

RESULTS OF TWO YEARS OF RANDOMIZED CLOUD SEEDING
EXPERIMENT IN THE DECCAN PLATEAU, INDIA

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ABSTRACT

A randomized experiment, using warm seeding technique, was conducted in the low rainfall region east of Poona in the Deccan Plateau during the southwest monsoon period of the years 1973 and 1974. The results of the experiment, evaluated on the basis of the daily rainfall reports, are presented. Measurements of various microphysical parameters were also made in the course of the experiment. A brief summary of the results of these measurements is included.

1. INTRODUCTION

A randomized cloud seeding experiment, with crossover design, using warm technique was conducted in the low rainfall region east of Poona, in the Deccan Plateau during the southwest monsoon of 1973 and 1974. The preliminary results of the first year of operation were reported (vide Krishna et al., 1974), hereinafter referred to as paper I. Detailed description of the experiment, the experimental area, meteorological conditions attending the experiment, choice of seedable days, the aircraft and seed dispensing gadget used in the experiment are given in Paper I, and are not repeated here. Figures 1 to 8 referred to therein which could not be printed in that paper are included here. The titles of the figures are self-explanatory. Figure 2 which gives the locations of raingauges has been revised and made up-to-date.

The results of the second year of operation as well as those of the two years put together are presented in this paper. In the course of the experiment, measurements were made of the various cloud microphysical parameters. A brief summary of the results of these measurements is also presented.

2. EXPERIMENTAL AREA AND RAINGAUGE NETWORK

The experimental area consists of 3 sectors each of 40 km x 40 km. The central sector is the buffer and the adjoining northern and southern sectors are the experimental sectors (Figure 2).

When the experiment commenced in 1973, there were 40 raingauges installed in the experimental areas giving a network density of 1 raingauge per 80 sq. km. When the experiment of 1974 began, 18 additional raingauges were installed increasing the network density to 1 raingauge per 56 sq. km. Figure 2 shows the locations of the raingauges.

3. SEEDING DETAILS

The details of seeding operation, namely seeded sector, duration of seeding, level of seeding, and quantity of material seeded on each seedable day are given in Table 1 for 1974. Similar information for 1973 is available in I. In 1974 the experiment could not be conducted, due to unavoidable reasons, during the month of August.

4. VISUAL OBSERVATIONS

In the 1973 experiment, visual observations were made of the vertical extent of the cloud and their response to seeding. The results were summarized in I. In the 1974 experiment similar observations were made and the conclusions arrived at in the previous year were confirmed. They are reproduced in Table 2.

5. ANALYSIS OF RAINFALL DATA

The experiment was conducted on 11 pairs of seedable days in 1974. The values of mean rainfall per station in target area (T) and control area (C) for north-seeded days and the corresponding values (T') and (C') respectively for south-seeded days are shown in Table 3. The square root value of the ratio product $\frac{T}{C} \times \frac{T'}{C'}$, which represents the result of seeding, is also shown in this Table. If the value is greater than 1, the result is positive and if it is less than 1, it is negative. In case the value is 1 or indeterminate, the result is inconclusive. The analysis pointed out positive result in 7 pairs, negative result in 2 pairs and inconclusive result in 2 pairs.

Combining the seeding efforts of 1973 and 1974 the experiment pointed out that, out of the total of 24 pairs of seeded days, the result was positive in 14 pairs, negative in 6 pairs and inconclusive in 4 pairs.

According to Mann-Whitney test, the results are not statistically significant considered either yearwise or for the two years put together.

TABLE 1

Date	Sector Seeded	Duration of seeding (minutes)	Level of seeding above MSL (km)	Quantity of material seeded (kg)
1974				
June 26	South	30	1.5 - 1.8	450
28	North	120	1.5 - 1.8	1500
June 30	South	76	1.5 - 1.8	1225
July 1	North	43	1.7 - 2.1	950
4	South	75	1.4 - 1.7	1250
5	North	73	1.6 - 1.7	1250
7	North	40	1.6 - 1.8	775
8	South	80	1.8 - 2.7	1200
11	North	63	1.2 - 1.7	1400
15	South	36	1.4 - 2.3	1125
21	South	40	1.5 - 1.9	1500
23	North	58	1.7 - 2.2	1475
27	South	40	1.5 - 1.9	1500
28	North	58	1.7 - 2.2	1475
29	South	65	2.0 - 2.3	1525
30	North	63	1.8 - 1.9	1500
Aug. 29	North	76	1.5 - 2.1	1500
30	South	90	2.0 - 2.3	1500
31	North	76	1.8 - 2.0	1500
Sept 1	South	70	2.1 - 2.4	1500
2	North	58	2.0 - 2.1	1500
3	South	55	2.4 - 2.7	1500

