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Very fast moving radar echoes as observed on CPS-9 Radar

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ABSTRACT. In this study, a few instances of very rapidly moving radar echoes, as observed on the CPS-9 Radar at Safdarjung (New Delhi), are presented and discussed in the light of available observations and existing theories. It has been shown that these echoes—apparently moving at speeds of more than 200 mph—cannot be due to radar returns from aircrafts or from birds. It has been concluded that these were in fact cases of radarscope misinterpretation; the radar beam at each successive rotation encountering a different blob in almost the same azimuth and range, and thus giving the impression that the successive echoes were due to the same radar object flying across the scope at a terrific speed of hundreds of miles per hour.

1. Introduction

The CPS-9 Radar* installed at Safdarjung (New Delhi) has been occasionally recording some rare but interesting types of angel echoes. In a recent communication (Kulshrestha 1961 a), the senior author has discussed observations of ring angels and squall precursor lines at New Delhi.

In this paper, three cases of very rapidly moving radar echoes are presented and discussed.

2. Details of radar observations

On 13 June 1960, the CPS-9 Radar was being operated on its usual search duty when three very fast moving radar echoes were observed. These were followed and are presented in Figs. 1 to 13. We shall first describe the movements of these echoes one by one—

(1) The first echo was detected at 1837 IST at 35 miles (azimuth 260° and height about 5000 ft above ground) and was found to be approaching the station (Fig. 1). By 1841 IST, the echo was only about 24 miles from the station and was at a height of about 3500 ft (Fig. 2). By 1843 IST, the echo was at about 15 miles and still in the same azimuth. This showed that it was approaching the station in an almost straight line path although continuously decreasing in altitude (Fig. 3). By 1845 IST, the echo was only about 7 miles from the station and at a height of about 2500 ft above ground but appeared to have shifted abruptly to 240° azimuth (Fig. 4). In fact at this stage, there were two similar echoes very adjacent to each other. The echo finally merged into ground clutter at about 1857 IST (Fig. 5) and did not emerge out on the other side. The average apparent speed of the echo was calculated, from its successive positions on the PPI photographs, to be more than 200 mph. The speed was found to be varying erratically between different positions of the echo.

(2) The second echo (not as strong as the one observed earlier) was first detected at 40 miles from the station in 200° azimuth at a height of about 7000 ft above ground (Fig. 5). After this, photographs were taken every minute. Within a minute, the echo was found to be at a distance of 34 miles at 1858 IST (Fig. 6). At this time, another echo appeared simultaneously with the one under observation. This is described separately below. Since it was becoming increasingly difficult to keep track of the echo, the radar antenna was put in azimuth sector scan of 25° on either side of 185° azimuth. By 1859 IST

*Characteristics of the CPS-9 Radar: X-band, 3·2 cm wavelength, 250 KW peak power, 1° conical beam, pulse width 0·5 μs and 5·0 μs the echo, which was at 34 miles at 1858 IST, shifted abruptly to 195° azimuth and was observed to be at a range of 27 miles (Fig.7). The echo continued to approach the station and had come to 22 miles within the next minute (Fig. 8). At 1901 IST it was at 18 miles from the station (Fig. 9). After this the range of the scope was switched to 25 miles and the echo was detected at about 16 miles at 1902 IST (Fig. 10). At this stage, the one mile range markers were brought into operation. The echo was found at 13 miles at 1903 IST and appeared to have shifted further south to 190° azimuth (Fig. 11). The echo was at 10 miles at 1904 IST (Fig. 12) and merged with the ground clutter during the next minute. In this case also, the average apparent speed of the echo was found to be more than 200 mph and to be varying erratically between different positions of the echo.

