Letters to the Editor.

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Dampier's "Discourse of the Winds" and the Distribution of Wind on the Earth's Surface.

DAMPIER'S "Voyages" are well known, at any rate by name, but his "Discourse of the Winds" is seldom referred to. It is, however, well worth careful examination and, so far as I can judge, contains as much information about the distribution of winds as any of the modern works on the same subject.

In this "Discourse" Dampier propounds no theories, but aims at setting down the general character of the winds encountered by ships in all parts of the world, using for this purpose his own observations, and such other information as he has gathered from sources which he considers trustworthy.

It must be remembered that in Dampier's time (late seventeenth and early eighteenth centuries), the ships employed even for the longest voyages were small, and the direction and strength of the prevailing winds were much more important to navigators than they are at the present time. It is true that there are still plenty of small sailing craft in various parts of the world, the captains of which are probably well acquainted with local conditions, but these men as a rule are not of the type who place their knowledge on record. With the "Discourse" Dampier publishes maps of the hemispheres in which his observations are summarised.

For his purposes he divides the earth's surface into four regions, namely, the two trade wind areas and those to the north and south of them. These latter he calls the "Regions of Variable Winds." The directions of the trades are indicated in the maps by lines and arrows, but naturally and rightly the regions of variable winds are left blank.

No indication is given of the directions of the wind on land, but what he calls coastal winds, that is winds the direction of which is influenced by the proximity of land, are shown in some detail.

Parts of the maps are here reproduced (on the original scale) which show that "coastal" influence in the trade wind areas extends farther to the west (*i.e.* to leeward) of the continents than to the east.

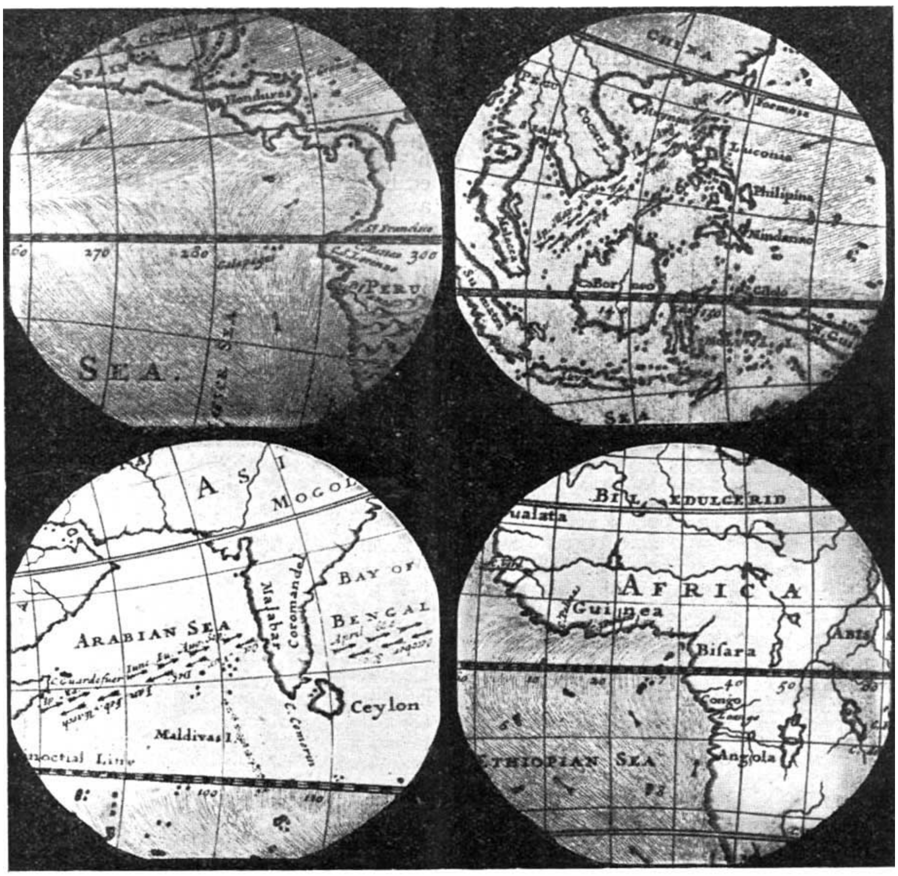

FIG. 1.—Reproduction of parts of Dampier's Maps to show coastal winds in the Trade wind areas.

