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CAPABILITIES OF THE THERMAL ACOUSTIC FATIGUE APPARATUS

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SUMMARY

The Thermal Acoustic Fatigue Apparatus (TAFA) is a facility for applying intense noise and heat to small test panels. Modifications to TAFA have increased the heating capability to 44 BTU/ft-sec, making it possible to heat test panels to 2000 °F and concurrently apply 168 dB of noise. Results of an acoustic survey showed that the overall noise level (band-limited 50 to 500 Hz) was within 0 to 3 dB of a noise reference measurement obtained 4-1/2 inches in front of the panel on its center line. Coherence values of the measurements were close to unity for the frequency range 50 to 500 Hz across the panel and from 50 to 850 Hz from top to bottom of the panel. The results of the thermal survey on the 0.09-inch steel panel showed relatively symmetrical temperature distributions across and from top to bottom of the panel. The results on a thin-skinned insulated panel showed a lack of symmetry from top to bottom of the panel, apparently caused by the non-uniform air flow and large convective heat loss of the thin-skinned panel. For the same power, air flow caused a 230 °F decrease in temperature near the center of the panel.

INTRODUCTION

Future hypersonic aircraft such as the National Aerospace Plane (NASP) will be subjected to high thermal and acoustic environments. To test various components of the NASP or other high speed aircraft, the Langley Research Center has modified the Thermal Acoustic Fatigue Apparatus (TAFA) to obtain heating capability of 2000 °F concurrently with an acoustic environment of 168 dB. TAFA, which is a grazing incidence high-intensity progressive wave tube, had the capability of sound pressure levels of 120-160 dB, both sinusoidal and random, in the frequency range of 40-500 Hz with essentially no heating capability. An intermediate modification was described in reference 1 where a temperature of 1000 °F was obtainable.

This paper will describe the current configuration of TAFA. It will then give the results of acoustic and thermal surveys.

THERMAL ACOUSTIC FATIGUE APPARATUS

Configuration

Acoustic capabilities.- The Thermal Acoustic Fatigue Apparatus (TAFA) is a grazing incidence, high-intensity noise apparatus with capability of sound pressure levels from 125 to 168 dB, both sinusoidal and random, in the frequency range of 40 to 500 Hz (figure 1). The noise source is two 30,000-watt acoustic modulators (Wyle Model WAS 3000) using filtered pressurized air. The sound is coupled to the 6-foot by 6-foot test section by an exponential horn with a 27-Hz low frequency cut-off. Test panels or plates can be mounted in one movable wall of the test section; for example, see figure 2.

Thermal capabilities.- For tests with thermal loads in conjunction with acoustic loads, a 1-inch thick clear quartz window, 18 inches by 28 inches, is mounted on the opposite wall. Behind the window, a heat bank of quartz lamps (figure 3) is mounted on a movable platform (figure 4). The heat bank consists of ten lamp fixtures (Research, Inc. Model 5208) assembled in a slightly staggered manner to obtain more even heating. Each fixture of six quartz lamps, each rated at 6000 Watts and having a lighted length of 10 inches, is powered by one SCR (silicon controlled rectifier) power supply. The fixture is both air- and water-cooled. The capability of this heat bank is 44 BTU/ft^2-sec. Both walls on the inside of the progressive wave tube have 1/2-inch thick high temperature insulation, and the top of the tube has a 1/4-inch thickness of the same kind of insulation. The bottom of the tube is lined with glass-rock bricks. When no thermal testing is being conducted, the glass window is replaced with a 1/4-inch thick aluminum plate, and an 1/8-inch plate covers the edges of the insulation (figure 5). The lamp bank is moved away from the test section during non-heated tests.

Control room.- The control room (figure 6) is isolated from the test cell electrically, structurally, and acoustically. All control, signal conditioning, recording, and analyzing equipment is housed in this room.

The control equipment allows the operator to obtain the desired noise levels and temperatures (within TAFA limits) for a test configuration. Adequate manual and automatic controls maintain test conditions. Adequate safety systems are utilized to assure successful safe testing and measuring. In addition, two television cameras monitor the exterior of both sides of the test section.

Signal conditioning equipment is available for high and low temperature strain gages, accelerometers, and thermocouples. Adequate meters and monitors are available to ensure accurate measurements.

Recording and analyzing systems are utilized. The basic recording system is a 14-channel, 1-inch, adjustable-speed tape recorder. Personal computers are also used, both in storing and analyzing the data. There is a 28-channel dynamic analyzer for obtaining power spectra and phase, cross- and auto-correlation, and coherence. This instrument stores and then analyzes the data. Another dynamic analyzer records eight channels of data, conducts the analyses, and shows the results in real time. Suitable printers are connected to each analyzer and computer.

Strain gages.- Various types of strain gages are used, namely, high, low, and ambient temperature strain gages. They are connected to appropriate bridge connection units mounted on the movable test panel carriage (figure 9). The outputs of the bridge completion units are directed to amplifiers and then to appropriate recording and analyzing equipment.

THERMAL AND ACOUSTIC SURVEYS

Test Panels

Three test panels were used in these surveys, one acoustical and two thermal.

Acoustic survey.- A photograph of the rear view of an 11- by 15-inch panel used in the acoustic survey is shown in figure 7. Five microphones were mounted in a bar of bakelite that could be moved from one position to the next. Two microphones were mounted in the TAFA wall. These positions and locations are shown in figure 8. The locations of the microphones were 1.5 inches in from all four sides, with 3 inches between each horizontally and 2 inches between each vertically.

Thermal survey.- A photograph of the rear view on a 0.090-inch thick steel panel, 12 inches by 15 inches, mounted in TAFA is shown in figure 9. Horizontally, the thermocouples are located at 1 inch, 4 inches, 7-1/2 inches, 11 inches, and 14 inches. Vertically, they are located at 1 inch, 3 inches, 6 inches, 9 inches, and 11 inches. No thermocouples were on the front of the panel.

A photograph of the front of a second panel, 12 inches by 12 inches, used in the thermal survey is shown in figure 10. Twenty-five thermocouples are on the front surface at 1-inch intervals, except near the edges. The ones nearest the edges are 1/2-inch from the edge. A photograph of the rear of this panel is shown in figure 11. A mounting plate covers up the three thermocouples mounted on the rear surface. This panel was a TPS (Thermal Protection System) panel, considered for the Shuttle Spacecraft, constructed of Inconel and titanium honeycomb sandwich panels separated by two layers of fibrous insulation material. For an additional description, see reference 2.

Instrumentation

The instrumentation consists of microphones, thermocouples, strain gages, TAFA controls, and data recording and analyses equipment.

Microphones.- For normal operation, two microphones are used; one 4-1/2 inches ahead of the test panel and one 4-1/2 inches behind it (figures 7 and 8). These are specially configured to measure the noise level near the test panel during high temperature operation. The microphones are located 18 inches behind the rear surface of the panel in a T of a 1/4-inch diameter pipe penetrating the test section. Fifty feet of 1/4-inch tubing behind the microphone tends to eliminate reflective tube resonances.

The microphones are calibrated using a noise driver as a source to drive noise down a 1-inch pipe. The end of the 1/4-inch pipe normally penetrating the test section is sealed in one side of the 1-inch pipe and a calibrated microphone is sealed directly opposite it. The output of the test microphone is adjusted to equal the output of the calibrated microphone at 124 dB and 250 Hz.

During normal testing, microphones are located near the throat of the test section and also beyond the exit of the test section, sufficiently far away to be unaffected by the heat lamps. These microphones are calibrated with a standard calibrator.

For conducting the noise survey, a special steel panel was made with 25 holes just large enough for the microphones to be flush mounted without touching the panel. During the survey seven microphones were used, five movable on the panel and two fixed, one upstream and the other downstream of the panel. Figure 9 shows these microphones with the five movable in their lowest position, position E. Figure 2 shows a front view of this panel. Figure 8 shows all the microphone locations. One test was made with the five movable microphones located at the midspan of the panel to obtain measurements at all five midspan positions simultaneously.

Thermocouples.- Both J and K type thermocouples were utilized during the tests. During the thermal survey, 34 thermocouples were used on the insulated panel: 28 type K on the test panel (25 on front, 3 on rear) (figure 10), two type J near the microphones on the 1/4-inch pipe, and four type J thermocouples (used in safety circuits) located in the test section wall around the heat bank. The thermocouples on the rear surface (figure 11) are obscured by the mounting plate.

Data Reduction

Acoustic data.- Overall rms sound pressure levels and spectral data were obtained from 20 sets of digital values over 10 seconds of data averaged in a real-time analyzer. The rms levels were verified by obtaining the microphone outputs on true-reading RMS analog meters. D.C. outputs of the meters proportional to the meter readings were recorded by computer 10 times over an 8-second period, averaged, and converted to rms sound pressure levels. Spectral and overall rms-level data were obtained on each microphone, obtaining seven measurements at a time.

To verify the overall noise level during a 30-second measuring period, a few recorded noise levels were analyzed using 16 averages over a 3-second time period. This procedure was repeated 10 times in this 30-second interval. These levels showed from ±0.2 to ±0.4 dB variation over the 30-second time period.

Thermal data.- The thermal measurements were directed to the computer. Six sets of data were obtained over a 40-second time period for 40 channels of thermocouple data. The sets of six data points varied less that ±4 °F at high temperatures and ±1 °F at low temperatures.

RESULTS AND DISCUSSION

The results and discussion will be presented in two sections; one acoustic survey and one thermal survey. The results for the acoustic and thermal surveys are shown in table I and in figures 12-19 and in tables II-V and in figures 20-27, respectively.

Acoustic Survey

The survey was conducted over the noise levels from 125 dB, the level that occurs when air is introduced into the test section through the modulators with no modulation, to 160 dB. Differential data for the 130 dB condition is shown in figure 12. The differential (ΔdB) is the difference in sound pressure level between the test point along the test panel and the sound pressure level measured at the location 4.5 inches ahead of the test panel (see figure 8). Most sound pressure levels are about 2 dB less than the reference level, with a few data points at 3 dB less than the reference level. Thus, across the test panel, the sound pressure levels vary less than 3 dB. From the top to the bottom of the panel, the sound pressure level difference is less than 3 dB.

Differential data for the 140 dB condition is shown in figure 13. Positions A, B, and D have the largest deviations along the panel, namely less than 3 dB from the reference, or 2 dB among themselves. From the top to the bottom of the panel, the deviation is about 4 dB. Very similar effects are shown at the 150 dB and 160 dB sound pressure levels (figures 14 and 15). All these data plus, the levels measured ahead of and beyond the panel, are given in table I.

Examples of the power spectral density and coherence of the microphone signal are shown in figures 16-19. The upper trace in figure 16 represents the response of the microphone nearest the leading edge of the panel in position C, and the lower trace represents the output of the microphone at the trailing edge of the panel in position C at about 160 dB.

Although the trace shapes are essentially the same in figure 16, the drop-off in signal would have been expected to be much greater above 500 Hz, since the white noise random input signal was band-passed from 50 to 500 Hz. However, due to resonances and harmonics within the apparatus, the drop-off in acoustic response is less than expected. The responses obtained at all 27 microphone locations were essentially the same.

An example of coherence between microphones is shown in figure 17. The coherence of the outputs of the same microphones mentioned above, position C near the leading and trailing edges, are shown. A coherence of unity is desired. Up to 200 Hz, excellent coherence is obtained. Unfortunately, a resonance at about 200 Hz due to the height of the test section resulted in a very low value of coherence at 200 Hz. Above 200 Hz, other resonances and harmonics caused low values of coherence. All coherence measurements of microphone output at the same height (Positions A - E) showed essentially the same coherence values.

The upper trace in figure 18 represents the response of the microphone at the midspan location of Position A, and the lower trace represents the response of the microphone at the midspan of the panel at position E, both at about 160 dB. The traces are essentially the same up to about 850 Hz and appear very similar to those shown in figure 16.

Coherence values for the above microphone outputs are shown in figure 19. It is seen that the coherence from near the top of the panel to near the bottom of the panel is near unity up to about 850 Hz. It may be concluded from the above discussion that the spanwise deviation from the microphone reference sound pressure level (ahead of the panel) is about -3 dB, and that the deviation from near the top to near the bottom of the panel is about 2 dB. Coherence across the center of the panel is near unity only for the first 200 Hz, whereas from near the top to near the bottom of the panel, coherence is near unity to about 850 Hz.

Thermal Survey

The thermal survey was conducted in two parts on two different panels. The first series of tests was on a 0.090-inch thick steel panel (rear view shown in figure 9) with nine type K thermocouples attached to its rear surface. The center thermocouple was used as the control. Occasionally a thermocouple would fail, resulting in no data for that point. The maximum temperature of 1955 °F at 160 dB was obtained at the center of the panel with 100 percent voltage applied to the lamp bank.

A temperature survey in the direction of the air flow is shown in figure 20 for numerous temperature levels. At high temperatures (1700-1900 °F), there appears to be a drop of about 100 °F near (about 1 inch) the leading and trailing edges of the panel. The survey from near the top of the panel to near the bottom of the panel at midspan is shown in figure 21. Again, the center of the panel is the hottest. These results are shown numerically in table II.

The second series of tests was on a TPS insulated panel (front view in figure 10). Twenty-five temperature measurements were made with 25 thermocouples on the front surface and 3 on the rear surface. Using only 42 percent voltage on the heat bank, 2000 °F was obtained. Since the reference thermocouple at the center of the panel failed early in the survey, the adjoining upstream thermocouple was used as the reference control thermocouple.

A detailed temperature survey of the panel in the direction of air flow is shown in figure 22. The temperature distributions are skewed downstream of the center of the panel, thus indicating a significant heat loss to convection. These results are tabulated in table III.

The temperature survey from the top to the bottom of the panel taken midway across the panel is shown in figure 23. At all temperatures shown, the shapes of the curves of temperature level from top to the bottom of the panel are similar. However, the drop in temperature near the center and below the center of the panel was unexpected. It was first thought that the temperature response was due to the internal construction of the TPS panel. Thus, additional measurements were obtained with the panel rotated 180 degrees. Very similar results were obtained, indicating that the drop in temperature is probably related to a non-uniform air flow plus a relatively large convective loss due to the very thin surface of the panel.

The effect of noise on the temperature distribution along center lines of the panel is shown in figures 24 and 25, respectively, across the panel and from top to bottom of the panel for 42 percent voltages. As the overall sound pressure level is changed from 140 to 160 dB at constant heating voltage, the temperature dropped approximately 100 °F at locations 7-10 in the horizontal direction and approximately 70 °F at locations 7 and 8 in the top to bottom direction. The reversal of temperatures in positions 7-10 from top to bottom of the panel is not clearly indicated due to the lack of data—certain data points were unavailable, as shown by the dashes in table IV.

The effect of air flow on temperature is shown for 16 percent voltage in table V and in figures 26 and 27, respectively, across the panel and from top to bottom of the panel. With no air flow, the heating is relatively symmetric about the vertical and horizontal axes of the panel. There is a significant temperature decrease when air is allowed through the modulators even with no modulation. The scales of these plots have been expanded to more easily see the temperature differences. The effect of air flow in the horizontal direction is to both lower the temperature of the panel and skew the temperature distribution downstream.

In the vertical direction, there is no temperature reversal when there is no air flow through the modulators. With air flow, the temperature reversal is clearly evident figure 27). Apparently, the non-uniform air flow and large convective heat loss of the thin-skinned panel is causing this temperature reversal. Near the center of the panel (position 5), there is about a 230 °F temperature decrease due to the air flow at the heating level of 16 percent voltage.

