View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by NASA Technical Reports Server

NASA TECHNICAL MEMORANDUM

NASA TM X-62,423

NASA TM X-62,423

CORRELATION OF LOW SPEED WIND TUNNEL AND FLIGHT TEST DATA FOR V/STOL AIRCRAFT

Woodrow L. Cook and David H. Hickey

Ames Research Center
Moffett Field, Calif. 94035

April 1975

(NASA-TM-X-62423) CORRELATION OF LOW SPEED WIND TUNNEL AND FLIGHT TEST DATA FOR V/STOL AIRCRAFT (NASA) 13 p HC $3.25 CSCL 01C

N75-23557

Unclas
G3/05 21877

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
TM X-62,423		

4. Title and Subtitle	5. Report Date
CORRELATION OF LOW SPEED WIND TUNNEL AND FLIGHT TEST DATA FOR V/STOL AIRCRAFT	
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Woodrow L. Cook and David H. Hickey	A-5998
9. Performing Organization Name and Address	10. Work Unit No.
Ames Research Center Moffett Field, Calif. 94035	514-54
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
National Aeronautics and Space Administration Washington, D. C. 20546	Technical Memorandum
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

The availability of wind tunnel test data for correlation purposes of the same V/STOL aircraft tested in flight is very limited. This is due in a large part to size limitations of wind tunnels and the number of wind tunnels available for testing of full-scale aircraft.

The NASA Ames Research Center has tested two research aircraft — the XV-5B fan-in-wing aircraft and the YOV-10 RCF rotating cylinder flap aircraft — in the Ames 40- by 80-Foot Wind Tunnel. The tests were conducted specifically to provide for correlation between wind tunnel and in-flight aerodynamics and noise test data. Correlation between aerodynamic and noise data are presented and testing techniques that are related to the accuracy of the data, or that might affect the correlations, are discussed.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Aircraft design, Testing Performance Noise	Unclassified — Unlimited STAR Category 05

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified	13	$3..5

*For sale by the National Technical Information Service, Springfield, Virginia 22151

CORRELATION OF LOW SPEED WIND TUNNEL AND FLIGHT TEST DATA FOR V/STOL AIRCRAFT

by Woodrow L. Cook and David H. Hickey
Ames Research Center, NASA
Moffett Field, California 94035

SUMMARY

The availability of wind tunnel test data for correlation purposes of the same V/STOL aircraft tested in flight is very limited. This is due in a large part to size limitations of wind tunnels and the number of wind tunnels available for testing of full-scale aircraft.

Since the AGARD meeting at Rome in 1965 the NASA Ames Research Center has tested two additional research aircraft – the XV-5B fan-in-wing aircraft and the YOV-10 RCF (rotating cylinder flap) aircraft – in the Ames 40- by 80-Foot Wind Tunnel. The tests were conducted specifically to provide for correlation between wind tunnel and in-flight aerodynamics and noise test data. Correlation between aerodynamic and noise data are presented and testing techniques that are related to the accuracy of the data, or that might affect the correlations, are discussed.

NOMENCLATURE

A_L	area of V/STOL lifting element, $n(\pi D_L^2/4)$	PNdB	perceived noise level (PNL), dB
A_M	momentum area of aircraft, $\pi b^2/4$	q	dynamic pressure
A_T	wind tunnel cross-section area	S	wing area
a	acceleration, g	T	fan or propeller thrust
b	wing span	V	velocity
b_t	tunnel width	v	relative jet velocity, $V_j - V$
C_D	drag coefficient, D/qs	W_F	aircraft weight
C_L	lift coefficient, L/qs	α	angle of attack, deg
D	aircraft drag	β_V	fan louver vector angle, deg
D_L	diameter of lifting element, fans or propellers	γ	aircraft flight path angle, deg
L	lift	δ_e	elevator deflection
ND	aircraft nose down	δ_f	flap deflection
NU	aircraft nose up	θ	aircraft angle to horizon, deg
n	number of fans or propellers	SPL	sound pressure level

Subscripts

a	aerodynamic	n	normal
e	elevator	R	relative to free stream velocity
F	flight aircraft	T	wind tunnel
f	flaps	V	fan louver
j	jet	x	horizontal
M	momentum		

1. INTRODUCTION

At the Rome AGARD Flight Mechanics Panel Meeting in September 1965, a paper (ref. 1) was presented reporting the correlation of wind tunnel aerodynamic test data with flight test data for several V/STOL aircraft. Four of the aircraft were tested both in the Ames 40- by 80-Foot Wind Tunnel and in flight. More recently, additional specific data have been obtained in flight tests of the XV-5B fan-in-wing aircraft (Fig. 1) and the YOV-10 RCF (rotating cylinder flap) STOL aircraft (Fig. 2). The specific aerodynamic data test points simulating level flight and decelerating, descending flight conditions for the two aircraft were also obtained in the 40- by 80-foot wind tunnel over the low speed range for correlation with similar flight test points. This approach reduced the interpolation of the data and the reliance on parametric information for correlation purposes. Measurements have also been made of the noise characteristics of the XV-5B and YOV-10 RCF aircraft and correlated with noise data measured in the wind tunnel at the same flight conditions of speed, attitude, power, and fan louver settings or propeller pitch settings.

The correlation of noise measurements made with a J-85 engine mounted on a F-106 aircraft during low altitude flyovers with the same J-85 engine mounted on a model and tested in the Ames 40- by 80-Foot Wind Tunnel are also reported.