Although it is impossible to determine *a priori* what the true wind should be at any given spot, it is not without interest to consider what would happen in certain imaginable conditions much simpler than those actually existing, and to see whether in such conditions the air currents, etc., would at all resemble those which are observed.

Starting with the earth as the only body in the universe, without rotation, and at a temperature of absolute zero, let its surface be uniform and level, and let its volume and that of adjacent space be divided into elementary conical cells proceeding from the earth's centre. Let the walls of the cells be non-conductors of heat but transparent to radiation.

Now let this earth be warmed by a source of heat equivalent to the sun, but in the form of a distant ring surrounding it in the plane of the equator. Let the atmosphere be transparent to radiation and take its heat only from the floor of the cell which contains it.

In the course of time the contents of each cell will reach the temperature of the floor, which will be a maximum at the equator, and will vary as the cosine of the latitude to absolute zero at the poles.

The barometric pressure in each cell will be the same; were all the cells removed the atmosphere would be in equilibrium. The equilibrium, however, would be unstable, and the least departure from the original stratification of density would cause ultimately a circulation to be set up, in which, in the absence of turbulence, warm air would flow from the equator towards the poles at high levels, while cooled air would travel in the opposite direction near the surface of the earth. A steady distribution of temperature would be reached when each element of the surface lost by radiation as much heat as it received from the source plus that supplied by the circulation, and this distribution probably would not differ much from that which now exists, though the fact that the real atmosphere is more or less opaque to long waves would introduce a sort of "green-house" effect, and raise the mean temperature above that appropriate to perfect transparency. Again if the imaginary earth were completely covered by a deep ocean, a separate circulation would be set up in the latter, and the temperature distribution would be somewhat modified in the direction of greater uniformity.

Since the energy of the circulation is derived from the source of heat, there will be no change of pressure due to the velocity, and supposing for the moment that the air is incompressible, then in the nearly horizontal path which constitutes the greater part of each stream line circuit, the cross-section velocity and dynamic head for each will be constant, though not necessarily the same for different streams. The cross section of the ascending and descending parts of the streams will bear to the cross section of the horizontal part the ratio of the length of the earth's quadrant to the height of the homogeneous atmosphere, and thus in the neighbourhood of the poles and the equator there will be a small increase of pressure. The form of the stream lines due to temperature circulation in a spherical shell is indicated diagrammatically in Fig. 2.

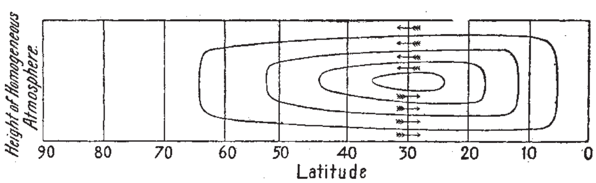

FIG. 2.—Stream lines of the circulation in a meridional element of a spherical shell, the density of the fluid being supposed constant.

As regards the distribution of temperature, the results would be much the same whether the earth were stationary or rotating, but the direction and velocity of the wind referred to a fixed point on the solid surface would be very different in the two cases. If, in the absence of surface friction, the earth were given its present angular velocity the apparent wind would have an easterly component of about 1000 miles per hour at the equator while at the poles there would be a calm. If, on the other hand, when the rotation was started, the air was given the same velocity as the surface under it, the apparent wind would vary in direction and force in a period equal to that of the circulation.

