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ERRATA.

P. 88, line 2 from bottom, for "northeast," *read* "east."—P. 178, lines 3 and 5 from bottom, for "Tannenschein," *read* "Sonnenschein."

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[SECOND SERIES.]

ART. I.—*Approximate Cotidal lines of Diurnal and Semi-diurnal Tides of the Coast of the United States on the Gulf of Mexico;* by A. D. BACHE, Superintendent U. S. Coast Survey.

(Communicated by authority of the Treasury Department.)

AT successive meetings of the American Association I have presented approximate cotidal lines for the Atlantic and Pacific Coasts of the United States, drawn from the tidal observations of the Coast Survey. I now present similar lines for our coast on the Gulf of Mexico.

The problem is a very different one from either of the others referred to. The tides on the Atlantic Coast are of the regular semi-diurnal class and easily discussed by the forms already elaborately prepared by Lubbock and Whewell. The diurnal inequality is not large; indeed though easily recognized at particular periods and then quite characteristic, in general it is difficult to trace and often irregular in magnitude and even in sign.

Those of the Pacific Coast are remarkably regular in the semi-diurnal and diurnal waves, and both rise to such heights as to make observation easy. On the Gulf Coast on the contrary the tides are small, and therefore easily influenced by extraneous circumstances, and as a rule, on more than two thirds of the coast the semi-diurnal tides are very small, and in fact are masked by the diurnal tides. The comparatively imperfect discussion which has been made of these tides requires many steps in the discussion to be supplied, and sometimes leaves us in doubt as to the exact interpretation of the results.

By way of preparing for the present discussion and to avoid running into too great length at this time, I gave at the last meeting of the Association an account of the tidal observations made on our Gulf Coast, and showed the type curves for the different stations from Cape Florida to the Rio Grande.* I also explained the method of decomposition of the curves of observation into diurnal and and semi-diurnal waves, and gave the analysis of the type curves at the several tidal stations. From Cape Florida and along the keys, and up the western coast of the peninsula, to St. George's, the tides are of the half day class with a large diurnal inequality; from St. George's which belongs to the day class to South West Pass they are of the day type, the semi-diurnal tide almost disappearing; at Dernière Isle, Calcasieu and Galveston they resume as a rule the half day type, and lose it almost completely at Aransas and the mouth of the Rio Grande. The Dernière Isle and less distinctly, the Calcasieu tides show cases of interference in the semi-diurnal wave, two high waters being at times easily traced in the semi-diurnal curves.

The character of the tidal phenomena themselves, the peculiarities in configuration and in depth of the basin, the limited extent over which our researches spread, and various other circumstances contribute to render this work less satisfactory than the former. Some of these will in the end disappear as the Gulf is more fully explored in the progress of the survey. Our information thus far extends to but one entrance of the basin, that by the Gulf of Florida, and of this to but one shore; while of the nature of the tide wave which enters from the Caribbean Sea through the Straits between the western end of Cuba and the eastern end of Yucatan, we have no reliable information. Some of these causes render general speculation premature, and lie at the very threshold of attempts to trace out the great interference problems which present themselves.

The progress of this discussion has also shown that observations of longer period are necessary in many cases to give data for conclusive results.

This of itself is a great point gained and the practical results for the charts of this coast have themselves repaid all the labor which has been expended on the observation. Navigators were absolutely without information other than the most vague in regard to the tides of the Gulf.

The hourly observations at each station being plotted in diagrams upon a suitable scale, the curves of observation were decomposed by the graphical method introduced by Mr. Pourtales, into a diurnal and semi-diurnal curve. It may be proper to observe here that several comparisons have been made between this method and that which I had formerly used by the sine

* Proceedings Amer. Assoc. Adv. Sc., Providence meeting, 1855, p. 152, and Am. Jour. Sci. and Arts, Jan. 1856, p. 28.

curves and with generally coincident results. The graphical method besides being less laborious is free from the hypothesis of the sine curve. These decompositions were made chiefly by Messrs. Fendall and Heaton of the tidal party, and occasionally by Prof. Pendleton and Mr. S. Walker.

That the diurnal wave is the principal feature in these tides will appear from the annexed table (No. 1) which gives the

TABLE 1.

Stations.	Height of semi-diurnal tides.	Height of diurnal tides.	Height of observed tides.
	ft	ft.	ft.
Cape Florida,	1·6	0·2	1·5
Indian Key,	1·9	0·6	1·8
Key West,	1·2	0·7	1·4
Tortugas,	1·0	1·0	1·2
Egmont Key,	1·1	1·6	1·4
Cedar Keys,	2·4	1·5	2·5
St. Marks,	2·2	1·8	2·2
St. George's Island,	0·2	1·6	1·1
Pensacola,	0·2	1·1	1·0
Fort Morgan (Mobile Bay),	0·2	1·1	1·0
Cat Island,	0·3	1·2	1·3
South-West Pass,	0·2	1·2	1·1
Dernière Isle,	0·4	1·6	1·4
Calcasieu,	1·3	1·5	1·1
Galveston,	0·5	1·1	1·6
Aransas,	0·5	1·3	1·1
Brazos Santiago,	0·3	0·8	0·9

names of the tidal stations; the average rise and fall of the tide at each, and the height of the diurnal and semi-diurnal waves composing the observed tides. Table No. 2 shows the

TABLE 2.

Tide stations on the Gulf of Mexico, the results of which are discussed in this paper.

No.	Stations.	Date of Observation.	Kind of gauge.	Observers.
1	Cape Florida, Fla.	April 22, to Oct. 31, 1854.	S. R.*	L. E. Tansill.
2	Indian Key, "	Jan. 21, to April 16, 1855.	S. R.	do.
3	Key West, "	April 20, 1850, to Dec. 31, 1851.	Box.	W. Lane, and G. W. Goss.
4	Tortugas, "	April 1, to June 2, 1855.	S. R.	C. T. Thompson, and F. Buxton.
5	Egmont Key, "	April 22, to Aug. 23, 1854.	"	C. T. Thompson.
6	Cedar Keys, "	Jan. 10, to March 16, 1852.	Box.	G. Würdeman.
7	St. Marks, "	Nov. 3, 1854, to March 2, 1855.	S. R.	C. T. Thompson.
8	St. Georges Isl. "	April 11, to Aug. 16, 1852.	Box.	G. Würdeman.
9	Pensacola, "	Aug. 27, to Oct. 31, 1852.	"	do.
10	Fort Morgan, Ala	May 20, 1850, to May 26, 1851.	"	do.
11	Cat Island, La.	Dec. 29, 1847, to Feb. 13, 1849.	"	G. Würdeman, and R. T. Bassett.
12	South W. Pass, La.	Nov. 19, 1852, to Mar. 28, 1853.	"	G. Würdeman.
13	Dernière Island, "	April 5, to June 12, 1853.	"	do.
14	Calcasien, "	Feb. 24, to May 26, 1854.	S. R.	do.
15	Bolivar Point, Tex.	Oct. 1, 1853, to June 1, 1854.	"	L. E. Tansill.
16	Galveston, "	March 21, 1851, to Jan. 1, 1853.	Staff.	G. Price and F. Muhr.
17	Aransas Pass, "	Nov. 1, 1853, to Jan. 31, 1854.	Box.	G. Würdeman.
18	Braz's Santiago, "	July 7, to Oct. 13, 1853.	"	do.

* Self-registering tide gauge.

the period during which the tidal observations were made, and the names of the observers.

A diagram (No. 1) shows these results graphically. A curved line corresponding to the general outline of the shore cutting off its irregularities, is drawn on the chart of the Gulf Coast, and then developed into a straight line. Thus the tidal stations are plotted at their distances from each other, measured along the general line of the coast. For use by navigators, any intermediate stations may be marked in, in the same way, and a rough approximation to the character of the tide be obtained by the interpolation.

The least observed height is 0·9 feet at Brazos Santiago, and the greatest 2·5 feet at Cedar Keys. The least height of the average semi-diurnal tide is 0·16 feet at South West pass, and the greatest 2·40 feet at Cedar Keys. The least height of the average diurnal tide is 0·21 feet at Cape Florida, and the greatest 1·80 feet at St. Mark's. Of course these numbers are for reasons easily seen only approximations.

As we enter the Gulf of Mexico by the Straits of Florida the height of the tide first increases, then decreases. Passing into the bight at the upper end of the Florida peninsula the rise is greatest. West of St. George's it diminishes, to rise again in the bight formed by the Southern coast of Louisiana and the eastern coast of Texas.

In the decompositions here traced, and in the very laborious discussions tentative and final of the whole of the observations upon which this paper is based, I would acknowledge the great assistance derived from the labors of Assissant L. F. Pourtales in charge of the tidal division of the Coast Survey. The unwearied assiduity of his own labors and his intelligent supervision of the work of others, has been felt at every step in the progress of these investigations. They have required on his part great reources of ingenuity, patience and knowledge.

In discussing semi-diurnal tides, the lunitidal interval of high or low water varying only from a certain mean within moderate limits affords a cardinal datum (the establishment) for the times. In the diurnal tide this datum is wanting. The law of the change of the diurnal tide as expressed in the formula of Prof. Airy (Tides and Waves, Encyc. Metrop., p. 254, Art. 46) is in general represented, but the great flatness in the form of the curves at particular relations of the moon's right ascension and declination, required by the formula does not occur. The general form of these curves is shown upon the diagram No. 2 where the abscissæ represent the days, and the ordinates the lunitidal intervals of high water. About the maximum of declination for some four to six days the lunitidal intervals are moderately constant, and the average of these is what I have taken for a comparison of the lunitidal intervals to trace the progress of the diurnal wave. The variations from day to day being less than the probable irregularities in the times of high water and the uncertainties in the observations; these means give suitable numbers for comparison. The result would not have been greatly different had only a few of the observations at either end of the declination period been thrown off, but after examination we found these numbers to present apparently the best results.

At four of the stations, namely, Key West, Fort Morgan, Cat Island, and Galveston, hourly observations were continued during a year and upwards, and the decompositions in all the cases but Cat Island embrace that period. The annual change of diurnal establishment is very clearly seen in all these cases and is shown in the diagram No. 3. The law of the change is beautifully developed in the larger tides of the Western Coast and, as deduced from the San Francisco observations, is shown upon the same diagram. In all the cases the actual computed results for the different half-monthly periods are represented by the broken lines on the diagram and the line representing the curve is drawn with a free hand among the points. The general resemblance of these curves with however different maximum ordinates, is very striking, showing that the law of the change is the same, only the coëfficients of the fractions varying.

On the diagram of the San Francisco results the curve derived from Prof. Airy's formula (Theory of tides and waves, Ency. Metrop., p. 254, Art. 46) is drawn as well as that from observation and the general conformity is quite striking.

In making use of the curves as expressing the law of annual change, one of the branches has been turned over upon the other so as to use the mean of the two periods of six months.

At the other fourteen stations on the Gulf of Mexico the observations were continued from one to three lunations, and fell in different parts of the year. To reduce these therefore to the same period of the year it is necessary to employ the data from the localities where the whole annual change was embraced. The results are plotted on the several diagrams, those from the Brazos to South West Pass on the curve from Galveston, those from the South West Pass to St. George's on the curve from Fort Morgan, and those from St. George's to Cape Florida on the curve from Key West. There is, except in one case, a general conformity in the observed changes and in those deduced from the other comparisons, at least there are no greater contradictions than those presented by the observations from which the mean curves are drawn. From these plottings the correction necessary to reduce the result to the mean of the year are deduced and the annexed table shows the diurnal interval as deduced directly from the observations and as corrected. It is satisfactory to see that the correction makes the results more conformable to law, increasing therefore the probability that the correction is rightly applied and is approximately correct in magnitude.

TABLE 3.

	Stations.	Lat.		Long.		Long. in time.		Mean diurnal Lunitidal interv'l near max. of moon's Dec.		Sum of Long. and Estab.		Correc. for transit.		Correc. for depth.		Correction for yearly variati'n of diurnal lunit. interval.		Corr'ted cot. hour.	
		°	'	°	'	h.	m.	h.	m.							h.	m.	h.	m.
1	Cape Florida,...	25	40	80	9	5	21	14	27	19	48	0	27	0	20	+ 0	18	19	19
2	Indian Key,....	24	52	80	44	5	23	17	00	22	23		34		20	− 0	42	20	47
3	Key West,.....	24	27	81	53	5	28	18	32	24	0		37		19	0	0	23	4
4	Tortugas,.......	24	34	82	59	5	32	18	5	23	37		36		10	+ 0	43	23	34
5	Egmont Key,...	27	36	82	46	5	31	19	19	24	50		39		20	+ 0	1	23	52
6	Cedar Key,.....	28	58	82	57	5	32	22	27	27	59		43		45	− 0	57	25	34
7	St Mark's,.....	30	0	84	11	5	37	21	56	27	33		42		22	+ 0	20	26	49
8	St. George's Isl'd.	29	35	85	12	5	41	19	41	25	22		42		25	+ 0	37	24	52
9	Pensacola, ...	30	18	87	15	5	49	21	28	27	17		42		17	+ 0	22	26	40
10	Fort Morgan,...	30	9	88	0	5	52	21	21	27	13		42		14	0	0	26	14
11	Cat Island,.....	30	6	88	38	5	55	22	21	28	16		43	1	21	− 0	11	26	1
12	South West Pass.	28	56	89	22	5	57	19	28	25	25		39		21	+ 0	59	25	24
13	Dernière Isle,...	28	58	90	58	6	4	19	19	25	23		38		24	+ 1	37	25	58
14	Calcasieu,.......	29	40	93	21	6	13	19	22	25	35		39		17	+ 1	27	26	6
15	Bolivar Point,...	29	23	94	46	6	19	21	40	27	59		43		12	+ 1	24	28	28
16	Galveston, ...	29	18	94	41	6	19	22	29	28	48		43		30	0	0	27	35
17	Aransas Pass, ..	28	15	96	31	6	26	19	46	26	12		40		17	+ 0	43	26	0
18	Brazos Santiago	26	6	97	10	6	29	20	21	26	50		41		15	− 1	39	25	16

The first column of the annexed table No. 3 contains a number for reference, the second, the name of the tidal station, the third, fourth, and fifth, the latitude and longitude, the latter in degrees and in time, the sixth, the lunitidal interval about the maximum of declination, the seventh, the sum of this last named number and the longitude in time, the eighth, the correction to reduce the observations to the same transit, the ninth, the correction for depth, carrying them by the law of depth to deep water, the tenth, the correction to reduce the observed lunitidal interval at maximum to the corresponding mean of the year, the eleventh, the corrected cotidal hour.

The table enables us satisfactorily to trace the diurnal wave from Cape Florida to the Tortugas, across by the deep water of the Gulf to South West Pass at the entrance of the Mississippi, and from this line of deep water to the Western Coast of the peninsula of Florida by Egmont Key (Tampa), Cedar Keys, St. Marks and St. George's, and in the bay between South West Pass and St. George's by Cat Island, Fort Morgan, Pensacola, and St. George's. Again in the bight between East Bayou and the Rio Grande, to Isle Dernière, the Rio Grande, Calcasieu, and Aransas up to Galveston. In obtaining the general direction of the cotidal lines, I have followed the method of grouping used in my former papers in the form given by Professor Lloyd. It is easy to obtain a general view of the movement of the diurnal wave in this way, but the selection of the groups required a tedious set of trials and the discussion of many groups which appeared natural, proved very unsatisfactorily. The burthen of the computation for this work has fallen upon Mr. John Downes.

Table No. 4 shows the groups selected, with a letter attached for reference, the names of the stations constituting the groups, the mean latitude and longitude, and cotidal hour of the group, the values of the coefficients of each, the angle of the cotidal line with the meridian, the velocity of movement of the wave, and the same in miles per hour.

TABLE 4.

Stations.	Mean Longitude.	Mean Latitude.	Mean cotidal hour.	M Diff. of cotidal hour for one geog. mile of Longit'e.	N Latitude.	Angle tang $\frac{N}{M}$ Co-tidal angle.	$\sqrt{M^2+N^2}$ Diff. of cotidal hour correspond'g to one geog. mile perpend. to cotidal line	Miles per h. tidal wave.
	° '	° '	h. m.			° '		
A Cape Florida, Indian Key, Key West.	80 55	25 0	21 3	−1·978	−0·509	−14 28	2·052	29·2
B Indian Key, Key West, Tortugas.	81 52	24 38	22 28	−0·890	−3·240	74 38	3·360	17·8
C Key West, Egmont Key, Cedar Keys.	82 32	27 0	24 10	5·251	1·695	−17 53	5·518	10·9
D Cedar Keys, St. Marks, St. Georges.	84 7	29 31	25 45	1·095	2·358	−65 5	2·600	22·7
E St. George, Pensacola, Ft. Morgan.	86 49	30 1	25 55	0·055	2·645	−88 49	2·645	22·7
F Cedar Key, St. Marks, St. George's, Pensacola, Ft. Morgan, Cat Island, S. West Pass.	86 31	29 43	25 56	0·048	0·911	−86 58	0·910	66·0
G St. Georges, Pensacola, Ft Morgan, Cat Isl'd, South West Pass.	87 41	29 49	25 50	−0·275	1·092	75 52	1·127	53·1
H South West Pass, Dernière Isl'd, Calcasieu, Galveston, Aransas, Brazos.	93 45	28 28	26 3	−0·241	+0·944	63 19	0·974	61·6

On the character of these groups I would remark as follows. Groups A, Cape Florida, Indian Key, and Key West, and B, Indian Key, Key West, and Tortugas, give a natural movement for that of the wave, though showing a more abrupt change than is probably real. The computed and observed cotidal hours differ at the greatest but one minute and a quarter. The next group C, gives a satisfactory idea of the movement of the wave passing round the Tortugas and up along the coast of the peninsula, over the extensive flat which borders it. The next group D, Cedar Keys, St. Marks, and St. George's, presents a perfect agreement between the computed and observed cotidal hours, and a direction and velocity agreeing with what might have been supposed. The same is true for group E, St. George's, Pensacola, and Fort Morgan. The more general group F, including the stations from Cedar Keys to South West Pass agrees in its indications with those given by the partial groups, as does also G, including the stations from St. George's to South West Pass. In passing westward and southward the direction of the line changes rapidly and no satisfactory adjustment by groups could be made. From South West Pass to Brazos Santiago the smaller groups give decidedly anomalous results for adjacent stations, pointing to the more general arrangement of the line shown by group H, composed of South West Pass, Dernière Isle, Calcasieu, Galveston, Aransas, and Brazos Santiago.

The agreement of the cotidal hours as computed and observed is less satisfactory in the larger groups than in the smaller ones as might be expected. On the map No. 5, a rough outline of the Gulf Coast is traced, and the cotidal hours are marked near the stations. The mean cotidal line for each group and the hour before and after the mean hour are marked on the map, showing the direction and velocity of the diurnal wave as given by the groups. From a consideration of these and of their necessary connection the cotidal lines are approximately drawn. The great cotidal line of the Gulf as traced upon the chart is that of twenty five hours.

The cotidal lines of 19 to 23 hours only appear on the coast of the Florida Keys. The line of 24 hours is well marked near Egmont Key (Tampa). The line of 26 hours is at the head of the bight between St. George's and Cedar Keys, and in that near Cat Island. The line of 27 hours appears only at the head of the bay formed by the coasts of Texas and Louisiana.

The table No. 5 of semi-diurnal tides is in the same form as No. 3 for diurnal tides. It contains a number for reference, the name of the station, its latitude, the longitude in arc and in time, the establishment, the same in Greenwich time, the correction for transit and for depth, and the corrected cotidal hour.

In tracing the semi-diurnal wave as it enters the Straits of Florida we find after a slight contradiction between Cape Florida and Indian Key, a general increase of the cotidal hour in the right direction to the Tortugas. The semi-diurnal wave here gives a difference of time between Cape Florida and the Tortugas of but $1^h, 24^m$, while the diurnal wave gave $4^h, 03^m$. The lagging of the diurnal wave which at Cape Florida was $1^h, 44^m$, at Indian Key is $3^h, 22^m$, at Key West $4^h, 31^m$, and at the Tortugas $4^h, 23^m$.

The semi-diurnal wave passes across the Gulf to the South West Pass as did the diurnal. The time of crossing by the semi-diurnal wave is, however, $1^h, 13^m$, while by the diurnal wave it was $1^h, 50^m$.

TABLE 5.

	Stations.	Lat.	Longitude in arc.	Longitude in time	Est'blishment of half daily tide.	Establishment Gr'nwi'h time.	Correction for transit.	Correction for depth.	Corr'ct-ed co-tidal hour.
		° ′	° ′	h. m.	h. m.	h. m.	m.	m.	h. m.
1	Cape Florida,........	25 40	80 9	5 21	8 17	13 38	– 17	– 20	13 1
2	Indian Key,.........	24 52	80 44	5 23	8 2	13 25	– 16	– 15	12 54
3	Key West,.........	24 27	81 53	5 28	9 10	14 38	– 18	– 19	14 1
4	Tortugas, ...	24 31	82 59	5 32	9 22	14 54	– 19	– 10	14 25
5	Egmont Key,.......	27 36	82 46	5 31	11 26	16 57	– 23	– 20	16 14
6	Cedar Key, ...	28 58	82 57	5 32	13 9	18 41	– 26	– 45	17 30
7	St. Marks, ...	30 0	84 11	5 37	13 37	19 14	– 27	– 22	18 25
8	St. George's Island,.	29 35	85 12	5 41	14 59	20 40	– 30	– 25	19 45
9	Pensacola, ...	30 18	87 15	5 49	10 53	16 42	– 22	– 17	16 3
10	Fort Morgan,........	30 9	88 0	5 52	11 9	17 1	– 22	– 14	16 25
11	Cat Island, ...	30 6	88 38	5 55	12 53	18 48	– 26	– 81	17 1
12	South West Pass, ...	28 56	89 22	5 57	10 23	16 20	– 21	– 21	15 38
13	Dernière Island, ...	28 58	90 58	6 4	13 37	19 41	– 27	– 24	18 50
14	Calcasieu,...........	29 40	93 21	6 13	14 56	21 9	– 30	– 17	20 22
15	Bolivar Point, ...	29 23	94 46	6 19	16 47	23 6	– 34	– 12	22 20
16	Galveston, ...	29 18	94 41	6 19				– 30	
17	Aransas Pass, ...	28 15	96 31	6 28	14 30	20 58	– 29	– 17	19 12
18	Brazos Santiago, ...	26 6	97 10	6 29	14 45	21 14	– 29	– 15	20 30

The lagging of the diurnal wave behind the semi-diurnal which at the Tortugas was 4^h, 23^m, at the South West Pass is 4^h 49^m. The mean computed depth of the portion of the Gulf traversed by the wave from the semi-diurnal wave is 1666 fathoms and from the diurnal 666 fathoms, for the mean result of the two 1000 fathoms. The actual depth has not been ascertained, but probably does not exceed 1000 fathoms. From this line of deep water the semi-diurnal wave reaches the stations on the western coast of the Florida peninsula in their order from south to north and west. The movement west of St. George's appears to be in the order of Pensacola, Fort Morgan, and Cat Island, while for the diurnal wave it was Cat Island, Fort Morgan, and Pensacola. At South West Pass there is a sudden increase of establishment as if another semi-diurnal wave brought the tide there; the mean establishment of the six stations west of South West Pass is 20^h, 15^m, while that of the six east of it is 17^h, 31^m, a difference of about three hours. This table with the remarks already made in regard to the appearance of two high waters in the curves for Isle Dernière and Calcasieu, indicate a system of interferences yet to be unravelled. As was the case with the diurnal wave, the stations at Isle Dernière and Calcasieu furnish cotidal hours nearly like those of Brazos Santiago, and Aransas, and Galveston is later than either. Upon the whole then, there is a general resemblance in the motion of the two waves as assigned by observation with some considerable discrepancies. The annexed table No. 6 shows the difference between the cotidal hours of the diurnal and semi-diurnal waves at the several stations.

TABLE 6.

Comparison of Establishments of semi-diurnal and diurnal tides, in the Gulf of Mexico.

	Stations.	Diff. between diurnal & ½ diurnal. h.	m.
1	Cape Florida,	6	28
2	Indian Key,	8	16
3	Key West,	9	22
4	Tortugas,	9	26
5	Egmont Key,	7	54
6	Cedar Keys,	8	21
7	St. Marks,	8	39
8	St. George's Island,	5	19
9	Pensacola,	10	57
10	Fort Morgan,	10	12
11	Cat Island,	9	17
12	South West Pass,	10	4
13	Dernière Island,	7	19
14	Calcasieu,	5	53
15	Bolivar Point,	6	17
16	Aransas Pass,	5	59
17	Brazos Santiago,	4	48

When we come to follow these results into the discussion of the groups, they are far from satisfactory. Perhaps this was to have been expected from the circumstances before stated, the groups were nevertheless elaborately examined, though without much fruit.

The table of groups (Table 7) is arranged as for the diurnal tides, containing as before a number for reference, the names of the stations, and their latitude and longitude, the values of the coefficients of each, the angle made by the cotidal line with the meridian, the movement of the wave perpendicular to the cotidal line expressed by the number of minutes employed in traversing a mile, and the number of miles per hour.

TABLE 7.

	Stations.	Mean Longitude. °	'	Mean Latitude. °	'	Mean co-tidal hour. h	m.	M Diff of cotidal hour for one geog. mile of Longit'e.	N Diff of cotidal hour for one geog. mile of Latit'de.	Angle tang $\frac{N}{M}$ Co tidal angle. °	'	Diff. of cotidal hour corresp'nding to one geog. mile perpend. to cotidal line. $\sqrt{M^2+N^2}$	Miles per hour tidal wave
A	Cape Florida, Indian Key, Key West,	80	55	25	0	13	19	1·515	1·151	37	14	1·902	31·5
B	Indian Key, Key West, Tortugas,	81	52	24	33	13	47	-0·551	-1·284	-66	49	1·401	42·8
C	Egmont Key, Cedar Key, St. Mark's,	83	18	23	51	17	22	0·049	0·935	-87	0	0·935	64·2
D	Fort Morgan, Cat Island, South West Pass,	88	40	29	44	16	21	-1·260	1·387	56	16	2·269	26·4
E	Isle Dernière, Calcasieu, Bolivar Point,	93	2	29	20	20	37	-1·245	-1·517	50	36	1·963	30·6
F	South West Pass, Dernière Island, Calcasieu, Bolivar Point, Brazos,	93	7	28	37	19	32	-1·243	1·488	50	7	1·939	30·9

Groups A and B, composed of Cape Florida, Indian Key, and Key West, and of Indian Key, Key West and Tortugas, especially the first, give plausible results and the computed establishments vary but 1·5 mins. at the greatest, from the observed. I have not been able to form any satisfactory connection between these groups and those on the western coast of the peninsula.

The next group which gives a tolerable result is Egmont Key, Cedar Keys, and St. Marks. In this the direction of the cotidal line, the velocity and the establishments are satisfactory. The establishment of St. George's station is irregular and is very probably erroneous. The semi-diurnal wave is composed of two very small ones, and it has been necessary to reconcile the discrepancies which they presented, sometimes one being the governing tide and sometimes the other.

Group D, composed of Fort Morgan, Cat Island, and South West Pass is the next which gives a good result. E, composed of Isle Dernière, Calcasieu and Bolivar Point, and F, of all the stations from South West Pass to Brazos Santiago except Aransas, give good results as to direction and velocity.

The computed establishments as in the case of the diurnal wave present considerable discrepancies from the observed. The least difference is $8^{m}\cdot5$ and the greatest 67^{m}. These groups are marked upon the chart No. 6 and the cotidal hour next before and after the mean cotidal hour of the groups.

An approximation to the cotidal lines from these data is also shown upon the chart. The corrected cotidal hours of the several stations are marked upon the chart.

In comparing the two sets of cotidal lines for the diurnal and semi-diurnal waves we find a general resemblance in the great bay between the western coast of Florida, and the eastern coast of Louisiana, the lines of 24, 25, and 26 of the diurnal tide on the eastern side of the bay corresponding generally with 16, 17, and 18 of the semi-diurnal tide, and 25 and 26 hours of the diurnal tide on the western side of the bay corresponding generally to 16 and 17 of the semi-diurnal. On the southern coast of Florida by the Keys on the contrary the lines of 19, 20, 21, 22, and 23 hours succeed each other rapidly between Cape Florida and the Tortugas in the diurnal series, while 13 and 14 hours occur only along the same shores in the semi-diurnal tide. On the contrary, in the bay between Louisiana and Texas, or west of South West Pass, the lines of 25, 26 and 27 hours occur only at considerable distances in the diurnal system, while 16, 17, 18, 19, 20, and 21 occur in the same space, between South West Pass and the Brazos Santiago in the semi-diurnal tide. I shall continue to collect observations bearing upon the facts discuss d in this paper and to have them worked up, and so as to amend the imperfections of the approximate results now presented. There are simultaneous observations at some of the stations which were formerly examined with but little satisfaction as to the conclusions; these will now be resumed and may throw additional light upon the results at some of the doubtful stations.

The interference problems will be taken up when more extended data give better hopes of a satisfactory solution of them.

ART. II.—*Notes on the Progress made in the Coast Survey, in Prediction Tables for the Tides of the United States Coast;* by A. D. BACHE, Superintendent U. S. Coast Survey.

(Communicated to the American Association for the Advancement of Science, by authority of the Treasury Department.)

As soon as tidal observations had accumulated sufficiently to make the task a profitable one, I caused them to be treated, under my immediate direction, by the methods in most general acceptance. The observations of Old Point Comfort, Virginia, were among the earliest used for this purpose, and the labors of Commander Charles H. Davis, U. S. N., then an Assistant in the Coast Survey, were directed to their reduction, chiefly by the graphical methods pointed out by Mr. Whewell. This work was subsequently continued by Mr. Lubbock's method, by Mr. Henry Mitchell: and next the tides of Boston harbor were taken up as affording certain advantages in the observations themselves, which could not be claimed for those of Old Point.

The system of Mr. Lubbock is founded on the equilibrium theory, and in it the inequalities are sought by arranging the elements of the moon's and sun's motions, upon which they depend. Having obtained the co-efficient of the half monthly inequality of the semi-diurnal tide at Boston, from seven years observations, through the labors of the tidal division, and approximate corrections for the parallax and declination, I was much disappointed in attempting the verification by applying them to individual tides for a year during which we had observations. There was a general agreement on the average, but discrepancies in the single cases, which were quite unsatisfactory. Nor were these discrepancies without law, as representing their residuals by curves did not fail to show. By introducing corrections for declination and parallax of the moon increasing and decreasing, we reduced these discrepancies, but still the results were not sufficient approximations. With the numerical reductions of the observations before referred to, was commenced in 1853, under my immediate direction, by Mr. L. W. Meech, a study of the theory of the tides directed chiefly to the works of Bernouilli, La Place, Airy, Lubbock and Whewell. The immediate object which I had in view was the application of the wave theory to the discussion of our observations. I thought that the mind of an expert mathematician, directed entirely to the theoretical portions of this work, with directions by a physicist, and full opportunities of verifying results by extended series of observations, the computations of which should be made by others in any desired form, would give, probably, the best results in this combined physical and mathematical investigation.

The general form of the different functions expressing the tidal inequalities is the same in the different theories, and may be said on the average to be satisfactory as to the laws of change which these inequalities present. Whether we adopt, with La Place, the idea that periodical forces produce periodical effects, or with Airy that the tidal wave arrives by two or more canals: or with Bernouilli and Lubbock, the results of an equilibrium spheroid, or with Whewell, make a series of inequalities, semimenstrual, parallax, and declination, with different epochs, we arrive at the same general results, that the heights and times of high water, may be represented by certain functions, with indeterminate co-efficients, in the form of which the theories in a general way agree. By forming equations from the observations and obtaining the numerical values of the co-efficients, by the method used so commonly in astronomical computations, the result is accomplished.

A general consideration of the co-ordinates in space of the moon and sun, without any special theory, would lead to the same results, representing the lunitidal intervals by series of sines and co-sines, with indeterminate co-efficients.

Calling I the luni-tidal interval from observation, λ the mean luni-tidal interval, H the clock time of observation, $l't$ the moon's longitude, P' the moon's parallax, $\delta P'$ the hourly variation of the moon's parallax, we have for the formula representing the correction for half monthly inequality, $s \sin 2H + s_1 \cos 2H$; for the moon's parallax correction, $p(P'-57') + p_2(P'-57') \sin 2H + p_3(P'-57') \cos 2H$; for the correction for hourly difference of the moon's parallax, $p_1(\delta P') + p_4(\delta P') \sin 2H + p_5(\delta P') \cos 2H$, and for the moon's declination corrections including the rate of change $d \sin 2l't + d_1 \cos 2l't + q_1 \sin 2l't \sin 2H + q_2 \sin 2l't \cos 2H + q_3 \cos 2l't \sin 2H + q_4 \cos 2l't \cos 2H$. There are corresponding terms for the inequalities produced by the sun's action. The whole formula takes the form:

$$I = \lambda + s \sin 2H + s_1 \cos 2H \quad \Big\} \text{Mean interval and half monthly inequality correction.}$$

$$p(P'-57') + p_2(P'-57') \sin 2H + p_3(P'-57') \cos 2H \Big\{ \text{Moon's parallax correction.}$$

$$p_1(\delta P') + p_4(\delta P') \sin 2H + P_5(\delta P') \cos 2H \Big\{ \text{Hourly difference of moon's parallax correction.}$$

$$\left.\begin{array}{l} d \sin 2l't + q_1 \sin 2l't \sin 2H + q_2 \sin 2l't \cos 2H. \\ d_1 \cos 2l't + q_3 \cos 2l't \sin 2H + q_4 \cos 2l't \cos 2H. \end{array}\right\} \text{Moon's declination corrections.}$$

$$\left.\begin{array}{l} +t_1 \sin lt \sin 2H + t_2 \sin lt \cos 2H \\ +t_3 \cos lt \sin 2H + t_4 \cos lt \cos 2H \end{array}\right\} \text{Sun's parallax corrections.}$$

$$\left.\begin{array}{l} +Q_1 \sin 2lt \sin 2H + Q_2 \sin 2lt \cos 2H \\ +Q_3 \cos 2lt \sin 2H + Q_4 \cos 2lt \cos 2H \end{array}\right\} \text{Sun's declination corrections.}$$

The grouping of the observations of one year at Boston, to apply this method, the formation of the equations and their solution by the method of indirect elimination has been the work of Mr. R. S. Avery, who has labored most assiduously and successfully, ingeniously checking his work where the system of checks could be applied, at every step. He has determined the values of λ and of the co-efficients for Boston, as follows:—

$\lambda = +38{\cdot}47$, $d = -3{\cdot}17$, $d_1 = -35{\cdot}62$, $p = -0{\cdot}93$, $p_1 = -1{\cdot}56$
$s = -19{\cdot}49$, $s = +11{\cdot}97$, $p_2 = +\ 1{\cdot}31$, $p_3 = -1{\cdot}21$, $p_4 = +0{\cdot}23$
$p_5 = +0{\cdot}60$, $q_1 = -7{\cdot}17$, $q_2 = +\ 1{\cdot}81$, $q_3 = +2{\cdot}91$, $q_4 = -1{\cdot}99$
$t_1 = +\ 5{\cdot}14$, $t_2 = +2{\cdot}26$, $t_3 = -\ 0{\cdot}76$, $t_4 = -1{\cdot}37$
$Q_1 = -21{\cdot}25$, $Q_2 = +28{\cdot}39$, $Q_3 = +27{\cdot}10$, $Q_4 = +23{\cdot}13$

There are propositions for facilitating this work, growing out of the experience acquired in the computations, but requiring more examination than they have yet received before pronouncing upon them. It is possible that by applying Lubbock's method of averages to some of the terms, approximate values may be found more readily than by the method we have employed. Two additional terms for the sun's declination, $D \sin 2\,lt$, and $D_1 \cos 2\,lt$, will be introduced.

I present to the Association the tables computed by Mr. Avery for applying this method to the prediction of the tides at Boston harbor.

In order to test the co-efficients, computations were made for different parts of the months of the year 1853, for which we have observations. Transit C was used as the transit of reference. The differences between the predicted and observed results are shown in the annexed table, the first column of which contains the dates, the second the computed, the third the observed, and the fourth the observed *less* the computed results.

From the table it appears that in twenty pairs of tides, the morning and afternoon results being grouped in the fifth column to get rid of the diurnal inequality, there are two differences of less than 2^m, thirteen of more than 2^m and less than 4^m, three of more than 4^m and less than 10^m, two of more than 10^m. The probable error of the prediction of a single pair of tides is $4^m{\cdot}12$.

These laborious researches are still in progress, but I have thought that the results already obtained, required a notice of them, and a recognition of the labors of Messrs. Meech and Avery.

Comparison of observed and predicted times of high water, Boston, Mass.

DATE. 1853.		Time of high water.				Diff. Obs Pr. M.	Mean of Pairs M.
		Predicted.		Observed.			
		h.	m.	h.	m.		
March	21	8	4·7	8	3	− 1·7	
"	21	20	32·9	20	32	− 0·9	− 1·3
"	25	11	28·0	11	21	− 7·0	
"	25	23	49·8	23	48	− 1·8	− 4·4
"	29	2	21·7	2	20	− 1·7	
"	29	14	45·3	14	42	− 3·3	− 2·5
April	2	6	16·9	6	21	4·1	
"	2	18	51·5	18	59	7·5	5·8
"	6	10	19·8	10	18	− 1·8	
"	6	22	40·2	22	36	− 4·2	− 3·0
June	21	11	18·4	11	18	− 0·4	
"	21	23	44·7	23	49	4·3	2·0
"	25	2	34·5	2	39	4·5	
"	25	15	2·3	15	3	0·7	2·6
"	29	5	57·7	6	7	9·3	
"	29	18	24·3	18	37	12·7	11·0
July	3	9	27·4	9	31	3·6	
"	3	21	52·2	21	53	0·8	2·2
"	7	0	0·1	0	3	2·9	
"	7	12	10·3	12	12	1·7	2·3
September	24	3	59·4	4	7	7·6	
"	24	16	24·8	16	24	− 0·8	3·4
"	28	7	39·7	7	44	4·3	
"	28	20	11·6	20	15	3·4	3·9
October	2	11	6·1	11	4	− 2·1	
"	2	23	31·1	23	30	− 1·1	− 1·6
"	6	1	44·7	1	40	− 4·7	
"	6	14	7·7	14	7	− 0·7	− 2·7
"	10	5	24·5	5	19	− 5·5	
"	10	17	57·8	17	58	0·2	− 2·7
December	21	3	7·2	3	9	1·8	
"	21	15	28·4	15	30	1·6	1·7
"	25	6	32·6	6	31	− 1·6	
"	25	19	0·7	18	52	− 8·7	− 5·2
"	29	10	22·4	10	26	3·6	
"	29	22	53·3	22	42	− 11·3	− 3·9
January	2	1	29·4	1	2	− 27·4	
"	2	13	51·0	13	41	− 13·0	− 20·2
"	6	4	45·8	4	53	7·2	
"	6	17	33·9	17	30	− 3·9	1·7

Final mean, - - - - - - - - - - - 0·5
Probable error, minutes, - - - - - 4·12

Number of differences, less than 2 minutes - - - - - = 2
Number of differences more than 2 minutes, and less than 4 - = 13
" " " 4 " - - - 10 - - = 3
" " " 10 " - - - - - = 2

ART. III.—*Observations to determine the cause of the increase of Sandy Hook, made by the Coast Survey for the Commissioners on Harbor encroachments of New York;* by Prof. A. D. BACHE, Sup. U. S. Coast Survey.—(Abstract.)

IT is known as one of the developments of the Coast Survey that the peninsula of Sandy Hook is gradually increasing, growing to the northward into the main ship channel. A spot north of the Hook where there was forty feet of water when Captain Gedney made his survey, in less than ten years was nearly bare at low water. The importance of determining the cause of this increase, as leading to the means of controlling it, cannot be overestimated. The Commissioners on Harbor Encroachments had early attended to this matter, and requested that the necessary observations for its investigation should be made. These were made under my immediate direction, by Henry Mitchell, one of the sub-assistants in the Coast Survey, with all desirable zeal and ability. Various causes had been assigned for this growth, by the action of the waves and winds sometimes on the outer side and sometimes on the inside of the Hook. The effect of the opening and closing of Shrewsbury Inlet had also been insisted upon. To examine these and other probable causes, laborious observations of tides and currents had been made in the vicinity at stations marked upon the map presented to the Association. Careful measurements of the low water line had also been made in connection with these observations, and with others, of the force and direction of the wind. Objects easily distinguished from the land, and of various specific gravities and shapes, had been deposited near the shore of the Hook to determine the power and direction of transportation of matter along the shores of the Hook. It is easy to see how laborious all of these observations are, and that some of them are obtained with considerable danger: hence the credit to be given to Mr. Mitchell may be measured. The results of the observations have not yet been worked out in all their detail, but the conclusions from them are perfectly safe, and are of the highest importance. It turns out that this growth of the Hook is not an accidental phenomena, but goes on regularly, and according to determinable laws. The amount of increase depends upon variable causes, but the general fact is, that it increases year by year; and the cause of this is a remarkable northwardly current, the amount and duration of which these observations assign along both shores of the Hook, the outer one extending across the whole breadth of False Hook channel with varying velocity, and the one inside of the Hook extending nearly one-third of the distance across Sandy Hook bay. These currents run to the north during both the ebb and flood tide, with varying rates, and result from these tides directly and indirectly. The inner current is the one by which the flood and ebb tides draw, by the lateral communication of motion, the water from Sandy Hook bay, and the outer is similarly related to those tides as they pass False Hook channel. The velocities and directions which have been found, prove this conclusively. An important observation for navigation results from this, for more than seven hours out of the twelve there is a northwardly current running through False Hook channel, which assists vessels entering New York harbor on the ebb tide, and is to be avoided in passing out with the ebb. This northwardly current runs on the inside for eleven hours out of the twelve. It is the conflict of these two northwardly currents outside and inside, and the deposit of the materials which they carry to the point of the Hook, which causes its growth. Within a century, it has increased a mile and a quarter, and at about the rate of one-sixteenth of a mile a year, on the average, for the last twelve years. Flynn's knoll, on the north side of the main ship channel, does not give way as the point of the Hook advances. The importance of watching this movement cannot, therefore, be overstated. The mode of controlling the growth is obvious from the results obtained. The observations are still continued to obtain the necessary numerical results.

ART. IV.—*Notice of Observations to determine the Progress of the tidal wave of the Hudson River, made by the Coast Survey for the Commissioners on Harbor Encroachments;* by A. D. BACHE, Supt. U. S. Coast Survey.—(Abstract.)

PROF. BACHE explained the importance of a knowledge of the movement of the tide wave up the Hudson River to the determination of the shore line of New York bay and harbor, and the subject of encroachment upon the area of the harbor, and stated that the New York Commissioners had directed a full series of observations to be made for the examination of this point in the bearing just referred to, and also on the character of the improvements projected for the Hudson river at the Overslaugh, and indeed in the whole distance from Troy to New Baltimore. Nine tidal stations were in the course of occupation between Governor's Island, New York, and Greenbush, opposite Albany. At the two terminal stations Saxton's self-registering guages were placed, and he had expected to invite members to see the Albany guage, but the late freshet in the river had required its removal for the present. Prof. Bache explained the selections made of the localities of the tidal stations and the reasons for their special positions, and stated that the results of the work would hereafter be laid before the Association.

ART. V.—*On the Characteristic Action of the Barometer during the passage of a Revolving Storm, such as a Hurricane or Tornado, being a small rise and not a great fall;* by JOHN CHAPPELL-SMITH.

I WISH to call attention to some facts which afford evidence that a great fall in the barometer is not an essential element in all storms, as Redfield and Espy have assumed in their storm theories; that, on the contrary, the effect on the barometer of hurricanes and tornadoes, or of all storms accompanied with electric explosions, is a rise when the axis or centre of the storm passes near it. Some of the facts which lead to this conclusion will be found in the Smithsonian Contributions to Knowledge, in an article by me on a tornado near New Harmony, Indiana, April 30, 1852. In that article, the bearing of these facts on the subject was not pointed out, because I was not then impressed with their full force; my object was chiefly to point out facts directly opposed to the rotary or cyclonic theory of storms, so far as the proof of that theory depends on the direction in which bodies are prostrated by the progress of a storm. After a careful examination of all that had appeared in this journal in support of Mr. Redfield's views by himself and others, I could not resist the conclusion that the method of collecting and presenting the facts by the parties who had investigated storm phenomena was inconclusive; to pass over the field of the wreck of a tornado, select a tree here and a tree there, place them on a diagram, then assert that these were sufficient proofs of the rotary or cyclonic theory of storms is not enough. A much more laborious examination than this appeared to me to be necessary to attain just views. A tract of a square mile, at least, required to be plotted, with the magnetic bearings and relative distances of the prostrated bodies. This labor I performed, and gave, in the contribution referred to, a plot of a square mile, on which is shown the magnetic bearing and relative distances of nearly 7000 trees which had been prostrated by the tornado in little more than a minute. Sections made in a like manner across the track, at 2 and at 8 miles distance, were also given, which show a uniformity in the mode of action of the prostrating power; the whole furnishing, as I think, a complete refutation of Mr. Redfield's theory, so far as he has attempted to establish it by evidences of this kind.

But my object in this paper is not to dilate on what has been done in that contribution, but to point out the bearing of the barometrical facts, contained therein, upon Mr. Redfield's theory; facts which prove that the low barometer, which frequently exists at the time of the passage of a tornado or hurricane, is not aused by the tornado, but is dependent on some other cause.

The facts to which I principally refer are set forth in the following diagram. Here it will be perceived that from the morning

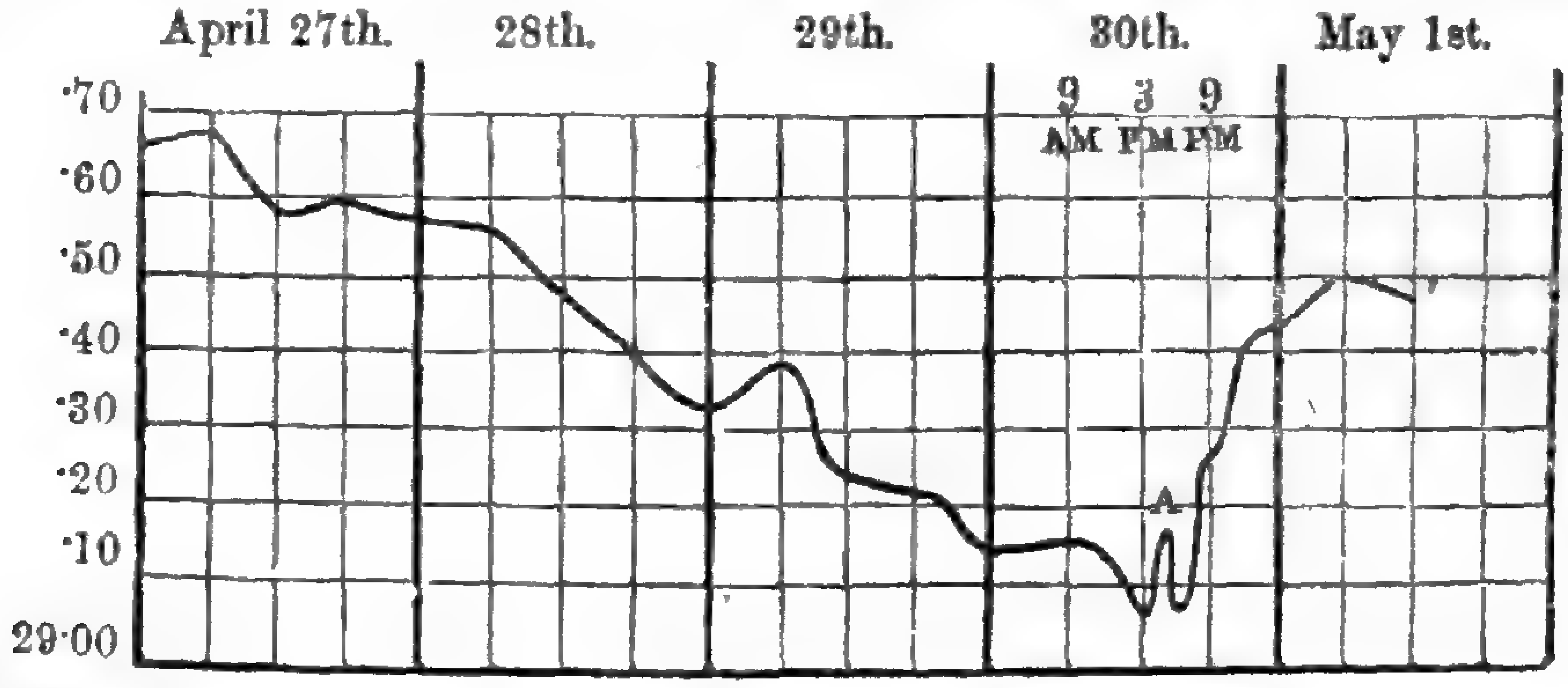


Diagram representing the barometric fluctuations on the day of the tornado, and on the three preceeding days at New Harmony, Indiana.

The horizontal lines are equal to fluctuations amounting to $\frac{1}{10}$ of an inch. The vertical lines represent the height of the barometer at the time of sunrise; 9 A. M. 3 P. M., and 9 P. M. on each day; the darker lines representing the sunrise observations.

A represents the fluctuation of the barometer between the hours of 3 and 6 P. M., on the 30th of April, at which hours the atmosphere was calm and clear; but between which the tornado came up, committed its ravages and passed on.

of April 27th, to 3 P. M., on the 30th, the barometer had been slowly and gradually falling, the only interruptions appearing to be those due to the maximum horary oscillation at 9 A. M., the wind at any time during the period scarcely exceeding a gentle breeze; at 3 P. M., a little more than an hour previous to the centre of the storm's passing the meridian of New Harmony, all was calm, and, with the exception of a slight haze, clear, without any sign to indicate the near approach of so fearful a storm. Soon after this, sounds of distant thunder were heard, and at 4 P. M., there was slight rain, strong wind, vivid lightning and loud thunder; the storm now began to exert its terrific violence, the rain fell in torrents accompanied by a shower of hailstones of extraordinary size, the wind blew in all directions and the barometer had *risen* ·050 of an inch. By 4·30 P. M., the storm had reached its height, and the barometer had *risen* ·030 of an inch more. The storm now began to abate, the barometer to *fall*, and by 5·30 P. M., all was again calm and clear, the barometer standing at the same point at which it stood previous to the coming up of the storm. Now this *rise* of near $\frac{1}{10}$ of an inch in the barometer, which commenced as the storm began to rage, which reached its maximum when the storm reached its height, and this *fall* which began as the storm began to abate, which reached its minimum as the storm cleared off, is surely a very significant fact; and if, as my experience, aided by that of others, has shown, this be a constant characteristic of the barometer in all storms accompanied with electric explosions; if the barometer invariably rises as the centre of a storm passes near an observer, though that rise seldom exceeds $\frac{1}{10}$ of an inch, does it not give strong grounds for concluding that the condition of low barometer, which often exists at the time of the passage of a whirlwind or tornado, is not caused by these meteors; does not the low barometer appear to be due to some other cause, and to be only a contingent, and not, as storm theorists have assumed, a conditional phenomenon?

In reference to the diagram, at the first glance a person may regard it as presenting a remarkable confirmation of Mr. Redfield's views: a great fall of the barometer as the axial area of the whirlwind approaches, and then a great rise as it passes away. But a little consideration will show that it is widely at variance with his views. Let us refer to them as given in his last communication to this Journal in September, 1854. He there states that the normal condition of the lower wind stratum consists of a constant occurrence and progression of cyclones from the equator in various degrees of activity; he defines a cyclone to be a moving disk or stratum of rotating atmosphere, which sometimes manifests itself by light and feeble, and sometimes by strong and violent, winds; the more inert and passive cyclones, he says, constantly occupy in their transit the greater portion of the earth's surface, and move in orbits corresponding to the more active cyclones traced on his storm charts; and that the effect on the barometer of any cyclone is proportionate to the general activity of the rotation considered as a whole. In another place he describes the effect as depressing the barometer, and says that the intensity of the depression rapidly increases as the axial area of the whirlwind approaches; that this axial area is the point of greatest depression, and that the latter is obviously due to the centrifugal force of the revolving motion in the body of the storm.

Now bearing these views of Mr. Redfield in mind, let us consider them in connection with the fall of the barometer represented in the diagram above. The fall, which commenced at New Harmony on the 27th of April, three days previous to the axial area of the whirlwind's or cyclone's arrival there, cannot be supposed to be due to the advancing portion of the rotating disk of the cyclone which reached New Harmony on the 30th, because, the distance of the axial area at the time must have been upwards of 4000 miles, supposing that it moved uniformly with the velocity with which it was known to move over 300 miles of the track, viz., 60 miles per hour; but suppose that its average velocity was 30 miles per hour, this would make the distance of the axial area upwards of 2000 miles, a distance so great, that Mr. Redfield would allow, that it would be preposterous to suppose that the fall of the barometer on the morning of the 27th could be caused by the advance of a storm whose axial area at that time was at that distance.

I will now give some facts which appear to prove that the tornado of the 30th did not exercise any influence at New Harmony up to one and a half hours of its axial area reaching there. From a slight account of the barometric condition which existed over the United Sates at about the time of the occurrence of the tornado at New Harmony, for which account I acknowledge my obligations to Professor Henry of the Smithsonian Institution, it appears that in all the States in the basin of the Ohio, including Wisconsin, Iowa and Missouri, a very low barometer prevailed; while a high barometer prevailed in the New England States, Pennsylvania and Virginia; and a very high one in Carolina, Florida, Georgia, Alabama, Louisiana and Mississippi. In the valley of the Ohio, on an area of the diameter of 400 miles, of which New Harmony is the centre, the barometer at 3 P. M. stood at nearly 29·100 inches. At this time the atmosphere at New Harmony was perfectly calm, although at about the distance of 90 miles, a storm of about 30 miles diameter was making its way through this area of low barometer with a velocity of 60 miles per hour; a storm which had the power over a track one mile in width to prostrate trees, to twist and bend them, as if they were reeds, at the rate of 7000 a minute, although many of them had a circumference of several feet. As this storm or cyclone approached, the barometer was watched, but there was not any indication of that direct barometric depression which Mr. Redfield says is produced by the increasing rapidity of the leftwise rotation of the cyclone in approaching its axial area. Instead of the intensity of the barometric depression rapidly increasing as the axial area of the whirlwind approached, which Mr. Redfield says is so obviously due to the centrifugal force of the revolving motion in the body of the storm, the barometer was seen actually to *rise* as the axial area approached, and to *fall* as it passed away. What becomes then of the theories built upon this assumed barometric depression? a depression which Redfield and Espy aver must be [as a general thing, EDS.] a consequence of such meteors, and on which assumed enormous depression they have based their theories. On a future occasion, in addition to a statement of further barometrical observations of my own, I will strengthen my position by a reference to the experience of celebrated navigators and meteorologists who advance facts similar to those which I have recited, but who, apparently influenced by a popular belief, have failed to notice their significant bearing on the question.

The phenomena of the New Harmony tornado which I have referred to, also offers insuperable objections to the cyclonic theory of storms when considered in connection with Mr. Redfield's idea of their origin. He says that the cyclones originate in the tropics, and are mainly the result of the mechanical gravitation of the atmosphere as connected with the rotative and orbital movements of the earth's surface; he says that their earliest activity and violence may be explained by the action of local currents; that opposite winds may coalesce in a vast gyration, instead of following their usual stratiform course without interference with each other: and that when once the fall of the barometer and the involute vortical movement has been established, the extraneous and tangential forces of contiguous winds is not necessary to continue the action; for the law of centrifugal action must produce an accumulation of pressure beyond the active verge of the whirlwind, and the pressure of the external atmosphere alone, around the basin of the storm, constantly keeps up the involute vertical movement, and is sufficient to maintain the existing vortical action.

Now I ask those who entertain this idea, to view it in connection with the conditions that existed in the valley of the Ohio on the afternoon of April 30th, particularly in the vicinity of New Harmony. Granting that the circumstances described by Mr. Redfield did generate a cyclone or rotary storm, is the cause he has assigned, consisting of the mere mechanical force of rotation, sufficient to impel a rotating disk of atmosphere of some 30 miles in diameter, as in the tornado in question, many hundreds of miles, which disk had carried with it, and still maintained, as it entered the valley of the Ohio, a power that could prostrate thousands of trees on successive miles in successive minutes, which swept off houses, and carried cattle up far in the air?* To me the thing is inconceivable, the cause is not adequate to the effects; and it is the more inconceivable when it is known that, in this, as in other storms of the kind, the destructive action was *intermittent*, that some parts of the track were passed over without destruction, and that in others it was exerted with various degrees of violence. This spasmodic action is not in accordance with the inherent mechanical force ascribed to the cyclone; and some other cause is requisite for the production of these effects of this now retarded, and now accelerated, mechanical force. But Mr. Redfield says that it is not requisite; extraneous aid, he says, is not necessary to keep up the vortical action, for when once the fall of the barometer and the involute vortical motion has been established, the law of centrifugal action must produce an accumulation of pressure beyond the active verge of the whirlwind, and this pressure alone, around the basin of the storm, must keep up the involute vortical action. But, as experience shows in the New Harmony tornado, in opposition to Mr. Redfield's theory, there was not any diminution of pressure near

* The writer has here mistaken the views of Mr. Redfield, who makes the movement of the cyclone over the earth's surface in no sense a consequence of the rotation: and who has further shown that spasmodic action is a necessary consequence when the axis of the cyclone is not vertical.—Eds.

the axial area of the storm, and there was not any accumulation beyond its active verge, as I have shown in describing the condition of the surrounding area of 400 miles in diameter through which the tornado progressed.

Of course the same objections apply to Mr. Espy's theory: he admits that a tornado may very greatly depress the barometer; and "if it should depress it more than 3 inches" then, he says, that something more is necessary than is provided for in his theory,—"perhaps electricity." It is not a little remarkable that when Mr. Espy presented his storm views to the British Association, Sir John Herschel observed, that if an ascensional column be the cause of storms, the barometer *ought to rise in the centre of the storm or column;* a fact which the observation of what actually occurs during the passage of a tornado has now verified; for whether the storm progress in the form of an ascensional column, or of a cyclone, the facts I have advanced prove that the *barometer does rise in its centre.*

Art. VI.—*On the Spirality of Motion in Whirlwinds and Tornadoes;* by W. C. Redfield.

Read before the American Association at Albany, Aug. 26, 1856.

1. An aggregated spiral movement, around a smaller axial space, constitutes the essential portion of whirlwinds and tornadoes.

2. The course of the spiral rotation, whether to the right or left, is one and the same in this respect throughout the entire whirling body, so long as its integrity is preserved. But the oblique inclination which the spiral movement also has to the plane of the horizon, is in opposite directions as regards the interior and exterior portions of the revolving mass. Thus, in the outward portion of the whirlwind the tendency of this movement is obliquely downwards, when the axis is vertical; but in the interior portion, the inclination or tendency of the spiral movement is upward. This fact explains the ascensive effects which are observed in tornadoes and in more diminutive whirlwinds.

3. Owing to the increased pressure of the circumjacent air in approaching the earth's surface, the normal course of the gradually descending movement, in a symmetric whirlwind, is that of an involuted or closing spiral; while the course of the interior *ascending* movement of rotation is that of an evolved or opening spiral. Hence, the horizontal areas of the higher portions of the whirl exceed greatly those of its lower portions.

4. The area of the ascending spiral movement in the vortex, as it leaves the earth's surface, is by far the smallest portion of

the whirling body; for the reason that the rotation here is proportionally more active and intense, being impelled by the aggregated pressure and momentum of the more outward portion of the whirlwind as it converges from its larger area, on all sides, by increasingly rapid motion, into the smaller area of ascending rotation.* That this interior portion of the whirl resembles an inverted hollow cone, or column, with quiescent and more rarified air at its absolute center, may be inferred from the observations which have been made in the axial portions of the great cyclones. Into this axial area of the tornado the bodies forced upward by the vortex cannot fall, but will be discharged outward, from the ascending whirl. The columnar profile of this axial area sometimes becomes visible, as in the water spouts so called.

5. Accessions caused by circumjacent contact and pressure are constantly accruing to the whirling body, so long as its rotative energy is maintained. A correlative diffusion from its ascending portion must necessarily take place, towards its upper horizon; and this is often manifested by the great extent or accumulation of cloud which results in this manner from the action of the tornado. In other words, there is a constant discharge from the whirling body in the direction of least resistance.

6. The spirality of the rotation and its inclination to the horizon, in the great portion of the whirl which is exterior to its ascending area, is not ordinarily subject to direct observation. Nor is the outline or body of the more outward portion of the whirlwind at all visible, otherwise than in its effects.

7. In *aqueous* vortices the axial spiralities of the exterior and interior portions are in reverse direction to those in the atmosphere, the descending spiral being nearest to the axis of the vortex. Hence, lighter bodies and even bubbles of air are often forced downward in the water, in the manner in which heavier bodies are forced upwards in the atmosphere.

The foregoing is simply a statement of results which I have derived from a long course of observation and inquiry. It does not include the partial and imperfect exhibitions of whirlwind action, which often occur; nor the various movements and phenomena which are collaterally associated with tornadoes and whirlwinds, some of which are of much significance.

* The law of increment in the velocity of the whirlwind, as it gradually converges into smaller areas by its spiral involution, is that which pertains to other bodies when revolving around interior foci towards which they are being gradually drawn or pressed nearer and nearer, in their involute course;—the line of focal or centripetal pressure, thus sweeping *equal areas in equal times*, at whatever diminution of distance from the center; except as the velocity may be effected in degree by the resistance of other bodies. Such resistance is of little effect in a tornado, because its revolving mass is mainly above all ordinary obstacles, such as orchards and forests, into which the spirally *descending* and accelerated blast, near the contracted extremity of the inverted and truncated cone of the whirl, penetrates with constant freshness and intensity of force; already acquired in the higher and unobstructed region.

ART. VII.—*On the Application of the Mechanical Theory of Heat to the Steam Engine*; by R. CLAUSIUS.

[Concluded from vol. xxii, p. 374.]

39. I believe that it will not be without interest, if before I attempt to make these equations more convenient for application, I show how we may also, for an imperfect steam engine, arrive at the same expressions by the inverse method formerly pointed out as by that previously followed. In order, however, not to be too prolix in this digression, I will take into consideration only two of the imperfections which are considered in the foregoing equations, namely, the presence of the injurious space, and the less pressure of the steam in the cylinder than in the boiler during the influx. On the other hand I will assume that the expansion is complete, in which case we must put $T_3 = T_0$ and that also the quantities T_0, T'_0 and T''_0 are equal to each other.

We have to apply in this determination the equation (2), which we will here write in the following form:

$$W' = \frac{1}{A}\left(Q_1 - T_0 \int_0^{Q_1} \frac{dQ}{T}\right) - \frac{T_0}{A} N.$$

The first term on the right side signifies the work which we should obtain by means of the applied quantity of heat Q_1, which for our case is represented by $m_1 r_1 + Mc(T_1 - T_0)$, if these imperfections did not take place. This term is already calculated in § 23 where the following expression was found:

$$\frac{1}{A}\left[m_1 r_1 + Mc(T_1 - T_0) - T_0\left(\frac{m_1 r_1}{T_1} + Mc \log \frac{T_1}{T_0}\right)\right]$$

The second term signifies the loss of work which is occasioned by these two imperfections. The quantity N which occurs in it, is also already calculated, namely, in § 36, and is represented by the expression cited in equation (38).

If we substitute these two expressions in the foregoing equation, we have

$$(44) \quad W' = \frac{1}{A}\left[m_1 r_1 - \frac{T_0}{T_1} m_2 r_2 + Mc(T_1 - T_0) - (M+\mu)cT_0 \log \frac{T_2}{T_0} + \mu_0 r_0\right]$$

We easily see that this equation corresponds in fact with equations (XIV) if we introduce into the first of them the mass m_2 for the mass m_3, which may be done by means of the third equation, and by then putting $T_3 = T_0 = T'_0 = T''_0$.

In the same manner we can take into account the loss of work which arises from the incomplete expansion, by calculating the uncompensated transformation which occurs during the passage of the steam from the cylinder into the condenser and include this in N. By this calculation, which I will not here actually execute, we arrive completely at the expression given in (XIV) for the work.

40. In order now to be able to apply the equations (XIV) to a numerical calculation, it is first necessary to determine more nearly the quantities p'_1, p'_0 and p''_0.

No generally valid law can be established as to the manner in which the pressure changes in the cylinder during the influx, because the opening and closing of the steam pipe takes place in different machines in different ways.

Consequently it is impossible to assign, once for all, a definite value holding good for the relation between the mean pressure p'_1 and the final pressure p_2 when the last is strictly considered.

This however becomes possible by slightly changing the signification of p_2. The cutting off of the cylinder from the boiler cannot of course take place in an instant, but the necessary motion of the clapper or slide valve requires, according to the different feed arrangements, a greater or less time, during which the steam in the cylinder expands somewhat, because during the contraction of the opening less new steam can enter than corresponds to the velocity of the piston. We may therefore in general assume that at the end of this time the pressure is somewhat less than the mean pressure denoted by p_1.

If, however, we do not restrict ourselves to bring into calculation precisely the end of the time necessary for closing, as the moment of the cut-off, but allow some liberty in fixing this moment, we may obtain other values for p_2. We may then consider the point of time as so chosen, that if up to that time the whole mass M had flowed in, a pressure would take place at this instant which would be exactly equal to the mean pressure calculated up to this instant. If we put the instantaneous closure, more nearly determined in this manner, in the place of the gradual closure which actually takes place, we commit only an insignificant error with respect to the work calculated from it. We may therefore accept this modification of Pambour's assumption that $p'_1 = p_2$, whereby, however, it remains reserved for especial consideration for each particular case, to determine correctly the period of the cut-off, with reference to the prevailing circumstances of the case.

41. With respect to the counter pressure p'_0 which takes place during the return of the piston, the difference $p'_0 - p_0$ is evidently smaller under otherwise equal circumstances, the smaller p_0 is. It will therefore be smaller in machines with condensers than in machines without condensers in which p_0 is equal to one atmosphere. In the most important machines without condensers, the locomotives, a particular circumstance usually occurs

which contributes to increase the difference, namely: that we do not offer to the steam the shortest and widest possible channel for its passage into the atmosphere, but conduct it into the chimney, and there let it flow out through a somewhat narrow tube in order to produce in this way an artificial draught.

In this case an accurate determination of the difference is important for the reliability of the result. We must also consider that the difference is not constant in one and the same machine, but depends upon the rate of motion, and must determine the law according to which this dependence takes place. I will not however here enter upon these considerations and the investigations which have already been instituted upon this subject, since they have nothing to do with the mechanical theory of heat.

In machines in which this application of the steam which passes from the cylinder does not occur, and particularly in machines with condensers, p'_0 is so little different from p_0, and can therefore change so little with the rate of motion, that it is sufficient for most investigations to assume for p'_0 a mean value.

As further, the quantity p_0 occurs in equations (XIV) only in a term affected by the factor σ, and therefore exerts a very slight influence on the value of the work, we may without fear put for p_0 the value which is most probable for p'_0.

The pressure which takes place in the injurious space p''_0 depends as already mentioned upon whether the cutting off from the condenser takes place before or after the end of the motion of the piston, and may therefore vary greatly. But this pressure also, and the quantities which depend upon it, occur in equations (XIV) only in such terms as are affected with small factors namely, with μ and μ_0 so that we may satisfy ourselves with an approximate estimate and omit an accurate determination of this pressure. In such cases, where no particular circumstances lead us to believe that p''_0 deviates much from p'_0, we may neglect this difference, as well as that between p_0 and p'_0, and assume the value which represents the mean counter pressure in the cylinder with the greatest probability as a common value for all these quantities. This value may then simply be denoted by p_0; by the introduction of these simplifications, equations (XIV) pass into

$$(\text{XV}).\quad\left\{\begin{aligned} W' &= \frac{1}{A}\left[m_1 r_1 - m_2 r_2 + Mc(T_1 - T_3) + \mu_0 r_0 - \mu c(T_3 - T_0)\right] \\ &\qquad + m_3 u_3 (p_3 - p_0) \\ m_2 r_2 &= m_1 r_1 + Mc(T_1 - T_2) + \mu_0 r_0 - \mu c(T_2 - T_0) + A\mu_0 u_0 (p_2 - p_0) \\ &\qquad + AM\sigma(p_1 - p_2). \\ \frac{m_3 r_3}{T_3} &= \frac{m_2 r_2}{T_2} + (M + \mu) c \log \frac{T_2}{T_3}. \end{aligned}\right.$$

42. It is assumed in these equations that beside the masses M, m_1, μ and m_0, of which the first two must be known by direct observation, and the last two can be determined approximately from the magnitude of the injurious space, the four pressures p_1, p_2, p_3, p_0, or what is the same, the four temperatures T_1, T_2, T_3, T_0, are given. This condition is however only partially fulfilled for the cases which occur in practice, and we must therefore take other data to assist us in the calculation.

Only two of these four pressure-forces are to be supposed as known, namely p_1 and p_0, the first of which is given immediately by the boiler pressure-guage, and the last may be inferred, at least approximately, from the indications of the condenser-guage. The two others, p_2 and p_3, are not given, but instead of them we know the dimensions of the cylinder, and at what position of the piston the cut-off from the boiler takes place. From this we may deduce the volumes which the steam in the cylinder takes up at the moment of the cut-off and at the end of the expansion, and these two volumes may therefore take the place, as data, of the pressure-forces p_2 and p_3.

We have now to bring the equations into such a form that we can execute the calculation by means of these data.

43. Let us again denote, as in setting forth Pambour's theory, the whole space which becomes free in the cylinder during one stroke, including the injurious space, by v', the space which becomes free up to the cutting-off from the boiler, by $c\,v'$, and the injurious space by $\varepsilon v'$. Then we have, according to what has already been said, the equations

$$\begin{aligned} m_2 u_2 + (M+\mu)\sigma &= ev' \\ m_3 u_3 + (M+\mu)\sigma &= v' \\ m_0 u_0 + \mu\sigma &= \varepsilon v'. \end{aligned}$$

The quantities μ and σ are both so small that we may neglect their product, so that we have

$$(45)\quad \begin{cases} m_2 u_2 = ev' - M\sigma \\ m_3 u_3 = v' - M\sigma \\ \mu_0 = \dfrac{\varepsilon v'}{u_0}. \end{cases}$$

Furthermore, according to equation (VI) we have

$$r = A\,T u\,g,$$

if we introduce the letter g for the differential co-efficient $\frac{dp}{dT}$ contained in it, which will in what follows occur so often that a simpler notation is advantageous. According to this, we may replace the quantities r_2 and r_3 in the above systems of equations by u_2 and u_3. Then the masses m_2 and m_3 occur only in the products $m_2 u_2$ and $m_3 u_3$, and for these we may substitute the values given in the first two of equations (45).

In like manner, by means of the last of these equations, we may first eliminate the mass μ_0, and as for the other mass, this may it is true be somewhat greater than μ_0. As however the terms which contain μ as a factor are, in any event, very insignificant, we may substitute without hesitation also for μ the same value which is found for μ_0 that is, for the purpose of numerical calculation, we may drop the assumption made for the sake of generality, that the mass which was originally in the injurious space was partly fluid and partly vapor, and consider the mass in question as wholly in the form of vapor.

The substitution just signified may be effected in the general equations (XIV) as well as in the simplified equations (XV). As the substitution however presents no difficulties, we will here confine ourselves to the last, in order to obtain the equations at once in a form which is suited to numerical computation.

After this change they read as follows:

$$
(\text{XVI})\left\{
\begin{aligned}
&W'=\frac{m_1 r_1+Mc(T_1-T_3)}{A}-(v'-M\sigma)(T_3 g_3-p_3+p_0)+\varepsilon v'\frac{r_0-c(T_3-T_0)}{Au_0}\\
&(ev'-M\sigma)T_2 g_2=\frac{m_1 r_1+Mc(T_1-T_2)}{A}+\varepsilon v'\left(\frac{r_0-c(T_2-T_0)}{Au_0}+p_2-p_0\right)\\
&\qquad\qquad+M\sigma(p_1-p_2)\\
&(v'-M\sigma)g_3=(ev'-M\sigma)g_2+\left(M+\frac{\varepsilon v'}{u_0}\right)\frac{c}{A}\log\frac{T_2}{T_3}.
\end{aligned}
\right.
$$

44. In order to refer these equations, which determine the work of one stroke or of the quantity of steam M_1, finally to the unit of weight of steam, the same process is to be applied by means of which formerly equations (35) were converted into (XII). We divide namely the three equations by m_1 and then put

$$\frac{M}{m_1}=l,\ \frac{v'}{m_1}=V,\ \frac{W'}{m_1}=W.$$

The equations now become

$$
(\text{XVII})\left\{
\begin{aligned}
&W=\frac{r_1+lc(T_1-T_3)}{A}-(V-l\sigma)(T_3 g_3-p_3+p_0)+\varepsilon V\frac{r_0-c(T_3-T_0)}{Au_0}\\
&(eV-l\sigma)T_2 g_2=\frac{r_1+lc(T_1-T_2)}{A}+\varepsilon V\left(\frac{r_0-c(T_2-T_0)}{Au_0}+p_2-p_0\right)\\
&\qquad\qquad+l\sigma(p_1-p_2)\\
&(V-l\sigma)g_3=(eV-l\sigma)g_2+\left(l+\frac{eV}{u_0}\right)\frac{c}{A}\log\frac{T_2}{T_3}.
\end{aligned}
\right.
$$

45. The application of these equations to the calculation of the work may be made in the following manner. We determine the volume V, which belongs to the unit of weight of steam, by means of the evaporating power supposed to be known, and of the rate of motion which the machine thereby assumes. With the help of this value, we calculate in the first place from the

second equation the temperature T_2, then from the third the temperature T'_3, and these we finally apply in the first equation to the determination of the work.

In this process we meet, however, a peculiar difficulty. In order to calculate the temperatures T'_2 and T'_3 from the two last equations, these ought properly to be solved according to the temperatures. They contain these temperatures however, not only explicitly, but also implicitly, inasmuch as p and g are functions of the temperature. The equations for further treatment would become too complicated, if we were to substitute for the elimination of these quantities one of the usual empirical formulas which express the pressure of the steam for p, and its differential co-efficient for g. We might now perhaps help ourselves out in the same manner as Pambour has done, namely, by setting up new empirical formulas which should be more convenient for the present purpose, and if not for all temperatures, at least within certain intervals, sufficiently accurate. I will not however, here make such attempts, but instead of them will direct attention to another process in which the calculation, it is true, is somewhat tedious, but easily executed in its single parts.

46. When the tension-series of the vapor is known with sufficient accuracy for any one fluid, we may calculate from it the values of the quantities g and $T\,g$, for various temperatures, and unite them in tables just as it is customary to do with the values of p. I have executed such a calculation with the help of Regnault's tension-series for the vapor of water, which, up to this time, has been almost exclusively employed in steam engines, and for the interval of temperature within which the application holds good, namely, from 40° to 200° C.

I ought properly for this purpose to have differentiated the formulas which Regnault has used to calculate the single values of p below and above 100° according to t, and by means of the new formulas thus obtained to have calculated g. As however these formulas do not answer their purpose so completely as to make this tedious labor worth while, and as the establishment and calculation of another more appropriate formula would have been still more prolix, I have contented myself with using the numbers calculated for the pressure, for an approximate determination of the differential co-efficient of the pressure. If for instance, we denote the pressure for the temperatures 146° and 148° by p_{146} and p_{148}, I have assumed that the quantity

$$\frac{p_{148}-p_{146}}{2}$$

represents with sufficient accuracy the value of the differential co-efficient for the mean temperature 147.

For this purpose I have used above 100° the numbers cited by Regnault* himself. Moritz† has recently directed attention to the fact, with reference to the values under 100°, that the formula which Regnault has applied between 0° and 100° is somewhat inaccurate, particularly in the neighborhood of 100°, in consequence of the use of seven-figure logarithms in calculating the constants. Moritz has therefore calculated these constants with ten-figure logarithms, assuming the same values from observation, and has communicated the values of p deduced from this improved formula in so far as they differ from Regnault's, which first occurs above 40°. I have used these values.

After the quantity g is calculated for the single degrees of temperature, the calculation of the product Tg presents no longer any difficulty, since T is determined by the simple equation

$$T = 273 + t.$$

I have collected the values of g and $T\,g$, thus found in a table communicated at the end of this memoir. For the sake of completeness I have added the values of p belonging to them, those of Regnault above 100°, those calculated by Moritz below 100°. In each of these three series of numbers, the differences of every two successive numbers are given, so that we may find from this table, for every given temperature, the values of those three quantities, and conversely, for every given value of one of those three quantities, the corresponding temperature.

After what has already been said as to the calculation of g, I scarcely need to add that I do not consider the numbers of this table as accurate, but only communicate them for lack of better. As, however, the calculations which occur in the steam engine always rest upon rather uncertain data, we may apply for this purpose these numbers without hesitation, without having to fear that the uncertainty of the result will be thereby sensibly increased.

One observation is however still necessary. In equations (XVII) it is supposed that the pressure p and its differential co-efficient g are expressed in kilograms upon a square meter; in the tables, on the contrary, the same unit of pressure is retained to which Regnault's tension-series refers, namely, millimeters of mercury. In order, notwithstanding, to be able to apply the table, we only need in these equations to divide all the terms which contain neither p nor g as a factor by the number 13·596.

I will, for the sake of brevity, denote this number, which is nothing else than the density of mercury at 0° compared with that of water at its maximum density, by k.

This modification of the formulas produces almost no increase of calculation, inasmuch as it consists in substituting in every

* Mém. de l'Acad. des Sciences, T. xxi, p. 625.

† Bulletin de la Classe physico-mathematique de l'Acad. de St. Petersburg, T. xii, p. 41.

place, instead of the constant factor, which has according to Joule the value already cited, 423·55, the other constant.

$$(46) \qquad \frac{1}{Ak} = \frac{423 \cdot 55}{13 \cdot 596} = 31 \cdot 1525,$$

and besides, in place of the work W, the quantity $\frac{W}{k}$ is first found, which must then be multiplied by k.

47. Let us now return to equations (XVII) and first consider the second of them.

This equation may be written in the following form:

$$(47) \qquad T_2 g_2 = C + a(t_1 - t_2) - b(p_1 - p_2),$$

in which the quantities C, a, and b are independent of t_2, namely,

$$(47_a) \quad \begin{cases} C = \dfrac{1}{e V - l \sigma}\left[\dfrac{r_1}{Ak} + \varepsilon V\left(\dfrac{r_0 - c(T_1 - T_0)}{Aku_0} + p_1 - p_0\right)\right] \\ a = \dfrac{c\left(l + \dfrac{\varepsilon V}{u_0}\right)}{Ak(e V - l\sigma)} \\ b = \dfrac{\varepsilon V - l\sigma}{e V - l\sigma}. \end{cases}$$

Of the three terms on the right side of (47) the first preponderates by far, and hence it becomes possible to determine the product $T_2\, g_2$, and thereby at the same time the temperature t_2 by successive approximation.

In order to obtain the first approximate value of the product which we may call $T'g'$, substitute on the right side t_1 in the place of t_2, and in like manner p_1 in place of p_2, then we have

$$(48) \qquad T' g' = C.$$

The temperature t' belonging to this value of the product is to be looked for in the table. In order to obtain the second approximate value of the product, put the value t' just found and the corresponding value p' of the pressure on the right side of (47), for p_2 and t_2, whereby we obtain, taking the previous equation into consideration,

$$(48_a) \qquad T'' g'' = T' g' + a(t_1 - t') - b(p_1 - p').$$

The temperature belonging to this value of the product t'' may be determined as before from the table. If this do not represent the sought temperature t_2 with sufficient accuracy, repeat the same process. Substitute on the right side of (47), t'' and p'' in place of t_2 and p_2, by which we obtain, taking the previous equations into consideration,

$$(48_b) \qquad T''' g''' = T'' g'' + a(t' - t'') - b(p_1 - p''),$$

and can find the new value of the temperature t''' in the table.

In this manner we might continue as long as we please; but the third approximate value differs only by the $\frac{1}{100}$ of a degree, and the fourth by less than the $\frac{1}{1000}$ of a degree, from the true value of the temperature t_2.

48. The treatment of the third of the equations XVII is quite similar. If we divide this by $V-l\sigma$, and for the sake of more easy calculation introduce Briggs's logarithms, which may be denoted by the symbol Log., in place of the natural logarithms denoted by the symbol log., in which case it is only necessary to add the modulus M of this system as a divisor, the equation takes the form

$$(49) \qquad g_3 = C + a \log \frac{T_2}{T_3},$$

in which C and a have the following values independent of T_3.

$$(49a) \qquad \begin{cases} C = \dfrac{e\,V - l\sigma}{V - l\sigma} \cdot g_2 \\[2ex] a = \dfrac{c\left(l + \dfrac{\varepsilon V}{u_0}\right)}{M.Ak(V - l\sigma)}. \end{cases}$$

In equation (49) the first term on the right side is again preponderant, so that we may apply the process of successive approximation. If we substitute in the first place T_2 in the place of T_3, we obtain as a first approximate value of g_3:

$$(50) \qquad g' = C,$$

and can find in the table, the temperature t' which belongs to it, and from this easily form the absolute temperature T'. If we substitute this in (49) for T_3, we have

$$(50a) \qquad g'' = g' + a \log \frac{T_2}{T'},$$

from which T'' is found. In like manner, we obtain farther

$$(50b) \qquad g''' = g'' + a \log \frac{T'}{T''}.$$

49. It only remains to determine the quantities c and r in order to be able to proceed to the numerical application of equations XVII. The quantity c, that is the specific heat of the liquid, has been considered as constant in the foregoing development. This, it is true, is not quite correct, since the specific heat increases somewhat with an increase of temperature. The errors cannot however be significant, if we select as a common value the value which is correct at about the middle of the interval which embraces the temperature occurring in the investigation. In engines driven by steam, 100° may be taken as such a mean temperature, which in a common high pressure engine with a con-

denser is about equally distant from the temperature of the boiler and that of the condenser. We will accordingly apply to water, the value which according to Regnault represents the specific heat at 100° putting

$$(51) \qquad c = 1{\cdot}0130.$$

To determine the quantity r, we set out from the equation which Regnault has established for the whole quantity of heat which is necessary in order to warm a unit of weight of water from 0° to the temperature t, and to convert it into steam at this temperature, namely,

$$\lambda = 606{\cdot}5 + 0{\cdot}305\,.\,t.$$

If we substitute in this for λ, the sum corresponding to the previous definition $\int_0^t c\,dt + r$, we have

$$r = 606{\cdot}5 + 0{\cdot}305\,.\,t - \int_0^t c\,dt.$$

We must apply in the interval for c, the temperature function more accurately determined by Regnault, in order to obtain exactly the values of r which Regnault gives. I believe however that it is sufficient for our present purpose to employ in this case also for c the constant before cited. Hence we obtain

$$\int_0^t c\,dt = 1{\cdot}013\,.\,t,$$

and may now contract into one the two terms of the preceding equation depending on t, which reads $-0{\cdot}708\,.\,t$.

We must, at the same time, also change somewhat the constant term of the equation, and we will so determine it that that observation-value of r which is probably most accurate of all is also correctly represented by the formula. Regnault has found for the quantity λ at 100°, as a mean of 38 observations, the value 636·67. If we subtract from this the quantity of heat which is requisite to heat the unit of weight of water from 0° to 100°, and which according to Regnault is equal to 100·5 units of heat, there remains, if we satisfy ourselves with one decimal,

$$r_{100} = 536{\cdot}2.^*$$

By employing this value, we obtain for r the formula

$$(52) \qquad r = 607 - 0{\cdot}708\,.\,t.$$

A comparison of some of the values calculated from this with those given by Regnault† in his table will show that this simpli-

* Regnault himself does not give in his table exactly the above number but 536·5. This arises however only from the fact that instead of the previously mentioned value 636·67 he has put for λ at 100° in the calculation in round numbers 637.

† Mém. de l'Acad. des Sciences, T. xxi, p. 748.

fied formula corresponds with sufficient accuracy to the more strict mode of calculation before signified.

t	0	50°	100°	150°	200°
r acc. to (52),	607·0	571·6	536·2	500·8	465·4
r acc. to Regnault,	606·5	571·6	536·5	500·7	464·3

50. In order to be able to distinguish in their action the two different kinds of expansion to which the two last of equations XVII refer, it appears to me advantageous to consider, in the first place, a steam engine such that only one of them occurs in it. We will therefore begin with a machine which works without expansion.

In this case we must put for the quantity e, which signifies the ratio of the volumes before and after expansion, the value 1, and at the same time make $T_3 = T_2$, whereby equations XVII assume a simpler form.

The last of these equations becomes identical and therefore disappears. Furthermore, many terms of the first equation which only differ from the corresponding terms of the second in this, that the first contain T_3 and the others T_2, now become equal to them, and may therefore be eliminated. Hence we obtain by introducing at the same time, the above-mentioned quantity k,

$$\text{(XVIII)} \begin{cases} \dfrac{W}{k} = V(1-\varepsilon)(p_2 - p_0) - l\sigma(p_1 - p_0) \\ (V - l\sigma)\, T_2 g_2 = \dfrac{r_1 + lc(T_1 - T_2)}{Ak} \\ \qquad + \varepsilon V\left(\dfrac{r_0 - c(T_2 - T_0)}{Aku_0} + p_2 - p_0\right) + l\sigma(p_1 - p_2). \end{cases}$$

The first of these two equations is exactly the same as that which we obtain according to Pambour's theory, if we put in (XII) $e=1$ and introduce the volume V in place of the quantity B. The difference exists thus only in the second equation, which has taken the place of the simple relation between volume and pressure assumed by Pambour.

51. Let us assume the quantity ε occurring in these equations, which represents the injurious space as a fraction of the whole space which becomes free for the steam, as equal to 0·05. The quantity of liquid which the steam carries with it, on its entrance into the cylinder, is different in different machines. Pambour says that it amounts on the average in locomotives to 0·25, in stationary steam engines however, to much less, perhaps to 0·05 of the whole mass which enters the cylinder. We will use the last datum for our example, according to which the ratio of the whole mass which enters the cylinder to the portion of it which is in the form of steam is as 1 to 0·95. Furthermore, let the pressure in the boiler be assumed to be 5 atmospheres,

to which the temperature 152°·22 belongs, and suppose that the machine has no condenser, or what is the same a condenser with a pressure of 1 atmosphere. The mean counter pressure in the cylinder is then greater than 1 atmosphere. In locomotives, this difference, as above mentioned, may by a particular circumstance become considerable, in stationary steam engines on the contrary, it is less. Pambour, in his numerical calculations for stationary machines without condensers, has quite neglected this difference, and as our object here is only to give an example for the comparison of the new formulas with those of Pambour, we will in this also agree with him, and put $p_0=1$ atmosphere. The following values accordingly come into application in equations (XVIII) for this example:

$$(53) \qquad \begin{cases} \varepsilon = 0{\cdot}05 \\ l = \dfrac{1}{0{\cdot}95} = 1{\cdot}053 \\ p_1 = 3800 \\ p_0 = 760. \end{cases}$$

If we assume in addition the once for all fixed values

$$k = 13{\cdot}596$$
$$\sigma = 0{\cdot}001,$$

there remain in the first of the equations (XVIII), besides the sought quantity W only the quantities V and p_2.

52. We must now first find out what is the least possible value of V.

This value corresponds to the case in which the same pressure takes place in the cylinder as in the boiler; and we need only substitute p_1 in the place of p_2, in the last of equations (XVIII). Hence we have

$$(54) \qquad V = \frac{\dfrac{r_1}{Ak} + l\sigma\,.\,T_1 g_1}{T_1 g_1 - \varepsilon\left(\dfrac{r_0 - c(T_1 - T_0)}{Aku_0} + p_1 - p_0\right)}.$$

In order to give an example at once of the influence of the injurious space, I have calculated two values from this expression, that which would arise if no injurious space were present, and therefore $\varepsilon=0$, and that which must ensue from the supposition made by us that $\varepsilon = 0{\cdot}05$. These two values are expressed as fractions of a cubic meter for one kilogram of steam passing out of the boiler,

$$0{\cdot}3637 \text{ and } 0{\cdot}3690.$$

That the last of these two values is greater than the first, arises from the fact that, in the first place, the steam penetrates into the injurious space with great velocity, the living force of this motion is then converted into heat, and this again causes the evaporation of a portion of the liquid mechanically carried along; and that, in the second place, the steam which was in the injurious space before the influx, in like manner, contributes to increase the whole quantity of steam which is afterward present.

If we substitute the two values found for V in the first of equations (XVIII) whereby ε is at one time made $= 0$ and the other time $= 0{\cdot}05$, we obtain as corresponding quantities of work expressed in kilogram-meters,

$$14990 \text{ and } 14450.$$

According to Pambour's theory, it makes no difference, with reference to the volume, whether one portion of it is injurious space or not; it is determined in both cases by the same equation (29_b) if we substitute in it for p the particular value p_1. Thereby we obtain

$$0{\cdot}3883.$$

That this value is greater than that previously found for the same quantity of steam, 0·3637, may be explained from this, that we have hitherto considered the volume of steam at the maximum density, as greater than it can be according to the mechanical theory of heat, and this earlier view finds also its expression in equation (29_b.)

If we determine by means of this volume the work under the two suppositions that $\varepsilon = 0$ or $= 0{\cdot}05$, we have

$$16000 \text{ and } 15200.$$

These quantities of work are, as was to be foreseen as immediate consequences of the greater volume, both greater than those beforehand, but not in an equal ratio, inasmuch as the loss of work occasioned by the injurious space is less, according to the equations developed by us, than it should be according to Pambour's theory.

53. In a machine of the kind considered here, which Pambour studied in action, the velocity which the machine actually assumed, is to that which may be calculated from his theory, as a minimum velocity for the same power of evaporation and the same pressure in the boiler, in one experiment, as 1·275 : 1, and in another with a less load, as 1·70 : 1. The volumes 0·495 and 0·660 would correspond for our case to these velocities. We will now choose as an example for the determination of the work, a velocity which lies between these two, by putting in round numbers

$$V = 0{\cdot}6.$$

We have now first to find the temperature t_2 for this value of V. For this purpose equation (47) which assumes the following special form will serve:

$$(55) \qquad T_2\, g_2 = 26577 + 56{\cdot}42\,.\,(t_1 - t_2) - 0{\cdot}0483\,.\,(p_1 - p_2).$$

If we execute by means of this equation, the successive determination of t_2 described in § 47, we obtain in succession the following approximate values:

$$t' = 133^\circ{\cdot}01$$
$$t'' = 134\ {\cdot}43$$
$$t''' = 134\ {\cdot}32$$
$$t'''' = 133\ {\cdot}33.$$

Still further approximations would differ only in the higher decimal places, and we have accordingly, inasmuch as we will content ourselves with two decimals, to consider the last number as the true value of t_2. The pressure belonging to this is

$$p_2 = 2308{\cdot}30.$$

If we apply these values of V and p_2, at the same time with the other values closely determined in § 51, to the first of equations (XVIII) we obtain

$$W = 11960.$$

Pambour's equation (XII) gives for the same volume 0·6, the work

$$W = 12520.$$

54. In order to show still more distinctly the dependence of the work upon the volume, and at the same time, the difference which prevails in this respect between Pambour's and my theory, I have executed the same calculation as for the volume 0·6 for a series of volumes increasing at equal distances. The results are comprised in the following table. The first horizontal series of numbers, which is separated from the others by a line, contains the values found for a machine without injurious space. For the rest the arrangement of the table is easily understood.

V	t_2	W	According to Pambour.	
			V	W
0·3637	152°·22	14990	0·3883	16000
0·3690	152 ·22	14450	0·3883	15200
0·4	149 ·12	14100	0·4	15050
0·5	140 ·83	13020	0·5	13780
0·6	134 ·33	11960	0·6	12520
0·7	129 ·03	10910	0·7	11250
0·8	124 ·55	9880	0·8	9980
0·9	120 ·72	8860	0·9	8710
1	117 ·36	7840	1	7440

We see that the quantities of work calculated according to Pambour's theory, diminish more rapidly with the increasing volume than those calculated according to our equations, so that while they are at first perceptibly larger than the latter, they gradually approach nearer to them, and at last actually become smaller. This is explained from the fact that according to Pambour's theory, in the expansion which takes place during the influx, the same mass always remains in the form of steam, which was so in the beginning; according to our theory, on the contrary, a part of the mass which is carried along in the fluid state, subsequently evaporates, and the more so the greater the expansion.

55. We will now in a similar manner consider a machine which works *expansively*, and we will for this purpose choose a machine with a condenser. With reference to the amount of expansion, we will assume that the cut-off from the boiler takes place when the piston has passed through one-third of its stroke. We have then to determine e the equation

$$e-\varepsilon=\tfrac{1}{3}(1-\varepsilon),$$

and hence we find, if we retain for ε the value 0·05,

$$e=\frac{1\cdot 1}{3}=0\cdot 3666\ldots.$$

Let the pressure in the boiler be, as before, assumed at five atmospheres. The pressure in the condenser with good arrangements can be maintained under one-tenth of an atmosphere. As it is not however always so small, and as, besides, the counter pressure in the cylinder somewhat exceeds the pressure in the condenser, we will assume for the mean counter pressure p_0, in round numbers, one-fifth of an atmosphere, or 152^{mm}, to which the temperature $t_0=60^\circ\cdot 46$ belongs. If we retain finally for l the value previously assumed, the quantities which come into application in this example are the following:

$$(56)\quad \begin{cases} e=0\cdot 36667. \\ \varepsilon=0\cdot 05. \\ l=1\cdot 053. \\ p_1=3800. \\ p_0=152. \end{cases}$$

It only remains now, in order to be able to calculate the work to give the value of V. In order to have a fixed point in choosing it, we must first know the least possible value of V. This is found, exactly as in the case of machines without expansion, by putting p_1 in the second of equations (XVII) in the place of p_2, and changing in like manner the other quantities connected with p. We find in this manner for our case the value

$$1\cdot 010.$$

Setting out from this we will assume as a first example that the actual velocity of the machine exceeds the least possible velocity in about the ratio of 3 : 2, putting in round numbers

$$V=1\cdot 5,$$

and we will determine the work for this velocity.

56. In the first place, the two temperatures, t_2 and t_3, must be determined by substituting this value of V in the last two of equations (XVII). The determination of t_2 has already been somewhat more closely considered in the case of the machine without condenser, and as the present case is distinguished from that one only in this, that the quantity e, which was there put

$=1$, has here another value, I will not enter upon the subject again, but will only state the final result. We find namely,

$$t_2 = 137^\circ{\cdot}43.$$

The equation (49) which serves to determine t_3 takes for this case the following form:

$$(57) \qquad g_3 = 26{\cdot}604 + 51{\cdot}515 \log \frac{T_2}{T_3}.$$

From this we obtain in succession the following approximate values.

$$t' \;=\; 99^\circ{\cdot}24.$$
$$t'' \;=101\ {\cdot}93.$$
$$t''' =101\ {\cdot}74.$$
$$t'''' =101\ {\cdot}76.$$

The last of these values, from which the later ones would only differ in the highest decimals, we consider as the correct value of t_3, and apply it together with the known values of t_1 and t_0 to the first of equations (XVII). Thence we have

$$W = 31080.$$

If we calculate the work according to Pambour's equation (XII), attributing the same value to V, we find

$$W = 32640,$$

whereby however we must not take the values of B and b as in the machine without condenser from equation (29*b*), but from equation (29*a*) determined for machines with condensers.

57. In the same way, as is here indicated for the volume 1·5, I have also calculated the work for the volumes 1·2, 1·8, and 2·1. I have besides added also the following cases in order to be able to exhibit in one example, in a clear point of view, the difference which the different imperfections of the machine exert upon the quantity of work.

(1.) The case of a machine which has no injurious space, and in which, besides, the pressure in the cylinder during the influx is equal to that in the boiler, and the expansion is driven until the pressure has diminished from its original value p_1 to p_0. This, if we only assume that p_0 accurately represents the pressure in the condenser is the case to which equation (XI) refers, and which gives the greatest possible work for a given quantity of heat, if also the temperatures of absorbing and giving out heat are considered as given.

(2.) The case of a machine in which again no injurious space occurs, and the pressure in the cylinder is equal to that in the boiler, but the expansion does not take place as before completely, but only in the ratio of $e:1$. This is the case to which equation (X) refers, only that there, in order to determine the quantity of the expansion, the change of temperature produced by the expansion of the steam, was considered as known, while here, the expansion is determined according to the volume, and the change of temperature must first be calculated from this.

(3.) The case of a machine with injurious space and imperfect expansion, in which, of the former advantageous conditions only this one remains, that the steam in the cylinder during the influx exerts the same pressure as in the boiler, so that thus the volume has the least possible value. With this case, finally, are connected those already mentioned, in which also the lost advantageous condition is absent, inasmuch as the volume instead of the smallest possible value has other given values.

All these cases are also calculated according to Pambour's theory for the sake of comparison, with the exception of the first, for which equations (29*a*) and (29*b*) do not suffice, inasmuch as even that one of them which is determined for a less pressure can still only be applied up to $\frac{1}{2}$, or at the utmost downwards to $\frac{1}{3}$d of an atmosphere, while here the pressure is to diminish to $\frac{1}{5}$th of an atmosphere.

The numbers resulting from our equations for this first case, are as follows:

Vol. before expansion.	Vol. after expansion.	W
0·3637	6·345	50460

For all other cases, the results are embraced in the accompanying table, in which again the numbers which refer to the machine without injurious space, are separated from the others by a line. Only the numbers which hold good for the volume after the expansion are cited, because the values before the expansion are given, inasmuch as they in all cases are smaller in the ratio of $e:1$.

V	t_2	t_3	W	According to Pambour. V	According to Pambour. W
0·992	152°·22	113°·71	34300	1·032	36650
1·010	152°·22	113°·68	32430	1·032	34090
1·2	145 ·63	108 ·38	31870	1·2	33570
1·5	137 ·43	101 ·76	31080	1·5	32640
1·8	131 ·02	96 ·55	30280	1·8	31710
2·1	125 ·79	92 ·30	29490	2·1	30780

58. The quantities of work given in this table, as well as those of the former table for machines without condensers, refer to the kilogram of steam passing out of the boiler. We may, however, according to this, also easily refer the work to a unit of heat delivered by the source of heat, if we consider that, for every kilogram of steam, as much heat must be delivered as is necessary to heat the mass l, which is somewhat greater than one kilogram, from its initial temperature with which it enters the boiler, to the temperature which prevails in the boiler itself,

and at this last to convert a kilogram into steam, which quantity of heat may be calculated from the data already given.

59. In conclusion, I must add yet a few words on the friction, in which however I will confine myself to justifying my course in leaving the friction entirely disregarded in the equations hitherto developed, by showing that instead of introducing the friction into the first general expressions for the work as Pambour has done, we may bring it into calculation, according to the same principles, subsequently, which in fact has been done in the same manner also by other writers.

The forces which the machine has to overcome, when in action, may be distinguished in the following manner. 1. The resistance which is opposed to it from without, and the overcoming of which forms the useful work required of it. Pambour calls this resistance the load (*charge*) of the machine. 2. The resistances which have their origin in the machine itself, so that the work consumed in overcoming them is not externally useful. We comprehend all these last resistances under the name of the friction, although besides the friction, in the more narrow sense, other forces occur among them, particularly the resistances of the pumps belonging to the steam engine, with the exception of the one which feeds the boiler, and which has already been considered in what precedes.

Pambour introduces into calculation both kinds of resistances as forces which are opposed to the motion of the piston; and in order to be able to unite them conveniently with the pressure-forces of the steam upon both sides of the piston, he selects the notation in the same manner as this is done for the pressure of the steam, namely, so that the symbol does not signify the whole force, but the whole portion of it which comes upon the unit of surface of the piston. Let the letter R denote the load in this sense.

A still further distinction must be made in the case of the friction. The friction, namely, has not a constant value for every machine, but increases with the load. Pambour decomposes it therefore into two parts, that which is already present when the machine moves without load, and that which is first added by the load. With respect to the last, he assumes that it is proportional to the load. He accordingly expresses the friction referred to the unit of surface by

$$f + \delta . R,$$

in which f and δ are quantities which, it is true, depend upon the arrangement and dimensions of the machine, but which according to Pambour, are to be considered as constant for a particular machine.

We may now refer the work of the machine, instead, as heretofore, to the moving force of the steam, to these resisting forces, since the negative work done by these must be equal to the positive work done by the former, since otherwise an acceleration or retardation of the motion would occur, which contradicts the supposition made, according to which the motion is to be uniform. The surface of the piston describes the space $(1-\varepsilon)V$, while a unit of weight of steam passes into the cylinder, and we therefore obtain for the work W the expression

$$W = (1-\varepsilon)\,V[(1+\delta).R+f].$$

The *useful* portion of this work, on the other hand, which, to distinguish it from the whole work, may be denoted by (W), may be represented by the expression

$$(W) = (1-\varepsilon)V.R.$$

If we eliminate the quantity R from this equation by means of the previous one, we have

$$(58) \qquad (W) = \frac{W-(1-\varepsilon)V.f}{1+\delta}.$$

With the help of this equation, we may deduce the useful work W from the whole work (W) as soon as the quantities f and δ are given, since the quantity V is to be supposed as known.

I will not here enter upon the manner in which Pambour determines these last, since the determination still rests upon too uncertain foundations, and the friction in general, is foreign to the particular object of this memoir.

TABLE CONTAINING THE VALUES OF THE PRESSURE p WHICH HOLD GOOD FOR STEAM, OF ITS DIFFERENTIAL CO-EFFICIENT $\frac{dp}{dt} = g$ AND OF THE PRODUCT $T.g$ EXPRESSED IN MILLIMETERS OF MERCURY.

t Centigrade.	p	Δ	g	Δ	$T.g$	Δ
40°	54.906	3·003	2·935	0·139	919	46
41	57·909	3·145	3·074	0·144	965	49
42	61·054	3·291	3·218	0·149	1014	50
43	64·345	3·444	3·367	0·155	1064	52
44	67·789	3·601	3 522	0·161	1116	55
45	71·390	3·766	3·683	0·167	1171	57
46	75·156	3·935	3·850	0·173	1228	59
47	79·091	4·112	4·023	0·180	1287	62
48	83·203	4·294	4·203	0·185	1349	64
49	87·497	4·483	4·388	0·193	1413	67
50	91·980	4·679	4·581	0·199	1480	69
51	96·659	4·882	4·780	0·207	1549	72
52	101·541	5·092	4·987	0·213	1621	74
53	106·633	5·309	5·200	0·221	1695	78
54	111·942	5·533	5·421	0·228	1773	80
55	117·475	5·766	5·649	0·237	1853	83
56	123·241	6·006	5·886	0·244	1936	87
57	129·247	6·254	6·130	0·252	2023	89
58	135·501	6·510	6·382	0·260	2112	93
59	142·011	6·775	6·642	0·269	2205	96
60	148·786	7·048	6·911	0·278	2301	100
61	155·834	7·330	7·189	0·286	2401	103

TABLE—CONTINUED.

t	p	Δ	g	Δ	$T.g$	Δ
62°	163·164	7·621	7·475	0·296	2504	107
63	170·785	7·922	7·771	0·305	2611	111
64	178·707	8·231	8·076	0·314	2722	114
65	186·938	8·550	8·390	0·325	2836	118
66	195·488	8·880	8·715	0·334	2954	123
67	204·368	9·218	9·049	0·344	3077	126
68	213·586	9·568	9·393	0·355	3203	131
69	223·154	9·928	9·748	0·365	3334	135
70	233·082	10·298	10·113	0·376	3469	139
71	243·380	10·680	10·489	0·387	3608	144
72	254·060	11·072	10·876	0·398	3752	149
73	265·132	11·476	11·274	0·410	3901	153
74	276·608	11·892	11·684	0·422	4054	159
75	288·500	12·320	12·106	0·433	4213	163
76	300·820	12·759	12·539	0·445	4376	168
77	313·579	13·210	12·984	0·458	4544	174
78	326·789	13·675	13·442	0·471	4718	179
79	340·464	14·152	13·913	0·484	4897	185
80	354·616	14·642	14·397	0·497	5082	190
81	369·258	15·146	14·894	0·511	5272	197
82	384·404	15·664	15·405	0·524	5469	202
83	400·068	16·194	15·929	0·538	5671	208
84	416·262	16·740	16·467	0·552	5879	214
85	433·002	17·299	17·019	0·577	6093	220
86	450·301	17·874	17·586	0·582	6313	227
87	468·175	18·463	18·168	0·597	6540	234
88	486·638	19·067	18·765	0·612	6774	240
89	505·705	19·687	19·377	0·628	7014	248
90	525·392	20·323	20·005	0·644	7262	254
91	545·715	20·975	20·649	0·660	7516	262
92	566·690	21·643	21·309	0·676	7778	269
93	588·333	22·328	21·985	0·694	8047	276
94	610·661	23·031	22·679	0·712	8323	285
95	633·692	23·751	23·391	0·728	8608	292
96	657·443	24·488	24·119	0·747	8900	300
97	681·931	25·243	24·865	0·765	9200	309
98	707·174	26·017	25·630	0·783	9509	317
99	733·191	26·809	26·413	0·787	9826	320
100	760·00	27·59	27·200	0·805	10146	328
101	787·59	28·42	28·005	0·840	10474	343
102	816·01	29·27	28·845	0·855	10817	350
103	845·28	30·13	29·700	0·865	11167	356
104	875·41	31·00	30·565	0·885	11523	367
105	906·41	31·90	31·450	0·915	11888	378
106	938·31	32·83	32·365	0·935	12266	388
107	971·14	33·77	33·300	0·955	12654	397
108	1004·91	34·74	34·255	0·975	13051	407
109	1039·65	35·72	35·230	0·990	13458	414
110	1075·37	36·72	36·220	1·010	13872	424
111	1112·09	37·74	37·230	1·030	14296	434
112	1149·83	38·78	38·260	1·060	14730	448
113	1188·61	39·86	39·320	1·080	15178	457
114	1228·47	40·94	40·400	1·100	15635	467
115	1269·41	42·06	41·500	1·125	16102	479
116	1311·47	43·19	42·625	1·150	16581	491
117	1354·66	44·36	43·775	1·170	17072	502
118	1399·02	45·53	44·945	1·185	17574	509
119	1444·55	46·73	46·130	1·220	18083	526
120	1491·28	47·97	47·350	1·245	18609	537
121	1539·25	49·22	48·595	1·260	19146	547

TABLE—CONTINUED.

t	p	Δ	g	Δ	$T.g$	Δ
122°	1588·47	50·49	49·855	1·290	19693	560
123	1638·96	51·80	51·145	1·315	20253	574
124	1690·76	53·12	52·460	1·335	20827	583
125	1743·88	54·47	53·795	1·365	21410	599
126	1798·35	55·85	55·160	1·400	22009	615
127	1854·20	57·27	56·560	1·415	22624	624
128	1911·47	58·68	57·975	1·430	23248	633
129	1970·15	60·13	59·405	1·470	23881	652
130	2030·28	61·62	60·875	1·500	24533	666
131	2091·90	63·13	62·375	1·520	25199	678
132	2155·03	64·66	63·895	1·550	25877	694
133	2219·69	66·23	65·445	1·575	26571	706
134	2285·92	67·81	67·020	1·600	27277	720
135	2353·73	69·43	68·620	1·630	27997	735
136	2423·16	71·07	70·250	1·670	28732	755
137	2494·23	72·77	71·920	1·685	29487	765
138	2567·00	74·44	73·605	1·710	30252	778
139	2641·44	76·19	75·315	1·750	31030	798
140	2717·63	77·94	77·065	1·770	31828	810
141	2795·57	79·73	78·835	1·810	32638	830
142	2875·30	81·56	80·645	1·835	33468	844
143	2956·86	83·40	82·480	1·865	34312	860
144	3040·26	85·29	84·345	1·895	35172	876
145	3125·55	87·19	86·240	1·920	36048	891
146	3212·74	89·13	88·160	1·960	36939	911
147	3301·87	91·11	90·120	1·990	37850	928
148	3392·98	93·11	92·110	2·015	38778	943
149	3486·09	95·14	94·125	2·045	39721	959
150	3581·23	97·20	96 170	2·085	40680	980
151	3678·43	99·31	98·255	2·120	41660	999
152	3777·74	101·44	100·375	2·140	42659	1012
153	3879·18	103·59	102·515	2·175	43671	1032
154	3982·77	105·79	104·690	2·220	44703	1054
155	4088·56	108·03	106·910	2·250	45757	1073
156	4196·59	110·29	109·160	2·270	46830	1085
157	4306·88	112·57	111·430	2·310	47915	1107
158	4419·45	114·91	113·740	2·345	49022	1127
159	4534·36	117·26	116·085	2·375	50149	1144
160	4651·62	119·66	118·460	2·410	51293	1165
161	4771·28	122·08	120·870	2·445	52458	1184
162	4893·36	124·55	123·315	2·490	53642	1209
163	5017·91	127·06	125·805	2·510	54851	1222
164	5144·97	129·57	128·315	2·545	56073	1244
165	5274·54	132·15	130·860	2·585	57317	1265
166	5406·69	134·74	133·445	2·620	58582	1286
167	5541·43	137·39	136·065	2·670	59868	1314
168	5678·82	140·08	138·735	2·685	61182	1326
169	5818·90	142·76	141·420	2·725	62508	1348
170	5961·66	145·53	144·145	2·765	63856	1372
171	6107·19	148·29	146·910	2·795	65228	1390
172	6255·48	151·12	149·705	2·830	66618	1412
173	6406·60	153·95	152·535	2·880	68030	1440
174	6560·55	156·88	155·415	2·920	69470	1464
175	6717·43	159·79	158·335	2·935	70934	1476
176	6877·22	162·75	161·270	2·980	72410	1502
177	7039·97	165·75	164·250	3·025	73912	1529
178	7205·72	168·80	167·275	3·060	75441	1550
179	7374·52	171·87	170·335	3·090	76991	1570
180	7546·39	174·98	173·425	3·140	78561	1599
181	7721·37	178·15	176·565	3·170	80160	1619

TABLE—CONCLUDED.

t	p	Δ	g	Δ	$T.g$	Δ
182°	7899·52	181·32	179·735	3·205	81779	1642
183	8080·84	184·56	182·940	3·255	83421	1670
184	8265·40	187·83	186·195	3·280	85091	1688
185	8453·23	191·12	189·425	3·320	86779	1714
186	8644·35	194·47	192·795	3·370	88493	1743
187	8838·82	197·86	196·165	3·400	90236	1763
188	9036·68	201·27	199·565	3·445	91999	1792
189	9237·95	204·75	203·010	3·480	93791	1814
190	9442·70	208·23	206·490	3·515	95605	1837
191	9650·93	211·78	210·005	3·550	97442	1861
192	9862·71	215·33	213·555	3·595	99303	1889
193	10078·04	218·97	217·150	3·645	101192	1919
194	10297·01	222·62	220·795	3·675	103111	1941
195	10519·63	226·32	224·470	3·715	105052	1966
196	10745·95	230·05	228·185	3·750	107018	1991
197	10976·00	233·82	231·935	3·795	109009	2020
198	11209·82	237·64	235·730	3·840	111029	2048
199	11447·46	241·50	239·570	3·885	113077	2077
200	11688·96		243·455		115154	

ART. VIII.—*On the Agency of the Gulf Stream in the Formation of the Peninsula and Keys of Florida;* by JOSEPH LECONTE, M. D., Prof. Natural Sciences, University of Georgia.

Read before the American Association for the Advancement of Science at Albany, August, 1856.

IN the winter of 1851, and during the months of January and February, I enjoyed the rare opportunity of visiting and examining the keys and reefs of Florida, in company with Professor Agassiz. I then and there became deeply interested in a subject which has continued to occupy my thoughts from time to time until now—viz., the mode of formation of the peninsula of Florida.

Until the time referred to, nothing definite was known of the geology of Florida, but it was supposed to consist of a southward prolongation of the eocene of Georgia and Alabama, and its shell limestone to bear some general resemblance to the white limestone of these states. But the observations of Professor Tuomey during the summer of 1850,* and the more full and careful observations of Professor Agassiz during the following winter†, brought to light the remarkable fact, that the keys and the larger portion of the peninsula of Florida are of recent origin, and as far as could be examined, the work of corals still living in the vicinity, and still engaged in the work of extension; that they are in fact, superficially at least, the result of the growth of successive coral reefs concentrically arranged, one outside of the other, from north to south. My object in the present paper will be to show that coral agency alone is not sufficient to account for the phenomena, but that there has been another and still more powerful

* This Journal, [2], vol. i, p. 390. † Report of Coast Survey for 1851, p. 145.

agent at work, preparing the ground and laying the foundation for these builders, and that this agent has been the Gulf Stream. A clear understanding of the subject renders necessary a succinct account of the views of Tuomey and Agassiz.

1.

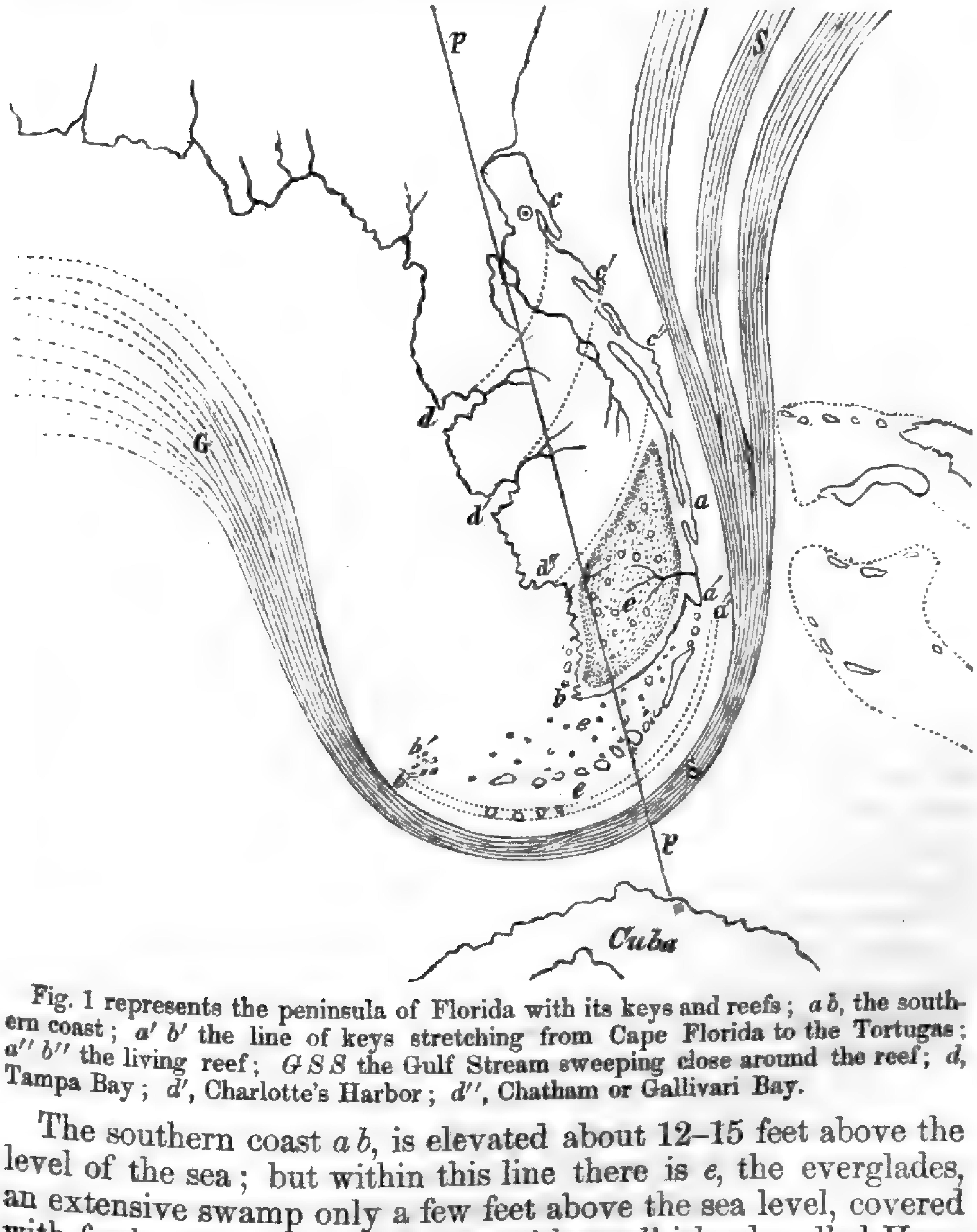


Fig. 1 represents the peninsula of Florida with its keys and reefs; *a b*, the southern coast; *a′ b′* the line of keys stretching from Cape Florida to the Tortugas; *a″ b″* the living reef; *G S S* the Gulf Stream sweeping close around the reef; *d*, Tampa Bay; *d′*, Charlotte's Harbor; *d″*, Chatham or Gallivari Bay.

The southern coast *a b*, is elevated about 12–15 feet above the level of the sea; but within this line there is *e*, the everglades, an extensive swamp only a few feet above the sea level, covered with fresh water and dotted over with small islands called Hammocks. Between the southern coast *a b*, and the line of keys *a′ b′*—a distance at the point *b* of about 40 miles—the water is very shoal, navigable only for the smallest fishing craft, and dotted over with small low mangrove-islands. Between the line of keys *a′ b′* and the living reef *a″ b″* there is a ship-channel 3 or 4 fathoms deep and 5 or 6 miles wide. Beyond the reef *a″ b″* the sea bottom slopes rapidly into the almost unfathomable abyss of the Gulf Stream.

Now, we have the best evidence that the Everglades, the southern coast and the keys are all formed by coral agency. The evidence is briefly as follows:

It is a well known fact that corals cannot grow above the surface of the water. The islands, therefore, so commonly found on coral reefs cannot be formed by the agency of these animals alone, but are due to the violent action of waves breaking off huge coral heads and overturning coral trees, bearing them from the outer and more exposed side, and piling them on the middle and inner side of the reef. These coral boulders form the nucleus around which cluster smaller fragments and coral sand; the whole is then firmly cemented by carbonate of lime in solution in the sea water, and the island thus formed is finally covered with vegetation and inhabited by animals and man. The whole embryonic development, if I might use the expression, of coral islands may be observed upon the keys and reefs of Florida. On the outer or living reef a few have commenced to form only a few years ago, and exist as yet only in the form of isolated boulders of dead coral, and not yet dignified with the name of keys. Others are formed of similar boulders, mingled with smaller fragments, and coral sand, and firmly cemented by carbonate of lime; but the large boulders are still conspicuous above the surrounding land, though immovably fixed. Still others are so covered with coral sand that the boulders are not observable, except by excavation or by examination of the outermost portion of the island towards the sea. The coral sand is always affected with the cross and oblique stratification so common in materials exposed to the violent action of the waves. All the islands on the outer reef are very small, of very recent origin, (some only a few years old,) and, therefore, as yet entirely barren.

The examination of the larger and older inhabited islands of the line of keys prove beyond question that they have been formed in a similar manner. We have here also the same coral boulders, mingled with smaller fragments and coral sand, and the whole firmly cemented into solid rock, the same cross and oblique stratification indicating the former action of waves on an exposed shore. The boulders here also sometimes stand above the surrounding cement exposed in their superior portions, as at Key Vaca; and at others completely covered with coral sand, as at Key West, and most other keys. This exposure of the larger boulders above the surrounding cement in which they are firmly fixed led Tuomey into the error of supposing that they were the prominent points of the original reef, elevated above the sea level by igneous agency, and that the keys were formed by igneous rather than by aqueous agency. That such is not the case is proved by more attentive examination and comparison with the smaller keys of the outer reef. There can be no doubt, therefore, that the line $a'b'$, marks the position of a former reef changed into keys by the action of waves alone.

It has been pointed out by Tuomey, and proved by Agassiz, that in a similar manner, the southern coast of Florida was the position of still another and earlier reef. The character of the rock is the same as that of the keys of the main range, or of the smaller ones on the living reef. Here also Tuomey has seen, as he supposes, the evidence of elevatory forces, while Agassiz sees nothing but the action of the waves.

There seems to be no reasonable doubt, therefore, that at some former period, the northern shore of the everglades was the position of the southern coast, and at the same time the present southern coast was the position of a reef. The general sequence of changes has been as follows: The reef $a\,b$ became gradually converted into a line of keys, and was finally added to the mainland, and the shoal water became the everglades, and its mangrove islands, the hammocks which overdot this swamp. In the meantime, that is, while the present southern coast was still a line of keys, another reef was formed farther out. This became in time converted also into a line of keys, and will eventually be added, in its turn, to the main land and become the southern coast—the shoal water between $a\,b$ and $a'\,b'$, with its mangrove islands, becoming another everglade, with its hammocks. In the meantime, still another reef has been formed still farther out, (viz: the present or living reef,) and upon this, too, the process of key formation has already commenced. Any farther extension, however, in this direction, by the growth of still another reef, seems precluded by the proximity of deep water. Standing upon the reef, the blue waters of the Gulf Stream are distinctly seen at the distance of but a few hundred yards. Thus it appears that not only the keys, but the mainland of Florida, certainly as far north as the northern shores of the everglades, has been formed superficially, at least, by coral agency. The evidence in favor of a similar origin for that portion of the peninsula lying north of this line is less abundant, and perhaps less conclusive, and yet we have every reason to believe that the greater portion of this also was formed in a similar manner. Although the geology of this part has not, as far as I know, been examined by any one capable of deciding definitely as to what portion of the peninsula is tertiary and what is recent coral formation, yet specimens of coral rock precisely similar to that of the southern coast and keys, sent to Professor Agassiz from the shores of Lake George and other parts of Florida as far north as St. Augustine, leave no doubt that on the eastern coast at least the coral formation extends as far north as that ancient city. I have myself a fragment of Meandrina from the neighborhood of St. Augustine, undistinguishable from fragments which may be picked up anywhere upon the keys. The western shore is still less known, but Conrad and Tuomey state it as their opinion that the bluffs of Tampa are Eocene Tertiary. Supposing this to be a fact, though it is still problematical, then all that portion of the peninsula lying south of the line *c d* is almost certainly of coral origin and formed in the manner already indicated, viz: by the growth of successive reefs. As to the position of these supposed reefs we know absolutely nothing. The position of the lines $c\,d$, $c'\,d'$, $c''\,d''$ has been merely suggested by the succession of bays which indent the western coast. May they not all have been formed like Chatham Bay, by the imperfect filling up of the shoal water, separating successive reefs from the mainland?

Such is a brief account of Professor Agassiz's views concerning the mode of formation of the peninsula and keys of Florida. I will now attempt to show that coral agency alone is not sufficient for this purpose, and that to suppose so would violate all probability, and contradict all that we know of the laws which govern the growth of these animals.

It is a well known fact that reef-building corals cannot grow at a greater depth than from ten to twelve fathoms. It is also certain that they cannot grow above the surface of the water at low tide. Thus they are limited in a vertical direction to a space of about sixty or seventy feet. Unless there is subsidence of the sea bottom, therefore, it is impossible that a reef should be more than sixty or seventy feet thick. To this may be added in the case of coral islands from ten to fifteen feet for material accumulated above the sea level by the agency of waves. If there is no subsidence, therefore no coral formation can be more than eighty feet in thickness. Now, nothing can be more certain than that there has been no subsidence whatever of the sea-bottom upon which grow the reefs of Florida, for otherwise the extension of the peninsula by means of coral agency would have been impossible. It necessarily follows, therefore, that the coral formation of Florida, whether upon the main land, or upon the keys, or upon the living reef, can no where be more than seventy or eighty feet thick. In other words, it is evident that Florida and the keys are only faced or encrusted with coral formation. If, then, corals have been the only agents in this work, if the sea bottom has remained substantially unchanged during the whole time the coral work was progressing, it is evident that the sea, for the enormous distance of five degrees of latitude, viz: from St. Augustine to the present reef, was nowhere more than sixty or seventy feet in depth, and Florida must have been represented by a tongue of shoal water three hundred miles in length—a circumstance possible, certainly, but so improbable that it behoves those who maintain the theory that coral alone has formed the peninsula to account for it.

But even if we admit the probability of such a condition of things, we do not get rid of the main difficulty; for in that case there is no apparent reason why the coral should not grow over the whole area at the same time, as an immense coral forest, instead of in the form of successive reefs. In a word, the fact that the corals grew in the form of successive reefs, concentrically disposed from north to south, proves, as it seems to me, incontestibly, that the conditions necessary for coral growth have also been progressively formed in the same direction. The horizontal extension of coral through so great a space proves also the progressive extension of necessary conditions; in other words, it proves that the sea bottom has been gradually rising from the north towards the south.

Such a gradual rising of the sea bottom may be attributed to one of two causes, viz:—first, gradual elevation by igneous agency; and second, filling up by sedimentary deposit. As we have already seen, Professor Tuomey has thought that there are evidences of such igneous elevation upon the keys as well as upon the main land; but the more careful observations of Prof. Agassiz have satisfactorily explained these deceptive appearances, so that we may now say with confidence that there is not the slightest evidence of such elevation, but much evidence to the contrary. Neither the mainland nor the keys are anywhere higher than may be accounted for by the action of waves, viz: from ten to fifteen feet, and it is inconceivable that this elevation should have gone on progressively preparing ground for the growth of successive reefs, without in the slightest degree affecting the contiguous and recently formed land. But this is precisely the mode of action of sedimentary deposit. Sediment cannot, of course, affect anything but the sea bottom. It is to sedimentary deposit, therefore, that I attribute the gradual rising of the sea bottom from north towards the south, which, as we have seen, forms the necessary condition for the horizontal extension of coral reefs through so great a distance.

Having thus shown that sedimentary deposit is almost absolutely necessary for the explanation of the southward extension of the reefs of Florida, let us attempt to prove that such deposit has in fact taken place under the influence of the Gulf Stream.

It is a well known law of currents bearing sediment, that if from any cause their velocity is checked, they deposit a portion of their sediment upon the bottom; but if, on the contrary, their velocity is increased, they abrade their beds and banks. If, therefore, the velocity of a stream is greater on one side than on the other, abrasion will take place on the former, and deposit on the latter. Now, if such a stream, bearing sediment, make a sweep or curve, the velocity will always be greater on the outer, and least on the inner side of the sweep. Hence there must necessarily be abrasion of the outer bank and deposit upon the inner. Thus, in proportion as the outer curve extends by abrasion of the outer bank, the inner curve will extend also by deposit, and the tongue of land around which the sweep is made will grow longer and longer. If this tongue be cut away by artificial means, so as to convert this portion of the stream into a lake, around the outer margin of which sweeps the current, the still water within the sweep will become more and more shoal, until it is again converted into a tongue of land. Now, this is necessarily true under all circumstances. It makes no difference whether the stream runs between banks of solid matter or between banks of still water. If a stream, leaving sediment, runs through still water, making a sweep or curve, the sediment must deposit principally upon the inner side of the curve, making shoal water at this part: the curve will extend, and the shoal water will extend in the same proportion.

Now, the Gulf Stream is such a current. The sweep which it makes around the point of Florida is seen in fig. 1. If, therefore, the Gulf Stream bears any sediment, the conclusion seems irresistable that the sweep of the curve has been increasing with the course of time, and that the tongue of land within the curve, viz: the Peninsula of Florida, has been extending, *pari passu*, by means of sedimentary deposit. Or, even supposing that the position of the Gulf Stream has always been the same as at present, and that Florida was once represented by a tongue of still water within the curve, this tongue of still water must have become more and more shoal by sedimentary deposit. I repeat, then, that upon any conceivable theory as to the position of the Gulf Stream, whether its curve has been increasing or has been always the same as at present, if it carries sediment, according to the laws of currents, there must have been a progressive shoaling of water within the curve from north toward the south, and, consequently, a progressive formation of the conditions necessary for the growth of coral, and their extension in the same direction. What evidence, then, have we that the Gulf Stream does indeed carry sediment?

The Gulf Stream is supposed to be a continuation of the great equatorial current which, stretching across the Atlantic from the coast of Africa, strikes upon the wedge-shaped point of the eastern coast of South America, and divides into a northern and southern branch. The northern branch, uniting with the water of the Amazon and Orinoco, runs along the coast of South America, through the Caribbean Sea, under the name of the Caribbean current, enters and receives strength in the Gulf of Mexico from which emerging it sweeps round the point of Florida and along the coast of the United States, on its way to the coast of Europe.

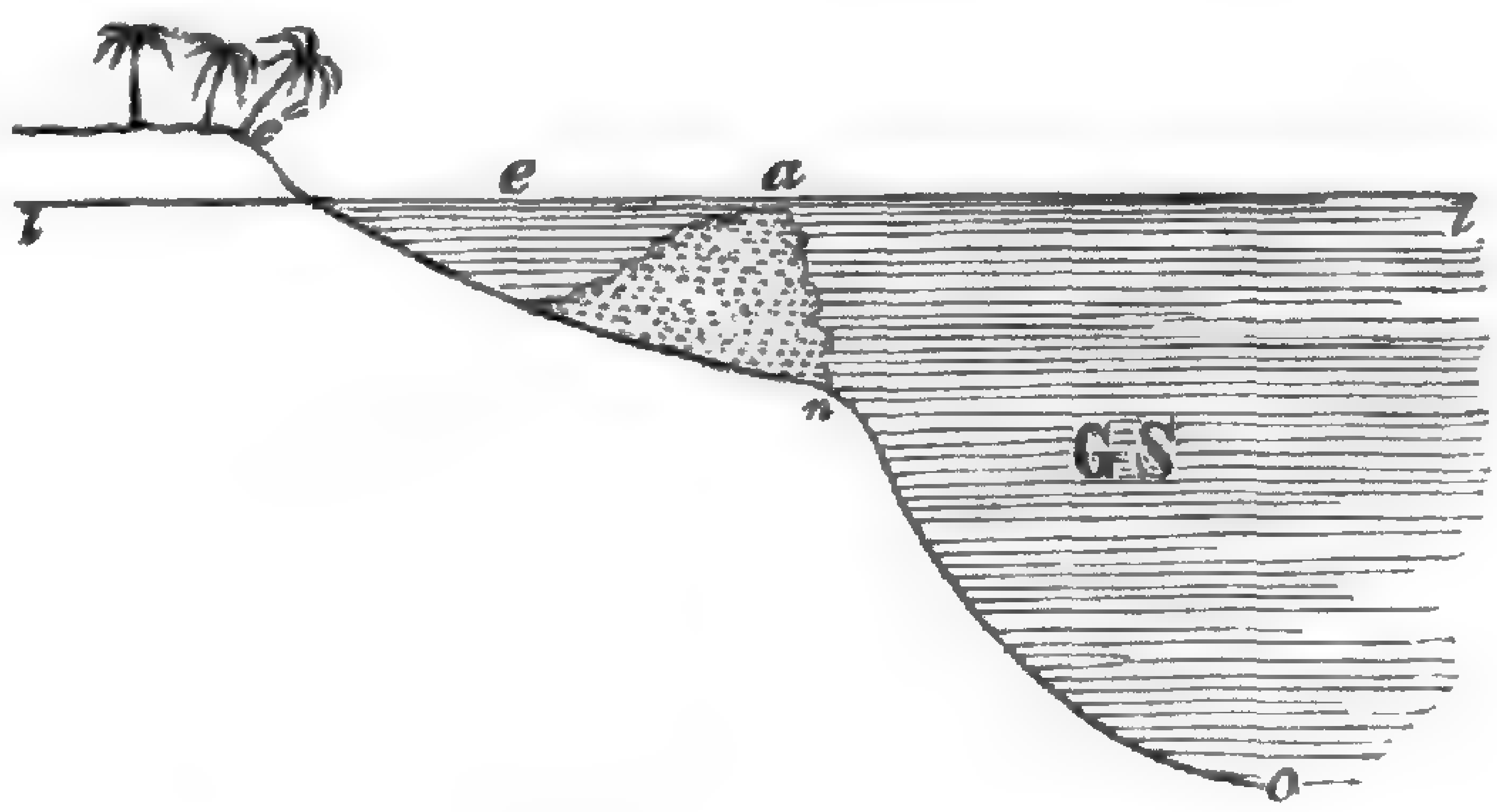
Now, is it possible that a stream which washes so many shores, which runs through seas into which are poured such enormous quantities of sediment, brought down by the largest rivers in the world, is it conceivable that such a stream should carry no sediment? On the contrary, it is well known that the sediment both of the Amazon and Orinoco rivers is carried by this stream, and is distinctly traceable for several hundred miles. Much of it is doubtless deposited along the coast and in the Caribbean Sea, but "according to Humboldt, much sediment is carried again out of the Caribbean Sea into the Gulf of Mexico."* Into this same Gulf is also poured the enormous amount of sediment brought down by the Gulf rivers, especially by the Mississippi. Out of this Gulf, the waters of which are thus highly charged with sediment, comes the Gulf Stream on its way round the point of Florida. If, then, this stream mingles at all with the waters of the Gulf rivers, it must necessarily carry sediment. That it does thus mingle, is proved by the fact mentioned by Lyell,† that drift timber from the Mississippi is carried by this stream to the shores of Iceland and Europe. Now, unless we suppose that the whole of this sediment is deposited in the Gulf, it must reach, and, by the law of currents already insisted on, be deposited, much of it, on the point of Florida. But we have the best reason for believing that it is not all deposited in the Gulf. The distance from the mouth of the Mississippi to the Tortugas is about five hundred miles. Taking the velocity of the Gulf Stream through the Gulf of Mexico at three miles per hour, it would traverse this distance in about seven days. Now, the finest sediment will not sink more than‡ an inch in an hour; but supposing the mud brought down by the Mississippi sinks at the rate of one foot per hour, in seven days it would sink 168 feet. But the depth of the Gulf of Mexico and the Gulf Stream is much greater than this. Therefore, fine sediment from the Mississippi would reach the point of Florida, and what was not deposited there would even be carried much farther on. We have farther evidence of this in the soundings made by the Coast Survey off the eastern coast of Florida, and the nature of the bottom which has thus been brought up. It can scarcely be doubted for a moment that the banks of sand and mud, found in the bed and on the margin of the Gulf Stream off the eastern coast of Florida, were deposited there by that stream.

But it will be objected that the water of the Gulf Stream is remarkable for its transparency. This objection, however, will entirely disappear when we consider the difference between river and ocean currents. The former are of slight depth, and run over rough bottoms, and between banks possessing many ine-

* Lyell's Prin., p. 328. † Lyell's Prin., p. 721. ‡ Lyell's Prin., p. 328.

qualities of surface, and offering, therefore, much resistance; hence are generated partial currents upward and downward, to the right and left, which thoroughly mix, as if by a sort of ebullition, the waters of the river. It is impossible that matters in suspension or solution should exist in one part and not in another; *e. g.*, that sediment should be carried by the deeper strata, while the superficial strata remain transparent. But with oceanic streams the case is quite different. Their great depth, and the fact that they are bounded on all sides by still water; in other words that they run over perfectly even beds and between perfectly smooth banks, causes them to flow without the slightest agitation, without the ripples and inequalities which mark the currents of rivers. The currents of oceanic streams, therefore, do not in the slightest degree interfere with the natural subsidence of materials in suspension. They are equally as favorable to subsidence as perfectly still water. The surface transparency of the Gulf Stream, therefore, forms no objection whatever to the supposition that it carries sediment in the deeper strata. Such sediment would necessarily sink beyond observation in the course of a few hundred miles.

2.



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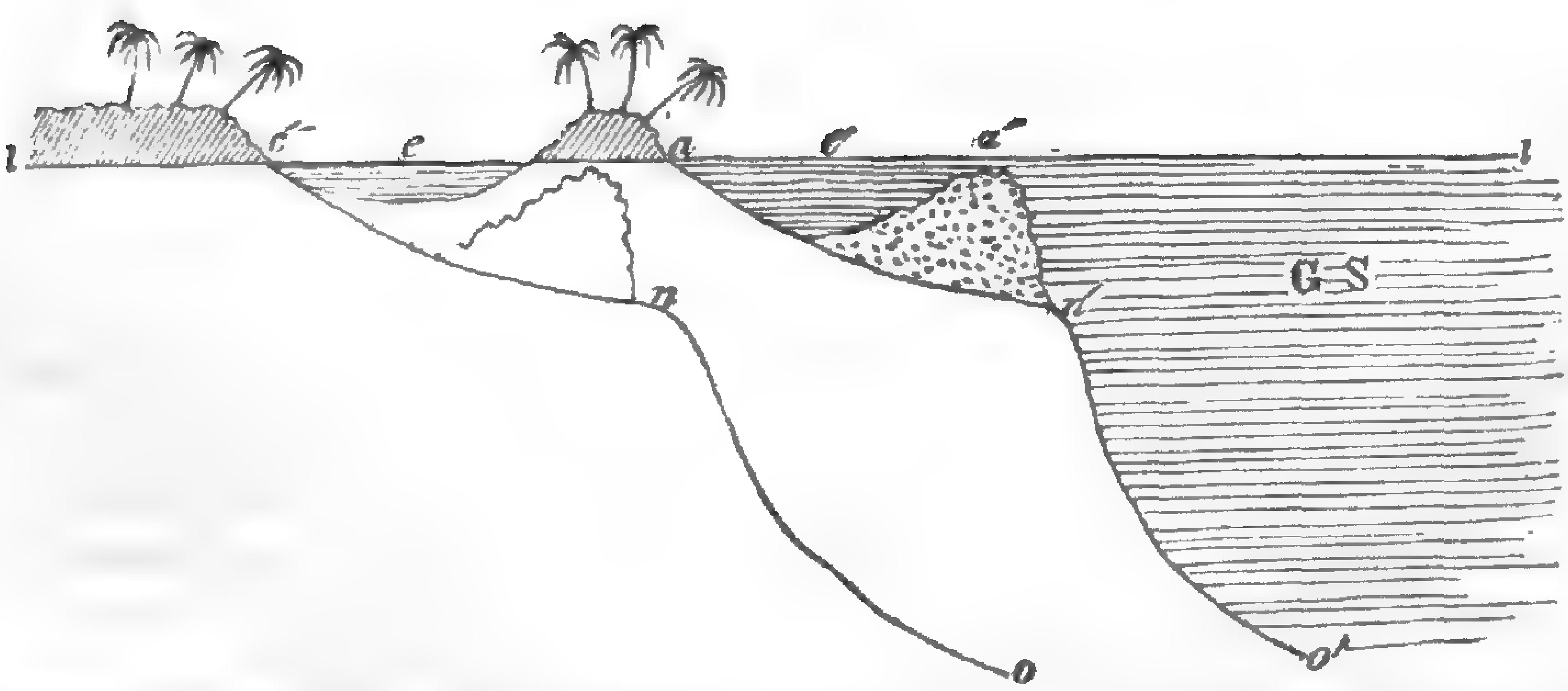
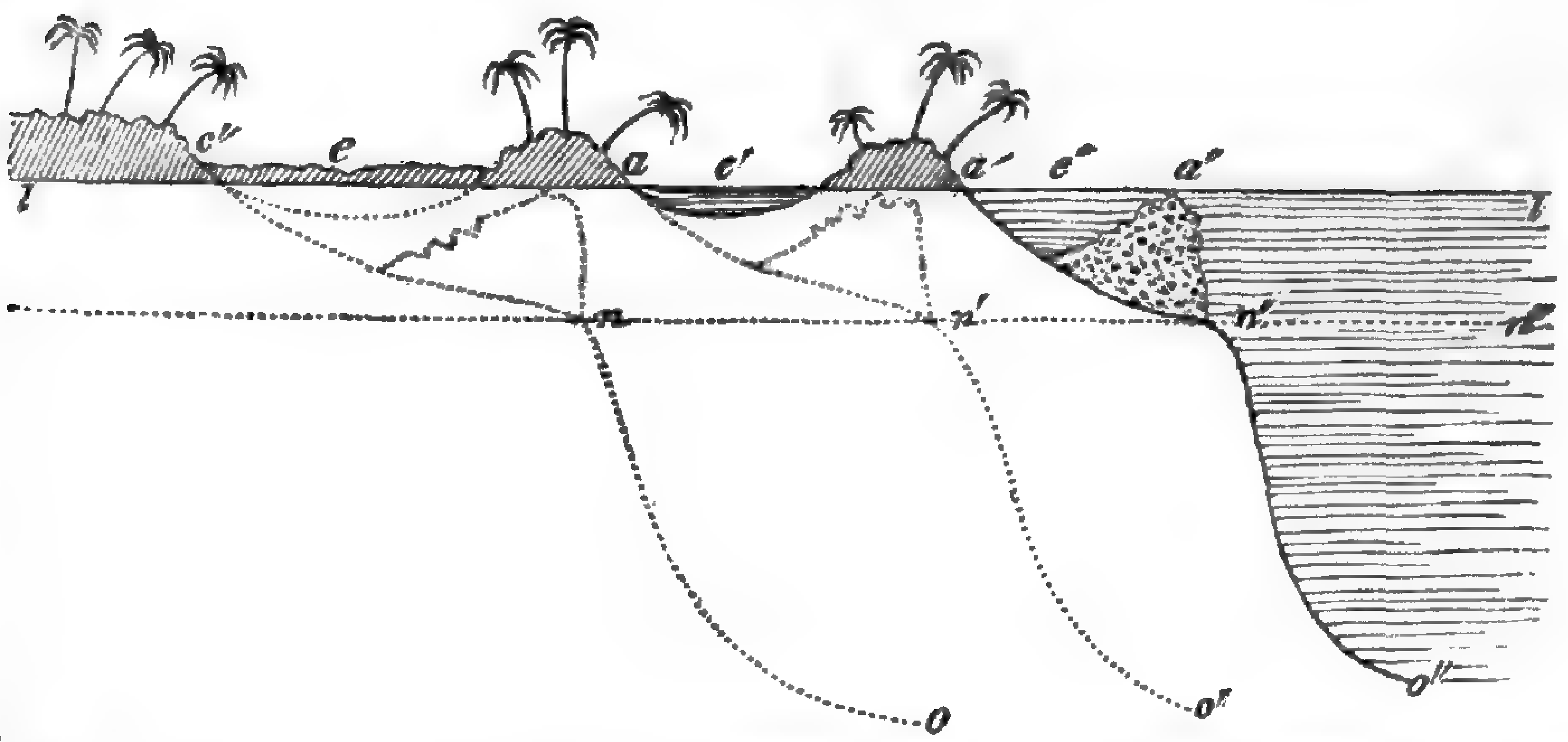


After what I have said above, the bare inspection of the accompanying figures will explain the application of the theory to the formation of the Peninsula and Keys.

4.



Figs. 2, 3 and 4, are ideal sections through the middle of the Peninsula and Keys, along the line *p p* fig. 1, representing the different stages of the process; *l l* the sea level, *G S* the Gulf Stream, *c'' a a' a''* sections of the lines *c''d'' ab a'b' a''b''* of fig. 1. Fig. 2 represents the condition of things at some period anterior to the present elongation of the Peninsula, *e. g.*, when the southern coast was in the position of the northern shores of the everglades, *c'' n o* the supposed configuration of sea bottom at that time. At the point *n* at the depth of 60 feet would form a reef, *a*, leaving a ship channel *e* between the coast and reef. Fig. 3 represents the condition of things when the sea bottom by sedimentary deposit had advanced to *a n' o'*. The reef, *a*, has become now a line of Keys, the ship channel *e* has become shoal water dotted over with mangrove islands, (not here represented) and another reef, *a'*, has formed at the limiting depth of 60 feet, leaving another ship channel *e'* between the reef and the Keys. Fig. 4 represents the condition of things when the sea bottom had advanced to *a' n'' o''*. Now *a*, the line of Keys of the last figure, has become the southern coast, the former shoal water *e* has become the Everglades, *a'*, the reef of last figure has become a line of Keys and its ship channel *e'* shoal water, and at the limiting depth of 60 feet still another reef, *a''* viz., the present living reef is formed with its ship channel *e''*. This figure therefore represents the present condition of things.

It is evident that if this theory be correct, and no insuperable obstacle is interposed, the Gulf Stream may continue to move its bed, and the point of Florida to extend almost indefinitely. But such an obstacle is interposed in the island of Cuba. The Gulf Stream cannot move much beyond its present position, nor Florida extend beyond the position of the present reef, except at the expense of Cuba and the Bahama Banks. Cuba can never be annexed by any natural agency, whether coral or current.

Or even supposing (as I have already done) that the position of the Gulf Stream has always been the same as at present, and that the peninsula of Florida was originally represented by a tongue of still water, yet, substantially, the same changes would necessarily have occurred.

It is evident that as the point of Florida approached the Gulf Stream, the slope of the bottom would become steeper, and therefore the limiting depth would be attained at a shorter distance from shore, the consecutive reefs would be formed nearer and nearer to one another, and the intervening ship channels would become narrower.

5

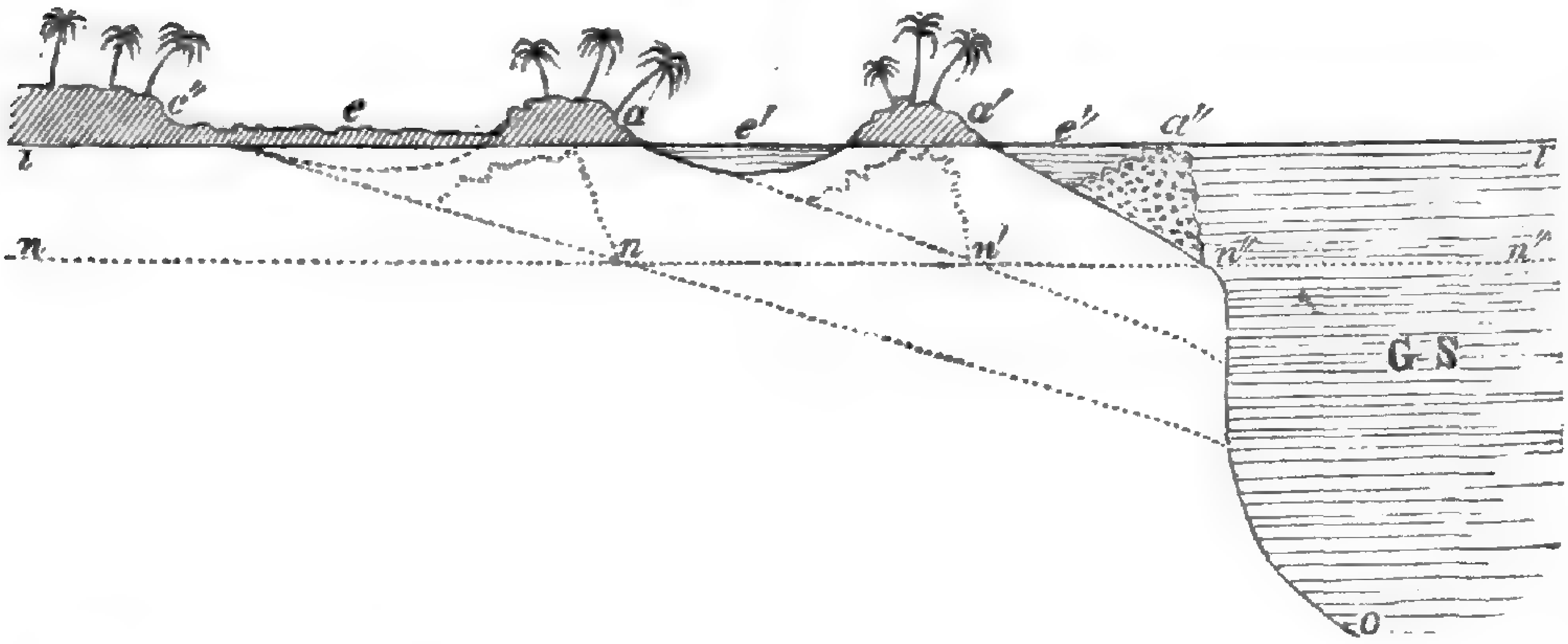


Fig. 5 is an ideal section showing the succession of changes which would occur on such a supposition. The letters represent the same things as in figs. 2, 3, and 4.

Inspection of fig. 1 shows that this has actually been the case at least for the last three reefs.

We have chosen to trace this process only as far as the northern shore of the everglades, because thus far we have the most indisputable evidence of the recency of the formation. But in the same manner we might carry it still farther back in time and northward in space, and represent the successive reefs by which the superficial portion of the rest of the peninsula was formed.

There is one other fact of great importance, and otherwise inexplicable, which receives a ready explanation upon this theory, and which I think, therefore, is strongly confirmatory of its truth. I allude to the fact that the successive reefs are found at some distance from one another; in other words, that the peninsula is formed by a succession of barrier reefs, instead of a continuous southward growth of fringing reef. The reefs of Florida are in some respects entirely peculiar. Barrier reefs have heretofore been considered as always the result of subsidences of the sea bottom, and are invariably looked on as the sign of such subsidence. But in Florida we have barrier reefs where it is certain there has been no subsidence. We have here, therefore, a new form of barrier reef. This important fact did not, I am sure, escape the attention of Professor Agassiz, for my own attention was first drawn to it by him; but I have seen no publication in which he has alluded to the fact, nor as far as I know, has he ever attempted or even thought of a probable explanation. The explanation which I would offer is as follows:—

It is a well known condition of coral growth that the sea water must be pure and transparent. Corals will not grow, therefore, on muddy shores, or in water upon the bottom of which sediment is deposited. Now, it must be borne in mind that while the Gulf Stream bears sediment in its deeper strata, it is superficially transparent, and we have already shown that this must of necessity be the case with ocean streams. Suppose, then, that the matter held in suspension by the waters of the Gulf of Mexico be of such a degree of fineness that it sinks to the depth of sixty feet by the time it reaches the point of Florida. It is evident that the sea bottom within the curve cannot rise by deposit above this level, for all the sediment is below. A stream bearing sediment in all its strata from bottom to top—such as a river, for instance—will make land within the curve, but an ocean stream will only make shoal water within the curve. In the case supposed, where the bottom of the shoal rises to within sixty feet of the surface, it will cease to receive deposit, and the water will remain perfectly transparent. Here, then, it would seem we have the conditions necessary for coral growth. It must be recollected, however, that upon sloping shores, with mud bottom—such as we have supposed always existed at the point of Florida—a fringing reef cannot possibly form, for the water is rendered turbid by the chafing of waves against the mud bottom; but at some distance from shore, that is, where the depth of sixty or seventy feet is attained, and where the bottom is unaffected by the waves, the conditions favorable for coral growth would be found. Here, therefore, would be formed a barrier reef, limited on one side by the muddiness, and on the other by the depth of water.