2. COMPARISONS OF AERODYNAMIC DATA

Table I shows some of the characteristic features of the XV-5B and YOV-10 RCF aircraft, reported in refs. 2, 3 and 4. Tip turbine driven 1.1-pressure-ratio fans were utilized in the XV-5B wings with each fan providing approximately 6800 lb (3090 kg) of thrust. The YOV-10 RCF aircraft was operated in landing approach up to lift coefficients of about 4.3. The trailing edge flaps had four 12-in. (0.305 m) diameter rotating cylinders mounted at the forward edge of the flaps and driven by hydraulic turbines at the end of each of the four cylinder sections at speeds of 7500 RPM. In general, the XV-5B approaches were flown at

$\gamma = -10°$ and started at about 80 knots decelerating to hover conditions and vertical landing. The YOV-10 RCF aircraft approaches were at constant speed for a range of speeds from 55 to 75 knots with approach angles varying from 3° to about 8°.

<u>XV-5B V/STOL Fan-In-Wing Aircraft</u>: The XV-5B aircraft was mounted in the 40- by 80-foot wind tunnel in the conventional manner with a tail strut support as shown in Fig. 3. Wind tunnel measurements were made of specific flight test points for steady, level flight, 1 g conditions, and for decelerating flight at 10° descent angle. The results of the wind tunnel tests, compared to flight test results for several level flight indicated air speed conditions, are shown in Fig. 4, where aircraft power, angle of attack, and louver angle were set at the same values as during flight test. Longitudinal control was then set to the necessary position for trimmed moment conditions in the wind tunnel resulting in a measured total lift and drag of the aircraft. Good correlation of stick position for trim conditions was obtained. The results also indicate that the lift in the wind tunnel for the lower speeds, 30 to 70 knots, was within 1 percent of the flight values of weight. However, at 85 knots the wind tunnel lift was measured at a value 4.7 percent greater than that obtained from the flight test results, perhaps partially due to a known problem with one of the lift recording systems. This discrepancy is equivalent to a difference in angle of attack of 1.2° and is within the accuracy expected from ref. 1. The result is not surprising because the aerodynamic lift is a relatively small portion of the total lift value (5% at 30 knots and 36% at 86 knots); thus the lift is relatively insensitive to errors in angle of attack. The same may be said for longitudinal control, because even at 85 knots a major portion of the longitudinal control is provided by the reaction controls.

In Fig. 5 the wind tunnel and flight test data for the XV-5B in decelerating, descending flight at $\gamma = -10°$, are compared. Comparisons are shown for longitudinal control stick position, normal and axial acceleration for the aircraft having the same power conditions, fan exit louver angles, and angle of attack. For these data the aircraft axis was approximately parallel to the flight path and the aerodynamic lift coefficient was about 0.5. A similar comparison is shown in Fig. 6 with the aircraft axis approximately horizontal during decelerating approaches at $\gamma = -10°$. The aerodynamic lift coefficient was about 1.2 for the latter approach condition. Good correlation is shown for stick position and normal acceleration with the aircraft deck parallel to the flight path; however, the axial deceleration values measured in the wind tunnel are 0.05 to 0.1 g less, (the greater differences occurring at higher forward speeds) than those obtained in flight test for the same power and louver angle conditions. Some of this difference may be due to the inability to determine strut interference effects which would have a larger effect on the aerodynamic drag at the high forward velocities. The wind tunnel support struts were directly in front of the XV-5B landing gear and, hence, could have reduced the gear drag and accounted for part of the deceleration value differences. Better correlation was obtained with the aircraft deck parallel to the flight path and with lower aerodynamic lift coefficient than with the aircraft deck horizontal during the descending flight tests. Normal and horizontal deceleration values measured in the wind tunnel differed by as much as 0.15 g from the flight test results for the latter condition.

At the lower transition speed range, the differences between the acceleration values measured in the wind tunnel and flight tests are equivalent to less than 2° louver deflection angle for comparable deceleration values; J-85 engine speeds must be 0.5 percent and 2.0 percent less for comparable normal acceleration values in the wind tunnel for deck parallel and deck horizontal approach conditions, respectively. However, at forward velocities above 55 knots, where the differences in acceleration are greater, the louver angles in the wind tunnel must be 9° and 7° more vertical to obtain comparable deceleration values; J-85 engine speeds must be 2 percent and 8 percent less for comparable normal acceleration values for the deck parallel and deck horizontal approach conditions, respectively.

<u>YOV-10 RCF STOL Research Aircraft:</u> The YOV-10 aircraft mounted in the Ames 40- by 80-Foot Wind Tunnel on two separate mounting systems is shown in Figs. 7 and 8. The mounting system shown in Fig. 7 was used prior to the flight test, primarily for functional check out, under air load, of such systems as the rotating cylinder flaps, modified propeller, and interconnect systems with the Lycoming T-53 engines. The strut system shown in Fig. 8 was used specifically for the flight and wind tunnel test data correlation.

As shown in Fig. 7, the tail strut is mounted on the lower surface of the horizontal tail, fairly close to the quarter-chord point, and could have caused an adverse disturbance in the flow field on the lifting side of the tail where high negative pressure gradients exist. The horizontal tail elevator setting requirements for trim are shown in Fig. 9 for both the flight results and the tests with the aircraft mounted on the two strut systems. As shown, the wind tunnel test data taken with the strut interference effects on the horizontal tail shows large differences in elevator requirements for longitudinal trim and in static stability compared to flight test results; on the other hand, elevator requirements for longitudinal trim and static stability using the noninterference strut location show close correlation with flight test results. The flight test data indicate elevator requirements for trim that fall between uncorrected wind tunnel data and wind tunnel data incorporating conventional wind tunnel wall corrections.