(3) At 1858 IST, when the second echo was at a range of 27 miles at 200° azimuth, another echo was detected at 46 miles in 175° azimuth (Fig. 6). By 1859 IST, it was at 39 miles from the station (Fig. 7). Within the next one minute, this echo came to 34 miles maintaining almost the same azimuth (Fig. 8). By 1901 IST, this echo was at 31 miles only (Fig. 9). Fig. 10 does not show this echo as it was still beyond 25 miles and the range of the scope presentation having been changed to 25 miles, the echo did not show itself in this photograph. But by 1903 IST, this echo was just beginning to appear at 25 miles range at about 179° azimuth (Fig. 11). The echo came to 22 miles within next one minute (Fig. 12) and was found to be at a range of 17 miles at 180° azimuth and at an altitude of 4000 ft above ground at 1905 IST as revealed by the RHI photograph in Fig. 13. It is worthy of note that this RHI photograph also shows another echo at 12 miles in the same azimuth but at a height of only about 1500 ft above ground. This particular echo could not be detected in any of the earlier PPI photographs. Within the next two or three minutes, both these echoes merged into ground clutter. As in the case of the earlier two echoes, the average apparent speed of the third echo was also estimated to be more than 200 mph.

Every effort was made to locate them but the echoes seemed not to emerge on the other side. No other echoes were recorded after that.

3. Evidence of turbulence in the lower atmosphere

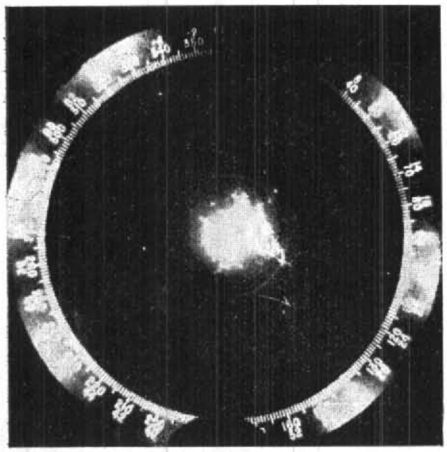
On 13 June 1960, weather had been dry over northwest India. A steep pressure gradient existed over Rajasthan causing gusty and dust raising winds. Due to dust, the sky was indiscernible till 1430 IST. At about 1440 IST, when the sky became slightly clearer, altocumulus cloud of the cloudlet type was observed and was found to cover 5 to 6 octas of sky.

The day had been marked with widespread angel activity when 'blobby' or 'spotty' angels, of the type due to thermals or bubbles, had been observed in the afternoon. An example of the type of angel activity observed is shown in Fig. 14. Various examples of this type of angel activity have been discussed elsewhere by Kulshrestha (1961 b). For the present, it is important to note the striking resemblance between the individual angel echoes in Fig. 14 and the rapidly moving echoes shown in Figs. 1 to 13. By about 1800 IST, the widespread angel activity had died down and only a few blobs could be seen on the PPI scope.

The existence of the altocumulus cloud of the cloudlet type and the 'blobby' angels strongly indicate the existence of turbulence in the lower atmosphere. This fact will be of help in understanding the nature of these rapidly moving radar echoes as discussed in the next section.

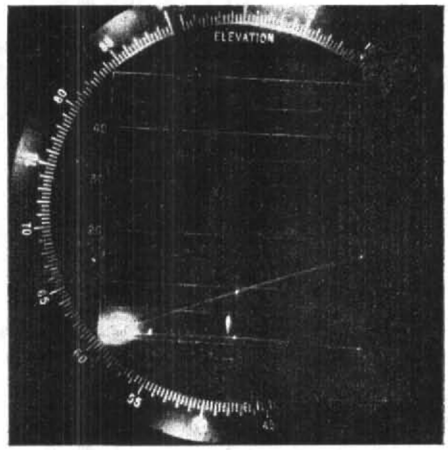
4. Discussion of the nature of the very fast moving radar echoes

The very nature of the RHI presentation of these echoes, the fact that these, having merged with the ground clutter, did not emerge on the other side, the continuously decreasing heights at which the echoes



