

A NOTE ON SOME ADDITIONAL FACTORS THAT MAY BE FOUND
USEFUL IN INTERPRETING THERMODYNAMIC DIAGRAMS FOR
THUNDERSTORM LIABILITY.

Thermodynamic diagrams (tephigrams) have been in use in India for a long time to find out thunderstorm liability of a particular upper air regime. For this purpose, the wet-bulb curve is plotted alongside the sounding (D. B. curve) and Normand's criterion of latent instability is made use of to find out the magnitude of positive and negative areas (cf. Pisharoty¹). A consideration is then given to the factors that may wipe out the negative area and make the latent instability realisable. It has been shown by several workers² that the upper air regime most favourable for the building up of a

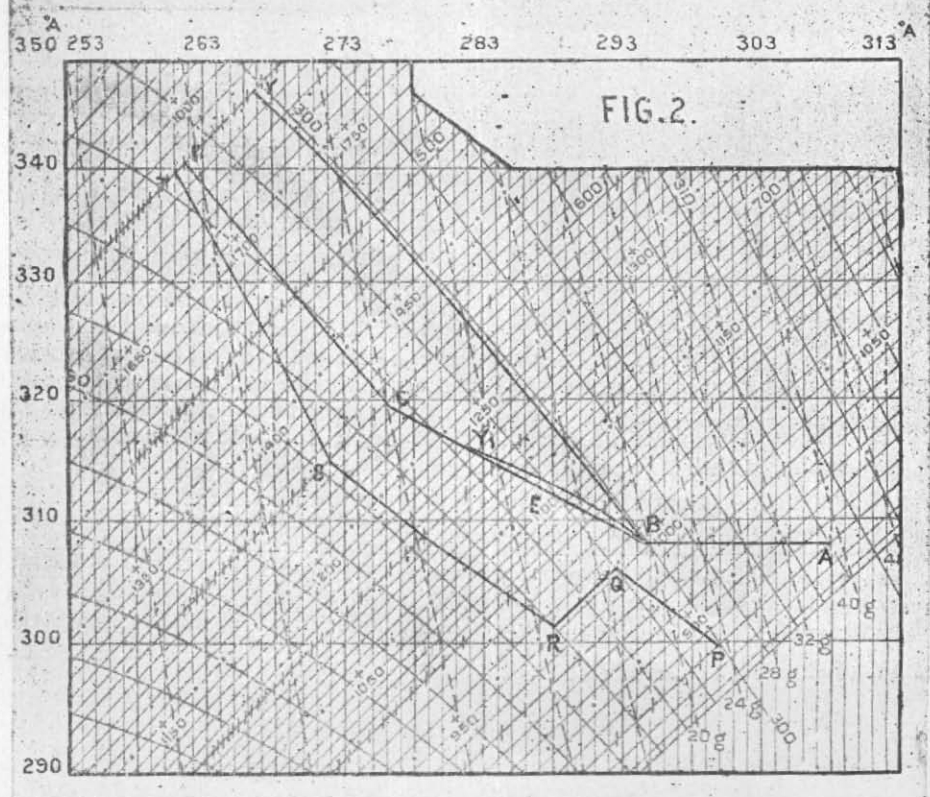
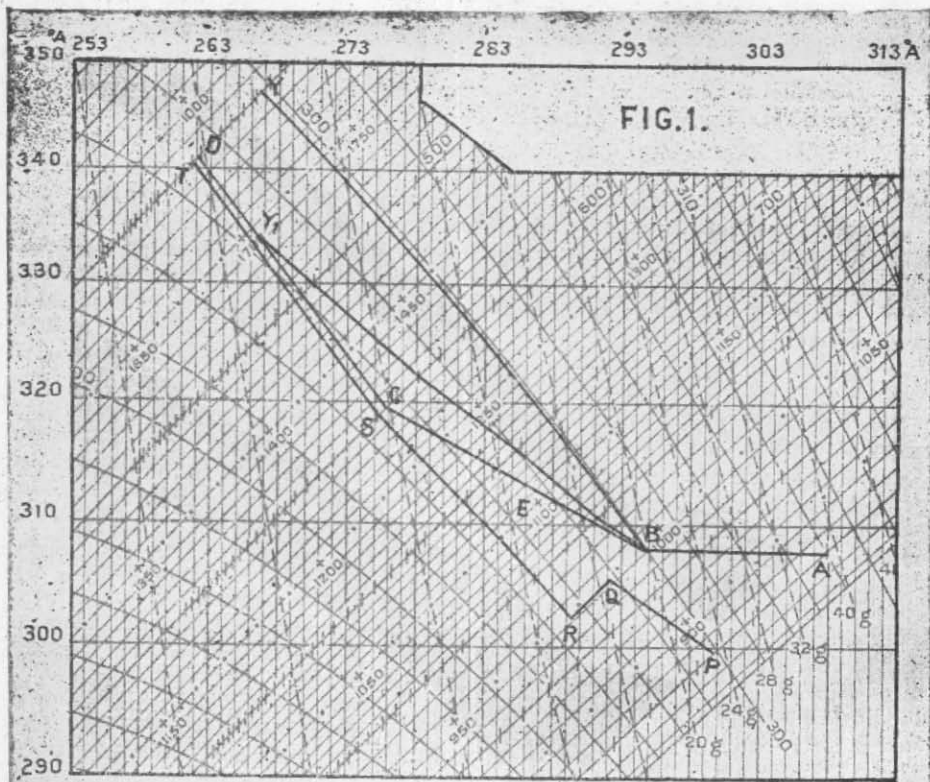
large amount of latent instability is a moist (T_m)* air from surface upto about 1.5 Km. and a hot (T_c)* air with steep lapse rate above. If the negative area is small and the positive area large, one should normally expect a thunderstorm to develop, when a trigger is available to overcome the negative area. The criterion has, however, been found to give only a limited amount of success. The general conclusion is that a fairly large positive area with a small negative area is necessary to realise a thunderstorm but the converse is not true, that is to say, even when we have a large positive area with a small negative area, a thunderstorm may not be realised. Obviously, other factors must be operative which determine thunderstorm liability under conditions which give approximately the same size of positive and negative areas on the tephigrams.

