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Lockheed Aircraft Corporation

ADVANCED DEVELOPMENT PROJECTS
BURBANK, CALIFORNIA

REPORT NO. SP-815
DATE 1 June 1965
COPY NO. 7

MODEL YF-12A

TITLE FLIGHT TEST SONIC BOOM MEASUREMENTS

PREPARED BY

STAT

REVIEWED BY

APPROVED BY Clarence L. Johnson
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Vice President
Advanced Development Projects

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SUMMARY

Sonic boom overpressures of 1.2 to 1.7 pounds per square foot were measured under the aircraft track during the YF-12A record runs. The Mach number range was 2.6 to 3.1 M. at altitudes of 60,000 to 76,500 feet above terrain. Fifteen nautical miles to the side of the aircraft track the overpressure was reduced from 1.7 to 0.8 PSF and the boom was described as "very faint".

Fifty-one sonic boom recordings were obtained in the low supersonic Mach number range. The maximum overpressure was 5.0 PSF and the minimum was 0.3 PSF. Statistically, 4% of these data points were between 4.0 and 5.0 PSF, 67% were between 2.0 and 4.0 PSF and 29% were less than 2.0 PSF.

The data are the average of five microphones individually recorded by an oscillograph. The system was calibrated using AC calibrations in the frequency range from approximately 400 to 1200 cps. Present plans are to obtain additional data using five DC calibrated pressure transducers.

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DISCUSSION

YF-12A Record Runs

The sonic boom overpressures measured during the YF-12A record runs are shown in Figures 1 through 6. Figures 1 and 2 show overpressures of 1.2 to 1.7 pounds per square foot measured at a recording station located under the aircraft track. Also shown is a measurement made approximately 15 nautical miles to the side of the aircraft track during the 500 kilometer run. This data point shows a reduction in overpressure from 1.7 to 0.8 PSF, slightly more than 50%.

The Mach numbers for the various runs were 2.6 to 3.1 M. and altitude was 60,000 to 76,500 feet above the local terrain level. Note that the two recording stations were located outside of the traps for the course, therefore the Mach numbers and altitudes at time of data recording were somewhat different than the records established over the official course. Figure 7 shows the location of the two data recording stations in respect to the aircraft track.

Figure 1 compares the measured YF-12A data with measured B-58 data. Although there is a disparity in the size and Mach number of

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YF-12A Record Runs (continued)

the two aircraft, the measured overpressures are in good agreement.

Figure 2 compares measured and theoretical YF-12A data. Measured values are consistently higher than would be expected from theory. The theoretical data are based on the "signature" curve for the YF-12A developed by the ADP Aero/Thermo department.

Figures 3 through 6 are actual recorded data tracings. These figures also show the layout and spacing of the five microphones and the operator's comments on the nature of the boom. Note that the sequence of the pressure pulses can be used as an indication of the aircraft flight path. For example, Figure 3 shows microphones D, E, A, C and B pulsing in sequence, indicating the aircraft approached from the WSW. Also of interest is the difference in peak pressure recorded by individual microphones. Figure 3 shows a 0.5 PSF difference between microphones B and D located 100 feet apart. This represents 33% of the average of the five microphones. Figure 5 shows a 0.46 PSF difference between microphones A and E located 50 feet apart, which is 27% of the average for the five microphones.

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YF-12A

COMPARISON OF MEASURED SONIC BOOM OVERPRESSURE WITH MEASURED B-58 DATA

DATA FROM RECORD RUNS 4 MAY 1965

RUN	SYM	TIME	LOCATION	GROSS WEIGHT	MACH NO
16/25 Km	△	0905-1010 HR	JELLY 2	70000 To 75000 LB	3.1 (COCKPIT-TDI)
SUSTAINED ALT	◊	1550-1630 HR	JELLY 2	70000 To 75000 LB	3.1 (COCKPIT-TDI)
500 Km	□	1715-1745 HR	JELLY 2	75000 To 85000 LB	2.6 (PILOT COMMENTS)
500 Km	◇	1715-1745 HR	JELLY 3	75000 To 85000 LB	2.6 (PILOT COMMENTS)
1000 Km	NO	DATA			

