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On a destructive pendant cloud at Bamrauli

D. VENKATESWARA RAO and BIJAY BHUSAN SEN
Civil Aviation Training Centre, Allahabad

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ABSTRACT. The meteorological conditions leading to the appearance of a balloon-shaped pendant cloud at Bamrauli at 1255 IST on 14 September 1956 have been investigated. The nature of the destruction wrought by this cloud is described and discussed.

1. Introduction

A balloon-shaped pendant cloud associated with a thunderstorm passed over Bamrauli and its environs at 1255 IST on 14 September 1956. A narrow and intensely localised trail of devastation was left by the cloud along its trajectory on the surface. A destructive cloud of this type was never experienced in this locality.

2. The topography of Bamrauli and its environs

In Fig. 1, are shown the part of the residential camp of the staff of the Civil Aviation Training Centre and Aerodrome (Bamrauli, Allahabad) and the immediate purlieu, which were affected by the phenomenon. At a distance of about 2 miles to the north of the camp runs the Ganges from the west to the east. There are two small villages between the camp and the river; the nearest one Punghat lies on the outskirts of the camp to the north and the other called Mariwadi is at a distance of about a mile to the northwest of Punghat. Both these villages suffered damage.

3. The trail of destruction

The curvilinear track over which the destructive cloud passed is also shown in Fig. 1 by the thick arrowline. The village of Mariwadi was the first to be affected. Interrogation of the villagers revealed that a black balloon-shaped cloud moved across their place from the Ganges side a little before 1 P.M. on 14 September. As it passed over this village, roofs of 15 tiled houses blew off with explosive suddenness. Big branches of trees were ripped off and small trees were uprooted within an incredibly short time. The trail of destruction ran across this village from the northwest to the southeast and it was about 50 yards wide. Outside this corridor, there was scarcely any noticeable damage.

The balloon-shaped cloud also passed over the southwestern fringes of the village, Punghat. Here, one tree was uprooted and another cyclonically twisted. The phenomenon did not fortunately pass over any habitations of this village It swept over a 'jowar' field, mowing down all the plants in a narrow lane varying in width from 10 to 20 yards. The plants on either side of this lane remained erect and unscathed.

The cloud then moved across the plains towards the camp. The crown of a *Bel* tree growing over a ridge, marked by X in Fig. 1, was snipped off and was observed by some of the residents in the camp to have been carried along spinning up to a distance of about 50 yards to the south where it was dropped. The corrugated iron-sheet roof of barrack No. 199 was lifted off from the north and practically over the whole length and flung to the south. Photographs of this barrack taken from the south and north are shown in Figs. 2 and 3 respectively. It is significant that the roof of this building was detached at the northwest angle, which faced the full fury of the phenomenon and was folded over the other side together with the wooden girders, clearly showing the cyclonic nature of the twist. The phenomenon then hit barrack No. 197 broadside on and rolled back the roof completely to the south side. Photographs of this barrack taken from the southwest and the northwest are shown in Figs. 4 and 5 respectively. The cloud then came near barrack No. 205, the roof of which was heaved up and the walls and pillars slightly damaged. It later passed over the plains, twisting the branches of a tree marked in Fig. 1 by Y. Another tree near the Grand Trunk Road (marked Z in Fig. 1) was uprooted. No damage was discernible anywhere to the south of this tree. Heavy thundershowers followed immediately in the wake of this destruction everywhere.

The inmates of barrack No. 199 reported that some flat metallic plates, from which food was being taken at the time, rose up in the air against gravity, as if sucked upwards.

4. Synoptic situation and weather conditions at Bamrauli

A depression formed on 9 September 1956 with its centre at 0830 IST about 100 miles southeast of Calcutta. Moving northwest, it was centred near Gaya on 11 September and lay over east Uttar Pradesh as a low pressure trough at 0830 IST on 14 September. It rapidly filled up *in situ* thereafter. In association with this depression, Allahabad experienced intermittent moderate to heavy rain from the morning of 8 September till the evening of 14 September, the rainfall recorded during this period being 11·42 inches.

