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Radar upper wind measurements at New Delhi using Decca wind finding radar — Type WF 2

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ABSTRACT. This note gives a brief description of the Decca wind finding radar type WF2 acquired by the India Meteorological Department. An analysis of the series of upper wind measurements taken with this radar at New Delhi during the monsoon months, July to September 1960, and the winter months, December 1960 to February 1961, is given. The structure of the upper winds over New Delhi during these months as revealed by the composite wind velocity profiles, is also indicated. The ratios of the maximum wind speed to the mean wind speed between the ground level and level of maximum wind were computed for all these ascents and the mean ratio was found to be 2·78. The comparison of the radar upper winds with the Rawin winds indicate close agreement at lower levels and when the winds are light. However, at higher levels in winter the radar winds are stronger than the Rawin winds.

1. Introduction

The radar wind finding technique is one of the latest additions to the other wind finding methods in vogue such as the pilot balloon and the Rawin methods. These methods have, however, some severe limitations. The pilot balloon method being dependent entirely on visual tracking of the balloons, becomes impracticable under conditions of poor visibility of low cloud. Even though this limitation is obviated in the Rawin method, it perhaps fails to give accurate results at long ranges or low angles of elevation, especially when the angles less than 15° are encountered during the season when the upper winds are very strong or when the upper air "Jet" streams are present. The radar wind finding is accomplished by tracking with the radar, a suitable target made of metallised paper or a radar reflecting nylon mesh carried aloft by a sounding balloon. The radar wind finding technique tides over the above said limitation to a great extent enabling the balloon carrying the target to be tracked down to very low elevation angles, however depending on the nature of permanent obstructions in the near vicinity surrounding the site. The direct determination of the height at any point of the ascent is possible in the radar method, as the slant range of the balloon is measured at every instant and perhaps this information is of immense value in detecting the variations in the vertical air currents at different levels, especially in the tropics.

A few years back the India Meteorological Department acquired a Decca wind finding radar type WF2, the first of its kind, to be installed at New Delhi. This equipment operates in the 3 cm band, with a nominal peak power of 75 Kw. The transmitter and receiver use a parabolic dish aerial system with a rotating wave guide feed. The brief technical specifications of the same are given below—

Transmitter :	Frequency 9375 mcs ± 30 mcs Peak power 75 Kw nominal Pulse length 0·25 microsec 0·50 " Pulse recurrence frequency 500 pps
Aerial system :	Parabolic dish of 8′ diameter with off set feed providing conical scan
Beam width :	1° narrow 5° wide
Aerial tilt :	—10° to 90°
Display :	I-Scope presentation on a C.R. Tube 9″ diameter
Designed Slant range :	200 km under normal propagation conditions using a target having equivalent reflecting area of 725 m²
Tracking :	Manual in both azimuth and elevation

The method of presentation of the echo from the return signal used in this radar is known as I-scope presentation in which the target echo appears as a complete circle when the radar is on target. The target echo as seen on the display at high gain is given in Fig. 1. The echo appears only as an arc of a circle when the radar is not on target, thereby enabling the radar to be oriented in line with the target by manipulating the azimuth and elevation suitably. The distance from the arc to the centre of the display tube is proportional to the range. The accurate tracking of the target is made possible by the one degree narrow beam whereas for hunting the target soon after the launching of the balloon, the five degree wide beam is used. A small auxiliary reflector can be brought into use by remote control

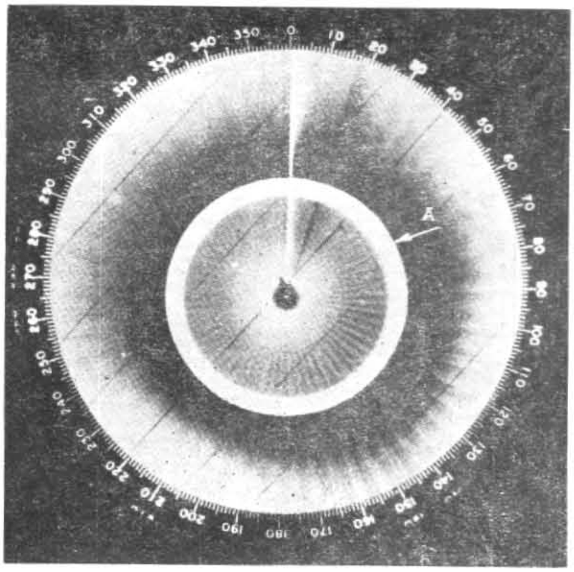

Fig. 1. Photograph showing the echo pattern (Marked 'A') from the target in the WF 2 Radar. Stroke marker merged in echo

when required for target acquisition thereby facilitating operation on two basic conditions either "Search or follow positions". The azimuth and elevation information are obtained from the mechanical position of the aerial reflector when the system is on target.