It is evident then that the Peninsula and Keys of Florida have been the result of the combined action of at least three agencies. First, the Gulf Stream laid the foundation; upon this, corals built up to the water level; and finally the work was completed by the waves. Fig. 4 illustrates the relative importance of these agencies. All below the line $n\,n'\,n''\,n'''$, even to the bottom of the Gulf Stream, is due to the agency of that stream; all between the line $n\ n'\ n''\ n'''$ and the line $l\,l$ to the agency of corals and above the line $l\,l$ to waves.

I have said that a stream running through still water and making a curve would deposit most of its sediment on the inner side of the curve. This is certainly true; but it is a more general expression of the truth to say that a stream running through still water will deposit sediment on both sides, just where it comes in contact with the still water, and is retarded by it. It would do so for the same reason that rivers which habitually overflow their banks form natural levees on either side where the rapid current of the river comes in contact with the comparatively still water of the river swamp. It is well known that the natural levees of the Mississippi continue out to sea in the form of submarine banks, evidently formed by the checking of the velocity of the current on either side by contact with the still water of the Gulf. If the current is straight the deposit on both sides will be equal, and thus the stream will form banks for itself. If the stream is curved the deposit will be mostly on the inner side of the curve, as already said. Is it not probable that the Bahama banks, or at least that portion of them that lie to the east of Florida, may have been formed to a great extent in the same way? That while the peninsula of Florida has been made on one side, the Bahama banks have been made on the other? It will be observed that the great Bahama banks lie off the eastern coast of Florida, and that the Gulf Stream runs in a narrow channel between them. At the point of Florida the deposit would, of course, be on the inner side of the curve, and would go, therefore, mostly or entirely to the extension of that peninsula; but after the stream turns northward and becomes nearly straight the deposit would be also on the other side, and thus probably have originated these banks. Even if we suppose, as is most probable, that there originally existed in this position islands or submarine hills, which turned the stream around the point of Florida, these have doubtless been greatly modified and extended by sedimentary deposit. Probably also even the general form of the Alantic bottom—very sloping until the Gulf Stream is reached, and then plunging rapidly into an almost unfathomable abyss, forming a deep bed for that stream—may, to some extent, at least, be accounted for in a similar manner, for certain it is that a stream running through still water, no less than one running over land, will make its own bed; only in the latter case by abrasion it cuts out its own channel, while in the former, by deposit, it builds its own banks.

This property of ocean streams, viz.: that they form banks or ridges where they come in contact with still water, affords a possible and, as it seems to me, even a probable explanation of certain remarkable peculiarities of sea bottom, brought to light by recent soundings across* the Gulf Stream. Commencing at Charleston, the bed of the ocean slopes at first very gently, so that at a distance of 50 miles from shore it attains only the depth of 20 fathoms, and then very rapidly, so that in 25 miles more it sinks to the depth of 700 fathoms or more. At the additional distance of another 25 miles (*i. e.* 100 miles from shore), at the depth of 300 fathoms is found a ridge rising from unfathomable depths on one (coast) side, and 1,500 feet above the hollow on the other side. At the distance of a little more than 20 miles more is found another ridge 500 feet high, followed by still another hollow. Further observation shows that the Gulf Stream is divided into longitudinal bands or streams of warm and cold water, see fig. 1, and that the warm bands correspond to the bottom and the cold bands to the ridges.

* Proc. Am. Assoc., Washington Meeting, p. 140.

Now, these ridges and hollows may be conceived to have been formed in either of two ways, viz.: by igneous or current agency. As upon land valleys are formed either by igneous or aqueous agency, *i. e.*, may be valleys of elevation or valleys of erosion; so also in the sea, ridges may be formed by igneous or current agency, *i. e.*, may be ridges of elevation or ridges of deposit. In either case there would be conformity between the direction of the ridges and the direction of the current, only in the one case the current would conform to the ridges, and in the other the ridges would conform to the current.

In order to account for these ridges by this current theory, the only supposition which it is necessary to make is, that there exists in the bed of the Gulf Stream somewhere to the southward of the Charleston section, *i. e.*, at the southern extremity of the ridges, two or more submarine peaks or mountains—possibly a spur of the Bahama chain. If two such peaks existed in this position, and rose so high as to part the lower strata of the Gulf Stream, there would evidently be formed bands of comparatively still water to the northward, and as evidently there would be lines of deposit determined by the still water, and the necessary result would be the ridges discovered by the Coast Survey. We see the same thing on a small scale in river currents. Every obstacle which parts the current determines the position of a sand ridge on the lower side of the obstacle, and in the direction of the current. There is this remarkable difference, however, between river and ocean currents—that while in the case of rivers the parted current quickly closes again, and the resulting ridge is therefore very short, in ocean currents, such as the Gulf Stream, the space between the two parts would be quickly filled by the cold water of the ocean. The parted current would have, therefore, no disposition to coalesce, but would continue as bands of warm Gulf water separated by bands of cooler and stiller Atlantic water, and the resulting ridges would therefore continue for great distances. I know not whether there have been any observations to test the comparative velocity of the warm and cool bands, but it seems to me that on any conceivable theory as to the formation of the ridges the velocity of the cool bands would be less.

Now, though it may be impossible in the present condition of science to determine with absolute certainty whether these ridges were formed previous to the existence of the Gulf Stream, by igneous agency, or whether they have been formed since by the sediment carried by the stream itself, yet, when we recollect that all the other peculiarities of the Gulf Stream and the contiguous sea bottom are mainly referable to sedimentary deposit; when we reflect how simple and natural is the only supposition required, and how easily it explains all the phenomena, particularly the cold bands, which seem inexplicable on any other theory, unless we suppose the existence of lateral currents, it seems to me that the weight of probability will strongly incline to sedimentary deposit as the cause also of these ridges. In fact, everything about the Gulf Stream seems to point to the conclusion that it has been the architect of its own curves, its own banks, and its own configuration of sea bottom.

There is one other conclusion which, though not connected with any particular theory of the formation of Florida, is, nevertheless, naturally suggested by the subject of this paper. We have seen that the peninsula of Florida has been progressively advancing towards Cuba as a fixed point, and the Gulf Stream has been becoming more and more narrow. If, therefore, as is probable, the quantity of water carried by the Gulf Stream has remained constant, it follows that the velocity with which the stream emerges from the Straits of Florida, and therefore the distance to which it penetrates the still water of the Atlantic, has been progressively increasing. Now, unless there has been some very remarkable change in the direction of this current, it necessarily follows that its warming influence upon the European continent has also been progressively increasing. Have we not here, if not a sufficient cause, at least one of the true causes of that great change which we know has taken place in the climate of Europe since the glacial period?

Thus we see that the advancing point of Florida has been progressively warming the climate of Europe, and thus, perhaps, controlling the destinies of the human race. Can we conceive a more beautiful instance than this of that sympathy which exists between the most distant portions of our globe, and which binds all its members together in one organic whole?

ART. IX.—*On Screw-Propellors;* by W. ROGERS HOPKINS, Assistant Professor, U. S. Naval Academy, Annapolis.

Is it not strange that while in heavy machinery on land revolving at high velocities no difficulty is found in preventing heating in the journals, from friction, that few propellors are afloat at sea that have not suffered seriously from this cause? We hear of vessels on both sides of the Atlantic, mercantile and armed, that are retarded by the heating and wearing in the stuffing boxes and bearings of their shafts.

It appears to the writer that the causes for this can be easily explained, and the effects modified if not prevented. The heating of the bearings inside a vessel results from one cause: the wear and heat in the stuffing box and outside journals result from totally different causes.

In most cases the machinery of a steamship is placed in the centre of the vessel, and thence motion is carried to the propellor blades by a long shaft rigidly connected. If the frame of the vessel springs at all by the motion of the sea, the shaft is thrown out of line and must consequently heat. To remedy this the shaft should be allowed some *play* in the couplings where the *lengths* of the shaft are joined together.

But it is the wearing of the journals and bearings outside the vessel that is most prejudicial, most frequent, and most difficult of repair. One cause of this wear is that the blades are not made smooth and not balanced, so that the centre of rotation and the centre of gravity do not coincide. No machinery in revolving works well under these circumstances.

But the most important disturbing cause is the following. The propellor blades of a vessel on leaving port are set in motion in a plane at right angles to the vessel's keel. The propellor blades tend to "persist" in this plane, and the greater their momentum the greater their resistance to any cause tending to draw them from this plane. But the motion of the vessel is a constant disturbing cause, and in resisting the motion of the vessel the revolving propellor presses with great force on the bearings.

Suppose, as in some vessels, the propellor (blades and hub) to weigh fifteen tons. Propellors of this size have their centres of oscillation moved at the rate of thirty-six feet per second when in full action. We have then a weight of fifteen tons moving at thirty-six feet per second, to be deflected from its line of action whenever the vessel rises or falls. The wear caused by this action has been attempted to be overcome by putting wooden linings in bearings; how far successfully has yet to be shewn.

It would undoubtedly be better to remove the cause than to remedy the effects. It seems to the writer that the cause may be easily removed by simply so arranging the propellor blades (or the frame in which they are mounted), that the propellor blades can keep in the original plane of rotation however the vessel may move in a sea way. The plans for effecting this are not easily explained without drawings. But means of so arranging the propellor blades that they will keep vertical however the vessel may move will occur to most persons acquainted with machinery.

ART. X.—*Statistics of the Flora of the Northern United States;* by ASA GRAY.

[Continued from vol. xxii, p. 232.]

THE Catalogues of the alpine and subalpine species of our Flora of the Northern States, given on pp. 230 and 231, in the former part of this communication, are found to be very imperfect, through some unaccountable omissions. They are here reproduced in a corrected form.

1. *List of Phænogamous Species found only in our small Alpine Region.*

Cardamine bellidifolia.
Viola palustris.
Silene acaulis.
Sibbaldia procumbens.
Potentilla frigida.
Epilobium alpinum, var. majus.
Saxifraga rivularis.
Saxifraga stellaris, var. comosa.*
Gnaphalium supinum.
Nabalus Boottii.
Nabalus nanus.
Vaccinium cæspitosum.
Arctostaphylos alpina.
Cassiope hypnoides.
Phyllodoce taxifolia.
Loiseleuria procumbens.
Rhododendron Lapponicum.
Veronica alpina.
Castilleia septentrionalis.
Diapensia Lapponica.
Oxyria reniformis.
Betula nana.
Salix phylicifolia.
Salix Uva-Ursi.

* This is a recent discovery, on Mount Katahdin, Maine, by Joseph Blake, Esq. Pursh had given *Saxifraga stellaris* as a native of Canada, but this was hardly credited: it has long been known from Labrador. But the *S. foliolosa,* which is plainly a state of *S. stellaris,* was known in this country only from the Arctic Islands, and from Sitcha on the northwest coast. With this species I replace *Dryas integrifolia* of the former list, which I think cannot have been really found on the White Mountains or elsewhere within our limits: Pursh must have mistaken something else for it in Prof. Peck's herbarium, as well as for *Alchemilla alpina.* Moreover, it is wrongly marked in the Manual of Bot. N. States, as also European.

The following points likewise need correction:

On p. 207, line 24, the Alleghany Mountains are said, in round numbers, to rise to an elevation of about 6300 feet. My excellent and accurate friend, Professor Guyot, informs me that the results of his barometrical measurements made during the past summer assign to the Black Mountain an elevation of fully 6710 feet above the level of the sea. Yet the summit was covered with trees (mostly *Abies Fraseri*), which, however, are now being cut away.

Page 217, et seq. The following additions may be made to the table, in their proper places. To the second column, i. e. Extra-European genera of E. North America, *Phaseolus* and *Aralia.* To the fourth column, of temperate E. Asia, including the Himalayas, *Elodea, Stylosanthes, Phaseolus, Galactia, Amphicarpæa, Centrosema, Itea, Fothergilla, Aralia, Triosteum? Spermacoce, Nabalus, Gaultheria, Mimulus, Phytolacca, Sassafras? Podostemon* (and others remain to be added),—essentially increasing the remarkable number of Eastern Northern American genera which are represented in an antipodal region, of analogous extreme climate, but not in the less distant regions of Western Europe and Western North America, the greater parts of which are endowed with a more equable climate.

Page 239. In the heading of the third column, second line, occurs a misprint of "and" for "not."

Page 232, line 4, "*Cirsium pumilum*" is to be erased, as it occurs in Missouri, according to Dr. Engelmann.

Salix repens.
Salix herbacea.
Luzula arcuta.
Luzula spicata.
Juncus trifidus.
Carex capitata.
Carex atrata.
Carex rigida.
Phleum alpinum.
Calamagrostis Pickeringii.
Poa laxa.
Aira atropurpurea.
Hierochloa alpina.

They are 37 species in number. Of these all but the five printed in *italic* are natives likewise of Europe.

2. *List of Subalpine Phænogamous Species, which occur mainly in our Alpine Region, but are also found decidedly out of it.*

Alsine Grœnlandica.
Geum radiatum.
Rubus Chamæmorus.
Solidago thyrsoidea.
Solidago Virga-aurea.
Arnica mollis.
Vaccinium uliginosum.
Vaccinium Vitis-Idæa.
Euphrasia officinalis.
Polygonum viviparum.
Empetrum nigrum.
Platanthera obtusata.
Scirpus cæspitosus.
Carex scirpoidea.
Carex capillaris.
Trisetum subspicatum.

Making 16 species; of which all but the five printed in italic are likewise European; and two of these occur in Greenland.

3. *List of Species not found in our Alpine Region, and half of them not even in Subalpine Stations, although they are all Subalpine or Arctic in Europe.*

Saxifraga tricuspidata.
Saxifraga oppositifolia.
Saxifraga aizoides.
Saxifraga Aizoon.
Artemisia borealis.
Juncus Stygius.
Carex gynocrates.

The last two of these seven species are likewise remarkable for not having been found in continental British or Arctic America nor in Labrador; but one of them occurs in Newfoundland, and the other in Greenland.

It would be in order now to consider the range of our species generally north and south. But I will for the present restrict the inquiry to a special and small part of them, namely, to the species which we possess in common with Europe.

The Northward Range in this country of the Phænogamous Species which are common to us and to Europe.

This is an interesting point of inquiry, from its bearings upon the mooted question of the single or multiple origin of the species:—upon whether they may have been diffused each from a common centre, or were originally given to two or more widely separated parts of the world. The arctic regions form one botanical province. The greater part of their plants are common to the Old and the New Worlds; and the same species is as likely to occur at any two stations within the arctic circle as at any other two stations equally distant. We naturally look northward for the connection of our flora with that of the Old World; and as we meet with United States plants identical with those of Europe, we are interested to know whether they range northward into or near to the area of common northern vegetation. The *data* now in our possession furnish the following results.

Of our species common to Europe, we know only five which do not occur north of the 40th parallel of latitude, or which barely cross this line. These are

Callitriche pedunculata.
Juncus maritimus.
Convallaria majalis.
Cyperus rotundus.
Carex flacca.

The first of these has doubtless been overlooked. The second is a little-known plant with us, and the identification is not perfect. The fourth is a tropical species, and evidently an immigrant into the southern United States as well as into southern Europe, nor is it impossible that our Nut-Grass may again be specifically distinguished from *Cyperus rotundus*. The fifth is here found only in New Jersey, between lat. 40° and 41°. Unless it has been overlooked in the Northern States (which seems unlikely), or unless our plant has been wrongly referred to the variable *Carex flacca*, it affords a remarkable instance of the local occurrence here of a species which is widely diffused in the Old World. It seems not likely to have been introduced from Europe. The third is the most remarkable case; that of the Lily of the Valley (*Convallaria majalis*). This species—or one which I could not in any respect distinguish from it on a comparison of living specimens—abounds in the higher Alleghanies of North Carolina, I believe also in those of Georgia, and it extends north to the Peaks of Otter in Virginia, lat. 37½°, at an altitude of 4000 feet; but it is not known to occur anywhere beyond this; while in Western Europe it extends nearly to lat. 70°. It is not a plant which could well have escaped observation in the Northern States.

The following 15 species are not known to occur north of lat. 45°:

Myosurus minimus.
Subularia aquatica.
Centunculus minimus.
Veronica officinalis.
Myosotis arvensis.
Salicornia mucronata?
Polygonum dumetorum.
Castanea vesca, var.
Polygonatum latifolium.
Rhynchospora fusca.
Carex vulpina.
" muricata.
" lævigata.
Spartina juncea.
" stricta.

Myosurus minimus occurs with us only in the valley of the Mississippi,—thence south to Texas and west to the Pacific, but not extending northward beyond lat. 45°. It has all the appearance of being indigenous; and in Oregon it is accompanied by a second species which is also a native of Chili. In Europe it occurs as far north as Finland.

Subularia aquatica seems to be a very rare plant in North America, found only in the northeastern corner of the United States.* From its size, aspect, and place of growth it is exceedingly liable to be overlooked. It is to be sought in Nova Scotia, Newfoundland and Canada East. It reaches lat. 70° in Europe.

Centunculus minimus, which extends northward to lat. 60 in Europe here scarcely passes the 41st parallel in the valley of the Mississippi, where alone it occurs in the Northern States.

Veronica officinalis is certainly indigenous in the Alleghany Mountains south of Pennsylvania, and apparently so in the western part of New York. It is not known north of lat. 44°, and in Europe it does not reach the Arctic circle.

Myosotis arvensis is not common here, and has probably been introduced.

Salicornia mucronata, Bigel., is most probably not identical with its homonym on the coast of Spain.

Polygonum dumetorum (if our P. scandens really belongs to it,) does not pass the 45th parallel with us, while in northern Europe it crosses the Arctic circle.

Our Chestnut is one of the few American trees which can anyhow be identified or confounded with European species. It nowhere occurs north of lat. 44° or 45° in this country; and as the European Chestnut is perhaps not really indigenous in any higher latitude in the Old World, we have here either a very anomalous case in geographical distribution, or else must regard our chestnut as specifically distinct. Analogy would favor the latter view, and (which is more directly to the purpose) so also would some little differences in the fruit, such, however, as would be of small account in case the trees were natives of the same district.

Polygonatum latifolium. This is a case of imperfect identification; the American plant so called being known to us only by specimens sent from Pennsylvania by Muhlenberg to Willdenow.

* In the *Genera of N. American Plants Illustrated*, i, p. 164, no less than in the *Manual*, I have made a mistake in respect to the habitat of this plant, which has kindly been pointed out by Prof. Tuckerman. Nuttall long ago gathered it in the ponds of Paris, Maine. I had supposed that Nuttall's station was rediscovered by Messrs. Tuckerman and Oakes; but I am informed that the locality and the only one now known in this country, is Echo Lake, in the Franconia Notch, New Hampshire, where it was detected in 1844 by Prof. Tuckerman, as is recorded by that accurate botanist, indeed, in the pages of this Journal, for September, 1848.

Rhynchospora fusca, and the three species of *Carex* would certainly be expected to have a more northern range. *C. lævigata* has been found but once. What is called *C. vulpina* is probably not distinct enough from *C. alopecoidea;* and *C. muricata*, if rightly identified, may have been introduced, at least into New England, where it occurs only in suspicious situations, and rarely.

The two species of *Spartina* belong properly to America, being found only in a few places on the coast of Europe, where they seem to have effected a chance lodgment.

The following species, 36 in number, are not known to reach in this country, or at least sensible to pass, the 50th parallel of latitude.

Ranunculus repens.
Nuphar Kalmiana.
Draba verna.
Drosera longifolia.
Sagina procumbens.
Oxalis acetosella.
" stricta.
Geranium Robertianum.
Vicia Cracca.
Geum strictum.
" rivale.
Potentilla argentea.
Lythrum Salicaria.
Circæa Lutetiana.
Myriophyllum verticillatum.
Xanthium strumarium.
Samolus Valerandi.
Scrophularia nodosa.
Atriplex hastata.
Salsola Kali.
Humulus Lupulus.
Betula alba, var.
Taxus baccata, var.
Typha angustifolia.
Vallisneria spiralis.
Spiranthes cernua.
Microstylis monophyllos.
Juncus Stygius.
" effusus.
Lemna gibba.
Najas flexilis.
Zannichellia palustris.
Ruppia maritima.
Cyperus flavescens.
Carex fulva.
Milium effusum.

Upon this list I remark, first, that two of the species, although admitted as indigenous in the *Manual of the Botany of the Northern United States*, were probably introduced from Europe since the settlement of the country; namely *Draba verna* and *Potentilla argentea*. At least the expression of doubt which in the work just mentioned is thrown upon the former, I now think equally applies to the latter. I never saw either of them growing in other than suspicious situations. They are found only in the Eastern United States and in the long-settled parts of Canada; while in Europe the first falls short of, and the second barely enters Lapland.

Lythrum Salicaria has better claims to citizenship, at least in Eastern New England, but it is not clear from suspicion. Douglas gathered it in wet meadows of Upper Canada; but if really indigenous to this country it is surprising that it does not extend farther north.

Some of the forms which I have felt obliged to join with *Xanthium strumarium* seem to be indigenous in the northwestern portion of our district; and so, along the coasts and great rivers, does the variety *echinatum* (which most botanists will still fancy to be very distinct); but the latter, more widely dispersed over the world, is probably an immigrant from farther south. The real home of the species is uncertain: it could not be expected to occur much north of lat. 46°.

Betula alba and *Taxus baccata*, var. *Canadensis* are the only woody plants upon the list. As to the first, I have followed Spach in considering our White Birch identical with the European. It occurs only from the eastern part of Pennsylvania and New Jersey to Maine, and not far from the coast, reaching barely to about the 46th parallel, one or two degrees beyond the Chestnut. In Western Europe *B. alba* extends into the arctic regions. The American tree should be critically compared anew with the European. At present the White Birch and the Chestnut are our only trees here considered as specifically identical with European ones; unless we add our low and procumbent representative of the Yew (*Taxus baccata*, var. *Canadensis*). If a striking difference in habit or mode of growth alone may be relied upon for characters, then our Yew must be specifically distinct from that of Europe. Other differences, however, have not been detected. Our Yew, according to Richardson, merely reaches the southern borders of the Saskatchawan basin, say about lat. 50°. In Oregon there are Yew trees with the port of the ordinary *T. baccata*, which appears not to occur in Northern Asia, although Dr. Hooker recognizes it in the Himalayas.

Drosera longifolia (*intermedia*), *Circæa Lutetiana*, and *Myriophyllum verticillatum* might be expected to extend farther north than lat. 47°, but they do not occur in Lapland.

Juncus Stygius is the most remarkable member of this list. Its only known habitat on the North American *continent* is a bog adjoining a small lake in Jefferson county, New York, lat. 44°, where I found it in great abundance twenty-four years ago. But it has been collected in Newfoundland, probably south of lat. 49°. This is a mainly Scandinavian species, of high northern range, not found in Denmark, according to Fries, but extending to Bavaria and the Alps. It has been said to occur in Northeastern Siberia, but Trautvetter corrects this in his *Florula Ochotensis:* what he had taken for it, he finds on reëxamination, to be *J. castaneus.* In all probability it grows in Lower Canada: but if in Northern British America it could hardly have been overlooked by Richardson and Drummond.

Carex fulva is another species unknown in Northern British America, found at only one station in the United States, and elsewhere only in Newfoundland, whence Goodenough received the specimens on which he founded the species. In Europe, it is scarcely found north of lat. 60.

Spiranthes cernua, if really European, is found only on the west coast of Ireland, and belongs to the same remarkable category as *Eriocaulon septangulare*, of the next list.

For the rest of the list, no particular remarks are needed. Their northern range in this country corresponds generally with that in Europe, making allowance for the difference in climate; that is, they range ten or fifteen degrees farther north in Western Europe than in North America. This is true even of *Vallisneria spiralis*, a plant of temperate climates, with a wide southern range, and neither Scandinavian nor North German. In North America it extends to about lat. 46° : in Russia it is recorded as occurring near St. Petersburg, lat. 60°.

The following species, 56 in number, range north of lat. 50, and many of them have been traced up to lat. 55°, but not much if any beyond the latter parallel.

Anemone nemorosa.
Cerastium arvense.
Trifolium repens.
Ludwigia palustris.
Sium angustifolium.
Bidens cernua.
Gnaphalium uliginosum.
Chimaphila umbellata.
Monotropa Hypopitys.
Statice Limonium.
Utricularia vulgaris.
" minor.
Lycopus Europæus.
Myosotis palustris.
Calysegia sepium.
Salicornia herbacea.
Rumex maritimus.
Ceratophyllum demersum.
Acorus Calamus.
Sparganium ramosum ?
" angustifolium.
Lemna trisulca.
" polyrhiza.
Potamogeton pectinatus.
" prælongus.
" lucens.
" heterophyllus.
Scheuchzeria palustris.
Alisma Plantago.
Anacharis Canadensis.
Liparis Lœselii.
Platanthera bracteata.
Eriocaulon septangulare.
Eleocharis acicularis.
Scirpus maritimus.
Eriophorum alpinum.
Carex teretiuscula.
" tenella.
" tenuiflora.
" maritima.
" irrigua.
" pallescens.
" flava.
" filiformis.
" Pseudo-Cyperus.
" ampullacea.
Leersia oryzoides.
Calamagrostis arenaria.
Kœleria cristata.
Glyceria aquatica.
" fluitans.
Poa serotina.
" compressa.
Phragmites communis.
Triticum caninum.
Aira flexuosa.

Concerning two plants on this list, doubts may fairly be raised whether they are indigenous to this continent, viz. *Gnaphalium uliginosum* and *Poa compressa*. The former is one of our commonest plants, but is only found along damp road-sides and in ground which is or has been tilled. It is found on the Saskatchawan;

but if there restricted to similar situations, I should consider it one of the species unwittingly introduced by man from Europe. *Poa compressa* here has wholly the appearance of a naturalized plant. Richardson and Drummond gathered it also on the Saskatchawan, I know not in what stations. E. Meyer records it as in Labrador.

Triticum caninum, like the common Couch-Grass (*T. repens*), as it generally occurs with us, is evidently of European derivation; but both species are indigenous from our northern borders northward and westward.

The White Clover (*Trifolium repens*) which springs up so copiously and promptly wherever forests are destroyed and the land turned into pasture, is in the same category, being wild at the north and the far West, and undoubtedly imported likewise at the settlement of the country.

Of *Cerastium arvense*, and probably of *Acorus Calamus* also, we have within our limits both an indigenous and an introduced stock.

With *Anacharis Canadensis* it is not certain that the German and Russian plant is identical, the flowers being unknown there: nor, if so, are we sure that the plant is truly indigenous on the continent of Europe any more than in England, although it is very likely to be so.

Platanthera bracteata is placed upon the list, although with doubt, Dr. Lindley and Sir Wm. Hooker having expressed the opinion that it is identical with *P. viridis* of Europe.

Eriophorum alpinum, a Scandinavian plant of high range,—also found on mountains in Western Europe as far south as the Alps, but scarcely extending into Siberia,—is not rare with us in cold peat bogs, from Pennsylvania to Lake Superior and Maine. It is also a native of Newfoundland, although not mentioned as such by Hooker. I think I have seen specimens from Lower Canada. But no more northern habitats are known except Michaux's, i. e. Lake Mistassins and Hudson's Bay, say lat. 51°. It surely ought to grow in Labrador; but it is nowhere recorded from that region, nor from Greenland.

Eriocaulon septangulare, an Eastern North American plant not ranging beyond lat. 55°, but singularly reappearing only in a few stations in the nearest part of Europe, requires some notice in a different connexion.

It is worth remarking that it is in the interior of the continent, namely, in the Saskatchawan country (long. 95° to 105°,) and not along the coast, that most of the plants of this list attain their highest latitude. We should expect this, as regards the eastern coast, from the rise of the isothermal lines and of the limit of trees on passing westward, and from the great rise of the isotheral lines in the district referred to. Still it will appear singular that only three of these 56 species are recorded as natives of Labrador, (namely, *Poa compressa*, already mentioned, *Statice Limonium*, and *Chimaphila umbellata*), until it is noted that the principal Labrador collections known were made between lat. 56° and 58°. Many Newfoundland and Canadian plants doubtless inhabit southern Labrador: but I can add only one of these on the present list, namely, *Calamagrostis arenaria*. Only about a dozen of these 57 species appear to occur north of the 50th parallel on the Pacific coast: but this number includes much the larger part of the species on this list which extend westward to the Pacific at all, even in a lower latitude.

The following 42 species range north of lat. 55°, but do not, as far as we know, cross the 60th parallel:

† Hepatica triloba.
†* Coptis trifolia.
Spiræa salicifolia.
† " Aruncus.
Agrimonia Eupatoria.
† Geum macrophyllum.
† Circæa alpina.
* Saxifraga Aizoon.
† Galium trifidum.
† Galium Aparine.
† " triflorum.
†* Plantago maritima.
† Glaux maritima.
Limosella aquatica.
† Veronica Anagallis.
† " serpyllifolia.
† Brunella vulgaris.
Calla palustris.
Lemna minor.
Potamogeton pusillus.
" compressus.
Potamogeton perfoliatus.
† " natans.
†* Triglochin maritimum.
†* Listera cordata.
†* Streptopus amplexifolius.
Scirpus lacustris.
† " sylvaticus.
† Rhynchospora alba.
† Carex pauciflora.
† " * canescens.
† " stellulata.
† " limosa.
† " Buxbaumii.
" * panicea.
" Œderi.
† Agrostis canina.
" vulgaris.
† Cinna arundinacea.
† Glyceria maritima.
† " distans.
† Poa annua.

Only 8 of these 42 species are recorded as natives of Labrador; namely, those marked with an asterisk in the list; while 29 of them are in Bongard's Florula of the Island of Sitcha (lat. 57°–58°) on the North West coast. These are marked with a (†). Among them are six of the eight Labrador species, namely, all except *Saxifraga Aizoon* and *Carex panicea*.

Two species only of the above list are doubtful natives of the United States; viz. *Galium Aparine*, which here is not found beyond Canada, and only in doubtful situations, but it seems to be truly indigenous on the Northwest coast; and *Poa annua*, a cosmopolite plant, found all round the world in high latitudes. *Agrostis vulgaris* and *A. canina* are in the same category with *Triticum caninum* and *T. repens*,—represented at the north by an indigenous, but generally by an imported stock.

Spiræa Aruncus claims a place in the list of disjoined species. It occurs in the Catskill mountains, New York, and southward along the whole extent of the Alleghanies; but here it ranges no farther northward. It is not a Scandinavian plant; but from France it extends eastward through Northern Asia to Kamtschatka, and thence to Sitcha and the mouth of the Oregon.

The following 63 species cross the 60th parallel, but so far as I can ascertain, are not known to cross the arctic circle on this continent.

* Caltha palustris.
Actæa spicata (rubra).
Turritis glabra.
Draba memorosa.
†Stellaria longifolia.
†Spergularia rubra.
Lathyrus palustris.
Fragaria vesca.
* Epilobium palustre.
†* Ligusticum Scoticum.
†* Linnæa borealis.
* Lonicera cærulea.
Galium boreale.
†Achillea Millefolium.
Artemisia Canadensis.
Lobelia Dortmanna.
* Campanula rotundifolia.
†* Ledum latifolium.
* Pyrola chlorantha.
†* Moneses uniflora.
* Primula farinosa.
Naumburgia thyrsiflora.
Utricularia intermedia.
†* Pinguicula vulgaris.
Veronica scutellata.
* Rhinanthus Crista Galli.
Scutellaria galericulata.
Stachys palustris.
†* Menyanthes trifoliata.
Blitum capitatum.
Polygonum amphibium.
†* " aviculare.
Callitriche verna.
" autumnalis.
†* Myrica Gale.
* Alnus incana.
Typha latifolia.
Sparganium simplex.
" natans.
* Triglochin palustre.
Goodyera repens.
Calypso borealis.
Corallorhiza innata.
Smilacina stellata.
†* " bifolia.
* Allium Schœnoprasum.
Juncus filiformis.
" Balticus.
" articulatus.
" bufonius.
Eleocharis palustris.
Scirpus pungens.
†Eriophorum vaginatum.
Carex chordorrhiza.
" aquatilis.
" salina.
† " livida.
† " vesicaria.
Alopecurus aristulatus.
Poa nemoralis.
* " pratensis.
Aira cæspitosa.
Phalaris arundinacea.

Twenty of these marked (*) are in the flora of Labrador; fifteen, marked (†) in that of Sitcha; and nine are common to the two.

It would appear, therefore, that of our Phænogamous plants common to Europe, only

5 do not range north of lat. 40°.
20, or 6 per cent, do not range north of lat. 45°.
56, or 17½ per cent, do not range north of lat. 50°.

113, or 35 per cent, do not pass north of lat. 55°.
155, or 48½ per cent, do not pass north of lat.60°.
218, or 68 per cent, scarcely, if at all, cross the Arctic circle.

In this inquiry we have thus far left our alpine and even subalpine species, common to Europe, wholly out of view, as not properly belonging to our temperate flora, and as expected to extend northward beyond the Arctic circle. In a few cases, however, this expectation is not exactly borne out. For instance,

Viola palustris is found only in the alpine region of the White Mountains, in Labrador, and perhaps in the Rocky Mountains about lat. 42°, but has not been noticed in arctic America proper. It occurs, however, in Greenland as well as in Kamtschatka.

Potentilla frigida,* or the plant of the White Mountains which I take for it, has not been elsewhere found in this country (unless confounded with some other species) except in Greenland, between lat. 73° and 80°, by Dr. Kane; nor is it known in the north of Europe!

Sibbaldia procumbens, although found in Labrador and Greenland on one side, and on the northern Rocky Mountains and at Unalaschka on the other, has not been detected in Arctic America within the Arctic circle.

Gnaphalium supinum, a rare plant of the White Mountains, has been elsewhere detected upon the continent only at Labrador: and it also occurs in Greenland.

Cassiope hypnoides, found on all our alpine summits, elsewhere occurs only in Labrador and Greenland, on the one hand, and at Unalaschka, below the Arctic circle, on the other.

Phyllodoce taxifolia occurs only on the White Mountains, in Labrador, and in Greenland.

Veronica alpina, although approaching the Arctic circle both east and west, is not recorded as crossing it, though it probably does so.

Salix phylicifolia occurs only on the White Mountains and in Labrador.

Juncus trifidus, an abundant plant in our alpine districts, is not recorded from any other part of North America, excepting Newfoundland!

Carex capitata, although found on Hudson's Bay and on the Rocky Mountains, is not recorded from within the Arctic circle.

Phleum alpinum, found in Labrador, Greenland, and Unalaschka, is not recorded from within the Arctic circle. On the other hand *Aira atropurpurea*, a Lapland species found on the

* The habitat of this rare plant has been casually left out of the Manual of Botany of N. U. States, p. 118. It was discovered, out of flower, by Dr. Robbins (who has long been one of the most zealous and successful explorers of New England botany), at a single station in the alpine region of the White Mountains of New Hampshire, where it is still rather abundant. Later the indefatigable Prof. Tuckerman detected it on Mount LaFayette, of the Franconia range. These are the only stations known on this continent.

White Mountains, is remarkable for not being found in Labrador, nor in Greenland that I am aware of, while it occurs on the Northwest Coast below lat. 60°, but nowhere in Siberia, Kamtschatka, &c., nor was it known in Arctic America until lately collected between Point Barrow and Mackenzie river, by Capt. Pullen, according to Mr. Seemann.

As to our subalpine list: *Alsine Grœnlandica* is wrongly said in the Manual to be European, as it has not been found beyond Greenland. It also occurs in Labrador, and with us as far south as the low Shawangunk Mountains in the southern part of New York; but is entirely unknown in Canada and in Arctic America.

Carex gynocrates, which we should expect to be alpine and arctic, but which is not known as either in this country, is connected with Lapland by the intermediate station of Greenland. Excepting this and *Juncus stygius* (which has already been commented on), and perhaps also *Euphrasia officinalis*, all our strictly subalpine species, as well those enumerated as to have been expected to be so, which are common to us and to Europe, extend northward along the central region of the continent quite to the Arctic sea-coast. While, curiously enough, eleven, or one-third of our strictly alpine species common to Europe,—all but one of them arctic in the Old World,—are not known to cross the arctic circle on this continent. This, however, might perhaps have been expected, as it seems almost certain that the interchange of alpine species between us and Europe must have taken place in the direction of Newfoundland, Labrador and Greenland, rather than through the polar regions; and this a critical study of the distribution of our plants northward would be likely to show.

Adding accordingly a dozen alpine or subalpine species, we have about 230 Phænogamous species common to Europe, or 72 per cent, which have not been detected within the Arctic circle upon the American continent.

Our species common to Europe which do extend into the Arctic zone,—exclusive of all those enumerated in the three lists of alpine, subalpine, and the seven *should-be* alpine or subalpine species given on p. 63, are these (52 in number):

Dicotyledoneæ.

Ranunculus aquatilis, var.
" flammula, var.
" sceleratus,
Nasturtium palustre.
Cardamine pratensis.
" hirsuta.
Arabis hirsuta.
Barbarea vulgaris.
Erysimum cheiranthoides.
Drosera rotundifolia.
Parnassia palustris.
Honkenya peploides.
Mœhringia lateriflora.
Stellaria longipes.
" uliginosa.

Stellaria crassifolia.
" borealis.
Sagina nodosa.
Lathyrus maritimus.
Potentilla Norwegica.
" Anserina.
" fruticosa.
" palustris.
Epilobium angustifolium.
Myriophyllum spicatum.
Hippuris vulgaris.
Ribes rubrum.
Viburnum Opulus.
Artemisia Canadensis.
Taraxacum Dens-leonis.
Vaccinium Oxycoccus.
Arctostaphylos Uva-Ursi.
Cassandra calyculata.
Andromeda polifolia.
Pyrola rotundifolia.
Pyrola minor.
Primula Mistassinica.
Mertensia maritima.
Gentiana detonsa.
Chenopodina maritima (?)
Alnus viridis.
Juniperus communis.

Monocotyledoneæ.

Luzula pilosa.
" parviflora.
" campestris.
Juncus bulbosus.
Eriophorum polystachyon.
" gracile.
Carex vulgaris.
Festuca ovina.
Triticum repens.
Hierochloa borealis.

If any interesting relation is to be traced between the more or less boreal range of our temperate species common to Europe, and the natural classes or orders they severally belong to, the means of instituting the comparison are at hand in the various foregoing lists. The subjoined columns give a comparison in this respect between our 52 non-alpine plants which extend into the Arctic zone, and the almost equal number whose northern limit is between the 40th and the 50th parallels. It shows nothing, however, except the diminution of the number of the orders, and of non-glumaceous Endogens, in high latitudes.

Non-alpine species of the above list with their boreal limit with the Arctic circle.		Non-alpine species with their boreal limit between lat. 40° and 50°.	
Ranunculaceæ,	3	Ranunculaceæ,	2
Cruciferæ,	6	*Nymphæaceæ,*	1
Droseraceæ,	1	Cruciferæ,	2
Parnassiaceæ,	1	Droseraceæ,	1
Caryophyllaceæ,	7	Caryophyllaceæ,	1
Leguminosæ,	1	*Oxalidaceæ,*	2
Rosaceæ,	4	*Geraniaceæ,*	1
Onagraceæ,	3	Leguminosæ,	1
Grossulaceæ,	1	Rosaceæ,	3
Caprifoliaceæ,	1	*Lythraceæ,*	1
Compositæ,	2	Onagraceæ,	2
Ericaceæ,	6	Compositæ,	1
Primulaceæ,	1	Primulaceæ,	2
Borraginaceæ,	1	*Scrophulariaceæ,*	2
Gentianaceæ,	1	Borraginaceæ,	1
Chenopodiaceæ,	1	Chenopodiaceæ,	3

Betulaceæ,	1
Coniferæ,	1
Dicotyledoneæ,	42
Juncaceæ,	4
Cyperaceæ,	3
Gramineæ,	3
Monocotyledoneæ,	10
21 orders,	52 species.

Polygonaceæ,	1
Urticaceæ,	1
Cupuliferæ,	1
Betulaceæ,	1
Coniferæ,	1
Dicotyledoneæ,	31
Typhaceæ,	1
Lemnaceæ,	1
Naiadaceæ,	3
Hydrocharidaceæ,	1
Orchidaceæ,	2
Liliaceæ,	1
Juncaceæ,	2
Cyperaceæ,	6
Gramineæ,	3
Monocotyledoneæ,	20
30 orders,	51 species.

Considered as to size and duration of the plants in connection with geographical range, our 320 species common to Europe, are divided as follows:

Only 3 of them are trees, namely, the Chestnut, White Birch, and Yew; and the latter is no tree in this country. All three have been and generally are still taken for peculiar American species, perhaps correctly. None of them extend north quite to lat. 50°, the Chestnut not beyond 45°. Two of them range a little south of lat. 40°, and one, the Chestnut, considerably south of lat. 36°. Their geographical distribution, taken in connexion with the comparatively restricted area of trees, favors the suspicion that these are specifically different from the European species.

Only 15 species are shrubs. All of them occur as far north as lat. 60°, or else are alpine, and 10 grow within the arctic circle.

Then 12 are suffruticose or suffrutescent plants, all of them arctic-alpine or subalpine, and with their southern limit under lat. 40°, except two; namely, *Arctostaphylos Uva-ursi,* which ranges from the arctic shores to lat. 35° and across the whole breadth of the continent at its widest part; and *Chimaphila umbellata,* which, from its northern limit of about 55°, is equally broadly distributed over the continent, and extends southwards even into Mexico.

The remaining 290 species are all herbs; and about 260 of them are perennials. Of the 30 annuals and biennials, few have a high boreal range, but at least 20 of them are among our species of widest southern range.

The Southward Range in this Country of our Phænogamous Species common to Europe.

This is not a subject of so much interest as the northern range. The subjoined table exhibits the main facts of the case, as well as I can now determine them, as respects our species which are neither alpine nor subalpine.

No. of species.	Whose boreal limit is	Of these the southern limit is beyond Lat. 30°.	Lat. 36° 30′.	Lat. 40°.	Found on DeCandolle's list of species of *vast area*; out of the whole No. (column 1.)	out of those rang'g S. of 40° (columns 3, 4, 5).
52	+66° 30′	6 spec.	11 spec.	16 spec.	10 spec.	9 species.
63	+60°–66°	9 "	16 "	8 "	11 "	9 "
42	+55°–60°	16 "	9 "	7 "	10 "	10 "
57	+50°–55°	17 "	12 "	16 "	10 "	10 "
36	+45°–50°	10 "	10 "	8 "	7 "	7 "
15	+40°–45°	4 "	3 "	4 "	1 "	1 "
5	+40°	2 "	2 "	1 "	0 "	0 "

DeCandolle's list (in Geogr. Bot. p. 564, et seq.) of Phænogamous species of vast area comprises those which, in their actual dispersion, are estimated to be diffused over at least one-third of the terrestrial surface of the globe. It therefore rarely includes maritime plants, although these are so wide-spread. Nor does it include several of our species which as wild plants have better claim than some which are admitted. Indeed a large proportion of those common to Europe which range south of lat. 36° 30′ are very widely spread species.

For example, the six *amphigœan* species which range from within the arctic circle to south of the 30th parallel, or to the Gulf of Mexico, are *Ranunculus aquatilis*, *Nasturtium palustre*, *Cardamine hirsuta*, *Drosera rotundifolia*, *Taraxacum Dens-leonis*, (probably introduced southward) and *Luzula campestris*, all but one nearly cosmopolite, and that one (*Drosera*) diffused over most northern temperate regions.

And the 9 which range from near the arctic circle to the same low latitude are *Spergularia rubra*, *Polygonum amphibium* and *aviculare*, *Callitriche verna* and *autumnalis*, *Typha latifolia*, *Juncus bufonius*, *Eleocharis palustris*, and *Scirpus pungens*. (*Caltha palustris*, which is on DeCandolle's list, does not extend quite so far south.) And among the 16 which range from lat. 55°–60° down to lat. 30° are such plants as *Agrimonia Eupatoria*, *Veronica Anagallis* and *serpyllifolia*, *Limosella subulata*, *Brunella vulgaris*, *Lemna minor*, *Potamogeton perfoliatus* and *natans*, *Scirpus lacustris*, and *Poa annua*,—a few of them not really indigenous there. One hardly to be expected is *Hepatica triloba*, which occurs in Florida.

Of our alpine species common to Europe, of course none occur south of Northern New York. And as to the eleven on the subalpine list, only two have been observed anywhere in the Alleghanies, (and these only south of lat. 36° 30′), viz. *Scirpus cæspitosus* and a form of *Trisetum subspicatum.* None of the rest are known in the Eastern United States so far south as lat. 40°.

The re-appearance of some northern species in high southern latitudes is another matter, and to be considered under the head of *disjoined species.*

The range of our amphigæan species might be considered in reference to the stations they affect or the medium in which they grow; but this would be likely to bring out no important results beyond the familiar ones that aquatic, palustrine and maritime species are among those of widest range in latitude. The lists already given enable any botanist to do it.

The Species common to this Country and to Europe in respect to the size of the Orders and Genera they belong to.

The species which we possess in common with Europe, being generally speaking those of widest geographical range, form good materials ready to our hands, as far as they go, for the enquiry whether there is any assignable relation between the size of a natural group and the area occupied by the species;—a subject which DeCandolle has briefly discussed, as regards families. By gathering the *data* from the table which begins on p. 208, it will be seen that our nine largest families (as enumerated in order on p. 213) come a little nearer to comprising half our amphigæan species than they do to half our whole number of species: i. e., they contain 158 species, or two less than half. But the tenth family, *Labiatæ*, being very poor in these common species, brings up the number to only 162, or barely two above half of the 320. And our different large families present such marked differences in the ratio of their amphigæan species,* that it is clear no results of the least moment are to be obtained in this way.

To be of any value, at least upon our limited scale, the comparison should be made with genera, as Mr. Darwin suggests; and from some investigations of his own, this sagacious naturalist inclines to think that species in large genera range over a wider area than the species of small genera do. Our 320 amphigæan species evidently tend to confirm this view. They belong to 171

* Compositæ,	out of	273	species,	9	are common to Europe.	
Cyperaceæ,	"	218	"	48	"	"
Gramineæ,	"	162	"	32	"	"
Leguminosæ,	"	91	"	4	"	"
Rosaceæ,	"	71	"	16	"	"
Ericaceæ,	"	62	"	19	"	"
Scrophulariaceæ,	"	54	"	10	"	"
Orchidaceæ,	"	51	"	10	"	"
Ranunculaceæ,	"	49	"	10	"	"
Labiatæ,	"	49	"	4	"	"

genera. Of these only 18, or 10·5 per cent, are monotypic, while 13·3 per cent of our whole number of genera are monotypic: 23 genera or almost 13 per cent contain only two or at most three good species apiece, and about as many more have only four or five good species. Therefore 64 of the smaller genera, or 37 per cent, fully come up to the general average of species to genus in our Phænogamous plants generally, viz. three each (supra, p. 216); while on the other hand, 15, or 8 per cent, are very large genera, such as *Carex*, *Solidago*, *Cyperus*, *Salix*, *Allium*, *Galium*, *Trifolium*, *Gentiana*, *Ranunculus*, &c. Though many of these are not very large genera in our region, nor do those that are large particularly abound in amphigæan species.

Comparison of the Flora of the Northern United States with that of Europe in respect to the Similar or Related Species.

Two floras may be, perhaps, as nearly related through their allied as through their identical species: at any rate, the comparison in this respect is equally important to be made. Such comparisons, however, are much more difficult, owing to the impossibility of estimating the degrees of resemblance among species, or at least of expressing them in any precise or definite way, or of bringing shades of difference to any common standard. In theory, indeed, only one grade of resemblance is supposed to be expressed in genera. But genera,—even those whose circumscription is either clearly defined in nature (which is far from being always the case) or is generally agreed upon, are by no means groups of equal value throughout; and the species of every genus, when several or numerous, resemble each other in very unequal degrees.

Still no two analogous but geographically separated floras of any size are so well known, as to their Phænogamia, and afford generally such facilities for the comparison of their related species, as those of the Northern United States and of Northern Europe.

If we judge of their relationship from the large proportion of the genera common to the two, we might infer it to be very close. After correcting a little the numbers published in the former article, on p. 216 *et seq.*, we count 326, or not much less than one-half of the 681 genera as belonging also to Europe. This indicates a great *amount* of related vegetation in the two floras, no doubt; but of the *degree* of relationship, taken comparatively, it gives us no correct idea, until we know how many of the genera common to the two are almost cosmopolite, or are wide-spread over the cooler parts of nearly the whole northern hemisphere; and how many are peculiar or strictly characteristic. Now, on going over the list, I find that an extraordinarily large proportion of the genera common to our flora and to Europe belong also to the floras of almost all the temperate regions of the world. Out of the 326 genera,

284, or 87 per cent are diffused around the northern hemisphere, or over the greater part of it;

201, or 61 per cent, extend into the tropics or cross the equator.

177, or considerably over half, are both widely diffused over the northern temperate zone and extend into or beyond the tropics:—leaving

18, or only 5½ per cent, as nearly peculiar to Eastern North America and to Europe; and very few even of these are strictly peculiar.

A simple enumeration of them will show how trivial a part these 18 American-European genera play in the two floras. They are:

Bellis,	Fedia,
Cakile.	Hottonia,
Calla,	Liparis,
Carpinus,	Melampyrum,
Cassandra,	Narthecium,
Cercis,	Ostrya,
Convallaria,	Scheuchzeria,
Corema,	Subularia,
Dupontia.	Waldsteinia.

Most of these are very small genera, four if not five of them having only a single species each. *Cercis* actually extends to California, and south to near the tropical line. *Dupontia* is a purely arctic genus, to which our species, so called, is referred with much misgiving. *Hottonia* is said to have a third species in Java, which would exclude it from the present list. Moreover, five of these genera are represented only by identical species.

The special resemblance of our flora to that of Europe, it is clear, is not owing simply either to the large proportion of genera in common, or to any thing striking or important in the few genera nearly or quite peculiar to the two. The latter, indeed, are insignificant in our flora, and not to be compared, as to any features they impart, with the much more numerous and really characteristic genera which are shared by the Eastern United States and Eastern temperate Asia. We must look for it in the species, partly in the identical ones (already noticed), and partly in those which closely answer to each other in the two floras.

The citation of *representative species*, to be of much value, should be more critical than it generally is in such comparisons. The degrees of affinity should be classified as strictly as the subject admits of, under several heads; beginning with the plants so closely related in each that they form a sort of *limbo* between the regions of identical and of allied species on either side, and which may or may not be reckoned specifically the same, according to our varying knowledge, and according to the views which different authors take respecting species. A good analysis of the subjects of comparison might perhaps be made into,

1. *Geographical Varieties*, or those cases in which the American plant is always or generally distinguishable from the European in some point or other, and is not unlikely to be reckoned specifically different even by sound botanists.

2. *Very Close Representative Species*, admitted as distinct, but not unlikely many of them to be reduced to geographical varieties.

3. *Strictly Representative Species*, pretty exactly answering to each other in the two floras, but of which there can be little if any question of specific identity.

4. *Strictly Congeneric Species*, but not falling into either of the former categories.

5. *Divergent Congeneric Species*, where the American type belongs to a different section or subgenus from the European.

To which these might be added, 6th, species of strictly analogous or representative genera.

I must not attempt here anything beyond an enumeration, made *currente calamo*, of such examples in question as occur to me under the first three heads:

1. *American Geographical Varieties, which not only have been, but are not unlikely to be again distinguished as Species, and therefore to be merged in No.* 2.

Ranunculus repens, Amer.: formerly	R. Marilandicus, &c.
Actæa spicata, vars. alba and rubra:	A. alba and rubra.
Nasturtium palustre, fructu brevi:	N. hispidum, &c.
Ribes rubrum, Amer.:	R. albinervium.
Solidago virgaurea, Amer., vars.:	S. humilis and multiradiata.
Monotropa Hypopitys, Amer.:	M. lanuginosa.
Statice Limonium, var.:	S. Caroliniana.
Samolus Valerandi, var. Amer.:	S. floribundus.
Lycopus Europæus, var. sinuatus:	L. sinuatus.
Stachys palustris, vars:	S. aspera, glabra, cordata, &c.
Myosotis palustris, var. laxa:	M. laxa.
Castanea vesca, var. Americana:	C. Americana.
Betula alba, var. populifolia:	B. populifolia.
Taxus baccata, var. Canadensis:	T. Canadensis.
Trisetum subspicatum, var. molle:	T. molle.

2. *Very Close Representative Species, almost all of them more or less liable to be reduced to Geographical Varieties.*

Northern United States.	*Northern Europe.*
Pulsatilla Nutalliana,	P. vulgaris.
Delphinium exaltatum,	D. elatum.
Berberis Canadensis,	B. vulgaris.
Nymphæa odorata,	N. alba.
Nuphar Kalmiana,	N. lutea.
Arabis lyrata,	A. petræa.
Sisymbrium canescens,	S. Sophia.
Cakile Americana,	C. maritima.
Viola Muhlenbergii,	V. canina.
Elatine Americana,	E. triandra.
Geranium Carolinianum,	G. dissectum.
Impatiens pallida and fulva,	I. noli-tangere.
Geum album,	G. urbanum.
Potentilla paradoxa,	P. supina.
Rubus strigosus,	R. Idæus.
Amelanchier Canadensis,	A. vulgaris.
Epilobium coloratum,	E. tetragonum.
Tillæa simplex,	T. aquatica.
Sedum telephioides,	S. Telephium.
Chrysosplenium Americanum,	C. oppositifolium.
Cornus Canadensis,	C. Suecica.
Sambucus pubens,	S. racemosa.
Galium trifidum.	G. palustre.
Valeriana sylvatica,	V. dioica.
Nardosmia palmata,	N. frigida.
Antennaria plantaginifolia,	A. dioica.
Ledum latifolium,	L. palustre.
Veronica Americana,	V. Beccabunga.
Melampyrum Americanum,	M. pratense.
Lithospermum latifolium,	L. officinale.
Euphorbia obtusata,	E. platyphylla.
" commutata,	E. Peplus.
Fagus ferruginea,	F. sylvatica.
Juniperus Virginiana,	J. Sabina.
Allium Canadense,	A. vineale.
Veratrum viride,	V. album.
Narthecium Americanum,	N. ossifragum.
Eleocharis rostellata,	E. multicaulis.
Scirpus pungens, &c.,	S. triqueter.
Hordeum pusillum,	H. maritimum.
Elymus striatus,	E. Europæus.
" mollis,	" arenarius.

3. *Strictly Representative Species, probably few of them to be confounded.*

Northern United States.	*Europe.*
Atragene Americana,	A. alpina.
Clematis ochroleuca,	C. integrifolia.
Ranunculus alismæfolius,	R. Lingua.
" abortivus,	R. auricomus.
Isopyrum biternatum,	I. thalictroides.
Aconitum reclinatum,	A. Lycoctonum.
Nasturtium lacustre,	N. amphibium.
Draba arabisans,	D. incana.
Lepidium intermedium,	L. ruderale.
Senebiera didyma,	S. Coronopus.
Tilia Americana,	T. Europæa,
" heterophylla,	T. argentea.
Staphylea trifolia,	S. pinnata.
Acer spicatum,	A. Tartaricum.
" saccharinum,	A. platanoides.
Hedysarum boreale,	H. obscurum.
Cercis Canadensis.	C. Siliquastrum.
Prunus Virginiana,	P. Padus.
Rubus triflorus,	R. saxatilis.
Pyrus (Sorbus) Americana,	P. aucuparia.
Ribes floridum,	R. nigrum.
Saxifraga Virginiensis,	S. nivalis.
" Pennsylvanica.	S. hieracifolia.
Hydrocotyle interrupta,	H. vulgaris.
Sium lineare,	S. latifolium.
Cornus sericea and stolonifera,	C. sanguinea.
Lonicera grata,	L. Caprifolium.
Sambucus Canadensis,	S. nigra.
Viburnum lantanoides,	V. Lantana.
Fedia radiata,	F. olitoria, &c.
Aster flexuosus,	A. Trifolium.
Bidens connata,	B. tripartita.
" chrysanthemoides,	B. cernua.
Artemisia Ludoviciana,	A. vulgaris.
Gnaphalium purpureum,	G. sylvaticum.
Hieracium Canadense,	H. prenanthoides, &c.
Azalea calendulacea,	A. Pontica.
Ilex opaca,	I. Aquifolium.
Diospyros Virginiana,	D. Lotus.
Androsace occidentalis,	A. elongata.
Trientalis Americana,	T. Europæa.
Hottonia inflata,	H. palustris.
Mentha Canadensis,	M. arvensis.
Myosotis verna,	M. stricta.
Gentiana Saponaria,	G. Pneumonanthe.
Asarum Canadense,	A. Europæum.
Corema Conradii,	C. alba.
Ulmus Americana,	U. pedunculata.

Ulmus fulva,	U. montana.
Celtis occidentalis,	C. australis.
Morus rubra,	M. nigra.
Urtica gracilis,	U. dioica.
Parietaria Pennsylvanica,	P. officinalis.
Platanus occidentalis,	P. orientalis.
Corylus Americana,	C. Avellana.
Carpinus Americana,	C. Betulus.
Ostrya Virginica,	O. vulgaris.
Alnus serrulata,	A. glutinosa.
Salix lucida, &c.,	S. pentandra, &c.
Populus tremuloides,	P. tremula.
Abies balsamea,	A. pectinata.
" nigra and alba,	" excelsa.
Larix Americana,	L. Europæa.
Sagittaria variabilis,	S. sagittifolia.
Cypripedium pubescens,	C. Calceolus.
Smilax rotundifolia, &c.,	S. aspera.
Polygonatum biflorum,	P. multiflorum.
" giganteum,	" officinale.
Erythronium Americanum and albidum,	E. dens-canis.

I omit, for the most part, the large genera, in which it becomes a nice question rightly to pair off representative species.

In all these lists it is sometimes the case that the species or forms of the second column also are indigenous to the United States, or to North America.

Adding now our about 115 closely representative species (of the second and third lists) to the 320 identical ones, we have a total of 435, or over one-fifth of our Phænogamous species, as the same as, or very much like European plants; and enough more of good representative forms might be selected from the large genera (Carex, Salix, Quercus, Juncus, &c.) to bring the proportion up to nearly one-third.

Equally prominent European features of our flora might be traced in the fourth list, if filled out. Here the greater number of allied species would fully make up for the somewhat less close affinity, and so exhibit an equal amount of resemblance. And this brings me to remark that,

Finally, it is in the number of familiar European forms,—especially of those most striking to the eye and most effective in the landscape,—that the general likeness of the vegetation, and the preponderant share of the botanical affinity of our flora to that of northern Europe consists. This might be illustrated in a variety of ways.

A very large part of the more conspicuous and popularly well-known European genera are represented here;—if not in indigenous, at least in naturalized plants, which the common observer never thinks of eliminating. Illustrations of so familiar a fact are superfluous.

Of trees and shrubs,—the most conspicuous members of a flora, and many of them among the most abundant in individuals,—I find only eleven genera in the British flora which are not in ours likewise; and five of these are probably not truly indigenous to Great Britain. Of the remainder we have here genera strictly analogous to each, except to *Erica*, *Daphne*, and *Ulex*. On the other hand, indeed, we have 46 extra-European genera of trees and shrubs, showing our superior richness in this respect, which has often been remarked upon: but, excepting Heaths, Furze, and Tamarisks, we lack scarcely any North European arborescent or woody type.

As to glumaceous plants,—likewise so prolific in individuals,—only three British genera of *Cyperaceæ* and 9 of Grasses are wanting here.

A vast preponderance of our species throughout belong to genera common to Europe. This has already been noted, as respects the orders, in my former article (p. 216). It is equally true as to the genera, as the following data serve to show.

The Phænogamous genera in our flora, as has been already stated, average three species apiece; and fully half of them are represented by more than one species. But of the 353 extra-European genera, as many as 234, or 66 per cent are represented in our flora by only one species; and of the remaining 34 per cent only 34 genera exceed the general average of 3 species. Only eleven of these, I believe, have as many as 9 species, and six of them have from 10 to 18, which is the maximum. On the other hand 40 of our genera common to Europe are represented in our flora by 9 or more species (not excluding the naturalized ones), and the 34 larger genera average as much as ten indigenous species apiece.

As to the relative number of species in our 34 largest amphigæan genera, it may be interesting to note that their sum in our flora is 637 species; in the Flora Germanica of Koch, 621;—the naturalized plants not being excluded; but these are quite as numerous in the German flora as in ours. Also 20 of these genera are larger in our flora than in the German. If the admitted species were brought to a common standard, the numbers would tell more decidedly in our favor. The large genera of which we possess the superior number of species are *Carex* (132 in our flora to 109 in the German), *Aster* (38 to 8), *Solidago* (35 to 1), *Panicum* (20 to 7), *Polygonum*, *Cyperus* (19 to 7), *Quercus* (18 to 5), *Eupatorium* (16 to 1), *Platanthera* (16 to 2), *Eleocharis* (16 to 7), *Hypericum*, *Polygala*, *Vaccinium* (11 to 5), *Utricularia* (11 to 4), *Scutellaria* (10 to 4), *Rhynchospora* (10 to 2), *Glyceria*, *Rubus*, *Viburnum* (10 to 3), and *Smilax* (10 to 1).

(*To be continued.*)

ART. XI.—*Observations on the Falls of Niagara, with reference to the changes which have taken place, and are now in progress;* by R. BAKEWELL.

IN a recent work entitled "A Manual of Coal, and its Topography, by J. P. Lesley, Topographical Geologist," the author under the head of "Theory of Denudation," makes some remarks which are intended to shew that the Falls of Niagara have undergone little or no change during the last one hundred and seventy-eight years,—with the exception of the lateral fall by Table rock, represented in Father Hennepin's drawing taken in 1678,—and he draws the conclusion that the ravine from Lewiston to the Falls was not caused by the action of the river. He says that "the only change in the Falls since Father Hennepin's day is the diversion of the small oblique cascade from Table rock, and the occasional droppings of the ledge, amounting perhaps in all to a few hundred tons a year." He refers in further corroboration to M. Desor, whose "experience in the Alps led him to feel how refractory such a plate of limestone rock must be, over which all the waters of the lakes might storm for generations without producing a change determinable by ordinary triangulation." Mr. Lesley, in referring to some observations which I had published in the years 1830 and 1846, says, that I was justified by reference to Father Hennepin's drawing in 1678, and Kalm's in 1754, and from reports of old men living in the neighborhood, in assigning three feet per annum as the rate of retrogression of the Falls. In the years 1829, '46, '51 and '56 I visited the Falls. During my visits I have taken many sketches at different intervals of time, and have noticed with much interest the changes which have taken place since 1829, proving conclusively I think, that there is a slow *onward* retrocession of the Falls—that the cataract of Niagara once poured over the precipice at Lewiston, as I have endeavored to shew by description and diagrams previously published. My object in this communication is to corroborate the views there entertained, and to exhibit, *not* what the Falls are supposed to have done in ages past, but what they are *now* doing. And let me first say, that my allusion to Father Hennepin's drawing had reference solely to the *noise* then produced by the Fall, as shewn by the hands of one of the persons in the view being placed on the ears; that further, I never saw the drawing by Kalm; and as to the reports of old men,—when at the Falls in the year 1829, I was informed by Mr. Forsyth, the proprietor of the Pavilion Hotel on the Canada side, that during his residence of forty years the Falls had receded forty yards.

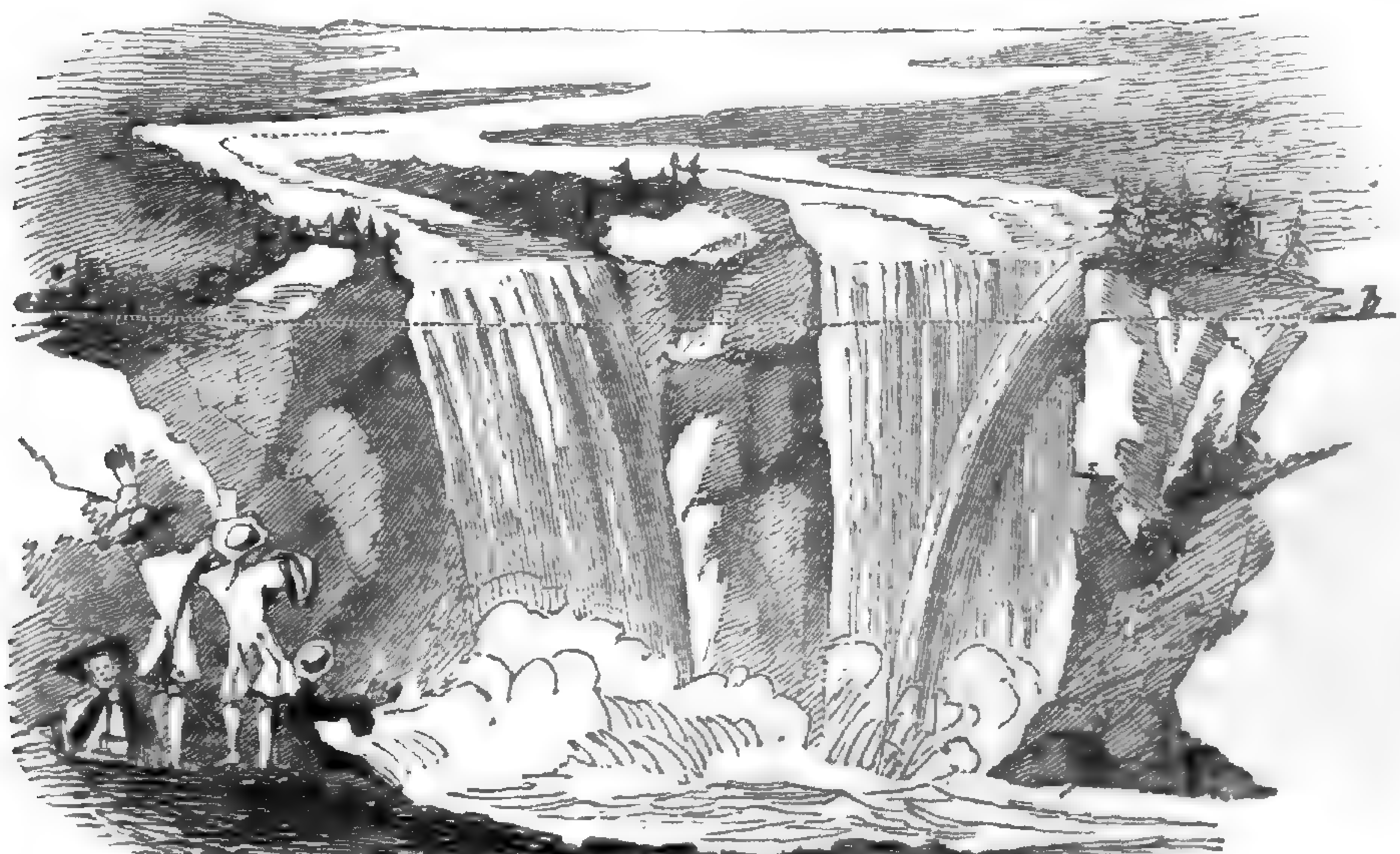
Moreover, with regard to the refractory limestone rock, it is well known and has often been stated that the limestone at the Falls rests on soft shale, only half of the height of the Fall being limestone, and this limestone is carried off, not by the action of the waters on it, but by being undermined, through the erosion of the shale, a rock full of joints, and therefore separating into blocks. The limestone falls away readily when through the undermining action it is left without support. We see therefore no force in the citation from M. Desor.

Every little torrent has its furrowed channel, and often its deep pot-holes, as a result of the action of the water, and it would be most strange, if the great flood of Niagara, should rush on its course for ages and produce no appreciable effect.

A few words on these pot-holes, and the great pot-hole of Niagara, before I proceed. Some of these excavations or pot holes I have measured in situations where there is little water flowing except in the spring of the year. There are three at the Bashapish Falls near Mount Washington, in the state of Massachusetts, succeeding each other in a narrow ravine within the space of forty yards. One of them was twenty-two feet in depth, independently of the debris at the bottom, the depth of which I could not ascertain. The diameter of this circular basin was about three yards. If then, a stream of water, active only a short period of the year, is capable of making such inroads in the hardest rocks, are the Falls of Niagara the only exception? Where, it may be asked, are the pot-holes of Niagara? I would reply: walk on the precipice of the chasm from Lewiston to the Falls, for an answer. Then, in imagination, let the flood above the rapids be held back, the river dried up, the whirlpool emptied of its contents; and then we shall have a magnificent pot-hole, the largest in the world, with two deeply fluted arms stretching north and south, each three miles in length. As I was standing a few yards south of the summer-house at the whirlpool this summer, I was impressed more than ever with what was taking place below me, especially in the very narrow channel through which the rushing torrent darts into the whirlpool. I regard this as one of the most interesting features connected with the Falls, and yet the least thought of by the thousands who visit the place. The gorge through which the waters rush is very narrow: I was told in 1846 by the proprietor of the place that the width was only 72 yards. This I believe to be nearly correct, for at the suspension bridge, which is at the commencement of the rapids, and where the river is much wider, I found by measurement on the bridge that the width was only 118 yards. I noticed that underneath the water, a portion of rock from each side extends, as well as I could judge, about five yards from each side of the entrance into the whirlpool, reducing to sixty-two yards the distance through which is flowing every minute the drainage of four great lakes, covering an area of about 135,000 square miles. The waters escape at the northern extremity of Lake Erie through a channel (as stated by Mr. Allen from measurements by Mr. E. R. Blackwell) 1,700 feet in width, 32 feet in depth, running at the rate of six miles an hour, equal to 22,440,000 cubic feet, weighing 701,250 tons; here the whole is confined to a breadth not exceeding 225 feet, and then it suddenly becomes sluggish at the whirlpool, (fig. 2, *h*, entrance into the whirlpool). The solution is found in the structure of the rocks. The very hard bed of quartzoze sandstone on which the debris at the rapids rests, is here broken through, under which lies a very soft red shale,* which has been scooped out by the resistless torrent from each side underneath this rock to an unknown width and depth. A passage is thus made for the flood to escape. The red shale crops out at Lewiston.

The annexed outline of Father Hennepin's drawing is carefully reduced from the lithographic print found in Lyell's Travels in North America in the years 1841 and 1842. From the original Utrecht edition, 1697.

1.



The drawing must have been taken from a high position, and on the Canada side of the river. Without regarding the straight line on the verge of both falls, it seems to teach that a change more great and surprising than poets yet have feigned has taken place. By measurement, the present distance across the American Fall and Goat Island to the commencement of the Canada Fall is, according to the guide-books, 430 yards, to which, if we add only one-third of the Canada Fall we shall have in all 630 yards.

* This is not the shale under the limestone as seen at the Falls.

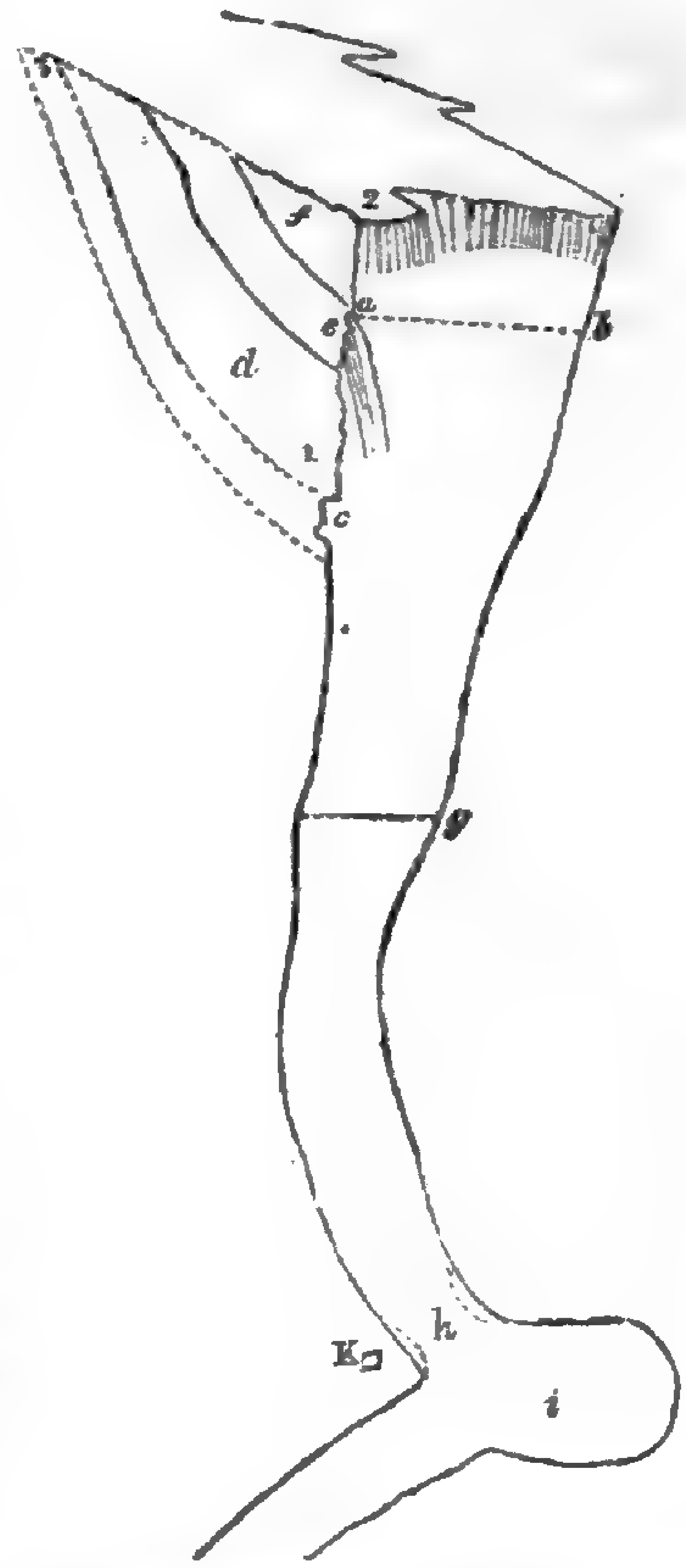
The height of the American Fall is 167 feet. We thence have the breadth equal to eleven times the height of the American Fall. But in the drawing the same distance equals only two Falls, although it represents a front view. To form a more correct idea of the relative proportion of the breadth and height of the Falls and Goat Island as they now exist, I have introduced the line (*a*, *b*) across the drawing. Thus faulty is the view on which arguments have been based respecting the rate of recession.

Father Hennepin modestly complains of his want of skill in description. He writes "J'ay souhaité bien des fois en ce temps là d'avoir des gens habiles à decrire ce grand et horrible saut." Describing the waters on each side of the Island (Goat Island) approaching the precipice—"Et c'est alors qu'elles se précipitent dans une abyme, qui est au dessous à *plus de sixcens pieds de profondeur.*" The height of the Falls he gives as more than 600 feet—more than three times their present height. The lateral fall as seen in profile must have been more than one-fourth of the width of the American Fall.

Mr. Lesley refers to M. Desor, who writes: "that such a rapidity of action by water on rock as three feet per annum (referring to my former statement) is unnatural." He argued that "if we grant the indentation in the American Falls which is only 132 feet back from a straight line across, to have been made since Father Hennepin's time 178 years ago, it only gives a partial recession of nine inches per year and an average of only half that or four and a half inches per year." Taking the recorded falls of Table rock as a basis of calculation, the British Falls could not have touched the American Fall at right angles less than six hundred and fifty centuries ago.

The American Fall has not the material to work with, that belongs to the Canada Falls. In one case the water is but thinly spread over a wide surface. In the other, the water is carried over one-third of the distance in one vast unbroken mass of great depth and volume,—an exhibition of power immeasurably beyond that of the American Falls. We have no definite measurement of the relative amount of water pouring over the two Falls; but we should not be far from the truth in saying that the water descending the Canada Fall is fifty times greater than that of the American. But, again, the inquiry may be made, what were the American Falls doing all these 65,000 years? Whence the necessity of supposing that the American Falls had any existence when the Canada Falls were where the American Falls now are? Six hundred of these centuries may have passed in which the Canada Falls were toiling night and day *alone* in that vast wilderness. It is highly probable that a slight deviation in the channel of the river above the rapids, carried off the waters on the American side more to the northeast, thus producing the American Fall, as may be seen by referring to fig. 2.

2.



c, the cave.
d, elevated bank between the cave and the American Fall.
e, American Fall.
f, Goat Island.
g, Suspension Bridge.
h, entrance into the whirlpool.
i, whirlpool.
k, summer house.

The dotted lines from *a* to *b* may represent the position of the Falls when at right angles with the American Falls (*e*) agreeably to the supposition of M. Desor. But, as I have before said, unless it can be shown that the American Falls *did exist* when the Canada Falls were at *a b*, and continued afterwards to exist, all the calculation based upon the slight indentation backwards in the outline of the American Falls amounts to nothing.

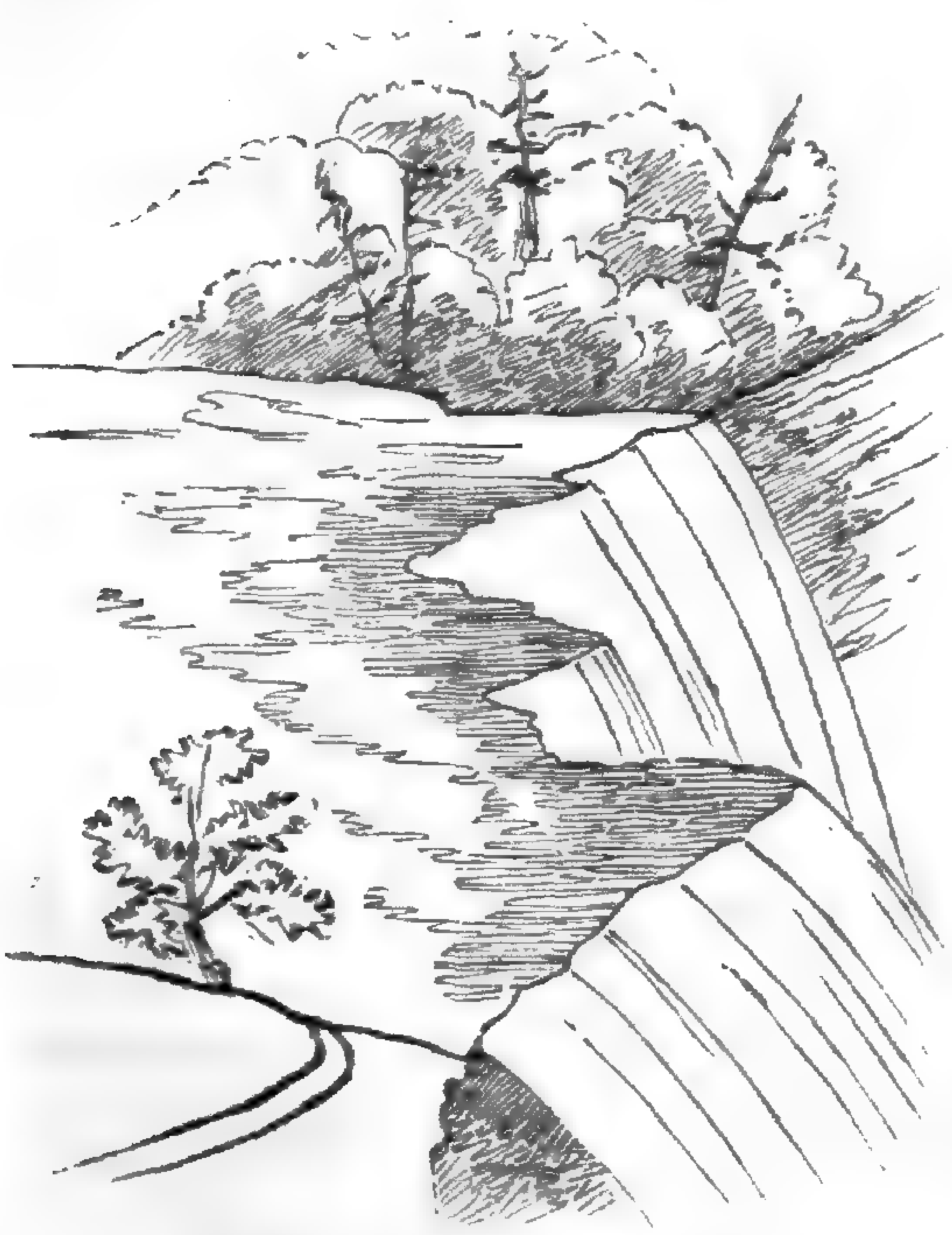
The following facts show that the probabilities are, that the American Fall is comparatively a recent diversion from the main channel, that when the Canada Fall was in the vicinity of *a*, there was a lateral fall at the cave (*c*). The dotted lines representing the course of the supposed river, Goat Island would then include the space in the triangle 1, 2, 3, the American Fall thus having no existence. If the dip of the bed of the river were to incline more to the west, or become deeper it would soon draw off the waters of the American Fall, and we should then have in its place a lateral dry bed, or channel, a repetition of what I believe formerly took place when the flood poured over the precipice at *c*, at a distance of about half a mile from the American Fall. Here, for more than 100 yards, the rock is quite bare, has a water-worn appearance, and presents a very remarkable outline on the edge of the precipice, reminding me the moment I saw it of the ragged outline of the rocks at the brow of the American Fall. It is interesting to compare one with the other. The resemblance is so similar in form as well as depth of indentation, that we might reasonably infer that the time spent on both in wearing and breaking down the edge of the precipice was nearly the same.

Fig. 3 is an outline sketch of the cave about half a mile from the American Fall, taken in 1846. (See fig. 2, *c*.) At the farther extremity of the cave was a small stream of water flowing down the precipice—the remains perhaps of the magnificent flood which once awoke the echoes of the place. In 1856 this had disappeared. The pure cold spring which gushed from the rock

3.

near by is still there. The outline of the American Fall is represented by fig. 4. It is reduced from an extended sketch I took from the top of a Pagoda, standing near what is called "Point view" (in 1846) which explains the map-like appearance it assumes. On passing the bare ledge of rock at the cave we come to a bank of drift thickly wooded, (fig. 2, *d*,) which continues on the edge of the chasm until we approach within a few yards of the American Fall, *e*, these few yards exhibit a zig-zag appearance on the precipice, and bare rock, as if the Fall had once been there, and indicates a movement sideways as well as backwards. The resemblance of this wooded elevation between the cave, *c*, and American Fall, *e*, suggests the high probability that it was once surrounded by water, and assumed the appearance which Goat Island now presents, the flood then going over the precipice of the cave, (*c*). The dotted lines represent the former river—the bed of which I did not trace back to its commencement, although I felt convinced in my own mind, that it did exist. As I had no thoughts of writing on the subject at the time, I unfortunately let the opportunity escape. But it gives me pleasure to say that since the above was written I have unexpectedly conversed with Mr. P., the very intelligent proprietor of this princely domain, and it is his politeness to an entire stranger which enables me to speak with more confidence ou this interesting point. I mentioned to him what my opinion was respecting a torrent having once poured over the precipice at the cave,

4.



and asked him if there was any indication of a bed of a river in the neighborhood of the Falls. Mr. P. informed me that *there is the appearance of a former bed of a river back of the village.* This information enables me with more confidence to trace out by the dotted lines, where it ran. He also informed me that a slight inclination of the bed of the river west of Goat Island had retarded the encroachments made by the current, and that he had thrown out breakwaters for further protection. He observed that the principal changes going on were on the Canada side, and he agreed with me in thinking that the waters were concentrating more into the centre of the Horse-shoe Fall. The falls instead of facing the north, as at present, will, as the waters gradually retire from the Canada side, make a right angle with the river and face towards the northwest, and contract their dimensions within another *narrow* gorge. It is a curious fact which I noticed along the course of the ravine that there are many of these contractions and expansions. There are two from the Falls to the Suspension Bridge, and there are several from the whirlpool to Lewiston.

When the Canada Fall has turned the angle which I think it is now making, the breadth of the river will then be greatly reduced in width, increasing its velocity and depth, causing in all probability the waters of the American Fall to be drawn off, leaving the Canada Falls once more to toil alone.

I was further informed by Mr. P. that the American Fall has been protected from erosion by the rocks which are exposed and piled up at its base. I would in connection with this, again advert to M. Desor's calculation as to the retrogression of the American Fall, to show that if the same method be adopted with the Canada Fall, we shall have a result very near to the statement of Mr. Forsyth before alluded to, viz., that the Falls had receded forty yards in 40 years. If a line be drawn across the Canada Fall from Table rock to Goat Island touching the water on each side, and a perpendicular line to the extremity of the indentation, as found in Prof. Hall's survey of the Falls of Niagara, we shall have a distance equal to 912 feet. Taking the width of the river at the ferry which is said to be 1,254 feet, as a scale of measurement, we shall then have the following result. To the extreme point of indentation 912 feet: half of this for an average depth of the whole Fall, will give 456 feet of recession in 178 years, rather more than 2½ feet per annum. This comes from following the data in Father Hennepin's drawing. But it cannot be supposed that there was no indentation at the time he made the drawing. Prof. Hall has justly remarked that, "in the absence of established landmarks, we are compelled to leave the rate of recession unsettled for the present. The accompanying trigonometrical map of the Falls will furnish the means of doing this, by the monuments which have been established, and which may be considered as permanent points of reference for the future."

Leaving, for the present, all speculation respecting the origin of the chasm extending for seven miles, let us look at the Falls as we *now* find them, and the ravine through which the waters rush on their way to Lake Ontario. On walking from Table rock by the precipice to the whirlpool, the high bank of drift to the left becomes less elevated, and retires a little farther to the west. At the whirlpool it caps the limestone at the precipice, through which there is the bed of a stream and over which during the spring of the year, and during heavy rains, the waters rush over the precipice. Passing this ravine we again ascend over the drift before we descend to the level of the whirlpool, when a magnificent scene opens upon us. Here, we have at one view the high wall-like appearance of the rocks stretching above and below the whirlpool on the American side. On the Canada side two bold promontories mark the entrance and the outlet of the whirlpool. These are thickly wooded down to the water's edge and encircle the scene.* On passing the ravine which is partly filled with drift, extending, as we are informed by Mr. Hall, to St. David's, we continue for a short distance along the margin of the whirlpool before we ascend the projecting rock which hangs over the outlet. The surface of this rock is denuded of drift for a short distance from the precipice, and the surface is very level. I noticed that with one exception, the precipice rises immediately from the river. Where this occurs, an amphitheatre is formed larger, I think, than at the whirlpool, the floor of which is wooded leaving the breadth of the river nearly the same. On passing round this semi-circle, the high drift again comes to the edge of the precipice, and through the drift a dry bed of a stream tends towards the precipice. The rocks on each side, as far as the rapids below the whirlpool extend, preserve about the same distance from each other as they do at the rapids above the whirlpool. The torrent for more than a mile rushes with the same impetuosity over hidden rocks as before, when it gradually subsides and moves on smoothly, but swiftly towards the outlet. On approaching the end of this gorge the drift again is found capping the limestone on which Brock's monument is erected.

* A very interesting incident took place as I was engaged in making a sketch of the scene. A beautiful little bird flew over my head, and perched upon a log of wood which was floating along on the outskirts of the vortex of the pool. I noticed that it did not appear satisfied with its position, and watching it very attentively, I observed (for it was not far from where I was stationed) that having sailed on the log a short distance the bird flew to a piece of wood which the motion of the water caused to tilt up and down. Having secured its hold on one end, it disappeared under the water. As the end of the stick rose with the bird to the surface, the bird fluttered its wings. This was thrice repeated,—after which it flew away.

On the American side, I have followed the ravine from the whirlpool to the Falls, the most remarkable feature is the abrupt turn which the river makes, almost at right angles with the ravine below the Falls. Here is a high bed of drift resting on the limestone.

I will now consider some of the changes which have taken place during the last twenty-seven years. In doing this I do not rely solely on my memory. I have my sketches to bear me out. In 1829 the whole of the Canada Fall was entirely covered with water, no bare rocks were seen as now, peeping out to indicate what was taking place. From below where the tower now stands, the most beautiful feature of this Fall was caused by the obstruction which the flood met with from projecting rocks, causing the water to *boil* over in magnificent white globes, increasing as they descended, at the same time entirely covering the obstruction. A similar obstruction would not now produce the same effect for want of water. The Fall, which was then more circular in form, now assumes a wedge-like appearance, and the deep indentation points to the American side of the river. The center has receded many yards from its former position—not that the whole has gone back, but only where the waters to the depth of 30 feet wheel over the precipice. On the Canada side of the Fall the water is not so deep, is more broken, and falls over more languidly than formerly, as it approaches what was once called Table rock. I miss another exceedingly beautiful appearance, similar to the one before alluded to on the American side. There was then a lateral stream which fell over in the direction denoted in Father Hennepin's drawing (fig. 1). This stream, in falling over the rock, was tossed about by the current of air sweeping from underneath the Fall. In 1846 it was not there. There is, indeed, now to be seen a lateral stream issuing from a hole in the rock; but this is the refuse water of the engine house which is pumped into a reservoir on the high bank. In 1829, as I was standing on Table rock, attempting to take a minute sketch of the Canada Fall, my india rubber dropped from my hand; I made a snatch at it, but it fell down the precipice. The consciousness of my danger, had I made a step in advance, compelled me for awhile to lay aside my drawing. This rock, the principal "stand point" at Niagara is now laying at the base of the Falls, an additional monument to "record the mischiefs they have done."

When at the Pavilion House in 1829, which was situated on the high ground west of Table rock, I made a panoramic sketch from the top of the house. I then saw and represented on my sketch a small bare gravel-patch situated about one-fourth of a mile west of the centre of the Falls, and distant from the Canada side one-third of the way. In 1846 this patch had considerably increased, and some bushes were growing on it. In 1851, when

I made another sketch of the same scene, it had become much larger, its longest diameter being about north and south. In 1856 the bushes had become young trees. Having nothing to compare it with, it is difficult to get a correct idea of the size of this new formed island. Judging from my sketch, I should say that it was about 100 yards long and 20 wide. If correct, the island of 1856 is five times the size of the gravel patch of 1829. My object in being so particular, is to show that there is a gradual and perceptible change going on, drawing the waters from the Canada to the American side, or rather, to the centre of the Fall. To this it may be replied that the increase was simply by deposition. The difficulty in this case would be to arrest the particles of sand and gravel in the midst of such a current. In review of some of the changes now going on, we have immense portions of rock now in sight which *once faced* the precipice at the Falls. We have on record at the present day that there has been a great disruption from falling rocks, hid from sight in the deep bed of the river, which have changed greatly the former outline of the Fall,—the retiring of the waters from the Canada side towards the middle of the river greatly increasing the power at work in wearing away and breaking down the precipice over which they plunge. The face of the Falls assumes a very different appearance from what it bore in 1829, scarred as they now are with deep lines of rock which may serve to indicate change though not enhance beauty.

If then, in the short period of twenty-seven years, so much has been done to change the character of the Falls, is it reasonable to suppose that they present now the same appearance as they did in Father Hennepin's day?

I would make an inquiry of those skilled in acoustics, why it is that the immense body of water which pours over the centre of the Canada Falls is comparatively so noiseless. On thinking of this when last at the Falls, I was more deeply impressed than ever with the fact. We hear the rush and turbulent noise of the waters of the rapids and of the American Falls, and the two sides of the Canada Fall. But that low, heavy, muffled sound is not the deafening roar which we should expect. The only explanation which occurs to me is, that the flood pouring over the precipice *unbroken*, continues unbroken until it reaches the bed of the river, there, first meeting with resistance *under* water, the sound is conveyed away *beneath*, or with *the flood*.

A person with his head under the river at the ferry would, I think, experience a fearful stunning sound. I regret that I did not try the experiment. If the water could for a moment be suspended, the first plunge after, would doubtless cause a terrific noise from the act of breaking the surface of the water; but when this was once broken, and the descending flood was in continuous flow, would not the noise be far less although still powerful beneath the water? I think that the drum must have been unmuffled when Father Hennepin visited the Falls.

In closing these remarks I would express the deep interest which I always take in this magnificent scene. Years have passed away since my first visit, and with them the recollection of much that I have seen of the grand and beautiful in nature. But my impressions of Niagara have not been effaced. And the more I am absorbed by the glorious view, the more does my feeling of its grandeur lose itself in admiration of its beauty.

New Haven, 1856.

ART. XII.—*Biography of Johann Nepomuk von Fuchs;* by FRANZ VON KOBELL.*

* * * JOHANN NEPOMUK VON FUCHS was born at Mattenzell near Brennburg in Bavaria on the 15th of May, 1774. He studied first for the clerical profession, but afterwards gave his attention to medicine, and graduated in this science at Heidelberg in 1801. A residence in Vienna led him to begin the study of chemistry under V. Jaquin, and his liking for this science and for mineralogy became so great that he abandoned medicine, and, supported by his government, went to Freiberg where he heard the lectures of Lampadius and Werner, and made himself familiar with mining and metallurgy. His intercourse with his friend, the celebrated crystallographer, S. Weiss, who was his fellow student at Freiberg, led him to cultivate mineralogy with special zeal. From Freiberg, he went to Berlin and continued his studies under Karsten, Klaproth and Valentine Rose, the latter of whom took a deep interest in his progress. He then made a short stay in Paris where he acquired the esteem of Hauy, as is shown in the correspondence of the great French mineralogist, even where in one case he controverts the views of Fuchs.

In 1805, the subject of our memoir settled at Landshut as *Privat-Docent* in the University there, and in 1807 he was appointed Professor in ordinary of chemistry and mineralogy. At that time he suffered so much from weakness of the chest that no one thought he could survive many years, and although this difficulty never quite left him, he had such confidence in the strength of his constitution that he manifested little anxiety about working in an atmosphere filled with acid vapors and noxious gases.

* Read at the Public Session of the Academy of Sciences at Munich, on the 28th March, 1856. Translated for this Journal by Prof. S. W. JOHNSON, of the Yale Scientific School.

In 1823, he was called to Munich and to the Academy of Sciences as Conservator of the national mineral collections, and when in 1826, the University was transferred from Landshut to Munich, he again entered the corps of professors, and instructed in mineralogy.

In 1833 he was appointed to the Higher Medical Commission, and Counsel of Instruction, and in 1835 he was named Chief Mining and Saline Counsellor, at the same time retaining his previous station. His new duties however were not of a kind compatible with his devotion to investigation, so that he shortly desired to return to his old pursuits, and in 1844, in full acknowledgment of his extraordinary ability he was pensioned as Chief Mining Counsellor, and was thus enabled to pursue undisturbed his manifold studies, which occupied him until 1852, when, at the age of 78 he was pronounced Privy Counsellor, and laid aside his active employments. Fuchs left behind him at his death a widow and one son.

The first considerable research of Fuchs was concerning the Zeolites, which he analyzed partly in connexion with Gehlen. This investigation was broken off by the death of the latter who perished from accidental poisoning by arseniuretted hydrogen, in the year 1815, and Fuchs was so dejected at the loss of his friend that he would never have resumed it but for the severe criticisms of Hauy upon some of the results which had been published.

Fuchs showed that the crystallization of the *Mésotype pyramidée* was not quadratic as Hauy had assumed, but was rhombic, and that Hauy's *Mésotype épointée* was no mesotype at all, but apophyllite. For the first, the difference of angle was only 1°, but this was an important difference, while, in case of the *mésotype épointée*, chemical analysis sufficiently demonstrated its identity with apophyllite. Fuchs also had announced Scolecite as a new species, which Hauy was disposed to doubt, partly from the similarity of its crystallization with his *mésotype pyramidée*, and partly because he considered the old analysis of Vauquelin, who like Fuchs had found lime instead of soda, to be incorrect from imperfections in the analytical method. The results of Fuchs were confirmed, and this controversy contributed to his reputation. In another investigation relating to Aragonite and Strontianite, he also discovered some inaccuracies in the determinations of Hauy, and first directed notice to the great similarity of crystallization between aragonite and strontianite, witherite and carbonate of lead, as also between heavy spar, celestine and sulphate of lead. Fuchs was then inclined to explain this similarity of form by the fact that these groups contain a common member; viz., their acid ingredient. If we combine these observations with an earlier paper of Fuchs, which he wrote on instituting the new species gehlenite, we find the elements of the doctrine of isomorphism that was subsequently announced by Mitscherlich.

In his paper on gehlenite, Fuchs considers the peroxyd of iron which that mineral contains, "not as an essential constituent of this species, but as only a *vicarious ingredient*, if such an expression be permissible,—a substitute for nearly the same quantity of lime, which in the absence of the peroxyd of iron should be present to maintain the stœchiometrical relations of the mineral," and he remarks, "I believe that varieties will be found which contain much less or no iron, and a correspondingly greater amount of lime." In the same article he mentions that sulphate of alumina can form alums, not only with potash, but with ammonia also, or with both together, and that Gehlen had also prepared a soda alum, which fact Fuchs connects with the composition of albite wherein soda replaces potash. How fully he recognized the value of this observation is evident from the following remark: "From this point of view we see that it is requisite to compare the results of many analyses of mineral bodies, if on the one hand we will harmonize their constitution with the doctrines of chemical proportions, and on the other hand prevent an unnecessary multiplication of species." In the same paper he instances correctly the ratio of the ingredients of vesuvian, although he likewise assumes that peroxyd of iron replaces lime. The reason that Fuchs did not then remark that only bodies of analogous constitution can replace each other, doubtless lay in the small quantity of the peroxyd of iron present, so that the difference between it and protoxyd was too slight to direct attention to the fact that the sesquioxyds cannot replace the protoxyds. The merit of Mitscherlich in developing the doctrine of isomorphism is unmistakable, but it were unjust to the memory of Fuchs to deny that by the above observations he first excited attention to this subject, and laid the foundations of our knowledge concerning it.

In 1816, Fuchs published a preliminary notice of some mineral phosphates, and two years later followed his researches on Lasionite and Wavellite.

These investigations distinguished him as a profound analyst. He found that a mineral from Amberg which he named Lasionite, was a compound of alumina, phosphoric acid and water, and after he had overcome the difficulties in separating phosphoric acid and alumina, by an entirely original method, viz., the application of silicate of potash,—he undertook the analysis of wavellite, suspecting that in it, phosphoric acid had been overlooked. In his paper he says—"The thought indeed occurred to me that wavellite which I had never yet seen (at the time of examining Lasionite) could not be very different, but I dared not entertain this idea against the testimony of three most celebrated chemists, Klaproth, Davy and Gregor, who had analyzed it and found nothing in it but alumina and water. Since, however, I have become satisfied," &c. His analysis in fact proved the identity of these minerals.

Already Fuchs had remarked that silica forms compounds in the wet way which perfectly correspond with some that occur in nature. The further study of these bodies continued to occupy him, and therewith are connected his later researches on the formation of porcelain clay, on soluble glass, and hydraulic lime. In his paper on Lazulite, besides proving in this mineral the presence of phosphoric acid, which had been overlooked by Trommsdorf and Klaproth, Fuchs makes the first mention of the fact that various insoluble silicates, viz., lazulite, prehnite, zoisite and vesuvian, are decomposable by acids after strong ignition.

In 1821, Fuchs analyzed wagnerite which had been previously confounded with topaz, and showed it to be a compound of phosphate of magnesia and fluorid of magnesium.

In the train of these researches appeared that on the formation of porcelain clay. At that time it was thought that potash feldspar was the material from which this clay was produced. Fuchs first showed that clay may originate from other minerals, and proved that the porcelain clay of Passau results from the decomposition of the so-called porcelain spar, which, it is remarkable, has hitherto been found in no other locality. So much vagueness still exists among mineralogists with regard to the process of weathering, that it may not be useless to recall the explanation of Fuchs. He says: the process of weathering is something similar to the spontaneous decomposition of organic bodies, and has been not unaptly compared with fermentation. Hence porcelain clay has a constant composition, and for this reason we must consider it as a distinct species, and not merely append it to porcelain spar, as Hauy, in the belief it originated from feldspar, has attached it to that mineral, under the name *Feldspath-Decomposé.* The porcelain clay has no more in common with porcelain spar, than alcohol has with the sugar from which it is derived, and it sounds just as strangely to call the clay decomposed porcelain spar as it would to designate alcohol as decomposed sugar. On occasion of these researches, Fuchs analyzed the precipitate first observed by Guyton Morveau, which falls when potash solutions of silica and of alumina are mingled together; and found that it contains a considerable quantity of potash, and that when it is treated with lime it gives up potash, and forms a compound similar to scolecite. In this connection, he observes, with regard to fluxing silicates by fusion with alkalies or other bases, that this process consists in the formation of "a new body, a new mineral, so to speak, which is similar to or identical with those natural compounds that are dissolved or decomposed by acids." Already in this paper occurs a passage reminding of the views of Fuchs on geological changes and his reaction against Plutonism. It reads—"Since, according to the foregoing observations, silica and alumina together, are a means of precipitating the fixed alkalies from their solutions, we have a way of explaining how potash and soda could be removed from the waters of the ancient world, and enter into the composition of feldspar, mica, &c., a consideration that would be very important to the geologist."

Fuchs always devoted great attention to blowpipe experiments, and to him we owe the characteristic reaction of phosphates; viz.: the greenish tinge they communicate to the flame after moistening with sulphuric acid; as well as the distinction between potash and soda by means of the yellow or reddish-violet colors they respectively impart to the flame of the blowpipe. The reddish color which spodumene gives the flame had fallen under his observation before the discovery of lithia, and I remember his expression of chagrin that he had omitted to investigate the cause of this coloration, for he was convinced that otherwise the discovery of lithia would not have escaped him. On the 27th of March, 1824, Fuchs delivered the customary oration before the Munich Academy of Sciences, and chose for his subject—the reciprocal influence of Chemistry and Geology. He showed that a great gap would be formed in chemistry should mineralogy be separated from it, and that the conclusions of the chemist cannot be drawn from chemical relations alone, but that he is greatly and indeed chiefly dependent upon the external or physical characters from which we first derive our conception and knowledge of bodies. He illustrated the importance of crystallography, and reminded how the chemist is often obliged to combine a problematical body with other substances, in order to recognize it by means of the physical characters of the product. Thus, alumina is united to sulphuric acid and potash, and then decisively made out from the octahedral form of the resulting alum. As thus, the physical properties of bodies serve the chemist, so in a much greater degree, the chemical characters assist the mineralogist. Fuchs asked—what would mineralogy be without chemistry? and replied—without chemistry, mineralogy would be but a chaos. She could never have assumed a form at all satisfactory or consistent with just expectations. Only a glance at the history of mineralogy is needful to see that it has not become what it now is by innate strength; it never could have learned the whole breadth of the applications of crystallography, even but by the help of chemistry. I am convinced, says he, that without the latter science we should to-day be seeking to find specific distinctions for minerals in the confusion of accidental forms and aggregations, in unimportant colors, degrees of transparency, &c. Minerals of crystalline, massive and earthy formation would be ranked together, and the mineralogist would go idling about among accumulations of moulds and marls among numberles varieties of clay, sand, wacke, &c. Who would have ventured to unite rock-crystal with flint, or calc spar with chalk, had not chemistry proved their essential identity? Fuchs denounced the so-called natural history method of Mohs, saying that it is mere fancy, not law:—it is not written in the book of nature that mineralogy has to deal only with the obvious external characters of minerals. The object of the science is to learn to recognize and distinguish minerals, and to acquire a comprehensive and thorough knowledge of them. This object cannot be attained without the assistance of chemistry.

In 1825 appeared a paper on soluble glass, a substance which has become useful in several ways, and still presents various interesting points for investigation, especially the nature of the precipitates it produces in solutions of metallic oxyds. Fuchs had already at that time directed notice to these precipitates, and had mentioned as characteristic the blue color which is obtained with cobalt salts. The first industrial application of the soluble silicate of potash was for rendering edifices fire-proof, and was made in 1824 on the then newly erected Theatre in Munich, after the necessary preliminary trials had shown the process to be satisfactory. The chief advantages of this substance lie in this, that it exerts no detrimental action on the combustible to which it may be applied, but rather serves eminently to shield it from damage by other causes, forming in fact, when properly prepared, a perfectly coherent and very durable coating, which suffers no change from meteoric influences, and furthermore is inexpensive. Fuchs showed that it might be used to make linen fire-proof as well as wood, that it could be employed in preparing artificial stone, and for cementing glass and porcelain. He also proved that the presence of lime and metallic oxyds in common glass is not so unimportant as had been supposed, and that from a pure silicate of potash or soda a durable glass cannot be manufactured. To what a degree the applications of soluble glass have recently been increased, is learned from a late account by Baron Liebig, wherein he mentions the extensive fabrication of it carried on by his friend Kuhlmann at Lille, and describes how it is used in enormous quantities to prevent the decay of walls, dwellings and churches, even when built of very inferior stone, besides being employed in print-works and tapestry-factories to fix colors upon cotton and paper. Liebig expresses himself "astonished and ashamed at this—ashamed because in Germany soluble glass exists only in chemical treatises and because he knew with what disappointments Fuchs was obliged during many years to contend, before he could see realized but one of its many useful applications." In immediate connection with the discovery of soluble glass, stands the art of *Stereochromy*, a a style of fresco-painting invented by Fuchs, a complete account of which he wrote but a short time before his death and left behind him, as an invaluable legacy to art. Kaulbach has the merit of first recognizing the advantages of this method, and putting it in use. His great frescoes on the New Museum at Berlin are stereochromically painted, and very recently we have seen specimens of this kind executed by Echter, for the Strasburg Minster. They are perfectly successful, and, it deserves to be noticed, are painted directly upon the sandstone which is used as building material. In carrying into practice the idea of fixing colors by means of soluble glass, numberless difficulties presented themselves. It was found, for example, that several new pigments must be invented. Fuchs finally succeeded in this, and among others he produced a white pigment of the finest quality, and especially faultless in its most important application, viz.: for mixing with other colors. This color is now used in oil painting. Stereochromy has decided advantages over ordinary fresco and encaustic painting, for the artist enjoys full freedom in laying on his colors, he is not confined to any limited time, he can alter and improve at will, because the fixing of the color is done after the painting is finished, and is to a certain degree a technical operation, which may be left to ordinary workmen. Numerous experiments have demonstrated the unchangeableness and durability of these pictures, many specimens of which have been purposely exposed to the severest trials without suffering injury. In 1851 Fuchs received a prize medal at the Great Exhibition, for this invention, and before his death, had the satisfaction to see stereochromy appreciated in his native land, and especially by his majesty, the reigning King Maximilian.

(*To be continued.*)

ART. XIII.—*On the Presence of Fluorine in the Blood;* by JEROME NICKLÈS.

FOR reasons which I shall soon have occasion to present, I have been led to verify the assertion so much contested, of the existence of fluorine in bones. My results having been in the affirmative, I next looked for fluorine in the blood—the only means by which it could penetrate into the osseous tissues. I have found there notable proportions, not only in human blood, but also in that of several Mammalia, (as the sheep, ox, dog,) and several birds (the turkey, duck, goose, hen).

Results so concordant, seem to give to fluorine an importance which it has not yet had in medicine and physiology. They set aside the opinion of Berzelius that the presence of fluorine in the bones is purely accidental and not in any case a necessary ingredient. If we wish other proof of the necessity of reconsidering the conclusion of this illustrious chemist, we have them in the following facts: that fluorine exists in the bile, in the albumen of the egg, in gelatine, in urine, in saliva, in hair; in a word, the animal organization is penetrated by fluorine and it may be expected to be found in all the liquids which impregnate it.

In view of these facts, which I have verified with exactness and all possible care, it is evident that fluorine plays in the blood and other liquids of the system a physiological part. Its absence or its diminution must constitute of itself a state of disease, a species of chlorose from the absence of fluorine, analogous to the chlorose from the absence of iron. This disease may be detected no doubt by a chemical examination of the urine or saliva, and may be met by a fluorid preparation. Thus far, my own experiments have been made only on normal urine, from an adult in perfect health or from healthy children.

On another time I will make known the simple process by means of which I have been able to recognize the presence of fluorine in all kinds of substances.

Nancy, Oct. 30, 1856.

ART. XIV.—*Correspondence of M. Jerome Nicklès, dated Paris, August, 1856.*

Obituary of Gerhardt.—The same week witnessed in France and England the death of two distinguished geologists, Buckland in one and Prévost in the other, both more than seventy years of age. These two learned men lived long enough to see the triumph of their views, and reap the fruits of their labors. But what have we to say of the young man, strong and full of health, who but yesterday made a great sensation by the profundity of his conceptions, the novelty of his ideas, and the brilliancy of his discoveries, and who has fallen at the age of forty years, almost without having been ill? Gerhardt closed his eyes the very day after giving up the last proof-sheet of his *Traité de Chimie Organique*, a continuation of the work of Berzelius. On the 19th of August, in consequence of an acute peritonitis, he died at Strasbourg, where he occupied the Chair of Chemistry in the Faculty of Science.

Born at Strasbourg, Aug. 21, 1816, he was destined by his father for trade, as a manufacturer of white lead; but like Laurent* he showed no liking for that career, and made every effort to extricate himself. He had acquired some notions of chemistry at the gymnasium of Strasbourg, where he had studied, and often applied himself to questions

* See the biography of Laurent in this Journal, Aug., 1853.

which the state of the science did not enable him to settle. At eighteen years of age he was directed by his father to travel at the expense of a business house for the sake of selling their manufactures. This employment of traveling clerk, though not congenial to him, gave him an opportunity to satisfy partially his inquiring spirit. It was thus that he reached Leipsic, where he sought out Prof. Erdmann who admitted him to his laboratory. At this time he had not learned to observe. Endowed with a vivid imagination, he allowed himself to be led by a preconceived idea and gave to it a degree of confidence not always warranted by facts. His first works especially bear this mark. They drew upon him severe criticism, and were the cause of intemperate discussions not yet forgotten. These discussions more than once occasioned for him wakeful nights; but they contributed on the one hand to call attention to him, and on the other to make him doubt his speculations, and submit them to experiment before publication. From this time he changed his methods of work and devoted to the laboratory a part of the time he had passed in his study. In this he was greatly aided by Laurent, who, in adopting his opinions on many questions, especially the constitution of draconic acid, and by admitting his equivalents for it, gave to Gerhardt and his theories an importance which before had been refused.

His first work was a note upon silicates, soon followed by another on the essential oil of elecampane (Helenium), containing extraordinary numbers and formulæ, which afterwards he himself corrected.

After he had learned with Bacon that in experimental science, experiment before everything else must decide, his synthetic and sagacious mind was of great service to him. At the occurrence of some ideas on the constitution of *Salicine* he made experiments which led him to a new method of preparing salicylic acid. He also prepared the nitrosalicylic acid and was not slow to suspect its identity with the indigotic acid, which he had never seen. He prepared the latter and ascertained in fact the correctness of his opinion.

Gerhardt was then twenty-five years old. Having quarreled with his father when he decided to devote himself to science by entering Erdmann's laboratory, he was soon obliged to leave for want of means. He returned to Strasbourg, but not having been able to overcome his father's will, and not being willing to pursue a career to which he was more and more opposed, he cut everything short by becoming a soldier. At nineteen years we see him enrolled in a regiment of lancers, doing military duty, grooming his horse, and mounting guard, while thinking still of chemistry and vaguely catching glimpses of relations which had not before been suspected.

But if being a traveling clerk was opposed to scientific speculation, military service was still more so. His father yielded, bought him off, persuaded that after this lesson the son would be docile. But the vocation of the young man was determined, and the promises he had made and the remonstrances of his father were alike powerless before his irresistible passion for science.

The year after Gerhardt was at Paris, having previously passed some months in Liebig's laboratory at Giessen. Without position or money he lived by making translations or giving lessons in chemistry. He made the acquaintance of Cahours, and undertook with him researches upon the essential oil of *cumin*, and made by means of it a series parallel to that which Laurent had established with benzoic acid. Noticed by Thenard, who, as far as he could, used his influence to give the means of work to young men who appeared to him to love science, he was soon in a condition to continue freely his labors. Thenard did for him in fact what he had done for so many others. He committed to him the chair of chemistry in the Faculty of Sciences at Montpellier, on the 16th of April, 1841. Gerhardt delivered as his inaugural address a remarkable memoir on chemical equivalents, advancing new equivalents, which, rejected then by all the chemists of his time, led him to fruitful results, among which may be mentioned the theory of homologous bodies, first brought out in his *Précis de Chimie Organique.*

As if he foresaw his premature end, Gerhardt was in haste to produce. His communications to the Academy succeeded one another with a rapidity that justified the distrust generally accorded to the results which he announced. Thus did he rudely expiate the errors of this first phase of his scientific career. But as has been said, he was not at this time the master of his imagination. However, all was not error in his assertions. Gerhardt had seen the truth in spite of his superficial and imperfect experiments,—as shown by the transformation of the essential oil of mustard into that of garlic, and the formation of nitrous ether by brucine and nitric acid. Much has been said and written against this last announcement made known in 1844; and about *quinoline* too, a volative and oily alkali found by Gerhardt in the products of the decomposition of quinine. Nevertheless this alkaloid exists: but as it was the first time that a product of the decomposition of alkaloids had been studied, its composition appeared more than doubtful, its properties having been imperfectly investigated. Emboldened by his imagination, and urged on by other ideas, Gerhardt threw open the subject to discussion by publishing it in the *Comptes Rendus* of the Academy of Sciences.

His inconsiderate publication on the formation of nitrous ether by means of *brucine* is due to a similar cause. Laurent was the first who did not absolutely reject the conclusions of this research,* so severely criticised by Liebig.†

It is true that at that time nothing allowed him to comprehend, much less to explain, the presence of the radical alcohol in an alkaloid, and before admitting such an opinion it was right to demand some well observed facts. The facts were sought for in vain in the memoir. They were afterwards discovered by the pupils of Liebig, who occupied themselves with the subject on the invitation of their master; their explanation is found in the works of Wurtz and Hofmann, *Sur la formation des bases organiques amminées.*

Gerhardt remained at Montpellier till 1848. His instructions had been attended with moderate success. Hoping for a chair at Paris he went to the capital at the end of March. This time the expectations of the chemist were entirely at fault. He was deceived, but on the other

* M. Liebig et la Chimie, Revue scientifique et industrielle, 1846.
† M. Gerhardt et la Chimie, ibid., 1846.

hand he met Laurent, who during these interviews was appointed to the Mint. Laurent was then arranging a small laboratory and with characteristic generosity he offered his hospitality to his friend.

Gerhardt now passed all his time in the damp and dark cellar where Laurent laid the foundation of the disease which prematurely caused his end. A great number of works published in common owe their origin to this partnership. Discussion was the order of the day in that laboratory and it continued in the presence of a third person, competent or not. The crucible had not time to grow cold, but was always on the fire.

Toward the end of Laurent's life, Gerhardt, to increase his resources, opened a laboratory for pupils. This enterprize had but little success, both because of the method which was there pursued and because of the inattention of the instructor, who seldom appeared, less from want of inclination than from lack of time. For, seeking security where there was none, he had undertaken all sorts of writing, and dissipated his strength in all sorts of directions, solely to be able to meet his engagements. Thus, he agreed to contribute to Bouillet's *Dictionaïre des Lettres des Sciences et des Arts* all that pertained to science, although he knew nothing but Chemistry! He undertook translations, wrote short treatises, and thus robbed science forcibly of precious time which he could have rendered more productive if his means of support had been guarantied. He remained in this precarious condition till February, 1855, when by the intervention of Dumas he was called to the Faculty of Sciences at Srasbourg. One idea governed him from this time,—to prepare a treatise on organic chemistry in continuation of Berzelius, a work he had commenced four years before under the following circumstances.

One of his friends, a chemist and somewhat of a physicist, who was also then in adversity, had just made an invention which was full of promise, and the success of which would secure him ease if not a fortune. This friend awaited only the realization of his hopes in order to buy up the whole edition of the *Traité de Chimie*, (which in Gerhardt's opinion had need of recasting,) and thus to withdraw it from trade so as to force its author to make a new edition. He informed Gerhardt of his project and invited him to enter upon the work without delay. The latter gave no occasion to repeat the proposal, but went to work with his accustomed eagerness, and in two months his work was almost done.

But before his friend was able to carry out the plan, an opportunity offered for completing the French edition of Berzelius. The idea of introducing his views and opinions into the work of his illustrious and terrible adversary pleased Gerhardt as much as the certainty of having for readers in France all the readers of the distinguished Swedish chemist. He put himself to the work, making a concession, however, on the subject of his notation. It consisted in marking with a bar the symbol of which the equivalent is represented by two atoms, such as ammonia which Berzelius represented by Az^2H^6 and which the partisans of equivalents wrote $Az\,H^3$. To reconcile such different notations Gerhardt wrote the A and H with a bar across, a manner of writing formulas already employed by Berzelius and which serves to show that Az and H^3 should be taken twice to represent one equivalent of azote and three of hydrogen.

Aside from this slight concession, Gerhardt presented his views and theories with all the rigidity of system. Knowing the great service which his ideas had already rendered to science, he had the right to believe that their part was not yet ended; only like all innovators he carried his conviction even to fanaticism. Less benevolent than Laurent, he did not allow his pupils to hold other views than his own, but like him he seized every opportunity to make known his ideas; all situations were good for this; but in talking chemistry he did not ask if his interlocutor understood chemistry, or if he knew of what it treated. If his partner was competent he often gave answers which provoked reflection and thus brought light on points before obscure,—the contradictor thus becoming, in the language of another, "*accoucheur d'idées*," and rendering a service which he rarely suspected.

It was thus that the idea of *paramorphism* came to Laurent at the end of a conversation with a friend of his, a chemist and crystallographer, who designated a particular case of isomorphism by the name of *isomorphisme de transition*. It was thus also that the idea of the chemical series came to Gerhardt at the conclusion of a conversation with a socialist, and with the botanist Dunal, whom science has just lost.

Nothing gave a premonition of the sudden death of Gerhardt. Five days before his death he had bathed in the Rhine and had corrected the last proof of his treatise on Organic Chemistry. Several times, however, he happened to say, "Provided I shall be able to finish the publication of my treatise." Having been on the evening of the 15th of August with Mad. Gerhardt to see the illumination of the Cathedral of Strasbourg, he said "I shall never see it thus illuminated again," he returned immediately, complained of cholic, and three days afterward he could say like Laurent, "I shall never see the triumph of my ideas."

Gerhardt had the good fortune to perceive the necessity of having an organ where he might make known his ideas. In 1845, he established the *Comptes Rendus des travaux de Chimie exécutés aux laboratoires de Bordeaux et de Montpellier*. In these *Comptes Rendus* he also analyzed from his own stand point, works published by other chemists and was not slow to raise against himself a general outcry from the freedom of his opinions and the boldness of his criticisms, which, it should be remembered, never went beyond the demands of courtesy and always left persons out of view in the question. It is known that his adversaries were less generous, and the epithets of deceitful man, and highway robber were lavished on him and Laurent. Justice has for a long time been done him, and those who uttered this injurious language were the first to regret it, and to agree that there was some good in the ideas originally condemned.

His *Comptes Rendus des travaux de Chimie*, a journal full of originality which will one day command a price like that of the *Memoirs d'Arcueil*, had a select and discriminating circle of readers. Notwithstanding this, the publisher, did not pay his expenses. Gerhardt then offered his aid to the *Journal de Pharmacie et de Chimie*, an important publication which worthily maintained its rank by the side of the *Annales de Chimie et de Physique*, and after 1846 he prepared for that journal, *la Revue des travaux Chimiques publiés à l'étranger*, a review which has twice since changed its editor.

In the hope of increasing his resources, by assuming in addition to a chair in the faculty of Sciences a chair of Chemistry in the School of Pharmacy at Montpellier, he entered the School of Pharmacy at Strasbourg in 1844. He there sustained a thesis, entitled *Sur la generation d'Ether*, in which he considered ether as a pyrogenous substance. This discussion caused a sensation, because of the difficulties raised by the Professor of Chemistry, then also Director of the School. He was a chemist little known, and jealous especially of young men who promised to distinguish themselves in science. But the objections which he raised against Gerhardt did not prevent his reception as a pharmaceutist, nor his succession soon after to the same chair of Chemistry. Gerhardt occupied this post at the time of his death.

This notice hastily written makes no pretension to being a biography of Gerhardt, and still less a critical examination of his works. Like the notice of Laurent written soon after his death in April, 1853, it is designed to aid whoever will write the history of these remarkable men. The moment of undertaking that task is not yet come, for no one can now determine the part which these two innovators have taken in the scientific movement of modern times, and the influence which they will have exerted on the progress of chemistry.

Submarine Telegraph.—According to late accounts, the telegraphic cable which was to connect Algeria and France had been laid up to a few miles from Galite, having traversed depths of 200 metres and more. A supplementary cable had been ordered at London, but while waiting for this supplement which was all that was necessary to the completion of this great work, a break was discovered in the cable already submerged—at a distance of 500 fathoms from the ship employed in the work.

Society of Acclimation—Results at the Central Nursery of Algiers.—We have already said that the government had established at Algiers a nursery for the purpose of experimenting upon the acclimation of vegetable productions. M. Hardy, the Director of this establishment, gives the following information:

Caoutchouc.—Three specimens of *Ficus elastica* from the coast of Coromandel, were planted about 12 years since. They are near 10 metres high and their trunks are 80 centimeters in circumference at one metre from the soil. Their branches which extend horizontally, occupy very great space, and from their branches spring new roots which planted, add greatly to the vigor of the tree. This mode of cultivation demands great areas.

M. Hardy has drawn from these trees a moderate quantity of caoutchouc, which was placed in the Universal Exposition of 1855. He hopes for much greater results, as a number of questions relative to these trees yet remain unsettled.

Wax and Tallow.—M. Hardy has not yet succeeded in acclimating plants of the family of *Guttiferæ.* The *Myrica sebifera*, of Louisiana, prospers, but needs marshy soils.

The *Croton Sebiferum* from China, is very prosperous. It is now six years old and commences to bear fruit. The wax palm, *Ceroxylon andicola*, which grows in the Andes gives hopes. The sugar-sorghe secretes at the surface of its stalks of full maturity, a white resinous powder, from which candles could be made. A hectar of Sorgho gives more than 100 kilograms of this substance.

The trials made to acclimatize the trees of Gutta Percha have not yet been successful. The same is true of the trees of quinina.

Artesian Wells in Paris.—The construction of Artesian wells in the *Bois de Boulogne*, spoken of in a previous number, is progressing with activity. The boring is now carried down 435 metres, and it is hoped to reach by the end of October a depth from which the water will rise.

No difference has yet been experienced in the nature and thickness of the earth pierced by the auger and that which it was necessary to pierce for the establishment of the Artesian well of Grenelle. It is known that the section of the wells at Passy will be 60 centimeters in diameter throughout its depth, and that it will be sunk at least 25 metres in the humid bed of greensand that lies at an average of 550 metres below the plain of Passy.

The boring is much easier at Passy than at Grenelle. The construction of the latter well continued through seven years; and it was several times abandoned because of discouragement. Arago and Hèricart de Thury by urgency secured the resuming of the works which it is well known were crowned with success, a jet of water having been obtained rising 28 metres above the soil.

When the well at Passy shall be finished its sides will be supported by an oak lining forming a *tube de retenue ;* such tubes have previously been of iron.

Unexpected accidents sometimes impede work. For some months the boring machine was occupied, at a depth of 366 meters in a mass of gray sandstone, where the resistance was so great that a part of the instrument weighing 50 kilogrammes rested in the rock. It was proposed to extricate it by means of powerful electro-magnets, but it appears that the German laborers employed in the work opposed this experiment so decidedly that there was no other resource than to break the piece of iron by the chisel. Thirty-three days were spent on this tedious task. The pieces of apparatus are now arranged in order among the specimens of strata successively traversed, making a very interesting collection.

Charts of the Ecliptic.—Some time ago, on the proposition of Lalande, the Academy of Berlin undertook the first chart of the ecliptic. Their earliest reward was the discovery of the fifth small planet by Mr. Hencke of Driessen. Toward 1847, Mr. Valz of Marseilles developed a plan, the execution of which would lead to the detection of all the planets in the zodiac. Mr. Chacornac, then studying astronomy with Mr. Valz, immediately applied himself to these new charts of the ecliptic. Two months afterward, Sept. 1852, he discovered a new planet. England and Ireland engaged in the same direction; Hind and Cooper were soon to distance the French astronomers. However Chacornac, who meanwhile had been attached to the Observatory of Paris, continued his charts. They have just been published at the expense of that observatory. They will be more complete than the former, and quadruple the dimensions of those of Berlin, the scale being 50 millimetres for each celestial degree.

These charts contain all the stars of the 12th magnitude and many of the 13th magnitude: they extend above and below the ecliptic to 5° of declination. Their form is square. The number of stars inscribed on them already surpasses 125,000.

Aërostats.—The Academy of Sciences in Dijon having asked of that in Paris aid and money for an aërostatic ascension *à ballon captif* which it proposes to cause, a discussion arose in the Academy of Paris in regard to the utility of such ascensions were for scientific purposes. Marshal Vaillant, Minister of War, mentioned on that occasion the trials made in the Spring of 1855 at Vincennes under the direction of Artillery, Engineering and Marine officers. The object was to ascertain if it was possible to maintain a balloon 5 or 600 meters above a fortified town, and if so, to cause incendiary or fulminating balls to fall. Nothing was successful. The commission made two balloons, spent much money and gave up every thing. According to Vaillant, the force of a wind even moderate will always be enough to drive to the earth a captive balloon.

Biot on the contrary defended ascensions *à ballon captif*, having a scientific object. If the descent of the balloon is dangerous above a place of war it is otherwise in an open plain.

Biot who made in 1803 with Gay Lussac a celebrated ascension recalled the many and fruitful experiments made by the school of *aërostiers* founded under the first Republic and which rendered great service in the sieges of Charleroi, and Fleurus.

Jomard, the geographer, who attended this school stated that he had made and witnessed since 1797 a great number of ascensions *à ballon captif* and that Col. Coutelle, sub-director of the school of *aërostiers* never doubted the utility of such ascensions when well directed, which may not have been the case at Vincennes.

Correspondence of Jerome Nicklès, dated Oct. 30, 1856.

On Perfumes.—A new branch of industry is on the point of being brought out in Algeria, which will not fail to be introduced into other countries. This industry is that of Perfumes. A laboratory process has given origin to it. We have spoken several times of the experiments of Millon on wheat. On treating wheat or its farina with ether, some fatty or waxy matters are dissolved, which are more or less colored, and almost always have a strong odor; they are identical with the extract from the grain taken in mass. This aromatic principle is very persistent and may be distinguished still in the fatty matter after several years, though disappearing at the moment the fat becomes rancid.

This fact led to the experiments of which I speak, which had in view the extraction of the aromatic principle of flowers and of some plants peculiar to Algeria.

To avoid the alterations which flowers undergo on drying or distillation, Mr. Millon separates the aromatic part by dissolving it in a very volatile liquid which is afterwards expelled by distillation. With such a solvent, the distillation is attended with no inconvenience, for it may be performed at a low temperature; this chemist finds that the perfume undergoes alteration whenever a temperature is applied above that of the surrounding atmosphere. In some parts of northern Africa, the thermometer reaches $+70°$ C.; he then employs with success the volatile solvents, such as sulphuret of carbon, ether, chloroform, wood spirit, the point of ebullition in which is below this temperature. He has even succeeded with alcohol, whose point of ebullition is above 70°.

The solvents which succeed best are ether and sulphuret of carbon. The flowers are put into the apparatus, and the ether then poured on so as to cover it. In 10 or 15 minutes the liquid is run off and a new quantity of ether introduced to wash out what is left; this remains as long as the first. The ether dissolves all the perfume and deposits it again on distillation in the form of a variously colored residue, sometimes solid, sometimes oily or semi-fluid yet becoming solid after some time. This residue, when obtained in a thin layer, is fused by the solar heat or an equivalent temperature, and resoftened frequently until it exhales no longer the odor of the solvent.

The solvent, ether or sulphuret of carbon, should have been previously purified with the greatest care. That derived from the distillation may be used indefinitely, provided it is for the same flower and apparatus. Properly managed there is but very little loss of the solvent and the distillation is rapidly performed, much more rapidly and with a larger amount of leaves and flowers than by the ordinary method of distillation. But the gathering of the flowers should be done at the proper time of day for each flower. Thus the Carnation gives off its perfume after an exposure of two or three hours to the sun. Roses, on the contrary, should be collected in the morning as soon as well open; the Jessamine before sunrise.

In the distillation, as hitherto carried on, all the modifications of the flowers are mixed in one and the same essence, which corresponds to no one of them, the better portion partly correcting the rest. But with the Millon process, the slightest alteration is apparent in the perfume, and in order to obtain the freshness and delicacy of the flowers, it is necessary to have them fresh and sweet. The perfection of the flowers determines the perfection of the perfume.

At first, Millon operated by shutting out the contact of the air. But now he favors its presence, for he has found that the perfume, instead of dissipating rapidly like the essences, has great fixedness. It is only through contact with other principles of the plant that it undergoes alteration. Once isolated it is beyond their influence and experiences no further change. Millon thus for several years has kept perfumes at the bottom of open tubes or capsules open to the air without sensible alteration; and according to him, this fixedness or resistance to atmospheric change is a fundamental characteristic of perfumes.

It has not been possible yet to submit the perfumes to elementary analysis, the flowers furnishing so little of it; a kilogram giving only a few milligrams of the aromatic principle.

The residue of the operation by ether or sulphuret of carbon contains wax and fatty and coloring matters, and it is very difficult to separate the aromatic principle from them. Alcohol answers best for this purpose. It does not dissolve the waxy part, while it removes completely the odor. Operating with alcohol on a grain of the residue, the perfume is taken up with a little oil and the coloring matter, and the aromatic residue will have lost in the process only a few hundredths of its weight.

The perfume is almost indefinitely diffusible in the air, showing its presence by its odor, without any sensible loss of weight. It is equally diffusible in *distilled* water, when some drops of an alcoholic solution are poured into it; but in ordinary water the odor is dissipated, showing its easy alterability with reagents.

The facility with which these perfumes dissolve in alcohol, oils and fats, shows the ways in which it may be industrially employed. The essential point is that the small quantity of product afforded by the flower represents exactly the amount of perfume; and a gram of residue proceeding from a kilogram of flowers aromatises to the same degree fat or oil, and under a volume a thousand times less produces the same effects.

The process, then, takes the volatilisable part of the flower, concentrates and preserves it, and puts it up for transfer, without loss, to the perfumery shops, where the final preparations are made. Moreover, the work of incorporating the perfume of the flowers with the fats and oils, to-day so costly and so incomplete, will be replaced by a simple mixing or solution which may be done at any convenient time or place. It is for perfumery, a new art of extreme simplicity.

The interest which attaches in France to these researches of M. Millon will be understood when it is noted that the exports of perfumery from France amount to more than thirty millions of francs per year.

Manufacture of Aluminium.—We have more than once spoken of the efforts employed to render the preparation of aluminium an industrial operation. Dumas has just announced to the Academy that this problem is now solved. He has stated that the manufacture is actually carried on by workmen in a small shop in the Faubourg St. Jacques, at Paris, connected with a manufacture of chemical products. The methods have been contrived by H. St. Claire Deville and Morin. They differ little in general from those originally employed. It is necessary always to decompose the chlorid of aluminium, and decompose it by sodium, in order to obtain the aluminium. But the processes for the sodium and chlorid of aluminium have been simplified. The sodium process has already been described by us, and we now mention the improvements in that for the chlorid.

This chlorid is now made by the direct use of kaolin or even of clay —that of Dreux for example. But this is not all. The chlorid was difficult to manage in a large way because, after having been formed in vapor, it was often condensed in snowy crystals, rendering it necessary to collect it in chambers and detach it mechanically from the surfaces it coated. There was, *first*, a loss of the chlorid, the condensation being incomplete; *second*, danger for the workmen exposed to the respiration of the vapors; *third*, an enhancement of cost from the interruptions in the operations.

The improvement consists in submitting to a current of chlorine—not longer a mixture of alumina and charcoal, but—a mixture of alumina, charcoal and chlorid of sodium; this affords a double chlorid of aluminium and sodium which is volatile and liquifiable, running like water and becoming solid with cold. The preparation goes on uninterruptedly, proceeding with simplicity and regularity and exacting no other care than what is necessary for the production of the chlorid, the renewal of the preparation for decomposition, and the substitution, as soon as cooled, of earthen pots, in which cakes form from the double chlorid that flows in in a continued stream.

The chlorid is decomposed in a reverberatory furnace, into which, mixed with bits of sodium, it is introduced. The reaction of the two substances takes place after a few moments, but so quietly that it may be done on a large scale without danger. It leaves the aluminium in plates, globules, or a powder. It is separated from the common salt either mechanically or by means of water.

Dumas asserts that the cost of making sodium is at the most 7 francs a kilogram, and that its manufacture is easier than that of phosphorus and also as simple as that of zinc.

By acting on a mixture of carbonate of soda, carbon and chalk, the reaction is so complete that the result agrees with calculation, and so easy that we may substitute for the iron bottle commonly used, luted copper tubes.

In the manufacture of sodium the carbon is now replaced by coal. Deville uses a coal which burns with considerable flame. It is important that the mixture should be well dried before subjected to decomposition. The proportions used are as follows:

Carbonate of soda,	30 kil.
Coal,	13 "
Chalk,	5 "

The soda ought to be from the crystallized carbonate; the soda of the shops gives bad results without Deville's knowing precisely why.

Origin of Urea in the Animal Economy.—Dumas has announced with much enthusiasm the confirmation of his views already old respecting the origin of urea in the animal economy, viz., that the urea proceeds from the albuminoid substances destroyed in the blood by an oxydating process. This is now established by M. Bechamp, Professor at the School of Pharmacy of Strasbourg, who has succeeded in changing albumine fibrine and gluten into urea by a slow combination produced by means of a solution of permanganate of potash at the temperature of about 80° C. The following is the process:

Ten grams of aluminum are dissolved in 300 grams of water; and to this by degrees 75 grams of permanganate of potash are added. The reduction, which is at first very active, soon ceases. It is then heated to 40° C. in a water bath, and from time to time saturated with sulphuric acid, yet so as to leave it still a little alkaline. When the discoloration is completed, it is filtered, and exactly saturated with dilute sulphuric acid. The solution, now perfectly limpid, is evaporated in a water bath; and when reduced to a small volume, an excess of concentrated alcohol is added; it deposits some sulphate of potash and sulphate of ammonia. The alcoholic solution is evaporated in its turn to the consistence of honey and treated with hot absolute alcohol which dissolves the urea.

Whilst M. Bechamp was bringing out this transformation, a physiologist, M. Picard, made, also at Strasbourg, some observations bearing on the subject, having reference to the presence of urea in the blood and its diffusion through the system.

It is known that according to MM. Dumas and Prévost, urea shows itself in the blood of animals after the removal of the kidneys, and that they conclude from the fact that the kidneys remove the urea, while not producing it.

M. Picard has completed the demonstratation. He has compared, as regards the presence of urea, the arterial and venous blood by precipitating the urea with nitrate of mercury. The renal artery of a dog afforded 0·0365 per cent of urea, and the renal vein only 0·0186 per cent. In studying the question with reference to man, he has observed that the arterial blood which passes into the kidneys leave there about 28 grams of urea; while the quantity of urea in the urine of the subjects submitted to experiment, varied between 27 and 28 grams for the 24 hours. This proves that the kidneys remove but do not make urea, as announced thirty-five years since by Prévost and Dumas.

Electricity. Theory of the voltaic pile.—During the thirty years in which the theory of the pile has been under discussion, research has favored apparently at one time the *chemical*, and at another the *contact* theory. We are able now, as we believe, to announce that the discussion is closed. The chemical theory has definitely triumphed. As explained in the Traité d'Electricité Théorique et Pratique of De la Rive, this theory meets all difficulties and proves that if contact is often necessary for exciting electricity, it is not that which produces it; chemical actions are always the source. This learned physicist demonstrates that all chemical action causes a disengagement of electricity, whilst not a single experiment can be cited in which electricity is produced simply by contact.

He reviews and explains all the alleged facts in favor of the theory of contact. He thus shows up the objection so often urged, that in order to displace by iron the copper of the sulphate of copper it is necessary to put the iron in contact with the saline solution, and that the chemical action begins only after the iron is covered with copper and when it has thus formed a voltaic couple. De la Rive first proves that in this experiment there is a voltaic couple which precedes that formed by the iron and by the displaced copper; this couple is formed by the iron and the oxyd of iron adhering to its surface or by iron and carbon or some other foreign body; for by using iron chemically pure and a surface perfectly clean, no precipitation of copper is obtained.

No physicist is better fitted than De la Rive to undertake the delicate task of giving a theory of the pile. His studies as well as his discoveries lead him in this direction.

De la Rive was the first who recognized the important fact that zinc chemically pure is not attacked by hydrated sulphuric acid; that two metals on which pure nitric acid, for example, has no action, such as gold or platinum, give not the slightest trace of a current when put to the extremity of a galvanometer and plunged into the nitric acid; that on the contrary, they produce an instantaneous current when a drop of chlorohydric acid is added. The theory of contact has never yet explained this fact.

The third volume of his work is reserved for the applications of electricity. The important part which De la Rive took in the invention of galvanoplasty is well known, and we may expect to see this branch of industry illustrated in his work with new views and a precision and exactness, of which the first two volumes have given us such fine examples.

Galvano-caustic.—We have already had occasion to speak of the experiments made towards applying in medicine and surgery, the heating effects which are suddenly produced by means of the pile. This question, besides others, was the occasion of some trials by Mr. Amussat. Recently a surgeon, Mr. Middledorp, brought before the Academy a series of instruments and of surgical apparatus, calculated for the employ of electricity, and especially for using the heating effects of the pile in behalf of suffering humanity. The author designates under the name of *galvano-caustic*, the series of operations executed by this means.

The source of heat employed is a Grove's pile. The instruments are, 1, different cauterizers; 2, a galvanic seton; 3, a "porte ligature" for penetrating where there is access to no other cutting instrument, and combining at once the advantages of an incision, ligature and cauterization. A commutator fitted to the conducting wires, serves to excite or suspend the action.

We have already spoken of the advantages of this method of operation. While avoiding hemorrhage from small vessels, it is adapted to produce energetic action, very precisely limited, and to penetrate into regions inaccessible to the bistoury and cautery. By means of the electric heat directed by appropriate instruments, we may cut, make incisions or cauterizations large or small, arrest hemorrhages, provoke the inflammation of tissues, the coagulation of the blood, etc. Moreover, being introduced cold, the galvano-caustic instruments excite no fear; once in place a movement of the finger will develop the requisite temperature.

Crystallogeny.—It is a long time since it was observed by Mr. Marloye, a skilful constructor of acoustic instruments, that when the angle of a crystal is removed with a knife and the surface polished, the crystal, if left for a time in the solution, completes itself again. This fact has been called to remembrance by an observation of Dr. Marbach of Breslau, who adds to it a supplementary fact of interest. The chlorate of soda crystallizes in the cubic system and its solution in water has no action on polarized light. But when this solution crystallizes, it produces crystals which have a rotatory power like rock crystal, some turning to the right and others to the left; and if the crystals of the same kind are separated from the other and dissolved anew, not only the solution has no rotatory power, but also, if left to crystallize, it affords crystals of both kinds, although only those of one kind were used.

This peculiarity of the crystals is connected with the fact that they are hemihedral, and have the reverse hemihedrism corresponding to each kind of rotation. Still the hemihedral planes are of rare occurrence and are produced only when operating on a large scale. But Mr. Marbach has found a means of rendering them distinctly hemihedral; as done by Mr. Marloye, he cuts the angles and edges of the chlorate of soda and then puts the crystal thus mutilated into a concentrated solution of the same salt; the crystal forms new faces which present the right and left hemihedrism.

Artificial milk.—For some time a liquid has been prepared which is said to have so far the qualities of milk that it is called artificial milk or "lait-viande." It is prepared as follows. Into a Papin's digester three kilograms of fresh pounded bones are put and one kilogram of meat, with five or six times as much of water. The top is hermetically closed: double sides surround it, and in the cavity between, a current of steam circulates which raises the temperature of the digester up to 140° F. At the end of forty minutes after reaching this temperature, a stop-cock with a small orifice is opened which lets out a vapor having the odor of broth; but some seconds after, there issues a white liquid which is nothing but the *artificial milk.* After this milk has passed out, the digester contains only the meat, the boiled bones, and a soup of inferior quality. The artificial milk resembles milk in color, consistence, odor, and even taste. But in composition it is different; for it is only an emulsion produced by the fat mixed with the water by means of the gelatine. Although the name artificial milk is not proper, it has some nutritious qualities, and for this reason it is now under trial at the hospitals of Paris.

Universal Exhibition of Photography.—In a recent exhibition in Belgium for the encouragement of the useful arts, a large part was devoted to photography. Many of the objects had already been exhibited at Paris; but there were some novelties. Heliographic engraving, brought out but yesterday, has already attained great perfection, judging from the specimens exhibited by Mr. Riffaut as well as Mr. Negre. Fine photolithographic views were exhibited by Mr. Poiterin and Dr. Harless, the latter after a process of his own invention.

Among the photographic objectives on exhibition, those of Mr. Jamin, of Paris, deserve special mention. There was one of 14 inches which would answer for obtaining pictures 1·6 meters to 1·2. There was a portrait taken on a glass 60 centimeters by 80, with a double objective of 22 centimeters diameter. The objective was furnished with a conical centralizer.

Bibliography.—*Traité d'Electricité théorique et appliquée,* par A. De la Rive. Vol. II, 836 page. Paris: Baillière.—In announcing the 1st volume of this remarkable work we stated that it would consist of two volumes. But the author has given so much greater extension to some subjects, especially to the theory of the pile, already alluded to, that he has found it necessary to add a third to include the applications of electricity. The present volume treats of the *Preparation of Electricity; its calorific and luminous effects; the chemical effects of dynamical electricity; the physiological effects of dynamical electricity on organized bodies.* An important chapter is devoted to the sources of electricity, such as heat, mechanical actions, and finally the chemical actions to which De la Rive has himself contributed so largely. The mathematical branch of the subject is treated in a chapter by itself, and a note is devoted to the mathematical theory of the pile. The 3d volume will appear next year.

Elémens de Cosmographie, par Costambert. 1 vol. in 12mo, with an atlas. Paris: Hachette.

Médecine Domestique, par le Dr. Beaugrand. 1 vol. in 12mo. Paris: Hachette.—Dr. Beaugrand is a distinguished physician of Paris.

La Telegraphie électrique, par V. Bois. A pamphlet in 12mo.—The object of this small work, which has passed rapidly to a 2nd edition, is to popularise the subject of the Telegraph.

Les Abeilles et l'Apiculture, par M. de Frarière. 1 vol. in 12mo. Paris. Hachette.—The author is a great lover of bees. He has made them the subject of much study, and gives in this work the results of his useful labors.

Compositions de Mathematique et de Physique, par M. Jouve. 1 vol. in 8vo. Paris: Hachette.—This work contains a large number of problems in Physics and Mathematics, intended for the education of the young who have science, commerce or the arts in view. It is highly appreciated by masters and students, connected with the educational institutions of Paris, and France generally.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the wave length of the most refrangible rays and of those which act chemically upon iodid of silver.*—Eisenlohr has communicated some interesting additional facts with respect to the diffraction of the more refrangible rays of light. The author's earlier results have already been mentioned in this Journal: those now communicated were obtained by photographic impressions of diffraction spectra taken upon a film of collodium-iodid of silver placed at a distance of 5·58 metres from the objective of the lattice. The author measured the distances from the middle of the image of the slit to the borders of the different lateral spectra and thence determined the wave lengths of the corresponding rays by the formula

$$u\,\lambda = e \sin \psi.$$

By a comparison of the wave lengths thus obtained it appears that we may assume, *that the limit of the invisible most refrangible rays is at the same time one limit of the rays which act chemically upon iodid of silver, and that the other limit of the less refrangible rays acting upon the iodid is as definite and sharp as the first.* Both fall between the wave lengths $0·000354^{mm}$ and $0·000433^{mm}$. The author remarks that this sharp limitation might also have been inferred from a communication of Müller (in Pogg. Ann. vol. 97, p. 137) who projected prismatic spectra upon photographic paper. It is certainly true for rays of sunlight acting upon iodid of silver, but the author is not prepared to say that it is true for all kinds of light. According to Crookes the chemical rays in gas light fall in a different part of the spectrum from those of sunlight, also the rays between F and G which have no action on iodid of silver readily decompose the bromid. The author proposes to investigate this subject by means of the diffraction spectrum. The intensity of the chemical action upon iodid of silver is greatest and nearly uniform between the lines G and H or the wave lengths 396 and 429 millionths of a millimetre. It diminishes slowly from 396 to 354, but rapidly from 429 to 433, which probably arises from the great number of the dark lines which Stokes has denoted by l, m and n. The author further states, that from analogous experiments there appears to exist just as definite a limit for the thermic action of light.—*Pogg. Ann.*, xcix, 159, *August*, 1856.

2. *On Tantalum and its compounds with chlorine and bromine.*—Rose has communicated an interesting memoir upon this most difficult subject to which he has devoted so much time and talent. The author remarks that tantalum has hitherto been found with certainty only in two

minerals, namely, tantalite and yttro-tantalite, the tantalite occurring in Finland, Sweden and France, yttro-tantalite at Ytterby in Sweden. The tantalic acid employed was obtained partly from the Finland mineral and partly from materials left by Berzelius. The acid was prepared from tantalite by fusing the finely pulverized mineral in a platinum crucible with bisulphate of potash: the fused mass was washed with cold water and the undissolved acid fused with three times its weight of a mixture of carbonate of soda and sulphur. Water then removed all the tin as sulphid. The tantalic acid was washed with water containing sulphid of ammonium, and then digested and boiled with chlorhydric acid to remove the sulphid of iron, and finally completely washed. An acid obtained by decomposing the chlorid with water was also sometimes employed, but this differs in many particulars from that obtained as above. The author obtained metallic tantalum by decomposing the double fluorid of tantalum and sodium by metallic sodium. As thus obtained, tantalum is a black powder which is a good conductor of electricity, though mixed with much acid tantalate of soda. When ignited in the air it oxydizes to tantalic acid with evolution of light and heat. Nitric, chlorhydric and nitromuriatic acids have no action upon it even by long boiling. Fluohydric acid slowly dissolves the metal with evolution of hydrogen. A mixture of nitric and fluohydric acid quickly dissolves the metal with evolution of red vapors. The solution when evaporated to dryness and heated, yields a residue of tantalic acid while fluorid of tantalum is given off. Sulphuric acid has no action on the metal, but by long fusion with the bisulphate of potash it is oxydized to tantalic acid. The density of the metal was found to be 10·078, and after ignition in hydrogen 10·776; the metal employed was not, however, pure. The author prepared the chlorid of tantalum by igniting the acid with carbon and passing a current of chlorine over the mixture. The chlorid has a pure yellow color and only looks whitish when it contains aci-chlorid; it must volatilize completely by heating in an atmosphere of chlorine. The color of this chlorid is somewhat brighter than that of chlorid of niobium: it is easily fusible and at about 221° C. becomes a yellow liquid which sublimes to a crystalline sublimate. It begins, however, to volatilize before it melts, namely at 144°. The chlorid gives no double compounds with alkaline chlorids. It is soluble in anhydrous alcohol and is not precipitated from the solution by sulphuric acid even after boiling. When the alcoholic solution is distilled, a syrupy liquid remains which probably consists chiefly of tantalate of ethyl. The determination of the equivalent of tantalum was effected by the analysis of the chlorid which was decomposed by water, and the solution filtered after addition of a little ammonia: the chlorine was then determined in the filtrate by nitrate of silver. In this manner twelve experiments were made, which, however, do not exhibit as close a coincidence as could be desired. The author takes a mean between the result of the first and eleventh analyses, which exhibit a close correspondence between the quantity of oxygen found and that calculated from the amount of chlorine. According to these results the composition of the chlorid and oxyd in parts per cent is

Tantalum,	49·25	Tantalum,	81·14
Chlorine,	50·75	Oxygen,	18·86
	100·00		100·00

These results differ greatly from those obtained by Berzelius. Rose, after much consideration adopts the formula TaO_2 for tantalic acid, which gives in connection with the above results 860·26 (O=100) or 68·82 (O=8) for the equivalent of the metal. The author obtained a bromid of tantalum by passing the vapor of bromine over an ignited mixture of tantalic acid and carbon. The bromid has a yellowish color, and resembles the chlorid; water decomposes it into bromhydric acid and tantalic acid. Rose did not succeed in obtaining a corresponding iodid of tantalum.—*Pogg. Ann.*, xcix, 65, *August*, 1856. W. G.

II. MINERALOGY AND GEOLOGY.

1. *Description of a new Meteoric Iron from Chili, containing Native Lead; and an account of a fall of a large mass of Meteoric Iron at Corrientes in South America;** by R. P. Greg, Esq., (Phil. Mag., July, 1855.)—(1.) A short time since I purchased a mass of meteoric iron weighing upwards of seventeen pounds; its shape was irregular and cup-like, considerably convex or hollowed out on one side, and the external surface more or less covered with small angular and conchoidal projections. It was found by Mr. Greenwood, Reporter of Mineral Properties, on the 26th of February, 1840, on the desert of Tarapaca, eighty miles northeast of Talcahuano, and forty-six miles from Hemalga; and was afterwards analyzed, in 1853, by Mr. George Darlington, of the Museum of Practical Geology, with the following results:—

	a	*b*
Iron,	93·41	93·48
Nickel,	4·62	4·56
Cobalt,	0·36	0·37
Manganese,	0·20	0·18
Phosphurets,	1·21	1·26
Chromium,	*trace*	*trace*
	99·80	99·85

In general composition it therefore closely resembles the majority of meteoric irons hitherto analyzed. I am unable at present to say if it contains *Schreibersite.*

The specific gravity of a slice weighing six ounces, containing, however, cavities and other matter, I found to be about 6·5. For meteoric iron it is perhaps unusually soft; and though it shows no regular *crystalline* or Widmannstättian figures when a polished surface is treated with nitric acid, yet there is apparent a slightly welded or mottled texture, brighter in some parts than in others.

