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LEVEL II



RADC-TR-78-111
In-House Report
May 1978

RADC TEST CHAMBER CARBON FIBER VELOCITY MEASUREMENTS

Mr. John S. DeRosa

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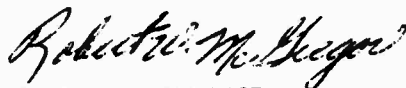
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PREFACE

This report was prepared by the Test Control Section, Reliability and Compatibility Division of the Rome Air Development Center. The author, John S. DeRosa, was assigned the task of determining the fall velocity of carbon fibers in the RADC test chamber for Project R20SHAVE. He wishes to acknowledge the excellent support from John Hrim and Milton Thompson of the Test Environment Section (RADC/RBTV) during the data collection and data reduction phase.

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I. OBJECTIVE

To determine the average fall velocity of two (2) specific types of carbon fibers (CF) of 3, 6 and 9 mm nominal length in the test environment at the RADC test chamber.

II. TEST PROCEDURE

A. General

It is possible to view scintillations from the falling carbon fibers with the naked eye if the fibers are back lighted with a collimated light beam in the darkened test chamber. This effect is due to the off axis forward scattering of the light caused by the presence of the CF in the beam. Most CF can be seen if the observer (or instrument) is positioned looking toward the light source at an angle of less than ten (10) degrees from the beam axis.

B. Method (See Figure 1)

1. Collimated Light Beam

A collimated light beam was generated inside the chamber by cutting a 3.8 cm aperture in the rear chamber wall. Clear acetate was used to cover the aperture to prevent release of CF. The outside rear wall was then flooded with light from a 150 watt spotlight at a distance of 12 feet. This spotlight was positioned so that the interior beam, formed by the aperture, traversed the center of the chamber with an upward tilt of seven (7) degrees and exited the chamber through the observation window in the front chamber wall.

This beam allows observers, positioned at the window, to view the CF falling through the beam, and also permits video recording for quantitative velocity analysis.

2. Pre-test Requirements

Prior to any velocity measurements, tests involving careful adjustment of CF dispenser airflow and deflector plates were run. These tests were run to insure that movement of CF caused by air currents (turbulence) was below observable levels.

3. Video Recording Technique

A video camera (Camera # 1 in Figure # 1) was placed inside the chamber and covered with clear plastic to preclude CF penetration. It was positioned, facing the rear chamber wall, with its optical axis