CONCLUDING REMARKS

Modifications to the Thermal Acoustic Fatigue Apparatus (TAFA) have increased the heating capability to 44 BTU/ft-sec, making it possible to heat test panels to 2000 °F and concurrently apply 168 dB of noise. Results of acoustic and thermal surveys were shown. Two test items, a 0.09-inch steel panel and an insulated panel, were used in the thermal survey.

Results of the acoustic survey showed that the overall noise level (band-limited 50-500 Hz) was within 0 to -3 dB of a noise reference measurement obtained four and one-half inches in front of the panel center line, depending on the location and noise level. Coherence measurements showed a value close to unity for the frequency range 50 to 200 Hz across the panel and from 50 to 850 Hz from top to bottom of the panel.

The results of the thermal survey on the 0.09-inch steel panel showed relatively symmetrical temperature distributions across and from top to bottom of the panel. The results on a thin-skinned insulated panel showed a lack of symmetry from top to bottom of the panel, apparently caused by the non-uniform air flow and large convective heat loss of the thin-skinned panel. For the same power, air flow caused a 230 °F decrease in temperature near the center of the panel.

REFERENCES

1. Ng, C. F.; and Clevenson, S. A.: High Intensity Acoustic Test of a Thermally Stressed Aluminum Plate in TAFA. NASA TM 101552, February 1989.

2. Leatherwood, J.; Clevenson, S.; and Daniels, E.: Acoustic Testing of High Temperature Panels. Presented at AIAA 13th Aeroacoustics Conference, October 22-24, 1990, Tallahassee, FL, AIAA-90-3939.

TABLE I.- VARIATION IN NOISE LEVELS FROM REFERENCE

		Approximate Noise Levels, dB				
Position	Location	125	130	140	150	160
A	L.E.	0	0	0	0	0
	1	-0.5	-0.8	-1	-1.9	-2
	2	0	-2.7	-2.7	-2.7	-2.2
	3	-1	-2	-2.8	-2.6	-0.2
	4	-0.5	-1.9	-2.7	-3.6	-3
	5	-0.6	-2.4	-2.3	-2.1	-1.5
	T.E.	-0.6	-1.2	-1.2	-0.7	0
B	L.E.	0	0	0	0	0
	1		-0.2	-1.1	-0.6	-2.4
	2		-1	-2.9	-2.5	-2.4
	3		-2.2	-2.9	-2.5	-2.4
	4		-2.2	-2.8	-3.1	-2.7
	5		-1.9	-2.4	-2.3	-2.6
	T.E.		-1.1	-1.2	-0.6	-0.5
C	L.E.	0	0	0	0	0
	1	-0.2	0	0.5	0	-2.2
	2	-1.8	-2	0.9	0.7	-2.5
	3	-0.8	-1.7	0.6	0.3	-2.6
	4	-0.8	-1.7	0.2	0.1	-2.3
	5	0	0.2	0.8	0.8	-1.8
	T.E.	0	-0.4	0.5	0.7	-0.7
D	L.E.	0	0	0	0	0
	1	4	-1	-2.8	-2.4	-2
	2	-1	-3	-3	-2.1	-2.2
	3	-1	-2.8	-2.7	-2.5	-2.2
	4	0	-2.1	-2.4	-2.4	-2.1
	5	0	-2.2	-1.2	-1.4	-1.5
	T.E.	0.5	-1	-1.6	-0.3	0
E	L.E.	0	0	0	0	0
	1	2.6	-2	-1.6	0.9	-0.1
	2	1.8	-2.3	-1.4	0.7	-0.5
	3	-1.7	-2.5	-1.7	0.7	0.2
	4	2.3	-2.5	-1.5	0.2	-0.7
	5	-1	-0.7	-2.5	-1.5	-1.6
	T.E.	0.3	-2.4	-1.9	0.8	-0.6

TABLE II.- SURFACE TEMPERATURES OF THE 0.090-INCH STEEL

PANEL AT 160 dB OASPL AND VARIOUS HEATING LEVELS

Temperature, Deg. F					
% Voltage	Location Across Panel, Inches				
	1	4	7.5	11	14
10	771	-	846	813	733
20	1195	-	1270	1196	1127
30	1392	-	1506	1424	1362
40	1485	-	1650	1584	1515
60	1711	-	1800	1735	1684
100	1953	-	1993	1941	2002
	Location From Top of Panel, Inches				
	1	3	6	9	11
10	733	812	846	830	761
20	1155	1218	1270	1259	1169
30	1394	1429	1506	1485	1403
40	1513	1586	1650	1611	1533
60	1618	1717	1800	1776	-
100	1925	2000	1993	1991	2002

TABLE III.- SURFACE TEMPERATURES OF THE INSULATED

PANEL AT 124 dB OASPL AND VARIOUS HEATING LEVELS

Temperature, Deg. F												
% Voltage	Location Across Panel, Inches											
	0.25	1	2	3	4	5	7	8	9	10	11	11.8
11	657	672	702	789	820	8741	933	939	939	946	925	771
16	1026	1101	1156	1230	1265	1302	1341	1333	1340	1331	1296	1171
25	1376	1483	1331	1594	1620	1656	1675	1664	1666	1658	1623	1492
30	1528	1638	1686	1751	1775	1810	1829	1817	1823	1810	1766	1626
38	1759	1859	1906	1971	1976	2033	2049	2042	2043	2030	1990	1871
	Location From Top of Panel, Inches											
	0.25	1	2	3	4	5	7	8	9	10	11	11.8
11	703	814	-	964	985	1031	799	823	873	903	878	759
16	1062	1215	1308	1354	1373	1405	1229	1234	1296	1307	1291	1044
25	1397	1550	1637	1684	1701	1731	1577	1580	1634	1627	1614	1376
30	1549	1700	1782	1834	1855	1887	1750	1735	1778	1764	1752	1504
38	1778	1929	2002	2050	2064	2102	1969	1962	2013	-	1975	1742

TABLE IV.- SURFACE TEMPERATURES OF THE INSULATED PANEL

FOR VARIOUS SOUND PRESSURE LEVELS, CONSTANT 42% VOLTAGE

Temperature, Deg. F												
Sound Pres., dB	Location Across Panel, Inches											
	0.25	1	2	3	4	5	7	8	9	10	11	11.8
140	1746	1871	1927	1993	2015	2048	2064	2055	2059	2052	2008	1885
150	1672	1819	1889	1969	1988	2228	2034	2229	2036	2032	1980	1830
160	1568	1729	1813	1912	1930	1967	1962	1957	1964	1960	1873	1669
	Location From Top of Panel, Inches											
	0.25	1	2	3	4	5	7	8	9	10	11	11.8
140	1791	1929	2022	2067	2075	2111	2004	1989	-	-	1979	1745
150	1717	1880	1991	2033	2046	2082	1991	1936	-	-	1930	1686
160	1590	1787	1897	1938	1955	1994	1936	1920	1928	1804	-	1548

TABLE V.- SURFACE TEMPERATURES OF THE INSULATED PANEL

WITH AND WITHOUT AIR FLOW, CONSTANT 16% VOLTAGE

Temperature, Deg. F												
	Location Across Panel, Inches											
	0.25	1	2	3	4	5	7	8	9	10	11	11.8
Flow	1026	1101	1156	1230	1265	1302	1341	1333	1340	1331	1296	1170
No Flow	1400	1547	1582	1594	1593	1600	1577	1577	1557	1540	1489	1354
	Location From Top of Panel, Inches											
	0.25	1	2	3	4	5	7	8	9	10	11	11.8
Flow	1062	1215	1308	1354	1373	1405	1229	1234	1296	1307	1291	1044
No Flow	1342	1483	1569	1586	1601	1617	1585	1568	-	-	1476	1250

Figure 1.—Photograph of exterior of TAFA

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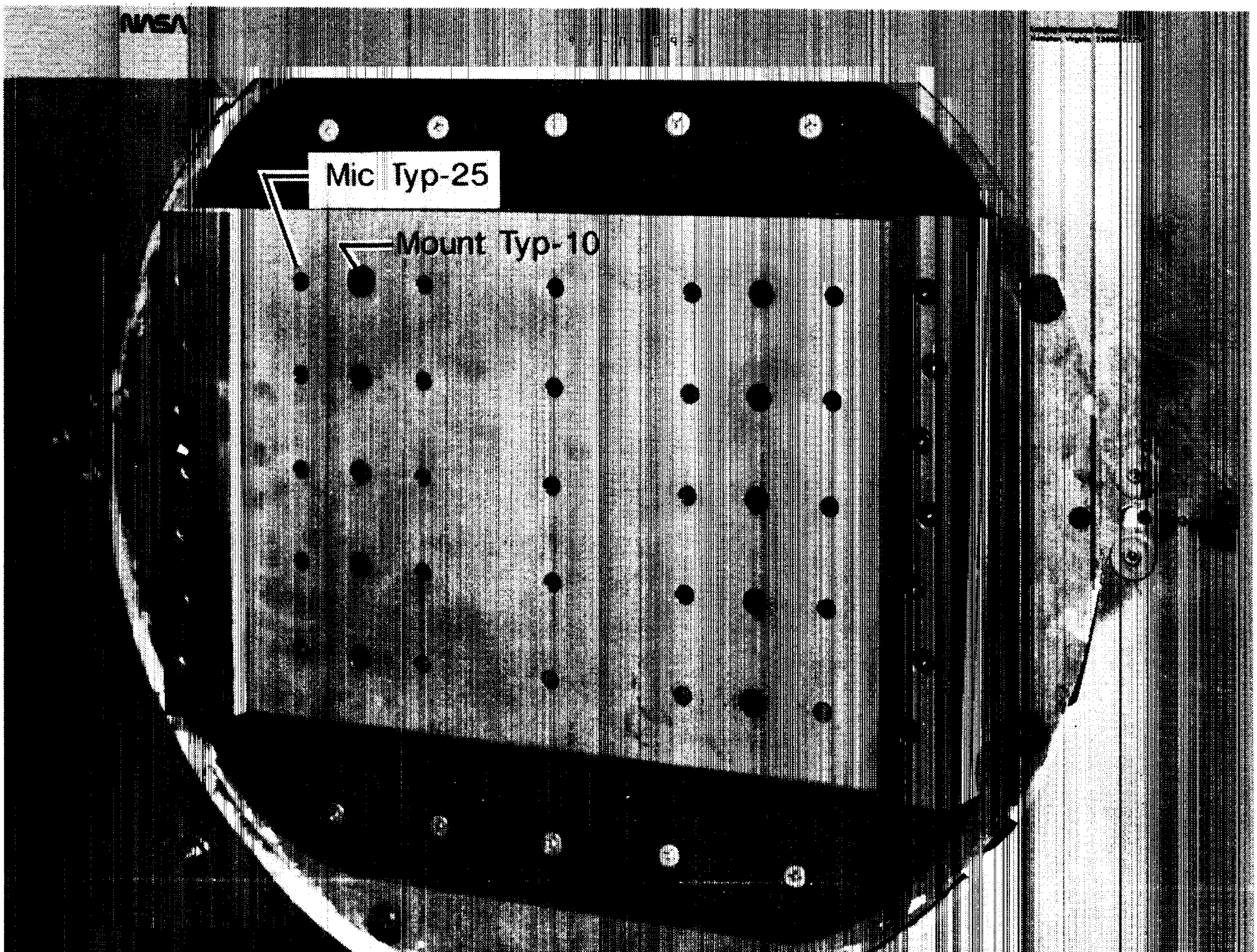

Figure 2.- Photograph of 11-in x 15-in test panel with 25 microphone locations.

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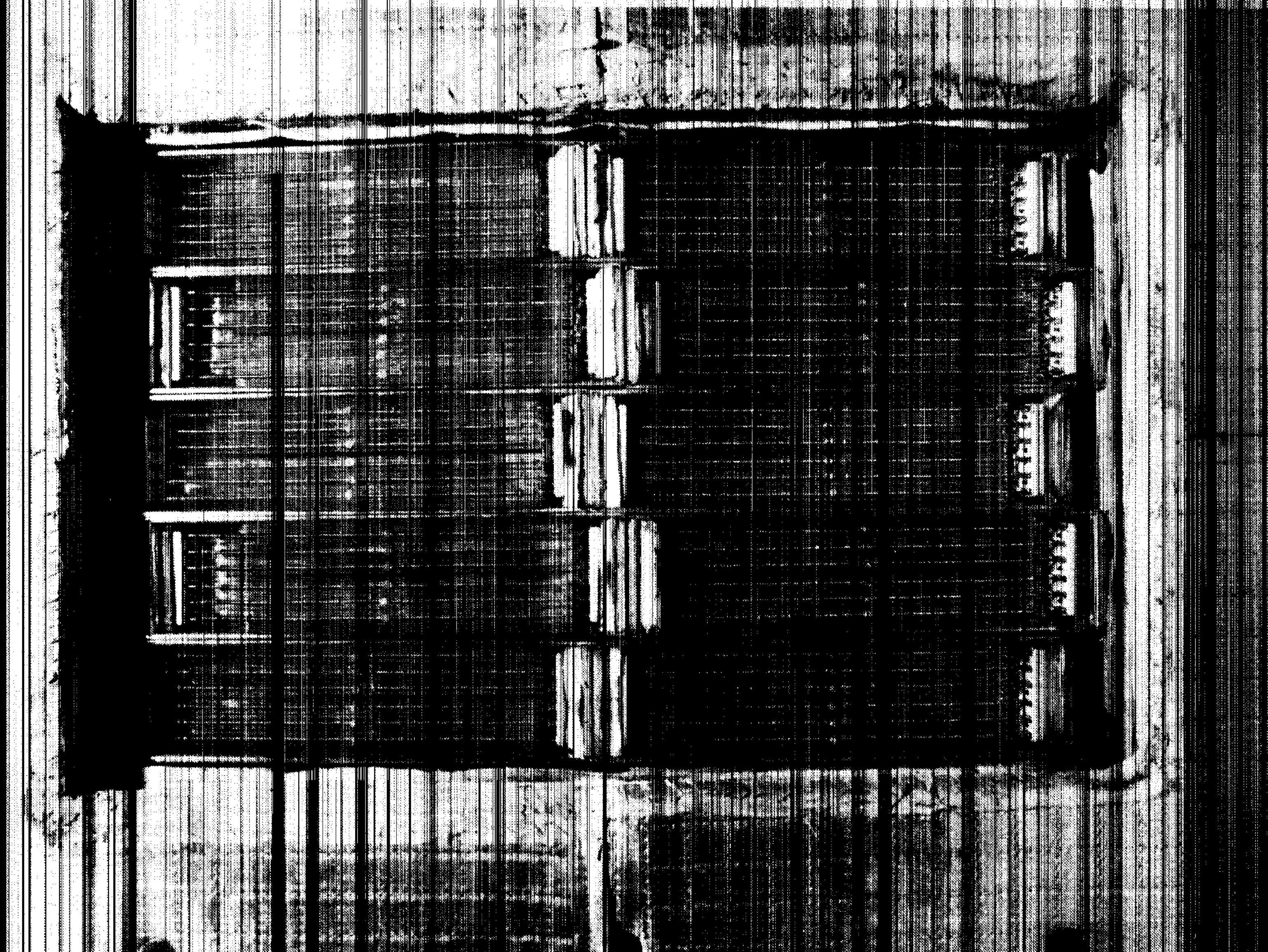

Figure 3.- Photograph of the lamp bank showing the 10 fixtures with 6 lamps mounted in each.

