HEAVY RAIN EFFECTS ON AIRPLANE PERFORMANCE

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ABSTRACT

The objective of this activity is to determine if the aerodynamic characteristics of an airplane are altered while flying in the rain. Wind-tunnel tests conducted at the NASA Langley Research Center (LaRC) have shown losses in maximum lift, reduction in stall angle, and increases in drag when a wing is placed in a simulated rain spray. For these tests the water spray concentration used represented a very heavy rainfall. A lack of definition of the scaling laws for aerodynamic testing in a two-phase, two-component flow makes interpolation of the wind-tunnel test uncertain.

Tests of a large-scale wing are to be conducted at the LaRC. The large-scale wing is mounted on top of the Aircraft Landing Dynamics Facility (ALDF) carriage. This carriage (which is 70-foot long, 30-foot wide, and 30-foot high) is propelled with the wing model attached down a 3000-foot long test track by a water jet at speeds of up to 170 knots. A simulated rain spray system has been installed along 500 foot of the tests track and can simulate rain falls from 2 to 40 inches/hour. Operational checks are underway and the initial tests should be completed by the Fall of 1989.

HEAVY RAIN EFFECTS

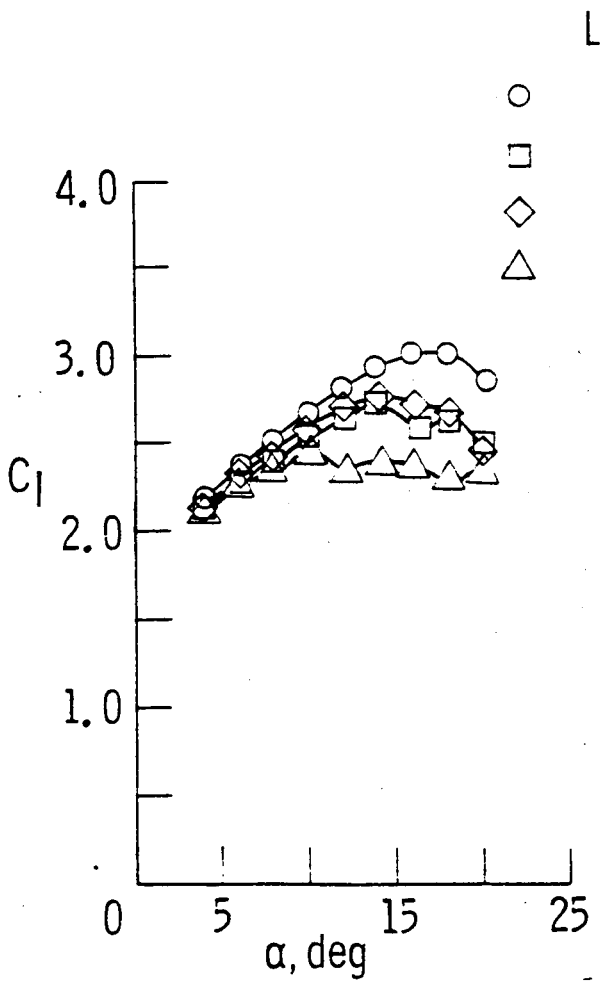
TECHNICAL ISSUE

ARE THE AERODYNAMIC CHARACTERISTICS OF AN AIRPLANE ALTERED WHILE FLYING IN THE RAIN?

HEAVY RAIN EFFECTS

- Wind Tunnel Tests
- Large Scale Tests
- Results
- Status and Plans

WIND TUNNEL TESTS RESULTS



- Effects greatest at high lift
- C_{Lmax} loss
- Reduced stall angle

Scaling of Test Results

"Dry Aerodynamics"

- C_L = f (angle of attack, Reynold's Number, Mach Number)
- Scaling Laws Established

"Wet Aerodynamics"

- C_L = f (angle of attack, Reynold's Number, Mach Number, Weber Number, Geometric Scaling of spray drop diameter and spacing)
- No Scaling Laws Available

