surface, *Salix polaris* being the most common form. Of other species found, the following have, up to the present, been recognized: *Salix herbacea*, *Dryas octopetala*, *Betula nana*, *Polygonum viviparum*, *Saxifraga cæspitosa* or an allied species, mosses, &c.

From Kunda we went to Hellenorm in Livonia (8), where we were welcomed by the old Siberian traveller, A. Th. van Middendorff, who took a great interest in my researches. On the day of our arrival Prof. Schmidt found a leaf of *Salix reticulata* in a bed of clay at Samhof. In another clay-bed in the vicinity, at Kinzli, I found *Dryas octopetala*, *Betula nana*, *Salix* sp., mosses, &c.

Then we went to Fellin (9), where I found the Arctic plants at two different localities, Pingo and Wieratz. The species obtained were *Dryas octopetala*, *Betula nana*, *Salix reticulata*, *Potamogeton* sp., &c. I then parted from Prof. Schmidt, and went to Rjeshiza (10), in the Government of Vitebsk, accompanied by Dr. J. Klinge, of Dorpat. In Rjeshiza we were welcomed by Dr. E. Lehmann, a skilful botanist; and on the very day of our arrival we discovered the following Arctic plant-fossils, *Dryas octopetala*, *Betula nana*, *Polygonum viviparum*, &c., in two different localities in the vicinity of the town. My ignorance of the Russian language made it impossible for me to continue my researches further eastwards into the interior of the country, and I consequently turned westwards to Königsberg, in Eastern Prussia. There Prof. A. Jentzsch reminded me of the discovery of *Hypnum turgescens*, in an alluvial deposit at Kuhrische Nehrung, made by Berendt many years ago. As this is a mountain species, it is possible that it may have been found in a glacial fresh-water deposit, and this locality has consequently been indicated on the sketch map (11).

Accompanied by Prof. A. Jentzsch, of Königsberg, and by Prof. H. Conwentz, of Danzig, I now went to Marienburg, in Western Prussia, and at Schroop (12), about 10 kilometres south-east of this town, a locality yielding Arctic plant-fossils was discovered. They occur here under precisely the same conditions as in Scania or at Kunda, in Esthland; *Salix polaris* and *Dryas octopetala* being found in the lower strata, whilst *Betula nana* occurs somewhat higher. The next locality discovered was at Krampkewitz (13), near Lauenburg, in Pomerania, whither I had gone with Prof. Conwentz. The plant-fossils found were *Dryas octopetala*, *Betula nana*, and some others.

Owing to heavy rains, a visit to Breslau proved fruitless, and for the same reason the fresh-water deposits near Waren and Rostock were inaccessible, but acting on the advice of Prof. E. Geinitz, of Rostock, I examined a small peat-moss at Nantrow (15), north-east of Wismar, where I found *Betula nana* and some *Salices* in mud and sand underneath the peat. The following day I examined the sections at the great North Sea–Baltic Canal at Holtenau, north of Kiel (16), under the guidance of Prof. R. v. Fisher-Benzon, of Kiel. We succeeded in finding two fresh-water basins yielding plant-fossils. The first basin, of which only a small portion now remained, contained fruits of *Betula nana*, together with some other species, not yet determined, but probably indicating a sub-Arctic climate. In the other basin, which was also cut through by the canal, the glacial fresh-water strata underneath the peat were laid bare, yielding abundant leaves of *Salix polaris*, sometimes intermingled with those of *Dryas octopetala*, mosses, &c.

In view of these facts, thus briefly communicated, I think it may be accepted as proved that the Arctic flora flourished on the plains south and east of the Baltic round the margin of the ice-sheet, and some time after the inland ice had melted away (see the accompanying sketch map). There can also be hardly any doubt that this same flora may have lived round the margin of the great northern inland ice at the climax of the glaciation. For otherwise it is difficult to understand how it could have obtained so great an extension as from Suffolk to Kunda, in Esthonia, or why it should have flourished during so long a time after the amelioration of the climate, which caused the melting of the ice, had commenced. The fresh-water deposits with Arctic plants are sometimes so thick that they probably indicate an interval of several thousand years, during which the Arctic flora prevailed. If the margin of the ice-sheet at the climax of glaciation had been surrounded by a forest growth, this ought still more to have existed round the margin of the retreating ice. But as we have shown that this is not the case, we are entitled to conclude that the Arctic flora formerly flourished, not only round the margin of the great northern inland ice, but probably also over a part at least of the area between this ice and the glaciers of the Alps. In connection with this, it ought not to be overlooked that the Arctic tundra-fauna, which Prof. Nehring discovered at Thiede, underneath the steppe-fauna, perfectly harmonizes with this view, as this locality is situated relatively near to the outermost margin of the great northern ice-sheet. The existence of *Salix polaris* in Suffolk and Norfolk may also be considered as a strong argument for the same hypothesis. Thus the theory advanced by E. Forbes so far back as 1846—that the Alpine flora of Europe, so far as it is identical with the flora of the Arctic and sub-Arctic zones of the Old World, is a fragment of a flora which was diffused from the north, and that the termination of the glacial epoch in Europe was marked by a recession of an Arctic fauna and flora northwards—may now be regarded as definitively proved.