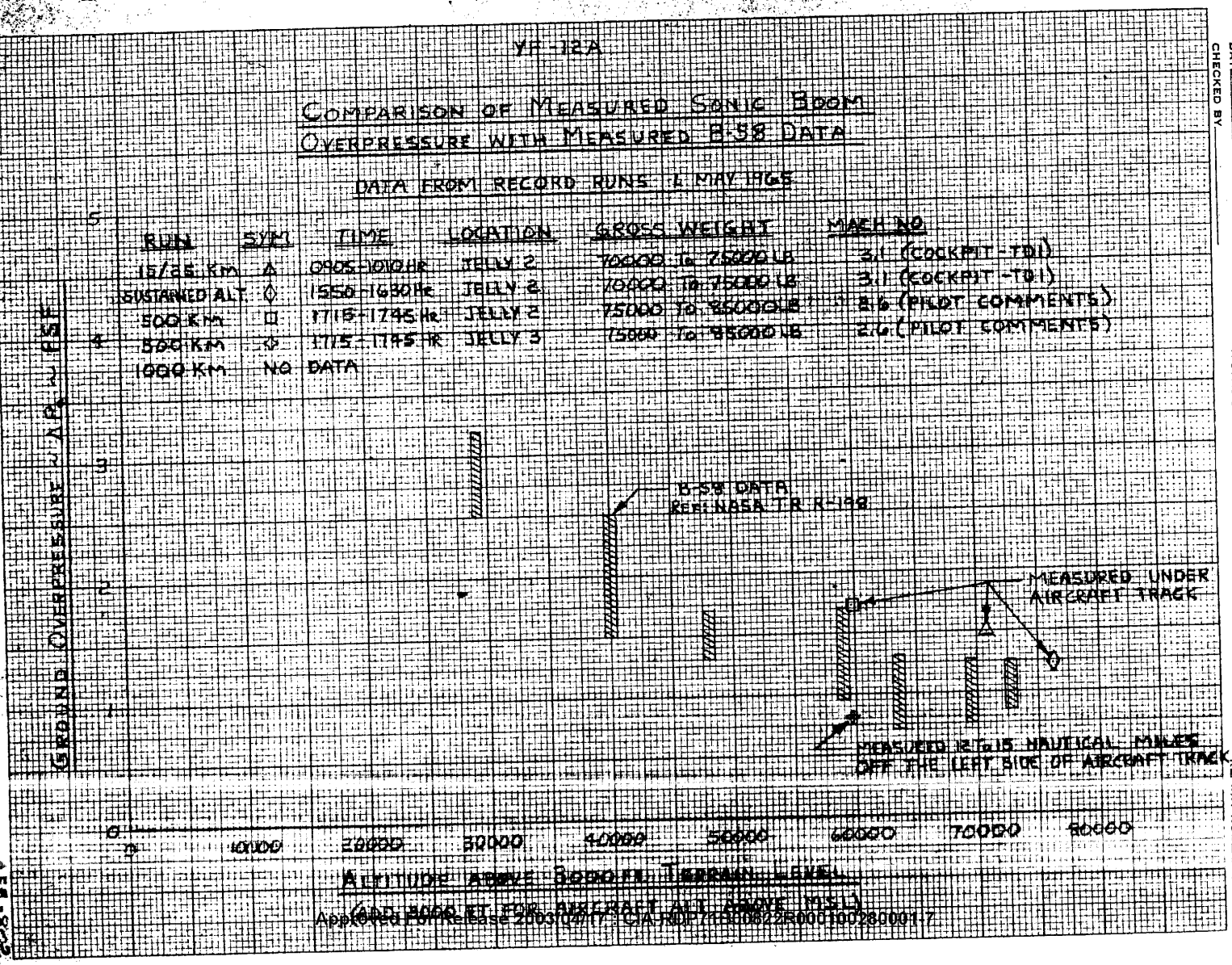

Figure 1

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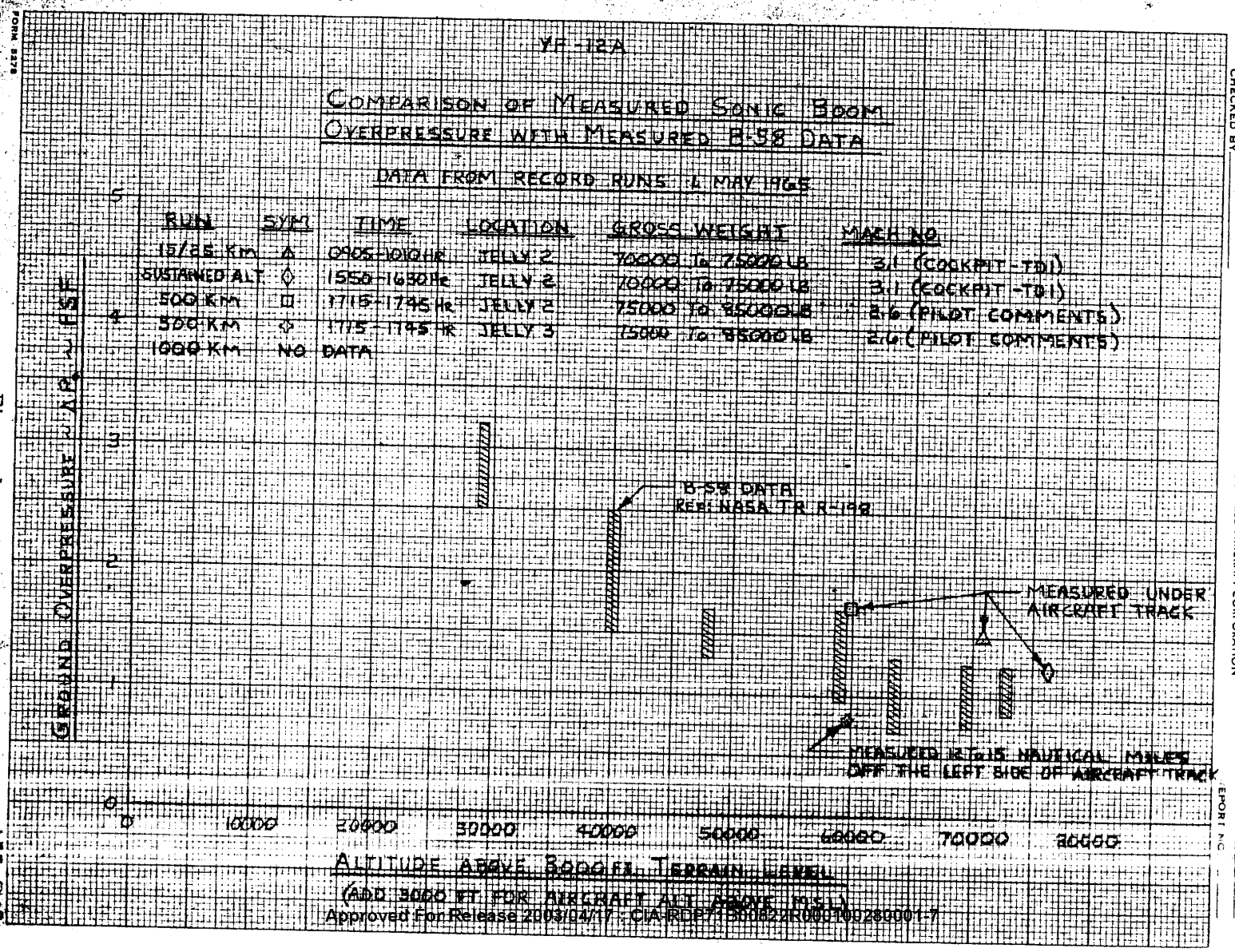

Figure 1

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YF-12A

COMPARISON OF MEASURED SONIC BOOM OVERPRESSURE WITH VOLUME & LIFT THEORY

DATA FROM RECORD RUNS 1 MAY 1965

RUN	SYM	TIME	LOCATION	GROSS WEIGHT	MACH NO
15/25 KM	△	0905-1010 HR	JELLY 2	70000 TO 75000 LB	3.1 (COCKPIT-TDI)
SUSTAINED ALT	◊	1550-1630 HR	JELLY 2	70000 TO 75000 LB	3.1 (COCKPIT-TDI)
500 KM	□	1715-1745 HR	JELLY 2	75000 TO 85000 LB	2.6 (PILOT COMMENTS)
500 KM	◇	1715-1745 HR	JELLY 3	75000 TO 85000 LB	2.6 (PILOT COMMENTS)
1000 KM	NO DATA				