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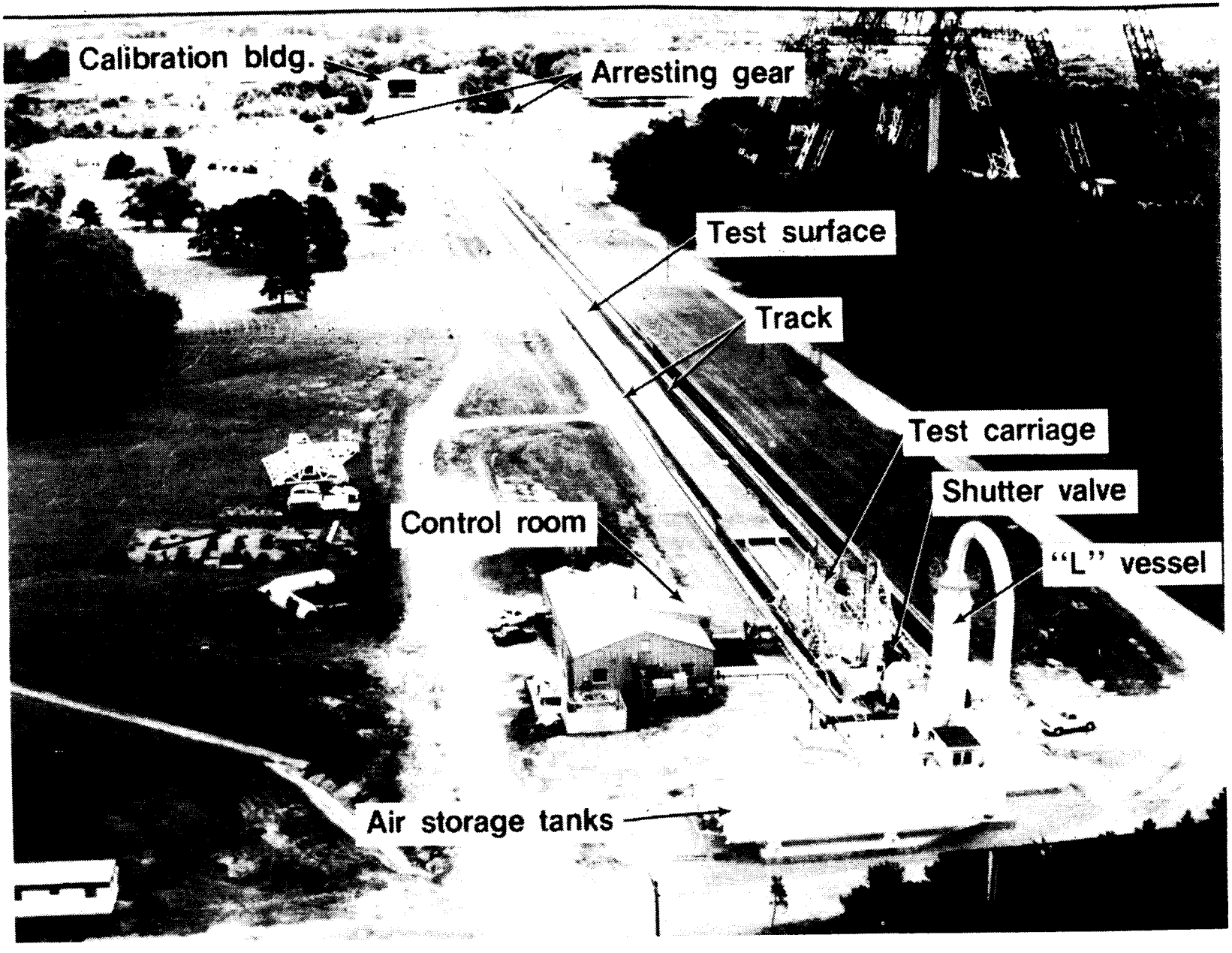