1837 75 1°

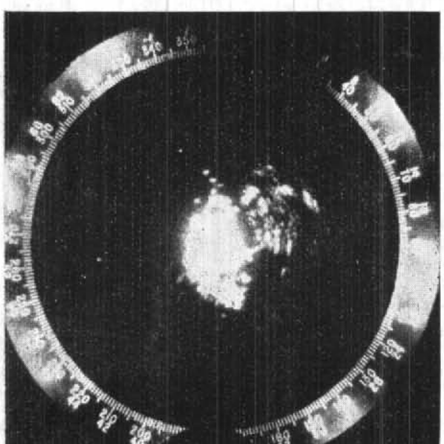
Fig. 1



1841 50 260°

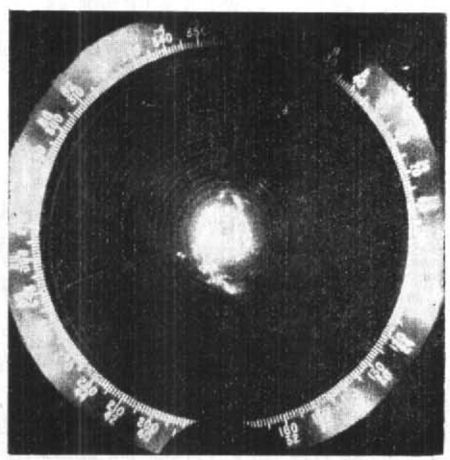
Fig. 2

(Markers : 25 miles)



1843 25 2°

Fig. 3



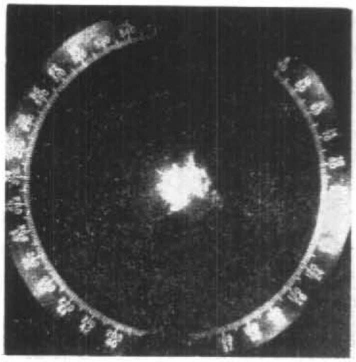
1845 25 4°

Fig. 4

(Markers : 1 mile)

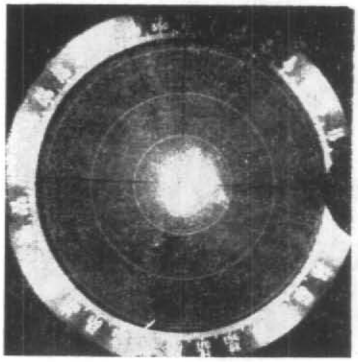
Photographs of very fast moving radar echoes as observed on CPS-9 Radar, New Delhi

Figures given below the photographs indicate (from left to right)—Time (IST), Range in miles and Elevation/Azimuth in degrees respectively



1857 75 1°

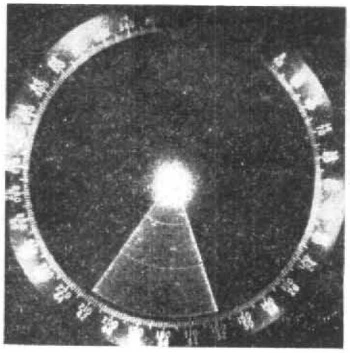
Fig. 5



1858 75 1°

Fig. 6

(Markers : 5 miles)



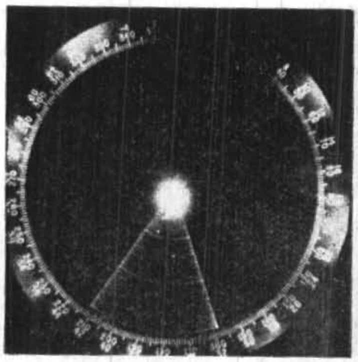
1859 75 1°

Fig. 7

(Markers : 5 miles)

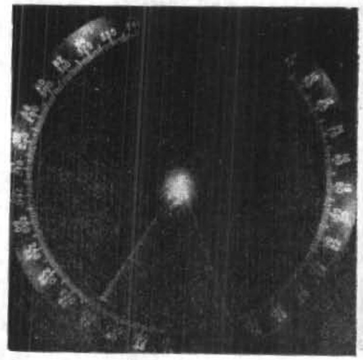
Photographs of very fast moving radar echoes as observed on CPS-9 Radar, New Delhi

Figures given below the photographs indicate (from left to right)—Time (IST), Range in miles and Elevation/Azimuth in degrees respectively



