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NOISE MEASUREMENTS FOR A TWIN-ENGINE COMMERCIAL JET AIRCRAFT DURING 3° APPROACHES AND LEVEL FLYOVERS

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16. Abstract

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Extended center-line noise determined during the 3° approaches with 40° flaps showed that the maximum reference A-weighted sound pressure level $(L_{A,max})_{ref}$ varied from 100.0 A-weighted decibels at 2.01 km (1.08 n. mi.) from the threshold to 87.4 dB(A) at 6.12 km (3.30 n. mi.) from the threshold. These test values were about 3 dB(A) higher than estimates used for comparison. The test data along the extended center line during approaches with 30° flaps were 1 dB(A) lower than those for approaches with 40° flaps.

Flight-test data correlating $(L_{A,max})_{ref}$ with thrust at altitudes of 122 m (400 ft) and 610 m (2000 ft) were in agreement with reference data used for comparison.

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SUMMARY

Noise measurements have been made with a twin-engine commercial jet aircraft making 3° approaches and level flyovers. The flight-test data showed that, in the standard 3° approach configuration with 40° flaps, effective perceived noise level (EPNL) had a value of 109.5 effective perceived noise decibels (EPNdB). This result was in agreement with unpublished data obtained with the same type of aircraft during noise certification tests; the 3° approaches made with 30° flaps and slightly reduced thrust reduced the EPNL value by 1 EPNdB.

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Flight-test data correlating $\left(L_{A,max}\right)_{ref}$ with thrust at altitudes of 122 m (400 ft) and 610 m (2000 ft) were in agreement with reference data used for comparison.

INTRODUCTION

One of the broad objectives of the NASA terminal configuration vehicle (TCV) program is to reduce terminal area noise by operational procedures. In order to accomplish this and other program objectives, NASA has recently acquired a short- to medium-range jet aircraft. The aircraft is equipped with advanced avionics equipment and a research cockpit located in the passenger compartment of the aircraft. Additional details of the experimental systems of the test aircraft are given in reference 1.

This aircraft has been utilized in a series of noise tests conducted by the Langley Research Center (LRC) at the Wallops Flight Center (WFC). This report presents the results of three flight tests using 3° approach paths and the results of a fourth flight test where level flyovers were made. (Part of these data have been presented in ref. 2.) The purpose of the 3° approach tests (made with landing flaps at 30° and 40°) was to define the noise for conventional approaches so that experimental approach path noise data may be compared with it. The level flyover test was made to obtain noise-thrust-altitude correlations for use in developing improved aircraft noise-prediction methods.

In addition to these noise test results, this report presents detailed descriptions of the test techniques, supporting instrumentation systems, and data reduction methods employed in the experiments.

SYMBOLS AND ABBREVIATIONS

Values are given both in the SI and in the U.S. Customary Units. The measurements and calculations were made in U.S. Customary Units.

EPNL	effective perceived noise level, EPNdB
EPR	engine pressure ratio
F_n	net thrust, newtons
GMT	Greenwich mean time
KIAS	knots indicated airspeed
L_A	A-weighted sound pressure level, dB(A) (ref. 20 μPa)
T	temperature, kelvin
t	time, seconds
V_C	cross-wind velocity, knots
V_S	stall speed, knots
V_W	wind velocity, knots

x	longitudinal distance from reference point
y	lateral distance from extended center line
z	vertical distance above reference point
δ	atmospheric pressure ratio
δ_f	flap deflection, degrees

Subscripts:

max	maximum value
test	data not corrected to reference conditions
ref	data corrected to reference conditions

DESCRIPTION OF THE AIRCRAFT AND DATA SYSTEMS

Aircraft

The aircraft used in the noise level tests is a twin-engine jet transport. (See fig. 1.) Equipped with triple-slotted trailing-edge flaps, leading-edge slots, and Kruger leading-edge flaps, the aircraft was designed for short-haul operations to small airports with short runways. Longitudinal control and trim are achieved by the elevator and movable stabilizer, respectively, whereas lateral control is obtained by a combination of ailerons and spoilers. (The spoilers can also function as speed brakes when so selected by the pilot.) A single-surface rudder provides directional control of the aircraft. Aircraft dimensions and design data are presented in both table I and figure 2. The noise data used for comparison were obtained from tests with an aircraft that was 1.93 m (6.3 ft) longer than the test aircraft. Except for this difference in fuselage length, both aircraft were identical and had JT8D-7 engines.

Data Systems

The performance of these noise experiments involved a number of different data systems that are described herein. The systems include noise measurements, meteorological measurements, aircraft position measurements, and aircraft performance parameter measurements.

Noise measurement system.- The noise measurement system used for these tests is described in appendix A. Briefly, it consisted of 1.27-cm (1/2-in.) condenser-type pressure microphones, cables, signal conditioning equipment, and the recording equipment needed to obtain noise data in accordance with appendixes A, B, and C of reference 3. At the beginning and end of each test day, this system was calibrated according to the procedure outlined in the field system calibration section of appendix A.

Measurements for the three 3° approach flights were made with microphones located at various sites along the extended runway center line as shown in figure 3. The microphones were mounted 1.2 m (4 ft) above ground level with their longitudinal axis parallel to the ground and perpendicular to the vertical projection of the aircraft flight path. The microphone locations were determined by survey. Figure 4 is a photograph of a typical noise site (site 1). The mobile van containing the recording equipment is in the foreground. The microphone was located in the open field in the center of the photograph. The other three sites were in open fields well away from roads. During one approach flight (R-060), no data were taken at station 2. For the level flyovers, a microphone was located near the threshold of runway 35 as shown in figure 5. This site is designated station 5 in this report.

Meteorological measurement system.- The meteorological site for the level flyover flight (R-020) and for the first 3° approach flight (R-019) was located near the end of WFC runway 10 as shown in figure 5. A photograph of this site is shown in figure 6. The facilities at this site included the following:

(1) A hygrothermograph which measured and recorded surface temperature and relative humidity, and a microbarograph which measured the atmospheric pressure. These instruments were located in the shelter shown in the center of figure 6.

(2) An anemometer (left center, fig. 6), located 10 m (32 ft) above ground level, which measured wind direction and wind velocity.

(3) Radiosondes which measured relative humidity and temperature through the test altitude range. The sonde release site was located about 100 m (320 ft) northeast of the anemometer location (right background, fig. 6).

(4) Theodolites which measured the position of the radiosondes during ascent.

"Temperature" sondes and "humidity" sondes were alternately released at 30-min intervals during the flight testing. Sonde, anemometer, and theodolite data were recorded in the mobile van (right center, fig. 6). The theodolite data were used later to determine wind velocity and direction in the test altitude range. During approach flights R-060 and R-061, the instrumentation was moved closer to the test runway threshold, as shown in figure 5.

During the first two flights (R-019 and R-020), the meteorological surface data were monitored in the WFC meteorological office; however, during the later flights (R-060 and R-061), all meteorological data, including conditions aloft, were monitored at the meteorological site. Surface conditions recorded routinely at the WFC weather station provided a backup source of data for all the flights.

Aircraft position measurements system.- Aircraft position data during flights R-019 and R-020 were determined by an AN/FPQ-6 radar located about 11.1 km (6 n. mi.) south of the airfield. These data were recorded on tape and were also displayed and monitored in real time at the WFC range control center. During flights R-060 and R-061, an AN/FPS-16 radar located on the airfield (fig. 5) was used to obtain position data. These data were monitored in real time in the WFC radar complex control center. Table II presents some pertinent specifications for these two radar systems.

After each flight, the radar types were processed to provide x, y, and z position data at 0.5-sec intervals. For all the 3° approach flights, the position data were referenced to the extended center line and to a projected touchdown point 305 m (1000 ft) from the runway threshold. For level flyovers, the position data were referenced to the noise site location at the runway threshold center line.

Aircraft performance measurements.- The aircraft parameters of primary interest in these tests were engine pressure ratio (related to net thrust), airspeed, flap deflection, landing gear position, and aircraft weight. During the 3° approaches, all these parameters except weight were recorded onboard on a wide-band magnetic tape recorder. Other data that were also recorded during the approaches include:

Total air temperature	Pitch rate
Airspeed	Roll rate
Radar altitude	Yaw rate
Flap position	Rudder position
Gear position	Aileron position
Speed brake position	Spoiler position
Engine pressure ratio	Stabilizer position
Throttle position	Elevator position
Angle of attack	Pedal position
Pitch attitude	Control column force
Yaw attitude	Control wheel force
Roll attitude	

Correlation of these data with ground measurements was provided by an onboard time code generator that was synchronized with WFC range time at the start of the tests. An onboard observer determined aircraft weight by adding the fuel weight from the fuel quantity gages to the weight of the aircraft without fuel.

During the level flyovers the onboard recording system was inoperative. For these tests, the onboard observer recorded values of engine pressure ratio from the engine pressure ratio (EPR) gage, and checked airspeed, flap, and gear indicator values specified in the Plan of Test prior to each run. Weight values were determined in the same manner as in the approaches.

TEST PROCEDURES AND CONDITIONS

Test Procedures

The basic test procedure used for the 3° approach flights was to have the test aircraft make a series of runs (using ground-generated guidance) over the noise range shown in figure 3. Center-line noise, meteorological position, and aircraft performance were recorded during each run. The approach runs were made with landing gear and leading-edge slats extended, and with landing flaps at 30° and 40°.

Table III(a) presents both the nominal approach speed and test weight for the runs at the two different flap settings and the nominal heights that were recorded directly over each measuring station. In order to allow operational flexibility and still provide reasonable weight consistency between runs, variations of ±1361 kg (±3000 lb) from the nominal test weight value were allowed.

The approach guidance system is shown schematically in figure 7. Aircraft position data from radar were recorded during each approach run and were compared with the desired coordinates of the flight path by use of a computer. Glide-slope and localizer deviations were computed and transmitted to the test aircraft in real time. This information was displayed in standard format on the aircraft's Flight Director system.

Figure 8 shows the localizer and glide-slope geometry used in the computer program. The nominal altitudes above the four measuring stations are shown in table III(a).

For the 3° approach flight runs, the glide slope was generally intercepted about 18.52 km (10 n. mi.) from the threshold. Once the glide slope was intercepted, the pilot then established the desired configuration and selected EPR settings (related to net thrust, F_n) for the nominal approach speed. These conditions were stabilized 9.7 km (5 n. mi.) from the threshold. At that point, data recorders were turned on and engine pressure ratio, net thrust, and the configuration remained constant until the runway threshold was reached. Once runway threshold was reached, the runs were broken off. Control of approach speed during this stabilized period was provided by speed brakes. All runs with

40^o flaps were made at the same EPR, and all runs with 30^o flaps were made with a constant, but slightly lower, EPR setting.

As shown in table III(b), the level flyover flight (R-020) consisted of five different combinations of net thrust and altitude. To maintain the nominal airspeed for these combinations, various flap and landing-gear positions were used. These are also noted in table III(b). Each combination was repeated three times. Control of aircraft weight was maintained by making fuel stops, as was also done during the 3^o approaches.

Since the microphones for the level flyovers were located at the threshold of runway 35, the flight procedure used for these runs was to have the aircraft approach the threshold, hold the desired altitude until approximately 1.85 km (1 n. mi.) past station 5, and then break off the run. Although guidance was not used in this flight, the real-time aircraft position data from radar were used to voice vector the aircraft onto and along the proper flight path until the runway was in sight. The flight-test conditions were usually established at least 5.5 km (3 n. mi.) from the station. In order to minimize changes in airspeed, the speed brakes were deployed as was done during the 3^o approach flights.

The meteorological noise testing criteria of reference 3 were used as guidelines for all these tests. These conditions are listed in table III(c).

Test Conditions

The actual test conditions for the three 3^o approach flights are shown in table IV. The meteorological conditions are given at the time that the test aircraft was over station 1. Approach speed, thrust level, and weight are averaged values for the portion of each run between stations 4 and 1; these parameters were relatively consistent for each run between the two stations. The altitude data in table IV are from radar and are given at the time the aircraft was directly over each measuring station.

Data in table IV also show that all the meteorological test conditions were within the specifications of reference 3 except for the 1-knot excess cross winds on three runs during flight R-019 (table IV(a), runs 2.1.1.1, 2.1.2.1, and 2.1.2.3). The approach speeds, while relatively consistent between runs, were usually somewhat slower than the nominal values for both the 30^o and 40^o flap settings. The thrust levels for approaches with 30^o flaps were also lower than those with 40^o flaps. By refueling, test weights were maintained between 38 056 kg (83 900 lb) and 40 804 kg (89 959 lb).

The measured altitude data in table IV show that for the runs in flight R-019 (table IV(a)), the aircraft position data were slightly lower than the nominal value at the downrange stations. For the runs in flights R-060 and R-061 (tables IV(b) and IV(c)), however, the aircraft position was slightly higher than the nominal value at all the stations. It should be emphasized, however, that the deviations were never very large, and a band about ±15 m (±49 ft) above and below the nominal track would encompass virtually all the position data in table IV. The procedure for correcting the noise data for these deviations is discussed in a later section of this report.

Table V presents the actual test conditions for runs made during the level flyover flight. During the entire flight all the meteorological surface conditions (given at the time the test aircraft was over station 5) were within the test specifications of reference 3. Since airspeed and thrust data were not recorded onboard during this flight, the nominal values from table III are given for these parameters. The pilot and onboard observer noted that the actual airspeeds were within ±3 knots indicated airspeed of the nominal values on all level flyover runs. Estimates of thrust variations that were made from onboard observations of engine pressure ratio indicated that actual F_n/δ per engine values were within ±890 N (±200 lb) of the nominal values.

Values of relative humidity, temperature, and wind direction in the test altitude range were determined by radiosondes that were released during each flight. The only anomalous variation in any of these parameters was a mild temperature inversion that occurred during a portion of the level flyover flight. This is shown in figure 9 where the inversion is seen to have occurred between 20:30:XX GMT and 22:30:XX GMT. The data from the sonde released at 21:32:XX GMT show an increase in temperature of 1.5 K (2.3° F) at altitudes between about 160 m (525 ft) and 300 m (984 ft). Level flyover runs 1.1.4.1, 1.1.4.2, 1.1.4.3, and 1.1.5.3 were made at a nominal altitude of 610 m (2000 ft) during this period. This mild inversion, however, was found to have had no discernible effect on the noise measurements and is discussed in more detail in a later section of this report.

DATA ANALYSIS

Figure 10 schematically shows the basic elements in the acoustic data reduction system. The analog tapes from the recorder in the van were processed through the one-third-octave band analyzer (with reference to the microphone system calibration level) to yield digitized sound pressure levels in the one-third-octave bands between 25 Hz and 20 000 Hz with a resolution of 0.25 dB. These data, determined at 0.5-sec intervals, were then entered in the computer which corrected for system frequency response, amplifier dynamic response, microphone windscreen effects, and ambient noise levels. After these operations, the corrected one-third-octave band sound pressure levels were then reprocessed by the computer in order to obtain the desired noise parameters.

The noise data presented in this paper are in terms of L_A and EPNL. The method of reference 4 was used to calculate $(L_A)_{test}$ from the corrected spectra at 0.5-sec intervals. Values of $(L_{A,max})_{test}$ for each run were determined from the $(L_A)_{test}$ time histories.

In order to provide a direct comparison between the various data runs and to permit a direct comparison with other data, corrections were applied to normalize $(L_{A,max})_{test}$ to the reference atmospheric pressure and weight conditions given in table VI. This table also presents the reference conditions used in determining EPNL in accordance with the procedure of reference 3.

