ter months; the high mean temperature of the autumn months; the very large rainfall, which came within half an inch of the extraordinary precipitation of the year 1876; the unusual percentage of cloudiness; the low velocity of the wind; the decided preponderance of south winds over north winds; and the increased percentage of atmospheric humidity.

The master of the steamship British King, from Swansea, reports, Jan. 15, in latitude 41° north, longitude 67° 10′ west, encountering an electric storm which lasted about four hours. The weather had been overcast with heavy rain from noon until six P.M., when the wind shifted from south-west to west, followed by loud claps of thunder and vivid flashes of lightning. At the same time large balls of 'St. Elmo's fire' were seen on all the yard-arms and mastheads. All of the stays and back-stays were covered with sparks of fire of a bluish tint.

Professor Kiessling of Hamburg has issued a circular in the name of the Hamburg-Altona branch of the German meteorological society, asking practised observers, accustomed to noting the appearance of the sky, for reports on the colors still visible in the neighborhood of the sun in clear weather, as well as for records of the dates on which these peculiar displays first became visible. He regards them as sequels to the extraordinary twilights of 1883, and considers all these optical effects as results of the Krakatoa eruption. The phenomena on which observations are especially desired are the vaguely defined, smoky, reddish ring enclosing a brilliant whitish disk around the sun; and the pale red tint that has been seen between clouds at a greater distance from the sun, while the solar disk itself was hidden. Observations from distant, out-of-the-way stations are particularly valuable; and the records of mountain observatories are of greater interest than those of lower levels, as the solar diffraction ring is much more distinct when seen in the relatively clean upper air than when viewed through the dust-laden strata of the lower atmosphere. Professor Kiessling has published valuable papers on the optical theory of the brown-red ring in the *Naturforscher* and in *Das wetter*.

In his report on the New-Hampshire state triangulation in 1884, Prof. E. T. Quimby says, "It may be proper to mention that while the 'red sunsets' have not been so marked as they were a year ago, the Krakatoa dust has been constantly and plainly visible from sunrise to sunset every day when the sky has been free from clouds. There has been no day when the sky has had its normal blue."

THE CHEMISTRY AND PHYSICS OF THE SEA.

FORCHHAMMER showed in 1864, by his analysis of several hundred samples of sea-water, that, though the water of the ocean may vary greatly in degree of dilution, the composition of the saline matter in solution is, for surface-waters, and so far as concerns the chlorides and sulphates of sodium, magnesium, and calcium, — the principal components, — constant within the limits of error of his work. Besides these more important constituents, other substances to the number of twenty-four elements are known to occur, but in their entire sum amount to but a small fraction of one per cent of the total saline matter.

In part i. of the volume before us, Professor William Dittmar gives his researches into the composition of ocean-waters collected by the Challenger. Seventy-seven samples, representing different stations upon the ocean, and various depths beneath the surface, yielded figures, which, agreeing fairly well with those of Forchhammer, and better still among themselves, seem to warrant the conclusion that the composition of the salts in sea-water is independent of the latitude and longitude of the station from which the water is taken, and of depth also, so far as concerns the chlorine, sulphuric acid, magnesia, potash, soda, and bromine. The proportion of lime, however, increases with the depth of the water. The following table contains Professor Dittmar's figures for the mean composition of the salts in sea-water, in comparison with those of Forchhammer: —

	Per hundred parts of total salts.	Per hundred of halogen calculated as chlorine.	
	Dittmar.	Dittmar.	Forchhammer.
Chlorine	55.2920	99.8480	Not determined.
Bromine	0.1884	0.3402	Not determined.
Sulphuric acid (SO_3)	6.4100	11.5760	11.88
Carbonic acid (CO_2)	0.1520	0.2742	Not determined.
Lime (CaO)	1.6760	3.0260	2.93
Magnesia (MgO)	6.2090	11.2120	11.03
Potash (K_2O)	1.3320	2.4050	1.93
Soda (Na_2O)	41.2340	74.4620	Not determined.
(Basic oxygen, equivalent to halogens)	(−12.4930)	–	–
Total salts	100.0000	180.5840	181.10

Or, combining acids and bases arbitrarily,

Chloride of sodium	77.758
Chloride of magnesium	10.878
Sulphate of magnesium	4.737
Sulphate of lime	3.600
Sulphate of potash	2.465
Bromide of magnesium	0.217
Carbonate of lime	0.345
Total salts	100.000

The difference between surface and intermediate waters in the contents of lime was 0.0125

Report of the scientific results of the voyage of H. M. S. Challenger during the years 1873–76. Physics and chemistry. Vol. i. London, *Government*, 1884. 307 p., 278 pl., map. 4°.

parts, and that between surface and bottom waters 0.0132 parts, referred to a hundred parts of halogen. The fact that deeper waters do contain more lime than surface-waters, Professor Dittmar attributes to the action of life near the surface in removing lime from solution, and to the tendency of bottom-waters to take it up from the ocean-floor.