1900 75 1°

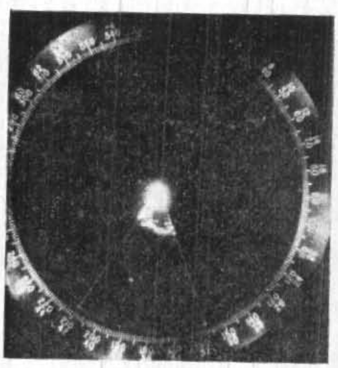
Fig. 8



1901 75 3°

Fig. 9

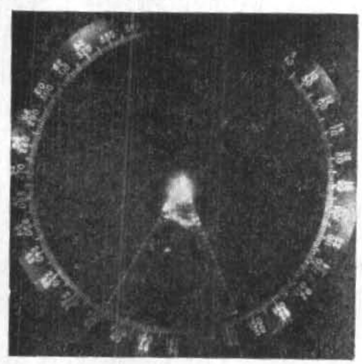
(Markers : 5 miles)



1902 25 3°

Fig. 10

(Markers : 5 miles)



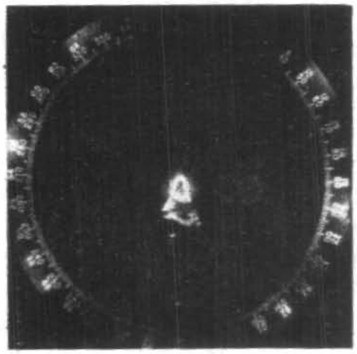
1903 25 3°

Fig. 11

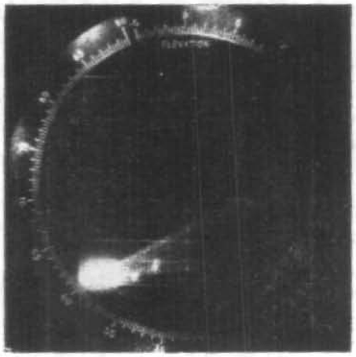
(Markers : 1 mile)

Photographs of very fast moving radar echoes as observed on CPS-9 Radar, New Delhi

Figures given below the photographs indicate (from left to right)—Time (IST), Range in miles and Elevation/Azimuth in degrees respectively

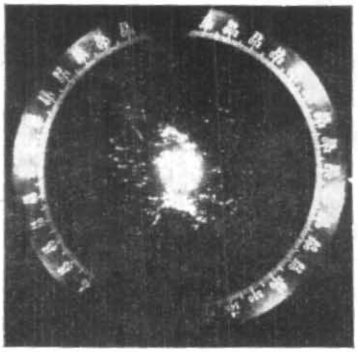


1904 25 3°
Fig. 12



1905 50 180°
Fig. 13

(Markers : 1 mile)



1500 25 3·5°
Fig. 14

(No markers)

Photographs of very fast moving radar echoes as observed on CPS-9 Radar, New Delhi

Figures given below the photographs indicate (from left to right)—Time (IST), Range in miles and Elevation/Azimuth in degrees respectively

occurred, and the direction of their approach from the direction of the prevailing wind (which was westerly to southwesterly from ground to 13,000 ft and thereafter westnorthwesterly upto 25,000 ft) completely exclude the possibility of these echoes being due to any aircraft.

These echoes can also not be due to birds or insects. Firstly, birds and insects are known not to fly at temperatures below 5°C or above 35° C. Secondly, the indicated angel source sizes of at least some hundreds of feet are not readily explained by birds or insects, in any case , not by the birds or insects found over inland areas. Perhaps the only insect found over inland areas, flocks of which may give appreciable radar return, is locust. However, no locust swarms were reported over the area on this day. Thirdly, the indicated speeds were perhaps a little too much for the type of birds expected to fly in the mid-summer afternoons or evenings at New Delhi. Finally, the concentration of birds or insects should tend to increase in the evenings whereas the angel activity was maximum at about 1500 IST (Fig. 14) and decreased towards evening.

Having thus completely eliminated the possibility of these fast moving echoes being due to aircraft or flocks of birds, we now turn to attempt a suitable explanation for these curious "Radar flying saucers". In this attempt, the authors take their clue from the existence of turbulence in the lower atmosphere, as brought out in the Section 3 of this paper.