2. Targets

The type of targets used with this radar are corner reflectors assembled by clipping togther the basic triangular elements made of paper backed aluminium foil, stretched over prestressed duralumin metal wire frame. The foil has good reflecting and re-radiation properties as well as of very high conductivity. The corner reflectors are either assembled in the form of a tetrahedron or octahedron clusters having three mutually perpendicular electrically conducting planes. The weights of each tetrahedron and octahedron cluster are 590 and 875 gms respectively. These targets are attached at a distance of 3′ from the balloon to minimise the drag.

3. Analysis of data

The upper wind measurements taken at New Delhi using this radar during the monsoon months of July to September 1960 and winter months from December 1960 to February 1961, are discussed below.

Fig. 2 shows a composite picture of the variation of wind velocities with height as measured with the radar during the monsoon months July to September 1960 over New Delhi. The total number of ascents taken during this period is 23. The type of balloon used was mostly SR 875 gms, with an average rate of ascent of 18·7 kmph. The targets used were the large tetrahedron type described earlier which weigh about 590 gms. The maximum height the target reached in these ascents during this period was about 27·0 km, whereas the average height reached was about 20 km. The wind speeds were generally less than 40 knots at all levels upto 25 km. The average slant range reached was small of the order of 30 km. The elevation angles in these ascents were quite high as the balloon was ascending rapidly because of the light winds. Most of these flights terminated due to the bursting of the balloons.

The second series of 36 ascents discussed here, were taken during the winter period from December 1960 to February 1961. During these months the winter jet streams are present over Delhi. To obtain upper wind information up to great heights during this season it was found that the rate of ascent of 20 kmph normally used with the existing radiosonde/Rawin ascents had to be increased considerably to nearly 30 kmph. The average rate of ascent realised in these series of ascents was 24·4 kmph using the SR 875 gms balloons. As the balloons were found to drift to low angles, the octahedron cluster targets weighing about 900 gms were used to get a good return signal. Figs. 3 to 5 show the composite picture of wind velocity profiles with heights during the months of December 1960 to February 1961. The examination of these profiles reveal that —

1. On most of the occasions the balloon carrying the target crossed through the core of very strong winds and emerged out into the regions of the upper atmosphere where the winds are comparatively light. This is shown clearly from Figs. 3 to 5.

2. The maximum upper wind jet speeds during these months were found to be as high as 160 knots, occurring at some level between 11 and 12 km.

3. The upper wind velocities have been more than 80 knots in a deep layer of about 6 km thickness above 8 km height. And at some height between 16 and 18 km it is seen that nearly all the winds fall off to velocities below 40 knots.

4. It was also noticed that over a period of more than a fortnight in January 1961 the upper wind velocities had become quite low. It seems that the upper air jet stream during these months over Delhi appears in spells.

The mean wind speed between the ground level and the level of maximum wind was calculated for each sounding taken during the winter months. The ratio between maximum wind speed and the mean wind speed was worked out in all cases and the results are given in Table 1. The mean of the