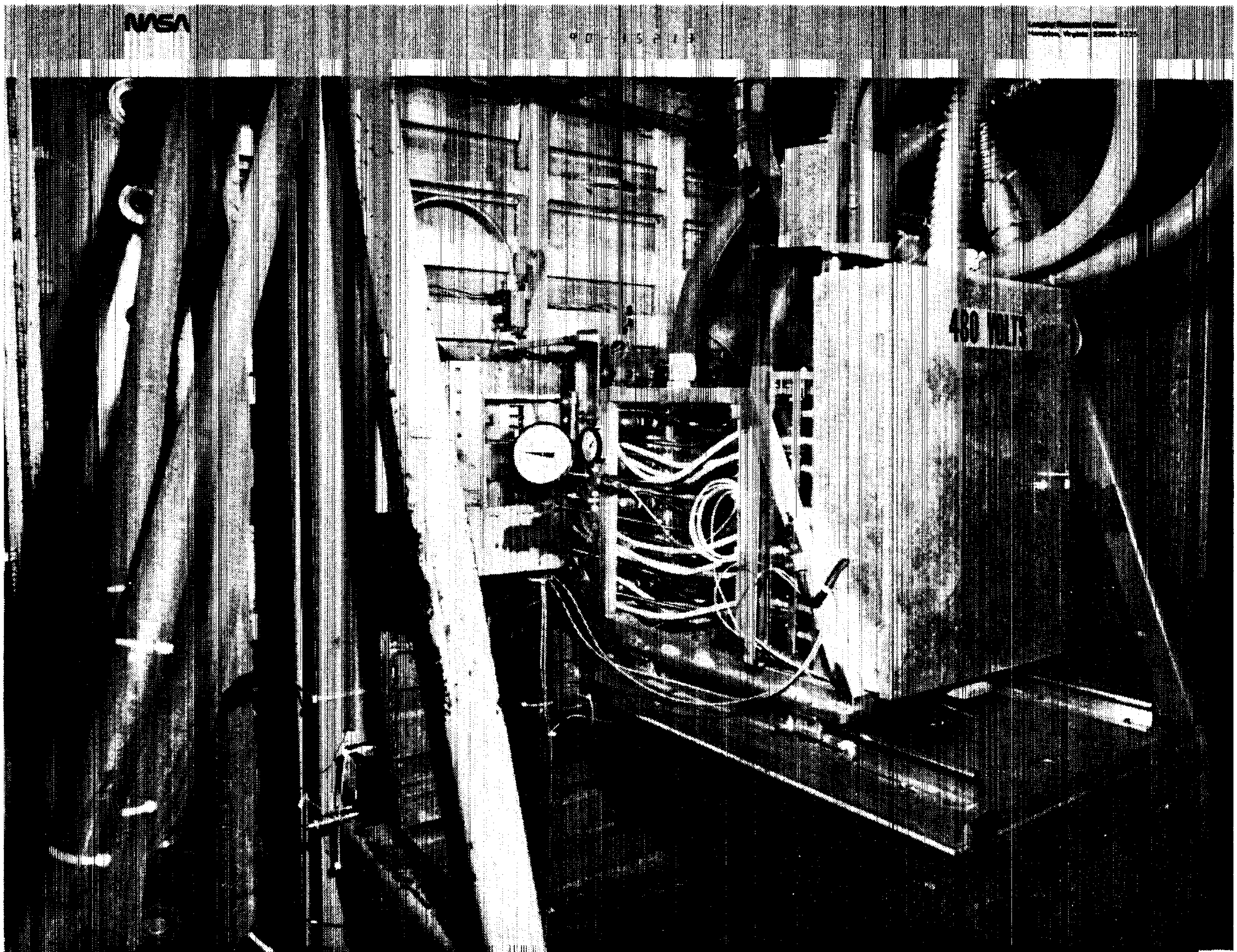

Figure 4.—Photograph of the movable platform containing the 10 lamp fixtures

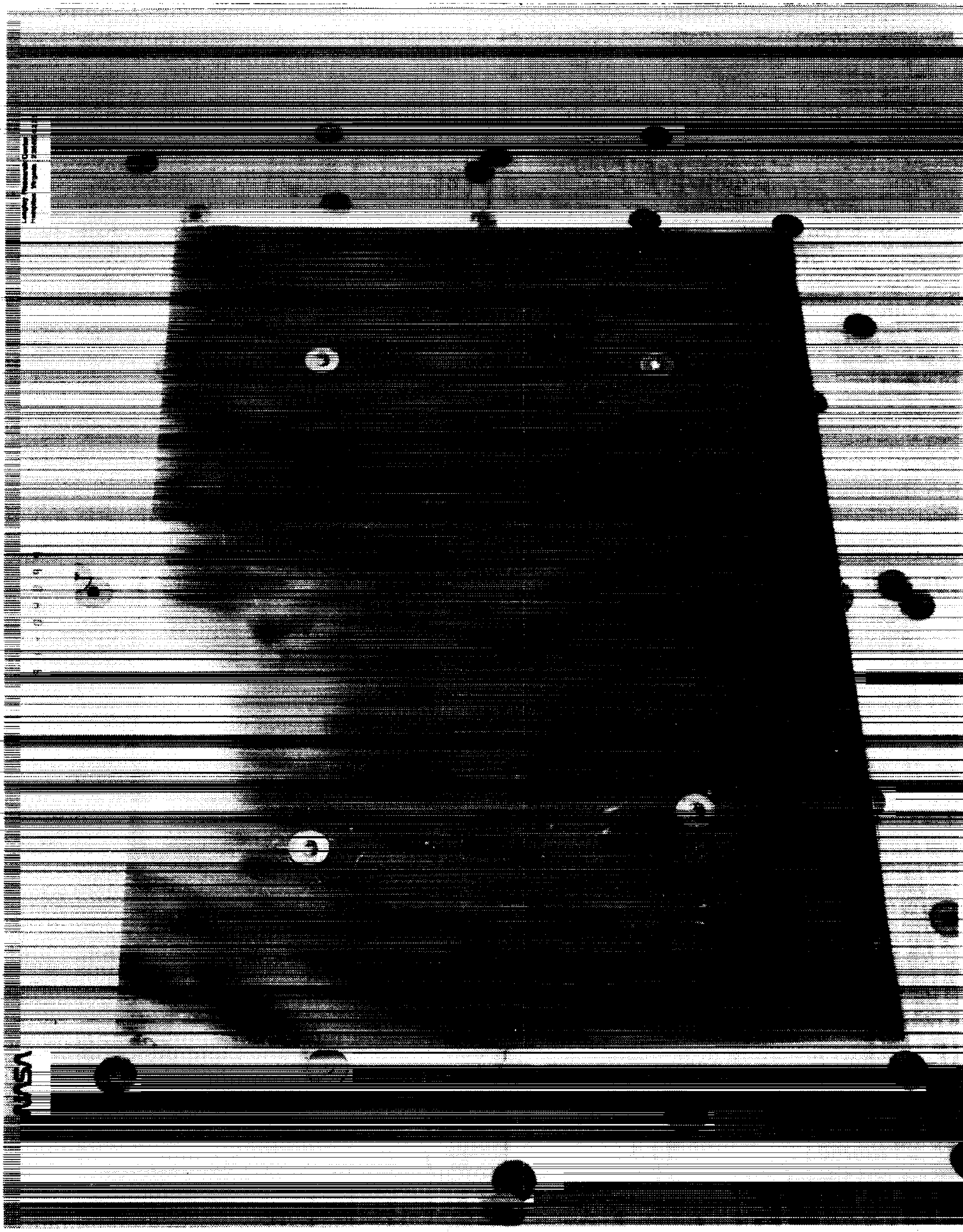

Figure 5.—Photograph of the plate protecting the 1-inch thick quartz window

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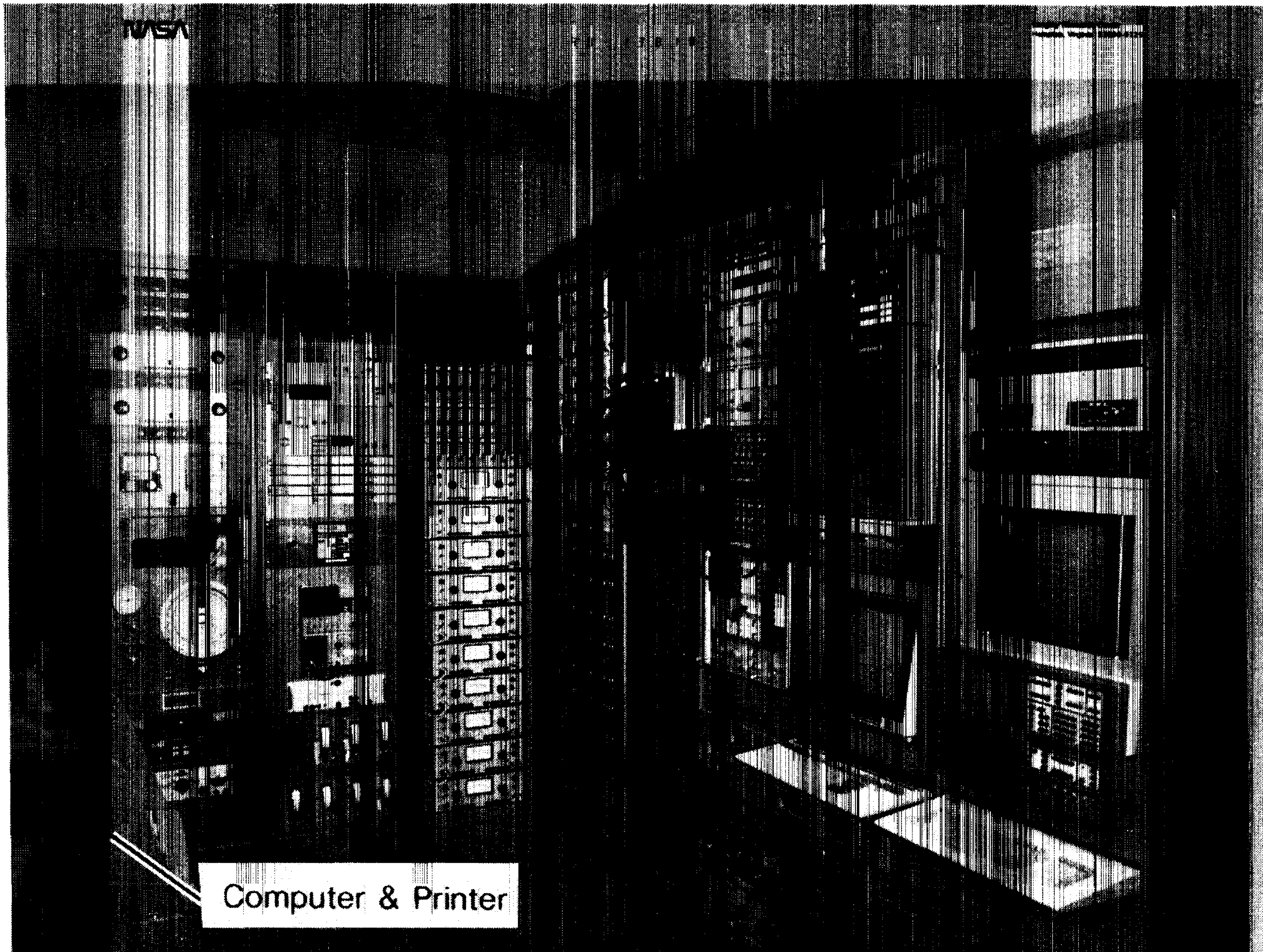

Figure 6.- Photograph of TAFA control room.

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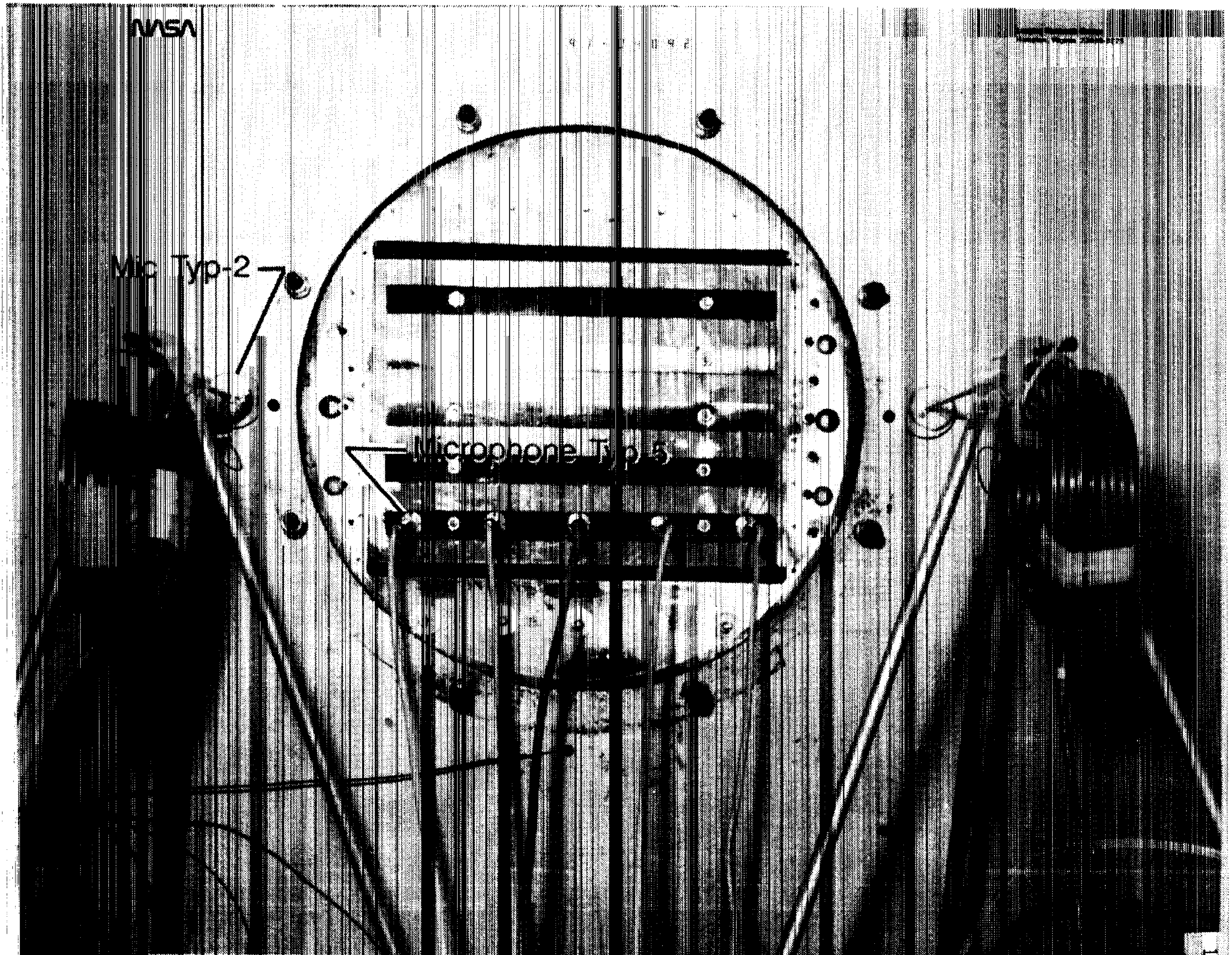