ORIGINAL PAGE IS
OF POOR QUALITY

The lift, drag and angle of attack based on $\alpha = \theta - \gamma$ for given conditions of steady flight and propeller thrust are shown in Fig. 10 for flight test and wind tunnel results. Good correlation is shown with the noninterference struts; although not shown, good correlation was also obtained with the tail strut mounted at the horizontal tail for all parameters except the previously discussed longitudinal control and static longitudinal stability. Introducing conventional tunnel wall correction appears to over correct the data when it is compared with flight test results. Correlation between flight and wind tunnel test data for lift coefficient and angle of attack was quite good when angle of attack was determined from aircraft attitude, θ (measured with an Attitude/Heading Reference System) and calculated flight path angle, γ. (This technique was also used for the XV-5B and the data in ref. 1.) However, as shown in Fig. 11, the angle of attack, α, measured by the vane on the nose boom, was approximately 6° higher than the angle determined by the $\theta - \gamma$ method; the difference was due to the high upwash effects on the vane at these high lift coefficients. The angle of attack vane was located 2.13 chord lengths forward of the wing leading edge and 0.47 chord lengths below the wing chord plane.

<u>Wind Tunnel Test Parameters for V/STOL</u>: Wind tunnel sizing parameters for testing V/STOL aircraft or models, Fig. 12, were suggested in ref. 1 for unaccelerated flight conditions. The XV-5B and YOV-10 aircraft

were sized within the test parameters shown in the figure. The size of the aircraft, span to tunnel width, the lifting element area, and the momentum area parameters appear to be reasonable based on the correlation results for level flight test conditions of these types of V/STOL aircraft in the 40- by 80-foot wind tunnel. Although the measurements made for decelerating, descending flight were less conclusive, it appears that if all factors (such as strut interference drag effects) could be accurately accounted for, fairly good prediction of flight path descent angle, power requirement, deceleration, and vectoring requirement could be made from wind tunnel test results with models sized within the parameters outlined in ref. 1.

3. COMPARISON OF ACOUSTIC MEASUREMENTS

Because of a forward speed effect on the generation of the noise, correlation of noise data from a static test stand with flight test data is often poor. Fig. 13 illustrates some of the possible forward velocity effects. Although some acoustic research can be carried on in flight, the environment is relatively uncontrolled, data samples are necessarily short, and the testing is expensive. Furthermore, diagnostic studies of the effect of velocity on the noise source are extremely difficult. For these reasons, Ames has concentrated on developing techniques for measuring noise in the 40- by 80-foot wind tunnel. Of course, the final proof of these techniques is a comparison of noise measurements made in the wind tunnel with those measured in flight. This section of the paper will briefly describe the technique used for measuring noise in a wind tunnel, and will then present comparisons of noise data obtained in wind tunnel tests with those obtained in flight tests for both fan-powered and jet-powered flight of the XV-5B aircraft, and the YOV-10 RCF aircraft. Results of a joint program with Lewis Research Center are also presented. Noise measurements in a wind tunnel may be contaminated by the reverberant sound field and the background noise. These problems are discussed independently although solutions for one problem may alleviate the other.

The wind tunnel is semireverberant in that the sound energy flows out of the test section from the upstream and downstream end. The resultant propagation of noise in the test section is shown in Fig. 14 as the change in sound pressure level as a function of distance. In the free field, the sound pressure level drops 6 dB per doubling of distance. In the test section, however, the noise approaches a constant value at some distance from the source because the reverberation signal is added to the direct signal. The final level and distance from the source is dependent on the frequency as shown in the figure, and also on the direction. To obtain free field measurements in this environment, it is necessary to subtract the reverberant field strength from the measurement.

The reverberant field strength is determined by a calibration procedure which is illustrated in Fig. 15. The characteristics of a source, depicted by the loudspeaker in the figure, are measured in an anechoic chamber, or outside, to determine the free field characteristics. The source is then placed in the wind tunnel test section, where its characteristics are again measured. The increment between these two measurements is the strength of the reverberant field. This increment is subtracted from the wind tunnel data on a 1/3 octave band basis. For compact noise sources, a speaker can usually be used in the determination of the reverberation correction; however, for extended sources, such as supersonic jets, the correction can best be determined by deriving the corrections using the actual source to be measured. The wind tunnel, struts, and microphone mounts all contribute background noise, which for simple measurements must be less than the noise from the source being studied. For no significant background noise contribution, 10 dB separation is required, while data with greater than 3 dB separation can be corrected. All data used in this paper were sufficiently above the background noise level of the wind tunnel to extract the data. Where the background level is too high for conventional measurements, a phased microphone array (ref. 5) can be used to extract the noise being measured from the background noise. Wind tunnel data used in the following comparisons was corrected for reverberations as previously described. In addition, some of the data in the F-106 jet noise comparison were corrected for background and near-field effects. The effect of measurements in the near field was obtained by subtracting a noise increment from the data that were derived from a comparison of near-field and far-field data from the static test stand.

Flight test data have been corrected for ground reflections and, where necessary, the doppler shift. The treatment for different measuring distances varies with the particular test and is described in each case.

