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PROFESSORS B. SILLIMAN, B. SILLIMAN, Jr.,

AND

JAMES D. DANA,

IN CONNECTION WITH

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NUMBER LXII.

SCIENTIFIC INTELLIGENCE.

Corrections to Prof. Rogers's Paper on Binocular Vision.—Part I, in vol. XX. (1) P. 89, line 10 from top, omit *any*. In figure 3, *r* should be straight and perpendicular to the length. (5) Page 95, line 17 from bottom, for "P and Q," read P_1 and Q_1. Page 96, line 12 from top, for P and Q, read P_1 and Q_1.

Part II. (6) Page 207, line 4 from top, for "lower," read *higher*. (9) Page 209, top line, for "conveyed," read *converged*. Page 210, line 19 from top, erase B. (12) Page 215, line 5 from top, for "or" read a. Fig. 25, the right hand figure should be reversed. (18) Page 328, line 5 from top, after "union," insert *of a and c*. (20) Page 333, line 15 from bottom, for "nearer," read *farther*.

Part III. Page 91, line 9 from top, after from, add, *the denominators of*.

ERRATUM.—P. 159, l. 7 from top, for $^{\circ\prime\prime}6$, *read* $0''6$.

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THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

Art. I.—*On the Tides of the Western Coast of the United States.—Tides of San Francisco Bay, California;* by A. D. Bache, Superintendent U. S. Coast Survey.*

Tidal observations have been made, in connexion with the hydrography of the Coast Survey, at several points on the Western coast, agreeing in showing the same interesting fact of the large diurnal inequality of the tides, already traced by Mr. Whewell in the observations at the Russian settlement of Sitka.

The diurnal inequality in height of the tides on the Atlantic coast is much more considerable than in Europe, and the diurnal inequality of interval is also well marked; but both require numerous, carefully made observations to establish their laws, in consequence of the particular relation between the semi-diurnal and diurnal waves. On the Gulf of Mexico west of St. George's Island, the semi-diurnal tide is almost merged in the diurnal, but the total rise and fall is quite small.

At Key West, and along the western coast of Florida, where the diurnal inequality is large, the whole rise and fall of the tides is small, rendering numerous observations necessary to obtain reliable numerical results. The same is not the case on the Western coast; observations made for a short period through the whole twenty-four hours showing a peculiarly large diurnal irregularity as the most remarkable phenomenon of the tides. It becomes

* Report of the Superintendent of the Coast Survey, showing the progress of the Survey during the year 1853. Washington, 1854. p. *77—82*.

one of great practical importance to the navigator; for, in San Francisco bay, a rock which has three and a half ($3\frac{1}{2}$) feet of water upon it at the morning high water, may be awash at high water of the afternoon; and charts, of which the soundings are reduced to mean low water, will have no accurate significance, being liable to an average error of the soundings at either low water of the day, of 1·18 foot.

The results which I now present, and propose to discuss, are of two series of tides observed in connexion with the Coast Survey at Rincon Point, in the city of San Francisco, California. The observations were under the direction of Lieutenant Commanding James Alden, U. S. Navy, one of the assistants in the Coast Survey. They were made hourly, except about the time of high and low water, when the regular intervals were fifteen minutes, and the attempt was made to seize the precise time of high and low water.

The first series extended from January 17 to February 15, 1852, and the second from January 23 to February 17, 1853. Another set of similar observations was made at Saucelito, on the northern side of the Bay of San Francisco, but not with the same care which appears to characterize these. The results are in general accordant with those deduced from the Rincon Point series.

The reduction of the work of 1852 was made by Mr. W. W. Gordon, and that of 1853 by Messrs. Fairfield, Mitchell, and Heaton, of the tidal party of the Coast Survey office.

The results of 1852 are projected in the curves shown in diagram A, where the abcissæ represent the times from 0 hours midnight, and the ordinates represent the heights. The scale is such that the intervals between the vertical lines correspond to two hours, and between the horizontal lines to half a foot. The curve begins with midnight of the calendar day, January 16, 17, and ends with noon of February 15. The epochs of the moon's phases, and of zero, and of maximum declination of the moon, are marked at the head, and the times of transit at the foot of the diagram, the curves upon which, for convenience of the page, have been divided into two parts, so arranged with respect to each other that the days of corresponding declination fall nearly over and under each other. The curves of the series of 1853 present the same general results, with about the same extent of irregularities.

These tides obviously present a case of large diurnal inequality in height;* the interference of the diurnal and semi-diurnal waves going to produce one large and one small tide in the twenty-four

* The quantity given as the diurnal inequality in height, is the whole difference between the heights of two successive high waters or low waters and that for the interval, the whole difference between the lunitidal intervals of two successive high waters or low waters.

lunar hours. When the declination of the moon is at its maximum, the difference in the heights of consecutive high and low waters is nearly at its maximum; and when the declination is nearly zero, the difference is the smallest.

The diurnal inequality in the interval is also perfectly well marked in these tides, amounting when greatest, to about two hours for high water, and one hour and eleven minutes for low water.

The usual discussions of the times and heights, corresponding to the same time of transit of the moon, were made from the two series of observations; a defect having been found in the operation of referring the level of one tide-gauge to the other, the two series of heights were combined, by assuming the mean height in each series to have been the same. The results were plotted on a diagram like B, but on a larger scale, for the purpose of graphical corrections in the mode used by Mr. Whewell.

The ordinates of the diagrams Nos. 1 and 2, (diagram B,) correspond to the lunitidal intervals, and of Nos. 3 and 4 to the heights—the abcissæ, in each case, to the hours of the moon's transit. The scale is shown at the top and side of each diagram. No. 1, diagram B, shows the results for the half-monthly inequality of interval of high water, and the curves traced by them; No. 2 the same for low water; No. 3 shows the half-monthly inequality in the height of high water, and No. 4 in that of low water; the dots show where the observations fall. The comparison of the curves, with observations, is given in the annexed table:

TABLE No. 1.

Comparison of approximate curves of half-monthly inequality of the tides at Rincon Point, with observations.

Moon's age.	INTERVAL.				HEIGHT.				Moon's age.
	High water.		Low water.		High water.		Low water.		
Transit F.	From curve.	Observ'n. — Curve.	From curve.	Observ'n. — Curve.	From curve.	Observ'n. — Curve.	From curve.	Observ'n. — Curve.	Transit F.
H. M.	H. M.	M.	H. M.	M.	Ft.	Ft.	Ft.	Ft.	H. M.
0 30	11 59	−10	17 45	− 9	7·90	− 3	3·02	+ 3	0 30
1 30	36	− 2	37	− 3	·75	+ 4	·10	− 8	1 30
2 30	27	0	28	1	·45	+ 2	·20	−20	2 30
3 30	24	7	24	7	·10	+ 2	·38	+29	3 30
4 30	28	− 4	28	− 9	6·90	− 4	·52	− 6	4 30
5 30	48	− 7	42	18	·78	+12	·68	−29	5 30
6 30	12 18	− 1	18 05	− 1	·80	−13	·70	+26	6 30
7 30	43	12	24	− 7	7·00	+00	·67	−18	7 30
8 30	46	−12	33	9	·30	+15	·50	−41	8 30
9 30	39	− 2	27	− 6	·50	−15	·40	+27	9 30
10 30	27	− 1	15	− 3	·69	+ 5	·25	−19	10 30
11 30	11	8	17 57	− 2	·80	− 4	·10	+06	11 30
Mean	12 03	+27 −39	17 55	+35 −40		+39 −40		+110 −106	

The results, both for intervals and heights, are very good, considering the small number of observations (four,) of which each is the mean. The heights are, as usual, less regular than the times, and the results for the inequality of the height of low water are the least regular of all.

The approximate mean lunitidal interval for high water, or corrected establishment of Rincon Point, is 12h. 03m. This corresponds to an epoch of 0 hours, showing that the tides belong to the next preceding transit (transit F) of the moon, and not to the fifth preceding, (transit B,) as was found by Mr. Lubbock for the tides of Great Britain. The epoch for low water corresponds also almost exactly to 0 hours. The same thing is shown, less forcibly, however, by the discussion of the observations before referred to at Saucelito.

From curve No. 1, it appears that the difference in the lunitidal intervals for 3h. and for 9h. is 1h. 20m., or (A) of Mr. Lubbock (tan 20°) is 0·342. The difference between the heights of high water, at spring and neap tides, is, from diagram No. 3, 1·12 foot, and E of Mr. Lubbock $\frac{1{\cdot}12}{2(A)} = 1{\cdot}66$. The two series of observations, discussed separately, gave results which did not differ materially from these. These numbers will serve as a first approximation.

TABLE No. 2.

Diurnal inequality of interval and height for high and low water, from observations in January, 1852 *and* 1853, *at Rincon Point, San Francisco, California.*

High water.		Low water.		
Interval.	Heights.	Interval.	Heights.	
H. M.	Ft.	H. M.	Ft.	
1 44	−1·85	−0 51	3·01	Jan. 19, 1852, and Jan. 25, 1853.
1 57	−1·81	−1 03	3·44	
1 47	−1·63	−0 47	3·75	Moon's max. dec.
2 17	−1·59	−0 40	3·72	
1 41	−1·62	−0 40	3·46	
1 43	−1·33	−0 30	3·07	
1 41	−1·05	−0 23	2·57	
1 20	−0·66	+0 07	2·00	
0 39	−0·17	0 38	1·37	Moon's dec. zero.
0 52	0·32	1 05	0·50	
0 23	0·71	0 50	−0·41	
−0 18	1·72	0 58	−1·44	
−1 01	1·90	1 01	−2·19	
−1 42	2·01	1 14	−2·85	Feb. 1, 1852, and Feb. 3, 1853.
−1 55	1·88	1 12	−3·36	
−2 01	1·86	1 00	−3·48	Moon's dec. max.
−1 49	1·84	0 57	−3·48	
−1 12	1·90	0 41	−3·28	
−1 41	1·65	0 42	−2·99	
−1 26	1·42	0 35	−2·50	
−1 09	1·00	0 20	−1·90	
−0 59	0·29	−0 08	1·29	Moon's dec. zero.
−0 32	−0·30	−0 35	−0·50	
−0 09	−0·97	−1 15	0·26	
0 29	−1·42	−1 17	0·95	
0 46	−1·56	−1 12	1·85	
1 51	−1·70	−0 46	2·51	
1 58	−1·62	−0 30	2·99	Feb. 15, 1852, and Feb. 17, 1853.
2 11	−1·35	......	......	
Mean 1 21	1·36	0 47	2·36	

It should not be forgotten that, the observations having been made in successive years in the same month, the moon's age and declination, and the sun's declination are not very different, and the sun's declination is nearly the same on the corresponding days.

The *diurnal inequality* obtained by the usual method is given in the annexed table, No. 2. The two series are combined by taking the averages for the days on which the declinations correspond in the two series. Each average is thus the mean of four individual results.

These numbers are projected on diagram C, where the ordinates correspond to the intervals for one curve and to the heights for the other, and the abcissæ to the tidal days for both. Notwithstanding the small number of observations, the curves can be traced with tolerable certainty and follow the general law of the inequalities.

Each curve shows an inequality increasing and decreasing with the moon's declination nearly, crossing the zero line at or near the zero of declination, and reaching a maximum or minimum at the maximum of north or south declination. The observations do not furnish sufficient evidence to decide positively that the epochs of the several inequalities coincide with those of the declination or otherwise. On the average they are about half a day before the corresponding declinations.

The inequality in the height of high water and in the interval of low water increase and decrease together, and so of the inequality of high water and height of low water.

The declination of the moon and the inequality in interval of high water and in height of low water have the *contrary* sign; the reverse is the case with the other two inequalities.

The inequality in the height of low water is in general greater than that of high water, exceeding it when at the maximum in the proportion of two to one, (nearly 1·9 to 1). The same relation exists between the maximum inequality in interval of *high* water as compared with that of *low*, (1·7 to 1).

The maximum inequality in the height of low water is 3·60 feet, and of high water 1·85 foot. The maximum inequality of interval of high water, as shown by the curve, is 1h. 53m., and of low water 1h. 7m.

I am indebted to Mr. Heaton, of the tidal party, for the decomposition, under the direction of Mr. W. W. Gordon, of the curves of the daily observations in 1852, by the method adopted by me for the discussion of the tides of the Gulf of Mexico. Though, from some trials which I have made, these decompositions may be improved, they are, nevertheless, of great interest, and show well the causes of the forms assumed by the curves of diurnal inequality in height and interval, and for high and low water and their relations. When the observations now in progress on the Western coast shall have given additional results, I propose to take up this branch of the subject again. In the mean time, it appears to me, the results now obtained are of sufficient interest to be presented to the Association.

I have taken, as an example of the decomposition, the curve from the observations of January 21, 1852, the results corresponding nearly to the maximum of the moon's declination and to full moon.

The diurnal curve, the interference of which with the semi-diurnal produces the form shown in diagram A, and also on a larger scale in diagram D, is given on the diagram. Its maximum ordinate, as found by summing the two series of heights from the hourly observations in which the same values of the ordinate of the diurnal curve occur with opposite signs, and referring to the curve of sines for their relation to the maximum ordinate, is 2·20 feet.

The sum of the squares of the differences between observation and computation is the least when the interference takes place, as shown in diagram D, the maximum ordinate of the diurnal curve being seven hours and a half from the maximum ordinate of the semi-diurnal curve. Subtracting the ordinates of the diurnal curve, assumed as a curve of sines, from the heights given by the hourly observations, we have a residual curve, which is traced on the diagram. The average of the four loops of this curve is almost precisely a curve of sines, of which the maximum ordinate is 2·30 feet.

The tidal curves near the maximum of declination, and for several days each side of it, result from the interference of a semi-diurnal and diurnal wave, which at the maximum of each are nearly equal in magnitude, the crest of the diurnal wave being at that period about eight hours in advance of that of the semi-diurnal wave.

The following table gives the comparison made in the diagram. The first column contains the ordinates of the curve of observation; the second, those of the diurnal curve of sines; the third, those of the residual curve; the fourth, the ordinates of the semi-diurnal curve, which most nearly satisfy the residual; and the fifth, the small remaining differences—on the average, being about 0·14 foot. The crest of the diurnal curve is seven and a half hours from the semi-diurnal, and its maximum ordinate is 2·2 feet.

For equal maximum ordinates of the diurnal curve and semi-diurnal curve, 2·1 feet, we have for E=8 hours the diurnal inequality in height of high water 2·03 feet, or ·18 foot greater than the mean found by the curve of diurnal inequality, and of low water, 3·57, or 0·3 foot less than the value given by the curve. So, also, for the inequality in the intervals of high and low water, we have, respectively, 105 and 61 minutes, instead or 113 and 66 given by the diagram, differing but 8 and 5 minutes, respectively, and having the same ratio to each other as the latter numbers. The mode of interference thus explains satisfactorily the curious relations of the inequality of both time and height of high and low water.

TABLE No. 3.

Analysis of curve of observation for January 21, 1852. *Rincon Point.*

Ordinates, curve of observations.	Ordinates, diurnal curve of sines.	Ordinates, residual curve.	Ordinates, semi-diurnal curve of sines.	Differences.
Feet.	Feet.	Feet.	Feet.	Feet.
− 0·23	− 0·28	+0·05	0·00	+0·05
− 1·63	− 0·83	− 0·80	− 1·10	·30
− 2·98	− 1·33	− 1·65	− 1·82	·17
− 3·63	− 1·72	− 1·91	− 2·27	·36
− 4·03	− 2·00	− 2·03	− 2·20	·17
− 3·68	− 2·16	− 1·52	− 1·70	·18
− 2·73	− 2·16	− 0·57	− 0·70	·13
− 1·48	− 2·00	+0·52	+0·70	− 0·18
− 0·23	− 1·72	1·49	+1·65	− 0·16
+ 0·77	− 1·38	2·15	+2·20	− 0·05
1·47	− 0·83	2·30	+2·30	·00
1·72	− 0·28	2·00	+1·90	·10
1·52	+0·28	1·24	+1·60	− 0·36
·77	·83	− ·06	0·00	− 0·06
·17	1·33	− 1·16	− 1·30	+0·14
− ·33	1·72	− 2·05	− 2·05	·00
− ·28	2·00	− 2·28	− 2·28	·00
+ ·07	2·16	− 2·09	− 2·15	·06
·87	2·16	− 1·29	− 1·50	·21
1·87	2·00	− 0·13	− 0·20	·07
2·72	1·72	+1·00	+1·20	−·20
3·32	1·33	1·99	+1·97	·02
3·27	·83	2·44	2·32	·12
2·62	·28	2·34	2·20	·14

Taking the values of the maximum ordinate of the diurnal curve (D) as deduced by Mr. Heaton, tracing a curve for them and folding this over on its greatest ordinate, as a hinge, we bring five values of D to the determination of each point in the curve from the observations of 1852. Treating the curve of twice the sine of the moon's declination in the same way we obtain a curve for comparison with the former. Neglecting the sun's action, we have from theory m sin. $2\delta'=$D. Taking the mean of the values of D, which nearly correspond to each other in the half declination, and the mean of the corresponding values of the sine of twice the declination, we obtain $m=29$ nearly.

The following table, No. 4, gives a comparison of the values of the semi-diurnal ordinates, and of m sin. $2\delta'$.

I have also deduced the diurnal inequality, from Mr. Heaton's compound or interference curves, and have compared it in the same way with m sin. $2\delta'$. The value of m found from these, was $m=28$. The last column of Table No. 4 refers to this comparison.

TABLE No. 4,

Showing the values of the maximum ordinate of the diurnal curve (D) deduced from analyzing the curves of observation and comparison with theory; also the value of comparison of the diurnal inequalities measured on the compound curves.

No.	D.	M sine 2δ'	Difference.	Diurnal inequality—Ht. H. W. from curve.
	Feet.	Feet.		Feet.
1	2·13	2·17	·04	2·2
2	2·01	2·00	−·01	2·05
3	1·79	1·83	·04	1·85
4	1·54	1·55	·01	1·5
5	1·16	1·20	·04	1·1
6	0·81	0·76	−·05	1·6
7	0·25	0·26	·01	0·0

The agreement of the several results compared appears very satisfactory.

The changes in the value of E have been distinctly traced by Mr. Heaton from the observations; but before presenting the conclusion on this subject, I desire to subject them to the test of further computations, which are now in progress.

In order not to interfere with the regular work of the hydrographic party, a separate tidal party has been organized under the direction of Lieutenant Trowbridge of the corps of engineers, assistant in the Coast Survey, and supplied with the necessary means for a full investigation of the tides of our Western coast. It is proposed to establish three permanent relf-registering tide-gauges, under intelligent supervision, at San Diego, San Francisco, and Columbia river entrance, and to connect them by observations at suitable intermediate points. There are difficulties to be overcome in the character of the coast itself, and of the aborigines who still inhabit portions of it, but I expect, nevertheless, entire success from the zeal and ability of Lieutenant Trowbridge.

The following tide table results from the observations already discussed.

Corrected establishment at Rincon Point: High water, 12 hours 3 minutes; low water, 17 hours 51 minutes.

Mean rise and fall of tides, 3 feet 11 inches; of spring tides, 4 feet 11·8 inches; of neap tides, 2 feet 11 inches.

Mean duration of rise 6 hours 30 minutes, including half the stand; fall 5 hours 52 minutes, including half the stand; stand, 30 minutes.

	High water.	Low water.
Diurnal inequality of height.	Ft. In.	Ft. In.
Average for the whole month,	1 03	2 04
Greatest value,	2 11	3 06½
Diurnal inequality in interval.	H. M.	H. M.
Average for the whole month,	1 02	0 45
Greatest value,	2 00	1 06

Difference in height of highest tide and lowest tide in day: average, 5 feet 11 inches; greatest, 7 feet 7 inches.

When the moon's declination is north, the highest of the two high tides of the day is the one which occurs about twelve hours after upper culmination.

I have given elsewhere, for the use of navigators, a set of rules founded on these observations, and containing no technical term unfamiliar to them.

Notes on the Tides at San Francisco, California.

Besides the ordinary changes in the time and height of the tides known to all navigators, it is important to note the following, generally applicable to the Western coast, and particularly to San Francisco bay. They relate to peculiarities in the tides which occur on the same day, the necessity for knowing which is shown by the fact that a rock having *three feet and a half* of water upon it at *low tide*, may, at the *succeeding low water*, on the same day, be awash:

1. The tides at Rincon Point, in San Francisco bay, consist generally of a large and small tide on the same day; so that of two successive high waters in the twenty-four hours one is much higher than the other, and of two successive low waters one is much lower than the other.

2. The difference in height of two successive tides (either high or low waters) varies with the moon's declination. When the declination is nothing, the difference is nothing, or very small. When the declination is greatest, whether south or north, the difference is greatest. When the moon's declination is nearly nothing, the intervals between two successive high or two successive low waters are nearly twelve hours, and twenty-five minutes, and differ most from this when the moon's declination is greatest.

3. The inequalities in the heights of successive low waters are more considerable than those of successive high waters; while, on the contrary, the inequalities in the times of high water are more marked than those of low.

4. The average difference between the heights of two successive high waters is one foot three inches; and of two successive low waters, two feet and four inches. The average difference of these same heights, when the moon's declination is greatest, is for the successive high waters two feet, and for the low waters three feet six inches.

5. The average variation from twelve hours and twenty-five minutes in the interval between two successive high waters is one hour and twelve minutes, and between two successive low waters fifty-three minutes. The average variations of the same interval when the moon is farthest from the equator are, respectively, two hours and one hour and a quarter.

6. When the moon's declination is north, the higher of the two high tides of the twenty-four hours is the one which occurs about eleven and a half hours after the moon crosses the meridian, (souths) and when the moon's declination is south, the one which occurs about twenty minutes after the moon's meridian passage, (southing).

6 *bis.* Or the following rule may be used, which applies when the moon crosses the meridian between midnight and $11\frac{1}{2}$ A. M., or between noon and $11\frac{1}{2}$ P. M.:

If the moon is *south* of the equator, and passes the meridian (souths) in the morning, the morning high water will be higher than the afternoon high water, if, in the afternoon, the afternoon high water will be the higher.

If the moon is *north* of the equator, and passes the meridian (souths) in the morning, the afternoon high water will be the higher; if in the afternoon the morning high water will be the higher.

7. The lowest of the two successive low waters of the twenty-four hours occurs about seven hours after the highest of the two high waters.

8. The average difference between the height of the highest high water and of the lowest low water is five feet eleven, and the greatest difference is seven feet seven.

ART. II.—*Comparison of the diurnal inequality of the tides at San Diego, San Francisco, and Astoria, on the Pacific Coast of the United States, from observations in connection with the Coast Survey;* by A. D. BACHE, Superintendent.*

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

AT a meeting of the American Association in August, 1853, I submitted some remarks on the diurnal inequality of the tides as observed at San Francisco. I propose now to compare this important inequality at the three ports of San Diego in California, San Francisco in California, and Astoria in Oregon. The results are the first fruits of the tidal observations under the immediate charge of Lieut. Trowbridge, of the Corps of Engineers, to which I referred at the same meeting, as in progress. The series is intended to develop the tidal phenomena of that coast, and the three stations referred to are those for permanent reference, at which self-registering tide-gauges have been put up. The results now communicated are derived from observations at Asto-

* From Report of the Superintendent of the Coast Survey, showing the Progress of the Survey during the year 1854, p. 152. Washington: 1855.

ria, from July 11 to October 31, 1853; at San Francisco, from January 17 to February 15, 1852, and from January 5 to February 26, 1853; and at San Diego, from September 22 to November 31, 1853. All the observations were made with Saxton's self-registering gauge. I submit specimens of the actual curve traced by the gauge. The results have been computed, under the direction of L. F. Pourtales, Esq., assistant United States Coast Survey, by Messrs. H. Heaton and P. R. Hawley, and the diagrams were drawn by Mr. C. Fendall.

Some of the curves of observation on a reduced scale are shown in diagram No. 1. The place of observation, and the dates for each series of curves, are stated on the diagram. The diagram represents the times from 0 hours to midnight, on a scale in which the distance between the vertical lines corresponds to two hours, and the heights on a scale of half a foot of rise or fall of the tide to each division between the horizontal lines. The phases and declinations of the moon are inserted at the top of the diagrams, and the times of the moon's transit at the foot.

The curves have a striking similarity, and show a large diurnal inequality in both high and low water, in time and in height, at or near the greatest declination of the moon. The greatest inequality of the height is 2·76 feet at Astoria, 2·40 feet at San Francisco, and 2·77 feet at San Diego. The mean rise and fall, estimating the highest high and lowest low waters of each day only, is for the three places respectively, 7·86 feet, 5·92 feet, and 5·46 feet. Some of the daily curves of San Diego, near the period of greatest declination of the moon, approach in form to those at Fort Morgan, on the Gulf of Mexico.

The curves of half-monthly inequality of high and low water will be so much better determined hereafter, that I merely refer to them now in passing, to show their general resemblance to those formerly produced for San Francisco.

The crude corrected establishment for the three places is—

For Astoria,	12*h*.	53*m*.
For San Francisco,	12	4
For San Diego,	9	37

The value of A (the tangent of the difference of luni-tidal interval for three and for nine hours) and of E of Mr. Lubbock's notation, (half the difference in height of neap and spring tides divided by 2 A) are, for—

Places.	Data for A.		A.	E.
	In time.	In arc.		$\frac{h-h'}{2A}$
Astoria,	1*h*. 08*m*.	17° 30′	0·31	2·63
San Francisco,	1 18	19 30	0·35	1·59
San Diego,	1 26	21 30	0·39	1·71

These, of course, are but approximations.

Diurnal inequality in intervals and heights of high and low water at San Francisco, San Diego, and Astoria.

	Inequality in interval of high water.			Inequality in height of high water.			Inequality in interval of low water.			Inequality in height of low water.		
	S. Francisco.	San Diego.	Astoria.	S. Francisco.	San Diego.	Astoria.	S. Francisco.	San Diego.	Astoria.	S. Francisco.	San Diego.	Astoria.
	h. m.	h. m.	h. m.	feet.	feet.	feet.	h. m.	h. m.	h. m.	feet.	feet.	feet.
	1 44	1 56	1 19	-1·85	-1·62	-1·94	-0 51	-2 00	-1 15	3·01	2·90	3·81
	1 57	1 16	2 00	-1·81	-1·18	-1·58	-1 63	-1 13	-1 12	3·44	2·87	3·27
	1 47	1 36	1 14	-1·63	-0·67	-1·31	-0 47	-0 35	-0 55	3·75	2·48	3·20
	2 17	1 12	1 05	-1·59	-0·17	-1·02	-0 40	-0 05	-0 41	3·72	1·76	2·56
	1 41	0 46	0 53	-1·62	0·07	-0·75	-0 40	0 00	-0 33	3·46	1·01	1·68
	1 43	0 17	0 33	-1·33	0·45	-0·17	-0 30	0 06	-0 16	3·07	0·28	1·25
Zero dec. ☽	1 41	-0 05	0 18	-1·05	0·83	0·27	-0 23	0 30	0 02	2·57	-0·35	0·74
	1 20	-0 20	-0 02	-0·66	1·20	0·67	0 07	0 29	0 19	2·01	-0·99	0·09
	0 39	-0 37	-0 16	-0·17	1·49	1·21	0 38	0 33	0 41	1·37	-1·39	-0·61
	0 52	-0 58	-0 27	0·32	1·78	1·42	1 05	0 47	1 09	0·50	-1·70	-1·14
	0 23	-1 16	-0 51	0·71	1·97	1·53	0 50	1 17	1 04	-0·41	-2·05	-1·74
	-0 18	-1 15	-1 12	1·72	2·10	1·54	0 58	1 36	1 09	-1·44	-2·26	-2·70
	-1 01	-1 50	-1 33	1·90	2·04	1·63	1 01	1 57	1 02	-2·19	-2·34	-2·75
☽'s dec. max. N.	-1 42	-2 23	-1 47	2·01	2·25	1·42	1 14	1 45	1 03	-2·85	-2·65	-3·36
	-1 55	-2 51	-1 47	1·88	2·07	1·28	1 12	2 22	0 45	-3·36	-2·71	-3·39
	-2 01	-3 10	-1 37	1·86	0·98	1·14	1 00	1 39	0 48	-3·48	-2·69	-3·27
	-1 49	-3 03	-1 31	1·84	0·58	0·86	0 57	0 57	0 34	-3·48	-2·48	-2·98
	-1 12	-2 00	-1 22	1·90	0·41	0·71	0 41	0 36	0 24	-3·28	-2·32	-2·33
	-1 41	-1 26	-0 51	1·65	0·27	0·60	0 42	-0 04	0 21	-2·99	-1·81	-2·06
☽'s dec. zero.	-1 26	-0 50	-0 33	1·42	0·09	0·20	0 35	-0 21	0 21	-2·50	-1·14	-1·40
	-1 09	-0 46	-0 13	1·00	0·65	-0·25	0 20	0 31	0 06	-1·90	-0·93	-0·83
	-0 59	-0 20	0 02	0·29	0·32	-0·30	-0 08	0 03	-0 21	-1·29	-0·29	-0·11
	-0 32	0 05	0 17	-0·30	-0·08	-1·12	-0 35	-0 46	-0 35	-0·50	0·97	0·81
	-0 09	0 41	0 22	-0·97	-2·33	-1·70	-1 15	-0 38	-0 52	0·26	2·49	1·24
	0 29	0 55	0 46	-1·42	-2·68	-2·00	-1 17	-1 16	-0 54	0·95	2·96	2·12
	0 46	2 06	1 01	-1·56	-2·41	-2·18	-1 12	-1 42	-1 18	1·85	2·47	2·75
☽'s dec. max. S.	1 51	1 53	1 15	-1·70	-2·22	-2·25	-0 46	-1 43	-1 21	2·51	2·84	3·24
	1 58	2 23	1 38	-1·62	-1·95	-2·01	-0 30	-2 00	-1 20	2·99	2·79	3·85
	2 11	2 55	1 34	-1·35	-1·32	-2·54	....	-2 27	-1 08	....	3·09	3·79
	1 22	1 25	0 59	1·36	1·28	1·23	0 47	1 02	0 46	2·36	1·97	2·17

The foregoing table shows the diurnal inequality in time and height of high and low water at the three places before named.

The whole difference in height and interval between the A. M. and P. M. tides is taken as representing the diurnal inequality, and no correction is made for the half-monthly inequality in preparing the tables. I may observe that upon trying the corrections with the half-monthly inequality, as at present determined, no special advantage resulted; and until the half-monthly inequality is determined by more numerous observations, I adhere to this form of discussion.

The results are shown in diagram No. 2, in which the ordinates denote the inequality in interval and height on the days from zero of declination of the moon, denoted by the abscissæ. The dots show the actual observations, and the curves are drawn with a free hand among them. The results for the three places are distinguished as marked on the diagram. The following are the inferences from the discussion:

1. In every case, the inequalities increase and decrease with the moon's declination, reaching zero at or near the time of the moon's crossing the equator. The average epoch of the inequalities agrees almost exactly with the time of the zero of declination.

2. The inequality in height of high water, and in interval of low water, increase and decrease together, and so for the inequality in time of high water and in height of low water, as was remarked in the case of San Francisco.

3. The declination of the moon, and the inequality in interval of high water and in height of low water, have contrary signs at all three of the places: the reverse being true of the other two inequalities.

4. The inequality in the height of low water is, in general, greater than that of high water, as was before stated for San Francisco. The proportion of the average and maximum inequalities is nearly as follows:

Places.	Average inequality.	Maximum inequality.
San Francisco, - - - - - - - -	1·8 to 1	1·9 to 1
San Diego, - - - - - - - - -	1·5 to 1	1·2 to 1
Astoria, - - - - - - - - - - -	1·8 to 1	1·5 to 1

5. The inequality in the interval of high water is, in general greater than that of low water, as follows:

Places.	Average value.	Maximum value.
San Francisco, - - - - - - - -	1·7 to 1	1·8 to 1
San Diego, - - - - - - - - -	1·4 to 1	1·3 to 1
Astoria, - - - - - - - - - - -	1·3 to 1	1·5 to 1

6. The average and greatest inequalities in interval and height are shown in the following table:

Places.	Average inequality.				Greatest inequality.			
	Time.		Height.		Time.		Height.	
	H. W.	L. W.	H. W.	L. W.	H. W.	L. W.	H. W.	L. W.
	h. m.	*h. m.*	*feet.*	*feet.*	*h. m.*	*h. m.*	*feet.*	*feet.*
San Francisco, - - -	1 21	0 47	1·36	2 36	2 17	1 17	2·01	3·75
San Diego, - - - -	1 25	1 02	1·28	1·97	3 10	2 27	2·68	3·09
Astoria, - - - - -	0 59	0 46	1·23	2·17	2 00	1 21	2·54	3·85

7. The comparison of the values of the diurnal inequality in height with the theoretical expression $m \sin 2\delta'$ is given in the annexed table and diagram, in which the value of m is taken at 2·35. The inequality results are grouped by the declinations.

Comparison of daily inequality with moon's declination.

	San Diego.			Astoria.		
	Obs. inequality, height of H. W.	m sin $2\delta'$.	Difference.	Obs. inequality, height of H. W.	m sin $2\delta'$.	Difference.
	feet.	*feet.*		*feet.*	*feet.*	
1	2·03	1·90	·13	1·94	1·80	·14
2	1·93	1·83	·10	1·75	1·72	·03
3	1·55	1·70	−·15	1·73	1·60	·13
4	1·26	1·48	−·22	1·32	1·40	−·08
5	·84	1·14	−·30	·98	1·10	−·12
6	·63	·75	−·12	·49	·71	−·22
7	·69	·28	·41	·24	·28	−·04

The observations of which these form a part are still in progress, under the direction of Lieutenant Trowbridge, whose assiduity and intelligence have already been rewarded by the success I had ventured to anticipate in my former reference to the tides of the western coast.

Art. III.—*Preliminary determinations of Co-tidal lines on the Atlantic Coast of the United States, from the Coast Survey Tidal Observations;* by A. D. Bache, Superintendent.*

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

In the progress of the hydrography of the Atlantic coast of the United States, numerous tidal observations have necessarily been made for correcting the soundings and determining the establishments of the ports. With them I have connected observations of a more permanent character, intended to furnish the data for ascertaining the laws of the tides in important localities, and others for tracing the progress of the tide-wave along the coast generally, and in special cases in sounds, bays, and rivers. These observations are still in progress; indeed, those for developing the laws of the tides, and determining the constants of theory, depend for their value upon their long continuance. So many authentic results have now, however, been obtained, that it appears desirable to put them together, and to ascertain the conclusions towards which they tend as to the co-tidal lines, and by the agreement of the separate results with general laws, or their departure from them, to determine which of them require further observations to check their first results, and where new stations of observations are necessary for the purpose. My attention has been called, also, by the request of a valued friend, the Master of Trinity College, Cambridge, to some attempt of this sort, and his labors in connection with this subject on our own coast have entitled his request to the most respectful consideration.

* Report of the Superintendent of the Coast Survey showing the progress of the Survey during the year 1854, p. 147. Washington, 1855.

I am indebted to L. F. Pourtales, Esq., in charge of the tidal party of the U. S. Coast Survey, for the revision of the computations given in this paper. The labor of reducing the observations themselves has fallen chiefly upon Messrs. Heaton, Fendall, and Hawley. The diagrams have been prepared by Mr. C. Fendall, under the direction of Mr. Pourtales.

TABLE No. 1.

Observations for co-tidal hours.

Stations.	No. of observed lunations.	Years.	Remarks.
Cape Sable, N. S.	....	....	Furnished by Captain Shortland, R. N.
Ellenwood's Island, N. S.	....	....	
Fourchue Island, N. S.	....	....	
Portland, Me.	6½	1852–3	Self-registering.
Portsmouth, N. H.	11	1851–2–3	Self-registering in 1852-3; all the sets agree pretty well.
Newburyport, Mass.	2	1851–2	
Ipswich,	2	1852	
Gloucester,	1	1853	
Salem,	2½	1850	
Boston Light,	3½	1847	Results reliable.
Boston Dry-dock,	6½ yrs.	1847–'53	Best series.
Wellfleet,	1	1849	
Provincetown,	10	1833–4	From Maj. Graham's survey.
Monomoy,	1½	1852	
Great Point, Nantucket,	1½	1849–'50	
Siasconsett,	3	1853–4	
Nantucket Harbor,	13	1846 to 1850	Irregular.
Tuckernuck,	1	1850	
Wasque Point,	1	1852	
Edgartown,	7	1846–7–'51–2	
Holmes' Hole,	6	1846–'51–2	
Wood's Hole (east),	3	1849–'52	
Tarpaulin Cove,	3	1849–'51	
Quick's Hole (south),	2	1851	
Menamsha Bight,	1	1852	
Fort Adams,	16	1844–'46	
Point Judith,	6	1844–5	
Watch Hill,	2¾	1848	
Montauk Point,	2½	1848	Not a good series.
Fire Island,	2	1850	Not a good series.
Sandy Hook,	17	1835–6–'44–'51	
Cold Spring inlet,	11	1843–4	Day tides only.
Cape May landing,	2	1847	
Delaware breakwater,	10½	1840–'41–'43–'47	
Old Point Comfort,	65	1846–'51	
Hatteras,	1	1850	
Beaufort, N. C.	2	....	
Smithville,	9	1851–2	
Georgetown, S. C.	1½	1852	
Charleston,	6	1853	
Fort Pulaski,	13	1851	
St. John's river,	1	1853	
Cape Canaveral,	11 tides.	1850	Quite unreliable.
Cape Florida,	1	1852	

The stations at which observations of the tides have been made, of the more reliable class are thirty-three in number, extending on the Atlantic coast from Cape Florida to Portland, Maine. I have been able, through the kindness of Captain Shortland, R. N., in charge of the Admirality survey of Nova Scotia, to extend the results to the entrance of the Bay of Fundy.

Table No. 1 gives the names of the places of observation with the time during which the observations of high and low water were made, and remarks in relation to them. The stations marked (*) in Table No. 2, have been made use of in determining the co-tidal lines for this paper. A few stations have been embraced in the results where the number of observations is not comparable to those at the other points, chiefly to introduce localities important in position, and to sift the observations already made at them. Old Point Comfort, New York, and Boston Harbor, have been permanent stations for some years; Charleston, Tybee entrance, Portsmouth, and Portland, have been more recently added to them.

To the short series of observations, especially there should be applied corrections for declination and parallax; but after computing several cases, I was satisfied that the errors from other sources, and especially from the positions almost indispensably necessary to the tide gauges, more than made up for any irregularities from this source, and determined in the preliminary inquiry to omit these corrections, which amount only to a few minutes even in extreme cases.

A much more important correction is that for the position of the gauge in a harbor or river entrance, in many cases within a bar. Where our charts are completed, we have the elements for computing this correction by the law of depth, supposing the wave to move in the channel with a velocity proportional to the square root of the depth. This law, when applied to two very different cases, Savannah river and Boston harbor, where we had the means of testing it by measured distances and known depths, was so completely verified, that I have not hesitated to apply it in the other cases.

The following Table No. 2 contains in the first column a number for reference; second the names of the stations; third, the mean luni-tidal intervals or establishments; fourth, the longitude from Greenwich; fifth, the approximate co-tidal hour obtained by adding to the establishment the difference of longitude; sixth, a correction of one minute for every half hour of the establishment, to correct for the different transits of the moon used in reducing the observations, (see Mr. Whewell's paper, Phil. Trans. 1836, p. 293;) seventh, the co-tidal hour thus corrected; eighth, the co-tidal hour corrected for depth, where data were at hand for the purpose; ninth, the latitude of the station.

In order to obtain the best results from the observations, they have been divided into groups, in the way and from considerations which will be hereafter explained.

TABLE No. 2.

Co-tidal hours of ports on the Atlantic coast.

No.	Stations.	Corrected establishm'nt	Longitude from Greenwich.	Corrected establishment in Greenwich time.	Correction.	Co-tidal hour.	Co-tidal hour carri'd to coast by correct'g for depth of wat'r.	Latitude.
		h. m.	*h. m.*	*h. m.*	*m.*	*h. m.*	*h. m.*	° ′
1	*Cape Sable,	8 50	4 23	13 13	18	12 55	.....	43 25
2	*Ellenwood's Island,	9 45	4 24	14 9	19	13 50	.....	43 39
3	*Fourchue Island,	10 00	4 25	14 25	20	14 5	.....	43 47
4	*Portland, Maine,	11 25	4 41	16 6	23	15 43	.....	43 35
5	*Portsmouth, N. H.	11 23	4 42	16 5	23	15 42	.....	43 3
6	*Newburyport, Mass.	11 22	4 43	16 5	23	15 42	15 27	42 48
7	Ipswich, "	11 32	4 43	16 15	23	15 52	.....	42 41
8	*Gloucester, "	11 10	4 43	15 53	22	15 31	.....	42 37
9	*Salem, "	11 13	4 43	15 56	22	15 34	15 19	42 31
10	*Nahant, "	11 12	4 43	15 55	22	15 30	.....	42 25
11	*Boston Light, "	11 12	4 43	15 55	22	15 33	.....	42 20
12	*Boston Dry Dock,	11 22	4 43	16 5	22	15 53	15 30	42 20
13	*Wellfleet,	11 5	4 40	15 45	22	14 43	.....	41 56
14	*Provincetown,	10 35	4 41	15 16	21	14 55	.....	42 3
15	Monomoy,	12 5	4 40	16 45	24	16 21	.....	41 36
16	Great Point,	12 4	4 40	16 44	24	16 20	.....	41 23
17	Siasconsett,	11 53	4 40	16 33	24	16 9	.....	41 15
18	Nantucket,	12 11	4 40	16 51	24	16 27	.....	41 17
19	Tuckernuck,	11 35	4 41	16 16	23	15 53	.....	41 18
20	Wasque Point,	9 19	4 42	13 1	19	12 42	.....	41 21
21	Edgartown,	11 6	4 42	15 48	22	15 26	.....	41 24
22	Holmes' Hole,	11 43	4 42	16 25	23	16 2	.....	41 28
23	Wood's Hole (east),	8 12	4 42	12 54	16	12 38	.....	41 31
24	Tarpaulin Cove,	8 4	4 42	12 46	16	12 30	.....	41 28
25	*Quicks' Hole (south),	7 32	4 42	12 16	15	11 59	.....	41 26
26	Menamsha Bight,	7 52	4 43	12 35	16	12 19	.....	41 20
27	*Fort Adams (Newport harbor),	7 45	4 45	12 30	15	12 15	.....	41 29
28	*Point Judith,	7 32	4 45	12 17	15	12 2	.....	41 22
29	Watch Hill,	9 00	4 47	13 47	18	13 29	.....	41 19
30	Montauk Point,	8 10	4 46	12 56	16	12 40	.....	41 4
31	Fire Island,	7 18	4 52	12 10	15	11 55	.....	40 38
32	*Sandy Hook,	7 29	4 56	12 25	15	12 10	.....	40 28
33	*Cold Spring Inlet,	7 32	4 59	12 31	15	12 16	.....	38 57
34	*Cape May (landing),	8 19	4 59	13 18	17	13 1	.....	38 56
35	*Delaware Breakwater,	8 00	5 0	13 00	16	12 44	.....	38 48
36	*Old Point Comfort,	8 17	5 6	13 23	17	13 6	12 3	36 55
37	*Hatteras,	6 57	5 2	11 59	14	11 45	.....	35 15
38	*Beaufort, N. C.	7 40	5 7	12 47	15	12 32	12 18	34 37
39	*Smithville, "	7 19	5 12	12 31	15	12 16	11 40	33 54
40	Georgetown, S. C.	7 52	5 16	13 08	16	12 40	.....	33 22
41	*Charleston (Castle Pinckney),	7 13	5 19	12 32	14	12 18	11 38	32 43
42	*Fort Pulaski, (Tybee Entrance),	7 20	5 23	12 43	15	12 28	12 00	32 1
43	*St. John's River,	7 31	5 26	12 57	15	12 42	12 27	30 20
44	*Cape Canaveral,	7 21	5 22	12 43	15	12 28	.....	28 27
45	*Cape Florida,	8 26	5 20	13 46	17	13 29	.....	25 40

Supposing the stations to be really connected in the physical group and assuming that the space over which the observations extend is such that the co-tidal lines may be taken as straight lines, we obtain by least squares the position of the co-tidal lines, which will best satisfy the equation. The mean latitude and longitude of each group is taken, and the group is referred to this point as the origin of co-ordinates; the mean co-tidal hour is also taken. In the equation of the co-tidal line—

$$M\,x + N\,y = z$$

x and y represent the known co-ordinates, the difference of longitude being reduced to the same unit of the geographical mile as the difference of latitude. The co-efficients M and N are determined by the equations—

$$M\,\Sigma\,x^2 + N\,\Sigma\,xy = \Sigma\,xz$$
$$M\,\Sigma\,xy + N\,\Sigma\,y^2 = \Sigma\,yz$$

$-\frac{N}{M}$ is the tangent of the angle which the co-tidal line makes with the meridian, and $\sqrt{M^2 + N^2}$ gives the motion of the tide-wave, or difference of co-tidal hour for one geographical mile perpendicular to the co-tidal lines.

In this I have merely followed the admirable example given by Professor Lloyd, in the joint paper of himself and Colonel Sabine, on the magnetic survey of the British Islands.

Having investigated separate groups in this way, it is easy to draw the co-tidal curves which represent the observations; the investigation tests the grouping in an interesting way, by the coincidence or discrepancy of the computed and observed co-tidal hours.

The first approximate indication from the discussion is the correspondence of the tides on our Atlantic coast to the supposition of a tide-wave moving from S. 53° E. to N. 53° W.; but this is only a rude statement of the phenomena.

In scanning the co-tidal hours along the coast, we observe that they divide themselves into two groups, one south of Martha's Vineyard, and the other north of Cape Cod, with a short anomalous group between them.

The co-tidal hours from Cape Florida to Quick's Hole, Martha's Vineyard sound, are not greater than 13*h*. 30*m*., nor less than 11*h*. 38*m*. Hatteras is decidedly, as was pointed out by the Master of Trinity, the Rev. Mr. Whewell, a point of divergence, the establishments on the north and east of it, and the south and west of it, being as a general rule, greater than the establishment of Hatteras. Our value for the co-tidal hour there differs from Mr. Whewell's, and further observations now in progress, will decide between the two results.

From Provincetown, Cape Cod, to Cape Sable Island, the co-tidal hours vary between 12*h*. 55*m*. and 15*h*. 43*m*.

Beginning at Tybee entrance, Fort Pulaski, Savannah river, we have a good series of tidal stations to Hatteras, five in number forming group *a*, Table No. 3. The mean co-tidal hour is 11*h*. 52*m*., and the angle which the co-tidal line makes with the meridian is 50° 09′, agreeing very nearly with the trend of the coast.

The motion perpendicular to the direction of the co-tidal line is twenty-four miles in half an hour, agreeing nearly with the velocity due to the depths, as will be seen by inspecting the chart of co-tidal lines which accompanies this paper, upon which the fifty and one hundred fathom curves are drawn from the best data we yet have. The mean discrepancy of the computed establishments and of those observed for this group, is 16*m.*; that of Beaufort differing most, and for Cape Fear the least.

If no correction had been applied for the positions of the tide-gauges within harbors, the results would have been as stated in group *a bis*, Table No. 3, which, while the position of the co-tidal line is but little changed, gives a result for the movement of the tide-waves which is entirely too small, as must of course be the case.

The next group north and east of this, *b*, consists of Old Point Comfort, Delaware Breakwater, Cold Spring inlet, and Sandy Hook, embracing a part of the coast having the same general direction. The mean co-tidal hour is 12*h.* 18*m.*; the angle of the co-tidal line with the meridian is 22° 21′, agreeing again with the general trend of the coast, which is about 26°, the true value of the motion being masked by the irregularities of the establishments. The computed establishments agree well with the observed, differing but five minutes in the average, and six minutes at the greatest.

In the next group, *c*, four stations are placed from Sandy Hook to Quick's Hole, viz: Sandy Hook, Point Judith, Newport, carried to the entrance of the bay by the depth, and Quick's Hole; the mean co-tidal hour is 12*h.* 6*m.*, the direction of the co-tidal line 63° 27′ east of the meridian; the distance gone over by the tide-wave in half an hour, forty miles; the mean difference in the computed and observed establishments is less than three minutes, and the greatest difference five minutes. Fire Island and Montauk are omitted from this series as anomalous; if, however, they are included, the result shown in *c bis*, Table No. 3, is given, in which the direction of the co-tidal line is 58° 36′, and from which a decidedly erroneous velocity results.

Montauk looks like a point of convergence, as termed by Mr. Whewell; but its result is uncertain, and the observations there and at Fire Island must obviously be repeated.

The group *d* consists of six stations between Cape Cod and Cape Ann, viz: Provincetown, Wellfleet, Boston, Nahant, Salem, and Gloucester. It gives for the mean co-tidal hour 15*h.* 15*m.*, for the inclination of the co-tidal line to the meridian 31° 17′, and for the distance gone over by the tide-wave in 30*m.*, thirty-two miles. The average difference between the computed and observed co-tidal hour is less than four minutes, and the greatest difference less than ten.

Group *e* contains Newburyport, Portsmouth, Portland, Fourchue Island, Ellenwood's Island, and Cape Sable. The mean co-tidal hour is 14*h.* 37*m.*, the angle of the co-tidal line with the meridian 44° 04′, and the motion of the tide-wave thirty miles in 30 minutes. The average difference of the computed and observed co-tidal hour is rather more than ten minutes, and the greatest difference in the case of Cape Sable Island amounts to 23*m.* Newburyport, which is brought to the sea establishment by the depth, differs but six minutes in the computed and observed numbers.

The twelve stations of the last two groups combined in one group, give 14*h.* 56*m.*, for the mean co-tidal hour, 38° 46′ for the inclination of the co-tidal line, and thirty-three miles in half an hour for the motion.

Between *c* and *d* is the anomalous group which occupies Martha's Vineyard and Nantucket sounds, and includes the sea of the southern and eastern shores of these islands, and the passage between them. A side sketch shows the anomalous co-tidal hours, varying from 12*h.* 19*m.* at Menamsha Bight, and 12*h.* 38*m.* at Wood's Hole, to 16*h.* 02*m.* at Holmes' hole. The observations yet collected are not sufficient to trace with precision the details of these changes, though abundantly so to establish the general phenomena. They show, conclusively, that this is a case of interference, and point to the nature and amount of it. I prefer to obtain further observations necessary to give the particulars of this interference, before entering upon a discussion of this curious series. The heights concur with the times in giving the same solution to these cases, a mean rise and fall of one foot at Nantucket island being placed, as it were between a rise and fall of 3·3 feet at Menamsha Bight, and of 11·5 feet at Provincetown. The shoal ground off Nantucket and its influence in the direction of the co-tidal lines, are roughly traced upon the chart.

Group *f* is at the extreme southern portion of the series where the tide-wave is turned by the Bahama banks, and makes its way through the straits of Florida. The three stations in that group are Cape Florida, Cape Canaveral, and St. John's entrance; of this Cape Canaveral affords but a vague result. The co-tidal line makes an angle of 117° 12′ with the meridian, and the motion in half an hour is twenty-nine miles. These results are collected in Table No. 3.

From the general indications of these groups, and with the approximate form of the curves of depths, it is not difficult to trace the probable forms of the co-tidal lines. With the assistance of Mr. Pourtales the chart now presented has been prepared. It shows the co-tidal line of 12*h.*, following the trend of the southern coast from Tybee towards Hatteras, running close to the shore as it passes southward into the Straits of Florida, interrupted between Cape Lookout and Hatteras in passing northward and eastward, re-appearing again north and east of Hatteras, and following the coast inwards towards Sandy Hook, and then towards Point Judith, and leaving the coast off the shoals of Nantucket and Cape Cod. The lines of $11\frac{1}{2}h.$ and $11h.$ are approximately drawn outside of the line of $12h.$ which, in general, is quite near to the coast, and conforms to its sinuosities from Tybee to Narragansett entrance.

TABLE No. 3.

Letter of group.	Groups of stations.	Mean co-tidal hour.	$-\frac{N}{M}$.	$\angle$	Increase of z for every minute of distance perpendicular to co-tidal hour $\sqrt{M2+N2}$.	Geog. aphical miles perpendicular to co-tidal lines for $30m.$ of z.	
		h. m					
a . . .	Five stations from Savannah to Hatteras.	11 52	1·303	50° 9′	1·25	24	Tybee, Charleston, Cape Fear, Beaufort, Hatteras.
a bis.	The same uncorrected for depth.	12 16	1·298	52 23	2·31	13	
b . . .	Four stations from Old Point Comfort to Sandy Hook.	12 18	0·411	22 21	4·47	6	Old Point Comfort, Delaware breakwater, Cold Spr'g inlet, Sandy Hook.
c . . .	Four stations from Sandy Hook to Quick's Hole.	12 6	2·00	63 27	0·76	40	Sandy Hook, Point Judith, Beavertail, Quicks' Hole.
c bis.	Six Stations from Sandy Hook to Quick's Hole.	12 10	1·638	58 36	0·13	231	Sandy Hook, Fire island, Montauk Point, P't Judith, Beavertail, Quicks' Hole.
d . . .	Six stations from Provincetown to Cape Ann.	15 15	0·608	31 17	0·924	32	Provincetown, Wellfleet, Boston, Nahant, Salem, Gloucester.
e . . .	Six stations from Cape Ann to Cape Sable.	14 37	0 968	44 4	1·006	30	Newburyport, Portsm'th, Portland, Fourchue island, Ellenwood's island, Cape Sable island.
e bis.	Twelve stations from Provincetown to C. Sable.	14 56	0·803	38 46	0·910	33	
f . . .	Three stations,	12 48	- 0·514	117 12	1·05	29	St. John's river, Cape Canaveral, Cape Florida.

The co-tidal line of $15h.$ is the one which characterises the indentation between Cape Cod and Cape Sable, the probable connection of the depth of the sea there, and of the co-tidal lines, being traced on the chart. The lines connecting these two systems are uncertain. The tide-wave appears to move backward from the northern extremity of Cape Cod to the southern, or Monomoy Point; but this part of the subject requires further observations for its elucidation.

I have tried, in discussing these observations, several other groups, but chiefly to learn whether stations must be multiplied or observations repeated; and it is not necessary to occupy the time of the association with a detail of these trials, or with their results. They will be used in the progress of the further observations.

Art. IV.—*Approximate Co-tidal lines of the Pacific Coast of the United States, from observations in the United States Coast Survey;* by A. D. Bache, Superintendent. Communicated by authority of the Treasury Department.

The western coast of the United States, between San Diego, California, and Columbia river, extending through 13° 35′ of latitude, and 6° 43′ of longitude, is divided into three reaches, (see plate,) the first from San Diego to Point Conception, the second from this point to Cape Mendocino, and the third from that Cape to Cape Disappointment at the mouth of the Columbia. The first reach, about 220 miles in extent, is curved, the general trend being about N. 56° W. The second, about 430 miles in extent, is in general straight, with moderate indentations only, and its trend is about N. 27° W. The third, 370 miles in extent, is also nearly straight, trending nearly N. 5° E.

The soundings on the coast generally, except in the harbors, have been for the purpose of general reconnoissance, and are not detailed enough to show the configuration of the bottom.

Tidal Observations.

Tidal stations for long series of observations have been established at San Diego, San Francisco, and Astoria, (Columbia river,) and between these, temporary stations at the points and for the periods stated in the annexed general table. Saxton's self-registering gauge has been employed at the permanent stations generally and at some of the temporary stations also.

The observations are under the direction of Lieut. W. P. Trowbridge, U. S. Corps of Engineers, and Assistant in the Coast Survey. They were commenced in 1853, and are still in progress. The very intelligent and careful supervision of this officer is a guaranty for the character of the observations. The observers too were especially selected by him for their faithfulness and intelligence.

The number of results collected is such as to warrant an approximate determination of the cotidal lines of this coast, to be checked when further results are obtained. This attempt has the advantage of pointing out deficiencies in the series, which otherwise would not so clearly appear. The following table shows the localities of observation and the duration of each series embraced in this discussion, the name of the observer, and the kind of gauge employed.

TABLE I.

Tide Stations on the Western Coast of the United States, the results of which are discussed in this paper.

	Stations.	Time.		Gauges.	Observers.
1	San Diego, ...	9 months	(1853–4)	Self-registering.	A. Cassidy.
2	San Pedro, ...	4 "	(1853–4)	"	T. A. Szabo.
3	San Luis Obispo, ...	2 "	(1854)	Box, ...	G. Sherman.
4	Monterey, ...	2 "	(1854)	Self-registering.	J. Ord.
5	Santa Cruz, ...	1 "	(1853)	Staff.	?
6	San Francisco,........	12 "	(1853–4)	Self-registering.	G. Sherman. H.E.Uhrlaudt.
7	Bodega, ...	3 "	(1854)	"	T. A. Szabo.
8	Humboldt Bay,.......	2½ "	(1854)	Box, ...	J. A. Black.
9	Port Orford, ...	2½ "	(1854)	Self-registering.	T. A. Szabo.
10	Cape Disappointment, .	2 "	(1854)	Staff.	J. A. Black.
11	Astoria, ...	9 "	(1853–4)	Self-registering.	J. Wayne.

These results were in part tabulated by Lieut. Trowbridge, and in part in the Tidal Division of the Coast Survey office under the immediate direction of Assistant L. F. Pourtales. The discussions were made in general by Messrs. Heaton and Hawley of the same division.

The times of high water are referred to the next preceding transit of the moon, transit F of Mr. Lubbock's nomenclature, the epoch having been found to correspond to that transit. The mean interval between the time of high water, or the establishment corrected for half-monthly inequality for each station is given in the following table. A correction to carry the results to deep water is applied in the way described in my paper on the cotidal lines of the Atlantic coast of the United States,* giving the establishment used in obtaining the cotidal hour.

The latitude and longitude from Greenwich of each tidal station is given in the table to the nearest minute. The cotidal hour found from the establishment corrected for depth and the longitude from Greenwich is in the last column of the table. It is not necessary to apply a correction for the different transits as the difference between the greatest and least corrections amounts to but five minutes.

TABLE II.

Data for the Co-tidal lines of the Pacific Coast of the United States.

	Stations.	Corrected estimates.	Correct'n for depth	Final corr. estimate.	Latitude N.	Longitude W.	Co-tidal hour.
		h. m.		h. m.	° ′	° ′	h. m.
1	San Diego,............	9 42	10	9 32	32 42	117 13	17 21
2	San Pedro,....	9 37	10	9 27	33 43	118 16	17 20
3	San Luis Obispo, ...	10 4	3	10 1	35 11	120 43	18 04
4	Monterey, ...	10 20	0	10 20	36 36	121 54	18 28
5	Santa Cruz, ...	10 16	3	10 13	36 57	122 0	18 21
6	San Francisco, north beach,	11 56	9	11 47	37 48	122 26	19 57
7	Bodega,..............	11 19	9?	11 10	38 18	123 3	19 22
8	Humboldt Bay,.........	12 2	9	11 53	40 45	124 10	20 10
9	Port Orford,...........	11 26	0	11 26	42 44	124 29	19 44
10	Columbia River (Cape Disappointment), ...	12 0	16	11 44	46 17	123 56	20 00

* Proceedings of the Amer. Assoc. Adv. Science, Washington meeting, 1854.

Co-tidal Hours.

The cotidal hours thus far obtained between San Diego and Cape Disappointment, Columbia river, are contained between $17^h\ 20^m$ and $20^h\ 10^m$, increasing as a general rule, but with striking exceptional cases, and not regularly in passing northward. The cotidal hour of $17^h\ 20^m$ characterizes the two stations in the southern reach referred to in the description of the coast; 18^h, 19^h, 20^h are found on the middle reach, and 20^h characterises the northern.

Co-tidal Groups.

In discussing these results I have followed the same course as in the paper on the cotidal lines of the Atlantic, dividing the stations into natural groups, and applying Lloyd's mode of discussion of magnetic lines to them.

The northern group of stations, between Cape Disappointment and Cape Mendocino, (see plate) is composed of Cape Disappointment, Port Orford, and Humboldt. The mean cotidal hour is $19^h\ 58^m$. The mean of the longitudes of the stations is 124° 12′; the mean of latitudes 42° 15′. Calling the differences between the mean longitude and the longitude of each station when reduced to nautical miles x, the differences between the latitude of each station and the mean y, the difference between the cotidal hour at each station and the mean cotidal hour z, and assuming Σ as the sign of the algebraic sum of the numerical quantities obtained for the co-efficients of the equations furnished by each station, we form and solve the equations:

$$\mathrm{M}\Sigma\, x^2 + \mathrm{N}\Sigma\, x\, y = \Sigma x\, z$$
$$\mathrm{N}\Sigma\, x\, y + \mathrm{M}\Sigma\, y^2 = \Sigma y\, z.$$

In the case before us M gives for the co-efficient of the longitude 1·2 and N for that of latitude, 0·006. The tangent of the angle which the cotidal line makes with the meridian $\frac{\mathrm{N}}{\mathrm{M}} = 0{\cdot}05$ and the angle is 2° 52′. The distance in nautical miles perpendicular to the cotidal line corresponding to one minute of establishment or $\sqrt{\mathrm{M}^2+\mathrm{N}^2}$ is 1·2 miles, and therefore the progress of of the tide wave in one hour, 50 miles. This is a velocity less than the depth would indicate to be correct, and from the small differences in the establishments of the stations, this must be an uncertain datum. We shall see however that in the next group where the establishment varies more considerably this datum is still less probable than the one here obtained.

The direction of the line is nearly coincident with that of the trend of the coast, the cotidal angle being 2° 52′ and the general trend of the coast differing but two degrees from it.

The cotidal hours calculated from the separate equations are for Cape Disappointment 20ʰ 00ᵐ, Port Orford 19ʰ 44ᵐ, agreeing precisely with the observed, and for Humboldt 20ʰ 09ᵐ, differing but one minute from the observed.

The observations bearing upon this group are extending northward, but the difficulties in the way of maintaining the stations are such, on a coast inhabited by aborigines, that I do not venture to count upon speedy results. Lieut. Trowbridge is using his best efforts to establish the necessary stations.

I precede the discussion of the *Middle Group* of stations by a table giving the results corresponding to several different hypotheses which will in turn be examined.

TABLE III.

Discussion of the Middle Group of Tidal Stations between Cape Mendocino and Point Conception.

	Stations.	Mean Longitude.	Mean Latitude.	Mean co-tidal hour.	M Diff. of cotidal hour for one geog. mile of Longitude.	N Diff. of cotidal hour for one geog. mile of Latitude.	Angle [tang.—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'r tid'l wave	Observ'd-computed tidal hour for San Luis Obispo.	Monterey.	Santa Cruz.	San Francisco	Bodega.
		° ′	° ′				° ′							
1	San Luis Obispo, Monterey, Santa Cruz, San Francisco, Bodega.	122 01	36 58	18 50	3·83	2·78	35 30	4·7	18	7	12	30	12	·4
2	San Luis Obispo, Monterey, San Francisco, Bodega.	122 02	36 58	18 58	3·11	2·32	36 48	3·9	15	1	1		2	8
3	San Luis Obispo, Monterey, San Francisco.	121 41	36 32	18 50	3·07	2·35	37 26	3·9	15					
4	San Luis Obispo, Monterey, Santa Cruz.	121 32	36 15	18 18	4·1	2·7	33 06	4·9	18					
5	Monterey, Santa Cruz, San Francisco, Bodega.	122 21	37 25	18 47	3·5	2·6	36 30	4·42	14					
6	Monterey, San Francisco, Bodega.	122 28	37 34	19 16	3·35	2·6	37 37	4·2	14		0		−1	−2

Taking the five stations between Cape Mendocino and Point Conception as one group, we find from the table the angle of the cotidal line with the meridian N. 35° 30′ W. and the mean cotidal hour $18^h\ 50^m$, the difference of establishment for one geographical mile perpendicular to the cotidal line 4·7 minutes. As the observations at Santa Cruz were comparatively few in number, it may be more proper to leave out that station, which will give for the corresponding results to those just stated N. 36° 43′ W., for the angle of the cotidal line, $18^h\ 58^m$ for the mean cotidal hour, and 3·9 minutes for the cotidal difference in one geographical mile.

Omitting Bodega from this group we obtain for the cotidal angle N. 37° 26′ W., for the mean cotidal hour $18^h\ 50^m$, and for the change of hour in one mile 3·9 minutes.

Omitting Bodega and San Francisco from the first group, the three southern stations, San Luis Obispo, Monterey and Santa Cruz, give for the same values N. 33° 06′ W., $18^h\ 18^m$, and 4·9 minutes. The direction of the cotidal line being nearly the same, its denomination only is changed. The $18\frac{1}{4}$ hours would give nearly $18\frac{3}{4}$ if carried to the cotidal line of the first hypothesis, $18^h\ 50^m$, which is a good agreement.

Omissions at the other end of the group produce the same result. Leaving out San Luis Obispo from 1, we obtain for the cotidal angle N. 36° 30′ W., cotidal hour $18^h\ 47^m$, change per mile 4·4 minutes. The same result is obtained by other omissions in the series.

The introduction of Humboldt into a group with Bodega and San Francisco gives results materially different from those obtained, reducing the cotidal angle to 18° 05′, and increasing the velocity to 40 miles per hour.

The combination of San Pedro with southern stations also changes the results so rapidly as to prove that the group is limited to the south of Point Conception.

The proof seems complete that these five stations form a single group. Using the determination in which Santa Cruz is omitted for reasons already stated, we have for the cotidal angle N. 36° 43′ W., which gives an inclination to the general line of the coast of about ten degrees. The line of nineteen hours meets the coast north of Point Año Nuevo, and between it and Point San Pedro.

The comparison of the observed and computed establishments from either of these hypotheses, is very satisfactory, from that of the five stations. Santa Cruz alone stands out with a difference greater than fifteen minutes. For the second list of four stations the greatest difference is twelve minutes, and the mean without regard to signs is but six minutes.

The velocity of the tide wave is less satisfactory from the other data rising to but fifteen miles per hour. The depth should give a greater velocity and the comparison with the northern group would indicate a much greater.

In drawing the chart of cotidal lines I have not followed the velocities strictly. This group however lies favorably for the determination of the rate of motion of the tide wave, and the results of the various hypotheses in the table are quite consistent with each other in giving a low velocity.

The southern group is imperfect as having but two stations in it. Further observations are required here and on the islands which separate Santa Barbara Sound from the great ocean. Combining San Luis Obispo with San Diego and San Pedro would require a retrograde wave, showing that they do not belong to the same group. The computations required in these discussions were generally made by Mr. Heaton of the Tidal Division under my immediate direction or that of Assistant Pourtales.

Chart of Co-tidal lines.

From this discussion I have drawn a chart of approximate cotidal lines for the coast of Oregon and California (see plate). The chart on a scale of $\frac{1}{10,000,000}$, the same which was used in presenting the cotidal lines of the Atlantic coast of the United States, shows the general configuration of the coast.

The cotidal hours are marked near the several tidal stations.

The straight lines resulting from the discussion of the northern and middle groups are delineated for the northern group the cotidal lines of XIX and XX hours, and for the middle group of XVII, XVIII, XIX and XX hours.

The curves representing the approximate cotidal lines of 17, 18, 19 and 20 hours are drawn in dotted lines, the character of the dots differing for the several lines.

The line of $17\frac{1}{3}$ hours would follow the coast nearly from San Diego to Point Conception, then the line of 18 hours nearly to Point Pinos. North of this point the lines of eighteen and nineteen hours meet the coast obliquely at an angle of about ten degrees, the line of 20 hours appearing near Point Arena and following the coast generally to Cape Disappointment, the receding parts having a little later and the projecting parts a little earlier hour.

Throughout the extent of coast examined, the cotidal lines are either sensibly parallel to, or make a small angle with the general direction of the coast. The angle made with the coast between Point Conception and Cape Mendocino is greater than is general on the long reaches of Atlantic coast.

The successive charts of cotidal lines of the Pacific have been tending toward the representation now given as more reliable observations have been collected.

The last chart in 1848 of the Master of Trinity (Rev. Mr. Whewell*), to whom this subject owes so much of its progress, in comparison with that of Rear Admiral Lutke,† or with his own earlier map,‡ shows this tendency, the inclination of the lines to the coast being assured at each step.

ART. V.—*Notice of the Tidal Observations made on the Coast of the United States, on the Gulf of Mexico, with type curves at the several Stations, and their decomposition into the curves of diurnal and semi-diurnal tides;* by A. D. BACHE, Sup't.

(Communicated to the American Association for the Advancement of Science under Authority of the Treasury Department.)

Abstract.—The stations are eighteen in number. At four, hourly observations were made for one year or more, and at the remainder for not less than two lunations and generally for more. The stations at Cape Florida, Indian Key, Key West and Tortugas were intended to trace the tide wave through the Florida Channel; those at Egmont Key, Tampa, Cedar Keys, and St. Marks, to trace it along the Western Coast of Florida; at St. George's, Pensacola, Fort Morgan, Cat Island and E. Bayou, (entrance to the Mississippi,) to trace it along the south coast of Florida, Alabama, Mississippi and part of Louisiana, at E. Bayou, Dernière Isle, Calcasieu, Bolivar Point and Galveston, Aransas and Brazos Santiago for the coast of Louisiana and Texas.

The observations were chiefly made by Mr. Gustavus Würdemann with different assistants. At a few stations they were made by Corporal Thompson of the Engineers, Mr. Bassett, Mr. Tansill and Mr. Muhr. The reductions were made in the Tidal Division of the Coast Survey office by Assistant Pourtales, Mr. Gordon, Mr. Mitchell, Mr. Heaton and others. The methods used were those pointed out in my previous papers to the Association, the decomposition being in some cases made graphically, and at a part of the stations where the semi-diurnal wave is considerable, the ordinary method of working being used as well as those considered peculiarly applicable to these tides. As it would be tedious to present the results of these elaborate discussions in detail, when the co-tidal lines are introduced, I have thought it best briefly to refer now to the types of different tides, and to present to the Association the diagrams for the several stations showing upon a uniform scale the normal curves and their decompositions into the diurnal and semi-diurnal waves.

* Royal Society's Transactions, vol. lxi, 1848.

† Bulletin de la Classe Physico-Mathematique de l'Acad. Imp. des Sciences de Petersbourg, tome ii, No. 1.

‡ Royal Society's Transactions, vol. li, 1833.

ART. VI.—*On the Distribution of Temperature in and near the Gulf Stream, off the Coast of the United States, from Observations made in the Coast Survey;* by A. D. BACHE, Superintendent.*

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

I PROPOSE to present to the Association a brief summary of the result of observations made in the progress of the Coast Survey, in exploring the Gulf Stream, so far as the distribution of temperature is developed by them. The entire observations have been reduced anew, under my immediate direction, by Professor Pendleton, U. S. N., assistant in the Coast Survey, who has also gone over with me, systematically, the discussion of the work, preparatory to its publication in detail, and whose care, assiduity, and intelligence in the matter I desire here to acknowledge.

At the Cambridge meeting of the Association, in 1849, I explained the general plan of the exploration of the Gulf Stream, and presented the results of the observations made up to that time by Lieutenants C. H. Davis, Geo. M. Bache, S. P. Lee, and Richard Bache of the U. S. Navy, in command of hydrographic parties in the survey.

Since then, the work has been continued by Lieutenants T. A. M. Craven and J. N. Maffitt, U. S. N., and has been extended south from Hatteras to Cape Canaveral. In addition to the sections across the stream, upon which the temperature had then been examined, between Cape Cod and Cape Hatteras, others have been since explored from Cape Fear, Charleston, St. Simon's, St. Augustine, and Cape Canaveral, and new and interesting results have been developed in relation to the distribution of temperature across the sections, and to the connection, at least in some of them, between the peculiar distribution and the form of the bottom of the sea.

The examination now made extends from about 42° north latitude to 28½°, and from about 65½° west longitude to 80½°. It authorizes the construction of a chart of the Gulf Stream, showing the distribution of temperature in and near it, not only at the surface but at various depths.

1. *Distribution of temperature at different depths.*

Having gone very fully into this subject, which was one of the first satisfactorily shown by the observations, I do not intend to repeat here what was then stated, except in a general way. The distribution of temperatures below a certain depth, in the cold current which exists between the shore and the Gulf Stream, and over which the warm waters of the Gulf flow, thinning out

* From Rep. Superintend. Coast Survey, for 1854, pp. 156*—*161.

as they approach the land, was shown to belong to a state of equilibrium of temperature which would be assumed by a mass of water having warm water above it and cold water below it, to be represented by a logarithmic curve, and therefore to be due to conduction. That in the Gulf Stream varied according to a different law, indicating a disturbance of equilibrium. Diagram No. 1 shows the distribution of temperature with depth, in the water between the shore and Gulf Stream, as deduced from the observations of Lieutenant G. M. Bache. The ordinates of the curve represent the depths, and the abcissæ the temperatures. The depths, in fathoms, are written at the side of the diagram, and the temperatures by Fahrenheit's scale, at the top. The position at which the temperatures at various depths, recorded in this diagram, were obtained, was in latitude 36° 15′ north, longitude 73° 52′ west, on the section intended to be made from Cape Henry perpendicular to the axis of the stream. This curve, and others of the same kind, were compared with the logarithmic curves which would best represent the observations, and their close coincidence with them shown. The curves were deduced by least squares, from an ingenious investigation by J. H. Lane, Esq., then of the Coast Survey, now one of the chief examiners, in the U. S. Patent Office.

Diagram No. 2, taken also from Lieut. G. M. Bache's observations, shows the character of the curve of distribution near the axis of the Gulf Stream. These particular results were obtained in one of the positions on the Cape Henry section, in latitude 35° 53′ N., and longitude 73° 34′ W.

The projecting form of the curve towards 300 fathoms, and the moderate change of temperature, ten degrees, from 150 to 400 fathoms, shown in that diagram, are characteristic features of the distribution in similar positions. The change from the surface to 150 fathoms was 17° Fahrenheit. Diagram No. 3 represents a corresponding curve to No. 2, from Lieut. Maffit's observations on the Charleston section, in latitude 33° 58′ N., longitude 73° 58′ W. In this the change between 100 and 400 fathoms is still less than in the former case, being but five degrees.

Diagram No. 3 *bis* shows the curve corresponding to that of diagram No. 1, but on the Charleston section nearer to the shore than the axis of the stream in latitude 31° 48′ N., longitude 78° 47′ W.

2. *Distribution of temperature at the same depth, on sections perpendicular to the axis of the Gulf Stream.*

Diagram No. 4 contains the results of observations on the section perpendicular to the stream from Sandy Hook, and shows the mode in which the observations were discussed. The positions where the temperatures were observed are marked at the head of the diagram, and above them the distance from Sandy Hook in nautical miles. The temperatures are marked on the side of the diagram. At each position a diagram was drawn similar to those of Nos. 1, 2, and 3, and from the curves traced with a free hand among the points, the results at the several depths, which are shown on diagram No. 4, were obtained. The curves traced among these points so as to preserve as far as possible consistent results for the various depths, are those given in the diagram. In the preliminary discussion of the results, I used the observations themselves at the different depths, and am, therefore, enabled to say, that while the curves present fewer irregularities by the last mode of discussion, as might be expected, the general results are not in any essential particular changed by its adoption. The diagram shows the curve of distribution of temperature at thirteen different depths from the surface to five hundred fathoms. The depths at which observations were taken were the more numerous nearer the surface, where the changes of temperature were the most rapid. These curves were next separated into groups, following the arrangement, which seemed best to apply to the sections generally. On the Sandy Hook section, for example, as shown in diagram No. 5, the results from the surface to 30 fathoms, from 40 to 100 fathoms, at 200 and 300 fathoms, are grouped respectively in the curves *n*, *o*, and *p*, and that for 400 fathoms is given in curve *r*.

The point where the axis of the Gulf Stream, or line of highest temperature, is cut by the section, is distinctly shown on the diagram, and the minimum of temperature or "cold wall" within thirty miles of it, nearer the shore. These are the prominent features in every case. Further from shore than the axis of the stream, the Sandy Hook curves show one point of maximum and two points of minimum temperature. In the comparatively cold water of the in-shore-counter-current, two maximum points and one minimum are also distinctly marked. This diagram is in fact a general type of the results according to which the ocean in and near the Gulf Stream is divided into successive warmer and colder bands. The number and the general arrangement of them can, of course, only be made out by a comparison of the several sections. In the discussion, such a diagram was drawn for each section.

The curves of diagram No. 5 do not at all indicate at what depths the temperature would approach to equality across the section.

The corresponding results for the Cape Henry section are shown in diagram No. 6 *bis*. The first or "cold wall" minimum, the axis maximum, two minima and two maxima beyond the axis, are well made out in all the groups, for the surface to four hundred fathoms. The mean of the results at 0, 5, 10, 20, and 30 fathoms, is shown by the curve *n*; that of 50, 70, 100, and 150 fathoms, by *o*; and of 200, 300, and 400 fathoms, by *s*.

Not to multiply diagrams too much, I have omitted those for Hatteras and Cape Fear, which, besides, have nothing very especially characteristic in them, unless it may be that the Hatteras section is one where the results are most disturbed.

The next diagram No. 7, shows the results of the Charleston section. The groups *m*, *n*, and *o*, from 5 and 10 fathoms, 20 and 30 fathoms, and 20, 30, and 50 fathoms, resemble each other very much; *p*, the mean of 70, 100, and 150 fathoms, is slightly irregular; and so is *r*, the 400 fathoms curve. The curves from 5 to 50 fathoms show extremely well the division of the stream, the first or "cold wall" minimum, the first, second, and third maxima, and the second and third minima. In-shore, from the first minimum, is a maximum. The irregularities in these observations, though obtained with registering instruments at such considerable depths, are less than those which stationary thermometers, sunk in the ground, show in the passage of heat to them.

Diagram No. 8 represents the Canaveral section, where the same results which have been stated are shown, but on a very diminished scale. The observations were not carried far enough from the shore to reach the second maximum. The first and second minima and the axis maximum are well marked.

I have omitted, for reasons already stated, the diagrams of the other sections. The same phenomena are in general repeated in all the sections.

The permanency of the division of the stream in different years, and the accuracy and sufficiency of the observations, may be tested in two ways: the first by comparing the results of running the same section in different years by different observers; the second by the consistency or inconsistency of the results obtained at one depth when compared with those at other depths.

In order to compare the results of different years, some one section was to be explored in the successive seasons. Thus the Cape Henry section, connected the work of Lieuts. G. M. Bache, S. P. Lee, and R. Bache, having been explored by each. The Hatteras section was common to the work of Lieuts. R. Bache and J. N. Maffitt, and the same Charleston section was intended to be run by Lieuts. Maffitt and Craven.

The Cape Henry section was three times run over; and it appears, by comparing the results of each season with the mean of the whole, that in each group of observations represented by one of the curves of diagram No. 6, there is an uncertainty of rather less than seven miles in the determination of the maxima and minima generally. The best determined points are the first and second minima and maxima—the "cold wall" minimum and axis maximum having an average probable error of 5½ miles, and the other three points have an average probable error of eight miles.

This accordance is satisfactory whether viewed in relation to the probability of recognising the band in passing through it, or in reference to the determination of the positions of the observations themselves, or to the distances apart of the positions. Diagram No. 6 represents in different lines the results of three years' observations on the Cape Henry section, showing, with differences which might be expected, the same general division of the stream. The observations were made during the summer season, partly for nautical reasons, and also as giving a nearer approach to equilibrium than the winter.

The differences in the temperature of the whole mass of water at the same season of different years are often more considerable than the difference in distribution.

The second test of the probable accuracy of determination of the several principal maxima and minima was by a comparison of the independent determination of the maximum and minimum points in the curves of distribution at the same depth, corresponding to various depths from the surface. It was first established, by a general induction, that all the points of maximum and minimum, except the "cold wall" minimum and axis maximum, are probably, as a rule, vertically over each other. Next the curve was found, by which the recession of the first minimum and maximum from the shore, as the depth increased, could be represented. The differences then, from the mean curve of recession, for the first two points, and from the vertical line or average position for the other points, gave the probable discrepancy of determination. It would be out of place here to give all these labored details. This discussion gives as might be expected, smaller probable errors than the other; for this takes in accidental errors only, and that includes real changes. The mean probable error of determination of the first four points from this investigation was for Cape Henry section, for the mean of the three years, one mile; and of the other three points rather more than two miles. This includes three determinations of which each result is the average.

The corresponding results for all the sections are given in Table No. 1 and show on the average less than one mile of uncertainty for the mean determination of the first or "cold wall" minimum; two miles and a half for the first or axis maximum, and the second minimum between them; and four miles for the next three points, and about eight and a half for the fourth minimum, which was shown on but three of the sections.

The Hatteras section presents, as before remarked, the most considerable discrepancies in its results, incident, most probably, to the nature of the phenomena themselves in that region.

TABLE No. I,

Showing the probable uncertainty in determination of the maximum and minimum points.

Name of section.	Uncertainty, in miles.						
	Cold wall, or first minimum.	Axis of, or first maximum	Second minimum	Second maximum	Third minimum	Third maximum	Fourth minimum.
Sandy Hook, ...	....	·75	0·00	3·94	7·99	.....	.....
Cape May, ...	·82	1·25	2·54	1·57	.....	4·03	4·87
Cape Henry, (3 years),	·84	·61	·55	1·70	1·06	·94	4·42
Cape Hatteras, (2 y'rs),	.....	6·77	6·36	9·31	5·69	6·23	.....
Cape Fear,..........	.....	1·25	.....	.....	2·98	3·49	13·37
Charleston, ...	1·25	1·57	·72	2·09	2·40	·82	.....
St. Simon's, ...	·00	·74	1·27	·41	.....	.. ..	.....
St. Augustine, ...	·52	·51	·44	·44	·55	.....	.....
Cape Canaveral,......	·95	1·69	·39	.....	.....	.....	.....
Final value, ...	·83	2·49	2·49	4·00	4·01	3·71	8·45

3. *Connection of the figure of the bottom of the sea with the distribution of temperature.*

The discovery that soundings could be carried nearly across the Charleston section of the Gulf Stream, and that after losing them on this section for a short distance they were reached beyond the axis of the stream, was communicated to the Association at the Cleveland meeting, as resulting from the observations of Lieuts. J. N. Maffitt and T. A. Craven, U. S. N., assistants in the Coast Survey. The connection between the figure of the bottom and the division of the stream, which the observations of these officers established as applicable to the sections south of Charleston, is illustrated in diagram No. 9, in which the curves of equal temperature, the depths corresponding to them, and the figure of the bottom, are given. In the diagram the distances from the shore are marked in nautical miles on the top, as also the positions at which the temperatures were explored; and the depths in fathoms are stated on the left hand-side. Each curve is marked with the temperature (by Fahrenheit's scale) which it indicates, and the curves are drawn for every five degrees from 57° to 77° Fahrenheit.

The bottom of the sea slopes gradually on this section for some fifty miles, reaching a depth of about twenty fathoms; then more rapidly to about 65 miles, and the depth of one hundred fathoms; and suddenly falling off to a depth greater than six hundred fathoms—at about one hundred miles from the shore, where the depth is three hundred fathoms, a ridge, with a very steep slope on the in shore side, and a little less to seaward, occurring fifteen hundred feet above the hollow to seaward of it, and distant about twelve miles from it. A second rise of five hundred feet, on a base of twelve miles, is followed by a depression of three hundred feet on a base of fifteen miles, and then by a gentle slope upward.

It is altogether probable that all the depths found by observation are greater than the actual ones; but the bottom was brought up in several cases showing that the lead had reached it, and it is most probable that the proportions are not far from correct.

The close conformity of the curves of temperature to those of the bottom is obvious from an inspection of the diagram. The descent of the curve of 57° in the deepest part of the section is a remarkable feature, not obliterated in the curves above it, but reaching nearly to the surface. In the midst of general coincidences there is no one discrepancy which indicates that there may be other causes which produce the distribution of temperature in warm and cold bands besides the figure of the bottom. Further observations will show if this is so, or if it is an error of observation.

We see in this diagram the cold water pressing towards the shore-side, following the form of the bottom along which it lies, and forcing the layers above it, to take the same general conformation.

On the crest of the steep slope in the St. Simon's section there is a forcing up of the cold water to a considerable height, as is shown less distinctly at position No. 1 of the Charleston diagram. This corresponds to the "cold wall" in those sections.

Whether this remarkable discovery may be the clue to the general distribution of temperature in the Gulf Stream, on the deeper sections north of these, is well worth examining, and instructions have been given accordingly.

4. *The "Cold Wall."*

It is difficult to fix the depth of the Gulf Stream current, though easy to see, from the observations, that it is comparatively superficial, extending certainly, on the Charleston section for example, to a less depth than three hundred to five hundred fathoms, and resting upon cold water belonging to a much higher latitude than that in which it is found. Off Cape Florida, about twelve nautical miles east from the light-house, at the depth of 550 fathoms, the temperature was but 49° Fahrenheit in June, 1853. The mean temperature of the coldest month in the year, on the coast in the same latitude with the point of the axis of the Gulf Stream at the surface on the Charleton section, is about 53½° Fahrenheit. At Key West the mean temperature of the coldest month of the year is, from tbe report of the Surgeon General U. S. Army, 69·3°. Deep-sea temperatures of the ocean generally, are required for determining this and other questions of a similar kind.

The lateral limits of the stream are more easily defined, especially in the northern sections, where the change is so sudden from the warm water of the Gulf to the cold stream inside of it towards the shore, that the cold stream was likened, by Lieut. Geo. M. Bache, to a "cold wall" confining the warm water.

The diagrams of the Sandy Hook sections, Nos. 4 and 5, show this sudden change very strikingly between positions 13 and 14, the probable minimum lying, however, inside of 13. So, also, the Cape Henry diagrams, Nos. 6 and 6 *bis*. The "cold wall" minimum and axis maximum are shown on diagram 10, on the same scale of miles at the top of the diagram, and temperature at the side. That the "cold wall" exists south of Hatteras is proved by the same diagram, where the Cape Fear, Charleston, and St. Simon's sections are compared with those for Cape Henry, Cape May, and Sandy Hook. The difference of temperature is less for the southern sections, but it is still strikingly marked.

In the cold water inshore from the Gulf Stream, Acting Master Jones, of Lieut. Maffitt's party, found a current setting southward, as also in the cold band outside of the axis. These results, if shown to be permanent, will be in the highest degree important. As it is, the existence of them at any time shows the cause of many anomalies noticed by navigators in relation to the currents of the Gulf Stream.

The investigations relating to currents remain to be made in detail, though some results have already been procured. It is important in work like this to confine the special attention of observers to a few problems at a time, that they receive close examination.

As the warm water of the Gulf Stream flows onward and outward from the axis at and near the surface, the stratum, as a general rule, becomes thinner. The current is then outward from the axis as well as onward.

5. The changes of the position of the remarkable points in the sections with the season, and other circumstances, are undergoing investigation, some results having been already collected.

6. *Chart of the Gulf Stream.*

The alternate bands of warm and cold water into which the ocean in and near the Gulf Stream is divided, are shown in the chart now presented, as deduced from the discussion already referred to. The higher temperatures are represented by the darker shades. The axis of the stream is marked by the darkest full shade, and the axis of the colder and warmer bands on each side of it by thinner shades, distinguished as stated on the chart. The axis, where it crosses the Sandy Hook section, is seen to take the general direction of the trend of the coast, which is even more closely followed by the "cold wall" axis. These lines are drawn with a free hand among the points by which they would be rigidly determined in the several sections, so as to give a general consistency to their form. The variations from the points rigidly determined are generally of the same order with the probable errors of those points. The probable outer limit of warm water is designated on the chart.

Within the "cold wall" minimum is a band of higher temperature crossing the Sandy Hook section, and generally well marked, followed by a minimum which appears pretty well determined on the northern sections.

The limits of the chart show the limits of the Gulf Stream explorations up to the summer of 1853, inclusive, the work being still in progress.

Art. VII.—*Notice of Earthquake Waves on the Western Coast of the United States, on the 23d and 25th of December*, 1854; by A. D. Bache, Superintendent U. S. Coast Survey.

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

In February 1855, I received from Lieut. W. P. Trowbridge, of the Corps of Engineers, Assistant in the Coast Survey, in charge of the tidal observations on the Pacific coast, a letter calling my attention to the singular curves traced by the self-registering tide-gauge at San Diego, on the 23d and 25th of December, and remarking that the irregularities of the curve could not be produced by disturbances from storms, as the meteorological records for the whole coast showed a continuance at that time of an ordinary state of weather, and the length of the wave was too great to be explained by such action.

"There is every reason to presume," he continues, "that the effect was caused by a submarine earthquake." No shock however has been felt at San Francisco.

When the record sheet of the self-registering gauge at San Francisco was received, similar irregularities in the curves for the same days were found upon it. The sheet for Astoria presented little or no special irregularity. These were the only self-registering gauges actually in operation at this time.

Waves of short period would of course escape detection by the ordinary hourly or half-hourly observations.

About the 20th of June, we received accounts from Japan of a violent earthquake on the 23d of December, the notice of which was more circumstantial than usual, from the damage to the Russian Frigate *Diana*, in the port of Simoda, in the island of Niphon, from the excessive and rapid rise and fall of the water.

A detailed account of the phenomena of this earthquake and of the rise and fall of the sea produced by it in different places on the coast of the Pacific, is much to be desired, and I have thought that by the publication of the results obtained by the Coast Survey, the publication of official reports of the phenomena might be induced, perhaps even similar observations may have been made, and these registers of the self-acting tide-gauge, will show what observations it is desirable to have for comparison.

Thus far we are left to the public prints for the information obtained,* and the different accounts are quite discrepant where they give details, and are usually, as intended merely for general information, too vague in the statements to give satisfactory means of comparison.

A correspondent of the New York Herald writing from Shanghae gives the following notes, stated to be derived from an officer of the Frigate *Diana.*

"At 9 A. M. on the 23d of December, weather clear, thermometer 72°, barometer 30, a severe shock of an earthquake was felt on board the frigate, shaking the ship most severely. This shock lasted full five minutes and was followed at quick intervals by rapid and severe shocks for 30 minutes."

"At 9·30 A. M. the sea was observed washing into the bay, in one immense wave thirty feet high, with awful velocity. In an instant the town of Simoda was overwhelmed and swept from its foundations. * *

"This advance and recession of the water occurred five times. * * By 2·30 P. M. all was quiet."

A communication in the same paper, purporting to give an extract from the log-book of the *Diana,* states that—

"At a quarter past nine, without any previous indication, the shock of an earthquake, which lasted two or three minutes, causing the vessel to shake very much, was felt both on deck and in the cabin. At ten o'clock a large wave was observed entering the bay. * * *

"The rising and falling of the water were very great; the depth varying from less than eight to more than forty feet, and these changes at intervals of about five minutes continued until noon. * * * * Scarcely had half an hour elapsed when the rising and falling of the water became more violent than before. Between this time and a quarter past two, (when the agitation again became much less,) the frigate was left four times on her side, and once while thus laid in only four feet of water. * * * * *

* Since reading this paper I have received through the kindness of Commodore M. C. Perry, a copy of a letter from Captain H. A. Adams, U. S. N., who visited Japan in the Steamer Powhatan, to exchange ratifications of the treaty between Japan and the United States. Capt. Adams says: "Simoda has suffered dreadfully since your visit there. On the 23d of December there were several shocks of earthquakes; the sea rose in a wave five fathoms above its usual height, overflowing the town and carrying houses and temples before it in its retreat. When it fell it left but four feet of water in the harbor. It rose and sunk this way five or six times, covering the shores of the bay with the wrecks of boats, junks, and buildings. Only sixteen houses were left standing in the whole place.

"The entire coast of Japan seems to have suffered by this calamity. Yedo itself was injured, and the fine city of Osaka entirely destroyed."

Captain Adams then gives an account of the disaster to the Russian Frigate Diana, Admiral Pontiatine commanding, which was so injured in the harbor of Simoda as to lead finally to her entire loss.

"Continuing to decrease in violence and frequency by 3 P. M. the agitation of the water and the motion of the vessel consequent thereon, were very slow." * * * * * *

"At this time a fresh west wind was blowing, the barometer stood at 29·87, and the thermometer was 10·50 degrees R. (about 55·63 degrees F.)"

The official report of the disaster to the frigate will probably contain further and more precise particulars of the phenomena.

Mr. P. W. Graves gives in the *Polynesian* a notice, for which I am indebted to Mr. Meriam, of an extraordinary rise and fall of the waters at Peel's Island, one of the Bonin Islands, on the 23d of December. The first rise noticed was fifteen feet above high water, followed by a fall which left the reefs entirely bare. The hour when this occurred is not stated. "The tide continued to rise and fall during the day, at intervals of fifteen minutes, gradually lessening" until the evening.

At Peel's Island the waters rose on the evening of the 25th of December to the height of twelve feet. I have not however seen any notice of an earthquake on that day.

I present to the Association a copy of the curves traced by the self-registering gauges at the Coast Survey tidal stations at San Diego, San Francisco and Astoria on the 23d and 25th of December, 1854 (see plate). The curves representing tides of short period being traced upon the falling or rising curve of the regular tide, their peculiarities are not so readily seen as when shown in the second diagram (see plate), where the regular tidal curve is represented as a horizontal line. The times of the San Diego curve are reduced to San Francisco time. The curve at San Diego presents many minor irregularities from the motion of the float not having been sufficiently checked to prevent the recording of the waves caused by the wind.

Upon a falling tide the crest of these waves will be met earlier and the hollows later than upon a horizontal surface and the intervals from crest to crest, or from hollow to hollow, will be affected by the change of rate of fall. Upon a rising tide the reverse will occur.

There can be no doubt that these extraordinary rises and falls of the water at short intervals, were produced by the same cause which determined the extraordinary rise and fall in the harbor of Simoda, in Japan, and at Peel's Island.

The San Francisco curve presents three sets of waves of short interval. The first begins at about $4^h\ 12^m$, and ends at $8^h\ 52^m$, the interval being $4^h\ 40^m$. The second begins at about $9^h\ 35^m$, and ends at $13^h\ 45^m$, the interval being $4^h\ 10^m$. The beginning of the third is about $13\frac{3}{4}^h$, and its end is not distinctly traceable. The crest of the first large wave of the three sets occurred at the respective times of $4^h\ 42^m$, $9^h\ 54^m$, and $14^h\ 17^m$, giving intervals of $5^h\ 12^m$, and $4^h\ 23^m$.

The average time of oscillation of one of the first set of waves was 35^m, one of the second 31^m, and one of the third about the same. The average height of the first set of waves was ·45 of a foot on a tide which fell two feet; of the second ·19 of a foot on a tide which rose three feet; of the third somewhat less than ·10 of a foot, on a tide which fell some seven feet. The phenomena occurred on a day when the diurnal inequality of the tide was very considerable. The greatest fall of the tide during the occurrence of the first set of waves was ·70 feet, and the corresponding rise ·60 feet. In the second the corresponding quantities were ·30 feet, and in the third ·20 feet. These waves would not have attracted general attention.

There is a general analogy in the sequence of the waves of the three sets, which seems to mark them as belonging to a recurrence of the same series of phenomena. In the diagram No. 3 A (see plate), the heights of the successive waves of the first set at San Francisco are shown by the dots joined by full lines, and of the second by those joined by the fine dotted line. The full faint lines show the heights of the first series at San Diego and the broken faint lines the heights of the second. The heights in hundredths of a foot are marked at the side of the diagram, and those of the successive waves are placed at regular intervals, the waves being numbered from 0 to 7 at the top of the diagram. The height is the mean of the fall from a crest to a hollow and of the succeeding rise from the same hollow to the next crest. The times of oscillation from one crest to the next succeeding, are placed on the same diagram, the times being written at the right hand, and the wave being designated at the lower part of the diagram No. 3, B. The full line represents the times of the first series at San Franciso and the broken line the times of the second. The full and broken faint lines represent the times of the first and second series at San Diego.

The intervals between the times of occurrence of the crests of the successive waves in the first and second series diminish from 5^h 10^m to 4^h 48^m by irregular differences.

The effect of the rising or falling tide upon which these waves occur is of course greater in disturbing the heights than the times.

The series itself looks like the result of several impulses, not of a single one, the heights rapidly increasing to the third wave, then diminishing, as if the impulse had ceased, then renewed, then ceasing, leaving the oscillation to extinguish itself.

If we had a good scientific report of the facts as they occurred at Simoda, the subject would lose the conjectural character which must otherwise belong to it. Although we have no account of the place where the earthquake had its origin, the violence of its effects in Japan and the diminished effects at Peel's Island, show that Japan was certainly not far from the seat of action.

Five successive waves of considerable height are spoken of as having occurred at Simoda, while by the gauge we trace eight, of which seven are of considerable height. The highest wave at Simoda was estimated at thirty feet, at Peel's Island fifteen feet;—at San Francisco it was 0·65 feet and at San Diego in the first series 0·50 feet.

At *San Diego* the same three series of waves are distinctly shown. The first begins $1^h\ 22^m$ later than at San Francisco, correction having been made for the difference of longitude, and ends $0^h\ 52^m$ later. The interval is 30^m less than at San Francisco, the oscillations being rather shorter than at the last named point. The second begins at $0^h\ 54^m$ later than at San Francisco, and ends 34^m later. The third begins about 54^m later than at San Francisco. The average time of oscillation of the first set of waves is 31^m, and of the second 29^m, being respectively 4^m and 2^m less than of the corresponding series at San Francisco.

The average height of the first set of waves was ·17 feet lower than at San Francisco, and the second as much higher. This fact taken with the difference in the times of oscillation leads me to suppose the difference in the two series due to interference, which is also suggested by the position of San Diego in reference to the islands separating the Santa Barbara sound from the ocean.

The general analogy in the succession of heights of the mean of the two series as shown in diagram No. 3, C, and in the times as shown in D of the same diagram, is very satisfactory.

The difference in the periods of the tide at which the waves occurred would tend to cause discrepancies.

The first series occurred on a rising tide of 4 feet, while at San Francisco it was upon a falling one of 2 feet. The second began near high water and was chiefly upon a falling tide of 7 feet, while at San Francisco it was upon a rising tide of 4 feet.

The forms of some of the individual waves in the second series at San Francisco and San Diego, accord remarkably, as those marked 1, 3, 4, 5, and 6, when reduced to the horizontal line. The comparison on the curve where the distortion remains is also very instructive. The waves marked 1, 4, 6, and 7, are not unlike in the first and second sets at San Diego.

The observations at San Diego confirm then, in general, the inferences derived from those at San Francisco.

The register at Astoria throws no new light on the subject. The bar at the entrance of the Columbia river would explain why the oscillations were lost or greatly reduced at Astoria, even if they arrived off the entrance of the river. The disturbance is marked on the register but in an irregular and confused manner. It was also apparently preceded by unusual oscillations of the water.

After allowing for the very free action of the float of the San Diego gauge, there appears to have been indications of disturbance previous to the great earthquake shocks and following them, occurring at intervals for several days after the 23d of December. The San Francisco gauge presents similar indications.

No special effect appears to have been produced upon the time or height of high or low water by the earthquake which merely caused series of oscillations upon the great tidal wave.

I now proceed to draw from these results some conclusions as to the progress of the ocean wave accompanying the earthquake.

The latitudes and longitude of the places referred to, are as follows:

	Latitude N.	Longitude.	W.
			H. M.
San Diego,	32° 42′	117° 13′	7 49
San Francisco,	37 48	122 26	8 10
Simoda,	34 40	221 02	14 44

The distance from San Diego to Simoda from these data is 4917 nautical miles, and from San Francisco to Simoda 4527 nautical miles.

According to one account the disturbance began at Simoda at 9 A. M. or $22^d\ 23^h\ 44^m$ Greenwich mean time, and the first great wave half an hour after. The first disturbance at San Francisco was at $23^d\ 4^h\ 12^m$, or $12^h\ 28^m$ after that at Simoda, and the first great wave at $23^d\ 4^h\ 42^m$ giving the same interval. The distance and time from this account give for the rate of motion of the wave 363 miles per hour or, 6·0 miles per minute.

The second account would give for the time of transmission $12^h\ 13^m$, and for the rate of motion 370 miles per hour, or 6·2 miles per minute.

The San Diego observations give for the time of transmission of the wave from Simoda to San Diego $13^h\ 50^m$ by the first account, which combined with the distance gives 355 miles per hour, or sensibly the same result as derived from the beginning at San Francisco. The first great wave would give identically the same result.

From the results obtained we may determine the mean depth of the Pacific ocean in the path of the earthquake waves. We have found for the rate of motion, from 6·0 to 6·2 miles per minute, and for the duration of an oscillation 35 minutes at San Francisco and 31 at San Diego. This would give for the length of the wave on the San Francisco path 210 miles to 217 miles, and on the San Diego path 186 to 192 miles.

A wave of 210 miles in length would move with a velocity of 6·0 miles per minute in a depth of 2230 fathoms. (Airy, *Tides and Waves*, Encyc. Metrop., p. 291, Table II.) One of 217 miles with a velocity of 6·2 miles per minute in a depth of 2500 fathoms. The corresponding depth on the San Diego path is 2100 fathoms.

The disturbance of the 25th of December presents at San Francisco three sets of waves of seven each, and at San Diego one set of seven, agreeing in their general features with those at San Francisco, and then a set of seventeen, in which at first, intermediate waves seem to be wanting at San Francisco, or which have no analogous oscillations there. The crests of the first set occurred at a mean about 17^m earlier at San Diego than at San Francisco, the heights on the average were nearly the same, being ·39 feet at San Diego and ·44 feet at San Francisco, and the time of oscillation at the two places the same, namely 41^m. The origin of the disturbance was probably nearer to San Diego than to San Francisco.

Art. VIII.—*Description of a Self-sustaining Voltaic Battery;* by George Mathiot.*

Many inquiries have been made in regard to the principles of construction of my battery, with commendation of its working properties, and I have even received large commercial orders for its construction, which, of course, I could not execute, so that, up to this time, a few sets only have been made for use in government works. I now give a thorough description of the battery, and of the principles on which its action depends, hoping that thereby the recent important applications of voltaic currents may be facilitated through my labors.

The first forms of the voltaic battery were so expensive and cumbrous, and withal so uncertain and fleeting in action, that the idea of applying galvanic currents to the great business affairs of life would certainly have gained nothing more than a smile from even the most sanguine philosopher. But, from the continued researches of electro-chemists, the world has now the benefit of electro-metallurgy and the electric telegraph. Even the batteries now employed are uncertain to a considerable degree, and require constant attention. Any consideration, therefore, tending to the improvement of the instrument, so as to avoid the necessity for frequent attention, cannot but be appreciated at this time, when the world is asking science for a telegraph across the Atlantic, and we are looking for a line from the Pacific to the Mississippi, on which there must needs be many stations or relays of batteries, that from the uninhabited state of the country cannot be constantly attended or even frequently visited.

* From the Report of the Superintendent of the Coast Survey, 1854. Washington: 1855, p. *193.

The construction which I have devised will, I think, obviate many of the difficulties attending telegraphing; and the principles of electro-chemistry, and even experience, justify me in saying that batteries may be constructed to be buried in the earth or sunken in the sea, which will certainly and uniformly continue in action for very long periods, even for a hundred years.

In my battery there is no new element, neither is the form such as to attract attention in respect to anything in it materially different from the batteries now in use. It is only in all the parts being constructed with rigid adherence to the principles of electro-chemistry that its peculiarity consists, and therefore a consideration of the principles is necessary to its appreciation.

A charged voltaic battery may be considered as a factory of electrical power, just as a charged and ignited furnace is a factory of heat, and similarly in both cases the rapidity with which the fuel is consumed, and the steadiness of action, will depend on the arrangement of the parts. A furnace in action consumes the fuel; whether the generated caloric be applied to use or suffered to run waste, the chemical affinity will sooner or later consume the fuel; and though the action may be diminished to some extent by cutting off some of the conditions of combustion, the extent of that action will depend on the construction of the furnace. If a furnace could be made so that we might draw off the requisite amount of caloric to boil a pound of water just as it might be required, and retain the residue until we again had occasion to use the fire, then such a furnace would be a storehouse of caloric, just as a granary is a storehouse of grain from which we draw a supply, and keep the residue in store.

The same remark will apply to the battery; once charged, the chemical affinity consumes the material sooner or later, usefully or not, and we can entirely arrest action only by unloading. Much indeed can be done by modifying the conditions of action, but, as in the furnace, all will depend on the construction.

To make a battery which can keep the action in reserve, is the problem of a depot of electricity.

The uncontrollable nature of the voltaic conditions, I conceive, to be the cause why batteries have not hitherto been constructed with reference to the *whole amount* of force, as well as to the *strength* or rate of working.

Previous to my own efforts I know of no attempts at putting a quantity of galvanic material in store ready for action just when required.

A cell of the reservoir battery is in form a four-sided prism of stone-ware, eight inches long, three inches wide and ten inches deep.

On the side, at the depth of three inches, is formed a trough or tray, an inch wide and half an inch deep, running the length of the side. This tray is made with the jars.

It is indispensable that the jars should be completely water-tight, but they are difficult to obtain; and thus far I have had none which have given full satisfaction. The best were of chemical stone-ware, but only half of them were water-proof. A coat of glazing cannot be depended upon for sealing, as in vessels for culinary and table purposes, as sulphate of zinc penetrates even the beautiful stone-ware called "granite."

When unable to obtain good rectangular jars, I have used cylindrical glass jars, and formed the tray with cement on a plate of glass or gutta-percha, a little less in width than the inner diameter of the vessel. The plate can be kept from moving by projecting jogs, which catch on the edge of the vessel. The plate, tray, and jogs can easily be moulded in one piece in glass.

The conducting plate of the battery is of the platinized silver introduced by Mr. Smee; but the mode of preparing it is different. I first puncture it closely with a square-pointed awl. The holes should not be cut with a punch, which removes the metal, but formed by pushing the metal up in burs, like those on the common tin grater. In this way none of the surface is lost, and both sides of the silver are rendered efficient to a single surface of zinc. After the plate has been punctured, it should be well cleaned, and then electro-plated until the deposit begins to roughen; this very much improves the stability of the plate, and greatly augments the extent of surface. The cyanids should then be well washed away with hot water, and the plate be platinized. I find that the platinizing is very durable, if the arrangements for depositing the platinum are made so that the bright metallic platinum shall first be deposited, and the amorphous form (black deposits) gradually succeed it. The reguline deposit of platinum can readily be obtained by using a mixture of chlorid of platinum and chlorid of sodium, (instead of the acid solution of chlorid of platinum recommended for obtaining the black powder,) with a train of small batteries and a platinum electrode.

The conducting plate is attached to a square bar of lead nine inches long, and five-eighths of an inch across the sides. The bar rests on the top of the jar, and is kept from moving horizontally by studs near the ends. At the distance of an inch and a half from each end of the bar is a pendant an inch long, and of nearly the same section as the bar. The plate is attached to the bar by sawing a slit a third of an inch deep in each pendant, in the direction of the length of the bar, inserting the silver in the slit, and thoroughly closing down the lead on the plate. This is conveniently done by biting the pendant in the jaws of a common bench-vice. In the side of the bar, near the middle, is screwed a thick copper wire, which projects out horizontally two inches and a quarter, and then drops three inches and an eighth. Into the end of this wire is tapped a piece of platinum wire, which is left projecting about an eighth of an inch. Every part of the copper-wire should be thoroughly coated with cement or encased with a glass tube, or the vertical part may be encased with glass and the horizontal with cement; but when glass is used, it should be cemented on so as to exclude entirely the liquid of the battery, thus preventing its contact with the copper. If cement alone is used, the wire should first be wrapped, otherwise the cement is liable to become detached, as it does not hold so well to the copper as it does to the wrapping.

The zinc plates of the battery should be one-fourth of an inch thick, and of the length of the inside of the jar or tray. The zinc should be well amalgamated, and then placed in the jar with the edge resting in the tray, and the tray filled with mercury. The plate is secured in place by its length and by the encased wire from the adjacent cell, which hinders it from falling forward.

But the terminal zinc must be secured by a wire similarly encased and tipped with platinum to dip into its mercury tray, and then bent down against the outside of the jar to a glass or iron cup containing mercury, for continuing the circuit.

The wire from the terminal silver should dip into a similar cup. If, then, the conductor which continues the circuit be encased and tipped with platinum, the current may be led off from any portion of the train by inserting the conductor into the mercury tray.

The jars are charged with a mixture of one part of sulphuric acid, and six parts of water. These proportions are calculated for dissolving all the zinc and all the sulphate formed, and leaving a slight excess of acid and water.

When the mixture of acid and water is made, it should be allowed to get cold before it is put into the jars, if the silvers are to be put in; for a hot solution of sulphuric acid would act on the silver, and dissolve a portion, which, though very small, would ruin both the silver and the zinc plates, as will presently be made to appear.

Lastly, the silver plates should never be put into the acid when the zincs are not in, as in that case the silver, not being enfilmed by hydrogen, would be in danger from the acid.

To hinder evaporation from the jars, the battery is placed in a box made with a double rim on the lid so as to form a deep trough or recess, into which the walls of the box go when the lid is put on. When the battery is to remain a long time without attention, the box should be completely air-tight.

I have devised no special plan for hindering the evaporation, for the particular circumstances in which the battery is placed will cause the rate of evaporation to be great or small: thus, when the battery is exposed to frequent changes of temperature, the loss from the jars will be great, (even though a box is used) if the air can flow in and out. But when the battery can be placed in a vault or cellar having a uniform temperature, and not subjected to frequent changes of air, then no box will be required, if the battery can be filled up every few months. When a vault cannot be had, a heap of earth over the box will greatly hinder changes of temperature and evaporation. Only let it be remembered that the jars should be kept full, either by refilling or by hindering evaporation.

The form of a battery described above has advantages over all others in simplicity and cheapness, as well as certainty and economy of action. Its riddance of the usual appliances for making *contact*, such as binding screws, clamps, and soldered joints, so expensive in manufacture, and yet so very uncertain in use, will certainly commend it to every one who knows the endless trouble which invariably attends the use of these joinings. How often has a lecture been spoiled because there was a bad contact which could not be detected; and how often do we hear of a whole day being lost in telegraphic operations, from the nitric acid having eaten off the solder which joined a platinum to a zinc in the Grove's battery. Moreover, we have no residues of the zincs—no necessity for re-amalgamation.

To show all the advantages of the arrangements described, for maintaining the conditions of voltaic action, would be to take a full view of the theory of the generation and diffusion of voltaic electricity, which would be impossible in this communication. Yet, to set these advantages in some light, I will take but a glance at the voltaic action.

The universal feature of a voltaic combination is that of three substances in a series, in which the two extreme bodies have dissimilar properties with respect to the intermediate, which is a compound body, so constituted that one of its components can be eliminated by one of the extreme bodies, and the other component by the other extreme body. In all useful batteries, one of the extreme bodies is zinc; the other, some less oxydable conductor; and the intermediate, water, or water with some acid, generally the sulphuric. The relations and actions of these three substances will embrace all that relates to the generation of the voltaic current.

We will suppose that the function of the zinc is to disturb the electrical equilibrium, by combining with the oxygen of the water, (or, if we consider the electrolyte as sulphate of hydrogen, the action will be the same,) that the function of the water is to transmit the disturbance by a wave of decomposition and recomposition, and that the function of the less oxydable substance (the conducting plate) is to produce equilibrium, by eliminating hydrogen from the electrolyte.

The chemical affinity generates the electricity by the combination of the zinc with the oxygen, and the decomposition of the water. Therefore the amount of electricity, and the consequent tension which the affinity can generate in a given time, will depend on the favorable circumstances for chemical action, such as the presence of acid to dissolve the oxyd of zinc, which otherwise would soon exclude the electrolyte by encrusting the zinc; the presence of water to dissolve the sulphate of zinc; temperature affecting the solvent capacity of the water, and the reaction of the tension against the affinity.

When a battery is first charged, all the conditions are prime; from this there is a decline by several ways to the point of no action. The decline may result from a changing of the electrolyte or of the conducting plate. The character of the change, and the rapidity of decline, will depend wholly on the construction of the battery. The construction may be such that the action will wholly cease before even a small portion of the material is consumed. When the zinc plate of a battery is placed in such a situation that the generated sulphate of zinc cannot flow away, as when the plate is placed at the bottom (horizontally) of the jar, and the arrangements are made such that the quantity of electricity, and the consequent formation of zinc salt, shall exceed the rate at which the diffusion of the salt can take place, the zinc plate will soon become coated with a crop of crystals. As the cessation of action here is visibly due to exclusion of the excitant, it follows that in whatever position the zinc plate is placed, just in proportion as the sulphate of zinc excludes the excitant, will the capacity of the chemical affinity to generate the electrical tension decrease.

Many plans for removing the sulphate of zinc from the cell have been devised. The most of these have been based upon the idea that the sulphate by its superior gravity would subside and saturate the lower parts of the solution. I have tested the value of this idea by the following method: Vessels thirty-eight inches deep were filled with solutions of the sulphate of various degrees of saturation; then, after letting the solutions repose for several days at a uniform temperature, I drew off a portion of the liquid at the bottom, and a portion from the depth of three inches from the top, and in no case found a difference of density to produce more than one degree of Baumé's hydrometer. But I have found that even a saturated solution will always be considerably deficient *just at the top*, provided that it is not subjected to agitation. By this I learned that a *calm solution cannot be saturated on the top.* On this basis I formerly, in conjunction with Mr. J. Green, the well known maker of philosophical apparatus, constructed batteries with the zinc arranged horizontally within half an inch of the top of the liquid. These horizontal batteries required perishable mechanical contrivances for keeping the plates in position, which would quite unfit them for telegraphic operations, though I still consider them superior to all others for electrotyping. By the action of these horizontal batteries we found that the grains of salt were deposited in crystals, at the bottom, while the top of the solution remained unsaturated. From a single cell of these horizontal batteries, which held four gallons, and was only eight inches deep, I have frequently taken two and a half gallons of crystals of sulphate of zinc. I have sought to make use of these advantages about the top of the solution, in the construction of the reservoir battery, as far as practicable with simplicity of construction. In all other batteries, the important principle of the subsidence of the salt has been wholly overlooked; for although it has been proposed to draw off the saturated solution from the bottom, while fresh excitant was supplied at the top, yet the plates have invariably been placed with their lengths vertical.

From what is said above concerning the horizontal battery, will be seen the advantage of using in the reservoir a long, narrow plate of zinc, with the length horizontal. This also has an advantage in regard to the mercury keeping the plate always well amalgamated, from not having a great height to climb.

The self-amalgamation of the zinc has been introduced not merely with reference to the saving of labor and mercury, but with reference to the continued action of the battery. This mode of re-amalgamating appears somewhat specious at first; but soon the question arises, how far can the mercury creep up the plate and efficiently amalgamate it? This will depend on the quality of the zinc, as will appear from a consideration of the uses of amalgamation.

All commercial zinc contains mechanical impurities, such as charcoal, stones, &c., and is alloyed with various metals, but chiefly with iron. As the action of the solvent reduces the surface and leaves the impurities projecting, they are placed in situation to form voltaic circles having the least possible resistance—which is being most favorably disposed for action. Every particle of foreign matter on the zinc surface acts as a conducting plate to it, evolving hydrogen from the electrolyte, and most rapidly consuming both the zinc and the solvent.

If now the zinc plate is mercurialized, the enormous cohesive force of the mercury causes it to contract over the particles of carbon, iron, &c., and the surface of the plate is made homogeneous, and consequently as the particles which evolved the hydrogen are now excluded from the electrolyte, their action on it ceases. The mercury itself, if more strongly charged with zinc in one place than in another, might evolve the hydrogen; but fortunately having a most perfect polish, it binds the hydrogen firmly to it. This action of the polished metal we will consider presently.

But as the consumption of the zinc goes on, the impurities accumulate on the surface, and project so far that the mercury cannot envelope them; hence the efficacy of the amalgamation at any place will depend on the amount of limpid mercury at that place, and the amount of the impurities to be covered. So I find that with the ordinary English and New Jersey zinc, the solution of twenty-five grains from a square inch of the surface (a depth of $\frac{1}{69}$th of an inch) will leave the impurities projecting so far that the quantity of mercury which can adhere to the zinc when in a vertical position, cannot prevent violent chemical action in the minute galvanic circles. But the zinc known in commerce as the "Musselman's" is so easily protected that I find the corrosion may go to the depth of one-fourth of an inch, and the mercury still be efficient when flooded over the surface. Here, then, is the answer to the question as to how far the zinc plate may be protected or efficiently amalgamated by standing it in a flood of mercury. If the plate is not to be dissolved to a very great depth, the good commercial zinc will be sufficiently protected; but for a longer time the zinc should be redistilled, and for a very long time nothing but chemically pure zinc should be employed. Practically I find that the "Musselman's" answers well for one year.

From what has been said concerning the action of the impurities of the zinc, it will be perceived that if any carbonaceous matter falls on the battery, it may attach itself to the zinc, and thus rapidly destroy the voltaic conditions by consuming the materials; since the evolution of hydrogen would continue while there remained zinc to be oxydized, acid to dissolve the oxyd, and water to dissolve the salt. This shows the necessity of a box to prevent currents of air from sweeping over the battery; for even the dust which subsides from the atmosphere, may set up the destructive action.

From the same kind of reasoning, it is obvious that the presence of the least particle of any salt reducible by zinc or by hydrogen should be avoided; and such a salt coming in contact with the zinc, would instantly form a conducting plate. If we would avoid every risk of this destructive action, the fixtures of the battery must not be made of a metal which can form a soluble salt with sulphuric acid.

I shall have occasion to refer again to the employment of the oxydable metals for the battery fixtures; here I will merely state that I have found by experience that even silver is unsuitable, for when I employed a silver bar and silver pendants to hold the conducting plate, sulphate of silver was formed.

We now come to the consideration of the most delicate part of the battery—the conducting plate. The function of this plate is solely the elimination of the hydrogen of the electrolyte. The plate, indeed, does conduct the positive electricity from the electrolyte. But by the chemical theory of the voltaic generation, *the elimination of the hydrogen from the electrolyte is the conduction of the positive electricity; and the conduction of the positive electricity is the elimination of the hydrogen*—the one is inseparable from the other, conduction and decomposition being *identical* in an electrolyte.

By this it will appear that the liberated hydrogen should not be suffered to adhere to the conducting plate, for the gas being a very bad conductor, it will resist conduction, and consequently chemical action.

The office of this part of the battery has generally been considered a mystery, being subject to very great and sudden changes, which being unaccountable by mere inspection, were attributed to occult power called the "electro-motive force." But certainly rational investigation can refer all the battery changes to known forces. By late investigations we know that the gases adhere to, and condense on, all solid bodies. If the attraction between a sheet of metal and a molecule of gas is regulated by those same laws which govern the planetary masses, then we can easily conceive that the more definite the plane of attraction, the more strongly will the molecule be drawn, and consequently the denser and higher will be the adhering layer of gas. And, by the same laws, we can see that an indefinite plane will act with opposing forces, as we see in the deviation of the plummet in the vicinity of mountains; as we see in the perturbation of the planets; and as we suppose when a body descends toward the centre of the earth from the surface. The former of these conditions is fulfilled when the surface is polished; the latter when it is rough or unpolished.

We can conceive the mounts of the roughness to rise so high above the plane of maximum force, that the adhesion to the prominences will be almost destroyed. And we can conceive the mounts to react so much against the pits that the plane of attraction shall be nearly or quite destroyed. We can conceive of a surface thrown into such fine points and recesses that a molecule of gas might float in equilibrium in the cavities, or adhere with the least determination to the prominences. Hence the great advantage of the deposit of finely divided metal.

A surface atomically rough will hold only an atmosphere of the least possible height and density. But this is not attainable. We get the nearest approximation to an atomic roughness when a surface has been covered with amorphous metal by electro deposition. Then it may be said to be rough or unpolished to the greatest degree for that metal.

Could we view such a surface, or rather I should say want of surface, we doubtless should find it many thousand fold more rugged, uneven, and porous, than the common sponge.

The various metals let go the hydrogen in the voltaic circuit with very different degrees of readiness. From my observations, I conclude that the attraction of the various metals for the gas is directly as their specific gravities. All the less dense metals decompose water, (evolve hydrogen). Sodium and potassium evolve the gas in torrents. The base metals proper have less action on water, and a stronger attraction for the gas. The noble metals hold the gas very firmly, and are without action on water.

The order in respect to evolution is the reverse in respect to gravity; and the order in respect to gravity is consequently the reverse of the order of fitness for a conducting plate in respect to the evolution of hydrogen. Platinum, gold, and lead, hold the gas very hard. When polished plates of these metals are used, the hydrogen adheres in large bubbles, which very slowly creep up the plate. Mercury I do not compare, because its mechanical form is the best possible for adhesion; but could we but polish the solid noble metals as perfectly as the atomic polish of the mercury, I have no doubt but that the mercury, according to its density, would follow after gold. Silver answers better than the other noble metals. Experiment has not enabled me to decide that copper is better than silver, but I am much inclined to consider the copper as best. Iron is decidedly better than any metal above it in density, and requires no special preparation to make it evolve freely. Zinc is so prone to evolution that it is with difficulty that the hydrogen can be made to adhere. The metals of the alkalies cannot be invested with hydrogen like the denser. A mere particle of zinc will coat a surface of copper or iron with hydrogen, and protect it from oxydation forever; but as soon as potassium or sodium is deposited, it is instantly recombined with oxygen, because it cannot be coated with hydrogen. Here I may remark that the newly reported aluminum which is said to have the nobility of silver, with the density of only 2·5, ought, by the above views, to make a most admirable conducting plate.

By the above view, the adhesion of hydrogen is very nearly the reverse of the affinity for oxygen. Here we find silver with a medium adhesion and a low affinity. This at once indicates that it is the metal which will be generally used for making batteries. Iron, which is the most oxydable metal that can be employed for conducting plates, has a very low adhesion, and fortunately a mechanical advantage from its ever-fibrous or granular form, which greatly increases its fitness for evolution. Could it remain as iron in the battery, it would probably be all we should ever desire. Yet though it acts vigorously when newly cleaned, its affinity for oxygen soon makes it worthless. This objection holds not only for iron, but for some kinds of batteries holds even against silver, and we are sent at last to the more noble metals.

The difference between gold and platinum in respect to the adhesion, and also in respect to the liability to chemical change, is so small as to make the employment of one or the other merely a question of economy. But there is another property—one which quickly determines the preference; this is the capability of being put in the best mechanical form for non-adhesion, or making the closest approximation to atomic roughness.

Of all the metals, platinum has the greatest tendency to the amorphous state, (excepting its relatives, rhodium, iridium, &c.) I do not remember having seen that its crystal has ever yet been determined. Not so with gold, its crystalline tendency is so strong, that it aggregates so much in precipitation, even from extremely dilute solutions, that the deposit has a decidedly yellowish tinge, and the slightest pressure makes the deposit conglomerate. I here need scarcely remind you of Wollaston's tedious process for metallizing spongy platinum.

If the above views of the nature of the adhesion are correct, then it follows that the surface of the conducting plate should be amorphous platinum, and nothing but amorphous platinum; and consequently, if we wish our battery to *retain* its capacity to remove the hydrogen from the electrolyte, which, let it be borne in mind, is the capacity to conduct electricity, then there should not be the remotest liability of the amorphous platinum to have a deposit of any other metal, or any oxyd formed on it.

On this consideration I have carefully avoided using any reducible base metal about the battery, in such a way that its salt might get into the cell. I have before shown what would be the consequences of this on the zinc plate, and equally injurious would be its action on the conducting plate, whether it were deposited on it as metal or as oxyd. In either case the hydrogen would adhere, the conduction resistance would be increased, the tension would rise proportionally and react against the affinity; the chemical action, the soul of the battery, would proportionately decline. That the mutations of the battery from adhering coats of hydrogen, metals, or oxyds, on the conducting plate, are to be attributed to *conduction resistance*, I shall expect will be regarded by the advocates of electro-polar forces as wholly untenable, and the resistance to be considered as incompetent to produce the effect. But that the gas resists is indisputable, and that it adheres to the conducting plate is equally indisputable, for we know that the very dust of the fields attracts and condenses the gases; and is it not, therefore, but as fair an inference that it adheres somewhat to dense metallic plates? The thickness of the adhering film may be extremely small, but its resistance may be quite considerable, for the resistance of airs is almost incomparable to that of metals. We know that a battery has penetrated over 3,000 miles of iron wire, and when a battery of 2,000 pairs had the poles parted only the least distance that could be manipulated, then the galvanic action could not be exhibited.

It remains now only to notice the electrolytic changes, with reference to continued action. The generated sulphate of zinc alters the conditions of action, not only by saturating the acid and water, but the dissolved sulphate itself is an electrolyte, and therefore may coat the conducting plate with zinc, and deteriorate it just as was shown would result from the salts of the other base metals. Fortunately, there is not so much danger of the plate becoming wholly coated with zinc as with the other base metals, for the deposited zinc is rapidly removed by its great tendency to become salt, in which it is assisted by the close proximity of the uncoated portions of conducting plate, forming good local circles with it. Should there be no portions of the plate bare to reduce the counter-tension generated by the resolution of the deposited zinc, then we should have the tension acting against the battery current. This probably can never happen, yet the plate is often made nearly inefficient by the reduced zinc, when the acid is mostly saturated.

The acidulated water or sulphate of hydrogen is electrolyzed by a far less tension than decomposes sulphate of zinc; it is only, therefore, when the quantity of sulphate of hydrogen becomes proportionately small, and causes the tension to rise by its increased resistance, that the sulphate of zinc is decomposed.

But it is unquestionable that that force which is the result of the combination of the elements of sulphate of zinc, cannot of itself undo that combination; yet while the battery is working, zinc is constantly being deposited and re-dissolved. In considering this action of the galvanic current, which is apparently so anomalous to the exhibition of every other known force, I have concluded that we should look for some additional force acting conjointly with the current, rather than for a moment admit the absurdity of an "electro-motive force," with its supposed capacity of acting infinitely without expending itself. Such an additional force I conceive can be found in the attraction of the matter of the conducting plate for the heavy element of the electrolyte.

If the conditions under which the deposition of the zinc takes place be considered, it must appear that it is the attraction which makes the determination. In the first place the deposition is nothing when the proportion of sulphate of zinc about the plate is small in comparison to the sulphate of hydrogen; but as the proportion of sulphate of zinc increases, the decomposition of it begins to show itself, until it becomes very copious in a nearly saturated solution. The supposition I have made is, that the deposition is effected by the conjunction of the attraction with the current or electrical tension; consequently the deposition can only take place when the tension is so high that the addition of the attraction enables it to overcome the affinity. This exactly conforms to the conditions; the good conducting sulphate of hydrogen being removed, the bad conducting solution of zinc will cause the tension to rise. I cannot now go into the discussion of the specific weights of the elements of the two electrolytes, to show that the attraction will act in the same direction with the electric tension. It is at once evident that if we admit that the matter of the plate attracts the elements or atoms—and what physicist at this day would think of denying it?—then it follows that altering the aggregation of the surface of the plate will diminish that attraction, just as it diminishes the adhesion of the hydrogen; yet, as the molecule of zinc is so much heavier than the hydrogen atom, the disturbed aggregation should extend much deeper into the plate for destroying the attraction for the zinc than is merely required for preventing the adhesion of the gas. On these principles I have made the conducting plate, with the disintegrated state of the surface extended to the greatest depth admitting of the requisite mechanical durability, for which the plate is electro-plated to the beginning of roughness before putting on the coating of platinum.

I have sought to describe the peculiarities of this battery, by exhibiting the actions of the various parts, and the principles which guide me in their construction. These principles, I acknowledge, are new in their application to the galvanic phenomena. I have only to say for them, that they are the acknowledged principles of matter and motion, and consequently the principles of universal nature. But it may be that my solutions are wrong, and that further research will not sustain these views; yet, I ask for them a trial as to their conformity with the admitted solutions of the great multitude of natural phenomena. Thus we know that oxygen is condensed with a force of nearly a thousand atmospheres on spongy platinum; and does not geometry show us that if the disintegrated mass attract thus strongly, the solid surface will attract enormously? and if oxygen is so strongly attracted by the solid surface, then why may it not attract hydrogen, which is only sixteen times lighter, sufficiently to condense a layer which the battery liquid cannot displace because it is denser than the liquid? I must here ask that I may not be misunderstood by supposing that I refer to the bubbles of gas which adhere to smooth surfaces by the superincumbent pressure: geometry, indeed, shows us that these bubbles are dispersed by a rough surface, but it also shows that these bubbles are hemispheres, and therefore that they cannot entirely prevent contact of the plate and liquid.

That the deposition of the zinc, also, should be referred to the attraction of the plate, is that which the universal principle of attraction demands. Why not admit that that attractive force which we know exists in all things, concurs with the electrical tension to produce this, when we are constantly seeing the greatest anomalies produced by concurring forces? Thus we *know* that the affinity of copper for oxygen, at low temperatures, is superior to that of hydrogen; yet, when a piece of coal is saturated with hydrogen and immersed in a solution of sulphate of copper, the hydrogen is oxydized and copper reduced, simply because the attraction of the coal for the copper, added to the affinity of the hydrogen for oxygen, make a united force superior to the affinity of copper for oxygen. Here we have a voltaic circle composed of coal, sulphate of copper and hydrogen, which becomes active by the help of attraction, and is enabled to decompose an electrolyte whose affinities are even *stronger* than those of the produced electrolyte.

It has been considered as the standing miracle of electricity, and the unanswerable argument against the chemical theory of electrical excitation, that a battery will work in a neutral solution of sulphate of zinc, and deposit zinc on the conducting plate; for, say the advocates of the electro-motive force, the force is greater than the affinity of zinc for the negative element, for after overcoming the conduction resistance, it is still enabled to separate zinc from the negative element. But there is a little experiment which shows conclusively that it is the state of the surface of the conducting plate which determines the electrolysis, and not a supposed electrical condition involved in the nature of the substance of the plate. Let a battery of several pairs be connected with a pair of large platinum electrodes, in a solution of sulphate of zinc, containing a little free acid—or a single battery may be used if an electrode of zinc is used to receive the oxygen,—then, if the platinum electrode be well polished, zinc will be rapidly deposited on it, and there will be no hydrogen given off; then let the deposited zinc be dissolved off, and the platinum electrode roughened with emery and well platinized, and then restored to its former connection with the battery; now, the same battery, with the same solutions and electrodes, will chiefly electrolyze the sulphate of hydrogen; there will be very little zinc deposited, but the hydrogen will fly off in copious streams.

As the reservoir battery is designed chiefly for telegraphs, I may, with propriety, before closing, say a few words relative to the quantity of electricity required to work a telegraph. I have measured the quantity of the current on some lines by interposing voltametres in the circuit.

The quantity near the battery is very great compared with the quantity on the part remote from the battery, for the insulation is always imperfect; and of the whole quantity that leaves the battery, only a small proportion reaches the remoter part. But to get all the waste included in my measurement, I measured near the battery, and found when the line was in good working order, the *quantity* of the electricity was that represented by the solution of one grain of zinc per hour. Sometimes the line would work well with much less than a grain; and often after the batteries had been recently charged, the quantity was ten grains; but mostly, when the line was in fine order, the quantity was about the grain.

Supposing the current to be on about seven hours per day, (which I think comes near the time,) then one pound of zinc will supply all the electricity used in 1,000 days, or, say three years of business days. From this it will appear that my idea of a battery to serve 100 years is, at least, not so extravagant as to be without some show of probability. Such a battery would require zincs of only thirty-three pounds weight, or (allowing for some local action, as there is some always carried on, even by the mercury) say fifty pounds, which is a cube of less than six inches square.

I have lately had a fair opportunity of knowing the value of this battery. In May last, I charged six cells, which were put in a box in the upper laboratory, to be used in the experiments on photographic engraving. The battery has since been in almost daily use for gilding deep-sea thermometers, or other instruments, or else in the experiments. During the six months which have elapsed, it has been used probably 2000 times, in which there was nothing more required to get the current than to complete the circuit. During the intensely hot spell of the past summer, I three times added a little water to supply the loss from evaporation, and these were the only times the box was opened.

Art. IX.—*The Vegetable Individual in its relation to Species;* by Dr. Alexander Braun.—Translated from the German by Chas. Francis Stone, B. A.

Part II. (Concluded.*)

While thus, on the one hand, all the facts seem to unite in establishing the individual nature of the shoot, on comparing shoots in their qualitative relations, phenomena are brought to view which seem to contradict such a view of its individuality. The higher departments of the animal kingdom usually present as individuals representatives of the specific type agreeing in all essential respects, though, perhaps, not perfectly identical. The fact of the separation of the sexes was all that modified this view; and here, indeed, the essence of the species does seem to be divided between two different individuals. Attempts have not been wanting to obviate this contradiction by the Platonic doctrine of the original unity of the sexes, by the assertion of Paracelsus;† that, in fact, the two together must be regarded as the one real individual,—and such like.

This contradiction to the usual view of what constitutes the individual is shown in a far higher degree by *qualitative* comparisons of vegetable shoots, not merely of the same species, but also of the same stock. Thus we see, e. g., in *Equisetum arvense* (Field-Horsetail) shoots totally different in aspect proceeding from the same root-stock; in early spring they are pale, discolored, unbranched, terminating with a strobilaceous-like fructification; later, green and foliaceous ones appear, verticillately ramified. Investigations into subterranean vegetation show even other varieties of shoot-formation, viz., offsets dwindling down to a point, and club-shaped buds which, at a later period, drop off of themselves. The Colt's-foot (*Tussilago Farfara*) presents similar phenomena, in early spring putting forth leafless shoots, with asparagus-like scales terminating with yellow capitula, which in summer are followed by others bearing leaves. The flowers in the little capitula of the first present a third variety of shoots in their lateral branchlets. Even in common life we distinguish leaf-buds from flower-buds, on many trees. Let us consider this relation in the Cherry tree, for example. On the same branch we find, on the one hand, buds which develop into branches bearing leaves, without producing flowers; on the other hand some bearing only little squamate leaves on the shortened axis,

* For Part II, see the number for September, 1855.

† "For this ye must know: man without woman is not a whole; only with woman is he a whole. That is as much as to say: both together make man, and neither alone."

from whose axils the flowers rise and form a third kind of shoot.

On examining closer into the real origin of these differences, we find their ground to be a partition of the different steps of the metamorphosis (of the formations) among different shoots. True there are many plants which go through the whole series of formations, from the inferior* and the foliaceous formations up to flower and fruit; but the cases are quite numerous in which this does not take place, in which the single shoot is not able to produce all the formations. Thus there are shoots which are only able to realize the lower steps, and never attain to flowers and fruit; while others overleap all the inferior degrees and commence immediately with the formation of flowers. Hence, on the one hand, we see the metamorphosis interrupted, a stoppage taking place at a determinate step; on the other, the metamorphosis attained by passing over the intermediate steps. Still more remarkable are the cases in which the retardation is not merely an interruption at a determinate step, but appears as a real retrogression in the metamorphosis, whereby an alternate rise and fall,—an oscillation,—usually takes place, which may at last pass over in victorious progress to the formation of flower and fruit; though in most instances it prevents the shoot in question from ever attaining its end. *Helleborus niger* is an example of the first case; for after many years of inferior- and foliaceous-leaf formation, at last it attains superior leaves and fruit by overleaping the formation of foliaceous-leaves which until then had prevented its farther progress.† Many of our trees with true foliage present examples of the second case. Their branches commence with bud-scales (inferior-leaves), the succeeding foliaceous branch ends with a terminal bud, (thus falling back to inferior-leaf formation,) and in the next period of vegetation they rise again to foliaceous-leaf formation,‡—as in the Oak, Beech, and Poplar. A similar oscillation between inferior-leaf formation and

* On the terminology of the leaf-formations, see *Wydler:* Bot. Zeit., 1844, 36tes. Stück., and A. Braun Verjüngung, p. 66. (Henfrey's Transl. Ray Soc., 1853, p 62, T.)

† Analogous cases occur in the branches in *Æsculus* and many Maples which attain to flowers. Among herbaceous plants *Anemone nemorosa* and *Asarum Europæum* also belong here, and especially remarkable is the Tulip, the plants of which, not yet ripe for flowering, annually develop one single foliaceons leaf, followed by a central-bud hidden in the middle of the bulb and composed of several inferior-leaves. This bud preserves this position in bulbs deep in the ground, but in those nearer the surface it is, as it were, led out of the centre of the bulb, and sinks deeper into the earth, causing an indentation of the surrounding base of the preceding leaf in form like a spur, boring through the old bulb and penetrating vertically into the ground, and at the same time sinking itself into a deeper stratum with the spur;—an arrangement explained, but not with sufficient clearness by *Henry* in Nov. Act. Nat. Cur., vol. xxi, p 275, t. 16 et 17.

‡ In such librations, of course, the formation of the flower can only be attained by particular branches, deviating in character from the rest,—the catkins which pass over leaf-formation advancing from the inferior-leaves immediately to the superior-leaves out of whose axils the flowers are emitted.

foliaceous-leaf formation, keeping pace with the change of season, is seen in the creeping main-shoot of *Adoxa*, and in the stock of *Hepatica nobilis*, creeping close to the soil, with its short internodes, and which in so far deserves its French name (la fille avant la mère) as its flowers, which unfold before the foliage, do not belong to the same individual as the foliage, but are produced laterally as a "daughter generation" from the axils of the inferior-leaves of the maternal stem.* A similar phenomenon only in a higher degree, (a rising and falling between foliaceous- and superior-leaf formation.) is presented by those plants whose inflorescence ends in a foliaceous coma, as is remarkably the case in the Pine-Apple, and also in the New Holland species of *Melaleuca* and *Callistemon*, whose crowded, brush-like inflorescence (i. e. the region covered with superior-leaves and bearing the flowers in the axils of these) returns and forms foliaceous-leaves, and in the following year again attains an inflorescence.

While every leaf-formation may bring the progress of the metamorphosis on a single shoot to a consummation, it is conceivable that one shoot may be allowed to each step for itself alone. Thus, there are shoots which represent inferior-leaf formation alone; e.g. the root-stock of *Paris quadrifolia*, the tuberiferous branches of the rhizoma of the Potatoe,† and there are some which are endowed with the foliaceous-leaf formation only, as the primary axis of many species of *Veronica*, the sterile leafy branches of several *Euphorbiæ*, as well as the leafy branches of those woody growths which have no bud-scales and no terminal inflorescence, (e. g. *Rhamnus Frangula*). Cases of pure superior-leaved shoots may be seen in the peduncles of *Veronica Chamædrys*, *officinalis*, etc., in the (always lateral) spike-bearing scapes of *Plantago*, and the racemes of *Convallaria majalis*, which shoot out of the axil of the highest lower-leaf as branches. Even the leaf-formation belonging to the flower can be divided among different

* The same obtains in *Galanthus nivalis*, in which every annual generation consists of one inferior-leaf, one foliaceous-leaf with a vagina, and one without a vagina, which follow each other in simple alternation, in a distichous arrangement. The flower, as a branch, is emitted from the axil of the second foliaceous-leaf while the direct continuation of the shoot returns again to inferior-leaf formation. In striking contrast to the extremely simple relations of this plant we find *Oxalis tetraphylla* and other species of that genus, in which the subterraneous main-stem also presents an alternation of inferior leaf-formation and foliaceous-leaf formation, advancing with the change of season, but conjoined with a rare abundance of leaves and a complicated phyllotaxis. The number of the inferior-leaves amounts to several hundreds; and transverse sections of the bulbs, which last through the winter and are formed by the close approximation of these leaves, form some of the prettiest specimens of phyllotaxis, showing 21-15 arrangement through easily computable 8-, 13- and 21-ranked oblique spirals. The number of the foliaceous-leaves is not so large; they develop in the summer, and form an 8 to 13 leaved rosette, out of which the axillary inflorescences issue, with their long peduncles.

† In case (as sometimes occurs) the tuber does not pass through this formation and advance to foliaceous-leaf formation. The tuber is the thickened apex of the inferior-leaf shoot. Cf. the figure by *Turpin*: Mém. du Mus. d'Hist. Nat., t. 19, pl. 2.

shoots, and thus the flowers may be produced piecemeal, so to say; as is the case in all diœcious plants, where the two most essential formations of the flower (the stamens and pistils) are found, not in the same flower, but in two separate ones. Even the less essential parts of the flower, the sepals and the petals, may occur separated from the other particular shootlets; as may be seen in the neutral flowers in the coma of the spike of *Muscari comosum* and in the ray-flowers of the cyme of *Viburnum Opulus*. The destitution of the shoot may be carried so far as to cause it to produce but one single leaf, or one single formation (whether from the sphere of the plant-stock, or from that of the leaves); in which case the individual represents only one single organ; as, for instance, in the branches which form the axis of the inflorescence in *Vicia monanthos* and other Leguminosæ with racemes reduced to one flower, bearing one single superior-leaf, from whose axil the flower proceeds. The male flower of *Euphorbia* is a peduncle whose flower consists of one single stamen.* Must we, now, still regard as individuals, these shoots, so partially endowed, and the last-named so destitute? Certainly! For if the individual can fall short, though ever so little, of the perfect realization of the specific idea, then there are no limits to its imperfection and destitution; for, after all, the realization of this vegetable Idea by the different members of the vegetable kingdom is precisely similar to the realization of the species by its single individuals. To be sure our idea of a plant implies that it shall

* The genuine cases will be of rare occurrence if we look at the cases which belong here rigorously, that is, if we take into account the dwarfed foliaceous formations which may possibly exist, suppressed or scarcely discernible. The male flower of *Euphorbia* itself properly belongs here only in appearance, as two small scales (inferior-leaves) occur, more or less developed, at the base of the peduncle. The small involucre of the male flower proceeds to develop itself out of one of these scales. (Cf. *Wydler:* Linnæa, 1843, p. 409.) Another example of a one-leaved shoot (though a spurious one) is presented in the Californian *Pinus monophyllos* (*Fremont*), whose lateral branchlets bear a fascicle of needle-shaped leaves reduced to one single needle: but this, as well as the pair of such leaves of our ordinary pines, is preceded by a vagina composed of several bud-scales. Perhaps another deception is played upon us in this case, for the perfectly round form of this needle excites the suspicion that it may be composed of two which have grown together through their whole length. The seed-bearing fruit-scales of the cone of *Abietinæ*, which are placed in the axils of the scales, also appear to be one-leaved shoots; but the series of changes which these scales present in cones of *Pinus Larix* which have completed their growth, proves that these fruit-scales are composed of two concrete leaves. The spurious axis of the Grape is a concatenation of alternating one- and two-leaved leaf-shoots, if we do not count the one or two little dwarfed superior-leaves, which in most cases are perceptible on the apex of the single shoot which finally forms a cirrhus. *Ophioglossum* presents a genuine case of a one-leaved shoot. The spike of this plant is a single fertile leaf, standing in the axil of the sterile one and hence belonging to a lateral axis, of which however nothing is perceptible but this leaf. (Cf. *Schnizlein:* Icon. fam. nat., Heft II, t. 32.) The utriculus of *Carex* is the solitary leaf of an axis which in its normal condition develops no farther, and out of which, as the axillary formation of the utriculus, the female flower is emitted. And the so-called neutral flower of *Panicum*, and the related grasses, is a shootlet which develops nothing but one leaf (the bract of the flower).

manifest its life in a series of successive formations, that it shall put forth its leaves, flowers and fruit by successive steps; and yet there are plants which produce no leaves and no fruit (the Cryptogamia); again, there are others which hasten on to form flower and fruit with various intermissions of the regular steps, as is especially the case with the ugly parasites destitute of that green foliage which elsewhere is so characteristic a product of the vegetable world.* One of these (the *Hydnora*,† which preys upon the root of the South African *Euphorbiæ*) seems entirely devoid of all the foliage which is usually formed before the flower. Hence, therefore, in general we cannot necessarily regard individuals as perfect representatives of the specific idea, and hence, too, we cannot regard them as representations invariably identical in their realizations. Individuals appear rather as living attempts, by which the Idea is more or less attained, and is thus realized with various modifications. From this point of view even the differences in individuals, as pointed out by the doctrine of shoots, within the limits of vegetable species will no longer surprise us; on the contrary it will open to us a deeper insight into that independence presented to us even in the life of nature, in the realization of the internal problems of the creation.

But here, too, as is so variously the case in nature, the regulative law is admirably united to the free configuration; for what gives a peculiar interest to the differences among shoots in the same species is the regular reciprocal relation among the shoots, as they reciprocally complete each other by their very one-sidedness, and thus form a higher whole. In this respect the qualitative difference of shoots bears a certain relation to their origin, that is, to the order of ramification to which they belong. And as the formation of shoots, as was shown, is a process of propagation, we see here, in the history of the development of the species, propagation taking the place of individual development. A second individual takes up the thread of reproduction which the preceding one was unable to carry any farther. Thus, what we are accustomed to see elsewhere attained in the individual, is here reached by the generation in a more or less strictly determined cycle,—in other words, where the single shoot is incapable, a determinate succession of shoot-series arises to bring the

* *Orobanche*, *Lathræa*, *Monotropa*, *Cynomorium*, all of which agree in the inferior-leaf formation passing immediately into superior-leaf formation, and thus the formation of foliaceous-leaves is omitted. In the celebrated *Rafflesia* the immense flower is preceded by bud-scales only, which must be considered as the inferior-leaf formation. The same occurs in *Frostia*, which preys upon the branches of arborescent *Leguminosæ*, and which resembles a mere flower so much that one might doubt whether it is merely a monstrous papilionaceous flower or a real parasite. (Cf. *Endlicher:* Gen. plant., p. 76, and *Guillemin:* Nouv. Ann. des. sc. nat., II, t. 1, and as to parasites in general, *Unger:* Annalen d. Wiener Museums, part II.)

† *E. Meyer:* Nov. act. acad. L. C. nat. cur. XVI, 2, p. 771, t. 58 et 59, and *R. Brown:* On the female flower and fruit of *Rafflesia* and *Hydnora*, 1844, pl. 6–9.

internal problem of its existence to a consummation,—to complete the metamorphosis into flower and fruit. This remarkable phenomenon,—which is a very frequent one in the vegetable kingdom, and is one of the essential characteristics of many of the most important families of plants, e. g., the grasses, *Synanthereæ*, *Labiatifloreæ*, *Cruciferæ*, *Leguminosæ*, etc.,—is the same as that which in the animal kingdom (in whose lower orders it re-appears) was, we cannot say discovered, but brought to a clearer comprehension not long since by the Norwegian naturalist Sars,* completed and confirmed by von Siebold's investigations into the history of the development of *Medusa aurita*,† and soon after substantiated in its universality by the Dane, Steenstrup, under the name of "alternation of generation," or propagation and development by alternate series of generations.‡ Single cases of alternation of generation had been already carefully observed:§ but they were too much in opposition to the usual mode of reproduction to be understood in their true meaning. It was attempted to reconcile them with the customary mode by an unnatural interpretation, which regarded them as subversive exceptions to the general rule; while on the contrary almost all later works‖ bring to light a multitude of unexpected facts which take their places naturally under the law of alternation of

* In *Wiegmann's* Archiv, 1844, where the observations published in the author's earlier works, on the adolescent states of *Medusa* are completed and concluded.

† Beiträge zur Naturgesch. der wirbellosen Thiere. Danzig, 1839.

‡ Ueber d. Generationswechsel, übersetzt von *Lorenzen*, Copenhagen, 1842.

§ *Bonnet's* industrious observations, the first that were made, of the alternating mode of reproduction of *Aphis*, published in his Traité de l'Insectologie in 1745, though made in 1740, belong here. Also *Chamisso's* correct observations of alternation of generation in *Salpæ* described in his Memoir: de Animalibus quibusdam e classe vermium Linnæana, Fasc. I, 1819. Fragments in regard to the alternation of generation of *Trematodæ* were known, (but as such they did seem very enigmatical,) by *Bojanus's* Beschreibung d. königsgelben Würmer (the "nurses" of *Trematodæ* according to Steenstrup) aus welchen Cercarien (the larvæ of the final generation) herauskommen (Isis, 1818), and by *v. Bauer's* important work on *Cercariæ* and the related *Bucephalus*, (Beiträge zur Kenntniss d. niederen Thiere. Act. nat. cur., Vol. XIII, 1827).

‖ Of the later works, by which the field of alternation of generation has been extended, I will adduce in particular; *Sars:* Fauna litoralis Norwegiæ, 1846, in which the sections especially important in relation to alternation of generation are those on *Syncoryna*, *Podocoryna*, *Perigonimus*, *Cytais*, as well as on *Agalmopsis*, *Diphyes* and *Salpa*.—*Van Beneden:* Recherches sur l'embryogénie des Tubulaires (1844); Mém. sur les *Campanulaires* de la côte d'Ostende (1845 in the mém. de l'Acad. roy. de Bruxelles, T. XVII); Recherches sur l'anat., la physiol., et le dével. des *Bryozoaires* (Mém. de l'Acad. roy. de Br. T. XVIII).—*Dujardin:* Sur le dével. des Méduses et des Polypes hydraires (Ann. des sc. nat., Nov. 1845).—*Krohn:* Bemerkungen über die Geschlechtsverhältnisse de Sertularinen (in Müller's Archiv, 1843, p. 174); Ueber d. Fortpfl. u. Entw. der Biphoren (Froriep's neue Notizen, No. 868, 1846).—*Busch:* Beob. über Anat. u. Entw. d. Infusorien (Arch. f. Naturgesch. XV, p. 92). How great an importance must be attributed to the discovery of alternation of generation in dispelling the darkness which until then settled on the history of the life and development of *Entozoa*, may be seen in particular in *v. Siebold's* pregnant communications in *R. Wagner's* Handwörterbuch d. Physiologie, p. 640 (Article: Parasiten).

generation as now known, and substantiate the pertinent words of Gœthe with which Steenstrup opens his Memoir: "Nature keeps on her course, and what seems an exception is in rule." It was Sars, however, who first gave the answer to the riddle, the key to the newly opened domain, when he said of the course of development of *Medusa*, that here "it was not the individual, but the generation, which underwent the metamorphosis."* This was the true point of view; for Steenstrup dwelt too exclusively on the physiological side, the functional relations, of the alternating generations. Steenstrup, in fact, considered that the significance of alternation of generation consisted in its being an organic nursing of the brood connected with particular generations, for which reason he termed the individuals of *these* generations "nurses;"—a mode of viewing the subject, which, with all Steenstrup's pregnant elaboration of his idea, and with all the analogies he pointed out between it and the well-known phenomena of nursing the brood by particular individuals among bees, wasps, ants and termites, does not seize the *essential* point of the phenomenon of alternation of generations.† R. Leuckhardt‡ conceives alternation of generation from a more comprehensive physiological point of view, in connection with the totality of all the other phenomena of the formation of different individuals, whether it occurs in a different or in the same generation; regarding all these phenomena from the point of view of a division, not merely of the generic task, but of the vital task in general, among certain individuals; considering it as a polymorphism determined by a division of labor. But even this view must lead to the morphological one; for the division of labor is deter-

* *Sars:* l. c., p. 29. This assertion, of course, must not be understood as if the particular generation did not come in for its part of a metamorphosis. Sars' view is most beautifully corroborated by a comparison with plants; as in plants the metamorphosis of the individual itself is connected with the formation which leads to the completion of new parts, which in their turn have their own subordinate metamorphosis.

† Steenstrup's explanation is most correct in regard to the history of the development of *Distomæ*, whose nurses and grand-nurses are at last utricles entirely filled with the brood, and forming mere receptacles of the brood. Its application is less happy to those cases where the transition from the preparatory generations to the final generation takes place through *external* shoot- or bud-formation, as in *Sertulariæ*, *Campanulariæ*, and *Corynæ*, whose nurses forming the polypstem can continue to live even after the concluding generations, comparable to the flower in plants, separate or wither off. Hence the vital activity of the preparatory generations is not exhausted in the production of the brood. Steenstrup's view, accordingly, would only be correct if non-sexual brood-production (by internal or external shoot-formation or by division) and alternation of generation were *correlative* conditions of each other. But this is not the case, as reproduction by shoots takes place without any alternation of generation in a great number of animals (*Ascidia, Bryozoa, Madrepora*), and by division as well (*Astræa, Annulata, Infusoria*). These cases are comparable to the occurrence of *unessential* branches in plants; while alternation of generation represents the succession of *essential* shoots.

‡ Ueber d. Polymorphismus d. Indiv. od. d. Ersch. der Arbeitstheilung in d. Natur. Ein Beitrag z. Lehre v. Generationsw. (1851.)

mined by the organic development, while this itself obtains its peculiar character from the determinate step of the metamorphosis at which the development ceases;—and this is just what is so unmistakable in the phenomena of alternation of generation in plants. Hence as a typical phenomenon of development, as a metamorphosis of generation, alternation of generation (as well as the metamorphosis of the individual) presents analogies with the graduated series in the animal and vegetable kingdoms, and the organic scale of the creation, in general;—a point to which V. Carus* called attention, and Reichert, his predecessor, as well.

The difficulties which the qualitative differences of shoots of one and the same species seem to present to our conception of shoots as individuals, will be entirely obviated if we can demonstrate that a partial outfit and equipment of individuals, perfectly analogous to those found among plants, are likewise found in the animal kingdom, where in most cases there is less doubt as to what is an individual,—if we can show that in both kingdoms, and in a similar manner, a polymorphism of individuals occurs which depends upon a division of the steps of development and of the vital problem of the species among individual members, whether of the same generation (divisions of generation), or of different generations cyclically succeeding each other (alternation of generation).

Let us first compare the phenomena of alternation of generation (or, as it should be called, *cyclical succession of generations*) in both kingdoms.† As is the case in the alternation of generation

* Zur näheren Kenntniss d. Generationsw. (1849); and, Einige Worte üb. Metam. u. Generationsw. (*v. Seibold u. Kolliker:* Zeitschr. f. wiss. Zool. III, 1851, p. 359).

† These remarks on alternation of generation in plants, do not depend, as one might perhaps be disposed to think, upon a zoological doctrine fancifully applied to plants. But I recognized the phenomenon as the same, and I treated of it in my papers, if not under the same name, still in the same meaning, before my attention was called to the occurrence of this phenomenon in the animal kingdom by Steenstrup's work. As soon as the doctrine of the shoot as the vegetable individual was assumed in all its consequences, a determinate succession of generations emitted one from the other necessarily appeared to be the ground of the flower's first making its appearance in many plants in a determinate degree of ramification, and of the occurrence of a determinate succession of steps in the series of axis up to this goal, caused by a peculiar partition of the leaf-formations. Hereby the essential shoot-succession, which is the one which represents alternation of generation, was accurately distinguished from the unessential one. Twenty years ago, or more, *C. Schimper* distinguished between essential and unessential shoots, denominating the first (in a wider sense of the word) "Ableger" [off-setts], the latter "Ausleger" [out-sets]. In the Versammlung d. Naturforscher in Mayence in the autumn of 1842, I made a communication on this subject, and at the same time in particular I called attention to the frequent importance of the characteristics involved in these relations when applied to improving the differentiation and grouping of species. Of this communication a report appeared in the Flora for 1842, p. 962, though, indeed, somewhat distorted by inaccuracies. *Wydler* treated the same subject in the Bot. Zeit. 1844, St. 37, under the heading "Achsenzahl der Gewächse," and gives a compendium of examples, in which, however, much appears which needs qualification. As Wydler informs us, Aug. de St. Hilaire is said to have turned his attention to ascertaining the number of essential axes in plants; however I find nothing in the place referred

of animals, a twofold reproduction appears in plants: sexual and non-sexual. Disregarding for the present the various relations of alternation of generation among the Cryptogamia, we find sexual reproduction (in animals by fertilized ova,—in plants by fertilized seeds) always vested in the generation which concludes the cycle of generations. That the consideration of this generation as the concluding one is not arbitrary, is shown by comparing it with the usual course of the metamorphosis; for the concluding generation is invested with the concluding formations of the metamorphosis (flower and fruit), in the same way in fact as in the animal the complete development of the organs of generation occurs at the summit of the individual metamorphosis. The preceding (preparatory) generations, which Steenstrup calls "nurses," on the contrary invariably produce their brood by non-sexual reproduction; in the animal kingdom this takes place, now through germ-granules which develop in the interior of the body (as the nurses of Distomæ), now by a process of division in the posterior part of the body (the nurse of the *Medusæ*, the *Tapeworm*), or finally by external, persistent or deciduous, shoot-formations, (*Corynæ*, *Campanulariæ*, *Sertulariæ*, etc.). Among Phanerogamia the last is the only kind occurring subservient to alternations of generation.

In animals, as in plants, the number of the generations in which the cycle of alternation of generation is completed, is for the most part a determinate one. *Medusæ, Salpæ, Corynæ, Tubulariæ* conclude this cycle in the second generation; according to Steenstrup's showing, *Distoma pacificum* has a trimembral alternation of generation, and the family stock of *Pennatula* seems also to be formed by a trimembral succession of shoots. *Campanularia* has a quadrimembral cycle, in which however the two first generations are of the same character. Among *Sertulariæ* cycles of still more numerous members appear to occur; eight to ten generations form the annual cycle of generation of *Aphides*, though, excepting the last one, they are all similar and not even determinate as to number.

To these examples from the animal kingdom much more numerous ones from the vegetable kingdom might be added, though

to in the *Leçons de Botanique* but the distinction between determinate and indeterminate growth, which has been known since Joachim Jung's time, and was brought forward especially by Rœper and applied by him to classifying infloresences. It is exemplified, in that place, by creeping stems, upright root-stocks, and by bulbs; and the section on indeterminate stems is unluckily exemplified by wrong cases, viz., *Scirpus palustris*, *Primula officinalis* and *Menyanthes*, to which indeterminate main-shoots are falsely ascribed.—Steenstrup, also lays down an alternation of generation in plants, in the concluding remarks in his work quoted above, as well as in his later book, "Ueber das Vorkommen des Hermaphroditismus in der Natur," (On the phenomenon of hermaphroditism in Nature), though in an entirely different manner from mine as here given, for he compares the single leaves of the plant with the individual in animals,—a mode of viewing the subject in regard to which I have already expressed my opinion in the Introduction.

I will only adduce a few of them here. Most *Labiatifloræ, Synanthereæ, Grasses, Polygaleæ, Primulaceæ,* the *Dictamnus, Iris, Galanthus nivalis,* etc., have a bimembral alternation of generation in different ways, according to the partition of the formations. In *Paris,* for example, the first generation takes the lowest grade: it presents a subterranean inferior-leaf shoot, (rhizoma) which never leaves the darkness of the earth, only reaching the world of light, towards which all plants strive, in its posterity, viz., in the quadrifoliate and unifloral lateral shoots which it sends up. The first generation of *Viola odorata* and related species forms foliage proper; still, the main axis tarries close to the earth, and the second generations (the lateral flowers) scarcely rise above the foliage. In *Lysimachia nummularia,* the main-shoot, a rooting leaf-stem, creeps along the surface of the ground, growing indefinitely, and terminating only in the (essential) lateral branches by its golden-yellow flowers. The main shoot rises perpendicularly, forms foliage proper, and passes on to superior-leaf formation in many species of *Veronica,* e. g., *V. acinifolia,* producing its flowers as a second generation out of the axils of the leaves. The same holds good in regard to *Orobanche ramosa,* which fixes itself and preys upon the root of hemp, though its main-shoot has no green leaves. A very remarkable bimembral alternation of generation is shown by *Adoxa,* now so famous, its name to the contrary notwithstanding.* The main-shoot creeps along the ground, oscillating with the seasons between leaf- and inferior-leaf formation,—at every return of the latter stretching out like a runner and boring into the earth. Flowers and fruit, frustrated by the invariable retrogression of the main-shoot, are produced by the aspiring perpendicular branches, after a pair of small leaves on the scape, and several insignificant superior-leaves, out of whose axils the lateral flowers are emitted as unessential shoots of the third degree. *Hepatica* presents a similar division of the formations among the two generations of shoots; but the main-shoot, rejuvenated from year to year and alternating between inferior-leaf and leaf-formation, is short and upright. The branches with their single flowers, forming the second generation arise in the axils of the scale-like inferior leaves. A bimembral succession of shoots occurs in *Convallaria, Polygonatum,* the genus *Alœ,* all species of *Plantago, Veronica officinalis, Chamædrys,* etc., *Viola sylvatica, Lysimachia thyrsifolia, Alyssum saxatile* and some other *Cruciferæ, Echeveria coccinea,* all the species of *Melilotus, Medicago, Galega,* in *Pisum,* and many other leguminous plants, and in *Succisa pratensis, Anacyclus, Pyrethrum, Polygonum Bistorta,* etc. A familiar example occurs in

* E. g. *Adoxa moschatellina,* which derives its name from δόξα (fame). The relations of growth in this plant have been correctly described by *Wydler: Bot. Zeit.* 1844, p. 657.

Secale. Its spiciferous culm forms the shoot of the first degree, the lateral spikelets which compose the spike itself are those of the second,* and the florets in the axils of the superior leaves (paleæ) of these spikelets are the shoots of the third degree, i. e., the third generation of the cycle. A quadrimembral succession of shoots occurs in *Trifolium montanum*, *Hedysarum coronarium*, and in several of the New Holland phyllodineous *Acaciæ*. Several species of *Carex*, e. g., *C. maxima* and *leptostachys*, have a trimembral succession of shoots up to the male flower and a five-membral one up to the female.

If we were to reckon the similar generations which are reared one above the other until the tree gains strength enough to perfect its flowers, in many trees without terminal buds, as, in the Willow, the Linden,† we might find a number of generations equal or even much superior to that presented by *Aphis*.

Besides the generation *essential* to itself, and by which it gives existence to the next grade in the cycle, every generation can have still another unessential reproduction, which only extends the same grade. As above we distinguished between essential and unessential shoots, so here accordingly we must distinguish an essential succession of generations,—the true alternation of generation,—and an unessential one. Very often both occur in the same species of plants. A fine example of this is shown in *Lysimachia nummularia*, from whose creeping and rooting leaf-axis are emitted not only peduncles, but here and there new creeping leaf-axis exactly repeating the original one (except as to the two early-lost cotyledons): and from the undetermined leaf-bearing main-axis of *Tropæolum minus* are emitted in regular alternation three lateral flowers at a time, and then again one (unessential) leaf-shoot. In *Cardamine amara* the first generation (the stem bearing foliaceous and superior-leaves) is repeated in a two-fold manner, by lateral branches from the cauline leaves, and by creepers from axils of the root-leaves. Similar relations obtain in *Mentha* and a large number of other plants. This same phenomenon is repeated in the animal kingdom. The polyp-like nurses of the *Medusa* increase as such (according to Sars and von Siebold) by lateral buds and runners. *Syncorynæ* are spadix-polypi, which represent trees by their formation of unessential branches, emitting finally from every branch and from the middle stock a whorl of individuals of the second (and last) degree. *Campanulariæ* and *Sertulariæ* put forth runners from the bases of the main-individual, which again shoot up and become new main-stems, or new stems emerge out of them; and perhaps the

* *Secale*, in fact, has no terminal spicule; neither has *Triticum monococcum*, while the other cultivated species of *Triticum* have.

† I have described the grape in reference to this subject in another place, (Verjüngung, p. 49,) [*Henfrey's* Transl. op. cit. p. 46. T.].

ramifications of *Bucephalus* (which according to Steenstrup's supposition is the larva of *Aspidogaster conchila*) as represented by Baer in Nov. Act. Nat. Cur., xiii, 2 belong here.

In our qualitative comparison of shoots, it was shown how the shoot can be limited to a few leaves, or even to a single one; in like manner the animal individual, in the division of *rôle* which occurs in alternation of generation, can become the representative of one single organ, of one single function. Thus the females of *Coryne squamata* are hardly anything more than egg-stocks, and the males than seed-stocks.* The members of the *tapeworm*, which are so many individuals of the final generation, hardly represent anything more than hemaphrodite sexual apparatus. As an analogous example in the vegetable kingdom perhaps the *Willow*† may be compared to the *Coryne;* here too the shoots of the last degree are nothing but naked unisexual apparatus of reproduction. In *Potamogeton*,‡ on the contrary, they are hemaphrodite, as in the tapeworm. The construction of many of the lower animals, which when considered as individual animals seem to be the strangest monsters, becomes more intelligible as soon as they are regarded from this point of view, —as soon as we make up our minds to regard the supposed individuals as a family stock, and its parts (formerly held to be mere organs, and which, physiologically considered, are really nothing more) as individuals. In particular this is true of *Physophora*, *Stephanomia* and *Agalmopsis*.

In many cases we find alternation of generation connected with division of generation, that is, the appearance of heterogeneous individuals in one and the same generation. Just as is the case in animal and vegetable forms without alternation of generation, so where it is connected with alternation of generation, division of generation relates principally to the sexual functions; and a glance at the animal kingdom shows us relations of alternation of generation complicated by division perfectly similar to those which occur in the vegetable kingdom. In animals which go through an alternation of generation the individuals of the preparatory generations are non-sexual; still they may nevertheless have a determinate importance in relation to the completion of the race which is to form their posterity. When in fact the final generation does not consist of hemaphrodite individuals, as obtains, for instance, in the tapeworm, various alternations are conceivable: the final individuals of both sexes can be nourished by the same nurse, and hence the sexual division will first take place in the second, or generally speaking, in the last generation;

* Hence *Rathke* regards the male individuals as mere testicles. Cf. *Wiegm.* Archiv., 1844, p. 155, and *Steenstrup:* Hermaph., tab. I, f. 17–20.

† The two stamens in the Willow, and the floriferous bud as well, is preceded by only two very small bracts, which grow together and form a little scale.

‡ The flowers of *Potamogeton* are branches which bear only stamens and carpels

or, different nurses may nourish the two sexes so that a division of generation will occur even at the degree of nurse-formation. If in the last case the nurses are not single ones, but even then form *per se* a family stock, then on the same stock we may either have male-bearing and female-bearing nurses together, or these two kinds of nurses may be divided among different stocks, according as the division of generation occurs in a determinate later generation, or is present already in the first. Although as yet the observations of these relations by no means form an unbroken chain,* still this much is certain, that in animals, in the same way as in plants, both monœcious and dœcious forms occur; and hence there are families partly bisexual, partly unisexual. *Corynæ*, *Tubulariæ*, *Campanulariæ*, and probably all *Sertulariæ* (hence, doubtless, the greater part of *Hydroids*), also *Veretillum*, *Cynomorium*, according to Steenstrup, Krohn and other observers, are diœcious,—whether they form small simple stocks as *Coryne squamata*, or small ramified trees, as *Syncorynæ*, *Campanulariæ*.† etc. On the other hand *Siphonophoriæ*, according to Milne Edwards' description of *Stephanomia*‡ (and judging from Sars' description of *Agalmopsis*), are monœcious family stocks; Hydræ are also monœcious.§ To enter any further into these relations as they occur in the lower animals would lead us too far from our subject; but it may be in place to give some details as to the manifold relations under which sexual division of generation occurs in plants.

Diœcious relations may occur without alternation of generation when, in fact, the flower has a terminal inflorescence and no branches, or only unessential ones,—when, therefore, as it is usually expressed, it is "uniaxial," as e. g., in *Rubus*, *Chamœmorus*, *Lychnis*, and *Viscum*. Much more frequently, however, division of the sexes occurs in plants which at the same time have a cyclical succession of shoots (alternation of generation),—a succession which each of the two heterogeneous stocks passes through independently, and not always *pari passu*. This is a circumstance which must not be neglected in considering the differences of *habitus* in male and female flowers. Thus, in *Mer-*

* Thus e g., as far as I know, it remains to be shown whether the single nurses of *Medusae* produce *Medusae* of both sexes, or, as is most probable, only those of the same same sex. In *Aphis* also this point still needs to be more accurately determined.

† *Steenstrup:* Hermaph., pp. 66, 67, 72

‡ Ann. des Sc. Nat., 1841, p. 217, pl. 7–10.

§ The later investigations into *Siphonophoriæ* by *Huxley:* Edin. Phil. Journ., 1852, *Kölliker:* Zeitschr. f. wiss. Zool., 1852, and *Leuckardt:* Zool. Untersuch., 1stes Heft, 1853, corroborate the monœcious relations of these wonderful creatures as regards most of their genera, e. g., *Agalma*, *Agalmopsis*, *Stephanomia* (*Apolemia*), *Physophora*, and the other closely related genera; *Busch's* researches into the group of *Diphyidæ* have proved them to be diœcious, and the same obtains in the related genus *Epibulia*. (Later note.)

curialis the female plant bears flowers even on the second axis; in the male plant, however,—if I do not misunderstand the inflorescence (a spike composed of small glomerules)—this first occurs on the third. In *Carex dioica*, vice versa, the male plant, flowers in the second line and the female in the third.* In other diœcious plants on the other hand, the male and female flowers appear in the corresponding generation, e. g., in the second: *Stratiotes*, *Empetrum* and *Taxus*; in the third: *Salix*, *Populus*, *Myrica*, *Cannabis*; in the fourth: *Phœnix*. In Hemp the extremely heterogeneous appearance of the inflorescence of the male and female plants does not depend upon a division of the flowers of the two sexes among different axes, but upon the production of numerous unessential peduncles in the male inflorescence.†

Monœcism necessarily presupposes a succession of shoots (alternation of generation); in the simplest case at least for one of the two sexes, as both cannot be united in the same terminal flower: but *vice versa*, both may easily appear in determinate (equal or unequal) degrees of ramification. The most important circumstance to be considered in monœcious relations, consists in both the sexes (i. e., the shoots which bear them) occurring either subordinately or coördinately,‡ for one either arises out of the other, or they both spring from a common mother-stem. In the first case, the female flower usually belongs to the earlier, the male to the later (subordinate) generation; the male flower-shoot springing from the female,§ as e. g., in *Euphorbia*, *Ricinus* and *Poterium*, in which the female flower terminates the main axis, and the male occurs as a lateral shoot.‖ In *Buxus* the female flower occurs as the second, the male as the third axis; in many species of *Phyllanthus* (e. g., *Ph. niruri*) the female as the third, the

* The second axis, which is a complete dwarf or a mere bristly spine bears the so-called Urceolus, in the axil of which the female flower is placed, as the third member of the succession of generations.

† The female flowers are placed at the sides of the primary branches as branches of the second degree. In the same place where one single flower occurs in the female plant, a furcately ramified inflorescence is found in the male, produced by branching out of the two bracts of the original flower.

‡ Both these cases doubtless occur in the animal kingdom, the first probably in *Alcyonella*, where the stock is said to be composed partly of males and partly of females. As the stock is here formed by individuals continually shooting out of each other, one sex must shoot out of the other. The second case occurs in *Agalmopsis* (according to Sars,) where partly female (seminal vesicles,) and partly male individuals grow out of the same main-stem.