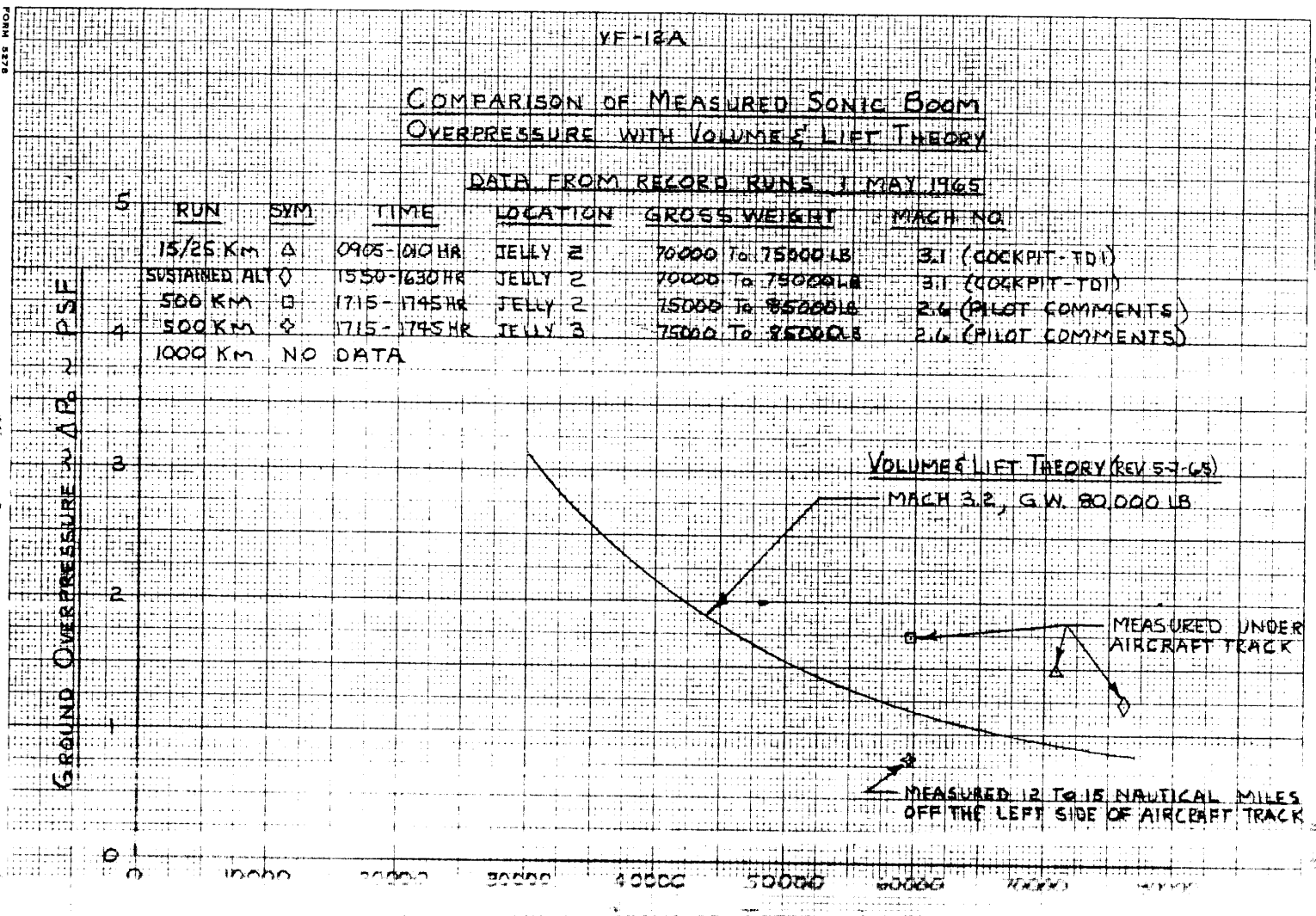

Figure 2

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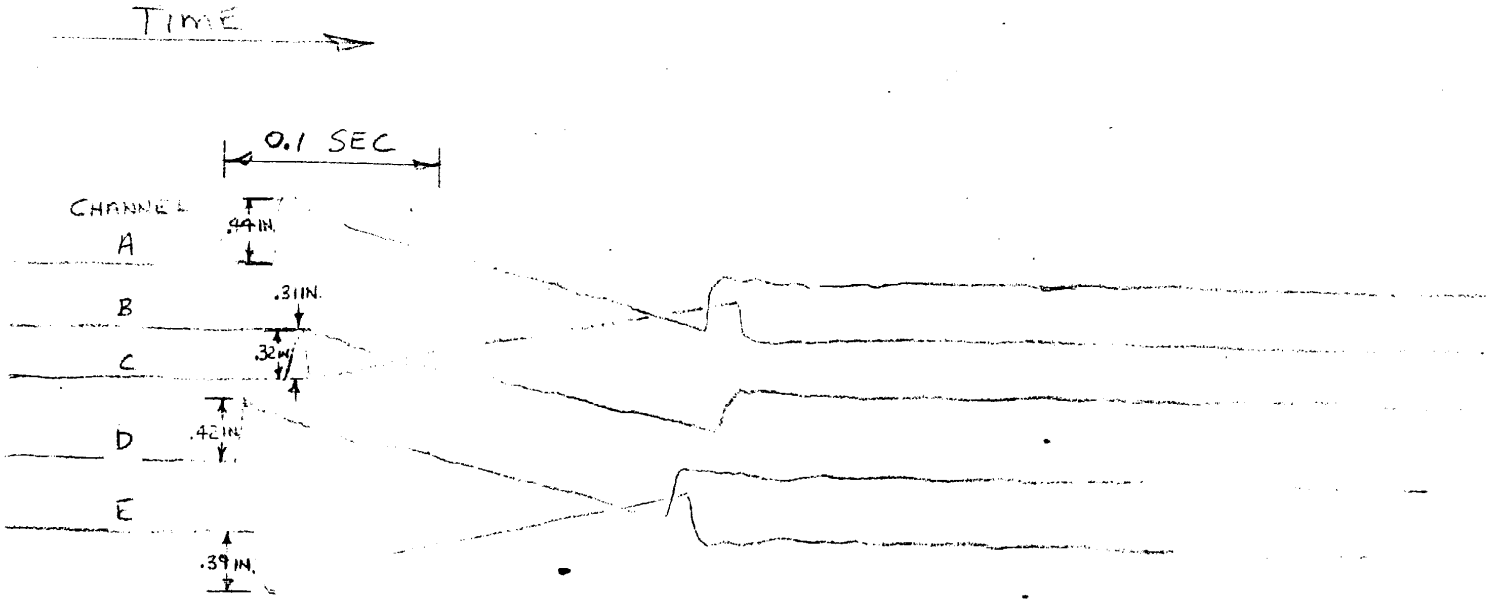
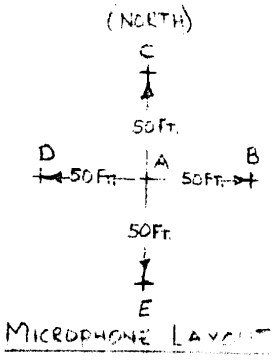
TRACING OF OSC. BOOM RECORDINGS



CALIB		OVERPRESSURE
A	3.5 PSF/IN.	1.54 PSF
B	3.8 PSF/IN.	1.18 PSF
C	4.6 PSF/IN.	1.47 PSF
D	4.0 PSF/IN.	1.68 PSF
E	4.0 PSF/IN.	1.56 PSF
		1.49 PSF (AVG)

JELLY STATION #2
1 MAY 1965 10:04 HRS.
"MEDIUM DOUBLE BOOM"



MICROPHONE LAYOUT

Figure 3

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Page 6

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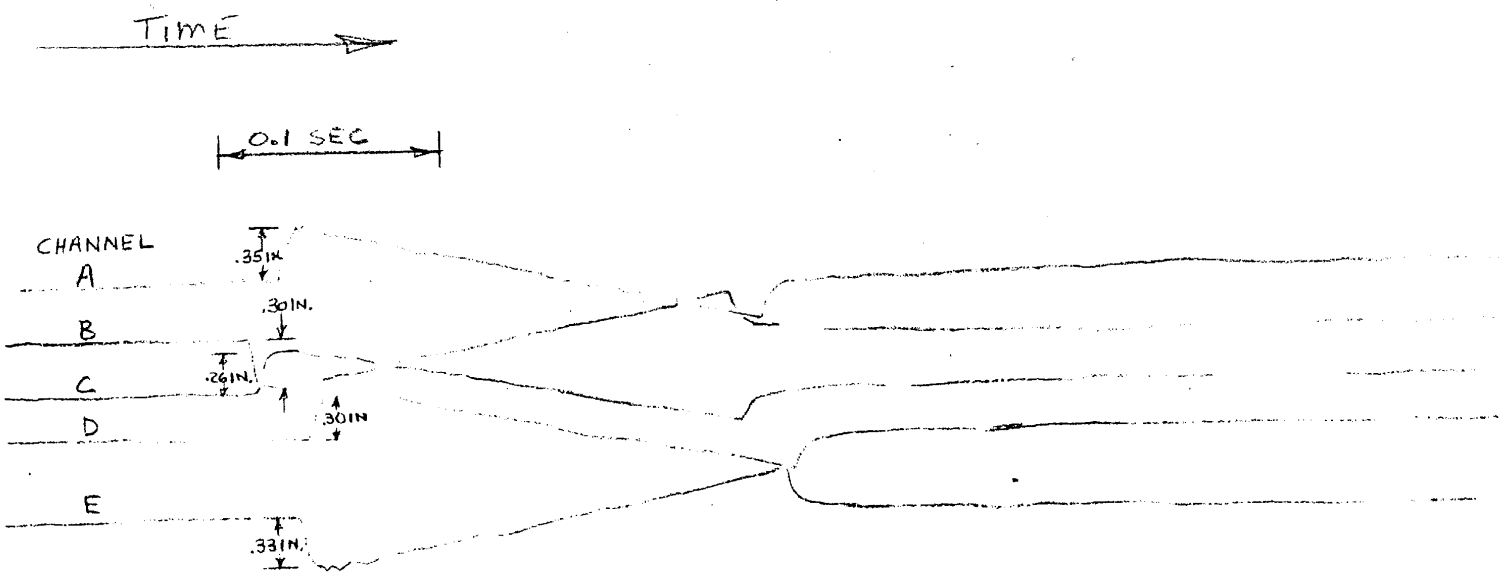
TRACING OF OSC. BOOM RECORDINGS

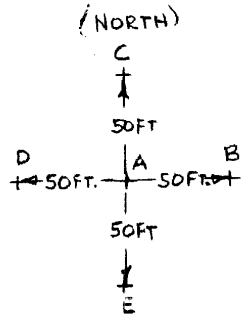


CALIB		OVERPRESSURE
A	3.5 PSF/IN.	1.23 PSF
B	3.8 PSF/IN.	1.14 PSF
C	4.6 PSF/IN	1.20 PSF
D	4.0 PSF/IN	1.20 PSF
E	4.0 PSF/IN	1.32 PSF
		1.22 PSF (AVG.)

