Letters to the Editor.

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Plotting Upper Air Temperatures.

SIR NAPIER SHAW has recently devised a method of plotting upper air temperatures in the form of a curve which he has named a tephigram (T-ϕ-gram). The curve is plotted on squared paper on which the abscissæ represent absolute temperature and the ordinates entropy or log potential temperature. The condition of a mass of dry air can be described as well by its temperature and potential temperature as by its temperature and pressure, and the tephigram in utilising this method has an advantage over the older form of pressure-temperature diagram in that the work which will be done by a sample of air in rising through any given environment when conditions are unstable is shown directly on the diagram as an area which may readily be measured by planimeter. Tephigrams are unfortunately somewhat difficult to comprehend at first sight, and are therefore unsuitable for presenting the results of upper air work to those who are not in close touch with the subject; but workers in this field of meteorology find that the graphs possess most of the advantages of the older pressure- (or height-) temperature diagram with the added advantage that, as explained above, they show the energy available from a sample of air placed in unstable surroundings at a glance.

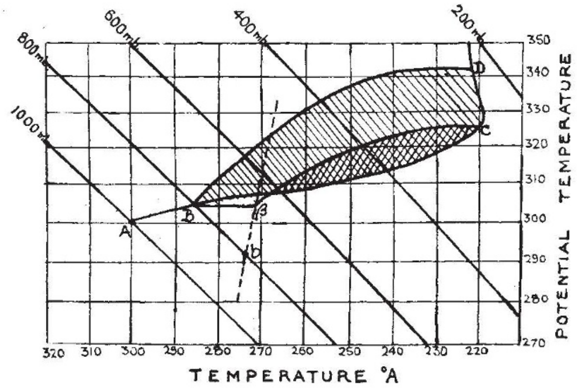

FIG. 1.

If moisture did not exist in the atmosphere, the technique of plotting upper air data in the new manner might be regarded as fully worked out, but in all considerations of stability, moisture is of as great importance as lapse rate, and it is essential to indicate the water contents of the air by means of dew point or otherwise if the diagrams are to be of practical value.

To illustrate the following remarks a tephigram is sketched in Fig. 1. Potential temperatures are on the right of the diagram on a logarithmic scale, temperatures at the foot on a linear scale increasing from *right* to *left*, while lines of equal pressure slope down from left to right. Certain details have been omitted for the sake of clearness, only essential lines being shown.

The changes of temperature and potential temperature from the surface to the stratosphere are shown by the curve ABCD, the portion ABC where potential temperature changes but slowly being in the troposphere, while CD with its almost constant absolute temperature is in the stratosphere. If the air at the point marked B were saturated, the energy which would be liberated as one kilogram of the air rose from B to D is indicated by the whole area shaded on the diagram. The upper boundary of the area is an adiabatic line for saturated air, and it will be seen that as between B and D this line is everywhere to the left of the environment line ABCD, the rising air will throughout be warmer than its environment and will therefore have buoyancy and be capable of doing work as it rises.

The method of plotting humidities on the diagram which has been suggested by Sir Napier Shaw is to plot the dew point as well as the air temperature on each pressure line. Thus in the diagram B shows the temperature (286° A) at 800 mb. pressure and *b* the dew point (274° A). (See Q.J. Royal Meteorological Society, vol. 51, p. 206, footnote.) The length of the line B*b* gives an indication of the dryness of the air. This method is probably the best that can be devised for showing the variations of humidity throughout an ascent, but it does not seem to be the most suitable for a study of the energy available in a mass of air rising from any particular layer. An alternative plan which appears to have advantages is to calculate the weight of water vapour per kilogram of dry air present in the air at B, and to mark the temperature β on the horizontal through B at which this weight of water vapour is the saturated content of air. Lines showing the number of grams of water vapour which will saturate one kilogram of dry air are printed on the tephigram paper (one is shown in the figure passing through *b* and β) and render plotting the point β easy. By this means the energy available in the actual non-saturated air at B is shown at once on the diagram, being the double shaded area which lies between the environment curve ABC and the saturated adiabatic through β.

This is easily seen, for if a sample of air from B is raised in the atmosphere its temperature-potential temperature curve will run horizontally from B to β, where the sample will become saturated; thereafter it will follow the curved saturated line from β to C. During the first stage the air will be colder than its environment and work will be needed to raise it. During the last part of the course it will be warmer than its environment and will do work, as indicated by the double-shaded area. This method of plotting appears likely to have value in the study of instability in the atmosphere. It will make it plain that in many cases where large quantities of energy would be available if the air were saturated, in the conditions actually existing there is no energy available at all.

One criticism may be raised. On some few days the lapse rate reaches the dry adiabatic, and the environment curve ABC becomes for part of its course a horizontal line. Thus several successive points β may also fall on the same horizontal line, and it will be difficult to say which of the β's corresponds with any one B. If, however, each point on the temperature curve is denoted by a separate letter, and each corresponding point on the moisture curve by a corresponding letter (Bβ, Cγ, etc.), it will be easy to relate the two. It appears that if paper of a sufficiently open scale is used this objection need not be given too much weight.

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