§ The opposite case seems to occur very rarely or not at all. A monstrosity, which, for some reasons might be adduced here, is found in *Larix Europæa* and *Picea alba*, in which transitions of the amentaceous male flowers into female cones occur, where the fruit scales are emitted from the axils of stamens which are often only slightly abnormal.

‖ As in all the examples adduced, the unessential aggrandizement of the inflorescence must be disregarded, which occurs in *Ricinus* and *Poterium* in the form of lateral female flowers emitted beneath the terminal female flower.

male as the fourth ; in *Xylophylla*, the female (on the margins of the spurious leaves) as the fourth, the male arising from the bracts of the female flower, (as in ***Phyllanthus***) as the fifth. In ***Momordica***, ***Ecbalium***, ***Cephalanthera*** and some other ***Cucurbitaceæ***, the female flower, placed in the axils of the foliaceous leaves of the main stem, belongs to the third axis, and the male to the fourth ; for the third axis, which here arises from the base of the peduncle of the female flower as main axis of the racemose male inflorescence, is a superior leaf-shoot. In the other cases,—in which the succession of shoots, in order to arrive at the two kinds of flowers, separates into two coördinate lines,—both kinds of flowers can appear either immediately in the first generation after this separation, or, since here again preparatory generations are intercalated, in a later one. Further, the number of the generations (axes) in the two lines arising from the division, may be either equal or unequal. A few examples may serve to explain the manifold cases which thus occur. In ***Musa***, ***Myriophyllum*** and ***Sagitaria*** the coördinate male and female flowers appear in the first generation after the separation, and in the whole as a second system of axes. Here the female flowers stand in the lower, the male in the upper part of the spicate or racemose inflorescence. The contrary holds true of ***Cucurbita*** and the monœcious ***Bryoniæ***;* for here the earlier flowers, which appear in the axils of the foliaceous leaves, are male ; while the later ones which appear on the farther continuations of the stems are female. ***Arum***† has below female, in the middle male, and above again female flowers, though these last are dwarfed and sterile. Likewise in the first generation after the separation, but in the whole as the third system of axes, we find both kinds of flowers in ***Pachysandra*** and *Acalypha*, and here again, as is usually the case in indeterminate spicate inflorescences of mixed sexes, the female flower is in the lower, the male in the upper part of the inflorescence. The same obtains in monœcious Palms with axillary spadices ; though here the flowers appear in ramified spikes from the fourth system of axes. When the flowers make their appearance in the second generation after the division, they cannot easily be united in the same inflorescence, and special male and female inflorescences will arise. Thus, e. g., in ***Platanus***, ***Liquidambar*** and ***Sparganium***, in which the female inflorescences occur on the lower part of the main shoot, and the male in the upper ; likewise in ***Quercus*** and ***Fagus***, though here, ***vice versa***, the male inflorescences are the lower, and the female the upper. Finally, if the division of the succession of shoots is an unequal one in

* *Bryonia* has apparently axillary racemes, but a more careful investigation shows that they do not spring immediately out of the axil of the foliaceous leaf, but (as secondary branches) out of the peduncle of a single flower standing directly in the axil of the leaf which exactly corresponds to the flower in *Cucurbita*.

† The inflorescence in *Arum* is terminal, as well as that in *Calla*.

the separated lines of generation leading to the two kinds of flowers; i. e., if the number of essential axes is unequal, it is greater sometimes for one sex and sometimes for the other. In the Walnut (*Juglans*) it is the male flower which attains the higher degree of ramification; in *Xanthium* and the species of *Carex* with separated male and female spikes it is, on the contrary, the female flower.*

Other dimorphisms or even polymorphisms of the flowers, more or less independent of sex, occur when the sexes appear in the two different lines of generation; for even among flowers of the same sex, whether hermaphrodite, male, or female, differences often reveal themselves of a very striking character, which are generally coördinate according to fixed laws of division of generation. Thus, in all *Primulæ*, and in several *Labiatæ*, two kinds of hermaphrodite flowers occur, in a state of diœcious separation: one with a large corolla and strongly developed stamens (*forma brevistyla*), the other with a small corolla and strongly developed pistils (*forma longistyla*). Acccording to C. Schimper's observations† both forms occur at times in *Labiatæ* even on the same stock and in the same inflorescence, e. g., in *Dracocephalum Moldavica*. Many species of *Viola* also produce two kinds of hermaphrodite flowers on the same stock: early ones of the usual form, and late ones without petals. In *Viola mirabilis* the first arise directly out of the main stem (as branches of the first degree) and are mostly sterile, while the latter spring from the foliaceous branches (as branches of the second degree) and are fertile. In *Impatiens* sterile flowers with perfect corollas and apetalous fertile ones occur in the same raceme. The cases in which normally formed above-ground and abnormally formed underground flowers appear belong here; the latter have their corolla developed slightly or not at all, and are merely female, and, *par excellence*, fertile. If both kinds of flowers are fertile, the subterranean fruit differs from that borne above the soil; such cases are found especially in the family of *Leguminosæ*, e. g., in several species of *Lathyrus* and of *Vicia*, in *Amphicarpæa*, and in *Arachis*;‡ and also in the very remarkable Abyssinian *Con-*

* In species of *Carex* with terminal male and lateral female spikes, the male flower belongs to the first generation after the division, and the female to the third. In most of the species where the shootlet which bears the inflorescences is a continuation of the main axis of the plant, the male flowers represent in general the second generation and the female the fourth; in those species, on the other hand, which have a shortened main axis, which forms a mere rosette of leaves whence the shootlets bearing the inflorescences proceed as branches,—in these species the male flower is the third system of axes, and the female the fifth; as e. g., in *Carex maxima, leptostachys* and *pilosa*.

† Communicated in the Versam. d. Natur. zu Wiesb. in Sept. 1852.

‡ For details, vid. *Treviranus*: Bot. Zeit., 1853, p. 393.

*volvulacea, Hygrocharis Abyssinica.** Among the most striking cases of dimorphous flower-formation are those described by *Jussieu*† in *Gaudichaudia, Camarea*, and other *Malpighiaceæ.* Here, besides the flowers conjoined in racemes or in corymbs, and formed according to the common type of the family, other apetalous flowers occur, standing alone and hid in the axils of the leaves. Besides the normally formed glandulose corolla, they have only one stamen and two carpels. In several cases the dimorphism of the flowers is confined to the formation of the fruit alone, as, e. g., in some species of *Æthionema*, (especially *Æ. heterocarpum*, Gay,) which in the same raceme bear partly dehiscent silicles with two cells and several seeds, and partly one-celled and one-seeded indehiscent silicles. *Ceratocapnos*,‡ a North African genus of *Fumariaceæ*, bears in the lower part of the spike oval, ribbed, one-seeded nutlets, and in the upper part, lanceolate two-valved and two-seeded siliques. Polymorphism of flowers and fruit occurs in the most heterogeneous manner in the family of *Compositæ;* I will only refer to *Zinnia, Dimorphotheca, Heterotheca, Thrincia, Geropogon, Crupina;* and especially to *Calendula*, where the hermaphrodite blossoms of the ray produce three different forms of fruit, so that, including the male flowers of the disc, the capitulum presents four different forms of flower-shoots (belonging to the same generation). As somewhat similar cases in the animal kingdom, the instances of dimorphal insects, of which there are several, might be adduced.§

A separation of the series of generations into several distinct lines occurs in fact not only as regards the flower, but also, though less frequently, even among the inferior formations of the plant; this is especially the case where a particular lateral line is allotted to the leaf as well as to the flower. The true Pines afford the best known example of this. Their fascicles of needle-shaped leaves are nothing but foliaceous branches of circumscribed growth,‖ which lie outside of the line which leads to the two kinds of flowers, while they are essential as the leaf-formation

* *Hochstetter:* in Schimp. Iter Abyss., No. 572 et 1701. The same plant is called *Nephrophyllum Abyssinicum* by *Richard:* Tent. Flor. Abyss., and figured in pl. 76. The two kinds of flowers are emitted from the axils of the foliaceous leaves of the same creeping stem; those provided with corolla, stamens and pistil stand upright; the others without corolla and stamens, bend down to the ground on their long peduncles.

† *Adr. de Jussieu:* Monographie des Malpighiaceés. (1843.)

‡ *Durieu:* Explor. scient. de l'Algérie, pl. 78. *Endlicher:* Gen. plant., Suppl. IV, p. 32.

§ The first in several species of *Dycticus* (*D. marginalis, circumcinctus, Lapponicus, Kœselii*, according to *Erichson:* Gen. *Dyticeorum*, 1832, p. 31; the last in *Aphis Quercus* according to *Bonnet.*

‖ That the fascicles of leaves in *Pinus* are branches, is proved by the phenomenon of percrescence, which is not unfrequent, especially in young pines.

appears on them alone.* Here the generation splits up into three kinds of essential and coördinate shoots: 1st, the small leaf-shoots which after some few inferior-leaves forming the vagina, bear two, three, or five foliaceous leaves; 2d, the male flowers, or small shoots, which are provided with stamens only; 3d, female inflorescence, shoots with superior-leaves (the integumentary scales of the strobile) in whose axils the fruit-scales of the cone are formed, belonging to a farther system of axes. In the animal kingdom cases analogous to these occur in monœcious *Siphonophoræ*, especially in *Stephanomia* and *Agalmopsis*, where even more than three kinds of coördinate individuals are emitted from the main axis: in particular motory individuals (the so-called *swimming-bells*), nurses, the proboscis-like formations or imbibing tubes, and as already mentioned, two kinds of sexual individuals.

The differences of shoots thus far considered depend principally upon this: one portion represents exclusively the vegetative formation, or a certain part thereof; the others represent the degrees of formation which belong exclusively or principally to the sphere of fructification. Hence, in regard to the division of functions, to one portion the functions of nutrition are allotted, to the others those of generation. For this reason the different kinds of shoots of such a partial character must unite in a determinate succession, and complete each other; and even those which we have designated as unessential are of importance in enriching, preserving, and increasing the plant-stock. Finally, we have still to consider those shoot-formations which properly do not belong either to the essential or the unessential succession of shoots, but rather to an *aberrant* formation; as they neither conduce to the perfection of any of the common steps of the metamorphosis, nor perform any essential physiological function in the plant, but at the best are only of some service as organs of defence, support or adherence. These are the shoots which take the form of thorns, bristles, hooks and tendrils, which for the most part owe their peculiar abnormal character to an entire suppression of the leaf-formation, and a final induration of the point of vegetation: these seem to be the last, terminal or lateral members of the generation, abortive in every respect. Not unfrequently they form the last ramification of paniculate and dichotomous inflorescences, like terminal flowerless peduncles, as, e. g., in *Teloxys* (*Chenopodium aristatum*, L.), *Acroglochin*, and in a very peculiar form, branching and complicated by aculeate or setiform leaf-formations, in *Pupalia*, *Desmochæta*, *Digera* and

* The main-stem, as well as all the elongated branches essentially resembling the stem, bear only leaf-scales, which may be best compared to bud-scales, and ascribed to the inferior-leaf formation. It is only in early youth (in the first and second years) that the main-stem itself bears needle-shaped leaves.

Cometes;* also, in *Scleropus*, where they take the form of short, thick, cartilaginous stalks, with two converging leaf-apicules. Among the grasses they are known under the form of bristles in *Setaria*. In many Rhamnaceous and Sapindaceous plants (*Helinus*, *Cardiospermum*) they appear as small cirrhi, not as the last sterile ramifications of the inflorescence, but on the contrary as the first, followed by other fertile peduncles. They often occur in the axils of foliaceous leaves; and wherever they make their appearance they naturally arrest the farther succession of shoots, when they have neither of the two leaves at their origin, out of whose axil an additional shoot may be developed. This is the case in *Passiflora*, whose flower arises from the axil of a leaf situated at the side of the base of the tendril. The thorns of *Ononis*, *Elæagnus* and *Maclura*† present the same phenomenon. In other cases the succession of generation thus arrested by the aculeate shoot is restored by secondary formations; when, with the thorn, a second shoot follows out of the axil, which in some cases may form a leaf-shoot, and in others a flower-shoot. This happens in *Gleditschia*, in several *Acaciæ* (e. g., *A. pulchella*), in *Prinsepia utilis*,‡ the Lemon, the Egyptian *Balanites*, *Duranta*, *Bouganvillea* and *Randia*, in which the secondary shoot arises close under the spine; while in *Celastrus pyrrhacantha*§ and *Europæus*, as well as *Pisonia aculeata*,‖ the secondary shoot occurs above the thorn. In *Uncaria pilosa*¶ and *Strychnos spinosa*, pairs of leaves with axillary thorns alternate with pairs which have peduncles in their axils.

Have even these phenomena of extreme alienation of the individual (as they occur in the thorns and hardened shoots of plants) analogous forms in the animal kingdom? Yes, I believe they have! I believe I may assert that in the animal kingdom itself there are individuals which occur as mere fixed claws, pincers, scourges, tactual and predial filaments, etc.,—individuals which perform neither functions of nutrition nor of reproduction in the society to which they belong, but which probably merely assist in seizing the food, or lend a helping hand in defending the community. The cases which I have here in mind are of frequent occurrence among Bryozoa, and especially in the group

* The plumose tails which form the "envelope" of *Cometes*, are the last branches of the dichotomous inflorescence, accompanied by similar accessory (secondary and tertiary) branchlets. All these numerous sterile branchlets are elongated and beset with setiform leaflets arranged in spiral order ($\frac{2}{5}$), commencing with two similar anterior leaves. The direction of the phyllotaxis in all these branchlets follows the law of furcate inflorescence.

† Here belongs also the curious hook of *Uncinia*, which is also visible, though less developed, in many species of Carex. The utriculus is a leaf at the base of this spine.

‡ *Boyle:* Illustr. of the Bot. of Himal., pl. 38, fig. 1.

§ *Boissier:* Voy. bot. en Espagne, t. 38.

‖ *Rheede:* Hort. Malab., vii, t. 17.

¶ *Wallich:* Plant. As. rar., t. 170.

of *Cellariæ*. Individuals in the form of horns (which usually conclude the series of complete cell-inhabiting individuals) occur, e. g., in *Eucrabea cornuta*,* and *Cordierii*;† in another form (reminding us of *Teloxys*,) as forked terminal spines, in *Vesicularia spinosa*.‡ Moveable individuals, representing mere weapons, in form like a bird's beak, a crab's claw or a pincers, appear in *Acamarchis avicularia*§ and *flustroides*,‖ *Retepora cellulosa Scrupocellaria scruposa*¶ and many others. In the last named *Cellariæ*, besides the claw-individuals, there are also scourge-individuals, which Van Beneden himself compared to the cirrhi in plants, and which even Leuckardt** acknowledges to be individuals. Beside the 'Swimming-bells' evidently resembling *Medusæ*, the peculiar retractile predial filaments of the *Siphonophoræ* doubtless belong here also; they are remarkable for a purplish-red swelling on or under the apex, and they shoot out singly as branches from the stalk of the nutritive individual (imbibing-tubes), and themselves bear a series of similarly formed filaments as secondary branches. They are found with unimportant departures from this form, especially in *Physophora*,†† *Diphyes*‡‡ and *Agalmopsis*. In the last named genus, according to Sars,§§ they have even three modifications: the spadiciferous terminal piece ends in a long simple filament, or in a short two-parted one, or without any filament at all. In *Stephanomia*‖‖ numerous filaments, called tentacles, arise out of the stalk of the nutritive animals (the so-called proboscis-formed organs) without such colored swellings, which in the same manner may also be regarded merely as individuals with a very incomplete outfit of organs.¶¶

* *Ellis*: op. cit. pl. 21, f. 10. (*Cellaria cornuta*); *M. Edw.*: Ann. d. Sc. Nat., (1838) t. 8, f. 2 (*Crisidia cornuta*).

† Déscrip. de l'Eypte: Polypes, t. 13, f. 3.

‡ *Van Beneden*: Rech. sur les Bryozoaires, t. 4, f. c.

§ *Van Beneden*: l. c., t. 6, f. 1–8 (*Cellularia avicularia* Pall. *Crisia avicularia* Lamx.)

‖ *Ellis*: op. cit., pl. 38, f. 7.

¶ *Van Beneden*: l. c., t. 5, f. 8–16 (*Cellaria scruposa* Auct.)

** *Leuckardt*: Polymorphism. p. 17.

†† *Philippi*: Müller's Archiv, 1843, taf. 5.

‡‡ *Sars*: Fauna lit. Norw. tab. 7.

§§ Ib. tab. 5.

‖‖ *Milne Edwards*: Ann. d. Sc. Nat., 1841, pl. 7–10.

¶¶ Since Sars observed the separation of the Medusa-like sexual individuals in *Agalmopsis*, the view that *Siphonophoræ* are composite animal stocks has gained ground more and more among zoologists. But this mode of viewing the subject was for the first time carried out (after a fashion,), consequently in Leuckhardt's latest work on strange animal forms (Zool. Unters, erstes Heft: Siphonophoren, 1853); and this idea had forced itself upon me as early as 1847, when I compared the description *Diphyes* with *Agalmopsis*, in Sars' Fauna lit. Norw. In the above named work, Leuckhardt extends the view which allows individual importance to the parts of the stock of *Siphonophoræ* not only to the tentacles and predial filaments, but also to the covercles, which in most of the genera are placed close above the nutritive individual as protective envelopes; these formations, like all the other appendages of individual importance, being emitted from the stem as shootlets, and in the first stages of their formation, resemble the tentacles in particular. Accordingly *Siphonophoræ* have not less than *eight* different forms under which the individual may appear on the whole stock. . . . (Later note.) [I have omitted the enumeration of these forms.—T.]

After having in the foregoing review regarded all lateral shoots which spring from the main axis of the plant as real individuals, however unimportant a fraction of the total specific character they may realize, it will hardly be deemed surprising if we finally apply this mode of view to the *branches of the root* and to *adventitious shoots.* It is only possible for the main-shoot to develop freely both the points of vegetation of the axis; yet even here the lower point remains undeveloped. On the contrary, the lateral shoots, thus far considered, have no lower point of vegetation; for their base is united to the maternal shoot, and hence they are mere developments of the upper point of vegetation. Opposed to these, there are, however, other shoots by which the lower point of vegetation is represented, and which on the other hand have no upper point of vegetation. Among these may be reckoned not only the root-branches which take their rise from the main root, but also all adventitious roots which spring from the stem at determinate or indeterminate places. I must, however, content myself with this general hint, as any attempt to particularize these relations could after all only show the deficiency of the investigations into this subject, and how desirable a more comprehensive work is on root-formation in the vegetable kingdom.

The few points which I have selected out of the inexhaustible field of shoot-formation in the vegetable kingdom may in the mean time suffice to show that the comparison of the vegetable shoot with the animal individual is not far-fetched or arbitrary, but is presented to us by Nature herself. The solution of the difficulties which this mode of conceiving the vegetable individual encounters in the lowest grades of the vegetable kingdom, I must defer to a later day. These difficulties are founded upon the less complete organization of the inferior plants, and at all events cannot invalidate the results gained in considering the higher organizations. We may therefore consider it settled, that although the individual has not exactly the same importance in the vegetable kingdom as in the animal, plants still realize their vital cycle in sections which are not only comparable to the animal individual, but are in fact its complete analogues. What distinguishes plants is the formation of family-stocks, (a formation manifested in the highest vegetable representations, and here in the richest fullness),—as ancestral trees organically connected, variously disposed in their ramifications, and comprising numerous generations, rendered reciprocally complete through individuals variously endowed. And this leads us back again to the tree from which we set out; in which even our natural perceptions seemed to discern something more than one common individual, and whose high import scientific research must confirm. Just what at the outset appeared to be an obstacle to our allowing the single shoots of the tree their true significance,—now that we have compared them with alternation of generation in animals at length proves to be the most conclusive demonstration of the correctness of our first conception. The conception of these so heterogeneous shoots as individuals of one and the same species has led us, in fact, to a more profound and more pregnant conception of individuality, which will no longer seem paradoxical when we perceive it is confirmed even in the highest realms of life—in the sphere of the mental development of the individual. Or are the differences of human individuals in mental endowment and development less important than those which we have seen in the morphological and physiological endowment and development of shoots? Do we not meet with a similar reciprocal completion, a similar division of labor among the individuals of the family, of the state and of nations, and cannot even the human individual become likewise a mere organ? Do we not see the development of the human race itself bound up with a succession, in which the later generations continue the edifice their predecessors began, like branches depending upon the earlier stocks and nourished by them;—in which generation is added to generation, and cycles to cycles; so that thus by the ever-renewed labor of the individual the problem of human life may be ceaselessly aspired to, and at last reach its final accomplishment?*

* The preceding pages were almost all printed when I was fortunately enabled to read Reichert's memoir (die monogene Fortpflanzung, Dorpat, 1852,) upon a subject closely allied to the one here discussed. His work is full of new views of the subject, elaborated with great acuteness. The vegetable individual itself is considered in detail, and the author is thus led to a mode of viewing this subject similar to the Schultz-Schultzenstein-ian doctrine of *anaphyta*—regarding not only the shoot, but even its single parts, the internodes, with their leaves, as series of individuals shooting out of each other, or intimately connected by continuable bud-formation. Since, however, it is implied in the idea of an individual, that it shall somehow be limited by, and distinguishable from, (notwithstanding it is connected with) others; it seems to me that even from this point of view Reichert's idea can by no means be carried out. I will not deny that there are still other considerations in the nature of the shoot which it is difficult to reconcile with the idea of the simple individual, and I can only find the ground of this phenomenon in the fact, that the individual appears in its full import in the higher steps of the series of created beings, while in the lower it loses more and more its reality, if I may so say. I must reserve farther remarks on this subject until I treat of the individuality of the lower plants.

[We cannot but think, after all, that this view of Reichert's, &c., which our author rejects, is the legitimate conclusion, to which the very line of argument so completely and ably presented in the preceding pages, when fully carried out, naturally leads. It is merely a question of *degree* of individuality. As yet, perhaps, no sure middle ground has been secured between the two extreme views,—one of which regards all the vegetative offspring of a seed, however numerously multiplied, as philosophically the individual; while the other views the phyton, or in the simplest lower plants the cell, as philosophically representing the individual,—real individuality being incompletely realized (and with various grades of incompleteness) in all vegetables, and in many animals. The mind is reluctant to accept either of these conclusions, and seeks—thus far in vain—for some stable intermediate view. Of the two extreme views, if forced to the choice, we should incline to prefer the latter.—A. G.]

ART. X.—*Observations on Binocular Vision;* by Professor WILLIAM B. ROGERS.

PART THIRD

Of successive or alternating combinations of lines.

WHEN the figures presented to the two eyes consist of lines capable of being united in two or more different ways these combinations may be produced successively by a voluntary change of convergence, and in certain cases they are observed to follow one another in quick alternation without our being conscious of effort in producing them.

21. *Alternation of Vertical lines.*

The simplest example of this effect occurs when a figure composed of three equal verticals is so placed in the stereoscope that we may unite one of the extreme lines with either of the other lines successively.

Thus placing fig. 45 on the upper stage of the instrument so that *a* may be in front of the left eye while *b* and *c* are both presented to the right eye, we may combine *a* with *b*; and keeping the eyes directed to their resultant, we at the same time observe the line *c* a little to the right. Now changing the optic convergence to a point somewhat more remote we can cause *a* to quit *b* and to pass more or less rapidly over to *c* leaving *b* alone on the left. By thus changing the convergences backwards and forwards we may continue to unite *a* alternately with *b* and *c* with but little effort and as often as we please. When the distance between *b* and *c* is very small, say one twentieth of an inch, this change seems to me almost involuntary and occurs with the rapidity of a flash whenever we transfer our attention from the resultant *a b* to the simple line *c*, or back again from the resultant *a c* to *b*. Indeed, as we view the resultant and the parallel beside it, the line *a* is seen as it were to *flit* backwards and forwards between *b* and *c*, and it is only by fixing the attention resolutely on the resultant that we can prevent the alternate decomposition and recomposition of the lines. A dot placed a little above the line *a*, by accompanying the line in its movements, enables us to mark its successive union with *b* and *c*.

45.

22. *Alternation of Vertical with Oblique lines.*

Still more curious illustrations of alternating combinations are presented when the picture includes one or more inclined lines as in fig. 46. Placing this on the upper stage of the stereoscope so that *a* shall be in front of the left, and *b* and *c* in front of the

46.

right eye, we may alternately combine a with b and with c, giving rise in the former case to a perspective resultant (ab) which recedes as it descends, and in the latter case to one (ac) which approaches as it descends. By fixing the attention on either resultant for a moment we see that its extremity is marked by the dot and that therefore it includes the line a along with one of the others. If now we turn to the remaining line we observe the dot and with it the line a to flit over to this line and we are at once presented with the other perspective resultant. When b and c are but little separated this alternate transference of a from one to the other takes place without effort and almost instantaneously, causing the two perspective resultants to present themselves in such quick succession as to have the appearance of being simultaneously produced.

This *seeming coëxistence* of the two perspective lines is particularly striking when the two oblique lines of the diagram meet, as in fig. 47, and we so direct our view as to unite the lower end of a with the angular point. Looking at the lower dot which is then immediately below the angle we see the two resultants diverging from this point, the one receding upwards and the other downwards, and we find it impossible to discern anything like successiveness in their formation. The moment however we carry our view along one of these perspective resultants we find it to include the line a as shown by the upper dot, and *soon after*, we see the other resultant subside from its perspective position. The remarkable simultaneousness of the resultants in this case is no doubt due to the fact that when the combination is made at the angle, the lower point of a is at the same instant united with the lower end of both b and c, and that as the change of convergence necessary to combine the adjoining lower part of a with that of b and c successively is extremely slight, *the ascending and descending perspective lines near the angle are formed in an interval of time so entirely insensible as to make the impression of their being coëxistent.* When however we begin by uniting the upper end of a with that of either b or c, a much greater change of convergence is required in passing from the one combination to the other, and therefore a much longer time is consumed in forming the successive resultants.

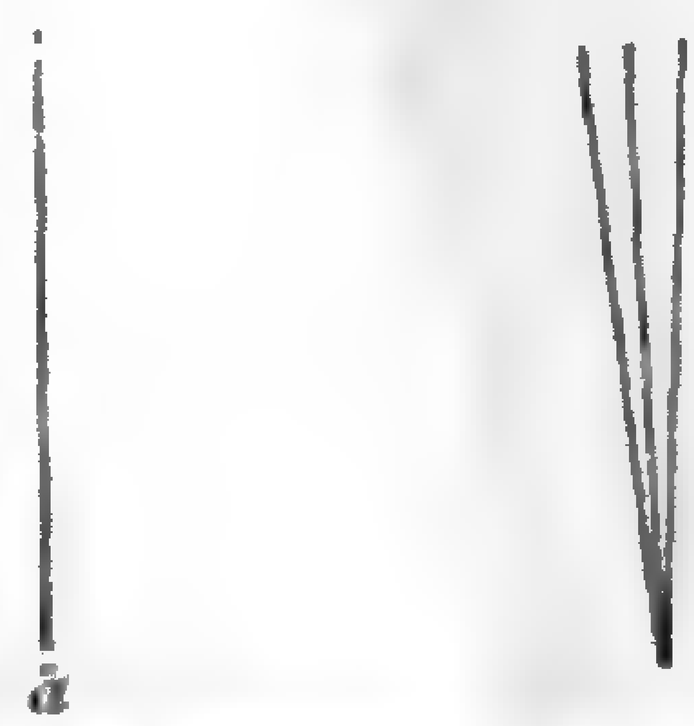
47

It has been remarked above that in looking at one of the resultants the other line soon after subsides from its perspective position. It may naturally be asked why this line does not lose its appearance of relief the moment it ceases to be a resultant, that is, the moment the line a is observed to quit it. The explanation is I think to be found in *the disposition of the mind to retain the perception of relief previously associated with the line until impressed with some other definite idea as to the distance of its several parts.*

When for some time we continue to carry the eyes backwards and forwards along the upper half of the perspective resultant, a curious effect presents itself. The other line after subsiding to the plane of the diagram and thus losing its previous relief may be observed to continue this revolving motion until it has taken a perspective position *the reverse of what it had before,* in which attitude its different points are at the same distance from the eye as the corresponding parts of the resultant. This effect is in conformity with the law formerly mentioned (2) that while look-looking intently on any one object we are inclined to refer all others seen at the same time to the same distance.

If for *b* and *c* we substitute three or more very slightly divergent lines as in fig. 48, the successive union of *a* with all of them is so rapid especially when the attention is directed to the angular point, as to cause them all to appear in relief seemingly at the same time. But a more steady gaze directed to the upper part of the fissure will show the dot of *a* flitting from one to the other, as the line *a* forms the successive resultants.

48.



An interesting modification of this experiment is seen in the combination of a vertical with two intersecting lines equally and oppositely inclined to the vertical as in fig. 49. In this case the resultant presents the appearance of two intersecting perspective lines. Here the effect is not produced by combining *a* with the whole of *b* and the whole of *c* alternately. The same axial convergence which unites the upper end of *a* with that of *c* suffices to unite the lower end of *a* with that of *b*, and as this is true for each pair of corresponding points in the upper half of *c* and the lower of *b*, it is plain that *the same gradation of axial movement* which combines the lower half of *b* with that of *a* will simultaneously combine the upper half of *c* with that of *a*. It is only necessary to continue the movement in the same direction, to combine the lower half of *c* and the upper of *b* with the corresponding parts of *a*. Thus the two perspective intersecting lines are produced by the combination successively and alternately of *a* with the two near halves and the two remote halves of *b* and *c*. At the moment when the two near halves are thrown into perspective by uniting with *a* the dots appear at their extremities, and when by a slight optical change the two remote halves are combined with *a* the dots are seen to dart across to the ends of these halves.

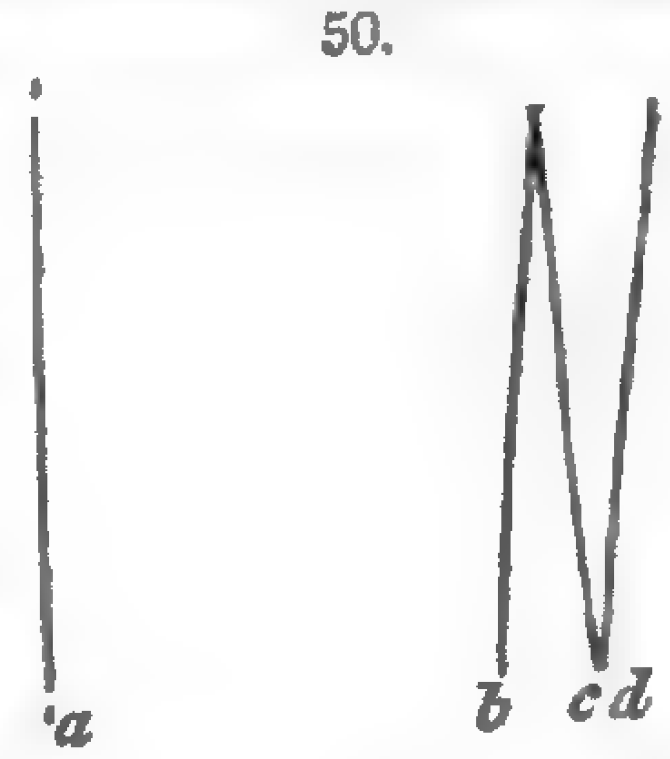
49.

In this experiment the coëxistence of the two perspective resultants is so nearly perfect that it is only by fixing the gaze most intently on one of the extremities that I can modify the perspective figure. In looking towards the intersection, it is impossible by any steadiness of view to change the relief of the two resultants. The small range of axial movement through which the eyes vibrate involuntarily even in our effort to keep them steady, is sufficient to develop both the resultants, so that they appear to be quite simultaneous.

As in this combination we do not first form one entire perspective line and then the other, but begin to form both at the same moment and complete the combination for both in the same insensibly short interval, it follows that the two intersecting resultants are produced by the same gradation of convergence and in the same time as would be required to combine *a* with *b* alone or with *c* alone. Hence *the effect is as perfect and as nearly instantaneous as when a single resultant is developed from two inclined lines.*

One of the most simple and striking illustrations of an alternating combination is furnished by fig. 50, in which the lines *b c d* are made to unite successively or alternately with *a*. The diagram being adjusted on the upper stage, so as to bring *a* opposite the left and *b c d* opposite the right eye, if we begin by uniting *a b* at the lower extremity, and then glance upwards, we find *a* to be wholly united with *b*, forming a perspective line rising from the plane of *c d*. Glancing at the upper angle we observe *c* also in perspective but in an opposite direction, and when we pass to the lower angle we have *d* as well as *c* in relief, while *b* tends to subside from its perspectiveness. The passage from one of these combinations to the other is so easy and rapid that it is quite difficult to maintain the figure in any one of these phases for more than one or two seconds; and as we carry the eyes generally over the lines we have a clear image of all three resultants united into a zigzag or N in a perspective position, in which the successive combinations seem to be almost simultaneous.

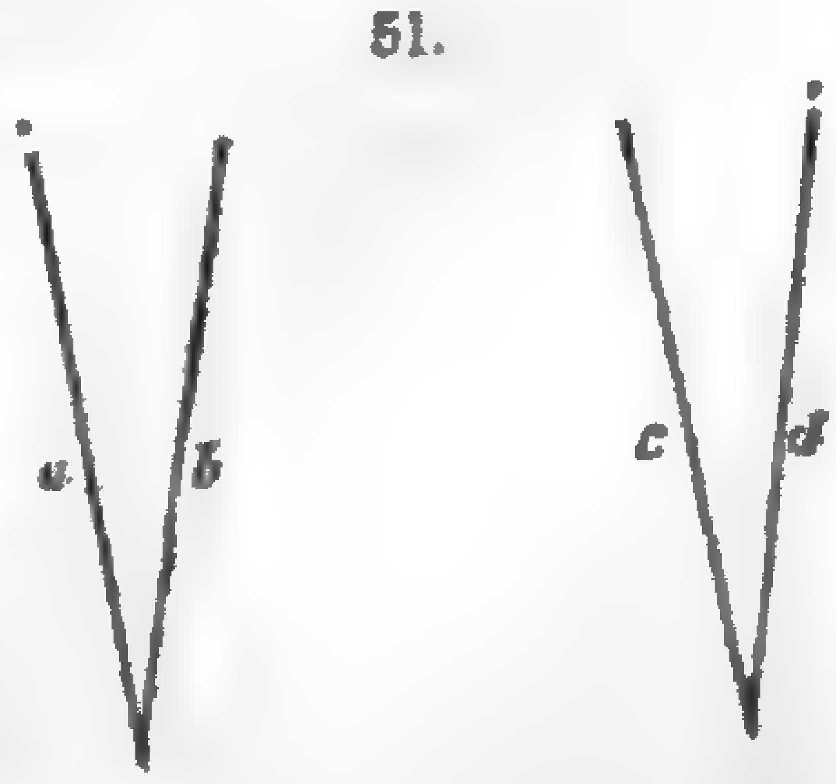
50.



23. *Alternations of more complex figures.*

Very curious alternations of combination are afforded by fig. 51, when placed on the stage of the stereoscope so that *a b* and *c d* may be opposite the left and right eye respectively. Beginning by effecting the union of *b* and *c* we have a figure consisting of the perspective resultant of these lines in a position *approaching as it ascends* and ter-

51.



minated below by the angular point formed by the junction of the lower ends of *a* and *d*, which lines now constitute a V parallel to the plane of the paper. The whole figure is that of the three edges of a solid angle pointing downwards, formed by *a*, *d*, and the resultant *b c*, the two former in a plane parallel to the paper, and the latter inclining towards us from the apex.

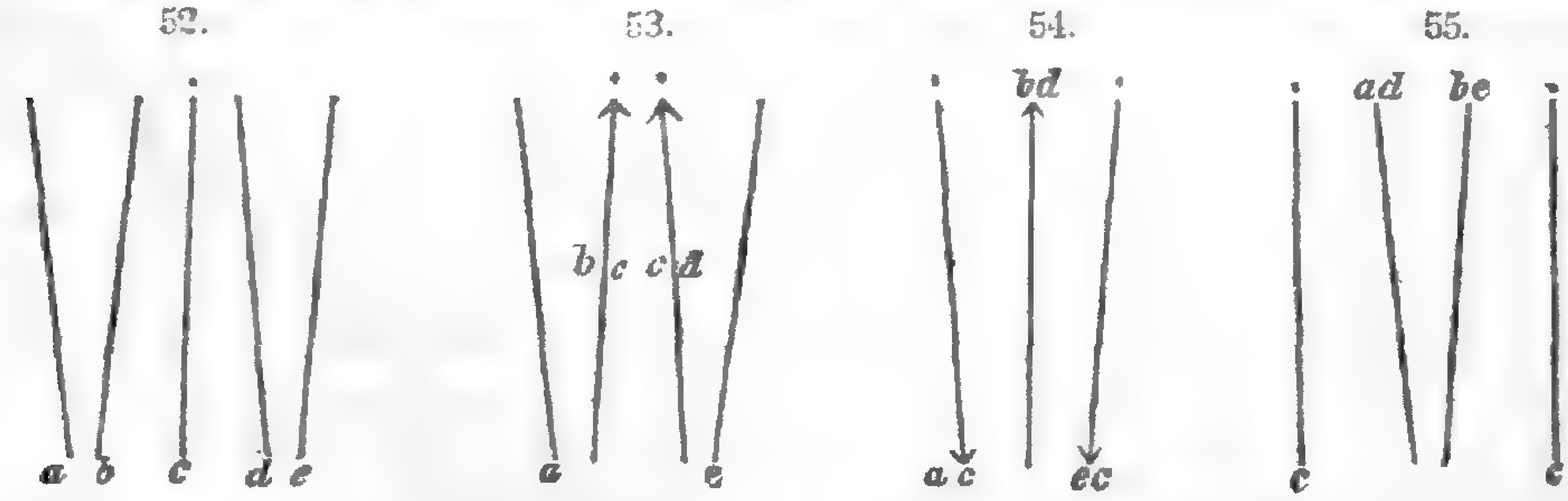
By a slight change of convergence we may next bring *a* and *c* to coincide, which is best effected by directing the attention to the two angular points of the figure. The same convergence will of course unite *b* and *d*, and the resultant figure will be a simple V lying in a plane parallel to the paper.

By converging the axes to a still remoter point we can next cause *a* and *d* to unite. In this case we obtain a figure composed of the perspective resultant of these two lines in a position *receding as it ascends*, and the lines *b c* united at their lower ends to form a V in a plane parallel to the paper. In other words we have a solid angle like that in the preceding case except that the perspective edge lies beyond the plane of *b c* instead of being on the near side of it.

When the lines of the diagram diverge at a very small angle these changes follow in quick alternation, but the V or second figure above mentioned is that which most frequently recurs and is most persistent, a result due no doubt to the circumstance that all parts of the V are formed by the same axial convergence and therefore at the same time.

When the diagram contains a vertical line we can readily adjust it on the upper stage of the stereoscope so as to make this line *visible at the same time to both eyes*, and thus have a double use of the line in alternating combinations with the rest. Adjusting fig. 52 in this way we obtain the following curious results:

52. 53. 54. 55.



By converging the eyes a little beyond the plane of the paper, we may unite *b* with *c*, and *d* with *c*, forming two perspective resultants each marked by the dot. These approach us as they extend upwards. At the same time *a* and *c* are brought nearer together and are seen to the left and right of the resultants severally. Indicating by the arrow heads the nearest extremities of the resultants, the entire effect of this combination is represented by fig. 53.

56.

If now we remove the point of convergence a little further, so as to combine *a* with *c* and *e* with *c*, we obtain from them two perspective resultants approaching us as they extend downwards, and since the same convergence serves to unite *b* with *d*, we have a third perspective resultant between the other two, dipping away from us. Under these conditions the result is that indicated by fig. 54.

By converging the axes to a point still more distant we may combine *a* with *d*, and *e* with *b*, and as these pairs are severally parallel, the resultants will be in a plane parallel to the paper. At the same time the line *c* as seen by the right eye will appear on the left side of the resultant of *a d*, and as seen by the left eye will be placed on the right side of the resultant of *b e*. The effect will be that represented in fig. 55.

Directing the eyes to a still more distant point we may next unite *a* with *e* so as to form a perspective resultant in the middle of the optical picture. At the same time *b* and *d* will exchange sides, and *c* being doubled will appear on the extreme right or left. These transpositions and combinations are indicated in fig. 56.

The four distinct combinations above described are observed to alternate with one another rapidly and in different ways without our being conscious of any effort in producing them, and hence the unpractised observer may find it difficult to retain either of them long enough for deliberate examination. A few trials, however, will enable him to do it with ease.

PART FOURTH.

Of the coincidence of unequal figures.

It was first observed by Prof. Wheatstone that "two squares or circles differing obviously but not extravagantly in size" may through binocular combination with or without the stereoscope be made "to coalesce and occasion a single resultant perception," and that "the binocular image is apparently intermediate in size between the monocular-ones." In remarking upon the insufficiency of the theory of successive vision to explain the effect, Prof. W. has not that I am aware of, advanced any other explanation. Sir D. Brewster admits the apparent coincidence, but ascribes it to the fact that "whenever two images interfere with one another so as to impede vision one of them disappears,—or rather is not taken cognisance of by the eye."

In considering the extensive class of effects of which the above experiments are only special instances, it is important to distinguish between the influence of inequality in the *horizontal* and in the *vertical* direction. The binocular adjustment in the two cases is entirely different, and it will hereafter be shown that a much greater disparity of measurement is compatible with apparent coalescence in the former case than in the latter. As this essential distinction has not been adverted to by preceding enquirers, it will be proper to consider the two effects separately before treating of the union of figures unequal in both directions.

FIRST.—*Of the union of figures having the same height but differing in horizontal measurement.*

Most of the illustrations given under the last two heads are properly referable to this class. Thus the apparently simultaneous union of pairs of verticals of which the intervals are unequal (fig. 17), and the combination of a vertical with two oblique lines meeting or intersecting each other, are but examples of the apparent coincidence of figures of equal vertical and unequal horizontal dimensions. In all these cases we have seen that although the combination is really successive and alternating, it is effected so rapidly and unconsciously as to make the impression of a figure developed simultaneously in all its parts.

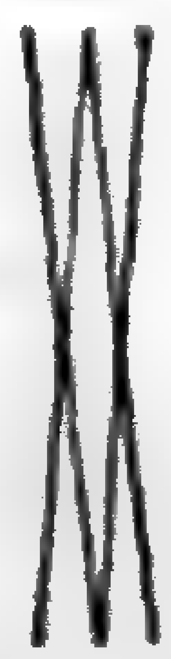
The union of pairs of points at unequal distances on a horizontal line or what amounts to the same thing, the combination of the unequal horizontal lines connecting such points, gives, as already shown (20), a perspective resultant in the horizontal plane; and this, when the difference of the length is not too great, is as truly a case of coincidence as the combination of two mutually inclined lines into a perspective resultant. In neither case is the union absolutely simultaneous throughout. When the eyes dwell upon either end of the resultant, the components separate at the other end, in the case of the inclined lines by a divergence of their remote extremities, in the case of unequal horizontal lines, by the sliding of one upon the other. As long however as the eyes are suffered to glance from end to end of either perspective line the union of the extremities is perfect and apparently coëxistent.

24. *Union of a right line with a system of right lines.*

Examples of this class of combinations have occurred under the preceding heads, but the following instances will serve to illustrate more strikingly the union of dissimilar and unequal figures.

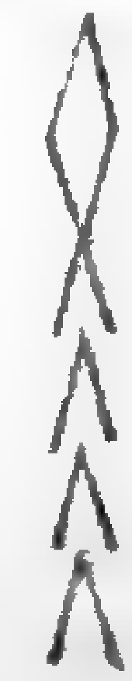
57.

58.



59.

60.



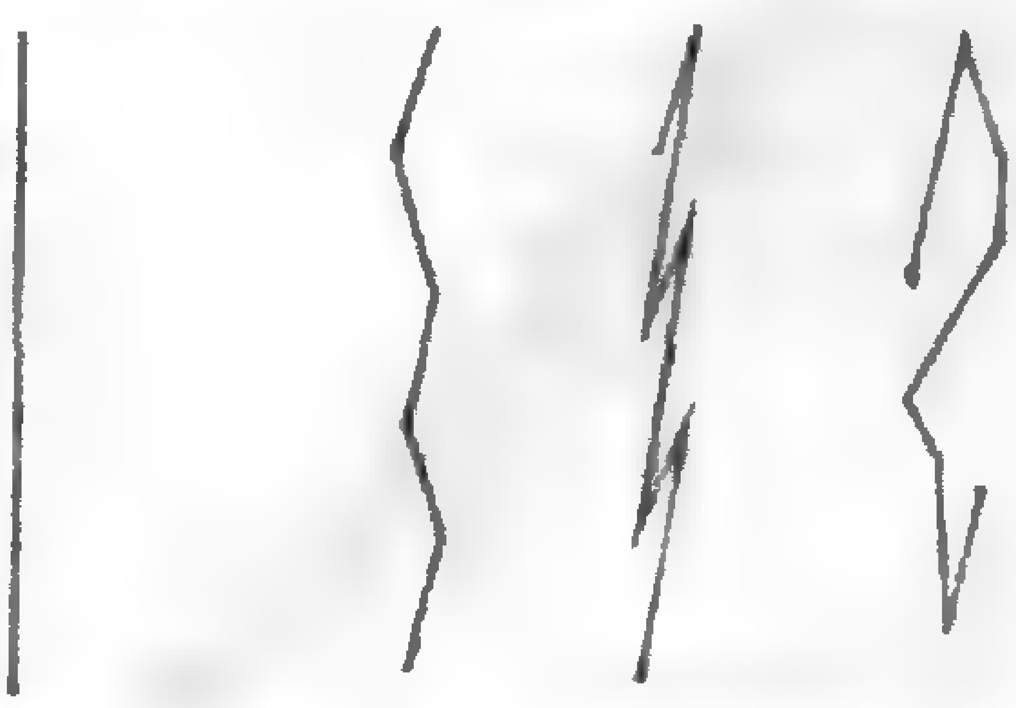
(1.) A vertical line with a rhombus (fig. 57). In this case the small converging movement measured by the breadth of the rhombus suffices to combine the vertical line successively with the two near and the two remote sides of the figure, and to develop as a resultant the form of a square in steep perspective. As the slight vibration which attends our ordinary efforts at fixing the eyes is quite sufficient for this, the apparent coincidence and the consequent relief are perfect, and nothing short of a continued and even painful direction of the view to one end of the horizontal diameter enables us even partially to separate the components.

(2.) A vertical, with two pairs of intersecting lines (fig. 58). This gives a resultant formed as in the preceding experiment of a steeply perspective square, but the sides of the square are prolonged in the same perspective plane. The union is complete and apparently simultaneous.

(3.) A vertical, with one or two sets of short parallel oblique lines (figs. 59, 60). With the former of these figures we have the beautiful effect of a row of parallel perspective lines or short pins stuck in the paper at a rather steep angle. As the axial movement necessary to unite any one of the short lines with the corresponding part of the vertical is the same for each of these lines, it is evident that all the perspective resultants are formed at the same time. The combination therefore is just as perfect as in the case of one of these oblique lines with the vertical; and hence the apparent coincidence of the right line with the series of oblique parallels is complete. Fig. 60 combined with the vertical presents a quadrilateral and three open angles all in the same perspective plane.

(4.) A vertical with zigzag or serrate lines (fig. 61), or with an irregular line. In each of these cases the resultant is formed as promptly and with as perfect clearness of relief as in any of the preceding combinations.

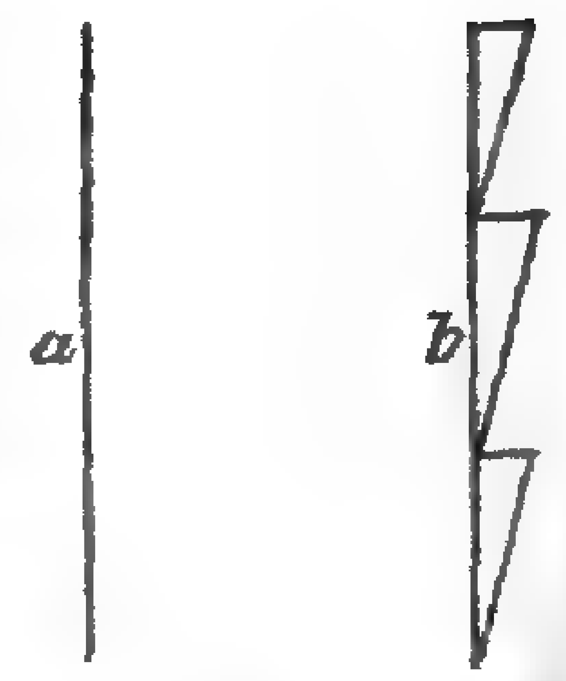
61.



In the above and a multitude of other forms which might be suggested the only conditions necessary for a satisfactory result are that none of the *leading* parts of the complex line or system of lines shall be so much inclined to the vertical as not readily to unite with the corresponding part of that line, and that the entire horizontal breadth of the figure shall be small enough to allow all its parts to be united with the vertical in an insensibly short time.

It will be remarked that in the preceding figures each linear element makes so small an angle with the vertical as to be capable of uniting with it. But as indicated above this is not essen-

62.



tial to the full perspective effect. In fig. 62 the horizontal lines of course cannot be so combined, and yet when the oblique ones are thrown into relief by their union severally with the opposite parts of *a* these horizontal lines are seen to form parts of the resulting perspective figure. As might be expected in this case the appearance of relief ceases when the eyes are directed to the vertical line *b*, which forms the base of the three perspective triangles, that is when we maintain fixedly the convergence uniting *a* with *b*. But as soon as the optic axes are allowed to vibrate towards the points of the triangles the relief is resumed.

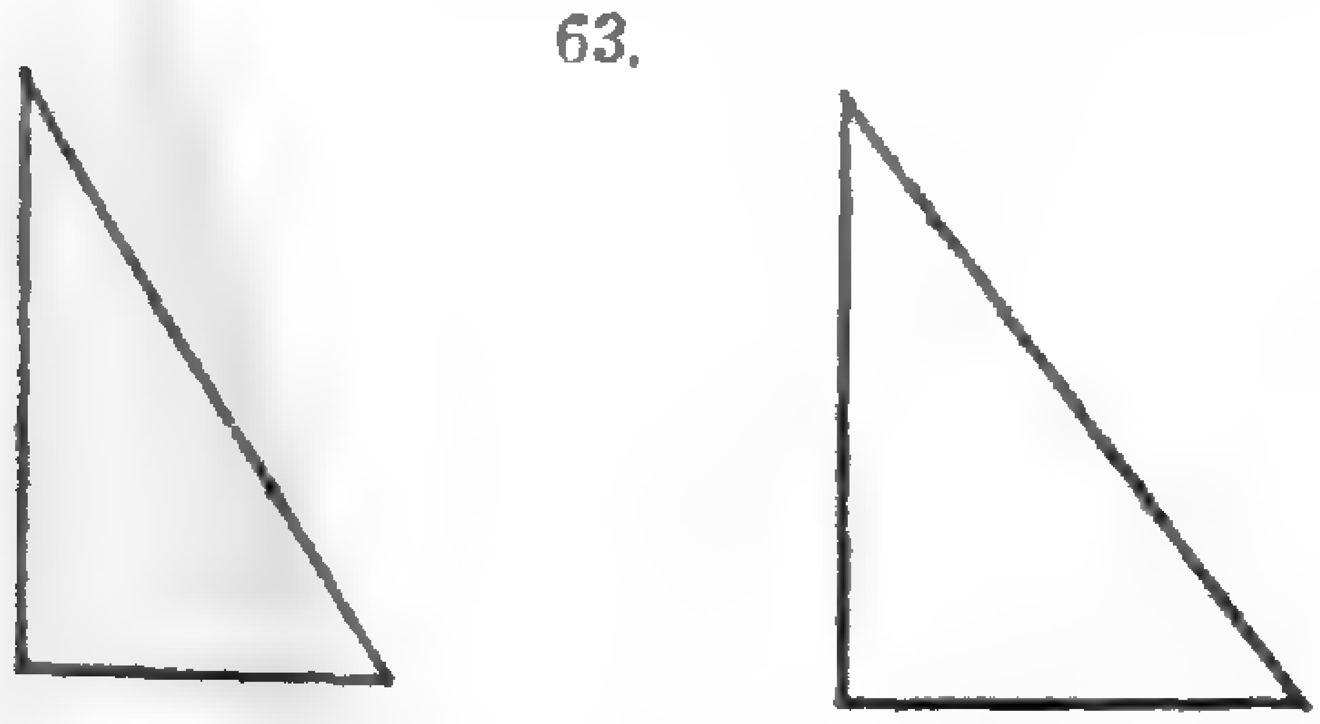
The particular case of combination just described is interesting from its resemblance to the experiment referred to by Sir D. Brewster (Phil. Mag., 1844, vol. 24, p. 442), and in regard to which he states a quite different result. Using a figure like the above, excepting that the three oblique lines are drawn at a much greater angle with the vertical, he remarks that the line *a* (A B in his figure) will not coalesce with the three oblique lines at once (marked C D in his figure); but each separate portion of A will, when the two other portions are concealed or removed, coalesce with the corresponding portion of C D. On repeating the experiment with the same figure I find that the binocular combination of all three of the oblique lines with the vertical is as readily effected as that of any one of them separately. On uniting one of them with the opposite segment of the vertical A, I always observe that the two others *at the same moment* assume a like perspective attitude. Owing to the great horizontal breadth of the figure in Brewster's experiment, the union in either case is imperfect, and unless the axes are kept in quick vibration from side to side, the relief disappears. But when, as in fig. 62, the oblique lines are less inclined to the vertical, and the breadth of the figure much reduced, the perspective resultant for the whole is at once obtained. It is proper to add that precisely the same effects present themselves, whether I employ Brewster's, Wheatstone's, or my own stereoscope, or effect the combination without any instrument.

In the simple experiments above described, where the right line is used as one of the objects, there is some thing surprising even to the practised observer, in the transformation wrought upon the complex figure as soon as the right line coincides with it. We see it approach until it touches the figure, then it instantly vanishes as a separate object, and at the same moment, as if by magic, the perspective resultant stands before us.

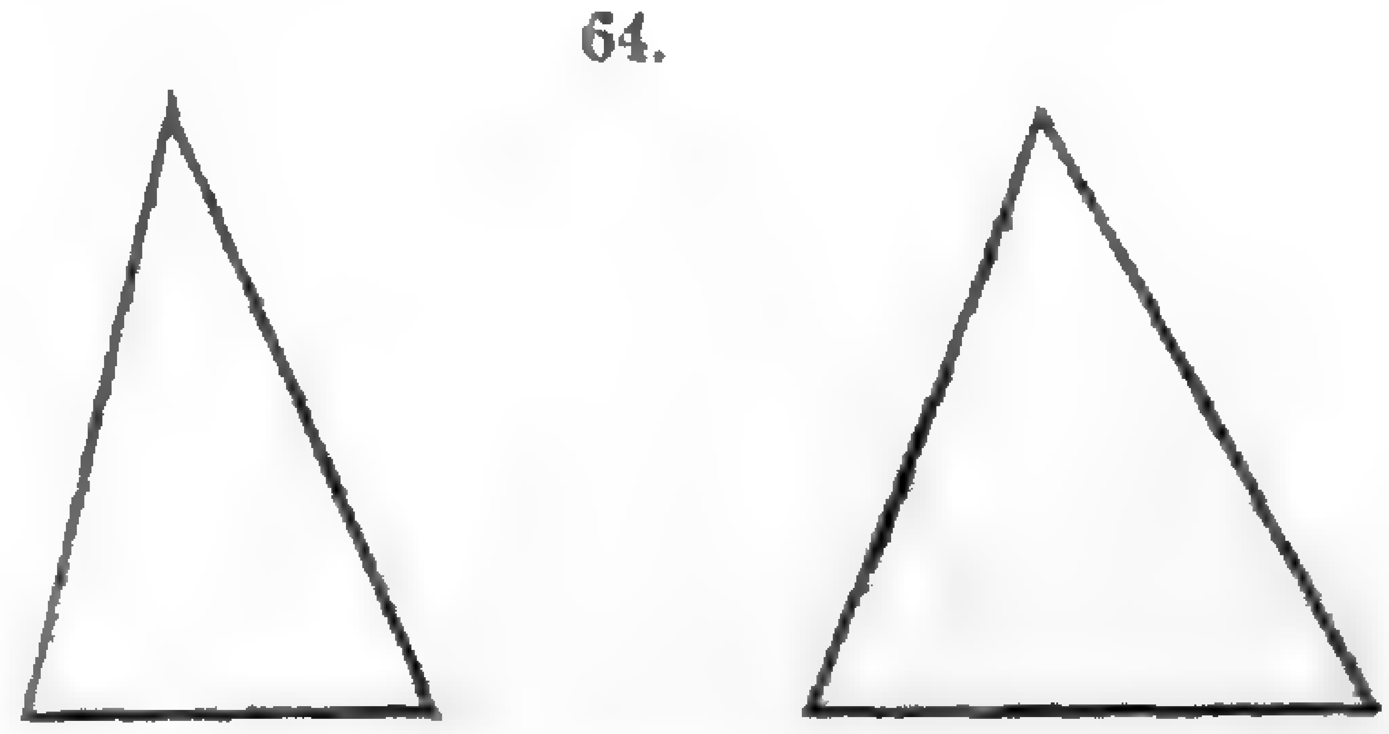
It is well to remember that all these beautiful effects can be readily obtained from the figures (57, &c., to 62) as they stand on the page, by first covering with a slip of white paper all the drawings but the vertical line and the figure to be combined with it, and then effecting the union of these two, by cross vision, in front of the paper.

25. *Union of plane figures of unequal horizontal dimensions.* We have already seen that *two rectangles* of the same height but of different breadth may be united into a single quadrilateral figure (20—fig. 44) having a perspective position and of which the near vertical side is shorter than the remote one. With *the triangles*, fig. 63 and fig. 64, the coincidence and the perspective effect are very beautifully exhibited.

63.



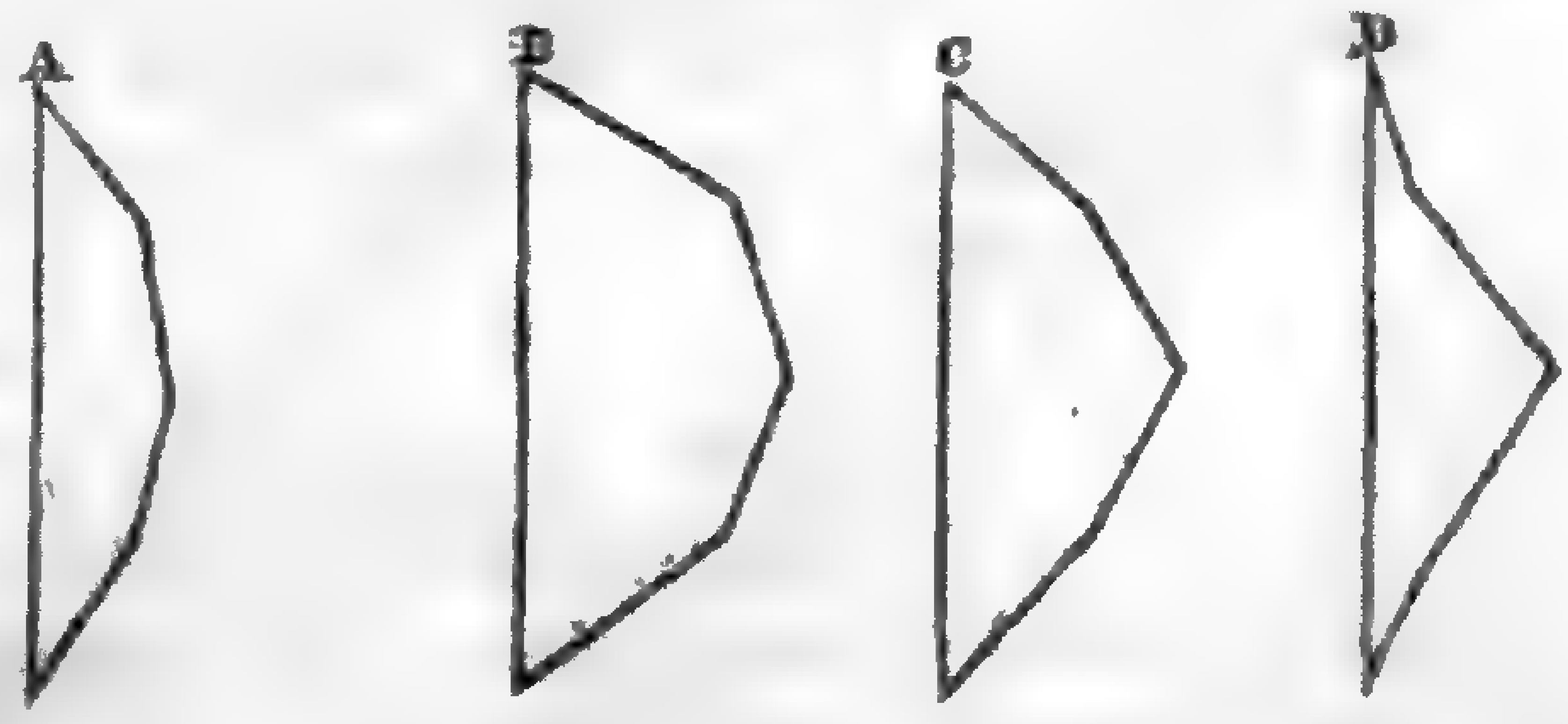
64.



In this case the resultant triangle turns the left extremity of its base towards the observer and averts the other, when the combination is effected by convergence beyond the plane of the paper; and it takes the reverse attitude of relief when the eyes are converged to a point nearer than the plane of the paper. In fig. 63 the horizontal inequality or difference of bases is $\frac{1}{8}$th of an inch, in fig. 64 it is $\frac{1}{4}$th inch; and as might be expected in the latter case, a very slight pause of the view at either angle of the base causes the components of the side opposite to separate as two lines diverging from the apex of the figure. A difference amounting to the fourth of an inch in horizontal breadth is about the limit of inequality which I have found in figures of this class to be compatible with a clear and satisfactory sense of the coalescence of the outlines.

In extending these experiments to the case of plane figures of many sides, it is to be observed that the corresponding sides or those which are to be binocularly combined ought to be of equal vertical height, that is, should lie between the same horizontal parallels. When this condition is complied with, as in fig. 65, A, B, C, D, the resultant is brought out in admirably clear relief, although the corresponding horizontal dimensions belonging to A, and the other figures, B, C, and D, intended to be united with it, differ largely from one another.

65.



Supposing in each case that the union is effected by converging the axes to a point beyond the diagram, we obtain the following results.

The combination of B with A gives us a perspective figure having the vertical line for its near edge and having all its sides situated in one and the same plane, which slopes away from us towards the right.

Uniting C with A we have a resultant consisting of parts lying in two differently inclined planes both of them receding towards the right; that formed by the sides about the middle angle sloping away from us more steeply than the part adjoining the vertical side.

When we combine D with A we have a resultant figure which like the preceding is inflected into two planes, but in this case the part next the vertical slopes *towards* us from that line, and the remaining part as before recedes towards the right.

It thus appears that right line figures having the same vertical dimensions for all their corresponding parts, but differing in their horizontal breadth, afford by their binocular union two classes of resultant figures—those of which all the parts are situated in one plane and those in which they lie in two or more differently inclined planes.

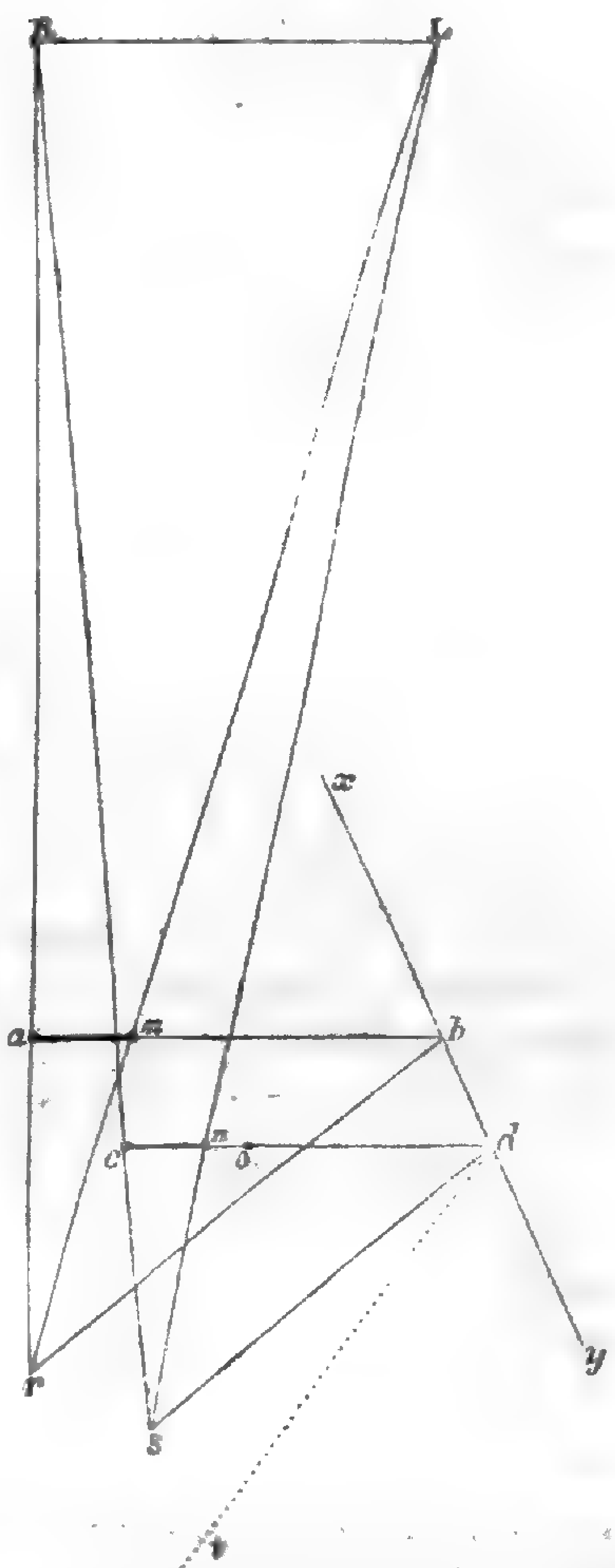
26. *Conditions according to which the resultant will lie in one or in several planes.*

The geometrical conditions determining the character of the resultant figure in this respect are simply the following. *When the figures which are to be combined are of such form that their corresponding horizontal dimensions bear a constant ratio to one another, for all points of the height, their binocular resultant will lie wholly in one perspective plane,—when the ratio varies, the resultant will lie in an inflected surface composed of two or more mutually inclined planes, each change of ratio being accompanied by a change of direction of the surface.*

As this proposition is important from its generality, and will in the sequel be applied to curvilinear figures, the following short proof of it may be acceptable to the reader.

Let $a\,b$ and $c\,d$ (fig. 66) denote the horizontal breadths of the larger figure at the points b and d, and $m\,b$, $n\,d$ those of the narrower one at the same points respectively. Also let R and L be the centres of the two eyes, and suppose $x\,y$ to be the line in which, by a suitable axial convergence, the equal vertical heights of the figures are made to coalesce. As long as this particular degree of convergence is maintained unaltered, it is obvious that m and n will not coincide optically with a and c, but must continue to be seen at the intervals $a\,m$ and $c\,n$ as in the diagram. By a farther axial movement, however, a and m are made to coincide at r, and again c and n at s. We are now to determine the positions of r, s and the other resultant points similarly formed. To to this end we have

66.



$$am : RL = ar : Ra + ar,$$

whence $RL - am : am = Ra : ar$, and therefore

$$ar = \frac{Ra \cdot am}{RL - am}.$$ By a like process also, we have $$cs = \frac{Rc \cdot cn}{RL - cn}.$$

Since in these experiments, am and cn are very small compared with RL, they may without material error be expunged from the above values of ar and cs; and since the distance ac must always be inconsiderable compared with Ra or Rc these two lines may be assumed as sensibly equal and parallel, and as a consequence of the latter the angles bar and dcs may be taken as equal. With these qualifications, the former values when compared with one another give us the proportion, $ar : cs = am : cn$.

If now the two figures binocularly combined be of such construction that the corresponding breadths are in a constant ratio, we will have

$$ab : cd = mb : nd,$$

whence $am : cn = ab : cd$.

This compared with the former proportion gives

$$ar : cs = ab : cd.$$

But we have seen that the angles at a and c are practically equal, therefore the line ds is parallel to br, and as its end d lies in the plane of xyr, the whole line must lie in that plane. Consequently the resultant point s is situated in the plane of xyr. In the same way it may be proved that any other resultant points similarly formed must be situated in the plane of xyr. Hence the whole resultant figure must lie in that plane.

It is scarcely necessary to add that from the approximate nature of the above reasoning, we are not to consider the resultant as *coinciding absolutely* at all points with the given plane but as being so nearly coincident with it as to make any deviation entirely imperceptible.

On comparing the diagrams A and B, fig. 65, it will be remarked that their breadth at corresponding heights are every where in the ratio of one to two. The above conclusion therefore applies to them, viz., that their binocular resultant must lie wholly in one plane, and this effect as already seen, accords with observation.

Let us now suppose the two figures to be such that their corresponding breadths are *not* in a constant ratio to one another.

Let us imagine, for example, that while the point m, fig. 66, retains its present position in $a\ b$ dividing that line in the proportion of 1 to 4, the point n, from being similarly situated in $c\ d$, is transferred to o, so as to divide $c\ d$ in the ratio of 1 to 3. It is obvious that the resultant of c and o will be in some position t, below s, and not in the plane of $x\ y\ r$, and further that all other pairs of points of the two figures whose relative distances from $x\ y$ are the same as those of c and o will, (by the previous demonstration) form their resultants in the plane of $x\ y\ o$. It thus appears that every change in the ratio of the breadths of the figures at corresponding heights is accompanied by an inflexion of the resultant into a new plane.

Applying this to the combination of C with A (fig. 65), we observe that while the breadth of C at the middle angle is nearly twice that of A at the same level, its breadth at the angle above or below is about one and a fourth that of the corresponding part of A. The former ratio determines the direction of the plane containing the second and third sides of the resultant figure counting from the top, and the latter that of the plane containing the first and fourth sides together with the vertical; and as the former is a ratio of greater inequality than the latter, it is evident that the plane of the second and third sides will have a steeper inclination than the other. This corresponds with what was stated in describing the appearance of the resultant figure. By similar reasoning we might deduce the form of the resultant produced by the union of D with A, but enough has been said to illustrate the conditions which determine the position generally of the resultant of right-line figures of unequal horizontal dimensions.

27. *Of the union of a straight line with a curve.*

Among the simpler cases of combination there is none which exemplifies more curiously the effect of binocular union than the coalescence of a right line with a curve. Thus when a and b, fig. 67, are brought together by converging the eyes to points behind or in front of the paper, we are at once presented with a curve standing out with great clearness and in strong relief, and turning its apex in the one case towards us and in the other from us, but in both positions directed a little to the left side. The great steepness of the flanks of this perspective arch is an obvious result of the considerable angle which the terminal parts of b make with the corresponding parts of a.

67.

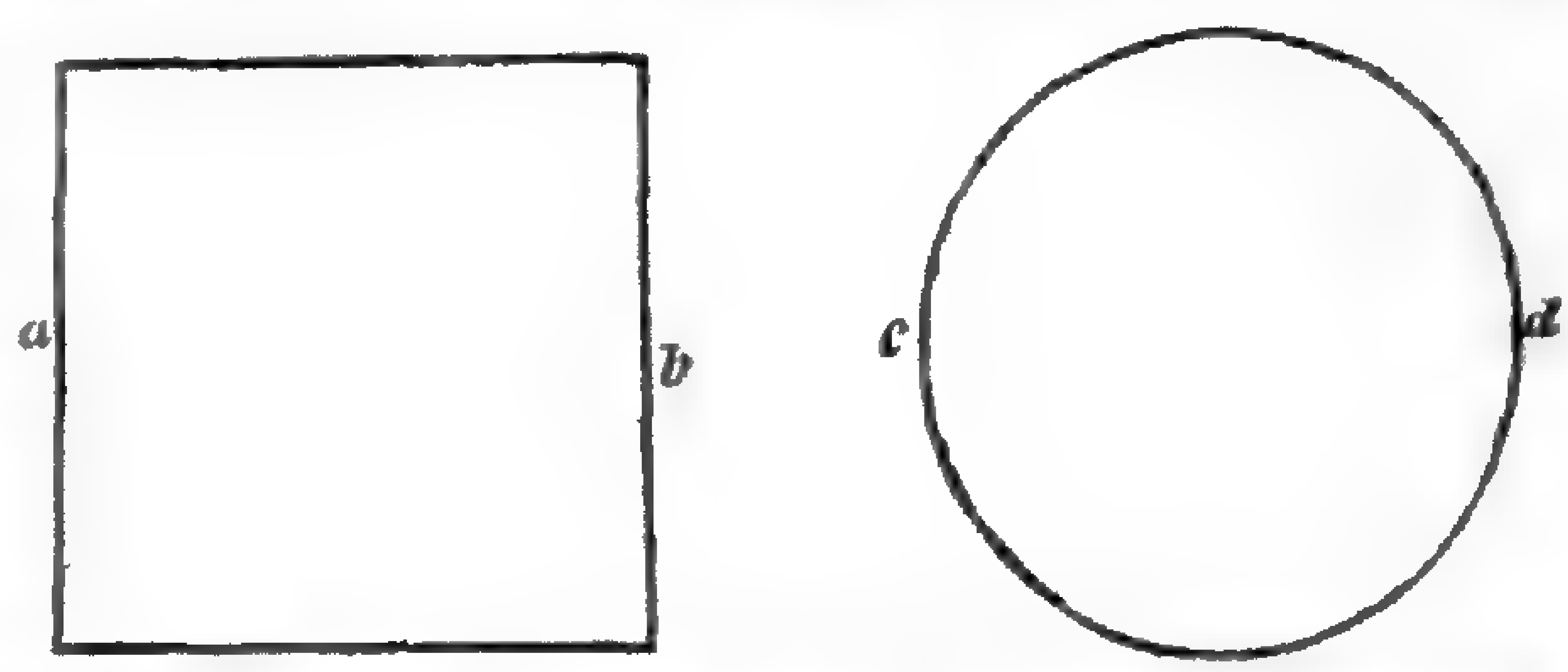
In this experiment the union beginning at the middle of a and b extends simultaneously along the upper and lower halves including in this interval a total converging movement measured by the distance between the middle of b and its chord.

Drawing chords from middle to the ends of *b* and combining the figure, thus modified, with *a*, we obtain, along with the perspective curve before seen, two perspective chords extending from its apex to the upper and lower ends. All these lines are developed with perfect distinctness and so rapidly as to appear quite simultaneous. By fixing the attention however on the apex of the perspective curve we see the right line separating from it at the ends, and by great steadiness of convergence we may even succeed in bringing the vertical into the position of a tangent at the apex, in which case the figure loses its relief

It will be found in the sequel that *the perspective curve formed by the union of a right line with the arc of a circle is in all cases a conic section,* the special nature of which is dependant on the conditions of the experiment.

When the curvature of *b* is much greater than in the figure its apparent coincidence with *a* is always imperfect towards the extremities, although clear and satisfactory throughout the intermediate space. An extreme case of this kind is presented in the attempt at uniting the square and circle of fig. 68. When in this experiment the parts *a* and *c* are brought together by converging the axes beyond the paper, we have a steep perspective curve with its apex towards us; when *b* and *d* are brought together we have a similar curve with its apex averted. But in both cases the coincidence entirely fails towards the upper and lower parts of the figure. By passing rapidly from the one to the other combination, we have momentary glimpses of a *warped surface* which combining the two flexures appears convex on the left and concave on the right side.

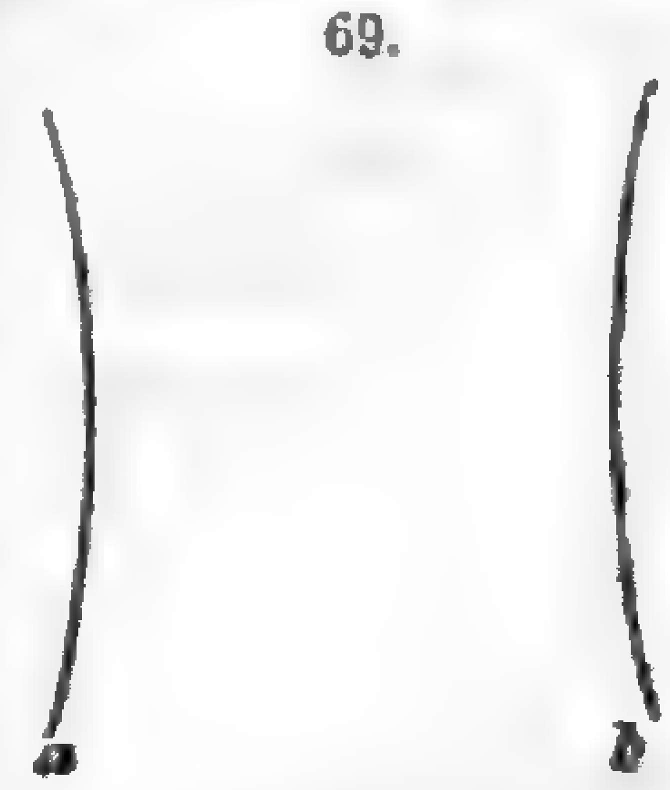
68.



28. *Of the union of one curve line with another.*

The simplest combination of this kind is that of two equal and similar circular arcs whose convexities are turned in opposite directions. (Fig. 69.) These are readily united either with or without the stereoscope, and form a resultant curve which lies *in a plane perpendicular to that of the diagram.* Of course when the union is effected beyond the figure the resultant curve turns its apex towards the observer, when it is produced on the near side it turns its apex in the opposite direction. In either case, the depth of the perspective is evidently dependant on the sum of the convexities of the two arcs. As will be shewn hereafter the form of the resultant is a conic section.

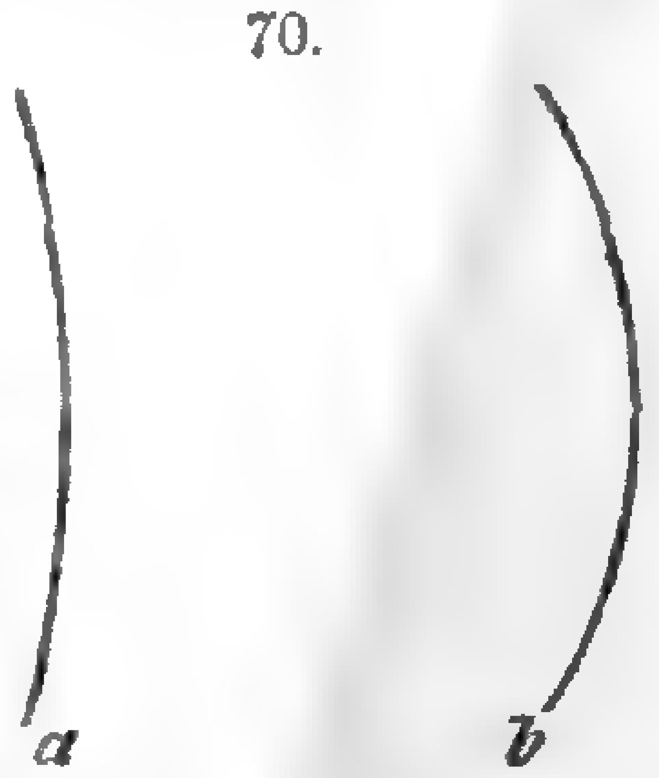
69.



If the arcs be of *unequal convexity* the resultant curve will no longer have the perpendicular altitude, but will incline a little to the one or other side according to circumstances. Thus if *b* be more convex than *a* the resultant curve will turn its apex towards the left, and if *a* be more convex than *b* it will turn it towards the right.

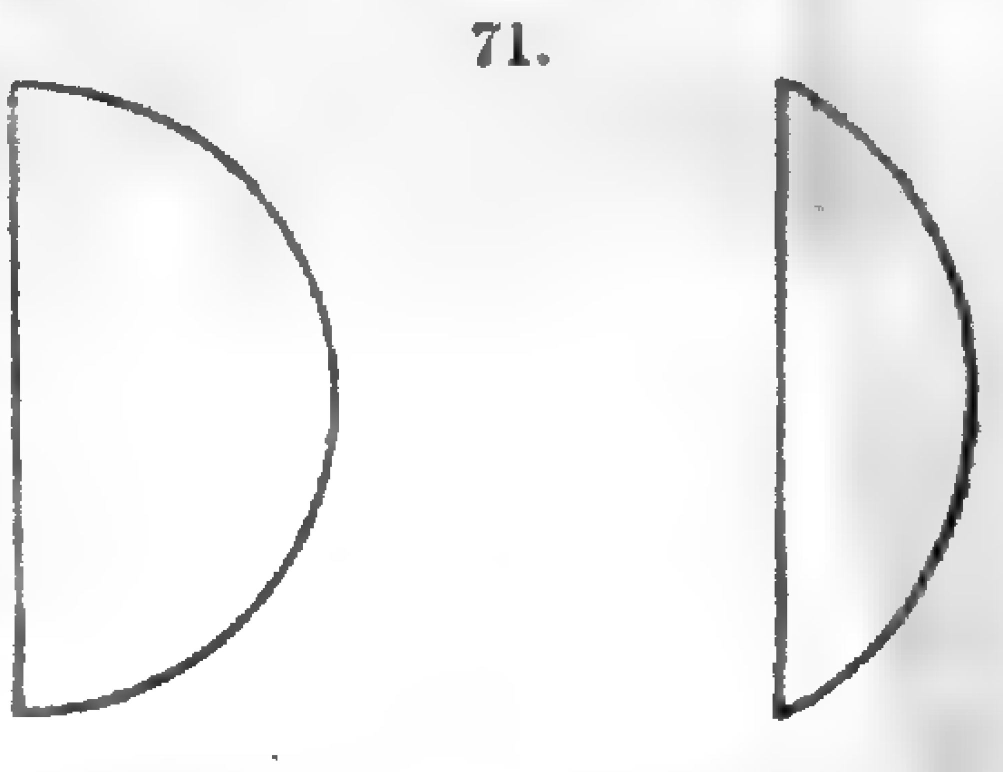
When the curvatures of *a* and *b* are turned the same way the depth of the relief will obviously be proportional to the difference of the convexities of the two arcs. With equal curvatures they will form a resultant arc similar to either component and having no relief. When they have unequal convexity as in fig. 70, the resultant is a perspective curve in an oblique position. If, as in the figure, *b* should have the greater curvature of the two, the apex of the resultant curve will incline towards the right; if that of *a* should be the greater the apex will turn towards the left.

70.



With arcs of no greater curvature than those of the last figure, all the points of the resultant curve appear to lie in one and the same plane. In strictness, however, they are not thus situated, *but lie in a curved surface.* To prove this we have only to use arcs of much greater incurvation as in fig. 71. Here when we form the resultant in front of the diagram we find it to consist of a curved surface bounded by the resultant curve, and a vertical straight line due to the union of the two chords. Beginning at the near edge formed by this vertical line, the surface *recedes* with a *concave* sweep, at first rapidly, and then more gently towards the apex or farthest point. When the combination is made beyond the plane of the paper, the curved surface traced from the vertical edge, *approaches* the observer in a *convex* sweep, rapidly at first, but more slowly towards the apex.

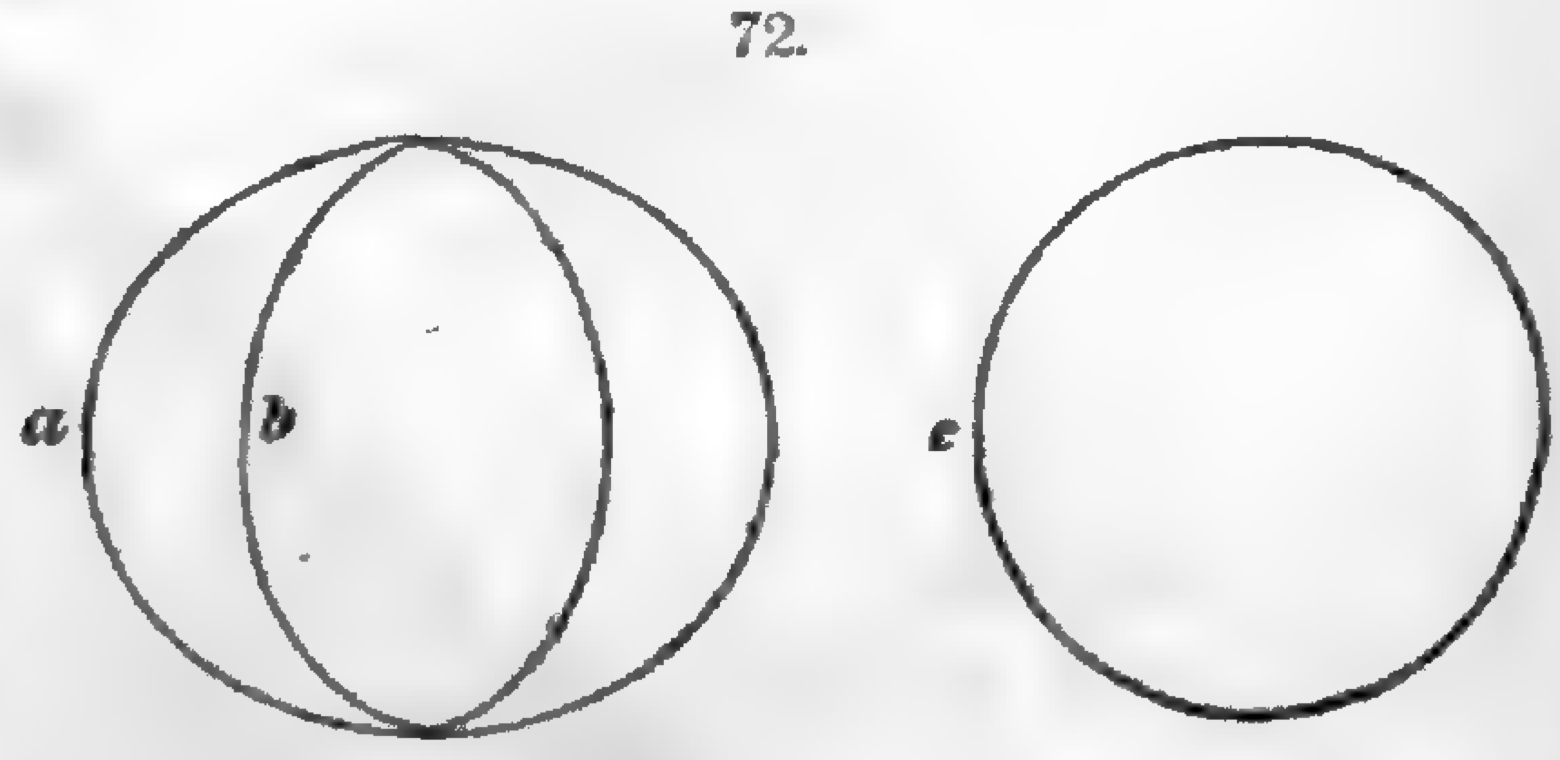
71.



When the curves which are united are a *circle and an ellipse* whose vertical axis is equal to the diameter of the circle, or when they are *two ellipses* of equal vertical diameters, the resultant curve lies wholly *in one plane.*

On combining the ellipse *a* with the circle of *c* fig. 72, we have for the resultant an ellipse in a perspective plane, which recedes towards the right when the combination is formed in front of the paper, and towards the left when formed behind. Substituting the ellipse *b* for *a* in this experiment, we obtain as before a resultant ellipse in

72.



a perspective plane, but in this case under the same conditions of combination with the preceding, it is inclined the opposite way. A like effect is produced by removing the circle and putting *b* in its place, and then combining *b* and *a*. In all three resultants the longer axis of the ellipse is horizontal. Its length is greatest in the ellipse formed by the binocular union of *a* with *b*.

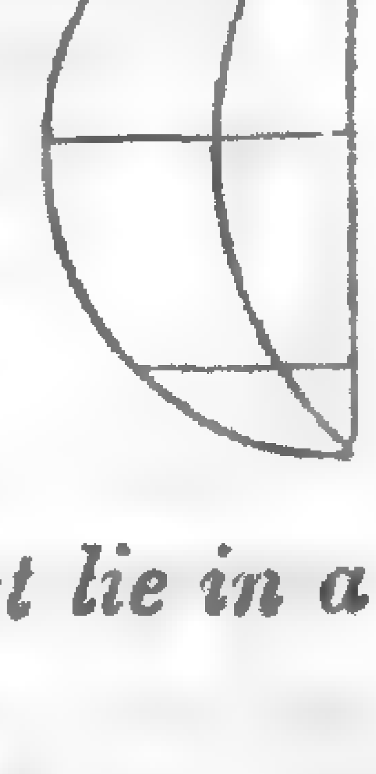
If now *both ellipses*, placed as in the figure, be used at the same time to combine with the circle, we obtain by rapid alternation of combinations a resultant consisting of two perspective ellipses intersecting in their shorter or vertical diameter. It is to be remarked that in this experiment it sometimes happens that we cannot pass from one combination to the other rapidly enough to obtain the effect of an apparently simultaneous view of the whole of the two resultant ellipses. In this case the two near halves or the two remote halves of the intersecting ellipses, or either ellipse entire, is all that we distinctly see, but it is only necessary to pass quickly from one to the other to perceive the whole of the curves together.

We have thus seen that the resultant formed by the union of two elliptic arcs or of an elliptic and circular one, under the given conditions, lies wholly in one plane, while that formed from arcs of unequal circles lies in a curved surface. This remarkable difference of effect is readily explained when we compare the geometrical conditions demonstrated under a previous head (26) with the properties of these associated curves.

In the case of the *ellipse* and *circle* or the *two ellipses*, (figure 72,) placed in the position described in a preceding paragraph the horizontal breadths of the component figures, at equal heights, must, according to a well-known property of the ellipse, have every where the same proportion as the horizontal diameters of the two curves. These figures therefore belong to the class whose corresponding horizontal dimensions have a constant ratio, and hence *they form their resultant wholly in one plane.*

When the associated curves however, are *circular ones* of unequal curvature, as in fig. 71, the corresponding horizontal dimensions cease to have a constant proportion. Bringing them together as in fig. 73, we perceive that the *relative inequality* of breadths of the two segments is greatest at the bottom and top and least at the middle height of the figure, and that it continually diminishes according to a certain law from the extremities towards the middle. As we have seen (26,) that for each change of ratio the resultant must be inflected into a new plane, it follows that in this case an inflexion must occur at each successive point, in other words, that *the resultant must lie in a curved or warped surface.*

73.



(*To be continued.*)

Art. XI.—*On a new Fossil Fish, and new Fossil Footmarks;* by Prof. Edward Hitchcock, of Amherst College.

1. *History of the Discovery and general character of the Jaw of a new Family of fossil fishes.*

This specimen was presented to the American Association for the Advancement of Science, at its meeting in Providence in August, 1855. I received it from Rev. John Hawks, of Montezuma, in Park County, Indiana; to whom it was presented for me, by Dr. S. B. Bushnell of the same place. Mr. Hawks says, "it was found in Park County, Indiana, near the Wabash river, in a layer of slate, about one foot beneath the surface of the ground. Immediately beneath the layer of slate, which was about one foot in thickness, was a *coal bank.*"

Having stated to the Association that this beautiful specimen was evidently the jaw of a shark, but of most peculiar structure, I had not the presumption to throw out my crude suggestions concerning it, when a gentleman present to whom the intricacies of fossil ichthyology were as familiar as household words. I therefore requested Professor Agassiz to give his views of the specimen.

That gentleman expressed his conviction that the specimen was the jaw of a new and extraordinary family of sharks, allied to the sword fish, or Pristis. He stated that the sword of the Pristis was originally composed of more than one bone, which became united. If those bones were to be permanently separated and armed with teeth only on one side, they would resemble the fossil specimen, except that the latter is curved. Such an arrangement he supposed to have existed in the fish from which this jaw was taken: that is, it had two swords, armed on the outer side with sharp serrated teeth. The supposition seemed so reasonable that it was received by the Association with applause.

Prof. Agassiz said that such an animal would not only form a new genus of fossil fishes, but a new family. And he regarded the discovery of as great importance almost, in fossil ichthyology, as was that of the Ichthyosaurus and Plesiosaurus in fossil Herpetology. The specimen will be committed to him for description. But it seemed desirable, on several accounts, to give this brief history of its discovery, and a popular description of its characters. The whole of it is a good deal mineralized, being converted mostly into black limestone; and from its weight, I suspect the presence of iron in some form.

2. *Description of a new and remarkable species of Fossil Footmark, from the Sandstone of Turner's Falls, in the Connecticut Valley.*

Not long since, my attention was called by Roswell Field, Esq. to an extraordinary footmark in a quarry upon his farm near Turner's Falls in Gill. I advised him to get out if possible a slab containing a series of the tracks, which he did with much judgment and skill, and subsequently I purchased the specimen for the Ichnological Cabinet of Amherst College, where it is now deposited.

I have regarded the Otozoum Moodii as the most remarkable animal, so far as we can judge from footmarks, that ever trod the valley of the Connecticut. But the animal that made this new track must have been quite as remarkable and as unlike existing forms. I have called it *Gigandipus caudatus*, (γιγας and διπους,) *the tailed giant biped.* The following is a systematic description of the genus and species, according to the plan which I adopted in my paper on *Footmarks and the Animals that made them,* in the *Transactions of the American Academy of Arts and Sciences.*

Gigandipus.

Bipedal: tailed: tetradactylous: the three toes pointing forward broad and long; the fourth curved, narrow and short, proceeding inward almost laterally from the back part of the heel.

Gigandipus caudatus.

Divarication of the middle and inner toes, 20° to 23°. Of the outer and middle toes, the same; of the lateral toes, do.; of the outer toes 40°. Length of the middle toe, 12 inches; of the outer toe, 8 inches; of the inner toe, the same; of the hind toe, 4 inches. Width of the middle toe, 2½ to 3 inches; of the inner toe 2½ to 3 inches; of the outer toe, 2 to 3½ inches; of the hind toe ⅞ of an inch. Length of the foot, 16 inches; of the step 3 feet 3 inches to 3 feet 4 inches; from tip to tip of the lateral toes, 10 inches; between the tips of each lateral toe and the middle toe, 7½ inches. The three forward toes, thick, rounded, blunt, without claws, and slightly curved outwards. The hind toe considerably curved backward, somewhat acuminate, making an impression along its whole length, and nearly as deep as the large toes. Heel rounded and broad; but as there are no phalangeal impressions from the toes, the line of junction between them and the heel cannot be traced. Axis of the foot coincident with the line of direction. Tracks generally in a right line. Right and left foot distinguishable by the position of the hind toe, which is alternately on the right and left side of the track. Trace of a tail very manifest; passing across the middle of the tracks, except when the animal changed its course. Width of the trace from a quarter to half an inch, with a somewhat feathery appearance on each side, such as is exhibited by the slight ripples, when a body is drawn rapidly through water.

The accompanying sketch represents the only specimen of the track of this animal yet found, one-twenty-third part of the natural size. Several small tracks of a biped, (the Ornithopus gallinaceus?) are also shown—one row of seven and another of four. A few scattering quadrupedal tracks, not very distinct, exist on the slab but are not shown in the drawing.

On first looking at this slab, a person would suppose the tracks were those of Brontozoum giganteum. But he would soon discover the fourth toe, which I have never seen upon the more than a hundred tracks of the Brontozoum giganteum which have fallen under my notice, and which were deeper than those of the Gigandipus, and must therefore have shown a toe had it existed. Then the outer and inner toes of the Gigandipus are of almost exactly equal length, but never so in the Brontozoum. No claw or phalangeal impressions are seen upon the track of the Gigandipus, although the rock is extremely favorable for showing such characters, had they existed in the foot.

But the unmistakable evidence of a tail is the most remarkable thing about this animal. It cannot be doubted, I think, by any one who will look at the slab, and it leads one at once to look sharply for marks of its quadrupedal character. But no trace of more than two feet is to be found, although the existence of so many small tracks on the slab shows that the rock is a fine one for retaining the marks of the fore feet if they had existed. The only supposition making its quadrupedal character at all plausible, is, that the fore feet might have made an impression not quite so deep as the hind ones, and the layer containing them, may have been scaled off without our noticing their existence. I saw the tracks before they were fully uncovered, and observed no signs of fore feet; and Mr. Field has had great experience in such matters, so that had they existed, I think he must have seen them.

Upon the whole, the evidence is very strong that this animal was an enormous biped with a very long tail! I say a *long* tail; for when the tracks of a biped follow one another almost in a straight line, the animal must have had long legs. Three of these tracks are almost exactly in a line. At the fourth step it trod a little to the right, which swayed the body and consequently the tail, somewhat in that direction.

The inquiry naturally arises, whether these facts do not weaken very much the proof that any of the tracks in the sandstone of the Connecticut valley were made by birds. For here we have a biped with feet that might easily be mistaken for those of birds, and yet we know, from the existence of a tail, that it could not have been a bird. The Otozoum, however, had already presented us with an example of a biped which could not have been a bird, as is proved from the number of its toes and phalangeal impressions, and the remarkable web on its foot. The only difference in the case of the Gigandipus, is, that its track has more the aspect of a bird's. But the grand argument for the ornithic origin of some of the tracks, I mean the number of phalangeal impressions, still remains untouched. Should this fail, I freely confess that but little ground would remain for such an opinion to rest upon. I confess too, that the evidence is increasing for the supposition, already repeatedly hinted at by me in former descriptions of footmarks, that many of these extinct animals may have belonged to a type of animal existence intermediate between that of birds and the lower classes of vertebrates. But I have no time to follow out this thought.

But whatever opinion we may form as to the place in a scientific arrangement occupied by these animals, all must be struck with their extraordinary size and peculiarities. It is amazing how different were the former from the present occupants of this peaceful valley. I venture to say, that the Otozoum and Gigandipus were as wonderful creatures as ever walked the earth or swam in the water. No species have been dug from the rocks of the eastern world more gigantic and anomalous than these.

Art. XII.—*On Kilauea;* by Rev. Titus Coan, (from a letter to J. D. Dana, dated Hilo, Hawaii, July 18, 1855.)

You are aware that no eruption has occurred at Kilauea since 1840, except such as have been confined within its own mural walls; that the whole central area of the crater floor has been elevated some 600 feet, forming a broad and high table land, terminating on the east side in a long and lofty ridge of debris, so abrupt and toppling as to defy the ascent of man; but at many points on the other sides accessible by an inclined plane. The distance from this great central platform to the outer or main walls of the crater may average half a mile, and this surrounding zone or belt, is where the old "black ledge" used to be; but it is now lower by 200 feet, than some points in the central platform. At the southern verge of this elevated region, separated, by a broken and abrupt depression, stands the great dome over the fiery abyss, called "*Halemaumau.*" The elevation of this dome is equal to that of the great table rock just described; and on its summit opens a valve 200 feet in diameter down which you look, as into Tartarus, and see, and hear and feel the tossings and the ragings of the burning gulf. On the western side of this immense dome a fissure has been opened, and near its base a cragged, smoking cone has been elevated which breathes out "smoke, and fire, and brimstone." You are aware that for many years past, up to 1855, the crater has been unusually dull; so much so, that many believed this great forge would never go into blast again. But this was a mistake. For months past this awful furnace has been brightening, and glowing, and raging, and roaring with fearful intensity. The action, however, is all confined to the great dome and the girdle between the central table and the outer walls; while the elevated interior is unaffected, and even begins to produce plants and Ohelo berries. But it is surrounded by the burning streams of Phlegethon, and stands as a burnt island in a sea of fire. The great dome is thundering and throwing up columns of dashing fusion from its horrid throat to a height of 200 feet, while its walls tremble at the fury of those waves which rage and dash within. Occasionally a burning river bursts through the rent chasm near its base and rolls its glaring waves over all that region, flooding the heavens with light, and filling the spectator with mingled emotions of delight, of awe, and of terror. But this is not half. The whole of the surrounding belt, from its periphery at the base of the great walls of Kilauea, to the elevated central platform—and over eight miles in circumference by half a mile in diameter, is in a state of intense activity. Over this surface I could count sixty lakes of fusion whose flaming fires were sparkling, and surging, and dashing, and leaping in the most fantastic and brilliant manner, exceeding all that pen or pencil can paint. The whole of this surface is not, of course, broken and fused at once; but it is every where rent with fissures, studded with burning cones, and dotted with boiling lakes and pools of igneous fusion; and even the solid portions of the surface are so hot as almost to crisp the scle of one's shoes, while the smoke and the pungent gases render it difficult to travel in some parts and impossible in others. At the terminus of the winding trail by which you descend into the crater, a great lake of fire has been opened, so that a party which visited Kilauea some three months ago, returned without effecting an entrance into the crater.

During the last week in May and the first in June, visitors and passing travelers reported a fiery girdle around the whole circumference of Kilauea, along the base of her lofty walls—and, so intense was the heat, so suffocating the gases, so fearful the hissings, so awful the surgings, and so startling the detonations, that horses wheeled and plunged with panic, and men retired from the old Kau and Hilo road which, as you may recollect, lay near the upper precipice, and passed the great fissure at a respectful distance. And I have been told by those who observed and felt it, that so great was the heat on the road above the western precipice, 700 feet above the fires, that they were obliged to hold their hats between their faces and the crater, and pass rapidly along to avoid it. The upper banks also of the crater are smoking and steaming intensely, and sometimes the vast cauldron of Kilauea is so filled with dense masses of steam and smoke as to obscure all the glowing fires below, and to represent by a fact which mocks all fable, those Plutonic realms where fire and darkness forever reign.

Again when the winds are free and the fires more active, this suffocating mass of heated gases, vapor and smoke rolls off, and leaves the abyss below, all radiant with ten thousand brilliants, while the sparkling and dancing fires shine up gloriously upon the heavens, forming a lurid pillar whose brilliance is seen along the shores of Hilo, Puna, and Kau, and far off at sea.

For twenty years I have watched the movements of this great crucible of nature,—this Hawaiian volcano—with intense interest, and never perhaps, have I seen the fires more extensively distributed over the crater or more active and vivid in their play.

We may be entertained with another grand eruption; but when and where it will burst the adamantine walls which now confine the molten seas, we know not.

I said that I had lately visited Kilauea. During the latter part of June, I left Honolulu where our mission had held its annual meeting, in company with a party of ladies, gentlemen and children, bound to Hilo, via Kau and Kilauea. We reached the volcano on the third of July, and left in on the fourth. But I regret to say, that, in consequence of a sprained foot, I was unable to descend into the crater. I could therefore only survey it from the upper banks, and receive the reports of a party who went down to the fires.

At Kilauea I was met by my son, T. Munson, from Hilo, with an instrument to measure the angle of inclination of the stream of lava on the northern precipice of the crater. On the fourth of July he went down for the purpose; but as all that portion of the crater was full of boiling cauldrons, and as the whole bank was enveloped in dense smoke and deadly gases, he was unable to approach it. Meanwhile I had proceeded on toward Hilo with the ladies and children, none of whom could be persuaded to go down into that fiery abyss on account of the fearful activity of the fusion.

I exceedingly regret this failure, and the more so as I know not when I shall be able to visit the spot again. Should I be permitted however, to revisit the scene, nothing but an impossibility shall prevent me from attending to your request, and sending you the angle of that slope.* I am ashamed that it has not been done before, and my apology is, as stated, want of opportunity, unless I had gone up on purpose. Meanwhile, you will I think, rest assured that that angle is not less than 40.° As I have measured other slopes, I compared them in my mind to what I recollect of that when with extreme difficulty I clambered up it in 1835. I intend however, to give it to you correctly, if spared to visit Kilauea again.

You ask if there were any small cones thrown up along the course of the eruption of 1852. There were a few.

* In the writer's Exploring Expedition Report on Geology, p. 179, these streams of solid lava descending the enclosing slopes of Kilauea are mentioned. Mr. Coan writes in reply to a request that he should measure the angle of declivity, there being some doubt with respect to it.——The above account by Mr. Coan will be better understood after a reference to the sketch of Kilauea in volume ix, of this Journal, p. 352. The great dome *Halemaumau* corresponds to the lake, *a*, in the southwest extremity of the crater.—J. D. Dana.

Art. XIII.—*On the Aperture of Object Glasses;* by F. H. Wenham, republished* from the London Quarterly Journal of Microscopic Science for October, 1855.

Professor Bailey having noticed in the July number my remarks bearing reference to the fact of his being able to discover the markings on the most difficult tests known, when mounted in balsam, I beg to state, that my observations were dictated by no other motive than the desire of establishing a correct fact, and that I was not prejudiced by any favorite theory.

Professor Bailey says, 'It is apparent from the above that Mr. Wenham has convinced himself, both by reason and experiment that I *ought* not to have seen the markings on delicate test-objects when mounted in balsam.' From this I infer that Prof. Bailey had not seen a paragraph contained in my communication in the 'Quarterly Journal of Miscroscopic Science' for January, 1855, page 162, or I feel assured that he would not have thought it necessary to make this form of reply, for I therein assert that subsequent experience had induced me to recall my remarks, and that I had lately succeeded in bringing out the striæ of some very difficult tests when in balsam. I will now corroborate this by saying that I am convinced that Prof. Bailey is perfectly correct in his statement with respect to balsam tests which must henceforth be recorded in the list of facts. Thus far we are quite agreed; but as Prof. Bailey's allusions extend beyond this point, self-defence will be my apology for taking some notice of them. Referring to me, Prof. Bailey says, 'the error in his arguments will be sufficiently obvious to any one who will trace the course of a divergent pencil *out of* the balsam instead of *into* it, as in Mr. Wenham's experiments, and it will then be seen that large angles of aperture are as useful for balsam-mounted specimens as for others.' Surely Prof. Bailey cannot have well considered this extraordinary, because extremely incorrect, assertion, which is tantamount to saying, that a divergent pencil of rays from a luminous point, submerged in balsam will in each case continue their course in the same straight line without suffering any refraction *after* emerging from a plane surface of the medium. This is contrary to all reason, for in the trigonometry of optics where there are sufficient data connected with the position and direction of the rays, it comes to precisely the same thing whether they are traced *into* the refractive medium or *out of it.* But taking Prof. Bailey on his own statement, I will explain what is the real effect in the case. Suppose a series of rays diverging from a balsam mounted object; from the mean

* By request of Prof. Bailey.

refraction of the balsam and glass cover (the indices being about 1·54 and 1·53) total reflection would take place from the upper surface of the latter at an angle of very nearly 41° from the perpendicular. This therefore at once limits the angle of rays collected by the object glass to 82°, and as total reflection begins where refraction ceases, all rays beyond this point will be entirely reflected down again into the balsam and lost by dispersion; and the extreme rays of the pencil of 82° that just exceed total reflection by passing through the glass, so far from continuing their course in a straight line, are brought down by refraction to the very level of the top surface of the cover itself, so that if it were possible to use an objective of 180° of aperture, the effect of the balsam mounting would reduce it at once to 82°, and allowing for all possible variation of the refractive power of the balsam and cover, I have no hesitation in affirming that any object mounted in the usual manner in the medium, has never been seen with an angle greater than 85°; but in all probability the extreme limit has been about 78°. This statement is not the result of mere hypothesis, but admits of ocular demonstration, by experiments that will prove it at least half a dozen different ways, and is so true in theory, that to endeavor to disprove it will be to take the difficult course of attempting to undermine the ground upon which I stand, by denying the first laws of refraction upon which my assertion is based.

Prof. Bailey has, no doubt, experienced the advantage of the utmost extent of aperture that can be obtained, in that particular department of investigation in which he has so eminently distinguished himself; and I am willing to admit that if the highest powers are to be used only for viewing thin and flat objects, like the *Diatomaceæ*, the aperture may be as near to 180°, as may be practically convenient for this especial purpose; but considering all the requirements and perhaps more useful application of the object glass, I am still of opinion that beyond 150° there is no real advantage to be gained. I have expended much time and taken special delight in the cultivation of the largest apertures, and possess an assortment ranging up to the greatest possible limit, and I can even now bring out striæ with 150° as readily as with anything beyond it, with the positive advantage of a greater distance between the first lens and object. Some of the phenomena described in my communication to the present Journal are extremely severe tests of all the good qualities of an object glass, and yet I have had some whose performance is unrivalled upon a difficult diatomaceous test, repeatedly break down and fail in their effective duty when applied to the investigation of plant-circulation, from the fact of their possessing *too much* aperture.

Art. XIV.—*Remarks on Mr. Wenham's paper on Aperture of Object Glasses*; by Professor J. W. Bailey.

As Mr. Wenham now frankly admits the correctness of my statements with regard to the possibility of resolving difficult test-objects even when balsam-mounted, no further remarks are necessary upon that point, but a few words of comment are required by other portions of his paper.

That my reply was written before I could have had any knowledge that Mr. Wenham had recalled his remarks in which doubt appeared to be thrown on my positive statement of facts will sufficiently appear by the date of my reply, which was published in the American Journal of Science for January, 1855, the very time in which Mr. Wenham's retraction of his remarks appeared in the Quarterly Journal for Microscopic Science.

If Mr. Wenham finds anything objectionable in the form of my reply, he should bear in mind that this discussion is not one of my seeking, and that I put the best possible construction upon his remarks which seemed to call in question the correctness of my assertions. I am utterly averse to anything like scientific controversy, and would make no further remarks in this connection, if Mr. Wenham had not so entirely mistaken my statement, as to represent me as having published sheer nonsense. The statement on which Mr. Wenham animadverts is as follows. "The error in Mr. Wenham's arguments will be sufficiently obvious to any one who will trace the course of a divergent beam *out* of the balsam, instead of *into* it, and it will then be seen that large angles of aperture are as useful for balsam-mounted specimens as for others." This statement *as it stands*, I still hold to, but I must protest against its being considered "tantamount" to any such absurdity as that into which Mr. Wenham has translated it, which is indeed "contrary to all reason."

I mean to assert, however, what Mr. Wenham so emphatically denies, viz., that it does make a difference whether rays are traced *into* a refractive medium or *out* of it. I cannot admit that these two cases "come to precisely the same thing."

Mr. Wenham surely does not need to be told that if "the trigonometry of optics" establishes anything, it proves that the same medium which bends an incident ray *towards* the perpendicular when it enters, will bend it *from* the perpendicular when it emerges. Hence a beam of divergent rays from a point within a medium is rendered still more divergent when it emerges, and in fact is spread out so that the extreme rays which emerge, are in the plane of emergence, or make an angle of 180° with each other.

Mr. Wenham seems to confine his attention to the fact that a large portion of the rays from a balsam-mounted object are lost by internal reflection. This, of course, I never meant to deny, and in fact it is one obvious reason why balsam-mounted test objects are, as I long ago stated, far more difficult to resolve than when mounted dry. The loss of a portion of the rays in this manner, however, has nothing whatever to do with the present question, which is simply whether of the rays that *do* emerge, (and which make every angle with each other from 0° to 180°) more will be collected by a lens of large or small aperture. Certainly Mr. Wenham cannot deny that the larger aperture will receive the larger number of rays, and if so, then my statement is fully confirmed that "large angles of aperture are as useful for balsam mounted objects as for others."

The distinction I have alluded to above, between the intensity of illumination of the balsam-mounted object and the effect of large angle of aperture, is alluded to by Dr. Robinson in his paper "On a new method of measuring Angular Aperture," where he states in a note that the effect of mounting in balsam "is in fact equivalent to reducing the aperture of the objective below 100°, *as far as illumination is concerned, though a much larger one may be required to take in the pencil.*" As to the question whether large angles of aperture are *always* desirable, each one will be apt to decide according to the merits of his own glasses, I can only say that I have as yet seen nothing to make me fear that I may have lenses of *too much* aperture.

Art. XV.—*On certain Adaptations of the Compound Microscope;* by Ogden N. Rood.

The compound microscope and some of the pieces of apparatus which generally accompany it, can, in the absence of certain especial optical instruments, be made very conveniently to perform their part; we propose to mention briefly a few of the uses for which it may be employed.

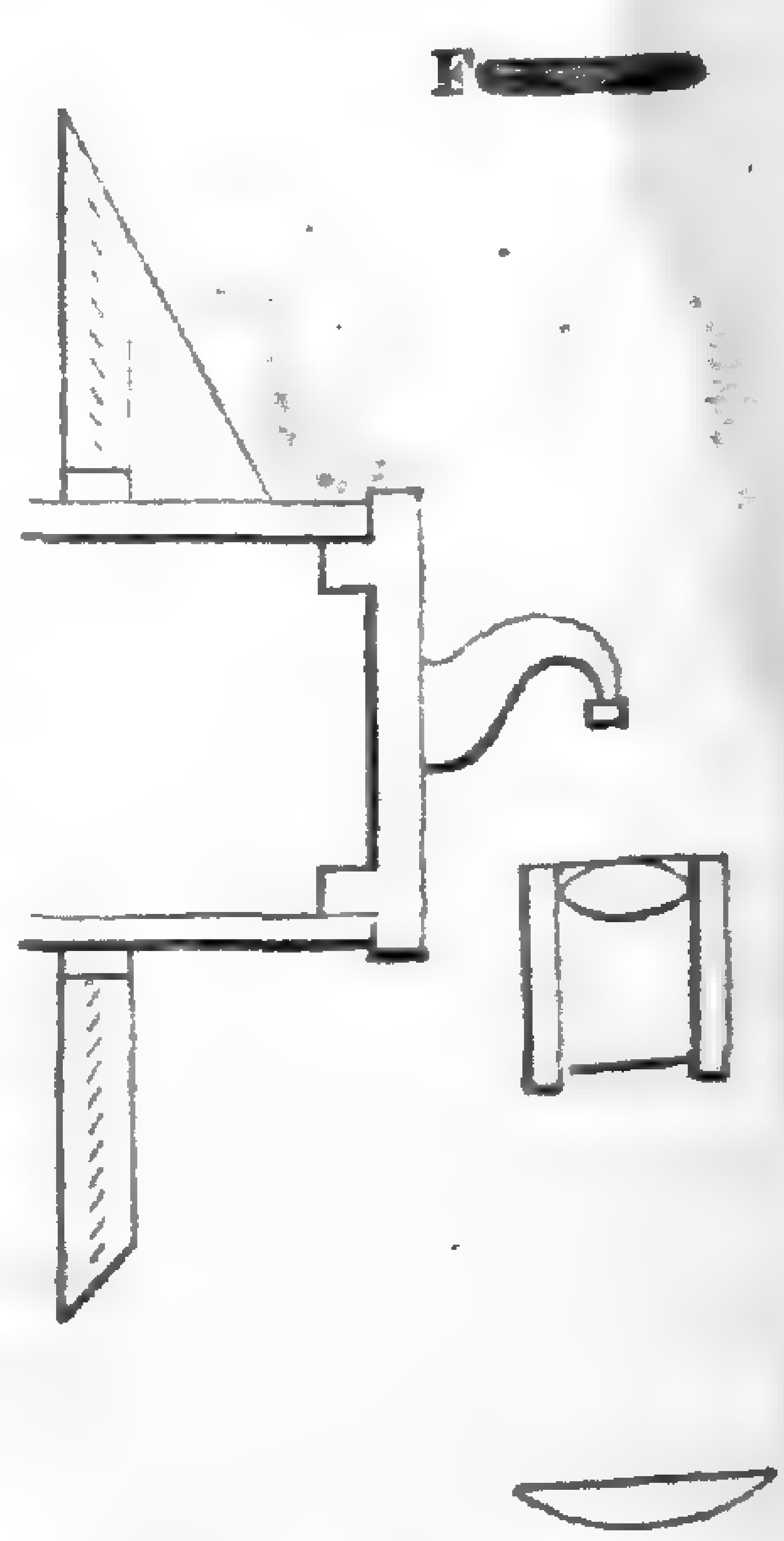
As *a goniometer*, for the measurement of the angles of *large* crystals. Good compound microscopes as now made, are ordinarily furnished with a small graduated circle which fits around the end of the draw-tube and which is intended for the measurement of microscopic crystals: if the circle have a diameter of from three to three and a half inches, and be provided with a proper vernier, minutes can conveniently be read. In case of a reflecting goniometer not being at hand, it is evident that the angles of large crystals can be measured with this apparatus; all that is necessary is, to bring the microscope to an upright position, to remove the eye-piece, and substitute in its place a brass plate which fits into the end of the draw-tube; if then a second brass plate of the same size be placed on the first with three small pieces of wax intervening and the crystal be attached to the topmost plate with a little wax, it can be centered and its angles measured in the ordinary manner.

For the measurement of the angles of *microscopic crystals*, an apparatus has long since been devised, consisting as before stated, of a divided circle fitting around the draw-tube and a vernier which is attached to the eye-piece; a divided slip of glass or a cobweb-line is placed in the focus of the eye-lens; this is successively applied to different sides of the magnified image of the crystal, and measurements are so obtained. This arrangement is however, open to many serious objections, as any one who has used it for actual work will be ready to acknowledge. It is in general impossible to measure interfacial angles, plane angles being for the most part the only ones which can be obtained, and the measurement even of these is subject to great inaccuracy: if the faces do not lie perpendicular to the axis of the compound body, only the projected angle can be obtained and this will vary largely from the truth: add the fact, that owing to refraction and total reflexion within the crystal and the inability to turn it around, ordinarily no idea can be formed of its general shape—some faces which are even on the uppermost side of the crystal not appearing, and some being seen which have no real existence—an idea of the difficulty of using this arrangement will be formed. By far the best mode of proceeding is to view the crystal as an opaque object under light concentrated by a bull's-eye-condenser, and to make a free use of the revolving stage.

Having had occasion lately to measure the angles of some microscopic crystals, the following methods were devised. The microscope is brought into a horizontal position, the brass plate above mentioned occupying the place of the eye-piece; a small piece of wax is moulded to a conical shape, the microscopic crystal attached to its pointed extremity and the whole fastened to the brass plate as seen in fig. 1. The light from the flame (F) of a candle is then to be concentrated on the crystal and it is to be viewed from all sides, by an achromatic inch or half-inch objective held in the hand; by revolving the crystal on the axis of the instrument its faces will be seen to flash into brightness as they fall into positions to reflect the light. In this manner a good idea can be formed of the number and position of its faces, and if necessary, a wooden model can be cut for future reference.

(*a*.) If the faces to be measured are larger than $\frac{1}{500}$ of an inch, the following method may be employed for measuring their inclination. Without disturbing the crystal the wax is to be bent into such a shape as to make the edge of intersection of the two faces coincident with the axis of the compound body: it can readily be determined by the inch lens which is to be supported on a stand in the position seen in fig. 1, when this is nearly accomplished. Two hairs crossing each other at right angles are to be fastened to the end of the brass tube in which the lens is set. If now one of the faces under consideration be made to reflect the light so as to be seen brilliantly illuminated by the inch lens, the condenser removed and a second lens of about two inches focal length, (the field lens of one of the eye-pieces will answer for this purpose,) be held by the hand behind the inch lens, after a little trial a position can be found, where, instead of the illuminated face of the crystal, a distinct image of the flame, more or less inclined to the perpendicular cross-hair, will be seen. The wax is then to be bent till the image of the flame assumes an upright position and coincides with the perpendicular cross-hair, and the same is to be done with the other face. It is not necessary that the two-inch lens should be supported otherwise than by the hand, the cross-hairs not being attached to it; their position in relation to the image of the flame does not change with the motion of the hand. This is very convenient, enabling the observer to view at pleasure and without loss of time the face of the crystal or the reflected image of the flame. A little rod of wood $\frac{1}{10}$ of an inch in diameter is to be supported in a horizontal position between the flame and the crystal: it answers the purpose of the "window bar" in the ordinary form of the experiment.

1.



The crystal can thus be turned on the axis of the instrument till by viewing the image of the flame through the two-inch lens, the bar and horizontal cross-hair are seen to coincide, &c., the farther manipulation being the same as in the common mode of using the reflective goniometer. This method in practice will be found easy, and it is evident that any desirable amount of accuracy can be attained. Sometimes it may be found better not to remove the condenser; it then should be brought somewhat nearer the crystal than the distance of its focus when the image of the flame will be seen as before: in this case the wax should be previously blackened.

(*b.*) When the faces are smaller than $\frac{1}{500}$ of an inch, the crystal is attached to the pointed extremity of the wax as before, it is to be viewed by the fixed lens and the line of intersection of the two faces made to coincide as nearly as possible with the axis of the instrument. To measure the angle the condenser is removed and the crystal is to be turned on the axis of the instrument till one of the faces is seen by the fixed lens brightly illuminated: it is then to be turned till the bright reflexion is just gone: 0 on the vernier is then made to coincide with 180° on the circle: the crystal is now to be turned till the second face brightly reflects the light, and the reflexion just disappears, when the angle is to be read off. If the crystal be viewed in both cases at the moment of the disappearance of the light through the *same* portion of the lens, as for example the upper, the error will not be greater than 5′ or 6′. It is evident that by this method approximate measurements can be obtained on crystals whose faces are large enough *to be seen*, when brightly illuminated, by an inch or ½-inch achromatic lens.

(*c*.) For crystals whose faces are smaller than the above, a small compound microscope is to be substituted for the single lens: the centering can be more perfectly accomplished, for the edge of intersection can be made to coincide with a hair line in the focus of the eye-lens, and the greater lengthening and shortening of the projection of the edge of intersection furnishes a means of knowing when the adjustment is effected.

When the crystals are exceedingly small and numerous, the point of the wax is to be dipped into them, some particular crystal selected under the microscope and the others dissected away with the aid of a fine needle. It is plain that these three modes of measuring microscopic crystals are adapted to the ordinary reflective goniometer.

Index of refraction.—If a brass tube of about ½-inch in diameter be taken and to one end of it be attached the posterior lens of the inch objective, to the other, in a sliding tube, an achromatic lens of ½ or ¼-inch focal length selected from some of the combinations, a little telescope of low power will be formed which can be used in measuring the index of refraction of such substances as can be ground into prisms. For this purpose it is to be firmly attached to the brass plate above referred to, in such a way that the object-glass of the telescope shall *not* project beyond the axis of the compound body, or the center of the goniometer circle. A cross-wire, or better, a divided slip of glass is placed in the focus of the eye-lens; a small round plate capable of turning on its axis is brought before the object-glass of the telescope and adjusted so that its axis shall coincide with the axis of the compound body.

It is easy to ascertain with accuracy by previous observations the value in minutes and seconds of the spaces on the divided glass slip. For measuring the index of refraction the telescope is first pointed at the slit from which the light is received, 0 on the circle made to coincide with 0 on the vernier, the prism is brought before the object-glass, and the telescope and prism turned and adjusted till the minimum deviation is reached when the angle for any particular colored ray is read off, and the refraction calculated by the formula,

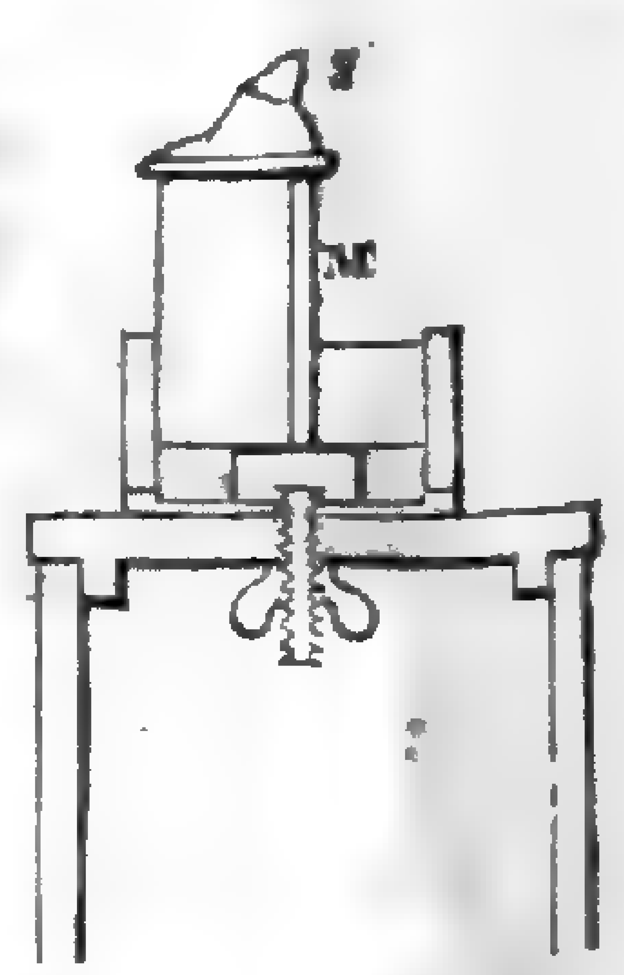
$$m=\frac{\sin\frac{1}{2}(a+d)}{\sin\frac{1}{2}a},$$

having previously ascertained the value of a by the method alluded to in the first part of this article. The dispersion is measured at the same time, more particularly with the aid of the divided slip.

Such an arrangement costs but little, is convenient, and its accuracy can be depended on as far as three places of decimals.

Herschel in his treatise on light proposes a certain method of ascertaining the *polarizing angle*, of opaque substances having at least one polished face, of set gems and of substances too small to be formed into prisms; and thence, their index of refraction. This method was found in practice to be very uncertain and difficult: the following modification gave better results. A little piece of apparatus is to be constructed, consisting of a mirror, M, set as seen in fig. 2, and capable of being firmly attached to the plate fitting in the end of the compound body: it is to be adjusted so that the axis of the compound body shall lie in its plane. The substance under examination, S, is attached by wax in the position seen in the figure, and its polished face brought into a position parallel to the face of the mirror: this is effected by making the reflected image of a distant object as seen by the mirror, coincide with the unreflected image of another distant object, and then bringing the face of the substance under examination into such a position that a similar coincidence is observed. A candle is then placed on a level with the mirror, at about three feet distance, and its face turned till it is perpendicular to a line drawn from the flame to its center. This is effected by placing the eye behind the flame and turning the mirror on its axis till the reflected image is seen to coincide with the flame: the error in this mode of adjustment is far within the necessary error of observation. A Nicol's prism is then supported between the candle and the instrument. The flame of the candle as seen by light coming through the Nicol's prism and reflected by the face under examination, is then observed, any necessary adjustment of the Nicol's prism is made and the substance revolved till its polished face ceases to reflect the polarized beam, when the angle is read off. Any deviation in the apparent direction of the flame caused by the Nicol's prism can be ascertained beforehand with accuracy and applied as con-

2.



stant error. By this mode the following approximate results were obtained for fluor spar, alum and crown glass:

Fluor spar, - -	1·419	1·434	as given in optical tables.
Alum, - -	1·445	1·457	
Crown glass, - -	1·490		

If the microscope is furnished with a pair of Nicols' prisms or tourmalines, but little management is required to arrange its parts so that it will answer as a polariscope for large objects, and for viewing the rings around the axes of crystals: it also furnishes a good extemporaneous apparatus for examining the circular polarization of liquids: the necessary arrangements and additions will readily suggest themselves. Also by means of the graduated circle the inclinations of the axes of biaxial crystals can be measured.

The inclination of the ordinary to the extraordinary ray when the light falls perpendicularly on two parallel faces of the crystal and thus at certain inclinations to the optical axis, can with the microscope be readily determined even for very small crystals.

For this purpose a piece of tin-foil is firmly pasted on a glass plate and afterwards with the point of a knife a fine slit is made across it: the crystal is laid over this slit and viewed by perpendicularly transmitted light and a power of from 50 to 200 diameters, and the distance apart of the two images of the slit, or the tangent of the angle of their inclination measured with the eye-piece micrometer. The crystal is then turned on its edge and its thickness measured in the same way. If t = the thickness, and d the distance of the two rays apart, we have $\frac{Rd}{t}$ = tang. of angle of inclination.

There is made in Munich by A. Greiner, a thermometer in which the degrees, (centigrade,) are divided into tenths: if one of these instruments be attached to the stage of the microscope and the termination of the mercury column be viewed by a power of from 50 to 100 diameters, it will be seen to end in a sharply defined straight line which can be made to coincide accurately with the divisions of the eye-piece micrometer. This straight line does not curve sensibly when the column is in motion, unless indeed the bulb be taken directly in the hand. As it is easy to ascertain the values of the micrometer divisions in fractions of a degree, very small changes of temperature can be accurately measured: indeed with such an arrangement it is seen that the thermometer is almost never at rest. With a 1-inch objective, 1½-inch eye-piece, and a finely divided micrometor, as small a variation as $\frac{1}{1400}$ of a degree can be measured.

Munich, Oct. 1st, 1855.

Art. XVI.—*On the Distribution of Rain in the Temperate Zone;* by H. W. Dove.

Continued from page 397.

It is now clear that if the Trade Wind has unchanging limits, all places within its range are either continually within it, or about its inner limits, or lying just beyond these limits. The first would be rainless; while over the second and third, for the whole year through, there would be rains. If the characteristic of the Subtropical zone is the change from a rainless season at the time of the sun's highest ascension, to a heavy fall of water at its lowest, there will be no Subtropical zone on the outer limits of the constant Trade Wind. If in America there is any approach to such unchangeableness, the consequences stated will gradually be proved.

On this account I have long been anxious to ascertain the distribution of rain in the parts of Asia and America on the extreme limits of the Tropics, where the conditions of wind currents and barometric heights are very different from those in Europe. Since however the quantity of rain, taking only a few years together, would seem to vary much, I have been compelled to wait until the observations covered a longer period. Except a few stations taken from that excellent work, "Drake's Systematic Treatise, Historical, Ethnological, and Practical, on the principal Diseases of the interior valley of North America, as they appear in the Caucasian, African, Indian and Esquimaux varieties of its population: Cincinnati, 1850," I have had to collect the whole material and make all the calculations; and this too I have also had to do for the observations in Northern Asia.

Going from the south point of Florida, Key West and India Key, first, westwardly to the North coast of the Gulf of Mexico to the mouth of the Mississippi, past New Orleans, Natches, Vicksburg, to St. Louis, and past Fort Crawford to the Falls of St. Anthony on the parallel of 45°, near Fort Snelling, then to the west coast of the interior valley by Forts Jessup, Towson, Smith, Gibson, Leavenworth, to the north, there is nowhere any trace of the conditions required by a Subtropic. Only on the lower Florida Keys there falls in winter somewhat more rain than in summer; but from the north coast of the Gulf of Mexico on, fully nine degrees more to the south than Algiers, this is nowhere the case.

The quantity of rain in the observations of a few years, is so irregularly divided, that we must wait for a longer series of observations, to deduce safely any rules. Only this much is established, that on going to the north, the quantity of rain falling in winter diminishes at the expense of the summer, since it is known what excessively cold winters there are even in these parts of America, (very different as I have shown from Europe in this,) and that the direction of the wind here is more northerly in winter than in summer, while in Europe the reverse takes place. On that account the excessive quantity of 64″ of rain in Mobile falls at Fort Snelling to 24″.

If we go along the east coast upward from Savannah, past Charleston, Washington, Baltimore, Philadelphia, Boston, to Houlton, from lat. 32 up to lat. 46, the more extended the observations, so much the more decidedly marked is the maximum in summer, while there is also a less diminution of the annual quantity than in the interior, namely a mean between 35″ and 45″. On a third line falling between the two just indicated, passing from Hauteville over Nashville, Louisville, St. Louis, Cincinnati, Marietta, to Wisconsin, the same thing is found, the observations at these stations covering several years.

I have especially labored over the observations in the State of New York, with the hope that from the great number of stations and the frequency of the observations, the influence of locality would be very clearly discernible. In the accompanying tables, I begin with stations lying on the sea, East Hampton, Jamaica and Flatbush on Long Island, and I continue on from New York in the valley of the Hudson beyond Albany to the shores of the Mohawk over the chains of the Alleghanies to the shores of the St. Lawrence and Lake Ontario, by Mexico to Potsdam and Delhi, then along the south shore of the Ontario to lake Erie, where the chief stations are Oxford, Cazenovia, Pompey, Auburn, Rochester, Middlebury and Fredonia. Here there is this peculiarity, that in the vicinity of the great fresh water lakes the autumn rains are somewhat stronger than the summer rains. It is so at least in Toronto (Canada,) in Fredonia, Springville, Milville, Rochester, Lowville and Mexico. This somewhat greater quantity appears to extend only over a limited space, and on the heights of the lakes even to have no effect, for both Ontario and Erie reach their greatest heights in June.

In no part of the earth does the physiognomy of the land change so quickly as in the New World. Richly cultivated fields surround crowded cities, where a few years before hardly a human sound disturbed the quiet of the forest. At the same spot where to-day a solitary fort is the first point of permanent settlement, perhaps in a year the lively bustle of a village population will be at work. In this way the great forests are first attacked by cultivation, which spreads so widely that finally the forests are diminished to single clumps. Can this be done without influencing the distribution of rain? If this question can be answered any where in the Temperate zone, it is in America. Does the soil of Virginia, exhausted by tobacco crops, condense as much water vapor into rain as it did when covered with forests? We do not know: but are not the new States supplying many opportunities of answering this question? For the Tropics, we well know the extensive influence of that desolating system, called land cultivation. The Cape Verde Islands and the Canaries, when the primeval forests fell before the axe of European settlers, or were burnt as on the Azores, became more and more like bare rocks; for with the destruction of the woods which clothed them and shaded their soil, those rains that fed the earth either disappeared or very much diminished. From similar causes, as Boussingault explains, in South America, the springs in the neighborhood of colonies of rapid growth gradually dry up. But as the long contests which followed the liberation of the colonies from Spain, frightened away colonists, the forests won back the ground that they had before lost, and since that time. the old wealth of waters is returned, and just in proportion, the rains have again become frequent.

The natural inference from all this is, that with increased cultivation of the country, when all material for combustion has to be sought under the earth, the continually increasing population of the earth, in its effort to maintain itself, will plant in nature the germ of a period of death, when vapors should no more condense into clouds over the treeless earth, and even the seed in the soil refreshed only by dew would lose its power of budding, or if it should shoot up, would slowly wither and die. But the world as well as the whole universe is so ruled as to bear within itself both a principle of destruction and of preservation: it is thus—in the petty earth which we inhabit. No matter what changes may alter or affect the outer surface of the earth, the permanent remains permanent, the changeable changeable; for what in proportion to the great features of sea and land are the trifling changes of drained lakes and dried up ponds? If the sun stands over the southern hemisphere with its broad waters, there will then be a greater extent touched by the warmth thus created, than if it beam in northerly limits over a broad solid surface. The vapors with which the atmosphere becomes charged in excess between the autumn and the spring equinoxes in the southern hemisphere, return in the other half year back to the earth in the shape of snow and rain, and in excess over the northern hemisphere. If however, under the hand of man local differences of ground gradually disappear, then this quantity of rain will diminish, but according to regular rules of universal application; from a more equal, or rather an irregular distribution of the quantity of rain, there will certainly result the extreme dry and wet seasons, just as has been observed in the valley of the Rhine, owing to the decrease of the forests since the French Revolution, where within the last ten years especially, sudden floods have risen to heights never before known. Our river banks are not calculated for such differences of level, and it is ruinous if a river like the Oder, which regularly proves the English saying, that a river is only a contrivance to build a canal in, suddenly sets up the Nile for an example.

If an improved cultivation of the country has the effect of altering the fall of rain at certain epochs subject to the universal influences of the atmosphere, then the longer cultivated Europe, when compared with America, must show, under like conditions, greater conformity to rules in the distribution of rain than in America, and this is in fact the case. The rain-curves exhibiting tolerable accordance in the course of a few years, require in America a longer circle of observations, because single annual terms often differ very strikingly. It is not impossible that the coasts of the Mediterranean deprived of the woody covering, over their mountains, show more clearly than formerly the contrast of their wet and dry seasons, and that in ten years of European occupation in Algiers more than one rainy day has been added to July.

If the destruction of forests and the cultivation of the soil lessen the causes which affect the change of atmospheric vapor into rain, then is it clear that if we compare with one another two places differing very much in reference to the cultivation of the soil, in which however the quantity of rain is the same, that place which retains most of its natural peculiarities will be relatively drier, at least in the lower layers of the atmosphere, since there the temperature of the air must be a good deal nearer to the condensation point of vapor than in the other. To this greater dryness of the air, Desor, has given particular attention in an Essay "Du Climat des Etats Unis et de ses effets sur les habitudes et les mœurs." The quick drying of their wash affords an agreeable astonishment to all emigrating German housekeepers, while, to their despair, the bread so soon gets stale that they finally fall into the fashion of native Americans, and bake at least every other day; but fruit and greens are kept in their cellars much longer. In winter, in spite of the bitter cold, they miss the characteristic ice-flowers on the windows; the garden-path requires much more careful construction, and the lady's Vienna piano soon gets out of tune, owing to this very dryness. When in Boston, in a freshly plastered room, a collection of mammals and birds were put up without any method of drying, and M. Desor expressed his astonishment, the superintendent answered: 'vous oubliez que nous sommes dans la nouvelle Angleterre et non pas en Europe.'

In the latitude of Edinburgh, in Sitka, beyond the Rocky mountains, 90″ of rain are known to fall. This is the only point within my reach on the Pacific Ocean, but it shows that the Equatorial currents changed by the motion of the earth to a south-easterly direction, there lose their vapor, and that the nearness of the sea cannot supply on the east coast that which the southerly origin of these west winds secures to the west coast.

In place of a sudden diminution in the quantity of rain like that on this side the Rocky mountains of America, there is only a gradual change in the old Continent, where the steep ranges do not come quite down to the west coast. To the rain-torrents which pour down along the foot of the Sierra d'Estrella and made the siege of Coimbra under Don Miguel so tedious, there had been a parallel only in Norway where the mountains run down so sharp to the westward that the sea fills the transverse valleys, making them fiords, until lately the occurrence of that unheard of fall of rain which swept down in the neighborhood of the Cumberland Lakes and excited such universal wonderment in England. They knew of course, that, as the captains in the North Sea ask one another if it rains in the mountains, so a traveller on the west coast of England enquired impatiently "if it always rained there," and got the quieting answer, "no, it sometimes snows;"—but no one supposed that in Langdall there fell 123 inches of rain, in Gatesgarth 136, in Scathwaite 142. In Ireland, this diminution of the quantity of rain on the west coast comes more gradually; but here too, there is, as Lloyd has shown, a peculiarity depending on the position of the mountains with reference to the point where the observations are made: a range of mountains to the northeast having great influence, but little if to the southwest. Hence it is that we find in Cahirciveen 59″·4, and in Portarlington only 21″; for the former lies, like West Point with 45″·9, and Castletownsend with 42″·5, on the SW side of high mountains, on the other side of which are Portarlington on the Slievebloom, just as Kellough with 23″·2 on the NE of the Mourne Mts., although all these stations are right on the edge of the sea. This diminution is seen clearly in Prussia; for the 30″ of Cleve become 25″ in Cologne, Bonn, Aachen (Aix la Chapelle), and Trier, 22″ in Berlin, 19″ in Posen. The Riesengebrige of Silesia makes a dividing wall, which gives on the south side heavy showers, on the north side generally only inconsiderable rains. Thus the insignificant quantity of 14″ in Prague becomes 33″ in Hohenelb, and diminishes in Neisse to 16. Still more remarkable is this fall in Russia; for the 17 English inches in Petersburg, Bohoslowsk and Slatoust, become 15 in Catharineburg and 11 in Barnaoul. Ajansk on the Sea of Ochotsk, with 35″, shows that here too the increase landward is conditional, since the moving air of the continent here make east winds; for of these 35″, 30 come in summer and autumn; Pekin shows the influence of the monsoons, since of its 27″, 20 come in the three summer months.

The time of the maximum amount of rain as well as the small annual diminution of atmospheric pressure in the south, extends through Central Asia into Hindostan. There is just as little trace of a Subtropic zone here as in America. In Redutkale on the southern slope of the Caucasus, there fall 58″ of rain, in Kutais 50″, in Tiflis only 19″ for high chains of mountains lie SW of it. The significant quantity of 43″ in Lenkoran, whose distribution recalls the Subtropical rains, diminishes on the other side of the chief range of the Caucasus in Baku to 13·4, in Derbent to 15·7, a proof that the source of that fall is not to be sought in the Caspian Sea which washes these places, but lies off to the SW. The inconsiderable amount of rain appears to show that the masses of air over Africa are unaccompanied by heavy vapors; hence from Africa to the interior of Asia in the direction of SW to NE, there lies a waste tract, in which the evaporation exceeds the fall of rain; consequently, the level of the interior waters, as in the Dead Sea, the Caspian and Aral, is below the level of the Ocean, and just in proportion as they are nearer to the Equator; while on the southern slope of the Andes and Appenines the Sirocco betrays, through powerful rains, its cradle, which lies, as I have long since demonstrated, not in Africa, but in the Sea of the West Indies.

Why in England the autumn rains are so much more important than the summer rains, a subject which has attracted Dalton's attention, will not be fully ascertained until for many years, such registering instruments as those of Osler at the Liverpool Obsevatory, have been in general use for ascertaining all the phenomena accompanying each shower, and especially the direction and intensity of the wind.

The distribution of rain in annual periods is very different in different neighborhoods; it may become the same however, after a time in different localities, and from very different causes. Unless attention be paid to all these causes the graphic exhibition of the results may make the explanation more difficult, instead of simplifying or elucidating the subject. [We omit the tables, which follow, referring to the original paper in Poggendorff's Annalen, for January, 1855, vol. xciv, p. 58.]

Art. XVII.—*Correspondence of M. Jerome Nicklès, dated Paris, Oct. 30, 1855.*

Death of M. Magendie.—At the opening of one of the recent sessions of the Academy of Sciences, the President announced the death of Dr. Magendie, after a long and painful sickness. In another communication I propose to give a biographical sketch of this savant, whose labors have done so much for the progress of experimental physiology.

M. Braconnot.—The decease of M. Braconnot was noticed in the May number of this Journal, and I now add a brief memoir of this chemist, as then promised.

Henry Braconnot was born on the 29th of May, 1780, at Commercy, Department of the Meuse. His father, a lawyer, died seven years after, leaving two sons, of whom Henry was the older. His property was not large, but was still sufficient to give his two children, who were bright and active, a good education. At that time, the education of children was wholly in the hands of the clergy who recognised no punishment excepting corporeal inflictions. Braconnot was placed in a college of Benedictines, and brought little honor to his teachers. The slightest misdemeanor was met with a blow of the ferule—a mode of correction calculated to exasperate rather than improve, and especially injurious to this rather impetuous child. He grew more and more ungovernable, and finally stood in open revolt against his reverend oppressors; uniting with one of his companions equally spirited, and having like him a feeling of a man, he became the terror of his governors. His mother in despair, took him from the Benedictine college and entrusted him to a village schoolmaster noted for his severity; but the pedagogue succeeded no better than the Benedictines; he sent young Henry home, presaging for him a dark future.

Meeting with the Benedictines, at this time, they expressed the same opinion of his comrade. But they were mistaken in both. We know what Braconnot was; his companion in frolic became afterwards Dr. Marjolin, formerly Professor at the Faculty of Medicine at Paris, and one of the first physicians of the modern school.

Young Braconnot now engaged earnestly in chemical studies. He spent four years at Strasburg. He then returned to Paris to perfect his education, where he attended the courses of Fourcroy, Geoffroy St. Hilaire, Desfontaines in Botany, and Faujas de St. Fond in Geology. He was noted for his zeal, carried off prizes, and published his first work entitled "Analysis of a fossil horn found in an ancient cave." This memoir was soon followed by another "on the assimilating force in plants," which was published in the Annales de Chimie et de Physique. It attracted the attention of Fourcroy, then of great influence, who secured for him the directorship of the Botanical Garden of Nancy (1807). The death of his father-in-law now left to his mother a large fortune which ultimately came to Braconnot; his mother living until her death at Nancy.

From this time his memoirs succeeded one another without interruption. In his analyses, he discovered successively pectine, populine, equisetic acid, ellagic acid, and pyrogallic acid. In 1820 he suddenly changed his line of investigation, and took up the products of the decomposition of ligneous fibre by acids, discovering xyloidine, leucine, sugar of gelatine, and the transformation of wood into sugar—this last a work of the very highest merit.

Braconnot in mature years was the reverse of what he was in youth; modest and mild even to extraordinary timidity, he was understood by only a few friends. His townsmen thought him of contracted mind, and one day were surprised to learn that he was a Member of the Institute. But alongside of his timidity, there were decided opinions. Profoundly sceptical, he believed nothing and doubted especially medicine. Always at war with the doctors, he would have none of their advice when ill. He thought that nature could do everything, and he died with great suffering from a cancer in the stomach, unwilling to the last to take council from the doctors or his friends.

Bayle, Diderot, Voltaire, were his favorite authors. His tastes and habits were of extreme simplicity; he lived on little and had no diversion but the theatre and the promenade. He saw his mother unfortunately married, and he suffered much from his father-in-law who was a physician; and this may have occasioned his celibacy, and his hatred of medicine.

Like Scheele, he made his researches with very restricted means. He had one good thing in his laboratory—his reagents, which he prepared himself, of extreme purity. But he was unwilling to admit any one into his laboratory. Arago on a visit to him asked the favor in vain. He was often at Paris, and took part in the sessions of the Institute, but not at their banquets open to the public. His timidity even hindered him from visiting chemists, being contented with seeing them at a distance.

Heat produced through the action of the magnet on bodies in motion.—The gyroscope of Foucault, described in a former volume of this Journal, is far from having said its last word. The author has just established by means of it, the recent views as to the relation between mechanical force and heat. M. Babinet announced the results to the Academy on the 17th of September last with a vivacity and enthusiasm quite indescribable, and which was shared by his auditors.

Foucault placed between the poles of a strong electro-magnet the solid of revolution belonging to the gyroscope. This solid is a torus of bronze connected with a toothed pinion of a motive wheel, which has a handle and is made by the hand to make 150 to 200 turns per second. To render the action of the magnet more effective, two pieces of soft iron are added to the bobbins, prolonging the magnetic poles and thus concentrating them close to the revolving body.

When the apparatus is moving at its greatest velocity, a current from six Bunsen's couples passed through the electro-magnet stops the motion in some seconds, as if an invisible rein had been thrown around it. This is the experiment of Arago developed by Faraday. But if now force is applied to the handle in order to restore the motion, the resistance compels the use of a certain amount of power, which is represented in heat in the interior of the turning body. By means of a thermometer, the progressive elevation of temperature was noted. Taking the apparatus, for example, at the surrounding temperature 16° C., Foucault found the mercury rise to 20°, 25°, 30°, 40°, when heat was quite sensible to the hand.

Foucault thinks he may easily construct an instrument which will exhibit on a large scale this phenomenon. By means of a machine easily made consisting only of permanent magnets, we may produce an elevated temperature and exhibit to a public assembly this curious example of the conversion of labor into heat.

On the neutral combinations of saccharine substances with the acids.—At the same session of the Academy, a research by M. Berthelot excited equal attention. We have spoken of Berthelot's reproducing synthetically the existing fatty bodies; he now prepares a multitude of new bodies by combining with acids certain organic substances analogous to glycerine, such as *mannite; Dulcose* $C^{12}H^{14}O^{12}$, a peculiar sugar found by Laurent in a Madagascar product; *Quercite* $C^{12}H^{12}O^{10}$, discovered by Braconnot in acorns, though confounded by him with lactine and afterwards proved to be a distinct principle by Dessaignes; *Pinite*, $C^{12}H^{12}O^{10}$; *Erythroglucine*, $C^{12}H^{15}O^{12}$, cane sugar and glucose.

When these different substances are put into a closed tube containing the acid with which it is proposed to combine them, and sufficient heat is applied, the combination usually takes place; and on opening the tube, after cooling, it is only necessary to remove by appropriate solvents the new substance from the material about it. Thus mannite, quercite, and the other substances mentioned have been obtained combined with acetic, butyric, stearic, oleic, palmitic, benzoic acids.

Chevreul in presenting this memoir, which he did with animation, equal to that of M. Babinet for the memoir of Foucault, said: "Thirty years since I foresaw that most of the neutral fatty bodies could result from a combination of glycerine with a fatty acid. To demonstrate this law, rigorous quantitative analyses were necessary, which I then thought impossible. Since then Science has moved on, and the probable has become the ascertained composition. But Berthelot has gone further. By the reaction of pure acids on glycerine also pure, he has succeeded in forming with precision many neutral fatty bodies—not only those before known, but others which had not been isolated. Glycerine, as is well known, has a sweet taste; and it was hence natural to enquire whether the other saccharine substances could be united, by synthesis, to those same acids. This is the object of Berthelot's recent investigations, which have been so eminently successful.

Observations on Cholera.—The subject of the cholera still continues to occupy the Academy. The developments as to its causes and cure have not yet been deemed sufficient to call for the 100,000 francs offered by the chemist Bréant: still some interesting results have come out, the influence of climatal conditions favoring or combating the disease have been shown in statistical researches. The statement is also noted that from the time of a great fire at Varna, the cholera, which had been very fatal, began immediately to diminish and the sick were in rapid convalescence. Dr. Burg has deduced from his researches that persons working in copper and brass escape this pestilence, even when living in infected districts. In 1832, when the cholera was prevailing at Paris, the tanners and leather-dressers escaped it almost entirely, although occupying the worst parts of the city. Dr. Hubertz, a Danish physician, has made similar observations at Copenhagen.

He says, "persons employed in emptying privies, even those used by cholera patients, were not attacked by cholera. The same was true of men employed in drying fish, in making cat-gut, and other employments regarded as unhealthy because of the putrid emanations attending the work. Even those employed carrying the dead and digging graves were completely spared.

New process of manufacturing soda and sulphuric acid.—In place of a dull and imperfect review of the "Universal Exposition," it seems better to describe a new process, yet unpublished, which promises to change one of the most important industries of the age.

Notwithstanding the improvements in the manufacture of artificial soda, Leblanc's process is still continued in practice with few changes, furnishing hence very large residues of oxysulphuret of calcium and preventing the sulphur of the sulphuric acid from serving several times. This is owing to the great degree of perfection to which the manufacture of sulphuric acid is now carried; the very perfect condensation of the hydrochloric acid and its applications; the low price of the materials used, the lime and combustibles, and the simplicity of the apparatus required for transforming the sulphate of soda into the carbonate; and finally the fact that the manufacture of sulphuric acid in connection with that of artificial soda, constitutes a complete and symmetrical work in which nearly all the products are utilized. Improvements that have been proposed have not been adopted, either because they derange this symmetry of operations, or else because of the cost of introducing them, or they are adapted only to certain circumstances or localities. The process now brought forward escapes these objections. It is by M. Emile Kopp, formerly Professor in the School of Pharmacy of Strasburg, and has already been put into practice in a manufactory in Lancashire, England, at Church near Manchester.

The process consists in decomposing sulphate of soda by a mixture of oxyd of iron and carbon, and treating the product of the reaction in the way described below. The proportions employed are as follows:

Sulphate of Soda (SO^3NaO),	125	kilograms.
Peroxyd of Iron (Fe^2O^3)	80	"
Carbon,	55	"

The sulphate of soda may without inconvenience contain some common salt; but then the oxyd of iron and carbon should be proportioned only to the pure and dry sulphate of soda present in the crude material. A furnace for calcination is used, taking care to break up the larger lumps. The oxyd of iron should be weighed dry and in a fine powder, and should be as pure as possible.

For the first operation, instead of the artificial or native peroxyd of iron, the carbonate (spathic iron) may be employed, or the magnetic oxyd, or even iron filings. But in the case of the last, the quantity of carbon should be diminished, since metallic iron acts as a reducer of the sulphate of soda. It will be soon seen, that whatever the compound of iron used, there will be shortly only the peroxyd, and this is regenerated constantly in the operation.

The mixture of sulphate of soda and oxyd of iron which is obtained as a residue in the process of decomposing common salt by the sulphate of iron, is readily adapted to Kopp's process, since, if the proportions are correctly taken, it is only necessary to add the requisite quantity of carbon. This carbon may be coke, or any other organic reducing substance; but the quantity will vary with its reducing properties. In England they use ordinary coal.

The amount of oxyd of iron must be such as will combine with all the sulphur of the sulphate of soda to form SFe. For 9 of the pure and dry sulphate, not less than 5 parts of the pure and dry oxyd of iron are required; a small excess of oxyd of iron is advantageous. If the oxyd contains lime it should be removed by treating with hydrochloric acid and washing; for the lime would give rise to CaS, then $CaOSO^3$, and then again CaS, increasing unnecessarily the volume of material under manipulation, and causing a loss of carbon and heat. The carbon should not be in excess, as it favors the formation of sulphuret of sodium, and because also of this excess remaining with the sulphuret of iron, will afterwards afford, in the roasting of the latter, some sulphurous acid mixed with the carbonic acid. The proportion of carbon should hence be diminished until there is a minute proportion of the sulphate of soda left undecomposed in the blocks of crude ferruginous soda.

The quantity of the mixture that may be put into the calcining furnace at one time will depend of course on its size: but the amount may be full twice as large as in the Leblanc process, since the ferruginous soda works more easily than the ordinary soda.

For *calcination*, the furnace may be similar to that for the calcareous soda: but to economise heat, there had better be two or three stories, the lowest nearest the fire. The furnace then holds three charges at once, which are moved downward in succession, another being added above when one is taken out below.

The treatment in the furnace is like that for the crude calcareous soda, and the phenomena are nearly the same. The whole softens, becoming pasty, and the fluid as the action goes on disengages a yellow flame; then the action, which has been very bright, diminishes as the flames become less abundant, and when the mass is homogeneous, it is finished. It is then removed immediately from the furnace, being run while still red into a waggon on wheels in which it cools and solidifies, having been partially covered for security from contact with the air. When cold, it is a block in the form of a parallelopiped, blackish in color and more or less porous, very hard and of considerable density. The surface has a coppery reflection. In fracture, it has a uniform aspect, a crystalline texture, and a greenish and brilliant metallic reflection.

It now remains to treat this crude ferruginous soda, so as to draw off on one side the soluble carbonate of soda, and on the other the insoluble sulphuret of iron. The method used with the crude calcareous soda would give only bad results. In fact, the mass expands on the action of water, becomes very voluminous, difficult to wash, and affords a liquid containing much caustic soda and also sulphuret of sodium.

The washing is however easy after a preparatory operation which M. Kopp calls "*délitation.*" It is as follows.—The crude ferruginous soda left exposed to the air under a shed, undergoes a change, which is the more rapid if the air be charged with moisture and carbonic acid. The lustre fades, the block breaks to pieces and becomes covered with an abundant blackish pulverulent material; and this goes on so rapidly that in a few hours it is reduced to a hillock of this powdered substance.

This change is due to the absorption of oxygen, water and carbonic acid, while heat is given out, which without care may rise even to ignition, in which case the powder has a reddish aspect, and contains sulphate of soda with 10 to 15 p. c. of carbonate of iron and a little sulphuret. But this high heat is prevented by removing the powder from the surface as it accumulates, so as to leave the interior open to the air and carbonic acid. Water then separates from it carbonate of soda, and the residue consists principally of sulphuret of iron.

M. Kopp aids the process by an artificial supply of cold and moist carbonic acid, as the action of the air is very slow. This process, which he calls "*carbonation*," is as follows.—In a chamber, at a height of two and a half meters, a grating of cast-iron is placed, whose spaces are one and a half centimetres. The earth is removed to about a depth of one meter. The roof of the chamber is about two and a half meters above the grating. The walls have numerous holes for the passage and circulation of the air. In the lower part, the carbonic acid is introduced. The blocks of crude ferruginous soda are placed on the grating, on their small face; and as they crumble, the powder falls below where it encounters and rapidly absorbs the carbonic acid. A block of 250 kil. requires as a maximum a space of a meter, and the process is complete in eight or ten days. Consequently a space of 20 meters by 10, will answer for 200 blocks, which will furnish more than 50,000 kilograms in 10 days, equivalent to 5000 kilograms a day. Ten metric quintals of coke, worth in England 7 to 8 francs, suffices to carbonate 90 to 100 quintals of dry and pure carbonate of soda.

The material when ready for lixiviation should be pulverulent, fine, gray or blackish-gray in color, and without hard fragments. It is well to use a course seive to remove the stony matters present, retaining them to be lixiviated apart, taking care to reject the insoluble residue. The sifted powder forms with water a lye which is clear in five to ten minutes, holding a heavy deposit, with often a coppery reflexion.

The *lixiviation* should be carried on methodically either by filtration or decantation, by means of warm water at 30° to 40° C. Weak solutions are used in lixiviating new portions of the powder.

When the exterior temperature is not too high, the solutions furnish after 24 to 48 hours, without concentration, an abundance of finely crystallized limpid carbonate of soda. By dropping in a bit of dry carbonate of soda, the crystallization is often hastened.

The residue, principally sulphuret of iron, is received on a filter or porous surface. In this state, it alters slowly. It is dried by heat or pressure and made into a brick. It is so combustible that it will take fire below 100° C., when the drying is nearly complete. This sulphuret affords the sulphur for making sulphuric acid, in which change, the iron becomes peroxyd and is then ready to be used again. It is thus seen that a single proportion of sulphur may be utilized a large number of times, in transforming common salt into sulphate of soda. But the oxyd of iron gradually becomes impregnated with the impurities of the common salt, the sulphate of soda and coal, and it must then be renewed; yet it may be used when it contains even 40 p. c. of impurities.

When the oxyd of iron contains sulphate of soda, it is necessary to change the proportions of the mixture for the crude soda. It has been found by experiment that the proportions most convenient are—

Sulphate of soda, ...	125 kilograms.
Peroxyd of iron, proceeding from the sulphuret,	140 "
Carbon, ...	70 to 75 "

and these proportions should be preserved for the subsequent operations, as long as the rotation of the same oxyd and same sulphuret of iron continues.

The same process may be used with the oxyds of manganese and zinc, but with greater difficulties, as the "délitation" and "carbonation" in these cases are more complicated.

Bibliography.—Recueil des Travaux Scientifiques de M. EBELMEN, Professeur de Docimasie à l'ecole des Mines de Paris, Administrateur de la Manufacture de Sèvres, etc., publié par M. Salvetat. 2 vols. in 8vo. Paris: chez Mallet-Bachelier.—Ebelmen died on the 2nd of April, 1852, at the age of 38 years, having been born in 1814. He passed through the Polytechnic school and the School of Mines, and finally became one of the Professors in the latter. He there made his important researches on the gas of high furnaces, on boracic and silicic ethers, on artificial hyalite, etc. Appointed afterward "Administrator" at the manufacture of Sèvres, he entered upon a fruitful line of discovery in his researches on compounds crystallized by the dry way; he made artificially several minerals such as spinel, chrysoberyl, chrysolite, corundum, Brookite, Perofskite, and also glucina.

The process which he employed in his investigations are described in the work just published. His labors are presented under the heads of Ceramic Chemistry, Reports on Ceramic Industry, Geological researches, Metallurgical researches, Metallurgy of Iron, and Heating of Locomotives. Some of his labors rank among the highest in the scientific world, especially his synthesis of minerals, in which he devised methods of making even some of the gems. His publications will be welcomed both by men of science and those interested in the industrial arts.

Leçons de Cosmographie; par M. FAYE, Membre de L'Institut. 1 vol. in 8vo, 2de edition. Paris: chez Hachette & Co.—The first edition of this work has been promptly exhausted. The new edition has been adapted to the programme on Cosmographie made out for the candidates at the Polytechnic school. M. Faye adds to his knowledge of astronomy, the talent of a distinguished writer. The chapters of greatest interest are those relating to the construction of geographical charts, in which the methods used in the chart of France are described with full details. Other subjects of special interest are Comets, Zodiacal Light, the Milky Way, Nebulæ, Solar Spots, the Tides.

Elements de Physique expérimentale et de Météorologie, par POUILLET, Membre de l'Institut. 2 vols. in 8vo, with an Atlas. Paris: chez Hachette & Co.—M. Pouillet was one of the most eloquent professors of Paris, and had the happy talent of making the most abstruse subjects clear to his audience. His work exhibits the same characteristics. The sixth edition is just issued, and the sale of it is far from coming to and end.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the direction of the vibrations of the ether in the case of polarized light.*—Haidinger has made a communication from Stokes the occasion of an interesting examination of the long mooted question whether the vibrations of the ether take place in the plane of polarization or at right angles to it. The former opinion it will be remembered was held by Maccullagh and Neuman and at one time by Cauchy; the latter is the view taken by Fresnel, Cauchy, Beer and the majority of physicists who have written upon the subject. Our readers will remember that the question considered from the mathematical point of view amounts to this. Is the density of the ether to be considered constant and its elasticity variable; or is the elasticity to be considered constant and the density variable? the former supposition leads to the conclusion that the vibrations are at right angles to the plane of polarization; the latter that they are in this plane. It is only an appeal to experiment which can decide the question, or rather it is only this appeal which can throw the weight of probability upon the one side or the other. Haidinger supports Fresnel's view and bases his reasoning upon the phenomena of pleochroism in doubly refracting crystals. We shall simply translate the author's succinct expression of his own argument.

I. Let the object be a dichroöus crystal and let equal thicknesses of its substance be investigated.

II. The following positions are considered as demonstrated.

a. The vibrations of the luminiferous ether are transverse.

b. To the same colors belong equal wave lengths; to different colors different wave lengths.

III. Mode of investigation.

(1.) *Observation.*—In the horizontal zone (of a uniaxial crystal) whose edges are parallel to the axis in all azimuths, one ray or bundle of rays, (an image of the dichroscopic lens or of any doubly refracting prism,) viz., the ordinary ray, is polarized parallel to the axis with the color A, and one ray or bundle of rays, the extraordinary ray, is polarized perpendicular to the axis with the color B.

Inference.—The vibrations are either perpendicular to the plane of polarization or in this plane.

Hypothesis.

1. The vibrations are perpendicular to the plane of polarization.	2. The vibrations are in the plane of polarization.

Consequence.

1. The direction of the vibrations of the ordinary ray is perpendicular to its plane. There are an infinite number of such directions; they are perpendicular to the axis.	The direction of the vibrations of the ordinary ray lies in its plane. For all azimuths there is but one such direction of vibration. It is in the direction of the axis.

2. To one color A or wave length belongs an infinite number of directions of vibration, but in as many different planes of polarization.	To one color A or wave length belongs only one direction of vibration.
3. To an infinite number of planes of polarization belongs an infinite number of directions of vibration. The directions are perpendicular to each plane.	To an infinite number of planes of polarization belongs but one direction of vibration.
4. The direction of vibration of the extraordinary ray is perpendicular to its plane. There is but one such direction; it is parallel to the axis.	The direction of vibration of the extraordinary ray lies in the plane of polarization. There is an infinite number of such directions. They lie in all azimuths perpendicular to the axis.
5. A color B, that is a wave length, is in all azimuths united to one direction of vibration.	A color B is united to an infinite number of directions of vibration, one in each azimuth.
6. To one plane of polarization belongs one direction of vibration.	To one plane of polarization belongs an infinite number of directions of vibration.

(2.) *Observation.*—In the vertical zones whose edges are perpendicular to the axis of the crystal, in all azimuths. The ordinary ray is polarized in the direction of the axis with the color A. The extraordinary ray is polarized perpendicular to the axis, and goes from the direction of the observation, beginning perpendicular to the axis, to the direction of the axis itself, passing from the color B to the color A. Observed in the direction of the axis the colors of both rays perpendicular to each other are perfectly similar in all azimuths and possess the tone A.

Consequences and Hypotheses as above.

7. The direction of vibration of the ordinary ray is perpendicular to its plane. There is but one such direction for every plane. It is perpendicular to the axis.	The direction of vibration of the ordinary ray lies in its plane. There is an infinite number of such directions for every plane. They include with the axis all possible angles from 0° to 90°.
8. To one color or wave length belongs but one direction of vibration.	To one color or wave length belongs an infinite number of directions of vibration.
9. The direction of vibration of the extraordinary ray is perpendicular to its plane of polarization. There is in every principal section an infinite number of such directions between 0° parallel to the axis and 90° perpendicular to the axis.	The direction of vibration of the extraordinary ray is in its plane of polarization. There is for every principal section only one such direction. It is perpendicular to the axis.

10. To the succession of colors or wave lengths from B to A belongs an infinite number of directions of vibration inclined from 0° to 90°.

To the whole series of colors from B to A belongs, notwithstanding the different wave lengths, but a single direction of vibration.

(3.) *Combination of the observations and conclusions in* III, 1, *and* III, 2.

11. The same direction of vibration is connected with the same tone of color or the same wave length.

The same direction of vibration is connected with the same tone of color, only perpendicular and parallel to the axis. In all other directions it is connected with all possible gradations of color.

12. In the direction of the axis we do not see the color B because the direction of vibration belonging to this color has a longitudinal position.

In the direction of the axis we do not see the color B although the vibrations belonging to it takes place in all azimuths perpendicular to the axis.

13. The constant (or limiting) tones of color A and B are connected with vibrations, B in the direction of the axis, A perpendicular to it.

The constant tones of color A and B are connected with vibrations, B perpendicular to the axis, A parallel to it, perpendicular to it, and making all intermediate angles with it.

14. In the direction of the axis we see the color A by vibrations perpendicular to the axis. In a direction perpendicular to the axis we also see the same color A by vibrations perpendicular to the axis.

In the direction of the axis we see the color A by vibrations perpendicular to the axis. In a direction perpendicular to the axis we see the same color A by vibrations parallel to the axis.

15. Vibrations perpendicular to the axis take place only for the color A.

Vibrations perpendicular to the axis take place for A, B and every intermediate color.

16. Vibrations in the direction of the axis take place only for the color B. This color is therefore invisible in the direction of the axis.

Vibrations perpendicular to the axis take place for the color B. Notwithstanding this color is invisible in the direction of the axis. Just such vibrations however take place for the color A and yet this color is visible in the direction of the axis.

17. for the color A the vibrations take place only perpendicular to the axis.

For the color A the vibration takes place in all azimuths perpendicular to the axis, in all azimuths along the axis, and in all azimuths of the principal section.

18. In the mixed tones of color each color appears according to its appropriate direction of vibration, dependent on the cosine of the inclination of the last with the usual ray.

Mixed colors occur without a change in the direction of vibration.

19. The same direction of vibration belongs to the color A when the observation is in the direction of the axis or perpendicular to it.	To the color A belong, when the observation is in the direction of the axis, vibrations perpendicular to the axis. When the observation is perpendicular to the axis the vibrations are in the direction of the axis and perpendicular to all those of the last case. Yet there is no trace of any action on the part of the first set.
20. For the same direction of vibration and the same wave length there is the same color throughout the whole crystal.	For the same direction of vibration there are different colors and therefore different wave lengths.

The author concludes from this reasoning that the assumption of vibrations perpendicular to the plane of polarization leads to clear, simple consequent and connected views of the whole subject, while the opposite supposition involves obscure, overloaded and contradictory representations. Similar arguments may be drawn from a consideration of biaxial or trichromatic crystals. We must however refer to the original paper for a fuller exposition of the authors views and arguments.—*Pogg. Ann.*, xcvi, 287, *October*, 1855.

2. *On the constitution of the Mellonids.*—LIEBIG has at length renewed the discussion of this interesting subject and has established by numerous analyses indirectly the composition of mellonhydric acid and of several crystalline and well defined mellonids. Mellonhydric acid has the formula $C_{18}N_{13}H_3$. The acid is tribasic and admits of the replacement of one, two, or three equivalents of hydrogen by an equal number of equivalents of metal. The acid is easily prepared in solution by dissolving mellonid of mercury in dilute cyanhydric acid and passing a current of sulphuretted hydrogen through the solution. The prussic acid may then easily be removed by gentle heating there; remains a strongly acid liquid which expels carbonic acid from its salts with effervescence and when neutralized with potash gives crystalline mellonid of potassium. The acid is decomposed by evaporation and gives a white and somewhat crystalline mass which is only partially soluble in cold water.

Mellonid of potassium crystallizes in very fine silky white needles which are hardly to be distinguished from sulphate of chinin. It is much more soluble in hot than in cold water; insoluble in alcohol. Its solution tastes as bitter as that of sulphate of chinin, but in doses of a drachm it appears to exert no marked action either upon man or animal. Dried at 200° C., the salt has the formula $C_{18}N_{13}K_3+10Aq$ The acid salts have the formulas $C_{18}N_{13}H_2K$ and $C_{18}N_{13}HK_2+6HO$. The neutral salt fuses at a red heat without giving off a trace of ammonia and is decomposed at a higher temperature into cyanogen, nitrogen, and cyanid of potassium.

Mellonid of silver is easily prepared by double decomposition as a white precipitate. Its formula is $C_{18}N_{13}Ag_3$. In conclusion the author shows that cyameluric acid in its dry potash salts contains no hydrogen and has the formula $C_{12}N_7O_6K_3$. The decomposition of mellonid of potassium by caustic potash solution is represented by the equation,

$$2C_{18}N_{13}K_3 + 18HO = \underbrace{2C_{12}N_7O_6K_3}_{\text{cyam. potash.}} + \underbrace{C_{12}N_9O_6H_9}_{\text{ammelid.}} + 3NH_3.$$

Ann. der Chemie und Pharmacie, xcv, 257, *Sept.*, 1855.

3. *On fulminuric acid, a new cyanic acid.*—In experimenting upon fulminate of mercury, Liebig remarked that this body by long boiling with water changes color and gradually loses its fulminating properties. The investigation of this change led to the discovery of the acid which forms the subject of the present notice and which Liebig terms fulminuric acid. The new acid is formed from 3 equivalents of fulminic acid just as cyanuric acid is formed from 3 equivalents of cyanic acid. While however cyanuric acid is tribasic, fulminuric acid is unibasic.

When freshly prepared, well washed, and still moist fulminate of mercury is boiled for a quarter of an hour in a glass flask with a very dilute solution of an alkaline chlorid, the fulminate is completely dissolved. In a short time, decomposition commences and oxyd of mercury separates with a bright yellow color. The clear solution is to be filtered and a solution of sal-ammoniac added which throws down the remaining mercury as white precipitate. The solution after filtration and concentration gives crystals of the fulminate of the alkali the chlorid of which was employed. The author represents the reactions in these cases by the two following equations.

$$3CyO, HgO + 3MCl = 3CyO.MO + 3HgCl = 3CyO\left.\begin{matrix}2HO\\MO\end{matrix}\right\} + \left.\begin{matrix}HgCl\\2MCl\end{matrix}\right\} + 2HgO.$$

The formula of the acid dried at 100° is $C_6N_3H_3O_6$ or $C_6N_3H_2O_5 + HO$, the salts are $C_6N_3H_2O_5 + MO$.