The synoptic chart, showing the position of the shallow depression at 0830 IST on 14 September is reproduced in Fig. 6. Isobars have been drawn at one millibar intervals to bring out the inherent peculiarities clearly. The axis of the trough is seen on this chart to extend latitudinally slightly to the north of Allahabad. The amounts of rainfall caused by this trough line during 0830 to 1730 IST of 14 September are also shown. A small anticyclonic vortex appears on this chart to the northwest of Allahabad. It is seen that showery type of precipitation occurred all along the axis of this trough from Allahabad on the west to Darjeeling on the east during 0830 to 1730 IST, the most intense rainfall occurring near its Allahabad end.

There was occasional slight rain till 0645 IST on 14 September after which the sky remained overcast with high and medium clouds. A thunderstorm was seen to approach the station at 1230 IST. It was observed by the authors from a spot about a mile to the south of the camp at 1300 IST to approach from the northeast and the edge of the advancing cloud was noticed to be extremely low and almost hovering over the ground. It was somewhere along this edge, that the balloon-shaped cloud was noticed by the people of the neighbouring villages. A squall from the northnortheast, with a maximum speed of 48 mph was experienced at 1300 IST in association with the balloon-shaped cloud and was followed immediately thereafter by heavy showers, a fall of 1·2 inches being recorded upto 1330 IST and of 0·7 inch later up to 1630 IST by the N.S. raingauge in the meteorological office at the aerodrome, which is located at a distance of about 1 mile from the affected area of the camp. The rainfall practically ceased altogether after 1630 IST. Histograms showing the rainfall totals at fifteen-minute intervals on 14 September during 1000-1500 IST are shown in Fig. 7(a).

The relative humidity at Bamrauli on 14 September which was about 90% till 1200 IST became 85% by 1300 IST. It then rose suddenly to 94% during the succeeding 8 minutes and remained practically so for the rest of the day. The dry bulb temperature which rose steadily from 77·8° F at 0900 IST to 82·8° F by 1300 IST dropped suddenly to 75·6° F and remained steady thereafter at about 76° F till the following morning. The barometric pressure registered a gradual fall from 994·1 mb to 991·6 mb during the period 1030 to

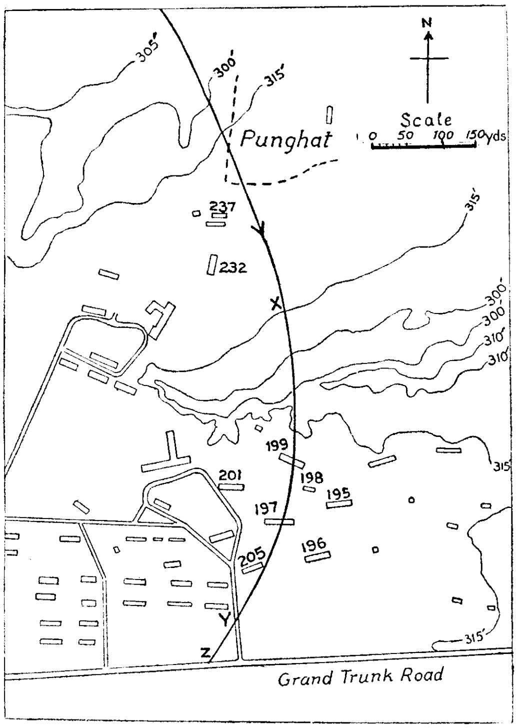
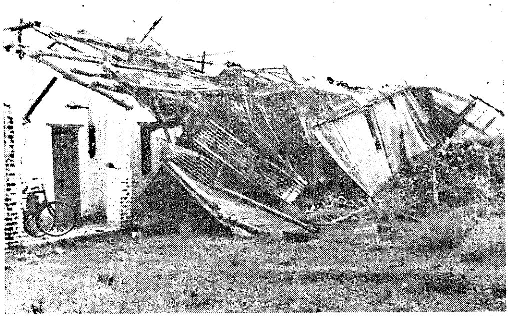