JELLY STATION #2

1 MAY 1965 16:25 HRS

"MEDIUM DOUBLE BOOM"



MICROPHONE LAYOUT

Figure 4

SP-815
Page 1

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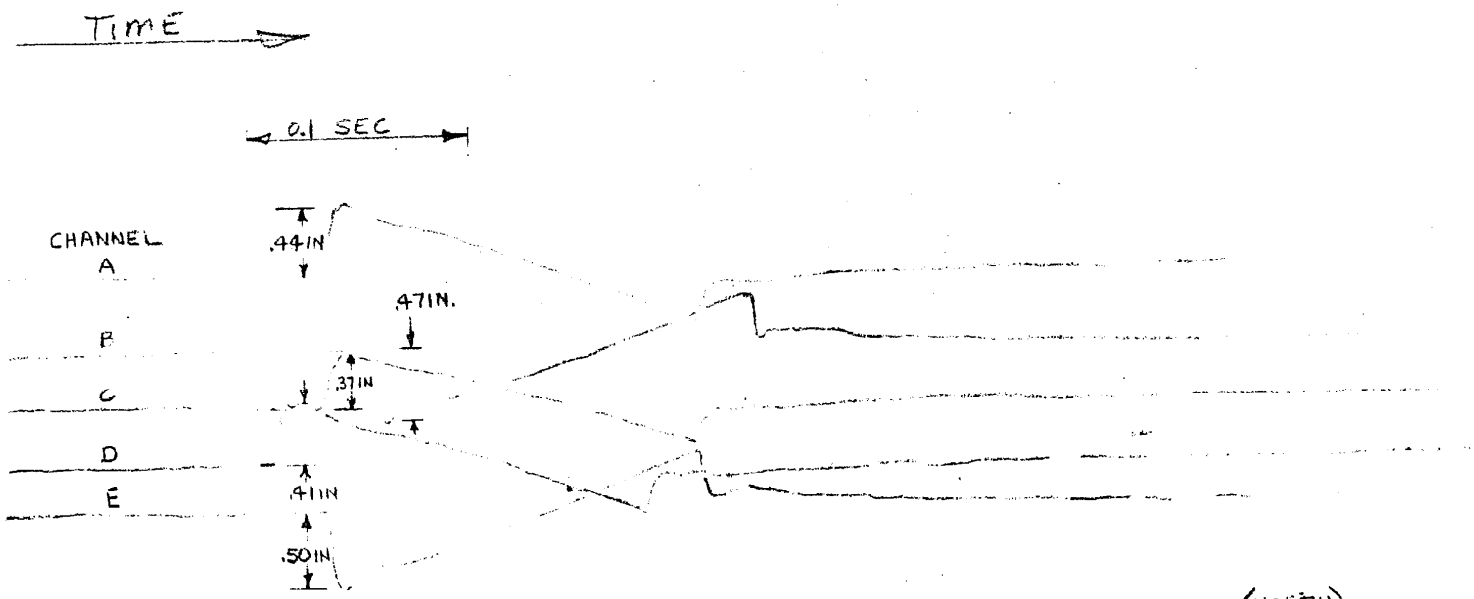
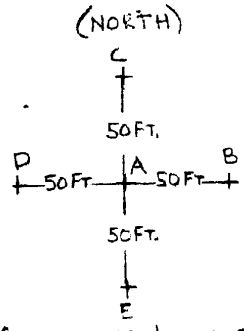
TRACING OF OSC. BOOM RECORDINGS.



CALIB.		OVERPRESSURE
A	3.5 PSF/IN	1.54 PSF
B	3.8 PSF/IN	1.79 PSF
C	4.6 PSF/IN	1.70 PSF
D	4.0 PSF/IN	1.64 PSF
E	4.0 PSF/IN	2.00 PSF
		1.73 PSF (AVG.)

JELLY STATION #2
1 MAY 1965 17:37 HRS
"MEDIUM DOUBLE BOOM"



MICROPHONE LAYOUT

Figure 5

SF-315
Page 8

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AFB-812

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TRACING OF OSC. BOOM RECORDINGS

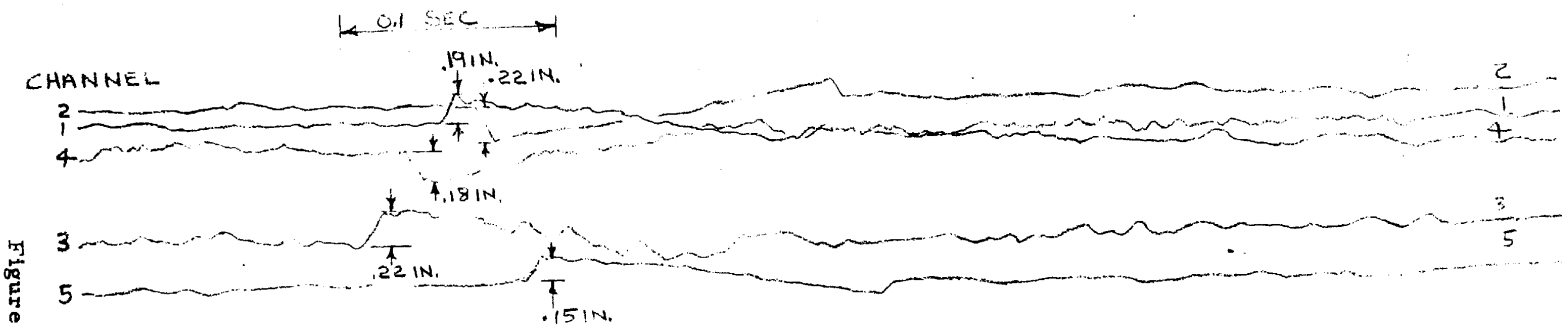


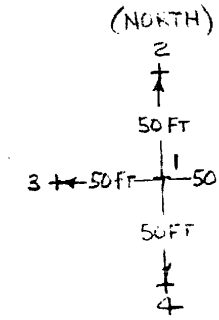
Figure 6

CALIB.		OVERPRESSURE
1	4.5 PSF/IN.	0.85 PSF
2	3.7 PSF/IN.	0.81 PSF
3	3.8 PSF/IN.	0.84 PSF
4	4.7 PSF/IN.	0.85 PSF
5	4.5 PSF/IN.	0.68 PSF
		0.81 PSF (AVG)

JELLY STATION # 3

1 MAY 1965 17:37 HRS.

"AIRCRAFT ON SOUTHEAST HEADING - VERY FAINT"



MICROPHONE LAYOUT

Page 9

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AFB-813.