Fulminurate of potash crystallizes in long prisms of high lustre and strong refractive power. It is anhydrous. The fulminurates of ammonium, baryta and silver and the basic fulminurate of lead have respectively the formulas,

$C_6N_3H_2O_5 + BaO + 2Aq$ $\qquad$ $C_6N_3H_2O_5 + NH_4O$.

$C_6N_3H_2O_5 + AgO$

$C_6N_3H_2O_5 + PbO + PbO$

Fulminuric acid is easily prepared by decomposing the lead salt by sulphuretted hydrogen. The solution has a very acid taste and can be evaporated without decomposition. In a warm place the acid becomes a solid yellowish scarcely crystalline mass. Mineral acids decompose the solution of fulminuric acid, giving a salt of ammonia with evolution of carbonic acid and forming a brown substance which was not examined. The author did not succeed in obtaining an ether of fulminuric acid.—*Ann. der Chemie und Pharmacie*, xcv, 282.

4. *Isocyanuric acid.*—Léon Schischkoff has published the results of an investigation of the action of iodid of potassium upon fulminate of mercury. These results are identical with those obtained by Liebig as above described. From the sources of information before us we are unable to ascertain to whom the first discovery of the new acid is due. In any event, the name proposed by Liebig appears to be preferable. —*Chemisch Pharmaceutischer Central Blatt*, No 45 and 46, 1855, quoting *Bullet. de St. Petersb. Class. phys. math.*, t. xiv, p. 98–112

5. *On a new and advantageous mode of preparing Aluminium.*—H. Rose has found that Cryolite, the well known double flourid of alumin-

ium and sodium may be advantageously employed in place of chlorid of aluminium in the preparation of this remarkable metal. The author recommends small crucibles of cast iron; into these the Cryolite powder is pressed with thin layers of sodium; the whole is then covered with a layer of chlorid of potassium and heated. The proportions used were 5 parts of Cryolite, 2 of sodium and five of chlorid of potassium, and the crucible was kept at a red heat for half an hour. The fused mass is to be treated with water in a platinum or silver vessel; grains of aluminium weighing half a gramme are thus obtained. These are to be cleaned and melted under a layer of fused chlorid of potassium or better of the double chlorid of aluminium and potassium. The largest yield which the author obtained was 0·8 gramme of aluminium for 10 grammes of Cryolite instead of 1·3 gr. which the mineral contains. In many cases however only 0·3 gramme or less was obtained. Rose considers these results as proving at least that it will be well worth while to make further experiments with Cryolite as a substitute for the much more expensive chlorid of aluminium employed by Deville. After commencing his investigation he found that large quantities of Cryolite were to be had in Berlin at the very low price of 3 thalers—about $2,50 —per hundred weight. It appears that the mineral was brought from Greenland to Stettin viâ Copenhagen and sold to the soap boilers under the name of mineral soda. By boiling with caustic lime a caustic lye was obtained which, as Rose observes, on account of the alumina held in solution is well adapted to the manufacture of some kinds of soap. The Cryolite proved to be of great purity.—*Pogg. Ann.*, xcvi, 152.

[NOTE.—It may be worth while to remark that kryolite would be of great value in the laboratory as a means of obtaining pure fluohydric acid for mineral analyses. On distillation with sulphuric acid, a residue of sulphate of soda and sulphate of alumina would remain which could readily be removed from the leaden or silver retort without injury to the latter. I will also here make a suggestion which I think deserves at least a few experiments from those who have it in their power to make them. By igniting a silicate with an excess of kryolite it appears very probable that the whole of the silica would be expelled in the form of fluorid of silicon, in which case the quantity of silica in the mineral could readily be calculated from the loss of weight. This promises to furnish an expeditious and accurate mode of determining silica. Iron, lime and magnesia could be estimated, if necessary, in the residual ignited mass.—W. G.]

6. *On the different methods of determining the strong or weak basic properties of an oxyd.*—Upon this subject H. Rose has published a portion of a very interesting investigation which promises to yield results of much value in analytical chemistry. In the paper before us the author treats of the behavior of different bases toward the salts of ammonium and particularly toward sal-ammoniac. With respect, in the first place, to the alkalies, Rose found that beside the hydrates and carbonates, the borates and silicates of soda decompose sal-ammoniac by boiling. Antimonate of potash forms an acid salt while a small quantity of ammonia escape. Arsenate of soda $AsO_5, +2NaO$ gives a faint smell of ammonia when boiled with sal-ammoniac, which is not the case with arsenate of potash, $A\dot{s}O_5 . KO$. The phosphates of soda

represented by the formulas $PO_5.2NaO.HO$ and $PO_5.3NaO$ easily decompose sal-ammoniac on boiling. The same is the case though in a less marked degree with pyrophosphate of soda, $PO_5.2NaO$, and even with the metaphosphate, $PO_5.NaO$. That the hydrates and carbonates of the alkaline earths are easily decomposed by boiling with sal-ammoniac is a fact with which chemists are familiar. The same is true, as Rose finds, for the borates of lime, baryta, and strontia. Phosphate of lime, $PO_5 2CaO, HO$, is with difficulty and incompletely decomposed by long boiling with sal-ammoniac. Apatite appears to undergo no sensible decomposition by the same process. The native silicate of lime, table-spar, is slowly dissolved with evolution of ammonia by boiling with the salt, but the decomposition is not complete; titanate of lime, Perofskite, is not dissolved even when finely pulverized. Oxalate of baryta is somewhat soluble when heated with a solution of sal-ammoniac but no ammonia is evolved. Oxalate of strontia is much less soluble in sal-ammoniac solution; oxalate of lime scarcely at all so. *Magnesia usta* is easily dissolved by boiling with a solution of sal-ammoniac, ammonia being given off. Even after the magnesia has been exposed to the heat of a porcelain furnace and has become crystalline in structure, it is quite readily dissolved after having been pulverized. Commercial magnesia alba and the carbonate, $MgOCO_2+3HO$, are also dissolved with great ease by boiling with sal-ammoniac. On the other hand the native carbonate, magnesite, resists the action of the ammoniacal salts very obstinately, and requires long and continued boiling. Freshly precipitated Yttria is easily dissolved by heating with a solution of sal-ammoniac, ammonia being given off. The ignited earth is less easily soluble. The same is true for the mixture of the oxyds of Cerium, Didymium, and Lanthanum, contained in Cerite. The protoxyds of manganese, zinc, and iron are in like manner easily dissolved, and the same is true for Galmei, carbonate and borate of zinc. Freshly precipitated oxyd of nickel is easily dissolved by solution of sal-ammoniac; on the other hand the ignited oxyd is dissolved with great difficulty and in very small quantity. The carbonate and borate of nickel are also readily dissolved. Oxyd of cobalt is easily dissolved in sal-ammoniac solution even after ignition, but the author did not succeed it separating it from oxyd of nickel by this means as the latter oxyd was always dissolved in part when associated with cobalt. Suboxyd of copper is easily dissolved by a solution of sal-ammoniac; the black oxyd dissolves more slowly but completely. The protoxyd and carbonate of lead are both slowly but completely dissolved on boiling with the solution. The same is true for the corresponding compounds of Cadmium. Protoxyd of tin is dissolved very slowly and only after long boiling. Oxyd of silver is rather slowly dissolved by a solution of nitrate of ammonium, but the carbonate and borate are readily soluble in the same solution. In the presence of caustic potash or of bicarbonate of soda, nitrate of ammonia converts suboxyd of mercury into metal and nitrate of the protoxyd. Protoxyd of mercury is quite easily dissolved by a solution of sal-ammoniac to a clear solution, while ammonia is freely given off. Protoxyd of Palladium easily decomposes sal-ammoniac and dissolves. The author finally cites glucina as the last of the bases which are capable of decomposing a solution of sal-ammoniac, and at the same time as the only one possessing a different atomic constitution from the bases already mentioned which enjoys this property. Glucina precipitated from its solution in carbonate of ammonia by heating is very slowly but completely dissolved by long boiling with a solution of sal-ammoniac. After ignition at a white heat, however, glucina is absolutely insoluble in chlorid of ammonium, but is completely soluble after long digestion in chlorohydric acid. In another notice we hope to give the conclusion of the author's further unpublished researches upon this subject.—*Pogg. Ann.*, xcvi, 195, *Oct.*, 1855.

7. *On quantitative determinations of sugar in urine.*—Wicke and Listing have instituted a comparison of the results obtained in the determination of diabetic sugar by fermentation, by means of solutions of copper, and by the optical method. The general result is that the copper method gives about one per cent. more sugar than the method of fermentation, and that the optical method agrees best with the latter. In the absence of any absolutely accurate process it is not easy to infer from the investigation in question which of the three methods is to be preferred.—*Ann. der Chemie und Pharm.*, xcvi, 87.

8. *On a new method of preparing Propylene.*—Dusach has presented to the Academy of Sciences a note upon a new method of preparing this gas which possesses much theoretic interest. When a mixture of an alkaline acetate and oxalate is distilled in such a manner that acetone in the nascent state is brought into contact with carbonic oxyd also nascent, there is a decomposition of the acetone and formation of carbonic acid and propylene. The reaction is represented by the equation $C_6H_6O_2 + 2CO = 2CO_2 + C_6H_6$. As the decomposition of the two salts is not perfectly simultaneous an oily matter is always produced at the same time, and the quantity of propylene indicated by theory is never obtained. It is very interesting to remark that in the reaction above given we pass from the acetic to the propionic series—from a lower to a higher organic compound.—*Comptes Rendus*, xli, 495.

9. *On the transformation of toluol into benzoic alcohol and into toluic acid.*—Cannizzaro has succeeded in obtaining the compound $C_{14}H_7Cl$ by the action of chlorine upon toluol and the fractional distillation of the products. The chlorid boils at 175°–176° C., and is identical with chlorid of benzyl. Treated with acetate of potash, chlorid of potassium and acetate of benzyl are formed, while acetate of benzyl boiled with an alcoholic solution of caustic potash gives acetate of potash and benzoic alcohol, identical with that obtained from oil of bitter almonds. When chlorid of benzyl is boiled with an alcoholic solution of cyanid of potassium, chlorid of potassium and cyanid of benzyl are formed. Cyanid of benzyl boiled with caustic potash slowly evolves ammonia and finally dissolves completely. The solution on addition of chlorhydric acid gives a crystalline precipitate of toluic acid.—*Comptes Rendus*, xli, 517.

10. *On amylic alcohol.*—Pasteur has made the very interesting discovery that raw amylic alcohol consists generally of two chemically similar but optically different bodies. One of these bodies is active and the other passive with respect to polarized light, and all the compounds of the former are active and those of the latter passive. The propor-

tions of the two species differ with the source of the alcohol. The oil which is obtained from beet-juice contains one-third of the active and two-thirds of the passive alcohol; that from molasses contains about equal proportions of both. As the two have the same boiling point or very nearly so they cannot be separated by distillation. The author finds that the only method consists in preparing a very large quantity of sulphamylate of baryta from the raw oil. The crystals do not differ in form or in chemical constitution, but one portion is about two and a half times more soluble than the other. The more soluble portion contains the active alcohol, which in a cylinder of 50 centimeters in height turns the plane of polarization about 20° to the left, while the alcohol prepared from the less soluble portions exerts no action whatever. The separation of the two baryta salts may be effected by taking advantage of the difference in their solubility and recrystallizing them 15–20 times. The active salt is concentrated in the mother liquor. It is very remarkable that the two salts are perfectly isomorphous, and that it is only the difference in their solubility which enables us to separate them. Between the two alcohols there is a slight difference in density, the active oil being about $\frac{1}{100}$th heavier than the other.—*Comptes Rendus*, xli, 296. W. G.

11. *Ultimate Analysis of certain pure Animal Oils*; by J. H. Alexander and Campbell Morfit.

		Elements.		
	Sp. Gr. at 64°·5 F.	Carbon.	Hydrogen.	Oxygen.
Winter sperm oil,	0·87971	0·76490	0·12150	0·11360
Lard oil,	0·91546	0·76658	0·10586	0·12756
Whale oil,	0·92000	0·77511	0·11430	0·11059

In mixing these oils, and probably all animal oils, no change of volume occurs. The following are the specific gravities observed at and calculated for a temperature of 65°·25 F. of equal volumes respectively mixed as under

Mixed Oils.	Spec. Gravity observed.	Sp. Gr. calculated.
Winter sperm + lard,	0·89736	0·89735
" " + whale,	0·89905	0·89962
Lard + whale,	0·91778	0·91750

If we assume as constant for all the mean of the respective factors of condensation from the original gaseous volumes into the volume of resulting liquid, we can calculate upon the sp. gravity of said liquid the proportions of the elements it should contain. The following shows the result of such a calculation for the carbon in each of the above: viz.,

	Sperm O.	Lard O.	Whale O.
Carbon calculated,	0·76118	0·78367	0·75854
do. found,	0·76490	0·76658	0·77511

The differences here between calculation and experiment, amounting to about $1\frac{2}{3}$ per cent for lard and whale oils, and $\frac{3}{8}$ per cent for sperm, are attributable, 1, to certain errors of observation; 2, to possible error in assuming the factor of condensation as constant in the different kinds of oil; and 3, to probable physical variations in the constitution of different samples of the same oil. These variations may, however, be taken provisionally as covering the whole margin indicated by the above differences.

University of Maryland, Baltimore, Dec. 1, 1855.

II. Botany.

1. *Alphonse De Candolle: Géographie Botanique Raisonnée, ou Exposition des Faits principaux et des Lois concernant la Distribution Géographique des Plantes de l'époque actuelle.* Paris and Geneva, 1855. 2 vols., 8vo.—We have here merely to announce this work, as one of the most important that has appeared of late, and one of the most generally interesting, as well on account of the subjects it treats of, as for the signal ability and thoroughness with which they are handled. Other demands upon our columns have prevented a full and early notice of these volumes. But hereafter, as time and space permit, we intend to give a detailed analysis of the work, and a discussion of some of the topics which it considers. A. G.

2. *Flora Indica; being a Systematic account of the Plants of British India, together with observations on the Structure and Affinities of their Natural Orders and Genera;* by J. D. Hooker, M.D., &c., and Thomas Thomson, M.D., &c. &c. Vol. I, (*Ranunculaceæ to Fumariaceæ,*) *with an Introductory Essay.* London: Pamplin, 1855. 8vo. —One half of this volume is occupied by the Introductory Essay, in which a series of important general topics, akin to those discussed in the introduction to Dr. Hooker's New Zealand Flora,* are treated with equal boldness and judgment, and with the same freshness and originality of illustration. These are arranged under six general heads, viz., 1. The object, scope and design of the Flora Indica. 2. General considerations connected with the study of Systematic Botany. 3. The variation and origin of species, the effects of hybridization, and the geographical distribution of species. 4. Summary of the labors of Indian Botanists. 5. Sketch of the Meteorology of India. 6. Sketch of the physical features and vegetation of the provinces of India. To which two maps are added, one of monthly isotherms, from Dove; the other a large and original map illustrating the physical geography of India and its botanical provinces. A complete alphabetical index to this part of the work is appended, as well as a detailed table of contents.

To enumerate, even, the principal points which are discussed would require a space which we are unable now to devote to this subject; Some of them we may hope to consider hereafter in other connections. Among the conclusions or suggestions that strike us as most true and timely are—the great want on the part of many naturalists of clear and logical views in respect to classification and system;—"the prevailing tendency on the part of students of all branches of natural history to exaggerate the number of species, and to separate accidental forms by trifling characters;"—the unphilosophical and detrimental character of "the modern system of elevating every minor group, however trifling the peculiarities by which it is distinguished, to the rank of a genus;" in other words, of considering every group of species to form a genus,—evincing a want of appreciation of the true value and nature of classification;—the fact that in the vegetable kingdom we do not discover that close and obvious connection between structure and function which is almost universally apparent in the animal kingdom, giving to physi-

* For an abstract of which see this Journal, vol. xvii, p. 241, 334.

ology a greater influence over classification in zoology than in botany, and offering a guide to determining the relative value of structural characters in the one kingdom which is comparatively little available in the other, but yet may not safely be neglected.

Our authors assume, as most accordant with known facts on the whole, that species are *distinct* creations, and not arbitrary assumptions of the systematists; and they adopt that idea of species which alone appears to give to them a perfectly clear and intelligible, distinct, objective existence in nature, namely,—that they consist of individuals which have originated each from a common stock. They assume not only their original, but their continued definiteness in nature; that their variations, surprising as they often are, are restricted within certain limits,—to which we may add that these limits are not *a priori* determinable. Among the causes inducing variation, or tending to produce a blended series of individual forms, if such did not exist from the beginning, they first consider the effects of hybridization; and remark that recent experiments have led to the following results:

"1. It is a much more difficult operation to produce hybrids, even under every advantage, than is usually supposed. The number of species capable of being impregnated, even by skillful management, is very few; and in nature the stigma exerts a specific action, which not only favors and quickens the operation of the pollen of its own species, but resists and retards the action of that of another; so that the artist has not only to forestall the natural operation, but to experience opposition to his conducting the artificial one.

"2. Even when impregnation is once effected, very few seeds are produced; still fewer of these ripen; and fewest of all become healthy plants, capable of maintaining an independent existence.

"3. The offspring of a hybrid has never yet been known to possess a character foreign to those of its parents; but it blends those of each;—whence hybridization must be regarded as a means of obliterating, not creating, species.

"4. The offspring of hybrids are almost invariably absolutely barren, nor do we know an authenticated instance of the second generation maturing its seeds.

"5. In the animal kingdom hybrids are still rarer in an artificial state, are all but unknown in a natural one, and are almost invariably barren."

Perhaps some of these *dicta* are too unqualifiedly stated; indeed they are manifestly intended to affirm the results to which the whole evidence points, rather than those which can be said to be thoroughly verified.

The third proposition, however, is absolutely true; and in connexion with it, well do our authors say, that all we could legitimately conclude is, that were hybrids of the general occurrence which some botanists imagine, they would have long ago obliterated all traces of species as definite creations; whereas, exceptional in art, and not proven if not almost impossible in nature, they cannot be assumed to have produced any appreciable result. There is one point, however, which our authors do not take into consideration, but which should not be overlooked, viz., what is generally admitted as a fact, that a hybrid may readily be fertilized by the pollen of either of its parents; and that if hybrid plants are occasionally produced in nature, they would ordinarily stand a very good chance of being fertilized in this way. In such cases they are said to revert to the type of the species of the impregnating parent; but would they return exactly to that type, inheriting as they do a portion of the blood of a cognate species? And where,—as not unfrequently occurs—two or more generally well-marked forms in nature are connected by certain occasional individuals of intermediate character, is it not very supposable that two species may have partially blended in this way? At any rate, here is a *vera causa*, or what passes as such, which requires to be taken into account, as has not yet been done, so far as we know. This doubtless has operated in the case of cultivated plants, and contributed, along with other causes, to the inextricable blending of certain species. But we are not disposed to exaggerate its influence in nature; since we suppose, with Dr. Hooker, that wild plants rarely hybridize! Yet the possibility, and even the probability of the occurrence must not be overlooked in a thorough discussion of the general question of the limitation and permanence of species.

However it may be as a blending influence, hybridization is far from being a considerable, or the most potent cause of the variation of species, since "the offspring of a hybrid has never yet been known to possess a character foreign to those of its parents." And we equally agree with our authors that the known facts of the case, "especially warn us not to consider the influence of climate as paramount in determining the distribution of species or the prevalence of forms," or even as the most efficient cause of variation. What the cause is that the legitimate offspring does occasionally possess a character foreign to those of its parents we are wholly unable to say: but the fact is undoubted. and perhaps of more frequent occurrence than is generally supposed, It is usual to say that the abnormal forms originate only in cultivated or domesticated individuals: it were perhaps better to say that they are perpetuated, or are favorably situated for continuation and full development, only under these circumstances, on account of the greater segregation: for of the very various species of plants which are cultivated none are free from the tendency to "sport" into races, whether of ancient or recent introduction. Why their existence is so transitory in nature, and so capable of being continued and further developed in domestication, it is not difficult to imagine. Our authors perhaps, in common with naturalists generally, do not sufficiently recognise the natural tendency to perpetuation of individual characteristics.

As regards ordinary variation between different individuals of the same species, the want of due consideration of what every good observer knows to be true, has indeed "mainly contributed to such an undue multiplication of species in the vegetable kingdom as botanists unfamiliar with large herbaria and exotic plants are slow to believe, and to the exaggerated estimates of the supposed known extent of the vegetable creation that gain common credence." Our authors believe that the number is swelled one-third beyond its due extent by the introduction of bad species founded on habit, and on accidental variations produced by soil, exposure, &c.; and, we would add, on the imperfection of the materials from which the greater part of the species that crowd our books were originally described, most of them without due elaboration of already published species, and drawing after them an ever lengthening train of nominal species, founded on mere guesses at supposed differences from vague and incomplete descriptions, without any collocation of specimens.

We have already exceeded our limits, while yet at the beginning of Drs. Hooker and Thomson's interesting and suggestive volume. We regret that we must omit all notice of their remarks upon *habit* as indicating specific difference, which, contrary to the general view, they regard as "most deceptive,"—and must pass over their important section upon geographical distribution in general, and its dependence upon specific centres. We only add, that whoever would attain a clear comprehension of the configuration, the diverse climates, and the general botanical geography of those extensive and widely varied regions which are comprised, and in most minds confused, under the general name of India, has only to study the admirable sections on the Meteorology of India, and on the Physical features and Vegetation of its provinces which occupy a large portion of the Introductory Essay. The present commencement of the Flora itself, although comprising only 15 natural orders, is also an inviting subject for extended comment and almost unqualified commendation. A. G.

3. *Bryologia Britannica;* containing the Mosses of Great Britain and Ireland, systematically arranged and described according to the method of Bruch and Schimper, with illustrative plates: being a new (third) edition, with many additions and alterations, of The Muscologia Britannica of Messrs. Hooker and Taylor; by William Wilson. London: Longman, Brown, Green & Longman. 1855.—Next to the admirable Bryologia Europæa of Bruch and Schimper, we consider Mr. Wilson's book the most important contribution that has, within the last thirty years, been made to Bryology. It purports to be a third edition of the well-known, and in its day, valuable "Muscologia Britannica" of Hooker and Taylor; of which, however, besides the reproduction of the original plates, more or less emended, scarcely a feature is recognisable. The work, all in the English language, has been entirely re-written, important changes made in the classification, and a very large amount of new matter added. It extends to 450 rather large octavo pages handsomely printed in small type. The well written Introduction gives, among other things, a succinct account of the andrœcium and gyrœcium of a moss;—the common Funaria hygrometrica being selected for that purpose. Next follows "an analytical Key to the genera, dichotomically arranged, and a synopsis to the Genera." The 444 species described in the body of the work are distributed into three orders, Andreæaceæ, Sphagnaceæ, and Bryaceæ; each of the first two containing but one genus; the last comprising 88 genera, arranged under 36 sub-orders or groups which have in view the collecting together of species according to their natural affinities, but are not defined, and indeed do not appear to admit of as neat and satisfactory definitions as similar assemblages in other closely related families of Cryptogamous plants; but whatever may be wanting in this re-

spect, is amply made up in the very full and complete generic descriptions. The great merit of the work, however, is to be found in the accurate, thorough and judicious manner in which the species are elaborated, evidently the result of years of sedulous and well-directed investigation;—nothing is stated on the authority of others, every thing is submitted to the test of the dissecting-knife and the microscope. Throughout the work are found many valuable observations on species belonging to other Floras than the British. The "illustrative plates," (sixty-one in number,) containing in many cases figures of the distinctive points only of the species and sketched in outline, will be prized by the working Bryologist. A glossary of terms not in common use and an excellent alphabetical Index to generic and specific names, close the volume. W. S. S.

III. Astronomy.

1. *New Planets.*—Two more planets supposed to belong to the group situated between Mars and Jupiter, were discovered on the fifth of October last;—one by Luther at Bilk,—which has been named *Fides*,—whose R. A. at 9 P. M. of that day was 2° 25′, and Dec. +52′: and the other by Goldschmidt of Paris,—which has been called *Atalanta*,—which on the eighth of October at 7^h 15^m, was situated in R. A. 344° and Dec. −7° 30′. They were observed to have a retrograde motion of about 15′ daily.

2. *Elements of Comet* 1855, I, (Astron. Nach., 961.)—Given below are the elements of the comet discovered by Dr. Schweitzer of Moscow on the 11th of April last; they were computed from the Moscow observations of the 14th and 19th of April, and those of Hamburg and Altona of May 5.

Perihelion passage,	1855, Feb. 9.3615,	M. T. Berlin.
Long. perihelion, -	224° 45′ 23″	App. eqnx.
" asc. node, -	189 39 8	April 19.
Inclination, - -	51 18 45	
Log. q, - - -	0·34623	
Motion retrograde.		

3. *Elements of Leucothea* (35), (Astron. Nach., 963.)—The following elements of this planet were computed by J. C. Oudemans from the Bilk observations of April 20, and those of Leyden of April 27 and May 5.

1855, May, 0.0, M. T. Greenwich.

Mean anomaly, - -	0° 26′ 5″·5	
Long. perihelion, - -	196 59 34 ·6	Mn. eqnx.
" asc. node, - -	356 20 56 ·8	Jan. 1, 1855.
Inclination, - - -	8 8 15 ·3	
Angle of excentricity, -	12 15 17 ·9	
Mean daily motion, - -	706″·337	

IV. Miscellaneous Intelligence.

1. *Eruption of Mauna Loa*, (from a letter addressed to J. D. Dana, dated Hilo, Hawaii, Oct. 15, 1855.*)—In a few days we may be called to announce the painful fact, that our beautiful Hilo is no more—that our lovely, and inimitable landscape, and crescent-bay are blotted out. A fiery sword hangs over us. With sure and solemn progress the glowing lavas advance through the dark forest and dense jungle in our rear, cutting down ancient trees of enormous growth and sweeping away all vegetable life.

For sixty-five days the great summit furnace on Mauna Loa has been in awful blast. Floods of burning desolation have swept wildly and widely over the top and down the sides of the mountain. The threatening stream has overcome every obstacle, winding its fiery way from its high source to the bases of "the everlasting hills," spreading in a molten sea over the plains—penetrating ancient forests—driving the bellowing herds, the wild goats and the affrighted bird before its lurid glare—consuming all vegetable life with its sulphureous breath, and leaving nothing but blackness and ruin in its track.

On the 12th of July, I wrote you on the state of old Kilauea,† and on the 27th of Sept., I announced to our mutual friend, Mr. Lyman, the fact and the state of our present eruption. Having made my quarterly pastoral tour I started on the second instant for the scene and the source of the eruption which is the theme of this letter. Our party consisted of Lawrence M'Cully, Esq.—a graduate of Yale and our present acting magistrate, four natives and myself. Taking the channel of the Wailuku (the stream which enters Hilo bay) as our track, we advanced with much toil, through the thicket along its banks, about twelve miles, the first day.. Here we rested at the roots of a large tree during the night. The next day we proceeded about twelve miles farther, for the most part along the bed of the stream, the water being low. During both of these days volcanic smoke had filled the forest and given the rays of the sun a yellow and baleful hue.

At night, when the shades gathered over those deep solitudes, unbroken except by the bellowing of the untamed bull, the barking of the wild dog, the grunt of the forest boar, the wing and the note of the restless bird, the chirping of the insect, the falling of a time-worn tree, the gurgling of the rill and the wild roar of the cataract, we made our little bed of ferns under the trunk of a prostrate tree, and here, for the first time, we found that the molten stream had passed us by, many miles, on its way toward Hilo. But as its track was several miles to the left of us, and as the jungle here was nearly impenetrable, we proceeded the next day, up the stream, and at half-past one P. M., found ourselves fairly out of the forest, having been a little more than two and a half days in accomplishing this part of the tour.

I cannot stop to describe the beautiful and romantic scenery along our winding valley gorge, the cascades, basins, caves and natural bridges of this wild and solitary stream. Nor can I speak of the vel-

* Received from Rev. Mr. Coan, Dec. 18th, just before closing this number.

† See this Journal, page 100.

vet mosses, luxuriant creepers hanging in festoons, the ancient forest trees and other tropical glories which were mirrored in its limpid waters. We needed an artist and a naturalist to fix the glowing panorama, and to describe its flora and fauna. Wild cattle, dogs and hogs of the mountains have penetrated these forests and have appeared, of late, on the very confines of improvements within five miles of our bay.

But to proceed. When we emerged from the upper skirts of the woods on the third day, a dense fog obstructed our view of all distant objects. We encamped early in a cave, but during the night the stars came out and we could see the play of the volcanic fires from the summit to the base of the mountain and far down in the forest toward Hilo. The next morning, Friday, we left our cavern early, and at half past seven A. M. came to the smouldering lava-stream. From this time to ten A. M., we walked on the right border of the stream, when we crossed over to the opposite side. This occupied us an hour and a quarter, and we judged the stream to be three miles wide at this point, which, however, was one of its "*narrows*." In some places it spread out into wide lakes and seas, apparently from five to eight miles broad, enclosing, as is usually the case, little islands, not flooded by the fusion. Passing up the southern verge of the stream we found many trees felled by the igneous current, and lying crisped and half charred upon the stiffened and smoking lava. All this day we passed up the stream, sometimes on it and sometimes along its margin, as the one or the other track was the easier or the more direct. At night we slept upon the lava, above the line of vegetation, with the heavens for our canopy and the stars for our lamps. From this high watch-tower we could see the brilliant fire-works far above and far below us, as the dazzling fusion rushed down its burning duct, revealed here and there by an opening through its rocky roof, serving as a vent for the gases.

Early on Saturday, the 6th, we were ascending our rugged pathway amidst steam and smoke and heat which almost blinded and scathed us. At ten, we came to open orifices down which we looked into the fiery river which rushed furiously beneath our feet. Up to this we had come to no open lake or stream of active fusion. We had seen, in the night, many lights like street lamps, glowing along the slope of the mountain at considerable distances from each other, while the stream made its way in a subterranean channel, traced only by these vents. From 10 A. M. and onward, these fiery vents were frequent, some of them measuring ten, twenty, fifty or one hundred feet in diameter. In one place only, we saw the river uncovered for thirty rods and rushing down a declivity of from 10° to 25°. The scene was awful, the momentum incredible, the fusion perfect (a white heat), and the velocity forty miles an hour. The banks on each side of this stream were red-hot, jagged and overhanging, adorned with burning stalactites and festooned with immense quantities of filamentose, or capillary glass, called "Pele's hair." From this point to the summit crater all was inexpressibly interesting.

Valve after valve opened as we went up, out of which issued "fire and smoke and brimstone," and down which we looked as into the caverns of Pluto. The gases were so pungent that we had to use the greatest caution, approaching a stream or an orifice on the windward side and watching every change or gyration of the breeze. Sometimes whirlwinds would sweep along, loaded with deadly gases, and threatening the unwary traveller. After a hot and weary struggle over smoking masses of jagged scoria and slag, thrown in wild confusion into hills, cones and ridges, and spread out over vast fields, we came at 1 P. M., to the terminal or summit crater.

This we found to be a low, elongated cone, or rather, a series of cones, standing over a great fissure in the mountain. Mounting to the crest of the highest cone, we expected to look down into a great sea of raging lavas, but instead of this the throat of the crater at the depth of one hundred feet, was clogged with scoria, cinders and ashes through which the smoke and gases rushed up furiously from seams and holes. One orifice within this cone was about twenty feet in diameter, and was constantly sending up a dense column of blue and white smoke which rolled off in masses and spread over all that part of the mountain, darkening the sun and obscuring every object a few rods distant. So toppling was the crest of this cone, so great the heat, and so deadly the gases, that we could find no position where we could look down the throat or orifice; and could we have done so, it is not probable that we should have seen the deep fountain below us, as the lavas were forced up its horrid chimney from the burning bowels of the earth. I have no doubt that the point at which the igneous river flowed off in its lateral duct was at least five hundred, perhaps a thousand feet below us.

The summit cone which we ascended was about one hundred feet high, say five hundred feet long and three hundred broad at base.

Several other cones below us were of the same form and general character, presenting the appearance of smoking tumuli along the upper slope of the mountain. As you descend the mountain these cones become lower and less frequent, but here they are the rims or jagged jaws of those orifices through which we look into that subterranean tube of angry fusion which hurries with such fearful speed down the side of the mountain.

The molten stream first appears some ten miles below the fountain crater, and as we viewed it rushing out from beneath the black rocks, and, in the twinkling of an eye, diving again into its fiery den, it produced indescribable feelings of awe and dread.

This summit crater I estimate at *twelve thousand feet elevation*; the principal stream (there are many lesser and lateral ones) including all its windings, sixty miles long; average breadth, three miles; depth, from three to three hundred feet, according to the surface over which it flowed.

Late on Saturday afternoon we came a short distance down the mountain, when we encamped on the naked rocks until Monday.

Unwittingly we passed the last watering place in our ascent, on Friday morning, at seven o'clock, and having only one quart in our canteen, this was our whole supply until 9 A. M. on Monday. There being six of us, we were soon reduced to a single spoonfull each, and this only at our meals. Our food being dry and hard, we suffered not a little, for want of nature's beverage. The dew which fell upon our garments, our food-buckets and the rocks around us congealed and became frost or thin scales of ice, and from our oil-cloth, spread for the purpose, we collected a few spoonsfull of the latter, while our parched lips readily kissed the rocks to obtain a little moisture from the frost. There was snow on another part of the mountain, far below us, but it was not in our track. The fires had melted all in this region.

The present eruption is between those of 1843 and 1852, and from our high tower we could see them both and trace their windings.

Early on Monday we decamped and set our faces for Kilauea, distant some thirty-five miles, hoping by a forced march to reach it at night.

At eight A. M., we passed the seat of the grand eruption of 1852, and travelled for miles in its cinders. A little steam, only, issues from that cone whose awful throat, in 1852, sent up a column of glowing fusion to the height of a thousand feet.

At the base of this cone, on the opposite side, the ground was thickly powdered with a hoar frost, and so intense was our thirst that our whole party lay down together and eagerly licked it from the rocks and sand.

At nine we found water, for which we gave heartfelt thanks to our great Shepherd. At one P. M., a dense fog obscured our track, our guide lost his way, and we were obliged to encamp.

Early on Tuesday morning we were astir, wandering through jungle and over rough fields of scoria, when fortunately, at half-past nine we found the only track which could lead us out of this cruel labyrinth.

At half-past one P. M., we reached old Kilauea, where we regaled ourselves on Ohelo berries, water, and such stores as were left in our larder.

The next day we explored Kilauea, made some measurements, collected specimens, etc., and on Thursday the 11th inst. we reached Hilo, having been absent ten days. Kilauea is still very active, though not as intensely so as in months past.

On the mountain and in Kilauea I took the angles of several lava streams, one of 49°, another of 60°, and two of 80° each. Several streams on the mountain flowed down banks of scoria twenty-five and thirty feet high.

The fusion was complete—the streams cooled in a perfect state.

I also saw thin strata, say one inch thick or less, which had flowed down the face of perpendicular rocks, adhering to the rocks like paste, and thus cooling. Will you say that I spoil my demonstration by *proving too much*, when I assert that I saw more than one place where the fusion flowed on an angle of 95°—like the Indian's tree which grew so bolt upright that it "leaned the other way," thus flowing down a rock or bank until it came to where said rock *retreated*, it would follow the inward curve in a thin layer like molasses, adhering to the rock and thus cooling. It is therefore a fact capable of entire demonstration that our Hawaiian lavas flow freely down every slope, from an angle of 30′ to a perpendicular—in the latter case in a very thin layer of course. At one point we saw the great igneous river flowing like oil down an angle of 35°, and in another place it leaped a precipice, forming a brilliant cascade.

But I lack time and space to tell you half which we saw, and heard and felt.

Hilo is now in a state of solemn and thoughtful suspense. The great summit fountain is still playing with fearful energy, and the devouring stream rushes madly down towards us. It is now about ten miles distant—nearly through the woods, following the right bank of the Wailuku, and heading directly for our bay.

Some are planning—some packing—many running to and fro and all talking and conjecturing. Never was Hilo in such a state before. And all is hushed, and solemn.

Daily messengers go up to the fire, mark its progress and report. Nothing but the hand of Omnipotence can arrest its fearful progress, and save our beautiful town from utter desolation.

Oct. 22.—I have retained this letter until the present time, to watch the progress of the lava stream and to report more definitely: and I am happy to say, that, as yet our fears have not been realized. The great summit crater still pours out its burning floods with unabated energy, and the atmosphere of the island is still loaded with smoke; every thing looks dingy, often baleful. The stream of fusion still glows and groans in the forest between us and Mauna Loa; but its intensity seems a little abated and its progress retarded. Probably it is partially obstructed or diverted in its subterranean passage, while the basins, ravines, gorges, etc. it fills in the woods, together with the great forest which it must consume, render its progress very slow. Consequently the apprehensions of our people are much abated. There has been nothing like panic from the beginning, either among foreigners or natives; but there was an anxious look, an inquiring tone, a serious concern among all classes. These have greatly subsided: not that the fire is extinct, or that it is not nearer than it was two weeks ago; but simply that its progress for the last week has been almost imperceptible. Still it may come when least expected. Should it succeed in pushing through the woods it will then flow down on an angle of from 1° to 2° with little to obstruct it; or, should it dive into subterranean chambers, it may burst out unexpectedly near our shores.

I have said that daily messengers went up to the fire and reported its progress. This plan we commenced; but it has not been fully carried out. Several natives have been up at different times and reported the point where they found the stream. But their reports have conflicted and have not been entirely reliable. A foreigner went up a few miles and returned. Others have talked of going, but rains, flooded streams and other obstacles have hindered, and an apparent abatement of action at the point nearest us has cooled the ardor of some who had thought to have visited the scene.

I am hardly rested from the extreme fatigue of my recent tour, and so many are my professional and domestic duties, that I have found no time, as yet, for another exploration; but, should the weather and all things favor, I purpose to start next week out through the jungle and not return without definite knowledge as to the state of the stream and its distance from our town.

It is now seventy-two days since the eruption commenced, and, as remarked before, the fountain is in full force. The matter disgorged is of the same general character as in former eruptions. We saw nothing new. Among the salts, sulphur and sulphate of lime, are the most abundant. They are scattered freely at several points along the line of flow.

We cannot determine satisfactorily that there is a sympathy between this mountain crater and old Kilauea. In my last letter I have stated that the latter was intensely active during the latter part of May and the early part of June. After this the action gradually moderated until the summit crater broke out, and it remains now much as it was then. There are now about a dozen open lakes of raging lavas in Kilauea, extending in two semi-circular lines from the great fountain lake—*Halemaumau*—along the eastern and western sides of the crater, and evidently forming vents to igneous subterranean canals which are carrying the incandescent floods from this great active vent to the northern parts of the crater, sometimes overflowing this region and sometimes heaving up the ponderous superincumbent strata, like the surface of an agitated ocean. The great dome over Halemaumau, is swept away, and a raised and jagged rim from 20 to 60 feet high, now encircles it. The fusion may be 100 feet below. The movement of the streams northward, is distinctly seen through the valves or vents mentioned above. The great central plateau, of 200 feet elevation, as mentioned in my last letter, is now nearly covered with fresh lava from the overflowing of its fiery zone—or of that half which surrounds it, and to which the recent action has been confined. This belt or lava zone has been raised from 100 to 200 feet since April, 1st, by uplifting forces; 2d, by successive overflowings.

The commencement of this eruption is mentioned in an earlier letter from Mr. Coan, addressed to Rev. C. S. Lyman, of this place. It is dated Hilo, Sept. 27, 1855. He says:

"On the evening of the 11th of August, a small point glowing like Sirius, was seen at the height of 12,000 feet on the northwestern slope of Mauna Loa. This radiant point rapidly expanded, throwing off coruscations of light, until it looked like a full orbed sun." The sequel is described in the letter above.

2. *Earthquake at Japan*, (Asiatic Society, in "Overland China Mail.")—Dr. Macgowan read a paper *on resent Physical Phenomena in China and Japan.* The communication related to the Earthquake at Simoda, which appears in many of its features to have resembled that which destroyed Lisbon in 1775, when the lakes of Scotland were suddenly elevated, and the sea at Maderia rose to a prodigious height.—Thus, the late earthquake at Japan was followed by a rise of the inland waters of Chihkiang in China, and by an extraordinary receding and subsequent elevation of the sea at the Bonin Islands. The appearance of "white hairs," as they are styled by the natives, following earthquakes in China, was alluded to; and it was suggested that they are a salt formed by the emission of vapor and sulphuric acid coming in contact probably with alumina in the earth. Notice was made also of the rise and subsidence of a volcanic island near Formosa in 1854; of showers of dust in the China Sea; and of the high temperature of the Formosan current. The thanks of the Society were voted to Dr. Macgowan for his valuable paper.

3. *Coal in China*, (Asiatic Society.)—Dr. Macgowan gave some information relative to a journey he had lately made to the Bohea hills, in the interior of Fŭhkeen province, to examine the anthracite mines in the coal measures of that district, near the head of the "Nine Drag-

on" river. The mineral is sometimes found equal to the best American variety, and can be landed at the port of Amoy at \$4½ per ton. At present, only a small quantity is produced, chiefly however on account of the limited demand that exists for it, as the natives employ it only in the burning of lime; the smelting furnaces of the adjacent iron mines not being furnished with a sufficiently powerful blast to allow of anthracite being used in them. He could not speak positively of the extent of the coal fields, but, judging from the enquiries he had made, he thought any amount might be procured, especially when the natives become better acquainted with the art of mining. Dr. Macgowan remarked, that at this time, when the steam navigation of the Chinese waters is becoming so much extended, every accessible locality of coal becomes extremely important, and should be visited and explored as far as possible.

Specimens of the coal and accompanying shales were exhibited, and Dr. Harland stated that some fragments of fossils in the specimen of the "*Under-clay*" which he had examined, appeared to be identical with similar remains of *Stigmariæ* from corresponding strata of the carboniferous series of England and the United States.

4. *On Raindrop marks;* by J. Wyman, (Proc. Bost. Soc. Nat. Hist., Nov., 1855, p. 253.)—Prof. Wyman's investigations show that ordinary rain-marks are characterized by the existence of radiating lines around the circumference of the impressions; which are caused by fragments of the drops, as they are dispersed, often impinging upon the plastic surface.

If a mass of water is thrown into the air, and allowed to fall on soft clay, the form of the impression will depend upon the condition of the drops at the time of contact. In descending, the drops assume the following forms, viz.: first, that of a flattened sphere; second, that of a cup with the concavity downwards; third that of a ring; and fourth, those of two or more spheres formed by the rupture of the ring.

If the sphere be above a certain size, the impression presents a reticulated appearance in the centre, with radiating lines around the circumference. The impression formed by the cup is reticulated in the centre without radiating lines. The ring forms an impression corresponding with its shape, with radiating lines on its inner border, and sometimes on its outer border.

Prof. Wyman thought that rain-marks could be distinguished from those of spray.

The rain-mark is modified by the condition of the surface on which it strikes; if the latter is hard, or of coarse material, the minuter details are not shown. On examining the fossil rain-marks, he had not found that the radiating lines were preserved. They were doubtless destroyed by the drifting in of the new material by which they were covered up. In other respects, they resembled recent rain-marks, and could be accounted for in no other way, than by the contact of drops of falling water.

5. *New mode of cleaning Diatomaceous deposits;* by Prof. J. W. Bailey.—Having found the following method of cleaning diatomaceous deposits, more speedy and efficacious than any other I have tried, I re-

commend it to all those who may have occasion to prepare specimens of the *siliceous* organisms in soundings, guano, mud, &c. Dissolve out the lime compounds, if present, by means of nitric or chlorohydric acid, wash and filter. Then put the moist contents of the filter into a porcelain capsule with enough strong *sulphuric acid* to make of the whole a fluid mass. Heat the capsule over a spirit lamp until the organic matters are all charred, and continue the heat until strong acid fumes are evolved. Keep the capsule hot, and add in minute portions at a time finely powdered *chlorate of potassa.* If the acid is hot enough to give off fumes, the chlorate will be immediately decomposed without the accumulation of explosive gases, and it will exert so powerful an oxydizing action that in a few moments a carbonaceous material as black as ink will become perfectly clean and colorless. Nothing now will remain to be done, but to wash off the acid which is best done by the addition of water and repeated decantations. I also would advise that the materials thus cleaned should not be dried, but should be kept in bottles with a little alcohol, which prevents their felting together, and does not allow the growth of the byssoid plants which often develop in water.

It is necessary to caution those not familiar with chemistry against using the chlorate of potassa with sulphuric acid in any other way than above directed, as violent and dangerous explosions might result. The process as above given is perfectly safe, and very effective.

6. *Influence of light on the disengagement of carbonic acid by animals*, (L'Institut, No. 1132.)—M. J. Moleschott has placed some frogs in a glass tube and exposed them to a current of air containing no carbonic acid, first exposed to reflected sun-light, and then in the dark. He finds that the quantity of carbonic acid given out by the frog in the reflected light is one-quarter more than in the dark, other conditions being the same. The same experiment repeated on a rainy day obtained hardly an appreciable difference between the amount of carbonic acid given out and that in the dark.

7. *Fall of Meteoric Stones.*—A fall of meteoric stones took place near Bremervorde a short distance from Hamburg, on the 13th of May last, at 5 o'clock, P. M. It took place during a storm accompanied by thunder and lightning. A number of the stones have been found. One of them weighed nearly 7 lbs., another 3⅓ lbs., a third two-thirds of a pound. They were covered with a black crust apparently the effect of fusion. In the fracture, the stone has a gray color, and shows se veal minerals, among which there is a large quantity of native iron and pyrites.

8. *Rotascope of Prof. Walter R. Johnson.*—This instrument described by the late Prof. Johnson in the 21st volume of this Journal, 1832, has been recently noticed in a paper in L'Institut for Nov. 15, 1855, (Paris,) in an article describing Foucault's gyroscope, (see this Journal [2], xv, 263, and xix, 141). Prof. Johnson's instrument is one of great beauty and utility, as a means of philosophical illustration; and it derives increased interest from its anticipating some of the peculiarities of the gyroscope.

9. *Zeuglodon.*—Mr. Koch, who formerly exhibited a skeleton of the Zeuglodon, in New York and other places, which has since reached

the Royal Museum at Berlin, Prussia, has recently obtained another, including the head, which he now has mounted at St. Louis. As it stands, it is 90 feet long. The bones of the former one were not all of one individual. The new one is said to be far more perfect and all of the same animal.

10. *The U. S. Naval Astronomical Expedition to the Southern Hemisphere, during the years* 1849–'52, Lieut. J. M. Gilliss, Superintendent, with Lieut. A. MacRae, Acting Master S. L. Phelps, and Captain's clerk E. R. Smith, Assistants. Vol. 1.—*Chile, Its Geography, Climate, Earthquakes, Government, Social Condition, Mineral and Agricultural Resources, Commerce, &c.;* by Lieut. J. M. Gilliss, A. M., Mem. of the Amer. Phil. Soc., etc. Illustrated by maps and plates. Washington, 1855.—This important volume is the first part of the Report by Lieut. Gilliss, relating to the recent expedition to Chile. It gives in a popular style, an account of the country and its people, including details respecting the Earthquakes of that portion of South America. It presents first an account of the topography of the country, and then proceeds to its political divisions and resources, its climate, earthquakes, etc. The general reader, political economist, geographer, and historian, will find in this volume by Lieutenant Gilliss, an attractive and instructive work.

Volume II, consists of a series of Chapters connected with the results of the Expedition, as follows:

1. The Andes and Pampas, an account of two journeys by different passes across the Andes,—the Uspullata and Portillo passes—by Lieut. Archibald Mac Rae—67 pp.

2. Minerals and mineral waters of Chile, by J. Lawrence Smith.

3. A description of the Indian antiquities brought from Chile and Peru with numerous illustrations, by Thomas Ewbank.

4. Mammals, (with a fine plate of the *Chlamyphorus truncatus*,) by S. F. Baird.

Birds, (with colored plates of Falco nigriceps, Psaracolius curæus, Agelaius thilius, Sturnella militaris, Chrysomitris marginalis, Calliste cyanicollis, C. larvata, C. gyroloides, C. Desmarestii, Euphonia rufiventris, Chlorophonia occipitalis, Ericornis melanura, Scytalopus fuscus, Psittacus ochrocephalus, Bernicla antarctica, B. magellanica, Querquedula creccoides, Fuligula metopias, Phalacrocorax brasilianus,) by J. Cassin.

6, 7, 8. Reptiles and Fishes, (with figures of many species) and also descriptions of two species of Crustacea, Rhyncocinetes typus, and an Æglea, by C. Girard.

9. List of Shells brought home by the expedition, by A. A. Gould.

10. Botany, by A. Gray.

11. Palæontology: Description of a portion of the lower jaw and a tooth of the Mastodon Andium, and also a tooth and fragment of the femur of a Mastodon from Chile, by Jeffries Wyman; some remarks on the organic remains from Chile with descriptions of the Species, by T. A. Conrad.

Such contributions to knowledge are most honorable to our Government, as well as to the Expedition, and all who have here united their labors; and eminently to Lieut. Gilliss, who has carried forward his duties with ability and zeal. The Astronomical portion of the work is yet to be published.

We have room at this time only for a single citation, from Volume I.

Antuco.—An hour's ride brought them to a rough granite ridge some three hundred feet high, from the top of which the view was magnificent: in front, Antuco, black and desolate; to the southward, Sierra Belluda, a lofty, rugged, and Alpine pile, white with eternal snows, down whose sides innumerable cascades dash headlong to the valleys; to the north, a lower though picturesque range of mountains; and at their feet the river Laja, here a small but romantic stream foaming through a deep gorge, its volume augmented at short intervals by torrents that fall over nearly vertical cliffs. At the foot of this ridge they entered upon volcanic scoria, volcanic sand, ashes, and other evidences of former explosions. Over this they traveled for about three hours, to a massive stream of hardened lava, the outpouring of some previous eruption. Beyond it, there is a belt of vegetation, with grass and wild strawberries; and a little farther on, another though a smaller stream of scoriaceous lava. Ascending the cone of an extinct crater, perhaps three hundred feet high, the new crater was immediately before, and the lake of La Laja below them, to the eastward. Here they intended to have passed the night, in full view of the burning mass; but a sudden storm of rain drove them to the trees for shelter. From thence they witnessed the glare, but heard no explosions during the night; and early on the following morning ascended a hill, from which there was a better view than was permitted from that to which the rain had driven them.

Antuco is a regular cone, with sides inclined at an angle of 45°. It is covered with snow perpetually for about one-third of the distance from its apex downwards; and showers of sand and ashes, thrown out at intervals, keep it blackened. Though perceptible at no great distance, the light and smoke from its summit are incessant, and have been witnessed from time immemorial. The last eruption formed two small craters, about two-thirds of the height of the mountain up the northern side; and the current of descending lava has dammed up the outlet of the lake by a solid wall more than 250 yards wide and 15 yards thick. This is black as the volcano itself, and, with the other analogous masses in the vicinity, presents a grand, almost terrible, scene of desolation. In the midst of snow-peaked mountains, without a tree on its margin, or a fowl on its surface, the lake seemed lifeless; indeed, the whole locality was apparently marked for the display of nature's wildest phenomena—a gloomy and inhospitable region, whose silence is rarely broken except by the thunders of the volcanos, the violence of storms, or the whoops of wandering Pehuenches.

The eruption had nearly ceased when they arrived. There were occasional small descending streams like molten iron, but no violent outbursts. At the same time there was heard a noise resembling the rolling of a cart-load or rather of a hundred cart-loads of iron over a rough road, as if broken masses of rock were jostling one another in a war for supremacy in the bowels of the earth.

11. *Spherical Astronomy;* by W. H. C. Bartlett, LL.D., Prof. of Nat. and Ex. Phil., at West Point; pp. 465. New York, 1855: A. S. Barnes & Co.—This work is worthy of the present state of the science, and as a text-book for the higher classes in colleges, it has no equal in this country and perhaps none in the language.

The peculiarities of the work seem to be these: instead of the geometrical explanations, to which we have been accustomed in our Astronomical text-books, of various phenomena such as the tides, the stations and retrogradations of the planets, their phases, and the changes of the seasons, the author deduces the effects analytically, and the explanation is contained with great neatness in the analytical formulæ and their interpretation. The elements of the planetary orbits are deduced with much conciseness and beauty, the more difficult investigations being made in the Appendix and their results introduced in the text. The great improvements of modern science in this particular are here brought within the reach of every diligent student.

In explaining the projection of a solar eclipse, the author leaves the observer upon the earth instead of obliging him to transport himself to the sun. Obviously, the first is the superior method of explanation; while for a complete investigation of the whole subject of eclipses, Mr. Woolhouse's paper is published in the Appendix.

We really possess in this work what the author has endeavored to present, "a concise course of Spherical Astronomy in its relationship to Celestial Mechanics, of which it is the offspring."

The book is very handsomely published. Several well executed plates of instruments, of planets and remarkable nebulæ add much to its value and beauty.

12. *Report of the Superintendent of the Coast Survey, showing the Progress of the Survey during the year* 1854; 92 and 288 pages, 4to with 58 maps and plates. Washington, 1855.—The Annual Report of the Coast Survey, besides being an announcement of the progress of the survey, illustrated by maps, has become a repository of researches in Physics—researches carried on through the personal labors of Prof. Bache, and an able corps under his direction. The tides, oceanic currents, and modifications produced from year to year on the ocean's borders, are among the grandest problems before us relating to our planet. Their study falls necessarily into connection with a Coast Survey; and no part of the duties require profounder attainments in physical science. These subjects are receiving full investigation, in the Survey, and the Report for 1854 contains many maps and pages of text illustrating the important results thus far reached—results which have an immediate practical bearing as well as scientific interest. Some of these papers from this and others of these Reports are cited in the early part of this number. The volume also exhibits great progress in the Surveys; and the maps published are numerous and beautiful.

13. *Results of a Series of Meteorological Observations made in obedience to instructions from the Regents of the University at sundry Academies in the state of New York, from* 1826 *to* 1850, *inclusive:* compiled from the original returns of the annual reports of the Regents of the University; by Franklin B. Hough, A.M., M.D., Corresponding Member of the N. Y. Historical Society. Published by

Legislative Authority. 502 pp., 4to, with 3 plates and a map of the state.—Dr. Hough has performed an important service to Meteorology in his labors over this volume. All the various meteorological observations made through the state under the direction of the Regents of the University, are here reduced and tabulated, for the thermometer, winds, weather, etc., and apparently with great care and skill. The present number of stations is 62. The Tables of each station are given separately, for each month through the series of years, together with a recapitulation of results, and comparisons of the Temperature, Winds, Rains, etc.—After thus going through with all the stations, there is a general summary for the state in several different tables. There then follows, a detailed table of Auroras, made out both from personal observations and from data gathered from various sources at home and abroad. Both their frequency at stations and the extent of particular Auroras are mentioned as far as ascertained, and besides, descriptions of some of special note. The observations of Capt. Lefroy and others in Canada are included, so that the tables have a continental value. The volume is a beautiful specimen of typography and is every way creditable to the state under whose patronage Dr. Hough has carried forward his labors.

14. *Wharton and Stillé on Medical Jurisprudence.* A Treatise on Medical Jurisprudence by Francis Wharton (author of "A Treatise on American Criminal Law," &c. &c.) and Moreton Stillé, M.D, (Lecturer on the principles and practice of Medicine &c.,) Philadelphia, Kay and Brother, Law Booksellers and publishers. 1855. 8vo, pp. 815. —This is an original and truly valuable work reflecting much credit on its authors and upon this department of American science. The learned treatise of Dr. Beck upon the same subject has long been justly esteemed by those whose duties as teachers or medical jurists have led them to study its contents. The present work covers all the important ground occupied by the former with superior method and compactness, while it is much fuller in American references both medical and judicial. It enjoys the singular advantage of being the joint production of two authors—a jurist and a medical man, both skilled in their respective departments. The great abuse of the plea of insanity in recent times has given much importance to a critical and searching analysis of this subject. Accordingly we find more than one-fourth of the whole volume devoted to two chapters,—mental unsoundness in its legal relations, and mental unsoundness considered psychologically—in which this subject is considered in all its relations in a most able manner. Dr. Stillé in his portion of the work (of which we feel ourselves better able to speak than of the labors of his learned colleague) has shown great good sense and taste in the brief references he makes to the well known and historical illustrations of European origin, and with which all readers of Christison, Taylor and Orfila are familiar. He thus avoids encumbering the work with superfluous matter (to which, however, exact reference is made in all important cases) and makes room for new or less familiar examples and philosophical or critical analyses. It is a source of constant regret in the perusal of the present work that the untimely death of Dr. Stillé should have deprived medical science of a mind so able and well-balanced in the early morning of his usefulness.

15. *Geological Survey of Missouri—First and Second Annual Reports;* by G. C. SWALLOW, State Geologist. 204 and 240 pp., 8vo, with many plates and sections.—This volume is an important publication on the geology of the West, although the work of but eighteen months' exploration. The state of Missouri is nearly one-half larger than New York, and a complete account of its geology cannot be expected for many years. It is to be hoped that the survey may be carried to its full completion. The value of such researches to the science depend on exactness of detail and a thorough exhibition of the palæontology. The survey is developing the mineral resources of the state, bringing to light its wealth in iron, coal, lead, and other metals, in marble, building stone, materials for cements and other important purposes of the arts. The volume contains, 1st, the Report of Mr. Swallow, 207 pages; 2d, the Reports of Dr. Litton, Mr. Meek, Mr. Haven and Dr. B. F. Shumard, Assistants, the last also Palæontologist. Besides the other plates, there are three plates of fossils.

16. *The Year-Book of Agriculture, or the Annual of Agricultural Progress and Discovery for* 1855 and '56, exhibiting the most important discoveries and improvements in Agricultural Mechanics, Chemistry, Botany, Geology, Zoology, etc., together with Statistics of American Growth and Productions, a list of recent agricultural publications, classified tables of American Agricultural Patents for 1854 and '55, a catalogue of fruits, adapted to the different sections the country, with a comprehensive Review by the editor of the Progress of American and Foreign Agriculture for the year 1855; illustrated with numerous engravings; by DAVID A. WELLS, A.M. 400 pp. 8vo. Philadelphia: Childs and Peterson.—This volume contains much valuable information, and is calculated to disseminate agricultural knowledge through the country. The book is of a popular character, and does not enter profoundly into the chemistry of agriculture, while at the same time devoting many pages to facts in that line.

17. *Esquisse Géologique du Canada, pour servir à l'intelligence de la carte géologique et de la collection des Minéraux économiques envoyées à l'Exposition Universelle de Paris*, 1855; by W. E. LOGAN, Member of the Royal Society of London, etc., and T. STERRY HUNT, Member of the Geological Society of France, &c. 100 pp., 12mo. 1855. Paris: H. Bossange et Fils.—This volume on the geology of Canada, by Messrs. Logan and Hunt, is intended as explanatory of a geological chart of Canada now in course of publication at Paris, and of the Canada geological collections at the Paris Crystal Palace. The government of Canada with great liberality have sent a full and most interesting representation of the mineral and other products of the country to the Paris exhibition, and Mr. Logan and Mr. Hunt are in Paris in connection with the Canada commission. The progress of the Geological survey of Canada has always been viewed with great interest in this country and abroad, and with much satisfaction that it is in the hands of those so able and so determined to make it a thorough survey. The work though brief, gives an excellent outline of the geological features and formations. The map, we have reason to believe, will be a fine one, in style much in advance of the geological maps of this continent hitherto published.

OBITUARY.

Dr. T. Romeyn Beck.—We are pained to announce the death of Dr. T. ROMEYN BECK, which occurred at Albany, N. Y., November 19, 1855. He was born in Schenectady, N. Y., Aug. 11, 1791, and graduated at Union College in 1807. He studied medicine, and in 1815 he was appointed Professor of the Institutes of Medicine in the College of Physicians and Surgeons of Western New York. In 1817 he was appointed Principal of the Albany Academy, which place he held at the time of his death. He was also for many years Secretary of the Board of Regents of the University of the State of New York. He was distinguished for his cultivation of the liberal sciences, but is most widely known by his valuable treatise on *Medical Jurisprudence,* a work which has passed through four editions in America, and four in England, and has been translated into the German.

STRAY LEAVES FROM THE BOOK OF NATURE: by M. Schele de Vere, of the University of Virginia. 291 pp., 12mo. New York: G. P. Putnam & Co.

J. W. DAWSON: Acadian Geology. An account of the Geological Structure and Mineral Resources of Nova Scotia, and portions of the neighboring Provinces of British America. Small 8vo. 1855. Edinburgh: Oliver & Boyd.

W. S. SYMONDS: Old Stones; Notes of Lectures on the Plutonic, Silurian and Devonian Rocks in the neighborhood of Malvern. 12mo. Malvern, 1855.

AMEDÉE BURAT: Geologie appliquée: Traité du gisement et de l'exploitation des minéraux utiles. 3d edition, 2 vols. Paris.

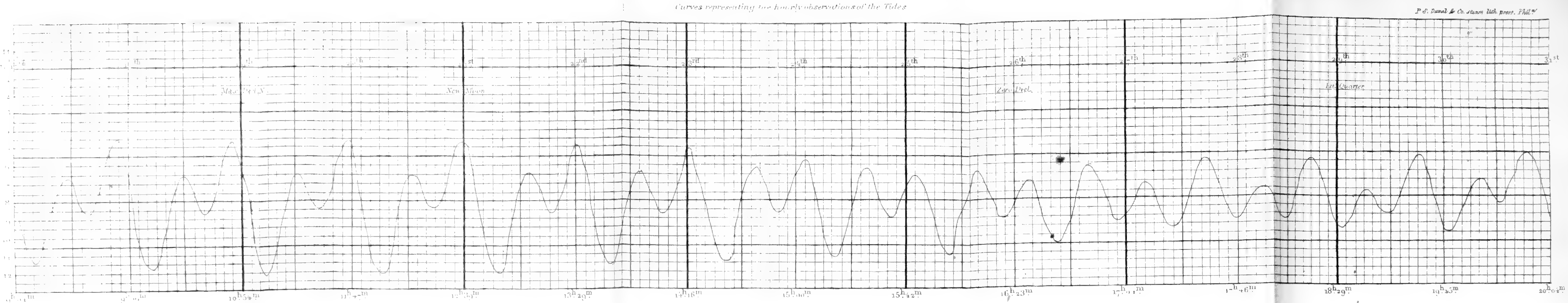
PICTET: Traité de Paléontologie, 2d edition. Third volume, with plates in 4to. Paris: Bailliere. One more volume completes the work.

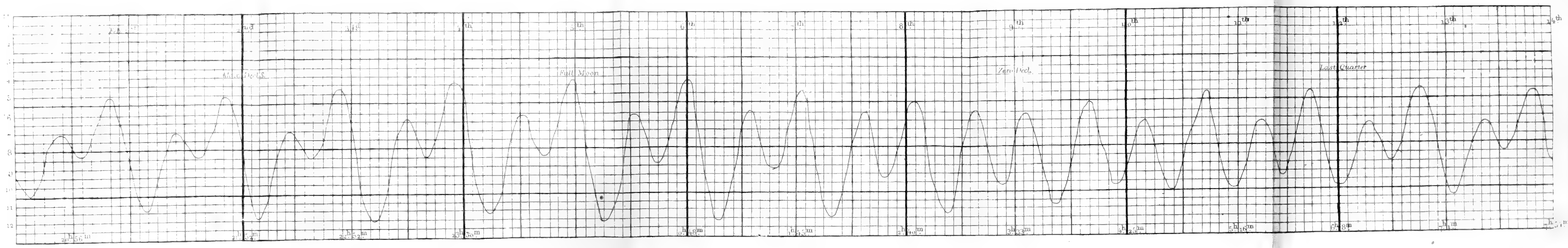
REPORT OF THE TWENTY-FOURTH MEETING of the British Association for the Advancement of Science, held in Liverpool in September, 1854. London. 440 and 190 pages, 8vo.—326 pages of this volume are occupied by the Third Report on the facts of Earthquake Phenomena, by Robert Mallet.

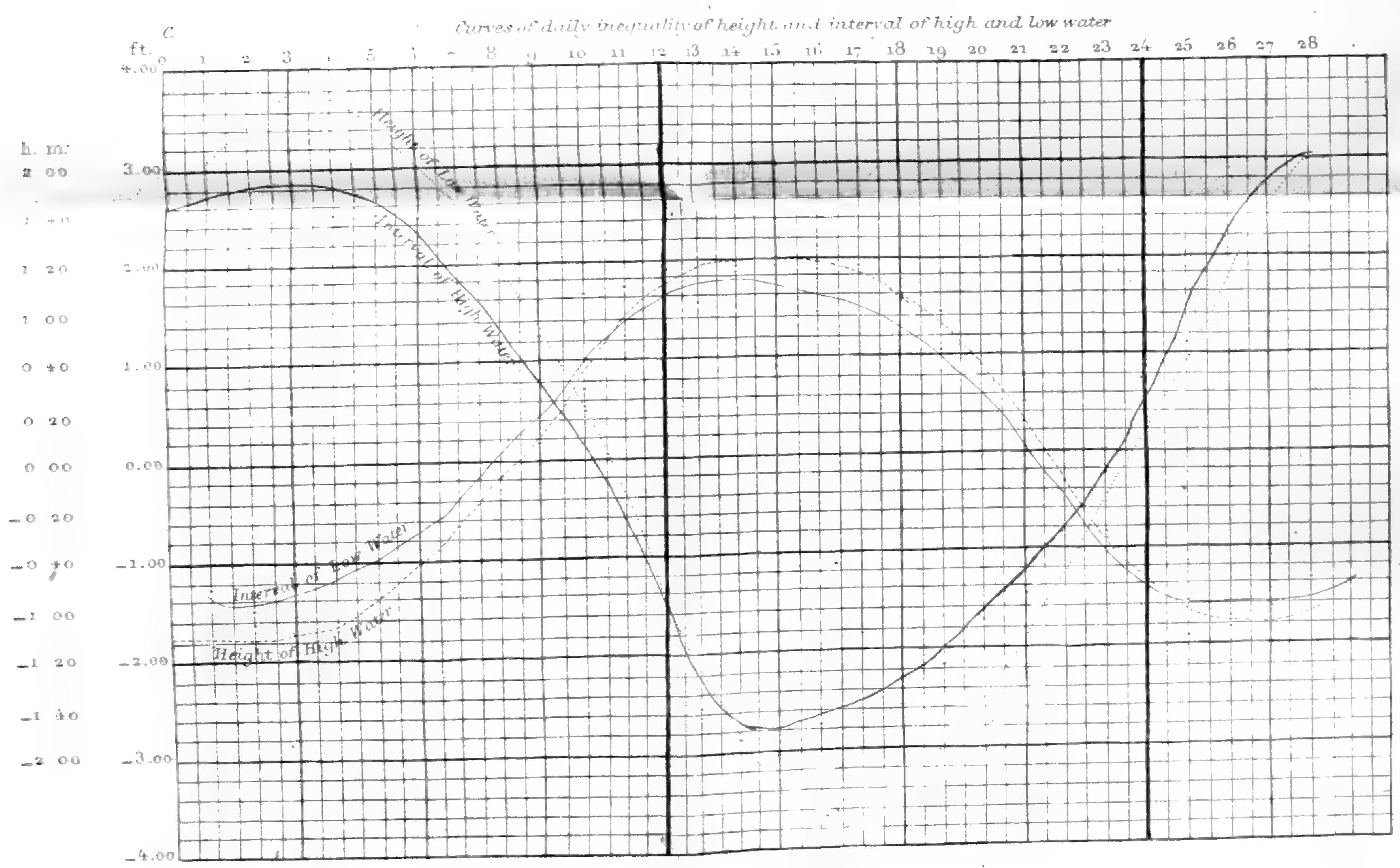
BOSTON SOCIETY OF NATURAL HISTORY. Vol. V. OCTOBER.—p. 226, Laterite in India; *F. Mason.*—p. 228, Descriptions of new freshwater shells, (species of Unio, Anodon, Cyclas); *A. A. Gould.*—p. 231, Note on the Improvement of Sycamores. —p. 232, On different kinds of steel; *C. T. Jackson.*—p 224, Notes on an Opate Indian; *Kneeland.*—p. 238, Fossil bones of the Connecticut valley; *J. Wyman.*—NOVEMBER.—p. 242, Notes on the Geology of parts of New Brunswick and Nova Scotia; *C. T. Jackson.*—p. 250, On the existence of native iron in a malleable state in Liberia, Africa; *A. A. Hayes.*—p. 253, On rain-drops; *J. Wyman.*

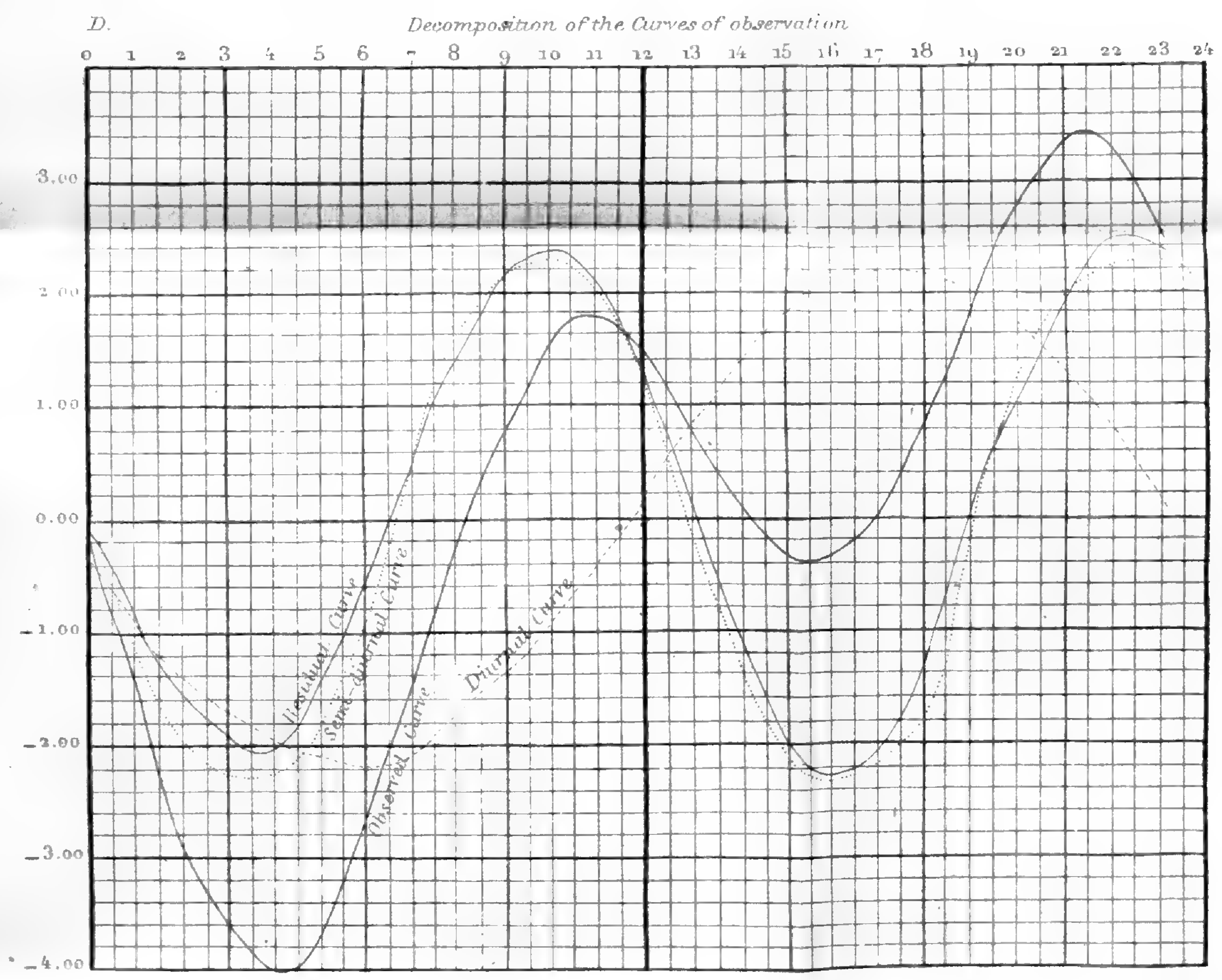
PROCEEDINGS ACAD. NAT. SCI. PHILADELPHIA. Vol. VII, No. X.—p. 385, Descriptions of new marine Invertebrata from the Pacific and Japan seas; *W. Stimpson.*—p. 395, Indications of 12 species of Fossil Fishes (Cretaceous and Eocene); *J. Leidy.* —No. XI. p. 400, On new species of Astacus from Georgia; *J. LeConte.*—p. 402, On a new Gelasimus; *J. LeConte.*—Remarks on two species of American Cimex; *J. LeConte.*—p. 405, On Artificially formed Skulls from the Ancient World; *Prof. A. Retzius.*—p. 410, Catalogue of Marine Algæ, discovered at Beesley's Point during the past summer, with some remarks thereon; *S. Ashmead.*—p. 414, Indications of five species with two new genera of extinct Fishes; *J. Leidy.*

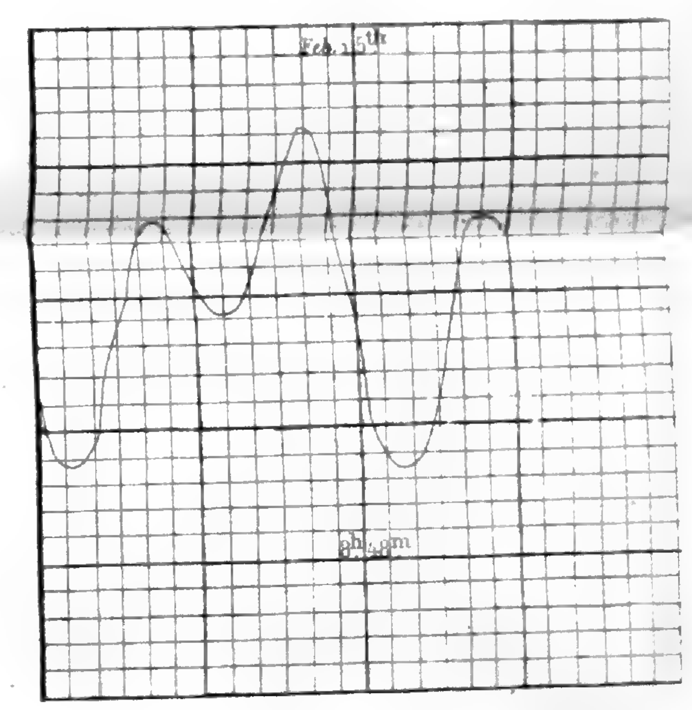
PROCEEDINGS OF THE ACAD. OF ARTS AND SCIENCES, BOSTON, Vol. III.—p. 107, On the Natural Coke of Virginia; *W. B. Rogers.*—p. 109, On the value of the different kinds of prepared Vegetable food; *J. Dean.*—p. 127, Characters of new genera of Plants, mostly from Polynesia, in the collection of the U. S. Exploring Expedition; *A. Gray.*—p. 166, Observations on the first appearance of a circulating system in the higher animals; *L. Agassiz.*—p 173, On the Cochituate water; *A. A. Hayes.*—p. 178, ibid, *Dr. Bacon.*—p. 181, New Mosses collected by U. S. Expl. Expedition; *W. S. Sullivant.*

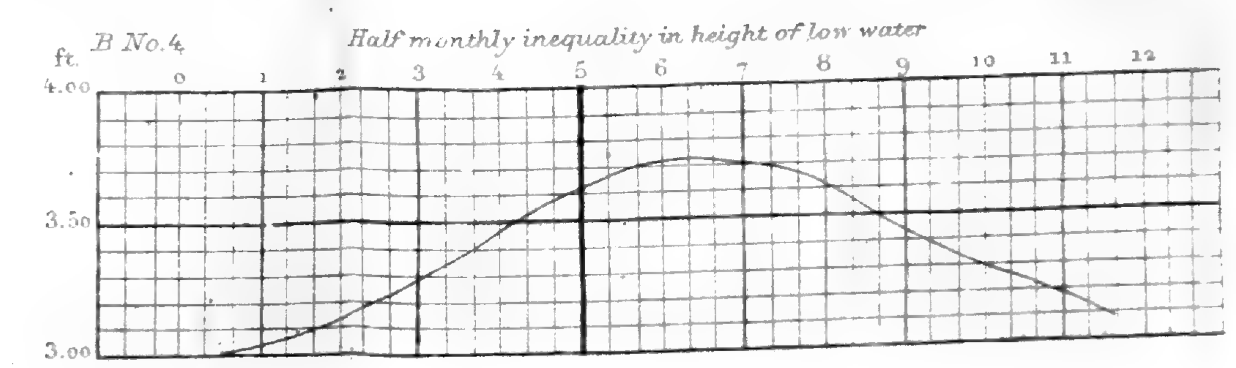


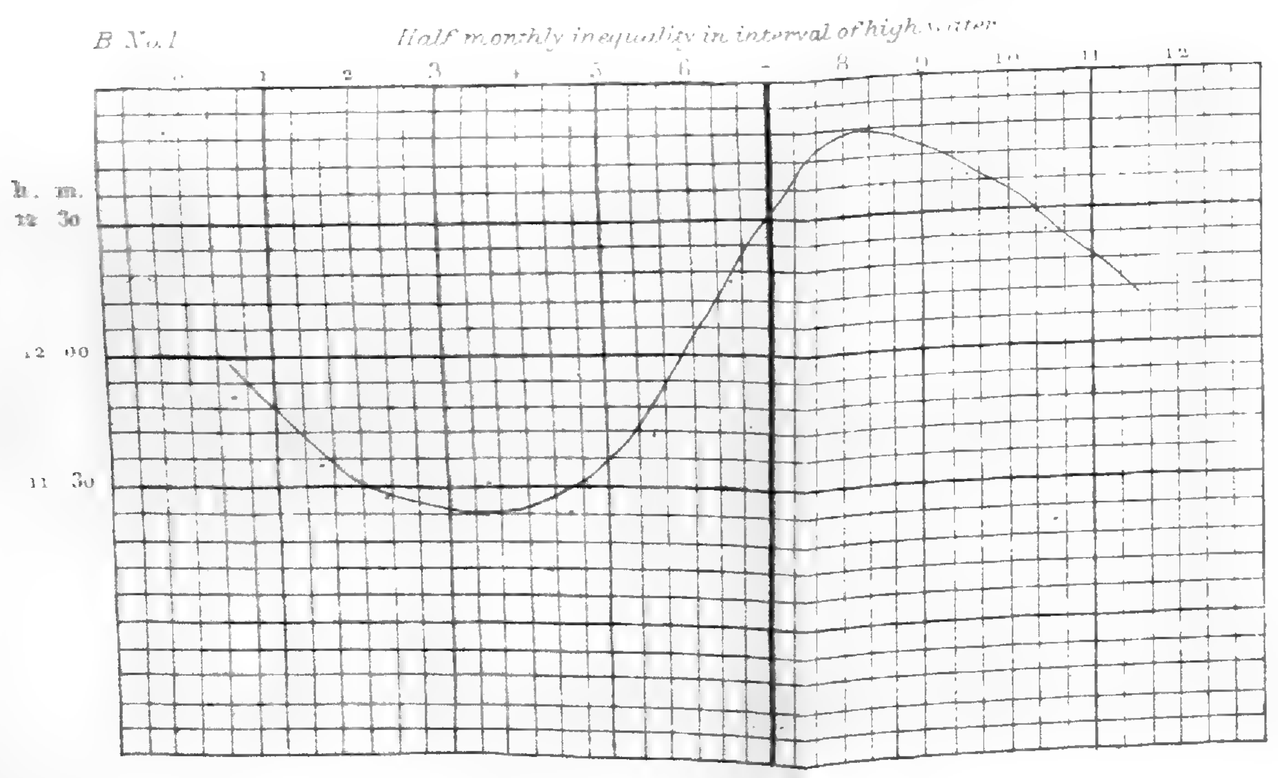


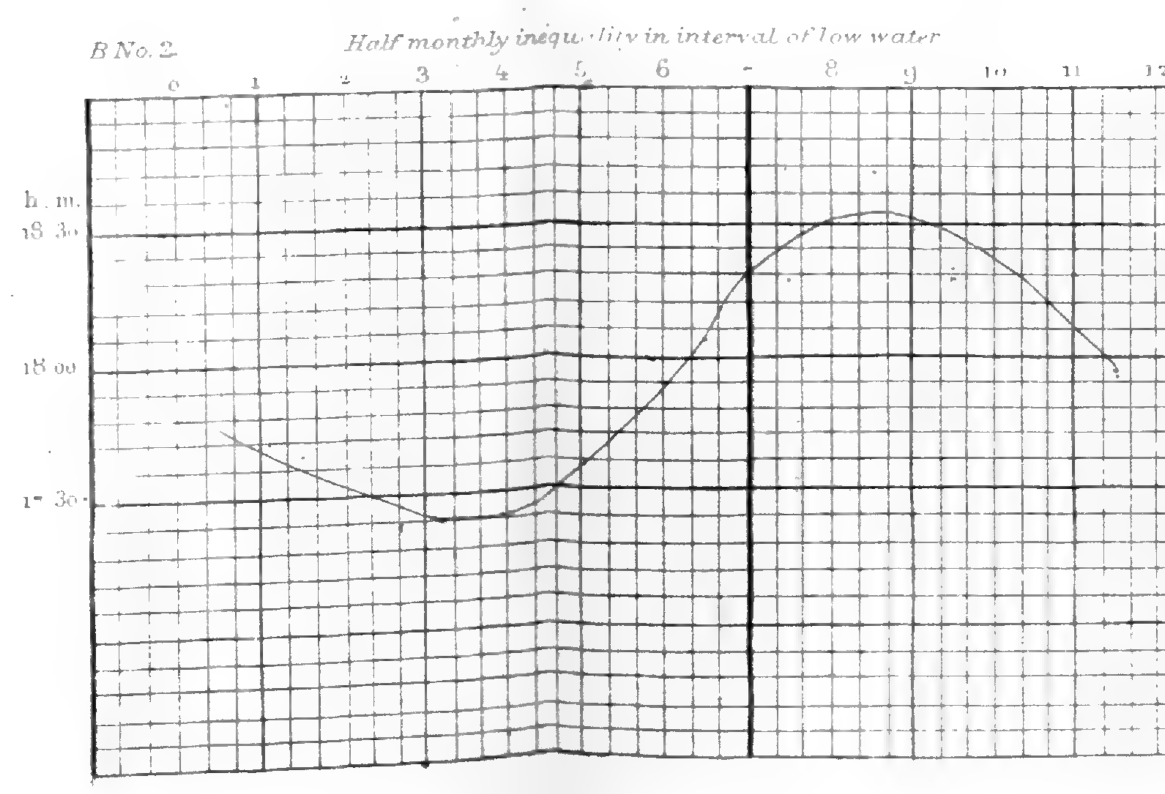


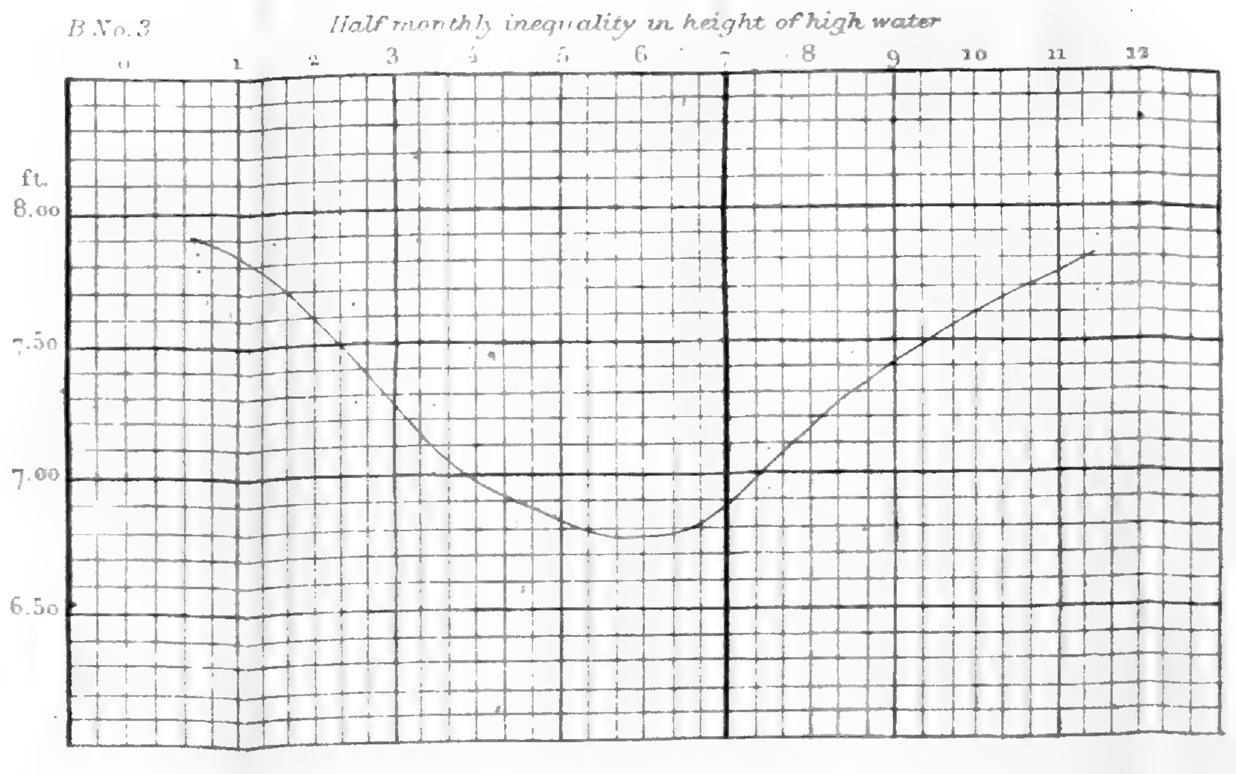












U. S. COAST SURVEY

A.D. Bache Superintendt.

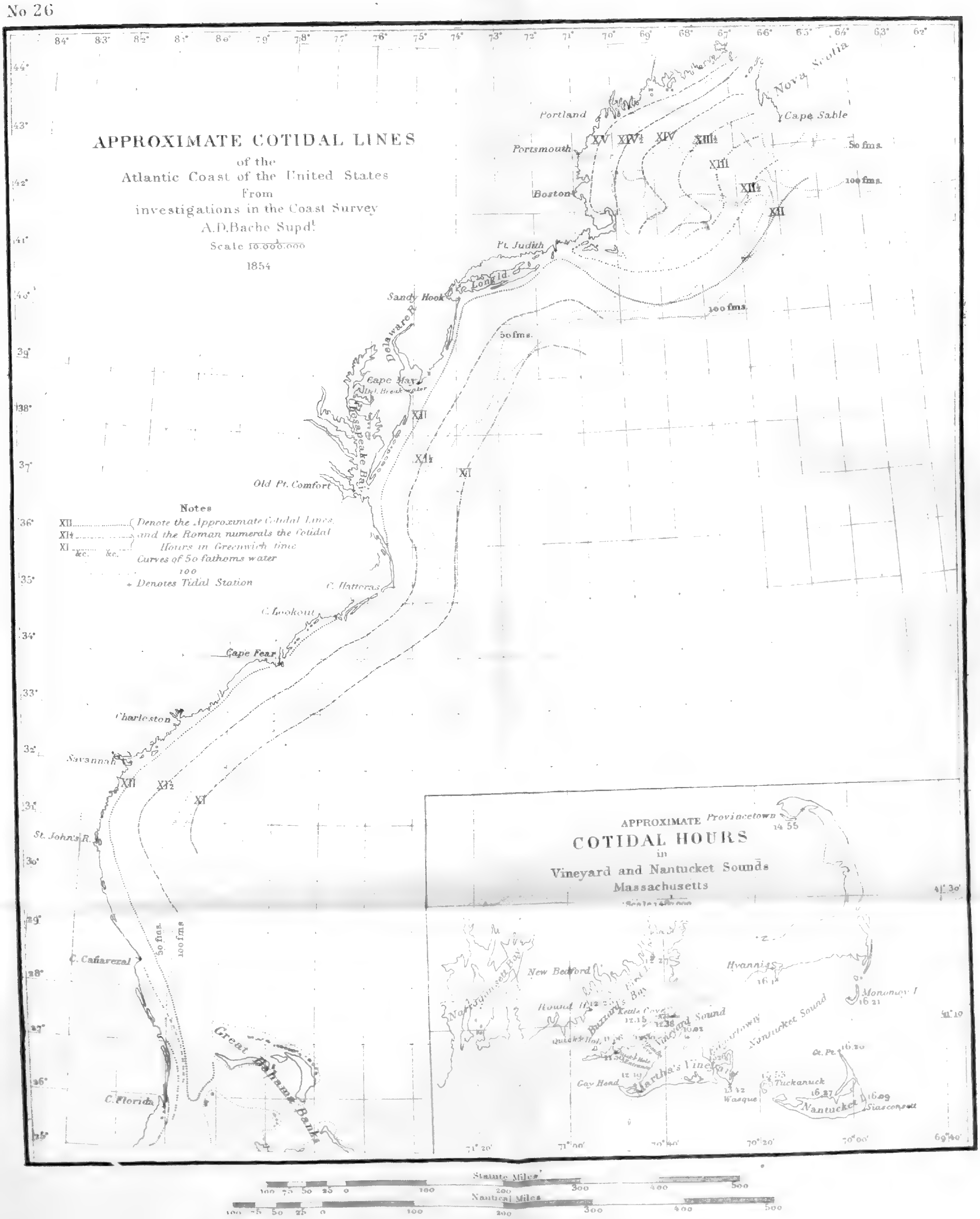
Tides at Rincon Point San Francisco

CALIFORNIA

Jan. & Feb.

1853

No 26


APPROXIMATE COTIDAL LINES
of the
Atlantic Coast of the United States
From
investigations in the Coast Survey
A.D.Bache Supd^t.
Scale 1/10.000.000
1854
Notes
XII .... Denote the Approximate Cotidal Lines,
XI½ .... and the Roman numerals the Cotidal
XI &c. &c. Hours in Greenwich time
Curves of 50 fathoms water
100
+ Denotes Tidal Station
Nova Scotia
Cape Sable
Portland
Portsmouth
Boston
Pt. Judith
Long Id.
Sandy Hook
Delaware R.
Cape May
Del. Breakwater
Chesapeake Bay
Old Pt. Comfort
C. Hatteras
C. Lookout
Cape Fear
Charleston
Savannah
St. John's R.
C. Cañaveral
C. Florida
Great Bahama Banks
50 fms.
100 fms.
XV
XIV½
XIV
XIII½
XIII
XII½
XII
XI½
XI
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COTIDAL HOURS
in
Vineyard and Nantucket Sounds
Massachusetts
Provincetown
14 55
New Bedford
Narragansett Bay
Buzzard's Bay
Vineyard Sound
Nantucket Sound
Hyannis
Monomoy I.
Kettle Cove
Gay Head
Martha's Vineyard
Edgartown
Wasque
Tuckanuck
Nantucket I.
Siasconsett
Gt. Pt.
16.20
16.27
16.09
16.21
Statute Miles
Nautical Miles

P.S.Duval & Co. steam lith. press Phil

CURVES OF OBSERVATION OF TIDES AT RINCON PT. SAN DIEGO AND ASTORIA

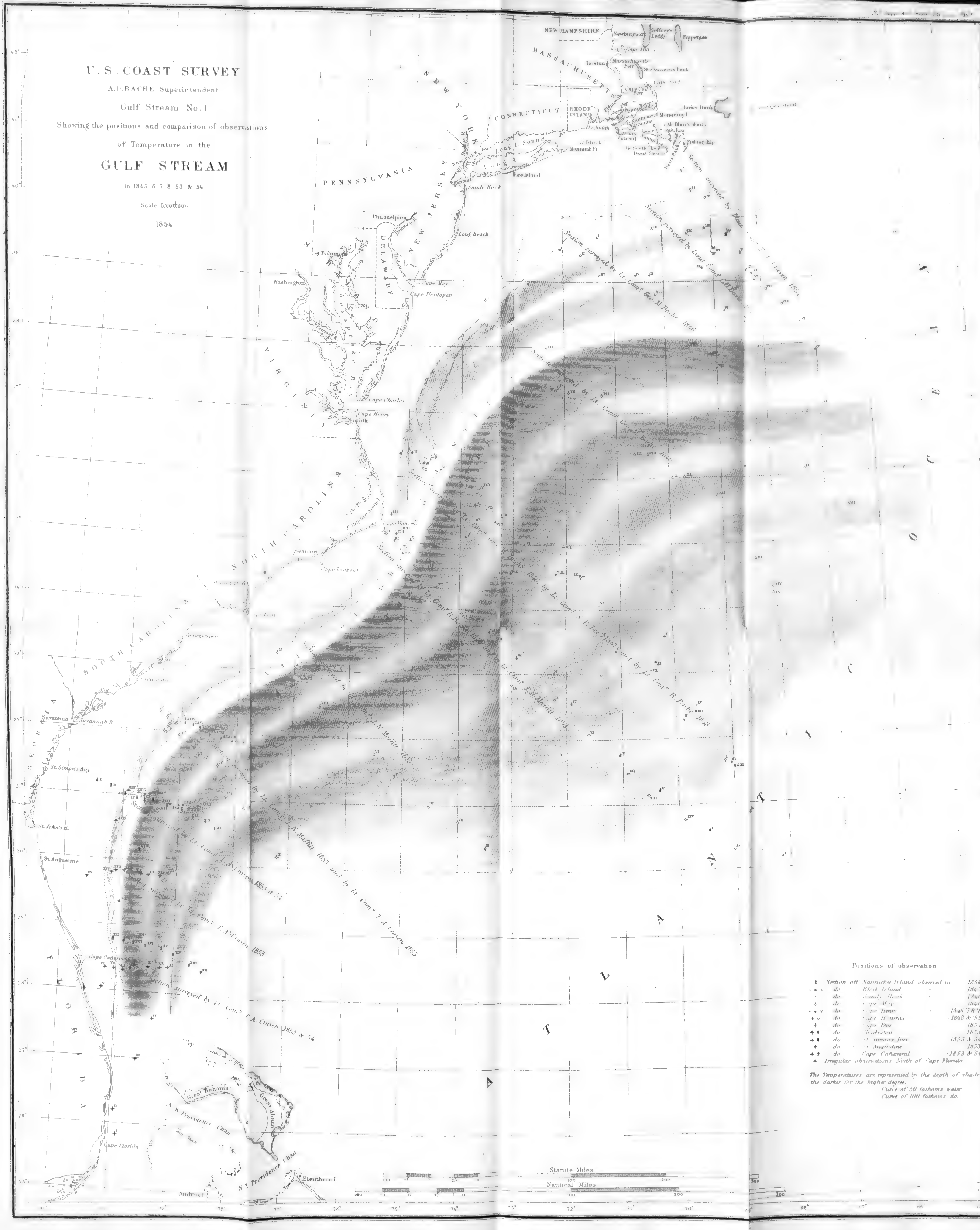
WESTERN COAST OF THE UNITED STATES

U. S. COAST SURVEY A. D. BACHE SUPERINTENDENT

1854

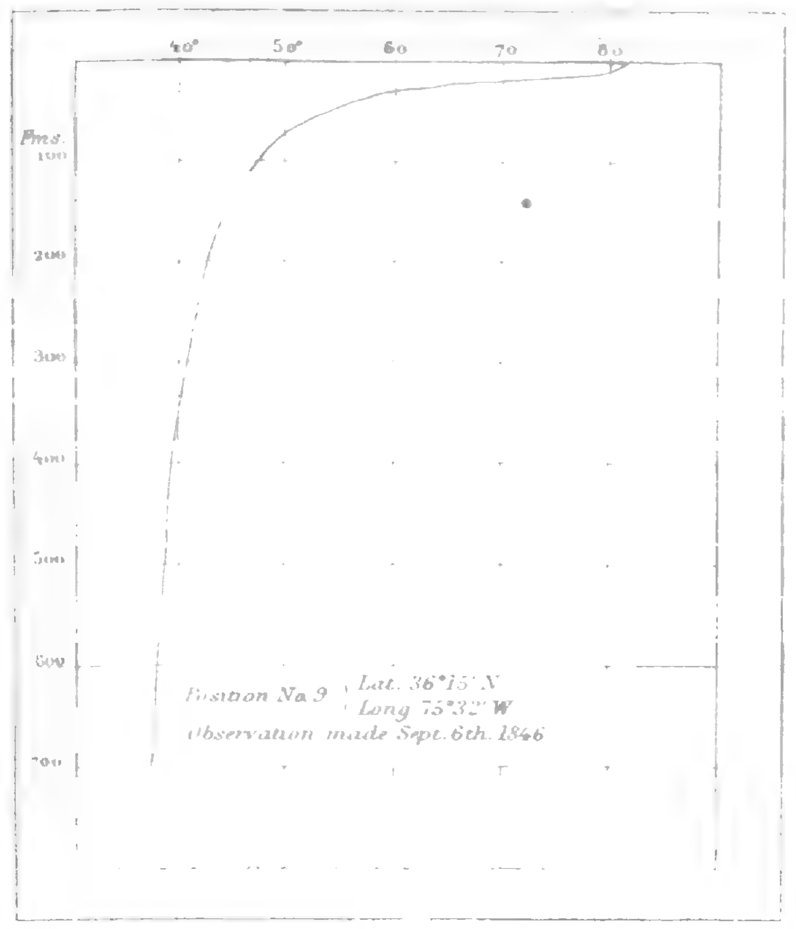
No. 49

N° 24

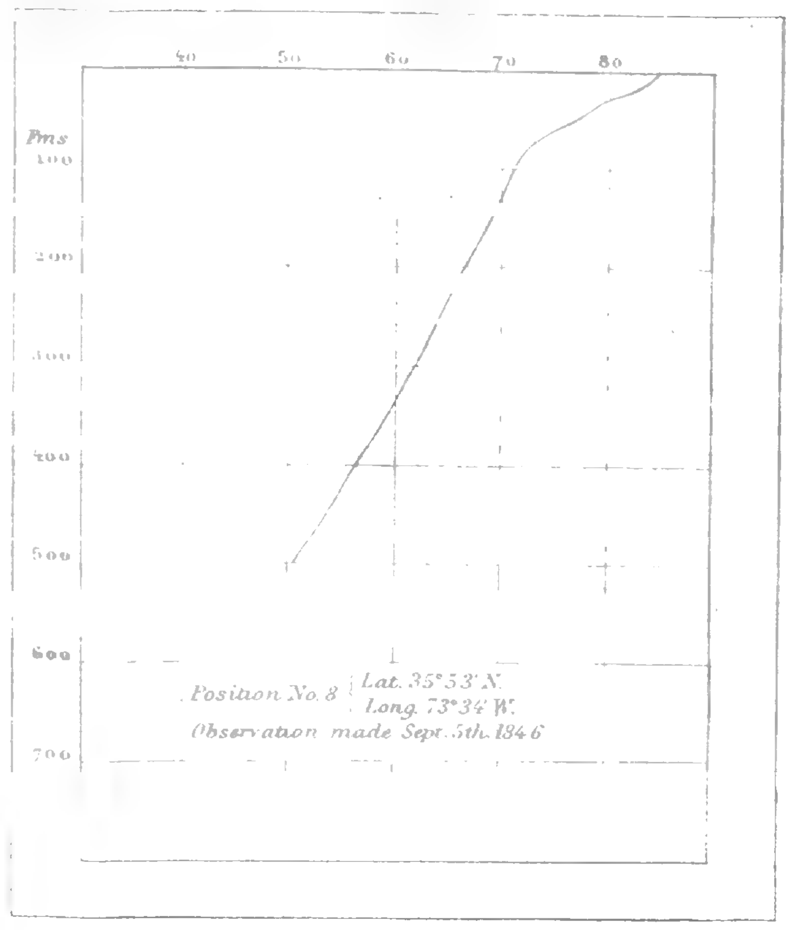

U. S. COAST SURVEY
A. D. BACHE Superintendent
Gulf Stream No. 1
Showing the positions and comparison of observations
of Temperature in the
GULF STREAM
in 1845 '6 '7 '8 '53 & '54
Scale 5,000,000
1854
NEW HAMPSHIRE
MASSACHUSETTS
CONNECTICUT
RHODE ISLAND
NEW YORK
PENNSYLVANIA
NEW JERSEY
DELAWARE
VIRGINIA
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
FLORIDA
Newburyport
Cape Ann
Boston
Cape Cod
Nantucket
Block I.
Montauk Pt.
Fire Island
Sandy Hook
Philadelphia
Long Beach
Baltimore
Washington
Cape May
Cape Henlopen
Cape Charles
Cape Henry
Norfolk
Cape Hatteras
Cape Lookout
Georgetown
Charleston
Savannah
St. Simon's Bay
St. Johns R.
St. Augustine
Cape Canaveral
Cape Florida
Great Bahama
Great Abaco
Eleuthera I.
Andros I.
N.W. Providence Chan.
N.E. Providence Chan.
ATLANTIC OCEAN
Section surveyed by Lt. Comg. Geo. M. Bache 1846
Section surveyed by Lt. Comg. J. N. Maffitt 1853
Section surveyed by Lt. Comg. T. A. Craven 1853 & 54
Section surveyed by Lt. Comg. T. A. Craven 1853
Statute Miles
Nautical Miles
Positions of observation
Section off Nantucket Island observed in 1854
do Block Island 1845
do Sandy Hook 1846
do Cape May 1846
do Cape Henry 1846 '7 & '8
do Cape Hatteras 1848 & '53
do Cape Fear 1853
do Charleston 1853
do St. Simon's Bay 1853 & '54
do St. Augustine 1853
do Cape Cañaveral 1853 & '54
Irregular observations North of Cape Florida
The Temperatures are represented by the depth of shade the darker for the higher degree.
Curve of 50 fathoms water
Curve of 100 fathoms do.

SECTION OFF CAPE HENRY

No. 1 Temperatures observed at Position No. 9



No. 2 Temperatures observed at Position No. 8



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A.D. BACHE Supdt.

DIAGRAMS SHOWING THE RESULTS

of the

GULF STREAM EXPLORATIONS

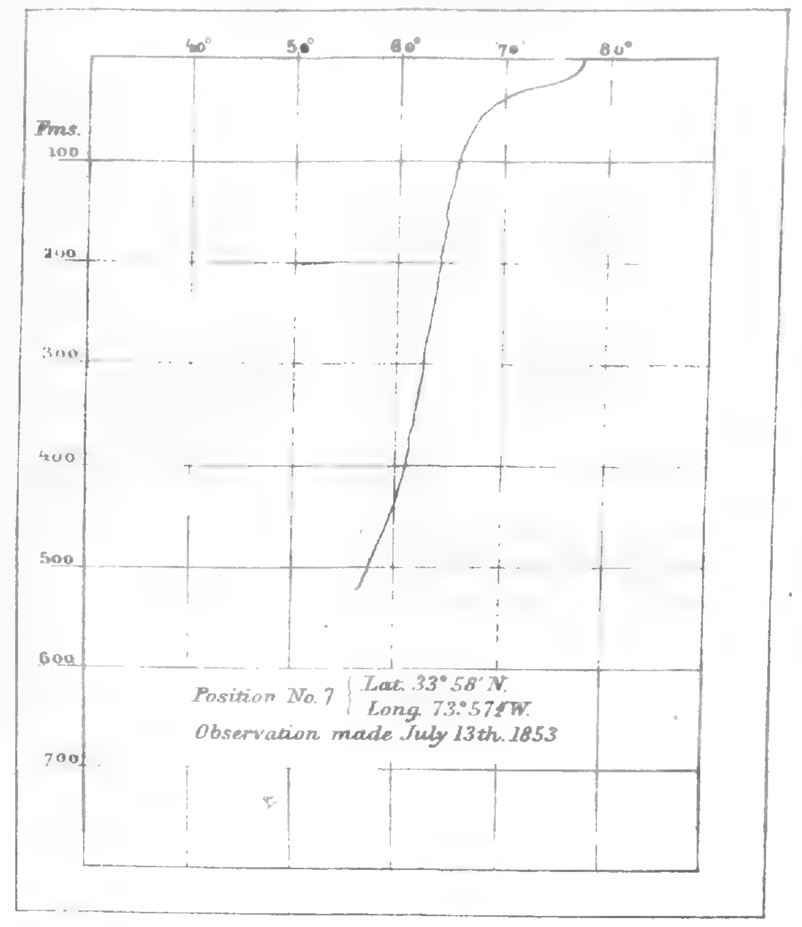
From

Observations made in 1845 '46 '47 '48 & '53

1854

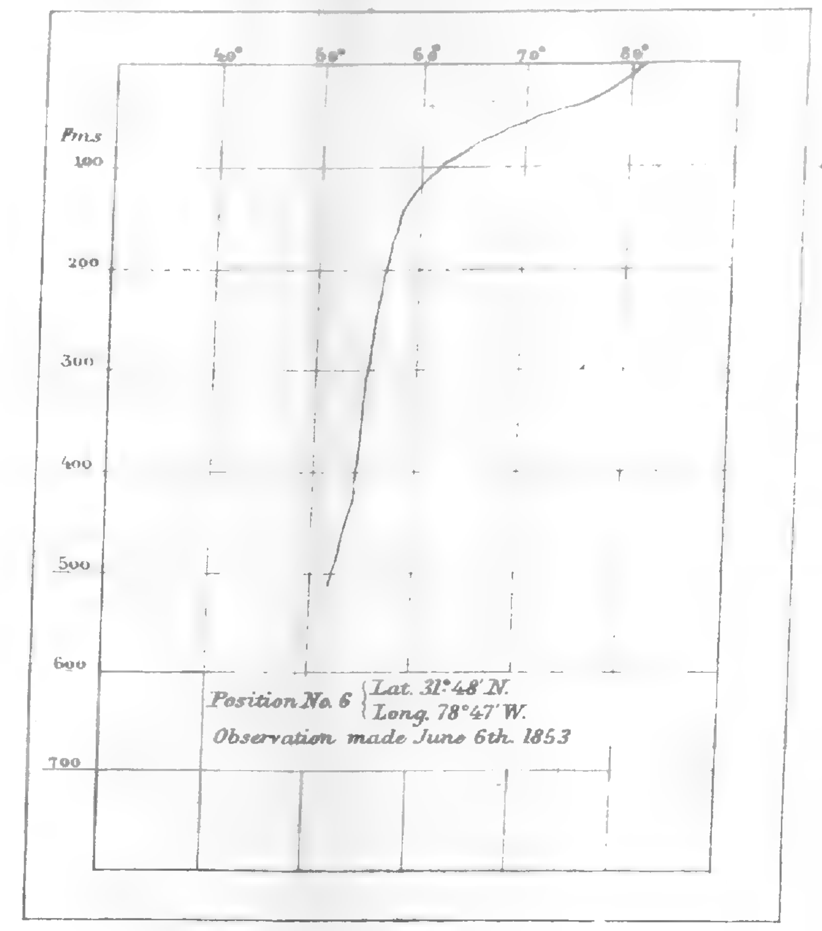
SECTION OFF CAPE HATTERAS

No. 3 Temperatures observed at Position No. 7



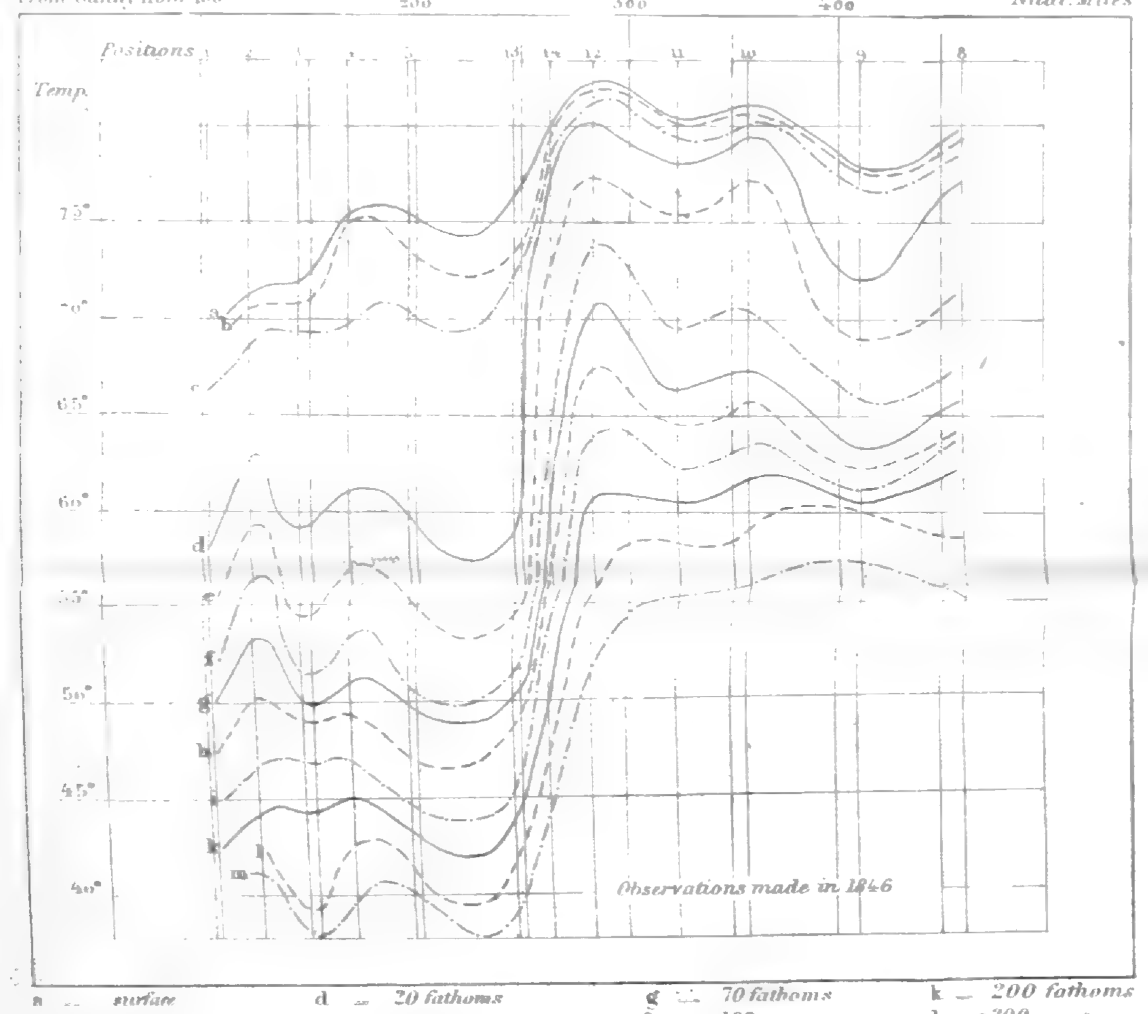
SECTION OFF CHARLESTON

No. 3 bis Temperatures observed at Position No. 6



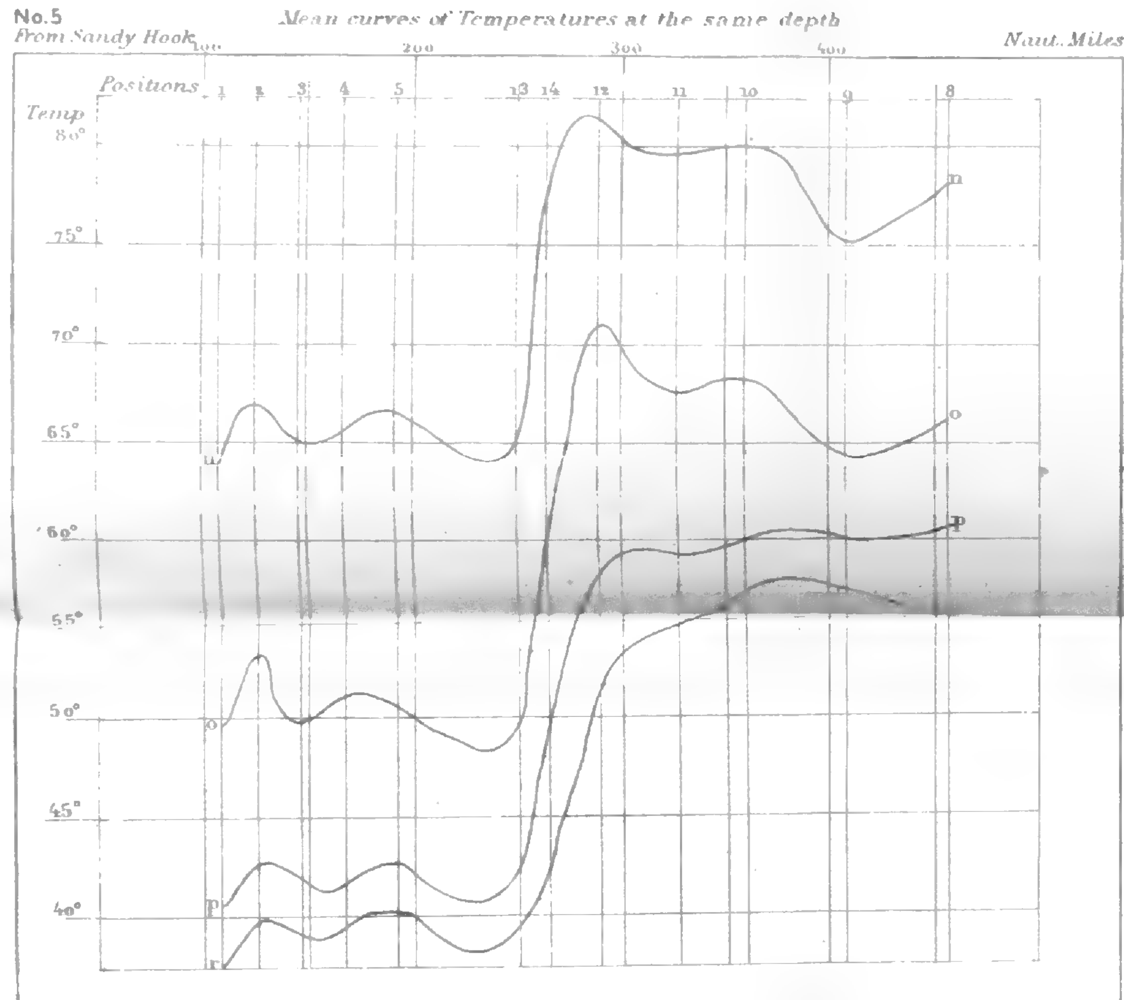
SECTION OFF SANDY HOOK

No. 4 From Sandy Hook — Curves of Temperatures at the same depth — Naut. Miles



a — surface; b — 5 fathoms; c — 10 —; d — 20 fathoms; e — 30 —; f — 50 —; g — 70 fathoms; h — 100 —; i — 150 —; k — 200 fathoms; l — 300 —; m — 400 —

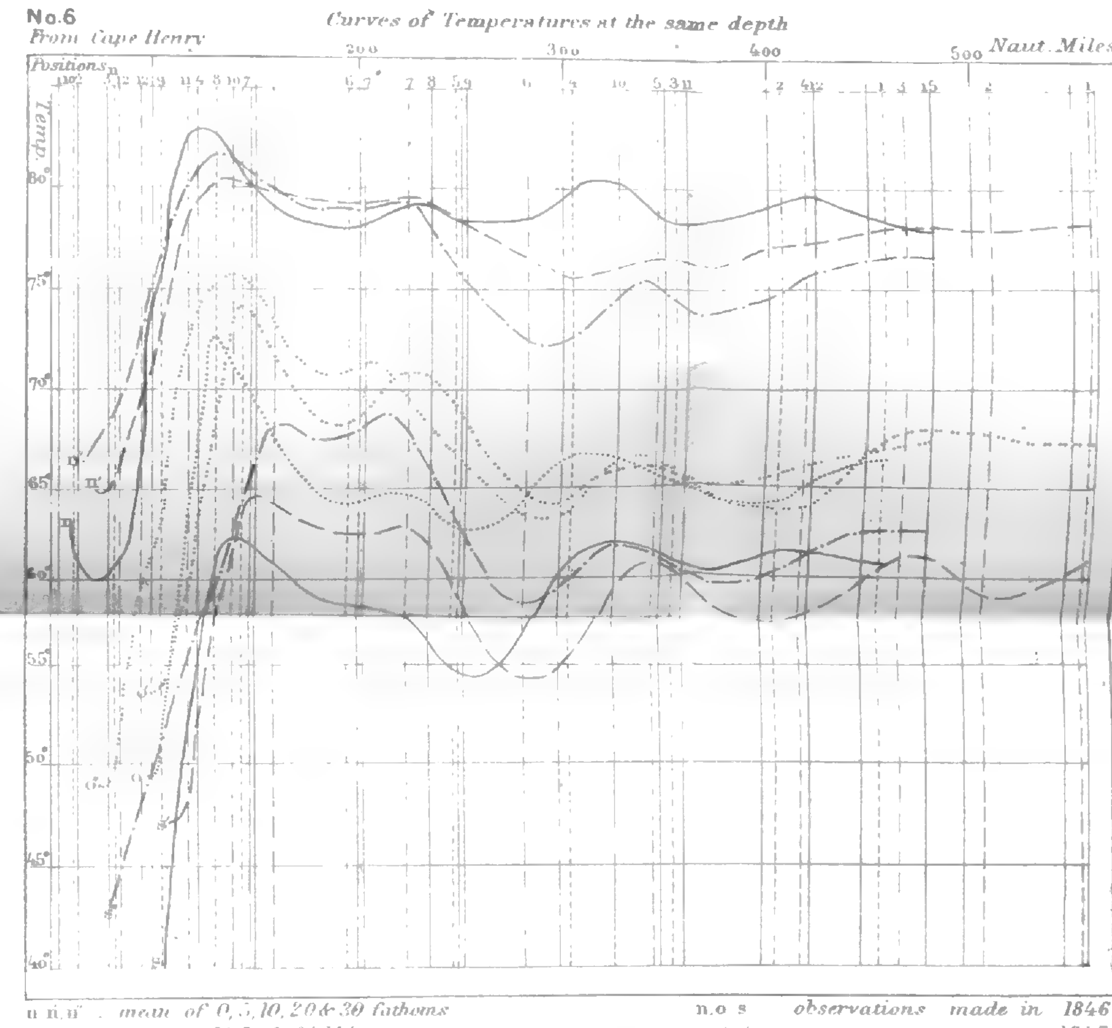
No. 5 From Sandy Hook — Mean curves of Temperatures at the same depth — Naut. Miles



n — mean of 0, 5, 10, 15, 20 & 30 fathoms; o — 40, 60, 80 & 100; p — mean of 200 & 300 fathoms; r — 400

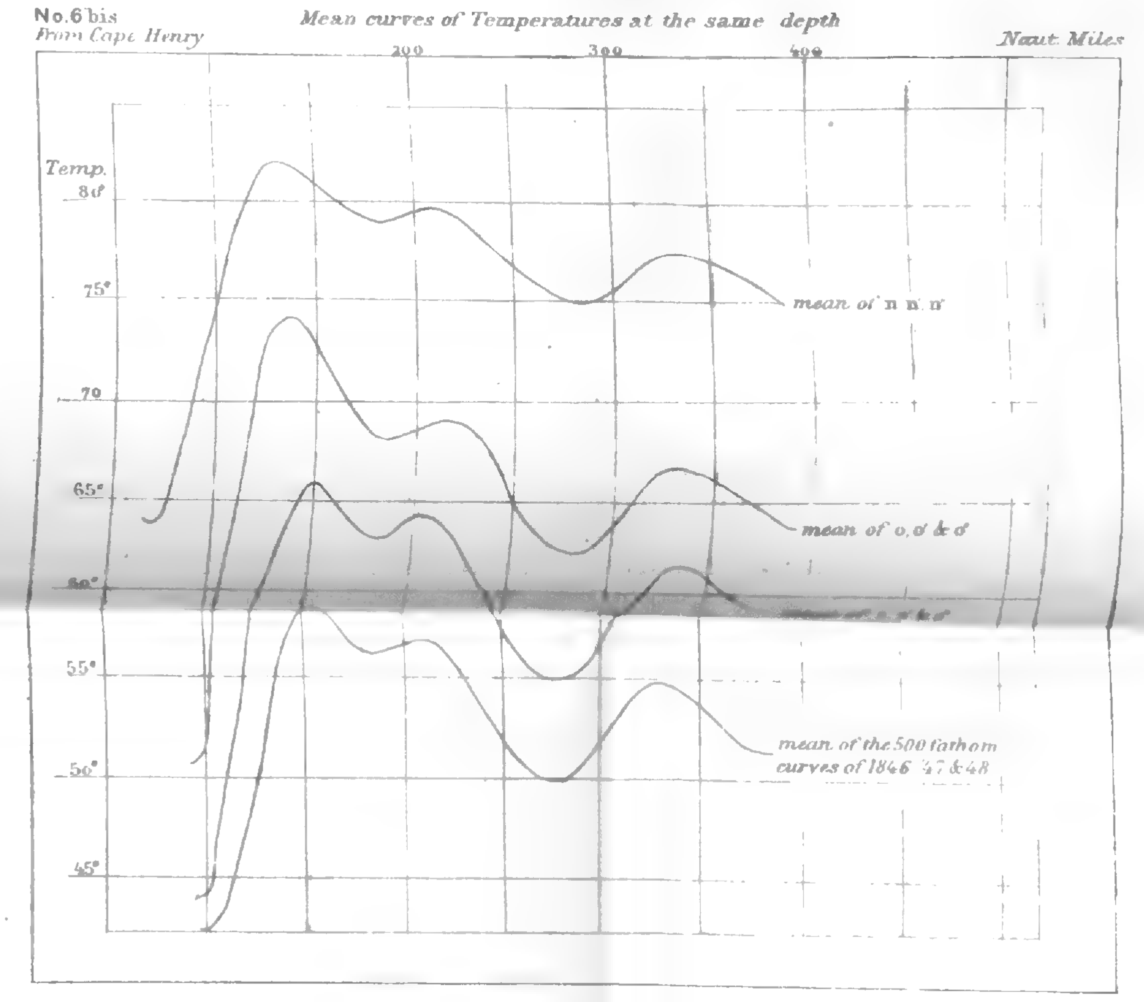
SECTION OFF CAPE HENRY

No. 6 From Cape Henry — Curves of Temperatures at the same depth — Naut. Miles



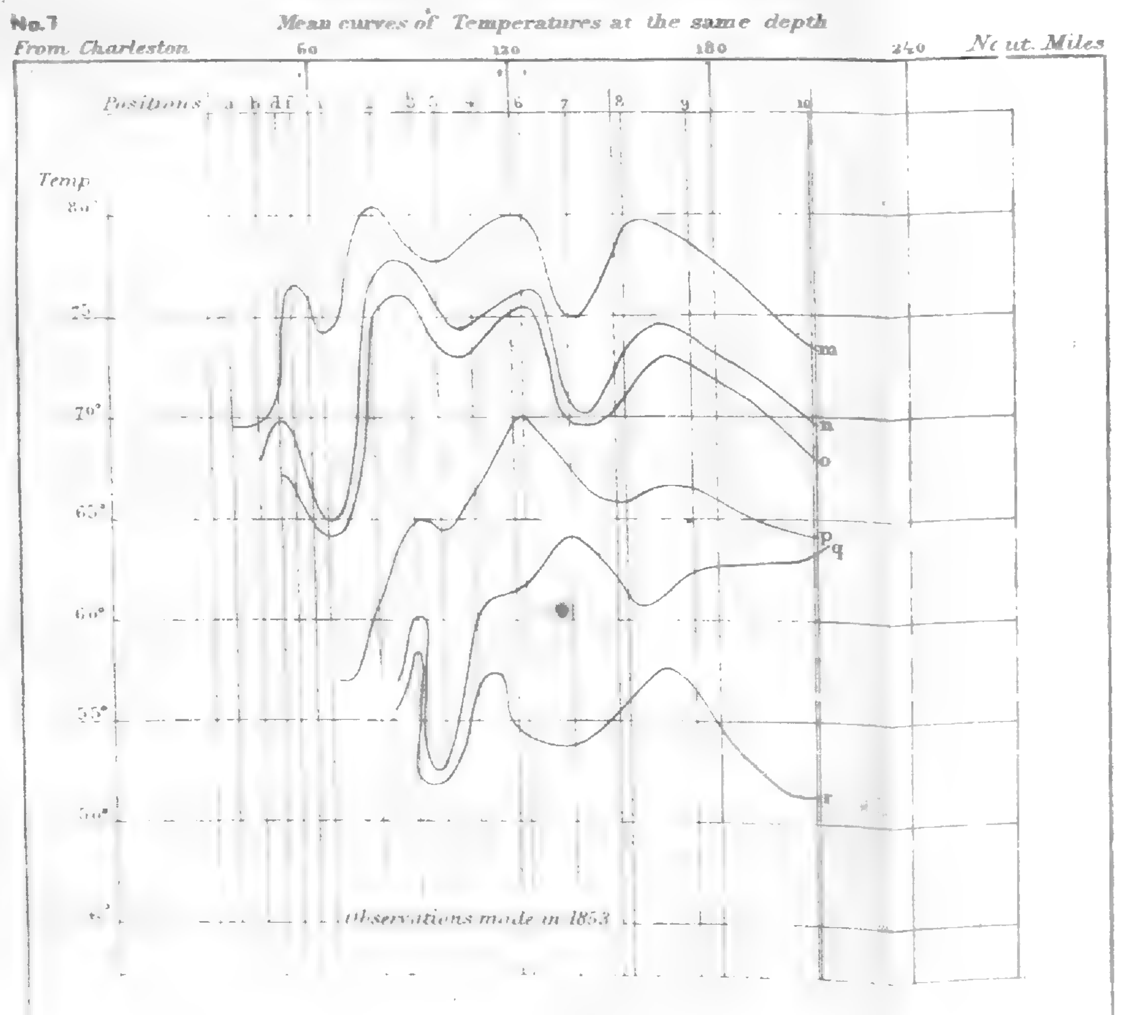
n. n' n'' — mean of 0, 5, 10, 20 & 30 fathoms; o. o' o'' — 50, 70, 100 & 150; s. s' s'' — 200, 300 & 400; n. o. s — observations made in 1846; n'. o'. s' — 1847; n''. o''. s'' — 1848

No. 6 bis From Cape Henry — Mean curves of Temperatures at the same depth — Naut. Miles



SECTION OFF CHARLESTON

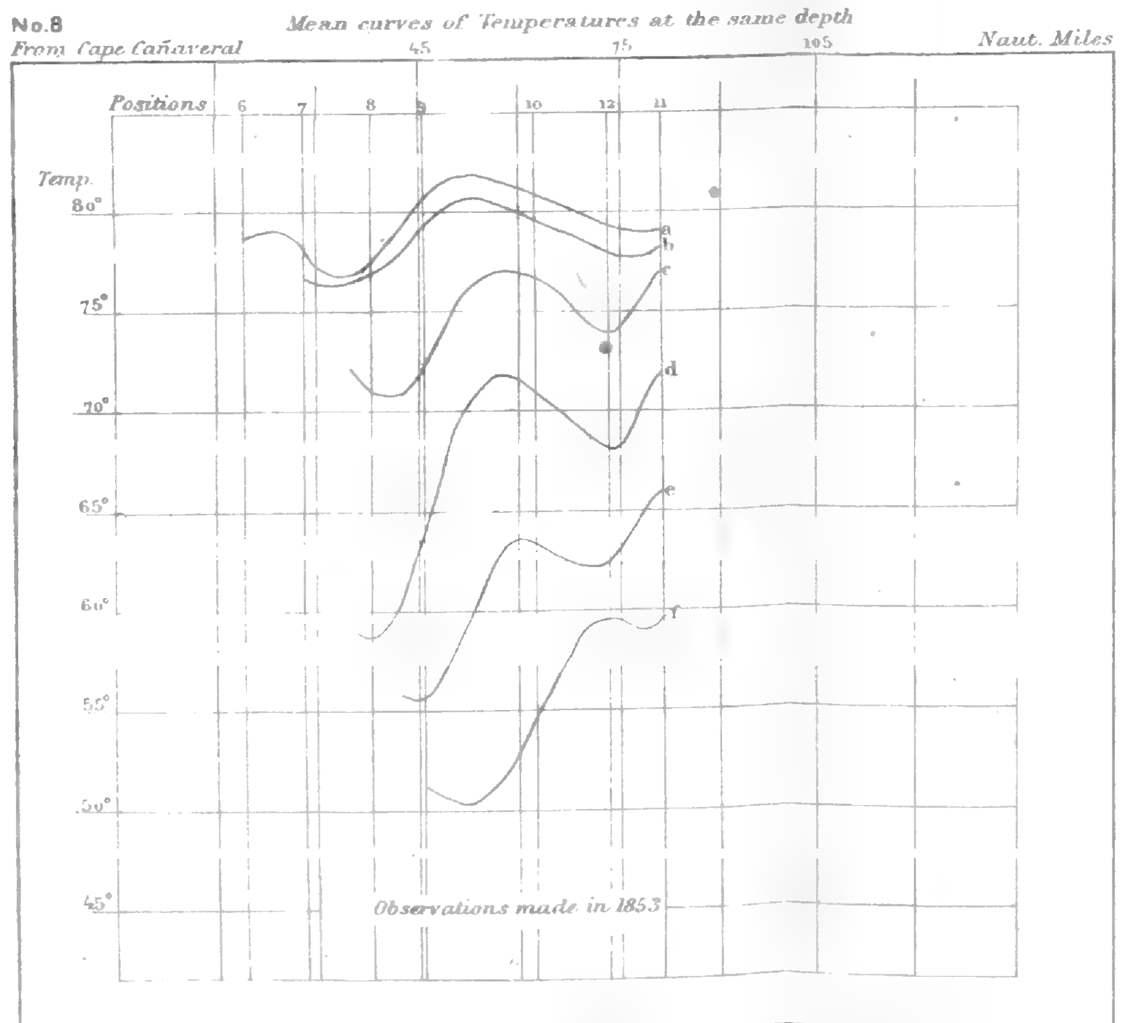
No. 7 From Charleston — Mean curves of Temperatures at the same depth — Naut. Miles



m — mean of 5 & 10 fathoms; n — 20 & 30; o — mean of 20, 30 & 50 fathoms; p — 70, 100 & 150; q — mean of 200 & 300 fathoms; r — 400

SECTION OFF CAPE CAÑAVERAL

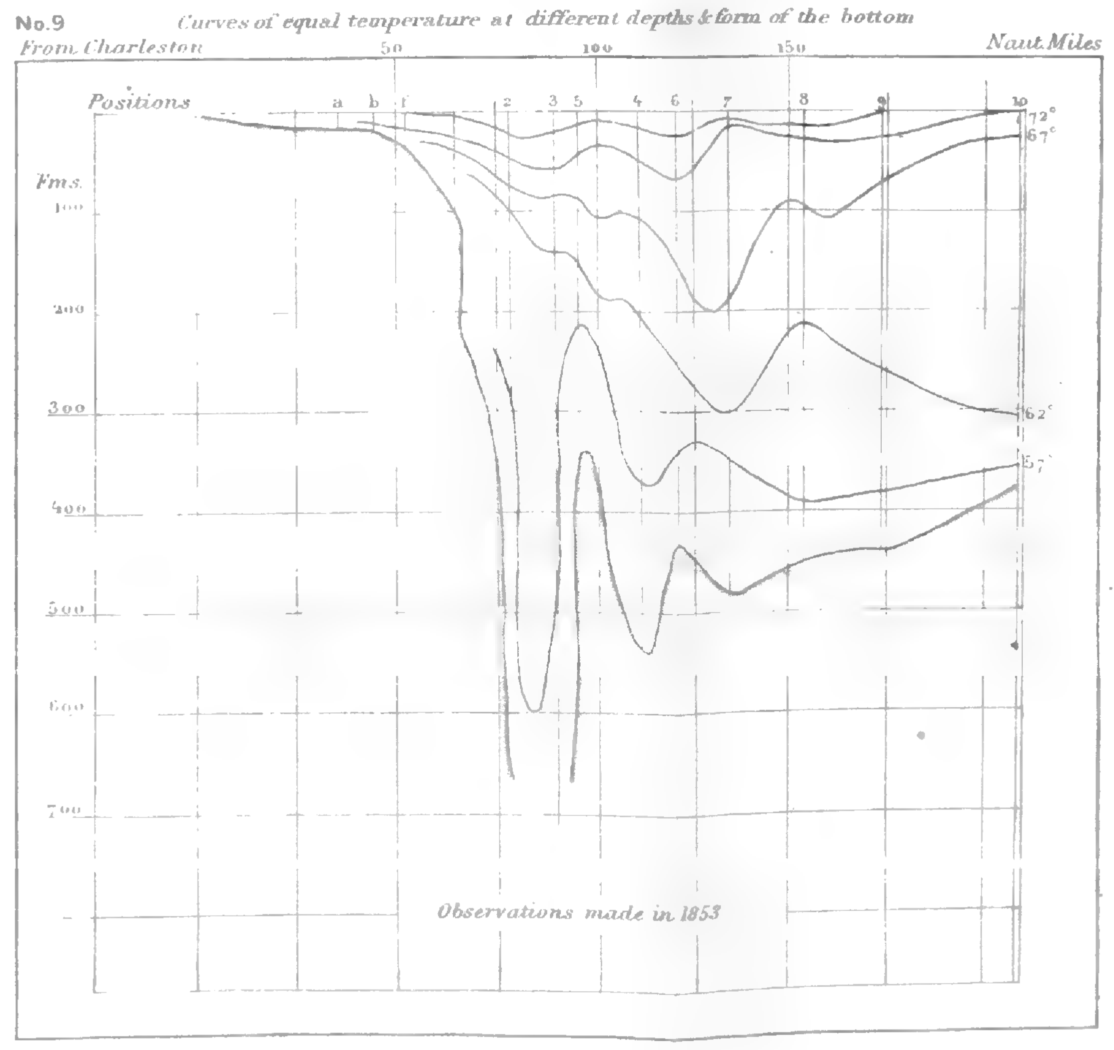
No. 8 From Cape Cañaveral — Mean curves of Temperatures at the same depth — Naut. Miles



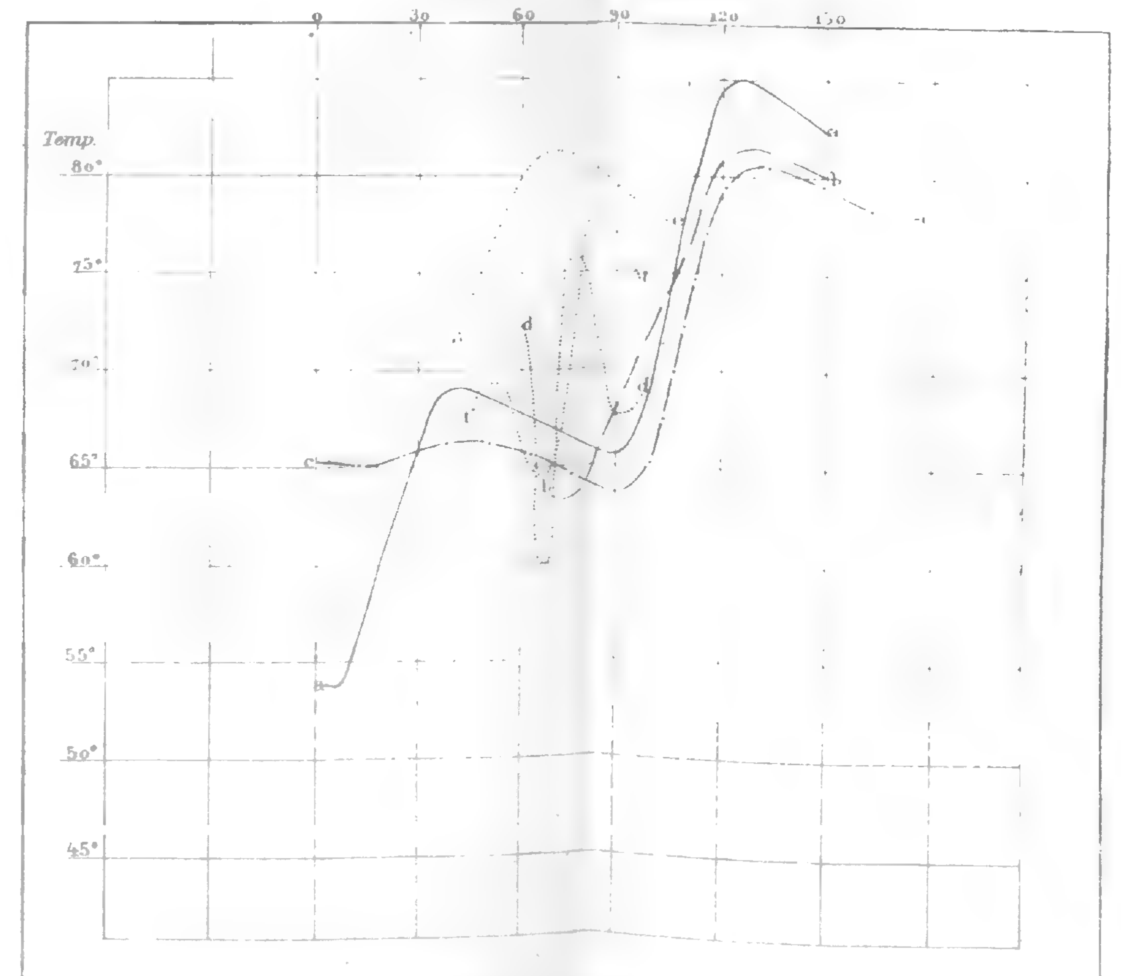
a — mean of 0 & 5 fathoms; b — 10 & 20; c — mean of 30 & 50 fathoms; d — 70 & 100; e — mean of 150 & 200 fathoms; f — 300 & 400

SECTION OFF CHARLESTON

No. 9 From Charleston — Curves of equal temperature at different depths & form of the bottom — Naut. Miles



No. 10 Comparative curves of the cold wall



a — mean of 0, 5, 10, 15, 20 & 30 fathoms at Cape May Section; b — 0, 5, 10, 15, 20 & 30 — Cape Henry Section 3 years; c — 0, 5, 10, 15, 20 & 30 — Sandy Hook; d — 30 & 50 — St. Simons; e — 0, 5, 10, 15, 20 & 30 — Cape Fear; f — 20 & 30 — Charleston

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DIAGRAMS ILLUSTRATING EARTHQUAKE WAVES OF DECEMBER 23rd. 1854 AT SAN FRANCISCO, SAN DIEGO AND ASTORIA

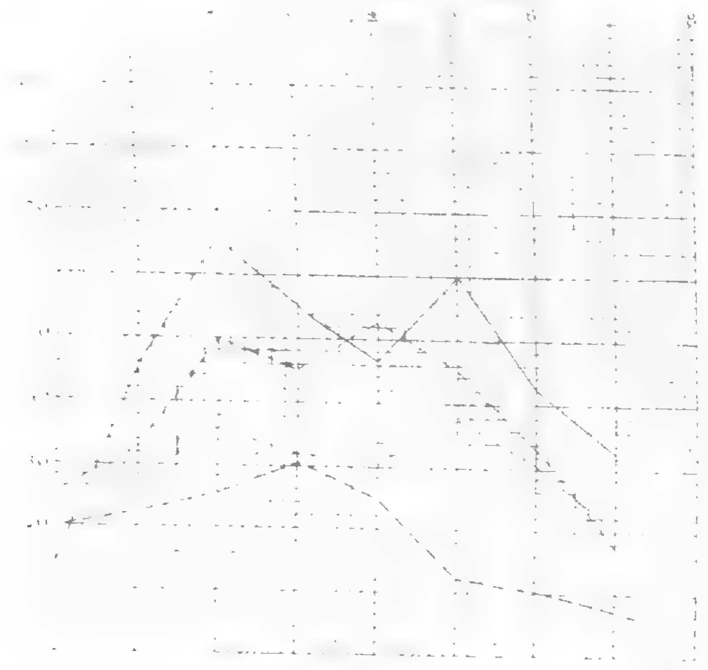
FROM CURVES RECORDED ON SELF REGISTERING TIDE GAUGES

1855

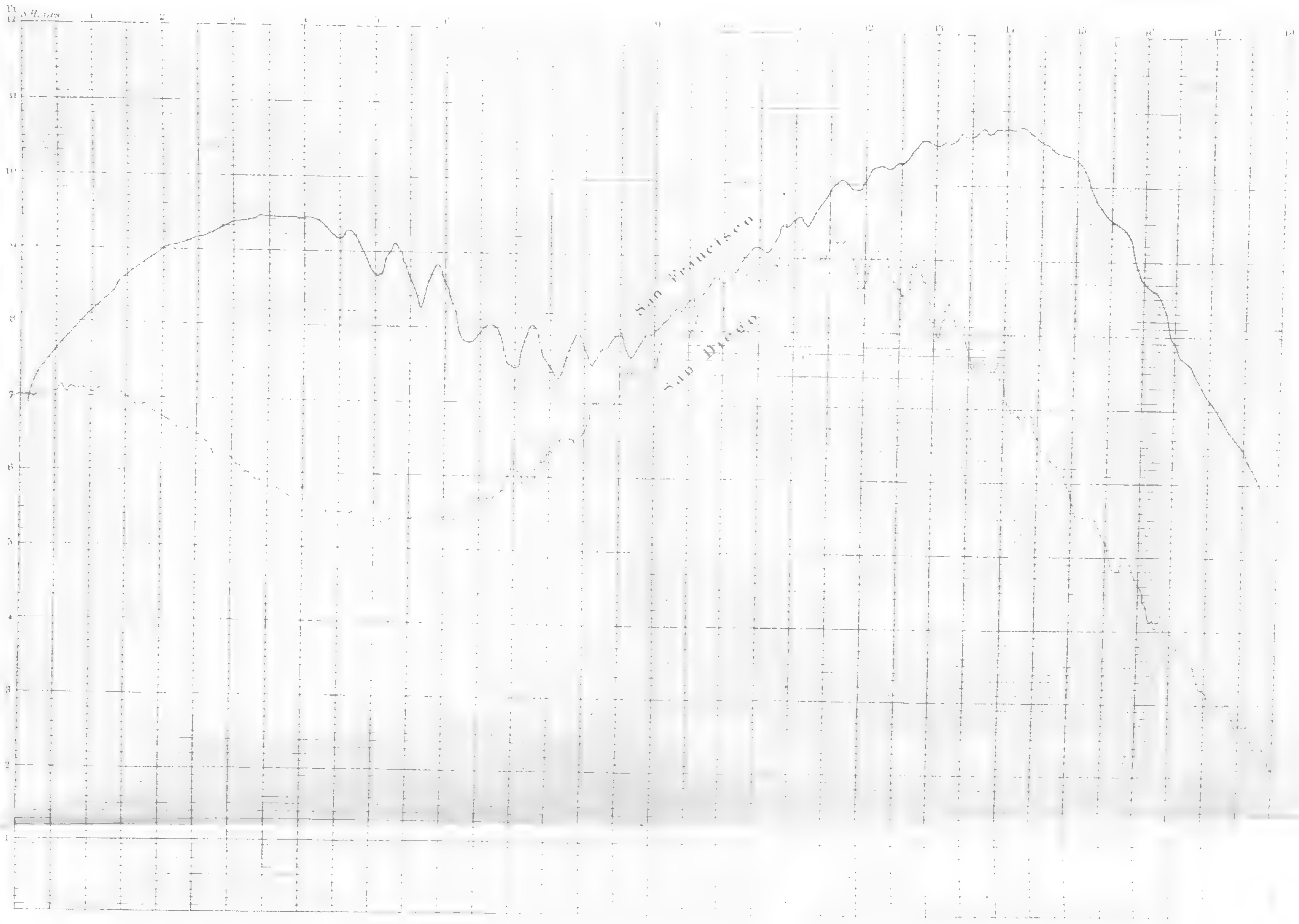
A

Comparison of Heights

at San Francisco and San Diego



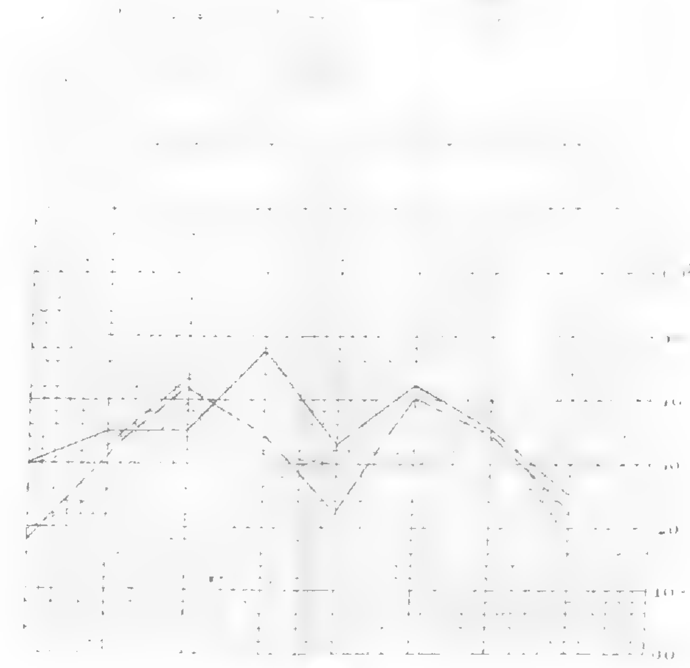
Curves at San Francisco and San Diego



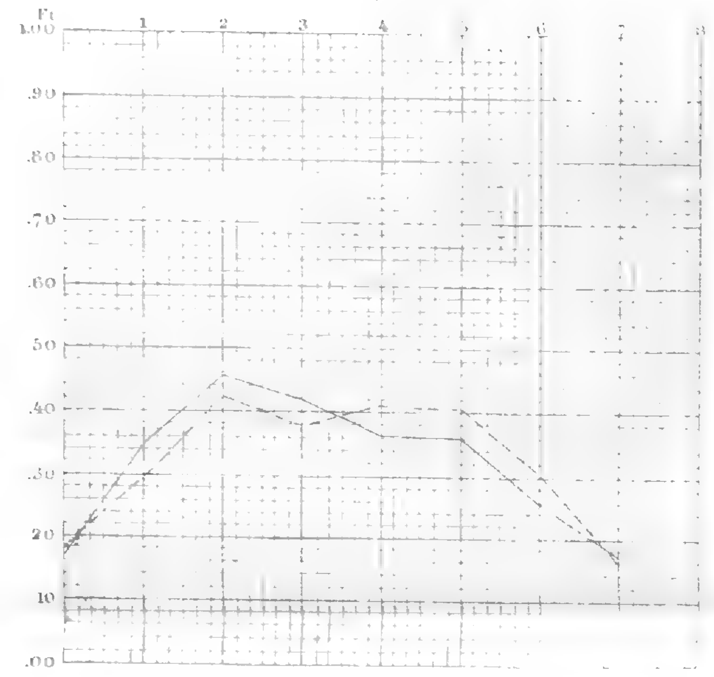
B

Comparison of Times

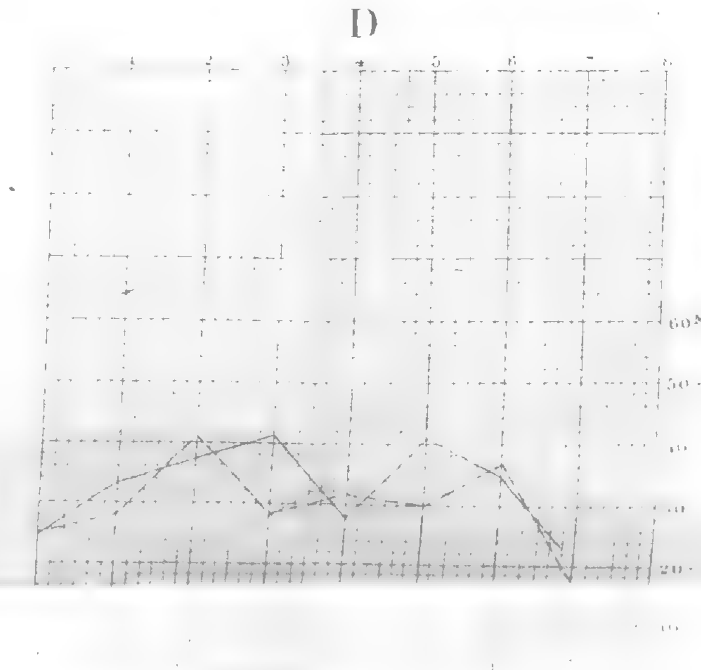
at San Francisco and San Diego



C



D



Note

In Diagrams A & B the full lines refer to the heights and times of the first series the broken lines to those of the second series. The strong lines refer to San Francisco, and the faint ones to San Diego. In Diagrams C & D the full lines refer to San Francisco, and the broken ones to San Diego.

Diagram of Oscillations in the level of the Sea at Astoria

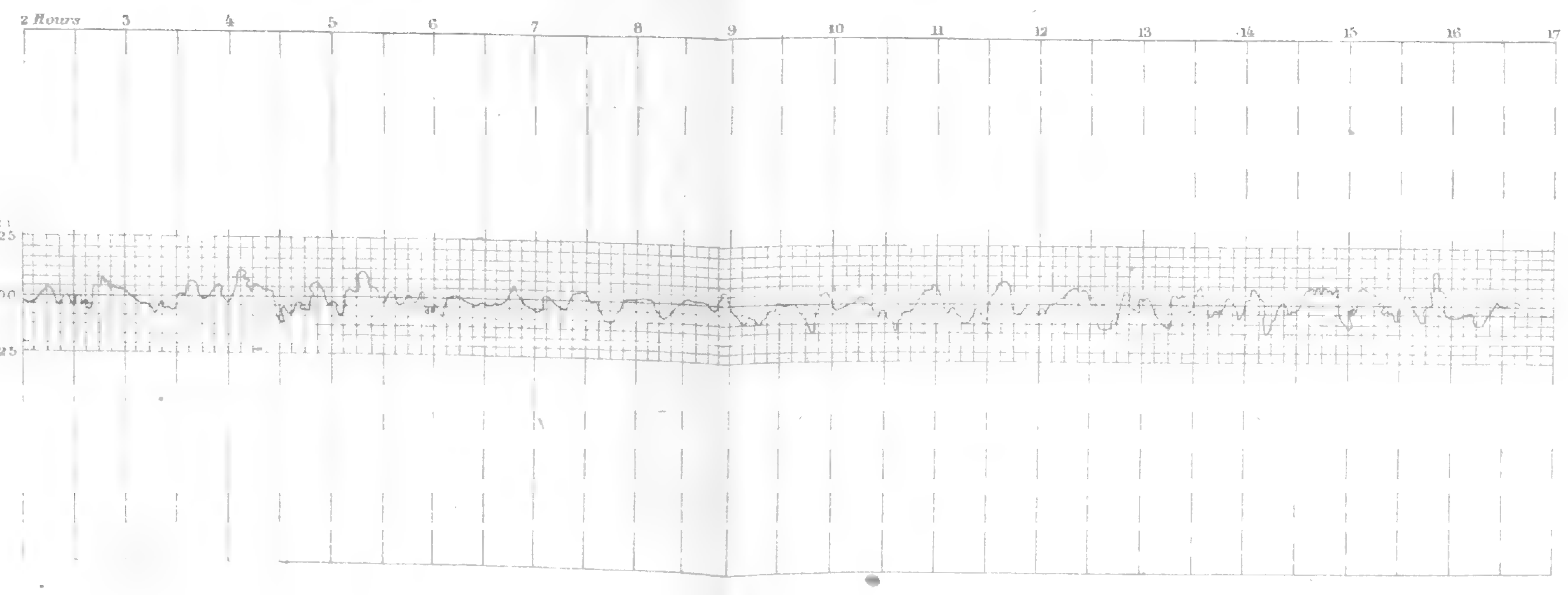
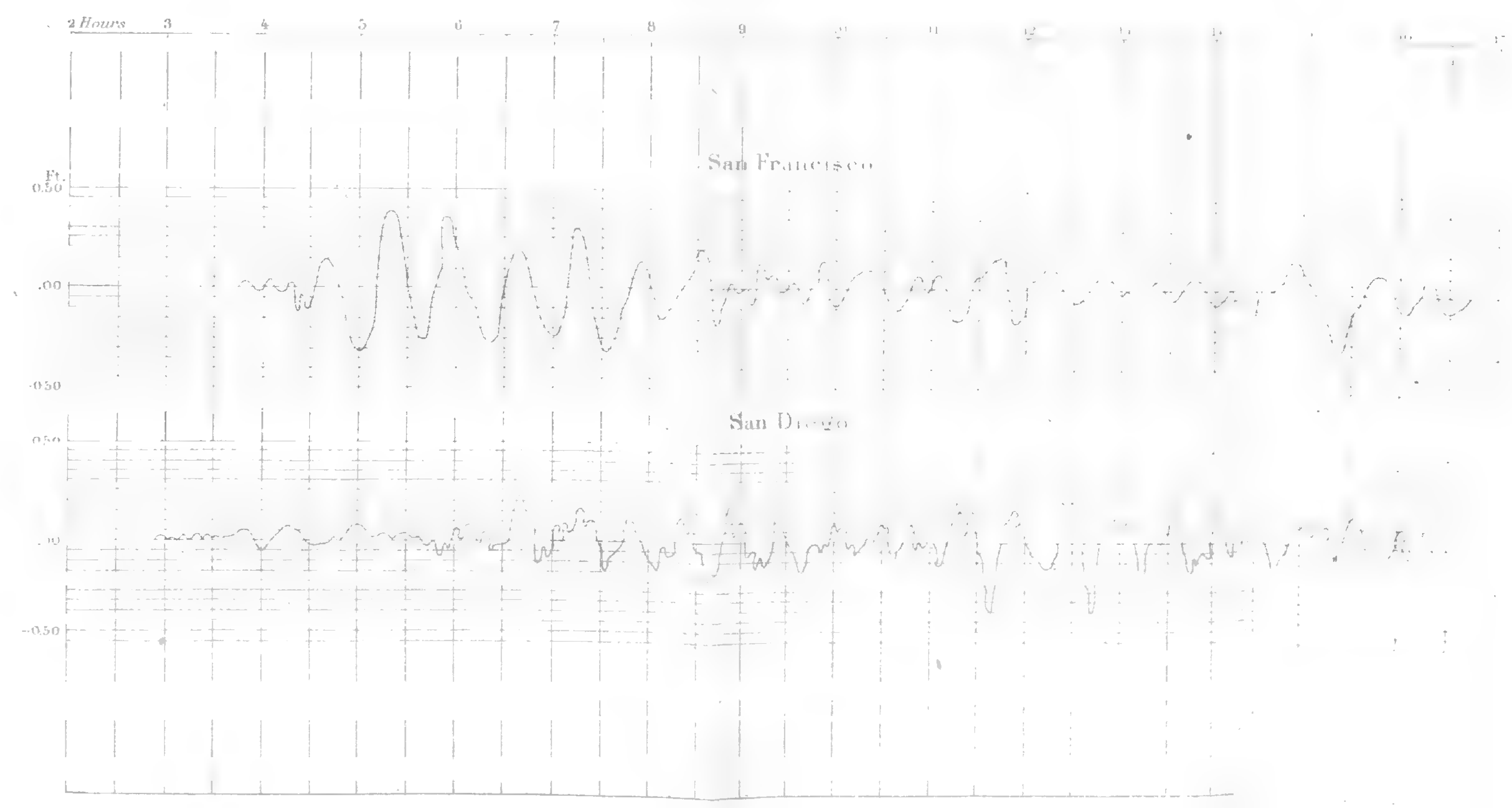


Diagram of Oscillations in the level of the Sea at San Francisco and San Diego



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[SECOND SERIES.]

Art. XVIII.—*On a Specimen of Native Iron from Liberia, Africa;* by Dr. A. A. Hayes.

[Read at a meeting of the American Academy, Boston, August, 1855.]

It is with pleasure that I submit to the inspection of the Academy, a specimen of Native Iron from Liberia, believed to have been taken from the tract of country bordering the St. John's River, recently acquired by the New Jersey Colony. This specimen was placed in my hands by Rev. Joseph Tracy, Secretary of the Massachusetts Colonization Society, for examination; and its physical characters at once arrested my attention as differing from those of any artificially produced iron. As I deem the discovery of native iron, existing unalloyed, a matter of much interest to naturalists and chemists, it is proper that the evidence on which the statement rests, should be submitted somewhat in detail. In the African Repository, vol. xxx, No. 8, August, 1854, at p. 240, is a letter from Rev. Aaron P. Davis, a resident missionary at Bassa Cove, from which the following extracts are taken: "I send you a piece of African ore just as dug from its native bed, or broken from among rocks. I have seen and conversed with a number of natives, who affirm that it is actually the pure ore, or just as taken from its native bed. I obtained a piece through Hon. Geo. L. Seymour, who had tried in vain to dissect it: and I being of that craft, he brought it to my shop for that purpose. When he brought it, it appeared like a craggy rock, of yellowish color on its surface, and with a very small exception it could not be separated but by heat, and hard pounding with my largest sledge hammer, and a chisel prepared for the purpose. I also send you a tea spoon, which I made from some of the ore, which in its crude state is superior to the iron brought here for sale by English merchant vessels. I am told by the natives that it is plentiful, and about three days' walk from our present place of residence, (Bassa Cove,) it is gotten by digging and breaking rocks. It is also said to be in large lumps. In these parts the natives buy no iron, but dig it out of the ground, or break the rocks and get it, as the case may be."

The larger specimen before you, when received by me, bore on one side the impress of the chisel, the coarse fracturing of a tough metal, and marks of oxydation by fire. It was further identified by Wm. Coppinger, Esq., of Philadelphia, as the piece received with the letter of Mr. Davis. Mr. Coppinger gave the specimen to Rev. H. M. Blodgett, who sent it to Rev. Joseph Tracy, from whose hands I received it. Soon after I had expressed to Mr. Tracy my belief that the specimen was native iron, he placed before me a large amount of written evidence, showing that malleable iron, sufficient in quantity to meet the wants of the natives, is obtained by heating, and thereby fracturing the rocks of the country. The writers use the term *ore* incorrectly, as Mr. Davis does, apparently in the belief that iron ores increasing in richness become malleable. The metallurgical knowledge of the natives is so limited that they are unable to produce copper from the carbonate of copper, (Malachite,) which they carry five or six hundred miles, as a medium of traffic; while their weapons of iron which I have examined, show the characters of native iron after it has been heated and hammered.

Physical Characters.—On developing the internal structure of the mass of iron, by immersion for a few moments in strong nitric acid, and immediately after washing in a mixture of lime and water, it was apparent that the minute crystalline particles were arranged in a manner closely resembling those of the pure iron in meteoric masses, and entirely unlike the particles in artificial iron.*

* The character which is here noted has a higher value in a research of this kind, than would have been inferred from a cursory examination. In a description of the remarkable meteoric iron published in this Journal, (Nov. 1844,) I alluded to the fact, that these masses are not made up of iron alloyed with nickel and other metals, but consist of pure iron through which are mixed portions of an alloy of nickel and iron and iron and nickel, and other bodies as distinct *electro-negative matter* in relation to the pure iron. The Texas meteoric mass, and the small particles of the Weston meteorolite had the same mechanical constitution. Since the first publication of my results, these researches have been extended so as to include the metals of commerce and the well known alloys. The numerous analyses made on these forms of matter have not yet shown an exception to the condition, that, *the metal existing in the largest proportion is in part pure, while one, two, three or more alloys may exist*, distributed through it. When we take the results on a mass of crude iron in the state of pig-iron, and on portions of the less, and more malleable iron of the different steps of the manufacture, we not only pursue the constituents chemically, but

Where the mass had been heated and had received blows, there was an approach to the appearance presented by artificial iron; but the internal parts and nearly the whole of the mass showed no marks of percussive, or laminating action. By the more complete development of the structure, certain points appeared which were evidently extraneous matter. Under the microscope these points showed crystalline minerals, which when separated proved to be quartz and octahedral oxyd of iron. A mineral with a lime and soda base, was also found. The iron was most readily acted on by chemical agents, where it was in contact with these minerals. Exposure of a surface to the action of an acid, not only brought the mineral particles to view, but produced cavities at the points where they existed, showing degrees of porosity influenced by their number.

The specific gravity of the most compact portion was 6·708. Its color lighter gray than any sample of artificial ductile iron I have seen. Repeated bending back upon itself, did not separate one fragment, but generally flaws appear, and thin portions break when doubled close. The presence of the minerals imbedded is felt when we file or saw the metal, but when heated and hammered these fuse into slags and the metal spreads and draws off like the best irons, yet showing the cavities and flaws, where the simple minerals had existed.

Chemical Characters.—It dissolves with effervescence in diluted hydrochloric acid, and if the acid and water are perfectly pure, the evolved gas has no odor. 200 grains dissolved in hydrochloric acid, the hydrogen gas was passed through pure alcocol kept cool, and was then allowed to bubble through an ammoniacal solution of nitrate of silver. The alcohol had not acquired odor, nor was there any coloration or change in the silver solution. The solution of iron was turbid, but soon deposited suspended matter, which was light gray colored, some heavy white

the mechanical state of the iron is at the same time open to view. A mass of pig-iron thus becomes associated with meteoric iron in the mechanical arrangement of its parts, and generally consists of perfectly pure and malleable iron, disturbed in the arrangement of its crystalline particles, by the interposition among them of a compound of iron and carbon, and of graphitic carbon; besides sulphids, phosphids, and arsenids of the alkaline metals. In the ductile iron these bodies have been nearly all removed by heat and mechanical operations, and new features impressed upon the metal. By simply removing the interposed foreign matter by chemical means solely, crude iron is left malleable, and its particles then show their subcrystalline forms, but not as they exist in the pure iron of the more perfect meteoric masses. All manufactured iron presents them arranged in lines, and interlaced by the action of the hammer, or extended in bundles in the act of drawing: while the laminating mill breaks them down, shingling them over, and felting together their serrated edges, in striking analogy of effect, to the operations of textile manufacturing. The mechanical texture of a mass of iron cannot be shown fully by the simple step of immersion as above given, but this is sufficient to enable one to observe whether the crystals have arranged themselves as aggregates, or been broken up and disturbed by violence; and often will serve to show the kind of mechanical action employed.

sandy grains, and some dark, nearly black particles had fallen. After collecting and drying these substances, they were placed under the microscope, which showed the heavier bodies to be quartz, with some facets and fragments of octahedral crystals proved to be magnetic iron ore. The light body was silicic acid rendered gray by iron oxyd.

Chlorine was passed into the filtered iron solution, which after being heated and cooled, was precipitated in a partly closed flask by gaseous ammonia passed into it in excess. After being heated by a vapor bath, the precipitate was separated by filter and washed.

The filtrate and washings evaporated were reduced to a dry mass, which afforded a minute quantity of soda and lime; no other substance was present.

Separate parcels of the precipitate by ammonia were used for the detection of phosphorus, arsenic, and boron, alumina and other earths and oxyds: a little silicic acid only was found.

Fifty grains of the filings of the iron were wet with a few drops of perfectly caustic soda solution, mixed hastily with crystals of pure nitrate of soda and chlorate of potash, and heated in a nearly closed platina crucible rapidly to bright redness in twenty minutes: no deflagration occurred and the fused salts were colorless.

The crucible after cooling, digested in a closed vessel with recently boiled pure water, gave its soluble part to the water. After subsidence the clear fluid was added to a dilute saturated solution of lime in ammonia in one vessel, and to a dilute solution of baryta in another These vessels were closed and left twelve hours and then presented nearly transparent solutions, no precipitates had fallen, but both showed the presence of silicic acid. The absence of sulphur and carbon was thus proved, and other trials confirmed these results.

Analysis.—In the following analysis and in repetitions, different slabs of the metal were used so as to obtain an average percentage composition of the mass.

A solution in pure water, of about one hundred and fifty grains of pure sulphate of copper, was used as a medium, in which the iron dissolved replaced by electrolysis, the copper deposited on the negative electrode of platinum, connected with a feeble constant battery.

26·30 grs. of iron solved in the fluid and 29·78 grs. of copper were deposited on the platinum, while 0·32 gr. of matter was precipitated.

The equivalent of pure iron being 28, the deposits of copper should have weighed 29·71; an accordance as near, as these experiments allow, when more than one form of matter is present.

0·32 the precipitate consisted of angular portions of quartz, fragments of crystals of magnetic iron ore and a flock of silica:

the microscope showed no carbon, by this, the most certain and delicate mode of testing known to me.

The slab of iron had lost 26·60 grains. The partly ferruginous solution, decomposed by hydrosulphuric acid, evaporated and calcined, afforded traces of lime and soda; which in every case have been found to result from the solution of this iron. These bases had been united to the flock of silicic acid and they had increased the deposition of the copper, above the amount equivalent to the iron.

Reduced to per cent proportions, 100 parts of this slab consisted of

Pure iron, - - - - - -	98·87
Quartz, iron ore and silicate, -	1·13
	100·

Another slip from the centre of the mass more nearly an average, afforded in 100 parts,

Pure iron, - - - - - -	98·40
Quartz crystals, magnetic iron ore and silicate of soda and lime,	1·60
	100·

These little slabs which had formed the positive electrodes, had not disengaged a bubble of gas, which always occurs when the metals of alkaline bases are alloyed. They also exhibited in their substance, the cavities which had contained the mineral bodies found.

I was desirous of making some comparative experiments, on a specimen of iron having the characters of native iron, as distinguished from meteoric iron. My friend, Prof. B. Silliman, Jr., kindly supplied me with two slips from the specimen, well known as having been found at Canaan, Conn. He expressed to me at the time a doubt, respecting the certainty of this mass being native iron.

On subjecting a slip to analysis by electrolysis, it broke up into iron, iron and carbon and pure graphite. Reduced to per cent proportions,

Pure iron, - - - - -	93·057
Carbon, - - - - - -	2·666
Iron from carbon, - - - - -	1·361
Graphite, - - - - - -	2·916
	·100

In the arrangement of the alloy of carbon and iron and the lamina of graphite, it differed in no respect from "Kishy" iron, which has been allowed to repose in a heated state and is unquestionably an artificial iron: a product of the blast furnace.

16, Boylston st., Boston, July, 1855.

ART XIX.—*On the Telescopic Appearances of Saturn with a 7½-inch Telescope**; by the Rev. W. R. DAWES.

IN the spring of last year (1854) I availed myself of an opportunity of increasing the optical means in my possession, by the purchase of a 7½-inch object-glass, having a focal length of nearly 9½ feet. It is the work of Mr. Alvan Clark, of Boston, U. S., who has long been known in that city as a most successful painter of portraits, but took to the manufacture of telescopes as an amateur. Being dissatisfied with reflectors, on which he commenced his operations, he attempted the manufacture of object-glasses; and succeeded so well, that in the autumn of 1851 he communicated to me the places of some new and very close double stars, which he had discovered with glasses whose apertures were 4¾ and 5¼ inches. In the following year he completed an object-glass of 7⅛ inches aperture for the observatory at Williams College, which was tried at the Harvard Observatory by the Messrs. Bond, and highly approved; immediately after which he commenced one of 7½ inches aperture, intended to be retained and mounted equatorially for his own use. At his requet I sent him some extremely difficult tests, selected from Mr. Otto Struve's *Pulkova Catalogue;* several of which have a central distance of little more than half a second, and some even less. Yet of all these I soon received from the ingenious maker (who has also proved himself an acute observer) perfectly correct diagrams; together with the places of one or two extremely difficult new double stars which he had discovered with this glass. As a specimen of these, I may mention 95 *Ceti*, which is at present favorably situated for observation. Though unwilling to part with this glass, Mr. Clark consented to let me have it to try against my Munich telescope; and in March, 1854, it arrived, with its tube, finder, and eye-pieces.

Though the crown-glass has a considerable number of small bubbles, the performance of the telescope is not sensibly affected by that circumstance. In other respects the materials are good; and the figure is so excellent, and so uniform throughout the whole of the area, that its power is quite equal to anything which can be expected of the aperture; and consequently, both in its illuminating and separating power, it is decidedly superior to my old favorite of 6⅓ inches aperture. As a specimen of its light, I may mention the companion of v *Ursæ Majoris* as having been pretty steadily seen with it; and also that I have never seen *Saturn* under tolerable circumstances during the present apparition without detecting *Enceladus*, even when at or very near his con-

* Extracted from the Monthly Notices of the Royal Astronomical Society for Jan. 7, 1855.

junctions with the planet. When exterior to a tangent to the extremity of the ring, this satellite has frequently been perceived as soon as my eye was applied to the telescope. Last spring it was seen several times in strong twilight; for instance, on March 16th, 17th, and 20th, at about 7^h G. M. T. In separating power, the glass is competent to divide a sixth-magnitude star composed of two equal stars, whose central distance is $0''\cdot6$.

I have thought it proper to premise thus much respecting the performance of the telescope, that a correct idea may be formed as to the degree of dependence to be placed upon the views it has afforded me of *Saturn;* the special subject of my present communication, to which I will now proceed.

1. *The outer Ring* A.—The interior edge of this ring is decidedly its brightest part: its light rapidly fades away towards the middle, where there is a very dark, narrow, well-defined line concentric with the ring, and about one-fifth of its breadth by careful estimation. This line has been always seen when the air was in a tolerably good state, and much more readily than last year. On the 26th of November, 1854, it was traced more than half way round towards the ball, and was equally well seen at both ansæ. I have recorded on 10th January, 1855, "I am surprised at the positiveness of the dark line near the middle of this ring. It was well seen with every power from 355 to 1000." This is now the fourth apparition of *Saturn* in which I have noticed this dark line, and it does not appear to me to have varied in its position on the ring, or in its breadth and depth of shade.

2. *The interior bright Ring*, B.—The concentric shaded bands on this ring have been on two or three of the most favorable occasions very well brought out. On this appearance I find the following notes in my journal:—

"1854, Nov. 26. The ring B is decidedly in *stripes*, and they are not *regularly* darker from the exterior one inwards. About one-fifth of the breadth of the ring, from its exterior edge, is very bright; then a narrow stripe is lightly shaded; immediately within that is a stripe decidedly lighter, though not so bright as the exterior fifth; next to that is a considerably darker stripe, and then a *much* darker one extending nearly to the interior edge, where there is a *very* narrow *bright* line, far less decided than it was in 1851 and 1852."