Fig. 1. Plan showing the track of the pendant cloud and the area affected by it at Bamrauli

Fig. 3. View of barrack No. 199 from the north



(Courtesy : A. B. Patrika, Allahabad)

Fig. 4. View of barrack No. 197 from the southwest

(Courtesy : A. B. Patrika, Allahabad)

Fig. 2. View of barrack No. 199 from the south

Fig. 5. View of barrack No. 197 from the northwest

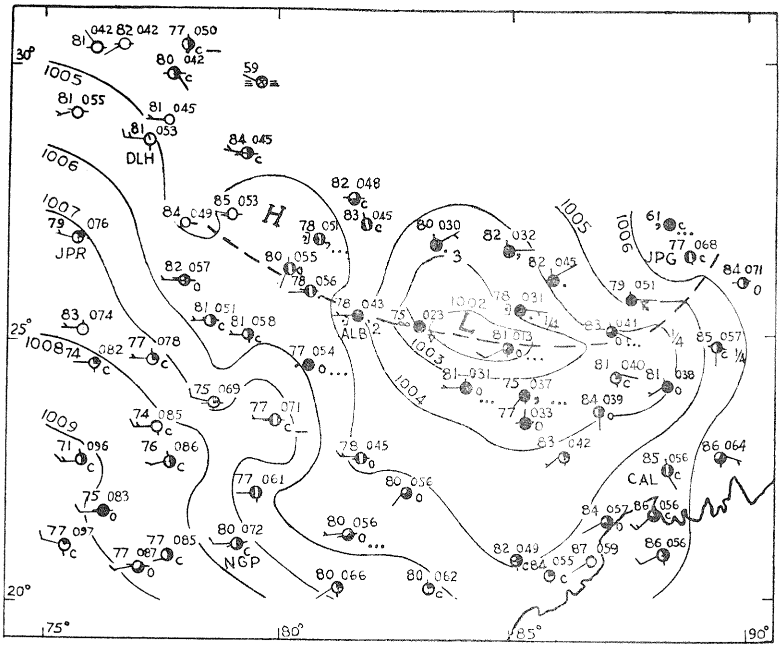


Fig. 6. Synoptic chart of 0830 IST on 14 September 1956 with the rainfall totals between 0830 and 1730 IST

1248 IST. It rose sharply later to 992·9 mb by 1305 IST, there being an instantaneous rise of about 1 mb at 1255 IST. The barogram also showed nine pressure oscillations of small amplitude with an average period of oscillation between 25 and 30 minutes during 0500 to 0900 IST. Graphs showing the trends of these various elements during 1000 to 1500 IST on 13, 14 and 15 September are reproduced in Fig. 7(b). The fluctuations of the above autographic elements would doubtless have been of an appreciably larger magnitude nearer the track of the pendant cloud.

5. Discussion

The shape of the pendant cloud depends upon the slope of the condensation-pressure isobaric surface. The slope is usually steepest near the axis of rotation but sometimes excessive friction greatly reduces the innermost slope. Brooks (1951) observes that, under such conditions, the tornado is prevented from reaching the ground and it assumes the shape of a basket or balloon. From the foregoing description of the balloon-shaped cloud at Bamrauli and the nature of the meteorological changes and the destruction caused by it, the cloud appears to be identical with a tornado, in which the pendant failed to reach the surface. One of the authors (Rao 1946) observed a similar tornado cloud at Madras near about noon-time on 8 October 1945, which formed and vanished in the air, without reaching the surface. The Madras tornado was, however, funnel-shaped. Veryard (1934) reported the occurrence of a typical tornado at Peshawar at 1155 LMT on 5 April 1933 in association with a cold front. The conditions favourable for the appearance of tornadoes or tornado clouds are not, therefore, sometimes unrealised in India. These conditions appear to develop at about noon-time at discontinuities of the cold front type in pre-monsoon and post monsoon depressions.