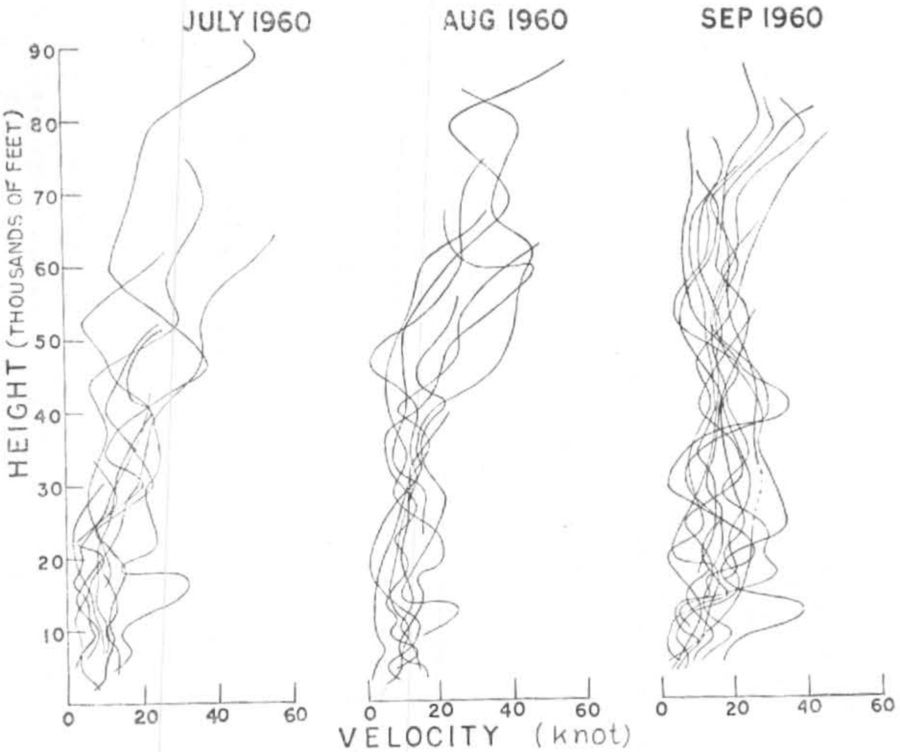

Fig. 2 .Radar upper wind velocity profiles, New Delhi

TABLE 1

New Delhi (Lat. 28° 35′N, Long. 77° 12′E) — December 1960 to February 1961

Date	Max. wind speed (knots) V_{max}	Mean wind speed from ground level to level of max. wind V_{mean}	$\frac{V_{max}}{V_{mean}}$	Mean ratio	Date	Max. wind speed (knots) V_{max}	Mean wind speed from ground level to level of max wind V_{mean}	$\frac{V_{max}}{V_{mean}}$	Mean ratio
16-12-60	93	38·1	2·45		20-1-61	74	35·3	2·10	
18-12-60	149	47·0	3·18		23-1-61	68	25·0	2·71	
19-12-60	153	61·0	2·52		24-1-61	73	35·5	2·08	2·78
21-12-60	160	39·6	4·04		2-2-61	132	52·2	2·54	
23-12-60	142	65·0	2·18		3-2-61	126	47·0	2·70	
24-12-60	154	48·2	3·20		6-2-61	121	45·2	2·68	
26-12-60	131	49·0	2·68		14-2-61	140	54·4	2·58	
27-12-60	160	51·6	3·10	2·92	15-2-61	136	50·2	2·72	
2-1-61	142	44·6	3·18		16-2-61	134	38·0	3·52	
6-1-61	120	46·6	2·58		20-2-61	130	54·5	2·48	
9-1-61	164	52·2	3·14		21-2-61	132	53·6	2·46	
11-1-61	152	45·5	3·32		22-2-61	128	55·7	2·30	
12-1-61	156	47·1	3·31		23-2-61	160	67·2	2·38	
16-1-61	105	42·3	2·50		25-2-61	156	51·8	3·01	
17-1-61	104	48·5	2·14						
19-1-61	106	30·0	3·52		27-2-61	136	54·0	2·51	2·65