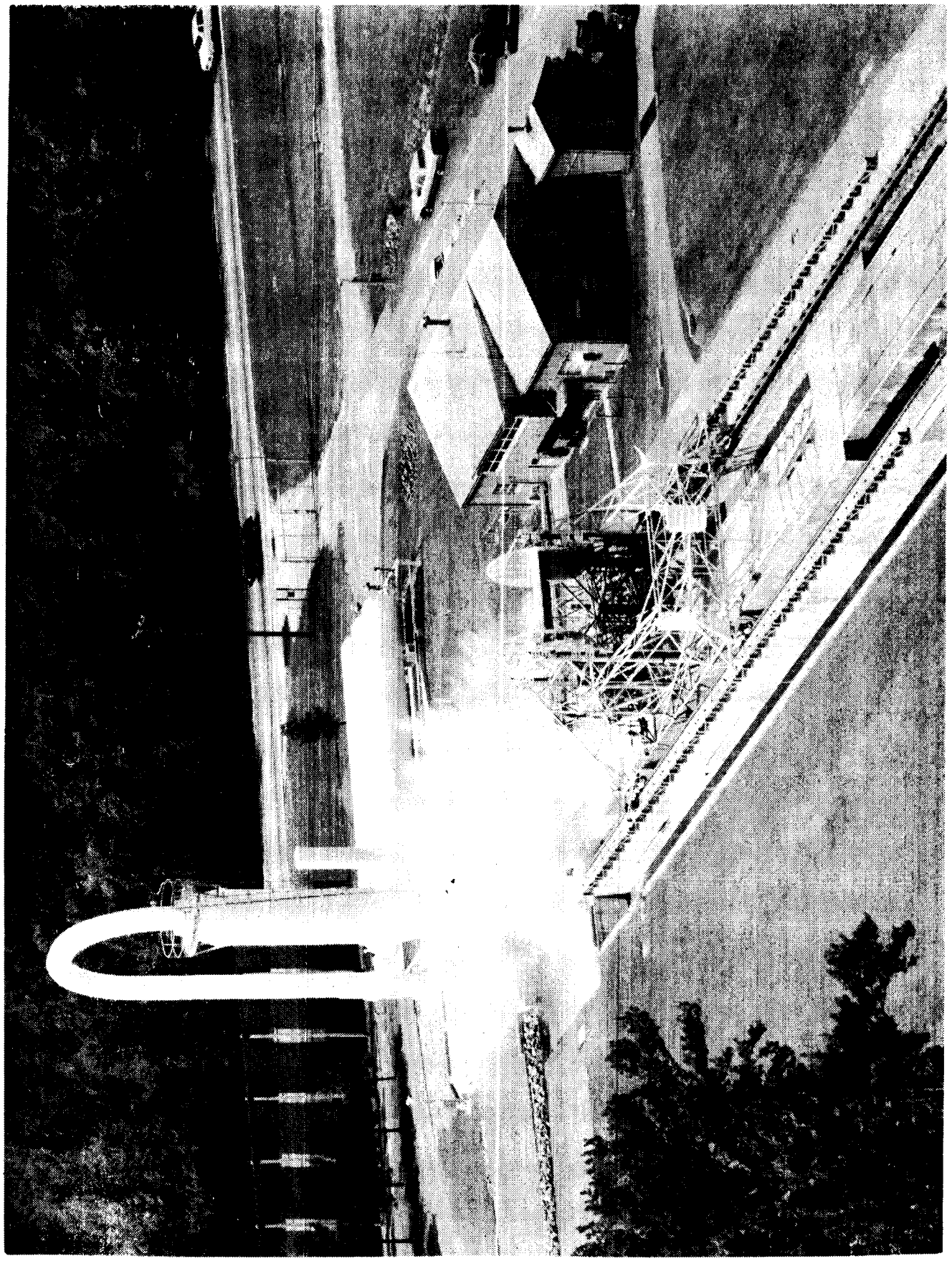