The procedure of reference 3 for correcting EPNL for attenuation and position errors was also used in correcting $(L_{A,max})_{test}$ data to $(L_{A,max})_{ref}$. In this case, however, the reference closest approach distances for the 3^o flights were taken as the nominal altitudes above the measuring stations (see table III(a)). The $(L_{A,max})_{test}$ data for the level flyovers were also corrected by using this method, except that the reference flight-path angle was taken as 0^o, and the reference closest approach distances were taken as 122 m (400 ft) for runs 1.1.1.1 to 1.1.3.3, and as 610 m (2000 ft) for runs 1.1.4.1 to 1.1.5.3.

These procedures for normalization of the parameters to reference attenuation and position conditions required accurate time correlation between recorded noise and position data. It was found that a time code error was present on the noise tapes from flight R-019. Consequently, EPNL and $(L_{A,max})_{ref}$ could not be determined from that flight. The $(L_{A,max})_{test}$ data, however, were not affected by this problem and these data are included in this report. Some estimated values of EPNL from this flight are given in reference 2.

The procedures and data used in making corrections for weight and velocity are given in reference 5.

RESULTS AND DISCUSSION

3^o Approaches

Figure 11 presents time histories of $(L_A)_{test}$ during a typical run (flight R-061, run 3.1.5) as determined from sound pressure level data recorded at stations 1 and 4. In this figure, the aircraft was directly over the stations at $t = 0$ sec.

The data in figure 11 show that the maximum value was recorded about 4 sec after the aircraft had passed station 4 and 2 sec after it had passed station 1. The duration of the noise peaks, based on the 10-dB down point, decreased from about 17 sec at station 4 to 6.5 sec at station 1. These characteristics are typical of other flight tests (refs. 6 and 7) with different types of commercial jet aircraft.

Figure 12 presents the spectral distribution for the two maximum values of $(L_A)_{test}$ in figure 11. These spectra are typical of the 3^o approaches at stations 1 and 4. The spectrum taken at station 1 shows considerable noise energy at high frequencies (about 2000 Hz) which is attributed to engine fans and compressor stages. The spectrum from station 4 shows reduced noise energy at all the frequency bands although reduction is most prominent at the high frequencies.

Table VII presents the results of the 3° approach flights with both 30° and 40° flap settings. Data at stations 3 and 4 for flight R-019, and some data from station 4 for flight R-061 are omitted pending further analysis. No data were taken at station 2 during flight R-060.

All the data in tables VII(b) and VII(c) show both good repeatability between runs and only small corrections from test to reference conditions. Since all the $\left(L_{A,max}\right)_{ref}$ and EPNL data in tables VII(b) and VII(c) were normalized to the same conditions, they were numerically averaged to determine the mean values given in table VIII.

Since station 2 was not used during flight R-060, there were only two 40° flap runs (runs 3.1.4, and 3.1.5 of flight R-061, see table VII(c)) from which to obtain averaged $\left(L_{A,max}\right)_{ref}$ data at this station. However, this was justifiable in this case since there was considerable agreement between the $\left(L_{A,max}\right)_{test}$ from flight R-061 and similar data from the 5 runs over that station in flight R-019. (See table VII(a).) Since the $\left(L_{A,max}\right)_{test}$ data at this station were consistent for 7 runs, and since the difference between $\left(L_{A,max}\right)_{test}$ and $\left(L_{A,max}\right)_{ref}$ was small for all the approach runs, the averaged value of $\left(L_{A,max}\right)_{ref}$ given in table VIII for station 2 is felt to be a reliable value even though the direct statistical sample is small. No data are given at station 2 for 30° flaps.

The summary data in table VIII show that the mean EPNL value for the 40° flap was 109.5 EPNdB. Unpublished noise data from certification tests of the same type of aircraft show a value of 107.9 EPNdB at the same reference conditions. This agreement is good if the possible differences in terrain where the measurements were made and the accumulated errors due to possible differences in measurement and data reduction techniques are considered.

The data in table VIII also show that the EPNL value for the flaps setting of 30° (slightly reduced F_n/δ) was 1.0 EPNdB less than the EPNL value for the 40° flaps.

The variation of $\left(L_{A,max}\right)_{ref}$ with distance from the threshold is shown in figure 13. Extended center-line flight data for 30° and 40° flaps (from table VIII) are shown, along with values estimated from data in reference 5. The data of reference 5 were gathered for the same type of aircraft with the same type of engine as the test aircraft, but with a 1.93 m (6.3 ft) longer fuselage. The data are all normalized to the reference conditions given in table VI. Center-line values for the 40° flap approach increased from 87.4 dB(A) at 6.12 km (3.30 n. mi.) from the threshold to 100 dB(A) at 2.01 km (1.08 n. mi.) from the threshold. The center-line test data with 30° flaps were about 1 dB(A) lower than the 40° flap test data over this range.

Values of $(L_{A,max})_{ref}$ for the 40° flap approaches were estimated from reference 5 by using a value of F_n/δ of 19 794 N/engine (4450 lb/engine) to find $(L_{A,max})_{ref}$ at several altitudes. These estimated values are also shown in figure 13. The estimated value is about 3 dB(A) lower than that for the 40° flap flight-test data over the range of distances shown. The flight data and the estimated data both show essentially the same variation in $(L_{A,max})_{ref}$ with distance from the threshold.

Level Flyovers

Histories of $(L_A)_{test}$ for a typical 122-m (400-ft) altitude and low thrust run (1.1.2.1) and a typical 610-m (2000-ft) altitude and high thrust run (1.1.5.1) are shown in figure 14. The 122-m altitude data were typically very similar to the station 1 data shown in figure 11 for the 3° approaches. The 610-m altitude data in figure 14(b), however, showed a long peak noise duration time (approximately 31 sec), the maximum $(L_A)_{test}$ value occurring about 7 sec after passing the station.

The measured spectral distributions at the times of the maximum values of figure 14 are shown in figure 15. The presence of considerable noise energy at the high frequencies was evident for the 122-m (400-ft) altitude run. For the 610-m (2000-ft) flyover spectrum, however, low frequency noise predominated, even at the higher thrust levels.

Table IX presents values of $(L_{A,max})_{test}$ and $(L_{A,max})_{ref}$ for all the level flyover runs, as well as averaged values for each of the five test conditions. The agreement in the test data between similar runs was reasonable and the corrections due to nonreference conditions were small.

The test data in table IX can also be used to evaluate the effect of the mild temperature inversion noted earlier. The only significant difference in test conditions between runs 1.1.5.1, 1.1.5.2, and 1.1.5.3 was that run 1.1.5.3 occurred during the inversion, and 1.1.5.1 and 1.1.5.2 were conducted before it developed. A comparison of the data from these three runs indicates that the effect of this anomaly was not significant.

The averaged $(L_{A,max})_{ref}$ data from table IX are plotted in figure 16 as functions of both F_n/δ and altitude. Data from reference 5 at the same reference conditions are also presented in this figure. A comparison of the data indicates excellent agreement.

CONCLUDING REMARKS

The 3° approach flight data indicated that effective perceived noise level (EPNL) has a value of 109.5 effective perceived noise decibels (EPNdB) for the standard approach configuration with 40° flaps. This value was in agreement with unpublished certification noise test data for the same type of aircraft. Approaches with 30° flaps and slightly reduced thrust reduced the EPNL value to 108.5 EPNdB.

Center-line values of the maximum reference A-weighted sound pressure level $\left(L_{A,max}\right)_{ref}$ from the flight test with 40° flaps increased from 87.4 A-weighted decibels (dB(A)) at 6.12 km (3.30 n. mi.) from the threshold to 100 A-weighted decibels at 2.01 km (1.08 n. mi.) from the threshold. Values estimated from data in FAA-EQ-73-7,4 (1973) for these conditions were about 3 dB(A) less than the flight-test data. Flight data with 30° flaps were about 1 dB(A) lower than the 40° flap test values over this range of distances.

Flight-test data correlating $\left(L_{A,max}\right)_{ref}$ with thrust at altitudes of 122 m (400 ft) and 610 m (2000 ft) were in agreement with the estimate based on FAA-EQ-73-7,4.

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APPENDIX A

NOISE MEASUREMENT SYSTEM DESCRIPTION AND CALIBRATION PROCEDURE

This appendix presents a technical description of the data acquisition system utilized by NASA Langley Research Center to record the noise data of this report. The system consisted of the microphones, cables, signal conditioning, and recording equipment needed to obtain flyover data in accordance with reference 3. The system incorporated field-proven commercial hardware from recognized manufacturers. Certain commercial equipment and materials are identified in this appendix in order to adequately specify the experimental procedures. In no case does such identification imply recommendation or endorsement of the products by NASA, nor does it imply that the equipment or materials are necessarily the best available for the purpose.

The discussion presented herein includes a narrative description of the systems, tabulation of pertinent specifications, block diagrams, calibration, and test procedures employed to verify system performance.

System Description

Data acquisition system block diagrams for typical microphone channels are shown in figure 17. Principal system components are pressure microphones with accessory windscreens and preamplifiers, signal conditioner, and an FM tape recorder. No pre-emphasis filter was used. An oscillograph was used to verify in-field data and to establish optimum recording levels. Specifications for all commercial hardware items in figure 17 are given from manufacturer's manual in appendix B.

The microphones of the system were configured with the standard grid cap and used Bruel and Kjaer Model UA0237 windscreens. The microphones were oriented for grazing incidence at a height of 1.2 m (4 ft) above plowed earth. Free-field frequency response corrections applied to the microphones resulting from the Bruel and Kjaer Model UA0237 windscreen are also described under the specifications for the microphones.

The tape recorder was operated at 76.2 cm (30 in.) (IRIG Intermediate Band FM) for all measurements. IRIG B time code, 1000-Hz modulated signal, was recorded on magnetic tape simultaneously with microphone data in all cases.

The Model 2804 power supplies used included an integral line driver installed by Bruel and Kjaer as a factory modification to drive the 450-m (1476-ft) signal cables.

APPENDIX A

Calibration of System in Laboratory

Prior to the field measurements, extensive system calibration and testing were conducted in the laboratory to verify proper system operation and document system performance. All system components were individually calibrated in accordance with the manufacturer's recommended procedures or by an alternate method approved by NASA. General calibration laboratory policies and procedures were those recommended in reference 8. All test measurements were made with instruments whose calibration was traceable to the National Bureau of Standards (NBS). To determine the frequency response of the microphone, an electrostatic calibration was performed by using a Bruel and Kjaer Model 4142 microphone calibration apparatus. Microphone sensitivity was determined by using a Bruel and Kjaer Model 4220 piston phone. Specifications for these devices are given in appendix B.

The systems were assembled and the critical parameters of frequency response, distortion, linearity, and noise floor were documented. System level tests are summarized in table X. Typical system frequency response plots are shown in figure 18. The roll-off at high frequencies exhibited by all frequency response plots is a function of the low-pass filter in the tape-recorder reproduce electronics which is the only deviation from straight-line response above 20 Hz.

Calibration of System in Field

All system microphone channels were field calibrated prior to each test day as follows:

1. End to end system sensitivity was determined by using a Bruel and Kjaer Model 4220 piston phone. The calibration signal of 124 dB at 250 Hz was recorded on magnetic tape.

2. An oscillator signal was inserted at the preamplifier input and system frequency response was verified through the tape recorder.

3. A pink noise signal from a General Radio Model 1382 random noise generator (see appendix B) was inserted at the preamplifier input and recorded on magnetic tape as a frequency response reference for subsequent data reduction.

4. At the conclusion of the test day, calibration 1 was repeated.

APPENDIX B

MANUFACTURER'S SPECIFICATIONS

Manufacturer's specifications for the equipment used for the tests are given in this appendix.

Microphone, Bruel and Kjaer Model 4134

The specifications for the microphone, Bruel and Kjaer Model 4134, are

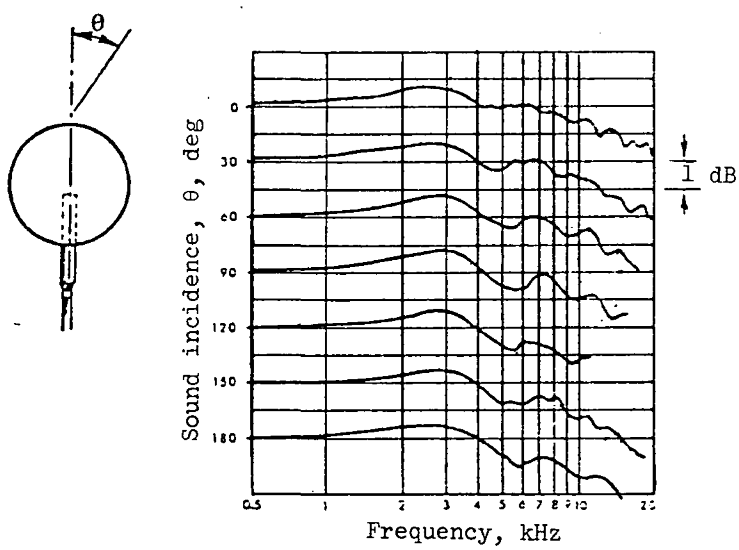
Diameter . . . . 1.27 cm (1/2 in.)

Polarization voltage . . . . 200 V

Open circuit sensitivity . . . . 12.5 mV per N/m^2 at 250 Hz

Frequency response (pressure) . . . . 10 Hz to 5 kHz ±0.5 dB
5 Hz to 10 kHz ±1.5 dB
4 Hz to 20 kHz ±2.0 dB

Free-field frequency response corrections for a microphone with the UA0237 windscreen are shown in the following curves:



Dynamic range (open circuit) . . . . Lower limit determined by preamplifier noise.
Upper limit 164 dB (ref. 20 μPa)

Capacitance . . . . 18 pF (polarized)

Temperature range . . . -50^{o} to 60^{o} C, temperature coefficient better than 0.006 dB/^{o}C

Influence of ambient pressure . . . . -0.1 dB/100 mm Hg (133.3 mm Hg = 1 Pa)

Influence of humidity. . . . . Less than 0.1 dB in absence of condensation

APPENDIX B

Preamplifier, Bruel and Kjaer Model 2619

The specifications for the preamplifier, Bruel and Kjaer Model 2619, are

Gain	1:1 (0.05 dB typical attenuation)
Frequency response[1]	2 Hz to 200 kHz
Input impedance	4000 MΩ
Output impedance	25 Ω
Temperature range	-20° to 60° C
Output signal	1 V root mean square to approximately 5 kHz (450-m (1500-ft) cable) 0.1 V root mean square to approximately 40 kHz (450-m (1500-ft) cable)
Polarizing voltage	+200 V
Noise	Less than 50 μV with 1.27-cm (1/2-in.) microphone
Distortion	Less than 1 percent for normal operating conditions
Power	120 V dc, 28 V dc

[1]The frequency response cited is the maximum obtainable for the preamplifier only. In the system configuration, the low-frequency response is effectively controlled by source (microphone) capacitance and the high-frequency response is a function of signal amplitude and output cable capacitance.