It was not, however, until the iron had been cut up into slices for the purpose of polishing and for exchange, that I discovered it had not a perfectly homogeneous structure, but was in many places more or less honeycombed with cavities, some of which actually contained what appeared to be pure *lead!* In some the lead was not larger than a pellet, and did not fill the entire cavity contained in it; in others the entire cavity was filled with lead, in size equal to a pea. Professor Shepard of

* From the Liverpool Literary and Philosophical Society's Journal.

the United States, who is so well acquainted with meteorites, along with Dr. Heddle and myself, saw some slices of this iron slit in the workshop of Mr. Young the lapidary, at Edinburgh, and we took lead out of the cavities immediately after they left the lathe, so that there could be no deception whatever.

To be quite certain, my friend Dr. Heddle examined some of it, and found it to be chemically pure lead; when the tarnished surface was not scraped off, small quantities of iron and alumina, and mere traces of phosphorus and magnesia were found.

There are also two other substances in some of the cavities of this singular iron, which Dr. Heddle, when he has analyzed, will separately report upon; the one a very hard, grayish-black, semi-metallic mineral; the other yellowish-brown, insoluble in acids, and with an earthy texture.

This is the first authentic instance of the existence of lead in meteoric bodies, and to find it so closely allied with, and buried, as it were, in metallic iron, is not only in itself singular, but difficult to account for. It is, however, probable that the lead was originally held in alloy along with the nickel and cobalt, and on intense heating or partial fusion of the iron mass, "sweated" out into vesicular cavities.

Should this be a correct view, it is a proof of the intense heat to which iron meteoric masses appear to have been subjected at the time of, if not previous to, their reaching the surface of the earth. Indeed meteoric *stones* seem to have been subjected to a much smaller degree of heat while falling, than *iron* masses, if we may judge by appearances, the only sign of fusion in *stones* being quite external, and merely marked by a thin, black, and shining crust.

Iron falls are extremely rare compared with what are called *stone* falls; so much so, indeed, that there are not more than three or four authentic accounts of the fall of *iron* masses, and these not large ones, bearing no comparison to the enormous masses weighing from five to twenty tons, which have been occasionally found on the plains of Mexico and South America. (See Phil. Mag. for Dec. 1854.)

(2.) Should any one be inclined to doubt the fact that such immense masses of iron have, strictly speaking, a meteoric origin, I have added to this paper some particulars of the fall of one in South America in the year 1844, that first appeared in a philosophical journal some years ago, but which, from having a local circulation, has not received the notice which it so eminently deserves.

It is important to notice the state of intense fusion exhibited by the entire mass at the time of falling; Mr. Symond's description is most graphic. The account was given in a letter, read by Mr. Dickinson, from the observer of the phenomenon, a Mr. H. E. Symonds; and the following is an extract:—

"Having been deeply engaged in Argentine politics and wars in 1843 to 1844, I accompanied the Corrientine army in its invasion of the province of Entre Rios. This army returned from that expedition in January, 1844. Our rear, in which I marched, was so continually harrassed by Entrerian skirmishers, that for ten days before we had gained the Corrientine frontier we had no time to sleep or change clothes; but soon after passing this, in Carritas Paso, on the river Mocorita, we placed a guard in the pass, and deeming ourselves secure, the whole division abandoned itself to the profoundest sleep.

"From this sleep we were all simultaneously awakened at about two o'clock in the morning; and as if actuated by electricity, each individual of our division (about 1400 men) sprung on his feet at the same moment. An aërolite was falling. The light that accompanied it was intense beyond description. It fell in an oblique direction, probably at an angle of about 60° with the earth, and its course was from east to west.

"Its appearance was that of an oblongated sphere of fire, and its tract from the sky was marked by a fiery streak, gradually fading in proportion to the distance from the mass, but as intensely luminous as itself in its immediate vicinity. The noise that accompanied it, though unlike thunder, or anything else that I have heard, was unbroken, exceedingly loud and terrific. Its fall was accompanied by a most sensible movement of the atmosphere, which I thought at first repellent from the falling body, and afterwards it became something of a short whirlwind. At the same time I and my companions all agreed that we had experienced a violent electric shock; but probably this sensation may have been but the effect on our drowsy senses of the indescribably intense light and noise. The spot where it fell was about one hundred yards from the extreme right of our division, and perhaps four hundred from the place where I had been sleeping. Accompanied by our general (Dr. Joaquin Madauaga), I went within ten or twelve yards from it, which was as near as its heat allowed us to approach.

"The mass appeared to be considerably imbedded in the earth, which was so heated that it was quite bubbling around it. Its size above the earth was perhaps a cubic yard, and its shape was somewhat spherical; it was intensely ignited and radiantly light, and in this state it continued until early dawn, when the enemy, having brought his artillery to the pass, forced us to abandon it to continue our march. I may mention, that, at the time of its fall, the sky above us was beautifully clear, and the stars were perhaps more than usually bright; there had been sheet lightning the previous evening.

"I never afterwards had an opportunity of revisiting the Mocorita, for our permanent encampment was thirty-five leagues to the north of that pass, between which and our encampment the country was entirely depopulated by our long war; but as the spot where the aërolite fell was known to many of our subaltern officers, who were frequently sent to observe the frontier of Entre Rios, I have heard them describe it as a 'piedra de fiérro,' *i. e.* a stone of iron; and I once provided one of the most intelligent of them with a hammer in order that he might bring me a sample of it. On his return, he told me it was so excessively hard that the hammer bent, and was broken in unsuccessful attempts to break off a small piece of it."

2. *Hard Guano of Monks Island;* by A. Snowden Piggot, (from a letter to one of the Editors).—I was not a little surprised to read Professor Shepard's views of the hard guanos. There is no trap rock at all about the majority of the beds of this substance. It covers ordinary

"alluvial guano" as the Captain called the common variety brought from the Caribbean Sea. Indeed I have seen nothing that looked to me like trap from any of those islands, I have seen quartz crystals, granite, gneiss and some crystalline rocks that I could not determine among the cargoes. Besides, the constitution of the phosphates proves conclusively that they have not been hardened by fire. I have made another examination of the rock, without the enamelled surface and am fully convinced of the correctness of my views. The following are the results:

The phosphoric acid in this table does not include the small amount existing in the phosphates of iron and magnesia which were estimated separately.

Phosphoric acid,	46·22
Lime,	38·75
Phosphate of iron,	0·35
Phosphate of magnesia,	0·61
Sulphuric acid,	1·96
Chlorine,	*trace*
Organic matter, salts of ammonia, and combined water,	8·95
Hygroscopic water,	2·34
Sand,	0·63
	99·81

If we take from the lime sufficient to combine with the sulphuric acid, we have remaining of that earth 35·95, which when combined with the phosphoric acid and 5·78 parts of water, give a salt of the formula $2CaO, HO, PO_5$.

The small quantity of the phosphates of iron and magnesia in this specimen is worthy of notice. It is a little remarkable, that in these guanos generally, while the entire amount of phosphoric acid varies but slightly, there is a very wide difference in the proportions of the bases with which it is combined.

The "body of the rock" of which the above table expresses the composition, was carefully separated from the white enamel before analysis.

Baltimore, November 11th, 1856.

3. *On Columbian Guano, its composition and character*; by James Higgins, M.D., and Charles Bickell, Ph.D.—Columbian guano presents itself in the form of irregular stony lumps, apparently composed of two distinctly different parts, viz: of an *exterior layer*, only a few lines in thickness, and of the "body, the great mass of the rock," directly underlying the exterior part. The former is of a grey or dirty white color, with vitreous lustre, hard but brittle, and therefore easily ground in a mortar; the interior part is of a dark brown mottled color, without any lustre, tough, horny and tenacious as to texture, and with difficulty reduced to powder.

A proper chemical examination of this substance is therefore naturally divided into two separate analyses, that of the exterior layer, and that of the body or great mass of the rock; the latter representing at the same time the composition of the genuine commercial article.

Several carefully conducted analyses resulted in the following composition of the respective parts:

	Exterior layer.	Body of rock.
Lime,	41·76	39·01
Magnesia,	3·10	0·22
Peroxyd of iron,	0·34	0·11
Phosphoric acid,	39·92	43·50
Calcium,	1·34	——
Fluorine,	0·85	——
Chlorine,	0·75	*trace*
Soda,	1·61	——
Sulphuric acid,	2·07	7·08
Water and organic matter,	8·60	10·75
Sand,	0·02	0·02
	100·36	100·69

The relative proportions of the different constituent substances above given, necessarily lead to the following state of their combination:

Exterior layer.

Tri-phosphate of lime,		77·71
containing of lime,	41·76	
" " phosphoric acid,	35·95	
Tri-phosphate of magnesia,		6·77
containing of magnesia,	3·10	
" " phosphoric acid,	3·67	
Phosphate of iron,		0·64
Fluorid of calcium,		1·76
Chlorid of calcium,		1·18
Sulphate of soda,		3·68
Water and organic matter,		8·60
Sand,		0·02
		100·36

Body of the rock.

Common phosphate of lime,		82·48
containing of lime,	34·04	
" " water,	5·44	
" " phosphoric acid,	43·00	
Common phosphate of magnesia,		0·66
containing of magnesia,	0·22	
" " water,	0·05	
" " phosphoric acid,	0·39	
Phosphate of iron,		0·22
Sulphate of lime,		12·05
containing of lime,	4·97	
" " sulphuric acid,	7·08	
Water and organic matter,		5·26
Sand,		0·02
		100·69

It will be seen from the above that in both parts of the rock the phosphoric acid is present in the form of a tribasic phosphate (containing three atoms of base to one atom of acid), with the difference that in the *exterior layer* the three atoms of base are made up by lime alone, thus forming the so-called *tri-phosphate of lime,* whilst in the *body of the rock* only two of them are lime and the third is water, a combination which is known as *common phosphate of lime.*

In the following we add a few items which may prove the correctness of this view:

(1.) Common phosphate of lime, when exposed to a high degree of temperature, loses its volatile atom of base (the water) and is consequently transformed into a phosphate of two atoms of fixed base, or a pyrophosphate. Tri-phosphate of lime, under the same conditions, remains unaltered. In accordance with this, the hydrochloric acid solution of the natural, as well as of the heated powder of the *exterior layer,* if treated with ammonia, produces a precipitate which is, in both cases, soluble in acetic acid. This is also the case with the natural powder of the *body of the rock;* whilst its heated powder, if treated in the same manner, remains insoluble in acetic acid, as pyrophosphates do. But pyrophosphates can only be produced in this way by common phosphates; therefore, the *body of the rock* is composed of common phosphate of lime, the *exterior layer* of tri-phosphate of lime.

(2.) Common phosphate of lime, when brought into contact with ammonia, is converted into triphosphate of lime, whilst phosphate of ammonia is found in solution. This fact may explain the relation which exists between the *exterior layer* and the *body of the rock.* The latter, we have seen, is composed of common phosphate of lime and some organic matter; on its surface, where it was exposed to rain and to the influence of the atmospheric ingredients (especially ammonia), its organic matter became slowly decomposed, and ammonia evolved from it. The ammonia thus produced by the organic matter of the rock, as well as that portion conveyed to it by the atmosphere, necessarily came in close contact with the common phosphate of lime on the surface of the rock, and consequently transformed it, according to the above, into the triphosphate of lime, of which the *exterior layer* is composed, whilst the resulting phosphate of ammonia, on the other hand, was washed away by the rain.

It was found upon experiment that, on account of the peculiar state of aggregation of the particles of the rock, liquid ammonia had to remain for a long time in contact with it before appreciable quantities of phosphate of ammonia could be found in solution.

(3.) If extracts of both parts of the rock in water were treated with dilute alcohol, that of the *body of the rock* produced a voluminous, white precipitate of sulphate of lime, whilst that of the *exterior layer* remained clear, though it produced instantly a precipitate with chlorid of barium after having been acidulated with hydrochloric acid. This is a proof that in the *exterior layer* the sulphuric acid is present in the form of sulphate of soda, whilst the *body of the rock* contains it as sulphate of lime.

4. *Chemical Analysis and Comparison of Serpentine Marbles known under the name of Verd Antique;* by Charles T. Jackson. (Read before the Boston Society of Natural History, February 20th, 1856.)—Having made the original geological surveys of the great masses of ser-

pentine marbles, which occur in the northern part of the State of Vermont, and described such as would furnish a marble identical with the celebrated verd antique of Europe, I have since been requested to institute a mineralogical and chemical comparison of the European and Vermont varieties.

The results to which I have arrived possess some scientific as well as practical interest, for they not only show a curious replacement of carbonate of magnesia for carbonate of lime, the magnesite being most abundant in the Vermont marble, while calcite is the predominant spar in the European variety. It has also been ascertained, by experiments made by me some years since, that the Vermont serpentine marble and that mixture called verd antique, are uncommonly durable, resisting not only atmospheric agencies, but also the action of acids, and to a remarkable extent that of fire.

Dr. Hayes, in an interesting report on this marble, has confirmed these results, and I am happy in being able also to verify his analysis of some of the magnesite veins, while I also add now some new analyses of other veins in the Vermont marble, and of the calcite of the European verd antique. I offer like analyses of the serpentine of the verd antique, both of Europe and of Vermont, showing their identity of composition, and also an analysis I made many years since of the softer serpentine of Lynnfield in this State.

Serpentine consists essentially of hydrous silicate of magnesia and silicate of the protoxyd of iron, with occasionally a little oxyd of chromium—these oxyds giving the green color to the serpentine. The presence of water of composition in serpentine materially affects its hardness, the softer varieties containing the largest proportion of water. In some varieties I found as much as 15 per cent, while the lowest was 7 per cent. Both the verd antique serpentine of Europe and of Roxbury, Vermont, contain between 12 and 13 per cent of water. That from Proctorsville, Vt., contains but 7 per cent, and of Roxbury 13, while that from Europe contains 12·5 per cent, and that of Lynnfield 15 per cent.

Verd antique marble may be defined to be serpentine mixed with or containing numerous veins of magnesian carbonate of lime. The relative proportions of these ingredients may vary considerably on account of the isomorphic, or rather plesiomorphic characters of the two minerals. Carbonate of the protoxyd of iron, in like manner being plesiomorphic with both carbonates of lime and of magnesia, replaces either of those minerals in all proportions, without changing the angles of the crystals more than one degree.

It will be observed on examination of the analyses I have made, that in the Vermont serpentine the white spar veins are chiefly composed of magnesite, while there are also veins consisting of magnesian carbonate of lime and of carbonate of iron. The relative proportions of these magnesian and ferrous carbonates in the Vermont marble are nearly the reverse of those in the European variety, while according with the law of isomorphous substitution of mineral ingredients.

Owing to the refractory nature of serpentine, and the difficult erosion of the magnesite, the Vermont verd antique is less liable to decomposition from atmospheric agencies, and also has the property of resisting a high temperature, and even the action of minerals and other acids, far beyond the celebrated verd antique of Italy. When highly polished, it is a rich and beautiful green marble, veined with white, and sometimes is richly mottled with magnesite and dolomite spar. Its polished surface is not liable to erosion from atmospheric causes, and will offer no hold for lichens, mosses, or other parasitic vegetation, which so frequently mar the beauty of our more open grained white monumental marbles.

1st. Chemical analysis of the white veins of European verd antique. These veins, picked out with great care to avoid any mixture of particles of serpentine, yielded per cent—

Carbonate of lime, - - -	81·00
Carbonate of magnesia, - - -	11·70
Carbonate of iron, - - -	7·30
	100·00

2d. Chemical analysis of the white veins of Roxbury, Vermont, verd antique marble. These veins were quite common in the slabs examined by me. They were picked out with care to avoid any admixture of serpentine. On analysis they yielded—

Carbonate of magnesia, - -	80·00
Carbonate of lime, - - -	15·00
Carbonate of iron, - - -	3·50
Silica and loss, - - - -	1·50
	100·00

It will be observed that the carbonate of lime, in the European marble, is represented by carbonate of magnesia in the Vermont variety, and the carbonate of magnesia by carbonate of lime, a reversal of these ingredients.

3d. Chemical analysis of the magnesite veins in Roxbury, Vt., verd antique.—These veins are probably like those analyzed by Dr. Hayes. They yielded per cent—

Magnesia, - - - -	38·88
Carbonic acid, - - - - -	37·12
Protoxyd of iron, - - -	9·00
Undecomposed serpentine, - -	15·00
	100·00

The protoxyd of iron was originally in combination with carbonic acid in the stone, forming carbonate of iron, an isomorph with carbonate of magnesia.

4th. Chemical analysis of the dolomite spar veins in Roxbury, Vt., serpentine.—A cleavage crystal, with angles of 106·15°, was analyzed, and yielded—

Carbonic acid, - - -	46·50
Lime, - - - - -	30·52
Magnesia, - - - -	18·47
Protoxyd of iron, - - -	4·25
Silica, - - - -	0·05
	99·79

In this mineral the carbonic acid is combined with the lime, magnesia and protoxyd of iron.

5th. Chemical analysis of the serpentine of the verd antique of Europe.—It was picked out clean as possible, reduced to small grains, and washed with very dilute muriatic acid, to cleanse it from adhering carbonate of lime. The attack was made by means of carbonate of soda, in the usual manner of rendering insoluble silicates soluble in acids. The results obtained were:

Silica,	42·40
Magnesia,	31·20
Protoxyd of iron,	13·90
Water,	12·50
	100·00

The Roxbury, Vermont, serpentine, analyzed in the same manner, yielded:

Silica,	42·60
Magnesia,	35·50
Protoxyd of iron and ox. chromium,	8·30
Carbonate of lime,	0·60
Water,	13·00
	100·00

Chemical analysis of serpentine from Lynnfield, Mass.—a light green and rather soft variety.

Silica,	37·5
Magnesia,	41·0
Protoxyd of iron,	2·5
Carbonate of lime,	4·0
Water,	15·0
	99·0

This variety of serpentine is capable of being decomposed by boiling sulphuric acid, and was at one time used in the manufacture of sulphate of magnesia.

It is too soft to be used for ornamental marble, but it withstands heat perfectly after it has been gradually baked, so as to expel its water of composition.

It comes nearer to the precious or noble serpentine in composition than to that of the serpentines of verd antique marble, which are much harder than noble serpentine.

III. BOTANY AND ZOOLOGY.

1. *DeCandolle's Prodromus*, vol. xiv, Part I. 1856. pp. 492.—We are grateful to M. DeCandolle for having issued this publication without longer waiting for the large family of *Laurineæ*, still in the hands of Professor DeVriese. Only we beg, that when the concluding part of volume thirteen is given us, it may be paged continuously with the present part. For the thousands of references that will have to be made to it in botanical writings, it should suffice to cite volume and page, with-

out having to intercalate an additional numeral for the part, as in vol. xiii;—where, however, it could not be well helped, except by counting the *Solanaceæ* and *Plantaginaceæ* as a whole volume, which would have been the better way on every account.

The present issue, which has long been anxiously expected by botanists, comprises the *Erigoneæ* (115 species in seven genera) by Mr. Bentham, and the rest of the *Polygonaceæ* by Prof. Meisner, long the principal authority for this order; the *Mirysticaceæ*, by M. DeCandolle himself; the *Proteaceæ*, by Prof. Meisner; the *Penæaceæ* and the *Geissolomaceæ*, by M. DeCandolle, the last named order comprising only a single genus of a single known species. For United States botanists, therefore, the interest of the volume centers in the *Polygonaceæ*, which from the great knowledge and talent of the monographers, are doubtless admirably elaborated. To the *Eriogoneæ*, which have increased from the three species known to Pursh to 115 here described, considerable additions may already be made, from recent discoveries in our southwestern regions. A. G.

2. *Flora Vectensis: being a Systematic Description of the Phænogamous or Flowering Plants and Ferns indigenous to the Isle of Wight;* by the late WILLIAM ARNOLD BROMFIELD, M.D., &c. Edited by Sir WM. JACKSON HOOKER, K.H., &c., and THOMAS BELL SALTER, M.D. London: Pamplin, 1856, pp. 678, 8vo. Accompanied by a Botanical Topographical Map of the Isle of Wight, separately mounted.—The many American friends of the lamented Dr. Bromfield, who had the pleasure of personal intercourse with him during his visit to this country ten years ago, will be glad to know that the great work for which he had made such extensive preparation, and left unfinished at his premature death (at Damascus, in 1851), has been edited by most competent and friendly hands, and, through the devotion of a near surviving relative, is at length given to the world. Although it is not all that Dr. Bromfield would have made it had he been spared for its completion according to his plans, it is still an important contribution to general botanical science, as well as a model local Flora. The descriptions, so far as they were written out by Dr. Bromfield, were in all cases drawn from fresh specimens growing on the island; and the pages abound with critical annotations. Many of these relate to North American species observed by the author during his travels in this country. A. G.

3. *Seemann's Botany of the Voyage of the Herald;* parts 7 and 8, published together, comprise the Flora of North Western Mexico; i. e. as represented in the collections made by Lay and Collie in Beechey's voyage, by Barclay, Hinds, and Sinclair, in the voyage of the Blossom, under Capt. Belcher, and in the voyage of the Herald by Mr. Seemann himself; to which are added a few plants collected by Mr. Potts at Chihuahua. Mr. Seemann penetrated from Mazatlan to Durango, but at a late season of the year, unfavorable for botanical collections. In an Introduction, the author sketches the general features of the country, as much of it as he saw, noticing especially the native and the cultivated vegetable productions. The flora itself here extends to the *Polemoniaceæ*. The determinations, as would be expected, concern some of our

United States plants. *Clematis Pitcheri* is referred to *C. reticulata:* the flowering specimens of the two are sometimes puzzling, but the carpels are quite different. *C. lasiantha*, Nutt. is identified with *C. Peruviana*, DeC.; and *C. pauciflora*, Nutt. is suspected to be *C. hexasepala*, DeC. Nuttall's *Polygala alba* is superseded by the posterior name of *P. bicolor*, H. B. K., because "the color of the flower varies, being greenish-white, white, rose-color, and dark-purple;" but for the same reason the name of *bicolor* is almost as objectionable. *C. asperuloides*, H. B. K. would be a better name to adopt, if it really belongs here, which is doubtful. *P. Americana* is here supposed to include *P. grandiflora*, Walt., *ovatifolia* and *puberula*, Gray, and *ovalifolia*, DeC., besides two or three more like it. *P. leptocaulis*, Torr. and Gr. is said to be *P. verticillata!* *Rubus Neo-Mexicanus*, Gray, is referred to *R. trilobus*, Moc. and Sesse, perhaps with reason. The *Cactaceæ* are elaborated by Mr. Scheer, from inadequate materials, chiefly supplied by Mr. Potts of Chihuahua. A considerable number of new species are characterized; all of which will have to be collated with Dr. Engelmann's recent detailed monograph. *Philadelphus Mexicanus*, Schlect, is said to embrace *P. serpyllifolius*, Gray. The *Compositæ* are elaborated by Dr. Schultz, who makes this vast family a special study. He has overlooked the determination of *Clavigera dentata*, DeC. (in Pl. Wright, 1, p. 83), and affixed that specific name to a wrong species. Dr. Schultz reduces *Delucia* and even *Cosmos* to *Bidens;* and, if formerly inclined to undue multiplication of genera, now makes, perhaps, more than amends, by not only acceding to the reduction of *Acourtia*, *Dumerilia*, &c. to *Perezia* (as proposed by the writer), but even referring the whole to *Trixis*, which is rather more than we counted on, although perhaps a logical consequence: also by reducing *Chaptalia*, *Leria*, *Lieberkuhnia*, *Loxodon*, *Oxydon*, &c. to *Gerbera!* The plates of this fasciculus which belong to the Mexican flora are three, viz.: two new species of "*Viscum*," both *Phoradendra*, and *Galactia marginalis*, Benth., which as figured looks as unlike that species as possible. A. G.

4. *Synopsis of the Cactaceæ of the United States and Adjacent Regions;* by George Engelmann, M.D. (From the Proceedings of the American Academy of Arts and Sciences, vol. iii), Cambridge, 1856. pp. 58.—Besides his ample and fully illustrated memoirs on *Cactaceæ*, in one of the Pacific Railroad Survey Reports, and in the Report of the Mexican Boundary Commission, still unpublished, Dr. Engelmann has prepared this general synopsis, giving a connected and systematic view of all our species, now so numerous, with full characters of those which he has not before well described. Altogether, these memoirs constitute a very full and invaluable elaboration of an extremely difficult, but very interesting family,—difficult not only from the peculiar obstacles to collecting and preserving adequate specimens of these unwieldy and uncomfortable plants, but likewise from the great uncertainty as to what are reliable characters. Linnæus knew only one Cactus of our region. Nuttall about forty years ago added four species, from the Upper Missouri, and, much later, one from California. Now, Dr. Engelmann enumerates 117 North American species, besides some extra-limital ones, holding out, however,

some hopes that, when better known, they may have to be reduced to not less than 67 species! As to geographical distribution, the author assigns them to eight separate regions, as follows:—

(1.) *The Atlantic region*, which has only one common indigeneous species; and one more from the south has just come to light.

(2.) *The Mississippi region*, with one species.

(3.) *The Missouri region*, with five species.

(4.) *The Texan region*, with twenty species, fourteen of them peculiar.

(5.) *The New Mexican region*, with sixty-six species, forty-six peculiar.

(6.) *The Gila region*, with thirty-six species, thirty of them peculiar.

(7.) *The Californian region*, with six species, five of them peculiar.

(8.) *The Northwestern region* (North California, Utah, and Oregon), with one species, and some indications of others.

This indefatigable botanist has also nearly completed a monograph of the North American species of *Euphorbia;* which however, may not be published until after his return from Europe, where he is now occupying himself with various important botanical investigations. A. G.

5. *The Musci and Hepaticæ of the United States, east of the Mississippi river;* by WILLIAM S. SULLIVANT. New York: George P. Putnam & Co. 1856. 8vo, with 8 copper-plates.—All who are now interested in the study of our *Mosses* and *Liverworts*, and the many, who, attracted by such an able guide, will yet enter this pleasant domain of botanical science, owe a large debt of gratitude to the author of this beautiful volume. Published as a contribution to the second edition of Dr. Gray's excellent Manual of the Botany of the Northern United States, it appears also simultaneously in a separate form. It grew out of an elaboration of these Cryptogamous Orders, furnished by the same skillful hand for the first edition of the Manual; but so numerous and important are the changes made, that it must be regarded as a new work. Its geographical range is judiciously extended to the whole region lying east of the Mississippi; a multitude of new and newly discovered species, both from the Northern and Southern States, have been added; the old genera and species have been thoroughly and critically revised, and brought up fully to the present Bryological standard; but, above all, eight tables of copper plates, crowded with figures in illustration of the genera, greatly enhance its value. These illustrations, from the pencil of Mr. Sullivant himself, are worthy of the highest praise, as well for the beauty as the fidelity of their execution. The engraving also is unsurpassed if not unequalled by any work of this kind. Looking at the superb volume before us, we scarcely know which to admire most, the scientific skill and marks of labor visible on every page, or the noble generosity which places within the reach of the lovers of Mosses, such a guide, at a price which must fall far short of covering the expenses incurred. Of minds and hearts like these the nation has just reason to be proud. From this point we date a new era in the study of American Bryology; and when Prof. Tuckerman does the like for our *Lichenes*, Dr. Curtis for our *Fungi*, and Prof. Harvey for our *Algæ*, the entire field of our lower Cryptogamia will be fairly open to the adventurous seeker after knowledge. T. C. P.

6. *On the probable Origin of the Organized Beings now living in the Azores, Madeira, and the Canaries;* by OSWALD HEER, (in a letter to A. DECANDOLLE).—In your Geography of Plants you have adopted the opinion of Edward Forbes, that in the Miocene period the European continent extended to the Azores and Canaries, and supported it by fresh proofs.* In fact, the predominant European character of these Islands, which occurs in their insects as well as in their flora, proves that they were anciently joined to the continent. Nevertheless we must not forget that, as compared with Europe, these islands are very different from those of the Mediterranean. They are distinguished in the first place by a much greater number of peculiar species, which constitute a third or a fifth of the plants; and in the second by some American types, which make their appearance in all these islands. There are not only certain American species which might have reached them accidentally by the agency of the winds and currents, or of man, but American genera which are represented by peculiar species. I will instance the genera *Clethra*, *Bystrobogon*, and *Cedronella*, as also the unique pine of the Canaries (*Pinus canariensis*, Sm.), which belongs to the American forms with acicular ternate leaves. The relations of the laurels is very remarkable in this respect; they form a great part of the forests of Madeira and the Canaries, dividing into four species and playing an important part. Two species (*Oreodaphne fœtens* and *Persea indica*) are essentially American types; the third (*Phœbe Barbusana*, Webb) belongs to a genus which occurs in India and America; and the fourth (*Laurus canariensis*, Webb) corresponds with the European species. By the possession of these laurel forests the islands of the Atlantic differ greatly from the African continent, where they are entirely wanting, and approach America rather than Africa, notwithstanding the proximity of the latter.

These facts obtain great importance by the observation that the flora of the Atlantic islands has much resemblance to the Tertiary flora of Europe.

In my 'Flora Tertiaria Helvetiæ,' I have proved that a considerable number of plants of the Tertiary epoch corresponded with species peculiar to Madeira and the Canaries, in such a manner that there must be a relation between the two floras. On the other hand, our Tertiary flora indicates a great resemblance to the flora of the southern United States. Many perfectly characteristic genera, such as *Taxodium*, *Sequoia*, *Liquidambar*, *Sabal*, &c., were distributed over the whole of our tertiary country, and composed partly of species very closely allied to those which now grow in America; other genera belong equally to America and Europe (such as *Quercus*, *Corylus*, *Populus*, *Acer*, &c.), and occur in the European Tertiary epoch, composed of species corresponding with the American forms.

We find similar cases amongst the terrestrial mollusca and insects, although this is not so positive as with regard to plants.

These remarkable circumstances are explicable, if we suppose that during the Tertiary epoch a terrestial formation united the continents of Europe and America, and that this surface was extended by some projection to the Atlantic islands. A glance at the map of the depths of

* DeCandolle, Géographie Botanique raisonnée, p. 1310.

the ocean by Maury, shows that the bottom of the Atlantic forms a longitudinal valley, of which the deepest parts are between the twentieth and fortieth degrees of north latitude, nearly at an equal distance from Europe and Africa, but that on the two sides of this deep valley there is a vast *maritime plateau*, which includes the Atlantic islands, as well as the whole space between the European continent, Newfoundland, and Acadia. Beyond this space another long valley, but of less depth, takes its rise, in a direction from south to northeast between Madeira and the Azores; it loses itself close to the coast of Oporto.

If we may attribute any importance to these very general data, we must admit that during the miocene period the maritime plateau above indicated was solid ground.

This country, this ancient Atlantis, would have had the same plants as central miocene Europe, of which the remains are found in the molasse of Switzerland in such astonishing profusion, that I shall be able to give descriptions and figures of about six hundred species in my 'Flora Tertiaria.' On the coast of this country the marine shells presented a great conformity in America and Europe; and this remarkable phenomenon is still reproduced, that Europe has more littoral than deep-sea species of shells and fishes in common with America; which proves that at one period a band of firm ground must have united these two parts of the world. The Atlantic islands had already risen towards the south coasts of this continent at the diluvian period. That this country was at the bottom of the sea during the miocene epoch, is shown by the fossil shells of Porto Santo and St. Vincent in Madeira and those of the Azores; but that it had emerged at the diluvian period is proved by the terrestrial mollusca of Caniçal, and the fossil plants of St. Jorge in Madeira.*

The islands formed at this epoch would have received their vegetation from the Atlantis in the diluvian period, and consequently at an epoch when this continent had entered upon a new phase of development. If we suppose, that then, by a subsequent depression of the soil, the connection with America was destroyed, and subsequently that which existed with Europe, we shall obtain the elements for the explanation of the existing flora of these islands. We there find the remains of the flora of the ancient Atlantis, and in consequence many types of the Tertiary flora are retained there whilst they have disappeared in Europe. These remains, with a certain number of other species, form the peculiar plants of these isles, corresponding in part with the American species because they have issued from the same centre of formation. But it is with Europe that these islands have the most species in common, probably because their connection with this continent lasted longer.

At the diluvian period the flora of central Europe was displaced by great changes of climate (extension of glaciers, &c.); and as by the depression of the Atlantis the connection with America was destroyed, the new European vegetation could not extend on that side, but only towards the east. It is thus that the characters of the new vegetation would be explained, particularly that of the lower countries, whilst the Alps and the north have undergone less change. This also is the reason of the

* See Heer, "Ueber die fossilen Pflanzen von San Jorge in Madeira." Zurich, 1855.

great analogies which occur between the north of Europe, Asia, and America. I arrive therefore at the same conclusion with yourself as regards these latter countries, namely, that the alpine vegetation is certainly the most ancient in our country, and that subsequently when the climate became warmer, after the glacial epoch, it rose from the low countries to the mountains and Alps.—*Ann. Mag. Nat. Hist., Aug.* 1856, p. 183, *from Bibliothèque Univ. de Genève, April,* 1856, *p.* 327.

7. *On the Ruminant Quadrupeds and the Aboriginal Cattle of Britain;* by Professor OWEN, F. R. S., (Proc. Roy. Inst. Great Britain, May, 1856.)—The speaker introduced the subject of the Ruminant order of quadrupeds, and the source of our domesticated species, by some general remarks upon the classification of the class *Mammalia*, and on the characters of the great natural group defined by Ray and Linnæus as the *Ungulata*, or hoofed mammalia.

These are divisible into two natural and parallel orders, having respectively the *Anoplotherium* and *Palæotherium* as their types, which genera, as far as geological researches have yet extended, were the first, or among the earliest, representatives of the *Ungulata* on this planet.

The brilliant researches by Baron Cuvier, the founder of palæontological science and the reconstructor of those primeval hoofed animals, from fragmentary fossil remains in the gypsum quarries at Montmartre, were alluded to.

Diagrams of the entire skeletons of the Anoplotherium and Palæotherium were referred to, in illustration of their dental and osteological peculiarities.

The *Anoplotherium*, with the typical dentition of

$$\textit{incisors}\ \frac{3-3}{3-3},\ \textit{canines}\ \frac{1-1}{1-1},\ \textit{premolars}\ \frac{4-4}{4-4},\ \textit{molars}\ \frac{3-3}{3-3}=44,$$

had all its teeth of the same length, and in a continuous unbroken series: this character is peculiar to man in the existing creation. The *Palæotherium*, with the same dental formula as the *Anoplotherium*, had the canines longer than the other teeth, and developed into sharp-pointed weapons; necessitating a break in the dental series to receive their summits in closing the mouth.

The anoplotherium had 19 vertebræ between the neck and sacrum, viz., 13 dorsal, and 6 lumbar. The palæotherium had 16 dorsal, and 7 lumbar vertebræ.

The anoplotherium had a femur with 2 trochanters, and the fore-part of the ankle-bone, called "astragalus," divided in 2 equal facets. Its hoofs formed a symmetrical pair on each foot. Cuvier has very justly inferred that its stomach must have been complex, and probably, in some respects, like that of the camel or peccari. The palæotherium had a femur with 3 trochanters, an astragalus with its fore-part unequally divided, and hoofs, 3 in number on each foot. It most probably had a simple stomach, like that of the tapir and rhinoceros, which, amongst existing animals, most nearly resemble that extinct primitive hoofed quadruped, with toes in uneven number.

Every species of ungulate mammal with an uneven number of hoofs or toes, that has been introduced into this planet since the Eocene Tertiary period, whether it have 1 hoof on each foot, as in the horse, 3 as in the rhinoceros, or 5 as in the elephant, resembles the palæotherium in having more than 19 dorso-lumbar vertebræ, which vertebræ also differ in number in different genera; 22, *e. g.* in the rhinoceros, 23 in the mastodon, 27 in the hyrax. The typical pachyderms, with an odd number of hoofs, have also 3 trochanters on the femur, the fore-part of the astragalus unequally divided, and the pattern of the grinding surface of the molar teeth unsymmetrical, and usually crossed by oblique enamel ridges. All the existing odd-toed or perissodactyle mammals have a simple stomach, and a vast and complex cæcum; the horned species have either a single horn, or two odd horns, one behind the other on the middle line of the head, as *e. g.*, in the one-horned and two-horned rhinoceroses.

Every species of ungulate animal with hoofs in even number, whether 2 on each foot, as in the giraffe and camel, or 4 on each foot, as in the hippopotamus, resembles the anoplotherium in having 19 dorso-lumbar vertebræ, neither more nor less; in having 2 trochanters on the femur, in having the fore-part of the astragalus equally divided, and in having the pattern of the grinding surface of the molar teeth more or less symmetrical. The horned species have the horns in 1 pair, or 2 pairs. All have the stomach more or less complex, and the cæcum small and simple. In the hog the gastric complexity is least displayed; but in the peccari the stomach has 3 compartments; and in the hippopotamus it is still more complex. But the most complex and peculiar form of stomach is that which enables the animal to "chew the cud," or submit the aliment to a second mastication, characteristic of the large group of even-hoofed *Ungulata*, called "*Ruminantia.*"

These timid quadrupeds have many natural enemies; and if they had been compelled to submit each mouthful of grass to the full extent of mastication which its digestion requires, before it was swallowed, the grazing ruminant would have been exposed a long time in the open prairie or savannah, before it had filled its stomach. Its chances of escaping a carnivorous enemy would have been in a like degree diminished. But by the peculiar structure of the ruminating stomach, the grass can be swallowed as quickly as it is cropped, and be stowed away in a large accessory receptacle, called the "rumen," or first cavity of the stomach; and this bag being filled, the ruminant can retreat to the covert, and lie down in a safe hiding-place to remasticate its food at leisure.

The modifications of the dentition, æsophagus, and stomach, by which the digestion in the Ruminantia is carried out, were described and illustrated by diagrams.

The speaker next treated of the various kinds of horns and antlers; the manner of growth, shedding, renewal, and annual modifications of the deciduous horns, the peculiarities of the persistent horns, the mechanism of the cloven foot; and the provision for maintaining the hoofs in a healthy condition, were pointed out.

The following were the chief varieties of the ruminating stomach. In the small musk-deer (*Tragulus*), there are three cavities, with a small intercommunication canal between the second and last cavity; the "psalterium" or third cavity, in the normal ruminating stomach, being absent. This cavity is likewise absent in the camel-tribe, which have the cells of the second cavity greatly enlarged, and have also accessory groups of similar cells developed from the rumen, or first cavity. These cells can contain several gallons of water. The relation of this modification, and of the hump or humps on the back, to the peculiar geographical position of the camel-tribe, was pointed out.

The modifications of the ruminating stomach, the discovery of rudimentary teeth in the embryo *Ruminantia*, which teeth (upper incisors and canines) have been supposed to characterize the pachyderms; the occurrence of another alleged pachydermal character, viz., the divided metacarpus and metatarsus in the fœtus or young of all ruminants, and its persistence in the existing *Moschus aquaticus*, and in a fossil species of antelope; the absence of cotyledons in the chorion of the camel-tribe, with the retention of some incisors as well as canines in the upper jaw of that tribe; the ascertained amount of visceral and osteological conformity of the supposed circumscribed order *Ruminantia*, with the other artiodactyle (even-toed) Ungulata; above all, the number of lost links in that interesting chain which have now been restored from the ruins of former habitable surfaces of the earth—all these and other similar facts have concurred in establishing different views of the nature and value of the ruminant order from those entertained by Cuvier, and the majority of systematic naturalists up to 1840. Thus instead of viewing the *Anoplotherium* as a pachyderm, the speaker, having regard to the small size of its upper incisors and canines, to the retention of the individuality of its two chief metacarpal and metatarsal bones, and to the non-development of horns at any period of life, would regard it rather as resembling an overgrown embryo-ruminant—of a ruminant in which growth had proceeded with arrest of development. The ordinal characters of the anoplotherium are those of the *Artiodactyla*. On the other hand, instead of viewing the horse as being next of kin to the camel, or as making the transition from the pachyderms to the ruminants, the speaker had been led by considerations of its third trochanter, its astragulus, its simple stomach, and enormous sacculated cæcum, the palæotherian type of the grinding surface of the molars, and the excessive number of the dorsolumbar vertebræ, to the conviction of the essential affinities of the *Equidæ* with other perissodactyles (odd-toed hoofed beasts).

The primitive types of both odd-toed and even-toed ungulates occur in the eocene tertiary deposits: the earliest forms of the ruminant modification of the *Artiodactyla* appear in the miocene strata. The fossil remains of the aboriginal cattle of Britain have been found in the newer pliocene strata, in drift gravels, in brick-earth deposits, and in bone caves. Two of these ancient cattle (*Bovidæ*) were of gigantic size, with immense horns; one was a true bison (*Bison priscus*), the other a true ox (*Bos primigenius*); contemporary with these was a smaller species of short-horned ox (*Bos longifrons*), and a buffalo, apparently identical in species with the Arctic musk-buffalo (*Bubalus*, or *Ovibos moschatus*).

The small ox (*Bos longifrons*), is that which the aboriginal natives of Britain would be most likely to succeed in taming. They possessed domesticated cattle (*pecora*) when Cæsar invaded Britain. The cattle of the mountain fastnesses to which the Celtic population retreated before the Romans, viz., the Welsh "runt" and Highland "kyloe," most resemble in size and cranial characters the pleistocene *Bos longifrons*. Prof. Owen, therefore, regards the *Bos longifrons*, and not the gigantic *Bos primigenius*, as the source of part of our domestic cattle.

From the analogy of colonists of the present day he proceeded to argue that the Romans would import their own tamed cattle to their colonial settlements in Britain. The domesticated cattle of the Romans, Greeks, and Egyptians bore the nearest affinity to the Brahminy variety of cattle in India. As the domestic cattle imported by the Spaniards into South America have, in many localities, reverted to a wild state, so the speaker believed that the half-wild races of white cattle in Chillingham Park, and a few other preserves in Britain, were descended from introduced domesticated cattle. The size of the dew-lap, and an occasional rudiment of the hump in these white cattle, as well as the approximation to the light grey color characteristic of the Brahminy race, seemed to point to their primitive oriental source. But the speaker could not regard the pure white color as natural to a primitive wild stock of oxen. It is now maintained by careful destruction of all piebald calves that are produced by the so-preserved half-wild breeds.

If the blood of any of the aboriginal cattle, contemporary with the mammoth and hairy rhinoceros, still flowed in the veins of any of our domesticated races, he thought it would be that of the *Bos longifrons* transmitted through the short-horned or hornless varieties of the oxen of the mountains of Wales and Scotland.

In conclusion the speaker referred to the subjoined table of the classification of recent and extinct hoofed quadrupeds, as indicative of the progressive extinction of those forms of *Ungulata* least likely to be of use to man, and of the substitution of the ruminant forms, which from the perfect digestion of their food, elaborate from it the most sapid and nutritious kinds of flesh.

UNGULATA.

Typica.

ARTIODACTYLA.*		PERISSODACTYLA.†
Anoplotherium.	*Auchenia.*	Palæotherium.
Chalicotherium.	Merycotherium.	Paloplotherium.
Dichobune.	Merycopotamus.	Lophiodon.
Cainotherium.	*Hippopotamus.*	Coryphodon.
Poebrotherium.	Dichodon.	*Tapirus.*‡
Xiphodon.	Hyracotherium.	Macrauchenia.
Moschus.‡	Hyopotamus.	Hippotherium.
Antilope.	Anthracotherium.	*Equus.*
Ovis.	Hippohyus.	Elasmotherium.
Bos.	Chœropotamus.	*Hyrax.*
Cervus.	*Dicotyles.*	*Rhinoceros.*
Camelopardalis.	*Phacochærus.*	Acerotherium.
Camelus.	*Sus.*	

* Αρτιος, *par*; δάκτυλος, *digitus*.
† Περισσοδάκτυλος, *qui digitos habet impares numero.*
‡ Only those genera printed in *italics* now exist.

Aberrantia.

TOXODONTIA.	SIRENIA.
Toxodon.	*Manatus.*
Nesodon.	*Halicore.*
	Rytina.
PROBOSCIDIA.	Halitherium.
Elephas.	Prorastomus.
Mastodon.	
Dinotherium.	

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Notice of the Scientific Results of the Expedition to the North Pacific Ocean, under the command of Com. John Rodgers;* by W. STIMPSON. (From a letter to J. D. DANA, dated Washington, Dec. 1, 1856.)

Prof. DANA: *Dear Sir*—Our Expedition having returned, thinking you would be interested in some account of the zoological results, I transmit herewith a general view taken from the catalogues, which will give you some idea of the character and extent of what has been done. As the Expedition had for its object marine explorations and surveys only, no opportunity was afforded for inland research; so that fishes and invertebrates—the chief inhabitants of the sea—form the mass of the collections. The principal object kept in view has been, when on coasts little known zoologically, the numerical accumulation of species. This course was not only indicated by the importance of adding to our very imperfect knowledge of the geographical distribution of animals in those seas, but was, so to speak, necessitated by the shortness of our stay at the different points visited. Minute anatomical examinations are always made with difficulty on board ship, beside requiring much time; and if these be carried on during the few days spent in harbor, the collection of specimens and the investigation of the general character of the fauna of the district must be neglected; in other words, for the sake of complete examinations of two or three species, opportunity is lost for gathering and briefly noticing a large number of forms, many of which may prove to be of the greatest interest to science.

The course pursued has been this. At each place visited, daily excursions were made to such distances as were necessary for the collection of as large a number of species as could be examined and preserved during the remainder of the day. As soon as the proper amount of materials was secured, they were immediately brought on board ship and spread out for examination. The soft animals were attended to first, together with those whose structure will not allow of preservation in alcohol (as *Nudibranchiates, Planariæ*, etc.) These, if new species, were drawn and described in full upon the spot, whatever expense of time might be necessary, as no other means exists of preserving their forms and colors. Then the colors of those animals (as the fishes, crabs, and echinoderms) whose *forms* are easily preserved, are rapidly noted and the specimens killed and placed in their proper receptacles. In the mean time such animals as expand their tentacula, branchiæ, or other parts under favorable circumstances (as polyps, holothurians, bivalve mollusks, etc.), have been lying quietly in the vases of sea-water allotted to each, and glanced at from time to time, that they might be drawn at the favorable moment, the animals of the rarer shells were treated in this latter manner, many remaining undisturbed for hours before they would show themselves to the anxiously watching Malacologist, and then timidly withdrawing at the least alarm.

The endeavor has always been made to secure full notes of all such external phenomena as pertain to the *living* animal, and such as cannot be observed in preserved species. Thus notes of greater or less extent, from a full description and colored drawing down to simple statements of locality, habits, and station, have been made upon over 3000 species.

By far the greater part of the animals observed during the expedition have been invertebrates. At the present day new forms of mammals and birds are rare, and only to be sought for in the interior of continents, or of the larger and less known islands, as those of Japan. As the objects of the expedition did not include land-travelling to any extent, only such kinds of the larger animals were secured as could be obtained in short excursions from the ship. In Japan, a considerable variety might doubtless have been collected, did not the laws of that country, and a stipulation in our treaty, expressly forbid "the shooting of birds and animals." Perhaps the most interesting species are those collected on the shores of Behring's Straits.

About ninety species of reptiles were brought home, one-third of which will probably prove new to science. Fishes we had always good opportunities of procuring, and specimens of more than five hundred species were collected, a large proportion of which are those smaller forms which have not yet been studied. Of the larger kinds there are several curious species not yet to be found in any of our collections.

As before said it was not to be hoped that any great number of novel forms of Vertebrata would occur, as these have naturally occupied the primary attention of former collectors; while many of the ports visited by the expedition have been long inhabited by Europeans, and repeatedly searched. With the Invertebrata the case is different. These are chiefly inhabitants of the sea, or of such places on land or freshwater as to elude all observation except such as is expressly directed to their search. In many their very minuteness enables them to escape notice. A large proportion live in the depths of the ocean, and can only be brought to light by dredging, which, in the Pacific has as yet been carried on to little extent. It is at once apparent that this is the field in which the most successful gleanings are to be made at the present day, and to this chief attention was directed.

The expedition was fortunate in having for its commander one who appreciated the value of all departments of science, even of those whose utility is not at once apparent, not forgetting natural history. To Capt. Rodgers we are indebted for the whole of the rich collection of invertebrates made in the Arctic Sea, during the month of August, 1855, the dredge being almost constantly used from the ship, although the whole of the scientific corps were then making explorations on shore at Seniavine Straits.

Generalizations, including those upon geographical distribution, for which a large amount of materials has been accumulated, cannot of course now be made or presented here, and will properly be considered and compared with former deductions after the new species have been worked up, and their bearing upon the various groups and subdivisions established.

The whole number of species collected, in all departments, is about 5300. The number of specimens may be stated approximately as 12,000. The species are distributed among the various groups as follows:

Mammalia,	31	Naked Gasteropoda,	180
Birds,	175	Testacea,	1970
Reptiles,	90	Tunicata,	40
Fishes,	550	Bryozoa,	50
Insects,	400	Holothuridæ,	70
Crustacea,	980	Echinidæ,	66
Annelides,	220	Stelleridæ,	150
Turbellaria,	96	Polypi,	90
Cephalopoda,	20	Medusæ,	30

2. *On the Meteor of July 8th;* by Prof. N. K. Davis, of Howard College, Marion, Alabama.—All the notices of this meteor I have seen omit the mention of what appears to me the most remarkable phenomenon connected with it. The meteor itself I did not see, but on the afternoon of the above date, as nearly as I can remember, about 4 o'clock (I did not note the time) a friend called me out into the middle of the street stating that he had just seen a brilliant meteor and pointed to the place over the house tops. On looking I saw a dense white cloud, which he stated had been left by the meteor, about 1° in width and 8° in length, nearly perpendicular to the horizon, and having its lower extremity elevated about 25°. Its bearing was west of northwest, I should judge farther west than the writer in the Journal makes it. This appearance struck me as remarkable and I watched it with great interest. The air being clear, its great apparent density, its sharpness of outline and its considerable elevation, deceived me at the first glance respecting its distance, and my first impulse was to mount a horse and gallop to the spot indicated by its direction; but on changing my position purposely to ascertain, I found that it had no sensible parallax which undeceived me. By information since received, I find it must have fallen somewhere in Mississippi, at least 150 miles from this place. Of course no sound was heard here. The fumes were intensely white and dense, reminding me strongly of the fumes of chlorid formed when powdered antimony is projected into a jar of chlorine. The cloud gradually took a zigzag form and the aerial currents then slowly dispersed it, though it retained its dense appearance after it had spread considerably. I have never seen a notice of a similar fact, and the question arose in my mind—may not the luminous trail left by nocturnal meteors, which all close observers will grant is *not* always the impression retained by the retina, be due to the momentary phosphorescence of similar fumes? I say 'fumes' because I suppose the cloud to be a product of combustion in the air; but what this product may be, from its appearance alone I should be at loss to determine.

3. *Credit to whom credit is due;* extract from an Address before the American Institute, New York City, by Prof. A. D. BACHE.—I wish I could so speak for the Continent, and especially for France. Since the wane of that great light of the French Academy, Arago, American scientists have had much to complain of. Since its final earthly eclipse they have more. The official publications of the doings of our real men of science are either overlooked entirely, disregarded, or named to be treated with disrespect. This, too, from those who once professed to be amongst the most devoted of the admirers of Arago, and under his lead, to cultivate friendships which might almost be termed *sentimental*, with our savants. "Write to me," said one of these distinguished men to one of our friends, "at the equinoxes and I will answer at the solstices." I wrote said the American at the equinoxes, *but the solstices* have never come. True there are cases of exception which according to the law maxim prove the rule. Not to indulge in generalities, I state, after full examination, that the methods advanced by Le Verrier, a man who of many, has no need to slight the claims of others, for determining differences of longitude by the telegraph, are but the reproduction of those used in the Coast Survey of the United States for now these eight years, the fruits of the labors and studies of Walker and Loomis, Gould and others. Neither the method coincidences which he lauds, nor that of signalizing the transit of stars, which he considers of the highest merit, *are new*, but have been practiced for years, and every few months have been published over and over in official reports, in the proceedings of recognized scientific bodies, and constitute in part, what may properly be called the American method of telegraphic longitudes. The Astronomer Royal of Great Britain, in a far different spirit, has given to the automatic register of astronomical observations by the galvanic circuit, the title which generously recognizes our claims, and assigns the origin to the United States—in the title of American method of observation.

A lesser light too, of the old world, Wychmann, of Königsberg, has just published an article on the difference of longitude by telegraph, stimulated by that of Le Verrier, and containing an outline of his mode of proceeding, which might almost serve as a history of the olden time methods of the coast survey.

Better things than this were to be expected from a German physicist. They of all Europeans have, in former days, been sore under the infliction of the egotism or neglect of the French physicists, and I remember well the unction with which the story was told me by one of these men who read all languages, that when Becquerel was reproached with his neglect of German electricians in his work on electricity, he exclaimed with a nonchalance considered typical of the Academy, "Must one know all languages to write a book?"

4. *Geographical Discoveries in Africa;* by Rev. Mr. LIVINGSTON, (Letter dated "River of the Bashukulompo, near its confluence with the Zambesi, latitude 15° 47′, longitude 28° 50′ east, 20th December, 1855.) Cong. Jour., Sept. 26, 1856.—A little leisure obtained, together with a bountiful supply of pork for my party, enables me to commence an epistle to my Yankee brother. We number 115 in all, so you may wonder whether we have a Cincinnati in intertropical Africa. We got a hippo-

potamus last night, and some elephants appearing this morning, the men ran off, and soon killed a fine cow with their spears. The flesh of the river horse is very like pork, and much esteemed in the colony as such. My men are now all cutting it up into long strips for drying, roasting it, and boiling it, and laughing. I am sitting on some grass in the midst of ranges of beautiful tree-covered hills, and after this introduction will proceed as follows.

We came down the river from Sesheki convoyed by Sekeletu and principal men, with about 200 followers. About ten miles below the confluence of the Chobe, the rapids began, which compelled us to leave the canoes, and march along the bank on foot. Twenty miles brought us to the island of Sekote or Kalai. As it was necessary to turn off to the northeast from this point, in order to avoid Tsetse, I took a canoe and went about eight miles farther down to see the Falls of Mosioatunya. When five or six miles distant, we saw five columns of smoke ascending *apparently* to the clouds. Taking a little light canoe, when about a mile above the spot, and men well acquainted with the rapids, we went to an island situated about the middle of the ledge over which the Zambesi rolls, and then crawling to the edge, peered over into the wonderful abyss which constitutes Mosioatunya (smoke sounds).

"There is always something new from Africa," said Scipio, or somebody as wise. You may see your big Niagara, but you cannot see a river leaping into a straight jacket. Imagine the Thames filled with low tree-covered hills, 300 feet high from the tunnel down to Gravesend, and its bottom formed of basalt instead of mud. Then fancy farther, a rent made in the bed from bank to bank, down through the roof of the tunnel, and the pathway to be about 100 feet below instead of what it is, the lips of the fissure being from 50 to 100 feet apart, and the whole mass of water flowing southerly, leaping down into this, and suddenly compressed from a thousand yards into fifteen or twenty, then compelled to flow from east to west, or from the right to the left bank, there turning a corner, it resumes in the fissure prolonged in that direction, its southerly course. The fissure in passing through the hills for about thirty miles, becomes much deeper, probably 300 feet. Then the river opens out again, and our goodly Zambesi flows placidly away to the northeast.

In looking down into the fissure on the right, one sees nothing but a dense white cloud with two rainbows on it. It was near midday when we visited it, and the southern declination of the sun nearly equal to the latitude. An amount of vapor rushes up which I never saw equalled anywhere else. Rising about 300 feet it becomes black, and descends in a smart shower, which soon wet us to the skin. In the distance it resembles African grass burning. We have no idea of the depth of the fissure on the right side. On the left, a large piece has fallen in, and that seems about 100 feet from the lip over which we are looking. The lip over which the water flows has its edge worn about three feet down at the three portions into which the water divides itself at low water.

At this time the falls are about 600 yards broad. There are two smaller ones, hence the five columns of vapor. This lip may be said to be serrated on the edge, several large pieces having fallen in, and it is from 50 to 100 feet distant from the opposite one, which has a clean sharp edge; both are quite perpendicular. The opposite lip is ornamented with a large straight hedge of evergreen trees, whose leaves are constantly wet by the perpetual shower. Little streams run down from the hedge into the gulf, but never reach the bottom; the ascending mass of vapor blows them all aloft again.

In former times, the three principal falls were places of worship for three chiefs who lived in the neighborhood. I suppose they thought the feelings of awe which the scene inspires were appropriate in praying to the Barimo (gods, or departed spirits). The never ceasing roar might convey an idea of the flood gushing forth from beneath the footstool of the Eternal, and the bright rainbows immovable on the fearful turmoil below, that of Deity presiding over all unstable things, Himself alone unchangeable. But they never knew him as we do, a God of benevolence and love. They were a bloody, imperious crew. In all their villages are seen numerous human heads mounted on poles. I counted between fifty and sixty so exhibited in one village. On asking the son of the head man, who had killed the owners, what had been his father's motive, he replied, "to show strangers his fierceness." But many of these were mere boys, and he was not ashamed to own it. They had been returning, half famished, from an unsuccessful expedition against Sebituane, and this was the hospitality they met with.

I returned next day with Sekeletu on a little speculation of my own. The island on which we stood in the middle of the falls, is covered with trees which are nourished by occasional puffs of the wind carrying a gentle shower from the columns over the island. I have often planted fruit tree stones, but the climate, though much more humid than the south, is troubled with intermittent droughts, which destroy tender plants. I always lost my plants by my friends forgetting to supply moisture. Seeing it clear, therefore, that Mosioatunya would not forget to throw up vapor, nor the winds to blow, I made a little nursery for peaches, apricots and coffee, at a part of the island which I think will get about a proper quantity of the condensed vapor. The only enemy I have to fear is the hippopotamus, of which we saw footprints on the island. But a Makololo promised to make a hedge, and if the brutes don't break it, I have great hopes of Mosioatunya's abilities as a nurseryman. When the river rises four or five feet the island is totally unapproachable by man, and there is a continuous fall of a thousand yards. I am, however, a miserable judge of distances on water. I showed a naval officer a space in the bay of Loanda which I thought of the same breadth as the Zambesi, and called 500 yards. He replied, "that is 900 yards;" and yesterday, I put down the river Bamuki at a broader part than the ford, as 200 yards, but having to wade two-thirds of it, I found the whole to be 300 yards. I believe no one will, in future years, say I have overstated the size of parts described.

In coming through the country of the Balonda, we passed a little lake called Dilolo. There is a river connected with it called Lotembua, which has the singular fortune of running two ways at once. The upper or northern portion of it flows northwest into the Casai; the lower or southern half runs into the Seeba, which again flows into the Zambesi. As the Casai is the main branch of the Congo or Zaire, the Lotembua pours some of its waters into the sea on the west coast, and some into the same receptacle on the east coast, or to write more magniloquently, Lotembua divides its waters between the Atlantic and Indian oceans.

The real form of the continent is not, as was imagined, an elevated table land, with high mountains—African Cordilleras—running from north to south, but a hollow basin with an elevated ridge, distant in both cases, about 300 miles from the coast. This is clearly evident from all the sources of the Casai flowing from the western ridge towards the centre of the continent. The feeders of the Zambesi on the west, as Loete, Simah and Chobe, flow in this direction into the Zambesi or Leambye, and all the feeders of the Leambye on the eastern side, as the Loapola, River of Babisa, &c., flow westwards, or towards the centre of the basin. Casai and Leambye run north and south respectively, till they find openings in the ridges, one by fissure (see Tuckey) and the other by Mosioatunya (see above). Lotembua is about the highest point in the basin, hence it runs both ways. The courses of all the extra basin rivers, as Couza, &c., are necessarily short. Now take care to imbibe the real idea I mean to convey, for I have more than the philosophy of the thing in view. The middle of the continent is without doubt a basin, but only with respect to the longitudinal ridges named, and *not as regards the level of the sea.*

Lake Ngami is the lowest spot in it I have visited. Water boils there at 206½°, (this is from memory,) and it therefore is a little more than 2,000 feet; Linyanti, 205½°, Lotembu, the highest part, 203°, the top of the ridges on both sides, 202°. Not having a table by me, I can only conjecture, from recollection, that this indicates between 3,000 and 4,000 feet above the level of the sea. When we came to the high land overlooking the Quango and Cassenge, I thought we had been traveling on elevated table land; but we were just on the ridge (202°) and the opposite side, which, in ascending, seems higher, is actually much lower (206°). The denudation has been more vigorously executed below it than below the eastern ascent.

In relying on the boiling point of water, I am quite aware it is not a very precise way of measuring altitudes, still, no one will despise the results, when corroborated by the general courses of the rivers, and the general direction of the ranges of hills north-northwest and south-southeast. Such, too, is the strike of the strata, and the dip is toward the centre of the continent. These rocks are of the series which form the bottom of the oldest silurian, sometimes of sandstone, with banks of shingle, and not a trace of vegetable existence; others of mud, now schist, but nothing impressed on it but the ripple mark of the hot primeval ocean; and at other times of sandstone schist, containing impressions of Algæ, and other of the lowest forms of vegetable existence. Pieces of the last have often been brought up by eruptive rocks, which have partially elevated and filled portions of the basin. Without dosing you *ad nauseam* with geology, for the pursuit of which science I have myself always had more inclination than leisure, I may add that before the fissure of Mosioatunya was made, there was a vast lake west of it, which included Lake Ngami, Libele, Linyanti, &c. &c., in its bosom. The Zambesi then flowed in a bed on the left of the fissure, and in which a small stream called Lekono now flows, but it runs away back and joins the river above the falls. The beginning of the ancient bed is on the same level as Linyanti. Leaving it, and going northeastward, we come to another called Ungnesa, which also turns backward and joins the river above the rapids. On the centre of the ridge runs the Kalomu—scarcely more than mountain torrents all of them—but it flows south and joins the Zambesi below the falls. Then the Mozuma, which is the first showing inclination eastward. The boiling point of water corresponds to 202° on the Kalomo. This ridge is perfectly salubrious, and so is that on the west. There are no marshes on it. The grass is short, and well suited for pasturage.

It once contained a very large population, as the ruins of towns everywhere testify, and is well adapted for raising native produce. It has again and again been overrun by fire and sword. The people are humbled by these calamities, and after the first suspicions were over, received us joyfully as harbingers of peace. "Give us sleep," said they, "that we may repose without dreaming of men pursuing us with spear in hand." They are very degraded, dress *in puris naturalibus*, and make one think that man is the most inelegant animal alive. I asked an old man with as much civility as I could muster—for it is as useful among savages as among savans—if he had never thought of a slight departure from his original costume, a fig leaf, for instance, though he might not approve of "going into bags," (they call our dress so). He looked at me with that sort of leer which the so-called freethinkers adopt when pitying our weakness for believing that the Bible is verily God's message to man, and answered with a smile, "he was not troubled with my weak prejudices!"

The Makalolo once lived on the ridge, and I remember that on asking Sebituane if his country were all as unhealthy as Linyanti, he referred me to this, and told me he was forced to leave it by the Matibale. It has all the appearance of salubrity, open, undulating downs, with but few trees except on the hills, which are always covered with them. Both eastern and western ridges have the same character, indeed, many of the trees are identical with those on the slopes down from Cassenge; and so are the plants and rocks—mica slate glancing in the sun like burnished gold. They extend a long way north.

Examination of the fissure which drained such a vast extent of the basin, shows it is of no great antiquity. There are indications that the force acted also at the falls of Gonge, and drained the Borotse valley; the Roovooma, Simpopo, and other eastern rivers, were liberated in the same way, and so were the Orange and Congo. Besides banks of shells on both coasts, showing recent elevation, there are other indications in the failure of nearly all streams and fountains within the ridge whose course was to it or westwards, and if this is the geological process now going on—a draining process on a vast scale—it is, perhaps, not too speculative to think it tends to a healthy millennium for Africa. * * *

We have a very nice bean in this country called earth nut. Some were taken out at our second visit to the Lake, and Mr. Moffatt, Jr., sent a few to Natal. They are now an article of export thence. It requires only four months from planting to maturity, and as it yields beneath the soil, I think it might be acclimatized in the United States. It yields the sweet oil of commerce by being pounded and thrown into boiling water. When roasted, and when not quite ripe, it far exceeds almonds or walnuts.

We hope to reach the coast in a month or two. It is an entirely new path; no European ever crossed the continent before. Arabs, however, have done it frequently, and it was accomplished by two native Portuguese. This fact was deemed of so much importance, it was noticed in the history of Angola. There never was any chain of stations across the continent, as mentioned by some Portuguese. Pereira's journey to Cazembe is known; he was heard of only here. Indeed the use they apply the ivory to shows they had none. The chief's grave at Kalai had seventy large tusks placed around its edges, the points looking inwards, the bodies sunk half way in the ground; there were thirty on other graves, all rotten from exposure to the weather. This was the common application among all these tribes.

5. *On Isothermal Lines;* by Prof. HENNESSY, (Proc. Brit. Assoc., Aug. 1856, Ath. No. 1503.)—After some preliminary remarks as to the general influence of the distribution of land and water on the forms of isothermal lines, the author proceeded to discuss the distribution of these lines in islands. By considering an island situated so as to have its shores bathed by a warm oceanic current, if the influence of direct solar radiation be obstructed, it appears that the isothermals would be closed curves surrounding the centre of the island and having some relation to its coast line. The influence of ranges of mountains, and in general of inequalities in the surface of the island, as well as the modifying action of general winds, and the resulting changes in the shapes of the isothermals, were explained. By the introduction of solar radiation it now follows from the mathematical theory of heat that the entire quantity of heat received by a unit of surface of the island will depend on two principal terms: one, a function of the distance of the point from the coast, and capable of being expressed in some cases as a function of the difference of latitude of that point and the nearest point on the coast,—and, secondly, of a term depending on the latitude and on an elliptic function of the second order, having for its modulus the sine of the inclination of the equator to the ecliptic. It hence follows that the effect of solar radiation will be to transport the centres of all the closed isothermals towards the pole of the hemisphere in which the island is situated. Some of the lines may thus ultimately terminate at the coast with their convex sides turned towards the equator, while others may still continue as closed curves in the interior. If the influence of difference of latitude and direct solar radiation were greatly predominant compared to other causes affecting the temperature of the island, the isothermals might all terminate on the coast. If the continents may be considered as immense islands so circumstanced, they become subjects for the application of these views. Prof. Hennessy then proceeded to show that the isothermals of Ireland strictly conformed to his theory. On discussing the observations collected and arranged by Dr. Lloyd, in his "Memoir on the Meteorology of Ireland," it appears some of its isothermals are actually closed curves, while others terminate at points on the coast, the shortest being close to the equator. The physical structure of Ireland, and the difference of nearly 4° between the tem-

perature of the seas bathing its shores and the air above them, rendered it probable, *à priori*, that Ireland should present a good example for the application of the theory. From the general nature of his views, Prof. Hennessy anticipated that the discussion of observations in other islands would lead to their further confirmation,—and it would ultimately follow that not only are isothermals sinuous in their shapes and not generally parallel to the equator, but that many would be found which do not at all circumscribe the axis which joins the opposite poles of the earth.

6. *Machine for Polishing specula of reflecting Telescopes*, (Proc. Brit. Assoc. Aug. 1856; Ath., No. 1503.)—Dr. R. Greene exhibited a beautiful working model of a machine, invented by him, last year, for polishing the specula of reflecting telescopes. His object in constructing it was to produce a machine at the cost of 60*s.* or 70*s.* which should be equally efficacious for that purpose as a very complex machine invented by Mr. Lassell, of Liverpool, which has produced the finest telescopes ever constructed. Having accurately attained this object, the Doctor found that by adding three or four more pulleys to the machine it was capable of moving the polisher over the speculum in an almost endless variety of curves, so that the operator could choose any variety of figure he might fancy to experiment with. We have ourselves seen a great variety of those beautiful figures traced by the machine itself by fixing a black-lead pencil on the working crank. A machine costing not more than 60*s.* or 70*s.* is amply powerful for polishing a speculum of 12 or 14 inches in diameter, which it will generally finish in from four to six hours. The principle of the machine consists of a vertical shaft carrying a sliding crank and an horizontal table or chuck attached to another vertical shaft, but which, being supported by sliding collars, can have its axis moved at pleasure to any distance out of the line of direction of the axis of the crank. The table can be made to revolve from right to left, or the reverse, at pleasure, and move with various velocities. All the journals move in box-wood collars or boxes, which the Doctor finds after many years' trial to be superior to bell-metal, as not heating, soiling the oil, or working loose, and recommends them for general use in mounting every kind of machinery. He also mentioned the great advantage he derived from placing the centre of the speculum a little out of the centre of the revolving table, thus making the excentricity a variable quantity, being sometimes the *sum* and at other times the *difference* of the two excentricities of the table and of the speculum on the table. Lastly, he recommended making the polisher of the three circular pieces of light wood joined together, one in the centre and the other two at right angles to the centre-piece, in place of two pieces only as usually employed, and which are liable to warp, while three pieces will never warp with any change in the dryness or dampness of the atmosphere; and in place of forming the grooves in the pitch by indentation with the edge ot a strip of thin wood, the Doctor preferred fastening small squares of thin wood to the face of the polisher, and covering them with the pitch, leaving about a quarter of an inch space between the squares.

The paper gave rise to an animated debate, in which many members joined, particularly Mr. Lassell, who highly approved of the machine and the Doctor's suggestions in using it.

In the course of the discussion upon this paper, the interest in which was much increased by Mr. Lassell's taking part in it, Prof. Stoney remarked that two of the main points now brought forward have been already published. The motion which is given to the spindle carrying the speculum in order to secure the requisite motions without complex mechanism above, and the scoring up of the polisher so that the pitch may have ample room to expand laterally without getting into ridges, were both parts of the Earl of Rosse's original invention, as published in the Philosophical Transactions for 1840. Lord Rosse not only was the first to polish large specula successfully by machinery, but further pointed out in the clearest manner the principles which should be kept in view in contriving other machines to effect the same result.

7. *Observations with the Aneroid Metallique and Thermometer during a Tour through Palestine and along the Shores of the Dead Sea;* by Mr. H. Poole, (Proc. Brit. Assoc., August, 1856; Ath. No. 1504.)—During a recent tour through Palestine I carried an aneroid metallique, and though I would not presume to say that the results of observations made with it are quite correct, yet as the readings in many instances are close approximations to the calculation of Lynch and other travellers, I wish to draw attention to that instrument as affording an easy mode of obtaining approximate levelings of heights in unsurveyed countries. It is light, and can be easily carried by a strap over the shoulder. From the rack-work being visible a readjustment can be easily made when required upon ascending high mountains. A table of corrections is, however, required, and which I found must be *additive* with an *increase* of temperature (being the reverse of mercurial barometers and vacuum aneroids), as indicated by the variation in the readings at different temperatures at the same localities, as recorded in the accompanying table. In Dent's Tables 85 feet are calculated for the difference of each tenth of an inch of barometer: this multiplied by 39·37 inches, equal to a metre, gives 33·46 feet, or 33·50 feet in common practice, as the multiple of each division in the aneroid metallique. In practice I found it very nearly correct:—for instance, there are 47 steps with a six-inch rise going down into the Tomb of the Virgin Mary in the Valley of Jehoshaphat, 23·5 feet; and by aneroid I read a difference of 7 millimetres $\times$ by $33{\cdot}5 = 23{\cdot}45$ feet. Again, the minaret of the Church of Ascension on the top of the Mount of Olives measured 36·5 feet; by aneroid the difference was 11 millimetres $\times$ by $33{\cdot}5 = 36{\cdot}85$ feet. If the aneroid were mounted with a vernier scale, the observations could be more closely read off.

I particularly mention these comparisons of the aneroid with actual measurement, as they gave me confidence in it at the time, and also because I found on my return to London that I had arrived very nearly at the same results as Lieut. Lynch up to 2,000 feet above the level of the Mediterranean Sea, and also in the depression of the Dead Sea, 1313·5 feet by aneroid, while Lynch made it 1316·7 feet by level, and Capt. Symonds calls it 1312 feet. There is also a variation in the line of level of the Dead Sea at different seasons of the year, for I found at Ras Em Burghik three distinct lines of drift wood, one above the other,—opposite to Usdum the line of salt incrustations was 40 yards and the line of drift 70 yards distant from the edge of the sea, while along the west side of the peninsula "El Lisan" a reef of rocks was exposed about a quarter of a mile distant from the shore, which does not appear to have been noticed by Lieut. Lynch's party,—I therefore think I must have been there when the water was unusually low. I found the temperature of the Dead Sea at the north end 82° Fahr. at 5 A. M., and 83° at the south end at 4 P. M. River Jordan and brooks on the Lisan and at the Ghor 64° each; brine spring 90°, where the small fish "Lebia" was caught close to the edge of the Dead Sea; Wady Em Burghik, temperature of water 76°; spring at Engedi 83°. At Ain Terabêh the sea was 80°, also a brine spring close to the shore, and the freshwater spring was 79°,—in the latter were a number of Lebia swimming about, the largest appearing to be about 3 inches long. A sulphurous smell was observed on passing the white hills south of Sebbeh, near Wady El Mahras, at Birket El Khalil,—but not at other places. It often blew hard during the day, but the waves never appeared to be more than 2 feet high, and the sea quickly went down after the wind ceased. Several nights were quite calm, but I never observed any phosphorescence on the water. The table of the dry and wet bulb thermometer was made by the same instrument, as unfortunately I had broken two others, and there were not any to be procured in Jerusalem. I therefore obtained the lower, or wet-bulb, temperature by wetting the bulb and waving the instrument in the shade, not having any muslin to cover it with. The relative humidity by this rough means was from 50 to 25 per cent., on the shore of the Dead Sea. The force of vapor being between 6 and 3 inches by Regnault's formula. The vapor arising from the Dead Sea when looked at from the heights of Ain jedi (Engedi) and Ghomran, had the same appearance as the fumes produced at brass castings.

8. *Geological Progress of the World;* note by J. D. DANA.—In a note to page 348 of last volume, I state that the law of progress,—"unity evolving multiplicity of parts through successive individualizations, proceeding from the more fundamental onward"—has been recognized among philosophers. It is in fact embraced in the systems of nature of the German metaphysicians; yet it is generally with them rather a vague idea, than a definitely appreciated principle. The true comprehension of the formula as it is exemplified in the Earth's physical progress, was first brought out by Prof. Arnold Guyot; and an exposition of it from several points of view is presented in his admirable work on Physical Geography entitled "Earth and Man". He has found it a fruitful principle also in the study of human history.

9. *Anatomical models by H. D. Schmidt, Philadelphia.*—In a recent visit to Philadelphia, we accompanied Prof. Leidy to examine the anatomical museum of the University of Pennsylvania. Among many rich objects of interest we observed a number of large anatomical models, of great beauty, which were made at the University by H. D. Schmidt. The models are constructed after nature under the inspection of Prof. Leidy, and are made of leather. One is a colossal model exhibiting the distribution of the great sympathetic nerve; another exhibits the superficial nervous system; and a third presents on a grand scale the anatomy of the brain. Nothing could be better adapted to aid in the teaching of human anatomy than these models, which are superior to anything hith-

erto brought from Europe, the imitation of nature being excellent, and the models themselves light and durable. They may be had at comparatively moderate prices by applying to the artist, at the University in Philadelphia. J. D. D.

10. Obituary.—*Death of Prof. Nicholas M. Hentz.*—Prof. N. M. Hentz died after a lingering illness, on the 25th November, 1856, at the residence of his son, Dr. Charles A. Hentz, at Marianna, Florida.

Prof. H. was a native of France and came to the United States many years since. He was associated with Hon. George Bancroft as a teacher in the Round Hill School at Northampton, Mass. He was subsequently engaged at Cincinnati, Ohio, and then at Chapel Hill, N. C., as professor of modern languages and belles letters. From an early period he gave much study to some departments of natural history, and devoted especial attention to the arachnida and insects. Two papers of his appeared in the first series of this Journal, viz., a Conspectus of the Spiders of North America, (vol. xxi, p. 100–109;) and a description of an American Spider constituting a new sub-genus, *Spermophora*, (vol. xli, p. 116, 117). We trust that a full account of his life and scientific labors will be published by some friend acquainted with the particulars of his history.

11. *Wm. Yarrell.*—This distinguished zoologist died on the 1st of September last at Great Yarmouth, England. He was in his seventy-third year, having been born in 1784. The two prominent works of Mr. Yarrell are "The History of British Fishes," and "The History of British Birds." He also contributed various papers to scientific periodicals and society transactions. He was buried at Bayford in Hertfordshire, the last of a family of twelve brothers and sisters. His father was a news-agent in London.

12. *Professor Bojer.*—Professor Bojer, the well-known botanist of the Mauritius, died on the 4th of June last, at the age of fifty-six. His first visit to Mauritius was made in 1820. In 1837 he published his Hortus Mauritianus; and a year before his death he became Professor of Natural Philosophy in the Royal College on that island.—*Edinb. New Phil. J.*, Oct., 1856.

13. *A Treatise on Mineralogy;* by Charles Upham Shepard, No. II. 451 pp., 8vo, New Haven, 1857.—This part completes the issue of the third edition of Prof. Shepard's work, the first part of which appeared in 1852. We defer to another time a farther mention of the work.

14. *Elementary Course of Geology, Mineralogy, and Physical Geography;* by Prof. David T. Ansted, M.A., F.R.S., etc., Consulting Mining Engineer, etc. 2nd edition, 606 pp. 12mo. London: 1846. John Van Voorst.—This convenient text-book commences with "Physical Geography" embracing under this head, the topics of Dynamical Geology. Part II is devoted to Mineralogy which is treated at considerable length, 120 pages being devoted to it. Part III includes "Descriptive Geology" or Rocks and their fossils, in which the author begins as he should with the earliest rocks; and Part IV treats of Practical Geology. This concluding part covers 120 pages. The work is not especially adapted to American students, yet for a text-book of the size, we know of no better in our language.

15. *Chemical and Pharmaceutical Manipulations:* A Manual of the Mechanical and Chemico-mechanical operations of the Laboratory. For the use of Chemists, Druggists, Manufacturers, Teachers, and Students. 2nd enlarged edition, by CAMPBELL MORFIT, Professor of Analytic and Applied Chemistry in the University of Maryland, and CLARENCE MORFIT, Assistant Melter and Refiner in the United States Assay Office. 626 pp., 8vo, with 537 illustrations. Philadelphia: 1857. Lindsay & Blakiston. —This large volume on chemical manipulations enters fully into the construction of laboratories, as well as apparatus and processes employed in chemistry. Its chapters treat severally of the laboratory, the balance room, the furnace room as to all its arrangements and apparatus, the operating room, the division of substances (trituration, levigation, &c. &c.), the balance, weights, weighing, determination of specific gravity (including a long table of specific gravities), measures and measuring, measurements of temperature, sources and management of heat, baths, mode of producing low temperatures, fusion, ignition, cupellation, sublimation, distillation, lutes, the barometer, solution, evaporation, crystallization, desiccation, precipitation, decantation, filtration, washing; practical relations of electricity; blowpipe manipulations, glass blowing, corks, weights and measurements. Prof. Morfit is the author of several works on chemical subjects and his books are all valuable.

16. *Miscellaneous Chemical Researches;* Inaugural Dissertation for the Degree of Doctor of Philosophy, addressed to the Philosophical Faculty of the University of Göttingen; by CHARLES F. CHANDLER, of New Bedford. Göttingen: 1856.—The researches here included are an important contribution to mineralogical science. We defer a special notice of the results to another time. Besides the analyses of minerals, there is a paper on the "oxyds of the cerium metals with a view to finding a method for their quantitive separation," and on artificial heavy spar.

17. *The Microscope and its Revelations;* by WM. B. CARPENTER, M.D., F.R.S., F.G.S., Examiner in Physiology and Comparative Anatomy in the University of London, President of the Microscopical Society of London, with an Appendix containing the Applications of the Microscope to Clinical Medicine, etc., by FRANCIS GURNEY SMITH, M.D., Professor of the Institutes of Medicine in the Medical Department of Pennsylvania College, etc. 724 pp., 8vo, illustrated by 434 engravings on wood. Philadelphia: 1856. Blanchard & Lea.—Dr. Carpenter brings to the work of writing on the microscope, a long experience with the instrument in the way of profound original research, and stands in this respect far ahead of most other writers on the subject. He is the well known author on General and Comparative Anatomy, and other related works. An Appendix by the American editor contains a brief notice of American microscopes, and also a chapter on clinical applications of the microscope mainly from the manuals of Beale and Bennet. The work enters with fullness into micoscopic forms and structures both animal and vegetable. The illustrations are numerous and excellent.

18. *The Quarterly Journal of Pure and Applied Mathematics;* edited by J. J. SYLVESTER, M.A., F.R.S., Professor of Mathematics in the Royal Military Academy, Woolwich, and N. M. FERRERS, M.A., Fellow of Gon-

ville and Caius College, Cambridge; assisted by G. G. Stokes, M.A., F.R.S., Lucasian Professor of Mathematics in the University of Cambridge, A. Cayley, M.A., F.R.S., late Fellow of Trinity College, Cambridge, and M. Hermite, Corresponding editor in Paris. London: John W. Parker & Son, West Strand. Each number 5*s.*—This able quarterly, edited by some of the best mathematicians of England, commenced in 1855.

19. *Patent Office Report for* 1855; Charles Mason, Commissioner of Patents. Vol. I, Agriculture; 488 pp., 8vo, with many illustrations. Vol. II, Mechanics; 380 pp., with 348 plates.—The first volume besides much valuable information in various departments of agriculture, contains papers of considerable length on Insects frequenting the Cotton plant, and the Climatology of the Cotton districts of the globe. There is also a report by D. J. Brown on the seeds and cuttings recently obtained by the Patent Office, with suggestions as to the expediency of introducing others.

The part on Mechanics, by the publication of plates of woodcuts of the inventions patented, has become a work of very great value to the land. Three hundred and forty-eight pages are made up of closely crowded woodcuts of this kind, arranged under twenty-one heads, commencing with Agriculture 33 plates, Metallurgy 24 plates, Fibrous and Textile Manufactures 37 plates, Chemical Processes, and so on.

20. *The Illustrated Annual Register of Rural Affairs and Cultivator Almanac for* 1857, containing practical suggestions for the Farmer and Horticulturist, embellished with one hundred and fifty engravings, including Houses, Farm Buildings, Implements, Domestic Animals, Fruit, Flowers, &c.; by J. J. Thomas, author of the "American Fruit Culturist," &c. 140 pp., 12mo. Albany: Luther Tucker & Son.

21. *United States Japan Expedition,* Volume III: Observations on the Zodiacal Light, from April 2, 1853, to April 22, 1855, made chiefly on board the U. S. steam frigate Mississippi, during her late cruise in eastern seas, and her voyage homeward, with conclusions from the data thus obtained; by George Jones, A.M., Chaplain U. S. Navy. xliii pages of text and 703 plates.—The labors of the Rev. Mr. Jones on the zodiacal light have already been mentioned in this Journal. This volume contains the record of his observations—a vast collection, and a rich contribution to astronomical science. We propose to notice the work more at length at another time. The author, in his zeal for the department of science he has so much advanced, has gone to the mountains of Quito, South America, to continue his observations, where he proposes to remain for a year.

22. *First Report on the Noxious, Beneficial, and other Insects of the State of New York:* made to the State Agricultural Society, pursuant to an appropriation for this purpose from the Legislature of the State; by Asa Fitch, M.D., Entomologist of the N. Y. State Agricultural Society, Member of the Entomological Society of France, &c. 180 pp., 8vo. Albany.

23. *Smithsonian Contributions to Knowledge,* Vol. VIII. 1856.—This volume contains: Article 1st, Introduction. Article 2nd, Archæology of the United States, or sketches historical and bibliographical, of the pro-

gress of information and opinion respecting Vestiges of Antiquity in the United States. Article 3rd, On the recent secular period of the Aurora Borealis, by Prof. Denison Olmsted. Article 4th, The Tangencies of Circles and of Spheres, by Benj. Alvord, Major, United States Army. Article 5th, Researches, chemical and physiological, concerning certain North American Vertebrata, by Joseph Jones, M.D. Appendix, Record of Auroral Phenomena observed in the higher Northern Latitudes, compiled by Peter Force.

23. *Journal of the Academy of Natural Sciences of Philadelphia.* Vol. III, Part III.

Art. XIII.—Description of some remains of fishes from the Carboniferous and Devonian Formations of the United States. By Joseph Leidy, M.D.

Art. XIV.—Description of some remains of extinct Mammalia. By Joseph Leidy, M.D.

Art. XV.—On the Sandstone Fossils of Connecticut River. By James Deane, M.D.

Art. XVI.—Plantæ Kaneanæ Grœnlandicæ. Enumeration of Plants collected by Dr. E. K. Kane, U. S. N., in his first and second expeditions to the Polar regions, with descriptions and remarks. By Elias Durand.

Art. XVII.—A Commentary on the Synopsis Fungorum in Americâ Boreali mediâ degentium, by L. D. de Schweinitz. By the Rev. M. J. Berkeley, M.A., F.L.S., and the Rev. M. A. Curtis, F.A.A.A.S.

Art. XVIII.—Synopsis of the Melolonthidæ of the United States. By John L. LeConte.

Charles Wye Williams, Assoc. Inst. C. E.: Prize Essay on the Prevention of the Smoke Nuisance. 34 pp. large 8vo. London, 1856. The special Gold Medal was awarded for this essay, by the Society for the Encouragement of Arts, Manufactures and Commerce.

A. Delesse, Ingenieur des Mines, etc.: Matériaux de Construction de l'Exposition Universelle de 1855, 420 pp., 8vo. Paris, 1856.—A volume of much value on the various architectural materials of France and other countries, represented at the Great Exhibition at Paris, in 1855.

Compte Rendu Annuel addressé à S. Exc. M. de Brock, Ministre des Finances, par le Directeur de l'Observatoire Physique Central, A. T. Kupffer. Année 1854. 110 pp. 4to. St. Petersbourg, 1855.

Jahrbücher der k. k. Central-Anstalt für Meteorologie und Erdmagnetismus, von Karl Kreil; iv. Band., Jahrgang 1852. viii, and 400 pages 4to. Published by the Royal Academy of Sciences of Vienna. Wien, 1856.—A work of superior style and excellence.

Denkschriften der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe. 10th volume with 26 plates, and 11th volume with 61 plates. Many of the papers are geological, with full and beautiful illustrations, many of fossils. The 10th volume contains plates and description by A. E. Reuss, of a Carboniferous Crustacean, related to Erypterus and Pterygotus. He calls it *Lepidoderma Imhofi.* In the 11th volume, J. J. Heckel has a paper on Austrian fossil fish, with plates; and F. Unger one on fossil plants: there are besides many others of special interest.

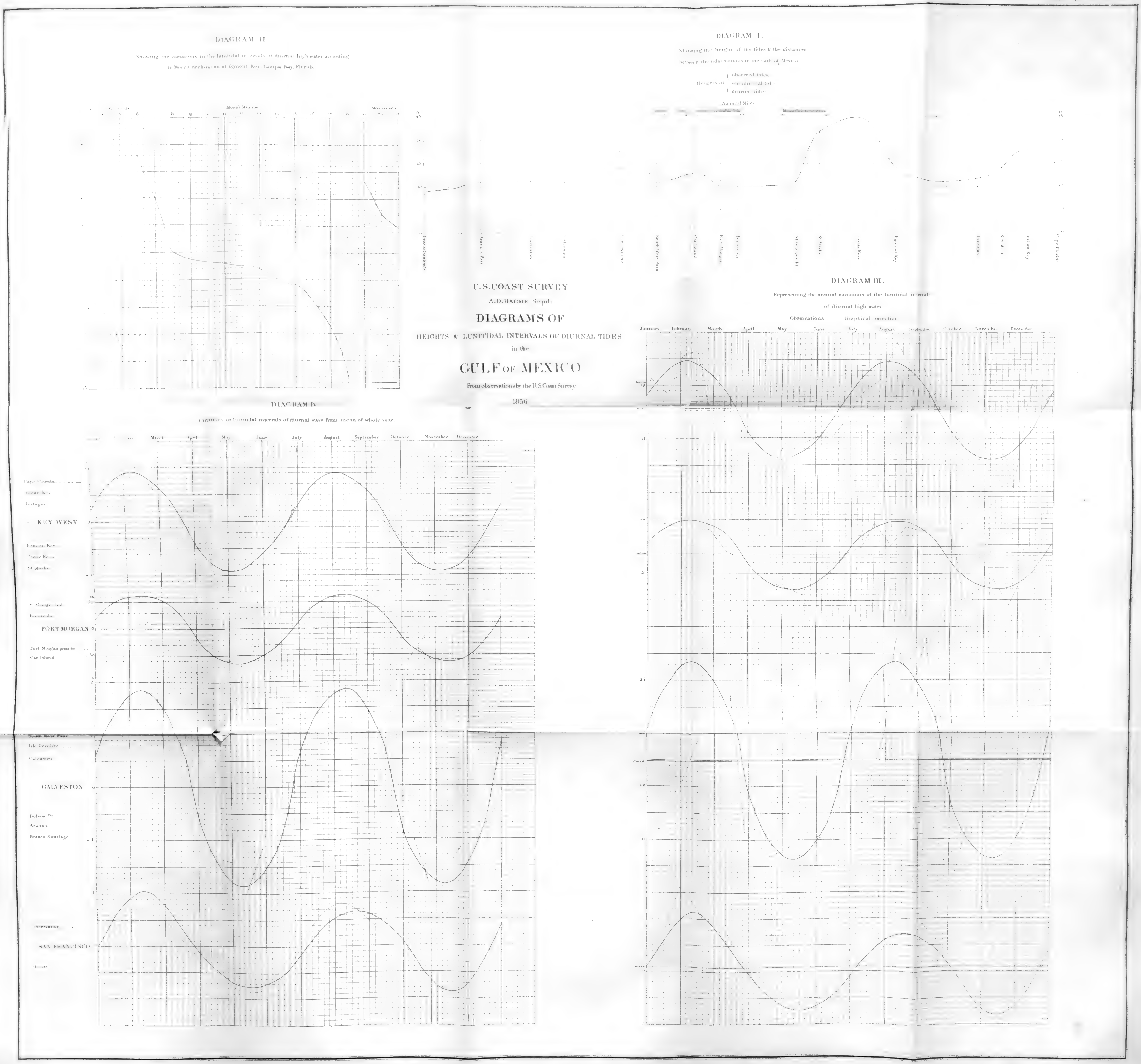
Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften, Vienna—For January, February and March, 1856.—Each No. an 8vo volume of near 300 pages, finely illustrated. The February No. contains a systematic review of the birds of Northeast Africa, by Dr. Th. v. Heuglin.

Jahres-Bericht der Chemischen Technologie, von Dr. J. R. Wagner. Erster Jahrgang: 1855. Mit 65 Originalholzschnitten. 8vo. Leipzig, 1856. 508 pp.—The work should be in every University or College Library.

Verhandlungen des naturhistorischen Vereines der preussischen Rheinlande und Westphalens. 1856. Erstes Heft. Bonn.

Proceedings Boston Soc. Nat. Hist., Vol. V. Sept. 1856.—p. 386, Description of two new Argonauts and notice of the "leaf-fly" of Mauritius; *J. C. Parkinson.*—p. 391, *Plotus Anhinga* and *Tantalus Loculator* found in Illinois.—p. 391, Crystalline salt (hydrous sulphate of soda and magnesia) from South America; *N. H. Bishop:* and analysis; *A. A. Hayes.*—p. 394, Notes on the Alewive (Alosa vernalis); *J. Wyman.* Vol. VI.—p. 1, Prof. Jeffries Wyman, President of the Society. p. 2, List of Mollusca of Herkimer and Otsego Cos., N. Y.; *J. Lewis.*—p. 4, Note on the Nashville Warbler as found in Massachusetts; *Brewer.*—p. 6, Note on the Geographical Distribution of the Turtles in the United States; *Agassiz.*—p. 9, Probable viviparity of the Haddock; *Agassiz.*—p. 11, Descriptions of new shells; *A. A. Gould.*—p. 16, On the bituminous Coal formation of Elk Co., Pa.; *C. T. Jackson.*—p. 22, Note on the Process of Exuviation of the Limulus; *J. Wyman.*—On the Beryl rock of Grafton, N.H.; *F. Alger, C. T. Jackson.*—p. 24, Note on the Reproduction of Parasitic animals.—p. 27, Trilobites of Eastern Massachusetts; *W. B. Rogers.*—p. 30, On the Coal formation of Deep River, N. C.; *C. T. Jackson.*—p. 32, Chemical analysis of a variety of Agalmatolite; *C. T. Jackson.*

Proceedings Acad. Nat. Sci. Philadelphia, Vol. VII, No. IV.—p. 140, On a new genus and species of Urodela; *C. Girard.*—p. 141, Note on larva of Bufo Americanus and new species of Rana; *E. Hallowell.*—p. 144, Description of fifteen new species of exotic Melaniana; *I. Lea.*—p. 146, New species of Hyla from Georgia, with a plate; *J. LeConte.*—Note on the Reptiles in the collection of the Museum of the Academy; *E. Hallowell.*—p. 153, On new Reptiles ibid.; *E. Hallowell.* No. V.—p. 162, On a boring sponge (Cliona); *J. Leidy.*—p. 163, Notice of some remains of extinct Vertebrata; *J. Leidy.*—p. 165, Researches on Cyprinoid fishes of the U. States west of the Mississippi; *C. Girard.*—p. 217, Notice of species of the genus Salmo of authors chiefly from Oregon and California; *C. Girard.*—p. 220, On vertebrated remains of New Jersey; *J. Leidy.*—p. 221, On Reptiles in the Academy Collections; *E. Hallowell.*—p. 238, On a collection of Reptiles from Kansas and Nebraska; *E. Hallowell.*—p. 253, On birds in the Collection of the Academy; *J. Cassin.*—p. 255, On Vertebrated Remains from North Carolina.—p. 256, On some remains of Fish from Missouri; *J. Leidy.*



U.S.COAST SURVEY
A.D.BACHE Supdt.
DIAGRAMS OF
HEIGHTS & LUNITIDAL INTERVALS OF DIURNAL TIDES
in the
GULF OF MEXICO
From observations by the U.S.Coast Survey
1856
DIAGRAM II.
Showing the variations in the lunitidal intervals of diurnal high water according to Moon's declination at Egmont Key, Tampa Bay, Florida.
Moon's Max. de.
Moon's dec. o
DIAGRAM I.
Showing the height of the tides & the distances between the tidal stations in the Gulf of Mexico.
Heights of
observed tides
semidiurnal tides
diurnal tides
Nautical Miles
Brazos Santiago
Aransas Pass
Galveston
Calcasieu
Isle Derniere
South West Pass
Cat Island
Fort Morgan
Pensacola
St Georges Id.
St Marks
Cedar Keys
Egmont Key
Tortugas
Key West
Indian Key
Cape Florida
DIAGRAM III.
Representing the annual variations of the lunitidal intervals of diurnal high water
Observations
Graphical correction
January
February
March
April
May
June
July
August
September
October
November
December
DIAGRAM IV.
Variations of lunitidal intervals of diurnal wave from mean of whole year.
Cape Florida
Indian Key
Tortugas
KEY WEST
Egmont Key
Cedar Keys
St Marks
St Georges Isld.
Pensacola
FORT MORGAN
Fort Morgan graph. for
Cat Island
South West Pass
Isle Derniere
Calcasieu
GALVESTON
Bolivar Pt.
Aransas
Brazos Santiago
Observation
SAN FRANCISCO
Theory

DIAGRAM V

Lith. of J. Bien 107 Fulton St. N.Y.

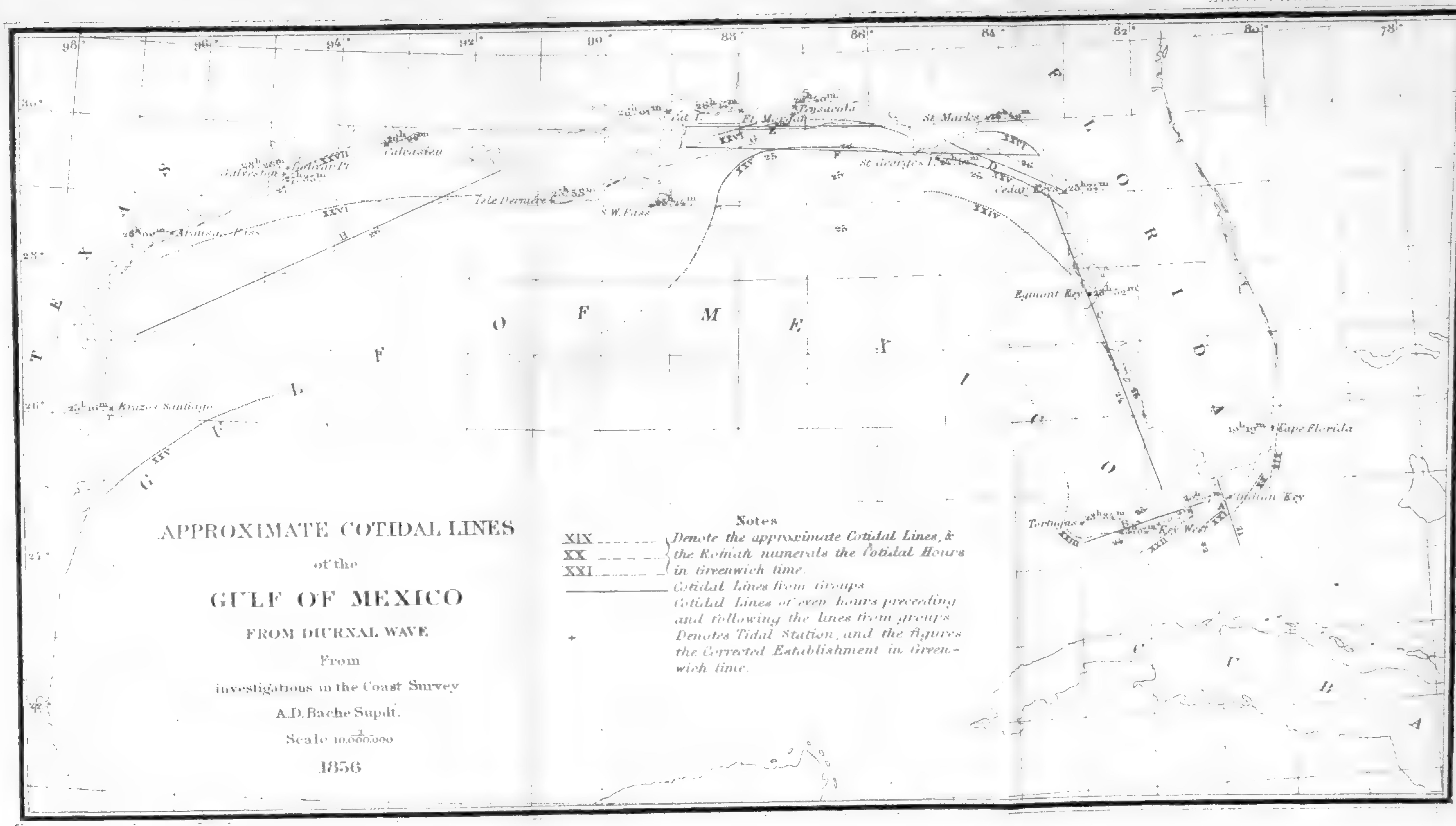
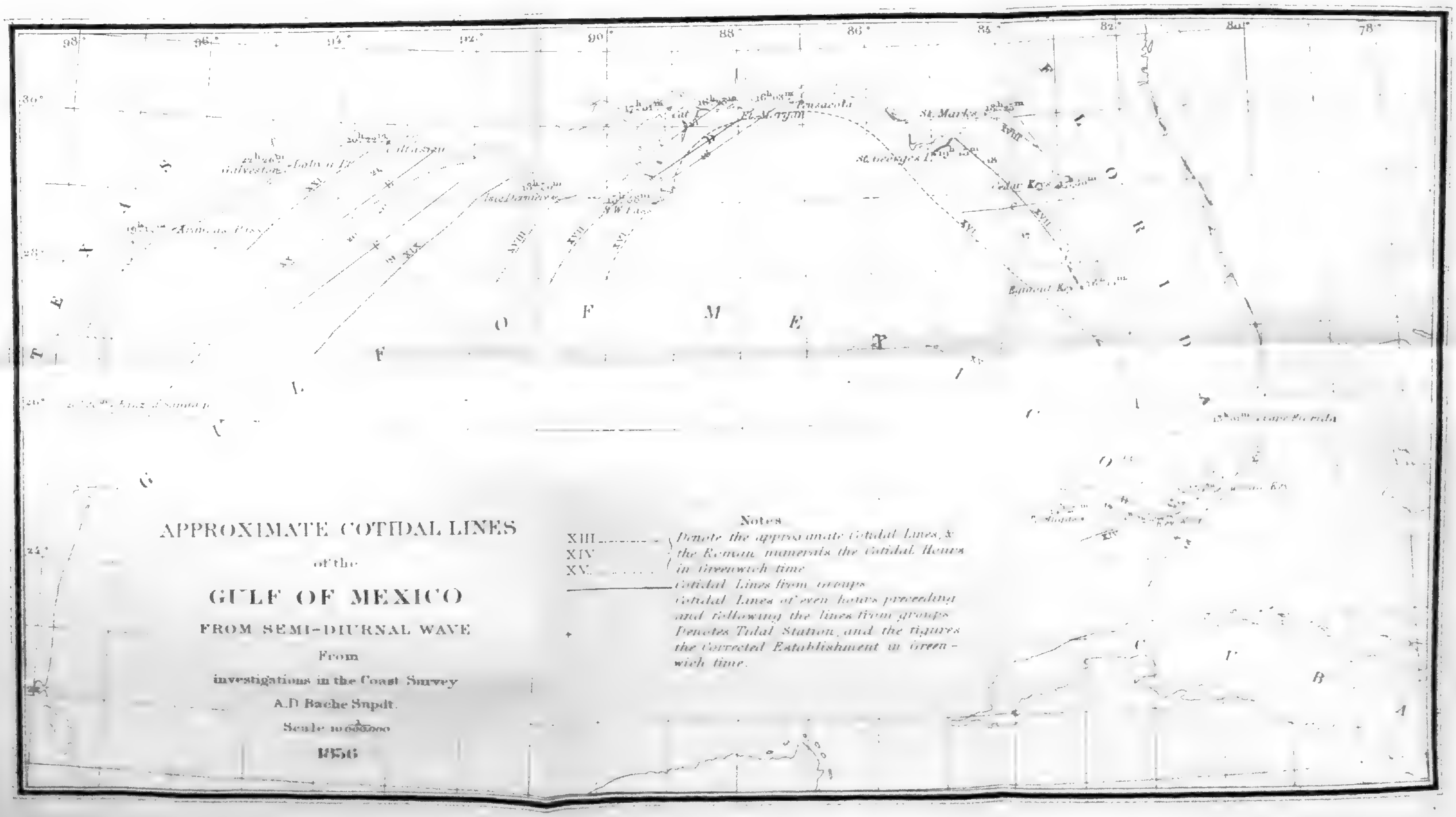


DIAGRAM VI



THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

ART. XV.—*Report upon the Results of Microscopic Examinations of the Soundings made by Lieut. Berryman, of the U. S. Navy, on his recent voyages to and from Ireland in the Arctic;* by Prof. J. W. BAILEY, addressed to Lieut. M. F. MAURY, National Observatory.

THE specimens submitted to examination were of two series, viz., those collected on the voyage to Ireland, which will be referred to as series 1, and those made on the return voyage, which form series 2. The specimens of series 1 were from the following localities, viz:*

No.	Latitude.	Longitude.	No.	Latitude.	Longitude.
1.	47° 59′ North.	52° 00′ West.	13.	52° 24′ North.	29° 16′ West.
2.	48 00 "	51 41 "	14.	52 26 "	27 18 "
3.	43 13 "	51 20 "	15.	52 26 "	26 20 "
4.	40 27 "	50 58 "	16.	52 02 "	24 51 "
5.	48 40 "	50 36 "	17.	51 41 "	22 23 "
6.	48 51 "	50 10 "	18.	51 41 "	21 19 "
7.	50 05 "	40 26 "	19.	51 50 "	20 12 "
8.	50 20 "	38 30 "	20.	52 01 "	17 06 "
9.	50 44 "	37 15 "	21.	52 05 "	16 05 "
10.	51 06 "	35 50 "	22.	52 03 "	15 02 "
11.	51 15 "	34 08 "	23.	51 52 "	13 16 "
12.	51 38 "	32 20 "	24.	51 54 "	12 27 "

* As a corrected series of *depths* has not yet been furnished for either series, the depths are for the present omitted in both tables. The least depth marked upon any specimen was 85 fathoms for No. 4, and the greatest was 2070 fathoms for No. 12.

In stating the results obtained from the specimens, they will be referred to by the numbers as above given. Numbers 1 to 4 inclusive are composed of fine siliceous sands, the grains of which are mostly of small size with sharp angles. The organic contents are not abundant; of the calcareous Polythalamia there is scarcely a trace, but some of the siliceous Diatomaceæ may be found in the light parts which may be rinsed from the sand. Among the Diatoms numerous fragments and some perfect discs of Coscinodisci* are the most abundant. Some species of the genus Chætoceros† were also seen, which are believed to be of northern origin. No. 5 is a coarse gravel, composed of common and jaspery quartz, with some feldspar, &c. It is much the coarsest of all the specimens examined.‡

Some of the quartz grains are rounded by attrition, while a large portion are quite sharp and unabraded. Among the organic contents a very few Polythalamia were noticed with some Diatomaceæ and sponge spicules.

No. 6 is a fine calcareous mud which effervesces briskly with acids, and yields by this treatment a large residue of siliceous sand with some Diatoms and Spongiolites. This specimen is interesting as indicating the commencement of that great calcareous deposit extending nearly across the Atlantic, which will be referred to in subsequent paragraphs.

Nos. 7 to 21 inclusive are fine calcareous muds which effervesce briskly with acids, and abound in the calcareous Polythalamia and particularly in species of Globigerina. They also contain numerous and very interesting species of the siliceous Polycistins, Diatoms, and Spongiolites. The mineral residue from acids is usually quite small in relative amount, and consists of minute sharp-angled grains among which quartz predominates.

Nos. 8 to 21 inclusive contain, in addition to what is above mentioned, what appear to be well characterized *volcanic ashes*, in the shape of minute fragments of pumice and obsidian, crystals of various minerals single and in groups, with vitreous products penetrated with crystals. These substances generally form but a small portion of the residue left by the acids, and may be more readily detected when this residue is in water than when mounted in balsam. They are particularly recognizable in No. 14.§

* Many fragments and some very fine and perfect specimens of *Coscinodiscus oculus iridis*, Ehr., *C. borealis*, B., and *C. crassus*, B., were found in these specimens.

† Among these were *Chætoceros boreale*, B., and *C. furcillatum*, B. The latter occurs also in the Sea of Kamtschatka. See this Journal, vol. 22, pl. 1, fig. 4.

‡ The rinsings from the coarse gravel of No. 5 gave a few Polythalamia, and some Diatoms.

§ They are scarcely less so in No. 15 to 18. In the specimens No. 8 and No. 21 the volcanic products were found, but only in small proportion and after careful search.

No. 22 is a fine calcareous mud with some Globigerinæ. It is chiefly noticeable as leaving with acids a considerable amount of fine quartz sand mingled with microscopic globules of *iron pyrites.* It yielded no recognizable volcanic products and very few siliceous organisms.

Nos. 23 and 24 are similar in character to No. 22 but they yielded no globules of iron pyrites.

Some general remarks on the results of the examination of the specimens above referred to will now be given.

1st. The employment of acid enables me to correct an erroneous statement which I made sometime since concerning the deep soundings of the Atlantic. Having at that time only a small portion of the soundings, and being unwilling to destroy a morsel of matters so precious, I did not apply acids, and hence overlooked the portion of mineral matter which though often very small is *invariably present.*

2nd. The mineral matter in these soundings generally shows no signs of abrasion, the sharpest edges and angles of even the softest minerals being retained. The minute size of the particles and their sharp angular state appears to show that they have been quietly deposited from gentle currents and not subsequently disturbed. Even the coarsest and most abraded materials may have been deposited from icebergs.

3rd. The gradual increase of calcareous matter as the Gulf Stream is approached, and the presence of calcareous organisms from its western margin almost completely across the Atlantic is in accordance with observations previously made on the Coast Survey soundings of the Gulf Stream obtained farther south, which show that calcareous marls, rich in Polythalamia, Polycistins, Diatoms, and Spongiolites, form the bed of the Gulf Stream throughout its whole course as far as yet examined, and also occur in vast extent in the Gulf of Mexico.

4th. These marls contain a great number of undescribed organisms, both siliceous and calcareous. Many species which occur as far south as Florida and the Gulf of Mexico are found in the northern soundings above described, while some very remarkable species found in the northern soundings have not been detected at the southern localities, and vice versa. The description of the new species is in preparation for speedy publication.

5th. Only a few imperfect casts of Polythalamia and no well characterized green-sand casts have been detected in these northern soundings, while their presence is rather the rule than the exception with regard to the southern soundings above referred to.

6th. The occurrence of what appear to be volcanic products in the bed of the ocean for a distance of about twenty-two degrees of longitude, or about a thousand miles, is an extraordinary fact and one which deserves careful scrutiny. That any one familiar with the microscopic appearance of volcanic ashes, &c., would pronounce these matters of volcanic origin I have no doubt. As, however, the ingenious suggestion was made to me that these igneous products might be derived from the fires of the ocean steamers, along or near whose pathway these soundings were made, it was important that these furnace products should also be studied. This I was enabled to do by the kindness of Geo. Manning, Esq., who procured for me from the steamers themselves, specimens of such matters as are thrown overboard from the ash pits of the steamers Asia and Baltic.

Careful examination of these specimens showed that they contained a group of products which could not possibly be confounded with the supposed volcanic matters. In fact there was no relation between the two classes of bodies except that both were evidently the results of intense heat upon different mineral matters. Among the furnace products of the steamer Baltic were numerous single and aggregated glass spheres of minute or even microscopic size, which if they should ever be found in ocean soundings would be very puzzling without this clue to their origin.*

7th. The question of the original source of the volcanic products is one of great interest. How far these plutonic tallies may have traveled and in what directions, whether from the Azores, the Mediterranean, or Iceland, involves a study of currents and an examination of soundings which are yet to be made.

The specimens of the second series were as follows:

No.	Latitude.	Longitude.	No.	Latitude.	Longitude.
1.	49° 12′ North.	49° 42′ West.	5.	49° 49′ North.	45° 54′ West.
2.	49 36 "	49 05 "	6.	49 50 "	44 43 "
3.	49 40 "	48 29 "	7.	51 43 "	13 44 "
4.	49 49 "	46 43 "			

* Since the above was written I have received through the kindness of Lieut. Maury a very extensive series of soundings made in the North Pacific, Sea of Ochotsk, &c., by Lieut. Rodgers, of U. S. Navy. I have had as yet no opportunity of studying these specimens, but my attention was attracted to one of them from its striking resemblance to soundings made in the Gulf Stream off Key Biscayne, Florida, by the U. S. Coast Survey. It was in fact a true Globigerina marl, largely composed of Polythalamia, but yielding also, like the Florida specimens, fragments and perfect specimens of Hyalea and other Pteropods. It also agreed with the Florida specimens in containing well characterized green-sand casts of Polythalamia. It differed however from the Florida specimens in containing very few siliceous Diatoms or Polycistins, forms which are remarkably abundant in the Gulf Stream and Gulf of Mexico.

This specimen presented another remarkable character, which I detected even with a common pocket lens. It contains a very large proportion of volcanic products, not better characterized than in the Atlanic specimens, but vastly more abundant, and of larger size. The perfect correspondence of these products to those in the Atlantic is additional evidence of the volcanic origin of the latter. On referring to the map for the position of this remarkable specimen, its latitude 30° 35′ north, longitude 130° 40′ east, placed it in the very place where a resemblance to the Gulf Stream of the Atlantic was to be expected, viz., in the "Japanese Gulf Stream." As for the volcanic products there are but too many active sources for such materials along the line of this Asiatic current.

They will be referred to by the numbers given in the above table.

Nos. 1 to 6 are calcareous muds, containing much mineral matter, and only a small portion of Polythalamia. The siliceous organisms are also comparatively few consisting of some large Coscinodisci, a very few Polycistinæ, and some Spongiolites. No volcanic products were detected.

No. 7 is also a fine calcareous mud showing to the naked eye but few Polythalamia, but rather rich in microscopic organisms, consisting of minute Polythalamia, with Polycistins, Diatoms, and Spongiolites. No volcanic products were detected.

Hoping that the above will answer the purpose of a general report upon the microscopic character of these soundings, I reserve for a subsequent publication the details of the zoological results afforded by these highly interesting series of soundings.

ART. XVI.—*Coal Fields of the East Indian Archipelago.**

Labuan, Bruni and Sarawak.—Little more than ten years ago, the only known coal-bed in the Indian Archipelago was that of Pulo Chermin, at the entrance of the Borneo River. Subsequent researches, however, shew that the mineral is scattered pretty plentifully over the area included in the great bank of soundings which extends to the southeast, from the Malayan and Indo-Chinese Peninsulas to the Bonirati Group, south of Celebes. But in countries where manufacturing industry has made little progress, coal is only required in large quantities for the use of steam vessels, and the beds become valuable or otherwise in proportion to the facilities offered for supplying depots. As freight forms the most important item in the cost, those coal fields which happen to be in the immediate route of steamers, and admit of their receiving it direct from the pit's mouth, are necessarily the most important, and it was for this reason that we gave precedence in our series to that of Mew Bay in the Strait of Sunda.

Of the coal fields of the northwest coast of Borneo, those of Labuan and Bruni, where the seams are of a thickness calculated to astonish the home miners, are capable of supplying steam lines in the neighboring seas for many years to come, and, although Labuan lies out of the direct track between Singapore and Hongkong, it is more than probable that when the increase of competition causes the new lines between India and China to be less profitable than at present, it will be found necessary, for the sake of economy, that the steamers shound call at Labuan, either going or returning, for a supply of coal to last the entire round. Nor will much time be lost by so doing, as smoother water is ex-

* Cited from the Singapore Free Press, for March 6, 13, and April 3.

perienced during both monsoons on the coast of Borneo than on the other side of the China Sea, a point of importance to auxiliary screw steamers when making the passage against the monsoon. But the spirited proprietors of the Labuan mines do not seem disposed to await the course of events, and the steam-collier they have sent out to run from Labuan to this port and Hongkong, (a vessel of 1,000 tons burthen and peculiarly adapted for the service,) is likely soon to settle the question as to whether the produce of the mines of Borneo can compete with British coal at the Eastern depots. Sail-vessels are not well adapted for service as colliers in these seas, where the periodical winds blow for six months together in opposite directions, except when it happens that the mines and market are so situated with regard to each other that the passage can be made both ways with a fair wind, as is the case with Sourabaya and the coal fields of South Borneo.

The last overland mail brought intelligence that a company had been organized for working a coal field in Sir James Brooke's territory at Sarawak. Very little seems to be known about it except by the parties interested, but there can be little doubt of its becoming a valuable acquisition to steamers frequenting this settlement, as the distance across is rather under 500 miles. The Sarawak mine, however, from its inland situation, will not be so well adapted as a coaling station for steamers as that of Labuan, which lies on the shore of a navigable strait, so that passing vessels can load their coal from the pit's mouth without diverging from their course.

Banjar-Massin and Koti.—The island of Borneo appears to be one great coal field, for every large river intersects a coal-bed, and it seems only necessary to seek and mineral is found. Thus every settlement, indeed every spot frequented by Europeans, has its mines more or less convenient. Labuan, Bruni, Bintulu, and Sarawak, on the north coast, the banks of the Kapuas on the west coast, Banjar-Massin and the banks of the Great Dyak River on the south coast, and Pulo Laut, Pagattan and Koti on the east coast, each has its coal-field, although those only which we notice are worked at present for other than local purposes. The mines of Banjar-Massin, which lie about 70 miles above the town, on the banks of the Batu-Api River, are the most important of those at present worked within the Dutch-Indian territories, not on account of the superiority of the coal-measures, for the main seam is only 9 feet through, but owing to the favorable position of Banjar-Massin for communication with Sourabaya, the chief naval arsenal of the Dutch in these seas, and where the consumption of coals is probably greater than in any port of India excepting Calcutta. In addition to the supplies required for war-steamers, and for the boats employed in keeping up the communication with Celebes and the Moluccas, steam engines are pretty constantly employed in pumping out the dry-dock and in working the machinery of the great steam factory, where the engines of government, and of the sugar *fabriques* in the eastern part of Java are made and repaired. The Banjar-Massin coal is well adapted for steam purposes, as it burns freely and does not cake or "clinker," but for the same reason it is not so well adapted for the forge as English or Australian Newcastle coal. The cost of the mineral, delivered at the depot in Banjar-Massin is 2 guilders (3s 4d) per ton, and the freight across to Sourabaya varies from 5 to 8 guilders more. It is usually exported in large blocks of an oblong form, the small coal being either thrown aside or kept for home use. Large prahus and square-rigged vessels belonging to Arab and native traders of Sourabaya and Grisse are chiefly employed in the transport, and as they would otherwise have to lie idle during several months of the year, the freight is sometimes very low. During the southeast monsoon, the voyage across, both ways, rarely lasts more than two or three days.

The mines of Koti lie on the banks of the river of that name, about eighty miles from the mouth. They are worked by Mr. King, an English trader who has resided there for some years past, but the demand is not very great, owing to their inconvenient position with regard to a market. The coal is of the same highly bituminous character with that of Labuan and Banjar-Massin. Whenever steam comes to be generally employed in these seas for the transport of merchandize, the Koti mines will be found useful in supplying coal depots in the Strait of Macassar. The distance across to Paré-Paré on the opposite coast of Celebes is about 100 miles.

Seams of coal have been found at Retéh and Palembang, on the east coast of Sumatra; near Macassar, on the island of Celebes; at Bawean, an island in the Java Sea; and at Bachian, in the Moluccas; but those we have already enumerated are the only beds that admit of being worked with convenience and profit. It will be found on examination that all these are included within the submerged plateau which extends from the south-eastern part of Asia nearly two-thirds of the distance across to the nearest point of the continent of Australia, and further examination will show that they occur only on those parts of the plateau which have been subjected to violent upheaval since the formation of the sedimentary rocks, a process which has tilted and broken through the strata, exposing sections to the view of any traveller who may be passing over the country. It is thus that every known coal field in this part of the world has been discovered, and we believe that in every instance the discoverers have been the natives of the country, to whom, indeed, the existence of some of the most important beds seems to have been known through many generations. Now there is no peculiarity in the geological structure of the regions where coal is known to exist, which renders them more favorably constituted for the formation of the mineral than other parts of the plateau, say the island of Singapore itself; indeed there is not only a possibility but a reasonable probability that it exists under our very feet. Certainly nature has not been so considerate as to display her workings to the public gaze, as is the case in the regions bounding us on either side; but does not science furnish us with the means of ascertaining the character of the earth's crust to any required depth, with small expense and labor, by means of boring? No doubt, were the result successful, an outcry would be raised against the government authorities for having heretofore neglected so simple and inexpensive a means of ascertaining the *internal* resources of the island, so that no movement can reasonably be expected in that quarter; but the authorities of the Steam Navigation Company would be fully justified in devoting a small portion of their immense revenue to carrying out a series of experiments, which, if successful, would be the means of curtailing their expenditure to the extent of some tens of thousands per annum. Probably no more favorable spot could be found for commencing operations than the immediate neighborhood of their depot at New Harbor, where the surface indications, shale and sandstone, are such as are always associated with the coal beds, although their presence does not imply the actual existence of the more valuable mineral. That such measures may be carried out even by private enterprise, will be seen by an extract we append, which gives the result of a similar experiment at Ipswich, a small but rising town of the Moreton Bay district of New South Wales, by two gentlemen, who, we are informed, follow the occupation of millers and storekeepers. The Moreton Bay district was not occupied until some years after this settlement had been formed, and the town of Ipswich is scarcely ten years of age. This successful experiment nearly doubled the value of the town allotments in the course of a few hours after the result became known:

"We have great pleasure in calling attention to the recent discovery of a valuable seam of coal on the property of Messrs. Walter Gray and Co., situated on the north bank of the Bremer, about one mile from the town. This desirable work was commenced some months ago, and notwithstanding great difficulties supervened, such as boring through masses of hard rock, those difficulties have been surmounted, and the discovery of a seam of coal nine feet in thickness has rewarded the exertions of the enterprising proprietors. The shaft was sunk to the depth of 100 feet before the miners came to the coal, and from the nature of the superincumbent strata it is expected that the mine can be worked both with profit to the owners and security to the people employed. A sample of the coal has been forwarded to town, and has been submitted to the inspection of competent judges, who have pronounced it to be quite equal, if not superior, in quality to any hitherto discovered. It appears to be that description which is known as *caking* coal, and we understand it is very pure, and leaves after combustion a very small percentage of ash. The sample before us seems to be highly bituminous, and well adapted for the purpose of producing steam which sets machinery in motion.—*North Australian.*"

Since writing the above, while looking through the 1st volume of the *Journal of the Indian Archipelago* for information respecting the coal deposits of Kedah and Ligor, we came upon a paragragh (p. 165) to the effect that a mass of anthracite was discovered near the base of Pearl's Hill in 1846, when the excavations were being made for the foundation of Tock Sing's Hospital. It is singular that so certain an indication of the existence of coal in our immediate vicinity was not followed up, as a gallery driven horizontally from the base of the hill would soon have brought its contents to light. Certainly the value of anthracite as fuel was not so well known as at the present time, although then, as now, it was used by steamers in preference to bituminous coal throughout the United States; nor was the consumption of fuel by steamers frequenting this port equal to a twentieth of the present amount. The time has now arrived, however, when any delay in prosecuting an inquiry of so much promise would impair the enterprising character of the inhabitants of this settlement.

ART. XVII.—*Observations on the Zodiacal Light;* by Rev. GEORGE JONES, A.M., Chaplain United States Navy.*

To appreciate the vast amount of labor bestowed by the Rev. Mr. Jones on his zodiacal light researches, the volume whose title is given below should be carefully examined. It consists almost wholly of celestial maps with the position of the light noted down, as ascertained at each of his observations, the maps being the actual records as they were made by him at sea, accompanied by the notes or remarks that were written down at the same

* Observations on the Zodiacal Light from April 2. 1853 to April 22, 1855, made chiefly on board the United States Steam Frigate, Mississippi, during her late cruise in Eastern Seas, and her voyage homeward, with conclusions from the data thus obtained, by Rev. George Jones, A.M., Chaplain U. S. Navy:—being Volume III of the United States Japan Expedition. Washington, 1856.

time. There are 350 of these maps. The author has been scrupulously exact in giving his original records without any modification from views subsequently arrived at. The first 40 pages are devoted to historical and theoretical considerations, and include a brief explanation of the theory which he has been led to adopt.

There are points in the researches upon which more light is required; and Mr. Jones, aware of the doubts with which some of his observations may be received, and desirous also to give greater completeness to a subject that has occupied so much of his time, has now gone to the high plateau of Quito to continue his investigations. He has announced his safe arrival there, but has not yet sent forward any farther results.

The statements in the work most likely to be questioned are, the division of the light into a brighter centre and more diffuse borders by a boundary which is definable; the existence of a moon zodiacal, and the occasional waving character of the light. After citing from his account of his observations and certain general conclusions, we give his explanations of the theory which he favors, the existence of a nebulous ring around the earth. The objections brought forward by him to the prevalent view of a nebulous body around the sun, are here omitted. The subject is submitted to our readers without discussion.—Eds.

* * * * * * *

My first observations were of a very desultory kind. I contented myself with making records of having seen the Light, and with giving its boundaries, by written descriptions, in a general way. But the necessity of *precision* soon showed itself; and, as I went on, of yet still greater precision; and I then constructed a star-chart from an excellent little globe. By laying folds of paper below this, and sticking pins through the stars, I multiplied the charts, till, after nearly a year's work in this manner, I was able to have the chart cut in wood at Canton, and thus I found myself well prepared for work. My custom was, at evening, to watch for the earliest appearance of the Zodiacal Light; and, as soon as I could get reliable boundaries, to notice their course among the stars, and draw these boundary-lines on the chart, with such annotations as the case might require; then, again, after the interval of half an hour or an hour, to go out once more, and as the boundaries would be changed in that time, to take the new ones in a similar way; and so proceed till the light could be no longer seen: and thus also, in a reverse order, in the morning. And after having once fairly commenced—say about the first of March, 1853—I never failed for one evening or morning, (Sundays always excepted,) till our reaching home on the 22d April, 1855, to see, and, with one exception, to make record of the Zodiacal Light, when the moon and clouds did not interfere to prevent. In the case of that one exception, I saw the light; but being shut up among the houses in Canton, I could not get reliable boundaries.

The development of facts in the Zodiacal Light came upon me gradually, and, before they had disclosed themselves, much valuable time in the high southern latitudes, at the early part of our cruise, was lost; on our return, however, we went still further to the south, and I was able to make amends in some measure for this loss.

There is no mention made in any books on the Zodiacal Light, of any differences in the light itself;* but I very soon began to notice that there was a Stronger Light at the central part, or along the axis; while, beyond this, on either side, and also above, a dimmer kind of light extended itself, as if the matter giving us this light was more condensed at its central parts, and was thinned out beyond. I have called these the *Stronger* and the *Diffuse* Light, and have marked the boundaries of the former on my chart by full lines, while the bounds of the Diffuse are designated by lines of dashes, each having the hours of the observation affixed to it. Sometimes, beyond the Diffuse Light, there was also what seemed to be, not a positive light, but rather as if the sky were slightly paled (if the reader will allow the word); so slightly, that I could not trust my own sight respecting it, till I had called in repeatedly the aid of other persons. I consider it only as the more diffuse matter greatly attenuated at its outer edge, which, by the sinking of the ecliptic towards the horizon, was now brought so as to make its reflection visible to us. In the case just referred to, it presently changed into the Diffuse Light itself. The Stronger Light is evidently the one of which Cassini has given the boundaries in his written accounts.

It is not to be supposed by the reader that any of these kinds of light was bounded by sharp lines easily detected in the sky. On the contrary, the stronger passed by degrees into the diffuse, and the latter also gradually faded away. Yet there was, in the former case, a line of greater suddenness of transition, which, when my eye had got accustomed to observations, I was generally able to make out without much difficulty; and this is the line or the boundary which is given in my charts. The outer boundary of the Diffuse Light was also tolerably well marked. That I was not fanciful in this, is shown by the frequency with which other persons on board, both officers and seamen, when requested to do so by me, and without any leading questions, drew boundary-

* Unless, as seems probable, the following extract from Mairan's *Traité Physique et Historique de l'Aurore Borealé*, refers to such a difference: "J'ai encore observé plusieurs fois, qu'après que la Lumière Zodiacale avait cessé de paraître le soir sous sa forme de lance ou de fuseau, toute la partie du couchant démeurait plus éclairée que la reste du ciel, sur 30 ou 40 dégrés d'amplitude." P. 36.

lines which corresponded exactly with those which I had just drawn, mentally, myself. Sometimes they differed from me; but still the promptness with which they designated such boundaries is proof that the transitions were perceptible to the eye. Generally, much careful looking took place, and perhaps repeated attempts, before I ventured to draw my lines. Often I was in doubt after all possible pains-taking, and the doubts are noted down. As a general fact, late in the evening the Stronger Light would melt away gradually, or rather would seem to be merged in the Diffuse Light, which alone would be left, the latter at first with a degree of brightness greater than it lately possessed; and then the diffuse would pass away, in the increasing night. In the morning the reverse was the case. It should be here observed, also, that this gradation in the strength of the Zodiacal Light was not only lateral from the centre outward, but also from the horizon upward to the terminating point. But the transition, in this latter case, was by insensible degrees, except in the cases of a more intense light near the horizon; even the Stronger Light, towards its apex, was so dimmed as to be distinguished with great difficulty, and often I could make it out only by following up the boundary-lines from the lower portion.

I remember very well my feelings of surprise and wonder when the *lateral* changes in the Zodiacal Light, as the night advanced, for the first time forced themselves on my attention. Those changes, as may be seen from my charts, are of constant occurrence; yet I do not find them noticed in any writings on this Light, except an allusion by Cassini in one of his observations, in which, however, he tells us that, both then and afterwards, he could come to no certain conclusions as to their existence.*

These changes running all through the observations, will be found to be of great consequence when we come to draw conclusions from our data. They are greatest and most striking when the ecliptic has declined considerably towards the horizon; and there is great uniformity in them, but they are not without contradictions among themselves; but these incongruities are rare, and are probably owing to extraneous causes.† I would not

* "Je doutai si elle n'avait pas un peu de mouvement particulier vers le septentrion; car les deux plux luisantes d'Aries qu'elle frisait au commencement par son côte septentrional, furent ensuite comprises dans cette clarté; ce qui a été depuis confirmé par les observations des jours suivans. Mais je ne fus pas en être entièrement assuré ni alors, ni après plusiers jours, parceque l'extremité de cette clarté était de tous côtes trop douteuse, s'affaiblissant peu-à-peu; de sorte qu'il était extrèmément difficile de la déterminer précisement."—*Mémoires de l'Academie Royale des Sciences, tom. viii.*

† Cassini remarks on the character of the Zodiacal Light as follows: "Il ne faut néanmoins prétendre réduire les apparances de cette lumière à un régle aussi exacte que l'anneau de Saturne, parcequ'il s'en faut beaucoup qu'elle soit si bien terminée et qu'elle ait autant de consistence; étant assez évident, par les differences accident-

advise any one to draw conclusions from *exceptions*, in a matter where mistakes can be so easily made by the observer, but only from the general facts of this book; I have put down all, exceptions and incongruities as well as others, not feeling authorized to omit any portion; for who can say, in a new science, that what seem to be exceptions are not a part of the general rule.

Among the most important of these observations are those when the Zodiacal Light was seen near and at midnight, simultaneously on both the western and eastern horizons—a circumstance never observed before.* I had not expected it, and the manner in which it came upon me is recorded, with the care, also, to have other eyes than my own brought to bear on the subject, and also my carefulness in watching the western and eastern skies through all the changes of the light, from early in the evening till dawn. It is probable that this appearance can never be seen except when the ecliptic at midnight is at right angles, or nearly so, to the spectator's horizon; which can only be the case where his latitude is equal to the sun's declination, but on the opposite side of the equator. I saw this again in the following year; and in both instances the ecliptic was not only vertical, or nearly so, at midnight, but bore east and west from me; but the latter circumstance, I presume, had nothing to do with the results. I have been puzzled to know by what kind of lines to designate the boundaries of this midnight light; for it was very dim, quite as much so as the Diffuse Light; yet when I came to bound it by lines of dashes, I found they produced confusion when the Diffuse Light itself was marked down; so I gave it a line of alternate dashes and dots, and thus it is designated in the charts.

Sometime early in 1854, I saw in a newspaper a brief notice of the pulsations in the Zodiacal Light seen at the Kew Observatory; but as the newspaper did not state where they were observed, or the authority, and as I had now been observing for a year without having noticed anything of the kind, I set it down as an ocular deception, and the thing passed entirely from my mind. But in March of this year, I was surprised, one evening, at seeing the Zodiacal Light fade sensibly away, dimmed to almost nothing, and then gradually brighten again. This was repeated several times; but the effect, after all, was to leave me only in amazement and doubt. Subsequent nights, however, gave abundant exhibitions of this kind, of which, with the times and changes, I have made ample records with the particularity

ales qu'elle fait paraître d'un jour à l'autre, qu'elle reçoit des variations réelles, outre celles qui viennent des causes externes, comme des diverses dégres de la clarté de l'air et du concours de la lumierè des astres. et même de la disposition des yeux de l'observateur."—*Mémoires de l'Academie Royale, tom. viii, pp.* 163, 164.

* Unless, indeed, we class this with what a German writer calls the *gegenschein.*

that the case required. It was a great satisfaction, after my return home, to find that Baron Humboldt had observed the same thing while in southern latitudes, though he thought it more probable that it was owing to "processes of condensation going on in the uppermost strata of air, by means of which the transparency, or rather the reflection of light, may be modified in some peculiar and unknown manner." My records, however, will show that there is a regularity of appearance at the closing off of these pulsations, which proves that they do not belong to so uncertain a cause as atmospheric changes, but to the nebulous substance itself. They seem to intimate a great internal commotion in the nebulous matter, for they were too rapid to be occasioned by irregularities in its exterior surface.

I noticed them again the following year, but must refer the reader to my records and charts. The changes were a swelling out, laterally and upwards, of the Zodiacal Light, with an increase of brightness in the light itself; then, in a few minutes, a shrinking back of the boundaries, and a dimming of the light; the latter to such a degree as to appear, at times, as if it was quite dying away; and so back and forth for about three-quarters of an hour; and then a change still higher upwards, to more permanent bounds.

A reference to the charts will show zigzag lines in some of them down near the horizon. These are the boundaries of a very effulgent light which appeared at the times specified, and within these bounds. It has no other distinction than its greater brightness, and the cause of it I cannot surmise. Cassini appears to have noticed the same thing as will be seen by reference to his annotations.

I now, however, come to what may perhaps be the most important of all these observations; but a part in which my observations are meagre, compared with the rest. I had, at an early period, queried whether the moon might not give a Zodiacal Light, and had given attention to the subject; but, probably, had looked too high up in the sky, and, at all events, had failed to see anything of the kind. But, one evening, when I was finishing some boundaries from the western sky, the quartermaster on duty said to me: "The moon is going to rise;" and, on crossing the deck, I was struck at once with the resemblance between the light then showing itself in the eastern sky and the morning Zodiacal Light, in every thing except its elevation. In breadth, in the peculiar boundaries laterally of the Zodiacal Light, and in coloring, it was all the same; and, in its subsequent rapid changes, it still kept strictly within the Zodiacal Light bounds. The following night I was prepared to make records; and I never failed afterwards to watch for recurrences of such light. But they did not often present themselves; for the ecliptic should be at a high angle, otherwise the light is apt to be so scattered along the horizon as to be unsatisfactory. It also happened, that we almost always had cloudy weather when such observations are most desirable—namely, at the full of the moon. * * * *

On two occasions, March 6th, and December 25th, 1854, I had also an undoubted *joint sun and moon Zodiacal Light.* That is, when the moon was about its first quartering,* and, at the time of the observations, about 63° above the western horizon, a bright streak appeared in the western sky, along the ecliptic; the joint light from the sun and moon, reflected from the nebulous matter, being apparently sufficient to overcome the bright moonlight in our atmosphere, and thus to make itself manifest. On both occasions I brought other persons to look (in the latter case, the captain and several other officers), whom I got to draw boundaries which corresponded to my own view of the subject. The latter occasion was also the more striking, because the streak of light did not stretch up exactly *towards* but *to one side* of the moon, that satellite having then a southerly latitude of four and a half degrees.

The observations here given commence on the 2d day of April, 1853; for, although I had been a careful observer since December 22d of the previous year, I consider the interval as having been necessary in order to gain experience, and I have consequently rejected all up to the period mentioned. My first intention was to reject still more, and to commence this publication with June of that year; but the extraordinary interest of some of the observations in April, and the great care which I took in them to be precise as well as correct, have led me to insert them. The *unbroken* series commences at June 7, 1853. From that time, till our arrival in New York on 22d April, 1855, every observation is recorded; and, except on Sunday, I never once failed to have observations, if the moon or clouds did not prevent. * * * * * *

At this stage of our work, effected and proposed, it may, perhaps, seem to be premature to draw conclusions; but still there are certain things that seem to force themselves on the mind from the data here afforded; and, if the conclusions which I shall now proceed to draw are not decisive to the reader's mind, they can at least furnish subjects for discussion that may, in the end, bring us to the truth.

It seems to be quite conclusive, on an inspection of these charts, that *we never, at any one time, see the whole actual extent of the Zodiacal Light.* This subject can perhaps be elucidated by noticing a common event,—a cloud, silvered at one edge by the

* March 1854, first quarter at Greenwich, *6d. 7h.*; December 1854, do. *26d 0h. 37m.*

rays of the declining sun. The sun may be shining on the bordering, quite around that cloud; and, if so, it is sending off, from every portion of the border, an equally brilliant, silvery light. But our eye is in a position to catch this reflection from only one portion of it, and the rest is dull to our vision. If we could with great rapidity change our positions, other portions of the silvered edge would show themselves according to our changes of place. So, also, when a rainbow is presented to our eye: the myraids of drops of falling water in the whole rain-shower are sending off, from each drop, reflections of light in all directions, and the universal atmosphere about us is full of these brilliant, variously-colored rays; but only that portion which, to us, forms the rainbow-arch, can reach our eye, and all the rest is lost to our sight.

So it is also with the Zodiacal Light; and the proof that we never see the whole of its extent at once, is manifest in the following facts:

1. That when I was in a position *north* of the ecliptic, the main body of the Zodiacal Light was on the *northern* side of that line.

2. When I was *south* of the ecliptic, the main body of the Zodiacal Light was on its *southern* side.

3. When my position was *near* or *on* the ecliptic, this Light was equally divided by the ecliptic, or nearly so.

4. When, by the earth's rotation on its axis, I was, during the night, carried rapidly to or from the ecliptic, the change of the apex, and of the direction of the boundary-lines, was equally great, and corresponded to my change of place.

5. That, as the ecliptic changed its position as respects the horizon, the entire shape of the Zodiacal Light became changed, which would result from new portions of the nebulous matter coming into position for giving us visible reflection; while portions lately visible, were no longer giving us such a reflection.

*A plane passing through the centre of the Zodiacal Light, as it shows itself through the varying latitudes of these observations, would correspond pretty nearly with the ecliptic;** but how near the two planes approach to a coincidence, it seems to be yet impossible to say. Through all of April, 1853, and December, 1854, there appear to be proofs of an evident crossing of the two planes. Through July of 1854, the apices, in the evening, were decidedly on the northern side of the ecliptic, though my latitude was only about 25° N; while, in September of the same year, though my latitude was nearly as before, the apices were on the southern side of the ecliptic, as shown by my morning observations; the

* Which is the reason why I have chosen the ecliptic for the central line of my charts; and why I refer so often to the position of the spectator as regards the ecliptic.

mornings then being very favorable for correct observation, on account of the high angle of the ecliptic with the horizon. Again, in April, 1855, the apices and greatest body of the light, were north of the ecliptic, even at times when I was, myself, to the southward of that line; as was the case in the first hours of the evening observations, up to the 13th of that month. The following general view rather shows us that there is something on this subject which may yet be learned, than that we have now the materials for anything definite and certain on the subject.

1853. April.—The planes of ecliptic and Zodiacal Light cross each other.

July.—By evening observations, the apex of Zodiacal Light appears to be north of the ecliptic. Morning observations are not satisfactory, either way.

1854. March 27 to April 18, strong proofs of crossing of the planes, by both morning and evening observations.

July.—Apex decidedly to the northward, by both evening and morning observations.

September.—Apices on the south, by morning observations, during this month.

December.—Apex decidedly to the northward, through all this month.

1855. January.—Apex as decidedly to the south of the ecliptic, by both morning and evening observations.

March.—Apex south of the ecliptic, by evening observations; the morning observations place it on the ecliptic.

April.—Apex north. No signs of a crossing of planes.

* * * * * * *

[The discussion of theories here follows in the volume and after objections to others, he comes to the one adopted.]

The hypothesis of a nebulous ring, with the earth for its centre.—There are certain deductions which appeared to come up in the examination of the preceding theories, which I will now bring together, and exhibit in a united form. They are: 1. That the substance giving us the Zodiacal Light must be *equally near* to us in all its parts, inasmuch as the lateral changes of the light—*i. e.* the changes of boundaries—have a uniform character, and mostly a parallelism in their whole extent from apex to base; 2. That no part of this substance can be *very remote* from us, inasmuch, as the outlines of the light, were clearly and decidedly affected by my own position on our globe, and even by my change of position, in a single night; and 3. That the laws of reflected light require an arrangement, or a shape, of this nebulous matter, which will give us, at the base of the Zodiacal Light, larger angles between the lines of the incident and reflected light, than at other portions, and also a regular decrease of such angles from the base to the apex of the light, as produced by such a shape. These three requirements appear to be fully met by an hypothesis, which, if the theories already examined are untenable, is now the only one remaining to us.

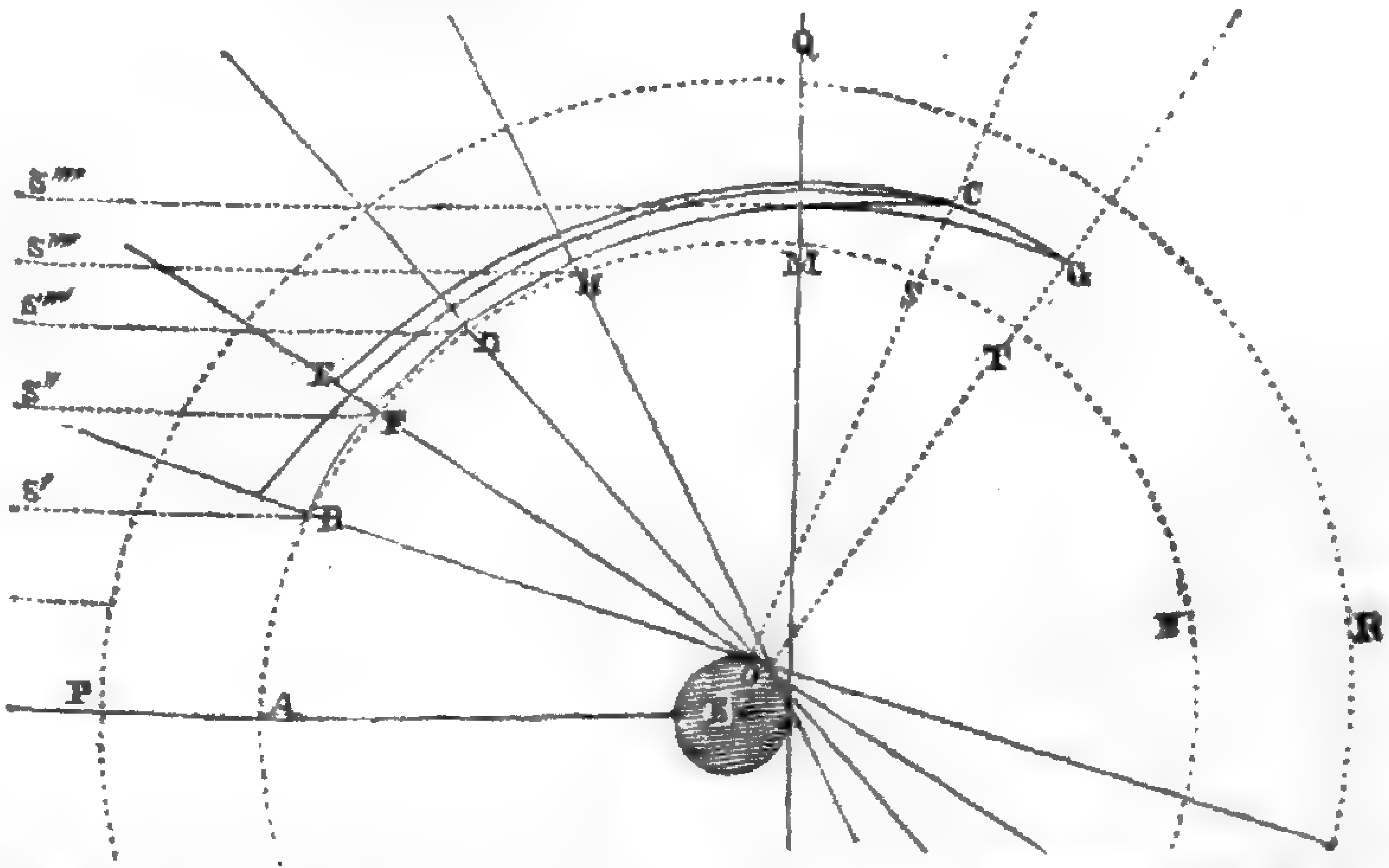
The hypothesis is that of *a ring around the earth.*

The thought is a somewhat startling one, yet startling only from its novelty; for it is entirely in accordance with what we know of one of our sister planets (Saturn), and also with the whole of Laplace's celebrated theory of the formation of globes.

That great writer, after stating his ideas of the central condensation from an immense body of nebulous, rotating matter, and thus of the formation of our sun, and of the rings about him, produced from the remainder of that nebulous matter, thus proceeds:

"If all the particles of a ring of vapors continued to condense without separating, they would at length constitute a solid or a liquid ring. But the regularity which this formation requires in all the parts of a ring, and in their cooling, ought to make this phenomenon very rare. Thus, the solar system presents but one example of it—that of the rings of Saturn. Almost always each ring of vapor ought to be broken into several masses, which, carried on with velocities differing little from each other, would continue to circulate at the same distance around the sun. These masses ought to take a spheroidal form, with a movement of rotation in the direction of the rotation, since the inferior molecules have a motion less than the superior ones; they have thus formed so many planets in a state of vapor. But, if one of them has been sufficiently powerful to unite, successively, by its attraction, all the others around its centre, the ring of vapor will have thus become transformed into only one spheroidal mass of vapors, circulating around the sun with a rotation in the same direction as its revolution. Now, if we follow the changes which further cooling ought to produce in the vapory planets, of whose formation we have just spoken, we shall see grow up in the centre of each of them, a nucleus, incessantly increasing by the condensation of the atmosphere which surrounds it. In this condition, the *planet* resembles perfectly the sun in the nebulous state, in which we have just been considering it; the cooling ought, then, to produce, at different limits of its atmosphere, phenomena similar to those we have described; namely, rings and satellites circulating around *its* centre, in the direction of its motion of rotation, and turning on their axes in the same direction."—*Systéme du Monde. Paris edition:* pp. 467–468.

This great theory of Laplace, called his nebular theory, appears to be looked upon by astronomers with wonder, almost with awe, and as a thing which they may scarcely dare to touch. It is regarded with favor, yet there are few cosmologists who venture a decided opinion upon it; and, indeed, while there are few points from which it can be controverted, Laplace himself seems to have exhausted what can be said in its favor, in the few lines which he has given to it, in a manner far from positive, and in a retired corner of his book. If that theory be true, however, we have reason to think that no one of the planets may have absorbed in itself all the nebulous matter of the ring from which it was originally formed; and that, consequently, there may be, to each of them, a remainder substance, in the form of a ring, or rings, with the planet for its centre. In the case of Saturn, such rings are visible by the aid of our glasses. To Jupiter, such rings have given four satellites; for our own globe, one satellite has been produced. And we may well query, whether there may not be still a remainder of the nebulous matter left from the ring originally producing the earth; the nebulous substance of that ring not having been all exhausted in the formation of our earth and its moon, and showing itself in a ring such as we are now considering.



Between PQR and AMN the nebulous ring.—E, the Earth.—S′ B, S′′ F, etc., direction of the Sun.—B, F, D, H, M, horizons; B, at 4h 30′; F, at 3h 30′; D, at 2h 30′; H, at 1h 30′; M, at midnight.—S, T, vertices; S, at 4h 30′; T, at 3h 30′.

But avoiding any consideration of these topics, as regards other planets, and confining ourselves simply to the facts of the Zodiacal Light, and of a ring central to the earth, to which they seem to lead us, we proceed to apply the results of Bouguer's experiments to this case.

In the annexed diagram, constructed according to this supposition,* the observation quoted in the former sections—that of

* The relative proportions of the earth and the ring, and also its distance, are, of course, not given in this diagram with any effort at certainty; the upward extent of the ring is probably far greater than can be here represented. The diagram, is, however, sufficiently correct for our present purposes of elucidation.

September 4th, 1853—is again taken as an example, and for the same reason; namely, that it is a simple one, and one also in which the spectator is near the plane of the ecliptic. The horizons, at $4^h\ 30^m$, $3^h\ 30^m$, $2^h\ 30^m$, $1^h\ 30^m$, and at midnight, are given, together with the lines of the spectator's vertices, as well as his positions, *o o*, &c., at $4^h\ 30^m$, and $3^h\ 30^m$, &c. A B F C are the boundaries of the Zodiacal Light at $4^h\ 30^m$, and E F G at $3^h\ 30^m$; the apices C and G are carried a little above the more condensed portion of the ring; but the reader is at liberty to suppose them to be at any other part, as he may think best. The direction of the sun is given; and S′, S″, S‴, S⁗, S′′′′′, are supposed to be rays of light proceeding from that luminary.

In this diagram, the sun's rays being S′, S″, &c., B O, F O, &c., will be the reflected rays; and the several angles between these lines of incidence and reflection, together with the number of rays reflected to the eye, out of every 1,000 incident rays, according to Bouguer, are in the following table:

Angle.	Rays reflected from smooth water.	Rays reflected from plate-glass not quicksilvered.
S′, B O .... 161°	343	422
S″, F O .... 146°	184	270
S‴, D O .... 131°	101	162
S⁗, H O ...... 116°	59	105
S′′′′′, at midnight, 90°	18	25
S′′′′′, C O ..... 67°	18	25

Still acknowledging that we know not what nebulous matter is, and therefore that we cannot, with certainty, argue about its properties of reflection; yet still claiming as a high probability, amounting almost to certainty, that the laws of reflection, applying to all other bodies, to solids, to vapors, to the molecules of our atmosphere, apply also to nebulous matter, we find in the above table a strong argument for such a ring around the earth. The figures, taking either of the two columns, for water or for glass, correspond in a very striking degree with the varying intensity of the Zodiacal Light, from the base upward, as we have it on any clear morning or evening when the ecliptic is at a high angle with the horizon, and when, consequently, the nebulous figure is not brought angularly to our eye. They also correspond to what is, indeed, almost synonymous with that which has just been stated—namely, to the fact, that at $4^h\ 30^m$, the Zodiacal Light at the horizon is far greater at its base than it is at $3^h\ 30^m$; at $3^h\ 30^m$, than it is at $2^h\ 30^m$, &c., back to midnight. Any person, who has ever looked attentively at this light, when making a high angle with his horizon, will see at once the coincidence between the proportions in the above figures, showing the number of reflected rays, and what has been always presented to his eye. If the reader will also carry these lines of incident and reflected light beyond the midnight horizon-line, to any point there of the nebulous ring, he will see how we may easily get what is referred to in my charts under the German name of *gegenschein*—*i. e.* a dim light, seen, when the circumstances are favorable for it, in those portions of the sky opposed to the sun. This hypothesis shows also, very clearly, how I could have the Zodiacal Light above both horizons at the midnight hours, as I was often able to do, and it harmonizes fully with the strength of the light as then presented to the eye.