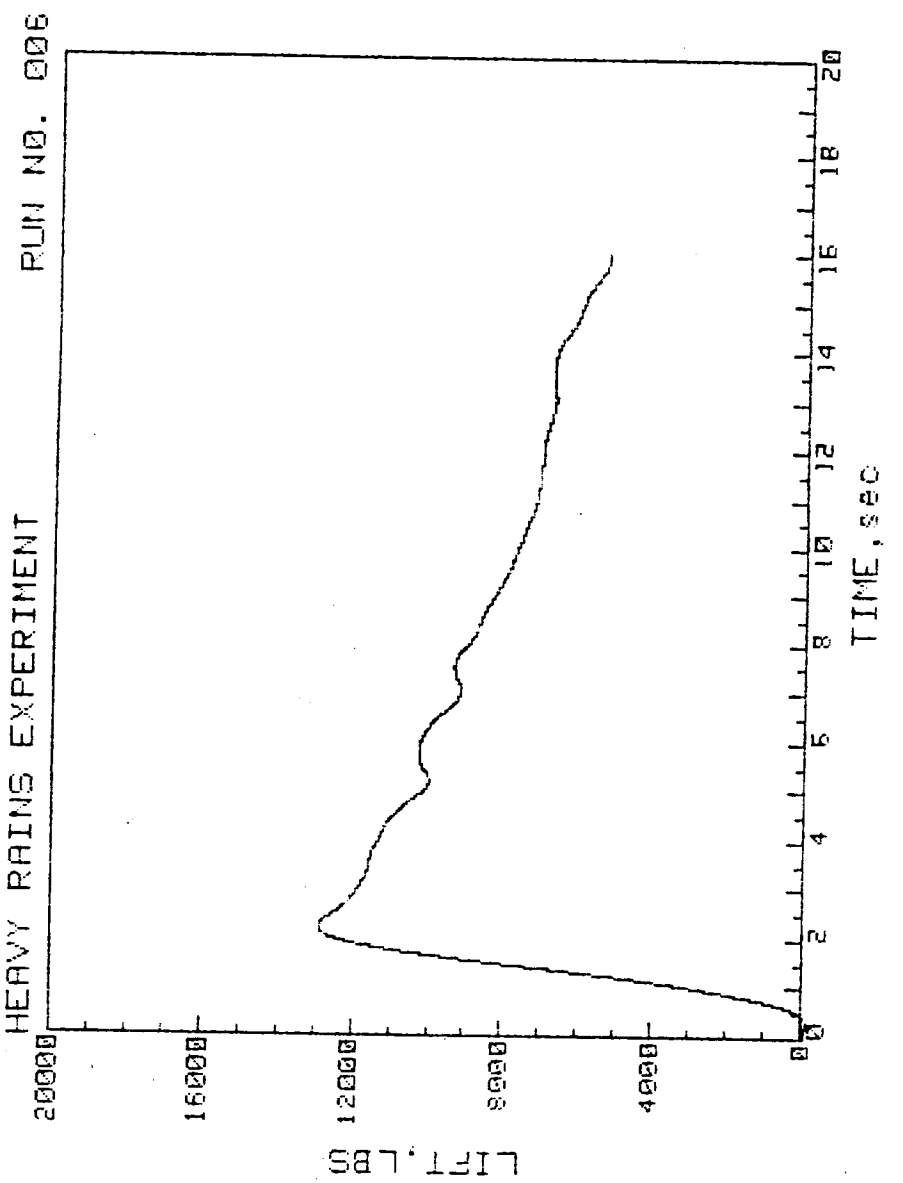
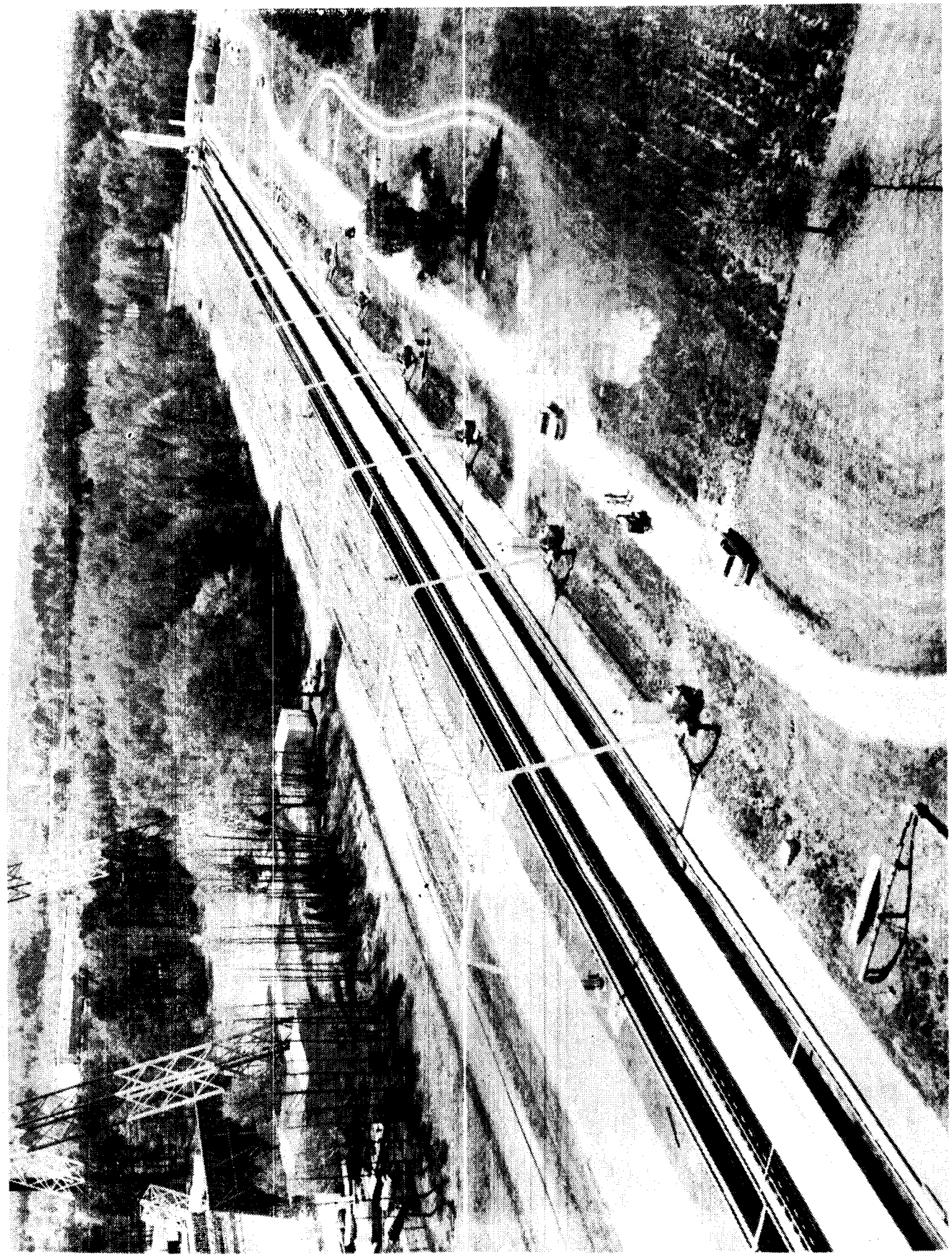