"Dec. 7. By brief views the step-like character of the shading on ring B is visible; and I think the *outer* shaded band is *darker than the next interior one*, as I noticed one night before."

"1855, Jan. 10. The bands of shading towards the interior edge of this ring are occasionally well brought out; and I think the *second* from the outside is not quite so dark as the first,—at least in some parts of it, for I doubt if it be quite uniform. The narrow bright line at the interior edge is visible, but is not, I think, so bright as it was in the two previous apparitions."

3. *The obscure semi-transparent Ring* C, has been very well seen on several occasions; and I have noticed nothing remarkable about it except the occasional variations of its tint in different parts. Respecting this I have recorded as follows:—

"1854, Sept. 26. The dark ring is plainly seen, and appears to-night of the same tint at both ansæ. Its semi-transparency is very obvious across the ball, the edges of which can at times be distinctly traced down to the inner edge of ring B."

"Dec. 26. The dark ring is remarkably clear: the following end is *ruddier* than the preceding."

"1855, Jan. 10. The ring C is wonderfully well seen in general: rather ruddy on the preceding side, slate-colored on the following side. The ball is seen plainly, though faintly, through it."

4. *The Ball.*—Of its appearances I have the following notes:

"1854, Sept. 26. The belts on the ball are not very distinct. The southern boundary of the broad dark belt, which is immediately south of the equator, is *not uniform*, or parallel to its northern edge. Tho belt therefore, varies in breadth in different parts, and is at present ($13^h\,45^m$ G. M. T.) broadest near the eastern edge of the ball. There is a very narrow light line seen interruptedly crossing the belt from east to west, a little south of its middle. The rest of the southern hemisphere is nearly uniform in color, except that round the south pole is a belt of rather darker tint, and at about 40° of south latitude there is a very narrow belt less dark than the polar one."

"Dec. 7. The annexed sketch" (in the journal) "shows the form of the shadow of the ball on the ring B. It does not extend to the ring A at all; but I think a very small portion ($0''2\pm$) of the southern edge of the ball is projected upon A."

"Dec. 16, $12^h\,30^m\pm$G. M. T. The south pole, or rather the most southerly part of the ball, is very dark,—much darker than the ring A, and I think rather darker than the broad belt near the equator. This renders the contrast with the small visible portions of its shadow less evident. I feel pretty sure that the southern edge of the ball encroaches a trifle on the ring A. There are no distinct and well defined belts on the ball now."

"1855, Jan. 10, $9^h\pm$ G. M. T. The whole of the southern hemisphere of the ball is ruddy, and the parts near the equator and at the southern edge are the darkest. Examined very carefully, and with all the various powers" (extending from 355 to 1000), "the position of the southern edge with respect to the edges of the rings at that part. The edge of the planet is so dark that it gives the impression sometimes of having a dark line there marking its contour. This darkness of the shading, at the very edge of the ball, renders it difficult to distinguish it from the division between the rings. But after long and careful examination, I am satisfied that ***the ball extends over the division, and en-***

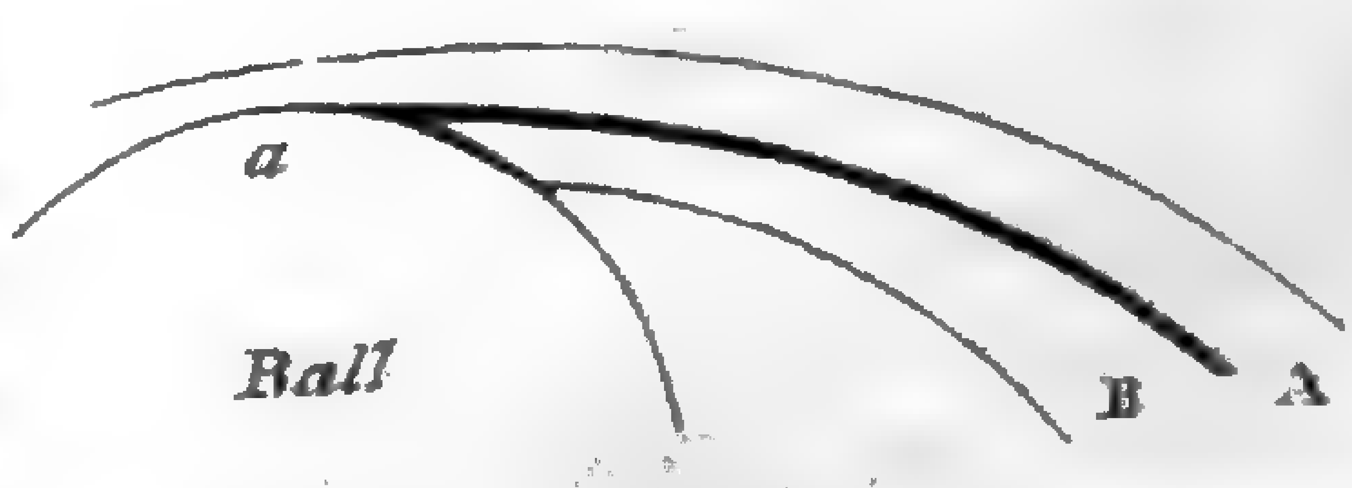
croaches 0″·2 *or* 0″·3 *on the ring* A. By carrying my eye across from the black division on one side to the other, I can see that, if continued in an uninterrupted line, it would *cut off a thin slice from the edge of the ball.* With very high powers (705 to 1000) the difference of color of the southern edge of the ball, and the ring A at that point is more marked than with the lower powers; and long scrutiny with them confirms my impression that the ball encroaches slightly on A."

"10^h 36^m±G. M. T. Applied an excellent Huygenian eye-piece, giving power 860. It is admirable. The difference of color of the southern edge of the ball and ring A is obvious; and there is no doubt at all of the slight encroachment of the ball on its interior edge. Finding the light of the planet produce a very unfavorable effect upon my eye while endeavoring to estimate the degree of encroachment of the ball on A, it occurred to me to apply my solar eye-piece for the purpose of excluding the rest of the ball and rings, and leaving visible only the southern portion of the ball and the adjacent portion of the rings A and B. Power 506 (the highest, a double-convex lens). The effect is admirable. My eye having rested upon it for some time, the outline of the southern edge of the ball was far more distinctly seen than before, and leaves no doubt of its encroaching on the interior edge of A, to about 0″·3 by careful estimation. At times a little mottling can be discerned very near the southern limb of the ball. Its color is very different from that of ring A; and it completely interrupts the black division which comes sharply up to the ball on both sides of it."

5. *The Shadow of the Ball on Ring* B. On this appearance I have noted as follows:—

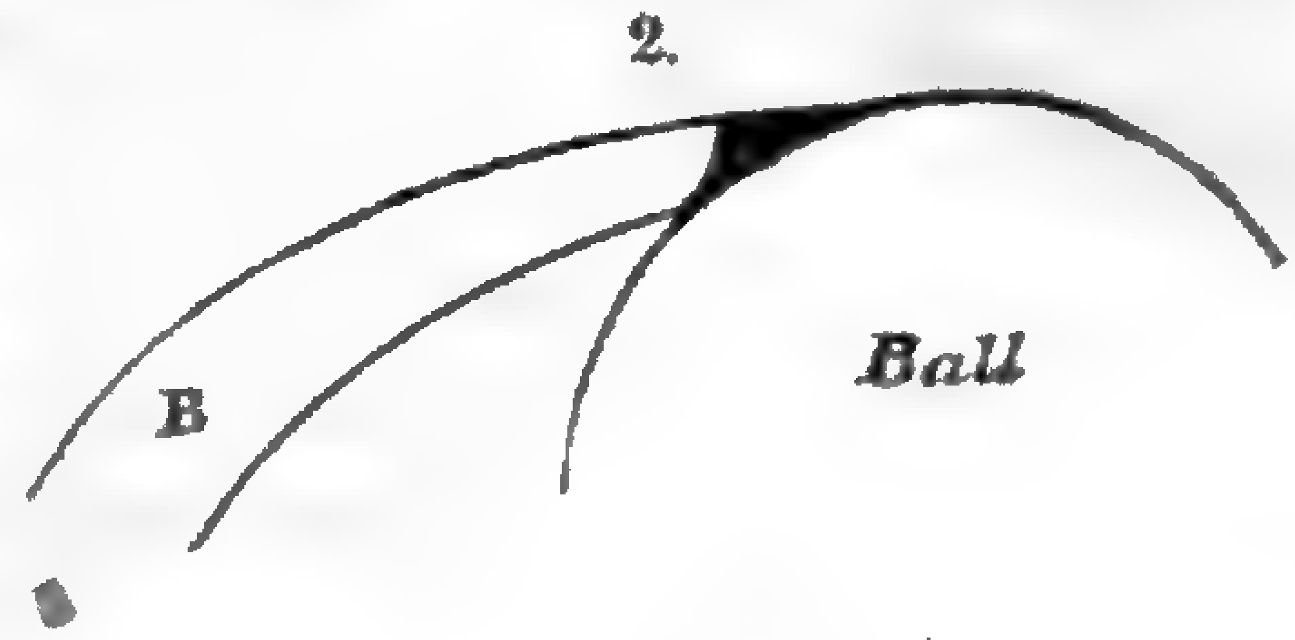
"1854, Sept. 26. The shadow of the ball on ring B is nearly a straight line."

1.



On Sept. 29 the projecting portion of the shadow, which has been noticed the last two or three years, was seen for the first time this season on the eastern side of the ball; cutting off the acute point of the ring B intercepted between the edge of the ball and the black division, as at *a* in the sketch, in which the appearance is much exaggerated.

2.



At the same date I have remarked,—"I doubt if the shadow of the ball on ring B is really a straight line, though nearly so. It seems to be a little curved towards the southern end of it, close to the division." In the place indicated the edge is *convex* towards the ball.

"Nov. 26. Only a *very* narrow line of shadow from the ball falls on the west side, but there is a curious angular projection in the shadow on both the west and east sides of the apex of the ball."

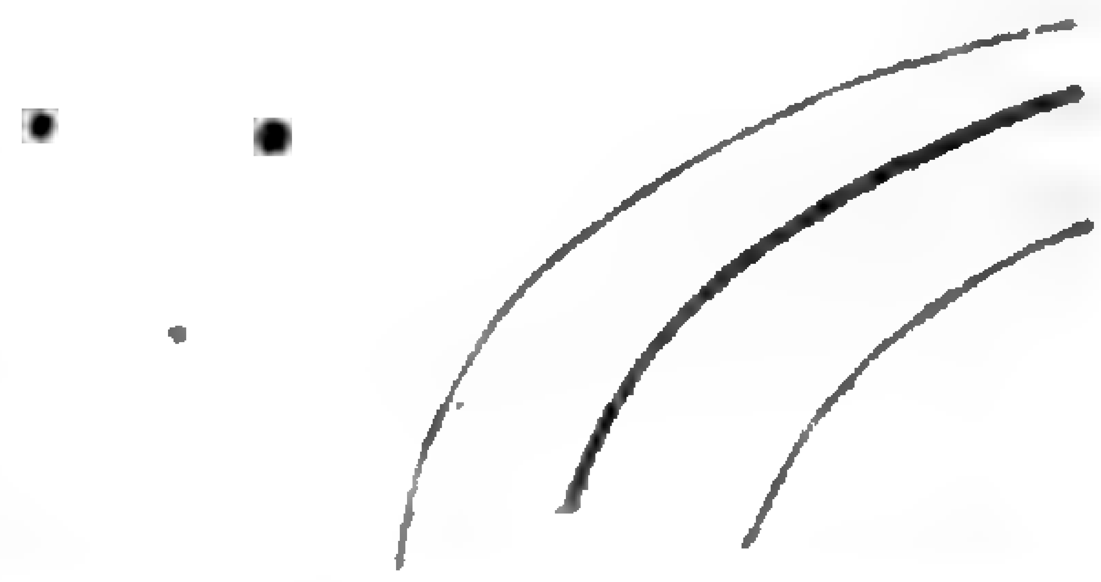
"Dec. 7. The annexed sketch shows the form of the shadow

3.

of the ball upon ring B." (Exaggerated in the sketch as respects the *size* of the shadow.)

6. *The Satellites.*—I have usually estimated *Tethys* to be brighter than *Dione*, even when it has been nearer to the planet. This was remarkably the case on the 10th of this month, at $7^h \pm$ G. M. T., when both the satellites were near their greatest western elongation. At 11^h 19^m G. M. T., *Dione, Tethys*, and *Enceladus*, formed an equilateral triangle south-preceding the western end of the ring, thus,—

4.



In No. 929 of the *Astron. Nachrichten*, is a most interesting account by Professor Secchi of the appearance of *Saturn* in the Munich equatorial refractor, recently erected at the Observatory at Rome. The dimensions of the telescope are the same as those of the Dorpat refractor, the aperture of the object-glass being 9 Paris inches. The Professor characterizes the night of Nov. 19 as one of extraordinary excellence, and doing full justice to the telescope. He describes the dark line on ring A as being just like a *pencil line* drawn upon it, which perfectly agrees with the views I have had of it since 1851; and with my description as "narrow, very dark, but not black." And when the dusky hue of the ring A is considered, it seems probable that this line would appear almost black if contrasted with a much brighter ground, such, for instance, as the exterior edge of the ring B. It deserves to be remarked that a dark line, precisely similar to this in appearance and situation, was seen on the *northern* surface of this ring, in the year 1838, by Professor Encke; and by Mr. Lassell and myself in 1842 (when we were not aware of Encke's observation). It may not be a *division* in the ring, as it was then supposed to be; but, if it is not, it is certainly extraordinary that precisely the same appearance should exist *on both surfaces of the ring*, and should be, as it would seem, a permanent phenomenon in respect of its situation on the ring, and the darkness of its shade.

Professor Secchi has also described the step-like concentric bands of shading on ring B, exactly as they were described by myself on October 26, 1851: and as I have occasionally seen them almost precisely in the same way to the present time, it may fairly be concluded that they form a permanent feature of this ring. The Professor does not notice the *comparatively bright line* at the interior edge of B, which seems to me to render that edge pretty definite, though it is certainly less bright now than it was two or three years ago.

In one important point the impression received by Professor Secchi differs decidedly from my own, as stated in the present paper: viz., the place to which the southern edge of the ball is seen to extend on the rings. He states that the opening of the ring is such, that *the upper edge of the ball exactly touches the interior edge of the black division between A and* B, which was visible throughout the whole of its elliptic perimeter. It is singular that, on the 26th of September I arrived at precisely the same conclusion; but the state of the air was not such as to permit the advantageous use of high powers; and my subsequent observations, under much better circumstances, and especially on the 10th of this month, convinced me that my first impression was erroneous, or that a change to a considerable, and in fact *unaccountable*, amount had taken place.

The *first* satellite of *Saturn* (now usually called *Mimas*) is stated by Professor Secchi to have been seen on November 19th, near its great western elongation; having been found by putting the planet nearly out of the field, and afterwards seen steadily with the planet in full view. It is surprising that he does not mention *Enceladus*, which must have been close to *Mimas* at that time, if the latter occupied the place indicated. As my telescope has not shown me *Mimas*, I cannot say where that satellite might have been; but my own observations prove that *Enceladus* occupied precisely the situation which the Professor has ascribed to *Mimas;* and I cannot but think it probable that further observations may have convinced him that it was not the *first*, but the *second*, satellite which he saw.

The *bright zone on the ball*, which commences almost precisely at the equator, and extends northwards as far as the ring permits it to be seen, forms one of the most conspicuous features of the planet. It has been repeatedly referred to by Professor Secchi, as *caused by the reflection of the sun's light from the surface of the ring*. Two considerations seem to me to be quite conclusive against its arising at all from that cause. One is, that this bright zone occupied precisely the same situation, and was very conspicuous, *when the plane of the ring passed through the sun*. (See "Remarks on the Planet Saturn," by the Astronomer Royal, in the *Greenwich Observations* for 1844, p. 44.)

The other is, that the reflection of the sun's light from the *southern* surface of the ring, which now receives it, must necessarily fall upon the *southern* hemisphere of the ball, which has been remarkably dark ever since the southern surface of the ring has been illuminated; while the bright zone lies wholly in the *northern* hemisphere. The remarkable obscurity of the southern hemisphere at the present time seems to indicate that the effect of the reflection from the surface of the ring is quite inappreciable as seen from the earth.

Wateringbury, Jan. 11, 1855.

Postscript.—"Jan. 14. The night proving fine, I again carefully examined *Saturn*, and made the following entry in my journal:—

"'$12^h\ 45^m$ G. M. T. *Saturn* is very fine at times, though about $3\frac{3}{4}^h$ past the meridian. It bears 705 very well; and with this power I have no doubt of the southern edge of the ball extending over the division between A and B, and encroaching a trifle on the interior edge of A. With low powers (355 or less) there is sometimes an appearance of the division extending across; but I am persuaded that this arises from the combined effect of the division coming up on each side so near the apex, and the *very* deep tint of the apex itself, which I think is *darker* than the darkest part of the broad belt close to the equator of the planet. It is certainly much darker than the ring A.'"

Art. XX.—*On a new and advantageous mode of preparing Aluminium;* by Prof. H. Rose.

[Translated and read before the National Institute, Washington, D. C., Oct. 5, 1855, by J. Tyssowski, U. J. Dr.*

Since the discovery of Aluminium by Wöhler, Déville has recently taught us a method of obtaining it in larger connected masses, in which this metal shows qualities, which had not been observed in the metal as obtained in the form of a powder by the process of Wöhler. While in the latter form it burns with great brightness to a white clay, it may be, if fused into larger balls, heated to redness, without perceptibly oxydizing. These differences may be attributed to finer division and greater density, although according to Déville, Wöhler's metal contains some platinum which accounts for its less fusibility.

After the publication of Déville's investigations I tried also to obtain aluminium from chlorid of aluminium and sodium, by means of an additional dose of sodium. I did not follow entirely the method of Déville, but stratified the salt with the

* Poggendorff's Annalen, vol. xcvi, page 152.

sodium and then applied heat. I however obtained no satisfactory results. Rammelsberg also followed closely the method of Déville but obtained no good results; moreover he was seldom able to prevent the bursting of the glass-tubes with which he experimented in consequence of the action of the vapors of sodium upon the chlorid of aluminium. It appeared to me that considerable time, labor, expense and long experience would be necessary in order to obtain even small quantities of this remarkable metal.

The application of chlorid of aluminium and its compounds with the alkaline chlorids, is particularly objectionable for the reason that they are volatile, attract moisture very readily, and therefore the access of air must be prevented when treating them with sodium.

I therefore early thought of substituting for the chlorid of aluminium the fluorid of aluminium, or rather the compounds of the latter with alkaline fluorids and which are known to us from the investigations of Berzelius. Berzelius pointed out the strong affinity of fluorid of aluminium for fluorid of potassium and fluorid of sodium, and that the cryolite occurring in nature is a pure combination of the fluorid of aluminium with the fluorid of sodium.

This compound, in consequence of its constituents, is as well adapted to the preparation of aluminium by means of sodium, as the chlorid of aluminium and its compound with chlorid of sodium. And in addition to this, the cryolite not being volatile, easily reducible to the finest powder, free from water, and not attracting moisture from the atmosphere, it presents peculiar advantages in comparison with the fore-mentioned compounds.

I succeeded in fact in obtaining aluminium by heating powdered cryolite with sodium to redness in a small iron crucible much more easily than by a similar treatment of chlorid of aluminium and its compound with chlorid of sodium. The scarcity of the mineral however prevented me from continuing my experiments.

A short time since, I returned to them, on having obtained through Mr. Krantz in Bonn, a considerable quantity of the purest crystals and at a trifling expense (1 kilogram for 2 Prussian dollars). But my zeal was exalted by the unexpected news reaching me that cryolite may be obtained here in Berlin and at incredibly low prices.

Mr. Krantz had communicated to me his having heard that cryolite exists in masses in commerce, yet he could not learn where. A short time since Mr. Rüdel the Superintendent of the chemical manufactory of Mr. Kunheim near the Halle gate, presented to me a specimen of a white coarse powder, large quantities of which it is said have been sent from Greenland, through Copenhagen to Stettin under the name of mineral soda at three Prussian dollars per cwt. Samples of 40 lbs. had been handed to the soap-manufacturers of this place: and in fact by treating them with burnt lime, a soda-ley was prepared from it, which probably from its very admixture with alumina proved very superior for the manufacture of certain soaps.

I recognised in this powder the mineral *Cryolite* of the same purity as the crystals obtained through Mr. Krantz. It dissolved perfectly (in a platinum vessel) and without leaving any insoluble matter in hydrochloric acid; the solution evaporated with sulphuric acid to dryness, showed a deposit, which heated to the expulsion of the free sulphuric acid. proved perfectly soluble in water with the aid of some hydrochloric acid. In the solution, a considerable precipitate of alumina was obtained by ammonia. A filtered solution thereof gave after evaporation and heating a deposit of sulphate of soda, which contained no potassium. Besides this, the powder showed the known reactions of fluorine in a very high degree.

This powder is therefore cryolite of great purity. Still the coarse powder which I obtained at first, was not the original form in which it comes in commerce. The cryolite arrives here in Berlin in large masses. For the purpose of preparing aluminium it must be reduced however to a very fine powder.

In my experiments for the preparation of the metal which I made conjointly with Mr. Weber and with important aid from him, I have used, thus far, for the most part, small iron crucibles $1\frac{3}{4}$ inches high, and $1\frac{3}{8}$ inches diameter, which I had cast in a foundery of this place. In these I stratified the fine cryolite powder with thin layers of sodium, stamped the whole pretty strongly, and covered it with a good cover of chlorid of potassium, and the crucible with a well fitting porcelain cover. Of all the fluxes, I found the chlorid of potassium the most advantageous; it has the least specific gravity, which in view of the very small density of the aluminium is of great consequence. Besides it fuses with the fluorid of sodium to a mass more fusible than the latter alone. I usually employed equal proportions of chlorid of potassium and of cryolite, and for five parts of the latter I took two parts of sodium. Ten grams of cryolite powder answered the best for the crucible.

The whole was then exposed to a powerful red heat, by means of a blowing apparatus, in which atmospheric air and illuminating gas is forced through pipes constructed after the principle of Daniell's pipe in the explosive gas-blowpipe apparatus. It appeared to be the best to continue the red heat during half an hour and no longer, keeping all the time the crucible carefully closed. Meanwhile the whole is well fused. After cooling, the contents of the crucible are best cleared by means of a chisel, which operation may be facilitated by gentle blows with a hammer on the outside of the crucible. The crucible may be used repeatedly for new operations; though finally it will fall to pieces, in consequence of the blows applied.

The fused mass is treated with water. Usually no gases or only inconsiderable and hardly perceptible quantities of gas are evolved. The small amount of hydrogen given out has the same unpleasant odor as the gas forming during the solution of iron in hydrochloric acid. The carbon comes from the minute portion of naphtha which adheres to the sodium even after drying.

In consequence of the difficult solubility of the fluorid of sodium the fused mass softens but slowly. The addition of chlorid of potassium somewhat increases the solubility. After twelve hours the lumps are softened so much that after pouring away the liquid they may be flattened with a pestle in a porcelain mortar. Larger globules of aluminium are then found, weighing from 1·3 to 0·4 grams, which are separated. I have recently found them of a weight of 0·5 grams. The smaller globules cannot be separated by lixiviation from the alumina simultaneously formed and the cryolite underlying the latter, these being heavier than the aluminium. The whole is treated cold with dilute muriatic acid. This, although it does not separate the calcined alumina, yet gives the aluminium globules their metallic lustre. They are dried, and then the alumina particles and the non-decomposed cryolite powder is separated by rubbing upon silk muslin, the little metallic globules remaining upon the tissue.

The pouring of water over the fused mass is done in platinum or silver cups. Porcelain vessels ought to be avoided, their glazing being attacked strongly by the solution of the fluorid of sodium. The solutions clarified by being left standing in a large silver cup may be evaporated in platinum cups, in order to obtain the fluorid of sodium, which however is mixed with a considerable portion of chlorid of potassium.

The small globules of aluminium can be fused together in a small covered porcelain crucible under a cover of chlorid of potassium by means of a blowpipe. Attempts to unite them without the use of the crucible never succeed. The small globules can not be fused like small globules of silver, because the aluminium, although apparently it does not oxydize while heated with access of air, still it is during that process covered with an almost imperceptible pellicle of oxyd, which prevents the fusion.

The fusion under chlorid of potassium is always attended with a loss of aluminium. A globule of aluminium of 3·85 gr. weight lost by fusion under chlorid of potassium 0·05 gr. The chlorid of potassium after being dissolved in water, did not show any alumina, a small quantity of which however separated undissolved. Another part of aluminium unquestionably decomposed the chlorid of potassium; chlorid of aluminium and of potassium must have volatilized by the fusion. Other metals comport themselves similarly, as copper and even silver.

I followed therefore the direction of Déville, and fused the globules of aluminium in a covered porcelain crucible under a cover of chlorid of aluminium and sodium. The salt was first fused and then the globules were introduced into the molten salt. In this way the loss of metal is none or very minute, at the most only a few milligrams.

If the aluminium is melted under a cover of chlorid of potassium, its surface is not thoroughly even, but shows minute excavations, which is not the case if it is melted under chlorid of aluminium and sodium.

The quantities of chlorid of aluminium and sodium to be employed for this purpose, are most easily prepared by bringing the mixture of alumina and charcoal in a glass tube of as large a diameter as possible, and by introducing in it another glass tube open at both ends of a smaller diameter filled with pulverized table-salt. By heating the space containing the mixture of alumina and charcoal very strongly, and that which contains the chlorid of sodium less, while passing the chlorine gas through the tube, the vapors of the chlorid of aluminium will be absorbed so eagerly by the chlorid of sodium, that no chlorid of aluminium or only a trace of it deposits on the other parts of the apparatus. If the smaller glass tube with the chlorid of sodium has been weighed beforehand, the quantity of the chlorid of aluminium it has absorbed can be easily determined. The latter however is not combined equally with the chlorid of sodium; that part which was next to the mixture of clay and charcoal, contains the most of it.

I have varied the process for the reduction of aluminium in many ways, but have returned to that described. Often the sodium was placed alone on the bottom of the crucible, over it the cryolite powder, and then the chlorid of potassium. In this case, copious vapors of sodium escaped, burning with a strong yellow flame, which did not take place if the sodium was cut in thin slices and stratified with the cryolite powder when the process goes forward very quietly. From the start, the incandescent crucible suddenly glows up vehemently while the decomposition of the compounds takes place. At this point the heat must not be reduced, but kept on, not however beyond half an hour. Through a longer glowing heat, a great loss would be experienced in consequence of the action of the chlorid of potassium upon the aluminium. Neither will the globules of aluminium become larger by a longer glowing heat, which was tried, up to two hours; this effect was produced only through the most intense heat possible. If, however, after the highest incandescence of the crucible, that is after five or ten minutes, the heating ceases, the gain in aluminium is remarkably small, the metal then not having yet formed in globules, remaining in the form of a powder and burning up during the cooling of the crucible.

No greater gain is obtained if the cryolite powder be first mixed with a part of the pulverized chlorid of potassium and then stratified with the sliced sodium.

I also tried covering the cryolite stratified with sodium, with a layer of chlorid of aluminium and sodium, and heated the whole as usual. But I found no gain in this way.

I often employed, in place of chlorid of potassium, chlorid of sodium (common table-salt heated) without observing any considerable difference in the result. Only the heat has to be raised higher than when using chlorid of potassium.

The operation may also be performed in hard, fusible unglazed stone-ware crucibles of the same size as the cast iron crucibles aforesaid. At a very high temperature they only resist with more difficulty the action of the fluorid of sodium and melt in one or more places. The iron crucibles melt also, if when filled with the mixture for the preparation of aluminium they are exposed to a very intense charcoal fire.

The amount of aluminium obtained has, up to this time, been very variable, even with the same process and the same proportions of materials. The quantity of metal contained in the cryolite treated has never been reached. The latter contains 13 per cent of aluminium. By employing 10 grms. of cryolite a quantity, which was the standard in all experiments with the small crucibles, the most favorable product was 0·8 grm. of aluminium. If however, only 0·6 or even 0·4 grm. were obtained out of the 1·3 grm. which, according to calculation were contained in the cryolite treated, the result would still be called satisfactory. Often only 0·3 grm. and less were obtained.

These so different results depend on various circumstances, principally however, upon the degree of heating. The greater the heat the more the small globules unite into larger ones, and the less aluminium remains in the state of powder, which could during the subsequent cooling oxydize into alumina. I succeeded sometimes in uniting by fusing in a stone-ware crucible and with a very great heat, almost the whole quantity of the aluminium obtained into one single globule of 0·5 grm. weight.

The heat, which I am enabled to give by means of the blowpipe apparatus, is not equal at all times of the day, depending as it does upon the varying pressure to which the illuminating gas is subject in the gas metres of the city. But that a great loss of aluminium is caused through a very slow cooling under access of air which favors the oxydation of the small particles of the reduced metals, is proved by the following experiment.

In a large iron crucible 35 grams of cryolite powder were stratified with 14 grams of sliced sodium, and the whole covered with a thick stratum of chlorid of potassium. The crucible covered with a porcelain cap, was placed in a larger earthen-ware crucible, also covered, and exposed during an hour to a good charcoal fire in a well drawing wind furnace, and cooled as slowly as possible. The product in aluminium was in this case remarkaly small, only 0·135 gram. in globules being separable from the molten mass.

The varying result originates also in this, that through the varying stratification of the sodium with the cryolite powder, a large amount of the latter often escapes decomposition. The more sodium employed, the less is this the case ; but because of the great difference in the price, I never took more than 4 grm. of sodium for 10 grms. of cryolite.

To avoid the loss resulting from the oxydation of the pulverulent aluminium during cooling, I tried some other methods of operation. 20 grms. of cryolite were strongly heated in a gun barrel exposed to a current of hydrogen, and then the vapors of 8 grms. of sodium passed over it. This was accomplished simply by introducing the sodium placed on a sheet-iron pan in that part of the gun-barrel which stood out of the furnace, and pushing the same in the fire only at the moment when the cryolite powder reached its highest point of incandescence. The operation went on admirably. I permitted the whole to cool in the hydrogen current. After lixiviation in water, in which the fluorid of sodium dissolved with great difficulty, I obtained a great quantity of a black powder, which for the most part consisted of iron, and which in its solution in hydrochloric acid showed but little alumina.

The smallness of the products which I obtained in most instances, must not deter from further investigations. They are the results of the first experiments in which I have been engaged and for a short time. Now when the cryolite may be obtained at so low a price, and as sodium (for the increased facilities of reducing which we are so much indebted to Déville) will also in future be much cheaper, any one may undertake to produce aluminium, and certainly in no distant time methods will be found that will afford satisfactory results.

Anyhow, I am of the opinion that the cryolite among all the compounds of aluminium will prove the most eligible for the production of aluminium. It possesses so many advantages over the chlorid of aluminium and the chlorid of aluminium and sodium, that it would be employed with the greatest benefit even if its price were considerably higher.

Aluminium has yet hardly been obtained directly from alumina. Potassium and sodium appear to effect the reduction of the metallic oxyds only when the nascent potassium or sodium is at hand to combine with a part of the oxyd not yet reduced. Pure potash and soda, the properties of which are almost unknown to us, do not appear to form at that moment. And as alumina can very readily combine with alkalies to form an aluminate, it should be inferred, that the reduction of alumina through the alkaline metals might succeed in the end.

But even if it should become possible to obtain aluminium directly from alumina, still cryolite may for a long time be employed for the purpose, unless its price should rise immoderately. Nature furnishes this substance in a state of rare purity, the aluminium is combined in it only with fluorine and sodium—two substances which cannot act injuriously during the production of the metal. Clay or aluminous earth is however seldom found in a pure state, and always of great density. To reduce aluminous earth in large quantities from its compounds and to purify it from substances which could act injuriously during the production of aluminium—would be attended with great difficulties.

The globules of aluminium obtained by me are for the most part so extensible, that they may be flattened very considerably and rolled into the thinnest sheets without their showing fissures on the sides. They have at the same time a strong metallic lustre. On the contrary some few masses, found on the bottom of the crucible and sometimes adhering to it and which had no globular form, showed fissures when rolled, and differed somewhat in color as well as in lustre. They evidently were not as pure as the great majority of the globules, and probably contain some iron.

A larger globule of aluminium of 3·8 grm. weight having been sawn in two, it could be plainly seen that the metal was brittle for about half a line from the outside; but inside it was soft and pliable. Sometimes excavations are found in the interior of the globules.

According to the observations of Déville I happened also to obtain the aluminium in crystalline form. One of the greater globules became in cooling radiated with crystals on its under surface. Déville believes he has obtained regular octahedral crystals, but does not however assert this positively. According to the investigations of my brother, the crystalline structure does not appear to belong to the regular system.

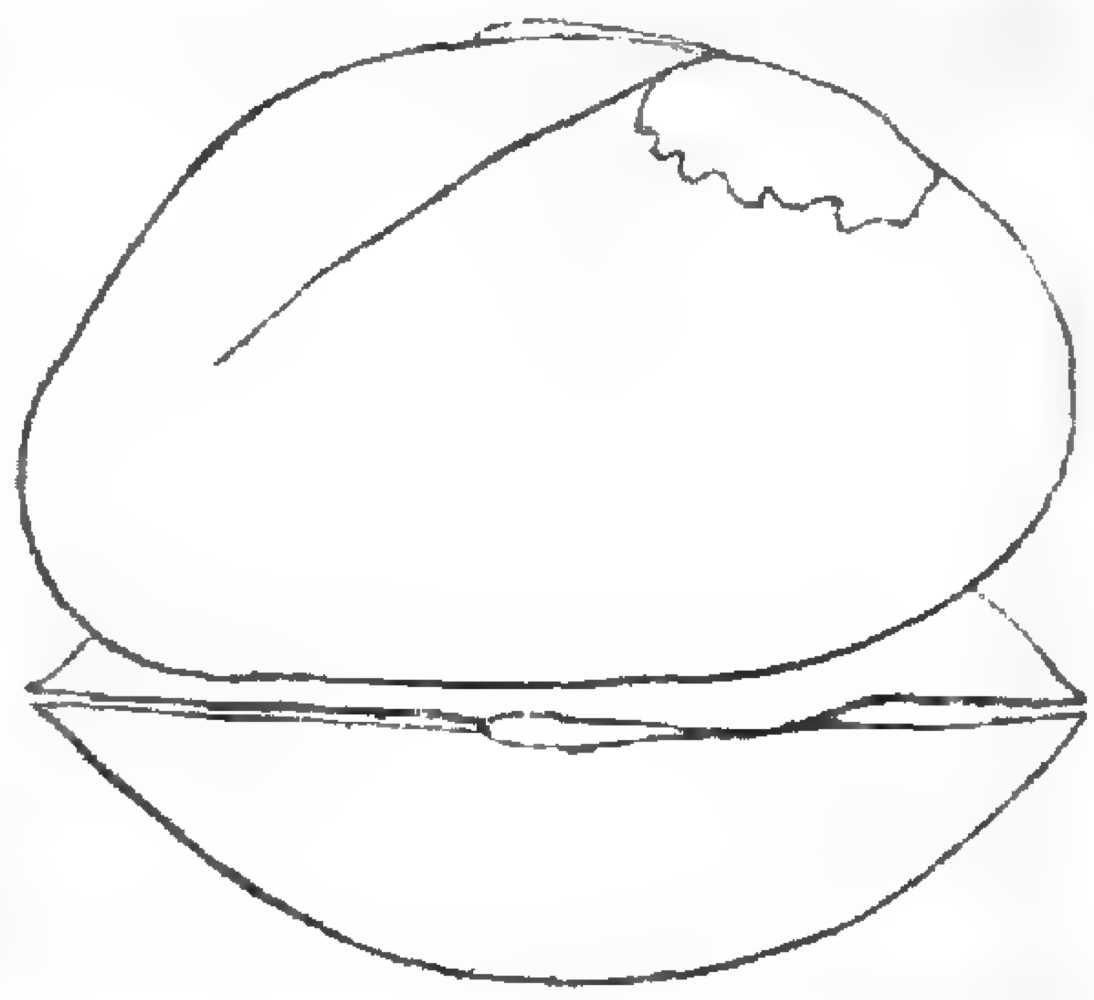
Trying to melt a larger globule accidentally contaminated after being rolled without flux, before the heat rose so as to melt the whole, small globules went floating on the surface. The impure aluminium is less fusible than the pure which is mixed with it, expands in melting and rises out of the mass not yet fused. It is a phenomenon similar to that observed by Mr. Schneider with impure bismuth.

I have stated that the cryolite has been employed here in Berlin under the name of mineral soda for the preparation of caustic soda-ley, which owing to its aluminous earth appears eminently adapted to the manufacture of soap. In fact the pulverized cryolite is decomposed entirely if boiled in this condition with caustic lime and water. The fluorid of calcium thus generated contains no aluminous earth, this being entirely dissolved in the hydrate of soda, which again is free from fluorine or shows but a trace of it.

Art. XXI.—*On a new Species of Unio;* by T. A. Conrad.

Unio diversus.

Trapezoidal, ventricose, inflated posteriorly, substance of shell generally thin, thicker anteriorly and thickest or somewhat callous towards the base; valves contracted from beak to base, posterior margin obliquely truncated, rectilinear, ligament and basal margins parallel; posterior extremity obtusely rounded; basal margin contracted; umbonal slope rounded; beaks decorticated; lines of growth profound; epidermis yellowish olive



clouded with dark brown; rays obsolete or wanting; within greenish or wax-colored; dirty white towards the anterior base; cardinal tooth in right valve compressed, oblique, crested, prominent; in the opposite valve 3-lobed, the posterior lobe opposite the apex, middle lobe small or obsolete; lateral teeth straight, reversed.

Inhabits Shoal Creek, N. Alabama. Prof. Thomas P. Hatch.

Remarkable for its resemblance to *U. heterodon*, Lea, and like that species having the double lateral tooth in the right valve. The cardinal tooth of the left valve has the same extended character as the *heterodon*, and I think these two species will be found to constitute a distinct subgenus when the animals have been compared.

U. viridis, Raf. Perhaps it may interest conchologists to learn that this species inhabits the Schuylkill river, at Phœnixville, where I found three specimens in a very limited time; and some years since I procured a number of living specimens in the Delaware, opposite Trenton, just below the falls.

Art. XXII.—*Observations on Binocular Vision;* by Professor William B. Rogers.

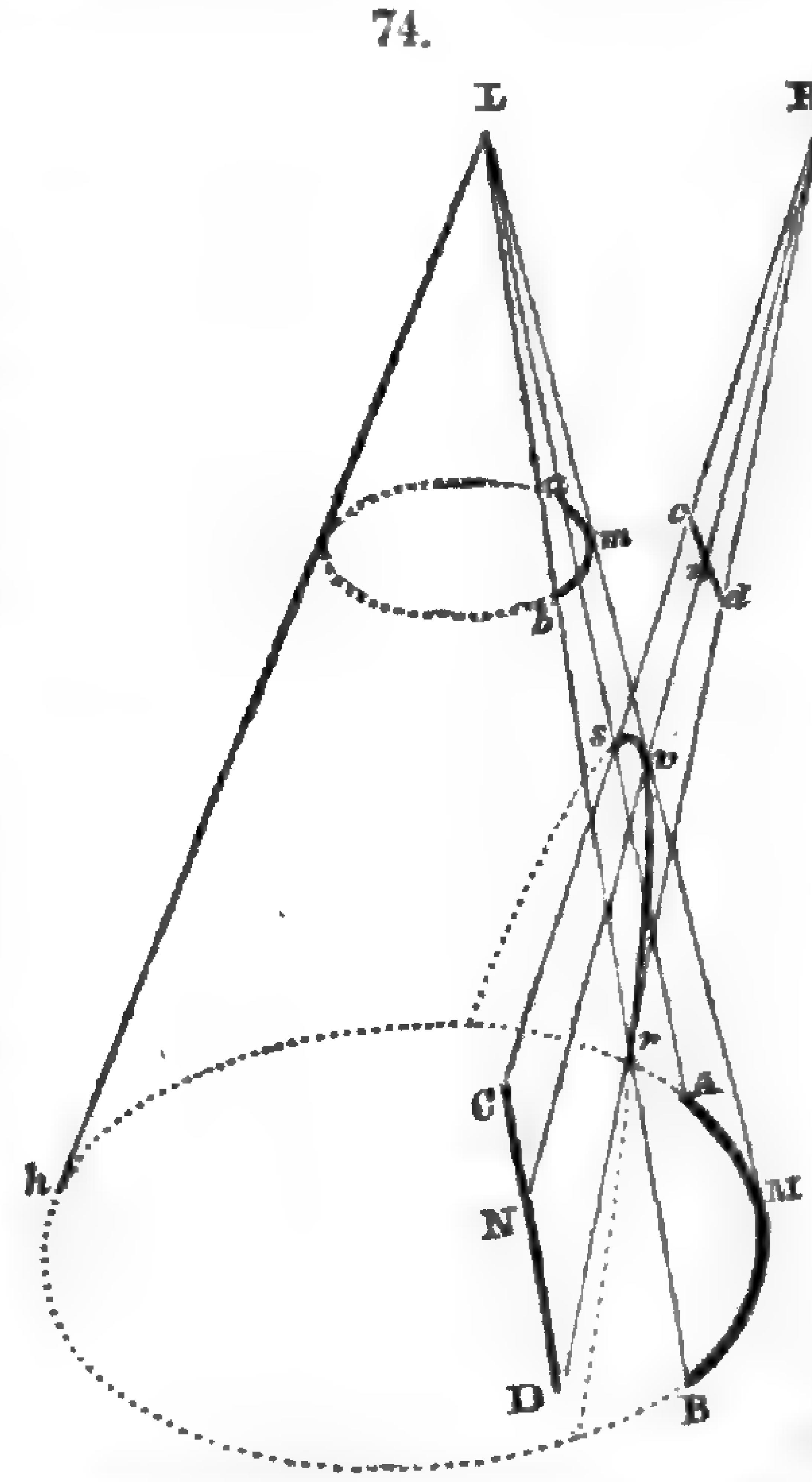
(Concluded from page 95.)

29. *Of the form of the curve resulting from the binocular union of a straight line with a circular arc or of two equal circular arcs with one another.*

A. *Binocular resultant of a straight line and a circular arc.*

Assuming the optical centres of the two eyes L and R, figs. 74 and 75, as fixed during the act of combination, it is evident that the centre of the eye directed to the circular arc *a b* or A B may be regarded as the vertex of a cone whose surface includes all the positions of the optical axis of that eye as successively directed to the different points of the arc. This cone will of course be right or oblique according to the direction in relation to the plane of the paper, of the line joining the optical centre with the centre of the circle of which the arc is a part. The axis of the other eye in ranging from end to end of the vertical line *c d* or C D vibrates in a plane R C D which during the binocular combination intersects the conical surface, in an attitude depending on the distance between the optical centres, the place of the diagram, and the position of the component lines, *a b*, *c d*... or A B, C D.

74.



The two optical axes directed each moment to corresponding points of the vertical line and the arc, as *m*, *n* .... *a*, *c* .... *b*, *d* or M, N .... A, C .... B, D, &c., meet in the conical surface, forming optically a series of resultant points, *v*, *s*, *r*, &c., which together constitute the binocular resultant curve. *This curve must therefore be a conic section,* the nature of which will depend on the direction of the cutting plane in reference to the conical surface. The effects of the several conditions of the experiment will be seen more clearly by considering separately each of the following cases which taken together include all the variations that can occur.

First. When the arc is *convex* towards the right line and the two are combined by directing the optic axes *beyond* the plane of the diagram.

These conditions are represented in the upper part of fig. 74. Here the arc *a b* and right line *c d* have for their binocular resultant the curve *r v s*. Since the points *m* and *n* unite optically at a less distance behind the diagram than any other pair of corresponding points in *a b* and *c d*, it follows that the vertex *v* in which they combine must be the point of the resultant curve, nearest to the observer, and as the curve lies wholly in the plane R C D it must therefore present its convexity *obliquely forwards*.

According to the proportions assumed in the figure, the line R *v* N is more steeply inclined than the line L *h* to the base of the cone, and in these conditions therefore the curve *r v s* is an hyperbola. But by placing *a b* and *c d* a little nearer one another we may cause R N to become parallel to L *h*, in which arrangement the resultant will be a parabola; and if we bring *a b* and *c d* still nearer together so as to make R N converge downwards towards L *h*, we transform the curve *r v s*, into an arc of an ellipse. In the conditions included in the first case therefore the binocular resultant may have the form of either of the curves just mentioned.

Second. When the circular arc is *concave* towards the right line, and the two are united in *front* of the plane of the diagram.

This case is represented in the lower part of fig. 74. Here the component lines are the circular arc A B and the right line C D, which by cross-vision are made to unite in front of the plane in which they are placed in the experiment. The resultant curve *r v s* will evidently vary in form according to the distance between A B and C D. As shown in the figure this curve is an hyperbola, but by *increasing* the interval between A B and C D it may be converted into a parabola or into the arc of an ellipse. Thus in the conditions of the second case also the binocular resultant may have the form of either of these curves.

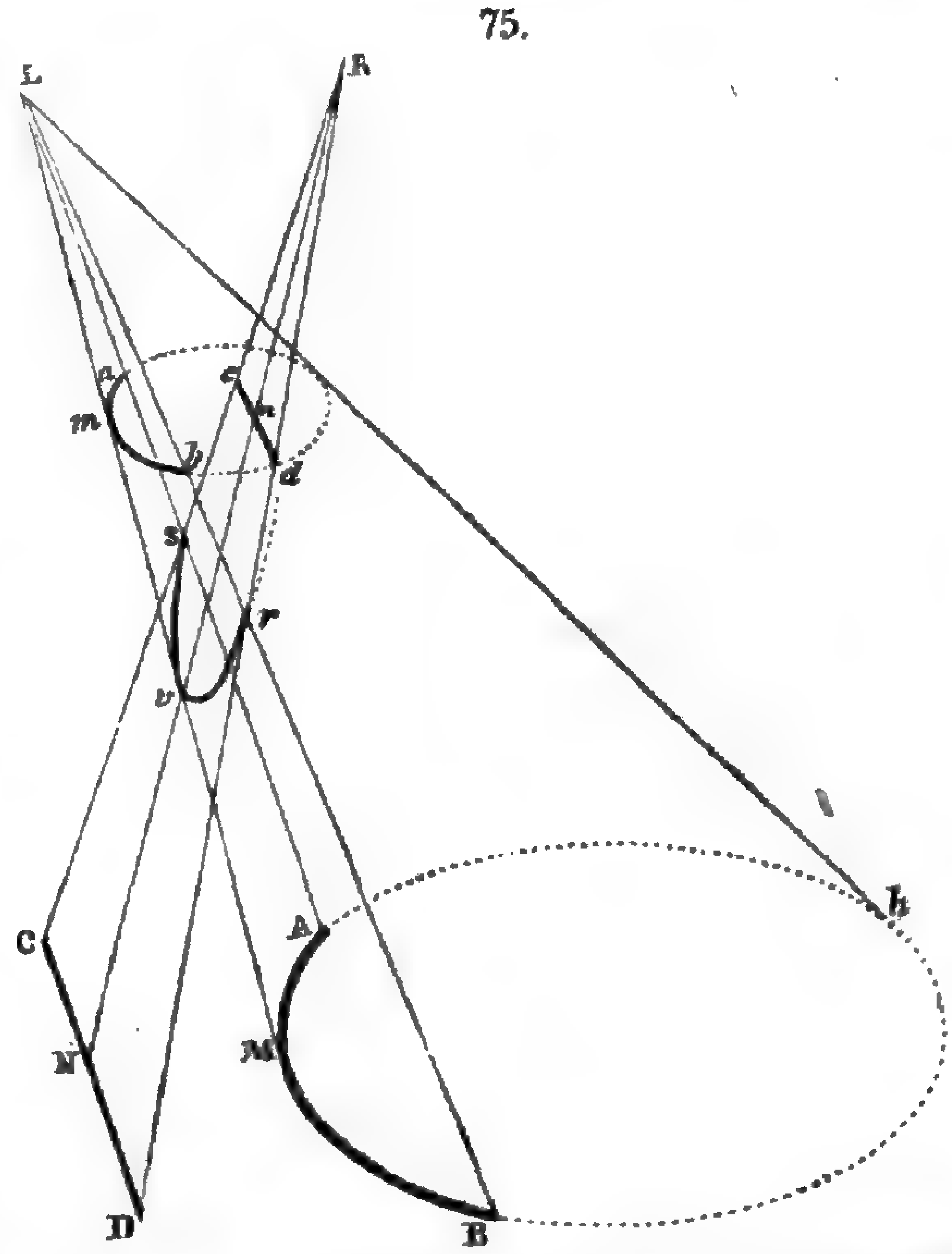
Third. When the circular arc is *concave* towards the right line and the two are binocularly combined *behind* the plane of the drawing.

The combination here specified is shewn in the upper part of fig. 75. In this case the vertex of the resultant curve *r v s* being formed by the optical union of the two points *m* and *n*, of the component lines which are farthest apart, must be at a greater distance behind the plane of these lines than any other point of the resultant; and since the curve *r v s* lies entirely in the plane of R C D it must always turn its convexity *obliquely away* from the observer. As the optical conditions here supposed require that R *n* produced shall intersect L *m* produced, it follows that the plane R *c d* when extended will pass *entirely through the cone*. In this case the resultant curve can never be either a hyperbola or parabola but must be an elliptic arc, varying in form according to the interval between *a b* and *c d*. Where the visual cone is oblique as is most likely to happen, the curve *r v s* will of course become an arc of a circle whenever the cutting plane takes the position of the *sub-contrary section.*

Fourth. When the circular arc is *convex* towards the right line and the two are combined in *front* of the plane of the diagram.

The conditions here referred to are exhibited in the lower part of fig. 75. In this case A B and C D are the component arc and right line, and *r v s* is their binocular resultant formed by cross-vision in front of the plane in which they are presented to the observer. Since in this mode of combination the optic axes are required, for all points of the resultant, to intersect somewhere between the plane of A B C D and the eyes, it is evident that the plane R C D must pass entirely through the cone. Hence the resultant curve *r v s* must be an arc of an ellipse. As in the preceding case the form of the ellipse will vary with the distance between A B and C D, and it will become circular in the position of the sub-contrary section.

75.



These various effects of the binocular union of a right line with a circular arc may be thus summed up.

(*a.*) When the arc is *convex* to the right line and the union is effected *beyond* the plane of the diagram, or when the arc is *concave* to the line and they are combined *in front of* the diagram, the binocular resultant may be either an *ellipse, a parabola, or an hyperbola,* but in either case it will turn its *convexity obliquely towards the observer.*

(*b.*) When the arc is *concave* to the right line, and they are united *beyond* the plane of the diagram, or where it is *convex* to the line and they are combined *in front of* the diagram the binocular resultant is always *an arc of an ellipse* turning its *convexity obliquely away from the observer.*

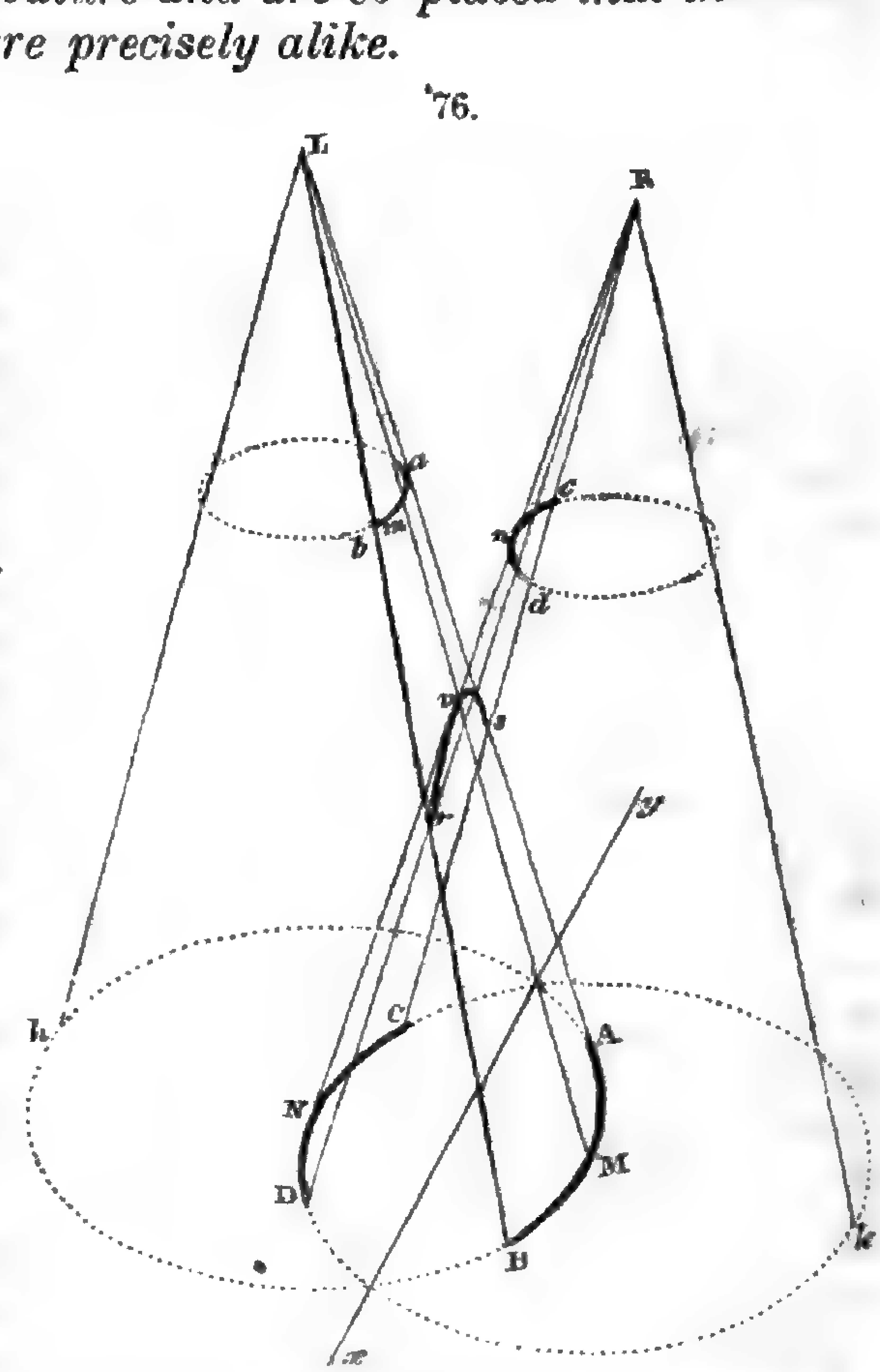
B. *Binocular resultant of two circular arcs.*

In this as in the preceding combinations the optical centres are to be regarded as immoveable during the experiment. Each eye while viewing the successive points of the arc presented to it, revolves in such a manner as to carry its optical axis around in a conical surface. Thus two conical surfaces are generated, having for their respective apices the centres of the two eyes and including all the directions which the optical axes assume in combining the successive pairs of corresponding points of the circular arcs. In general terms therefore *the binocular resultant in all such cases may be described as the curve line in which the surfaces of the two visual cones intersect one another.*

It is only however under special conditions that the resultant thus formed is *a plane curve.* When the circular arcs presented to the two eyes are of unequal curvature the visual cones, by their intersection produce a curve which cannot be included in a plane but lies in an inflected surface, and this accordingly is the form which the resultant takes whenever circular arcs of *unlike* curvature are combined either with or without a stereoscope.

In what follows the figure and position of the resultant will be considered under the simplest conditions, viz.: *when the circular arcs have equal carvature and are so placed that the intersecting conical surfaces are precisely alike.*

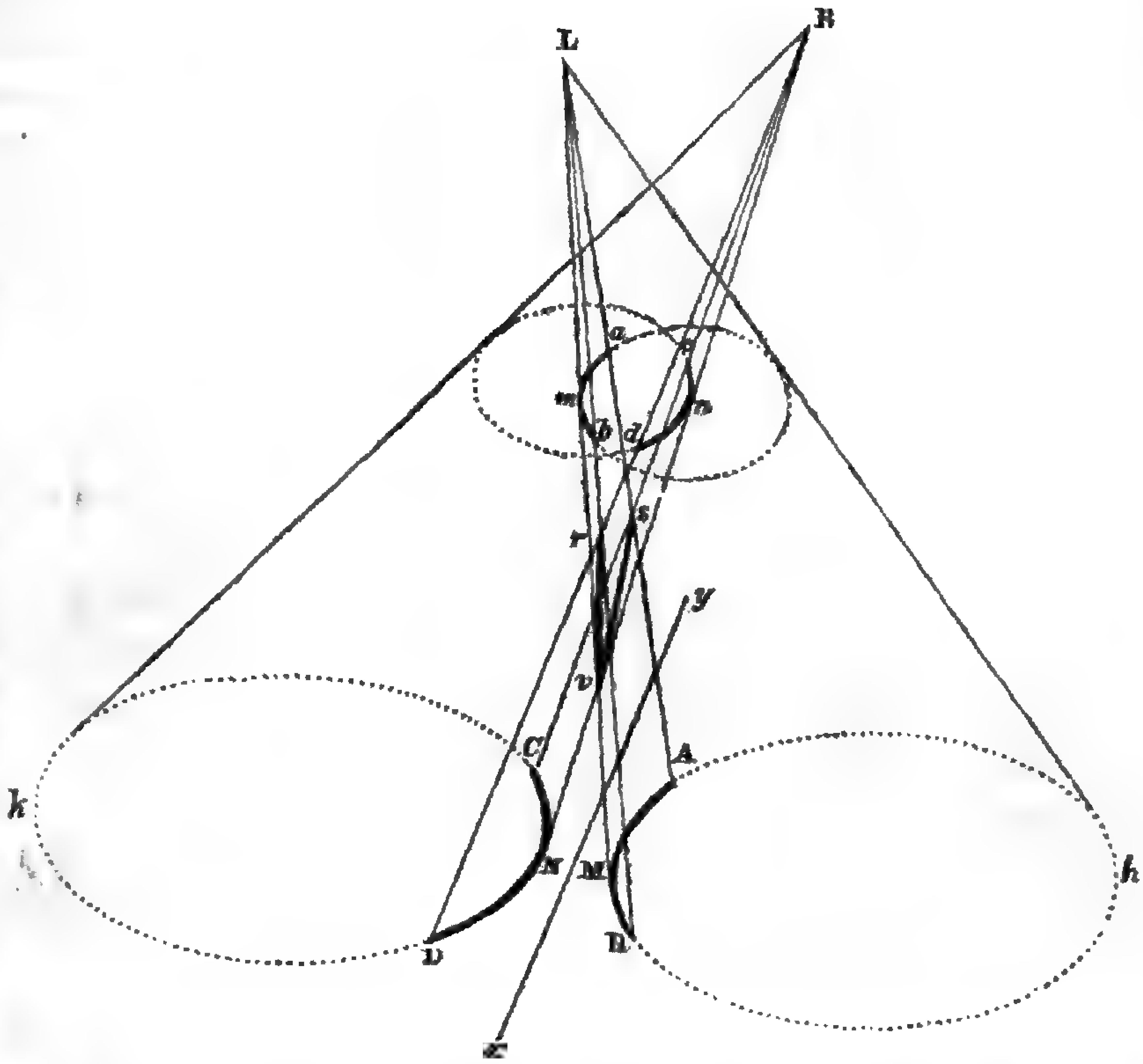
'76.



These conditions are represented in figs. 76 and 77, where the circular arcs *a b* and A B are respectively of the same length and curvature as *c d* and C D, and are supposed to be so placed that the visual lines directed to the several points of one arc shall be equal to those which are directed to the several points of the corresponding arc; thus making L *a* ... L *m* ... L *b*, &c., respectively equal to R *c* ... R *n* ... R *d*, &c., and in like manner L A ... L M ... L B equal to R C, R N, R D, &c.

From this construction it follows that the corresponding or intersecting visual lines L A and R C ... L M and R N, &c., are equally and oppositely inclined to the plane of A B C D or *a b c d*. Hence each point of the resultant curve as *r* ... *v* ... or *s*, is placed at the apex of an isosceles triangle D *r* B ... N *v* M ... or C *s* A formed by the lower segments of the visual lines.

77.



Let us now assume a line *x y* midway between M and N and parallel to tangents at these points, and let us imagine a vertical plane including this line to extend indefinitely upwards. Since *v* is vertically over the middle of M N and *r* ... *s* and the other points of the resultant *r v s* are similarly situated in regard to lines parallel to M N and connecting the two arcs, it follows that *v* ... *r* ... *s*, &c., are situated vertically above the line *x y*, and therefore that the *resultant curve* lies in the before-mentioned *vertical plane.*

In combinations of this kind, as in the case of the right line and circular arc, elsewhere explained, the particular form and attitude of the resultant will depend on the aspect in which the two arcs are presented to one another, and the place, in regard to the plane of the diagram, in which they are combined. In fig. 76 we have the resultant as produced either by the union of mutually convex arcs beyond the plane in which they are situated, or of concave ones in front of it. In fig. 77 we see the resultant of mutually concave arcs behind or of convex ones in front of the plane of the components.

In the former case, the resultant curve as represented in the figure is an *hyperbola.* But if we suppose the component arcs to be so placed that the outer sides L h . . . R k of the visual cones are vertical the resultant becomes a *parabola*, and if we imagine this change to be carried so far as to make these sides converge downwards, the resultant takes the form of an arc of an *ellipse.* As m and n are the points of the upper component arcs which are nearest together, their resultant point v, the vertex of the resultant curve, must be nearer the observer than any other part of the curve; and the same conclusion follows from considering v as the binocular resultant of M and N, the points of the lower component arcs which are farthest from one another. Hence in both cases the resultant curve must be convex towards the observer.

In the conditions of union represented in fig. 77, the vertical plane extending upwards from $x\,y$ must necessarily pass entirely through both of the visual cones. Hence the resultant curve $r\,v\,s$, which is at the same time the line of intersection of the two conical surfaces with one another, and that of the vertical plane with each surface, cannot be a parabola or hyperbola, but must always be an arc of an ellipse. From the construction it is evident that v, the resultant of m and n, the points of the upper component arcs which are farthest apart, must be the point of the resultant curve $r\,v\,s$ which is most distant from the observer, and therefore that the curve will present its concavity in front.

These several effects of the binocular union of circular arcs of equal length and curvature, may be thus summed up.

(*a.*) When the arcs are *convex* to one another and they are combined *behind* the plane of the components, or when they are *concave* to one another and combined *in front* of this plane, *the resultant may be either an hyperbola, parabola, or ellipse, but in either case it will be convex towards the observer, and situated in a vertical plane.*

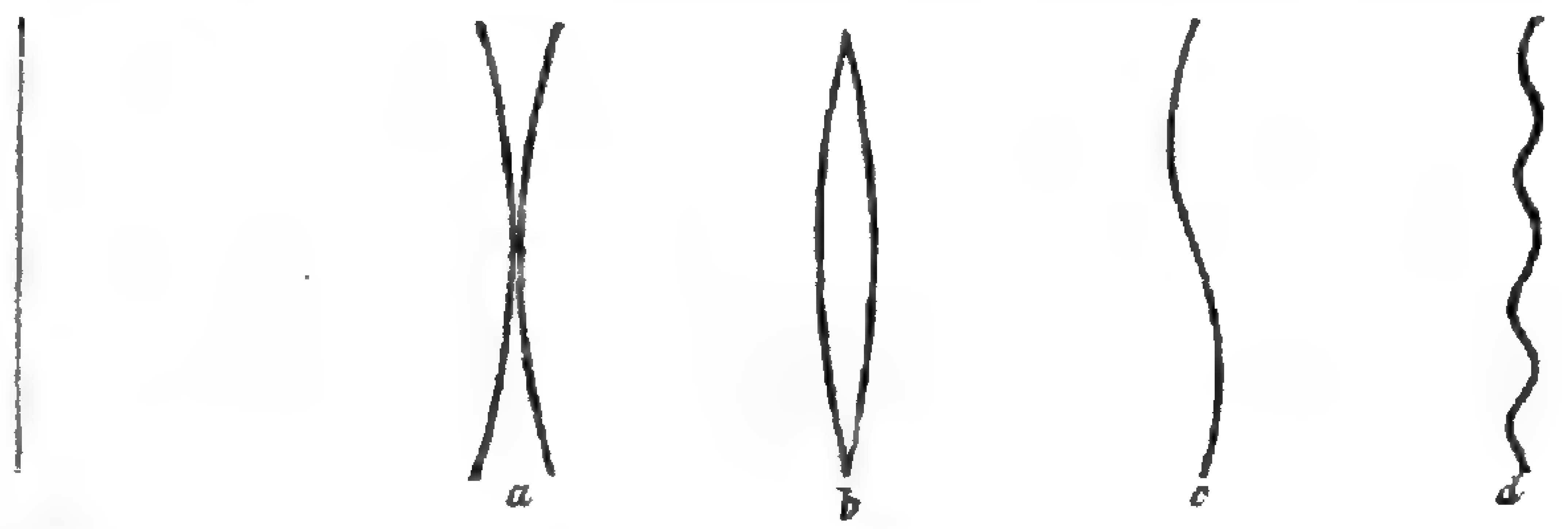
(*b.*) When the arcs are *concave* to one another and they are combined *behind* the plane of the components, or when they are *convex* to one another and combined *in front* of this plane, *the resultant is always an arc of an ellipse concave towards the observer and situated in a vertical plane.*

It is scarcely necessary to add that in either of these cases, as in the combination of the right line and circular arc, wherever the resultant curve takes the position of the sub-contrary section it becomes the arc of a circle.

30. *Further examples of the union of right and curve-line figures of equal height.*

From what has been shown of the combination of a right line with a simple arc (27) and of the union of such a line with a figure composed of several right lines (24), we may infer the effect which will result when a right line is combined with a figure composed of two or more curves. When the breadth of the latter is so small as to allow of a very rapid alternation of union, the resultant presents itself in perfect relief, at the same time apparently in every part. This is well shown when the vertical line, fig. 78, is combined with either of the compound

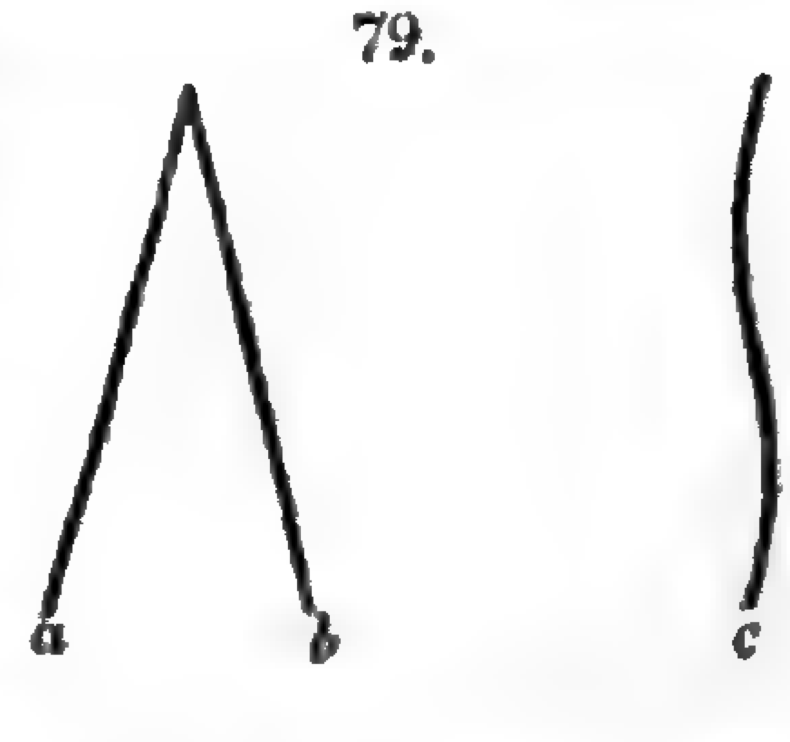
78.



curve figures *a, b, c, d.* When combined with *a* it gives a resultant consisting of two curves (conic sections) in relief with their vertices touching, with *b* the effect is that of two curves like the former uniting to enclose a perspective plane, with *c* it presents a sigmoid line turned somewhat edgewise towards the view and with *d* an undulating line in a similar position.

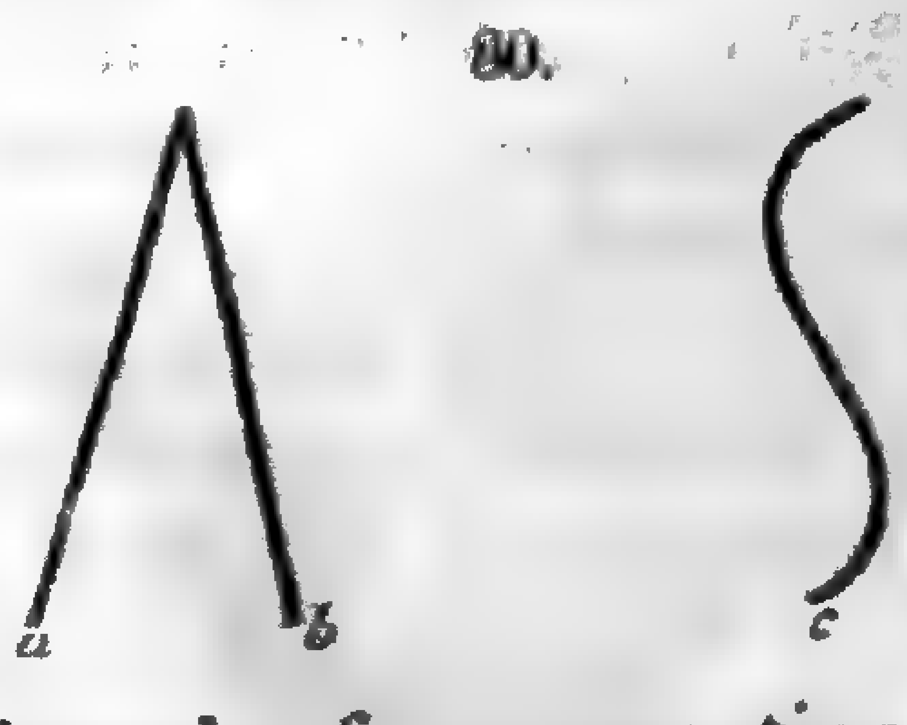
A remarkable example of this kind of combination is furnished by fig. 79 which from its bearing on an observation of Prof. Wheatstone to be cited hereafter is deserving of more particular mention. Placing *a b* before the left and *c* before the right eye, we may readily unite either of these lines with the sigmoid *e* and with a slight change of optical convergence pass from the one combination to the other. In each case as might be expected the resultant is a deeply inflected doubly-curved line in a perspective attitude.

79.



Even when the bent line has the rapid flexure represented in fig. 80, we have no difficulty in producing the alternating union of *a* and *b* with parts of the sigmoid which are not too greatly inclined to these lines. In making this experiment it will be observed that while we readily succeed in combining *b* with the whole length of *c*, excepting a short distance at each end, we cannot at any one time produce an entire union of *a* with *c*. We may however by separate efforts combine the two upper or the two lower halves of these lines successively. This difference is explained by the fact that the distances between the corresponding points of *b* and *c* do not

80.



greatly vary throughout these lines, while between *a* and *c* they are much greater for the lower than the upper halves. The same remarks apply to fig. 81, except that in this case it often happens that the upper half of *a* and the lower of *b* or the upper of *b* and the lower of *a*, unite simultaneously or nearly so with the corresponding parts of *c*. In all these cases of course the union does not extend to the extreme parts of the lines.

81.

In consequence of the fluctuation of optical convergence whether spontaneous or voluntary, the various modes of union above described present themselves in irregular alternation, but the easiest of these combinations, that of *b* with the whole of *c*, is the one which most frequently occurs first and which continues longest.

The experiment of Prof. Wheatstone referred to above, includes, it will be seen, the same conditions as that last described. It was as follows. He presented the letters S and A drawn of equal height and enclosed in equal circles, one to each eye. On attempting to combine them, he says, "the common border will remain constant while the letter within it will change alternately from that which would be perceived by the right eye to that which would be perceived by the left eye alone. At the moment of change the letter which has just been seen breaks into fragments while fragments of the letter which is about to appear mingle with them and are immediately after replaced by the entire letter." (Phil. Mag., April, 1852.)

In repeating this experiment with the figure appended to Prof. Wheatstone's memoir and bringing the letters together either with or without the stereoscope, and by convergence of the axes either beyond or in front of the paper, I have never failed to remark *partial and capricious binocular combinations* between the corresponding portions of the two letters, as in the cases above described. In these circumstances most of the A disappears in the resultant and sometimes, especially when the eyes are fatigued, the whole letter seems for a moment to vanish. The upper or lower part of the heavy stroke of the S and sometimes the whole of this part of the letter are thrown into perspective and greatly changed in shape and attitude, but I have very rarely observed it to disappear.

As from the small size of the letters in Prof. W.'s figure, and the rapid changes of combination thence resulting, I have found it difficult to mark the phenomena distinctly, I prefer using letters of the size and form of fig. 82, omitting the enclosing circles as unessential to the experiment. With this I find the union of the heavy part of the one letter with that of the other to take place at once; while the other combinations of a more partial kind require a special effort. Substituting the letters D . . . V of the same size as in fig. 82 equally striking effects of partial combination may be observed.

82.

A S

In these experiments the observer cannot fail to notice the occasional invisibility of parts of lines when very near to others but not quite coincident with them. This effect, first pointed out by Sir David Brewster, has no doubt an influence in the seemingly capricious changes above described, which as a class this philosopher has so well designated by the name of *ocular equivocation.* But judging by my own visual experience in the analysis of the phenomena, I am satisfied that most of the changes which present themselves in such cases, including the apparent breaking up and reunion of parts of letters mentioned by Prof. Wheatstone, are really due to imperfect and shifting combinations of portions of the one letter with those of the other. As it is the general and necessary incident of binocular combination that each component line or part of a line is seen only in the binocular position and as merged and included in the resultant, we *should expect* in the present case to lose sight of the component right line as a right line and to see the curve only in its changed shape and attitude. It seems to me therefore that *the shifting appearances* in Prof. Wheatstone's experiment as well as in all other attempts at uniting complex and very dissimilar pictures, *arise in a large degree from alternating combinations between parts capable of binocular union and cannot be ascribed except very partially to the actual vanishing and re-appearing of the components.*

SECOND.—*Of the binocular union of figures differing both in height and breadth.*

Having in the preceding section considered the laws of binocular combination in the case of figures of equal height, but differing in breadth, I now propose to examine briefly the conditions of apparent coincidence where the figures are unequal in both dimensions.

31. *Phenomena of vertical binocular adjustment.*

In referring to the binocular combination of vertical lines slightly differing in height, and whose lower ends are placed on the same horizontal level, it was remarked (6) that a slight turning of the head sufficed to unite the upper extremities and that this movement when very small was made almost unconsciously. But while this adjustment explains in certain cases the optical coincidence of points and lines situated at unequal distances above or below the horizontal direction, it does not apply to the cases in which the head is kept perfectly fixed during the act of combination. In these conditions the coincidence would seem to result from a vertical rotation of one or both eyes, or perhaps an equivalent change in the direction of the transmitted pencil due to some alteration of the form of one or more of the refracting surfaces. As such an adjustment has not, I believe, been suggested by preceding writers on vision, the following details founded on personal observation may, it is hoped, throw light upon the subject.

Recurring to the experiment mentioned under a former head (6) and using a similar diagram (fig 83), I place it beyond the

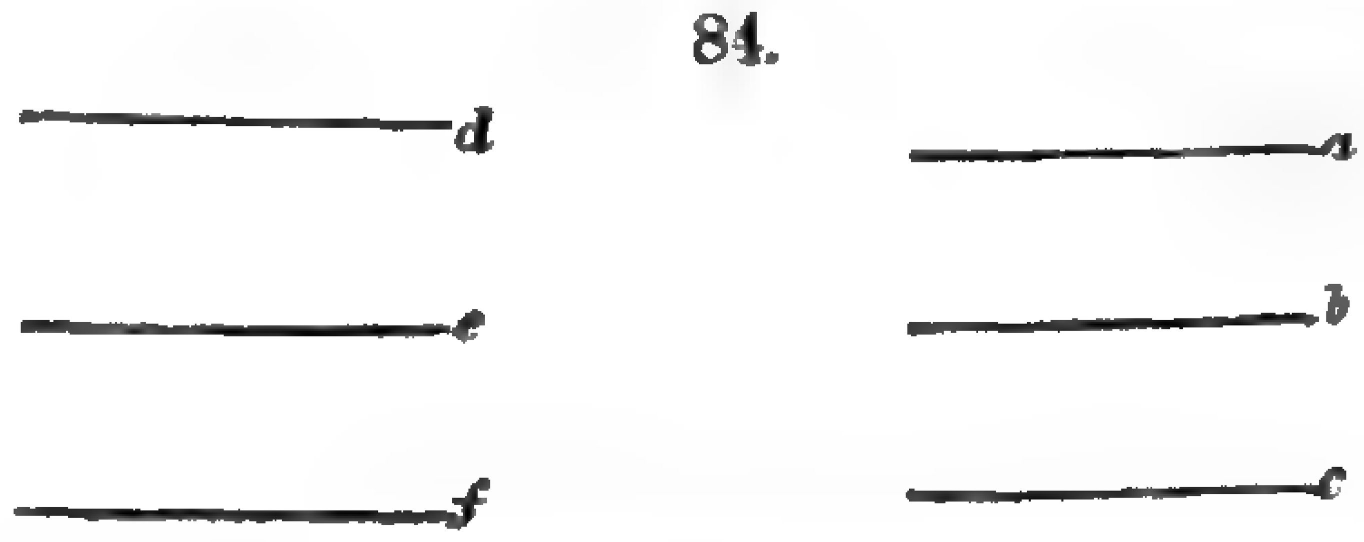
83.

limit of distinct vision, so that the optic axes directed crosswise to its right and left sides may intersect in front of the diagram at that limit. I now adjust the lines so as to be visually horizontal and proceed to unite them by directing the right eye towards *b* . . *c*, and the left towards *a*. In doing this I find as formerly stated, that *a* and *b* readily coalesce. I then turn the paper so as slightly to depress *a*, and repeating the effort I observe *a* taking a position just beneath and close to *b*, but quickly after uniting with it. Turning the paper still further in the same direction, until by the usual convergence I bring *a* below *b* and midway between this line and *c* I find that with some effort I can still cause the two to unite. Lastly, I depress *a* a very little more, so that the converging action may carry it below the middle of the interval between the other lines, and now I see it quickly coalesce with *c*. Usually this union does not take place instantly unless *a* is brought to the same level with *c*—that is, to such a position that the corresponding ends of the two lines are in the same horizontal direction. The effect in this case, is a little different from that of the experiment formerly described (6) where the axes were made to intersect much nearer than the limit of distinct vision, as in the present conditions the action of the two eyes is more nearly equal. It should be remarked also that the limit of vertical separation compatible with a union of *a* with *b* or *c* is liable to considerable variation, especially when the eyes have become fatigued by the experiment.

It would appear from these results that the eyes possess an adjusting power which enables them to unite two lines or points situated at different heights above the horizontal direction, even when the optical centres are kept in a fixed horizontal position. In my own case moreover it is evident that the range of vertical adjustment is much greater when the object viewed by the right eye is the lower of the two than when their relative altitudes are reversed. From what I have noticed in the experience of other observers I am disposed to conclude that a like inequality of adjusting movement is of common occurrence, having in some cases the same relation to the right and left eyes as that above described, and in others the reverse. The effect of the vertical adjusting power however, is obviously the same whether we consider it under either of these conditions or as having equal range above and below a perfectly horizontal line.

In order more completely to study its action in producing the apparent coincidence of figures of unequal height, I use the system of parallel lines shown in fig. 84. Holding this at a distance

84.

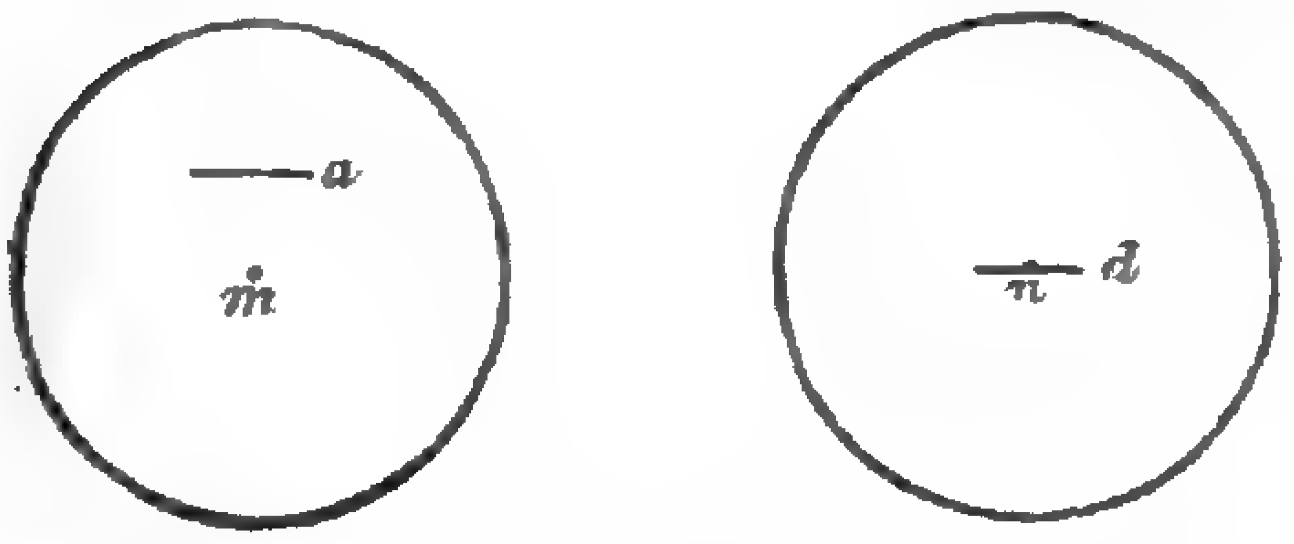


in such position that all the lines shall be visually horizontal and bringing together the parts of the figure by cross vision, I remark that the lines of either of the pairs *a d* . . . *b e* . . *cf* to which the view is for the time directed appear to coalesce, and that they continue united as long as the attention is fixed upon them; at the same time the lines of the two other pairs are seen not to coincide. Thus, when I fix my eyes on *a d* during the convergence I see them united as a single line, but while this union is maintained, *b* appears just below *c* and almost touching it, and *c* above *f* at a greater interval. Directing the view to *b c*, these lines become coincident, while *a* takes a position slightly below *d*, and *c* above *f*; and so when I unite *c f* each of the other pairs appears as two closely adjacent parallel lines. In this figure the interval from *d* to *c* exceeds that from *a* to *b* by about the fifteenth of an inch; and the interval from *c* to *f* exceeds that from *b* to *c* by about one-thirtieth. When the lines *a* and *d* are more nearly equidistant above the horizontal and *c* and *f* below it, the vertical adjustment necessary for the successive union is so quickly effected that *the coincidence appears to take place simultaneously throughout all the pairs.*

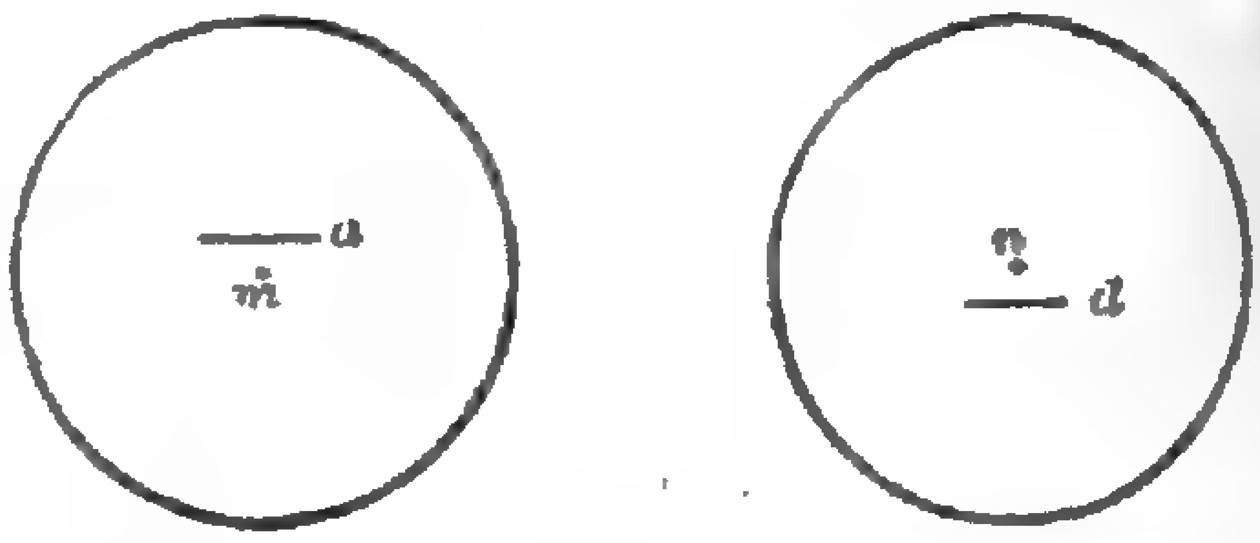
32. *Explanation of these phenomena by a vertical rotation associated with the converging movement of the eyes.*

To show in what manner the hypothesis of a vertical rotation of one or both eyes may be applied to explain these phenomena, let us suppose *m* and *n* to be the central points of the retinas of the two eyes L and R, fig. 85, and let us assume that while the optical centres of the eyes are fixed in a horizontal position the lines *a*, *d*, . . . of fig. 85 are adjusted to paralellism with this

85.



86.



direction. Further let us assume that in converging the axes by cross vision to bring *a* and *d* together, there is an entire absence of vertical rotation. In this case if the axis of the eye R be directed to the line *d* which is on a higher level than *a*, the axis of L will pass above *a*. Thus the picture of *d* will fall *centrally* on the retina of R, and that of *a above* the retinal centre of L. If again we suppose both axes to range in a horizontal line midway in height between *a* and *d*, fig. 86, the pictures of *a* and *d* will fall *at equal distances* respectively *above* and *below* the centres *m* and *n*. In all these cases the vertical distance between *a* and *d* on the two retinas will be the same. Under these conditions it is impossible according to received laws of vision that the two images should produce a single perception, in other words, that *a* and *d* should appear as a single line.

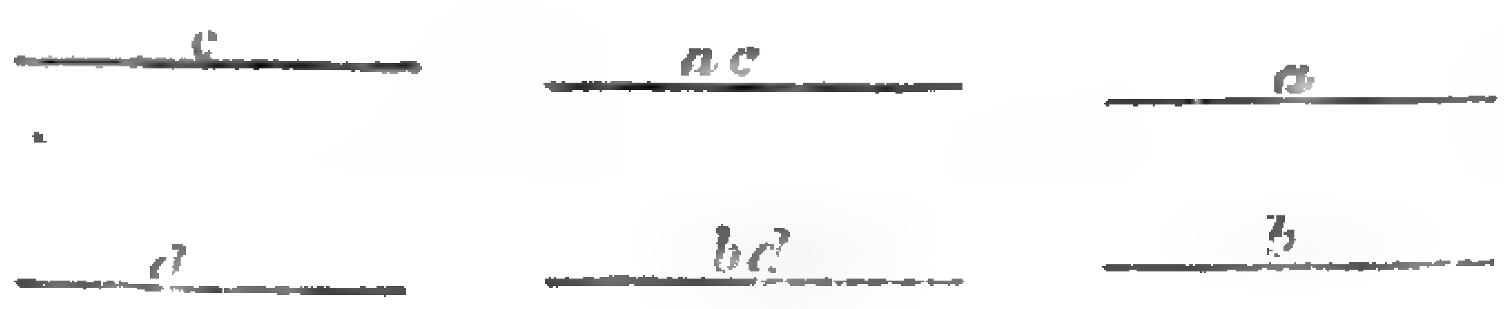
If now we imagine a slight vertical rotation of one or both eyes, during or at the close of the ordinary converging movement, it is easy to see that the images *a* and *d* may be made to cover the centres or other corresponding parts of the retinas above or below. In the case of fig. 85, we may suppose the left eye to revolve so as to carry the centre *m* up to *a*, while the other centre *n*, is kept fixed in its coincidence with *d*. In the case of fig. 86, we may imagine the left eye to rotate upwards and the right downwards, until *m* and *n* are brought severally to coincide with *a* and *d*. Thus the pictures of the two lines would make their impressions centrally on the two retinas, and might be expected according to known laws of vision to give rise to the perception of a single resultant line.

It is to be observed that in this adjustment the two optic axes do not actually meet or intersect but pass by one another at a very small interval where nearest together. The *distance* which we usually assign to the resultant is evidently determined by the point of closest proximity of the axes, and its position as to height is midway between the upper and lower components, supposing these to have been brought by ordinary convergence to be vertically one above the other. According to this view the law of binocular direction would apply to the vertical as well as the horizontal inclination of the optic axes, so that when in the above experiments the two lines are made to appear as one by the combined action of both kinds of adjustment, we perceive the resultant in a direction which is the binocular direction both as regards the vertical and the horizontal plane.

In the above experiments the effects described are obtained by crossing the axes, and so as to form the resultant in front of the picture, but similar phenomena present themselves when the combination is made behind the picture. Any further reference to the latter is therefore unnecessary.

33. *Why the height of the resultant is a mean of the heights of the component figures.*

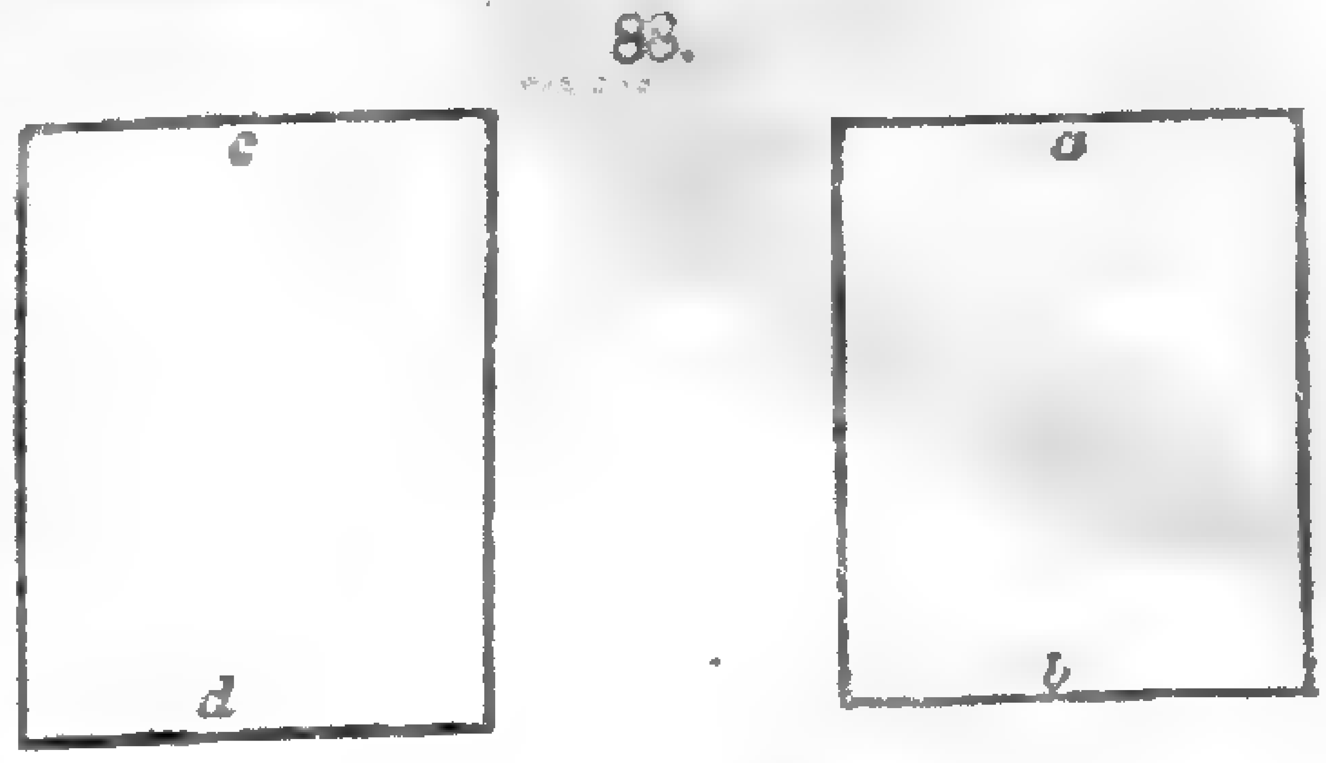
87.



If in combining *a* with *c*, (fig. 87,) by the process before described, we also keep in view the lateral images of these lines formed one in each eye we find that the resultant takes a position midway in vertical as well as in horizontal direction between the lines *a* . . *c*, thus laterally seen, and a similar effect occurs in uniting *b* with *d*, and when the difference of level of these lines is so small as to allow the vertical adjustments to be made in quick succession we perceive both resultants apparently at the same time in their positions of midway elevation as shown in the lines *a c* . . . *b d*, of the figure.

It is readily seen that this visual reference of the resultant to the position of mean height between the components, is due to the same vertical adjustments which cause the images of the latter to fall severally on the centres of the two retinas. Thus when the axis of the right eye is directed to *c*, (fig. 87,) and the picture of this line is formed centrally on the right retina that of *a* will of course take a position in the same eye laterally to the left and at a higher level on the retina. Hence *a* as laterally seen will appear to the right and lower than *c*, as seen centrally. So in regard to the left eye, *c* laterally seen will appear to the left and higher than *a* seen centrally. But as in virtue of the binocular union of the central images of *a* and *c*, these lines as centrally seen appear to occupy but one place, viz., that of the resultant, it follows that *c* laterally viewed must appear higher, and *a* similarly seen, lower, than this resultant.

88.



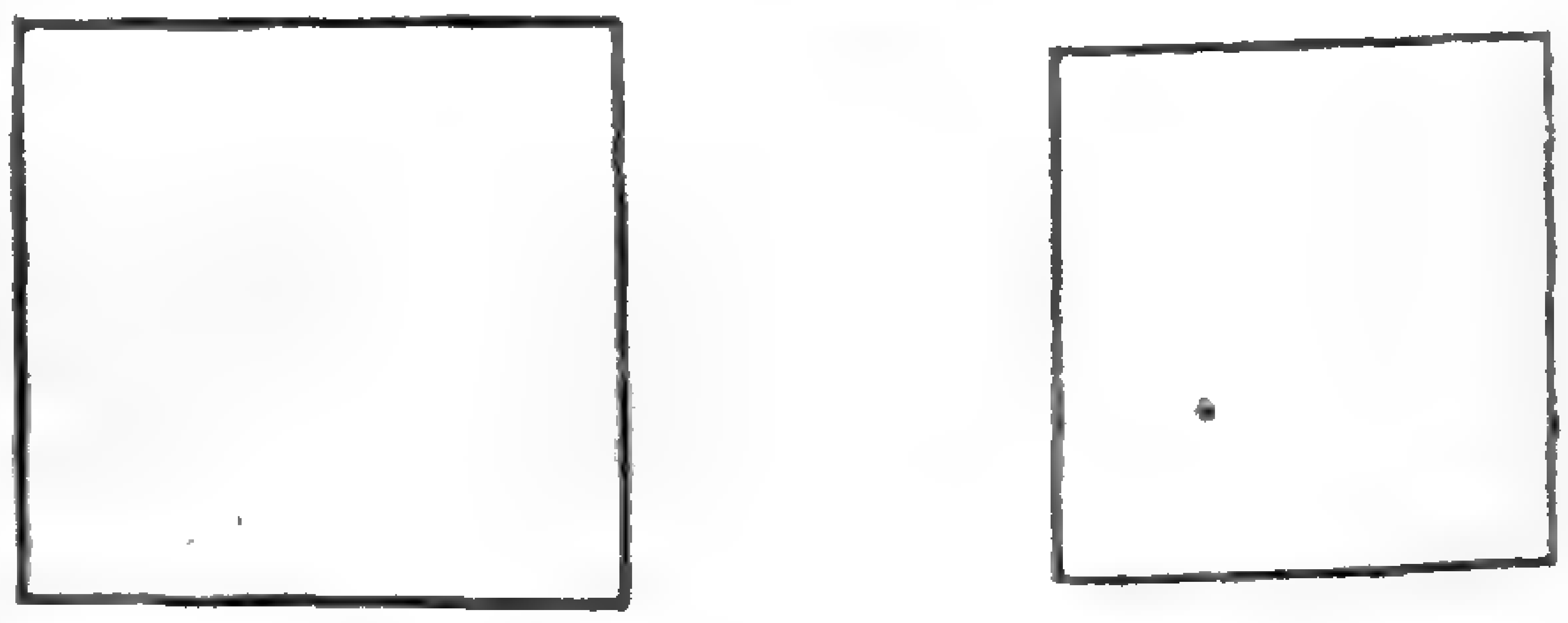
If now *a* . . . *c* and *b* . . . *d* be made the upper and lower sides of two rectangles, figure 88, we may effect the union of these figures by the same adjustments as in the previous experiments, and in this case the resultant or binocular figure will have a height intermediate between that of the two figures seen laterally at the same time, in other words, between the left and right pictures of the diagram. This conclusion, it will be observed, corresponds, so far as vertical effect is concerned, with the observations of Prof. Wheatstone, cited on a previous page.

34. *Limited range of the vertical compared with the horizontal power of combination.*

The details which have been presented indicate the narrow limits within which the power of vertical adjustment and combination is restricted as compared with those of binocular combination by ordinary convergence. Hence in combining figures which differ to the same extent in the horizontal and vertical directions, we generally find that while the coincidence on the right and left sides of the resultant is perfect and apparently simultaneous, the union at the top and bottom is but partial and is obviously successive. Indeed it is only *when the disparity of heights is very inconsiderable* that the combination appears to be equally complete in all parts of the resultant.

As an example of this, in attempting to unite the two squares of fig. 89, with the precautions as to adjustment before described, I find that while the vertical sides of the resultant figure appear each as a perfectly clear and distinct single line, the lower side appears double until the view has been fixed upon it for a sensible time and that on carrying the eyes to the top of the resultant this side also seems for a moment to be double. When however, the disparity between the heights is reduced to half the amount in the figure the upper and lower sides of the resultant present themselves in the shape of single lines as immediately and to all appearance as simultaneously as the vertical sides, and of course the resultant figure appears of a height intermediate between that of the right and the left hand figures. Like effects are exhibited by unequal circles and other pairs of figures geometrically similar.

89.

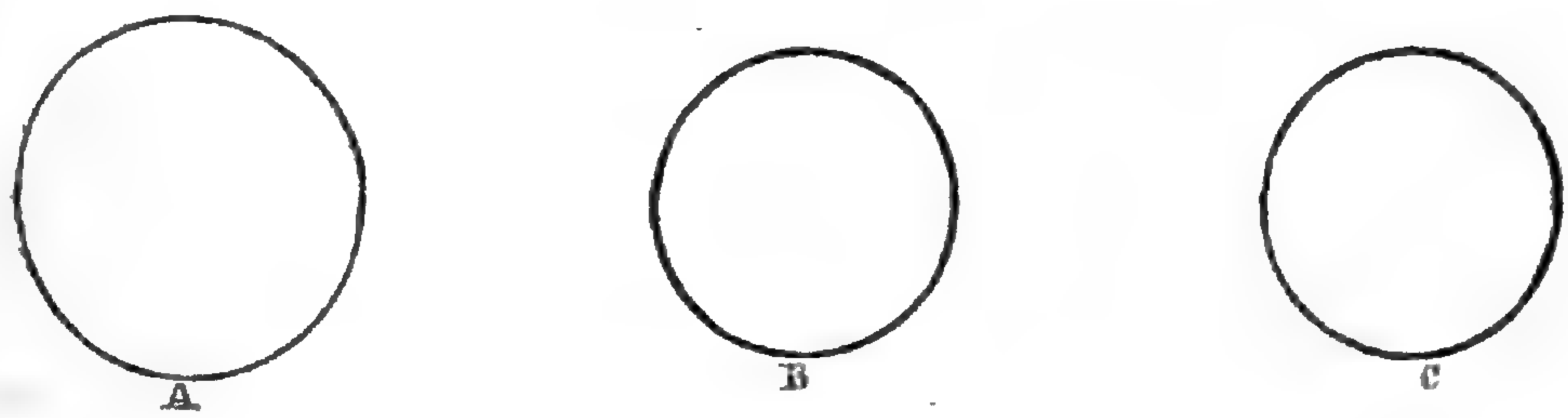


35. *Perspective position and usually warped figure of the resultant.*

We have seen in the preceding section that when figures of unequal horizontal breadth are united binocularly they form a resultant having an oblique or more or less perspective position. This effect must evidently occur in the case of unequal squares or circles or of any other figures differing in *breadth* as well as height. Thus when by cross vision I combine the squares of fig. 89 I see the left hand side of the resultant figure nearer to me than the opposite side, so that the whole has an oblique or perspective attitude either as a plane or concave surface. At the same time the near side appears shorter than the other as in cases previously explained, (fig. 44,) and thus the resultant of the two squares is visually a quadrilateral of *unequal sides.*

In combining by the same process the two unequal circles A . . . B, fig. 90, the left hand side of the resultant appears nearer

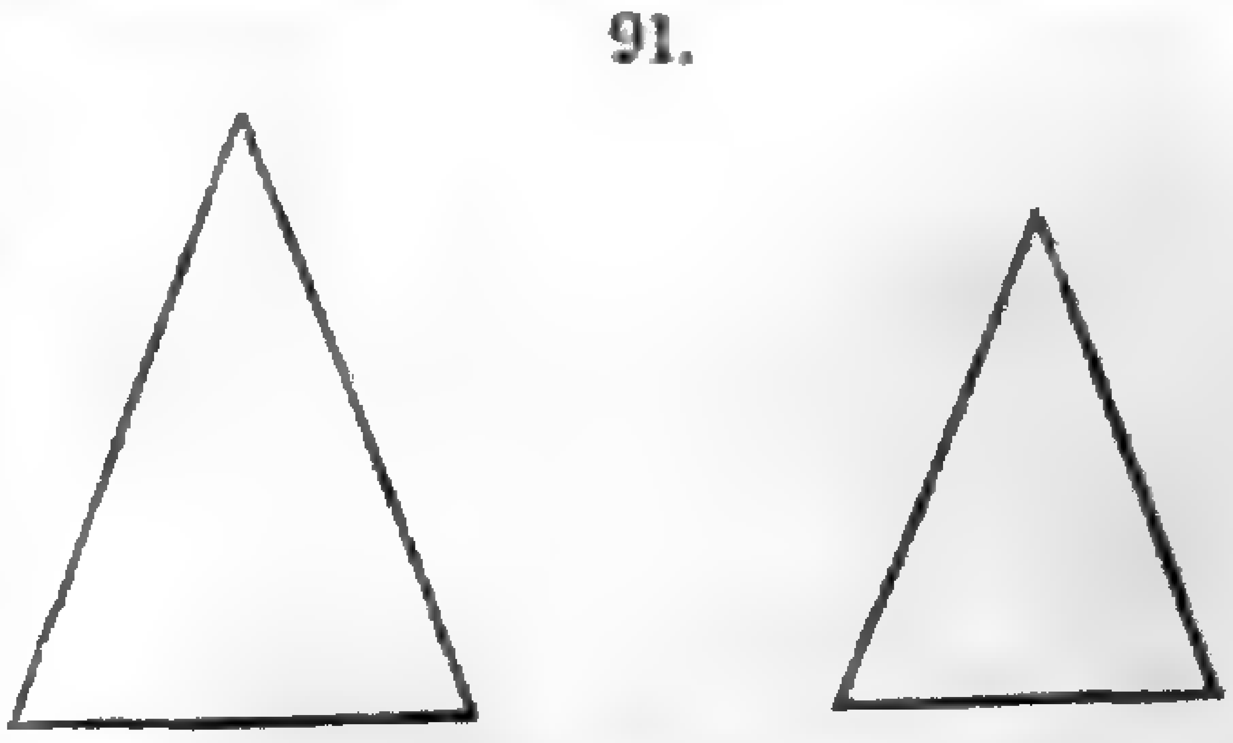
90.



than the other and is concave while the other is convex, giving the figure an oblique position and a strangely warped appearance. This effect is made more striking if we combine the equal circles B . . C and the unequal ones B . . A in quick succession, in which case the oblique and twisted resultant of B A forms a marked contrast with the perfect circle which lying in a plane at right angles to the binocular direction results from the union of B and C. In the figure, the circles are placed at equal intervals in order that the same crossing of the optic axes may serve to effect both combinations and that the reader may have the advantage of comparing the resultants side by side.

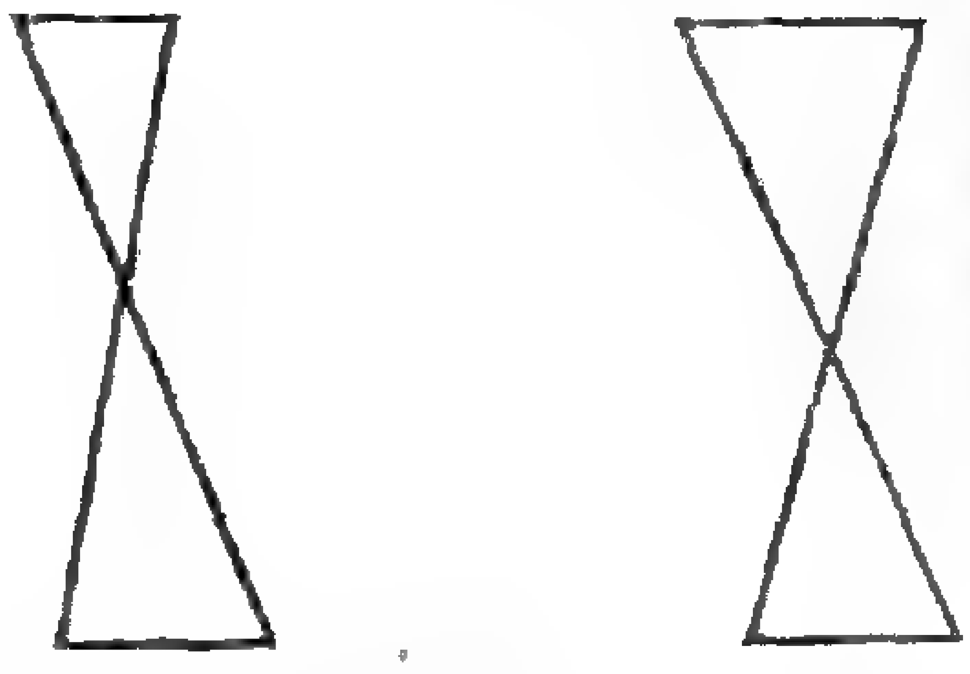
When by cross vision we bring together the similar triangles A B, fig. 91, we observe towards the apex of the resultant a peculiar twist of the surface by which the right side is then thrown obliquely behind the other, and as we carry the view to the base of the figure and back again to the apex, the whole resultant takes the shape of a warped surface not unlike that of the mould board of a plow. By turning the diagram until the vertex of B is brought to the horizontal visual line the resultant is converted into a plane figure at right angles to the binocular direction, but containing the bases of A and B as separate parallel lines. A yet more remarkable flexion of surface is produced by combining the triangles of fig. 92, which are at the same time unequal and *dissimilar*, or by uniting the double set of unequal triangles forming fig. 93.

91.



92.

93.



The association of unequal vertical rotation of the eyes with their ordinary converging adjustment occurs in viewing an object very much to the right or left of the medial line of vision. Thus when I hold a straight wire in a vertical position on the extreme left, and direct my view to the wall at some distance behind it, I see two unequal pictures of it on that surface as represented in fig. 94, the right hand or longer line being that proper to the nearer or left eye and the other that proper to the right eye. It is obvious that to see the wire single while in this position the same optical adjustments must be made as in uniting these two unequal pictures of the wire, and thus therefore vertical rotations differing for the two eyes either in amount or direction are as necessary in this case as in preceding experiments.

94.

In referring to the results of oblique vision as related to the union of unequal figures, Prof. Wheatstone remarks that "were it not for the binocular coincidence of two images of different magnitudes objects would appear single only when the optic axes converge forwards," &c. (Philos. Trans., 1838.) Sir D. Brewster on the other hand maintains that the apparent coincidence of unequal figures arises from an actual disappearance of one of them and that "in very oblique vision one of the eyes resigns its office and leaves the other to view the object distinctly and singly." (Phil. Mag., 1844). As regards the latter explanation I have before endeavored to show that the fitful vanishing and reappearing of parts of the figures often observed in these experiments is not directly connected with the development of the resultant (19), and that this latter actually includes both the components. In further support of this view, I would here adduce the fact, above proved, of the *intermediate magnitude* of the resultant figure. This seems to mark the visual perception as *binocular*, and not as the result of either impression singly, and to indicate that *the two retinal images are equally concerned in the single perception which is produced.* The sense of binocular direction attending these combinations is also in favor of this view.

In respect to the conditions of the binocular coincidence perceived in these combinations, I conclude from the preceding observations that unequal vertical images or equal ones not correspondingly placed in the eyes do not of themselves and directly produce the single resultant perception, that the coincidence however seemingly simultaneous for all parts of the figure is really the effect of rapidly successive adjustment applied to the vertical and horizontal elements of the diagram, and that this process applied *partially or throughout*, according to circumstances, gives rise by suggestion, to the mental resultant.

Other observations bearing on this subject are now in progresss more especially as regards the union of pictures seen in Dove's experiment by instantaneous or electric light, but they are not sufficiently matured to be communicated at this time.

Art. XXIII.—*Abstract of a Meteorological Journal kept at Marietta, Ohio, for the year* 1855—Lat. 39°·25′—Long. 4°·28′ West of Washington City; 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, ...	35·23	65	12	12	19	2 50	S. W. & W.	30·10	28·45	1·65
February, ...	26·17	58	6	9	19	1·50	N., & W. N. W.	29·75	28·85	·90
March, ...	37·80	66	4	16	15	2·67	W., N. & S.W., E.	29·75	28·80	·95
April, ...	55·33	91	18	20	10	2·08	S., S. W., & N.	29·85	29·10	·75
May, ...	61·41	90	32	20	11	5·17	W., S.W., N. & E.	29 58	29·00	·58
June, ...	66·81	97	42	13	17	5·68	S. & S. W.	29·60	28·90	·70
July, ...	75·84	96	52	18	13	6 00	S., N. & E.	29·70	29·25	·45
August, ...	73·97	94	48	18	13	3·09	S., N. & N.W., E.	29·75	29 15	·60
September, ...	70·36	91	42	15	15	8·00	S. W., & E. S. E.	29·65	29·20	·45
October, ...	50·14	75	28	20	11	1·85	S.W., & W.N.W.	29·55	29·08	·47
November, ...	48·08	75	20	16	14	3·55	S. E. & N. W.	29·65	28·90	·75
December, ...	33·66					3·63				
Mean, ...	53·15					45·75				

Remarks on the year.

The year 1855 exhibits a strong contrast to that of 1854, in several particulars, but more especially in the temperature, and amount of rain. Last year was noted for its excessive heat and great lack of moisture. The drought of the preceding year was continued into the following one. As late as the last of April and the first of May, people began to express their fears of another season of drought and heat which would in a manner ruin the country. The first four months affording less than nine inches of rain, an amount which has sometimes fallen in a single one. But in May, rain began to descend abundantly, so that in this and the three following months there fell nearly two feet, being twelve inches more than fell in the same months in 1854. Such a quantity had not fallen before in many years. This abundant supply had an astonishing effect on the crops. Wheat, Indian corn and grass sprang up with renewed energy, yielding an amount of produce unprecedented in the annals of Ohio. Wheat turned out, in some instances over fifty bushels to the acre. Indian corn on the uplands afforded as many bushels, as in ordinary years are grown on the rich bottoms; in one instance reaching the enormous quantity of one hundred and fifteen bushels. The stalks attaining a great height, even to twenty feet, loaded with ears, filled to their extremities with grain. This was the greatest growth known in the valley of the Ohio, and was in part occasioned by the preceding drought, pulverizing and warming the earth to an unusual depth, affording a loose mellow soil for the roots of plants to descend deeply, and thus acquire more food than usual. This light porous condition of the earth was noticed by all the farmers in plowing their lands in March and April. The meadows also yielded abundantly, but much of the hay was injured by excessive rains in July, with a lack of sunshine to cure it. A great quantity of wheat was sprouted or germinated, after it was cut and placed in shocks, before the weather would allow of its being stacked or put away in the barn. August was less wet, having only half the quantity of July—while September, usually a dry month, exceeded any other in the year, affording eight inches. The rivers, from early in the spring to the last of December, were in the best condition for boating, not lacking a sufficiency of water all through the summer and autumn. The great rains of September filled to overflowing the small rivers and creeks, causing much damage to the crops of corn and potatoes on the bottoms, a circumstance rarely if ever known before. Fruit of all kinds was abundant, especially apples and peaches. The grape crop was much injured by the excess of wet, many of the berries perished, leaving the bunches small, while the juice lacked saccharine material. It is a calamity, to which our vineyards will be liable in wet seasons, until the ground on which the vines are planted is deeply trenched and ameliorated by underground drainage. Sweet potatoes were abundant, of a good quality, but not so rich in sugar as in dry seasons. Irish potatoes were excellent in every respect. Beans, an important crop, along the Ohio river, were much damaged by the rains, affording not more than half the usual amount fit for market, occasioning a great advance in their price.

Year.—The mean temperature of the year is 53°·15, being 1°·10 below that of 1854. The amount of rain and melted snow is $45\cdot\frac{75}{100}$ in., making about seven inches more than the past year.

Seasons—Winter.—The mean temperature for the winter months is 31°·20, or about two degrees below that of 1854, and is chiefly attributable to the low temperature of February, being no less than eleven degrees and a half colder than this month in that year, the mean for the month being 26°·17; this is below that of any other since the year 1835, when the mean was 25°·00, while in 1834 it was 43°·33, showing a difference of eighteen degrees, in the average of this month. The Ohio river was frozen over early in December, 1854, from the low stage of water being on the 7th day of the month. The winter solstice rains opened it again on the 29th with a rise of ten feet, so that steamboats could run for the first time in several months. It closed again on the 29th January following, with thick strong ice of ten or twelve inches, strong enough to bear loaded teams. In the mean time there fell ten inches of snow. It continued shut up until the 19th Feb., when it again gave way to a rise from rains on the head branches. The river now remained open, but encumbered with floating ice, until the 26th of the month, when it again froze over, and so continued until the 7th of March, closing and opening three times during the winter, while the usual habit of our winters is to shut up the rivers the last of December, and open early in February, when the severe cold ceases.

Spring months.—The mean temperature for spring is 51°·51, which is nearly two degrees below last year. The season was later than usual. Peach trees not in bloom until the 21st April. Pears and plums the 24th. There was a smart frost the 10th of May, killing corn and beans, requiring early fields to be replanted. It was remarked of the apple and peach blossoms, that they were larger and fairer than usual, producing many double peaches and some triplets. It was probably caused by the dry and hot summer ripening and perfecting the fruit buds earlier than common, which therefore were less injured by the cold of winter. The spring months afforded ten inches of rain, more than half of which fell in May, retarding the use of the plow and deferring corn planting to a later period than usual; still, the crops were never more prolific.

Summer.—The season of summer was temperate, with a few hot days, the mean being 72°·20. The mercury rising above 90°, only on three days in June, ten days in July, and four in August, while in 1854, it rose above that point on twenty-six days during these months. The nights were also of a pleasant temperature, and comfortable for sleeping. The rain amounted to nearly fifteen inches, exceeding the former year by five inches. The growth of plants was rapid and uniform, and as they began to decay, with the surplus of water in the low grounds, the inhabitants in the vicinity of rivers and creeks, suffered from intermittant fevers of a mild type, more generally than for thirty years past.

Autumn.—The mean for this season is 56°·47, which is nearly four degrees above the mean of this period, it rarely reaching this point. September was the most rainy month in the year, there falling eight inches of water, while in 1854, a little over two inches. So much rain injured the potato crop, while it was congenial to Indian corn, filling out the ears to their extremities with grain. The weather continued mild until late in December. The first smart frost was on the 13th of October, temperature at 28°, and not so low again until the 29th of November.

Floral Calendar.—April 2nd, Garden Crocus in bloom; 3d, stalks of Crown Imperial three inches high; 11th, Blackbirds in flocks; 12th, Hepatica triloba; 13th, Early Hyacinth opening, Acer saccharinum; 15th, Dafodill; 16th, Golden bell or Forsythia; 17th, Sanguinaria canadensis; 21st, Peach tree, Pyrus Japon., Hyacinth in full; 22nd, Crown Imperial, Double flowering peach, Spirea prunifolia; 24th, Magnolia purp., Pear tree, Purple plum; 25th, Pie plant fit to cut; 24th, Apple tree, nearer the time of the peach than common by six days; 25th, Red Bud or Judas tree; 27th, Strawberry; 29th, Uvularia.—May 2nd, Apple shedding its blooms; 4th, Tulip in full; 5th, Quince. Peonia arb. purp.; 10th, smart frost, killing corn and beans, with many grapes on the low hill-sides—higher up escaped harm; also some fruit of the apple, peach, &c.; 18th, Locust; 20th, Liriodendron; 21st, Crimson peony; 23d, a tornado from the west, at 6 P. M., blowing down trees and unroofing some buildings; 24th, white peony; 6th, Syringa frag.; 28th, Roses generally in bloom; 30th, Peonia frag.; 31st, Syringa Philad. June 1st, Purple Peony; 3d, Red Raspberry; 5th, first peas on table—planted early in March; 15th, Rosa Grevilia multiflora; 22nd, Catalpa; 27th, early Russian cucumber, in open air, fit to eat; 28th, Red Raspberry ripe.

Art. XXIV.—*Supplement to the Mineralogy of J. D. Dana;* by the Author.—Number II.

Since the publication of the preceding supplement, but few new species of minerals have been announced. The more important works issued are the Russian Mineralogy of von Kokscharov of St. Petersburg, the Mineralogical notices and Annual of Kenngott of Vienna, and the volumes of Volger on pseudomorphism or the alteration of minerals. The principal papers on American Mineralogy are those of Dr. J. Lawrence Smith, on the Minerals of the Wheatley Mine, Pennsylvania, and T. S. Hunt on the Feldspars, etc. of Canada.

1. *List of New Works.*

Axel Erdmann: Lärobok i Mineralogien, 480 pp., 8vo. Stockholm, 1853.—A Manual of Mineralogy in Swedish.

———: Vägledning till bergarternas Kännedom, med Särskild Hansyn till sveriges geologiska Förhaollanden, etc. 206 pp., 8vo. Stockholm, 1855.—An excellent work on rocks, their kinds and structure, and geological relations.

Dr. Adolf Kenngott: Supplement zu dem Werke das Mohs'sche Mineralsystem. 38 pp., 8vo. Wien, 1854.—Presents a synopsis of a classification of minerals on the system of Mohs.

———: Synonymik der Krystallographie. 176 pp. 8vo. Wien, 1855.—A review of the general principles and forms in Crystallography, with the explanations of the terms employed by different authors or systems. The work is especially valuable to any one studying thoroughly the subject of Crystallography.

———: Uebersicht der Resultate mineralogischer Forschungen im Jahre 1853. 174 pp. 4to. 1855, Leipzig. T. O. Weigel.—Kenngott's Mineralogical Annual, gives a full review of the analyses of Rocks and mineral waters, as well as minerals, for 1853.

———: Mineralogische Notizen, which are referred to by their numbers beyond, have reached No. 17. No. 14 is contained in the Sitzungsberichte of the Royal Academy at Vienna, vol. xiii, p. 462, 1854; No. 15, in vol. xiv, 243, 1854; No. 16 in vol. xv, p. 235, 1855; No. 17, in vol. xvi, p. 152, 1855.

Dr. Sigmund Aichhorn: Anleitung zur Flächenzeichung einfacher Krystallgestalten. 56 pp., 8vo., with 3 plates. Wien, 1855.

G. H. Otto Volger: Versuch einer Monographie der Borazites; eine fassliche angewandte Darstellung des jetzigen Standes der Krystallologie und ihrer neuesten Richtung; Ein Beitrag zur Geschichte dieser Wissenschaft und zur Kenntniss der Steinsalz-Lagerstätten und ihrer Bildung. 244 pp. 8vo. Hanover, 1855.

———: Die Krystallographie. 8vo. Stuttgart, 1854, 1855.

———: Aragonit und Kalzit: eine Lösung der ältesten Widerspruches in der Krystallographie, nebst Untersuchungen über den Asterismus der Krystalle. 64 pp. 8vo. Zurich, 1855.

———: Die Entwicklungsgeschichte der Mineralien der Talkglimmer-Familie und ihrer Verwandten sowie der durch dieselben bedingten petrographischen und geognostichen Verhaltnisse. 634 pp. 8vo. Zurich, 1855.—A work on Pseudomorphous changes, both as to general principles and their applications to special cases, including Calcite, Dolomite, Magnesite, Brucite, Serpentine, Steatite and other examples of pseudomorphism.

F. A. Kolenati: Elemente der Krystallographie. 216 pp., 8vo. Brünn, 1855.

Nicolai von Kokscharov: Materialen zur Mineralogie Russlands. 1st volume complete, and vol. II partly so, with many copper plates.—The figures are numerous and well drawn, the descriptions full, and the measurements of angles show great precision in the use of the goniometer.

J. Schabus: Bestimmung der Krystallgestalten in chemischen Laboratorien erzeugter Producte; von der Kais. Akad. der Wissench. in Wien gekrönte Preisschrift. 208 pp. 8vo, with 30 plates of forms of crystals. Wien, 1855.—M. Schabus is one of the best crystallographers (mathematically and practically) of Europe, and it is well for chemistry that he is engaged on the crystals of laboratory products. The work is extensive, the measurements numerous and exact, and the whole crystallization of each product is thoroughly made out and described. The figures are drawn with great precision and beauty. Like the author's Monograph on Euclase, each subject he takes up is finished when it leaves his hands.

B. Cotta: Die Gesteinlehre von Bernhard Cotta, Prof. Geog. zu Freiberg. 256 pp. 8vo. Freiberg, 1855.—A valuable work on rocks.

2. *Crystallography, Formation of Minerals, etc.*

On the Plesiomorphism of Mineral Species; by M. Delafosse. 38 pp. 8vo. Paris, 1854.—This paper, although published in 1854, was read, as it states, at the Academy of Sciences on the 14th of April, 1851. Professor Delafosse brings forward views similar in many respects to those published by the writer in this Journal, vol. xviii; the printing of his paper was a few months later, but in the reading of it, he has the priority. The principal point, and it is one of great interest, is, the relations in angle between species of the inequiaxial systems of crystallization, and the forms of the monometric or tesseral system. Various groups of pseudomorphous species are mentioned, and approximations in angle in hexagonal, dimetric, trimetric and oblique crystals, to the monometric octahedron or dodecahedron, are pointed out.

On the artificial production of mineral silicates and aluminates, by the reaction of vapors upon rocks; by M. Daubrée, Comptes Rend., July, 1854, p. 135, and Phil. Mag. [4], ix, 315.—The author shows that by the action of chlorid of silicon in vapor on the required bases, crystals may be obtained of the species *wollastonite, chrysolite, kyanite, pyroxene (diopside), feldspars, willemite, idocrase, garnet, phenacite, emerald, euclase, zircon, tourmaline,* besides *quartz.* With chlorid of aluminium on lime *corundum,* in crystals, is obtained, and with magnesia, crystals of *spinel,* etc. Chlorid of titanium affords in like manner *brookite;* perchlorid of iron on lime, affords *specular iron;* or with chlorid of zinc, *franklinite;* and chlorid of magnesium acting on lime affords *periclase,* a known volcanic product.

Solubility of Silica in pure water, &c.; by C. Struckman, (Ann. d. Ch. u. Pharm. xciv, 337).—Hydrated silica being digested in 100 parts of pure water, it lost 0·021 p. c., or $\frac{1}{48}$ p. c. of $\dddot{\mathrm{Si}}$. Digested in carbonated waters (pure water, through which for 6 days and 13½ hours $\ddot{\mathrm{C}}$ had been passed), it lost 0·0136 p. c., or $\frac{1}{74}$ p. c., of $\dddot{\mathrm{Si}}$. Digested in dilute muriatic acid, sp. gr. 1·088, for 11 days in the cold, lost 0·0172 parts, or $\frac{1}{59}$ p. c. of $\dddot{\mathrm{Si}}$. Hence the loss with pure water was $\frac{1}{2}$ greater than with carbonic acid and $\frac{1}{5}$th greater than with muriatic acid. Digested in 5 parts of carbonate of ammonia and 95 of water, the loss is 0·02 parts or $\frac{1}{50}$ p. c.; and in a very dilute solution of carbonate of ammonia containing only 1 p. c. the loss was 0·062 parts, or about $\frac{1}{16}$ p. c. of $\dddot{\mathrm{Si}}$.

Again 100 parts of liquid ammonia which contained 19·2 p. c. of dry ammonia, the loss was 0·071 parts, or about $\frac{1}{14}$ p. c.; and with only 1·6 p. c. of dry ammonia, loss 0·0986 p. c. or about $\frac{1}{10}$ p. c. of $\dddot{\mathrm{Si}}$.

The results correspond approximately with those of J. Fuchs (Ann. d. Ch. u. Pharm., lxxxii, 119), who found that 100 parts of cold water dissolved 0·013 of $\dddot{\mathrm{Si}}$, and dilute muriatic acid of 1·115 sp. gr., only 0·009 p. c. of $\dddot{\mathrm{Si}}$. The obvious conclusions hence are that all ordinary waters may dissolve silica even more than carbonated waters. With the ammonia, the silica is supposed to form a silicate of ammonia.

Calcite: M. Peligot finds that 50,000 parts of pure water dissolve 1 of carbonate of lime. (L'Institut, June, 1855).

On a graphic method of measuring small crystals; by W. Haidinger, (Sitz., Wien, xiv. 1).—The method is proposed for crystals which cannot be otherwise measured, and consists in drawing by the eye lines on paper parallel to the edges or faces of the crystal, as magnified, and measuring the inclination of these lines.

On the Atomic volume, Crystalline form, &c., of the Carbon Spars; F. H. Schröder, Pogg., xcv, 441, 562.

On the Tetartohedrism in the Tesseral System; E. F. Naumann, Pogg., xcv, 465.

On Polymerous Isomorphism; by Th. Scheerer, Pogg. xcv, 497.

Ueber die Ausbildung der Krystalle; by von Frankenheim, Pogg. xcv, 347.

On the formation of crystals with nuclei; H. Kopp, Ann. d. Ch. u. Pharm., xciv, 118.

3. *Descriptions of Species.**

Æschynite, see under *Columbite.*

AKANTHITE. Description by A. Kenngott, (Min. Not., No. 16, and Pogg., xcv, 462). Related to Silver Glance. Crystallization, trimetric; forms usually slender and acute, and hence the name from *αχανθα a thorn.* A rhombic pyramid, and an acute macrodome $m\breve{\imath}$, making together an acute double 6-sided pyramid. Shorter terminal edges of the pyramid meeting at the apex in an angle of 50°, and the longer in an angle of 65°; also other planes $i\breve{\imath}$, $\breve{\imath}\breve{\imath}$, $m\bar{n}$ and $m\bar{n}$. Cleavage indistinct. Fracture uneven, lustrous. H.=2·5 or below. G.=7·31—7·36. Closely like Silver-glance before the blowpipe, fusing easily to a black bead and affording after a while a grain of silver.

Occurs at Joachimsthal with finely granular pyrites, silver-glance and calcite, usually in quartz.

Allanite [p. 208].—Analysis of Orthite from Wexiö in Sweden, occurring in red granite with epidote, afforded C. W. Blomstrand, (Oefv. Akad. Förh., 1854, p. 296, and J. f. pr. Ch. lxvi, 156):

$\bar{\bar{Si}}$	$\ddot{\bar{Al}}$	$\ddot{\bar{Ce}}$	$\ddot{\bar{Fe}}$	$\dot{Y}$	$\dot{Ca}$	$\dot{Mg}$	$\dot{K}$	$\dot{Na}$	$\dot{Mn}$	$\dot{H}$ and loss.
33·25	14·74	14·51	14·30	0·69	12·04	0·74	0·29	0·14	1·08	8·22

New loc. at Manchester, N. H., Proc. Boston Soc. N. Hist., v, 189.

Allophane [p. 336].—Analysis of Allophane from Tennessee, by C. T. Jackson, (Proc. Bost. Soc. N. Hist., v, 120, 1855):

$\bar{\bar{Si}}$ 19·8 $\ddot{\bar{Al}}$ 41·0 $\dot{Ca}$ 0·5 $\dot{Mg}$ 0·2 $\dot{H}$ 37·7=99·2

Aluminite, see *Websterite.*

Ammiolite [p. 142].—A mineral from Chili in red powder, which appears to be the Antimonite of Quicksilver of Domeyko, (ammiolite, D.) has been analyzed by Rivot. He obtained (Ann. d. Mines, [5], vi, 556):

Sb 36·5, Te 14·8, Cu 12·2, Hg 22·2, quartz 2·5, Fe & S *tr.*, Oxygen & loss 12·6.

Rivot observes that from the composition and the reactions, the mineral appears to be a mixture of tellurid of mercury with antimonic acid and antimonate of copper.

Anatase [p. 121].—A crystal from Tremadoc, Wales, according to Dauber (Pogg. xciv, 407), has the new planes $\frac{1}{5}$, and $\frac{1}{7}$-∞, the pyramidal angles of which, as measured, are 112° 47′ and 159° 58′. Dauber also mentions the occurrence of the pyramid $\frac{3}{7}$, in a crystal from Tavistock in Devonshire.

Andalusite [p. 257].—Crystals of the Andalusite of Lisenz in the Tyrol, according to Kenngott (Min. Not., No. 15), afford the following planes: ∞, $\infty\text{-}\bar{2}$, $\infty\text{-}\breve{2}$, $\infty\text{-}\bar{\infty}$, $\infty\text{-}\breve{\infty}$, 0, $1\text{-}\bar{\infty}$, $1\text{-}\breve{\infty}$, 1, $2\text{-}\breve{2}$, or in letters I, $i\bar{2}$, $i\breve{2}$, $i\bar{\imath}$, $i\breve{\imath}$, O, $1\bar{\imath}$, $1\breve{\imath}$, 1, $2\breve{2}$. Angles: I, 90° 50′; $i\bar{2}$, 127° 32′; $i\breve{2}$, 53° 48′; $1\bar{\imath}$, 109° 4′; $1\breve{\imath}$, 109° 51′; 1, octahedral angles, 119° 31′, 120° 28′, 90° 1′; $2\text{-}\breve{2}$, 135° 6′, 63° 35′, 115° 10′.

New locality in California, Am. J. Sci., [2], xx, 84.

Andesine, see *Feldspar.*

Anglesite [p. 370].—Analysis of anglesite from Phœnixville, Penn., J. L. Smith, Am. J. Sci., [2], xx, 244.

Anhydrite [p. 369].—Structure of crystals from Aussee in Styria, Kenngott, Min. Not., No. 17.

Ankerite [p. 441].—Analyses of ankerite from the Acadian Iron mines, Londonderry, Nova Scotia, by C. T. Jackson, (Proc. Bost. Soc. N. H., v, 246):

$\dot{Fe}\ddot{C}$	$\dot{Mn}\ddot{C}$	$\dot{Ca}\ddot{C}$	$\dot{Mg}\ddot{C}$	$\bar{\bar{Si}}$
23·45	0·80	44·80	30·80	0·10 =99·95
20·30		49·20	30·20	—— =99·70

* The paging following the name of the species, is the number of the page where the species is described in the Mineralogy.

ANORTHITE [p. 234].—Analysis of anorthite from I. St. Eustache, by Deville, (Ann. Ch. Phys. [3], xl, 286 and Lieb. u. Kopp., 1854, 832); specific gravity 2·73:

$\dddot{\text{Si}}$ 45·8 $\quad\dddot{\bar{\text{Al}}}$ 35·0 $\quad\dot{\text{Ca}}$ 17·7 $\quad\dot{\text{Mg}}$ 0·9 $\quad\dot{\text{Na}}$ 1·0 =100·4

ANTIMONY GLANCE [p. 33].—Loc. in California, Am. J. Sci. [2], xx, 82.

APATITE [p. 396].—Kokscharov, in Min. Russl., ii, 39, (1854), adds the new planes $\frac{3}{2}$ and 3. He figures many new crystals. From his measurements of crystals from the Ural Emerald mine, $O:1=139^\circ\ 41'\ 37''$, the same as from Ehrenfriedersdorf crystals: for crystals from Achmatowsk $O:1=139^\circ\ 53'\ 39''$, same as for the Lake Laach crystals. The Spanish apatite affords 139° 47′.

Analyses: 1. Yellow apatite from Miask, by G. von Rath, (Pogg., xcvi, 331); 2, from the Siegengebirge, R. Bluhme (Verh. nat. Ver., Bonn, 1855, 111, and Ann. d. Ch. u. Pharm., xciv, 354):

	$\ddot{\bar{\text{P}}}$	$\dot{\text{Ca}}$	Ca	$\dddot{\bar{\text{Fe}}}$	$\dddot{\bar{\text{Al}}}$	$\dot{\text{Mg}}$	$\ddot{\text{C}}$	$\dddot{\text{Si}}$	$\dot{\text{H}}$	loss
1.	42·08	49·75	3·87	0·16	——	——	——	——	0·17	3·97=100
2.	37·33	47·50		——	3·28	2·70	2·20	3·50	1·65	1·84=100

In analysis 1, as 3·87 Ca require 3·62 fluorine, the loss is probably all fluorine excepting 0·35 p. c.

ARAGONITE [p. 448].—An Aragonite in columnar crystallization of unknown locality, *containing fluorine*, afforded G. Jenzsch, (Pogg., xcvi, 145):

$\dot{\text{Ca}}\ \ddot{\text{C}}$	$\dot{\text{Sr}}\ \ddot{\text{C}}$	$\dot{\text{Mg}}\ \ddot{\text{C}}$	$\dot{\text{K}}\ \ddot{\text{C}}$	$\dot{\text{Na}}\ \ddot{\text{C}}$	Ca Fl	$\dot{\text{Ca}}^3\ddot{\bar{\text{P}}}$	$\dot{\text{Ca}}\ \dddot{\bar{\text{S}}}$	$\dot{\text{H}}$
91·17	0·27	0·48	0·62	0·59	3·27	1·24	0·86	2·26 = 100·76

Color snow-white. G.=2·830. Fluor was detected in the Aragonite of Volterra, etc.

AUGITE, see *Pyroxene*.

AURICHALCITE [p. 460].—Loc. in Lancaster, Pa., W. J. Taylor, Am. J. Sci., xx, 412.

AZURITE [p. 459].—Analysis of Azurite from Phœnixville, Pa., J. L. Smith, Am. J. Sci., xx, 250.

BABINGTONITE [p. 178].—Babingtonite is brought by Dauber into close connection with the Paisbergite (Pogg., xciv, 402). From an examination of 82 crystals, he arrives at the angles $ab=112^\circ\ 12'$, $ac=92^\circ\ 32'$, $bc=87^\circ\ 24'$. Referred to the form of Augite (see figure under Paisbergite) these angles are $O:I'=112^\circ\ 12'$, $O:I=92^\circ\ 32'$, $I:I'=87^\circ\ 24'$. Cleavage parallel to c (I), less so parallel to b (I').

BARYTES [p. 366].—Crystallographic structure of crystals as ascertained by erosion with acid, Leydolt, Acad. Wiss. Wien, May, 1855.

BERYL [p. 178].—Many figures of Russian crystals by Kokscharov, Min. Russl., 1854, p. 147. One crystal affords the plane $12\frac{12}{11}$. Specific gravity of transparent crystals: from Mursinka, yellow, 2·694; ib. greenish-yellow, 2·683; ib. greenish-yellow, 2·681: from Schaitanka, colorless, 2·694, 2·695; pale rose-red, 2·725; apple-green, 2·710: from Adun-Tschilon, bluish-green, 2·677: from Urulga, green, 2·702. $O:1=150^\circ\ 3'\ 24''$.

The Emeral of the Ural afforded A. B. Kammerer, sp. gr. =2·710–2·759; 2·742, a mean of the best results.

BITUMEN [p. 469].—Locality in California, W. P. Blake, Am. J. Sci. [2], xix, 433, xx, 84.

Pitch lake of Trinidad, N. S. Manross, Am. J. Sci. [2], xx, 153.

BLENDE [p. 49].—Analysis; from Phenixville, Pa., J. L. Smith, Am. J. Sci., xx, 250.

BORACITE [p. 393].—The massive boracite of Stassfurth, which occurs in large or small masses, of a pure snow-white color, dissolves easily in dilute muriatic, nitric, or sulphuric acid, and in concentrated hydrofluoric acid, without heat, unlike the Boracite of Lüneburg and Segeberg. When pulverized the particles show electric polarity like those of the crystallized Boracite, (G. H. O. Volger, Mon. d. Borazites, 1855, p. 68).

BRONGNIARDITE [p. 76].—Damour states (Ann. d. Mines [5], vi, 146) that a specimen of this mineral from Bolivia (the original locality) contains cavities in which it is crystallized in regular octahedrons with replaced edges. Damour observes that the species is thus related to Dufrenoysite, which has the same crystallization and a similar formula. The formula of Brongniardite is (Pb, Ag) S+$\frac{1}{2}$Sb^{2}S^3, and Dufrenoysite PbS+$\frac{1}{2}$As^{2}S^3.

BROOKITE [p. 123].—Sp. gr., according to Romanowsky, of transparent crystals from the Urals, 4·21–4·23; of untransparent, 4·15–4·16; of pulverized mineral, 4·20. Analysis $\ddot{T}i$ 94·31, $\ddot{F}e$ 3·28, ign. 1·31=98·90. (Kokscharov's Min. Russl., ii, 79.)

BRUCITE [p. 133].—Loc. in Russia, Kokscharov, Min. Russl., ii, 111.

BURATITE, see *Aurichalcite.*

BYTOWNITE [p. 237].—Note on Bytownite, by T. S. Hunt, Am. J. Sci. [2], xix, 429.

CALAMINE [p. 313].—Dauber (Pogg., xcii, 245) adds the planes $\frac{1}{2}$, $\frac{3}{2}$, $3\text{-}\breve{\frac{3}{2}}$, $\frac{4}{3}\text{-}\breve{4}$, from crystals from Altenberg; and gives for $O:1\text{-}\bar{\infty}=148°\ 34'$; $O:1\text{-}\breve{\infty}=154°\ 31'$.
Loc. at Phœnixville, Pa., J. L. Smith, Am. J. Sci. [2], xx, 250.

CALCITE [p. 435].—Singular crystallization of Calcite from Phœnixville, Pa., Am. J. Sci., xx, 251.
A new twin of Calcite, Kenngott, Min. Not., No. 17.
Calcite associated with the red zinc ore of New Jersey, gave Jenzsch (Pogg. xcvi, 147):

$\dot{C}a\ddot{C}$	$\dot{M}g\ddot{C}$	$\dot{M}n\ddot{C}$	$\dot{F}e\ddot{C}$	$\dot{Z}n\ddot{C}$	Ca Fl	$\dot{H}$	$\ddot{S}$	
79·96	1·94	11·09	0·60	0·58	5·35	0·32	*tr.*	=99·84

It is white, and has the Zinc ore and Franklinite disseminated through it. G.=2·788; or in grains, carefully separated from impurities, 2·810–2·817. Cleavage angle 104° 57½. Jenzsch has found fluor also in Calcite from Brientz, white cleavable from Freiberg (Himmelsfurst mine), Andreasberg (Abendrothe mine), Kupferberg in Silesia, Adelsberg cave, scalenohedrons from Junge Hohe Birke mine near Freiberg, white from Sala in Sweden, flesh-red from Arendal, wine-yellow from Sangerhausen.

CALOMEL [p. 89].—New planes on crystals from Moschellandsberg, observed by F. Hessenberg (Lieb. u. Kopp, 1854, 869), as follows, $\frac{1}{4}$, 2, $\infty\text{-}\frac{4}{3}$, $\frac{4}{5}\text{-}2$, 2-2, $2\text{-}\frac{3}{2}$. $O:1\text{-}\infty\ (1i)=129°\ 40'$; $O:2\text{-}\infty\ (2i)=112°\ 35'$.—[In the Mineralogy, $O:1i=112°\ 5'$ should read $O:2i=112°\ 5'$.—D.]

CANCRINITE [p. 233].—Analysis of the Cancrinite of Miask (Kokscharov's Min. Russl., ii, 77):

$\ddot{S}i$	$\ddot{\bar{A}}l$	$\dot{C}a$	$\dot{N}a$ (*tr.* of $\dot{K}$)	$\ddot{C}$	$\dot{H}$	
35·50	28·16	6·16	20·20	5·83	3·80	=99·65.

CLINOCHLORE [p. 293].—The clinochlore of Pennsylvania has been examined carefully by M. Senarmont (Ann. d. Mines, [5], vi, 568), who confirms the results of Mr. Blake. On examining a hexagonal crystalline plate, the plane of the optic axes was found to be parallel to one side of the hexagon, and consequently to the principal section of the oblique prism. The two optical axes, which are very divergent, have this divergence increased by heat, and the inclination to the plane of cleavage: moreover the system of rings the most inclined to this plane passes out of the field of the microscope, while the other remains sensibly immoveable. The "clinochlore" of Achmatowsk and Schwarzenstein do not act at all like that of Pennsylvania; an oval system of rings is seen elongated in the direction of the shorter diagonal, and hence the two optic axes are but little inclined to one another; the divergence, if there be any, is too slight to be determined; moreover heat has no effect on it.
The Pennine of Zermatt and Ala acts in general like crystals of the hexagonal system.

On Clinochlore of Achmatowsk in the Urals, Kokscharov, Min. Russl., ii, 7, and Am. J. Sci., [2], xix, 176.

CERUSITE [p. 452].—Loc. Phœnixville, Pa., J. L. Smith, Am. J. Sci., xx, 245.

CHABAZITE [p. 319].—*Glottalite* has been referred to Chabazite by R. P. Greg, Jr., Phil. Mag. [4], x, 118.

Chalcopyrite [p. 68].—Analysis; from Phœnixville, Pa., J. L. Smith, Am. J. Sci., [2], xx, 249.—Loc. in California, Am. J. Sci. [2], xx, 81.

Chondrodite [p. 186].—Transparent crystals of Chondrodite from limestone at Pargas have been measured by N. A. E. Nordenskiöld (Pogg., xcvi, 118). The form is a right prism but hemihedral so as to have a monoclinic aspect, as with the chondrodite of Orange Co. The planes given for the common form are I, $i\bar{\imath}$, $i\breve{\imath}$, $\frac{1}{3}\breve{\imath}$, $1\breve{\imath}$, $\frac{5}{3}\,\bar{\frac{5}{4}}$, $1\bar{\frac{3}{4}}$; $I : I = 114° \; 37'$, $i\breve{\imath} : 1\breve{\imath} = 136° \; 1'$, $i\breve{\imath} : \frac{1}{3}\breve{\imath} = 109° \; 3'$, $I : \frac{5}{3}\,\bar{\frac{5}{4}} = 159° \; 14'$, $I : 1\bar{\frac{3}{4}} = 156° \; 17'$.

The axes, a (vertical): $b : c = 1{\cdot}0361 : 1 : 0{\cdot}6417$.

[The author cites the figure by the writer as given in the third edition of his mineralogy, but has not seen his later views in his fourth edition, and in this Journal, vol. xiv, p. 175, 1852. By changing the position of the crystal, making c the vertical axis, it then corresponds very closely with Scacchi's second type of Humite. The lettering of the crystal above given, I, $i\bar{\imath}$, $i\breve{\imath}$, $\frac{1}{3}\breve{\imath}$, $1\breve{\imath}$, becomes (see Min., p. 187), $1\bar{\imath}$, $i\bar{\imath}$, O, $2\breve{\imath}$, $\frac{2}{3}\breve{\imath}$.

Chondrodite, Nordenskiöld.	Humite, Type II, Scacchi.
$1\bar{\imath} : 1\bar{\imath} = 114° \; 37'$	$115° \; 6'$
$O : 2\breve{\imath} = 136° \; 1'$	$135° \; 52\frac{1}{2}'$
$O : \frac{2}{3}\breve{\imath} = 109° \; 3'$	$108° \; 58'$

These angles fix the dimensions of the crystals. The agreement is much nearer than between either two of the three types of Humite.—J. D. D.]

Chromic Iron [p. 106].—Loc. in California, Am. J. Sci., [2], xx, 82.

Chrysocolla [p. 309].—Analysis of a Chilian specimen by J. L. Smith (Gilliss's Exped., ii, 92): $\dddot{Si}$ 31·35, $\dot{Cu}$ 42·51, $\dot{H}$ 21·62, $\dddot{\overline{Fe}}$ 1·97, $\dddot{\overline{Al}}$ 2·83=100·28; formula nearly $\dot{Cu}^3 \dddot{Si}^2 + 6\dot{H}$.

Chrysolite [p. 184].—Analysis of a wine-yellow chrysolite from the Eiffel by Th. Kjerulf (Nyt. Mag., viii, 173, and J. f. pr. Chem., lxv, 187):

$\dddot{Si}$ 42·21, $\dot{Mg}$ 49·29, $\dot{Fe}$ 8·91, $\dddot{\overline{Al}}$ 0·18 $\dddot{\overline{Cr}}$ 0·004, ign. 0·12=100·72.

Cinnabar [p. 48].—Mine in California, Am. J. Sci. [2], xx, 80.

Coal [p. 26].—Analysis of mineral charcoal, by T. H. Rowney, (Edinb. N. Phil. J. [2], ii, 141 (each a mean of two analyses):

	C	H	N	O	Ash.	
1. Glasgow coal fields,	82·97	3·35	0·75	6·85	6·08	= 100
2. Stonelaws coal,	72·74	2·35	5·83		19·08	= 100
2. Ayrshire coal,	73·42	2·94	8·25		15·39	= 100
9. Fifeshire, Splint coal,	74·72	2·74	7·67		14·87	= 100
4. " "	81·17	3·85		14·98		= 100

The hard coals associated with the last two charcoals consist of

	C	H	S	N	O	Ash
1.	80·63	5·16	0·84	1·33	10·61	1·43
2.	80·93	5·21	0·63	1·57	10·91	0·75

The charcoals differ from the hard coals but slightly in composition, and Mr. Rowney prefers the name *Fibrous Anthracite*, used by Prof. Bischoff, to that of Mineral charcoal.

Columbite [p. 353].—The metallic acids of the Columbite of Middletown, according to Hermann (J. f. pr. Chem., lxv, 74), consist, in 100 parts, of Columbic (niobic) acid 58·44 parts, Ilmenous acid $Il^2 \, O^3$ 18·26, Ilmenic acid $\ddot{Il}$ 23·30. The whole composition according to Hermann is—

$\dddot{W}$	$\dddot{\overline{Co}}$	$\dddot{\underline{Il}}$	$\ddot{Il}$	$\ddot{Sn}$	$\dot{Fe}$	$\dot{Mn}$	$\dot{Mg}$	
0·26	45·71	14·28	18·23	0·40	14·06	5·63	0·49	= 99·06

and affords him the formula $3\dot{R}\,(\dddot{\overline{Co}}, \dddot{\underline{Il}}) + 2\dot{R}\,\ddot{Il}$.

The atomic weight of Ilmenium is stated to be 2042·0, and that of Columbium (niobium) 2230·14.

The Columbite of Bodenmais affords:

$\ddot{\mathrm{E}}\mathrm{o}$	$\ddot{\mathrm{C}}\mathrm{o}$	$\ddot{\mathrm{S}}\mathrm{n}$	$\dot{\mathrm{F}}\mathrm{e}$	$\dot{\mathrm{M}}\mathrm{n}$	$\dot{\mathrm{C}}\mathrm{u}$
45·40	35·67	0·45	14·30	3·85	0·13 = 99·80

Formula deduced $\dot{\mathrm{R}}\,\ddot{\mathrm{E}}\mathrm{o}^2 + 3\dot{\mathrm{R}}\,\ddot{\mathrm{C}}\mathrm{o}$.

Samarskite has the formula $3\dot{\mathrm{R}}^2\,\underline{\ddot{\mathrm{I}}}\mathrm{l} + 4\dot{\mathrm{R}}^2\,\ddot{\mathrm{I}}\mathrm{l}$, consisting of—

$\underline{\ddot{\mathrm{I}}}\mathrm{l}$	$\ddot{\mathrm{I}}\mathrm{l}$	$\dot{\mathrm{M}}\mathrm{g}$	$\dot{\mathrm{M}}\mathrm{n}$	$\dot{\mathrm{F}}\mathrm{e}$	$\dot{\mathrm{U}}$	$\dot{\mathrm{Y}}$	$\dot{\mathrm{C}}\mathrm{e}$, $\dot{\mathrm{L}}\mathrm{a}$	ign.
33·25	23·11	0·50	1·20	8·87	16·63	13·29	2·85	0·33 = 100·03

Æschynite has the formula $2\dot{\mathrm{R}}\,\ddot{\mathrm{I}}\mathrm{l} + \ddot{\mathrm{E}}\mathrm{e}\,\ddot{\mathrm{T}}\mathrm{i}^3$, containing

$\ddot{\mathrm{I}}\mathrm{l}$	$\ddot{\mathrm{T}}\mathrm{i}$	$\ddot{\mathrm{E}}\mathrm{e}$	$\dot{\mathrm{C}}\mathrm{e}$	$\dot{\mathrm{L}}\mathrm{a}$	$\dot{\mathrm{Y}}$	$\dot{\mathrm{F}}\mathrm{e}$	ign.
33·20	25·90	22·20	5·12	6·22	1·28	5·45	1·20 = 100·57

Yttroilmenite contains $\ddot{\mathrm{I}}\mathrm{l}$ and $\underline{\ddot{\mathrm{I}}}\mathrm{l}$ 57·81, $\ddot{\mathrm{T}}\mathrm{i}$ 5·90, $\dot{\mathrm{Y}}$ 18·30, $\dot{\mathrm{F}}\mathrm{e}$ 13·61, $\dot{\mathrm{M}}\mathrm{n}$ 0·31, $\dot{\mathrm{C}}\mathrm{a}$ 0·50, $\dot{\mathrm{U}}$ 1·87, $\dot{\mathrm{C}}\mathrm{e}$ and $\dot{\mathrm{L}}\mathrm{a}$ 2·27 = 100·57.

Pyrochlore (the Fluopyrochlore of Miask) contains $\underline{\ddot{\mathrm{I}}}\mathrm{l}$ 46·25, $\ddot{\mathrm{I}}\mathrm{l}$ 14·58, $\ddot{\mathrm{T}}\mathrm{i}$ 4·90 $\dot{\mathrm{C}}\mathrm{e}$, $\dot{\mathrm{L}}\mathrm{a}$ 15·23, $\dot{\mathrm{Y}}$ 0·94, $\dot{\mathrm{F}}\mathrm{e}$ 2·23, $\dot{\mathrm{C}}\mathrm{a}$ 9·80, $\dot{\mathrm{M}}\mathrm{g}$ 1·46, K 0·54, Na 2·69, Fl 2·21 = 100·83, corresponding to $\dot{\mathrm{R}}\,\underline{\ddot{\mathrm{I}}}\mathrm{l} + \dot{\mathrm{R}}^2\,(\ddot{\mathrm{I}}\mathrm{l}, \ddot{\mathrm{T}}\mathrm{i}) + 2{\cdot}21$ p. c. Fl. [The existence of Ilmenium is yet in dispute.]

Copper and Copper Ores.—In California, Am. J. Sci. [2], xx, 81.—Chili, J. L. Smith, Gilliss's Exped. ii, 88.

Corundum [p. 111.]—*O* : 1, according to measurement by Kokscharov, equals 122° 25′ (Min. Russl., ii, 80).

Cryolite [p. 97].—M. Leydolt has investigated the molecular structure of crystals of anhydrite and cryolite, and he shows that cryolite is identical with anhydrite in form, cleavage, color, lustre, hardness and specific gravity, and differs only in the facility of cleavage and in chemical composition.—Akad. Wiss., Wien, April, 1855.

Danburite [p. 212].—The analyses of Danburite, by Smith and Brush (this Journal, xvi, 365,) are questioned without good reason by Kenngott in his Min. Forsch. for 1853, p. 106.

Datholite [p. 334].—The crystallization of Datholite has been carefully studied by F. H. Schröder, in order to ascertain whether the prism is right as stated by Brooke and Miller and Hess, or oblique. He makes it slightly oblique, though still leaving it in doubt, the inclination obtained being 90° 6′; he gives *O* : 2ĭ [see Min., p. 334] = 135° 11′, *O* : 1 = 153° 34′.—Pogg. Ann., xciv, 235.

Dolomite [p. 441].—Coral rock of Matea afforded T. S. Hunt, $\dot{\mathrm{C}}\mathrm{a}\,\ddot{\mathrm{C}}$ 60·50, $\dot{\mathrm{M}}\mathrm{g}\,\ddot{\mathrm{C}}$ 38·77, $\ddot{\mathrm{S}}\mathrm{i}$, etc., 0·30 = 99·57.—Am. J. Sci., [2], xix, 429.

Analyses of compact magnesian limestone of Missouri, by Dr. Litton (Rep. Geol. Missouri, 1855):

	$\dot{\mathrm{C}}\mathrm{a}\,\ddot{\mathrm{C}}$	$\dot{\mathrm{M}}\mathrm{g}\,\ddot{\mathrm{C}}$	$\ddot{\mathrm{A}}\mathrm{l}$, $\ddot{\mathrm{F}}\mathrm{e}$	Insol. or $\ddot{\mathrm{S}}\mathrm{i}$
1. Chouteau Springs,	48·23	34·93	2·01	13·90 = 99·07
2. Atkisson's Well,	47·01	38·86	0·52	13·27 = 99·66
3. Cotton Rock,	50·80	40·56	1·07	6·21, $\dot{\mathrm{H}}$ 0·21 = 98·85
4. From Coal Measures,	61·18	25·70	9·00	3·04 = 98·92

The same report contains analyses also of Missouri limestones not magnesian.

Dufrenoysite [p. 77].—J. C. Heusser observes in Pogg., xciv, 334, that the mineral named *Scleroclase* by von Waltershausen [see preceding Suppl., this Journ., vol. xix, p. 355], should retain the name *Dufrenoysite*, given it by Damour, and that the species called *Arsenomelan* by him, has for some time borne the name *Binnite*, being so called in Krantz's Catalogue.

Epidote [p. 206].—Analysis by Scheerer (Pogg., xcv, 501):

	$\ddot{\mathrm{S}}\mathrm{i}$	$\ddot{\mathrm{A}}\mathrm{l}$	$\ddot{\mathrm{F}}\mathrm{e}$	$\dot{\mathrm{C}}\mathrm{a}$	$\dot{\mathrm{H}}$	
1. Guttanen,	38·05	26·39	9·72	23·54	2·02 = 99·72	G.=3·373
2. Sustenhorn, *gnh-bn*,	38·43	26·18	8·77	24·13	2·46 = 99·97	G.=3·326
3. Lole, *gnh-bn*,	38·39	28·48	7·56	22·64	2·30 = 99·37	G.=3·359
4. Gotthard, (*Escherite*),	38·08	27·74	8·26	23·53	2·04 = 99·65	G.=3·384
5. Kaverdiras, *bnh-gn*,	37·66	27·35	8·89	23·91	2·33 = 100·14	G.=3·369
6. Gotthard, *bnh-gn*,	38·28	27·52	8·66	22·87	2·41 = 99·74	G.=3·378
7. Bourg d'Oisans,	37·35	22·02	15·67	22·54	2·35 = 99·93	

These analyses give Scheerer for the mean oxygen ratio, for

$\dot{\dot{H}}$, $\dot{R}$, $\dddot{R}$, $\dddot{Si}$, 2·02 : 6·66 : 15·28 : 19·73.

Scheerer, in accordance with his hypothesis, supposes 3$\dddot{R}$ to replace 2$\dddot{Si}$, and 3$\dot{H}$ replace 1$\dot{R}$, and thus arrives at the ratio for [$\dddot{Si}$] : ($\dot{R}$), of 4 : 1. The oxygen ratio for $\dddot{Al}$ and $\dddot{Fe}$ in the epidote of Bourg d'Oisans, Arendal and Traversella is 2 : 1; in that of Guttanen, 4 : 1; that of Kaverdiras, 5 : 1; that of Lole, 6 : 1.

The Zoisite of the Saualpe in Carinthia, where it occurs in gneiss, contains zirconia according to an analysis by Kuleszna, in which he obtained—

$\dddot{Si}$ 44·00, $\dddot{Al}$ 30·97, $\dot{Ca}$ 17·76, $\dddot{Fe}$ 4·92, $\dddot{Zr}$ 2·00 = 99·67.

The author observes that Klaproth's analyses are erroneous.

EUCLASE [p. 267].—Mean of four analyses by M. A. Damour (Comptes Rend., xl, 944):

	$\dddot{Si}$	$\dddot{Al}$	$\dddot{Be}$	$\dot{Ca}$	$\dot{Fe}$	$\ddot{Sn}$	$\dot{H}$	Fl
	41·63	34·07	16·97	0·14	1·03	0·34	6·04	0·38=100·60
Oxygen,	21·61	15·92	10·73				5·37	

[The oxygen ratio between the bases and the silica is between 5 : 4 and 4 : 3. With the latter, the formula is $(\frac{2}{5}\dddot{Be}+\frac{3}{5}\dddot{Al})\,\dddot{Si}^{\frac{4}{3}}+\frac{1}{5}\dot{H}$, or $2\dddot{Be}\dddot{Si}^{\frac{4}{3}}+3\dddot{Al}\,\dddot{Si}^{\frac{4}{3}}+\dot{H}$, differing from the analyses of Mallet and Berzelius in containing the $\dddot{Be}$ and $\dddot{Al}$ in the ratio of 2 to 3 instead of 1 : 1, and also in the water as well as fluorine.—D.]

EUKAMPTITE, *Kenngott* (Min. Forsch. for 1853, 58).—Thin foliated or micaceous and resembling chlorite, occurring in granite near Pressburg, Hungary. Very thin plates brown to hyacinth-red or reddish-yellow. Streak grayish-green to brownish-green. G.=2·73. H. a little above 2. Not magnetic. In the flame of a spirit lamp, becomes pinchbeck-brown, to white, semi-metallic and opaque. In a tube exfoliates and yields water. BB. blackens; thin leaves fuse on the edges to a magnetic globule. With borax fuses easily; with salt of phosphorus difficultly, yielding a silica skeleton; with soda swells up and shows a manganese reaction. Analysis by v. Hauer:

$\dddot{Si}$	$\dddot{Al}$	$\dot{Fe}$	$\dot{Mn}$	$\dot{Mg}$	$\dot{H}$
38·13	21·60	19·92	2·61	13·76	3·98=100.

Oxygen ratio for $\dot{R}$, $\dddot{R}$, $\dddot{Si}$, $\dot{H}$, 3 : 3 : 6 : 1=1 : 1 : 2 : $\frac{1}{3}$.

The name alludes to the softness and flexibility of the mineral.

[Excluding the water, the composition conforms to the general formula of Biotite $(\frac{1}{2}\dot{R}^3+\frac{1}{2}\dddot{R})\,\dddot{Si}$, or $\dot{R}^3\,\dddot{Si}+\dddot{R}\,\dddot{Si}$.—J. D. D.]

ENSTATITE, *Kenngott* (Min. Not., No. 17).—Augitic in crystallization, although having some resemblance to Scapolite. *I* : *I*=87°. Cleavage parallel to *I* distinct, and having a pearly lustre. Color grayish or yellowish-white. H.=5·5. G.=3·10–3·13. BB. infusible, and to this the name alludes. No action with muriatic acid. According to von Hauer contains, $\dddot{Si}$ 56·91, $\dddot{Al}$ 2·50, $\dot{Fe}$ 2·76, $\dot{Mg}$ 35·44, $\dot{H}$ 1·92 (0·41 lost at 100° C.); and hence it is a bisilicate of Magnesia ($\dot{Mg}^3\dddot{Si}^2$), as Wollastonite is a bisilicate of lime ($\dot{Ca}^3\,\dddot{Si}^2$).

The augite group hence includes

Wollastonite	$\dot{Ca}^3\,\dddot{Si}^2$,	Diopside $(\dot{Ca}, \dot{Mg})^3\,\dddot{Si}^2$,
Enstatite	$\dot{Mg}^3\,\dddot{Si}^2$,	Hedenbergite $(\dot{Ca}, \dot{Fe})^3\,\dddot{Si}^2$,
Grunerite	$\dot{Fe}^3\,\dddot{Si}^2$,	Bustamite $(\dot{Ca}, \dot{Mn})^3\,\dddot{Si}^2$,
Rhodonite	$\dot{Mn}^3\,\dddot{Si}^2$,	Hypersthene $(\dot{Fe}, \dot{Mn})^3\,\dddot{Si}^2$,

besides other related compounds, included under pyroxene.

FELDSPAR [p. 234 to 242].—On some feldspathic minerals from the Hypersthene rock of Canada, by T. S. Hunt, Phil. Mag., [4], ix, 354. The paper contains the following analyses, besides others contributed to the Mineralogy:

	$\overline{Si}$	$\overline{\overline{Al}}$	$\overline{\overline{Fe}}$	$\dot{Ca}$	$\dot{Mg}$	$\dot{Na}$	$\dot{K}$	ign.
1. *Andesine,*	59·55	25·62	0·75	7·73	*tr.*	5·09	0·96	0·45=100·15
2. "	59·85	25·55	0·65	6·94	0·11			0·30
3. "	58·50	25·80	1·00	8·06	0·20	5·45	1·16	0·40=100·57
4.	55·80	26·90	1·53	9·01	0·27	4·77	0·86	0·45= 99·59
5.	57·20	26·40	0·40	8·34	——	5·83	0·84	0·65= 99·66
6.	57·55	27·10		8·73	——	5·38	0·79	0·20= 99·75
7.	54·45	28·05	0·45	9·68	——	6·25	1·06	0·55=100·49
8.	58·15	26·09	0·50	7·78	0·16	5·55	1·21	0·45= 99·89

1, 2, color flesh-red, reddish, greenish and grayish-brown, G.=2·667–2·674; 3, granular greenish base of same rock, G.=2·665–2·668; 4, pale greenish and bluish-gray, finely granular, G. of greenish-gray portion, 2·681; 5, 6, color pale lavender-blue, G.=2·680–2·692; numbers 1 to 6 from Chateau Richer;—7, from district of Montreal, bluish, G.=2·691; 8, from La Chute, associated like the above with crystalline limestone, color lavender-blue, G.=2·687.

Mr. Hunt supposes that albite and anorthite are the only two distinct species of triclinic feldspar, and that others, intermediate in composition, are mixtures of these two homœomorphous species.

On the composition of some Feldspars (*Orthoclase*) of the granite of the Dublin and Wicklow mountains, J. A. Galbraith, Phil. Mag., [4], ix, 40 (anal. 1—7), and x, 115 (anal. 8):

	$\overline{Si}$	$\overline{\overline{Al}}$	$\dot{Mg}$	$\dot{Ca}$	$\dot{K}$	$\dot{Na}$	ign.	
1. Dalkey, Co. Dublin,	64·00	18·11	0·57	*tr.*	12·73	3·00	0·55= 98·96;	G.=2·540
2. Three Rock Mountain,	65·40	17·71	1·77	*tr.*	10·68	3·26	0·69= 99·51;	G.=2·562
3. L. Bray,	65·44	18·36	——	0·80	12·34	2·73	0·52=100·19;	G.=2·554
4. L. Dan, Co. Wicklow,	65·05	17·72	*tr.*	0·23	13·42	2·75	0·36= 99·53;	G.=2·559
5. Glenmacanass, "	64·19	18·39	0·34	0·70	11·39	2·95	0·58= 98·54;	G.=2·553
6. Glendalough, "	63·60	18·84	0·40	*tr.*	14·33	1·92	0·60= 99·69;	G.=2·453
7. Glenmalur, Co. Dublin,	64·48	19·04	1·02	*tr.*	10·74	2·64	0·78= 98·70;	G.=2·560
8. Near Dublin,	70·32	16·12	$\overline{\overline{Fe}}$ 3·20	1·34	4·65	3·39	0·96= 99·98	

A variety of *Orthoclase* containing lithia, from the vicinity of Radeberg, afforded G. Jenzsch (Pogg., xcv, 304):

	$\overline{Si}$	$\overline{\overline{Al}}$	$\dot{Mg}$	$\dot{Li}$	$\dot{Na}$	$\dot{K}$	Fl and $\overline{B}$ (ign.)
	65·24	20·40	0·84	0·71	0·27	12·35	0·52=100·33
Oxygen,	33·87	9·53	0·34	0·39	0·07	2·10	

G.=2·548. H.=6. Color smalt-blue to milk-white. Associated with lithia mica.

Pseudomorph of potash mica (muscovite) after feldspar, from the granite of Hirschberg. Analysis by Kjerulf (J. f. pr. Chem., lxv, 190):—

	$\overline{Si}$	$\overline{\overline{Al}}$	$\overline{\overline{Fe}}$	$\dot{Mg}$	$\dot{K}$	$\dot{Na}$	F
1. Orthoclase,	70·82	17·37	0·66	0·35	8·89	1·91	——=100
2. Mica pseud.,	51·73	28·75	5·37	0·62	8·28	2·14	0·83=97·83

The orthoclase analyzed may not have been quite pure, as it was selected in grains from the mica scales.

Analysis of *Labradorite,* (1) from a Hypersthene rock of Silesia, (2) from Gabbro, by G. von Rath (Pogg., xcv, 538—see Hypersthene, under *Pyroxene*):

	$\overline{Si}$	$\overline{\overline{Al}}$	$\overline{\overline{Fe}}$	$\dot{Ca}$	$\dot{Mg}$	$\dot{K}$	$\dot{Na}$	ign.
1.	52·25	28·32	2·44	11·61	0·48	0·64	4·52	0·62=101·18
Oxygen,	27·29	13·24	0·72	3·30	0·19	0·11	1·16	
2.	50·31	27·31	1·71	10·57	0·78	1·55	4·81	2·20=99·24
Oxygen,	26·14	12·75	0·51	3·01	0·31	0·26	1·23	

Color bluish-gray, without opalescence. For 1, G.=2·715; for 2, G.=2·707.

Labradorite occurs in the Witchita Mts., west of the Mississippi, (Marcy's Rep. Expl Red River, p. 137.)

Deville regards *Vosgite* as an altered *Labradorite,* (Ann. Ch. Phys. [3], xl, 271). He has analyzed the mineral from Ternuay, and obtained:

	$\dddot{Si}$	$\overline{\dddot{Al}}$	$\dot{Ca}$	$\dot{Mg}$	$\dot{Na}$	$\dot{K}$	ign
1.	59·07	26·67	7·96	0·58	4·95	*tr.*	0·77 = 100
2.	57·01	28·05	7·53	0·39	5·47	0·12	1·43 = 100
3.	52·40	24·78	15·02	0·51	5·10	0·14	2·05 = 100

No. 1 is analysis of the whole crystal; No. 2 of the inner portion; No. 3 of the outer; the last afforded 2·6 p. c. of carbonate of lime. Oxygen ratio for $\dot{R}$, $\overline{\dddot{R}}$, $\dddot{Si}$ of No. 1, 0·90 : 3 : 7·43; of No. 2, 0·84 : 3 : 6·78; and of 3, 1·41 : 3 : 705.

Andesine, according to Deville (Ann. Ch. Phys., [3], xl, 283), is altered oligoclase. Specimens of the porphyry of Marmato afford 3·5 to 5 p. c. of carbonate of lime. Three trials gave—

	$\dddot{Si}$	$\overline{\dddot{Al}}$	$\dot{Ca}$	$\dot{Mg}$	$\dot{Na}$	$\dot{K}$	ign	
1.	63·85	24·05	5·04	0·38	5·04	0·88	0·76 = 100;	G = 2·61
2.	60·69	26·04	3·89	0·85	5·32	1·01	2·20 = 100;	G = 2·62
3.	58·11	28·16	5·35	1·52	5·17	0·44	1·25 = 100	

No. 1 gives Deville for the oxygen ratio for $\dot{R}$ $\overline{\dddot{R}}$, $\dddot{Si}$, 0·96 : 3 : 8·86; No. 2, 0·72 : 3 : 7·78; No. 3, 0·79 : 3 : 6·89. No. 1 appeared unaltered; No. 2 afforded 1·4 p. c. of carbonate of lime. Deville refers here also the Ryakolite (?) of Teneriffe.

Analysis of *Labradorite* from Sweden (from the north slope of the Linderöds Mts.), sp. gr. 2·68, by Blomstrand (Oefv. Ak. Förh., 1854, p. 296.):

$\dddot{Si}$	$\overline{\dddot{Al}}$	$\overline{\dddot{Fe}}$	$\dot{Ca}$	$\dot{Mg}$	$\dot{K}$	$\dot{Na}$
53·82	26·96	1·43	11·20	0·20	1·34	5·00 = 99·95

Felsobanyite [Suppl. I]. Found at Kapnik in Hungary.

Fluor [p. 94].—Kenngott (Min. Not., No. 14) describes a green trisoctahedron of fluor which has very narrow dodecahedral planes of a violet-blue color. It has some resemblance to a crystal from Saxony in which the three axial sections were colorless, while the rest of the crystal was violet-blue.

He describes and figures an octahedral crystal of the same species, from Schlackenwald, which has a small dodecahedron of fluor on each angle. The color is pale violet-blue.

Still another form he mentions, which is a peculiar twin presenting faces of the cube and the tetrahexahedron $\infty O3$. Small globular concretions violet-blue to colorless, have been found at Kapnik.

For fluor in *Aragonite* and *Calcite*, see those species.

Galactite [1st Suppl.]—Kenngott states from Haidinger, that Galactite occurs white, and that the locality is Glenfarg in Perthshire, Scotland.