Indeed, while Bouguer's results are antagonistic to all the theories discussed in the previous sections, and seem to be utterly irreconcilable with them, they fully coincide with this, in every one of its aspects; and, so far as they can go, they satisfy the mind, in all the varying characters of the Zodiacal Light.

I said, so far as they can go; for there are points in this subject, such as the pulsations of light, and what in the annotations to these charts is called the "effulgent light," which belong to something in the nebulous matter which we have not yet fairly reached, and which must be left for explanation to yet further observations.

While there are some things still left unexplained, I have yet, not been able to see anything in this hypothesis antagonistic to the facts of the Zodiacal Light. On the contrary, almost all of them are explained by it; and they all, as far as I can perceive, fully harmonize with it, through the whole of the manifold changes which the light underwent, either from the changes of the ecliptic towards any fixed spot, or from my numerous and great changes of latitude during our cruise. In examining them in detail, we must remember the deduction just drawn, (see p. 167, last paragraph,) from the general mass of data—namely, that as the spectator's place is changed relatively to different portions of the nebulous ring, such portions change, for him, their reflected light; just as is done every day, to our eye, by clouds or other terrestrial objects. Remembering this, he will, I think, fully understand why, when I was on the northern side of the ecliptic—*i. e.* towards the northern edge of the ring—its reflection was chiefly on that side; why its southern portions gave me the chief reflection when I was towards its southern side; and so, why all the various aspects detailed in Nos. 1, 2, 3, 4, 5, were, at different hours or seasons, presented to my eye.

If it should be objected to my deductions from Bouguer's law of reflection, that the intensity of light, which his results would give this ring when brought between our eye and the sun, ought to make the ring a very striking object to us during a total eclipse of the sun; I reply, that the increased intensity of the Zodiacal Light, from the apex to base, is a *fact* independent of any theories; that, on any supposition of causes, it can scarcely be doubted that this reflection, so increasing from apex to base at the horizon, goes on still increasing in force below the horizon, towards the direct line between our eye and the sun; and that, consequently, if the Zodiacal Light is not a striking object in a total eclipse, stretching off from each side of the sun, this fact is not more against the hypothesis of a ring around our earth, than against a ring around the sun or in any other place. As respects such eclipses, however, if the observer of them is in a high latitude, north or south, he will, except at only one portion of the year, have the ecliptic at a very low angle with his horizon (even, under the best circumstances, not at a high angle,) and therefore cannot expect to have a good exhibition of the Zodiacal Light at the time of eclipse. There was, however, an observation made in Peru, during a total eclipse, on the 30th of November, 1853, from which we might expect something of a more decisive character. The observer was Prof. Carlos Moesta, of the Observatory of Santiago, who at the suggestion of Lieutenant Gillis, U. S. N., was sent to Peru, by the government of Chili, for that purpose, and who afterwards made a highly interesting and valuable report to the Minister of Public Instruction, with a sketch of the heavens as they appeared at the time of the total obscuration of the sun. His place of observation was in lat. 14° 21′ 21″ S, and consequently he had the ecliptic at a high angle with his horizon: the sun at that time having a declination of 24° 42′ S,—*i. e.* 7° 21′ south of the observer. Every thing was favorable, as regards an observation for the Zodiacal Light, on that occasion; and we have, in his engraved plate, in addition to the corona usual in total eclipses, a long ray projecting from the sun S 70° E, and another, also a prominent and striking object, but not quite so long, stretching off N 80° W. He says: "Nearly all the northern part of the ring [corona] was uniform; the opposite side was evidently composed of numerous rays, which appeared to come from the ring, and all which had the same length, with the exception of two very large ones. Of these last, one was in an upward direction, and inclined about 20° S of E, and according to estimation, its upward extent is as large as a diameter of the moon; the other extended from the ring downward, not diametrically opposite to the former, but inclined about 10° N of W, and was a little shorter than the other. The appearance of these two rays was much like that of a comet, narrower at the end than near the nucleus, and clearly radiating in its structure; since it could be seen, perfectly well that these rays were not of a homogeneous light, but composed of a vast number of very small rays. Soon after the eclipse I made the annexed sketch, in which I have endeavored to represent this ring [corona] as nearly like the original as possible."

It should be added to this that Mr. Moesta's drawing was from a view through the telescope; I have, myself, always found the naked eye better for viewing the Zodiacal Light than telescopes. Through our ship's glasses I was never able to see it all.

If we could have a Zodiacal Light of an undoubted character produced by the *full* moon, not only would the question before us be set at rest, but the ring would be shown to be within the orbit of the moon: and how near we came to a case of that kind on the evening of February 14,* 1854, the reader will decide for himself. There was no subject connected with these observations, in which I was so carefully watchful; but, in summer, the moon, when full, must rise long before the crepuscule ceases, and it is only in winter months that satisfactory observations of this nature can be made; and in the few instances of this kind which offered, clouds interfered to prevent them.

For myself, I have no doubt that what I saw, in all the cases given in these charts, was really *Zodiacal Light produced by the moon.* When the equator and ecliptic were furthest removed from each other, the light still kept closely with the ecliptic, and, therefore, could not have been atmospheric; and the boundaries, though only in one case having the altitude of the sun's Zodiacal Light, still, as far as they ascended, always resembled fully those produced by the sun.

From the deductions made, (see p. 167, last paragraph,) it is apparent that we cannot expect to get a parallax of this ring; and that we can hope for only approximations to its width. In the morning observations I appear to have got the full lateral extent northward of the Stronger Light, about 30°; and of the Diffuse Light 45°; but the evening observations of June, July, and August, 1853, differ somewhat from these. The inference from the whole of these data would seem to be about 60° for the full width of the Stronger, and 90° for that of the Diffuse Light.

I endeavored to have simultaneous observations made in Connecticut while I was in the extreme southern latitudes, but did not succeed.

This ring must, according to the laws of matter, rotate on its centre; and it seems to be full of commotions within itself. The existence of the pulsations, so often referred to in this book, seems scarcely to admit of a doubt, recorded as they have been by observers in such distant quarters of the globe. They were, as a general thing very obscurely marked; but at times they appeared to be so decided that I had no longer a doubt of their reality. They could scarcely be owing to irregularities on the surface; for the changes appear to have been too rapid and extensive for such a cause. But that is possible. The following, respecting the rings of Saturn, is from Laplace's *Mécanique Céleste*:

* The moon was full at Greenwich February 12, 14*h.* 56*m.*; allowing for the difference in longitude, the observation was 1*d.* 6*h.* 43*m.* after the full; the next evening's observation, with still more decided results, was 2*d.* 7*h.* 28*m.* after the full.

"Hence it follows that the separate rings which surround the body of Saturn, are irregular solids, of unequal width in the differents parts of their circumferences; so that their centres of gravity do not coincide with their centres of figure. These centres of gravity may be considered as so many satellites, which move about the centre of Saturn, at distances depending on the irregularities of the parts of each ring, and with velocities of rotation equal to those of their respective rings."—*Bowditch's Tr.*, Vol. V, p. 516.

If we allow an irregularity of width to the earth's ring, it may account for the changes in its intensity of light; the Zodiacal Light this spring (1856) having been considered as of much greater brightness than in previous years.

If this nebulous matter gives us its reflected light only from certain portions of it—*i. e.* only from portions in position for admitting such reflection to our eye, may not the light from the tails of comets* (query: portions of *very* elliptic rings, the plane of the rings then coinciding with our eye?) be given and withdrawn in the same manner; so that, instead of such appendages suddenly shot out, and as suddenly withdrawn or dissipated, and at times, contrary to all laws of dynamics, preceding the body from which it emanates, we have, more philosophically, a substance always permanent, but giving its light to our eye only in certain portions of its orbit?

ART. XVIII.—*On some Compounds of Ethylene;* by H. S. BUFF. [Communicated to this Journal by A. W. HOFFMAN, Ph.D.]†

AMONG the hydrocarbons which are capable of replacing hydrogen, the radicals of the general formula CnH(n+1) *i. e.*, the homologues of ethyl, are best examined. There is another class of hydrocarbons which may be represented by the general formula CnH(n−1). The only well known term of this series is the radical allyl C_6H_5 to which the attention of chemists has been especially called of late by the researches of Messrs. Hoffmann and Cahours on allylic alcohol. These researches have established the most perfect parallelism between the two classes of radicals and their derivatives. Both the radicals CnH(n+1) and CnH(n−1) are *monatomic*, *i. e.*, molecules capable of replacing

* "The tail of the great comet of 1680, immediately after its perihelion passage, was found by Newton to have been no less than 20,000,000 of leagues in length, and to have occupied only two days in its emission from the comet's body; a decisive proof, this, of its being darted forth by some active force, the origin of which, to judge from the diameter of the tail, must be sought in the sun itself."—*Sir J. Herschell's Outlines of Astronomy.*

† From the Proceedings of the Royal Society, received June 10, 1856. Read the 19th June, 1856.

one equivalent of hydrogen. These two classes stand in the closest relation to each other, and it is by no means improbable that one class may pass over into the other, for instance, that the radical propyl C_6H_7 or a propyl compound may be converted into allyl or an allyl compound.

There exists a third series of hydrocarbons, which, again both by composition and origin are closely allied to the former two. They are represented by the general formula CnHn and methylene C_2H_2, ethylene C_4H_4, and propylene C_6H_6 are well known terms belonging to this series. These hydrocarbons are also radicals, they differ however, in their nature essentially from those of the former groups, inasmuch as they are *biatomic* molecules, *i. e.*, molecules capable of replacing 2 equiv. of hydrogen.

There exist parallel with these three series of radicals which form alcohols, three other groups of radicals, which in *acids* play exactly the same part that in the *alcohols* is assigned to the hydrocarbons. These acid-forming radicals contain, in addition to carbon and hydrogen, oxygen or other elements belonging to the oxygen group. They are closely connected with the radicals of the alcohols and this close connection is particularly well established between the first series of *alcohol-forming* radicals and the corresponding series of *acid-forming* radicals.

$$\begin{aligned} &\text{Methyl, } C_2H_3 - 2H + 2O = \text{Formyl, } && C_2HO_2 \\ &\text{Ethyl, } C_4H_5 - 2H + 2O = \text{Acetyl, } && C_4H_3O_2 \\ &\text{Propyl, } C_6H_7 - 2H + 2O = \text{Propionyl, } && C_6H_5O_2 \end{aligned}$$

Formic, acetic and propionic acids are formed by the imperfect oxydation of methyl-, ethyl- and propyl-alcohol; and we may consider them to be simple substitution products of these alcohols.

By means of the electric current we are able to produce ethyl, methyl and hydrogen from propionic, acetic and formic acid, and these acids we may reproduce again by the action of hydrate of potassa on the cyanogen compounds of hydrogen, methyl and ethyl.

Both series of radicals are chained together by these reactions, and we may view acetyl and propionyl as formyl, the hydrogen of which is replaced by methyl and ethyl.

$$\begin{aligned} &\text{Formyl, } && = C_2(H)O_2 \\ &\text{Acetyl, } && = C_2(C_2H_3)O_2 \\ &\text{Propionyl, } && = C_2(C_4H_5)O_2 \end{aligned}$$

There is no doubt that the same relation exists between the hydrocarbons of the other series of radicals and the radicals of the corresponding acids, between allyl C_6H_5 and the radical of acrylic acid, acryl $C_6H_3O_2$ and between methylene C_2H_2, ethylene C_4H_4, propylene, &c., and the radicals of the bibasic acids, which are homologues of succinic acid $C_8H_6O_8$.

The biatomic radicals are in general less studied than the monatomic radicals; still they occur in many compounds, and are met with in different departments of chemistry.

In addition to the terms already mentioned, we find them in the phenyl, benzyl, napthyl and other series.

In the hope of adding some facts to the history of the polyatomic radicals I have made some experiments with chlorid of ethylene $C_4H_4Cl_2$.

This compound, as well as bromid of ethylene, refused to act in many instances, in others it underwent the same change which is induced by the action on it of a solution of potassa in alcohol, splitting into the compound C_4H_3Cl and hydrochloric acid.

On boiling chlorid or bromid of ethylene with an alcoholic solution of sulphocyanid of potassium, a very definite reaction takes place. The change being completed, the alcohol is separated by distillation, and the residue treated with a small quantity of cold water in order to remove chlorid or bromid of potassium, which is produced and the excess of sulphocyanid of potassium. The more or less colored residue is then dissolved in boiling alcohol, and the solution, after digestion for some time with animal charcoal and a few drops of hydrochloric acid, filtered while hot. This solution deposits on cooling brilliant and large rhombic plates of a hard and brittle white substance.* The analysis of this substance leads to the formula

$$C_4H_4Cy_2S_4$$

and its formation may be represented by the equation

$$C_4H_4Cl_2+2K\,CyS_2=2K\,Cl+C_4H_4Cy_2S_4,$$

which in the conception of this view may be called *anylene-sulphurous* acid, the cyanogen is replaced by hydrogen, whilst the sulphur has been oxydized into the compound radical S_2O_6, which in sulphurous acid we assume united with hydrogen.

$$\begin{array}{c}\text{Two molecules}\\\text{of water,}\end{array}\begin{array}{l}\left.\begin{matrix}H\\H\end{matrix}\right\}O_2\\\left.\begin{matrix}H\\H\end{matrix}\right\}O_2\end{array}\quad\begin{array}{l}\text{Two equivs. of}\\\text{bisulphite of}\\\text{potassium,}\end{array}\begin{array}{l}\left.\begin{matrix}H\\K\end{matrix}\right\}S_2O_6\\\left.\begin{matrix}K\\H\end{matrix}\right\}S_2O_6\end{array}\quad\begin{array}{l}\text{Ethylene-}\\\text{sulphurous}\\\text{acid,}\end{array}\begin{matrix}H\\C_4H_4\\H\end{matrix}\begin{matrix}\}\,S_2O_6\\\}\,S_2O_6\end{matrix}$$

Since we find that the hydrogen-molecules in polybasic acids are replacable by two or more molecules of different metals or radicals, witness tartrate of potassium and sodium, oxalovinate of potassium, the idea naturally suggests itself that the biatomic alcohol-forming radicals may be capable of uniting two molecules of different elements or compounds of the oxygen group. It is

* Whilst Mr. Buff was engaged in these researches, Mr. Tannenschein has communicated some experiments made in the same direction, which have likewise led to the discovery of this substance. Tannenschein's results, which are published in the Journ. für prac. Chem. June, 1855, came to our knowledge only after a summary of the results had been sent to the editor of the Ann. der Chem. und Pharm.—A. W. H.

probable, for instance, that the ethionic acid, discovered by Mr. Magnus, may be such a compound, namely, *ethylene-sulphuro-sulphurous acid.*

Disulphetholic acid $\left.\begin{matrix}H\\C_4H_4\\H\end{matrix}\right\}\begin{matrix}S_2O_6\\S_2O_6\end{matrix}$ Ethionic acid $\left.\begin{matrix}H\\C_4H_4\\H\end{matrix}\right\}\begin{matrix}S_2O_6\\S_2O_8\end{matrix}$

The following table contains some of the known ethylene and succinyl compounds compared with the corresponding derivatives of the ethyl and propionyl series.

Compounds of the Alcohol-forming Radicals.

Ethyl Series.		Ethylene Series.	
Ethyl,	$\left.\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right\}$	Ethylene,	C_4H_4
Chlorid of ethyl,	C_4H_5Cl	Chlorid of Ethylene,	$C_4H_4Cl_2$
Sulphid of Ethyl,	$\left.\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right\}S_2$	Sulphid of Ethylene,	$C_4H_4S_2$
Mercaptan,	$\left.\begin{matrix}C_4H_5\\H\end{matrix}\right\}S_2$	Sulphocyanid of Ethylene,	$\left.\begin{matrix}C_4\\C\ H_4\\Cy\end{matrix}\right\}\begin{matrix}S_2\\S_2\end{matrix}$
Sulphocyanid of Ethyl,	$\left.\begin{matrix}C_4H_5\\Cy\end{matrix}\right\}S_2$	Ethylene-mercaptan,	$\left.\begin{matrix}H\\C_4H_4\\H\end{matrix}\right\}\begin{matrix}S_2\\S_2\end{matrix}$
Bisulphid of Ethyl,	$C_4H_5S_2$	Bisulphid of Ethylene,	$C_4H_4S_4$
Ethylsulphurous acid,	$\left.\begin{matrix}C_4H_5\\H\end{matrix}\right\}S_2O_6$	Ethylene sulphurous acid,	$\left.\begin{matrix}H\\C_4H_4\\H\end{matrix}\right\}\begin{matrix}S_2O_6\\S_2O_6\end{matrix}$
———		Ethylene sulphuro sulphurous acid,	$\left.\begin{matrix}H\\C_4H_4\\H\end{matrix}\right\}\begin{matrix}S_2O_6\\S_2O_8\end{matrix}$
Sulphovinic acid,	$\left.\begin{matrix}C_4H_5\\H\end{matrix}\right\}S_2O_8$	———	

Compounds of the Acid-forming Radicals.

Propionyl Series.		Succinyl Series.	
Chlorid of propionyl,	$C_2(C_4H_5)O_2Cl$	Chlorid of succinyl,	$C_4(C_4H_4)O_4Cl_2$
Propionic acid,	$\left.\begin{matrix}C_2(C_4H_5)O_2\\H\end{matrix}\right\}O_2$	Succinic acid,	$\left.\begin{matrix}H\\C_4(C_4H_4)O_4\\H\end{matrix}\right\}\begin{matrix}O_2\\O_2\end{matrix}$
Anhydrous propionic acid,	$\left.\begin{matrix}C_2(C_4H_5)O_2\\C_2(C_4H_5)O_2\end{matrix}\right\}O_2$	Anhydrous succinic acid,	$C_4(C_4H_4)O_4O_2$
Propionyl amid,	$N\left\{\begin{matrix}H\\H\\C_2(C_4H_5)O_2\end{matrix}\right.$	Succinamid,	$\begin{matrix}N\\ \\ \\ \\N\end{matrix}\left\{\begin{matrix}H\\H\\C_4(C_4H_4)O_4\\H\\H\end{matrix}\right.$

ART. XIX.—*On the Rose-colored Mica of Goshen, Mass.;* by J. W. MALLET, Ph.D., Professor of Chem. in the Univ. of Alabama.

THE very beautiful mica which occurs in finely developed crystals of a delicate tint of rose-red at the above-named locality has been usually considered as Lepidolite, mainly on account of its color; but in Dana's Mineralogy* it is noticed as "of difficult fusibility and slight lithia reaction, and possibly not belonging to the species Lepidolite."

Wishing to determine the true mineralogical character of this substance I resolved to ascertain the nature and amount of its alkaline constituents, and accordingly reduced a pure specimen to powder, and decomposed it by fusion with carbonate of lime and a little chlorid of calcium. The earths and oxyds of heavy metals having been removed in the usual way, and ammoniacal salts expelled, the chlorids of the alkalies were treated with a mixture of ether and absolute alcohol, and chlorid of lithium having been extracted by this solvent, the chlorids of potassium and sodium were separated by chlorid of platinum.

The mica was found to yield:

Potash, - - - - - -	9·08	p. c.
Soda, - - - - - - - -	·99	"
Lithia, - - - - - - - -	·64	"

so that it contains the three fixed alkalies, but of these potash only in notable quantity.

As the mineral gives off scarcely a trace of water when heated in a glass tube, I obtained an approximate determination of the fluorine which it contains by igniting intensely a portion weighed in a platinum crucible, and calculating from the loss, considered as ter-fluorid of silicon. 17·996 grm. (dried at 250° F.) thus treated lost ·443 grm. = ·3394 grm. of hydro-fluoric acid, or 1·89 p. c. This small percentage of fluorine, and the very small amount of lithia found, both go to prove that the Goshen mica does not belong to the species Lepidolite, but rather to that of Muscovite or common oblique mica.

As a final test of the character of the mineral, it was submitted to optical examination. Professor Benagh of this University was kind enough to measure for me the angle between the optic axes and found it to read about 74°–76°. Prof. Silliman gives 75°–76° for the angle between the axes of the *yellowish-green* mica which occurs in the same granite vein with this rose-colored mineral at Goshen, and there can I think be little doubt that both are essentially potash-micas of the species Muscovite, the rose-colored being probably tinged by oxyd of manganese.

* Fourth edition, vol. ii, p. 227.

ART. XX.—*Results of some Analyses made for the Geological Survey of the State of Alabama;* by J. W. MALLET, Ph.D., Professor of Chemistry in University of Alabama.

A LARGE number of analyses have been made of specimens collected by those in charge of the field-work of the Geological Survey of Alabama under the direction of Professor Tuomey, State Geologist, but the value of most of these is of a technical or agricultural character, and the results will appear most appropriately in the Report upon the State Survey. It is intended in the present paper merely to extract a few analyses which seem to possess a distinct scientific interest, and to notice very briefly their results.

A *marble* of a delicate pale pink color, from Talladaga Co., was found to contain

Carbonate of lime,	35·67
Carbonate of magnesia,	2·51
Alumina (with trace of Fe^2O^3),	·39
Insol. matter,	61·15
	99·72

and the portion undissolved (by muriatic acid) was fluxed with carbonate of soda, and gave—

		Atoms.	
Silica,	63·67	1·406	5·6
Magnesia,	30·24	1·512	6·
Alumina,	2·05		
Peroxyd of iron,	·39		
Lime,	*trace*		
Oxyd of manganese,	*trace*		
Water,	3·34	·371	1·5
	99·69		

The sp. gr. of this insoluble matter was 2·626, and it is obviously a talc or steatite, which is found intimately mingled with the carbonate of lime of the marble. The latter is very homogeneous in appearance, but derives a slight greasy lustre (and feel to the fingers) from the presence of this steatitic mineral.

Three careful analyses were made of the "*prairie*" or "*rotten*" *limestone* of the Cretaceous formation, from the disintegration of which rock, some of the richest soils of the south are derived. The results were as follows:

		1.	2.	3.
Sol. in HCl.	Carbonate of lime,	75·07	80·48	64·37
	Carbonate of magnesia,	·72	·53	·79
	Peroxyd of iron,	1·44	1·24	2·19
	Alumina,	·79	·98	·75
	Phosphate of lime ($3CaO, Po^5$),	·4035	·3710	·5432
	Silica,	·14	·194	·059
Insol. in HCl.	Silica,	11·99	9·04	19·58
	Alumina,	3·38	2·19	3·97
	Peroxyd of iron,	1·84	1·55	2·49
	Lime,	1·47	1·01	·78
	Magnesia,	——	——	*trace*
	Potash,	·0945	·1135	·0410
	Water,	2·49	2·22	3·58
		99·83	99·91	99·14

No. 1 was from Demopolis; its sp. gr. =1·976 (containing air between its particles). No. 2 was from Jones Bluff on the Tombigbee River; sp. gr. =2·064. No. 3 from Cahawba; sp. gr. = 1·923. The alkali, which was sought for with particular care, was determined for the whole mass of the limestone, but is set down in the above statement of results amongst the constituents insoluble in muriatic acid, as being supposed to be in combination with silica.

The *Greensand* of Alabama has also been examined with reference to its agricultural value and the content of several greensand marls in phosphoric acid, potash, and lime, has been determined. The greensand grains do not often occur of sufficient size and purity for separate analysis, but the composition of those from two localities has been ascertained, and may possess some interest as enabling us to compare the mineral as found here with that of New Jersey and other Atlantic states.

Picked greensand grains from Coal Bluff on the Alabama River gave as the mean of two analyses—

Silica,	57·56
Alumina,	6·56
Protoxyd of iron,	20·13
Lime,	1·04
Magnesia,	1·70
Potash,	4·88
Water,	8·17
	100·04

and another analysis of a specimen from the same locality gave

Silica, - - -	58·91	(of which 11·85 insol. in carbonate of soda.)
Alumina, - - -	5·48	
Protoxyd of iron, -	19·24	
Lime, - - - - -	·71	
Magnesia, - - -	·87	
Potash, - - - -	4·58	
Water, - - -	8·17	
Iron pyrites, - - -	1·46	
	99·42	

Sp. gr. of the grains =2·297.

Another specimen, from Gainsville, sp. gr.=2·349, apparently slightly altered by exposure, yielded

Silica, - - -	58·74	(of which 23·89 insol. in carbonate soda.)
Alumina, - - -	4·71	
Protoxyd of iron, -	21·06	(traces as peroxyd.)
Lime, - - - - -	·92	
Magnesia, - - -	1·48	
Potash, - - - -	3·26	
Water, - - -	9·79	
	99·96	

The analyses of the mineral from these two localities agree very well together, and agree also, on the whole, well with the results of Prof. H. D. Rogers* for the greensand of New Jersey —the quantity of silica being somewhat greater in the Alabama mineral, and the proportion of potash less—although these differences are less in reality than appearance, since some of the silica is insoluble in carbonate of soda, and therefore does not exist in combination with the other constituents. If the percentage of silica really belonging to the mineral be thus reduced, the quantity of potash present will of course be proportionally increased, and thus brought nearer the amount found in specimens from New Jersey.

Two fine white *Porcelain Clays* were analyzed. The first, from above Jacksonville, gave the following results, on treatment with strong caustic potash and sulphuric acid alternately, as recommended by Brongniart and Malaguti:

* Report on the Geology of New Jersey, p. 200, et seq.

		Atoms.	
Combined silica,	39·75	·877	1·2
Free silica,	4·85		
Alumina,	38·92	·757	1·
Peroxyd of iron,	·78		
Lime, potash, &c.,	1·03		
Water,	13·38	1·487	2·
Undecomposed mineral,	·90		
	99·61		

The second, from Randolph Co., yielded

		Atoms.	
Combined silica,	19·85	·438	1·
Free silica,	17·44		
Alumina,	31·92	·621	1·4
Peroxyd of iron,	*trace*		
Potash, lime, and magnesia,	·72		
Water,	15·09	1·676	3·8
Undecomposed mineral,	14·28	(of which 7·49 = finely divided quartz.)	
	99·30		

The former of these analyses corresponds nearly to the formula Al^2O^3, SiO^3+2HO, which is that of the greater number of specimens examined by Brogniart and Malaguti, while the latter gives the formula $3Al^2O^3$, $2SiO^3+8HO$, approaching more closely the composition of a clay from Wilmington (Delaware), than that of any other in the list of the above-named experimenters.

A considerable number of *Iron ores* have been analyzed, and among them one may be mentioned as containing a notable amount of titanium. It was a specimen of magnetic iron from near Oak Bowery; sp. gr.=4·827. It was decomposed by fusion with bi-sulphate of potash, and yielded

* { Peroxyd iron,	61·37
Sesquioxyd of titanium,	9·21
Protoxyd of iron, }	28·80
Magnesia,	·08
Alumina,	*trace*
Silica,	·54
	100·

I shall notice but a single other analysis—that of an incrustation from the walls of an iron-furnace in Benton Co. It appeared as a hard solid mass, of a dark grayish green color, and sp. gr. =5·172, and proved to consist of nearly pure oxyd of zinc, as shown by the following analytical results:

* Calculated from 93·37 p. c. of Fe^2O^3, and 10·21 of TiO^2.

Oxyd of zinc, - - - - - -	97·77
Protoxyd of iron, - - - - - -	1·21
Oxyd of manganese, - - - - -	*trace*
Silica, - - - - - - - - - -	·64
Carbon, - - - - - - - -	·08
	99·70

This incrustation is interesting, since similar accumulations of oxyd of zinc in large quantity during the smelting of iron ores have been noticed before, although they do not seem to occur very frequently. One is mentioned in Prof. H. D. Rogers' 4th Report upon the Geology of Pennsylvania, p. 214. It was from the walls of a furnace in Cumberland Co. (Penn.), and contained in 100 parts, oxyd of zinc 92·48, oxyd of lead 6·48, peroxyd of iron 1·00, carbonaceous matter *trace*, =99·96.

Another similar incrustation, from the mouth of a blast-furnace in Shropshire (England), has been described by Prof. Crace-Calvert,* and contained, oxyd of zinc 93·00, oxyd of iron 2·10, sulphuret of zinc 2·00, carbon 2·45, silica ·45=100·00. The iron ore (clay iron-stone nodules), and the coal employed at the furnace from which this last specimen was taken were found to contain little crystals of zinc-blende, the coal also including little particles of galena. Wishing to ascertain the origin of the Benton Co. incrustation, I carefully tested the iron ores there used for zinc, but without detecting any indication of its presence; possibly the limestone used as flux may be found to contain a little blende diffused through it.

University of Alabama, Nov. 12, 1856.

Art. XXI.—*Note on "Red Sulphur;"* by J. W. Mallet, Ph.D., Professor of Chemistry in the University of Alabama.

In a paper by M. Ch. Sainte-Claire Deville, published in the *Annales de Chimie et de Physique* for May, 1856, in which the various modifications which sulphur undergoes when heated are considered, the author states that the *red* variety of sulphur can be produced only by subjecting the same mass of this substance *several times* alternately to heat and rapid cooling, the permanent red coloration being never obtained *by one tempering.*

Magnus speaks in the same way of this modification of sulphur in his memoir contained in the number of the same journal for June, 1856.

* Number of the "Chemist" for Sept., 1856, p. 706.

Having observed a few months ago the accidental production, by a single heating, of red sulphur, which retains its color perfectly unchanged up to the present time, I will mention the circumstances under which it was obtained, and the properties which it appears to possess.

Some clean roll-sulphur was melted in a glass evaporating dish for the purpose of exhibiting to students the production of the plastic modification on pouring it while thick and viscid into cold water. A portion was so poured into water, and the remainder was heated up to a higher temperature, so as to show the renewed fluidity of the melted mass. Being forgotten for a few minutes over the lamp, the temperature of the sulphur rose so high that it took fire, and the lamp was then removed, and the flame extinguished by throwing a cloth over the dish.

On examining the sulphur an hour or two after, it was found solidified in a cake of distinctly prismatic crystalline structure, and of a brownish-red color. It was broken up into pieces of a size to go into a bottle, and in the interior were observed some little cavities lined with stout prismatic crystals.

This sulphur, having been set aside for several months, presents just the same appearance now as when first prepared. Its color is nearly chocolate-brown, verging on red, and its hardness is greater than that of common roll sulphur. Re-fused at a gentle heat it forms a thin, very dark brown liquid, appearing almost black by reflected light. If left to cool slowly in the air this solidifies again to a crystalline mass like the original cake, but a little darker in color. If a portion be poured while melted into cold water it forms drops of a deep red color (like Pyrope) by transmitted light, and almost black by reflected light. These drops do not solidify at once but remain soft, so that on touching them with a wire under water they may be drawn out into threads. When perfectly solidified they have a vitreous lustre and the same very dark red color as in the plastic state, resembling somewhat "glass of antimony." They gradually, in the course of two or three days, become in part opaque and of a light red-brown color, this change being confined for the most part to the surface of the drops, of which the interior remains glassy as before, but in some cases extending in veins and striæ through the interior of a drop. The change from the glassy to the opaque state begins usually at distinct points, and spreads gradually over the surface.

A portion of the original cake was melted and poured into cold water ten or twelve times in succession, as in the process for preparing red sulphur of MM. Magnus and Sainte-Claire Deville, but after these numerous heatings and coolings it presented very nearly the same appearance as at first, whether it were examined after slow cooling in the air or rapid solidification in cold water; it was perhaps rather darker in color than that which had been but once re-melted. It became also slowly opaque and light in color on exposure to the air for two or three days.

Some fragments of the original cake, with prismatic crystals upon them, were treated with bi-sulphuret of carbon. This rapidly dissolved out ordinary sulphur, forming a pale yellow solution, which became brownish orange on heating with the insoluble residue. The solution, allowed to evaporate spontaneously in the air, left octahedral crystals of ordinary yellow sulphur, tinged in places by a very little red, and round the edges of the evaporating dish was an amorphous crust of red sulphur; the quantity of the latter being quite small in proportion to that of the yellow modification dissolved, as observed by Deville and Magnus.

The portion insoluble in bi-sulphuret of carbon was of a red-brown color, and amorphous; it retained in some cases the prismatic form of the crystals in which it had been inclosed, but fell to the bottom of the vessel, on shaking, as a flocculent amorphous powder. A little of this insoluble red sulphur was heated in platinum foil, and burned without any residue.

A fragment of the original cake, heated in a test tube up to the boiling point of sulphur, sublimed, and appeared after sublimation with its ordinary yellow color; the unsublimed part resolidifying as it cooled with the same red-brown tint as before.

Comparing all these characters with those of the red sulphur obtained by MM. Magnus and Sainte-Claire Deville by *repeated* heatings and coolings, it seems certain that a considerable portion of the same allotropic modification had been produced by a *single* heating in the unintentional experiment mentioned in this note.

ART. XXII.—*Observations upon the Carboniferous Limestones of the Mississippi Valley;** by JAMES HALL. [Abstract.]

THE object of this communication was to show that certain reliable and well marked subdivisions exist in the "*Carboniferous limestone,*" as it is usually termed, of the Mississippi valley. The subdivisions heretofore proposed were founded, in part, upon certain supposed characteristic fossils, such as the Archimedes, the Pentremites, etc., which, though reliable as individual species in their geological range, are not, as genera, characteristic of the subdivisions. The subdivisions proposed in the report of Dr.

* From the Proceedings of the American Association for the Advancement of Science. The same subject essentially forms a part of the Report of Progress of the Iowa Geological Survey.

D. D. Owen are, first, an upper and lower series, each of which is again subdivided into several distinct beds or groups. For the sake of comparison, this table of Dr. Owen's is here given.

"SECTION OF SUB-CARBONIFEROUS LIMESTONES OF IOWA.

Coal Measures.	
20 feet.	Upper concretionary limestone.
10 feet.	Gritstones.
30 feet.	Lower concretionary limestones.
10 feet.	Gritstones.
10 feet.	Magnesian limestone.
30 feet.	Geodiferous beds.
50 feet.	Archimedes limestone.
15 feet.	Shell beds.
15 feet.	Keokuk cherty limestone.
70 feet.	Reddish brown encrinital group of Hannibal.
55 feet.	Encrinital group of Burlington.
75 feet.	Argillo-calcareous group, Evans' Falls."

The above expresses the measurements and succession of the rocks as given in Dr. Owen's section.

Prof. Swallow, in his Report on the Geological Survey of Missouri, subdivides the Carboniferous limestones and rocks below the lower coal measures as follows:

Carboniferous limestone.	E. Lower coal measures,	140 feet.
	F. Ferruginous sandstone,	195 "
	G. St. Louis limestone,	250 "
	H. Archimedes limestone,	200 "
	I. Encrinal limestone,	500 "
Chemung group.	J. Chouteau limestone,	70 "
	K. Vermicular sandstones and shales,	75 "
	L. Lithographic limestones,	60 "

Under each of these divisions are given numerous localities where the rock is well developed.

In descending the Mississippi river, we come upon the lowest and most northerly outcrop of these limestones at Burlington, Iowa. At this locality we have the following section, in the descending order.

1. Encrinal limestone.
2. Oolitic limestone, fossiliferous.
3. Compact arenaceous limestone.
4. Fine grained argillaceous sandstone or grit stone, with casts of Spirifer, Chonetes, Productus, Bellerophon, Orthoceras, etc.
5. Green shale.

The entire thickness of 2, 3, 4, and 5, is about 70 to 80 feet; the base of the green shale however has not been observed.

These members constitute the argillo-calcareous group of Evans' Falls, in Dr. Owen's section, and the members J, K, and L, of Prof. Swallow's section. The higher beds belong to the age of the Chemung group, containing the same fossils as the rocks of that group in New York and elsewhere, and have been carefully traced throughout the intermediate space. It is quite probable that, in strict parallelism, the green shale of Burlington and Evans' Falls, which weathers to an "ash colored earthy marlite," should be referred to the Portage group, since here it lies between well marked Hamilton beds and the Chemung. And it is likewise probable that the Lithographic limestone of Prof. Swallow will be found more closely allied to the Hamilton than to the Chemung group.

We have however in the light colored, friable sandstones of the Chemung group a well marked and reliable horizon. The oolitic bed is more allied by its fossils with the Chemung below, than with the encrinital limestones above; though between the latter there is often no well marked physical line; so gradual and imperceptible is the change from what is termed Devonian to the acknowledged Carboniferous rocks.

The encrinital limestone of Burlington, or, as we shall hereafter term it, the *Burlington limestone*, is characterized by its great numbers of crinoids, of which Drs. D. D. Owen and B. F. Shumard have described numerous species. The rock is in a great measure composed of the broken and comminuted remains of this family of fossils: large masses of the rock consist almost entirely of the separated but unbroken joints of the columns of various species.

This rock includes the "Encrinital group of Burlington," and the "Reddish brown Encrinital group of Hannibal," in Missouri of Dr. Owen's section; the latter being in no respect different from the former, and holds precisely the same position in the series, having the same beds above and below. The "Encrinital limestone" of the Missouri report is likewise identical with the Burlington limestone, and is so recognized by Prof. Swallow.

The Burlington limestone is succeeded by cherty beds with intercalated beds of light gray limestone. These have a thickness altogether of sixty to seventy-five feet, and constitute the beds of passage to the next division of the limestones. The cherty beds form the rapids above Keokuk, so well known in the navigation of the Mississippi river. These are termed by Dr. Owen the Keokuk cherty limestones. The so-called siliceous formation of Tennessee and Alabama are of the same strata.

The second important limestone is recognized in the sections both of Prof. Swallow and Dr. D. D. Owen as the "*Archimedes limestone*," from containing a bryozoan of the genus *Fenestella*, with a spiral axis,—the *Archimedes* of Lesueur.*

On descending the Mississippi river, this limestone is found at Dallas, at Appanoose, and opposite to Madison, and at Nauvoo, Ill., and is largely developed at Keokuk; the shell beds of Dr. Owen forming a subordinate member of the mass. The *Archimedes* is extremely rare in all these localities, as well as at Quincy, Ill., where the lower part of the rock is seen resting on the cherty beds which separate it from the Burlington limestone.

This limestone which may for convenience be termed the Lower Archimedes limestone or Keokuk limestone, contains numerous characteristic fossils. In the upper part the *Archimedes* occurs sparingly, with *Cyathophylla*, *Spirifer striatus*, *fish teeth*, etc. Among the crinoids are *Platycrinus Saffordii*, *Actinocrinus Humboldtii*, *Agaricocrinus tuberosus*, and others.

The Keokuk limestone is limited above by a mass of shales or marls with impure limestones, known locally as the "*Geode bed*," from the numerous geodes, lined with quartz crystals, chalcedony, calc spar, etc. which it contains, and which have been distributed very widely throughout the United States. This

* See observations upon the genus Archimedes or Fenestella, following this article.

mass constitutes the "Geodiferous beds" of Dr. Owen's section, but has not been recognized in the Missouri section.

Succeeding the geode bed, and recognized in the same localities near Warsaw, Ill., at Appanoose, and other places, is a bed of magnesian limestone, given in Dr. Owen's section under the same name.

To the magnesian bed, which has a thickness of some ten feet, and is doubtless only of local development, succeeds a series of beds of blue marlites, with intercalations of impure limestones, or in some places of impure limestones separated by seams of blue marlite. The upper portions become arenaceous, and sometimes contain small pebbles, forming the gritstone of Dr. Owen's section. The central and principal portion is highly fossiliferous, abounding in reticulated bryozoa; and among these the axis of a species of *Archimedes* occurs in great numbers and of extraordinary size and perfection. So abundant is it that a dozen individuals may sometimes be seen in the space of a few feet. The species is quite different from the one in the Keokuk beds, being more robust and the volutions of the spiral axis less rapidly ascending.

This *second* Archimedes limestone seems not to have been recognized in the section of Dr. Owen; and judging from localities cited, it appears to have been confounded with the *lower* Archimedes or Keokuk limestone. The position however of the Warsaw Archimedes limestone is above the geode bed, the *Archimedes* is a distinct species and it is associated with several species of crinoids, fish teeth, etc., which do not occur in the lower beds.

The arenaceous bed which terminates this group, and which likewise contains *Archimedes* and joints of crinoidal columns, is succeeded by a light gray, compact limestone, which is often concretionary or brecciated in its structure. Its most conspicuous fossil in many localities is *Lithostrotion floriforme.*

This limestone is termed by Dr. Owen the "concretionary limestone," and by Prof. Swallow the "St. Louis limestone."* It is the same rock which forms the low cliff below Keokuk, near the mouth of the Desmoines river at St. Francisville, Mo.; the greater part of the bluffs of the river for some distance above Alton, Ill.; the limestone of St. Louis in whole or in part; the limestone of St. Genevieve; the limestone of Prairie du Rocher, Ill.; and in part, the bluffs bordering the American Bottom, below Alton, Ill.

At this point the sections both of Dr. Owen and Prof. Swallow cease, so far as limestones are designated. The Concretion-

* After a careful examination of the locality cited by Dr. Owen, I am unable to find a second concretionary limestone, though it is not difficult to see how such an error should have occurred in measuring the section near the mouth of the Desmoines river.

ary limestone of Dr. Owen is succeeded by sandstones and shales of the coal measures, which is the true order at the mouth of the Desmoines and other places, but not universally true. In the section of Prof. Swallow, the St. Louis limestone (Concretionary limestone of Owen) is shown to be succeeded by a brown or ferruginous sandstone, F, of section of Missouri report, and upon this rests the lower coal measures. This order is likewise true of some parts of Missouri and of Illinois, but it is not everywhere true in these states.

The ferruginous sandstone is in turn succeeded by an extensive and important limestone formation, consisting of beds of limestone of greater or less thickness alternating with thin seams of marl or shale, and in some parts heavy bedded limestone of considerable thickness, without shaly partings or with very thin ones. The group embraces likewise one or more heavy sandstone beds, and a mass of green shale or marl more than fifty feet thick.

This formation constitutes the limestones of Kaskaskia and Chester, Ill., and those below St. Genevieve in Missouri. They occur at other places on the river, and form the greater part of the limestones of southern Illinois and Indiana, and those of Kentucky. This limestone is likewise known as the Archimedes limestone and sometimes as the Pentremital limestone, from the abundance of its Pentremites. It has evidently been always confounded with the lower Archimedes or Keokuk limestone, as is shown by the citation of localities in the reports above mentioned, and in other publications upon western geology.

The species of Archimedes which it contains in great numbers is quite distinct from the other two named, and the character of its axis alone is sufficient to distinguish the rock from either of the lower ones. The stratigraphical position of this rock is most clearly defined and readily determinable. The assemblage of fossils is distinct from all those in the rocks below, and there remains no reason for confounding it with either of the other divisions.

In following down the course of the Mississippi river, the St. Louis limestone is seen to pass beneath the ferruginous sandstone F, and upon the latter rests the limestone group of Kaskaskia and Chester in Illinois, and of St. Mary's in Missouri.

From these data we are prepared to show the true order of the successive beds among the Carboniferous limestones of the Mississippi valley; and also in Indiana, Kentucky, Tennessee and Alabama.

The following section illustrates the preceding statements regarding the order of superposition among the different members of the limestone series.

VII.	Coal measures.	
VI.	Kaskaskia limestone, or Upper Archimedes limestone,	Kaskaskia and Chester, Ill. St. Mary's, Missouri, etc.
V.	Gray, brown or ferruginous sandstone, overlying the limestones of Alton and St. Louis,	Below St. Genevieve, Mo. Between Prairie du Rocher and Kaskaskia, Ill.
IV.	"St. Louis limestone," or "Concretionary limestone."	St. Louis; highest beds below Keokuk. Alton; St. Genevieve.
III.	"Arenaceous bed," Warsaw or Second Archimedes limestone, "Magnesian limestone,"	Warsaw and above Alton, Ill. Keokuk, Iowa. Spergen Hill, Bloomington, Ia.
	Beds of passage, soft shaly or marly bed with geodes of quartz, chalcedony, etc.	
II.	Keokuk limestone, or Lower Archimedes limestone,	Keokuk, Quincy, Ill., etc.
	Beds of passage, cherty beds 60 to 100 feet.—Rapids above Keokuk.	
I.	Burlington limestone,	Burlington, Iowa; Quincy, Ill.; Hannibal, etc., Missouri.
	Oolitic limestone and argillaceous sandstone of the age of the Chemung group of New York.	Burlington, Iowa. Evans Falls. Hannibal, Mo.

The difficulties which have occurred in the way of a reconciliation of the views of Western geologists have arisen in great part from the fact that these different limestones have not an equal geographical distribution; there being no point on the Mississippi within our knowledge where a section at right angles to this valley will embrace all the beds here enumerated. The limestones likewise change their character when examined in a north and south direction, owing to causes which will be explained. The fossil forms which have mainly been relied upon for characterizing the divisions have been to a considerable extent of generic value only; and specific differences have not always been properly recognized.

In the geographical distribution and the changes of lithological character at different points we have yet much to learn. These groups of limestone have been successively deposited in an ocean which was gradually contracting its limits upon the north. The lowest or Burlington limestone has therefore a greater extension northward than either of the succeeding groups; and its gradually thinning edges stretch far towards Iowa city, near which latitude was the northern boundary of the ocean, or at least the limit of its animal life. Considerably to the southward of this, we first find the attenuated northern edges of the Keokuk limestone, mingled with much earthy sediment, and often consisting of a few thin beds of Encrinal limestone intercalated among other beds of an argillaceous character. It is only farther south, in the neighborhood of Nauvoo and Keokuk, that this limestone first exhibits decidedly its characteristic features. The limits of the ocean admitting of rock deposition at this period never extended so far north by many miles as in the period of the Burlington limestone.

The Warsaw Archimedes limestone appears to have been nearly coextensive with that below, so far as known at present. The St. Louis limestone extends northward also, nearly or quite to the same limit, but only in a thin brecciated or conglomeratic mass which has been rarely recognized above the lower rapids of the Mississippi. It is only on descending the valley to the neighborhood of Alton that this rock appears in any considerable force.

To these limestones succeeds the sedimentary deposit of ferruginous sandstone, which in the river valley is not known far to the north of St. Louis, while the succeeding Kaskaskia limestone becomes important in the vicinity of the Kaskaskia river, and is known in the interior as far north as Prairie de Long, and increases in force as we go southward.

We have most clearly therefore the evidence that the limits of the ocean admitting of calcareous deposits was gradually contracting, at least in the direction from north to south, leaving the more southern portions as the areas of greatest development for these limestones.

Some interesting inquiries are suggested by these facts, and at the same time they afford in some degree the solution of a difficulty which has heretofore been unexplained.

It is well known that no limestone of the age of those here described, occurs beneath the coal measures on the western side of the Appalachian coal field north of the Ohio river; nor upon the eastern side of the same field, till we reach the central part of Virginia. The same is true of the coal fields of Nova Scotia and New Brunswick according to Prof. Dawson, the northern sides exhibiting no underlying limestones, while these rocks do appear coming out from beneath the coal measures on the southeastern side. The same phenomena occur in regard to the northern portions of the Illinois and Iowa coal basins.

At the same time I have ascertained in the most satisfactory manner that the coal fields of Iowa, Missouri and Illinois, rest unconformably upon the strata beneath, whether these strata be the Carboniferous limestones, the Devonian, the Upper Silurian, or the Lower Silurian rocks. In either case the measures are unconformable, differing only in degree.

It would appear, that at a period long preceding the commencement of the carboniferous limestone deposits, the ancient ocean began to contract its area; that this contraction was due to the uplifting of the older rocks upon the north; and that this state of things continued throughout all the period of the limestone deposits. It would also appear, that during this period or at its close, and previous to the deposition of the coal measures, the older strata, becoming uplifted and at some points broken by faults, acquired in many places an inclination of from ten to thirty degrees; that denudation to some extent wore down the inequality caused by this uplifting agency, and produced other irregularities of the surface.

The coal measures extend much farther to the north than the northern limits of the Carboniferous limestones, and are spread out over the thinning and slightly inclined edges of these beds, and over the more disturbed and more highly elevated edges of the rocks of the preceding periods; so that the coal measures rest respectively upon all the formations from *lower Silurian* to the *Carboniferous limestones.* The only explanation we can offer is that the area of the ocean which had contracted up to the time of the coal period, was afterwards extended by the sinking of the land, allowing the sandstones and shales of the coal measures as well as subordinate beds of limestone, to be spread over much wider areas than the preceding formations of carboniferous limestone.

This accounts for the absence of the carboniferous limestones on the northern margins of all the coal fields.

It is true however that the carboniferous limestones of Nova Scotia have a more northerly extension than the northern limits of the Appalachian coal field; but if these limestones of Nova Scotia be of the same age as those at the southwest, their occurrence there may be due to the direction of the ancient sea margin or the line of ancient coral reefs. It appears that this direction may have been from the southwest to the northeast, at least for that portion of country east of the Cincinnati axis; while to the west of that line the carboniferous limestones make a northerly bend, as if at that period that part of the ocean now the valley of the Mississippi admitted of a greater extension of the coral reefs in that direction.

This view, sustained by facts, while it offers a general solution of the difficulty respecting the non-occurrence of carboniferous limestones on the northern margins of all the coal measures, at the same time suggests an explanation of the greater accumulation of conglomerates and coarse materials in the same position.

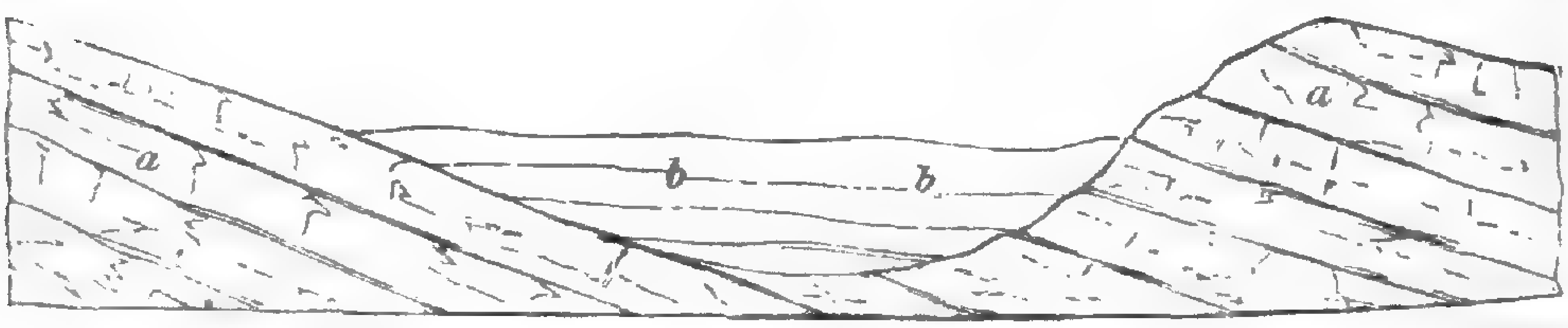
The high angle of elevation of the older strata, and the inequalities of surface on which the western coal measures rest, prove conclusively that extensive denudation had taken place previous to the coal period; and this fact should suggest a caution in our conclusions regarding the vast influence of modern denudation upon the surface of the globe.

Among the remarkable and interesting consequences of this ancient denudation, it is not uncommon to find depressions among the inclined strata of the Silurian rocks, filled with regular coal deposits, lying usually nearly horizontal or with a slight dip varying from the surrounding rock. These outcrops which sometimes occur in ravines or the valleys of water courses have all the aspect of regular coal measures; from the direction of the bedding they would penetrate the bank, but are nevertheless cut off by the inclined strata frequently within a few yards. Isolated masses of this kind are not uncommon, both in Iowa, Illinois and Missouri, lying at the foot of elevations and apparently penetrating the adjoining higher ground. These in many instances in Missouri have been worked entirely out, and proved to have no connexion whatever with the adjoining beds, or with any other coal in the vicinity.

In several localities on the Mississippi in Iowa, the older rocks dip to the northward at an angle of from ten to fifteen degrees, presenting the outcropping edges at points more or less distant from each other, while the intermediate space is occupied by strata of the coal measures, lying in a horizontal position. These phenomena have been mistaken for faults, but their origin is far different; and the coal measures have apparently never been disturbed from the time of their deposition.

Among the examples of this kind may be noticed more than one between Davenport and Le Claire. Within three miles of the latter place the strata of upper Silurian limestones dip to the northward, and between two points of outcrop, the horizontal beds of coal shales, sandstones and iron ore, occupy the space, thus:

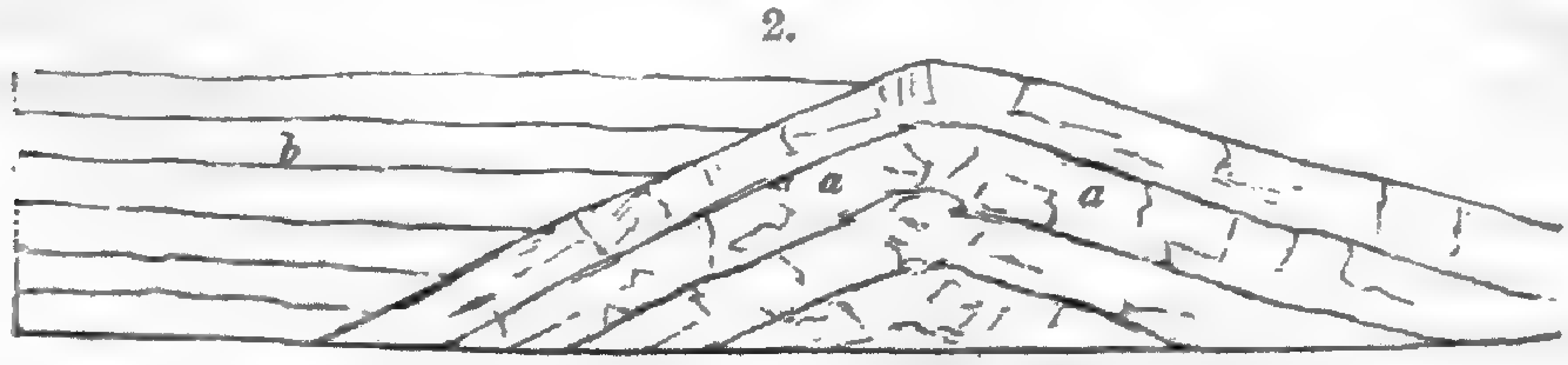
1.



a, a, outcrops of Silurian limestone as seen above the level of the river, dipping to the northeast.
b, b, coal shales and sandstones lying in a horizontal position.

In another instance the coal measures present the following relations to the underlying rocks:

2.

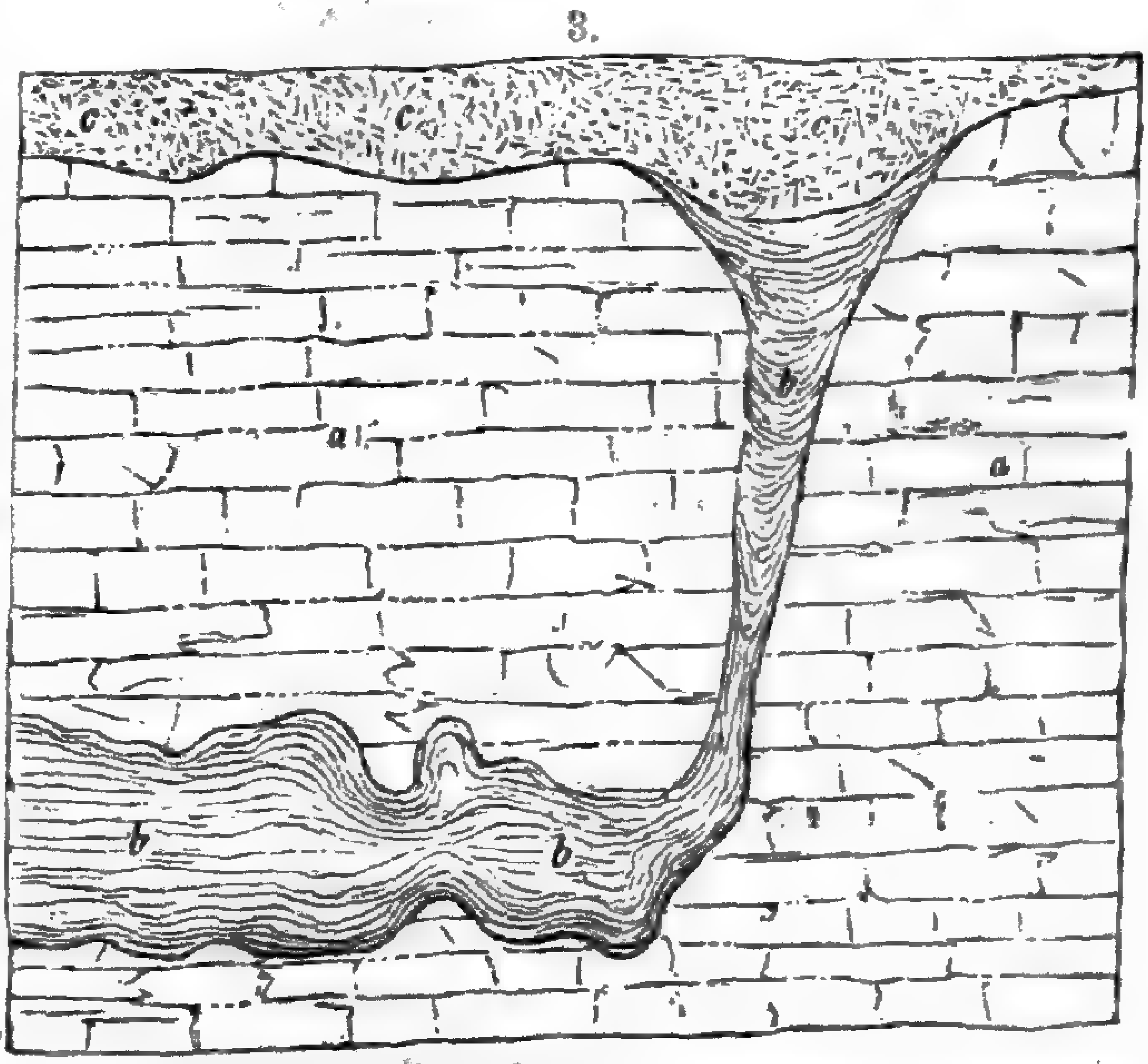


a, a, axis of Silurian limestone.
b, horizontal coal measure strata traced to within three feet of actual contact with the limestones which dip at an angle of 30°.

A still more interesting exhibition of phenomena attendant upon this condition of the strata, and consequent upon this ancient denudation, is the occurrence, in the limestones of the age of the Hamilton and Upper Helderberg groups, of rounded or irregular masses of clay, like the underclay of coal seams. These masses which are seen in sections along the river, and in quarries, often present simply the appearance of a spheroidal mass of clay, sometimes a narrow seam of clay connects this mass with a similar one in a higher bed of limestone; and it not unfrequently happens that these clay seams, which are always vertical to the bedding of the limestone, may be traced to the surface, where the clay mingles with the superincumbent materials of the drift, as if having the same origin. On examining the parts of contact between the clay and limestone, we find the former adhering closely, and when separated, the limestone still retains a striated coating of the clay. The clay is laminated, and the laminations are curved or irregular, but never parallel to the lines of bedding in the limestone.

A single instance of this character satisfied me that these masses of clay were of subsequent deposition to the limestone, and that they filled cavities which had been made by denudation like modern caverns in limestone. This example was seen in the vertical face of a quarry presenting an elevation of 30 or 40 feet. From the loose soil above is a depression at the surface of the limestone; this is the commencement of a broad funnel-shaped opening, which gradually narrows below till within 10 feet of the bottom, where it spreads out on one side; having an irregular arching roof with numerous small archings and an unequal floor. Its extension to the left had been in part cut off. This cavity from top to bottom is filled with hard clay like the underclay of coal seams. At the mouth of the funnel it is of a reddish brown hue, but soon becomes of the ordinary gray

3.



a, a, a, Limestone of Devonian age.
b, b, b, Ash colored clay, similar to the underclay of a coal seam.
c, c, c, Gravel and yellowish colored loam.

color below.* The laminations of this clay, in the upper part, conform to the curvatures and irregularities of the roof of the ancient cavern, and exhibit every appearance of having flowed in while in a semi-fluid condition; while the hydrostatic pressure of the mass above, operating through the deep funnel, had forced the soft mass against the roof, causing it to assume in its laminations the same curvatures and irregularities.

In the midst of this mass of clay, was seen the impression of a large Euomphalus, quite distinct from any fossil known in the surrounding rock, and very similar to a carboniferous form. The shell itself was not seen. With this exception, no remains of fossils were observed in the clay at this locality.

It seems impossible therefore to resist the conclusion, that subsequent to the uplifting of these rocks, the denudation of their surfaces and the wearing into caverns, the materials of the coal measures were distributed, filling these cavities, and depositing the successive members of the coal series upon the surface of these older rocks.

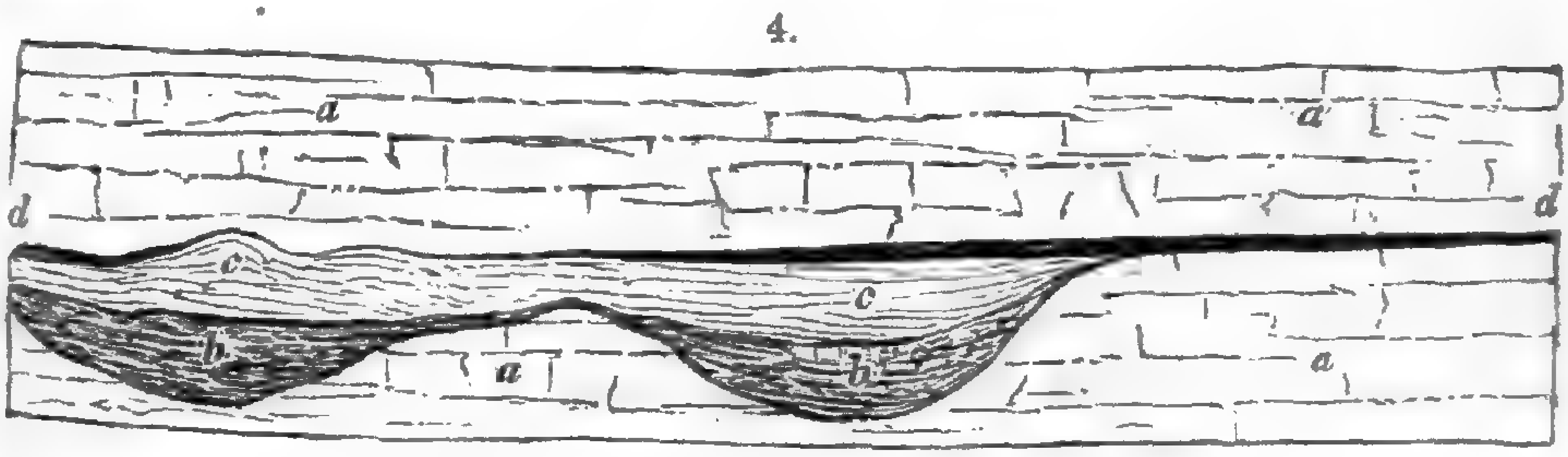
If anything were wanting to complete the chain of facts, and carry the most conclusive evidence, it is found in a section near Iowa city. In a cliff of limestone, of the age of the Upper Helderberg of New York, where the strata are nearly horizontal, we have the following phenomena.—Along the line of separation between two beds of limestone appears a black band extending for thirty or forty feet; beneath this, and of less horizontal extent, is a thicker layer of clay, precisely like that of the cavities before described, and of the character of underclay; still below this, and occupying the depth of the cavity is a coarse sandstone. This sandstone follows in its lines of lamination or bedding the curvatures of the limestone upon which it lies, gradually filling up the cavity, and extending its laminæ above. Upon this comes the underclay filling the upper and broader part of the cavity, and having a greater horizontal extent than the sandstone below. Above this underclay, stretching for several yards upon each side and filling the open seam between the layers of limestone, is a band of black carbonaceous mud, the lower part slaty, and the upper part having the character of *cannel coal.* Here we have all the phenomena attending a coal-measure seam of coal. The sandstone, the underclay, and the seam of coal resting upon the latter, and, as if to complete the analogy, the slaty portion of the seam contains *fish teeth* of carboniferous character. All this is enclosed in limestones, which, in the state of New York, where the series is more complete, lie at a depth of more than 5000 feet below the coal measures.

In this instance the explanation is clear enough. It is only a little more perfect in its members than the preceding case, and

* The reddish brown color is simply due to infiltration from the ferruginous drift above.

the aperture of admission is not visible in the same exposure. The coarse and fine sand were first transported, and falling through the fissure in the rock, continued in deposition in this cavity, while a bed of similar sandstone was being formed outside, and upon the bed of the sea. This ceased, and then came the clay which was continued in like manner, while the underclay of an exterior coal bed was in process of deposition. Lastly the carbonaceous mud derived from a coal seam, or the materials forming one, were filtered through the fissure and spread out in the narrow seam below.

4.



a, a, a, a, Limestone of Devonian age.
b, b, Coarse sandstone in curved laminæ.
c, c, Ash colored and greenish ash colored underclay.
d, d, Coal seam with shaly mud containing fish teeth.

There has been no mingling of the materials as if resulting from the breaking up of a coal seam at a later and modern period, and the subsequent filtration through a seam into this rock. Every part is as distinct as in the coal measures elsewhere; and it could only have resulted from a participation in the causes then operating to produce those extensive beds of sand, clay, shale, and coal, which make up the coal measures.

It should not be forgotten that this point is near the northeastern margin of the coal measures, and beyond the limits of any known productive coal seam; a few isolated patches of sandstone and shale being all the remaining evidences of the extension of this series in that vicinity.

The fissures and caves occupied by the lead ores in Wisconsin, Illinois, Iowa and Missouri are apparently of similar character and origin; the period of their production, being a point of discussion. Whatever may be said to the contrary, it appears still very certain that these lead-bearing fissures have no connexion with the rock below; and also that the character of the fissures, with the materials filling them, indicates an action from above. That these cavities were excavated, and subsequently filled or partially filled with the ores of lead, zinc and iron, by infiltration from above, seems, as elsewhere stated by the writer,* as well settled a problem, as that the coal seam just noticed is due to infiltration from above. The age of the rock in which the lead

* The same views, in reference to the origin of the lead ores, are entertained and have been published by Mr. J. D. Whitney.

occurs is not a question affecting the origin of the mineral matter, for while in Iowa, Wisconsin and Illinois the lead-bearing rock is an upper member of the Trenton limestone period, it is in Missouri the Calciferous sandstone, a rock much older than the Trenton period. The mode of occurrence of the ore is similar in both places.

The fact that the calciferous sandstone in Missouri is the lead-bearing rock, and that sometimes in Upper Iowa and Wisconsin the same rock contains some lead ore, has induced the belief that the origin of the ore is from below. It is true that the Calciferous sandstone is spread over large areas of country on the north of the productive lead region of Illinois, Iowa and Wisconsin; but thus far it has been found to contain no lodes of value. It is likewise less cavernous than the lead-bearing or Galena limestone, and far less so than the same rock in Missouri. From what we know, it appears that neither the Carboniferous limestone nor the coal measures ever reached so far north as the northern lead-bearing rock, while these strata occupy the country around the lead region of Missouri, and outliers of the coal measures often rest directly on the Calciferous sandstone, the lead-bearing rock of that State.

There is therefore strong presumption in favor of regarding these fissures and caverns, whether filled with mineral matter or otherwise, as having been formed during the Carboniferous period, and previous to the deposition of the coal.*

The elevating forces which have raised the pre-carboniferous strata to their present inclination throughout the west, have had a determinate direction, and this direction has been from northwest to southeast, parallel to the great mountain ranges on the west and at a nearly right angle with the great Appalachian chain on the east. So far as my opportunities permitted the determination of the direction, it is north 40° or more west.

In descending the Mississippi river we first notice that the strata rise and fall in broad undulations, which cross the direction of the valley from northwest to southeast. Still lower down we meet with more abrupt anticlinal axes, and in one of these at the Upper Rapids and below are several minor plications. Below Davenport we find considerable regularity; and between

* In making this statement, the writer would not be understood to say that similar fissures and caverns may not have been produced in these rocks during the modern or intermediate periods, through the drift and other degrading agencies, which at the same time may have removed the clay or other mineral matter from caverns of previous date, rendering the determination of the period of their origin, a matter of considerable difficulty. At the same time, the fissures filled with mineral matter, accompanied or unaccompanied by a peculiar clay quite different from the drift materials of the region, or with this clay alone, or with indurated clay like the underclay of coal seams, either with or without the presence of sandstone and coal, all point to a period long anterior to that of the modern drift.

that point and Cap au Gris we again notice only broad undulations, which reveal successively all the strata from the Carboniferous limestone to the lower Silurian rocks. In approaching Cap au Gris from the north, there is a gradual rising of the lower strata, so that the Trenton limestone is beautifully defined for a considerable distance; and beneath it lies a magnesian limestone, apparently of no great thickness. The dip to the northeast increases, and from beneath these limestones, the sandstone rises in a bold escarpment continuing for three-fourths of a mile, and presenting several hundred feet of thickness. This elevation suddenly declines to the southward, and we find the Burlington or lower Carboniferous limestone standing vertically by the side of the lower sandstone. The limestone soon assumes a steep and gradually a more gentle dip to the south, and the succeeding members come in successively. This fault, which is in fact an anticlinal axis, has a northwest and southeast direction, and, according to the observations of Mr. Worthen, extends far into Illinois.

Below St. Louis, in the vicinity of Selma, there is another decided anticlinal axis, bringing up the lower sandstone. According to the Missouri Report the lower limestones and sandstones are again brought up in the vicinity of Bailey's Landing; but I have personally examined the strata at this place only so far as to decide that the Upper Silurian strata appear from beneath the Upper Helderberg and Hamilton groups, beyond which the Carboniferous limestones appear to come on unconformably in the synclinal axis.

Still another axis of very decided character brings up the Trenton limestone in great force at Cape Girardeau on the Missouri side, and at Orchard Creek below Thebes on the Illinois side. This axis affects all the southern portion of Illinois below a line drawn from Fountain Bluff on the Mississippi to near Golconda on the Ohio. In some parts of its course this axis would appear to deviate from the meridian no more than 35° west of north and 35° east of south. In a country however, where denudation has taken place to such an extent, and succeeding strata are spread over the uplifted edges of those below, it is not always easy to determine the exact direction until traced over a wide extent.

That these low axes crossing the Mississippi are the results of the great movement which elevated the fundamental strata of the western mountain chain, we can have little doubt. The forces that there acted upon the huge pile of sedimentary strata, raising them into high mountain chains, here operated upon a thickness of a few hundred feet; and we may have not only the dying out of the elevating force, but also the diminished thickness of the strata for the subject of its action. If the action which elevated the great mountain chains of the west operated only on the palæozoic strata, the greater amount of material in that direction would give greater elevation to the ridges, which under similar force would die out in the Mississippi valley for want of material to be elevated.

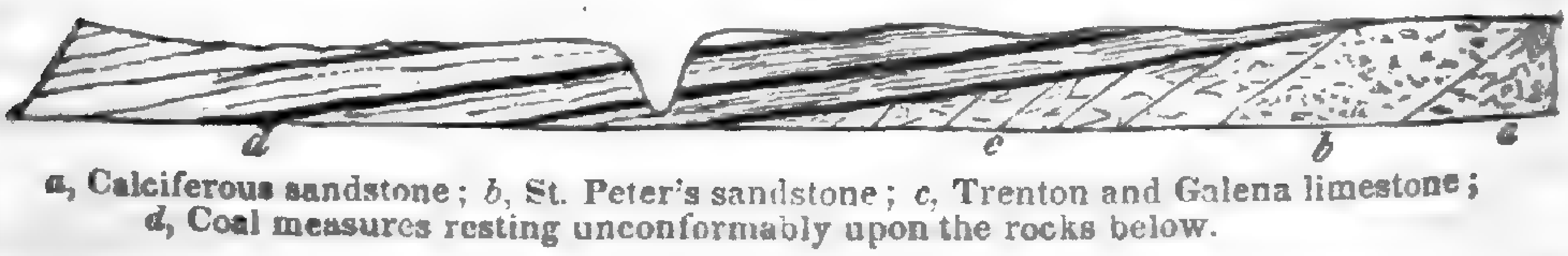
The discussion of this part of the subject however does not properly enter into the present paper, and will be postponed to another occasion.*

A few words may express the general features of the series of these limestones on the south of the Ohio. All the members, with the exception of the higher or Kaskaskia limestone, gradually thin out to the south.

The "*Siliceous group*," as it is termed in the Geological Report of Tennessee, there lies at the base of the Carboniferous limestone. This group is simply an extension of the cherty beds lying between the Burlington and Keokuk limestones, and which become largely developed in the south. The Burlington limestone is rarely seen occupying a few feet of thickness beneath the "siliceous group," and is usually not recognized as a distinct mass. The Keokuk, Warsaw, and St. Louis limestones have thinned out so far as to form no important feature in the series; while the Kaskaskia limestone predominates over the whole country, and is there the great "Carboniferous limestone," yielding its abundance of Pentremites and Crinoids throughout its extent in Tennessee and Alabama.

Note.—So far as known to the writer, the first notice of the unconformity of the western coal measures with the older rocks was brought out at the Providence meeting of the American Association for the Advancement of Science, in a discussion upon a section of the coal measures of northern Illinois, presented by Edward Daniels, Esq. This gentleman afterwards visited and re-examined the locality, and communicated to me the following section, as confirmatory of the views I had there expressed. The communication bears date of November, 1855.

5.



a, Calciferous sandstone; *b*, St. Peter's sandstone; *c*, Trenton and Galena limestone; *d*, Coal measures resting unconformably upon the rocks below.

* See Introduction to Vol. III. Palæontology of New York.

I may remark in this place that the observations made and the collections brought home by Capt. Stansbury from the Salt Lake region, demonstrated that the *upper* carboniferous limestone, in an unaltered or scarcely changed condition, and bearing numerous fossils, rests unconformably upon metamorphic rocks of older date, corresponding with what is so well shown in the Mississippi valley. The topography accompanying these observations also shows that these mountains of limestone have a nearly north and south direction, corresponding doubtless with the direction of the fundamental axes of the country.

In a "Report upon the Mineral Resources of the Illinois Central Railroad, by J. W. Foster," published in 1856, a section similar to the one above is given; and the credit of the discovery of the relative position of the two series of rocks is there attributed to Dr. Norwood, the geologist of Illinois. It is certainly probable that Dr. Norwood has been aware of this fact for a long time, and the writer, in common with many of his friends, has had occasion to regret that Dr. Norwood has not long since published some portion of the accumulated facts of many years of investigation.

Although aware for several years of this relative position of the lower rocks and the coal measures, yet I was never fully impressed with the high interest and importance of the matter, until I had carefully followed out the successive members of the Carboniferous limestone series. Disclaiming any desire to appropriate the discoveries of others, the writer has presented in the preceding paper the facts that came under his own observation, and the conclusions which seemed legitimately deducible therefrom.

I should do injustice to my own feelings were I not in this place to acknowledge the valuable aid rendered to me by Mr. A. H. Worthen, my assistant in the Iowa Geological Survey, whose intimate knowledge of the principal localities of the carboniferous limestones in the Mississippi valley enabled me to accomplish my investigations in much less time and with far more satisfaction than I should otherwise have been able to do in a single season. We explored together these formations as far as the mouth of the Ohio, after which Mr. Worthen carried on, under my direction, the observations through Tennessee and Alabama, with a view to the recognition of the groups established in the investigations in Iowa, Illinois and Missouri.

ART. XXIII.—*Remarks upon the Genus Archimedes or Fenestella from the Carboniferous Limestones of the Mississippi Valley;* by JAMES HALL.

THE term *Archimedes* has long been in use among American geologists, and is the generic name given by Lesueur to a Bryozoan, which consists of broad reticulate expansions, thickening at their base, and spirally arranged around an elongated axis or stem, or, perhaps more properly the thickened base forms the axis. The axis is solid or irregularly cellular in its interior structure, the expanded portions have the general character of *Fenestella* upon the lower or external side, while the upper or inner side is in like manner celluliferous. The cellules are cylindrical with circular or sub-circular mouths, arranged along the branches in two or more rows; the branches are rounded or angular above, connected by transverse processes, leaving oval or subquadrangular interstices.

In all the essential characters, the foliate expansions of *Archimedes*, correspond to *Fenestella*, according to the extended description of this genus given by Mr. Lonsdale, and in detached fragments it cannot generally be distinguished from other forms of the same genus. Some of the species have more than a double row of cells on the branches, and correspond to the genus Polypora of McCoy, but nevertheless this character is found in true Fenestellæ as above cited.

The mode of growth therefore, constitutes the only reliable character for separating *Archimedes* from *Fenestella*, and should this be hereafter considered of sufficient importance, I propose to retain the original name of Lesueur, "Archimedes," for fossils having this character.

Dr. D. D. Owen has several times alluded to "Archimedes" in his various reports; and in a paper published in the American Journal of Science and Arts, vol. xliii, p. 19, he gives a figure of one of the species as the "Archimedes of Lesueur," but suggests that it may be only a new species of Retepora. This figure of Dr. Owen is of a large species; but being merely the spiral axis it furnishes no character for specific identification. It retains the thickened base of the foliate expansion, and where this is broken through presents the irregularly cellular structure common to the axis of all the species.

This structural character or the remains of the fenestrules on the edge of the spire, as seen in the figure, have been mistaken by M. D'Orbigny for the animal cells, and upon this character he proposes a new genus *Archimedipora* having the cells arranged upon the salient angles of the spiral band, and places the fossil in the Devonian system. It is scarcely necessary to say that no such fossil is known in the Devonian system in this country, up to the present time.

The description of M. D'Orbigny is as follows: "cellules longues placèes aux angles saillents d'une spirale autour d'une tige allongèe."

It is quite unnecessary to say that the "*Archimedes*" of the carboniferous limestones exhibit no characters corresponding to this description, and the palæontologists of our country who are disposed to adopt the name Archimedipora will do well to compare the generic characters given by M. D'Orbigny with the fossil itself.

For descriptions of several species of this genus see proceedings of the American Association for the Advancement of Science, Meeting of 1856.

ART. XXIV.—*On the Avoidance of the Violent Portions of Cyclones; with Notices of a Typhoon at the Bonin Islands;* by JOHN RODGERS, Commander, U. S. N., and ANTON SCHÖNBORN, Assist. Astronomer. Communicated by W. C. REDFIELD.*

(Read before the American Association at Albany, August, 1856.)

U. S. Ship Vincennes.

Dear Sir,—I am a firm believer, out of my own experience, in the truth of your theory of hurricanes. I think that you have enabled me to avoid storms, into whose centers I should have been unwilling to be involved, and I feel therefore that I am under personal obligations to you for your happy meteorological discoveries. You have conferred by them a great good to the nation and to the world.

I do not know whether my notes of weather have any value in regard to the hurricane experienced by the Mississippi on Oct. 7th, 1854. On Sept. 23d preceding this typhoon we were in the China Sea in lat. 21° 44′ N., lon. 119° 17′ East. The weather was very threatening. We were standing to the southward and a black cloud was ahead of us, with vivid lightning, with a cross and violent sea, with heavy rain, and fitful squalls continually increasing in frequency and force. I considered that I saw a cyclone before us, and that we should avoid its force, by sailing away from it. We stood to the northward. The barometer soon rose and the wind moderated.

At the Bonin Islands on October 28th, 1854, we had a typhoon. The harbor of Port Lloyd is formed by the crater of an extinct volcano. The sides rise precipitately above the water to the height of some twelve hundred feet. You will easily perceive then, that the anchorage must be in a great degree protected from the violence of the wind. Yet it blew awfully. It stripped all the leaves from the trees, all vegetation was blighted, and even the sweet potatoe vines in the sheltered valleys were destroyed by it. As I could not at first believe that the wind had destroyed them, I attributed their wilting and turning black to some unseen electrical agency. I afterwards concluded that the wind had twisted and torn their sap vessels, so as to destroy their vitality.

This storm was not so marked as to give any distinct warning of its approach. The evening before the hurricane the surf broke more heavily upon the mouth of the harbor than I had ever seen it. Had we been at sea I have little doubt but that we should have known of its approach. This storm is well de-

* This communication having been kindly placed at my disposal by Commander Rodgers, by way of answer to some earlier inquiries, I deem it improper to withhold it from publication.—W. C. R.

scribed in the accompanying paper by Mr. Schönborn, assistant astronomer on board.

We had a gale on Nov. 9th, 1854, in lat. 28° 22′ N., lon. 143° 45′ E., which I thought was the edge of a typhoon. We ran on until I had satisfied myself as to its character, and then we hove the ship to on the starboard tack heading away from it. We soon raised the barometer and improved the weather. This case is also described in the accompanying paper of Mr. Schönborn.

In the steamer John Hancock, which I commanded, we were on May 20th, 1854, upon the verge of a typhoon. The weather was not violent but the seas were peculiar, rising up into sharp cones and running in every direction. They buffeted the vessel in every part, striking her upon the lee bow and weather quarter at once. I remarked to the officers on board that I felt sure we were upon the edge of a typhoon. It gave me however no uneasiness. I concluded that we were behind it and that keeping the vessel away would increase our distance from it.

We steered off once, in a fresh squall, for about fifteen minutes, and hauled up to our course again. We ran on with a fair wind. I expressed a wish to know how any vessel some one or two hundred miles to the northward and eastward of us was faring. This curiosity was satisfied by the accompanying extract from the log-book of the British ship Harkura. She was a large Indiaman, well out of water, and in appearance such a strong wholesome vessel as a seamen would select to stand heavy weather.*

Typhoons are rare in the China seas in the month of May. This is therefore not without interest.

Very respectfully, your obedient servant,

JOHN RODGERS,

Commanding U. S. Surveying Expedition.

[*Extracted from Hong Kong Gazette of June* 14*th*, 1854.]

* The ship Harkura left Hong Kong for London May 16th, 1854, and returned to port under jury masts on the 11th of June. She had fine weather till the 18th, on which day boarded the Dutch bark Johan Paul, then just escaped from pirates. On the 19th, wind fresh and steady at E. and E. N. E. On the afternoon of 20th [nautical time] moderate winds from E. N. E., the barometer falling in the evening, with lightening at the southward. Latitude at noon of that day 16° 22′ N., lon. 113° E. At 10 P. M. a heavy bank rising in the S. E. with lightening and distant thunder; close reefed the topsails and stowed mainsail, spanker and jib. At midnight barometer still falling, took in mizzen topsail and foresail, and at 2 A. M. stowed main topsail. Not much wind, but sea getting cross and high. At 5 A. M. strong winds and heavy rain, barometer fallen three-tenths since the preceding noon. Sent down all top hamper and secured all sails with extra gaskets. At 10 A. M. [Sat. 20th] gale increased to a hurricane, with a fearful cross high sea. Stowed fore topsail and topmast-staysail and brought ship on to port tack, got a sail in mizzen rigging to keep ship to the wind, then so violent that no sail could stand it. At noon (commencement of 21st, nautical time), lat. by acc. 15° N., lon. 112° 20′ E.

The afternoon commenced with a severe gale speedily increasing to a perfect hurricane, barometer fallen down to 28·50. At 2 P. M. ship lying with her lee yard-arms

U. S. Ship Vincennes, Port Lloyd,
Bonin Islands, Oct. 27th, 1854.

During the past five days the weather had been rather warm, but very fine. Light winds from S. E. were prevailing, which kept the temperature of the air even in the night above 80°, yet in the warmest hours of the day it would seldom be over 85° in the shade. This morning before sunrise light squalls from S. E. accompanied by drizzling rain interrupted for the first time the

in the water, and bar. still falling rapidly. Fearing the ship would founder, cut away fore and mizzen topmasts; but that being insufficient to right the vessel, cut away the fore topmast. The vessel then righted a little, the wind still blowing with fearful violence and increasing. The main topmast now went over the side, taking with it the head of the mainmast. Immediately after this it fell a flat calm, the barometer down to 27·70. Got the wreck of main topmast cut away from along side, as well as that of the foremast which hung to windward. At 3 P. M. the wind flew to the N. W., veering to west and southwest, blowing with tenfold violence. The lee bulwarks all gone with everything moveable about the deck, the sea up to the combings of the main hatch. The starboard side of forecastle washed out and also starboard poop cabin. At 3.45 P. M. ship righting a little, rigged two pumps and pumped her dry. At 6 P. M. the fury of the typhoon moderated and barometer commenced rising. Gale continued at S. W., veering round to south. Commenced rigging jury masts. May 22d [nautical time] lat. 15° N., lon. 112° 10′ E. At 8 P. M. [21st, true time] weather moderated. Sea going down and barometer rising. Wind south and southeast.

CAPT. CROWE'S REMARKS ON THE ABOVE TYPHOON.—The evening of Friday the 19th of May [civil time], the weather looked very threatening, but nothing gave reason for suspecting the vicinity of a typhoon. [?] The clouds had a dirty red appearance, but the quickly repeated flashes of lightening and the distant moaning of the thunder in the southeast quarter were portentous of an approaching gale. The barometer did not give early indication of what was coming, [?] only three-tenths of fall appearing up to the time of the commencement of the gale. The fall then however was very rapid, and in all of a twenty years experience (eleven in command) I never saw the mercury so low in the tube by an inch. During the lull, when we were in the vortex, the barometer, a standard one by Shepherd of London, stood at 27·50; afterwards, when we were engaged about the wreck of the masts, it was reported to me as standing at 27; in fact altogether out of sight. The wind commenced at E. N. E.; stood in that quarter 24 hours (moderate in early part), veered to N. E., whence it continued steady till we cut away the masts; then it suddenly subsided into a calm, which continued for half an hour; then, without a moment's warning, it opened out in nor'west in a most frightful tornado, so violent that words cannot express its force, and so continued for an hour, when it veered to west, and gradually afterwards to sou'west and south, with continued violence. Rain throughout very heavy. Had not the vessel been brought to on the port tack, as Horsburgh directs, when the wind shifted after the lull, the vessel must certainly have gone down stern foremost; as it was, the gust taking her over the stern, she came up to the wind and so lay in safety during the remainder of the cyclone.

[NOTE.—The interests of navigation require it to be stated, that on the evening before the disaster Capt. Crowe had, in the falling state of the barometer and the direction of the wind, sufficient evidence to show that *near by in the southeast was a typhoon, then crossing his path.* Had he wore ship at this time, or even brought to on the starboard tack, till the wind should have veered eastward and the barometer commenced rising, he would have sustained no damage. But in maintaining his course under the unchanging northeasterly wind and falling barometer, he pushed directly into the heart of the cyclone, as has too often been done by others.

Commander Rodgers was fortunate in falling behind the violent portion of this terrific cyclone, and was thus able to escape its force without changing his track. He appends the log-book records of the John Hancock, from which it appears that continued fine weather we had experienced. At noon the wind changed to the north of east, the rain ceased, it began to clear up and I could see the blue sky at times between the slowly moving cumuli. In the afternoon about 3 P. M. being on shore, I heard some peals of far off thunder, seemingly to eastward; the same had been noticed on board ship. A range of mountains obstructed the sight to N. E., E., and S. E.; in the latter direction I perceived the high white tops of heavy clouds (cum.-str.) some distance off. Occasionally rain squalls passed on both sides of us. In the evening the squalls were more frequent, it rained often and profusely; the sky became overcast and hung round with dark looking clouds, especially to S. W., where we could see the horizon. At 8 P. M. barometer 29·859; sympesometer 29·896; aneroid 29·822; temperature of air 81°·1; of water 78°·7; of rain water 75°·2. About 8 P. M. flashes of vivid lightening to E. and N. E. and peals of heavy thunder occurred, which were repeated several times until 10 P. M. at intervals, stronger or fainter.

October 28*th*, 4 A. M.—During the night the squalls came from N. E. and increased much in violence. About 4 A. M. the wind hauled to eastward and began to blow more steadily. The rain fell all night and morning very abundantly and in large drops. bar. 29°·654; symp. 29·675; an. 29·639; temp. air 80°·6; water 77°·6; rain-water 75°·7. Towards 6 A. M. the wind hauled to S. E. by E., increasing; it lessened somewhat about 8 A. M. but regained soon its former strength from E. by S. Rain now fell incessantly, but in smaller quantity. Temp. of rain-water 77°. The weather had a very dark and threatening appearance, a thick mist covered the horizon seawards, the surf broke high and violently on the reef near the entrance of the harbor and on the rocks outside.

At 9 A. M. bar. 29·471; symp. 29·465; an. 29·450; temp. air 81°·1; water 77°·7; rain-water 77°; wind S. E. by E., force 7. After 10 A. M. the wind increased continually, shifting by degrees to S. E.; the barometers and sympiesometers fell rapidly. A waterspout was observed at 11 A. M. in the mouth of the harbor moving quickly southwestward. It had nearly the height of the neighboring south bluff, behind which it disappeared. By going over the breakers, a great quantity of spray was carried away with it, whirling around the cylinder. The clouds were not de-

before 3 P. M. of May 20th the barometer fell to 29·60; in which time the wind veered by the N. W., to W. by N., its greatest force, 6; the course of the vessel about N. N. E. Lat. at noon 11° 55′ N., lon. 111° 17′ E. This corresponds to the Harkura's *nautical* date of 21st; her distance from the John Hancock then being 195 miles; the Hancock being then about 180 miles from the vortex. From 3 to 6 P. M. the barometer rose but little. Later in that day the wind was W. by S., and then variable, the bar. rising to 29·80. The 21st commenced with wind at S. S. E., which continued so till noon, in lat. 13° 51′, lon. 112° 47′. Course N. by E. After meridian the wind varied from S. S. E. to E., diminishing in force to 3.—W. C. R.]

fined except the scud, which flew swiftly at no great distance above us. Shortly before noon the weather became thicker, the surrounding hills appeared as indistinct shadows, indeed we were sometimes so entirely enveloped in mist and fog, that we could not see a ship's length around us.

Noon, bar. 29·123; symp. 28·956; an. 29·100;* temp. air 79°·8; water 77°·7; rain-water 75°·7; wind S. E. ½ E., 10. At 1·45 P. M. the wind had attained its greatest force aud blew with unabated fury until 3·30 P. M., veering in this time from S. E. by S. gradually to S. W. ½ W. There was no calm at the climax of the storm noticeable. The sympiesometer stood lowest at 2·20 P. M. (at 28·233, wind S. by W.) and the barometer and aneroid at 2·30 P. M. (at 28·443 and 28·482, wind S. ½ W.)† All three instruments remained but a few minutes at their lowest position and rose then as rapidly as they had fallen. It rained almost continually, rather lightly, but the drops fell with great violence and made me at first believe them to be mixed with hailstones, which idea however I found contradicted by examination and by the temperature of the rain-water. As the wind turned to the westward of south, there came a heavy swell through the entrance of the harbor, which increased as the wind hauled more to the west. After 3·30 P. M. the force of the wind diminished slightly.

At 5 P. M., bar. 29·169; symp. 29·060; an. 29·178; temp. air 77°·7; water 77°·7; wind W. by S. ¼ S., 10. Towards sunset the weather moderated, the clouds assumed shapes again and for a short time had a remarkably lurid appearance, the whole atmosphere, filled with vapor, seemed to be lighted up and gave to the surrounding landscape a yellowish tinge.

At 8 P. M. bar. 29·533; symp. 29·459; an. 29·529; temp. air 77°·6; water 77°·7; wind S. W. by W., 8. Fresh squalls of light rain from S. W. by S. and W. S. W. passed frequently. The form of the clouds looked loose and jagged. Now and then the sky was partially clear overhead and the stars were visible even through the thinner mist-like clouds.

* [Mr. Schönborn appends an excellent diagram showing the fall and rise of the barometer under the successive winds of this cyclone as it passed over the ship, as determined by frequent and careful observations. He adds also the curves indicating the movements of the sympiesometer and aneroid during the same period. It is a graphic exhibition of the effective action of the cyclone, and affords a fair test of the relative value of these several instruments, under the successive phases of the storm. He adds two other diagrams of like character; one of which, together with that just noticed, I have reduced for these pages, so far as relates to the barometer. I regret that they could not be reproduced entire, on this occasion.—W. C. R.]

† [The nearest approach of the axis or center was indicated by these lowest observations. As the gradual veering of the wind was in accordance with the apparent daily course of the sun, and no lull or remission having occurred at the crisis of the gale, it is evident that these observers were to the right of the axis-path, which swept around to the southward and westward of Port Lloyd. Thus at the time the barometer was lowest here, the cyclone had partially completed its recurvation and was entering upon its northeasterly course of progression.—W. C. R.]

October 29th, 4 A. M., bar. 29·748; symp. 29·652; an. 29·744 temp. air 78°; water 78°; wind W. S. W., 5. The weather has been improving much during the night.—9 A. M,, bar. 29·853; symp. 29·830; an. 29·850; temp. air 80°·8; wind light from the westward; weather very fine. Very respectfully,

ANTON SCHÖNBORN,
Assistant Astronomer.

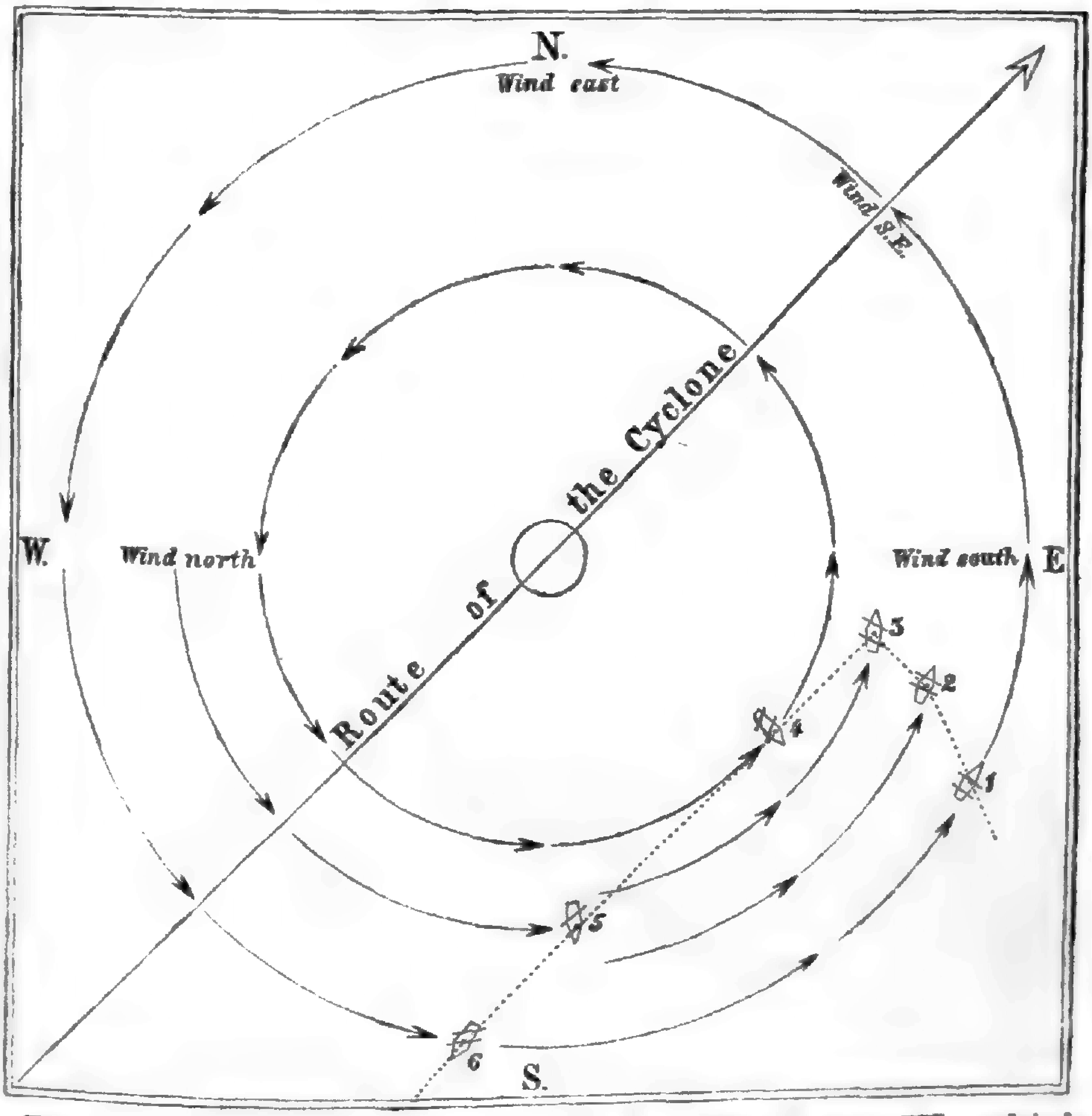
U. S. Ship Vincennes, November 9th, 1854.

During the day we had pleasant weather. A steady south wind blew all the morning, advancing us speedily on our way to the north. In the afternoon the wind freshened, hauling to S. S. W. The barometer and sympiesometer had been falling since 8 P. M. of the previous day, and stood at 3 P. M. at 29·717 and 29·710; temp. air 81°·1; water 78°·4; wind S. S. W., 7. We were then in lat. 28° 43′ N., lon. 143° 59′ E.

Towards evening when the sun neared the horizon, he glared with unusual brightness through the clouds, and the sunset was magnificent. The gilded edges of the cumuli to N. W. contrasted finely with the dark appearance of the cloud-bank which began to rise on the horizon. South and westward the upper and lower strata of clouds exhibited a great variety of colors from pale yellow to brilliant purple, and some of them, which passed swiftly overhead, were even of a greenish hue. A low compressed mist, orange colored, lay on the water to the west, serving as a line of demarkation between the calm and beautifully decorated sky above and the already troubled sea below.

As the glow of the sunset lessened, the cloud-bank to N. W. and W. N. W. began to rise, and when it became dark, flashes of vivid lightening followed each other in rapid succession, illuminating at times the whole northwestern part of the heavens. The wind veered back to S. by W. increasing considerable in force, accompanied by sudden puffs. The waves became high and irregular, owing to a cross swell from S. and N. W. A thick mist enveloped us sometimes so that only a small space overhead was clear. The barometer fell constantly. At 8 P. M. *the ship was hauled by the wind on the starboard tack, with the head to the eastward.* The barometer and sympiesometer stood lowest at 9·20 P. M. (29·548; 29·572). At this time also the wind was most vehement from S. S. W. The barometer began to rise after half past 9 o'clock. Towards midnight the weather moderated slightly. The wind blew in gusts from S. W. veering by degrees to westward and some showers of rain fell. At 4 A. M. on the 10th the force of the wind had greatly diminished, hauling to W. N. W., and the weather cleared up.

It is very probable that we were in the southeastern wing of a cyclone. From the collected facts the following diagram has been constructed. By the general appearance of the sky and the swell, which came at first from N. W. and afterwards from N. it seemed, that the storm moved to N. E. We ran at first into it, and by lying to the storm left us, passing on its way to N. E. We entered the circle at No. 1 with a course of N. N. E., which was soon after changed to N. by E.; our position on the diagram therefore became successively that of No. 2 and No. 3.



Position No. 1.—Nov. 9th, 2 P. M. Wind S. S. W.; ship's course N. N. E., which was changed at 4 P. M. to N. by E.

No. 2.—6.30 P. M.; wind S. S. W.; ship's course N. by E.; cloud-bank to N. W. (towards the center of the storm.)

No. 3.—8.20 P. M.; wind S. by W.; ship's course N. by E.; after which the ship was hove to, head eastward.

No. 4.—9.20 P. M.; wind S. S. W.; lowest barometer, strongest wind. (Nearest the center.)

No. 5.—Nov. 10th., 1 A. M.; wind westward. Weather moderating.

No. 6.—3 A. M.; wind W. N. W.

Very respectfully,

ANTON SCHÖNBORN,

Assistant Astronomer.

ART. XXV.—*On the Mode of Formation of Cannel Coal;* by J. S. NEWBERRY.

(Read at the Albany meeting, Amer. Association, Aug. 1856.)

CANNEL coals as a class, when compared with other bituminous coals, are characterized by greater homogeneity of physical structure and of chemical composition, have a more laminated fracture,—in pure specimens conchoidal across the planes of stratification,—contain more earthy and more volatile matter,—and of course less fixed carbon,—and evolve gases having a higher illuminating power. The fossils which they contain are either aquatic or exhibit marks of the action of water. No satisfactory explanation of these differences having been given by writers on the subject, I was led to seek such explanation in the phenomena presented by the numerous strata of cannel coal which are found in the Ohio portion of the Alleghany coal-field.

A series of observations on these beds of cannel, on the changes which they exhibit in going from one point of outcrop to another, their physical and chemical characters, their structure as indicative of their mode of deposition, their fossils and geological associations, has resulted in giving me the conviction that the peculiarities of cannel coals are due, principally, *to the chemical and mechanical influence of water in which they were deposited*, secondarily and locally, *to the presence of a portion of animal matter.*

The facts which have led me to these conclusions are briefly these:—

1st. Cannel coals always exhibit a tendency to assume the foliated structure of slates and shales,—a structure which they must have derived from aqueous deposition. They are frequently found shading into bituminous shale, into which they are converted, simply by accessions of earthy matter. Bituminous shale and cannel coal may, therefore, be considered as the same substance in different degrees of purity; that is, carbonaceous paste, deposited from aqueous suspension with different admixtures of earthy matter.

The carbonaceous matter in bituminous shale, as in cannel, exhibits a preponderance of volatile matter over fixed carbon, and the gases furnished by it contain a larger proportion of the more volatile hydro-carbons, and possess a higher illuminating power than those derived from ordinary bituminous coal.

2nd. The chemical composition of cannel coal—so rich in volatile ingredients—and its homogeneity, are such as would naturally follow the decomposition of vegetable matter while constantly submerged.

Plants when deprived of their vegetative life, and exposed to the action of the air, are slowly decomposed by the process of decay; a process, which, unattended by the sensible phenomena, heat and light, is however really a combustion and consists in the union of oxygen with their hydrogen to form water, with their carbon to form carbonic acid, and of their carbon and hydrogen to form carburetted hydrogen, &c.

When vegetable matter is covered with wet earth or clay, these changes are both modified and retarded, and an intermediate state, that of bituminization, is assumed by a portion of the organic matter.

Under water the changes terminating in decay go on still more slowly, and a larger portion of the vegetable tissue becomes bituminized.

The process of bituminization in such circumstances consists in the oxydation of a small portion of carbon—which escapes as carbonic acid,—of hydrogen to form water, the union of carbon and hydrogen to form carburetted hydrogen and other hydrocarbons, and the combination and removal of a portion of the alkaline carbonates, of nitrogen, &c., all of which go to make up the loss, which is relatively small. The residuary hydrogen and oxygen unite with a portion of the carbon to form bitumen, which closely resembles, physically and chemically, the resins produced by the vital functions of many plants. This bitumen unites mechanically with the uncombined or fixed carbon, the remaining alkalies and inorganic matter, to form coal.

It is evident that the more ready the access of oxygen to the carbonaceous matter during the process of bituminization, the larger proportion of the products of complete combustion will be mingled with those of this process, and the more perfectly the oxygen is excluded, the larger proportion of the more volatile (i. e. more oxydable) constituents of the wood will be retained.

Of the conservative influence of water on vegetable matter we have evidence, not only in the great durability of wood when constantly submerged, but in coal itself.

In all coal strata except where the process of volatilization is complete, as plumbago and perfectly gasless anthracites, the work of decomposition is constantly going on. To this, as to ordinary combustion, water is an extinguisher.

Coal mines are commonly opened in this country by penetrating the coal on some hill-side where it is not covered by water. In these circumstances a progressive change, both chemical and physical, is noticeable in the coal from its outcrop to the point where atmospheric influences cease to act. Near the surface it is friable, lustreless, and nearly destitute of gas, having much the appearance and character of decayed wood. As it is more deeply penetrated it becomes harder and more brilliant, and contains more volatile matter, till under water or a sufficient cover of incumbent rock, it is protected from the action of oxygen.

On the contrary, whenever the outcrop of a coal stratum is constantly covered with water, even though it have no other covering it will be found hard and bright, and containing nearly its maximum quantity of volatile ingredients.

3rd. The higher illuminating power of the gases of cannel is a natural consequence of the preservation of the more volatile constituents of wood, by its continued submersion in a hydrogenous liquid.

It is also probable that the illuminating power of cannel gas is often somewhat increased by the animal matter which it contains. I have found remains of fishes in slaty cannel, surrounded by bitumen having in a high degree the characteristics of the bitumen of cannel.

That a more resinous vegetation has given cannel this character is, I think, not probable. I have often found unchanged resins in common bituminous coal, but never in cannel.

4th. The greater relative proportion of earthy matter in cannels would be a necessary result of the submersion of the vegetable matter in a fluid having a greater specific gravity than air, and, of course, greater power for the suspension and transportation of sediment. In the few instances known where the cannel is of equal purity with bituminous coal, we may I think discover evidences that the vegetable matter has been deposited in confined bodies of quiet water, entirely without currents, or, at least, receiving little or no surface drainage.

5th. The fossils contained in cannel coal are among the most significant indications of its aquatic origin.

Fishes are found in cannel in abundance, scales, teeth, spines, coprolites, and entire individuals being, in some localities, so profusely scattered through its substance as to prove conclusively that they must have lived and died in great numbers in waters, at the bottom of which comminuted vegetable matter was accumulating as a carbonaceous paste, with which their remains have mingled, and the whole, consolidated, has become a stratum of cannel.

I have before me as I write, pieces of beautiful cannel from England, in which are impacted teeth of *Megalichthys*, scales of *Paleoniscus*, and many other forms of aquatic life. And in Ohio I have found fishes in large numbers in a thin stratum of cannel underlying a thick seam of bituminous coal; which last contains none.

Shells too are not unfrequently found imbedded in the middle of a stratum of cannel.

The vegetable remains which I have observed in cannel are *Stigmariae*,—roots and rootlets of trees which grew in the coal-marshes,—generally occurring in detached fragments—shapeless portions of the trunks of *Lepidodendra* with their markings nearly obliterated, *Lepidostrobi* reduced to their woody skeletons, fern fronds of which nothing but rachis and veins remain, all evidently macerated till only their most resistant tissues are left.

Strata of ordinary bituminous coal usually consist of thin layers of brilliant bitumen alternating with others of bituminous shale or cannel. This arrangement I consider due to the variable quantity of water saturating and overflowing the coal marshes: the cannel layers having been deposited during the prevalence of high water.

ART. XXVI.—*Abstract of a Meteorological Journal kept at Marietta, Ohio, for the year* 1856—Lat. 39°·25 N., Long. 4°·28 W.; by S. P. HILDRETH.

MONTHS.	THERMOMETER. Mean temperature.	Maximum.	Minimum.	Fair days.	Cloudy days.	Inches of rain and melted snow.	Winds.	BAROMETER. Maximum.	Minimum.	Range.
January,	17·87	45	−13	15	16	2·75	W. N. W. & S. W.	29·90	28·90	1·00
February,	25·50	50	−15	14	15	1·66	W., N. & S. W.	29·70	28·60	1·10
March,	32·13	57	−10	16	15	1·34	W. N. W. & N.	29·70	28·75	·95
April,	54·33	85	19	23	7	2·25	W., S. S. W. & E.	29·70	29·00	·70
May,	61·20	90	38	16	15	4·16	N., S. & S. W.	29·60	29·03	·57
June,	72·44	95	46	22	8	5·25	W., S. E. & S.	29·55	29·20	·35
July,	75·53	100	52	30	1	2·50	S. W. & S.	29·65	29·12	·53
August,	73·43	93	46	21	10	2·75	W., N. W. & S. W.	29·55	29 00	·55
September,	64·77	95	35	20	10	1·17	S., S. W. & S.	29·60	29·10	·50
October,	53·76	87	28	18	13	2·42	S., S. W., & E. S. E.	29·75	29·20	·55
November,	41·41	70	16	17	13	4·00	S. W., W., & E.	29·70	28·65	1·05
December,	29·23	54	0	16	15	2·21	N., N. W., & S. W.	29·80	28·96	·92
Mean,	50·13			228	138	32·46				

THE year which has just closed has been marked by some peculiarities, different from common years; the most prominent of which, were the excessive cold of the winter, and extreme heat of the summer—also the drouth of the spring months and hottest portion of the season; the failure of some of the crops, and unusual exemption from disease, in all portions of the valley of the Ohio.

Remarks on the seasons.—Winter.—The cold in January was longer continued than in any preceding year, reducing the mean temperature of the month to 17°·87, the lowest mean temperature of any winter month in the last forty years, the minimum being a little below 21°. On several mornings the mercury was at twelve and thirteen degrees below zero, and on seven mornings at and below that point. The extreme of cold was not so great as in January, 1852, when it was −23°, on one morning only and the mean for the month was 24°·36; on the 9th and 11th of this month in 1856, at 4 o'clock, A. M. the temperature was −21°, as observed by a gentleman who lives four miles above Marietta, near the Muskingum river. Eighteen miles above, it stood at −25°, as observed by Dr. Bowen of Waterford, at the same hour—my period for observing being 6 o'clock or about sunrise. The greatest degree of cold noted by myself during the winter was in February, when it was at −15° the fifth day of the month. This season was also one to be remembered, for the great amount of snow, there falling during this period four feet and six inches at thirty-two different times. The greatest quantity at a single fall was thirteen inches, but by additions accumulated to about twenty-four inches, especially in the forests. Twenty-five miles north of Marietta it was several inches deeper, and near Pittsburgh was said to be three feet. By the aid of light rains and occasional slight thaws, the snow became consolidated, and nearly as heavy as ice. It did not melt much until early in March, and in the forests and on the north hill sides, was from twelve to eighteen inches deep until after the 20th of the month. The ice in the Ohio and Muskingum rivers was from twelve to twenty inches thick, having been constantly increasing since the first of January, when the rivers were frozen over. Boats ceased to run on the 30th of December, and did not resume navigation till the 3d or 4th of March, when the ice gradually gave way without much of a rise in the head waters, beginning from below and working gradually up stream, contrary to the usual course, without much damage to boats. From the unusual quantity of snow, it was expected a great flood, like that of 1832, would attend the breaking up of the rivers, but the snow was so much consolidated that it melted very slowly and thus happily disappointed the fears of the inhabitants along the borders of the rivers. The mean temperature of the winter months of 1855–56, was 25°·67, which is the lowest on record—that of 1846 being 29°·91—but usually our winters range from 32° to 36°.

Spring months.—The mean temperature for spring is 49°·22, which is more than two degrees below that of the year 1855, and four below that of 1854, which is mainly attributable to the low grade of the month of March, being in 1854, 47°·55; and in 1856, 32°·13; a difference of more than fifteen degrees, occasioned by the great amount of snow on the ground until near the close of the month. The blossoming of fruit trees was much retarded; the peach, where the fruit buds escaped the deadly effects of the winter, not opening until the 22d of April, and the pear and cherry on the 29th, twenty days later than the ordinary period. The season was uncommonly backward—much trouble was experienced by our farmers in the germination of seeds, especially of Indian corn, in many fields requiring two or three plantings;

the grain rotting in the ground, probably the effect of the last winter's cold acting on the vitality of the imperfectly ripened grain. Frosts as late as the middle of the month also retarded its growth, so that until the first of June the prospect of a poor crop of corn was very apparent; the dry weather which set in with the heat, completed these fears, and the result was a very light yield of this important bread stuff. The amount of rain for the spring months is $7\frac{75}{100}$ inches. In 1854 it was nearly twelve inches.

Summer months.—The mean of the summer temperature was 73°·80, which is somewhat higher than in 1854, the latter being 73°·55, the extreme heat in 1856 being greater than in 1854 by two degrees, rising on the 17th of July to 100°, while the highest in the hot summer of that year was 98°. The nights were cooler than in 1854, generally of a temperature not uncomfortable to the sleeper. The quantity of rain during the summer was $10\frac{50}{100}$ inches. In 1854 it was $9\frac{36}{100}$ inches, a difference of a little more than an inch. Nevertheless the smaller amount in the spring, nearly five inches, caused earlier and greater suffering of the crops, than in 1854, especially in corn, hay and potatoes, which were very light. The good results of deep and thorough tillage were fully seen this year, as in the former one—the mellow condition of the soil to the depth of ten or twelve inches affording a satisfactory return, when four or five inches was a complete failure. Should these dry seasons continue to recur as a permanent condition of our climate, the only remedy will be irrigation or very deep plowing. From the broken and hilly condition of southern Ohio, it is probable that irrigation can but partially remedy the evil, while deep tillage is within the control of every cultivator. The crop of wheat was good, as its growth was chiefly attained in the cooler and more moist season of the year. The yield of apples was light, and those much injured by the Curculio and other insects. Peaches, an entire failure, being killed in the bud by the winter; grapes, quite light, many vines being entirely, or partially killed. The fruit was of excellent quality, full of sacharine juice, perfected by the great heat of the summer. Sweet potatoes, now an important portion of good living, were greatly lessened in amount by the drouth, but were of good size and perfect in all respects as an article of food. Melons were abundant and in perfection, the hot and dry weather agreeing better with their nature and habit, than any other production. Many of the pear buds were killed by the cold of winter, and crop light, but of good quality. In Iowa and northern portions of Illinois, all the pear trees and a great many apple trees were seriously injured or killed. Peach trees fared still worse, being of a more delicate nature. Plum trees and cherry trees were nearly all destroyed, indicating a gloomy future to the fruit grower, as what has once happened may again be expected.

The mean temperature of autumn was 53°·31, over three degrees less than in 1854, and in 1855. The early frosts in September, did considerable harm to the unripened corn, as it was nearly a month later than usual from the necessity of repeated plantings; from the combined effects of drouth and frost, the crop of corn was unusually light and poor in quality. The price ordinarily twenty-five cents was increased to fifty or sixty cents. Potatoes were much lessened in amount, but fine in quality, selling from one dollar, to a dollar and a quarter a bushel. The amount of rain in autumn was $7\frac{50}{100}$ inches, against 13 inches in 1855, and 9 inches in 1854. From the low stage of water, it was the 5th of December before the smaller class of steamboats could run on the Ohio, a fall of rain on the 28th November of $2\frac{80}{100}$ inches, caused a rise of three or four feet and finally to six feet, enabling the flat boats to take off the productions of agriculture, coal, salt, and the great amount of manufactured articles which had accumulated in the last few months. The Ohio was clear of ice until the middle of December, and closed on the 18th, it was frozen over at several points by the 23d, the temperature on this morning falling to zero. On the 22nd, snow fell to the depth of two inches, with light showers on the following days. The ice, in still water, by the 25th had thickened to six or seven inches, and the dealers in that article were filling their houses for summer use.

The mean temperature of the year is 50°·13, which is lower than known before since 1836; then it was 50°·02. The amount of rain and melted snow is $32\frac{46}{100}$ inches, being ten inches below the mean average for this place, and one below any former year—1839 being $33\frac{32}{100}$ inches.

Injurious effects of the winter on plants.—The blossom buds of the Magnolia conspicua and purpurea were killed, as well as much of the wood of the latter. Pyrus Japonica, nearly all the buds but not so much of the wood as in 1852. Forsythia viridissima, the flower buds but not the wood. Weigelia rosea, and Spirea Prunifolia, from the same region of China, were uninjured, thus establishing their hardihood, and adaptation to this climate. The tree peony, although protected as usual with matting, was much damaged, nearly every bud being killed and much of the wood to the ground. Chinese Lonicera or evergreen honeysuckle, killed to the roots. Tree box, in exposed positions killed, much of the tops, and the dwarf box mostly destroyed root and branch, even where covered with snow. English yew tree, killed much of the foliage and some of the branches. Paulonia imperialis, greatly damaged, and large branches entirely killed; the Catalpa, although of the same family not injured. The American Holly of the Southern States much injured. Chinese Aborvitæ, damaged. Peach buds destroyed; and many old trees killed. A portion of the apple trees injured, killing the bark in the forks of the branches, so long in contact with the frozen snow. It was the hardest winter ever known in Ohio.

Floral Calendar.—March 6th, Robin heard singing this morning; 29th, Yellow Crocus in bloom, later than usual.—April 2nd, Blackbird appears, White Crocus in bloom; 3d, Crown Imperial, 6 inches high; 9th, Hepatica triloba opening its petals; 12th, Early Hyacinth; 15th, Hepatica in full bloom; 16th, Sanguinaria Canadensis; 17th, Forsythia viridissima, near the ground where protected by the snow; 18th, Crown Imperial; 19th, Daffodill, Pyrus Japonica, a few blooms, mostly killed by the winter; 23d, Peach in blossom, where protected by buildings, generally killed; 26th, Cherry and Spirea Prunifolia; 28th, Pear tree, such buds as escaped; 26th, Red Cherry. May 1st, Apple tree in bloom, Circis Canadensis or red bud; 2nd, Papau, Tulip opening; 5th, Tulip in full bloom; 8th, Horse-chesnut, European species; 10th, Quince tree; 11th, Apple tree shedding its blossoms; 12th, Ranunculus, single flowered tree peony, more hardy than the double yellow mocasin, or Calceolaria; 15th, Lily of the valley; 16th, Haw tree; 18th, white mocasin; 19th, Locust tree; 20th, Magnolia tripetala; 22nd, Purple peony; 23d, Weigelia rosea and Blackberry; 25th, white herbaceous peony; 28th, fragrant Syringa; 29th, fragrant peony; 30th, frost this morning, killing melon plants, &c. June 2nd, Peonia Whitleji; 3d, Strawberry ripe; 5th, Kalmia latifolia; 6th, Syringa Philad.; 20th, Pomegranite, Red cherry ripe; 24th, Catalpa in bloom; 28th, Red Raspberry ripe.

Uncommon Insects.—Early in the month of May there appeared on the white oak trees on the hills near Marietta, and in the neighboring towns, vast numbers of worms; when fully grown they were about an inch and a quarter in length, and an eighth of an inch in thickness, cuticle smooth, color of india ink, tinged with blue, two black lines extended the length of the back; the sides marked with pale green, lozenge-shaped figures, head black; fourteen feet, six on a side, the two anal ones standing out like the tail of a swallow. They were exceedingly active in their movements, and great devourers, destroying all the leaves on a large white oak tree in a few days, so effectually that many of the extreme branches perished in the course of the summer. They were so numerous on young trees, as in one instance to bend the top, six feet high, to the ground. They had completed their course by the 10th or 15th of June, when they were inclined to come down to the earth, they descended by the aid of a silken thread, spun for that purpose. They made no webs or nests like ordinary caterpillars. In many respects they resemble the canker-worm of New England, "Phalæna vernata." Their favorite tree was the white oak, but where adjacent to the forests, they visited and devoured the leaves of the apple tree, and also the young shoots of Indian corn. Before apple trees were planted in America, it is probable the oak and elm were their natural food. This worm has not been noticed before here, at least in such multitudes; it was new to all our old farmers, and should it prove to be the real canker-worm it will be a serious pest and evil to the orchards in this part of Ohio. I had a number collected when full grown and tried to feed and make them hybernate in a flower pot filled with moist earth, but they all perished before entering the ground. Had this succeeded, a more perfect history of the insect could be given, with drawings of both the male and female moth. All I accomplished was the preservation of several of the larves in alcohol.

ART. XXVII.—*On some Soluble Basic Salts of Tin;* by JOHN M. ORDWAY of the Roxbury Laboratory, Mass.

SOME years ago a singular liquid came to my notice, in the course of my business, under the strange sounding but appropriate name of nitrate of tin; and while seeking to determine its nature, some things were observed that are unexplained in systematic treatises on chemistry. But some properties since shown to belong to the salts of alumina have been found, by further experiments, to be possessed also by certain combinations of tin.

It is well known that when we attempt to dissolve tin directly in pure nitric acid, the metal is simply changed to insoluble stannic acid, nitric oxyd being given off. To be sure, if feathered tin is put into very weak nitric acid, say of specific gravity 1·15, a small quantity is quietly taken up, but in a short time it is thrown down again as a white powder containing no nitric acid. If however a very little chlorhydrate of ammonia is first added to the dilute acid, the reaction is different; nitrous oxyd is given off and the metal remains permanently in solution. A small proportion of chlorhydric acid answers the same purpose as the ammonia salt, since the first portions of tin added, deoxydize a portion of nitric acid and ammonia is formed, according to a well known reaction. Indeed as circumstances vary, we may have the formation of ammonia, the evolution of nitrous oxyd, or the disengagement of nitric oxyd; and often all three phenomena occur in the same experiment.*

* The same, as is well known, is partially true of some other metals. Thus I have observed in making nitrate of lead in the large way, that nitric acid of sp. gr. 1·14 dissolves lead rapidly, giving off protoxyd of nitrogen almost pure, while a stronger acid acts more slowly and nitric oxyd is evolved.

It is not easy to determine whether the presence of ammonia is essential to prevent the formation of stannic acid, for we cannot keep it out. We might infer that nitrate of ammonia would answer instead of the muriate, but such I have not found to be the case. It seems more probable that the chlorhydric acid is what exerts the needed influence.

The nitrate of tin before mentioned, was made by dissolving one equivalent of sal-ammoniac in nine of nitric acid of specific gravity 1·16 and dropping in gradually six equivalents of tin. It can be made right only in cool weather. It is a brown liquid which behaves with most reagents like the proto-salts of tin, and but for its color we might take it to be merely a protonitrate. But by operating with a stronger nitric acid mixed with a large proportion of muriatic acid, we may push the matter a great deal farther and get entirely beyond the reach of such a supposition.

In repeating former trials, experiments have recently been made with nitric acid of specific gravity 1·39, and muriatic acid of specific gravity 1·16, mixed in various proportions. In one case equal parts of each acid took up tin enough to make a liquid of specific gravity 2·24, having about the color and consistence of molasses. Analysis showed this solution to contain about 24 equivalents of tin to 3 equivalents of nitric acid, 6 equivalents of chlorhydric acid, and 2 equivalents of chlorhydrate of ammonia.

Here we have eight equivalents of tin retained in solution by three of acid.

Another sample made with four parts of nitric acid to three of muriatic acid, had the specific gravity 2·443 and had four equivalents of tin to one of acid.

These highly basic combinations keep well except in the hottest summer weather. They unite with water in all proportions without change. Weak acids produce no alteration of the color. The alkaline carbonates in excess, precipitate a yellow oxyd of tin, leaving the liquid colorless. Such nitromuriates show no tendency to crystallize, but by spontaneous evaporation dry down to a tough, shiny, translucent mass, which readily dissolves again in water. In fact they very much resemble the basic nitrates of iron mentioned in a former volume of this Journal.* And in making the tin solutions, as in adding iron to nitric acid, the reddish color begins to appear when the compounds begin to become basic. Reagents show that the tin exists in neither the highest nor the lowest degree of oxydation. The protochlorid of tin cannot be made in the slightest degree basic without precipitation; and the same seems to be true of all

* Vol. ix, [2], p. 30.

protosalts. To be sure, strong chlorid of zinc, as we often see in making large quantities, on being tested with metallic zinc, oxydizes and dissolves an excess of the metal, and the solution remains perfect after cooling, but dilution causes an immediate precipitation of oxychlorid. The basic nitrates and acetates of lead are, on the other hand, but slightly soluble in cold water. While the basic sesquisalts are uncrystallizable and miscible with water in all proportions.

It was therefore natural to suppose that in the tin salts in question, the tin must be in the form of sesquioxyd; and farther that the production of such combinations would settle a hitherto mooted point, by showing that there is a salifiable sesquioxyd of tin as truly as a sesquioxyd of iron.

And now to determine whether any fallacious appearances could originate from the nitric acid or the ammonia present, another mode of formation was resorted to. Twelve equivalents of protochlorid of tin,—the "tin crystals" of commerce,—were dissolved in their own weight of warm water, and one equivalent of crystallized chlorate of potash was added by degrees, as fast as the violent reaction would allow. The result was a clear, high-colored liquid containing of course no foreign matter except a very little chlorid of potassium. By adding a solution of nitrate of lead, a red nitrate of tin was formed. Carbonate of lead added to such a nitrate or to the muriate, removed nearly half the acid without any precipitation of tin.

In this way then permanent solutions may be made containing about three equivalents of tin for two of acid, but for some reason they cannot be made more basic without gelatinizing; perhaps because of the great degree of dilution necessary to enable the neutralization of the acid to go on, for it appeared in the direct way of making, that a mixture of weaker acids, would dissolve much less tin.

But the chlorate of potash process proved too much, since it was found that when one equivalent of the chlorate acted on six equivalents of the protochlorid, the tin was completely oxydized making a clear and almost colorless liquid. So the permuriate of tin may be basic and yet soluble. And it further appeared on adding carbonate of baryta or carbonate of lead, that two thirds of the acid might be abstracted without gelatinization. Three equivalents of bibasic permuriate would bear the addition of two equivalents of alkali, and if three equivalents of protochlorid of tin were also present it would bear no more, and therefore the basic sesquinitrate might be looked upon as a mixture of protonitrate and basic pernitrate.

Various other experiments have established the hitherto unnoticed fact that *the soluble salts of binoxyd of tin may be made* *highly basic and yet remain soluble,** a fact of some practical importance, and one which seems likely, in connection with others already observed, to lead to the more comprehensive generalization that the soluble salts of the peroxyds, remain soluble when the larger part of the acid is abstracted.

As for the existence of true salts of the sesquioxyd of tin, there appears to be as yet no other evidence but such as may be drawn from color. The fact that the sesquioxyd dissolves in ammonia, while the protoxyd does not, of itself proves nothing, for why might not stannic acid render protoxyd of tin soluble in ammonia, just as arsenic acid does the sesquioxyd of iron? But the hydrated protoxyd and peroxyd of tin and their ordinary salts, as well as the stannates, are colorless, while intermediate substances may be formed that are colored. This becomes strikingly apparent if we make a basic permuriate of tin by oxydizing neutral protochlorid of tin with chlorate of potash or nitric acid, and then drop into the colorless or slightly yellow solution a few crystals of protochlorid of tin which will presently strike a red color. This red solution gives a reddish precipitate with alkaline carbonates, thus showing that Fuchs's sesquioxyd of tin may not be colored by iron, as is generally supposed. A mixture of two colorless oxyds, could not be yellow, and it would be strange if a stannate of a white protoxyd were not white. Frémy's metastannate of protoxyd of tin, made by digesting metastannic acid in neutral protochlorid, is indeed yellow; but is it certain that SnO, Sn_5O_{10} represents the true composition? At any rate, I find that this product, gives with weak chlorhydric acid a greenish brown solution which darkens somewhat on exposure to sunlight,—a singular action for a true salt composed of colorless constituents.

A brown hue is sometimes developed on dissolving in hot water the residue obtained by boiling tin in strong sulphuric acid. Again crystallized protochlorid of tin when kept for a long time in loosely stoppered bottles, is apt to turn yellow, especially on the side next the light.

Color appears to arise then during the deoxydation of peroxyd or of basic persalts, or the oxydation of the protosalts. So unless it can be shown that the olive and the red forms of the protoxyd may enter into combination retaining their respective colors, we seem forced to admit the existence of one or more intermediate oxyds of tin.

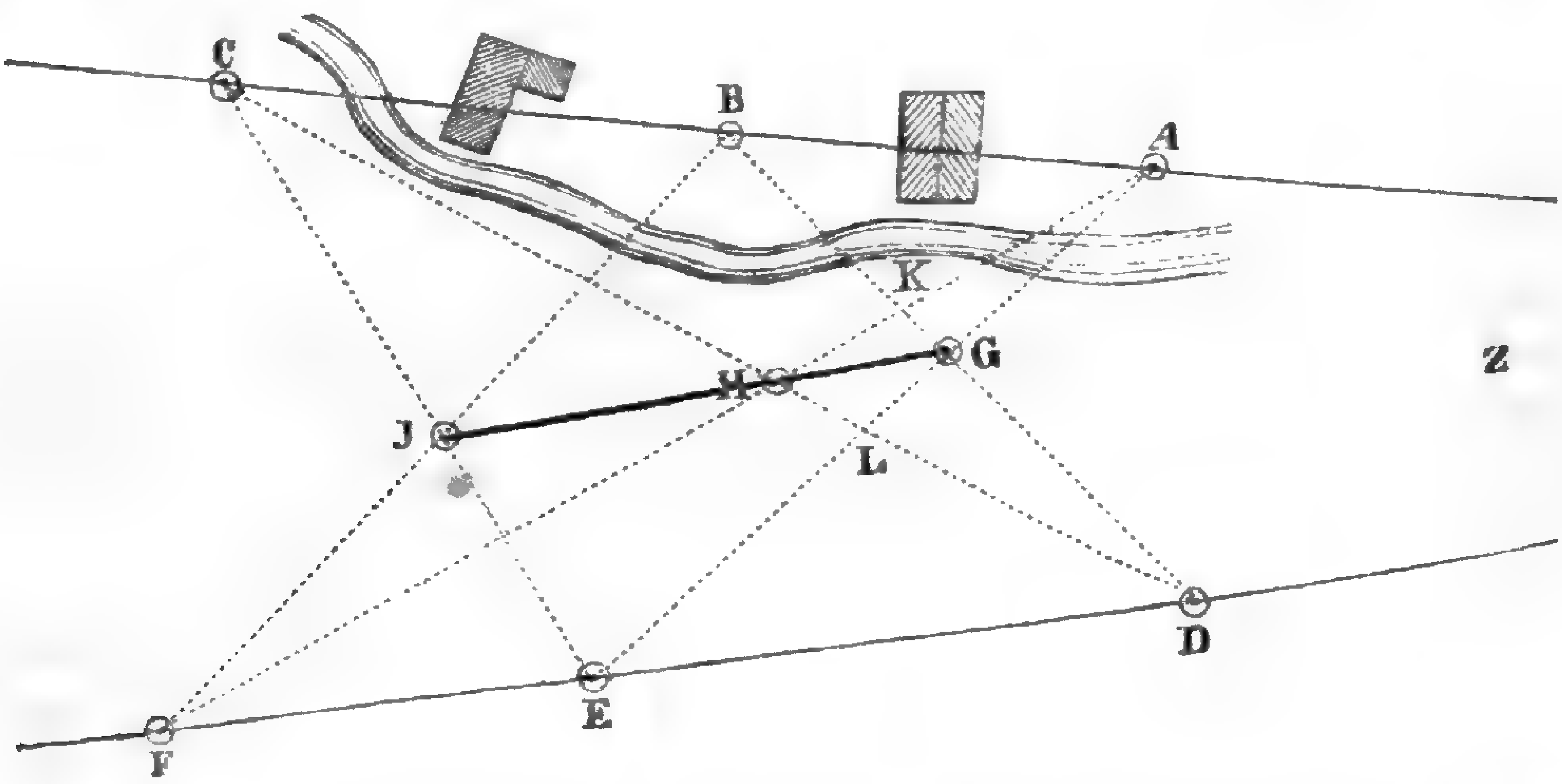
Roxbury, Mass., January 10th, 1857.

* Gmelin misled by theoretical reasoning, says, "If a normal stannous salt is to be converted into a normal stannic salt by the action of air or nitric acid, it must first be mixed with a quantity of acid equal to that which it already contains; in default of the requisite quantity of acid, a precipitate is formed during the oxydation, consisting either of the hydrated stannic oxyd or a basic salt."—*Handbook*, Cav. Soc's. Ed., v., p. 75.

Now as far as oxydation by nitric acid is concerned, this statement has been found at variance with actual results.

ART. XXVIII.—*A Problem in Practical Surveying: demonstrated by means of Transversals;* by W. M. GILLESPIE, Prof. of Civil Engineering in Union College.

LET A and B represent two points, inaccessible, and invisible from one another. Let it be required to find a third point, C, in the line of A and B, but invisible from them. It is supposed that no means of measuring either distances or angles are at hand.



The problem may be solved thus. Set three stakes, D, E, F, in a straight line. Set a stake, G, in the line of DB and EA; set a stake, H, in the line of FA; and a stake, J, in the line of FB, and at the same time in the line of GH. Then range out the lines DA and EJ, which will meet in a point, C, which will be the one required. Any number of such may be similarly obtained to verify the work.

This problem is given in a recent number of the Vienna Engineer's Journal (*Zeitschrift des Oesterreichischen Ingenieur Verein,* 1856, p. 245) by an Austrian mathematician, who represents it as employed by practical surveyors, but as not having any known geometrical proof. He proceeds to give an analytical investigation of it, saying, "I have in vain tried to prove the problem in the synthetic way, by pure geometry." The "Theory of Transversals," however, the foundation of the "Recent Geometry," or "Geometry of Segments," (too little cultivated beyond a small circle of French geometers) will furnish a simple and perfect demonstration, as follows.

The theorem to be proved is equivalent to the assertion that if A, B, C, and D, E, F, lie respectively in two straight lines, and lines be drawn as in the figure, then will the intersections G, H, J lie in one and the same straight line.

Conceive the two given lines produced to meet in Z, beyond the limits of this figure. The triangle BFZ is so cut by the transversal CE as to give the equality

$$BJ \times FE \times ZC = JF \times EZ \times BC.^*$$

The triangle AFZ, cut by CD, gives $FH \times AC \times DZ = HA \times CZ \times FD.^*$

The triangle ABG, cut by CD, gives $BC \times AL \times GD = BD \times CA \times GL.^*$

The triangle DEG, cut by CZ, gives $GA \times EZ \times BD = EA \times DZ \times BG.^*$

The triangle DEG, cut by AF, gives $GK \times DF \times AE = KD \times EF \times AG.^*$

The triangle AGK, cut by HD, gives $KD \times GL \times AH = GD \times AL \times KH.^*$

Multiplying together the corresponding members of these six equations, we get a new one containing eighteen factors on each side. Of these, fifteen factors in each member can be cancelled, and we have left $BJ \times FH \times GK = JF \times BG \times KH$. This shews,† that the points G, H, J, lie in a straight line, which is a transversal to the triangle BFK.

What Poinsot said, forty years ago, that "The simple and fruitful principles of this ingenious theory of transversals deserved well to be admitted into the number of the elements of geometry," is even more true and desirable at the present time.

ART. XXIX.—*Biography of Johann Nepomuk von Fuchs;* by FRANZ VON KOBELL.

[Concluded from p. 101.]

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IN 1829 Fuchs published a paper on Lime and Mortar. Some years later this was followed by his essay "On the Properties and Composition of Hydraulic Cement," which received a prize from the Academy of Sciences at Harlem.

Notwithstanding the chemical relations of lime and its carbonate had been already, as it might appear, thoroughly studied, Fuchs occupied himself anew with the processes of burning and slaking lime, and investigated the so-called half-burning and dead-burning. He thus discovered the basic carbonate of lime, and the compound of hydrate with carbonate. He discussed the properties of soluble and insoluble silica, ascribing their differences to difference of coherence, and studied the reactions of lime on silica and on the silicates in the wet way, as chiefly underlying the theory of the solidification of mortar. He con-

* By the theorem "If a straight line be drawn so as to cut any two sides of a triangle and the third side, one or all being prolonged, thus dividing them into six segments (the prolonged sides and the prolongations being taken as segments) then will the product of any three of those segments whose extremities are not contiguous, be equal to the product of the other three segments."

† By the converse of the preceding theorem.

vinced himself by numerous experiments that lime is capable of uniting in the wet way with silica and its compounds, even with such as already contain lime. The completest proof of this he found in the facts that certain insoluble silicates, and silica itself "in a certain degree of coherence," gelatinize with acids after they have been mixed for some time with lime in a moist state, and that these mixtures also increase more and more in hardness and solidity. These instructive experiments were instituted on quartz, opal, artificially prepared silica, and its gelatinous hydrate, feldspar, porcelain earth, clay, garnet, prehnite, analcime, apophyllite, &c. He confirmed the result which he had obtained twelve years before, that by this treatment a part of the alkali which may be present in silicates is set free, and he expressed the idea that this reaction might some day be employed for the preparation of potash and soda. After Fuchs had further examined common and hydraulic mortar, and the so-called cements, he recognized all the conditions which are demanded in the production of hydraulic mortar, and showed that it could be prepared from most marls, and taught how they could be tested as to their value for such a purpose. He drew attention to various marls in Bavaria, and to the ashes of the turf of her vast moors, as material for cement, and proposed that it be prepared by burning marl, using the turf as fuel.

His prize essay may be regarded as a continuation of the paper on Lime and Mortar, and sums up clearly the experimental results, with this conclusion; that the hardening of hydraulic cement depends essentially upon a chemical union of silica with lime, which gradually takes place in the wet way. Accordingly, there can be no hydraulic cement without silica, and further, there is produced a hydrated silicate or zeolitic compound. He discovered that but very few natural silicates (some volcanic products excepted) are so constituted that lime acts on them directly in the wet way, they mostly require to be burned, some of them indeed must be burned with a little lime, before they are acted on. What Fuchs had said in his academical oration with regard to the relations between chemistry and mineralogy, he thus demonstrated practically. He could hardly have been so successful in this research had he not been acquainted with both these sciences, since the latter furnished the materials for the solution of the problems that occurred to him. These results explain the advantages of burning clay as has been practised in agriculture. On this point Baron v. Liebig remarks in his "Familiar Letters on Chemistry," as follows: "These interesting facts were first observed by Fuchs at Munich; they have not only led to a most intimate knowledge of the nature and properties of the hydraulic cements, but, what is far more important, they explain the effects of caustic lime upon the soil, and guide the agriculturist in the application of an invaluable means of rendering it soluble, and setting free its alkaline substances so important, nay, so indispensable to his crops."

Fuchs rendered an important service to mineralogy when in 1831 he made public his method for the quantitative separation of the protoxyd and peroxyd of iron. His method consists in the use of carbonate of lime or baryta, which precipitates the peroxyd but not the protoxyd, from hydrochloric acid solution. This process has been found further applicable to the separation of peroxyd of iron from protoxyd of manganese, of alumina from magnesia, and for precipitating other analogous oxyds. Instead of carbonate of lime or of baryta, the carbonates of magnesia, copper, zinc, and manganese may be used, and thus the separations effected in sulphuric acid solution. This method also serves for precipitating phosphoric and arsenic acids with peroxyd of iron, so that these acids may be separated and determined in this way. In presence of these acids then, this method is useless for the determination of iron. Knowing this, Fuchs sought another process on occasion of the analysis of a phosphate of iron from Bodenmais, which he named Melanchlor. He was thereby led to the discovery of the valuable method which is founded upon the fact that hydrochloric acid does not dissolve metallic copper in exclusion of air, but that it is dissolved in an acid solution of perchlorid of iron. Protoxyd of iron may also be determined if it be peroxydized. The quantity of copper in a solution, may be estimated also by the same method; the chlorid of that metal is converted into subchlorid by contact with strips of metallic copper, the loss of weight of the latter is equal to the copper originally in the solution. Fikentscher has applied this method to testing the amount of available oxygen in manganese, and I have directed the attention of copper etchers to the use of perchlorid of iron as a substitute for aqua fortis; it attacks the copper without formation of the dangerous fumes which are evolved in the old process. By this method too, Fuchs discovered the sesquioxyd of titanium, and he has shown how it may be employed in analyzing silicates containing titanic acid.

The labors of Fuchs so far as already noticed, evidence much connectedness and a systematic development the one from another; this is again manifest in his paper on amorphism presented to the Academy of Sciences in 1833.

Although the condition of amorphism had already attracted some attention,* nevertheless Fuchs first characterised it, and

* In Fuchs' Theory of the Earth (1837) the gelatinizing of fused epidote, garnet, &c. with acids, is thus spoken of—"this change can only be explained by the supposition, that on fusion, these bodies lose their crystalline and assume an amorphous condition." In Kastner's Archives, vol. v, p. 165, the writer has thus expressed himself (1825) on this matter, "the reason of this phenomena appears to lie herein, that by fusion the attractive force of the different simpler compounds of these minerals for each other, is (relatively) suspended, *with the suspension of the crystalline condition.*"

made it prominent by interesting examples. He begins by mentioning some facts from his paper on lime and mortar, viz., that powdered opal unites with lime in the wet way, and is easily soluble in boiling caustic potash solution, while the finest quartz is unattacked by lime, and dissolves with exceeding slowness in potash solution. This behavior can only have its foundation in a difference of aggregation (or solidity)—(*Zustand des Starren*), which is either crystalline, or the opposite of crystalline—amorphous. Common glass is an amorphous body, which may assume the crystalline condition by long exposure to heat, as in Reaumur's porcelain. Glass and Reaumur's porcelain have the same relation to each other as opal to quartz.

Among amorphous bodies belong obsidian, pumice, pitchstone and pearlstone (he was inclined to reckon leucite among them), also allophane, psilomelane, thraulite, &c., the fossil coals, resins and gums, gelatine, and many other substances. He instanced especially the product formed by pouring highly heated sulphur into water, which after a time recovers the crystalline structure; further examples of bodies occurring in both the amorphous and crystalline condition are charcoal and diamond, kermes and crystallized sulphid of antimony, precipitated sulphid of mercury and cinnabar. Very interesting is his remark upon *deformation*, i. e., the transition from the crystalline to the amorphous condition. He says, "In my view deformation precedes, nay, must precede every chemical synthesis. The process whereby dissimilar bodies unite to one homogeneous body, is one we can hardly hope ever to understand fully, something however is always gained, when an erroneous notion which directs away from the truth, is set aside. Such a false idea, I hold to be that, according to which, the act of chemical union consists merely in the crystalline* molecules of two or more bodies arranging themselves in juxtaposition, so that in fact a chemical product is nothing more than a very intimate mixture. My opinion is rather, that before two substances can combine they must first lay off the crystalline form ordinarily peculiar to them (become amorphous), and then are they in a condition to take on together the new form which they are inclined to assume, or to which the resultant of their innate forces disposes them. This view is sustained by the fact that crystallization acts like a repulsive force against affinity, and must be overcome before that power can exercise itself. Every inorganic body must also become amorphous before it can enter the organic kingdom, and be assimilated to an organic substance. Crystallization and life are absolutely incompatible with each other, and so soon as a substance in an organic body begins to crystallize, so soon it falls into the inor-

* The original is *gestaltet*, and might be rendered by the word *morphous*, the opposite of amorphous.—Tr.

ganic realm. The crystal is, so to speak, the boundary-stone between the two kingdoms."

Fuchs also makes the amorphous state a condition of the fitness of mineral matter for vegetable nutrition, and thereby explains the richness of volcanic soil, the fertilizing effects of many burned silicates, &c. As silica (Tabasheer) passes through the vegetable, so doubtless the phosphate and carbonate of lime pass the animal body in an amorphous state, and in the formation of shells, pearls and coral, the carbonate of lime is probably at first deposited in a gelatinous (amorphous) state.

In a later article Fuchs discussed the so-called isomerism, and pointed out the possibility of explaining it, partly at least, by the differences between the crystalline and amorphous structure. All these considerations are highly worthy of notice, and Fuchs made them the basis of certain geological views which he presented to the Academy, April 25, 1837. In this address, "On the theories of the Earth," Fuchs opposed the Plutonists, and the theory of upheavals, without however, accepting literally the doctrines of the Neptunists. He reasoned against the view that the crystalline rocks were once in a state of fusion, as follows, using granite as the illustration: If granite were once in a molten condition, then as it cooled, in the first place, quartz must have crystallized out, and would have sunk down through the still molten mass, while feldspar and mica must have crystallized at a much later stage of the cooling, as the necessary result of their different degrees of fusibility. Further, the inclusion of arsenical pyrites, sulphid of antimony, tourmaline, garnet, fluor-spar, &c., by quartz, is incompatible with the crystallization of the latter from a state of fusion. Accordingly, the doctrine of upheavals cannot be sustained. In enunciating his own views, Fuchs begins with the proposition that amorphism must precede crystallization, and assumes that originally, the solid part of the earth consisted of silica and silicates in the amorphous form, while the liquid portions were largely made up of solutions of lime and magnesia or their carbonates, in the then existing excess of carbonic acid. "This I conceive to have been the primal or chaotic condition of our globe, this may indeed have been preceded by another condition, but to this state it must have come before the formation of rocks could begin."

In this explanation, may perhaps be found a means of harmonizing and uniting the well-founded views of Fuchs, with the plutonic theories, in so far as these are also sound—how, I can indicate only, in this place. The formation of rocks began, according to Fuchs, with the silicates. The stupendous crystallization thus induced must have developed light and heat. The latter must have acquired great intensity—even that of ignition. The products were different as determined by circumstances, viz., granite, syenite, porphyry, mica slate, &c., which in fact, as is known, pass into each other, and may be included together under the term granitic rocks. Also at a later period members of the silicious group were formed, but not so perfectly as at first; examples are clay-slate, and many sandstones. The limestones and calciferous rocks began to be formed simultaneously with the silicious rocks, and the production of both ran parallel through all epochs, down to the most recent times. After the deposition of carbonate of lime, the vast quantities of carbonic acid which had served to hold it in solution, became the material which should especially contribute to the sustenance of organic nature. Says Fuchs "this acid had from the beginning of the creation a three-fold office; firstly to keep the carbonate of lime separated from the silicates, and for a certain time to retain it in solution; secondly to furnish the atmosphere with oxygen, and thirdly to supply carbon for the production of fossil coal and organic bodies. In recent geological times have probably been formed by their decomposition, two kinds of products, viz., bituminous, containing much hydrogen, and humus-like, containing both hydrogen and oxygen."

Fuchs notices here the objection, that there is not now enough free oxygen in the atmosphere to form carbonic acid with all the carbon of the globe. Accordingly a part of the oxygen originally present must have been devoted to other purposes, and he assumes that it was mostly consumed at a later period in the formation of gypsum. He supposes that before gypsum was formed, there existed the easily soluble hyposulphite of lime, and that it passed into gypsum by oxydation. For such a phenomenon Fuchs offers two explanations, both of which accord with chemical principles, and one of which at the same time, accounts for the presence of free sulphur in the gypsum beds. Either the hyposulphite of lime might be converted into gypsum by immediate oxydation, and the free sulphuric acid thereby formed also yield gypsum, by contact with neighboring carbonate of lime; or the hyposulphite of lime might be resolved into sulphur and sulphite of lime, and the latter pass into gypsum by absorption of oxygen.

Instead of the theory of upheaval, Fuchs proposes a theory of collapse, since by the crystallization of the amorphous masses they would assume a smaller space, and thereby cavities and breaches must be formed, which would result in dislocations, and the falling down of large bodies of rock. The half solid mass which was not crystallized might then penetrate the rifts of the neighboring rock, thus giving origin to veins and dykes. In these revolutions however Fuchs also admits certain upheavals.

In a subject like this it is naturally impossible that speculation, be throughout, founded upon positive knowledge, or be capable of control by experiment. We continually find gaps in our reasoning, and are obliged to have recourse to hypothesis. For example, with regard to the chemical relations of bodies under the influence of very high temperatures and pressures, we know indeed that these circumstances modify the ordinarily observed phenomena to a very remarkable degree; combinations and decompositions being effected of a character entirely different from those which occur under common conditions: but we are unacquainted with the precise nature of these changes, and do not know all of the processes by which a given mineral product may be formed. It need not surprise us then that Fuchs has allowed some play of the imagination in his theory of the earth, as when he assumes that our globe was once self-luminous from the light which might have been developed in the crystallization of the granitic rocks, and when he supposes that rock-masses may have been vitrified and metamorphosed by superficial electric discharges instead of subterranean fires; or, that waterspouts may perhaps have been the means of transporting erratic blocks. As an evidence however that Fuchs did not give himself up to one-sided views, he reminds us of the truism which deserves before all others to become a proverb among geologists. "The same does not always happen in the same manner."

The views of Fuchs have found many objectors. Among others Berzelius controverted them and sought to weaken his chief argument againt the assumption that the earth was originally in a state of fusion, viz., that in such case all lime must exist now as silicate and none as carbonate, because at a high temperature silica expels carbonic acid from its combinations, by asserting that the density of the vast quantity of aqueous vapor in the atmosphere at that time would have been sufficient to balance the tension of carbonic acid, so that it could remain in combination with lime even in presence of silica.* To this Fuchs replied,† that at the fusing point of silica, a temperature far higher than that of melted platinum, the tension of carbonic acid must be so exalted that the pressure of the atmosphere could not have prevented its escape, especially since the tendency of silica to combine with lime must have facilitated this separation. We see how impossible it is in this kind of study to avoid building upon hypothesis, because we do not know even approximately what is the melting point of silica, and still less are we acquainted with the conditions involved in the fusion of carbonate of lime, or what was the atmospheric pressure in those primeval times.

* Berzelius Jahresbericht, 19, p. 742.
† In Dr. A. Wagner's Geschichte der Urwelt. 1845.

It is perhaps possible to show that the silicates of lime might have been at a later period, again decomposed by the action of the excess of carbonic acid then existing in the atmosphere, and with vastly greater readiness than happens now under the present pressure; but here is not the place to proceed with this discussion. I must however mention that it is to be regretted that Berzelius, who in opposing Fuchs, recognized him as an able chemist, did not take the trouble to read through the paper in question, and thus avoid raising an objection to his theory of the formation of gypsum, which were it well founded implied a gross error on the part of Fuchs, but which was the error of Berzelius himself. The greater the authority a scientific man acquires, the more careful and conscientious should be his criticisms, because the multitudes always follow such a man blindly, and are glad thereby to save the trouble of investigating for themselves; and yet it is precisely these who are most ready to sound the trumpet, and thus error instead of truth is often promulgated to the injury of science and her followers.

I should lead you too far should I give an analysis of the numerous shorter papers of our departed fellow-laborer, e. g., his observations on graphite, &c., on the sesquioxyd of tin and purple of cassius, the discovery of iodine in the salt spring of Hall, the analyses of triphyline, iron-apatite, &c., &c. They abound in interesting statements and have borne fruit to science as well as to the arts.