TABLE 2

SUMMARY OF THE VISUAL OBSERVATIONS MADE ON ISOLATED
 SEEDED CLOUDS OF DIFFERENT VERTICAL THICKNESS

<u>Vertical Thickness</u>	<u>Observation</u>
Less than 300 meters	Dissipation
300 - 500 meters	Tendency for dissipation
500 - 1000 meters	Tendency for rain
1 - 2 km	Rain
Greater than 2 km	Heavy rain

TABLE 3

Pair	Date	<u>North-seeded days</u> mean rainfall in mm per station		Date	<u>South-seeded days</u> mean rainfall in mm per station		$\left(\frac{T \times T'}{C \times C'}\right)^{\frac{1}{2}}$	Result
		Target (T)	Control (C)		Target (T')	Control (C')		
1	June 28	3.65	3.85	June 26	6.84	4.75	1.168	Positive
2	July 1	0.29	0.63	30	0.43	0.07	1.682	Positive
3	July 5	3.11	0.52	July 4	1.42	1.98	2.051	Positive
4	July 7	0.32	0.26	8	0.38	1.54	0.551	Negative
5	July 11	4.81	0.39	15	0.27	0.06	7.451	Positive
6	July 23	0.11	0.21	21	0.02	0.00	Indeterminate	Inconclusive
7	July 28	5.88	5.24	27	3.43	0.68	2.371	Positive
8	July 30	25.37	11.68	29	6.98	11.72	1.137	Positive
9	Aug. 29	1.01	1.46	Aug. 30	0.16	0.47	0.485	Negative
10	Aug. 31	0.00	0.00	Sept 1	0.06	0.14	Indeterminate	Inconclusive
11	Sept 2	0.08	0.14	3	0.12	0.00	Infinity	Positive

NOTE: When the mean rainfall is 0.05 mm or less, it is considered as zero.

6. RESULTS OF MICROPHYSICAL MEASUREMENTS

i) Broadening of droplet size distribution

Using coated glass slides with hand-operated gadgets, observations were made of droplet size distribution in the clouds before and after seeding. The result of the observations were published (Kapoor et al., 1975, 1976). In 6 out of the 7 cases studied, the values of median volume diameter, maximum cloud droplet size and liquid water content increased after seeding. The increase noticed in the median volume diameter was as high as 478 per cent. The liquid water content and the maximum droplet size increased upward of 60 and 31 percent respectively.

ii) Dynamic effect of salt seeding.

Temperature observations were made with the vortex thermometer on the aircraft. Measurements of cloud liquid water content (LWC) were made with Johnson - Williams hot wire meter model LWH. Observations of vertical thickness of the cloud were made from the aircraft from vantage points.

Following seeding, the cloud, in certain regions, showed a rise in temperature from 1° to 2°C as well as rise in LWC up to 2 gm/m^3 . The cloud also grew by a few thousand feet, in the vertical, following seeding. These characteristic features, which appear to be the dynamic effect of salt seeding (Ramachandra Murty et al., 1975 a;b) were noted in all the situations when the initial vertical thickness of the cloud exceeded 1.5 km at the time of seeding. A kind of chain reaction, involving the process of condensation and updraft, has been invoked to explain qualitatively the features observed.

ACKNOWLEDGEMENT

The authors express their gratitude to the India Meteorological Department for extending its full cooperation for the experiment, to the Indian Air Force for making available facilities for the flights from the airport at Poona, to M/s. Air Works India for providing enthusiastic air crew for the operation and to the Instruments and Observational Techniques Division of the Institute for taking active part in the physical measurements.

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LIST OF DIAGRAMS

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- Figure 8: Track of the seeding plume as seen from the ground.

