$$\frac{p}{D_c} = \frac{H(D_a - D_c)}{D_c} \quad , \quad . \quad (2)$$

and the velocity in the flue will be found from the expression

$$\frac{V'^2}{2g} = \frac{H(D_a - D_c)}{D_c} \quad . \quad . \quad (3)$$

or,

$$V' = \sqrt{\frac{2g\,H(D_c - D_a}{D_c}} \quad (4$$

But from the Mariotte-Guy Lussac law we have—

$$\frac{D_c}{D_a} = \frac{T_a}{T_c} \text{ or } D_c = D_a \frac{T_a}{T_c} \quad (6)$$

substituting this value of D_c in formula (4) then results—

$$V' = \sqrt{2g\,H.\left(\frac{T_c - T_a)}{T_a}} \quad (7)$$

In this expression the theoretical velocity of flow is expressed in terms of the height of the flue and the absolute temperatures of the flue air and the external air. From formula (7) we have—

$$T_c - T_a = \frac{V'^2}{2g\,H} \times T_a \quad . \quad (8)$$

The quantity of heat transferred to the air may be represented by

$$\phi = W.\,c.\,(T_c - T_a) \quad . \quad (9)$$

in which ϕ represents the quantity of heat in units of heat per second, and c the specific heat of air at constant pressure ($c = 0.238$.)

All of the above formulas are well known. The following are believed to be new:

The quantity of heat imparted to the air may also be represented by $\phi' = \frac{S.\,r.\,(T_s - T_a)}{3600}$ in which is the quantity of heat imparted per second, and as from the nature of the problem $\varphi = \phi'$ we have

$$\frac{S.\,r.\,(T_s - T_a)}{3600} = W.\,c.\,(T_c - T_a) \quad (10)$$

or

$$T_c - T_a = \frac{S.\,r.\,(T_s - T_a)}{W.\,c.\,3600} \quad . \quad . \quad (11)$$

combining this equation with (8) we have—

$$S'.\,r.\,\frac{(T_s - V_a)}{3600} = \frac{V'2}{2g\,H.} \times T_a \quad . \quad (12)$$

and

$$S' = \frac{V'^2.\,W.\,c.\,T_a}{2g\,H.\,r.\,\frac{(T_s - T_a)}{3600}} \quad . \quad . \quad . \quad (13)$$

This expression gives the total heating surface in the pipes in terms of the velocity, the height of the flue, the weight of air discharged per second, and the absolute temperature of the external air.

If we substitute for V′ its value in terms of V, the actual velocity, we have—

$$S' = \frac{K^2\,V^2\,W.\,c.\,T_a}{2g\,H.\,r.\,\frac{(T_s - T_a)}{3600}} \quad . \quad . \quad (14)$$

and since

$$W. = D_c\,V.\,A.$$

$$S' = \frac{K^2\,V^3\,D_c\,c.\,A.\,T_a}{2g\,H.\,r.\,\frac{(T_s - T_a)}{3600}} \quad . \quad . \quad (15)$$

another expression for S'.

These two expressions exhibit the laws of the movement of the air, giving the quantity of heating surface required under any special conditions of area and height of flue, temperature of external air, and velocity of discharge.

The constant (r) may be found approximately from the experiments of Mr. C. B. Richards, made at Colts Arms Co., of Hartford. The constant K depends upon the frictional resistance which the air encounters in its passage into and through the flues. The velocity V may be assumed, and should not be greater than four or five feet per second. The smaller the velocity and the larger the flues, the less will be the required heating surface, and the greater the economy of the apparatus for ventilation.

The following paper was read by Prof. H. L. FAIRCHILD:

ON A PECULIAR COAL-LIKE TRANSFORMATION OF PEAT, RECENTLY DISCOVERED AT SCRANTON, PENN.

The material which we shall notice this evening has naturally been regarded, on account of its associations, as illustrating in some degree the formation of coal. A brief description of that alteration of peat which has resulted in the formation of coal, is therefore desirable.

Peat results from decomposition of vegetable matter under water. The latter excludes the atmosphere and largely prevents the oxidation, which removes the vegetable debris on the upland, and which if rapid we call combustion, or if slow, decay. In northern regions peat-swamp vegetation is commonly a sort of moss (Sphagnum) which grows upward as it dies below. Great peat deposits are also produced in lower latitudes from the debris of forest trees. The great Dismal Swamp is a fine example, and in the Hackensack and Newark meadows we have examples of peat-formations of great depth, produced by the slow subsidence of the region and the accumulation of salt-marsh vegetation.

