

## Vertical Currents in a Thunderstorm observed with the F-type Radiosonde\*

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It is well known that there are very strong upward and downward currents in a thunderstorm. The observations are based mostly on the occurrence of hail and the experiences of pilots who have occasionally ventured into them. While a few downward and upward motions of sounding balloons have been observed, and reported, it has not been possible to state definitely whether the observed downward motion of the balloon observed from the record is due to the vertical currents or due to the accumulation of snow or due to the heavy rain experienced by the balloon. In the present paper it has been shown, how the F-type radiosonde of the India Meteorological Department differs from other and it is possible to definitely locate and measure the vertical currents.

The F-type radio-meteorograph like the Vaisala or the British Meteorograph, employs a fan which rotates during the ascent of the balloon, but the design and mounting of the fan of this instrument is very different from those in others. The fan in the F-type meteorograph is made from a single sheet of paper and is mounted in the instrument so as to rotate about a vertical axis when the balloon rises in the atmosphere (Fig. 1). In the Vaisala and British instruments, the fans are made of 3 or 4 cone cups mounted about a horizontal axis and the cups rotate both due to vertical ascent of the balloon and due to horizontal winds.

The chief feature of the fan in the F-type radio-meteorograph is that it rotates only

when it moves relative to the air along the axis of rotation in the upward direction and the horizontal winds at any level have very little effect. Moreover, during the ascent, the balloon moves horizontally with the speed of the wind and therefore the effect of the horizontal wind is unimportant.

As the fan in the F-type radio-meteorograph operates only during the upward motion along the axis of rotation, the rate of rotation of the fan serves as a very useful indication of the existence of vertical currents in the atmosphere. If the balloon develops a leak, the rate of ascent will first decrease, and later the balloon will descend. This will be reflected in the rate of rotation of the fan, which will first begin to slow down and later stop when the balloon begins to descend. On the other hand, if snow accumulates on the balloon, the rate of rotation will decrease gradually and the rotation will stop as soon as the accumulation is sufficiently large to exceed the free lift of the balloon and the balloon descends. However, in this case, when the balloon descends below the freezing level, the accumulated snow will melt, and the balloon will rise again; and the fan will restart working. Suryanarayana and Kachare (1951) have described such observations during F-type radiosonde ascents during steady rain not associated with thunderstorm. Kachare *et al.* (1957) have shown in detail the effects of rain water and snow accumulating on the balloon.

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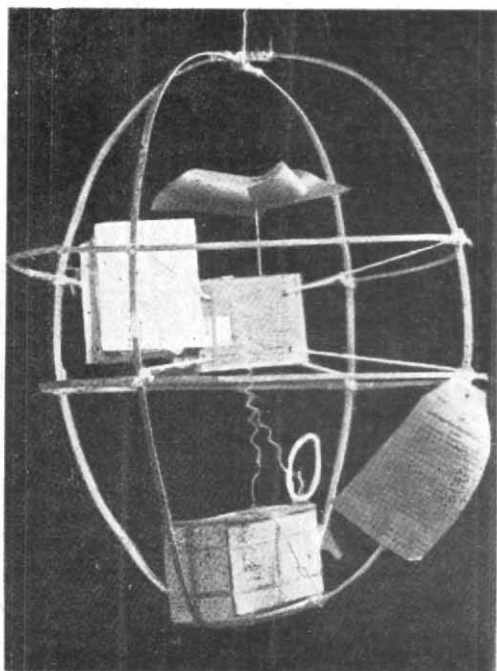


Fig. 1

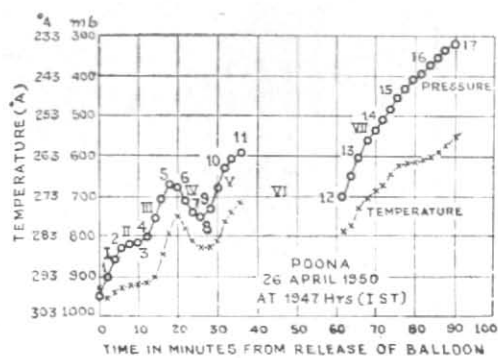


Fig. 2

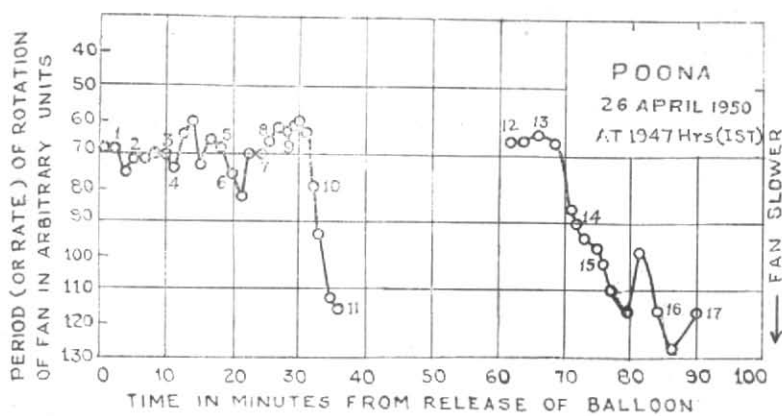


Fig. 3

While in the case of all other types of radio-meteorographs, one can observe the movement of the balloon up and down in the atmosphere from the pressure and temperature data, it cannot be said whether they are due to vertical currents of air or due to accumulation of snow. In the case of the F-type radiosonde, however, if the balloon descends due to a strong downward current of air, the fan will be continuously rotating and the rate of descent due to this downward current can be estimated from the rate of increase of pressure and temperature. An instance when the balloon was forced down due to strong downward currents in a thunderstorm at Poona on 26 April 1950 is described below.

