-weight of 543 kilos; hickory and southern pine follow closely; ash was found to stand very well up to a certain point, and then it gives way suddenly and without warning, generally shattering badly; California red-wood shatters thoroughly when it breaks, and shows the effect all over, rendering the entire stick worthless; white oak is inferior to several other oaks and to southern pine, the average breaking-weight of 40 specimens being 386 kilos, while the average of 8 specimens of the southern low oak was 528 kilos; 27 specimens of southern pine gave 490 kilos; 36 specimens of the Douglas fir from the Pacific coast, 374 kilos; 6 specimens of western larch, 523 kilos; 13 specimens of white pine, 274 kilos; 11 specimens of beech, 454 kilos; 16 specimens of large nut shell-bark hickory, 464 kilos; 20 specimens of white hickory, 512 kilos; 24 specimens of white ash, 378 kilos; 8 specimens of locust, 543 kilos.

The next series of tests were made on specimens of the same-sized square as before, and 32 centimetres long, compressing them in the direction of their fibres. Nine specimens of locust stood an average weight of 11,206 kilos; 5 specimens of western larch, 10,660 kilos; 35 specimens of white oak, 8,183 kilos; 24 specimens of southern pine, 10,498 kilos. The effect of the pressure on the specimens was very curious. Professor Sharples exhibited a number of specimens thus treated, which showed curious changes under the pressure.

The third series of tests was to find the force necessary to indent the wood at right angles to the grain. These are not yet finished, and I can give only a few general results. The load was noted at every one-hundredth of an inch of indentation, and it was found that the first one-hundredth was the hardest to make. After that the amount of force necessary diminished with each one-hundredth, until, at one-tenth of an inch indentation, it was found that the force required was only twice that at one one-hundredth. The specimens were often destroyed, however, before reaching the greater depth. In closing this paper, I wish to express my public thanks to Col. Laidley for many valuable suggestions made during the work, and to Mr. Howard for his careful aid in bringing the tests to a successful issue.

The eozoic and lower paleozoic in South Wales, and their comparison with their Appalachian analogues.

BY DR. PERSIFOR FRAZER OF PHILADELPHIA.

This paper embodied the observations of the author at St. David's, South Wales, during a visit at the invitation of Prof. Archibald Geikie, director-general of the geological surveys of Great Britain and Ireland, and Mr. B. N. Peach, geologist in charge of the survey of Scotland. The occasion offered a rare opportunity for studying those classic rocks, — the Cambrian; but there were other series of rocks exposed of the greatest interest to the student of Appalachian geology, not only from their points of resemblance to other rocks met with frequently on the Atlantic border of the United States, but from the similar relations which they seemed to bear to the measures in contact with them. At Roch's Castle is an area of Llandeilo flags, resembling what Dr. Frazer has often designated as argillaceous shale; and, in specimens where the decomposition into clay had proceeded very far, there was almost invariably the same disposition to split into prisms of unequally large pairs of parallel planes, no two of which were perpendicular to each other, giving them a remote resemblance to some of the indefinitely numerous varieties of triclinic crystals. Like similar argillaceous shales and slates near the town of York, Penn., and elsewhere in America, the slabs split up into almost any desired degree of thinness. The rock on which the castle is built is a silicious, greenish rock, showing everywhere included crystals of more or less definite outline, and generally of about the size of a buckshot, and containing a whitish or yellowish feldspar. The analogy between this rock and the 'jaspers' of Rogers, of which Dr. T. Sterry Hunt was the first to point out the real character, is striking. In the porphyry of Roch's Castle, the feldspar is oftener yellowish-green than in the orthofelsite porphyries of the South Mountain and of the eastern United States, as there is much of the Welsh orthofelsite which shows flesh-colored feldspar, and much of that of the South Mountain which exhibits green and other colors. The lamination and flaggy structure, when it was apparent, seemed to be entirely due to the arrangement of the cleavage surfaces of numbers of small crystals in the same plane; because a large part of the rocks defied all attempts to define sedimentary structure. Similiar exhibitions of orthofelsite are found in quantity on the eastern slope of the South Mountain in Pennsylvania, from Dilsburg to Monterey. In the latter regions, however, the beds, which are generally in contact with them, have a more chloritic and a more schistose character than the Llandeilo flags. They are marked, too, in America, for a part of their extent, by an horizon of copper ores, of which no trace was observed in South Wales. To the west and north of the beds of intrusive rock which seem to underlie St. David's, and in the harbor of Porth Ceri, there occurs a thick series of greenish, arenaceous beds, showing numerous streaks of chlorite. They are of very great interest, because they are unmistakably hydro-mica schists of light greenish or grayish color, very finely laminated, and resembling the rocks of parts of the South Valley Hill, and of parts of Fulton and Manor townships on the Susquehanna river. Similar schists, which (according to the writer's theory of structure, based on the study of south-east Pennsylvania) are associated with distinctively chlorite schists, are in contact with the orthofelsite of the South Mountain, in Adams and York counties, Penn. Very similar schists may also be met (though in this case without the presence of orthofelsite) in the Chestnut-hill ore-banks, just north of the town of Columbia, on the lower Susquehanna, and in the Grubb ore-bank, Hellam township, York county. Parts of these rocks in Porth Ceri are very hard, and resemble strikingly some of the greenish grits on the left bank of the Susquehanna, near the Maryland line. These beds on their exposed surfaces become more and more distinct from each other in color as their disintegration proceeds; and it is impossible to overlook the analogies which even these physical features present to the variegated clays, chiefly red and white and pink, which border the bases of the South Mountain, both on the east and in the Cumberland Valley, in Pennsylvania. Another paragenesis, strikingly analogous to that in the South Mountain, is found at Trelethyn, about one mile west by north of St. David's, near one of the largest bands of 'greenstone,' which are colored as such on the geological map. Here is a hard, silicious, greenish rock, with interstitial spaces, filled with milk quartz and epidote, the latter in large excess. This mixed rock, as is the case very frequently in Pennsylvania, forms low ridges in the midst of the softer chloritic schists and orthofelsites, with which it is almost always closely associated. About a mile west by south of St. David's is a hummock, pronounced to be a porphyritic lava, and which greatly resembles the hard green silicious rock, which occurs near Williamson's Point, on the left bank of the lower Susquehanna, near the Maryland line. It is a very important point in the proper understanding of the structure here, and its analogy with the Appalachian phenomena, to determine whether the band of schists which intervene between the two belts of intrusive beds be really Cambrian, or whether they may not correspond with the horizon, to which Dr. Hunt and the writer have supposed that the enormous masses of crystalline schists which stretch from Vermont to Georgia belong. On this point the writer feels unwilling to differ with the able geologists who have assigned their position to the English schists, without attaining, at least, to a portion of their information and experience of this terrain. It is certain that if they be in reality Cambrian, there are great difficulties in the way of considering the orthofelsite beds to the north-west as forming a part of the Huronian. Dr. Frazer studied carefully the structure, with especial reference to the mooted questions connected with the age of the syenitic granite passing through St. David's; and from the appearances of injection of syenitic matter into the elastic beds of the Cambrian shales, regarded the conclusion as unavoidable, that the whole of the syenitic granite mass, of which a part forms the foundation of south-eastern St. David's, is younger than the schists which lie to the south-east of it. If this be so, there is good reason for ascribing the rocks to the north-west of this granite belt to the same age, and of explaining their somewhat modified lithological characters to the alteration produced by this large igneous mass. In summing up his impressions, Dr. Frazer said, —