A. G. NATHORST.

CYCLONES IN THE ARABIAN SEA.[1]

THIS discussion was undertaken primarily by the Meteorological Office with the object of throwing some light on the very exceptional storm which was experienced at Aden in the summer of 1885, but advantage was taken of this opportunity to produce synchronous weather charts of the Arabian Sea for a limited period, since it was felt that such charts would be of especial interest, dealing as they do with a part of the ocean which is subject to the regular change of monsoon winds. The charts also exhibit the occurrence of a second cyclone which had originated over the eastern portion of the Arabian Sea before the full effect of the first disturbance had passed away. The Gulf of Aden and the northern portion of the North Indian Ocean are rarely visited by cyclones or typhoons, and consequently the occurrence in these waters, in the summer of 1885, of a violent cyclone, causing the loss of several vessels, among them the German corvette *Augusta*, and the French despatch-boat *Renard*, attracted considerable attention. The number of ships' logs which have been collected and utilized in the preparation of the charts is 239, and the information has been obtained from all available sources, including our own Navy and mercantile marine, and those of many foreign countries. For the first few days of the period discussed, the normal conditions were apparently prevailing over the Arabian Sea, the wind was north-westerly near the Indian Peninsula, but the south-west monsoon was blowing steadily near the African coast and for some distance over the sea on the western side of the district. Until about May 20, the weather in the neighbourhood of Ceylon seems to have been quiet, and the wind fairly steady from the south-westward. On the 20th, Her Majesty's ships *Briton* and *Woodlark* experienced somewhat disturbed weather at Trincomalee, the squalls attained the force

[1] "Daily Weather Charts for the Period of Six Weeks ending June 25, 1885, to illustrate the Tracks of Two Cyclones in the Arabian Sea." (London: Published by the authority of the Meteorological Council, 1891.)

of a moderate gale from the north-westward, and much thunder and lightning occurred. Unsettled weather continued from the 21st to the 24th, and from this day a storm area can be clearly traced travelling to the westward. The cyclone reached its greatest violence on June 2 and 3, when the barometer is reported as reading 27·86 inches in close proximity to the centre of the disturbance. A hurricane occurred at Obokh during the evening of the 3rd, and it was reported that all the houses but one had been blown down, and trees had been uprooted. The position of the storm area is not only marked throughout its passage across the Arabian Sea by the cyclonic circulation of the winds, but also by the rain area which accompanied the disturbance; the rate of progress of the storm from May 24 to June 3 was rather less than seven miles an hour.

The second cyclone which is shown by the charts appears to have originated not far distant from Ceylon at the commencement of June, and on the 4th a strong south-westerly gale was blowing on the equator in the longitude of 76° E. This storm can be traced for the next ten days, during which time it passed to the northward and westward towards the entrance of the Persian Gulf. The weather was very disturbed over nearly the whole of the Arabian Sea from the 9th to the 13th, and the area of the storm was much larger than in the case of the Aden cyclone, and gales were experienced from the coast of Africa to that of India, extending over a distance of about 1500 miles. The synchronous weather charts for the last few days of the discussion, after the cyclonic disturbances had passed away, show that the south-west monsoon had extended over the whole of the Arabian Sea, whereas in the middle of May it was limited chiefly to the western side.

Each daily chart contains the observations from several ships in the Red Sea, where the wind direction and other elements of the weather are very instructive. The southerly march of the northerly or north-westerly wind, which throughout the whole period prevails over the northern portion of the Sea, and the gradual backing down of the southerly winds in the southern portion of the Sea are well shown. The northerly wind in the northern portion of the Red Sea often attains the force of a gale, but there is no instance in the charts of the southerly winds attaining gale force. The air temperature is generally higher in the Red Sea than over the more open water in the Arabian Sea, the reading of the thermometer commonly reaching 90°, and on June 14 the temperature at 10 o'clock in the morning was 102° over the open sea, nearly abreast of Musawwá. The charts show many other points of interest, among these the flow of the current under the influence of disturbed weather as well as when the sea is comparatively quiet, and doubtless the volume will throw some additional light on the winds and weather in this part of the world, where at present the meteorological changes are not too well understood.