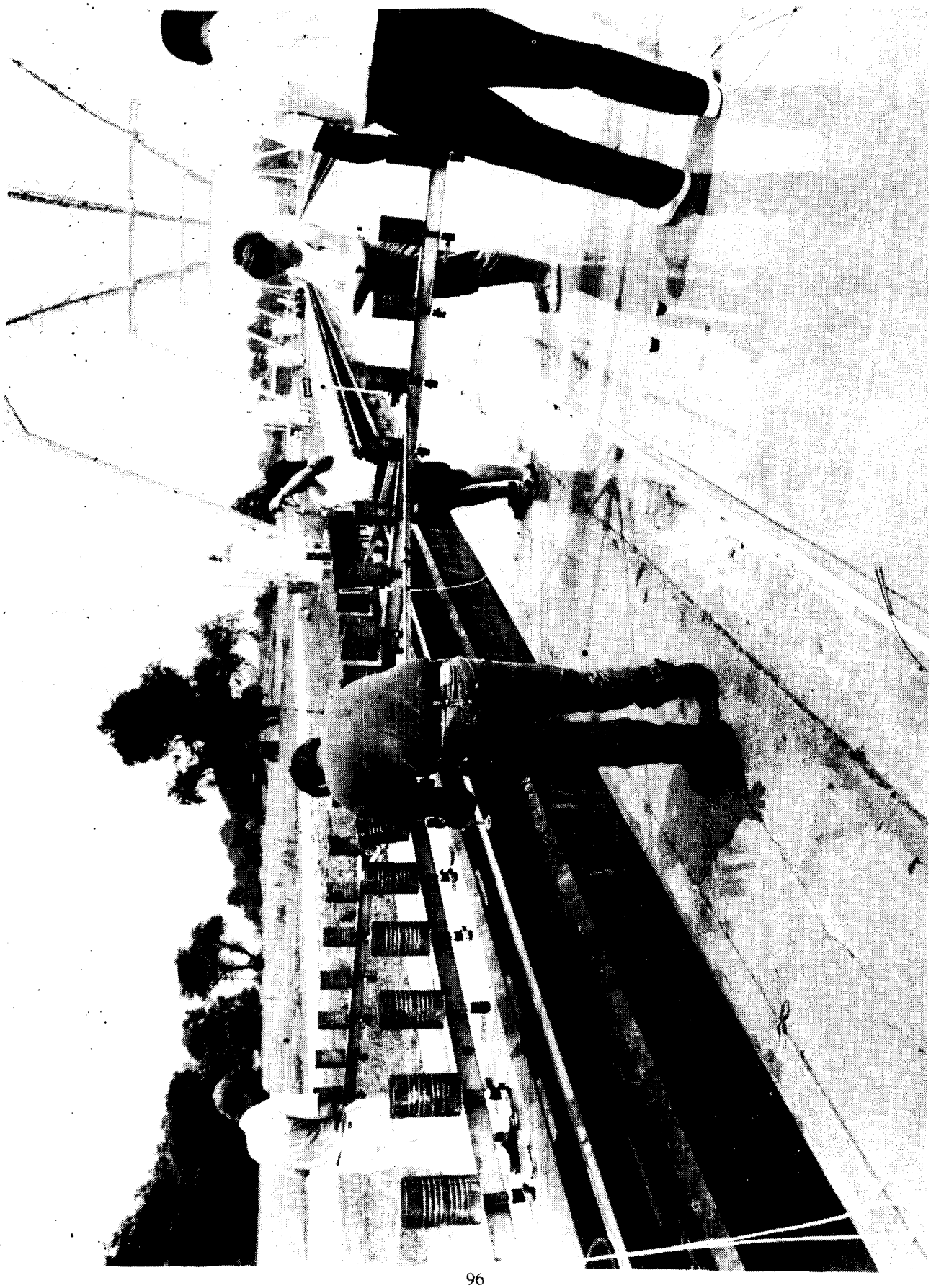
AIRCRAFT LANDING DYNAMICS FACILITY