In scientific research as in common life Fuchs was conscientious and honorable. He was free from pedantry, and through all his frequent corporeal sufferings maintained a calm serenity. He recognized with joy the merits of others, and he accorded approbation to earnest effort; but superficialness and charlatanism excited his indignation and sarcasm. In discourse he was clear and connected, and knew how to interest hearers in his subject. Weakness of the chest prevented him from speaking without frequent interruption, his manner however was forgotten in the matter. His mineralogical lectures were published in 1842. The chemical part especially, is full of choice observations, and thus it forms a valuable complement to the ordinary text-books. Fuchs was no friend of complicated methods, even when they were thus planned for the purpose of obviating sources of error, for he considered the errors involved in the practical execution of such methods. He was accustomed to say, "over-sharp does not cut, and over-pointed does not sting."

I have often been surprised at the interest which he manifested even in his latest years in scientific intelligence, and at the attention he bestowed on matters which it would be thought, could have no longer any value in the estimation of one so old. He looked forward calmly and with christian resignation to the time of his dissolution, and his spirit was strong and unclouded to the last.—He died on the fifth of March 1856. Although his nature was phlegmatic rather than excitable, he could warm with the fullest enthusiasm, in the discussion of scientific subjects, especially when as frequently happened, his own labors had been misunderstood or misrepresented, or when his results were ignored by those who entered the fields of inquiry which he had explored. Although his scientific achievements have been sometimes underestimated, on the other hand they have received the highest appreciation from the most illustrious philosophers of his day. He was constituted member of very numerous learned societies, and of the academies at Berlin and Vienna. He was decorated with the highest Bavarian orders of Knighthood, and under circumstances of especial honor received the Prussian order of the Red Eagle. In the ministerial despatch accompanying the latter occur the following words; "His Majesty the King of Prussia on occasion of the reception of Vicats' work on the formation of Hydraulic Cement, through the Prussian embassy at Paris, has become aware of the distinguished merits of the Royal Bavarian Chief Mining Counsellor and Professor, Dr. Fuchs,—merits surpassing even those of Vicat,—especially in the purely scientific part of the subject. In recognition, &c."

On his seventieth birthday, which was celebrated as a festival by his numerous disciples and friends, Fuchs uttered these modest words: "Had I enriched science with only *one* established principle, I could receive these demonstrations of honor without a sense of shame, but towards this I have only made some slight contributions." He said still further, "remembering the old saying, *nisi utile est quod facimus stulta gloria*, I have sought sometimes to give my labors a practical direction—I will not however say by this, that science is useful only when she enters the affairs of life and brings us material gains. All science is a product of mind and reacts on mind to its development; this of itself is its greatest use, because the expansion of our spiritual nature is the chiefest good that can be attained. Only a shallow brain, only a narrow or perverted reason, can behold in nature the monster Materialism."

While the memory of Fuchs will be perpetuated by his discoveries that have passed into and enriched our practical life, it will not the less be held in reverence in the history of science, for he truly belonged among her CONSECRATED ONES.

ART. XXX.—*Researches on the Ammonia-cobalt Bases;* by WOLCOTT GIBBS and F. A. GENTH. Part I.

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THE facility with which alkaline solutions of many metallic protoxyds absorb oxygen from the air, attracted the attention of chemists at an early period. The protosalts of iron, manganese and cobalt, are particularly remarkable in this respect. In the presence of an excess of the fixed caustic alkalies and their carbonates, salts of the protoxyds of these metals are more or less rapidly converted into basic salts of their higher oxyds. A similar effect appears to be produced by all of the more powerful fixed bases, while it is remarkable that neutral or acid solutions of the same salts are oxydized much more slowly, an effect which is perhaps owing to the tendency which per-salts in general exhibit to become basic, and to the influence which an excess of acid exerts in producing neutral or acid compounds.

Ammonia acts like potash and soda in causing the oxydation of solutions of iron and manganese. In the case of these two metals either basic salts or hydrates of the peroxyds are formed, which contain no ammonia, at least in chemical combination. With salts of protoxyd of cobalt the result of the oxydation is very different. The sesquioxyd of cobalt at the instant of its formation unites with a certain number of equivalents of ammonia so as to produce a conjugate base of which ammonia forms an integral portion. The new base partakes in some measure of the properties of the alkalies, the peculiar character of the salts of cobalt being wanting. It is with this class of bases that we have at present to deal.

The earliest observations which we possess upon the oxydation of the salts of cobalt are due to Leopold Gmelin, who, in a memoir, published in 1822,* described the changes of color which are produced when ammoniacal solutions of the chlorid, sulphate, and nitrate of cobalt are exposed to the air. The solutions under these circumstances absorbed oxygen and became brown, and Gmelin considered it probable that they contained a cobaltic acid. Dingler,† who subsequently endeavored to determine the amount of oxygen absorbed, inferred that the cobaltic acid consisted of one equivalent of cobalt and two equivalents of oxygen, since the brown solution gave with sulphid of ammonium a black precipitate of bisulphid of cobalt. Winkelblech‡ denied

* Neues Journal der Chemie und Physik. Neue Reihe, V, 235.
† Kastner's Archiv, xviii, 249.
‡ Annalen der Pharmacie, xiii, 148, 253.

the existence of a metallic acid in the solution, but though his memoir contained many interesting and valuable contributions to our knowledge of the oxyds of cobalt, it threw no light upon the true nature of the ammoniacal compounds, except by establishing in them the existence of sesquioxyd of cobalt. The subject was next investigated by Beetz,* who analyzed an ammoniacal sulphate and nitrate of sesquioxyd of cobalt formed during the direct oxydation of ammoniacal solutions. These analyses led to the formulas $Co_2O_3.3SO_3+3NH_3+NH_4O$, and $Co_2O_3.3NO_5+3NH_3+NH_4O$, but as the substances employed were not crystallized, and as the analytical methods were difficult to execute, but little reliance could be placed in the results. Beetz, however, considered the sesquioxyd of cobalt in these compounds as playing the part of an acid, the ammonia being present as a salt of ammonium.

The oxydation of ammoniacal solutions of various salts of cobalt was also observed by Rammelsberg,† and the products of the action in several cases analyzed. None of the formulas obtained, however, appear to belong to well defined and distinct compounds.

A memoir published by one of ourselves, in 1851,‡ contained the first distinct recognition of the existence of perfectly well defined and crystallized salts of ammonia-cobalt bases; in fact we have not been able to trace in any earlier paper even the idea of the existence of such a class of compounds. The results made public in this paper had been obtained by the author, in Marburg, in 1847, had been at that time freely though verbally communicated, and a suite of the salts obtained had been left in the laboratory at Giessen. Want of opportunity prevented a complete and systematic investigation, particularly from the analytical point of view. The memoir in question contained, however, besides several analyses, an accurate description of the two bases now to be described under the names of Roseocobalt and Luteocobalt. Though the analyses were from necessity not sufficiently complete and extended to fix the constitution of the bases in question, yet the fact is indisputable that this memoir contained, not merely the first announcement of the existence of ammonia-cobalt bases, but also a scarcely less accurate and complete description of two of these bases than any which has since appeared.

As its title states, the memoir in question was intended simply as a preliminary notice; circumstances, however, prevented a resumption and continuation of the subject. In a paper pub-

* Pogg. Ann., lxi, 494, 480, 490.
† Pogg. Ann., xlviii, 208. xliv, 268.
‡ Nordamerikanischer Monatsbericht für Natur. und Heilkunde, 1. Januar. 1851. Vorläufige Notiz über gepaarte Kobaltverbindungen von Dr. Friedrich August Genth.

lished in 1851,* Claudet described with some detail the properties of the chlorid of Purpureocobalt, and the mode of obtaining it, as well as a few other ammonia-cobalt salts. With the exception, however, of more complete analyses, the memoir in question contained nothing which is not to be found in the previously published paper above alluded to. In two notices communicated to the Academy of Sciences† in the same year, Frémy announced as his own, the discovery of a class of compounds containing cobalt and ammonia, and produced by the oxydation of ammoniacal solutions of protosalts of cobalt. In the following year his complete memoir appeared.‡ In this Frémy describes anew the ammonia-salts of protoxyd of cobalt, first obtained by H. Rose, passes then to the description of two new classes of compounds discovered by himself, and named by him Oxy-cobaltiaque and Fusco-cobaltiaque, and finally describes at some length the principal salts of Genth's two bases, the constitution of which he correctly determines. Frémy appears not to have been aware that these two bases had been described in a manner little less complete than his own two years before the appearance of his memoir. The chlorid of Luteocobalt and its platinum salt have also been described and analyzed by Rogojski,§ and what we now term the chlorid of Purpureocobalt, by Gregory,‖ who corrected the analyses of Frémy.

The researches of Claus¶ on the ammonia-iridium and ammonia-rhodium bases established the existence of compounds of these metals exactly analogous to Roseocobalt and its salts, and chemists will look with impatience for the publication of his results in detail. Recently Weltzien has published some theoretical views on the constitution of the ammonia-cobalt bases which possess much interest.

The salts of Xanthocobalt were discovered in November, 1852, by W. G., and the principal results which are contained in the present memoir were communicated to the American Association for the Advancement of Science, at its meeting in Cleveland in August, 1853. The formulas of several of the more remarkable bases are also given in a Report on the recent progress of organic chemistry, read before the same association, at its Providence meeting in August, 1855. The nomenclature of the ammonia-cobalt bases proposed by Frémy is so simple and convenient that we have adopted and extended it to meet every case. We have, however, considered it desirable to drop the

* Phil. Mag., ii, 253, and Ann. de Chimie et de Physique, xxiii, 483.
† Comptes Rendus, xxxii, 509, 808.
‡ Ann. de Chimie et de Physique, xxxv, 257.
§ Journal für praktische Chemie.
‖ Ann. der Chemie und Pharmacie, lxxxvii, 125.
¶ Bulletin de l'Académie de St. Petersburg, 1855, xiii, 97, quoted in Handwörterbuch der reinen und angewandten Chemie, vi, 843.

terminal syllable "iaque," employed by Frémy, not merely because it is not an English termination, but because by omitting it we obtain shorter and more convenient words. Thus, we say Roseocobalt and Luteocobalt, instead of Roseo-cobaltiaque and Luteo-cobaltique, or Roseo-cobaltia and Luteo-cobaltia, which are the English equivalents. The shorter names, as will hereafter appear, also agree better with our own theoretical views, since we consider the compounds in question conjugate metals and not ammonias.

With the view of making the description of our salts as complete as possible, we have followed the excellent example of Frémy, and referred the colors of these substances to Chevreul's chromatic scale. Frémy had the advantage of Chevreul's own determinations. We have employed, for the purpose, the chromatic scales recently published in Paris by Digeon, and which appear to be reliable; in any event they give *some* precision to determinations of color. As we have found that very many of the salts of the ammonia-cobalt bases exhibit a well marked dichroism, we have in most cases examined the light reflected from layers of crystals, by Haidinger's dichroscopic lens, and have given the colors of the ordinary and extraordinary images as obtained in this way. As a curious physical result, we may here mention that, in general, the cobalt color predominates in the ordinary image.

We are indebted to Prof. Dana for the determination of the systems to which many of our crystals belong, and of their principal forms, as well as for our figures, and embrace this opportunity of expressing our grateful acknowledgement of his valuable assistance.

METHODS OF ANALYSIS.

The accurate quantitative determination of the different elements which enter into the constitution of the ammonia-cobalt bases and their salts, is attended with great difficulties. We have in general found it necessary to study out with much labor the methods of analysis proper to be used in each particular case; and it has been only after many trials that we have at length been able to obtain accurate results. Before proceeding to the description of the compounds in question, it may therefore be proper to state the analytical methods employed.

Cobalt.—The determination of the cobalt in these salts may, in most cases, be very easily and accurately effected by the following process. A weighed portion of the salt is gently heated in a deep platinum crucible, with a quantity of pure and strong sulphuric acid sufficient to moisten the whole mass. Some effervescence is generally produced by the addition of the acid, but there is no danger of loss if the crucible be sufficiently large, and if the heat be applied only after the first action of the acid is over. The mixture is to be gently heated over a spirit lamp, until the excess of the acid, sulphate of ammonia, and other volatile matters have been expelled. During the whole time of heating, the cover of the crucible must be so placed as to prevent the possibility of loss by spattering, and at the same time to permit the escape of volatile matters. When, however, the quantity of acid has not been too great, the whole process goes on very quietly to the end, when the mass becomes dry. The heat is finally to be raised, for an instant, to low redness, the cover of the crucible being quickly lifted off and then replaced. The crucible is then to be allowed to cool and weighed, when the quantity of cobalt may easily be calculated from the weight of the dry and pure sulphate. After the weighing, the mass in the crucible must be carefully examined. It should have a fine rose color, and be perfectly soluble in warm water, leaving no black residue. In case this is observed, which happens only when the heat has been too high, a drop of sulphuric acid and a few drops of oxalic acid may be added, and the whole evaporated to dryness, and again ignited. When, however, there is much oxyd of cobalt present, it is better to reject the analysis at once. With a little care and practice the operation succeeds almost invariably, and the result, as we shall hereafter show, leaves nothing to be desired in point of accuracy. When chlorine is present in the salt to be analyzed, a little free chlorine is sometimes found among the products of the action of the sulphuric acid, and the platinum crucible is slightly acted upon. In such cases we usually add a little oxalate of ammonia to the salt before dropping the acid upon it. The quantity of salt to be taken for analysis may vary from three to five decigrammes; when more is used, there is apt to be some loss from effervescence. In consequence of the small quantities of substance employed, the weighings must be as accurate as possible. In calculating the weight of the cobalt from that of the sulphate, we have the advantage of determining one substance from another with an equivalent more than twice as high.

In certain cases, as, for example, when phosphoric acid, chromic acid, &c., are present, the above method cannot be employed. In such compounds we have found it advantageous to separate the cobalt as a hydrate of the sesquioxyd, by boiling the salt with a solution of caustic potash, washing the precipitate thoroughly, and estimating the ignited precipitate as Co_6O_7, or as metallic cobalt after reduction by hydrogen. Frémy justly observes that this ignited oxyd usually contains potash; but an accurate result may always be obtained by washing it well with boiling water after the ignition, and weighing a second time. It is remarkable that Frémy asserts that cobalt may be accurately estimated in the form of sulphate, in consequence of the stability of this salt, while the direct application of the method, as we have described it above, appears to have escaped him entirely.

Hydrogen.—We have in almost all cases determined hydrogen directly by combustion with chromate of lead, metallic copper being placed in the anterior part of the tube. In the case of the nitrates, however, an excess of hydrogen in the result is almost unavoidable, because it is impossible, even with freshly reduced copper, to decompose completely the great quantity of oxyds of nitrogen formed during the combustion. In other cases this effect is much less marked, and the hydrogen determinations are at least as accurate as in ordinary organic analyses.

Chlorine.—The accurate determination of the chlorine in the ammonia-cobalt salts is very difficult. Nitrate of silver, it is true, precipitates chlorine from most of its combinations in these salts, but the precipitation is never complete, because the chlorid of silver is somewhat soluble in the ammonia-cobalt chlorids, forming with them peculiar double salts. By long boiling with free nitric acid in the solution, nearly all the chlorine may be determined as chlorid of silver, but very accurate results cannot be obtained in this manner. The best method consists in igniting the chlorid with lime in a combustion tube, in the manner usually practised with organic bodies. In some cases, however, we have obtained very good results by decomposing the solution of the chlorid by sulphurous acid, or by boiling the solution of the salt until it is completely decomposed, adding sulphurous or nitrous-nitric acid to reduce the sesquioxyd of cobalt, and then precipitating with silver. The process is, however, always troublesome, and requires much time and great care.

Carbon.—This element is best determined by the usual process of organic analysis. In consequence, however, of the very large quantity of oxyds of nitrogen, which are always produced during the combustion of these salts, we have found it very advantageous to employ a method first suggested, we believe, by Winkelblech, and which consists in mixing with the oxyd of copper a quantity of finely divided metallic copper, in the form in which it is obtained by reducing the oxyd by hydrogen. In this manner the formation of the oxyds of nitrogen may be completely prevented. Great care must, however, be taken when it is wished to determine hydrogen at the same time with carbon, because, copper reduced from the oxyd by hydrogen, always contains water, which it is difficult to separate.

Nitrogen.—No element has presented such difficulties as nitrogen. We have found it impossible to obtain results within two or three per cent of the truth by employing the old methods of analysis, that of Dumas for instance. The quantity of nitric oxyd formed during the combustion is surprising, and it is absolutely impossible to get rid of it by means of ignited metallic copper, placed in front of the combustion tube. Will and Varrentrapp's method with soda lime is inapplicable, because one equivalent of ammonia is always decomposed by the equivalent of oxygen set free in the reduction of sesquioxyd to protoxyd of cobalt. Good results could not be obtained by boiling the salts with caustic alkalies, collecting the ammonia in chlorhydric acid, and determining it by bichlorid of platinum. Even after the reduction of the sesquioxyd of cobalt to protoxyd by means of sulphurous acid, this method was found unreliable. The improvements made by Simpson in the absolute determination of nitrogen by volume at last furnished us with a reliable process; and nearly all the analyses in this memoir were executed by his method. The improvement introduced by Simpson consists essentially in mixing oxyd of mercury with the oxyd of copper employed to effect the combustion. The vapor of metallic mercury completely decomposes the oxyds of nitrogen, and any excess of free oxygen is absorbed by means of metallic copper. By this method we have analyzed most of our compounds without special difficuly, though we have often found it necessary to employ a much larger proportion of oxyd of mercury than is recommended by Simpson. One class of ammonia-cobalt bases have, however, been the source of frequent analytical failures, and of great loss of time and material. We refer to the salts of Xanthocobalt, a base containing deut-oxyd of nitrogen, and giving off this gas at a gentle heat, below that at which oxyd of mercury is decomposed. Simpson's method has not always been found accurate, since even when a very large amount of oxyd of mercury is employed there is frequently much nitric oxyd in the nitrogen collected for measurement. In many cases the simple admixture of a large proportion of metallic copper with the oxyd, as recommended by Winkelblech, has been found to give most excellent results. It is proper also to state here that, in consequence of difficulties in obtaining proper apparatus with which European chemists do not have to contend, we have, in the majority of cases, measured the volume of nitrogen in the old way, using, however, very accurately graduated tubes for collection, and correcting with great care for temperature and pressure. We have also found it advantageous to operate upon quantities of substance sufficient to yield at least two hundred cubic centimetres of gas, since in this way the error of reading becomes extremely small.

Sulphuric acid.—This acid cannot be accurately determined in the ammonia-cobalt salts by direct precipitation with chlorid of barium. In almost all cases, a great apparent excess of acid is obtained, and this may amount to five per cent, even when the sulphate of baryta appears to have been completely washed. We have, therefore, in all cases preferred to decompose the salt to be analyzed, by boiling it with a little ammonia. After complete precipitation of the sesquioxyd of cobalt, chlorhydric acid is to be added to reduce and dissolve the oxyd, when the sulphuric acid may be directly thrown down by chlorid of barium. Even with these precautions, our results are not unfrequently two-tenths or three-tenths of one per cent too high, almost never too low.

Oxalic acid.—The ordinary methods for the quantitative estimation of this acid fail entirely with the class of salts under consideration. A solution of terchlorid of gold is reduced only after very long and tedious boiling, and then incompletely. Even after previous reduction of the cobalt to the form of protoxyd, the method is found to be very inconvenient and inaccurate. The conversion of the oxalic into carbonic acid by oxydation, and its determination from the weight of this last, gave no better results, inasmuch as the oxydation is effected with difficulty. We have therefore in all cases had recourse to the ultimate organic analysis, which alone gives reliable results.

The methods employed in the determination of other substances will be described, when necessary, in treating of particular compounds.

ROSEOCOBALT.

The description of the salts of Roseocobalt forms, upon the whole, the most convenient starting point in a statement of the results of our investigation. These salts are in general easily obtained, and the products of their decomposition include several of the other bases, which we shall have occasion to describe. They are almost all well crystallized, and are in general nearly insoluble in cold water, soluble without decomposition in warm water slightly acidulated, but easily decomposed when the neutral solutions are boiled, a hydrated hyper-oxyd of cobalt being thrown down, while free ammonia is given off. The salts of Roseocobalt have a purely saline, not metallic taste; their color varies, being sometimes dull or brick-red, and sometimes cherry-red. They are usually dichrous, though a few of them do not exhibit this property in a marked degree. Heat decomposes the dry salts readily, the final products of the decomposition being usually ammonia, a salt of ammonium and a salt of protoxyd of cobalt. Intermediate products are, however, sometimes formed, as we shall hereafter see. Thus in many cases the salts of Roseocobalt on boiling yield salts of Luteocobalt, which then, by continued boiling, are completely decomposed. The salts of Roseocobalt may almost always be prepared by the direct oxydation of ammoniacal solutions of salts of protoxyd of cobalt, but the particular circumstances, which accompany the formation of each one, will be best considered in treating of the separate compounds. Roseocobalt is a triacid base.

CHLORID OF ROSEOCOBALT.

An ammoniacal solution of chlorid of cobalt absorbs oxygen readily from the air, becomes at first brown and then gradually passes through various shades of color to a deep red. The red solution leaves upon a filter a quantity of hydrate of sesquioxyd of cobalt, which is sometimes almost inappreciable, sometimes in comparatively large amount. In one experiment, in which we employed perfectly pure chlorid of cobalt and pure ammonia, there was no deposit whatever of oxyd. In this case, however, no chlorid of Roseocobalt, but only chlorid of Purpureocobalt was formed. When impure materials are used the precipitate is abundant, and contains many of the impurities of the substances employed, as well as much sesquioxyd of cobalt. The rate at which oxygen is absorbed varies much with the degree of concentration of the solution, with the temperature, with the quantity of ammonia present, and with the extent of liquid surface exposed to the air. Frequent agitation of the solution materially shortens the time required for complete oxydation, and the same effect is produced by passing a current of oxygen directly through the liquid, which soon becomes brown and subsequently red. As a general rule, the first effect of the oxydizing action is to give the liquid a brown color, the layer next the surface being the first to change its tint. The brown color then passes gradually into a deep red, and the oxydation is complete, when the whole mass of liquid has the color of red Burgundy wine.

The presence of chlorid of ammonium is not necessary in this process; a large quantity of this salt in the solution often gives a lilac or purple precipitate as the oxydation advances, but this is composed principally of the chlorid of Purpureocobalt. As will be seen from the above, the chlorid of Roseocobalt is not always formed during the oxydation of an ammoniacal solution of chlorid of cobalt. On the contrary, it often happens that not a trace of this salt can be obtained from the oxydized solution, which contains only the chlorid of Purpureocobalt. We have observed the absence of the chlorid of Roseocobalt only in solutions which had been oxydized in a warm room, or during the summer season. This fact, taken in connection with the facility with which heat transformes solutions of Roseocobalt into those of Purpureocobalt, renders it, to say the least, extremely probable, either that a comparatively high temperature prevents the formation of the chlorid of Roseocobalt entirely, or else that this salt is converted into chlorid of Purpureocobalt as fast as it is formed in the solution.

To obtain the chlorid of Roseocobalt from the oxydized solution, cold and strong chlorhydric acid is to be added to it, the slightest elevation of temperature being carefully avoided. A brick-red precipitate is thrown down, which is to be washed with strong chlorhydric acid and then with ice-cold water, thrown upon a filter, and dried by pressure, great care being taken to operate at as low a temperature as possible.

As the formula of the chlorid of Roseocobalt is $5NH_3 . Co_2Cl_3 + 2HO$, its formation by the oxydation of the ammoniacal solution of chlorid of cobalt may be explained by the equation

$$6CoCl + 10NH_3 + 3O = 2(5NH_3 . Co_2Cl_3) + Co_2O_3.$$

In those cases in which no sesquioxyd of cobalt is precipitated, we may suppose that the sesquioxyd unites directly with ammonia, as represented by the equation

$$6CoCl + 15NH_3 + 3O = 2(5NH_3 . Co_2Cl_3) + 5NH_3 . Co_2O_3.$$

On adding an excess of chlorhydric acid to such an oxydized solution, $3(5NH_3 . Co_2Cl_3)$ must be formed, which satisfactorily explains the precipitation of the brick-red chlorid by the acid.

Frémy assigns to the brown substance, which is the first product of the oxydation, the formula $4NH_3 . Co_2O_3$. We have not yet been able to obtain this substance in a condition fit for analysis, and Frémy does not consider the formula, which he proposes, as by any means established.

It will be seen from the above that, in the formation of the chlorid of Roseocobalt, the elements of ammonia unite with sesquioxyd or sesquichlorid of cobalt at the instant that these are formed by the absorption of oxygen from the air. Claus has recently shown that the sesquichlorid of rhodium* unites directly with five equivalents of ammonia to form a chlorid exactly analogous to the chlorid of Roseocobalt, and having the formula $5NH_3 . Rh_2Cl_3$. We have made various experiments to determine whether sesquioxyd of cobalt once formed could unite directly with ammonia. A solution of chlorid of ammonium was poured upon freshly prepared sesquioxyd of cobalt, strong ammonia-water added, and the whole allowed to stand for some time in a closed bottle and in a rather dark closet. Even after many weeks, however, only traces of chlorid of Roseocobalt could be detected. A quantity of sesquioxyd of cobalt was dissolved in strong acetic acid, and to the solution chlorid of ammonium and ammonia-water added. In this case chlorid of Roseocobalt was formed after a few days, but it is doubtful whether its formation was not due to the oxydation of a small quantity of protoxyd of cobalt in the sesquioxyd employed. In another experiment, strong ammonia was added to

* Since the above was written, Claus has extended his observation to the sesquichlorid of iridium, which forms a similar base with five equivalents of ammonia.

freshly prepared sesquioxyd of cobalt, and the whole allowed to stand for several weeks, after which time it was boiled with chlorhydric acid, and considerable quantities of chlorid of Purpureocobalt, Luteocobalt, and Praseocobalt, were obtained. This experiment leaves no doubt that the ammonia-cobalt bases can be prepared by the direct action of ammonia upon sesquioxyd of cobalt, though this mode of preparation is not economical.

The chlorid of Roseocobalt may also be prepared by adding cold and strong chlorhydric acid to a completely oxydized solution of the ammoniacal nitrate or sulphate of cobalt. A brick-red precipitate is formed in either case, which must be purified by repeated washing with chlorhydric acid. Strong chlorhydric acid also precipitates the chlorid from solutions of the sulphate and nitrate of Roseocobalt. In all these cases, however, it is difficult to obtain the chlorid in a perfectly pure state.

The chlorid of Roseocobalt is usually precipitated as a brick-red powder, which, under the microscope, appears to be composed of indistinct granular crystals. It may be purified, though with difficulty, by solution in ice-cold water and spontaneous evaporation in the cold. The salt is soluble in cold, as well as in hot water, with a dark-red but not a violet-red color, the portions still undissolved becoming lilac or purple before dissolving. The most remarkable property of this salt is the facility with which it is converted into chlorid of Purpureocobalt. The hot solution yields, on cooling, small but brilliant crystals of the latter chlorid; in fact even solution in warm water converts a portion of chlorid of Roseocobalt into chlorid of Purpureocobalt, as may easily be observed by the change of color. This transformation is, however, far more striking when a solution of chlorid of Roseocobalt is boiled with a little chlorhydric acid: the solution speedily changes its color from a dull-red to a beautiful violet-red, and on cooling deposits an abundant crystallization of chlorid of Purpureocobalt. There is in this case a direct conversion of Roseocobalt into Purpureocobalt, an isomeric radical; the reactions of the violet-red solution being entirely different from those of the same solution previous to boiling with acid, except in one or two particulars, to be pointed out hereafter. The dry chlorid of Roseocobalt is also slowly converted into chlorid of Purpureocobalt by keeping, changing its color to violet-red; in this case, however, the change is not complete, even after a long time, unless heat be applied. The formula of the chlorid of Purpureocobalt, as we shall hereafter show, is

$$5NH_3.Co_2Cl_3.$$

This differs from that of the chlorid of Roseocobalt only by containing no water of crystallization. The change which takes place in the conversion of one chlorid into the other does not, however, consist in the mere loss of water. As we shall show, the chlorid of Roseocobalt corresponds to a triacid oxyd, while that of Purpureocobalt yields a biacid oxyd. It is to be carefully borne in mind, that the substance which we have called chlorid of Roseocobalt is not the chlorid of Roseo-cobaltiaque of Frémy, Claudet, and other chemists who have studied the subject. To the chlorid described by Frémy under the name of chlorid of Roseocobaltiaque we have given the name of chlorid of Purpureocobalt. The necessity of this change of name has arisen from the fact that hitherto two different bases have been confounded, the chlorid of Purpureocobalt having been considered as the chlorid corresponding to the sulphate and nitrate of Roseocobalt.

The chlorid of Roseocobalt is dichrous, the ordinary being paler than the extraordinary image; both are rose-red, with a faint brownish orange tint.

Chlorid of Roseocobalt, as already mentioned, has the formula

$$5NH_3 . Co_2Cl_3 + 2HO,$$

as the following analyses show:

0·7291 grs. gave 0·4235 grs. of sulphate of cobalt = 22·10 per cent of cobalt.
0·6247 grs. gave 0·3619 grs. " " = 21·99 " "
0·9834 grs. gave 0·5742 grs. chlorid of silver = 39·57 " chlorine.
1·8112 grs. gave 2·9095 grs. " " = 39·71 " "
2·2390 grs. gave 1·2829 grs. water = 6·37 " hydrogen.
1·4993 grs. gave 0·8784 grs. " = 6·50 " "
1·2235 grs. gave 282 c. c. nitrogen at 22°·5 C. and 766mm·82 (at 23° C.) = 254·91 c. c. at 0° and 760mm = 26·16 per cent.

The formula requires—

	Calculated.	Found.	
Cobalt, - -	21·97	21·99	22·10
Chlorine, - -	39·66	39·57	39·71
Hydrogen, -	6·33	6·37	6·50
Nitrogen, - -	26·08	26·16	——

With respect to this formula, it must be remarked that it is extremely difficult to obtain this chlorid perfectly free from chlorid of Purpureocobalt, into which it is so easily converted. The uncertainty, however, will concern only the number of equivalents of water. The chlorid of Roseocobalt combines with the chlorids of the electro-negative metals to form well defined salts. The platinum salt, which we have not yet fully examined, appears to have the formula

$$5NH_3 . Co_2Cl_3 + 3PtCl_2 + 8HO.$$

A neutral solution of the chlorid of Roseocobalt is easily decomposed by boiling, with evolution of ammonia, and precipitation of a black powder. This powder is probably a hydrate of the magnetic oxyd, $Co_3O_4 + xHO$, but we have deferred its examination to the second part of our memoir. The reactions of the chlorid of Roseocobalt are as follows:

Terchlorid of gold gives no precipitate at first, but after standing a lilac or purple precipitate, which is probably merely the chlorid of Roseocobalt.

Bichlorid of platinum gives a pale orange red precipitate.

Chlorid of mercury gives a pale rose or flesh-colored flocky precipitate.

Ferridcyanid of potassium gives beautiful orange-red oblique rhombic crystals.

Cobaltidcyanid of potassium gives fine red crystals.

Ferrocyanid of potassium gives a cinnamon, passing to a chocolate brown precipitate.

Oxalate of ammonia gives a brick-red precipitate of small granular crystals.

Neutral chromate of potash gives no precipitate.

Bichromate of potash gives a dark brick-red precipitate.

The following reactions, which were obtained with a solution of the hydrated nitrate of Roseocobalt may also be introduced in this place.

Pyrophosphate of soda gives a dull rose-red precipitate soluble in an excess of the precipitant to a clear red liquid, which in a few minutes solidifies to a mass of fine rose-red needles.

Picrate of ammonia gives a fine bright orange red precipitate soluble in hot water.

Iodid of potassium gives no precipitate either with the chlorid or nitrate.

The precipitate with chlorid of mercury is readily soluble in chlorhydric acid, and the solution after standing gives beautiful small granular crystals of a brownish red color.

The reactions which are peculiar to the sulphate of Roseocobalt will be described when speaking of that salt.

SULPHATE OF ROSEOCOBALT.

An ammoniacal solution of sulphate of cobalt absorbs oxygen readily from the air, becoming at first brown and then dark red. The time required for complete oxydation varies remarkably. The process is sometimes complete in a few days, but often requires many weeks. From the perfectly oxydized solution, sulphuric acid cautiously added usually throws down the sulphate of Roseocobalt as a bright red crystalline powder, which, after washing with cold water, is readily purified by solution and crystallization, a very small quantity of acid being added to prevent decomposition.

The sulphate of Roseocobalt is, however, not always the only salt formed under these circumstances. In some cases in which the ammoniacal liquid was allowed to stand several months until there remained only a dry mass of red crystals, warm water dissolved out a red salt in small quantity, much more sobuble than the sulphate of Roseocobalt, and giving different and very characteristic reactions. In other cases, and especially when a little chlorid of cobalt was originally present, warm water dissolved out another sulphate, crystallizing in octahedra of an orange-red color, the examination of which is not yet complete.

We are unable to confirm Frémy's assertion that sulphuric acid precipitates from oxydized ammoniacal solutions of sulphate of cobalt, an *acid* sulphate of Roseocobalt, having the formula

$$5NH_3.Co_2O_3, 5SO_3+5HO.$$

The salt precipitated under these circumstances is merely the neutral sulphate, as repeated analyses have shown, and as the crystalline form at once proves. The formula of the neutral sulphate is

$$5NH_3.Co_2O_3, 3SO_3+5HO,$$

as the following analyses show:

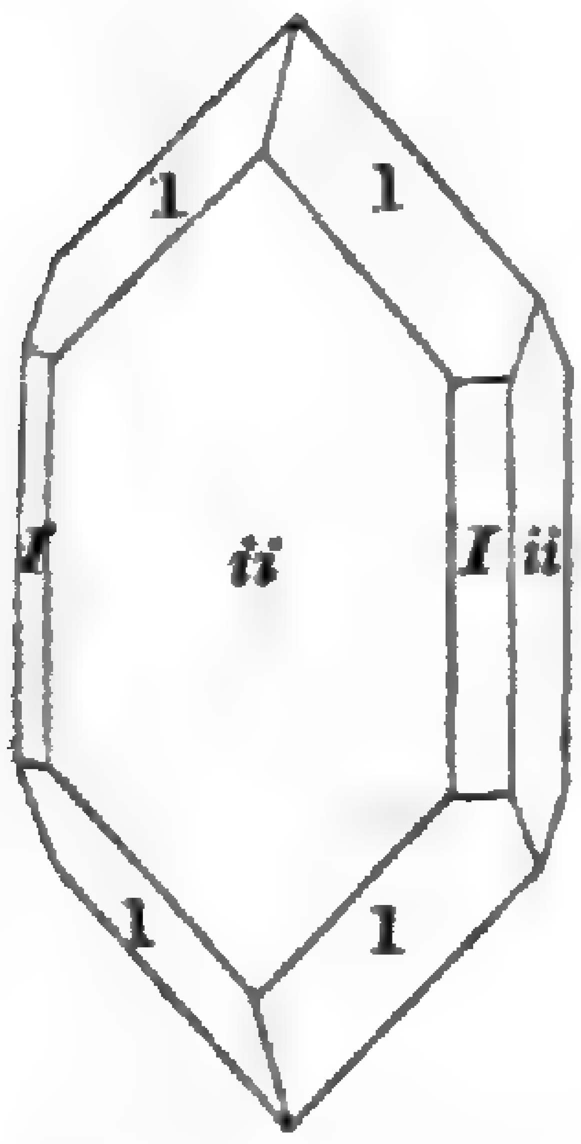
0·8160 grs. gave 0·3800 grs. sulphate of cobalt = 17·72 per cent cobalt.
0·8272 grs. gave 0·3869 grs. " " = 17·79 " "
0·2760 grs. gave 0·2908 grs. sulphate of baryta = 36·11 per cent sulphuric acid.
0·5731 grs. gave 0·6074 grs. " " = 36·38 " " "
1·4925 grs. gave 0·8250 grs. water = 6·14 " hydrogen.
1·2840 grs. gave 0·7109 grs. " = 6·15 " "
1·2108 grs. gave 220·5 c. c. nitrogen at 18°·4 C. and 761^{mm}·23 (at 18°·9) = 201·97 c. c. at 0° and 760^{mm} = 20·95 per cent nitrogen.
1·0404 grs. gave 194·2 c. c. nitrogen at 20°·5 C. and 754^{mm}·37 (at 20°·5) = 174·67 c. c. at 0° and 760^{mm} = 21·08 per cent nitrogen.

The formula as above stated requires

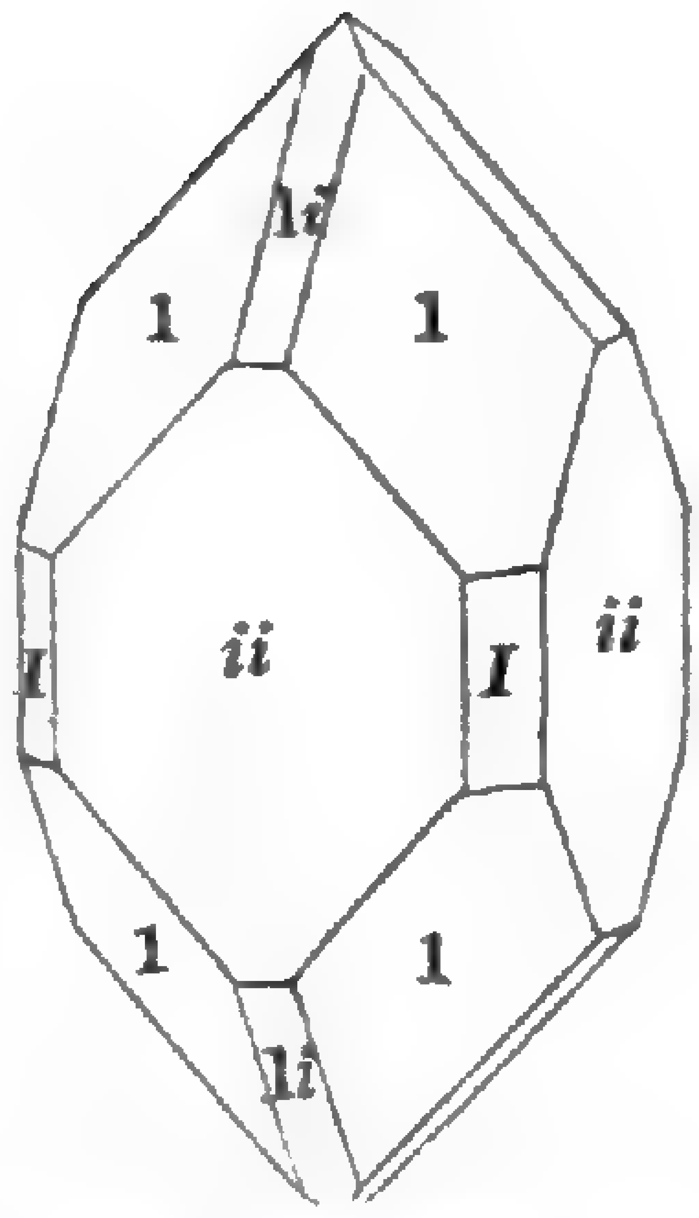
	Eqs.	Calculated.		Found.		Mean.
Cobalt,	2	59·0	17·71	17·72	17·79	17·75
Sulphuric acid,	3	120·0	36·03	36·11	36·38	36·24
Hydrogen,	20	20·0	6·00	6·14	6·15	6·14
Nitrogen,	5	70·0	21·02	20·95	20·08	21·01
Oxygen,	8	64·0	19·24	——	——	18·86
		333·0	100·00			100·00

The sulphate of Roseocobalt has a fine cherry-red color. The light reflected from a layer of the crystals when analyzed by the dichroscopic lens, gives a rose-red ordinary, and an orange-red extraordinary image. The dichroism is very distinct. In this, as in our other observations upon dichroism, the reflected rays examined made an angle of about 60° with the normal, but no material variations of color could be observed by changing the angle of incidence. The exact color of the crystals is, according to Chevreul, the second red $\frac{2}{10}$ths. The crystals of sulphate of Roseocobalt belong to the dimetric or square prismatic system, as determined by Prof. Dana. The observed forms are represented in figs. 1, 2, and 3. The measured angles are as follows:

1.



2.



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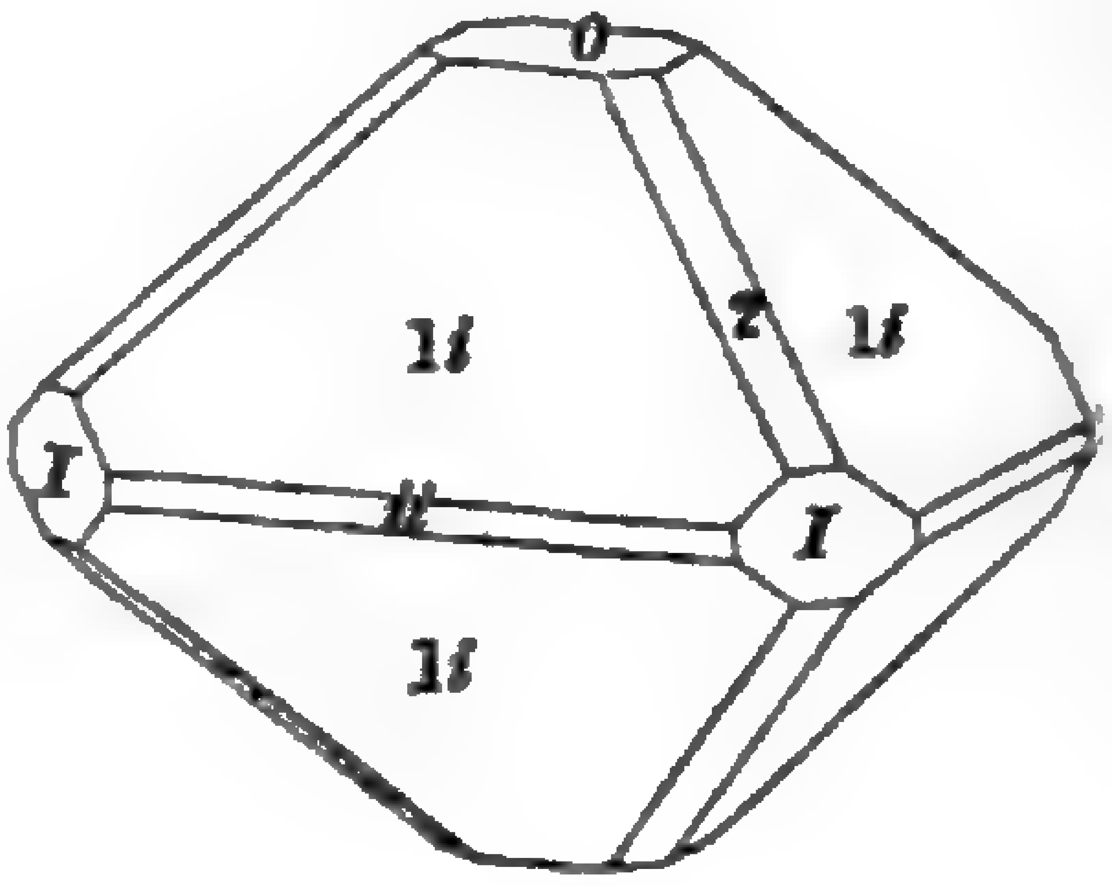


$1:1 = 107° 20'$; $1:ii = 126° 20'$; $ii:1i = 137° 21'$; $O:1i = 132° 35'$ (calc. $132° 39'$); $a = 1{\cdot}0866$.

Prof. Dana remarks that the angles are very close to those of Cerasine; and also to those of Scheeletine or tungstate of lead, if $1i$ be $\frac{1}{2}$ and 1 be $1i$.

The sulphate of Roseocobalt is nearly insoluble in cold water, but is soluble in much boiling water, and crystallizes readily as the solution cools. By slow evaporation, it may be obtained in large crystals, which, however, seldom exhibit very perfect faces. Ammonia in dilute solution dissolves the sulphate, giving a fine purple solution, from which the salt crystallizes unchanged. The neutral solution is readily decomposed by boiling, ammonia being evolved, and a dark brown precipitate of the hydrated magnetic oxyd of cobalt, Co_3O_4+3HO, thrown down, while sulphate of Luteocobalt remains in solution. The decomposition in this case extends to the sulphate of Luteocobalt also, so that much less than one equivalent of this salt is obtained for two equivalents of the sulphate of Roseocobalt decomposed.

Strong ammonia poured upon dry sulphate of Roseocobalt usually changes its color almost immediately from a red to a buff yellow, while the liquid itself becomes red. The buff colored substance formed in this case, is the sulphate of Luteocobalt; the red solution contains sulphate of Roseocobalt.

When dry sulphate of Roseocobalt is carefully heated in a porcelain or platinum crucible, ammonia is evolved, and there remains a lilac-red mass, which contains sulphate of Luteocobalt, sulphate of Purpureocobalt, and a leek-green crystalline substance which we have called provisionally Praseocobalt.

We shall speak of all these reactions more fully when treating of the sulphate of Luteocobalt.

A current of the red gas which arises from the action of nitric acid upon starch, and which probably consists chiefly of NO_4, converts an acid, neutral, or ammoniacal solution of sulphate of Roseocobalt into one of the nitrate of Xanthocobalt.

A solution of sulphurous acid gently heated with sulphate of Roseocobalt gives, in a few minutes, an orange precipitate of a substance containing ammonia, sesquioxyd of cobalt, sulphurous and sulphuric acid, and which we shall describe fully in the second part of our memoir.

Strong sulphuric acid digested with sulphate of Roseocobalt yields, under some circumstances, sulphate of ammonia and sulphate of Luteocobalt. In other cases it yields the acid sulphate of Purpureocobalt. By double decomposition with salts of barium the sulphate of Roseocobalt yields the other salts of this base.

The reactions of the sulphate are somewhat different from those of the chlorid, as will be seen from the following statement.

Ferridcyanid of potassium gives no precipitate at first, but after two hours very distinct and well defined small augitic crystals.

Cobaltidcyanid of potassium behaves in a precisely similar manner, giving red crystals.

Neutral chromate of potash gives no precipitate. The bichromate gives none at first, but after two or three hours, groups of reddish brown needles.

We shall hereafter state our reasons for believing that in certain cases there is a conversion of the triacid Roseocobalt in the sulphate of this base, into the biacid Purpureocobalt.

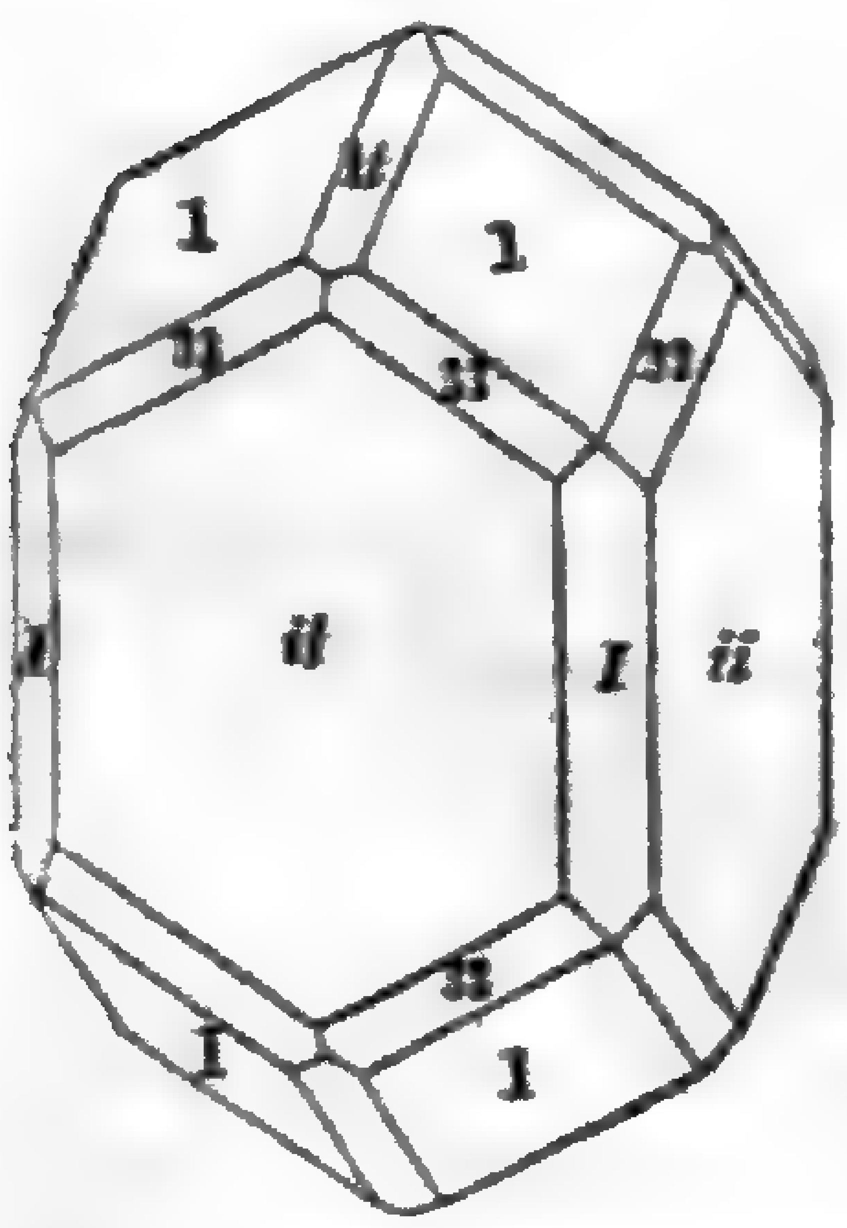
ANHYDROUS NITRATE OF ROSEOCOBALT.

The ammoniacal solution of nitrate of cobalt absorbs oxygen very readily from the air, and the oxydation is usually complete after a few days. As a general rule, a considerable quantity of nitrate of Luteocobalt is formed under these circumstances, and being insoluble in the ammoniacal liquid, forms a bright yellow crystalline precipitate upon the bottom and sides of the vessel. During the process of the oxydation, crystals of the compound described by Frémy as the nitrate of Oxycobaltiaque are frequently formed in some quantity, but these disappear at a later stage of the oxydation, when the liquid takes a deep wine-red color. The crystals of nitrate of Oxycobaltiaque were first observed by Leopold Gmelin. We have not particularly examined or analyzed them, though Frémy's analyses do not appear to us satisfactory.

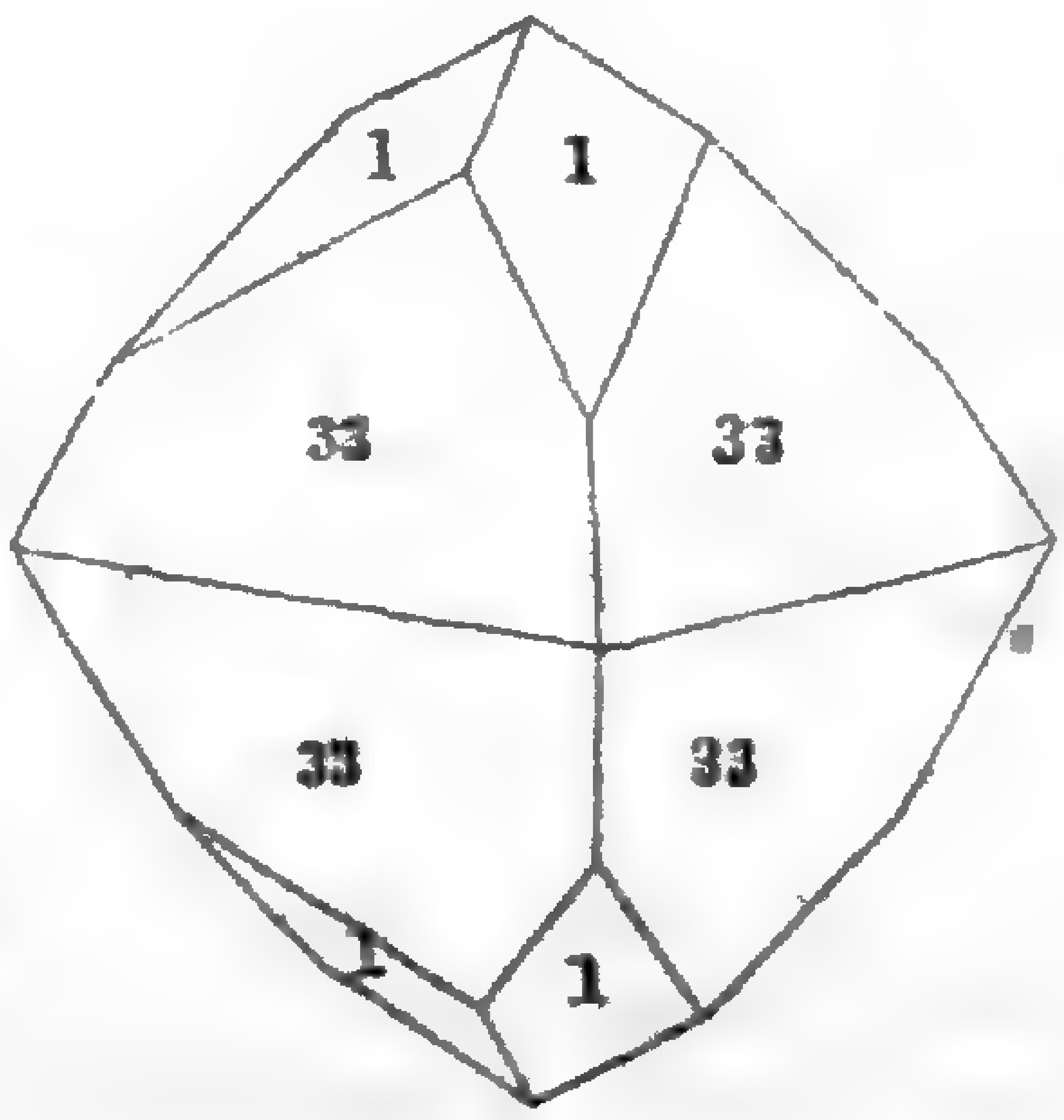
The dark-red liquid formed under these circumstances contains nitrate of Roseocobalt. When nitric acid is added to this solution, a brick-red precipitate is thrown down, which is the hydrated nitrate of Roseocobalt. This nitrate is readily soluble in water, and exists unchanged in the solution, but by boiling with nitric acid, the solution yields a fine violet-red crystalline precipitate of the anhydrous nitrate of Roseocobalt. The presence of nitrate of ammonia facilitates the oxydation and formation of nitrate of Roseocobalt, but is not indispensable.

The preparation of pure nitrate of Roseocobalt is attended with difficulty, as the precipitated crystalline nitrate almost always contains a little nitrate of Luteocobalt. It is best to dissolve the crude nitrate in water, to which a little ammonia has been added, to filter and allow the solution to evaporate spontaneously. After some days, large and well defined crystals of the nitrate are formed, while the bottom of the evaporating vessel is covered with minute red crystals of the same salt. The difference between the appearance of the large and small crystals is so great that we suspected a difference in their constitution. Analysis and the behavior of the two kinds towards reagents, showed, however, no difference. A marked variation in the color of the large and small crystals of the same substance is very commonly observed in the ammonia-cobalt compounds, and might easily lead to erroneous conclusions. The nitrate of Roseocobalt is readily prepared by decomposing a solution of the chlorid with nitrate of silver, but the solubility of the chlorid of silver in chlorid of Roseocobalt renders it somewhat difficult to obtain a pure salt in this manner. Nitrate of copper also gives nitrate of Roseocobalt with chlorid of copper, when mixed with an equivalent proportion of chlorid of Roseocobalt, but the purification is difficult. Finally, a pure nitrate may be prepared by double decomposition of nitrate of baryta and sulphate of Roseocobalt. The anhydrous nitrate of Roseocobalt, when in large crystals, has a fine red color, which, according to Chevreul's determination, as given by Frémy, is the first red $\frac{2}{10}$. The crystals are dichrous; the ordinary image is clear rose red, the extraordinary image bright red. According to Prof. Dana, this salt, like the sulphate, crystallizes in forms belonging to the dimetric system. Figs. 4 and 6 represent some of the more usual combinations, fig. 5 is a very rare form, which was obtained only once.

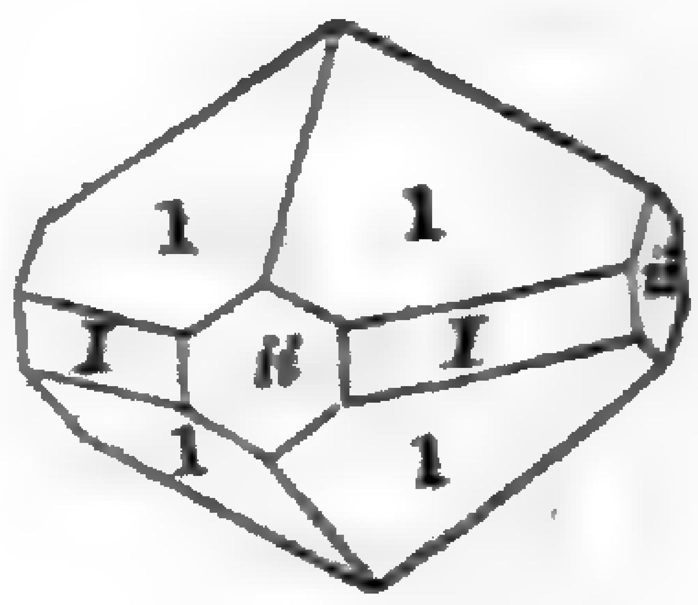
4.



5.



6.



1 : 1 (over the base) = 82° 40′. Whence 0 : 1 (not observed) = 138° 20′; *I* : 1 = 131° 40′.

Ammonia dissolves the nitrate with a fine purple red tint, and the salt usually crystallizes unchanged from the solution, though sometimes the hydrous nitrate is obtained. In cold water the nitrate is rather insoluble, though more soluble than the sulphate. Hot water dissolves it rather more easily; but the solution, unless it be acid, is quickly decomposed, and this effect is very speedily produced by boiling. The products of the decomposition in this case are a dark-brown oxyd of cobalt, and a solution containing the nitrate of Luteocobalt and nitrate of ammonia. The quantity of Luteocobalt is small in comparison with that of the nitrate of Roseocobalt employed.

When heated, the nitrate of Roseocobalt explodes, though not with violence. A black anhydrous oxyd remains, which is probably Co_2O_3. The reaction in this case is easily explained, if we remark that the oxygen in the nitric acid is exactly sufficient to form water with the hydrogen of the ammonia. The simplest equation representing the reaction is

$$5NH_3.Co_2O_3, 3NO_5 = Co_2O_3 + 8N + 15HO.$$

In point of fact, however, the decomposition is less simple, as red vapors are always evolved.

When a current of NO_4 is passed through a solution of nitrate of Roseocobalt a rapid absorption takes place, and after a short time crystals of nitrate of Xanthocobalt are deposited.

A solution of sulphurous acid converts the nitrate of Roseocobalt, at first into an orange-colored compound containing SO_2, and afterward reduces this completely to nitrate and sulphate of cobalt and nitrate of ammonia.

Nitrate of Roseocobalt has the formula

$$5NH_3.Co_2O_3, 3NO_5,$$

as the following analyses show:

0·2308 grs. gave 0·1081 grs. sulphate of cobalt = 17·82 per cent cobalt.
0·1272 grs. gave 0·0599 grs. " " = 17·92 " "
0·1448 grs. gave 0·0681 grs. " " = 17·90 " "
0·9370 grs. gave 0·3915 grs. water = 4·64 per cent hydrogen.
0·6632 grs. gave 0·2862 grs. " = 4·79 " "
2·7812 grs. gave 1·1258 grs. " = 4·57 " "
0·5564 grs. gave 168 c. c. nitrogen at 24° C. and 766^{mm}·31 (at 24°·5) = 150·54 c. c. at 0° and 760^{mm} = 33·98 per cent.
0·7400 grs. gave 213 c. c nitrogen at 13°·5 C. and 764^{mm}·28 at (13°·8) = 200·55 c. c. at 0° and 760^{mm} = 34·03 per cent.

The formula above mentioned requires

	Eqs.	Calculated.		Mean.	Found.		
Cobalt,	2	59·0	17·87	17·88	17·82	17·92	17·90
Hydrogen,	15	15·0	4·55	4·60	4·64	4·79	4·57
Nitrogen,	8	112·0	33·93	34·01	33·98	34·03	——
Oxygen,	18	144·0	43·65	43·51	——	——	——
		330·0	100·00	100·00			

When nitrate of Roseocobalt is dissolved in water containing much nitrate of ammonia and a little ammonia, and the solution is allowed to evaporate spontaneously, beautiful purple-red scaly crystals separate. These crystals cannot be purified by recrystallization, as they are decomposed by solution in water. When boiled with chlorhydric acid there is copious effervescence and a purple-red solution is obtained, which appears to contain the chlorid of Purpureocobalt. The empirical formula of the scaly nitrate appears to be $5NH_3.Co_2O_3, 2NO_5+7HO$. From the effervescence with muriatic acid we are disposed to consider it $4NH_3.Co_2O_3, NO_5+NH_4O, NO_5+6HO$, but further investigation is required before we can pronounce with certainty on this point.

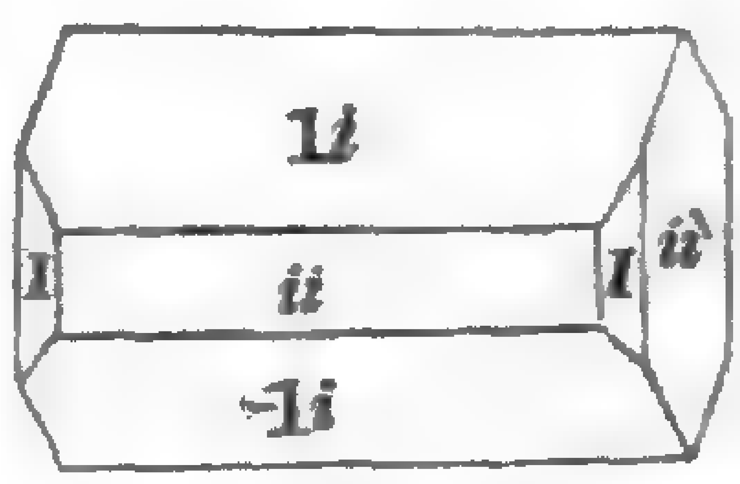
HYDROUS NITRATE OF ROSEOCOBALT.

When ammonia is added in excess to a solution of the nitrates of cobalt and of ammonia and the solution is exposed to the air, oxydation takes place with considerable rapidity, and as we have already stated when speaking of the anhydrous nitrate, the solution becomes dark purple-red, while yellow scales of the nitrate of Luteocobalt are more or less abundantly deposited upon the bottom of the vessel. When the red liquid is boiled with nitric acid in excess, a dark crimson precipitate of nitrate of Roseocobalt is formed, while a portion of the same salt remains in solution. It has hitherto been supposed from these facts that the anhydrous nitrate of Roseocobalt is a direct product of the oxydation of the ammoniacal liquid. This, however, is not the case. If the oxydized liquid be filtered from the nitrate of Luteocobalt and allowed to evaporate spontaneously, very fine large oblique rhombic crystals are formed, which are the hydrous nitrate of Roseocobalt.

The crystals of this nitrate belong to the monoclinic or oblique rhombic system, according to Prof. Dana's determination. The observed forms are *I*, 1*i*, *ĭi*, -1*i*, *iĭ*, or in other symbols, ∞, 1-∞, ∞-∞, —1-∞, ∞-∞̆. Fig. 7. The angles are

I : *I* = 103°
1*i* : *ii* = 136°
-1*i* : *ii* = 140° 30′
1*i* : 1*i* = 96° 30′ and 83° 30′

7.



The hydrous nitrate of Roseocobalt is readily soluble even in cold water; the hot neutral solution is very easily decomposed with evolution of ammonia and precipitation of a black powder. The addition of a few drops of nitric acid prevents the decomposition. An excess of nitric acid added to a cold solution of the nitrate produces a brick-red precipitate, which is readily soluble in cold water, and which is the unchanged salt. The solution has a dark brick-red color, and exhibits all the reactions of the chlorid of Roseocobalt. When boiled with an excess of nitric acid for some time, the brick-red color gradually becomes violet-red, and there remains at last a beautiful violet precipitate, which is the anhydrous nitrate of Roseocobalt. From this it appears that, in some cases at least, and particularly when nitrate of ammonia is present during the oxydation, the hydrous nitrate of Roseocobalt is the first product of the oxydation of an ammoniacal solution of nitrate of cobalt, and that it is the action of nitric acid upon this salt which converts it into the anhydrous nitrate. The nitrate of Roseocobalt obtained by direct oxydation may be recrystallized by adding to its solution a few drops of nitric acid and allowing it to stand a few days for spontaneous evaporation. In this manner beautiful crystals are obtained, adhering to the bottom of the evaporating vessel, and mixed with a dull-red matter in crystalline crusts, which exhibits the same reactions with the large and clear crystals, and appears to have the same constitution, though upon this point we cannot speak with certainty at present.

We consider the formula of the hydrous nitrate of Roseocobalt as most probably

$$5NH_3 . Co_2O_3, 3NO_5 + 2HO$$

as the following analyses indicate:

0·8265 grs. gave 0·3703 grs. sulphate of cobalt = 17·05 per cent cobalt.
0·5275 grs. gave 0·2370 grs. " " = 17·09 " "
0·8012 grs. gave 217·8 c. c. nitrogen at 11°·5 C. and $761^{mm}·48$ (at 11°·4 C.) = 206·05 c. c. at 0° and 760^{mm} = 32·30 per cent.
0·7667 grs. gave 207 c. c. of nitrogen at 14° C. and $766^{mm}·56$ (at 14°·2 C.) = 194·91 c. c. at 0° and 760^{mm} = 31·92 per cent.

The formula requires

	Eqs.	Calculated.	Found.	
Cobalt,	2	16·95	17·05	17·09
Nitrogen,	8	32·18	32·30	31·92

It is true that the analyses here agree with the formula as well as can be reasonably expected. We have, however, found in other crystals from the same mass 17·82, 17·86, 17·92, 18·06 per cent cobalt, numbers which agree much better with the formula of an anhydrous nitrate, having the same formula as the nitrate of Roseocobalt already described, which contains 17·87 per cent. In any event, the doubt appears to be simply with respect to the quantity of water in the salt, the ratio of the equivalents of cobalt and nitrogen being as 1 to 4, or 2 to 8. We shall return to this point at another time.

OXALATE OF ROSEOCOBALT.

The oxalate is precipitated from the chlorid almost immediately by the addition of a solution of oxalate of ammonia. From a solution of the nitrate it is deposited much more slowly, often only after some hours, and sometimes in remarkably distinct and well formed crystals. The oxalate as first thrown down may be purified by solution in ammonia-water and recrystallization by spontaneous evaporation. The salt then forms beautiful prismatic crystals, which are nearly insoluble in water, and which have a fine cherry-red color, resembling the crystals of sulphate of Roseocobalt. The crystals are dichrous, the ordinary image being pale violet, while the extraordinary image is dark rose-red. The precipitated oxalate has a dull brick-red color. According to Prof. Dana, the crystals of oxalate of Roseocobalt belong to the right rhombic or trimetric system, the observed forms being a rhombic prism of about 101° 48′, with a brachydome of 108° 54′.

The constitution of the oxalate of Roseocobalt is represented by the formula

$$5NH_3.Co_2O_3, 3C_2O_3+6HO$$

as the following analyses show:

0·5504 grs. gave 0·2625 grs. sulphate of cobalt = 18·15 per cent.
0·3325 grs. gave 0·1585 grs. " " = 18·14 "
1·5381 grs. gave 0·6170 grs. carbonic acid = 32·82 per cent oxalic acid.

The formula requires

	Eqs.	Calculated.	Found.	
Cobalt, - -	2	17·87	18·15	18·14
Oxalic acid, - -	3	32·73	32·82	——

COBALTIDCYANID OF ROSEOCOBALT.

This beautiful salt is precipitated from a solution of the chlorid or hydrous nitrate of Roseocobalt, by a solution of cobaltidcyanid of potassium. It may be prepared with equal facility from a solution of the chlorid of Purpureocobalt, which under these circumstances, as we conceive, undergoes a direct change into a salt of the triacid Roseocobalt. The cobaltidcyanid is usually precipitated at once in the form of cherry-red prismatic crystals, which, so far as it is possible to judge from their appearance under the microscope, belong to the oblique rhombic or monoclinic system, much resembling some of the simpler forms of augite. The salt is very insoluble in cold water; hot water readily decomposes it. It forms an extremely characteristic test for the salts of Roseocobalt in general, as well as for the chlorid of Purpureocobalt, but, as already remarked, it is precipitated from the sulphate of Roseocobalt only after some hours. The crystals are usually remarkably large when compared with the mass of liquid from which they are thrown down. They are more distinct in form the more slowly the precipitation takes place. The salt has the formula

$$5NH_3 . Co_2Cy_3 + Co_2Cy_3 + 3HO.$$

as the following analyses show:

0·1924 grs. (from chlorid of Purpureocobalt) gave 0·1540 grs. sulphate of cobalt = 30·46 per cent cobalt.

0·7150 grs. (from chlorid of Roseocobalt) gave 0·5755 grs. sulphate of cobalt = 30·63 per cent cobalt.

0·8111 grs. (from chlorid of Roseocobalt) gave 272 c. c. of nitrogen at 10° C. and 761^{mm}·99 (at 10° C.) = 259·48 c. c. at 0° and 760^{mm} = 40·18 per cent.

The formula requires

	Eqs.	Calculated.	Found.	
Cobalt, - -	4	30 57	30 63	30 46
Nitrogen, - -	11	39·89	40·18	

The analyses of the ferridcyanid of Roseocobalt give additional evidence of the correctness of the formula adopted for this salt.

FERRIDCYANID OF ROSEOCOBALT.

The ferridcyanid is formed like the cobaltidcyanid by adding a solution of ferridcyanid of potassium to one of chlorid or nitrate of Roseocobalt or chlorid of Purpureocobalt. A very beautiful orange-red precipitate is thrown down in distinct and usually extremely well-defined crystals, which under the microscope, exactly resemble those of the corresponding cobalt salt. The crystals exhibit a remarkable dichroism, the ordinary image being of a fine purple rose color, while the extraordinary image is bright orange red. The crystals are insoluble in cold water; hot water easily decomposes them, ammonia being evolved, while a dark-brown precipitate is thrown down. Heat decomposes the dry salt very gradually and uniformly, and leaves a black residue which contains much carbon. We availed ourselves of this fact to determine accurately the sum of the cobalt and iron in the salt, by first decomposing it by heat, then burning off the carbon in a gentle current of oxygen, and finally reducing the mixed oxyds of cobalt and iron in a current of hydrogen. The formula of this salt is

$$5NH_3 . Co_2Cy_3 + Fe_2Cy_3 + 3HO$$

as the following analyses show:

0·3613 grs. gave 0·1086 grs. metallic iron and cobalt = 30·05 per cent.

1·5028 grs., burnt with oxyd of copper and oxygen, gave 1·0302 grs. carbonic acid = 18 69 per cent carbon.

The formula requires

	Eqs.	Calculated.	Found.
Cobalt and iron, - -	4	30·02	30·05
Carbon, - - -	12	18·79	18·69

There can be no reasonable doubt that this salt is isomorphous with the corresponding cobalt salt. Like the latter it is an extremely valuable test for the salts of Roseocobalt and for certain salts of Purpureocobalt.

OXYD OF ROSEOCOBALT.

The oxyd of Roseocobalt exists only in solution. It is obtained either by decomposing the chlorid by oxyd of silver, or by adding baryta-water to a cold solution of the sulphate; the latter method is the better one, because the chlorid of silver is soluble in solutions of the chlorid of Roseocobalt. The solution as thus obtained is red, has an alkaline non-metallic taste and reaction, and is very easily decomposed. By standing in the air it absorbs carbonic acid and forms a carbonate.

MAGNETIC OXYD OF COBALT.

In connection with the salts of Roseocobalt we may perhaps with propriety describe the peculiar oxyd of cobalt, which is, in some cases at least, one of the products of their decomposition. The hydrated oxyd which is precipitated by boiling the neutral salts of Roseocobalt with an alkaline solution is considered by Frémy as a hydrate of the sesquioxyd, and he attributes to it the formula Co_2O_3, HO. According to the same chemist, all the other ammonia-cobalt bases give this hydrate by boiling with solutions of the alkalies. It does not appear probable that the oxyd obtained by boiling the neutral solution should have a different constitution. We have however found that the dark-brown oxyd obtained by boiling a solution of sulphate of Roseocobalt, and afterward washing and drying the precipitate in the air, has the formula

$$Co_3O_4+3HO$$

as the following analyses show:

I. 0·4430 grs. gave 0·6990 grs. sulphate of cobalt = 60·05 per cent of cobalt.
II. 0·9269 grs. gave 0·1672 grs. water (ignited with chromate of lead) = 18·03 per cent.
III. 0·7150 grs. ignited in hydrogen gas gave 0·3010 grs. water, which in connection with the 2nd analysis gives 21·38 per cent oxygen in the oxyd of cobalt.

The formula requires

	Eqs.		Calculated.	Found.
Cobalt, - -	3	88·5	60·00	60·05
Oxygen, - -	4	32·0	21·69	21·38
Water, - -	3	27·0	18·30	18·03
		147·5	100·00	99·46

Frémy's formula requires 64 per cent of cobalt. Claudet gives also the formula Co_3O_4+3HO as probable, but without analyses. On the other hand, it is possible that the different salts, not only of Roseocobalt but of the other similar bases, may give different oxyds by decomposition. We propose to examine this point more fully hereafter.

The hydrate above mentioned and analyzed is a very dark-brown powder, which dries to a black mass with a gummy lustre. The powder is dark brown. Oxalic acid dissolves it to a green solution, without evolution of gas, but this is decomposed by heating. Chlorhydric acid also dissolves the oxyd, with evolution of chlorine and formation of the protochlorid.

We have already mentioned that the anhydrous magnetic oxyd of cobalt is sometimes obtained during the decomposition of the chlorid of Roseocobalt by heat. We are, however, not able to state precisely under what circumstances this occurs; either water or the oxygen of the air must take part in the decomposition, since the chlorid contains no oxygen. The anhydrous oxyd occurs in the form of small steel-gray octahedra, which are very hard, and which can only be dissolved by long heating with sulphuric acid, or by fusion with sulphate of potash. Nitric, chlorhydric, and nitro-muriatic acids have no decided action upon them.

1·6425 grs. of this oxyd gave 1·2059 grs. of metallic cobalt = 73·41 per cent.
1·6425 grs. ignited in hydrogen gave 0·4879 grs. water = 25·91 per cent oxygen.

The formula Co_3O_4 requires

	Eqs.		Calculated.	Found.
Cobalt, - -	3	88·5	73·44	73·41
Oxygen, - -	4	32·0	26·56	25·01
		120·5	100·00	99·32

This oxyd has recently been described by Schwarzenberg, who obtained it by igniting chlorid of cobalt with free access of air, until the chlorine is expelled. It is, therefore very probable that in the decomposition of chlorid of Roseocobalt by heat, the chlorid of cobalt is first produced, and then decomposed in the manner observed by Schwarzenberg.

With respect to the black sulphid which is thrown down from solutions of the ammonia-cobalt bases by sulphid of ammonium, it can scarcely be doubted that this is the bisulphid, as Claudet's analyses lead directly to the formula CoS_2, corroborating the results obtained by Dingler already alluded to.

PURPUREOCOBALT.

The salts of Purpureocobalt are often found among the direct products of the oxydation of ammoniacal solutions of cobalt. They are often formed from the salts of Roseocobalt by heating or by boiling with strong acids, the cobalt passing, as we conceive, from one modification to another. The salts of Purpureocobalt are also formed in great abundance by the action of acids upon salts of Xanthocobalt, and we are disposed to think that they may also occur, though rarely, among the products of the decomposition of salts of Luteocobalt.

The salts of Purpureocobalt are distinguished by a fine violet-red or purple color, which is common to nearly all of them, and which is very different from the comparatively dull red of the salts of Roseocobalt. They are in general somewhat less soluble than the compounds of Roseocobalt, and crystallize, for the most part, in well defined crystals. When neutral they have a purely saline, non-metallic taste.

Heat readily decomposes the salts of this base; the final products of the decomposition are the same as in the case of the salts of Roseocobalt, but intermediate products are often formed. The neutral solutions are readily decomposed by boiling, the products of the decomposition being a black or dark-brown oxyd of cobalt and a salt of ammonium, free ammonia being given off. In some cases, however, salts of Luteocobalt are intermediate products of this decomposition.

All the salts of Purpureocobalt by long boiling with an excess of chlorhydric acid yield the chlorid.

CHLORID OF PURPUREOCOBALT.

The substance which we shall describe under the name of chlorid of Purpureocobalt is the same as that to which Frémy gave the name of chlorid of Roseocobaltiaque. In the course of our investigations it at length became clear that, under the name of salts of Roseocobalt, the compounds of two perfectly distinct bases have hitherto been confounded. It became, therefore, necessary to devise a new name. The purple color of the salts which correspond to the chlorid now to be described, led us to adopt the name of Purpureocobalt for the radical of these salts, as more appropriate than Roseocobalt, which we have retained for most of the salts to which it was originally applied. Such a change is to be regretted; it could not, however, have been avoided, without an introduction of two entirely new names.

We have already stated that the chlorid of Purpureocobalt is often a product of the direct oxydation of an ammoniacal solution of the chlorid of cobalt exposed to the air. In these cases it is sometimes mixed with chlorid of Roseocobalt, and sometimes forms the entire product of the oxydation. We believe that the temperature at which the process of oxydation goes on is the condition which determines the character and the amount of the chlorid which is formed during the oxydation. The chlorid of Roseocobalt is, in our view, the first product of the oxydation under all circumstances. At a moderately high temperature, however, the chlorid passes as fast as it is formed into chlorid of Purpureocobalt, which may thus be the only final product of the oxydation, or may be mixed with variable proportions of the chlorid of Roseocobalt.

In one experiment made during the summer season, and in which chemically pure chlorid of cobalt and ammonia were employed, the process of oxydation went on very slowly, without the precipitation of any trace of sesquioxyd of cobalt. The liquid had a dull purple color, and gave with reagents no precipitates or reactions to indicate the presence of chlorid or oxyd of Purpureocobalt or Roseocobalt. On boiling with chlorhydric acid, however, the chlorid of Purpureocobalt was thrown down in abundance, and no other substance could be detected in the supernatant liquid. In this case the oxydized liquid gave no precipitate with chlorhydric acid in the cold, but the cold solution, after some hours standing, deposited distinct crystals of chlorid of Purpureocobalt. We believe that in this case a combination of the oxyd and chlorid existed in the solution, so that, as we have already suggested in speaking of the chlorid of Roseocobalt, the oxydation itself would be expressed by the equation

$$6CoCl+15NH_3+3O=5NH_3.Co_2O_3+2(5NH_3.Co_2Cl_3).$$

If we admit that the oxyd and chlorid of Purpureocobalt as thus formed are actually in combination so as to form a sort of oxychlorid, and are not merely mechanically mixed, we may perhaps explain, why no precipitates of salts of Purpureocobalt are obtained in the oxydized liquid, since the reagents added might not be able to overcome the affinity between the oxyd and chlorid. It is easy to see that by boiling with chlorhydric acid, the combination of oxyd and chlorid will give the chlorid alone, since we may have the equation

$$5NH_3.Co_2O_3+2(5NH_3.Co_2Cl_3)+3HCl=3(5NH_3.Co_2Cl_3)+3HO.$$

We have already mentioned that the chlorid of Roseocobalt is readily converted into chlorid of Purpureocobalt, by boiling with chlorhydric acid, or even by gently heating its solution. This circumstance explains why only the chlorid of Purpureocobalt is obtained by boiling a completely oxydized ammoniacal solution of chlorid of cobalt, even when this solution contains only Roseocobalt, or a mixture of Roseocobalt and Purpureocobalt. It also enables us to understand why all writers upon the ammonia-cobalt bases, up to the period of the present investigation, entirely overlooked the chlorid of Roseocobalt, and consequently described the salts of that base, as if they corresponded to, and contained the same radical as chlorid of Purpureocobalt.

It is not necessary to add chlorid of ammonium to the ammoniacal solution of chlorid of cobalt, in preparing the chlorid of Purpureocobalt. It is, however, advantageous to do so, because, the oxyd of Purpureocobalt is converted by it as fast as formed into the chlorid, and the formation of the oxychlorid is prevented. To prepare the chlorid of Purpureocobalt in a pure state from the oxydized liquid, it is only necessary to boil this with an excess of chlorhydric acid. A crimson powder is thrown down, while the supernatant liquid becomes nearly colorless, provided, at least, that a pure salt of cobalt was employed, and that the oxydation was complete. The mother liquor is to be poured off and the precipitate dissolved in a large quantity of boiling water, to which enough chlorhydric acid has been added to render the solution distinctly acid. On cooling, the solution gives small but beautiful crystals of the chlorid, almost perfectly pure. A second crystallization usually removes all traces of impurity. It is not, however, necessary to use a pure chlorid of cobalt in preparing the chlorid of Purpureocobalt. Any commercial oxyd will answer, even when arsenic, nickel, iron, &c., are present. On the other hand, it is easy to prepare a perfectly pure chlorid of cobalt, by heating the chlorid of Purpureocobalt in a porcelain crucible until vapors of ammonia and chlorid of ammonium cease to be given off. The pure chlorid of cobalt thus obtained, is remarkable for its beauty of color, the anhydrous chlorid forming pale blue talcose scales, while the solution and the crystals obtained from this have a very fine violet-red tint.

The chlorid of Purpureocobalt may be prepared by other methods. One of the most interesting of these is, by the action of strong chlorhydric acid upon a salt of Xanthocobalt. It is almost a matter of indifference which salt of Xanthocobalt is employed. As, however, the nitrate is, perhaps, most easily obtained in a pure state, it is usually most advantageous to employ this. The nitrate has the formula

$$NO_2.5NH_3.Co_2O_3,\ 2NO_5+HO.$$

On boiling with chlorhydric acid, the salt is slowly converted from a brown-yellow to a lilac-purple powder, which is insoluble in the supernatant acid liquid. After boiling strongly for an hour or two, almost all the original salt is decomposed, NO_2 is given off in abundance during the boiling, while a lilac colored uncrystallized mass remains at the bottom of the flask. The supernatant liquid is to be poured off, and boiling water added to the insoluble portion. A brown-yellow or dark sherry wine colored solution is usually formed, which is again to be poured off, and the washing repeated till the liquid has a clear purple color. The red mass is then to be dissolved in boiling water, to which a little chlorhydric acid has been added, and filtered. On cooling, the chlorid of Purpureocobalt crystallizes in small brilliant crystals, which must be repeatedly recrystallized to separate all traces of impurity. The washings, on boiling with chlorhydric acid, yield a fresh portion of the chlorid. The reaction which takes place under these circumstances may be expressed by the equation

$$NO_2.5NH_3.Co_2O_3,\ 2NO_5+3HCl=NO_2+2NO_5,\ HO+ 5NH_3.Co_2Cl_3+HO.$$

As already remarked, the chlorid or sulphate of Xanthocobalt may be employed in a precisely similar manner, and also yield the chlorid of Purpureocobalt. When the sulphate is used, however, the resulting chlorid is apt to retain sulphuric acid with much obstinacy, and can with difficulty be freed from it.

Another method of preparing the chlorid of Purpureocobalt, consists in boiling the chlorid or nitrate of Roseocobalt with chlorhydric acid. This method is very convenient, and yields a very pure chlorid.

The chlorid of Purpureocobalt may also be prepared by boiling the acid sulphate of this base with chlorhydric acid. In this case, however, as in all others in which sulphuric acid is present in the solution, the chlorid should be boiled with a little chlorid of barium, and repeatedly recrystallized, to separate traces of the isomorphous sulphate of Roseocobalt formed at the same time.

The chlorid of Purpureocobalt has a beautiful violet-red or purple color, and is dichrous, the ordinary ray being colorless, while the extraordinary ray has a rich violet-red tint. Its solution is violet-red. The salt is nearly insoluble in cold water, but is soluble without decomposition in boiling water to which a few drops of chlorhydric acid have been added. From this solution it separates, on cooling, in very brilliant small crystals, which are simpler in form, the purer the solution from which they have crystallized. The crystals belong to the square prismatic or dimetric system, according to Prof. Dana, and not to the regular system, as stated in previous memoirs. The observed forms are the octahedron and first and second prism. $P.\infty P\infty.P\infty$. The angles in Dana's notation are (see fig. 1):

$1 : 1$ over the base $= 114° 8'$; over the top $= 65° 52'$.
$1 : 1$ over the terminal edge $= 107°—107° 20'$ (calculated $107° 12'$).
$O : 1$ (calculated) $= 122° 56'$.
$O : 1i$ (calculated) $= 132° 30'$.
$1i : 1i$ over the base $= 95°$; over the top $= 85°$.
$a = 1{\cdot}0916$.

The crystals are usually small but extremely well formed; those which are obtained from solutions containing a little chlorid of mercury most frequently exhibit the planes of the first and second prism, and are larger than those which separate from pure solutions. From these measurements, it appears that the chlorid of Purpureocobalt is isomorphous with the sulphate of Roseocobalt. This isomorphism is the more remarkable, inasmuch as a precisely similar case occurs with the chlorid and sulphate of Luteocobalt, between which there is a similar difference of constitution. Thus we have

$$5NH_3 . Co_2Cl_3 = 5NH_3 . Co_2O_3, 3SO_3 + 5HO$$
$$6NH_3 . Co_2Cl_3 = 6NH_3 . Co_2O_3, 3SO_3 + 5HO.$$

From this it appears that in both cases we have the crystallographic equallity

$$3Cl = O_3, 3SO_3 + 5HO.$$

The density of the crystals of chlorid of Purpureocobalt, as taken in alcohol, is 1·802 at 23° C.; the atomic volume of the chlorid is consequently 139·0.

The chlorid of Purpureocobalt has the formula

$$5NH_3 . Co_2Cl_3$$

as appears from the following analyses:

0·5215 grs. gave 0·3230 grs. of sulphate of cobalt = 23·58 per cent cobalt.
0·4962 grs. gave 0·3073 grs. " " = 23·57 " "
0·8514 grs. gave 0·5279 grs. " " = 23·55 " "
1·4116 grs. gave 0·8732 grs. " " = 23·55 " "
0·7550 grs. gave 0·4105 grs. water = 6·04 per cent hydrogen.
0·6116 grs. gave 0·3412 grs. " = 6·19 " "
0·6124 grs. gave 0·3365 grs. " = 6·10 " "
1·4184 grs. gave 0·7800 grs. " = 6·11 " "
1·6636 grs. gave 2·8540 grs. chlorid of silver = 42·40 per cent chlorine.
0·4754 grs. gave 0·8200 grs. " " = 42·49 " "
0·1966 grs. gave 0·3365 grs. " " = 42·31 " "
0·4972 grs. gave 0·8553 grs. " " = 42·52 " "
0·5963 grs. gave 143 c. c. nitrogen at 18° C. and $772^{mm}·4$ (at 18°·4 C.) = 113·19 c. c. at 0° and 760^{mm} = 28·05 per cent nitrogen.
0·5542 grs. gave 134 c. c. nitrogen at 19° C. and $766^{mm}·56$ (at 19°·4 C.) = 123·26 c. c. at 0° and 760^{mm} = 27·93 per cent nitrogen.
0·6036 grs. gave 168·16 c. c. nitrogen at $752^{mm}·60$ and 15° C, h = $93^{mm}·5$, t = 15°·6 C, = 135·08 c. c. at 0° and 760^{mm} = 28·11 per cent nitrogen.
0·5755 grs. gave 160·39 c. c. nitrogen at $771^{mm}·39$ and 15° C, h = $112^{mm}·7$, t = 15° C, = 128·86 c. c. at 0° and 760^{mm} = 28·12 per cent nitrogen.

The nitrogen in these as in all our analyses was moist.

Hence we have

	Eqs.		Theory.	Mean.	Found.			
Cobalt,	2	59	23·55	23·56	23·58	23·57	23·55	23·55
Chlorine,	3	106·5	42·50	42·43	42·49	42·31	42·52	42·40
Hydrogen,	15	15	5·98	6·11	6·04	6·19	6·10	6·11
Nitrogen,	5	70	27·97	28·01	28·05	27·93	28·12	28·11
		250·5	100·00	100·11				

The agreement of these analyses leaves no reasonable doubt that the true formula of the chlorid of Purpureocobalt is $5NH_3 . Co_2Cl_3$, as first correctly determined by Rogojski, and subsequently by Gregory. Frémy gives in addition one equivalent of water, while Claudet makes 16 in place of 15 equivalents of hydrogen. That the salt, however, contains but 15 equivalents is clear, from the fact that free nitrogen and hydrogen are found among the products of its decomposition by heat in an atmosphere of carbonic acid gas, which could not be the case upon Claudet's view, since we should then have the equation

$$N_5H_{16}Co_2Cl_3=5NH_3+2CoCl+HCl,$$

while the presence of free nitrogen and hydrogen renders it probable that the decomposition is in reality expressed by the equation

$$5NH_3.Co_2Cl_3=2CoCl+NH_4Cl+3NH_3+N+2H.$$

We have more than once endeavored to determine the amount of gas actually given off during this decomposition, with the view of verifying the equation just given. In every case, however, a portion of the chlorid of cobalt was reduced, either by the free ammonia or by the hydrogen, so that much metallic cobalt was found mixed with the chlorid. A neutral solution of the chlorid of Purpureocobalt is readily decomposed by boiling, a dark-brown precipitate, probably of the hydrated magnetic oxyd, being thrown down, while the solution becomes brown-yellow, and contains chlorid of ammonium and chlorid of Luteocobalt, ammonia being at the same time given off. The quantity of chlorid of Luteocobalt which is thus formed is always very small, being very much less than one equivalent for two equivalents of the chlorid of Purpureocobalt.

On the other hand, a solution of chlorid of Purpureocobalt may be boiled for a very long time with concentrated chlorhydric acid without decomposition, and this stability in the presence of acids is one of the most remarkable peculiarities of the whole class of ammonia-cobalt bases.

Chlorhydric acid and the alkaline chlorids precipitate chlorid of Purpureocobalt from its solutions almost completely, slowly in the cold, but instantly on boiling. Ignited in a current of hydrogen, the salt yields metallic cobalt as a gray spongy mass. Heated in an open crucible, the salt fuses and swells up, giving off abundant vapors of chlorid of ammonium and ammonia, while pure chlorid of cobalt remains in lavender-blue scales. In some cases, however, this is mixed with metallic cobalt, while in others, in which the ignition takes place with free access of air, brilliant iron-black octahedra are formed, which are the anhydrous magnetic oxyd of cobalt, Co_3O_4. The red gas arising from the action of nitric acid upon starch or sawdust exerts a very remarkable influence upon the chlorid of Purpureocobalt, converting it into the nitrate of a base, which will be described further on under the name of Xanthocobalt.

Sulphurous acid solution throws down from solutions of the chlorid a dull orange-brown precipitate, which appears to be a sulphite. By boiling with an excess of the acid this is reduced, and there remains a solution of a protosalt of cobalt.

Sulphuric acid, under certain conditions, converts chlorid of Purpureocobalt into the acid sulphate of the same base.

Zinc may be boiled a long time with an acid solution of the chlorid without producing decomposition or reduction. Formic and oxalic acids have no reducing action. Protochlorid of tin simply unites with the chlorid of Purpureocobalt so as to form a chloro-salt.

The chlorid of Purpureocobalt exhibits a remarkable tendency to unite with metallic chlorids to form chloro-salts. Such compounds are formed with the chlorids of Platinum, Palladium, Mercury, Tin, Zinc, and various other metals. The chlorid of Purpureocobalt even dissolves chlorid of silver in large quantity, doubtless forming with it a double chlorid. It is for this reason, that it is not generally advantageous to prepare the salts of Purpureocobalt by double decomposition between the chlorid and salts of silver.

The reactions of a pure solution of the chlorid of Purpureocobalt are as follows:

Ferrocyanid of potassium gives a yellowish precipitate which quickly becomes chocolate-brown.

Ferridcyanid of potassium gives a beautiful bright orange-red crystalline precipitate.

Cobaltidcyanid of potassium gives a fine red crystalline precipitate.

Oxalate of ammonia gives a beautiful purple-red precipitate of fine needles.

Pyrophosphate of soda gives a lilac precipitate easily soluble in an excess of the precipitant.

Neutral chromate of potash gives a brick-red precipitate.

Bichromate of potash gives orange-yellow scales.

Picrate of ammonia gives a beautiful yellow precipitate.

Terchlorid of gold precipitates the chlorid unchanged.

Bichlorid of platinum gives a fine cinamon-brown precipitate of crystalline scales.

Sulphid of ammonium gives a black precipitate.

Chlorid of mercury gives fine rose-red needles, easily decomposed.

Bichlorid of tin gives pale peachblossom-red silky needles.

Molybdate of ammonia gives a pale peachblossom-red precipitate.

Alkalies and their carbonates give no precipitate.

Iodid and bromid of potassium give no precipitate.

Chlorhydric acid and the alkaline chlorids throw down the chlorid of Purpureocobalt from its solutions as a violet-red powder. The reactions of the chlorid of Purpureocobalt with the ferridcyanid and cobaltidcyanid of potassium and with oxalate of ammonia are not sufficient to distinguish it from the chlorid of Roseocobalt, which, when pure and freshly prepared, gives also precipitates with these reagents. The character of the precipitates with oxalate of ammonia, bichlorid of platinum, and bichromate of potash enable us, however, readily to distinguish the chlorid of Purpureocobalt from chlorid of Roseocobalt, with which, however, it is not likely to be confounded.

(To be continued.)

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the alloys of Aluminum.*—MM. C. and A. Tissier have communicated a short note on this subject which is of importance at the present time when the interest in aluminum which had somewhat fallen off is beginning to revive. The authors find that the valuable properties of aluminum are injured by the presence even of small quantities of other metals. One-twentieth of iron or copper make it almost impossible to work the alloy, while one-tenth part of copper renders aluminum as brittle as glass. An alloy of 5 parts of silver with 100 of aluminum works like silver but is harder and takes a finer polish. The one-thousandth of bismuth renders aluminum so brittle that it cracks under the hammer even after being repeatedly annealed. The presence of aluminum in other metals often communicates valuable properties when the quantity is not too large. Thus $\frac{1}{20}$th part of aluminum gives copper a beautiful gold color and hardness enough to scratch the standard alloy of gold employed for coins, whilst at the same time injuring the malleability of the copper. One-tenth of aluminum gives with copper a pale gold-colored alloy of great hardness and malleability, and capable of taking a polish like that of steel. Five parts of aluminum with 100 parts of pure silver give an alloy almost as hard as silver coin containing $\frac{1}{10}$th of copper, and thus permits us to harden silver without introducing a poisonous metal.—*Comptes Rendus*, xliii, 885, *Nov.* 3, 1856.

Debray has also communicated the results of experiments on the alloys of aluminum, apparently more numerous and varied than those of the MM. Tissier. An alloy of aluminum and sodium easily decomposes water, a fact which was the occasion of much loss in the early experiments on the manufacture of aluminum. The aluminum is however easily purified from sodium as well as from iron by a simple fusion with saltpeter. An alloy of 95 parts of iron with 5 of aluminum does not differ essentially in properties from iron. An alloy of 90 parts of copper with 10 of aluminum may be forged by the aid of heat and is not acted on by sulphydrate of ammonia. It has a fine yellow color but is inferior in lustre to the alloy of 95 copper to 5 of aluminum. An alloy of 97 parts of aluminum and 3 of silver has a very beautiful color, and is not acted on by sulphuretted hydrogen.—*Comptes Rendus*, xliii, 925, *Nov.* 10, 1856.

2. *On the preparation of Lithia.*—Troost has given an easy and simple method of preparing this earth from its ores. When a mixture of lepidolite, carbonate and sulphate of baryta is heated in a good wind furnace the matter fuses and gives at the bottom of the crucible a viscid glass above which an extremely fluid liquid is found which may be poured off while the crucible is hot. If the crucible be allowed to cool, two solid masses are formed, which are easily separated. The upper mass is crystalline and white or slightly rose colored from the presence of manganese. This mass is a combination of the sulphates of baryta, potash, and lithia; by simple washing the alkaline sulphates may be separated from the sulphates of baryta. The same process succeeds with petalite if we add to it such a quantity of sulphate of potash as will make the total quantity of alkali about the same as in lepidolite. By adding more potash to lepidolite itself, the author succeeded in separating still more of the lithia, about 3 per cent. Sulphate and carbonate of lime may be used in place of the salts of barium.—*Comptes Rendus*, xliii, 921.

3. *On Glycol.*—Wurtz has given the name of glycol to a new organic body, obtained from the iodid of elayl, $C_4H_4I_2$, and having the formula $C_4H_6O_4$. When the iodid is mixed with 2 equivalents of dry acetate of silver a violent reaction ensues which yields among other products a neutral fluid which is the acetate of glycol. The reaction is simply $C_4H_4I_2 + 2C_4H_3AgO_4 = C_4H_4O_2, 2C_4H_3O_3 + 2AgI$. The acetate is a limpid liquid, neutral and without odor. It boils at 185° C., and is heavier than water. The acetate has the formula $C_4H_4O_2 \begin{cases} C_4H_3O_3 \\ C_4H_3O_3 \end{cases}$, the base being biacid. When the acetate is digested with 2 equivalents of fused caustic potash for several hours in an oil-bath at 180° and then distilled at 250°, the glycol passes over as a colorless liquid, which boils at 195° and distills unchanged. Glycol is a limpid oily liquid which has a sweetish taste, and is soluble in all proportions, in water and alcohol. Its formula is $C_4H_6O_4$, and it therefore differs from alcohol in containing 2 eqs. more of oxygen. The author considers it as a true biatomic alcohol, so that we have

Alcohol	$C_4H_6O_2$	uniatomic,
Glycol	$C_4H_6O_4$	biatomic,
Glycerin	$C_6H_8O_6$	triatomic.

While alcohol loses one equivalent of water in forming acetate of ethyl, glycol loses two in forming its corresponding diacetate, and glycerin three in forming its triacetate. In this way is shown, as the author states for the first time in organic chemistry, the principle of inorganic chemistry, that the number of equivalents of an acid which saturates a base is in a simple ratio to the quantity of oxygen in the base.

All salts of silver are decomposed by the iodid of elayl, and in this manner a great number of bodies are obtained which stand midway between the ethers and the fats. Bromid of propylene $C_6H_6Br_2$, acts upon acetate of silver and yields the acetate of propyl-glycol $C_6H_6O_2$, $2C_4H_3O_3$, from which potash separates propyl-glycol $C_6H_8O_4$. Acetal is a mixed ether of glycol, its formula being $C_4H_4O_2, 2C_4H_5O$. The author has also prepared the analogous bodies $C_4H_4O_2 \left\{ \begin{matrix} C_4H_5O \\ C_2H_3O \end{matrix} \right.$ and $C_4H_4O_2 \left\{ \begin{matrix} C_2H_3O \\ C_2H_3O \end{matrix} \right.$; they are etherial liquids which are not decomposed by potash.—*Berichte der Berliner Akad. der Wissen. quoted in Journal für prakt. Chemie,* lxviii, 111.

4. *Action of iodid of phosphorus upon glycerine.*—BERTHELOT and DE LUCA have published a memoir upon allyl and its ethers which adds many interesting facts to those already observed by Hofmann and Cahours (see this Journal, vol. xxi, p. 415), and by Zinin. The authors in the first place give a sketch of the properties and formulas of the allyl compounds already known and pass then to the description of the radical itself. Allyl may be prepared by the action of sodium upon iodid of allyl, C_6H_5I. The radical is a volatile liquid having a peculiar penetrating etherial odor analogous to that of horseradish. It boils at 89° C.; its density is 0·684 at 14° C. The density of its vapor is 2·92 = 2 vols. The action of the halogens upon allyl is peculiar. These bodies unite directly with the radical to form compounds containing 2 equivalents of the halogen to one of allyl. Of these the chlorid is liquid while the bromid and iodid are crystalline solids. The authors point out the distinction between iodated propylene, C_6H_5I, and iodid of allyl, $C_6H_5I_2$, which differ in constitution only by one equivalent of iodine and which would be naturally supposed to contain the same radical, being related to each other apparently as a protiodid and deutiodid. This however is not the case, since it is not possible to convert the one into the other. Hence the carburet set free by sodium from iodated propylene does not bear the same relation to the iodid from which it is derived which a radical does to its own iodid. On the other hand sodium regenerates allyl from its bromid and iodid, $C_6H_5Br_2$ and $C_6H_5I_2$. The authors point out the necessity of admitting the existence of three distinct radicals having the formula C_6H_5, which exist in the compounds of propylene, allyl, and glycerine respectively. In like manner allyl-alcohol has the same composition and the same equivalent as acetone and propionic aldehyd, while its chemical and physical properties are very different.—*Ann de Chimie et de Physique,* xlviii, 286, *Nov.,* 1856.

5. *Action of the chlorids and bromids of phosphorus upon glycerine.*—The same chemists have studied the action of the chlorids and bromids of phosphorus upon glycerine. The products in the case of the chlorids of phosphorus have been described by Berthelot. They are monochlorhydrine $C_6H_7ClO_4$, dichlorhydrine $C_6H_6Cl_2O_2$, and epichlorhydrine $C_6H_5ClO_2$. The bromine compounds are analogous, but in addition the authors give various other substances as products of the reaction. Among these are hemibromhydrine $C_{12}H_9BrO_4$, hexaglyceric bromhydrine $C_{36}H_{29}BrO_{14}$, acroleine $C_6H_4O_2$, a phosphorus amid $C_{12}H_9Br_2P$, tribromhydrine $C_6H_5Br_3$, an amid having the formula $C_{12}H_{12}BrNO_4$, and glycerammine $C_6H_9NO_4$. The new base glycerammine is liquid and soluble in water and ether; its platinum salt has the formula $C_6H_9NO_4, HCl+PtCl_2$. Glycerammine forms the first instance of an alkaloid formed by a body belonging to the class of sugars.—*Ann. der Chimie et de Physique,* xlviii, 304.

6. *On the formation of urea by the oxydation of albuminous matters.*—Béchamp has succceeded in showing that urea is one of the products of the oxydation of albuminous bodies. The author effects the decomposition by an alkaline solution of hypermanganate of potash. The fibrine of the blood and gluten yield also urea by the same process. From these experiments it is clear that the oxydation of albuminous matters under an alkaline influence yields products very different from those obtained at a higher temperature by means of oxydizing mixtures of peroxyd of manganese or bichromate of potash and sulphuric acid.—*Ann. de Chimie et de Physique*, xlviii, 348.

7. *On triphenylamin.*—Gössmann finds that when oil of cassia is shaken with a concentrated solution of acid sulphite of ammonia, a crystalline mass is produced which when washed with alcohol and distilled with lime gives among other products an oily colorless base, which is triphenylamin. The base changes easily in the air, as do its salts. The platinum salt is a dark yellow flocky precipitate which is soluble in alcohol and crystallizes over sulphuric acid in large chestnut-brown crystals belonging to the regular system. Its formula is $C_{36}H_{16}NCl+PtCl_2$ or $N(C_{12}H_5)_3HCl+PtCl_2$. Iodid of ethyl when heated with the pure base in closed tubes give the iodid of triphenyl-ethyl-ammonium.—*Ann. der Chemie und Pharmacie*, c, 57.

8. *On some products of the oxydation of alcohol.*—Debus has discovered among the products of the oxydation of alcohol by nitric acid a new acid which he terms glyoxylic acid, and which has the formula $C_4H_4O_8$ or $C_4H_3O_7+HO$. The acid does not crystallize but forms a thick yellowish syrup. It is easily soluble in water, decomposes the carbonates and saturates the strongest bases.—*Ann. der Chemie und Pharm.*, c, 1–19.

9. *On the quantitative determination of boric acid.*—Stromeyer finds that Berzelius's process for the determination of boric acid in the form of fluoborate of potassium yields accurate results when the boric acid is combined with an alkali, particularly potash, at least one equivalent of potash being present for one of acid. The boric acid is first united with a sufficient quantity of potash, pure fluohydric acid added, and the whole evaporated to dryness, an excess of fluohydric acid being present. The fluoborate separates at first as a jelly which afterward forms small hard crystals. The dry mass is to be stirred with a solution of acetate of potash of 20 per cent, and allowed to stand for some hours, when the supernatant liquid is to be poured upon a weighed filter; this is repeated several times, when the fluoborate is also brought upon the filter and washed with the acetate until the filtrate is no longer precipitated by chlorid of calcium. The acetate is then to be washed out by alcohol of 84 per cent and dried at 100° C. A solution of acetate of potash dissolves chlorid of potassium, nitrate, phosphate, and even, though with difficulty, sulphate of potash. The presence of soda salts should be avoided as the fluorid of sodium is soluble with difficulty. The author obtained however, good results with borax. Other bases must be previously separated. The fluoborate takes up but little space; the filtration must be performed on a funnel of gutta-percha or india-rubber. The evaporation must be performed in vessels of silver or platinum.

10. *On organic compounds containing metals.*—FRANKLAND has discovered two remarkable acids which result from the action of nitric oxyd upon zinc-ethyl and zinc-methyl. Zinc-ethyl slowly absorbs nitric oxyd, forming a crystalline body which inflames in the air. This body is a compound of dinitro-ethylate of zinc and zinc-ethyl. Water decomposes this body, yielding oxyd of zinc, dinitro-ethylate of zinc, and ethyl-hydrogen, the reaction being

$$N_2C_4H_5O_4Zn+ZnC_4H_5+HO=C_4H_5,\ H+N_2C_4H_5O_4Zn+ZnO.$$

Dinitro-ethylic acid is monobasic and has the formula $N_2C_4H_6O_4$ or $N_2C_4H_5O_3+HO$. The acid exists only in solution and is easily decomposed; its salts are soluble in water and alcohol and do not crystallize easily. A salt of this acid, when heated with concentrated sulphuric acid at 0°, is decomposed, yielding nitrogen, nitrous oxyd, nitric oxyd, and olefiant gas. Zinc-methyl forms precisely analogous compounds. Frankland considers it difficult in the present state of our knowledge to give a satisfactory theory of the constitution of these bodies, but in the mean time refers them to the type of nitrous acid, in which one equivalent of oxygen is replaced by one of an alcohol radical, so that we have

$$N \left\{ \begin{array}{l} CnHn+1, \\ NO_2, \\ O. \end{array} \right.$$

Ann. der Chemie und Pharm., xcix, 333.

[I will here throw out the suggestion that Frankland's new acids may possibly be conjugates of protoxyd of nitrogen. Thus the dinitro-ethylic acid may be $2\overset{\frown}{NO.C_4}H_5O+HO$. This view would satisfactorily explain the decomposition of the salts by sulphuric acid as well as the formation of the acid, which last would be represented by the equation

$$C_4H_5.Zn+2NO_2=2\overset{\frown}{NO.C_4}H_5O+ZnO. \qquad \text{W. G.]}$$

11. *Action of sulphuric acid upon the nitriles and amids.*—BUCKTON and HOFMANN have studied the action of sulphuric acid upon the amids and nitriles, setting out from the known fact that strong sulphuric acid converts cyanhydric acid into carbonic oxyd and bisulphate of ammonium. As we have in this case the reaction

$$HC_2N+HO+H_2S_2O_8=2CO+\left.\begin{array}{l} H \\ NH_4 \end{array}\right\} S_2O_8,$$

it might be expected that we should also have the reaction expressed by the equation

$$C_2H_3C_2N+2HO+H_2S_2O_8=2CO+\left.\begin{array}{l} H \\ NH_3(C_2H_3) \end{array}\right\} S_2O_8.$$

Experiment however did not confirm the expectation but led to the discovery of a new series of sulpho-acids of remarkable character. By the action of sulphuric acid upon acetonitril (cyanid of methyl) or acetamid the authors obtained a new acid, the barium salt of which has the formula $C_2H_2Ba_2S_2O_{12}+4aq$, or $C_2H_2S_2O_{10}+2BaO+4aq$. Buckton and Hofmann call the new acid disulphometholic acid; it is bibasic and forms numerous crystalline salts. The sulphacetic acid of Melsens is also formed during the action of sulphuric acid upon acetonitril and acetamid, and the authors regard the reaction as divided into two phases which may be explained by the following equations:—

$$C_4H_3N+2HO+2H_2S_2O_8=C_4H_4S_2O_{10}+\left.\begin{matrix}H\\NH_4\end{matrix}\right\}S_2O_8,$$

$$C_4H_3N+3H_2S_2O_8=C_2H_4S_4O_{12}+\left.\begin{matrix}H\\NH_4\end{matrix}\right\}S_2O_8+2CO_2.$$

By precisely analogous processes the authors obtained disulphetholic acid $C_4H_4H_2S_4O_{12}$, and sulphopropionic acid $C_6H_4H_2S_2O_{10}$, disulphopropiolic acid $C_6H_6H_2S_2O_{12}$, and sulphobutyric acid $C_8H_6Ba_2S_2O_{10}$, disulphobenzolic acid $C_{12}H_4H_2S_4O_{12}$, and sulphobenzoic acid. The new series of acids may empirically be regarded as compounds of one equivalent of marsh gas and its homologues with five of anhydrous sulphuric acid. By the action of fusing sulphuric acid upon Gerhardt's sulphanilic acid B. and H. obtained a new acid which they term disulphanilic acid, the barium salt of which has the formula $C_{12}H_5Ba_2NS_4O_{12}$ or $C_{12}H_5NS_4O_{10}+2BaO$. In conclusion the authors establish the identity of disulphometholic acid with Liebig's methionic acid obtained by the action of anhydrous sulphuric acid upon ether at a low temperature. Strecker has established the same fact in an independent investigation of methionic acid and its salts.—*Ann. der Chemie und Pharm.*, c, 129 and 199, *Nov.*, 1856.

W. G.

II. MINERALOGY AND GEOLOGY.

1. *Note on the occurrence of Telluret of Silver in California;* by William P. Blake, (Proceedings Acad. Nat. Sci. California).—A specimen obtained from Georgetown, California, resembling a fragment of tarnished lead or silver glance, is found on examination to be chiefly composed of silver and tellurium. The mass is about one inch in length and breadth, and is entirely free from gangue, but incloses native gold, which appears at several points on its surface. An aggregation of cubical crystals, resembling galena, is implanted on one side, and the other is deeply indented with angular cavities probably the prints of quartz crystals. The massive parts of the specimen are sectile and do not show any traces of crystallization; they may be cut with a knife like lead, and give a brilliant metallic surface. Hardness about 2 of Mohs' scale.

In the open tube, before the blowpipe flame, the mineral fuses quietly, coloring the glass a bright yellow under the assay; a white or gray sublimate is deposited at a short distance from, or immediately over it, which, on being heated, fuses into transparent drops resembling oil.

On charcoal, it fuses readily to a leaden-colored globule, which, on cooling, becomes covered with little points or dendrites. This globule flattens under the hammer, but breaks on the edges. With the addition of a little carbonate of soda a globule of silver is readily obtained. A fragment heated to redness in a closed tube or matrass with carbonate of soda and charcoal dust, gives on the addition of a few drops of boiling water the beautiful violet-red or purple solution described by Berzelius as characteristic of tellurium. This solution loses its color after standing for some time, and a dark colored powder is deposited. The mineral dissolved in hot nitric acid with the separation of tellurous acid in crystals.

It is probably the species *Hessite*, but the decision upon this point is reserved until further examinations are made. Its color is darker than the hessite of Savodinsky, Siberia, and it is not quite so hard.

This very rare mineral has not hitherto been observed in America, and its occurrence is therefore of peculiar interest. I am indebted to P. C. Currier, Esq., of Georgetown, for the specimen. It was obtained in that vicinity and probably taken from the auriferous drift, but it can not have been transported far from the original source.

The crystals give reactions for lead and sulphur, and a trace of selenium. They are probably galena but may contain tellurium.

A specimen seen in California in 1854, weighing about two ounces, greatly resembled the massive part of the specimen above described. A small fragment of it which was then obtained also gives the reactions for tellurium and silver. Its precise locality is unknown.

It is probable that tellurium combined with silver, lead, or bismuth will be found in the auriferous quartz of Grass Valley and other localities. A few specimens in my possession contain small brilliant grains resembling tetradymite, but their exact character is not yet determined.

2. *Notices of Remains of Extinct Vertebrated Animals discovered by Professor E. Emmons;* by JOSEPH LEIDY, M. D., (Proc. Acad. Nat. Sci. Philad., viii, 255).—CETACEA. (1.) *Orycterocetus cornutidens*, Leidy (*O. quadratidens*, Proc. A. N. S., vii, 378).—The genus was originally proposed on several long horn-like teeth, together with fragments of jaws found in the miocene deposit of Virginia. Prof. Emmons has also discovered a tooth, apparently of the same species, in the miocene deposit of North Carolina. The tooth bears a wonderful resemblance to the horn of a young ox. It is nearly 5 inches long in the curve and over an inch in diameter at base, which is hollowed into a deep conical cavity, as in the spermaceti whale.

(2.) *Drepanodon impar*, Leidy.—This species is founded on the crown of a tooth discovered by Prof. Emmons in the miocene deposit of Cape Fear, North Carolina. The specimen, in form, bears a strong resemblance to the crown of the inferior canine tooth of a bear, but it has only one trenchant ridge, and this is situated postero-internally. The enamel is thin and smooth; the base of the crown is hollowed conically. Length of specimen 10 lines; breadth at base antero-posteriorly 7 lines, transversely 5 lines.

(3.) *Pliogonodon priscus*, Leidy.—Founded on two much mutilated specimens, consisting of the crowns of teeth, discovered by Prof. Emmons in a miocene deposit of Cape Fear, in North Carolina. Teeth elongated conical, nearly straight or only slightly curved inwardly, in section circular, with a pair of opposed carinæ on the inner side; surfaces divided into numerous narrow planes, with a few vertical interrupted plicæ, which are more numerous on the inner side. Enamel finely wrinkled; and the dentine concentric. Base of crown hollowed. Probable length of crown when perfect 2 inches, breadth of the base $\frac{3}{4}$ of an inch. The teeth differ from those of *Mosasaurus* in their narrower proportion, straightness, circular section, and plicæ of enamel; from those of *Polyptychodon* in the possession of divisional planes and opposed carinæ; and from those of *Pleiosaurus* in the former character and the circular section.

(4.) *Palæosaurus? (Compsosaurus) priscus*, Leidy, ante p. 165.—Half a dozen isolated teeth of this saurian are contained in the collection of Prof. Emmons.

(5.) *Omosaurus perplexus*, Leidy.—An Enaliosaurian, based upon a number of teeth of varied character, vertebræ, fragments of ribs and other bones, and the impression of a dermal plate, obtained from the coal-field [mesozoic] of Chatham Co., North Carolina, by Prof. Emmons and also by Prof. M. Tuomey. Teeth elongated conical, pointed, nearly straight, or more or less moderately curved inwardly, with opposed carinæ on the inner side, which are entire or denticulated; transverse section subcircular, flattened internally; surfaces even, or more or less distinctly fluted on the outer side or all around, and covered with minute interrupted ridges, which are vertical on the even surface, oblique on the fluted surface, and divergent downward in the vicinity of the carinæ. Crown solid, enamel thin, dentine concentric; fang subcylindrical, hollowed at base. Length from 5 lines to $1\frac{3}{4}$ inches, breadth from 2 lines to $4\frac{3}{4}$ lines. Bodies of the vertebræ bi-concave and much constricted, as in *Palæosaurus?* and *Clepsysaurus*. Length of one of the posterior cervical bodies 16 lines, depth of its articular surfaces 17 lines, width 15 lines. Dermal plate covered with radiating, bifurcating and anastomosing ridges. Allied to *Clepsysaurus* and *Centemodon*, Lea, and probably identical with them.

Labyrinthodonta. (6.) *Dictyocephalus elegans*, Leidy.—Founded on the upper portion of a cranium discovered by Prof. Emmons in the coal-field of Chatham Co., N. C. Plates of the cranium covered with reticular ridges in a general radiant manner. Parietals comparatively short, broader in front than behind; parietal foramen near the centre of the bones. Occipitals quadrate, a little longer than broad. Posterior outline of the cranium with a superficial transverse concavity on each side and not a deep sinus as in *Trematosaurus* and *Archegosaurus*. Breadth of occipital outline 28 lines; length of parietals $8\frac{1}{2}$ lines, breadth anteriorly $3\frac{3}{4}$ lines, posteriorly 3 lines. Probable length of head, considering it to have had nearly the proportions of *Trematosaurus*, 4 inches, breadth $2\frac{1}{4}$ inches.

Pisces. (7.) *Ischyrhiza antiqua*, Leidy.—The genus was originally based on a tooth found in the Greensand of New Jersey. Two teeth apparently of a second species have been obtained by Prof. Emmons on the Neuse River, N. C. Crown of the teeth, when perfect, apparently, laterally compressed conical. Fang robust, quadrately pyramidal, curved; with a rugged base which is bifurcated antero-posteriorly and more deeply before than behind. Pulp cavity entirely closed at bottom. Probable length of specimens when entire $1\frac{1}{2}$, and 2 inches; length of fang 10 lines, and 1 inch; breadth of crown at base antero-posteriorly 5 lines, 6 lines; laterally $3\frac{3}{4}$ l., $4\frac{3}{4}$ l.; breadth of fang at bottom antero-posteriorly 7 l., $8\frac{1}{2}$ l.; laterally $6\frac{1}{2}$ l., 7 l.

3. *Report of the Geological Survey in Kentucky, made during the years* 1854 *and* 1855; by David Dale Owen, Principal Geologist, assisted by Robert Peter, Chemical Assistant, Sidney S. Lyon, Topographical Assistant. 416 pp., large 8vo, with plates, maps and sections. Frankfort, Kentucky.—This fine and large volume is new evidence that the people of the land appreciate the importance of searching into the rocks for their mineral wealth, and studying the strata also for their scientific developments. Geological surveys have been carried on in nearly all the states of the Union, and although much remains to be done, we

are beginning to know the country we inhabit, and develop its abundant resources. Kentucky is now adding her part to the rock-map of the continent, and we trust the work over that large state will be carried on until its geology is thoroughly understood. Her coal and iron beds are inducements enough for extended research, if these were the only results to be looked for. Already the Breckinridge coal region is becoming the seat of a new manufacture for the county, the distillation undertaken, on a large scale, yielding benzole, lubricating oil, paraffine, and other valuable products.

This volume presents the results of nearly two years exploration. It gives a general sketch of the rocks as far as now explored, with details of portions brought under special examination. The formations recognized in the state are briefly mentioned as follows:—

"(1.) Superficial Deposits or Quaternary loam, marl, clays, and gravel, belonging to the age of the Mammoth, Mastodon, and Megalonyx, or Pleistocene formation.

This includes all those fine deposits of comparatively recent date, which appear to have settled in wide expansions of our great rivers, just previous to the time when they contracted into their present channels, together with the associated gravel beds.

(2.) The Coal Measures: embracing the sandstones, shales, ironstones, millstone grit, and conglomerate, together with the limestones associated with the *workable* beds of coal.

(3.) Subcarboniferous Limestone, chert and fine grained sandstones, being the strata on which the coal measures repose, and extending down to the

(4.) Black Lingula Shales: i. e., all the dark argillaceous beds on which the Subcarboniferous sandstones and limestones of the Knobby Regions rest, near the mouth of Salt river, the head of Green river, and that part of the Cumberland situated between its Narrows and the Turkey Neck Bend, belonging to the Devonian Era.

(5.) Grey Coralline Falls Limestones, including the limestones under the black shales which form the falls of the Ohio, down to the chain coral or *Catenipora* limestone, and which are referable to the Devonian Epoch.

(6.) The Chain coral and Upper Magnesian Cliff Limestones, such as occur on Beargrass and elsewhere in Jefferson county.

(7.) The Blue, Shell and Birdseye Limestones of Fayette and Franklin counties, and throughout most of the so-called Blue-grass counties of Middle and Northern Kentucky.

As yet no formations of more ancient date than this latter have been discovered; hence, all its formations, so far as at present known, belong to the sedimentary and fossiliferous series, of purely aqueous origin, and, with the exception of the Lacustrine loams, marls, and subordinate gravel beds, all have been formed beneath the bed of an ocean."

Among the facts under the first of these divisions, a description is given of the bone deposit on Canoe Creek, a tributary of the Ohio, five to six miles below Henderson. The bones belong to the *Megalonyx Jeffersonii.* They were found 70 feet below the ancient channel of Canoe Creek, and 5 or 6 feet above the ordinary low stage of water. With them occur, in the ferruginous sand, shells of *Paludina ponderosa*, *Melania canaliculata*, *Cyclas rivularis, Physa heterostropha, Lymnæa elongata, Planorbis bicarinata, P. lens, Valvata tricarinata* (all of *Say*), along with fragments of Unios, and stems and limbs of trees. The specimens of Megalonyx bones are described in the Smithsonian Contributions by Dr. Leidy. Lignite or brown coal is not uncommon in the Quaternary deposits.

The extent and general features of the Coal Measures are thus described:—p. 29.

"A very large area of Kentucky is occupied by this, the most important of geological formations, in a practical point of view. There is, indeed, no State in the Union, except Kentucky, whose territory extends over a large area of *two* coal fields.

In southwestern Kentucky the whole of eight counties and a part of four other counties are embraced in the Middle coal field of the Mississippi valley, or the coal field which lies partly in Illinois, partly in Indiana, and partly in Kentucky. In Eastern Kentucky fifteen counties, and a large area of five more counties, are included in the great Appalachian coal field, i. e., in the coal region occupying the western slopes of the Alleghany mountains and the Cumberland range, situated partly in Pennsylvania, Virginia, Ohio, Tennessee, and these above mentioned eastern counties of Kentucky.

Of the hundred and three counties of this State, more than twenty-six counties may be considered as situated upon the Coal Measures—or over one quarter of the whole area of the State.

The geological formations of the southwestern coal field of Kentucky are better understood, at present, than its eastern coal field, lying more remote from the Ohio river. I have spent, however, several months last summer in a reconnoissance of a considerable portion of the eastern coal field, and am able now to furnish important information in regard to its extent, resources, and the qualities of some of the principal beds.

The approximate boundaries of the southern coal field, situated in Kentucky, are as follows: commencing on the Ohio river at the mouth of Tradewater, it runs up the valley of that stream, whose course very nearly coincides with its southwestern limits. From near the sources of Tradewater, in the northern part of Christian county, its southern boundary runs by the head-waters of Pond river, near the lines dividing Muhlenberg, Todd, Logan, and Butler counties, crossing Muddy river near its forks; thence through the southern part of Butler county, crossing Barren river between the mouth of Gasper river and the junction of Barren river and Green river; thence east along the divide between those rivers, through Warren and Edmonson counties, to near the mouth of Nolin creek; thence nearly north to the mouth of Dismal. Either an outlier or tongue of the coal measures appears to stretch away to the east, to the confines of Grayson and Hart counties, and even on to the waters of Roundstone; but the main boundary takes from Dismal creek a northwesterly course south of Grayson Springs, near the sources of Clay Lick and Caney creeks, towards the Falls of Rough creek; thence north by the sources of Panther creek, nearly along the line dividing Hancock and Breckinridge counties, until it strikes the Ohio river again at the Great South Bend, near the limits of the above counties.

Such are the general boundaries of this coal field, as far as at present ascertained. All the territory included between this line and the Ohio river may be regarded as belonging to the coal formation, but the line cannot be defined in all its meanders until the detailed survey shall have been carried through Hopkins, Muhlenburg, Christian, Todd, Butler, Warren, Edmonson, Grayson, Hart, Breckinridge, and Hancock, and their topography plotted accurately, as has been accomplished of Union and part of Crittenden counties.

The coal beds included in these counties naturally divide themselves into Upper and Lower Coal Measures. These are separated from each other not only by a prominent sandstone formation, but they have been cast off from continuity, immediately on the Ohio river, by an extensive uplift and dislocation of the geological formation which stretches from Gold Hill, on the Illinois side of the Ohio river, across the bed of that stream, at Shawneetown, to Bald Hill, in Union county.

The Topographical Assistant, in his detailed survey of Union county, has traced a continuation of this upheaval in a nearly east and west course through the entire county. Beyond the Valley of Cypress this disturbed belt has an increased width to the boundary of Henderson county. Beyond this point it has not yet been systematically followed; but the occurrence of disturbances, with a reversal of dip, near the confluence of Pond and Green rivers, render it probable that it can be traced completely through the coal field.

In Kentucky there is no evidence whatever that this disturbance occurred prior to the deposition of the coal measures; on the contrary it has implicated in its movements not only the Subcarboniferous limestone and Millstone grit, but also the entire coal formation, which lies in conformable dip on either side of the axis. In the northeast edge of Union county, and in the bed of the Ohio river, the tilted strata, lying immediately in the line of greatest disturbance, are cast up on edge and lie in great confusion—especially where the strata seem to have partially sunk back into the chasm—and thus been much fractured, crushed, and thrown out of place, so as to convey, to limited observation, the appearance of unconformability; but it can be conclusively shown that the coal measures north and south of this disturbance were deposited in one and the same basin. For a limited space along the Ohio river, the Shawneetown fault has rent asunder the coal measures, and thrown off the upper coal measures to the north, and the lower coal measures to the south; but in the interior of Union county the upper coal measures occur on both sides of the disturbance, and, though their continuity is broken for a certain distance, the perfect identity of some of the beds on both sides of the disturbance is clearly apparent. North of this disturbance the upper coal measures prevail as high up the river as its south bend, in Davies county; south of this disturbance, down to the mouth of Tradewater, the coal measures extend even to the elevated ridges of Duffis' creek."

The upper coal measures comprise at least eight workable beds of coal, in a thickness of nearly 2000 feet.

The rock separating the upper and lower coal measures has been called the *Anvil Rock*, a name originating from the accidental form of two masses in Union county, southwestern Kentucky. The thickness of the beds of the lower are over 900 feet, and they contain ten workable beds of coal, one of them about five feet thick and the others one to three feet. Average specific gravity of the coal 1·284, giving very nearly eighty lbs. to the cubic foot. The coal of the five foot seam gave for its specific gravity 1·308, and for the total volatile matter 39·5 per cent with five per cent of light gray ashes.

The Coal Measures afford numerous beds of iron ores. In the upper 400 feet of the strata of the southwestern coal field, there are from four to six different beds of limestone; one, the Carthage limestone, cropping out on the Ohio river, a mile below Uniontown, is eight feet thick, and two others have about the same thickness. The lower 900 feet of the coal measures afford only two limestone beds worthy of note, immediately on the Ohio river; one over the first coal under the Anvil Rock (observed in Illinois but not yet in Kentucky), and one about four feet thick, lying under the sixth bed of coal above the Anvil Rock called the Curlew coal. The lower southern Coal Measures are richer in limestones than their southwestern equivalents. A seven-foot coal bed in Hopkins and Muhlenberg counties has generally a heavy dark bituminous limestone two or three feet thick overlying it. At Greenville there is a brecciated layer seven or eight feet thick.

Almost all the beds of coal rest on a bed of fire-clay, and these underclays very generally afford remains of *Stigmaria ficoides.*

The *Black Lingula shale* which underlies the Subcarboniferous rock is a little over 100 feet thick at the Falls of the Ohio, where it is in sight. To the north it gradually thins out.

The Report, besides chapters also on the Devonian and Silurian rocks, contains a long and valuable chemical report by Dr. Robert Peter, giving the results of 169 analyses of iron ores, coals, limestones, soils, etc., with important observations on these materials. It also treats of some mineral waters. The volume closes with a Topographical Geological Report of that portion of Kentucky including Union and part of Crittenden counties, surveyed in 1854 and 1855 by Sidney S. Lyon, Topographical Assistant, illustrated by a large map.

4. *On a Shower of Ashes over the plains of Quito;* by Rev. George Jones, U. S. N. (From a letter to Prof. Silliman, dated Quito, Ecuador, Dec. 13, 1856.)—*Non cuivis homini contingit adire Corinthum*—said Horace; and I suppose the same fact respecting Quito will help to give an interest to a letter from an old friend at this place. The interest to you will be increased when I tell you that I write in the midst of what looks like one of our snow-storms at home, the important difference being that our skies are dropping upon us *ashes* instead of snow. Yesterday morning we noticed that at the south the sky had an unusual appearance, being of a purple color for about 90° along the horizon and so up to about 45° in height, the edge of this being mixed up with patches of white. About 12 o'clock ashes began to fall; first in small quantities, but, by 8 o'clock, the fall had got to be so considerable as to powder the clothes quickly, on our going out; and people coming into a house would look as we do at home when coming in from a snow-storm.

We all presumed that this must come from Cotopaxi, which is about thirty miles from us in a South by East direction, and has been in a greater or less state of activity for about a year. We had, here, a fall of ashes about a month ago, but that was so slight as scarcely to be perceptible. The ashes then were black and coarser than in the present case: I send you a specimen of these which are falling now. I have just taken a careful measurement, and find that the depth, on a level, is one-quarter of an inch. This may not appear to be a great deal; but when we consider our distance from Cotopaxi, and that the whole country is covered over to that depth, the aggregate will be seen to be considerable. The fall of ashes is now not so great, but they are still coming down, looking in the air like a thin mist or a light snow-storm. The country has a most singular and melancholy appearance. The ashes are heavy and the trees are bowed under their loads, while every where, in the streets and on the hill sides, there is the same ashy color, to which the sun, scarcely seen, gives only an additional sickly hue. Last night, although the moon was but one day past being full, was the darkest night that I think I have ever seen. [The ashes appear under a lens to be feldspar grains.]

There has been considerable uneasiness and anxiety in this place, probably through fear of convulsions in Cotopaxi that may reach to Quito; while indeed the sufferings to cattle must now be considerable, as all the grass has on it this thick coating of ashes. The bells of the city have been tolling through alarm almost constantly since 8 o'clock last evening; services have been held in the churches; and late in the night there was a procession of citizens in double rank, with candles and lanterns; the procession was more than a quarter of a mile in length, and made the round of the churches, having a service in each, as it passed through. The people chanted as they passed along the streets; they were enveloped in shawls and ponchos to protect them from the falling ashes; and their dim, ghostlike appearance, their sad chant, *Ora pro nobis, Ora pro nobis*, with the haze about their candles, the ashy appearance of the sky so far as illumined by the lights, the blackness above, and the solemn tolling of the bells all over the city, had a most melancholy effect. They carried, in the procession, three images of a peculiarly sacred character, brought from Rome.

We have not yet heard from places nearer Cotopaxi, but are expecting sad accounts both from the ashen shower and from the melting of the snows on that mountain and the consequent overflowings of the rivers in its neighborhood. There is a city of some size, Latacunga—(where Cassola's college is situated) not far from Cotopaxi; which city has in several instances been a very severe sufferer in the convulsions originating in the volcano.

1 o'clock.—The fall of ashes has recommenced as thick as ever and the bells are tolling again. Another procession has just passed the door. It was a very sad and solemn spectacle. The people were seven deep on each side of the street, the inmost line with candles and lanterns; the women with rebosos and shawls over their heads, the men bare-headed, their heads and garments all covered with ashes. They had several images on platforms; and bands of music playing mournful tunes; sometimes chanting.

7 P. M.—The ash-shower has ceased; but Cotopaxi is thundering at a prodigious rate.

Monday evening, 15th.—It is now pretty well ascertained that the ashes were not from Cotopaxi, but from a volcano called Laraurco, in a wild country to the eastward of this, a considerable distance. There was a similar shower of ashes from that volcano in 1844, about as heavy as this, but on that occasion the air was more obscured than at this time, so much so that people had to use lanterns along the streets in Quito, at midday.

Wednesday.—Still doubts about the origin of the ashes; more probably they are from Cotopaxi.

5. *Palæotrochis* of Emmons.—This supposed fossil coral, described by Prof. Emmons in volume xxii, p. 389 of this Journal, is regarded by Prof. James Hall, after an examination of many specimens, as nothing but concretions in quartz rock.

III. BOTANY AND ZOOLOGY.

1. *Origin of the Embryo in Plants.—The Development of the Ovule of Santalum album; with some Remarks on the Phenomena of Impregnation in Plants generally;* by ARTHUR HENFREY, F.R.S., etc.—This is a paper in the *Linnæan Transactions*, vol. xxii, and was read before the Linnæan Society of London a year ago, before the publication of Dr. Radlkofer's memoir, which we gave some account of in the November number of this Journal. The results of these two contributions to embryology nearly correspond in their main features, although expressed in a somewhat different way; and they close a long and lively controversy, giving *coup de grace* to the "theory of the pollinists," as we have already stated.* In Santalum, Prof. Henfrey finds the germinal vesicle, or primordial cell of the embryo, to exist antecedent to impregnation, i. e. before the arrival of the pollen-tube; that the latter, (contrary to what Griffith supposed) does not penetrate the embryo-sac, but becomes firmly adherent to its surface; that the germinal vesicle within is at some distance from the wall of the embryo-sac; and that, between the two a pair of corpuscles or "coagula" are interposed, placed side by side, with a narrow space between. He thinks it probable that the walls at the point of adhesion of the pollen-tube and the embryo-sac are absorbed, and that the pollen-tube thus discharges its contents into the embryo-sac, which contents reach the embryonal nucleus and determine its conversion into a cell; he therefore looks upon the process as analogous to conjugation in the lower Algæ,—a process which, by the way, we have always wondered that Mohl should deny to belong to sexual reproduction. Of this direct communication, however, Prof. Henfrey has no proof to offer; and in fact this is just the problem for embryologists to resolve, viz, how does the pollen act, to determine the conversion of a *protoplasmic nucleus* into the initial embryo? Prof. Henfrey, in this paper, as he had announced in anticipation of its publication, regards what has been called the embryonal vesicle as merely a soft nucleus of protoplasm, which acquires a cellulose coat, and so becomes a real cell, only as the result of impregnation, and after the adhesion of the pollen-tube with the embryo-sac. The closing paragraph of the memoir, which is dated Jan. 30, 1856, embodies the view to which he had then arrived. "In my memoir on Orchis Morio, I described the

* A French translation of Radlkofer's memoir is given in *Ann. Sci. Nat.*, tom. v, No. 4, 1856. His results are essentially those of Tulasne, completed by a demonstration of the existence of the embryonal vesicle antecedent to impregnation, or rather of the existence of a pair of embryonal vesicles, adherent to the summit of the embryo-sac, of which the one generally contiguous to the extremity of the pollen-tube without becomes abortive, while the other developes into the suspensor of the embryo.

nascent germinal vesicles as cells. Hofmeister and others in like manner call them cells; but comparison of my older drawings and those of Hofmeister with new observations, *leads me to believe* that, on careful examination, these bodies will be found to consist of nuclei or 'protoplasts' before fertilization. I may note in reference to this, that I have already some confirmation from another case besides Santalum, and I trust to bring forward hereafter more complete evidence on the subject." A. G.

2. *Botanical Necrology for* 1856.—The more distinguished botanists who have deceased during the past year, are the following:

Dr. Wikström, Professor of Botany at Stockholm, author of several botanical works of merit, and of a series of Annual Reports on the Progress of Botany, published by the Academy of Sciences of Stockholm. He had reached the age of 67 years.

Dr. von Steudel, of Esslingen, in Wurtemburg, author of the well known *Nomenclator Botanicus*, and of the *Synopsis Plantarum Glumacearum*, noticed in a recent volume of this Journal.

George Don, of London, a brother of the more distinguished David Don, who died several years ago, and author of the Synopsis of Dichlamydeous Plants published several years ago, in 4 heavy 4to volumes, under the title of a *General System of Gardening and Botany.*

Prof. Bojer of Mauritius, aged 56. An interesting biographical notice of him is published in Hooker's Journal of Botany for October last.

Dr. Dozy, of Leyden, the distinguished Bryologist, has followed within a year his associate, Dr. Molkenboer. The admirable muscological works published conjointly by these two botanists have been noticed in this Journal. The *Bryologia Javanica*, which Dr. Dozy was continuing unaided since the death of his lamented associate, was one of the most elaborate and best works of the age in this department of science, after the *Bryologia Europæa.* Although it will hardly be possible to supply Dr. Dozy's place in this work, yet we learn that endeavors will be made to carry it on to a completion, making use of a good deal of unpublished materials left by Dr. Dozy.

Dr. Liebmann, Professor of Botany and Director of the Botanic Garden at Copenhagen, after a long illness, died on the 29th of October last, at the early age of 43 years. This excellent botanist and most interesting man had travelled largely in Mexico, and made vast collections of plants, upon which he had published several memoirs. He had, we believe, completed his splendid *Monograph of Mexican Oaks*, in folio, with 40 plates,—a work for which he had accumulated all the available materials now in Europe, and which will have a particular interest for us, on account of our numerous related Oaks of New Mexico and California. Dr. Liebmann's death is a great loss to science, and will be sincerely mourned, even in this country, by those to whom his amiable and excellent qualities had greatly endeared him.

Prof. Dunal, of Montpelier, one of the earliest pupils and most attached friends of the late DeCandolle, the elaborator of the *Solanaceæ* for the Prodromus, and author of several important monographs, is referred to by the French correspondent of this Journal (in the January number), as recently deceased. We have not yet received any notice of this event through the botanical journals or private correspondence. A. G.

3. *Gray's First Lessons in Botany and Vegetable Physiology, illustrated by over 360 wood-engravings from original drawings by Isaac Sprague, to which is added a copious Glossary or Dictionary of Botanical Terms,* a volume of about 250 pages,—intended for schools and classes generally, and as an Introduction to the *Manual of the Botany of the Northern United States,*—is just published by G. P. Putnam & Co. and Ivison & Phinney, New York.

The same publishers have issued a School and College edition of the *Manual of the Botany of the Northern United States,* with six plates, at a greatly reduced price.

4. *On the Causes of the Opening and Closing of Stomates;* by Hugo von Mohl, (Botanische Zeitung, 1856, No. 40, p. 697, et seqq.)—In this memoir von Mohl corroborates by actual experiments the general impression, the truth of which had not been demonstrated, that stomates shut when the guardian cells collapse, and open when they become turgid.

The opening of the stomate is guarded by two crescent-shaped cells, the guardian-cells, which generally take the following form. On their external surface each bears a cuticular projection which is usually formed by a thin membrane; in other cases however it consists of the cell-wall considerably thickened, or the cell-wall is sometimes even thick enough to form a salient protuberance. The edges of these projections unite at both the ends of the stomate, so as to make an orifice above the true opening of the stomate; this orifice may be wider or narrower than the true opening. It leads into a continuation of the true opening, filled with air and lying above the opening; this von Mohl calls the anterior cavity, or ante-chamber, (Vorhof), and the opening, the orifice of the ante-chamber. It is bounded on both of its lower sides by the upper part of the lateral surfaces of the guardian-cells, these surfaces being concave horizontally and convex vertically. Turned towards the stomatic cavity, on the lower side of the guardian-cells, there lies in most plants another projection like that on the upper side, but generally smaller, by which a posterior cavity corresponding to the anterior cavity, is separated from the cavity of the stomate.

A transverse section usually shows that the thickness of the walls of the guardian-cells is very unequal in different places; the part of the wall contiguous to the epidermal cells is generally rather thin, so that these cells must prevent the guardian-cells from swelling out at this part.

Having cut through the epidermal cells, so as to discharge their contents and thus prevent them from exerting any lateral pressure on the guardian cells, it was found that when placed in *water* (which they imbibe) the guardian cells increased the space between them very perceptibly; but when placed in a *solution of sugar,* (into which they exude a portion of their contents) they closed it completely. By changing from water to a solution of sugar, the same opening might be alternately opened and closed. Another series of experiments on *intact* leaves showed that this action of the guardian cells is impeded by the pressure of the epidermal cells in proportion as they come into contact with the former. This is also shown by the fact that when this pressure is taken off by emptying the epidermal cells of their contents (which may be done by immersing the latter in a solution of sugar) the guardian-cells always open. As the epidermal cells contain more sap than the guardian-cells the same result is obtained by letting a leaf wither off. The orifices of intact leaves cut off in the morning were found to be closed; when exposed to the sun for several hours they opened again, but closed with rapidity when immersed in water; showing that the power of the guardian-cells is increased, in comparison with that of the epidermal cells, by the influence of light and heat quite independently of the humid state in which they may occur. This, the author thinks, can hardly be explained except by assuming that when the guardian-cells are exposed to the influence of these agents they form such combinations as are able to induce a powerful endosmosis, and are more or less decomposed when light is withdrawn; for, as is well known, the guardian-cells, like the cells of the parenchyma, contain chlorophyllaceous matter.

Direct comparative measurements show that the projecting part of the guardian-cells, beyond the anterior cavity, contracts but slightly, so that the process is effected chiefly by the change in the form of the boundaries of the true opening.

The guardian cells expand most in a vertical direction, and thus change their transverse diameter from a circular to an elliptical form, so as to draw in the thinner portion of the lateral surface which lies free in the opening of the stomate. This explains why the opening is not closed when these cells are distended by the water which fills them.

C. F. Stone.

5. *On a boring Sponge;* by J. Leidy, (Proc. Acad. Nat. Sci., Philad., viii, 162.)—Dr. Leidy also directed the attention of the members to several shells of the oyster and clam (*Ostrea virginiana* and *Venus mercenaria*) much perforated, which are common on the ocean shore, where they are noticed by all visitors. Dr. L. had for a long time suspected that the perforations were due to some other molluscous animal or a worm; and he had frequently sought for them. The last summer, in dredging, in company with Mr. Ashmead and Prof. Baird, on an old oyster bed, at Great Egg Harbor, New Jersey, a large number of these perforated shells were obtained, and all of them were observed to be occupied by a sulphur yellow sponge of the genus *Cliona.* This boring sponge forms an extensive system of galleries between the outer and inner layer of the shells, and protrudes through the perforations of the latter tubular processes, from one to two lines long and one-half to three-fourths of a line wide. The tubes are of two kinds; the most numerous being cylindrical and expanded at the orifice in a corolla form, with their margin thin, translucent, entire, veined with more opaque lines, and with the throat bristling with silicious spiculæ. The second kind of tubes are comparatively few, about as one is to thirty of the other, and are shorter, wider, not expanded at the orifice, and the throat unobstructed with spiculæ. Some of the second variety of tubes are constituted of a confluent pair, the throat of which bifurcates at bottom. Both kinds of the tubes are very slightly contractile, and under irritation may gradually assume the appearance of superficial wart-like eminences within the perforations of the shell occupied by the sponge. Water obtains access to the interior of the latter through the more numerous tubes, and is expelled in quite active currents from the wider tubes.

In structure the sponge is composed of an intertexture of granular matter and pin-like silicious spiculæ. Several species of *Cliona* are indicated by European naturalists, but are not characterized with sufficient detail to determine whether the one above indicated is distinct or not from them.

Dr. L. further added, it might appear only of scientific interest to observe a structure so low as the sponge is classified in the organic kingdom, endowed with the power of penetrating such dense and hard bodies as the shell of the clam and oyster, but he suspected that the agency of the boring sponge was a highly important one in the sequence of natural phenomena, as it is a means by which dead shells are rapidly decomposed to be dissolved in the ocean water, where they may again serve as the elements of construction of the habitations of the rising generations of molluscous animals. In confirmation of this view Dr. L. stated, that an extensive bed of oysters, which had been planted by Mr. Thomas Beasley, at Great Egg Harbor, and which was in excellent condition three years since, had been subsequently destroyed by an accumulation of mud. The shells of the dead oysters, which were of large size and in great number, in the course of two years have been so completely riddled by the boring Cliona that they may be crushed with the utmost ease, whereas without the agency of this sponge the dead shells might have remained in their soft, muddy bed, devoid of sand and pebbles, undecomposed perhaps even for a century.

6. *Appendix to a paper on Reptiles in the Collection of the Academy of Natural Sciences of Philadelphia;* by E. Hallowell, (Proc. Acad. N. S. Phil., viii, 236.)—The Reptiles of Jamaica appear for the most part to be specifically distinct from those of Cuba. The following is a comparative list of those enumerated by Duméril and Bibron, Mr. Gray, Mr. Gosse, and others, including those described or mentioned in this paper. To these I have added a list of the reptiles of Martinique, for the habitat of which I am indebted to Duméril and Bibron.

Cuba.	*Jamaica.*	*Martinique.*
CHELONIA.	CHELONIA.	CHELONIA.
Cheloniadæ.	Cheloniadæ.	Chelonidæ.
Chelonia mydas.	Sphargis coriacea.	
Chelonia virgata.		
Chelonia caouana.		
Testudinidæ.	Testudinidæ.	Testudinidæ.
	Testudo carbonaria?	
Emydidæ.	Emydidæ.	Emydidæ.
Emys decussata.	Emys decussata.	
Emys rugosa.		
SAURIA.	SAURIA.	SAURIA.
Crocodilidæ.	Crocodilidæ.	
Crocodilus acutus.	Crocodilus acutus.	
Crocodilus rhombifer.		
Geckotidæ.	Geckotidæ.	Geckotidæ.
Hemidactylus mabouia.	Hemidactylus stenodactylus.	Hemidactylus mabouia.
Sphæriodactylus sputator.	Sphæriodactylus sputator.	Sphæriodactylus sputator.
Sphæriodactylus cinereus.	Sphæriodactylus punctatissimus.	Sphæriodactylus punctatissimus.
	Sphæriodactylus Argus, G.	Sphæriodactylus fantasticus.
Gymnodactylus albogularis.	Sphæriodactylus oxyrhinus, G.	Gymnodactylus albogularis.
	Platydactylus theconyx.	Platydactylus theconyx.

Cuba.

IGUANIDÆ.

Cyclura Harlani.
Anolis equestris.
Anolis Sagræi.
Anolis vermiculatus.
Anolis Carolinensis.
Anolis lucius.
Anolis angusticeps, H.
Anolis heterolepis, H.
Anolis (Acantholis) Loysiana.
Anolis chamæleonides (Chamæleolis Fernandina).
Holotropis microlophus.
Holotropis vittatus.

LACERTIDÆ.

Ameiva Auberi.

CHALCIDIDÆ.

Amphisbæna punctata.

SCINCIDÆ.

Diploglossus Sagræi.

OPHIDIA.

BOIDÆ.

Tropidurus melanurus.
Leionotus maculatus.
Epicrates anguliferus.
Notophis bicarinatus.

DIACRANTERIDÆ.

Dromicus Antillensis.
Dromicus Cursor.
Dromicus angulifer (Coluber cantherigerus).

TYPHLOPIDÆ.

Typhlops lumbricalis.
Typhlops Richardii.

BATRACHIA.

HYLIDÆ.

Hylodes Ricordii.
Trachycephalus marmoratus.
Phyllobates bicolor.

BUFONIDÆ.

Bufo peltocephalus.

Jamaica.

IGUANIDÆ.

Anolis Edwardsii.
Anolis punctatissimus, H.
Anolis Sagræi.
Anolis iodurus, G.
Anolis *opalinus*, G.
Placopsis ocellata, G.
Cyclura Collei.
Cyclura lophoma.

LACERTIDÆ.

Ameiva Sloanei.

SCINCIDÆ.

Eumeces Sloanei.
Diploglossus Shawii.

OPHIDIA.

BOIDÆ.

Chilabothrus inornatus.
Leinotus maculatus.

LEPTOGNATHIDÆ.

Ischognathus DeKayi.

DIACRANTERIDÆ.

Dromicus Antillensis.
Natrix atra ? G.
Natrix callilæma ? G.
Natrix capistrata ? G.

TYPHLOPIDÆ.

Typhlops lumbricalis.

BATRACHIA.

HYLIDÆ.

Litoria luteola, G.
Trachycephalus lichenatus, G.
Hyla brunnea, G.

Martinique.

IGUANIDÆ.

Anolis Alligator.
Anolis marmoratus.
Anolis cristatellus.
Anolis vermiculatus.
Anolis lineatus.
Anolis pulchellus.
Anolis chloro-cyanus.
Basilicus mitratus.
Iguana tuberculatus.
Iguana nudicollis.
Holotropis Herminieri.
Tropidolepis (Sceloporus) undulatus ?

LACERTIDÆ.

Ameiva *Pleii*.
Cnemidophorus lemniscatus.
Cnemidophorus sexlineatus.

CHALCIDIDÆ.

Amphistæna cœca.

SCINCIDÆ.

Eumeces mabouia.
Diploglossus Pleii.
Gymnopthalmus quadrilineatus.

OPHIDIA.

BOIDÆ.

Epicrates Cenchris.

OXYCEPHALIDÆ.

Oxybelis æneus.

DIACRANTERIDÆ.

Dromicus Antillensis.
Dromicus cursor.
Dromicus *Pleii*.

STENOCEPHALIDÆ.

Homalocranion semicinctum.

DIPSADIDÆ.

Dipsas annulata.

CROTALIDÆ.

Bothrops lanceolatus.

BATRACHIA.

HYLIDÆ.

Hylodes Martinicensis.

BUFONIDÆ.

Bufo Agua.

Hence it would appear, that with the exception of Emys decussata, Crocodilus acutus, Sphæriodactylus sputator, Anolis Sagræi, Leionotus maculatus, Dromicus Antillensis, and Typhlops lumbricalis, unless several of the others have been incorrectly determined, the species belonging to the islands Jamaica and Cuba, although but ninety miles distant, are altogether different, and that several of the genera which exist in the one are wanting in the other. Besides the above we have in our collection a small serpent of the size of a Calamarian, with a very short and broad frontal (vertical) plate, a large pre-ocular, no loral and broad gastrostega, carinated scales and a double row of black spots along the back, from Jamaica, included in the donation of Dr. Pennock, which is identical with Storeria DeKayi, B. & G. (Ischognathus DeKayi, Dum. et Bib.)* With the exception of Anolis Carolinensis, the reptiles of Cuba differ in their species altogether from those of the United States, even the southern portion of it; and not only so, but with the exception of Emys, Hylodes and Bufo, and perhaps Ischognathus, there does not appear to be even a genus common to the two countries. Were the Herpetology of each of the West India Islands fully known and very accurately determined, many highly interesting and important facts would be developed, tending much to elucidate the laws which govern the geographical distribution of species.