Comparison of Noise-Data XV-5B Aircraft: Noise was measured in the wind tunnel and in flight for the XV-5B flying in both the fan-powered and jet-powered flight modes. Flight noise data were corrected to the microphone distance for the wind tunnel noise measurements. Figs. 16 through 18 show spectra from wind tunnel and flight for the XV-5B in the fan-powered mode at an airspeed of 70 knots. In Fig. 16 the microphone was far ahead of the aircraft. The spectra agree within ± 3 dB across the spectrum and overall sound pressure level agrees within 1.7 dB. The main cause of this discrepancy is a 2 dB discrepancy at the fan fundamental tone. The microphone for the data in Fig. 17 is also ahead of the aircraft, just forward of the nose. Again, the spectra agree within ± 3 dB, but the overall sound pressure level is within 0.7 dB. The data in Fig. 18 are from a microphone behind the aircraft. In this case, the spectra are in good agreement to 1600 Hz; however, the fan tone in the wind tunnel was 5 dB higher than in flight, and the wind tunnel measurements at high frequency were consistently above the flight measurement. In assessing the shape of the spectra and comparing with the other two microphone positions, it appears probable that the flight measurements of blade passing frequency, SPL, are in error rather than the wind tunnel measurements. In any case, the wind tunnel noise measurements give a good representation of the flight measurements for the XV-5B in fan-powered flight.

Figure 19 shows the noise spectra for the XV-5B in jet-powered flight. These data were reported in ref. 6. In this case, the noise was predominantly broadband in nature. The spectra shown agree within ± 3 dB, which was also the accuracy of the spectra for all of the measuring positions. In terms of overall sound pressure level and perceived noise level the wind tunnel and flight measurements agreed within 1 dB.

Comparison of Noise Data - YOV-10 RCF Aircraft: During the wind tunnel tests on the YOV-10 RCF aircraft, noise was measured and then compared with flight tests. Figure 20 shows noise spectra from the wind tunnel and flight test for a microphone directly under the nose of the aircraft. The data have been corrected to the microphone distance of 19 ft (5.8 m) the distance of the wind tunnel measurements for this comparison. The spectra agree very well, both for the blade passing frequency components and the broad band components.

There does appear to be a problem at 10,000 Hz that may be caused by excessive line length for the flight test measurement setup. As shown in ref. 6, this good agreement was typical for all microphone locations.

The overall FAR-36 takeoff and landing noise levels for the YOV-10 RCF aircraft are very low. During takeoff, 3.5 nautical miles from start of ground roll, the noise level was less than 83 PNdB and during landing approach, with a descent angle of 8°, the noise directly beneath the aircraft at distance of 1 nautical mile from touchdown was about 88 PNdB. This is partially due to the steep gradient STOL performance capability of the aircraft, but in large part is due to the low tip speed of the reduced diameter propellers.

Exhaust Suppressor Measurements J-85 Engine: Although not directly related to V/STOL, a comparison of wind tunnel and flight measurements of noise of exhaust suppressors provides further information on the question of whether ground-based facilities can be used to evaluate flight noise signatures. For some time, Lewis Research has studied the effectiveness of mixer-suppressor exhaust nozzles in flight using the F-106 as the test bed (Fig. 21). A nacelle with a J-85 jet engine and appropriate suppressor hardware was mounted underneath the wing. The aircraft was then flown over a noise test range at 300 ft altitude with the primary power plant throttled back as much as possible.

The same nacelle, with the J-85 engine, and some of the same mixer-suppressor nozzles were tested in the 40- by 80-foot wind tunnel (ref. 7). The nacelle was mounted under the wing of a 3/4 scale model of the F-15 (Fig. 22) to simulate the installation effects. In order to maximize signal-to-noise ratio for the quieter suppressors, the microphones were at a 13-ft (3.96 m) sideline distance from the jet. The effect of measuring in the near field was corrected by an amount determined in outdoor static tests. The wind tunnel data was extrapolated to a 300-ft (91.5 m) sideline for the comparison. In these cases, spectra from the flight data were not always available, so the comparison is of perceived noise level.

Figure 23 shows the results for a conical ejector nozzle. Wind tunnel and flight test data agree within ±2 dB except for the rear-most angle. Figure 24 shows results for a 104 tube nozzle where the wind tunnel and flight test data agree within ±1 dB. Finally, figure 25 shows data for the 104 tube nozzle with an acoustic shroud which shows agreement within ±2 dB. It should be noted that the data for 104 tube nozzle without suppressors was not available at some angles from the wind tunnel tests because the background noise level was too high. Thus the background noise level of the facility can seriously limit the data obtained. Use of a phased microphone array described in ref. 5 would have solved this problem.

4. CONCLUDING REMARKS

Further correlations between wind tunnel and flight test data for aircraft have tended to confirm the model-to-wind tunnel size ratios suggested in ref. 1 for V/STOL testing with small wall corrections. As was emphasized in ref. 1, these limits apply only for level, unaccelerated flight at speeds above 30 knots. Indications are that for descending/decelerating flight of $\gamma = -10°$ and 0.2g, the data will be useful, but normal and axial accelerations may be in error.

Correlation of noise measured in the wind tunnel with that measured in flight was generally good, indicating that large wind tunnels can be used to make meaningful noise measurements at forward speed.