Galena [p. 39].—The Galena of Missouri afforded Dr. Litton usually a trace of silver—the highest per-centage ·0027. Mine La Motte Galena gave ·0012 to ·0027, Rep. Geol. Missouri, 1855, in which there are notices of the various mines of the state.

Galena at Phenixville, Pa., Smith, Am. J. Sci., xx, 248.

Garnet [p. 190].—A black Garnet occurring with green feldspar in Norway, contains yttria; analysis by Prof. Bergemann (Sitz. nied. Ges., Bonn, July, 1854):

$\ddot{Si}$	$\overline{\dddot{Fe}}$	$\dot{Ca}$	$\dot{Mn}$	$\dot{Mg}$	$\dot{Y}$	$\overline{\dddot{Al}}$
34·94	30·01	26·04	1·09	0·50	6·66	*tr.*

Specific gravity 3·88. H. = 5, or like apatite.

Glauber Salt [p. 386].—Analysis of the Salt from Guipuscoa, Spain, by Rivot (Ann. d. Mines, [5], vi, 558):

$\dddot{S}$ 24·8 $\dot{Na}$ 19·5 $\dot{K}$ *tr.* $\dot{Ca}$ 0·3 $\dot{Mg}$ 0·5 $\dot{\overline{H}}$ 54·5

It corresponds to the formula $\dot{Na}\dddot{S}+10\dot{\overline{H}}$. Occurs in a thick bed, and is compact, massive, of a white color. Effloresces rapidly.

Glauconite or Green Sand [p. 288].—Composition of the Green Sand of Essen in Rhenish Westphalia, according to D. H. von Dechen (Verh. nat. Ver., Bonn, 1855, 176):

$\dddot{Si}$ 58·17 $\overline{\dddot{Al}}$ 10·09 $\dot{Fe}$ 18·75 $\dot{Mg}$ 3·37 $\dot{K}$. 3·37 $\dot{\overline{H}}$ 6·25 = 100

These green grains make up 33·1 p. c. of the sand; of the rest 41 p. c. are quartz sand, and 2·59 p. c. are a calcareous cement, consisting of

$\dot{Ca}\ddot{C}$ 78·1 $\dot{Mg}\ddot{C}$ 1·6 $\dot{Ca}^3\dddot{\dddot{P}}$ 10·3 $\overline{\dddot{Al}}$ 6·4 $\overline{\dddot{Fe}}$ 3·6 F *tr.* = 100

Glottalite [p. 319].—See *Chabazite.*

Gold [p. 7].—W. P. Blake on the California mines, Am. J. Sci. [2], xx, 72.

Gold Amalgam [p. 15]—Found at Mariposa, California. Analysis by F. Sonnenschein (Zeitsch. d. deutsch geol. Gesellsch., vi, 243, in Lieb. u. Kopp., 1854, p. 807). Gold 39·02 and 41·63, with quicksilver 60·98 and 58·37. Color yellowish-white. In 4-sided prisms. M. Schmitz is stated to be authority for this locality.

Graphite [p. 29].—According to Kenngott (Min. Not., No. 14), a specimen of a graphite from Ticonderoga, contains crystals in hexagonal tables, having the planes of two pyramids on the basal edges, and of a rhombohedron on the angles. Angle between the base (O) of the prism and one pyramid, 110°, between O and the other pyramid, 137° ; O and the rhombohedron, 122°. The last gives by calculation for $R : R$=85° 30′, or exactly 85° 29′. Calling this the fundamental rhombohedron, R, the pyramids are 2P2 and $\frac{2}{3}$P2. Haidinger, in his Handb. der bestim. Min., p. 513, mentions a pyramid having for the angle at the side edge 40° 56′. It is probably $\frac{1}{4}$R, in which this angle would be 38° 13′. If the pyramid belongs to the same zone with 2P2, it may be $\frac{1}{4}$P2, which affords the side angle 43° 37′. Specific gravity of the Ticonderoga graphite, 2·229.

Crystals of graphite from Ersby and Storgard have been studied by N. A. E. Nordenskiöld (Pogg., xcvi, 110) and pronounced monoclinic; the form a short 6-sided oblique table much like common mica. *ii* (cleavage face) on faces of an oblique prism c''=106° 21, $c'' : c''$=122° 24′. Inclination of the vertical axis 88° 14′.

Gypsum [p. 377].—Abundant west of Mississippi, Marcy's Rep. Expl. Red River, p. 148, 164, &c. In California, Am. J. Sci., [2], xx, 83.

Hausmannite [p. 118].—A form of compound crystal of Hausmannite similar in general character to figure 295A, Min., p. 69, has been observed by Kenngott (Min. Not., No. 16). It presents the octahedral planes 1, and on the angles, 4 planes, $\frac{1}{3}$.

Dauber (Pogg., xciv, 406) has obtained for the pyramidal angle of 1, 105° 50′; and for $\frac{1}{3}$, 140′ 31, from the Hausmannite of Ilmenau.

Hematite (Specular Iron) [p. 113].—Octahedrons, pseudomorph after magnetite, Nöggerath (Sitz. nied. Ges., Bonn, July, 1854).—On ore of Missouri, Geol. Report by G. C. Swallow, 1855.

Herrerite [1st Suppl.]—Identity with Smithsonite, Am. J. Sci., xx, 118.

HEDDLITE, *Greg.*—A native oxalate of potash, according to M. Forster Heddle; color-purplish red, arising from some oxalate of cobalt. From a copper mine at the Old Man, near Coniston Lake in Westmoreland, England, associated with Conistonite of Greg. Edinb. N. Phil. J., [2], i, 365.

HIRCINE, *Piddington.*—A fossil resin supposed to be new. Arch. d. Pharm., lxxiv, 318, and Kenngott's Min. Forsch for 1853, p. 134.

Hornblende [p. 170].—The greenstone of Neurode in Silesia consists of Saussurite (Labradorite) 43½ p. c., and a hornblende having the composition of augite, and therefore uralite (56½ p. c.). Part of the hornblende shows evidence of alteration. G.=3·273. Analysis by von Rath (Pogg., xcv, 557):

$\dddot{\mathrm{Si}}$ 48·70 $\dddot{\mathrm{Al}}$ 0·82 $\dot{\mathrm{Fe}}$ 25·21 $\dot{\mathrm{Ca}}$ 11·25 $\dot{\mathrm{Mg}}$ 12·01 alkalies *tr.* ign. 1·01=99·00

affording the oxygen ratio for $\dot{\mathrm{R}}$, $\dddot{\mathrm{R}}$, $\overline{\mathrm{Si}}$, 13·60 : 0·38 : 25·30.

A hornblende-like mineral, a constituent of the Zircon-Syenite of Norway, afforded von Kovanko the following composition—except that the iron, in accordance with a subsequent examination by v. Puzyrewsky, is made part peroxyd, (Th. Scheerer in J. f. pr. Chem., lxv, 341):

	$\dddot{\mathrm{Si}}$	$\dddot{\mathrm{Al}}$	$\dddot{\mathrm{Fe}}$	$\dot{\mathrm{Fe}}$	$\dot{\mathrm{Mn}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{Mg}}$	$\dot{\mathrm{Na}}$	$\dot{\mathrm{K}}$	$\dot{\mathrm{H}}$
	37·34	12·66	10·24	9·02	0·75	11·43	10·36	4·18	2·11	1·85=99·93
Oxygen	19·38	5·91	3·07	2·00	0·17	3·27	4·14	1·08	0·36	1·64

Oxygen ratio for $\dot{\mathrm{H}}$, $\dot{\mathrm{R}}$, $\dddot{\mathrm{R}}$, $\overline{\mathrm{Si}}$, 1·64 : 11·02 : 8·98 : 19·38.

Scheerer by his theory (taking $3\dddot{\text{R}}=2\dddot{\text{Si}}$, and $3\dot{\text{H}}=1\dot{\text{Mg}}$) makes out the formula $(\dot{\text{R}})[\dddot{\text{Si}}]+(\dot{\text{R}})^3[\dddot{\text{Si}}]^2$, the hornblende formula.

[The composition obtained is near that of Epidote; the propriety of calling the species hornblende may be questioned.—J. D. D.]

NORDENSKIÖLDITE is identical with Tremolite, (Kenngott, Sitz. Wien, xii, 297.)

HYPERSTHENE, see *Pyroxene.*

IDOCRASE [p. 197].—Analyses and descriptions by Rammelsberg (Pogg. xciv, 92) —the results here cited, mean of 2 or 3 analyses—

	$\dddot{\text{Si}}$	$\dddot{\text{Al}}$	$\dddot{\text{Fe}}$	$\dot{\text{Ca}}$	$\dot{\text{Mg}}$	$\dot{\text{K}}$		
1. Vesuvius, *ywh-bn,*	37·75	17·23	4·43	37·35	3·79	—	=100·55	G.=3·382
2. " *dull bn,*	37·83	10·98	9·03	35·69	4·37	—	= 97·90	G.=3·428–3·429
3 Monzoni, *ywh,*	38·25	15·49	2·16	36·70	4·31	0·47	= 97·38	G.=3·344
4. " *brown,*	37·56	11·61	7·29	36·45	5·33	—	= 98·24	G.=3.385
5. Dognazka,	37·15	15·52	4·85	36·77	5·42	0·35	=100·06	G.=3·378
6. Haslau, near Eger,	39·52	13·31	8·04	35·02	1·54	1·32	= 98·75	G.=3·411
7. Egg near Christiansand,	37·20	13·30	8·42	34·48	4·22	0·31	$\ddot{\text{Ti}}$ 1·51=99·44	G.=3·436
8. Eger,	37·88	14·48	7·45	34·28	4·30	—	$\dot{\text{Fe}}$ 0·45=98·89	G.=3·384
9. Sanford, Me.,	37·64	15·64	6·07	35·86	2·06	—	$\ddot{\text{Ti}}$ 2·40=99·67	G.=3·434
10. Wilui,	38·40	10·51	7·15	35·96	7·70	—	= 99·72	G.=3·415
11. Ala,	37·15	13·44	6·47	37·41	2·87	0·93	= 98·27	G.=3·407

The oxygen ratios afforded for the $\dot{\text{R}}$, $\dddot{\text{R}}$, $\dddot{\text{Si}}$, are given by Rammelsberg as follows. (1) 1·3 : 1 : 2·1; (2) 1·5 : 1 : 2·5; (3) 1·5 : 1 : 2·5; (4) 1·6 : 1 : 2·5; (5) 1·5 : 1 : 2·2; (6) 1·3 : 1 : 2·4; (7) 1·4 : 1 : 2·4; (8) 1·3 : 1 : 2·2; (9) 1·3 : 1 : 2·3; (10) 1·9 : 1 : 2·8; (11) 1·5 : 1 : 2·3. Whence he deduces that 1·5 : 1 : 2·5 is the true ratio, [or adding the protoxyds and peroxyds 2·5 : 2·5=1 : 1]. Rammelsberg also shows that by regarding the iron as oxyd or partly so, the analyses of Magnus and Varrentrapp afford the same ratio nearly. Formula hence deduced, $3\dot{\text{R}}^3\dddot{\text{Si}}+2\dddot{\text{R}}\,\dddot{\text{Si}}$.

Analysis by J. W. Mallet (Am. J. Sci., [2], xx, 85):

$\dddot{\text{Si}}$ 38·32 $\dddot{\text{Al}}$ 25·68 $\dot{\text{Fe}}$ 8·13 $\dot{\text{Ca}}$ 25·29 $\dot{\text{Mg}}$ 0·39 Cop. pyrites 1·91 = 99·79

The copper may possibly be present as oxyd instead of sulphuret. Loc. Ducktown, Tennessee. G.=3·359. Form of crystals *O*, 1, *I*, 1*i*, *ii*. Nearly colorless.

Scheerer has also analyzed different Idocrases, as follows (Pogg. xcv, 520):

	$\dddot{\text{Si}}$	$\dddot{\text{Al}}$	$\dddot{\text{Fe}}$	$\dot{\text{Mn}}$	$\dot{\text{Ca}}$	$\dot{\text{Mg}}$	$\dot{\text{H}}$	H Cl	
1. Ala,	37·35	11·85	9·23	*tr.*	32·70	6·03	2·73	0·015	= 99·90
2. Vesuvius,	37·80	12·11	9·36	*tr.*	32·11	7·11	1·67	undet.	=100·16
3. Eger, *bnh-gn,*	37·73	13·49	5·95	0·47	37·49	1·98	1·89	undet.	$\dot{\text{Fe}}$ 0·95= 99·95

Mean oxygen ratio, for $\dot{\text{H}}$, $\dot{\text{R}}$, $\dddot{\text{R}}$, $\dddot{\text{Si}}$, is 1·86 : 11·86 : 8·28 : 19·53. [Excluding the water, the oxygen ratio for $\dot{\text{R}}+\dddot{\text{R}}$ and $\dddot{\text{Si}}$ is very nearly 1 : 1. Taking 566·25 as the equivalent of Silica, the ratio becomes 1·86 : 11·86 : 8·28 : 19·93, which is still nearer 1 : 1.—J. D. D.].

Scheerer makes out, by his polymerous isomorphism the augitic formula $(\dot{\text{R}})^3\,[\dddot{\text{Si}}]^2$.

The percentage of water in Idocrase has been determined as follows by G. Magnus (Pogg., xcvi, 347):—

	Water.	$\ddot{\text{C}}$		Water.	$\ddot{\text{C}}$
1. Slatoust,	2·44	0·15	3. Vesuvius, green,	0·29	undet.
2. Ala,	2·98	undet.	4. " brown,	1·79	0·06

Another specimen of the last gave for $\dot{\text{H}}$ 2·03.

The loss by strong ignition for several Idocrases was as follows:

Slatoust, 2·68, 2·10 p. c.; Bannat, 2·41, 2·41; Wilui, 0·73; Egg, near Christiansand, 2·21, 2·19; Vesuvius, green, 2·80; ib. brown, 2·33, 2·15; Ala, 3·10.

Garnet on the contrary affords only a trace of water. Grossular from Wilui, 0·12; Almandine of Slatoust, 0·00; Red Cinnamon Stone, 0·25, 0·34.

On the crystallographic structure of idocrase as shown by subjection to fluohydric acid by Leydolt, Akad. Wiss. Wien, May, 1855.

Locality at Fahlun in talcose slate, Kenngott, Min. Not., No. 16.

IRIDIUM [p. 13].—The gold of California is well known to be associated with Iridium. Traces of it have remained in the coin of the Philadelphia mint. In a paper by H. Dubois (cited in Ann. d. Mines, [5], vi, 518, 1854), it is stated that the coin had undergone in England a depreciation of four pence per ounce on account of the iridium; and much difficulty had been encountered in using it for jewelry, on account of the hard points, some grains of iridium present in the gold weighing even 40 milligrams. Mr. Dubois proposes effecting the separation by making an alloy of gold with silver, as usual, and then allowing it to stand melted 15 minutes; the iridium, whose specific gravity is 19, will settle to the bottom in an alloy of 12 or 13. A repetition of the process a few times will remove the whole. 20,000 ounces of California gold have thus afforded 21 ounces of iridium.

JAULINGITE, *Zepharovich.* Akad. Wiss. Wien, May, 1855.—Announced as a new mineral resin from the lignite of Jauling. It is in rounded masses in the trunk of a species of pine imbedded in a bed of lignite two feet thick. According to M. Ragsky, the resin consists of two kinds of resins distinct in composition and other particulars.

JUNKERITE [p. 446].—Kenngott confirms the conclusion that Junkerite is Spathic Iron. (Min. Not., No. 14.)

KYANITE [p. 263].—Analysis of Kyanite from Wermland, by J. Igelström: (J. f. pr. Chem., lxiv, 61, from Oefv. Ak. Förh., 1854, p, 66):

$\ddot{S}i$ 40·02, $\bar{\bar{A}}l$ 58·46, $\bar{\bar{F}}e$ 2·04. G.=3·48.

LAZULITE [p. 404].—Analysis of Lazulite occurring with Svanbergite (see beyond), by Igelström (loc. cit.):

$\dddot{\bar{P}}$	$\bar{\bar{A}}l$	$\dot{M}g$	$\dot{C}a$	$\dot{F}e$	$\dot{M}n$	$\dot{\bar{H}}$
42·52	32·86	8·58	*tr.*	10·55	*tr.*	5·30=99·81.

Streak and powder blue. G.=2·78.

LEUCOPHANE [p. 182].—R. P. Greg, Esq., in Phil. Mag. for July, 1855, p. 510, describes and figures a large crystal of Leucophane. Calling O the basal plane, I, I', the left and right lateral planes of the prism, $O:I$ or I' is 90°, $I:I'$ 90°—93° (91° 3′, Brooke and Miller). There is also a plane d on the left basal edge, e on the right, and f on an angle between; $O:d$=118° 30′, $I:d$=154°, $O:e$=117°, $I':e$=151°, $O:f$=126°—126° 25′, $I:f$=124°, $I':f$=128° 30′. There is also another plane g $(m-n)$ on the angle between O and I', giving $O:g$=140° 30′, $I':g$=126° 30′, $I:g$=101° 30′. Descloizeaux has shown that the crystal gives two systems of rings, when examined with polarized light perpendicular to O, exactly like topaz. Like topaz it also has cleavage parallel to O, but also two other cleavages, one parallel to f, and another to the vertical diagonal plane in the same zone; the cleavages O and f are inclined at 126°, and O and the diagonal at 90°.

[As the prism is right, $O:d$ and $I:d$ should together make 270°, and so also $O:e$ and $I':e$. A discrepancy above of 2° to 2½°, shows the allowance which is to be made for imperfect measurements on account of want of smoothness in the planes. Admitting this, we may regard the prism as a trimetric rhombic prism, with $I:I'$ about 91°. d, e, will then be planes of the same octahedron, and f, a macrodome. The form is hence near Andalusite or Æschynite. If d, e, are the octahedron 2, $O:2$=118° (nearly), $O:2\bar{\imath}$=126° 25′, $I:I$=91°. $O:1\bar{\imath}$ by calculation is 145° 52′, while it is 144° 33′ in Andalusite, 145° 58′ in Æschynite, and in Natrolite 144° 23′. $O:2$, by calculation 117° 49′. The plane g $(m-n)$ appears to be hemihedral; but the other on the same angle may be suppressed only by distortion, not by true hemihedrism. The cleavages O, f, and the diagonal, are the same as cited in the Mineralogy; the angle 126° 25′ being the supplement nearly of 53¼, and 36¾ the supplement of the inclination of f on the diagonal plane (ii).—J. D. D.]

LIMONITE [p. 131].—Analysis of ore from near the mouth of Niangua, Missouri, by Dr. Litton (Rep. Geol. Mo., 1855), $\bar{\bar{F}}e$ 83·27, $\dot{\bar{H}}$ 11·11, $\bar{\bar{A}}l$ 1·08, $\ddot{S}i$ 4·36. From half a mile west of Warsaw (ib.) $\bar{\bar{F}}e$ 88·85, $\dot{\bar{H}}$ 10·01, $\bar{\bar{A}}l$ 0·87, $\ddot{S}i$ 2·11, S 1·05=102·89. From near Buffalo (ib.) $\bar{\bar{F}}e$ 84·80, $\dot{\bar{H}}$ 11·62, $\bar{\bar{A}}l$ 0·64, $\ddot{S}i$ 2·88, S 0·12=100·06.

Loc. in California, Am. J. Sci., [2], xx, 81; Phœnixville, Pa., ib., xx, 250.

MAGNESITE [p. 441].—Bolton, Lower Canada, T. S. Hunt, Am. J. Sci., xix, 429.

MAGNETITE [p. 405].—Loc. in California. Am. J. Sci. [2], xx, 82.

MALACHITE [p. 458].—Analysis of malachite from Phœnixville, J. L. Smith, Am. J. Sci. [2], xx, 249.

MANGANESE ORE in the Jura.—A. Müller, Verh. Nat. Gessellsch. in Basel, 1844, 95.

MANGANESE SPAR, see *Rhodonite*.

MARCYLITE, *C. U. Shepard.*—A species instituted on a mass rather more than an ounce in weight, looking like black copper, from the south part of the Red River near the Witchita Mountains. H.=3. G.=4–4·1. BB. in small fragments fuses in the flame of a candle, giving it a rich blue and green color, which is still more distinct with the blowpipe; chlorid of copper is volatilized and spreads over the charcoal support; pure copper finally obtained. Powdered mineral almost wholly dissolved in ammonia, giving out muriatic acid. Contains copper 54·30, oxygen and chlorine 36·20, water 9·50=100.—Marcy's Expl. Red River, 8vo, p. 135. Washington, 1854.

A black copper from the same region afforded copper with traces of iron 35·30 (to 40·00), silica 30·60, oxygen and water 34·10=100. (Ib.)

MEIONITE [p. 200].—Measurements of crystals from Vesuvius by Rammelsberg (Pogg., xciv, 434); 1 : 1 over summit 116° 12′, giving for basal angle 63° 48′ and for pyramidal angle 136° 8′; the last by observation, 136° 12′.

Measurements by Kokscharov (Min. Russl., ii, 105) 1 : 1=136° 11′ or 136° 10′—136° 11½. *Mizzonite* affords 1 : 1=135° 58′.

MELANCHYME, *Haidinger.*—A bitumen-like substance of earthy fracture occurring according to Reuss, at Zweufelsreuth in the district of Eger. Kenngott's Min. Forsch., for 1853, p. 134.

MELLITE [p. 475].—Dauber's measurements of mellite from Artern afforded (Pogg. xciv, 410), for the pyramid 118° 14′, whence $a:c=1{\cdot}34:1$: Kupffer obtained 118° 13¼′, Kenngott, 118° 16′, G. Rose, 118° 14⅓′, Breithaupt, 118° 16⅓, Phillips, 118° 17′.

MICA [p. 217].—Von Kokscharov has measured the biaxial mica of Vesuvius and sustains the conclusion (Min. Russl., p. 126, Pogg. xciv, 212), that it is monoclinic. He obtained as a mean of his results, $I:I$=120° 45′, $O:I$=98° 38′, $O:1$=106° 54′, 1 : 1=122° 50′, I : 1=154° 29′, $I:ii$=119° 38′, $O:\frac{4}{3}i$=114° 29′, $ii:\frac{4}{3}i$=155° 31′. $a:b:c=1{\cdot}64656:1:0{\cdot}57735$. C, or inclination of vertical axis=30°.

Leydolt has described a *Muscovite* containing crystals of biotite (or rhombohedral mica) in regular positions, the plane of composition being a rhombohedron R^n and a pyramid. He also shows that the striæ and lines and the transverse cleavage, producing what is called prismatic mica, is due to the intercalation of thin plates of mica.

Refraction of mica (muscovite) according to Haidinger, for extraordinary ray, 1·581, for ordinary, 1·613.—Sitz. Wien., xiv, 330.

S. Haughton refers to *Margarodite*, which he sustains as a good species, micas from Ireland, analyzed with the following results (Phil. Mag. [4], ix, 272):

	$\dddot{\text{Si}}$	$\overline{\text{Al}}$	$\overline{\text{Fe}}$	$\dot{\text{Ca}}$	$\dot{\text{Mg}}$	$\dot{\text{K}}$	$\dot{\text{Na}}$	ign.
1. Dublin Co.	43·47	31·42	4·79	1·38	1·13	10·71	1·44	5·43 = 99·77
2. Wicklow Co.	44·71	31·13	4·69	1·09	0·90	9·91	1·27	6·22 = 99·92
3. Carlow Co.	44·64	30·18	6·35	—	0·72	12·40	*tr.*	5·32 = 90·61
4. (mean)	44·27	30·91	5·27	0·82	0·92	11·01	0·90	6·66

Oxygen ratio for $\dot{R}$, $\overline{R}$, $\dddot{Si}$, $\dot{H}$, deduced for No. 1, 1·13 : 6·00 : 8·59 : 1·80; for No. 2, 1 : 6 : 8·97 : 2·083; for No. 3, 0·9 : 6·0 : 8·74 : 1·77; for the mean, 1·01 : 6 : 8·66 : 1·89. The author adopts the mean ratio 1 : 6 : 9 : 2, and deduces the formula $\dot{R}\,\dddot{Si}+2\overline{R}\,\dddot{Si}+2\dot{H}$. The angle between the optic axes is for No. 1, 53° 8′; for 2, 70° 4′; for 3, 72° 18′.

[The oxygen ratio for $\dot{R}+\overline{R}$ and $\dddot{Si}$ is 1 : 1·20 in No. 1; and 1 : 1·27 in Nos. 2 and 3.—D.]

MILLERITE [p. 49].—In the Millerite of Joachimstahl, Kenngott observes (Min. Not., No. 14) that the planes of the fundamental hexagonal prism and the one intermediate are distinct.

On some needles of Millerite he found small green rhombohedral crystals giving the angle $R : R = 105° \; 15'$, which were too few for analysis, but may have been a calcite containing a carbonate of nickel.

Mimetene [p. 401].—Analyses, etc., Phœnixville, Pa., J. L. Smith, xx, 248.

Mispickel [p. 62].—Analyses of Mispickel of Copiapo, by J. L. Smith (Gilliss's Exped., ii, 102): S 20·25, As 44·30, Fe 30·21, Co 5·84 = 100·60.

Mispickel pseudomorphous after Pyrrhotine has been observed by Kenngott, in specimens from Freiberg in Saxony (Min. Not., No. 14).

Molybdate of Iron (?) [p. 144].—Locality in Heard Co., Georgia, Am. J. Sci. [2], xix, 429.

MORENOSITE, *A. Casares.*—A nickel vitriol occurring in Spain (Hartm. Zeit. vii, 37, and Kenngott's Min. Forsch. for 1853, 16), in needles or thin prisms. Soluble in water, solution green. Reactions indicate $\dot{N}i$, $\dddot{S}$, (and also $\dot{H}$?) with mixed $\dot{C}u$ and $\dot{F}e$.

Naphtha [p. 469].—On some of the basic constituents of coal Naphtha, by C. Greville Williams, Edinb. N. Phil. J. [2], ii, 324.

Native Iron [p. 17].—The supposed Native Iron of Canaan, Ct., has been analyzed by Dr. A. A. Hayes of Boston, and proved thus to be a furnace product. It contains carbon and affords full evidence that it has been artificially reduced from iron ore.

Dr. Hayes has examined masses of iron purporting to be native, from Liberia, Africa, and finds them absolutely pure from carbon, unlike any artificial iron, and moreover particles of quartz are disseminated through it; and the evidence from these sources and also from the reports that come from Liberia through Americans resident there, appears to be conclusive that the iron is native. The structure of the iron is massive with only very minute crystalline grains. Analysis afforded, pure iron 98·40, quartz grains, magnetic oxyd of iron, and zeolite 1·60 = 100·00. The locality is in the hill country above Bexley, Bassa county, Liberia. It probably occurs in large deposits.

Nepheline [p. 232].—Mt. Somma crystals afforded v. Kokscharov, (Min. Russl., ii, 160), $1:1 = 139° \; 17'$, $I:1 = 134° \; 5\frac{1}{4}'$, $O:1 = 135° \; 54\frac{3}{4}'$. Breithaupt obtained for $I:1$, $134° \; 5'$; Haidinger, $134° \; 3'$; Scacchi, $133° \; 57\frac{1}{2}'$.

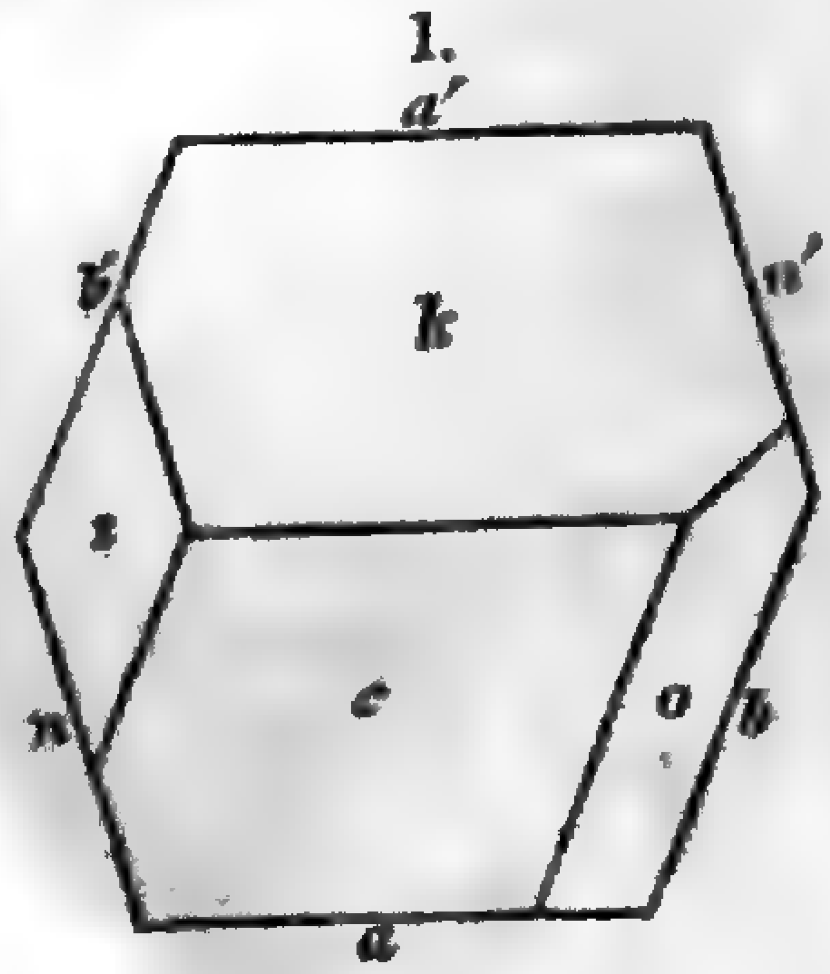
Okenite [p. 306].—Mean of two analyses by C. v. Hauer, (Jahrb. geol. Reichs., 1854, 190, Wien): $\dddot{S}i$ 54·81, $\dot{C}a$ 27·23, $\dot{M}g$ *tr.*, $\dot{H}$ 18·04 = 100·08, giving the received formula $\dot{C}a^3 \, \dddot{S}i^4 + 6\dot{H}$.

Ostranite [p. 196].—Kenngott confirms (Min. Not. No. 15), by a crystallographic examination, the identity of Ostranite with Zircon. The Ostranite is from Brevig, in Norway.

Paraffine (native).—Hofstädter, in J. f. pr. Chem., lxiii, 410).

Paisbergite [p. 168).—H. Dauber (Pogg. xciv, 398), describes this mineral as occurring in transparent shining crystals with garnet and chlorite. Crystallization triclinic, the prism affording, the angles $a : \breve{b} = 111° \; 8\frac{1}{2}'$, $a : \breve{c} = 93° \; 28\frac{1}{2}'$, $b : c = 87° \; 38'$; and $a : b : c = 1·8291 : 1·1579 : 1$. Cleavage parallel to $\breve{b}$ and c, nearly equally perfect.

1.



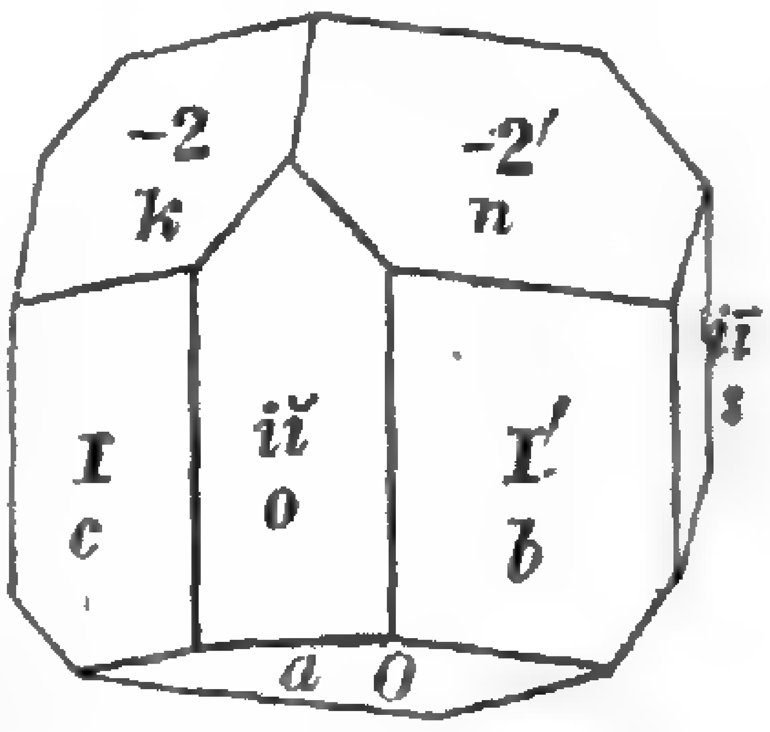
Angles	*a c* = 93° 28½′,	*a′k* 117° 45½′,	*c k* 148° 47½′,	*a b* 111° 8½′
	a n 106° 8½′,	*b n′* 142° 39½′,	*b c* 87° 38′,	*b′c* 92° 22′
	o c 136° 8½′,	*o b* 131° 27′	*s c* 138° 11½′,	*s b′* 134° 0½′
	n c 94° 36′,	*n′c* 85° 24′	*k b′* 102° 58′	*k s* 139° 43′
	n s 126° 11′,	*k o* 118° 58′	*a o* 107° 16′	*k b* 76° 59′

A silicate of manganese from Longbanshytta, Sweden, and Przibram, Bohemia, and the *Fowlerite*, present according to Dauber, a similar form to that of the Paisbergite ; the following are the angles he has obtained :

1 Longbanshytta,	$a\,b$=111° 6′	$a\,c$=93° 15′	$b\,c$=87° 18′
2. Przibram,	111°–112°	94° 11′–92° 6′	87° 6′–87° 54′
3. Fowlerite,	111° 38′–112° 6′	92° 21′–93° 38′	86° 11′–88° 17′

These minerals therefore are all referred by Dauber to *Paisbergite.*

2.



[This is an important observation, by Dauber. The cleavage of Fowlerite confirms this determination. The species should properly be called *Fowlerite,* this being the earlier name.

M. Dauber recognizes the approximate similarity in the cleavage (parallel to b and c) to augite. But by the position he gives the crystals the further resemblance is not seen. The annexed figure shows this relation to be a close one, and exhibits the analogies between the monoclinic and triclinic forms. The lettering assists in a direct comparison of the forms (see Min. p. 159). The following angles show plainly the parallelism.

Paisbergite, Dauber.	*Augite.*	*Paisbergite.*	*Augite.*
$b\,c$ $(I:I')$ = 87° 38′	$I:I$ = 87° 5′	$b\,s$ $(I':\breve{i}\breve{i})$=134° ½′	$I:ii$=136° 27½′
$c\,k$ $(I:-2)$=148° 47′	$I:-2$=144° 35′	$c\,s$ $(I:\breve{i}\breve{i})$=138° 11½′	$I:ii$=136° 27½′
$b\,u$ $(I':-2')$=142° 39½′	$I:-2$=144° 35′	$o\,a$ $(\breve{i}\breve{i}:O)$=107° 16′	$ii:O$=106° 1′
$c\,o$ $(I:\breve{i}\breve{i})$ =136° 8½′	$I:ii$ =133° 32½′	$b\,a$ $(I':O)$=111° 8½′	$I:O$=100° 57′
$b\,o$ $(I':\breve{i}\breve{i})$=131° 27′	$I:ii$ =133° 32½′	$c\,a$ $(I:O)$= 93° 28½′	$I:O$=100° 57′

J. D. D.]

Pectolite [p. 305].—In a paper by M. F. Heddle and R. P. Greg, Esq., (Phil. Mag. [4], ix, 248), we learn that Thomson's "Stellite" is undoubtedly pectolite, as well also as his "Wollastonite" from Kilsyth, the mineral from Costorphine Hill analyzed by Walker, the "Wollastonite" from the Castle Rock of Edinburgh analyzed by Kennedy. Other English localities are Talisker in Skye, Girvan and Knockdolian Hill in Ayrshire, and Ratho near Edinburgh. The Ratho mineral occurs with steatite, calcite, barytes, and as pseudomorphs after analcime. Analyses by Dr. Heddle, and others cited by him (loc. cit.):

	$\dddot{S}i$	$\dot{C}a$	$\dot{N}a$	$\dot{H}$	$\ddot{\bar{A}}l, \ddot{\bar{F}}e, \dot{M}g, \dot{K}$	
1. Kilsyth,	52·74	31·68	9·60	2·00	3·39	*Thomson.*
2. Costorphine Hills,	54·00	30·79	5·55	5·43	2·59 ($\dot{M}g$)	*Walker.*
3. Castle Rock,	51·50	32·00	8·50	5·00	1·00	*Kennedy.*
" "	53·06	33·48	9·98	3·13	0·75	*Heddle.*
5. Ratho, *fibrous,*	52·53	32·79	9·75	3·04	0·88 ($\ddot{\bar{A}}l$)	*Heddle.*
6. " *crystalline,*	52·58	33·75	9·26	2·80	1·46 "	*Heddle.*
7. Knockdalian Hill,	53·24	32·22	9·57	3·60	1·00 "	*Heddle.*
8. Talisker,	53·82	29·88	9·55	3·76	2·73	*Heddle.*
9. Girvan,	53·48	34·38	9·88	3·26	0·42	*Heddle.*
10. Bishoptown,	52·07	32·80	9·60	2·00	4·20	*Thomson.*
11. Bavaria, *Osmelite,*	52·91	32·96	6·10	4·01	0·86, $\dot{K}$ 2·79,	*Adam.*

Dr. Heddle deduces from the Ratho analyses, the oxygen ratio for $\dot{N}a$, $\dot{C}a$, $\dddot{S}i$, $\dot{H}$, 1 : 4¼ : 11 : 1, which he takes at 1 : 4 : 11 : 1 and writes the formula $3\dot{N}a\,\dddot{S}i + 4\dot{C}a^3\,\dddot{S}i^2 + 3\dot{H}$ =Silica 52·57, lime 34·95, soda 9·68, water 2·80=100. He reckons the $\ddot{\bar{A}}l$ with $\dot{C}a$.

The Ratho crystals are oblique 4-sided prisms, twinned sometimes parallel to a face of perfect cleavage c; of the other two faces u and y, u is a face of perfect cleavage, $c:u$=95° 23′, $c:y$=54° 05′, $y:u$=93° 30′.

[Recalculating the oxygen ratio, we obtain, taking for the equivalent of silica 577·31, 1 : 4·22 : 11·43 : 1·04 ; whence for $\dot{R}:\dddot{S}i$, 5·22 : 11·43=4 : 8·76, or near the hornblende ratio. Taking 566·25 as the equivalent of silica, we have for $\dot{R}:\dddot{S}i$, 5·22 : 11·65=4 : 8·93, which is still nearer 4 : 9. $\dot{R}^4\dddot{S}i^3+\dot{H}$ is hence as near the analyses as that deduced above, it corresponding (if $\dot{N}a$ to $\dot{C}a$=1 : 4 and $\dddot{S}i$=577·31,) to, Silica 52·9, lime 34·2, soda 9·5, water 3·4=100. The form approximates to that of Paisbergite.—In the Mineralogy, p. 306, 3d l. from top, for *alumina,* read *lime.*—J. D. D.]

Pennine [p. 295].—Haidinger has shown that the crystallization of Pennine is rhombohedral (Pogg., xcv, 620); he found for the refraction of the extraordinary ray 1·575, of the ordinary 1·576. Angle of the rhombohedron by measurement 67° 24′.

Perofskite [p. 345].—This mineral occurs in the valley of Zermatt, Switzerland, according to Damour (Ann. des Mines, [5], vi, 512). Color pale yellow, honey yellow, orange yellow, sometimes reddish brown; semi-transparent, and thin fragments sometimes transparent. Streak or powder, white. A druse of minute transparent cubes observed on one specimen. G.=4·037—4·039. H.=5·5. Attacked by hot muriatic acid and partially dissolved; not acted on by nitric acid; sulphuric acid at 300° C. decomposes it entirely, dissolving the titanic acid and forming sulphate of lime. Mean of two analyses: titanic acid 59·23, lime 39·92, protoxyd of iron 1·14 =100·29, affording the constitution $\dot{C}a\,\ddot{T}i$. The other minerals of this locality are garnet, idocrase, diopside, chlorite, ripidolite, serpentine, sphene, zircon, corundum, rutile, magnetic iron, titanic iron.

The planes of the crystals of Perofskite from the Urals, stated to be $\frac{3}{2}$-$\frac{3}{2}$ and $\frac{9}{4}$ are, according to Kokscharov (Min. Russl., 1854, i, 199), 2·2 and 3·3.

Phosphorchalcite [p. 425].—Aanalysis of Lunnite from Cornwall, by Dr. Heddle (Phil. Mag., [4], x, 39):

$\dddot{P}$ 22·73 $\quad\dot{C}u$ 68·13 $\quad\dot{H}$ 8·51 $\quad$ mixed quartz 0·48=99·85

consists of aggregated congeries of minute spheres; G.=4·25.

The presence of a trace of selenium in this ore from Rheinbreitenbach has been confirmed by Bödeker (Ann. d. Ch. u. Pharm., xciv, 356). He obtained one-sixth grm. from 50 grammes of the ore.

Plagionite (Min. 75).—A crystal from Wolfsberg, presenting the planes *O*, 2, *ii*, and another of *O*, 2, are figured by Kenngott (Min. Not., No. 16).

Platinum [p. 12].—Loc. at Pt. Orford, California. Am. J. Sci., [2], xx, 79.

Polyhalite [p. 377].—An analysis by Dr. G. Jenszch (in the laboratory of Prof. H. Rose), of a specimen that came from Berthier, and is now in the museum of the Berlin Academy, afforded, on calculating from the results (Pogg. xciv, 175):—

$\dot{C}a\,\dddot{S}$	$\dot{M}g\,\dddot{S}$	$\dot{K}\,\dddot{S}$	$\dot{N}a\,\dddot{S}$	Na Cl	$\ddot{S}i$	$\ddot{\overline{F}}e$	$\ddot{\overline{A}}l$	$\dot{M}g$	$\dot{H}$
44·11	19·78	25·87	1·69	0·24	0·11	1·01	0·39	0·02	6·16 =99·38,

proving that this dark red mineral from Vic is Polyhalite.

PREHNITOID, Blomstrand (Oefv. Akad. Förh., 1854, p. 296).—Massive and columnar. Pale green. Lustre vitreous. H.=7. G.=2·50. BB. fuses easily to a white enamel, acting like prehnite. Mean of 5 analyses:

	$\dddot{S}i$	$\ddot{\overline{A}}l$	$\dot{C}a$	$\dot{N}a$	$\dot{K}$	$\dot{M}g$	$\dot{F}e$	$\dot{M}n$	ign.
	56·00	22·45	7·79	10·07	0·46	0·36	1·01	0·18	1·04=99·36
Oxygen	29·08	10·49	2·21	2·58	0·08	0·14	0·22	0·05	

Oxygen ration for $\dot{R}$, $\ddot{\overline{R}}$, $\dddot{S}i$, 5·28 : 10·49 : 29·08=1 : 2 : 6=$3\dot{R}\,\dddot{S}i+\ddot{\overline{A}}l^2\dddot{S}i^3$.

[As the oxygen ratio of $\dot{R}$, $\ddot{\overline{R}}$ and $\dddot{S}i$ is 1 : 2, we may write in place of this improbable formula, (combining silicates of the ratios 1 : 3 and 6 : 9,) the augite formula $(\dot{R}^3,\ \ddot{\overline{R}})\,\dddot{S}i^2$, or more precisely $(\frac{1}{3}\dot{R}^3+\frac{2}{3}\ddot{\overline{R}})\,\dddot{S}i^2=\dot{R}^3\dddot{S}i^2+2\ddot{\overline{R}}\,\dddot{S}i^2$, in which it approaches spodumene, the oxygen ratio of the protoxyds and peroxyds in the latter being 1 : 4 instead of 1 : 2.—J. D. D.]

Prosopite [p. 502].—Composition and pseudomorphous character of crystals, G. J. Brush, Am. J. Sci., xx, 273.—Ibid., J. D. Dana, 274. The crystals examined consisted partly of kaolin and partly of fluor spar.

Scheerer in J. f. pr. Chem., lxiii, 450, endeavors to sustain his deduction respecting the analogies in the formulas of barytes and prosopite, notwithstanding the want of a complete analysis and a wide difference in the crystalline forms. As the formula of barytes is BaO, SO^3, so he writes for prosopite CaF, Al F^3, $\dot{H}$. The conclusion involves the extraordinary supposition that Al and S are isomorphous.

Pyromorphite [p. 400].—Loc. Phœnixville, Pa., Smith, Am. J. Sci., xx, 247.

PSEUDOPHITE, Kenngott, Min. Not., No. 17.—Has the appearance of serpentine. Compact with conchoidal fracture. Color grayish, olive or pistachio green; streak white; lustre weak. Feel somewhat greasy. H.=2·5. G.=2·75—2·77. BB. becomes white or yellow, but is infusible. In muriatic acid, imperfectly soluble and forming no jelly. Composition:

$\dddot{S}i$	$\dddot{\bar{A}}l$	$\dot{F}e$	$\dot{M}g$	$\dot{H}$
33·51	15·42	2·58	34·41	13·21 (of which 0·46 lost at 100° C.)

Affording the oxygen ratio for $\dot{H}$, $\dot{R}$, $\dddot{\bar{R}}$, $\dddot{S}i$, 9 : 12 : 6 : 15.

Pyroretin [1st Suppl.].—This resin is apparently identical with that described by Dr. Mallet under the name of *Scleretinite* (Phil. Mag., [4], iv, 261, and Min., 468). Excluding the ash of the latter, Dr. Mallet's first analysis afforded carbon 79·99, hydrogen 9·18, oxygen 11·11, and the second gives a similar result, and both the same formula with the pyroretin. (Mallet, in a letter to the Author.)

Pyroxene [p. 158].—Analysis of pyroxene from the Eiffel, and of a mica pseudomorph after the augite by Th. Kjerulf,

	$\dddot{S}i$	$\dddot{\bar{A}}l$	$\dot{F}e$	$\dot{C}a$	$\dot{M}g$	ign.
1. Augite,	50·21	6·94	7·59	19·85	13·66	0·33=98·58
2. Mica pseud.,	43·10	15·05	23·25	0·81	10·82	1·50, with

$\dot{K}$ 4·62, $\dot{N}a$ 0·82, and $\ddot{T}i$ 1·03 as impurity with the mica.]

A Diallage from Achmatowsk according to Hermann contains (Bull. Soc. Imp. Nat. Moscou, 1854, p. 273):

	$\dddot{S}i$	$\dddot{\bar{A}}l$	$\dot{F}e$	$\dot{C}a$	$\dot{M}g$	$\dot{H}$
	51·47	1·15	1·80	27·81	15·63	2·39
Oxygen	26·72	0·51	0·40	7·89	6·13	2·12

Form of crystal ∞, ∞-3, ∞-∞, 0, or in letters, *I*, *i*3, *ii*, *O*. Cleavage *ii* very perfect, with a sub-metallic inclined to vitreous lustre. H.=4·5. G.=3·21.

Analyses of *Hypersthene* from a Hypersthene rock of Silesia by G. von Rath (Pogg., xcv, 541):

	$\dddot{S}i$	$\dddot{\bar{A}}l$	$\dot{F}e$	$\dot{C}a$	$\dot{M}g$	ign.	
1. Black,	51·78	1·12	10·97	20·04	15·58	0·22=99·71.	G.=3·336
2. Dark gn.,	50·34	——	8·47	21·85	16·86	1·23=98·76.	G.=3·249
3. Dark gn.,	50·00	0·42	8·54	21·11	15·87	1·69=97·63.	G.=3·244

Oxygen ratio for $\dot{R}$ and $\dddot{S}i$ in No. 1, 1 : 1·87; in 2, 1 : 1·75; in 3, 1 : 1·85.

Von Rath observes that the earlier analyses of Diallage, given in Rammelsberg's Handwörterbuch, and another in the 2nd Supplement, conduct to the same ratio.

A Diallage from Gabbro, in Silesia, afforded $\dddot{S}i$ 53·60, $\dddot{\bar{A}}l$ 1·99, $\dot{F}e$ 8·95, $\dot{M}n$ 0·28, $\dot{C}a$ 21·06, $\dot{M}g$ 13·08, ign. 0·86=99·82, giving the oxygen ratio 13·46 : 0·93 : 27·85.

See further *Enstatite.*

On a serpentine-like pseudomorph of diopside, Kenngott, Min. Not., No. 17.

Pyrrhotine [p. 50].—Note on formula of pyrrhotine, T. S. Hunt. This Journal, [2], xix, 428.

Quartz [p. 145].—Density according to Deville before heating 2·663; after fusion 2·220, showing a diminution of 0·17. In a similar manner labradorite shows under the same circumstances a diminution of 0·06, orthoclase of 0·08, hornblende of 0·12, pyroxene of 0·14, iron chrysolite of 0·16. Corundum 4·022 before fusion, 3·992 after fusion.

Memoir on the crystallization of quartz, by M. Descloizeaux, Acad. Sci., May, 1855, a paper of great value, containing figures and descriptions of numerous new crystalline forms, etc. See a notice in this Jour., xx, 270.

Prof. F. Leydolt has published (Sitz. Wien, xv, 59) an important paper on the structure of quartz crystals as developed by the action of hydrofluoric acid, illustrated by plates and wood cuts.

On the tetartohedrism of quartz, Kenngott, Min. Not., No. 15.

Salt [p. 90].—Loc. in California, Am. J. Sci., [2], xx, 83.

Pseudomorphs in hopper-shaped crystals, &c., Nöggerath, Verh. nat. Ver., Bonn, 1854, p. 385.

Sarcolite [p. 200].—Measurements by Kokscharov (Min. Russl., ii, 110), *O* : 2= 128° 38′. *O* : 2*i*=138° 30′.

SAUSSURITE [p. 254].—According to von Rath (Pogg., xcv, 555) the Saussurite from the greenstone of Neurode in Silesia, has the cleavage, hardness, and tabular twins of Labradorite; color mostly porcelain white. G. in powder, 2·998, in small fragments 2·991.

	$\dddot{Si}$	$\bar{\bar{Al}}$	$\bar{\bar{Fe}}$	$\dot{Ca}$	$\dot{Mg}$	$\dot{K}$	$\dot{Na}$	ign.
	50·84	26·00	2·73	14·95	0·22	0·61	4·68	1·21 = 101·24
Oxygen	26·42	12·14	0·82	4·26	0·09	0·10	1·21	

Forms with hornblende (uralite) the greenstone of Neurode; see hornblende above.

SCAPOLITE [p. 201].—Kokscharov makes $O:1$ in scapolite 148° 10′, 1 : 1=136° 11′. (Min. Russl., ii, 82.) Se farther, *Meionite.*

In Am. J. Sci., [2], xix, 428, and Phil. Mag., [4], ix, 382, Mr. T. S. Hunt gives some results, and aims to show that *Wilsonite* is a distinct species.

In Am. J. Sci., [2], xx, 269, a reëxamination of *Wilsonite,* by E. J. Chapman, showing that its crystallization and other characters are those of Scapolite.

SCHEERERITE [p. 471].—Crystallization according to Kenngott (Min. Not., No. 15) of the Scheererite of Uznach in Switzerland, monoclinic; crystals very small, thin, and slender prismatic, having a hemipyramid in front and a hemidome behind at the extremity. Front edge of prism on face of hemidome 101° 30′; on edge of hemipyramid 123° 30′.

SCLERETINITE.—See *Pyroretin.*

SERPENTINE [p. 282].—Analyses by S. Haughton (Phil. Mag., [4], x, 253) of the serpentine (1.) of Cornwall called serpentine porphyry, the red earth base being taken: (2.) of Galway; (3.) of Zermatt, Switzerland; (4.) of Syria:

	$\dddot{Si}$	$\bar{\bar{Al}}$	$\dot{Fe}$	$\dot{Mg}$	$\dot{H}$	$\ddot{C}$
1.	38·29	——	13·50	34·24	12·09	—— = 98·12
2.	40·12	*tr.*	3·47	40·04	13·36	2·00 = 98·99
3.	42·88	——	3·80	40·52	12·64	—— = 99·84
4.	41·24	——	7·41	36·28	14·16	—— = 99·09

A so-called soapstone from Cornwall, afforded Mr. Haughton (loc. cit.), $\dddot{Si}$ 42·47—42·10, $\bar{\bar{Al}}$ 6·65—7·67, $\dot{Mg}$ 28·83—30·57, $\dot{H}$ 19·37—18·46. Oxygen ratio deduced for $\dot{R}$, $\bar{\bar{R}}$, $\dddot{Si}$, $\dot{H}$, 1 : 0·27 : 1·92 : 1·49 and 1 : 0·27 : 1·8 : 1·34.

SILVER ORES.—Ores of Chili, J. L. Smith in Gilliss's Exped., ii, 94.

SMALTINE [p. 56].—Analysis of specimen from Atacama by J. L. Smith (Gilliss's Exped., ii, 102):

As 70·85 Co 24·13 Fe 4·05 Cu 8·41 Ni 1·23 S 0·08=100·75.

Kenngott has observed cubic crystals of Smaltine, whose faces were convex and presented distinct traces of planes of a tetrahexahedron (Min. Not., No. 14, Sitz, Wien, xiii, 462).

SODALITE [p. 229].—Loc. in Russia, Kokscharov (Min. Russl., i, 224).

SORDAWALITE [p. 177].—Analysis by Wandesleben (N. Jahrb. Pharm., i, 33, in Lieb. u. Kopp., 1854, 842):

$\dddot{Si}$ 47·70 $\bar{\bar{Al}}$ 16·65 $\bar{\bar{Fe}}$ 21·32 $\dot{Mg}$ 10·21 $\dddot{\dddot{P}}$ 2·26=98·14

SPINEL [p. 103].—Loc. in Russia, Kokscharov (Min. Russl., i, 211).

STEPHANITE [p. 86].—Crystallization of Stephanite by F. H. Schrœder (Pogg., xcv, 257). An elaborate paper describing many new forms, simple and compound, giving a large number of angles. The following are the simple forms: O, $i\breve{i}$, $8\breve{i}$, $\frac{15}{2}\breve{i}$, $7\breve{i}$, $4\breve{i}$, $2\breve{i}$, $1\breve{i}$, $\frac{2}{3}\breve{i}$, $i\breve{11}$, $\frac{22}{7}\breve{11}$, $3\breve{9}$, $\frac{7}{2}\breve{7}$, $15\text{-}\breve{5}$, $\frac{5}{2}\breve{5}$, $1\breve{5}$, $8\breve{4}$, $i\breve{3}$, $\frac{3}{2}\breve{3}$, $1\breve{3}$, $\frac{3}{4}\breve{3}$, $4\breve{2}$, $\frac{4}{3}\breve{2}$, $\frac{13}{3}\frac{\breve{13}}{7}$, $5\frac{\breve{5}}{3}$, $\frac{5}{2}\frac{\breve{5}}{3}$, $6\frac{\breve{3}}{2}$, I, 1, $\frac{2}{3}$, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $i\bar{3}$, $3\bar{3}$, $\frac{3}{2}\bar{3}$, $i\bar{i}$, $1\bar{i}$.—The angle $I:I=$ 115° 39′, $O:1$=127° 51′.

SULPHUR [p. 22].—Loc. in California, Am. J. Sci., [2], xx, 84.

SVANBERGITE.—Announced as a new mineral by Igelström (Oefv. Ak. Förh., 1854, p. 156, and J. f. pr. Chem., lxiv, 252). Occurs in Wermland, in a gangue with kyanite, pyrophyllite, mica, quartz, and iron glance. Crystallization monoclinic, semitransparent. Cleavage distinct and parallel to the base. Color, and color of powder, pale red. G.=3·30. H.=5. Composition according to Igelström:

$\dddot{\bar{S}}$	$\bar{\ddot{P}}$	$\dddot{\bar{Al}}$	$\dot{Ca}$	$\dot{Fe}$	$\dot{Na}$	$\dot{\bar{H}}$	Cl
17·32	17·80	37·84	6·00	1·40	12·84	6·80	*tr.*

BB. on coal fuses only on the thinnest edges: a red hepatic mass with soda in the reduction flame, which becomes green with water, and with dilute acid develops sulphuretted hydrogen. In borax easily soluble to an iron-colored glass. With salt of phosphorus a colorless glass. With cobalt solution fine blue.

Sylvine [p. 90].—The occurrence of pure chlorid of potash at Vesuvius with remarks, A. Müller, Verh. Nat. Gesselsch. in Basel, 1854, 113. It is without a trace of lime, magnesia, and alumina and contains only a trace of soda.

Tannerite [p. 73].—This species is named *Emplektite* by Kenngott in his Min. Forsch. for 1853, published in 1855.

TAURISCITE, *Volger.* A new iron-vitriol. Description by G. H. O. Volger (Leonh. u. Bronn. Jahrb., 1855, p. 152). Trimetric. In slender white or glassy prisms; form near that of epsomite. Occurring planes, $\infty\text{-}\breve{\infty}$, $1\text{-}\breve{\infty}$, $\infty\text{-}\breve{2}$, $2\text{-}\breve{2}$, ∞, 2, 1, $2\text{-}\bar{2}$, $\infty\text{-}\bar{\infty}$, $1\text{-}\bar{\infty}$, or in letters, $i\breve{\imath}$, $1\breve{\imath}$, $i\breve{2}$, $2\breve{2}$, I, 2, 1, $2\bar{2}$, $i\bar{\imath}$, $1\bar{\imath}$. Formed along with Melanterite from the decomposition of pyrites, in the Windgalle, St. Gothard.

Tennantite [p. 84].—A mineral probably tennantite at Lancaster, Pa., W. J. Taylor, in Am. J. Sci., xx, 412.

Tetrahedrite [p. 82].—Analysis of a Tetrahedrite, containing quicksilver, by G. von Rath (Pogg., xcvi, 322).

	S	As	Bi	Sb	Cu	Pb	Zn	Fe	Hg
1.	22·54	3·18	0·96	18·56	35·42	(0·21)	0·64	0·80	17·27 = 99·58
2.	22·11	3·13	0·66	19·54	34·83	0·21	0·75	0·99	(17·27)= 99·51
3.	22·94	2·50	(0·96)	19·93	35·76	(0·21)	0·67	0·81	(17·27)=101·05

Sulphur of arsenic, bismuth and antimony, to sulphur of other metals, as, (1), 2·95 : 4; (2), 3·04 : 4; (3), 2·95 : 4. Formula $4MS+(Sb, As, Bi)^2S^3$, in which $\dot{C}u$ is to the sum of the other basic metals as 2·5 : 1.

Specimen a crystal weighing about 13 grammes. G.=5·070, or in powder 5·356. Color light steel gray.

Von Rath also reviews the earlier analyses.

Analysis of Tetrahedrite of Freiberg, Saxony, by J. Wandesleben (N. Jahrb. Pharm., ii, 105, and Lieb. u. Kopp, 1854, 814). S 27·27, Sb 17·40, As 2·40, Cu 42·02, Fe 8·41, Zn 1·89, Ag 0·06=99·45.

Analysis of the ore from Chile by J. L. Smith (Gilliss's Exped., ii, 91): S 26·83, Sb 23·21, As 3·05, Cu 36·02, Fe 2·36, Zn 4·52, Ag 3·41=99·40.

The ore from Coquimbo analyzed by F. Field has been named *Fieldite* by Kenngott, Min. Forsch., for 1853, p. 126.

Titanic Iron [p. 115].—Analysis of ore from Wermland, by J. Igelström (J. f. pr. Chem., lxiv, 62). $\dddot{T}i$ 15·76, $\dddot{F}e$ 84·24. Occurs in quartz rock in small grains.

Tombazite.—According to Kenngott (Min. Not., No. 14), Trombazite from Lobenstein is much like Nickeline, or nickel green, having a greenish color and giving out arsenous acid before the blowpipe in a glass tube, with no sulphur; and on charcoal it acts like nickeline.

Tourmaline [p. 270].—Kenngott describes a compound crystal of Tourmaline from Brazil, which consists of an interior triangular prism with replaced edges (∞P) enclosed by the hexagonal prism ∞P2, only on three edges of which occur the planes ∞P.

Loc. of tourmaline in California, Am. J. Sci., [2], xx, 84.

Zeuxite is referred to this species by R. P. Greg (Phil. Mag., [4], x, 118).

Vanadate of Lead [p. 362].—Analysis of vanadate from Phœnixville, Pa., J. L. Smith, xx, 246.

Vosgite, see *Feldspar.*

Websterite or Aluminite [p. 389].—The so-called paraluminite, according to Kenngott, is nothing but aluminite (Min. Not., No. 16).

WILSONITE, see *Scapolite.*

WÖLCHITE [p. 82].—The Wölchite from St. Gestrand, occurs according to Kenngott (Min. Not., No. 14) in trimetric prisms, affording the planes, ∞, ∞-$\breve{\infty}$, m-$\breve{\infty}$, m'-∞, O, or in letters I, $i\breve{\imath}$, $m\breve{\imath}$, $m'\bar{\imath}$, O. $I:I$=93° 30′, $O:m\breve{\imath}$=146½°, $O:m'\bar{\imath}$=141° approximately. G.=5·828. The form is near that of Bournonite, but the composition appears to be different. Analysis by Schrotter, recalculated by Kenngott.

S	As	Sb	Cu	Pb	Fe
28·47	6·04	16·65	17·35	29·93	1·35=99·79

corresponding to 17·8 sulphur, 0·8 As^2, 1·3 Sb^2, 2·7 €u, 2·9 Pb, 0·5 Fe, or 17·8 S, 2·1 As^2+Sb^2, 6·1 €u+Pb+Fe. Kenngott takes the ratio as at 8S : 1 (As^2, Sb^3,) : 3(€u, Fe, Pb). It is more nearly 9 : 1 : 3; but the mineral requires a new investigation.

WOLFRAM [p. 351].—The analysis, Suppl. I, p. 18 (this Jour., vol. xix, p. 370) is by Petzold in a notice by Schneider.

WOLLASTONITE [p. 156].—Analysis of Wollastonite from the Morne Mts., by Mr. F. Heddle (Phil. Mag., [4], ix, 452):

	$\dddot{Si}$	$\dddot{F}e$	$\dot{C}a$	$\dot{M}g$	$\dot{H}$	$\ddot{C}$
1.	51·36	0·98	42·50	0·48	1·48	*undet.*
2.	50·43	0·84	43·92	0·40	1·36	2·37 =99·32

The mineral contains a little mixed carbonate of lime.

WULFENITE [p. 349].—Analysis and crystal of Wulfenite from Phœnixville, Pa., J. L. Smith, xx, 245.

XENOTIME [p. 401].—Twin of Xenotime with Malacone, Zschau, Am. J. Sci., xx, 273.

ZAMTITE, *A. Casares.*—Supposed to be a hydrous carbonate of nickel, but not yet analyzed. Resembles the emerald nickel, and is from Spain. Color dull emerald-green. Not crystallized. May be scratched with a knife. Powder apple-green. Lustre waxy, or somewhat vitreous. BB. blackens but does not fuse; with soda and a little borax affords a metallic globule of a dull yellow color; which is magnetic and has the properties of nickel. In a tube yields water. Kenngott's Min. Forsch. for 1853, p. 22. [See Min., p. 457.—D.]

ZEUXITE [p. 270].—See Tourmaline.

ZINCITE (or RED ZINC ORE) [p. 110].—Isomorphism with Greenockite, Kenngott, Min. Not., No. 17.

ART. XXV.—*On a new locality of Meteoric Iron, in the Orange River Country, South Africa, and a supposed new locality of the same, in Mexico;* by CHARLES UPHAM SHEPARD, M.D.

THIS fine meteoric iron mass was brought to London from the Cape of Good Hope, in August last, by the master of a Scottish ship, to whom it had been intrusted by a farmer of the Orange river district, where the mass is supposed to have been recently discovered. It was taken directly to Prof. Tennant, by whom it was purchased; and a few days subsequently was transferred to my possession,—this being the second large metallic meteorite from Africa, which I owe to the same source.

Its weight is 328 pounds. Its figure in one position, as shown by the drawing of Mr. Robert Bakewell here given, is somewhat cubical or block-like, though exhibiting very blunt edges, and upon one side, a very remarkable gash, or reëntering angle.

The indentations of the surface are strongly marked. The depressions are large, and strikingly uniform throughout in their dimensions.

Upon the top of the mass, as represented in fig. 1, there is a broad plate-shaped depression (itself made up of many smaller ones), which is surrounded at its brim with a double series of elongated concavities, each one of which points with its longer diameter, towards the centre of the general concavity. There are no sharp edges or asperities connected with the block, for which reason, it reminds one of a freshly made and highly perfect casting of bronze or of cast-iron.

There is also an almost perfect absence of oxydation over the entire surface, which in place of the usual coating of hydrated oxyd of iron, exhibits a thin black crust, closely adhering to the mass, and not thicker than wrapping paper. In this respect it strikingly resembles the Braunau meteoric iron; and leads to the surmise that the mass is of recent origin.

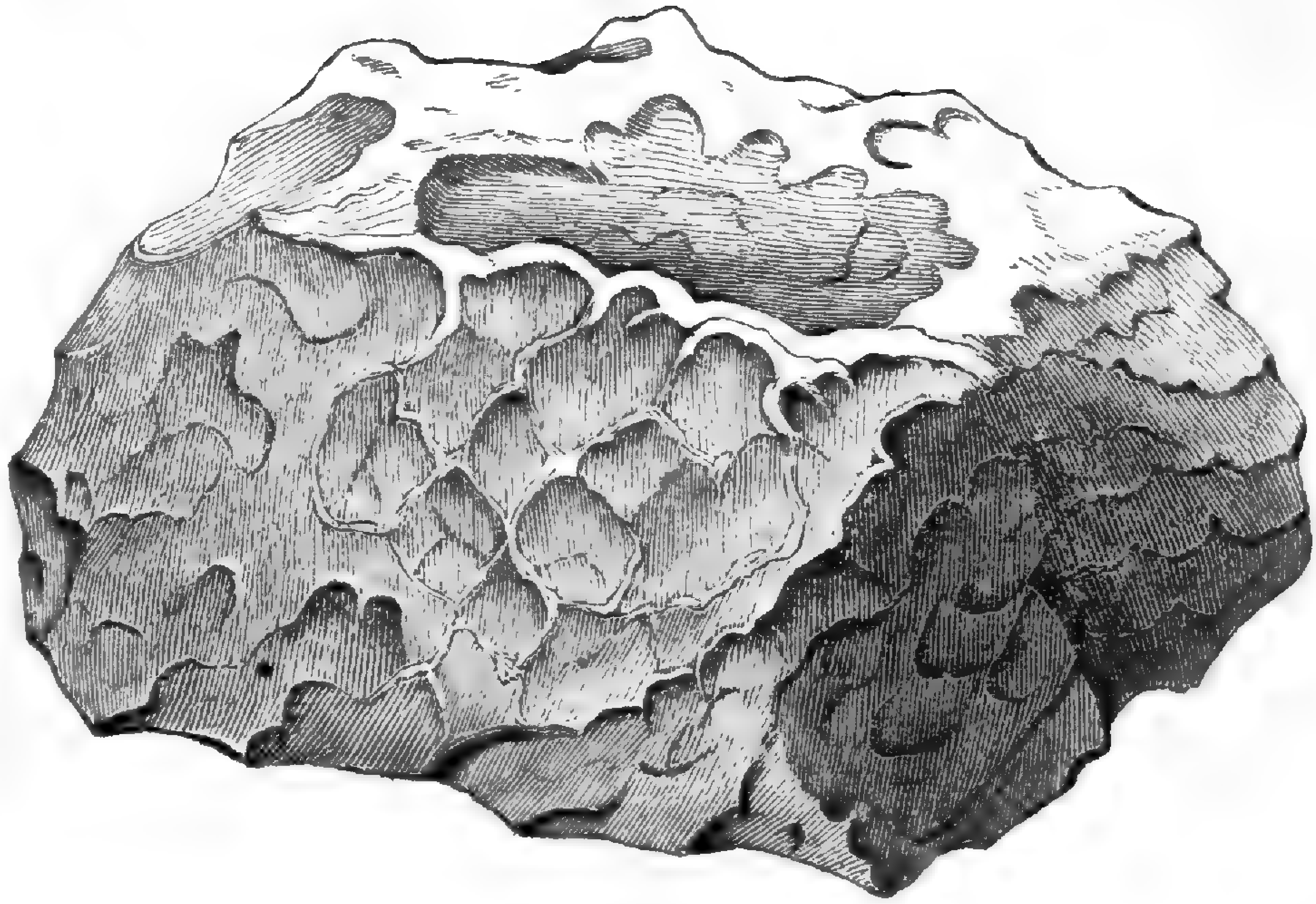
Fig. 2. represents the block in an inverted position, which owing to an anvil-like projection of one of its angles, produces some modification in its general appearance. It brings into view also, a singular opening (*a*) perfectly circular in form, and about three quarters of an inch in diameter, and the same in depth. This opening is slightly concave at bottom, and has at its centre a small projecting pimple; the whole seems to have been wrought artificially; and yet it bears no mark of any tool or instrument, by which it could have been done.

It is sawed with less difficulty than most meteoric irons, being unusually homogeneous in its texture. It is perfectly crystalline in structure, throughout; and apparently the crystallization of the entire block is conformable to the planes of a single individual. Cleavages are effected with facility, giving rise to octahedral and tetrahedral fragments. The polished surfaces show no tendency to oxydation before or after etching; and present an uncommonly white color. When etched, it reveals a regularity of crystallizations wholly unsurpassed; and most resembles that of the Putnam county (Ga.) iron, although the lines and bands of the Orange River iron are much bolder and more strongly marked, than in that from Georgia.

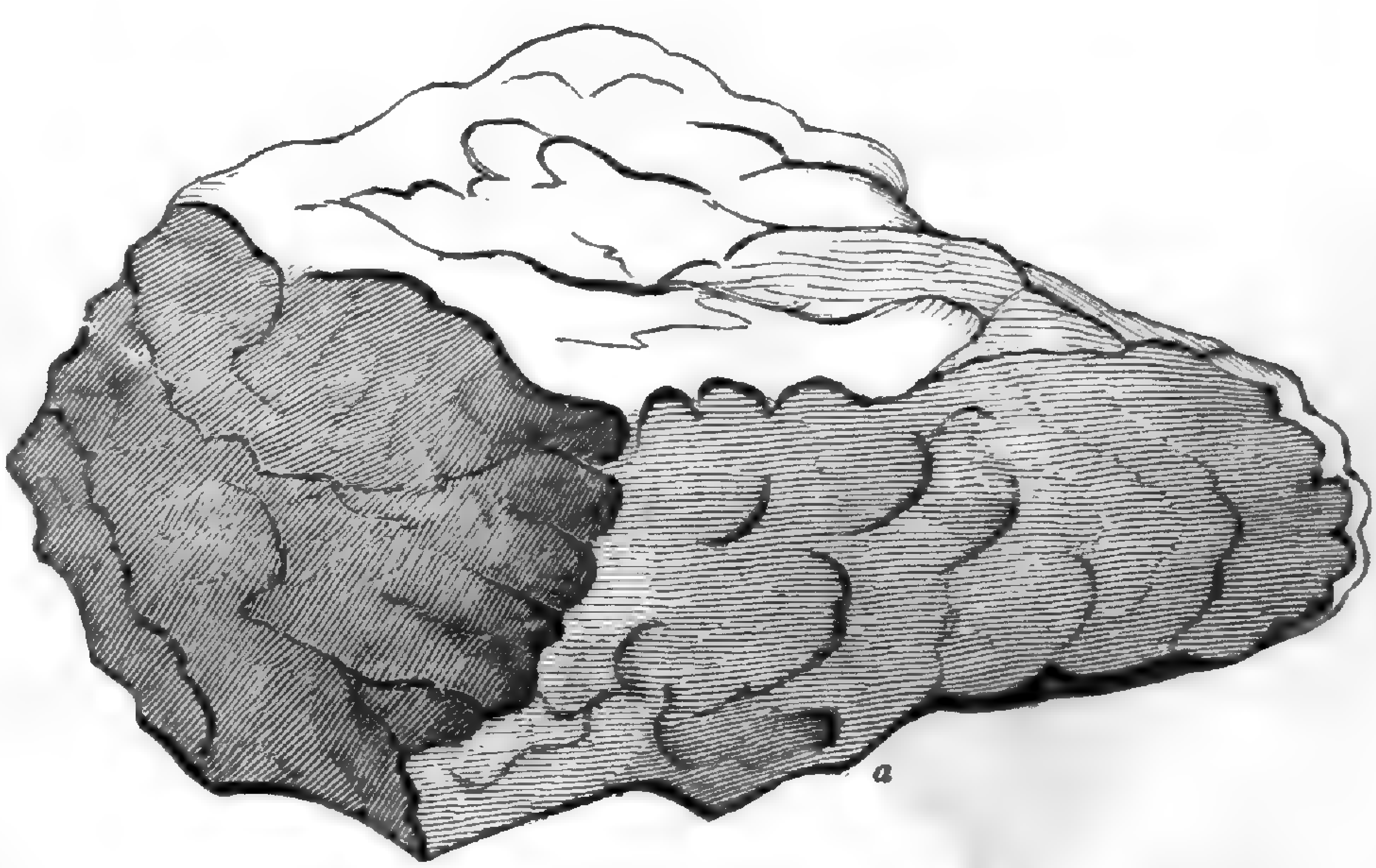
The specific gravity, as determined upon a single specimen weighing sixty grains, is 7·3. But I believe this below the average; and a more satisfactory determination of this property is reserved to a future occasion.

Thus far, I have discovered no indication of the presence of sulphur. No examination was made for tin or copper. In dissolving in dilute nitro-hydrochloric acid, a small residuum was left, which consisted chiefly of nearly round, semitransparent grains of a mineral, which I consider identical with chladnite;

1.



2.



and the same as found, though much more abundantly, in the Tuczon, Sonora iron. The remainder of this insoluble matter was composed of Schreibersite, through which were diffused a few minute specks of chromite. The following result was obtained:

Iron, with traces of chromium, - -	90·48
Nickel with traces of Cobalt, - -	8·94
Chladnite, - - - - -	0·56
Schreibersite, - - - - -	0·02
Chromite, - - - - - -	*traces*
	100·

A Supposed new locality of Meteoric Iron in Mexico.

When landing the above described iron from the steamer on my arrival at New York, it accidentally fell under the observation of Mr. Peter McDermot, a deputy custom-house officer, whose attention was arrested by its perfect coincidence in size and general configuration with a mass he had seen in 1847 at Ceralvo, a town situated halfway between Camargo and Monterey, on the great road from this country to Mexico. Mr. McDermot was then a first sergeant in the United States service; and met with the mass in a well known blacksmith's shop at Ceralvo. It was there used as an anvil, one of its faces having been smoothed off to fit it for the purpose. His curiosity was much excited at the time, by the peculiar indentations upon the surface of the mass: and never having seen anything of the kind before, he was led to doubt whether the metal was really iron. Being a blacksmith by trade, he made a cut into its side with a cold chisel, in order to satisfy his curiosity upon the subject. The experiment left no doubt in his mind, that it was composed of soft, tough iron. He had never seen or heard of an undoubted specimen of meteoric iron except on the present occasion; and after inspecting it, felt no doubt that the anvil he had examined at Ceralvo belonged to the same class of objects, and had a similar origin. It is to be hoped, that this notice may lead to an early recognition and testing of the iron seen by Mr. McDermot.

ART. XXVI.—*On the Theory which attributes the Zodiacal Light to a Nebulous Ring surrounding the Earth;* by F. A. P. BARNARD, LL.D., Professor of Mathematics and Astronomy in the University of Mississippi.

AMONG the papers read before the American Association for the Advancement of Science, at the recent meeting in Providence, no one excited a more general interest than that presented by the Rev. George Jones, of the United States Navy, on the subject of the Zodiacal Light. The entire absence of any previous record of continuous and persevering observations upon this well known but little understood phenomenon, rendered peculiarly acceptable the large collection of delineations of its phases as seen from hour to hour and from night to night, during a long period of time, and encouraged the expectation that materials might be found to have at length been gathered for the construction of a theory of the phenomenon which should be completely satisfactory. In this anticipation and hope, the present writer partook quite equally with others; nor is he yet prepared to adopt a different opinion. If the voluminous records submitted to the Association by Mr. Jones, and which carry along with them abundant evidence of the ability and the fidelity with which they were prepared, have not yet suggested the true explanation of the remarkable appearance to which they relate, they must be regarded, in their fullness and their minuteness, as holding out encouraging promise that it will yet be found in them. That collection, indeed, embraces the only mass, large or small, of well ascertained facts, which has yet been brought together on this subject: and even if no speculations whatever had yet been put forth in regard to the significancy of those facts, the publication of the whole would be urgently demanded in furtherance of the interests of science. Since, however, they have been presumed by many, who have studied them attentively, to favor a particular theory in regard to the source of the light, and since that theory, as briefly explained by Mr. Jones at the meeting referred to, was received with marked approbation, and without a single expression of doubt or dissent from any one present, the desirability of the early publication of the entire mass of graphic delineations, with all the accompanying memoranda, is rendered still more urgent.

The writer yields to no one, in his admiration of the zeal, perseverance and manifest ability with which the observations of Mr. Jones were followed up; or of the minuteness of detail with which all the simultaneously accompanying meteorological facts were registered. Nor can he refrain from expressing the gratification which he felt, at the entire freedom from bias with which the observer seemed to have entered on his task; and the resolute determination displayed by him to ascertain, first of all, the facts, no matter to what conclusions they might lead. The conclusions, however, to which they *have* led in the mind of Mr. Jones himself, and apparently in the minds of most of those who had the pleasure of listening to his explanations, are attended, as the writer is forced to believe, with some difficulties, which it is the design of this communication to set forth. These difficulties would have been brought to the notice of the Association, during the meeting, but that the authority by which the theory of Mr. Jones was so immediately and so emphatically endorsed, presented a front too imposing, and too entirely undivided, not to induce hesitation, and awaken some distrust of objections which were then but the suggestions of the moment. Reflection, however, has had no other result but to confirm the convictions of the writer in the validity of those objections; and it is on this account that they have been finally reduced to the present form, in the hope that, if they are ill-founded, their fallacy may be made to appear.

Before proceeding farther, it is proper to state, specifically, what is the hypothesis of Mr. Jones, which it is proposed here to examine; for though a statement of this hypothesis is to be found in a former number of this Journal, (No. 58, July, 1855,) some months have now elapsed since it appeared. Mr. Jones accounts for the phenomenon known as the zodiacal light, on the supposition that it is a reflection* of the sun's light from a nebulous ring encircling the earth, having its plane coincident with that of the ecliptic, and possessing a density too feeble to intercept the light of the stars. This hypothesis is deduced from the observations, not so much by showing that they embrace an irresistible mass of evidence in its favor, as by gathering from them proofs to invalidate all other hypotheses heretofore suggested to account for the same phenomenon. If the existence of "the earth's ring" has been demonstrated, the demonstration is mainly indirect. Its principal points are embraced in the following propositions.

1. The light, whatever be its source, cannot proceed from a body enveloping the earth.

2. It cannot proceed from a body concentric, whether as an atmosphere or as a ring, with the sun, and interior to the earth's orbit.

3. It cannot proceed from a ring concentric with the sun and exterior to the earth's orbit.

4. It cannot proceed from a nebulous planet or comet, revolving about the sun in an orbit either wholly interior to that of the earth, or wholly or partly exterior.

* Mr. Jones regards it as a specular reflection.—Eds.

This fourth proposition was not perhaps distinctly enunciated by Mr. Jones; but as it is sustained, equally with the others, by the observations, it is added, in order that the exclusion of all previous hypotheses may be complete; for if these four propositions be admitted, every conjecture which has hitherto been esteemed worthy of a moment's serious consideration, in regard to the source of the zodiacal light, is effectually cut off. No alternative seems to remain to us but to attribute the appearance to a ring surrounding the earth and illuminated by the sun.

But though the evidence in favor of this hypothesis is mainly negative, the writer has no disposition to deny that certain positive indications furnished by the observations seem to point in the same direction. To such, however, he attaches less importance than he might otherwise be disposed to attribute to them, for two reasons, viz., 1, they are in themselves so indecisive, that, but for the negative evidence, they would have little weight; and, 2, they are of a kind, of which, if the earth has really such a ring as is supposed, we ought to have many and conclusive examples, instead of occasional and doubtful ones. Upon this point it is proposed briefly to dwell, further on. In the mean time, a remark or two may be made in regard to the first of the foregoing propositions; in support of which the reasons assigned by Mr. Jones appear to be not quite satisfactory. According to him, if we are ourselves involved in a nebula, we can discover nothing in regard to its form—we can obtain no outline—and yet the zodiacal light presents to us a constant and distinct shape. This mode of reasoning would be very just, if applied to a cloud enveloping the observer so dense as to be capable of absorbing the light from its remoter parts before it could reach him; and it would be no less so of any nebula, dense or rare, which should be equally extended in all directions from the point of observation. But the case is evidently very different with a transparent body very limited in one dimension and very much extended in another. It is not necessary to assert that the apparent outline of such a body obtained by an observer immersed in it would be very sharp and well defined. It would probably not be so at all; but herein it would correspond very happily to the appearance of the zodiacal light; since nothing can be more uncertain or more difficult than the exact determination of the outward limits of this light, even when its central portions are brightest. The galaxy presents an admitted case, in which the observer obtains a pretty good outline of a nebula, and even of its ramifications, though himself immersed in it; and, in this instance, the sharpness of definition is, to most eyes, much superior to that of the zodiacal light. These considerations are presented without the design of attaching to them any very high importance; but because the hypothesis we are considering derives its plausibility mainly from the want of plausibility in any other, and depends upon a series of exclusions, of which the very first in order is decidedly not established.

The evidence of the truth of his second proposition is found by Mr. Jones, in the fact that a zodiacal light was visible to him in the east and the west at the same time, when the sun was depressed ninety degrees below the horizon. That neither of these lights could have been reflected from a ring interior to the earth's orbit, is obvious.

The third proposition is regarded as established by the considerable changes which the lateral boundaries of the light undergo, as the position of the observer to the ecliptic is altered by the earth's diurnal motion; these changes being too great to spring from such a cause, if we refer the source of the light to a distance of more than 190,000,000 of miles, as we must do if we attribute it to a ring external to the earth's orbit. An argument more decisive than this, and to the same effect, would seem to be deducible from the fact that, if such were the source of the light, it ought to be vastly brighter in the quarter of the heavens opposite to the sun, than in that where it is in fact seen.

The *positive* evidence confirmatory of the truth of the hypothesis of a ring concentric with the earth, is embraced in these three facts:—

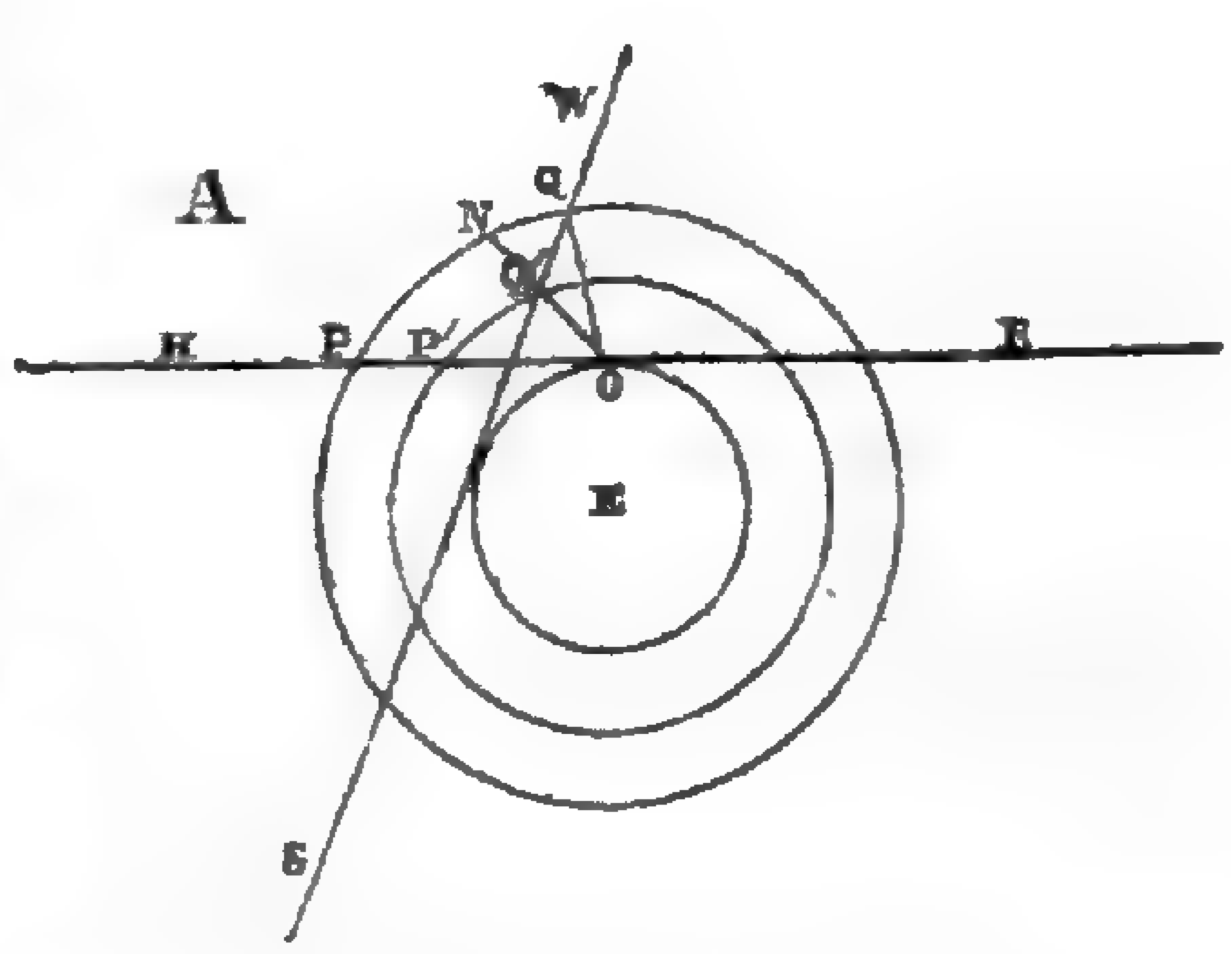
1. In low latitudes, the light is visible throughout the year.
2. To an observer who has the ecliptic vertical at midnight, the light appears both in the east and in the west, at the same time.
3. The moon appears occasionally to produce a zodiacal light.

Having thus stated the grounds on which the theory of the zodiacal light proposed by Mr. Jones rests, it is in order to consider the difficulties which this theory suggests. These are the following:

1. The aspect of the light itself is not such as a ring ought to present.
2. The axis of the light undergoes no parallactic displacement, however great be the observer's change of position; and the explanation offered of this difficulty by Mr. Jones is not satisfactory.
3. The geometrical inferences to which the hypothesis legitimately leads, as they are deduced from different observations are inconsistent with each other.
4. To adopt the supposition of a nebulous ring surrounding the earth in order to explain the phenomena which are actually observed, involves unavoidably a necessity that other still more striking phenomena should present themselves, which are *never* observed.

To explain more particularly what is intended by the first of these propositions, we may remark that the appearance of a ring remote from the earth, and seen by reflection just previously to the morning, or at the close of the evening twilight, ought to present some characteristics which are wanting in the zodiacal light. That it is never visible in the quarter of the heavens opposite to the sun, may be attributed to the fact that it there falls into the shadow of the earth; but toward the sun its form should be unlike what it is. Considering it as limited by the shadow, we should expect that its upper portion should display a brightness gradually fading, (as it actually does,) but we certainly should not look to see this fading commence from the very horizon itself. If, in the annexed figure, E be the earth, SW the tangent limiting the shadow, HR the horizon, and PP′Q′Q the portion of a nebulous ring concentric with the earth visible to the observer at O, then the angle HOQ will measure the apparent altitude of the illumination, the point Q being the intersection of the tangent, SW, with the most distant stratum of the ring which is capable of reflecting light in sufficient force to impress the eye. The point Q′ will be the intersection of the same tangent with the nearest stratum of the ring. Within the angle Q′OQ will necessarily be observed a fading brightness, the maximum being at Q′, and the minimum, which is zero, at Q. But below Q′, and within the angle HOQ′, the brightness should be uniform, and the breadth also:—or if there be any difference, it should be in favor of the point Q′ in both these respects, on account of its greater proximity to the observer. This circumstance would make a very sensible difference, unless the ring were much more remote than any observations yet made justify us in placing it. If, in regard to the point of brightness, it be said that the line of vision OQ′N, at a determinate altitude above the horizon, would intersect the ring less obliquely than OP′P, in the horizon, and would therefore encounter a smaller number of illuminated particles than are met by the other, it may be said, on the other hand, that the horizontal ray is much more powerfully absorbed by our atmosphere than the other; so that the probability of the greater conspicuousness of the portion of the ring at Q′ is not seriously affected by the objection. Now we know that, at the very earliest moment at which we are able to observe this light after sunset, (which is the close of twilight,) the appearance presented is that of an uninterrupted diminution both of breadth and brightness, from the very horizon upward. There is certainly no limit, as at Q′, dividing a part, Q′P′, uniformly bright, or decreasing downward in brightness, from the

1.



other part Q′Q, in which the brightness decreases upward. What then can we conclude, if we adopt the ring theory, but that the point Q′, where the tangent, SW, meets the lower surface of the ring, is itself in the horizon or below it? But at the close of twilight this same tangent (when the light happens to be in the vertical passing through the sun, as it is occasionally in low latitudes) intersects the upper stratum of the atmosphere precisely in the horizon; and hence, so far as the mere aspect of the light can furnish a basis of argument, we are forced to conclude, that if the brightness is a reflection from a body concentric with the earth, this body cannot be one having any sensible interval intervening between it and the atmosphere.*

The absence of a parallax appears, secondly, to furnish a serious objection to the ring theory. Mr. Jones's mode of explaining away this difficulty is ingenious, but it will hardly bear examination. He supposes the ring to have considerable breadth, and that the *locus* of the light (or more properly of its axis) is different for different observers; being in all cases in a plane passing through the eye, parallel to the ecliptic. Mr. Jones seems to look upon this as an optical necessity; but apparently without sufficient reason. In the first place, it is probable that the supposed nebulous ring, if visible at all, would be visible throughout its whole breadth, and would present no sensible lateral variation of brightness. Secondly, should such a body exhibit an axis of maximum brightness, this axis would not be of necessity, nor usually, parallel to the ecliptic. The case is by no means that of a cylindrically concave solid reflector. In that case, parallel rays at right angles to the axis of the cylinder, would undoubtedly be reflected to an observer within the curve, in a plane also perpendicular to the axis, and passing through his eye; and if the reflector were an imperfect one, there would be an elongated luminous *locus*. In the case of a transparent nebulous body, however, there is no such thing as a continuous reflecting surface; but each particle is an independent reflector, the intensity of the light which it throws to the eye being unaffected by the neighborhood of other particles, or by the general form which the entire group may possess; but varying only with the angle included between the incident and reflected rays. Of all the parallel rays falling upon the particles of such a group, that one will be most forcibly reflected to the observer, which after reflection, makes the largest angle with its incident direction. Accordingly, if the sun, being below the horizon, but near it, illuminate a nebulous mass of uniform thickness or depth (in the direction of vision) it is manifest that, of any row of particles in that mass taken horizontally,

* This argument does not suppose the reflection specular, as Mr. Jones claims—a kind of reflection which requires a polished surface to the particles of the nebula. —Eds.

the brightest (so far as there is a difference) will be that which is in the vertical passing through the sun; and, therefore, that, if the nebula is extensive enough, this same vertical plane, by its intersection with the nebula, will determine the *locus* of principal brightness. It can rarely happen, however, that the ecliptic will pass through the observer's zenith; and when it happens, the state of things can be but momentary. The fact therefore, that the axis of the zodiacal light appears to be always in the ecliptic, and that it is not displaced laterally by any change of position in the observer, appears to the writer to furnish a proof almost decisive that this light cannot proceed from a nebulous ring encircling the earth.

In admitting, in the foregoing argument, the possibility that the light reflected to a nebulous body may have an axis of maximum apparent brightness, it will be observed that the admission rests upon the supposition that, in a certain plane, the angle between the incident and reflected rays will be maximum. This, however, can only occur with parallel incident rays so long as this angle exceeds ninety degrees. When the same angle is less than ninety, this central plane will be the plane of minimum intensity, instead of maximum; and therefore, if a nebulous ring surrounding the earth, should be illuminated in the portions above the horizon when the sun is ninety degrees below, it is impossible that its brightness should be restricted to a limited portion of its breadth. Yet the delineations of the zodiacal light, as observed under these circumstances, in Mr. Jones's diagrams, presented no peculiarity—certainly no enlargement of breadth. We can form no other conclusion, therefore, but that the nebulous body from which this light proceeds, is always seen illuminated throughout its whole extent; and consequently that the absence of a parallax is inadequately accounted for by the explanation suggested by Mr. Jones.

The foregoing observations in regard to the appearances which an illuminated nebula may be expected to present, are confirmed by the actual phenomena of twilight. When the sun is very near the horizon, the point where he is about to rise is marked by a greater degree of brightness than any other; but this brightness is not restricted within very narrow limits, nor is it wholly owing to more intense reflection, but in a measure to the greater depth (in the direction of vision) of the mass of air illuminated. At a distance so far from the sun that the reflected rays come to us making with the incident an angle less than ninety degrees, or not much greater, the sky is uniformly bright in every direction. And when the sun has sunk so low as only to illuminate the borders of the western horizon, we observe no greater inequality of brightness throughout the whole extent of the illumination, than is fairly attributable to the varying depth of the mass illuminated.

Mr. Jones himself furnishes an argument almost conclusive in disproof of the hypothesis of an illumination merely local, in his record of the aspect of the light as it appeared, on one or two occasions, in presence of the moon. He considers it to be well established that the ring was made visible by a reflection of the moon's light; or at least that its visibility was partially due to that cause. He attaches particular importance to one of these observations, because the moon was, at the time, *without* the boundaries of the light. Yet if the sun produces a luminous *locus*, there is no reason why the moon should not do the same; and it is obvious that the two *loci*, under the circumstances just described, could not possibly be coincident. On the other hand, the fact that the moon illuminated the ring in a line not passing through, but passing *by* itself, would seem to demonstrate pretty conclusively that the nearer margin of the brightness was the actual boundary of the ring. The circumstances must have been peculiarly favorable which brought the moveable reflection of the sun's light at the same time, upon the same margin also.

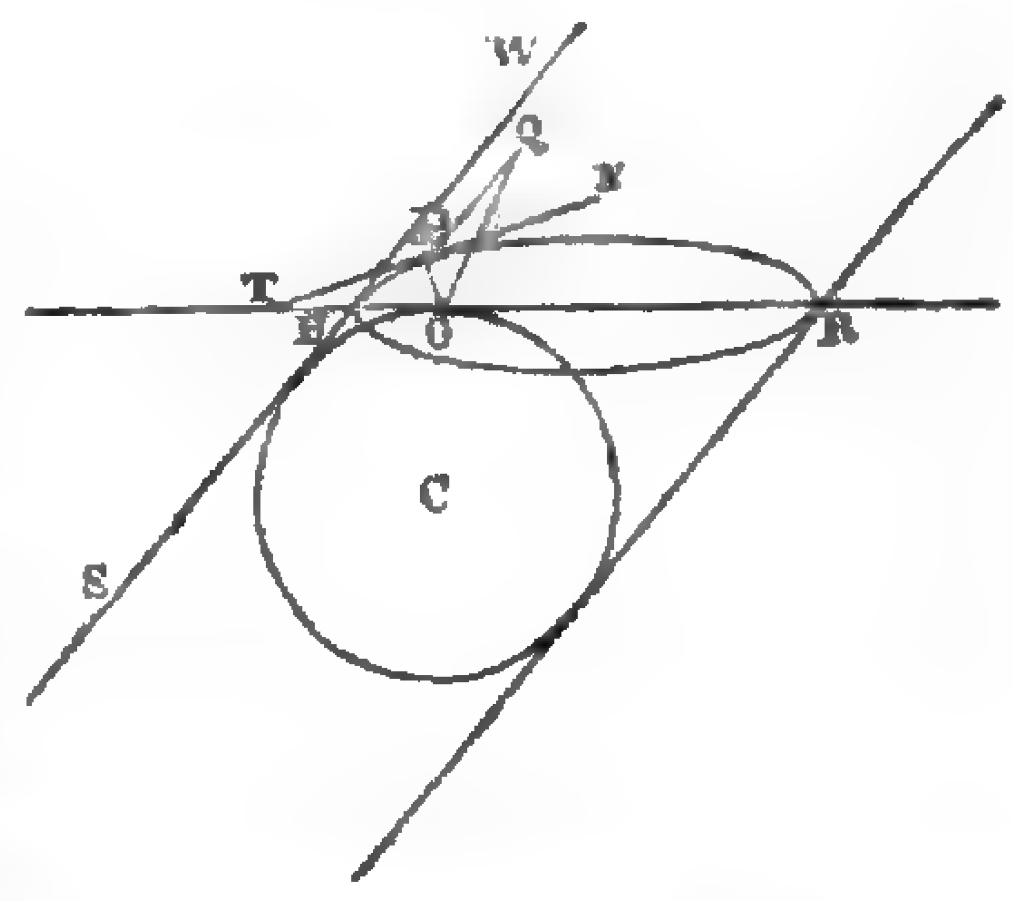
Upon this point there remains to be added but a single further observation. If the zodiacal light is but a luminous *locus*, shifting its place as the observer moves, and occupying but a limited portion of a broad nebulous ring, then either this light should be more or less visible at all seasons and in all latitudes when the sun is below but near the horizon (and more conspicuously so in proportion as the ring is more distant from the earth) or at certain inclinations of the ecliptic to the vertical, it should grow narrower by losing a portion of its breadth on one side only, and should thus disappear by a gradual extinction proceeding from side to side. The first of these cases corresponds to that of a ring having a breadth at least equal to the earth's diameter; the second supposes the breadth to be less than this diameter; and the inclination of the ecliptic which should cause the axis of the brightness to pass off from the ring may be found by the equation,

$$\text{sin. zenith dist. of ecliptic} = \frac{\frac{1}{2}\text{ breadth of ring}}{\text{earth's radius}}.$$

These propositions which, if no lateral parallax is admitted, would represent rigidly the truth in regard to a nebulous ring concentric with the earth, are believed not either of them to hold of the zodiacal light.

The third source of difficulty in regard to the ring theory is found in the inconsistency of the results legitimately deduced from different observations. Assuming the theory to be true, the place of the summit of the light when visible must be determined by the intersection of the uppermost strata of the ring with the earth's shadow. The axis of the light being also visibly parallel to the ecliptic, we need but a single observation of the zenith distance of the summit to enable us, with a knowledge of our latitude and the sun's hour angle and place in the ecliptic, to determine the distance in miles. A general method for this purpose may be sketched out as follows:

2.

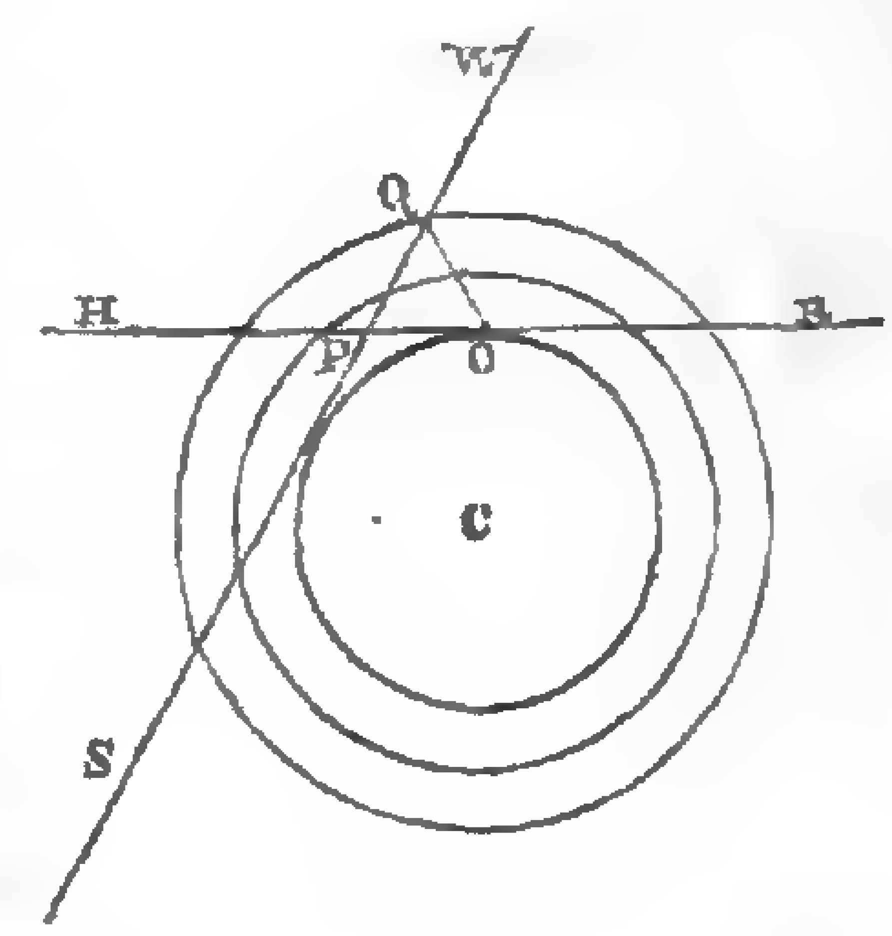


The intersection of the horizon with the conical shadow of the earth is an ellipse, of which, according to a well known and general property of conic sections, the point of contact with the earth, or the observer's place, is a focus. Now if, to an observer at O, the centre of the light at its base be in the direction OP, and the summit in the direction OQ, then the plane OPQ intersects the convex surface of the shadow in a line sensibly straight, PQ. If we regard the shadow as a cylinder—as for the purposes of this inquiry we may do without appreciable error, PQ will be truly straight and parallel to the axis of the shadow.

The latitude and the hour angle enable us to find the sun's depression below the horizon, which is the measure of the inclination to the horizon of the axis of the shadow, which we may represent by the letter I. If we put D for the earth's diameter, then the major axis, HR, of the ellipse, will be equal to D×*cosec.* I, and the minor axis will be D itself.

The sun's place in the ecliptic, combined with the data above mentioned, will give the difference of azimuth of the point P and the sun, or the angle HOP, and the inclination of the plane OPQ to the horizon. The observed vertical altitude of Q, combined with this last, will give the angle POQ. The axes of the ellipse and the azimuthal angle HOP enable us to determine the length of the focal radius, OP. From the same azimuthal angle and the angle I, we deduce the inclination to the horizon also of a plane touching the cylinder in PQ, of which TN is the trace; and also the angle QPN. Then, at P, we have a solid angle contained by the tangent plane just mentioned, the plane of the horizon and the plane OPQ, in which one of the containing plane angles and two of the inclinations are known. Hence we derive the plane angle QPO, giving, us finally, in the triangle OPQ, two angles and a side, from which OQ is ascertained; and of this the inclination to the horizon has been found by observation. The distance of the point Q from the centre of the earth is therefore determined, and consequently the altitude of the superior stratum of the ring.

3.



The process is however greatly simplified, if we make the observation from a station where the ecliptic happens to be vertical when the light is in view. Let OQP be a vertical plane, PQ being apparently in the axis of the light and Q the summit. PO is the tangent (to the earth's radius) of half the sun's depression, and is therefore known. In the plane triangle OPQ, the angle at P is equal to the entire depression of the sun, and POQ is determined by observation. These, with the known base, OP, will give OQ, from which the height of the ring above the earth's surface may be determined as before.

Now to make an application of this method, not with a view to obtain a result perfectly accurate, for which no observations sufficiently precise are at hand, but in order to find an *outside limit* to the possible altitude of the visible ring; it is safe to assume that the luminosity has never been seen extending more than seventy degrees vertically upward, even when observed immediately after the disappearance of evening twilight. The writer has never had an opportunity of seeing the light perfectly at right angles with the horizon, though he has often seen it nearly so; and its utmost extent has never appeared to him to exceed sixty degrees. But a calculation based upon the data just stated, viz., that, with the sun 18° depresssed, the angular altitude of the luminous column when at right angles to the horizon is 70°, gives us but 186 miles as the extreme height of the superior portions of the ring above the surface of the earth:—a height which is increased only to 204 miles, if we assume, what is believed to have never yet been observed, that the light may reach from the horizon entirely to the zenith.

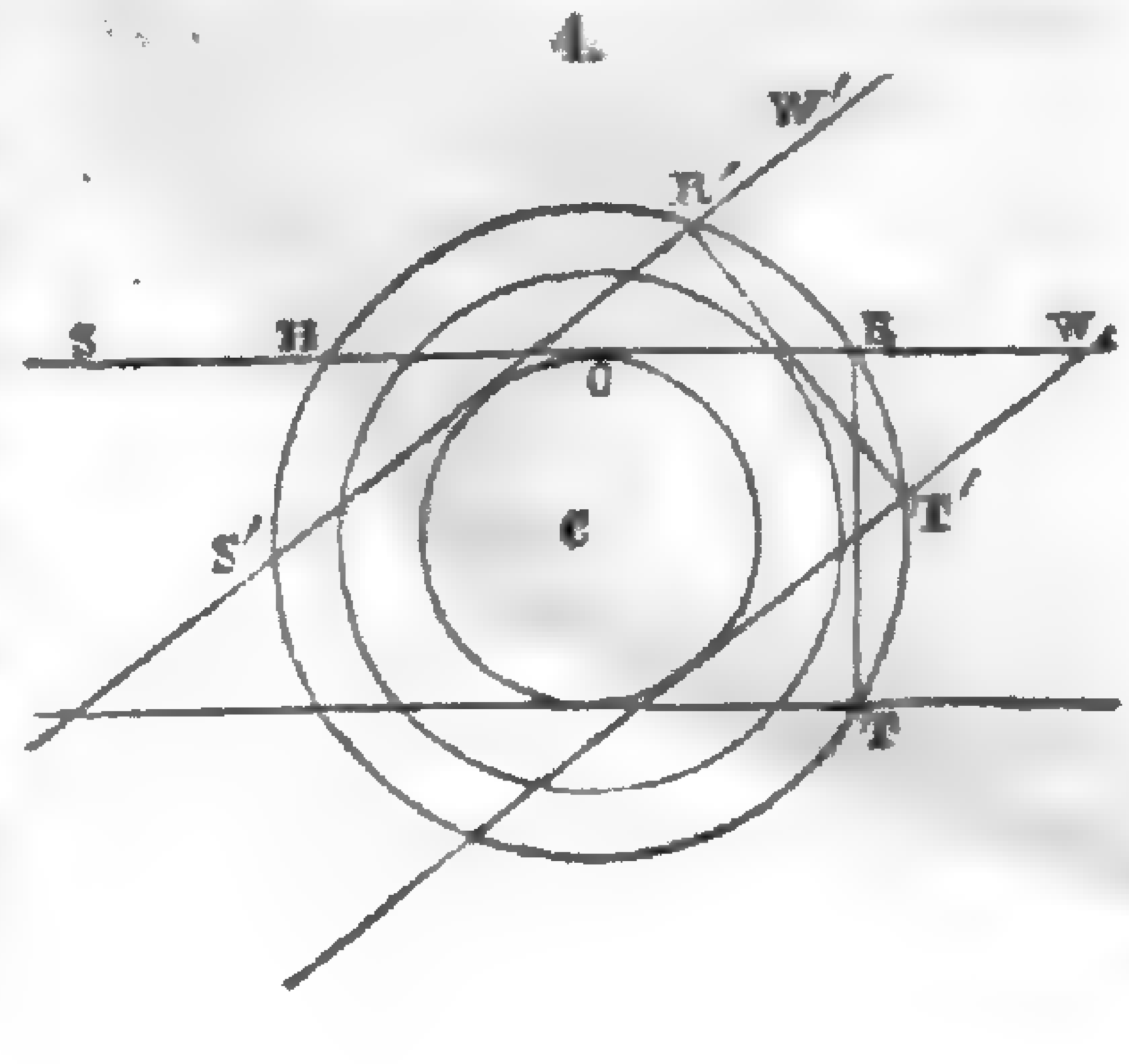
This result gives us, it must be confessed, but a mean opinion of the magnificence of "the earth's ring." Yet there is little doubt that it is even more favorable in respect to dimensions, than could be deduced, by the help of the same mathematical method, from most of the observations hitherto made of this phenomenon, whether by Mr. Jones or by any other observer. The probability is that the results of such an examination would all be more or less discordant with each other; while it is manifest that, in a few instances, we should reach conclusions singularly at variance with the mass. Mr. Jones several times observed the light simultaneously in the east and west horizons, when the sun was depressed ninety degrees. The two columns continued to be both visible for the space of two hours. They must consequently, at midnight, have had considerable altitude—as in fact his diagrams proved, although the measured height, if it was stated by him, is not remembered. Now had the light been at that hour but barely perceptible in the horizon, it is manifest that the intersection of the tangent limiting the earth's shadow with the outer stratum of the ring, could not have been below the horizon. Supposing then that intersection to have been situated exactly at the horizon, its distance from the earth's centre would be equal, in miles, to $3956\sqrt{2}$, or 5596:—giving a distance above the earth's surface of 1640 miles. Supposing the angular altitude of the light at the same time to have been thirty degrees, the distance of the apparent summit from the earth's surface must have been 3434 miles, or nearly equal to a radius of the earth; and allowing it to have been forty-five degrees, the same distance would have been 4890 miles.

The singular discrepancies to which the different observations conduct us, lead us almost irresistibly to the conclusion that the ring hypothesis is untenable. They cannot be explained but by making assumptions in regard to the reflecting power of the nebulosity, such as to destroy the value of all observations upon this phenomenon, and to conflict, at the same time, with established laws of optics.

But, in the fourth place, in accepting the hypothesis of a ring, we must accept along with it, not merely those consequences which it may be convenient to us to admit, but all the consequences which it legitimately involves. We must show that the visible arch which we regard as a portion of this supposed ring, conforms, under all circumstances, to the geometrical conditions which the hypothesis imposes. That we may be able to judge how far this is the case, let us consider how these conditions may be investigated.

Suppose a spherical surface to be generated by the revolution of the ring about the line which joins the centres of the earth and sun, and which, being produced, forms the axis of the shadow. In this spherical surface the ring must always be found, being subject only to the condition that one of its diameters shall coincide with this line which we have assumed as the axis of revolution. The intersection of the shadow of the earth (considered for the present purpose as cylindrical) with the same spherical surface, will be a small circle of the sphere; and the intersection of the plane of the horizon will be another small circle. Assume the position of the sun to be ninety degrees from the zenith of the observer, and it will be at once self-evident that the arc-radius of one of these small circles will be complementary to that of the other. If, in the figure, HR be the projection of the circle of the horizon and RT,

4.



or R′T′, that of the circle of the shadow, it is plain that the extremities of the illuminated arch will always be found in the circumference RT, or R′T′; but the question of the visibility of either of these extremities will depend on the relation of the plane of the ring to that of the horizon. For convenience, let the circle RT be called the limit of illumination, or more briefly, the limiting circle; and in order as much as possible to simplify the illustration, let the sun be supposed to be in the equinox, and the observer at the equator. At the moment of sunset, the limiting circle will be in contact with the other by its upper or preceding limb. As the sun sinks, the circles will intersect; and in what follows, we may distinguish three cases, according as the limiting circle is equal to, less, or greater than, the circle of the horizon. If the two circles are equal, the intersection will continue until the sun's depression becomes 90°, when the planes of the circles will coincide. During all this time it is possible that one of the illuminated cusps of the ring may be above the observer's horizon, and therefore in a situation to be seen. There is, in fact, but one position which can possibly be given to the ring, by which it may be kept wholly invisible; and that is, a position at right angles to the equator, which in the case in hand is excluded by the condition that the plane of the ring shall coincide with the ecliptic. Only one cusp, however can, in this case, ever be seen at a time; but as the first cusp disappears at midnight, the second one will immediately make its appearance, and continue to be visible until dawn. At the moment of sunrise, the limiting circle will touch the horizon again, but will make the contact, this time, by its following limb.

If the limiting circle be less than the circle of the horizon, then the sun descending as before may bring into view one of the cusps immediately; and in a right sphere it would do so, though not necessarily in an oblique one. When the centre of the limiting circle, however, reaches the horizon, one of the cusps must appear, whatever be the observer's latitude; and both of them may do so. But the appearance of the second is not a matter of necessity until the limiting circle touches the horizon by its following limb. At the depression of 90°, the planes of the two circles will be parallel, and the two cusps will be equal; after which the preceding one will diminish and the following one will increase; the phenomena preceding the dawn corresponding in inverted order to those which followed the twilight. The observations made by Mr. Jones of the two luminous columns simultaneously visible at midnight would indicate that, if they were the cusps of an interrupted ring, the case which actually exists in nature is that which is here described.

The third case supposes the limit of illumination to be greater than the horizontal circle. In this case, the intersection of the planes begins, as before, at the setting of the sun, and continues until the preceding limb of the limiting circle touches the limb of the horizontal circle opposite to its first point of contact. During this period, one cusp may possibly be visible, and in a right sphere probably would be. But after this second contact, neither could be seen until after midnight, the following limb of the limiting circle should touch the horizon at the original point of contact, when the second cusp might in its turn become visible. In this case, it is not matter of necessity that the light should be seen at all during the sun's absence; nor that, when seen, it should extend over an enormous arc of the heavens; and in these two particulars it best corresponds to the facts of ordinary observation.

Now in order to discuss the necessary aspects of the ring under definite conditions, it is to be observed, that we have, upon the surface of our imaginary sphere, two fixed points, the zenith and the pole of diurnal rotation; and two moveable ones, the pole of the limiting circle (which is the centre of the earth's shadow), and the extremity of the illuminated arch. By the aid of these, when the latitude is known, the sun's depression below the horizon given, and the arc-radii of the limiting circle and of the circle of the horizon determined by assuming any distance for the ring from the earth's centre which the observations may seem to warrant, we may ascertain what circumstances, if any, will limit the visibility of the light, what ought at any time, to be the apparent extent of the illuminated arch, what should be its apparent altitude above the horizon, within what limits of latitude it ought always to be visible in both the morning and the evening sky, and within what it should be seen either in the morning or the evening, with various other particulars which may serve to assist in determining how far the light as actually observed fulfills all the conditions of a ring surrounding the earth. The discussion may be pursued on the supposition either that the ring has a parallax or that it has not. In the first case, if the ring could be supposed as remote as the moon, or nearly so, the indefiniteness of its outlines would probably render it somewhat difficult to detect the parallax, though real; and we might proceed with our discussion, at least for the purposes at present in view, as if no such parallax existed. But if, on the other hand, we find ourselves compelled (as, from what has already been said, it is evident that we are,) to limit the distance to one or two of the earth's radii from the centre, then the effect of parallax will be enormous; and the ring, though really lying in the plane of the ecliptic, can never appear to be so, except when vertical.

Let us, for example, assume, in the first instance, that moderate distance to which we have seen that the ordinary observations would lead us—that is to say, a distance not exceeding two hundred miles; or as, under a favorable supposition, we have determined it, 186 miles above the earth's surface. The arc-radius of the circle of the horizon would in this case be 17° 14′; and that of the limiting circle 72° 46′. Now, as the zodiacal light is always most conspicuous just after twilight, or just before the dawn, let us assume the depression of the sun to be 18° below the horizon. The centre of the shadow, which is the pole of the limiting circle, will be equally elevated. In the figure, AOB is the earth, O being the place of the observer.

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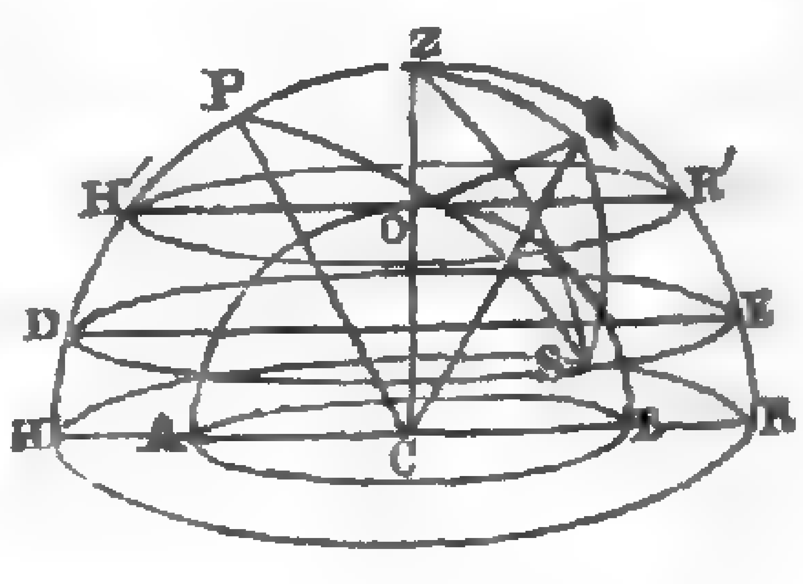
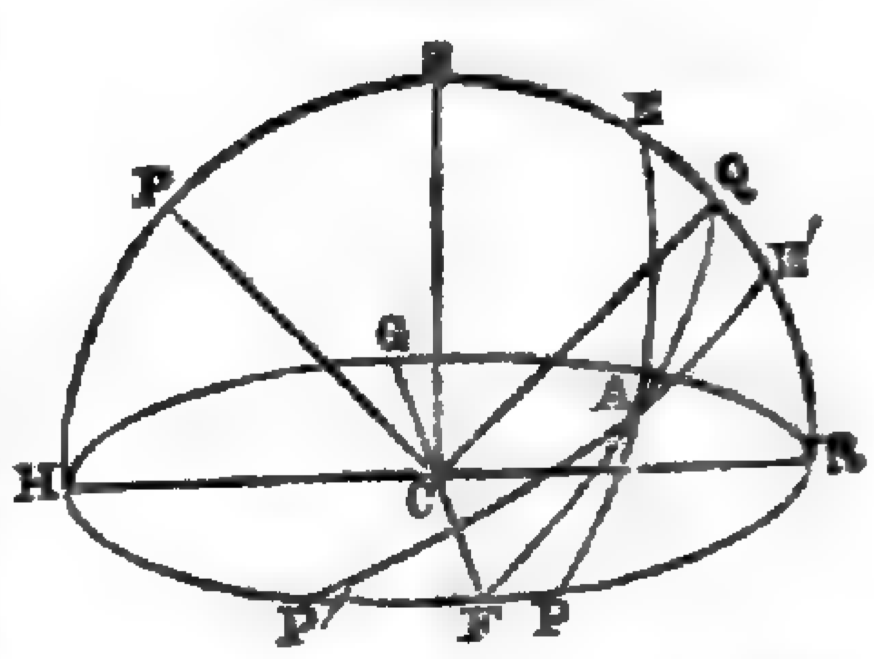


HR is the rational, and H′R′, the sensible horizon. HZR is the imaginary concentric sphere, generated by the revolution of the ring, and P is the pole of diurnal rotation. S is the point opposite the sun, or the pole of the limiting circle, which must always be somewhere in the circumference of a small circle, DE, parallel to the horizon, HR, and distant from it by an arc equal to the sun's depression. Now if Q be taken as the extremity of the light, any where upon the circumference of the limiting circle (not drawn) of which S is the pole, the four points involved in our discussion are P, Q, S, and Z. ZS is the complement of the depression of the sun; PS is the co-declination; ZP, the co-latitude; and SQ, the arc-radius of the limiting circle. SQ being in the plane of the ecliptic, the sun's place in longitude will furnish the means of determining the angle PSQ; and the depression will enable us to find PSZ: consequently, ZSQ, or the angle made by the ecliptic with the vertical passing through the sun will become known. Consequently ZQ, which is the zenith distance of the cusp, as seen from the centre, C, will be ascertained. By reduction to the surface, O, we shall obtain the apparent direction of the light.

If we now assume the point Q to be somewhere upon the circumference of the small circle, H′R′, we shall be able to find what is the maximum angle, ZSQ, made by the ring with the vertical, at which the cusp can be seen by the observer at O. And comparing this with the angle made, at different seasons, by the ecliptic with the vertical, at the assumed depression of the sun, we can determine the various aspects which the light ought to assume. Taking, for example, the latitude of Oxford, Mississippi, which may be roughly stated at 34° 30′, it will appear that the summit of the light ought to be in the horizon, when the angle between the ecliptic and the vertical passing through the sun, at the close of twilight, is 18° 4′; and also that the point where the summit is last seen, is distant from the sun, in azimuth, more than 90°. The ecliptic will at this time have an apparent inclination of 17° 9′ to the vertical drawn to its setting point, and this point will differ from the sun in azimuth less than six degrees.

If we take the season when, at the close of twilight, the ecliptic makes the largest angle with the horizon—that is to say, when the vernal equinox is in the western horizon at that moment—the apparent altitude of the extremity of the light should be less than eight degrees*, and this extremity should be 90° distant in azimuth from the sun, while the base should be distant about 42°, making the length of the luminosity, about 48°. Its apparent inclination to the horizon should be 19½ degrees. The ecliptic, in the mean time, will have an apparent inclination of 79° to the horizon, and its setting point will be distant in azimuth from the sun less than four degrees. Upon the supposition we are now considering, the zodiacal light should never be seen in the evening sky in the winter, until the close of January, and it would reach its maximum conspicuousness during the first week in March. It would be too faint however, to be noticeable until probably the middle of February, or later, so that its sensible duration would be but a few weeks.

6.



* That the minimum inclination of the ecliptic to the horizon will occur when the autumnal equinox is setting, and the maximum, when the setting point is the vernal equinox, is perhaps sufficiently evident to require no demonstration. It may be established, however, as follows: If HPR be the western horizon; P, the pole; FAQ, the equator, and Z the zenith: then, if PAE represent the ecliptic intersecting the meridian at E, the equator at A, and the horizon at P, A will be the vernal equinox. Also, the triangle, EPR, will be right angled at R, and the angle at P will be the inclination of the ecliptic to the horizon. ER will be the altitude, and EZ the zenith distance, if the culminating point of the ecliptic. Then,

Cos inclination (EPR) $=$ cos ER $\times$ sin PER $=$ sin EZ $\times$ sin PER. But ZE $=$ ZQ $-$ EQ $=$ latitude minus the declination of the culminating point of the ecliptic. Put I $=$ inclination, L $=$ latitude, D $=$ declination EQ, and E $=$ angle PER; then,

$$\cos I = \sin (L-D) \sin E.$$

And if declination south be regarded as negative, the same formula will express equally the inclination for the position P′E′ of the ecliptic, when A is the autumnal equinox.

$$\text{But, } \sin (L-D) = \sin L \cos D - \cos L \sin D\text{; whence}$$
$$\cos I = \sin L \cos D \sin E - \cos L \sin D \sin E.$$

But, in the triangle AEQ, cos D sin E $=$ cos EAQ ($=$ obliquity of the ecliptic), which put $=$ O; and sin D sin E $=$ sin EAQ sin AQ ($=$right ascension of the culminating point of the ecliptic), which put $=$ A. Then,

$$\cos I = \sin L \cos O - \cos L \sin O \sin A,$$

in which the only variable is A, the right ascension of the culminating point of the ecliptic.

It is manifest that cos I is least, and I greatest, when sin A is at its positive maximum—that is to say, when the R. A. of the point of the ecliptic on the meridian is 90°. In like manner, cos I is greatest, and I least, when sin A is at its negative maximum; or when the R. A. of the same point of the ecliptic is 270°. But in the former case the vernal equinox is on the western horizon, and in the latter the autumnal.

The foregoing formula furnishes a convenient means of ascertaining at what season the ecliptic will have a given inclination to the horizon at a given hour of the day or night; and thus to determine between what limits of time a phenomenon will be observable, whose visibility depends on this inclination. Such an application is made of it a little further on; and it is on this account, and not so much for the sake of the proposition directly demonstrated, that it is introduced here.

It is hardly necessary to point out how entirely different are these results from the facts of observation. If, on the other hand, we suppose the light to be a mere *locus* of brightness, moveable laterally with the observer, then in this latitude, it should never be invisible either in the morning or in the evening sky:—at least, it should never be invisible unless the breadth of the nebulous ring is less than $2 \times 3956 \times \sin 58°$, ($58°$ being the greatest zenith distance of the nonagesimal in this latitude). Its length, when most reduced, ought to exceed $50°$, (supposing it to be $70°$ when vertical, which is the supposition on which the distance was determined,) and consequently it either ought to be very conspicuous always, or it ought to become extinct by growing very gradually narrower and narrower for many days or weeks, without losing in length,—a process which should be very observable, but which yet has never been observed.

One further consideration remains to be added. Whatever may be thought of the probability in regard to a lateral parallax in a case of this kind, no one would think of questioning the fact of a parallax in a longitudinal direction. Now the duration of this phenomenon in the evening sky is entirely too great to be consistent with the supposition that its source is so near to us. If the arc-radius of our horizontal circle is only $17° 14'$, then the preceding limb of the limiting circle will, at the close of twilight, have passed the zenith by $46'$; and it will have to advance but $17° 14' - 46' = 16° 28'$, in order to pass off from the horizontal circle entirely. The total duration of the phenomenon, therefore, up to the vanishing of the last trace of light, should be less than the duration of the preceding twilight—which, in this latitude is in the early part of March, less than an hour and a half. If we consider also that, long before it should entirely set, it would become inconspicuous and probably hardly visible, we shall see that it ought sensibly to disappear very soon after first presenting itself in the evening sky, instead of seeming to partake, as it does, in its descent, of the general motion of the heavens.

It may be said, however, that we ought not to rest our reasonings upon an assumption of so inconsiderable a distance for the ring; since its visibility at midnight, and with the sun depressed $90°$, demonstrates that it must be more distant. I am willing to take the largest distance that can be adduced from any observations; or even a *larger* distance than would be required to satisfy any. We have seen that, if the light were visible in both horizons at midnight, with a vertical altitude of $45°$, it would conduct us to a distance of less than 5000 miles above the earth's surface. Suppose therefore that we adopt 9000 miles as the radius of the ring, or rather, that of its highest visible stratum. The consequence, if in a few particulars more favorable to the hypothesis than before, will in many others, conflict with it even more violently.

It is totally impossible, in short, to admit that the ring can be seen at all at midnight, without being forced to require that it *shall* be seen spanning an immense arch in the heavens, earlier or later in the night. Suppose, for instance, that at the time of the midnight observations of the zodiacal light by Mr. Jones, when the columns appeared in his prime vertical and equal to each other, there had been an indefinite number of observers posted along the great circle of the earth which was coincident at the moment in plane with the ecliptic; all of them, therefore, having the ecliptic vertical. We must be permitted to take it for granted that the luminous columns visible to Mr. Jones would also have been visible to every other such observer, whose horizon did not pass above the illuminated substance whatever it may be, on the one hand, nor approach so near to the sun as to be affected by his light, on the other. And consequently the eastern column must have appeared more extended, to observers east, and the western, to observers west, than they did to Mr. Jones. Now if we take an observer among this number, to whom the sun was but 18° depressed, and assume that the light produced from a ring interrupted by the earth's shadow, and (in the first instance) presenting to one in the position of Mr. Jones, only a trace of brightness in the east and west horizons, then this supposed observer of ours must have seen the light stretching 158° from the horizon on the side of the sun through his zenith, and therefore to a point only 22° above the opposite horizon.

The ecliptic is only vertical in the inter-tropical regions, and I remember no records of the phases of the zodiacal light in those latitudes, made earlier than those of Mr. Jones. Though I have not had the opportunity of examining his diagrams particularly, I think I am correct in presuming that he has recorded no aspect of the light, in which it seemed to pass the zenith. In the latitude of Tuscaloosa, Alabama (33¼°), I have often observed the light when the ecliptic passed within 10° of the zenith, and when the effect of inclination would not have been to reduce the length of the column a single degree; yet I never saw the summit of the brightness approach anywhere near to the meridian.

If we make the radius of the supposed ring 9000 miles, then the maximum apparent length of the arch will exceed 160°, or approach within less than 20° of the opposite horizon. To follow out with greater particularity the consequences of this supposition, we observe that it will make the arc-radius of the circle of the horizon very nearly 64°, and that of the limiting circle, 26°. Assuming that the light is not a mere luminous *locus*, moveable laterally, we shall find that it must always be visible at the close of twilight, so long as the angle between the ecliptic and the vertical passing through the sun is less than 67° 26′; which, the sun being depressed 18°, will make the minimum inclination of the ecliptic to the horizon, at which it can be seen, 28° 34′. Now as the minimum inclination of the ecliptic to the horizon in any latitude (which occurs in the northern hemisphere when the autumnal equinox is on the western horizon) is evidently equal to the co-latitude diminished by the obliquity of the ecliptic to the equator, we may easily ascertain within what limits of latitude the light ought never to be absent from either the evening or the morning sky. For this purpose we have the equation,

$$\text{Co-lat.} - \text{obliq.} = 28° \ 34'.$$

Whence Co-lat. $= 52° \ 2'$, and Lat. $= 37° \ 58'$, or 38° nearly.

At Tuscaloosa, however, which is considerably within this limit, the zodiacal light is very far from being constantly present.

Similar considerations enable us to find a limit beyond which the supposed ring can never be visible. This is obtained from the equation,

$$\text{Co-lat.} + \text{obliq.} = 28° \ 34'.$$

Whence, Co-lat. $= 5° \ 6'$ and Lat. $= 84° \ 56'$, or 85° nearly.

Thus, in favorable positions of the ecliptic, the light should be seen in any latitude not within 5° of the pole.

In the latitude of Oxford, say 34° 30′, the minimum inclination of the ecliptic to the horizon is about 32°. The ecliptic will have this position at the close of twilight, when the sun's longitude is about 144° 20′, the autumnal equinox being in the western horizon at its intersection with the prime vertical. The ecliptic will be inclined 58° to the prime vertical, and 63° to the vertical passing through the sun. These conditions enable us to determine, that under the circumstances least favorble to its visibility, the zodiacal light in this latitude should stretch along the horizon more than 71°, its base being distant from the sun in azimuth nearly 83°, and the extremity reaching to a distance in azimuth from the sun of 154°. The extremity would be elevated only about $1\frac{3}{4}°$, but the middle portion of the arch would approach 6° of altitude. The arch, however, could not be a circle of the sphere, but a spherical conic section. This would be the state of things at the close of twilight, about the end of August, if the light were a reflection from such a ring as we have supposed. We should therefore, at this season and at this hour of the evening, see a brightness in the south and southeast extending nearly a quadrant along the horizon; but rapidly rising and passing over to the west as a greatly inclined pyramid, and finally disappearing, about half an hour after midnight, at a point some 35° from the southern point of the horizon.

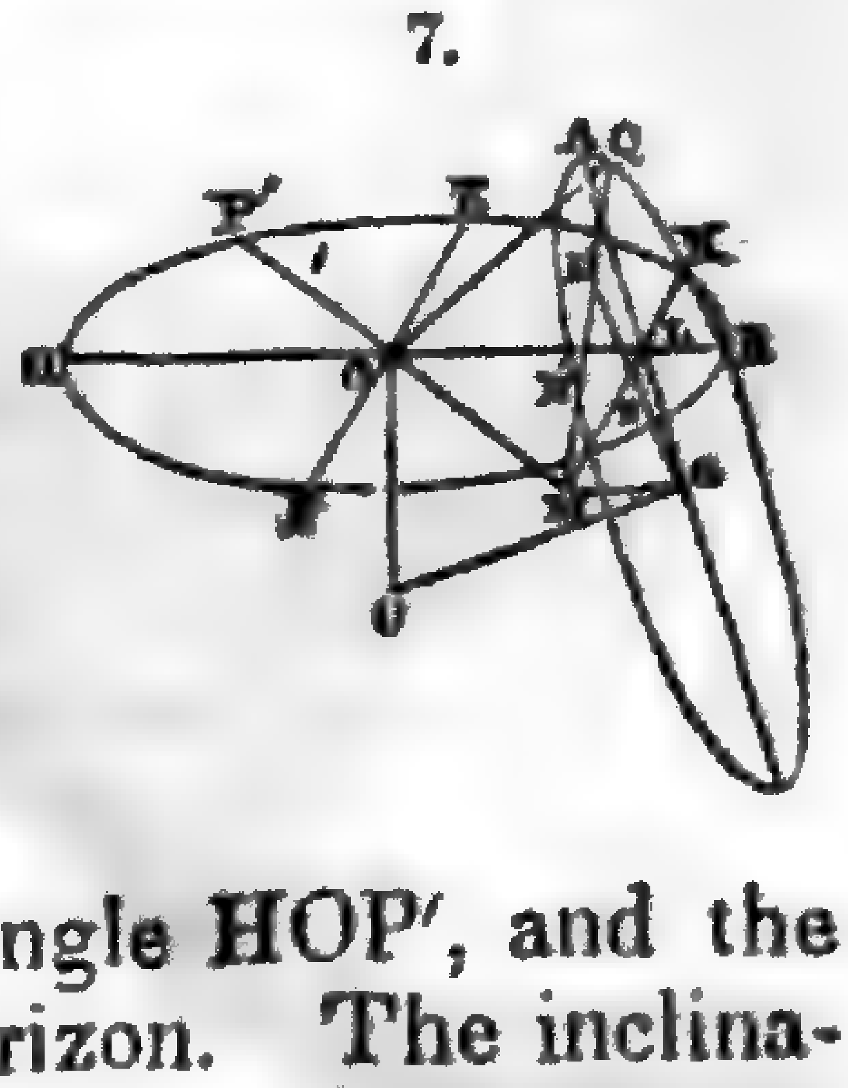
But about $2\frac{1}{2}$ hours before midnight, the other branch should appear. Its apparent length at midnight should be 72°, and the apparent altitude of its summit 21°. At dawn, this arch should have attained a length of more than 108°, and an altitude approaching 66° at its middle point, its inclination to the horizon being about $62\frac{1}{2}$°. Its base should be 26° south of the east point, and $57\frac{1}{2}$° distant in azimuth from the sun. It is evident, therefore, that on this supposition, the light would usually be very far apparently from the ecliptic.

Nor will the case be much improved, if we suppose no lateral parallax to exist; for though, by this means, we may reduce the apparent place of the phenomenon to that in which it is actually observed, by so doing we shall only render the discrepancy between theory and observation, in regard to the conspicuousness and magnitude of the phases, more striking. To investigate this case geometrically, we must suppose a plane passing through the observer's eye, and parallel to the ecliptic, to intersect our imaginary sphere. The intersection will mark the locus of the light. But, if the ring is to be regarded as a hollow cylinder, then as, in the new position of the luminosity, it is a small circle of the sphere, we should, if we aimed at extreme accuracy, increase the radius according to the formula,

$$R = \sqrt{\overline{9000}^2 + \overline{3956 \,.\, \sin Z D}^2},$$

in which R is the radius of our imaginary sphere concentric with the earth; Z D is the zenith distance of the nonagesimal; 9000, the radius heretofore assumed; and 3956 the radius of the earth. With this new value of R, we should calculate again the arc-radii of our two circles of limitation and of the horizon. As, however, the radius already assumed is larger than any which can be deduced geometrically from any observation, and as the error resulting from a neglect of the correction is not in favor of the views taken in this paper, the inquiry will not be unnecessarily complicated by taking account of this circumstance.

7.



In the annexed figure HERF is the circle of the horizon; AKBN, the limiting circle, and P′PMQ the plane of a circle parallel to the ecliptic (of which the circumference is not drawn). Q is the summit of the luminosity, and OQ is the line of its apparent direction from the observer. From the latitude, the sun's place in the ecliptic, and his depression below the horizon, we have no difficulty in finding the angle HOP′, and the inclination of the plane P′OPMQ to the horizon. The inclination of the plane AKBN is equal to the complement of the depression, and the angle OML is the complement of HOP′. O being the centre of the circle of the horizon, and G that of the limiting circle, the depression enables us to find OL, GL. $ML = OL \cdot \tan MOL$; and $GM = \sqrt{GL^2 + ML^2}$. Also, angle GML is easily found. Now the three planes make a solid angle at M, of which one of the containing plane angles (OML) is known, and also two of the inclinations; whence the angles QMO and QML may be ascertained. Also, $GMQ = GML + LMQ$: consequently, if a perpendicular, GL′, be dropped from G on MQ, its length may be found, and also the ordinate QL′, and the line L′M: whence QM is known. OM is found in the triangle OLM: and therefore, in the plane triangle OMQ, we have OM, MQ and the angle OMQ, from which to obtain the angle MOQ. This, and the known inclination of the plane OMQ to the horizon, enable us to determine the apparent altitude of Q.

This method has been applied to determine the aspect of the light as it would, under this supposition, appear in this latitude, at the close of twilight, when the inclination of the ecliptic to the horizon is at its minimum. The arch would follow the course of the ecliptic, from a point on the horizon 31° 20′ distant in azimuth from the vertical passing through the sun, one hundred and forty-one degrees. The highest point of the arch would be 32° above the horizon, and the extremity of the light would have an apparent altitude of 19½°. There would also be a trace of the opposite cusp, rising about 2½° from the horizon. This being the appearance under the circumstances least favorable to visibility, at all other times both cusps ought to be seen, both morning and evening, throughout the year; and one of them ought always to have an enormous length when the sun is within 18° of the horizon.

These results being optical and geometrical necessities consequent upon the hypothesis of a nebulous ring surrounding the earth and illuminated by the sun's light, and being all of them unconfirmed by observation, it seems impossible to arrive at any other conclusion but that the hypothesis is untenable.

We appear, therefore, to be conducted to one and the same conclusion by the application to this theory of four distinct tests; each one of them having no slight independent weight, and all of them combined possessing an irresistible force. The zodiacal light must consequently be regarded as presenting a problem still unsolved. The observations of Mr. Jones, when published, may possibly present some clew to the mystery which has not yet been detected in them. But whatever else they may show, the present writer cannot but believe that they will furnish, in themselves, most conclusive proof, that the luminosity does not reside in any substance physically connected with the earth.

Upon the whole, whatever difficulties may attend the theory which regards the zodiacal light as having its seat in some appendage of the sun, there seems to be as yet no other supposition possessed of greater plausibility.

University of Mississippi, Oxford, Oct. 30, 1855.

Art. XXVII.—*On the Recent Eruption of Mauna Loa;* by Rev. T. Coan.*

It is now ninety-seven days since the great valve opened on the mountain, and still the volcano works with unabated energy, pouring out its floods of fire in ceaseless torrents. Long ago we had expected to witness the molten sea sweeping over our fields, choking our harbor, driving our ships from their moorings and our citizens from their homes. But though the igneous flood still approaches us, its approach is *so slow* that our fears are greatly allayed. Reasoning mathematically, and assuming that the high fountain remain in force, the future terminus of the stream must be the seas; thus it is only a question of *time.*

After returning from the mountain, and having rested and attended to necessary duties, I determined to cut through the jungle to the lower end of the stream. Several natives had been up and reported the fire as making its way toward us, like the dogged and slow approaches of the allies before Sevastopol; but no white man had penetrated the jungle. On the 31st of October Mr. Ritson, an English gentleman, and myself, with three natives, entered "the bush," and beat our way through mud and jungle, until we came to a large and rapid tributary of the stream called Wailuku. Up this stream we wended our way with incredible toil, wading for miles together in water from one to three feet deep and along an uneven bottom of slippery stones, crossing and recrossing scores of times, to avoid rapids, deep basins and cataracts, slipping, falling, and plunging along, and when reaching an impassable basin, rapid, or precipice, crawling up the bank and beating slowly through the wet and entangled jungle, until the obstructions in the stream were passed, and then tumbling down again into its tortuous bed. Thus we urged our toilsome way under a drenching and continuous rain, at the rate of from one half a mile to one or two miles an hour, as obstacles were more or less serious.

* From a letter to Rev. C. S. Lyman, dated Hilo, Nov. 16, 1855. This account is in continuation of that published in the last number, page 139.

So soon as we entered this stream we found it discolored with pyroligneous acid from burning wood, whose odor and taste became more and more positive the farther we advanced up the stream. The discoloration also became more apparent as we proceeded, until the water was almost black. This showed that the lava flow had crossed the head waters of the stream and its small tributaries, consuming the forest and jungle, and sending down what could not be evaporated of the juices to mingle with the stream.

A little before sundown, our guide led us at right angles from the stream we had been threading for six hours, and in a few minutes the fires of the volcano glared upon us through the woods. We were within six rods of the awful flood which was moving sullenly along on its mission towards Hilo. The scene beggared description, and for a moment we stood mute and motionless. Soon, however, we moved on to the verge of the igneous river. Thrusting our poles into the fusion, we stirred it and dipped it up like pitch, taking out the boiling mass and cooling all the specimens we desired. We were on the right or southern verge of the stream, and we also found that we were about two miles above its terminus, where it was glowing with intense radiance and pushing its molten flood into the dense forest which still disputed its passage to the sea.

We judged the stream to be two or three miles wide at this point, and over all this expanse, and far as the eye could see above, and down to the end of the river, the whole surface was dotted with countless fires, both mineral and vegetable. Immense trees which had stood for hours, or for a day, in this molten sea were falling before and below us, while the trunks of those previously prostrated were burning in great numbers upon the surface of the lava. It is impossible to give you any just conception of the scene.

You are aware that the great fire-vent on the mountain discharges its floods of incandescent minerals into a subterranean pipe which extends, at the depth of from 50 to 200 feet, down the side of the mountain. Under this arched passage the boiling fusion hurries down with awful speed until it reaches the plains below. Here the fusion spreads out under a black surface of hardened lava some six or eight miles wide, depositing immense masses which stiffen and harden on the way. Channels, however, winding under this scorified stratum, conduct portions of the fusion down to the terminus of the stream, some 65 miles from its high fountain. Here it pushes out from under its mural arch, exhibiting a fiery glow, across the whole breadth of the stream. Where the ground is not steep and where the obstructions from trees, jungle, depressions, etc., are numerous, the progress is very slow, say one mile a week.

On the evening of our arrival we encamped within ten feet of the flowing lava, and, as before stated, on the southern margin of the stream, some two miles above its extreme lower points. Here, under a large tree, and on a bank elevated some three feet above the igneous flood which moved before us, we kept vigils until morning. During the whole night the scene was indescribably brilliant and terribly sublime. The greater portion of the vast area before us was of ebon blackness, and consisted of the hardened or smouldering flood which had been thrown out and deposited here in a depth of from ten feet to one hundred.

Not only was the lava, as aforesaid, gushing out at the end of this layer, but also at its sides. These lateral gushings came out before and behind us, and two-thirds surrounded our camp during the night, so that in the morning, when we decamped, the fusion was just five feet, by measurement, in front of us, six feet in our rear, and three feet, or the diameter of the trunk of our camp-tree, on our left. The drenching rain and our chilled condition induced us to keep as near the fire as we could bear it. Evening and morning we boiled our tea-kettle and fried our ham upon the melted lavas, and when we left, our sheltering tree was on fire. A large tree fell within ten feet of us during the night. Often, too, would the dried vines, parasites and leaves of immense trees take fire and running up to the height of seventy or eighty feet, throw off countless scintillations which sparkled and glanced amidst the gloom like myriads of fire-flies. But another exhibition exceeded all the rest in interest. At thousands of points on the solidified crust of the stream, the accumulating fusion, fed from above, was swelling and raising this superincumbent stratum into tumuli of endless form and size, and then, bursting open the cone or dome thus raised, either laterally or at the apex, when flowing off for several rods over the old substratum, the stiffening flood became solid. Soon, perhaps, another layer is spread upon this, and thus on indefinitely, until thirty or forty strata may be deposited in succession, raising the whole from a few feet to fifty or one hundred in thickness, and presenting a heaving surface like an agitated sea suddenly solidified. Thus the deposits become enormous, the fusion spending itself, and thus retarding its progress towards Hilo.

The whole breadth of the lava stream lies between the river Wailuku whose course is east, and one of its largest tributaries which flows from the southwest. As we have said, this branch was our route by which we threaded our way to the fires, the lava stream lying within half a mile of its banks, at the place where we left it, and having fallen into its head waters above us. An effort to cut across below the lava stream was made that we might get a more definite idea of its width, that we might obtain a front view of it, and, finally, that we might reach the channel of the Wailuku and descend in it to Hilo, the passage along this stream being much easier than in the branch by which we had reached the fire. Previous to our efforts to cut through the woods from one stream to the other, we had made an attempt to cross directly over *on the lava stream itself.* This we tried first directly from our camp; but failing here, we beat our way through the thicket up the verge of the stream, hoping to find a point where the fires were less active.

At length we made another effort to cross. But the hardened surface of the stream was swelling and heaving at innumerable points by the accumulating masses and the upraising pressure of the fusion below; and valves were continually opening, out of which the molten flood gushed and flowed in little streams on every side of us. Not a square rod could be found on all this wide expanse where the glowing fusion could not be seen under our feet through holes and cracks in the superincumbent stratum on which we were walking. The open pots and pools and streams we avoided by a zigzag course; but as we advanced, these became more numerous and intensely active, and the heat becoming unendurable, we again beat a retreat after having proceeded some thirty rods upon the stream. It may seem strange to many, that one should venture on such a fiery stream at all, but you will understand that the greater part of the surface of the stream was hardened to the depth of from six inches to two or three feet; that the incandescent stream flowed nearly under this crust like water under ice, but showing up through ten thousand fissures and breaking up in countless pools. On the hardened parts we could walk, though the heat was almost scorching, and the smoke and gases suffocating. We could even tread on a fresh stream of lava only one hour after it had poured out from a boiling caldron, so soon does the lava harden in contact with the air. Finding no way to cross the igneous flood, and the rain falling in torrents, our guide admonished us that we must hasten back, as the water course up which we came was rapidly filling. We therefore reëntered the channel at ten A. M., and found the stream so swollen and so grand in its wild rushings and plungings, that it was with the greatest difficulty and danger we effected a retreat. Mercifully we reached home, scorched, smoked, exhausted, and "water-logged."

Nov. 20th.—Three different parties have returned from the fire since this letter was commenced. It has made two miles progress since my return and it is estimated to be within eight miles of the shore. Notwithstanding the winding and difficult way, one can now go up, dip up the fusion, and return the same day.

It is only four hours walk from us, and it might be reached in two hours, were the route direct and the road good. The rate of progress now is about one mile a week. It may come faster when it gets through the forest. Probably six or eight weeks will decide the question whether Hilo shall remain in its verdant robes or be swept with a besom of fire.

Art. XXVIII.—*On Volcanic action at Mauna Loa;* by James D. Dana.

The recent eruption of Mauna Loa, so vividly described by the Rev. Mr. Coan of Hilo, sustains fully the conclusions of the writer in his Expl. Exp., Geological Report; and as those conclusions are, in part at least, at variance with preconceived notions, a review of them will not be out of place. It will probably require many reiterations of the facts, before so magnificent an attendant upon volcanoes as earthquakes shall be allowed to have only an incidental place among the phenomena.

The main conclusions to which I refer, are briefly as follows:—

1. *The quietness of the eruption.*—According to Mr. Coan, the lava has reached in its windings a distance of 65 miles: yet it broke out *without an earthquake;* as in the eruption of 1852 and 1846, a light on the mountains was the first announcement. The progress also has been as quiet as the commencement.

2. *The eruption through opened fissures.*—The craters at summit did not overflow; the mountain was broken through at a height of 12,000 feet—and the fissure or fissures continued down the mountain, the lavas flowing in the fissure at a rapid rate—as they should, with a head, more than 12,000 feet above the sea;—in some places overflowing, and spreading widely, and in others confined to the fissure.

Mr. Coan describing the *appearance*, speaks as if the lavas occupied a channel or covered way. It is obviously impossible that a volcano should open any other channel through its sides than a fissure. The forces are, 1st, the hydrostatic pressure of the lava column in the mountain; and 2nd, the expansive force of vapors arising from the igneous mass below. The fracture produced must be a fissure opening from below upward, or several fissures along a common direction; and the fissure or fissures may extend so as to reach the surface only at intervals, so that the outbreaks shall be more or less interrupted. Thus it has been in all the modern eruptions of Mauna Loa and Kilauea. The idea of a shaft being suddenly struck through, so as to become the conduit of a side crater, and this crater the source of lava of the eruption, is wholly opposed by the facts on Hawaii, as well as by the very nature of volcanic forces. The fractures of such a vast mountain as that of M. Loa—14,000 feet high, and 50 miles in diameter at base, must have their starting point from a depth as far down at least as the water level; and if such a fracture opens so as to make a fissure of a mile anywhere at the surface, it will have many times that length below; moreover, owing to the strain producing such a rupture within, there would probably be several other lines of surface fracture, along the slopes between the first outbreak and the sea.

The lateral cones formed along the line of such an eruption mark the points of widest fracture or the intersections of fractures, and are not the sole sources of the lava.

3. *A volcanic mountain whose average slope is 6° to 7° may have eruptions extending from the summit to the base.*—The three great eruptions of M. Loa directly sustain this fact. Moreover, as Mr. Coan states, while the average slope is 6° to 7°, there are many intervals where the angle is 25° to 30°, and some of 49° and 60° or more, down which the lavas poured, and where they afterwards hardened. We have not however definite statements as to the thickness of the lava stream along these steeper declivities. The facts at least set aside the notion that the lavas of a crater are thrown out at an angle not exceeding 3°, and that a higher angle is a result of elevating forces below at centre, thumping it upward. Elevation by uplifting action beneath is part of the history of every lava cone. But it begins, as the facts in Kilauea prove, with the first formation of the cone, and continues with its progress—growth by overflow and elevation going on together; and if there be any difference, the uplifting action should diminish (instead of decrease,) as the crater loses its original activity.

4. *The basaltic character of the lavas.*—The rock, Mr. Coan states, is similar to that of the other eruptions. Indeed the recent lavas all over Hawaii are much alike; they vary in the amount of chrysolite, but otherwise are quite similar. There are no trachytic or phonolitic lavas, among the modern products, although a true phonolite, almost a porphyry, occurs among the rocks at the very summit of M. Loa, near the central crater.

5. *No lofty cinder ejections.*—Those eruptions of fiery cinders, which mark so strikingly the spiteful Vesuvius are almost wholly wanting about the craters and eruptions of M. Loa. Instead of jets of glowing fragments to a height of one to ten thousand feet as in the Italian volcano, they rise when highest only to three or four hundred feet, and to this height only in connection with the last breathings of some lateral cone attendant upon an eruption.

The idea therefore that the larger the crater the greater the projectile force, is utterly at variance with facts and reason. M. Loa contains material enough for one hundred and twenty-five Vesuviuses: and two thousand feet below its summit it has a thickness of twenty miles,—a massiveness in the great volcano that would seem to fit it for lofty projection towards the celestial regions; and yet it makes out to toss its little cinders a few hundred feet when it does its best. This is not strange, when it is understood that in a boiling fluid, whether lava or anything else, the projectile force of the escaping vapors depends on the viscidity of the fluid, and also the narrowness of the vent above: and where the lavas have the fluidity that enables them to make craters three miles in diameter and mountains fifty miles broad, or the far larger dimensions that are observed in the moon, they must necessarily make a poor fist at throwing stones.

6. *The process of eruption cyclical and not paroxysmal.*—It has been a common opinion that the eruptions of volcanoes depended on some accidental ingress of waters, or formation of vapors. But on Hawaii, both Kilauea and also the central or summit crater of M. Loa show that after an eruption there is a gradual progress in the lavas, until their accumulation and the pressing vapors force another outbreak. The process goes on constantly in regular systematic action: and when the time of outbreak comes, it takes place as if it were in the direct line of operations, and not as an accidental catastrophe.

Kilauea, in 1823, 1832, and 1840, had grand eruptions. In each case, the crater, a thousand feet deep and seven and a half miles in circuit, was filled up, just before the outbreak, four or five hundred feet; and at the eruption, the lavas sunk to the former level: the cauldron had been tapped and to that level emptied.

In 1849, it was again filled, but afterwards became quiet, the lavas sinking away, though without a sinking of the craters bottom. There was evidence in this of a partial eruption, though the fissures did not reach the surface of the island. According to the account by Mr. Coan, Kilauea was again the past year in extraordinary activity: and whether it will this time break through to the surface remains to be seen.

The great central crater of the same mountain pursues a course like that of Kilauea. But it is remarkable that after such an eruption as that of 1852,—when the lavas first broke out at an elevation of 13,500 feet, and then, four thousand feet below, in a magnificent fiery jet of liquid rock, one thousand feet in diameter and three to seven hundred feet high, evidently worked by the head of lava in the central lavas of the mountain—another should have taken place in the same quiet business-like way within three years, breaking out 12,000 feet above the sea.

7. More wonderful than all else connected with M. Loa is the fact of such an outburst of lavas and so free a play of lava foun-

tains at heights of 10,000 to 14,000 feet, when Kilauea on the flanks of the same mountain 6000 to 10,000 feet below, hold its capacious gulf wide open, and heedless, keeps on its boilings and mutterings. A syphon with the fluid lava standing in one leg 10,000 feet higher than the other, and yet without sympathy between the two—the upper at times even playing a jet of 1000 feet diameter and many hundred feet high,—is a strange problem for the geologist. Deny the connection,—and the hypothesis of a communication now existing betwen a modern volcano and the earth's interior fires has but a poor foundation. Admit the connection,—and a mystery remains to be solved.

We may say that a connection exists; and that, as the craters are twenty miles apart, the junction may be at least 100 or 150 miles below; so that the friction or resistance to free motion in the long conduit is not more than counterbalanced by 10,000 feet in height of lava.—Or, we may suppose, as the writer suggests in his Report, that as the aetion causing the eruptions is comparatively superficial or within a depth of a few miles, it being in fact, a rising from developed vapor, as a vessel of fermenting syrup froths over, (as suggested by C. Prevost,) such an action, a kind of inflation, does not necessarily increase much the weight of the column compared with that of its whole length.

Both causes may indeed operate. Still, supposing the lava column of the central crater two miles in diameter at top and that of Kilauea three miles, these being the diameters of the craters, we should naturally infer that the heat and the diameter would increase downward rather than decrease; and that the passage of the syphon would therefore be free. Yet the law of latent heat, by which much more heat is required to produce fusion than the sensible heat of the fused material, makes it possible that a melted mass may be held within a basin made of the same material unmelted, as water in a basin of ice; and it also increases the facility with which the melted mass, be it even the conduit of a volcano, would be encroached upon by the cold rock, the latter congealing it by conduction.

This great question may therefore be regarded as still unsettled. If the thickness of the earth's crust be but thirty miles, as has been sustained on good grounds, it exceeds only one-half the distance between the summit crater of M. Loa and Kilauea; and in that case a connection of the two conduits could hardly take place at all except through the central fluid mass of the globe; for to bring them together within twenty miles of the surface would require a rapidity of convergence between them, which, although possible, cannot be deemed probable.

Art. XXIX.—*Investigations on the Properties of Telluramyl and Selenmethyl;* by F. Wöhler and John Dean.*

[Read before the American Academy, by Prof. Horsford.]

1. *Telluramyl.* $C_{10}H_{11}Te$.

Telluramyl was prepared by a method analogous to that employed in the preparation of tellurethyl; viz., by distilling tellurid of potassium with sulphamylate of lime. The combination is readily formed, though not so easily as in the case of the methyl compound, nor is it attended with so much frothing. By gently heating, yellowish vapors soon form, which condense to yellowish red drops of telluramyl, passing over together with water, under which it sinks. Soon however drops of undecomposed fusel oil are seen to accompany it, and we could not succeed in separating the two completely. The method which gave the nearest approach to success was the following: the mixture of telluramyl and fusel oil was dissolved in concentrated nitric acid, and as the fusel oil dissolved with much difficulty, the greater part of it could be volatilized before going into solution. Sulphite of ammonia was then added, by means of which the telluramyl was reduced and precipitated in oily drops. It was separated from the fluid by distillation. The surface of the telluramyl obtained in this manner was invariably coated with reduced tellurium. Towards the close of the original distillation, a thick, almost solid matter was obtained, of somewhat darker color than the first distillate, which was probably a bitelluret.

Three analyses of different portions of telluramyl obtained as above gave the following results.

C_{10}	44·4	39·5	38·3	36·1
H_{11}	8·1	7·4	8·2	6·9
Te	47·5	37·0	35·4	
	100·0	83·9	81·9	

It is evident from these analyses that the substance analysed was impure.

The carbon and hydrogen of the first analysis agree very closely with the composition of the still unknown tellurbutyl C_8H_9Te which would contain in 100 pts.

C	39·60
H	7·42
Te	52·98

* From an Inaugural Dissertation, On the Organic Compounds of Tellurium and Selenium. By J. Dean, Göttingen, 1855.

The estimated amount of tellurium however differs very widely from this. But if we reckon it from the loss we obtain 53·1 and 53·5 per cent, numbers agreeing very closely with the formula. We can perhaps think that in this compound, only $\frac{2}{3}$ of the tellurium is precipitated, when treated by the general method for the estimation of tellurium. We must further think that under such conditions, butyl C_8H_9 together with C_2H_2 is formed from amyl $C_{10}H_{11}$ which perhaps can occur from the action of the sulphuric acid upon the fusel oil in the preparation of sulphamylate of lime. Whatever this body may be it appears to be separated with the aid of heat into tellurium and the alcohol radical, depositing even when heated in an atmosphere of carbonic acid gas, metallic tellurium in beautiful crystals, and as this decomposition must have already begun during the original preparation, it is easy to see that the product must be mixture of different bodies. At any rate the body which is the chief constituent, is entirely analogous to tellurmethyl and tellurethyl in its reactions, being a radical combining with oxygen, chlorine, etc.

Telluramyl is a reddish yellow liquid heavier than water, of a disagreeable, though somewhat aromatic smell. A portion from the specimen analyzed boiled at 198° C. On exposure to the air it is oxydized, leaving a white residue: distilled in an atmosphere of carbonic acid gas, it deposited a considerable portion of finely crystallized tellurium.

Nitrate.—By the action of nitric acid a yellowish white resinous substance is formed, of a pleasant etherial, aromatic odor, soluble in boiling water, from which a part is deposited in oily drops on cooling: by allowing the remaining solution to stand for several days, the nitrate crystallizes out in clear, transparent, colorless plates. The crystals heated in a closed tube melt and burn with a blue tellurium flame. It fuses at 40° C.

An analysis of the crystals gave 37·8 per cent. of tellurium; had the compound been $C_{10}H_{11}TeO, NO_5$ it would have given 32·56 per cent. The formula $C_{10}H_{11}TeO, HO + C_{10}H_{11}TeO, NO_5$, corresponding to the formula of the sulphate and oxalate of tellurethyl*, gives 36·9 per cent.

Chlorid.—Hydrochloric acid precipitates a clear, colorless, heavy oil, without odor, when added to a solution of the nitrate.

Bromid.—Hydrobromic acid precipitates a clear, pale yellow, heavy oil, without odor.

Iodid.—This is precipitated, on the addition of hydriodic acid or iodid of potassium, in yellow drops which collect together as a dark red oil, heavier than water. Boiled with alcohol it is changed into a pale yellow amorphous powder, without odor, which becomes vermillion red when treated with ammonia, and

* Ann. Chem. Pharm. lxxxiv, 75, 76.

dissolves by heating; on cooling it is deposited again as a vermillion powder, from which nitric acid removes the iodine.

Oxyd.—The chlorine compound, treated with oxyd of silver and water, formed a strongly alkaline solution, depositing chlorid of silver. The solution on being evaporated to a syrupy consistence possessed strong alkaline properties, evolving ammonia from chlorid of ammonium. On the addition of hydrochloric acid the chlorid was formed. Sulphurous acid reduced reddish yellow drops of telluramyl.

Sulphate.—Obtained by treating the oxyd with sulphuric acid: on evaporation the salt crystallizes in groups of small colorless prisms.

2. *Selenmethyl.* C_2H_3Se.

The recent experiments of Joy* upon selenethyl, and those of Wöhler upon tellurethyl† and tellurmethyl‡ induced us to investigate the corresponding compounds of selenium with the radical of methylic alcohol, with a view of establishing more completely the analogy between the organic compounds of selenium and tellurium. We have not succeeded in obtaining compounds analogous to Joy's selenethyl series; but, as will be seen in the following pages, have obtained a series of bodies possessing entirely different properties, being much more closely allied to the compounds of sulphur with the alcohol radicals, than to those of tellurium. It is to be regretted that, owing to the small quantity of material, we had to work with, these experiments are very incomplete; but they appear to be sufficient to indicate that the radical selenmethyl is possessed of very remarkable properties, and will serve to form the groundwork at least of future and more complete investigation.

The method employed in preparing selenid of potassium was the following. Powdered selenium was converted into selenious acid by the action of concentrated nitric acid, the solution evaporated until all the nitric acid was expelled, and a mass of white needle crystals of selenious acid remained sublimed in the flask. The selenious acid was then dissolved in water and saturated with potassa, the solution mixed with finely powdered charcoal, evaporated to dryness, and heated some time in order to expel as much water as possible from the porous mass. The mass was then very gently heated in a glass retort: the reduction took place at quite a low temperature, attended by vivid deflagration spreading itself gradually through the whole mass, which glowed and shrank almost as if fused: so vivid was the deflagration that a small quantity of metallic selenium was lost, going forth from the neck of the retort in copious red vapors. After the retort

* Ann. Chem. Pharm. lxxxvi, 35.
† Ann. Chem. Pharm. lxxxiv, 69.
‡ Ann. Chem. Pharm. xciii, 223.

was quite cold, it was broken, the mass coarsely pulverized and thrown into a flask containing a solution of sulphomethylate of baryta, the flask quickly connected with a Liebig's condensing apparatus, and the solution distilled: the chief difficulty which occurred was from the excessive foaming of the liquid as soon as it was heated which however can be mostly obviated by heating the flask from the sides, and not from the bottom; but notwithstanding all precautions the quantity of foam was so great, that we were obliged to purify the selenmethyl by redistillation. It was unnecessary to fill the flask and other apparatus with carbonic acid gas, as the selenid of potassium does not appear to be as easily oxydizable when exposed to the air as the telluride: care however must be taken to have the apparatus prepared beforehand so as to expose the selenid to the air as little as possible, and the solution must be distilled rapidly at first to expel the air from the apparatus. The selenmethyl appears to be formed in the solution very easily, as its characteristic odor can be perceived almost immediately, and, as soon as the flask is heated, yellow vapors can be seen to form, condensing to clear yellow oil drops on the neck of the flask.

Selenmethyl is a clear, reddish yellow, very mobile fluid heavier than water, with which it is not miscible, of an extremely offensive etherial odor, resembling very much the odor of the tellurium and sulphur compounds of ethyl and methyl: it is easily ignited, burning with a bluish flame: on exposure to the air for some time it is oxydized. It dissolves in cold concentrated nitric acid with great facility, the acid often becoming quite warm from the violence of the reaction. Hydrochloric acid gives no precipitate when added to the acid solution. Sulphurous acid reduces selenmethyl.

If the nitric acid solution be evaporated to the consistence of a syrup, a new reaction takes place, appearing to be a further oxydation of the selenmethyl, attended by a very considerable evolution of nitric oxyd: this evolution becomes at last so violent, that if greater care is not taken in the application of heat, the mass is entirely decomposed with violent deflagration, and production of extremely acrid vapors of an intensely disagreeable and penetrating odor, which are almost insupportable, and attack the eyes with such acridity as to occasion blindness for some minutes.

If proper care be taken however, the oxydation can be carried on slowly until the solution is nearly evaporated to dryness: on cooling, the syrupy mass crystallizes in beautiful colorless groups of needle crystals, which increase in size till the entire mass becomes solid.

These crystals possess strong acid properties, appearing in fact to constitute a new acid.

They are quite deliquescent, very soluble both in hot and cold water and also in alcohol, having a disagreeable odor, and a most disgusting metallic taste which continues for a long time in the mouth. Ignited they burn with a blue selenium flame. Sulphurous acid reduces from their solution selenmethyl. Hydrochloric acid gives no precipitate.

The crystals melt at 122° C., to a clear yellow fluid, which becomes on cooling a yellow crystalline mass: on heating further it deflagrates slightly, burning with a strong, very acrid smell, and attacking the eyes. On heating in a closed tube it is partially decomposed at about the melting point, and a small quantity of yellow oil is volatilized, smelling like selenmethyl: by increasing the heat it is decomposed, and crystals of selenious acid are formed in the cool part of the tube, together with water and drops of a beautiful dark red oil, part of the selenium remaining behind in fused globules.

On dissolving this crystalline body (produced by the action of nitric acid on selenmethyl) in ammonia, a crystalline salt is obtained, from which potassa sets free ammonia.

Silver salt.—The acid, on being mixed in an agate mortar with carbonate of silver, (prepared by precipitating a solution of the nitrate with carbonate of soda, and carefully washing the precipitate,) was immediately acted upon on moistening the mass with water, carbonic acid being evolved in considerable quantity. The mass was then placed upon a filter and washed for a long time with hot water, as the silver salt seems to be soluble with difficulty. By evaporating the solution, beautiful stellate groups of fine colorless and transparent needle crystals are obtained.

This body is probably analogous to the acids obtained by the action of nitric acid upon the sulphids of ethyl and methyl, which have for their formulæ

$$\left.\begin{matrix} C_2H_3O \\ H\,O \end{matrix}\right\} S_2O_4\text{* and } \left.\begin{matrix} C_4H_5O \\ H\,O \end{matrix}\right\} S_2O_4\text{†.}$$

The formula for this acid would accordingly be

$$\left.\begin{matrix} C_2H_3O \\ H\,O \end{matrix}\right\} Se_2O_4\text{—or, } C_2H_4Se_2O_6\,;$$

And that of the silver salt would be

$$\left.\begin{matrix} C_2H_3O \\ AgO \end{matrix}\right\} Se_2O_4\text{—or, } C_2H_3AgSe_2O_6.$$

Several analyses were made from this salt; but we could arrive at no satisfactory results, as in the silver determinations the chlorid of silver was always rendered impure through admixture of selenium or selenid of silver, which appeared to be precipitated

* Kolbe, Ann. Chem. Pharm. liv, 174. † Gerhardt, Traité de Chem. Organ. ii, 287.

with the chlorid, rendering the latter when fused quite black. 0·8825 grm. dried at 100° C. gave 0 5355 grm. chlorid of silver.

0·6597 grm. gave 0·4025 grm. chlorid of silver.

		Found.	
C_2	4·8		
H_3	1·2		
Ag	43·2	45·8	45·9
Se_2	31·6		
O_6	19·2		
	100·0		

These estimations differ somewhat widely from the theoretical formula, and it is to be regretted that lack of material prevented us from making further determinations; but the formula is better established by the analysis of the chlorine compound, which will be presently given. The silver salt heated in a closed tube is very easily decomposed, puffing and burning, forming water, selenious acid and selenid of silver. By continued heating of a solution of the salt even below the boiling point, it is slightly decomposed, depositing metallic silver and selenid of silver. The crystals themselves by drying in the air change color somewhat, like all silver salts, showing a beautiful silvery surface; they are slightly decomposed by continued heating at 100° C., and burn giving off red vapors of selenium at 110° to 120° C.

Baryta Salt.—By neutralizing the acid with ammonia, and adding chlorid of barium to the hot solution, the baryta salt is obtained as a white, crystalline precipitate. From the analysis of this salt we could only conclude, owing to the small quantity we had, that it probably contains two equivalents of baryta to one of the acid.

The great difficulty in the analysis of these salts consists in their easy decomposition by heating, either when dry or in solution. They all possess the same smell and disgusting metallic taste as the acid itself.

Chlorine Compound.—To a solution of the above-mentioned acid hydrochloric acid was added; no precipitate was formed, but by gentle evaporation, beautiful transparent needle crystals were formed: when free nitric acid was present, only an amorphous mass was obtained.

These crystals, which have a strong acid reaction, are probably a simple substitution product, in which one atom of chlorine takes the place of an atom of oxygen, the reaction being as follows:

$$\left.\begin{matrix} C_2H_3O \\ H\ O \end{matrix}\right\} Se_2O_4 + HCl = \left.\begin{matrix} C_2H_3Cl \\ H\ O \end{matrix}\right\} Se_2O_4 + HO.$$

An analysis of the crystallized body, dried over chlorid of calcium, gave the following results:

0·364 grm. of the body gave 0·097 grm. CO_2 and 0·106 grm. HO.

0·684 grm. gave 0·313 grm. of selenium.

0·9788 grm. gave 0·8477 grm. of chlorid of silver.

0·719 grm. gave 0·6035 grm. of chlorid of silver.

		Found.	
C_2	7·0	7·2	
H_4	2·4	3·3	
Cl	20·8	20·7	21·0
Se_2	46·3	45·7	
O_5	23·5	23·1	
	100·0	100·0	

The determination which agrees least with the calculation is that of the hydrogen, which may easily be too great, as the crystals are decomposed under 100° C.

Heated in the air the compound burns with the characteristic blue selenium flame. It melts at 88°—90° C. to a clear, dark brown oil, (being probably partially decomposed,) solidifying on cooling to a dark apparently amorphous mass. Heated in a closed tube it melts and burns, part of the selenium being sublimed as selenious acid, while another portion is reduced and remains behind in fused globules, drops of a yellow oil being also formed.

It is very soluble in water and alcohol, but is apparently not deliquescent; it has quite an unpleasant smell, and most disgusting taste; it gives no precipitate with bichlorid of platinum. Sulphurous acid reduces from its solutions a dark red fluid, apparently heavier and of thicker consistency than selenmethyl, (perhaps biselenmethyl). Hydriodic acid precipitates a dark black oil, an iodine substitution product. The chlorinated product dissolves easily in ammonia, forming a salt, crystallizing in prisms collected together in stellate groups, from which potassa sets free ammonia. Mixed with oxyd of silver and moistened, it is instantly decomposed with violent reaction and evolution of heat, as soon as the water touches it: the mass was then placed upon a filter and washed with hot water; on evaporation crystals were obtained in long fine needles, colorless and transparent, clustered together in thick stellate groups; they are somewhat insoluble in water, and give with hydrochloric acid a precipitate of chlorid of silver. A solution of the salt is somewhat decomposed by heating, depositing a small quantity of silver. Owing to the very small quantity of this salt which we had, we were unable to investigate further its properties. In the form of its crystals and all its physical properties, taste, odor, etc., it closely resembles the silver salt described above (p. 249). This chlorinated product $\left.\begin{matrix}C_2H_3Cl\\ H\ O\end{matrix}\right\} Se_2O_4$ may be another acid forming salts of the formula $\left.\begin{matrix}C_2H_3Cl\\ R\ O\end{matrix}\right\} Se_2O_4$: or $\left.\begin{matrix}C_2H_3Cl\\ H\ O\end{matrix}\right\} Se_2O_4$ may with RO form RCl and regenerate the acid $\left.\begin{matrix}C_2H_3O\\ H\ O\end{matrix}\right\} Se_2O_4$, forming, with the excess of RO present, salts of the simple acid. The latter appears to be the more probable view.