Figure 7.—Photograph of the rear view of the microphone survey panel

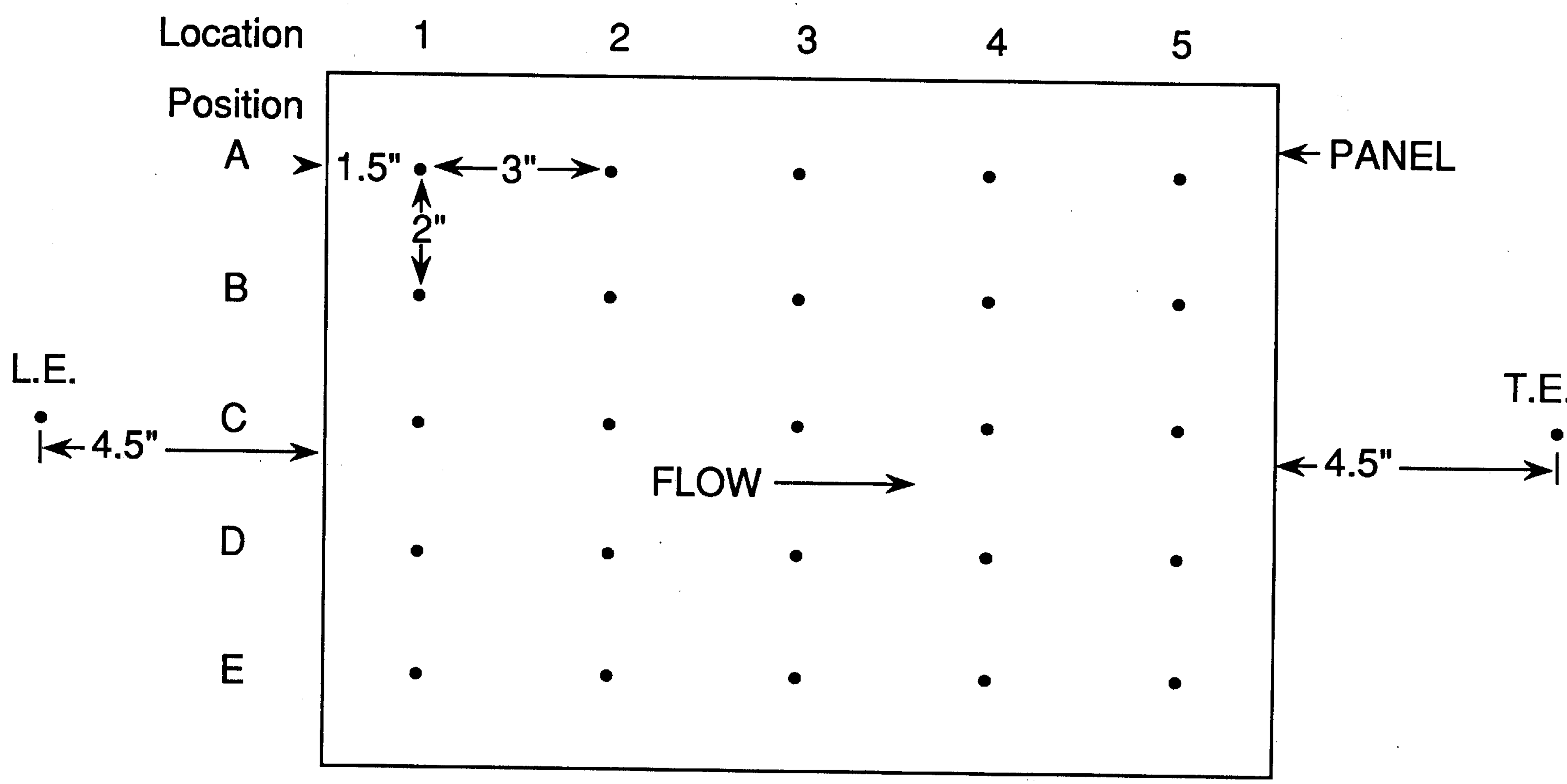

Figure 8.–Twenty-seven locations of microphones used in noise survey, 25 on the 11-inch x 15-inch panel.

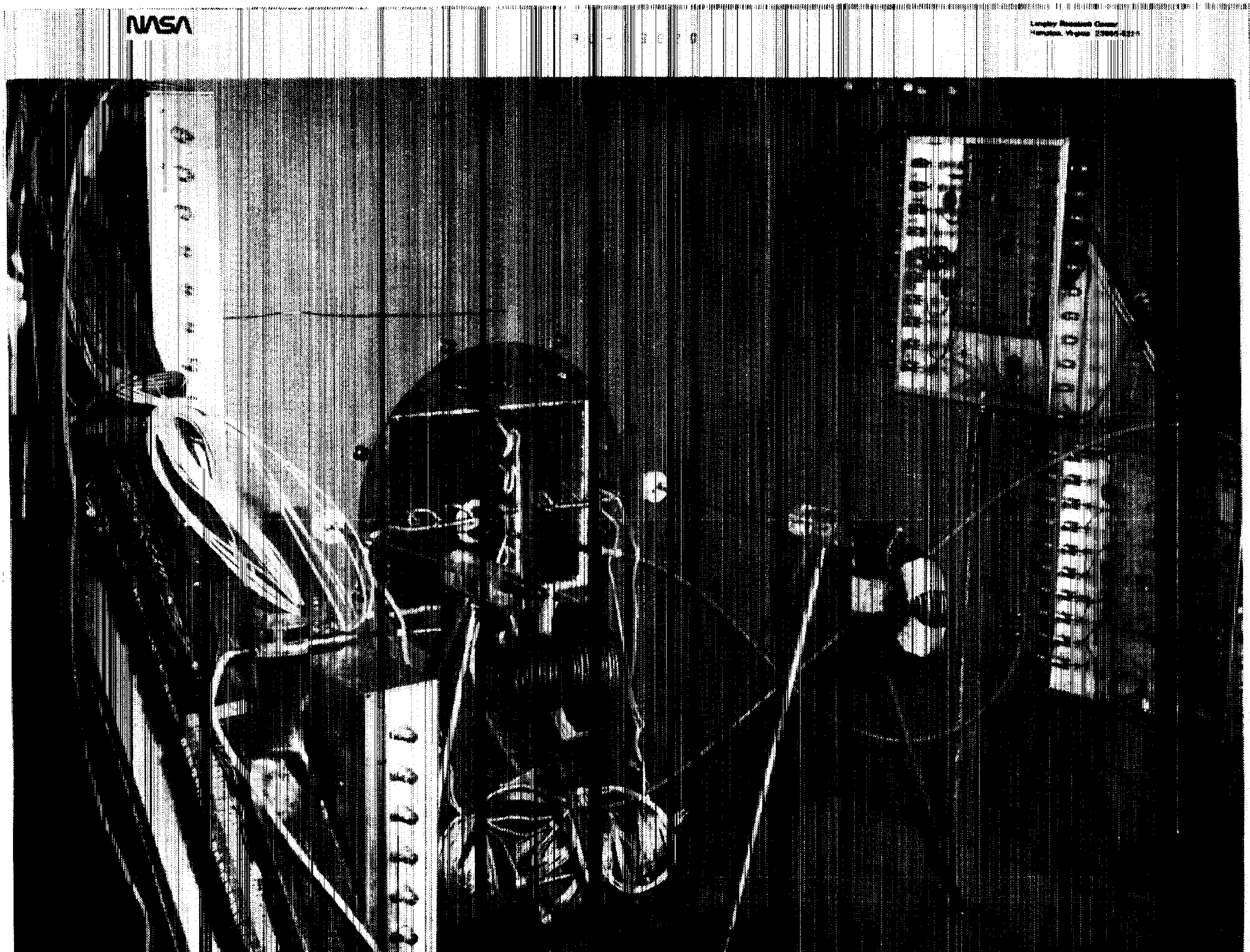

Figure 9.- Photograph showing rear view of the 0.09-inch steel thermal test panel.

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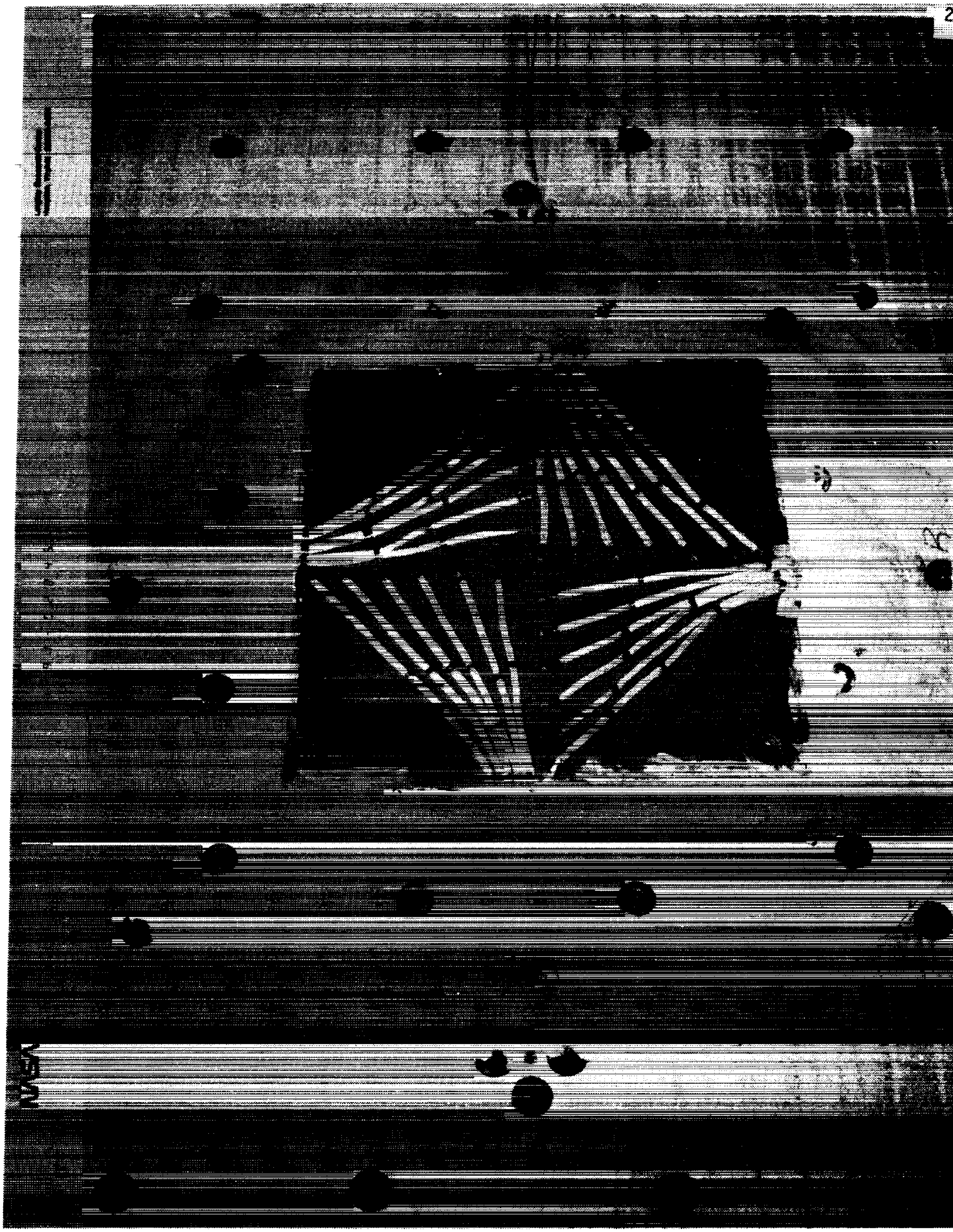

Figure 10.—Photograph of 25 thermocouples on the front of the insulated test panel.

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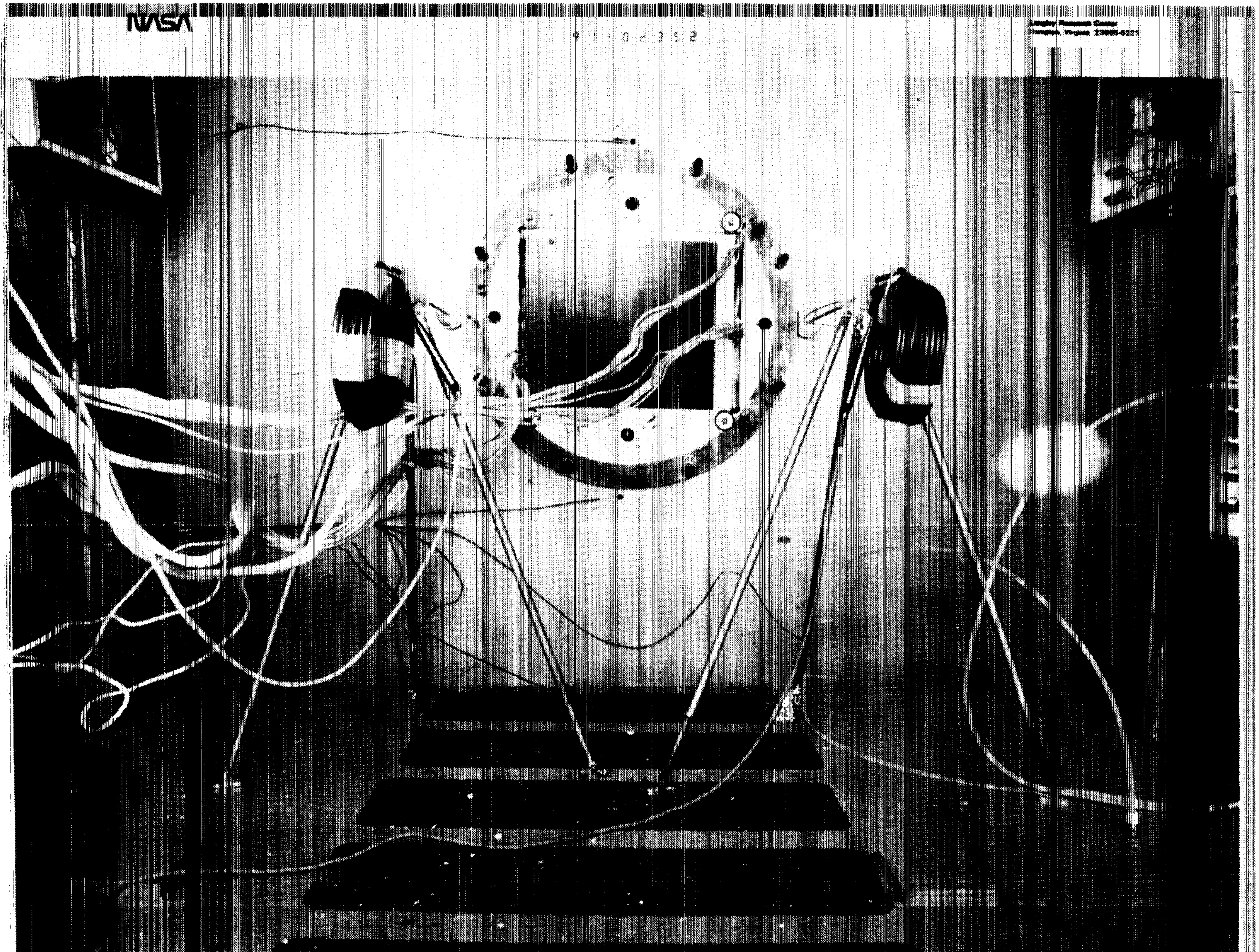

Figure 11.—Photograph showing the rear of the insulated thermal test panel and a direct view of the two microphone assemblies used during normal testing.