In former geological ages, immense peat deposits were produced in the vast lowlands along the borders of the continents, or at the deltas of the ancient rivers. These great swamps were frequently submerged in the sea and deeply buried beneath mud and sand. This event occurred perhaps many times in a single locality. The buried peat slowly decomposed. Much of the hydrogen and oxygen of the vegetable tissue, and some of the carbon, were eliminated. The remainder was consolidated by the weight of the superincumbent strata, and the result is bituminous coal. Thus we have the six to twenty coal beds of Pennsylvania, or the one hundred coal-seams of Nova Scotia.

The evidence that our coals are primarily formed in this manner is abundant, clear and incontrovertible. Few subjects are by our inductive science more definitely settled than this. We find these buried vegetable deposits in every stage of decomposition and alteration. Where the containing rocks are undisturbed, lying in their original positions, the coal contains a large proportion of volatile matter, and is bituminous. But where the rocks are dislocated and folded the coal is, by the pressure and heat, changed to anthracite or perhaps to graphite. The proportion of fixed carbon, or the degree of alteration, is always proportionate to the amount of disturbance which the associated rocks have suffered. Hence anthracite coal is a metamorphosed coal, just as marble is metamorphosed limestone, or quartzyte is metamorphosed sandstone. The metamorphism of coal is still going on. The escape of the volatile matter, in which the change consists, is observed in the mines, in the production of the explosive "fire-damp," and the poisonous "choke-damp."

Running from cellulose through wood, peat, and coals up to graphite we have a complete series; the difference being the loss of hydrogen, oxygen and in a less degree of carbon. This table, after LeConte, exhibits the proportions of the elements *by weight*, the carbon being reduced to a fixed quantity:

	Carbon.	Hydrogen.	Oxygen.
Cellulose	100	16.66	133.33
Wood	100	12.18	83.07
Peat	100	9.83	55.67
Lignite	100	8.37	42.42
Bituminous Coal	100	6.12	21.23
Anthracite Coal	100	2.84	1.74
Graphite	100	0.00	0.00

Anthracite coal, it will be seen contains a very small proportion of volatile matter, and graphite none at all. No two specimens of coal from different beds or areas are likely to yield upon analysis exactly the same results. This is due to differences in degree and manner of decomposition, the varying degree of metamorphism, the varying impurities, and perhaps a difference in the kind of vegetation. Anthracite coal naturally contains more ash than bituminous, because it is more concentrated, and of course peat has the least proportion of ash, simply derived from the inorganic matter of the plant.

The substance to be described was found in a peat-bog in the city of Scranton during the past summer. It has received attention from the newspaper and scientific people of the eastern coal region of Pennsylvania; and has been recently mentioned in the *Am. Jour. of Science* for Dec. by a quotation from a letter of a Scranton gentleman to the *Engineering and Mining Journal.*

Scranton lies in the midst of the Lackawanna anthracite coal-basin, which forms the northern half of the Wyoming basin. Since the financial panic of 1872 the city has grown but slowly, and a swamp lying in the midst of the city had remained unoccupied, except as an old dumping-ground for cinders from the furnaces. The city having been lately made the county-seat of the newly created Lackawanna county, this swamp was selected as the site for a court-house. In excavating for the foundations there was found a bed of excellent peat, 10 to 14 feet deep. I visited the excavation and collected specimens from depths of 3, 5, 8, and 13 feet. These specimens, of which a series are before you, were, of course, when fresh and saturated with water, several times their present bulk.

The peat from the greatest depth was highly decomposed, or very "ripe." It was fine-grained, close in texture, and although soft held its shape well, cutting like cheese. The color, when freshly cut, was a yellowish-brown, but changed rapidly to a dark-brown, almost black, in a few minutes. Upon drying, the color becomes a lighter or grayish-brown. The rock below the ripe peat is a clayey sand. This is somewhat impervious to water; but it is likely that beneath it is a more clayey bed which originally held the water and occasioned the swamp.

In the midst of the ripe peat, termed muck in the letter above mentioned, there was found, at various times and at different places, in excavating for the division walls, a substance resembling to the eye a bright coal—anthracite if you please. This did not occur in beds or layers, or in any apparent regular manner, but in irregular scattered or branching masses. You will observe in these dried specimens how intimately the coal-like matter and the ordinary peat are mingled. The two kinds cannot be separated, and it is with difficulty that the dried material can be gotten entirely pure for purposes of analysis. It shrinks upon drying, to a greater degree than the unchanged peat. Masses which I thought would afford fair-sized dry samples have nearly disappeared. The fresh material has been described as a tough jelly, which is perhaps a fair description. It was somewhat elastic, like a mass of soft india-rubber, but would break before bending greatly. I should compare it to a very firm but brittle jelly. The fracture had the lustre of a true coal, and in the dried state the resemblance is perfect. Being found in the midst of an anthracite basin, unscientific people naturally supposed from its associations that whatever bearings it might have upon coal would relate to anthracite coal, not knowing, or not remembering, that anthracite is a metamorphic coal.