APPENDIX B

Power Supply, Bruel and Kjaer Model 2804

The specifications for the power supply, Bruel and Kjaer Model 2804, are

Outputs:
- Polarization . . . . 200 V
- Power supply . . . . 120 V dc and 28 V dc
- Auxiliary . . . . 28 V dc
- Heater (external battery) . . . . 6 V dc to 12 V dc

Battery voltage . . . . 3.5 V to 5 V

Battery life when driving 2619 preamplifier . . . . Approximately 40 hr

Noise and ripple . . . . Adds no additional noise to Model 2619 preamplifier

Gain (with custom line driver) 1:1

Cross-talk attenuation . . . . Better than 100 dB to 20 kHz

Temperature range . . . . 0° to 40° C

Maximum relative humidity . . . . 95 percent

Custom line driver:
- Output impedance . . . . 50 Ω
- Output level . . . . 1 V root mean square minimum
- Frequency response . . . . Flat to at least 10 kHz with 450-m (1500-ft) coaxial cable
- Power . . . . 9 V battery, 4 mA current drain

Signal Conditioner, Bruel and Kjaer Model 2426

The specifications for signal conditioner, Bruel and Kjaer Model 2426, are

Number of channels 4

Gain . . . . 10-dB steps from -50 dB to 60 dB plus an additional 5-dB attenuator switch

Frequency response . . . . 2 Hz to 200 kHz ± 0.2 dB

Output impedance . . . . Approximately 10 Ω

Maximum outputs, volts . . . . 1 V root mean square

Power . . . . 100 V ac to 240 V ac; 50 Hz to 400 Hz

APPENDIX B

Magnetic Tape Recorder, Honeywell Model 5600

The specifications for the magnetic tape recorder, Honeywell Model 5600, are

Number of channels: 7 or 14

Tape speeds: 1524, 762, 381, 190.5, 95.3, 47.6, and 23.8 mm/sec $\left(60, 30, 15, 7\frac{1}{2}, 3\frac{3}{4}, 1\frac{7}{8}, \text{ and } \frac{15}{16} \text{ in./sec}\right)$

Tape speed accuracy: 0.15 percent

Power: 105 V to 129 V, 48 Hz to 420 Hz

Operating temperature range: 0° to 50° C

Relative humidity: 5 to 95 percent noncondensing

Flutter:

Tape speed, mm/sec	Tape speed, in./sec	Bandwidth, Hz	Cumulative flutter 2 sigma, percent peak to peak
1524	60	0.2 to 10 000	0.3
762	30	.2 to 5 000	.4
381	15	.2 to 2 500	.5
190.5	$7\frac{1}{2}$	.2 to 1 250	.6
95.3	$3\frac{3}{4}$	.2 to 625	.7
47.6	$1\frac{7}{8}$	.2 to 312	.9
23.8	$\frac{15}{16}$	.2 to 156	1.1

Direct record and reproduce:

Dynamic characteristics: It is based on standard IRIG head configuration without an FM channel on an adjacent track and with recommended iron oxide tapes. It is capable of operation with chromium dioxide tapes.

Tape speed		Bandwidth, Hz ±3 dB	rms signal/rms noise	
mm/sec	in./sec		dB filtered*	dB unfiltered
1524	60	300 to 300 000	32	30
762	30	150 to 150 000	32	30
381	15	100 to 75 000	32	30
190.5	$7\frac{1}{2}$	50 to 37 500	30	28
95.3	$3\frac{3}{4}$	50 to 18 750	30	28
47.6	$1\frac{7}{8}$	50 to 9 300	28	26
23.8	$\frac{15}{16}$	50 to 4 700	28	26

*Measured at the output of a band-pass filter having 18 dB/octave attenuation beyond bandwidth limits.

Harmonic distortion: Normal record level set for 1 percent third harmonic distortion of a 1-kHz signal recorded at 1524 mm/sec (60 in./sec)

Input level: 0.3 V root mean square fixed at recorder input terminals, with gain trim adjustment

Input impedance: 100 kΩ resistive paralleled by 100 pF, unbalanced to ground

Output level: 1.0 V root mean square fixed into 10 kΩ, with gain trim adjustment

Output impedance: Less than 100 Ω

Equalization: Mounted on plug-in equalizer cards. Each reproduce amplifier accepts two equalizers, the correct one being selected by the speed control switch

FM record and reproduce (±40-percent deviation):

Record amplifier: Incorporates nine center frequencies, selected by speed switch and shorting pin for mode selection. Bias recorded in mixed direct/FM systems

Reproduce amplifier: Accepts two center frequency per filter units, selectable by speed switch. Filters convertible from flat to transient response by pin change

Dynamic characteristics: Variation of S/N ratio with bandwidth is as follows:

Tape speed		S/N ratio for –		
mm/sec	in./sec	Standard (low band)	Extended (intermediate band)	DX (wideband group 1)
1524	60	46 (10 kHz)	44 (20 kHz)	42 (40 kHz)
762	30	45 (5 kHz)	43 (10 kHz)	41 (20 kHz)
381	15	44 (2.5 kHz)	43 (5 kHz)	40 (10 kHz)
190.5	$7\frac{1}{2}$	43 (1.25 kHz)	41 (2.5 kHz)	39 (5 kHz)
95.3	$3\frac{3}{4}$	42 (625 Hz)	40 (1.25 kHz)	38 (2.5 kHz)
47.6	$1\frac{7}{8}$	40 (312 Hz)	38 (625 Hz)	36 (1.25 kHz)
23.8	$\frac{15}{16}$	40 (156 Hz)	36 (312 Hz)	34 (625 Hz)

APPENDIX B

Total harmonic distortion:	1.5 percent maximum
Linearity:	+1 percent of full deviation from best straight line through zero
Drift:	1 percent of full deviation over 10 days and 10° C to 35° C ambient
Input level:	1.0 V root mean square fixed for ±40-percent deviation with zero and gain trim adjustments
Input impedance:	Nominal 20 kΩ paralleled by 100 pF maximum unbalanced to ground
Output level:	1.0 V root mean square fixed into 10 kΩ with zero and gain trim adjustments
Output impedance:	100 Ω maximum

APPENDIX B

Magnetic Tape Recorder, Bell and Howell Model VR-3300

The specifications for the magnetic tape recorder, Bell and Howell Model VR-3300, are

Number of channels: 7 or 14

Tape speeds: 1524, 762, 381, 190.5, 95.25, and 47.63 mm/sec $\left(60, 30, 15, 7\frac{1}{2}, 3\frac{3}{4}, \text{and } 1\frac{7}{8} \text{ in./sec}\right)$

Tape speed accuracy: ±0.25 percent when operated with 60 Hz

Power: 105 V to 125 V, 48 Hz to 63 Hz

Flutter: Cumulative peak-to-peak

Tape speed		Bandpass, Hz	Flutter, percent	Bandpass	Flutter, percent
mm/sec	in./sec				
1524	60	0.2 to 312	0.30	0.2 Hz to 10 kHz	0.50
762	30	.2 to 312	.40	.2 Hz to 5 kHz	.65
381	15	.2 to 312	.50	.2 Hz to 2.5 kHz	.70
190.5	$7\frac{1}{2}$	.2 to 312	.65	.2 Hz to 1.25 kHz	.80
95.25	$3\frac{3}{4}$	.2 to 312	.80	.2 Hz to .625 kHz	1.00
47.63	$1\frac{7}{8}$	.2 to 312	1.20		

Operating temperature: 0° to 50° C

Direct record and reproduce system:

The frequency response and signal-to-noise ratio (SNR) are given in the following table:

Tape speed		Frequency response at ±3-dB points referred to 1.0 kHz as 0 dB	SNR, over frequency response bandwidth specified, dB	SNR, 300 Hz to upper band edge specified, dB
mm/sec	in./sec			
1524	60	100 Hz to 300 kHz	-30	-32
762	30	100 Hz to 150 kHz	-30	-32
381	15	100 Hz to 75 kHz	-30	-32
190.5	$7\frac{1}{2}$	100 Hz to 37.5 kHz	-30	-32
95.25	$3\frac{3}{4}$	100 Hz to 18.7 kHz	-28	-32
47.63	$1\frac{7}{8}$	100 Hz to 9.4 kHz	-28	-30

Input level: 1 V root mean square nominal (0 dB) to produce normal recording level

Input sensitivity: 0.25 V to 10 V root mean square; adjustable with input potentiometer for normal record level

Input impedance: 20 kΩ minimum, unbalanced to ground

Output level: 1 V root mean square nominal (0 dB) across a 600 Ω minimum and 3000 pF maximum load impedance (at normal recording level)

Output impedance: Less than 100 Ω unbalanced to ground

Distortion: 1 ± 0.1 percent third harmonic distortion of a 1-kHz signal and less than 0.6 percent intermodulation distortion for $f_1 \pm f_2$ products

Bias frequency: 1.0 MHz

FM record and reproduce system:

Frequency response, carrier, signal/noise ratio (SNR), and total harmonic distortion are given in the following table:

Tape speed		Center frequency, kHz	Information frequency, kHz ± 0.5 dB	Full scale SNR (rms signal/rms noise),* dB	Harmonic distortion, percent
mm/sec	in./sec				
1524	60	108.0	0 to 20	45	1.5
762	30	54.0	0 to 10	45	1.5
381	15	27.0	0 to 5	44	1.5
190.5	$7\frac{1}{2}$	13.5	0 to 2.5	44	1.5
95.25	$3\frac{3}{4}$	6.75	0 to 1.25	38	1.5
47.63	$1\frac{7}{8}$	3.375	0 to .625	38	1.5

*Including FM to FM cross talk.

Input level: 1 V root mean square nominal (0 dB) to produce full-scale modulation (±40-percent deviation) of the carrier

Input sensitivity: 0.5 to 10 V root mean square; adjustable with input potentiometer for full-scale modulation (±40-percent deviation) of the carrier

Input impedance: 10 kΩ minimum, unbalanced to ground

Output level: 1 V root mean square nominal (0 dB) across a 10-kΩ load impedance, for full-scale modulation

Termination impedance:	Operates into a 10-kΩ load, with 1000-pF shunt capacitance
Phase shift:	Linear within 5 percent of best straight line through dc for frequencies in the passband
dc linearity:	±0.5 percent of full scale
ac linearity:	±0.5 percent of full scale
Drift:	Less than 1.0 percent of full scale in an 8-hr period at constant temperature within -12.2° to -23.3° C (±10° F)
Transient response:	Adjustable on low-pass filter in FM reproduce amplifier for flat frequency response or optimum transient response. Frequency response specified above exhibits high-frequency rolloff at approximately one-half band edge frequency when system is adjusted for optimum transient response

APPENDIX B

Time Code Generator, Systron-Donner Model 8120

The specifications for the time code generator, Systron-Donner Model 8120, are

Time base:	Crystal-controlled oscillator with stability of ±1 in 10^5 within 0° to 60° C and an aging rate of ±1 part in 10^7 per 24 hr after 72 hr. Provisions included for use of an external 1-MHz time base
Display:	Six-digit in-line planar readout to indicate time of day or elapsed time in hours, minutes, and seconds (three additional digits if days and identification (ID) numbers option are included)
Code format:	Modified IRIG B format in terms of hours, minutes, and seconds (days and ID number optional)
Modulated code:	The modulated code is generated on a precise 1-kHz carrier with an adjustable amplitude from 0 to 10 V peak to peak from a low impedance 15 mA peak source and an adjustable modulation ratio (mark to space) from 2:1 to 6:1. Connector is rear panel BNC type
dc level shift code:	The dc level shift code is generated with an adjustable amplitude from 1 to +10 V into a 600-Ω load. Connector is rear panel BNC type
Pulse rates:	Simultaneous rates of 1, 10, 100, and 1000 pulses per second are provided with leading edge "on time." Levels are 0 to +5 V nominal from a 6-kΩ source (transistor-transistor logic (TTL)) compatible. Connector is Amphenol 57-40500 (mating connector supplied)
Parallel BCD outputs:	Updated time is provided as 20 parallel BCD lines representing hours, minutes, and seconds (12 additional lines for days and ID number or msec options)
Code:	8-4-2-1
Logic:	Binary "1" = 5 (±0.5) V, 6-kΩ source Binary "0" = 0 (±0.5) V, 10-mA sink
Connector:	Amphenol 57-40500. Mating connector supplied
Environment:	0° C to 50° C at up to 95 percent relative humidity
Power:	115 to 230 V (±10 percent), 48 to 62 Hz

APPENDIX B

Galvanometer amplifier, Bell and Howell Model 1-172

The specifications for the galvanometer amplifier, Bell and Howell Model 1-172, are

Number of channels:	6
Gain:	Controlled by plug-in feedback network resistor boards
Frequency response (ac position):	1 Hz to 10 kHz ± 3 dB
Input impedance:	1 MΩ, shunted by 45 pF
Input configuration:	Single ended
Maximum input voltage:	400 V dc or peak ac without damage
Ambient temperature:	0° to 50° C
Linearity:	±0.25 percent of full scale from best straight line to ±80 mA or ±6.8 V from amplifier, whichever is less
Power:	105 to 125 V, 60 Hz

Oscillograph, Bell and Howell Model 5-124

The specifications for the oscillograph, Bell and Howell Model 5-124, are

Data channels:	18
Galvanometer model:	7 to 361
Frequency response:	0 to 5000 Hz ± 5 percent
Optical arm:	29.2 cm (11.5 in.) at zero deflection
Recording media:	18-cm (7-in.) paper
Trace width:	Less than 0.0254 mm (0.01 in.)
Maximum writing speed:	1270 m/sec (50 000 in./sec)
Record speeds:	0.63, 2.54, 9.16, 36.64, and 146.56 cm/sec (0.25, 1, 4, 16, and 64 in./sec)
Power:	105 to 125 V, 50 to 60 Hz

APPENDIX B

Microphone Calibration Apparatus, Bruel and Kjaer Model 4142

The specifications for the microphone calibration apparatus, Bruel and Kjaer Model 4142, are presented. These specifications apply to the determination of microphone frequency response, by using the Model UA0033 electrostatic actuator supplied with the calibration apparatus.

Frequency range:	20 to 20 000 Hz
Accuracy:	±0.5 dB (estimate)
Polarization voltage:	800 V
Power:	115 V, 60 Hz

Piston Phone, Bruel and Kjaer Model 4220

The specifications for the piston phone, Bruel and Kjaer Model 4220, are

Accuracy:	±0.2 dB
Sound pressure level:	124 dB (ref. 20 μPa)
Frequency:	250 Hz ± 1 percent
Distortion:	Less than 3 percent
Temperature range:	0^{o} to $+60^{o}$ C (including batteries)
Humidity:	Relative humidities of up to 100 percent will not influence the calibration
Power:	7 Mallory RM-3 (R) mercury cells

APPENDIX B

Random Noise Generator, General Radio Model 1382

The specifications for the random noise generator, General Radio Model 1382, are

Spectrum: Either (a) white noise (constant energy per hertz bandwidth) ±1 dB, 20 Hz to 25 kHz, with 3-dB points at approximately 10 Hz and 50 kHz; (b) pink noise (constant energy per octave bandwidth) ±1 dB, 20 Hz to 20 kHz; or (c) ANSI noise, as specified in American National Standard Institute (ANSI) Standard S1.4-1961

Waveform: The waveform is indicated by the following table:

Voltage	Gaussian probability density function	Amplitude-density distribution
0	0.0796	0.0796 ± 0.005
$\pm\sigma$	.0484	.0484 ± 0.005
$\pm 2\sigma$	.0108	.0108 ± 0.003
$\pm 3\sigma$	.000898	.000898 ± 0.0002
$\pm 4\sigma$	.0000274	.0000274 ± 0.00002

These data measured in a "window" of 0.2σ, centered on the indicated values where σ is the standard deviation or root-mean-square value of the noise voltage.

Output voltage: Greater than 3 V root mean square maximum, open circuit for any bandwidth

Output impedance: 600 Ω

Amplitude control: Continuous adjustment from full output to approximately 60 dB below that level

Power required: 100 to 125 V, 50 to 400 Hz

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5. Williams, B. G.; and Yates, R.: Aircraft Noise Definition, Individual Aircraft Technical Data, Model 737. FAA-EQ-73-7,4, 1973.