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YF-12A

TRACK FOR SONIC BOOM RECORDINGS DURING RECORD RUNS ON 1 MAY 1965

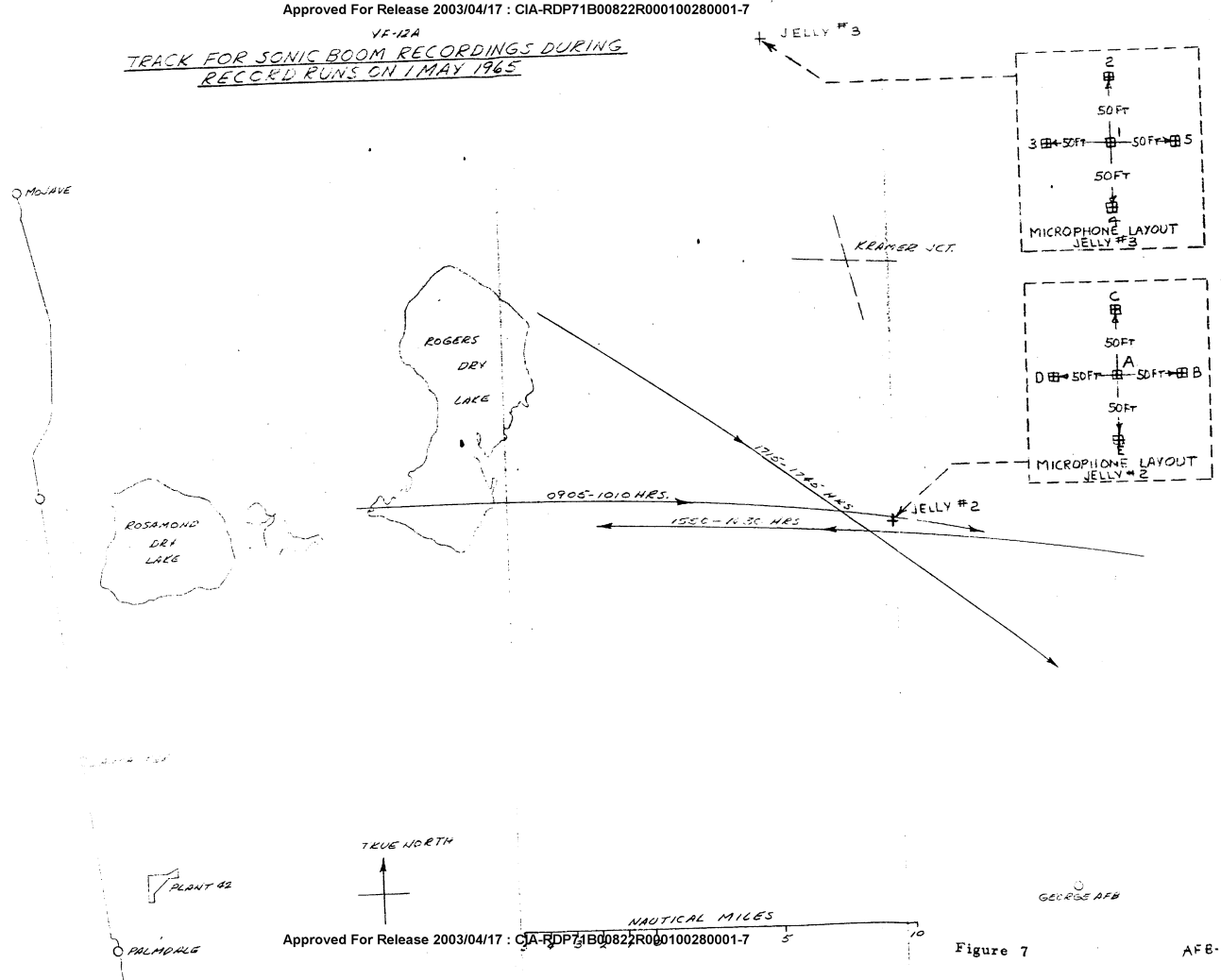

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Figure 7

AFB-803.2

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Observers' Comments

Experienced observers located at the YF-12A service area commented that the booms were generally quite light. As shown in Figures 3 through 5, the operator at the recording station under the aircraft track reported "medium" booms. Figure 6 shows that the operator at the recording station to the side of the aircraft track reported that the 500 km course boom was "very faint". This is consistent with the data and only indicates the effect of different locations with respect to the aircraft track.

Atmospheric Conditions

Figures 8 and 9 show the ambient air temperature variation and wind direction and velocity measured on the day of the runs. At the altitudes concerned, the temperature was within $\pm$ 5°C of standard and wind velocity was 10 knots or less, varying from West to North. The maximum wind velocity was approximately 65 knots at 40,000 feet from WSW. These data are included because of the possible effects on the sonic boom recordings.

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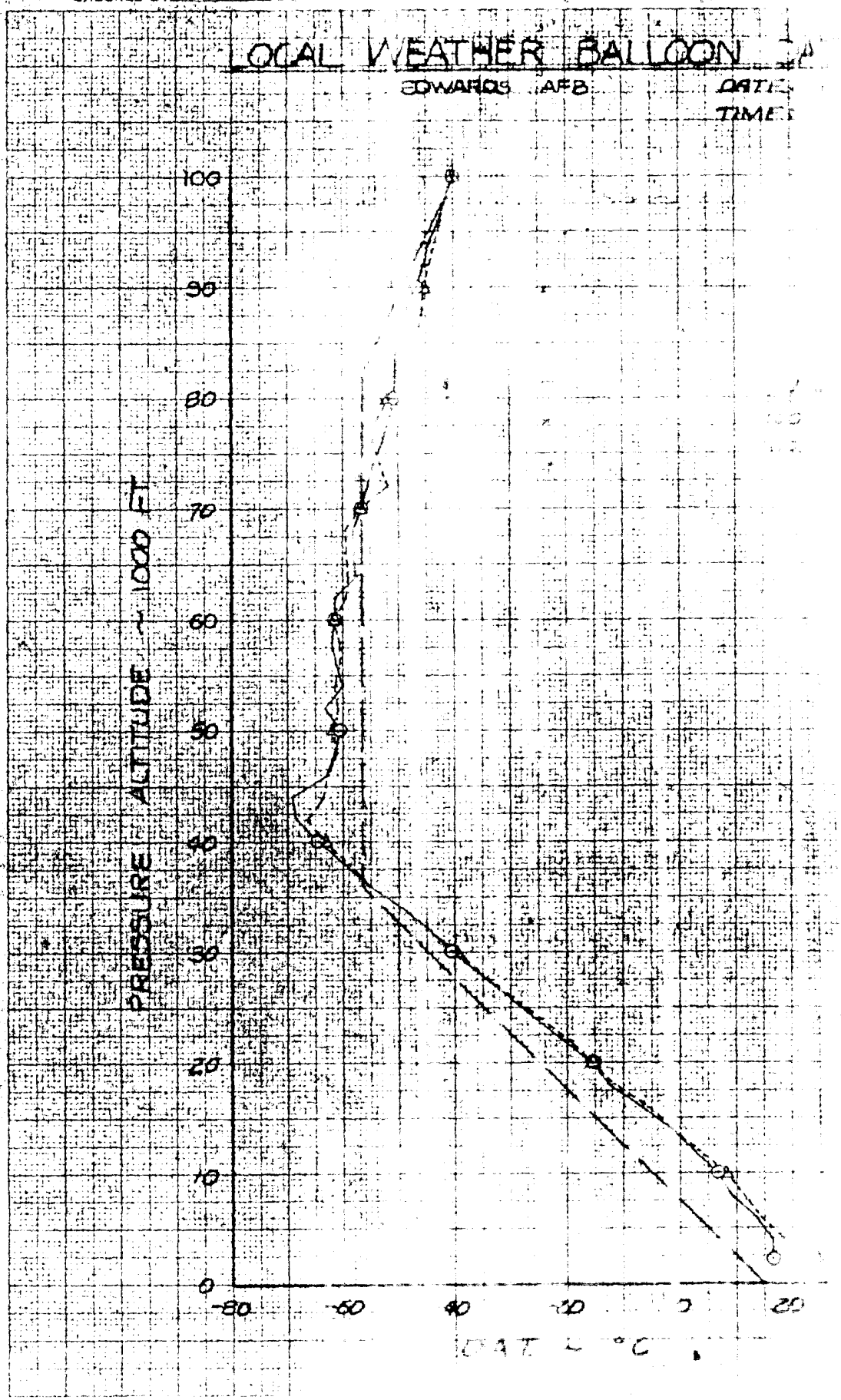

