ATMOSPHERIC CIRCULATION.*

HOW CYCLONES AND ANTI-CYCLONES ARE FORMED.

BY R. F. STUPART.

THE astronomer Halley in 1686 enunciated the theory that as the temperature of the air decreases from the equator to the poles, there ought to constantly exist an upper wind or equatorial current blowing from the equator to the poles, and a lower wind or polar current blowing from the poles to the equator. This theory was supplemented by Halley in 1735 by the statement that whatever be the direction followed by an atmospheric current, the earth's rotation deviates this current to the right in the northern hemisphere and to the left in the southern hemisphere.

Halley's theory seemed reasonable, but as observation showed that the general drift of the atmosphere in the middle and higher latitudes is from the westward, it became necessary for the more modern meteorologist to find directly what are the true movements of the atmospheric currents and then formulate a theory in accord with ascertained facts.

The earliest data available regarding the circulation of the upper air, based on cloud movements, was provided by many keen observers, among whom the Rev. Clement Ley of England and Prof. H. Hildebrandsson of Sweden stand pre-eminent. Further and still more conclusive data as to atmospheric movements have been obtained within the past few years by means of kite and balloon, and among the most energetic investigators were Prof. A. Lawrence Rotch of Boston, Mass., and M. Teisserenc de Bort of Paris, France.

In a zone near the equator—a zone encircling the globe, and comprising the region of highest temperature, and which oscillates northward and southward, moving always with the sun—observations show that the atmospheric currents at every height, and almost without exception, are from east to west.

North and south of this equatorial zone, approximately to latitude 35 deg., are found the steady persistent northeast and southeast trade winds, the prime factor in producing the great ocean currents, and above these trade winds there prevails an anti-trade from the southwest in the northern hemisphere, and from the northwest in the southern. Beyond the trade-wind

zones, over the middle latitudes, the prevailing drift of the atmosphere is from west to east, and with this atmospheric drift move the cyclonic areas which lead to the summer shower as well as to storm and rain and snow. Charts of barometric pressure indicate that the whole wind system of lower latitudes is directly connected with pressure conditions, there being a belt of low barometer readings around the globe in the equatorial zone, and belts of high barometer readings to the northward and southward, the whole system having an annual oscillation with the changing declination of the sun.

The tropical belts of high pressure have sometimes been explained as a result of the crowding of the upper currents from the equator advancing along the converging meridians, but this can only be in part correct, for if the convergence of the meridians determined an increase of pressure, the pressure should be highest at the poles, whereas it is highest between latitudes 30 and 40.

Observation has shown pretty conclusively that the equatorial currents in the upper regions turn away to the eastward in the direction of the earth's rotation and form a continuous whirl around the earth over all the higher latitudes, and it is now believed that the high pressure which should result from the low polar temperature and the shape of the earth, is reversed into low pressure by the forces which lead to the circumpolar whirl; and the air thus held away from the polar regions is found in the tropical belts of high pressure.

The distribution of continent and ocean tends toward complexity. As land absorbs the solar heat much more rapidly than does the ocean, and, conversely, parts with heat more readily, the range of temperature between summer and winter of continental areas is vastly greater than over the ocean, and the circulation of the atmosphere near the earth's surface is in consequence greatly modified by land and sea.

The most marked evidence of this is found in southern Asia, where with great heat in summer is situated the lowest barometric pressure of the northern hemi-

sphere, which leads to the southwest monsoon of the Indian Ocean, and which is indeed the southeast trade wind deflected to the southwest after passing to the northward of the equator. In winter, on the other hand, over the great land area of Asia is found a vast anticyclonic system which may perhaps not unreasonably be regarded as a portion of the extra-tropical pressure drawn northward and intensified by the contraction of the atmosphere owing to low temperature, and leads to the northeast monsoons of the Indian Ocean and China Sea, which are closely related to the northeast trade winds of Atlantic and Pacific.

It is clearly evident, however, that while the effect of continent and ocean is far-reaching, it is but one of several factors governing the atmospheric circulation. The fact that the highest winter barometric pressure in Asia is found far south of the greatest cold, together with the general appearance of the chart of mean pressure, suggest that the factors which lead in general to the extra-tropical belts of high pressure are predominant. In the southern hemisphere, with a vast preponderance in area of the ocean over land, the extra-tropical high-pressure belt is more continuous and persistent throughout the year, merely changing its position with much regularity with the changing declination of the sun.