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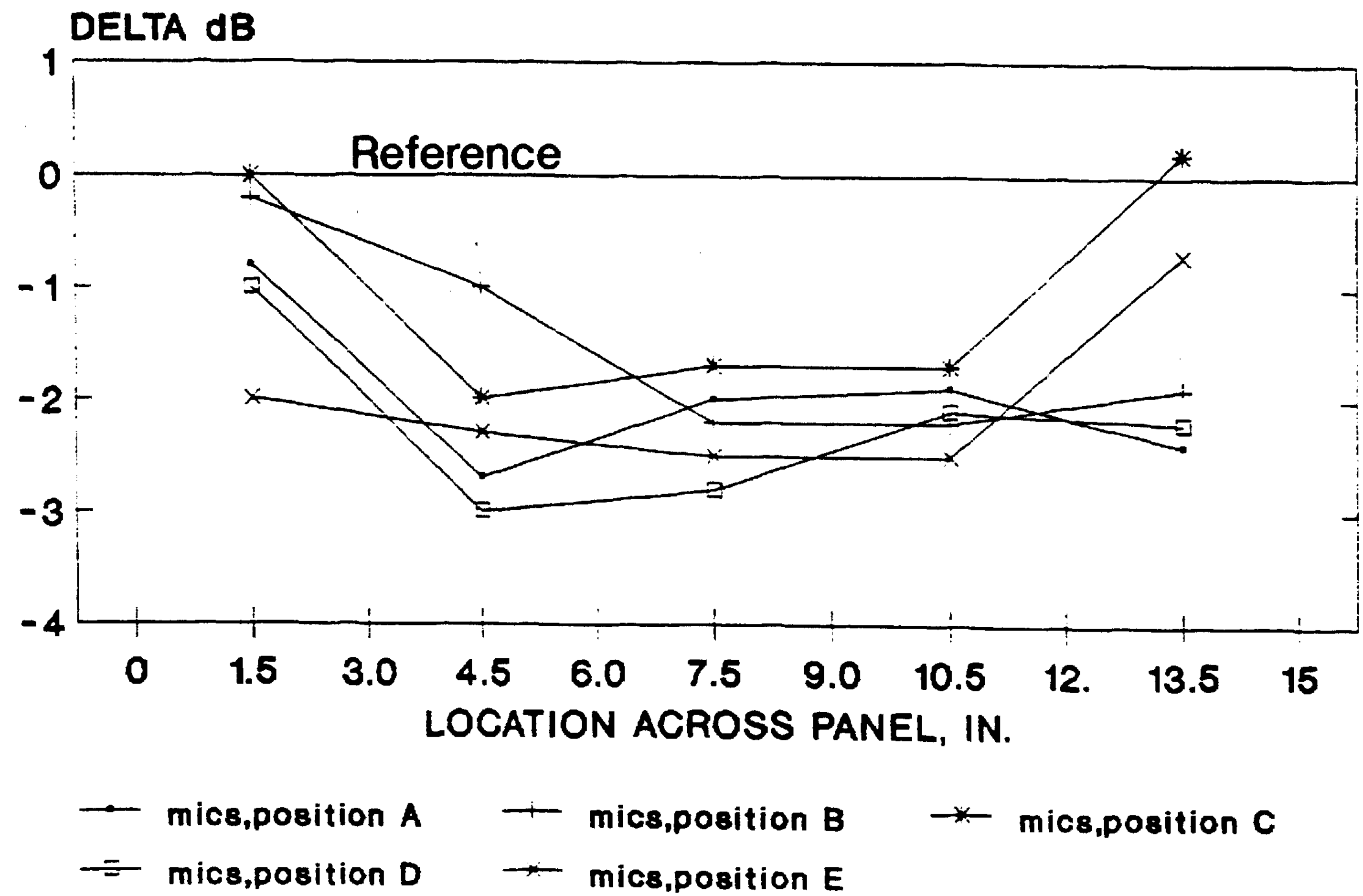

Figure 12.- Variation in sound pressure level on 11-in x 15-in panel. Reference microphone 4.5 inches ahead of leading edge. Reference level ~130 dB OASPL.

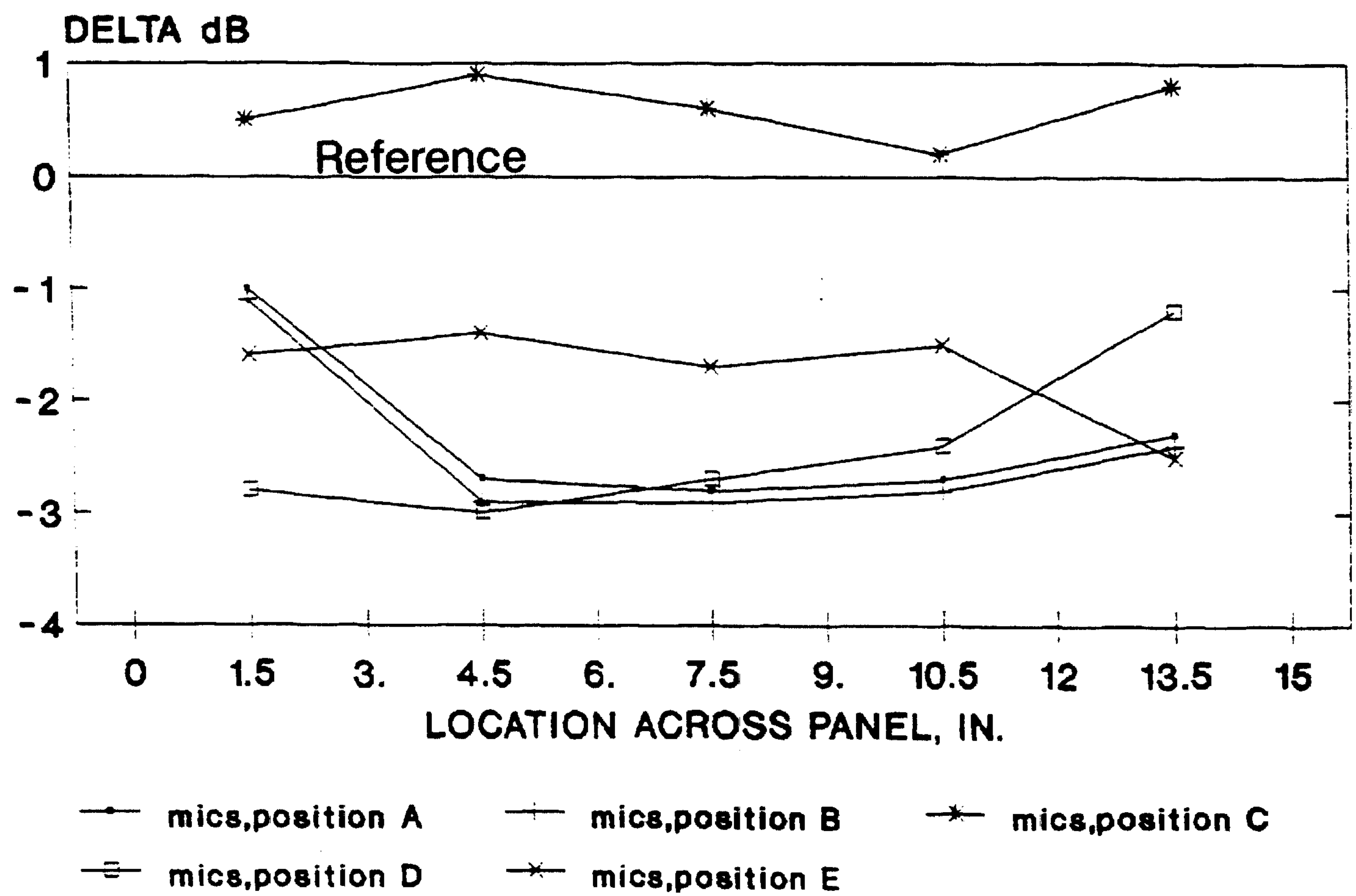

Figure 13.- Variation in sound pressure level on 11-in x 15-in panel. Reference microphone 4.5 inches ahead of leading edge. Reference level ~140 dB OASPL.

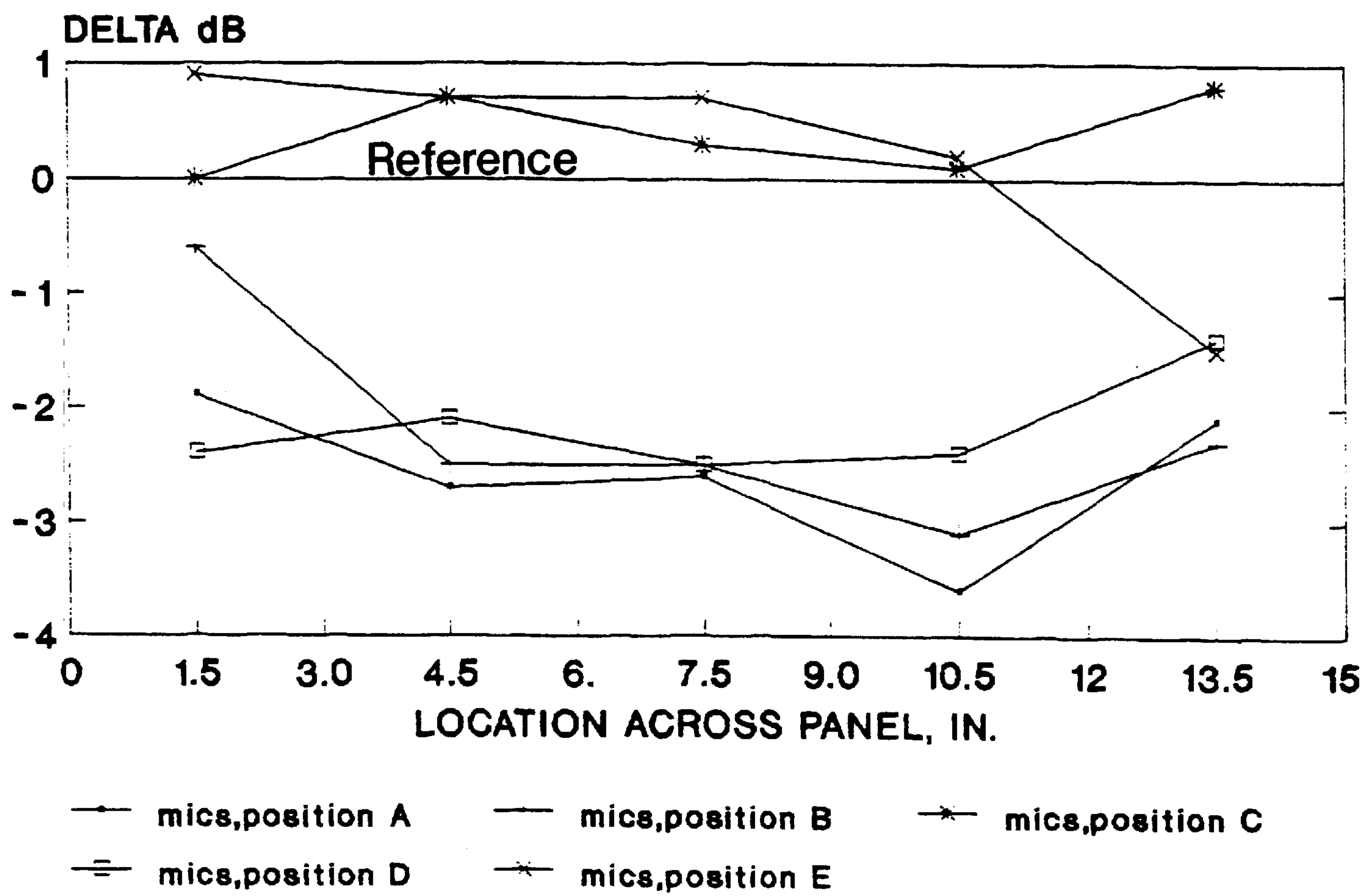

Figure 14.- Variation in sound pressure level on 11-in x 15-in panel. Reference microphone 4.5 inches ahead of leading edge. Reference level ~150 dB OASPL.

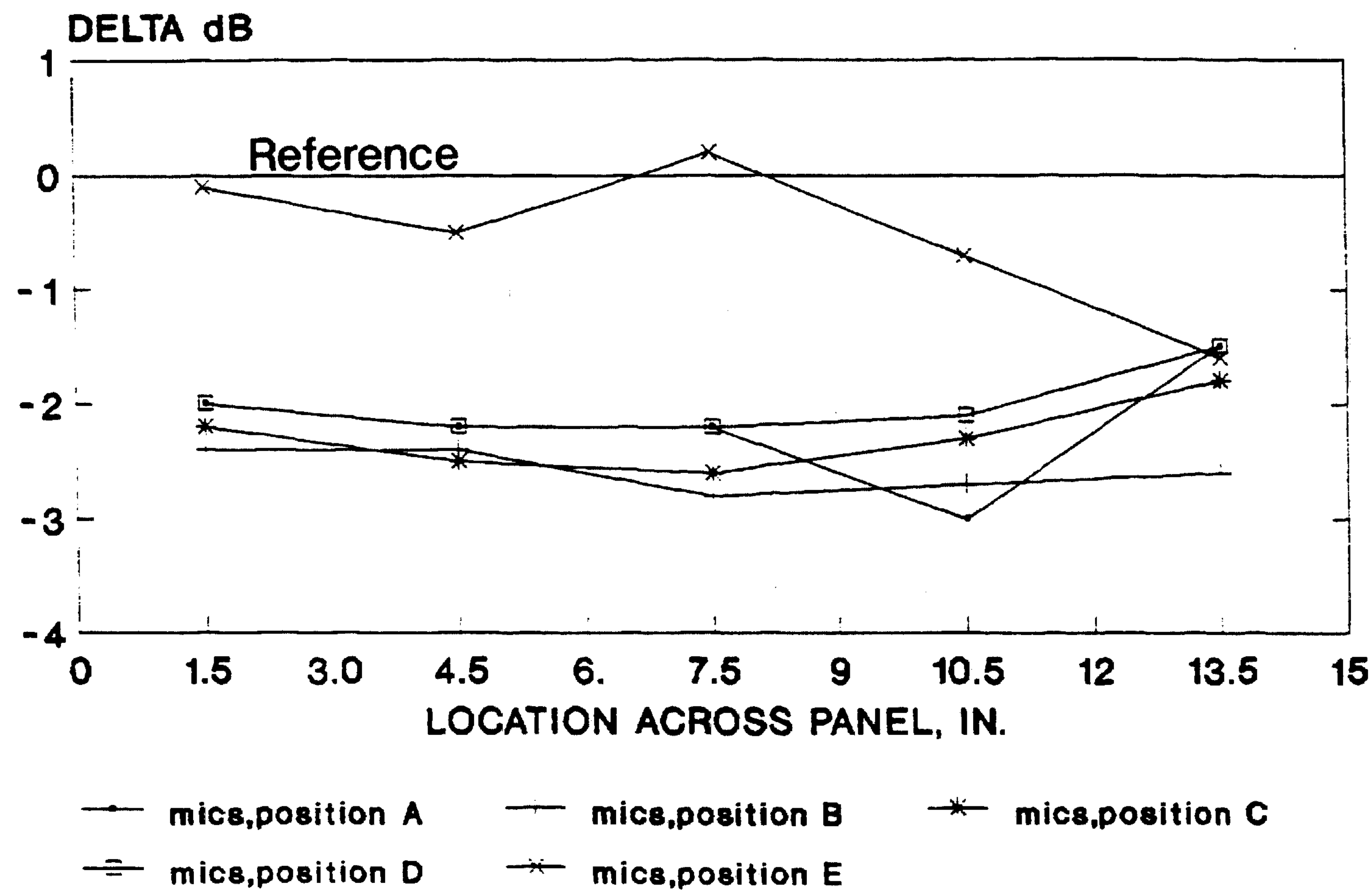

Figure 15.- Variation in sound pressure level on 11-in x 15-in panel. Reference microphone 4.5 inches ahead of leading edge. Reference level ~160 dB OASPL.