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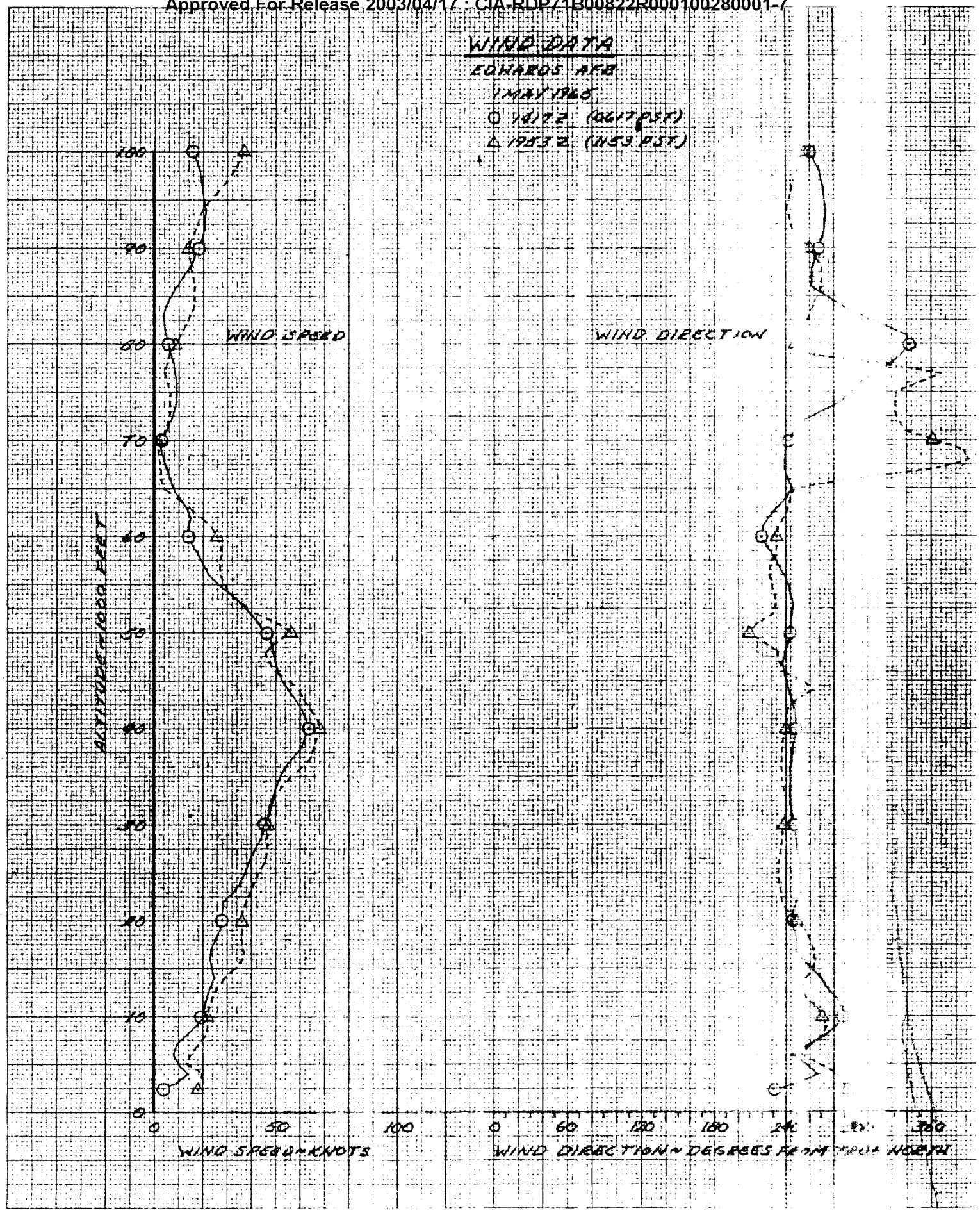

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Figure 9

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Supplementary Data

Figure 10 shows YF-12A data obtained during a practice flight prior to the actual record runs. This data point also agrees well with measured B-58 data.

Figures 11 and 12 are data obtained from a different series of flight tests. In this case, the recording station was located at 5000 feet terrain level and all of the data were obtained in the low supersonic Mach number range at altitudes from 25,000 to 42,000 feet above terrain. The maximum measured overpressure was 5.0 PSF and the minimum was 0.3 PSF. Statistically, 51 total data points were measured of which 4% were between 4.0 and 5.0 PSF, 67% were between 2.0 and 4.0 PSF, and 29% were less than 2.0 PSF. The largest variations were at lower altitudes where the aircraft was near "cutoff" Mach number; that is, the minimum supersonic Mach number at which a sonic boom will reach the ground. Aircraft attitude, flight path and atmospheric variations become more critical at this condition. Overpressure variations of this order undoubtedly will be typical of actual service operation.

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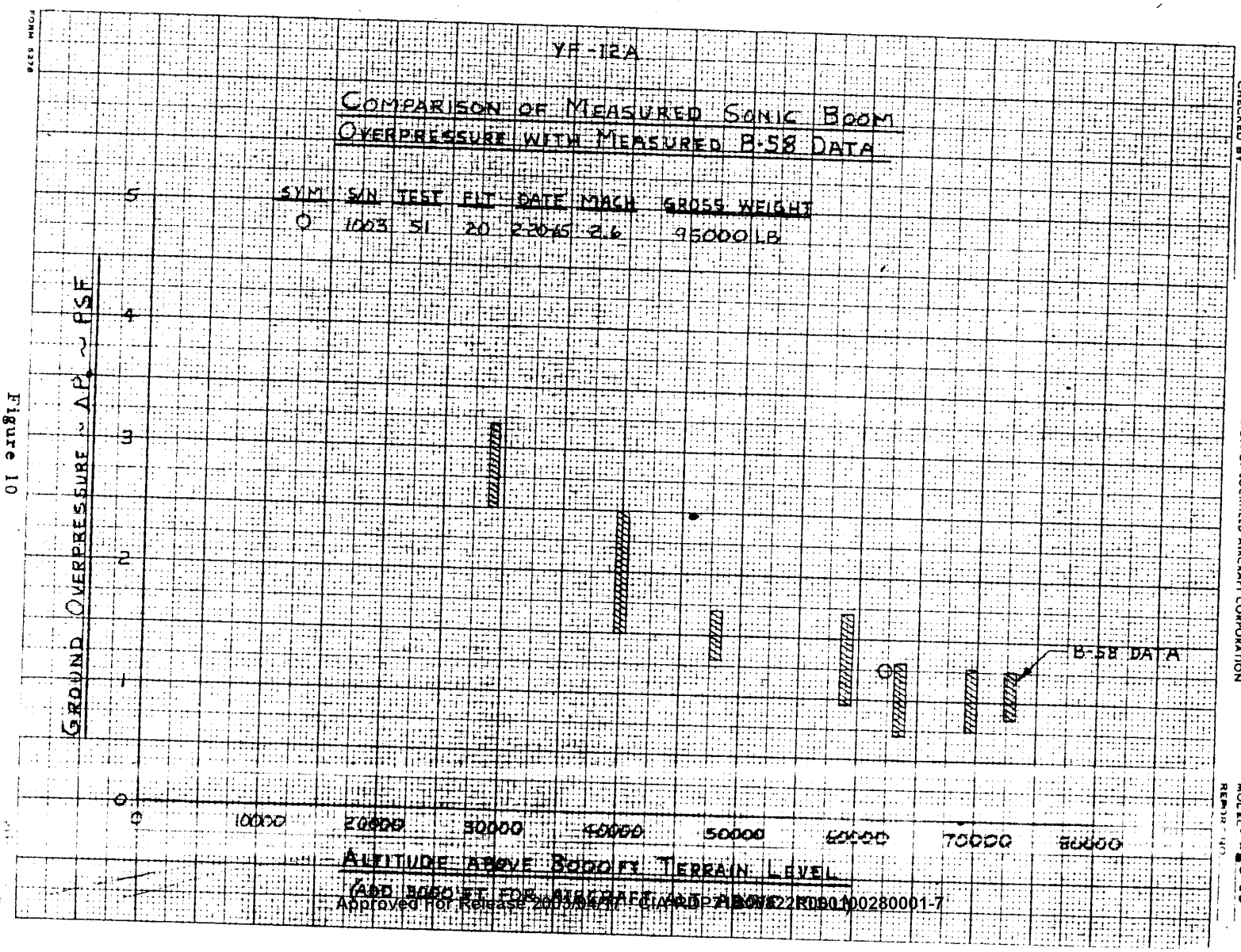