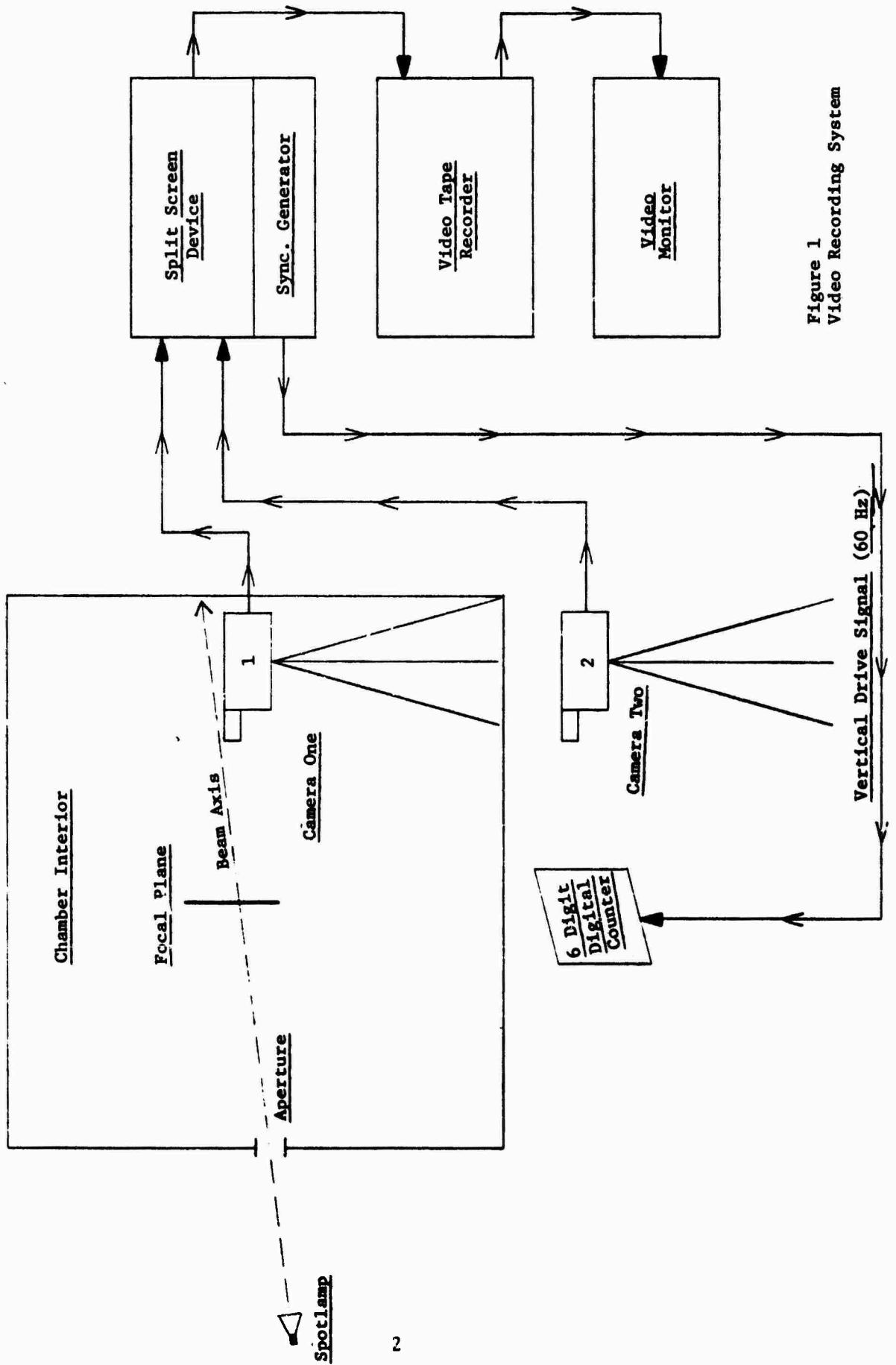


Figure 1
Video Recording System

parallel to the chamber floor. The camera was then focused on a piece of translucent graph paper suspended in the light beam at a point directly over the center of the chamber floor (see Photos 1 and 2).

a. Distance Calibration

The camera zoom lens was adjusted so that the circular area of the graph paper, illuminated by the light beam, filled the screen vertically on a 12" video monitor placed outside the chamber. The 1 cm vertical and horizontal divisions, as they appear on the video monitor, were permanently transferred to the monitor screen with a black marker (see Photos 3 and 4). The graph paper was then removed from the chamber.

Fibers falling through the beam at or near the plane previously occupied by the graph paper (the focal plane) appear as white fiber images against a black background on the monitor screen. The divisions marked on the screen represent actual 1 cm distance calibration in this plane. The lens aperture is set fully open at f1.8. This provides a narrow depth of field and insures that any fibers seen in focus on the monitor are at a point close to this focal plane.

b. Time Calibration

A second video camera was focused on a six (6) digit digital frame counter display. This counter was designed to increment by one at the start of every vertical scan of the video system. This scanning occurs at a precise 60 Hertz rate (the field rate, 2 fields equal 1 frame) generated by a 31.5 KHz master oscillator and a digital countdown chain. Every increment of the counter display, therefore, corresponds to 16.7 milliseconds in real time.