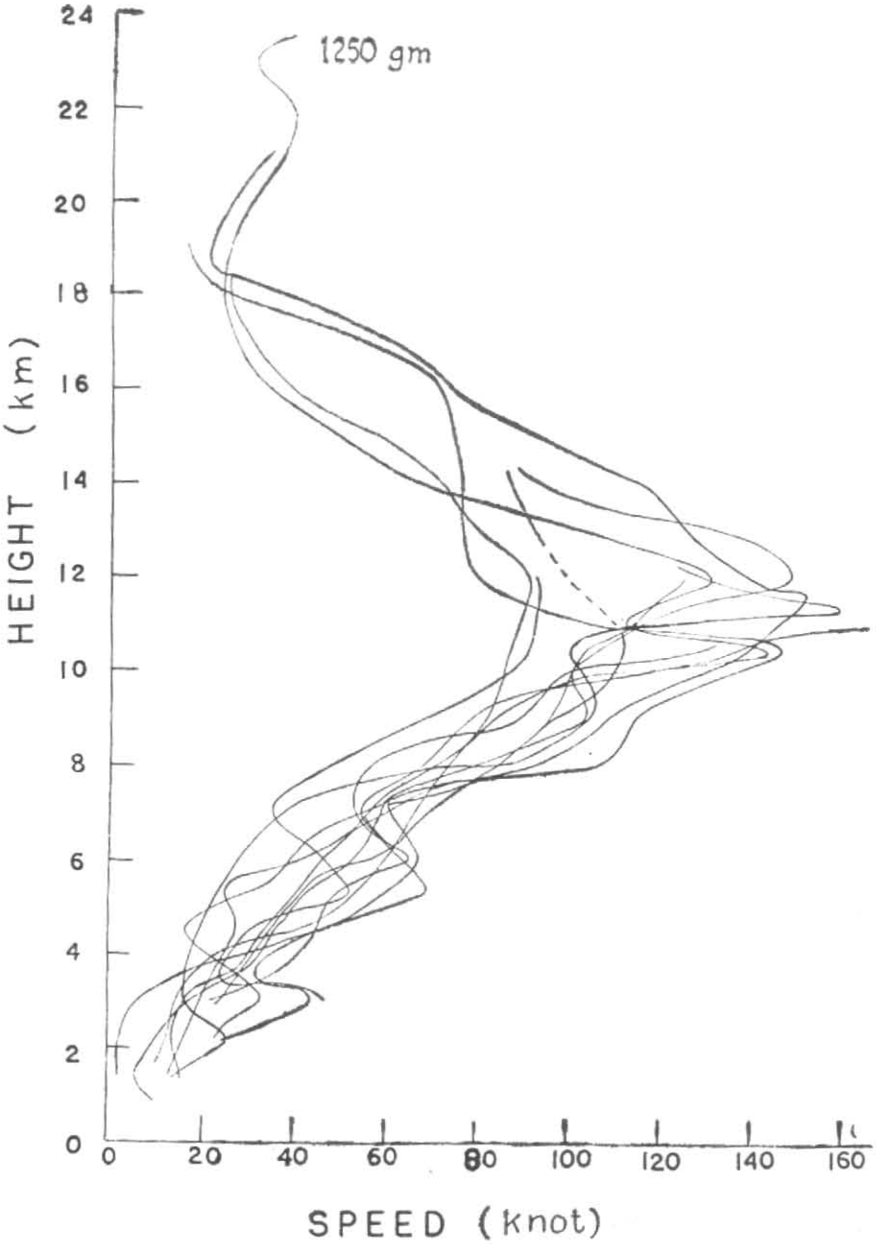

Fig. 3. Radar upper wind velocity profiles, New Delhi, December 1960

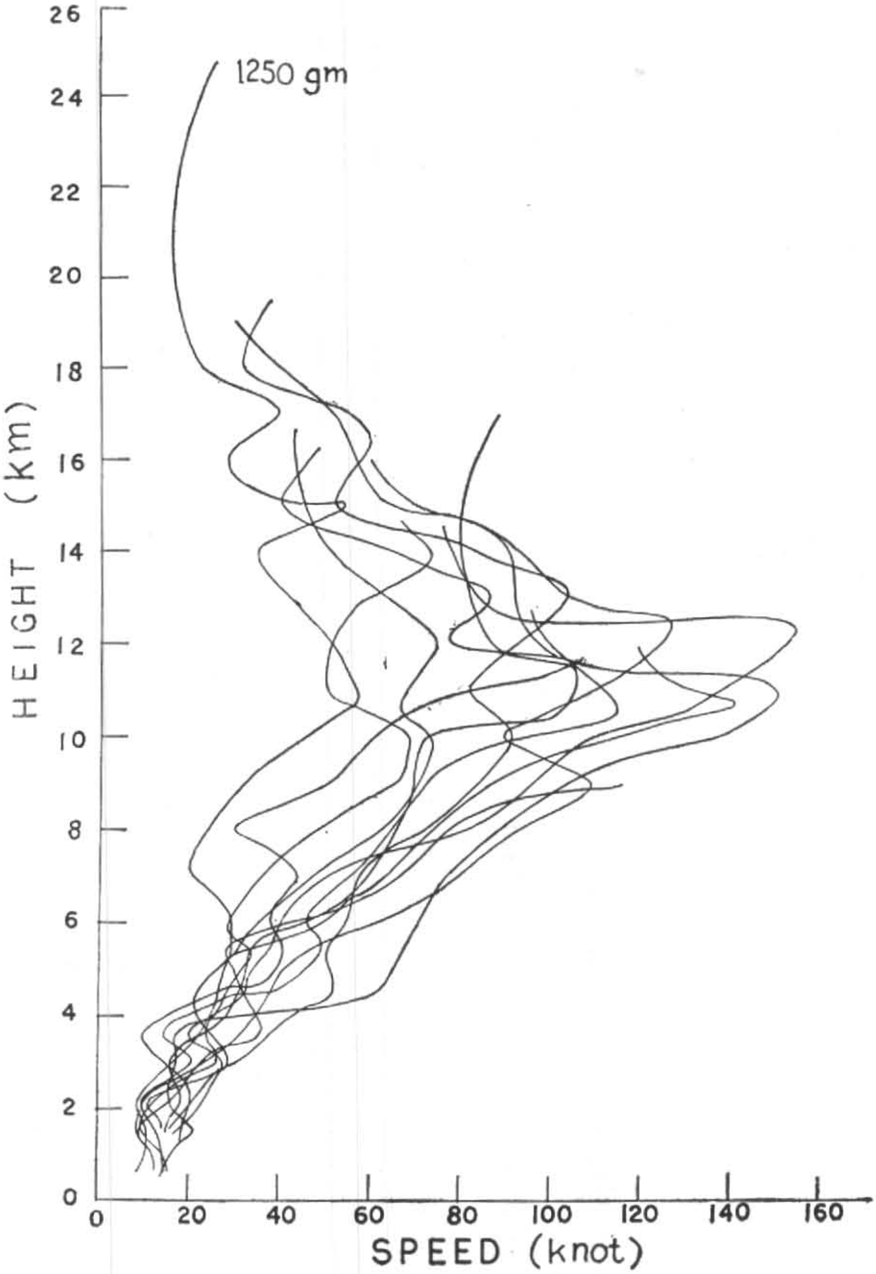

Fig. 4. Radar upper wind velocity profiles, New Delhi, January 1961

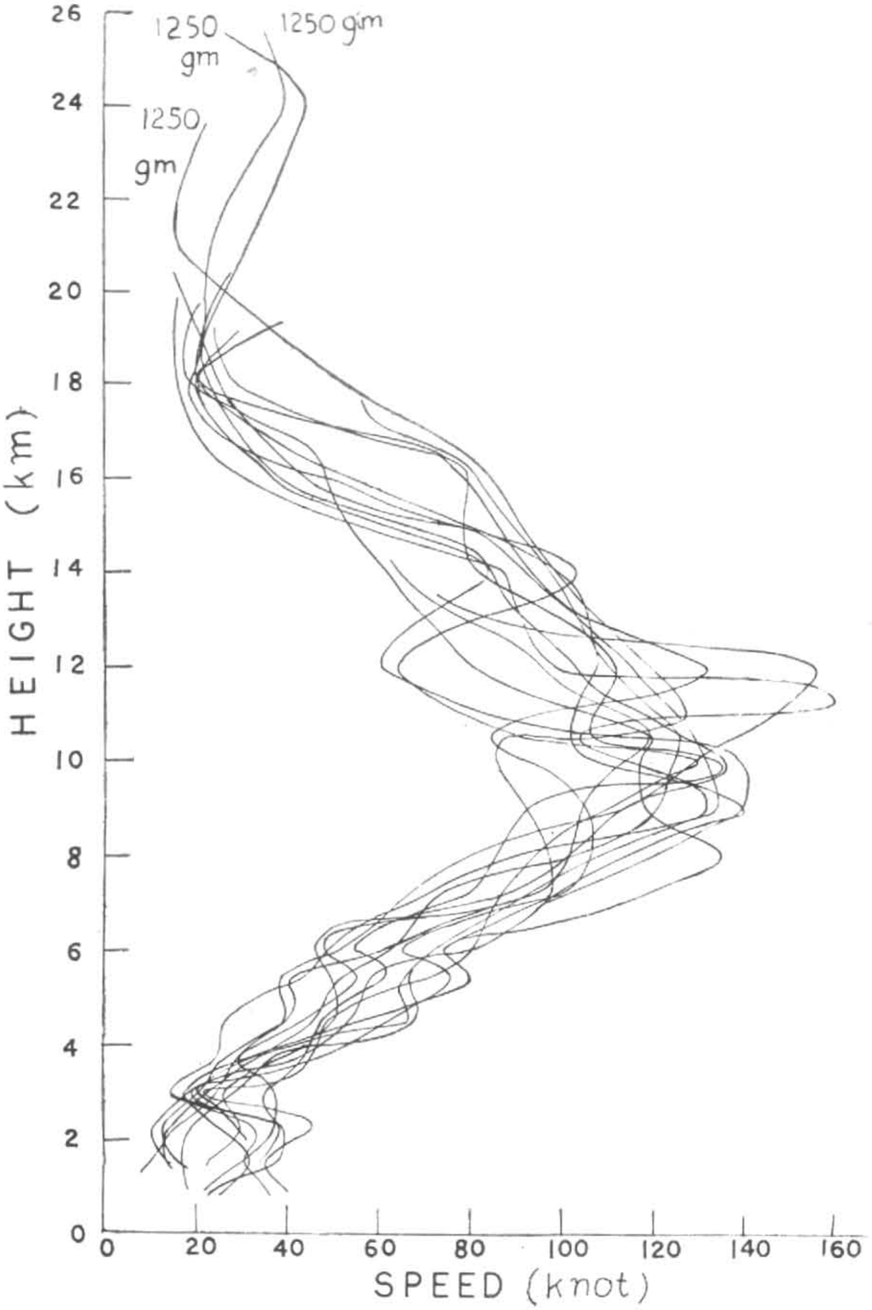