Figure 10

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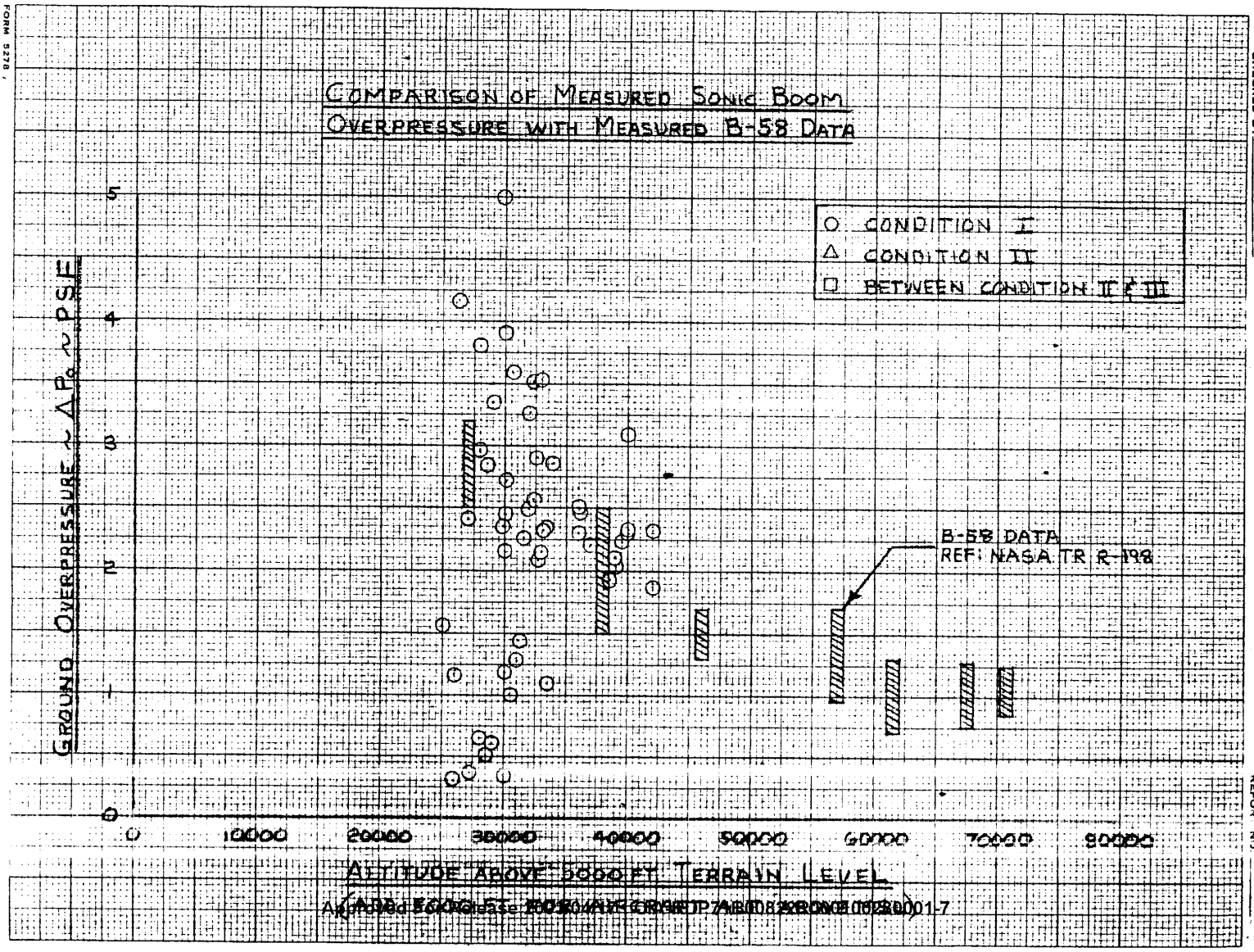

Figure 11

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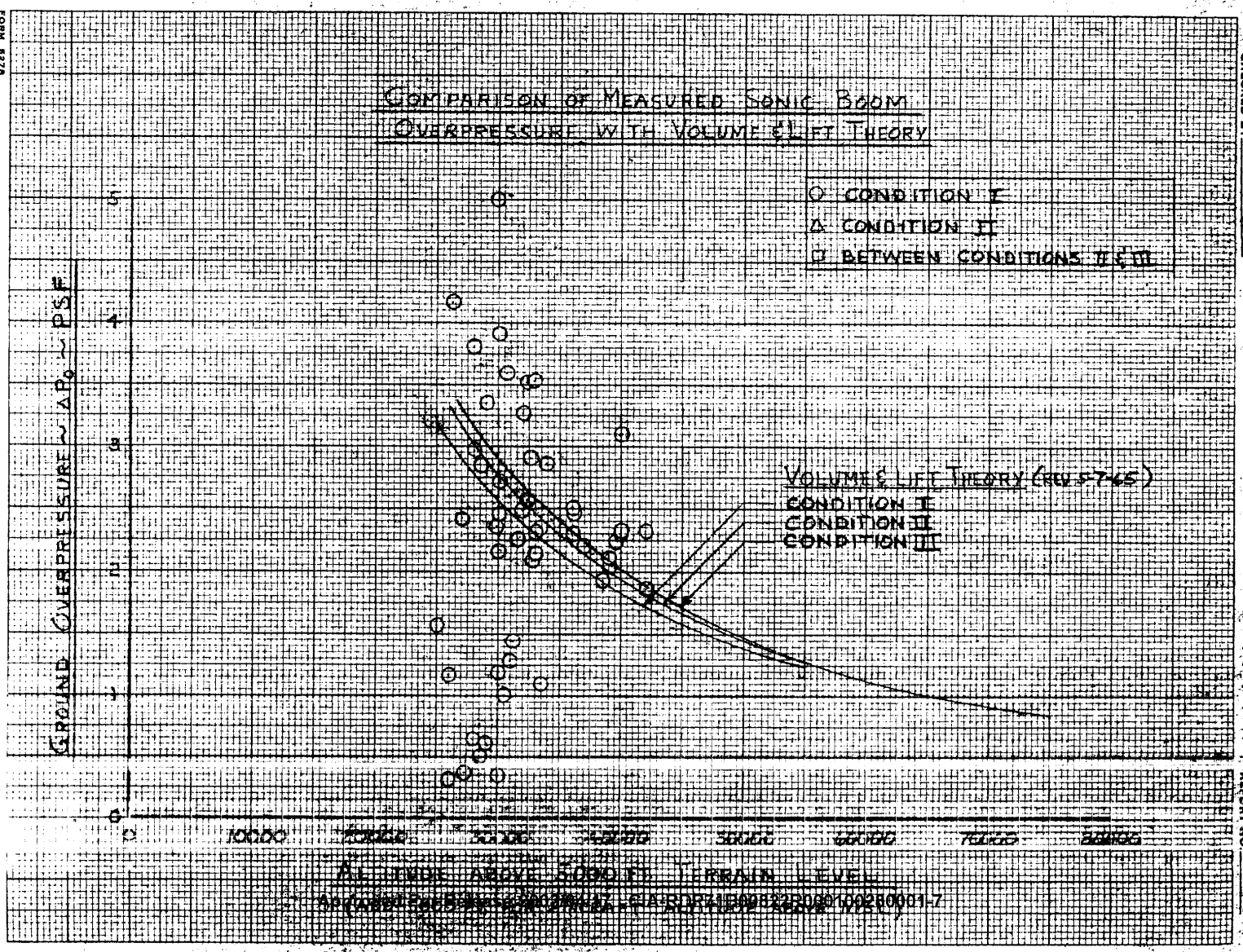

Figure 12

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Instrumentation

All of the foregoing data were obtained with the same equipment used by Lockheed during the FAA Oklahoma City tests. Similarly, the microphones and recording system were calibrated using AC calibrations in the frequency range from approximately 400 to 1200 cps. It can be argued that DC calibrations are inherently more accurate because there are few sonic boom frequencies above 100 cps. Figures 13 and 14 show data obtained over a wide Mach number and altitude range but measured with a single, DC calibrated pressure transducer. In general, the measured overpressures were less than shown in Figures 1 through 12. However, other effects may have been introduced since these were essentially "unsolicited" tests and the flight conditions were not as well controlled as the record runs. Present plans are to obtain additional data using five DC calibrated pressure transducers.