Mr N. L. BRITTON, Geological assistant at the School of Mines, New York, has made approximate analyses of this altered peat, from material which I carefuly selected; also of the peat contiguous to the transformed matter (within the distance of an inch); and of the ripe peat from a depth of 13 feet in another part of the excavation. The analyses are of thoroughly and equally dried samples, and afford the following percentages:

	Moisture at 115° Cent.	Volatile Matter.	Fixed Carbon.	Ash.
1. Ripe Peat..........	6.225	63.875	4.625	25.275
2. Peat adjacent to 3...	3.775	22 125	4.625	69.475
3. Transformed Peat...	11.350	52.800	24.725	11 125
4. Transformed Peat...	66.758	9.826	4.012	19.404

Number 4 is by the Pennsylvania State Chemist, as published in the *American Journal of Science.* The moisture is taken at 212° Fahr., and the analysis is evidently of the fresh material.

To obtain a fairer comparison, and if not strictly accurate, yet sufficiently so for our purpose, I have computed the percentages with the moisture eliminated.

	Volatile Matter.	Fixed Carbon.	Ash.
1. Ripe Peat..............	68.115	4.932	26.953 (White)
2. Adjacent to 3...........	22 993	4.806	72 201 (White)
3. Transformed Peat......	59.560	27.891	12.549 (Pink)
4. " (State Chemist)	29.559	12.069	58.372
Bituminous Coals.........	30. to 60.	40. to 70.	3 to 6

From this table it will be seen that the composition of the transformed peat, number three, is about that of a very "fat" bituminous coal, that is, one containing a large proportion of volatile combustible matter, such as are desired for making gas. In number four, the volatile matter and the fixed carbon have nearly the same proportion to each other.

The very large amount of ash in these samples is to be expected, on account of the small size of the peat-swamp, which allowed much inorganic matter to be blown or washed in over the whole surface. But the varying amount of ash would indicate that the peculiar physical character of the peat was not due to the *amount* of inorganic matter. The ash of numbers one and two was white, while that of number three was decidedly pink. This color probably indicates iron; which may possibly afford a clue to the cause of the transformation. The presence of considerable iron either inherent in the mass itself, or derived from the surrounding mass by something like concretionary action would probably hasten the decomposition; bearing upon this point, the large amount of inorganic matter without iron in the peat contiguous to the transformed peat is remarkable. The physical characteristics are undoubtedly due to the finely divided state of the carbon, mingled with the water and volatile matter. But, however produced, we have here something that is apparently coal, in the midst of peat that is not yet coal.

Except as this substance illustrates a degree or phase of peat decomposition, it is not likely to have any bearing on the formation of coal. The decomposition of a buried peat, bed under great pressure probably involves the whole mass at the same time, and does not proceed by the expansion of such centres of decomposition as are here found.

Samples have been placed in the hands of Mr. Spencer B. Newberry, of Cornell University, who is making a full chemical examination.

DISCUSSION.

DR. L. ELSBERG then said that some 20 years ago he was engaged in experiments on the subject of converting peat into coal by a more rapid process than that occuring in nature. He found that moisture, heat and pressure were, as he supposed, the elements which, together with time, nature had employed; and these three factors could and can be used really to make a very good coal. On some future occasion he would bring specimens of the manufactured coal and of various kinds of coal to the Academy, and give an account of these experiments and the methods. For a long time his experiments were futile, because it was impossible to make a machine of iron or steel strong enough to withstand the pressure which must be applied to the prepared pulp to reduce it to coal. By the action of super-heated steam, peat is converted into a perfectly homogeneous pulp. By passage of this through any of the ordinary compressing machines used for making bricks, etc., blocks or cylinders are obtained of a substance which, so far as its economic uses are concerned, is not inferior to most qualities of bituminous coal, for gas or fuel. Every effort was made to render the bore perfectly smooth and polished in the cylinder from which the peat was finally pressed out, and for this purpose even glass and porcelain were employed. However the peat was found to be so impalpable that it was forced into the microscopic pores of the metal, and even of porcelain and glass. The peat thus inserted itself in the finest possible particles which acted like wedges, chipping off small pieces from the interior of the cylinder. No matter how fine and smooth the bore of the cylinder was made, after very beautiful working for a few days, gradually this material would insert itself in the microscopical interstices of the metal, until gradually the working of the machine was stopped or an explosion ensued. A great many trials were made and much money spent, and finally the enterprise was given up.