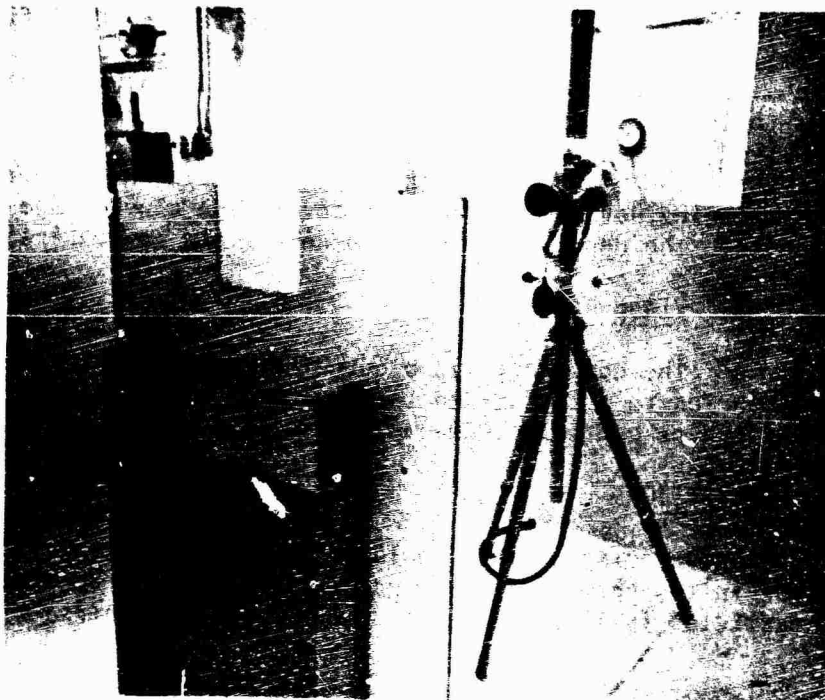
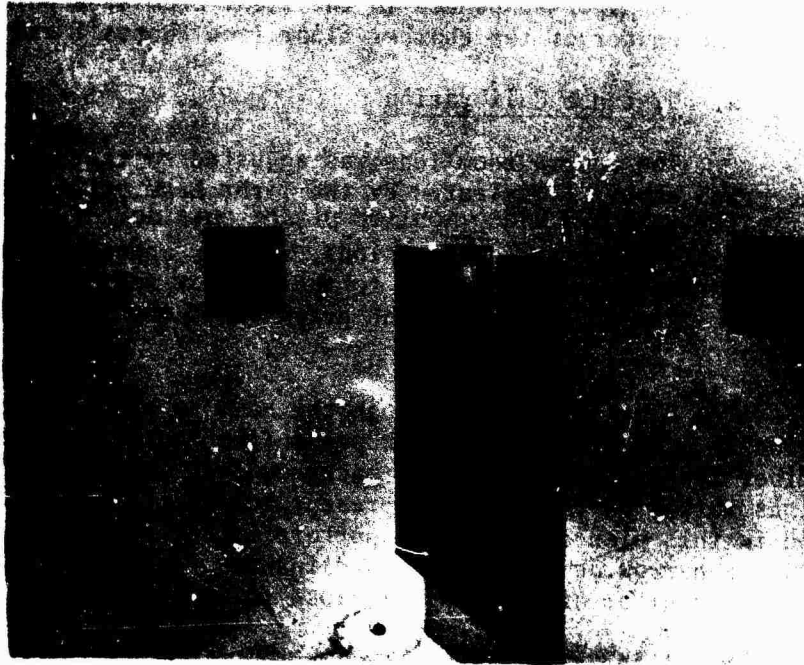
The video signals from the two (2) cameras were fed to a split screening device. Using this device the clock image (camera 2) was inserted into the upper right hand corner of the camera # 1 picture.

c. Video Recording

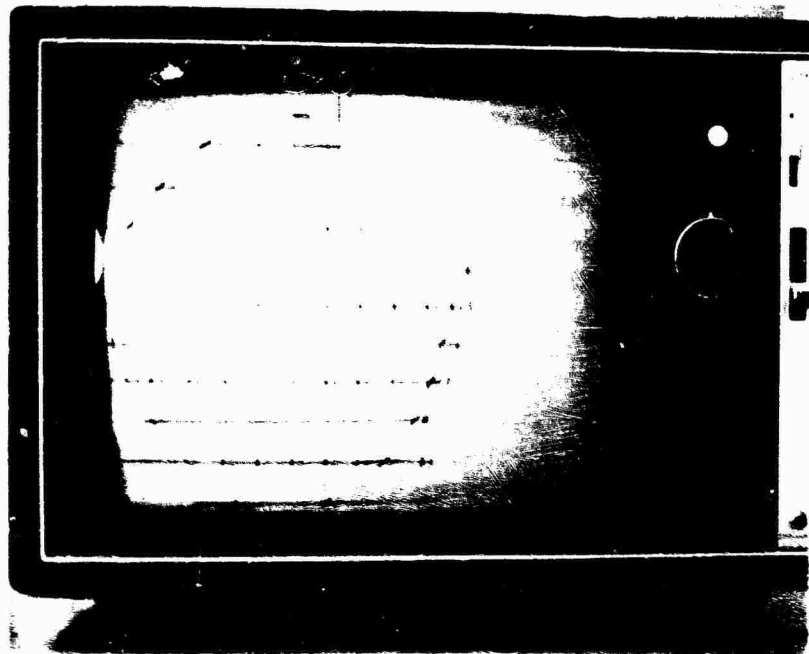
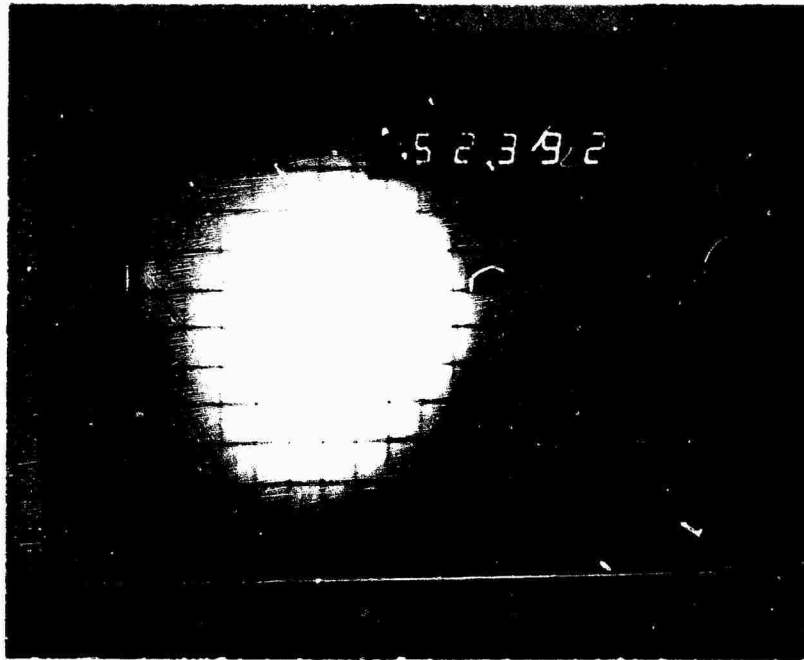
The composite video output from the split screening device was then fed to a 1/2" video tape recorder equipped with slow and stop motion playback controls (Panasonic Model NV3020SD).

