The Stratosphere over North India.

ASCENTS of sounding balloons carrying Dines meteorographs carried out from the Upper Air Observatory, Agra, during the last two and a half years have yielded interesting information regarding the height and temperature of the base of the stratosphere over northern India and their remarkable seasonal variations. A brief summary of the results may be of interest to readers of NATURE.

All the three types of transition from the troposphere to stratosphere classified by W. H. Dines, namely—

Type I—When the stratosphere commences with an inversion;

Type II—When the stratosphere begins with an abrupt transition to a temperature gradient below 2° C. per kilometre without inversion; and

Type III—When the decrease of lapse-rate takes place gradually;

are met with. In addition, a fourth composite type with I above II or III is common between the months November to April.

During the period April 1926 to March 1928, 46 records of ascents going up to the stratosphere are available. The mean height of the tropopause (H_c) is 15·9 geodynamic or 16·3 ordinary kilometres and the mean temperature (T_c) 199° A.

In Fig. 1 are plotted the heights and temperatures of

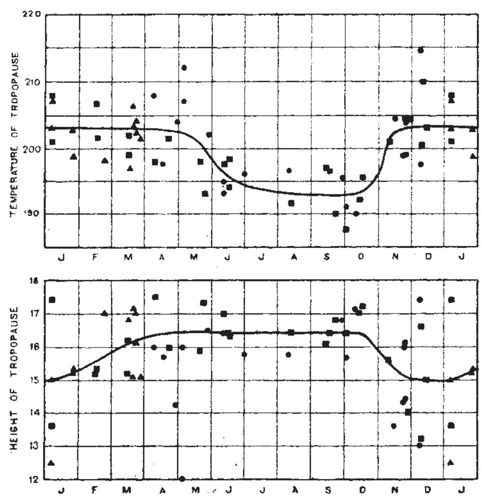

FIG. 1.—Variation of the height and temperature of the tropopause over Agra during the year.
●, Observations in 1926.
■, „ „ 1927.
▲, „ „ 1928.
Total Number of Observations, 46.

the tropopause obtained from the records of these ascents. When the transition is of the composite type, both positions of rapid changes of lapse-rate are plotted. The sudden jump of temperature and height of tropopause between October and November is specially noteworthy, as it occurs more than a month and a half later than the time of withdrawal of the monsoon from north India. From the point of view of seasonal variation, we may divide the year broadly into two parts :—

(1) *Middle of May to end of October.*—During this period, the type of tropopause is either I or II ; if II, the initial sudden change of lapse-rate is followed by an inversion soon after, so that there is always an inversion of temperature in the stratosphere. The mean value of the height of the tropopause is 16·5 geodynamic kilometres, and its mean temperature 194·5° A. The period of activity of the monsoon in northern India is July to September.

(2) *November to middle of May.*—In this period, types III and IV are more frequent. Even here there is almost always an inversion of temperature above 17 geodynamic kilometres. The mean values of H_c and T_c during this period are 16·2 gkm. and 201° A. if we take the values corresponding to the higher value of H_c on occasions when the transitions were of type IV, and 14·9 gkm. and 203·5° A. if we take values corresponding to the lower values of H_c.

A significant feature shown by the results of the monsoon period is the comparatively high temperature

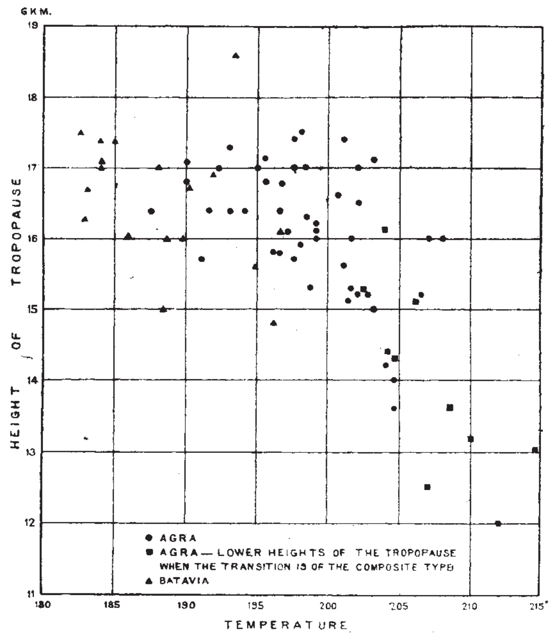

FIG. 2.

between 4 and 13 gkm. and the close agreement of the height-temperature lines between these limits with those of saturation adiabatics.

In Fig. 2 are shown the values of T_c plotted against the corresponding values of H_c. The values obtained by Bemmelen from ascents at Batavia are also plotted for comparison. The general tendency of H_c to approach a limiting value of about 17·5 gkm. with decreasing T_c is very suggestive.

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The Velocity Coefficient of a Homogeneous Bimolecular Gas Reaction.

THE theory of kinetic activation has been shown by Hinshelwood to lead to a simple explanation of homogeneous bimolecular reactions (" Kinetics of Chemical Change in Gaseous Systems," Oxf. Univ. Press). According to this view, two molecules react on collision when their joint kinetic energy at impact exceeds a certain limiting value E, termed the critical increment for the reaction. The number of binary impacts of this kind per second in a gas can be calculated by means of the kinetic theory as

$$\sqrt{2}\pi\sigma^2\bar{u}n^2e^{-E/RT},$$

where σ is the molecular diameter, $\bar{u}$ the root mean square velocity, and n the number of particles per cubic centimetre. By comparing this expression with the actual number of molecules reacting, we can calculate the value of the critical increment E. Thus, if k is the velocity coefficient of a bimolecular reaction measured in gram molecules per minute per litre, we have

$$2\sqrt{2}\pi\sigma^2\bar{u}n^2e^{-E/RT} = k \, . \, C^2 \, . \, \frac{6\cdot06 \, . \, 10^{23}}{10^3 \, . \, 60},$$

where C is the concentration of the reacting substance in gram molecules per litre.