Mr. A. A. Julien remarked upon the voluminous literature connected with the study of peat, and the widely varying results, notwithstanding the enormous amount of labor that has been expended. The study of this material has been approached by investigators from two economic points of view; its relations to agriculture, and its employment as fuel. In investigations of the former class the larger number of analyses have been ultimate—*i. e.*, to determine the carbon, oxygen, hydrogen, nitrogen, etc., which make up peat and its allied products. This gives very conflicting results; the slightest possible change in the amount of water, the oxidation or dissociation of the material, even while during analysis, yielding very different results even in the hands of a single investigator. The other method is approximate, simply intended for the estimate of the value of coal or peat as applied to the purposes of fuel, and is that represented in the analysis of Mr. Britton. Such analysis, however, can throw but little light on the origin of the substance; organic acid seems to be further indicated by the red ash derived from the coal-like substance (Analysis No. 3), the white ash of the enclosing peat showing the residue of silica and alumina insoluble in the humus acids.

Further, the physical characteristics of the substance described by Prof. Fairchild, its brittle jelly-like character while moist, and extreme shrinkage on drying to bright coal-like brittle flakes, are identical with those of apocrenic, humic and other organic acids. These considerations render it highly probable that this substance has been produced within the peat at Scranton merely by the leaching out of the upper portions of the bog and the concentration of soluble salts of organic acids, in part crenates, along certain planes and in small cavities within the denser part of the peat toward the bottom of the bog. There is as yet no evidence, however, that these facts have any important connection with the formation of bituminous coal, much less with that of anthracite, represented by these specimens. A third method of the examination of peat is founded upon the determination of its proximate constituents or compounds, both those of amorphous character and various organic acids. From insufficient knowledge of the exact constitution and nature of these acids, especially in their various hydrated forms, the method is very difficult and has thus far had but limited application. Only such a mode of examination can throw light upon the character of the bright jelly-like substance in the Scranton peat.

Some statements by Prof. Fairchild, however, give a clue to its identity. He has mentioned a rapid change of color in specimens of the peat taken from a depth of thirteen feet, the yellowish brown color of the surface becoming blackish brown in a few moments while being handled. This seems to indicate not the trifling change produced by drying, but the characteristic reaction of crenic acid, well known to chemists by its immediate oxidation and partial conversion into apocrenic acid. This affects not only the acid but its ordinary salts, *e.g.*, those of iron, and has been observed both in its artificial product in the laboratory, and in nature, in the deposit of iron crenate beneath peat bogs and from the waters of many springs.

Prof. **D. S. Martin** called attention to the resemblance of the lighter colored and solid variety of this peat to the darker variety of the "turba" of Brazil. In the latter he had also observed thin seams of a black bituminous substance which was much like that which occurs in this peat.

The subject was further discussed by Prof. Hubbard and Mr. Parsons.

MICROSCOPICAL SOCIETY OF ILLINOIS.

The regular meeting of the State Microscopical Society of Illinois, was held at the Academy of Sciences, No. 263 Wabash avenue, on Friday evening, December 9, 1881, President Dr. Lester Curtis in the chair. After the reading of minutes and other routine business, the secretary announced the following donations:

From Dr. Schmidt, of New Orleans, one dozen slides, consisting of nerve-fibers and other Histological preparations.

"Botanical Notes" from Prof. E. J. Hill, of Englewood, Ill.

Bulletin of Microscopical Society of Belgium, and the report of the Microscopical Society, of Liverpool.

Dr. Angier, of St. Madison, Iowa, spoke in reference to some Acari which he had found under the skin of a chicken.

Prof. Burrill, of Champaign University, was introduced and spoke in reference to the poison of the poison ivy. He took some of the exudation and found it teeming with bacteria, and he questioned whether the poisoning and the bacteria come from the plant or otherwise. The speaker stated that upon examination of the workings of the leaves, he found the same forms; the milky fluid which exuded from stem contained numbers of them and the effect of placing some of this upon h. arm had been attended with quite serious results.

The speaker went on to say that he had found the foregoing facts true with other plants among which he mentioned the chicory, buckwheat and dandelion.

Dr. Curtis described a new half-inch objective made by Gundlach and owned by Dr. J. Hollist. The glass was claimed by the maker to have an angle of 100°. Its angle had not been measured since leaving his hands.

It has the society screw and can be used on any ordinary stand. The back lens of the objective is large and extends beyond the border of the opening in the screw. This opening, therefore, acts as a diaphragm. In order to secure the benefit of the full aperture the portion of the objective can be removed and an adapter furnished with the Butterfield broad range screw can be substituted. It has also another screw of about the same diameter as the Butterfield screw, but provided with a finer thread, the name and description of this screw was not known. The front of the objective is ground down to a conical shape. For ordinary use this front is covered with a brass cap, having an aperture in the centre to allow the conical end of the objective to pass through. The cap can be removed when it is desired to use the objective for the examination of opaque objects. On removal of the cap the conical sides of the lens are seen to be covered with some sort of black varnish to prevent the passage of