Bromine Compound.—By adding hydrobromic acid to the chlorinated body, a very slight white precipitate is formed, which redissolves on heating: by evaporation, a crystalline substance is obtained, which melts and is probably decomposed considerably under 100° C., forming a black oil resembling bromine: on cooling this hardens to a black semi-crystalline mass, nearly insoluble both in water and alcohol, but somewhat soluble in ether, which dissolves out a substance crystallizing in transparent yellow plates. By adding to the solution of the chlorine compound free hydrobromic acid, and allowing the solution to evaporate by exposure to the air, beautiful, transparent, flat yellow prisms are obtained, which easily decompose by contact with organic substances; from the mother liquor, sulphite of ammonia precipitates a splendid scarlet oily body, together with free selenium. The crystals obtained by spontaneous evaporation are without doubt a substitution bromine compound, probably of the formula $\left.\begin{matrix}C_2H_3Br\\ H\ O\end{matrix}\right\} Se_2O_4$. They are very soluble in ammonia, and form a crystalline salt, from which potassa sets free ammonia.

The bromine compound on heating melts, and burns with the same appearances as the chlorine compound.

Iodine Compound.—On treating the preceding bodies with hydriodic acid or with a solution of iodid of potassium, a precipitate was formed consisting of minute drops of a reddish black oil, which soon collected together forming a very heavy black oil, with a shining greenish metallic luster, of extremely disagreeable odor: it is quite soluble in an excess either of hydriodic acid or iodid of potassium, slightly soluble in water, to which it imparts an orange-yellow color, quite soluble in alcohol: by allowing the alcoholic solution to spontaneously evaporate, it passes off with the alcohol vapors, leaving no residue. On allowing this oily precipitate to stand for some time in a closed tube, part of it appeared to become solid, as if crystals were formed in the oily mass; but I was unable to study their properties.

On one occasion by adding a solution of iodid of potassium to a solution of the first acid, (obtained by the action of nitric acid on selenmethyl,) a precipitate was formed, which redissolved on heating, and by evaporation was obtained in fine red crystals:

we were however unable to obtain the same body again, although the experiment was repeated several times with every precaution, and are therefore unable to conjecture what these crystals were.

The conclusions which the foregoing experiments seem to indicate are as follows:

1st. The continued action of nitric acid on an alcohol radical containing selenium produces, besides a nitrate of the oxyd of the radical, as in the case of selenethyl (according to Joy), and tellurethyl and methyl, a new acid, probably analogous to the acid produced by the continued action of nitric acid on the compounds of sulphur with the radicals ethyl and methyl; the formula of the acid being by analogy $\left.\begin{matrix}C_2H_3O\\HO\end{matrix}\right\}Se_2O_4$, to which the name of selenomethylic acid might be given.

2ndly. The chlorinated product is probably a simple substitution product, in which one atom of chlorine is substituted for one atom of oxygen.

$$\left.\begin{matrix}C_2H_3O\\HO\end{matrix}\right\}Se_2O_4+HCl=\left.\begin{matrix}C_2H_3Cl\\HO\end{matrix}\right\}Se_2O_4+HO$$

The product which Joy obtained,* by allowing chlorid of selenethyl to remain for some time in a solution containing free nitro-hydrochloric acid, is without doubt the corresponding body of the ethyl series. He was unable to obtain these crystals in an arbitrary manner. They appeared to be an acid, forming a crystalline mass with ammonia, which latter was liberated on the addition of potassa. The formula for the corresponding ethyl compound would be $\left.\begin{matrix}C_4H_5Cl\\HO\end{matrix}\right\}Se_2O_4$.

The result of his analysis is as follows:

			Joy.
C_4	13·0	—	13·6
H_6	3·3	—	4·2
Se_2	42·8		
Cl	19·2	—	20.6
O_5	21·7		
	100.0		

3dly. Treatment with hydriodic and hydrobromic acids gives similar products.

4thly. The chlorinated body $\left.\begin{matrix}C_2H_3Cl\\HO\end{matrix}\right\}Se_2O_4$ may either give salts corresponding to the formula $\left.\begin{matrix}C_2H_3Cl\\RO\end{matrix}\right\}Se_2O_4$ or with the oxyd RO may form $\left.\begin{matrix}C_2H_3O\\HO\end{matrix}\right\}Se_2O_4$ and RCl, the original acid

* Ann. Chem. Pharm. lxxxvi, 35.

being regenerated, and forming with the excess of RO, $\left.\begin{matrix} C_2H_3O \\ R\ O \end{matrix}\right\} Se_2O_4$. The latter view seems to be the more probable, as the salts obtained both from the bromine and chlorine bodies were exactly similar in physical properties to the salts of the simple acid.

5thly. In the body obtained by the continual action of nitric acid on selenmethyl, selenium seems to display a close analogy to sulphur; while in the case of the products obtained by Joy from selenethyl there seemed to be also a close analogy between selenium and tellurium: thus selenium appears in its organic compounds of the alcohol series to fulfill the functions both of sulphur and tellurium, and may justly be regarded as the connecting link between these bodies.

Art. XXX.—*Correspondence of M. Jerome Nicklès, dated Paris, January* 5, 1856.

Death of M. Sturm.—Mathematical Science has experienced a great loss in the death of the geometrician Sturm, the author of the theorem which bears his name and which has done so much for the progress of Algebra. Besides a series of memoirs on differential equations and on partial differences, he has also published a memoir on vision, another on optics, important researches on mechanics, and in particular, a remarkable theorem on the variation which force undergoes when a sudden change is given to the parts of a system in motion.

Sturm entered the Institute in the place of Ampère, and in many respects he resembled him. He was, like him, candid, indifferent to the wealth and show of the world, gifted with an inventive mind united with an encyclopedic range of knowledge, neglected or even disdained by those skilled in office seeking, but exerting a high influence over the youth of schools who admire genius, and possessing, without having desired it or hardly knowing it, an immense popularity.

M. Sturm died at the age of 51 years, in consequence of a moral as much as physical malady which for some years has prevented his laboring for the progress of science.

Death of Adrien Chenot.—The fertile inventor, who has often been mentioned in this Journal, the originator of a new system of Metallurgy, which the "Universal Exposition" has rewarded with the grand medal of honor, for an "Ensemble remarquable de faits nouveaux et importtants au point de vue metallurgique, particulièrement pour les procédes économiques appliques au traitement des minerais de fer pour obtenir le métal," has died, just after his triumph, and at the time when he was gathering the fruit of his long labors, and when the prospect of a brilliant future to his family was attaching him most strongly to life.

I mentioned not long since, in giving an account of the toxical effects of carbonic oxyd,* that M. Chenot was the first to try them;

* This Journal, Jan. 7, 1854, p. 120.

that he experimented on himself, and that he had since continued in a sickly febrile condition. His limbs trembled and at times he had fainting turns. A fit took him as he went out upon the balcony of his chamber to take the air. He remained there a moment resting on the balustrade his body inclined a little towards the street; the fit increased instead of diminishing, his strength failed him, and as the balustrade was low, he fell over to the ground, a height of four stories. It was on the 27th of November, 1855. Chenot was 50 years old.

The inventions and discoveries of M. Chenot have a universal importance; and yet they are not known as they merit to be, as he had not the talent of pushing his labors into notice. In 1836 he prepared some of the metals in the spongy state and made known their curious properties. He afterwards applied this property to the treatment of ores and the fabrication of steel, and raised this part of metallurgy from the empiricism in which it had hitherto remained. He pointed out a method of determining which ores are the best for steel, showing that in case of two ores of the same composition, the measure of value was marked by the relative quantity of cement which the metal that the ore affords, will take up without becoming brittle; thus, between the ore of the Ural and that of Elba, the former will imbibe 6 p. c. of carbon, without losing its malleability, while the latter is brittle with only 4 p. c. of carbon. This property of retaining more carbon he attributes to a peculiar earth which has some analogies with alumina and which is found in all ores that furnish good steel. The method of cementation is simple; it is only necessary to plunge the iron sponge into tar, oil, or some other liquid highly carbonised and then heat to fusion.

One consequence of his labors is the application of electricity to the cleaning of iron ores. The machine works automatically, and will separate many tons of ore per day, cleaning it perfectly from the earthy gangue which absorbs so much of the combustible employed in the furnaces.

The reduction of the metallic oxyds by the oxyd of carbon, or by the mixture of this oxyd with hydrogen such as is obtained in decomposing the vapor of water by coal at a red heat, will sooner or later transform the industry of the metals. In treating sulphate of lead by the iron sponge, sulphate of iron is obtained along with lead in the metallic state. By impregnating the iron sponge with boracic acid and heating, excellent steel is obtained which contains no carbon; and steel of another quality is formed by adding the ores of aluminium. Long before the bruit which has been made with regard to this last metal, M. Chenot insisted upon the part which aluminium acts in metallurgy and upon the alloys which it forms with iron.

In Chenot's view, the quality of iron depends more on the region from which it comes than upon the manner of treating the ores; the locality of the ore bed has as much influence on the iron and especially the steel, as that of the vineyard on the wine it affords.

The manufacture of the sponge can be made with all kinds of combustibles; even those which are rejected in other industrial pursuits may be employed. He first sought to normalize combustibles by getting rid of the sulphur, phosphorus, and arsenic, which affect the quality of the iron. This he accomplished by treating the ores with common salt or an alkali. His first attempts date from 1850. In 1851 he made some trials in the Catalan Forges of Ariège. Having been denounced after the events of December, 1851, as a suspicious person by a jealous superintendent of iron works, M. Chenot was taken from his labors and thrown into prison; and this man, so useful, mild, loyal and honest, would have been transported with many other victims to Cayenne, were it not for the intervention of some influential friends.

The purification of combustibles, by means of common salt, has lately been undertaken in England; and it has been stated that in the process the sulphuret of iron is transformed into chlorid of iron which is volatilized and sulphuret of sodium which flows off with the scoria; but this practice is evidently bad, for at a high temperature sulphuret of sodium is decomposed by iron.

Another invention, full of promise, due to M. Chenot, is the application of the hydraulic press to the compression and molding of metallic substances. By compressing the sponges in the cold, he obtained results which dispense with the employment of high temperatures and produce an economy of combustible amounting nearly to 75 per cent. He was convinced that with sufficient force, the moulding of metals in the cold would become almost universal, even for forms the most complicated, and with various combinations of metals whatever art may require, so that copper, iron, steel, gold, silver, etc., may be combined in any way that may be desired.

There are endless applications in the inventions of M. Chenot. Unfortunately, this inventor had not the talent to see his true interests. Instead of exhibiting in his writings the importance of the metallic sponges and their many uses, he indulged in long discursions on the physics of the globe, and in throwing out philosophical views far more appropriate in a special work. In this way he repelled practical men, and Chenot was unnoticed at the London exhibition. He was near being overlooked at the Paris exhibition. But on studying the processes of the method of Chenot, and examining the products, Mr. T. Sterry Hunt from Canada was enabled to exhibit the facts to his colleagues on the jury, and put them in the way of doing justice to a man whose inventions had long been neglected. It is not common that earnest inventors succeed in France. Capitalists of little intelligence prefer to risk their capital on foolish enterprises put in train by men of adroitness and tact. Moreover, Chenot's method was not first appreciated in France. His encouragements came to him from Spain, where for many years, his processes have been in practice. There is a large establishment in Biscay, copied after that of Cléchy la Garenne, which was founded by the Spanish metallurgist, M. Villalonga, who had spent some time in the laboratory of Chenot, and who had studied his system. The journals have not rendered justice to Chenot any more than industrial men, or men of science. To this general silence, the American Journal of Science may claim rightly to be an exception. Men of genius, as more than one example has shown, may be ignored or even contemned in France; and justice has often first come, as in the case of Chenot, through foreigners.

"*Universal Exposition.*"—If the reader will run over the list of laureates of the Paris exhibition, he will find many names which the

American Journal has rendered familiar, as Boutigny, Ruhmkorff, Duboscq, Soleil, Deleuil, Perreaux, Thomas de Colmar, Franchot, Mirand, Dumoncel, Dubrunfaut, Leplay, DeMilly, Aubert and Gerard, Kestner, Silbermann, all of which names attest to the spirit of justice with which we have reviewed the progress of discovery in this journal, and anticipated official honors. Mr. Goodyear has received the Grand Medal of Honor, of the 10th class, for his discoveries and inventions connected with India rubber.

Telegraph across the Mediterranean.—Among the inventors who have received the decoration, there occurs with justice the name of M. Jacob Brett, the maker of the first submarine cable. He had nothing on exhibition, but his brother had brought forward specimens of the cables which had been laid. When the prizes were under discussion, M. Babinet, vice-president of the jury of the 9th class, and as such, member also of the jury of presidents, proposed a reward to M. Brett, stating that he merited the medal of the "Legion d'Honneur." But as the name of John Brett was alone on the catalogue, he received the nomination and was felicitated on the honors he was to receive on the morrow. He called to thank M. Babinet, when the latter perceived the mistake that had been made, and hastened to correct it by substituting the name of Jacob Brett, who was found with some difficulty and drawn out of his retreat in order to be present at the distribution.

John Brett would have been decorated had he not failed in his attempt to lay down the Mediterranean cable. The failure moreover was not his fault. No steamer could be found large enough to take the third section of the Algerian cable, it being 200 kilometers long and weighing more than 1500 tons; and they were therefore compelled to freight a sailing vessel, the *Result*, of 1700 tons burthen. The vessel was ready by the 30th of July, and on the 6th of September it arrived at Cagliari in Sardinia after a violent gale in the Bay of Biscay. On the 24th the *Result* accompanied by the French steamer *le Tartare*, steered for Cape Spartivento, which it reached before night. At 6 A. M. on the 25th, the cable was attached to the shore, and put in connection with the electric telegraph of the land; and at 3 P. M. the laying of the cable commenced. By midnight, 22 miles had been laid. At 3 A. M. the work recommenced and by 9 they communicated with Cagliari, distant 40 miles. The cable had descended to a depth of 1640 meters. But the sailing vessel could make only three miles an hour, and it did not lend itself to the unrolling of the cable whose tension had become enormous from the great depth of submergence: suddenly, the cable broke the stop, and run out with a frightful velocity, three miles slipping off in ten minutes, without any possibility of stopping it, the vessel at the time hardly changing its place. In the run of the last two miles, the coarse wire enveloping the cable gave way and the cable was drawn into knots or bights. The capstan was next set to work, during the 27th to the 29th of September, and 300 fathoms were drawn up, in which only one bight was found. But on the 29th the capstan broke. The sea was tempestuous, and it created general surprise that the cable was strong enough to hold the careering vessel. On repairing the capstan, it was found that the turning around of the vessel had added to the bights in the cable, seven being counted in a length of less than four meters. Moreover the insulation of the wires was no longer perfect. Finally a heavy sea caused the cable to break at the tangled bights, and all hope of recovering the cable then out was given up. A large amount of cable remained on board, and on the 5th of October another beginning was made at Spartivento. They put to sea on the 6th, and worked till ten in the evening, when the sea became exceedingly heavy, and they had to stop. The next day at ten they again commenced; but the sea was rough, and the vessel could make but little headway; and they were forced to so many deviations from their course that it was evident they would not have length enough to reach Galita. Their only course, therefore, was to cut the cable and return and wait for a more propitious season.

Such is the history of this unfortunate undertaking. Mr. Brett would have been successful during the months of January, July or August; but the terms of his engagement would not admit of his waiting, except before an impossibility.

The operation will be taken up anew by the French government; and as they have required that the line should end at Bona, the cable will have to be 200 miles long. Mr. Brett proposes, as a change, that in place of seven conducting wires, the cable should contain only three, which will suffice for the existing necessities of correspondence. The cable will then weigh only five tons per mile in place of twelve; at the same time more care will be expended on its construction. This project is accepted, and the construction of the cable for uniting France and Algiers is going on with all despatch.

Aluminium and Silicium.—The memoir of M. H. Rose on the preparation of aluminium from cryolite has been the means of important improvements in this manufacture. Deville had recognised that with the addition of fluorid of calcium to the bath of the double chlorid of aluminium and sodium, aluminium may be obtained, while it is not possible with the chlorid alone. The fluorids are therefore excellent solvents.

A mixture of alumina and fluorid of sodium wet with fluohydric acid may be decomposed by sodium, and aluminium obtained. A mixture of fluorid of potassium and fluorid of sodium is an excellent solvent. It is very fusible and is capable of dissolving much silica, some titanic acid, and a little alumina. This addition of foreign matter even augments the fusibility and renders the fusion as liquid as water. By the aid of the galvanic pile, silicium may be obtained, which forms an alloy with the electrodes unless they are of platinum.

M. Deville has satisfied himself that alumina is not decomposed by sodium, while silica is decomposed. He has even prepared sodium by bringing together capillary glass and sodium in vapor. But the great difficulty in these experiments is in the nature of the vessels used for the experiments and the alterability of the electrodes. For gas carbon is dissolved rapidly in the baths of fluorids when it is used in the preparation of silicium.

Aluminium is manufactured now on quite a large scale at Amfréville near Rouen. The vapors set free in this process are very noxious, as they consist of chlorid of silicium, chlorid of aluminium, chlorid of sulphur and chlorohydric acid. These are disposed of by interposing in their passage a furnace of lime, heated by an adjoining fire, into which, through the draught of the chimney, come the vapors of the reducing process, and also the flame that heats the limestone.

Alcohol: new mode of manufacture.—The subject of alcohol continues to occupy attention on the European continent, and each improvement is a step towards the time when its manufacture will be wholly independent of the vine or wheat. Already we have arrived so far that on an extensive farm, alcohol is made from beets simply to obtain the pulp of the beets for fattening cattle. A process has just come out which accomplishes this last result completely, and at the same time it is founded on a scientific fact of the highest interest. Observation and invention are both known characteristics of M. Leplay, who is already familiar to our readers for the part he has taken in the manufacture of the sugar of barytes.*

Beets minced up, (or any other vegetable substance containing sugar,) introduced into the juice in fermentation, ferments in its turn; the sugar is transformed into alcohol, which remains behind and is removed by the aid of a current of steam. The process dispenses with rasping the beet and pressing out the juice. The following is the method pursued.

After washing the beets, they are cut in pieces. The form is not unimportant: they should be square, of a centimeter each side and twenty centimeters long, or ribons of three to four centimeters long, one broad and four to five millimeters thick. The beet thus subdivided is placed in the juice of the beet obtained in the ordinary way, and which has undergone a good alcoholic fermentation, taking care to immerse them completely. They are kept in the liquid by a cover, pierced with holes for the escape of carbonic acid set free in the course of the fermentation. But during the process it is necessary to add successively sulphuric acid in sufficient quantity to set free the vegetable acids which are combined with the alkaline bases contained in the beet; without this addition, the fermentation loses its regularity and produces lactic and other acids. If the proportions of sulphuric acid are right, all the sugar will be converted into alcohol. The amount will vary with the character of the soil that produced the beet, a calcareous soil requiring a little more than an argillaceous soil. In the case of the latter, five to five and a quarter litres of sulphuric acid may be added for 2200 kil. of beets. An excess of sulphuric acid injures the fermentation, and for this reason it should not be all added at once, but from time to time as the beets are added.

It is also important to have a constant and uniform relation between the liquid serving as a ferment and the charge of beets. This relation is 2200 kil. of beets to 43 to 45 hectolitres of fermented juice for one fermenting vat containing 80 hectolitres, or two parts of juice to one of sliced beets. When the process has once begun, it goes on with great rapidity and at the end of ten or twelve hours, the sugar in the cellules of the beets is changed to alcohol, so that the cellules contain alcohol in place of sugar. The pieces of the beets do not change form in the process, though they become somewhat less rigid; and the proportion of juice is not essentially changed, and moreover it may serve for use

* This Journal, 1853, p. 103.

several times without any addition of yeast, provided at each operation the right proportions of sulphuric acid have been added. Thus, at the great manufacturing establishment under the direction of M. Leplay at Douvrin (Pas-de Calais), the same juice has been kept in action from Nov. 1, 1854, to the end of April, 1855, and, what is remarkable, the fermentations which took place in November in twenty-four hours, required in April only ten to twelve hours. It should be said, however, that to retain this fermenting quality, he added each week a kilogram of yeast to each vat.

When in winter, the charges of beets are added, the temperature lowers, and it is necessary to restore it again by means of steam to about 25° or 26° C.

To extract the alcohol thus produced, it is only necessary to pass through the mass a current of steam. The apparatus used for this purpose is a cylinder of wood or sheet iron, similar to the black filters (filtres à noir) employed in the sugar refineries. This apparatus has above a cover hermetically closed; and an opening communicating with a worm which is cooled by water; in the lower part there is a diaphragm pierced with holes upon which the heat is thrown. Between this diaphragm and the bottom of the cylinder, there is a void space for receiving the waters of condensation which are formed during the heating of the sliced beets by steam; and in the lower part of this space there is a stop-cock for admitting steam. The steam after entering the space escapes up through the holes among the bits of beet, and heats the whole, setting free the alcohol which passes into the next layer of beets above, and so on from layer to layer, concentrating more and more as it rises through the column of beets three to four meters in height, so that in the end, alcohol of 70° to 80° is obtained. Each bit of beet and even each cellule becomes in this operation an apparatus of rectification, in which are produced the phenomena of condensation of the vapors the more aqueous, and an enrichment of the vapors the more alcoholic: the lower layers of beets thus lose finally all their alcohol, while the upper contain the alcoholic vapor in a high state of purity. The residue of the beet is a pulp retaining all the nutritious parts, even to the soluble salts of potash and soda excepting sugar, which has been turned into alcohol.

In continuing the process, several cylindrical vessels such as have been described, charged with the fermented beet, are placed one over the other, and a communication is established between them, so that the vapors which are given out from the upper part of the first will pass to the lower of the second and so on upward. To prevent the vapors breaking a way among the irregularities of the beets or along the sides, for rapid passage through, there are diaphragms pierced with holes, placed at equal distances in the column, twenty-two centimeters apart; they thus keep up a uniform pressure in the mass and compel the vapors to spread equally. These diaphragms are connected by a bar of iron, secured to the under surface, which also serves to help in lifting out the pulp, which is done at a single operation by means of a crank. The complete apparatus consists of three cylinders arranged either in a curved or straight line; one of the cylinders is always in process of being charged or discharged, while the other two are connected one above the other in such a way that the first is emptying itself when the second is in distillation.

In the largest arrangement of the kind constructed by MM. Leplay and Co., the three cylinders are each 3·40 meters high and 1·42 in diameter. They contain 12 diaphragms. Each charge of a cylinder contains 2,500 to 2,800 kil. of beets. In twenty-four hours, the distillation and emptying of fourteen cylinders may be done, corresponding to 35,000 to 40,000 kil. of beets. Two such apparatuses, distilling 9 million kilograms of beets have been kept in operation at Douvrin during the last harvest. This method has been put in practice also in other parts of France and in Belgium. We have not room for more details; we add only that the residue or pulp is much sought for by those who raise cattle, and the animals eat it with avidity.

It is apparent that the principal merit in the process is in its not requiring the rasp or the press, and its obtaining the alcohol at the first nearly pure. In this way, too, the viscous, acetic or putrid fermentation is avoided, and consequently a vat charged with beets may be kept for fifteen days without loss or injury, while in the fermentation of the juice an alteration often takes place even in twenty-four hours.

Bibliography.— Visite à l'Exposition Universelle de Paris in 1855, par MM. Tresca, Peligot, Silbermann, etc., 1 vol. in 12 mo. Paris: chez Hachette.—We have neither time nor space for describing the Exhibition at Paris; but there is here a book costing only 3 francs, giving an account of each object exhibited, and a history of each invention. The names of the authors guarantee exactness and fidelity in all facts and details.

Precis de Chemie Industrielle, par A. Payen, 3d edit., in 1 vol. 8vo., of 1070 pages, with an atlas. Paris: chez Hachette.—Since the publication of the first edition of this work, all the technological journals have drawn freely from its pages; for as Professor of Chemistry in the Conservatory of Arts and Trades at Paris, M. Payen is in the way to know better than any one else in France, all that relates to the newest results in industrial chemistry in his own and other countries. Two editions have successively been exhausted within a short time. The third was called for, and the Paris Exhibition has enabled the author to give it greater completeness. It contains special details upon caoutchouc, gutta percha, illuminating gas, manufacture of paper, chemical matches, starch, sugar, artificial soda, the fatty bodies, sulphuric acid, phosphorus, etc. etc.

Des Substances Alimentaires, by M. Payen, in 12mo. Paris: price three francs.—This work written for the people and for artisans who have little knowledge of chemistry, is especially interesting for the methods which it gives for improving articles of food, preserving them, or detecting adulterations, etc.

Leçons de Chémie générale élémentaire, par M. Cahours, 2 vols. in 12mo. Paris: chez Mallet-Bachelier.—These lessons are arranged after the lectures which M. Cahours delivers at the "Ecole Centrale des Arts et Metiers" as successor to Dumas. A clear, simple and methodical style characterises this small work, in which we recognise the able instructions of M. Dumas, worked up by one of the most distinguished of his students.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Effect of Chlorine in Coloring the Flame of Burning Bodies;* by D. Forbes, F.G.S., F.C.S., A.I.C.E., (L., E. and D. Phil. Mag., xi, 65.)—A considerable time back, while examining some saline minerals for boracic acid, and employing the usual test as to the power of coloring flame green, when treated with sulphuric acid and alcohol, it was found that a green flame presented itself, very similar to that which would be expected in case boracic acid were present in the minerals. On the most careful examination, however, no traces of boracic acid could be detected, and it was evident that the coloration of the flame must have proceeded from some other source.

As chlorine was present in considerable amount in the minerals in question, it became interesting to see whether its presence might have produed the green color; and the experiments made on the subject fully confirmed this view. A number of other experiments on the power possessed by chlorine to color flame, led to the following conclusions, which are stated briefly, as the results themselves sufficiently explain the *modus operandi.*

Chlorids treated with concentrated sulphuric acid and a very small amount of alcohol produced green flames similar to those eliminated from borates under like treatment. Quantitatively, however, the flames were of less intensity; that is, the same weight of a borate would produce considerably darker green flames than when a chlorid was used.

When chlorids were moistened with sulphuric acid and heated in the blowpipe flame, a faint green coloration was observed, which generally confined itself to the inner flame.

When hydrochloric acid is dropped cautiously on the flame of burning alcohol, a greenish tinge is observable.

A jet of chlorine or of hydrochloric acid gas directed upon the flame of a spirit-lamp or of coal-gas. produces a jet of green flame; this was also found to be the case when (by means of a convenient burner) chlorine gas was passed into the centre of a flame of burning coal-gas, or of vapor of alcohol.

When burning alcohol was injected into a globe filled with chlorine gas, the alcohol vapor continued burning at the mouth of the globe with a very flickering but often brilliant green flame.

From the above experiments, it will be seen that chlorine has in itself a decided coloring action on the flames of burning bodies, which may consequently in some cases lead to its being confounded with boron, as the green color imparted to flame has hitherto been regarded as a most characteristic test of the latter element. When, as often happens, chlorine and boron occur together, this test consequently becomes nearly valueless.

2. *On some points of Magnetic Philosophy;* by Prof. Faraday, D.C.L., F.R.S., (Proc. Roy. Inst. of Great Britain, Jan. 1855, p. 6.)—The magnetic and electric forms of power being dual in their character, and

also able to act at a distance, will probably aid greatly in the development of the nature of physical force generally: and if (as I believe) the dualities are essential to the forces, are always equal and equivalent to each other, and are so mutually dependent, that one cannot appear, or even exist, without the other, the proof of the truth of such conditions would lead to many consequences of the highest importance to the philosophy of force generally. A few brief experiments with the electric power quickly place the dual cases before the contemplative mind. Thus, if a metallic vessel, as an ice-pail, be insulated and connected with a delicate gold leaf electrometer, or other like instrument, and then an insulated metallic globe, half the diameter of the ice-pail, be charged with positive electricity and placed in the middle of the pail, the latter being for the moment uninsulated by a touch outside, and then left insulated again, the whole system will show no signs of electricity externally, nor will the electrometer be affected: but a carrier applied to the ball within the vessel will bring away from it positive electricity, showing its particular state of charge; or being applied to the lower inside surface of the vessel will bring away negative electricity, proving that it has the contrary state: or the duality may be proved by withdrawing the ball, when the vessel will show itself negative by the electrometer, and the ball will be found positive. That these dualities are equal, is further shown by replacing the ball within the vessel, observing the electrometer, bringing the ball and vessel in contact, and again observing the electrometer, which will remain unchanged; and finally withdrawing the ball, which comes away perfectly discharged, and leaves the vessel externally in its unchanged and previous state. So the electric dualities are equal, equivalent, and mutually sustained. To show that one cannot exist alone, insulate the metallic vessel, charge it strongly by contact with the machine or a Leyden jar, and then dip the insulated ball into it; and after touching the bottom of the vessel with the ball, remove it, without touching the sides: it will be found absolutely free from charge, whatever its previous state may have been; for none but a single state can exist at the bottom of such a metallic vessel; and a single state, *i. e.*, in an unrelated duality, cannot exist alone.

The correspondent dualities, *i. e.*, the northness and the southness of the magnetic force are well known. For the purpose of insulating, if possible one of these, and separating it in any degree from the other, numerous experiments have been made. Thus six equal electro-magnets, formed of square bars, were put together in the direction of three lines perpendicular to each other, so that their inner ends, being all alike in polarity, might inclose a cubical space and produce an experimental chamber. When excited, these magnets were very powerful in the outer direction, as was found by nails, filings, spirals, and needles; but within the chamber, walled in on every side by intense north poles, there was no power of any kind: filings were not arranged; small needles not affected, except as they by their own inducing powers caused arrangement of the force within; revolving wire helices produced no currents: the chamber was a place of no magnetic action. Ordinary magnetic poles of like nature produced corresponding results. A single pole presented its usual character, attracting iron, repelling bismuth; a like pole, at right angles to it, formed a re-entering angle, and there a weak pole of magnetic action was caused; iron was attracted from it to the prominent corners; bismuth moved up into it; and a third like pole on the opposite side made the place of weak force still weaker and larger; another pole or two made it very weak; six poles brought it to the condition above described. Even four poles, put with their longer edges together, produced a lengthened chamber with two entrances; and a little needle being carried in at either entrance passed rapidly through spaces of weaker and weaker force, and found a part in the middle where magnetic action was not sensible.

Other very interesting results were obtained by making chambers in the polar extremities of electro-magnets. A cylinder magnet, whose core was 1·5 inches in diameter, had a concentric cylindrical chamber formed in the end, 0·7 in diameter, and 1·3 inches deep. When iron filings were brought near this excited pole, they clung around the outside, but none entered the cavity, except a very few near the outer edge. When they were purposely placed inside on a card they were quite indifferent to the excited pole, except that those near the mouth of the chamber moved out and were attracted to the outer edges. A piece of soft iron at the end of a copper wire was strongly attracted by the outer parts of the pole, but unaffected within. When the chamber was filled with iron filings and inverted, the magnet being excited, all those from the bottom and interior of the chamber fell out; many, however, being caught up by the outer parts of the pole. If pieces of iron, successively increasing from the size of a filing to a nail, a spike, and so on to a long bar, were brought into contact with the same point at the bottom of the inverted chamber, though the filing could not be held by attraction, nor the smaller pieces of iron, yet as soon as those were employed which reached to the level of the chamber mouth, or beyond it, attraction manifested itself; and with the larger pieces it rose so high that a bar of some pounds weight could be held against the very spot that was not sufficient to retain an iron filing.

These and many other results prove experimentally, that the magnetic dualities cannot appear alone; and that when they are developed they are in equal proportions and essentially connected. For if not essentially connected, how could a magnet exist alone? Its power, evident when other magnets, or iron, or bismuth is near it, must, upon their removal, then take up some *other form*, or exist *without action*: the first has never been shown or even suspected; the second is an impossibility, being inconsistent with the observation of force. But if the dualities of a single magnet are thrown upon each other, and so become mutually related, is that in right lines through the magnet, or in curved lines through the space around? That it is not in right lines through the magnet (it being a straight bar or sphere) is shown by this, that the proper means as a helix round the magnet, shows that the *internal* disposition of the force (coercitive or other) is not affected when the magnet is exerting its power on other magnets, or when left to itself (*Experimental Researches*, 3119, 3121, 3215, &c.); and like means show that the *external* disposition of the force is so affected: so that the force in right lines through the magnet does not change under the circumstances, whilst the force in external (and necessarily) curved lines does.

The polarity of bismuth or phosphorus in the magnetic field is one point amongst many others essentially dependent upon, and highly illustrative of the nature of, the magnetic force. The assumption that they have a polarity the reverse of that of paramagnetic bodies involves the consequence, that northness does not always repel northness or attract southness; or else leads to the assumption that there are two northnesses and two southnesses, and that these sometimes associate in pairs one way, and at other times in the contrary way. But leaving the assumptions and reverting to experiment, it was hoped that a forcible imitation of the imagined state of bismuth in the magnetic field, might illustrate its real state, and, for this purpose, recourse was had to the indications given by a moving conductor. Four spheres of copper, iron, bismuth, and hard steel have been prepared, and rotated upon an axis coincident with the magnetic axis of a powerful horse-shoe magnet; each sphere has a ring of copper fixed on it as an equator, and the ends of a galvanometer wire were brought into contact with the axis and the equator of the revolving globe. Under these circumstances, the electric current produced in the moving globe was conveyed to the galvanometer, and became the indicator of the magnetic polarity of the spheres; the direction of rotation, and the poles of the magnet, being in all cases the same. When the copper sphere, as a standard, was revolved, deflection at the galvanometer occurred in a certain direction. When the iron sphere replaced the copper and was revolved, the deflection at the galvanometer was the same. When the bismuth sphere was employed, the deflection was still the same:—and it still remained the same when the steel sphere was rotated in the magnetic field. Hence, by this effect, which I believe to be a truthful and unvarying indication of polarity, the state of all the spheres was the same, and therefore the polarity of the magnetic force in the iron, copper, and bismuth, in every case alike (*Exp. Res.* 3164, &c.). The steel sphere was then magnetized in the direction of its axis, and was found to be so hard as to retain its own magnetic state when in a reverse direction between the poles of the dominant magnet, for upon its removal its magnetism remained unchanged. Experiments were then made in a selected position, where the dominant magnet force was not too strong —(a magnet able to lift 430 lbs. was used)—and it was found that when the steel magnet was placed in accordance, *i. e.*, with its north pole opposite the south pole of the dominant magnet, the deflection was in the same direction as with the bismuth sphere: but when it was changed so as to be in the magnetic condition assigned by some to bismuth (*i. e.* with reversed polarities), it then differed from bismuth, producing the contrary deflection.

It is, probably, of great importance that our thoughts should be stirred up at this time to a reconsideration of the general nature of physical force, and especially to those forms of it which are concerned in actions at a distance. These are, by the dual powers, connected very intimately with those which occur at insensible distances; and it is to be expected that the progress which physical science has made in latter times will enable us to approach this deep and difficult subject with far more advantage than any possessed by philosophers at former periods.

At present we are accustomed to admit action at sensible distances, as of one magnet upon another, or of the sun upon the earth, as if such admission were itself a perfect answer to any enquiry into the nature of the physical means which cause distant bodies to affect each other; and the man who hesitates to admit the sufficiency of the answer, or of the assumption on which it rests, and asks for a more satisfactory account, runs some risk of appearing ridiculous or ignorant before the world of science. Yet Newton, who did more than any other man in demonstrating the law of action of distant bodies, including amongst such the sun and Saturn, which are nine hundred millions of miles apart, did not leave the subject without recording his well-considered judgment, that the mere attraction of distant portions of matter was not a sufficient or satisfactory thought for a philosopher. That gravity should be innate, inherent, and essential to matter, so that one body may act upon another at a distance through a vacuum, without the mediation of anything else, by and through which their action and force may be conveyed from one to another, is, he says, to him a great absurdity. Gravity must be caused by an agent, acting constantly according to certain laws; but whether this agent be material or immaterial he leaves to the consideration of his readers. This is the onward looking thought of one, who by his knowledge and like quality of mind, saw in the diamond an unctuous substance coagulated, when as yet it was known but as a transparent stone, and foretold the presence of a combustible substance in water a century before water was decomposed or hydrogen discovered: and I cannot help believing that the time is near at hand, when his thought regarding gravity will produce fruit: and, with that impression, I shall venture a few considerations upon what appears to me the insufficiency of the usually accepted notions of gravity, and of those forces generally, which are supposed to act at a distance, having respect to the modern and philosophic view of the conservation and indestructibility of force.

The notion of the gravitating force is, with those who admit Newton's law, but go with him no further, that matter attracts matter with a strength which is inversely as the square of the distance. Consider, then, as a mass of matter (or a particle), for which present purpose the sun will serve, and consider a globe like one of the planets, as our earth, either created or taken from distant space and placed near the sun as our earth is;—the attraction of gravity is then exerted, and we say that the sun attracts the earth, and, also, that the earth attracts the sun. But if the sun attracts the earth, that force of attraction must either arise *because* of the presence of the earth near the sun; or it must have *pre-existed* in the sun when the earth was not there. If we consider the first case, I think it will be exceeding difficult to conceive that the sudden presence of an earth, ninety-five millions of miles from the sun, and having no previous physical connection with it, nor any physical connection caused by the mere circumstance of juxtaposition, should be able to raise up in the sun a power having no previous existence. As respects gravity, the earth must be considered as inert, previously, as the sun; and can have no more inducing or affecting power over the sun than the sun over it: both are assumed to be *without* power in the beginning of the case;—how then can that power arise by their mere approximation or co-existence? That a body without force should raise up force in a body at a distance from it, is too hard to imagine; but it is harder still, if that can be possible, to accept the idea when we consider that it includes the *creation of force.* Force may be opposed by force, may be diverted, directed partially or exclusively, may even be converted, as far as we understand the matter, disappearing in one form to reappear in another; but it cannot be created or annihilated, or truly suspended, *i. e.*, rendered existent without action or without its equivalent action. The conservation of power is now a thought deeply impressed upon the minds of philosophic men; and I think that, as a body, they admit that the creation or annihilation of force is equally impossible with the creation or annihilation of matter. But if we conceive the sun existing alone in space, exerting no force of gravitation exterior to it; and then conceive another sphere in space having like conditions, and that the two are brought towards each other; if we assume, that by their mutual presence each causes the other to act,—this is to assume not merely a creation of power but a *double creation*, for both are supposed to rise from a previously inert to a powerful state. On their dissociation they, by the assumption, pass into the powerless state again, and this would be equivalent to the *annihilation* of force. It will be easily understood, that the case of the sun or the earth, or of any one of two or more acting bodies, is reciprocal;—and also that the variation of attraction, with any degrees of approach or separation of the bodies, involves the same result of creation or annihilation of power, as the creation or annihilation (which latter is only the total removal) of either of the acting bodies would do.

Such, I think, must be the character of the conclusion, if it be supposed that the attraction of the sun upon the earth arises *because* of the presence of the earth, and the attraction of the earth upon the sun, because of the presence of the sun: there remains the case of the power, or the efficient source of the power, having pre-existed in the sun (or the earth) *before* the earth (or the sun) was in presence. In the latter view it appears to me that, consistently with the conservation of force, one of three sub-cases must occur: either the gravitating force of the sun, when directed upon the earth, must be removed in an equivalent degree from some other bodies, and when taken off from the earth (by the disappearance of the latter) be disposed of on some other bodies;—or else it must take up some *new* form of power when it ceases to be gravitation, and consume some other form of power when it is developed as gravitation;—or else it must be *always* existing around the sun through infinite space. The first sub-case is not imagined by the usual hypothesis of gravitation, and will hardly be supposed probable: for, if it were true, it is scarcely possible that the effects should not have been observed by astronomers, when considering the motions of the plants in different positions with respect to each other and the sun. Moreover, gravitation is not assumed to be a dual power, and in them only as yet have such removals been observed by experiment or conceived by the mind. The second sub-case, or that of a new or another form of power, is also one which has never been imagined by others, in association with the theory of gravity. I made some endeavors, experimentally, to connect gravity with electricity, having this very object in view (*Phil. Trans.* 1851, p. 1); but the results were entirely negative. The view, if held for a moment, would imply that not merely the sun, but all matter, whatever its state, would have extra powers set up in it, if removed in any degree from gravitation; that the particles of a comet at its perihelion would have changed in character, by the conversion of some portion of their molecular force into the increased amount of gravitating force which they would then exert; and that at its aphelion, this extra gravitating force would have been converted back into some other kind of molecular force, having either the former or a new character: the conversion either way being to a perfectly equivalent degree. One could not even conceive of the diffusion of a cloud of dust, or its concentration into a stone, without supposing something of the same kind to occur; and I suppose that nobody will accept the idea as possible. The third sub-case remains, namely, that the power is always existing around the sun and through infinite space, whether secondary bodies be there to be acted upon by gravitation or not: and not only around the sun, but around every particle of matter which has existence. The case of a constant necessary condition to action in space, when as respects the sun the earth is *not* in place, and of a certain gravitating action as the result of that previous condition when the earth *is* in place, I can conceive, consistently, as I think, with the conservation of force: and I think the case is that which Newton looked at in gravity; is, in philosophical respects, the same as that admitted by all in regard to light, heat, and radiant phenomena; and (in a sense even more general and extensive) is that now driven upon our attention in an especially forcible and instructive manner, by the phenomena of electricity and magnetism, because of their dependence on dual forms of power.

II. Geology.

1. *Description of the Fossils and Shells collected in California;* by Wm. P. Blake, Geologist of the U. S. Pacific Railroad Survey in California, under the command of Lieut. R. S. Williamson, in 1853–54. 34 pp. 8vo. War Department, Washington, 1855.—The explorations of the Rocky Mountains and Western America by the Pacific Railroad Expeditions have brought in large contributions to science in its various departments, and it is most gratifying to know that they are to be published with full details and figures. The important pamphlet here referred to gives in brief some of the geological results in anticipation of the final Report. The facts are of special interest to the science, and we cite the general conclusions.

Report of Mr. T. A. Conrad on the Fossil Shells collected in California by Wm. P. Blake.—I have examined the very interesting organic remains which you collected in California, and the drawings of such species as were too fragile to preserve, and I herein submit a few remarks upon their geological relations. There appear to be several distinct groups; but I cannot pretend, from such scanty materials, to designate what particular formation every group represents. There is no obscurity resting on the deposits of Santa Barbara and San Pedro, which represent a recent formation, in which you inform me the remains of the mammoth occur. The shells are generally those which live in the adjacent waters, and indicate little if any change of temperature since their deposition. The littoral character of this formation is very evident. Water-worn shells and fragments show the action of the surf, whilst entire specimens of bivalves, and Pholadidæ, and Saxicavæ, remaining undisturbed in their self-excavated domicils, exhibit the same disposition of marine shells that is familiar to the observer on all sandy and argillaceous shores. They burrow in clay, mud or sand, beyond the ordinary action of the surf; whilst some are scooped out by the tempest-driven surge, and others preyed upon by fishes and marine animals of various kinds, and are thus broken up and deposited among the living species.

Of the Eocene, and the recent formation alluded to, I can speak with confidence; but the intermediate beds are of uncertain age. The *Ostrea vespertina*, *Anomia subcostata* and *Pecten vespertinus*, occurring in the bank of Carizzo creek, are unlike any recent forms that I am acquainted with from the Pacific coast, but analogous to Miocene species of Virginia. This formation may, therefore, be regarded as of Miocene origin—an opinion in which I am confirmed by some fossils collected in California, by Dr. Heermann, consisting of decidedly Miocene forms; a *Mercenaria*, (*M. perlaminosa*,) Con., scarcely differing from a species of Cumberland county, N. J., (*M. Ducatelii*, Con.), a *Cemoria*, *Pandora* and *Cardita* of extinct species, closely analogous to Miocene forms. I am inclined, also, to refer to this period a very different group from Ocoya creek, the forms of which you sketched in California, as the specimens were too friable to be preserved. I do not recognize any recent species among them, nor any contained in an Eocene deposit.

The rock at San Diego is replete with shells, generally of a small size, and appears to have a certain palæontological relation to those of Monterey, Carmello, and those from the rocks near Astoria in Oregon, collected by Townsend, and Dana, which I have referred to the Miocene period. Two species of San Diego, if not identical, approach Oregon shells; *Nucula decisa* is similar to *N. divaricata*, and both, in their markings, resemble *N. Cobboldii* of the English Miocene. *Mactra Diegoana* is nearly related to the Oregon *M. alboria*.

The Eocene period is unequivocally represented by the beautifully perfect shells from the Cañada de las Uvas, which, though not found in situ, are evidently derived from strata occurring on the Pacific slope of the Sierra Nevada. This is very remarkable, inasmuch as three species correspond with forms of Claiborne, Alabama, and seem to indicate a connexion with the Atlantic and Pacific oceans during the Eocene period. The vast distance between the two localities will account for the general distinction of species, and it was, indeed, an unexpected result to find any identical. If I had imagined any eastern species to occur in California, it would have been the very one which does occur, and, apparently, in abundance, that "finger-post" of the Eocene, *Cardita planicosta*, a fossil of the Paris basin, and also abundant in Maryland, Virginia, and Alabama. This species originated and perished in the Eocene period, and is so widely distributed that it may be regarded as the most characteristic fossil of its era. As the boulder from which these shells were derived was quite small, and yet furnished thirteen species, when it shall be investigated in situ, doubtless a great many other forms will be obtained, and very likely some with which we are already familiar in eastern localities. Although the rock is a very hard sandstone, the shells may be exposed in great perfection by careful management, and we look forward with great interest to their further development, and to the discovery of the rock in situ.

List of Species.—[Species not new are marked with an asterisk; all are Conrad's except Natica gibbosa and Anodonta Californiensis of Lea, Cardita planicosta, and Fissurella crenulata of Sowerby.]

(1.) Eocene.—Cardium linteum, Dosinia alta, Meretrix Uvasana, M. Californiana, Crassatella Uvasana, C. alta, Mytilus humerus, Cardita planicosta,* Natica œtites, N. gibbosa,* Turritella Uvasana, Volutatithes Calforniana, Busycon ? Blakei, Clavatula Californica.

(2.) Miocene and recent formations.—Cardium modestum, Nucula decisa, Corbula Diegoana, San Diego; Meretrix uniomeris, Monterey county; M. decisa, Ocoya creek; M. Tularana, Tulare valley; Tellina Diegoana, San Diego; T. congesta, Monterey, Carmello, and San Diego; T. Pedroana, San Pedro; Arca microdonta, Tulare valley ?; Tapes diversum,* Saxicava abrupta, Petricola Pedroana, Schizothœrus Nutalli, San Pedro; Lutraria Traskei, Carmello; Mactra Diegoana, San Diego; Modiola contracta, Monterey county; Mytilus Pedroanus, San Pedro; Pecten Deserti, Anomia subcostata, Ostrea vespertina, O. Heermanni, Colorado desert; Penitella spelæum, San Pedro, (recent); Fissurella crenulata,* San Pedro; Crepidula princeps, Santa Barbara; Natica Diegoana, Trochita Diegoana, San Diego; Crucibulum spinosum, —— ?; Nassa interstriata, N. Pedroana, Strephona Pedroana, Littorina Pedroana, San Pedro; Stramonita petrosa, Tulare valley; Gratelupia mactropsis, Meretrix Dariena, Tellina Dariena, Isthmus of Darien; Natica Ocoyana, N. geniculata, Bulla jugularis, Pleurotoma transmontana, P. Ocoyana, Scytopus Ocoyanus, Turritella Ocoyana, Colus arctatus, Tellina Ocoyana, Pecten Nevadanus, P. catilliformis, Cardium —— ? Arca —— ? Solen —— ? Dosinia —— ? Venus —— ? Cytherea decisa ? Ocoya or Posé creek; Ostrea —— ? Pecten —— ? Turritella biseriata, San Fernando; Trochus —— ? Turritella —— ?, Benicia; Buccinum interstriatum ? Olivia Pedroensis, San Pedro; Anodonta Californiensis,* Colorado desert.

Remarks in conclusion, by W. P. Blake.—From this report by Mr. Conrad, we find that in the collection of sixty-one determinable species, fifty-five are new and are now described for the first time. Of these, ten are from one locality at the southern extremity of the Tulare valley, at the entrance to the pass called the Cañada de las Uvas. They are considered to be of the age of the Eocene by Mr. Conrad, who notes the similarity between three of the species and those of the Alabama Eocene deposits at Claiborne. These fossils were imbedded in a boulder of compact sandstone that had been washed out of the ravine of the pass by floods. The rock was not found *in situ* at that point, but a few miles to the westward a similar rock occurs in place, and is replete with fossils. These are believed to be the first fossils of the Eocene age that have been procured from the Pacific slope of the United States.

The sedimentary formations of Ocoya creek (Posé creek) are considered to be of the age of the Miocene, and twelve new species from that locality are described. There were numerous specimens of other species in the collection, which were not sufficiently characteristic for determination, but which are probably new. Eight new species of Miocene shells are described from San Diego, and ten of a more recent formation from San Pedro. These last occur in a bank fronting the bay, and which is partly undermined by the surf. The bank is filled with shells, and the principal stratum is about 30 feet above tide.

The fossils from the sandstones along Carrizo creek, near the point where it spreads out and is lost in the desert, are all new and of Miocene age.

The Miocene formation appears, therefore, to flank the Peninsula Sierra on both sides in the latitude of San Diego, and to underlie the alluvial deposits or delta of the Colorado. There is a remarkable difference in the appearance of the fossils on the east and west sides of this chain. Those on the desert side form a stratum four or five feet thick *of shells alone*, consisting almost wholly of the genera Ostrea, Anomia and Pecten; while on the west side, bordering the Pacific, there is a greater variety of genera and species; shells of the genera Cardium, Nucula, Corbula, Tellina, Mactra, Natica and Trochita being abundant. An interesting relationship between the existing and fossil shells of the Gulf side of the chain is indicated, and it is probable that the crest of the chain divided the waters of the Gulf and the Pacific during the Miocene era.

At the pass of San Fernando, between Los Angeles and the granitic mountains, the sandstone strata contain numerous fossils, and fragments of shells belonging to the genera Ostrea, Pecten, and Turritella were procured. These, being imperfect, have not been specifically described by Mr. Conrad.

At Navy Point, Benicia, I obtained several casts of shells in an imperfect state, and, also, a small shark's tooth. The shells were probably of the genera Trochus and Turritella. Numerous specimens of lignite were also found at that place, imbedded in the compact sandstone.

At San Francisco, on the west side of the peninsula, near the lagoon on the beach, numerous specimens of fossil Spatangi are thrown up by the surf. They are inclosed in a matrix of bluish-green sand, resembling in color and composition the blue sandstone of the bay. It is, however, more friable, and seems to consist of the debris of the strata.

The town of Monterey is built over the line of junction of the granite of Point Piños, with an extensive series of tertiary strata, remarkable for containing immense deposits of the remains of Infusoria. These remains form white beds of siliceous earth, intercalated with semi-opaline strata of a very compact texture. They are now upraised nearly 500 feet above the water of the bay. Portions of the underlying strata—those in which the *Tellina congesta*, Con., occurs so abundantly—are also charged with small chambered shells, (Foraminifera of D'Orbigny,) and offer a rich treat to the micro-geologist. With the aid of a glass thousands of these little shells can be seen on the fractured surfaces of the rock.

From this report, and the preceding remarks, it will be seen that fossils in sufficient numbers to determine the geological age of the deposits in which they occur have been obtained from many and distant points on the Pacific coast.

The occurrence of Eocene strata at one point has been satisfactorily established. We also find that the Miocene division of the tertiary formations is extensively developed, over broad areas, in California, flanking nearly all the great lines of elevation, not only in the coast mountains, but in the interior, along the borders of the San Joaquin and Tulare valleys. Further observations are required to connect, chronologically, the Miocene deposits along Ocoya creek with the extensive, and in many respects similar, strata further north, along the Tuolumne and Stanislaus rivers.

Notice of the Fossil Fishes found in California by W. P. Blake; by L. Agassiz.—Most of the fossil remains of fishes placed in my hands by Mr. Blake for examination and identification belong to the family of sharks, one belongs to that of skates, and another is remotely allied to the family of mackerels. No fossil sharks' teeth having been found west of the Rocky mountains before; the discovery by Mr. Blake of a variety of species belonging to several genera of the family of sharks constitutes one of the most interesting additions to our knowledge that could have been obtained from that quarter, and the importance of these fossils to science is further enhanced by the peculiar relations they bear to similar fossils found in the Atlantic states and in Europe and to the sharks now living along the shores of the old and of the new world.

(1.) *Echinorhinus Blakei*, Agassiz.—One of the most interesting and important discoveries since the publication of the "Poissons Fossiles" is that of the tooth of the genus Echinorhinus, in the tertiary deposits of Ocoya creek (Posé creek), at the western base of the Sierra Nevada, California. The genus Echinorhinus was founded by Blainville for the *Squalus spinosus* of Linnæus, the only species of the genus thus far known which inhabits the Mediterranean and the European and African coasts of the Atlantic.

I figured the teeth of the same genus under the name of Goniodus for the same species, (see *Poissons Fossiles*, vol. iii, p. 94, pl. E, fig. 13,) so that this name must give way to the Echinorhinus of Blainville.

The discovery of a fossil species of this genus in the tertiaries of the western slope of the Sierra Nevada is not only important as carrying back this curious type of sharks to a period older than ours, but also in disclosing the existence upon the American continent of types in a fossil state known in the old world only among the living. The fossil species of Echinorhinus differs from the living, having the main point of the tooth more prominent, and at the same time shorter, an appearance which arises from the less prominence of the marginal denticles. This difference may be distinctly seen by comparing the figures with those of the living species given in Poissons Fossiles, pl. E, fig. 13.

(2.) *Scymnus occidentalis*, Agas.—The few species upon which Cuvier founded the genus Scymnus have been of late subdivided by Müller and Henle into two genera: Scymnus proper, and Læmargus; all of which are only known among the living. It is another of the highly interesting discoveries of Mr. Blake, to have brought home two teeth from the tertiaries of California belonging to this remarkable type. I would even not hesitate to consider them as indicating a distinct genus, were the number of specimens sufficient to warrant the inference that the teeth present, in every position of the mouth, as great a difference from the Scymnus and Læmargus as the two latter present when compared with one another. At all events, the teeth belong to the genus Scymnus, as established by Cuvier, and it constitutes a very distinct species on account of the strong bend backwards of the main point of the tooth, and the distinct and rather marked serration of the edges of the crown. Moreover, the inclination of the central point upon its basis gives these teeth a certain resemblance with those of Spinax and Centrophorus, and still more with Galeocerdo. The connexion of the teeth of the same row of the jaw with one another, was evidently the same as in the Scymnus and Læmargus, as is plainly shown by the notch upon the inner surface of the root, and the articulating tubercle at the base of the enamel in both sides.

The discovery of a fossil Scymnus in the tertiaries of California is particularly interesting in a geographical point of view since thus far no representative of the type has been found in the Pacific ocean.

(3.) *Galeocerdo productus*, Agass.—Two species only of living Galeocerdo have been known thus far—one from the Indian ocean and one from the Atlantic. The fossil species have been traced from the chalk to the upper tertiaries.

The Atlantic States have already yielded satisfactory indications of the presence of this genus during the tertiary period, on the eastern coast of America. Now we receive from the collection of Mr. Blake a new addition to the range of this remarkable genus. The new species he has discovered resembles so closely the Galeocerdo aduncus from the Eocene of Europe, especially common in the Molasse of Switzerland, that were there not several specimens in the collection agreeing with one another in every respect, and unitedly differing from those in the Old World, I should have been at a loss to distinguish them. The California species differ from the European chiefly in having the anterior margin of the tooth less arched, with much more minute crenulations, and the serratures on the basilar margin rather smaller.

(4.) *Prionodon antiquus*, Agas.—Thus far no fossil shark of the tribe of *Carcharias* has been known among the fossils, and as shown in the Poisson Fossiles, all the species formerly referred to the genus Carcharias have been ascertained to belong to the genus Carcharodon. Few discoveries in this field, therefore, could be of more interest than finding among the tertiaries of Ocoya creek a number of teeth agreeing in the deep notch upon the base of the root, but differing in their width as well as in the shape of their edge; belonging evidently to the genus Prionodon of Müller and Henle. The larger and broader ones have the edges serrated, especially near the base, while the narrower ones are smooth and sharp. These differences correspond exactly to the differences observed by Müller and Henle between the teeth of the upper and lower jaw in some species of the genus Prionodon. A transverse section of the fossil under consideration, moreover, shows these teeth to have a central cavity, as in those of the whole tribe of Carcharias. There can, therefore, be no doubt that we have here the first instance of a fossil species of the type of Carcharias of the genus Prionodon, which it will be possible, under all circumstances, to distinguish from Sphyrna by the difference in the shape and serrature of the teeth in the upper and lower jaw. The species may be designated *Prionodon antiquus.*

My *Galeocerdo denticulatus*, from Maestricht, may, however, belong to this genus. The tooth of this species being rather erect, while in Galeocerdo the crown of the tooth is bent backwards, and its posterior margin is deeply notched. In *Prionodon antiquus*, as well as in *G. denticulatus*, the crown is but slightly inclined backwards, and though it tapers rapidly to a conical point, that point does not stand so distinctly out from its base as in true Galeocerdo.

(5.) *Hemipristis Heteropleurus*, Agas.—The genus Hemipristis was established by me from fossil teeth of the middle tertiaries of Europe. Dr. R. W. Gibbes has since indicated their existence among the tertiaries of the Atlantic shores of America, and now we owe to Mr. Blake the discovery of a tooth of this genus in the deposits of Ocoya creek, California.

I have already remarked how difficult it is to perceive the difference existing between Galeocerdo aduncus of Europe, and the species of that genus existing in California. I am still more doubtful about the propriety of distinguishing the species Hemipristis of the west from those of Europe. It would seem extraordinary, however, to find the same species of sharks extending from the Pacific coast of this continent to central Europe, especially when we find, upon closer examination, our living sharks more closely circumscribed within narrow limits than was formerly supposed. And yet all the differences I perceive between the Hemipristis of California and those of Europe consist in a marked inequality between the serrature of the hinder margin when compared with that of the anterior margin of the tooth. As this may be found to be a constant character, I would introduce the western species provisionally, under the name of *H. heteropleurus*, or until the discovery of more specimens decides whether this difference in the serrature of the margin of the inner sides of the teeth is constant or not.

(6.) *Carcharodon rectus*, Agas.—Of all the types of sharks' teeth that of Carcharodon, next to Lamna and Oxyrhina, is the most numerous in the tertiary deposits, though there is only one living species known.

Mr. Blake has brought a finely preserved specimen of a medium sized species of this genus from California. Rather smaller than *Carcharodon angustidens*, the tooth has the same form as in that species, only there are no accessory points upon the sides of the base. Considering its size, this tooth is remarkable for its thickness, and in that respect it reminds one more of *Carcharodon angustidens* than any other species. The surface is flat and the tooth straight, as in *C. angustidens*, and to this character the name *rectus* is intended to allude.

Several species of this genus have been described by Dr. R. W. Gibbes as occurring in the tertiary of the Atlantic slope.

(7.) *Oxyrhina plana*, Agas.—Since the teeth of Oxyrhina are known to differ in size so widely as they do in different parts of the jaws, nothing is more difficult than to combine fossil teeth found separated in such a manner as to leave no doubt about their specific identity.

Several teeth of a very interesting species of Oxyrhina are found among the specimens of fossils brought by Mr. Blake from California, and its resemblance to the O. —— of the Mediteranean is very striking. But the character by which they differ most strikingly from the living species and the fossils already described consists in the greater flatness of the teeth as compared with their width. Some of them are straight, and others slightly bent backward. This species I propose to name *O. plana*.

Several species of this genus have been described from the Atlantic States by Dr. R. W. Gibbes.

(8.) *O. tumula*, Agas.—The existence of a second species of the genus Oxyrhina in the tertiary of California is indicated by several teeth remarkable for the size and thickness of the roots as compared with the lengths of their curves. The specimens agreeing in this character differ greatly in size, and yet not more so than may be seen in the same jaw of our living species.

Found with the preceding by Mr. Blake.

(9.) *Lamna clavata*, Agas.—Two teeth from Ocoya creek indicate the existence in California of a species of Lamna allied to *L. cuspidata* of the European Miocene, from which it differs, however, by its smaller size, its shorter and narrower crown, in which respect it agrees more with *L. Hopei* of Sheppy. The crown, however, is less arched than the latter. The posterior surface is smooth as in *L. cuspidata*.

Found with the preceding in the tertiary formation of Ocoya creek.

(10.) *L. ornata*, Agas.—A second species of Lamna has been brought from California by Mr. Blake. It occurs in the sandstone of Navy Point, Benicia, and is allied to *L. elegans*, Agas. (See Recherches des Poissons Fossiles, vol. iii, p. 289.) It is, however, a smaller species, and tapers more gradually, while in *L. elegans* it tapers more suddenly near the top, and the folds of the enamel on the inner side of the tooth are coarser. The base of the tooth is more compressed than in *L. elegans*, in which respect the tooth resembles more *L. acuminata*.

The small tooth found with the specimen may be one of the lateral teeth of the same species; but it is difficult to determine this without a microscopical examination of its structure. These fossils are unquestionably of tertiary age. *L. elegans* is found in the Calcaire grossier in the environs of Paris, and in the London clay at Sheppy. The same species is also found fossil in the Crag, having been transported with the remains of many other species from the London clay. Several species of this genus have been described from the Atlantic States by Dr. R. W. Gibbes.

(11.) *Zygobates*, —— ?—A fragment of a tooth of the genus Zygobates is interesting inasmuch as it shows that this genus of the order of the family of skates, with pavement-like teeth, to have occurred in California during the tertiary period; though the fragment of the tooth before me is too imperfect to allow the species to be identified. It may not be out of place to remark that no species of this genus, or the allied genera Rhinoptera, Ætobates, or Myliobates have thus far been found in the Pacific ocean.

Several fragments of bone found with the teeth at Ocoya creek (Posé creek) belong to the family of Scomberoides, but are too imperfect to admit of being identified.

2. *On the Relations of the Crystalline Rocks of the North Highlands to the Old Red Sandstone of that Region, and on the Recent Fossil Discoveries of Mr. C. Peach;* by Sir RODERICK I. MURCHISON, (Proc. Brit. Assoc., 1855, Ath., No. 1457).—Having referred to his earliest publications relating to the Old Red Sandstone, in 1826 and 1827 (being associated in the latter year with Prof. Sedgwick), the author explained how the classification originally proposed by his colleague and himself had been extended and improved by the researches of Mr. Hugh Miller. Having stated that his matured and condensed views as to the true equivalents of the Old Red Sandstone being the Devonian rocks of other countries were given in his last publication, entitled 'Siluria,' Sir Roderick called the special attention of the Section to the consideration of the true relations of these deposits to the crystalline rocks of the Highlands. To satisfy his mind on this point, and to see if it was necessary to make any fundamental change in his former views, the author has spent the last five weeks in re-surveying his old ground in Sutherland, Caithness, and Ross-shire, on which occasion he was accompanied by Prof. James Nicol. Obtaining ample evidence to induce him to adhere to his former opinion, that all the crystalline rocks of that region, consisting of gneiss, mica schist, chloritic and quartzose rocks, limestones, clay slate, &c., were originally stratified deposits, which had been crystallized before the commencement of the accumulation of the Old Red Sandstone, he first gave a rapid and general sketch of those ancient rocks, whose crystalline character he thus attributed to a change, or metamorphism, of their pristine sedimentary condition. They have a prevalent strike, varying from NE and SW to NNE and SSW, and in the northernmost counties of Scotland their prevailing inclination is to the ESE or SE, usually at high angles. In combating a theoretical idea, which had only very recently been applied to the crystalline rocks of Scotland, viz., that their apparent layers were simply a sort of crystalline cleavage, by which the different minerals were arranged in parallel folia or laminæ, and were independent of the original lines of deposit, he showed how every geologist who had long studied these rocks in Scotland had formed an entirely different opinion. Hutton, Playfair, Hall, Jameson, M'Culloch, and Boué, all believed that the variously constituted and differently colored layers of these rocks truly indicated separate original deposits of sand, mud, and calcareous matter. He cited numerous cases of interstratified pebble beds and limestones as completely demonstrative of their true original status. Alluding to the real distinction between stratification and cleavage, as first defined by Prof. Sedgwick, he expressed his belief that, whilst in no part of the Highlands did there exist that perfect and symmetrical fine crystalline cleavage which prevails in North Wales (the thick slates of Ballyhulish and Easdale usually cleaving in coincidence with the laminæ of deposit), there was, nevertheless, a very marked and prevalent division of all such crystalline rocks into rhombic and other forms by rude cleavages and very decisive joints.

In describing two traverses which he made across the direction of these crystalline rock masses in the north coast of Sutherland,—the first, twenty-eight years ago, with Prof. Sedgwick, the other, in the weeks preceding this meeting, with Prof. Nicol,—and, in mentioning with due praise a memoir, of intermediate date, by the late Mr. Cunningham, it was stated, that the oldest, or lowest, visible stratified rock in that region was a very hard, gray, quartzose gneiss, traversed by veins of granite, as seen on the shores of Loch Laxford, Cape Wrath, the escarpment of Ben Spionnach, in Durness, and other places. At the last-mentioned locality, and near Rispond, the older gneiss is unconformably overlaid by a copious series of quartz rocks, of white and grey colors, occasionally passing into mica schists or flagstones, and, also, into stratified masses, which are truly gneiss, inasmuch as they are composed of quartz, mica, or feldspar. With a copious interstratification of bands of limestone, near their lower parts, these crystalline rocks are very clearly exhibited between Loch Durness and the Whiten Head on the coast, or between Ben Spionnach and Loch Eribol, in the interior. It is in one of the beds of limestone subordinate to the lower white quartzites of this great series, some courses of which range into Assynt, in south-west Sutherland, and to Gairloch, and Kishorn, in Ross-shire, at Balnakiel, in Durness, that Mr. Charles Peach recently discovered organic remains; and, as their discovery has led to certain suggestions, including one which would consider these crystalline rocks as the representatives of the Devonian or Old Red Sandstone formation, the author begs to show why such an opinion seems to be untenable, and to point out that, both from their physical position and the nature of the imbedded remains, they are most probably of Lower Silurian age. For, whether the section be made across the various strata between Loch Durness and Loch Eribol, or from the latter to Loch Hope, the same limestones subordinate to quartz rocks of white and grey colors (including some rare coarse white grits, as in the summit of Ben Spionnach), and associated with many siliceous concretions (of various colors, red and dark grey) are distinctly and conformably overlaid by and pass up into micaceous quartzite and dark colored schists, both chloritic and talcose, which are followed by other and differently composed stratified masses, having the character of gneiss. Along the north coast these overlying masses extend to the west shore of Loch Tongue, before they are interfered with by any mass of granite; and it is, therefore, unquestionably true, that the band of limestone containing the fossil shells discovered by Mr. Peach is one of the lowest members of this great crystalline series of stratified rocks of very diversified characters. It was suggested that the fossils in question being of a whorled or circular form might prove to be the Clymenia of the Devonian rocks; but this suggestion is now set aside by Mr. Salter, who, after a close examination of the fossils submitted to him by Sir Roderick Murchison, has unreservedly expressed his belief that they are not chambered shells, and cannot, therefore, be either Clymenia or Goniatites. Mr. Salter suggests that they much resemble the Lower Silurian genus Maclurea, with which, however, they cannot be identified, as it is a sinistral shell, whilst the Durness fossil is dextral; and, on the whole, he is disposed to refer them to the genus Raphistoma, a shell which has been found in the Lower Silurian limestones of Ayrshire, (Girvan). So far, therefore, as the fossil evidence goes, it is in accordance with the geological succession of the region, and countenances the idea expressed some years ago by Prof. Nicol and the author, that many of the stratified crystalline rocks of the Highlands would prove to be the metamorphosed equivalents of the fossiliferous Lower Silurian rocks of the south of Scotland.

Sir Roderick adverted to a feature in the older series of crystalline rocks of the west coast of Scotland, which still required to be more accurately defined than had hitherto been done. Prof. Sedgwick and himself had formerly called attention to the occurrence, near Ullapool, of a red conglomerate coarse grit, subordinate to the crystalline rocks, but which must not be confounded with the true Old Red series, as developed on the north and east coasts of the counties of Caithness, Ross, Inverness, Nairn, Moray, &c. During his excursion of this year, Prof. Nicol and himself saw, near Inchnadampff, in Assynt, a similar interposition of hard red conglomeritic grit, resting at once unconformably in the older gneiss; but bad weather prevented their ascertaining whether this mass, as exposed on the road to Loch Inver, is really surmounted by the quartz rock; nor were they able to determine the relations of the great red conglomerates of the mountains of Coul More, Sulvein, Coulbeg, and Canish, to their ancient red rock. He pointedly cautioned young Scottish geologists not to be led away by the notion, that all conglomerates made up of crystalline pre-existing rocks represented the so-called *old red* conglomerate, and particularly referred to the coarse red conglomerate of Girvan in Ayrshire, which Prof. Nicol and himself had shown to be a part of the Lower Silurian series of the south of Scotland. Whilst, however, it is probable that the red conglomerate of the West Highlands, which is associated with the series of crystalline rocks, may be also of Lower Palæozoic age, it is clear that even on that account the stupendous masses of red sandstone which constitute the mountains of Applecross and Gareloch are unquestionably of a younger date. Positive proof of this was formerly given by Prof. Sedgwick and himself from unconformable junctions of the two classes of rock in the West Highlands at Ullapool, and on the eastern coasts also, where the oldest conglomerate and sandstone of the Old Red or Devonian age of Caithness, clasps round the quartzose and micaceous rocks of the Scarabin Hills, and is made up of the materials derived from those crystalline rocks which are contiguous to it. He then expressed his firm conviction, that, from the immense length of time which must have passed in its accumulation, the vast deposits called the Old Red Sandstone were the full and entire equivalents of the Devonian rocks of the south-west of England, and of the Rhenish provinces, and of large portions of other parts of Germany, as well as of France, Spain, and other countries. He strongly insisted on the fact, that in Russia, where he had traced such a very extensive range of rocks of this age, regularly interpolated between the Silurian and Carboniferous systems, there occurred a mixture of the same species of fossil fishes (*Asterolepis*, *Dendrodus*, *Glyptosteus*, *Bothriolepis*, *Holoptychius*, *Cricodus*, *Ptericthys*, &c.) which prevail in the north of Scotland, with the shells which characterize the formation in the slates and calcareous type which it assumes in Devonshire. He then announced that, in addition to the fossils previously elaborated and described by Mr. Hugh Miller and other authors, a number of plants had recently been discovered, chiefly by Mr. C. Peach, of Wick, but also by Mr. J. Miller and Mr. Dick, of Thurso, in the very heart of the Caithness flagstones—the great fossil Piscaria of the series. Of these plants, the large number of which Mr. Peach had submitted to him seemed to be of terrestrial origin, he hoped to obtain an account at a future period from Dr. Joseph Hooker, whom he had requested to write a decade upon them in the 'Memoirs of the Geological Survey of the British Isles.' The importance of correctly determining the character of these plants will be at once seen when it is considered that, with the exception of the minute and rare vegetable forms detected by the author in the uppermost Silurian rocks, which form a passage into the Devonian rocks or Old Red Sandstone, these Caithness fossils are probably the oldest known and clearly recognizable land plants; it being believed that the fossil vegetables hitherto found in the so-called Old Red, chiefly occur in the upper meshes of the system.

Such are certain plants discovered by Dr. Fleming and others in Shetland and Orkney, by the geological surveyors in Ireland; and such is the position of the very remarkable and beautiful Flora, detected by Mr. Richter of Sahlfield, in Germany, and which he alluded to last year, as being under the description of M. Unger, the celebrated fossil botanist of Gratz. The singular plant, however, formerly described by Mr. Hugh Miller as occurring in the Cromarty strata, must be considered to be of quite as old a date as the Caithness plants.

In recapitulating, Sir Roderick called special attention to the system of the older crystalline or metamorphic rocks, and expressed his conviction that the same series was several times repeated in the contiguous tracts of Sutherland and Ross by great heaves of the masses,—such breaks being marked by the chief lochs or friths. He also dwelt on the very remarkable fact, that in these two northern counties there was an apparent symmetrical succession from older to younger masses in proceeding from the west to the east coast. Even the physical watershed of one portion of the region, as seen in the steep precipices of the Balloch of Kintail, only four miles distant from the western salt water of Loch Duich, indicating no anticlinal; the flagstones of gneissose rocks plunging rapidly to the east-south-east, a feature which was as forcibly presented in many places to the recent observation of Prof. Nicol and the author as it was to the latter and his former associate Prof. Sedgwick. Where these ancient rocks are developed in the more southern portions of the Highlands, and where they usually still preserve the same general strike from northeast to southwest as far north-north-east to south-south-west, their dips are, however, frequently anticlinal, owing to the powerful intrusion of massive igneous eruptive rocks: so that from Fort William or Ben Nevis southwards we have first in the porphyry of that mountain, and afterwards in the porphyries and syenites of Glencoe or the granite of Ben Cruachan, as well as in other points still farther south, great centres of disturbance by which the same series of quartzose, micaceous, and chloritic rocks with limestones, and in which clay slate more prevails than in the north, is repeated in vast undulations, some of which dip to the west-north-west and others to the east-south-east. One of the most southern of these anticlinals may be seen in the centre of Loch Eck, where the masses dip off to Strachur and Inverary on the northwest, and to the Clyde on the southeast.

In conclusion, the author enforced his view of the posteriority of the Old Red Sandstone to all such crystalline rocks by showing (as indeed Prof. Sedgwick and himself had done many years ago) that the coarse conglomerates of the Old Red Sandstone series, not only wrapped round those ancient rocks, but were absolutely made up of their fragments, and are seen in many places distinctly to overlie them, as at Loch Ewe, Gairloch, Applecross, &c. He further adverted to the great diversity of the strike and dip of the two classes of rock and of their entire unconformity to each other, of which he cited an instructive example at the head of Loch Keeshorn, where the lofty massive mountains of the Old Red Sandstone of Applecross, the beds of which had a steady, slight inclination of 10° or 12° to the northwest, whilst the low flanking and conterminous primary limestones, quartzites, mica schists and gneissose rocks extending from Keeshorn to Loch Carron plunge rapidly to the east-south-east. In short, whilst the limestone of Durness in Sutherland (identical in all its mineral characters and associations with quarzites with that of Keeshorn in Ross) is of very remote antiquity, and is probably, from its fossils of Lower Silurian age, the base of the Old Red Sandstone, forms a great belt composed of the regenerated materials of such older rocks, and distinctly overlies in a transgressive position the pre-existing crystalline rocks on the west, north, and east coasts of the Highlands. Referring in conclusion to the labors of Mr. Page, who had been zealously endeavoring to bring the Scottish Palæozoic classification into accordance with that of England, the author remarked, that, in respect to the position of the English "Tilestones" there existed no sort of ambiguity. These "tilestones" constitute a thin zone which exhibits in many places a mineral transition for the Upper Silurian rocks into the base of the Old Red or Devonian series, and in which we found one species of a fossil fish which occurs in unequivocal Old Red Sandstone, thin shells which range through the Ludlow rocks. They also contain forms of a remarkable genus of Crustaceans, the Pterygotus, which is known in the Arbroath paving-stones of Forfar. If, indeed, the Scotch grey paving-stones should prove to be the true representatives of the English tilestones (the species of Pterygotus of each being identical), and that it be truly shown that the great conglomerate on the flanks of the Grampians underlies such Arbroath flagstones, then it will probably follow that a great coarse angular conglomerate of the Highlands, or at least part of it, represent in time some portion of the Upper Silurian rocks. With his present amount of knowledge, however, the geologist must believe that in this part of the Scottish Palæozoic succession there is a great hiatus, since no suite of organic remains hitherto discovered has shown the presence of the Ludlow and Wenlock or Upper Silurian rocks, as exhibited in England, Sweden, Norway, Bohemia, and North America.

3. *Description of the Mineralogical Cabinet of the Garden of Plants at Paris;* by M. J.-A. Hugard, Assistant to the Professor of Mineralogy. 12mo, pp. 190. Paris, 1855.—This admirable guide to the mineralogical museum of France, deserves to be made known to the cultivators of mineralogy who never expect to make use of it in examining the collection itself, for which it was expressly prepared, inasmuch as

the felicity of its execution renders in no small degree a model for all similar undertakings.

The first part of the work is historical; the second descriptive. Under the former head we have an account of the origin of the collection; of its gradual growth to the present day; of the succession of Professors; of the extent of the geological and mineralogical cabinets, and of the mode of cataloguing and ticketing adopted in the museum. Under the descriptive part falls first, a description of the building devoted to the reception of the collections and the general manner according to which they are distributed. In this manner thirty pages are occupied, and then commences a more detailed description of the most interesting objects in the mineral collection beginning with the different glazed cases which contain the specimens, disposed in a systematic order around the sides of the most splendid gallery devoted to this purpose in the world. The contents of one hundred and ninety-two distinct cases or compartments are noticed between pages 31 and 154. The remainder of the work is devoted to the geological collection, which occupies side-galleries on the second floor of the edifice, that communicate with the lower floor or the mineral-cabinet proper by eight flights of stairs.

We cite only a few details from the work as likely to interest American mineralogists.

It was about the year 1750 that the mineral collections under the supervision of Buffon and Daubenton were first separated from other objects of natural history and arranged by themselves. In 1772, a considerable collection was given to Buffon by the king of Poland. This was immediately added to the cabinet. From 1777 to 1785, Dombey collected with a view to its increase, in Mexico, Chili and Peru. It was he who first sent home the Atacamite, the Euclase and the Nitre of Peru. The Emperor Joseph II. of Austria presented in 1784, a splendid series of the minerals from Hungary and Transylvania; and the Empress Catharine II. of Russia in the year following, did the same, in respect to those of her vast territory. From 1770 to 1800, Dolomieu collected a magnificent series of the rocks and minerals of Portugal, Sicily, of the Alps, the Grisons and of Tyrol, which together with the fine cabinet of Faujas de St. Fond (formed among the extinct volcanoes of Viverais and Auvergne), fell to the royal collection at the Garden of Plants. It was farther enriched in 1795 by receiving the cabinet of Stathouder. In 1796, the government added a rich collection of precious stones, which had previously been deposited at the mint. The king of Denmark presented some valuable specimens in 1800. The cabinet was much enriched from 1800 to 1806, by voyages of discovery in the east. In 1802 the Garden purchased the fine cabinet of 1600 specimens of Prof. Weiss, (now of Berlin,) to the accumulation of which he had devoted twenty years of diligent labor. Then followed in succession the following valuable additions: 1, (1802 to 1808) the collection of Geoffroy St. Hilaire, remarkable for its diamonds and topazes from Brazil; 2, (1810 to 1825) collections from the king of Sweden; 3, (1823) additional specimens of value from the mint; 4, (1815) splendid specimens from Italy and Germany presented by the Emperor of Austria; 5, (1826) the king of France presented his private cabinet; 6, (1835) the valuable collection of Gillet de Laumont consisting of 4000 specimens, was purchased; 7, (1836) the School of Mines at St. Petersburg presented a very choice collection of Russian Minerals; 8, the celebrated cabinet of 8000 specimens, formed by the Abbé Haüy was purchased in England of the Duke of Buckingham and added to the museum; 9, (1855) a splendid collection of Russian minerals which in 1853 had been presented by the Emperor Nicholas to the Institute of France, and which embraced a very precious series of emeralds, topazes, malachites and native gold.

The mineralogical catalogues number as high as 27,000 specimens. In the year 1829, Cordier was made professor of geology in the museum. The collection in this department then contained scarcely 1200 specimens of rocks of all sizes, the most of them without localities, and about 300 specimens of fossils. The collection now contains 175,000 specimens of rocks, without including detached organic fossils, of which the number exceeds 23,000 specimens, or trays often containing numerous individuals. M. Hugard very well observes, "*Ces chiffres sont assez éloquents pour montrer l'importance de la collection de geologie actuelle.*"

When the traveller from the United States views the extent of this vast museum of mineralogy and geology, and contemplates the system with which it is disposed and the care with which it is preserved, a feeling of mortification is sure to be felt, at the thought that his own great and flourishing country has nothing of the kind to show wherewith to excite the pride and study of her ambitious and intelligent sons.

S.

III. Botany and Zoology.

1. *Synopsis Plantarum Glumacearum; auctore* E. G. Steudel. Stuttgard. 1854–5. Imp. 8vo. 2 vols. in one. Pars I, *Gramineæ.* pp. 474. Pars II, *Cyperaceæ, Restiaceæ, Eriocauloneæ, Xyrideæ, Desvauxieæ et Junceæ.* pp. 348.—We have noticed already the earlier fascicles of this work, now brought to a completion. The bringing together in one volume all the genera and species of Glumaceous plants, scattered through a vast number of books, is an undertaking which was much needed, and which has been faithfully done by our author, so far as we know. That he should collate and thoroughly revise the characters and rectify the synonymy was not to be expected, nor is it desirable that such a task should be attempted by any botanist resident in a German provincial town, remote from all the great herbaria. Kunth, who published the last Agrostographia and Cyperographia, possessed better means and greater experience; but his work did him little credit. If Steudel had confined himself to compilation, he would have conferred an unalloyed benefit. Unfortunately, he has described as new species several hundreds of specimens, in his own and some other herbaria, most of which doubtless belong to species already published, and which figure in his pages, each perhaps under several names besides the new ones. As a contribution to science, therefore, this work is worse than Kunth's Agrostographia;—and that is saying a great deal. A. G.

2. *Flora of Tasmania;* by JOSEPH DALTON HOOKER, M.D. Part I, 1855. Royal 4to, 80 pages, with 20 colored plates.—The labors of assorting and distributing the vast Indian herbarium formed by Dr. Thomson and himself, and of publishing the first volume of the *Flora Indica* (noticed in our last number) have not prevented Dr. Hooker from proceeding to print his Flora of Tasmania, almost as soon as that of New Zealand was completed. The letter-press of this first part comprises the orders from *Ranunculaceæ* to the commencement of *Leguminosæ.* Noteworthy points are, the transference of *Monimiaceæ* (including *Atherospermeæ*) to the same group of orders with the Magnoliaceæ, for satisfactory reasons, assigned in the Flora Indica: the union of *Mniarum* with *Scleranthus:* the detection of our *Elatine Americana*, or of a plant which Dr. Hooker cannot distinguish from that species, in Van Diemens Land: and the identification of a considerable number of Tasmanian species with those of other widely distant parts of the world. A. G.

3. *Flora van Nederlandsch Indië, door* F. A. W. MIQUEL. Amsterdam, 1855.—Prof. Miquel, one of the most active and learned of Dutch botanists, has commenced a general Flora of the Netherland's East Indian possessions, of which two parts have reached us: viz.—336 pages royal 8vo, and with 4 plates, from drawings by Ver Huell. The specific characters and technical descriptions are in Latin; the rest of the letter-press in Dutch. The work begins with the Leguminosæ, and these two parts do not complete that large order. From the author's well known industry and perseverance we may expect the publication to proceed somewhat rapidly, and that it will be executed in a very creditable manner. A. G.

4. *The Micrographic Dictionary, a Guide to the Examination and Investigation of the Structure and Nature of Microscopic Objects;* by Dr. GRIFFITH and Prof. HENFREY, published by Van Voorst, to which we have called attention during its issue, is now completed in seventeen fasciculi. It makes a stout 8vo volume of about 750 pages, including the Introduction, illustrated by 41 plates, and 816 wood-cuts; and it contains an amount of well-digested and authentic information upon the wide variety of subjects it is devoted to, which is nowhere else to be found in any one work or set of works. We find it an admirable volume for reference. The articles on the subjects we are familiar with are correct and well worked up as far as they go; and the bibliographical citations at the end of each considerable article direct us to the best and latest sources of fuller information. But it is to the general student or amateur of natural history, and to the medical student, who can rarely be expected to possess a general scientific library rich in works of original investigation, that this volume will be invaluable; and to these we cordially commend it. A. G.

5. *Algarum Unicellularium Genera Nova et minus Cognita; præmissis observanibus de Algis unicellularibus in Genere;* auct. ALEX. BRAUN. pp. 111, tab. 6, 4to. Leipsic. Engelmann. 1855.—One-celled plants, being the simplest form of vegetation, are of great interest in a physiological, and also in a morphological and systematical point of view. Prof. Braun has long been particularly conversant with these simple plants, and his writings upon the subject will command the great-

est attention. A complete history of them would form one of the most interesting treatises in the whole range of natural science, and would touch upon most of the important questions discussed at the present day, as to the nature, origin and propagation of cells, the limits of vegetable and animal life, and as to what constitutes the individual in plants. Prof. Braun's little treatise is an important contribution to this subject, although he illustrates only six genera. In the introduction he gives his general views upon the one-celled Algæ, their limits, systematic arangement, &c.

We notice also, that, in sketching the outlines of the grand divisions of the vegetable kingdom, considered as to their grade of evolution, Prof. Braun adopts Brongniart's view,—towards which there has been for some time a general tendency—claiming for the Gymnospermous Phanerogamia the position of a class, of equal rank with the common Dicotyledons and Monocotyledons combined. No new reasons for this, however, are adduced. This point is one likely to be contested, and which now demands a thorough discussion. A. G.

6. *On some specimens of deep sea bottom, from the sea of Kamtschatka, collected by Lieut. Brooke, U. S. N.;* by Prof. Bailey.

[The following copy of a letter from Prof. Bailey to Lieut. Maury, of the National Observatory, Washington, D. C., dated West Point New York, January 29th, 1856, has been sent to us for publication.—Eds.]

I have examined with much pleasure the highly interesting specimens collected by Lieut. Brooke of the U. S. Navy, which you kindly sent me for microscopic analysis, and I will now briefly report to you the results of general interest which I have obtained, leaving the enumeration of the organic contents and the description of the new species for a more detailed account which I hope soon to publish.

The specimens examined by me were as follows:

No. 1. Sea bottom 2700 fathoms, lat. 56° 46′ N, long. 168° 18′ E, brought up by Lieut. Brooke with Brooke's lead.

No. 2. Sea bottom 1700 fathoms, lat. 60° 15′ N, long. 170° 53′ E. brought up as above, July 26th, 1855.

No. 3. Sea bottom 900 fathoms, temperature (deep sea) 32° Saxton, lat. 60° 30′ N, long. 175° E.

A careful study of the above specimens gave the following results.

1st. All the specimens contain some mineral matter, which diminishes in proportion as the depth increases, and which consists of minute angular particles of quartz, hornblende, feldspar and mica.

2d. In the deepest soundings (No. 1. and No. 2.) there is least mineral matter, the organic contents (which are the same in all) predominating, while the reverse is true of No. 3.

3d. All the specimens are *very rich* in the siliceous shells of the Diatomaceæ which are in an admirable state of preservation,—frequently with the valves united and even retaining the remains of the soft parts.

4th. Among the Diatoms, the most conspicuous are the large and beautiful discs of several species of Coscinodiscus. There is also (besides many others) a large number of a new species of Rhizosolenia, a new

Syndendrium, a curious species of Chætoceros with furcate horns, and a beautiful species of Asteromphalus, with from five to thirteen rays, which I propose to call Asteromphalus Brookei, in honor of Lieut. Brooke to whose ingenious device for obtaining deep soundings, and to whose industry and zeal in using it, we are indebted for these and many other treasures of the deep.

5th. The specimens contain a considerable number of the siliceous spicules of sponges, and of the beautiful siliceous shells of the Polycistineæ. Among the latter I have noticed Cornatella clathrata *Ehr.*, a form occurring frequently in the Atlantic soundings. I have also noticed in all the soundings (and shall hereafter describe and figure) several species of Eucyrtidium, Halicalyptra, Perichlamidium, Stylodictya and many others.

6th. I have not been able to detect even a fragment of any of the calcareous shells of the Polythalamia. This is remarkable for the striking contrast it presents to the deep soundings of the Atlantic which are chiefly made up of the calcareous forms. This difference can not be due to temperature as it is well known that Polythalamia are abundant in the Arctic seas.

7th. These deposits of microscopic organisms, in their richness, extent, and the high latitudes at which they occur, resemble those of the Antarctic regions, whose existence has been proved by Ehrenberg; and the occurrence of these northern soundings of Asteromphalus and Chætoceros, is another striking point of resemblance. These genera, however, are not exclusively polar forms, but, as I have recently determined, occur also in the Gulf of Mexico, and along the Gulf Stream.

8th. The perfect condition of the organisms in these soundings, and the fact that some of them retain their soft portions, indicate that they were very recently in a living condition, but it does not follow that they were living when collected at such immense depths. As among them are forms which are known to live along the shores as parasites upon Algæ, &c., it is certain that a portion at least have been carried by oceanic currents, by drift ice, by animals which feed upon them, or by other agents, to their present position. It is hence probable that all were removed from shallower waters in which they once lived. These forms are so minute, and would float so far when buoyed up by gases evolved during decomposition, that there would be nothing surprising in finding them in any part of the ocean, even if they were not transported (as it is certain they sometimes are) by other agents.

9th. In conclusion, it is to be hoped that the example set by Lieut. Brooke will be followed by others, and that in all attempts to obtain deep soundings the effort will be made to bring up a portion of the bottom. The soundings from any part of the ocean are sure to yield something of interest to microscopic analysis, and it is as yet impossible to tell what important results may flow from this study.

The above is only a preliminary notice of the soundings referred to. I shall proceed without delay to describe and figure the highly interesting and novel forms which I have detected, and I hope soon to have them ready for publication.

IV. Miscellaneous Intelligence.

1. *Contributions to Meteorology.—Mean results of Meteorological Observations made at St. Martin, Isle Jesus, Lower Canada,* (nine miles west of Montreal,) *for* 1855, by Charles Smallwood, M.D.— The geographical co-ordinates of the place are 45° 31′ N. Lat., and 73° 36′ W. Long. from Greenwich. Height above the level of the sea, 118 feet.

The readings of the barometer are corrected and reduced to 32° F. The whole of the means are obtained from three daily observations taken at 6 a. m., 2 p. m., and 10 p. m.

The mean height of the *barometer* in January was 29·926 inches, in February 29·400, in March 29·716, in April 29·847, in May 29·637, in June 29·757, in July 29·803, in August 29·862, in September 29·834, in October 29·695, in November 29·838, in December 29·429 inches.

The highest reading for the year was on the 8th of January and indicated 30·721 inches; the lowest reading was at 6 a. m. on the 10th of December, and was 28·689 inches; the yearly mean was 29·730, which was 0·059 more than the yearly mean of last year; the mean of the monthly range for the year was 1·050 inches, which was 0·033 less than the range of 1854.

The *atmospheric wave* of November was marked by its usual fluctuations; the highest crest was on the 9th day and indicated 30·265 inches; there were distinct troughs on the 1st, 7th, 16th, 23d, and 20th days, the lowest trough occurred at 4 a. m. on the 28th day, the barometer then stood at 28·997 inches; there was a very sudden rise of the barometer from midnight of the 23d of November till sunrise of the 24th day, of 0·521 inches, accompanied by a very high wind from the NW, which reached a velocity of 38·10 miles per hour. The thermometer fell 25° 0 for the same period.

Thermometer.—The mean temperature of the air by the *standard thermometer*, was in January 17°·88, in February 11°·23, in March 24°·08, in April 40°·15, in May 56°·85, in June 62°·39, in July 72°·73, in August 64°·94, in September 58°·55, in October 46°·35, in November 31°·58, in December 20°·84. The highest reading of the *maximum thermometer* was on the 2nd of August, and was 97° 0; the lowest reading of the *minimum thermometer* was on the 7th of February, and was −33°·9 (below zero). The mean temperature of the quarterly periods was, Winter 12°·15, Spring 40°·36, Summer 66°·68, Autumn 45°·49. The yearly mean was 42°·29, which was 0°·72 degree higher than the yearly mean of 1854; the mean of the yearly range was 61°·1, which was 1°·15 higher than the mean range of 1854. The greatest monthly range was in February, and was 74°·5, and the least monthly range was in October, and was 45°·6. The greatest intensity of the sun's rays was in July, and indicated 127°·2, the lowest point of terrestrial radiations was in February, and was −34°·4 (below zero).

The mean humidity (saturation being 1·000) was, in January ·897, in February ·857, in March ·815, in April ·808, in May ·743, in June ·809, in July ·757, in August ·773, in September ·803, in October ·849, in November ·884, in December ·872. The yearly mean was ·822, which was ·018 *plus* of last year.

Rain fell on 98 days; it was raining 437 hours and 39 minutes: it was accompanied by thunder and lightning on 14 days. The amount of rain exceeded 1·438 inches the amount which fell in 1854. The amount which fell in January was 1·436 inches, in February none, in March 0·531, in April 4·194, in May 1·756, in June 8·217, in July 2·351, in August 4·366, in September 3·471, in October 8·728, in November 3·923, in December 2·970 inches. Total amount 41·943 inches.

Snow fell on 42 days; it was snowing 312 hours 15 minutes, and amounted to 85·91 inches on the surface, which amount was less by 11·54 inches than the amount of snow which fell in 1854. The monthly fall was as follows: in January 20·10 inches, in February 15·00, in March 15·60, in April 4·34, in October 2·10, in November 8·34, in December 20·43 inches. The first snow of the winter 1855–6, fell on the 24th day of October; the whole amount of snow which fell during the winter 1854–5, was 77·91 inches; the present winter set in on the 22d day of December, ferry boats were crossing the day before on the St. Lawrence at Montreal. The first time the thermometer fell to zero was on the 17th of December: the first frost occurred on the 18th of August, and was also felt on the 23d, 27th, 28th, and 31st of the same month, which was very early, and did considerable damage to the crops; (the first frost of 1854 occurred on the 21st of September). The river Jesus was first crossed with loads on the 15th of December.

The amount of evaporation was measured regularly from the 1st of May to the 31st of October, and was discontinued owing to frosty nights. The amount of evaporation in May was 4·22 inches, in June 2·61, in July 3·19, in August 3·80, in September 3·04, and in October 1·40 inches, amounting to 18·26 inches, which was 3·24 inches less than the amount of last year for the same period.

The most prevalent wind, during the year was the west, the least so, the E-by-N; in the winter quarter the most prevalent wind was the NE by E, the least so, the E; in the spring quarter, the most prevalent wind was the W, and the least so, the NE-by-E; in the summer quarter, the most prevalent wind was the WSW, and the least so the S; in the autumn quarter, the most prevalent wind was the W, and the least so the S-by-W. The greatest velocity of the wind was from 2 to 3 P. M. on the 26th April, and was 49·64 miles per hour; the yearly mean of the *maximum velocity* was equal to 15·33 miles per hour. The yearly mean of the *minimum velocity* was 0·16 miles per hour. The quarterly means of the velocities are as follows: *Winter* mean maximum velocity 18·81 miles per hour, mean minimum velocity 0·00. *Spring* mean maximum velocity 21·20 miles per hour, mean minimum velocity 0·05 miles per hour. *Summer* mean maximum velocity 10·18 miles per hour, mean minimum velocity 0·25 miles per hour. *Autumn* mean maximum velocity 17·69 miles per hour, mean minimum velocity 0·36 miles per hour. November and December were more than usually windy, the total amount of miles traversed by the wind in November was 5794·10 miles, and of December 5952·20 miles.

Wild geese, *Anser canadensis*, were first seen here on the 22d of April, swallows, *Hirundo rufa*, were first seen on the 18th of April. The *Rossignol* (the harbinger of the Canadian spring) was first seen on the 9th of April. Frogs, were first heard on the 23d of April, shad (*Alosa*) were first caught on the 31st of May, snipe were shot on the 30th of April. *Lampyris corusca*, (fire-flies,) were first seen on the 25th of June. Steamers were crossing between Ogdensburgh and Prescot on the 25th of March.

Crows did not winter here this year, they took their departure about the middle of November. *Snow-birds* were first seen on the 10th of November.

The Aurora Borealis was visible on 37 nights as follows:

January 2nd, 10 P. M. *Lunar Halo*, diam. 44° 4′.—10th. Aurora borealis, arch of moderate brightness, dark segment at the horizon.—13th. Slight shock of an earthquake at 5 40 A. M. Barometer 29·280 inches. —31st. *Lunar Halo* at 7 40, diam. 72°.

February 5th. Three mock suns visible at sunrise.—11th, 10 P. M., faint auroral arch; dark segment at the horizon.—12th, 10 P. M., faint auroral arch, dark segment at the horizon.—21st. Lunar Halo at 7 P. M., diam. 38°. *Zodiacal light* very bright during the month.

March 8th, 10 P. M. Faint auroral light to the horizon.—9th, 9 P. M. Extended auroral arch of moderate brightness, dark segment at the horizon.—12th, 7 10 P. M. Streamers shooting up from the horizon uniting in a small circle or corona at the zenith; at 8 5, three distinct auroral arches stretching from E to W, of moderate brightness; 9 P. M., splendid curtain of auroral light of a yellowish-green color changing to a violet and exhibiting the varied hues of the rainbow; 10 P. M., the appearance vanished leaving a bright arch to the horizon. —18th, 10 P. M. Dark stratus at the horizon, auroral arch behind shooting up brilliant streamers.—19, 10 P. M. Faint auroral light, dark segment at the horizon. *Zodiacal light* bright.

April 9th, 10 P. M. A dark mass of stratus in the north, forming a black curtain, behind which is seen an auroral light of moderate brightness, shooting up beautiful streamers of varied colors.—12th, 10 P. M. Extended arch of auroral light of moderate brightness to the horizon.— 15th, 10 P. M. Very faint auroral light at the horizon.—20th, 9 P. M. Dark segment at the horizon. Auroral arch of moderate brightness, frequent streamers. Corona at 11 A. M., diam. 21°.

May 1st, 10 P. M. Faint auroral light.—6th, 10 P. M. Auroral light of moderate brightness.—9th, 10 P. M. Faint aurora borealis.— 23d, *Lunar Halo* at 10 P. M., diam. 36°.—24th, 10 P. M. Auroral arch of moderate brightness, dark segment at the horizon. The eclipse of the moon was not visible here owing to cloudy weather.

June. No aurora was visible during this month. *Lunar Halo* on the 23d, diam. 41°.—24th, 10 P. M. *Lunar Halo*, diam. 47°.

July 7th, 10 P. M. Faint auroral light, dark segment at the horizon. —9th, 10 P. M. Faint auroral light to the horizon.—16th, 10 P. M. Very faint auroral light at the horizon.—23d, 10 P. M. Lunar Halo, diam. 38°.

August 5th, 10 P. M. Faint auroral light at the horizon.—10th, 10 P. M. Faint auroral light.—17th, 10 P. M. Faint auroral light.—23d, 10 P. M. Auroral arch of moderate brightness, dark segment at the horizon; 11 P. M., two distinct arches of bright auroral light, streamers from both arches intermingling, dark segment at the horizon.

Sept. 11th, 10 P. M. Faint auroral light at the horizon, a dark segment underneath; *Meteor* at 9·40 P. M., on the 11th day passing from

Algenib *Pegasi* to *H. Antinoi*, train like a rocket, noiseless.—13th, 10 P. M. Faint auroral light to the horizon.

October 3d, 10 P. M. Auroral light of moderate brightness, surmounting a dark bank of stratus clouds.—10th, 10 P. M. Very faint auroral light.—16th, 10 P. M. Very faint auroral light.—24th, 2 30 A. M. Lunar Halo, diam. 31°.

November 2nd. Faint auroral light at the horizon.—5th, 10 P. M. Dark segment at the horizon, surmounted by an arch of auroral light, 2° broad; another dark arch surmounted this arch, which was again surmounted by a bright auroral arch 4° broad; occasional streamers.—19th, 10 P. M. Faint aurora to the horizon.—29th, 6·30 P. M. Dark segment at the horizon, surmounted by an arch of auroral light of moderate brightness, intercepted here and there by whitish clouds or patches of auroral light. At 7 30, faint auroral light to the horizon, dark segment had vanished.—30th, 10 P. M. Dark segment at the horizon 6° high, faint auroral light seen above it.

December 5th, 10 P. M. Faint auroral light.—7th, 11 P. M. Bright arch of auroral light very low, horizon bright.—13th, 7 P. M. Faint aurora borealis.—30th, 8 P. M. Dark segment at the horizon surmounted by an auroral arch of moderate brightness. *Zodiacal Light* very bright during the month.

Electrical state of the atmosphere.—The atmosphere has afforded almost daily indications of electricity, varying in kind and intensity. I have been able from some years of careful observations, to draw the following inferences.

1st. The electricity of the atmosphere, in serene or windy weather, not accompanied by rain or snow, gives for the most part indications of a positive or vitreous character.

2nd. That during the storms of summer, accompanied by thunder and lightning, the electricity varies in character; it is not unusual to see the electrometer charged and changing its kind from *negative* to *positive* and vice versa, several times in a minutes. Rain falling, generally *fixes* the *kind* of electricity, which is in that case mostly negative in character.

3d. Storms in winter accompanied by snow, when the crystals are of a perfect form, is *always* accompanied by indications of electricity of a negative character and high intensity, but whenever the crystals are imperfect, or are shapeless masses of ice presenting no crystalline form, then the electrometers indicate electricity of a positive character, and of very feeble intensity.

The most perfect form of snow crystal is hexagonal, varying from 0·10 to 0·12 of an inch in diameter, the various angles are beautifully defined if examined immediately, but if allowed to remain for ever so short a time, the points or angles get rounded, and the crystal loses its primitive form and appearance and it is then difficult to define its shape,—I have never seen the hexagonal crystal and its compounds present, without strong indications of negative electricity.

Ozone.—The observations on the amount of ozone are still continued twice daily. I see no reason to suppose the amount has any connexion with the amount of electricity indicated in the atmosphere.

St. Martin, Isle Jesus, C. E., Jan. 24, 1856.

2. *On Papyrus, Bonapartea, and other plants which can furnish Fibre for Paper Pulp;* by Chevalier De Claussen, (Proc. Brit. Assoc., 1855; Athen., 1457.)—The paper-makers are in want of a material to replace rags in the manufacture of paper, and I have therefore turned my attention to this subject, the result of which I will communicate to the Association. To make this matter more comprehensible I will explain what the paper-makers want. They require a cheap material, with a strong fibre, easily bleached, and of which an unlimited supply may be obtained. I will now enumerate a few of the different substances which I have examined for the purpose of discovering a proper substitute for rags. Rags containing about 50 per cent of vegetable fibre mixed with wool or silk are regarded by the paper-makers as useless to them, and several thousand tons are yearly burned in the manufacture of prussiate of potash. By a simple process which consists in boiling these rags in caustic alkali, the animal fibre is dissolved, and the vegetable fibre is available for the manufacture of white paper pulp. Surat, or Jute, the inner bark of *Corchorus indicus*, produces a paper pulp of inferior quality bleached with difficulty. Agave, *Phormium tenax*, and banana or plantain fibre (Manilla hemp), are not only expensive, but it is nearly impossible to bleach them. The banana leaves contain 40 per cent of fibre. Flax would be suitable to replace rags in paper manufacture, but the high price and scarcity of it, caused partly by the war, and partly by the injudicious way in which it is cultivated, prevents that. Six tons of flax straw are required to produce one ton of flax fibre, and by the present mode of treatment all the woody part is lost. By my process the bulk of the flax straw is lessened by partial cleaning before retting, whereby about 50 to 60 per cent of shoves (a most valuable cattle food) are saved, and the cost of the fibre reduced.

By the foregoing it will be seen that the flax plant only produces from 12 to 15 per cent of paper pulp. All that I have said about flax is applicable to hemp, which produces 25 per cent of paper pulp. Nettles produce 25 per cent of a very beautiful and easily bleached fibre. Palm leaves contain 30 to 40 per cent fibre, but are not easily bleached. The Bromeliaceæ contain 25 to 40 per cent fibre. *Bonapartea juncoidea* contains 35 per cent of the most beautiful vegetable fibre known; it could be used not only for paper pulp, but for all kinds of manufactures in which flax, cotton, silk, or wool are employed. It appears that this plant exists in large quantities in Australia, and it is most desirable that some of our large manufacturers should import a quantity of it. The plant wants no other preparation than cutting, drying, and compressing like hay. The bleaching and finishing may be done here. Ferns give 20 to 25 per cent fibre, not easily bleached. Equisetum from 15 to 20 per cent inferior fibre, easily bleached. The inner bark of the lime-tree (Tilia) gives a fibre easily bleached, but not very strong. Althea and many Malvaceæ produce from 15 to 20 per cent paper pulp. Stalks of beans, peas, hops, buckwheat, potatoes, heather, broom, and many other plants contain from 10 to 20 per cent of fibre,—but their extraction and bleaching present difficulties which will probably prevent their use. The straws of the Cereales cannot be converted into white paper pulp after they have ripened the grain, the joints or knots in the stalks are then so hardened that they will resist all bleaching agents. To produce paper pulp from them they must be cut green before the grain appears, and this would probably not be advantageous. Many grasses contain from 30 to 50 per cent of fibre, not very strong, but easily bleached. Of indigenous grasses the Rye grass contains 35 per cent of paper pulp; the Phalaris 30 per cent, Arrhenatherum 30 per cent, Dactylis 30 per cent, and Carex 30 per cent. Several reeds and canes contain from 30 to 50 per cent of fibre, easily bleached. The stalk of the sugar-cane gives 40 per cent of white paper pulp. The wood of the Coniferæ gives a fibre suitable for paper pulp. I made this discovery accidentally in 1851, when I was making flax cotton in my model establishment at Stepney, near London. I remarked that the pine wood vats in which I bleached were rapidly decomposed on the surface into a kind of paper pulp; I collected some of it, and exhibited it in the Great Exhibition,—but as at that time there was no want of paper material no attention was paid to it. The leaves and top branches of Scotch fir produce 25 per cent of paper pulp. The shavings and sawdust of wood from Scotch fir give 40 per cent pulp. The cost of reducing to pulp and bleaching pine wood will be about three times that of bleaching rags.

As none of the above-named substances or plants would entirely satisfy on all points the wants of the paper-makers, I continued my researches, and at last remembered the papyrus (the plant of which the ancients made their paper), which I examined, and found to contain about 40 per cent of strong fibre, excellent for paper, and very easily bleached. The only point which was not entire satisfactory was relative to the abundant supply of it, as this plant is only found in Egypt. I directed, therefore, my attention to plants growing in this country; and I found to my great satisfaction that the common rushes (*Juncus effusus* and others) contain 40 per cent of fibre, quite equal, if not superior, to the papyrus fibre, and a perfect substitute for rags in the manufacture of paper, and that one ton of rushes contains more fibre than two tons of flax straw.

3. *On the Hancornia speciosa, Artificial Gutta Percha and India Rubber;* by the Chevalier De Claussen, (Proc. Brit. Assoc., 1855; Athen., 1457.)—In the course of my travels as botanist in South America, I had occasion to examine the different trees which produce the india rubber, and of which the *Hancornia speciosa* is one. It grows on the high plateaux of South America, between the tenth and twentieth degrees of latitude south, at a height from three to five thousand feet above the level of the sea. It is of the family of the Sapotaceæ, the same to which belongs the tree which produces gutta percha. It bears a fruit, in form not unlike a bergamot pear, and full of a milky juice, which is liquid india rubber. To be eatable, this fruit must be kept two or three weeks after being gathered, in which time all the india rubber disappears or is converted into sugar, and it is then in taste one of the most delicious fruits known, and is regarded by the Brazilians (who call it Mangava) as superior to all other fruits of their country. The change of india rubber into sugar led me to suppose that gutta percha, india rubber, and similar compounds contained starch. I have therefore tried to mix it with resinous or oily substances, in combina-

tion with tannin, and have succeeded in making compounds which can be mixed in all proportions with gutta percha or india rubber without altering their characters. By the foregoing it will be understood that a great number of compounds of the gutta percha and india rubber class may be formed by mixing starch, gluten, or flour with tannin and resinous or oily substances. By mixing some of these compounds with gutta percha or india rubber, I can so increase its hardness that it will be like horn, and may be used as shields to protect the soldiers from the effect of the Minie balls, and I have also no doubt that some of these compounds in combination with iron, may be useful in floating batteries and many other purposes, such as the covering the electric telegraph wires, imitation of wood, ship building, &c.

4. *On the Artificial Propagation of Salmon at Stormont, near Perth;* by Mr. Edmund Ashworth, (Proc. Brit. Assoc., 1855; Ath., 1457.)—After giving an account of previous experiments on this subject, the author proceeded: On the 19th of July, 1853, a meeting of the proprietors on the Tay was held at Perth, for the purpose of considering a letter on the artificial propagation of the salmon, written by Dr. Esdaile. On that occasion, Mr. Thomas Ashworth, of Poynton, explained to the meeting the nature of the operations which had been carried on at Outerard by his brother and himself, and strongly recommended the adoption of similar measures in the Tay, under the direction of Mr. Ramsbottom. The proposals of Mr. Ashworth were agreed to, and a committee appointed to fix upon a suitable locality for planting boxes and the construction of ponds. The Earl of Mansfield, who was chairman of the meeting, and who has shown much interest in the success of these experiments, gave permission to the committee to make a selection of any portion of his extensive estates on which to carry out their operations. The situation selected was at Stormontfield Mill, near his Lordship's residence. A gentle slope from the stream which supplies the mill offered every facility for the equable flow of water through the boxes and pond. Three hundred boxes were laid down in twenty-five parallel rows, each box partly filled with clean gravel and pebbles, and protected at both ends with zinc grating to exclude trout and insects. Filtering beds were formed at the head and foot of the rows, and a pond for the reception of the fry was constructed immediately below the hatching ground.

On the 23d of November, 1853, operations were commenced, and by the 23d of December 300,000 ova were deposited in the boxes. The fish were taken from spawning beds in the Tay. The process of fecundation will best be understood by a quotation from Mr. Ramsbottom's pamphlet, in which he describes the means employed in impregnating the ova at Outerard. So soon as a pair of suitable fish were captured, the ova of the female were immediately discharged into a tub one-fourth full of water, by a gentle pressure of the hand from the thorax downwards. The melt of the male was ejected in a similar manner, and the contents of the tub stirred with the hand. After the lapse of a minute, the water was poured off, with the exception of sufficient to keep the ova submerged, and fresh water supplied in its place. This also was poured off and fresh substituted previous to removing the impregnated spawn. The ova were placed in boxes as nearly as possible to the condition they would be in under the ordinary course of natural deposition, with this important advantage: that they are not, as in the bed of the river, liable to injury and destruction. The alluvial matter deposited in time of flood will often bury the ova too deep to admit of the extrication of the young fry, even if hatched; and the impetuosity of the streams when flooded will frequently sweep away whole spawning beds and their contents: whilst, if deposited in boxes, the ova are protected from injury, and their vivification in large numbers is thus rendered a matter of certainty, and the young fish are reared in safety.

On the 31st of March, 1854, the first ovum was observed to be hatched, and in April and May the greater portion had come out, and were at large in the boxes; in June they were admitted into the pond, their average size being about an inch and a half in length. From the period of their admission to the pond the fry were fed daily with boiled liver, rubbed small by the hand. Notwithstanding the severity of the winter, they continued in a healthy condition, and in the spring of the present year were found to have increased in size to the average of three and four inches in length. On the 2nd of May, 1855, a meeting of the committee was held at the pond, to consider the expediency of detaining the fry for another year or allowing them to depart. A comparison with the undoubted smelts of the river then descending seawards with the fry in the ponds, led to the conclusion that the latter were not yet smelts, and ought to be detained. Seventeen days afterwards, viz., on the 19th of May, a second meeting was held, in consequence of great numbers of the fry having in the interim assumed the migratory dress. On inspection it was found that a considerable portion were actual smelts, and the committee came to the determination to allow them to depart. Accordingly the sluice communicating with the Tay was opened, and every facility for egress afforded. Contrary to expectation, none of the fry manifested any inclination to leave the pond until the 24th of May, when the larger and more mature of the smelts, after having held themselves detached from the others for several days, went off in a body. A series of similar emigrations took place until fully one-half the fry had left the pond, and descended the sluice to the Tay.

It has long been a subject of controversy whether the fry of the salmon assume the migratory dress in the second or third year of their existence. So favorable an opportunity of deciding the question as that afforded by the Stormontfield experiment, was not to be overlooked. In order to test the matter in the fairest possible way, it was resolved to mark a portion of the smelts in such a manner that they might easily be detected when returning as grilse. A temporary tank, into which the fish must necessarily descend, was constructed at the junction of the sluice with the Tay; and as the shoals successively left the pond, about one in every hundred was marked by the abscission of the second dorsal fin. A greater number were marked on the 29th of May than on any other day, in all about 1,200 or 1,300. The result has proved highly satisfactory. Within two months of the date of their liberation, namely, May 29 and July 31, twenty-two of the young fish so marked when in the state of smelts on their way to the sea, have been, in their returning migration up the river, recaptured and carefully examined; the conclusions arrived at are most gratifying, and prove what has heretofore appeared almost incredible, namely, the rapid growth of the young fish during their short sojourn in the salt water. This fact may be considered as still further established by observing the increased weight according to the date of the grilse caught and examined; those taken first weighing 5 to 5½ lb., then increasing progressively to 7 and 8 lb.; whilst the one captured on 31st of July weighed no less than 9½ lb. In all these fish the wound caused by marking was covered with skin, and in some a coating of scales had formed over the part. Although twenty-two only are mentioned, the taking of which rests on indubitable evidence, nearly as many more are reported from distant parts; the weights and sizes of these have not been forwarded.

The experiment at Stormontfield has afforded satisfactory proof that a portion at least of the fry of the salmon assume the migratory dress and descend to the sea shortly after the close of the first year of their existence; and what is far more important in a practical point of view, it has also demonstrated the practicability of rearing salmon of marketable value within twenty months from the deposition of the ova. A very interesting question still remains to be solved:—At what date will the fry now in the pond become smelts? Hitherto, they have manifested no disposition to migrate; and if the silvery coat of the smelt be not assumed till the spring of 1856, a curious anomaly will present itself. Some of the fry as smelts will, for the first time, be descending seawards, of the average weight of two ounces; some as grilse will be taking their second departure to the sea; and others still more advanced will even have completed their second migration, and return to the river as salmon 10 or 12 lb. in weight. It is much to be desired that the experiment at Stormontfield could be continued for a year or two longer, till the links in the chain of evidence now wanting to complete the natural history of the salmon should be obtained.

Sir W. Jardine expressed the obligation of naturalists, sportsmen, and epicures to the originators of these experiments. He thought, however, it was most desirable to fix the nomenclature of the young salmon, to abandon the local name of parrs, smelts, smolts, &c., and to adopt one name that should be recognized by naturalists and experimenters all over the country. There seemed now no doubt of the irregularity of the growth of the salmon in its earlier stages. He had himself caught grilses not more than 5 or 6 oz. in weight, but which were perfectly distinguishable from smolts; and in 1832, a very dry year, when no flood occurred in the Tweed to take down the later shoals of smolts, Mr. Selby, of Twizel, had caught grilse of 11 lb. in weight, which he (Sir William) considered to be the fry of that year which had never left the river. But he regarded the irregularity in the growth and in the time of departure of the young salmon as a natural fact, and not merely a circumstance of artificial breeding.

Sir Philip Egerton stated that not only did the smolts or parr go down the river and come up as grilse of 4 or 5 lb. weight; but he had seen marked grilse come up the river as salmon, weighing 12 lb. He did not think, however, that salmon when they went down came back any larger.

Mr. Ashworth said he had known salmon go down weighing **10** lb. and come up weighing 20 lb.

Sir Philip Egerton, in reply to an observation made by Dr. Lankester, stated that the subject of legislating for the artificial production of salmon had been very often considered by the Legislature, but the difficulty lay in securing property in the fish produced. The proper place to breed salmon was at the heads of rivers; but as the salmon came up from the sea they would be caught by proprietors lower down, and no benefit accrue to the individuals who bred them. There was no doubt the quantity of salmon might be enormously increased by the process recommended.

5. *On certain Curious Motions observable on the Surfaces of Wine and other Alcoholic Liquors;* by Mr. J. THOMPSON, (Proc. Brit. Assoc., 1855, Ath., 1457.)—The phenomena of capillary attraction in liquids are accounted for according to the generally received theory of Dr. Young, by the existence of forces equivalent to a tension of the surface of the liquid, uniform in all directions, and independent of the form of the surface. The tensile force is not the same in different liquids. Thus it is found to be much less in alcohol than in water. This fact affords an explanation of several very curious motions observable, under various circumstances, at the surfaces of alcoholic liquors. One part of these phenomena is that, if in the middle of the surface of a glass of water, a small quantity of alcohol, or strong spirituous liquor, be gently introduced, a rapid rushing of the surface is found to occur outwards from the place where the spirit is introduced. It is made more apparent if fine powder be dusted on the surface of the water. Another part of the phenomena is, that if the sides of the vessel be wet with water above the general level surface of the water, and if the spirit be introduced in sufficient quantity in the middle of the vessel, or if it be introduced near the side, the fluid is even seen to ascend the inside of the glass until it accumulates in some places to such an extent that its weight preponderates, and it falls down again. The manner in which Mr. Thompson explains these two parts of the phenomena is, that the more watery portions of the entire surface, having more tension than those which are more alcoholic, drag the latter briskly away, sometimes even so as to form a horizontal ring of liquid high up round the interior of the vessel, and thicker than that by which the interior of the vessel was wet. Then the tendency is for the various parts of this ring or line to run together to those parts which happen to be most watery, and so that there is no stable equilibrium, for the parts to which the various portions of the liquid aggregate themselves soon become too heavy to be sustained, and so they fall down. The same mode of explanation, when carried a step further, shows the reason of the curious motions commonly observed on the film of wine adhering to the inside of a wine glass when the glass, having been partially filled with wine, has been shaken so as to wet the inside above the general level of the surface of the liquid; for, to explain these motions, it is only necessary further to bring under consideration that the thin film adhering to the inside of the glass must very quickly become more watery than the rest, on account of the evaporation of the alcohol contained in it being more rapid than the evaporation of the water. On this matter, Mr.

Thompson exhibited to the Section a very decisive experiment. He showed that in a vial partly filled with wine, no motion, of the kind described, occurs as long as the vial is kept corked. On his removing the cork, however, and withdrawing, by a tube, the air saturated with vapor of wine, so that it was replaced by fresh air capable of producing evaporation, a liquid film was instantly seen as a horizontal ring creeping up the interior of the vial, with thick-looking pendant streams descending from it like a fringe from a curtain. He gave another striking illustration by pouring water on a flat silver tray, previously carefully cleaned from any film which could hinder the water from thoroughly wetting the surface. The water was about one-tenth of an inch deep. Then, on a little alcohol being laid down in the middle of the tray, the water immediately rushed away from the middle, leaving a deep hollow there, which laid the tray bare of all liquid, except an exceedingly thin film. These and other experiments, which he made with fine lycopodium powder dusted on the surface of the water, into the middle of which he introduced alcohol gently from a fine tube, were very simple, and can easily be repeated. Certain curious return currents which he showed by means of the powder on the surface, he stated he had not yet been able fully to explain. He referred to very interesting phenomena previously observed by Mr. Varley, and described in the fiftieth volume of the Transactions of the Society of Arts, which he believed would prove to be explicable according to the principles he had now suggested.

6. *On the Absorption of Matter by the Surfaces of Bodies;* by Sir D. Brewster, (Proc. British Assoc., from Athenæum, 1458.)—If we smear very slightly with soap the surface of a piece of glass, whether artificially polished or fused, and then clean it perfectly with a piece of chamois leather, the surface, when breathed upon, will exhibit in the most beautiful manner, all the colors of thin plates. If we breathe through a tube, the colors will be arranged in rings, the outermost of which is black, corresponding to the centre of the system of rings formed between a convex and a plane surface. In repeating this experiment on the surfaces of other bodies, Sir David found that there were several on whose surfaces no colors were produced. Quartz exhibited the colors like glass, but calcareous spar and several other minerals did not. In explaining this phenomenon, the author stated that the particles of the soap, which are dissolved by the breath, must either enter the pores of the bodies or form a strongly adhering film on their surface. This property of appropriating temporarily the particles of soap, becomes a new distinctive character of mineral and other bodies.

7. *On the Existence of Acari in Mica, etc.;* by Sir D. Brewster, (Proc. Brit. Assoc., Ath., 1458.)—While examining with a microscope a thick plate of mica from Siberia, about five inches long and three inches wide, he was surprised to observe the remains of minute animals, some the 70th of an inch, and others only the 150th of an inch in size. Some of these were inclosed in cavities, round which the films of mica were in optical contact. These acari were, of course, not fossil, but must have insinuated themselves through openings between the plates of mica, which afterwards closed over them.—Sir David also read a notice on the Remains of Plants in Calcareous Spar, from King's county,

Ireland, and an account of the analysis of the mineral made for him by Prof. Andrews, of Belfast. The same notice contained an account of specimens of calcareous spar from India, in which copper and iron pyrites were disseminated through them in minute crystals and arranged in strata with clear spaces interposed, parallel to the faces of the primitive rhombohedron.

8. *On the Phenomena of Decomposed Glass;* by Sir D. Brewster, (Proc. Brit. Assoc., 1855, Ath., 1458.)—A notice on the phenomena of decomposed glass, as exhibited in specimens from Nineveh, given to him by Mr. Layard, and in others found among the ruins of St. Leonard's College, St. Andrews. He gave a brief explanation of the manner in which the decomposition took place round different centres, and by which the brilliantly colored films were formed. In the St. Andrews specimen the silex had been restored to its crystalline state in minute prisms, while the manganese took a separate place in opaque crystals.

9. *Floral Calendar, for part of* 1855, *in Lauderdale Co., Ala.;* by Thos. P. Hatch, Prof. of Nat. Science in La Grange Coll., Florence, Ala.—The early spring was at least two weeks later than usual. Later, the progress of vegetation was so rapid as to bring it up with ordinary seasons.—In the following, *lvs.* is a contraction for leaves, *fr.* for fruit, (ripe.) When neither of these follow their specific name, inflorescence is understood. The plants are classified in accordance with Torrey & Gray's N. A. Flora.

March, 1st to 6th; Sambucus Canadensis, lvs.—5th to 10th; Hepatica triloba; Claytonia Virginica; Acer rubrum; Prunus Americanus; Saxifraga Virginica; Hedyotis cerulea; Syringa vulgaris, lvs.; Alnus serulata.—10th to 15th; Myosurus minimus; Isopyrum biternatum; Thalictrum anemonoides; Arabis lævigata; Cardamine rotundifolium; C. hirsuta; Dentaria diphylla, D. laciniata; Draba brachycarpa; Capsella bursa-pastoris; Sagina decumbeus; Cerastium nutans; Oxalis violacea; Aesculus pavia, lvs.; A. glabra, lvs.; Rubus villosus, lvs.; R. trientalis, lvs.; Senecio aureus; Mertensia Virginica; Phlox glutinosa; Benzoin odoriferum; Ulmus racemosa, U. fulva; Pachysandra procumbens; Quercus castanea, lvs.; Sisyrinchium anceps.—15th to 20th; Anemone Caroliniana; Aquilegia Canadensis; Cerastium vulgare; Negundo aceroides; Cerasus serotina; Rosa rubiginosa, lvs.; Symphoricarpus vulgaris; Antenaria plantaginifolia; Phacelia bipinnatifida; Ellisea microcalyx; Phlox divaricata; Sassafras officinale.—20th to 25th; Leavenworthia aurea; Viola palmata, V. pedata; Acer dasycarpum; Vaccinium arboreum, lvs.—25th to 31st; Ranunculus repens, R. abortivus; Liriodendron tulipifera, lvs.; Uvaria triloba; Podophyllum peltatum; Viola sagittata, V. cucullaria; Arenaria patula; Silene virginica; Oxalis stricta; Vicia Caroliniana, V. tetrasperma; Potentilla Canadensis; Cornus florida; Viburnum prunifolium, lvs.; Erigeron bellidifolium; Pedicularis canadensis; Lithospermum latifolium; Phlox pilosa, P. reptans; Syringa vulgaris; Celtis occidentalis; Quercus nigra; Carpinus americana; Ostrya virginica, lvs.; Liquidambar styraciflora, lvs.—Between the 1st and 15th, Cercis canadensis; Amelanchier canadensis.—Between 15th and 31st, Ranunculus Carolinianus; Vaccinium corymbosum.

April 1st to 5th, Thalictrum dioicum; Sanguinaria Canadensis; Claytonia Caroliniana; Tilia heterophylla, lvs.; Acer saccharinum; A. dasycarpum, lvs.; Negundo Aceroides, lvs.; Crataegus punctata; Veronica arvensis, V. peregrina; Quercus nigra; Carpinus americana, lvs.; Erythronium americanum.—5th to 10th, Clematis viorna; Oxalis corniculata; Rhus toxicodendron, lvs.; Acer nigrum; Aesculus pavia; A. glabra; Robinia pseudacacia; Rubus occidentalis; Hydrangea quercifolia, lvs.; Cornus florida, lvs.; Krigia Virginica; Taraxacum dens-leonis; Verbena aubletia; Benzoin odoriferum, lvs.; Carya alba; Pinus inops; Allium striatum; Uvularia flava.—10th to 15th, Actea alba; Corydalis aurea; Stellaria pubescens; Silene antirrhine; Acer saccharinum, lvs., A. nigrum, lvs.; Trifolium repens, T. pratense, T. procumbens; Gleditschia triacanthos; Rubus villosus; Sedum ternatum; Azalea nudiflora; Halesia tetraptera, lvs.; Dodecatheon media; Veronica serpyllifolia; Callicarpa americana, lvs.; Lithospermum canescens; Cynoglossum officinale; Nyssa nudiflora, lvs.; Carya tomentosa; Quercus alba; Q. obtusiloba, Q. falcata, Q. tinctoria, Q. rubra, Q. montana; Platanus occidentalis, lvs.; Morus alba, lvs. and fls.; Hypoxis erecta; Trillium sessile; Uvularia perfoliata.—Between 1st and 15th, Vaccinium stamineum; V. frondosum; Conopholis Americana; Plantago Virginica; P. pusilla.—15th–20th, Sagina decumbens, fr.; Geranium Carolinianum; G. maculatum; Staphylea trifolia; Fragaria virginica; Osmorhiza longistylis; Lonicera sempervirens; Viburnum prunifolium; Krigia virginica, fr.; Cynthia dandelion, C. virginica; Teconia crucigera; Salvia lyrata; Myosotis nana, M. stricta; Phlox maculata; Nyssa nudiflora; Iris cristata.—20th–25th, Ranunculus pusillus; Delphinium tricorne; Liriodendron tulipifera; Viola pubescens; Stellaria aquatica; Rhus toxicodendron; Rubus trientalis; Cratægus crus-galli; Hedyotis purpurea; Coreopsis auriculata; Senecio lobatus; Sonchus asper; Halesia tetraptera; Gratiola sphaerocarpa; Calistegia sepium; Chionanthus virginica, lvs.; Asarum canadense; Castanea vesca, lvs.; Salix nigra; Urtica dioica; Arum triphyllum; Smilax quadrangularis; Medeola virginica; Polygonatum multiflorum.—25th–30th, Ranunculus recurvatus; R. parvulus; Sanguinaria canadensis, fr.; Sisymbium canescens; Lepidium virginicum; Wisteria frutescens; Psoralea melilotoides, P. eglandulosa; Trifolium reflexum; Baptisea leucantha, B. leucophia; Calycanthus floridus: Heuchera Americana; Maruta cotula; Apogon humilis; Specularia perfoliata; Styrax grandifolium; Gratiola floridana; Verbena angustata; V. bracteosa; Monarda Bradburiana; Scutellaria parvula; Lamium amplexicaule; Ellisea microcalyx, fr.; Physalis viscosa; Amsonia tabernæ-montanum; Chionanthus virginica; Euphorbia corollata; Smilacina stellata; Chamaelirium luteum; Tradescantia virginica; Secale cereale.—Between 15th and 30th, Kalmia latifolia; Scylla esculenta.

May 1st–5th, Fragraria virginica, fr.; Rosa lucida; Hydrangea quercifolia; Bellis integrifolia; Apogon humilis, fr.; Sonchus asper, fr.; Prunella vulgaris; Euphorbia peplus.—5th–10th, Menispermum canadense; Sisymbrium canescens, fr.; Amorpha fruticosa; Oenothera sinuata, O. linearis; Sedum pulchellum; Itea Virginica; Philadelphus grandiflorus; Gallium aparine; Spigelia Marilandica; Circium altissimum; C. Virginianum; Sagittaria simplex; Allium canadense.—10th–15th, Viola primulæfolia; Tephrosia Virginica; Heliopsis lævis; Vaccinium arboreum; Blephilia ciliata; Marrubium vulgare; Onosmodium Carolinianum; Smilacina racemosa.—Between the 1st and 15th, Clematis cylindrica; Delphinium consolidum; Euonymus Americana; Vitis cordifolia; Gillenia stipulacea; Diospyros Virginiana; Sanicula Marilandica; Erigeron annuum; Gnaphalium purpureum; Plantago lanceolata; Verbascum blattaria; Leonurus cardiaca; Samolus floribundus; Pentstemon pubescens, P. digitalis; Solanum Carolinense, S. nigrum; Rumex acetellosa.—15th–20th, Polygala ambigua; Rosa setigera; Gallium circæzans; Coreopsis senifolia; Leucanthemum vulgare; Frasera Carolinensis.—20th–25th, Magnolia Fraseri; Polygala incarnata; P. purpurea; P. Boyrinii; Ceanothus Americanus; Rubus trientalis; Dianthera Americana; Monarda festulosa; Castanea vesca; C. pumila.—25th–30th, Tephrosia spicata; Trifolium arvense; Schrankia angustata; Decumaria barbara; Gallium trifidum; Cacalia reniformis; Salvia urticifolia.—Between the 15th and 30th, Opuntia vulgaris; Ascyrum crux-andreæ; Hypericum rosmarifolium; Linum virginicum; Lespedeza repens; Cryptotænia canadensis; Erigeron strigosum; Silphium scaberrimum; Lepachys pinnata; Dipteracanthus hybridus; Leonurus carsiaca; Teucrium canadense; Scutellaria integrifolia, S. pilosa; Datura stramonium; Asclepias variegata, A. obtusifolia, A. tuberosa; Anantherix viridis; Polygonum hydropiper; Phyllanthus Carolinensis; Aristolochia serpentaria.

June 1st–5th, Passiflora incarnata; Hydrangea radiata.—5th–10th, Anemone Virginana; Astragalus, n. sp.; Sambucus Canadensis; Actinomeris helianthoides; Phlox acuminata.—10th–15th, Cornus sericeus; Sericocarpus solidagineus; Achillea millifolium; Euphorbia maculata.—Between the 1st and 15th, Hypericum corymbosum, H. angulosum; Stylosanthes elatior; Sambucus pubescens; Leptopoda brachypoda; Lobelia glandulosa; Gerardia flava; Nepeta cataria; Calamintha nepeta; Hypopitis lanuginosa; Polygonum aviculare; Lilium Carolinianum.—15th–20th, Eupatorium rotundifolium.—20th–25th, Callicarpa Americana; Martynia proboscidia.—25th–31st, Portulacca oleracea; Diervilla trifida; Andromeda arborea; Verbena spuria.—Between the 15th and 31st, Cleone pungens; Impatiens pallida, I. fulva; Petalostemon violaceum, P. canadense; Rhyncosia tomentosa; Crotalaria sagittalis, C. ovalis; Rhexia mariana; Cephalanthus occidentalis; Pycnanthemum linifolium; Lobelia inflata; Tecoma radicans; Sabbattia angularis; S. calycosa; Phytolacca decandra; Polygonum Pennsylvanicum; Cypripedium pubescens.

July 1st–5th, Conoclinum cœlestinum; Hedeoma pulegeoides.—5th–10th, Agrimonia eupatoria; Cuphea viscosissima; Scrophularia nodosa.—10th–15th, Nelumbium nucifera; Desmodium nudiflorum; Circium lanceolatum; Euphorbia hypericifolia.—Between the 1st and 15th, Lathyrus palustris; Vernonia fasciculata; Pycnanthemum incanum; Commelina erecta.

Ferns.—Pteris atropurpurea; Adiantum pedatum; Camptosaurus rhizophyllus; Aspleneum ebeneum, A. pinnatifidum; Polystichum acrostichoides; Osmunda cinnamomea; Botrychium virginicum; Ophioglossum vulgare.

10. *Death of Dr. T. W. Harris.*—Died at Cambridge, Mass., on the 16th January, 1856, THADDEUS WILLIAM HARRIS, M.D., widely known as an eminent entomologist. He was the son of Rev. Thaddeus Mason Harris, D.D. of Dorchester, Mass., and was born in that town, Nov. 12, 1795. He was graduated at Harvard College in 1815, and after going through a regular course of medical study, he established himself in the practice of the profession in the town of Milton. Early imbued with an ardent love of nature, he relieved the laborious duties of his profession by the study of natural science. In 1831, on the death of Mr. Benjamin Peirce, he was appointed the Librarian of Harvard College, and he filled the office with credit and usefulness to the close of his life.

While faithfully discharging the duties of this station he found time for the pursuits of natural history, directing his attention chiefly to the important, but much neglected, field of Entomology. In this department of science he rose to distinction, and since the death of Say, he has unquestionably stood at the head of American entomologists. His earlier contributions in relation to insects appeared in the New England Farmer of Boston, and in other agricultural journals, and like his later papers were marked by accuracy and thoroughness. In October, 1832, he delivered the anniversary discourse before the Massachusetts Horticultural Society, (Camb. 1832, pp. 54 and 42, 8vo), in which he set forth in an interesting manner "the relations subsisting between insects and plants, and the useful results to be obtained by the cultivator from a knowledge of the habits and economy of insects." In 1833, in the Fourth Part of Prof. Hitchcock's Report on the Geology, &c. of Massachusetts, was published Dr. Harris's Systematic Catalogue of the insects of that State. This list, comprising 2350 species, nearly all contained in his own cabinet, although as he freely admitted, quite imperfect, is noticeable as the first printed general catalogue of the insects of any part of our country;—that of Melsheimer, published in 1806, being confined to the Coleoptera.

In 1837, he was requested to prepare a report on the insects of Massachusetts, to be included among the Reports of the Commissioners on the Zoological and Botanical Survey of the State. In so vast a range as lay before him, he wisely determined to limit himself to such a treatment of his subject as would best promote the agricultural interests of the Commonwealth. No person in this country was better qualified to undertake the task, and no one but Dr. Harris could have accomplished it so satisfactorily. His report was published by the State in 1841. A small impression of the work, with slight alterations, was issued at Cambridge in 1842 under the title of "*A Treatise on some of the Insects of New England which are injurious to Vegetation*," (Cambr. pp. 459, 8vo.) A second edition of the book, revised and enlarged, was published in 1852, (Bost. pp. viii, and 513.)

This admirable treatise was received with great favor both by the cultivators of the soil, and by the cultivators of entomological science. In a style simple, clear, and exact, Dr. Harris gives, after a general view of his subject, a systematic account of such of our insects as are specially important on account of their injuries to plants or fruits, describing with much fullness their forms and their habits, and pointing out the best methods of preventing or remedying their attacks. The work is a treasure of valuable information, and will be an enduring monument of the industry and learning of its author.

Dr. Harris was of modest and retiring habits, and so cautious to avoid error, so anxious for the whole truth, that his published writings fail to do justice to the full extent of his abilities. "Yet," to use the language of one who knew him well, "he had abundantly the self-respect which belongs to unselfish labors to advance the world in the knowledge of the works of its Maker, and to the uniform tenor of a pure, useful, Christian life."

11. *Rev. Zadock Thompson*, Professor of Natural History in the University of Vermont, died at Burlington, January 19, 1856, aged 59. Mr. Thompson early interested himself in the study of the history and physical features of the state of Vermont, and in 1824 published a Gazetteer of the State which to a large extent was made from information gathered by his personal labors. In 1842 this work was incorporated in a much larger one of wider range of subjects entitled "History of Vermont, Natural, Civil, and Statistical, in three parts," a thick 8vo volume of 650 pages, one third of it devoted to the Natural History of the State. A supplement to this work, of 64 pages, appeared in 1853, bringing down the subjects of the Natural History and physical geography of Vermont to the date of publication. Among Mr. Thompson's researches, the discovery of the remains of a whale in the vicinity of Lake Champlain as a post-tertiary fossil was of special interest, proving that in the latest of geological periods preceding man, Lake Champlain was a cruising ground for northern Cetaceans. All his investigations were pursued with great zeal, fidelity, and success, and at the same time without ostentation. At the time of his death he was officially engaged in making a survey of the State of Vermont, embracing its Physical Geography, Geology and Mineralogy, Botany and general Zoology.

12. *Theory of the Winds;* by Captain CHARLES WILKES, U. S. N., (Read before the American Association at Providence, Aug. 20, 1855), accompanied by a map of the World, showing the extent and direction of the Winds; to which is added Sailing Directions for a voyage around the world. 116 pp., large 8vo. Philadelphia, 1856.—This volume, as the author states in his Introduction, forms part of his Report on Hydrography, the xviith volume of the Government Edition of the United States Exploring Expedition Reports. Capt. Wilkes speaks of his Report as a "sealed book," like the other Reports of the Expedition, "for there are only one hundred copies ordered by the Government for the use of the world!" He has therefore published a portion of the work for distribution. To give a just exposition of the Theory would require a review of many pages; and we have therefore to refer the reader to the volume itself. Capt. Wilkes combats the common doctrine that the rotation of the earth has any thing to do with the course or velocity of the Trade winds, and also observes that we have no satisfactory evidence of currents in the atmosphere passing from the polar to the equatorial regions. He lays down as the prominent point in his theory, that if there is a change of temperature in the atmosphere, there is a disturbance of equilibrium, the denser and colder portion seeking the warmer from every direction to restore the equilibrium in the most direct lines it can follow: and after remarking on this principle, he

points out the areas of greatest mean heat, and his inferences therefrom. Connected with this subject, he discusses the relations and influence of vapors in the atmosphere, and also of electricity in great storms.

13. *Description of a portion of the lower Jaw and a Tooth of the Mastodon Andium; also of a Tooth and fragment of the Femur of a Mastodon from Chile;* by Jeffries Wyman. 10 pp., 4to, with two plates. From Gilliss's Report on Chili, vol. ii.—Dr. Wyman sustains the view that there are remains of two species of Mastodon in South America, the *M. Andium* and *M. Humboldtii*; and possibly a third from Chili.

14. *A Memoir on the Extinct Sloth Tribe of North America;* by Joseph Leidy, Prof. Anat. Univ. Pennsylvania, etc. 68 pp., 4to, with 16 lithographic plates, (from the Smithsonian Contributions to Knowledge).—Dr. Leidy has here reviewed the facts relating to the extinct Sloth tribe of North America, and added much that is new from specimens under his examination. The species described are Megalonyx Jeffersonii *Harlan*, Megalonyx dissimilis *Leidy*, Ereptodon priscus *Leidy*, Mylodon Harlani *Owen*, Megatherium mirabile *Leidy* (the North American Megatherium, which Dr. Leidy regards as distinct from the M. Cuvieri of South America.) The plates are excellent.

15. *Contributions towards a Knowledge of the Marine Invertebrate Fauna of the Coasts of Rhode Island and New Jersey;* by Prof. J. Leidy, M.D. 18 pp. 4to, with 2 4to plates. Philadelphia, 1855. (From the Jour. Acad. Sci., Philad., vol. iii, 2nd Series.)—This paper contains enlarged views of the lasso-cells of the Astrangia, first made known and figured by Agassiz, besides descriptions and figures of several new species of worms, Polyps, etc., and one Crustacean, *Cepon distortus*, found in the branchial cavity of the Gelasimus pugilator.

16. *An Essay on Meteorites;* by R. P. Greg, F.G.S. 40 pp. 8vo, Nov., 1855. Manchester.—This important essay was originally issued as an article in the Philosophical Magazine for November and December, 1854, and is now published by the author with additions, in which he considers at some length the lunar theory of meteorites. He gives a catalogue of known meteoric falls, and compares them for different periods and countries. He concludes, that the origin of meteorites "is not within the limits of the atmosphere, and that some of them at least cannot have had a lunar origin;" that they are probably distinct in nature and orbits from ordinary luminous meteors; and that the falls are least frequent when the earth is in perihelion, and most so when it is in aphelion, the mean system or mass of the asteroids being in their perihelion; and finally, that they may be reasonably considered as belonging to the group of planetoids or asteroids, and therefore as of the nature and conditions of asteroids.

17. *Synopsis of the Classification of the British Palæozoic Rocks;* by the Rev. Adam Sedgwick, M.A., F.R.S., etc., with a Systematic Description of the British Palæozoic Fossils in the Geological Museum of the University of Cambridge, by Frederick McCoy, F.G.S., etc. 4to, pp. xcviii, and 407–622, with many plates, 1855.—This 3d Fasciculus closes the Palæontological volume of Prof. McCoy. The whole is a grand contribution to science under the auspices of Prof. Sedgwick, and the Geological part is the result of his special labors. We defer to another number a farther notice of the volume.

18. *Vienna Scientific Publications.*—The scientific publications issued annually in Vienna are not exceeded by those of any other city in Europe.

The Academy of Sciences published in 1854, in its Mathematico-Natural History section alone, 2 thick 4to volumes, printed in a style of unusual elegance, containing articles of the highest character in almost every branch under that section, and illustrated by numerous elegant plates; and besides this, the Bulletin of the Academy in 10 parts of 250 to 300 pages each, also finely printed and profusely illustrated. The Kais. Kön. Geologischen Anstalt publishes a quarterly Bulletin of more than 200 pages in small 4to; and in 1852 issued a volume of Transactions in large 4to, with many fine plates of fossils, etc. There is also a large 4to volume issued, entitled "Jahrbücher der K. K. Central-Anstalt für Meteorologie und Erdmagnetismus von Karl Kreil, which is brought out under the auspices of the Academy of Sciences. The volume for 1851 was published in 1855.

Volume ix of the Transactions of the Academy (1855) opens with an extended account (in Latin) of the structure and relations of the *Chlamydophorus truncatus* of Harlan, with many plates of great beauty, illustrating its anatomical structure, by Joseph Hyrtl. The other papers are as follows:—Beitrag zur Kenntniss der Grundlagen von Piazzi's Sternkatalog, von K. v. Littrow, 73 pages.—Beit. z. Kenntn. der Cephalopoden Fauna der Hallstätter Schichten, mit 5 Tafeln, von Fr. R. v. Hauer.—Ueber zwei Polyparien aus den Hallstätter Schichten, mit 1 Tafel, von A. E. Reuss.—16 Gattungen von Binnenwürmern und ihrer Arten, mit 6 Tafeln, von Dr. K. M. Diesing.—Schildkrötenreste aus den Oesterreichischen Tertiär-Ablagerungen, mit 6 Tafeln, von K. F. Peters, (including fine plates of several new species of fossil turtles.)—Ueber die Brachiopoden der Hallstätter Schichten, mit 2 Tafeln, von E. Suess.—Ueber die Gastropoden und Acephalen der Hallstätter Schichten mit 2 Tafeln, von Dr. M. Hornes.—Brechung und Reflexion des Lichts an zwillingsflächen optisch-einaxiger vollkommen durchsichtiger Medien, von J. Grailich.

19. *Journal of the Academy of Natural Sciences of Philadelphia, New Series.* Vol. III, Part II. 1855.

Art. VIII. Notice of Fossils from the Carboniferous Series of the Western States, belonging to the genera Spirifer, Bellerophon, Pleurotomaria, Macrocheilus, Natica, and Loxonema, with descriptions of eight new characteristic species; by J. G. Norwood and H. Pratten, of the Illinois Geological Survey.

IX. Plantæ Pratteninanæ Californicæ: An enumeration of a collection of California Plants, made in the vicinity of Nevada, by Henry Pratten, Esq., of New Harmony; with critical notices and descriptions of such of them as are new, or yet unpublished in America; by Elias Durand.

X. Relation of Atomic Heat to Crystalline Form; by J. A. Meigs, M.D. (An important exhibition of the relations of bodies as to their atomic heat, crystalline form, atomic volume, etc.)

XI. Contributions towards a knowledge of the Marine Invertebrate Fauna, of the coasts of Rhode Island and New Jersey; by Joseph Leidy, M.D.

XII. Descriptions of New Species of Psittacidæ, in the collection of the Academy of Natural Sciences of Philadelphia; by John Cassin.

The Culture of the Grape and Wine making, by ROBERT BUCHANAN, with an Appendix containing directions for the cultivation of the Strawberry, by N. LONGWORTH. 6th ed. 142 pp. 12mo. Cincinnati, 1855.

The Unity of Matter: A Dialogue on the relation between the various forms of matter which affect the senses; by Alex. Stephen Wilson. 80 pp. 16mo. 1855, London: J. Highley.

Videnskabelige Meddelelser fra den naturhistoriske Forening i Kjöbenhavn for Aaret 1853. Udgivne af Selskabets Bestyrelse. Copenhagen, 1854.—Opens with observations on the Papilionaceæ, Scrophularineæ, Labiatæ, Malpighiaceæ and Gentianeæ of Central America; by A. GRISEBACH and A. S. OERSTED. 58 pages.—Also contains a paper on Greenland Ornithology by J. REINHARDT; and on new Mexican Plants by F. LIEBMAN; and new species of Castelia by the same.

Handbuch der Metallurgischen Hüttenkunde, zum Gebrauche bei Vorlesungen und zum Selbstudium, bearbeitet von BRUNO KERL, Königl. Hannov. Hüttenmeister und Lehrer der Hüttenkunde und Probirkunst an der Königl. Bergschule zu Clausthal. 3 vols. Freiberg, 1855.

PROCEEDINGS BOSTON SOC. NAT. HIST.—Vol. V, DEC. 1855.—p. 257, Abstract of a memoir on the fossil foot-prints in the Carboniferous strata of Pennsylvania (advocating the view that they were Reptilian); *J. Wyman.*—On the so-called verd-antique marble of Roxbury, Vermont; *A. A. Hayes.* (Analyses show that the white portions are carbonate of magnesia).—p. 265, Note on the bones of the Mastodon found near Shell River, N. America.—p. 266 and 282, On the terminal velocity of raindrops of different diameters; *W. B. Rogers.*—p. 268, Oyster shells found in Charles River.—On the cohesive properties of Gutta Percha pipe of different sizes; *H. R. Storer* and *C. Stodder*, with remarks by other members.—JANUARY, 1856.—p. 274, Notes on the dissections of a Chimpanzee; *J. Wyman.*—p. 275, On the foot-print of a living Ostrich; *J. Wyman.*—Note on the Filaria Medinensis; *S. Durkee.* —p. 278, Parentage of the "Aztec" Children.—p. 279, Copper veins of the Phenix Mine on Eagle River, L. Superior.—p. 283, On the origin of the carbonate of iron of the Coal measures; *W. B. Rogers.*

PROCEEDINGS OF THE ACAD. NAT. SCI. PHILADELPHIA.—Vol. VII, No. XII, 1855. —p. 415, Descriptions of a few species of Coleoptera supposed to be new; *P. R. Uhler.*—p. 420, Catalogue of the Human Crania in the Collections of the Academy; *J. A. Meigs.*—p. 423, Descriptive Catalogue of the Raninæ (species of Rana, etc.) of the United States; *J. LeConte.*—p. 431, Observations on the N. American species of Bats; *J LeConte.*—p. 438, Notice of some new and little known Birds in the collection of the U. S. Exploring Expedition in the Vincennes and Peacock, and in the collection of the Academy; *J. Cassin.*—p. 441, Note on the Miocene and Post-pliocene deposits of California, with descriptions of two new Fossil Corals and description of a new species of Pentamerus; *T. A. Conrad.*—p. 442, Descriptions of two new species of Hesperomys; *J. LeConte.*—p. 443, Notices of some Tape Worms; *J. Leidy.*—Enumeration of Mosses detected in the Northern U. States, not comprised in the Manual of A. Gray, some of which are new; *T. P. James.*

Works received from G. A. Koch's Verlagsbuchandlung, Th. Kunike:

Natalicia Regis augustissimi Friderici Gulielmi IV., A. D. xv. M. Octobr. Hora xii. in auditorio minore celebranda indicunt Universitatis Regiæ Gryphiswaldensis Rector et Senatus. Inest G. F. Schoemanni Dissertatio de veterum criticorum notis ad Hesiodi Opera et Dies. Gryphis-waldiæ. Typis Frid. Guil. Kunike, Reg. Acad. Typogr., 1855.

Index Scholarum in Univ. Litteraria Gryphiswaldensi per semestre Hibernum, Anni MDCCCLV–VI, a die xvi mensis Octobris habendarum. Inest G. F. Schœmanni Dissertatio de causa Leptinea.—Typis ibid.

Wörterbuch der Niederdeutschen Sprache älterer und neuerer Zeit, verfasst von J. G. L. Kosegarten. Ersten Bandes, erste Lieferung. A—Ai. Greifswald, 1856.

Mythologische Beiträge zu den neuesten wissenchaftlichen Forschungen über die Religionen des Alterthums mit Hülfe der vergleichenden Sprachforschung, von Dr. K. Th. PYL, Docenten für Archaiologie und neure Kunstgeschichte an der Universität, Greifswald.—1 Theil, Das Polytheistische System der Griechischen Religion nebst einer literaturhistorischen Einleitung. 218 pp. 8vo. Greifswald, 1856.

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CHEMICAL AND PHILOSOPHICAL APPARATUS, INSTRUMENTS, ETC.

See further, second page of Cover.

Corrections to Prof. Rogers's Paper on Binocular Vision.—Part I, in vol. xx. (1) P. 89, line 10 from top, omit *any.* In figure 3, *r* should be straight and perpendicular to the length. (5) Page 95, line 17 from bottom, for "P and Q," read P_r and Q_r. Page 96, line 12 from top, for P and Q, read P_r and Q_r.

Part II. (6) Page 207, line 4 from top, for "lower," read *higher.* (9) Page 209, top line, for "conveyed," read *converged.* Page 210, line 19 from top, erase B. (12) Page 215, line 5 from top, for "or" read a. Fig. 25, the right hand figure should be reversed. (18) Page 328, line 5 from top, after "union," insert *of a and c.* (20) Page 333, line 15 from bottom, for "nearer," read *further.*

Part III. Page 91, line 9 from top, after from, add, *the denominators of.*

The next No. of this Journal will be published on the first of May.

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SCIENTIFIC INTELLIGENCE.

(*For remainder of Contents, see third page of Cover.*)

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TO CORRESPONDENTS.

Twelve copies of each *original communication*, published in this Journal, are if requested at the disposal of the author. Authors should specify at the head of their MSS. the number of extra copies desired; it is too late after the forms are broken up.

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THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

Art. XXXI.—*The Climate of San Francisco for the year 1855*; by H. Gibbons, M.D.

In the following observations the temperature is stated at sunrise, 9 a. m., noon, and 10 p. m. This is not critically accurate in regard to the observations at sunrise and noon. A thermometrograph was used for the former, by which the lowest degree is noted, occurring generally a short time before sunrise. The "noon" observation was made at the warmest period of the day, varying from 12 to 2 or 3 p. m.

Towards the close of the year 1854, the miners and the farmers throughout the State were in trouble for want of rain. On the last day of December, the whole amount of rain fallen since the summer was only 2·60 inches, and nearly all of this was in October. But on December 31st set in a storm which changed the prospect. One third of an inch fell on that day, and the new year was ushered in by the most violent gale witnessed for a number of years. The wind was from the south, accompanied with heavy rain. It is worthy of note that this storm was felt in all parts of the State, in a range of five or six hundred miles north and south, at the same hour—a remark that will apply generally, as far as I can ascertain, to the southerly or south-easterly rainstorms of California. Houses were unroofed or prostrated and trees uprooted at San Francisco, and in the mining regions of the northern counties, a few hours before day light on the 1st of January. The storm was brief, the wind changing to west before sunrise, and bringing showers of rain and hail through the day.

The first week of January was cold and rainy. On the 6th the mercury fell to 33°, the coldest weather of the entire winter. Snow was visible on the coast mountains. For the remainder of the month the sky was almost cloudless, and the temperature moderate, ranging from 49° to 59° at noon, until the 20th, after which the range was from 60° to 72°—the highest point reached by the thermometer in January since the commencement of my observations in 1850. The warmest morning in the month was 57° and the coldest noon 48°. The mean temperature at sunrise was 44°·71, at 9 A. M. 49°·39, at noon 57°·29, at 10 P. M. 46°·87. Mean of extremes 51°·00. Proportion of clear sky 69 per cent. Thirteen days were entirely or nearly clear, and five entirely cloudy. Four foggy mornings. Rain fell on nine days, quantity 4·52 in. Winds NW and N nineteen days, NE and E one day, SE and S seven days, SW and W four days. Land winds 65 per cent., sea winds 35. High winds on two days. Light breezes on twenty-nine days.

Mean of barometer: sunrise 29·869 in., 9 A. M. 29·885 in., noon 29·860 in., 10 P. M. 29·867 in. Maximum 30·12 in., minimum 29·40 inches.

February, as usual, was warm and agreeable, and mostly dry until the last week. The night temperature ranged generally from 45° to 52°, and the noon temperature from 60° to 70°. One or two slight frosts occurred. The winds were very light, seldom rising above a moderate breeze. They prevailed from N and NW, and South. On the 19th and 20th a brisk gale from the north swept over the entire State, attended with a falling barometer, and followed by heavy rains, which by this time were much needed. An unusual quantity fell, for this month. The thermometrical means were, at sunrise 50°·25, 9 A. M. 55°·04, noon 63°·29, 10 P. M. 52°·32. Mean of extremes 56°·77—being the warmest February for five years. The maximum was 72°, and the minimum 41°. Warmest morning 56°, coldest noon 56°. Proportion of clear sky 60 per cent. Whole days clear thirteen, cloudy five. Fog on two mornings and one evening. Rain on nine days; quantity 4·64 in. Winds N and NW ten days; NE and E two days; SE and S nine days; SW and W seven days. Land winds 44 per cent, sea winds 56. Barometric means, sunrise 29·849, 9 A. M. 29·857, noon, 29·836, 10 P. M. 29·850. Extremes 30·06 and 29·48.

March.—Mean temperature at sunrise 51°·77, 9 A. M. 57·81, noon 67°·03, 10 P. M. 53°·68. Mean of extremes, 59°·40. Highest temperature 78°, lowest 44°. Warmest morning 57°, coldest noon 59°. Proportion of clear sky 53 per cent, cloudy 47. Only seven days were clear from morning to night, and four were cloudy throughout. Rain fell on twelve days, quantity 4·31 in.; mist on four mornings and one evening. Wind N and NW eight days, NE and E one day, SE and S nine days, SW and W thirteen days. Moderate breezes prevailed and there were no high winds. The month was remarkably warm, being five or six degrees above the average for a number of years past. There were several slight frosts, but not to impede the growth of vegetation. The general range of the thermometer at noon was from 64° to 70°, and on five days it rose above the latter figure. The rainy temperament of the last week of February was continued through the first two weeks of March, and was succeeded, in accordance with the habits of our climate, by a period of perfectly dry weather, lasting a fortnight. Copious rains again fell on the 30th and 31st. The streams in the interior were much swollen about the 6th.

Barometric means: sunrise 29·828, 9 A. M. 29·835, noon 29·791, 10 P. M. 29·828. Maximum 29·99, minimum 29·50

April.—Mean temperature at sunrise 50°·57, 9 A. M. 57°·43, noon 64°·90, 10 P. M. 51°·83. Mean of extremes 57°·73. Highest temperature 78°, lowest 40°. Warmest morning 57°, coldest noon 56°. Proportion of clear sky 63 per cent, cloudy 37. Whole days clear ten, cloudy three. Rain on ten days, quantity 5·59 in. Slight mist on two mornings. Wind NW and N eight days, NE and E one day, SE and S five days, SW and W sixteen days. Land winds 30 per cent, sea winds 70. In this month the sea breeze commences. Several of the afternoons were windy, and twice the wind was high. The temperature was rather below the usual mean for April. The nights commonly ranged from 46° to 55°, and the noonday temperature from 62° to 70°. There was a general white frost on the morning of the 2nd. A greater quantity of rain fell than in any other month of the year. From the 10th to the 17th every day was more or less rainy, but in all the rest of the month there were but two days on which rain fell, and then in very small quantity. About the middle of the month the streams in the interior were much swollen. Lightning was observed on the 11th and distant thunder on the 15th.

Barometric mean at sunrise 29·853 in., at 9 A. M. 29·861, at noon 29·859, at 10 P. M. 29·860. Extremes 30·17 and 29·47.

May.—Temperature at sunrise 50°·06, 9 A. M. 57°·84, noon 65°·37, 10 P. M. 52°·10. Mean of extremes 57°·72. Maximum 83°, minimum 44°; range 39°. Warmest morning 57°, coldest noon 61°. Proportion of clear sky 74 per cent, of cloudy 26. Whole days clear thirteen, cloudy two. Rain on five days; quantity 2·14 in.; mist on one morning and one evening. Wind NW and N five days; NE and E 0; SE and S three; SW one; W twenty-two. High winds on five afternoons, and the afternoons of sixteen other days windy. Land winds 16 per cent, sea winds 84. The temperature of the month was about the usual standard for May, though the extreme of 83° was uncommon. Slight frosts occurred on several mornings. The general range of the thermometer at sunrise was from 46° to 54°, and at noon from 62° to 68°. May is the transition month from the rainy season to that of permanent drought. A few light rains generally occur, but the quantity in 1855 was far beyond the ordinary supply. Nearly 1¼ inches fell on the 14th and four-tenths on the 19th and 20th, after which there was no more till Autumn.

Barometric means; sunrise 29·835 in.—9 A. M. 29·840,—noon 29·832,—10 P. M. 29·830. Extremes, 30·05 and 29·67.

June.—Mean temperature at sunrise 52°·00, 9 A. M. 61°·20, noon 67°·87, 10 P. M. 54°·40. Mean of extremes 59°·93. Maximum 82°, minimum 49°; range 33°. Warmest morning 57°, coldest noon 62°. Proportion of clear sky 87 per cent, of cloudy 13. Whole days clear nineteen, cloudy 0. No rain. Mist on ten mornings and six evenings. Wind SE and S two days, SW one day, West twenty-seven days. On twenty-two days the afternoons were windy, and on six of these the wind was high. On the 11th, 12th and 13th rains fell in the interior and northern counties. There was a very large proportion of fair weather and cloudless sky. The temperature observed the ordinary range for June, varying mostly from 50° to 54° at sunrise and from 63° to 70° at noon. Land winds 2 per cent, sea winds 98 per cent, or in other words there was almost no land wind.

Barometric means: sunrise 29·701 in., 9 A. M. 29·709, noon 29·706, 10 P. M. 29.695. Extremes 29·98 and 29·57.

July.—Mean temperature sunrise, 54°·90, 9 A. M. 61°.87, noon 67°·45, 10 P. M. 56°·71. Mean of extremes 61°·13. Maximum 90°, minimum 51°; range 39°. Warmest morning 64°, coldest noon 62°. Proportion of clear sky 61 per cent, of cloudy 39. Whole days clear ten, cloudy one. Mist on thirteen mornings, and ten evenings. Wind SE and S one day; SW three days; West twenty-seven days. Proportion of land winds 2 per cent, of sea winds 98 per cent. Windy afternoons twenty-four, of which three high winds. The general range of temperature at night was from 53° to 58°, and at noon from 62° to 70°. On one day, the 7th, it reached the extraordinary height of 90°. The warmest day next to this was 77°. There were but five days in all the month when the mercury rose as high as 70° at noon.

Barometric means for July: sunrise 29·738 in., 9 A. M. 29·750, noon 29·747, 10 P. M. 29·734. Extremes 29·86 and 29·59.

August.—Mean temperature at sunrise 55°·32, at 9 A. M. 63°·23, at noon 69°·61, at 10 P. M. 57·77. Mean of extremes 62°47. Maximum 79°, minimum 53°; range 26°. Warmest morning

57°; coldest noon 64°. Proportion of clear sky 77 per cent, of cloudy 23. Whole days clear sixteen, cloudy 0. Mist on three mornings and four evenings. No rain. On twenty-four days the afternoon was windy, and on three of these the wind was high. Wind SE and S three days, West twenty-eight days. Proportion of sea winds 100 per cent—that is to say the wind did not blow from the land for a single hour during the month. On the night of the 18th there was distant lightning, and on the 19th rain fell in Sierra county. The temperature was slightly above the mean of August for a series of years. At sunrise the mercury ranged between 54° and 57°, with a solitary exception when it stood at 53°. At noon the range was usually between 66° and 74°. On sixteen days the temperature at noon was at or above 70°, which can seldom be said of any month of the year at San Francisco. On the last day of the month was a slight frost in favorable situations, enough in some places to injure the tender vegetables.

Barometric means for August: at sunrise 29·727 in., at 9 A. M. 29·740, at noon 29·739, at 10 P. M. 29·728. Extremes 29·90 and 29.56.

September.—Mean temperature sunrise 54°·97, 9 A. M. 62°·50, noon 69°·90, 10 P. M. 57°·04. Mean of extremes 62°·43. Maximum 84°, minimum 50°; range 34°. Warmest morning 61°, coldest noon 63°. Proportion of clear sky 80 per cent, of cloudy 20. Whole days clear twelve, cloudy 0. No rain. Mist on seven mornings and nine evenings. Wind S and SE three days, SW two days, West twenty-four days, NW one day. Proportion of land winds 3 per cent, of sea winds 97 per cent. There were twelve windy afternoons, on five of which the wind was high. It is unusual to have high sea winds so late in the season. The range of temperature at sunrise was generally from 53° to 58°, and at noon from 64° to 78°, though on three days it rose above 80°. There is usually some rain in September, but none fell in the present month. In Oregon the first rain of the season was on the 3d, and heavy rains fell in the northern counties of California on the 16th and 17th. On the evening of the latter day, lightning was observed from San Francisco in the northern horizon.

Barometric means for September: sunrise 29·718 in., 9 A. M. 29·734, noon 29·727, 10 P. M. 29·677. Extremes 29·85 and 29·60.

October.—Mean temperature at sunrise 54°·77, at 9 A. M. 61°·14, at noon 68°·32, at 10 P. M. 57°·00. Mean of extremes 61°·55. Maximum 79°, minimum 51°; range 28°. Warmest morning 58°, coldest noon 61°. Proportion of clear sky 68 per cent, of cloudy 32; whole days clear ten, cloudy two. No rain. Mist on ten mornings, and seven evenings. Wind SE and S five days, SW one day, West twenty-four days, NW one day. Proportion of land winds 3 per cent, sea winds 97. The sea breeze always loses its force in this month, though it is apt to recur every afternoon with great regularity, as in the present instance. On eight days the afternoons were windy, but there were no high winds. The general range of temperature was from 52° to 58° through the night, and from 62° to 72° at noon. It was at or above 70° on eleven days.

Barometric means for October: sunrise 29·780 in., 9 A. M. 29·799, noon 29·751, 10 P. M. 29·778. Extremes, 29·95 and 29·59.

November.—Mean temperature at sunrise 46°·60, at 9 A. M. 55°·73, at noon 59°·20, at 10 P. M. 49°·37. Mean of extremes 52°·90. Maximum 67°, minimum 42°; range 25°. Warmest morning 58°, coldest noon 52°. Proportion of clear sky 70 per cent, of cloudy 30. Whole days clear eleven, cloudy two. Rain on seven days, quantity 1·15 in. Mist on five mornings and three evenings. Wind N and NW nine days, NE and E one day, SE and S seven days, SW and W thirteen days. Proportion of land winds 33 per cent, sea winds 67. Two days windy in part, and no high winds. A gale from north took place on the 2nd, extending over the State as do these northers in common, and portending rain, the barometer almost invariably falling during a strong north wind. The first rain was a shower on the 10th, after which several moderate rains were thankfully received, but the ground did not become wet enough for tillage till December. In the early part of the month were several white frosts, and there was also more or less frost nearly every morning after the 12th, the mercury ranging at sunrise during the latter period from 42° to 46°. At noon the general range was from 54° to 64°.

Barometric means for November: sunrise 29·862 in., 9 A. M. 29·879, noon 29·860, 10 P. M. 29·855. Extremes 30·16 and 29·50.

December.—Mean temperature at sunrise 43°·32, at 9 A. M. 47°·58, at noon 52°·19, at 10 P. M. 45·90. Mean of extremes 47°·76. Maximum 61°, minimum 29°; range 32°. Warmest morning 54°, coldest noon 41°. Proportion of clear sky 55 per cent, of cloudy 45. Whole days clear ten, cloudy eight. Rain on fourteen days, quantity 5·45 in. Mist on three mornings and two evenings. Wind N and NW seven days, NE and E six days, SE and S ten days, SW and W eight days. Proportion of land winds 42 per cent, sea winds 58. Parts of three or four days were windy, and there was one high wind accompanied with rain, from SW. This was as unpleasant a month as our climate can supply. The rains were mostly cold and in small quantities, and the sky almost constantly overcast. On the 7th was the very rare phenomenon of a genuine thundergust, arranged much in the style of the Atlantic States, and accompanied with a shower of hail. After the 23d the air was remarkably cold, the lowest point reached by the mercury being 29°, on the morning of the 24th. At noon it was 41°, with ice in the shade all day. After this, it was at or below the freezing point on five mornings, and during the last week of the month the ground continued frozen in the shade. In December 1850 the thermometer fell to 28°, and in January 1854 to 25°, but the last eight days of December 1855 had a lower mean temperature than any other similar period since the commencement of my observations in 1850. The mountains of the Coast Range in the southeast were seen covered with snow, and snow fell to a great depth in the northern counties.

Summary for the year 1855.—The mean temperature of the whole year was as follows: at sunrise, 50°·771, at 9 A. M. 57°·563, at noon 64°·368, at 10 P. M. 52°·916. The mean of the extremes, which represents the temperature of the year, was 57°·57, which coincides, it may be said *precisely*, with the mean temperature at 9 A. M. This appears to be nearly the mean temperature of our climate, as the following figures for five years will show:

Mean	temperature	of	1851, 56°·573
"	"	"	1852, 56°·537
"	"	"	1853, 58°·125
"	"	"	1854, 57°·209
"	"	"	1855, 57°·570
"		"	for five years 57°·203

December was not only the coldest month in the year, but the coldest within the range of my record, which extends back to the winter of 1850–51. The month of January, 1854, comes next in order, and then December, 1850. After the middle of January, the sun acquires sufficient power to raise the temperature very materially. Hence February is never a cold month, and April is sometimes as warm as July. The autumn months are the warmest of the year, the cold sea breeze at that season declining in force. In 1855, the warmest month was August; next comes September, then October, then July, then June, and then March.

The extreme heat of the year was 90°. The mercury has at no time in the course of my observations reached this elevation, except in September, 1852, when it stood at 97° and 98° respectively on two consecutive days. In the whole interior of the state, beyond the immediate influence of the ocean winds, this is a common temperature, and indeed much below the extreme heat of summer. Whenever such weather occurs at San Francisco, it is by a suspension of the ordinary programme, the sea-breeze holding off and allowing the climate of the interior to invade its domain. In some years the extreme heat at San Francisco is not above 84°. To what extent we are wont to suffer from heat in this latitude of 37½ degrees, may be determined from the fact that in the year 1855, the mercury rose to 80° or above, only on six days. In 1851 it reached that point on nine days, in 1852 on fourteen days, in 1853 on eleven days, and in 1854 on twelve days. More than one half of these warm days were in the autumn, and less than one third in the summer months.

The greatest degree of cold in 1855, was 29°, and the mercury was at or below the freezing point on six days, all of which were in December. It was below 40 on ten days, three of which were in January, and seven in December. In some winters there is no freezing weather, and the most tender plants may bloom in the gardens from season to season. The lowest temperature on my record is 25°,—in January 1854. Next to this 28°, in December 1850, and next, 29° in December 1855. In the year 1853 the mercury did not fall below 40°. The whole number of freezing mornings in 1850 was two, in 1851 one, in 1852 none, in 1853 none, in 1854 three, in 1855 six. The coldest noonday in 1855 was 41°. In December 1850 there was one day when the noon temperature was 38°, and in January 1854, a day when it rose no higher than 37°. Such weather however is extraordinary, and when it occurs every body declares the like was never before known, and that the climate is changing in deference to the American population.

The warmest morning in the year was 64°. The warmest morning for the last five years was 66°. There are but one or two mornings in the year which approach this figure. A sultry night is unheard of. A single night that could be called warm has happened in five years, and then the thermometer was 76° at 10 P. M. and 66° next morning.

The range of the thermometer in 1855 was 61°. In 1851 the range was 54°; in 1852, 63°; in 1853 48°; in 1854, 62°.

The greatest barometric pressure in the year was 30·16 in., the lowest 29·40 in. Range 0·76 in.,—which is nearly the mean range for a series of years. The lowest point reached in five years was 29·20 in.,—during a violent southerly storm.

The time occupied by the various winds is thus represented:

Land winds,	NW	33 days.	Sea winds,	SE	16	days.
" "	N	25 "	" "	S	48	"
" "	NE	11 "	" "	SW	17	"
" "	E	1 "	" "	W	204	"
Total land winds,		80 "	Total sea winds,		285	"

It may be well to explain that the northwest and southeast winds blow in a line with the coast, and are classed, the former as land winds and the latter as sea winds, not so much from their direction as their sensible qualities.

The rains were thus distributed:

Jan. rain on	9 days,	4·52 in.			July, rain on	0 days,	0·00		
Feb. "	9 "	4·64 "			Aug. "	0 "	0·00		
March "	12 "	4·31 "			Sept. "	0 "	0·00		
April "	10 "	5·59 "			Oct. "	0 "	0·00		
May "	5 "	2·14 "			Nov. "	7 "	1·15		
June "	0 "	0·00 "			Dec. "	14 "	5·45		

Total, rain on 66 days, 27·80 in.,—which is a larger quantity than common, as the following statement will show.