The behaviour of the autographic elements at Bamrauli on 14 September 1956 during

1255 to 1300 IST is indicative of the passage of a cold front. The anticyclonic vortex to the northwest of Allahabad appears to have transported a wedge of cold air, which advanced up to Allahabad by 1255 IST when the insolational effect could have become marked enough to contribute towards the development of auto-convective instability. The 0815 IST radiosonde ascent of 14 September revealed the existence of potentially warm air up to the 920-mb level with $\theta \simeq \theta_s \simeq 298°$ A and potentially cold air with $\theta = \theta_s \simeq 296°$ A from 900 to 500 mb, a steady transition from one value to the other taking place in the intervening layer. The maximum temperature reached on this day was 302°A at 1300 IST. The surface wind was 290°, 4-7 knots till 1300 IST when the squall occurred from the northnortheast. The wind later backed to the westnorthwest. It was generally 4-6 knots in speed till 1600 IST except for three gusts of 10-14 knots. It became practically calm later. The advancing cold wedge must have trapped some of the warm air near the surface. As the environment was almost saturated and the temperature reached by 1300 IST was quite appreciable, the air near the ground should have become auto-convectively unstable. The warm air trapped between the ground and the cold wedge must have exploded upwards through the wedge and thus conduced to the pendant formation. The temperature contrast of 3° A between the cold and the warm air masses was, however, not large enough for steepening the condensation-pressure isobaric surface parallel to the axis of the pendant to cause the extension of the latter down to the surface. The upper air temperature shown by the sounding at 2010 IST on 14 September disclosed a large fall of temperature above 700 mb, the amplitude of which increased with altitude reaching 9° A at 250 mb, indicating total replacement aloft of the warm air by a colder mass from the north by the time of this ascent. The tephigrams of 0815 and 2010 IST of 14 September are reproduced in Fig. 8. It is interesting to note that the trends shown

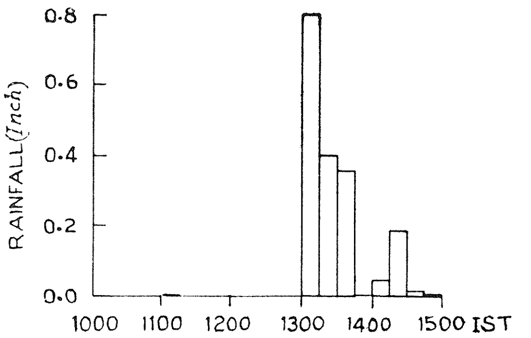


Fig. 7(a). Fifteen-minute rainfall totals on 14 September 1956 during 1000 to 1500 IST

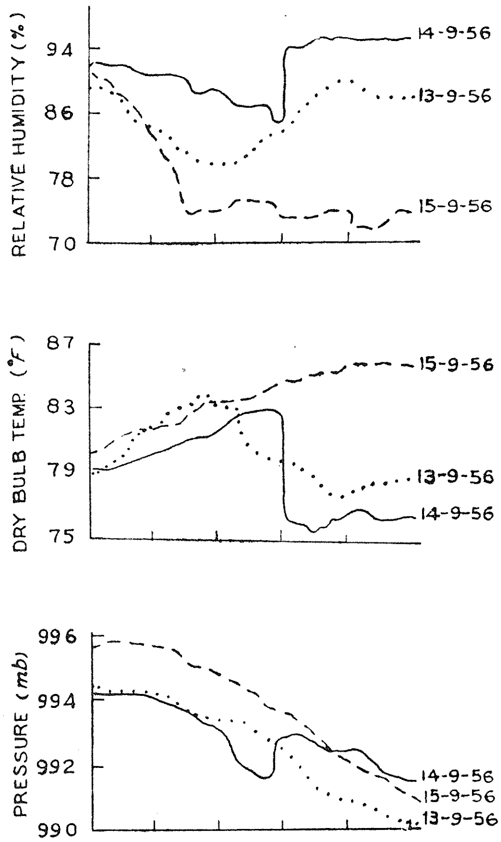


Fig. 7(b). Graphs showing variation of pressure temperature and relative humidity during 1000 to 1500 IST on 13, 14 and 15 September 1956