In the real atmosphere, the effects of turbulence, viscosity, and surface friction will ensure that the average velocity of the apparent wind shall in no place exceed 30 or 40 miles per hour. If unresisted air passes from lat. λ to $\lambda \pm \Delta\lambda$ the change of the linear speed of the ground under it, *i.e.* the change in the E. or W. component of the apparent wind, is $R\Delta\lambda(1-\sin\lambda)$ linear velocity in longitude, and if the apparent wind remains constant, it shows that surface friction is sufficient to accelerate or retard the atmosphere by this amount in the time taken in covering the distance $R\Delta\lambda$. In the case of the earth, this would imply that if the circulating velocity (*i.e.* the N. or S. component) is 15 m.p.h., surface friction suffices to change the speed of the apparent wind by about 15 m.p.h. per hour near the poles while in lat. 30° the corresponding change would be somewhat less than 2 m.p.h. per hour.

On the imaginary seasonless earth, the average wind would everywhere be a definite function of the latitude and coefficient of friction, provided that the going and returning parts of the circulation did not mix on the journey, and in low latitudes this would be true even when the effects of turbulence were taken into account. Farther north or south, however, the hot and cold streams would become interwoven in eddies the forms of which are incalculable, though the average winds would always be either from N. and E. or S. and W. Thus it might be expected that there

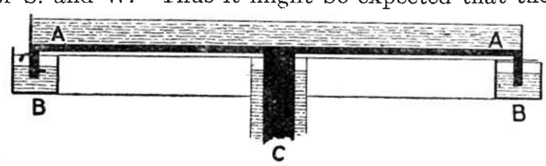

FIG. 3.—AA, Circular conducting plate and tank. BB, Annular hot water trough. C, Axis and cold-water tank.

would be calms at the equator, moderate and regular trade winds for some distance on either side, and beyond these, irregular winds, the intensity of which increased with the latitude. The barometric pressure would be nearly constant except in the eddies, and there the variation of pressure would depend, not on the actual velocity of the apparent wind, but on its difference from the average for the latitude.

Such a description with modification depending on the seasons, the presence of moisture in the air, and on the distribution of land and water agrees with the average conditions on the real earth. Dampier's maps show that coastal influence may be sensible through 10° of longitude or more, and it may be guessed that the direction of the monsoons is in some way influenced by the great area of land lying to the north of the parts where they blow.

There is not much information available concerning the wind structure of the atmosphere on the borders of the Trades, and a proper investigation of this subject would form an important addition to meteorological science; but such an investigation would require more than one *Challenger* expedition devoted to the exploration of the upper air instead of the deep sea.

Expeditions of this kind are not likely to be undertaken at the present time, but some notion of the manner in which the Trades break up might be gained by an experiment such as is indicated in Fig. 3, where a thick circular metal plate, provided with descending flanges at the circumference and a thick central axis, carries a shallow circular tank containing fluid. The flanges dip into a circular trough of warm water while the axis is kept cold. If the apparatus is stationary, a circulation is set up in the tank of the type shown in Fig. 2, but if it has an appropriate angular speed about the axis, the conditions will have a certain similarity to those existing in the atmosphere. The difference in the character of the circulation in the two cases could scarcely fail to give some useful hints.

Another illustration of the kind of flow to be expected near the borders of the Trades may be observed (although the analogy is not so close as in the experiment) whenever a current of water flows into a pond. The central part of the stream continues on its course for some distance unbroken, but the margins are bordered by eddies, which (looking down stream) are right-handed on the right, and left-handed on the left side, and consist of equal volumes of water from the stream and from the pond wrapped together after the fashion of a "roly-poly" pudding. When once formed, they have a certain life of their own, and follow erratic courses, often generating secondary eddies further from the main stream. In general their life is short, but occasionally vertical components in the flow of the main stream give rise to components in the eddies parallel to their axes, and in such cases the vortices may be sustained and intensified.

Much the same sort of action must be going on at the borders of atmospheric currents, and it must happen, especially in the turbulent regions, that either on account of the general circulation or from local causes, warm air will sometimes underlie colder strata, and this is what is required to prolong the life of eddies or vortices with vertical axes.