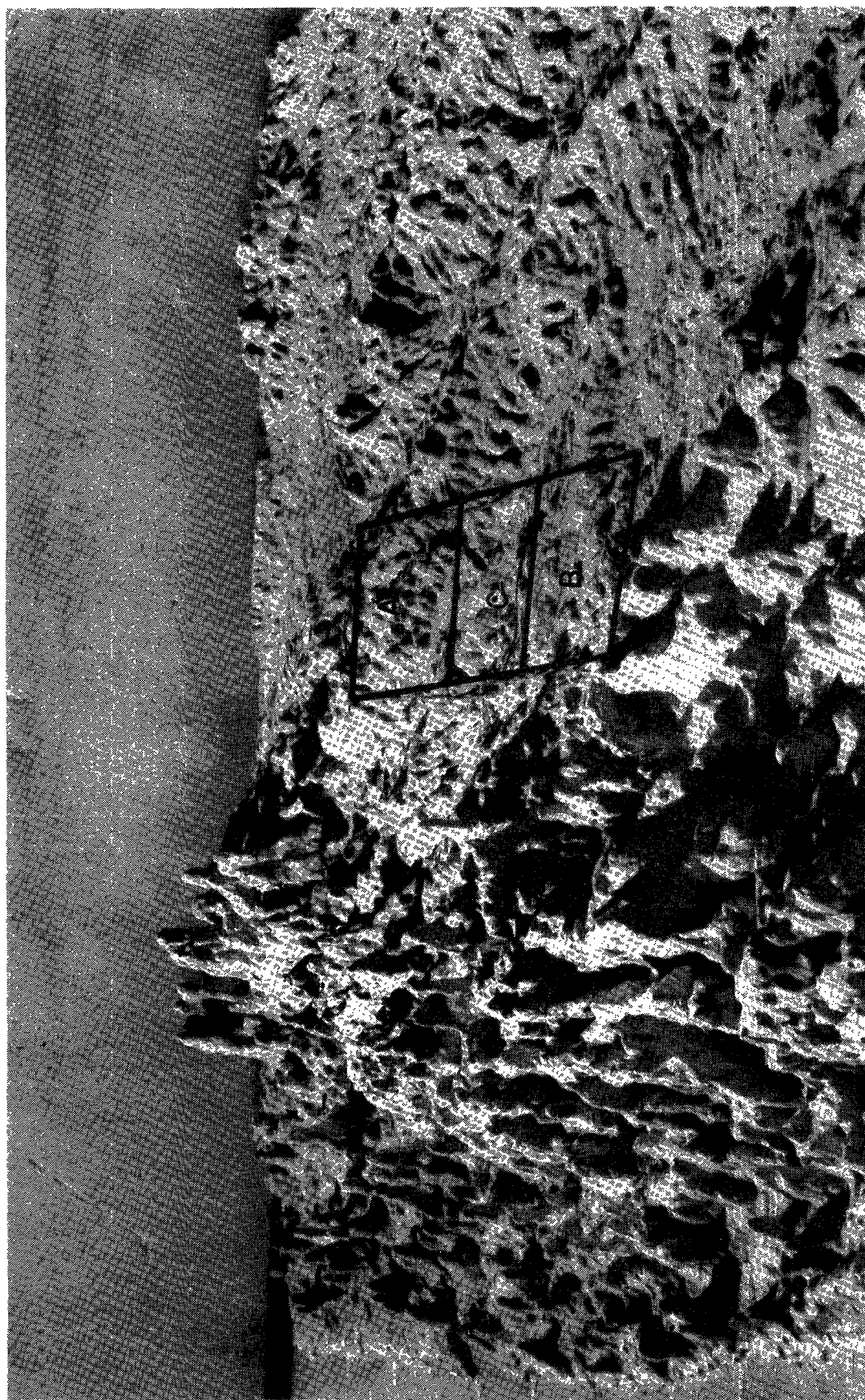


FIGURE 1

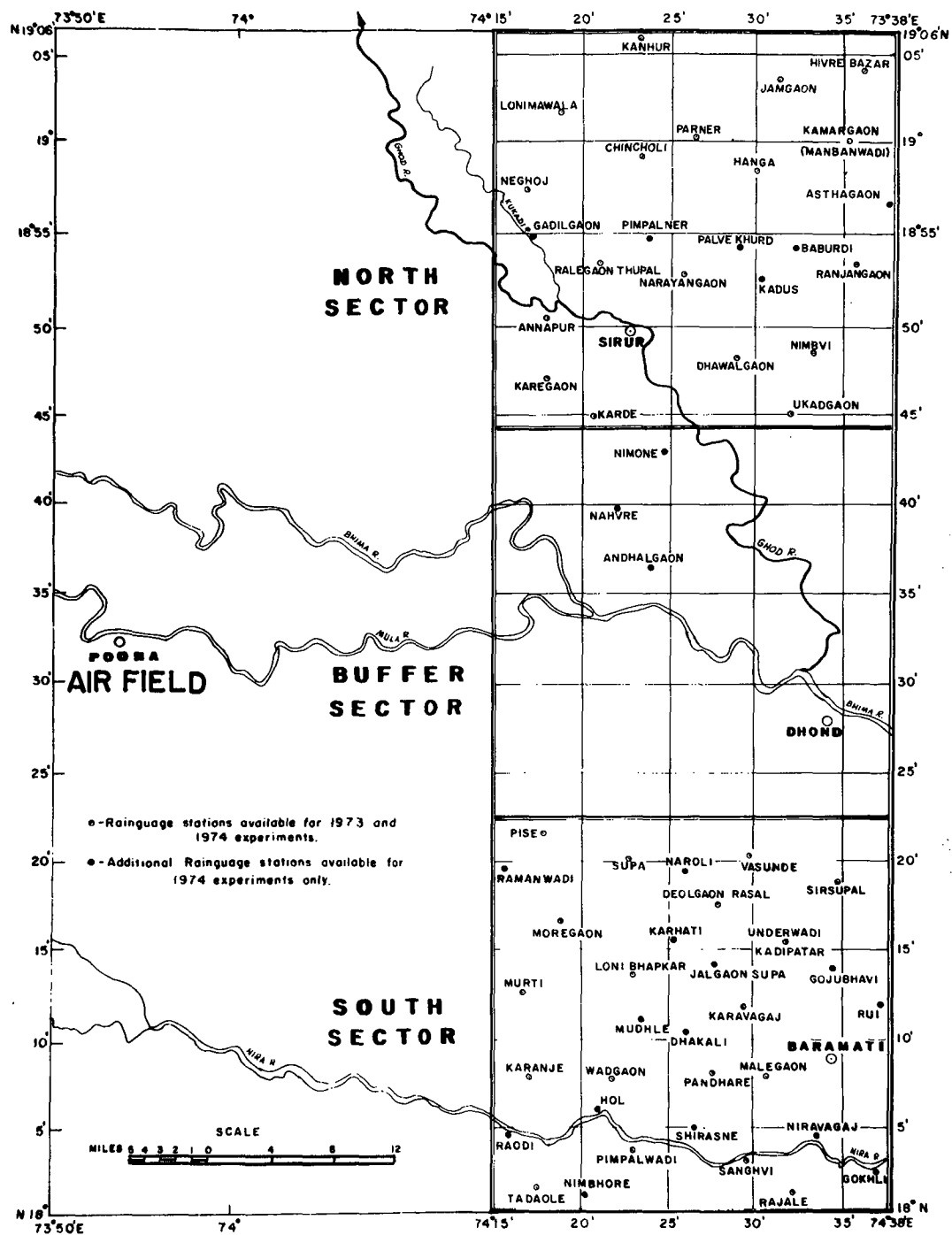