6. Copeland, W. Latham; and Clark, Lorenzo R.: Noise Measurements for a Three-Engine Turbofan Transport Airplane During Climbout and Landing Approach Operations. NASA TN D-6137, 1971.

7. Peery, H. Rodney; and Erzberger, Heinz: Noise Measurements Evaluation of Takeoff and Approach Profiles Optimized for Noise Abatement. NASA TN D-6246, 1971.

8. Calibration Program. Standards Laboratory Information Manual. Naval Inspector of Ordnance, Feb. 1958.

TABLE I.- CHARACTERISTICS OF THE TEST AIRCRAFT

General:	
Length, m (ft)	28.65 (94)
Height to top of vertical fin, m (ft)	11.28 (37)
Wing:	
Area, m^2 (ft^2)	91.04 (980)
Span, m (ft)	28.35 (93.0)
Mean aerodynamic chord, m (ft)	3.41 (11.2)
Incidence angle, deg	1.0
Aspect ratio	9.07
Dihedral, deg	6
Sweep, deg	25
Flap deflection (max), deg	40
Flap area, m^2 (ft^2)	14.94 (160.8)
Aileron deflection (max), deg	±20
Spoilers deflection, deg:	
Inboard	60
Outboard	40
Horizontal tail:	
Total area, m^2 (ft^2)	28.98 (312)
Span, m (ft)	10.97 (36)
Elevator area, m^2 (ft^2)	6.55 (70.5)
Elevator deflection (max), deg	±21
Stabilizer deflection, deg	12
Vertical tail:	
Total area, m^2 (ft^2)	20.9 (225)
Span, m (ft)	6.15 (20.16)
Rudder area, m^2 (ft^2)	5.22 (56.2)
Rudder deflection, deg	±24
Propulsion system:	
Pratt and Whitney JT8D-7 engines	2
Maximum uninstalled thrust per engine at sea level static pressure, N (lbf)	62 275 (14 000)
Weight:	
Maximum take-off gross weight, kg (lb)	44 361 (97 800)
Maximum landing weight, kg (lb)	40 687 (89 700)
Empty weight (zero fuel), kg (lb)	28 803 (63 500)

TABLE II. - RADAR SPECIFICATIONS

Characteristics	AN/FPQ-6	AN/FPS-16
Peak power output	3 MW	1 MW
Skin track range (1 sq m)	1296 km (700 n. mi.)	352 km (190 n. mi.)
Range precision, rms	±2.74 m (±9 ft)	±2.74 m (±9 ft)
Range rate precision, rms	0.035 m/sec (0.114 ft/sec)	
Angle precision, rms	±0.05 mil	±0.1 mil

TABLE III.- NOMINAL TEST CONDITIONS

(a) 3° approach flights

Flap setting, deg	Approach speed,* KIAS	Mass		Altitude over measuring station							
				1		2		3		4	
		kg	lb	m	ft	m	ft	m	ft	m	ft
40	136	39 463	87 000	121	397	160	525	226	743	337	1104
30	141	39 463	87 000	121	397	160	525	226	743	337	1104

*Nominal approach speed as used herein was ($1.3V_S \pm 10$ KIAS) at the specified flap setting and maximum landing weight of 40 598 kg (89 700 lb).

(b) Level flyover flight

F_n/δ		Altitude		Airspeed, KIAS	Mass		Flap position, deg	Gear position
N/eng	lb/eng	m	ft		kg	lb		
19 037	4 280	122	400	145	39 463	87 000	10	Up
24 064	5 410	122	400	150	39 463	87 000	30	Up
28 556	6 420	122	400	150	39 463	87 000	30	Up
46 706	10 500	610	2000	165	39 463	87 000	40	Down
56 937	12 800	610	2000	160	39 463	87 000	40	Down

TABLE III.- Concluded

(c) Meteorological conditions

Precipitation	None
Relative humidity	$\ngtr$90 percent or $\nless$30 percent
Ambient temperature at 10 m (32 ft) above ground	$\ngtr$303.2 K (89° F) $\nless$278.2 K (41° F)
Airport reported wind velocity at 10 m (32 ft) above ground	$\ngtr$10 knots
Cross-wind component	$\ngtr$5 knots
Temperature inversions on anomalous wind conditions that would affect noise level of aircraft when noise is measured	None

TABLE IV.- ACTUAL TEST CONDITIONS FOR 3° APPROACHES

(a) Flight R-019

Run	Meteorological conditions					Aircraft parameters					Position data							
	V_W, knots	V_C, knots	T		Relative humidity, percent	Approach speed, KIAS	F_n/δ		Mass		Altitude above measuring station							
											1		2		3		4	
			K	°F			N/eng	lb/eng	kg	lb	m	ft	m	ft	m	ft	m	ft
40° flaps, gear down																		
2.1.1.1	8	6	279.2	43	51	134	23 485	5280	40 461	89 200	119.2	391	159.7	524	220.4	723	332.5	1091
2.1.1.2	5	3	279.9	44	49	127	22 685	5100	39 780	87 700	112.8	370	144.8	475	210.3	690	317.0	1040
2.1.1.3	8	2	280.3	45	47	132	22 462	5050	39 146	86 300	121.9	400	155.5	510	217.9	715	326.1	1070
2.1.1.4	8	3	280.3	45	46	134	22 685	5100	38 511	84 900	114.3	375	149.4	490	213.4	700	315.5	1035
2.1.1.5	7	4	280.9	46	44	129	21 128	4750	38 057	83 900	121.9	400	164.6	540	225.6	740	332.2	1090
30° flaps, gear down																		
2.1.2.1	6	6	284.7	53	33	136	20 461	4600	40 098	88 400	125.0	410	157.0	515	221.0	725	318.5	1045
2.1.2.3	6	6	283.1	50	41	133	15 790	3550	39 735	87 600	114.3	375	144.8	475	210.3	690	318.5	1045
2.1.2.4	7	5	283.1	50	40	138	16 235	3650	39 191	86 400	115.8	380	152.4	500	213.4	700	313.9	1030
2.1.2.5	4	3	283.1	50	39	135	13 789	3100	38 601	85 100	117.4	385	146.3	480	198.1	650	309.4	1015
2.1.2.6	4	3	283.1	50	39	132	17 792	4000	38 193	84 200	112.8	370	146.3	480	213.4	700	313.9	1030

TABLE IV.- Continued

(b) Flight R-060

Run	Meteorological conditions					Aircraft parameters					Position data							
	V_W, knots	V_C, knots	T		Relative humidity, percent	Approach speed, KIAS	F_n/δ		Mass		Altitude above measuring station							
											1		2		3		4	
			K	°F			N/eng	lb/eng	kg	lb	m	ft	m	ft	m	ft	m	ft
40° flaps, gear down																		
3.1.1	4	1	299.8	80	47	129	19 794	4450	39 173	86 360	129.5	425	177.7	583	246.3	808	348.7	1144
3.1.2	4	3	300.4	81	48	118	19 794	4450	38 674	85 260	127.7	420	170.7	560	238.7	783	344.7	1131
3.1.3	4	3	300.4	81	48	122	19 571	4400	38 220	84 260	135.6	445	168.6	553	249.9	820	353.9	1161
30° flaps, gear down																		
3.2.1	1	1	299.8	80	50	135	19 571	4400	40 352	88 960	143.6	471	177.7	583	241.4	792	342.3	1123
3.2.2	3	0	299.8	80	48	139	18 237	4100	39 763	87 660	135.6	445	173.3	570	240.5	789	337.1	1100
3.2.4	4	0	301.0	82	38	140	16 902	3800	40 715	89 759	122.5	402	177.7	583	243.2	798	346.0	1135

TABLE IV.- Concluded

(c) Flight R-061

Run	Meteorological conditions					Aircraft parameters					Position data							
	V_W, knots	V_C, knots	T		Relative humidity, percent	Approach speed, KIAS	F_n/δ		Mass		Altitude above measuring station							
											1		2		3		4	
			K	°F			N/eng	lb/eng	kg	lb	m	ft	m	ft	m	ft	m	ft
40° flaps, gear down																		
3.1.4	3	0	302.7	85	49	124	19 794	4450	39 008	86 000	144.8	475	170.7	560	243.8	800	350.5	1150
3.1.5	5	1	303.2	86	48	123	19 794	4450	39 785	87 710	134.1	440	172.2	565	240.2	790	350.5	1150
30° flaps, gear down																		
3.2.3	2	1	302.1	84	49	135	14 323	3220	39 989	88 160	131.1	430	172.2	565	243.8	800	342.9	1125

TABLE V.- ACTUAL TEST CONDITIONS FOR LEVEL FLYOVERS (FLIGHT R-020)

Run	Meteorological conditions					Aircraft parameters					Position data	
	V_W, knots	V_C, knots	T		Relative humidity, percent	Airspeed, KIAS	F_n/δ		Mass		Altitude above station 5	
			K	°F			N/eng	lb/eng	kg	lb	m	ft
1.1.1.1	6	4	296.2	74	65	145	19 794	4 450	40 779	89 900	121.3	394
1.1.1.2	3	1	295.1	72	69	145	19 794	4 450	40 824	90 000	122.5	402
1.1.1.3	0	0	294.0	70	73	145	19 794	4 450	40 824	90 000	123.1	404
1.1.2.1	0	0	296.8	75	62	150	25 131	5 650	39 962	88 100	109.7	360
1.1.2.2	4	1	296.8	75	62	150	25 131	5 650	39 055	86 100	108.5	356
1.1.2.3	2	2	296.8	75	63	150	25 131	5 650	38 420	84 700	114.3	375
1.1.3.1	2	1	296.8	75	62	150	30 246	6 800	38 919	85 800	113.7	373
1.1.3.2	6	3	295.7	73	66	150	30 246	6 800	39 599	87 300	121.9	400
1.1.3.3	4	2	295.7	73	66	150	30 246	6 800	39 100	86 200	120.1	394
1.1.4.1	4	3	295.1	72	69	165	46 704	10 500	39 599	87 300	610.5	2003
1.1.4.2	2	0	294.5	71	70	165	46 704	10 500	39 599	87 300	609.0	1998
1.1.4.3	0	0	294.0	70	74	165	46 704	10 500	40 325	88 900	610.5	2003
1.1.5.1	5	3	296.8	75	62	160	56 044	12 600	40 144	88 500	612.7	2010
1.1.5.2	7	3	296.2	74	65	160	56 044	12 600	40 144	88 500	636.7	2089
1.1.5.3	5	1	295.1	72	69	160	56 044	12 600	40 189	88 600	630.6	2069

TABLE VI.- REFERENCE CONDITIONS FOR NORMALIZED NOISE DATA

	T		Relative humidity, percent	Flight-path angle, deg	Closest approach point	Airspeed	Mass	
	K	^{o}F					kg	lb
3^{o} approaches $(L_{A,max})_{ref}$	298.2	77	70	-3	Nominal altitudes over stations 1 to 4 (see table IV(a))		40 687	89 700
EPNL	298.2	77	70	-3	112.5 m (369 ft)	Nominal approach speeds (see table IV(a))	40 687	89 700
Level flyovers $(L_{A,max})_{ref}$	298.2	77	70	0	Nominal altitudes over station 5 (see table IV(b))			

TABLE VII.- 3° APPROACH NOISE

(a) Flight R-019

Run	$(L_{A,max})_{test}$, dB(A)	
	Station 1	Station 2
40° flaps, gear down		
2.1.1.1	98.4	95.1
2.1.1.2	98.2	95.3
2.1.1.3	98.7	94.3
2.1.1.4	98.6	95.6
2.1.1.5	97.8	93.9
Average	98.3	94.8
30° flaps, gear down		
2.1.2.1	94.4	92.9
2.1.2.3	94.5	91.6
2.1.2.4	95.4	91.9
2.1.2.6	95.6	92.4
2.1.2.6	95.6	93.1
Average	95.1	92.4

(b) Flight R-060

Run	$(L_{A,max})_{test}$, dB(A)			$(L_{A,max})_{ref}$, dB(A)			$(EPNL)_{ref}$, EPNdB
	Station 1	Station 3	Station 4	Station 1	Station 3	Station 4	
40° flaps, gear down							
3.1.1	99.0	90.5	87.2	100.1	92.1	88.1	109.3
3.1.2	99.0	90.4	86.6	99.7	91.4	87.3	109.2
3.1.3	97.9	90.0	86.4	99.4	91.6	87.5	109.6
30° flaps, gear down							
3.2.1	96.9	89.8	85.0	99.1	90.9	85.5	108.4
3.2.2	96.7	90.9	85.5	98.3	91.1	85.9	108.4
3.2.4	96.8	89.9	84.8	98.5	91.8	86.0	108.3

TABLE VII.- Concluded

(c) Flight R-061

Run	$(L_{A,max})_{test}$, dB(A)				$(L_{A,max})_{ref}$, dB(A)				$(EPNL)_{ref}$, EPNdB
	Station 1	Station 2	Station 3	Station 4	Station 1	Station 2	Station 3	Station 4	
40° flaps, gear down									
3.1.4	98.1	95.5	89.8	---	100.3	96.5	90.8	---	109.7
3.1.5	98.7	94.8	90.3	85.8	99.9	95.9	91.9	86.8	109.5
30° flaps, gear down									
3.2.3	97.7	---	88.6	---	99.1	---	89.8	---	108.9

TABLE VIII.- SUMMARY OF 3° APPROACH NOISE DATA

Parameter	Flaps 40°	Flaps 30°
$(L_{A,max})_{ref}$, dB(A):		
Station 1	100.0	98.8
Station 2	96.2	----
Station 3	91.6	90.9
Station 4	87.4	85.8
EPNL, EPNdB	109.5	108.5

TABLE IX.- LEVEL FLYOVER DATA

[Flight R-020]

Run	$(L_{A,max})_{test}$, dB(A)	$(L_{A,max})_{ref}$, dB(A)
1.1.1.1	97.4	97.2
1.1.1.2	96.6	96.6
1.1.1.3	96.5	96.4
Average	96.8	96.7
1.1.2.1	98.7	97.3
1.1.2.2	98.5	97.0
1.1.2.3	99.2	98.4
Average	98.8	97.6
1.1.3.1	99.8	99.0
1.1.3.2	98.9	98.9
1.1.3.3	99.9	99.6
Average	99.5	99.2
1.1.4.1	86.3	86.7
1.1.4.2	98.1	89.1
1.1.4.3	87.8	87.9
Average	87.7	87.9
1.1.5.1	94.3	94.3
1.1.5.2	91.5	91.8
1.1.5.3	92.6	92.9
Average	92.8	93.0

TABLE X.- SUMMARY OF SYSTEM LEVEL TESTS

Test	Procedure	Test results
Frequency response[1] (45 Hz to 11.2 kHz)	Apply oscillator signal at preamplifier input. Record system frequency response through tape recorder output.	±0.5 dB
Distortion	Apply signal at microphone using acoustic calibrator. Check system distortion through tape recorder output.	Less than 1 percent
Linearity	Apply oscillator signal at preamplifier input. Check system linearity at tape recorder output over expected range settings of variable-gain amplifier.	±1.0 percent of full-scale tape recorder deviation
Noise floor (ref. 20 μPa)	Short circuit preamplifier input and monitor system noise level at tape recorder output.	35 to 46 dB

[1]With respect to the calibration signal at 250 Hz.

L-73-6287

Figure 1.- Photograph of test aircraft.