ACKNOWLEDGEMENTS: The authors wish to thank those staff members of the Large Scale Aerodynamics Branch, Research Aircraft Projects Office, and the Flight and Systems Research Branch at the NASA Ames Research Center who conducted the necessary tests and assisted in collecting the data presented in this paper.

REFERENCES

1. Hickey, David H. and Cook, Woodrow L.: Comparison of Wind Tunnel and Flight Test Aerodynamic Data in the Transition Flight Speed Range for Five V/STOL Aircraft. AGARD Report 520, 1965 (Also available in Conference on V/STOL and STOL Aircraft, NASA SP 116, 1966).

2. Gerdes, Ronald M. and Hynes, Charles S.: Factors Affecting Handling Qualities of a Lift-Fan Aircraft During Steep Terminal Area Approaches. Presented at the 27th Annual National V/STOL Forum of the American Helicopter Society. May 1971.

3. Cichy, D. R.; Harris, J. W. and Mackay, J. K.: Flight Tests of a Rotating Cylinder Flap on a North American YOV 10 Aircraft. NASA CR 2135, November 1972.

4. Weiberg, J. A.; Giulianetti, D.; Gambucci, B. and Innis, R. C.: Takeoff and Landing Performance and Noise Measurements of a Deflected Slipstream STOL Airplane with Interconnected Propellers and Rotating Cylinder Flaps. NASA TMX 62,320, December 1973.

5. Soderman, Paul T. and Nobel, Stephen C.: A Directional Microphone Array for Acoustic Studies of Wind Tunnel Models. AIAA Paper 74-640, July, 1974.

6. Atencio, Adolph, Jr. and Soderman, Paul T.: Comparison of Aircraft Noise Measured in Flight Test and in the NASA Ames 40- by 80-Foot Wind Tunnel. AIAA Paper 73-1047, October 1973.

7. Beulke, M. R.; Clapper, W. S.; McCann, E. O. and Morozumi, A. M.: A Forward Speed Effects Study of Jet Noise From Several Suppressor Nozzles in the NASA/Ames 40- by 80-Foot Wind Tunnel. NASA CR-114741, 1974.

Table 1. – Research Aircraft Characteristics

CHARACTERISTICS	XV-5B	YOV-10 RCF
Gross weight, lb (kg)	12,100 (5500)	11,700 (5320)
Wing area, ft^2 (m^2)	260.3 (24.17)	244 (22.67)
Wing span, ft (m)	29.8 (9.07)	34.0 (10.36)
Fan or propellor diameter, ft (m)	5.16/3.0* (1.574)/(0.915)	9.42 (2.87)
T/W ratio, uninstalled	1.25(total)	0.45
Fan pressure ratio	1.1	-
Rotating cylinder, RPM/HP diameter, ft (m)	-	7500/30 1.0 (0.305)
Approach velocity, knots	100 → 0 Decelerating	57.0
Approach C_L	V/STOL	4.3
Approach γ, deg	-10 to -20	-3 to -8
Sideline Noise Level, PNdB (500 ft (152.5 m))		
Takeoff	113	99
Landing	112	93