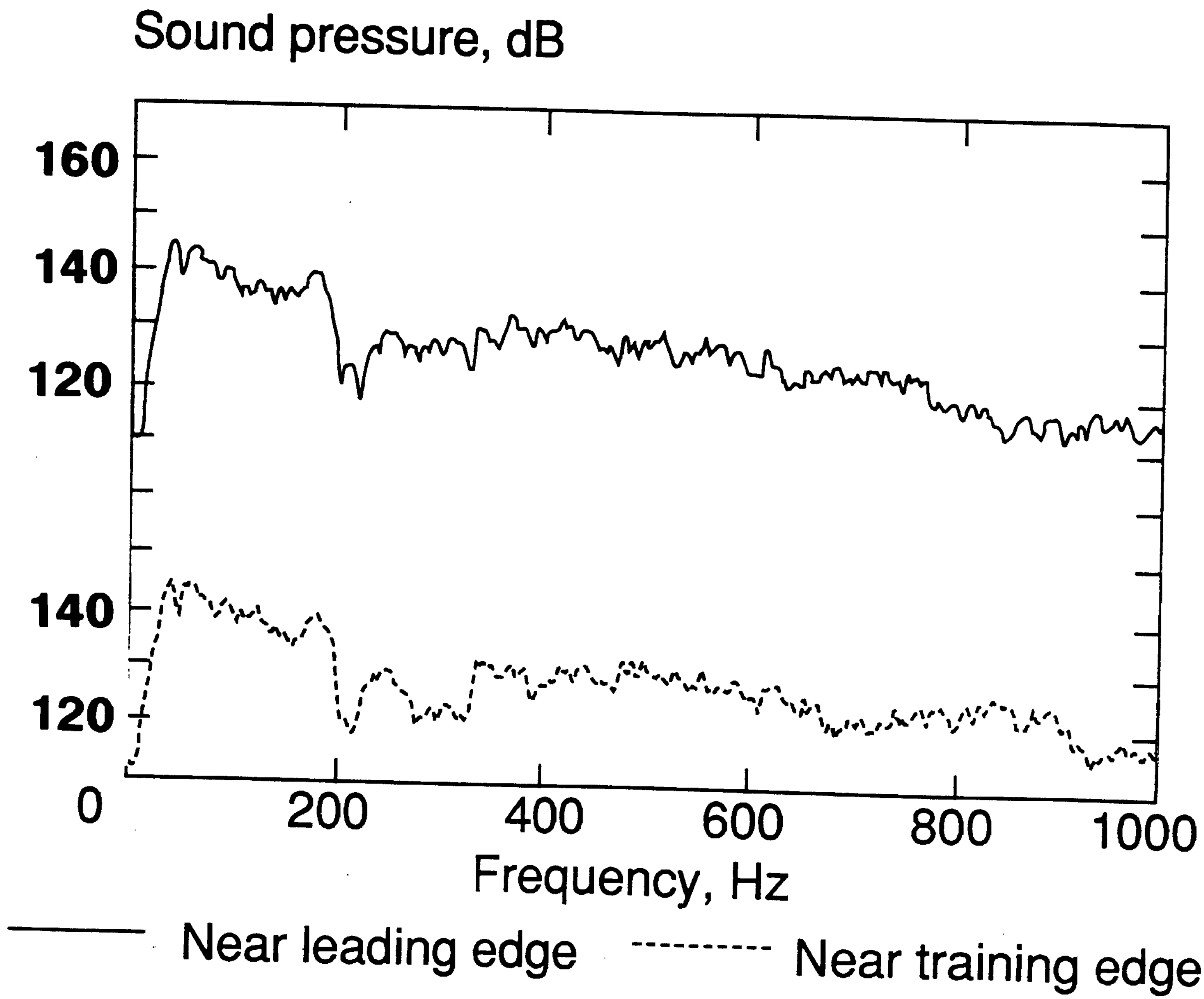

Figure 16.- Power spectral density of sound level for the leading and trailing edge microphones at position C, ~160 dB OASPL.

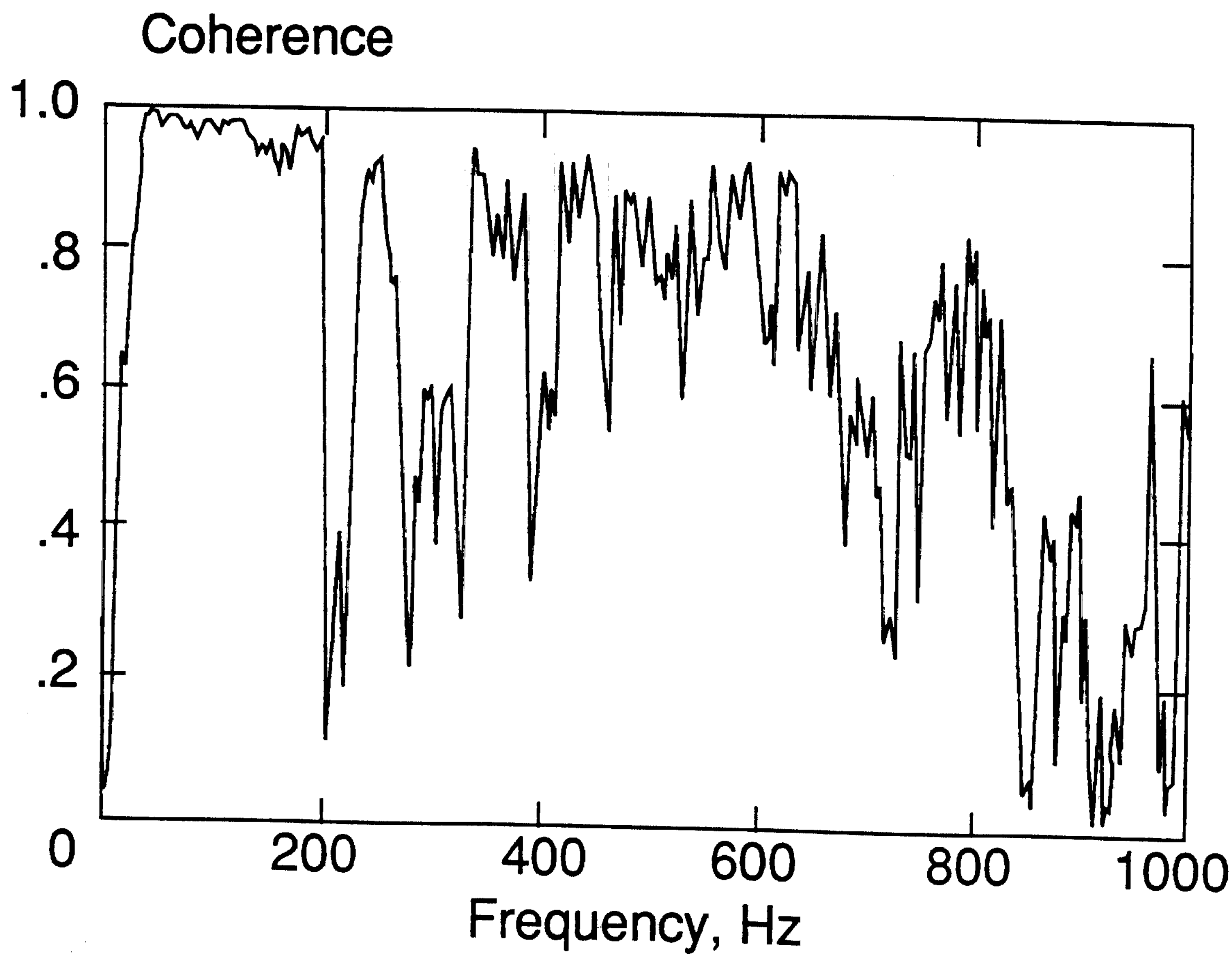

Figure 17.- Coherence in sound level for the leading and trailing edge microphones at position C, ~160 dB OASPL.

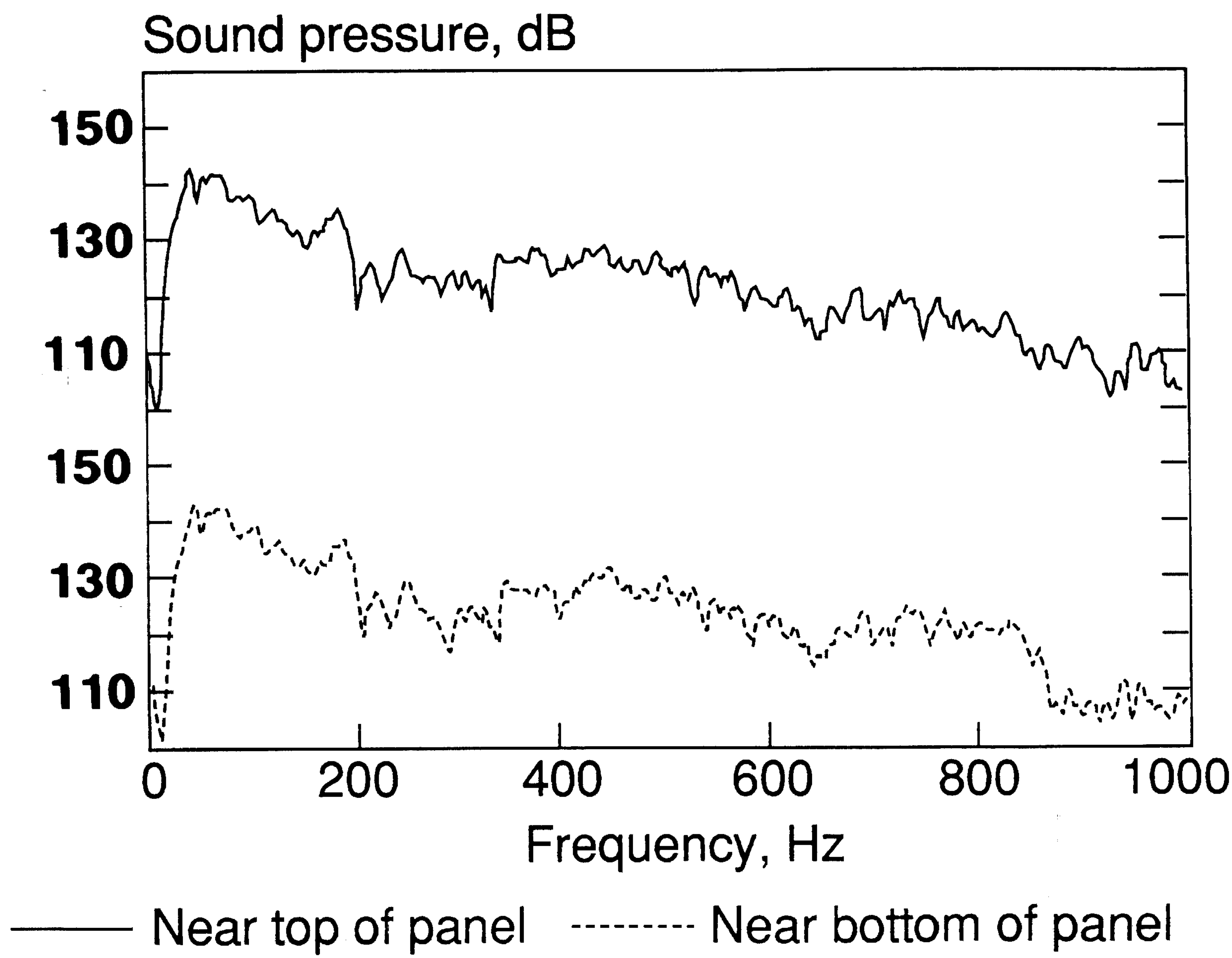

Figure 18.- Power spectral density of sound level for the top-and-bottom microphones at midspan, ~160 dB OASPL.

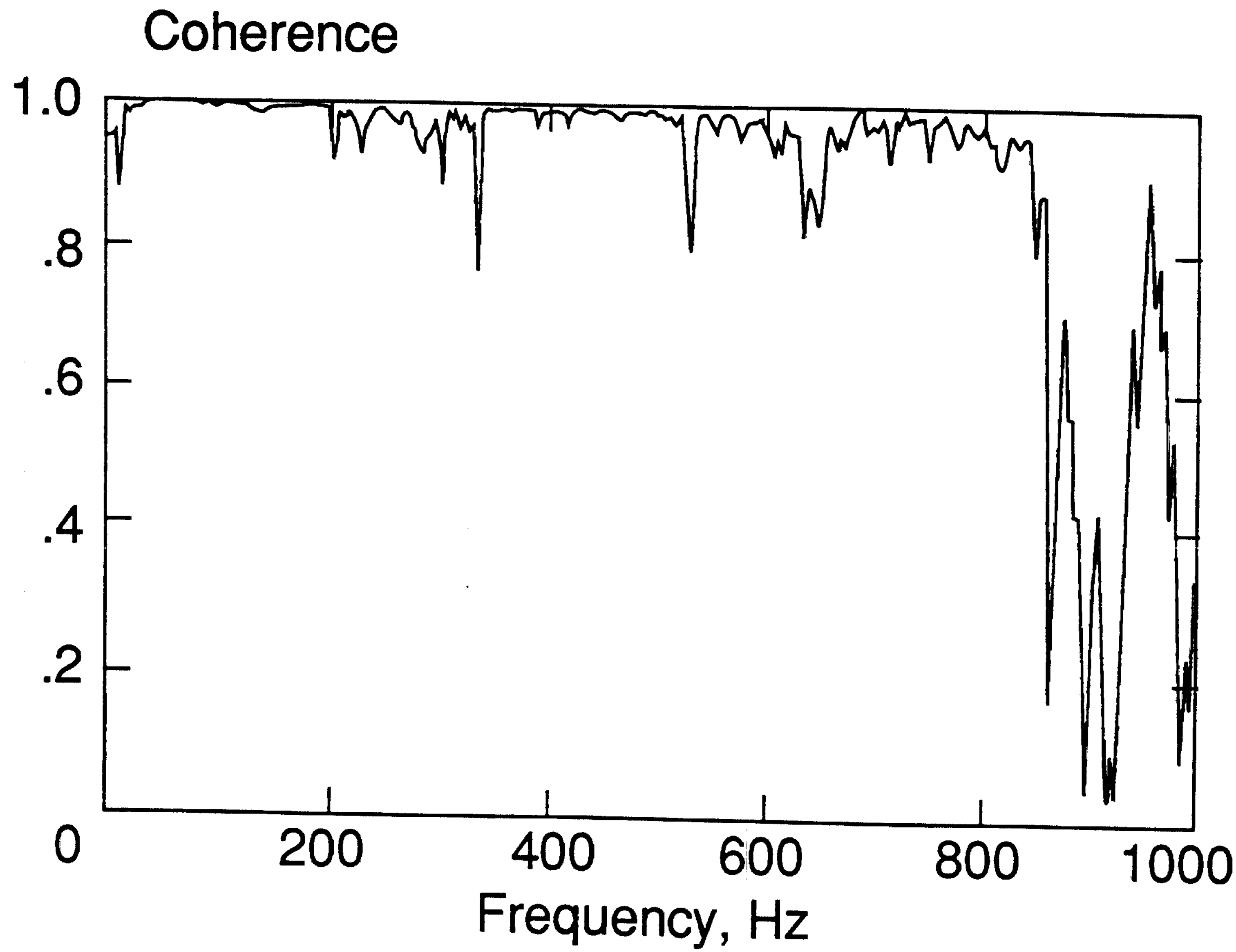

Figure 19.- Coherence in sound level for the top and bottom microphones at midspan, ~160 dB OASPL.