FIGURE 2

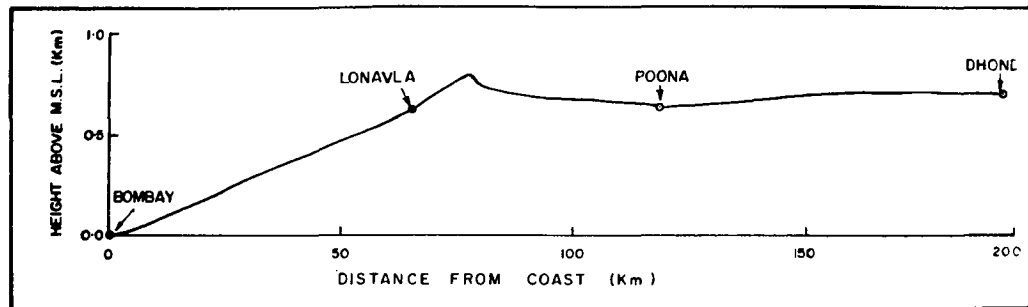


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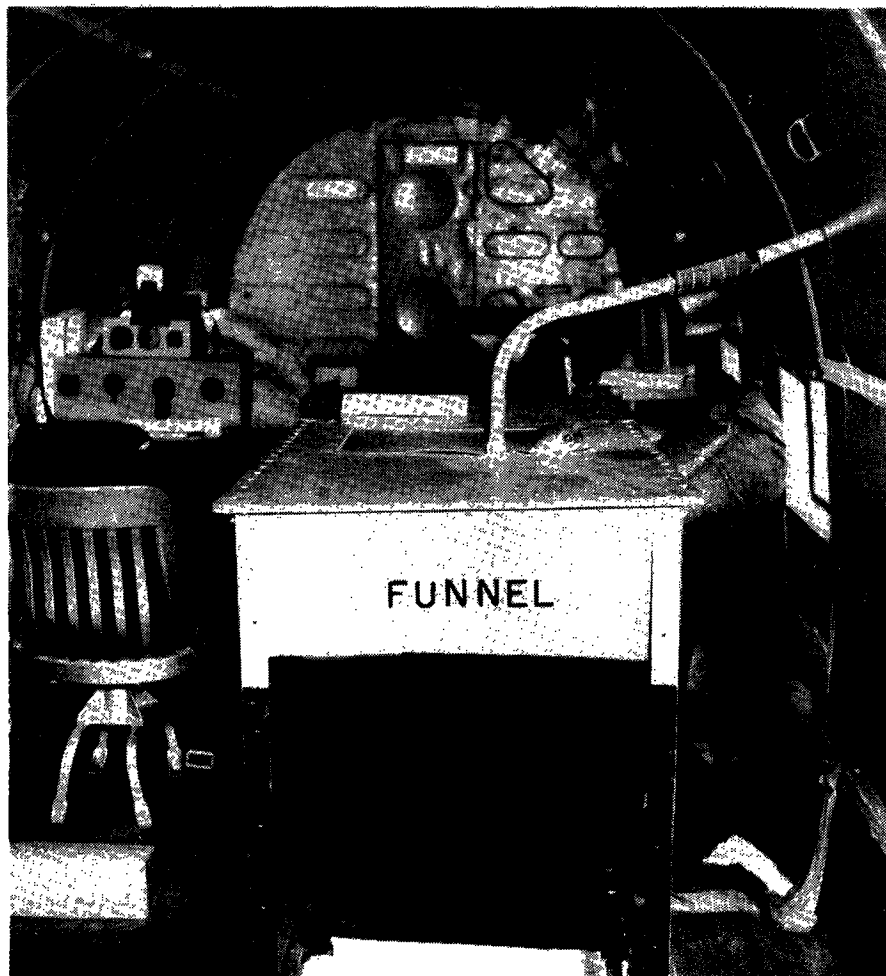