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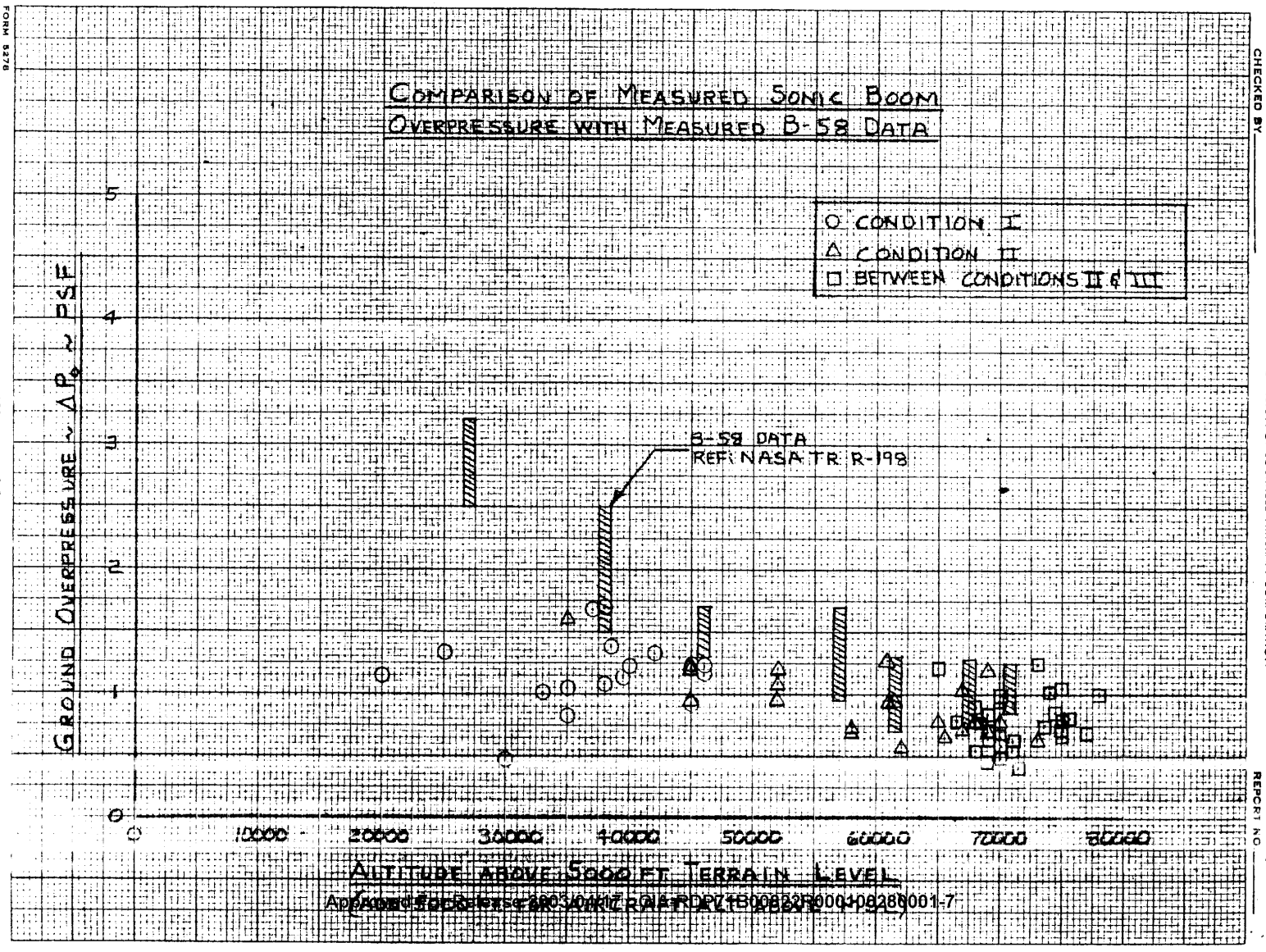

Figure 13

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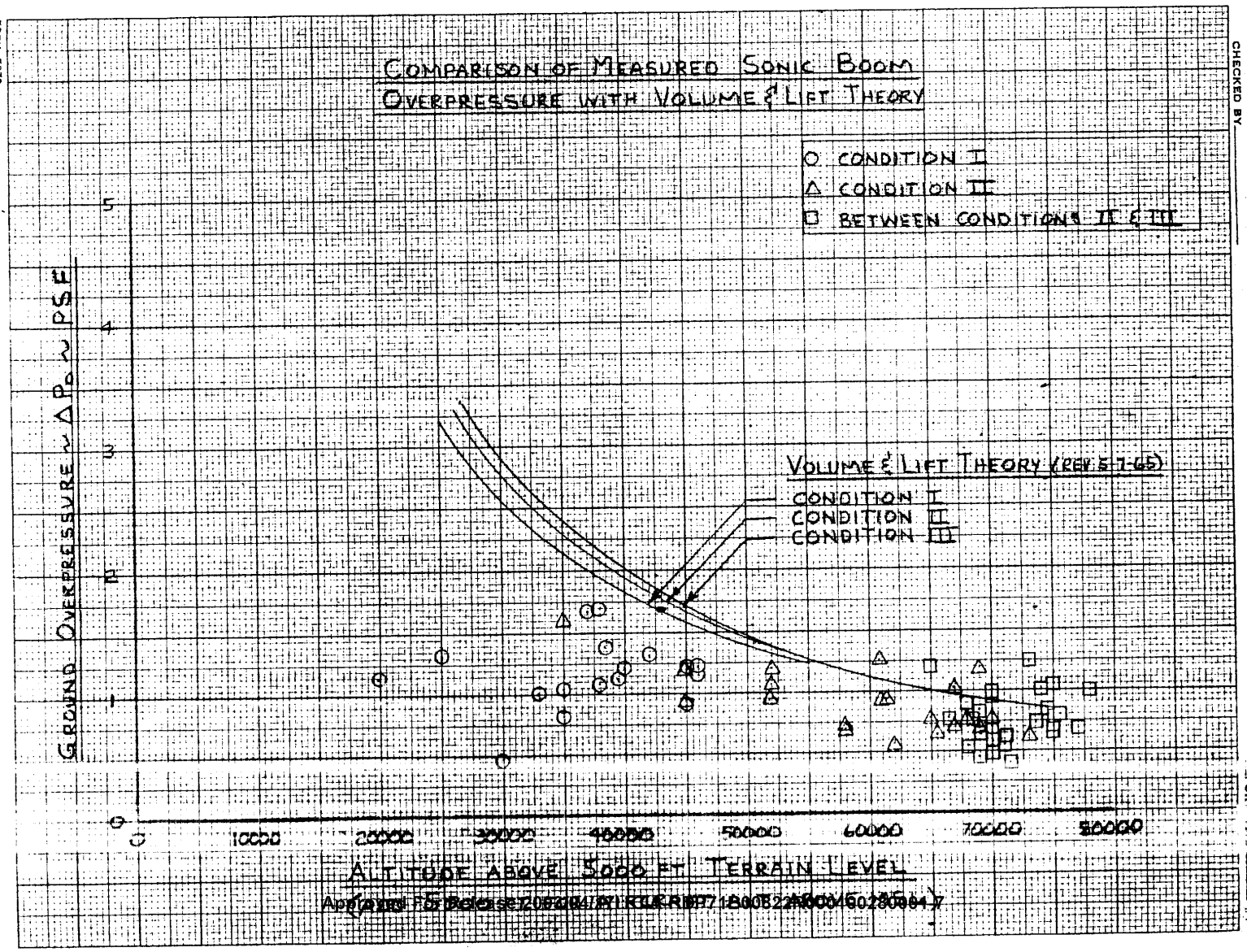

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Figure 14

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