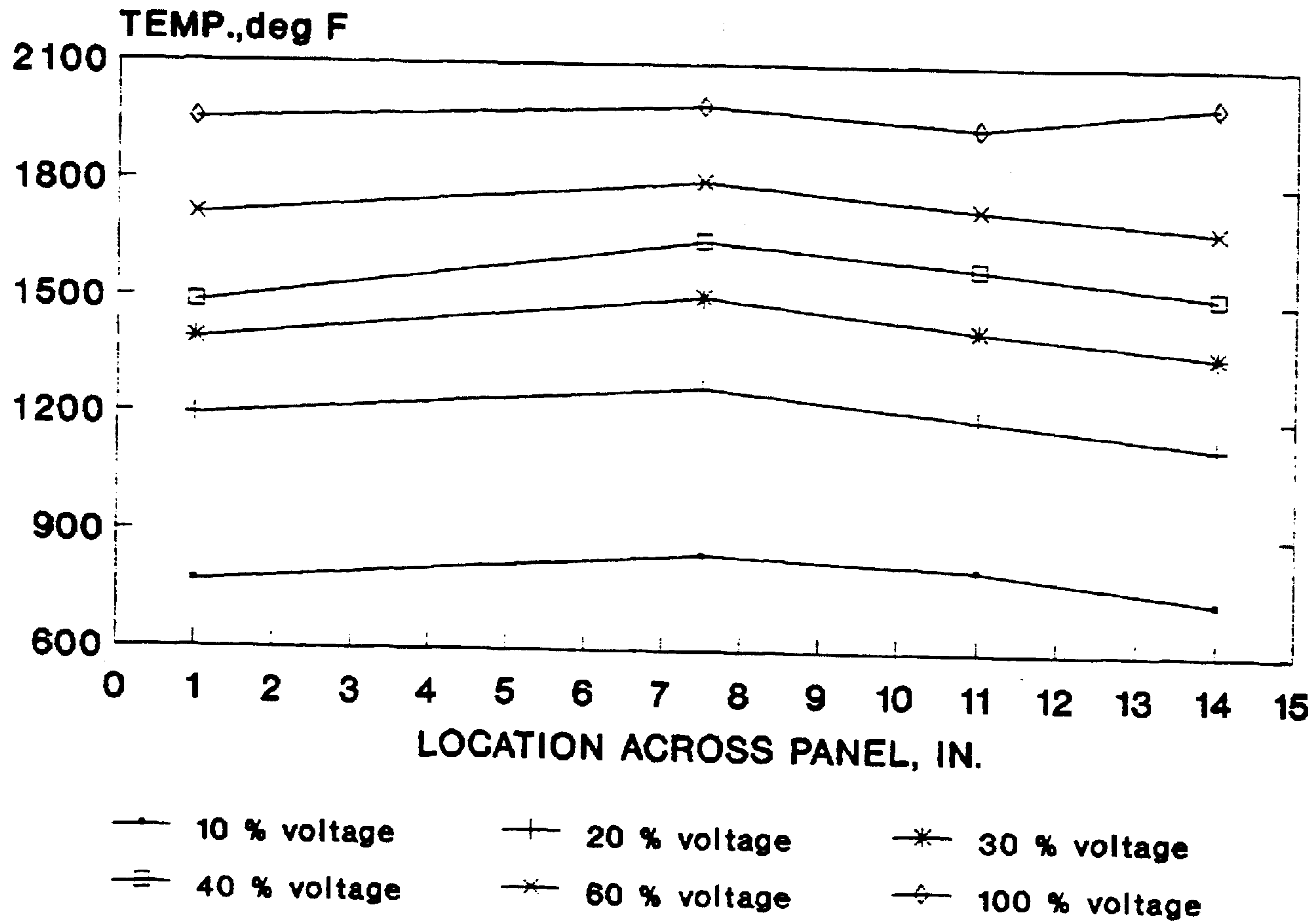

Figure 20.- Temperatures along the centerline of the 0.090-inch steel panel at various heating levels, ~160 dB OASPL.

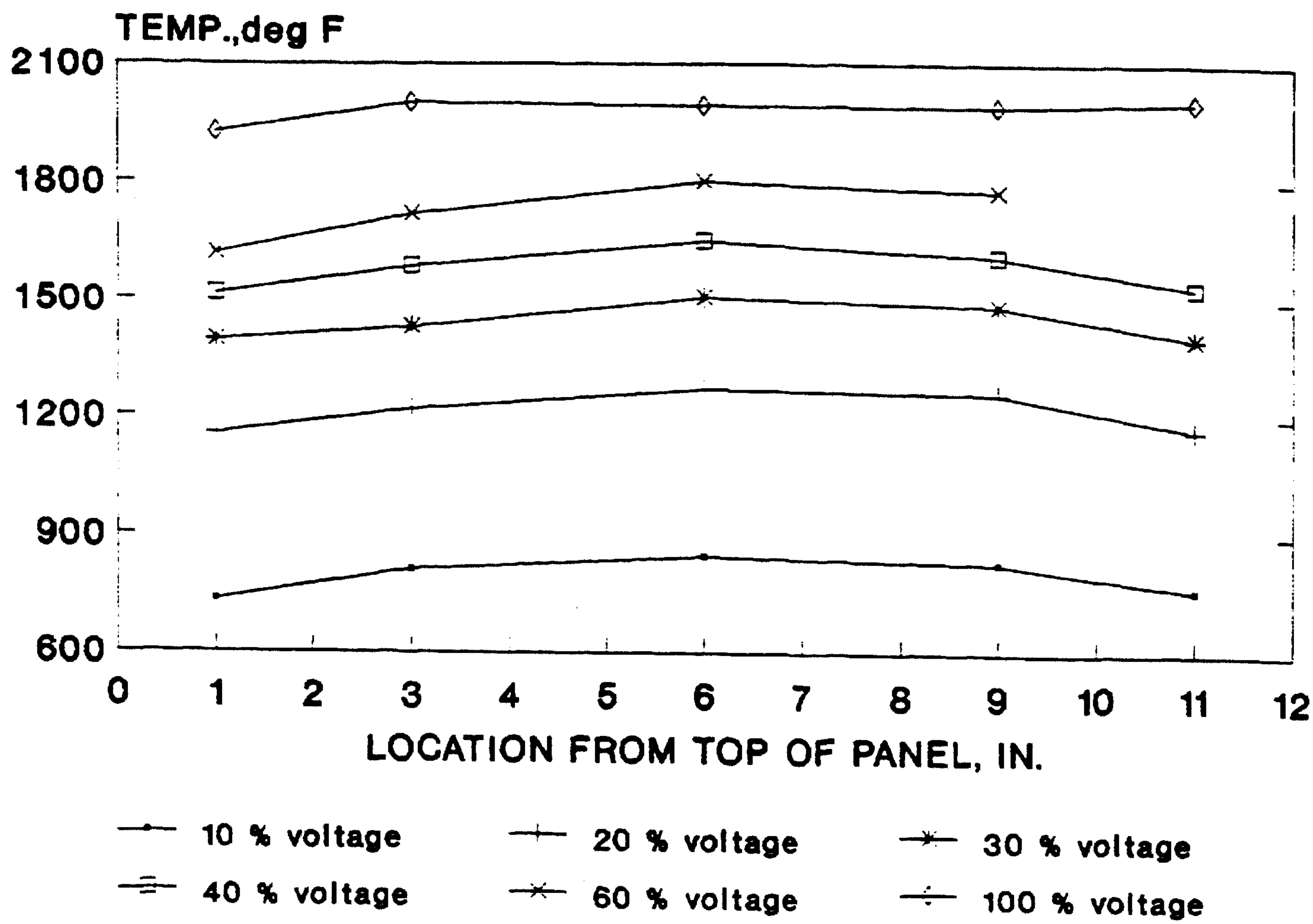

Figure 21.- Temperatures from top to bottom of the 0.090-inch steel panel at midspan at various heating levels, ~160 dB OASPL.

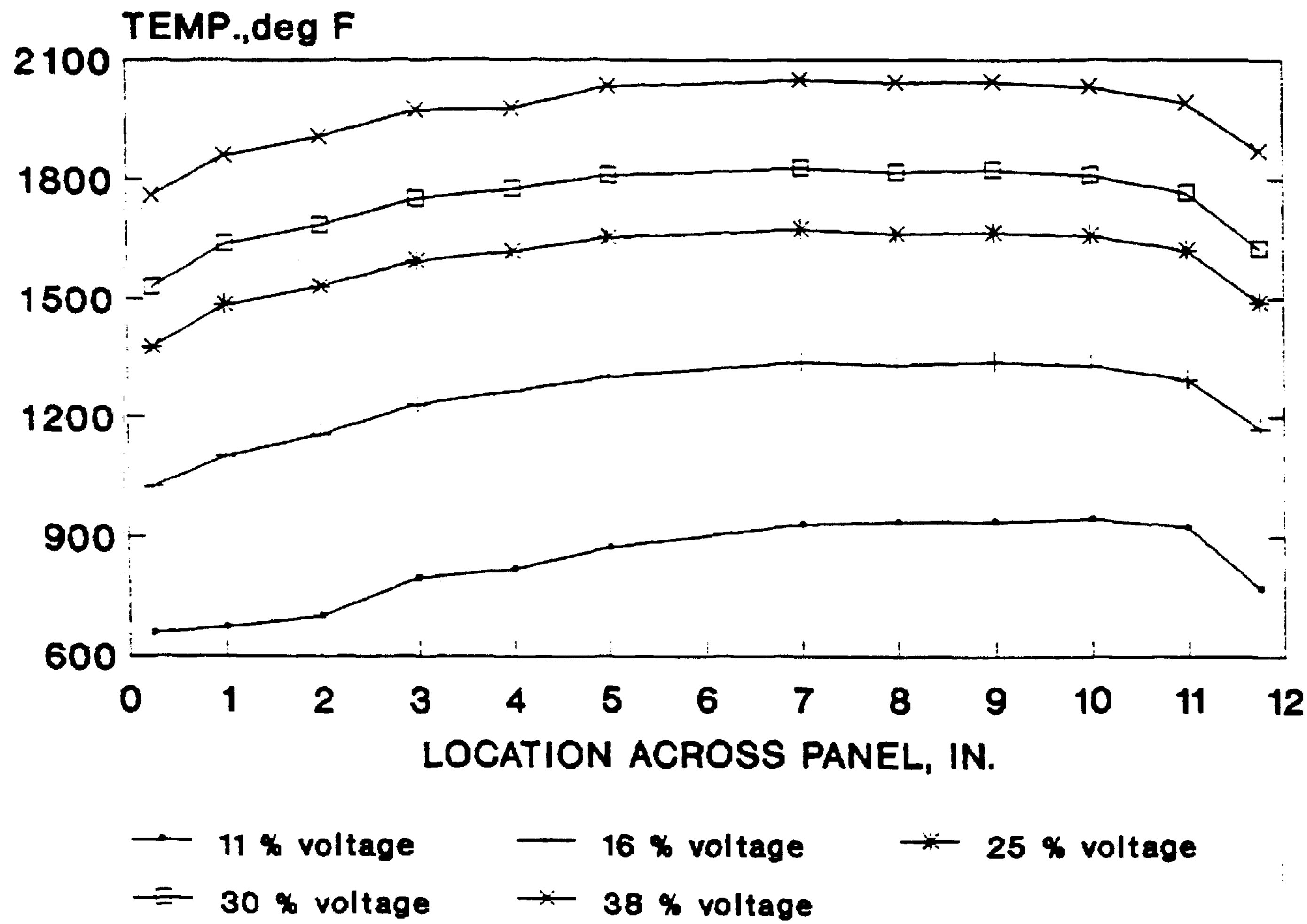

Figure 22.- Temperatures along the centerline of the insulated panel at various heating levels, ~125 dB OASPL.

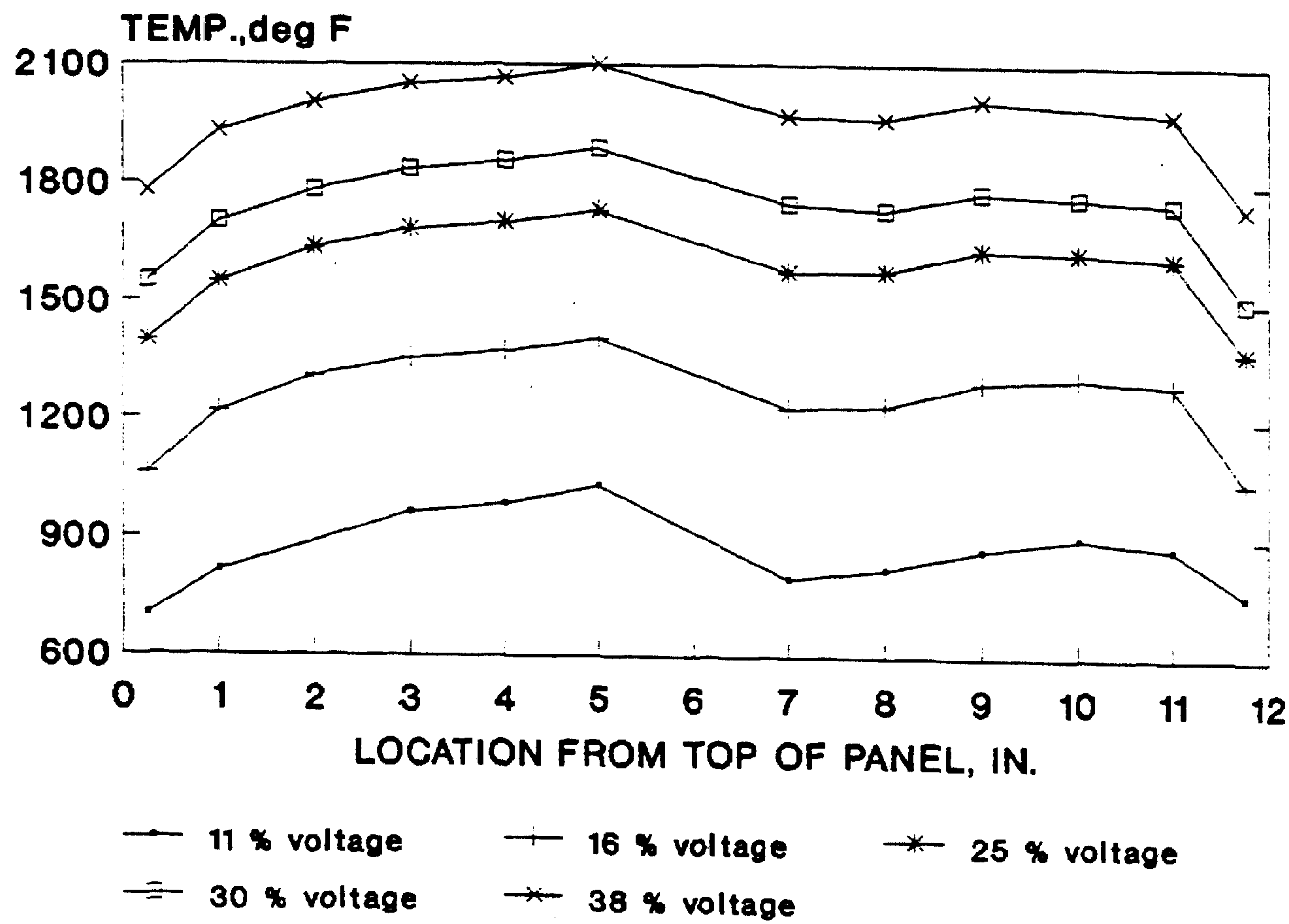

Figure 23.- Temperatures from top to bottom of the insulated panel at midspan at various heating conditions, ~125 dB OASPL.