7. *On some young Gar Pikes from Lake Ontario;* by L. Agassiz, (Proc. Bost. Soc. N. H., vi, 48.)—They were remarkable, he said, as still preserving certain embryological characters. The most conspicuous of these was the prolongation of the vertebral column in the form of a fleshy filament, distinct from the caudal fin, which had at times a vibrating motion, involuntary, and quite distinct from the motions of the tail itself, as is seen in some embryos. This singular formation shows that the caudal fin is properly an appendage to the lower surface of the dorsal column, a true second anal, and not the proper termination of the column. The specimens exhibited showed their affinity to reptiles, by their motions and attitudes; the spine being more flexible than in ordinary fishes, and their position, when at rest, being frequently more or less bent, particularly towards the tail; peculiarities arising from the ball and socket joints of the vertebræ,—a proper reptilian arrangement. The manner of feeding also is unlike that of fishes, and resembles that of reptiles. Other fishes take their food with open mouth, and swallow it at once; but this one approaches its prey slyly, sidewise, and suddenly seizing it holds it in its jaws, until, by a series of movements, it succeeds in getting it into a proper position for swallowing, as is the habit with alligators and lizards. The ball of food in the body of this fish is seen to move gradually, as it distends the body in its progress, from one end to the other, as is seen in snakes. This fish is also remarkable for the large quantity of air which escapes from its mouth. The source of this Prof. Agassiz had not been able satisfactorily to determine. At certain times it approaches the surface of the water, and seems to take in air, but he could not think that so large a quantity as is seen adhering in the form of bubbles to the sides of the gills could have been swallowed, nor could he suppose that it could be secreted from the gills themselves. These different interesting facts were noticeable in the specimens exhibited, which were fed for the occasion on live minnows, the only food they could be persuaded to take.

* This species has a wide range, being found in Massachusetts and Georgia. Duméril and Bibron say they have received a specimen from Mexico.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Observations on the Zodiacal Light;* by Rev. GEORGE JONES, U.S.N. (From the Astronomical Journal, No. 100, a letter dated Quito, Nov. 18, 1856.)—You are, perhaps, aware that I am spending at this place the time occasionally allotted to officers of the Navy, after a long cruise; and that I am continuing here a series of observations on the Zodiacal Light, commenced in the seas of China and Japan.

The advantages of this place are very great. 1st. I have the ecliptic vertical to me, at some one hour, every night in the year. 2dly. The ecliptic can never, at the farthest, make an angle of less than 66° with my horizon; and therefore the Zodiacal Light must always present itself favorably for observation. 3dly. The transparent atmosphere of this elevated plateau allows me to see objects in the sky with a wonderful degree of distinctness. Hence the distinctive features in every change of the Zodiacal Light can be marked, here, with an exactness that I never witnessed before.

My observations are made on the summit of the hill Ychinbía, immediately adjoining Quito on the east, a place where I have horizons sufficiently open and clear.

It is not my present object to give details of observations, but simply to notice one result, and to offer some queries to which it seems to lead, in hope of now drawing attention to the subject, and perhaps of inducing other observers to give it their particular notice. *I see here every night, and all through the night, a luminous arch, from east to west, quite across the sky.* This arch, 20° wide, is visible at all hours, when the sky is clear, but is brightest and most striking when the ecliptic is vertical; at which times it looks almost like another Milky Way. It is very evidently the Zodiacal Light. This luminous arch, I know, is not a new discovery, for Baron Humboldt saw it in the seas off Mexico, and Professor Brorsen has noticed it more fully in Germany. I also had glimpses of it in my late cruise in the Eastern seas. Here, however, it is developed with a remarkable degree of distinctness, and I am giving it particular attention. I am the more interested in it, from a suspicion which has arisen in my mind, that it is an independent light; that is, that the nebulous substance from which it comes is self-luminous, though also capable of giving us reflected light. This is only yet a surmise, for my observations, of only eleven weeks' continuance, (I have forty-four degrees of this arch recorded,) are yet too few to warrant more than this; and we must have numerous data before we can decide affirmatively on so important a subject. My chief grounds for this surmise now are,—1st, that while the Zodiacal Light, near the horizon (where it obviously is chiefly a reflected light), changes decidedly according to my change of place, as regards the ecliptic, and has a strong reference to my position, the light of the Luminous Arch has not so much reference to this position; 2dly, that while the Zodiacal Light near the horizon has a warm, sunny tinge, the light in the Luminous Arch is a cold, white light, resembling that of the Milky Way; and 3dly, that, while the Zodiacal Light over the horizon tapers off in intensity as it ascends upwardly, this of the Luminous Arch, after this other ceases, is uniform quite across the sky.

All this, however, as you will perceive, is ground only for surmise, and can now only sharpen observation; and it is a subject in which it will not do to hasten to conclusions.

Allow me, in this connection, to throw out some queries suggested in part by this, and in part by other things which I have seen at this place.—The thinness of the air on this plateau, by which, during the day, objects a great way off are seen with remarkable distinctness, and seem to be near by, might be expected to assist in atmospheric developments of several kinds unusual at other places; and such is also the fact. A phenomenon, which has sometimes drawn the attention of philosophers, namely, a general brightness in the air, at night, without any apparent cause for it, is, in some nights, very remarkable here. I find it has been noticed by others as well as myself. The brightness, without moon, or any assignable reason, has been so great, at times, that I have taken out printed papers or books, to ascertain whether I could not see to read by it.

Now, the queries that all this subject appears to suggest to us are these:—1st. May not self-luminosity be an inherent principle of nebulous matter? 2dly. May not all space be occupied by nebulous matter, diffused around in various degrees of tenuity, but mostly so thin as to be imperceptible, except in its occasional retardation of heavenly bodies; and, as a part of that query, is it not the cause of this well-ascertained retardation? 3dly. May not the light of what we call nebulæ be from such self-luminous nebulous matter, with stars or suns, its product, but not having absorbed it all, shining in its midst? 4thly. May not the light of our Milky Way itself be, in part, from such self-luminous nebulous matter, there collected in greater quantities than in other portions of our sky? In this case, the changes known in the Galaxy, and sometimes called by astronomers "the breaking up of the Milky Way," will not be a change in stars, but in the less stable substance from which stars and systems of worlds are made.

I offer all this as merely a subject for query; and perhaps even such queries are too bold for the data which we now possess.

In connection with my observations at this place, E. C. Herrick, Esq., at New Haven, Connecticut, Dr. Drayton, U. S. Navy, for a while on board the St. Mary's, at Panama, and Professor Moesta, of the National Observatory at Santiago, Chili, are making simultaneous observations on the Zodiacal Light, on the 1st, 10th, and 15th of each month, each being furnished with star-charts; and we may thus hope for a tolerably full set of results.

In conclusion, allow me to express my regret that there is not an astronomical observatory at or near this place. It seems to me that the whole world should bestir itself, at once, to have one here. It is worthy of a world's union. Or if that cannot be done, why will not some wealthy individual or individuals see it accomplished? There is much cloudy weather here; but when the nights are clear, they have a most surprising brilliancy, the smaller stars coming out so as to fairly crowd the firmament, and the Milky Way appearing with a brightness, and apparently a nearness, that is wonderful to behold. I have no doubt that an observatory here, even if the instruments were not of very extraordinary power, would make very interesting revelations in this science. The climate here is agreeable and healthy; living is very cheap; the government of Ecuador, to my knowledge, would be very glad to coöperate in such a matter, though they have themselves not the means. Why cannot it be done?

2. *On the Meteor of July*, 1856; by THOMAS M. PETERS.—On Tuesday, the 8th day of July, 1856, I was on the road leading from *Moulton*, (Ala.) to *Columbus*, (Miss.), about six miles south of *Thorn-hill* in Hancock County, Alabama. At about six o'clock in the evening, my friend, B. R. Delgraffenreid, Esq., who was with me, called my attention to a remarkable meteor, then falling. When I turned my eyes upon it, it was just too late to get a distinct view of it; but my friend, who saw it clearly described it, as very brilliant and startling, and six or eight inches in apparent diameter. It made its appearance or rather seemed to burst through the concave of the heavens, at a point near midway between the zenith and the horizon, and some thirty or thirty-five degrees west of south from our place of observation. It seemed to fall almost perpendicularly downwards, with a slight curving to the eastward. From the points of first appearance, it descended with great swiftness, until it reached a stratum of reddish-dun colored cloud, at about ten degrees above the horizon. In this cloud it seemed to disapper. *Above* the cloud, into which it seemed to fall, it left a long *train* of whitish smoky color, which gradually tapered, from the base upwards, in a well defined slender cone, regularly rounded at the apex, with ventricosely-waved margins—but perfectly distinct throughout. The color of the *train* was about that of *thick steam*, at low working temperature, and very much resembled it, except it was much more permanent. The singular peculiarity of the margins of the *train* suggest, that it may have been occasioned by some gaseous substance projected forward from the body of the meteor with considerable velocity, against the opposing atmosphere, which curved it backwards, (upwards in this instance), and outwards, in rolls; as happens to the smoke from the mouth of a cannon. These indications of violent projection were frequently, and somewhat regularly, repeated from the top to the bottom of the *train*. The breadth of this *train* was, apparently, about four inches at the top, and about eight or nine inches at the bottom. In color it was somewhat darker at the upper end, than it was below; and seemed to grow paler and thinner, from the top, downwards. It continued stationary throughout, and remained without apparent change for about ten or twelve minutes. Then it began to grow paler, and shortly afterwards became invisible. The whole *train* was vividly distinct in all its outlines, and remained visible about fifteen minutes, by my watch. At last, it began to disappear from the *top*, downwards, and seemed to fade away without dispersing, as if it had been absorbed as it stood.

There was no appearance of the meteor or its singular train *below* the cloud, into which it seemed to fall. There was no noise of explosion heard, though we listened attentively. At our place of observation it was calm and fair, though in the direction of the meteor it was cloudy; and as I learned afterwards, it rained heavily in the afternoon of that day, The position of this meteor from our point of observation, indicated that it must have fallen in the direction of *Columbus*, (Miss.): therefore it could not have been Prof. Harper's meteor, which was seen farther north, at Orford in that State, on the same day.

Moulton, Ala., Nov. 25th, 1856.

3. *On Dellman's Method of Observing Atmospheric Electricity;* by Prof. W. Thomson, (Proc. Brit. Assoc., August, 1856; Ath., No. 1505.) The author said:

"During my recent visit to Creuznach I became acquainted with Mr. Dellman of that place, who makes meteorological, chiefly electrical, observations for the Prussian Government, and I had opportunities of witnessing his method of electrical observation. It consists in using a copper ball about six inches diameter, to carry away an electrical effect from a position about two yards above the roof of his house, depending simply on the atmospheric 'potential' at the point to which the center of the ball is sent; and it is exactly the method of the 'carrier ball' by which Faraday investigated the atmospheric potential in the neighborhood of a rubbed stick of shell lac, and other electrified bodies ('Experimental Researches,' Series IX, 1839.) The whole process only differs from Faraday's in not employing the carrier ball directly, as the repeller in a coulomb-electrometer, but putting it into communication with the conductors of a separate electrometer of peculiar construction. The collecting part of the apparatus is so simple and easily managed that an amateur could, for a few shillings, set one up on his own house, if at all suitable as regards roof and windows; and, if provided with a suitable electrometer, could make observations in atmospheric electricity with as much ease as thermometric or barometric observations. The electrometer used by Mr. Dellman is of his own construction (described in Poggendorff's 'Annalen,' 1853, vol. 89, also vol. 85), and appears to be very satisfactory in its operation. It is, I believe, essentially more accurate and sensitive than Peltier's, and it has a great advantage in affording a very easy and exact method for reducing its indications to absolute measure. I was much struck with the simplicity and excellence of Mr. Dellman's whole system of observation on atmospheric electricity; and it has occurred to me that the Kew Committee might be disposed to adopt it, if determined to carry out electrical observations. When I told Mr. Dellman that I intended to make a suggestion to this effect, he at once offered to have an electrometer, if desired, made under his own care. I wish also to suggest two other modes of observing atmospheric electricity which have occurred to me, as possessing each of them some advantages over any of the systems hitherto followed. In one of these I propose to have an uninsulated cylindrical iron funnel, about seven inches diameter, fixed to a height of two or three yards above the highest part of the building, and a light moveable continuation (like the telescope funnel of a steamer) of a yard and a half or two yards more, which can be let down or pushed up at pleasure. Insulated by supports at the top of the fixed part of the funnel, I would have a metal stem carrying a ball like Dellman's, standing to such a height that it can be covered by a hinged lid on the top of the moveable joint of the funnel, when the latter is pushed up; and a fine wire fixed to the lower end of the insulated stem, and hanging down, in the axis of the funnel to the electrometer. When the apparatus is not in use, the moveable joint would be kept at the highest, and its lid down, touching the ball so as to keep it uninsulated. To make an observation, the lid would be turned up rapidly, and the moveable joint carrying it let down, an operation which could be effected in a few seconds by a suitable mechanism. The electrometer would immediately indicate an inductive electrification simply proportional to the atmospheric potential at the position occupied by the centre of the ball, and would continue to indicate at each instant the actual atmospheric potential, however variable, as long as no sensible electrification or diselectrification has taken place through imperfect insulation or convection by particles of dust or currents of air (probably for a quarter or a half of an hour, when care is taken to keep the insulation in good order). This might be the best form of apparatus for making observations in the presence of thunder-clouds. But I think the best possible plan in most respects, if it turns out to be practicable, of which I can have little doubt, will be to use, instead of the ordinary fixed insulated conductor with a point, a fixed conductor of similar form, but hollow, and containing within itself an apparatus for making hydrogen, and blowing small soap-bubbles of that gas from a fine tube terminating as nearly as may be in a point, at a height of a few yards in the air. With this arrangement the insulation would only need to be good enough to make the loss of a charge by conduction very slow in comparison with convective loss by the bubbles, and it would be easy to secure against any sensible error from defective insulation. If 100 or 200 bubbles, each $\frac{1}{10}$ inch in diameter, are blown from the top of the conductor per minute, the electrical potential in its interior will very rapidly follow variations of the atmospheric potential, and would be at any instant the same as the mean for the atmospheric during some period of a few minutes preceding. The action of a simple point is, (as I suppose, is generally admitted) essentially unsatisfactory, and as nearly as possible nugatory in its results. I am not aware how flame has been found to succeed, but I should think not well in the circumstances of atmospheric observations, in which it is essentially closed in a lantern; and I cannot see on any theoretical ground how its action in these circumstances can be *perfect*, like that of the soap-bubbles. I intend to make a trial of the practicability of blowing the bubbles; and if it proves satisfactory, there cannot be a doubt of the availability of the system for atmospheric observations.

4. *On the Tides of Nova Scotia;* by Prof. CHEVALLIER, (Proc. Brit. Assoc., August, 1856; Ath. No. 1505.)—The observations to which reference is made were taken by a tide-guage fixed upon a wharf at the north end of the naval yard at Halifax. The tides there are small in amount, the spring tides rising from 6½ to 9 feet at Halifax, and 8 feet at Sambro Isle, 12 miles south of that place. The tides themselves appear to be quite regular; but in addition to the ordinary tide-wave there occurs a series of undulations succeeding each other at intervals of twenty minutes or half an hour, the difference of elevation and depression rarely exceeding six inches, and being usually much less. They are more perceptible near low water; but occur at all times of tide, and are very distinctly marked upon the curve traced by the self-acting tide-gauge. The question to be considered is, what is the cause of these small waves? 1. They do not arise from any influence which the casual swell of the sea might exercise upon the tide-guage,—for the rise and fall of one of these waves very seldom takes less time than a quarter of an hour, and often requires half an hour, or even three-quarters of an hour. 2. They do not arise from undulatory motion in the whole waters of the harbor. In

order to examine this question, Mr. Edgcombe Chevallier, the storekeeper in Halifax Dockyard, went to Sambro, ten or twelve miles south of Halifax, and entirely clear of the harbor, and erected upon Power Island a temporary guage, with which he took the height of the water every five minutes for the whole day. Having laid off the results in a form similar to that employed with the fixed tide-guage at Halifax, it was found that every irregularity at Halifax was preceded ten or fifteen minutes by a larger irregularity at Sambro. These observations show that the irregular waves do not arise from the peculiar form of the harbor at Halifax. 3. At about sixty miles eastward from Halifax, outside Sable Island, the gulf-stream runs in nearly a northeastern direction with considerable velocity; and, between Sable Island and the land, a counter-current runs in nearly a south-western direction. One of these currents would elevate the surface of the sea near the middle of the currents; and such an elevation of the surface over which the tide-wave is propagated might give rise to undulations similar to those observed. I am informed, however, that the undulations in question are observed on the western side of Nova Scotia, to which any effect of those two currents could not extend. 4. Although the tides at Halifax and on the neighboring coast are small, that part of the ocean is near the indraught of the Bay of Fundy, where the peculiar form of the coast and its position with reference to the great tide-wave of the Atlantic give rise to a local forced tide of excessive magnitude. Such a tide, especially when reverberated from coast to coast in a comparatively narrow inlet, might not improbably give rise to perceptible undulations in a neighboring part of the sea. If this be the cause, it might be expected that a similar effect should be noticed where a forced tide of the like nature takes place. The Bay of Avranches is a locality of this kind, and the island of Jersey appeared to be a place where any undulations of the tide might probably be noticed. The extreme difference between high and low water at St. Helier's is forty-two feet, and the difference of height of the mean high and low water is thirty-six feet. On inquiry, I find that about ten years since a tide-guage was fixed at St. Helier's, but observed only at high water, when irregularities were observed of the same kind as those noticed at Halifax. This seems to give probability to the opinion that the irregularities observed in the tide at Halifax may be connected with the unusual tides in the Bay of Fundy. But whether they rise from this source, or are to be traced to some great reciprocating motion to which the waters of the Atlantic may be subject, the phenomenon deserves to be studied, as likely to lead to a more extended knowledge of the hydrodynamical conditions of our globe.

5. *Notice of a visit to the Dead Sea;* by H. Poole, Esq. (Proceedings Quar. Jour. Geol. Soc., xii, 203. Forwarded from the Foreign Office by order of Lord Clarendon. Abstract.)—Mr. Poole went to this district to look for nitre, which was reported to occur there; but he met with none, and found reason to suppose that the report was unfounded. The same word in Arabic means "bitter or rock salt," as well as "nitre," hence possibly the erroneous information. Further, the cave (at Usdum) in which the nitre was said to have occurred is called "the cave of the Gun-men," not from the Arabs getting their nitre there for gunpowder,

but as the spot from which they watch for the crossing of the hostile tribes across the plain.

Mr. Poole and Mr. E. Mashallam spent nearly two days at Usdum, going to several caves (in which fine stalactites of salt occur), climbing nearly to the top of the mountain, and walking about the shore, but in no instance could they find a deposit or even a sample of nitre. Mr. Finn, H. M. Consul at Jerusalem, also informed Mr. Poole that he had never seen any; nor had the Sheik Aboo Daook and his men. The Arabs generally make their own nitre by boiling the dung of goats; others scrape it off old walls or limestone-caves, but never in any large quantity.

The Arabs charge 60 piastres or 10 shillings for a camel-load of salt, about 500 lbs., delivered in Jerusalem, and the purchaser pays the Turkish government 15 piastres more for duty. Each camel will make about twenty-four trips in a year, thus carrying altogether 12,000 lbs. a year.

From Usdum Mr. Poole proceeded to El Lisan (the Peninsula), and travelled all around it. The ridge of high land is highly impregnated with sulphur; but the nodules of native sulphur are very rare.

At the present time it would be almost impossible to do anything on El Lisan, for the road between it and Usdum is open to the attacks of four independent tribes of Bedouins, including the Sultan of Kerak, over whom the Turkish government has no control.

Previously to visiting Usdum, Mr. Poole made a trip to the northern end of the Dead Sea. At Nebi Mousa (half-way from Jerusalem to the Dead Sea), there is a quantity of bituminous shale or "blind coal," from which ornaments are cut; and a thick bed of soil highly impregnated with sulphur occurs there. Nothing but saline incrustations were found on the north shore of the Dead Sea.

6. *Modification of the Barometer.*—M. Secchi proposes to substitute a method of measuring the changes in a barometer by *weight*, instead of the ordinary method by *volume*. The barometer is made with a large tube to make the amount of mercury greater, and is moveable up and down in the cup below; then, since the power to raise it will be equivalent to the weight of the atmosphere, the weight ascertained by a balance, or an index with a graduated scale, gives the atmospheric pressure with far more nicety than by the ordinary mode of sighting. If the tube has a section 10 centimeters square, and the pressure vary 1 centimeter in height, the total addition of weight will be 10 cubic centimeters of mercury, equal to 135 grammes, while if the tube were but 1 centimeter square, it would be but $13\frac{1}{2}$ grammes. This shows the advantage of a large tube. M. Secchi has constructed such a barometer for the College at Rome, which has the tube 15 millimeters in diameter. The variation of a tenth of a line in the mercury is marked by an index moving 6 lines.

The author observes also that with a large tube, the amount of mercury is so great that the movement may be used for moving a pencil for self-registration. Moreover the method is independent of the purity of the mercury, of temperature, and of the difference of gravity in different latitudes. In addition, the tube may be made of iron, or of any metal not acted on by mercury, instead of brittle glass, and there will not be any trouble from the adhesion of the mercury or from humidity, and the mercury may be boiled easily without danger of breaking. Barometers may consequently be made of water or other liquids in the same way, since metal tubes may be made of any length.

7. *On the Telescopic Stereoscope;* by JAMES ELLIOT, (Philosophical Magazine and Journal, Jan., 1857.)—I have recently succeeded in constructing what I believe to be a new form of the stereoscope. Its object is to unite *large* binocular photographic pictures in a different way from any that has hitherto been followed.

The pictures are placed side by side, and viewed through two small telescopes, like those of opera-glasses, with the directions of their axes crossing each other; the left-hand picture being viewed with the right eye, and the right-hand picture with the left eye. The two telescopes are connected together, the connecting apparatus being capable of two adjustments; one to suit the width of the eyes, and the other to give the obliquity required. When the instrument is placed on a stand, as I have it, two other adjustments are required; the first to bring the telescopes to the proper elevation, and the second to bring the plane of their axes into parallelism with the upper or lower margins of the pictures.

The instrument is constructed in such a way that these adjustments are made with great facility; and when the pictures are united, the effect is excellent.

8. *Amos Binney's* "*Terrestrial Mollusks and Shells of the United States.*"—Mr. W. G. BINNEY, (son of the late Dr. Amos Binney, who died after having published two volumes of his admirable work on the United States land Mollusks,) announces that he is engaged in preparing a continuation of the work of his father, and solicits assistance by way of land shells and information relating to the subject, with any addenda or corrigenda to the volumes published. We trust that Mr. Binney may be liberally aided in his undertaking. He resides at Germantown, near Philadelphia.

9. *Mastodon.*—A portion of a jaw has been found near Columbia, in California.—*Proc. California Acad. Nat. Sci.*, i, 27.

10. OBITUARY.—*Death of Wm. C. Redfield.*—As the last sheets of this number are passing through the press we hear the sad tidings of the death of WILLIAM C. REDFIELD, of New York. After an illness of about two weeks he died at his residence in that city, Feb. 12, 1857, aged 68. We make this record with emotions of more than common sorrow, for Mr. Redfield was a man whom, through a long course of years, we had honored as a philosopher, and loved as a friend. He was born at Middletown in this State, and with very limited advantages of early education, he rose from a humble position, and earned for himself a high rank among men of science. In early manhood he removed to New York City, where he thenceforward continued to reside, engaged in business connected with steamboat navigation and transportation on the Hudson. In the midst of active business he found time for self-improvement and for scientific inquiry and study. Although he took great interest and pleasure in many departments of science, he gave special attention to Geology, Physical Geography and Meteorology. In these fields of learning he did not content himself with becoming acquainted with the re-

sults of others, but was himself a diligent laborer. Mr. Redfield was one of the original members of the "Association of American Geologists and Naturalists," and when in 1847 that body agreed to resolve itself into the "American Association for the Advancement of Science," he was chosen its first president. At an early day he foresaw the great value of railroads in developing the resources of our country, and in 1828 he published a pamphlet indicating the most feasible route for a road to connect the Atlantic and the Mississippi, a route which was substantially adopted, and the last link of which was completed in 1854. But his most important labors were devoted to Meteorology, and his researches and discoveries in this science have rendered his name familiar throughout the nautical and scientific world. In the year 1821 his attention was directed to the investigation of a violent storm which had a short time previous passed through New England, and on collecting and sifting all the observations he could obtain, he came to the conclusion that this storm was *a travelling whirlwind.* This important discovery he followed up by collecting and studying observations and reports on the gales of the Atlantic and the hurricanes of the West Indies. He found that these storms were of the same general character, revolving in the same direction and pursuing paths essentially similar. Restrained by his characteristic modesty, Mr. Redfield did not publish his discoveries until at the urgent solicitation of Professor Olmsted he brought them out in the 20th volume (1831) of the first series of this Journal. From that time up to the close of life, his labors in this field of research have been most industriously continued, and the results have been made public principally through the medium of our Journal. Extending his inquiries to the gales and hurricanes of all parts of the world, he found those of the Northern hemisphere alike in direction of rotation and in course of travel, while those of the Southern hemisphere were found to revolve in the opposite direction and to pursue a reverse line of travel. In 1838, Lt. Col. Reid, of the British Royal Engineers, published at London a large volume entitled "An Attempt to develop the Law of Storms," in which work he adopted Mr. Redfield's views, ably supporting and extending them by new observations. Since that time the same doctrines (while they have not been universally accepted at home) have been embraced by several foreign authors, and have been reproduced in various publications.

Mr. Redfield's discoveries are valuable not merely to theoretical science; they are of great practical importance to the navigator. As early as the year 1834, (in Blunt's Amer. Coast Pilot, and vol. xxv, 1st ser. of this Jour.) he published some brief instructions to seamen, showing them how to avoid the fury of a gale in which they might be overtaken. Many intelligent navigators and naval officers have borne testimony to the great value of the directions, based on his theory, which have from time to time been published, for escaping storms at sea.

Mr. Redfield was a sagacious observer, an industrious collector of facts, an active and original thinker. In all the various relations of life the excellency of his character was conspicuous, and he approached the closing scene sustained by a humble trust in his God and Saviour.

We hope to present in some future number a fuller account of the life and labors of our departed friend.

11. *Hugh Miller.*—Hugh Miller, one of the best known and most honored of Scotland's sons, died at Portobello, near Edinburgh, his place of residence, on Wednesday the 24th of December. In consequence of excessive mental labor his mind had become disordered, and under derangement, he died by his own hand. He had just finished a new work, one of a series that has done more than all else published in the world to popularize and christianize science; and he leaves this "Testimony of the Rocks" as a testimony to his own greatness and goodness of soul, as well as to the treasures of wisdom in the volume of creation which he so delightingly read.—We cite the following from accounts abroad of this sad occurrence.

"Most people know that Hugh Miller has been a hard worker. He has not wrought out his way from the stone-mason's quarry to so distinguished a position in science and literature without living a life of incessant and wearing mental toil. In fact, he had worked much too hard and constantly. And, although a man of sturdy *physique*, his brain was unable to stand the stress of his will and the strain of his perseverance. Latterly, in addition to fulfilling the duties of editor of a newspaper, published twice a-week, he had been working very determinedly at his new geological work, to be called 'The Testimony of the Rocks.' His brain had become over-wrought; he was restless at night, and could obtain no refreshing sleep. This had most probably increased a latent tendency to walk in his sleep, which he had often mentioned to friends. His children have at times awoke during the night, and seen him pacing their bedroom in the somnambulistic condition. Indeed, on Monday last, he told a friend that he suspected having been out in the garden in the night, and in this abnormal state. Another cause of his over-excitement and derangement—for such a medical examination finds to have existed—may be found in the fact that he has suffered greatly of late from terror at the depredations of the 'ticket-of-leave' men, dreading lest they might break in and rob his museum of some of its cherished rarities. So much had this fear affected him, that he has asserted attempts to have been made upon that part of his house, although this was most probably an illusion. Mr. Miller has been accustomed to keep fire-arms for years past, and has been known to seriously present a pistol in his own defence when suddenly accosted in a street at night. He slept with a loaded pistol at the side of his bed. In consequence of his wife's long illness and his keeping late hours in his study, he had lately slept in a bed adjoining the study, which was at some distance from the sleeping apartments of the family. After seeing his medical advisers on Tuesday, and having been told that cessation from work was necessary, he went to bed somewhat early on Tuesday night, after using a sponge bath that had been prescribed. What caused him to get up in the night can never be known. The horrible trance, more horrible than ever, must have returned. All that can now be known of what followed is to be gathered from the fact that next morning, his body, half dressed, was found lying lifeless on the floor, the feet upon the study rug, the chest pierced with the ball of the revolving pistol which was found lying in the bath that stood close by. The body was lifted and laid on the bed. We saw it there a few hours afterwards. There was the massive brow, the firm-set, manly features, we had so often looked on admiringly, just as we had lately seen them, nothing but that overspread pallor of death to distinguish them from what they had been. We could not help thinking as it lay there in unruffled majestic repose, that the spirit had passed through a terrible tornado, in which reason had been broken down, but that it had made the great passage in safety, and stood looking back to us in humble grateful triumph from the other side.

"The announcement of the death of Hugh Miller will be heard with a thrill of genuine sorrow throughout the church in which he was a standard-bearer,—throughout Scotland, of which he was one of the most conspicuous ornaments,—throughout the world of science, which associates his honored name with those of the men most distinguished in our day, as fellow-workers in building up the stately fabric of the modern geology. * * To Mr. Miller, more than any other geologist, undoubtedly belongs the honor of having demonstrated, what previous observers had begun to suspect, that the Old Red Sandstone was entitled to rank as an independent formation, by its distinctive fossils, many of which he was the first to discover and describe. Mr. Miller had projected, and had advanced far in the preparation of a work on the general geology of Scotland; but it is with the Old Red Sandstone that his name as a geologist will be permanently connected. The work in which he traces the progress of his observations, has been probably perused more for its moral interest and its literary excellences than even for its geological descriptions. It is such a book as Oliver Goldsmith might have written, had he been a naturalist, which he was not. * * * To Mr. Miller's versatile talents, and the varied contributions of his pen to criticism, art, philosophy, and science, is applicable, also, more than to any other writer of the day, the panegyric pronounced upon Goldsmith, that there was no branch of knowledge which he did not touch, and which, touching, he did not adorn. His most profound work, the "Footprints of the Creator, or the Asterolepis of Stromness," is a contribution to natural theology of inestimable importance. It has been adopted as a text book by some of the most eminent teachers of geology in the Universities; and it has done more to expose the atheistical fallacies and sophistries of the "Vestiges of the Natural History of Creation" than even the elaborate essays of Sedgwick and Brewster. We rejoice that Mr. Miller has written his own biography. "My Schools and Schoolmasters" is a work already familiarly known.

"Thousands here and in other lands will join with us in the tribute of an honest tear to the memory of a man of true heart and noble powers of intellect, devoted to the loftiest purposes. Little did we think, when we met Mr. Miller last year, in the genial and kindly intercourse of the British Association, that we were to see his face no more; and that at the early age of fifty-four, he would be lost to the Church which he loved, and to the cause of Christian science, which owes so much to his example and labors. Death has made sad inroads of late years upon the ranks of the cultivators of natural science. Dr. Landsborough, Professor Edward Forbes, Dr. Johnston of Berwick, Mr. Yarrell, and now Mr. Hugh Miller, have passed away in rapid succession,—and Forbes and Miller have left behind them no equals."

12. *Gregory's Handbooks of Chemistry, Inorganic and Organic.**—A careful reprint of the latest English edition of Dr. Gregory's 'Handbooks' (the English editions of which are marred by numerous typographical errors) would be a valuable addition to our chemical literature. The volumes before us purport upon their titles to be such reprints, the one from the third, the other from the fourth English editions. But after a careful comparison of their several pages with the original we are sorry to say that they belie their titles. They are in fact printed almost wholly from the old stereotype plates of an American edition by the same editor, issued at Cincinnati in 1851 (July), and copied from the English edition of 1846 (Inorganic) and 1847 (Organic). So entirely is this edition reproduced from the old plates, that the erroneous references copied from the English original stand unchanged in this and refer to nothing! (e. g. on p. 15 (organic) we are referred to *cyanogen* and *mellone* in part i, p. 140—i. e. in the Am. reprint to *galvanic decomposition*—while the reference is unaltered from the original English edition of 1847 now before us.) Even the trivial typographical inaccuracies which any careful proof-reader should have corrected remain unchanged. In fact the old plates have been used by the new publishers, who are responsible with their editor for this bold attempt to deceive the public by passing off old wares with new labels. We have found it difficult to avoid in this connection the use of language which, however it might be justified by the aggravation of the case, is not appropriate here.

But it will be said, the American editor of these volumes has undertaken to supply to the inorganic chemistry the Physics of Chemistry, and to add to the organic part a "supplement," which is said to bring the science down to the last moment. The manner in which he has discharged these editorial labors it is our duty briefly to point out. In the "Preface" we are informed that "the original work of Dr. Gregory does not contain the imponderables, a very important department of modern chemistry. The first American edition was therefore devoid of *light, heat,* and *electricity,* an oversight which was felt by *those many* [the italics are ours] American professors who have adopted this work in *their colleges* as one which was almost inexcusable." Dr. Sanders has undertaken to supply this assumed deficiency in Dr. Gregory's handbook, and in contemplating the results of his labors to this end discourses as follows, in the preface. "Whilst the matter prefixed to this invaluable work of Dr. Gregory cannot be designated a compilation, the greater portion of it being written in the language of the editor" [no one, we feel quite sure, will dispute this modest claim to authorship], "it still cannot aspire to the dignity of an original composition." "The entire subject of the Imponderables is condensed as

* *Handbook of Inorganic Chemistry, for the use of students,* by William Gregory, M.D., F.R.S.E., Professor of Chemistry in the University of Edinburgh. 4th American from the 3d English edition, to which is added *The Physics of Chemistry,* by J. Milton Sanders, M.D., LL.D., Professor of Chemistry in the Eclectic Medical Institute of Cincinnati, Member of the American Association for the Advancement of Science, etc. New York: A. S. Barnes & Co., 51 and 53 John st. 1857. 8vo, pp. 426.

Handbook of Organic Chemistry, by the same. 4th American from the 4th London edition, with a Supplement. 8vo, pp. 480.

much as possible, therefore the writer has not thought it expedient to insert the many long and prolix tables upon the subject of heat which the larger works upon Physics contain." "At the same time we venture the assertion, that in the condensed matter contained in this volume the student will not fail to find the laws of these sciences, and the principal facts associated with their revelation clearly explained."

Dr. Gregory is an able chemist, and has the merit of being the chief expounder in our language of the chemical school of Liebig. We can readily imagine the vexation he must feel, and with it the unavoidable contempt for American science, at the manner in which his handbooks are here presented. It has never been our misfortune to see any good book more sadly spoiled by the bungling of an editor. His ignorance of his subject is equalled only by his audacity, and his short-comings in syntax. These broad assertions find ample illustration and support on every page which is not a literal reprint from Dr. Gregory. His bad English is seen in what we have already cited. Under Light we are told "That great philosopher (Newton) proved that light does not present—in the language of one who lived before him—'an instance of homogeneity'—but that it is really of a composite nature, and constituted of even more energies than he supposed." That is, Newton proved more than he was aware of. The student is informed (p. 39) that "the hypothesis of the undulations or waves in an attenuated ether, may perhaps, for the present answer for the luminous rays, but it will not stand the test in regard to those more refrangible ones which produce chemical action."

The following felicitous sentences introduce the student to chromatic polarization. "The following diagram (copied from Woodward) will illustrate the production of color by polarized light. It supposes that light is manifested by the vibrations of an attenuated medium termed the luminiferous. We have in another place given our reasons wherefore we regard the sun's light as a compound consisting of several activities. Perhaps, *for the present*, the calorific rays may be regarded as vibrations of the luminiferous medium, although this is not proved, and therefore should not be accepted as an ascertained truth.* That the diagram may be rendered as intelligible as its inventor, Mr. Woodward, has done in his able work upon polarized light, &c." With no adequate statement of the general phenomena of light, the chemical student is at once plunged into the irrelevant subjects of the "refraction of light through lenses," "spherical aberration of lenses," "chromatic aberration," and "polarization." Ninety pages (out of 191 devoted to the Physics of Chemistry) are given to Light, and of these over 50 are occupied by "Actino-Chemistry," giving numerous minute and technical details for the various processes of photography, which, granting their importance in their proper place, are completely out of place in a handbook of elementary chemistry.

* Dr. Sanders seems to labor under a deep conviction that the whole theory of physical optics stands upon a basis of such unstable equilibrium, that unless he constantly reminds his readers of the fact, some of them may unfortunately rest too much confidence in it.

This introduction upon chemical physics is also open to criticism, not only for errors in statement but for the omission of important subjects which belong peculiarly to chemical physics—the molecular condition of matter—the simple laws of crystallography—the mechanical properties of gases—the methods of volumetric analyses are not mentioned—while the student is entertained by an account of the editor's physiological experiments in removing mercury from the human system by the voltaic current and by examples illustrating the use of this force in medical practice.

Passing now to the organic chemistry, we find on the title page that it is reproduced from the text of the *fourth* English edition. The *fourth?* We have most carefully compared this reprint with the various editions page by page, and it is nothing but *the old stereotype plates of the Cincinnati edition* (1851) without the least change until the close of the 346th page, and is copied from the English edition of 1847. From the 346th page under the head "Nutrition of plants and animals," it is copied from the *third* English edition, also without change. But the "supplement," does not that lessen the force of this grave charge? The prefatory note of the American editor is perfectly in keeping in style with what we have already quoted. The editor is painfully impressed with the impossibility of evolving order out of the confusion of his subject. "The indefatigable industry of chemists has resulted in the accumulation of such a vast mass of knowledge, such a formidable array of isolated facts, that the author of an elementary work like this, is indeed greatly perplexed to select that which is most appropriate. *The editor, even in the preparation of the supplement to this work has encountered this difficulty in all its significance.*" * * "If we are not yet cognizant of the rational formula of a compound then we are not prepared to place it in its undeviating position in a scientific arrangement of organic compounds. *With these considerations uppermost in our mind, we have discarded the idea we at first conceived, of attempting a scientific arrangement of the substances we have presented in the Supplement.*" * * "Prof. Gregory has attempted a methodical and scientific arrangement of the products and theories of organic chemistry in the work we present to the student, and perhaps his arrangement is as scientific an exposition of the doctrines of the science as it is possible to adduce in its present state."

What does all this mean? Plainly, that the American editor has accomplished some great results, and that the supplement is where we must look for them. We have taken the pains to compare it carefully with the English editions of Dr. Gregory and have found that it is made up entirely (with trifling exceptions only), of extracts from the third edition of Gregory, and virtually without any acknowledgement whatever. These extracts are almost wholly on those topics which are not found in the edition of 1847, but they are printed in this supplement with no reference to the parts of the text which they illustrate, and not always in consecutive order. As the chemical reader turns over the pages of this part of the book he is startled at seeing among the *novelties* of the science, Dr. Gregory's chapter on chemical homologues entire—then one and another such old novelty. The most ludicrous anachronisms grow out of this mode of proceeding. Thus on page 431 he reproduces among the novel records of the science the same paragraph on *Kakodyle* which appears in its proper place in the text of his own edition on p. 160.

On p. 433 we are told "There are several combinations of ethyle with the metals, phosphorus, &c., which have been discovered, *quite lately*, and which it is important the student should be acquainted with. For instance," and then borrowing verbatim from Dr. Gregory's 3d edition, p. 223, &c., he gives us Zyncethyle, Stibethyle, &c., of refreshing novelty!

But enough of this! It is painful to see the evidence of such charlatanry, and more painful to be compelled to expose it. It would seem perhaps improbable that any chemical teacher would be misled into the adoption of this edition of Gregory in his classes; yet it is unfortunately too true that it is the habit of many school committees and boards of trustees arbitrarily to adopt text books without consulting teachers, and by an exercise of the same arbitrary power to select persons who know nothing of a subject as teachers.

The matter is made worse by the fact that the work is published by a most respectable house, who certainly did themselves and the public an injustice that they did not take counsel of their numerous scientific friends, before committing themselves to this unfortunate enterprize.

13. *Proceedings of the Geological Society of London, No.* 47.—The more important papers are:—On the raised beaches of the Western Islands, by Capt. J. Bedford. They are 40 feet above mean tide level.—Rev. S. Haughton on the Granites of Ireland.—Prof. Owen on Gastornis Parisiensis; the specimen a tibia $11\frac{1}{2}$ inches long, or within $1\frac{1}{2}$ inches of the length in an ostrich; found in the Lower Eocene conglomerate at Meudon, near Paris, lying between the Plastic clay and the chalk.—Prof. Owen on Mammalian Remains of the Red Crag of Suffolk (Rhinoceros, &c.).—J. W. Salter on the fossils of the Longmynd Rocks; a new sea weed or zoophyte, traces of marine worms and a Trilobite referred to a new genus and called Palæopyge Ramsayi.—Prof. R. Harkness on the lowest Sedimentary Rocks of the South of Scotland.

No. 48.—T. Wright on the Palæontological and Stratigraphical Relations of the so-called "Sands of the Inferior Oolite."—G. Poulett Scrope, on the formation of Craters and the nature of the liquidity of Lavas.—J. C. Moore, on the Silurian Rocks of Wigtownshire.—S. P. Woodward, on an Orthoceras from China.—J. Prestwich, on the Correlation of the Middle Eocene Tertiaries of England, France and Belgium.

14. *Proceedings of the California Academy of Sciences.*—These proceedings were commenced in Sept. 1854, and the last number received is dated May 12, 1856. They contain many valuable scientific papers, especially on the Fishes of that country by Dr. Wm. O. Ayres and Dr. W. P. Gibbons. There are also geological articles by Dr. J. B. Trask, botanical papers by Dr. A. Kellogg and Dr. Behr. Page 40, Dr. Trask describes an Ammonite (Ammonites Batesii) from Arbuckle's Diggings, Shasta Co., California; p. 41, Tertiary Fossils of Santa Barbara and San Pedro; also new species of Ammonite (A. Chicoensis) and Baculite (B. Chicoensis) from the rocks of Chico Creek, referred by the

author to the Tertiary; description of three species of Plagistoma from the Cretaceous Rocks of Los Angeles, with a plate. Also a paper by Mr. Wm. Stimpson on some Californian Crustacea.

15. *List of Works published by the Smithsonian Institution, Washington, D. C.**—

Quarto volumes.—Smithsonian Contributions to Knowledge. 1848. Vol. I, 4°, pp. 346, with 48 plates and 207 woodcuts. Contains No. 1.

Smithsonian Contributions to Knowledge. 1851. Vol. II, 4°, pp. 464, and 24 plates. Price $5,50, cloth; $5, paper. Containing numbers 3, 12, 20, 13, 14, 16, 17, 23, 15, 4, 6, 7, 11.

Smithsonian Contributions to Knowledge. 1852. Vol. III, 4°, pp. 564, and 35 plates. Price $7, cloth; $6,50, paper. Containing numbers 35, 36, 30, 32, 22, 33, 34, 29, 24.

Smithsonian Contributions to Knowledge. 1852. Vol. IV, 4°, pp. 426. Price $5, cloth. Containing number 40.

Smithsonian Contributions to Knowledge. 1853. Vol. V, 4°, pp. 538, and 45 plates. Price $7,50, cloth, colored plates; $6, uncolored, in paper. Containing numbers 44, 41, 45, 43, 42.

Smithsonian Contributions to Knowledge. 1854. Vol. VI, 4°, pp. 476, and 53 plates. Price $6, cloth. Containing numbers 46, 60, 61, 50, 52, 58, 54.

Smithsonian Contributions to Knowledge. 1855. Vol. VII, 4°, pp. 252, 70 woodcuts and 74 plates. Price $6. Containing numbers 59, 63, 70, 72, 73.

Smithsonian Contributions to Knowledge. 1856. Vol. VIII, 4°, pp. 556, 9 plates and 27 woodcuts. Price $6 cloth; $5 paper. Containing numbers 71, 81, 80, 82, 84, 85.

Smithsonian Contributions to Knowledge. Vol. IX. (In press.)

Mathematics and Physics.—(33) The law of deposit of the flood tide: its dynamical action and office. By Charles Henry Davis, Lieut. U. S. Navy. 1352. 4°, pp. 14. Price 10 cents.

(35) Observations on terrestrial magnetism. By John Locke, M.D., M.A.P.S. April, 1852. 4°, pp. 30. Price 25 cents.

(36) Researches on Electrical Rheometry. By A. Secchi. May, 1852. 4°, pp. 60, and 3 plates. Price 60 cents.

(80) The Tangencies of circles and of spheres. By Benjamin Alvord, Major U. S. Army. January, 1856. 4°, pp. 16, and 9 plates. Price 50 cents.

Astronomy.—(8) Occultations visible in the United States during the year 1848. Computed under the direction of the Smithsonian Institution. By John Downes. 1848. 4°, pp. 12.

(9) Occultations visible in the United States during the year 1849. Computed under the direction and at the expense of the Smithsonian Institution. By John Downes. 1848. 4°, pp. 24.

(10) Occultations visible in the United States during the year 1850. Computed by John Downes, at the expense of the fund appropriated by Congress for a Nautical Almanac, and published by the Smithsonian Institution. 1849. 4°, pp. 26.

* For sale by Geo. P. Putnam & Co., New York, and other Booksellers

(11) Occultations visible in the United States during the year 1851. Computed by John Downes, at the expense of the fund appropriated by Congress for the establishment of a nautical almanac, and published by the Smithsonian Institution. Oct., 1850. 4°, pp. 26. Price 50 cents.

(29) Occultations visible in the United States during the year 1852. Computed by John Downes, at the expense of the fund appropriated by Congress for the establishment of a nautical almanac, and published by the Smithsonian Institution. 1852. 4°, pp. 34. Price 20 cents.

(54) Occultations of Planets and Stars by the Moon during the year 1853. Computed by John Downes, at the expense of the fund appropriated by Congress for the establishment of a nautical almanac, and published by the Smithsonian Institution. 1853. 4°, pp. 36. Price 20 cents.

(3) Researches relative to the Planet Neptune. By Sears C. Walker, Esq. 1850. 4°, pp. 60. Price 30 cents.

(4) Ephemeris of Neptune for the opposition of 1848. By Sears C. Walker, Esq. 1849. 4°, pp. 8.

(4*) Ephemeris of the Planet Neptune for the date of the Lalande observations of May 8 and 10, 1795, and for the oppositions of 1846, '47, '48 and '49. By Sears C. Walker, Esq. April, 1849. 4°, pp. 32. Price 20 cents.

(6) Ephemeris of the Planet Neptune for the year 1850. By Sears C. Walker, Esq. April, 1850. 4°, pp. 10. Price 10 cents.

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T. Scheerer: An Introduction to the Use of the Blowpipe; translated, with additions, by H. T. Blanford. Leipsic and London, 1856.

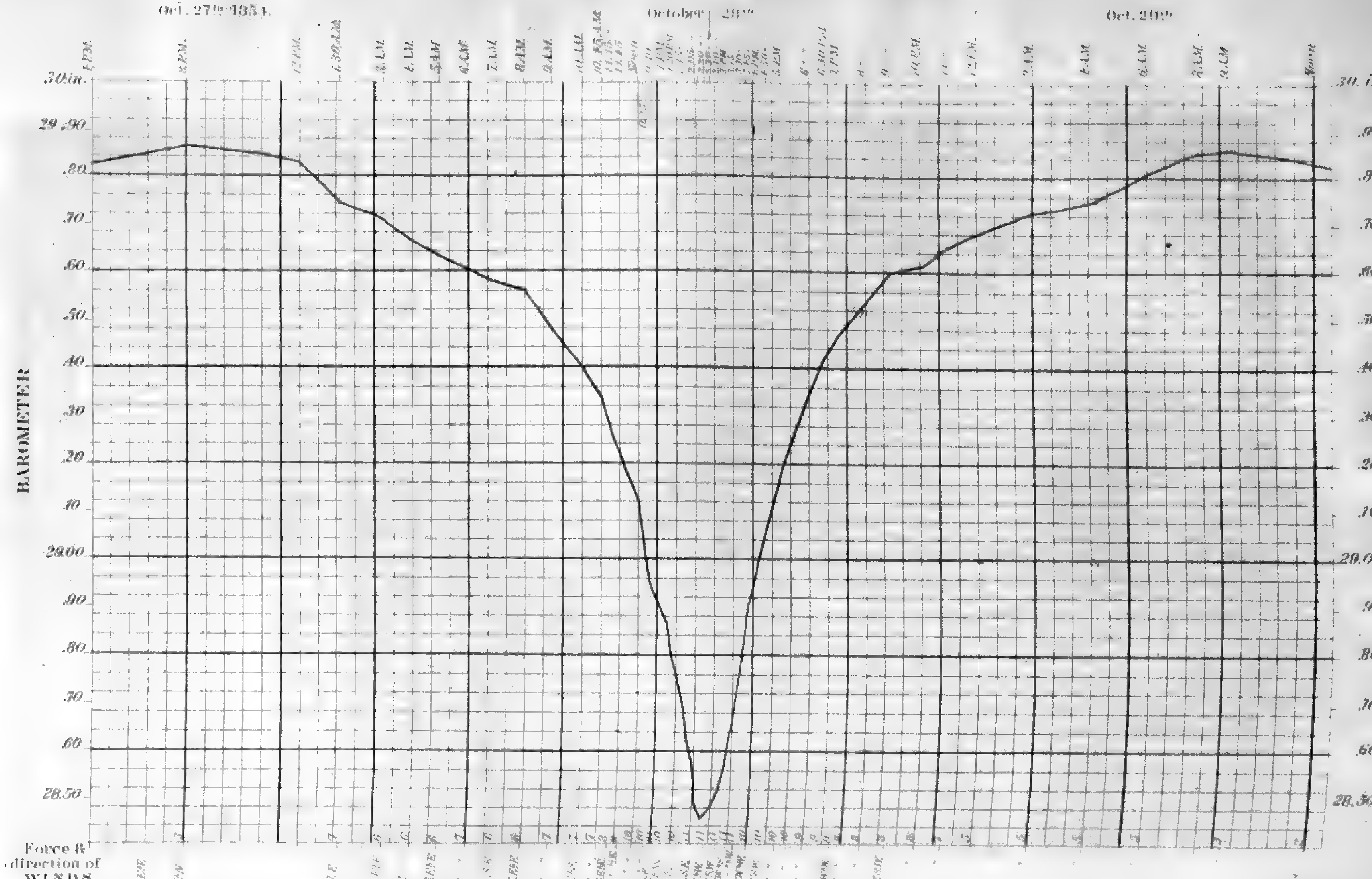
Liebig and Kopp: Jahresbericht for 1855, Parts 1 and 2. Giessen, 1856.

Thomas Say: Descriptions of Terrestrial Shells of North America. 44 pages, 12mo. Philadelphia: Childs & Peterson. A reprint of the papers of Mr. Say, by W. G. Binney.

Elliot Society, Charleston, S. C., Jan., 1856.—p. 29, Description of a new Ostræa found living in the waters of the coast of South Carolina; *F. S. Holmes.*—Monograph of the genus Cryptopodia; *L. R. Gibbes.*—Description of a new Baptisia (B. stipulacea), with a plate; *W. H. Ravenel.*—Notes on the American Devil Fish, with description of a new genus (Diabolichthys) from the harbor of Charleston, S. C., with a plate; *F. S. Holmes.*

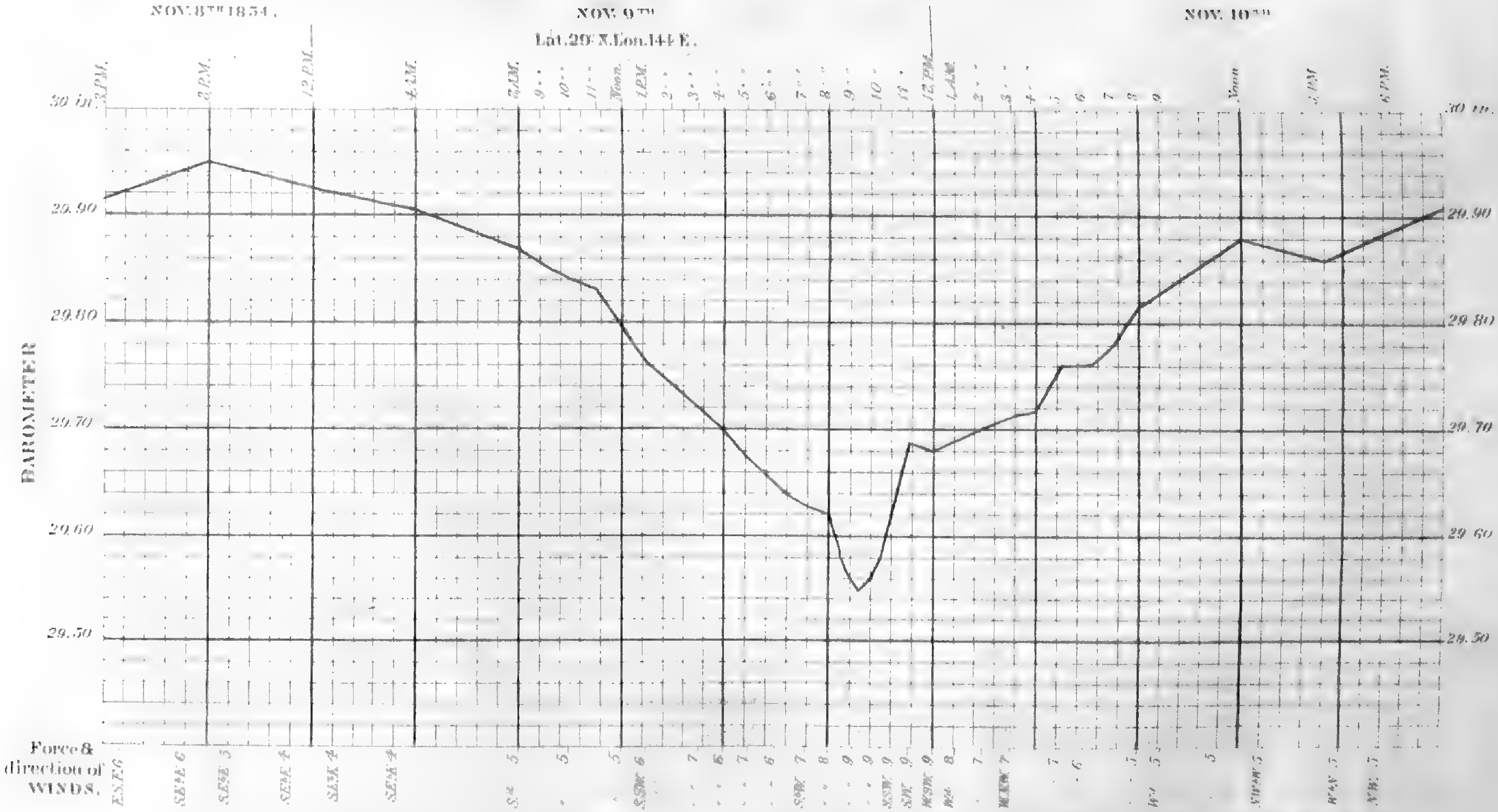
Proceedings of the Boston Soc. Nat. Hist., Dec., 1856.—p. 33, Observations on the North Carolina or Deep River coal; *C. T. Jackson.*—p. 34, Cause of change of color in birds, etc.; *D. F. Weinland.*—p. 37, Note on Petromyzon, and in the classification of Vertebrata; *L. Agassiz.*—p. 40, on the Fossil Trilobites of Eastern Massachusetts; *W. B. Rogers, C. T. Jackson.*—p. 44, Electric apparatus of *Raia lævis.*—p. 47, Young Gar-Pikes; *L. Agassiz.*

U. S. SHIP VINCENNES, JOHN RODGERS ESQ COM'DG.



AT PORT LLOYD, BONIN ISLANDS. LAT 27° 05' 35" N. LON. 142° 11' 31" E.

Observed & drawn by Anton Schonborn (Reduced by W.C.R.)



VINCENNES RUNNING Nº E. UNTIL 8.20 PM. NOV. 9TH THEN HOVE TO WITH THE HEAD TO S.E., ON STARB. TACK.

Observed & drawn by Anton Schonborn (Reduced by W.C.R.)

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

Art. XXXI.—*Remarks on the Huronian and Laurentian Systems of the Canada Geological Survey;* by J. D. Whitney.

From some of the most recent publications of the Canada Geological Survey it appears that Mr. Logan, the able director of that survey, holds certain views in regard to the position of the lowest rocks in the northwest, which differ from those which have been maintained by Mr. Foster and myself as the result of our examinations in that region, made under the authority of the United States government. Having enjoyed opportunities for part of two additional seasons of exploration in the vicinity of Lake Superior since the completion of our geological survey, it seems proper to endeavor to throw some additional light on the points in dispute, especially as the matter is one of considerable practical importance to the mining interests of that region.

All the geologists who have made any extended examinations in the northwest are agreed in opinion in regard to the age of the great sandstone formation which covers so much of the territory around Lake Superior, and spreads out over so large a portion of Wisconsin and Minnesota. It undoubtedly forms the base of the fossiliferous series, and is the equivalent, or continuation rather, of the Potsdam sandstone of the New York geologists. Beneath this sandstone, and unconformable with it, we find an immensely-developed series of slates, quartz-rock, &c., to which we have given the name of the Azoic System. This system embraces all the rocks lying beneath the lowest fossiliferous beds in the northwest, from which the azoic rocks are easily distinguished by marked differences of lithological character, and by unconformability of position.

Mr. Logan, however, recognizes two distinct systems below the Potsdam sandstone, and to which he has given the names of Huronian and Laurentian, thus differing from Mr. Foster and myself, who have admitted the existence of only one. If we examine the published reports and maps of the Canada Survey, we find this discrepancy of opinion to be due entirely to a different understanding of the origin and relations of the cupriferous formation of Lake Superior, and especially of that portion of it which belongs to the southern shore of the lake, within the limits of the State of Michigan. If we follow Mr. Logan, we admit that the series of sandstones, conglomerates and bedded traps forming the cupriferous belt, which extends from the extremity of Keweenaw Point to the west beyond the Montreal River, lies unconformably beneath the sandstone which shows itself along the south shore of the lake, almost uninterruptedly from its outlet to its western extremity. We must also admit that these cupriferous rocks are identical in age with the series of quartz, beds, and jaspery conglomerates displayed on the north shore of Lake Huron, and hence called "Huronian." Therefore, according to Mr. Logan's views, since the cupriferous series of Lake Superior rests unconformably on a still lower formation of slates, quartz-rock, &c., the rocks of Lake Huron must also do the same, although no such fact has been observed. Hence we must recognize two systems beneath the Potsdam sandstone; one, the Huronian, comprising the cupriferous rocks of Lake Superior and the formations of the north shore of Lake Huron, the other, the Laurentian, including all the rocks of Canada and the northwest which we should designate by the term "Azoic," with the exception of those of Lake Huron as before indicated.

The principal question to be settled, then, is this; what are the relations of the cupriferous rocks of Lake Superior?—do they constitute a distinct system by themselves, or are they part and parcel of the Potsdam sandstone itself? If they are only a local modification of the Lower Silurian sandstone, then they ought not to be removed from the place to which they belong, and they certainly cannot be made the basis of a new system. And if this is not done, then there is no proof of the existence of two unconformable systems beneath the Potsdam sandstone, since there is no evidence, either lithological or stratigraphical, for separating the rocks of Lake Huron from those which occur farther east, and which are classed by Mr. Logan as Laurentian.

The sandstone of the northwest, the base of the fossiliferous series, which is, as usually seen, three to four hundred feet in thickness, is made up of a coarse grained and rather friable grit, consisting of fine grains of quartz, with but little cement between the particles, and slightly colored by oxyd of iron. It is distinctly stratified, the layers varying in thickness from a few inches up to two feet, and having a very slight dip, which is in general to the south, with many minor undulations. From the extremity of Keweenaw Point, however, extending to the west for a distance of over 150 miles, we find a belt of rocks inclined at a considerable angle to the horizon and made up of alternations of trap, sandstone and conglomerate, which together have a thicknes of several thousand feet. The culminating portion of this belt consists of one or more ridges of trappean rock which rise in some places to a height of nearly a thousand feet above the level of the lake. The south side of the ridge usually presents a mural escarpment, sometimes 300 or 400 feet in perpendicular height. On this side of the cupriferous belt we find the sandstone dipping at a considerable angle in close proximity to the trap, but at a little distance from it acquiring its normal position and appearance. The deep adit-level, at the Norwich Mine, driven for 439 feet at the base of the trap range on its south edge, displays a most instructive section of this portion of the formation and shows conclusively that there has been an upheaval of the rocks to the north, along a line of fracture extending nearly east and west, while the region to the south was only slightly affected. The adit-level commences in the conglomerate which flanks the trap-range on the south. For twenty-four feet from its mouth, the rock excavated is conglomerate, without any recognizable bedding; then follows sandstone for fifty-five feet, which shows in the most marked manner the mechanical action by which the trap was uplifted. It is broken and crushed into fragments, which afford the most evident proofs of having been rubbed against each other with immense force, at the time the upheaval took place. The next $52\frac{1}{2}$ feet are occupied by trap, the southern portion of which is distinctly observed to dip to the south, although evidently much crushed and dislocated during its uplift, while the northern half has a steep inclination to the north. Nothing can be clearer than the evidence which is here afforded of a fracturing of the strata, and an immense mechanical force exerted in the upheaval of their northern portion. At about 130 feet from the entrance of the adit, is another belt of sandstone, which is about thirteen feet thick and has apparently the regular dip of the beds of rock in which the mine is wrought, about 44°. From this section, as well as from numerous other observations made along the southern line of junction of the cupriferous belt and the sandstone, it is evident that the latter participated in the uplifting movement of the trappean belt, and that it was not subsequently and unconformably deposited at its base.

In regard to the sandstone on the north side of the trap range, the evidence is equally clear that it cannot be separated from it, either lithologically or stratigraphically. Towards the eastern extremity of Point Keweenaw the sandstone is not exposed on the shore of the lake, having been washed away, but conglomerate and trap make their appearance and occupy the coast on the north side of the Point, to the distance of five miles west of the mouth of Eagle River. From this point onward, the sandstone appears in strata dipping at a low angle to the north and resembling in lithological character that which forms the shore of the lake from Saut Ste. Marie to the Pictured Rocks. Near the Porcupine Mountains and at the Montreal River, however, it has a higher dip owing to the proximity of the igneous rocks to the coast. On starting from the lake shore, at any point where the sandstone shows itself in horizontal beds, and going south towards the trap range, we find ourselves gradually rising, and the dip of the sandstone gradually increasing, so that the observer may form a pretty correct idea of his distance from the trap range by the amount of dip of the sandstone over which he is passing. The cupriferous belt itself is made up of a varying number of alternating beds of trap, conglomerate and sandstone, which latter differs from the sandstone at a distance from the trap only in being somewhat darker colored and having the quartzose grains more firmly cemented together. The number of alternations of sedimentary and igneous layers is very variable. In the Keweenaw Point district, where the igneous action seems to have been most intense, the sections across the cupriferous range show numerous beds of conglomerate and sandstone intercalated between masses of trappean rock of variable thickness.* In the Ontonagon district the number of alternations seems to be considerably less, while there is less regularity in the trappean ranges as well as in the sedimentary beds associated with them.

The beds of conglomerate are invariably found in juxtaposition with the trap, dividing this rock from the sandstone, or else separating two layers of trappean rock of different lithological character. Hence, the inference is not unreasonable that the formation of the ore is closely allied with the appearance of the other. On the north the range is usually flanked by a heavy deposit of conglomerate, while, to the south, the rock is only occasionally seen, and rarely attains any considerable thickness. The lithological character of the conglomerate indicates also the combined agency of igneous and aqueous causes in its formation. Much of it is made up of a coarse detritus or aggregate of broken and half-rounded fragments of trappean rock, showing the

* For detailed sections across the cupriferous range, see Foster and Whitney's Report, Part I.

action of sudden and violent forces, rather than of slow and long-continued ones.

The conglomerate appears to thin out rapidly as we recede from the igneous rocks, forming wedge-shape masses which gradually pass into sandstone. This fact has been actually observed in some instances, although, usually, the natural sections are not sufficiently favorable to allow the exact relation of the sedimentary to the igneous rocks to be made out. There are also patches of pebbly materials, formed exclusively by the agency of water, which occur among the sandstones, at a distance from the trap. These are of very limited extent, and are not at all comparable with the great conglomerate masses associated with the igneous rocks. They are evidently the result of local currents and the material of which they are composed is the same as that of the sandstone itself.

The dip of the series of bedded trap, conglomerate and sandstone is usually very regular, and varies from 40° to 50° along the culminating portion of the range, where it is highest. In only one locality, so far as observed, does it exceed 50°, and that is at the mouth of the Montreal River where it amounts to 80°. At this point there is a remarkable development of the conglomerate, which attain a thickness of about 1800 feet, and is overlaid by a still greater mass of dark shales and sandstones. The conglomerate rapidly thins out, both to the east and to the west, being apparently the result of the more intense action of igneous causes which took place in this portion of the range, tilting up the whole system at a higher angle than at any point on the south shore of the lake.

On the whole, we are unable, from a careful examination of numerous sections on the south shore of the lake, to see any reason for separating the cupriferous range from the sandstone which flanks it on both sides. It appears evident to us that it should be regarded as a local modification of the normal sandstone, and the result of the violent igneous action which prevailed along several parallel lines of fissure extending in a northeast and southwest direction through the Lake Superior region. It is certain that a portion, at least, of the sandstone had been deposited before the trap range assumed its present position, since there is abundant proof that the former was raised from its original position by the upheaval of the latter.

But if we were to admit that the cupriferous beds of the south shore of Lake Superior were to be classed as a system independent of the Potsdam sandstone, we can see no reason for parallelising them with those of the north shore of Lake Huron. These latter exactly resemble in lithological character the Azoic rocks of the Lake Superior survey, and are quite distinct from those of the native copper-bearing series.

The Huronian beds are chiefly made up of a compact and almost vitreous quartz-rock, in no respect resembling the sandstone of the south shore of Lake Superior, even where the latter is most hardened and metamorphosed by immediate contact with the trap. The beds of conglomerate in the Huronian series are of very subordinate importance and entirely differing in character from the great conglomerate bands associated with the igneous rocks of the south shore of Lake Superior. In the former case the base of the conglomerate is almost invariably quartz in a high state of vitrification, while the pebbles are made up of variously colored jaspers or hornstone, often blood-red, which contrast beautifully with the white quartz-rock in which they are imbedded and to which they are so firmly soldered that it is difficult to say that they may not, in some cases, be rather the result of segregating agencies within the rock, than actual pebbles imbedded in a matrix. The whole aspect of the rock is that of one having undergone a much higher degree of metamorphism than the Lower Silurian conglomerates have been subjected to.

Mr. Logan thus states the reasons for considering these formations to be of the same age. "The chief difference in the copper-bearing rocks of Lakes Huron and Superior, seem to be in the great amount of amygdaloidal trap present among the latter, and of white quartz-rock or sandstone among the former. But on the Canadian side of Lake Superior there are some considerable areas in which important masses of interstratified greenstone exist without amygdaloid, while white sandstones are present in others as on the south side of Thunder Bay, though not in the same state of vitrification as those of Huron. But notwithstanding these differences, there are such strong points of resemblance in the interstratification of the igneous rocks, and the general mineralized condition of the whole, as to render their positive or proximate equivalence highly probable, if not almost certain; and the conclusive evidence given of the age of the Huron would thus appear to settle that of the Lake Superior rocks in the position give to them by Dr. Houghton, the late State Geologist of Michigan, as beneath the lowest fossiliferous deposits, a position which, as will be seen by a reference to the Report of Progress I had the honor to submit to your Excellency in 1846, appeared to me to derive some support from evidences on the Canadian side of Lake Superior itself."*

In order to arrive at a better understanding of the matter in question, we will briefly notice some of the most important facts in the geology of the north shore of Lake Superior, where the phenomena are much more complicated and difficult to decipher

* Geol. Survey of Canada, Report on the North Shore of Lake Huron; 1849, p. 20.

than on the south side. On Isle Royale we have the exact counterpart of the principal mineral range of Keweenaw Point with the exception that the dips are in the opposite direction, being in each case towards the lake. Crossing over the channel which separates the island from the north shore of the lake, and which is from 15 to 20 miles in width, we find a great belt of trappean rock extending along the shore from Pigeon River to Fort William and rising in high cliffs. This portion of the trap is characterized by its unbedded character, is hard and crystalline, destitute of amygdules, and may be considered as the counterpart of the South or Bohemian Range of Keweenaw Point. From the west side of Thunder Bay to the east of Neepigon, the bedded trap and interstratified sandstones and conglomerates predominate. The peninsulas separating Black, from Thunder and Neepigon bays, as well as the larger islands which lie in front of these very considerable indentations in the north shore of the lake, must be referred to the same age as the rocks of Isle Royale and Keweenaw Point. There is no perceptible difference between the rocks of this portion of the north shore and those of the south side of the lake, either in lithological character or in the phenomena of the mineral veins associated with them, except that the beds of rock on the north shore being more broken up by short lines of fracture and thinner, the veins which intersect them are smaller and more irregular. The black slates of Thunder Cape are a local variation in composition of the sandstone like the dark and highly fissile beds of Montreal, Presqu' Isle, and Iron Rivers on the other side of the lake, which pass gradually into the usual red sandstone upwards and downwards. All the facts collected on the northern shore indicate a somewhat greater thickness of the interstratified igneous and detrital rocks, and a more powerful and irregular denudation than that which took place on the other side of the lake.

Underlying and uncomformable with all this great series of traps, conglomerate and sandstone, we have, as on the south shore, the azoic series, made up of talcose and hornblende slates and gneissoidal quartz-rock resting on a granitic and syenitic nucleus, which forms the high ridges to the northwest of Thunder and Black Bays, and extends into the interior to an unknown distance. The same series forms the principal portion of the eastern side of Lake Superior from the northeastern angle of Neepigon Bay down to the immediate vicinity of the St. Mary's River, the outlet of the lake. The small islands lying in front of the shore in the southeastern corner of the lake are made up of the sandstone of the lower Silurian series, a few isolated patches of this rock occurring at intervals along the shore down as far as Lake Huron.

The study of the vein phenomena of the various formations around the shores of Lake Superior seems to confirm the correctness of the views maintained above. The native copper-bearing veins are exclusively confined to the bedded trap of Lower Silurian age, and are not found in the azoic series at all. These veins are marked by peculiar gangues, in which one or more of the zeolitic minerals are rarely wanting, Prehnite and Laumonite being the most common. These minerals, however, do not form the main bulk of the vein-stone, but are mixed with a larger proportion of quartz and calc-spar. This is the case where the trap forms the wall-rock; but when the vein passes into the conglomerate, the predominating vein-stone is calc-spar. All the productive veins thus far, however, have been profitably worked in the trap alone, although large masses of copper have been occasionally met with in the conglomerate. In a few cases veins have been worked within the trap itself, which were made up almost entirely of calcareous spar; but in no instance has this been found to be a productive gangue, there being rarely more than a trace of copper mixed with it. In the unbedded trap, calc-spar and heavy spar are the predominating vein-stones, in some instances associated with crystallized quartz, but native copper does not occur in this association, the sulphuret of this metal, as also of zinc and iron, being the usual metalliferous ingredients of veins in this position. Copper pyrites is rarely found occurring in any considerable quantity in the veins of the unbedded or bedded traps associated with rocks of Silurian age. A few of the native copper veins exhibit occasional minute traces of this ore, while in the veins of the unbedded trap it is considerably more common, although never, as far as has yet been observed, predominating in quantity over the other ores, and usually falling far below them. It may be remarked, however, that the veins in this position, although frequently wide, regular and well-developed, have in no instance proved, on being worked, to contain ore enough to afford any reason to hope for their profitable exploitation; many of the best-developed ones contain hardly a trace of ore. Passing from the Lower Silurian to the Azoic System, we find an entire change in the character of the veins, both as regards their gangues and the associated ores. In every case in which mines have been wrought in rocks, which according to the views presented above, should be classed with the Azoic, quartz constitutes almost the exclusive vein-stone, while the only valuable ore occurring in sufficient quantity to be worthy of notice is copper pyrites, the native metal being never present in this association. Many of the veins in the Azoic are barren of copper ore but, contain, on the other hand, an abundance of iron pyrites; indeed the number of workable deposits of copper in this position appears to be small. Those which afford the greatest promise of success are included in the trap which accompanies the slates and quartz-rock. The granitic and gneissoidal rocks of this period are frequently traversed by heavy vein-like masses of quartz; but their mineral contents are usually confined to iron pyrites. In the Huron Mts., however, on the south shore of the lake, near Keweenaw Bay, there are some veins which carry considerable copper pyrites and which may, eventually, be found worthy of exploration.

The number of metalliferous deposits in rocks equivalent to the native copper-bearing range of the south shore, which are known to exist upon the north shore of Lake Superior, is very great. They are especially abundant upon Isle Royale and on the numerous points and islands which lie between Thunder and Neepigon Bays. Considerable money has been expended in exploring in this region, and in attempts at mining for copper. Abundant as are the localities in this portion of the lake in which this metal has been found, it may be doubted whether there exists a single vein which can be worked with profit, and it is certain that none of those on which, up to a recent period, mining operations have been commenced, show any very encouraging indications. Valuable deposits may perhaps yet be discovered; but it appears that the thinness and irregularity of the igneous beds and the frequent changes of lithological character have prevented the metalliferous veins from assuming that development which they have in the cupriferous range of the south shore.

The character of the metalliferous deposits which occur in the Azoic rocks still farther east than Lake Huron, is similar to that which they present in the region of this lake and Lake Superior. The sulphurets of copper, lead and zinc are the chief ores, and nowhere do we find any veins resembling in character those of the native copper-bearing rocks of the bedded trap series, neither do we find in the reports of the Canada Survey any indication of the Huronian System having been recognized to the east of Lake Huron, the Laurentian, or Azoic, being everywhere in that direction succeeded by the Potsdam sandstone, just as it is on Lake Superior in point of fact.

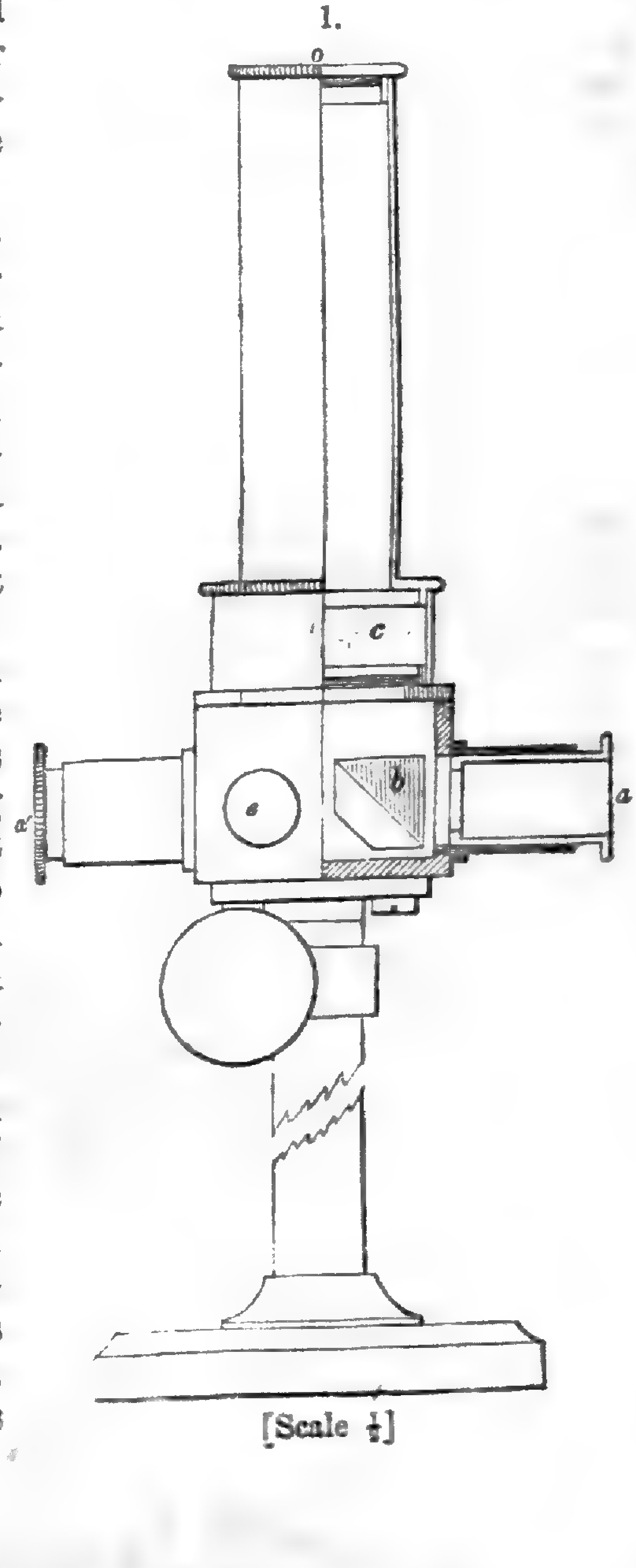
From these considerations, it appears to us that the native copper-bearing series of the north and south shores of Lake Superior cannot be separated from the Potsdam sandstone with which it is associated, and neither is there any reason whatever for placing it in the same line with the rocks of the north shore of Lake Huron. These latter, as well as the great mass of crystalline rocks to the north and east in Canada, are identical in position and lithological character with the series described by Mr. Foster and myself under the name of the Azoic System and which cover so large an extent of country in Michigan, Wisconsin, and Minnesota. These Azoic rocks were described by Mr. Logan in his various reports, previous to the one for 1852–3, under the name *metamorphic*. The term "Laurentian," proposed in that report for this series, had been previously adopted by Mr. Desor and the Geologists of the Lake Superior survey for the post-tertiary deposits, containing marine fossils, which are found in the valley of the St. Lawrence and elsewhere, and which had been called "second drift" by some geologists.* The use of the same term to designate a group or system at the other extremity of the geological scale seems likely to lead to confusion, and we hope that it will be dropped for the lower system, and retained for the deposits to which it was first applied. Strong objections may also be made to the use of the term "Cambrian," which has been applied by Messrs. Logan and Hunt, as synonymous with "Huronian," in the "Esquisse géologique du Canada," published at Paris in 1855, and which has also been used by other geologists in the United States to designate various groups low down in the series, and of doubtful age and position. The claims of the Cambrian to recognition as a distinct system, and the question how much of the Silurian it should be allowed to swallow up, have already been the cause of sufficient discussion in England and we trust that the controversy may not be imported into this country. By far the larger number of geologists have agreed in embracing all the fossiliferous rocks, down to the bottom of the series, within the Silurian series, and Prof. Sedgwick himself would agree, that to restrict the term Cambrian to the unfossiliferous portion of the groups to which he gives that name, would be not at all in accordance with his views, and more objectionable than to do away with it altogether. If we find in this country a series of fossiliferous beds below those at present recognized, and whose organic contents cannot be considered as being of Lower Silurian type, let us give them a new name, which shall not involve us in any Cambrian controversies; but, if, as appears from the evidence thus far collected, we have reached in the lower sandstones of the northwest the downward limit of organized existence, we are justified, for the present at least, in the use of the term Azoic to designate the rocks upon which these sandstones rest unconformably.

* See Bull. Geol. Soc. [2], viii, 422.

ART. XXXII.—*Notice of a Photometer and of some experiments therewith upon the comparative power of several artificial means of Illumination;* by B. SILLIMAN, Jr., and CHAS. H. PORTER.

THE photometers in general use for determining the comparative illuminating power of various sources of light, depend upon a comparison either of shadows or of illuminated discs. Rumford's well known instrument is of the former description, and Ritchie's is an example of the latter. Having found much difficulty in the adaptation of any of the instruments commonly in use to the accurate admeasurement of the illuminating power of various forms of gas jets, Prof. B. Silliman, Jr. was led to consult Messrs. J. & W. Grunow of New Haven, opticians of eminent merit, and requested them to give form to our mutual conclusions by constructing the instrument here described.

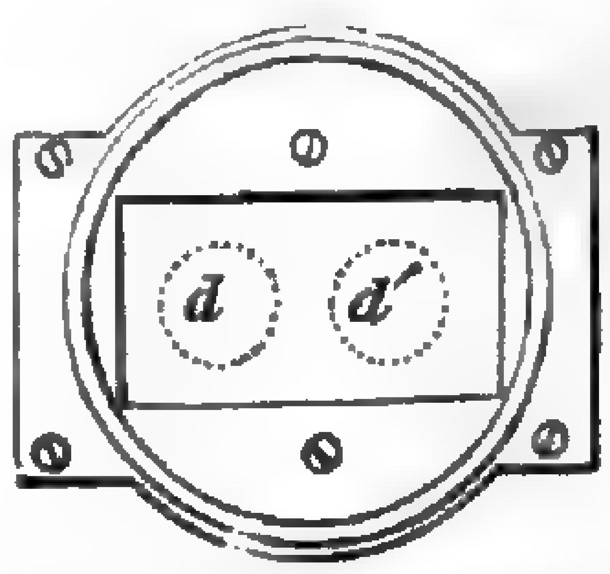
1.



[Scale ½]

Description of the instrument.—In this instrument the pencils of light are received through diaphragms of exactly equal magnitude, fig. 1, *a a'*, upon two equal triangular prisms of flint glass placed at the angle of total reflection. The opening is situated at the bottom of the draw tube, and may be varied in form or position at pleasure. The position of one of these prisms may be seen at *b*, showing one-half of the instrument in vertical section. The two illuminated discs are received upon a diaphragm of ground glass placed in a dark chamber *c*, 30 m.m. in diameter. Figure 2 shows the diaphragm in plan with the two discs *d d'* in relative position. Above this is the eye-piece *o*, and draw tube fitted with diaphragms of various apertures and of differently tinted glass. The whole instrument is mounted upon a sliding stand to allow of adjustment at different elevations. For convenient adjustment of the prisms at the angle of total reflection a slight motion of rotation is provided by the knerled heads *e*, fig. 1. The edges of the illuminated discs are brought near to each other, but should not overlap. The carriage upon which the instrument stands slides upon a graduated bar 150 inches long, and the readings are made with a vernier from a zero mark. The two lights to be compared are of course at the two extremities of the graduated bar and remain fixed at the same elevation. The photometer is then moved until an equality of illumination is seen in the two discs in the dark chamber. A yellowish green eye-glass has been found to be the most perfect compensation for differences of color produced by different lights. The facility of use and the accuracy of this instrument exceeded our best expectations. Persons wholly unacquainted with such observations readily appreciated very slight differences of illumination in the two discs, and where the instrument was purposely placed out of its proper position, such persons succeeded in the first attempt in bringing it surprisingly near its accurate adjustment. The eye readily detected a difference of one-fourth of an inch in the position of the instrument by the change in the brilliancy of the two discs. This quantity is equivalent to $\frac{39}{100}$ths of one per cent of the whole quantity. Some scientific uses may demand a greater degree of accuracy than this, but it is quite equal to the demands of the arts. The use of a colored eye-glass of the proper tint to compensate the red rays of the more feeble source of illumination and to allow the passage of the yellow rays is quite indispensable to accuracy. The photometer most resembling this is Ritchie's, but the superior accuracy and neatness of the instrument here described is very obvious. The dark chamber and compensating eye-piece give to the discs of light upon the ground glass diaphragm, a facility of compensation and of adjustment hardly inferior to the accuracy attainable by Babinet's polarizing photometer, to which there are some objections needless to be dwelt on here.

2.



Experiments with the instrument.—The following trials were made in the city of New Haven on the last evenings of January 1856, during very severe weather, upon two samples of coal gas. On the 1st and 5th evenings the coals used in charging the retorts consisted of a mixture of

	1st.	5th.
Fairmount (Maryland),	5,725 lbs.	5,642 lbs.
Newcastle (English),	5,725 "	5,641 "
Hillsboro' (New Brunswick),	750 "	750 "
	12,200 " +	12,033 " = 24,233 lbs.

There were produced from this mixture 102,724 cubic feet of gas or 4·24 cubic ft. to the pound of coal, and 40 bush. coke, weighing 39 lbs. to the bush. =1540 lbs. from 2000 lbs. coal.

On the 2nd, 3rd and 4th nights the "Ohio Diamond Coal" (Big Yellow Creek, O.), was used to the amount of 38,500 lbs. In the three days, there were produced 135,110 cubic feet of gas or 3·50 cubic feet to the pound of coal, and 30 bushels of coke weighing 41·5 lbs. per bush. =1245 lbs. from 2000 lbs. coal.

In order to avoid as far as practicable the errors likely to arise from the condensation of the more highly illuminating portions of the gas by the cold, and from other sources, the trials were made on the three first evenings at the gas-house, where the gas was obtained directly from the mains, before it had been refrigerated by distribution. On the fourth and fifth evenings the trials were made in the city, nearly three-fourths of a mile from the works. The contrast between the two sets of experiments is most striking, particularly on the last evening, as compared with the first, as on both these occasions it was the gas of ordinary supply which was used.

The standard of comparison or unit in these trials was a "Judd's patent sperm candle, No. 6," burning 127 grains in the hour. This was burned in a sheathed candlestick and by aid of a spring, (like a coach candle lamp,) was kept always at the same elevation. Observations were also made with the Carcel's mechanical lamp as a unit. The size of lamp employed was one inch diameter of wick, burning 796 grains per hour of the first quality winter-strained sperm oil, such as is used by the government light-houses in lamps of similar construction. This form of lamp is regarded as furnishing the most uniform light of any artificial source for a series of hours. In the following tables (see next page) the results are presented in as simple and condensed a form as practicable. The several burners compared are those most commonly used in the United States; the same set of burners was used in all the trials. The gas consumed was registered by a small registration meter, on the dial of which an index notes the cubic feet and fractions consumed per hour. As the same instrument was used throughout, no errors of importance can have arisen as between the several sets of observations. The meter was not compared with any absolute standard, nor was the density of the gas determined.

BURNERS.	I. "FAIRMOUNT," &c. at Gas Works. Pressure 2·40 in.			II. "DIAMOND," at Gas Works. Pressure 2·60 in.			III. "DIAMOND," at Gas Works. Pressure 2·40 in.			IV. "DIAMOND," at Marschal & Stratton's.			V. "FAIRMOUNT," &c. Marschal & Stratton's.			Average consumption per hour, in cubic feet.	Average cost per hour, in cents.	Light produced when burning average am't = to — candles.	Cost of light = to Carcel Lamp, per hour.
	Cubic feet consumed per hour.	Equal to — candles.	Burner consuming 5 ft. = to — candles.	Cubic feet consumed per hour.	Equal to — candles.	Burner consuming 5 ft. = to — candles.	Cubic feet consumed per hour.	Equal to — candles.	Burner consuming 5 ft = to — candles	Cubic feet consumed per hour.	Equal to — candles.	Burner consuming 5 ft. = to — candles.	Cubic feet consumed per hour.	Equal to — candles.	Burner consuming 5 ft. = to — candles.				
Union jet, (Scotch burner,)	19·59	4·9	19·58	4·3	20·80	24·18	4·8	21·77	22·67	5·2	22·95	22·07	5·1	16·18	15·86	4·86	1·944	20·25	·96
Cornelius' fish-tail, ...	14·39	5·	14·39	4·3	20·80	24·18	5·0	22·78	22·78	5·0	18·51	18·51	5·	13·35	15·35	4·86	1·944	17·96	1·082
Soule's flat top bat-wing, ..	13·74	4·	17·17	4·3	15·48	18·00	4·0	15·49	19·36	4·1	12·41	15·13	4·	12·92*	9·45	4·08	1·632	13·83	1·180
Munsig's single cut bat-wing,	9·82	4·5	10·91	4·	13·22	16·52	5·2	16·13	150·5	4·6	12·76	13·86	4·6	8·71	9·46	4·58	1·832	12·13	1·510
Batten's double cut bat-wing,	10·18	4·	12·73	3·5	13·22	18·88	3·3	9·48	14·36	3·6	9·87	13·70	3·	6·61	11·02	3·48	1·392	9·87	1·413
Stratton's Argand, ...	27·40	7·	19·6	6·0	28·88	24·07	7·0	23·86	17·04	6·67	24·02	18·00	7·	23·98*	12·98	6·73	2·692	25·67	1·049
Homan's double jet, ...	....	...	.....	5·75	31·94	27·77	5·0	26·21	26·21	6·0	20·73	17·28	6·	18·98	15·82	5·69	2·276	24·46	·926
Judd's patent sperm candle,	....	grs. 127	.....	....	....	....	....	....	....	....	....	....	...	....	....	grains 127·	1·001	....	10·01
Carcel Lamp, ...	10·	796	.....	....	....	....	....	....	....	....	....	....	...	....	....	796·	3·149	....	3·149

* Calculated.

ART. XXXIII.—*Researches on the Ammonia-cobalt Bases;* by WOLCOTT GIBBS and F. A. GENTH. Part I.

Continued from page 265.

CHLORPLATINATE OF PURPUREOCOBALT.

WHEN a solution of bichlorid of platinum is added to one of the chlorid of Purpureocobalt, a brown-red precipitate is thrown down, which is a combination of the two chlorids. When dried it has a fine rich brown-red color and high lustre. The crystals seen under the microscope are usually aggregations of flat pale reddish-brown needles. They are very distinctly dichrous, the ordinary image being pale violet-rose, while the extraordinary image is rich orange-red.

The chlorplatinate is nearly insoluble in cold, and with great difficulty soluble in hot water. It resists the action of reducing agents much more powerfully than the chlorplatinates of the alkaline metals. Thus it must be boiled for a very long time with zinc and chlorhydric acid before a complete reduction of the platinum is effected. If the process be interrupted before the reduction is complete, brilliant yellow granular crystals are often formed in the liquid. We have not determined the constitution of these crystals, but they are not chlorplatinate of ammonium. Sulphurous acid reduces this double chlorid readily, and yields a red solution containing the protochlorids of platinum and of cobalt. We may here remark, that so far as our observation has hitherto extended, the action of a reducing agent upon any constituent of a compound containing an ammonia-cobalt base extends invariably to the ammonia-cobalt base itself.

The chlorplatinate of Purpureocobalt has the formula

$$5NH_3 . Co_2Cl_3 + 2PtCl_2$$

as the following analyses show:

0·6765 grs. (reduced by boiling with SO_2 and the platinum precipitated as sulphid by $NaO . S_2O_2$ after adding HCl) gave 0·2267 grs. of platinum = 33·51 per cent.

0·9521 grs. gave 0·3169 grs. of platinum and 0·2483 grs. sulphate of cobalt = 9·93 per cent cobalt.

—— grs. gave —— grs. of chlorid of silver = 41·80 per cent chlorine.

The formula requires

	Eqs.	Calculated.	Found.
Cobalt,	2	10·10	9·93
Platinum,	2	33·50	33·51
Chlorine,	7	42·01	41·80

This salt is identical with the chlorplatinate described and analyzed by Claudet, and for which that chemist found the same formula, with the exception of the hydrogen, which he makes 16 in place of 15 equivalents. We have also obtained it from a chlorid which gave the reactions of chlorid of Roseocobalt, but we must leave it for the present undecided whether in this case there was a conversion of Roseocobalt into the isomeric Purpureocobalt, by the action of the chlorid of platinum, or whether the chlorid of Roseocobalt had already undergone the change. We consider it certain that the salt in question is a salt of Purpureocobalt, because it contains *two* in place of *three* equivalents of bichlorid of platinum. We shall show further on, that the oxygen salts of this base contain either *two* or *four* equivalents of acid, and it is well known that in the chlorplatinates there is—we believe invariably—but one equivalent of bichlorid of platinum for each equivalent of chlorine in the chlorid with which it is united. Since there are three equivalents of chlorine in this chlorid of Purpureocobalt, we infer that two of them are differently combined from the other two, so that the rational formula of the chlorplatinate is

$$5NH_3 . Co_2Cl . Cl_2 + 2PtCl_2 .$$

We shall develop this view more fully when speaking of the oxygen salts of Purpureocobalt.

OXALATE OF PURPUREOCOBALT.

This most beautiful salt is readily prepared by adding a solution of oxalate of ammonia to one of chlorid of Purpureocobalt. After a short time violet-red needles are thrown down, which may be washed with cold water. As thus prepared, the salt is almost chemically pure. The color of the oxalate of Purpureocobalt is the violet $\frac{6}{10}$ of the first circle of Chevreul's scale; the crystals are not sensibly dichrous. We have not, as yet, obtained measurable crystals of this salt. Under the microscope four- and six-sided acicular prisms are distinguishable, but without characterizing terminal planes.

The oxalate of Purpureocobalt has the formula

$$5NH_3 . Co_2O_3 ,\ 2C_2O_3 + 3HO$$

as the following analyses show:

0·2723 grs. gave 0·1574 grs. sulphate of cobalt = 22·00 per cent of cobalt.
0·3545 grs. gave 0·2045 grs. " " = 21·95 " "
0·8970 grs. burnt with oxyd of copper gave 0·2973 grs. carbonic acid = 27·11 per cent of oxalic acid.

The formula requires

	Eqs.	Calculated.	Found.	
Cobalt, - - -	2	22·09	22·00	21·95
Oxalic acid, - -	2	26·96	27·11	——

The oxalate is nearly insoluble in cold water, and not very soluble in boiling water, even after addition of free oxalic acid. The salt does not crystallize well from its solutions, and we have always obtained it in the most beautiful form by direct precipitation from the chlorid. The salt is neutral to test paper, and is the only neutral oxysalt of Purpureocobalt which we have yet obtained. It will appear from what follows, extremely probable that there is an acid oxalate of Purpureocobalt containing four equivalents of oxalic acid. We have not obtained such a salt however, in one or two experiments made for the purpose.

ACID SULPHATE OF PURPUREOCOBALT.

Our efforts to obtain a neutral sulphate of Purpureocobalt containing two equivalents only of sulphuric acid have hitherto been fruitless. When a solution of chlorid of Purpureocobalt is treated with sulphate of silver, chlorid of silver is formed, and the red supernatant liquid yields, on evaporation, crystals of sulphate of Roseocobalt. Precisely the same result is obtained with the chlorid and nitrate of silver; the red solution yielding crystals of nitrate of Roseocobalt. We consider it probable that in these cases the sulphate and nitrate of Purpureocobalt, $5NH_3.Co_2O_3, 2SO_3$, and $5NH_3.Co_2O_3, 2NO_5$, are really formed by double decomposition, but that during evaporation the equivalent of free sulphuric or nitric acid formed at the same time with the sulphate or nitrate, reacts upon this so as to convert it into a salt of Roseocobalt with three equivalents of acid. In equations we should have for the sulphate

$$5NH_3.Co_2Cl_3+3AgO, SO_3+HO=5NH_3.CO_2O_3, 2SO_3+HO, SO_3+3AgCl.$$

$$5NH_3.Co_2O_3, 2SO_3+HO, SO_3=5NH_3.Co_2O_3, 3SO_3+HO.$$

When oil of vitriol is poured upon chlorid of Purpureocobalt in quantity sufficient to make a thick paste, the mass assumes a fine purple color, and swells up very much at first, so that a large vessel is necessary. If the solution, after the evolution of chlorhydric acid has ceased, be diluted with about twice its volume of water, and allowed to stand for a few hours, a large mass of beautiful violet-red needles is deposited. The mother liquor, after standing for a longer time, deposits more crystals. These crystals are to be quickly washed with a little cold water, drained and dried by pressure between folds of bibulous paper. They are usually free from chlorine, and are very nearly pure acid sulphate of Purpureocobalt. The mother liquor contains more of the acid sulphate together with small quantities of another sulphate which we shall describe more fully hereafter, and frequently a little undecomposed chlorid. By boiling this mixture with chlorhydric acid chlorid of Purpureocobalt is formed, which may be employed in preparing a fresh portion of the acid sulphate.

The acid sulphate of Purpureocobalt may also be prepared by the action of strong sulphuric acid upon the sulphate of Roseocobalt. For this purpose oil of vitriol is to be poured upon the sulphate in quantity sufficient to produce an oily liquid on heating in a water bath. The digestion is to be continued for one or two hours, according to the quantity of salt employed, care being taken that no oxygen is evolved. The dark purple liquid is to be suffered to cool, diluted with an equal bulk of water, and allowed to crystallize.

The acid sulphate as thus obtained is difficult to purify. By dissolving it in a small quantity of hot water, and evaporating it quickly, fine crystals may sometimes be obtained. When, however, the solution is evaporated slowly in the air, crystals of sulphate of Roseocobalt are formed in abundance, while the mother liquor contains free sulphuric acid. When a solution of the acid sulphate is neutralized with ammonia, and allowed to crystallize by slow evaporation, the sulphate of Roseocobalt is also obtained, but by rapid evaporation dark-red, prismatic crystals are sometimes formed, which we have not yet obtained in sufficient quantity for a complete analysis. They may prove to be the neutral sulphate of Purpureocobalt.

The acid sulphate of Purpureocobalt crystallizes in fine, red, prismatic crystals, which, according to Prof. Dana, belong to the trimetric system, and are hemihedral. The observed forms are I, $i\breve{i}$, $\frac{1}{2}\breve{i}$, $\frac{1}{2}\bar{2}$, $i\bar{2}$ (?) or in other symbols ∞, $\infty\text{-}\breve{\infty}$, $\frac{1}{2}\text{-}\breve{\infty}$, $\frac{1}{2}\bar{2}$, $\infty\text{-}\bar{2}$ (?):

$I : I = 106°$.

$I : i\breve{i} = 127°$ (126° 50′—127° 10′)

$\frac{1}{2}\breve{i} : \frac{1}{2}\breve{i} = 122° 42′$.

$1\bar{2} : 1\bar{2} = 67° 54′$.

$a : b : c = 1{\cdot}0927 : 1 : 1{\cdot}3271$.

8.

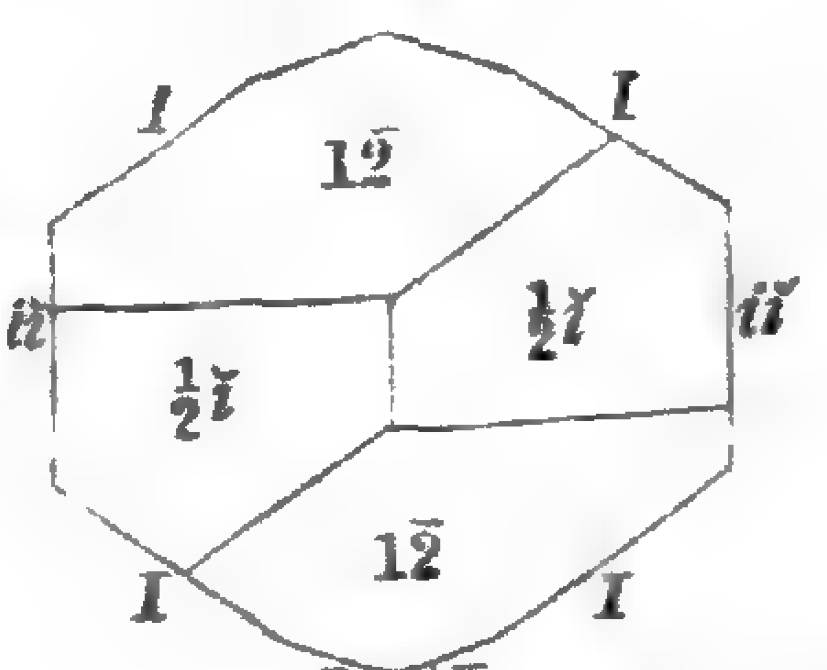


Fig. 8 represents an end view of a crystal of this salt; $1\bar{2}$ is hemihedral and $i\bar{2}$ usually so; the symbol $i\bar{2}$ is probably correct, though the observed angle varies much.

The acid sulphate is very soluble in water, and has a distinct though not strongly acid taste. It reddens litmus, and expels carbonic acid from the carbonates.

The formula of this salt is

$$5NH_3 . Co_2O_3, 4SO_3 + 5HO$$

as the following analyses show:

0·620 grs. gave 0·2577 grs. sulphate of cobalt = 15·82 per cent cobalt.
1·1402 grs. gave 0·4756 grs. " " = 15·86 " "
1·5317 grs. gave 1·9270 grs. sulphate of baryta = 43·19 " sulphuric acid.
1·5843 grs. gave 0·7570 grs. water = 5·31 per cent hydrogen.
1·1869 grs. gave 189·5 c. c. nitrogen at 15° C. and $775^{mm}·2$ (at 15°·3) = 179·6 c. c. at 0° and 760^{mm} = 19·00 per cent nitrogen.

The formula requires

	Eqs.	Calculated.	Found.	
Cobalt,	2	15·81	15·82	15·86
Sulphuric acid,	2	42·89	43·19	
Hydrogen,	20	5·36	5·31	
Nitrogen,	5	18·76	19·00	

The acid sulphate gives no precipitate with 3KCy, Co_2Cy_3, but only a fine red liquid, which, on evaporation, yields a red mass. Boiled with chlorhydric acid the sulphate yields the chlorid of Purpureocobalt, easily recognized by oxalate of ammonia, with which, however, the acid sulphate itself gives no precipitate. When precipitated with nitrate of baryta the acid sulphate yields a red liquid which probably contains a nitrate of Purpureocobalt, but which on evaporation gives crystals of nitrate of Roseocobalt. It is well worthy of notice, that this red liquid contains a large quantity of sulphate of baryta in solution, which it deposits during evaporation.

The products of the decomposition of the acid sulphate are similar to those of the other salts of Purpureocobalt. A rapid current of NO_x passed into the solution gives, after a short time, an abundant precipitate of the nitrate of Xanthocobalt.

The constitution of the acid sulphate might be represented by either of the following formulæ, besides that already given:

$$5NH_3.Co_2O_3,\ 3SO_3+HO,\ SO_3+4HO.$$
$$5NH_3.Co_2O_3,\ 2SO_3+2HO,\ SO_3+3HO.$$

We reject the first of these formulæ because Purpureocobalt is a biacid and not a triacid base. The second formula appears to us less probable than that which we have adopted, in the first place, because a salt so constituted ought to be strongly acid, and in the second place, because we shall presently show that there exists an oxalo-sulphate of Purpureocobalt, in which *two* equivalents of sulphuric are replaced by *two* of oxalic acid, and another and neutral oxalo-sulphate in which one equivalent of oxalic acid replaces one equivalent of sulphuric acid.

ACID OXALO-SULPHATE OF PURPUREOCOBALT.

When sulphate of Roseocobalt is boiled for several hours with an excess of a solution of oxalic acid, a clear red solution is formed, which on evaporation deposits an abundance of crystals of a bright brick-red color, and indistinct acicular form. These crystals are soluble in hot water without decomposition, and may be purified, though with difficulty, by recrystallization. Their constitution is represented by the formula

$$5NH_3.Co_2O_3,\ 2SO_3,\ 2C_2O_3+3HO$$

as appears from the following analyses:

0·7433 grs. gave 0·3315 grs. sulphate of cobalt = 16·97 per cent cobalt.
1·3912 grs. gave 0·9535 grs. sulphate of baryta = 23·50 " sulphuric acid.
1·6895 grs. gave 1·1564 grs. " " = 23·49 " sulphuric acid.
2·7702 grs. gave 0·7070 grs. carbonic acid = 20·88 " oxalic acid.
2·0198 grs. gave 340 c. c. of nitrogen at 14°·5 C. and 763mm·01 (at 15° C.)=318·1 c. c. at 0° and 760mm = 19·78 per cent nitrogen.

The formula requires

	Eqs.	Calculated.	Found.	
Cobalt,	2	17·00	16·97	
Sulphuric acid,	2	23·05	23·49	23·50
Oxalic acid,	2	20·74	20·88	
Nitrogen,	5	20·17	19·78	

The reactions of this remarkable salt resemble closely those of the acid sulphate. It has an acid taste and reaction, gives no precipitate with oxalate of ammonia, or cobaltidcyanid of potassium, and yields chlorid of Purpureocobalt by boiling with an excess of chlorhydric acid. The formula of this salt may be written in various ways. In the first place, we may consider it as a double salt represented by the formula

$$5NH_3.Co_2O_3,\ 4SO_3+5NH_3.Co_2O_3,\ 4C_2O_3+6HO.$$

The advantage of simplicity is evidently in favor of the formula we have adopted. We may also consider it as represented by

$$5NH_3.Co_2O_3,\ 2SO_3+2C_2O_3,\ HO+HO.$$

In this case the salt should have a strongly acid taste which it has not. On the whole the formula

$$5NH_3.Co_2O_3\left\{\begin{matrix}2SO_3\\2C_2O_3\end{matrix}\right.+3HO$$

appears to deserve the preference.

NEUTRAL OXALO-SULPHATE OF PURPUREOCOBALT.

When ammonia is added to a solution of the acid oxalo-sulphate just described, a fine violet-red color is produced, and if no more ammonia be added than is sufficient to completely neutralize the acid reaction, the liquid yields, on evaporation, beautiful red prismatic crystals of a neutral salt. The neutral oxalo-sulphate is much less soluble in water than the acid salt, and has a purely saline taste: it is easily decomposed by boiling. The formation of this salt is represented by the equation

$$5NH_3.Co_2O_3,\ 2SO_3,\ 2C_2O_3+2NH_4O=5NH_3.Co_2O_3,\ SO_3,\ C_2O_3+NH_4O,\ SO_3+NH_4O,\ C_2O_3.$$

The fact that the ammonia unites with both sulphuric and oxalic acid, and not simply with *two* equivalents of oxalic acid, throws much light on the constitution of the acid oxalo-sulphate, and shows, we think, clearly that the formula of this salt cannot be

$$5NH_3.Co_2O_3, 2SO_3+2C_2O_3, HO+HO.$$

The constitution of the neutral oxalo-sulphate is represented by the formula

$$5NH_3.Co_2O_3, \begin{cases} SO_3 \\ C_2O_3 \end{cases} +7HO$$

as appears from the following analyses:

0·6367 grs. gave 0·3217 grs. sulphate of cobalt = 19·23 per cent cobalt.
0·6721 grs. gave 0·2569 grs. sulphate of baryta = 13·12 " sulphuric acid.
0·9760 grs. gave 191 c. c. nitrogen at 17°·25 C. and 767mm·58 (at 17°·8) = 177·43 c. c. at 0° and 760mm = 22·83 per cent.

The formula requires

	Eqs.	Calculated.	Found.
Cobalt,	2	19·21	19·23
Sulphuric acid,	1	13·02	13·12
Oxalic acid,	1	11·72	
Nitrogen,	5	22·80	22·83

We may further remark that the character of the action of ammonia upon the acid oxalo-sulphate leads us to hope that the neutral sulphate of Purpureocobalt may be obtained by the action of this agent upon the acid sulphate, and that in fact, this is the salt already mentioned as so obtained, but not yet analyzed. The two oxalo-sulphates described constitute, we believe, the types of an entirely new class of salts, and lead to the idea that sulphuric and oxalic acids may possibly be capable of replacing each other in combinations.

OXYD OF PURPUREOCOBALT.

The oxyd of Purpureocobalt, like that of Roseocobalt, appears to exist only in solution. It may be prepared, either by decomposing the acid sulphate by baryta water, or by digesting a solution of the chlorid with oxyd of silver in the cold. The solution is not pure in either case, containing either sulphate of baryta or chlorid of silver in solution. The oxyd, as thus prepared in solution, forms a violet-red liquid, which absorbs carbonic acid readily from the air, and which is decomposed by concentration.

The constitution of the oxygen salts of Purpureocobalt, which we have described, as well as that of the chlorplatinate of this radical, appears to us to leave no reasonable doubt that the oxyd is essentially *biacid.* According to the rule that the number of equivalents of acid in a salt is equal to the number of equivalents of oxygen in the base, the rational constitution of the oxyd of Purpureocobalt will be expressed by the formula

$$5NH_3.Co_2O.O_2.$$

We shall develop this view more fully when occupied with the purely theoretical portion of the subject, and in the second part of our memoir we shall endeavor, by the analysis and description of other salts of Purpureocobalt, to throw more light upon the nature of this remarkable radical. The chromates, pyrophosphates, and picrate of Purpureocobalt have, in particular, occupied our attention.

We have mentioned, in speaking of the reactions of chlorid of Purpureocobalt, that both the cobaltidcyanid and the ferridcyanid of potassium give precipitates in its solution. The constitution, crystalline form and physical appearance of these two precipitates exactly agree with those of the cobaltidcyanid and ferridcyanid of Roseocobalt, and we have, therefore, not hesitated to identify them with these last. We believe that in this case there is a conversion of Purpureocobalt into Roseocobalt, since in the salts in question there are three equivalents of cyanogen in the electropositive for three in the electronegative cyanid, the formulæ being as mentioned above

$$5NH_3.Co_2Cy_3+Co_2Cy_3+3HO, \text{ and } 5NH_3.Co_2Cy_3+Fe_2Cy_3+3HO.$$

As Purpureocobalt is certainly biacid, its cobaltidcyanid and ferridcyanid should have the formulæ

$$3(5NH_3.Co_2Cy_3)+2Co_2Cy_3, \text{ and } 3(5NH_3.Co_2Cy_3)+2Fe_2Cy_3,$$

although the frequent occurrence of basic double cyanids may render this point less clear than the others which also involve the biacid character of the radical.

LUTEOCOBALT.

The salts of Luteocobalt have a yellow or brown-yellow color, and are almost always well crystallized. They are in general more soluble in water than the corresponding salts of Roseocobalt; the solutions have a brown-yellow color. The salts of Luteocobalt are very stable in the presence of acids in general, but are decomposed by long heating with sulphuric acid. The neutral and alkaline solutions are readily decomposed by boiling, like the salts of the other cobalt bases. Nearly all of them have a purely saline taste. When hydrated, these salts generally effloresce in dry air or in vacuo, and become opaque, with a peculiar porcelain-like lustre and reddish-buff color. The salts of Luteocobalt may be formed, like those of the other bases described, by direct oxydation: it is well worthy of notice, however, that they are often found among the products of the decomposition of the salts of Roseocobalt and Purpureocobalt. This is especially remarkable, because the constitution of Roseocobalt is simpler than that of Luteocobalt, the former base being $5NH_3.Co_2O_3$, while the latter is $6NH_3.Co_2O_3$. We have here a singular inversion of the usual law, that the products of the decomposition of a complex molecule are more simple in constitution than the body decomposed.

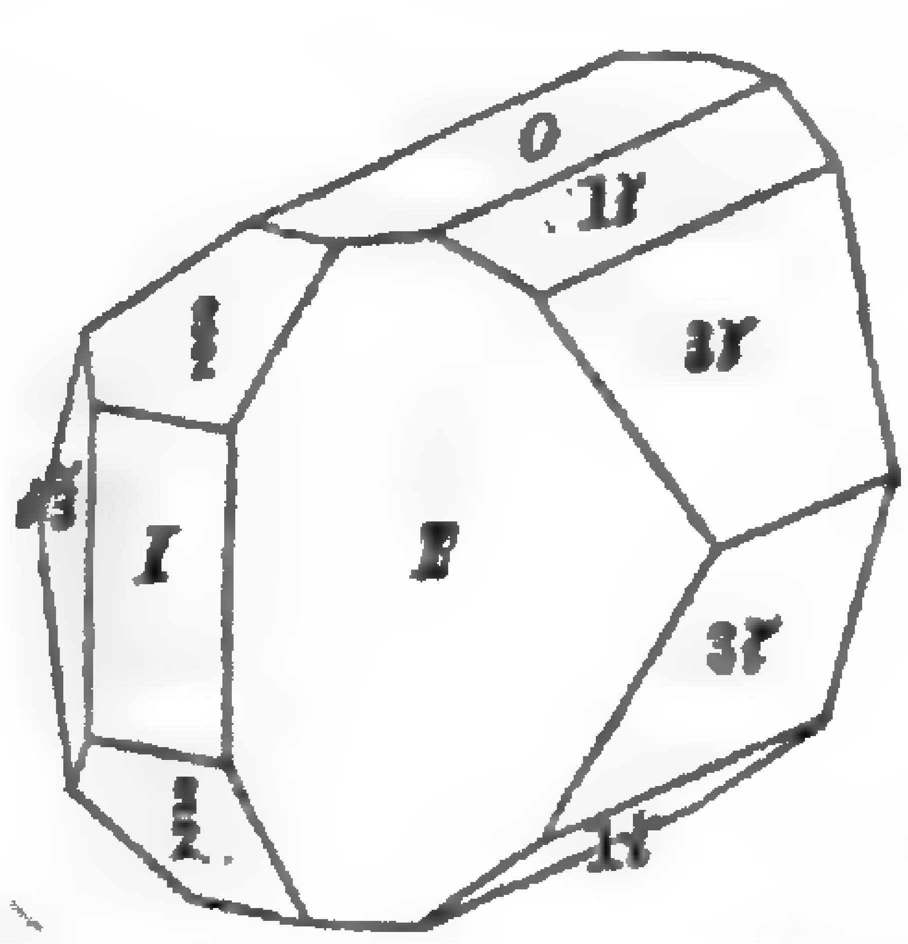
Luteocobalt, like Roseocobalt, is a triacid base.

CHLORID OF LUTEOCOBALT.

When an ammoniacal solution of chlorid of cobalt, to which a large quantity of coarsely powdered chlorid of ammonium has been added, is exposed to the air for some days, it often happens that no traces of chlorid of Roseocobalt or Purpureocobalt are found, but the bottom of the vessel becomes covered with orange-yellow crystals, which are the chlorid of Luteocobalt. Chlorhydric acid precipitates an additional quantity of the salt from the supernatant liquid. The raw chlorid, as thus obtained, is easily purified by solution in hot water, filtration, and repeated crystallization. This method of preparing the salt is by no means always successful, and very frequently results only in the formation of chlorid of Roseocobalt and Purpureocobalt, with scarcely a trace of the chlorid of Luteocobalt. We have, however, almost invariably succeeded in preparing, by this process, a mixture of the sulphate and chlorid of Luteocobalt, by employing a solution containing both the chlorid and sulphate of cobalt. The sulphato-chlorid resulting, by boiling with chlorhydric acid and chlorid of barium, yields a solution from which the pure chlorid may be obtained by repeated crystallization. The chlorid of Luteocobalt crystallizes by slow evaporation, in remarkably beautiful brownish-orange colored crystals, which belong to the trimetric or right rhombic system, and which are isomorphous with the sulphate of Luteocobalt. According to Prof. Dana, the usual forms are, in his modification of Naumann's notation, O, ∞, $\frac{\frac{3}{2}}{2}$, $\frac{\infty\text{-}\breve{3}}{2}$, $1\text{-}\breve{\infty}$, $3\text{-}\breve{\infty}$, with the angle $I : I = 113°\ 16'$. Fig. 9 represents a crystal of this salt with Dana's notation for the faces:

9.

$I : I = 113°\ 16'$.
$O : 1\breve{\imath} = 145°\ 55'$.
$O : 3\breve{\imath} = 116°\ 13'$.
$1\breve{\imath} : 1\breve{\imath} = 112°\ 2'$ (over O)
$3\breve{\imath} : 3\breve{\imath} = 52°\ 26'$ (over O)
$3\breve{\imath} : 3\breve{\imath} = 127°\ 34'$ (adjacent)
$O : \frac{3}{2} = 118°\ 35'$ (by observation)



Frémy states that this salt crystallizes in regular octahedrons; in this case it must be dimorphous, but we have never observed any forms belonging to the regular system.

The chlorid of Luteocobalt is readily soluble in boiling water, and crystallizes in a great measure from the solution on cooling. Chlorhydric acid and alkaline chlorids precipitate it unchanged. When boiled with sulphuric acid, the salt gives off abundance of chlorhydric acid gas, but it is difficult to drive off all the acid without decomposing a portion of the resulting sulphate. The salt is slowly decomposed by boiling ammonia, chlorid of ammonium, and a dark-brown oxyd of cobalt being the only products of the decomposition which we have been able to detect. Reducing agents in general act upon this salt as upon chlorid of Roseocobalt and Purpureocobalt. We have not yet, however, been able to obtain with the chlorid of Luteocobalt compounds analogous to those which are produced by the action of sulphurous acid and deutoxyd of nitrogen upon the chlorids of Roseocobalt and Purpureocobalt, although we have repeatedly made the attempt.

The chlorid of Luteocobalt is dichrous. In the dichroscopic lens the ordinary image is pale violet, while the extraordinary image is orange-violet. The color of the salt, in coarse powder, approaches the orange-yellow of the first circle, but the color of the mass of crystals could not be defined by the chromatic scale, which we employed. Chlorid of Luteocobalt exhibits a remarkable tendency to form chloro-salts with metallic chlorids. These salts are formed with great ease, by the direct union of the two chlorids, and are worthy of notice for their stability and capacity of crystallization. Of these salts, which are very numerous, we have examined only the compounds with gold and platinum.

The analyses of chlorid of Luteocobalt lead to the formula

$$6NH_3 . Co_2Cl_3,$$

0·2036 grs. gave 0·1180 grs. of sulphate of cobalt = 22·05 per cent cobalt.
0·3350 grs. gave 0·1938 grs. " " = 22·01 " "
0·5110 grs. gave 0·2970 grs. " " = 22·11 " "
0·3335 grs. gave 0·1930 grs. " " = 22·02 " "
0·2942 grs. gave 0·4723 grs. chlorid of silver = 39·67 per cent chlorine.
0·4886 grs. gave 0·7846 grs. " " = 39·78 " "
0·3902 grs. gave 0·2346 grs. water = 6·68 per cent hydrogen.
0·4617 grs. gave 0·2800 grs. " = 6·73 " "
0·7305 grs. gave 200·5 c. c. of nitrogen at 21°·5 C. and 765^{mm}·80 (t = 22°·2 C.) = 182·3 c. c. at 0° and 760^{mm} = 31·34 per cent nitrogen.
0·7773 grs. gave 212 c. c. of nitrogen at 18° C. and 762^{mm}·75 (t = 18°·6 C.) = 194·94 c. c. at 0° and 760^{mm} = 31·49 per cent nitrogen.

Comparing these with the calculated results, we have

	Eqs.		Theory.	Mean.	Found.			
Cobalt,	2	59·0	22·06	22·05	22·05	22·01	22·11	22·02
Chlorine,	3	106·5	39·79	39·73	39·68	39·78	—	—
Hydrogen,	18	18·0	6.73	6·70	6·68	6·73	—	—
Nitrogen,	6	84·0	31·42	31·41	31·49	31·34	—	—
		267·5	100·00	99·89				

The formula $6NH_3 . Co_2Cl_3$ is given, by both Frémy and Rogojski, and no reasonable doubt can be entertained of its accuracy. The density of the chlorid of Luteocobalt, as taken in alcohol, is 1·7016 at 20° C., its atomic volume is consequently 157·2.

The reactions of the chlorid of Luteocobalt are as follows:

Iodid of potassium gives a bright yellow precipitate.

Bromid of potassium gives a less brilliant yellow precipitate.

Ferrocyanid of potassium gives a chamois colored precipitate, which becomes black on boiling.

Ferridcyanid of potassium gives beautiful yellow needles, which are nearly insoluble.

Cobaltidcyanid of potassium gives a pale fawn colored precipitate of fine needles.

Terchlorid of gold gives bright yellow granular crystals of the chloraurate.

Bichlorid of platinum gives yellow or orange-yellow needles of the chlorplatinate.

Chromate of potash gives a bright yellow precipitate of the chromate.

Oxalate of ammonia gives a buff yellow precipitate, soluble in oxalic acid.

Tribasic phosphate of soda gives, after a short time, a yellow precipitate.

Pyrophosphate of soda gives a pale buff colored precipitate.

Picrate of ammonia gives a beautiful yellow precipitate of very fine silky needles.

Alkalies and their carbonates produce no precipitate in the cold.

Sulphid of ammonium gives a black precipitate.

CHLORPLATINATE OF LUTEOCOBALT.

Chlorid of platinum produces, immediately, in a solution of the chlorid of Luteocobalt, a beautiful orange or yellow precipitate of the chlorplatinate. When the solutions employed are concentrated, the precipitate is orange colored; when the solutions are dilute, yellow needles are thrown down. The difference is here only in the quantity of water of crystallization, and the orange granular crystals may be converted into the pale yellow needles by solution in a large quantity of hot water and recrystallization.

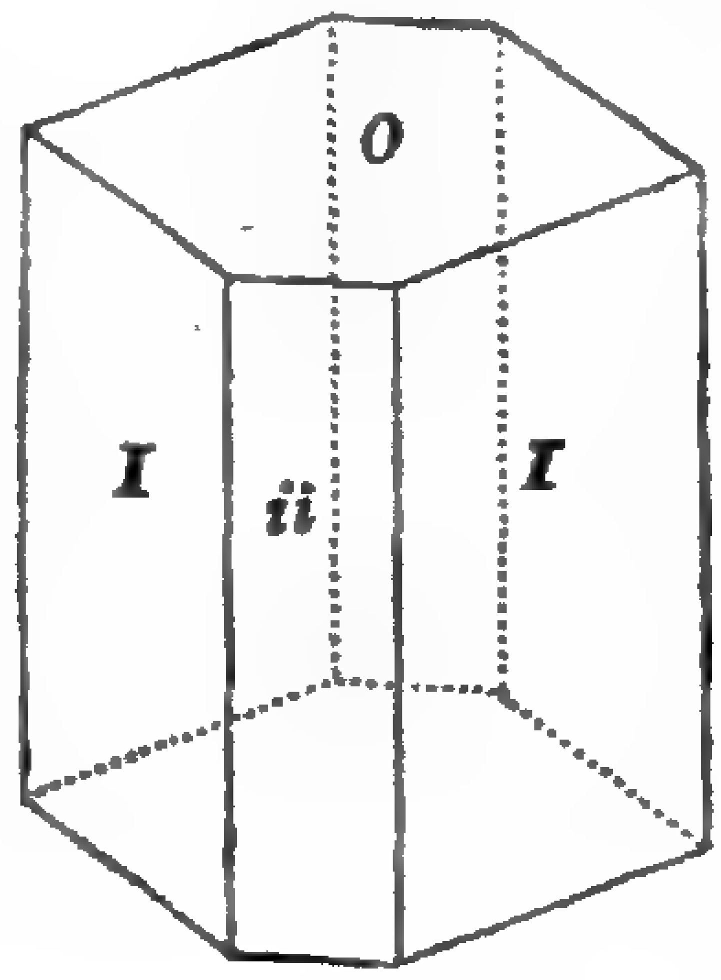
According to Prof. Dana's measurements, the acicular crystals belong to the monoclinic system, so far as it is possible to determine. The crystals are usually hollow and much striated longitudinally. The observed forms are *I*, *ii*, and *O*, and the angles

10.

$I : I = 107° 10'$.

$I : ii = 143° 50'$.

$O : ii = 114° 15'$.



Twin crystals are frequent, the composition being parallel to the plane O. The salt is very slightly soluble in cold water, but dissolves in much boiling water, from which it separates on cooling. When gently heated in a porcelain crucible it gives off ammonia and chlorid of ammonium, and becomes green. The green mass, on solution in water, gives globular aggregations of minute crystals of a buff color, which may be a new salt, but which we have not specially examined. Zinc decomposes the chlorplatinate of Luteocobalt only by very long boiling in an acid solution, metallic platinum being separated as a black powder, while chlorids of cobalt and ammonium are formed.

The formula of the orange salt is

$$6NH_3 . Co_2Cl_3 + 3PtCl_2 + 6HO$$

as the following analyses show:

1·220 grs. gave 0·4321 grs. metallic platinum = 35·41 per cent.
1·220 grs. gave 0·2261 grs. sulphate of cobalt = 7·05 per cent cobalt.

	Eqs.	Calculated.	Found.
Cobalt, - -	2	7·10	7·05
Platinum, - -	2	35·64	35·41

The formula of the yellow salt is

$$6NH_3 . Co_2Cl_3 + 3PtCl_2 + 21HO$$

as appears from the analyses:

0·2638 grs. gave 0·0822 grs. metallic platinum = 31·16 per cent.
0·4449 grs. gave 0·6037 grs. chlorid of silver = 33·54 per cent chlorine.

	Eqs.	Calculated.	Found.
Platinum, -	3	30·99	31·16
Chlorine, - -	9	33·42	33·54

Rogojski found in this salt but one and a half equivalents of water, but his analyses are not very satisfactory, giving a large excess of platinum, hydrogen, and cobalt.

CHLORAURATE OF LUTEOCOBALT.

A solution of terchlorid of gold produces immediately in solutions of the chlorid of Luteocobalt a beautiful yellow precipitate of small granular crystals. These crystals are very insoluble in cold water, but more readily soluble in boiling water acidulated with chlorhydric acid. Reducing agents separate gold with full metallic lustre. The formula of this salt is

$$6NH_3 . Co_2Cl_3 + AuCl_3$$

as the analyses satisfactorily show:

0·7308 grs. gave 0·1025 grs. Co_5O_7 = 10·53 per cent cobalt.
0·7308 grs. gave 0·2530 grs. gold = 34·62 per cent.
0·6457 grs. gave 0·9714 grs. chlorid of silver = 37·36 per cent of chlorine.

	Eqs.	Calculated.	Found.
Cobalt, - -	2	10·33	10·53
Gold, - - -	1	34·50	34·62
Chlorine, - -	6	37·30	37·36

IODID OF LUTEOCOBALT.

Iodid of potassium produces immediately in solutions of the chlorid, sulphate, or nitrate of Luteocobalt, a remarkably beautiful bright yellow precipitate of the iodid of Luteocobalt. This precipitate is rather insoluble in cold water, but readily soluble in hot water. The solution yields by spontaneous evaporation brown-yellow crystals, which appear to have the same form as the chlorid.

0·2224 grs. of this salt gave 0·06308 grs. sulphate of cobalt, corresponding to 10·79 per cent cobalt.

The formula $6NH_3 . Co_2I_3$ requires 10·88 per cent cobalt.

The color of the precipitated and dried iodid is very fine, and its brilliancy led us to hope that it might be advantageously employed as a pigment. On trial, however, the color was found wanting in body; the yellow, moreover, changes to a brown-yellow when the powder is ground in oil or water.

BROMID OF LUTEOCOBALT.

Bromid of potassium gives a rather dull yellow precipitate in solutions of Luteocobalt. The precipitate, re-dissolved in hot water, gives, on slow evaporation, wine-yellow crystals of the bromid. These crystals have the same form as those of the chlorid, and their formula is therefore

$$6NH_3 . Co_2Br_3.$$

COBALTIDCYANID OF LUTEOCOBALT.

Cobaltidcyanid of potassium produces in solutions of Luteocobalt a pale yellowish flesh-colored precipitate of the double cyanid of cobalt and Luteocobalt. The salt is insoluble in cold water, and easily decomposed by boiling water. It cannot, therefore, be re-crystallized for analysis. Under the microscope the crystals are seen to belong to the oblique rhombic system;

they are too small to admit of accurate measurement. The formula of this salt is

$$6NH_3 . Co_2Cy_3 + Co_2Cy_3 + HO.$$

0·4835 grs. gave 0·3923 grs. sulphate of cobalt = 30·88 per cent cobalt.
0·7652 grs. gave 0·3580 grs. water = 5·19 " hydrogen.
2·1845 grs. gave 0·6800 grs. carbonic acid = 18·83 " carbon.

	Eqs.	Calculated.	Found.
Cobalt, - -	4	30·57	30·88
Carbon, - -	12	18·70	18·82
Hydrogen, -	19	4·93	5·19

A solution of ferridcyanid of potassium produces a most beautiful precipitate of orange-yellow needles in solutions of Luteocobalt. These, under the microscope, have the same form as the corresponding cobalt salt, and their formula is therefore

$$6NH_3 . Co_2Cy_3 + Fe_2Cy_3 + HO.$$

SULPHATE OF LUTEOCOBALT.

The sulphate of Luteocobalt is easily procured mixed with the chlorid, when solutions of both chlorid and sulphate of cobalt are rendered ammoniacal and exposed to the air after the addition of coarsely powdered chlorid of ammonium in large excess. The mass of yellow crystals formed upon the bottom of the vessel, after a few days, is a mixture of the two salts. To obtain the sulphate from this mass, the solution in hot water is to be filtered and digested with sulphate of silver, after addition of a few drops of sulphuric acid. In this manner the whole of the chlorid may be decomposed, and the filtered solution on evaporation will yield fine crystals of the sulphate. We have frequently prepared large quantities of the sulphate by this method. Another mode of preparing the sulphate of Luteocobalt, which is often very convenient, consists in pouring ammonia upon the sulphate of Roseocobalt, thrown down by cautious addition of sulphuric acid to perfectly oxydized solutions of the ammoniacal sulphate of cobalt. When this sulphate is powdered, and strong ammonia poured upon it, its color frequently changes from red to a dull buff, while the supernatant liquid takes a fine red color. The buff powder on solution in hot water and evaporation yields crystals of sulphate of Luteocobalt. The red liquid is merely a solution of sulphate of Roseocobalt in ammonia. The reaction which takes place in this case may be represented by the equation

$$5NH_3 . C_2O_3, 3SO_3 + NH_3 = 6NH_3 . Co_2O_3, 3SO_3,$$

the sulphate of Roseocobalt simply absorbing one equivalent of ammonia. The quantity of sulphate of Roseocobalt dissolved in the ammonia is very variable, being sometimes extremely small. In other cases, however, no sulphate of Luteocobalt is formed, but only a solution of sulphate of Roseocobalt in ammonia, from which, by evaporation, the sulphate crystallizes unchanged in large dark-red crystals, frequently of the form represented in fig. 3. We are unable to assign a satisfactory reason for the capriciousness of the behavior of the red sulphate towards ammonia.

Frémy asserts that sulphuric acid, cautiously added to a completely oxydized ammoniacal solution of sulphate of cobalt, throws down an acid sulphate of Roseocobalt to which he assigns the formula $5NH_3 . Co_2O_3, 5SO_3 + 5HO$. When this acid sulphate is boiled for a few minutes with ammonia, a yellow precipitate of sulphate of Luteocobalt is thrown down. The author does not attempt to explain the reaction which takes place in this case, but states that the red mother liquor from which the sulphate of Luteocobalt has separated, yields on evaporation crystals of the neutral sulphate of Roseocobalt. We have never succeeded in preparing an acid sulphate of Roseocobalt by the process above mentioned, nor by any other. On the contrary, we have uniformly found that sulphuric acid precipitates from the oxydized solution only the neutral sulphate of Roseocobalt in small bright-red crystals, easily recognized by their form. Frémy's salt must have contained free sulphuric acid, in consequence of imperfect washing.

When a pure solution of the sulphate of Roseocobalt is boiled, ammonia is evolved, while sulphate of ammonia and sulphate of Luteocobalt remain in solution, and a dark-colored oxyd of cobalt is precipitated. From the solution the sulphate of Luteocobalt may be obtained by evaporation and crystallization. This method yields but little, and is not to be recommended.

Sulphate of Luteocobalt is also sometimes obtained, with other products, by digesting sulphate of Roseocobalt with sulphuric acid, before the period of complete decomposition sets in.

A very simple and easy method of preparing the sulphate of Luteocobalt consists in decomposing the dry sulphate of Roseocobalt by heat. When the latter salt is gently heated in a porcelain crucible over a spirit lamp, or better still, in a glass flask in a bath of rosin oil to about the temperature of melting lead, ammonia is given off in abundance, and the mass, which should be constantly stirred, assumes a fine purple-lilac hue. The heat, when the lamp alone is used, must never arise to low redness, and no vapors of sulphate of ammonia should be given off. The resulting mass is then to be dissolved in hot water, which gives a fine purple-red solution, and chlorhydric acid added in excess. An orange precipitate of sulphato-chlorid of Luteocobalt is immediately thrown down, which is easily purified, as above, by sulphate of silver and recrystallization. The acid mother liquor sometimes deposits more sulphate on cooling. The supernatant liquid contains chlorid of Luteocobalt, chlorid of Purpureocobalt, and a leek-green crystalline body, which we have called provisionally Praseocobalt, but which we have not yet carefully studied.

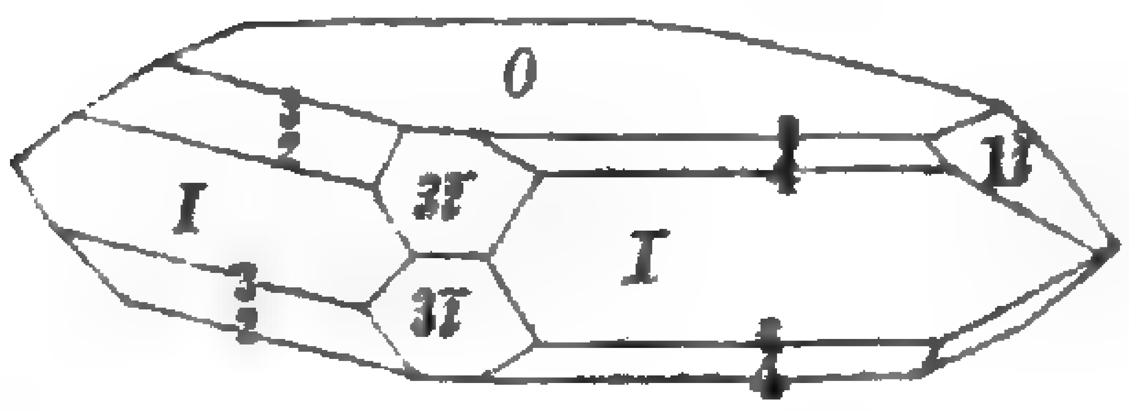
The sulphate of Luteocobalt, like the chlorid, has a fine wine-yellow color, and crystallizes readily. The crystals belong to the right rhombic or trimetric system; they are hemihedral and isomorphous with the chlorid of Luteocobalt. According to Prof. Dana's determinations, the more usual forms are represented in figs. 11, 12, 13, 14. In figs. 13 and 14 the sulphate is mixed with the chlorid.

$I:I = 113° \ 38'$	$O:\frac{3}{4} = 137° \ 19'$	$i\breve{\tfrac{3}{2}}:i\breve{\tfrac{3}{2}} = 88° \ 44'$ and $91° \ 16'$
$O:1\breve{i} = 146° \ 4'$	$O:\frac{3}{2} = 118° \ 28'$	$1\bar{i}:1\bar{i} =$ (over O) $= 88° \ 22'$
$1\breve{i}:1\breve{i} = 112° \ 8'$ (over O)	$O:3\bar{i} = 107° \ 57'$	
$3\breve{i}:3\breve{i} = 127° \ 18'$ (adjacent)	$O:1\bar{i} = 134° \ 11'$	

These forms in other symbols are O, ∞, $3\text{-}\bar{\infty}$, $\frac{3}{2}_{2}$, $\frac{3}{4}_{2}$, $1\text{-}\breve{\infty}$, (fig. 11). O, ∞, $\frac{3}{2}_{2}$, $\frac{3}{4}_{2}$, $1\text{-}\breve{\infty}$, $3\text{-}\breve{\infty}$ (fig. 12). $1\text{-}\bar{\infty}$, $\infty\text{-}\breve{\tfrac{3}{2}}$, $3\text{-}\breve{\infty}$ (fig. 13). $1\text{-}\bar{\infty}$, $\infty\text{-}\breve{\tfrac{3}{2}}$, $3\text{-}\breve{\infty}$, $1\text{-}\infty$ (fig. 14).

$$a:b:c = 1{\cdot}039:1:1{\cdot}539.$$

11.



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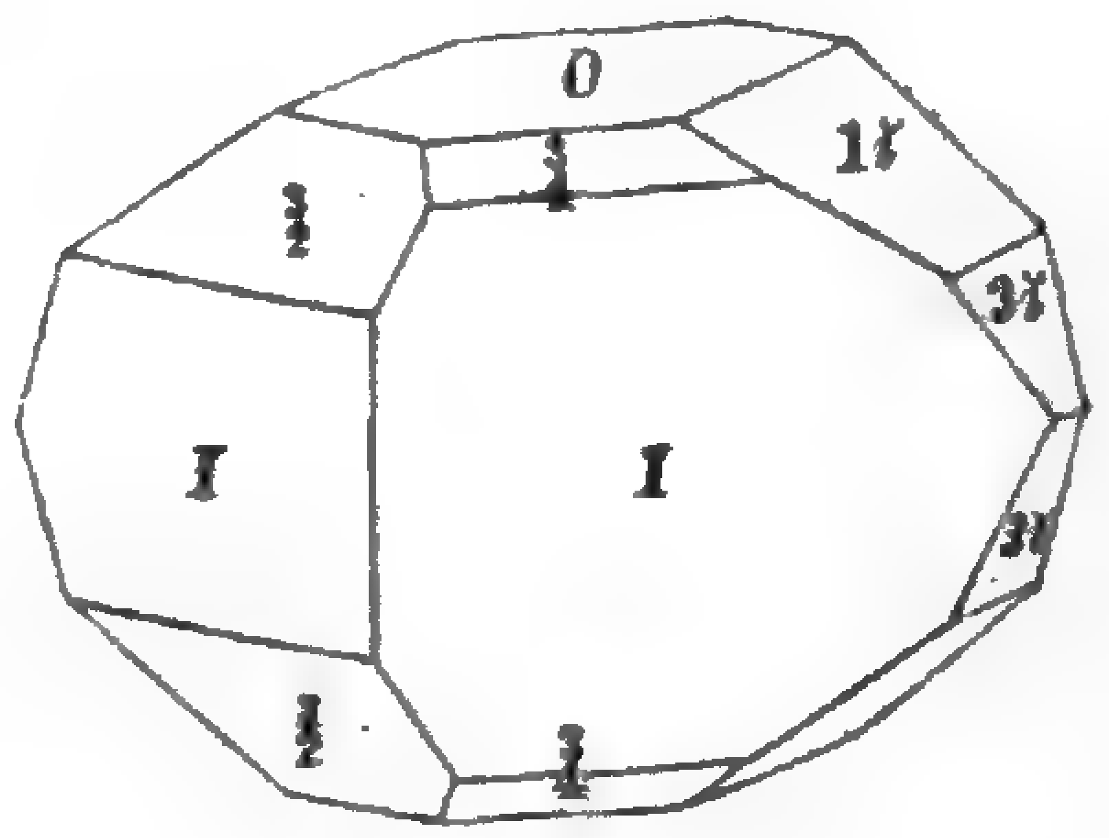
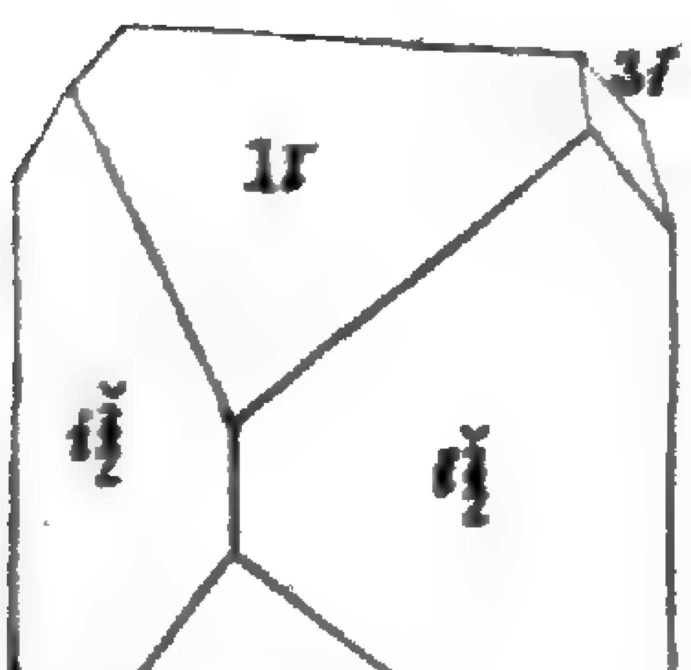
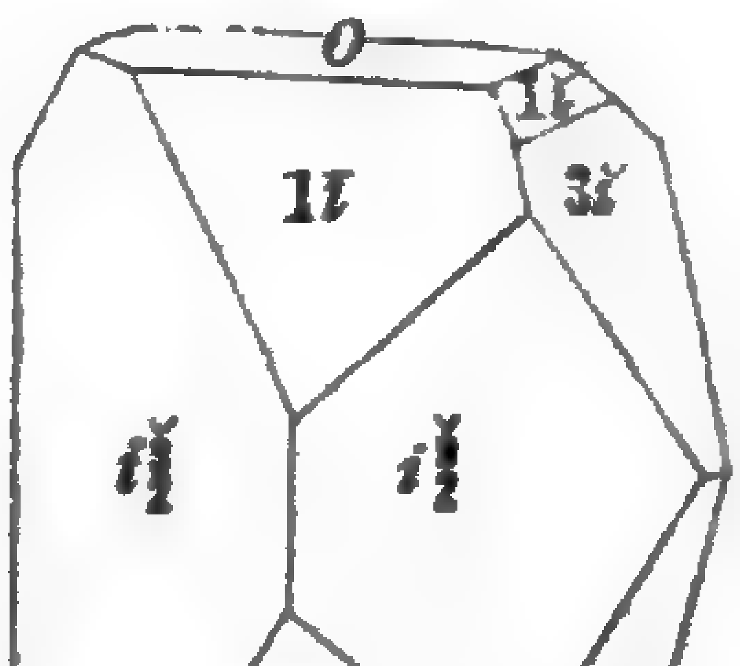


13.



14.



Figs. 15, 16, 17, are different in habit from the preceding, and do not agree precisely in angles. The forms as lettered are referred to a different fundamental form. Adopting the same fundamental form as in the above figures, the lettering would be as follows:

Lettering on figures,	O	$i\breve{2}$	$1\breve{2}$	$\frac{1}{2}$	$1\breve{\imath}$	I	$i\breve{\imath}$	$\frac{1}{2}\breve{\imath}$	$\frac{1}{4}$	$\frac{3}{4}$.
New lettering,	O	I	$\frac{3}{2}$	$\frac{3}{2}\breve{2}$	$3\breve{\imath}$	$i\breve{2}$	$i\breve{\imath}$	$\frac{3}{2}\breve{\imath}$	$\frac{3}{4}\breve{2}$	$\frac{9}{4}\breve{2}$.

Angles obtained and calculated for fig. 13 (putting the lettering on the figure in brackets):

$I:I\,(i\breve{2}:i\breve{2}) =$ 64° 28′ and 115° 32′ $\quad$ $\frac{3}{2}\breve{2}:\frac{3}{2}\breve{2}$, $(\frac{1}{2}:\frac{1}{2}) =$ 124° 3′ (adjacent).

$O:\frac{3}{2}\,(O:1\breve{2}) =$ 120° 36′ $\quad$ $O:3\breve{\imath}\,(O:1\breve{\imath}) =$ 119°.

$O:\frac{3}{2}\breve{2}\,(O\,\frac{1}{2}) =$ 130° 59′ $\quad$ $i\breve{2}:i\breve{2} =$ 103° 10′ (by calculation).

Angles obtained and calculated for figs. 14, 15:

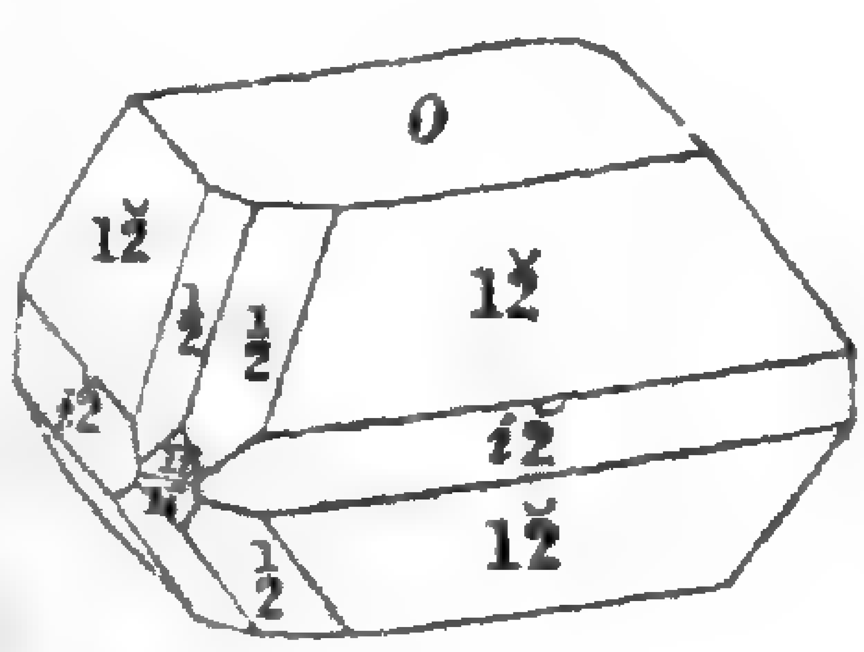
$i\breve{2}:i\breve{2}\,(I:I) =$ 103° 30′ $\quad$ $O:\frac{3}{4}\breve{2}\,(O:\frac{1}{4}) =$ 150° 16′.

$O:\frac{3}{2}\,(O:1\breve{2}) =$ 120° 40′ $\quad$ $O:\frac{9}{4}\breve{2}\,(O:\frac{3}{4}) =$ 120° 16′.

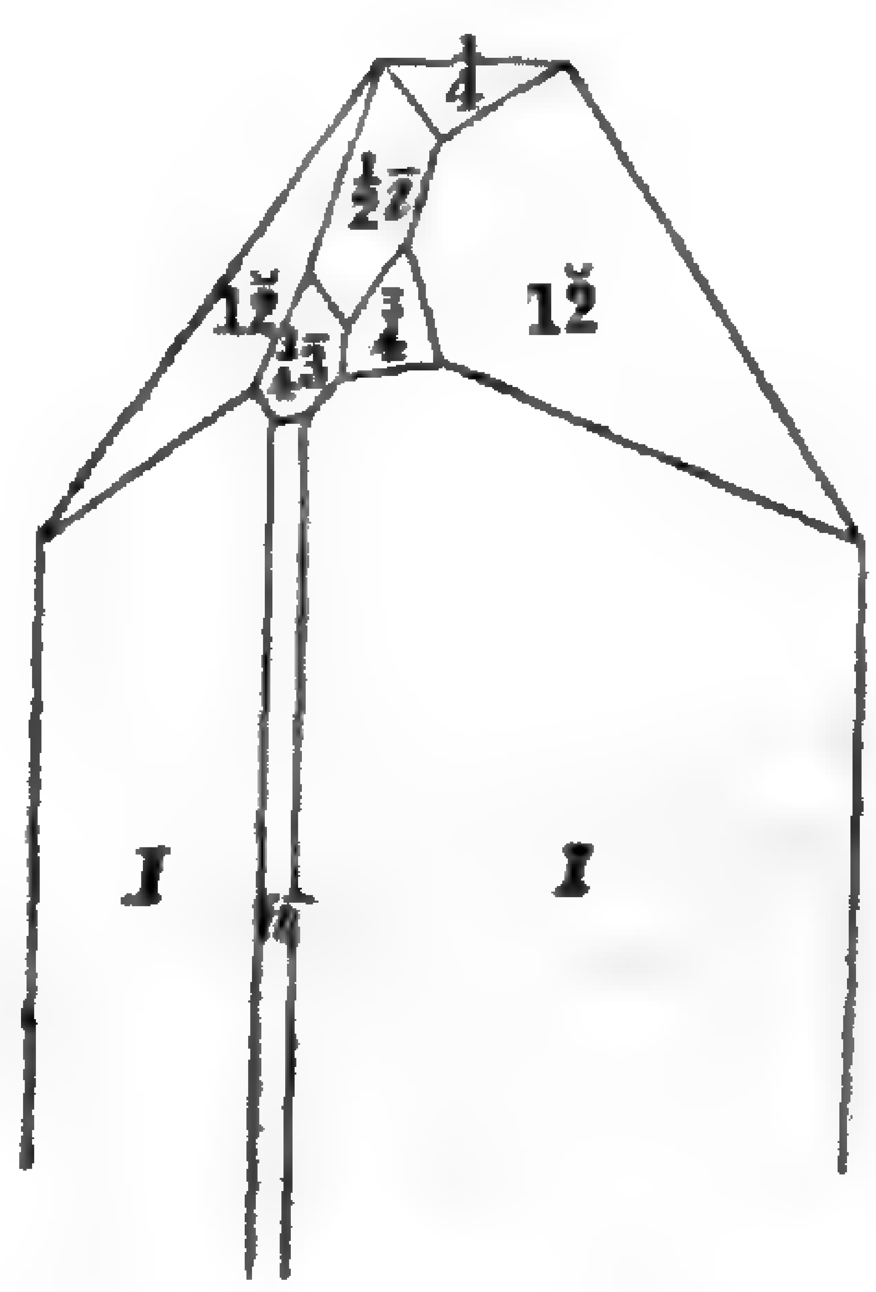
$O:\frac{3}{2}\breve{\imath}\,(O:\frac{1}{2}\breve{\imath}) =$ 138° 6′.

Fig. 18 has still a different habit. The occurring vertical prism, lettered I, gave the angle (approximately) 101° 30′, and the dome $1\breve{\imath}$ has the angle 109° 36′, giving $O:1\breve{\imath} =$ 144° 48′, near the angle in figs. 11, 12.