Fig. 2 gives the variation of pressure and temperature with time experienced by the radiosonde; Fig. 3 gives the rate of rotation of the fan operating the radio-meteorograph. The rate of rotation is measured by the length of paper tape per complete Olland cycle and is given by the distance between two consecutive signals from the fixed reference contacts in the instrument. Fig. 4 gives the tephigram obtained from the ascent giving the distribution of dry bulb and wet bulb temperatures.

It can be observed from Fig. 2 that in Phase I, the balloon was rising uniformly for about 16 minutes till it reached the 827-mb level when its rate of ascent was reduced for about 6 minutes. Later, it again rose uniformly for about 6 minutes more till it reached the 671-mb level after which the balloon descended to the 750-mb level in about 8 minutes. It again rose for about 10 minutes till it reached the 593-mb level. After this no signals were received from the fan for about 24 minutes; later the signals were again received, but from a lower level, viz., 700 mb and continued thereafter till it reached 320 mb.

The approximate rates of ascent or descent of the balloon in the different phases are given in Table I.

TABLE 1

Phase	Characteristic points	Approx. rate of ascent (kmph)	Remarks
I	upto 2	13	
II	2-4	3	
III	4-5	15	
IV	5-8	-7	Balloon descending at about 11 kmph between points 6 and 7
V	8-11	11	Rate of ascent about 18 kmph between 9 and 10
VI	11-12	..	Balloon descent due to accumulation of snow

From the ascent curves in Figs. 2 and 3, it will be observed that during the Phases II and IV, though the balloon was rising at an appreciably lower rate in Phase II and even descending in Phase IV, the fan in the meteorograph was rotating almost at the same rate as during the period immediately after the release of balloon. As the fan can rotate only when there is an opposing wind, the balloon must have experienced strong downward currents in these two phases. Comparing the rate of ascent in the region corresponding to Phase I with that at Phase II, it is observed that the rate of ascent had decreased from about 13 to about 3 kmph, from which it can be inferred that the downward current was approximately 10 kmph in Phase II. Similarly, a rate of ascent of about 15 kmph in Phase III became a rate of descent of about 7 kmph in Phase IV, the maximum downward current experienced by the balloon then being not less than 22 kmph. In Phase VI, the balloon was descending and as the fan was not rotating, the descent must have been due to thick icing on the balloon. That this is so is confirmed by the fact that the temperature of the air at the level corresponding to the beginning of Phase VI was about 2°C. As the rate of ascent began decreasing even from the 630-mb level, it is

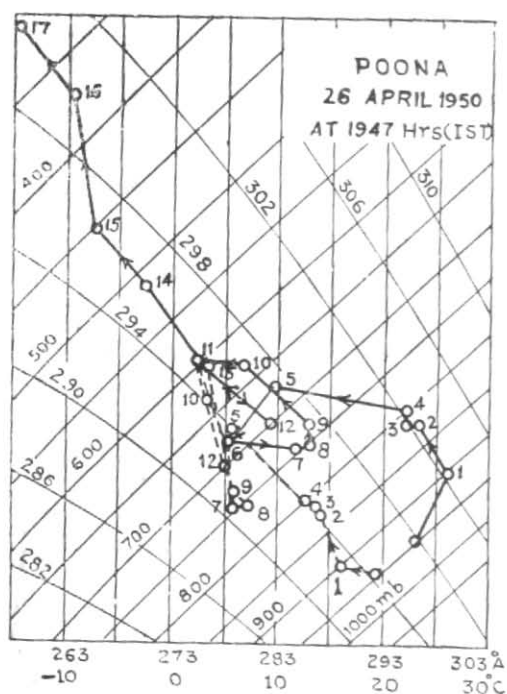


Fig. 4

possible that the snow had started falling and accumulating on the balloon even from this level.

When the balloon descended, the ice should have melted and, therefore, the balloon began rising again as shown in Phase VII. But the rate of ascent now was only 8 kmph and this is probably because the balloon started rising before all the snow collected on it had

melted, and even reached the freezing level again when further melting would not be possible.

From the tephigram in Fig. 4, it will be observed that there was a ground inversion due to the rain cooled air. When the balloon reached the 671-mb level, the dry bulb fell suddenly to that of the wet bulb indicating a very high super-adiabatic lapse rate. Simultaneously, the balloon was caught in the downward current which brought it down from the 671-mb level to the 750-mb level. During this descent, the rise of temperature was almost along the dry adiabat. An examination of the wet and dry bulb curves seems to indicate that the downward current was due to the rain cooled air.

If the points 2 to 4 in Phase II are now examined on the tephigram, it will be noticed that there was a sharp fall of temperature from points 2 to 3 and they depict the conditions similar to those in Phase IV, but to a much lesser degree. This is also supported by the fact that the rate of rotation of the fan were not affected, while the rate of ascent was appreciably decreased.

The radiosonde ascent of this day has brought out many interesting features in the thunderstorm, and this is primarily due to the unique features in the radiosonde instruments. These observations would not be feasible with other types of radiosondes now in general use in various countries.

## REFERENCES

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| Suryanarayana, D. and Kachare, N. R.                                     | 1951 | <i>Ibid.</i> , 2, 4, pp. 306-308.                   |