*Wing Fan/Nose Fan Diameters

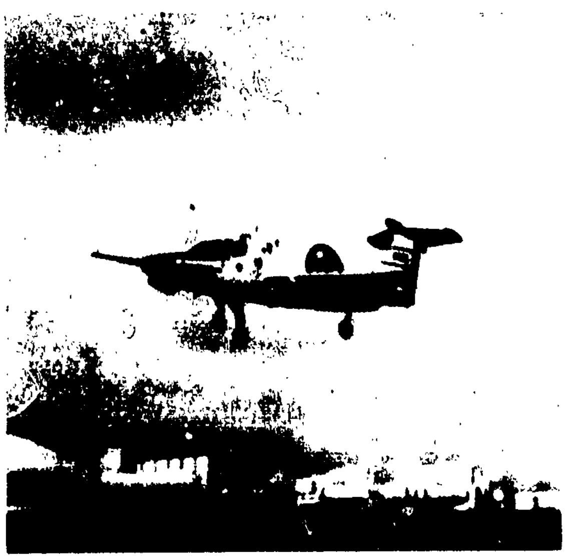

Fig. 1 XV-5B fan-in-wing aircraft in flight test

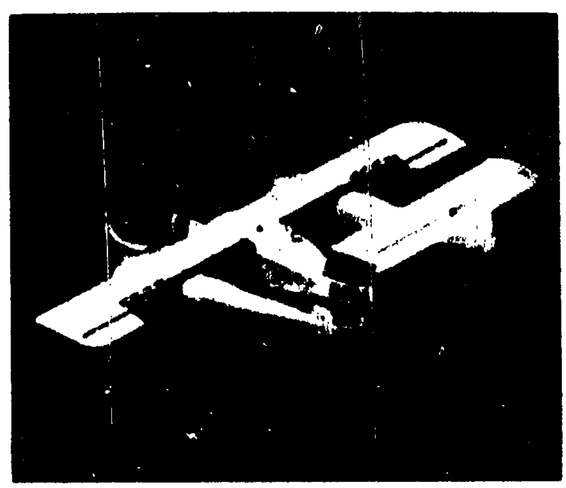

Fig. 2 YOV-10 RCF Aircraft in flight test

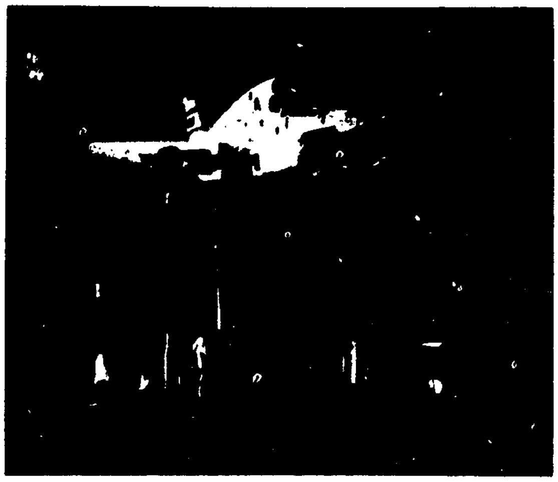

Fig. 3 XV-5B Fan-in-wing aircraft mounted in Ames 40x80-Foot Wind Tunnel

Fig. 5 Comparison of XV-5B decelerating, descent, γ = -10° data for aircraft deck parallel to flight path. (C_{L_d} = 0.5)

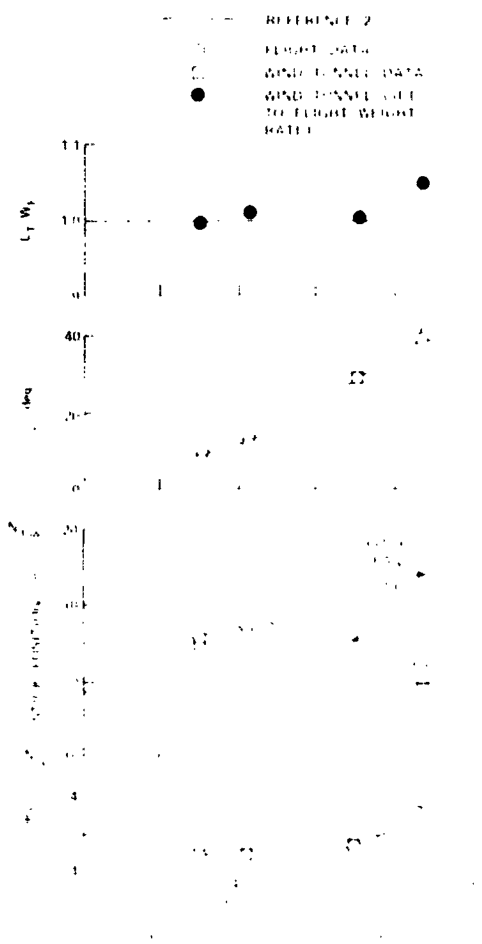

Fig. 4 [illegible]

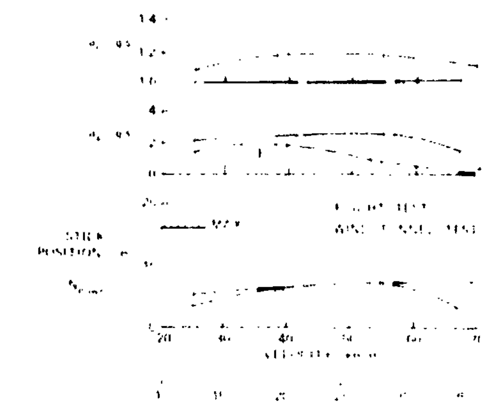

Fig. 6 Comparison of XV-5B decelerating, descent, γ = -10° data, for aircraft deck horizontal [illegible]

[illegible]

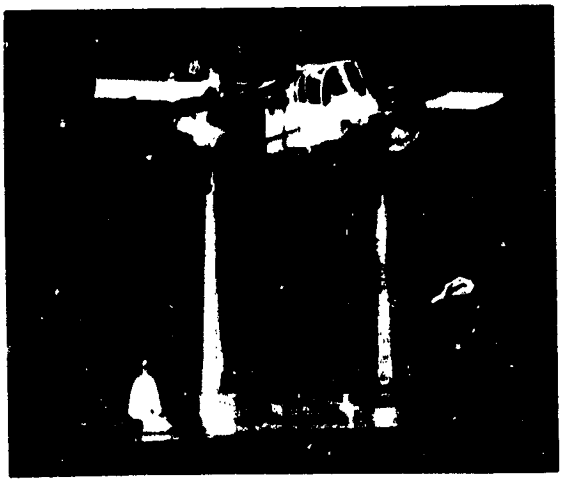

Fig. 8 YOV-10 RCF aircraft in the Ames 40X80-Foot Wind Tunnel with strut mounted at forward fuselage

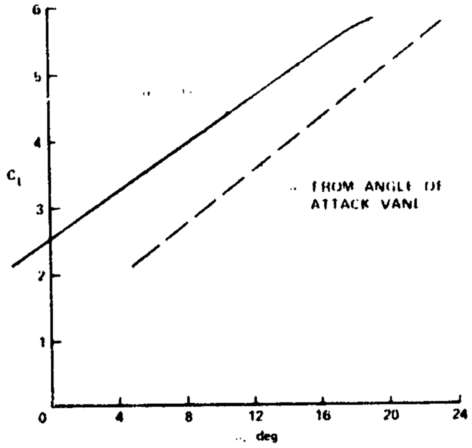

Fig. 11 YOV-10 RCF STOL aircraft upwash effects on angle of attack vane. δ_f = 50/25