HEAVY RAINS EXPERIMENT
RUN NO. 006
LIFT, LBS
20000
16000
12000
8000
4000
0
0
2
4
6
8
10
12
14
16
18
20
TIME, sec





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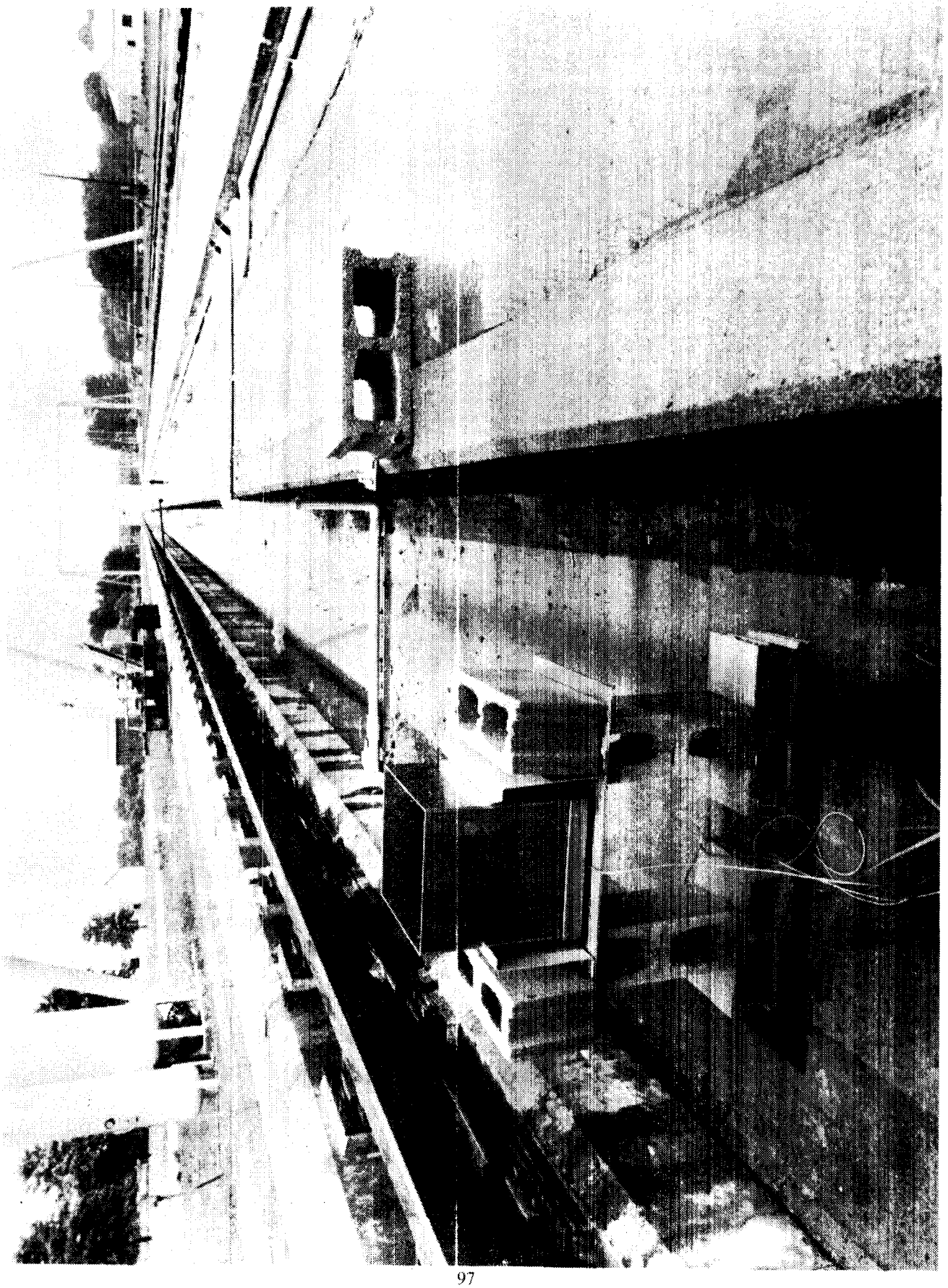
BLACK AND WHITE PHOTOGRAPH