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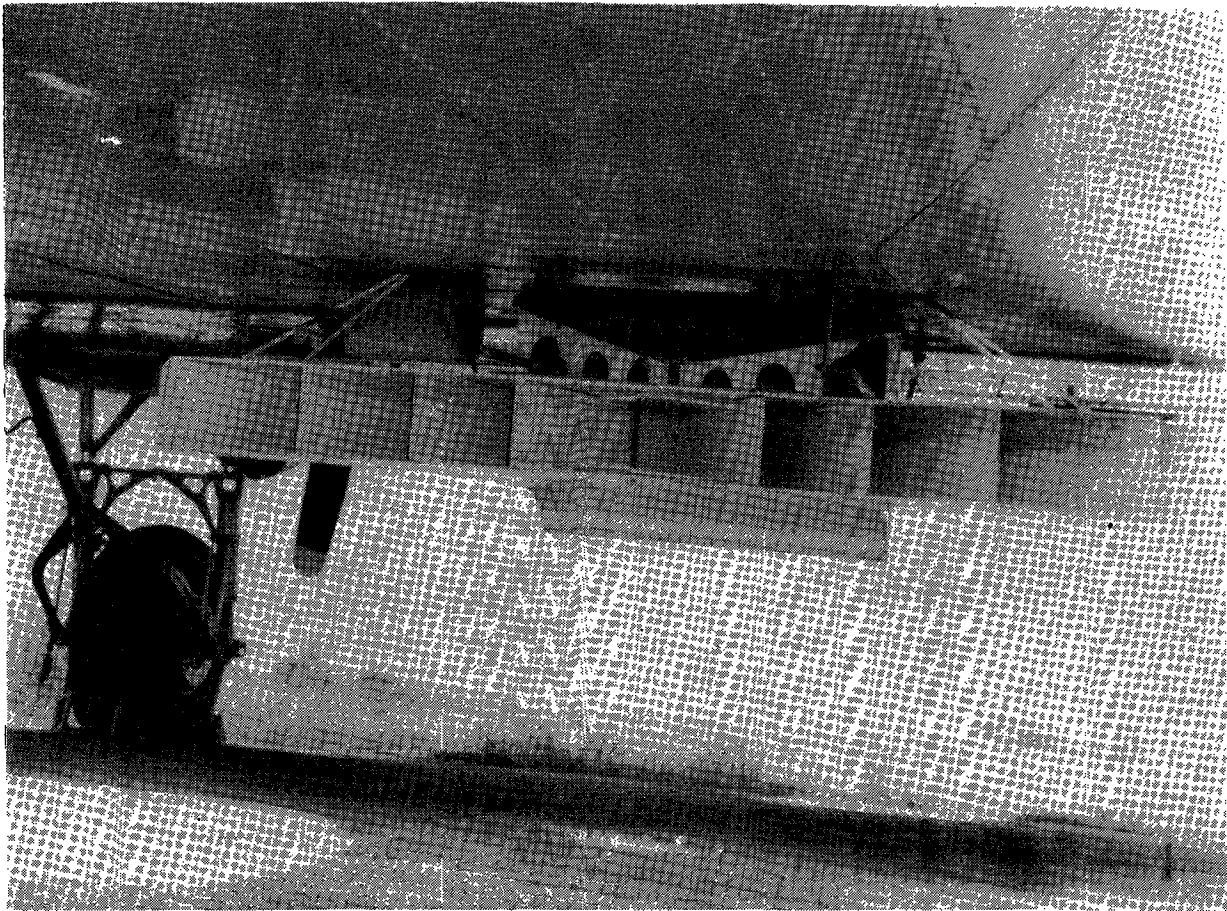


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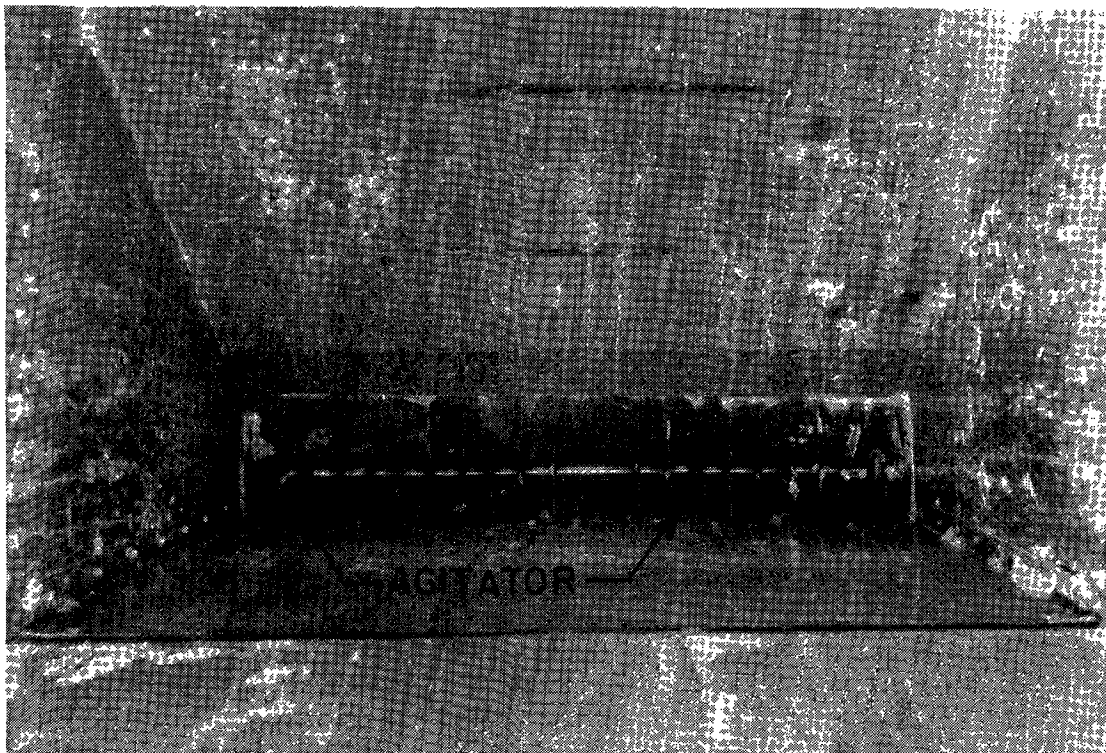