As is natural, the alkalinity, too, increases with depth; and the difference between surface and bottom waters in this respect corresponded in Professor Dittmar's determination to 0.014 of lime, which is so near to the figures found in the direct determination of the lime, that the closeness of agreement must be accidental.

Concerning carbonic acid in sea-water, the evidence goes to show, that, as a rule, it is present in insufficient amount to convert to bicarbonate that base which is in excess of the sulphuric acid and halogen, and is free only exceptionally; that in surface-waters it varies inversely with the temperature, and for equal ranges of temperature seems more abundant in the waters of the Atlantic than in those of the Pacific Ocean. The quantities of oxygen and nitrogen absorbed by sea-water are functions of the temperature. Nitrogen varies within the same limits in deep and shallow waters; oxygen is generally present to a smaller extent than the hypothesis of surface absorption of atmospheric air, at the temperature corresponding to the amount of nitrogen found, would demand; and the absolute amount of oxygen in waters of great depths, and occasionally in waters of only moderate depths, is often exceedingly small.

Professor Dittmar discusses his analyses with great elaboration, and devotes much space to chapters upon the salinity and specific gravity, bromine, carbonic acid, alkalinity and absorbed gases of ocean-water. In the analysis the desirability of preciseness was constantly in view. Thus, for example, much stress is laid on the necessity of *weighing* portions for analysis, as is usual with concentrated mineral waters; and, in the estimation of total halogen by Volhard's method, Professor Dittmar secures greater accuracy by *weighing* the precipitating solution of silver nitrate, and then effecting the final titrations with centesimal solutions of ammonium sulphocyanate and silver nitrate. It is quite plain, however, and much to be regretted, that the lack of water at Professor Dittmar's disposal (never exceeding, and often falling short of, two litres) has affected the value of the work. Very few processes of analysis can bear the magnifying of inherent error a hundredfold; and 10 cm^3 of sea-water, to which Professor Dittmar felt restricted for single determinations of total halogen, is an exceedingly small portion when the result is to be expressed in grams to the litre of water, or in parts to the hundred grams of total salts. With an adequate quantity of material at hand, 40 cm^3 need not have been made to serve for a determination of lime and magnesia; nor would such processes as the estimation of magnesia as pyrophosphate, and sulphuric acid as barium sulphate, have been denied ordinary care to insure the purity of the substance weighed. In the case of the lime, it was found, when some of the residues of analysis were combined and tested, that the average error amounted in one set of thirty determinations to eight per cent, and in another series of twenty-six to nine per cent, of the total. With so large a margin of error, the application of the mean correction to individual determinations, as well as to the determinations of a series of twenty-one, the residues of which were not available for examination, is fraught with too much uncertainty. The difference, for example, between the corrections of eight per cent and nine per cent, would amount to nearly three times the difference which Professor Dittmar finds between surface and bottom waters as regards their contents of lime. Fortunately, Professor Dittmar's interesting conclusion concerning the distribution of lime in ocean-water does not rest upon the individual determinations alone, but depends upon his results with the mixtures of 'surface,' 'intermediate,' and 'deep-sea' waters, which allowed him ten times the material for an analysis which he had previously employed, and permitted the adoption of proper precautions.

Professor Dittmar's report closes with some very pertinent suggestions as to future work.

Part ii. contains Mr. J. Y. Buchanan's record of something like fifteen hundred hydrometric determinations of the specific gravity of waters from various parts and different depths of the ocean, and several plates illustrating the variation of density over the surface and in depth. It appears that the waters of the open ocean vary in density between the limits 1.02780 and 1.02400, pure water at 4° C. being taken as the standard.