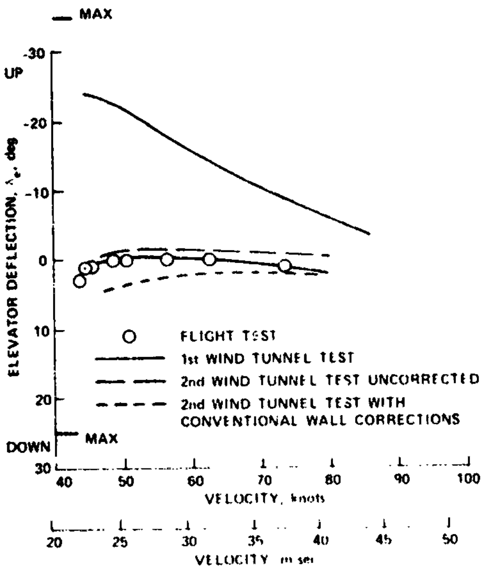

Fig. 9 Comparison of flight and wind tunnel measured elevator deflection for trim YOV-10 RCF aircraft, δ_f = 50/25

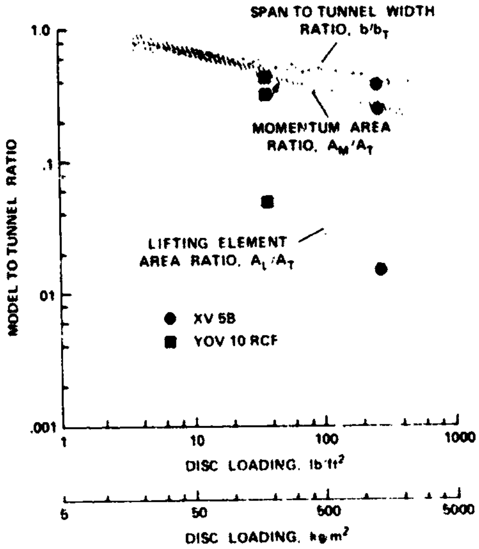

Fig. 12 Three model-to-wind-tunnel sizing parameters

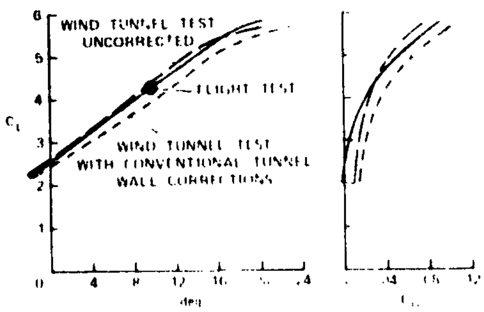

Fig. 10 Comparison of flight and wind tunnel measured lift and drag data for YOV-10 RCF aircraft, δ_f = 50/25

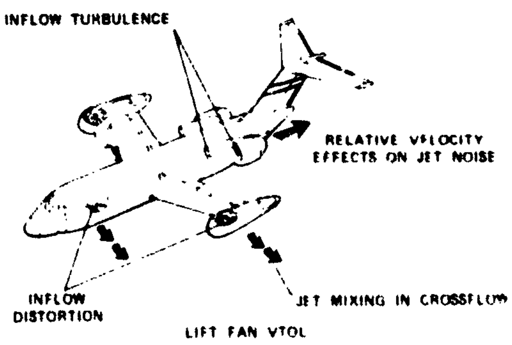

Fig. 13 Noise sources influenced by forward speed

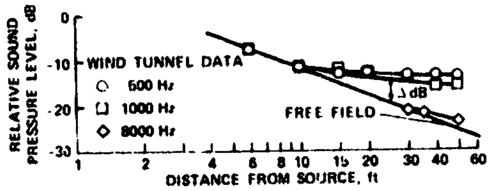

Fig. 14 Reverberant field measured in the 40-by 80-foot tunnel from an omnidirectional sound source

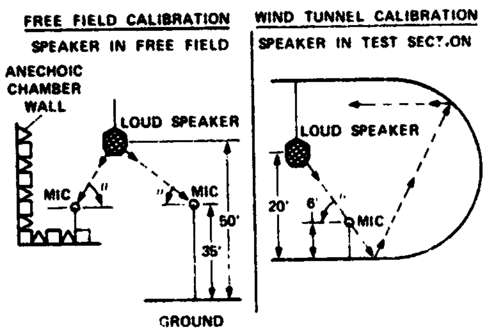

Fig. 15 Reverberation calibration

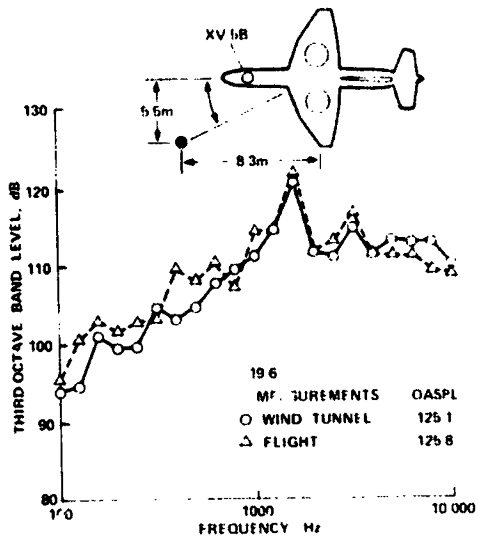

Fig. 17 Comparison of noise spectra in the wind tunnel and in flight for the XV-5B in fan powered flight, V = 70 knots