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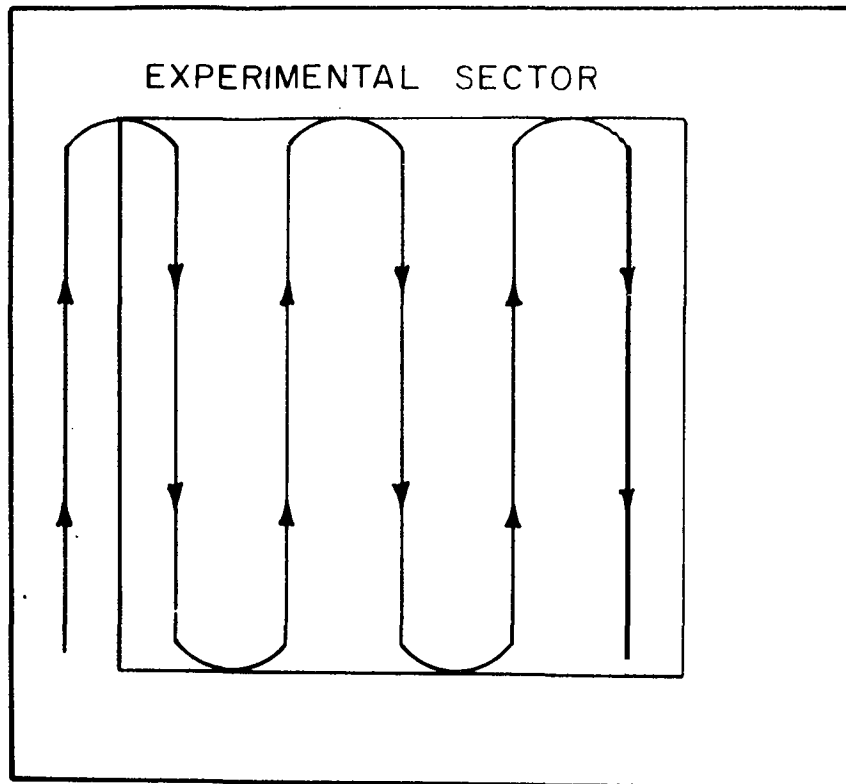


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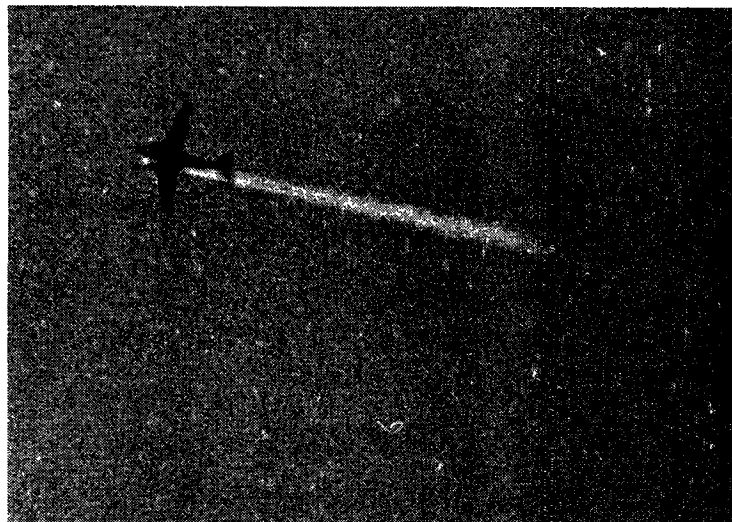


FIGURE 8