It may be said with some confidence that tornadoes, sand pillars, and waterspouts are due to local causes of this kind, and it seems highly probable that the deep barometric depressions which accompany the greater storms have a similar origin depending on inversions of level of the general circulation. In referring to warm and cold strata, the temperature must be supposed to be compared at the same altitude since, so far as thermometric readings are concerned, the upper air is always colder than that near the ground.

A. MALLOCK.

9 Baring Crescent, Exeter,
August 10.

The Conditions of Sex-change in the Oyster (*Ostrea edulis*).

IN the issue of NATURE for August 12, p. 212, and in several previous numbers, Dr. Orton has given some interesting information concerning the old question of the breeding habits of oysters, especially sex-change and its conditions. This problem has been discussed in a certain number of ancient treatises (Davaine, Van Beneden, Lacaze-Duthiers, Hoek, etc.), but has been but little investigated in the course of the last few years. During my work at the Danish Biological Station I have, since 1919, been making experiments and investigations on the biology of the oyster in the Limfjord. As my results in several respects confirm and amplify those of Dr. Orton, I will give here a short account of some of the most important. In the course of the winter a more detailed paper will probably be published in the Report of the Danish Biological Station.

Dr. Orton confirms the observation, made by Möbius, that in European oysters a specimen directly after breeding produces spermatozoa, and I fully agree with him. In several cases I have proved, through experiments with oysters, in the shells of which a little hole had been bored, that an oyster in the course of less than a week changes from a female to a male.

Dr. Orton further mentions the interesting fact that he has been able to state that an oyster born in 1921 was spawning already in 1922; this phenomenon he ascribes, and very rightly, to the high temperature of the summer 1921. I have investigated several thousand oysters in the Limfjord: the youngest female found by me was at least three years old, which is no doubt due to the lower temperature of the Limfjord. Neither did I ever find that oysters had ripe spermatozoa in the summer in which they were born; in the Limfjord that phenomenon only occurs in the following summer. Formerly the earliest time for an oyster to breed was much discussed. If we examine from where the different authors have obtained their material, it appears that those who advocated early breeding had got theirs from Southern France, while those who advocated two to three years as the age for breeding had had material from the English Channel and the North Sea.

From my experiments, and from the study of previous papers on this subject, I have come to the conclusion that the duration of the male stage depends on temperature, so that the colder it is the longer the stage lasts. At the temperature which ordinarily prevails in the Limfjord (15°-16° in July), this stage will last three to four years. The oyster, therefore, breeds for the first time (the first stage being the male stage) when it is three to four years old; further, every single oyster individual in ordinary circumstances of temperature breeds only every third or fourth year, in especially cold years still less often, in warm years more often. These phenomena, together with the shorter duration of the female stage, explain the fact that in a certain number of oysters in the Limfjord we always find only a relatively small percentage of females. This likewise explains why the oyster breeds more sparingly the further north it is, and decreases regularly in number without any sharp boundary-line.

The breeding of the oyster is in at least three respects influenced by temperature. A high temperature increases the number of times an oyster may breed in its life, it shortens the time which the breed passes in the mantlecave of the mother animal, and, according to Hagmeier, it shortens the pelagic larva stage.

R. SPÄRCK.

Copenhagen, September 5, 1922.

Rise in Temperature of Living Plant Tissue when infected by Parasitic Fungus.

WHILE engaged on some work connected with the export of citrus fruits from South Africa to England, we have come across a point of interest to plant pathologists and bacteriologists which would seem worth recording at this stage.

In investigating the effects of inoculating oranges and grapefruit with *Penicillium digitatum* we found that a very definite rise of temperature took place in the infected tissue. We are not aware of such an observation having been made before in connexion with the invasion of plant tissue by a parasitic fungus, and it will be interesting to ascertain whether a similar rise of temperature takes place in all cases where living plant tissue is attacked by parasitic fungi or bacteria.

To what extent direct reaction of the host is responsible for the rise of temperature is still to be determined; certainly no rise of temperature was observed when the host tissue was killed prior to inoculation. Mercury-in-glass thermometers were used in making these observations, but the employment of thermo-electric apparatus will naturally be necessary to carry the investigations further.

This observation of ours would seem to open up