1. There is a striking analogy between some of the beds which constitute the lower Cambrian in South Wales, and some of the beds which constitute the horizons proximate (both above and below) to the primal of Rogers, or the Potsdam of the New-York geologists. These analogies are not confined to kinds of rocks, but embrace paragenesis, topography, and accessory mineral contents.

2. There is a strking analogy between the orthofelsites, ash-beds, syenitic granites, diabases which here seem to be *younger* than the above, and the same rocks which in the Appalachian region of America seem to be *older* than the primal.

According to the current views of the English geologists, the entire coast-line, which forms the subject of these notes, is minced up by faults of different extents and directions. The writer was not able to convince himself of the existence of all of these faults, nor has he ever seen so many together. At the same time he does not wish to compare on equal terms the experience gained in his short visit with the greater experience of his hosts. Still, he cannot accept the view of so many faults; and mainly on this account he believes the study of the structure in South Wales to be especially important to American geologists, although it seems to support a view of the age of orthofelsites and crystalline rocks in South Wales which the author has always combated, and still combats, as inapplicable to the eastern United States. If, however, there were a network of faults, such as has been stated, the attempts to present a theory of superposition would be attended with the greatest difficulties, and, with no more investigation than he has had opportunity to make, would be entirely fruitless.

The business meeting.

Dr. Thomas M. Drown, the secretary, presented the report of the council, from which it appeared that the receipts of the institute for the year had been $13,169.05, and the expenses $8,140.53; leaving a balance of $5,028.52, which will be invested by the council. The receipts were much higher than in the previous year, the result of a large increase in membership. The tenth volume of the proceedings has been issued, and there will soon be published an index of all the volumes thus far published. Regular meetings were held at Washington and Denver, at which it was gratifying to note the large increase of papers on the mining and treatment of the ores of the precious metals. During the year 10 members have resigned, 25 have been dropped for non-payment of dues, and 8 have died, leaving the present membership at 1,213; of these, 5 are honorary, 50 foreign, and 149 associate members.

The following-named gentlemen were elected officers for the ensuing year: president, Robert W. Hunt, Troy, N.Y.; vice-presidents (for two years), S. F. Emmons, Denver, Col.; W. C. Kerr, Washington, D.C.; S. T. Wellman, Cleveland, O.; managers (for three years), John Birkinbine, Philadelphia, Penn.; Stuart M. Buck, Coalburgh, Kanawha County, W. Va.; E. S. Moffat, Scranton, Penn.; treasurer, Theodore D. Rand, Philadelphia; secretary, Thomas M. Drown, Easton, Penn.