As yet it is not known why the atmospheric circulation varies somewhat from year to year. It certainly does vary, and this variation may be sufficient to wholly account for the changeableness in the character of corresponding seasons in different years. Investigation of the solar radiation, together with barometric gradients and wind velocities in the tropics, may not prove abortive.

An interesting problem, now receiving attention in the Meteorological Office, is that of the formation of anticyclones in the higher latitudes. It seems not improbable that these anticyclones represent the coming to earth of branches of the great equatorial overflow, and it is important to investigate the connection between them and pressure changes and wind movements in the tropics.

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NEW RADIOACTIVE PHENOMENA

THE RADIATION OF METALLIC PLATES BOMBARDED BY BETA RAYS.

M. DOBLER has investigated the relations existing between the velocity of the bombarding β rays, the thickness of the plate and the intensity of the induced radiation. The β rays were caused to move in the arc of a circle by subjecting them to the influence of a magnetic field. From the radius of the circle and the intensity of the field the velocity of the β particles can be computed by the usual formula, employing Kaufmann's value of the ratio of charge to mass. The

FIG. 1.—FIRST ARRANGEMENT.

R, tube containing radium bromide; P, B, S, lead screws; F, slit; L, photographic plate; E, brass screen.

radius is known when three points of the circle have been determined. These three points are given by the radiant substance, a slit in a screen and the corresponding point of the photographic image.

The source of radiation was 15 or 20 milligrammes (about $\frac{1}{4}$ grain) of radium bromide. In the first series of experiments the photographic plate made an acute angle with the plane determined by the radioactive substance and the slit in the leaden screen (Fig. 1). In the second series the plate was perpendicular to this plane (Fig. 2). The electromagnet having been standardized, the intensity of the field could be calculated from the strength of the current as indicated by a galvanometer.

The magnetic field being established and the photographic plate exposed, the line of intersection of the plate with the plane of the source and slit is traced on the sensitive plate by the influence of the γ rays. Beyond this line extends the region affected by the β rays, the maximum effect being produced by the rays of medium velocity. Half of the sensitive plate is then covered with a thin plate of platinum. The effect is to intensify part of the image and to weaken the remainder. In one region the intensity remains unchanged because the secondary radiation from the platinum exactly balances its absorption of the primary rays.

M. Dobler studied the influence of the thickness of the platinum plate upon the velocity of the β rays and obtained a relation between the intensity of radiation, the thickness of the plate, and the velocity. Curves of equal velocity were plotted by employing the thickness of the plate as abscissa and the intensity of the photographic effect as ordinate. The results appear to be represented, to a first degree of approximation, by Paschen's formula which gives the intensity of the secondary radiation as a function of the thickness of the metallic plate.

Metals bombarded by Roentgen rays likewise emit secondary radiations composed of Roentgen and cathode rays. M. Dorn has measured the velocity of the cathode rays thus produced, on the assumption that

the ratio of charge to mass, $\frac{e}{m}$, is the same as in other cases of radioactivity. The cathode rays were subjected to an electric field and a magnetic field so arranged as to cause deviation in opposite directions. It is easily proved that those electrons whose velocity is equal to $\frac{F}{H}$, the ratio between the intensities of the electric and magnetic fields, undergo no deviation. If

the electric field is suppressed the rectilinear trajectory is converted into a spiral. M. Dorn thus finds a minimum velocity of 1.72×10^7 C. G. S., instead of the value 1.8×10^7 C. G. S. obtained by earlier experimenters.

The annual report of the National Physical Laboratory contains an interesting account of a series of experiments carried out by Mr. W. A. Price with a view to devising a satisfactory form of electric heating unit. The form finally adopted was to wind a thin strip of Eureka resistance material on a thin sheet of mica, the electrodes of copper strip being then threaded into

FIG. 2.—SECOND ARRANGEMENT.

the mica and hard soldered to the Eureka strip. A thin sheet of mica is laid on each side and sewn round the edges, and the whole is slipped into a thin copper envelope, which is let into and soldered to the lower side of the bath. This envelope being a nice fit round the mica, the unit can be easily removed for renewal or repair without moving or emptying the bath. Some of the units, it is stated, have been in use for several months for heating baths up to 100 deg. C. without a single case of breakdown. Each unit is made in two sections, each of which will take four amperes at 100 volts—i. e., a total of 800 watts per unit—and by means of switches they can be put in series, or singly, or in parallel, as occasion demands.