The authors believe that what was actually observed on the radarscopes was a case of scope misinterpretation. At a casual glance, one is apt to think that the echo return presented on successive rotations of the sweep was derived from a single moving source when really the radar returns were unrelated ones. In the treatment that now follows, an attempt has been made to explain the mechanism responsible for these fast moving radar echoes.

It has been known since long that radar reflections in the lower atmosphere, referred to as angels, are the result of atmospheric turbulence which creates abrupt changes in the dielectric constant (Gordon 1949). In the present case, the turbulent atmosphere gave rise to numerous thermals or bubbles, which were responsible for the widespread angel activity (observed in the afternoon and shown in Fig. 14) due to refraction of energy at the refractive index inhomogeneities at the interface of the thermals or blobs set in the unstable turbulent atmossphere (Atlas 1959) and at a time when most of these thermals were still not sufficiently developed to reach the cloud formation stage. (Such of these thermals, as reached the cloud formation stage, gave rise to the altocumulus cloud of the cloudlet type.) So long as there was widespread angel activity, the radar beam at its successive rotations encountered innumerable thermals or blobs, resulting in the PPI display of the type presented in Fig. 14.

By 1800 IST, due to the absence of insolation, the turbulence had mostly died down with the result that altocumulus cloud had almost disappeared and only a few thermals remained over the area round the station. These thermals or blobs were naturally randomly distributed.

Now if the radar beam, at each of its successive rotations, came across a different blob in almost the same azimuth, it would appear to the radar observer that the same echo is moving with a fast speed, depending upon the distance between the two independent blobs. That this was the actual mechanism is also evident from the fact that the first echo appeared to shift abruptly from 260° azimuth to 240° azimuth and the second echo also appeared to change its azimuth from 200° to 195° and then to 190° suddenly. All these changes of azimuth took place within the short intervals of just one minute each. What actually happened was that after the blob encountered by

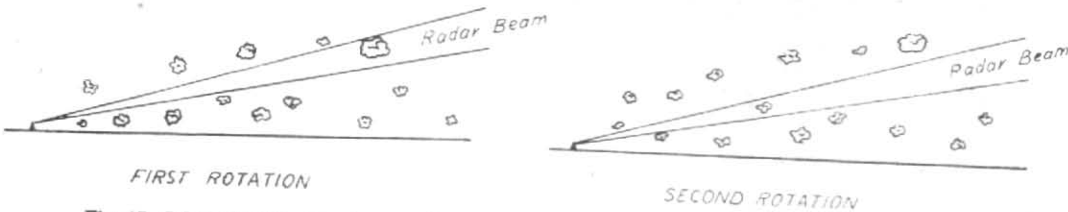


Fig. 15. Schematic diagram showing the mechanism by which the so called 'very fast moving radar echoes' or 'radar flying saucers' appear on the radarscopes

the radar beam at 34 miles 200° azimuth, the beam on its next rotation encountered another blob at 27 miles 195° azimuth; the first blob by this time having gone above the cone of the radar beam. Similar thing must have taken place in other cases where a sudden change in the position of the echo was observed. Also in Fig. 13, an echo was observed at 12 miles at a height of 1500 ft above ground. This echo was not observed in the earlier photographs as the blob giving rise to this echo, probably did not exist at all at the time of the earlier photograph. This mechanism will be clearly understood by a reference to the schematic diagram presented in Fig. 15 which is based on a diagram by Plank (1956).

5. Conclusion

It will be evident from the above discussion that these very fast moving radar echoes or the "radar flying saucers", as they are popularly called, provide a fine example of radarscope misinterpretation. The radarscope sweep at every successive rotation encounters a different blob in almost the same azimuth and range. The net result is that, the radar returns in all these cases being similar, it presents the unique spectacle of a so-called radar object flying across the scope at terrific speeds of hundreds of miles per hour. This also highlights the need for extra carefulness on the part of the aircraft surveillance radars, specially in defence establishments, so as not to initiate an unwanted aircraft warning.

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