ON VAN DER WAALS'S ISOTHERMAL EQUATION.

IN reply to Prof. Tait's criticism (NATURE, December 31, 1891, p. 199) of my paper (December 17, p. 152), I wish to say that I certainly do not consider Van der Waals's b as an absolute constant. Perhaps it may be interesting to show how the limits of its variability can be determined.

Leaving aside the question of the attractive forces, which probably has been sufficiently elucidated in the course of this discussion in the columns of NATURE, and considering gases as aggregations of elastic spheres, then in the formula—

$$p_1(v - xb_1) = \tfrac{1}{3}\Sigma mu^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

x can be proved to be equal to 4 for large volumes and *small* pressures.

Again, in the case of *extremely large* pressures, when the volume is nearly reduced to the smallest possible dimensions, it is easy to see that a formula—

$$p_1(v - \mu b_1) = \tfrac{1}{3}\lambda \,.\, \Sigma mu^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

must hold good, where $\mu b_1 = 3\sqrt{2}/\pi \,.\, b_1 = 1{\cdot}35 \,.\, b_1$ represents the space in which the spherical molecules can be inclosed when they are motionless, and λ is a certain numerical coefficient whose determination might present some interest, and perhaps is not beyond the scope of mathematical analysis. (For one-dimensional motion $\lambda = 1$.) Be this as it may, putting (2) in the form—

$$p_1\left[v - \left(1 + \frac{\lambda - 1}{\lambda} \,.\, \frac{v - \mu b_1}{\mu b_1}\right) \,.\, \mu b_1\right] = \tfrac{1}{3}\Sigma mu^2, \quad . \quad . \quad (3)$$

it is clear that in *this* case x approaches the value $\mu = 1{\cdot}35$.

Now surely, for *intermediate* volumes and pressures, xb_1 cannot be considered as a constant; still, along the large range of these pressures, the correction required must be called *relatively* slight, and the more so as it is beyond doubt that a considerable part of the change from 4 to 1·35 takes place near those extreme pressures where, according to (3), x may be very variable. Whether at the critical volume this coefficient has undergone already a practically important change from its original value, 4, seems to me a question which cannot easily be answered by purely theoretical considerations.

In my opinion, in all cases except in that of large volumes the formula (1) is preferable to a formula

$$p_1 v = \tfrac{1}{3}\left(1 + \frac{4b_1}{v} + \frac{\sigma b_1^2}{v^2}\right) \,.\, \Sigma mu^2, \quad . \quad . \quad . \quad (4)$$

even if the numerical value of σ could be exactly calculated; therefore the question at issue does not simply turn on the introduction or rejection of terms of the order β^2/v^2, and it was looking at the matter from this point of view that in my paper I once called a formula of the form (1) the *true* one as distinguished from a formula of the form (4), and not from any formula given by Prof. Tait. Certainly, none of the isothermal equations given by different authors can be named *true* in the sense of representing with absolute exactness the conduct of real gases; and of course, when more constants are introduced in these equations than are contained in that of Van der Waals, a better approximation to the conduct of these gases may be reached.

In conclusion, I beg to add a few words about Prof. Tait's third remark. It seems to me that he has no right to identify the process of putting arbitrarily $\gamma = \beta$ with that of calculating the correction indicated by Prof. Lorentz.

D. I. KORTEWEG.

Amsterdam, January 6.

NOTES.

SEVERAL scientific meetings have been postponed in consequence of the death of the Duke of Clarence. Prof. W. E. Ayrton, F.R.S., was to have delivered his inaugural address, as President of the Institution of Electrical Engineers, on January 14. It will be delivered at a meeting of the Institution on January 28. The annual general meeting of the Royal Meteorological Society, fixed for the 20th, will be held on the 27th, when the President, Mr. Baldwin Latham, will deliver an address on "Evaporation and Condensation." The annual meeting of the Entomological Society is also adjourned from the 20th to the 27th.

THE forty-fifth annual general meeting of the Institution of Mechanical Engineers will be held on Thursday and Friday evenings, February 4 and 5, at 25 Great George Street, West-