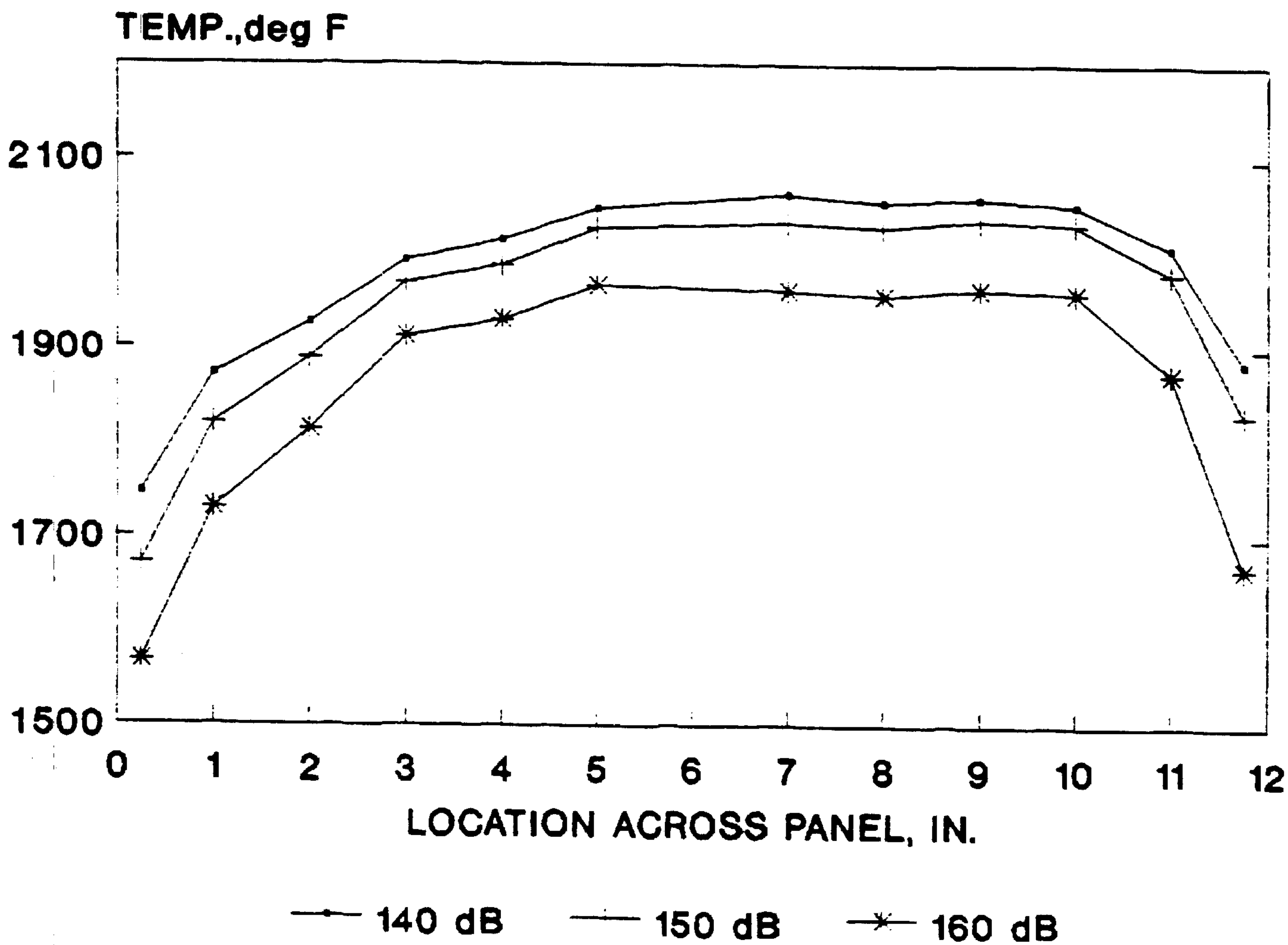

Figure 24.- Temperatures along the center line of the insulated panel for various OASPL at constant voltage of 42 percent.

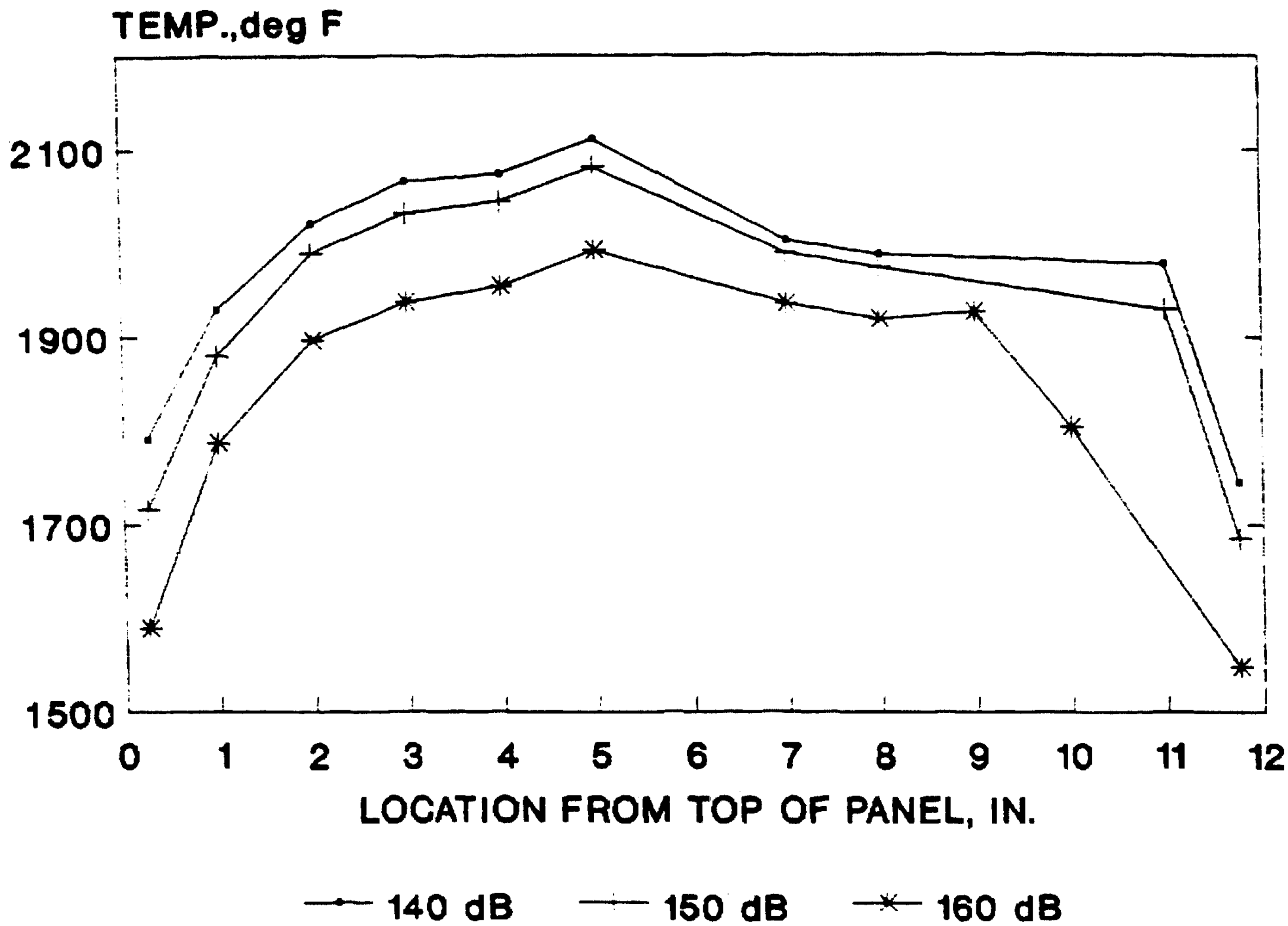

Figure 25.- Temperatures from top to bottom of the insulated panel at midspan for various OASPL at constant voltage of 42 percent.

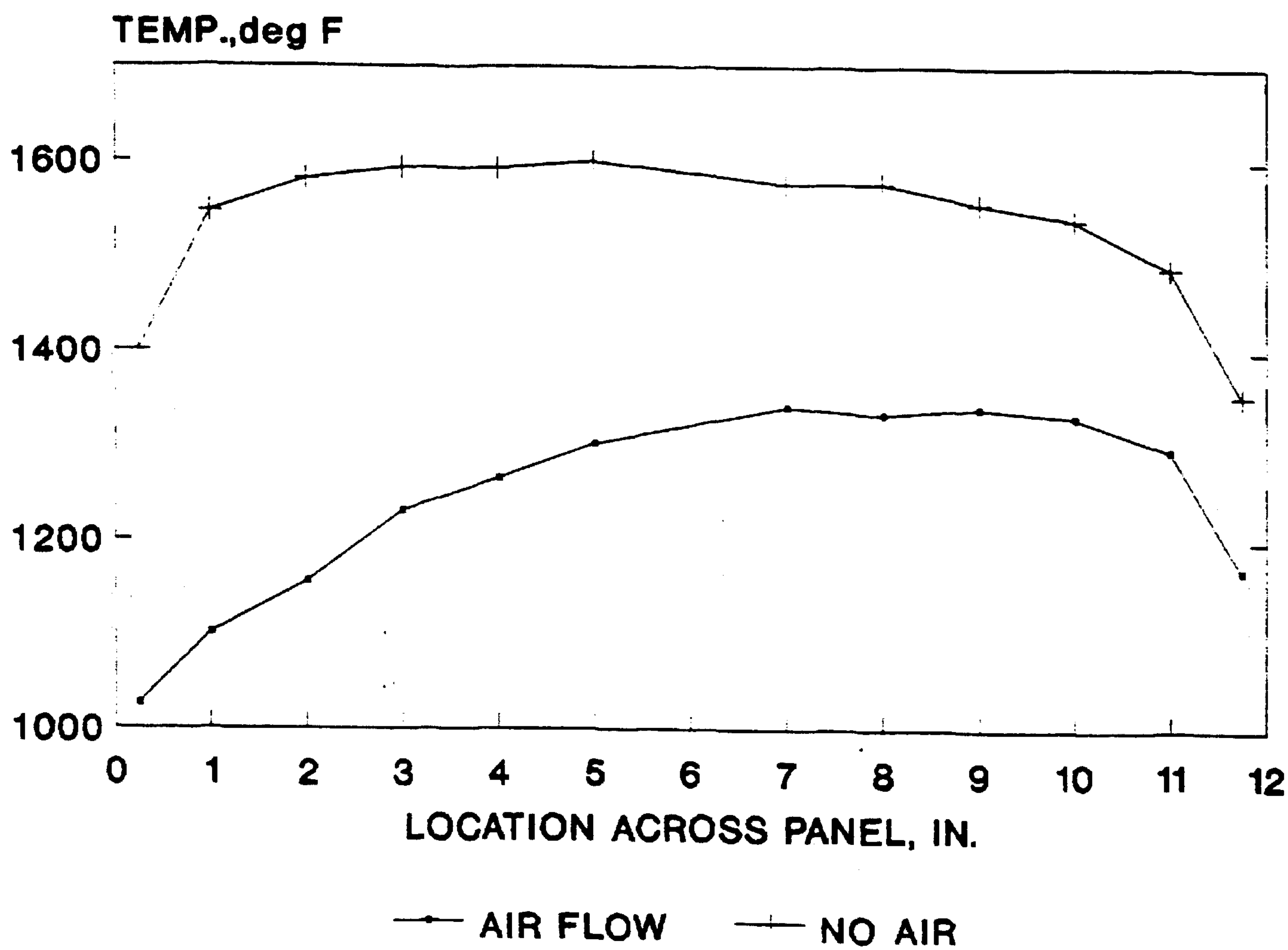

Figure 26.—Effect of air flow on the insulated panel temperatures across the panel at constant voltage of 16 percent.

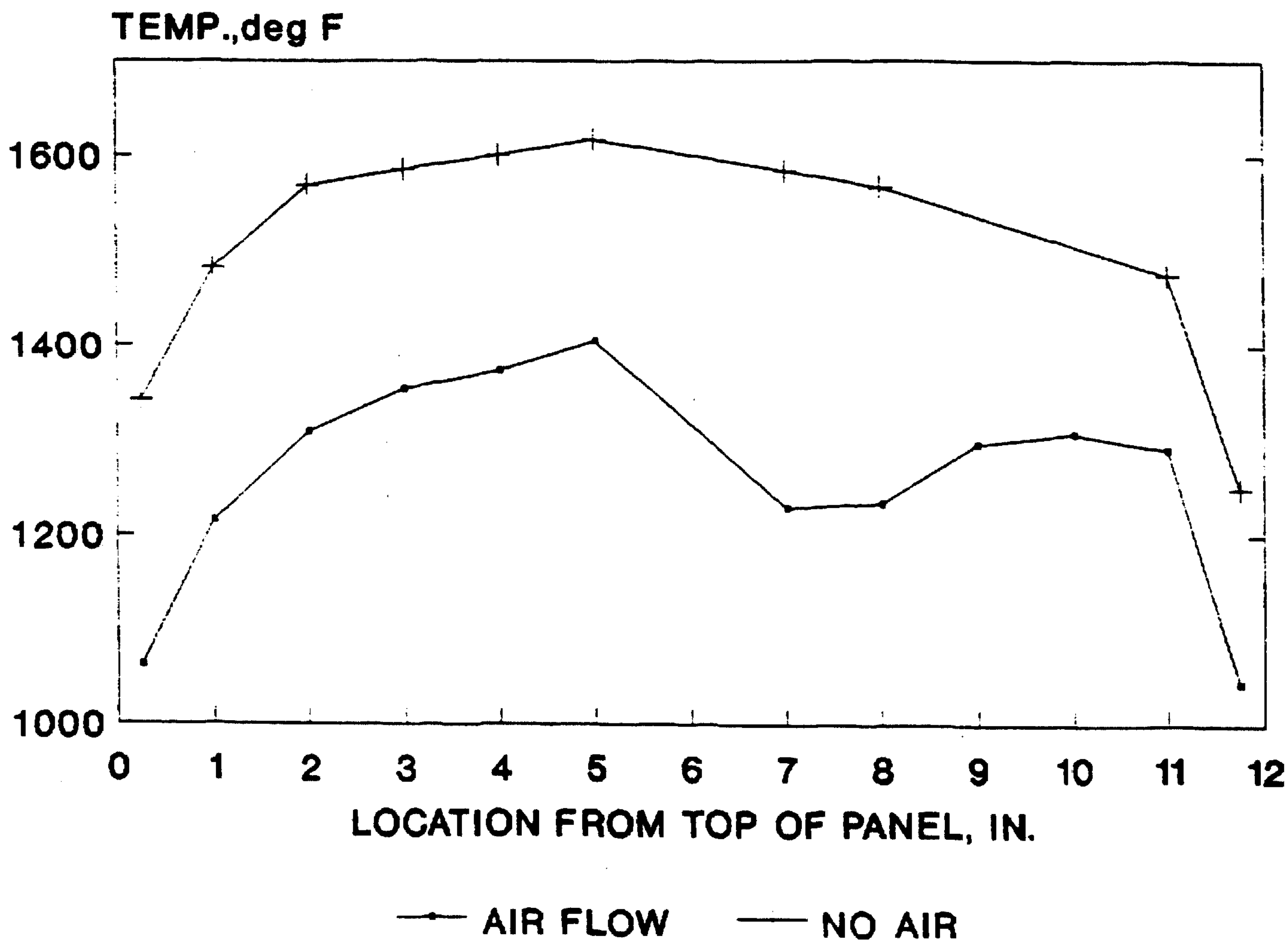

Figure 27.—Effect of air flow on the insulated panel temperatures from top to bottom of the panel at constant voltage of 16 percent.

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The Thermal Acoustic Fatigue Apparatus (TAFA) is a facility for applying intense noise and heat to small test panels. Modifications to TAFA have increased the heating capability to 44 BTU/ft-sec, making it possible to heat test panels to 2000°F and concurrently apply 168 dB of noise. Results of acoustic and thermal surveys were shown. Two test items, a 0.09-inch steel panel and an insulated panel, were used in the thermal survey.

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