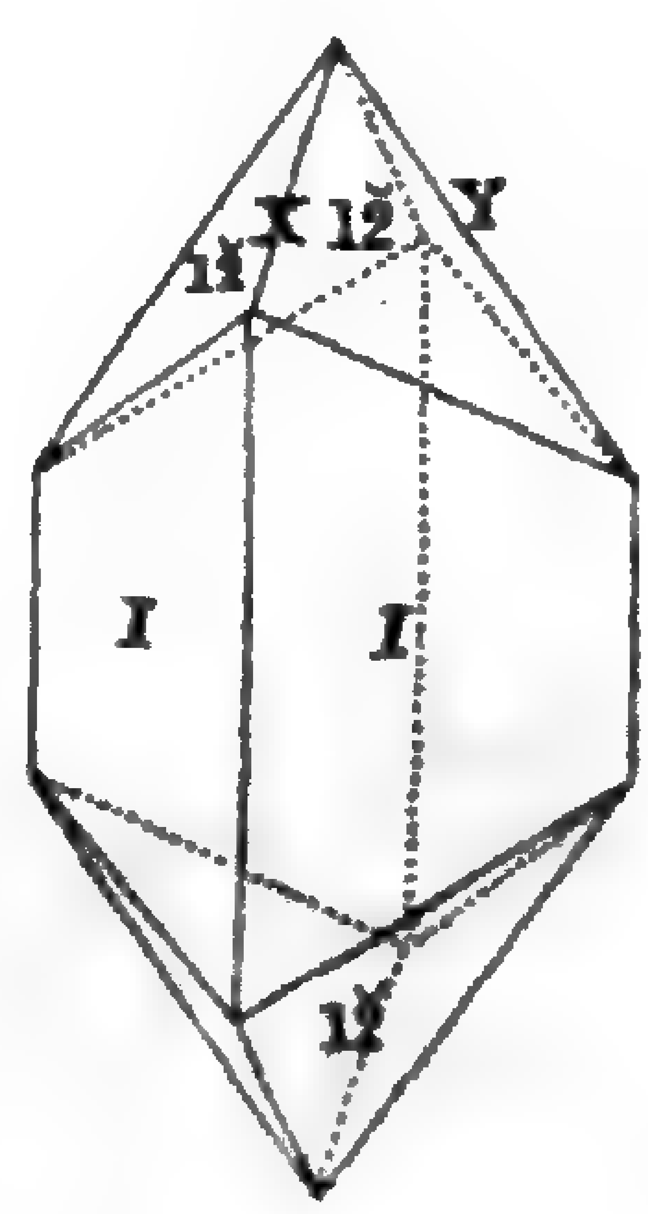
15.



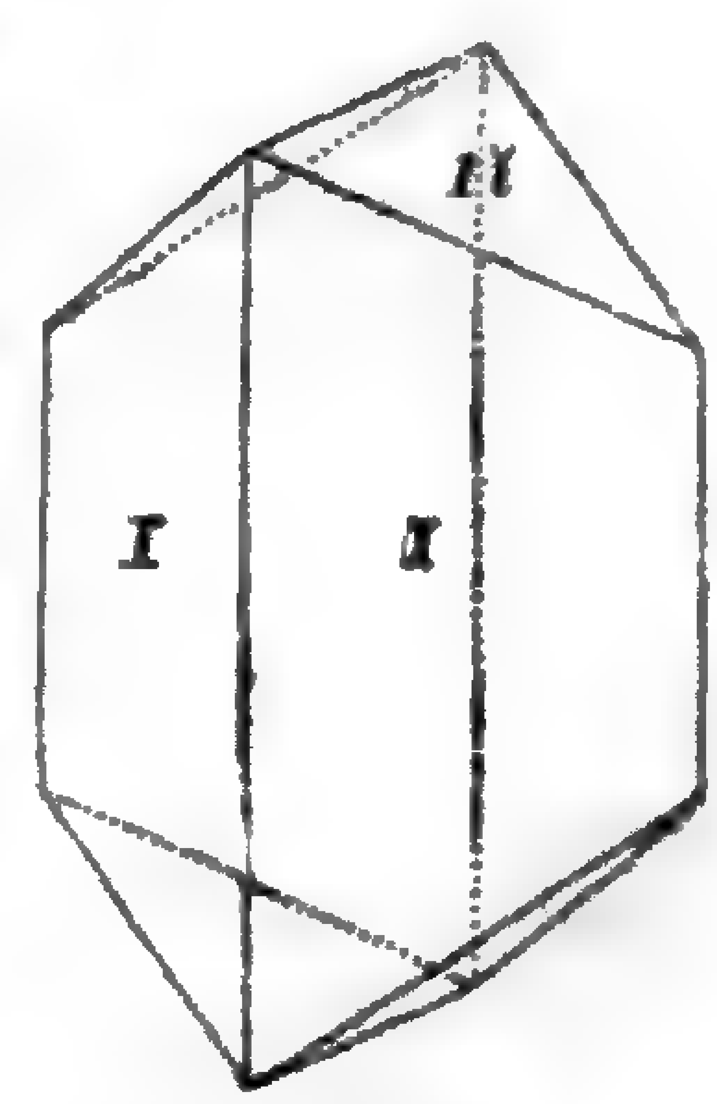
16.



17.



18.



The sulphate is rather insoluble in cold but is freely soluble in hot water; the dilute solution is yellow, the concentrated solution dark sherry wine colored. By double decomposition with salts of barium it yields the other salts of Luteocobalt. The sulphate like the chlorid is dichrous, the ordinary image being pale rose-red while the extraordinary image is bright orange. The color of the salt in coarse powder approaches the orange No. 5 of the first circle.

Sulphuric acid does not precipitate this salt from its solution, but chlorhydric and nitric acids throw down in the cold mixtures of the chlorid with the sulphate and nitrate. The salt is decomposed with very great difficulty by long boiling, even after the addition of a little ammonia. No new base is formed during the decomposition. When, however, the dry salt is gently heated in a porcelain crucible, ammonia is evolved, and if the heat be regulated so that no sulphate of ammonia is given off, while the mass is constantly stirred, there remains after a few minutes a red mass, which on solution in water gives a fine red liquid containing a sulphate of a red base, which is probably Purpureocobalt. The reaction is, however, a very uncertain one, and has succeeded in our hands but once. We have in most cases obtained by the process described only a mixture of sulphate of Luteocobalt, sulphate of cobalt, and sulphate of ammonia. We shall consider this subject more fully hereafter. Sulphuric acid, if not too dilute, readily decomposes the sulphate of Luteocobalt when the solution is heated. It appears probable that there exists an acid sulphate of this base, as there is an acid carbonate, but we have not been able to obtain it as yet.

Sulphate of Luteocobalt has the formula

$$6NH_3.Co_2O_3,\ 3SO_3+5HO$$

as the following analyses satisfactorily show. The salt analyzed was dried by pressure between folds of bibulous paper only.

0·3618 grs. gave 0·1600 grs. sulphate of cobalt = 16·83 per cent cobalt.
0·4993 grs. " 0·2205 grs. " " = 16·80 " "
0·4790 grs. " 0·2122 grs. " " = 16·85 " "
1·2023 grs. " 1·2020 grs. sulphate of baryta = 34·32 per cent sulphuric acid.
0 8203 grs. " 0·8250 grs. " " = 34·52 " " "
0·9355 grs. " 0 5650 grs. water = 6·71 per cent hydrogen.
1·1194 grs. " 0 6722 grs. " = 6·67 " "
1·0005 grs. gave 205 c. c. nitrogen at 12°·5 C. and 753^{mm}·61 (at 12°·7) = 191·16 c. c. at 0° and 760^{mm} = 24·00 per cent nitrogen.
0·9018 grs. gave 185·5 c. c. nitrogen at 19° C. and 763^{mm}·36 (at 19°·5) = 171·26 c. c. at 0° and 760^{mm} = 23·85 per cent nitrogen.

Our formula requires

	Eqs.		Calculated.	Mean.	Found.		
Cobalt,	2	59·0	16·85	16·83	16·80	16·85	16·83
Sulph. acid,	3	120·0	34·28	34·42	34·52	34·32	
Hydrogen,	23	23·0	6·57	6·69	6·71	6·67	
Nitrogen,	6	84·0	24·00	23·97	24·00	23·85	
Oxygen,	8	64·0	18·28	18·09	——	——	
		350·0	100·00				

According to Frémy, the sulphate contains but four equivalents of water of crystallization. In vacuo or in dry air the sulphate of Luteocobalt effloresces, becomes opaque and reddish buff colored, and loses 4 eqs. or 10·13 per cent of water.

Rogojski did not succeed in obtaining the sulphate of Luteocobalt by decomposing the chlorid with sulphate of silver. According to this chemist, there is produced under these circumstances a sulphato-chlorid which has the formula

$$6NH_3.Co_2O_3, 3SO_3+6NH_3.Co_2Cl_3.$$

We have already mentioned, however, that the chlorid and sulphate of Luteocobalt are isomorphous, and we have accordingly found, as might be expected, that these two salts are capable of crystallizing together in all proportions, and cannot be separated by crystallization alone. To show the variation in the constitution of the mixed chlorid and sulphate, it will be sufficient to give a few cobalt determinations made with the salt as prepared at different times.

0·1510 grs.	gave	0·0673 grs.	sulphate of	cobalt	= 16·96	per cent	cobalt.
0·7075 grs.	"	0·3210 grs.	"	"	= 17·26	"	"
0·1205 grs.	"	0·0680 grs.	"	"	= 21·47	"	"

The parallel which Rogojski draws between the salt which he analyzed and the sulphate of Gros's base, which Gerhardt considers as a sulphato-chlorid of Diplatinamin, must therefore be considered as illusory.

CHROMATE OF LUTEOCOBALT.

A solution of the neutral chromate of potash gives a fine yellow precipitate in solutions of the chlorid, nitrate, and sulphate of Luteocobalt. The precipitate is soluble in hot water, and crystallizes readily from the solution in brown-yellow crystals, which resemble those of the sulphate. We have not analyzed this salt, but it is almost certain that its true formula is

$$6NH_3.Co_2O_3, 3CrO_3+5HO,$$

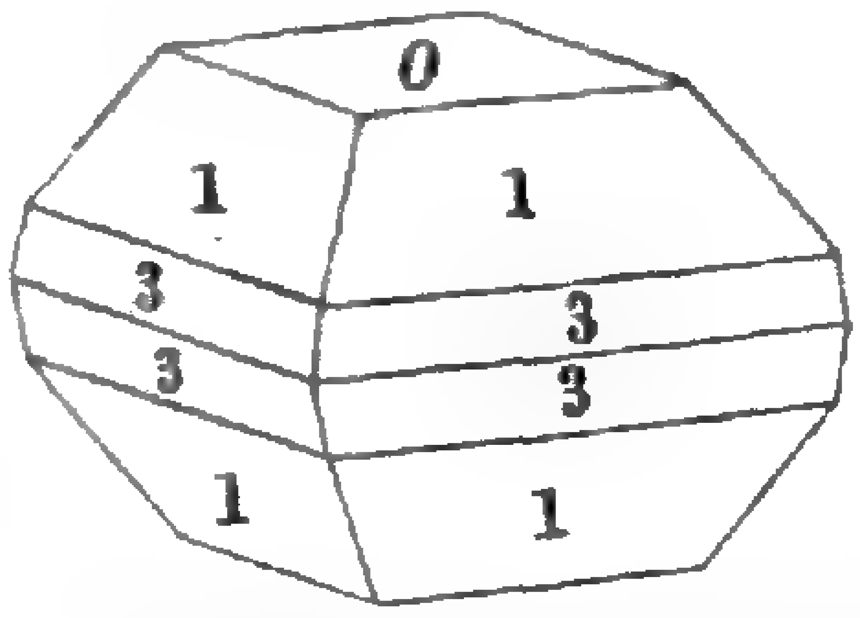
since it forms with chlorid of Luteocobalt crystallizable mixtures in various proportions, which exhibit in the greatest beauty and distinctness the characteristic forms of the crystals of the sulphato-chlorids above alluded to. The pure chromate can only be obtained by precipitating the nitrate of Luteocobalt by chromate of potash, as the precipitate from the chlorid always contains chlorine, and that from the sulphate, sulphuric acid.

NITRATE OF LUTEOCOBALT.

This beautiful salt is almost invariably obtained during the oxydation of an ammoniacal solution of nitrate of cobalt, and is deposited upon the bottom of the vessel in bright orange crystalline scales. The supernatant liquid is usually red, and contains nitrate of Roseocobalt. The orange-yellow salt is easily purified by re-crystallization. The salt may also be easily prepared from the chlorid or sulphate by double decomposition with nitrate of silver or of baryta. The nitrate of Luteocobalt crystallizes readily in forms which belong to the square prismatic or dimetric system. According to Professor Dana, the dimensions and angles of the crystals are as follows:

1 : 1 (over the base) = 110° 20′
O : 1 = 124° 50′
O : 3 = 103° 4′
3 : 3 (over the base) = 135° 52′
a = 1·0161
O : i (not observed) = 134° 33′

19.



The crystals are usually small and often very brilliant. The salt is readily soluble in hot water, and separates in small crystals on cooling. Chlorhydric acid throws it down from its solution as a yellow crystalline powder; nitric acid also precipitates it, but sulphuric acid converts it into sulphate with more or less complete decomposition. The nitrate of Luteocobalt is anhydrous, and has the formula

$$6NH_3.Co_2O_3,\ 3NO_5$$

as the following analyses show:

0·1972 grs. gave 0·0880 grs. sulphate of cobalt = 16·98 per cent cobalt.
0·2090 grs. " 0·0928 grs. " " = 16·87 " "
1·0859 grs. " 0·5151 grs. water = 5·27 per cent hydrogen.
0·9126 grs. " 0·4337 grs. " = 5·28 " "
0·6242 grs. gave 188 c. c. at 11°·5 C. and 772^{mm}·40 at 11°·94 = 180·56 c. c. at 0° and 760^{mm} = 36·33 per cent nitrogen.
0·7394 grs. gave 226 c. c. at 13°·5 C. and 766^{mm}·05 at 14° = 213·29 c. c. at 0° and 760^{mm} = 36·23 per cent nitrogen.

The formula requires

	Eqs.	Calculated.	Mean.	Found.	
Cobalt . . .	2	17·00	16·93	16·98	16·89
Hydrogen . .	18	5·18	5·27	5·27	5·28
Nitrogen . .	9	36·31	37·28	36·23	36·33

Frémy and Rogojski deduce the same formula from very imperfect analyses. Heat decomposes the dry nitrate of Luteocobalt with a slight explosion, a black powder of an oxyd of cobalt remaining. It may be remarked that the oxygen and hydrogen in this salt are exactly in the ratio to form water.

OXALATE OF LUTEOCOBALT.

When a solution of oxalate of ammonia is added to one of a soluble salt of Luteocobolt, a buff colored precipitate of fine needles is thrown down, which is insoluble both in hot and cold water, but which readily dissolves in a solution of oxalic acid. From this solution the neutral oxalate crystallizes in beautiful prismatic crystals, having the color of the sulphate and chlorid. In dry air the crystals lose water like those of the other hydrated salts of Luteocobalt. The oxalate has the formula

$$6NH_3.CO_2O_3,\ 3C_2O_3+4HO$$

as the following analyses show:

0·4330 grs. gave 0·2040 grs. sulphate of cobalt = 17·99 per cent cobalt.
0·4228 grs. gave 0·2000 grs. " " = 18·00 " "
0·5345 grs. gave 0·2529 grs. " " = 18·01 " "
2·0805 grs. gave 0·8380 grs. carbonic acid = 32·95 per cent oxalic acid.

The formula requires

	Eqs.	Calculated.	Found.		
Cobalt . . .	2	17·93	17·99	18·00	18·01
Oxalic acid . .	3	32·82	32·95	——	——

It would *à priori* appear probable that there exists an acid oxalate of Luteocobalt corresponding to the acid carbonate, but we have not yet been able to obtain such a salt. The oxalic acid in this compound cannot be easily reduced by a solution of terchlorid of gold, nor can it be completely separated from the base by means of a solution of chlorid of calcium.

CARBONATES OF LUTEOCOBALT.

The neutral carbonate of Luteocobalt is readily formed by decomposing a solution of chlorid of Luteocobalt by carbonate of silver. The yellow solution, by evaporation, yields sherry-wine colored crystals of the carbonate. The salt closely resembles the other soluble salts of Luteocobalt; is easily soluble in hot water, and crystallizes well by slow evaporation. During evaporation, however, the solution absorbs carbonic acid from the air, and crystals of the acid carbonate are found mixed with those of the neutral salt. According to Prof. Dana's measurement, the crystals of the neutral carbonate belong to the trimetric system, and approach aragonite in form. Fig. 20 represents a crystal of this salt:

20.

$I : I = 116° 50'$

$I : i\breve{\imath} = 121° 35'$

$1\breve{\imath} : 1\breve{\imath}$ (top) $= 114° 16'$

$1\breve{\imath} : 1\breve{\imath}$ (over) $i\breve{\imath} = 65° 44'$

$a : b : c = 1{\cdot}0509 : 1 : 1{\cdot}6265$

The constitution of the neutral carbonate appears to be represented by the formula

$$6NH_3.Co_2O_3,\ 3CO_2+7HO.$$

0·2495 grs. gave 0·1220 grs. sulphate of cobalt = 18·61 per cent cobalt.
0·3518 grs. gave 0·0786 grs. carbonic acid = 22·34 per cent.

The formula requires

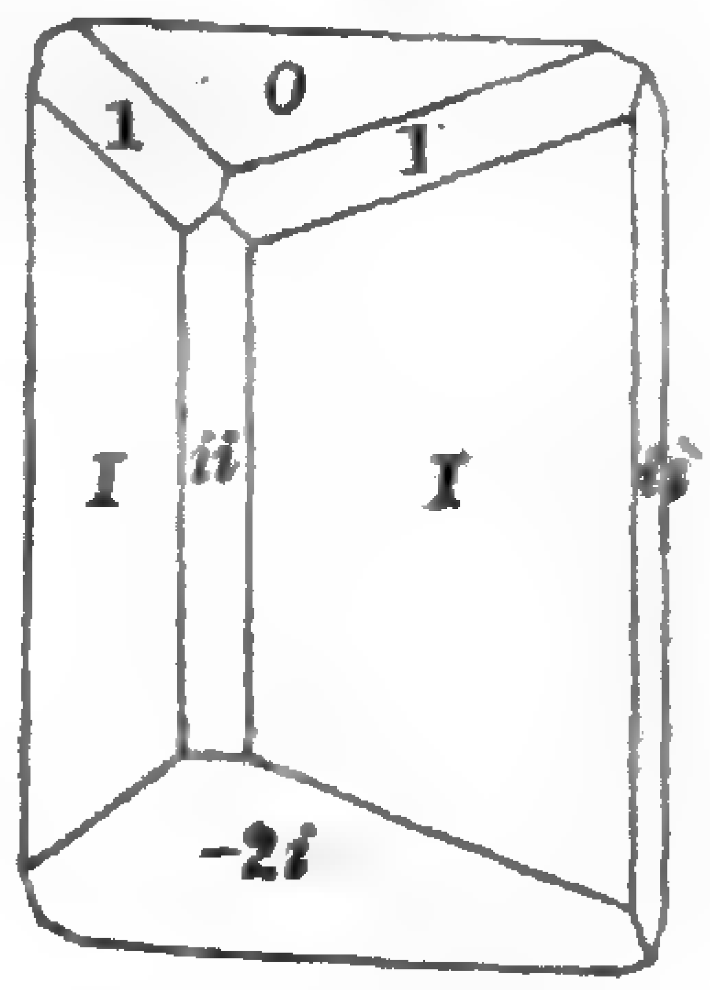
	Eqs.		Found.
Cobalt, - -	2	18·79	18·61
Carbonic acid - -	3	21·01	22·34

The excess of carbonic acid and the deficiency in cobalt, are doubtless due to the presence of a portion of the acid carbonate. The neutral carbonate loses its water of crystallization in dry air, and becomes opaque, with the lustre of porcelain, like many other hydrated salts of this base.

The acid carbonate of Luteocobalt is most readily prepared by passing a current of carbonic acid gas into a solution of the neutral salt. The acid carbonate usually separates, after a very short time, in the form of large brown-red or sherry-wine colored crystals, which are less soluble than those of the neutral carbonate. According to Prof. Dana, the crystals of this salt belong to the monoclinic system, and closely approach Barytocalcite in form. Fig. 21 represents a crystal of this salt.

$O : ii = 108° 16'$
$O : I = 77° 40'$ and $102° 20'$
$I : I = 85° 54'$
$O : 1 = 139° 50'$
$I : 1 = 142° 30'$
$O : \text{-}2i = 111° 46'$
$a : b : c = 0·7219 : 1 : 0·8398.$
$C = 71° 44'.$

21.



In Barytocalcite the angle corresponding to $O : ii = 106° 54'$ and that corresponding to $I : I = 84° 52'$.

The acid carbonate of Luteocobalt retains its water of crystallization in the air, but loses it under the air-pump. The salt is particularly interesting as being the only acid salt of Luteocobalt which we have as yet been able to obtain. The formula of this salt is

$$6NH_3 . Co_2O_3, 3CO_2 + HO, CO_2 + 5HO$$

as the following analyses show:

0·4715 grs. gave 0·2246 grs. sulphate of cobalt = 18·12 per cent cobalt.
1·0506 grs. gave 0·2830 grs. carbonic acid = 26·93 per cent.

The formula requires

	Eqs.		Found.
Cobalt, - - - -	2	18·04	18·12
Carbonic acid, - -	4	26·91	26·93

The very distinctly marked triacid character of Luteocobalt, considered as a base, renders it, to say the least, improbable that the formula of this salt should be written

$$6NH_3 . Co_2O_3 . 4CO_2 + 6HO.$$

OXYD OF LUTEOCOBALT.

The oxyd of Luteocobalt may be obtained by decomposing a solution of the sulphate with baryta water. The solution is brown-yellow, and has an alkaline taste and reaction. It cannot be evaporated without decomposition, ammonia being evolved and a black powder separated. The solution absorbs carbonic acid from the air, and on evaporation, yields crystals of the carbonates; with acids it yields the salts of the base. The oxyd of Luteocobalt appears to form compounds with salts of copper, which may be analogous to the ammonia-salts of that metal, or which again may be only double salts of copper and Luteocobalt. A solution of the oxyd added to one of sulphate of copper gives, after standing, beautiful chrome-green crystals of a new salt, which we have not yet had an opportunity of examining.

(To be concluded.)

Art. XXXIV.—*Earthquakes in California during the year* 1856; by Dr. J. B. Trask.*

At the close of 1855, I presented to the Association a statement of the occurrence of earthquakes in this state for that year and a term of years preceding.

During the year just passed, I have kept a careful record of these phenomena, that have been noticed in this city, and other parts of the State, which will be found below, with their dates, and the hour of the day on which they took place. They comprise all that have occurred, with perhaps two exceptions, the dates for which were so obscure as to render it impossible to determine with accuracy the precise period of their occurence. So far as I am informed, those shocks which have taken place in this State during the past year have not been marked with more severity than has been usual in years preceding. They frequently amounted to a slight tremor, and at other times to more distinct movements; three only possessed sufficient intensity to command general attention during the busy hours of day.

Very few have been noticed by persons who were standing upon the earth at the period of their occurrence. By far the greater proportion were observed in high situations from the ground, and in the more retired parts of the city, or on the alluvial covering of the country to the west and south.

The total number for the past year is sixteen, and of this number thirteen were observed between sunset and sunrise, a fact

* Read before the California Academy of Natural Sciences, at San Francisco, January 12, 1857.

sufficient in itself to show the lightness of their character; for, did they possess that severity so often attributed to them, the attention of the people would much more often be directed to them. Yet we find that their first knowledge of such an occurrence is usually its announcement by the daily press.

By reference to the statistics below, it will be seen that even in the mountain districts, where during the day there is much less of turmoil and noise arising from business than in the populous city, of all these noticed, none have been of sufficient intensity to attract the attention of the inhabitants during the hours of daylight. These facts, though few in themselves, are of importance, to disabuse the public mind in relation to the danger to be apprehended from the occurrence of these phenomena. The reputation which we sustain both at home and abroad, of being in constant danger of being swallowed up by these occurences, and the idea that our country is but a bed of latent volcanoes, ready to burst forth at any moment, spreading devastation over the land, is a very needless source of alarm.

We should remember that when speaking of California as a state, that we include a line of territory equalling that of the seaboard lying between Cape Hatteras on the south and the British Possessions on the north, and including eleven of the seaboard States of the Union; and when we place our comparative estimates on this basis, in matters of this character, it will become at once evident that the danger of annihilation from the causes under consideration, are not of that magnitude that at first sight would appear.

Along the coast of Mexico and Central America, to the south of California, from all the records that are obtainable here, there appears to have been a much greater exemption from those phenomena than has been usual in former years; this seems to have been the fact, also, throughout the Pacific, Oceanic and most of the continental islands along the coast of China, while to the north and northwest, beyond the fifty-fifth parallel, both volcanic and earthquake phenomena appear to have been more violent than usual. This has been observable, for the most part, in the neighborhood of the Aleutian Archipelago, along the northeast coast of Japan, and in the British and Russian Possessions of North America on the Pacific, and islands of the Ochotsk Sea.

It would be interesting to know more about these phenomena in those regions, and such information could be easily obtained from the commanders of the whaling fleet, if the proper measures were adopted to secure it.

Below will be found some interesting facts upon this subject, observed during the past year near the Straits of Ourinach.

The earthquakes which have occurred in this State during 1856, and the period of their occurrence, are as follows:

Jan. 2.—At a quarter before ten this morning, a smart shock of an earthquake was felt in San Francisco. The motion of the earth was undulatory, and came apparently from the northward. A pendulum indicated a motion of about five and a half inches.

Jan. 28.—At the town of Petaluma, Sonoma County, a shock of an earthquake occurred at a few minutes past three o'clock in the morning. It was sufficiently heavy to awake persons from their sleep.

Jan. 29.—At a quarter before one o'clock this morning, a slight shock was felt in San Francisco.—It was observed also at the Mission Dolores. There were three distinct tremors, with short intervals elapsing between. The motion was apparently from the westward.

Jan. 31.—Quite a smart shock occurred at four o'clock this evening; it was quite sharp in the southwest part of the city.

Feb. 15.—At five o'clock twenty-five minutes a severe shock of an earthquake was felt in San Francisco, the duration of which was about eight seconds. Persons sleeping were aroused, and many persons left their beds and sought the street. There were two distinct shocks, the second very light and scarcely perceptible. The motion was *undulatory* and *vortical*, and at the end of the first shock a very strong, profound jar, with which it ceased.

The upper part of a building on Battery street, for seventy feet in length, was thrown down, the whole that was above the cornice; but the mortar with which it was constructed had not become hardened, being easily removed by the fingers; it more resembled wet sand than a firm mortar.

There appears to have been but little difference in the sensations of persons situated either in upper or basement stories. It was preceded by a deep, heavy rumbling, and the motion apparently came from the northwest. A distinct shock was felt at eight minutes past two o'clock the same morning, by persons who were awake and up at the time.

The vortical movement was shown in the fact that small square bottles and boxes that stood upon a line, were moved from their position horizontally, describing an arc of thirty degrees and upwards, as shown by the dust upon the shelves on which they stood.

The first wave came with a force sufficient to project small articles three or four feet on the floor, from shelves on which they were placed; they were apparently all thrown in the same direction. Several clocks were stopped at precisely five hours twenty-five minutes.

All the cracks in walls and ceilings had a direction nearly northwest and southeast, and most of them had the appearance of having been produced at the moment of elevation.

The earthquake was felt heavily at Monterey, at 5 hours 20 minutes; it was also felt at Bodega, but no time is given.

The vessels on the coast, and ranging from San Pedro on the south to Southern Oregon, and at distances varying from eight to one hundred miles from land, did not experience any shock. They were twenty-two in number.

Up to the present date the most northern point of which we have any record of its having been felt, is at Santa Rosa, which is fifty-three miles north of San Francisco, and at Monterey, ninety miles south of the latter place; to the east of this city we have no record beyond Stockton. This would give for its length one hundred and forty-three miles, and its breadth sixty-six miles.

Inquiry was made through the State line Telegraph at El Dorado, Nevada, Downieville, Placerville, Marysville, Sacramento, Stockton, and San José; it was not felt in any of the localities named, excepting the two last, and at Stockton it was quite light.

If the time as given at Monterey was the same as at this city, (San Francisco) the velocity of the earth-wave must have been much slower than that of the great earthquake at Simoda.

March 24.—A slight shock was felt at Canal Gulch, Siskiyou county, also at Yreka, at 20 minutes before 10 o'clock, P. M. The motion is described as being horizontal.

March 31.—A light shock was felt in San Francisco at 25 minutes past 1 o'clock, A. M. It consisted of three light but distinct tremors.

April 6.—11½ P. M, A smart shock was felt at Los Angeles and the Monte. People were aroused from their beds.

May 10.—A light shock was felt in San Francisco at 10 minutes after 9 o'clock, P. M. The shock was accompanied by a loud report, like the discharge of a cannon; people mistook it for the signal gun of the mail steamer. This was felt at Monterey, Contra Costa county.

May 2.—A severe shock was felt at Los Angeles a few minutes past 12 o'clock P. M. It caused much trembling among the buildings, and considerable alarm among the people, many leaving their beds. The shock was preceded by two loud reports like the blasting of rock; it apparently came from the northwest; no damage was done.

August 2.—A light shock was felt in San Francisco at 20 minutes after 5 o'clock A. M. It was sufficiently strong to awaken persons in bed; it was evidently more severe in Stockton.

August 27.—An earthquake was felt at Mission San Juan, Monterey County, at 15 minutes before 9 o'clock P. M. There were two distinct shocks with short intervals elapsing, the second being the heaviest. The motion is described as undulatory and coming from the west. It was felt at Monterey and at Santa Cruz.

Sept. 6.—A smart shock felt at Santa Cruz, at 3 o'clock A. M. It created considerable consternation and many persons left their beds.

Sept. 20.—A very severe shock was felt in different parts of San Diego county, and at that town at 11½ o'clock, P. M. At Santa Isabel the ceilings of the dwellings was shaken down; the cattle stamped and ran bellowing in all directions, and the Indians seemed equally terrified. The walls of the adobe buildings were many of them cracked. The motion is described as oscillatory. A light shock occurred on the following Monday evening.

Nov. 12.—A smart shock occurred at Humboldt Bay at 4 o'clock, A. M. Another shock was reported, but no date given.

From the records before us it will be seen that fourteen being the total number of earthquakes recorded during 1856, seven have been felt in San Francisco in common with other parts of the state; seven have occurred south of this locality that were not observed here, and four north of it. Of the seven shocks noticed here, five only were not observed in any adjacent district, and may be considered as strictly local. The periods of the year at which the shocks have occurred, is as follows: During the winter months, five; during the autumn, three; during the spring and summer, six. Nine have taken place during the vernal and autumnal equinoxes.

We have records of considerable and violent volcanic phenomena throughout the northern seas, and islands both to the east and west of Alaska. The Russian frigate *Dwina*, while lying at Shuam Shu, brings intelligence of the outburst of a volcano in that city about the 22nd of June, and on the 25th of the same month passed through fields of floating pumice; the latitude by observation being 50° 53′ and longitude 158° 32′ east per chronometer.

An interesting account of a submarine volcano was reported by the Captain of the bark *Alice Frazer*, in latitude 54° 36′; longitude 135° west, which is as follows: A portion of the whaling fleet, four in number, were running through the Straits of Ourinack, on the 26th of July last; while passing the straits a submarine volcano burst out, sending a column of water several hundred feet upward; immediately following this, immense masses of lava were projected into the air, and the sea for miles and for days afterward, was covered with floating fragments of pumice. The ships *Scotland* and *Enterprise* were nearer the volcano than the ships *Frazer* and *Wm. Thomson;* on the decks of the two former considerable pumice, lava, and ashes fell. There were seven vessels in the straits at the time of the occurrence, the names of three of which I could not learn.

The outburst was accompanied with violent shocks of earthquake. It is the opinion of Captain Newell, of the *Alice Frazer*, that considerable shoaling has been the result of this submarine action.

Art. XXXV.—*On the Formation of Craters, and the Nature of the Liquidity of Lavas;** by G. Poulett Scrope, Esq., M.P., F.R.S., F.G.S.

CONTENTS.

Introduction.—It is now some thirty years since I published two works† upon the phenomena of Volcanos, Active and Extinct. I described in them as accurately as I could, by pen and pencil, what I had observed during a residence of some duration among the volcanic districts of France and Italy; and explained, in considerable detail, the laws which, from those observations, I believed to regulate the remarkable developments of subterranean energies usually called volcanic, which have played so important a part in the construction of the superficial crust of our planet.

The general principle on which I proceeded in the theoretical portion of these works was the same which had been previously employed by Hutton and Playfair, and was subsequently adopted, with signal success, by Sir Charles Lyell,—namely, to refer, so far as is possible, appearances, the origin of which has not been witnessed, to such causes as are seen or known to produce analogous appearances in the present day,—instead of resorting for the purpose to imaginary hypotheses.

In the earlier volume of the two (the Considerations on Volcanos), however, I certainly overstepped this wholesome rule, by entering towards the conclusion of the work upon some rather crude speculations on a general theory of the globe; and this, together with defects of style and arrangement, and likewise of illustration, of which I became sensible only when it was too

* Cited from Journ. Geol. Soc., xii, 326.

† "Considerations on Volcanos," &c., 1825–6. "On the Geology of Central France," &c., 1826–7.

late to amend them, sufficiently accounts for the different reception these two works met with from geologists at the time. Neither, however, I presume to hope, were wholly without some beneficial result. At the period of their publication, the Wernerian theory of the precipitation from some aqueous menstruum, not merely of granite, and what were then called the primitive formations, but even of all the trap-rocks, still prevailed, and had the support of a large school of geologists in this country. I venture to think that the facts reported in my two volumes (especially those represented to the eye in the atlas illustrative of the volcanic remains of Central France) had some share in the final extinction of that German romance,—which some geologists as old as myself may remember to have been regarded almost in the light of a gospel-truth, and defended with great acrimony.

Some of the opinions, however, expressed in these works with respect to the laws that govern volcanic action, were severely criticised at the time. Others have been since opposed by rival theories. And, as these disputed questions have an important bearing on some of the most interesting problems of geology, I trust it may not be unprofitable to call the attention of our Society to the more prominent among them.

I will advert on this occasion to two subjects especially, viz:

I. The origin, or mode of formation, of volcanic cones and craters.

II. The nature of the liquidity of lava at the time of its protrusion from a volcanic aperture.

I. *Formation of Cones and Craters.*—In both of the works to which I have alluded, I referred the formation of those remarkable circular hollows, usually called craters, which are of so frequent occurrence in volcanic districts, to explosive aëriform eruptions, breaking their way through the superficial rocks; and that of the external more or less conical hill or mountain which generally, but not always, environs a crater, and which, indeed, often occurs without a crater, but always characterized by the qua-qua-versal dip of its constituent beds of lava and conglomerates,—to the accumulation round and above an eruptive vent, of its fragmentary ejections and the lava streams poured out from it.

I considered this law to be without exception; attributing the differences in figure and structure apparent among volcanic cones to the greater or less number and violence of the eruptions to which they were owing,—some being the product of a single eruption, others of a vast number, often repeated through a series of ages,—to differences in the position of the orifices of discharge, whether from the summit of the cone, or its base, or any intermediate points,—and whether from under water, or in the air,—to the varying mineral character of the products,—and to the influences of subsequent degradation.

At the same time I remarked that the earthquakes which always more or less accompany volcanic eruptions render probable a certain amount of elevation in mass of the pre-existing superficial rocks; and moreover that the rents they cause in the solid substance of the cone of a volcano in repeated eruption, into many of which rents liquid lava will be injected from the column rising in the central chimney, and cool down afterwards into more or less vertical dykes of solid rock, must have added considerably to the bulk and elevation of such a mountain, by a sort of inward distension.

This was no closet-theory,—because as respects the cone and crater of Vesuvius at least, I had the advantage, in the years 1818, 1819, and 1820, of watching with my own eyes the outward growth of that cone, through a series of almost continual eruptions of a comparatively tranquil character, which during those years added considerably to its height and bulk by external accretions of ejected scoria and lava-currents. These last, the lava-streams, issued from small cones and craters formed upon the solid platform which then composed the summit of the great cone, and dribbled slowly down its slopes, consolidating so rapidly there as in few instances to reach the base of the cone at all; although night after night they were to be seen flowing from the summit in streams of considerable breadth and bulk, and glowing with a bright light on its steep sides.

Afterwards, in the latter part of the year 1822, I had seen the upper portion of this solid cone blown into the air (by which it lost a full third of its height), and a crater of vast dimensions drilled through its axis by continuous eruptive explosions of twenty days' duration.

I had previously made a close examination of the cones and craters of Etna, the Phlegræan Fields, the Lipari Isles, Central France, and the Rhine district; and their appearances accorded so completely with the supposition of an analogous mode of formation in these instances, that, upon the principle of explaining the unknown by the known, it seemed impossible, or at least unnecessary, to imagine any other origin for them.

"Elevation," "Denudation," and "Engulfment" Theories of Crater-formation.—It was, therefore, with no small surprise that I have since found this simple and natural mode of production denied to all cones and craters—including those of Vesuvius itself; and an hypothesis substituted of their originating in some sudden elevation of previously horizontal beds around a centre, —not (it would seem) of eruption, but of maximum elevation. I allude, of course, to the "Elevation-crater theory" of MM. Von Buch and Elie De Beaumont.

Sir Charles Lyell, M. Constant Prevost, and others have amply refuted this unphilosophical theory; which, however, still appears to hold its ground to some extent on the Continent, through the prestige of the great names attached to it. It may, therefore, not be wholly useless to adduce some additional proofs of its unwarrantable character. But I must first be permitted to remark, that even Sir Charles Lyell while supporting the view indicated above, of the generally eruptive origin of volcanic cones, has had recourse, in the case of some craters, to another agency, the influence of which I am induced to think he overrates;—I mean the excavating power of the sea in forming what he calls "craters of denudation." This phrase, I think, he first employed in a paper on the subject read before this Society in December, 1849. It is not repeated in the latest edition of his "Principles," and I imagine, therefore, that he is no longer desirous of maintaining its propriety.

I by no means doubt, that in the case of craters formed beneath the sea, or in such close vicinity to it as to allow its waves and currents to enter and sweep round their interiors, these circumstances must have considerably modified the result. In the former case, that of subaqueous eruption, the resistance of the water above the vent would probably tend to throw off the ejected materials over a wider area. And thus, perhaps, we may account for the vast horizontal dimensions of the great crateriform basins of Italy,—Bolsena, Bracciano, Albano, and others, evidently of submarine origin. In the latter case, that of subaërial craters to which the sea has had access through some lateral opening, no doubt great degradation of their internal slopes and cliffs, as well as of the outside, will have often taken place. Many, indeed, will have had their enclosures reduced to a mere skeleton, like Santorin. Some, like Graham's Isle, have been entirely swept away. But the question being as to the *origin* of these crateriform hollows, not as to the cause of any subsequent alteration of figure, this, I believe, may in every instance, without exception, be most reasonably referred to volcanic explosive eruptions. And, therefore, the employment of such a phrase as "craters of denudation," in contradistinction to "craters of eruption," can only lead to a wrong conception of the originating forces.

Where, indeed, is to be found a crater, the formation of which cannot be accounted for (making allowance for the subsequent modifications already referred to) by eruptive phenomena of the same character as those which have, before the eyes of trustworthy observers, repeatedly drilled enormous craters through the axis of the cone of Vesuvius?

Is it the vast size of some craters which should render such an origin incredible in their instances? For example,—of the

Val di Bué on the flank of Etna, the Caldera of Teneriffe, that of Palma, Santorini, or the external crater of Barren Island; which measure some three, five, or even six miles in diameter? But the crater of Vesuvius, formed in 1822, before my eyes, by explosions lasting twenty days, measured a mile in diameter, and was more than a thousand feet deep. The old crater of Somma, which half encircles the cone of Vesuvius, is about three times as wide as the crater of 1822. Are we, then, on that account alone, to believe that it could not have been produced by an eruption of proportionately greater violence,—when, too, such an eruption is known to have occurred about the time this crater must have been formed, namely in the year 79, and to have overwhelmed three cities at the base of the mountain beneath its enormous fragmentary ejections? Is it not, on the contrary, much more in accordance with sound philosophy to ascribe the excavation of the old concentric crater of Somma to the same cause which but the other day was seen to excavate the new crater of Vesuvius, through the heart of the same mountain, than to invent for the former a different and fanciful process? But if Somma be admitted, notwithstanding its extent, to be a true crater of eruption, the same origin cannot be denied to that of Palma, Santorini, or others, on the ground of their size, which scarcely, if at all, exceeds that of Somma.

Sir Charles Lyell seems to doubt the Val di Bué being a true crater of eruption upon two grounds. First, because the beds composing the surrounding cliffs do not show the usual qua-quaversal dip, but generally slope towards the sea. This, however, is merely the result of the eruption, having broken out on one side of the central axis of the mountain,—a circumstance of frequent occurrence; and naturally so, because the old central vent is apt to be sealed up by the consolidated products of former eruptions, and the point of least resistance to the subterranean eruptive force will often, therefore, be a little on one side,—probably on a fresh point of a fissure broken through the flank of the mountain.

In fact, there must be a contest between the resisting powers of the sides of the mountain and of its upper part; and the weakest part, whichever it is, will give way, and be blown up.

Sir Charles's second reason is, that a sufficient amount of conglomerates is not to be seen on the mountain-slopes around the Val di Bué, to account for the vacuity. But, besides that he himself speaks of "enormous masses of scoria on the flanks of Etna," it should be remembered that the aëriform explosions, when long continued, triturate the ejected matters, owing to their repeated fall into and rejection from the crater, to such a degree as to reduce the greater part at length to an impalpable powder, which is carried by the winds to a distance, sometimes of hundreds of miles, and spread in a thin layer over an enormous area of sea or land. And, moreover, the larger the dimensions of any crater, the more powerful and enduring will have been, in all probability, the explosions, and the more thoroughly triturated, during the process of its gradual enlargement, would be the fragments thrown up by them.

I remember being exceedingly surprised, after the termination of the Vesuvian eruption of 1822, forming a continual fountain of stones and ashes some miles in height, lasting through twenty days, and in the end completely gutting the mountain, to find that the prodigious amount of fragmentary matter thrown out from the crater had coated the outer slopes of the mountain only to an average thickness of a foot or two at most. But then the ashes which day by day were reduced to a finer and at length to an impalpable powder, so fine as to penetrate the closest rooms in the houses of Naples, were borne to vast distances by the winds. Much, too, was carried down into the plain, or the sea below the mountain, by the torrents of rain (producing *lave di fango*, or mud-lavas), such as overwhelmed Herculaneum, and which accompanied, as usual, the paroxysmal eruption of 1822.

Indeed, if we consider the statements adduced on good authority, of the prodigious distances to which ashes, and even large fragments of lapillo and of pumice, have been occasionally borne away from some of the volcanoes of South America and the Pacific (as, for example, in the eruption of Coseguina in 1835, and of Galongoon in 1822),—distances of more than a thousand miles (a large segment of the circumference of the globe), the whole of which intermediate space must have been strewn with them (and, in the first of these instances, it is said, to the depth of ten feet, at the distance of twenty-four miles from the volcano), we may well conceive that eruptions productive of such an enormous amount of ejected matters may (nay, must) have blown into the air entire mountains of a magnitude far exceeding that of Vesuvius and Somma itself, or the bulk of matter wanting in the Val di Bué, and left in their place craters of corresponding dimensions.

Sir Charles Lyell suggests (as others have done before him), in regard to some of the largest known craters, another possible origin, which he calls *Engulfment*—that is, the subsidence of the upper part, or a large area, of a volcanic mountain into some abyss suddenly opened beneath. With respect to this supposition, without attempting to dispute its possibility, I must say that I am not aware of any such process having been ever witnessed by any credible observer so placed as to be able to distinguish between engulfment and ejection; and consequently that it were well to be cautious in admitting the occurrence of such a phenomenon, if the ordinary mode of action be sufficient to explain the facts really observed. We possess reports, it is true, of eruptions and earthquakes in Java, Sumatra, the Andes, and elsewhere, having caused the disappearance of the entire summit of a mountain, leaving a vast cavity in its place. But this is precisely the result that was observable after the eruption of Vesuvius in 1822. And in that instance we know there was no subsidence. The leading example usually adduced of such immense (supposed) engulfments is the truncation of the lofty cone of Papandayang, in Java, by an eruption in the year 1772. There, it is always said, a great area of the volcano "fell in and disappeared," swallowed up in the bowels of the earth, together with forty villages and their inhabitants. Such are the phrases usually made use of on these occasions, and very naturally so, by alarmed and unscientific observers. But recent explorers, especially Professor Junghuhn, have stated that these towns and villages of Papandayang were not swallowed up at all, but buried, like Pompeii, under the ejectamenta of the volcano; and Dr. Junghuhn, therefore, very properly refers the truncation of the mountain to eruptive explosions, rather than to subsidence.

It is, no doubt, quite conceivable, that within a volcanic mountain some internal reservoir, or subterranean lake of liquified lava, coated over by a crust of hardened rock or the accumulation of fragmentary matter, may be *tapped*, as it were, by an earthquake, and empty itself out of an aperture in the side of the mountain at a low level, leaving a cavity, which another earthquake, or the explosion of vapor and gases accumulated within it and increasing in temperature, may cause to burst like a vast bubble,—the overlying crust of rocks falling inwards. But such a supposition is in the present state of our knowledge, purely conjectural, and unwarranted, if, as I have endeavored to show, the ordinary phenomena of eruption suffice to account for the formation of the largest known craters. If it is to be resorted to, in any case, it would be, perhaps, in that of the very small pit-craters, occasionally met with in volcanic districts, such as the Gour de Tazana, and the lakes Pavin du Bouchet, and Servières in Central France. But even these show marks of explosive eruption in the scoria sprinkled around their banks. And the occurrence of even a single bed of scoria is certain proof of some explosions having taken place from a body of liquid lava beneath; though, as I have said, this *may* have been accompanied or followed by engulfment. Perhaps the singular character of the crater of Kilauea, in Owyhee, may be thought to claim for it an origin in subsidence rather than eruption. It is described as a vast sudden depression in what would otherwise be almost a level plain, on the side of the gently sloping volcanic mountain of Mauna Loa. It has an irregularly oval form, from three to five miles in diameter, and is usually encircled by vertical cliffs some hundred feet high. Its bottom consists of a lake of lava, on some points (which occasionally change their situation) in continual ebullition, and at a white heat; but coated over for the most part by an indurated crust upon which it is often possible to walk. Sometimes, however, the incrusted portion is in the centre of the lake, forming a rough platform, surrounded by a circle of incandescent and seemingly fused lava,—sometimes the outer circle forms a solid shelf, within which an inner basin of lava boils at a greater or less depth below its edge. It is evident, from the account of this crater given by Professor Dana, in the "American Journal of Science," as gathered from the relations of various observers during nearly a century past, that the surface of a vast boiling lake of subterranean lava existing here, rises and sinks at irregular intervals of several years in duration; sometimes filling the entire cavity, and even pouring over its outer margin sheets of a very liquid lava,—sometimes sinking to a depth of a thousand feet or more,—especially when some outburst from a lower vent, or chain of vents, has *tapped* the internal reservoir. But, however, interesting the characteristic features of this crater, both from the facilities it affords for observation, and the great scale on which they are developed, they do not seem to me to prove the origin of the cavity other than that of ordinary craters. The phenomena of Kilauea are not so exceptional as, at first view, might be supposed. Visitors who looked down into the great Vesuvian crater for a few years after its formation in 1822, saw pools of liquid and incandescent lava at its bottom, and small cones of scoria thrown up by an almost constant ebullition. The difference in the violence of the explosions, and in the amount of ejected scoria, arises, no doubt, as Professor Dana very justly observes, from the difference in the relative liquidity of the lavas,—those of Kilauea being very liquid, those of Vesuvius much more viscid and unyielding.* So also during the Vesuvian eruption

* Dana, "American Journal," 1850, vol. ix, p. 383.

NOTE BY J. D. DANA.—I do not regard the origin of the crater of Kilauea essentially different from that of other craters. But there is this peculiarity, that the lavas have not in modern times, at least, overflowed the pit; and moreover the country around, neither in its height or slopes or scoria bears evidence of long continued overflows. There is no cone about the crater. It is a pit, which certainly overflowed at first, but for a long period has discharged itself by lateral fissures. There are several other large pit craters in the vicinity of Kilauea which are without any cones or slopes around them, being literally pits; they once contained boiling lavas to their top like the small active pools in the bottom of Kilauea, but a subterranean opening discharged them and left a deep pit with vertical walls like Kilauea. The sides of the walls in such a case are as clear from scoria as a cliff of stratified limestone, because the undermining, owing to the drawing off of the lavas, caused the sides to a certain distance around to fall from want of support, and so leave fresh fractures. I have attributed the origin of the Val di Bué (Bové) of Etna to the same cause that has produced Kilauea, and I still believe the view right. There is in a certain sense an "engulfment;" and so there is in the eruptions of Vesuvius. Mr. Scrope writes as if I had described from the observations of others alone, and does not appear to have seen my Report on the Volcanoes of the Pacific in my Geological volume connected with the Exploring Expedition.

of 1753, persons who ventured to the summit of the cone observed jets of liquid lava thrown up from the surface of a mass which occupied the bottom of the crater, and conducted itself exactly in the manner of a liquid in ebullition. Spallanzani remarked a similar appearance within the great crater of Etna in 1788. In the volcano of the Isle of Bourbon, Bory de St. Vincent describes a source of very liquid and glassy lava ceaselessly and somewhat tranquilly boiling over in concentric waves from the summit of a dome-shaped hillock composed of its overflowings.

Circular form of Craters.—A consideration which has not, perhaps, been sufficiently adverted to by geologists speculating on the origin of volcanic craters, is the cause of their invariably circular or nearly circular figure. If I am right in attributing their formation exclusively to aëriform explosions, it follows that each is in fact simply the external orifice of a more or less cylindrical bore drilled through the preëxistent rocks by repeated discharges of highly expansive aëriform fluids (probably for the most part steam) forcing their way upwards at some weak point; and that it is to the equal pressure in all directions of the expanding fluid that the circular form of the section of this orifice is due,—the same cause, in fact, which gives a spherical form to a bubble of air or gas rising through water. Indeed the eruptive explosions must be considered as occasioned by the rise of a succession of enormous bubbles from a great depth in the fluid lava below. Each single explosion attests the bursting of such a bubble from the surface of the liquid mass of lava in the vent. In moderately tranquil eruptions these succeed each other at considerable intervals. In the case of Stromboli, I noted that about five minutes usually occurred between every two explosions. When the eruption assumes a violent character, as in the Vesuvian one of 1822, the eructations, for such they are, succeed each other so rapidly as to produce an almost continuous roar, like the blowing off of a thousand steam-boilers. And each explosion gives birth to one of those great globular volumes of white vapor, which, rolling over and over each other as they rise in the air in a vast column, occasion one of the most remarkable and magnificent appearances of a paroxysmal volcanic eruption. In the midst of these clouds of snowy vapor, a black column of stones, scoria, and ashes may be seen to shoot up to a vast height, generally attended with copious discharges of electricity generated by the friction of the ejected fragments, and forming a singular contrast to the jet of aëriform matters.

In some rare cases it is possible to witness the actual rise and bursting of these great bubbles of vapor. Spallanzani on his visit to Stromboli in 1780 saw the liquid surface of lava at a white heat within the orifice of the volcano surge alternately upwards, and after bursting like a great bubble, fall back again out of sight. In 1819 I was myself able to witness the same interesting phenomenon probably from the same position, a high point of the external crater-rim which overlooks the vent. At each belch, a shower of tattered fragments of lava, torn from the surface of the bubble as it broke, rose into the air with a cloud of vapor and a fierce roar; while steam seemed to be at intervals blowing off from another neighboring vent. Hoffman, who visited the same volcano a few years later, describes in minute detail precisely the same phenomena.

The vast size of some craters, already noticed, may afford a notion of the enormous volumes of gaseiform matter that must have been discharged through them at the time of their formation by continuous explosions lasting for weeks and even months; since each individual bubble of vapor must have been of a magnitude to fill the entire horizontal section of the crater; and even for some time to aid in enlarging the area of this aperture by violent pressure against its rocky sides. The prodigious force with which they ascend, and therefore the great depth at which they are generated, may be judged from the vast vertical height, measured in miles, to which they have been seen to shoot up a continuous columnar fountain of ejections, consisting not merely of scoria and ashes, but often of rocky fragments of great size.

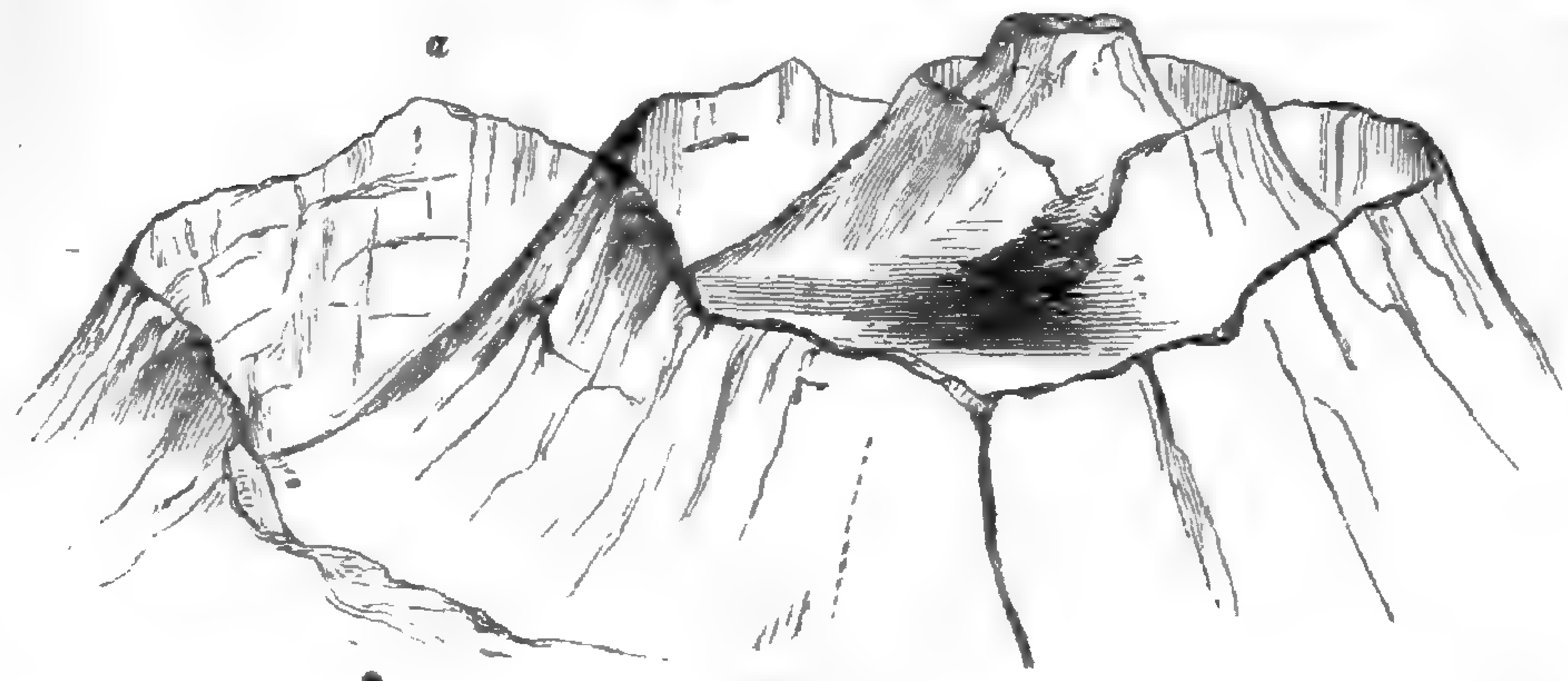
These, by their mutual friction, as they alternately fall back and are thrown up again, become, as has already been said, greatly comminuted; and the source of the explosive vapors having sooner or later exhausted its energies, the accumulation of these ashes in the vent at length appears to stifle their further development, and quiescence for a time ensues. [I am speaking here, of course, of the case of such a paroxysmal eruption as I had the advantage of witnessing in 1822.]

I have said that every crater is more or less circular in figure; but, since the orifice of discharge will almost necessarily be opened on the least resisting point of some fissure broken through the solid preëxisting rocks, we might expect its section to be often lengthened in the direction of this fissure, and consequently to be rather oval than strictly circular. And this expectation is justified by observation. Sometimes two orifices have been opened upon the same fissure so near together that their craters or cones intersect each other. In the range of Puys of Auvergne and the Velay such examples are frequent. And in the eruption of 1850 of Vesuvius two craters were formed on the summit of the cone divided only by a narrow ridge; their common horizontal axis coinciding with the line of the great fissure, which in the preceding year had been visibly broken through the side of the cone towards the northeast. Sometimes aëriform explosions take place from openings upon lateral fissures, and produce those minor, or (as they are often called) parasitic cones, of which several examples occur on the flanks both of Vesuvius and Etna. At other times, the explosions are confined to the central vent of the volcano, the lava alone welling out, perhaps, at some lateral orifice. This, indeed, is the normal character of these phenomena. And it is this habitual predilection (as it may be called) of volcanic eruptions for the same identical vent, that occasions in so many instances the heaping up of some vast mountain mass above and around it, subject to the occasional blowing up of the central portion, to be re-formed again and again by subsequent eruptions. The result of the irregular alternation of these paroxysmal explosions and subsequent gradual expulsions of new matter is the appearance, so common in volcanic mountains, of a minor and central cone with its crater, rising within the circumference of some larger crater of earlier date, or in its immediate vicinity. The walls of the latter crater are of course often broken down on one or more sides (generally on the line of the original fissure); —perhaps reduced to a mere segment of its original circuit, by the combined operations of volcanic convulsions and aqueous erosions. Whoever will take the trouble to examine carefully an accurate map, on a sufficiently large scale, of almost any volcanic district (such, for example, as Vesuvius and the Phlegræan Fields, Etna and the Lipari Isles, the Roman Territory, the Grecian Archipelago, Madeira, Teneriffe, the Azores, Bourbon, St. Helena, Barren Island, the Leeward Isles, &c.), will see numerous unquestionable examples of this law by which crater is formed within crater, and new cones upon the ruins of old ones.

History of Vesuvius.—At the risk of repetition, I must be permitted to illustrate this law by the trite, but instructive, example of Vesuvius,—which only comes so often before us because from its proximity to Naples it has been open to more constant and accurate observations than any other known volcanic mountain. What, in brief, is the history of this volcano during the last century? Precisely one hundred years ago, in the year 1756, Vesuvius possessed no less than three cones and craters, one within the other, like a nest of boxes, besides the great encircling crater and cone of Somma (fig. 1). Sir W. Hamilton gives us a drawing of its appearance in this state.

By the beginning of the year 1767, the continuance of moderate eruptions had obliterated the inmost cone and increased the intermediate one, until it very nearly filled the principal crater (fig. 2, A, B). An eruption in October of that year, 1767, completed the process, and re-formed the single cone into one continuous slope all round from the apex downwards (fig. 2, C). The dotted lines in fig. 2 (after Hamilton) represent the shape of

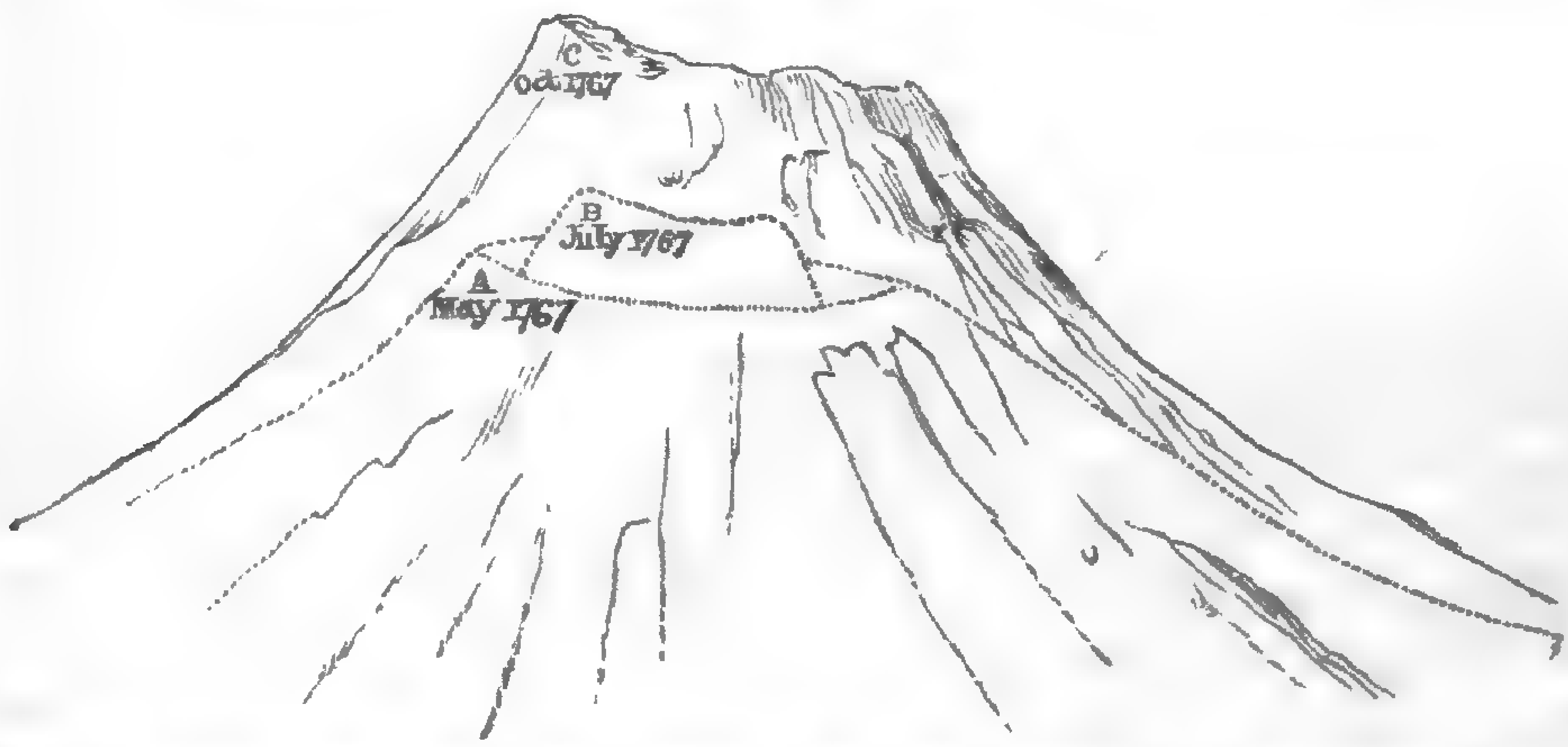
Fig. 1.—*Outline-sketch of Vesuvius as it existed in* 1756.



a. Somma.

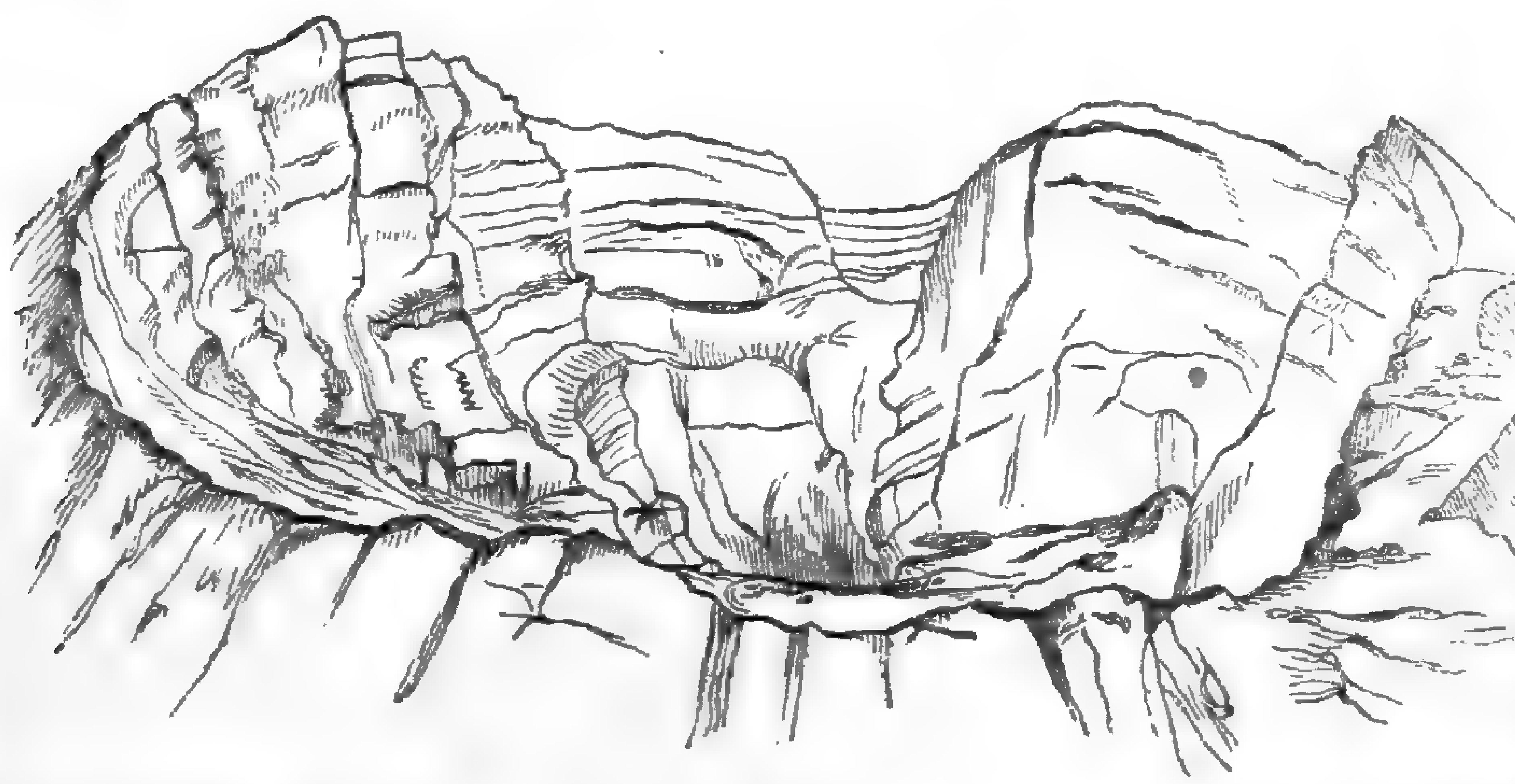
the outer and inner cones before this eruption, and the space between them and the firm outline represents the amount by which the cone was in the intervening ten years augmented in bulk and height by the ejectamenta of that eruption. An interval of comparative tranquillity followed, until, in 1794, the paroxysmal

Fig. 2.—*Outline-sketch of Vesuvius as it appeared in October,* 1767; *with dotted outlines of its form in July and in May of the same year.*



eruption occurred, described by Breislak, which completely gutted this cone, then solid, lowered its height, and left a crater of great size bored through its axis. Later eruptions, especially that of 1813, not merely filled up this vast cavity with their products, but once more raised the height of the cone by some hundred feet. When I first saw it in 1819 the top formed a rudely convex platform, rising towards the south, where was its highest point. Several small cones and craters of eruption were in quiet activity upon this plain, and streams of lava trickled from them down the outer slopes of the cone. So things went on until October, 1822, when the entire heart of the cone was again thrown out by the formidable explosions I have so often referred to, and a vast crater was opened through it; while the cone itself was found to have lost several hundred feet from its top. In fact, nothing but an outer shell of it was left (fig. 3). Eruptions, however, soon recommenced. In 1826–7 a small cone was formed at the bottom of the crater, and, continuing in activity, had reached a height which rendered it visible from

Fig. 3.—*Crater of Vesuvius after the Eruption of October,* 1822.



Naples in 1829, when of course it must have nearly filled up the crater. In 1830 it was 200 feet higher than the crater's rim; and in 1831 this cavity was completely filled, and the lava-streams began to flow over it down the outer cone. In the winter of that year a violent eruption once more emptied the bowels of the mountain, and left a new crater, which soon began to fill again from ejections upon its floor; and by the month of August 1834, this crater had been in its turn obliterated, and lava overflowed its edge towards Ottaiano. In 1839 the cone was again cleared out, and a new crater appeared in the shape of a vast funnel, accessible to its bottom, which for a few years then remained in a tranquil state. In 1841, however, a small cone began to form within it, and increased so rapidly, that in 1845 it was visible from Naples above the brim of the crater, which soon after was completely filled. And the cone from that time went on increasing in bulk and height from the effect of minor eruptions, until in 1850 one of a violently explosive character opened the two deep craters on its summit, of which I have already spoken. The more recent eruption of May last, being confined chiefly to a prodigious efflux of lava from the outer side of the cone, unaccompanied by any extraordinary explosive bursts from the summit, has not altered materially the form impressed upon it in 1850.

It is thus seen that within the last 100 years the cone of Vesuvius has been five several times gutted by explosive eruptions of a paroxysmal character, viz., in 1794, 1822, 1831, 1839, and 1850; and its central craters formed in this manner as often gradually refilled with matter, to be again in due time blown into the air. Meanwhile the old external crater of Somma is itself becoming choked up by the accumulation of all the lava-streams and fragmentary matter that are expelled towards the northern and outer side of the cone. It would be, therefore, in exact accordance with the habit of this volcano (as of volcanic mountains in general), if, after some further period either of quiescence or of moderate activity, the entire cone of Vesuvius should be blown up by a more than ordinarily violent paroxysm, and the crater of Somma itself reformed.

With this well-authenticated history of the mountain within our knowledge, would it not be wholly unphilosophical to deny (except upon such grounds of impossibility as have never been adduced) that the larger containing crater in the case of Vesuvius (and the argument applies to other similar volcanic mountains) had the same origin as the smaller contained ones; and that the external cones were produced in the same manner as the internal, and similarly constituted ones? And therefore those who refuse to believe the former to be of eruptive origin must be prepared to extend their incredulity to the latter. Indeed the elevation-crater theorists usually do not shrink from this consequence. With them the cone of Vesuvius, and that of Monte Nuovo itself, were not the products of eruption, but of elevatory expansion by a single shock. Obviously, it ought to follow, that no volcanic mountain was ever in eruption at all, that the whole is an ocular illusion; at least, that the lava-streams we see pouring for weeks and months from the summit of a cone and hardening there, and the enormous showers of fragmentary matter which, during equally long periods, we see thrown up from the crater and falling on the surface of the cone, do not, even in the lapse of ages, add to its bulk or tend by their frequent repetition to compose the substance of a volcanic mountain, but, by some unaccountable process, disappear without leaving a trace behind. I own that, to my mind, such an hypothesis is wholly unintelligible. I see in the ordinary phenomena of a volcanic mountain, such as I have described them in the brief record of the principal eruptions of Vesuvius during the last century, a simple and natural process by which such a mountain is gradually built up; and, having observed this mode of formation going on in some instances before my eyes, I think it reasonable to apply it to explain the mode of formation of other mountains of the same class, with their cones and craters, old and new, central and lateral, or parasitic; and making allowance, as I said at first, for a certain amount of internal accretion and elevation, by means of intrusive dykes and earthquake shocks, I know nothing in the appearance, figure, or structure of any volcanic mountain yet discovered, which such an ordinary and observed mode of formation will not account for.

(*To be concluded.*)

ART. XXXVI.—*On the Climate of Iowa: embracing the result of Meteorological Records of the year* 1856, *at Muscatine, Iowa, with a Synopsis of the records of the seven years from* 1850 *to* 1856, *inclusive;* by T. S. PARVIN, of Muscatine.

1. *Meteorological Journal, for the year* 1856.*

1856.	BAROMETER. H't reduced to freez'g p'nt.				THERMOMETER in the open air.						Force of Vapor, in inches.			Relative Humidity.		
MONTHS.	7 A. M.	2 P. M.	9 P. M.	Monthly Mean.	7 A. M.	2 P. M.	9 P. M.	Monthly Mean.	Maximum.	Minimum.	7 A. M.	2 P. M.	9 P. M.	7 A. M.	2 P. M.	9 P. M.
	Inch.	Inch	Inch.	Inch.	°	°	°	°	°	°	Inch.	Inch	Inch.			
January, [a]	29·62	29·59	29·59	29·60	2·1	14·8	5·8	7·52	26	-26	·049	·090	·057	84	84	83
February, [a]	29·42	29·41	29·44	29·42	10·1	22·2	12·8	15·03	42	–29	·072	·126	·079	76	82	80
March,	29·53	29·51	29·53	29·52	19·8	34·2	24·2	25·80	56	–17	·085	·164	·101	69	77	72
April,	29·35	29·34	29·35	29·34	43·9	59·8	48·6	49·37	77	27	·241	·426	·275	75	78	76
May,	29·39	29·38	29·38	29·38	54·5	70·2	59·1	61·38	90	40	·334	·487	·386	78	63	77
June,	29·38	29·33	29·36	29·35	65·1	79·8	66·4	71·79	97	50	·565	·712	·593	81	58	81
July,	29·41	29·40	29·41	29 43	67·7	81·1	69·9	73·51	93	55	·630	·941	·697	90	69	90
August,	29·45	29·42	29·42	29·43	57·3	77·9	60·9	65·40	91	40	·469	·671	·503	90	63	87
September,	29·45	29·44	29·43	29·45	50·1	71·1	56·5	59·00	91	28	·362	·492	·430	89	55	82
October,	29·54	29·50	29·49	29·51	44·4	61·5	51·7	52·85	82	25	·294	·405	·347	64	67	81
November,	29·29	39·31	29·32	29·34	28·1	38·8	32·1	32·79	54	4	·139	·189	·153	79	76	83
December,	29·53	29·50	29·53	29·52	11·5	20·0	14·2	15·63	42	–13	·077	·107	·081	82	85	81
Sums,	353·36	353·13	353·25	353·29	450·6	631·6	502·9	530·04	841	184	3 317	4·830	3·072	956	857	973
Means,	29·44	29·43	29·43	29·44	37·5	52·6	41·9	44·17	70	15	·276	·402	·306	79	71	81

[a] The Barometrical record for January and February is the "Observed Height."

2. *Clouds, Rains, Winds, &c.*

1856.	CLOUDS; Amount, Course and Velocity. Amount from 10 to 0: velocity from 0 to 10										WEATHER—Rain and Snow. Days and amount.							WINDS. Direction.			
MONTHS.	7 A. M.	2 P. M.	9 P. M.	N.—N. E.	E.—S. E.	S. S. W	W.—N. W.	7 A. M.	2 P. M.	9 P. M.	Clear.	Cloudy.	Variable.	No. days.	Amount in inches.	No. days.	Depth—inches.	N.—N. E.	E.—S. E.	S.—S. W.	W.—N. W.
January,	4·1	3·3	2·6			2	2	1·3	1·3		16	7	8			4	12·2	3	6	6	16
February,	6·4	5·0	4·4	1		3	4	2·3	2·6	1·3	5	4	20	1	4·34	7	12·0	6	1	11	11
March,	2·7	4·0	4·0	1		10	9	2·0	2·2	2·0	9	2	20	1	·25	6	3·6	2	2	11	16
April,	4·5	5·5	2·3	2	3	13	7	2·2	2·0	2·3	4	6	20	4	3·44			3	10	11	6
May,	3·7	4·8	4·4	3	3	6	7	2·0	2·0	1·4	9	6	16	12	4·39			6	9	8	8
June,	1·7	2·8	2·5	3	1	12	1	2·4	1·8	2·0	10	2	18	4	2·68			5	8	12	5
July,	2·5	2·4	1·9	1	5	15	2	1·9	1·4	1·5	15	2	14	9	2·74			3	10	9	9
August,	3·1	3·3	1·1	1	1	11	10	1·2	2·0	1·5	12	5	14	3	1·36			4	6	12	9
September,	3·3	3·4	2·8		3	13	11	2·2	2·3	1·7	13	5	12	3	2·45			1	6	12	11
October,	5·4	5 0	3·4	2	3	8	5	2·0	2·0	2·0	8	8	15	7	5·21			3	13	10	5
November,	5·9	6·1	5·4	2	1	12	3	2·0	2·0	2·0	6	11	13	10	3·83	2	5·2	3	6	7	14
December,	5·9	4·5	3·9	2	2	3	3	2·3	2·0	2·0	6	11	14	8	6·05	5	19·0	7	6	2	16
Sums,	49·2	50·1	38·7	18	22	108	64	23·8	23·6	19·7	113	69	184	60	36·74	24	52·0	47	83	111	126
Means,	4·1	4·2	3·2	1	2	9	5	1·9	1·9	1 6	9	6	15	5	3 06	5	10·2	4	7	9	10

Force of Winds at 7 A. M., 2 P. M. *and* 9 P. M.—*Force from* 0 *to* 10.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Sums.	Mns.
7 A. M.	1·5	1·5	1·7	2·1	1·7	1·5	1·4	1·2	1·7	1·4	1·5	1·8	19·0	1·7
2 P. M.	1·8	1·9	2·2	2·3	2·0	2·1	1·5	1·9	2·5	1·8	1·8	1·9	23·7	1·9
9 P. M.	1·6	1·4	1·7	1·7	1·7	1·4	1·1	1·1	1·5	1·5	1·7	1·9	18·3	1·5

* Latitude of Muscatine 41° 25′ North; Longitude 92° 2′ West, (proximate). Barometer 72·21 feet above low water in (and 586·21 feet above the mouth of) the Mississippi River.

3. *Miscellaneous Remarks*, 1856.

Lowest temperature, February 4, - 29°
Highest " June 24, 97°
Range of " - - - 126°

Lowest height barom'r, Nov. 21, 28·80 inch: therm. attached, - - 37°
Greatest height barom., Jan. 25, 30·00 inch: therm. attached, - - 15°

Frost last in the Spring, - April 19
Frost first in the Fall, - Sept. 24
Disappearance of frost from gr'nd, May 1

Mean temperature, - - - 44°·1
Average mean for 18 years, - 47°·12
[Range 43°·21, 1849; 50°, 1846.]

Range of barometer, - - 1·20 inch.
Mean height " - - - 29·44 "

Depth of ground frozen, - 2 ft. 6 in.
Thickness of ice on the river, 2 ft. 3 in.

Flowering of Fruit Trees.—Apple, May 12; Cherry, May 9; Peach;* Plum, May 12; Pear, May 15; Quince.*

Total quantity of rain in inches, 36·74 in.; in 1855, 24·55 in.; least 1854, 21·1 in.; greatest 1851, 72·4; mean, 41·90 in.

January and February.—Intensely cold; began to moderate about the 20th of February. *March and April.*—River high; Spring very backward; Peach and Quince trees all killed, and Pear, Cherry and Plum trees badly injured; the Apple also considerably injured. *August, September and October.*—River extremely low; weather dry until the middle of October. *November.*—Very wet; River good stage. *December.*—Very rainy and changeable; more snow than for many winters.

River Statistics.

Mississippi closed, Dec. 6. In 1855, Dec. 25
" opened, March 29.
No. of days closed, 94, double that of 1855.

Earliest closing (*in 20 years*), Nov. 26, 1842.
Latest " Jan. 29, 1850.
Average " December 31.

Shortest period Mississippi closed, 22 days, in 1850–'51.
Average period Mississippi closed, 60 days.

The greatest rise, May, - 13 ft. 3 in.
" " fall, September, 8 ft. 10 in.
Extreme rise and fall, - 4 ft. 5 in.

Earliest time of closing, Jan. 29, 1846.
Latest " " April 8, 1843.
Average " " March 1.

Longest period Mississippi closed, 133 days, in 1842–'43.

Mean Temperature of each of the Months and the Seasons for the years 1850–1856; *also of each for seven years, with the difference between the means of the year* 1856 *and those of the whole period of seven years.*

Months and Seasons.	Years—Temperature. 1850	1851	1852	1853	1854	1855	1856	Means. 7 years.	Diff. 1856 and mean.
December, 1849, ...	18°·34	19°·77	21°·37	22°·18	26°·67	26°·76	22°·40	22°·49	− 6°·86
January, ...	24·40	23·97	19·60	27·05	16·16	24·46	7·52	20·45	−12·93
February, ...	26·85	27·73	29·00	23·36	28·50	15·64	15·03	23·73	− 8·70
Winter mean, ...	23·19	23·82	23·32	24·19	23·77	22·28	14·98	22·22	− 7·24
March, ...	32·60	38·22	36·15	33·24	39·86	30·51	25·80	33·77	− 7·97
April, ...	41·22	43·52	42·74	47·81	51·13	53·93	49·37	47·10	+ 2·27
May, ...	53·30	58·19	59·96	55·65	60·03	60·42	61·38	58·42	+ 2·96
Spring mean, ...	42·56	46·64	46·28	45·56	50·00	48·28	45·51	46·40	− ·81
June, ...	70·17	64·64	66·80	71·22	68·96	67·02	71·79	68·65	+ 3·04
July, ...	74·22	71·62	72·36	68·82	76·16	73·01	73·51	72·81	+ ·70
August, ...	72·22	69·09	68·98	71·08	73·00	70·35	65·40	70·01	− 5·61
Summer mean, ...	72·20	68·45	69·38	70·37	72·37	70·16	70·23	70·44	− ·21
September, ...	59·83	68·34	59·76	62·21	68·23	67·92	59·00	63·61	− 4·61
October, ...	44·15	50·35	53·18	45·46	54·36	47·14	52·85	49·67	+ 3·18
November, ...	37·55	34·50	30·00	39·73	36·83	37·85	32·79	35·60	− 2·81
Autumn mean, ...	47·17	47·73	47·64	49·13	53·13	50·96	48·21	49·14	− ·93
Annual mean, ...	46·28	46·66	46·65	47·31	49·81	47·92	44·73	47·05	− 2·32

* All killed in this region by the severe cold of last winter.

Total quantity (in inches,) of Rain of each of the Months and Seasons for the years 1850–'56; also, the mean of each for seven years, with the difference between the total of the year 1856 and the mean of the septennial period.

Months and Seasons.	Years—Rain. 1850.	1851.	1852.	1853.	1854.	1855.	1856.	Means. 7 ye'rs.	Diff. 1856 and me'n.
	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
December, ...	·40	2·50	1·90	5·00	....	·41	2·02	1·75	+ 4·30
January, ...	4·40	1·50	2·20	·30	....	1·50	....	1·41	− 1·41
February, ...	·80	4·50	1·00	·70	1·25	....	4·34	1·79	+ 2·55
Winter total, ...	5·60	8·50	5·10	6·00	1·25	1·91	6·36	4·96	+ 1·40
" mean,........	1·87	2·83	1·70	2·00	·42	·63	2·12	1·65	+ ·47
March,..............	2·00	3·00	8·60	·70	1·12	1·22	·25	2·41	− 2·16
April, ...	3·30	3·60	5·30	11·80	1·76	2·55	3·44	4·54	− 1·10
May, ...	3·70	12·60	6·50	4·60	6·21	1·94	4·39	5·70	− 1·31
Spring total,.........	9·00	19·20	20·40	17·10	9·09	5·71	8·08	12·65	− 4·57
" mean,.........	3·00	6·40	6·80	5·37	3·03	1·87	2·69	4·16	− 1·47
June,................	3·50	14·30	2·20	6·40	·66	4·75	2·68	4·92	− 2·24
July,................	5·00	8·60	3·70	6·60	2·22	2·35	2·74	4·45	− 1·71
August,..............	13·00	14·00	2·80	1·70	3·33	3·51	1·36	5·66	− 4·30
Summer total, ...	21·50	36·90	8·70	14·70	6·21	10·61	6·78	17·05	− 10·27
" mean,.......	7·16	12·30	2·90	4·90	2·07	3·53	2·26	5·01	− 2·75
September, ...	3·90	3·50	8·30	6·20	1·13	1·84	2·45	3·90	− 1·45
October, ...	2·70	1·40	7·60	·20	4·29	2·81	5·21	3·45	+ 1·76
November, ...	3·50	3·50	5·50	4·10	·09	2·08	3·83	3·23	+ ·60
Autumn total, ...	10·10	8·40	21·40	10·50	5·51	6·73	11·49	10·59	+ ·90
" mean,.......	3·36	2·80	7·13	3·50	1·81	2·24	3·83	3·52	+ ·31
Annual total, ...	46·20	73·00	55·60	48·30	22·06	24·96	32·71	43·26	− 10·55
" mean,........	3·93	6·08	4·63	4·02	1·84	2·08	2·72	3·44	− ·72

Total quantity of Snow (in inches) of the Months and Seasons of Snow, for the years 1850–56; also the means of each for seven years, with the difference between the total of '56 and the means of the septennial period.

Months and Seasons.	Years—Snow. 1850.	1851.	1852.	1853.	1854.	1855.	1856.	Means 7 y'rs.	Diff. bet. '56 and mean.
	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
December ('49),......	4·70	3·70	1·50	11·40	3·20	1·00	13·00	5·50	+ 7·50
January,.............	2·20	·50	3·20	1·00	4·00	17·50	12·20	5·80	+ 6·40
February,............	....	8·40	....	2·00	5·50	7·10	12·00	5·00	+ 7·00
Winter total, ...	6·90	12·60	4·70	14·40	12·70	25·60	37·20	16·36	+20·84
" mean,........	2·30	4·20	1·56	4·80	4·23	8·86	12·40	5·48	+ 5·82
March, ...	·80	·30	....	2·00	1·10	6·50	3·60	2·04	+ 1·56
April, ...	·20	6·00	....	....	....	....	....	....	
November, ...	·90	1·30	2·60	8·00	1·00	1·50	5·20	2·93	+ 2·27
Annual total, ...	8·80	20·20	7·30	24·40	14·70	33·60	46·00	22·14	+23·86
" mean, ...	1·40	3·36	1·21	4.06	2·45	5·60	7·66	3·68	+ 3·98

Time of first and last Frosts and formation of Ice, for the years 1850–1856, *with the average period of each.*

Frost and Ice.	Years.							Mean Time.
	1850.	1851.	1852.	1853.	1854.	1855.	1856.	
Frost first, ..	Sept. 7	Sept. 28	Sept. 26	Sept. 10	Oct. 15	Sept. 27	Sept. 24	Sep. 24
" last,...	April 23	May 5	May 20	May 25	May 2	May 6	April 19	May 6
Ice first, ...	Sept. 29	Oct. 15	Sept. 26	Oct. 2	Oct. 15	Oct. 25	Sept. 24	Oct. 7
" last, ...	April 23	May 1	April 22	May 13	May 2	May 6	April 19	Apr. 29

Period of the Flowering of Fruit Trees, for the years 1850–56, *with the average period of each.*

Varieties.	Years.							Mean Time.
	1850.	1851.	1852.	1853.	1854.	1855.	1856.	
Apple, ...	May 3	May 3	May 10	May 4	Apr. 24	Apr. 29	May 12	May 3
Peach, ...	" 1	" 1	" 10	Apr. 30	" 20	May 1		" 1
Cherry, ...	" 1	" 1	" 5	May 1	" 22	" 1	May 9	" 1
Plum, ...		Apr. 29	" 1	" 3	" 21	" 10	" 12	" 8
Pear, ...			" 5	" 3	" 20	" 1	" 15	" 9
Quince, ...				" 5	" 24	" 10		" 13

Additional Remarks.

YEAR. *Temperature.*—The mean temperature of the year at this point for *seven* years past is 47·05 degrees, while that of the past year is only 44·73, or 2·32 less than the septennial average, and is the coldest year of the seven; the range being from 46·28°, in 1850, to 49·81°, in 1854. The winter was intensely cold, all the months ranging below the corresponding means, while the first spring month, the last summer month, and the first and last autumn months, were also below the corresponding means of those months.

The river did not open until the 29th of March, four weeks after the average period of its opening, and the spring was very late. The severe winter had killed all the peach, plum, and quince trees in this region, and about three-fourths of the pear, and nearly one-fourth of the apple trees were seriously injured or entirely killed by the low temperature.

Rain.—The total quantity of rain and melted snow for the year is 32·71 inches, (the discrepancy between this number and the footing in the first table arises from the fact that in that the legal year is accounted, and in this the astronomical year is recorded, and throughout the table of "Rain" and "Snow" December of '49 is counted and December of '56 omitted), being 10·55 inches less than the septennial mean of 43·26 inches. The annual range in quantity has been very great, from 22·06 inches in 1854, to 73·00 inches in 1851. It was in this latter year that the high water occurred in the Mississippi and its tributaries—the highest known to that mysterious person, "the oldest inhabitant." In 1854 occurred the "great drought" in this and the Western States generally, but owing to the porous nature of our soil, the crops with us turned out much better than in States east of the Mississippi.

Snow.—The total quantity of snow for the year ('56) is 46 inches, or 23·86 more than the mean. The smallest amount was in 1852, only 7·30 inches, while for the past two years the amount has greatly increased, and it is owing to the item of melted snow (ten inches of snow when melted making one inch of water) of the past and previous year that the amount of rain has been as large as it is, for the summer was very dry.

WINTER. *Temperature.*—The mean temperature of the winter is 7·24° below the average, the former being 14·98°, that of the latter 22·22°. The warmest winter was that of 1853, 24·19°. The coldest of twenty was that of 1855–56, when for days together the thermometer ranged below zero, sinking as low as −29°. Each of the winter months are below the mean. The prevailing winds are west and northwest.

Rain.—The quantity of rain including melted snow, is for '56 greater than the mean, but without it, less. In the winter of '54 there was no rain in December or January, in that of '55 none in February, and none in January of the past winter ('56). Total of rain and melted snow is 6·36 inches; the mean is 4·96 inches.

Snow.—The average depth of snow is 16·36 inches, while in the winter of 1855–56 we had 37·20 inches, exceeding the mean by 20·84 inches. In 1851–52 there were but 4·70 inches, which had steadily increased in the succeeding four years.

SPRING. *Temperature.*—The mean temperature is 45·51°, being only ·81° below the mean, which is 46·40°. The coldest spring was in 1850, the mean being 42·56°; the warmest was 1854, 50·00°. The temperature of the spring months of the past year was unequally distributed, March being much below the mean, while April and May were above.

Rain.—Each of the months was below the mean in quantity of rain, the total being 8·08 inches, and the mean 12·65 inches.

Snow.—There has been snow in March of each year, except that of 1852, and in 1850 and '51 there was snow in April. The total for March '56 was 3·60 inches, and the mean 2·04 inches.

The prevailing winds of the spring months are for March west and northwest; April south and southwest, and May east and southeast.

SUMMER. *Temperature.*—There was less than a degree difference between the temperature of this summer and the mean of the last seven years, the former being 70·23°, and the latter 70·44°. July is the warmest month. The summer temperature ranges from 68·45 in 1851, to 72·37° in 1854. From this comparison the past summer was neither too hot nor too cold.

Rain.—This season was very dry. The total quantity of rain was only 6·78 inches, while the mean reaches 17·05 inches, an excess over the last season of 10·27 inches.

The crops, were, notwithstanding the summer drought, more than an average yield both of corn and small grain, and the three or four dry seasons we have had has abundantly proved that the soil and climate of Iowa are unsurpassed on the continent for farming purposes.

The prevailing winds are southeast and southwest.

AUTUMN. *Temperature.*—The temperature of this season, too, was quite uniform, being less than a degree below the mean. September was colder than the mean by 4°, and there were several frosts this month which shortened the corn crop somewhat.

Rain.—September and the first half of October were very dry, but in the middle of the latter month the rains set in, and the latter half of October and the whole of November were unusually wet, exceeding the mean by near an inch. The total is 11·49 inches, and the mean 10·59 inches.

Snow.—In every year we have had snow in November; in 1856, 5·20 inches, mean 2·93 inches, an excess therefore of 2·27 inches.

In this and for several years past we have had no "January thaw," and during this year as well as the previous one, we had no "June rise." Notwithstanding the deep snows here and farther north, the river had only a moderate stage of water in the spring, and during the summer and autumn it was very low, so low as to prevent the passage of boats over the Rapids for months.

The prevailing winds are south and southwest.

January.—The mean temperature of this month for the past year was 7·52°; that of the seven years past, 20·45°. The coldest January was the past; (the lowest range of the thermometer in seven years was −29°, Feb. 4, '56;) the warmest in 1853, 27·05°. This is the coldest month of sixteen years. In '54 and '56 there was no rain, in 1850 there was 4·40 inches, the mean being 1·41 inches.

In 1851 there was but ·50 inch of snow, while in 1855 there were 17·50 inches, in '56 12·20 inches; the mean is 5·80 inches.

River low and closed all the month.

February.—The mean temperature for the year is 15·03, for the seven years, 23·73; that of 1856 being 8·70 below the mean, and the coldest February for seven years past; the warmest was that of 1852, the mean being 29·00.

The amount of rain for this month, including melted snow, is 4·34 inches; in 1851 it reached to 4·50 inches, and in 1855 there was none; the mean is 1·79, showing an excess for the last February of 2·55 inches.

In 1850 and 1852 there was no snow in February, while in 1856 there fell 12·00 inches, the mean being only 5·00 inches.

The River low and closed.

Prevailing winds in January and February, northwest and west.

March.—The most unpleasant month of the year, characterized in this region, by high, chilly winds, from a western direction. The frost which usually penetrates to a depth of from 20 to 25 inches, as it escapes, leaves the earth soft and wet, and the roads are soon cut up by the travel and rendered almost impassable.

The mean temperature of this month in 1856, is 25·80° or 7·97 less than the mean, which is 33·77°. This month of the past year, like the two preceding, is the coldest of the past seven years. In 1854 the mean temperature was 39·86°.

There was but little rain in March, only ·25 inch, the mean being 2·61 inches, and maximum 8·60, in 1852.

Snow has fallen every year in March, except 1852, the maximum being in 1855, 6·50 inches; the mean is 2·04 inches, while in the last March, there were 3·60 inches.

The Mississippi River opened on the 29th, having been closed ninety-four days; the average period of its opening for twenty years past is the first of March, and the average length of time closed is sixty days. River still low.

April.—This is *practically* in this climate the first spring month, as the winter "drags its slow length along" so far into its predecessor that but little out-door work can be done. The range of its mean temperature is from 41·22°, in 1850, to 53·93°, in 1855, that of 1856 being 49·37°, or 2·27 above the mean of 47·10°. In this month the fruit trees generally put forth their blossoms. and the birds of song make their welcome return.

In April 1850–51 there fell snow, in the latter year to the depth of 6·00 inches. The mean total of rain is 4·54 inches; that of '56 being 3·44 inches, or 1·10 less than the mean. The range is from 1·76, in 1854, the dry season, to 11·80, in 1853.

The melting snow did not materially raise the river, which continued at a low stage.

It was now that an inspection of the fruit trees showed how severe was the injury inflicted upon them by the past winter. The wood, which preserved its natural color, revealed by the incision of the pruning knife an entire absence of sap and vitality; even the forest trees were split open in many cases by the action of the frost.

May.—This and October are the most pleasant and delightful months of the year.

All the previous months of the year have revealed a temperature below the mean, that of this month is above by 2·96°, the mean being 61·38°, the highest in seven years, while that of the seven is but 58·42°; the lowest was in 1850, being 53·30°.

The total of rain is 4·39 inches; the mean of seven years 5·70, the maximum, in 1851, the year of highest water, 12·60 inches; the minimum, in 1855, 1·94 inches.

A gradual rise in the river, and a good stage of water.

June.—This month too shows a mean temperature (of 3·04°) above the average, the first being 71·79°, and the latter 68·65°, and was the warmest June in seven years; the coldest was in 1851, 64·64°.

The quantity of rain in this month is 2·68 inches, the mean 4·92. The greatest was 14·20 inches, in 1851, and the least in 1856, only ·66 inch.

The river at a good stage, but without the June rise; there was none in 1854 or '55, while in 1853 it came nearly up to the high water mark of '51.

July.—This is the hottest month of the year, the mean temperature being 72·81°; that of the coldest month (January) is 20·45°. The annual mean is 47·05°. The warmest month then exceeds the annual mean by 25·76°, and the coldest falls short 26·60°.

The mean for the last year is 73·51°, an excess of ·70 above the mean, the greatest of which is for 1855, 76·16°, and the least the year preceding, 68·82°. The highest range of the thermometer in seven years is 99°, August 31; range 128°.

The mean amount of rain for this month is 4·45 inches, the total for July 1856, 2·74 inches, and the range from 2·22 inches to 8·60 inches in the years 1854 and 1851, the dry and wet years of the seven, and indeed of the last nineteen (of our record.)

The river fell several inches during the month, and continued at a low stage, almost suspending navigation for this and the two succeeding months.

August.—This month for the past year was colder than in any of the preceding seven, its mean temperature being 65·40°, while the average mean is 70·01, and the greatest was in 1854, when it was 73·00°. It was very dry, notwithstanding its low temperature, the total of rain being only 1·36 inches, the least of the seven, the greatest (as before) being in 1851, 14·00 inches, and the mean 5·06 inches.

The health of the summer was good; in fact, a more healthy region or climate is scarcely to be found.

September.—This month, too, is below the average mean in its temperature, 4·61°, and like last August is the coldest of the seven years. Its mean temperature is 59·00°, the average 63·61°, and the maximum mean that of 1851, 68·34°. Occasionally frosts occur in the early part of this month, to the injury of the corn crop, which was the case partially last year.

The average amount of rain is 3·90 inches, and the total in September last, 2·45 inches, which amount was increased in 1852 to 8·30 inches, and diminished to 1·13 inches in 1853.

October.—The Autumns are always delightful in the region round about Iowa, and this is the pleasantest of its months. The mean temperature of this month differs from that of the season by being only ·53° greater, and exceeds that of the year 1·99° only; while April approximates to within ·05° of it.

The mean temperature is 49·67°, while the range is from 44·15 to 54·36°, in the years 1850 and '54 respectively.

The amount of rain in this month is 5·21 inches; the mean 3·45 inches. In 1850 there was only ·20 inch, and the greatest was the last year, when the latter part was very wet.

The river rose several inches in the latter part of this month.

November.—This is the last month of the *physical* year, and closes the autumn or fall season. The mean temperature for 1856 is 32·79°, and the average mean 35·60°. The consecutive years of 1852–53 furnish the extremes of means, the first being 30·00 and the last 39·73°.

This month was very wet, and more disagreeable than any for several years past, showing an entire absence of our usual "Indian Summers." The mean amount of rain is for November 3·23 inches, the total for 1856, 3·83 inches, an excess of ·60 inch. In 1854 the amount was only ·09 inch, and in 1852 it was 5·50 inches.

December.—In our tables, extending over the period of seven years, we have included December 1849 and excluded it for 1856.

The mean temperature, however, of this month for this latter year is less than any of the preceding, being only 15·63, 6·86 less than the mean, which is 22·49°, the maximum being in 1854, 26·76°.

In December, 1853, there was no rain; in the preceding year the amount was 5·00 inches; in the last December it reached 6·05 inches, while the mean is only 1·75 inches, showing an excess of 4·30 inches.

The average period of the closing of the River (Mississippi) is the 31st of this month; this year it closed suddenly on the night of the 6th, with a low stage of water.

ART. XXXVII.—*Statistics of the Flora of the Northern United States;* by ASA GRAY.

[Continued from p. 84.]

ALTHOUGH such details as I have to present are far from inviting to general readers, it is desirable to put them upon record, inasmuch as the facts they bring to view are useful to those philosophical naturalists who are discussing important problems respecting the present distribution of plants and animals over the world, and the causes which have determined the present state of things. This must be my excuse for continuing at such a length the present series of articles.

Having compared our flora with that of Europe in respect to closely allied species, it may be interesting to institute a similar comparison with that of Oregon and Northern California. The comparison might also be extended to Northwestern Asia, and especially to Japan, with which we have peculiarly interesting relations as to species; but this is better deferred until some recent collections from the northern part of Japan have been completely examined.

Comparison of the Flora of the Northern United States with that of the Pacific coast of North America (Oregon and North California) between lat. 46° and lat. 36°.

1. *As to Geographical Varieties.*

The following have been distinguished as species by excellent botanists, but in most cases, perhaps in all, they should rather be considered geographical varieties.

Natives of Eastern N. U. S.	*Natives of Oregon and California, lat. 46°–36°.*
Trautvetteria palmata,	T. grandis, *Nutt.*
Aquilegia Canadensis,	A. formosa, *Fisch.*
Actæa spicata,	A. arguta, *Nutt.*
Erysimum Arkansanum,	E. asperum and elatum, *Nutt.*
Honkenya peploides,	H. oblongifolia, *Torr. & Gr.*
Stellaria borealis,	S. crispa, *Cham.*
Euonymos atropurpureus,	E. occidentalis, *Nutt.*
Negundo aceroides,	N. Californicum, *Torr. & Gr.*
Vicia Americana,	V. Oregana, *Nutt.*
Astragalus Canadensis,	A. orthocarpus, *Dougl.*
Spiræa opulifolia,	S. capitata, *Pursh,* S. pauciflora, *Nutt.*
" Aruncus,	S. acuminata, *Dougl.*
Potentilla Pennsylvanica,	P. Hippiana, pulcherrima, bipinnatifida, &c.
Rubus Nutkanus (parviflorus, *Nutt.*),	R. Nutkanus,

Rubus occidentalis,	R. leucodermis, *Dougl.*
Rosa blanda,	R. fraxinifolia, *Lindl.*
Amelanchier Canadensis,	A. alnifolia, *Nutt.*
Heracleum lanatum,	H. Douglasii, *DC.*
Osmorrhiza brevistylis,	O. divaricata, *Nutt., &c.*
Sambucus Canadensis,	S. glauca, *Nutt.*
Galium boreale,	G. rubioides, *Linn.*
Chrysopsis villosa,	C. echioides, *Benth.*
Menziesia ferruginea, var. globularis,	M. ferruginea, *Smith.*
Pyrola rotundifolia,	P. bracteata, &c., *Hook.*
Plantago maritima, juncoides,	P. maritima.
Taxus baccata, var. Canadensis,	T. occidentalis, *Nutt.*
Xerophyllum setifolium,	X. tenax, *Pursh.*
Luzula campestris,	L. comosa, *Meyer.*

2. *Strictly Representative Species.*

The following are cases of species of our Flora of the Northern United States represented on the western side of the continent by *strictly representative species,* (including very *close representative species,*) many of which, although still admitted as distinct, are not unlikely to be regarded hereafter as geographical varieties. The very close representative species are printed in *italics.*

Natives of Eastern N. U. S.	*Natives of Oregon and California.*
Clematis Virginiana,	*C. ligusticifolia.*
Ranunculus recurvatus,	R. occidentalis.
" fascicularis,	R. orthorhynchus.
Myosurus minimus,	M. aristatus.
Isopyrum biternatum,	I. occidentale.
Delphinium exaltatum,	D. Californicum.
" tricorne,	D. Menziesii.
Aconitum uncinatum,	A. Napellus.
Cimicifuga Americana,	*C. fœtida.*
Dicentra eximia,	*D. formosa.*
Nasturtium obtusum,	*N. polymorphum.*
" sinuatum,	N. curvisiliqua.
Dentaria heterophylla,	D. tenella.
Cardamine rhomboidea,	C. purpurea.
" rotundifolia,	C. angulata.
Viola rotundifolia,	V. sarmentosa.
" *Muhlenbergii,*	*V. adunca.*
" *Canadensis,*	*V. ocellata.*
" *pubescens,*	*V. glabella.*
Parnassia asarifolia,	*P. fimbriata.*
Hypericum mutilum,	*H. anagalloides.*
Silene Virginica,	S. pulchra.
Alsine Michauxii,	A. tenella.
Mœhringia lateriflora,	M. umbrosa.
Claytonia Caroliniana,	*C. lanceolata.*

Oxalis Acetosella,	*O. Oregana* & trilliifolia.
Geranium maculatum,	*G. erianthum & Richardsonii.*
Rhus Toxicodendron,	*R. diversiloba.*
Rhamnus alnifolius,	*R. Purshiana.*
Frangula Caroliniana,	F. Californica.
Ceanothus Americanus,	C. Oreganus.
Lupinus perennis,	L. laxiflorus, &c.
Amorpha fruticosa,	*A. Californica.*
Cercis Canadensis,	C. occidentalis.
Prunus Virginiana,	*P. demissa.*
Spiræa corymbosa,	*S. betulæfolia.*
" *salicifolia,*	*S. Menziesii.*
" *tomentosa,*	*S. Douglasii.*
Geum radiatum,	*G. calthifolium.*
Potentilla arguta,	*P. glandulosa.*
Fragaria Virginiana,	F. Chilensis.
Rubus trivialis,	R. macropetalus.
Cratægus Crus-galli,	C. rivularis?
" tomentosa,	C. sanguinea?
Pyrus coronaria,	P. rivularis.
" Americana,	P. sambucifolia.
Calycanthus glaucus & lævigatus,	*C. occidentalis.*
Myriophyllum scabratum,	M. hippuroides.
Ribes rotundifolium,	*R. divaricatum & irriguum.*
" *prostratum,*	*R. laxiflorum.*
Tillæa simplex,	T. angustifolia.
Sedum pulchellum,	S. stenopetalum.
Saxifraga Virginiensis,	S. integrifolia.
Boykinia aconitifolia,	B. occidentalis.
Heuchera Americana,	H. glabra.
" villosa,	H. micrantha.
Tiarella cordifolia,	T. trifoliata.
Chrysosplenium Americanum,	*C. glechomæfolium.*
Philadelphus inodorus,	*P. Lewisii & Gordonianus.*
Cornus florida,	*C. Nuttallii.*
" *sericea,*	*C. Drummondii.*
" stricta,	C. glabrata.
Lonicera sempervirens,	L. ciliosa, &c.
Valeriana pauciflora,	*V. capitata.*
Baccharis glomeruliflora,	B. consanguinea & pilularis.
Gnaphalium decurrens,	*G. Californicum.*
Hieracium longipilum,	H. Scouleri.
Gaultheria procumbens,	G. Myrsinites.
Azalea viscosa & calendulacea,	*A. occidentalis.*
Rhododendron maximum,	R. Californicum.
Chimaphila maculata,	C. Menziesii.
Styrax grandifolia,	S. Californica.
Collinsia verna,	C. bicolor, &c.
Chelone glabra,	C. nemorosa.
Mimulus glabratus (Jamesii, *Torr.*)	M. luteus.

Gratiola Virginiana,	*G. ebracteata.*
Castilleia coccinea,	*C. Douglasii.*
Hydrophyllum macrophyllum,	*H. capitatum.*
Nemophila microcalyx,	N. parviflora.
Ellisia Nyctelea,	E. membranacea.
Frasera Carolinensis,	F. speciosa.
Gentiana Saponaria, &c.,	G. Menziesii, Sceptrum, &c.
Fraxinus sambucifolia,	F. Oregana.
Asarum Canadense,	*A. Hookeri.*
Aristolochia Sipho,	A. Californica, *Torr.*
Platanus occidentalis,	*P. Mexicanus.*
Quercus alba,	Q. Garryana & Douglasii.
Myrica cerifera,	*M. Californica.*
Betula nigra,	*B. occidentalis.*
Alnus serrulata,	*A. rubra.*
Pinus inops,	P. distorta.
" resinosa,	P. insignis.
" Strobus,	P. Lambertiana.
Abies balsamea,	A. grandis.
Larix Americana,	*L. Mertensiana,* &c.
Thuja occidentalis,	T. gigantea.
Cupressus thyoides,	C. Nutkatensis.
Symplocarpus fœtidus,	S. Kamtschaticus.
Platanthera dilatata,	P. leucostachys.
Goodyera pubescens,	G. decipiens.
Corallorhiza multiflora,	C. Mertensiana.
" *Macræi,*	*C. striata.*
Trillium sessile,	T. petiolatum.
" *erectum,*	*T. ovatum.*
" *grandiflorum,*	*T. obovatum.*
Clintonia borealis,	C. uniflora.
Scilla Fraseri,	S. esculenta.
Erythronium Americanum,	E. grandiflorum.
Prosartes languinosa,	*P. Hookeri* & Smithii.
Cyperus inflexus,	*C. occidentalis.*
Vilfa vaginæflora,	V. cuspidata.
Brizopyrum spicatum,	*B. boreale?*

About 114 of our phænogamous species are therefore represented by strict analogues on the western side of the continent, —to which might be added several from the foregoing list, which are generally deemed to be distinct species;—and the number might be considerably augmented, no doubt, by further examination.

An interesting list might also be drawn up of species which are represented on the western coast by congeners not so closely related, but yet characteristic: as our

Coptis trifolia, by C. asplenifolia.
Berberis Canadensis, by B. (Mahonia) Aquifolium.
Corydalis aurea and glauca, by C. Scouleri.

Claytonia Virginica and Caroliniana, by C. alsinoides, perfoliata, flagellaris, &c.

Æsculus Pavia and flava, by Æ. Californica.

Acer Pennsylvanicum and spicatum, by A. circinatum and macrophyllum.

Œnothera, by a much larger number of species of different sections of the genus.

Mitella diphylla and nuda, by M. caulescens and pentandra.

Sanicula Marilandica and Canadensis, by a different set of species.

Our few Pentstemons, by a large number of various kinds.

Our numerous Pycnanthemums by a peculiar Californian one.

Our Trichostema dichotomum by T. lanceolatum, oblongum, &c.

Our few Phacelias by a large number of Phacelias and Eutocas.

Our Chestnut by Castanea chrysophylla, of a Western Asian type, &c.

A list of remarkable representative genera of the two sides of the continent might also be drawn up: the following are some of the more striking.

Our Sarracenia represented on the western side by the equally curious Darlingtonia, *Torr.*

Stylophorum, by Meconopsis.

Callirhoë, by Sidalcea, *Gray.*

Flœrkea, by Limnanthes.

Lobelia, by Clintonia *Dougl.* (not of *Raf.*)

Leucothöe, by Gaultheria Shallon.

Schweinitzia, by Sarcodes, *Torr.*, and an unpublished genus, Hemitomes.

Conopholis, by Boschniakia.

Monarda, by Monardella.

Tetranthera, by Oreodaphne.

Saururus, by Anemiopsis, *Nutt.*

Taxodium, by Sequoia (including Wellingtonia of Lindley).

Najas, by Lilea (Heterostylus, *Hook.*).

Zostera, by Phyllospadix.

A proper discussion of the relations existing between the vegetation of the eastern and western sides of the continent would demand a notice of the remarkable *absence* west of the Rocky Mountains of a great variety of genera, tribes, and even orders, which are eminently characteristic of the flora of the Eastern States. For example, Oregon and California have no *Magnoliaceæ*, *Anonaceæ*, *Menispermaceæ*, nor *Cabombaceæ*, no *Nymphæa*, although a Nuphar is plentiful, no *Tilia* or Bass-wood, no *Camelliaceæ*, no indigenous Grape-vines, except one in California, only one *Polygala*, no Locust or other Leguminous trees, no Passion-flowers, no *Hydrangea*, no *Hamamelaceæ*, few *Rubiaceæ*, no *Vernoniaceæ*, and very few *Eupatoriaceæ*, very few *Asters* and *Solidagoes* (but the numerous *Compositæ* tend strongly to *Helenieæ*, and are mostly of genera which are neither Eastern

North American nor European in type), no *Lobelia*, no true Huckleberries (*Gaylussacia*) nor *Vaccinia* of the Blueberry type, (the section *Cyanococcus*), no *Clethra*, and few *Andromedeæ*, no *Aquifoliaceæ*, *Ebenaceæ*, nor *Sapotaceæ;* no true *Bignoniaceæ*, no *Acanthaceæ*, nor Gerardias, no *Sabbatia*, no *Dirca* nor *Podostemon*, solitary representatives here of their respective orders; no *Empetraceæ*, no Elms (although there is a *Celtis*), no Mulberry, no Walnuts, Hickories, or other *Juglandaceæ*, nor a Beech, Hornbeam nor Ironwood, no true *Araceæ*, *Hydrocharidaceæ*, *Hæmodoraceæ*, *Burmanniaceæ*, *Dioscoreaceæ*, *Pontederiaceæ*, *Commelynaceæ*, *Xyridaceæ*, or *Eriocaulonaceæ*, few *Orchidaceæ*, and still fewer *Cyperaceæ*, none of the latter either *Rhynchosporeæ* or *Sclerieæ*, and Paniceous and Andropogineous Grasses are altogether absent.

How these failures are made up by a large increase of peculiar generic and specific forms in a few families, I will not stop to illustrate. But it is worth noticing that, while our eastern flora possess so many orders which are not represented in the western, no order represented in Oregon or California is wanting in the flora of our Northern States, unless *Hydroleaceæ* and *Garryaceæ* be counted as independent orders; and both of these occur in the Atlantic states south of our geographical limits.

The Distribution through degrees of latitude of the Phænogamous Species generally of the Flora of the Northern United States.

Having devoted the greater part of our last article to the investigation of this subject as respects about 15 per cent of our species,—namely those common to this country and to Europe, —I shall not be expected to elaborate the range of our whole 2091 Phænogamous plants in the same detailed manner.

I have investigated, in this regard, the shrubs and trees separately from the herbaceous plants; the former being moderate in number, and those which extend into British America affording us the advantage of having had their northern limits laid down by Sir John Richardson, in the invaluable appendix to his Arctic Searching Expedition. Of our Phænogamous species about

1745, or 83·5 per cent, are herbaceous plants.
218, or 10·3 per cent, are shrubs or woody vines.
130, or 6·2 per cent, are trees.

Northward and Southward Range in this country of our Shrubs and Trees.

The average range in America of our 348 woody plants is through about 13½ degrees of latitude.

The 15 following species are those which appear to have the greatest range north and south, namely, through from 30 to 40 degrees of latitude.

	Northern limit.	Southern limit.	Range.
Prunus serotina, -	61°	29°	32°
" Virginiana, -	66	31	35
Rosa blanda,* -	69	39	30
Amelanchier Canadensis,*	66	30	36
Cornus stolonifera, -	69	38	31
Viburnum acerifolium,*	62	31	31
Arctostaphylos Uva-ursi,*	70	36	34
Cassandra calyculata,	67	34	33
Alnus viridis,* - -	68	35	33
Salix discolor, - -	67	36	31
" lucida,* - -	67	37	30
" longifolia,* -	68	35	33
Populus tremuloides, -	69	37	32
Abies nigra, - -	68	34	34
Juniperus Virginiana, -	67	26	41

All of these species, with four or five exceptions, extend into the Southern United States only along the Alleghany Mountains; consequently their climatic range is not so great as would at first appear. Those which have an extraordinary climatic range, being natives both of the Arctic and Subarctic regions and of the low country bordering the Gulf of Mexico are the following.

Viburnum acerifolium. In the Southern States this is not met with far from the Alleghany Mountains, and the few specimens I have seen from Middle Florida are of doubtful character.

Amelanchier Canadensis. The Shad-flower or Service-berry prefers the mountains or their vicinity, but is not unknown in some parts of the low country as far south as Florida.

Prunus serotina. The Wild Black Cherry ranges from near Great Slave Lake, at the north, well into Florida and Texas, and into the adjacent parts of Mexico. Although it varies from a moderate-sized shrub to a large tree, I have no idea that more than one species is covered by this name.

Prunus Virginiana. The Choke Cherry extends from the borders of the Arctic Circle to Louisiana, &c.; but in the Southern States it is chiefly restricted to elevated districts.

Juniperus Virginiana. The Red Cedar, with its immense range, in the United States inhabits the warmer rather than the colder districts of the country, and extends on the Gulf of Mexico quite to the mouth of the Rio Grande. As a tree it does not occur north of about lat. 54°, but the low and spreading or prostrate form, which, with Sir William Hooker I have not been able to distinguish specifically from J. Virginiana, advances a short distance within the Arctic Circle, where, according to Sir John Richardson, it bears fruit at an elevation of 1000 feet, Sir William Hooker unites not only this northern form, but the Red Cedar generally with *Juniperus Sabina* of Europe, which in this case ranges over nearly the whole extent of the northern hemisphere. I am not yet prepared to adopt this view.

If the high northern prostrate Savin is rightly referred to *Juniperus Virginiana,* this species extends from within the Arctic Circle to the Gulf of Mexico. It is the only woody plant which does so, except perhaps *Amelanchier,* which has been traced almost to the Arctic Circle, and possibly *Prunus Virginiana.*

Alnus viridis occurs southward only on the highest Alleghanies.

We naturally enquire whether these fifteen species range widely east and west. Seven of them, those to which an asterisk is annexed, extend from the Atlantic to the Pacific, or very nearly, south of lat. 46°; and of these only two (*Arctostaphylos Uva-Ursi* and *Alnus viridis*) are indigenous to the Old World. *Cornus stolonifera, Prunus serotina* and *P. Virginiana,* and probably *Salix discolor,* all peculiarly American, reach or cross the Rocky Mountains. *Cassandra* (of which I have some doubt about its reputed southern range to Georgia) is wholly eastern, and is also European. *Populus tremuloides* and *Abies nigra* are both exclusively Eastern North American in habitation.

The following 68 species of woody plants, range with us through between 20 and 29 degrees of latitude.

— * Tilia Americana.
† Rhus glabra.
— † " aromatica.
— * Vitis cordifolia.
— † Ampelopsis quinquefolia.
— † Acer rubrum.
— † Negundo aceroides.
— * Amorpha fruticosa.
— * Prunus Americana.
— * Spiræa opulifolia.
† " salicifolia.
† Rubus occidentalis.
— † " villosus.
‡ Potentilla fruticosa.
— * Pyrus arbutifolia.
† Ribes Cynosbati.
† " hirtellum.
‡ " lacustre.
‡ " rubrum.
‡ Lonicera cærulea.
† Sambucus pubens.
— † " Canadensis.
‡ Viburnum Opulus.
† Gaylussacia resinosa.
‡ Vaccinium Vitis Idœa.
‡ " Oxycoccus.
‡ Vaccinum uliginosum.
‡ " Canadense.
‡ Arctostaphylos alpina.
— † Epigæa repens.
‡ ? Cassiope hypnoides.
‡ Andromeda polifolia.
— † " ligustrina.
‡ Phyllodoce taxifolia.
‡ Kalmia glauca.
† Menziesia ferruginea.
‡ Rhododendron Lapponicum.
‡ Loiseleuria procumbens.
— † Fraxinus Americana.
‡ Shepherdia Canadensis.
‡ Empetrum nigrum.
— * Ulmus fulva.
— † " Americana.
— * Quercus obtusiloba.
— † " alba.
— † " rubra.
— * Fagus ferruginea.
— † Corylus Americana.
— † Ostrya Virginica.
‡ Myrica Gale.
† Comptonia asplenifolia.
‡ Betula pumila.

‡ Betula nana.
‡ " papyracea.
‡ Alnus incana.
‡ Salix cordata.
‡ " rostrata.
‡ " phylicifolia.
‡ " pedicillaris.
‡ " Uva-Ursi.
‡ Salix repens.
‡ " herbacea.
‡ Pinus Banksiana.
† Abies balsamea.
‡ " alba.
‡ Larix Americana.
† Cupressus thyoides.
‡ Juniperus communis.

The mark — prefixed to the name indicates that the species extends southward to the borders of the Gulf of Mexico. The asterisk * denotes a range northward to the Great Lakes; †, to the basin of the Saskatchawan; ‡ to the Arctic Circle, or at least to lat. 67°.

It appears then that 34 species, or one half of this list, are of boreal or alpine character, ranging northward to or within the Arctic Circle. Fifteen of these are exclusively alpine or subalpine plants, and occur only on our higher mountains as far south as lat. 44°. Of the rest, those of greatest climatic range are, *Alnus incana*, ranging from about lat. 68° to 39°; *Salix cordata*, with an equally wide range and probably reaching further south; *Larix Americana*, with about the same southern limit, but in an elevated region only; *Juniperus communis*, not found south of lat. 40°; *Myrica Gale*, and *Ribes Cynosbati*, *Potentilla fruticosa*, *Kalmia glauca*, *Betula pumila*, and perhaps *Ribes lacustre*, each have a range of 28 or 29 degrees, but none of them are found south of lat. 40°.

Twenty-two species of the foregoing list extend northward into the Saskatchawan basin, and all but three of them (which cross the 60th parallel and occur in the basin of the Great Slave Lake) find their northern limit there.

On the other hand, 24 species extend southward to the borders of the Gulf of Mexico. Fourteen of these have their boreal limit in the Saskatchawan district, and nine about the Great Lakes.

The following species, 57 in number, range through from 15 to 19 degrees of latitude:

† Hudsonia tomentosa.
* Rhus typhina.
— * " venenata.
— * " Toxicodendron.
— * Ptelea trifoliata.
— * Vitis Labrusca.
† Rhamnus alnifolius.
— * Ceanothus Americanus.
† Acer Pennsylvanicum.
† " spicatum.
* Acer saccharinum.
* " dasycarpum.
* Amorpha canescens.
† Prunus Pennsylvanica.
† Spiræa tomentosa.
† Rubus odoratus.

† " strigosus.
— * Rosa setigera.
— * " lucida.
— * Cratægus coccinea.
— * Cratægus tomentosa.
† Ribes prostratum.
† " floridum.
— * Hamamelis Virginica.
* Cornus sericea.
† Symphoricarpus occidentalis.
† " racemosus.
† Lonicera parviflora.
† " ciliata.
† Diervilla trifida.
— * Viburnum nudum.
† " Lentago.
† " pubescens.
* " lantanoides.
† Vaccinium macrocarpon.
— * " corymbosum.
* Gaultheria procumbens.
— * Kalmia latifolia.
* " angustifolia.
— * Azalea viscosa.
— * " nudiflora.
† Nemopanthes Canadensis.
* Fraxinus pubescens.
— * " viridis.
— * Benzoin odoriferum.
— * Platanus occidentalis.
† Corylus rostrata.
— * Carpinus Americana.
— * Myrica cerifera.
* Salix eriocephala.
† " petiolaris.
— * " angustata.
— * Populus angulata.
† " balsamifera.
† Pinus resinosa.
† Thuja occidentalis.
— * Smilax rotundifolia.

The marks prefixed to the names have the same signification as in the preceding list.

Not one of these species are alpine, or even subalpine, nor found within several degrees of the Arctic Circle. Only two of them (viz., *Symphoricarpus occidentalis* and *S. racemosus*) reach the 60th parallel, or the great northern basin. Twenty-four of them have their boreal limit in the Saskatchawan or Hudson's Bay region; and all of them extend as far north at least as to the Great Lakes, although a few (such as *Ptelea trifoliata* and *Populus angulata*) barely touch their most southern borders, viz., the south shore of lakes Erie and Michigan.

Twenty-three species range southward to the borders of the Gulf of Mexico or very nearly, while their boreal limit is on or near the Great Lakes, between 41° and 49°.

Without carrying this analysis any farther, let us turn to the shrubs and trees of narrowest northern and southern range. Those whose range is not known to exceed six degrees of latitude are 33 in number, viz:

Magnolia macrophylla.
" Umbrella.
Berberis Canadensis.
Hypericum Kalmianum.
Æsculus glabra.
Robinia Pseudacacia.
" viscosa.
Cladrastis tinctoria.
Spiræa corymbosa.
Cratægus cordata.
Calycanthus glaucus.
Fothergilla alnifolia.
Lonicera hirsuta.
" oblongifolia.
Baccharis glomeruliflora.
Gaylussacia brachycera.

Vaccinium erythrocarpon.
Leucothoë Catesbæi.
" recurva.
Andromeda floribunda.
Clethra acuminata.
Azalea arborescens.
Rhododendron Catawbiense.
Styrax Americana.
Ulmus racemosa.
Juglans nigra.
Carya microcarpa.
" sulcata.
Quercus palustris.
Pinus pungens.
Abies Fraseri.
Smilax Walteri.
" hispida.

Fifteen, or $45\frac{1}{2}$ per cent of these are trees; and out of 14 whose range is under four degrees of latitude, six are trees.

On the other hand, out of 140 species of wide or considerably more than average range, enumerated in the preceding lists, 42 (i. e. 30 per cent) may be counted as trees. Now, as almost 60 per cent of our woody plants attain under favoring circumstances the stature of trees, the general impression, that trees are more limited in range than shrubs, is not confirmed by the list last given, in which the percentage of trees is diminished instead of enlarged; but seems decidedly to be so by the list of wide-ranging species, even after the exclusion of the alpine plants, which of necessity are not trees. That is, local species are about as likely to be shrubs as trees, but shrubs are in general more widely distributed than trees.

A very few of our shrubs and trees, if rightly determined, extend southward much beyond the southern boundaries of the United States. Those which do so, principally, *Ascyrum stans* and perhaps *Zanthoxylum Carolinianum*, in the West Indies; and *Negundo aceroides*, *Sambucus Canadensis*, *Cephalanthus occidentalis*, *Vaccinium stamineum*, *Salix angustata*, and *Taxodium distichum*, in Mexico.

Northward and Southward range in this country of Herbaceous Plants.

Upon this subject my statements must be brief and general. Of the 1745 phænogamous herbaceous plants of the Flora of the Northern United States, diminished to about 1690 by the exclusion of the alpine and subalpine species, here left out of view—

843 species, or 50 per cent, range southward to the borders of the Gulf of Mexico.

538, or not quite 32 per cent, extend northward into the Saskatchawan basin or to Labrador.

107 of these reach or cross the Arctic circle.

24 species, or less than $1\frac{1}{2}$ per cent, range from the Gulf of Mexico to the Arctic circle.

180, or $10\frac{1}{2}$ per cent, range from the Gulf of Mexico to the Saskatchawan or Labrador.

248 species, or over 14½ per cent, range from the Gulf of Mexico to the Great Lakes or the St. Lawrence.

The twenty-four herbaceous plants of widest climatic range are

Ranunculus aquatilis.
" Cymbalaria.
" Purshii.
" sceleratus (a doubtful native southward).
Sarracenia purpurea.
Nasturtium palustre.
Cardamine hirsuta.
Barbarea vulgaris (not indigenous at the south ?).
Sisymbrium canescens.
Viola cucullata.
Drosera rotundifolia.
Spergularia rubra.
Lupinus perennis (if the plant growing on the Arctic sea-coast is correctly referred to this species).
Galium trifidum.
" triflorum.
Erigeron Philadelphicum.
Achillea Millefolium (probably introduced southward).
Senecio aureus.
Taraxacum Dens-leonis.
Dodecatheon Meadia.
Chenopodina maritima ?
Potamogeton pectinatus.
Luzula campestris.
Carex Novæ-Angliæ.

All except three or four of these species range westward to the Pacific; but one, *Sarracenia purpurea*, is remarkably restricted to the vicinity of the Atlantic. Only the seven printed in italics are indigenous to North America exclusively.

The Range of our Species compared with the size of the Genera they belong to.

The data before us may be used to test Mr. Darwin's surmise, that the species of large genera on the whole occupy a greater geographical area than those of small genera. Certainly almost half of the herbs of the last preceding list belong to very large genera; and all but four of them to genera of more than average size, that is, of more than ten or twelve species. I find, also, that 126 out of the 180 herbaceous species which range from the Gulf of Mexico to the Saskatchawan or Labrador, viz. 70 per cent, belong to genera containing above the average amount of species each, and about 112 of them belong to genera which are represented in the Flora of the Northern United States by above the average of indigenous species to genus.

And our woody plants of wide range tend more strongly to confirm this view, as the following table shows.

Woody plants ranging through	Whole No. of species.	Belonging to Genera, Of great size.	Of more than average size, i. e. of over 10 species.	Of a single species or nearly so.
30°–40° of latitude.	15	3	13	1
20° " "	68	20	48	6
15° " "	57	7	44	1
	140	30	105	8

That is, in the first list, or in the species of widest range, 86½ per cent; in the second, 70½ per cent; in the third, 76 per cent, or in all three together 75 per cent of the species belong to genera of above the average size.

The converse does not tell in the same way, so far as our list of 33 species of narrowest range shows; for at least 21 of them belong to genera of above the average size, and only two are monotypic. But here the particulars are too few to draw any useful induction from.

Species of the Northern United States which have some other and widely sundered habitation.

The plants which I here have in view belong to DeCandolle's category of *Disjoined Species* (Espèces Disjointes),* or those of which the individuals exist in two or more separated countries, and which cannot reasonably be regarded as having been conveyed from one to the other by any existing means of transport, whether on account of their mode of life, the character of their seeds, the extreme distance of their habitations, or any other reason. I restrict myself, however, to only one, and that a small, portion of the numerous species which DeCandolle treats of under this head. For in this view almost all the undoubtedly indigenous phænoganous plants common to this country and to the Old World are disjoined species. I exclude both those species which are rather widely distributed in Northern Europe or Asia as well as in this country, and those which are dispersed over a very considerable portion of the terrestrial surface of the globe,† and consider only those of remarkably isolated as well as distant habitats.

The following are the principal cases of the kind with which we have to do.

Anemone multifida. North America, from lat. 42° northward. South America from Chili, and perhaps Peru, southward.

Trautvetteria palmata. Illinois to Tennessee. Oregon on the Pacific: no intermediate station known.

Myosurus minimus. Florida and Georgia to Illinois, and west to Oregon and California. Europe, north to Finland.—It is remarkable that along with the common Mousetail in Oregon grows the only other species of the genus, *M. aristatus*, *Benth.*;

* *Géographie Botanique*, 2, p. 993.

† DeCandolle (*Géogr. Bot.*, 1, p. 564) gives a catalogue of 117 Phænogamous species which are now dispersed (whether by naturalization or otherwise) over at least one-third of the terrestrial surface of the globe,—a number which he supposes might be raised to 200. Some botanists, uniting nominal species, would add considerably to the number. Our *Flora of the Northern United States* comprises 103 of these, and perhaps should have comprised two or three more. Of this number 58 are reckoned as indigenous plants, and 45 as introduced species. A few species are probably to be transferred from the indigenous to the naturalized list, viz., *Galium Aparine*, *Gnaphalium uliginosum*, *Juncus bufonius*, and perhaps *Poa annua*.

which elsewhere occurs only in Chili, where it is the *M. apetalus* of Gay.

Brasenia peltata. Canada to Florida and Eastern Texas. Eastern Himalayas, Japan (*fide* Planchon), Eastern Australia. The only known species of the genus. The other genus of this group, *Cabomba*, was once thought to furnish another case of great disjunction; the original species inhabiting Cayenne and Brazil being long supposed to be identical with the species of the Southern United States. The latter I distinguished twenty years ago, chiefly by the form of the floating leaves, under the name of *C. Caroliniana;* but I should not be surprised if it were eventually reunited to *C. aquatica.*

Subularia aquatica. As already stated in a former article (vol. 23, p. 65), the only known stations of this plant in the New World are at most two, one in Maine, the other in New Hampshire. But it is a plant very likely to be overlooked. Northern Europe to lat. 70°, and Siberia.

Silene Antirrhina. United States, south to the borders of Mexico, and perhaps farther. South Brazil and Northern Patagonia.

Cerastium arvense. Northern parts of N. America and in the Old World. South Brazil and Chili to the Falkland Islands, according to Dr. Hooker.

Sagina procumbens. Northeastern States, rare. Falkland Islands. Perhaps not indigenous in the New World. Europe.

? *Elatine Americana.* New Hampshire to Kentucky. New Zealand! according to Dr. Hooker. But a further comparison is desirable.

? *Lathyrus maritimus.* Coasts of N. America north of lat. 40°, and in corresponding parts of the Old World. Southern border of Chili, lat. 47° S. Needs fuller confirmation.

Potentilla anserina. Pennsylvania to California and northward, and northern part of the Old World. Chili. New Zealand.

Potentilla frigida. Alpine region of the White Mountains of New Hampshire. Greenland. Swiss Alps.

? *Potentilla tridentata.* Alleghany Mountains to Arctic America, lat. 64°; generally subalpine, but found on the Coast of Massachusetts (Cape Cod, H. J. Clark,) and Maine; Labrador and Greenland. Clova Mountains, Scotland; found many years since by G. Don but by no one else. I had omitted to mention this as a European species, having the impression that it was supposed to have been wrongly introduced into the Flora of Great Britain. Hooker and Arnott, however, still retain it, although marking it as extinct. If it was really found indigenous in Scotland, then it is (as Prof. Tuckerman has aptly remarked to me) an exact counterpart to *Carex fulva*, which was first detected in this country, and once gathered in Massachusetts, but never found again in America, although it has proved to be not uncommon in

Western Europe. These indications of the extinction of a species on one side of the Atlantic, while it flourishes on the other, are very significant.

Circæa Lutetiana. This is not recorded from any station north of lat. 46°, nor west of the Mississippi. In Europe it ranges north to Scotland and Finland and east to Altai. Hence De Candolle includes it in his list of remarkably disjoined species.

Hippuris vulgaris. Rare in this country, but extending from far north to lat. 36° along the Rocky Mountains, and reappearing in Patagonia.

Sium lineare. Florida to the Saskatchawan and northern Oregon. Siberia.

Cryptotænia Canadensis. Eastern United States and Canada. Japan, *fide* Zuccarini.

Heracleum lanatum. Northern United States to Newfoundland; Oregon and Sitcha. Japan.

Hydrocotyle Americana. Eastern United States. Brazil. New Zealand, (*fide* Dr. Hooker.)

Crantzia lineata. Massachusetts to Texas. Buenos Ayres to the Falkland Islands. New Zealand.

Osmorrhiza longistylis. Northern United States and Canada to Oregon. Japan! (*O. Japonica*, Zucc.)

Aralia quinquefolia (*Panax quinquefolium*, Linn.). Canada to Georgia along the mountains. China? and Himalayas, (*P. Pseudo-Ginseng*, Wall.)

Viburnum lantanoides. Northern States, not crossing the Alleghanies, and Canada. Japan! (*V. plicatum*, Thunberg.)

Matricaria discoidea. St. Louis, Missouri. Probably a recent immigrant from Oregon, although thoroughly established. California to Unalaschka and adjacent parts of Asia. Sweden! Doubtless of recent introduction, but how introduced is unknown.

Monotropa uniflora. Canada to Louisiana; Oregon. Falls of Tequendama, New Granada, *Prof. Holton!* Sikkim and Khasian Himmalayas, *Dr. Hooker!* This isolated occurrence of a plant so peculiar in appearance and mode of life, in these districts so widely separated from each other, furnishes far the most remarkable case of anomalous distribution I know. The species is unknown north of Canada, and must be rare west of the Mississippi, as Nuttall alone mentions it from Oregon. But I should not be surprised to hear of it from Japan on the one hand, and the Mexican Andes on the other.

Plantago maritima, var., *juncoides*, &c. Northern hemisphere; on the Atlantic coast of North America south to lat. 40°; on the Pacific coast to lat. 36°. Straits of Magellan.

Primula farinosa. Northern hemisphere; in the United States south to lat. 42°, and in the Rocky Mountains to lat. 39°. Straits of Magellan and Falkland Islands!

Centunculus minimus. Florida to Illinois and Oregon, Southern Brazil! Europe, north to Norway. Perhaps introduced into Brazil?

Phryma Leptostachya. Canada to Florida; not found west of the Rocky Mountains. Nepal!

Veronica Anagallis. Around the northern hemisphere, in the temperate zone. New Zealand, *fide Dr. Hooker.*

Veronica serpyllifolia. Around the northern hemisphere. Quito and Falkland Islands, &c. Cape of Good Hope. Perhaps introduced in the southern hemisphere.

Dichondra repens. Virginia to Chili. New Zealand. Tasmania to Eastern Africa. Cape of Good Hope.

? *Salicornia mucronata.* Coast of New England; also on the coast of Spain, if the plant of Lagasca under this name is the same as ours. The two have never been compared; and the main object in the present mention of them is to ask that this may be done.

? *Castanea vesca.* Eastern United States, north to lat. 44°. Southern and Eastern Europe. (Vide vol. 23, p. 65.)

Betula alba. Northeastern United States, from lat. 40° to 46°. Northern Europe to the Arctic regions, and Siberia.

Convallaria majalis. Mountains of Virginia and Carolina. Europe and Northern and Eastern Asia. Japan.

? *Polygonatum latifolium.* Pennsylvania. Central and Southern Europe.

Smilacina stellata. Northern States to California, Oregon and Labrador. Norway.

Smilacina trifolia. Northern States, and from Labrador to Bear Lake, and the Rocky Mountains. Siberia.

Trillium erectum var. *album.* Northern States and Canada. Japan!

Vallisneria spiralis. United States east of the Mississippi, and Canada to lat. 46°. France to Italy; near St. Petersburgh? also on the Wolga. India?

Anacharis Canadensis. Eastern part of Canada and the United States. New Granada to Chili. Probably in intermediate stations.

Zannichellia palustris. Northern hemisphere, only in temperate regions; neither arctic nor tropical. New Zealand.

? *Spiranthes cernua.* United States, Canada, and Oregon. Western coast of Ireland.

Xerophyllum asphodelioides. New Jersey to Carolina; but nowhere west of the Alleghanies, except in Oregon and California.

Juncus stygius. Northern New York at one station. Newfoundland. Scandinavia; Bavaria and Switzerland.

? *Juncus maritimus.* Coast of the Atlantic United States south of lat. 40°. Europe, &c.

Eriocaulon septangulare. Eastern United States, north of lat. 40°, to the Saskatchawan and Newfoundland. Western Coast of Ireland, Isle of Skye, and the Hebrides.

Hemicarpha subsquarrosa. United States from Maine? to Texas. Brazil.

Rhynchospora fusca. Northeastern United States, lat. from 40° to $44\frac{1}{2}$°. Europe south of Sweden.

Carex flacca. New Jersey, lat. 40°. Europe from Finland southward.

Carex lævigata. Massachusetts? England to Portugal.

Carex fulva. Massachusetts; found only once. Newfoundland; where it was first detected, but has not been found again. W. Europe from Finland southward.

Carex canescens, Linn., (*C. curta,* Good.) Colder parts of the Northern hemisphere, south to lat. 40° in this country. Antarctic America.

Carex stellulata. Same general northern range as the last. New Zealand, *fide* Dr. Boott.

Carex teretiuscula. Same general range as the last. New Zealand, *fide* Dr. Boott.

Phleum alpinum. Alpine and Arctic regions in the northern hemisphere. Antarctic America, *fide* Hooker.

Agrostis canina. Only subalpine in the United States. Falkland Islands, *fide* Hooker.

? *Spartina juncea.* Atlantic coast of the United States. French coast of the Mediterranean, at one station only, near Fréjus. A chance introduction?

Spartina stricta (*S. glabra* and *S. alterniflora*). Atlantic coast of the United States to Guadeloupe and Cayenne. Coast of England to the Adriatic; at few stations. A case of accidental or oceanic transport?

Kœleria cristata. Temperate and colder regions of the northern hemisphere. New Zealand and Tasmania, *fide* Hooker.

Glyceria fluitans. Same general range as the last. Australia.

Poa nemoralis. Northern and colder parts of North America; more common in Europe. Antarctic America, *fide* Hooker.

Poa pratensis. Same general distribution as the last. Antarctic America, *fide* Hooker.

Festuca ovina. Same distribution as the preceding. New Zealand, *fide* Hooker.

Triticum repens. Same distribution generally as the preceding. Antarctic America, *fide* Hooker.

Hordeum jubatum. Atlantic and Pacific coasts of North America, chiefly northward on this side, and south to California on the other; also along the Great Lakes. Chili? Straits of Magellan, *fide* Hooker.

Aira flexuosa. Northern hemisphere, throughout the cooler parts. Patagonia and Falkland Islands.

Aira cæspitosa. Colder parts of the northern hemisphere. Antarctic America and New Zealand, *fide* Hooker.

Trisetum subspicatum. Alpine and arctic exclusively in Europe, Asia and N. America (except the var. *molle,* which is rarely ever subalpine in the Northern States); advancing south along the Rocky Mountains to about lat. 40°. Andes of Mexico, Colombia, and Peru, *fide* Hooker. Antarctic America and Campbell Islands: also Tasmania, *fide* Hooker.

Hierochloa borealis. Around the colder parts of the northern hemisphere. New Zealand, and Tasmania, *fide* Hooker.

To this list of 69 phænogamous species of our flora inhabiting very widely sundered stations, the following Ferns should be appended, namely:

Scolopendrium officinarum. Banks of a deep ravine in Madison County, New York, where it abounds; the only American habitat known. Europe and Northern Asia.

? *Camptosorus rhizophyllus.* Atlantic United States, chiefly along the Alleghanies, and north to the Saskatchawan. Siberia and Kamtschatka?

Adiantum pedatum. Eastern United States and Canada to Oregon and Unalaschka. Kamtschatka, Japan, Nepal.

Aspidium Lonchitis. Lake Superior, Rocky Mountains. Unalaschka, Northern Europe and Asia from Lapland to Altai.

Schizæa pusilla. Pine barrens of New Jersey, lat. 39½°–40°; very local, but abundant. Newfoundland; lat. 49°; and not elsewhere.

I do not include in this enumeration *Saururus cernuus* and *Stachys aspera,* adduced by DeCandolle as species extraordinarily disjoined and isolated. The latter I have considered as merely a variety of the polymorphous and widely diffused *S. palustris.* The second DeCandolle mentions on the authority of Hooker and Arnott, who were unable to distinguish Chinese specimens from our *Saururus cernuus.* But Japanese specimens of what I take to be *S. Loureiri,* Decaisne, seem to be marked by good specific characters. An analogous case, still needing examination is that of *Penthorum Chinense,* which the elder DeCandolle, however, distinguishes from our *P. sedoides* by its seeds.

These species of widely sundered habitation arrange themselves, for the most part, under three heads, viz:

1. Those which re-appear in high southern or antarctic latitudes. These, the most remarkable of all, are about 34 in number, or nearly half of our list. And to this number might be added several other species, common to our northern and to high southern regions, but not occurring in our Flora; such as *Draba*

incana, Montia fontana, Saxifraga exarata, Erigeron alpinum, Statice Armeria, Carex festiva, and *Alopecurus alpinus*, enumerated in Hooker's Flora Antarctica, as both Arctic and Antarctic American as well as European species.

2. Those which re-appear in Japan, the Himalaya, or some part of Northern Asia, but are not European; of which the following are the principal: viz, *Brasenia peltata, Sium lineare, Cryptotænia Canadensis, Heracleum lanatum, Osmorhiza longistylis, Aralia quinquefolia, Viburnum lantanoides, Monotropa uniflora, Phryma leptostachya, Smilacina trifolia, Trillium erectum*, var., *Camptosorus rhizophyllus*, and *Adiantum pedatum*. A goodly number of species common to Northwestern America and Japan, and of others common to the Himalayas, Europe, and North America, although as yet known from but few stations throughout large parts of this belt (such as *Spiræa Aruncus, Pyrola rotundifolia*, &c.,) and whose dispersion is scarcely more explicable than that of the foregoing by any existing agencies, serve nearly to bridge over the wide gap which, at first view, appears so markedly to separate these extraordinarily sundered plants from the generality of species.*

3. Species of Western Europe and (chiefly) Eastern North America, not reaching here to high latitudes, and mostly of limited range on one or the other side of the Atlantic. Of this sort are *Myosurus minimus* (in this country remarkably southern, but also far western in range), *Subularia aquatica, Circæa Lutetiana, Betula alba*, var., *Convallaria majalis, Juncus Stygius, Carex flacca, lævigata*, and *fulva, Scolopendrium officinarum*, and *Aspidium Lonchitis*, all much more local in this country than in Europe; and on the other hand, *Potentilla tridentata, Smilacina stellata, Vallisneria spiralis, Spiranthes cernua, Spartina stricta*, and *Eriocaulon septangulare*, all common and for the most part rather widely distributed plants in this country, but very local in Europe. All but four species on this list belong exclusively to the Atlantic border of North America. Cases of this kind are naturally regarded by some as indications of a former terrestrial connection between North America and Europe.

Only three or four of these species of widely sundered stations are maritime, and of these only *Spartina* and the *Salicornia* (if the latter be the same on both sides of the Atlantic, which there is no evidence of) could owe their present dispersion to oceanic currents. The light fruits of *Circæa* are provided with minute hooks; those of *Heracleum* and *Betula* are winged; the spike of

* Out of 49 species belonging to these first and second heads, as many as 10 belong to monotypic genera, and 21 to genera of less than ten good species;—six of the species belong to the vast genus Carex;—on the whole rather militating against the idea that the geographical extension of species bears some proportion to the size of the genus they belong to.

Hordeum jubatum breaks up into short joints, and the persistent glumes and the paleæ enclosing the seed are long-awned. But no others of the 69 phænogamous species above enumerated enjoy peculiar facilities for, or are endowed with any appliances favorable to adventitious transport.

Such cases, accordingly are much relied upon by its advocates in proof of the doctrine of the double or multiple origin of species. Even DeCandolle, who formerly maintained that doctrine, but whose matured opinion favors the idea that species of plants generally originated each in a single birth-place, is still inclined to view such cases as exceptions to the general rule. A fuller investigation will probably do away with this intermediate hypothesis. If the dispersion of other plants generally could be accounted for by existing agencies acting under the present state of things, and if there were really any marked line of difference to be drawn between these and other widely dispersed but less isolated species, the supposition of a double birth-place for the exceptional species would be the most natural; although one would then be inclined to regard them as mostly cases of closely related species whose points of difference are still unascertained or undervalued. For we no more know how nearly alike two species may appear and yet be specifically distinct, than we know how widely they may differ and yet own a common origin. The botanist's best conclusions regarding the limitation of species are seldom more than judgments on imperfect data, constantly liable to be questioned and revised.

But both these most striking cases, and the transitional ones between them and those of ordinary distribution, are becoming too numerous to bear this exceptional mode of explanation. DeCandolle lays much stress upon the isolated occurrence of a single peculiarly United States species, *Phryma leptostachya*, in Nepal. Now the foregoing catalogue includes three or four additional cases of the same kind, which Drs. Hooker and Thomson's Himalayan collections may probably double; and the considerable number of North American species which meet Himalayan ones in Japan already indicates the line of connection between these two distant floras. We should therefore look in one and the same direction for the explanation of these extraordinary no less than of the more ordinary cases of distribution, and, adopting the conclusion to which DeCandolle himself arrives, and maintains on various and convincing grounds,—viz., that plants must have been created at different epochs, and that the greater part of the existing species are older than the present configuration of our continents,—should refer such anomalous distribution to very ancient dispersion; and all the more confidently as the known examples of the kind increase in number.

As the discussion of this most difficult problem proceeds, the two antagonistic positions only seem likely to be tenable;—the one attributing much to changes of station, etc., occurring during a long lapse of time, and the other looking upon the whole actual area of each species as its original home. The supporters of the first view regard each species as having spread from a single and local birth-place, or even, as the more thorough-going (like Dr. Hooker) maintain, from a single individual or pair. The opposing view finds its hardiest and most consistent advocate in Agassiz, who contends, if I rightly apprehend him, that each species probably originated in as many individuals, and covering from the first as large an area as it subsequently possessed.

Of the first-named theory, the only question is whether it will sufficiently explain all the facts of distribution; the second supersedes the necessity of such explanation, by assuming the actual distribution to be essentially the original state. The first theory is based upon the natural idea of species as consisting of kindred individuals descended from a common stock, which, whether demonstrable or not as a fact, gives us a clear and distinct conception of *species*, and the only one we possess. The second theory, being incompatible with this conception, leaves species no objective basis in nature, and seems to make even the ground of their limitation a matter of individual opinion.

The Distribution of our Phænogamous Species, and of the Individuals which represent them, within the limits of our Flora.

The distribution of the materials of our flora over the surface included within its limits, is a subject which I have not room nor time left for discussing with anything of the fullness it deserves. Properly to discuss this and kindred topics would require a great amount of detailed investigation, and would expand these articles into a treatise.

Viewed as to its amount or prominence, the importance of each species as a constituent of our flora depends upon the extent of country it ranges over, and the relative abundance of its individuals. To get some general idea of both points, I have gone over the pages of the *Flora of the Northern United States,* and indicated by peculiar marks, 1, those species which are very local, either absolutely so, or because they barely enter within our borders, however widely they may range beyond them on any side; 2, those of narrow or restricted range within our limits, not extending over more than a tenth or an eighth part of our territory; and 3, wide-spread species, which have been found over nearly the whole length and breadth of our territory. Then, by a different set of marks I have indicated, 1, those species which are very scarce in individuals in their proper habitat; 2, those which are not abundant in individuals; and 3, those which ordinarily are very abundant in individuals wherever they occur. The latter includes our *social plants*, as well as a larger number which could not properly be so called. I should have distinguished the really social plants from the others if I knew how to draw any line between the two. It would be very difficult to fix upon any precise standard of scarcity or abundance: another botanist might give a considerably different estimate; and the same species must vary in abundance in different parts of so large an area. No great accuracy is therefore to be expected in the numbers. The introduced plants are of course left out of view: and the whole following statement may be taken to refer rather to the country in its wild state, than as now gravely modified in its botanical features by the agency of civilized man.

1. *As to the area occupied*, I compute that there are of

	Exogenæ	Endogenæ excl. Glumaceæ.	Cyperaceæ and Gramineæ.	Total.
1. Very local species, - -	228	26	44	298
2. Species of small or narrow range, compared with the extent of country embraced in the Flora, - - - - -	542	92	144	778
3. Species ranging over an area equal to between $\frac{1}{8}$th and $\frac{3}{4}$ths of our territory, i. e. all not included in No. 1, 2 and 4. - -	397	49	92	538
4. Species of widest range over our territory. - -	323	59	95	477

2. *As to the abundance of individuals* where the species occurs:

	Exogenæ.	Endogenæ.	Total.
1. Very scarce, - - - - - -	11	10	21
2. Not abundant, - - - - -	66	20	86
3. Moderately abundant (as far as known), - - - - -	493	47	540
4. Very abundant, - - - -	920	524	1444

To exhibit the distribution according to the genera, or even the natural orders, would require too much room.

In the last table I have not distinguished the Glumaceous from the Non-Glumaceous *Endogenæ*, because, in fact, all our *Gramineæ* and *Cyperaceæ* are abundant in individuals wherever they occur, so that I have thrown in the whole 375 under the fourth head; although probably one quarter of them might be better placed under the third. Of the 20 *Endogenæ* which are not abundant in their habitats, but yet not very scarce, all but four are *Orchidaeceæ*. The 21 scarcest species are

Exogenæ.	*Endogenæ.*
Sibbaldia procumbens.	Limnobium Spongia.
Saxifraga rivularis.	Platanthera rotundifolia.
Nardosmia palmata.	Listera cordata.*
Coreopsis bidentoides (a very obscure plant).	" australis.
Gnaphalium supinum.	" convallarioides.
Nabalus Bootii.	Calypso borealis.
Arctostaphylos alpina.	Tipularia discolor.
Pterospora Andromedea.	Liparis liliifolia.*
Schweinitzia odorata.	" Lœselii.*
Hemianthus micranthemoides (?)	Aplectrum hyemale.*
Obolaria Virginica.*	

Five of the plants in the first column (printed in *italics*) are alpine, and with us peculiarly local, species; and four of the remainder are very local, the two of considerable range being *Pterospora Andromedea* and *Obolaria Virginica.* Of the ten species in the second column all but one are *Orchidaceæ,* and all but one (*Aplectrum*) either very local species or of narrow range. None of the 21 species are known at many stations within our limits; only five of them (marked with an asterisk) have probably been collected at more than half a dozen places; and most of the rest are known at only two or three stations.