In part iii. Staff-Commander Tizard tabulates the deep-sea temperatures, and shows, by the method of co-ordinates, the manner in which temperature varies with depth for each station of observation. Tables summarizing the observations, grouping and averaging them by localities, are appended.

The discussion of the records of part ii. and part iii., together with the meteorological data of the expedition, is in course of preparation by Professor Tait and Mr. Buchan.

PUBLICATIONS OF THE NAUTICAL ALMANAC OFFICE.

In the first part of this volume, Professor Newcomb presents a detailed development of the perturbative function which is applicable to all cases, except extreme ones, in which a general development of planetary inequalities in terms of the time is sought, and by which any required derivatives of the function may be found with great facility. In order to afford some idea of its range of application, he compares this development with others having the same general object; viz., those of Laplace, De Pontécoulant, Peirce, Leverrier, Hansen, and Cauchy. The method of this development has previously been indicated by Professor Newcomb, in the *American journal of mathematics*, vol. iii. The second part of this volume of the 'Astronomical papers' (pp. 201–344) is a determination of those inequalities of the moon's motion which are produced by the figure of the earth, and is by Dr. G. W. Hill, assistant in the office of the *Nautical almanac.*

In Delaunay's 'Théorie du mouvement de la lune,' the perturbations of the moon by the sun were fully treated; but subordinate portions of the theory were in some cases unfinished, and in others untouched. Having waited more than ten years for the promised filling of these gaps by French astronomers, Mr. Hill has in this paper taken up, in his masterful way, the discussion of the perturbations which the moon undergoes on account of the figure of the earth, the appreciable character of which was first brought to light by the analysis of Laplace. In his 'Darlegung der theoretische berechnung,' etc., Hansen has dealt with these inequalities in a very thorough way; but Mr. Hill has investigated these perturbations to the same degree of algebraical approximation that Delaunay adopted in determining the solar perturbations, viz., to terms of the seventh order inclusive; and his memoir is thus most appropriately entitled 'A supplement to Delaunay's theory of the moon's motion.'

The third part of the same volume (pp. 345–371), by Professor Newcomb, treats of the motion of Hyperion. In several papers published during the past five years, Professor Asaph Hall has shown a remarkable retrograde motion in the peri-Saturnium of its orbit, the period of its revolution being about eighteen years. At first sight, this result appears inconsistent with the law of gravitation; for it is easily shown that in the case of a body moving in an eccentric orbit, and disturbed by another moving in a nearly circular one, the secular motion of the peri-centre will always be direct. As Titan is much the brightest, and much the nearest to Hyperion, of all the satellites of Saturn, Professor Newcomb investigates the results of its attraction upon this satellite, and shows that the ordinary theory of secular variations is entirely inapplicable to the mutual action of these satellites, and that we have here an entirely new case in celestial mechanics. The ordinary theory of secular variations presupposes that the mean motions of any two bodies to which it is applied are incommensurable; so that to any given mean longitude of the one, will correspond, in the course of time, every mean longitude of the other. The conjunctions of the two bodies will thus be scattered through every part of the orbit. But four times the mean motion of Hyperion is nearly equal to three times that of Titan; so that, if the two satellites are in conjunction at a given time, when Hyperion has completed three revolutions, Titan will have completed four, and another conjunction will occur at very nearly the same point. In its outer form, this relation between the two satellites is somewhat analogous to that among the satellites of Jupiter; but it is quite different in its cause. Professor Newcomb develops the modified formulae applicable to this case; and among other results of interest is the determination of the mass of Titan equal to $\frac{1}{12500}$ part that of Saturn.

Astronomical papers prepared for the use of the American ephemeris. Vol. iii. parts i.–iii. Washington, *Government*, 1884. 371 p. 8°.

FORCHHEIMER'S TUNNEL-BUILDING IN ENGLAND.

Dr. Forchheimer visited England in the spring of 1883, by ministerial authority, to inspect and report upon the class of engineering work represented by the title below, confining himself, for the most part, to tunnels in progress or recently completed. Several most instructive examples are to be seen there, and

Englische tunnelbauten bei untergrundbahnen, sowie unter flüssen und meeresarmen: ein reisebericht. Von Dr. Philipp Forchheimer, ingenieur, privatdocent an der königl. technischen hochschule zu Aachen. Aachen, *Mayer*, 1884. 8 + 69 p., 14 pl. 8°.