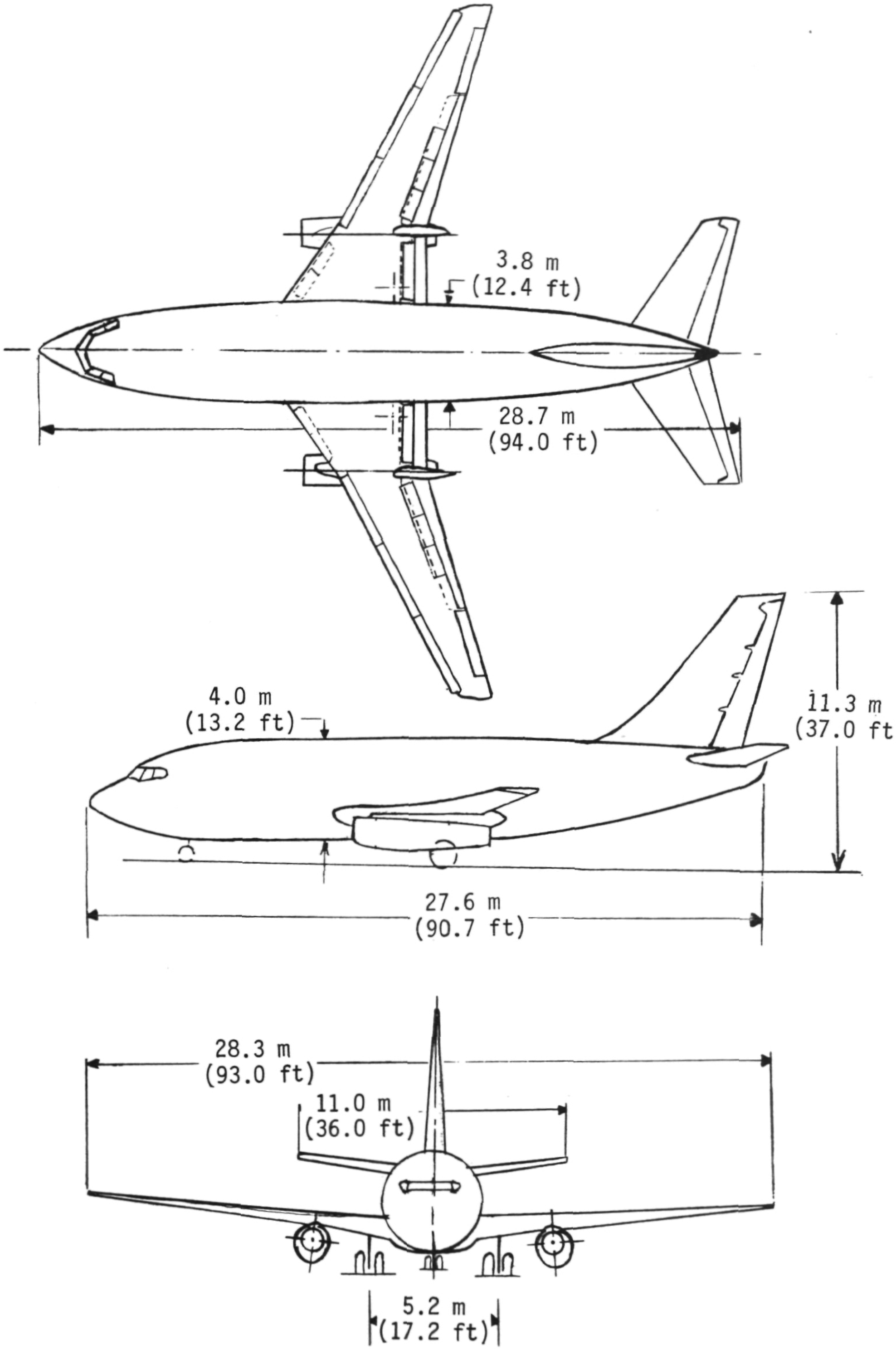


Figure 2.- Dimensions of test aircraft.

Site Location	Distance from threshold, km (n. mi.)
1	2.01 (1.08)
2	2.75 (1.48)
3	4.02 (2.17)
4	6.12 (3.30)
5	0

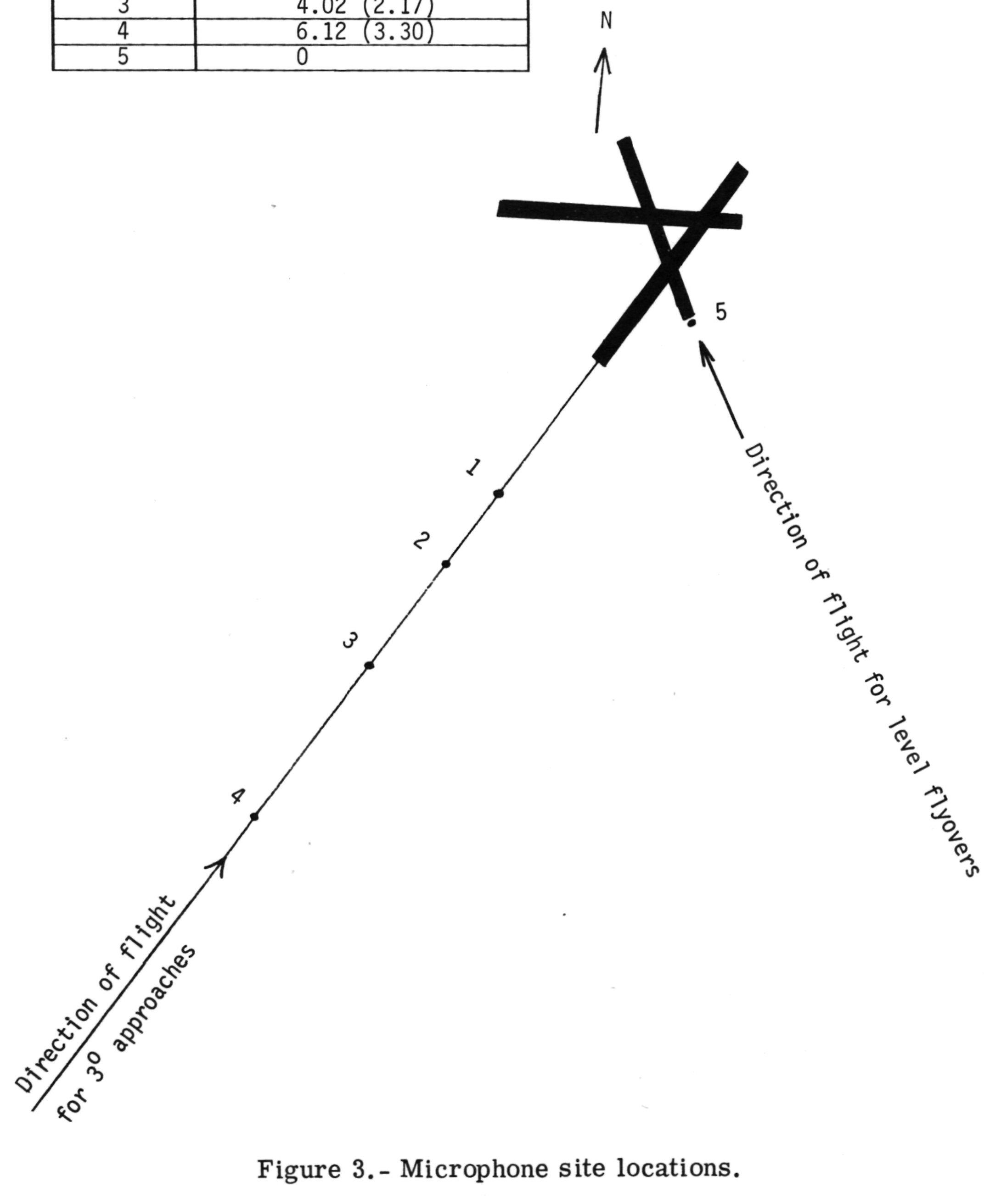
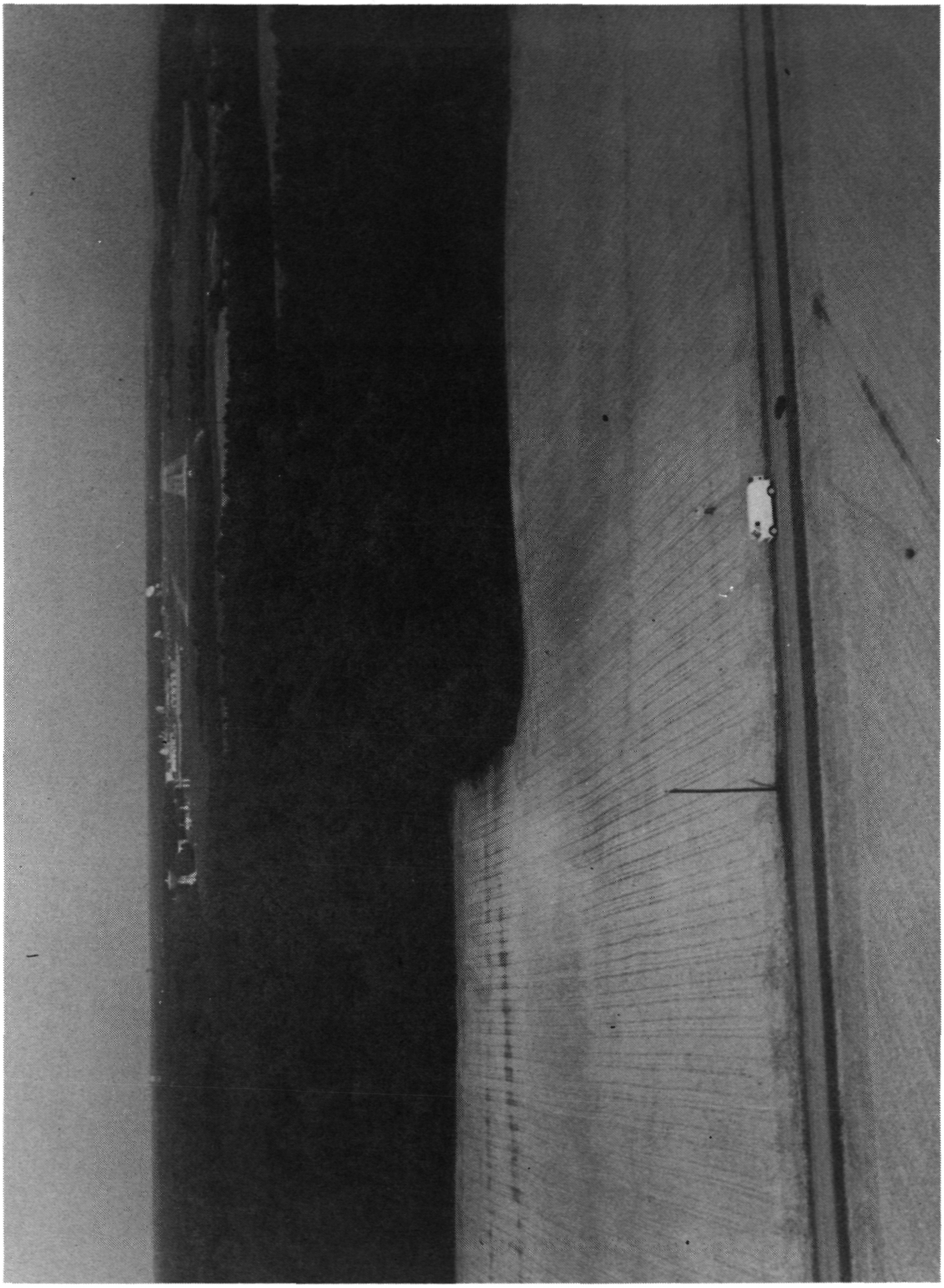


Figure 3.- Microphone site locations.



L-74-28

Figure 4.- Noise site.

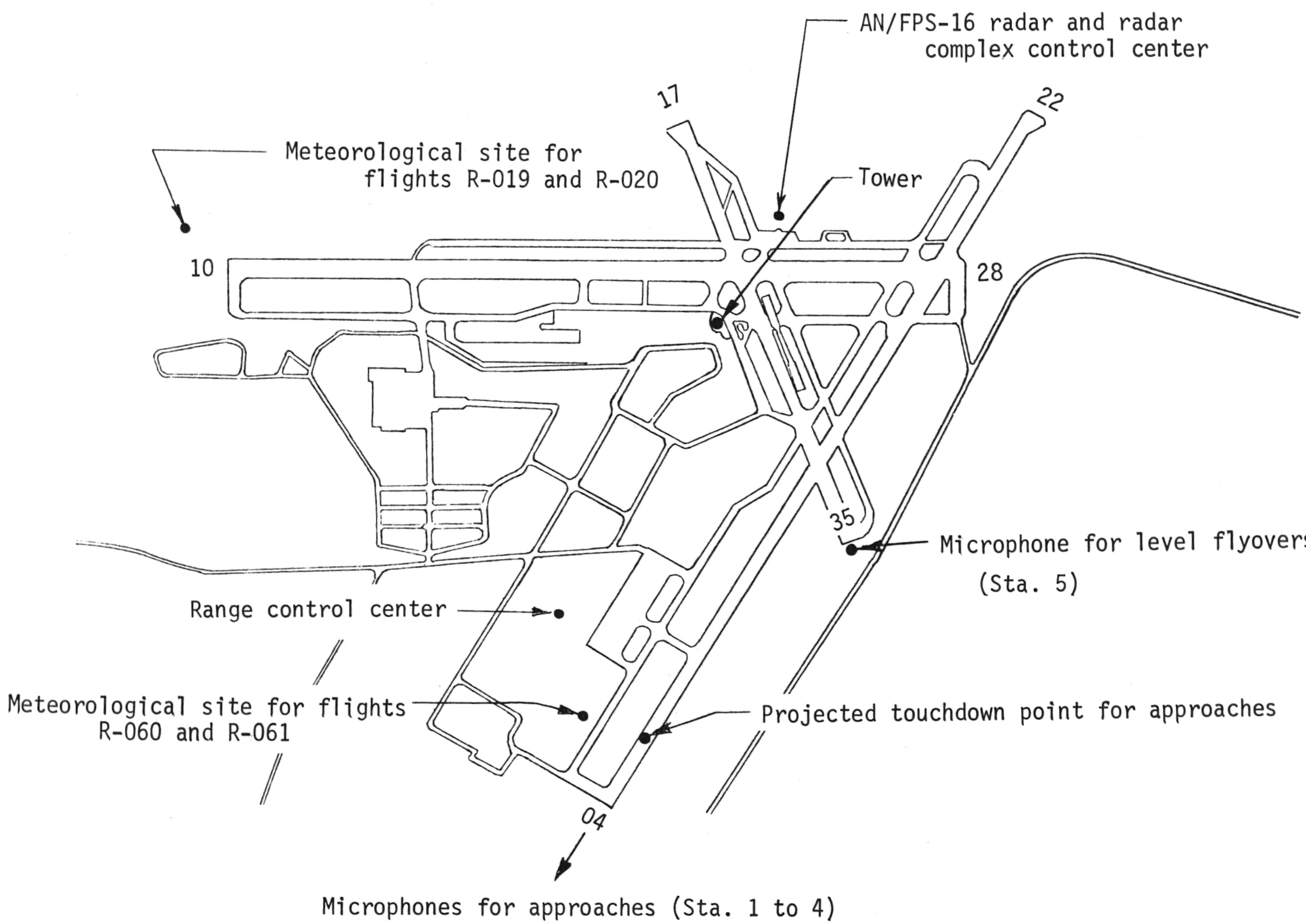
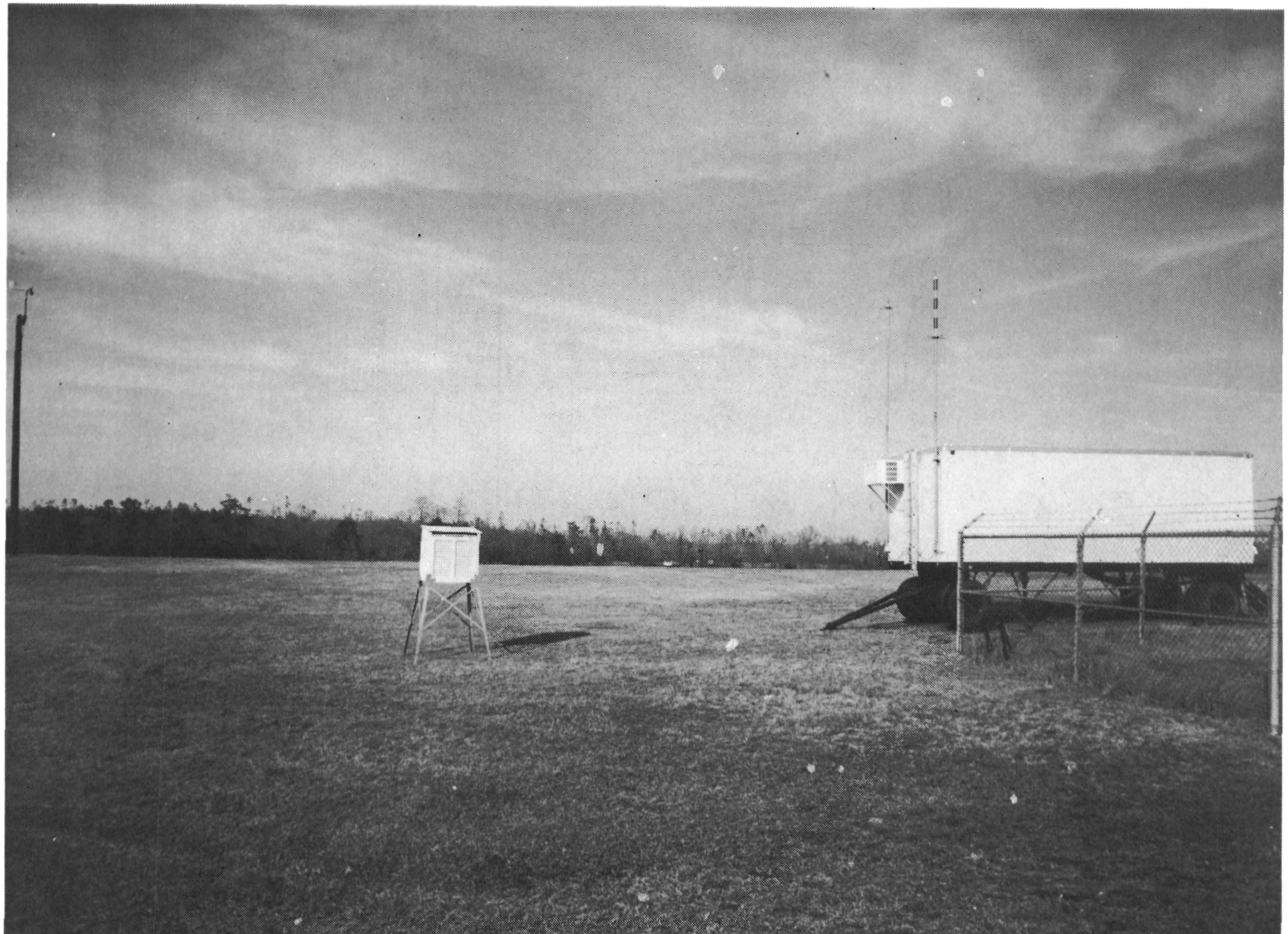