Rain in 1851	on	53 days,	15·12 in.
" 1852	on	60 "	25·60 "
" 1853	on	44 "	19·03 "
" 1854	on	54 "	22·12 "

Comparing one rainy season with another, a greater difference appears. The winter of 1850–51 furnished but 7·31 in., that of 51–52, 18·00 in., that of 52–53, 33·46 in., that of 53–54, 22·93 in., and that of 54–55, 24·10 in.

There was some hail in January, and again in December, but no snow. For a few days in each of these months the Coast Mountains in the SE were seen to be covered with snow.

The clouds were sensibly electrified five times—twice in April, once in August, once in September, and once in December. The lightning or thunder was distinct except in December when there was a regular thunder-gust with heavy thunder.

On the evenings of the 11th and 12th of August shooting stars were numerous, and still more so on the evening of December 11th. Nothing extraordinary was observed in November, about the anniversary of the great meteoric shower in 1833.

ART. XXXII.—*On the Geology of the Hudson's Bay Territories, and of portions of the Arctic and Northwestern Regions of America;** by A. K. ISBISTER, M.A., M.R.C.P. &c.

IN submitting to the society a Geological map of this extensive region, with a few explanatory remarks, my object has been to recapitulate very concisely the various observations of the geologists and travellers who have explored, and of the naturalists who have examined the organic remains of this portion of the American Continent, and to present as completely as possible the results which have been hitherto attained in the study of its geological formations. The numberless difficulties inherent in such an undertaking, embracing a range of country so vast and so difficult to explore, or even to obtain access to, must necessarily render any attempt of this nature very imperfect; but I have been

* Quart. Jour. Geol. Soc., xi, p. 497. London, 1855. [We omit the map.—EDS.]

induced to undertake it in the belief that, in the absence of any general view of the geological structure of this extensive but interesting region, even the most cursory classification of its formations might be useful to those employed in developing the structure of the crust of the earth,—the more especially as it is not probable that the attention of practical geologists will soon be directed to this distant and almost inaccessible field of investigation.

To render the present attempt as complete as the state of our knowledge will admit, I have carefully studied all the published documents and the geological collections relating to the subject to which I have been able to obtain access. And I have myself resided for many years in various parts of the territory, which I may add, I have traversed from one extremity to the other,—from the borders of the United States to the Arctic Ocean in one direction, and from the frontiers of Russian America to Hudson's Bay in the other.

The titles of the publications to which I have referred are indicated below, and may be considered as presenting a bibliographical view of what is known of the geology of this part of America.

LIST OF WORKS RELATING TO THE GEOLOGY OF THE NORTHERN PART OF NORTH AMERICA.

Northwest Coast and Russian America.

Geology of the United States Exploring Expedition under the command of Commodore Wilkes. By James D. Dana. New York, 1850.

Geological Appendix to Captain Beechey's Voyage to Behring's Straits in the ship "Blossom." By Dr. Buckland. London, 1839.

Beitrag zur Kenntniss der orographischen und geognostischen Beschaffenheit der Nord-West Küste Amerika's. Von Dr. C. Grenwingk. St. Petersburg, 1850.

Exploration and Survey of Peel's River; a portion of the chain of the Rocky Mountains and the country west of McKenzie's River. By A. K. Isbister. Journal of the Royal Geographical Society for 1846.

Hudson's Bay Territories and Arctic Regions.

Topographical and Geological Appendices to the Narratives of Sir John Franklin's First and Second Journeys to the Shores of the Polar Sea. By Dr. Richardson. And Note on the Fossils. By Prof. Jameson. London, 1825 and 1828.

Observations on the Rock Specimens collected during the First Polar Voyage of Captain Parry. By Charles König. London, 1824.

Notes on the Geology of the Countries discovered during Captain Parry's Second and Third Expeditions. By Prof Jameson. London, 1826.

Geological Appendix to the Narrative of an Attempt to reach the North Pole by Sir Edward Parry, in the year 1827. By Professor Jameson. London, 1828.

Geological Appendix to Dr. Scoresby's "Journal of a Voyage to the Northern Whale Fishery, including Researches and Discoveries on the East Coast of Grenland." By Professor Jameson. Edinburgh, 1823.

Discovery and Adventure in the Polar Seas and Regions: Edinburgh Cabinet Library; with a Chapter on Arctic Geology. By Sir John Leslie, Professor Jameson, and Hugh Murray. 1832.

Voyage of Discovery for Exploring Baffin's Bay. By J. Ross. 1819. Appendix on the Rock-specimens. By Dr. M'Culloch.

Journal of Captain Penny's Voyage to Baffin's Bay and Barrow's Straits, in search of Sir John Franklin. By Dr. P. C. Sutherland. With an Appendix on Geology. By J. W. Salter. London, 1852.

Arctic Silurian Fossils. By J. W. SALTER. 1853. Quart. Journ. Geol. Soc. vol. ix.

On the Geological and Glacial Phænomena of the Coasts of Davis's Straits and Baffin's Bay. By P. C. SUTHERLAND, M.D. 1853. Quart. Journ. Geol. Soc. vol. ix.

RINK, H., Geology of West Greenland. Trans. Roy. Soc. Denmark, 1852. (Om den geographiske Beskaffenhed af de Danske Handelsdistriker i Nordgrönland.)

STEINHAUER on the Geology of Labrador. 1814. Trans. Geol. Soc. vol. ii.

BAYFIELD, on the Geology of the N. Coast of the St. Lawrence. 1837. Trans. Geol. Soc. 2nd Series, vol. v.

On the Geology of Lake Huron. By Dr. BIGSBY. 1824. Trans. Geol. Soc. 2nd Series, vol. i.

On the Geology of the Lake of the Woods [and Rainy River]. By Dr. BIGSBY. 1852. Quart. Journ. Geol. Soc. Vol. viii.

On the Geology of Rainy Lake, South Hudson's Bay. By Dr. BIGSBY. 1854. Quart. Journ. Geol. Soc. vol. x.

On the Drift of the Lake of the Woods and South Hudson's Bay. By Dr. BIGSBY. 1851. Quart. Journ. Geol. Soc. vol. vii.

Narrative of the Arctic Land Expedition to the Mouth of the Great Fish River. By Captain BACK, R.N. Appendix on Geology. By W. H. FITTON, M.D. London, 1836.

Journal of a Boat Voyage through Rupert's Land and the Arctic Sea, in search of the Discovery Ships under Sir. John Franklin. By Sir. JOHN RICHARDSON. London, 1851.

On some points of the Physical Geography of North America. By Sir. J. RICHARDSON. 1851. Quart. Journ. Geol. Soc. vol. vii.

Report of a Geological Survey of Wisconsin, Iowa, and Minnesota, and incidentally of a portion of Nebraska Territory [including the Red River of Lake Winnipeg]. By DAVID DALE OWEN. Philadelphia, 1852.

The chief sources of information, however, on which I have relied in confirmation of my own observations are the valuable Memoirs of Mr. Salter on Arctic Silurian Fossils, published in the Quarterly Journal of the Geological Society, vol. ix, and in the Appendix to Dr. Sutherland's Journal of Capt. Penny's Voyage, and the extensive researches and the numerous able publications of the great Arctic traveller Sir John Richardson, to whom science is indebted for nearly all that is known of the natural history of the vast region surrounding Hudson's Bay.

The collections of rock-specimens and minerals brought to England by the expeditions of discovery through this territory, to which Sir John Richardson was attached, and the various Arctic expeditions by which its northern shores have been traced, as well as by those recently engaged in the search for Sir John Franklin, are very extensive, and throw much valuable light on the mineral structure of the various formations which prevail in the northern regions of America. It was not, however, until within the last few years that any considerable collection had been made of the *organic remains* belonging to these formations, by which alone their relative ages and their true characters can be determined. Some of the fossil remains alluded to have been described and figured by Mr. Salter in the papers already referred to, others by Dr. Dale Owen, of the U. S. Geological Survey, Dr. Buckland and others; and some (as will be subsequently noticed) have been described, though only incidentally and in general terms, by Sir John Richardson, Mr. Sowerby, the late Mr. König of the British Museum, and the late Professor Jameson of Edinburgh. A considerable number remain still undescribed in the Museum of the Edinburgh University, the British Museum, the Museum of Practical Geology in Jermyn Street, and the Museum of Haslar Hospital, or are mentioned for the first time in the present paper.

An examination of these specimens leaves no doubt of the existence of a vast development of palæozoic deposits, extending with little intermission (so far as is known) from the northern frontiers of Canada and the United States to the farthest point to which our researches have extended in the Arctic Ocean, and from Hudson's Bay on the east to near the Rocky Mountains on the west,—presenting altogether a geological horizon of a grandeur and extent unequalled probably in any other part of the world, largely as the researches of Sir Roderick Murchison, Sir Charles Lyell, and others have shown such formations to be developed in Russia and the United States.

A slight sketch of the chief physical features of this wide region will demonstrate the remarkable symmetry and unbroken condition of its sedimentary deposits, and to what an unusual degree they have apparently been exempted from those igneous disturbances which have complicated the geological structure of many other countries of far less extent in other parts of the world.

TERRITORIES EAST OF THE ROCKY MOUNTAINS.

Physical Features; and Range of the Crystalline Rocks.—Separated from Canada by the great granitic range of the Laurentine or Canadian Mountains, which form the division between the hydrographic basins of these northern regions and those of the St. Lawrence and its great lakes, the Hudson's Bay Territories may be considered as forming one vast plain, diversified only by a single low granitic ridge running northwards from the west end and almost the whole north shore of Lake Superior as far as Great Bear Lake, in a direction nearly parallel with the range of the Rocky Mountains. This low belt of crystalline rocks averages about 200 miles in breadth, and is evidently the northern continuation of the Laurentine range, which after extending uninterruptedly along the northern frontiers of Canada until it comes in contact with the northern spurs of the Alleghanies near the mouth of the St. Lawrence, is deflected northwards in a direction again nearly parallel with the Rocky Mountains through Labrador and along the shores of Hudson's Straits and Baffin's Bay until it finally disappears beneath the limestones of Lancaster Sound and Barrow's Straits. The striking correspondence between the direction of this granitic range, as thus traced, and the general contour of Hudson's Bay will be at once obvious from an inspection of the Map, and would appear to point out this vast mass of crystalline rocks as the probable axis of elevation of the great movement by which the Hudson's Bay Territories, as well as Labrador and the lands and islands along the west coast of Baffin's Bay, were first upheaved from the primeval ocean under which they once reposed. The grand chain of the Rocky Mountains may be considered also as forming a new axis of elevation, at nearly an equal distance farther west, upheaving in a similar manner the wide-spread strata which repose on its flanks.

The existence of lines of division, pursuing a parallel course, in a general meridional direction, like those just mentioned, is one of the most prominent general circumstances hitherto ascertained respecting the geology of this part of America. The course of the Rocky Mountain chain, from the Sierra of Mexico in lat. 30° to its termination on the coast of the Arctic Sea in lat. 69°, is about N by W, with very little deviation anywhere. This is also the general direction of the rugged and lofty coast range of Labrador and Baffin's Bay, as well as of the west coast of Greenland.

By carrying the eye over the map from point to point along the western edge of the crystalline belt running through the Hudson's Bay Territories, it will be seen that the average direction is the same; though, as it proceeds northwards it inclines slightly towards the Rocky Mountains, which it is to be observed however, begin here to lose their continuity; several of the western ranges being found to deviate from the general direction of the chain, and to develop themselves in irregular masses through the interior of Russian America.

We possess little reliable information respecting the structure of the mountain ranges of Labrador (on the east) or of the Rocky Mountains (on the west) north of the forty-seventh parallel, where they were crossed by Lewis and Clarke, in 1805, and no organic remains (so far as I am aware) from either locality. Sir John Richardson who is in possession of all the information respecting the Rocky Mountain range, collected from the traders of the Hudson's Bay Company and from the botanists Douglas and Drummond who crossed it between the sources of the Elk and Peace Rivers, describes the eastern slopes as consisting of conglomerate and sandstone, to which succeed limestone and clay-slates, probably of Silurian age, and granite. This view is to some extent borne out by the section of this range given by Marcou, at Fort Laramie, in lat. 42°, from the Surveys of the United State's geologists. Farther north, where the chain was explored by myself, near its termination in the Arctic Sea, the prevailing formations were found through their organic remains (as will be subsequently noticed) to be referable to certain members of the Carboniferous series, corresponding probably to the

Mountain Limestone of English geologists. From the highest part of the range, near latitude 55° N, where it attains an elevation of 16,000 feet above the sea, the four largest rivers of North America—the Missouri, the Saskatchewan, the Mackenzie, and the Columbia take their rise. It may be added, that these four feeders of opposite oceans not only take their origin from the same range of mountains, but three of them almost from the same hill,—the head-waters of the Columbia and the Mackenzie being only about "two hundred yards" apart, and those of the Columbia and the Saskatchewan, not more than "fourteen paces." It may be mentioned also as a singular fact, that one branch of the Mackenzie, the "Peace River" of Sir Alexander Mackenzie, actually rises on the western side of the Rocky Mountains within 300 yards of another large river flowing into the Pacific, the Tacoutchetesse, or Fraser's River, which discharges itself into the Gulf of Georgia, opposite Vancouver's Island.

Central Plateau of Crystalline Rocks.—Marcou, in his recently published Geological Map of the United States has traced the crystalline formation of the Laurentine Mountains a considerable distance to the westward of Lake Superior, where it appears to form the chief constituent of the low watershed which separates the waters of the Missouri from those of the Saskatchewan and other rivers flowing into Hudson's Bay.

The zone of crystalline rocks, chiefly gneiss, with granite and trap, previously alluded to as extending for a very great distance in a northwest direction from Lake Superior, is likewise very little elevated for the greater part of its extent above the surrounding country. Sir John Franklin on his first overland expedition to the shores of the Polar Sea, crossed this granitic chain nearly at right angles to its line of direction in proceeding from Hudson's Bay to Lake Winipeg, where it was 220 miles wide; it has been since crossed at various other points, and traced nearly along its entire length to the Arctic Sea. We are thus in possession of the requisite data for mapping its course and extent, and indicating its general features with considerable accuracy. Branching off from the Laurentine ranges, it assumes a northwesterly direction from the Lake of the Woods (where it first comes in contact with the limestones which underlie the prairies on the west), until it reaches Lake Winnipeg, along the eastern side of which it is then continued for about 280 miles in nearly a N NW direction. From Norway Point at the north end of Lake Winnipeg to Isle à la Crosse, a distance of 420 miles in a straight line, the western boundary has, according to Sir John Richardson, a WNW direction. For 240 miles from Isle à la Crosse to Athabasca Lake, its course turns in a somewhat irregular outline northward, enclosing the whole of that lake with the exception of its western extremity. Thence it is continued to

MacTavish Bay in Great Bear Lake, a distance of 500 miles in a general direction of about NW by W, and is marked according to Sir John Richardson, "by the Slave River, a deep inlet on the north side of Great Slave Lake, and a chain of rivers and lakes, including Great Marten Lake, which discharge themselves into that inlet." From Great Bear Lake to the sea it follows the general course of the Coppermine River, its termination being marked by the mouth of that stream in lat. 71° 55′ N and long. 120° 30′ W; or perhaps more correctly by Richardson's River, a little to the west of it. In this part for the first time the chain rises to the altitude of hills, marked on the Map as the Copper Mountains, which attain in some parts a height of 800 feet above the bed of the river. The slight elevations composing the main portion of the chain seldom rise, as has been already observed, much above the level of the surrounding country, giving to the entire range the character of a low swampy plateau of crystalline rocks, covered by an immense network of small lakes and swamps, connected by narrow and tortuous channels. The low rugged knolls of granite and gneiss, round which these channels wind, "have mostly," says Sir John Richardson, "rounded summits, and they do not form continuous ridges, but are detached from each other by valleys of various breadth, though generally narrow and very seldom level. When the valleys are of considerable extent, they are almost invariably occupied by a lake, the proportion of water in this district being very great; from the top of the highest hill on the Hill River thirty-six lakes are said to be visible. The small elevation of the chain may be inferred from an examination of the Map, which shows that it is crossed by several rivers that rise in the Rocky Mountains, the most considerable of which are the Churchill, and the Saskatchewan or Nelson Rivers. These great streams have, for many hundred miles from their origin, the ordinary appearance of rivers in being bounded by continuous parallel banks, but on entering the primitive district, they present chains of lake-like dilatations, which are full of islands and have a very irregular outline. Many of the numerous arms of these expansions wind for miles through the neighboring country, and the whole district bears a striking resemblance, in the manner in which it is intersected by water, to the coast of Norway and the adjoining part of Sweden. The successive dilatations of the rivers have scarcely any current, but are connected with each other by one or more straits, in which the water-course is more or less obstructed by rocks, and the stream is very turbulent and rapid. The most prevalent rock in the chain is gneiss; but there are also granite and mica-slate, together with numerous beds of amphibolic rocks."

The entire length of this remarkable plateau, from Lake Superior to its termination on the Arctic Sea, may be estimated at somewhat more than 1500 miles. Such an enormous extension of crystalline and eruptive rocks, nowhere assuming the character of a mountain district, is a remarkable example of the tranquil operation of an upheaving force exerted over an immense area, yet with a limited and regulated intensity, and a constancy of direction which render it worthy of attention, not only as a striking geological phenomenon, but as serving, perhaps, to throw some light on the dynamical conditions under which those vast sedimentary deposits which have excited the astonishment of geologists in America from their unparalleled extension have been originally upheaved.

It may be mentioned also as another remarkable circumstance in connexion with this granitic tract, that it is along its western margin, in the line of its junction with the limestones and other secondary deposits which extend between it and the Rocky Mountains, that all the great lakes of America are found. If we regard Lake Erie and Lake Michigan as expansions respectively of Lake Ontario and Lake Huron (being evidently component parts of the same lake-basins), we shall find the following series of great lakes—Lake Ontario, Lake Huron, Lake Superior, Lake Winipeg, Athabasca Lake, Great Slave Lake, Marten Lake, and Great Bear Lake, succeeding one another in a NNW direction along the line of fracture, and invariably bounded to a greater or less extent on one side (generally the northern or eastern) by crystalline rocks, and on the opposite side by limestones and other secondary formations; the northern coast-line being moreover indented nearly in the same general bearing by Coronation Gulf, where, as already stated, the line of crystalline rocks terminates. It is to be observed, however, that the rivers connecting these lakes run generally wholly in one formation or in the other.

Silurian Basin of Hudson's Bay.—The granitic tract just described is bounded to the eastward by a narrow belt of limestone, beyond which there is a flat swampy and partly alluvial district, forming the shores of Hudson's Bay. The west coast of the bay is everywhere extremely low, and the depth of water decreases so gradually on approaching it, that in seven fathoms of water the tops of the trees on the land are just visible from a ship's deck. Large boulder-stones are scattered over the beach, and sometimes form shoals as far as five miles from shore. A low and uniformly swampy aspect characterizes the surrounding country for several miles inland. The upper soil presents a thin stratum of half-decayed mosses, immediately under which we find a thick bed of tenacious and somewhat shaley bluish clay containing boulder-stones. Beyond this occurs an extensive deposit of limestone, completely encircling Hudson's Bay, and following the course of the crystalline rocks to the extreme limit of our researches in the Arctic Sea.

Dr. Conybeare, in his Report on Geology, to the British Association for 1832, had noticed the great similarity between the fossils brought to England by the Arctic Expeditions of Parry and Franklin, and those of the Silurian formations of our own country. The Geological Notices appended to the Narratives of those Expeditions by Professor Jameson, Mr. König, and Sir John Richardson, who had the advantage of Mr. Sowerby's assistance in examining the organic remains, had previously led to the same view; and it may now be considered as finally established by Mr. Salter's examination and description of the extensive collections from the Arctic Regions,* brought to England by the recent expeditions in search of Sir John Franklin. The formation described by Dr. Sutherland as extending along the shores of Wellington Channel and Barrow's Straits, and considered by Mr. Salter to belong to the Upper Silurian group, has since been identified, through its organic remains, at several points along the coasts of Hudson's Bay. Recognized by Mr. Logan at Lake Temiscamang, and at Lakes Abbitibie and St. John, on the northern edge of the Laurentine Mountains, it has been successively identified along the Moose and Albany Rivers flowing into James's Bay, at Marten's Falls,† and along the northern edge of the granitic plateau, thence to York Factory, along the Great Fish River of Sir George Back,‡ at Igloolik,§ and along both shores of Prince Regent's Inlet,‖ to which last-mentioned locality Mr. Salter's investigations bring us down. The extreme points here indicated are Lake Temiscamang, in 47° 19′ N, and the shores of Wellington Channel, between 77° and 78° N, giving the enormous range of 30 degrees of latitude, over which, as far as our present information reaches, the Silurian formation extends uninterruptedly without any important variation, so far as is known, either in its mineralogical constitution or its stratification. The fossils from this district hitherto submitted to Mr. Salter's examination belong exclusively to the Upper Silurian. They are comprised in the following list; and most of them are figured in the Appendix to Dr. Sutherland's Journal of Captain Penny's Expedition.

* Quart. Journ. Geol. Soc. vol. ix, p. 313.

† By Sir John Richardson and Mr. Barnston. "Boat Voyage through Rupert's Land," vol. ii.

‡ Dr. Fitton and Mr. Stokes. § Professor Jameson.

‖ Sir Roderick Murchison, 'Siluria,' p. 428. I cannot omit, in this sketch of the geology of so large a portion of the North American Continent, to refer to the very accurate discrimination and description of its leading features contained in the recently published work of Sir Roderick Murchison on 'Siluria.' To this important work, and to the long series of researches of which it is the fruit, the geologists of America must feel under the highest obligation, not only for the clear and comprehensive view it exhibits of the whole phenomena of Palæozoic rocks throughout that continent, but for the important and valuable aid it affords to the explorer and investigator of its organic remains, by the establishment of a definite and perspicuous standard of comparison and reference, by which its geological formations can be identified and described.

Crustacea.

1. Encrinurus lævis, *Angelin*?
2. Proetus, sp.
3. Leperditia Balthica, *Hisinger* sp., var. *arctica*, Jones.

Mollusca.

4. Lituites, sp.
5. Orthoceras Ommaneyi, *Salter.*
6, 7.——, 2 species.
8, 9. Murchisonia, 2 sp.
10. Euomphalus, sp.
11. Bellerophon nautarum, *Salter.*
12. Modiola (or Modiolopsis).
13. Strophomena Donnetti, *Salter.*
14. ——, sp.
15. Orthis.
16. Spirifer crispus, *Linn.* sp.?
17. ——, sp.
18. Chonetes lata, *Von Buch*?
19. Pentamerus conchidium, *Dalm.*
20. Rhynchonella Phoca, *Salter.*
21. —— Mansonii, *Salter.*
22. —— sublepida, *De Vern.*
23, 24. ——, 2 sp.
25. Atrypa reticularis, *Linn.* sp.

Encrinites.

26. Actinocrinus, sp.
27. Crotalocrinus, sp.

Corals.

28. Ptychophyllum.
29. Strephodes Pickthornii, *Salter.*
30. ——? Austini, *Salter.*
31. Favistella reticulata, *Salter.*
32. —— Franklini, *Salter.*
33. Fenestella, sp.
34. Favosites polymorpha, *Goldfuss.*
35. —— Gothlandica, *Linn.* sp.
36. 37. ——, 2 sp.
38. Columnaria Sutherlandi, *Salter.*
39. Halysites catenulatus, *Linn.* sp.
40. Syringopora, sp.
41. Heliolites (Porites).
42. Cystiphyllum, sp.
43. Cyathophyllum, sp.
44. Clisiophyllum, sp.
45. Aulopora, sp.
46. Cœnites (Limaria), sp.
47. Calophyllum phragmoceras, *Salter.*
48. Arachnophyllum Richardsonii, *Salter.*

Mr. König describes the limestones from which these remains have been obtained as of an ash-grey or yellowish and grey color, often fœtid, and sometimes crystalline or compact, strongly resembling the Transition limestones of Gothland, and some of the fœtid varieties of the Mountain Limestone of Derbyshire. He mentions also that it is filled with zoophytes and shells; and in some parts is quite made up of the detritus of Encrinites, the fragments of which are so comminuted that the rock might readily be mistaken for a granular limestone.

A small collection of fossils* recently procured by the writer from James's Bay (the southern extremity of Hudson's Bay), which have been submitted to Mr. Salter, but not yet named, exhibit the same general Upper Silurian character with those above quoted. They comprise specimens of the same Corals (*Favosites Cyathophyllum*, *Clisiophyllum*, and *Favistella*), the universal *Atrypa reticularis*, *Pentamerus oblongus*, several Spirifers and *Orthidæ*, *Orthoceras*. Mr. Barnston, of the Hudson's Bay Company's Service, who has resided for upwards of twenty years in various parts of the district under notice, and whose qualifications as an observer are highly spoken of by Sir John Richardson, has traced the Silurian rocks from James's Bay to Marten's Falls, near the source of Albany River, at the eastern

* The fossils were collected by Dr. Roderick Kennedy, the Medical Officer at Moose Factory.

edge of the granitic plateau, which would give an average breadth of about 200 miles for the formation in this part. The boat-route from Lake Winnipeg to York Factory crosses the limestone belt at right angles to its course at Rock Portage, and its breadth is there found to diminish to less than 100 miles. The average width of the formation may perhaps be estimated at about 150 miles.

The mineral structure of the rocks forming the northern shores of America has been so fully and minutely investigated and described by Prof. Jameson, Mr König, Dr. Fitton, and Sir John Richardson, that I shall here, as well as in the notices of the other formations of this territory, confine myself exclusively to the examination of their organic remains, referring the reader for every necessary information on the mineralogical character of the rocks in which they are found to the valuable publications of those authors.

Silurian Basin of Lake Winipeg.—To the westward of the plateau of crystalline rocks, and following its course for a considerable distance northward, lies an extensive deposit of horizontal limestone, underlying the wide prairie country which extends towards the Rocky Mountains. Lake Winipeg, which is situated on the line of junction of the two formations, is a long and narrow sheet of water, 230 geographical miles long, and about 40 wide; and with its associated lakes (Moose Lake, Muddy Lake, Winepegoos, and Manitoba Lakes), receives, through its affluents—the Saskatchewan, the Red River, and other streams —a wide extent of prairie drainage. The commercial route from Lake Superior up to this point lies almost wholly within the granitic tract, touching on Silurian deposits only at the mouth of Rainy River and at one of the southwestern arms of the Lake of the Woods, where Dr. Bigsby has detected a few organic remains indicative of the Upper Silurian formation.* The Winipeg flows wholly within the granitic district, and has the lake-like dilatations and other characteristics of the streams which traverse the crystalline tract. When we descend to Lake Winipeg, we come upon epidotic slates, conglomerates, sandstones, and trap-rocks, which bear a close resemblance to those of the mining district of Pigeon Bay on Lake Superior. After passing the straits of Lake Winipeg, we have granitic rocks on the east shore and Silurian rocks on the west and north, the basin of the lake being mostly excavated in the limestone. The granite and gneiss which form the east shore of Lake Winipeg strike off at its NE corner, and passing to the north of Moose Lake, go on to

* The following list is given by Dr. Bigsby: a small *Phacops*, small *Orthocerata*, minute Encrinital columns, *Favosites Gothlandica*, *Cyathophyllum*, *Murchisonia*, *Pentamerus Knightii*, *Leptæna*, *Avicula*, *Atrypa*, and *Spirifer*. Quart. Journ. Geol. Soc. vol viii, p. 405.

Beaver Lake, where the boat-route again touches upon them. The extension of the limestone in a westerly direction from Lake Winipeg has not been ascertained; but it has been traced as far up the Saskatchewan as Carlton House, where it is at least 280 miles in breadth. Beyond this it is either succeeded or covered by cliffs of calcareous clay, which bear some resemblance to those found along the banks of the upper portions of the Missouri, together with saliferous marls and beds of gypsum.

Skirting the base of the Rocky Mountains a remarkable lignite formation is met with, which is said to extend through the valley of the Mississippi and of Mackenzie River as far north as the Arctic Sea.

The limestone of Lake Winipeg, which undoubtedly covers a vast tract of country, may in general be characterized as compact and splintery, and of a yellowish-white color, passing into buff, and sometimes of an ash-grey, mottled, or banded with patches of light brown. In the district between Lake Winipeg and the Saskatchewan, more particularly examined by the Arctic Expeditions of Franklin and Back which passed through it on their way to the Arctic Sea, the limestone strata were found to be almost everywhere extensively exposed, and to be remarkably free from intrusive rocks. Professor Jameson enumerates *Terebratulæ*, *Orthocerata*, *Encrinites*, *Caryophyllidæ*, and *Lingulæ*, as the organic remains brought to England by Franklin's First Expedition; Mr. Stokes and Mr. Sowerby examined those fossils which were procured on the Second Expedition, and found amongst them *Terebratulites*, Spirifers, Corallines, and *Maclurites*. The *Maclurites* were probably the *Maclurea magna* of Le Sueur and Hall. Sir John Richardson has recently brought home from the same quarter a fine specimen of the *Receptaculites Neptunii*,—a fossil, which, though it occurs abundantly in some of the Devonian beds of the Eifel, is, with the Maclurite, characteristic in Canada, as in New York, of the Lower Silurian.

Along the southern shores of Lake Winipeg and in the Valley of the Red River, where the limestone rises in solid ledges from the surrounding prairies, and has been extensively quarried for building purposes, it has been distinctly identified as belonging to that formation by Dr. Dale Owen, Director of the Geological Survey of Wisconsin and Minnesota, who in the course of his explorations visited the small colony settled there by the Hudson's Bay Company. In his recently published Report, Dr. Dale enumerates the following fosssils procured by him from the quarries at Red River and from Lake Winipeg:—

1. Favosites basaltica.
2. Coscinopora sulcata.
3. Chætetes lycoperdon.
4. Pleurorhynchus, sp.
5. Ormoceras Brongniarti.
6. Leptæna sericea?†
7. —— alternata.
8. —— planoconvexa?
9. Calymene senaria.
10. Pleurotomaria lenticularis?

11. —— muralis.†
12. Orthis, sp.†
13. Lingula, sp.†
14. Terebratula, sp.†
15. Cytherina? †
16. Syringopora.
17. Pleurorhynchus?
18. Cephalic shield of a Trilobite allied to *Illænus arcturus.*†
19. Pustulated cephalic shield of an Illænus.†
20. Conularia, sp.
21. Several specimens of the shield of Illænus crassicauda.

NOTE.—Those marked † are figured in Dr. Owen's Atlas of Illustration.

Many of these, Dr. Owen states, "are identically the same fossils as occur in the lower part of 'Formation No. 3,' in Wisconsin and Iowa, in the blue limestones of Indiana, Ohio, Kentucky, and also in the Lower Silurian of Europe. The *Coscinopora* is precisely the same as the coral which is particularly characteristic of the lower beds of the Upper Magnesian Limestone of Wisconsin. The specimens of *Favosites basaltica* cannot be distinguished from those which abound in the Upper Magnesian Limestone of Wisconsin and Iowa and the Lower Coralline beds of the Falls of the Ohio."

It has been noticed that the limestones of this formation are distinguished by two different tints of color. From the following analyses of the two varieties published by Dr. Owen, it would appear that they differ also considerably in their mineralogical character.

Analysis of the Compact Limestone from Red River, containing *Leptæna.*	
Carbonate of Lime	53·7
Carbonate of Magnesia	40·5
Insoluble matter	0·8
Alumina, Oxyd of Iron, and Manganese	4·0
Water and loss	1·0
	100·0

Spotted and banded Limestone containing *Coscinopora.*	
Carbonate of Lime	78·1
Carbonate of Magnesia	17·8
Insoluble matter	1·0
Alumina, Oxyd of Iron and Manganese	1·4
Water and loss	1·7
	100·0

It has been stated that none of the fossils from the Hudson's Bay Basin hitherto submitted to Mr. Salter belong to the lower division of the Silurian. It is proper to observe, however, that Mr. Salter has expressed some doubt of the age of the limestone of Igloolik, Melville Peninsula, and Amherst Island, amongst the organic remains of which Professor Jameson and Mr. Stokes detected some Trilobites, a Maclurite, and a Coral, which last fossil from the description given of it may have been a *Receptaculites*; and it may be added, that Marcou, apparently on the authority of Mr. Logan, classes the limestones of Lakes Abbitibie and St. John as Lower Silurian. The limestones of the Kakabeka Falls were identified by himself as belonging to that division. The insufficiency of geological explorations, and the want of published documents, render it impossible as yet to define with any approach to accuracy the limits of the two great divisions of the formation in this part of America, while it may be safely asserted, however, that under one or other of its forms the Silurian formation attains probably a wider development in the Hudson's Bay Territories than in any other part of the world in which its existence has been hitherto ascertained. Sir John Richardson has detected it in the hollows of the granitic plateau, and he expresses a belief that it will be found to occupy all the valleys of that extensive district.

Devonian Formation of the Elk or Mackenzie River.—The extent of the Silurian formation of Lake Winipeg northward has not been accurately ascertained. Limestones very similar in character have been traced on Beaver River, the most westerly feeder of Churchill River, and situated midway between the Saskatchewan and Elk Rivers. The canoe-route does not touch upon this river, which has its outlets in one of the southwestern arms of Lake La Crosse; but it is observed that the country on entering Sandy Lake along the line of communication near this part suddenly changes its aspect. Banks of loam, sand, and rolled blocks of a fine quartzose sandstone are found along the channels of the rivers; and shortly after emerging from the granitic district through which the route lies for the greater part of the distance from Cumberland House to Fort Isle-à-la-Crosse, we come upon a formation of quite another character, occupying the basins of the Elk River and its affluent the Clear-water.

The Elk River, the most southerly feeder of the Mackenzie, originates in the Rocky Mountains, as already stated, near the northern sources of the Saskatchewan; and its bed, which forms with that stream two sides of an equilateral triangle, with its base resting on the western edge of the crystalline plateau, is not separated by any marked ridge from the Saskatchewan prairie country, which appears to extend with little interruption as far as the next great tributary of the Mackenzie, the Unjigah or Peace River. It is separated from the Churchill or Mississippi River system, having its outlet in Hudson's Bay, by the carrying place of Portage La Loche, a plateau of about ten miles in breadth, which forms the dividing ridge between the waters flowing into Hudson's Bay and those flowing into the Arctic Sea. Portage La Loche has at its highest point an elevation of about 60 feet above the sources of the Churchill River system; but it presents on the side of the Clear-water River a sudden and precipitous descent of 656 feet, disclosing a deep layer of sand, enclosing masses of sandstone, of about 600 feet in depth; the whole reposing upon an extensive formation of limestone which lines the whole bed of the Clear-water as far as its junction with the Elk River. The deposits of sand and sandstone alternate with thick beds of bituminous shale, in some parts more than 150 feet in depth. These bituminous deposits form the distinguishing features of the formation now under notice, and are developed to an enormous extent, having been traced at intervals along the whole length of Mackenzie River as far as the shores of the Arctic Sea. Springs and pits of fluid bitumen are of common occurrence, and along the banks of Elk River in particular the shale beds are so saturated with this mineral as to be nearly plastic. The whole formation bears a decided resemblance in its lithological character to the lower members of the "Erie Division" of the United States' geologists, which M. de Verneuil considers to be equivalent to the Devonian formation of Europe*. I have been enabled, through the kindness of Mr. S. P. Woodward, to examine the collection of fossils from this district in the British Museum; and although, from the poverty of organic remains (a circumstance characteristic of the formation also in the United States), the collection is a very small one, there can be no hesitation in assigning the bituminous deposits of the Elk and Mackenzie Rivers to the epoch of the Marcellus shales, and the associated limestones, of the New York Survey.

The most characteristic fossil of the bituminous beds is a small Pteropodous shell, thickly disseminated through the substance of the shale, apparently the *Tentaculites fissurella* of Hall, associated with *Strophomena mucronata*, *S. setigera*, and *Orthis limitaris*, of the same author; at least they cannot be distinguished from his figures of those fossils from the Marcellus shales.

Two corals from the associated bituminous limestone are, according to Mr. Woodward, characteristic of the same epoch, namely a *Strombodes* (of Hall), having its cysts filled with bitumen, and a *Favosites*, very like the common *F. polymorpha* of the Plymouth marbles. From the underlying limestones of the Elk River, Sir John Richardson collected several specimens of *Productus* (among them *P. subaculeatus*), an *Orthis* resembling *O. resupinata*, *Terebratula reticularis*, a *Posidonomya*, and a *Pleurotomaria*. There is a very fine and well preserved *Rhynchonella* amongst the collection, remarkable for retaining the original chesnut-colored bands of the shell.

Other Formations of the Mackenzie River Basin.—Silurian rocks of Great Slave Lake and River (*Onondaga Salt Group of Vanuxem and Hall?*).—After passing through Lake Athabasca the Elk River is joined by the Unjigah or Peace River, the largest tributary of the Mackenzie, and the united streams, under the name of Slave River, proceed onwards to Slave Lake along the edge of the district of crystalline rocks, flowing sometimes through limestone, at other times over granite, and sometimes between the two. The mouths of Slave River open into Slave Lake between the limestone and granite. The limestones along the banks of this stream are, like those of the Elk River, highly bituminous; but they are chiefly remarkable from their association with extensive beds of compact greyish gypsum, in connex-

* Bulletin Soc. Géol. Fr. 2 Sér. vol. iv, p. 646.

ion with extremely copious and rich salt-springs. Where they approach the crystalline rocks, they are found, like those of Lake Winipeg to be highly magnesian,—a circumstance which may deserve attention with reference to the hypothesis of *dolomization*, which regards the introduction or development of magnesia as subsequent to the deposition of the calcareous matter, and as connected with the proximity of masses containing that earth and heated to a very high temperature. Among the fossils collected from this district which are in the British Museum are *Spirifer crispus*, Dalm.?, *Rhynchonella phoca*, Salter, *Atrypa lævis*, Vanuxem, *Atrypa reticularis*, an *Orthis*, two small *Spirifers*, like *S. trapezoidalis*, Dalm. and *S. pisum*, Sow., and fragments of an Encrinital stem like that of *Actinocrinus*. Sir George Back, on his expedition down the Great Fish River, collected some fragments of Corals along the south shore of Slave Lake, which were considered by Mr. Stokes and by Mr. Lonsdale to belong some to *Catenipora escharoides*, and one to the genus *Stromatopora* of Goldfuss, and probably to his species *S. polymorpha*. From the circumstance of these fossils being chiefly Upper Silurian, it has been conjectured with every appearance of probability, that the salt-springs may belong to the "Onondaga Salt Group" of [below] the "Helderberg division" of the New York system.

Carboniferous Series (*Mountain Limestone?*).—Some of the organic remains procured by Sir John Richardson on a previous expedition from other points along the Mackenzie River would appear to indicate an ascending order in some of the deposits of that district from the Devonian limestones and the shales containing *Tentaculites* into beds of Carboniferous, or perhaps more recent age. In some specimens from the limestone* of the "Ramparts" in the lower part of Mackenzie River, brought to England in 1826, Mr. Sowerby discovered *Terebratula sphæroidalis*, together with a species common in the carboniferous limestone of Nehou in Normandy, some *Producti*, and a Coral of the genus *Amplexus*. From other parts along the banks of the same river several *Terebratulæ* were procured, one resembling *T. resupinata*, one *Spirifer acutus*, a *Cirrus*, some Crinoidal remains, and Corals,—a somewhat perplexing assemblage if they were all collected from the same spot. Most probably some of the specimens have been derived from the boulders and transported fragments with which this part of the country is covered.

* The limestone of the "Ramparts," which appears again lower down at a spot called the "Narrows," is continued in a westerly direction to the Rocky Mountains, the lower elevations of which are composed of it in that portion of the range through which Peel's River takes its course. It has all the characters of the Mountain Limestone of English Geologists,—a formation extensively developed in Russian America, where, as will be subsequently noticed, it has been clearly identified by its organic remains.

Lignite Formation.—The difficulty of deciding upon the age of the beds through which the lower part of Mackenzie River flows, is increased by the occurence among them of a Lignite-formation, covered in parts by deep beds of sand, capped by boulders and gravel. The soft friable shales forming the bank of the river near its termination in the Arctic Sea are also strongly impregnated with alum. These aluminous shales cover a large portion of the delta of Mackenzie River, are continued along the banks of Peel's River to the foot of the Rocky Mountains, and have been traced for a considerable distance along the coast, and also along the shores of Great Bear Lake. The aluminous shale is constantly associated with the bituminous formation, into which it often passes.

The lignite-formation is still more extensively developed; and, as the occurrence of coal in any form in these high latitudes is a question of much interest, I shall here state briefly the results of Sir John Richardson's observations and enquiries on the subject, to which he has given much attention.

The Mackenzie traverses very obliquely the basin in which the lignite-formation is deposited, while Bear Lake River cuts it more directly across; and it is at the junction of these two streams that the formation is best exposed. It there consists of a series of beds, the thickest of which exceeds three yards separated by layers of gravel and sand, alternating with a fine-grained friable sandstone, and sometimes with thick beds of clay, the interposing layers being often dark, from the dissemination of bituminous matter. "The coal, when recently extracted from the bed," says Sir John Richardson, "is massive, and most generally shows the woody structure distinctly; the beds appearing to be composed of pretty large trunks of trees, lying horizontally, and having their woody fibres and layers much twisted and contorted, similar to the White Spruce now growing in exposed situations in the same latitude. Specimens of this coal examined by Mr. Bowerbank were pronounced by him to be decidedly of coniferous origin, and the structnre of the wood to be more like that of *Pinus* than *Araucaria*; but on this latter point he was not certain. It is probable that the examination of a greater variety of specimens would detect several kinds of wood in the coal, as a bed of fossil leaves, connected with the formation, reveals the existence at the time of various dicotyledonous trees, probably *Acerineæ*, and one of which appears to belong to the Yew tribe." . . . . . "Different beds, and even different parts of the same bed, when traced to the distance of a few hundred yards, present examples of 'fibrous brown coal,' 'earth-coal,' 'conchoidal brown coal,' and 'trapezoidal brown coal.' Some beds have the external characters of a compact bitumen; but they generally exhibit on the cross fracture concentric layers, although from their jet-like composition the nature of the woody fibres cannot be detected by the microscope. Some pieces have a strong resemblance to charcoal, in structure, color, and lustre. Very frequently the coal may be named a 'bituminous slate,' of which it has many of the lithological characters; but, on examination with a lens, it is seen to be composed of comminuted woody matter mixed with clay and small imbedded fragments resembling charred wood. From the readiness with which the coal takes fire spontaneously, the beds are destroyed as they become exposed to the atmosphere, and the bank is constantly crumbling down; so that it is only when the debris has been washed away by the river that good sections are exposed."*

Formations similar to that found on Mackenzie River extend southward along the eastern base of the Rocky Mountains, as far as the Saskatchewan River. Sir John Richardson gives a detailed account of the various localities between these two points in which beds of coal have been exposed,—all pointing to the existence of a vast coal-field, skirting the base of the Rocky Mountains for a very great extent, and continued probably far into the Arctic Sea, where, as is well known, lignite, apparently of a similar character, has recently been discovered by Captain McClure in the same general line with the localities above mentioned.† In the coal of Jameson Land, lying in north latitude

* With reference to the southern portion of this coal-field, where it is exposed in the valley of the Saskatchewan, Sir George Simpson, Governor of the Hudson's Bay Territories, has the following remarks, in his 'Narrative of an Overland Journey round the World,' vol. i, p. 162:—

"Near Fort Edmonton a seam of coal, about 10 feet in depth, can be traced for a very considerable distance along both sides of the river. This coal resembles slate in appearance; and, though it requires a stronger draught of air than that of an ordinary chimney, yet it is found to answer tolerably well for the blacksmith's forge. Petrifications are also found here in abundance, and at the Fort there was a pure stone which had once been a log of wood about 6 feet in length and 4 or 5 in girth, the resemblance being so complete as even to deceive the eye."

Sir Alexander McKenzie traced the same formation along the upper parts of the Peace River; and it has been found by the traders of the Hudson's Bay Company at several intermediate points along the same general line; leading to the conclusion that the formation in question is continuous and uninterrupted.

† Similar deposits to those discovered by Capt. McClure have been found in the New Siberian Islands, and are thus described in Wrangell's Polar Voyages:—"Of these [speaking of the deposits of fossil wood in the New Siberian Islands] Hedenström observes in another place, 'On the southern coast of New Siberia are found the remarkable Wood Hills. They are 30 fathoms high, and consist of horizontal strata of sandstone alternating with strata of bituminous beams or trunks of trees. On ascending these hills, fossilized charcoal is everywhere met with, covered apparently with ashes; but on closer examination, this ash is also found to be a petrifaction, and so hard that it can scarcely be scraped off with a knife. On the summit another curiosity is found, viz. a long row of beams, resembling the former, but fixed perpendicularly in the sandstone. The ends, which project from 7 to 10 inches, are for the greater part broken. The whole has the appearance of a ruinous dyke.' Lieut. Anjou, who likewise examined these Wood Hills, says, 'They are merely a steep declivity, 20 fathoms high, extending about five wersts along the coast. In this bank, which is exposed to the sea, beams or trunks of trees are found, generally in an horizontal position, but with great irregularity, fifty or more of them together,

71° (on the east side of Greenland), and in that of Melville Island, in latitude 75° north, Professor Jameson found plants resembling those of the coal-measures of Britain; and similar remains have been reported from the coal-fields of Oregon and Vancouver's Island. These facts are sufficient of themselves, as is remarked by Sir John Richardson, to raise a world of conjecture respecting the condition of the earth when these ancient fossils were living plants. If the great coal-measures, containing similar vegetable forms, were deposited at the same epoch in distant localities, there must have existed when that deposition took place a similarity of condition of the North American Continent from latitude 75° down to 45.°*

Elevatory Movements; and Pleistocene deposits.—Into such questions, however, as the above, or into the discussion of the various hypotheses by which the elevations and depressions of the surface of these vast territories may be accounted for, it is beyond the province of the present paper to enter; nor, in the present state of our knowledge, would a summary of this kind admit of the necessary elucidation. I shall merely say, that, adopting the opinion of Sir John Richardson and the geologists of the United States, that "the eastern portion of the continent was first elevated, and that the older rocks on the west were subsequently overlaid by newer deposits," I consider that the great mass of the underlying formations surrounding Hudson's Bay are wholly palæozoic, and that the currents or waves of translation, if such there were, must have had an easterly direction in these latitudes, and gained strength as they rolled towards the Atlantic, when they swept away wholly or partially the fossiliferous deposits that covered the older rocks of Hudson's Bay, Canada, and the eastern parts of the United States; the former extent of the newer rocks being indicated by the patches which remain. The only recent formations overlying the Silurian rocks which have been hitherto discovered along the eastern coasts of Arctic America, are patches of pleistocene deposits, with marine shells of existing Arctic species (*Mya truncata,*

—the largest being about 10 inches in diameter. The wood is not very hard, is friable, has a black color and a slight gloss. When laid on the fire, it does not burn with a flame, but glimmers, and emits a resinous odor.'"—Narrative of an Expedition to the Polar Sea, by Admiral F. von Wrangell, of the Russian Imperial Navy, in 1820–23. (Edited by E. Sabine) Introd. p. cxviii.)

The "charcoal" and "ashes" are no doubt the result of the spontaneous combustion of the lignite, as is the case with the lignite deposits at Bear Lake and other parts of the Hudson's Bay Territories, where they take fire on being exposed to the air, and have been observed burning for the last hundred years. The Wood Hills in the New Siberian Islands are in the same general line with the lignite extending along the Rocky Mountains, and with the wood deposits discovered by Capt. Mc Clure.

* The coal bed of the Cowlitz, Oregon, is Tertiary, and the plants from Puget's Sound collected by Mr. Dana were also Tertiary. See also a note by Mr. Gibbs, in this Journal, [2], xx, 298.—Eds.

Saxicava rugosa, &c.); the whole crowned by an immense profusion of boulders and erratic blocks. The country forming the Hudson's Bay Territories is too flat for the immense erratic formation extending over every part of it to be explained by reference to the motion of glaciers; and I think it is more probably due to the action of icebergs and floating masses of ice, still so common along these coasts, and which are without doubt performing at the present day precisely a similar office, in strewing the bed of the ocean in which they are found with the fragments transported from the adjacent shores.*

With reference to the character of the pleistocene or drift formation, it may be mentioned that as we ascend the rivers of this region, especially along the basins of Lake Winipeg and its affluents in the prairie districts, the sandy and clayey deposits are found to abound with land and freshwater shells, such as *Unio*, *Helix*, *Pupa*, &c., of species now living on the borders, or in the beds of the rivers and lakes. The cliffs containing these shells are often raised more than 100 feet above the present levels of the banks of the streams, and appear to be ancient lake- or river-terraces; leading to a belief that, great as is the present extent of freshwater surface in the North American Continent, it was at one time still greater, and that the existing series of lakes, from the St. Lawrence northward, were perhaps anciently united in one or more vast freshwater seas, having their western margins indicated, perhaps, by the peculiar elongated strip occupied by the lignite-formation previously described, which presents precisely the appearance which would result from a long line of shelving beach, piled with masses of drift-wood accumulated through long successive periods, similar to what is now found covering the shores of the inland lakes and portions of the coasts of the Arctic Seas.

It has been stated as an exemplification of the wide changes which would result from a comparatively small alteration in the present level, even of such mountainous districts as Canada and the Northeastern States of the Union, that "a subsidence of 400 feet would cause the waters of Lake Ontario, to flow through the valleys of the Mohawk and Hudson into the Atlantic, and at the same time convert Lake Champlain into a maritime strait, thereby forming islands of the States of New York, New England, and Maine, and of the British Colonies of New Brunswick and Nova Scotia." A subsidence of one-fourth of that amount in the prairie districts of the Saskatchewan, continued to Great

* In the Appendix to Dr. Scoresby's 'Journal of a Voyage to the Northern Whale Fishery,' Professor Jameson enumerates among the specimens found on an iceberg near Cape Brewster the following:—

1. Transition clay slate.
2. Slaty talcose granite.
3. Granular felspar.
4. Hornblende mica-slate.
5. Gneiss.
6. Basaltic greenstone.

Bear Lake, would carry the waters of the Missouri and the upper portions of Churchill, and Mackenzie Rivers into Lake Winipeg and convert the plain country bordering on the Rocky Mountains, into an inland sea. Even at the present level the Missouri has twice within the last thirty years, inundated the valley of the Red River, flowing into Lake Winipeg; while it is a common occurrence for the country through which the lower part of the Saskatchewan flows to be laid under water for a distance of 200 miles above its outlet by an ordinary spring-flood. About forty years ago, in a season remembered especially for the land-floods, a gentleman in the service of the Hudson's Bay Company was drowned on the Frog Portage (the low watershed which separates the Saskatchewan and Churchill Rivers), by his canoe upsetting against a tree in passing from one stream to the other.

The raised beaches of Lake Superior, rising in four or five successive terraces to the height of more than 100 feet above the present surface of the water, and which have attracted the attention of Professor Agassiz and the geologists of the Canadian Survey, appear to point to the existence at some former period of a much greater body of water in this lake, at least, than is at present contained in it, and are to some extent therefore confirmatory of the view now suggested.

The Eocene basin of the Upper Missouri, with its very marked character of freshwater deposition, is stated by Marcou to extend along the upper waters of the Saskatchewan as far as Mackenzie River. I have no knowledge of any such formation myself, although in the unexplored territory west of the Winipeg basin there is undoubtedly ample room for its development. Its existence, if established, would lend additional probability to the inference deducible from the circumstances previously noticed.*

Territories West of the Rocky Mountains.—Physical Features.—"The great contrast between the east and west sides of the Rocky Mountains has been often mentioned,—the one abounding in sandstone with argillaceous limestones, *without* volcanos or volcanic rocks, while on the other side recent igneous rocks prevail (basalts, basaltic lavas, and trachytes),† and the

* The views here suggested are not to be considered as prejudging the question so ingeniously developed by Mr. W. Hopkins and supported by the late Prof. E. Forbes respecting the probability of the passage of the Gulf Stream at some former period up the valley of the Mississippi (Quart. Journ. Geol. Soc. vol. viii, p. 89, &c.),—a theory of the highest interest and importance in accounting for the changes of temperature and climate on the surface of our globe, and which, though based by its author upon purely physical considerations, is in harmony with all the geological facts and evidence which have come under the writer's notice.

The age of freshwater accumulations and deposits suggested in the text comes much nearer to our own times.

† Dr. Grewingk, in his Map of Russian America, assigns the localities of fifty-eight active volcanos on the Northwest Coast of America. They lie in a line running from the north end of Prince of Wales Island, in lat. 56° N, following the course of the coast through the peninsula of Aliaska and the Aleutian Islands. Many of

sandstones are comparatively of small extent." This remark, which I quote from the learned and beautiful work of Professor Dana, 'The Geology of the United States Exploring Expedition under Commodore Wilkes,' will prepare the reader for the examination of a country of a different character from what has above formed the subject of investigation.

The grand features of the country on the Pacific side of the Rocky Mountains arise from the development of three ranges of mountains, intersecting the country in a direction parallel with the general course of the coast-line. Three of these are north and south ranges,—the Coast Range, the Cascade Range, and the Blue Mountain Range. The first lies near the coast, the second 130 miles inland, and the third 350 miles from the sea.

The Cascade Range is much the most extensive of the three, and even rivals the Rocky Mountains in the height of some of its peaks. It may be traced, according to Professor Dana, far into California, and northward into Russian America; retaining throughout a direction nearly parallel with the coast. It terminates northward, according to Grewingk, in the lofty volcano of Mount Wrangell, in lat. 62° N, where it blends with the lateral volcanic range, forming the remarkable promontory of Aliaska. The main body of the Cascade range, in Oregon, is seldom over 5000 or 6000 feet in elevation. [The Sierra Nevada is a continuation of the chain; south it becomes the range of the California Peninsula.]

The Blue Mountains form the western boundary of the Valley of the Snake River (of Lewis and Clarke), flowing into the Columbia. Immediately to the north of this river, as far as Fort Colville, they are interrupted by an extensive level tract; but to the North of Fort Colville there is a range of heights which extends along the north branch of the Columbia River, and may be considered a part of the same general chain.

The short western slope of the continent from the Rocky Mountains to the Pacific differs from the eastern in its river-valleys being all more or less transverse,—the rivers flowing through passes or gorges of the intersecting ranges. The peculiar winglike projection in the north, towards Asia, is evidently due to the volcanic chain of Aliaska, which runs at right angles to the Rocky Mountains. The great transverse valley of the Yukon

their summits rise into the region of perpetual snow. The line in which the volcanic peaks of Aliaska lie when prolonged to the eastward, strikes the Big Reaver Mountains on the Yukon. On the side of the Atlantic, modern volcanic rocks occur in Jan Mayen's Island only, whose principal mountain, Beerenberg, rises 6870 feet above the sea.

I have been recently informed that the Basquiau Hills, which lie to the south of Cumberland House, on the Saskatchewan River, are volcanic, and that an eruption has been observed there within the last year. The report requires confirmation. No other example is known of the existence of a volcano in any part of America east of the Rocky Mountains.

(the Kwichpack of the Russian geographers) lies to the north of it. The Yukon is a river of great magnitude, probably the largest river in America flowing into the Pacific, not excepting the Columbia. For a considerable part of its course it flows to the North, but afterwards nearly due west, through a country which, as far as can be judged from the descriptive notices of it hitherto collected, closely resembles the valley of the Mackenzie, with some of the affluents of which it is in fact connected: so that here, as in other parts of the Rocky Mountain Chain, the rivers falling into opposite seas interlock at their origin. One or more low chains of mountains, formed by the lateral spurs of the Rocky Mountains, are prolonged along the Arctic Coast, north of the Yukon, giving origin to several small rivers between the mouth of the Mackenzie and Point Barrow.

Oregon Territory.—Our acquaintance with the geology of this district is very limited, and does not extend beyond the portion of country between the Coast Range and the sea, explored by the Expedition of Commodore Wilkes. From Mr. Dana's researches it appears to be occupied chiefly by the tertiary formation, which is found at various places from Puget's Sound to San Francisco along the coast-section of Oregon. The rocks of this formation are soft sandstones, more or less argillaceous and schistose, and clay-shales, either firm or crumbling, together with tufa and conglomerate. The sandstones and shales have been denuded on a vast scale.

The fossils collected by Mr. Dana were examined by the eminent conchologist, Mr. T. Conrad, who assigned them to the geological era of the Miocene. They are comprised in the following list.

Mammal.

1. Vetebræ of a Cetacean.

Fishes.

1. Vertebræ of a species of Shark.
2. —— of a species allied to *Trigla*.
3. ——, cast of; species not distinguishable.

Crustacea.

Callianassa Oregonensis. Balanus.

Mollusca.

Mya abrupta.
Thracia trapezoides.
Solemya ventricosa.
Donax? protexta.
Venus bisecta.
—— angustifrons.
—— lamellifera
—— brevilineata.
Lucina acutilineata,
Tellina arctata.
—— emacerata.

Pectunculus nitens.
Arca devincta.
Cardita subtenta.
Pecten propatulus.
Terebratula nitens.
Dolium petrosum.
Sigaretus scopulosus.
Natica saxea.
Bulla petrosa.
Crepidula prærupta; and sp.
Rostellaria indurata.

Tellina albaria.
—— nasuta.
—— bitruncata.
Nucula divaricata.
—— impressa.
Pectunculus patulus.
Cerithium mediale.
Buccinum ? devinctum.
Fusus geniculus.
—— corpulentus.
Nautilus angustatus.
Teredo substriata.

Echinoderms.

Galerites Oregonensis (n. sp).

Foraminifera, 3 sp.

Plants.

Abies ? robusta; Leaves of Lycopodium ?, Taxodium, Smilax, and others.

The plants were found near the mouth of Fraser's River, and indicate probably the commencement of the deposits of the coal strata, which are largely developed in the neighboring island of Vancouver, and along the coasts and islands of Russian America.*

The interior of Russian America, like that of Oregon, is unexplored; but, in the work of Grewingk (Beitrag zur Kenntniss der orographischen und geognostischen Beschaffenheit der Nord-West Kuste Amerika's), and in the Geological Appendix to Capt. Beechey's Voyage to Behrings Straits, by Dr. Buckland, we have a tolerably complete account of the chief formations occurring along the coast, and on the neighboring islands, from 52° N. lat. to Behring's Straits.

The only representatives of the palæozoic rocks in this part of America, hitherto discovered, are the Mountain limestone, and other members of the Carboniferous series, which are found covering the flanks of the mountains here bordering immediately on the sea, and prolonged into a dense archipelago of volcanic islands, several of them containing active volcanos, which skirt the entire coast from the parallel of 50° northward.

Dr. Grewingk has given in the Transactions of the Mineralogical Society of St. Petersburgh, for 1848–9, a complete list of the organic remains hitherto discovered in Russian America, including those described in the Appendix to Capt. Beechey's Voyage. They afford evidence of the existence of the following formations,—the Carboniferous, Jurassic, Tertiary, and Drift, which have been traced in detached sections along the coast; leaving much still to be desired, however, before a complete and connected view of the geological structure of this portion of the American Continent can be obtained.

Fossils of the Carboniferous Formation.—The limestones of this formation, which have been traced at several points along the coast, are most extensively developed in the NE extremity of the Continent, where they occupy the greater part of the coast-

* For lists of other fossils of Western America collected by Mr. W. P. Blake, see this volume, p. 268.

line from the north side of Kotzebue Sound to within a few miles of Point Barrow, and form the chief constituent of the lofty and conspicuous headlands of Cape Thompson, Cape Lisburn, and Cape Sabine. Near the last-named cape a vein of excellent coal is exposed, which burns with a good heat and a bright flame. The limestone, is according to Dr. Buckland, scarcely distinguishable from the Mountain Limestone of Derbyshire. Some specimens brought to England by Capt. Beechey were found to contain *Lithostrotion basaltiforme* (*Cyathophyllum basaltiforme*, Phil. G. Y.), *Flustra*, *Productus Martini*, *Dentalium*, several varieties of *Terebratula*, and a great abundance of Encrinital fragments, with the detritus of which the rock was in many places almost entirely made up. To these Dr. Grewingk adds, from the collections of Russian explorers, *Cyathophyllum flexuosum*, Goldf., *Turbinolia mitrata*, His., *Cyathophyllum dianthum*, Goldf., and *Sarcinula*, together with some *Spiriferi*, *Orthidæ*, and *Terebratulæ*.

Remains of coniferous plants belonging to the genera *Abies* and *Taxodium*, and of some Ferns, among which is *Neuropteris acutifolia*, have been discovered among the islands along the south coast of Aliaska.

A specimen of *Catenipora escharoides*, found in a rolled fragment on the island of Sitka, would appear to indicate the existence of Silurian deposits in the neighborhood; but no organic remains from rocks of this formation *in situ* have hitherto been discovered.

Jurassic Fossils.—Four fossils found in Katmai Bay, on the south coast of the promontory of Aliaska, have been referred by Dr. Grewingk, on the authority of M. Wosnessensky, Curator of the Zoological Museum of the Academy of Sciences of St. Petersburgh to the Jurassic formation. They include a new species of Ammonite, *A. Wosnessenskii*, *Ammonites biplex?*, Sow., and fragments of *Belemnites paxillosus* and *Unio liassinus*. Mayen (Nov. Act. Phys. tom. xvii, pl. 47, figs. 1 and 2) figures an *Ammonites biplex*, from some Jurassic deposits at the foot of the volcano of Maipu, in the Andes, south of Valpariso, which cannot be distinguished from the specimen from Aliaska. It may be doubted, however, whether upon such scanty evidence the existence of deposits of Jurassic age in these high latitudes, can be considered as established; no other indication of the existence of this formation having been hitherto discovered in any part of North America north of the United States.

Tertiary Fossils.—Traces of the tertiary formation have been discovered at various points between Oregon and Aliaska, but not beyond. This striking and well marked division of the coast may, therefore be considered, in the present state of our information, to be the northern limit of the extensive Tertiary formation along the shore of the Pacific. The fossils enumerated by Dr.

Grewingk include some well-known species of the Tertiary age in Europe; among which may be mentioned *Cardium Grœnlandicum*, Chemn., *C. multicostatum*, *Venerupis Petitii*, Desh., *Mya arenaria*, *Tellina edentula*, Sow., *Astarte corrugata*, *Mytilus Middendorffi*, and *Ostrea longirostris*, Lamk. Some new species of the same genera are added by Dr. Grewingk, together with some forms of *Saxicava*, *Pectunculus*, *Nucula*, *Pecten*, *Crassatella*, and *Venus*.

Fossils of the Drift.—Organic remains of the Pleistocene or Drift Period appear to be much more numerous on the west than on the east side of the Rocky Mountains. The cliffs and sand-banks, wherever they have been examined along the coast, abound with recent shells of the genera *Cardium*, *Venus*, *Turbo*, *Murex*, *Solen*, *Trochus*, *Mytilus*, *Mya*, and *Tellina*. Fossil remains of *Mammalia*, especially those of the Mammoth, are likewise abundant. Teeth of this animal have been discovered on the banks of several rivers north of Mount St. Elias; and there is a celebrated locality at Escholtz Bay, in Kotzebue Sound, where the thawing and wasting of the frozen cliffs is continually exposing the bones and tusks of Mammoths and other quadrupeds. Dr. Buckland, in his interesting account of the specimens collected at this place during Captain Beechey's Voyage, enumerates fragments of bones of Mammoths and of the *Urus*, the leg-bone of a large Deer, and a cervical vertebra of some unknown animal, different from any that now inhabit Arctic America. Along with these were found also the skull of a Musk-ox and some bones of the Rein-deer, in a more recent condition than the others. Similar remains including those of the Mammoth, have likewise been discovered, according to Dr. Grewingk, at Cape Nugwuljinunk, at Bristol Bay, and at Norton Sound, as well as in the Pribulon Islands, and lastly at Unalaschka.

The vast profusion of the bones and tusks of the Mammoth in Siberia and the adjacent islands is well known, and it is a somewhat remarkable circumstance that no similar remains have as yet been detected in the corresponding latitudes of America to the east of the Rocky Mountains. None have hitherto been found, according to Sir John Richardson, in the Hudson's Bay Territories, though the annual waste of the banks and the frequent land-slips would have revealed them to the natives or fur-traders had they existed even in small numbers. They are rare also, or altogether wanting, in Canada; but in the Valley of the Mississippi the "bone licks" are well known as most extensive, and as furnishing the remains of many new species of quadrupeds. In whatever way the circumstance may be accounted for, it seems to confirm the opinion to which most American geologists have arrived, that the countries on the eastern and western sides of the Rocky Mountains have been elevated at different periods and under different geological conditions.

Art. XXXIII.—*On the Origin and accumulation of the Proto-carbonate of Iron in Coal Measures;* by Prof. William B. Rogers.*

Proto-carbonate of iron, as is well known, presents itself in the coal measures in courses of lenticular nodules and interrupted plates usually included in carbonaceous shales, and in the fire-clays which underlie the seams of coal, and in such cases it often forms a heavy ore containing but little earthy or organic matter mixed with the proto-carbonate. But it is also frequently met with in a *diffused condition*, pervading thick strata of shale and shaly sandstone, and causing these rocks to present in their different layers all the gradations of composition, from a poor argillaceous and sandy ore, to beds of sandstone and shale, with little more than a trace of the ferruginous compound.

On comparing the different subdivisions of a system of coal measures, we may remark certain general conditions connected with the abundance or with the comparative absence of the proto-carbonate in the strata.

One of these is seen in the fact that *the lenticular ores and strata impregnated with proto-carbonate of iron are in a great degree restricted to such divisions of the carboniferous rocks as include beds of coal or are otherwise heavily charged with carbonaceous matter.* This is well shown on comparing together the four subdivisions of the carboniferous rocks of the great trans-Alleghany coal region, as classified under the head of the Seral coal series of the Pennsylvania and Virginia geology. In the first of these, designated as the *older coal measures*, the proto-carbonate is found in large amount, both in the shape of layers of lenticular ore and diffused through the substance of the shaly strata. In the next division above, distinguished as the *older barren shales*, and which, as the name implies, is comparatively devoid of carbonaceous matter, much less of the proto-carbonate is met with. In the third group, that of the *newer coal measures*, the ore again abounds, and in the uppermost division, or *newer barren shales*, it has a second time almost disappeared.

The connection between the development of the proto-carbonate in the strata, and the presence, either now or formerly, of a large amount of carbonaceous or vegetable matter becomes even more striking on a detailed examination of particular beds. Thus, in the coarse sandstones of the coal measures, which are comparatively destitute of vegetable remains, we find little admixture of the proto-carbonate. On the other hand, the fine-grained, flaggy, argillaceous sandstones, which are often crowded

* From Proc. Bost. Soc. Nat. Hist.

with the impressions and carbonized remains of plants, are at the same time more or less impregnated with this ferruginous compound. So, again, the soft argillaceous shales, in the midst of which the lenticular ore so frequently presents itself, show by their dark color and included impressions of plants, as well as by actual analysis, that they are richly imbued with vegetable matter. Nor do the nearly white fire-clays, which in many cases inclose thick courses of the lenticular ore, form any exception to this law. For although in their present state they contain little or no carbonaceous matter, the marks of innumerable roots of Stigmaria, and parts of other plants which everywhere penetrate the mass, show that at one time they must have been crowded with vegetable remains.

A further and yet more striking proof of the influence which the contiguous vegetable matter has had, in the formation of the proto-carbonate, is seen in the fact, that the most productive layers of the ore are commonly met with quite near to the beds of coal, and that frequently courses of the nodules are found in the carbonaceous shales or partings which lie in the midst of the seam itself.

While the strata including the proto-carbonate are thus distinguished by the admixture of more or less carbonaceous matter, they are *also remarkable for seldom exhibiting a distinctly red tint.* Presenting, where not weathered, various shades of greenish-gray and olive and bluish-black, they only become brown or red where, by exposure to the air, the proto-carbonate has been converted into the sesquioxyd of iron. On the other hand, those divisions of the coal measures which have been but slightly charged with vegetable matter, as for example the barren shales of the Seral coal rocks before alluded to, contain much red material, both in distinct strata and mottling the general mass, and are throughout more or less impregnated with the sesquioxyd.

A like general law as to color would seem to apply to the other great groups of sedimentary rocks, which include in particular beds accumulations of vegetable or other organic exuviæ. Thus, in the New and Old Red Sandstone formations, which generally include so large a proportion of sediment colored by the red oxyd of iron, organic remains are of comparatively rare occurrence, and when present are met with almost exclusively in the gray and olive and dark-colored strata which are interpolated in certain parts of the great masses of red material. This relation is beautifully shown in the middle secondary rocks of the Atlantic slope, which extend in a prolonged belt from the Connecticut Valley into the State of South Carolina. In the strata of red sandstone and shale, which form the chief part of the mass, vegetable or animal exuviæ are almost entirely absent. But where the remains of fish, and impressions of carbonized parts of plants, do occur in this group of deposits, they are found imbedded in layers of greenish and olive sandstones and dark bituminous shales. So, in the southern parts of the belt in Virginia and North Carolina, where these rocks include seams of coal and extensive beds of sandstone and shale containing the remains of plants, the usual red color is found to give place to the gray, olive, and dark tints of the old coal measures, and layers of proto-carbonate of iron show themselves in the vicinity of the coal seams.

Taken in mass, the red and mottled strata of the unproductive coal measures, or of the other groups of red rocks above alluded to, would no doubt be found to contain, in an equal thickness, as large an amount of iron as the coal-bearing strata which include the layers of carbonate; the difference being that, in the former case, the metal remains for the most part diffused through the rock as a sesquioxyd, while in the latter, having assumed the condition of proto-carbonate, it has to some extent been concentrated in particular layers or strata. According to a rough estimate of the amount of carbonate ore included in the lower coal measures of the Laurel Hill region of Virginia and Pennsylvania, derived from a detailed examination of the ores and associated strata at several points, it may be safely assumed that the equivalent of sesquioxyd of iron would not amount to one third of one per cent of the whole mass of this portion of the coal measures, and a proportion not exceeding this is deducible from the measured sections of ore and accompanying rocks in the carboniferous strata of other tracts subjected to a similar calculation.

But even allowing a quantity three times as great as this, to cover the diffused carbonate and the oxyd in some cases mingled with it, we should have only about one per cent to represent the proportion of ferruginous matter in the entire mass; an amount undoubtedly much less than exists in many of the strata of red and purple shales and shaly sandstones of the carboniferous series or of the groups of red rocks geologically above or beneath it.

In attempting to explain the origin of the proto-carbonate, under the conditions above described, it is important to keep in view the fact of the diffusion of this compound through many of the strata as a general constituent, and the frequent preservation, even in layers of the ore, of the lamination of the contiguous rock. The supposition of its being a chemical deposit formed from springs charged with carbonic acid, and holding proto-carbonate in solution, is evidently inconsistent with these conditions, and not less so with the fact of the great horizontal extension of individual beds of ore and impregnated shaly rocks.

In view of these various considerations it may be concluded :—

First, That throughout the coal measures and other groups of rocks above mentioned, as well in the portions containing coal and diffused vegetable and animal matter as in the barren parts, the original sediment was more or less charged with sesquioxyd of iron; and

Second, That this sesquioxyd, in the presence of the changing vegetable matter with which certain of the strata abounded. was converted into proto-carbonate, which remained in part diffused through these beds, or by processes of filtration and segregation was accumulated in particular layers.

It is well known that during the slow chemical changes by which vegetable matter inclosed in moist earth is converted into lignite, or coal, both light carburetted hydrogen and carbonic acid are evolved, and that these gases are even eliminated from coal seams and their adjoining carbonaceous strata. The reducing agency of the carbon and hydrogen, as they separate in their nascent state from the organic matter, is capable, as we know, of converting certain sulphates into sulphurets, and even more readily of transforming the sesquioxyd of iron into protoxyd. The latter change would doubtless be favored by the affinity of the carbonic acid present in the mass, for the protoxyd as formed, and in this way the sesquioxyd, would be entirely converted into the proto-carbonate of iron.

Conceiving a like process to have operated on a large scale in the coal measures or other strata containing, when deposited, a mixture of sesquioxyd of iron and organic matter, we have a simple explanation of the general conversion of this oxyd into carbonate, and of the loss of the reddish coloring in which these materials more or less participated. As these actions must be supposed to have commenced in each stratum as soon as the organic matter contained in it began to suffer chemical change, we may conclude that the formation of the proto-carbonate was already far advanced in the earlier strata when only beginning in those deposited at a later period. Each layer of vegetable matter, as it was transformed into coal, would not fail to impregnate the adjoining beds of shale and sandstone with the proto-carbonate, and thus the development of this compound was as it were coeval with that of the coal.

The gathering of the diffused proto-carbonate into bands and courses of ore began no doubt as soon as the production of this compound had made some progress, but it probably continued until long after the completion of the chemical changes above described; and indeed, it is possible that in some strata it is not yet entirely finished. In this process, which finds a simple explanation in *the combined action of infiltration and the segregating force,* it can hardly be questioned that *the carbonic acid,* pervading the mass of sediment, acted *a very important part.* The large amount of this gas evolved from the beds of vegetable matter undergoing change, would impart to the water of the adjoining strata the power of dissolving the diffused proto-carbonate, which, being then carried by infiltration through the more porous beds, would accumulate above and within the close argillaceous or shaly layers, forming in some cases bands of rock ore, in others courses of nodular and plate ores. Of these, the former would seem to have resulted from the accumulation by *gravity* of the dissolved carbonate in the substance of sandy shales near the upper limit of the more impervious beds, while we may regard the latter as having been collected in all directions from the general charge of proto-carbonate accumulated in the argillaceous mass, its mobility in the dissolved condition greatly aiding the gathering process of the *segregating force.*

ART. XXXIV.—*Subdivisions of the Palæozoic Strata of Great Britain, according to Prof. Sedgwick.**

I. *Lower Palæozoic Division, representing the Cambrian and Silurian Series in ascending groups.*

Cambrian Series.	1. Longmynd and Bangor group (Lower Cambrian)	*a.* Longmynd slates, &c. *b.* Llanberris slates; alternations of roofing-slates and grits. *c.* Harlech grits; sometimes approaching a conglomerate form.
	2. Festiniog group (Middle Cambrian)	*a.* Lingula flags. *b.* Tremadoc slates. *c.* Arenig slates and porphyries; Festiniog slates; slates, flags, and grits; indefinite alternations of porphyry and trap-shale: one irregular band of limestone near the top of the group. Thickness great.
	3. Bala group (Upper Cambrian)	*a.* Lower Bala rocks. (1) A great zone of dark and sometimes earthy slate. (2) A great series of slates, flags, and grits, ascending to the Bala limestone. *b.* Upper Bala rocks. Under this term are included—(1) the Bala and Hirnant limestone and the Llandeilo calcareous flag—(2) Flag-stones, slates, calcareous beds, and shelly sandstones of Caer Caradoc. The whole series ending, in North Wales, with slate and flagstone; and in South Wales, with slates, grits, and coarse conglomerates. The group of very great thickness.

Immediately above these three groups there is a great change of physical conditions. The most characteristic and abundant

* Extracted from the great work on The British Palæozoic Rocks, by the Rev. Adam Sedgwick, M.A., F.R.S., &c., and on British Palæozoic Fossils, by Professor Frederick M'Coy, F.G.S., &c., 4to, London, 1855, briefly noticed at page 302 of this volume.

of the older organic types disappear, and new types take their place. The sections are usually broken and discontinuous; and the upper (or Silurian) groups sometimes overlap the lower (or Cambrian) groups unconformably. Here, therefore, (to adopt a language in common use), we have the commencement of a new *system*. Without counting the vast thickness of the Longmynd slates, the thickness of the Cambrian series, where well developed, is, I think, more than 25,000 feet.

Lower Palæozoic Division continued.

Silurian Series.	1. Wenlock group	*a.* May Hill sandstone; Pentamerus (or Norbury) limestone.
		b. Woolhope (or Lower Wenlock) limestone.
		c. Wenlock shale.
		d. Upper (or great) Wenlock limestone.
	2. Ludlow group	*a.* Lower Ludlow rock.
		b. Aymestry limestone.
		c. Upper Ludlow rock.
		d. Tilestone.

The aggregate thickness of the series about 5000* feet.

The introduction of the May Hill sandstone as a part of the Wenlock group is the only important change I have made in the corresponding portion of the "Tabular View" which is prefixed to the "Second Fasciculus of the Cambridge Palæozoic Fossils." It gives a true physical and palæontological base to the Silurian series: and assuredly there is not (under this arrangement) any such thing in nature as a "Middle Silurian Group," which inseparably links together the Cambrian and Silurian series, and makes them into one system. The May Hill subgroup is not unfrequently discordant to the older groups, on which it rests; and its fossils unite it unequivocally to the Wenlock group. It must therefore, both on physical and palæontological evidence, be cut off from the shelly sandstone of Caer Caradoc and Horderly; to which it is discordant in position, and with which its palæontological relations are not comparatively so near as to the Wenlock group. It is in fact, as now given in the Table, an integral portion of the Wenlock group.

* I obtain this number from an estimate of the thickness of the "Upper Silurian" rocks, by Dr. Fitton, added to the thickness of the May Hill sandstone, as given by Professor Phillips. Aggregates of this kind are frequently too great. For, as a general rule, where one of a set of connected groups rises above the average thickness, another group will probably descend below it. For example. The Woolhope limestone of Presteign is a noble rock, but the Wenlock limestone is quite degenerate. At Wenlock the limestone forms a grand terrace, but the Aymestry limestone has almost vanished. At Leintwardine the Aymestry limestone is a grand rock, but the Wenlock limestone is degenerate. Many other examples might be quoted.

Lower Palæozoic Division as developed in the Cumbrian mountains of the North of England.

Equivalents of the Cambrian Series.	1. Skiddaw slate (Lower Cumbrian)	A group of vast thickness, and probably admitting of several subdivisions. In some of its upper beds a few graptolites and fucoids have been found. Generally it is without a trace of fossils. Near the granite of Skiddaw Forest entirely metamorphic. It is the supposed equivalent of the Longmynd slate (1 *a*) of the Cambrian series.
	2. Chloritic slate and porphyry (Middle Cumbrian)	A group of enormous thickness, composed of alternating masses of slate, sandstone, porphyry, porphyritic conglomerate, trap-shale, &c. &c. It forms no passage into the Skiddaw slate, and is sometimes separated from it by trappean conglomerates. The conglomerates become attenuated, and pass into trap-shales (*schaalstein*); and the shales pass into roofing-slate. The alternations are innumerable. The great deposits of slate are good mineral equivalents of the Llanberris and Festiniog slates. The group seems to pass, at one extremity, into the calcareous slates of the Coniston group; and (when taken collectively) may be considered as the equivalent of all that part of the Cambrian series which extends from the Llanberris and Bangor slates to the Lower Bala rocks inclusive.
	3. Coniston group (Upper Cumbrian)	*a.* Coniston limestone and calcareous slate. *b.* Flagstone; generally calcareous.*

The Coniston limestone appears to be the exact equivalent of the Bala limestone both in its mineral type and in its group of fossils; and the Coniston flagstone seems to represent (in a very degenerate form) the slate, flags, grits, shelly sandstones, and coarse conglomerates which in North and South Wales overlie the Bala limestone and the Llandeilo calcareous flagstone.

* While the May Hill sandstone was confounded with the Caradoc group, and the Coniston limestone and flagstone were confounded with the Caradoc sandstone and Wenlock shale, the Coniston grits appear to be quite anomalous among the true Silurian groups: but now that these grits have found their right place, the anomaly ceases altogether. They produce a remarkable impress on the physical features of the Silurian country of the North of England; and spite of their general sterility, they make a noble exhibition of the May Hill sandstone, and thus form the natural base of the Silurian series of the Cumbrian mountains.

There never was any real difficulty in the natural succession of the physical groups of Cumberland and Westmoreland; and I could have described this succession, in 1824, as well as, perhaps better than, it is given in this Tabular View. The only subsequent difficulty was in attempting to put the successive groups into coordination with those of Wales and Siluria; and so long as the sections, the fossil lists, and the nomenclature of the "Lower Silurian" rocks were taken as a key, the confusion among the groups was inexplicable; simply because the key was false to nature. But the moment the so-called "Silurian key" was thrown aside, the Coniston limestone naturally fell into the place I had first given to it. It became the equivalent of the Bala limestone; and the whole succession became, once more, perfectly natural, both on physical and palæontological grounds.

Equivalents of Silurian Series.		
	1. Coniston grits.	A thick group composed of hard siliceous sandstone, in some places of very coarse texture, and passing into a conglomerate form. It is very sterile of fossils, and the few which have been found give no decisive evidence as to its epoch. Without any obvious discordance of position it marks the commencement of a great change of mineralogical type; and immediately above it we find the commencement of a newer Fauna. It much resembles the sterile portions of the May Hill sandstone, and it appears to have the same place in the general series.
	2. Ireleth slate-group of great thickness.*	*a.* Lower Ireleth slate: coarse, and seldom applied to use as a roofing-slate. *b.* Ireleth limestone; concretionary and discontinuous; a few very obscure fossils. *c.* Upper Ireleth slate. Many subordinate beds of grit, and many alternations; largely quarried. *d.* Coarse slate and grit; seldom quarried for roofing-slate.*
	3. Kendal group.	*a.* A great group of flags, grits, &c.; beds without good transverse cleavage. North side of Kendal Fell and Valley of the Kent. Fossils abundant; prevailing type Lower Ludlow. *b.* Grit, sometimes in thick beds, and of coarse texture; flagstone; bands of coarse slate, generally without transverse cleavage; fossils in certain beds abundant, and of the Upper Ludlow type. The moors SE of Kendal. *c.* Tilestone, resembling that described in the "Silurian system;" fossils abundant, and of the Upper Ludlow type.

Collectively, the above series (from the Coniston grits to the Kendal group inclusive) is of very great thickness; yet, being almost without any subordinate beds of limestone, it is not so prolific of fossils as the corresponding groups in Siluria.

There are in the Woodwardian Museum, I believe, 166 ascertained species collected from the groups between the Skiddaw slate and the tilestone inclusive; and when these species are divided into *two groups*—the *upper* representing all the known fossil species down to the base of the Coniston grits, and the *lower*, all the known species below the Coniston grits—the two groups are found to have but five species in common. In other words, between the Cambrian and Silurian series in the north of England, there are not more than about three per cent of common species, and some of those belong to types which are not confined to the Lower Palæozoic Division.

The whole Silurian series of Westmoreland is overlaid by unconformable and discontinuous masses of red conglomerate; generally of very coarse structure, but sometimes passing into red

* The Ireleth slate-group is spread over a wide extent of country, and is of great thickness, and its fossils, though generally rare, are of the Wenlock type. In the sub-group (*d*) some of the fossils seem to belong rather to the Ludlow rocks; among which the *Hemithyris navicula* is in great abundance. This sub-group seems to pass into, and to be blended with, the sub-group (*a*) of the higher, or Kendal, group.

sandstone. These masses are the degenerate representatives of the Old Red Sandstone. Among the imbedded pebbles we find both Cambrian and Silurian fossils; and on the upper surface of the older rocks (whether Cambrian or Silurian) on which the conglomerates rest, are remarkable examples of mechanical abrasion.

II. *Middle Palæozoic Division.*

Devonian Series or Old Red Sandstone.

(1.) *In Herefordshire and South Wales.*

1. Cornstone group, - - -	*Cephalaspis*, &c.
2. Red sandstone and conglomerate,	*Holoptychius*, &c.

The aggregate thickness eight or nine thousand feet.

(2.) *In Devonshire and Cornwall.*

1. Liskeard or Ashburton group.	
2. Plymouth group.	*a.* Great Devon limestone. *b.* Calcareous slates. *c.* Coarse red sandstone and flagstone.
3. Dartmouth slate group.	Coarse roofing slates and quartzites; ending in North Devon, with beds of red, green, and variegated sandstone; analogous structure in South Devon.
4. Petherwin (or Barnstaple) group.	*a.* Marwood sandstones. *b.* Petherwin slate and *Clymenia* limestone; calcareous slates of Barnstaple.

The agregate thickness of this series is very great, but is not computed.

In Devon and Cornwall the above series has no base; and we are without any evidence as to the beds which are below the lowest Devonian group. Hence there is much uncertainty in the co-ordination of the series of Herefordshire with that of Devon and Cornwall: for the Herefordshire cornstone has characteristic fishes without characteristic shells and corals; while the Devonshire and Cornish series has characteristic shells and corals, but is without fishes.

In a former scheme the Liskeard and Plymouth groups were united; but they may, I think, be conveniently separated. The Herefordshire fish-beds (cornstone) I had formerly placed over the Plymouth group, on the understanding that certain supposed fish-beds of Cornwall were probably of the age of the Dartmouth group. But the Cornish fish-beds having now disappeared from the sections, I think it much the *safest plan* to place the Cornstone group below all the groups of Devonshire; especially as it seems in some places to pass downwards into the tilestone of the Ludlow group, and therefore *appears to give us* (what we do not find in Devon and Cornwall) a base to the Devonian series. On this hypothesis we might arrange the Devonian series of Herefordshire and the sub-groups of the Silurian series in a regularly ascending and unbroken numerical order; but the numerical series would be defective in its last term. The phenomena in Scotland seem however to be adverse to this hypothesis.

The Petherwin (or Barnstaple) group is *provisionally* arranged in the Devonian series. Physically, it is best connected with the older groups of Devonshire and Cornwall; but *palæontologically*, it is perhaps better connected with the rocks of the Upper Palæozoic division.* Here, therefore, there seems to be a *continuous ascending order of deposits*, and a *passage* from the Devonian series to the Carboniferous.

(3.) *Devonian Series of Scotland.*

Grand as is the development of the Old Red Sandstone of Herefordshire, it dwindles into insignificance when compared with the rocks which pass under the same name in Scotland. They are divided by Miller as follows:—

Devonian Series.

1. Great conglomerate and red sandstone.
2. Bituminous schists—*Dipterus, Pterichthys, Coccosteus*, &c.
3. Red and variegated sandstone.
   These three groups make up the "lower formation" of Miller, and are well seen in Caithness.
4. Gray sandstone, earthy slates, &c. This is the "middle formation" of Miller, and contains a peculiar group of fishes, *Cephalaspis*, &c.
5. Red sandstone and conglomerate.
6. Impure concretionary limestone.
7. Yellow siliceous sandstone.
   The last three, called by Miller the "upper formation," are characterized by *Holoptychius*, &c.

This vast North-British series has no true palæontological base; but its "upper formation" seems to graduate into the Carboniferous series.

Its lower groups have no known representatives in the Old Red Sandstone of Herefordshire, and cannot (with our present information) be drawn into a close and unequivocal comparison with the "*tilestone*" and fish-beds of the *Ludlow rock*. But its "middle and upper formation" seem to be represented, though imperfectly, by the "cornstone" and overlying conglomerates, &c. of Herefordshire. From this also it seems to follow, that the upper part of the Old Red Sandstone of Herefordshire is defective in its development; and the conglomerate form of its upper beds appears to sanction the conclusion. If this conclusion be received, it will follow that the Devonian series of Herefordshire is defective at its upper extremity, while the same series in Devon and Cornwall is defective at its base.

But if we take the Devonian series of Scotland as our type, a still more remarkable conclusion seems to follow: viz., that the Devonian series of Herefordshire (spite of its apparent passage into the tilestone) is *also defective at its base.* For we have little or nothing in Herefordshire to match the first three great groups, or "lower formation," of Miller. May we not, however,

* This question is discussed in a paper on the Slate Rocks of Devon and Cornwall, Quarterly Journal of Geol. Soc., vol. viii, 1852.

suppose that this "lower formation" actually descends below the Old Red Sandstone of England, and is on the parallel of the tilestone and fish-beds of the "Silurian system?"

III. *Upper Palæozoic Division including the Carboniferous and Permian rocks.*

Carboniferous Series.

1. Great scar-limestone: coal-field of the basin of the Tweed, and lower coal-field of Scotland. Under this group may, perhaps, be finally arranged the "Carboniferous slates" of Ireland, and also the Marwood and Petherwin groups above mentioned. The coal-field of the Tweed appears to include the "great scar-limestone" of Derbyshire and Yorkshire, and even to descend below it.
2. "Limestone shale" of Derbyshire, "Yordale series" of Phillips.
3. Mill-stone grit. A deposit variable in structure and thickness; seldom entirely wanting; in Yorkshire, a complicated group of great thickness, and containing beds of coal.
4. Great upper coal-field of England, to be divided into two or three sub-groups.

Upper Division continued.

Permian or Dolomitic Series.

1. Coarse red sandstone and conglomerate, generally unconformable to the Carboniferous strata. It contains (though rarely) true Carboniferous fossils (*Lepidodendra, Stigmariæ*, &c.), which may, perhaps, have been drifted mechanically out of the contiguous coal-fields into this coarse, overlying, Permian sandstone.
2. Marl-slate, and thin-bedded compact limestone; a few impressions of plants; shells of Palæozoic genera—*Productus, Spirifer;* some *Lamellibranchiata;* many impressions of fishes—*Palæoniscus, Platysomus, Pygopterus, Acrolepis*, &c.
3. Magnesian limestone, in some parts of the north of England of great thickness, and most complicated structure: *e.g.*.rarely a crystalline dolomite, compact, cellular, earthy, brecciated, globular, oolitic, &c., occasionally with organic remains—*Productus, Spirifer;* several *Lamellibranchiata; Synocladia, Fenestella*, &c.
4. Red gypseous marls, very slightly saliferous.
5. Thin-bedded gray limestone, sometimes cellular and dolomitic. A few traces of bivalves, &c.
6. Red gypseous marls. The above series is overlaid by the great red and variegated sandstone which forms the base of the *Trias.*

The preceding six groups are derived from the sections of Yorkshire and Durham, where the series is best developed. It is evident from the description of these groups, as well as from their general want of conformity to the carboniferous groups, that the Permian series of England is *physically* more nearly connected with the Triassic than with the Palæozoic rocks. But its fossils (even without including the undoubted *carboniferous* plants which have been found in the first group) are of a decided Palæozoic type—a fact which greatly astonished me when I examined the magnesian limestone groups more than thirty years since. If we adopt the term Permian, as a general designation of the series, it must be done with proper limitations derived from the English types. For to class under the Palæozoic name, Permian, the red sandstone of St. Bees' Head, or the great red sandstone of central England, would, I think, be perfectly erroneous. It would be the sacrifice of a natural and well-established sequence of the British deposits to the consistency of a newly adopted foreign name. On this account we have, I think, been premature in using the term Permian to define a British series, which appears not to be quite co-ordinate with the Permian series of Russia. The English type is in fact better, for the purpose of European comparison, than the Russian; and where we have a good and unambiguous English type it is an injurious anomaly, in the present condition of our nomenclature, to introduce a foreign name into the English series.*

In the south of England the whole series is sometimes represented by a mass of conglomerate. In central England, Warwickshire, &c., it is represented by a coarse red sandstone, some beds of which become calcareous; and the whole group is conformable to, and appears to pass into, the coal-measures. About the commencement of the Triassic period, these Permian sandstones underwent contortions along with the coal-strata; in consequence of which we see, in Warwickshire, the upper Triassic groups resting discordantly upon the inclined beds of these sandstones.

In conclusion we may remark,—

1. That it is not in all cases an easy matter to draw a clear line between this series and the carboniferous. Thus Mr. W. Smith, in his old geological map of Yorkshire, considers the lowest group (No. 5) as one of the coal-measures. The series most frequently commences with a discordancy of position and a co-ordinate change of organic types. With limited exceptions, the *flora* and *fauna* of the Permian groups differ from those of the Carboniferous period.

2. The several groups of the series admit of a very close comparison with the *Rothe-todte-liegende*, the *Kupferschiefer*, and the *Zechstein*, &c. of Germany.

General Conclusions.

On casting the eye over the above short Synopsis, or Tabular View, of the whole Palæozoic series, several conclusions seem to force themselves on any well-informed reader: and I will enumerate them here, though they involve a partial repetition of what has been stated above. A more detailed discussion of them will, I hope, before long form the subject of another essay.

First. There is a frequent difficulty in separating the collective groups, such as the Cambrian, Silurian, Devonian, &c., by

* The present nomenclature of the British groups, from the oldest Palæozoic to the newest Tertiary, is essentially geographic and local. The *Pomfret Series* would be a far better, and a far *less ambiguous* name for the English dolomitic series than the name *Permian*. The name Pomfret series (or system) would moreover connect the nomenclature with that of Mr. W. Smith, as recorded in his old map of Yorkshire, 1821. We have, however, done right in adopting one foreign designation, *Trias;* because in that part of the general series the English type is singularly defective.

well-defined lines of demarcation: and this difficulty is very little affected by our nomenclature; for it obviously remains the same, by whatever names we describe these collective groups. But the Cambrian series is now, physically and palæontologically, well separated from the Silurian by the intervention of the May Hill sandstone. Commencing with the May Hill group there is a sudden change of mineral type, and an obvious physical break, sometimes marked by a change of strike and clear discordancy of position; and along with these changes there is also a sudden (and almost complete) suppression of the *most abundant and characteristic* of the older organic types. So far as regards the evidence supplied by Wales, and the bordering English counties, and by the north of England, the question respecting this line of demarcation is, I think, perfectly set at rest: nor does there appear to be anything in the development of the older Palæozoic series of the continents of Europe or America which is opposed to this conclusion.

Secondly. The Silurian groups, from the May Hill (or Wenlock) sandstone to the upper Ludlow rocks inclusive, are by no means so well separated from the old red sandstone (or Devonian rocks) of Herefordshire and South Wales. The old red sandstone was subdivided by Buckland and Conybeare into the Tilestone group, the Cornstone group, and the red sandstone and conglomerate group; and this triple division, with many new and important additional details, was adopted in the "Silurian system." Chiefly on the combined physical and fossil evidence supplied by the corresponding groups of Westmoreland, this triple division of the old red sandstone was afterwards abandoned. The Tilestone was struck off from the Devonian series, and placed at the top of the Silurian. There is, therefore, in the typical Silurian country such a graduation or passage between the Silurian and Devonian groups as to place a physical difficulty in our way when we attempt to draw a line between them. This line, as it is drawn at present, might, however, be considered as very well fixed and determined, were it not for the enormous development of the old red sandstone of Scotland, which (as before hinted) seems to descend below the base line of the Devonian series of Siluria. And when we bear in mind that fishes begin first to appear in the Upper Silurian groups, and become eminently characteristic of the Devonian, we seem (through this vertebrate class of the animal kingdom) to make out a nearer connection between the Silurian and Devonian groups than was at one time imagined.

I am here discussing no evidence but what is supplied by British rocks; and assuredly the classification of British rocks should, in the first instance, be based on British evidence. But I may remark, by the way, that the lower Devonian groups of the continent (e. g. those of the Rhenish provinces) seem to run into an intimate union with the Silurian. Hence it appears to me by no means improbable that we may be hereafter induced (provided we continue to separate the whole Palæozoic system, as in the Tabular View, into three primary divisions) to place the Silurian series not in the *lower*, but along with the Devonian series in the *middle division* of Palæozoic rocks. I only throw this out as a mere hypothesis; and if it be hereafter adopted, it must be on a wider base of evidence than is at present supplied by the Palæozoic system of England.

Thirdly. Though the Devonian series, of the Herefordshire type, seems to pass downwards into the Upper Silurian groups, it does not appear to pass upwards into the Carboniferous. There is generally a palæontological and physical gap between them, which is in many places obscurely indicated by the upper conglomerates of the old red sandstone. Now this gap is, if I mistake not, filled up by the higher Devonian groups in Cornwall and Devonshire. In those counties, when we draw a line between the Devonian and Carboniferous rocks, we find the physical and palæontological evidence in positive conflict. For if we go on the single principle of counting species the Petherwin and Barnstaple groups (as was, I believe, first pointed out by Mr. Griffith on the specific determinations of Professor McCoy) must be packed with the Carboniferous series. But in so doing we deprive of all importance a grand group of dark slates and flags, which seem to have been laid down by nature's hand as the true and continuous base of the great Culm-trough of Devonshire and Cornwall. Nor is this all. The Petherwin and Barnstaple groups, along with many true Carboniferous types, contain several genera and species which have not hitherto been considered as Carboniferous. In such a case as this we may strike a balance in the conflicting weight of evidence offered by the groups, by giving them an undefined margin, and by adopting a provisional nomenclature.*

* The case of the Old Red sandstone of the north of England has not been prominently noticed. It generally appears (as above stated) in the form of a very coarse conglomerate, which, if I mistake not, represents *only the upper part* of the Devonian series. In following the base of the Carboniferous rocks (as they wind round the Cumbrian mountains) we in several places find them underlaid by a coarse red conglomerate, and in a few places both by red conglomerate and red sandstone. In the latter case (e. g. in the neighborhood of Shap Wells) the beds of red sandstone are perfectly parallel to the overlying beds of the great scar-limestone. Nor is this all. Beds of red sandstone, of an identical mineral type, alternate, in thick masses, with the beds of the great scar-limestone; as may be seen in several places in the fine sections between Ravenstone Dale and Shap, and thence into Cumberland. In all such cases there is obviously an intimate union between the Old Red and Carboniferous series—a fact which seems to sanction the opinion that the Old Red conglomerates of the north of England represent only the upper part of the Devonian series.

Fourthly. There is in like manner, in some localities, a great difficulty in drawing the demarcation between the Carboniferous and Permian series. This difficulty was acknowledged by Smith in his old geological map of Yorkshire,* in which he classed the "*lower red sandstone*" (or *Permian sandstone* of a more modern nomenclature) as one of the coal-measures. The difficulty was also fairly stated by myself in a paper (founded on independent observations made in 1821, 1822, and 1823) published in the "Transactions of the Geological Society;" in which, on *physical grounds*, I classed the magnesian limestone (now called Permian series) with the new red sandstone (now Triassic) series; while on *palæontological grounds* it was far more nearly connected with the Carboniferous.

Nor did the progress of discovery remove this difficulty: for near Whitehaven many true carboniferous fossil plants have been found in the Permian sandstone which underlies the magnesian limestone; and similar fossils have also, I believe, been found in the Permian sandstone of Yorkshire.

Again, as a prevailing rule, both in the northern and south-western English counties, the Permian groups (as before stated) are unconformable to the carboniferous. But in central England this rule fails. Thus, in the coal-fields north of Coventry there is a fine Permian sandstone which is perfectly conformable to the coal-strata, partakes of their accidents, and appears to pass into them.† On the contrary, it is overlaid discordantly by the gypseous marls, sandstones, &c. of the Triassic group.

Fifthly. There is a similar difficulty is drawing a fixed line of demarcation between the Permian and Triassic groups. In Yorkshire, where the Permian series is most perfectly developed, its upper beds are parallel to, and (through some red gypseous beds) seem to form a good mineral passage into the Triassic series. And on the coast of Cumberland, geologists are not agreed where to draw the line between the two great groups—Permian and Triassic. Sir R. I. Murchison has drawn the line above the red sandstone of St. Bees' Head. I think this is a mistake, and that the line ought to be drawn below that red sandstone; which is, I believe, the equivalent of the *Bunter sandstein*, or *Grès rouge* of the *Trias.*

After the remarks above made (under the five preceding heads) let no one suppose that I have any wish materially to change the

* A work not without some errors, but of *very great merit* considering the early date of its publication (1821).

† The words "to pass" may, perhaps, be considered inaccurate, when it is added, that (in the coal-fields alluded to) the Carboniferous series is separated from the Permian sandstone by one, and sometimes two, thin bands of limestone (exactly like the thin bands described in the Silurian system, in the same geological position) which are supposed to be of freshwater origin. Whatever be their origin, they are (in the country alluded to above) associated with true carboniferous plants.

nomenclature of the Palæozoic series as sketched in the Tabular View. Whatever may become of the three divisions of the Palæozoic series—whether they be retained as they are, or admit of a new adjustment—very little affects any important question of classification and nomenclature: but I see no ground for anticipating that the subdivisions into Cambrian, Silurian, Devonian, Carboniferous, and Permian, will ever require any material change or adjustment: at least so long as we continue to adopt a geographical nomenclature, which is based on the actual succession of physical groups and is fortified and defined by a co-ordinate weight of fossil evidence. Nor does it much matter by what names we call these several subdivisions. Whether each is to be called a *system* or a *series*, seems, at first sight, rather a question of taste than of science. I think, however, that the facts just stated do prove that the word *series* is a more correct description of the Palæozoic subdivisions than the word *system*—among other reasons because it is a less definite term, and admits of a broader margin: and to this reason we may now add, with perfect certainty, that the abuse of the word system has been a drag-chain on British Palæozoic geology, and has led to many and great mistakes, both in classification and nomenclature.

Sixthly. To the previous remarks I may add, that if the succession of our geological deposits were physically complete, we might, with proper caution, apply the percentage theory of Sir Charles Lyell to their limitation and nomenclature, by counting the well-ascertained species in each successive group. But in the actual condition of our palæontological series we cannot follow this rule, universally, without introducing the elements of confusion. Thus on the percentage theory, we should unquestionably be led to give a false date to the Red Crag of Suffolk; for this simple reason, that a great number of its fossils have been mechanically drifted out of an older deposit, the Coraline Crag—a fact first clearly pointed out by Mr. Charlesworth.

There *may not* be a similar example in the whole British Palæozoic series: but assuredly it is *not improbable* that among the coarser and more mechanical Palæozoic deposits (such as the red sandstone which overlaps the carboniferous rocks and forms the base of the Permian series; or such as the coarse mechanical beds of the May Hill sandstone, which, in like manner, overlap the Cambrian rocks, and form the base of the Silurian series) there *may* be some examples of species which have drifted out of the rocks of an earlier date. On this ground, while we are making a comparative estimate of the Cambrian and Silurian faunas, we can only count at a very low value such species as abound in the lower, and appear *very rarely* in the upper division; and appear *there* only within a very little distance of the line of demarcation between the two. To count such species of the same numerical value in the two faunas, would be as gross an instance of miscalculation as could well be imagined.

Seventhly. Without dwelling on cases of *immediate ambiguity*, we may affirm generally—that when we profess to give a comparative estimate of the fauna of any two Palæozoic groups, we have no right to overlook the question, whether certain species belong to a prevailing type in one of the groups; or, on the contrary, are rare (and perhaps doubtful) exceptions. I will take, for example, six species which are given by the author of "Siluria" as common to the Llandeilo, Wenlock, or Ludlow formations; viz. *Tentaculites anulatus*, *Petraia elongata*, *Trinucleus concentricus*, *Leptæna sericea*, *Orthis Actoniæ*, *Orthis vespertilio.* This list might be largely increased; but I select these six species for a reason given below. In many parts of the Cambrian series they are found in millions: and they produce a very characteristic impress on its fauna. But not so much as a single unequivocal fragment of any one of them is to be found in those parts of the Cambridge collection which are derived from beds below the May Hill sandstone. Negative facts cannot stand a moment against positive. This we all allow: but if negative facts be honestly and laboriously stated, they *may*, at least, prove that certain positive facts (such as the six examples above quoted of species common to Cambrian and Silurian rocks) are *very rare* and *exceptional* cases. Such cases are not to be received but on evidence that is unequivocal; viz., the production of the very species upon which the exceptional lists have been formed. Now I was informed by Professor McCoy (in a note which is now before me) that he had applied, at the Museum of Economical Geology, for a sight of five, out of six, of the very species above enumerated, and that not one of them was shown to him, or found in the Museum, under conditions which confirmed the assertion that they were common to Llandeilo, Wenlock, or Ludlow rocks. As to one of the six species (*Orthis Actoniæ*) I myself applied to Prof. Forbes for his authority. He replied that he could not give his sanction for this species as a type common to the (so-called) Upper and Lower Silurian rocks—that he had nothing but a field memorandum respecting it, and that he might very easily have mistaken the species, or mistaken the rock from which it was obtained.

Taking Sir R. I. Murchison's list, as published in the appendix to his "Siluria," and without any deduction whatsoever, it does not give us much more than ten per cent of species common to true Cambrian and true Silurian British rocks. But when we have struck out from this common list, (1.) all those species which range beyond the limits of the lower Palæozoic division, into the Devonian and Carboniferous groups; (2.) all species of doubtful authority; (3.) all species of which the geological place is not established on good physical evidence; (4.) all species which however abundant in the *lower series* disappear in the *upper*—either altogether, or ascend into it through so very limited a space above the line of demarcation as to produce no general impress on the upper fauna;—when all this has been done, I have no doubt that the number of *common species* will fall *considerably below ten per cent:* perhaps as low as the percentage shown by the Palæozoic series of North America or Bohemia; but not so low as the per centage shown by the Cambrian and Silurian rocks of the north of England.

Art. XXXV.—*New method of disintegrating masses of Fossil Diatomaceæ;* by Prof. J. W. Bailey.

Many masses of fossil Diatomaceæ are so strongly coherent, that they cannot be diffused in water, (for the purpose of mounting in balsam,) without a degree of mechanical violence which reduces to fragments many of the most beautiful and interesting forms. This is particularly the case with some specimens from the "infusorial deposits" of California. Some of these I endeavored to break up, by boiling in water and in acids, and also by repeated freezing and thawing when moistened, but without good results in either case. At last it occurred to me that the adherence might be due to a slight portion of a siliceous cement which the cautious use of an alkaline solution might remove without destroying any but the most minute shells of the Diatoms. As the case appeared a desperate one, a "heroic remedy" was applied, which was to boil small lumps of the diatomaceous mass in a strong solution of caustic potassa or soda. This proved to be perfectly efficacious, as the masses under this treatment rapidly split up along the planes of lamination, and then crumbled to mud, which being immediately poured into a large quantity of water ceased to be acted upon by the alkali, and gave when thoroughly washed, not only all the large shells of the Diatoms in a state of unhoped for perfection, but also furnished abundance of the minute forms. Having obtained by this method highly satisfactory results from specimens from many localities I can confidently recommend it as an addition to our modes of research.

The following directions will enable any one to apply the process. Put small lumps of the mass to be examined into a test tube, with enough of a solution of caustic potassa or soda to cover them; then boil over a spirit lamp for a few seconds, or a few minutes, as the case may require. If the solution is sufficiently strong, the masses will rapidly crumble to mud, which must be poured *at once* into a large quantity of water, which after subsidence is removed by decantation. If the mass resists the action of the alkaline liquor a still stronger solution should be tried, as while some specimens break up instantly in a weak solution of alkali, others require that it should be of the consistence of a dense syrup. The mud also should be poured off as fast as it forms, so as to remain as short a time as possible in the caustic ley.

The only specimens which I have found not to give good results by the method above given, are those from Tampa Bay, Florida, and the infusorial marls from Barbadoes. In the masses from Tampa the lapidification is so complete, that the alkali destroys the shells before the lumps break up; and in the case of the Barbadoes marls the cementing material is calcareous, and requires a dilute acid for its removal. In applying the above process one caution is necessary, which is to thoroughly wash the shells with *water*, and not with acids, as the latter will cause the deposit of a portion of the dissolved silica and materially injure the beauty of the specimens. When the washings are no longer alkaline, the specimens may then be thoroughly cleansed by acids or by the chlorate process described in the last number of this Journal. (See vol. xxi, p. 145.)

Art. XXXVI.—*On the non-existence of polarizing Silica in the Organic Kingdoms;* by Prof. J. W. Bailey.

It is now more than twenty years since Sir David Brewster announced the existence of polarizing or doubly refractive silica in the cuticle of Equisetum, and in that of some of the grasses. In Lindley's Natural System of Botany, the following account of Brewster's experiments is given. "On subjecting a portion of the cuticle of Equisetum hyemale to the analysis of polarized light under a high magnifying power, Brewster detected a beautiful arrangement of the siliceous particles, which are distributed in two lines parallel to the axis of the stem and extending over the whole surface. * * * Brewster also observed the remarkable fact that each particle has a regular axis of double refraction. In the straw and chaff of wheat, barley, oats and rye he noticed analogous phenomena." (Quoted by Lindley from Grevill. Fl. Edinens., 214.)

In Quekett's Treatise on the Microscope, 3d ed., p. 358, directions are given for preparing the siliceous cuticle of Equisetum hyemale for microscopic examination, by boiling in strong nitric acid, and it is added that "in balsam it forms a beautiful object for polarized light." Similar directions are given for preparing the silica in the chaff of wheat, oats, &c.

As these statements are contained in the last editions of each of the above-mentioned works, it is evident that no contradiction of the error involved in them has been pointed out; yet, notwithstanding the high authority on which they rest, the statements so far as the polarizing action of the silica is concerned are wholly erroneous. If the cuticle of the above-mentioned plants is completely deprived of its carbonaceous tissues it will be found wholly devoid of action on polarized light, and any preparation of the cuticle which is found to affect polarized light will also be found to blacken when heated in concentrated sulphuric acid, and if then decarbonised by throwing into the hot acid solution a little chlorate of potassa, the residual silica shows no signs of action under the polariscope, either alone or with the selenite plate, although it still retains the forms of the cells, stomata, &c.

It is clear then that the error in the above statements has been caused by the imperfect removal of the dense carbonaceous tissues which are deposited beneath the silica. I have examined several species of Equisetum and a large number of plants of the grass tribe which are most remarkable for their siliceous cuticles, but have found no trace of any action upon polarized light, when the carbonaceous matter was removed. But it is unnecessary to resort to artificial preparations to prove the correctness of my statements. Nature has made her own preparations, and deposited them by myriads beneath every peat bog, where may be found not only the siliceous shells of the Diatoms, and the spicules of the fresh-water sponges, but also a large number of the siliceous parts of the grasses, sedges, &c. Ehrenberg has shown, (Berlin Monthly Reports, May, 1848) and I can confirm his statements, that the silica in these Phytolitharia, as well as in the Diatomaceæ, Polycistineæ and Spongiolites is not doubly refractive. He makes an exception in the case of the shell of Arachnoidiscus, but my own experiments prove that when properly cleaned this shell forms no exception. As I have shown above that the silica in the cuticle of the Equisetum and grasses, agrees with that in the lower tribes in characters, I think the conclusion is warranted, that doubly refractive silica has no existence in the organic world.

ART. XXXVII.—*On the Pendulum experiments lately made in the Harton Colliery, for ascertaining the mean density of the Earth;* by G. B. AIRY, Esq., F. R. S., Astronomer Royal.*

THE speaker commenced with remarking that the bearing of the experiments, of which he was about to give a notice, was not limited to their ostensible object, but that it applied to all the bodies of the solar system. The professed object of the experiments was to obtain a measure of the density of the earth, and therefore of the mass of the earth (its dimensions being known); but the ordinary data of astronomy, taken in conjunction with the laws of gravitation, give the proportions of the mass of the earth to the masses of the sun and the principal planets; and thus the determination of the absolute mass of the earth would at once give determinations of the absolute masses of the sun and planets. To show how this proportion is ascertained, it is only necessary to remark, that a planet, if no force acted on it, would move in a straight line; that, therefore, if we compute geometrically how far the planet moves in a short time, as an hour, and then compute the distance between the point which the planet has reached in its curved orbit, and the straight line which it has left, we have found the displacement which is produced by the sun's attraction, and which is therefore a measure of the sun's attraction. In like manner, if we apply a similar calculation to the motion of a satellite during one hour, we have a measure of the attraction of its primary. The comparison of these two gives the proportion of the attraction of the sun, as acting upon a body, at one known distance, to the attraction of a planet, as acting upon a body at another known distance. It is then necessary to apply one of the theorems of the laws of gravitation, namely, that the attraction of every attracting body is inversely as the square of the distance of the attracted body; and thus we obtain the proportion of the attractions of the sun and a planet, when the bodies upon which they are respectively acting are at the same distance from both: and finally, it is necessary to apply another theorem of the law of gravitation, namely, that the attractions thus found, corresponding to equal distances of the attracted bodies, are in the same proportion as the masses of the attracting bodies (a theorem which applies to gravitation, but does not apply to magnetic and other forces). Into the evidence of these portions of the law of gravitation, the speaker did not attempt to enter: he remarked only that they rest upon very complicated chains of reasoning, but of the most certain kind. His only object was to show that the proportion of the masses of all bodies, which have planets or satellites re-

* Proc. Roy. Inst. of Great Britain, Part V, p. 17.

volving round them, can easily be found—(the proportion for those which have no satellites is found by a very indirect process, and with far less accuracy); and that if the absolute mass of the earth be known, the absolute mass of each of the others can be found. As their dimensions are known, their densities can then be found. Thus it rests upon such inquiries as those on which this discourse is to treat, to determine (for instance) whether the planet Jupiter is composed of materials as light as water, or as light as cork.

The obvious importance of these determinations had induced philosophers long since to attempt determinations of the earth's density: and two classes of experiments had been devised for it.

The first class (of which there was only one instance) is the attraction of a mountain, in the noble Schehallien experiment. It rests, in the first place, upon the use of the zenith sector; and, in the next place, upon our very approximate knowledge of the dimensions of the earth. [The construction of the zenith sector was illustrated by a model: and it was shown, that if the same star were observed at two places, the telescope would necessarily be pointed in the same direction at the two places, and the difference of direction of the plumb line, as shown by the different points of the graduated arc which it crossed at the two places, would show how much the direction of gravity at one place is inclined to the direction of gravity at the other place.] Now, from our knowledge of the form and dimensions of the earth, we know that the direction of gravity changes very nearly one second of angle for every hundred feet of horizontal distance. Suppose then, that two stations were taken on Schehallien, one on the north side and the other on the south side, and suppose that their distance was 4000 feet; then, if the direction of gravity had not been influenced by the mountain, the inclination of the directions of gravity at the two places would have been about 40 seconds. But suppose, on applying the zenith sector in the way just described, the inclination was found to be really 52 seconds. The difference, or 12 seconds, could only be explained by the attraction of the mountain, which, combined with what may be called the natural direction of gravity, produced directions inclined to these natural directions. In order to infer from this the density of the earth, a calculation was made (founded upon a very accurate measure of the mountain) of what would have been the disturbing effect of the mountain if the mountain had been as dense as the interior of the earth. It was found that the disturbance would have been about 27 seconds. But the disturbance was really found to be only 12 seconds. Consequently the proportion of the density of the mountain to the earth's density was that of 12 to 27, or 4 to 9 nearly. And from this, and the ascertained density of the mountain, it followed that the mean specific gravity of the earth would be about five times that of water. The only objection to this admirable experiment is, that the form of the country near the mountain is very irregular, and it is difficult to say how much of the 12 seconds is or is not really due to Schehallien.

The second class is what may be called a cabinet experiment, possessing the advantage of being extremely manageable, and the disadvantage of being exceedingly delicate, and liable to derangement by forces so trifling that they could with difficulty be avoided. Two small balls upon a light horizontal rod were suspended by a wire, or two wires, forming a torsion balance, and two large leaden balls were brought near to attract the small balls from the quiescent position. We could make a calculation of how far the great balls would attract the little ones, if they were as dense as the general mass of the earth; and comparing this with the distance to which the leaden balls really do attract them, we find the proportion of the density of the earth to the density of lead. The peculiar difficulty and doubt of the results in this experiment depend on the liability to disturbances from other causes than the attraction of the leaden balls, especially the currents of air produced by the approach of bodies of a different temperature; and after all the cautions of Cavendish, Reich, and Bailey, in their successive attempts, it seems not impossible that the phenomena observed may have been produced in part by the temperature of the great balls as well as their attraction.

These considerations induced Mr. Airy, in 1826, to contemplate a third class of experiments, namely, the determination of the difference of gravity at the top and the bottom of a deep mine, by pendulum experiments. Supposing the difference of gravity found, its application to the determination of density (in the simplest case) was thus explained. Conceive a spheroid concentric with the external spheroid of the earth to pass through the lower station in the mine. It is easily shown that the attraction of the shell included between these produces no effect whatever at the lower station, but produces the same effect at the upper station as if all its matter were collected at the earth's centre. Therefore, at the lower station we have the attraction of the interior mass only: at the upper station we have the attraction of the interior mass (though at a greater distance from the attracted pendulum) and also the attraction of the shell. It is plain that by making the proportion of these theoretical attractions equal to the proportion actually observed by means of the pendulum, we have the requisite elements for finding the proportion of the shell's attraction to the internal mass's attraction, and therefore the proportion of the matter in the shell to the matter in the internal mass; from which the proportion of density is at once found. Moreover, it appeared probable, upon estimating the errors to which observations are liable, that the resulting error in the density, in this form of experiment, would be less than in the others.

Accordingly, in 1826, the speaker, with the assistance of his friend Mr. Whewell (now Dr. Whewell), undertook a series of experiments at the depth of nearly 1200 feet, in the Dolcoath mine, near Camborne, in Cornwall. The comparison of the upper and lower clocks (to which further allusion will be made) was found to be the most serious difficulty. The personal labor was also very great. They had, however, made a certain progress when, on raising a part of the instruments, the straw packing took fire—(the origin of the fire is still unknown)—and partly by burning, and partly by falling, the instruments were nearly destroyed.

In 1828 the same party, with the assistance of Mr. Sheepshanks and other friends, repeated the experiment in the same place. After mastering several difficulties, they were stopped by a slip of the solid rock of the mine, which deranged the pumps and finally flooded the lower station.

The matter rested for nearly twenty-six years, the principal progress in the subjects related to it being the correction to the computation of "buoyancy" of the pendulum, determined by Colonel Sabine's experiments. But in the spring of 1854, the manipulation of galvanic signals had become familiar to the Astronomer Royal, and the assistants of the Greenwich Observatory, and it soon occurred to him that one of the most annoying difficulties in the former experiment might be considered as being practically overcome, inasmuch as the upper and lower clocks could be compared by simultaneous galvanic signals. Inquiries, made in the summer, induced him to fix on the Harton colliery near South Shields, where a reputed depth of 1260 feet could be obtained; and as soon as this selection was known, every possible facility and assistance were given by the owners of the mine. Arrangements were made for preparing an expedition on a scale sufficient to overcome all anticipated difficulties. A considerable part of the expense was met by a grant from the Board of Admiralty. The Electric Telegraph Company, with great liberality, contributed (unsolicited) the skill and labor required in the galvanic mountings. The principal instruments were lent by the Royal Society. Two observers were furnished by the Royal Observatory, one by the Durham Observatory, one by the Oxford Observatory, one by the Cambridge Observatory, and one by the private observatory of Red Hill (Mr. Carrington's). Mr. Dunkin, of the Royal Observatory, had the immediate superintendence of the observations.

The two stations selected were exactly in the same vertical, excellently walled, floored, and ceiled; the lower station in particular, was a most comfortable room or rather suite of rooms. Every care was taken for solidity of foundation and steadiness of temperature. In each (the upper and the lower) was mounted an invariable brass pendulum, vibrating by means of a steel knife edge upon plates of agate, carried by a very firm iron stand. Close behind it, upon an independent stand, was a clock, carrying upon the bob of its pendulum an illuminated disk, of diameter nearly equal to the breadth of the tail of the invariable pendulum; and between the two pendulums was a chink or opening of two plates of metal, which admitted of adjustment, and was opened very nearly to the same breadth as the disk. To view these a telescope was fixed in a wall, and the observer was seated in another room. When the invariable pendulum and the clock pendulum pass the central points of vibration at the same instant, the invariable pendulum hides the illuminated disk as it passes the chink, and it is not seen at all. At other times it is seen in passing the chink. The observation, then, of this disappearance determines a coincidence with great precision. Suppose the next coincidence occurs after 400 seconds. Then the invariable pendulum (swinging more slowly), has lost exactly two swings upon the clock pendulum, or the proportion of its swings to those of the clock pendulum is 398 : 400. If an error of a second has been committed, the proportion is only altered to 397 : 399, which differs by an almost insignificant quantity. Thus the observation, in itself extremely rude, gives results of very great accuracy. As the proportion of invariable-pendulum-swings to clock-pendulum-swings is thus found, and as the clock-pendulum-swings in any required time are counted by the clock dial, the corresponding number of invariable-pendulum-swings is at once found. Corrections are then required for the expansion of the metal (depending on the thermometer-reading), for the arc of vibration, and for the buoyancy in air (depending on the barometer-reading).

But when the corrected proportion of upper-invariable-pendulum-swings to upper-clock-pendulum-swings is found, and the proportion of lower-invariable-pendulum-swings to lower clock-pendulum-swings is found, there is yet another thing required:—namely, the proportion of upper-clock-pendulum-swings to lower-clock-pendulum-swings in the same time; or, in other words, the proportion of the clock rates. It was for this that the galvanic signals were required. A galvanometer was attached to each clock, and an apparatus was provided in a small auxiliary clock, which completed a circuit at every fifteen seconds nearly. The wire of this circuit, passing from a small battery through the auxiliary clock, then went through the upper galvanometer, then passed down the shaft of the mine to the lower galvanometer, and then returned to the battery. At each galvanometer there was a small apparatus for breaking circuit. At times previously arranged, the circuit was completed by this apparatus at both stations, and then it was the duty of the observers at both stations to note the clock times of the same signals; and these evidently give comparisons of the clocks, and therefore give the means of comparing their rates. Thus (by steps previously explained), the number of swings made by the upper pendulum is compared with the number of swings made in the same time by the lower pendulum.

Still the result is not complete, because it may be influenced by the peculiarities of each pendulum. In order to overcome these, after pendulum A had been used above and pendulum B below, they were reversed; pendulum B being observed above and A below; and this, theoretically completes the operation. But in order to insure that the pendulum received no injury in the interchange, it is desirable again to repeat the experiments with A above and B below, and again with B above and A below.

In this manner the pendulums were observed with 104 hours of incessant observations, simultaneous at both stations, A above and B below; then with 104 hours, B above and A below; then with 60 hours, A above and B below; then with 60 hours, B adove and A below. And 2454 effective signals were observed at each station.

The result is, that the pendulums suffered no injury in their changes; and that the acceleration of the pendulum on being carried down 1260 feet is $2\frac{1}{4}$ seconds per day, or that gravity is increased by —$\frac{1}{19190}$ part.

It does not appear likely that this determination can be sensibly in error. The circumstances of experiment were, in all respects, extremely favorable; the only element of constant error seems to be that (in consequence of the advanced season of the year), the upper station was cooler by 7° than the lower station, and the temperature-reductions are therefore liable to any uncertainty which may remain on the correction for 7°. The reductions employed were those deduced by Sabine from direct experiment, and their uncertainty must be very small.

If a calculation of the earth's mean density were based upon the determination just given, using the simple theory to which allusion is made above, it would be found to be between six times and seven times the density of water. But it is necessary yet to take into account the deficiency of matter in the valley of the Tyne, in the hollow of Jarrow Slake, and on the sea-coast. It is also necessary to obtain more precise determinations of the specific gravities of the rocks about Harton colliery than have yet been procured. Measures are in progress for supplying all these deficiencies. It seems probable that the resulting number for the earth's density will probably be diminished by these more accurate estimations.

ART. XXXVIII.—*On the rate of Evaporation on the Tulare Lakes of California;* By WM. P. BLAKE, Washington, D. C.

Read before the National Institute, Washington, D. C., March 4th, 1856.

THE Tulare plains of California wear a most desert-like and barren aspect during the summer and autumn. Treeless and without green vegetation, the surface becomes parched by the rays of an unclouded sun, and gives unobstructed passage to steady currents of air which pass inland from the ocean towards the Sierra Nevada. These winds, after passing the ranges of the Coast Mountains and becoming partially desiccated in their transit, impinge upon and traverse the plain, and reach the foot-hills of its eastern margin with a high temperature and apparently little moisture.

In the month of August, 1853, while with the U. S. Pacific R. R. survey, commanded by Lieut. R. S. Williamson, we encamped on the banks of Ocoya Creek, among the foot-hills of the Sierra, and every day felt the hot wind blowing inland toward the mountains. The parching effect produced by these winds, and the fact that after leaving the Coast Mountains they sweep over the broad and shallow Tulare lakes, induced me to desire to ascertain the rapidity of evaporation of water when fairly exposed to their action, and if possible to arrive at an approximate estimate of the amount of water removed daily from these lakes. For this purpose, I made the experiment of exposing water in a pan to the action of the wind, and noting the amount removed each day.

The valley of Ocoya Creek, in which our camp was located, has been formed by the erosion of the creek in a plateau of soft tertiary strata. It is thus bounded on each side by hills of horizontal stratification, and these were from 300 to 900 feet in height. They were perfectly barren and parched, and the only green vegetation visible was confined to the immediate banks of the creek. The altitude of the camp was 738 feet above mean-tide, and its distance from the open plain of the Tulares, two miles, from the lakes 25 miles, and from the sea in a direct east and west line 120 miles. The width of the valley was about one quarter of a mile, and its direction was nearly east and west, so that the breeze from the plain followed its course without deflection.

The wind usually blew gently from the mountains during the night and early in the morning, but after the sun had risen, and about 10 o'clock its direction was reversed and it blew steadily and often strongly from the west or northwest until sunset, when it generally ceased.

The experiment was conducted in the following manner. A large sheet-iron pan, such as is used by the miners for "prospecting," and which corresponds very nearly in size and shape with an ordinary milk-pan, was placed upon a firm stand about two feet above the surface of the ground. This pan was nearly filled with water and a thermometer and small ivory scale were immersed in it. The whole was in a situation favorably exposed to the action of the winds, and was protected from the direct rays of the sun by a shed, covered with brush and leaves. The shade preventing the sun from unduly heating the water by acting on the bottom and sides of the pan. The amount of evaporation was noted from time to time by the height of the water on the scale. The results are given in the annexed table.

Table showing daily evaporation at Posé Creek, Cal.

Date.	Time.	Ther. air.	Ther. water.	Quantity evapor't'd.	Daily evap'n.	Remarks—winds, &c.
1853.				Inches.		
Aug. 26	sunrise	65°	62°			
	12 M.					
	2 P. M.	100°	80°	$\frac{2}{16}$		
	6 "		78°	$\frac{2}{16}$	$\frac{4}{16}$	Wind NW and steady from 11 A. M. till sunset.
" 27	sunrise	60°	58°			
	9 A. M.	85°	70°	$\frac{1}{16}$		Wind rising and from the SW.
	12 M.	96°	78°			
	2 P. M.	100°	82°	$\frac{1}{16}$		Wind strong and from NW.
	4 "	100°	80°	$\frac{2}{16}$		
	5·30 "	96°	78°	$\frac{1}{16}$	$\frac{5}{16}$	
" 28	6 A. M.	60°	56°			
	12·30	95°	78°	$\frac{2}{16}$		Wind strong since 11 A. M.
	4·30 P. M.			$\frac{1}{16}$		
	6 P. M.			$\frac{1}{16}$	$\frac{4}{16}$	Wind ceased at 6.
" 29	6 A. M.	52°	50°			
	12·30 PM	86°	74°	$\frac{1}{16}$		Wind rising at 9 A. M.
	4 P. M.	90°	75°	$\frac{2}{16}$	$\frac{3}{16}$	

From this table it will be seen that the observations were continued for four days, and that the mean daily evaporation was *one quarter of an inch.* This was shown not only by the sum of the daily or hourly results, but by the total loss in the four days as indicated on the scale at the close of the experiment. This result was below my anticipations, and yet when the depth of evaporation is multiplied by the superficial area, the quantity appears enormous. The rapidity of the evaporation was doubtless retarded by impurities in the water, which was taken from the creek and soon deposited a slight sediment, and on the third day was covered with a thin film or pellicle, probably of light dust, which must have offered great protection from the action of the air.

It will be observed that the evaporation ceased at night. The temperature of the air was always rapidly reduced after sunset, but there was no dew. As these low, night temperatures did not influence the result, we may take the mean of the day temperatures both for the air and the water at the time of observation,—subject to the slight error caused by the deficiency of observations on the 26th and 28th—and obtain approximately the temperature conditions of the air and water for that amount of evaporation. These results are, for the air 83°·9, for the water 71°·5; time, 46 hours. Height of barometer 29·30.

Although at the time of these experiments I regarded the air as exceeding dry, I have since been forced to the conclusion that its condition was not the most favorable to great and rapid absorption of water. The crests of the ranges of the Coast Mountains are not greatly elevated in that region—being, probably, less than 4000 feet—and during the day they are much heated by the sun: they do not, therefore, cause the precipitation of all the moisture which the air brings with it from the sea, and its thorough desiccation is not accomplished. A great part of its moisture is necessarily retained, and a capacity for the absorption of more is given by the elevation of temperature which it suffers among the interior ranges and valleys of the coast, and finally upon the broad and heated plain. It is well to consider these conditions in connexion with the experimental results, and if the air is thus highly charged with moisture, the quantity taken up must be regarded as very large. At the rate of one quarter of an inch a day, seven inches and a half in depth will be removed in thirty days, or seven feet seven and a quarter inches in one year. According to Dr. G. Buist, the amount of evaporation from the surface of water at Aden, on the Indian Ocean, "is about eight feet for the year."* The bases of this statement is not given, but it is interesting to notice that the amount agrees with my experimental result.

The facts which have been given, derive importance and interest from the bearing they have upon the phenomena of the evaporation from the surface of the Tulare lakes. These lakes are broad, shallow sheets of water, with shelving marshy shores, without bluffs or terraces. They occupy the lowest parts of the Tulare valley and receive the drainage of the broad western slope of the Sierra Nevada for the whole distance south of the San Joaquin, a distance, if measured along the summit of the mountains, of nearly 200 miles. Among the streams which empty into them, are three of considerable magnitude, Kern river, King's river, and the Caweea or Four creeks. The flow in these streams is constant through the year, and they are often very much swollen by the melting of the distant snows, even

* Trans. Bombay Geographical Society, vol. ix, 1849–50, p. 39.

late in the summer. Although the lakes have no outlet, and they are daily receiving this immense supply of water, their level is not raised, but on the contrary the borders give evidence that they are gradually drying up. We must conclude from these facts that the evaporation from the lakes is equal to, if not greater than the supply.

If we regard the experimental result as a fair measure of the evaporation from the lakes, we may readily calculate the amount of water taken from them during a month or year. We have 36 cubic inches of water for the daily evaporation from one square foot of surface and consequently 522929·5 cubic feet from every square mile. This equals 16210·8 tons or 4,052,703 gallons—a quantity of which we can scarcely form an adequate conception, and yet it is for one day only. If we measure the amount of evaporation in depth, and assume that the quantity evaporated is equal during each month in the year, we have as before observed, seven feet seven inches and one quarter for the yearly evaporation. The conditions which I have detailed, do not, however, exist throughout the year. In the rainy months, the evaporation is much reduced or perhaps it almost ceases. It is almost certain however that the experiment does not show the full amount of evaporation for the summer; it is undoubtedly much greater, and the results can only be regarded as approximate. They are however important, and derive greater interest from the fact that few experiments of the kind have been made, and because the climatic conditions of that region are so peculiar.

Art. XXXIX.—*On Electric Conduction;* by Professor Faraday, D.C.L., F.R.S.*

Since the time when the law of definite electrolytic action was first laid down (*Exp. Res.* 783–966), it has become a question whether those bodies which form the class of electrolytes, conduct only whilst they are undergoing their proper change under the action of the electric current; or whether they can conduct also as metals, dry wood, spermaceti, &c., do in different degrees, *i. e.* without the accompaniment of any chemical change within them. The first kind of conduction is distinguished as the *electrolytic;* the transference of the electric force appearing to be essentially associated with the chemical changes which occur; the second kind may be called *conduction proper;* and there the act of conduction leaves the body ultimately as it found it. Electrolytic conduction is closely associated with the liquid state, and with the compound nature and chemical proportions of

* Proc. Roy. Inst. of Great Britain, Part V, p. 123.

the bodies in which it occurs; and it is considered as varying in degree (*i. e.* in facility) with the affinities of the constituents belonging to these bodies; there are, however, other circumstances which evidently, and indeed very strongly, affect the readiness of transfer, such as temperature, the presence of extraneous matters, &c. Conduction proper differs as to facility by degrees so far apart, that the quantity of electricity which could pass through a hundred miles of one substance, as copper, in an inappreciably small portion of time, would require ages to be transmitted through the like length of another substance, as shell-lac; and yet the copper with its similars offers resistance to conduction; and the lac, and its congeners, conduct.

The progress and necessities of science have rendered it important within the last three or four years, and especially at the present moment, that the question "whether an electrolyte has any degree of conduction proper" should be closely considered, and the experiments which are fitted to probe the question have been carried to a very high degree of refinement. Buff,* by employing the electric machine, and Wollaston terminals, i. e. platinum wires sealed into glass tubes, and having the ends only exposed, has decomposed water by a quantity of electricity so small that it required four hours to collect gas enough to fill a little cylinder only one-tenth of an inch in diameter, and the one-fifth of an inch in length; yet the decomposition was electrolytic and polar; and therefore the conduction was electrolytic also. When one pole only was in the water, and the other in the air over it, still the decomposition, and therefore the conduction, was electrolytic; for one element appeared at the pole in the water, and the other in the air or gas over the water at the corresponding pole. Buff concludes that electrolytes have no conduction proper. Many other philosophers have supported, with more or less conviction, the same view, and believe that electrolytic conduction extends to, and includes cases, which formerly were supposed to depend upon conduction proper. Soret advances certain experimental results,† but reserves his opinion from being absolute. Von Breda and Logeman adopt the more general view unreservedly.‡ De la Rive, I think, admits that a very little may perhaps pass by conduction proper, but that electrolytic conduction is the function of electrolytes.§ Matteucci has at one time admitted a little conduction proper, but at present, I believe, denies that any degree exists. On the other hand, Despretz,‖ Leon Foucault,¶ Masson,** and myself, have always admitted the possibility that electrolytes possess a certain amount

* MS. letter. † Annales de Chimie, xlii, 257. ‡ Phil. Mag., viii, 465.
§ Bibl. de Genève, xxvi, 134, 144; xxvii, 177. ‖ Comp. Rend., xxxviii, 897.
¶ Comp. Rend., xxxvii, 580; or Bibl. de Genève, xxiv, 263; xxv, 180; xxvi, 126.
** Prize Essay, Haarlem Trans., xi, 78.

of conduction proper—small indeed, but not so small as to prevent its being evident in certain forms of experiments: and beautiful and close as the electrolytic proofs have been carried, they are not by us considered as sufficient to show that the function of conduction proper is altogether absent from electrolytes.

(Some account was then given of the experiments and arguments on both sides; and of the striking electrolytic fact, that if a current of electricity, however small, is sent through a circuit containing a couple of platina plates in dilute sulphuric acid, the plates are found thereby electrically polarized.)

The inquiry as regards electrolytes takes on three forms. They may possess a degree of conduction proper at all times—or they may be absolutely destitute of conduction proper—or they may possess conduction proper up to a certain condition, governed either by requisite intensity for electrolyzation or by other circumstances, but which, when that condition is acquired, changes into electrolytic conduction; and these three forms may be further varied by considerations dependent upon the physical state of the electrolyte, as whether it be solid or liquid, hot or cold, and whether it be pure or contain other substances mingled with it.

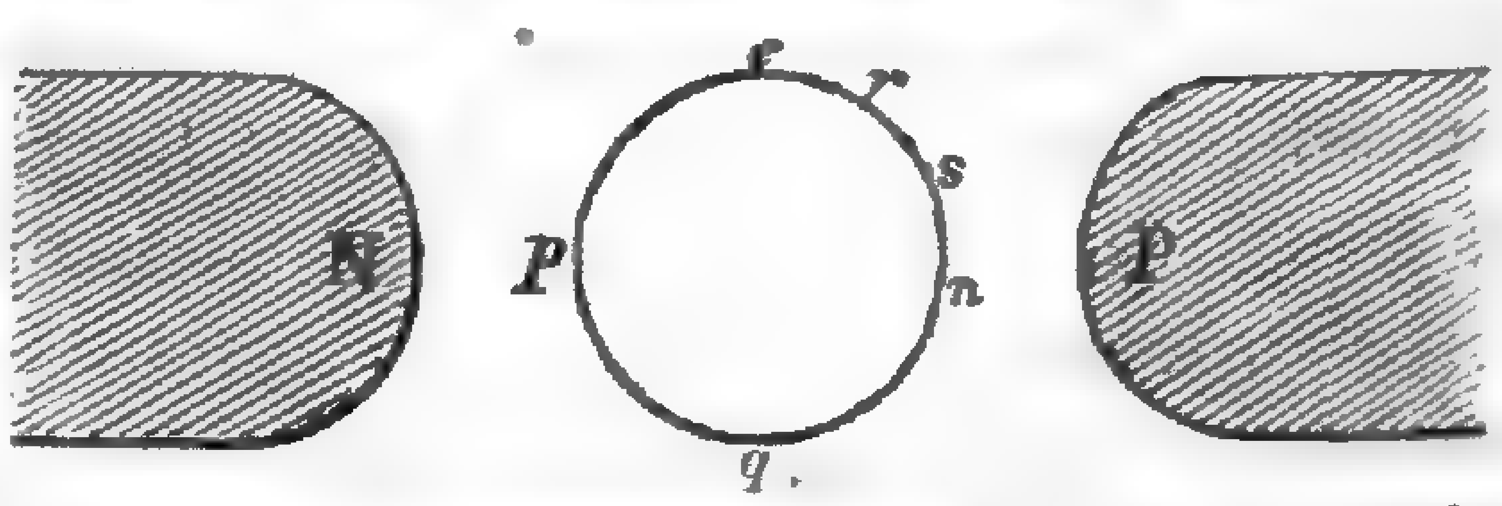
From the time when the question was raised by myself, twenty years ago, to the present day, I have found it necessary to suspend my conclusions; for close as the facts have in certain cases been urged by those who believe they have always obtained decomposition results, when an electrolyte has performed the part of a conductor, and freely as I could have admitted the facts and the conclusions if there had been no opposing considerations, still, because there are such considerations, I am obliged to reserve my judgment. In the first place all bodies not electrolytic, even up to gases (Becquerel,) are admitted to possess conduction proper; *a priori*, therefore, we have reason to expect that electrolytes will possess it also. If from amongst different bodies we retain for consideration the class of electrolytes only, then though the amount of electricity of a given intensity which these can transmit electrolytically when they are *fluid*, is often almost infinitely greater than that which they can convey onwards by conduction proper, when they are *solid;* still the conduction in the latter cases is very evident. A piece of perfectly dry solid nitre, and of many other electrolytes, discharges a gold leaf electrometer very freely, and I believe by the power of conduction proper; and that being the case, I do not see that the assumption of the very highest condition of electrolytic conduction when the nitre is rendered fluid is any argument for the absolute disappearance of the conduction proper which belonged to the body in the solid state, though it may override the latter for the time and make it insensible. These considerations are, however, such as arise rather from the absence of the final and strict proof on the opposite side, than from anything very positive in their own character; but it has occurred to me that the phenomena of static electricity will furnish us with many reasons of a positive nature, in favor of the possession by liquid electrolytes of the power of conduction proper. Some of these I will endeavor briefly to state, illustrating the subject by a reference to water, which in its pure state has but a low degree of electrolytic conduction.

The ordinary phenomena of static charge and induction are well known. If an excited glass rod or other body be held near a light gilt sphere, suspended from the hand by a metal thread, the inductive action disturbs the disposition of the electricity in the sphere, and the latter is strongly attracted: if in place of the sphere a soap bubble be employed, the same results occur. If a dish filled with pure distilled water be connected with the earth by a piece of moist bibulous paper, and a ball of excited shell-lac be suspended two or three inches above the middle of the water, —and if a plate of dry insulating gutta-percha, about eight inches long and two inches wide, have its end interposed between the water and the shell-lac, it may then be withdrawn and examined, and will be found without charge, even though it may have touched the shell-lac; but if the end once touch the water under the lac (and it may be dipped in,) so as to bring away a film of it, charged with the electricity the water has acquired by the induction, it will be found to possess, as might be expected, a state contrary to that of the inductric shell-lac.

In order to exclude any conducting body but water from what may be considered as a reference experiment, two calico globular bags with close seams were prepared; and being wetted thoroughly with distilled water, were then filled with air by means of a fine blow-pipe point; they were then attached to two suspending bands of gutta-percha, by which they were well insulated, and being three inches in diameter, they formed, when placed in contact, a double system six inches in length. A metallic ball, about four inches in diameter, was connected with the electric machine to form an inductric body, an uninsulated brass plate was placed about nine inches off to form an inducteous body; between these, the associated water balls could be placed so as to take part in the induction, and when the electric charge was so low that the moist atmosphere caused no transmission of electricity, the balls could be introduced into position and brought away without having received any permanent charge. Under these circumstances if the associated balls were brought into the place of induction, were then separated, withdrawn, and examined, they were found, the one charged positively and the other negatively, by electricity derived from themselves, and without conductive or convective communication with any other substance than their own water.

It is well known indeed that by the use of water we may replace metal in all electro-static arrangements, and so form Leyden jars, condensers, and other induction apparatus, which are perfect in principle though with imperfect action. The principles are the same, whether water or metals be used for conductors, and the function of conduction is essential to all the results; therefore conduction cannot be denied to the fluid water, which in all such cases is acting as the only conductor. In nature, indeed, the phenomena of induction, rising up to their most intense degree in the thunder-storm, are almost, if not altogether, dependent upon the water which in the earth, or the clouds, or the rain, is then acting by its conducting power; and if this conducting power be of the nature of *conduction proper*, it is probable that that function is as large and as important as any exercise of the electrolytic conduction of water in other natural phenomena.

But it may be said that all these cases, when accompanied by conduction, involve a corresponding and proportionate electrolytic effect, and are therefore cases of electrolytic conduction; and it is the following out of such a thought that makes me think the results prove a conduction proper to exist in the water. For suppose a water bubble to be placed midway between a positive and a negative surface, as in the figure, then the parts at and about *p* will become charged positive, and those at and about *n* negative, solely by the disturbance of the electric force originally



in the bubble, i. e. without any direct transmission of the electric force from N or P; the parts at *e* or *q* will have no electric charge, and from those parts to *p* and *n* the charge will rise gradually to a maximum. The electricity which appears at *p*, *n*, and elsewhere, will have been *conducted* to these parts from other parts of the bubble; and if the bubble be replaced by two hemispheres of metal, slightly separated at the equatorial parts *e*, *q*, the electricity (before *conducted* in the continuous bubble,) will then be seen to pass as a bright spark. Now the particles at any part of the water bubble may be considered under two points of view, either as having had a current passed through them, or as having received a charge; in either view the idea of conduction proper supplies sufficient and satisfactory reasons for the results; but the idea of electrolytic conduction seems to me at present beset with difficulties. For consider the particles about the equator *e q*, they acquire no final charge, and they *have conducted*, as the action of the two half spheres above referred to show; and they are not in a state of mutual tension, as is fully proved by very simple experiments with the half hemispheres. Therefore oxygen must have passed from *e* towards *n*, hydrogen from *e* towards *p*, i. e. towards and to the parts to which the electricity has been conducted, for without such transmission of the anions and cations there would be no transmission of the electricity, and so no electrolytic conduction. But then the questions arise,—where do these elements appear? is the water at *n* oxygenated, and that about *p* hydrogenated? and may the elements be at last dispersed into the air at these two points, as in the case of decompositions against air poles? (*Exp. Res.* 455, 461, &c.) In regard to such questions, other considerations occur respecting the particles about *p* and *n*, and the condition of charge they have acquired. These have received the electricity which has passed as a current through the equatorial parts, but they have had no current or no proportional current through themselves—the conduction has extended *to* them but not *through* them; no electricity has passed for instance through the particle at *n* or at *p*, yet more electricity has gone by some kind of conduction to them than to any other of the particles in the sphere. It is not consistent with our understanding of electrolytic conduction to suppose that these particles have been charged by such conduction; for in the exercise of that function it is just as essential that the electricity should *leave* the decomposing particle on the one side, as that it should *go to it* on the other: the mere escape of oxygen and hydrogen into the air is not enough to account for the result, for such escape may be freely permitted in the case of electrodes plunged into water; and yet if the electricity cannot pass from the decomposing particles into the electrodes, and so away by the wires, in a condition enabling it to perform its full equivalent of electric work anywhere else in the circuit, there is no decomposition at the final particles of the electrolyte, nor any electrolytic conduction in its mass. Even in the air cases above referred to there is a complete transmission of the electricity across the extreme particles concerned in the electrolysis.

If the above reasoning involve no error, but be considered sufficient to show that the particles at *p* and *n* are not electrolyzed, then it is also sufficient to prove that none of the particles between *p* and *n* have been electrolyzed; for though one at *e* or *q* may have had a current of electricity passed through it, it could not give up its elements unless the neighboring particles were prepared to take them in a fully equivalent degree. To stop the electrolysis at *n* and *p*, or at those parts of the surface where the moving electricity stops, is to stop it at all the intervening parts according to our present views of electrolysis, and to stop the electrolysis is to shut out electrolytic conduction; and nothing at present remains but *conduction proper*, to account for the very manifest effects of conduction which occur in the case.

It may be imagined that a certain polarized state of tension occurs in these cases in static induction, which is intermediate between it and electrolytic conduction (*Exp. Res.* 1164); or that a certain preparatory and as it were incomplete condition may be assumed, distinguishing the case of static conduction with globes of water, which I have taken as the ground of consideration from the same case when presented by globes of metal. Our further and future knowledge may show some such state; but in respect of our present distinctive views of conduction proper and electrolytic conduction, it may be remarked that such discovery is just as likely to coincide with the former as with the latter view, though it most probably would alter and correct both.

Falling back upon the consideration of the particles between *e* and *n*, we find, that whether we consider them as respects the current which has passed through them, or the charge which they have taken, they form a continuous series; the particle at *e* has had most current, that at *n* none, that at *r* a moderate current; and there are particles which must have transmitted every intermediate degree. So with regard to charge; it is highest at *n*, nothing at *e*, and every intermediate degree occurs between the two. Then with respect to these superficial particles, they hold all the charge that exists, and therefore all the electricity which has been conducted is in them; consequently all the electrolytic results must be there; and that would be the case, even though for the shell we were to substitute a sphere of water. For, if those particles which have had more current through them than others be supposed to have more of the electrolytic results about them than the others, then that electricity which is found associated chiefly, if not altogether, with these others, could have reached them only by conduction proper, which for the moment is assumed to be non-existent. So, to favor the electrolytic argument, we will consider the conduction as ending at, and the electrolytic results as summed up in, these superficial particles, passing for the present the former objection that though the electricity has reached, it has not gone through, these particles. Taking, therefore, a particle at *r*, and considering its electrolytic condition as proportionate to the electricity which has arrived at that particle, and given it charge, we may then assume, for we have the power of diminishing the inductive action in any degree, that the electricity, the conduction of which has ceased upon the particle that was there has been just enough to decompose it, and has left what was the under but is now the surface particle, charged. In that case, some other particle, in a higher state of charge, and nearer to *n*, as at *s*, will have had enough electricity conducted towards its place to decompose two particles of water;—but it is manifest that this cannot be the next particle to that at *r*, but that a great number of other particles in intermediate states of charge must exist between *r* and *s*. Now the question is, how can these particles become intermediately charged by virtue of electrolytic conduction only? Electrolytic action is definite, and the very theory of electrolytic conduction assumes that the particles of oxygen and hydrogen as they travel convey not a variable but a perfectly definite amount of power onward in its course, which amount they cannot divide, but must take at once from a like particle, and give at once to another like particle. How then can any number of particles, or any action of such particles carry a fraction of the force associated with each particle? It is no doubt true, that if two charged particles can throw their power either on to one, or to three or more other particles, then all the difficulty disappears. Conduction proper can do this: but, as we cannot conceive of a particle half decomposed, so I cannot see how this can be performed by electrolytic conduction, i. e. how the particle between *r* and *s* can be excited to the intermediate and indefinite degree, conduction without electrolysis being denied both to it and the particles around it.

If the particles between *e* and *n* be supposed to conduct electrolytically by the current which passes *through* them (dismissing for a time, amongst other serious objections, that already given that the products would not be found at the places to which the electricity has been conveyed) still the present argument would have like force. At *r* enough electricity may have passed through to decompose two particles of water, at *s* only enough to decompose one,—how is a particle between *r* and *s* to change elements with the particles either towards *r* or towards *s*, if electrolytic change only is to be admitted? or how, as before inquired, can two particles throw their power on to, or receive their power from one? Many other considerations spring out of the thought of a water bubble, under static induction; but these just expressed, with those that relate to the *seat* of electrolytic action, whether at the place of current or of charge, create a sum of difficulty fully sufficient, without any others, to make me suspend for the present any conclusions on the matter in question.

The conduction power of water may be considered under another point of view; namely, that which has relation to the absolute charge that can be given to the fluid. A point from the electrical machine can charge neighboring particles of air, and they issue off in streams. It can do the same to particles of camphene, or oil of turpentine;—it can do the same to the particles of water; and if two fine metallic wires connected with Ruhmkorff's apparatus, be immersed in distilled water, about half an inch apart, the motes usually present will soon show how the water receives charge, and how the charged water passes off in streams, which discharge to each other in the mass. Now such charge is not connected with electrolysis; the condition of electrolyzation is that the electricity pass through the water and do not stop short in it. The mere charge of the water give us no idea where any constituents set loose by electrolysis can be evolved, and yet conduction is largely concerned in the act of charging. A shower of rain falls across a space in the atmosphere subject to electric action, and each drop becomes charged; spray may be thrown forth from an electrified fountain very highly charged;—conduction has been eminently active in both cases, but I find it very difficult to conceive how that conduction can be electrolytic in its character.

When drops of water, oppositely electrified, are made to approach each other, they act by convection, i. e. as carriers of electricity; when they meet they discharge to each other, and the function of conduction is for the time set up. When the water bubble, described p. 372, is taken out of the sphere of induction, the opposite electricities about p and n neutralize each other, being conducted through the particles of the water. Are we to suppose in these cases that the conduction is electrolytic? if so, where are the constituents separated, and where are they to appear? It must be a strong conviction that would deny conduction proper to electrolytes in these cases; and if not denied here, what reason is there ever to deny it absolutely.

The result of all the thought I can give to the subject is a suspended judgment. I cannot say that I think conduction proper is as yet disproved in electrolytes; and yet I cannot say that I know of any case in which a current, however weak, being passed by platinum electrodes across acidulated water does not bring them into a polarized condition. It may be that when metallic surfaces are present, they complete by their peculiarities the condition necessary to the evolution of elements, which, under the same degree of electrification would not be evolved if the metals were away; and, on the other hand, it also may be that after the metals are polarized, and a consequent state of reactive tension so set up, a degree of conduction proper may occur between them and the electrolyte simultaneously with the electrolytic action. There is now no doubt that as regards electrolysis and its law, all is as if there were but electrolytic conduction; but, as regards static phenomena (which are equally important) and the steps of their passage into dynamic effects, it is probable that conduction proper rules with electrolytes as with other compound bodies: for it is not as yet disproved, is supported by strong presumptive evidence, and may be essential. Yet so distant are the extremes of electric intensity, and so infinitely different in an inverse direction are the quantities that may and do produce the essential phenomena of each kind, that this separation of conductive action may well seem perfect and entire to those whose minds are inclined rather to see conduction proper replaced by electrolytic conduction, than to consider it as reduced, but not destroyed; disappearing, as it were, for electricity of great quantity and small intensity, but still abundantly sufficient for all natural and artificial phenomena, such as those described, where intensity and time both unite in favoring the final results required.

But we must not dogmatise on natural principles, or decide upon their physical nature without proof; and, indeed, the two modes of electric action, the electrolytic and the static, are so different yet each so important, the one doing all by quantity at very low intensity, the other giving many of its chief results by intensity with scarcely any proportionate quantity, that it would be dangerous to deny too hastily the conduction proper to a few cases in static induction, where water is the conductor, whilst it is known to be essential to the many, only because, when water is the electrolyte employed, electrolytic conduction is essential to every case of electrolytic action.

Art. XL.—*On the Occurrence of numerous Fragments of Firwood in the Islands of the Arctic Archipelago; with Remarks on the Rock Specimens brought from that Region;* by Sir Roderick Impey Murchison, D.C.L., F.R.S., V.P.G.S., Director-General of the Geological Survey.*

On the present occasion I cannot attempt to offer any general, still less any detailed description of the rocks and fossils of the northwestern portion of that great Arctic Archipelago whose shores were first explored by Parry and Sabine. The specimens they brought home from Melville Island, and which were described by Mr. König, first conveyed to us the general knowledge of the existence there of fossiliferous limestones and other rocks analogous to known European types in Scandinavia. Since those early days, the voyages of Franklin, and of the various gallant officers who have been in search of our lamented friend, have amplified those views, and have shown us that over nearly the whole of the Arctic Archipelago these vast islands possess a structure similar to that of North America. We shall soon, I believe, be made acquainted with the characters of the specimens collected by the expedition under Sir Edward Belcher, who is preparing a description of the natural-history products of his survey. My chief object now is to call attention to the remarkable fact of the occurrence of considerable quantities of wood, capable

* From the Quarterly Journal of the Geological Society of London, vol. xi, p. 36.

of being used for fuel or other purposes, which exist in the interior, and on the high grounds of large islands in latitudes where the dwarf willow is now the only living shrub.

Before I allude to this phenomenon, as brought to my notice by Capt. M'Clure and Lieut. Pim, I would, however, briefly advert to a few rock specimens collected by the latter officer in Beechey Island, Bathurst Land, Eglinton Island, Melville Island, Prince Patrick's Island, and Banks's Land, where he joined Capt. M'Clure,—specimens which we ought to value highly, seeing that they were saved from loss under very trying circumstances.

From this collection, as well as from other sources to which I have had access, as derived from the voyages of Parry, Franklin, Back, Penny, Inglefield, and the recent work of Dr. T. Sutherland, I am led to believe that the oldest fossiliferous rock of the Arctic region is the upper Silurian, viz., a limestone identical in composition and organic contents with the well-known rocks of Wenlock, Dudley, and Gothland.

No clear evidence has been offered as to the existence of Devonian rocks, though we have heard of red and brownish sandstone, as observed in very many localities by various explorers, and which possibly may belong to that formation. Thus, in North Somerset, to the south of Barrow Straits, red sandstone is associated with the older limestone. Byam Martin Island was described by Parry as essentially composed of sandstone, with some granitic and feldspathic rocks; and, whilst the northeastern face of Banks's Land is sandstone, its northwestern cliffs consist (as made known by Capt. M'Clure) of limestone. But whilst in the fossils we have keys to the age of the Silurian rocks, we have as yet no adequate grounds whereon to form a rational conjecture as to the presence of the Old Red Sandstone, or Devonian group.

True Carboniferous *Producti* and *Spiriferi* have been brought home by Sir E. Belcher from Albert Land, north of Wellington Channel; and hence we may affirm positively, that the true Carboniferous rocks are also present. Here and there bituminous schist and coal are met with; the existence of the latter being marked at several points on the general chart published by the Admiralty. With palæozoic rocks are associated others of igneous origin and of crystalline and metamorphosed character. Thus, from Eglinton Island to the south of Prince Patrick's Island, first defined by the survey of Capt. Kellet and his officers, we see concretions of greenstone, associated with siliceous or quartzose rocks and coarse ferruginous grits; and in Princess Royal Island, besides the characteristic Silurian limestones, there are black basalts and red jaspers, as well as red rocks, less altered by heat, but showing a passage into jasper. Highly crystalline gypsum was also procured by Lieut. Pim from the northwestern shores of Melville Island. In the collection before us we see silicified stems of plants, which Lieut. Pim gathered on various points between Wellington Channel on the east and Banks's Land on the west. Similar silicified plants were also brought home by Capt. M'Clure from Banks's Land; and, through the kindness of Mr. Barrow, to whom they were presented, they are now exhibited, together with a collection made by Capt. Kellet, which he sent to Dr. J. E. Gray of the British Museum, who has obligingly lent them for comparison.

I had requested Dr. Hooker to examine all those specimens which passed through my hands, and I learn from him that he will prepare a description of them, as well as of a great number from the same region, which had been sent to his father, Sir W. Hooker, associated, like those now under consideration, with fragments of recent wood.

Of secondary formations no other evidence has been met with except some fossil bones of Saurians, brought home by Sir E. Belcher, from the smaller islands north of Wellington Channel; and of these fossils Sir Edward will give a description. Of the old Tertiary rocks, as characterized by their organic remains, no distinct traces have, as far as I am aware, been discovered; and hence we may infer that the ancient submarine sediments, having been elevated, remained during a very long period beyond the influence of depository action.

Let us now see how the other facts, brought to our notice by the gallant Arctic explorers who have recently returned to our country, bear upon the relations of land and water in this Arctic region during the quasi-modern period, when the present species of trees were in existence.

Capt. M'Clure states that in Banks's Land, in latitude 74° 48′, and thence extending along a range of hills varying from 350 to 500 feet above the sea, and from half a mile to upwards inland, he found great quantities of wood, some of which was rotten and decomposed, but much of it sufficiently fresh to be cut up and used as fuel. Whenever this wood was in a well-preserved state, it was either detected in gullies or ravines, or had probably been recently exhumed from the frozen soil or ice. In such cases, and particularly on the northern faces of the slopes where the sun never acts, wood might be preserved any length of time, inasmuch as Capt. M'Clure tells me he has eaten beef, which, though hung up in his cold larder for two years, was perfectly untainted.

The most remarkable of these specimens of well-preserved recent wood is the segment of a tree, which, by Capt. M'Clure's orders, was sawn from a trunk sticking out of a ravine, and which is now exhibited.* It measures 3 feet 6 inches in circumference.

* Through the kindness of Mr. John Barrow, to whom it had been given, this wood, with some silicified stems, has been presented to the Museum of Practical Geology.

Still more interesting is the cone of one of these fir-trees which he brought home, and which apparently belongs to an *Abies* resembling *A. alba*, a plant still living within the Arctic circle. One of Lieut. Pim's specimens of wood from Prince Patrick's Island is of the same character as that just mentioned, and in its microscopical characters much resembles *Pinus strobus*, the American Pine, according to Prof. Quekett, who refers another specimen, brought from Hecla and Gripper Bay, to the *Larch*.

In like manner Lieut. Pim detected similar fragments of wood two degrees farther to the north, in Prince Patrick's Land, and also in ravines of the interior of that island, where, as he informed me, a fragment was found like the tree described by M'Clure, sticking out of the soil on the side of a gully.

We learn, indeed, from Parry's 'Voyage,' that portions of a large fir-tree were found at some distance from the south shore of Melville Island, at about 30 feet above high-water mark, in latitude 74° 59′ and longitude 106°.* According to the testimony of Capt. M'Clure and Lieut. Pim, all the timber they saw resembled the present drift-wood so well known to Arctic explorers, being irregularly distributed, and in a fragmentary condition, as if it had been broken up and floated to its present positions by water. If such were the method by which the timber was distributed, geologists can readily account for its present position in the interior of the Arctic Islands. They infer that at the period of such distribution large portions of these tracts were beneath the waters, and that the trees and cones were drifted from the nearest lands on which they grew. A subsequent elevation, by which these islands assumed their present configuration, would really be in perfect harmony with those great changes of relative level which we know to have occurred in the British Isles, Germany, Scandinavia, and Russia since the great glacial period. The transportation of immense quantities of timber towards the North Pole, and its deposit on submarine rocks, is by no means so remarkable a phenomenon as the wide distribution of erratic blocks during the glacial epoch over Northern Germany, Central Russia, and large portions of our island when under water, followed by the rise of these vast masses into land. If we adopt this explanation, and look to the extreme cold of the Arctic region in the comparatively modern period during which this wood has been drifted or preserved, we can have no difficulty in accounting for the different states in which the timber is found. Those portions of it which happened to have been exposed to the alter-

* "Serjeant Martin of the Artillery and Capt. Sabine's servant brought down to the beach several pieces of a large fir-tree, which they found nearly buried in the sand at the distance of 300 or 400 yards from the present high-water mark, and not less than 30 feet above the level of the sea."—Parry's Voyage for the Discovery of the Northwest passage, p. 68.

nations of frost and thaw, and the influence of the sun, have necessarily become rotten; whilst all those fragments which remained enclosed in frozen mud or ice which have never been melted, would, when brought to light by the opening of ravines or other accidental causes, present just as fresh an appearance as the specimens now exhibited.

The only circumstance within my knowledge which militates against this view is one communicated to me by Capt. Sir Edward Belcher, who in lat. 75° 30′, long. 92° 15′, observed on the east side of Wellington Channel the trunk of a fir-tree standing vertically, and which, being cleared of the surrounding earth, &c., was found to extend its roots into what he supposed to be the soil.

If from this observation we should be led to imagine that all the innumerable fragments of timber found in these polar latitudes belonged to trees that grew upon the spot, and on the ground over which they are now distributed, we should be driven to adopt the anomalous hypothesis, that, notwithstanding physical relations of land and water similar to those which now prevail (*i. e.* of great masses of land high above the sea), trees of large size grew on such *terra firma* within a few degrees of the North Pole!—a supposition which I consider to be wholly incompatible with the data in our possession, and at variance with the laws of isothermal lines.

If, however, we adopt the theory of a former submarine drift,* followed by a subsequent elevation of the sea-bottom, as easily accounting for all the phenomena, we may explain the curious case brought to our notice by Sir Edward Belcher, by supposing that the tree he uncovered had been floated away with its roots downwards, accompanied by attached and entangled mud and stones, and lodged in a bay, like certain "snags" of the great American rivers. Under this view, the case referred to must be considered as a mere exception, whilst the general inference we naturally draw is, that the vast quantities of broken recent timber, as observed by numerous Arctic explorers, were drifted to their present position when the islands of the Arctic Archipelago were submerged. This inference is indeed supported by the unanswerable evidence of the submarine associates of the timber: for, from the summit of Coxcomb Range in Banks's Land, and at a height of 500 feet above the sea, Capt. M'Clure brought home a fine large specimen of *Cyprina Islandica*, which is undistinguishable from the species so common in the glacial drift of the

* Dr. Hooker informs me that all the specimens sent to him were collected in mounds of silt, rising up from the level of the sea to 100 feet or more above it; and he entirely coincides with me in the belief that the whole of this timber was drifted to the spots where it now lies.

Clyde;* whilst Capt. Sir E. Belcher found the remains of whales on lands of considerable altitude in lat. 78° north.

Reasoning from such facts, all geologists are agreed in considering the shingle, mud, gravel, and beaches in which animals of the Arctic region are imbedded in many parts of Northern Europe, as decisive proofs of a period when a glacial sea covered large portions of such lands; and the only distinction between such deposits in Britain and those which were formed in the Arctic Circle is, that the wood which was transported to the latter has been preserved in its ligneous state for thousands of years, through the excessive cold of the region.

P. S.—Since the above was written, Capt. Collinson transmitted to me an instructive collection of rock-specimens, collected during his survey. Most of them show the great prevalence of crystalline rocks along the north coast of America.

Art. XLI.—*On Serpentine Rock;* by Aug. A. Hayes, M.D., Assayer to the State of Massachusetts.

Having been engaged in testing the resisting power of a beautiful variegated serpentine, proposed as the material for a base of the monument in memory of Benj. Franklin, to be erected in this city, I have been led into a somewhat extended research, on the chemical composition of serpentine, from well known localities. 1st, Serpentine from Roxbury, Vermont. The quarries in this township, are in the immediate vicinity of the line of the Central Rail Road,† at a higher level, permitting advantageous working. Rough from the quarry the rock presents a mixture of tints from dark blackish green to snow white, often finely blended, though not generally shaded. Mere physical examination shows a variety of included minerals, such as talc in scales, compact and fibrous asbestus, dark green chloritic rock, and talcose and argillaceous slates with chromic iron. These minerals make the largest part of the mass and being generally angular, though sometimes rounded, their contact lines are variously modified. Uniting these into a remarkably compact mass, is a white, or white colored mineral, which constitutes a true cement.

This rock has received the name of Verd-antique Marble, a name not only incorrect, but conveying a false conception of its

* In Parry's 'Voyages' (page 61) we learn that a number of marine shells, of the *Venus* tribe, were found imbedded in the ravines of Byam Martin's Island; a fact which strengthens the view here adopted of the submergence of large portions of these tracts at a very recent geological epoch.

† These quarries are in a belt of magnesian aggregates, which extend within the State from New Fane northerly to Troy, and may be a continuation of the Massachusetts belt. Specimens from New Fane, Proctorsville, Roxbury, Kellyvale and Troy, are found in most mineralogical collections.

composition chemically, and of its value in a technical sense especially as regards its durability. It receives a high polish and its surface then exhibits a beautiful contrast of dark green and white colors, in forms of clouds and mottling in a manner pleasing to the eye, while the asbestus and other included minerals, have a play of lights equalling that of some gems.

The enduring character of the rock places it in the class of granites and syenites and fits it for external use, as well as for internal decoration and various purposes in the arts.

Through the kindness of Dr. T. Brewer I added to my collection of samples of the rock, some nearly pure pieces of the white portions, and the analytical results which are here detailed may be taken as representing in a general manner, the composition of the varieties hitherto quarried. Before these analyses were made, the composition of this rock, had been stated to be

Silica,	42·6
Magnesia,	35·5
Protoxyd of iron and Chromium,	8·3
Carbonate of Lime,	0·6
Water,	13·
	100.

The proximate method was adopted in this as well as similar cases by myself, and I may here remark, that the success of its application has been so great, that little doubt exists of its taking the place of other methods, in the study of the more truly simple minerals—as well as aggregates.

I. Analysis. That part which is purely white in color, can be separated from the general mass, in the form of milk-white fragments, translucent, crystalline; the cleavage planes reflecting a high lustre. In hardness exceeds any variety of calc spar; it scratches the harder dolomites. The powdered mineral loses some humidity at 212° F.; at 450° the whole loss is 0·08 per cent.

100 parts of the dried powder, consist of

Carbonic acid,	48·80
Magnesia,	45·60
Talc and trace of Silicic acid,	3·60
Silicate protox. iron,	1·96
	99·96

proving it to be an *anhydrous carbonate of magnesia.* In diluted acids it hardly effervesces until heat is applied, and then exhibits an astonishing power of resistance to solution at the temperature of ebullition. The powder exposed to heat, requires long calcination at bright redness for the expulsion of its carbonic acid, rendering its estimation difficult. This character may have caused an error in previous analyses of serpentine, and led to the conclusion that a hydrate of magnesia forms a part of the composition of all such rocks.

II. The following results embrace the averages on compact, nearly white portions:

Moisture,	0·08
Water from hydrated minerals,	0·98
Carbonic acid,	47·16
Magnesia,	44·24
Talc laminæ and trace of Silicic acid,	5·20
Silicate of alumina,	0·64
Protoxyd of iron from Sil. iron with manganese,	1·53
	99 83

showing the influence of a small admixture of the included minerals.

III. In the following results, the average of the whole rock as quarried is given, the dark greenish black, light green, and white colors, intermixed—

100 parts divide into

Moisture,	0·40
Carbonate of magnesia,	38·00
Included minerals,	61·60
	100·

61·60 of the various minerals forming the base of the compound rock, consisted of—

Combined water,	6·44
Silicic acid,	36·92
Magnesia,	10·52
Protoxyd manganese and proto-peroxyd of iron,	4·80
Alumina,	2·06
Chrome iron,	0·63
	61·37

The basis rock, thus proved to be the hydrated ingredient, is an indefinite mixture of so-called serpentine. It is however easily resolved into greenish-white talc, asbestus in various forms, rarely actinolite, ordinary slate as silicate of alumina and iron, constituting an aggregate. But the most remarkable fact is, the entire absence of the compounds of lime.

In view of this chemical composition and its physical characters, I propose that this rock quarried for ornamental purposes, be hereafter called serpentine marble.

Some early analyses of mine had shown the presence of carbonate of magnesia in the serpentines of Troy and Mt. Holly in Vermont, which also are aggregates of magnesian rocks, with some argillite. To represent more accurately the relations of these so well known serpentines, I next chose as the subject of analytical trials the rock occurring in the township of Cavendish, village of Proctorsville, Vt. This mineral has been described as a serpentine, and its physical characters generally, entitle it to be so considered. It is traversed by thin white veins producing a variety in its otherwise deep green color. The averages of a number of samples are included in the following determinations.

IV. 100 parts of the Proctorsville serpentine afforded—

Moisture,	0·40
Carbonic acid,	17·05
Magnesia,	16·00
	33·45

as the cementing material, leaving 66·55 as basis rock, composed of—

Combined water,	6·21
Silicic acid,	36·10
Magnesia,	18·70
Proto-perox. iron and manganese,	3·40
Alumina,	1·13
Chrome iron,	·92
	99·91

V. 100 parts afforded—

Water,	5·60
Carbonate of magnesia,	26·40
Basis rock,	68·00
	100·00

A number of similar determinations were made on the rock obviously composed of talc and compact asbestus, cemented by a small proportion of carbonate of magnesia, in an anhydrous state.

The serpentine of New Fane also afforded carbonate of magnesia, in variable proportions, whilst the so-called serpentine of Lynnfield was long since proved to be in part carbonate of magnesia, cementing a rocky base including argillite.

Several European specimens, from unknown localities, were found to consist of associated magnesian minerals, cemented by anhydrous carbonate of magnesia. As a general expression, asbestus is the most abundant simple mineral and it presents itself under forms, in which it is recognised with difficulty; talc is also largely intermixed, in the basis rock. The coloring material of serpentine is found in several minerals and although here included as a silicate of the proto-peroxyd of iron, I have deemed it worthy of a particular examination, at a future time.

16 Boylston st., Boston, 26th March, 1856.

Art. XLII.—*An account of an Indicator Stage for Microscopes;* by A. S. Johnson, Albany, N. Y.

In October last Messrs. Grunow of New Haven completed for me and adapted to my microscope a moveable stage, upon the principles stated by Prof. Bailey in his article upon the Universal Indicator. Carrying out his suggestions, they have succeeded in overcoming the difficulties which were pointed out as likely to attend attempts to apply the indicator to moveable stages. The indicator stage combines all the convenience of the best moveable stages, with all the advantages to its possessor of the universal indicator. By means of it all parts of a slide can be rapidly brought by equal sweeps under examination and the noteworthy objects registered. The registration is identical with that obtained by the universal indicator.

The stage is composed, as is usual, of three plates of which the lower is fixed. Upon it the other two move $1\frac{3}{5}$th inches from side to side; the top plate moves forward and back $1\frac{1}{5}$th inches upon the middle plate. The motions are effected by racks and pinions, the milled heads of which are under the stage. In the bottom plate are inlaid two scales graduated in 50ths of an inch, which extend from the middle of the side edges towards the centre of the stage. That on the left is graduated from 0 to 50; that on the right from 60 to 110. In the middle plate are two similar scales, extending from the middle of the front and rear edges of the plate towards its centre. The front scale is graduated from 20 to 50, the other from 50 to 80. Over each scale projects a steel index attached to the plate above, to facilitate accurate reading of the scales. Upon the top plate is engraved a horizontal line passing across the stage, intercepted of course by the hole in the centre, but so drawn that continued across the hole it bisects horizontally the field of view. At right angles to this line two others are engraved each crossing it on opposite sides of the centre at the distance of one inch from the centre of the field of view, which is also the centre of the stage.