An independent means of determining E is provided by a determination of the temperature coefficient, η, of the reaction and calculating according to the Arrhenius equation

$$\eta = e^{-\frac{E}{R}\left(\frac{1}{T} - \frac{1}{T+10}\right)}.$$

So far, the data for three different bimolecular reactions have been available for testing this theory of kinetic activation, namely, the homogeneous bimolecular decompositions of $2N_2O$, 2HI, and $2Cl_2O$, and the two methods of calculating the critical increment give values in good agreement. In the course of an examination of the data of Bodenstein and his co-workers on the formation and decomposition of the higher oxides of nitrogen (*Zeit. Phys. Chem.*, **100,** 68 ; 1922), I was struck by the fact that his investigation of the thermal decomposition of nitrogen peroxide provides the means of applying yet a further test to the above theory. Bodenstein and Ramstetter (loc. cit.) found that the thermal change

$$2NO_2 = 2NO + O_2$$

is a homogeneous bimolecular reaction and determined its velocity coefficient at a series of five temperatures between 592° and 656° Abs. From the data given for the velocity coefficient (for example, 204 gram-molecule of [$2NO_2$] per litre per minute at 627° Abs.) and from the temperature coefficient (1·51 for 10° rise of temperature), the critical increment can be calculated by the two methods outlined above. The only uncertain quantity is the molecular diameter. For this I take the value of $3\cdot33 \times 10^{-8}$ cm., by comparison with the identical values found by Rankine for the N_2O and CO_2 molecules. In any case the variation in the value of σ makes very little difference to the value of E, which, for example, is only altered to the extent of 3 per cent by a 100 per cent increase in the molecular diameter.

The results of the calculations for nitrogen peroxide have been added to the table of Hinshelwood given below, and the satisfactory agreement will be seen to provide a further confirmation of the theory of kinetic activation.

Reaction. Thermal Decomposition of	E vel. coeff.	E temp. coeff.	Abs. Temp. of Identical Vel. Coeff. (0·0914 g. mol./litre/sec.).
$2N_2O$	55,000	58,500	956
2HI	43,900	44,000	760
$2NO_2$	33,200	32,000	575
$2Cl_2O$	22,000	21,000	384

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Determination of Noon by Shadow.

CORRECT time is now so widely distributed that devices for the accurate reading of sundials are scarcely more than curiosities; but as a curiosity it may be worth while to put on record a method which I used from 1875 to 1880, by which the meridian passage of the sun was determined to within one second by means of a shadow, without any lens or other optical appliance, thus :

A straight rod, R (Fig. 1), in the plane of the meridian was used as the gnomon, and in the same plane and parallel to R was a straight piece of wire, W, at such a distance from R that the diameter of the latter when viewed from W was half the angular diameter of the sun. When the sun is on the meridian, W casts two shadows of equal intensity corresponding to the equal areas of the sun's disc which are not covered by R. The intensity of these shadows changes rapidly with the sun's motion. If R cuts the sun's limb at the four points A, B, C, D, the areas of the sun's disc left uncovered by R are (if $\angle AOB = \phi_1$ and $\angle COD = \phi_2$) proportional to $\frac{1}{2}\sin\phi_1$ and $\frac{1}{2}\sin\phi_2$, and the ratio of these two quantities gives the relative intensity of the shadow. This is shown in Fig. 2, where the ordinates give the intensity, and the abscissa time in seconds, the unit intensity being that due to illumination by half the sun's disc.

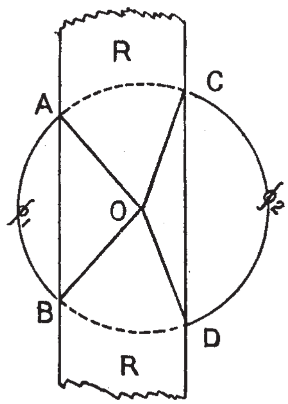

FIG. 1.

It will be seen that when the intensities of the two

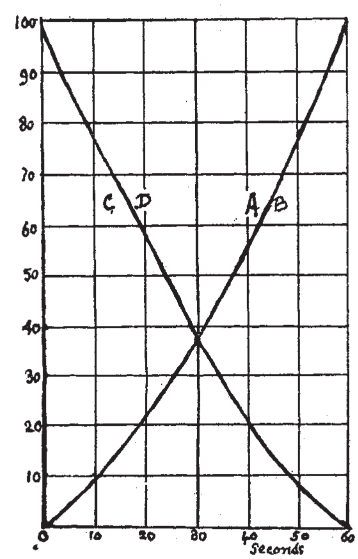

FIG. 2.—Viewed from W, one minute will elapse between the times at which the edge of R is a tangent to the sun's limb, and when the same edge forms a diameter. The curve AB gives the intensity of the shadow of W thrown by that part of the sun exposed between R and AB, CD being the simultaneous intensity of the shadow thrown by the corresponding area between CD and the other edge of R.

shadows are identical, the variation in intensity is rather more than 5 per cent per second, a difference which is readily appreciated by the eye, if the screen on which the shadows fall is protected from stray light.

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