Figure 5.- Location of ground support systems on the WFC airfield (not to scale).



WI-73-121

Figure 6.- Primary meteorological site located near the end of WFC runway 10.

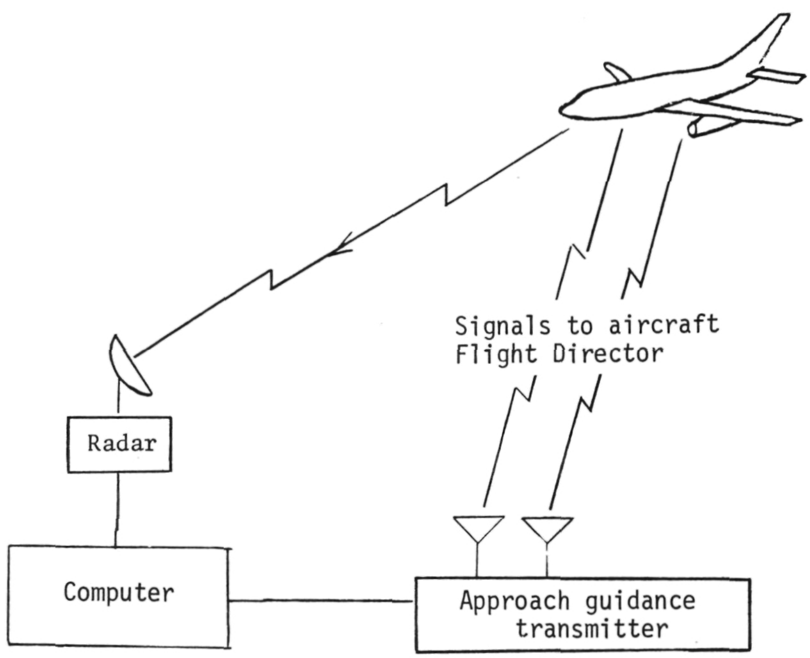
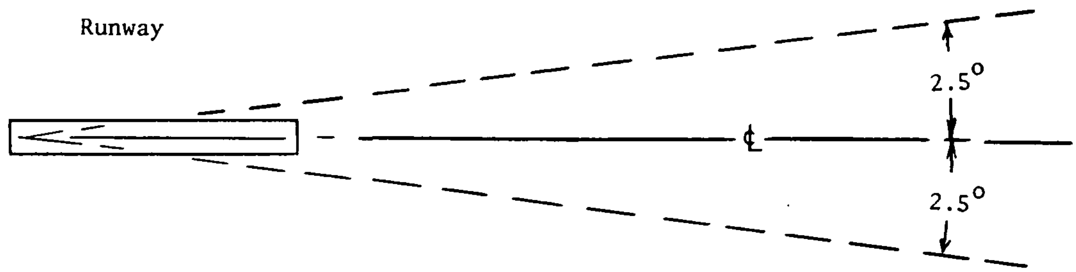
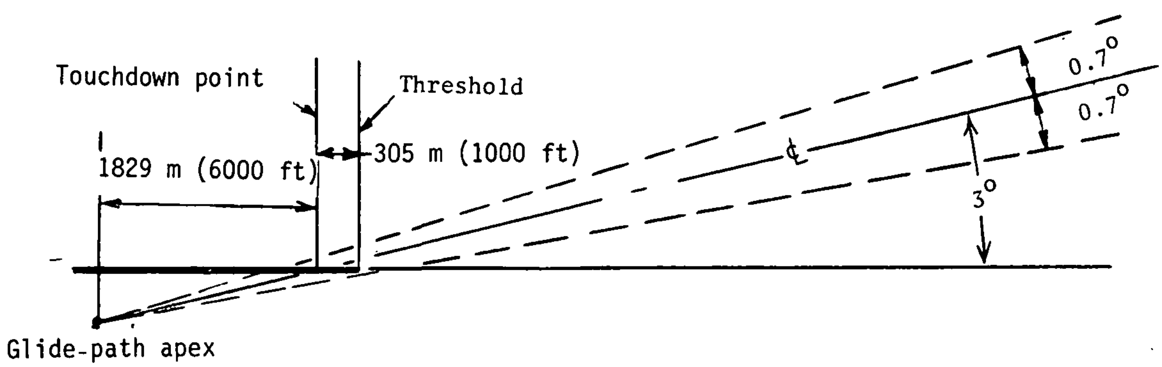


Figure 7.- Approach guidance system.



(a) Localizer.



(b) Glide slope.

Figure 8.- Approach guidance geometry.

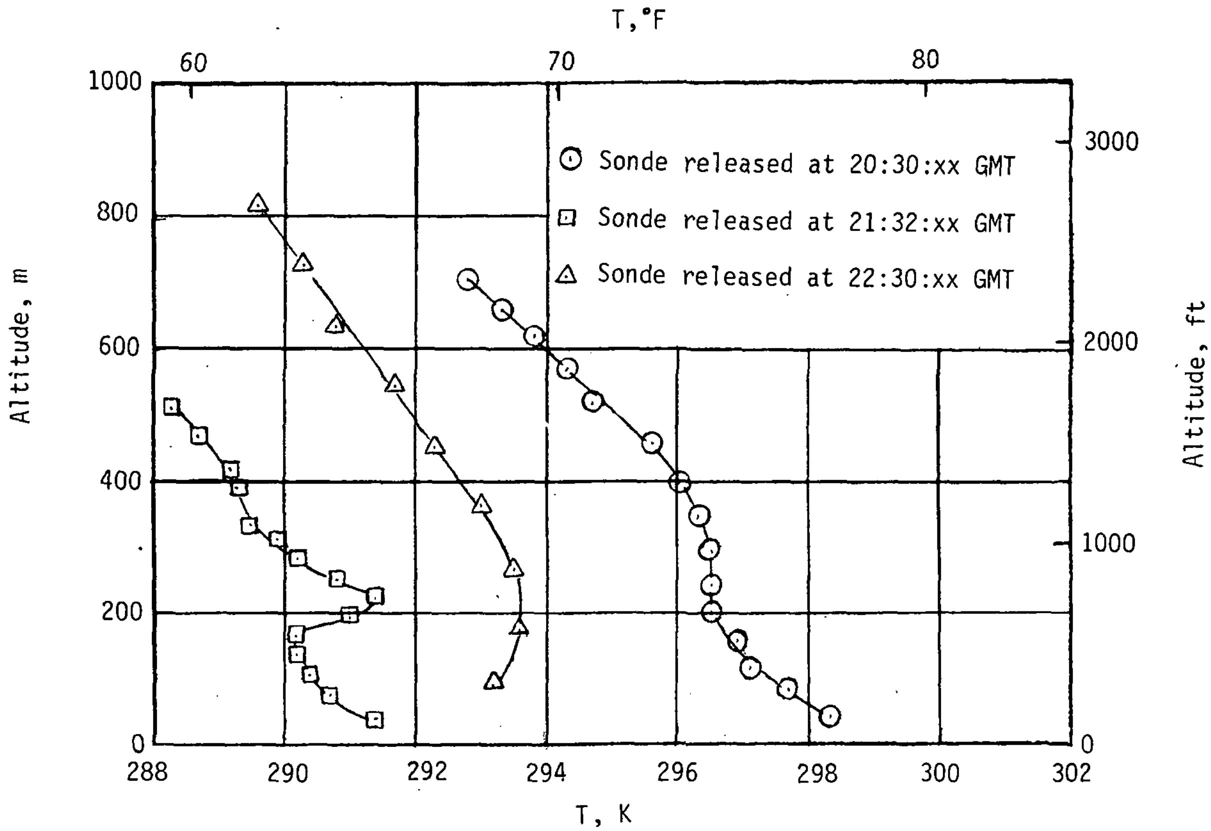


Figure 9.- Temperature variation with altitude during a portion of level flyover Flight R-020.

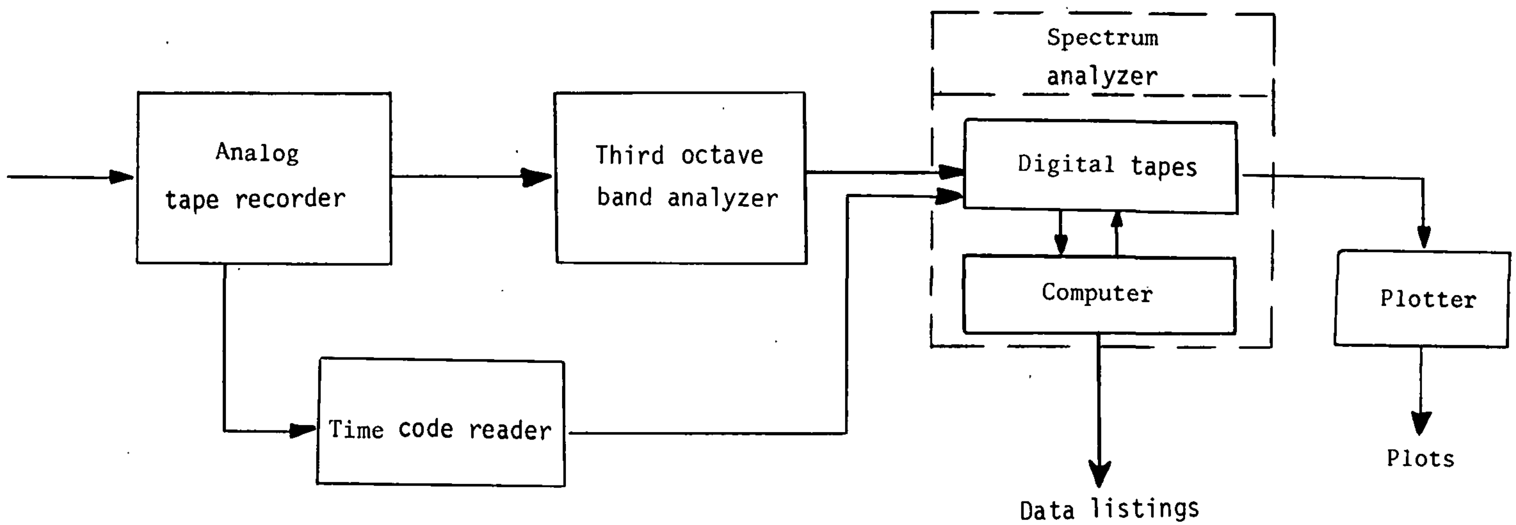
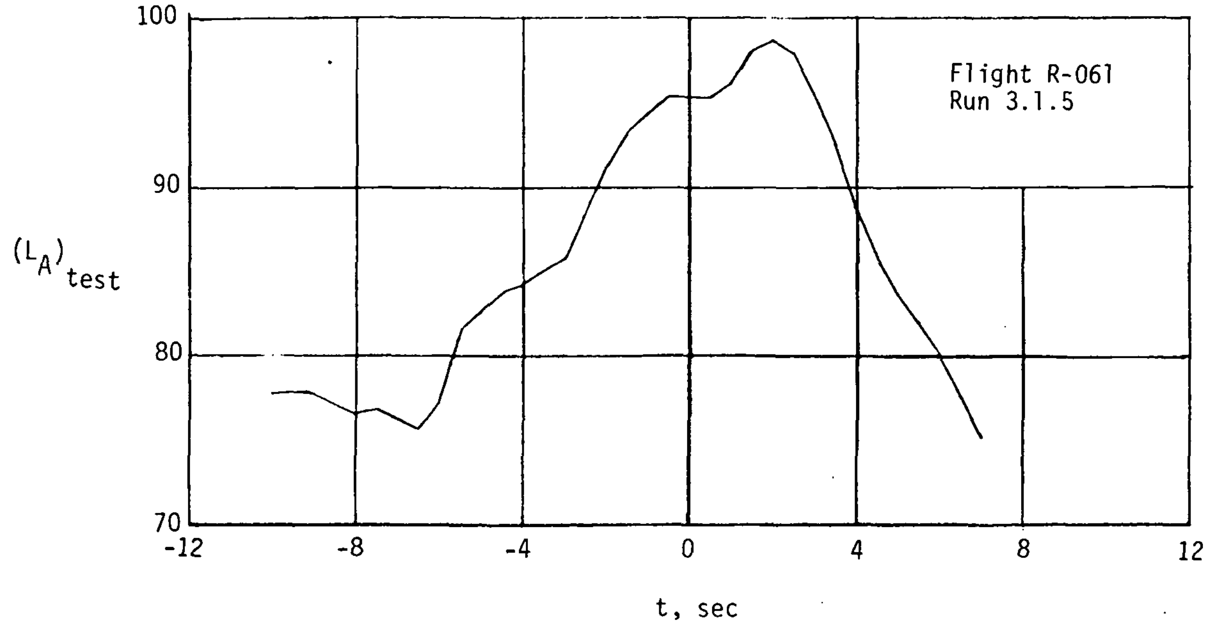
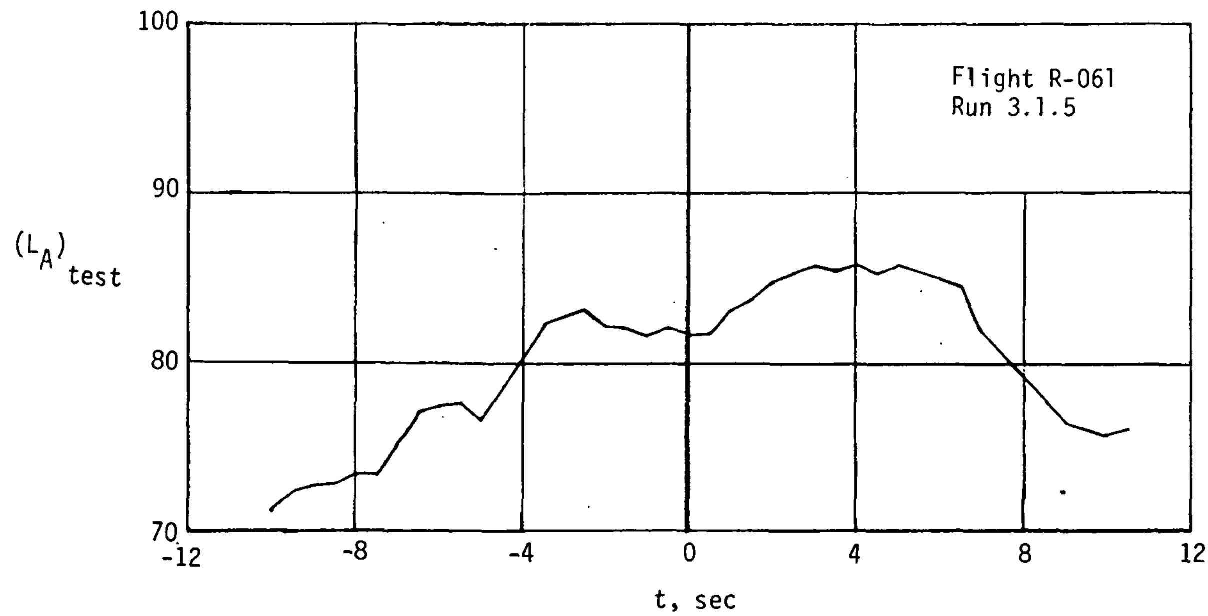