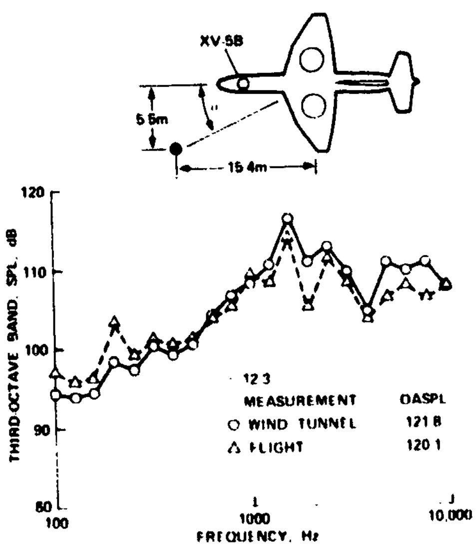

Fig. 16 Comparison of noise spectra in the wind tunnel and in flight for the XV-5B in fan powered flight, V = 70 knots

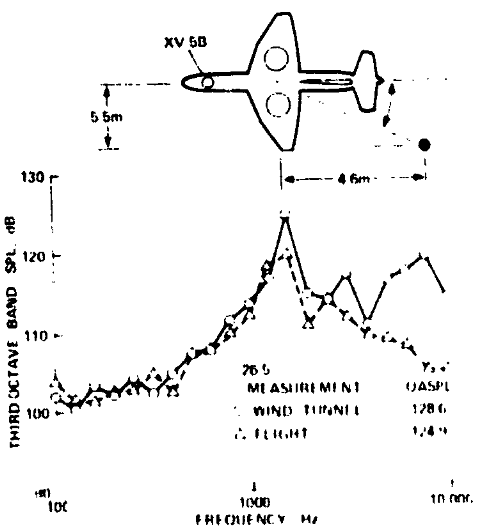

Fig. 18 Comparison of noise spectra in the wind tunnel and in flight for the XV-5B in fan powered flight, V = 70 knots

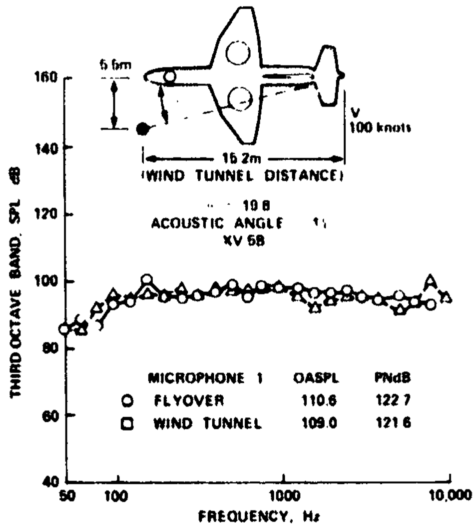

Fig. 19 Comparison of noise spectra in the wind tunnel and in flight for the XV-5B in jet powered flight

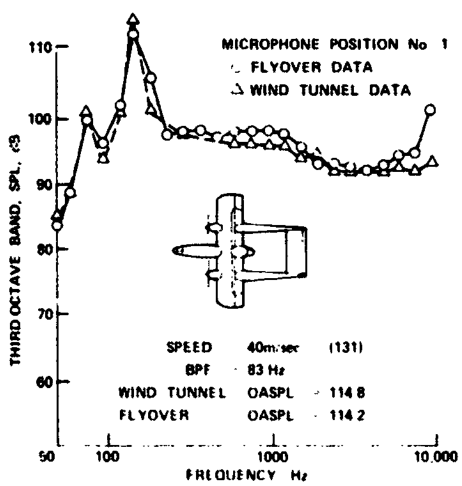

Fig. 20 Comparison of YOV-10 RCF aircraft noise data in flight and wind tunnel, δ_f = 30/15

Fig. 21 F-106 aircraft with J-85 engine mounted underneath wing

Fig. 22 J-85 engine mounted on large-scale F-15 model wing in the 40X80-foot wind tunnel

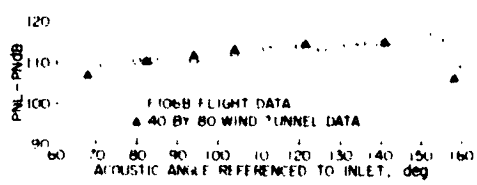

Fig. 23 Comparison of wind tunnel data with flight data for the conical ejector nozzle

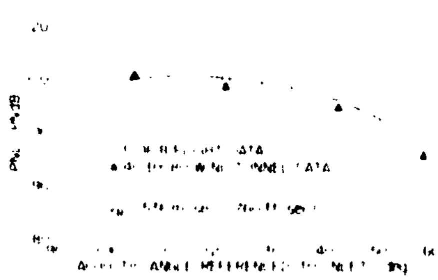

Fig. 24 Comparison of wind tunnel data with flight data for the 104 tube nozzle without acoustic shroud

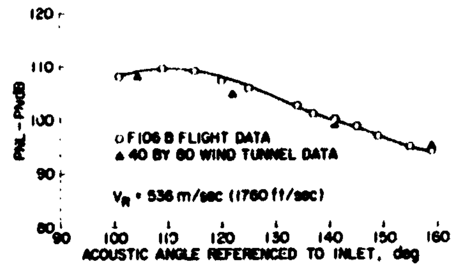

Fig. 25 Comparison of wind tunnel data with flight data for the 104 tube nozzle with acoustic shroud