Fig. 5. Radar upper wind velocity profiles, New Delhi, February 1961

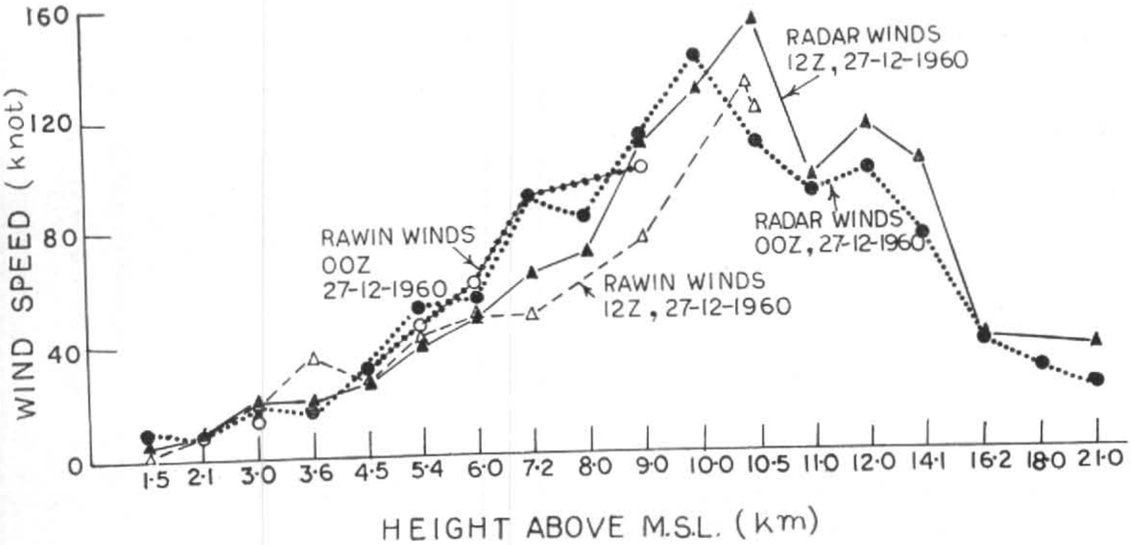

Fig. 6

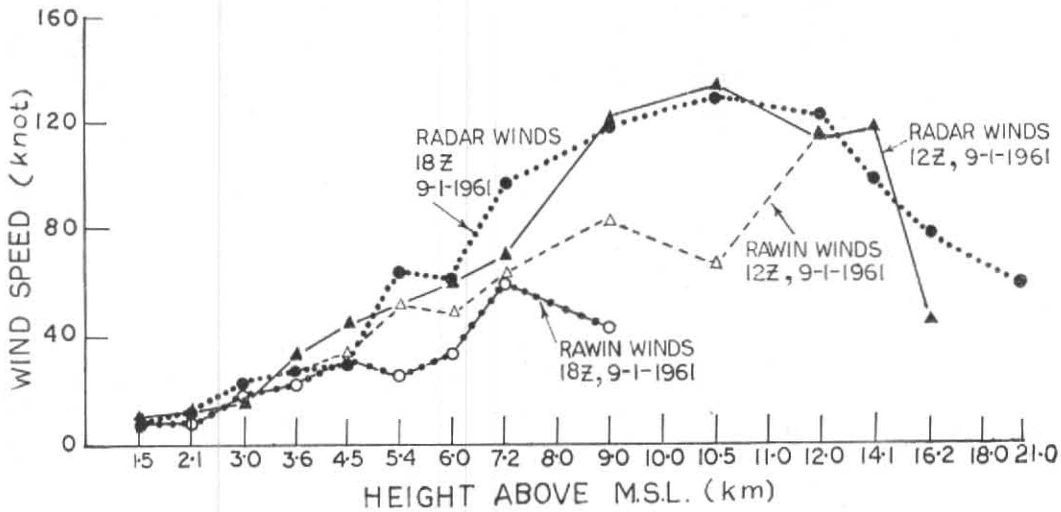

Fig. 7

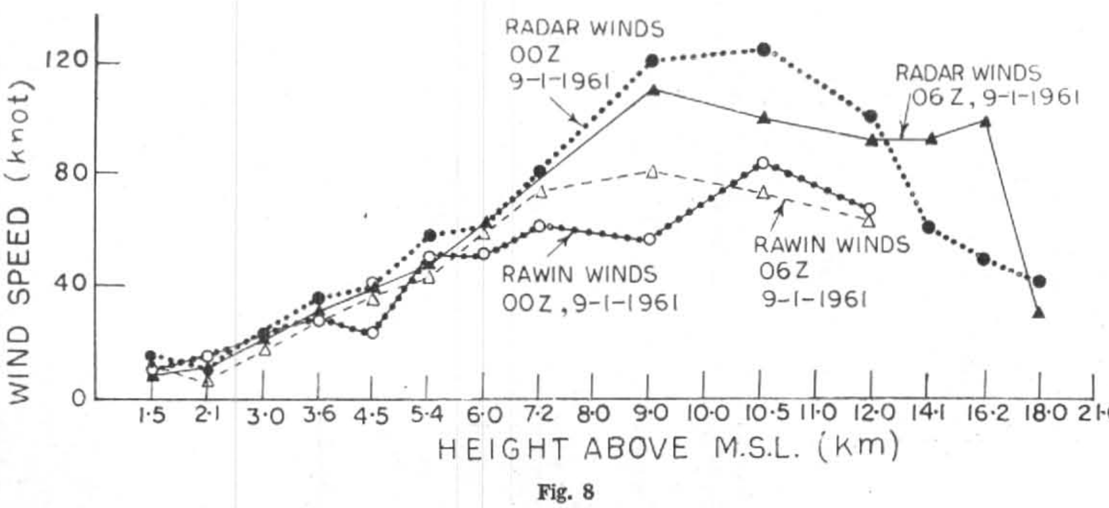

Fig. 8

Figs. 6-8. Comparison of Radar and Rawin winds, New Delhi

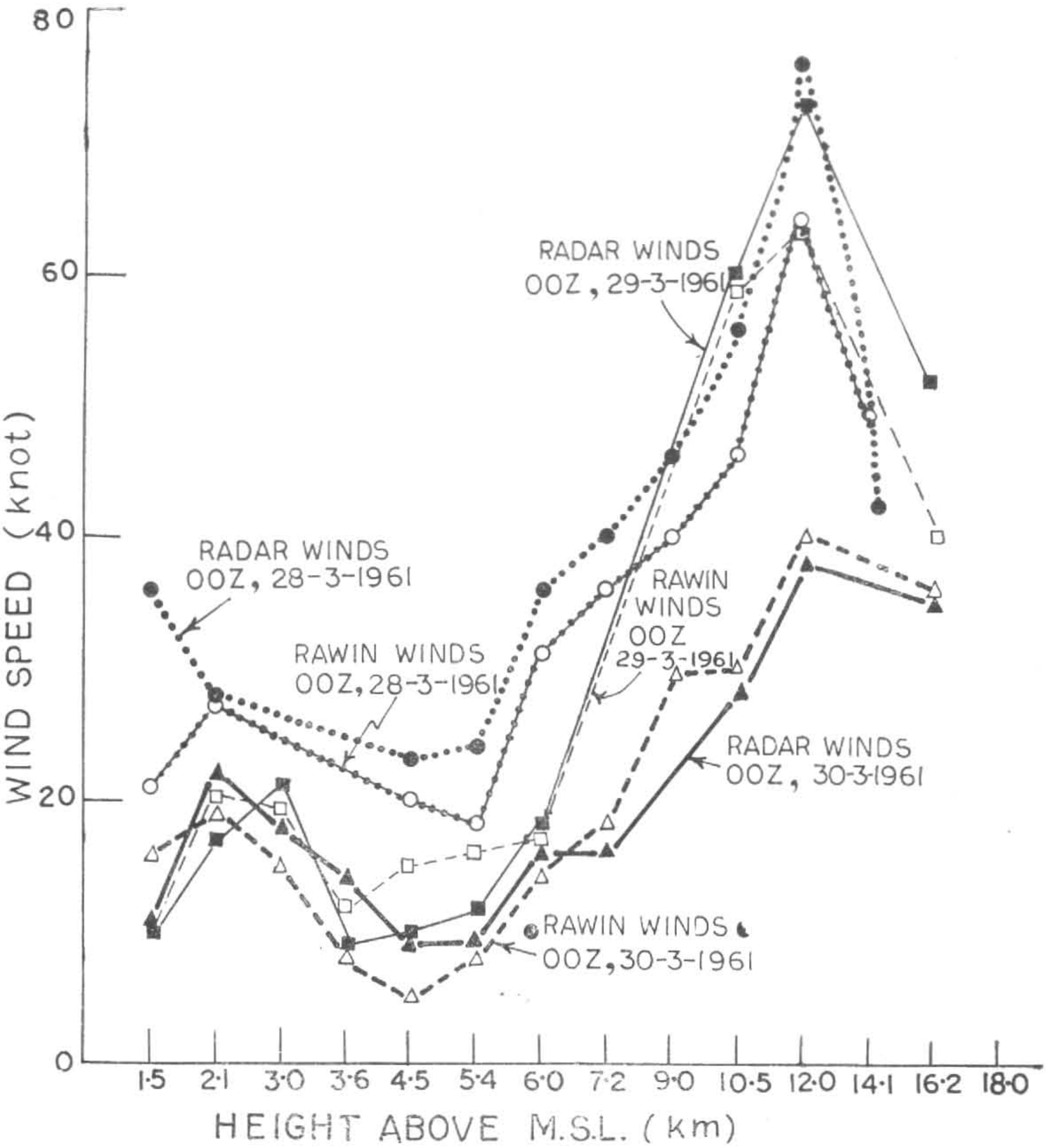

Fig. 9. Comparison of Radar and Rawin winds, New Delhi

ratio, which appears to be a useful index for the maximum upper air jet velocities, comes out to be 2·78.

A comparison was also made between the radar winds and the Rawin winds from the available data as shown in Figs. 6 to 9. These graphs indicate that there is a close agreement between the radar and Rawin winds especially when the wind speeds are small at the lower levels up to 6·0 km. At higher levels the radar computed winds are stronger than the Rawin winds especially in winter months as shown in Figs. 7 and 8. The difference may perhaps be the effect of very low elevation angles encountered due to very strong upper winds at higher levels in the winter season, on the accuracy of Rawin computations.

4. Acknowledgement

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REFERENCE

Decca Wind finding Radar (Type WF2) operation Manual