Figure 10.- Schematic diagram of the acoustic data reduction system.



(a) Time history at station 1.



(b) Time history at station 4.

Figure 11.- Typical $(L_A)_{test}$ histories during 3^o approaches as determined from data at stations 1 and 4.

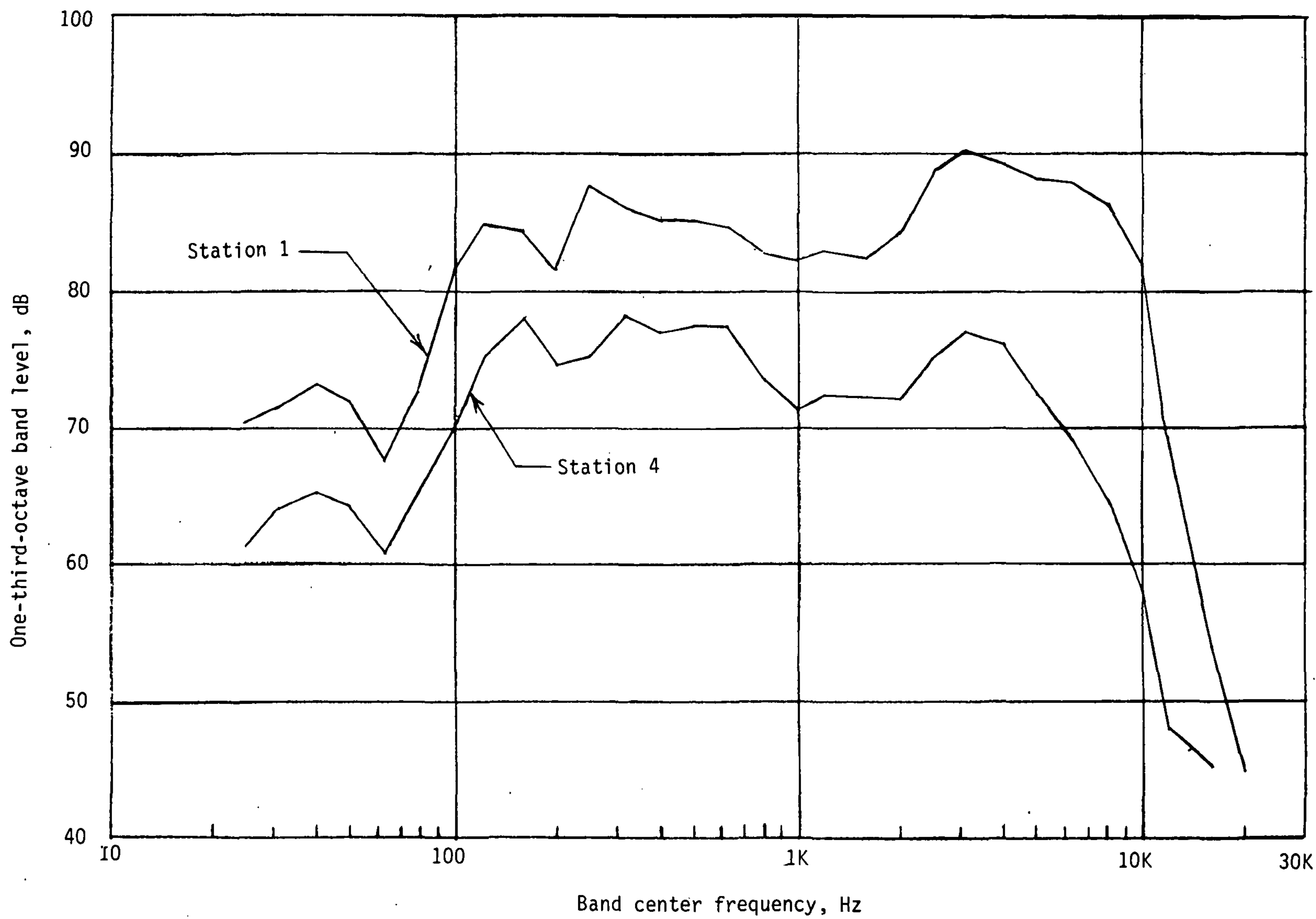


Figure 12.- One-third-octave band spectra at time of occurrence of $(L_{A,max})_{ref}$ as measured at stations 1 and 4 during run 3.1.5.

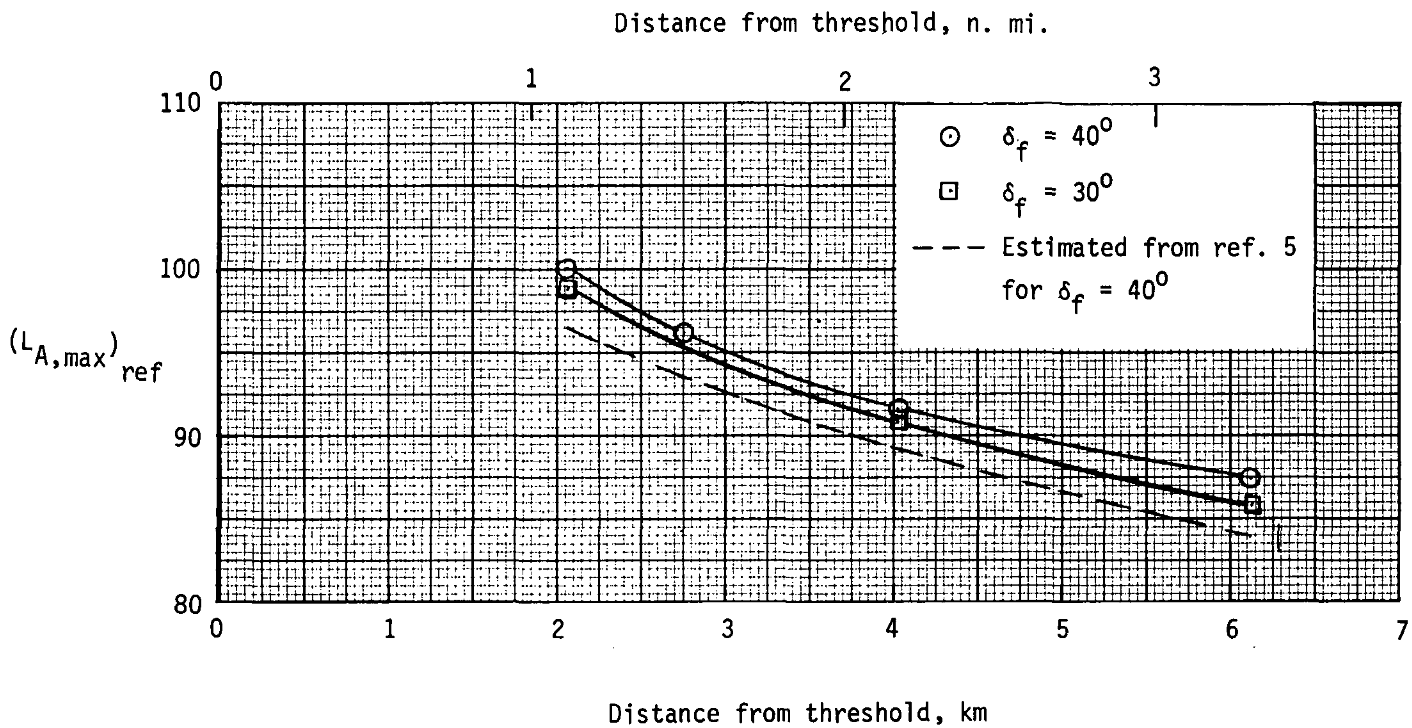
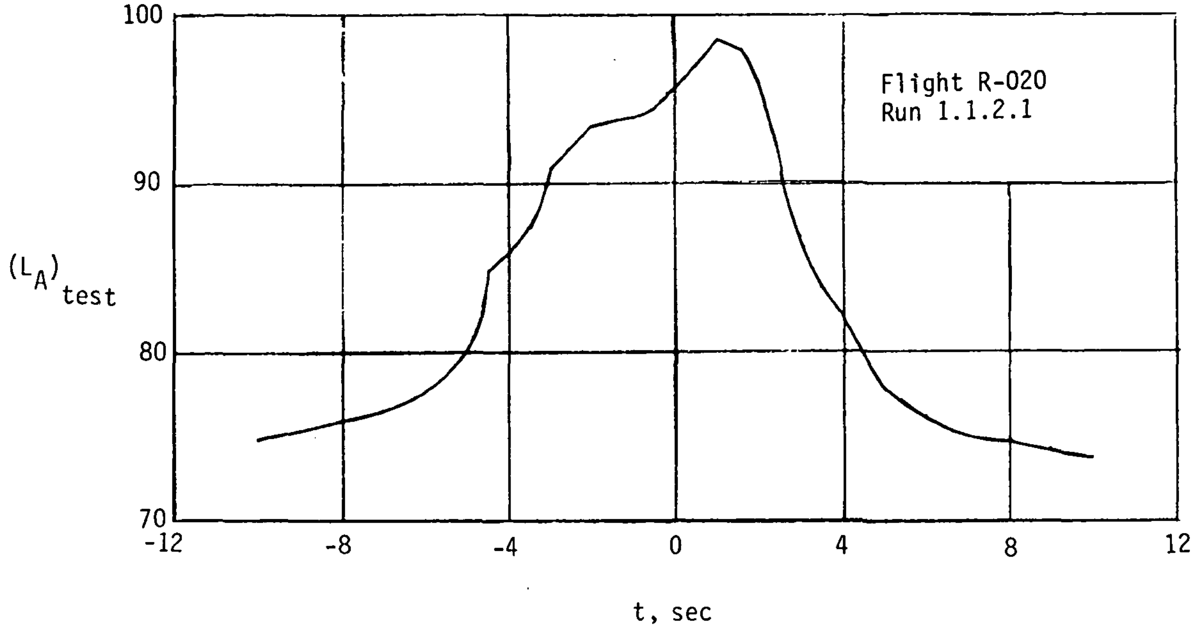
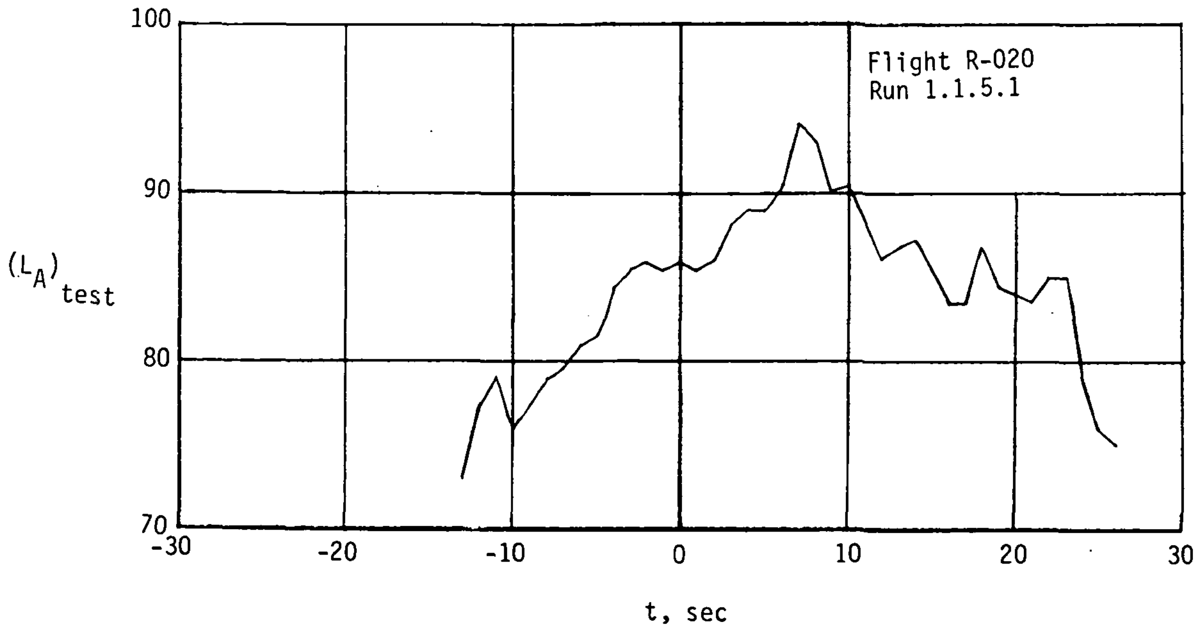


Figure 13.- Variation of $(L_{A,max})_{ref}$ with flap deflection and distance from threshold.



(a) Time history of flyover at 122 m (400 ft).



(b) Time history of flyover at 610 m (2000 ft).

Figure 14.- Typical $(L_A)_{test}$ histories for level flyover runs.