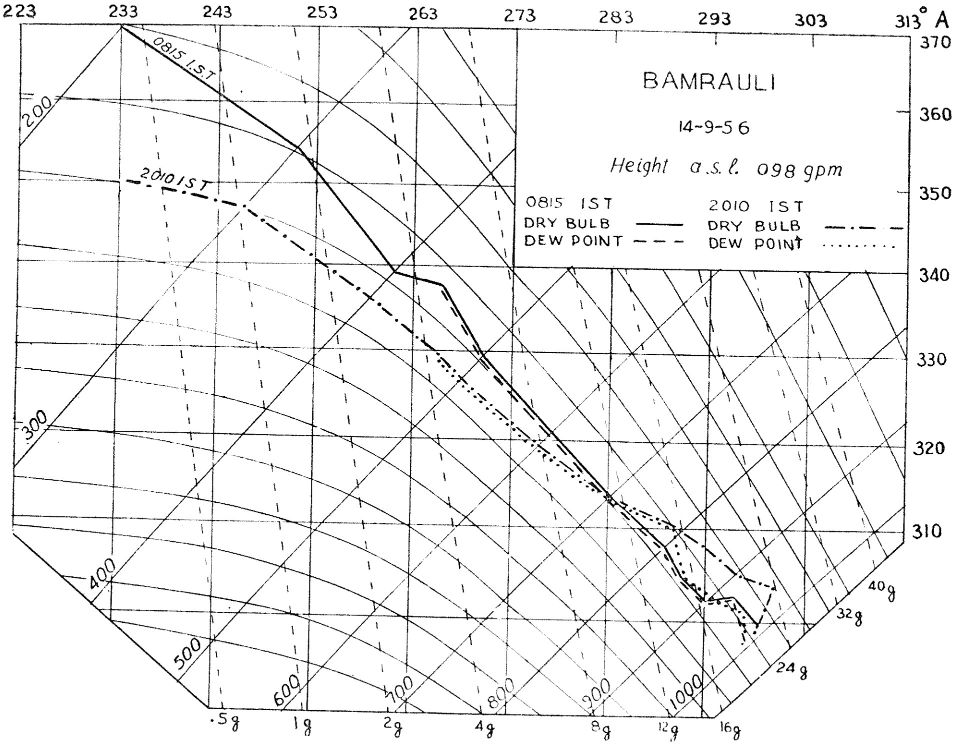


Fig. 8. Tephigrams of Bamrauli at 0815 and 2010 IST on 14 September 1956

by these curves bear a striking resemblance to those at Risalpur associated with the Peshawar tornado (Veryard 1934).

Finally, it is of interest to discuss the significance of the nine pressure oscillations observed in the microbarograms of Bamrauli during 0500 to 0900 IST on 14 September. Basu and Pramanik (1933), who examined pressure oscillations appearing in microbarograms at Peshawar showed that rainfall followed such oscillations in less than 11 to 12 hours of their occurrence. The periods of oscillation were found by them to have a most common range of 15 to 30 minutes.

The authors have found in the present case that the thunderstorm developed at Bamrauli within 8 to 4 hours of the first and last of the series of nine atmospheric oscillations. The average period of these oscillations was 27 minutes. These facts are in complete conformity with the generalisation arrived at by Basu and Pramanik.

6. Acknowledgement

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