III. DATA ACQUISITION

The CF chamber dispensers were loaded to dispense a high concentration of CF in the chamber. The high concentration increases the number of particles falling in the focal plane area of camera # 1.



PHOTOS 1 & 2 - TEST CHAMBER DISTANCE CALIBRATION SET-UP



PHOTOS 3 & 4 - VIDEO MONITOR SCREEN WITH DISTANCE CALIBRATION GRID

The dispensers were allowed to operate approximately three (3) minutes before the video field counter and video recorder were started. This allowed time for the CF concentration buildup.

Two (2) CF materials were tested; Celanese Type GY-70 and Union Carbide Type TP-4104B. Each material was tested at nominal fiber lengths of three (3), six (6) and nine (9) millimeters.

Approximately fifteen (15) minutes of video tape data was collected for each of the six (6) tests.

IV. DATA REDUCTION

The video tape data, collected by the recording system, was played back and visually analyzed. Only data from fiber images judged to be in proper focus was reduced. Data reduction consisted of determining the distance traveled by the fiber, and the length of time required to travel this distance. Utilizing the still frame control on the video recorder, instantaneous position and frame number was visible on the video monitor. This information was obtained by positioning a fiber image so that it was aligned with a horizontal calibration line in the upper portion of the video display. (See Photo 5). At this point, the initial position (P1) and video field number (F1) were annotated. The video tape was then advanced until the same fiber image was positioned on a lower horizontal line and the new position (P2) and field number (F2) were noted. (See Photo 6).

This procedure was repeated for each data point analyzed.