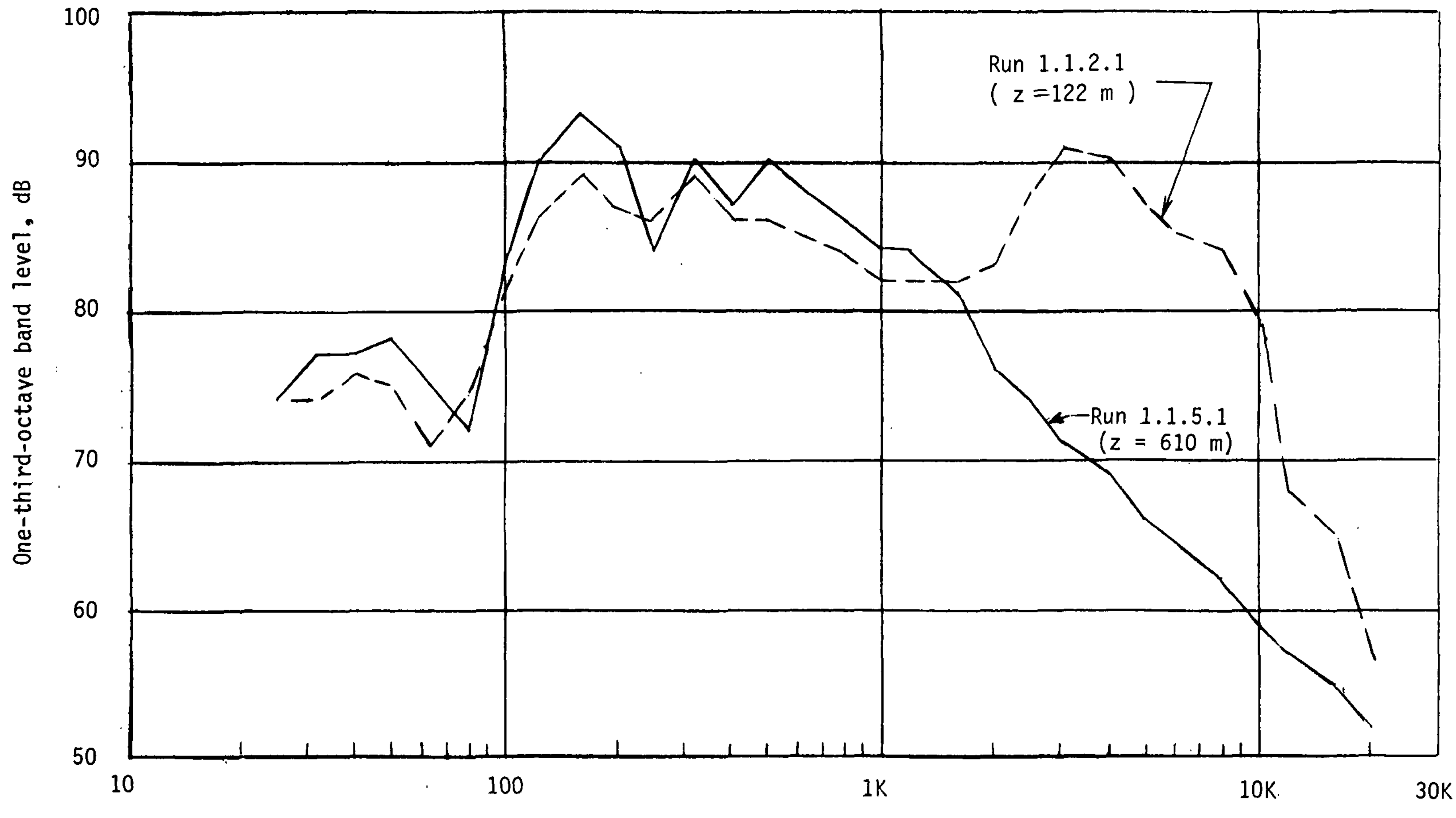


Figure 15.- One-third-octave band spectra at time of occurrence of $(L_{A,max})_{ref}$ as measured at station 5 during runs 1.1.2.1 and 1.1.5.1.

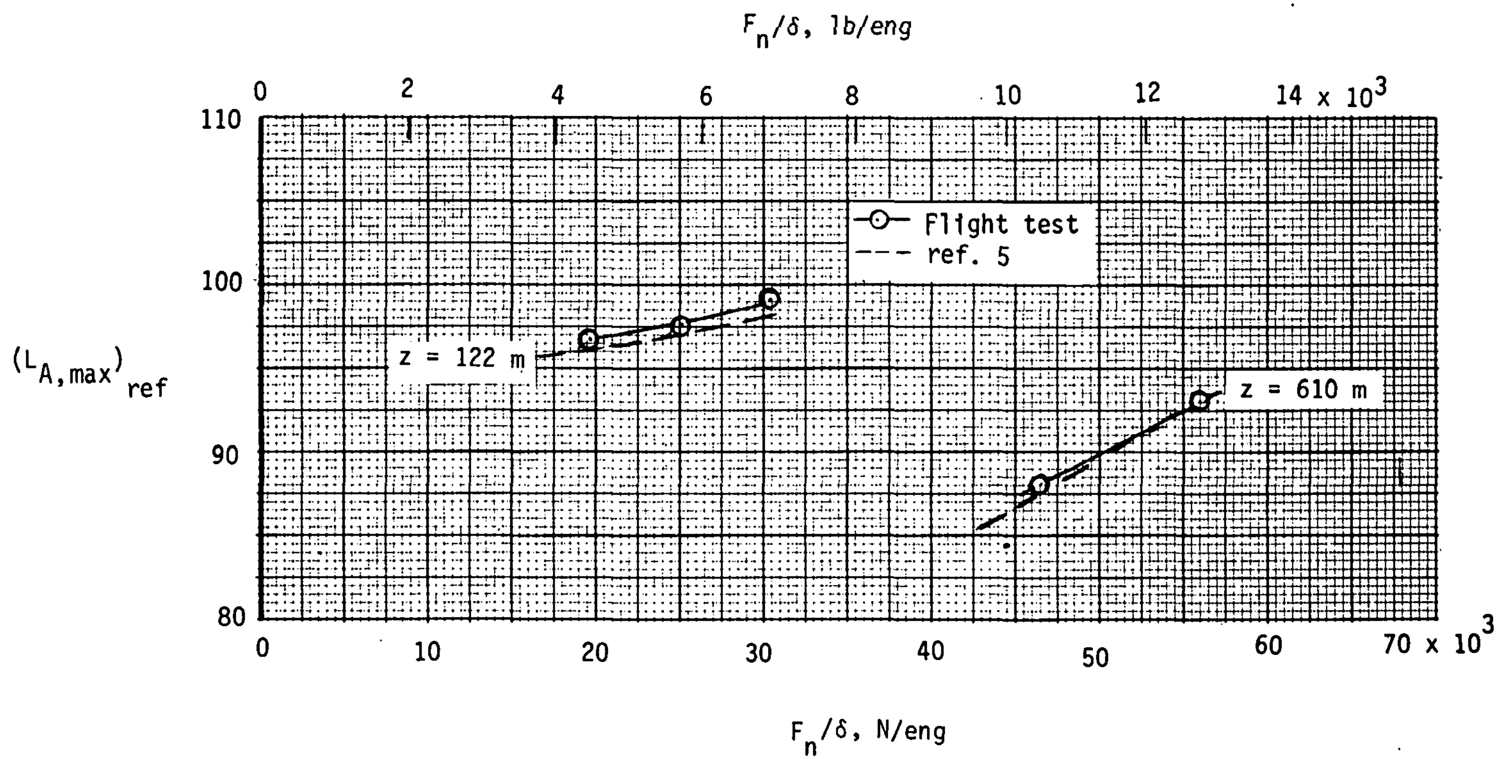


Figure 16.- Variation of $(L_{A,max})_{ref}$ with F_n/δ at altitudes of 122 m (400 ft) and 610 m (2000 ft).

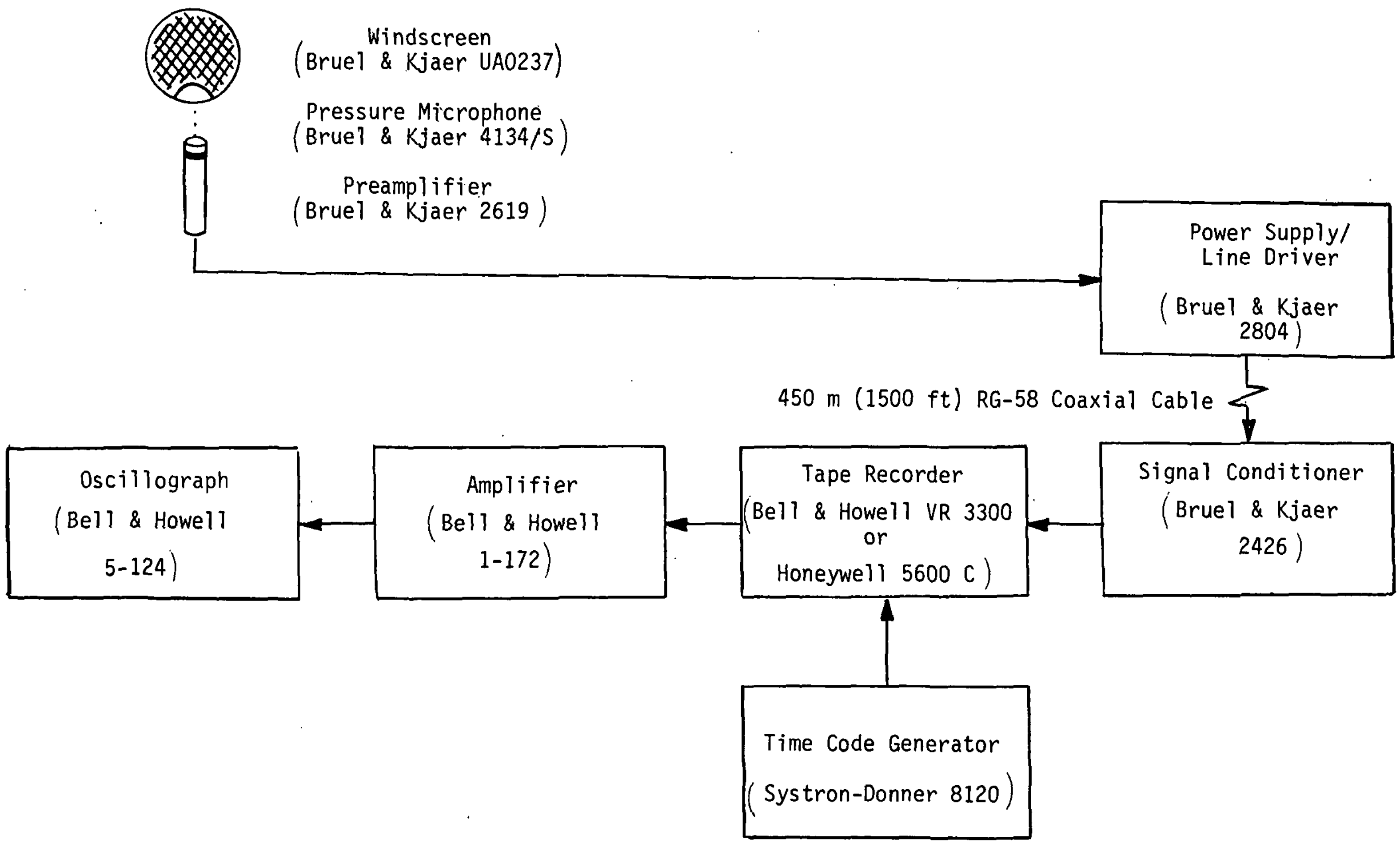


Figure 17.- Block diagram of noise instrumentation used for flyover measurements at Wallops Flight Center.

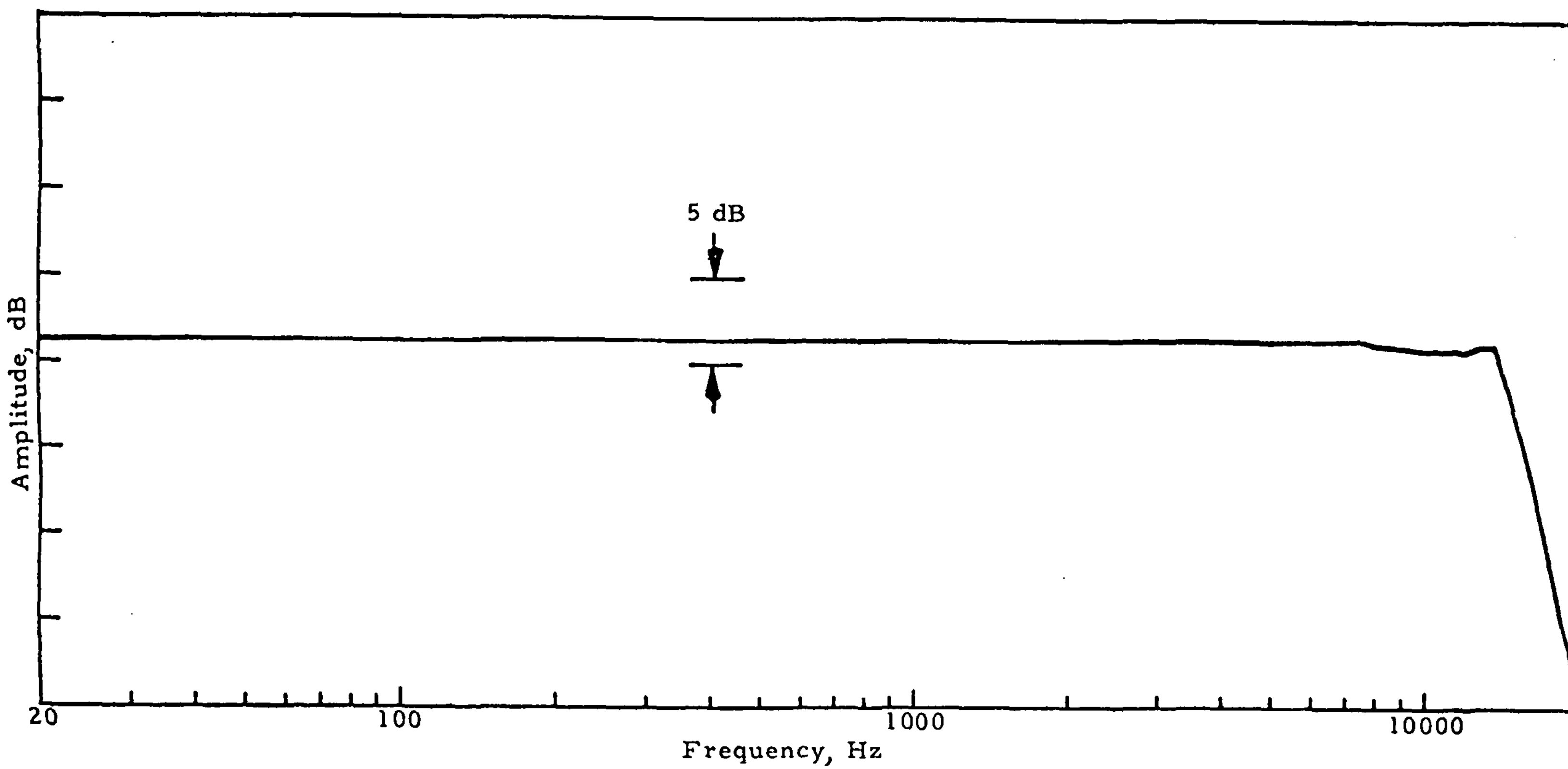


Figure 18.- Typical microphone channel frequency response.

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—NATIONAL AERONAUTICS AND SPACE ACT OF 1958

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