internal structures in the near future in order to examine the various parts and to ascertain which are duplicated and which single.

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The Past Cold Winter and the Possibility of Long-range Weather Forecasting.

MODERN meteorology has made notable advances in forecasting the weather of the next day, but when it attempts to predict the weather for more than a week ahead, the percentage of successes does not exceed fifty at the most. One reason for this failure is to be found in the refusal of the modern meteorologist adequately to take into account in the problem of weather prediction of direct terrestrial influences, such as that of the physical state of the surface waters of the oceans, even though he may be ready enough to take such an influence into account when dealing with one of those aerodynamical problems—for example, the life history of an Atlantic 'depression'—which he regards as lying within his particular province. Another reason is his neglect of the 'Polar Front' theory of Prof. Bjerknes, one of the greatest authorities on aerodynamics and hydrodynamics.

Prof. Bjerknes regards the polar regions as caps of cold air maintained largely in consequence of the local accumulations of ice and snow, offering a kind of cold circular wall facing the warmer winds of temperate latitudes. He considers that in conjunction with the strongly heated equatorial regions, they set up a circulation which brings warm air aloft from the equator to the pole, there to be cooled and to sink, weighed down by its increasing density, until it is absorbed into the polar cap; that these reservoirs of cold air at the poles are constantly discharging their accumulated air towards the equator along the earth, in accordance with 'impulses' supplied by the region of low barometer around the equator; that the trade-winds represent successful attempts on the part of such accumulations of polar air to reach the region of equatorial calms. He supposes, further, that the cyclones of the North Atlantic arise through the mixing of the cold and warm air-masses along the margin of the polar cap (the so-called 'polar front').

It is clear that a great simplifying theory such as this offers a basis for long-range forecasting of the weather in our latitudes. If we accept the theory, it is not difficult to see that the general character of the weather over long periods may follow changes in the extent and shape of the region of cold sea, for the polar caps must, in the long run, coincide with the regions of coldest water. For example, the presence of a tongue of warm water projecting into Arctic regions, such as the so-called Gulf Stream of the North Atlantic, will push this boundary back towards the pole, and cause contrasts such as are offered in winter by the cold climate of Labrador and the relatively mild climate of Iceland.

We may consider now whether the past severe winter cannot be connected with some modification of the normal temperature of the seas within the area of exceptional cold. The immediate cause of the severe weather has clearly been the persistence of northerly and easterly winds over Russia and Central Europe circulating round an 'anticyclone' or region of high barometer over Scandinavia and Finland; which anticyclone has generally been separated from the area of high pressure that normally covers Siberia in winter by a region of relatively low pressure over Russia. Now Prof. Witting found in the Baltic in the summer of 1927 a layer of cold water at a depth of about 10 fathoms, beneath the very warm surface water, heated by the sun, having altogether a volume much greater than that of a whole normal year's outflow from the Baltic into the North Sea, and having a temperature about 10° F. lower than the average. The surface waters of the Baltic are derived ultimately from the mixing of the river water with that finally ascending from such deeper layers, and this cold water might well chill their surface waters, and the air in contact with them, for two years or more, in accordance with the time that the water might be expected to take in passing away along the Norwegian coast.[1] Such chilling would cause the anticyclones which are so apt to form over Scandinavia to be more than usually persistent, as has been the case this winter. In this way the action of the cold water, which is far too small to produce directly a degree of cold such as has been observed, may do so indirectly through the agency of the wind, and the resulting accumulations of ice and snow will carry the process still further.

It seems clear that if the action of a single sea such as the Baltic can be so great, there is a great field open for international co-operation in the systematic study of the physical states not only of the Baltic but also of all the seas and oceans in and around Europe, including the Caspian and the Black Sea. This should be done once a year, if not twice, and the results should be published quickly, so as to be available for long-period weather forecasting. This was in fact the policy of the International Council for the Exploration of the Sea before the War. It is hoped that the remarks that I have made will show that permanently to abandon such a scheme may be to throw away the opportunities of saving millions of pounds that would be afforded by the prediction, in good time, of winters such as that of 1928–29.

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Refraction of Light Waves by Electrons.

IT is an established fact that wireless signals transmitted from any place are readily received at the diametrically opposite place on the globe. The explanation usually given of the phenomenon is that the ions in the Heaviside layer make the speed of propagation of the waves greater in that layer than in the ordinary air below and thus bend the waves round the earth by a process of refraction. Larmor has developed the mathematical theory of the refraction (*Phil. Mag.*, December 1924), and has shown that if c is the velocity of light in vacuum and c' in the presence of electrons, then c and c' are related by the equation

$$c'^{-2} = c^{-2}\left(1 - N \cdot \frac{e^2\lambda^2}{\pi m}\right),$$

where N is the number of electrons per unit volume, e and m are the charge (in e.m.u.) and the mass of an electron, and λ the wave-length. Assuming $\lambda = 10^5$ cm. for radio waves, calculations show that an electron density of 0·3 per c.c. is enough to produce the observed bending round the earth.

In the case of light waves, λ is of the order of 10^{-5} cm. This will lead to a large value of N in order that light waves may bend round the earth. If the refraction of light waves by electrons is to be observed in the laboratory, the curvature of the rays has to be much larger, and hence a still larger value of N will be required.

So far as we are aware, the bending of light waves by electrons has neither been attempted nor its possibility discussed. For some time past we have been

[1] The brackish water leaving the Baltic by the Oeresound and the Belts afterwards forms the 'Baltic current' along the west coast of Sweden and Norway.

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