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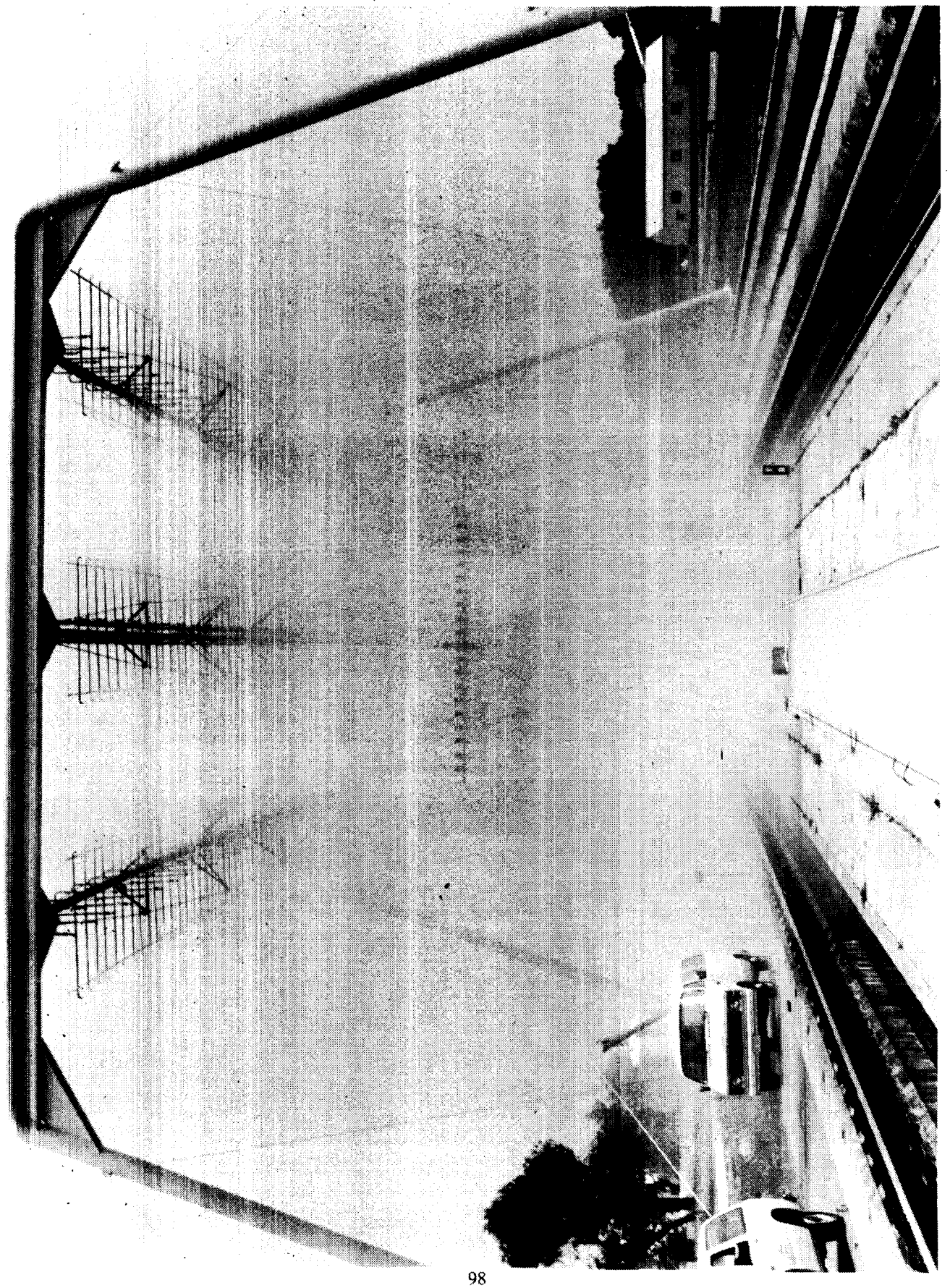