The position of the several scales is adjusted with reference to these lines as follows. When the horizontal line, continued across the hole in the stage, bisects the field of view, the indexes attached to the front and rear edges of the top plate stand at 50 on the two scales of the middle plate. As upon the universal indicator the horizontal line at 50 also passes through the centre of the field of view, it is obvious that the positions of that line and of the horizontal line on the stage are identical.

The verticals being each an inch distant from the centre of the field of view at their intersection with the horizontal line, and one inch being also the distance on the universal indicator from its centre to the points 40 and 70 in its horizontal line, the right hand index is made to stand at 70 on the right scale and the left hand index at 40 on the left scale. When the stage is set at 70 and a slide placed on the stage with its right vertical in coincidence with the right vertical on the stage, its position will be the same as if the slide were placed upon the universal indicator, with the right vertical at 70 of its horizontal graduation. It is hardly necessary to add that a motion of the stage carrying the slide is exactly equivalent to a motion in the same direction and of the same extent of the slide alone upon the universal indicator.

The top plate of the stage is furnished with a slide holder moving in grooves, by means of which a slide may be easily adjusted so that its horizontal guide line shall coincide with the horizontal line on the stage. This adjustment having been made, its right or left vertical is to be made to coincide with the corresponding vertical on the stage. The right verticals are to be used for numbers of the horizontal graduation from 60 to 110, and the left for those from 0 to 50.

In case of an object already registered, all that remains to be done is to move the stage by the milled heads of the pinions till the indexes stand at the registered numbers, and the object will at once be found. In case of a slide not registered when an object is found which it is desired to record, a glance at the indexes will give the proper numbers to be recorded.

It will be noticed that the vertical graduations extend only from 80 to 20. This being equal to $1\frac{1}{5}$th inches, affords ample room for all ordinary slides not covered with paper. But as some slides are still so covered, provision has been made for them. On the stage parallel to the horizontal line two others are engraved each $\frac{2}{5}$ths of an inch distant from the first. This distance being exactly equal to 20 divisions on the scales, in order to find an object registered by the universal indicator from the front edge of the slide, the same edge must be brought to the front line and the stage be set at 20 more than the registered number. If on the other hand the registration has been made by the lower edge, the rear line must be used and the stage set at 20 less than the registered number. In registering objects on such slides by the indicator stage, the registration ought always to be made as the numbers would appear on the universal indicator. To effect this it is only necessary, if the front line be used, to deduct 20 from the number indicated, if the rear line to add 20.

The manipulation with this stage is by no means complicated. With the stage before you, it can be mastered in ten minutes, and when once mastered its convenience and value are great. Registered objects can be found and new ones registered with great rapidity. To illustrate the great saving of time which it effects, I may say, that in less than four minutes, I put upon the stage and adjusted a slide and then found and brought to the centre of the field of a ½-inch object-glass ten recorded objects, for each of which both sets of numbers were different. It is true that I made haste, but I know no other method by which it could have been done in twice the time. One minute may then be reckoned as the maximum time requisite to find any recorded object. How great a gain this is, every one will feel, whose time and patience have both been many times exhausted in searching to rediscover some minute object, before the indicator was invented.

Art. XLIII.—*On the Earthquake of April* 2, 1851, *in Chile;* by Lieut. J. M. Gilliss, A.M., U. S. N.*

For several days previous to April 2nd, the sky had been unusually overcast, the barometer fluctuating as it does during winter rain-storms. Not far from 9 o'clock, on the the night of the 1st, there was a vivid, quick flash of lightning to the NNE, so intense in brightness as to illuminate within the observatory, where I had been at work some hours. I was startled by the sudden brilliancy, and listened for close-following thunder, but no sound came; neither was the flash repeated, nor was there the smallest speck of cloud even about the horizon in that direction.† Coming down the hill, about midnight, my left eye was found to be injured by over-exertion; and the pain which soon followed brought on nervous restlessness that kept me awake several hours. Sleep, long courted, came so profoundly at last, that when nature, in wrath, was shaking the city on its foundations, and a startled population fled with cries of terror, though roused by the incipient shock, nearly half its violence had passed before full consciousness returned. Habit brought me instantly to the floor, watch in hand, and in such a position that I could embrace, at a glance, the roofs across the street, a little mirror directly in front, and the wash-stand diagonally to the right. But reason was torpid. Though there was a consciousness of excessive oscillation of the floor, and most infernal subterranean roarings; a recognition that the pictures of the paper on the opposite wall were waving from side to side across the mirror; a conviction

* From the Report of the U. S. Naval Astronomical Expedition to Chile, by Lieut. Gilliss, vol. i, p. 108.

† Many of the most intelligent persons in Chile regard earthquakes as due wholly to electrical agency; and as we have no right to reject popular belief until every phase of the phenomenon is satisfactorily explicable without such influence, it is proper that the occurrence of such remarkable lightning—so short a time before the shock, and in the direction from which it came—should not be omitted. For the same reason Humboldt mentions (*Rélation Historique,* Liv. IV, Chap. 10) "two strong shocks simultaneously with a clap of thunder."

that the roofs and tiles of the houses in front were "dancing like mad;" and knowledge that the affrighted people were invoking the mercy of their God in the utmost distress, and the rattle of windows and doors was making no small addition to the uproar, still several seconds must have elapsed before I could realize the actual magnitude of the storm agitating the crust of our abiding-place. Nevertheless, experience having taught that the phenomenon is of little continuance, there was sufficient rationality to prevent my leaving the room; and I stood with senses gradually returning, thinking each vibration would be the last. But I watched and watched the dial of the monitor in my hand, and, instead of subsiding, there came accessions to the force of the moving power with each beat of its balance-wheel, till the walls on either side were swaying to and fro, the plank ceiling screeching overhead, and finally the doors flew open, exhibiting the opposite room filled with a cloud of dust, and its floor covered with broken adobes, which had fallen between the ceiling and walls. Half a minute had now elapsed, each second of which seemed at least a day; and in the fiercest violence, as the creaking of the ceiling was too ominous to disregard longer, I found myself creeping for shelter beneath the lintel of the door. Of a sudden the wall swayed away from the roof, showing the blue sky above, and a mass of rubbish fell, blinding and almost stifling me; so that it became necessary to take refuge under the lintel of the outside door, where fresh air might be obtained. As the tiles were falling in a shower from the roofs, escape to the patio was more hazardous than to remain under the doorway; for one had better risk being partially buried than have his head split with one of these heavy pieces of earthenware.

The motion had now become fearful, and the roar of the pent up vapor, as it moved heavily along, most awful; yet every little while there would reach me the clear ringing laugh of one of the assistants—inspired by the efforts of a companion to attain a place of greater apparent safety—marked contrasts of expressed human sensations in this terrestrial convulsion. I was not conscious of fear at any instant, nor was it possible to make the mind realize that the house might fall, although the walls were breaking all round, and at every few seconds the sky was visible through their crevices; but there was a sensation of dread—a feeling of absolute insignificance in the presence of a power that shook the Andes as willows in the breeze. I was humbled to the dust. Afterwards I learned, that among the mass in the streets there was but one thought, one desire—*flight.* But where fly to? The massive stone arches of the sanctuary had been broken, their key-stones had partially fallen, and the priests had been driven from the altars by masses of masonry precipitated around them; the hills were shaking huge rocks from crests where they had slumbered since the dawn of nature, their trains marked by streams of fire; in the streets tiles were falling in showers mid clouds of dust; and on the open plain, in addition to that most unearthly and distressing noise and the moaning of cattle in their brute terror, the trees were waving from side to side under the influence of that same unseen but omnipotent agent.

Preceded some seconds by the usual rumbling noise, the first shock commenced at $6^h\ 48^m\ 10^s$ A. M., and for eighteen seconds continued with nearly uniform violence, equal to, and in the kind of motion not altogether unlike, that of December 6th. This started the tiles and walls, though it broke nothing, a fact which may perhaps be accounted for by the greater rapidity with which the atoms at the surface of the earth were disturbed on the last occasion; for, if one may judge from bodily sensations, the shaking was certainly as great as in December, though the effects were much less. The most excessive displacements were between $6^h\ 48^m\ 28^s$ and $6^h\ 48^m\ 53^s$; and at $6^h\ 49^m\ 38^s$ terminated an earthquake unparalleled in central Chile since 1822. Less than one minute and a half: a brief period of one's life when marked only by events of ordinary occurrence—but an age when one stands on a world convulsed. Beginning at $6^h\ 48^m\ 28^s$, the oscillations, then quite distinct, rapid, and abrupt, were of such magnitude that one involuntarily sought support; and though this actually lasted only twenty-five seconds, the time seemed endless, when measured by the multitude of thoughts crowded into it. Liquids were tossed to the north and south; and at the end, the surface of the mercury in a cup with vertical sides was left 1·4 inch below the rim. A barometer suspended on a north and south wall was thrown down, and all objects not summarily shaken off were moved by successive jolts to the north or south; generally in the latter direction. Every wall in the house was broken, some of them so that day-light shone through; others were thrown permanently out of the vertical, and scarcely a tile remained in place on the roof. Our pendulum was still gyrating when we could venture into the room where it was kept. Unfortunately the board supporting

the glass for the register had not been secured to the ground, and was transferred during the severe agitations nine-tenths of an inch W by N, as well as thrown out of the horizontal plane. Thus it gave broken instead of closed curves precisely as represented here, which are traced from the original sheet.

But the direction of the moving power admitted of no doubt, the point of the pendulum having passed along a line very nearly S by W, and then described nearly elliptic curves, the major axis of one of which probably exceeded four inches. Observations of this character would be of high interest, could they be obtained in numbers; but local causes, as the geological formation, orology, &c., influence both direction and apparent violence to such extent that isolated observations are of little absolute value.

We suffered on Santa Lucia too. Whilst we were dressing our servant had been despatched immediately that the great shock ceased, to learn the condition of the instruments. Following a few minutes later, the rocky mass was found broken across from east to west between the observatories and castle, and a crevice remained, which, at the surface, was nearly an inch wide. A glance showed the instruments uninjured, but one of the piers supporting the meridian circle (the western) had been greatly disturbed. These piers are composed of three blocks each, forming massive obelisks six and a half feet high above the floor, and two feet square at the base, secured to each other and to the base of porphyry *in situ* with hydraulic cement. The joint nearest the floor of the west pier was opened; the blocks, no doubt, rocked, and the whole pier was shifted to the south, until it formed an angle of 5′ with the eastern pier. Our clock had not been stopped, or rather we found the pendulum oscillating; but observations proved that it had been retarded eleven and a half seconds! Every other pendulum clock in Santiago had come to a stand.

The streets were filled with an excited and still greatly alarmed multitude, wandering from place to place in examination of the ruins of walls and turrets, and the masses of tiles and rubbish that occupied a portion of every thoroughfare.

Where the tiles had not fallen, the roofs looked as though ploughs had upturned them; and men were at work in all directions pulling down the tottering ones. With every brief interval a new shock came, and one can scarcely conceive the terror and consternation with which many rushed from their doors at these times, or the despondent anxiety settled on the countenances of all. The injury throughout the city was very severe, and the loss of walls, roofs, glass, and furniture, extensive. On the Plaza the cathedral suffered most seriously; all its arches north and south were sprung, and the key-stones settled an inch or two; the tie-beams securing the outer and longitudinal arches in the same direction were drawn almost out of the walls, and masonry had fallen in piles. It was found necessary to close it forthwith. The central dome of the old palace and its western parapets were so broken that they were immediately pulled down to prevent further injury. Examination of these fractures showed that bricks had given way in many cases when mortar would not; and adobe walls had more tenacity than burned bricks, yielding to the flexure of the foundation without entire prostration. In every instance where objects could fall freely, they had gone off to the northward; though if not precipitated at the first shock, they generally jolted in the opposite direction. East and west of the line of motion through the Plaza, much less damage was done, a fact also peculiar in the December earthquake.

The loss of life was small. Three persons only were ascertained to have been killed, and some thirty or more wounded. Of the fatal cases—all women—two deaths had been caused by the fall of the cornice in the church of San Francisco, as the congregation rushed out; and the third was a poor girl who proved a victim to a custom of the country. In conformity with this custom, she could not be left alone, in an open house, whilst her mother attended early mass, and had been locked in the second story. When the earthquake came, she leaped in terror from the balcony, and the mother returned to find her a corpse.

There was a striking peculiarity about the great shock. Like a tense chord rudely struck, its vibration was perceptible for two hours without intermission; and its subsidence was so gradual as to leave one almost in doubt when it actually ceased. In addition to this, a somewhat similar vibration from 6^{h} 30^{m} to 8^{h} 30^{m} P. M., and a multitude of "slight tremors," we have the recorded times of eighteen sharp earthquakes before midnight. Two of the last, following at an interval of two seconds, appeared the effect of sudden and distinct explosions, without noise or tremor, unlike every motion we had felt, and Lieut. MacRae, in his surprise, writes them down "two distinct and sharp thumps underneath." The first of these occurred at 7^{h} 33^{m} 36^{s}, the other just two seconds later. The most severe subsequent shock during the day was at 11^{h} 34^{m} 36^{s}, which lasted seven seconds. By this time most of the populace had lost something of their apprehensions, and, having the magnitude of their sins brought thus pressingly to mind, had again flocked to the churches in numbers. As this was the season of lent, when the churchman expects to accomplish so much by compliance with prescribed ordinances, it is not difficult to believe that many would be reminded of their short-comings at mass, vespers, and confession, by such visitants as the morning had brought us. But there were few whose faith in the altar persuaded them to abide at its feet during the shock—none willing to return for the completion of devotions when the shock had passed; and the streets were again filled at a most unusual hour.

Most deplorable intelligence was soon brought from the neighboring villages and *haciendas.* Lampa and Renca, lying to the northwest, were reported in ruins; their inhabitants in the streets, and the dwelling-houses and dividing walls of adobes on the estates lamentably destroyed. By night there were travellers from Curacavi, a town of 5,000 people on the Valparaiso road, and beyond the first range of mountains. Among them was Mr. Campbell, the engineer of the Copiapó and Caldera railroad, who had passed through it about two hours after the earthquake. In many parts of the town of Curacavi he saw numbers of houses whose roofs had fallen in; and scarcely one remained which could be regarded safe so long as the agitation continued. At the first great shock a portion of the church steeple had been flung to NNE; other portions fell by degrees, crushing the roof and wholly destroying the building; but these latter had been prostrated in every direction. At one of the inns the earth had opened in a nearly east and west line, entirely across the court-yard; and the water of its well was rendered turbid for several hours. The same thing occurred with a number of the wells at Valparaiso. At Casablanca—still farther west—the destruction was even greater, no walls having escaped unbroken, no matter what their direction; indeed it was said, that the only safe house remaining was the inn. This was, undoubtedly, exaggeration, fright in the first hours having driven many to arbors and tents, which they were willing enough to abandon after a day or two. There were accounts, too, that the earth had opened in a great many places near the line of the road, particularly some three or four leagues west of Santiago, and also that water had been seen to issue from the crevices in considerable quantities; but subsequent investigation brought to light only one person, to the westward, who had actually seen water ejected, and this was near Viña la Mar, close to the sea-shore. It was also well attested, that the high bank of the Angostura (a little stream emptying into the Maypu) had opened, and a black and slimy substance oozed out. Unfortunately, when searched for some five days afterwards, a heavy rain had intervened and obliterated all traces.

As no intelligence from Valparaiso reached us before the arrival of the mail, next morning, the omen was regarded as most favorable. Yet it did not prevent the assembling of an immense crowd about the post-office at the hour when the letters were expected, and anxious impatience could only be gratified by one of the clerks reading aloud from the first paper obtained. This stated, that all the walls of houses in the Almendral had been shaken to their bases; many roofs wholly destroyed; the tiles of others flung into the streets; full five hundred houses were uninhabitable, and more than that number of people without any shelter whatever; and in short the residents remembered no such earthquake since 1822. Even those whose houses had not been seriously injured in many cases took refuge on board ships; others fled to the hills, and others again erected tents and wooden shanties in the plazas. The hotels, principally occupied by strangers, were deserted at once, the occupants taking to the water forthwith. It was especially remarkable, at Valparaiso, that the houses built on the sandy foundation of the Almendral were far more injured than those on the narrow rocky ledge of the port. Though the injuries had been greatest to those whose walls stood in a NE and SW line, no direction had proved a safeguard; and, as at Casablanca, every one in the Almendral had been broken.

Judging by a line in which a cross was thrown from the steeple of La Matriz church, and the place at which part of a marble fountain in the Plaza Victoria was left, the direction of the earth-wave must have been from NE-by-N to SW-by-S, the cross having been thrown nearly twenty feet from the body of the edifice in the former direction, and the vase of the fountain jolted on its pedestal two inches towards the latter point.* No lives were lost, nor were any serious wounds received, the hour of the day and long interval of warning having given people a chance to escape to the streets and patios. The family of one friend in the Almendral had been in agonizing tribulation. At the first tremor, the door of their chamber was permanently secured by the sinking of the ceiling; and they found themselves wholly unable to escape to the rescue of their children, occupying an apartment on the opposite side of the patio. Cries from the nurse told them that the door of her room was similarly beyond her power to force; and the thought passed through their minds that they would be buried without again embracing their children. But a moment after, the iron railings barring all the windows fell with a crash from the nursery, and the mother had the intense joy to hear the woman escape with her treasures. Then her husband and self lay down, not ready perhaps—and certainly not willing—but expecting and resigned to die, now that their children were safe.

Of eighteen shocks recorded at Santiago before midnight of the 2nd, some occurred whilst the assistants were at work on Santa Lucia, and of these they distinctly recognised the warning noise to the NE, in one instance, full fifteen seconds before the earth under foot was in motion. Most of them were slight: some lasted only a second or two; others continued nearly a quarter of a minute; and others again were followed at very brief intervals, as one or two seconds, by other tremors. Some

* Personally verified.

were preceded and accompanied by a rumbling noise, others were wholly in silence, and there was more than one instance of noise without the least perceptible disturbance.

On the following day I started for the purpose of examining the line of destruction in a southerly direction, and soon found that the effects diminished as the plain widened. Even at the Maypu, sixteen miles south of the city, had not attention been previously occupied, one would not specially have noticed crevices in the walls. Though the toll-receiver assured me he had seen large masses of earth thrown down from the vertical banks, on the south side of the stream, its bridge, with high abutments and supporting piers, was wholly uninjured. No crevices could be found in the banks near the bridge.

On a line west of the latter, where the Maypu passes through the Central Cordilleras, the latter make a sudden bend eastward; and the Andes—at a nearly opposite point—curving to the westward, the two chains closely approach each other at a pass twenty miles south of the stream, called the Estero de Payne. Indeed, the two chains of mountains, here about two thousand feet above the plain, are separated by a gorge of the same level as the plain, whose average width is not more than one hundred yards. Thus from the Cuesta de Chacabuco to the Angostura, except where the Maypu passes through the central range, there is a continuous though irregular elliptic plain, whose diameters will not vary greatly from fifty-five and twenty-five miles. The widest part of the basin or plain is where the Maypu crosses it in latitude 33° 42′, and here the high road to the south seemed to be near the eastern line of injurious disturbance. Subsequently, we learned by a traveller from Mendoza that a very slight though long tremor had been felt at 7^{h} 10^{m}, in that city, on the morning of the 2nd.

Proceeding toward the Angostura, from the Maypu, every quarter of a mile exhibited increase in the extent of injury done; and within a league of it, the destruction was excessive. Not only had houses, walls, and division lines been more completely destroyed than about the capital, but losses had been more universal. Neither dimension nor material of wall had saved it; those of adobe, thirty inches thick and extending round two sides of a parallelogram one hundred and twenty-five feet each way, were perhaps broken rather more frequently than short partitions, though not so much so as masonry. In one case the back wall of an old store-house was lifted bodily to the north and set down two inches from its former foundation; whilst a short piece at right angles to it, forming a sort of abutment to its eastern end, was shaken down piecemeal. The wall stood nearly east and west, was of adobes eighteen inches thick, some eighty feet long and nine feet high. Nothing but the roof, itself partially sustained by the stakes of an outer corridor, prevented the whole from going over. In the parlors to the mansion of this *hacienda,* things were thrown in all directions: lamps, chairs, books, fell in every possible line, almost inducing belief that the increasing resistance offered to the onward movement of the explosive agent by the rapidly approaching mountains, had converted rectilineal into gyratory motion. These objects fell in the several directions at different periods.

At the time of the shock, the proprietor was in the fields giving orders for the work of the day. Turning at the first rumble that reached his ear in the direction of the mansion, where his wife and children were, he put spurs to his horse, which had not yet become frightened. But an instant after, the poor brute suddenly stopped and spread out its feet, giving expression to the utmost terror by deep-breathed snorts and starting eyes, nor could any punishment make it move until the phenomenon had ceased. Apart from thoughts of his loved ones, this was a trying interval to my friend. Alone, and all nature convulsed! The earth heaved and trembled till foot-hold was not secure, its profoundly vaulted caverns pealing thunders stunning to the ears; the atmosphere was serene and balmy without a stirring breath, yet trees around were waving and bending half way to the very soil as in a storm; flocks of birds in rapid flight screamed their sympathy; and herds of cattle came tearing down the mountain sides, pursued by great boulders of granite, mid clouds of dust and sparks of fire.

Along the line of the road beyond the Angostura, there were scarcely any visible effects; and although the inhabitants of Rancagua say that the shock was extremely severe, there were only a few small crevices in the higher walls. If not exhausted to the northward of the gorge, the strength of the earth-storm had evidently passed to the westward of it, a supposition to which neither examination nor inquiry lent their support. The mountains *had* arrested the progress of the great earth-wave, and the re-action of its generating power was plainly exhibited on the alluvial strata of the deep terrestrial bay.

Travellers from as far south as Talca stated that the shock had been quite moderate at that city, and none had given it a thought beyond the Cachapual, except for its unusual length. Nearly all of them, however, as did those north of the Angostura, believed that its origin had been to the southward. Whilst at Rancagua, a violent rain-storm commenced on the morning of the 5th, preceded by excessive thunder and lightning. This was a widely extended storm, reaching from latitude 33° to latitude 40°.

As nothing further was to be gained in a southerly direction, I returned to Santiago, and two days afterwards crossed the axis of the earth-wave in the direction of Valparaiso, though without obtaining many new facts to relate. The disturbance had certainly been greater at Curacavi and Casablanca than at the capital and port, much property having been so injured that it was necessary to tear it down. Repairs were out of the question, for the walls were no longer stable. One crack in the earth, west of Casablanca, at the surface, was still nearly three inches wide, and about two hundred yards long. Its general direction was WNW and ESE. The same fact was observed on the Almendral as had been remarked near the Angostura; objects were thrown from tables and shelves in every imaginable direction, as though each vibration was from a different quarter. No special agitation was observed at the surface of the sea, nor did any great wave follow to wash away prostrate buildings, of which some forty were level with the ground. One of the papers stated that a lead line thrown overboard at the time from the U. S. frigate Raritan, was so buried in the sand that it could only be extracted with great difficulty; but this, like many of the wonderful stories told of earthquakes, should probably be received "*cum grano salis;*" else we must conclude that the ships, being unable to heave them up, probably left their anchors in the bay when about to sail. There was no indication whatever that the shores of the bay had been raised either by the great shock or the multitude of smaller ones continuing throughout the succeeding fortnight. I examined the rocky shores closely during several tides, but could find no unprotected memento.

Mr. R. Budge, F.R.G.S., considers* the motion to have been westward, because water in basins, jugs, &c., spilt over the east side; clocks whose pendulums vibrated east and west stopped, while those beating north and south did not; walls standing east and west were cracked in every way—particularly lengthways, and vessels at sea felt it at an hour corresponding to the difference of longitude. He supposes the phenomenon to have been subject to instantaneous cessations, and says that it turned round things on their base instead of throwing them down at an angle of 20°, showing a circular motion for at least an instant. I shall have something to say presently respecting the two vessels which felt the shock at sea. He goes on to remark: "I have experienced at this place (Valparaiso) three ruinous earthquakes—that of 1822, which I passed in the house until the back fell, that of 1829, and the present. On the last occasion the barometer and thermometer indicated nothing, nor was there the least warning of any description; but, as invariably occurs after a heavy shock, we had, on the third day after, a shower of twelve hours' rain, for which I had already prepared, aware of its being the consequence, happen whatever season it may. I conceive also that I have felt less relaxed than before it. I cannot understand all

* Report of British Association, 1851.

these things, unless electricity be the agent; while the atmosphere must be affected in some way to shower down rain at seasons when, under ordinary circumstances, it does not fall. * * * On that occasion (1822) the sea in the bay of Valparaiso retired considerably, and was several days in reaching its former level; while on this, no such thing was observed."

Only two vessels bound to Valparaiso felt the shock. One was forty miles to the southwest of the port, and the other a like distance to the northwest, and therefore they were some fifty-seven miles apart. Until he learned, after anchoring, that an earthquake had occurred on the morning of the 2nd, the master of the former was fully persuaded he had passed over a reef of rocks; the other felt no shock whatever, though at the time designated the crew had heard explosions like distant discharges of heavy artillery. San Antonio, near the mouth of the Maule, and Talcahuano, both experienced a tremor; Melipilla, between San Antonio and the capital, felt it severely. There was a violent shake at Quillota, also, and San Felipe de Aconcagua suffered some injury. Even the Copiapó papers mention a "*temblor*" on the morning of the 2nd; but nothing special was remarked, and it passed as one of those occurring almost daily.

Efforts to obtain reliable data for determining the velocity of earth-waves meet with little encouragement among those with whom "*mañana*" (to-morrow) is proverbial, and who have not yet learned that a few minutes are worthy of appreciation. Moreover, people generally are too much alarmed when the shock comes. Eternity occupies more of their thoughts than time; and had they self-possession to record the instants, probably no two time-keepers in the city agree within several minutes. Of the great shock one Talca paper says, "this morning a quarter before seven;" the other, "at twenty minutes past six in the morning." Even in Valparaiso, where government has placed a clock visible to nearly all the town, the papers differ two minutes, though the custom-house clock was stopped by the shock at $6^h\ 42^m$. But here are the Santiago mean times at which the greatest shock was felt at each place, with its bearing and distance from the capitol.

Name of city.	Time.	From Santiago.	Distance.
	h. m. s	°	*Miles.*
Talca, ...	6 25 00 6 45 00	S. 21 W.	112
Santiago, ...	6 48 40·5		
Valparaiso, ...	6 44 55·5 6 45 55·5	N. 67 W.	64
Quillota, ...	6 48 49·5	N. 62 W.	64½
San Félipe, ...	6 44 12	N. 16 W.	45
Mendoza, ...	7 03 18	N. 73 E.	105

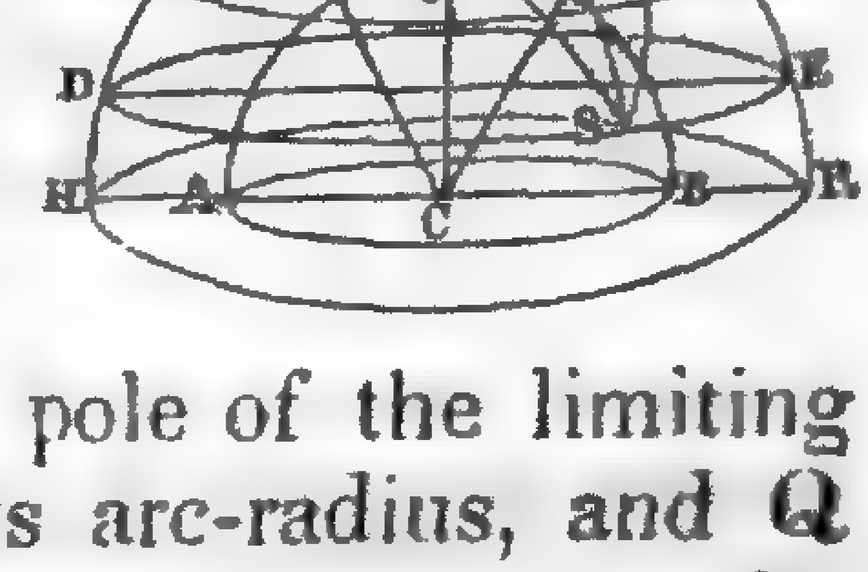
No possible supposition will reconcile them.

For days—it may be said weeks—after, the whole district of country disturbed by the principal shocks was visited by tremors. At Santiago the times of four were noted on the 3d; only one on the 4th; two or three on the 5th; and so on up to the 20th; indeed, for several months their occurrence was more frequent than during the same period of the preceding year. Having passed from the afternoon of the 6th at Aguila, the hacienda of a friend within the deep bay of the mountains, there were opportunities to experience some of them in the open fields.

ART. XLIV.—*Supplementary Note to the article on the Theory which attributes the Zodiacal Light to a Nebulous Ring surrounding the Earth*;* by F. A. P. BARNARD, LL.D., Professor of Mathematics and Astronomy in the University of Mississippi.

Prof. DANA,—Will you allow me space for a few words supplementary to the article on the zodiacal light, published in the March number of the Journal of Science. In that article the geographical limits of visibility of the cusps of a ring encircling the earth, lying in the plane of the ecliptic, illuminated by the sun and interrupted by the earth's shadow, are assigned for the moments when the sun is eighteen degrees below the eastern or western horizon. It is true, however, that there are certain limits of distance from the earth's centre, between which, if such a ring be situated, a certain portion of the part of it illuminated may be visible, under the circumstances supposed, as an illuminated arch, though the cusp may not be above the horizon.

In order to determine these limits, if we resume the consideration of fig. 5 in the article referred to, where AOB is the earth, HZR the imaginary spherical surface of which the ring is a great circle, H′R′ the horizontal small circle of this sphere passing through the place of observation O, S the pole of the limiting circle (i. e. the circle of the shadow), SQ its arc-radius, and Q the cusp of the luminosity, then when Q is on the horizon, the ring may touch the horizontal circle H′R′, or it may rise above it either on the illuminated or on the obscured side of Q. In the former case, a luminous arch will be visible to the observer at O. The tangency or the intersection which takes place at Q will be determined by the value of the angle at that point; contact occurring when this angle is ninety degrees, and the intersection favoring the visibility of the light, when the angle is greater than ninety.



* This volume, p. 217.

Put ☉'s depression $=\delta$, $ZQ=\varrho$, $SQ=\varrho'$, $ZQS=Q$. Then, in the triangle ZQS

$$\sin \delta=\cos \varrho' \cos \varrho+\sin \varrho' \sin \varrho \cos Q.$$

But, by the hypothesis, $\varrho+\varrho'=90°$. Consequently $\cos \varrho'=\sin \varrho$; and $\sin \varrho'=\cos \varrho$. Whence,

$$\text{Sin } \delta=\sin \varrho \cos \varrho\ (1+\cos Q)=\tfrac{1}{2} \sin 2\varrho\ (1+\cos Q).$$

$$\text{Or, } \cos Q=\frac{2 \sin \delta}{\sin 2 \varrho}-1.$$

When $2 \sin \delta=\sin 2 \varrho$, $\cos Q=0$, and the ring touches the horizon. When $2 \sin \delta > \sin 2 \varrho$, $\cos Q$ is positive, and the obscured part of the ring rises above the horizon. When $2 \sin \delta < \sin 2\varrho$, $\cos Q$ is negative, and the light is visible to the observer at O.

It is evident that, δ being constant, this phenomenon will be more remarkable as $\sin 2\varrho$ is greater. Putting, therefore, $\sin 2\varrho=1$, we have $\varrho=45°$; whence it is evident that such a ring as we have been considering would be most conspicuous as a luminous arch, after the setting of the cusp, provided it were placed at a distance from the earth's centre $=3956\sqrt{2}$, or 1640 miles above the surface.

If, while we make $\sin 2\varrho=1$, we make also $2 \sin \delta=1$, the ring will touch the horizon, and we shall have $\sin \delta=\frac{1}{2}=\sin 30°$. That is to say, the maximum depression of the sun at which the phenomenon can occur, is thirty degrees.

If we take the sun's depression $=18°$, as in the article referred to, then tangency will occur, when $\sin 2\varrho=2 \sin 18°$: which will give the value of $\varrho=19° 5'$, or $70° 55'$. If any value be assumed for ϱ between these limits, the phenomenon will be observable; but for any value beyond them it will not be observable at this depression of the sun. But the distance of the ring from the earth's centre corresponding to any value of ϱ, is expressed by the formula,

$$D=\frac{R}{\cos \varrho},$$

in which D represents this distance, and R the earth's radius. Whence the limits of distance which will make the light visible at the close of twilight or at the commencement of the dawn, though the extremity may be beneath the horizon, are 4186 miles for the lesser, and 12,100 miles for the greater, from the centre of the earth.

The inclination of the ring to the horizon when it just touches the circle H′R′ is equal to $90°-ZR'=\varrho'$. The geographical limits within which the light of a ring situated at any distance from the earth between the limits just determined, ought never to be absent in some form and during some portion of the night, or ought never to be present at all, may be ascertained by the equation

$$\text{co-lat.} - \text{obliquity of ecliptic} = \varrho',$$

for the first; and by the equation

$$\text{co-lat.} + \text{obliquity of ecliptic} = \varrho',$$

for the second. Putting D=9000, as in the March number of this Journal, $\varrho' = 26°$; and the equations foregoing will give the latitude 40° 32′ as the limit of perpetual apparition of the light, and 87° 28′ as that of its perpetual occultation.

By assuming, in the triangle ZSQ, $\delta = 18°$, and the position of Q on the circle H′R′, we shall find that the visibility of the light as an arch of which the extremity is beneath the horizon when the sun is 18° depressed, will be limited to places between the latitudes at which the maximum inclination of the ecliptic to the horizon is not less than 26° on the one hand, and the minimum not greater than 28° 34′ on the other; and the season of its greatest conspicuousness at any given hour, or at any given depression of the sun, may be found by putting I=28° 34′ in the equation given in the note on p. 231 of the last number of the Journal,* viz.

$$\cos I = \sin L \cos O - \cos L \sin O \sin A,$$

in which I is inclination of ecliptic to horizon, L latitude of observation, O obliquity of ecliptic, and A right ascension of the culminating point of the ecliptic. The value of A being found, the R. A. of the sun follows immediately, in case the hour angle is given; and is deduced without difficulty from the depression, if that is the given quantity.

Thus at Oxford, lat. 34° 30′, the arch could never be seen at the close of twilight, unless the cusp were at the same time visible; but at New Haven, about the time of the autumnal equinox, the axis of the light ought apparently to rise two or three degrees above the horizon at the same hour, though it would be impossible to see the extremity. Some further arguments unfavorable to the hypothesis which ascribes the zodiacal light to a luminous ring encircling the earth might be drawn from the considerations presented in this letter; but after what has been said, it is, perhaps, unnecessary to add more.

University of Mississippi, Oxford, March 15, 1856.

* In case the maximum inclination of ecliptic to the horizon is not so great as 28° 34′, substitute that maximum itself for I.

Art. XLV.—*On the Presence of Vivianite in Human Bones;* by J. Nicklès.

In the cemetery at Eumont, a village in the Department of La Meurthe, the earth of which is very ferruginous, there has been found among the bones, the accumulation of several centuries, two arm bones of a female, a cubitus and a radius, having a deep bluish green color. One of these bones having been broken through curiosity, it was discovered that the color was general through its whole thickness. This bone having been sent me, I have observed the following facts.

The color was decidedly greenish; but as the osseous paste was yellow, it was evident that the coloring matter was blue. By dissolving a fragment in chlorhydric acid and supersaturating with ammonia, a white precipitate of phosphate of lime slightly bluish in tinge was obtained, showing that the color was not due to copper. Reagents indicated the presence of iron; but as the bones all contained iron, it was not at first easy to ascertain whether this metal was in the coloring matter, although it much resembled phosphate of iron. My subsequent investigations proved that this last was true. On examining the medullary cavity with a lens, I found among the sinuosities left by the hardened marrow, brilliant points which were distinctly crystalline. With a microscope, they were found to be rhomboidal prisms apparently oblique, some of them surmounted with a horizontal prism, and others with octahedral planes having the terminal planes applied to the two extremities of the macrodiagonal. They were too small for measurement. But by chemical methods, they were found to have all the characters of phosphate of iron. Calcined with bicarbonate of soda, the acid and oxyd were readily separated; and on treating the calcined product with distilled water, I obtained a residue of oxyd of iron and an alkaline solution, which on neutralizing it, afforded an abundant precipitate with ammonia, chlorhydrate of ammonia and sulphate of magnesia. This was therefore phosphoric acid, and the substance a crystalline phosphate of iron, which can be only Vivianite. The presence of the bones in the ferruginous water explains its formation, the bones affording the phosphoric acid from the phosphate of lime.

This fact recalls to mind an observation made some years since by Schlossberger, who detected in the stomach of an ostrich that had died suddenly, two nails surrounded with an unctuous material of a bluish color, which coloring matter the author found to consist of a phosphate of iron, having the composition of Vivianite.

The bones mentioned above were in a perfect state of preservation, and afforded a skeleton of gelatine when treated with chlorhydric acid, proving that gelatine does not resist the absorption of the ferruginous compound. We know nothing as to their exact age. The presence of gelatine is not a matter of surprise, as is shown by the discovery of it in the fossil horn of an Aurochs (Bos urus) by Braconnot,* and the antediluvian soup of Cuvier. They probably date back hardly two centuries. Whatever the time, they illustrate the interesting fact of the modern origin of Vivianite and the conditions favoring it.

ART. XLVI.—*Correspondence of M. Jerome Nicklès, dated Paris, March* 2, 1856.

Academy of Sciences.—Distribution of Prizes.—The annual session of the Academy of Sciences was held on the 28th of January, when M. Flourens pronounced an historical eulogium on the distinguished geologist, von Buch.

Notwithstanding the fine discoveries made this year in the departments of physics and chemistry, no prize has been given to the indefatigable workers who have contributed to the progress of these sciences.

The prize of mechanics was given to Captain Boileau, Professor at the School of Artillery of Metz, on account of his researches in hydraulics—"a science which, in spite of all the remarkable works undertaken at different times in France, England and the United States, has not yet attained to the perfection and certainty required for precise calculations in the varied cases brought before the engineer." The Academy, in bestowing the prize, includes also a recognition of the delicate apparatus contrived by M. Boileau for studying the flow of water in open channels and over dams, as well as his experimental researches on the sawing of wood, through which the author has devised new sawing machines.

A prize extraordinary in statistics was conferred on M. Le Play, the late commissary general of the Universal Exposition, for his work entitled "Les Ouvriers Européens;" another to M. Vicat, for his statistical researches on calcareous hydraulic cements. M. Vicat in his work has aimed to point out the mineralogical resources of France, with special reference to materials for constructors; the work embraces references to the minerals found in 76 of the Departments.

Among the prizes relating to the arts that are injurious to health, one of 2500 fr. was given to M. Duméry for a contrivance for consuming the smoke of chimneys, which has worked with complete success in a series of comparative experiments under the inspection of the learned mechanician, M. Combes, Member of the Commission.

M. Duméry, in place of throwing in the fresh coal by the door of the furnace upon the burning combustible, as in ordinary fires, causes it to enter below by means of stoking bars worked with the hand in a kind of recurved funnel, with open sides, and extending to the grating on that side. This method was long ago suggested by Franklin; but

* Journal de Physique, August, 1806.

the arrangements here adopted are peculiar to this inventor and attain perfectly the end proposed.

The Commission has decreed three other prizes of less importance.

As usual the Commission in Medicine and Surgery has been just and generous in its prizes. It has not confined its attention to medical and surgical works, but has given prizes as in the last year, even to researches in chemistry and physics where they have some relations to medical science. A prize was thus bestowed upon Dr. Hannover of Copenhagen for his work on the Eye; another to Dr. Lehmann of Saxony for his Treatise on Physiological Chemistry, published in German at Leipsic, and which has just been strangely disfigured by a French edition that has of the work only its title.

Aluminium and Silicium.—M. Wöhler and M. Deville have both devised easy processes for obtaining pure silicium. Wöhler uses fluosilicate of potash, $3KFl+2SiFl^3$ in excess, which he fuses with the aluminium in a Hessian crucible. After cooling, the mass is found to contain a crystalline material, an alloy of silicium and aluminium, before observed by Deville, which after treating with chlorhydric acid deposits silicium in a graphite-like state.

Deville's process affords the silicium in a crystalline state. It consists in heating the aluminium in a porcelain tube traversed by a current of hydrogen saturated with vapor of chlorid of silicium: the treatment is continued until there is no disengagement of vapors of chlorid of aluminium. The crystallized silicium contains some impurities which are removed on treating it successively with nitro-muriatic acid, boiling fluohydric acid, and melted bisulphate of soda. As long as the operation is not complete, there are found small globules of siliciuret of aluminium, $SiAl^2$. The fluorid of silicium used in place of the chlorid would equally furnish silicium; at the same time, a new compound of fluorid of aluminium, Fl^3Al^2, is formed, crystallized in fine cubes and unattacked by almost all reagents.

Silicium crystallizes in octahedrons and tetrahedrons, and conforms therefore to the rule which I established in 1851,* that simple bodies crystallize generally either in the monometric or rhombohedral system.

By the same process, Deville has prepared crystallized boron as well as crystallized carbon with a hexagonal base, zirconium, and titanium. We will recur to the subject at another time, and then describe the new apparatus, such as tubes of carbon, &c., used in these operations, as executed at the Normal School, which institution, has, through the University, extended means of research.

Artesian wells.—An artesian well is in progress in the Bois de Boulogne a meter in diameter, and capable of supplying 10,000 cubic meters of water per day. The engineer who has it in charge, M. Kind, has so perfected the process, that he offers to go to a depth of 720 meters, and even to descend to a depth of 2000 meters. The boring was commenced on the 2nd of August with a diameter of 1·2 meters. Descending through marl and soft sandstone, the rate was five meters a day; in a bed of sand it was two to three meters; by the 1st of May the depth will reach 700 meters.

* Comptes Rend., xxxii, 853.

The process employed by M. Kind is an improvement on the Chinese method of percussion. A cylindrical rod of wood, is made of sticks of young pines, ten meters in length, united by sockets of iron fitted with screws. The quantity of iron added to each piece is just that required to counterbalance the water. As water is encountered at a depth of 20 or 30 meters, and it continues to fill the hole, it results that the shaft, which, whatever its length, is thus made to equal the water in weight, has relatively almost no weight, so that it is moved by a small force; and being made of pieces of wood put end to end, its strength is very great. The extremity of this rod carries a grapple at bottom which opens as it descends, and then closes when it is raised by means of a parallelogram connected at its angles with two cords, which cords reach up to the orifice of the well, where they may be managed with the hand or by means of machinery. At the bottom of the well, there rests a drill weighing 1800 kilograms, quite similar in form to that used for pounding and drilling rocks, but armed below with seven teeth of cast steel twenty-five centimeters long, fitted to drive into the bed of rock and break or abrade it. The drill has a shank above by which it may be seized and lifted.

The mode of operating is as follows:—With a steam-engine of twenty-four horse power, working a horizontal balance beam, the rod of wood is let down. The grapple at its bottom closes, seizing the handle of the drill; it then rises, lifting the drill to a height of some meters above the bottom; the grapple then opens, and lets the drill fall; thus the drill is raised twenty times a minute. After working in this way twelve hours, the entire rod is raised along with the drill, which is done with great rapidity; the sticks of pine are taken apart in less than a quarter of an hour. They are then refitted, and the drill is replaced by a bucket having a valve below which is opened and closed also by the aid of the cords and the grapple; the bucket opens below, and being pushed by the piston, penetrates into the pasty mass and fills, after which the valve is closed, and the whole is drawn up, and the drill again sent down.

As it traverses different strata, specimens are taken, and thus a true geological section of the basin of Paris is obtained. A steam engine of thirty horse power is sufficient for all the work, and the number of workmen required is only six, costing each day 49 francs. The teeth of the borer are rapidly worn in quartz; they lose nearly two centimeters in two hours work. The mean expense of boring is per meter 54·39 fr.

Electric clock.—The city of Marseilles has undertaken to establish a complete system of electric clocks. One hundred clocks will be set up by the 1st of May. The arrangements require the laying of 40,000 meters of conducting wire. The clocks will be placed in the street gas lamps, so that the hour may be read at night as well as by day. The whole will cost only 22,000 francs, and the care and supply of them per year 2000 francs.

Chlorimetry.—The anomalies presented at times in the process of treating with hypochlorite of lime (commonly called chlorid of lime) the standard test liquors of Gay Lussac, have just been explained by MM. Fordos and Gelis. A normal solution of the hypochlorite having, at the end of some time, lost its standard value without having lost its bleaching power, these chemists examined the liquid and found that a part of the hypochlorous acid was changed to chlorous acid, which bleaches indigo well, but does not act on the arsenous acid employed in the process of Gay Lussac.

This fact is of great importance in commerce; for on examining a hypochlorite of lime or soda, the merchant or dyer is not anxious to learn the quantity of hypochlorous acid present, but wishes to know the quantity of coloring matter a given weight of the hypochlorite will bleach.

MM. Fordos and Gélis have therefore sought for a better process; and after employing it for four years in the fine establishment founded by them on the Seine, they publish it for the benefit of the trade. They replace the arsenous acid with hyposulphite of soda, a salt that is definite in composition and unalterable of itself, which chlorous acid destroys easily. It is very soluble in water, and not poisonous, and therefore every way preferable to the arsenous acid.

Excepting this substitution, the process resembles that of Gay Lussac. 2·77 grammes of crystallized hyposulphite of soda dissolved in 1 litre of water, constitutes the test-liquor, corresponding to the arsenical solution of Gay Lussac. After having taken 10 cubic centimeters of this normal liquor, 100 parts of water are added and some drops of indigo; and as the hypochlorites are generally alkaline, and since the hyposulphite of soda does not decompose readily except in an acid liquid, some drops of sulphuric acid are added. As the solution of hyposulphite has been previously diluted with water, there is no danger that the hyposulphurous acid will be immediately decomposed in consequence of the slight excess of sulphuric acid added.

This hyposulphite is also an excellent antidote of bromine and iodine which are largely in use through the operations of photography.

Illuminating gas.—An important change has just been made in the six gas works from which Paris is lighted, in consequence of the discussions that have been going on the past two years, and large reductions have been made by the company in their charges.

From the 1st of January, 1856, the cubic meter of gas, which till then had cost the people 35 centimes, has been put at 15 centimes.

The contract made with the company is for fifty years; but at the end of sixteen years, if the annual profits exceed ten per cent, half the surplus will go to the city; and if a new mode of illumination less expensive should be discovered, it may be put in practise without any indemnity to the contractors.

An offer was made by an engineer, M. Pauton, to prove that the cost of a cubic meter of gas was much below the cost set down by the companies, which led to an examination by the government. A special commission was appointed, and an experimental laboratory having been constructed in the park of St. Cloud, nothing was neglected that would put the investigation under the best possible conditions for accuracy.

The results set forth by the company as having been obtained in the period between 1844 and 1853 are the following:—

100 kilograms of coal have produced—

Gas (C^4H^4, C^2H^4, CO), ...	21 cubic meters.
Coke, ...	69 kilograms.
Tar, ...	4·50 "
Ammoniacal liquid, ...	8·75 "

Combustible consumed in heating the furnaces, 24·75 kils. of coke.

The commission has obtained, as an average, for 100 kilograms of coal,

Gas, fit for illumination, ...	22·940 cubic meters.
Coke, ...	75·40 kilograms.
Tar, ...	6·73 "
Ammoniacal liquid, ...	7·31 "
Combustible consumed in the furnaces,	20·43 "

To the price 0·0791 fr. per cubic meter of gas set down by the companies, the commission opposes that of 0·208 fr. per cubic meter. In this amount are not included the octroi duty, laying of pipes, &c., for the 30,000,000 of cubic meters of gas which Paris consumes each year.

We cannot give all the details respecting this process which is of so immense importance to the inhabitants of Paris. The subject is presented in full in the Bulletin de la Société d'Encouragement for the month of December, 1855, to which all interested are directed.

Zoological Society of Acclimation.—This Society continues its labors with zeal and success. One of its principal importations is the Angora goat, of which we have spoken in our communication of November last. The Bulletin of the Society for January 1856, states that a similar importation was made into the United States in 1849 by Dr. Davis, six females and two males having been introduced by him into South Carolina. In that warm region, latitude 34°, it has rapidly increased, until in 1854 there are fifty animals of the pure breed, and a much larger number of mixed breed crossed with the goat of the country.

The goat has also been successful in France. The small flock at Marseilles is increasing; the other intrusted to the society of acclimation of the northeast zone, of which Nancy is the centre, and placed at first at Wesserling (Haut Rhin) is now in the vicinity of Nancy. A contagious disease appeared in the flock at Wesserling, and this led to the change. Dr. Sacc sent the goats to Nancy where they arrived at a cold and rainy time in the month of December. One of them died on the way, and the others were sick. They are now well and in the prospect of breeding. Nancy is in longitude 3° 50′ 16″ east of Paris, and latitude 48° 41′ 28″; and its mean altitude is 201 meters 46 centimeters above the level of the sea at Havre.

A kilogram of the Angora wool sells in France at six francs; and as a goat produces two kilograms, as much as a sheep, its value is three times as great. Dr. Sacc has made thread of the wool or rather hair, and sent some of it to the Society, along with a sample of velvet of the hair. The velvet has the lustre of silk and the firmness of wool velvet. But from both, it is distinguished by the surface showing no marks from pressure even if it be strong and long continued. The

Angora tissues are also colored with the same facility as those of wool or silk, which is highly important since tissues are now made of mixed silk and wool.

Bibliography.—Histoire et Fabrication de la Porcelain Chinoise; traduit du Chinois, par STANISLAS JULIEN, accompagné de notes et d'additions par M. SALVETAT. 1 vol. in 8vo. Paris: chez Mallet-Bachelier. Price 12 fr.—The Chinese, as is known, are our masters in the manufacture of porcelain. They have had some processes for ages which are still unknown to us, although we have surpassed them in other points. Thus we do not yet know how to produce at will the porcelain called "craqueleé." The book which has just appeared mentions three processes known for a long time in the Celestial Empire. The translator, whose work on the culture of silk worms and the mulberry in China has been translated into the principal languages of civilized nations, including the Russian and Arabic, may look for a like success with this new work on porcelain. It is not simply a translation. Through the aid of M. Salvetat, chemist at the manufactory at Sevres, the work has been rendered an important one to chemists and especially manufacturing chemists, notes being added and many comparisons of the Chinese methods with our own. In addition, the volume contains a chart of China pointing out the places of manufacture of porcelain, ancient and modern, and also a Chinese and French index of most of the words. It closes with a memoir on the porcelain of Japan, translated from the Japanese by Dr. Hoffmann, interpreter of the government of Holland in the Indies.

Etudes et Lectures sur les Sciences d'Observation et leurs Applications pratiques, par M. BABINET, Membre de l'Institut. 2 vols., in 12mo. Paris: chez Mallet-Bachelier. Price 2½ francs.—This work is for general circulation. It treats of—1, Turning tables and supernatural manifestations; 2, Working electricity; 3, Siberia and the climates of the north; 4, Influence of the currents of the ocean on climates; 5, on Earthquakes and the interior currents of the globe; 6, Astronomical Bulletin for the years 1853, 1854; 7, on the Water systems of the globe; 8, on Turning tables from a Mechanical and Physiological point of view; 9, Meteorology in 1854 and its future progress.

Dictionnaire Universel des Sciences des Lettres et des Arts, par M. BOUILLET. 4to. Paris: chez Hachette & Co. Price 25 fr.—In less than 2000 pages of two columns each, this work goes through in alphabetical order the different branches of human knowledge, and defines scientific, artistic, and industrial terms, with a precision and exactness which had not been realized in any other work of the kind.

La Pisciculture et la Production des Sangsues, by A. JOURDIER. 1 vol. in 12mo. Paris: Hachette & Co. Price 2 fr.—This is the first complete work on the different processes of pisciculture and on the production of leeches—a branch of industry which has had so great and rapid extension in France and elsewhere. It contains also a description of the Piscine of the College of France and that of the great establishment of Huningue.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On heat as the equivalent of work.*—Hoppe has contributed a memoir upon this most interesting and important subject which places the analytical theory in a remarkably clear, simple, and general point of view, so far at least as it relates to permanent gases. We shall give the author's investigation in extenso, making however a slight change in the symbols employed so as to assimilate them to those usually employed by writers on the calculus, in French or English. The temperature τ of an enclosed permanent gas may be expressed as a function of the pressure p and the volume v by the following formula which is a combination of the laws of Gay Lussac and Mariotte:

$$pv=\frac{ma}{\delta}(1+\alpha\tau) \qquad (1)$$

In this formula m represents the mass of the gas, a any definite pressure, that of one atmosphere for instance, δ the density at the temperature 0° and pressure a. If we consider the temperature to be measured by the increments of volume of the gas itself, α will be absolutely constant, and Mariotte's law will be the only fact resting upon experience.

Let ϑ denote the quantity of heat which the mass m of the gas must receive from without, in order to produce any changes whatever in p, v and τ. Then considering p and v as independent variables and τ as a function of both we can make

$$\frac{d\vartheta}{dv}=mc\frac{d\tau}{dv}; \qquad \frac{d\vartheta}{dp}=mc'\frac{d\tau}{dp}.$$

The magnitudes c and c', defined in this manner, express the capacities for heat at a constant volume and at a constant pressure, and may for the present be regarded as constant. Substituting in these expressions the values of the partial differential co-efficients of τ as obtained from (1) namely

$$\frac{d\tau}{dv}=\frac{\delta p}{ma\alpha}; \qquad \frac{d\tau}{dp}=\frac{\delta p}{ma\alpha}.$$

we have,

$$\frac{d\vartheta}{dv}=\frac{\delta cp}{a\alpha}; \qquad \frac{d\vartheta}{dp}=\frac{\delta c'v}{a\alpha},$$

and hence for the total differential of ϑ

$$d\vartheta=\frac{\delta}{a\alpha}(cpdv+c'vdp).$$

If now the gas pass from one state to another so that p and v change according to any definite law, p, v, and ϑ become functions of each other and we have

$$\vartheta=\frac{\delta}{a\alpha}\left(c\int pdv+c'\int vdp\right). \qquad (2)$$

If τ_0 denote the initial temperature then from the equation (1) we have

$$d\tau = \frac{\delta}{ma\alpha}(pdv + vdp),$$

and if we integrate between the same limits as those to which ϑ is referred and multiply by mc' we have

$$mc'(\tau - \tau_0) = \frac{\delta}{a\alpha}c'\left(\int pdv + \int vdp\right), \qquad (3)$$

which subtracted from equation (2) gives

$$\vartheta - mc'(\tau - \tau_0) = \frac{\delta}{a\alpha}(c - c')q \qquad (4)$$

where $q = \int pdv$ expresses the work done in the change of state. The result is therefore as follows. "The quantity of heat communicated to a gas during any change of volume and pressure consists of two parts, one of which expresses the heat necessary to raise the temperature at a constant volume, while the other is a constant-multiple of the work done." In particular we infer that this quantity of heat is in itself proportional to the work as soon as the initial temperature is regained, while the pressure and volume may have other values; as pure loss of heat it appears, it is true, only after a complete restoration of the original condition.

Let us now suppose that neither Mariotte's law nor the law of the invariability of the capacities is accurately true. If c and c' are subject to any small changes in consequence of changes of pressure or temperature, we may consider them as functions of p and v and write equations (2) and (3) as follows:

$$\vartheta = \frac{\delta}{a\alpha}\left(\int cpdv + \int c'vdp\right)$$

$$m\int c'd\tau = \frac{\delta}{a\alpha}\left(\int c'pdv + \int c'vdp\right)$$

whence by subtraction,

$$\vartheta - m\int c'd\tau = \frac{\delta}{a\alpha}\int (c - c')pdv.$$

If now during the change there is only work consumed or work performed, if consequently pdv undergoes no change of sign, we may by a known property of definite integrals, place the factors c and $c - c'$ before the sign of integration, when the last equation will correspond with equation (4): only we now understand by c' and $c - c'$ certain definite mean values between the greatest and least of those which these functions assume during the entire change. The validity of the relation between work and heat is consequently not changed by small variations in the capacities for heat. The proportional number itself is of course subject to simultaneous variations which however are smaller than the variation in the capacities.

If the gas be restored to its original volume so that at any time pdv must change its sign, the proportional number is no longer necessarily a mean value of $\frac{\delta}{a\alpha}(c-c')$; yet we see by representing specially the heat conveyed during positive and negative work, that this number can differ but little from the values of its expression as long as the excess is not too small. If however there remains from a large amount of work only a small positive excess, it might be difficult to show that the proportional number could not differ considerably from the values of its expression.

Finally if Mariotte's law be not strictly accurate, we may put $pv+\varrho$ for pv and consider ϱ as a small magnitude depending on p and v, which at the beginning of the motion is zero. In this case in place of pdv and vdp we shall have relatively

$$pdv+\frac{d\varrho}{dv}dv\text{ ; and }vdp+\frac{d\varrho}{dp}dp.$$

The last magnitude is cancelled and does not occur in the resulting equation. On the other hand q now becomes

$$q+\int\frac{d\varrho}{dv}dv.$$

Were ϱ of the form $\psi(p)+x(v)$ the quantity added to q would $=\psi(v)$ and would vanish after the restoration to the original volume. In genral however ϱ would produce a change in the quantity of heat, which evidently would be always small, inasmuch as a sudden or quick change in ϱ is very improbable.—*Pogg. Ann.*, xcvii, 30, *Jan.*, 1856.

2. *On the crystalline form and isomeric conditions of selenium, and on the crystalline form of iodine and phosphorus.*—Mitscherlich has communicated to the Academy of Sciences at Berlin an interesting paper upon these subjects from which we shall extract the more important details. At its boiling point, viz. 46°·6 C., 100 parts of bisulphid of carbon dissolves 0·1 part of selenium, which separates on cooling partly in thin transparent red and brilliant scales, partly in grains which are so intensely colored that they appear opaque and almost black; thin splinters show the transparency and color of the scales. The author obtained the largest crystals by exposing the solution sealed up in a strong glass vessel alternately to a temperature somewhat lower than the boiling point of water and to that of the atmosphere. The crystals though small were very perfect and could be measured with the reflecting goniometer.

They belong to the oblique rhombic system (monoclinic) and are rich in forms. The crystals are easily soluble in the requisite quantity of bisulphid of carbon; on heating them to 150° C. they lose their bright color and become so dark as to be almost black; at the same time they become insoluble in the bisulphid, however long they may be boiled with it. When however the crystals are fused and then rapidly cooled they are completely dissolved by the bisulphid. The sp. gr. of the crystals before heating was 4·46—4·509 at 15°, after the warming 4·7. Schaffgotsch found 4·801 and the author believes the smaller number found by himself to be occasioned by small cavities in the crystals. Hittorf has observed that when amorphous or glassy selenium is heated to 90° it rapidly becomes crystalline while the temperature rises more than 30°. The author finds that this crystallization and evolution of heat is most beautifully observed when large quantities are fused in a flask and heated to over 217° then allowed to cool down rapidly for 20° or 30° below this temperature and kept at this point for a while in an air bath. The temperature of the selenium there rapidly rises 20° or more and the whole mass becomes granular crystalline. This selenium is insoluble in bisulphid of carbon, and must be regarded as an allotropic modification. Large pieces of glassy selenium become granular-crystalline throughout when they are heated for some time in a glass tube plunged into boiling water. The external form is but slighly changed.

The insoluble selenium has a much darker color than the soluble form even when rubbed to a not very fine powder. When amorphous selenium as obtained by reducing selenium by sulphurous acid is covered with bisulphid of carbon, it is in a few weeks completely changed into crystalline selenium which is perfectly soluble in bisulphid of carbon. Glassy selenium under the same circumstances is gradually dissolved and then deposited in small crystals. From these facts the author concludes that the granular-crystalline selenium and that crystallized from a solution of selenid of sodium are identical and essentially different from that crystallized from bisulphid of carbon. Glassy selenium though amorphous belongs to the modification crystallized from the bisulphid.

The author has also obtained measurable crystals of iodine which, as Wollaston and Marchand found, belongs to the right rhombic (trimetric) system. A predominant form is the rhombic octahedron, the axes, *a*, *b*, &c. being in the ratio 1 : 2·055 : 1·505. The author's earlier investigations showed that the crystalline form of phosphorus is the regular dodecahedron. This observation is confirmed by the fact that crystals of phosphorus obtained from a solution in oil of turpentine exert no action upon polarized light and consequently can only belong to the regular system. Very beautiful crystals may be obtained by gently heating or exposing to the sunlight phosphorus contained in a glass tube either free from air or filled with a gas in which phosphorus does not oxydize. The phosphorus sublimes from one place to another and deposits itself on the cooler parts of the tube in small and brilliant crystals. Schrötter's red phosphorus presented no trace of crystalline structure.—*Journal für prakt. Chemie*, lxvi, 257.

3. *On the physical properties of chemical compounds.*—H. Kopp has published the continuation of his very valuable researches upon this subject, and we shall endeavor to present to our readers his general results though his memoirs scarcely admit of abstracts which do them justice. After a discussion of numerous particular cases the author arrives at the following conclusion in regard to the boiling points of homologous compounds in general. Homologous compounds which belong to the same series exhibit in general a difference in boiling point which is proportional to their difference in constitution. The difference in boiling points which correspond to a difference in constitution of C_2H_2 is the same in very many compounds and $=19°$. This difference however is not found in all series when the boiling points are compared at the usual mean pressure of the atmosphere; in some it is

greater, in others smaller. With respect to the specific volumes the author, after an extended historical introduction reviewing the results obtained by himself and communicated in a former paper, re-states these results in a more precise form and extends them by considering new classes of compounds. In this way it appears that in analogous compounds of the same difference of constitution we find the same difference in the specific volumes; for an x-fold difference of constitution there is an x-fold difference of spec. volume. The author illustrates this for a difference of constitution equal to $x . C_2H_2$ by citing the specific volumes of hydrocarbons, alcohols, ethers, acids of the acetic and oxalic series, aldehyds and acetones. Isomeric bodies belonging to the same type have (at their boiling points) equal specific volumes and consequently equal densities. Thus the spec. vol. of acetic acid, $C_4H_4O_4$, is 63·5, that of *formate of methyl*, $C_4H_4O_4$, 63·4, &c. &c. Equivalent quantities of oxygen and hydrogen may replace each other without very sensible change of volume: thus the spec. vol. of wood spirit $C_2H_4O_2$ is 41·9—42·2, that of formic acid $C_2H_2O_4$ is 40·9—41·8. It must however be remarked that the substitution of oxygen for hydrogen almost always produces a more or less perceptible change of volume. Equivalent quantities of carbon and hydrogen may replace each other without any material change in the specific volumes. Thus the spec. vol. of benzoic alcohol, $C_{14}H_8O_2$, is 123·7, that of amylic alcohol 123·6—124·4. For the spec. volumes of the elements themselves the author finds the following values; for carbon 5·5, for hydrogen 5·5, for oxygen contained within a radical 6·1, for oxygen outside of the radical 3·9. These four values may be brought together in the expression "The spec. vol. of a liquid $C_aH_bO_c\mathit{O}_d$ at its boiling point is $5{\cdot}5a+5{\cdot}5b+6{\cdot}1c+3{\cdot}9d$."

The symbol *O* is here used to denote the oxygen outside of the radical, and the author computes the spec. vols. of 45 liquids in satisfactory accordance with the observations, the difference being never 4 per cent of the whole value. The author remarks that the expression above given is simply to be regarded as a useful formula of interpolation to express the relations between the constitution and the spec. vols. of bodies. The enumeration of the specific volumes of bodies containing sulphur, chlorine, bromine and iodine leads to the following conclusions. With regard to sulphur the author remarks that this element enters into organic compounds in three different ways, (1) as replacing oxygen in compounds of the water type $\left.\begin{matrix}H\\H\end{matrix}\right\} O_2$, (2) as replacing carbon within a radical, (3) as replacing oxygen within a radical. In the first and second of these cases sulphur has the same spec. volume, namely 11·3: but when it replaces oxygen within a radical its specific volume is higher, namely, 14·3—14·4. It is remarkable that alcohol and bisulphid of carbon have the same spec. vol., viz. 62. For the compounds of chlorine the rules already laid down for combinations of oxygen, hydrogen and carbon also hold good. The spec. volume of chlorine must be taken as 22·8, which is very nearly twice that of sulphur. The spec. vol. of bromine is 27·8, and that of iodine 37·5. The author next directs his attention to the spec. volumes of inorganic compounds and points out the close correspondence between the spec. vols. of the analogous compounds PCl_3, $SiCl_3$, $AsCl_3$, of PBr_3 and $SiBr_3$, and of $SnCl_2$ and $TiCl_2$, from which it may be inferred that tin and titanium on the one hand, and phosphorus, silicon and arsenic on the other have the same specific volumes, which for tin and titanium $=18\cdot7$, and for phosphorus, silicon and arsenic $=25$. Antimony has a spec. volume of 33 as deduced from both its chlorid and bromid.

The author next points out the fact that the quotient obtained by dividing the specific volume by the number of equivalents in the compound is in 44 out of the 45 liquids in his table very nearly the same, namely, from 5·1 to 5·6; water being however a remarkable exception the quotient being here 4·7. A similar result is obtained for compounds containing chlorine, bromine, iodine and sulphur, and it is further shown that between the numbers thus deduced there exists approximately at least, simple numerical relations. The difficulties however in the way of admitting these relations are very serious. In the first place the mean spec. vols. of water and of bisulphid of carbon are very different from those of other substances—the former being 4·7 and the latter 6·2; yet the accuracy of the determination is beyond a doubt precisely in these cases. On the other hand the quotients in question in consequence of the smallness of the numbers appear to correspond more closely than they really do, the variation being from 10 to 16 per cent. For these reasons the author prefers to retain the numbers which directly express the specific volumes and not those which express the mean spec. vols. The memoir is concluded by many judicious observations and interesting isolated facts for which however we must refer to the original.—*Ann. der Chemie und Pharmacie*, xcv, 1, 2 *and* 3 *Heft*, *October to December*, 1855.

4. *On the different methods of determining the weak or strong basic properties of an oxyd.* —H. Rose has published the continuation of his researches on this subject, and has obtained some valuable analytical among his various results. Of the different sesquioxyds, glucina is the only one which is dissolved by a boiling solution of sal-ammoniac. It is consequently the strongest of all the sesquioxyd bases. Alumina is easily and completely separated from lime and sesquioxyd by boiling with a solution of sal-ammoniac, a method which in principle was already employed by Deville. The same is the case with sesquioxyd of iron: in both cases however all the oxyds must be freshly precipitated and not ignited. The author next studies the behavior of the various oxyds toward a solution of chlorid of mercury. In their relations to this substance all oxyds may be divided into three classes. 1st. Those which precipitate pure yellow oxyd of mercury. 2d. Those which precipitate a red brown oxychlorid. 3d. Those which produce no precipitate. The author also gives an elaborate and able discussion of the question of the true equivalent of glucina and arrives at the conclusion that this earth must be considered as a sesquioxyd.—*Pogg. Ann.* xcvi, 436, 550.

5. *On a new class of alcohols.*—Cahours and Hofmann have identified acroleine and acrylic acid with members of the propylene series. Their investigation may be regarded as a generalization of the results obtained by Zinin, Berthelot and de Luca, with the iodid of propylene, and they have succeeded in producing what may be regarded as the

keystone of the whole edifice, namely, the alcohol of the propylene series; the authors term this body acrylic alcohol. When iodid of propylene is brought in contact with oxalate of silver, iodid of silver and oxalate of acryl are produced, the reaction being represented by the equation $AgO.C_2O_3+C_6H_5I=AgI+C_6H_5O.C_2O_3$. The new oxalate is a colorless limpid liquid boiling at 207° C.: treated with dry ammonia it yields oxamid and acrylic alcohol $C_6H_6O_2$ or C_6H_5O+HO. The alcohol is a colorless liquid having a penetrating odor recalling that of mustard and boiling at 103°. It burns with a much more luminous flame than ordinary alcohol and mixes with water in all proportions; with potassium it gives a gelatinous mass which corresponds to potassic alcohol. This last is strongly attacked by iodid of acryl (propylene), iodid of potassium being formed while a colorless liquid is set free which is the acrylic ether C_6H_5O. In the same manner the mixed ethers $C_6H_5O+C_4H_5O$ and $C_{12}H_5O+C_6H_5O$ may be obtained. By distilling acrylic alcohol with the chlorid, bromid or iodid of phosphorus, the chlorid, bromid or iodid of acryl are easily prepared. With sulphuric acid acrylic alcohol forms a sulph-acrylic acid analogous to sulphovinic acid. Phosphoric acid removes two equivalents of water from acrylic alcohol, disengaging a colorless gas which is probably C_6H_4. Oxydizing agents readily attack the new alcohol. A mixture of sulphuric acid and bichromate of potash act very violently upon it, the products being acroleine and acrylic acid. Platinum black produces the same results. Bisulphid of carbon and potash give with acrylic alcohol a compound analogous to xanthate of potash. The authors have also prepared a large number of ethers which are remarkably well defined. The cyanate of acryl mixed with ammonia gives the body $C_8H_8N_2O_2$ which is thiocinnamine in which sulphur is replaced by oxygen. Heated with water the cyanate solidifies into a mass of sinapoline or diacryl-urea $C_{14}H_{12}N_2O_2=C_2\left\{H_2.(C_6H_5)_2\right\}N_2O_2$ the reaction being represented by the equation

$$2(C_8H_5NO_2)+2HO=C_{14}H_{12}N_2O_2+2CO_2.$$

The cyanate is decomposed by boiling with a solution of potash yielding sinapoline which floats on the surface and a distillate which is a mixture of methylamine, propylamine and acrylamine. The authors conclude by pointing out the perfect parallelism between acrylic alcohol and common alcohol, and draw attention to the fact that the acryl alcohol forms the third member of a new series of alcohols represented by the general formula $C_{2n}H_{2n}O_2$. The cyanid of acryl should furnish by the action of potash an acid homologous with acrylic acid. *Comptes Rendus*, xlii, 217, *4th Feb.*, 1856.

6. *Researches on iodated propylene.*—Berthelot and de Luca have continued their observations upon this substance and have obtained in the main the same results as those of Cahours and Hofmann above described. To the body C_6H_5 they give the name of *allyl* while C. and H. use the word *acryl*. By the action of sodium upon iodid of propylene the authors obtained iodid of sodium and allyl, $C_6H_5I+Na=C_6H_5+NaI$. Allyl or acryl is a very volatile liquid, having a peculiar penetrating etherial odor. It boils at 59° C. its density at 14° is 0·684, the density of its vapor at 100° is 2·92 so that the formula C_6H_5 corre-

sponds to 2 vols., as is the case with ethyl, methyl, &c. Allyl unites directly with chlorine, bromine and iodine; the bromid and iodid have the formulas $C_6H_5Br_2$ and $C_6H_5I_2$. As the formula of the iodid of allyl $C_6H_5I_2$ differs from that of iodid of propylene by one equivalent of iodine only, the authors sought, but without success, to transform one of these bodies into the other. These facts appear to show that the two iodids do not contain the same radical and there may therefore be two isomeric bodies having the formula C_6H_5. It must be remarked however that Cahours and Hofmann give C_6H_5Br and C_6H_5I for the formulas of the bromid and iodid of acryl and that they make no distinction between propylene C_6H_5 and acryl.—*Comptes Rendus*, xlii, p. 233.

7. *Researches on tungsten.*—Riche has obtained by the action of iodid of methyl upon metallic tungsten the iodid of a base having the formula $3(C_2H_3)W$. The iodid crystallizes from ether in large colorless plates which melt at 110° and have the formula $3(C_2H_3)W.I$. With oxyd of silver this iodid yields the corresponding oxyd as a white powder $3(C_2H_3)W.O$ which unites with acids and forms uncrystallizable salts.—*Comptes Rendus*, xlii, 205.

8. *New bases containing phosphorus.*—The discovery of basic compounds of phosphorus with methyl corresponding to methylamine, &c., is due to Paul Thenard who obtained them by passing chlorid of methyl over heated phosphuret of calcium. Cahours and Hofmann have resumed the subject and have prepared many new and interesting compounds. The authors employed in the first place the action of iodid of methyl upon phosphuret of sodium. In this manner they obtained the compounds $P(C_2H_3)_2$, $P(C_2H_3)_3$ and $P(C_2H_3)_4I$. A better method of preparing this class of bodies however consists in acting upon chlorid of phosphorus PCl_3 with zincmethyl, zincethyl, &c.; in this manner a solid mass is obtained which is a compound of chlorid of zinc with triphosphomethylamin, triphosphethylamin, &c. The reactions are

$$PCl_3+3(C_2H_3Zn)=3ZnCl+P(C_2H_3)_3$$
$$PCl_3+3(C_4H_5Zn)=3ZnCl+P(C_4H_5)_3$$
$$\&c. \qquad \&c.$$

When these compounds are distilled with caustic potash, liquids are obtained which have the smell of the arsenic bases and are strongly alkaline; triphosphomethylamin, triphosphethylamin &c. These bodies give with chlorhydric acid easily soluble salts which give crystallizable compounds with bichlorid of platinum. Triphosphomethylamin when heated with iodid of methyl gives a solid mass $P(C_2H_3)_4I$ which is easily soluble in alcohol and crystallizes in long needles. With the iodids of ethyl and amyl similar compounds are obtained, namely, $P(C_2H_3)_3(C_4H_5)I$, and $P(C_2H_3)_3C(_{10}H_{11})I$. The authors obtained the iodids of similar ammoniums containing amyl and ethyl in place of methyl. All of these iodids are easily decomposed by oxyd of silver and yield soluble and strongly basic oxyds. Chlorid of arsenic $AsCl_3$ yields similar compounds already known as triarsenmethylamin and triarsenethylamin. Chlorid of bismuth appears to give similar compounds though the reaction is less distinct.—*Comptes Rendus*, xli, 831.

9. *Nitrite of potash and sesquioxyd of cobalt.*—STROMEYER has carefully studied the beautiful yellow salt discovered by Fischer and some years afterward rediscovered by St. Evre. The author finds that the salt is insoluble in many saline solutions so that it may be washed with a solution of acetate of potash and afterward with alcohol; in this manner it may be used for analytical purposes. Caustic soda and baryta water easily decompose it separating a brown hydrate of sesquioxyd of cobalt. The author finds for this compound the formula

$$Co_2O_3, 2NO_3+3(KO, NO_3)+2HO$$

and explains its formation by the equation

$$2CoO, SO_3+5KO.NO_3+2HO+O=\{Co_2O_3, 2NO_3+3KO, NO_3+2HO\}+2KO.SO_3$$

When nitrite of potash is added to neutral solutions of salts of protoxyd of cobalt, no precipitate is at first produced; but the addition of a little diluted nitric or acetic acid causes an evolution of deutoxyd of nitrogen and the double nitrate is soon completely precipitated. Boiling water reduces the yellow salt completely, giving a red solution. When nitrite of potash and acetic acid are added to solutions of lead the liquid becomes yellow but there is no precipitate. The addition of a salt of cobalt produces a yellowish green, or in dilute solutions a brownish black, precipitate, which is highly crystalline and gives a yellowish green powder. The author found for this precipitate the formula

$$2(Co_2O_3 . 2NO_3)+3(KO, NO_3)+3PbO, NO_3)+4HO.$$

Ann. der Chemie und Pharmacie, xcvi, 218.

10. *On the quantitative determination of Copper.*—MOHR has suggested the use of zinc in place of iron to precipitate copper from its solutions and proceeds as follows. A copper salt containing no nitric acid is dissolved by chlorhydric acid in a porcelain crucible covered with an inverted watch-glass and pieces of distilled zinc thrown in. The copper is speedily thrown down as a spongy mass and the liquid soon becomes colorlesss, hydrogen being evolved. More zinc is to be added in case the evolution of hydrogen ceases before the color disappears. The complete precipitation of the copper is best recognized by testing a drop of the liquid with sulphydric acid water upon a porcelain plate. By stirring with a glass rod it is easy to determine whether the zinc is completely dissolved, the hard pieces of zinc being easily distinguished from the spongy copper. The clear liquid is then to be drawn off with a pipette, and a few drops of muriatic acid added to the copper which is to be gently warmed. The copper is then to be repeatedly washed in the crucible, the liquid being removed with a pipette, and finally the last portions with bibulous paper. The crucible with the copper may then be dried and weighed. The authors experiments with this method gave very satisfactory results. If the copper solution contain nitric acid, this must first be destroyed by boiling with muriatic acid avoiding a large excess.—*Ann. der Chemie und Pharmacie*, xx, 215.

[NOTE.—Zinc has long been employed in this country by assayers in the determination of copper, so that in Mohr's process nothing is new but the manipulation, which appears to be advantageous. It must be observed, however, that the presence of lead, silver, arsenic and many other substances in copper ores would render the method inapplicable in its present form.—W. G.]

11. *On metallic Uranium.*—PELIGOT has presented to the Academy of Sciences some specimens of uranium fused at a high temperature. The author employed sodium as a reducing agent and proceeds as follows. A quantity of sodium is introduced into a porcelain crucible and covered with very dry chlorid of potassium and then with a mixture of this salt and the green chlorid of uranium. The porcelain crucible is then to be placed within one of clay, the intervening space filled with charcoal dust, and the outer crucible also covered. The crucible is then heated till the reaction takes place, which is known by the noise heard at the moment; it is then to be placed in a furnace and heated to a red-white heat for fifteen or twenty minutes. On cooling, there is found in the crucible a scoria containing globules of fused uranium. As thus prepared, the metal has a certain malleability; its color recalls that of nickel or iron. In the air it assumes a yellowish tint from superficial oxydation. Heated to redness it becomes suddenly incandescent and is covered with a black voluminous oxyd. The density of fused uranium is 18·4, and consequently after platinum (iridium?) and gold it is the heaviest body known. The author proposes to continue the study of this metal which appears to possess interesting properties.—*Comptes Rendus*, xlii, 73, *Jan.* 1856.

12. *On crystallized silicon and carbon.*—WÖHLER has found that by fusing aluminium with an excess of fluosilicate of potassium, $3KF, 2SiF_3$, in a common crucible at the melting point of silver, a gray crystalline button is obtained which by treatment with muriatic acid yields silicon in bluish metallic hexagonal scales. Deville has obtained the same modification in crystals having the tetrahedral angle 70° 31′. At a high temperature it fuses and congeals in crystals with curved faces which appear to be analogous to diamond. By the action of chlorid of carbon upon iron, Deville has obtained carbon in small hexagonal plates with metallic lustre.—*Comptes Rendus*, xlii, 48. W. G.

13. *On Ozone and Ozonic actions in Mushrooms;* by M. SCHÖNBEIN, in a letter to M. Faraday, (Phil. Mag., [4] vol. xi, p. 137, Feb. 1856.)—You know that I hold oxygen, both in its free and bound state, to be capable of existing in two allotropic modifications,—in the ozonic or active, and the ordinary or inactive condition. All the oxy-compounds yielding common oxygen at a raised temperature I consider to contain ozonized oxygen; and I am further inclined to believe that the disengagement of common oxygen from those compounds depends upon the transformation of the ozonized oxygen into the inactive one, or, to denote that allotropic change, of $\overset{\circ}{O}$ into O. Now a general fact is this: that the oxygen thus set free always contains traces of $\overset{\circ}{O}$ more or less, according to the degree of temperature at which the oxygen happens to be disengaged from those compounds. The lower that degree, the larger the quantity of $\overset{\circ}{O}$ mixed with O; though I must not omit to state, that in all cases that quantity happens to be exceedingly small in comparison to that of O obtained at the same time. The best means

of ascertaining the presence of $\overset{\circ}{O}$ is the alcoholic solution of guaiacum recently prepared. You know that O does not in the least change the color of that resiniferous liquid, whilst free $\overset{\circ}{O}$ or $PbO+\overset{\circ}{O}$, &c. has the power of coloring it deep blue. The blue matter is, as I think I have proved it, nothing but guaiacum $+\overset{\circ}{O}$. Now if you heat the purest oxyd of gold, platinum, silver, mercury, the peroxyds of manganese, lead, &c., in fact any substance yielding oxygen, within a small glass tube into which you had previously introduced a bit of filtering-paper impregnated with the said guaiacum solution, you will see that bit of paper turn blue as soon as the disengagement of oxygen begins to take place; and all the circumstances being the same, you will further perceive that the paper is colored most deeply and rapidly by the oxygen eliminated from that oxy-compound which requires the lowest temperature for yielding part or the whole of its oxygen. Thus the oxygen disengaged from the oxyds of gold, platinum and silver, acts more energetically upon the guaiacum solution than does the oxygen eliminated from the oxyd of mercury, the peroxyd of manganese, &c. I trust these results will be obtained in the Royal Institution just as well as I get them in the laboratory of Bâle, or else my discovery will be a very poor thing. As there cannot, I should think, be any doubt that all the oxygen, contained, for instance, in the oxyd of silver previously to that compound being decomposed by heat, exists but in one state, be that state what it may, how then does it happen, we may ask, that at the same time two different sorts of oxygen, O and $\overset{\circ}{O}$, are disengaged from the compound named? The answer to this question seems to me to be, that one of the two kinds of oxygen eliminated must be engendered at the expense of the other; or to speak more correctly, that during the act of elimination of oxygen from the oxyd of silver, part of that oxygen suffers a change of condition. Now as the oxyds of gold, silver, &c., enjoy the power of coloring blue the guaiacum solution, just as free $\overset{\circ}{O}$ does, I draw from the fact the conclusion, that the condition of the oxygen contained in the oxyds of gold, silver, &c. is the ozonic one; and further infer, that by far the greatest portion of that $\overset{\circ}{O}$, under the influence of heat, is transformed into O. Why the whole of the oxygen disengaged from those oxyds does not happen to be O, I certainly cannot tell, but I think that the very fact of the mixed nature of the oxygen in question is, in a theoretical point of view, highly important, and speaks in favor of my notions rather than against them.

Although I have already heavily taxed your patience, I am afraid I cannot yet release you from further listening to my philosophical talkings, for I have still to speak of a subject that has of late deeply excited my scientific curiosity, and taken up all my leisure time. But to give you an idea of what I have been doing these last two months, I must be allowed prefacing a little. You know that I entertain a sort of innate dislike to touch anything in the slightest way connected with organic chemistry, knowing too well the difficulty of the subject and the weakness of my power to grapple with it; but in spite of this well-grounded disinclination, I have of late, and, as it were, by mere chance, been carried into the midst of that field, upon the intricacies and depths of which I have been used all my life to look with feelings of unbounded respect and even awe. The picking up of a mushroom has led to that very strange aberration of mine, and you will ask how such a trifling occurrence could do that. The matter stands thus: what the botanists tell me to be called "*Boletus luridus*," with some other sorts of mushroom, have the remarkable property of turning rapidly blue when their head and stem happen to be broken and exposed to the action of the atmospheric air. On one of my ramblings I found a specimen of the said *Boletus*, perceived the change of color alluded to, and being struck with the curious phenomenon, took the bold resolution to ascertain, if possible its proximate cause. I carried home the part, set to work, and found more than I looked for, which luckily enough happens now and then. Being, by the short space allotted even to the longest letter, prevented from entering into the details of the subject, I confine myself to stating the principal results obtained from my mushroom researches. *Boletus luridus* contains a colorless principle, easily soluble in alcohol; and in its relations to oxygen, bearing the closest resemblance to guaiacum, as appears from the fact, that all the oxydizing agents which have the power of bluing the alcoholic solution of guaiacum, also enjoy the property of coloring blue the alcoholic solution of our mushroom principle; and all the deoxydizing substances by which the blue solution of guaiacum is decolorized also discharge the color of the blued solution of the *Boletus* matter. From this fact and others, I infer that this mushroom principle, like guaiacum, is capable of combining with $\overset{\circ}{O}$, and is not affected by O. Now the occurrence of a matter so closely related to guaiacum in a mushroom is a fact pretty enough of itself, but as to scientific importance far inferior to what I am going to tell you.

The fact that the resinous *Boletus* principle, after having been removed from the mushroom (by means of alcohol), is not able to color itself spontaneously in the atmospheric air, whilst it seems to have that power so long as it happens to be deposited in the parenchyma of the *Boletus*, led me to suspect that there exists in the *Boletus luridus*, besides the guaiacum-like substance, another matter, endowed with the property of exalting the chemical power of common oxygen, and causing that element in its $\overset{\circ}{O}$ condition to associate itself to the resinous principle of the mushroom. The conjecture was correct; for I found that in the juice obtained by pressure from a number of mushrooms belonging to the genera *Boletus* and *Agaricus*, and notably from *Agaricus sanguineus* (upon which I principally worked), an organic matter is contained which enjoys the remarkable power of transforming O into $\overset{\circ}{O}$, and forming with the latter a compound from which $\overset{\circ}{O}$ may easily be transferred to a number of oxydable matters, both of an inorganic and organic nature; and I must not omit to state, that the peculiar Agaricus matter, after having been deprived of its $\overset{\circ}{O}$, may be charged with it again by passing through its solution a current of air. The easiest way of ascertaining the presence of $\overset{\circ}{O}$ in the said Agaricus juice, is to mix that liquid with an alcoholic solution of guaiacum, or the resinous matter of the *Boletus luridus.* If the juice happens to be deprived of $\overset{\circ}{O}$, the resiniferous solutions will not be colored blue; but if it contains $\overset{\circ}{O}$, the solution will assume a blue color, just as if they were treated with peroxyd of lead, permanganic acid, hyponitric acid, &c. From the facts stated, it appears that the organic matter in question is a true carrier of oxygen, and therefore, when charged with it, an oxydizing agent. Indeed, that matter may in many respects be compared to NO^2, which, as is well known, enjoys to an extraordinary extent the power of instantaneously transforming O into $\overset{\circ}{O}$, and forming a compound ($NO^2+2\overset{\circ}{O}$) with that $\overset{\circ}{O}$, from which the latter may easily be transfered to a multitude of oxydable matters. Now in a physiological point of view, the existence of such an organic substance is certainly an important fact, and seems to confirm an old opinion of mine, according to which the oxydizing effects of the atmospheric oxygen (of itself inactive) produced upon organic bodies, such as blood, &c., are brought about by means of substances having the power both of exciting and carrying oxygen.

Before dropping this subject, I must not omit to mention a fact or two more. The peculiar matter contained in the juice of the *Agaricus sanguineus*, &c., and charged with $\overset{\circ}{O}$, gives up that oxygen to guaiacum, and the latter transfers it to the resinous matter of the *Boletus luridus;* thus the different organic matters capable of uniting with $\overset{\circ}{O}$ as such, exhibit different affinities for that oxygen, a fact not without physiological importance. Another fact worthy of remark, is the facility with which the nature of our Agaricus matter may be changed. On heating the aqueous solution to the boiling-point, it not only loses the property, but also the capacity of again becoming an oxydizing agent, i. e. carrier of oxygen, however long it may be kept in contact with atmospheric air. I am very sorry to be prevented from entering more fully into the details of the subject, but from the little I have said about it you may easily understand why this mushroom affair has of late so much engaged my attention.

II. Geology.

1. *Description of two Icthyodorulites*, by Joseph Leidy, M.D., (Proc. Acad. Nat. Sci. Philad. vol. viii, p. 11.)—Stenacanthus nitidus, Leidy. The species of a genus supposed to be distinct from those which have been described, is indicated by an icthyodorulite, discovered by Charles E. Smith, Esq., in association with the remains of *Holoptychius*, in the old Red Sandstone formation of Tioga county, Pennsylvania. The specimen is partially imbedded in a mass of red sandstone; and it has its points broken of and is otherwise mutilated. The spine is straight throughout and indicates no disposition to curve. In its perfect condition it appears to have been about three inches in length, by about six lines in breadth at its base; and it gradually tapers towards the apex. The anterior margin is convex. The posterior border at the edge of the exposed surface of the fossil is furnished with a row of closely set serrations, directed obliquely downward, of which eight may be counted

within the space of seven lines. Whether there is a second row of serrations, the imbedded state of the very friable bone in a hard matrix will not permit me to determine.

The broad surface which is exposed in the specimen, so far as it is preserved, is longitudinally furrowed; and about three-fourths of an inch from the broken summit it exhibits a transverse zigzag fissure, which may probably be the result of an original fracture, although it has very much the appearance of being an articulation.

Cylindracanthus ornatus, Leidy.—On several occasions fragments of apparent fossil bones have been submitted to my inspection, the character of which has exceedingly puzzled me, and although I now view them as portions of ichthyodorulites, I am not positive of the correctness of my conclusion. The specimens alluded to are found in the cretaceous formations of New Jersey and Alabama. The most perfect one was obtained by W. Taylor, Esq., from near Pemberton, Burlington Co., New Jersey. It is over three inches in length with the extremities broken off, is straight and gradually tapering, and is perfectly circular in transverse section. At the thicker end it is six and one quarter lines in diameter, and at the other end five lines. The centre presents a double tubular perforation of comparatively small calibre. The surface is invested with a thick, enamel-like layer, which is dense, brittle, and shining, and deeply fluted; the intervening ridges being of nearly uniform diameter, with pairs occasionally converging into single ones in their course.

2. *Notices of some remains of extinct Mammalia, recently discovered by Dr. F. V. Hayden, in the bad lands of Nebraska;* by Joseph Leidy, M.D., (Ibid, p. 59.)—(1.) Hipparion occidentale, *Leidy.*—This second American species of *Hipparion* is established on specimens of five superior and one inferior molar teeth, discovered by Dr. Hayden, on the White River of Nebraska. The internal isolated enamel column of the upper molars, on the worn crown, is elliptical and more than twice the length of the breadth. The central columns of the same teeth are comparatively moderately folded. Antero-posterior diameter of the first upper molar 15 lines, transverse diameter $10\frac{1}{2}$ lines; antero-posterior diameter of the largest of the back upper molars 13 lines, transverse diameter 12 lines; smallest of the back upper molars 11 lines square; antero-posterior diameter of the back inferior molar 12 lines, transverse diameter $7\frac{1}{2}$ lines.

(2.) Hyopotamus americanus, *Leidy.*—This species is founded upon a number of specimens of molar teeth, which were discovered by Dr. Hayden, in company with remains of *Titanotherium*, in Nebraska Territory. The teeth indicate a species of the same size as *Hyopotamus bovinus*, Owen. Among the specimens are the posterior two upper molars of both sides of the jaw from the same individual; and they present almost a repetition of form of the homologous pair of *H. vectianus*, Owen. The collection also contains two premolars in conjunction, apparently from the same individual as the true molar just mentioned. They correspond to the second and third premolars of *Anthracotherium:* the crown of the second premolar consisting of a single large trihedral lobe, with a tubercle at its postero-internal basal angle; and the crown of the third premolar being formed of a transverse pair of lobes, of which the outer one is trihedral and the inner one is smaller and conical. These premolars undoubtedly belong to the permanent dentition, and if they are not the second and third of the series, they are certainly the latter and the fourth. In either case, they confirm an opinion formerly expressed (Anc. Fauna of Nebraska, p. 45,) that the teeth represented by Prof. Owen, as the third and fourth permanent premolars of *Hyopotamus vectianus*, (Lond. Quart. Journ. of the Geol. Soc., pl. vii, vol. iv,) really belong to the deciduous dentition; and therefore, although *Hyopotamus* may not be identical with *Anthracotherium*, it is much more nearly allied to it than was suspected by its distinguished author.

The measurements of some of the molar teeth of *Hyopotamus americanus* are as follows:

Antero-posterior diameter of the superior last true molar, externally,	13½	lines.
Transverse " " " anteriorly,	15	"
Antero-posterior diameter of the superior third premolar,	6	"
Transverse " " "	8¾	"
Antero-posterior diameter of the superior second premolar,	10½	"
Transverse " " "	8½	"

3. *Second Annual Report of the Geological Survey of the State of New Jersey, for the year* 1855. 248 pp., 8vo. Trenton: 1856.—This second Annual Report on the Geology of New Jersey, contains a Report on the Topographical Department of the State by E. L. Viele, State Topographical Engineer, on the Geology of the northern division of the State by Wm. Kitchell, Superintendent and State Geologist, and on the Geology of the southern division of the State by George H. Cook, Assistant Geologist. A good beginning has been made towards developing the structure and beds of the Cretaceous formation, a brief mention of which as made out the preceding year being given in vol. xix of this Journal, page 438. The observations are farther extended in this Report by local details: but the characteristic fossils of the beds remain to be catalogued. Mr. Cook observes that passing southeast from the Red Sandstone region, the first, or lowest beds reached are light colored clays, including fire and potter's clays, then black and chocolate colored astringent clays; then the several beds of greensand marl with intermediate beds of marl, and lastly the more recent beds of shell marl, sand, clay and gravel which make up the southeastern part of the State.

Evidences of wear and subsidence along the New Jersey coast are mentioned on pages 78—81, which merit a full investigation. We cite the following paragraphs:—

During the past season, while in the southern part of the State, my attention was frequently called to the rapid wearing away of the shores, and to the advance of the tide-waters on the land. Local causes were generally assigned for the increased height of the tides; but this and other phenomena were extended over so long a line of shore, that it was thought there must be some general cause for them; and this cause appears to be, the slow but continued settling or subsidence of the land.

At the mouth of Dennis creek, in Cape May county, and for several miles along the bay-shore, on each side of it, according to the local surveyors, the marsh wears away, on an average, about one rod in two years; and, from the early maps, it would appear to have been going on at that rate ever since the first settlement of the country. A map of Cape May, in the possession of Dr. Maurice Beesley, of Dennisville, and bearing the date of 1694, lays down Egg Island, the western point of Maurice River Cove, as containing 300 acres; at low water it now contains a half or three-fourths of an acre, and at high water it is entirely covered. All along the Delaware Bay and river where the marshes are banked in to keep off the tide, the banks or dykes are placed several rods from the water's edge, to allow for the wearing away of the marsh.

At Town Bank, which is the principal bold shore on the west side of Cape May, and where the first settlement was made as early as 1691, the solid gravel bank, which is from twelve to eighteen feet high, wears away, according to the owner, Mr. Thomas Hughes, about one foot a year. The foundations of the houses first built were long since undermined, and the waters of the bay now occupy the spot where they originally stood. At Cape Island, on the Atlantic shore, the wear is equally rapid, a full mile having been worn in since 1780, as I am informed by Mr. Ezekiel Stevens. During the war of that period a militia artillery company had its practicing ground here. Their gun was placed near a house which stood just outside the present shore line, and their target was set up three quarters of a mile east. This last point was at the outer edge of the cultivated ground, and there was a quarter of a mile of sand hills or *beaches* between that and the water's edge. The whole of this is now gone, and one of the boarding houses has been moved back twice, on account of the wearing away of the bank. The sand beaches on the Atlantic shore are drifting in every year. Dr. Leaming says that Ludlam's Beach, opposite his residence, has moved inward fully one hundred yards during the last twenty years; and that the salt marsh sods which formed west of the beach are now seen on the strand east of it.

That the tides rise higher upon the uplands than formerly, is the opinion of the oldest observers, upon the Atlantic and Bay shores, from Great Egg Harbor quite around to Salem creek. Their opinion is founded on the fact, that on the low uplands, or those going down to the salt marsh with a very gentle slope, the salt grass now grows where upland grass formerly grew; and where the land was in wood, narrow fringes of it next the marsh are frequently killed by the salt water, and marsh takes its place. Hon. Joshua Brick, of Port Elizabeth, estimates the amount of timbered land between Maurice river and West creek, in Cumberland County, which has been killed within the last fifty years, at one thousand acres. And the amount is proportionally great on all the low and wooded shores. Numerous *islands* (spots of hard ground surrounded by salt marsh) which, within the memory of men now living, have been cultivated, and others which were in wood, have been entirely lost in the advancing marsh, and their location is only to be known by the shallowness of the mud which covers them.

In all the salt marshes on the sea shore of southern New Jersey, and also in the salt and fresh tide marshes on Delaware Bay and river, stumps of trees, of the common species of the country, are found with their roots still fast in the solid ground at the bottom of the marsh, and this at depths far below low-water mark. A reference to localities for these is not necessary. The fact is known to every one living in the neighborhood of these marshes, and the evidence of it can be seen in the bottoms or in the banks of almost every ditch that is cut in them.

The time during which this settling has been going on cannot be estimated with any degree of accuracy. But some idea of it may be obtained by noticing the phenomena of the cedar swamps where buried timber is dug or *mined*. In these swamps, and in the salt marshes near them, underneath the standing trees, or under the stumps in the marsh, cedar logs are found buried—and these one under the other, in such numbers, and so sound, that they are valuable for timber. By sounding with an iron rod, these logs can be felt under the surface at all depths, from one to ten feet, and some have said for even more than this. At Dennisville a well was dug in the marsh eleven feet in depth. The mud near the surface was the common blue mud of the marshes; at a small depth the peaty cedar swamp earth was reached, and in it cedar timber, logs, and stumps, were found for several feet, and near the bottom the sweet gum (*Liquidambar styracifolia*,) and the spoon-wood or magnolia (*Magnolia glauca*,) were found. The well reached hard bottom. The white cedar grows on peat, and its roots run near the surface, so that it might be supposed the mud had settled with them, were it not for the fact that, when cedar grows where the mud is shallow, so that its roots reach hard bottom, its wood is unfit for timber, the grain or fibres being so interlocked that it will not split freely. Such is found to be the case in the buried timber; the bottom layer, as it is called, is worthless. From this the inference is conclusive that the hard ground was above tide level when those trees grew. Large stumps are frequently found standing directly on other large logs, and with their roots growing all around them, and then other logs still under these, so that one soon becomes perplexed in trying to count back to the time when the lower ones were growing. Dr. Beesley, of Dennisville, some years since communicated to the newspapers an article on the age of the cedar swamps, which was copied by Mr. Lyell in his Travels in the United States, Second Visit, vol. i, p. 34; in which Dr. B. says that he "counted 1080 rings of annual growth between the centre and outside of a large stump six feet in diameter, and under it lay a prostrate tree, which had fallen and been buried before the tree to which the stump belonged first sprouted. This lower trunk was five hundred years old, so that upward of fifteen centuries were thus determined, beyond the shadow of a doubt, as the age of one small portion of a bog, the depth of which is as yet unknown."

Mr. Thomas Shourds, of Hancock's Bridge, Salem County, informed me that the sluices in a meadow bank near his residence, on Alloways Creek, were fully three feet below low-water mark—so low, indeed, that within thirty years he has seen them but twice. The bank was built about the year 1700. Sluices are usually made in marsh earth, but it is said they do not settle much. And, in this instance, there is good reason to believe they are properly placed for what the tide must have been when they were set. On the opposite bank of the creek from these sluices there is an oak stump standing, the roots of which are in the solid bottom, and the top of it is about the level of high tide. The top is square, as if cut off by an axe, and the longest time since it was cut can be little more than one hundred and fifty years. And when alive it must have been not less than three feet higher than now, to be out of the way of the tide. Judge Brick, of Port Elizabeth, says the tides have advanced a foot within fifty years—which, it will be perceived, agrees with the evidence to be obtained from the stump.

Many persons have been disposed to estimate the rate of subsidence higher than this—but, in general, the statements are rather from impressions than from any fixed marks to refer to. I am confident, however, that two feet in a hundred years, is not above the rate at which the shore is now sinking. * * * * * *

From some facts collected, it would appear that the change on our own shore, is not confined to southern New Jersey. In the salt marshes on the Raritan, between New Brunswick and Perth Amboy, buried wood and stumps are common. Some years since a canal was dug across the marsh, from Washington to French's landing, to cut off some of the bends in South river, and the Raritan. The marsh cut through was from one to four feet deep, with a sandy bottom. Hundreds of stumps of the common yellow pine of the country, were found with their roots still firm in the sand as they grew; and though most of them were removed, a few are still to be seen at low water. The general impression at Washington is that the tides are fuller now than formerly. The marshes at the mouths of the Passaic and Hackensack are well known to contain great quantities of buried timber, and it is but a few years since they were covered with cedar trees. The same is true of the marshes on the shore of Long Island. Prof. Hitchcock, in his report on the Geology of Massachusetts, gives accounts of buried wood, erect stumps and peat, being found in the sea, at or below low-water mark, as at the harbor of Nantucket, at Holmes Hole, on Martha's Vineyard, and also near the southwest extremity of the same island. They are seen too on the north side of Cape Cod, also opposite Yarmouth, and in Provincetown bay. Mr. Lyell, in his second visit to the United States, mentions a submerged forest "at Hampton, on the way from Boston to Portsmouth," also one near Portsmouth, N. H., "now submerged at low water, containing the roots and upright stools of the white cedar, showing that an ancient forest must once have extended farther seaward." In his First Visit to North America, vol. ii, p. 143, he mentions a submerged forest somewhat similar near Fort Cumberland, in Nova Scotia. In the same work, vol. i, p. 131, in speaking of the coast of Georgia, he says, "I even suspect that this coast is now sinking down at a slow and insensible rate, for the sea is encroaching and gaining at many points on the fresh water marshes. Thus at Beauly, I found upright stumps of trees of the pine, cedar and ilex, covered with live oysters and barnacles, and exposed at low tides; the deposit in which they were buried having been recently washed away from around them by the waves." He records other observations in relation to the submerged trees at the mouth of Cooper river, near Charleston, and of the Altamaha, in Georgia. He quotes Bartram, the botanist, who wrote in 1792, as saying, "It seems evident even to demonstration, that those salt marshes adjoining the coast of the main, and the reedy and grassy islands in the rivers, which are now overflowed at every tide, were formerly high swamps of firm land, affording forests of cypress, tupelo, Magnolia grandiflora, oak, ash, sweet bay, and other timber trees, the same as are now growing on the river swamps, whose surface is two feet or more above the spring tides that flow at this day. And it is plainly to be seen by every planter along the coast of Carolina, Georgia and Florida, to the Mississippi, when they bank in these grassy tide marshes for cultivation, that they cannot sink their drains above three or four feet below the surface, before they come to a strata of cypress stumps, and other trees, close together as they now grow in the swamps."

Analyses are given of various clays—one of a South Amboy fire clay which is used for facing paper-hangings, others of pottery clays, &c.

Prof. Kitchell describes the crystalline rocks which prevail in the northern portion of the state (incorrectly called Azoic, as they are not of the Azoic age, although without fossils in consequence of metamorphic action), and gives many valuable details respecting the mines of copper, zinc, and iron. To this portion of the volume there are contributions from the results of Mr. Wurtz, the chemist to the survey, relating to the mines and their ores and other minerals. The mineralogical facts we propose to cite from, at another time.

The volume is illustrated by many beautiful engravings of scenery, representing landscapes in New Jersey, its lakes, mines, cedar swamps, etc.; and there are also some woodcuts, a map relating to the triangulation of the state, and another map of one of the mining regions.

4. *Geological Survey of Missouri.*—The first and second Annual Reports of the Geological Survey of Missouri, were announced in a former number as issued in a single octavo volume by the state geologist, Prof. G. C. Swallow, under the auspices of the legislature. We mention the reports again, to express our high estimate of the volume, and our earnest hope that a work so well begun may be carried on to its end. They are only the *annual* reports, not the final work; and we are free to say that none of the annual reports of our various surveys have come out in a manner more creditable to the authors or state, none in fact have equalled it in style of publication and illustrations. Some points no doubt remain for correction through future investigations, as happens in all such unfinished surveys, but, with few exceptions, the results appear to be carefully obtained as far as we can judge without going over the ground itself, and with judicious attention to points of geological interest, as well as to the best welfare of the state. The vast mines of iron, and those of lead, copper, and zinc, present the strongest inducements to a continuation of the work, regarding only its economical importance.

Prof. Swallow is aided in the survey by Dr. Litton, as chemist, who has in the volume a valuable report on the mines, with numerous analyses of ores and limestones; also by Dr. Meek, Mr. Hawn, and Dr. Shumard in the geology and palæontology.

5. *Pseudomorph of Smithsonite.*—We are informed by Mr. W. J. Taylor of Philadelphia, that he has observed at the Lancaster zinc mines, Pennsylvania, beautiful pseudomorphs of Smithsonite having the form of dolomite.

III. Botany and Zoology.

1. *For what purpose were plants created?* (addressed to Prof. Dana.) —Plants furnish all the food upon which animals live. Plants, by decomposing carbonic acid, &c., purify the air which animals breathe. In which of these offices may we say that the vegetable kingdom fulfills its essential purpose? In your admirable exposure of the character and tendency of Prof. Tayler Lewis's work, you take the view that the essential object of the vegetable creation is to purify the atmosphere for the breathing of animals, and assert that its use in providing food for animals is only incidental, or 'concomitant.'

May I venture to question this; and to remark that I have been accustomed to consider the opposite view as the more correct and philosophical. I think also that it would answer equally well the purpose of your argument. It is just because that general argument is so sound and able, and because it proceeds from such very high scientific authority, that I am induced to call your attention to this questionable point, not without the hope that you may see cause to correct or qualify the statement.

That the office of plants in the economy of the world is, not so much to purify the air for animals, as to supply them nourishment, may be argued,

1st. From the nature of the operation in which oxygen gas is liberated by vegetables. Plants take carbonic acid, water, &c., from the air, and decompose them, giving back to the atmosphere a part of the oxygen, while they transform the rest of the materials into vegetable fabric, or into vegetable products (mostly the prepared materials of vegetable fabric). The raw materials used contain more oxygen than the vegetable matter produced from them does. The surplus oxygen has to be eliminated, and is therefore given off in a free state. Which appears to be the essential thing here:—the formation of vegetable fabric, or of organic matter, by which alone the plant can grow, from its parts, and continue to exist; or the evolution of the oxygen gas necessarily separated in the process, and which has to be got rid of?

It is in this *deoxydizing* and *organizing* operation, no doubt, that the essence of vegetation consists: but, that the great purpose is the *organization*, rather than the elimination of oxygen, and that the uses the latter may subserve (however important) are only contingent or 'concomitant,' may be further inferred,

2d. From considering the kind and the degree of the dependence of the animal creation upon these two results of vegetation, namely, the vegetable matter produced, and the oxygen gas liberated. Now, upon the first, as is well known, the dependence of the animal creation is *entire* and *absolute:* upon the second only *remote* and *contingent.* For vegetable matter, so produced furnishes the whole food and fabric of animals. Without it animal life could not have existed at all; and were its production now to be suspended, all the herbivorous and then the carnivorous races would perish almost at once. On the other hand, the amount of the dependence of animal life upon the disengagement of oxygen gas by plants may be estimated by supposing existing vegetation to cease evolving free oxygen, or (which would come to the same thing) by supposing some new operation in the organic world to absorb this element as fast as it is given to the air by plants. How soon would the diminution of the oxygen of the air be felt even by the higher classes of animals. Making the needful calculations, M. Dumas has answered this question, by assuring us that the unbalanced action of the whole animal kingdom for a century would not consume more than $\frac{1}{8000}$ part by weight of the oxygen of the atmosphere;—"a quantity altogether inappreciable to the most delicate means of investigation we possess at the present day, and which very certainly would have no influence on the life of animals,"—that, as respects the higher races of animals, "it would require no less than 10,000 years before all the men on the face of the globe could produce an effect which should be sensible to Volta's Eudiometer, even supposing vegetable life to be extinct during the whole of this time;"—so vast is the original stock of this important element of the atmosphere.

Surely, then, we ought not to call this remotely needful action upon the air the *essential* office of vegetables in the economy of the world, nor view as a subordinate or concomitant end that operation of organizing matter, which provides the whole animal creation with sustenance, and the failure of which for a single year would depopulate the earth. Nor should we call that the essential office of vegetation which certainly was not essential (as the other *was*) to the existence of an abundant animal life before and during the epoch of the coal-formation, and which (however propitious) has not been proved to be *necessary* even to the existence of man.

Of course there is no question here of this as a function of vegetation, and of the reciprocal action of the two kinds of organized beings upon the air, as maintaining the balance of its elements; but even here it is not always considered that, as Sir Boyle Roche once said, "the reciprocity is all on one side;"—that though the animal kingdom could not exist at all without the vegetable, yet the vegetable kingdom might very well exist and flourish without the animal.

In other words, the vegetable creation is a provision for the animal, immediately and continually essential in one respect,—remotely and contingently needful—possibly essential to its *well-being*, but not to its *being*,—in the other. A. G.

Additional Note by J. D. Dana.—My meaning was this, that the whole structure and physiology of the plant was based on the great fact referred to, or its mode of living; and that this principle therefore, rather than the purpose of feeding animals, was that which in a sense determined the structure in this kingdom of life.

2. *Researches on the Foraminifera: Part I, General Introduction, and Monograph of the genus Orbitolites;* by WILLIAM B. CARPENTER, M.D., F.R.S., F.G.S., &c., (Ann. Mag. Nat. History, vol. xvi, p. 207.)—The group of *Foraminifera* being one as to the structure and physiology of which our knowledge is confessedly very imperfect, and for the natural classification of which there is consequently no safe basis, the author has undertaken a careful study of some of its chief typical forms, in order to elucidate (so far as may be possible) their

history as living beings, and to determine the value of the characters which they present to the systematist. In the present memoir, he details the structure of one of the lowest of these types, *Orbitolites*, with great minuteness; his object having been, not merely to present the *results* of his investigations, but also to exhibit the *method* by which they have been attained; that method essentially consisting in the minute examination and comparison of a *large number* of specimens.

The *Orbitolite* has been chiefly known, until recently, through the abundance of its *fossil* remains in the Eocene beds of the Paris basin; but the author, having been fortunate enough to obtain an extensive series of *recent* specimens, chiefly from the coast of Australia, has applied himself rather to these as his sources of information; especially as the *animals* of some of them have been sufficiently well preserved by immersion in spirits, to permit their characters to be well made out.

As might have been anticipated from our knowledge of their congeners, these animals belong to the *Rhizopodous* type; the soft body consisting of *sarcode*, without digestive cavity or organs of any kind; and being made up of a number of segments, equal and similar to each other, which are arranged in concentric zones round a central nucleus. This body is invested by a calcareous shell, in the substance of which no minute structure can be discerned, but which has the form of a circular disk, marked on the surface by concentric zones of closed cells, and having minute pores at the margin. Starting from the central nucleus,—which consists of a pear-shaped mass of sarcode, nearly surrounded by a larger mass connected with it by a peduncle,—the development of the Orbitolite may take place either upon a *simple*, or upon a *complex* type. In the former (which is indicated by the *circular* or *oval* form of the cells which show themselves at the surfaces of the disk, and by the *singleness* of the row of marginal pores), each zone consists of but a single layer of segments, connected together by a single annular stolon of sarcode; and the nucleus connected with the first zone, and each zone with that which surrounds it, by radiating peduncles proceeding from this annulus, which, when issuing from the peripheral zone, will pass outwards through the marginal pores, probably in the form of *pseudopodia*. In the *complex* type, on the other hand (which is indicated by the *narrow* and *straight-sided* form of the superficial cells, and by the *multiplication* of the horizontal rows of marginal pores), the segments of the concentric zones are elongated into vertical columns with imperfect constrictions at intervals; instead of a single annular stolon, there are two, one at either end of these columns, between which, moreover, there are usually other lateral communications; whilst the radiating peduncles, which connect one zone with another, are also multiplied, so as to lie in several planes. Moreover, between each annular stolon and the neighboring surface of the disk, there is a layer of superficial segments, distinct from the vertical columns, but connected with the annular stolons; these occupy the narrow elongated cells just mentioned, which constitute two *superficial* layers in the disks of this type, between which is the *intermediate* layer occupied by the columnar segments.

These two types seem to be so completely dissimilar, that they could scarcely have been supposed to belong to the same species; but the examination of a large number of specimens shows, that although one is often developed to a considerable size upon the simple type, whilst another commences even from the centre upon the complex type, yet that many individuals which begin life, and form an indefinite number of annuli, upon the simple type, then take on the more complex mode of development.

The author then points out what may be gathered from observation and from deduction respecting the *Nutrition* and mode of *Growth* of these creatures. He shows that the former is probably accomplished, as in other Rhizopods, by the entanglement and drawing in of minute vegetable particles, through the instrumentality of the pseudopodia; and that the addition of new zones probably takes place by the extension of the sarcode through the marginal pores, so as to form a complete annulus, thickened at intervals into segments, and narrowed between these into connecting stolons, the shell being probably produced by the calcification of their outer portions. And this view he supports by the results of the examination of a number of specimens, in which *reparation of injuries* has taken place. Regarding the *Reproduction* of Orbitolites, he is only able to suggest that certain minute spherical masses of sarcode, with which some of the cells are filled, may be *gemmules;* and that other bodies, enclosed in firm envelops, which he has more rarely met with, but which seem to break their way out of the superficial cells, may be *ova.* But on this part of the inquiry, nothing save observation of the animals in their living state can give satisfactory results.

The regular type of structure just described is subject to numerous *variations*, into a minute description of which the author next enters; the general results being, that neither the shape nor dimensions of the entire disk, the size of the nucleus or of the cells forming the concentric zones, the surface-markings indicating the shape of the superficial cells, nor the early mode of growth (which, though typically *cyclical* sometimes approximates to a *spiral*), can serve as distinctive characters of *species;* since, whilst they are all found to present most remarkable differences, these differences, being strictly gradational, can only be considered as distinguishing *individuals.* It thus follows that a very wide *range of variation* exists in this type; so that numerous forms which would be unhesitatingly accounted specifically different, if only *the most divergent examples* were brought into comparison, are found, by the discovery of those *intermediate links* which a large collection can alone supply, to belong to one and the same specific type.

After noticing some curious *monstrosities*, resulting from an unusual outgrowth of the central nucleus, the author proceeds to inquire into the *essential character* of the Orbitolite, and its relations to other types of structure. He places it among the very lowest forms of Foraminifera; and considers that it approximates closely to sponges, some of which have skeletons not very unlike the calcareous net-work which intervenes between its fleshy segments. Of the *species* which the genus has been reputed to include, he states that a large proportion really belong to the genus *Orbitoides*, whilst others are but varieties of the ordinary type. This last is the light in which he would regard the *Orbitolites complanata* of the Paris basin; which differs from the fully-developed Orbitolite of the Australian coast in some very peculiar features (marking a less complete evolution), which are occasionally met with among recent forms, and which are sometimes distinctly transitional towards the perfect type.

The author concludes by calling attention to some general principles, which arise out of the present inquiry, but which are applicable to all departments of Natural History, regarding the *kind* and *extent* of comparison on which alone specific distinctions can be securely based.

3. *Notes on British Foraminifera;* by J. Gwyn Jeffreys, Esq., F.R.S. (Ib., p. 209)—Having, during a great many years, directed my attention to the Foraminifera which inhabit our own shores, I venture to offer a few observations on this curious group, as Dr. Carpenter, who has favored the Society with an interesting and valuable memoir on the subject, seems not to have had many opportunities of studying the animals in the recent state.

Rather more than twenty years ago I communicated to the Linnæan Society a paper on the subject, containing a diagnosis and figures of all the species. This paper was read and ordered to be printed in the Transactions of that Society; but it was withdrawn by me before publication, in consequence of my being dissatisfied with D'Orbigny's theory (which I had erroneously adopted), that the animals belonged to the Cephalopoda; and my subsequent observations were confirmed by the theory of Dujardin. I have since placed all my drawings and specimens at the disposal of Mr. Williamson of Manchester, who has given such a good earnest of what he can do in elucidating the natural history of this group, by his papers on *Lagena* and the Foraminiferous mud of the Levant.

The observations which I have made on many hundred recent and living specimens of various species, fully confirm Dr. Carpenter's view as to the simple and homogeneous nature of the animal. His idea of their reproduction by gemmation is also probably correct; although I cannot agree with him in considering the granules which are occasionally found in the cells as ova. These bodies I have frequently noticed, and especially in the *Lagenæ;* but they appeared to constitute the entire mass, and not merely a part of the animal. I am inclined to think they are only desiccated portions of the animal, separated from each other in consequence of the absence of any muscular or nervous structure. It may also be questionable if the term "ova" is rightly applicable to an animal which has no distinct organs of any kind. Possibly the fry may pass through a metamorphosis, as in the case of the Medusæ.

Most of the Foraminifera are free, or only adhere by their pseudopodia to foreign substances. Such are the *Lagena* of Walker, *Nodosaria*, *Vorticialis* and *Textularia*, and the *Miliola* of Lamarck. The latter has some, although a very limited, power of locomotion; which is effected by exserting its pseudopodia to their full length, attaching itself by them to a piece of seaweed, and then contracting them like india-rubber, so as to draw the shell along with them. Some of the acephalous mollusks do the same by means of their byssus. This mode of progression is, however, exceedingly slow; and I have never seen, in the course of twenty-four hours, a longer journey than a quarter of an inch accomplished by a *Miliola*, so that in comparison with it, a snail travels at railroad pace.

Some are fixed or sessile, but not cemented at their base like the testaceous annelids. The only mode of attachment appears to be a thin film of sarcose. The *Lobatula* of Fleming, and the *Rosalia* and *Planorbulina* of D'Orbigny belong to this division.

Dr. Carpenter considers the Foraminifera to be phytophagous, in consequence of his having detected in some specimens, by the aid of the microscope, fragments of *Diatomaceæ* and other simple forms of vegetable life. But as I have dredged them alive at a depth of 108 fathoms (which is far below the Laminarian zone), and they are extremely abundant at from 40 to 70 fathoms, ten miles from land and beyond the range of any seaweed, it may be assumed without much difficulty, that many, if not most of them, are zoophagus, and prey on microscopic animals, perhaps even of a simpler form and structure than themselves. They are in their turn the food of mollusca, and appear to be especially relished by *Dentalium Entale.*

With respect to Dr. Carpenter's idea that they are allied to sponges, I may remark that *Polystomella crispa* (an elegant and not uncommon species) has its periphery set round at each segment with siliceous spicula, like the rowels of a spur. But as there is only one terminal cell, which is connected with all the others in the interior by one or more openings for the pseudopodia, the analogy is not complete, this being a solitary, and the sponge a compound or aggregate animal.

I believe the geographical range or distribution of species in this group to be regulated by the same laws as in the Mollusks and other marine animals. In the gulf of Genoa I have found (as might have been expected) species identical with those of our Hebridean coast, and *vice versâ.*

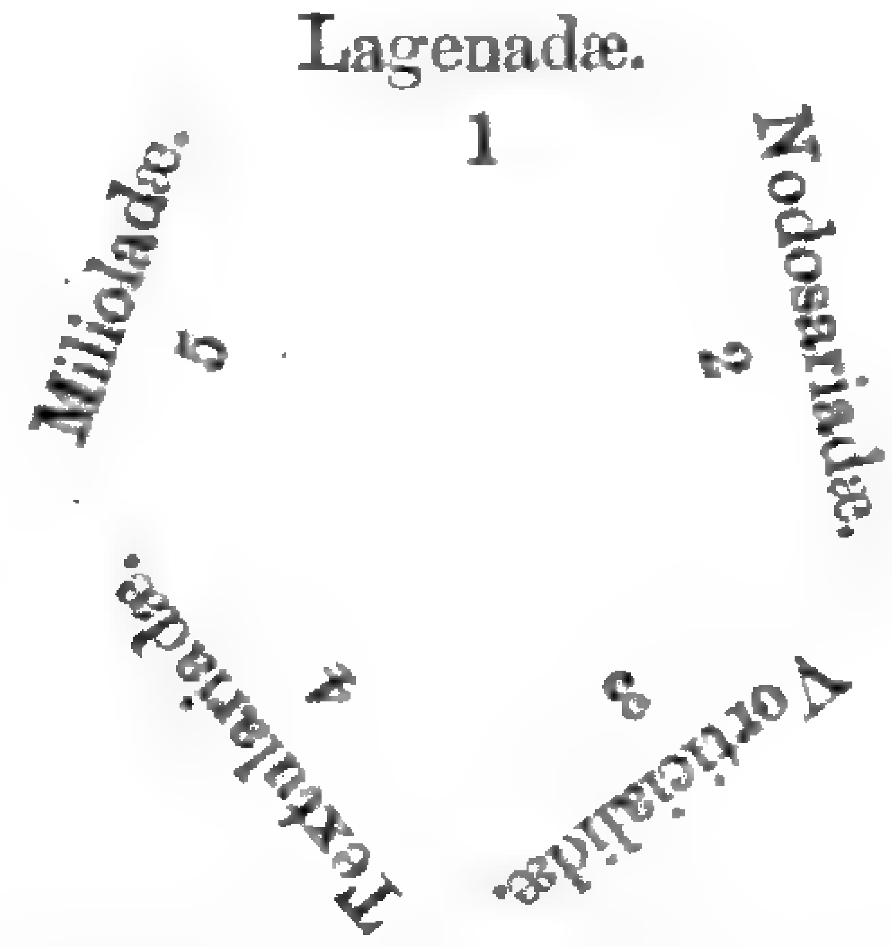
In common with Dr. Carpenter, I cannot help deploring the excessive multiplication of species in the present day, and I would include in this regret the unnecessary formation of genera. Another Linnæus is sadly wanted to correct this pernicious habit, both at home and abroad.

The group now under consideration exhibits a great tendency to variation of form, some of the combinations (especially in the case of *Marginulina*) being as complicated and various as a Chinese puzzle. It is, I believe, undeniable, that the variability of form is in an inverse ratio to the development of animals in the scale of Nature.

Having examined thousands (I may say myriads) of these elegant organisms, I am induced to suggest the following arrangement:—

1. *Lagena* (Walker) and *Entosolenia* (Williamson).
2. *Nodosaria* and *Marginulina* (D'Orb.), &c.
3. *Vorticialis* (D'Orb.), *Rotalia* (Lam.), *Lobatula* (Flem.), *Globigerina* (D'Orb.), &c.
4. *Textularia* (Defrance), *Uvigerina* (D'Orb.), &c.
5. *Miliola* (Lam.), *Biloculina* (D'Orb.), &c.

This division must, however, be modified by a more extended and cosmopolitan view of the subject, as I only profess to treat of the British species. To illustrate MacLeay's theory of a quinary and circular arrangement, the case may be put thus.



The first family is connected by the typical genus *Lagena* with the second, and by *Entosolina* with the fifth; the second is united with the third through *Marginulina;* the third with the fourth through *Globigerina;* and the fourth with the last through *Uvigerina.*

Whether these singular and little-known animals are Rhizopods, or belong to the Amœba, remains yet to be satisfactorily made out.

4. *On the presence of Diatomaceæ, Phytolitharia, and Sponge Spicules, in Soils which support Vegetation;* by William Gregory, M.D., F.R.S.E., Professor of Chemistry, (Ib., p. 219.)—Ehrenberg, in his late work, 'Mikrogeologie,' has stated that in specimens of soils from all parts of the world, he has found many microscopic organisms; he divides these into Siliceous and Calcareous, the former including *Diatomaceæ*, *Phytolitharia*, and *Polycystina*, as well as Sponge spicules, the latter minute Mollusks and other shells. The present observations are confined to the siliceous organisms, and among these, chiefly to the *Diatomaceæ*, with *Phytolitharia* and Sponge spicules, the soils examined being such as are connected with fresh water, in which the *Polycystina* do not occur.

Many of Ehrenberg's observations were made on the small portions of soil found adhering to dried plants in herbaria, and I requested Professor Balfour to supply me with such portions of soil. By his kindness I obtained upwards of sixty such specimens, almost all of which were of very small bulk, on an average not exceeding that of a pinch of snuff, and sometimes less. Of these a certain number consisted chiefly of earth, with some half-decayed vegetable matter, and many contained hardly anything but decaying vegetable matter, with a mere trace of earth. Of course, the latter are not fair specimens of soil; but I have subjected all to the same treatment, namely, boiling with nitro-muriatic acid, washing, straining through gauze, and examining the fine insoluble residue. This, of course, contained all the siliceous matter present, but it also contained much organic matter, of a brown or red color, insoluble in acids, which, if necessary, might be destroyed by ignition, when it would leave a trifling ash.

In every case I found *Diatomaceæ* in the residue, as well as *Phytolitharia.* Sponge spicules, apparently of freshwater sponges, were less frequent, but occurred in many. In a few cases, where the acid caused effervescence, there was calcareous matter present, but in most, this was not the case.

Of course, in those cases in which the proportion of earth was small, the residue consisted chiefly of the insoluble organic matters, through which, however, Diatoms and Phytolitharia were scattered, in greater or smaller proportion.

In the cases where the proportion of earth was larger, the residue was much richer in Diatoms and Phytolitharia, but almost always contained also the dark insoluble organic matter. In several, the proportion of Diatoms in the residue was so large, that it had the appearance of a regular Diatomaceous gathering, after boiling with acids. The most remarkable soils in this respect were one from the Sandwich Islands, one from Lebanon, one from the roots of a German moss, and one from Ailsa Craig.

It is to be noticed, however, that *Diatomaceæ* were found in every case, without exception, and that in all, their proportion to the whole non-calcareous earthy residue was considerable, and often large. In many of those where the proportion of earth was smallest, there was no siliceous matter in the residue, except *Diatomaceæ* and *Phytolitharia.*

The soils examined were from various and distant localities; there were about twenty from the Andes, several from Brazil and other parts of South America, a few from North America, a few from the West Indies, one from the Sandwich Islands, one from New Zealand, a few from India, one from Lebanon, a good many from Germany, some from France, a few from Spain, and some from Britain.

The great majority of the species of Diatoms in all these were found to coincide with our British forms, but a good many species occurred in the exotic soils which have not yet been found in Britain, and most of these not even in Europe, but which have been figured by Bailey, Ehrenberg, Kützing, Rabenhorst, &c.

A good may were observed, which, so far as I know at present, have not yet been figured or described. Lastly, a certain number of species, lately found by Smith, Greville, and others, as well as by myself in Britain, and some of which are scarce, have occurred in these exotic soils. Among these I may name here, *Navicula scutelloides*, W. Sm. (Lebanon), *Orthosira spinosa*, W. Sm., Grev. (Andes, Germany), *Cymbella turgida*, W. G. (Sandwich Islands), and *Navicula varians*, W. G. (various soils).

Of such species as are unknown to Europe, I shall only mention here *Terpsinoë musica*, one of the most striking of known forms, which I found in the first soil I examined, which was from Brazil. It is accompanied by *Nitzschia scalaris*, a fine form, which occurs in Britain, but is far from frequent here.

I am satisfied that a close examination of such specimens of soil, which are often thrown away in putting up specimens in herbaria, will bring to light many new forms, and supply us with many exotic and rare species. It is very desirable that collectors of plants should preserve a little of the earth adhering to their roots, and in this way copious materials would be obtained.

The above observations entirely confirm Ehrenberg's statements as to the distribution of the *Diatomaceæ.* They furnish evidence of the fact that these organisms are far less affected by climate and temperature than larger plants or animals; since many of the very same species are found in every latitude and in every country. For example, such common forms as *Achnanthidium lanceolatum*, *Achnanthes exilis*, *Gomphonema tenellum*, *G. constrictum*, *G. capitatum*, *Cocconeis Placentula*, *C. Pediculus*, *Cocconema lanceolatum*, *C. cymbiforme*, *Synedra radians*, *Navicula elliptica*, *N. rhomboides*, *Pinnularia viridis*, *P. major*, *P. oblonga*, *P. borealis*, *Surirella biseriata*, *S. ovata*, *Meridion circulare*, *M. constrictum*, *Cymbella maculata*, *C. scotica*, *C. cuspidata*, *Epithemia turgida*, *Ep. Argus*, *Himantidium Arcus*, *H. gracile*, *H. majus*, *Odontidium mesodon*, *Diatoma tenue*, *D. vulgare*, *Nitzschia linearis*, *N. amphioxys*, *Melosira varians*, and many others actually occur in every part of the world from whence these soils have come; and there is absolutely no difference between the exotic and the British forms.

Ehrenberg specifies two species, namely, *Pinnularia borealis* (*P. latistriata*, W. G.) and *Eunotia amphioxys* (*Nitzschia amphioxys*, W. Sm.), as having been found by him in almost every instance. My results confirm this. In no case have both of these been absent, and in at least nine-tenths of these soils both are present. They are often the predominant forms, and in a few cases almost the only forms present. *Gomphonema tenellum* and *Achnanthidium lanceolatum* are found in a large majority of these soils.

I am disposed to agree in opinion with Ehrenberg, that the microscopic organisms found in soils contribute materially to the increase of the soil. This is true both of the siliceous and calcareous forms. The *Diatomaceæ* live in moist earth. They obtain silica from the water, and at their death their shells are added to the soil. Where many are present, this process of transference of silica from the rock to the soil goes on very rapidly. We have so far evidence that they live in these soils, that we find them there very often in the state of self-division, which is not observed in old accumulations of the dead shells.

The peculiar capacity of the *Diatomaceæ* for resisting climatic changes, whereby the same species can live and thrive as well in the Arctic circle as under the line, corresponds well with the results of the study of the same organisms in the fossil state. In Ehrenberg's 'Mikrogeologie' will be found very fine figures of the Diatoms occurring in the different forms of Bergmehl, Tripoli or polishing slate, Kieselguhr, pumice, and other volcanic rocks, mountain limestone, amber, &c., and it will be seen that by far the greater number of the species are quite identical with recent ones. Microscopic organisms have been found so low down as the green sand of the Silurian system; but they rather belong to the *Polythalamia*. The earliest Diatoms, geologically speaking, as figured by Ehrenberg, agree in every point, as far as the great majority of the species is concerned, with those now living in our waters, and forming deposits which will become rock at some future time.

It was supposed that most of the species in the much more recent Bergmehl were no longer to be found living; but most of them have been since found. I myself have lately found two species of the Lapland Bergmehl to be still in existence, namely, *Eunotia octodon* and *Synedra hemicyclus*; and *Eunotia incisa*, which occurs both in the Lapland and the Mull earths, has been found recent by me in a dozen

British gatherings. Yet all these forms were supposed, not long since, to be exclusively fossil. We cannot say that there are no species exclusively fossil, but so many that have been thought so are daily found living, that it is probable the rest may be so found too, and at all events, a very large proportion of the forms in the oldest fossil deposits are absolutely identical with the forms of the present day.

I have only further to mention, that although so many species are universal in their habitat, some appear to be local. Thus, *Terpsinoë musica* does not occur in Europe, nor has it yet been found except in America, and, I think, in Australia.

Some species are decidedly Alpine; for example, *Orthosira spinosa*, which Professor Smith found on the Mont d'Or in Auvergne, and Professor Balfour on the Grampians. It occurs also in nearly every soil from the Andes.

5. *On the Injurious Effects of an excess or want of Heat and Light on the Aquarium;* by Robert Warington, Esq., (Ann. Mag. Nat. Hist., vol. xvi p. 313.)—Temperature is a point requiring great attention in carrying out successfully the principles of a permanent aquarium. The mean temperature of the ocean is estimated to be about 56° Fahr. and this, under ordinary circumstances, does not vary more than about 12° throughout the different seasons of the year. The causes of this equilibrium will be readily understood when we take into consideration the effects that must be produced by the continued flux and reflux of the tides, and by the enormous streams of water which must be flowing from the Arctic regions from year's end to year's end in one constant current, and which, by their movement, must necessarily cause other currents to flow in and take their place, thus forcing, as it were, the heated surface-water of the tropical seas towards the colder regions of the globe. Again, the whole surface of the earth, submersed below the ocean, is protected by this fluid coating from the effects of the cooling influences of radiation on the one hand, and from contact with the currents of the atmosphere on the other; and hence we perceive an always existent cause for the maintenance of a steady, equable temperature by the waters of the ocean throughout the year.

Many of the inhabitants of the sea are very sensitive to changes of temperature, and we find that a few degrees of variation will cause them rapidly to move their position and seek some cooler or warmer spot as the case may be. In the ocean it will be evident that the creatures have the power readily to effect this under ordinary circumstances, by seeking deeper water not liable to be affected by atmospheric influences, by partially or entirely burying themselves in the sand or shingle, or by shielding their bodies under the protecting shadow of the rocks or growing vegetation. In arranging the rock-work in the interior of the aquarium, therefore, great care should be taken to keep these points in view, and to afford as much protection as possible to the creatures from the cooling influences of radiation on the one hand, and from the heat of the sun's rays on the other.

From my own experience I find that the range of temperature should not be below 50° Fahr., nor above 70°; within these limits all appears to progress healthily, but beyond these points many of the creatures are rapidly affected. During the last long-continued and severe winter, it was found very difficult, in an ordinary sitting-room having a south aspect and a good fire maintained throughout the day—the tanks being also screened at night by a blind,—to prevent the powerful cooling effects from radiation on a clear frosty night; and on three several occasions, marking exactly the three severest frosts that we experienced during the winter, the thermometer immersed in an aquarium containing about thirty gallons of water, fell as low as 45° Fahr. The Shrimp and Crab tribes, and the Crustaceans generally, are especially affected by these changes, and on each of the three occasions alluded to, one or two individuals perished; the larger-sized Prawns, as *Palæmon serratus*, appeared to suffer more readily than the *P. squilla*, although this might arise from the smaller ones being able to find a shelter from the radiation by concealing themselves more completely among the rock-work or vegetation. *Anthea cereus* is also very sensitive to considerable variations of temperature, falling from its foot-hold to the bottom of the tank apparently dead.

Excess of heat and also strong sunlight are likewise to be as carefully guarded against, and I may state as an evidence of this, that on a particularly hot day during the summer of 1854, being absent from home, the servant omitted to screen a small case from the sun's rays during the hottest period of the day, and on my return I found every creature dead. It contained an *Anthea cereus*, *Actinia dianthus*, two specimens of *Athanas nitescens*, and several others.

Too much light has also the effect of rapidly propagating several of the minute animalcules of a green color, as the *Euglena* and its congeners, which under this influence multiply so rapidly as to render the whole water of a grass-green hue; this will at times subside to the lower part of the tank as evening approaches and disappear in the shingle bottom, but immediately the morning light shines strong upon the aquarium it will rise like a thin green cloud and diffuse itself throughout the whole of the water. Although this animalcular growth is not unhealthy, yet it causes the aquarium to present a very unsightly appearance, and prevents all observation on the habits of the inmates. The want of light, I need hardly observe, causes the rapid decay of the vegetation, and the products arising from this change are highly poisonous to animal life, the whole contents of the aquarium becoming of a black color, and very soon of an offensive odor.

IV. Astronomy.

1. *Variable Star*, (Compt. Rend., 41 : 950.)—Mr. Luther at Bilk has discovered a new variable star called *T. Piscium*. Its variation in magnitude is from 9–10 to 11. Its position for the equinox of 1800 was R. A. $0^h\ 20^m\ 26^s$ and Dec. $+13°\ 26'$.

2. *New Comets*, (Astron. Journ., 90.)—Mr. C. Bruhns at Berlin discovered a comet on the 12th of November, appearing like a feeble nebula. Its position at $17^h\ 22^m$ of that day was R. A. $149°\ 1'\ 26''$, and Dec. $+2°\ 7'\ 15''$, with a daily motion in R. A. of about $-20'$ of arc and in Dec. almost nothing.

On the 12th of Dec., William Mitchell of Nantucket reported the discovery, at eight o'clock on the preceding evening, of a telescopic comet in the neck of *Cetus*.

3. *Two New Planets.*—M. Chacornac, at Paris, discovered January 12, 1856, a new planet, (38) fainter than a star of the 10th magnitude. On the 8th February, he discovered another planet (39) having a brightness of a star of the 8th or 9th magnitude.

In announcing these discoveries to the Academy, M. Leverrier remarked that he was more and more convinced that a large number of small planets exists between Mars and Jupiter, and that before 1860 probably as many as a hundred will have been detected.

4. *Elements of Fides* (36) or (37), (Astron. Journ., 90.)—These elements were computed by Mr. George Rümker from the observations at Bilk Oct. 6, Berlin Oct. 23, Hamburg Nov. 2 and 13.

Nov. 0·0, 1855.	M. T. Greenwich.	
Mean anomaly,	322° 17′ 40″·3	
Long. perihelion,	63 26 6 ·9	Mean equinox,
" asc. node,	8 8 56 ·2	Jan. 0·0, 1856.
Inclination,	3 11 43 ·6	
Angle excentricity,	8 22 25 ·8	
Log. semi-axis major,	0·415680	
" mean daily motion,	2·926487.	

5. *Elements of Comet* 1855, III, (Ibid.,)—Mr. George Rümker has computed the following elements from the observations of Berlin Nov. 12, Bilk Nov. 15, and Hamburg Nov. 20.

Perihelion passage Nov. 25, 66041, 1855, M. T. Greenwich.		
Long. perihelion,	85° 21′ 41″	Apparent equinox,
" asc. node,	52 2 47	Nov. 15.
Inclination,	10 16 29	
Log. q.,	0·088070	

Motion retrograde.

V. Miscellaneous Intelligence.

1. *Postscript to Prof. Rogers's Paper on Binocular Vision;* by the Author.—Since the last page of this article was put to press I have seen in an elaborate memoir of Czermak, entitled "Physiologische Studien," the first clear recognition I have met with of the fact that in stereoscope vision there is necessarily an interruption of the usual relation between the axial and refractive adjustments of the eyes. Lest my illustration of this subject, in Part I . . 4 and 5, should be supposed to have been suggested by the remarks of this able observer, I deem it proper to state that this and the other chief points of Parts I and II of my memoir, having been for some time familiar to my thoughts, were communicated to the Warren Club in December, 1854, and to the American Academy, on the 31st of January, 1855. Czermak's memoir forms part of the Sitzungsberichte der K. Ac. der Wissenschaften for March, 1855. This number was issued on the 23d of May following, more than a week after my MS. was in the hands of the printer, and did not reach the Boston Nat. Hist. Soc., where I have just met with it, until the 16th of the present month, nearly eight months after my ideas on this subject were in print. I may add that it has given me much pleasure to find the views of so philosophical an observer coincident in this particular with my own. W. B. R.

Boston, Feb. 26, 1856.

2. *On a modern Submerged Forest at Fort Lawrence, Nova Scotia;* by J. W. Dawson, Esq., F.G.S., (Quart. Journ. Geol. Soc., vol. xi, p. 119.)—The extraordinary tides of the Bay of Fundy, and its wide marshes and mud-flats, are well known to geologists as affording some of the best modern instances of rapid tidal deposition, and of the preservation of impressions of footsteps, rain-drops and sun-cracks. Attention had not, however, been called to the fact which I propose to notice in this paper, that much, if not the whole, of the marine alluvium of the Bay of Fundy rests on a submerged terrestrial surface, distinct indications of which may be observed in the mud-flats laid bare at low tide, and in the deep ditches dug for drainage.

In their natural state, the alluvial soils of the Bay of Fundy are mud-flats overflowed by the high tide, and either quite bare or covered in part with salt-grass. Large tracts have, however, been reclaimed from the sea, and are distinguished by the name of "dyked marsh," or more shortly "dyke." There are in Nova Scotia 40,000 acres of dyked marsh, and in New Brunswick perhaps 10,000 acres. The soil of the marshes is everywhere a fine marine mud, deposited in thin layers by the tides, and of a brownish-red color; except in the subsoil and in the lower parts of the surface where the color has been changed to gray by the action of sulphuretted hydrogen on the ferruginous coloring matter. Though remarkably productive of grasses and cereals, no part of the marsh-land supports forest trees. Dyked and salt marshes occur in nearly every creek and inlet of the upper part of the Bay of Fundy, more especially in Minas Basin, Cobequid Bay, and Cumberland Basin; and it is in this latter that the submarine forest to which this paper refers is found to underlie the marine alluvium.

Fort Lawrence is a low point of upland, resting on Lower Carboniferous rocks, and separating the estuaries of two small streams, the La Planche and Missequash; the latter forming at this place the boundary between Nova Scotia and New Brunswick. Both of these rivers, as well as the other streams emptying themselves into Cumberland Basin, have at their mouths extensive tracts of marsh, and in this instance the marsh-land extends beyond and overlaps the upland point separating the rivers. At the extremity of the point the upland slopes gently down to the dyked marsh, beyond which there is a narrow margin of salt-marsh, scantily clothed with coarse grasses and *Salicornia*. This margin of marsh without the dyke is overflowed by the highest tides, and may therefore be taken as the high-water level. Owing to the toughness of the upper layer matted with roots, and the action of the neap tides, it presents at the outer edge a perpendicular front about five feet in height. Below this there is a sloping expanse of red mud, cut into many inequalities by the tidal currents, which appear here to be removing the old deposit rather than adding new material. On the surface of this mud I saw impressions of rain-drops and sun-cracks, tracks of sandpipers and crows, and abundance of the shells of *Sanguinolaria fusca.** There were also a few long straight furrows, which I was told had been produced by the ice in spring. Owing to the firmness of the mud, they remained (in August) quite sharply marked, though in places filled up with new mud.

* Probably identical with *Tellina Balthica*, Linn.

At the distance of 326 paces from the abrupt edge of the marsh, and about twenty-five feet below the level of the highest tides, which here rise in all about forty feet, the mud becomes mixed with sand and gravel, with occasional large stones, probably dropped by the ice. At this level appear erect stumps and many prostrate trunks of trees. The stumps are scattered as in an open forest, and occupy a belt of 135 paces in breadth and extending on either side for a much greater distance. I saw more than thirty stumps in the limited portion of the belt which I examined. Between the lowest erect stumps and the water-level at low tide is a space of 170 paces, in which I observed only fragments of roots and prostrate trunks, which may, however, be the remains of trees swept away by the ice from the portion of the shore on which these fragments now lie.

On digging around some of the stumps, they were found to be rooted in ground having all the characters of ordinary upland forest-soil. In one place the soil was a reddish sandy loam with small stones, like the neighboring upland of Fort Lawrence. In another place it was a black vegetable mould, resting on a whitish sandy subsoil. The smallest roots of all the stumps were quite entire and covered with their bark, and the appearances were perfectly conclusive as to their being in the place of their growth. I have no doubt that the whole of these stumps have been deeply covered with the marsh-deposit, and have been laid bare by the encroachments of the tides on this somewhat exposed point. In a few places the lowest layer of the mud originally deposited over the forest soil could be observed. It is a very tough unctuous blue clay, with a few vegetable remains resembling roots of grasses. This may have been the first deposit from sea-water, while the forest was still sufficiently dense to prevent the access of coarser sediment.

All the stumps and trunks observed were pine and beech (*Pinus strobus* and *Fagus ferruginea*), and it is worthy of notice that these are trees indicative rather of dry upland than of swampy ground. The pine-wood is quite sound within, though softened and discolored at the surface. The beech is carbonized at the surface, and so brittle and soft that trunks of large size can be cut with a spade, or broken across by a very slight blow. Owing to this softened condition of the beech-stumps, they are rounded at top, and scarcely rise above the surface of the mud; while some of the pines project more than a foot. Even these last, however, are much worn and crushed by the pressure of the ice. The largest stump observed was a pine, two feet six inches in diameter, and exhibiting about 200 lines of growth.

These appearances cannot be explained by driftage, for the trees are rooted in a perfect woodland-soil; nor can they be accounted for by landslips, for the stumps are separated from the nearest upland by marshes nearly a quarter of a mile in width, and the upland is low and gentle in its slope. The popular explanation is that the tides have at some former period been dammed out, or their entrance obstructed by a narrowing of the mouth of the Bay. This theory is countenanced by the present state of the tideway of the St. John River, in which a ledge of rock so obstructs the narrow entrance, that, while at low tide there is a considerable fall outward, at half tide the water becomes level, and at high tide there is a fall inward; the level within not rising to that of high water without, except in times of flood, when the excess of fresh water in the river supplies the deficiency of tide-water. It is evident that the complete removal of this obstruction would enable every tide to overflow ground now covered only by the annual river-floods; and, on the other hand, the river would be daily drained out to the level of the low tide. Such an obstruction would without doubt produce a change in the water-level of Cumberland Basin, and might even enable trees to flourish a few feet below the present high-water mark; but it could not under any circumstances enable upland-woods to grow nearly at the level of low tide in a country so well supplied with streams.

The only remaining mode of accounting for the phenomena is the supposition that the subsidence to the amount of about forty feet has occurred in the district. Such a subsidence is not likely to have been limited to Fort Lawrence Point; and accordingly I have been informed by intelligent persons, long resident in the neighborhood, that submerged stumps have been observed at a number of other places, in circumstances which showed that they were *in situ;* and that trees and vegetable soil have been uncovered in digging ditches in the marsh. Nor are these appearances limited to Cumberland Basin. At the mouth of Folly River, on the southern arm of the Bay, a submerged forest on an extensive scale is said to occur; and in the marshes of Cornwallis and Granville vegetable soils are found under the marsh. These facts render it probable that the subsidence in question has extended over the whole shores of the Bay, and that the marshes have been deposited and the present lines of coast-cliffs cut since its occurrence.

The marshes of the Bay of Fundy are known to have existed at or about their present level for 250 years. It is true that an opinion prevails in some of the marsh-districts, that the tides now rise higher than formerly, and in proof it is alleged that the dykes are now maintained with greater difficulty, and that tracts of marsh once dyked have been abandoned. The settling of the mud and the narrowing of the tidal channels by new embankments may, however, have produced these effects. For the antiquity of these submerged forests, we must therefore add to the two centuries and a half which have elapsed since the European occupation of the country a sufficient time for the deposition of the alluvium of the marshes. On the other hand, the state of preservation of the wood, after making every allowance for the preservative effects of the salt-mud, shows that its growth and submergence must belong to the later part of the modern period.

It is a singular coincidence that this comparatively modern instance of the submergence and burial of a forest should occur in the vicinity of the Joggins cliffs, which so well exhibit the far more wonderful events of a like character which occurred in the Carboniferous Period.

3. *Bohemian Forests and Peat-bogs;* by Dr. Hochstetter*.—The primitive forests on Prince Schwarzenberg's domain, viz., at Krumau, Winterberg, and Stubenbach, may at a considerable distance be easily

* From the Proc. of the Imp. Geol. Inst. of Vienna, Jan. 23, 1855; translated and communicated by Count Marschall. Cited from Mag. Nat. Hist. [2], xvi, 378.

distinguished from the cultivated and regularly cut forests by their irregular and angular outlines; whilst the cupola-shaped summits of the firs rise considerably above the pyramidal pine-tops. Seen from an elevation, the difference between the primitive forest, with its withered tops and somewhat scattered trees, and the compact and verdant cultivated forest, is still more striking.

In some localities in the interior of the forests, the trees stand in straight lines of 150 to 200 feet [=155·55 to 207·4 English feet] in length as if planted so. Wherever the seeds do not find in the deep vegetable soil a site favorable for germination, their growth is exclusively confined to the roots and prostrate stems in a state of decomposition. Long after these stems have completely rotted away, their original length and situation are visible from the rectilinear arrangement of the younger trees, growing in the mouldering substance of the decayed veterans. This growth of the young plant on the decaying roots and stems serves also to explain the frequent occurrence of trees supported above the ground by means of exposed columnar roots, and, as it is termed, "standing on stilts."

The age of the pines and the firs in the primitive forest reaches as much as 300 to 500 years; the pines grow occasionally to 200 feet in height, and contain 1900 cubic feet [=2118·5 English cubic feet] of wood in their stem alone. One of the finest of the firs, 30 feet [=31·11 English feet] in circumference at a man's height, stood in the Brandelwald, near Unter-Muldau; it was lately blown down, and it is estimated to contain 30 klafters [=3012·03 English cubic feet] of fire-wood. Besides pines and firs, the forests in question contain beeches, maples, elms, birches, willows, and some, but very few, yew trees.

At present the extent of Prince Schwarzenberg's primitive forests is estimated at 30,000 Austrian acres [=42,660 English acres]; and the quantity of wood in them at 6½ millions of klafters [=652,606,500 English cubic feet]. A large portion of the wood from these forests is consumed in the neighborhood for the use of the glass-furnaces, and for the fabrication of musical instruments and touchwoods; but the major part is floated to the lower countries for timber and for fuel. Large quantities of the timber are sent annually to England and Hamburg for ship-building.

Rapacious animals, as bears, wolves, and lynxes, were formerly very abundant in the Böhmer-Wald, but have been exterminated. A bear, the last of its race, is supposed to be still haunting the Jokuswald, near Salnau.

The beds of peat or bituminous turf, locally denominated "Auen" or "Filze," may be considered in connection with these old forests. The whole upper part of the Moldau Valley, as far up as the neighborhood of Ferchenhaid, for an extent of 7 Austrian miles [=32·998 English miles], and with an average breadth of ¼ Austrian mile [=1·178 English mile], is one continuous peat-bed, traversed by the windings of the Moldau, whose waters assume a brownish tint by dissolving the extractive substances of the peat.

In the mountainous parts the peat-deposits are more isolated, amid surrounding forests. The dense vegetation of pumilous birches and pines covering their surfaces attests their antiquity, and points to their analogy with the primitive forests. Lakes occur in the centre of the peat-beds near Innergefild and Ferchenhaid. A swimming island, probably owing its origin to the central swelling and bursting of the peat, is seen in the last-named locality.

Cultivation is busy converting the peat-beds into forests, meadows, and arable-fields. These deposits, however, are of great importance in the economy of nature, and it may become a question of national economy how far this cultivation may proceed without injurious consequences. The climatal and meteorological influence of the peat-beds is the same as that of the forests; they even act with more energetic and concentrated effect. By acting as natural sponges in periods when water is abundant, they attract the superfluous humidity, and so prevent inundations. In seasons of drought they give up their accumulated waters. They are the real water-reservoirs in mountainous regions; generally giving rise to the rivulets and rivers and keeping their water-level constant during every season.

4. *Fossil Footprints;* by J. Wyman, (Proc. Bost. Soc. Nat. Hist., v, 258.)—Prof. Jeffries Wyman read a part of a memoir on the Footprints discovered by Professor Henry D. Rogers in the carboniferous strata of Pennsylvania. (*Vide* Proceedings of meeting of April 4, 1855.) He gave an analysis of the anatomical characters by which Reptiles and Fishes are distinguished from each other, and attempted to demonstrate, that although there are but few osteological characters, which, taken by themselves, are of absolute value as distinctions between these two classes, yet when the combinations of characters, which exist in any given instance, are considered, there can be but little room for doubt as to the true zoölogical affinities.

There exist no known forms of recent or fossil reptiles or fishes, which, where all their osteological details are known, cannot be referred unequivocally to one or the other of these classes. A comparison of the Icthyoid Reptiles and Sauroid Fishes shows, that although it is through them that the two classes approach nearest to each other, yet there are no forms so completely intermediate, as to bridge over the space which separates them.

He made comparisons between the form and structure of the feet of reptiles and the fins of fishes, showing, that although they resemble each other as regards their functions, yet morphologically they are always distinct. There is no known fish, recent or fossil, the pectoral or ventral fins of which could produce a series of tracks like those discovered in the coal strata of Pennsylvania by Mr. Lea and Prof. Rogers. Although among Lophioid fishes, the pectoral fins are used for locomotion on the shores, yet they, in every instance, conform to the fish type—are fins and not feet. An analogous condition of things is found among Cetaceans and marine Saurians, where the limbs serve the purpose of paddles, and may be compared to fins, yet, morphologically, they can be referred only to the Mammalian or Reptilian types.

Prof. Wyman therefore thought, that, in the present state of knowledge, there was no ground for denying that the quadrupedal tracks found in the coal formations were made by Reptiles.

5. *On Gutta Percha tubes*, (Proc. Bost. Soc. Nat. Hist., v, 268.)—Dr. H. R. Storer reported the results of some recent experiments upon the cohesive properties of different sizes of Gutta Percha pipe, made in connection with Mr. Charles Stodder.

The first trial was with one thousand feet of a pipe, of one inch internal diameter and one and three-sixteenths external diameter, intended for an aqueduct at West Cambridge. Upon applying a pressure of 80 lbs. to the square inch, a fine hole was discovered; this hole being closed with a hot iron, a pressure of 100 lbs. was borne with ease. The remainder of the experiments were made with short pieces of pipe varying from one to three feet in length.

A piece of the same pipe was subjected to the full test; it bore 266 lbs., and burst at 272 lbs.

Another piece of the same diameter internally, with one and five-sixteenths external diameter, from a different factory, bore 300 lbs., and burst at 320 lbs.

Pipe of seven-eighths of an inch internal diameter, and one and one-eighth external diameter, stood a pressure of 280 lbs., and burst at 304 lbs.

Pipe of five-eighths internal, and one and one-thirty-second of an inch external diameter, stood 320 lbs., and burst at 360 lbs. This is the size used in Boston for the Cochituate Water, and is there subjected to a pressure of not more than 60 lbs.

Pipe of one-half an inch internal, and five-eighths of an inch external diameter, bore 234 lbs., and burst at 240 lbs.

Pipe of the same diameter but of another manufacture, intended for an ordinary pressure of 35 lbs., stood 360 lbs., and then burst.

Pipe of quarter of an inch internal, and five-eighths of an inch external diameter, stood 720 lbs., and burst at 760. This is a stout pipe, used in the shops for effervescing soda water, and generally subjected to a pressure of about 200 lbs.

Dr. A. A. Hayes asked at what temperature the experiments were made, as the power of cohesion would vary with the temperature.

Dr. Storer replied, at the common temperature of the Cochituate Water.

Prof. Wm. B. Rogers asked if these pipes were of recent manufacture. He had made experiments upon the cohesive properties of Gutta Percha and had found that a very remarkable molecular change takes place in the material after some length of time, so that it readily breaks up and becomes utterly worthless in that condition.

Mr. Charles Stodder stated that the material which had been in the market at different times was of very different qualities, and that the crude article itself, was extensively adulterated by the natives before exportation. When first introduced here and into England, much bad material was obtained. Some samples were found to be acid, and lime was recommended for its neutralization. This remedy however soon became an abuse, for lime and oxyd of zinc were at one time extensively used for its adulteration, no less than fifty per cent of lime being often introduced. Mr. Stodder has specimens of the pure gum, manufactured into different articles several years since, now in good condition.

Mr. C. C. Sheafe said he had a pipe, connected with bellows and freely suspended in the air, which had been in use about eight months, and which was now as fragile as glass.

Dr. N. C. Keep stated that he had used small quantities of Gutta Percha for several years. He had observed that when allowed to rest untouched for a considerable length of time, it uniformly lost its tenacity; but on being worked over again with the aid of heat, it appeared as tough and good as at first. The simple process of heating is not sufficient for this purpose, but the material should be re-wrought. The greatest nicety is required in determining the proper degree of heat, as brittleness may be occasioned by overheating. The use which he had made of it was in dental operations, principally as a temporary filling in sensitive cavities, etc.

6. *Army Meteorological Register for twelve years, from* 1843 *to* 1854 *inclusive;* compiled from observations made by the officers of the Medical Department of the Army at the military posts of the United States. Prepared under the direction of Brevet Brigadier General Thomas Lawson, Surgeon General United States Army. Published by authority of Hon. Jefferson Davis, Secretary of War. 764 pp. 4to., with several maps. Washington: 1855.—This large and fine volume, for which the world is indebted to the war department of our government, and to the labors especially of the medical staff of the army, and for its final elaboration to Assistant Surgeon Richard H. Coolidge, U. S. A., and his associate, Lorin Blodget, has an interest, which belongs to no similar volume hitherto published on the subject, derived from the very wide range of the continent over which its fifty-one meteorological stations extend, through the east, the west, and far west, between the meridians of 67° and 123° and latitudes 26° and 47°. The tables are not however complete for each station, through the twelve years. The volume mainly consists of tables of the observations for each month of each year, presenting those of all the stations for the same month together, and other tables giving summaries of the results for each branch of the observations, the temperature, winds, rains, etc., all of which are drawn up with fullness and evident care. There are also other tables of "consolidated tables and summaries," bringing together the results at each station. Following these tables, there are five isothermal charts of the United States, showing the mean distribution of temperature for each of the four seasons and also for the year, designed and prepared by L. Blodget. The remaining eighty pages contain a Report on the Prominent Features of General Climate in the United States, as exhibited in the distribution of temperature and of rain, and in explanation of several Hyetal or Rain Charts, made out by Lorin Blodget. As for the isothermal lines, each of the seasons, and the year also, has a separate chart devoted to it, and represents boldly to the eye the results of the observations as deduced by Mr. Blodget. Regions are shaded lighter or darker according to the amount of rain or number of inches for the season, two inches, three inches, five inches, seven inches, ten, and so on, making separate areas on the charts, and thus displaying the relative dry or wet character of different portions of the United States across the continent. More observations at a greater number of stations are required, to give full accuracy to such charts.

Dr. Coolidge, in whose hands the preparation of the work was placed, remarks in his preparatory communication, that while his own exertions have been unremitting, "the general arrangement of the tables and the grouping of the stations in climatological districts were adopted principally at the suggestion of Lorin Blodget, Esq., who has been associated with me in the preparation of the work. The isothermal and rain charts were designed and prepared exclusively by him, and he is entitled to whatever of scientific value may attach to them, and to the accompanying report explanatory of the principles upon which they were constructed, and of the results which they exhibit."

7. *The Philosophy of the Weather, and a guide to its changes;* by T. B. Butler. 414 pp. 12mo. New York, 1856, D. Appleton & Co.—The author of this new work on Meteorology has brought forward valuable results from his own observations, with regard to the clouds and winds, and reviewed the general subject of the winds and weather. We cite the following from his remarks on clouds.—

"First, then, commencing at the earth, we have what may be properly termed *fog*, or low fog. This forms, in still clear weather, in the valleys, and over the surface of the rivers and other bodies of water, during the night, and most frequently the latter part of it, and is at its acmé at sunrise, or soon after, limiting vision horizontally and perpendicularly, and dissolving away during the forenoon. It is rarely more than from two to four hundred feet in height at its upper surface, and often much less, and is composed of vesicular condensed vapor, sometimes sufficiently dense to fall in mist, and is doubtless in composition substantially what the clouds are in the other strata of the atmosphere, as observed by us, or passed through by aeronauts. I have never seen it carried up to any considerable height into the other strata by any of the supposed ascending currents, to form permanent clouds, and shall have occasion to allude to the fact in another connection. It disappears usually before mid-day, and has, when thus formed, no connection with any clouds which furnish rain.

To this Dr. Howard originally gave the name of stratus; but the latter term may be with greater propriety applied to the smooth uniform cloud in the superior strata from which the rain or snow is known to fall, and I shall retain and so apply it.

The next in order, ascending, is high fog. This is usually from one to two thousand feet in height at its lower surface. It forms, like low fog, during the night and in still weather; and is rarely, if ever, connected with clouds which furnish rain. It breaks away and disappears between ten and twelve in the forenoon, usually passing off to the eastward. This fog is most commonly seen in summer and autumn, particularly the latter, and unless distinguished from cloud will deceive the weather-watcher. It is readily distinguishable. Although often very dense, obscuring the light of the sun as perfectly as the clouds of a northeast storm, it differs from them. It forms in still clear weather, is present only in the morning, is perfectly uniform, and, before its dissolution commences, without breaks, or light and shade or apparent motion, and unaccompanied by scud or surface wind. The storm clouds are never entirely uniform or without spots of light and shade, by which their nature can be discerned, and rarely, when as dense as high fog, without scud running under them and surface winds.

There is another fog still, connected with rain storms, but it does not often precede them; occurring at all seasons but most commonly in connection with the warm southeast thaws and rains of winter and spring; and which usually comes on *after* the rain has commenced and continued for awhile, and the easterly wind has abated; occupying probably the entire space from the earth to the inferior surface of the rain clouds or stratus. Practically this does not require any further notice. It is an *incident* of the storm. When formed it remains while the storm clouds remain, and passes off with them. It is sometimes exceedingly dense in February and March, when it accompanies a thaw, and if there is a considerable depth of snow, it has the credit of aiding essentially in its disssolution.

The next in order, ascending, are the storm scud, which float in the northeast or easterly, southeast or southerly wind, before and during storms.

These, as the reader will hereafter see, are, *practically*, very important forms of cloud condensation—although they have found no place in any practical or scientific description given of the clouds. They are patches of foggy seeming clouds of all sizes, more or less connected together by thin portions of similar condensation, often passing to the westward, south-westward, north-westward, or northward with great rapidity. Their average height is about half a mile, but they often run much lower. They are usually of an "ashy gray" color.

At about the same height, but in a *different state of the atmosphere*, float the peculiar fair-weather clouds of the northwest wind. They usually form in a clear sky, and pass with considerable rapidity to the southeast. Sometimes they are quite large, approaching the cumulus in form, and white, with dark under surface, and at others, in the month of November particularly, are entirely dark, and assume the character of squalls and drop flurries of snow; and then resemble the nimbus of Howard. They assume at different times and in different seasons, different shapes like those of the scud, the cumulus, or the stratus.

They form and float in the peculiar northwest current which is usually a fair-weather wind, and are never connected with storms. In mild weather they are usually white, and in cold weather sometimes very black, and at all times differ *in color* from the ashy gray scud of the storm."

Then follow remarks on the cumulus, stratus, and cumulo-stratus varieties of clouds. The author combats the received theories of atmospheric currents, and urges another, dependent on the magnetic character or currents of the earth and clouds. Although this theory can hardly meet with favor, the work will abundantly repay perusal and study, for the facts and comparisons he has brought out, which, if they they do not sustain his particular theory, tend to elucidate the general characters of storm regions and winds.

8. *Sixty-ninth Annual Report of the Regents of the University of the State of New York.* 392 pp. 8vo. Albany, 1856.

9. *Geological Tour over the State of New York.*—We would commend to all students who wish to acquire a knowledge of American geology, the following announcement of Col. E. Jewett of Utica, New York. He is well acquainted with all the interesting localities of rocks and fossils and has himself one of the largest collections of New York fossils that have been made. He has gone on such tours with students for several years; and last year, as well as the preceding, several joined him from Cambridge, by the strong recommendation of Prof. Agassiz. New York is the key state of the continent in a geological point of view, and no better field for study on the part of a beginner in the science could be pointed out.—Col. Jewett writes as follows:

"I propose to be at Burlington, Vermont (where any student can join the party,) on Tuesday morning the fifth of August, and begin the campaign at Port Kent opposite, on the Potsdam sandstone.—If the weather is favorable the tour can be made in four weeks. The whole expenses for each individual will amount to about one hundred dollars, while with me, my fee is thirty dollars.

A very fair collection of fossils can be made by all who wish, and the tour itself is one of the most pleasant that can be marked out. We shall visit the beautiful cañon of the Au Sable, the Thousand Isle of the St. Lawrence, the Falls of the Genesee at Rochester, Niagara falls, Portage falls, Trenton falls, and all the other principal towns and cities of northern and western New York. All who have accompanied me have expressed their pleasure and entire satisfaction."

We understand also that Col. Jewett has labeled collections of fossils and rocks to dispose of.

10. *Earthquakes in California;* by W. P. Blake.—It is well known in California that it is an "earthquake country." The name given to one of the broad indentations of the coast—*Bahia de los Temblores* (Earthquake Bay)—shows their frequency as experienced by the early settlers. I might occupy much space in recounting the recorded earthquakes that have shaken various parts of California for the last fifty years. The severe earthquake of 1812, which destroyed one of the Southern Mission establishments, is not yet forgotten by the native Californians. This, however, is not the only severe shock which has been felt, and which has destroyed life and property. According to J. B. Trask, of California, who has made a record of all the known shocks since 1812, there have been fifty-nine earthquakes during the last five years. The earthquake which occurred at Fort Yuma in 1852 was sufficiently violent to throw down a portion of Chiminy Peak, a high pinnacle of rock many miles north of the Fort. I experienced two shocks in 1854 in San Francisco, one of them sufficiently violent to awaken me by the sudden movement of the bed. A notice of this was given in Silliman's Journal. A letter just received from Dr. Trask states that "the recent shock in San Francisco occurred at 5.25 P. M., February 15th. The motion was undulatory, and at the same time vertical. Square bottles and boxes were moved horizontally, and described an arc of about 30 degrees. In some of the stores on Montgomery and other streets small articles were thrown outwards two or three feet from the south side of the walls, and those next the north walls were thrown forwards in several cases." He further states that "it was the fifth earthquake felt in the city since the 2d of January."

11. *The Mastodon giganteus of North America*, by Dr. John C. Warren. 2nd edition, 260 pp., 4to, with 31 plates, Boston, 1855.—Dr. Warren has brought out a second edition of his great work on the Mastodon. The first edition was issued, through his munificence, simply for private distribution. As there have been frequent inquiries for it by those who wished to purchase copies, he has issued this second edition. The author has made some important additions, and among them three new plates.

12. *The Canadian Journal of Industry, Science, and Art;* Conducted by the Editing Committee of the Canadian Institute; New Series, Number 1, January, 1856, 96 pp., 8vo, Toronto, Canada West. —The Canadian Journal appeared with the January Number in octavo form, and from the character of its contributors as well as the sterling value of the number issued, it is evident that it will take a high stand among the Scientific and Educational Journals in our language. Its scope is partly literary as is apparent from the names of the Editing Committee (mostly Professors in Trinity College, Toronto), as follows: Prof. Daniel Wilson, LL.D., General Editor, Prof. E. J. Chapman, in Geology and Mineralogy, Prof. J. Bovell, M.D., in Physiology and Natural History; Prof. D. Wilson in Ethnology and Archæology; Prof. H. Y. Hind in Agricultural Science; Prof. H. Croft in Chemistry; Proff. Cherriman and Irving in Mathematics, F. W. Cumberland, C.E., and A. Brunel, C.E., in Engineering and Architecture.

13. *Die Fortschritte der Physik im Jahre* 1852; dargestellt von der physikalischen gessellschaft zu Berlin. viii Jahrgang. Redigirt von Dr. A. Krönig. In two parts, 8vo, of 794 pages, Berlin, 1855, George Reimer.—These two volumes contain abstracts or reviews of the various papers and works on Physics published during the year 1852, and is a whole library in a small compass. The work is prepared with great ability, being well classified, and embracing Physics in its wide range: Molecular Physics, Cohesion, Adhesion, Capillarity, Density, Mechanics, Hydromechanics, Aeromechanics, Elasticity, Fusibility, Condensation, Absorption, Acoustics, Optics in its various departments (theoretical optics, Refraction, Photometry, Polarization, Physiological optics, Chemical action of Light, Optical apparatus,) Heat with like fullness, Electricity, Physics of the Earth, (Electricity, Magnetism, Meteorological optics, &c.,) Physical Geography, (Hydrography, Orography, Volcanic phenomena,) Meteorology, etc.

14. *Annals of the Lyceum of Natural History of New York;* vol. vi, No v, 32 pp., 8vo, New York, Wiley and Halsted.—This new number of the Annals is illustrated by four finely colored plates of shells and one of a humming bird (*Mellisuga albo-coronata*, Lawrence). The contents of the number are as follows:—

Art. XVIII. F. Poey: on different points in the Natural History of Cuba, with reference to the U. S. Icthyology.

XIX. G. N. Lawrence: On a new Mellisuga, with a note on Trochilus aquila, Bourcier.

XX. W. Newcomb: Descriptions of new species of Achatinella.

XXI. T. Bland: On certain terrestrial Mollusks of the West Indies.

XXII. E. Chitty: On Two new species of Cylindrella, from Jamaica.

XXIII. W. A. Haines: On four new species of terrestrial shells from Siam.

XXIV. J. G. Anthony: On new species of Ancylus and Anculosa, from the Western States, U.S.

XXV. J. Gundlach: Description of a new Sylvicola.

XXVI. O. W. Morris: On the quantity of rain at different heights.

Those interested in Science, would promote the cause greatly, if they would become subscribers for the Annals of the Lyceum, the Proceedings of the Academy of Natural Sciences of Philadelphia, and the Proceedings and Journal of the Boston Society of Natural History. The annual charge is very small. The Journal of the Acad. Nat. Sci. of Philadelphia in 4to, is more costly, yet there are many through the country who would do well to science and themselves by taking it.

Officers for 1856.—*President*, Joseph Delafield; *1st Vice President*, William Cooper; *2nd Vice President*, J. Carson Brevoort; *Corresponding Secretary*, John H. Redfield; *Recording Secretary*, Robert H. Brownne; *Treasurer*, Charles M. Wheatley; *Librarian*, O. W. Morris.

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Committee of Publication.—William Cooper, Thomas Bland, Geo. N. Lawrence, John H. Redfield, John G. Adam, M.D.

A Geological Map of Europe, exhibiting the different Systems of Rocks, according to the more recent researches and inedited materials. By Sir R. I. Murchison, D.C.L., M.A., F.R.S., &c., Director General of the Geological Survey of Great Britain and Ireland, and James Nicol, F.R.S.E., F.G.S., Professor of Natural History in the University of Aberdeen. Constructed by A. Keith Johnston, F.R.S.E., &c., Geographer to the Queen. Size, 4 feet 2 by 3 feet 5 inches. Price in sheets, 3*l.* 3*s.*; in a cloth case, 4to, 3*l.* 10*s.* William Blackwood & Sons, Edinburgh and London; and W. & A. Keith Johnston, Edinburgh.

The Microscope and its Revelations; with numerous engravings on wood. By W. B. Carpenter, M.D., F.R.S. Fcap. 8vo, cloth, 12*s.* 6*d.*

A Manual of Photographic Chemistry, including the practice of the Collodion Process. By T. Frederick Hardwich, late Demonstrator of Chemistry, King's College, London. Second edition, fcap. 8vo, cloth, 6*s.* 6*d.*

Proceedings Acad. Nat. Sci. Philadelphia, Vol. XIII, No. 1.—p. 6, Description of several species of Urodela, with remarks on the geographical distribution and classification of the Caducibranchiate division of these animals; *E. Hallowell.*—p. 11, Description of two Ichthyodorulites, *J. Leidy.*—p. 12, Synopsis of Mycetophagidæ of the United States; *J. L. LeConte.*—p. 18. Note on the genus *Lithodus* Schonherr; *J. L. LeConte.*—p. 19, Three genera of Scarabæidæ found in the U. States; *J. L. LeConte.*—p. 25, Analytical table of the species of Chlænius in the U. States; *J. L. LeConte.*—p. 29, Synopsis of the species of Chrysomela and allied genera in the United States, with a plate; *W. F. Rogers.*—p. 39, On North American birds in the collection of the Academy and the National Museum, Washington; *J. Cassin.*—p. 42, Synopsis of Entozoa and some of their Ecto-congeners observed by the Author; *J. Leidy.*—p. 59, On some extinct mammalia from Nebraska; *J. Leidy.*

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Yale College, New Haven, July, 1855.

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The next No. of this Journal will be published on the first of July.

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