The parcel method is usually used to determine the size of positive area and one would expect that the use of "entrainment" method discussed by Austin,⁴ which gives a more realistic picture of the magnitude of positive area, might be of help. It may not, perhaps, be obvious how this would be so when, in the absence of any data of rate of entrainment on individual occasions, we have to be content with the use of average rate of entrainment, and that also a very rough one. However, as has been shown by Austin (loc cit), the positive area is determined not by the rate of entrainment alone, but by the moisture content of the environment as well and so long as the variation from level to level and from one occasion to another is not large, any assumed rate will allow for the moisture content of the environment fairly satisfactorily, as, in thermodynamic analyses we are usually not concerned with the absolute size of positive area but its relative size on different occasions. The parcel method takes no account of the moisture content of the environment, as will be clear from the illustrations in Figs. 1 and 2, in which ABCD is the dry bulb curve and PQRST is the wet bulb curve. In Figs. 1 and 2 the environment curve is the same at all levels, whereas the wet bulb curve is the same only below the convective condensation level. The air above the condensation level is much drier in the case of Fig. 2 than in the case of Fig. 1. If we consider a surface air particle†, the positive area, upto 400 mb. level, in both Figs. 1 and 2, is given in the parcel method by the area BYDCB, which is the same in the both, but by the entrainment method, the positive area BY₁EB in Fig. 2 is much less than the positive area BY₁CEB in Fig. 1, although the rate of entrainment of environment air is the same in both, viz., 25 per cent. in 50 mbs. It has been recognised by meteorologists for long that a dry environment inhibits the growth of thunder cloud and the "entrainment" lapse rate shows why this should be so. Although, therefore, the energy of the thunderstorm is realised from the ascent of the lower layers of T_m air, the condition of saturation of the environment above the condensation level is also of importance in the development of thunder clouds and this factor is allowed for automatically if "entrainment" lapse rate, in place of lapse rate by parcel method, is used. Incidentally, it should be noted that although a T_c air is required to provide the inversion and a steep lapse rate above it—two conditions necessary for storing up of a large amount of latent instability—the purpose is defeated if the T_c air is too dry or extends to great heights. Again, it has been recognised that, for the development of thunderstorm proper, the cumulus should grow beyond the freezing level. If, therefore, the lapse rate curve obtained by the "entrainment" method cuts the environment curve at a level lower or only slightly higher than the freezing level, the development of thunderstorm may be ruled out, even though the positive area may be otherwise fairly large.

Vertical shear as a factor inhibiting thunderstorm has been discussed fully by Byers and Battan⁵. If there is any appreciable vertical shearing, the tops of the

*The symbols for air masses used here are the ones suggested by Roy³.

†Although the positive area corresponding to the surface air parcel only is given here by way of illustration, it should be realised that in actual analysis the result of lifting air parcel from each significant level in the "layer of instability" has to be examined before a complete picture of realisable energy can be obtained.



clouds may be severed from the main updraft region and thus from its energy source. In addition to this, Byers and Battan have shown that vertical shearing is often responsible for the sustenance and the horizontal extension of downdrafts. The momentum of the downdrafts may be transferred in all directions, thus interfering with the updrafts. It is thus seen that shearing, by blowing off the tops of clouds from the region of energy source and also by the horizontal extension of the downdraft, can inhibit the growth of thunder cloud. If the updrafts are strong, shearing may not prevent a thunderstorm from developing, but can considerably reduce the period of its duration. It is easy to see that the inhibition due to shear will not be proportional to the shear vector itself but to the ratio between the shear vector and the velocity of and the area covered by updrafts. However, if we take the velocity of and the area covered by updrafts as proportional to the positive area, the shear vector itself can be taken to indicate the extent of inhibition, when the positive area is the same. As the growth of cumulus beyond freezing level seems essential for development of thunderstorm, the shear vector between friction free surface air (say, wind at about 500 metres level) and the freezing level may give a good indication of the amount of inhibition by the shearing process.

A preliminary examination of some cases has shown that by taking account of the above factors a better assessment of thunderstorm liability can be obtained. Further work is in progress.

Meteorological Office,
Poona,
September 27, 1949.

S. N. Ray Choudhuri.

REFERENCES:

1. Ind. Met. Dept. Tech. Note 13.
2. Proc. Nat. Inst. Sc. Vol. V, 97 (1949).
3. Ind. Met. Dept. Tech. Note 16.
4. Jour. Met. (American Met. Society) 5, 103-107.
5. Bulletin American Met. Society, 30, 168-175.