And generally, that our species of widest range are most abundant in individuals is shown by the fact, that, of our 477 most widely spread species, 420 (or 96 per cent) are marked as belonging to this category. These are distributed among the natural orders as follows.

Number of Species of each Natural Order which are both of widest Geographical Range in the Northern United States, and most abundant in Individuals where they occur.

Ranunculaceæ,	12	Anacardiaceæ,	5
Berberidaceæ,	1	Vitaceæ,	4
Cabombaceæ,	1	Rhamnaceæ,	1
Nymphæaceæ,	2	Celastraceæ,	1
Papaveraceæ,	1	Aceraceæ,	2
Fumariaceæ,	1	Polygalaceæ,	2
Cruciferæ,	5	Leguminosæ,	14
Violaceæ,	6	Rosaceæ,	20
Cistaceæ,	2	Lythraceæ,	1
Droseraceæ,	1	Onagraceæ,	5
Hypericaceæ,	5	Cucurbitaceæ,	1
Caryophyllaceæ,	4	Crassulaceæ,	1
Tiliaceæ,	1	Saxifragaceæ,	1
Oxalidaceæ,	1	Umbelliferæ,	6
Geraniaceæ,	2	Cornaceæ,	2
Balsaminaceæ,	2	Caprifoliaceæ,	4

Rubiaceæ,	7	Urticaceæ,	6
Compositæ,	57	Plantanaceæ,	1
Lobeliaceæ,	3	Juglandaceæ,	3
Ericaceæ,	6	Cupuliferæ,	7
Aquifoliaceæ,	1	Betulaceæ,	2
Primulaceæ,	2	Salicaceæ,	11
Lentibulaceæ,	1	Coniferæ,	2
Orobanchaceæ,	1		
Scrophulariaceæ,	15	Araceæ,	2
Verbenaceæ,	1	Typhaceæ,	3
Labiatæ,	11	Lemnaceæ,	3
Borraginaceæ,	2	Naiadaceæ,	6
Hydrophyllaceæ,	1	Alismaceæ,	3
Convolvulaceæ,	2	Hydrocharidaceæ,	2
Solanaceæ,	1	Orchidaceæ,	7
Gentianaceæ,	1	Amaryllidaceæ,	1
Apocynaceæ,	2	Iridaceæ,	2
Asclepiadaceæ,	6	Dioscoreaceæ,	1
Oleaceæ,	2	Smilaceæ,	3
Phytolaccaceæ,	1	Liliacæ,	4
Polygonaceæ,	10	Melanthaceæ,	2
Lauraceæ,	1	Juncaceæ,	8
Saururaceæ,	1	Pontederiaceæ,	2
Ceratophyllaceæ,	1	Cyperaceæ,	53
Callitrichaceæ,	1	Gramineæ,	39
Euphorbiaceæ,	3		
Exogenæ,	279,	Endogenæ,	141 = 420

These 420 species must form the most conspicuous elements of our flora taken as a whole; and if there were room to spare, it would be worth while to enumerate them. If we arrange the families they belong to in the order of the number of these common species they respectively contain, the largest ten will stand as follows:—

Compositæ,	57	Leguminosæ,	14
Cyperaceæ,	53	Ranunculaceæ,	12
Gramineæ,	39	Labiatæ,	11
Rosaceæ,	20	Salicaceæ,	11
Scrophulariaceæ,	15	Polygonaceæ,	10

On comparing this with the table on p. 213 of vol. 22, we perceive that the orders hold nearly the same relative rank, except that the *Rosaceæ* and *Leguminosæ* have interchanged places (the former having a much larger number both of wide-spread and of social plants than the latter); that the *Ericaceæ* and *Orchidaceæ* fall to a low position, and that in their stead the *Salicaceæ* and the *Polygonaceæ* are among the largest orders. This is owing to the general absence of *Ericaceæ* in our open or prairie country west of the Alleghanies, and to the small number of *Orchidaceæ* which endure much diversity of climate.

Moreover, seven orders comprise half of these plants; whereas it takes between nine and ten orders to embrace a moiety of all our indigenous species.

The species which I have counted as those of widest range are simply those which are known to occur along or not far distant from our frontiers on the four sides, without reference to the frequency of their occurrence within the area. And the species designated as very abundant in individuals are merely those which occur copiously wherever the species occurs at all, in a congenial station, even if only a single station be known, as is the case with *Sullivantia Ohioensis*, *Calamagrostis Pickeringii*, &c. It might well happen, therefore, that some of the foregoing 420 species of widest range within our territory, and of greatest abundance in their localities, should after all be uncommon plants, on account of the sparseness of the habitats. And on turning over the lists, indeed, I find that they contain species of very various degrees of abundance, above a certain point (which I am unable to express numerically), and of quite various degrees of frequency of occurrence, i. e. of the number and extent of the stations, throughout the country. But so true is it as a general rule, that species of wide range in our country are species of frequent occurrence, that I have not noticed any strongly marked exceptions to it in the lists from which the foregoing statements were deduced, viz., those which are also abundant in individuals,—meaning, of course, of frequent occurrence at the proper stations for each species; for very few plants are sown broad-cast over the land, and few occur under any wide diversity of physical circumstances. I was inclined to draw up a catalogue of those widely-ranging species which are most abundant generally throughout our district, and another of the least abundant. But I find, on trial, that this demands a critical consideration which I have not time to give, as well as a particular knowledge of the details of the vegetation of the different parts of so wide a country, which I am far from possessing. The area is much too large, and the climate, soil, &c., too diversified for the proper elaboration of such a mass of details. I conjecture that about two-thirds of the foregoing 420 species would find a place in a list of the 500 commonest plants of each of the eighteen States within our limits.

It may be mentioned that about 350 of these both wide-spread and abundant species are herbs, 42 are shrubs or woody vines, and 28 may be reckoned as trees. The latter, forming as they do an important feature in the vegetation of a country which was naturally for the most part forest-clad, are here enumerated:—

Tilia Americana.
Acer rubrum.
" dasycarpum.
Prunus Americana.
" Virginiana.
" serotina.
Cratægus coccinea.
" tomentosa.
Amelanchier Canadensis.
Fraxinus Americana.
" viridis.
Sassafras officinale.
Ulmus Americana.
Celtis occidentalis.
Platanus occidentalis.
Carya alba.
" glabra.
" amara.
Quercus obtusiloba.
" alba.
" coccinea.
" rubra.
Carpinus Americana.
Ostrya Virginica.
Salix nigra.
Populus tremuloides.
Pinus mitis.
Juniperus Virginiana.

The foregoing list, after all, includes none of our *most social* forest trees. The latter I should rank in the following order as to sociability:—

Abies nigra and alba.
Abies balsamea and Fraseri.
Thuja occidentalis.
Larix Americana.
Abies Canadensis.
Pinus Strobus.
Pinus Tæda, rigida, and the rest.
Taxodium distichum.
Cupressus thyoides.
Salix nigra.
Populus monilifera and angulata.
Fagus ferruginea.
Fraxinus sambucifolia.
Betula alba.
" papyracea.
Acer saccharinum.
Quercus nigra, obtusiloba, aquatica, &c.

The most social of the larger shrubs, rising occasionally to small trees, are:

Rhododendron maximum.
Kalmia latifolia.
Salix, various species.
Alnus incana and serrulata.
Myrica cerifera.
Quercus ilicifolia.
Rhus typhina, glabra, and venenata.
Amorpha fruticosa.
Zanthoxylum Americanum.
Pyrus Americana.
Cephalanthus occidentalis.
Vaccinium corymbosum.
Clethra alnifolia.
Azalea viscosa, &c.

Characteristics of the Vegetation of the principal Districts comprised in our Flora.

The main botanical districts, into which the territory embraced in our Flora is naturally divided, are three, with two subordinate ones. These are unmistakably defined by the general features of the country, and pretty strongly marked by their vegetation. They are,

1. The Southeastern low border (naturally wooded).
2. The great Middle and Northern Wooded Region.

3. The Western Unwooded or Sparsely wooded Region, characterized by prairies, oak-openings, &c. To which are appended,
4. The Alpine and Subalpine Region, forming a few isolated patches in the second district.
5. The line of Sea-coast, or Maritime District.

I. *The Southeastern District.*—If, from the intersection of the 80th parallel of longitude with the southern boundary of Virginia a line be drawn northeast to Washington and the city of New York, it will very nearly mark the inland limits of this district, except that a narrow prolongation of it, somewhat modified in character, skirts the coast as far as to Cape Ann, and vanishes at the southern point of Maine. The Pine-Barrens of New Jersey represent this district fully. Its prevalent forest-growth consists of Pitch Pines and Oaks, especially of the Spanish Oak, Post Oak, and Black Jack, and in low grounds of Red and White Maples and Birch. Few of the forest trees probably were ever large and stately, at least at the north. The characteristic trees and largest shrubs are *Pinus rigida* and *P. inops*, and at the south *P. Tæda* and *Taxodium distichum*, *Cupressus thuyoides*, *Betula alba* and *nigra*, *Castanea pumila*, *Quercus falcata*, *Phellos*, and *aquatica*, *Ilex opaca* (which at the south passes inland to the flanks of the mountains), *Liquidambar styraciflua*, *Chionanthus Virginica*, *Itea Virginica*, *Clethra alnifolia*, *Azalea viscosa*, *Cratægus parvifolia*, *Acer dasycarpum*, *Magnolia glauca*, and at the south *Persea Carolinensis*, with several southern trees (such as *Quercus virens*, *Olea Americana*, &c.) which however occur only on the coast of Virginia. Other most characteristic shrubs are *Gaylussacia dumosa* and *frondosa*, *Leucothoë racemosa*, and at the south *L. axillaris*, *Andromeda Mariana*, *Ilex* (*Prinos*) *glabra*, *Corema Conradi* and *Comptonia asplenifolia* at the north, and *Myrica cerifera* along the whole line of coast. The two species of *Ascyrum* and *Smilax laurifolia* may also be mentioned.

As to herbs, out of about 120 either wholly peculiar or otherwise characteristic species, I must barely mention *Drosera filiformis*, *Polygala lutea* and *ramosa*, *Clitoria Mariana*, three species of *Rhexia*, *Opuntia vulgaris*, *Eryngium Virginianum*, *Eupatorium leucolepis*, *resinosum*, *album* and *aromaticum*, *Aster Radula*, *surculosus*, *spectabilis*, and especially *A. concolor*, with *Solidago virgata*, *puberula*, and *pilosa*, four species of *Chrysopsis*, *Coreopsis trichosperma*, *Nabalus virgatus*, *Utricularia inflata*, *clandestina*, *striata*, *purpurea* and *resupinata*, *Schwalbea Americana*, *Pyxidanthera barbulata*, *Stylisma Pickeringii*, four species of *Sabbatia*, *Euphorbia Ipecacuanha*, *Gymnadenia flava* and *Platanthera cristata*, *Lachnanthes*, *Lophiola*, *Yucca filamentosa*, *Xerophyllum* and *Helonias bullata*, *Tofieldia pubens*, *Narthecium Americanum*, and *Amphicarpum*, the last two peculiar to the Pine-barrens of New Jersey.

II. *The Middle and Northern Wooded District* takes in the whole breadth of our territory along its northern boundary, but narrows rapidly towards the south into a wedge-like shape. A line drawn from Fond du Lac to the western end of Lake Erie, and thence south to the Tennessee line, would serve tolerably well for its western boundary. This vast tract naturally divides into three provinces, viz: the *Southern*, comprising all south of Pennsylvania and the Ohio River; the *Northeastern*, comprising all north and east of Pennsylvania, and all except the southwestern corner of that state; and the *Northwestern*, including all west of Pennsylvania. With some local and inconsiderable exceptions, this tract was originally covered with dense forest, composed in the higher and cooler or moister portions partly of Spruces, and in the valleys of White Pines, and partly of Beech, Maples and other deciduous trees, or in sandy tracts of Pitch Pines, Post Oaks, &c., and in the lower portions with stronger and deeper soil, of several kinds of Oak, of Hickories, Chestnut, &c.

The most characteristic and important tree of the whole region doubtless is, or rather was, *Pinus Strobus*, the White Pine, which everywhere at the north once filled the principal intervales with a most stately growth. Other prominent forest-trees of the whole district are the White, Red, Scarlet and Chestnut Oaks, the Chestnut, the Beech, three Hickories (*Carya alba*, *glabra* and *amara*), the Butternut, the White and Slippery Elm, the White, Red and Green Ash, the Sugar Maple, and of course the wide-spread Red Maple, as well as the common Lime-tree or Bass-wood; also, as we verge southward or westward, the Tulip-tree and the Cucumber-tree. Trees which belong wholly or characteristically to the southern province are *Abies Fraseri*, *Magnolia Umbrella* and *Fraseri*, *Asimina triloba*, *Tilia heterophylla*, *Negundo*, the Sweet Buckeye, the Common and the Clammy Locust-trees, the Red-bud, the Sorrel-tree, and *Rhododendron maximum;* which last, with *Kalmia latifolia*, rising into small trees in many places, form almost impassable thickets along the steep sides of the Alleghany Mountains. The Ohio Buckeye (*Æsculus glabra*), the Kentucky Coffee-tree, the Honey Locust, the American Crab-apple, the Black Walnut and *Carya sulcuta* are characteristic of the western province. *Pinus resinosa*, *Abies balsamea*, *Canadensis*, *nigra* and *alba*, *Larix Americana*, *Thuja occidentalis*, with *Betula papyracea*, *excelsa* and *lenta*, *Quercus palustris*, the Black Ash, and among small trees, *Pyrus Americana*, *Prunus Pennsylvanica*, *Acer Pennsylvanicum*, and *Rhus typhina*, are characteristic northern species. I must not stop to enumerate the characteristic shrubby and herbaceous plants.

III. *The Western District*, comprised between the boundary last mentioned and the Mississippi River, consists of glades, 'Oak-openings,' 'barrens,' and at length of prairies or open plains. Its trees, where these occur, are principally some of those of the foregoing districts, especially *Quercus nigra, imbricaria, rubra* and *obtusiloba* with *Q. macrocarpa, Carya olivæformis,* and along rivers the Cotton-wood, Blue Ash, &c. I can hardly enumerate any peculiar shrubs of the district, excepting *Amorpha canescens,* which is local this side of the Mississippi. The characteristic herbs of the prairies, &c., would seem to be *Compositæ,* especially Helianthoid Compositæ, such as *Helianthus rigidus, lætiflorus, occidentalis, mollis, hirsutus,* and in the river bottoms *H. doronicoides, Actinomeris helianthoides, Coreopsis aristosa* and *palmata, Echinacea purpurea* and *angustifolia,* and especially *Silphium laciniatum* (the Compass plant), *terebinthinaceum, integrifolium,* &c.; to which may be added *Cacalia tuberosa, Nabalus racemosa, asper* and *crepidineus, Ambrosia bidentata* and *psilostachya, Veronica fasciculata, Liatris pycnostachya, Eupatorium serotinum, Solidago Ohioensis, Riddellii,* and *Missouriensis, Aster oblongifolius, azureus, turbinellus,* and *sericeus.* As herbs peculiar to this district and its immediate borders, I may mention *Isopyrum biternatum, Delphinium tricorne, Stylophorum diphyllum, Hypericum sphærocarpum* and *dolabriforme, Psoralea Onobrychis* and *stipulata, Gillenia stipulacea, Geum vernum, Gaura filipes, Ludwigia polycarpa, Erigenia bulbosa, Solidago Shortii* and *rupestris, Monarda Bradburiana, Seymeria macrophylla, Lithospermum latifolium, Phlox bifida, Gentiana puberula, Platanthera leucophæa, Cypripedium candidum, Trillium recurvatum* and *nivale.* The only Grasses I know which are peculiar to the district, and not found east of the Alleghanies, are *Poa sylvestris, Diarrhena Americana,*—neither of them prairie-grasses,—and *Lepturus paniculatus,* which mainly belongs to salt-licks and to the dry plains farther west.

In fact,—looking at North American botany comprehensively,—this district cannot claim to be distinguished as a separate one. It is only a broad border along which the great naked plains of the west and the eastern forest region meet and blend through the most diversified gradations. And so, likewise our south-eastern district is only a narrow extension of the botany of the warm-temperate region of the Southern United States, prolonged northward upon the low coast, just as the botany of our cool-temperate region is prolonged southward along the Alleghanies.

IV. *The Alpine and Subalpine District* has been sufficiently illustrated already (vol. 22, pp. 207, 230, vol. 23, p. 62).

V. *The Maritime District* is inhabited by the following 60 species.

Ranunculus Cymbalaria.
Cakile Americana.
Hudsonia tomentosa.
Lechea thymifolia.
Honkenya peploides.
*Spergularia rubra.
Sesuvium Portulacastrum.
*Hibiscus Moscheutos.

Lathyrus maritimus.
*Prunus maritima.
Crantzia lineata.
Ligusticum Scoticum.
Archangelica peregrina.
*Aster flexuosus.
* " linifolius.
*Solidago sempervirens.
Pluchea camphorata.
Baccharis halimifolia.
*Iva frutescens.
Borrichia frutescens.
Plantago maritima.
*Statice Limonium.
Glaux maritima.
Limosella aquatica.
Gerardia maritima.
Mertensia maritima.
Sabbatia calycosa.
" stellaris.
" gracilis.
" chloroides.
Blitum maritimum.
*Atriplex hastata.
*Obione arenaria.
*Salicornia herbacea.
Salicornia mucronata.
" ambigua.
*Chenopodina maritima.
*Salsola Kali.
Euxolus pumilus.
*Acnida cannabina.
*Rumex maritimus.
*Euphorbia polygonifolia.
*Zostera marina.
*Ruppia maritima.
Triglochin palustre.
" maritimum.
Juncus maritimus.
" bulbosus.
Scirpus Olneyi.
* " maritimus.
Vilfa Virginica.
Calamagrostis arenaria.
Spartina polystachya.
* " juncea.
* " stricta.
Glyceria maritima.
" distans.
*Brizopyrum spicatum.
Uniola paniculata.
*Hordeum jubatum.

A little less than half of these maritime species occur also in Europe; and one not found in Europe (*Ranunculus Cymbalaria*) occurs in Northern Asia. Four of them are exclusively southern, not extending northward to the Delaware Bay; viz. *Borrichia frutescens*, *Sabbatia calycosa*, *Vilfa Virginica*, and *Uniola paniculata*, and nine others (including *Juncus maritimus*) are prevailingly southern, and find their boreal limit south of Massachusetts Bay. Four species (*Ligusticum Scoticum*, *Archangelica peregrina*, *Glaux maritima*, and *Mertensia maritima*) are exclusively northern, not occurring south of New England; and 23 species (those with an asterisk prefixed) range along the coast from Maine to Virginia, or nearly so. Several maritime species still linger on the shores of our Great Lakes, mementoes of their former saltness, viz. *Hudsonia tomentosa*, *Cakile Americana*, *Lathyrus maritimus*, *Calamagrostis arenaria*, and *Hordeum jubatum;* while *Ranunculus Cymbalaria*, *Glaux maritima*, &c. occur in saline soil far beyond the Mississippi, and the former, with *Hibiscus Moscheutos*, *Salicornia herbacea*, *Scirpus maritimus*, and the two species of *Triglochin*, spring up at most of our salt springs in the interior of the country, as at Salina, New York. Singularly enough, what seems to be truly *Triglochin maritimum* (the *T. elatum* of Nuttall) is of no uncommon occurrence throughout Western New

York, Ohio, Wisconsin, &c., in high sphagnous bogs which have not the least trace of saltness.

Only one of our maritime plants is a true shrub, viz. *Baccharis halimifolia*. *Iva frutescens* is more or less woody; and *Hudsonia tomentosa* is a heath-like under-shrub: the rest are herbs.

On the whole, I should say that the range of our maritime plants through degrees of latitude is not sensibly greater than that of our herbaceous species generally.

The Prominent Characteristics of the Flora of the Northern United States.

To answer the question as to what are the leading characteristics of the vegetation of the Northern United States, taken as a whole, we should have to consider, first: What are the more remarkable peculiarities of our flora, as discovered by the instructed botanist with the whole field systematically displayed to his mental view; and secondly, what are the plants or the forms of vegetation which, by their abundance or their prominence, impart to our flora its dominant features. The first is a matter of deduction from a variety of facts, many of which would never arrest the attention of the casual observer: the second relates to points which would most attract the notice of the passing botanical traveller or the ordinary observer. The answer to the former no less than to the latter enquiry, would depend upon the point of view. To the traveller from our Southern States, or from the great plains of the West, the novel features of our vegetation are those which it has in common with Europe. To the European visitor the striking peculiarities are those which we share with the southern part of the country, and these would increase in prominence as he proceeded southward and westward. And, in forming his idea of a flora, the botanist naturally, if not inevitably, takes that of Europe as his standard of comparison.

In comparing, as the botanist naturally would, our flora with that of Northern and Western Europe, the following would appear to be leading characteristices.

1. Our comparative richness in ordinal types;—our flora having, as already remarked (vol. xxii, p. 216), 26 orders which are absent from that of Europe, while the latter (exclusive of the Mediterranean basin) has only seven orders which are wanting here.

2. The prevalent subtropical character of our extra-European orders;—which has been already referred to, and which will be manifest to the botanist inspecting the list of such orders given in a former article (vol. xxii, p. 215).

3. Our richness in species of woody plants, and especially of trees; as already alluded to (p. 84). This will strikingly appear

from a comparison of our flora with an equivalent European one,—with the German flora, for example. In Koch's *Flora Germanica* (excluding the Adriatic region), I count 60 indigenous species of trees, belonging to 27 genera, and comprised in 14 orders. In our own *Flora of the Northern United States*, adopting the same estimate as to what constitutes a tree, I count 132 trees, in 56 genera, and belonging to 25 orders; as follows:—

Magnoliaceæ,	2	genera,	and	6	species	of	trees.
Anonaceæ,	1	"	"	1	"		"
Tiliaceæ,	1	"	"	2	"		"
Camelliaceæ,	1	"	"	1	"		"
Anacardiaceæ,	1	"	"	1	"		"
Sapindaceæ,	3	"	"	8	"		"
Leguminosæ,	6	"	"	7	"		"
Rosaceæ,	4	"	"	15	"		"
Hamamelaceæ,	1	"	"	1	"		"
Araliaceæ,	1	"	"	1	"		"
Cornaceæ,	2	"	"	4	"		"
Caprifoliaceæ,	1	"	"	1	"		"
Ericaceæ,	2	"	"	2	"		"
Aquifoliaceæ,	1	"	"	1	"		"
Ebenaceæ,	1	"	"	1	"		"
Sapotaceæ,	1	"	"	2	"		"
Oleaceæ,	3	"	"	8	"		"
Lauraceæ,	2	"	"	2	"		"
Urticaceæ,	4	"	"	8	"		"
Platanaceæ,	1	"	"	1	"		"
Juglandaceæ,	2	"	"	9	"		"
Cupuliferæ,	5	"	"	21	"		"
Betulaceæ,	1	"	"	5	"		"
Salicaceæ,	2	"	"	7	"		"
Coniferæ,	7	"	"	18	"		"

The only natural order containing trees in the German flora and not in ours is the *Rhamnaceæ;* the only order in which the German flora exceeds ours in arboreous genera is that of *Betulaceæ* (which comes from our not counting any of our Alders as trees); the only order in which the German flora has more species of trees than ours is that of the *Salicaceæ* (10 to 7), we counting but one truly arboreous indigenous Willow. On the other hand, our flora surpasses the German not only in the twelve additional orders (one of which is represented by nine species and another by six), but also having a greater number of species in ten out of the thirteen orders common to the two countries, and of genera likewise in all but three of them. That is, we possess of

Sapindaceæ (including Hippocastanaceæ and Aceraceæ),	2	more	genera	and	3	more	species	of trees.
Leguminosæ,	5	"	"	"	6	"	"	"
Rosaceæ,	0	"	"	"	2	"	"	"

Cornaceæ,	1	more	genus	and	3	more	species	of trees.
Ericaceæ,	1	"	"	"	1	"	"	"
Oleaceæ,	2	"	"	"	6	"	"	"
Urticaceæ,	2	"	"	"	5	"	"	"
Cupuliferæ,	0	"	"	"	11	"	"	"
Betulaceæ,	0 (—1)		"	"	3	"	"	"
Coniferæ,	3		"	"	10	"	"	"

4. Our flora, it may be seen, accordingly predominates in its species of Pine, Fir, Oak, Birch, Elm, Ash, arboreous as well as shrubby *Cornaceæ, Cratægi*, and of arboreous *Leguminosæ;* and its characteristic trees are the *Taxodium*, the Overcup, Willow and Chestnut-Oaks, the Hickories and Walnuts, the Planer-tree and two *Sapotaceæ*, which barely reach us from the South, the Persimmon, the Gum-trees (both *Nyssa* and *Liquidambar*), the Common and Honey Locusts, *Cladrastis*, and the Kentucky Coffee-tree, the Negundo and three species of Buckeye, the Sumac, the Loblolly Bay of our southeastern border, the Papaw-tree, the Tulip-tree, and our five species of Magnolia. We might have added *Zanthoxylum*, but no Prickly Ash fairly forms a tree within our geographical limits.

5. Our flora is equally rich in shrubs, of a great variety of families, especially in those which make an undergrowth in forests; and, among them, in *Vaccineæ, Andromedeæ* and *Rhodoreæ*, while it has no *Arbuteæ* rising above the surface of the ground, and no *Ericeæ* or Heaths at all.

6. It is also rich in *Compositæ*, especially Helianthoid *Compositæ, Eupatorinæ*, Asters, and Solidagoes, in the latter genera outnumbering any other region; but is poor in *Anthemideæ*, true *Senecioneæ*, and in *Cynareæ*, and especially so in *Cichoraceæ*.

7. It has an unusual number of *Cyperaceæ*, which is owing partly to the remarkable number of extra-European genera, and partly to the number of species of *Cyperus, Rhynchospora*, and *Carex*.

8. From the position of *Rosaceæ* on the list of the larger orders, our flora would be supposed to be unusually rich in that order also; but this result happens in consequence of our remarkable comparative poverty in *Cruciferæ, Umbelliferæ, Labiatæ*, and *Caryophyllaceæ*. Other orders in which our flora is much deficient, as compared with Europe, are *Borraginaceæ, Campanulaceæ, Liliceæ* in the larger sense, and *Iridaceæ, Crassulaceæ, Chenopodiaceæ, Primulaceæ*, and *Geraniaceæ*. Those in which we are correspondingly rich are *Asclepiadaceæ, Polemoniaceæ, Smilaceæ, Melanthaceæ, Araliaceæ*, and *Onagraceæ*.

9. To present the elements of the 26 orders represented in our flora but wanting in that of Europe, and in which characteristic features are necessarily comprised, would still further extend

an article already inconveniently protracted. The botanist can readily gather the needful details respecting them, and respecting our extra-European genera generally, from the data given in a former article.

As regards the plants most striking and important in the physiognomy of our vegetation, the first rank is undoubtedly held by the trees of social growth; and of these the principal are *Coniferæ*. The characteristic tree of the proper Northern States is, therefore, *Pinus Strobus*. This, the tallest and once the most plentiful of our trees, when the country lay in all the wildness of nature, must have given the dominant feature to a great part of the landscape. White Pines may probably be distinguished by their port and aspect from a greater distance than any other of our forest-trees, except perhaps the *Taxodium* of our Southern "Cypress" swamps, and the long-leaved Pine which so strikingly marks a belt of low and barren country stretching from the southeastern borders of Virginia to the Gulf of Mexico and the Mississippi.

Pinus Tæda near our southern limits, and, more northward, *P. rigida* and the other Pitch Pines, give a predominant feature to the "pine-barrens" of the Northern States.

Our Arbor Vitæ (*Thuja occidentalis*) of intensely social growth, is the physiognomic tree of our cold swamps at the North, and of Canada. Large tracts of cold and poor marshy land at the north, and on the mountains, are occupied with the well-marked Balsam Fir, or, where less damp, with the more sombre and stiff Black Spruce, or, with the closely related White Spruce; the latter, however, only along our northern frontier. *Abies Fraseri* replaces the common Balsam Fir in the Alleghanies south of Pennsylvania, and has just the same aspect. Hemlock Spruce woods (*Abies Canadensis*) cover hill-sides and sharp ridges of a light and thin soil, where water never stands, throughout the northern part of the country, with a truly characteristic forest-growth. Larch or "Tamarack" swamps are strongly marked in aspect, but are never large.

No other species of forest trees that I know monopolize the ground in so marked a manner, and impress their single features upon a tract of country. The Beech woods of elevated tracts, and the Sugar Maple in richer and lower ground, make the nearest approach to it: but ordinarily our woods of deciduous trees consist of a mixture of several species, in which different kinds predominate according to the situation. In enumerating, as I have done farther back, the trees most characteristic of our three principal districts, I have mentioned those which more than any other give character to our arboreous vegetation. As trees which possess marked individuality, and which may be known from far, I barely mention the common American Elm of our intervales, the Button-wood or *Platanus* on the banks of rivers and streams, the Sugar Maple, the various Hickories, the Black Walnut, and several Oaks, the White and the Paper Birch, conspicuous from the ghastly white bark of their trunks, as well as by their light and handsome foliage, the Sassafras, the Cucumber-tree, the Tulip-tree, the Honey Locust with its remarkably light and feathery foliage, and the *Gymnocladus* or Kentucky Coffee-tree, with its thick and stout branchlets, and its remarkably decompound foliage, rendered the more striking in aspect by the oblique or almost vertical position which the leaflets generally assume.

Of trees conspicuous in blossom, *Cornus Florida*, the two Umbrella-leaved Magnolias, the Locust, the *Cladrastis*, the Red-Bud, and the Crab-Apple hold the first place, and the Umbrella-trees with their rose-colored cones are equally conspicuous in fruit. The Loblolly-Bay, *Rhododendron maximum*, and the *Chionanthus* or Fringe-tree are equally showy, but they are generally shrubs rather than trees.

Considering our great variety of trees and shrubs, there is a remarkable absence of broad-leaved evergreens. The American Holly is our only tree of the sort of considerable size, and that is not a common one. Of large shrubs or small trees, *Rhododendron maximum* and *Kalmia latifolia*—our "Laurels,"—are our principal and truly characteristic evergreens, as they are among the most social of our woody plants.

The herbaceous plants which most strike the eye are of course the *Compositæ*, especially toward the close of summer, when golden Solidagoes and purple, blue, and white Asters are everywhere conspicuous. Of vernal flowers,—peculiarly delightful to us after a winter which destroys all herbaceous vegetation,—the most common species which strike the eye over the whole country (in their appropriate stations) are *Caltha palustris, Aquilegia Canadensis, Anemone nemorosa,* with *Thalictrum anemonoides, Sanguinaria Canadensis, Saxifraga Virginiensis, Viola cucullata, sagittata* or one or two other stemless Violets, *Claytonia,* one or the other species, *Oldenlandia* (*Houstonia*) *cærulea, Senecio aurens, Smilacina bifolia, Erythronium Americanum, Uvularia sessilifolia,* and, a little later, *Geranium maculatum.*

The part which introduced plants take in our flora, with some kindred topics, must be considered in a future article.

ART. XXXVIII.—*On the Meridian Instruments of the Dudley Observatory;* by Dr. B. A. GOULD, of Cambridge.

Proceedings of the American Association for the Advancement of Science at Albany, July, 1856.

Mr. GOULD described the meridian-circle and transit-instrument, now nearly completed for the Dudley Observatory, and gave some account of the principles adopted in their construction.

The meridian instruments now in use in the several observatories of the world may be classified in two divisions,—which may be designated as the German and the English styles,—and perhaps be justly described, the one as the instrument of the engineer, the other as that of the artist. For the former the circles are large and massive, frequently having a diameter equal to the entire focal length of the attached telescope; in the latter they are smaller and slighter. The new transit-circle of Professor Airy, at Greenwich, typifies the English style, and this instrument, with its counterpart at the Cape of Good Hope, presents the merits in the most conspicuous and impressive form. It is of iron, cast in a single piece; incapable of reversal, for which the observation of collimators is substituted; without a striding or hanging level, this apparatus being superseded by observations of the meridian thread as reflected from the surface of mercury; the circle is eight feet in diameter, and read by diverging microscopes firmly imbedded in a massive pier; and the pivot-forms are investigated by means of a collimating apparatus, of which the axis of rotation itself forms a part.

The instruments of the German school are of an entirely different order,—lighter and more mobile. Their circles are small in comparison with the length of the tube; the microscopes are supported upon a frame concentric with the axis, and form one system, the position of which is known by means of an attached level, whose indications furnish a correction to be applied to the mean of their several readings. The level is used, indeed, whenever its use is possible, and a great part of the precision of the results of observation is dependent upon the delicacy with which this highly trusted instrument may be constructed and used. Frequent reversals of the instrument are deemed indispensable; and in general the structure is devised with a view to easy, rapid and frequent changes in the relative position of all those parts which may be rendered movable. To sum up,—the one class of instruments is designed for securing absolute uniformity of circumstances in all observations; the other, for attaining as great diversity of circumstance as is consistent with the retaining of the same degree of accuracy.

The meridian-circle for the Dudley Observatory has been ordered of Messrs. Pistor and Martins, of Berlin, and in its form and the fundamental principles adopted, my aim has been to avoid the prejudices of education and the prepossessions of taste, and if possible to exercise an eclectic judgment, using however the greatest care to shun such a composite form as would impair the unity of idea, and fail of the preponderant merit which both the English and the German forms may claim, in being consistent developments of their fundamental idea.

All this seemed not impossible; nor indeed did it appear beyond attainment to combine, with such an eclectic form, sundry new and by no means unimportant additions. This has been the endeavor, and it remains to be seen how sound may have been the foundation for these hopes and expectations.

The object-glass is from material furnished by Messrs. Chance Brothers, of Birmingham, and made under the supervision of Mr. Masselin. It was my earnest desire that it might be ground and worked into form by some one of our own accomplished artists, but the Berlin mechanicians were unwilling to entertain any proposition of the kind,—desiring to take the whole responsibility, if any,—and were so strenuous that I refrained from pressing the matter. The clear aperture is ninety French lines; the focal length, ten English feet.

Both circles are divided, and capable of rotation round the axis, and they are read by means of four microscopes firmly set in each pier,—horizontal, not converging, although the divided silver limb is slightly oblique to prevent the dazzling image of the lamp from blinding the observer's eye. The piers being two feet in thickness, and the microscopes read from the outer side, these microscopes are not far from twenty-five inches in length, —a circumstance which gives rise to various not unimportant disadvantages; but the ingenuity and skill of Mr. Martins have surmounted the chief of these, the large amount of expansion and contraction of the metal due to changes of temperature, with great succes, by leaving the metal tubes free to extend or recede without hindrance, and without affecting either the distance of the lenses or their fixity in the stone.

To obviate the chief disadvantages of attaching the microscopes to the piers, namely, those arising from the unequal changes in the piers themselves, these will be coated with oil, or some other preparation for excluding moisture, wound around with list or baize, and then encased in wood. With these precautions, I am very confident that we are justified in awaiting from this more massive construction greater advantages than would be derived from the metallic connection of the microscopes, although continually subjected to scrutiny by means of the attached ether-level.

The circles are three feet in diameter, and entirely protected on the outer side by the piers. They are of the form which long experience has recommended to Messrs. Pistor and Martins as the best,—not too heavy at the rim, and with radial arms thickening in both dimensions towards the centre. The screen-tubes for the microscopes draw back automatically as soon as the counterpoises are relieved of a portion of their burden, and it is thus possible to have them very close to the circles, when in use, without incurring any danger of injuring the graduation when the instrument is lifted for reversal.

The eye-piece has a vertical as well as a horizontal motion; and the diaphragm, which is of course adapted for chronographic observation, is provided with both a horizontal and a vertical micrometer,—the former being especially intended for the observation of polar stars, according to the method recently adopted in the Paris Observatory, and which Professor Bache had investigated in 1849.

The method of Hansen for measuring and eliminating the effect of flexure comes from authority too high, and commends itself too strongly, to justify us in lightly setting it aside. But advantages entirely incompatible with its employment presented themselves in such number as to induce me to accede to the earnest recommendation of the artist, and abandon the original plan of interchangeable eye-piece and object-glass. Some of the decisive arguments, briefly expressed, are the following. It is only when the most absolute symmetry has been attained in every part of the tube and its accessory parts, that the flexure is absolutely determined in this manner; otherwise, we obtain the measure of an ideal, not a real, flexure. Furthermore, not only is the formula which attributes the maximum flexure to the horizontal position, and makes the flexure in other positions a simple function of the altitude, not trustworthy, but I will not hesitate to go farther, and, paradoxical as it may appear, to express my decided conviction, that the flexure is not necessarily a maximum for the horizon or minimum for the nadir and zenith, and that in almost every existing instrument, if not all, the flexure is unequal for the same altitude upon different sides of the vertical. The interchange of object-glass and eye-pieces presupposes either the absence of unsymmetrical parts within the tube, such as the apparatus for illumination and the shafts by which we regulate the amount of light admitted, or the disconnection of these from their gearing or screw-heads. Indeed, nothing like the former can be reasonably demanded,—a sacrifice which seems disproportionate to the end to be attained. Moreover, the new meridian-circle is equipped with more than a usual amount of internal mechanism, although the arrangement and support of this latter has been planned with an especial view to the avoidance of any prejudical effect arising from unsymmetric distribution of weight. The measurement of flexure may take place without disturbing the adjustments or parts of the instrument, by some apparatus analogous to the neat and practical contrivance of Professor Challis, who arranges a pair of collimators in such a manner that they are used in connection with each other at any desired angle of altitude. Moreover, the reversal of the instrument admits of a scrutiny and check upon the determinations, which provides all needful safeguard against erroneous results.

The circles are divided to 2′, and read by microscope to 0″·1. The unit's place of the degree is always visible within the field of the microscope, and the decades of degrees are engraved upon the rim of the circle. The finders read to 10′, and by vernier to 1′.

The axis is turned within as well as without, a precaution upon which I also insisted with regard to the tube. The cube measures thirteen inches and a half on each side, and the pivots are two inches in diameter. The difficulty of obtaining a satisfactory and suitably homogeneous piece of iron for the axis may be estimated from the circumstance that even in Berlin, justly renowned as is that city for knowledge and skill in everything pertaining to the founding of iron, three successive castings had to be rejected before a satisfactory piece could be obtained; and even then it became necessary to deviate from the original plan, not, however, as I trust, to the disadvantage of the instrument. The weight of the axis is about 350 pounds.

The illumination is entirely by gas, the light designed for the illumination of the field entering by one pivot, and that for the threads by the other. Arrangements are made for illuminating with lights of different colors, and for observing, when occasion requires, with bright threads upon a bright field. The levels are boxed, provided with air-chambers, and read from end to end, not from the middle outwards.

In fine, it has been my endeavor to incorporate in the design of this instrument the principle,—never before attained, so far as I am aware,—that every instrumental correction, without exception, should be capable of determination by two entirely distinct and independent methods; and in this respect also to combine the advantages of the German and the English forms. And I may claim for the new instrument that its errors of graduation, its errors of flexure, collimation, level, azimuth and nadir-point, may all be determined by two separate processes, free from any dependence, direct or indirect, upon each other. And whatever may be its errors of construction or of mounting, there is no fear that they will escape detection and accurate measurement. So earnest has been my desire to lose none of the advantages on either side of questions upon which experienced astronomers differ in opinion, that no point of detail has been deemed too minute for the application of this idea of duality, and I have even requested the artists to provide one set of microscopes with crosses, after the fashion of Troughton, and the other with close parallel threads, according to the custom of Repsold and the almost universal usage of the German mechanicians.

If this eclectic spirit shall prove to have been successful in attaining its ends without the sacrifice of unity, of artistic or theoretic elegance, of convenience, or of any scientific advantage, the care and labor bestowed upon the decision of the principles which should rule its design will be more than rewarded. But here, as in all instruments of a high order, it is the mechanical artist to whom most of the success is due, and to whose refined delicacy of judgment, taste, and skill we owe the chief advances of modern astronomy. Bessel once said that he could determine the place of a star with a musket-barrel and a cart-wheel. Few things were impossible to Bessel, but you will agree with me that at any rate even a Bessel would with such appliances hardly have determined so large a number of precise star-positions as, thanks to the genius of Fraunhofer, Reichenbach and Repsold, are contained in those noble Königsberg volumes, and are sufficient to render the names of the artist and the astronomer alike immortal.

It is my privilege, on this occasion, to become the organ of the Trustees of the Observatory in announcing that, at the instigation of the Scientific Council, they have given to the new meridian-circle which I have been describing,—which, in the grandeur of its dimensions, is rivaled only by the renowned and gigantic transit-circle of the Royal Observatory at Greenwich, and which, as we are trusting, may prove to be a forward step in instrumental astronomy,—a name which will render the exquisite instrument still more a source of pride to Albany and to the Dudley Observatory,—a name full of associations of disinterested and unassuming liberality, of generous public spirit,—the name of a man who knows no guile, a citizen of large, expanded mind and heart, whose efforts have, under the blessing of a favoring Providence, resulted in an affluence by which all around him are made happy, and without whose constant effort, protecting care, and wise counsel, neither this instrument, nor the Observatory for which it is designed, would ever have existed. The Trustees have authorized me to announce, that, in token of their respect for Thomas W. Olcott, of Albany, the instrument will be known as the OLCOTT Meridian-Circle, and that the name is already engraved upon the telescope at Berlin.

The transit-instrument is similar to the meridian-circle, so far as the latter is an instrument for the measurement of right ascension. It is the property of the Coast Survey of the United States, whose enlightened chief has authorized its employment at the Dudley Observatory for the present. The object-glass has a clear aperture of 72 French lines, and a focal length of 8 feet.

In both these instruments the Ys are so constructed that the level-arm may rest upon that part of the pivot which supports the instrument.

ART. XXXIX.—*On two Sulphurets of Copper from the Canton (Ga.) Mine;* by N. A. PRATT, Jr.

THE discovery in a new mineral locality of two beautifully crystallized sulphurets of copper, identical in composition with copper glance and covelline, the latter of which has never before been found in this country, and indeed in very few localities in the world, is a very interesting fact; but when these minerals are found intimately associated, while at the same time their crystallographic characters differ so widely from the above-mentioned species, and especially as they present a form in which they have never before been observed, they assume a mineralogical importance which demands an investigation of the conditions and manner of their occurrence.

The geological position and character of this mine, as well as the unusual variety of minerals occurring here, have been made the subject of a special and very flattering report by Prof. C. U. Shepard, but so few probably will ever see that report, that a brief outline of the formation will here be given, with only such facts as bear directly on the origin and crystallization of these ores.

The metalliferous rocks are confined to one of many alternations of metamorphic schistose strata, in which hornblendic and mica schists predominate. This 'mica slate' overlying a chloritic slate on the north, and underlying a talcose slate on the south, is itself slightly talcose and at different depths from five to ten feet wide. This whole series trends N. 65° E., and dips to the southeast at an angle varying from 60° to 80°. Whether they are altered beds of the Lower Silurian, such as those of Southeast Tennessee, and known as metamorphic Palæozoic, or belong to the Azoic series, limited investigation has not certainly decided. I think, however, on account of their distance from the Silurian of the State, and the character and uniformly high inclination of the intervening strata, that they will ultimately be found to belong to the Azoic. This, however, is by no means certain, and the subject acquires additional interest from the fact that these strata are contemporaneous with the great auriferous belt of the State, and gold is found in the neighboring strata both north and south.

The course of the metalliferous stratum, "the vein," is plainly marked on the surface, by the decomposed ferruginous character of the outcropping rocks. Crystals of staurotide of the thickness of a small needle and from $\frac{1}{8}$th to $\frac{1}{4}$th inch in length, similar to those which so abundantly accompany the ores below though somewhat decomposed, are found imbedded in these rocks, clearly indicating their existence prior to the decomposing action of water on the mineral contents of the vein. At 60 feet, the first traces of copper are found in the form of 'black oxyd,' which evidently contains the sulphuret; and at 96 feet this sulphuret with red oxyd and malachite has materially increased in quantity. These with the abundant existence of the hydrous protoxyd of iron indicate the very general action of oxygen and carbonic acid at this level. The first traces of galena are here found in the tunnel contiguous to the chloritic slate of the north wall; this, as will be seen below, seems to be the normal position of this mineral in the vein. Native copper in small sprigs is also found attached to the very quartzose veinstone.

At 116 feet, near the shaft, all signs of decomposition disappear. The siliceous mica slate, containing segregated masses of pure white quartz, fills the vein. Farther east, iron pyrites in cubes and imperfectly formed octahedrons, forms continuous masses, probably lenticular in shape, six inches to two feet in thickness. They lie nearly parallel to the walls, but are devoid of all signs of stratification. Galena and blende are disseminated through these, filling the interspaces of the crystals of pyrites and apparently acting as a cement to keep them together. In no case have I seen the galena in this connection at all well crystallized but always of a fine granular structure. The ordinary veinstone, a quartzy mica slate, intervenes between these masses, forming two, three, or four alternations according to their own thickness, and the width of the vein. But at 25 or 30 yards from the shaft to the east, the peroxyd of iron shows that at this point the decomposition has extended to greater depths than elsewhere. As the tunnel passes on, the roof presents a series of reddish-brown and white "flucanny" layers, evidently the decomposed continuations of the alternations above mentioned, which with these successive repetitions, taken in connection with the water, which with its salts of copper and iron in solution, is known to have trickled through them, suggests the idea of a huge voltaic pile, the galvano-chemical action of which may have exerted much influence on their own decomposition and the crystallization of the sulphurets in the immediate vicinity. The relative position of these sulphurets and the rocks with which they lie in contact is important as bearing directly on the formation of the former, as will be noticed in the sequel. The lower limit of decomposition, clearly defined and well marked both by the total disappearance of the peroxyd, and the restoration of the mica schist in its nornal condition, does not descend vertically in the plane of the vein, but takes a downward and easterly course pitching, within the walls of the vein, at an angle of 45°. (In this general direction a winze has been sunk, intersecting the 145 ft. level and communicating with the 200 ft. level below.) Here just at this lower limit of the decomposed area, reminding one, by its position, of the occurrence of the black oxyd, in the famous Ducktown mines, first occur the two sulphurets of copper, which are the subject of this paper. They first appear as a 'string' near but not immediately on the north wall, which while pitching at an angle of 45° to the east, rapidly enlarges to a fine 'bunch' of ore from 14 to 18 inches thick, which now occupies the central part of the metalliferous stratum. The minerals are however generally disseminated in the neighborhood of the 'bunch,' through the body of the vein, which is here 4 or 5 ft. wide, and are co-extensive downward, with the decomposition of the rocks. Solid masses of the ores of 40 and 50 pounds have been taken from the bunch. The latter however contained quartz.

The relative proportion of these minerals (which were at first confounded) varies. The most abundant is identical in its physical properties and composition with copper-glance, while its crystalline structure is that of galena, and on this account it has been made a new species, named 'Harrisite.' It occurs crystallized in considerable masses in contact on one side with the undecomposed veinstone, a quartzy mica slate, and is associated with massive white quartz and staurotide in slender reddish crystals from $\frac{1}{8}$th to $\frac{1}{4}$th inch in length. It also impregnates and gives a dark grey color to masses of granular quartz and staurotide, intimately mixed. Even when crystallized it is sometimes so closely associated with massive erubescite (variegated copper) that the two species cannot be separated. Fine crystals of quartz are found bedding their pyramidal terminations in the mass of the sulphuret. Faces of several quartz crystals sometimes meet at an angle, and the mineral appears wedged in between them, in one case I extracted an almost perfect tetrahedron, the faces formed partly by the crystalline faces of the quartz and partly by the natural cleavage of the ore, which is still eminently monometric.

Intimately associated with this is another new mineral also a sulphuret of copper (CuS) corresponding in its formula with the protoxyd (CuO). A careful analysis of this gave:

Copper 66·205, sulphur 33·490, impurities ·305 = 100.

The impurities consist of silver and staurotide, it being impossible to find a crystal of the sulphuret which does not contain small but perfect crystals of this mineral. Hardness 1·5–2. Specific gravity 4·18, mean of three determinations. Lustre submetallic, shining. Color and streak, blue-black. Thus in physical properties (except streak) and composition it is identical with 'covelline; but while covelline is hexagonal this is monometric and exactly similar to Harrisite and galena. It is also found impalpable. For this mineral I have proposed the name "Cantonite," from the locality. It is found in the greatest quantity and in the largest crystals in contact with much decomposed ferruginous quartz, and in an impalpable state is disseminated through a veinstone of granular quartz and staurotide, in which the latter seems to have replaced the mica of the ordinary veinstone which still retains its imperfectly stratified structure. Iron pyrites, variegated copper and staurotide are frequently bedded in pure Cantonite. It is also found finely crystallized in extremely well formed cubes diffused through large masses of rock made up of small cubic pyrites. It often encrusts the cubes in such a manner as to have the appearance of fine blue cubic Cantonite. Their nature is only discovered by testing their hardness. When we take into consideration the instability of this protosulphuret and its liability to oxydation, thus taking on a soluble form, the comparative scarcity of this mineral in this and other countries is amply accounted for. In fact in this mine, whenever air and moisture find access to strata containing it, the sulphate of copper is formed in fine crystals. I regret that I was unable to examine "in situ" the relative position of these minerals, which no doubt would have thrown much light on the conditions of their formation. They are thus far confined to this portion of the mine.

The galena at this depth is found only in interrupted strings along the foot wall of the vein, and in no case under my observation is it in contact with the sulphurets or in their immediate vicinity. Small sprigs of native copper are here implanted on the galena, and fine crystals of zinc spinel (automolite) occur. In the tunnels below this, at 145 and 200 ft., the veinstone remains fresh and undecomposed, containing copper pyrites, disseminated through its mass. Large cubes of pyrites, crystals of mispickel, copper pyrites and automolite, line and often fill crevices in the veinstone. Pure galena in small bunches is scattered through the slate, and the pyritiferous masses still alternate with the hard quartz slate. Galena still fills strings on the north wall, and it is remarkable that in this position the specimens exhibit a rather large cubical fracture, while in most and the largest bunches in the body of the vein, they show a compact granular structure. The percentage of silver in the galena of any mine varies with the position of the lead ore, and my examination shows that in this view it increases with its approach to the north wall. In different determinations I have found from 0·1 to 0·3 per cent, equal to 32 and 96 oz. per ton of ore. Kyanite is found in flat crystals facing crystals of galena. Carbon in the form of graphite occurs as a fine black coating on seams of galena.

The fresh undecomposed mica slate impregnated with copper pyrites, with its bands or plates of cubical pyrites, exhibited in the lower levels may, I think, be taken as representing the condition and appearance of the rocks above, previous to their decomposition. The sulphate of copper, formed during the oxydation of the copper pyrites, when taken in solution by the water percolating the mass, would be in a condition to assist in the formation of other compounds of copper, while the hydrous peroxyd of iron, formed during the same decomposition, would be left staining the strata from which the copper has been extracted. That the Harrisite and Cantonite were formed from the sulphate of copper in solution, is evident from their position at the lower limit of decomposition and the fact that they are found under no other conditions in the mine. As to the chemical agencies by which black oxyd, native copper, and these sulphurets have been precipitated, perhaps from the same solution—we have no positive evidence. In one case, at least, that of native copper, electro-chemical forces have no doubt been in operation. As regards the sulphurets—since graphite is found coating seams of galena the carbon of which was derived from organic matter in solution, analogy would look to the *possibility* of their formation by the reciprocal action of organic matter and the salt of copper, just as actual experiment has shown crystals of pyrites to be formed. And if future examination should prove that these are altered silurian strata, organic matter has not been wanting for all purposes of deoxydation.

But in galvano-chemical action we have, I think, an explanation of all the phenomena presented in the peculiar occurrence of the ores of copper in this mine; and I propose to embody in another paper, a series of experiments, showing, in this and other mines, the successive changes from copper pyrites, through variegated copper and copper glance to native copper and black oxyd. By the investigations of Mr. Robert Weir Fox and Mr. Robert Hunt on the Cornish veins, the fact was established, that in certain metalliferous veins, local galvano-electric currents existed, capable of producing chemical decomposition.

And in 1836, Mr. Fox submitted to the British Association an experiment showing that yellow copper (pyrites), in a dilute solution of sulphate of copper, under the influence of a weak galvanic current, undergoes a change by which "a black and somewhat friable crust" of sulphuret of copper was formed, and native copper deposited in "brilliant crystals" on the sulphuret.

That all the conditions for such decomposition and recomposition occur at the Canton mine, the above description will amply testify, and that such changes are in actual progress is proved by a specimen of copper pyrites in my possession, which is completely blackened by a very thin coat of the sulphuret, while mispickel and pyrites in immediate contact still retain their color and lustre. This power thus exerted in the formation of Harrisite and Cantonite is probably as active in pseudomorphic changes as in any other. The question then arises, Can they be pseudomorphs? On my first examination of these crystals in August, 1855, I considered them copper-glance in forms of galena, and their porosity, well exhibited in taking their specific gravity by the escape of air bubbles, strengthened that opinion. Subsequent examination of the locality and a greater variety of specimens, has entirely removed that impression. The occurrence of both minerals crystallized in connexion with erubescite renders it highly improbable that they replaced galena in that connection. Galena, with a cubical fracture (if it does in any form) does not occur in contact with the sulphurets. Nor are *they* found occupying the normal position of the galena, in strings along the wall.

This negative evidence, with some minor considerations, but especially the character of the crystals, the lustrous cleavage planes of which, with their sharp and well-defined angles, disagreeing so decidedly with pseudomorphic characters, renders some *positive* evidence necessary to prove them pseudomorphs.

Nor can Cantonite be Covelline in form of Harrisite, since the latter is never found among cubic pyrites, where the former is so beautifully crystallized. There is at least an improbability also that the easily decomposed protosulphuret could replace the very stable disulphuret.

In conclusion, I infer from the results of this investigation that copper glance is dimorphous, Harrisite being its monometric form. Also that Covelline is dimorphous, Cantonite being its monometric form. The cause of this latter dimorphism will probably be found in the fact that the monometric crystals are formed by aqueous, and the hexagonal (covelline) by igneous agency. Again, that Harrisite and Cantonite will not be found at great depths, but only within the range of decomposition. On the copper pyrites, then, and the argentiferous galena, will depend the value of this mine.

Art. XL.—*Contributions to Mineralogy;* by Dr. Frederick A. Genth.

Since my last contribution to Mineralogy, (Am. Journ. of Sci., xix, 15,) I have examined a number of minerals, the constitution of which appeared not to be satisfactorily settled, and in the following pages, give the results of my examinations.

1. *Bismuthine from Riddarhyttan in Sweden.*

The frequent occurrence of tellurium in minerals containing bismuth and the probability that both metals can replace each other, induced me to examine a specimen from Riddarhyttan. The bismuthine is implanted in actinolite, the crystals of which often penetrate it, and is associated with chalcopyrite and allanite (cerine), and by its broadly foliated structure and perfect cleavage somewhat resembles the tetradymite from Fluvanna county, Va. It was found to contain:

Sulphur,	18·19 p. c.
Tellurium with a trace of Selenium,	0·30 "
Bismuth,	77·33 "
Copper,	0·39 "
Iron,	0·31 "
Actinolite,	2·93 "
	99·45

After deducting the actinolite and 1·12 p. c. of chalcopyrite, the percentage of the pure mineral would be:

Sulphur,	18·65 p. c.
Tellurium,	0·32 "
Bismuth,	81·03 "
	100·00

From this analysis it appears, that the general formula for bismuthine should be written $(Bi, Te)S_3$.

2. *Harrisite* (Shepard), *a pseudomorph of Copper-glance after Galena.*

Prof. C. U. Shepard describes in his Report on the Canton Mine, (Savannah, 1855, and 2d edition, New Haven, 1856), under the name Harrisite, as a *new species* an interesting pseudomorph of copper-glance after galena.

Early in this year I examined the Canton mine and collected part of the material and data for the following investigation. I am also indebted to Dr. W. C. Daniell, Prof. Julien M. Deby and W. F. Harris, Esq., for minerals from this mine.

At the 115 foot east level of the Canton mine, the Harrisite* was found in a vein-like pocket, which dipped at an angle of about 30° towards the east, in the ore stratum, and extended as

* I may be permitted for the sake of convenience to use in this paper the names Harrisite, Cantonite, etc., for copperglance after galena, covelline after galena, etc.

far as the 141 foot level, where it gradually disappeared. At its widest place it was two feet in thickness and consisted of a very friable quartz with mica, supposed staurotide or partschine (Shepard) (?), automolite, Harrisite, Cantonite, pyrites, etc. At the 141 foot level the quartz becomes so much mixed up with pyrites, galena, chalcopyrite, etc., that it loses its vein-like character and has united with the wedge-shaped metalliferous mass in the ore stratum, where its presence can be recognized by the automolite and supposed staurotide or partschine. No Harrisite has ever been observed below 141 feet depth, and it has given place to the unaltered galena. It may be found again however, if the ore-stratum of the Canton mine or a similar one should be developed where the atmospheric influences have been favorable to such changes.

Harrisite has very much the appearance of a dark variety of galena, though it is always darker than the darkest, which I have ever seen. It occurs both in broadly foliated and granular masses, which show a perfect cleavage even to the smallest fragments. Between the cleavage planes, which are often tarnished, we frequently find a coating of clay.

It has lost its compactness and has become friable. Sp. Gr. (at 20° Cels.) = 5·485. H. = 3—3·5.

The material for the analyses was treated with chlorhydric acid, washed and dried over sulphuric acid, in order to obtain it in a state of perfect purity. I found:

	I.	II.
Sulphur,	20·648	20·647 p. c.
Selenium,	not determined.	0·047 "
Silver,	0·207	0·164 "
Copper,	77·298*	77·758 "
Lead,	0·056	0·060 "
Iron,	0·442	0·359 "
Insoluble,	0·272	0·667 "
	98·923	99·702

The eminent cleavage of this pseudomorph in the form of the original mineral has for a long time perplexed and kept me in doubt, whether it might not be a good species after all, but the more carefully I have examined the specimens in my possession and those at the Canton mine, the more have I become convinced that it is a pseudomorph.

Though we do not very often meet with pseudomorphs retaining the cleavage of the original mineral, yet several such cases have been observed, and they occur very naturally with those species of minerals that have an eminent cleavage. This caused them to change from a single one to an aggregate of innumerable individuals, by agencies, such as heat, pressure, etc., which would not have affected them, if the particles had been less easily sepa-

* Some was accidentally lost.

rable from each other. Before their conversion into the new mineral we have to consider such masses not as *one* individual, but as made up by the close juxtaposition of a great number of single individuals, each of which had been altered separately from the others, and which after their alteration had not the power to unite again into a single one.

A very remarkable pseudomorph of this kind is that of gypsum after anhydrite with perfect anhydrite cleavage from Pesey in Savoy; others are calcite after gypsum with the cleavage of the latter, and minium after galena with cubical cleavage; but the most interesting is a pseudomorph after Harrisite, which I shall describe presently, and which has been named Cantonite. Another proof that Harrisite is a pseudomorph after galena and Cantonite one after Harrisite, is their yield of silver, which is corresponding with that of the unaltered mineral. The galena contains from 0·10 to 0·18 p. c. of silver, the Harrisite from 0·16 to 0·20, and the Cantonite, as we shall see by comparing the analyses of it, from 0·30 to 0·35 p. c., which is nearly in the inverse ratio of the equivalents of galena, copper-glance and covelline. The presence of selenium, which I have also observed in the galena, is further to be remarked, both in the Harrisite and Cantonite.

Breithaupt, in his Paragenesis, p. 185, mentions copper-glance after galena as having been found in Saxony.

We may readily conceive how the Harrisite has been formed, if we bear in mind an observation of Anthon, that freshly precipitated sulphid of lead, throws down sulphid of copper, when added to solutions of coppersalts, and that I have found that galena precipitated sulphid of copper from the nitrate, though this reaction was gradual.

Whether Scheerer's copper-glance from Tellemark, Norway, with cubical cleavage is a similar pseudomorph or a distinct species, I am not prepared to say, but from the experiments of Mitscherlich and G. and H. Rose, that by fusion of sulphur and copper or copper-glance, a monometric subsulphid of copper can be obtained, it is not improbable that under favorable circumstances it may also be found in nature.

3. *Cantonite* (Pratt), *a pseudomorph of Covelline after Galena.*

Mr. N. A. Pratt announces (Am. Jour. Sci., xxii, 449) as a new species, which he calls Cantonite, a very rare and interesting pseudomorph of covelline after galena, or rather after Harrisite, the latter having been the intermediate result of the decomposition. He promises in his announcement to give in the next number of the Am. Jour. of Sci. a full description of it, but having failed to do so in the numbers for January and March 1857, I do not hesitate to give the results of my investigations.

It occurs associated with Harrisite, etc., in crystalline masses with perfect cubical cleavage. The color is dark indigo-blue, the lustre between submetallic and resinous. Its powder is bluish-black, when rubbed in the agate mortar, indigo-blue and shining. It is soft, very friable and somewhat sectile.

Sometimes it contains a nucleus of Harrisite (analysis II). It should be remarked that the angles of pyrites associated with the Cantonite have frequently rounded edges, and that black oxyd of copper often occurs with it. To free it from the latter the material for analysis was first digested with diluted chlorhydric acid. It contains:

	I.	II. (containing Harrisite.)	
Sulphur,	32·765	28·664 p. c.	
Selenium,	*trace*	*trace*	
Silver,	0·355	0·305 "	
Copper,	65·604	70·791 "	(from the loss.)
Lead,	0·107	0·025 "	
Iron,	0·251	0·084 "	
Insoluble,	0·157	0·131 "	
	99·239	100·000	

4. *Linnæite.*

a. Carrollite (Copper-linnæite) from the Patapsco Mine.

Although the constitution of this interesting mineral has been satisfactorily established by Smith and Brush (Am. Jour. Sci., xvi, 367), I considered a re-examination not to be out of place on account of the difficulty of obtaining pure material, such as is entirely free from chalcopyrite, copper-glance, etc. After having observed that carrollite is very little acted upon by nitric acid, I have endeavored to purify some of it, by digesting the mixture of chalcopyrite and carrollite with diluted nitric acid. I was disappointed in my expectations, finding that in the presence of chalcopyrite, the carrollite was far more readily dissolved, whilst the former appeared to be more protected. After having abandoned the idea of getting pure material by the help of chemicals, I was fortunate enough to obtain a perfectly pure specimen, weighing about four grammes.

The color was between steel-grey and tin-white, with a very faint reddish hue. It was not crystallized, and like all the carrollite which I have seen, did not show the least indication of cleavage, but a subconchoidal fracture.

Dissolves slowly in nitric acid *without* separation of sulphur. The results of the analysis agree with those of Smith and Brush.

Sulphur,	41·71 p. c.
Copper,	17·55 "
Nickel,	1·70 "
Cobalt,	38·70 "
Iron,	0·46 "
Quartz,	0·07 "
	100·19

I may state that I have also observed this mineral at the Springfield Mine, Carroll County, Md., from which locality I have an octahedral crystal.

In Prof. J. D. Dana's Mineralogy the formula is written

$$\text{€uS} + Co^2S^2 \text{ instead of } CuS + Co^2S^3.$$

b. Siegenite (Nickel-linnœite) from Mineral Hill, Md.

A mineral, which has sometimes been confounded with Carrollite, occurs at the Mineral Hill Mine, Carroll County, Md., about eight miles from Finksburg.

It is found in a vein in chlorite slate and is associated with chalcopyrite, erubescite, blende, pyrites, magnetite, actinolite and quartz. It is so intimately mixed with chalcopyrite that I found it impossible to pick out enough of pure material for a single analysis, though I had used several pounds of the mineral. The only impurity, as can be seen by examining it with a magnifier, being chalcopyrite, it is easy to correct the analyses by deducting it from the same.

The color is pale steel-grey, with a distinct yellowish hue, undoubtedly owing to an admixture of chalcopyrite; its cleavage is distinctly cubical.

Dissolves slowly in nitric acid, but more readily than Carrollite, without separation of sulphur.

The following results were obtained by the analyses of two different specimens:

	I.	II.	
Sulphur,	39·70*	41·15 p. c.	
Copper,	2·23	3·63 "	
Iron,	1·06	3·20 "	
Nickel,	29·56	50·76 "	(from the loss.)
Cobalt,	25·69		
Insoluble,	0·15	1·26 "	
	99·59	100·00	

The nickel and cobalt in analysis II. were in about the same proportion as in I.

Both the copper and iron result from the presence of chalcopyrite. That the pure siegenite from this locality does not contain any iron can be seen by calculating from and for the percentage of copper obtained, the quantity of iron requisite to form chalcopyrite. In analysis I. 2·23 p. c. of copper require 1·94 p. c. of iron and 2·25 p. c. of sulphur to form chalcopyrite, of which the mineral analyzed therefore contained 6·42 p. c.; in analysis II. 3·63 p. c. of copper require 3·20 p. c. of iron and 3·66 p. c. of sulphur, showing that the siegenite analyzed contained 10·49 p. c. of chalcopyrite.

c. Siegenite (Nickel-linnœite) from Mine La Motte, Missouri.

The cobalt and nickel-ore from Missouri has been used for a number of years for the manufacture of oxyd of cobalt and

* Some was accidently lost.

nickel, but I am not aware that a scientific examination of the pure mineral has ever been made. This may be owing to the difficulty in obtaining pure material, as it is always mixed with galena, chalcopyrite, marcasite, etc. I have endeavored to pick it out as pure as possible, and have pretty well succeeded in removing the greater portion of the remaining galena by previously treating it with strong and boiling chlorhydric acid.

The siegenite from this locality is rarely found in crystals; those which I have observed were both octahedra and cubo-octahedra. Its cleavage is very indistinct; the color between steel-grey and tin-white. It dissolves in nitric acid without separation of sulphur. The analysis gave the following results:

Sulphur,	41·54 p. c.
Lead,	0·39 "
Nickel,	30·53 "
Cobalt,	21·34 "
Iron,	3·37 "
Insoluble,	1·07 "
	98·24

with traces of copper and antimony.

5. *Enargite* (?)

In small cavities of a hornstone-like quartz at the Brewer's Mine, Chesterfield District, S. C., occurs very rarely an iron-black mineral with metallic lustre and perfect rhombic cleavage. I am indebted to the State Geologist of South Carolina, Oscar M. Lieber, Esq., its discoverer, for a small specimen of it.

Mr. Lieber in a qualitative examination found it to contain sulphur, arsenic and copper.

Before the blowpipe it decrepitates, on charcoal with soda gives hepar, the odor of arsenic and finally copper. Though the quantity placed at my disposal was entirely too small for a complete examination, I thought that I might be able at least to ascertain to what species it belongs. The following are my results: 0·0060 grs. gave 0·0149 grs. sulphate of baryta; 0·0040 grs. of oxyd of copper and 0·0005 grs. of magnesia, which is equivalent to 0·00094 grs. of arsenic. The percentage calculated from these results is:

Sulphur,	33·78
Arsenic,	15·63
Copper,	50·59
	100·00

Until larger quantities can be obtained, which permit of a more complete investigation, I think I am justifiable in calling this mineral Enargite.

6. *Coracite* (LeConte) *is Pitchblende.*

Dr. John L. LeConte kindly presented me with a specimen of the mineral from about 90 miles above Sault St. Marie on the north side of Lake Superior, which he had described as Coracite (Am. Journ. Sci. iii, 173).

Its great resemblance to pitchblende favored the opinion that it was really nothing else. Mr. Whitney (Bost. Soc. Nat. Hist., 1849, 36), suggested that the Uranium might be in the form of U_2O_3 and not of UO, U_2O_3, but stated, that it yields a green solution with chlorhydric acid.

I endeavored to extract the carbonate of lime, which is mechanically mixed with it, by very dilute acetic acid, but I soon observed that the coracite was also acted upon and that the liquid became green; I therefore washed it completely, dried over sulphuric acid and used the partly extracted substance, which was slightly acted upon by the acetic acid, for analysis.

Before giving the results, I will state that the protoxyd of uranium was determined by dissolving the mineral in a mixture of chlorhydric acid and chloraurate of sodium and by calculation from the quantity of reduced gold. The separations were made as usual with exception of that of uranium from iron. By qualitative experiments I ascertained that this separation could be made more easily and accurately by the precipitation of the sesquioxyds of iron and uranium by ammonia from a boiling solution and re-solution of the sesquioxyd of uranium by digestion with dilute acetic acid.

I obtained the following results:

Sesquioxyd of uranium,	46·21	contains	7·76	oxygen.
Protoxyd of uranium,	16·47	"	1·95	"
Sesquioxyd of iron,	3·51	p. c.		
Alumina,	0·52	"		
Magnesia,	0·56	"		
Lime,	5·33	"		
Oxyd of lead,	7·39	"		
Silicic acid,	13·15	"		
Carbonic acid and water,	6·14	"		
	99·28			

The ratio of oxygen in UO to U_2O_3 is very near $=1:4$. The excess of uranic oxyd may be accounted for by partial oxydation or perhaps by the presence of a combination of it with oxyd of lead, and though it is interesting that it is so readily soluble in chlorhydric acid, this fact alone is not sufficient to separate it from pitchblende.

7. *Epistilbite.*

Mr. C. A. Kurlbaum, Jr., has examined in my laboratory the epistilbite from Iceland with the following results:

Silicic acid,	58·74	p. c.
Alumina,	17·10	"
Sesquioxyd of iron,	0·12	"
Lime,	7·81	"
Soda,	2·06	"
Potash,	0·19	"
Water,	14·21	"
	100·23	

8. *Shepard's Plumbo-Resinite from the Canton Mine is Cyanosite.*

I am indebted to W. F. Harris, Esq., who had the advantage of Prof. C. U. Shepard's *own* mineralogical determinations for a genuine specimen of what the latter in his report on the Canton Mine calls Plumbo-Resinite. It forms as Prof. Shepard remarks, "*varnish-like coatings of a yellowish green color.*"

With great care I have separated some of the mineral from the quartz with which it occurs and examined it.

Before the blowpipe on heating loses water and becomes greyish-white; on being exposed to a higher temperature on charcoal it yields a black mass containing metallic copper; with carbonate of soda upon charcoal gives a hepar and metallic copper. Dissolves easily in water; the solution has a very astringent metallic taste, and contains oxyd of copper and sulphuric acid. It does not contain either alumina or oxyd of lead, and with a solution containing nitric acid only a very slight yellowish color could be produced by molybdate of ammonia.

9. *Cherokine* (Shepard) *is Pyromorphite.*

By the kindness of F. W. Harris, Esq., I have received a genuine specimen of Prof. Shepard's Cherokine. As he stated in his report on the Canton Mine, "*it resembles white lead ore (carbonate of lead) in its color, but possesses the crystalline form of pyromorphite, while it contains phosphate of alumina and oxyd of zinc and further differs from Plumbo-Resinite by containing much less water,*" etc. Some qualitative tests which I have made with a crystal of the mineral gave me very different results, and I have not been able to distinguish it from pyromorphite. A special search was made for water, alumina and oxyd of zinc, but neither were found. Before the blowpipe also it behaves like pyromorphite and melts easily, the globule assuming on cooling a polyhedral form.

10. *Vivianite.*

Mr. C. A. Kurlbaum, Jr., (analyses I and II) and I (III) have examined a massive indigo-blue variety of vivianite from Allentown, Monmouth county, N. J.

	I.	II.	III.
Phosphoric acid,	29·65	29·21	29·48
Protoxyd of iron,	27·62	not determined.	
Sesquioxyd of iron,	18·45	not determined.	49·70
Magnesia,	0·03	0·10	not determined.
Water,	25·60	not determined.	
	101·35		

The analyses afford the formula :

$$10(3FeO, PO_5+8HO)+3(3Fe_2O_3, 2PO_5+10HO)$$

11. *Wavellite.*

About one mile from the Railroad Depot at Steamboat, Chester county, Pa., wavellite has been discovered in great abundance and in beautiful varieties. By the kindness of Dr. Hartman of West Chester, I have received several specimens, which have furnished me with the material of investigation.

It is found in minute rhombic, sometimes stellated crystals, which, according to Prof. J. D. Dana's measurement have a prism of 123°—124°. Usually however they form stalactitic or botryoidal concretions coating limonite. The wavellite is often coated with a micaceous mineral, which I have not obtained in sufficient quantity to ascertain its composition.

After having found by some qualitative experiments that phosphoric acid could be *completely* separated from alumina by dissolving in an excess of caustic potash, and precipitation of the phosphoric acid by caustic baryta, I have analyzed this wavellite by this method, and satisfied myself afterwards that the separation had been complete.

I must add, however, that I have not always succeeded with this method, but as yet do not know the reason.

The stalactitic wavellite from this locality contains :

Phosphoric acid, -	34·68 p. c.	contains oxygen	19·44
Alumina, - -	36·67	" "	17·14
Limonite, - -	0·22		
Water, - -	28·29	" "	25·14
Fluorine, - -	*trace*		
	99·86		

The oxygen ratio of $PO_5 : Al_2O_3 : HO$ corresponds with the atomic ratio, 3·9 : 5·7 : 25, which very nearly gives the formula $3Al_2O_3, 2PO_5+12HO$, as Sonnenschein has already observed.

12. *Dufrenite.*

This mineral occurs in the green sand formation at Allentown, N. J., in radiated fibrous masses, forming a coating of one-eighth to half an inch in thickness. Its color is dark leek green, in some places, where it is beginning to change into limonite, it is brown. The powder has a dull greyish green color.

Mr. Chas. A. Kurlbaum, Jr. has examined the green mineral, which was apparently quite pure and obtained the following result:

Silicic acid,	0·72	p. c.		
Phosphoric acid,	32·61	"	contains oxygen	18·28
Protoxyd of iron,	3·77	"	" "	0·84
Sesquioxyd of iron,	53·74	"	" "	16·10
Water,	10·49	"	" "	9·32
	100·95			

From the oxygen ratio of $PO_5 : FeO : Fe_2O_3 : HO$, we find that the atomic ratio is $3·65 : 0·84 : 5·87 : 9·3$, which is equal to $13 : 3 : 19 : 33$, or very nearly gives the formula:

$$(3FeO, PO_5+8HO)+6(3Fe_2O_3, 2PO_5+4HO).$$

It appears that the mineral analyzed contained some vivianite mixed with it, and that the formula of the pure dufrenite would be $3Fe_2O_3, 2PO_5+4HO$.

The calculated percentage corresponding with this formula is:

Phosphoric acid,	34·10
Sesquioxyd of iron,	57·31
Water,	8·59
	100·00

It is remarkable that the amount of sesquioxyd of iron, calculating all the iron as sesquioxyd, would be 57·51 p. c. It is not improbable that this dufrenite is in the state of alteration into vivianite.

13. *Hitchcockite* (Shepard).

Hitchcockite, according to Prof. C. U. Shepard's statement (Report on the Canton Mine), is a "*white earthy shell, sometimes no thicker than a mere varnish,—a hydrated phosphate of alumina with oxyd of zinc,*" and is enumerated by him amongst the "*ores of zinc.*"

On my late visit to the Canton Mine I procured a considerable number of specimens of this interesting *new* mineral, and the following are the results of my examinations.

With a good magnifier only it can be observed that this mineral has a crystalline structure. It usually occurs in botryoidal concretions or small mamillary incrustations. Color white, yellowish, bluish and reddish-white; powder white. Lustre subresinous, subvitreous and dull. Translucent.

It has an argillaceous odor when breathed upon. Brittle; fracture uneven. H.=4·5. Sp. Gr. (at 20° Cels.) about 4·014.

Before the blowpipe shrinks but does not fuse; with cobalt solution gives a fine azure blue mass; with carbonate of soda on charcoal yields metallic lead and lead incrustations. Dissolves both in boiling nitric and chlorhydric acids, more readily in the latter. The following are the results of my analyses:

	I.	II.				
Insoluble,	1·11	0·48	p. c.			
Chlorine,	not determined.	0·04	"			
Carbonic acid,	not determined.	1·98	"	contains oxygen		1·44
Phosphoric acid,	18·74	18·74	"	"	"	10·50
Oxyd of lead,	not determined.	29·04	"	"	"	2·11
Alumina,	24·69	25·54	"	"	"	11·91
Sesquioxyd of iron,	0·68	0·90	"	"	"	0·27
Lime,	1·49	1·44	"	"	"	0·69
Water,	21·65	20·86	"	"	"	10·55
		99·02				

Deducting 0·72 of oxygen of bases RO for the quantity of carbonic acid found, and considering the carbonate as an impurity,

the oxygen ratio of	PbO :	$Al_2O_3(Fe_2O_3)$:	PO_5 :	HO
is equal to	2·08 :	12·18 :	10·50 :	18·55
or equal to the atomic ratio of	2 :	4 :	2 :	18

corresponding with the formula

$$3PbO, PO_5+3Al_2O_3, 2PO_5+3(Al_2O_3, HO)+24HO.$$

The calculated percentage of the pure mineral is therefore:

$3PbO$,	334·8	30·44 p. c.
$6Al_2O_3$,	308·0	28·01 "
$3PO_5$,	214·0	19·46 "
$27HO$,	243·0	22·09 "
	1099·8	100·00

14. *Lanthanite.*

To Dr. Montroville M. Dickeson, the discoverer of the beautiful and extremely rare lanthanite from near Bethlehem, Pa., I am indebted for a small specimen of this interesting mineral. I have to add only a few remarks to the investigations of Mr. Wm. P. Blake (Amer. Jour. Sci., xvi, 228) and Prof. James L. Smith (ibid., xviii, 378, 427), as the results of my analyses agree with those of Blake and Smith. Sp. gr. (at 20° Cels.) =2·605.

In analysis I, the crystals of lanthanite were carefully selected and appeared to be quite pure; in analysis II, the mixture of lanthanite, quartz, and an ochreous substance were treated with very dilute acetic acid, and the percentage given below is that of the soluble portion only, which did not contain anything else than lanthana and oxyd of didymium.

	I.	II.
Lanthana (with oxyd of didymium),	54·95	54·83
Carbonic acid,	21·08	——
Water (from the loss),	23·97	——
	100·00	

On boiling with water, the crystals of lanthanite are decomposed into a white powder, which is probably a basic carbonate. The quantity of material at my disposal was not sufficient to ascertain the composition of it. It is not improbable, however, that the Bastnaes mineral is the same substance and Hisinger's formula consequently correct.

I hope to be able hereafter to settle the doubts which exist on this point.

Prof. C. U. Shepard states (Report on the Canton Mine) that he has observed this mineral at the Canton Mine, he does not inform us, however, what induces him to take the pink-colored crystals for lanthanite. I have not been able to procure a specimen of it and also did not succeed in finding any indications of minerals containing cerium or lanthana, from the decomposition of which the lanthanite could have been formed.

15. *Bismuthite.*

I have made an examination of the bismuthite from the Brewer's Mine, Chesterfield District, S. C., with results not materially differing from those obtained by Prof. Rammelsberg (Pogg. Ann., lxxvi, 564). The material for examination was kindly furnished by Dr. Asbury of Charlotte, N. C., Prof. Lewis R. Gibbes of Charleston, S. C., and Oscar M. Lieber, Esq. of Columbia, S. C. The appearance of the specimens did not differ much except in the richness of the pieces, some of them containing a very large percentage of the brown ochreous residue, insoluble in dilute nitric acid.

I have analyzed a pale variety (I) and a darker one (II), and made two analyses of each, one by treating the finely powdered mineral with dilute nitric acid (*a*), the other by digestion with strong chlorhydric acid (*b*), by which everything, except the silicic acid, is dissolved.

The quantities of lime and magnesia were found to be very small and have not been determined.

The following are the results:

	I. *a*	I. *b*	II. *a*	II. *b*
Insoluble in dil. NO_5,	25·42	——	28·16	——
containing water,	(1·59)	——	(2·62)	——
Teroxyd of bismuth,	64·72	64·24	62·15	61·45
Tellurous acid,	——	0·05	——	0·06
Sesquioxyd of iron,	0·91	6·64	1·30	11·20
Alumina,	0·74	1·18	0·68	2·09
Silicic acid,	0·48	17·78	——	13·99
Carbonic acid,	——	5·08	——	5·12
Water,	——	3·94	——	5·41
		98·91		99·32

Deducting the amount of water, which the residue insoluble in nitric acid contains, from the whole quantity given in the analyses (*b*) we obtain pretty correctly (though somewhat too high) the amount of water combined in the pure bismuthite. We would have therefore:

	I. (b)				II. (b)			
Teroxyd of bismuth,	64·24	contains	6·65	oxygen,	61·45,	contains	6·36	oxygen.
Carbonic acid,	5·05	"	3·67	"	5·12	"	3·72	"
Water,	2·35	"	2·09	"	2·79	"	2·48	"

The atomic ratio of $BiO_3 : CO_2 : HO$ is therefore:

in analysis I, $2·22 : 1·83 : 2·35$
in analysis II, $2·12 : 1·86 : 2·48$

The first analysis corresponds nearly with the formula:

$$9(BiO_3, CO_2)+2(BiO_3, HO)+10HO,$$

the second with:

$$6(BiO_3, CO_2) + BiO_3, HO + 7HO.$$

These analyses, like the one made by Prof. Rammelsberg, prove, (and that is all, I think, which can be expected from the examination of so impure a mineral,) that the Bismuthite from Chesterfield District is a basic carbonate of bismuth with water.

A new locality of bismuthite is in Gaston county, N. C., where it has been discovered by Dr. Asbury of Charlotte, N. C., to whom I am indebted for specimens of it. It occurs there associated with native gold in yellowish-white concretions, which are usually pulverulent, but sometimes show a crystalline structure.

In the matrass it yields water, becoming yellow, and on higher heating fuses easily into a brown mass, which assumes a straw-yellow color on cooling. Upon charcoal it is easily reduced into metallic bismuth, whilst the charcoal is covered with yellow incrustations, having a white margin; for a moment the characteristic bluish green flame of tellurium may be observed.

Dissolves easily in chlorhydric and nitric acids with effervescence of carbonic acid. The solution gives the reactions of teroxyd of bismuth.

I hope to be able to procure more of it in order to make a complete examination which will be of interest, as the material can be obtained in the state of great purity and would assist in settling the doubts still remaining as to the composition of bismuthite.

Philadelphia, March 14, 1857.

ART. XLI.—*On the Separation of Lithia and Magnesia;* by J. W. MALLET, Ph.D.

IN the description of methods for the separation of magnesia from the fixed alkalies we find in the standard works on analytical chemistry but few observations referring specially to lithia; and yet the close analogy existing between the compounds of this alkali and those of magnesia would seem likely to render the separation more difficult than in the case of potash or soda.

The opinion has indeed been expressed by L. Troost,* who has lately made some experiments upon the salts of lithia in the laboratory of M. Sainte-Claire Deville, that the two bases in question are so closely analogous, that the only means of separating them is by the employment of caustic potash, which precipitates magnesia alone.

I have felt anxious to examine the grounds upon which this opinion rests, and in particular to ascertain whether lime or baryta may not be used with as good result as caustic potash, since I had depended upon the former of these earths for the purification from magnesia of the salt which I used in determining the atomic weight of lithium.†

I first examined the chlorid of lithium which had been prepared for the experiments on atomic weight, and found that caustic potash did not indicate the presence of a trace of chlorid of magnesium.

This chlorid of lithium then, and the sulphate of lithia prepared from it, might be looked upon as pure salts of the alkali, and safely used in the subsequent analytical experiments.

Among the methods in use for the separation of magnesia from potash and soda, but three appeared worthy of investigation with reference to lithia; the employment of oxyd of mercury as recommended by Berzelius, precipitation with baryta water, and precipitation with milk of lime. Ignition of the mixture of magnesia and the alkalies with carbonate of ammonia does not succeed well with lithia, as H. Rose remarks,‡ since the carbonate of lithia formed is with difficulty and imperfectly extracted by water.

In order to test the applicability of Berzelius's method, the use of HgO, the following mixtures were prepared. No. 1, ·5392 grm. of anhydrous LiCl was dissolved in a little water and added to ·0909 grm. of MgO dissolved in muriatic acid. No 2, ·5942 grm. of LiCl and ·2198 grm. of MgO.

To each of the solutions an excess of oxyd of mercury in very fine powder was added, and they were then gently evaporated to dryness in porcelain crucibles, and ignited until the whole of the mercury was driven off. Water was added to the contents of the crucibles after cooling. They were allowed to digest for some time, and the magnesia which had been formed was filtered, thoroughly washed, ignited, and weighed. The filtrate was evaporated to dryness with the addition of a slight excess of sulphuric acid, and the sulphate of lithia was ignited and weighed.

The mixture No. 1 yielded ·6067 grm. of LiO, SO_3 and ·2387 grm. of MgO. No 2 gave ·7108 grm. of LiO, SO_3 and ·3414 grm. of MgO. Reducing to LiO by calculation, and expressing the results for 100 parts, we have—

* Comptes Rendus, Nov. 10, 1856.—Republished in Chemical Gazette, Dec. 15, 1856. † This Journal, Nov. 1856. ‡ Handb. d. Anal. Chemie., B. 2, S. 45.

	Actually Contained.		Found.	
	No. 1.	No. 2.	No. 1.	No. 2.
LiO - - - -	67·67	48·83	58·84	45·13
MgO - - - -	32·33	51·17	84·95	79·48
	100·00	100·00	143·79	124·61

The gross inaccuracy of the above results proved on examination to arise from the action of oxyd of mercury upon chlorid of lithium, removing from it, as from chlorid of magnesium, chlorine, which was replaced by oxygen; so that a large amount of caustic lithia was found. The caustic alkali had acted energetically upon the porcelain crucibles, and both in the matter insoluble in water, which had been weighed as magnesia, and in the filtrate from this, silica, alumina, etc., were easily detected. The corrosion of the crucible went further, it will be seen, in the case of Mixture No. 1, in which a larger proportion of chlorid of lithium occurred, than in No. 2. There is a considerable loss of lithia in both cases, although the sulphate as weighed contained a little silica, &c.; this is owing in part to the retention of lithia in a state insoluble in water (but separable by muriatic acid) with the magnesia, silica, and alumina; and in part perhaps to a little of the chlorid having been volatilized as such.

To obtain some idea of the facility with which chlorid of lithium might be converted into lithia by means of oxyd of mercury, I made a separate experiment upon 1·2778 grm. of the pure salt. This quantity was dissolved in a little water, evaporated to dryness with 5 grm. of finely pulverized HgO, and ignited until the mercury was completely driven off. The residue in the crucible was dissolved in water with a little nitric acid, filtered, and chlorine precipitated from the filtrate by nitrate of silver, 3·3489 grm. of chlorid of silver were obtained =·8279 grm. of chlorine, or 64·79 p. c. of the LiCl employed;—83·53 p. c. is the proportion in the pure salt, so that about one-fourth of the chlorine had been replaced by oxygen.

The effect of ignition with oxyd of mercury having proved in this case so considerable, the experiment was repeated with chlorid of sodium; and even with this more stable salt it appeared that decomposition to some extent could be brought about. After ignition, the NaCl dissolved in a little water, reacted strongly alkaline to test paper, although the quantity of caustic soda formed was obviously not any larger, and the crucible did not seem to be attacked.

The method of Berzelius, therefore, thus applied, will not serve for the accurate separation of lithia and magnesia. The porcelain crucibles might be replaced by platinum ones, but lithia, acts, as is well known, with great energy upon platinum, and the vessels used would at least be seriously injured, even were we to go to the further trouble of removing from the magnesia obtained in the process any platinum which had been dissolved off by the caustic alkali. But chlorid of magnesium is decomposed by oxyd of mercury, even during the evaporation of the solution; and it remains to be seen whether this mere evaporation, at a temperature not exceeding 212°, may not suffice for the complete conversion of MgCl into MgO, LiCl remaining unchanged. Ignition would then remove the excess of HgO from the MgO, and the HgCl formed from the evaporated filtrate.

(To be continued.)

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *Electrodynamic measurements.*—KOHLRAUSCH and WEBER have presented to the royal Saxon Academy of Sciences a memoir on the reduction of the electrodynamic, magnetic, and electrolytic measures of current-intensity to mechanical measure. The measure of current-intensity is the intensity of that current which under the normal conditions produces the unit of measurable action. The normal conditions for the magnetic action of a current are as follows: *the current passes through a circular conductor which includes the unit of surface, and acts upon a magnet which possesses the unit of magnetism from an arbitrary but great distance* $=R$; *the center of the magnet lies in the plane of the conductor and its magnetic axis is directed toward the center of the circular conductor.* The moment of rotation D exerted by the current upon the magnet is different under these circumstances, according to the difference in the intensity of the current, as well as according to the distance R; but the product R^3D depends only on the intensity of the current, and is therefore the measurable action of the current, so that the measure of the current-intensity is the intensity of the current whose measurable action under the conditions described is given by the equation

$$R^3D=1.$$

This measure of current-intensity is at the same time the intensity of the current, which, when it flows around a plane of the unit of surface, exerts at a distance an action equal to that of a magnet placed in the center of the plane, having the unit of magnetism, and with its magnetic axis perpendicular to the plane; or it is also the intensity of the current by which a *tangent's-compass with a single circle of radius* R is held in equilibrium, with a deviation from the magnetic meridian

$$\varphi=\text{arc tan}\,\frac{2\pi}{RT}$$

where T represents the horizontal component of the earth's magnetism.

The normal conditions for observations of the electro-dynamic actions of a current are as follows: *the same current passes through two circular* *conductors, of which each one includes the unit of surface, and which lie at an arbitrary but great distance* $=R$ *from each other: the line of intersection of the two circular planes at right angles to each other halves the first circular conductor.* In this case, as above, the moment of rotation D depends upon the intensity of the current as well as upon the distance R, while the product R^3D depends only on the intensity of the current.

For observation of the electrolytic action of a current the normal conditions are as follows: *the current passes through water during an arbitrary accurately measurable time* T, *without undergoing any change in intensity.* The number of milligrammes of water decomposed by the current M, varies with the intensity of the current and the time T; but the quotient $\frac{M}{T}$ depends only on the intensity of the current, so that the measure of current-intensity is here the intensity of the current whose measurable action under the normal conditions is

$$\frac{M}{T}=1.$$

It remains to make these three measures comparable with each other. The comparison of the two first may be deduced from the general laws of electrodynamics, and Weber has already found (Electrodynamic measurements, ii, 261) that the first measure is to the second as $\sqrt{2}:1$. By a direct comparison of the electrolytic and magnetic action of the same current it was found that the third measure of current-intensity or the intensity of the current which decomposes 1 milligramme of water in 1 second is $106\frac{2}{3}$ times greater than the first measure.

The intensity of an electrical current may be determined not only from its action but also from its causes. The immediate causes of an electric current lie in the mass of the neutral electric fluid which is contained in a closed conductor, and in the velocity with which its two constituents, the positive and negative fluids simultaneously move in opposite directions. The mechanical measure of current-intensity is based upon these causes and may be expressed as follows. The mechanical measure of the intensity of the current is the intensity of that current which is produced by a velocity of the two electric fluids, such that the mass of each fluid which flows through the section of the conductor divided by the time in which it flows $=1$. The unit of quantity of positive electricity is here the quantity which when concentrated upon a point exercises upon an equal quantity of electricity at the distance of 1 millimeter a force which during one second communicates to the mass of 1 milligramme the velocity of 1 millimeter in a second.

The problem which the authors proposed to solve was to determine the quantity of electricity which flows through the section of the conductor in the unit of time in a current whose intensity is determined in units of magnetic, electrodynamic or electrolytic action. This quantity of electricity must be determined by the magnitude of the electrostatic fundamental force which it exerts. In other words, the intensity of such a current is to be compared with the quantity of electricity upon each of two small equally charged spheres which repel each other with the unit of force at the unit of distance, the unit of force being defined as above.

The method adopted by the authors for the solution of this problem was as follows. When a quantity of electricity E accumulated upon an insulated conductor is discharged to the earth through the wire of a galvanometer, it exerts during its passage a moment of rotation upon the needle. If the time of discharge be so increased, by introducing a column of water, that no discharge takes place between the windings of the wire, this time will still be only a very small fraction of the time of vibration of the needle. The action of the discharge upon the needle may therefore be regarded as an *impulse*, hence from an observation of the first elongation of the needle after the discharge, the angular velocity communicated to the needle may be determined by the laws of vibration, and this angular velocity will depend only on the quantity of electricity E.

With a constant current we may communicate a similar influence to the needle of the same galvanometer, if we allow the current to act only a very short time. The same quantity of electricity flows through the conductor in the time t with the intensity i as in the time $\frac{t}{n}$ with the greater intensity ni. Hence in this case also the angular velocity of the needle and consequently its elongation depends simply on the quantity of electricity which flows through a section of the wire during the passage of the current.

If now with the same galvanometer we produce equal elongations of the needle, at one time by the discharge of a known quantity E of positive electricity, and at another by a constant current of short duration, we may conclude that for the quantity of positive electricity x which flowed through the section of the conductor during which the short duration of the constant current

$$x = \frac{1}{2} E.$$

With these premises the solution of the problem rests on the two following points:

1. To measure the quantity of electricity E in the given electrostatic measure, and to observe the elongation of the needle of a galvanometer.

2. To determine the short time τ during which a constant current of intensity $=1$ (in magnetic measure) must pass through the multiplier of the same galvanometer in order to communicate the same elongation to the needle.

With respect to the second point, no particular experiments are required to determine τ, since the value of τ may be determined by calculation from the number and dimensions of the windings of the galvanometer, from the elongation of the tangent's-compass during the discharge and from the intensity of the earth's magnetism, much more accurately than by direct experiments. The determination of the quantity of electricity E requires a combination of several experiments. A large quantity of electricity is first to be divided into two parts in a previously determined ratio; the larger part is then discharged through the tangent's-compass to observe its magnetic action; while the smaller portion is measured by a Coulomb's torsion balance.

A Leyden jar whose outer coating was connected with the earth, was used as a source of electricity. By means of a Smee's-electrometer the author determined the relation between the charge of the jar before and after contact with a large sphere, and consequently the ratio of the residual charge in the jar to that of the sphere. The large sphere being then brought in contact with the fixed ball of the torsion balance, the quantity of electricity communicated was calculated from the ratio of the radii of the spheres. Proper corrections were introduced for the loss of electricity arising from various causes. Our limits do not permit us to give the details of the author's very elaborate experiments, and we must therefore content ourselves with a statement of their results. The most striking of these results are as follows.

The magnetic measure of current-intensity is $155370 . 10^6$ greater than the mechanical measure.

Since, as already stated, the magnetic measure is to the electro-dynamic measure as $\sqrt{2} : 1$, the electro-dynamic measure of current-intensity is $109860 . 10^6$ ($=155370 . 10^6 . \sqrt{\frac{1}{2}}$) greater than the mechanical measure.

The magnetic measure is to the electrolytic measure as $1 : 106\frac{2}{3}$, consequently the electrolytic measure of current-intensity is $16573 . 10^9$ ($=106\frac{2}{3} . 155370 . 10^6$) times greater than the mechanical measure.

These results are applied by the authors to several interesting cases, of which however, our limits will permit us to notice but two. These are the determination of the quantity of electricity necessary to separate 1 milligramme of hydrogen from 9 milligrammes of water, and the determination of the absolute force required to separate with a given velocity the oxygen and hydrogen in 1 milligramme of water. The authors find that to separate 1 milligramme of hydrogen from 9 milligrammes of water, $149157 . 10^9$ units—as defined above—are necessary. If such a quantity of positive electricity were accumulated in a cloud and an equal quantity of negative electricity concentrated upon the part of the earth's surface situated vertically under it, the result would be an attraction of the cloud by the earth, which at a distance between the two of 1000 meters would be equal to a weight of 45000 hundred weight or 2268000 kilogrammes. With respect to the force required to separate the oxygen and hydrogen of 1 milligramme of water, the authors find that if all the particles of hydrogen in 1 milligramme of water in the form of a column 1 millimeter long, were attached to a thread, and if all the particles of oxygen were attached to another thread, the two threads would have to be drawn in opposite directions each with a force of

147830 kilogrammes,

or about 2956 hundred weight in order to produce a decomposition of the water with the velocity with which 1 milligramme of water would be decomposed in a second. The tension would be proportionally less if the water were decomposed with a less velocity.—*Abhandlungen der mathematisch-physischen Classe der Königlich Sächsischen Gesellschaft der Wissenschaften. Leipzig*, 1856.

2. *On Boron.*—Wöhler and Deville have published the results of a very interesting investigation of this substance, which proves like carbon to have at least three allotropic modifications, two crystalline and one amorphous. The first of these modifications is the diamond-like boron which crystallizes in complicated aggregations of numerous small crystals,

the form of which has not yet been determined. These crystals are sometimes garnet-red and sometimes honey-yellow; the color however does not appear to be essential and may arise from slight impurities. The crystals have a lustre and refractive power like that of the diamond. They scratch corundum with the greatest ease and appear to be almost, if not quite, as hard as the diamond itself. Crystallized boron resists the action of oxygen even on strong heating, but at the temperature at which diamond burns, boron oxydizes superficially. Chlorine acts powerfully on boron which takes fire at a red heat in an atmosphere of the gas and burns to gaseous chlorid of boron. No acid acts upon boron, but acid sulphate of potash at a red heat reduces it, sulphurous acid being evolved. Hydrate and carbonate of soda oxydize it slowly at a red heat, but saltpeter has no action at this temperature. The preparation of crystallized boron is as follows: 80 grm. of aluminum in thick pieces are fused in a crucible of carbon with 100 grm. of fused and pulverized boric acid. The carbon crucible is placed in one of graphite, the interstices being filled up, and the whole heated in a wind furnace to the temperature at which nickel melts, for five hours. The crucible after cooling is found to contain two layers, of which one consists of boric acid and alumina, the other of alumina penetrated with crystallized boron. The metallic layer is heated with boiling soda lye to dissolve the aluminum, then with muriatic acid, and lastly with a mixture of nitric and fluohydric acids. The boron so obtained contains small plates of aluminum which can only be removed by mechanical means.

The second modification is the graphitoid boron which is best obtained by heating fluoborate of potassium with aluminum. Small masses of boron-aluminum are obtained, which on solution in muriatic acid leave the boron in small plates, often hexagonal and having the form and lustre of native graphite and graphitoid silicon. The plates are always opaque. Amorphous boron is best prepared by heating a small piece of aluminum with a large quantity of boric acid, purifying the product as above. It is a light chocolate-brown substance, possessing all the properties described by Berzelius, Gay Lussac and Thenard. The authors conclude that boron resembles carbon more closely than silicon.—*Ann. der Chemie und Pharmacie*, ci, 113. W. G.

3. *Notice of a supposed new case of Fluorescence;* by Prof. J. W. Mallet, (Communicated.)—A solution of thionurate of ammonia was boiled with muriatic acid for conversion into uramile. The solution after boiling exhibited very distinctly the phenomenon of "fluorescence" or "true internal dispersion" of Stokes. The modified light emerging from the liquid was of the same beautiful pale blue tint as that observable with solutions of quinine—most distinctly observable in the case of the mother liquor from which crystals of Herapath's iodo-disulphate of quinine have separated, a very little of which mother liquor suffices to render a large quantity of water fluorescent.

University of Alabama, Feb. 16, 1857.

II. GEOLOGY.

1. *Volcanic Action on Hawaii;* by Rev. T. Coan, (letter dated, Hilo, Oct. 22, 1856.)—During the whole of the past year, Lua Pele, (Kilauea) has been getting more and more profoundly asleep. A little sluggish lava is found in the great pit of Halemaemae (the old lake in the southeast part of the pit) and the steam issues from a thousand vents. But there is no subsidence of the floor of the crater. This vast area of hardened lavas keeps its elevation some 600 feet above the level of the floor that was formed at the eruption of 1840. * * *

I will now speak of the present eruption from Mauna Loa, which I have visited seven times, with ample opportunities for observation, besides enquiring of scores of other visitors. The apparent facts are these.

A fracture or fractures occurred near the summit of the mountain, which extended in an irregular line from the terminal point, say five miles down the northeast slope of the mountain. From this serrated and yawning fissure, for two to thirty yards wide, the molten flood rushed out and spread laterally for four or five miles, filling the ravines, flowing over the plains, and covering all those high regions, from 10 to 100 or 200 feet deep. Along this extended fissure, elongated cones were formed at the points of the greatest activity. These cones appear as if split through their larger diameter, the inner sides being perpendicular or overhanging, jagged, and hung with stalactites, draped with filamentous vitrifactions, and encrusted with sulphur, sulphate of lime, and other salts.

The outsides of these caves are inclined plains, on an angle of 40° to 60°, and composed of pumice, cinder, volcanic sand, tufa, etc. You will not, however, understand that these semi-cones were once entire, and that they have been *rent.* They are simply masses or ridges of cinder and dross deposited on each side of the fractures where the action is greatest, and where the greatest amount of fusion has been ejected. These ridges or scorified heaps and their substrata, together with the immense fields of refrigerated and uneven lavas for miles around, were all produced by ejections or *overflowings* from the fissures mentioned. *It is all a new deposit.*

While these immense floodings were going on laterally around the volcanic vents, incandescent streams were, of course, winding their way down the side of the mountain. These fiery streams, when united, formed a river some three miles wide on the side of the mountain, and in the plains at the base of the mountain it spread into a lake or sea, from five to eight miles broad. Again it narrowed to two or three miles and went into the woods, winding its way through the thicket, contracting and expanding, and eating the jungle till it came within five miles of Hilo. Now, after you leave the region of open fissures, near the summit of the mountain all below *appears to be a flow on the surface.*

1st. We can *see* no chasms or fractures except those always found in the surface flows. There is no visible evidence that the old substrata had been fractured, except on the higher regions of the mountain.

2d. Where there is a throat extending down to the fiery abyss below, there will, we think, always be a column of smoke and gaseous vapor ascending to mark the spot, so long as action continues. This is true of

Kilauea, and it is also true of *all* the eruptions I have noticed. Now if you were in Hilo, you would see a continuous volume of smoke ascending from the terminal point and another from the terminus of the stream —separated in a direct line forty miles, and by route of the flow seventy miles—while between these extreme points you see no smoke and have no evidence of fire* beneath, except the radiation of heat as you pass up, or cross and recross this immense stream of solidified lavas. The smoke at the fountain is *mineral*—that at the end of the stream is from *vegetation*, and *only* here the fusion now makes its appearance, pressing on its way into the woods—having come, as I believe, all the way from the mountain *under cover*, without showing itself at a single point. I do not mean that it has *tunneled* the mountain, or melted a lateral duct through its mural sides. The process is thus: lavas flowing on the surface and exposed to the atmosphere, unless moving with great velocity, as down steep hills, soon refrigerate on the surface, as water freezes first on the top. This hardened surface thickens, until it extends downward 1, 10, 50, 100 or 200 feet, as the case may be. Under this superstratum the lava remains liquid, the hardened cover protecting the fused stratum from the refrigerating influence of the atmosphere, and thus facilitating its longitudinal or lateral progress. Consequently, at the termini, and sometimes along the margins of the hardened streams, you see the fusion gushing out in red lines and points, and in irregular masses; and, where the ground is not steep, pushing sluggishly on, like the creeping of a slug, or by paroxysmal throes. When lavas refrigerate through the whole stratum, and thus rest upon an ancient or previous formation, they form dams, or obstructions, which divert the stream of lava from above, unless this obstruction is lifted, broken up, tilted or overflowed by fresh supplies of lava. Down the steep sides of the mountain such obstructions occur more rarely; consequently, after a few days of wide spreading over these high regions, and when the superficial hardening process is completed, the lava ceases to reach the surface, either at the fountain or down the sides of the mountain, but is confined to channels, mostly covered with fresh, solidified lavas—where it finds a free and rapid passage to the plains below. Here the movement is slow, the obstructions more numerous, and the force to overcome them less potent. This accounts for the spreading laterally, the upliftings, the tiltings, the vertical gushings, the submergings, the fractures, pits, domes, ridges, little cones, and the ten thousand irregularities which diversify the ever changing surface of lava streams, while the fusion is struggling to work its passage, or to keep open its ever choking channels below, i. e. between its own crust and the former surface of the earth. I have seen a dome, some 300 feet in diameter at base, raised 100 feet high, and split from the summit in numerous radii, through which the red and vicid fusion was seen; and I have mounted to the top of such a dome, in this state, thrust my pole into the liquid fire and measured the thickness of its shell, which was from two to five feet. Now this dome, which

* This has been the case for some eight months. At first the whole ridge of the mountain was lighted with fusion on the surface. When the hardening and blackening process had progressed, light was seen at a few points only on the slope of the mountain. Afterwards no fire was seen except at the end of the stream near Hilo.

may be represented by an egg standing on its larger end, was full of liquid lava, visible and tangible, through the cracked shell of which you could thrust a pole to great depth into the fusion. This dome, with thousands of similar ones, of various sizes, was formed simply by hydrostatic pressure. This force, and that of vapors formed by the combustion of vast quantities of trees and other vegetable matter, submerged by the mineral river, produce the marvellous and mighty effects seen on the surface of the lava stream. Wherever vegetable matter is being consumed, there is smoke; when this is exhausted, there is none. Consequently I argue that there are no fissures extending to the central fires of the earth, except for a few miles near the summit of the mountain.

3d. Again, and what is more reliable, I have surveyed the ground upon which lava streams have been approaching, for distances of five, ten, fifteen, or twenty miles, and have seen the burning flood move on, covering to-day, the ground on which I travelled yesterday, and consuming the hut where I slept; and the process is so familiar, that it is difficult to see how I can be mistaken. It is as if you poured millions of tons of pitch upon a mountain, and stationed men in front and on the sides to mark its flow. Or it is as if an enormous water fountain opened on an Arctic mountain, congealing as it flowed and covering the whole region with accumulating glaciers. Calculate for the greater consistency of yonder mineral liquid and you may account for the varied phenomena.

I *think* that this stream of lava is *now flowing* more than 60 miles longitudinally, under its own refrigerated cover; but I may be mistaken. No fire is *seen* any where except near the end of the stream. Here it still pushes out and spreads and heaps with little abatement, while the great mountain furnace sends up large and continuous volumes of smoke. A wonder this, and a problem for geologists. The preservation of Hilo is marvellous.

2. *Geological Survey of Wisconsin;* (communicated by I. A. Lapham.)—The legislature of the State of Wisconsin at its late session appropriated $36,000 to be expended under the direction of Professors James Hall, E. S. Carr and E. Daniels in continuing the Geological Survey of that State. In addition to the geology proper, they are to examine, analyze, and classify the soils and subsoils, with a view to ascertain their adaptation to particular crops, and the best method of preserving and increasing their fertility; also to collect the soils, native fertilizers, cultivated and other useful plants (as well as the rocks, minerals, &c.), and deposit them in the rooms of the State University at Madison, to constitute a museum of practical and scientific geology.

3. *On the Reactions of the alkaline silicates;* by T. Sterry Hunt.—(From a letter to J. D. Dana, dated Montreal, April 2d, 1857.)—I have lately been engaged in studying the reactions of the alkaline silicates with the carbonates of magnesia and iron. We have long known that carbonate of lime and alumina have the power to remove silica from a solution of soluble glass; and I find that when a mixture of silica and carbonate of magnesia is boiled with carbonate of soda, the silicate of soda at first formed is decomposed by the magnesian carbonate and the regenerated carbonate of soda is enabled to dissolve a new portion of silica, the result being a silicatization of the magnesia through the intervention of the alkali.

With soluble silica (as prepared by igniting the silica from the decomposition of an alkaline silicate), this reaction is very rapid, and even when pulverized quartz is boiled for several hours with carbonates of soda and magnesia, a large amount of magnesian silicate is formed. If we substitute proto-carbonate of iron and boil it with soluble silica and carbonate of soda, there is formed a hydrous silicate of the protoxyd permanent in the air.

It will be apparent that by virtue of the power of earthy carbonates to decompose an alkaline silicate, and that of the regenerated carbonate of soda to dissolve silica even in the form of quartz, a small amount of alkali may effect the combination of a great quantity of silica with earthy bases.

Suppose a solution of alkaline silicate, which will never be wanting among sediments where feldspar exists, to be diffused through a mixture of siliceous matter and earthy carbonate, and we have with a temperature of 212° F. and perhaps less, all the conditions necessary for the conversion of the sedimentary mass into pyroxenite, diallage, serpentine, talc, rhodonite, all which constitute beds in our metamorphic strata. Add to the above the presence of aluminous matter and you have the elements of chlorite, garnet and epidote. We have here the explanation of the metamorphism of the Silurian strata of the Green Mountain range, and I believe of rock metamorphism in general.

I have just communicated a detailed account of my investigations to the Royal Society of London, and will soon furnish you with farther observations.

III. BOTANY.

1. *Musci Boreali-Americani, sive Specimina Exsiccata Muscorum in Americæ Rebuspublicis Fœderatis detectorum, conjunctis studiis* W. S. Sullivant et L. Lesquereux. Columbi Ohioensium; sumptibus auctorum, 1856.—The importance of authentically named specimens, in the study of Cryptogamous plants especially, cannot be over-rated; and among the Mosses, distinguished as so many species are by nice characters, very difficult to be expressed in words, the student cannot really get on without them. The present publication of specimens will therefore be eagerly welcomed and much sought after, alike by students just entering upon a charming branch of botany, and by our more advanced cultivators of Bryology. For the latter, the simple announcement of the publication of this collection is sufficient. For the benefit of those not so well informed upon the subject, we may state, that the value and importance of these sets of specimens are greatly enhanced by the fact that they have been all studied and named by the author of the Muscology of the United States (east of the Mississippi), comprised in Gray's *Manual of Botany* (the only book in which our Mosses are described at all),—aided by his excellent coadjutor, M. Lesquereux,—that they are accordingly specimens of *the very things* described in that work; and that the sets are so complete that they comprise almost all the species of Musci (or true Mosses) contained in the Manual. On this account, as well as on account of the care with which the specimens have been selected, and their general copiousness, we may be permitted to say that these published sets are unsurpassed, if not wholly unequalled, by any previous muscological collection ever issued. The numbers on the printed

tickets extend to 355; but the many intercalated numbers (e. g. 10^b, 10^c, 100^b, 100^c, 100^d, etc.) raise the total to about 416 species or marked varieties. The specimens are mounted on small pieces of white paper to which the printed label is affixed, and laid in folded sheets of brown paper of folio size; a title page and complete Index of names and synonyms, filling two folio sheets, are appended, and the whole placed between strong covers bearing an additional title, tied up so as to form a convenient portfolio. Additional specimens of fully half the species are added to each set, left unattached, for more convenient examination, but enclosed in paper capsules, bearing the number to which each belongs: and it should be noted that these enclosed specimens are generally more perfect and choice than those which are glued to the paper. The proprietors, according to their fancy, may keep the specimens as they are, or may mount them in any way they prefer, and bind them in one or more folio volumes. The price of the sets, having before publication been announced at \$20, when it was supposed that the number of specimens would hardly reach 350, has not been raised; but it probably must be somewhat increased after the sets now in readiness are taken up. They are put up by Mr. Leo Lesquereux, of Columbus, Ohio, and sold by him, to recover a portion of the expense of collection and preparation. (Purchasers may likewise order sets through Prof. A. Gray of Cambridge, Mass.) That the spirit of the authors may be appreciated, we venture to mention,—at the risk of violating a confidential communication,—that the sets of this collection (supposing the whole edition to be demanded) have each cost in actual outlay about twice as much as they are sold for. A. G.

2. *Fungi Caroliniani Exsiccati;* by H. W. Ravenel. Fasc. IV.—The general remarks made upon Fasc. III. of this Collection will very well apply to this. In fullness, neatness, and general accuracy, it is equal to the preceding Number, and offers to Mycologists a very interesting century of North American Fungi. There are about 65 species exclusively American, besides *Trichocoma paradoxa*, Jungh., previously known only as an East Indian species. We might perhaps question a few of the species, but it would not be well to designate them without a more careful comparison than we have been able to make. Occasional errors are to be looked for in a work of this kind, and will be readily pardoned by all who are familiar with this obscure order of plants. They will doubtless be rectified in a critical Index of some future fascicle. We remark, in correction of our notice of fasc. III, that *Polyporus dealbatus* of that collection (which, in consequence of a temporary confusion in our Herbarium, we referred to *P. luteus*, Nees), is *P. mutabilis*, Berk. and Curt.; as Mr. Ravenel had himself suggested to us before publication. M. A. C.

3. *First Lessons in Botany and Vegetable Physiology*, illustrated by over 360 wood engravings, from original drawings, by Isaac Sprague: With a Glossary or Dictionary of botanical terms; by Professor Asa Gray. New York: G. P. Putnam & Co., and Ivison & Phinney. 1857.—Good elementary books in any branch of science are rare, while poor compilations are common enough. In the department of Natural History, for example, nothing is more easy than to gather from all quarters a mass of crude materials, and with the aid of old plates and drawings, suited only to a different latitude and designed for another purpose,

to make up cheap books, to the great profit of compiler and publisher, and the great loss of the young in whose hands no works except those of the highest character should be placed. Indeed, a good text-book of science, like a picture or a poem, is a work of art, the creation of which requires extensive knowledge, abundant resources and a generous and enthusiastic love of nature. And, even where these exist, none but a master can rightly sieze the leading facts and principles and exhibit them in language at once precise, clear and simple—can be brief without being obscure and thorough without being prolix—can so fashion his teachings as to charm the youthful mind and lead it on imperceptibly into the very heart of the science—can furnish fresh and original illustrations of familiar objects in drawings and engravings, and give them that perfect accuracy which only an eye trained to a close scrutiny of forms can fully appreciate. Hence really excellent elementary books are rare indeed.

There is a special satisfaction, therefore, when these requisites are fulfilled, as is true in the case of the "First Lessons in Botany and Vegetable Physiology" from the pen of Dr. Gray. It is a model of its kind; and meeting a want long and widely felt, it must sooner or later win its way into all our schools and seminaries of learning. After a chapter on the general relations of the science, it treats of the growth of the plant from the seed,—the nature of roots, stems and leaves,—the arrangement of the leaves, structure of the flower and functions of the several parts,—the fruit—vegetable tissues and the process of growth, or nutrition and circulation—the permanency of species—classification;—and closes with practical instruction on the best method of studying and collecting specimens and making herbaria. It comes to the beginner as a pleasant and easy stepping-stone to the larger "Botanical Text-Book," and from either, the student passes over to the "Manual of the Botany of the Northern United States," prepared to study our wild plants with advantage. Two impressions of the latter work have been lately published, one at a lower price than the other, for the express use of colleges and schools, the little studied portion on the Mosses and Liverworts being omitted for the sake of cheapness and convenience. Considering the intrinsic value of these books, the great care, labor and talent which have been devoted to their preparation, the good style in which they are published, and the great number and excellence of their illustrations (from drawings by Mr. Sprague), the wonder is, that they can be sold at so moderate rates. We trust that they may meet with a circulation, proportioned to their real merit. T. C. P.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

Correspondence of M. Jerome Nicklès, dated January 3, 1857.

1. *Electric illumination.*—A few weeks since, some experiments on electric illumination were made at Paris, surpassing all that had before been done. The success was due to an electric regulator invented by MM. Lacassagne and Thiers, called by them an *electro-metric* repeater. It is complicated in structure and cannot well be described here. The inventors placed four of their electric lamps on the platform of the Arc de Triomphe de l'Etoile, and projected the light one day on the Champs

Elysées, towards the Place de la Concorde, and a second on the avenues of Neuilly or de l'Impératrice, the change having been made because of the numerous gas lights of the Champs Elysées. These gas lights were made to look dull and smoky, yet diminished the effect of the electric light; but in the avenues of l'Impératrice the light presented intense brilliancy.

Each lamp was sustained by means of sixty of Bunsen's pairs, and furnished with a spherical reflector of metal, or of glass silvered by a battery in the manner described beyond.

2. *New Battery with a constant current.*—For some time a battery has been known having an improvement for economizing the residues. It was invented by Mr. Doat, an amateur of Alby (Department of Tarn). In this battery, the zinc is replaced by mercury, the acidulated water by iodid of potassium; the nitric acid or sulphate of copper of the batteries with two liquids, by iodine dissolved in the iodid of potassium, and which, put in to excess in the solid state, serves to maintain constant action. Carbon is employed as the negative pole. A square trough of gutta percha contains the mercury and the alkaline iodid. The carbon and the iodized iodid are put in a square porous cup which is immersed in the liquid of the trough to two centimeters above the level of the mercury.

This battery once in action, requires no other care than that of drawing off with a glass siphon the liquid saturated with iodid of mercury, which is to be restored to its primitive elements. We shall soon explain the method of restoration. The couple, as it was presented to the Academy of Sciences by Becquerel, possessed a feeble electro-motive force. It was but little stronger than a couple with sulphate of copper, and only one-third that of a couple with nitric acid. Its force was such that for a trough of about five decimeters square, and with a thickness for the bed of iodid of potassium of about three centimeters, it was equivalent to ten meters and a half of annealed copper wire one millimeter in diameter, this wire being at 0° C. in temperature.

The process adopted by Mr. Doat for economizing the residues admitting of some improvement, he has made changes which have increased the power of his batteries. The main point consists in substituting zinc amalgam for mercury; he obtains thence iodid of zinc, and the restoration of this compound to its elements, which at first appeared difficult, he has rendered easy by using a hydrated carbonate of copper. Whilst the soluble salts of oxyd of copper in reacting on the alkaline iodids precipitate only one-half, the basic salts, and especially the carbonate, exercise hardly a sensible action on the alkaline iodids, but act with the greatest rapidity on the alkalino-earthy or metallic iodids, and eliminate the whole of the iodine, the oxyd passing to the state of a suboxyd, and the metal combining with the iodine becoming oxydized. This action, which goes on rapidly at the ordinary temperature, is instantaneous at 50° C.

On the flat carbon pole, there is placed a broad filter of porous earth, containing hydrated carbonate of copper. When the battery has been for a while in action, the liquid, consisting of double iodid of zinc and potassium, is drawn from the troughs and thrown upon the filter, where it is decomposed by the copper salt. The alkaline iodid remains pure and the iodid of zinc is changed into an oxyd of this metal, whilst the iodine set at liberty is dissolved in the alkaline iodid, and passes with it through the filter and falls upon the carbon pole. Thus the processes for recovering the iodine requires only the drawing off the liquid and putting it in a filter charged with hydrated carbonate of copper. The products left on the filter are oxyd of zinc and carbonate of copper. They are mixed with charcoal and fused at a red heat. The result is a brass always in demand in commerce. The hydrated carbonate of copper is prepared by double decomposition by means of sulphate of copper and carbonate of soda. The latter is the only product which is lost: all the others, the iodine, iodid of potassium, mercury, zinc and copper, are re-obtained and may serve again in the battery or be useful elsewhere.

Mr. Doat does not perform the reduction of the zinc and copper except when it can be done on a large scale; for he then obtains a casting of brass, of greater commercial value.

3. *A Battery, called a Battery with triple contact.*—One element of this battery consists of a glass or stone ware cup, at the bottom of which there is a plate of non-amalgamated zinc communicating without by means of a conducting strip. Above the plate of zinc there is a spiral formed of a rolled copper plate having an attachment for making connections. A solution of sulphate of potash covers entirely a plate of zinc, and wets to a certain height the plate of copper. Immediately on making the connections between the copper and zinc, an electric current is established which continues constant for several weeks.

The inventor of this battery is an Italian, Francesco Selmi, Professor of Chemistry in the University of Turin. The novel and important point of it is the triple contact, viz. between the sulphate of potash and zinc, the sulphate of potash and copper, and between the copper and the air. Prof. Selmi has observed that there is a great advantage in this contact of the air with the copper immersed in the sulphate of potash, finding that the electric current is sensibly weakened when the copper is wet throughout.

4. *Nautical Telegraph.*—In place of the common light used as a beacon and for signals aboard ships, Mr. Trève proposes to substitute a simpler system more easy of execution. It is based on the use of illuminating gas light by a galvanic current of induction. The lamp at the mast head receives the gas through a tube of vulcanized caoutchouc having a spiral of copper wire within, and covered exteriorly by some impermeable material; it terminates on the deck where the gasometer is placed. By stop-cocks, the gas can be let in at will. A Ruhmkorff's apparatus* is used for inflaming the gas; two wires covered with gutta percha pass to the upper lamp. These wires branch off and are attached to the shank of each of the other lamps; and are so arranged as to give a spark at the beak of each burner. As the light will take place only at the beaks supplied with gas, the lights may be varied for signals by means of stop-cocks, any or all of the lamps being lighted or extinguished at will.

5. *Light-houses and Illumination.—Lenses and Reflectors.*—It is well known that Buffon, desirous to repeat the experiment of Archimedes with a burning glass, endeavored to construct a lens of water of large diameter.

* See this Journal, Jan. 1858, p. 114.

Two plates of glass of great thickness were curved by the heat of a concave metallic plate, worked and polished, and then fitted together with a border of metal and filled with distilled water. Buffon thus made a lens one meter in diameter and of great power. But he pursued it no further, because of the difficulty of the work, and the enormous expense of polishing the rough surfaces of the glass, the material being also rendered brittle by the second heating.

Since then, in England and more lately in France, there have been attempts to blow a glass lens in a mould of metal made in two halves. But the result has been imperfect, the glass uneven, giving no distinct focus. There has however been a recent improvement by Messieurs Lemolt and Robert, which is of great importance. It consists in using for constructing the lenses, a circular plate of glass, and a section from a sphere blown with great care, applying this to the plate and closing them together in a circle of metal, and putting water between or some other transparent liquid. It forms a plano-convex lens, which may be economically made, and has the purity and perfection nearly, without the cost, of lenses of massive glass.

Lemolt and Robert have also made improvements in reflectors, employing sections of glass more or less concave, cut from a sphere, in the same way as above mentioned, and having on the convex part a rich plating of silver from electric deposition. These reflectors can be cheaply made and require little care.

Lenses and reflectors of this kind have been used on the railroads of Paris. By combining the two, a new kind of lamp has been constructed, giving results of unexpected brilliancy, which have already been brought into use on board ships and at the entrances of ports as well as on railroads. A water lens of 38 centimeters will send its rays to a distance of 20 kilometers along a railway, producing the effect of a light-house light of the second order.

6. *Manufacture of Soda.*—Mr. Melsens, Professor of Chemistry at Brussels,—known for his works on chemistry and also in connection with the preparation of anhydrous acetic acid by means of bi-acetate of soda, the production of the chlorated bodies by means of an amalgam of sodium, etc.,—has patented a new method for the manufacture of soda, a process of great importance, if it be economical. It is based on the well known fact of the decomposition of sulphate of soda by carbonate of baryta. An equivalent of the former with one of the latter produces two-thirds of an equivalent of each carbonate of baryta and sulphate of baryta; one-third of an equivalent of each carbonate of baryta and sulphate of soda remaining unaltered.

Melsens has observed that the change will go on in the cold and with native carbonate of baryta, and this is the basis of his method.

This carbonate is powdered and subjected to a washing by means of a solution of sulphate of soda. This mode of washing, for a long time practised in the arts, enables him to obtain the carbonate of soda in a state of considerable concentration. Some little sulphate of soda however remains, which may be separated either by crystallization or by taking advantage of the fact that sulphate of soda is more soluble in water at 33° C. than in boiling water, it precipitating when the water is carried to the boiling point. The purification is finished by putting the liquid in contact with a solution of carbonate of baryta in carbonic acid. Mr. Melsens has also endeavored to decompose the carbonate of baryta and sulphate of soda by using high pressure furnished by a self-regulating machine. But no advantage has been found in this process.

As the carbonate of baryta is poisonous, it is proposed to pulverize it after moistening it with a solution of sulphate of soda. The sulphate of baryta obtained in the process is employed either in the manufacture of paper, or for paints, this last a use not honest perhaps, but yet, in these days, of extensive application.

7. *Astronomical News.—Paris Observatory.*—The observatory at Paris continues to make progress. It is well known that it has two wings, an eastern and a western; on the former, in the time of Arago, a revolving chamber for observation was constructed, whose mechanism is a chef-d'œuvre. The western wing is about to receive a telescope of the largest dimensions, at the expense of the government, and also an equatorial with a 11-inch aperture, constructed by Secrétan.

The objective of the telescope will be constructed with two disks of flint glass and crown glass, cast in the glass house of Chance & Co., Oldbury near Birmingham, which were on exhibition at the Crystal Palace in Paris. These glasses were imperfectly appreciated by the jury, for it was thought that after extracting certain portions that were not perfectly transparent and remelting them several times, they would not afford an objective over 40 centimeters in diameter. They were however deemed irreproachable and were purchased for 50,000 francs; and it is now expected that the objective made from them will have a diameter of 73 centimeters. The work will be carried on at the observatory by M. Secrétan. If the curvature obtained be perfect, the achromatism without fault, and the expected size be attained, France will have the most powerful lens in the world.

8. *Color of the Moon during eclipses.*—Prof. Faye, of the Faculty of Sciences at Nancy, observed a fact during the last eclipse of the moon, which serves to explain the peculiar color assumed by the moon when under the shadow of the earth. By covering the part not eclipsed by a distant object, such as the angle of a roof or the top of a chimney, the tint of the part eclipsed is entirely changed, and in place of a reddish-brown there is seen only a lively rose-red, like that which is so common on clouds near sunrise or sunset and which gave origin to the epithet rosy-fingered (ῥοδοδακτυλος) applied to the dawn. The color seen ordinarily in case of eclipse is consequently an effect of contrast, due to the usual yellowish shade of the moon's light.

9. *Works of Arago.*—The third volume of the Popular Astronomy has just appeared and is on sale with the first and second. While the second volume contains a fine study on the sun illustrated with five plates of the solar spots, and a treatise on comets followed by a catalogue of all that have been calculated to the number of nearly 200, the *third* takes up the subject of the earth and its satellite. The earth is described not only astronomically, but also with reference to its geology, meteorology, physical geography, and even history; and under these heads it treats of the age of mountains and volcanoes. It also discusses the question

whether the deluge was produced by a comet,—whether the moon was once a comet,—whether the moon has an atmosphere or water,—what influence has the moon on the earth's atmosphere, and what on animated life and especially certain diseases,—and the subject of *prognostics.* The volume closes with an article on eclipses and occultations. The work contains many drawings, and a fine map of the moon, and also an engraving representing the meridian telescope of the Paris Observatory. The *fourth* volume will soon be issued.

10. *Influence of Temperature on the phenomena of Capillarity.*—The influence of temperature on capillarity, considered null by some authors, is still real. Lalande was the first to announce it, in 1768; he showed that water did not stand as high when it was hot, or when the tube had been heated before making the experiment. Laplace and Poisson deduced from it that the height had some relation to the density of the liquid. Emmett, Frankenheim, Sondhauss, Frankenberg, Brunner, Jurin, Gay Lussac, Simon de Metz, Bède, Professor at the University of Liège, have each treated of this question, and from their results a wide divergence has been brought about between mathematical theory and experiment, and a complete separation of the phenomena of ascension and depression.

All these questions have been taken up from their foundation and definitely resolved by the laborious researches of M. Wolf, Professor of Physics at the Lyceum of Strasburg, which have been continued through several years. The following are the facts arrived at:—

(1.) The elevation of the same liquid in capillary tubes depends, other things equal, on the nature of the tube.

(2.) In the same tube, at different temperatures, the height to which a liquid rises is in the compound proportion of the density and the curvature of the meniscus; this diminishes as the temperature increases and becomes null at some specific temperature beyond which, the action is the reverse. The law of variation of pressure with the temperature for liquids which do not wet the glass, thus connects with the law of diminution of capillary elevation, and becomes a consequence of it. For if, at a given temperature, a liquid ceases to wet the glass, beyond this temperature the liquid takes a convex surface and depresses itself; whence it follows, that liquids like mercury not wetting the glass at the ordinary temperature, can wet it at a temperature quite low, and so present under the action of cold the same series of phenomena which ether presents under that of heat.

11. *Harmonic proportions of the human body.*—This subject interests both men of science and artists. It has often been objected to the metric system that it had no point in common with the human body, and differed thus widely from the older systems. M. Silberman has undertaken to demonstrate that the meter may also be found on the body of man.

At the introduction of this system, it was remarked that a cane a meter long, resting on the ground between the feet, would reach quite nearly to the height of the navel. By noting the discrepancy by the breadth of the fingers, each one may thus have his own meter measure with him.

M. Silberman, from the many measurements that have been made, concludes that the mean height of man is 1·64 meters. Buffon makes the height of woman one-twentieth less, so that the mean of both sexes will be 1·60 meters, and of woman 1·56 meters.

The size of man is often expressed by the number of heads it equals; and in a person well proportioned it corresponds to 8 heads. The mean height of the head will consequently be 20 centimeters. Mr. Silberman has observed that when the arms are thrown up vertically, the height of the body to the tip of the middle finger is 10 heads or 2 meters, and two men in a line, would make 4 meters. He remarks that this length of 4 meters or 20 heads plays an important part in nature; and after various observations, he has arrived at a number of laws as to the proportions in the human body. Thus the distances of the articulations are successively, $\frac{1}{3}$, $\frac{1}{9}$, $\frac{1}{27}$, $\frac{1}{81}$, $\frac{1}{243}$, &c. [The account is not sufficiently explicit to make it clear how or where these proportions are all obtained.] Silbermann states that the results he has arrived at accord with those of the ancients, who paid much attention to the subject. It is generally admitted for example, that in a well proportioned man, when both arms are extended horizontally, the distance between the tips of the fingers, is just equal to the total height of the man. Another fact, mentioned by Vitruvius, as a test of perfection of form, is this: that the circle which passes by the extremities of the four members extended in a cross, should have the navel as the center. These facts are confirmed by M. Silbermann.

12. *Bibliography.—Astronomie Populaire d'Arago*, vol. iii, and *Notices Scientifiques*, vol. iii. Paris. Gide et Baudry.—The first of these works we have noticed. The second work treats of light-houses, fortifications, artesian borings, filtration and elevation of water, free exchange, protection and patents.

Victor Masson has issued—

Etudes Biographiques pour servir à l'Histoire des Sciences, by Paul Antoine Cap. 1 vol. 12mo, of 408 pages.—This work is the first part of a series of biographical notices of chemists and naturalists. The volume issued, treats of Paracelsus, Palissy, Van Helmont, Moses Charas, Robert Boyle, Lemery, Rouelle, Van Mons, Labarraque, Bernard Courtois, Dupasquier, etc. The notices are well written and in an agreeable style.

Hydrotimétrie, ou Nouvelle Méthode pour déterminer les proportions des matières en dissolution dans les eaux de sources et de rivières, by MM. Boutron and Boudet. Pamphlet of 52 pp. 8vo.—Starting from the precipitation of calcareous salts by soap water, a reaction applied first by Clarke to the determination of lime, MM. Boutron and Boudet have contrived a quick method for ascertaining by means of a few trials the essential composition of a potable water. It is performed by means of standard solutions, and is simple, requiring little chemical knowledge.

L'Ozone, ou Recherches chimiques, météorologiques, physiologiques et médicales sur l'oxygène électrisé; by H. Scoutetten, "Médecin en chef" of the hospital at Metz. 1 vol. in 12mo, of 287 pages.—Dr. Scoutetten has attached his name to the subject of ozone by many important observations. His work commences with a historical review. The importance of the subject and the great number and variety of papers that have appeared upon it had rendered it very desirable that a collection of these materials should be made in one volume. Dr. Scoutetten has undertaken this labor, and has given a succinct account of all the results that have been published.

At BAILLIÈRE's, Rue Hautefeuille, Paris, has just appeared—*Etudes sur la géographie botanique de l'Europe et en particulier sur la végétation de plateau central de la France*, par M. LECOQ, Professeur à la Faculté des Sciences of Clermont.—This work, of which we have before spoken, is now at its 5th volume. No better writer on the geological or botanical description of the Central Plateau of France could be found than M. Lecoq, as he has there pursued his studies for thirty years. The 5th volume treats of a large number of the Dicotyledonous families, from the Papaveraceæ to the Leguminoseæ, including the Cruciferæ, the Polygaleæ, the Malvaceæ, etc. J. NICKLÈS.

13. *First Comet of* 1857, (Astr. Jour., March 31.)—A comet was discovered by Prof. d'ARREST, of Leipzic, February 22, 1857, its place then being at $16^h\ 40^m$ (Leips. m. t.) R. A. 320° 37′, and its N. decl. 22° 4′. The same comet was also detected on the 26th of March, by Mr. Van Arsdale at Newark, N. J., who describes it as bright and resembling an unresolved star-cluster. From observations of Feb. 22 and 25, Mr. Pape deduced the following elements.

March 14·088 Berlin m. t.	
Long. of perihelion,	197° 0′·4
" " asc. node,	323 31·7
Inclination,	87 6·2
Log. perih. dist.	9·82586
Motion,	retrograde.

14. OBITUARY.—*Prof. Jacob W. Bailey.*—In our last number we had the melancholy duty of announcing the death of Mr. W. C. Redfield, the meteorologist; and before another month had elapsed, two more men from the ranks of science, highly esteemed for their excellence of character as well as successful labors, had passed away,—Prof. BAILEY of West Point, and Prof. TUOMEY of Alabama.

Prof. Bailey had long been failing under a relentless consumption, and finally died on Thursday, the 26th of February last. For many months his voice had been reduced to a whisper; yet his mind was active, and as late as our last number (March), we published a contribution to science from him, as the result of his recent microscopic researches. Feebleness of health prevented his being present at the meeting of the American Association at Albany in July last. But the Association in view of his high attainments and valuable researches, elected him President for the following year,—an honor well merited; for few men in the land have exerted a wider and more beneficial influence on the science of the country.

Prof. Bailey, although a proficient also in chemistry, mineralogy, and botany, had been especially devoted to microscopic research, and with the exception of what Ehrenberg has done, the microscopic geology or "micro-geology" of this country has been mainly worked out by him. His first communication to this Journal, was published in 1837, and although chemical, it indicated that delicacy of manipulation which fitted him for microscopic researches. It related to the use of grasshoppers' legs as a substitute for frogs in galvanic experiments. In volume xxxv. (1839), commence his papers on fossil Infusoria, which were continued through many of the following volumes, down to the current year, and are too well known and appreciated to require remark at this time. The Continent along its Atlantic and Pacific borders and over its interior has passed under his microscope, and delighted him with many beautiful forms of life which had never before greeted a human eye. And lately, the ocean's bottom in the Atlantic to a depth of 12000 feet, and about the North Pacific to 16000 feet, has developed wonderful facts before his investigations. Prof. Bailey has also done a vast deal towards raising the standard of microscope manufacture through his discriminating use of tests, and his influence. His scale for microscopic slides by which the positions of the invisible specimens are exactly noted, is a happy thought well carried out. In these and various other ways, microscopy is vastly indebted to his labors. Mr. Bailey at his death was Professor of Chemistry, Mineralogy and Geology in the U. S. Military Academy at West Point. His life without reproach, his gentleness and modesty, his earnestness for truth rather than self, his untiring energy even when his physical system seemed to be dissolving away from his spirit, make a character that excites love as well as admiration.

Prof. Tuomey.—Prof. M. Tuomey died at Tuscaloosa on the 30th of March last. He had been one of the active geologists of the Southern States, and among them had taken the lead through his researches and publications. In 1844 he was put in charge of the Geological Survey of South Carolina, and four years afterward published his final Report in a large quarto volume. The Report treats of the various crystalline rocks and their metalliferous veins or ores, and dwells at length on the Cretaceous and Tertiary beds which had been with him more special subjects of study. In his survey, he brought out many facts of prominent interest, illustrating important principles in the geology of the continent and the history of seashore deposits.

The state of South Carolina is remarkable geologically for containing nothing of the carboniferous formation (unless metamorphosed); excepting the middle secondary red sandstone, which he traced from North Carolina to a distance of four or five miles into South Carolina where it is associated with trap dykes as in the Connecticut valley, there are no stratified rocks, yet observed, between the metamorphic beds and the Cretaceous.

Subsequently, Prof. Tuomey was appointed to the Chair of Geology of the University of Alabama at Tuscaloosa and to the charge of the Geological Survey of that State, which positions he held when he died. He had been actively engaged in his explorations during the year past, and both the State and the University have experienced a great loss in his decease. In connection with Dr. F. S. Holmes he has had in hand the publication of a splendid work on the Fossils of South Carolina, which has not been surpassed in the country for the beauty of its palæontological illustrations. Geological science is greatly indebted to Prof. Tuomey's zeal and fidelity, and has occasion for mourning that his labors have ceased.

Dr. Scoresby, the veteran of Arctic enterprise, died at Torquay, England, on the 21st of March last, after a lingering illness.

15. *New Granada: Twenty Months in the Andes;* by Isaac F. Holton, Professor of Chemistry and Natural History in Middlebury College. With maps and illustrations. New York, Harper & Brothers, 1857, pp. 605, 8vo.—If it fell within our province to review a book of travels, we

should speak of this as a very interesting one of its class, and as particularly rich in information of permanent value. But, what commends the volume to our attention is, that, along with the easy flow of entertaining narrative, there is an under-current of scientific observation, such as might be expected from a naturalist and chemist visiting a country so striking in its physical and climatic features. Of the vegetation, especially, Prof. Holton has succeeded in conveying to us, dwellers in northern climes, a very distinct conception, and that without any effort at description, and without much use of technical details. Should the work ever pass to a second edition, we advise the author to bring his great knowledge to bear upon this subject more directly and efficiently by adding a separate chapter on the Vegetation of New Granada, giving a comprehensive view of this flora in its main features, and in its distribution over the country according to climate, from the tropical sea-level up to the cold *paramos* and the isolated peaks clothed with perpetual snow.

Much to our surprise, the author speaks of the *Chirimoya*,—generally ranked among the three best tropical fruits of the world,—as little better than our *Asimina* or "Papaw;" which, moreover, he terms a congener, having through some oversight mistaken *Unona* for *Anona*. While suggesting corrections, we venture to question the physics and geology of a paragraph, commencing on p. 237,—the idea that the temperature of a higher *paramo* is at all dependent on the great thickness of the crust of the earth there than at the sea-level. We fear the author has not taken into account, the intensity of nocturnal radiation, and the more rapid evaporation under diminished pressure, as causes of refrigeration, as well as the dilatation of the air; and, on the other hand, has overlooked the fact that the neighborhood of active volcanoes, does not sensibly affect the temperature of a place. One word more upon another matter. As Prof. Holton's valuable work will be sure to find readers beyond the United States, we think it a disadvantage that words are used, now and then, in their New England rather than their general English sense. For example, the use of the word "town" for township, on p. 497, would inevitably lead an Englishman to conclude that our villages and small cities were rough and wild indeed.

16. *Memoir of John Dalton, and History of the Atomic Theory up to his time;* by Robt. Angus Smith, Ph.D., F.C.S. (Published also as vol. xiii, New Series, of the Memoirs of the Literary and Philosophical Society of Manchester). 298 pp., 8vo. London 1856, H. Baillière.—In the life of a philosopher or the history of a principle in philosophy, when either is faithfully executed, there is profound instruction. They not only teach us methods of research, but illustrate its true spirit and aim, and the secret of its strength. The young student will search the world over, unsuccessfully perhaps, for a subject for investigation. The philosopher finds a subject in the most familiar phenomena about him, and by steady scrutinizing labor, draws forth facts and principles of fundamental value. The history of Dalton and his atomic theory has for this reason as well as others a special value to the student in science. The work of Dr. Smith has a peculiar merit, from its bringing out Dalton's theory of atoms in its true relations to the speculations of former centuries. He treats briefly of the views on atoms among the ancient Greeks, and thence traces the

subject through the period of Alchemy and the earliest beginning of Chemistry to the development of Dalton himself when the mathematical basis of this science and its simple system of numbers were first made clear. A fine portrait of Dalton forms a frontispiece to the volume.

17. *Recent Papers by Prof. J. Leidy, M.D.*—Notice of Remains of the Walrus discovered on the Coast of the United States. Specimens were found on the sea beach of New Jersey: and the species appears to be the recent *Trichecus rosmorus*, probably of the drift or later post-tertiary period.—Description of Remains of Fishes from the Carboniferous limestone of Illinois and Missouri.—Remarks on *Saurocephalus* (Harlan) and its allies.—Observations on the extinct Peccary of North America. Dr. Leidy speaks of the large variations in the size and form of the skull and teeth of the recent *Dicotyles torquatus*, and afterwards remarks on the remains of the extinct Peccary and their variations; the one species *Dicotyles compressus* probably including the hitherto proposed species *Euchœrus* (*Protochœrus*) *macrops*, and *Protochœrus prismaticus*, *Platygonus compressus*, *Hyops depressifrons*, *Dicotyles depressifrons*, *Dicotyles costatus*.—Remarks on the Structure of the feet of Megalonyx.—From the Transactions of the American Philosophical Society, vol. xi, page 83 to page 106. Philadelphia, 1857.

18. *Millitary Map of Florida South of Tampa Bay;* with a memoir compiled by Lieut. J. C. Ives, Topog. Eng., under the general direction of Capt. A. A. Humphreys Topog. Eng., by order of the Hon. Jefferson Davis, Secretary of War, April 1856, War Department.

19. *Observations on the Physical Geography and Geology of the Coast of California, from Bodega Bay to San Diego;* by W. P. Blake; prepared for Prof. A. D. Bache, Superintendent of the United States Coast Survey, and published in the Report of the Coast Survey.

20. *Transactions of the Academy of Science at St. Louis;* 92 pp. 8vo. with plates, St. Louis, 1857.—This first number of the first volume of the St. Louis Academy promises much for the science of the country. The President of the Academy for 1857 is B. F. Shumard, M.D., the Vice Presidents, A. Wislizenus, M.D., and C. P. Chouteau. The first 36 pages are occupied with the Proceedings of the meetings, after which follow various important papers:—

1. J. Evans and B. F. Shumard: On some New Species of Fossils from the Cretaceous Formation of Nebraska Territory.
2. H. A. Prout: Description of a New Species of Productus from the Carboniferous limestone of St. Louis; with a plate.
3. J. Schiel: Observations on Glycerine.
4. T. C. Hilgard: Phyllotaxis, its numeric and divergential law, explicable under a simple organological idea; with a plate.
5. A. C. Koch: Mastodon Remains in the State of Missouri.
6. G. Seyffarth: Notice of a burnt brick from Nineveh; with a plate.
7. A. Wislizenus: Indian Stone Graves in Illinois.
8. B. F. Shumard: Description of New Fossil Crinoidea from the Palæozoic Rocks of the Western and Southern portions of the United States; with a plate.
9. A. Litton: Belcher & Brothers' Artesian Well; with a plate.

21. *Brechung und Reflexion des Lichts an Zwillingsflächen optisch einaxiger volkommen durchsichtiger Medien*, von Dr. Joseph Grailich, Privat-Docenten an der Wiener Universität. From the 9th volume of the Mathematico-natural History Section of the Royal Academy at Vienna. 1855 and 1856. Dr. Grailich is a profound mathematician and physicist, and in two papers has discussed the subject of the refraction and reflection of light in twin crystals with great ability.

22. *Abhandlungen der k. k. Geologischen Reichsanstalt*, Band III.—This 3d volume of Transactions from the Geological Survey of Austria or rather the Geological Department under the Austrian government, is occupied solely with a memoir on the Molluscan fossils of the Tertiary of Vienna by Dr. Moriz Hörnes with the assistance of Paul Partsch. It is a magnificent work in 736 quarto pages illustrated by 52 exquisite lithograph plates of crowded figures, the beauty of which can hardly be exceeded. This work is the first volume only of the memoir, treating of the Univalves. The Bivalves remain for another volume. Dr. Hörnes is "Custos. Adjunct" of the Royal Hof. Mineral Cabinet, of which Partsch is "Custos."

23. *Jahrbuch der k. k. Geol. Reichsanstalt*, 1855, No. 4, and 1856, No. 1.—This publication, is the Bulletin of the Geological Society of Vienna, containing numerous important geological papers, besides mining information. Each number, of which four appear annually, extends to between two and three hundred pages.

24. *Prodromus descriptionis Animalium Evertebratorum*, &c., of the North Pacific Expedition under Captain Rodgers, by W. Stimpson.—This pamphlet of 13 pages 8vo, contains brief descriptions by Mr. Stimpson of fifty-two species of *Turbellaria Dendrocœla* collected by him in the course of the North Pacific cruise on the Coasts of Asia and America, and adjoining islands.

C. F. Rammelsberg: Die neuesten Forschungen in der krystallographischen Chemie, as supplement to his Handbook on Crystallographic Chemistry, 227 pp. 8vo, with numerous woodcuts. Dr. Rammelsberg is performing an excellent service for science in collecting together the facts in crystallographic chemistry.

25. *Ruhmkorf's Apparatus constructed by E. S. Ritchie of Boston*, (From a letter to J. D. Dana from Prof. W. B. Rogers, dated Boston, April 16, 1857.)—You will I know be interested to learn that Mr. E. S. Ritchie, the well known instrument maker of this city, has succeeded in constructing a Ruhmkorf Induction Apparatus of such energy as greatly to surpass the Paris instruments, and, so far as I am acquainted with their action, to compare favorably with the recently improved form introduced in England. After encountering many difficulties in the insulation of the coil as well as the construction of the condenser and break-piece, he has devised such arrangements in regard to each as to secure a dense continuous spark, between the terminals of the secondary wire, of from 2 to 2½ inches long, and to permit the means of exhibiting all the effects of the discharge on a scale and with a brilliancy truly superb.

The columns of light in vacuo transversely stratified or waved, Gassiot's cascade, and other effects which I have found it to produce, and which we have exhibited at the Warren Club and elsewhere, are among the most magnificent electrical displays which I have ever seen. The primary current is developed by the action of four Bunsen cells of Deleuil's construction; the secondary wire is less than $1\frac{1}{2}$ miles long.

. This I believe is the first instrument of the kind yet made in this country, at least it is the first possessing such power; but Mr. Ritchie, not satisfied with his present success, is beginning the construetion of another from which we anticipate even greater effects, and which we hope will be completed in time for description in your July number.

A. Keith Johnston: A new Dictionary of Geography, Descriptive, Physical, Statistical, and Historical, forming a complete general Gazetteer of the world. 2nd ed. thoroughly revised. One large volume of 1300 pages. London. 36*s.* cloth.

A. Keith Johnston: Physical Atlas. New edition containing Murchison's Geological Map of Europe, Rogers's Geological Map of the United States, and other new charts. London and Edinburgh. 1856.

Normos: An attempt to demonstrate a central law of Nature. London.

E. Chevreul: The Principles of harmony and contrast of colors and their applications to the Arts. Translated from the French by C. Martel. 2nd edition, crown 8vo. London. 10*s.* 6*d.*

Charles John Anderson: Lake Ngami; or Explorations and Discoveries in Southwestern Africa. 2nd ed., royal 8vo. London. 30*s.*

Henry Bradbury: The Ferns of Great Britain and Iceland, *nature printed.* In imperial folio. London. 6*l.* 6*s.*—A splendid volume of folio plates and text.

Henry Bradbury: Nature Printing, its origin and objects. London. Bradbury & Evans, 11 Bouverie Street.

T. Scheerer: An introduction to the use of the Blowpipe; translated with additions by H. T. Blanford. Leipsic and London. 1856.

J. G. Beer: Die Familie der Bromeliaceen. 269 pp. 8. Wien. 1856.

Dr. H. O. Lenz: Zologie der alten Griechen und Römer. 656 pp. 8vo. Gotha, 1856.

Dr. G. Meckel von Hemsbach: Mikrogeologie. Ueber die Concremente im thierischen Organismus. Herausgegeben von Dr. Th. Billroth. 275 pp. 8vo. Berlin, 1856.

Prof. J. Müller: Di Aequatorialzone des gestirnten Himmels, mit Text, Folio. Freiburg.

Dr. H. Burmeister: Systematische Uebersicht der Thiere Brasiliens, welche während einer Riese durch die Provinzen von Rio de Janeiro und Minas Geraes gesammelt und beobachtet wurden. III Thl. Vögel. 2. Hälfte. 466 pp. 8vo. Berlin.

C. G. Carus: Ueber Lebensmagnetismus und über die magischen Wirkungen überhaupt. 306 pp. 8vo. Leipzig.

Cyclopædia of Natural History. (Based upon the Penny Cyclopedia.) In four volumes, with many hundred illustrations. London. 2*l.* 2*s.* Also *Cyclopedia of Geography.* In four volumes. Ibid.—Excellent works.

Proceedings Boston Soc. Nat. Hist.—Vol. VI. p. 48. On the state in which phosphate of lime exists in Sea-water; *A. A. Hayes*—p. 51, Fossil bones of Elephant, Megatherium and Mastodon from Texas (adding a third, to the two known N. American localities of Megatherium, of Skiddaway Island on the coast of Georgia, and Ashley River in S. Carolina); *J. Wyman.*—p. 55, Observations on the structure of bone in Python; *J. Green.*—p. 56, Effect of bite of Rattlesnake on a Mouse; *J. Wyman.*—p. 57, Corrosion of shells of freshwater Clams; *D. F. Weinland.*—p. 59, On a new genus of Tænioids; *D. F. Weinland.*—p. 63, Observations on the Classification of Fishes; *L. Agassiz.*—p. 63, Notes on the classification of Turtles; *J. E. Mills.*—p. 67, On the relation of respiration to action of the heart, and on the supra-renal Capsules; *Brown-Séquard.*—p. 71, Note on Orangs of Africa; *W. A. Gibson.* p. 72, Note on the Blind fish of the Mammoth Cave; *J. Wyman.*—p. 73, Biographical notice of Dr. John C. Warren; *J. Wyman.*—p. 84, New species of Crustacea from Western North America; *W. Stimpson.*—p. 97, Catalogue of the Binney Library [illegible]lysis of Slate from Somerville, Mass.; *L. M. Dornbach.*—p. 108, On Vireo sylvia; *T. M. Brewer.*—p. 112, On series in the Animal Kingdom; *D. F. Weinland.*—p. 114, List of Birds observed at Great Mapan and at Yarmouth, N. S., with notes; *H. Bryant.*—p. 123, Species of N. Atlantic and Behrings Straits partly identical; *A. A. Gould.*—p. 125, Dissection of eye of Sperm Whale; *J. Wyman.*—p. 126, On the Zonda Wind; *N. H. Bishop.*—p. 128, On Helix asteriacus; *E. S. Morse.*

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