The following papers were read by title only: Gas-producer explosions, by P. Barnes, Elgin, Ill.; Ice mining and storing, by Prof. W. P. Blake, New Haven, Conn.; The mining region about Prescott, Arizona, by John F. Blandy, Prescott; Blast-furnace practice, by Casimir Constable, New York, N.Y.; Notes on the geology of Egypt, with especial reference to the rocks from which the obelisks have been taken, by Dr. Persifor Frazer of Philadelphia, Penn.; Notes on a protected iron hot-blast stove, by Frank Firmstone, Easton, Penn.; The geology of Cape Hatteras and the south Atlantic coast, by Prof. W. C. Kerr, Washington, D.C.; The divining-rod, by Dr. R. W. Raymond, New York, N.Y.; Notes on the Linkenbach improvements in ore-dressing machinery used at Ems, by R. P. Rothwell, New York, N.Y.; Determination of manganese in spiegel, by G. C. Stone, Newark, N.J.; Gas analysis, by Magnus Troilius, Philadelphia, Penn.; Determination of copper in steel, by Magnus Troilius; History and statistics of the manufacture of coke, by J. D. Weeks, Pittsburg, Penn.; Notes on settling-tanks in silver-mills, by Albert Williams, jun., Washington, D.C.; Water-gas as a fuel, by W. A. Goodyear, New Haven, Conn.; The occurrence of gold in Williamson county, Texas, by Prof. C. A. Schaeffer, Ithaca, N.Y.; On the utility of the method adopted by the Pennsylvania geological survey of the anthracite fields, by B. S. Lyman, Northampton, Mass.; A new form of hydraulic separation for the mills of Lake Superior, by Prof. R. H. Richards, Boston. Mass.; An accident resulting from the use of blast-furnace slag-wool, by Prof. T. Egleston, New York, N.Y.

On motion of Mr. Bayles of New York, a proposed amendment to rule 6, requiring an additional regular meeting during the year, was laid on the table.

On motion of the same gentleman, a suitable vote of thanks was passed to all the gentlemen in Boston who had put the members of the institute under obligations; and, after a formal surrendering of his charge by the retiring president, Mr. Rothwell, the meeting was adjourned.

SIR CHARLES LYELL.[1]

II.

WHEN he returned from this journey, he entered Lincoln's Inn, and began a rather desultory life in the law; and for the five subsequent years his geology had little growth save in his holiday-time. But his eyes, weak from childhood, gave him more trouble as years went on. He found the studies little to his taste, and each vacation drew him more and more strongly to science. In 1823 he became secretary of the geological society. This seems to mark the turning-point in his career; for, though he nominally kept his place as a student for the bar, we find him more and more separated from it in interest. In this year he published his first geological paper.

Perhaps the most interesting part of his letters, at least to the general reader, are those to his father from Paris in 1823. He had an easy entrance to the society of that day, and his clear pictures of many of the scientific men are extremely entertaining. Humboldt, Cuvier, La Place, Broquiert, C. Prévost, Tromsoe, all came under his trenchant pen. Of these Constant Prévost was doubtless his most effective teacher; for his was a spirit of singular insight, and the lines of his thought somewhat resembled those of Lyell's own mind. He has left a scanty record in his writings, but his power is marked in his effect on all who came within his influence.

In 1825, at his father's request, he once again went about his law; was called, and for two years rode circuit with his mind on older, if less musty, things than Jarndyce *vs.* Jarndyce, and the like. This seems to have been the last chance the law had of winning a very keen intelligence to its fields: henceforth he seems to have left it altogether. In 1828 his Principles of geology first took definite shape in his mind, and until his first edition in 1830 he was busied in many journeys after facts for his work. Central France, Italy, Spain, and Germany gave him the most of his field-matter; endless talks with the workers of those countries, for which his considerable knowledge of modern languages well fitted him, did the rest. In these and other journeys, his letters and journals show his ready understanding of men and their societies. He was never a solitary worker: almost every thing comes out in talks and work with others. Even his journals are always addressed to some one. It was an admirable feature of his character, that he was generally out of himself, and even his antagonisms are sympathetic.

His southern journey carried him to Sicily; but it is curious to note that he was delayed in Naples by need of care in avoiding the Tripolitan pirates, by a steamship-journey. It seems strange, that, in the days of emancipation of British slaves, with all the navies of Europe free from larger calls to action, this nest of pirates should have been tolerated.

In 1831 he was appointed professor of geology in King's College, London. His nomination had to be confirmed by a board of bishops and other church-magnates; and his open opposition to the notion of a deluge and a seven-days' creation made it doubtful if he would receive it. At last, in a fine English way, they declared "that they considered some of my doctrines startling enough, but could not find that they were come by otherwise than in a straightforward manner, and logically deducible from the facts; so that, whether the facts were true or otherwise, there was no reason to infer that I had made my theory from any hostile view towards revelation."

His experience as a lecturer in Kings College was not such as to procure him much profit or intellectual gain: so, though he deemed his work successful, he soon abandoned it.

[1] Continued from No. 3.