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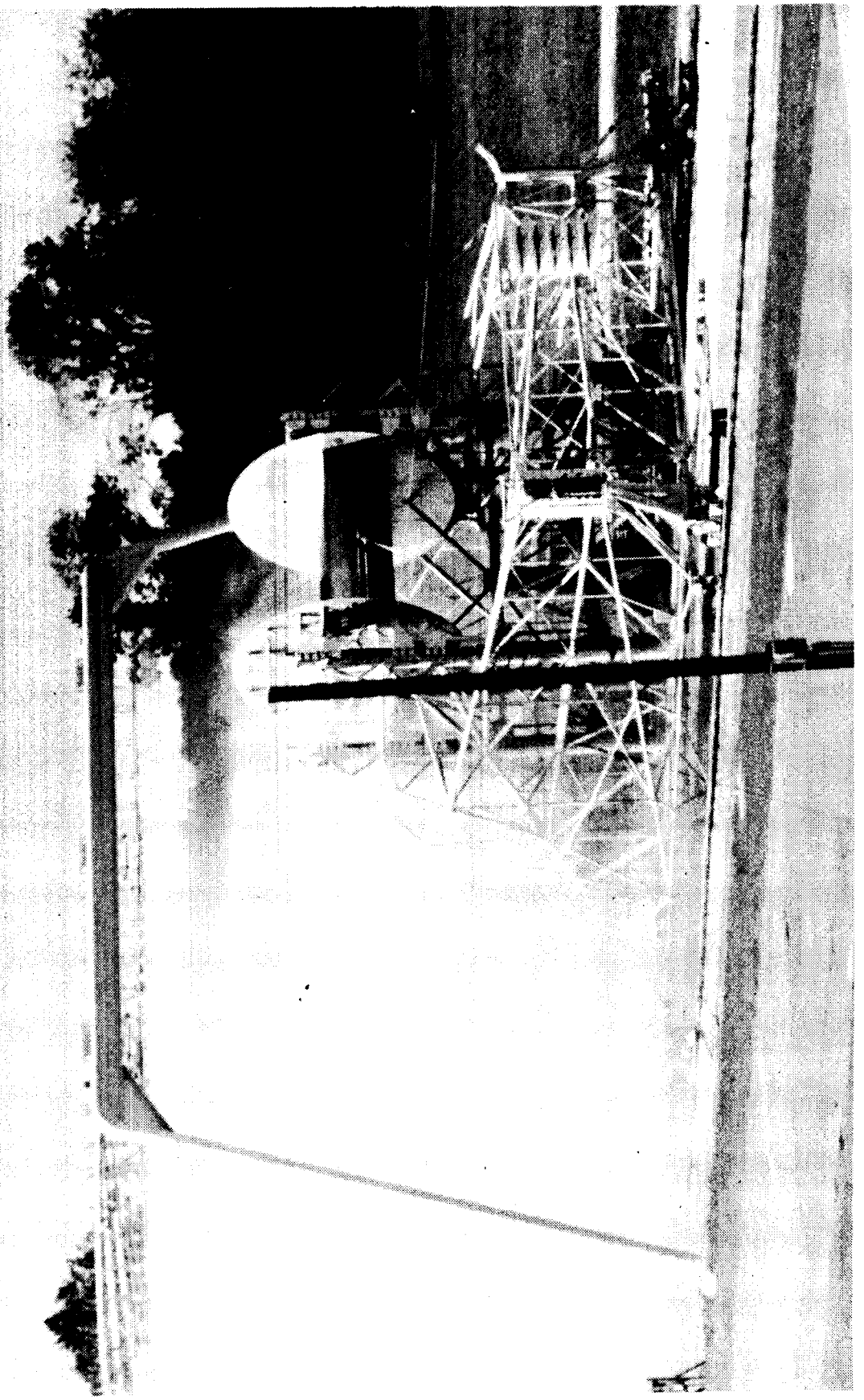

Large Scale Tests

- Spray system operational
- Wing/carriage Engineering checkout in progress
- Preliminary results indicate system capable of providing good aerodynamic data
- Majority of tests matrix to be completed by Fall 1989