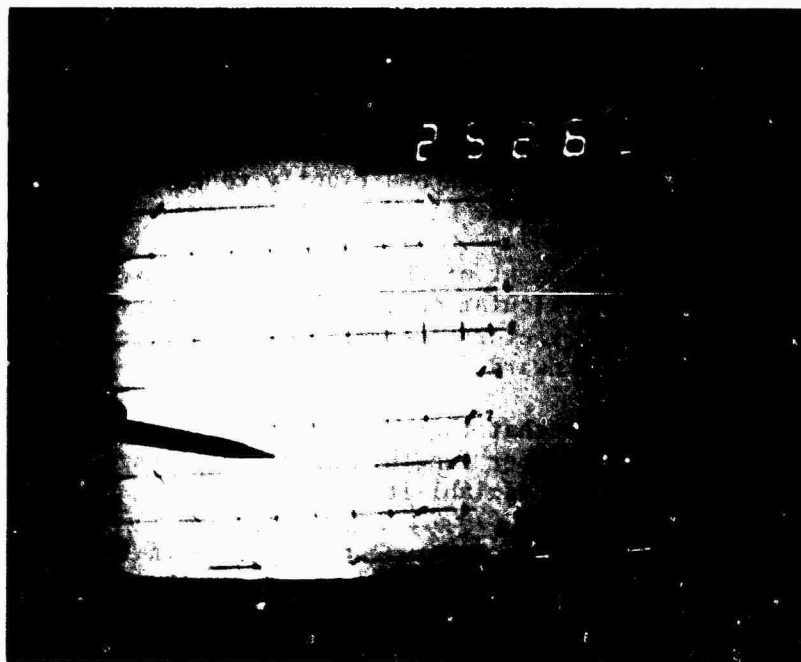
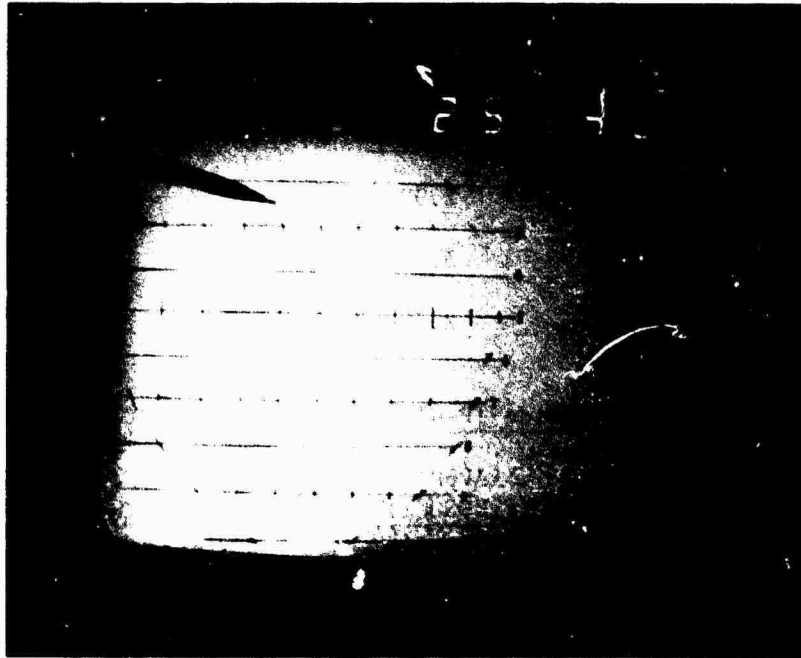
V. DATA ANALYSIS

Thirty-one (31) data points were randomly selected and analyzed for each test. Fiber velocity was calculated using the formula:

$$\text{Velocity (V)} = \frac{D}{T} \quad (\text{cm/sec})$$

$$\begin{aligned} \text{where: Distance (D)} &= P2 - P1 && (\text{cm}) \\ \text{Time (T)} &= (F2 - F1) \cdot 0.0167 && (\text{sec}) \end{aligned}$$

Statistical Mean and Standard Deviation was calculated from the thirty-one (31) data points for each test.



PHOTOS 5 & 6 - A CF IMAGE POSITIONED NEAR TWO DIFFERENT CALIBRATION LINES. (THE IMAGES ARE DISPLACED FROM THE CALIBRATION LINES FOR CLARITY)

VI. RESULTS

Material: Celanese GY-70

<u>LENGTH</u> (mm)	<u>AVERAGE VELOCITY</u> (cm/sec)	<u>STANDARD DEVIATION</u>
3	2.99	0.53
6	3.22	0.60
9	2.78	0.48

Material: Union Carbide TP-4104

<u>LENGTH</u> (mm)	<u>AVERAGE VELOCITY</u> (cm/sec)	<u>STANDARD DEVIATION</u>
3	7.99	0.90
6	7.89	0.86
9	7.70	1.23

VII. DISCUSSION

The velocities obtained in these tests are representative of the actual velocities existing in the RADC test chamber environment. The effects of air currents on CF movement have been minimized, but they have not necessarily been eliminated. For this reason, the velocities obtained may not correspond exactly to the static free fall velocity under ideal conditions.

Since horizontal movement of CF was minimal, only vertical displacement was used in calculation of velocity. Therefore, the direction of the velocity vectors determined in these tests is, by definition, vertically downward.

These tests indicate that there is no significant change in velocity as a function of fiber length. Some small length dependence may be masked by the normal variability in the data.

The velocity measurement instrumentation used in these tests has provided, for the first time, a means of observing the aerodynamic behavior of the fibers under dynamic test conditions. This has given RADC the added capability of testing under conditions ranging from free fall to turbulence, while observing the effects of aerodynamics on equipment vulnerability and fiber detection systems.

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