WIND TUNNEL EVALUATION OF PITOT NOSE CONFIGURATIONS ON INDICATED AIRSPEED ACCURACY

March 30, 1974

INTRODUCTION The purpose of the investigation was to determine the most accurate pitot nose configuration for the velocity range of 25 to 200 knots at angles of attack or sideslip from zero to forty degrees (40°).

Four nose pieces were tested in the 32-inch by 45-inch Low Speed Wind Tunnel at the United States Naval Postgraduate School at Monterey, California. Results indicated that although all four configurations performed well at low angles of attack, marked differences occurred as the angles increased.

This report describes the nose configurations tested, the method of test, the test data and calculated results, the rationale for configuration selection, final test of the selected configuration and results of the final tests.

Tests show the nose configuration selected to be accurate within 0.75 knot at all angles of attack or sideslip up through 30° and at all velocities from 25 to 200 knots. Performance is well within the specifications and the boom is considered as meeting all contractual requirements.

SUMMARY AND CONCLUSIONS The purpose of this program was the modification and testing of the SpaceAge Control, Inc. 100510 air data boom.

Requirements were:

1. Redesign the static and pitot parts to provide an absolute accuracy of ±4 knots at 25 knots with a linear variation of ±2 knots at 200 knots at 0° angle of attack or sideslip.
2. Modify the pitot nose to a stainless steel tip rather than aluminum.
3. Perform verification testing and provide calibration data for the pitot-static section at airspeeds from 25 through 200 knots at 0° angle of attack or sideslip.

Four pitot-static nose sections were tested in evaluation runs in the wind tunnel. The most accurate of these was selected and complete verification and calibration testing was performed with the following results:

1. The static-pitot section selected demonstrated an accuracy within 0.75 knots of actual at all velocities from 25 through 200 knots and at all angles of attack or sideslip from 0° through ±30°.
2. The pitot tip was changed to stainless steel and the design modified to provide nose section balance and true airstream pointing at all velocities from 25 through 200 knots.
3. Verification testing and calibration testing showed in-tolerance performance at all required velocities and angles as discussed in this report.

TEST EQUIPMENT The evaluation and calibration tests were conducted at the United States Naval Postgraduate School in Monterey, California in the Aerolab 32-inch high by 45-inch wide (test section) wind tunnel. A schematic of the tunnel is shown in Figure 1. The tunnel is driven by an electric motor through a four-speed transmission connected to a variable pitch propeller. In operation, the appropriate gearing is selected and tunnel velocity is adjusted by varying propeller pitch. The tunnel is rated as a 200-mile-per-hour tunnel although drag produced by test objects and their mountings reduces the upper end velocity. This is particularly noticeable when "dirty" configurations, such as high angles of attack, are set up or after prolonged runs at high velocities have produced frictional heating and increased the tunnel temperatures.

The tunnel is equipped with a Prandtl type pitot tube in the head end of the test section as shown in Figure 1A. This is connected to a slant tube manometer reading in centimeters of water column to 0.01 cm. A test pitot (referred to as the test probe on data sheets) was mounted below and slightly ahead of the test boom. This was also a standard Prandtl type pitot and was used as a reference for the test boom since both were mounted in the approximate center of the test section.

Pressure tubes from the boom and the test probe were connected to water manometers as shown. Slant manometers on a 30° incline were used for low pressures and vertical manometers were used for pressure readings over 10 inches of water column.

Potentiometers on the boom vanes were connected to a 28 VDC power supply as shown in Figure 9. The potentiometer

center tap and wiper were connected to a vacuum tube voltmeter. Positive voltage indicated positive angle of attack or sideslip and negative voltage the opposite. Vane voltage readings were used only as a reference as all attack and sideslip angles were established by the protractor segment below the tunnel floor.

TEST PROCEDURE Four different nose configurations were selected for evaluation. Two were equipped with hemispherical noses and two with Kiel-type sharp-edged venturi tips. The noses are illustrated in Figure 8. The four noses were initially run with nose locks in place so that the universal nose was rigidly aligned with the boom body. The boom assembly was then installed on the test fixture in the tunnel.

The test fixture was designed so it could be rotated (about a vertical axis) while the tunnel was in operation. The rotational axis was approximately at the mid-point of the universal nose so that the nose assembly remained in the center of the tunnel regardless of the angle of attack. A protractor segment was used to change the angle of attack from 0° to ±45°. The test probe was directly below and ahead of the boom. The two screws at the rear of the boom were used to vertically align the boom with the tunnel flow direction. Note that the angle of attack vane is vertical and above the boom. In all tests involved, vanes were oriented in this position to minimize flow turbulence caused by either the holding fixture or the test probe (ahead of the boom). The boom was rotated 90° about its own axis from the position shown to place the angle-of-sideslip vane uppermost.

For all runs, the boom was set up at zero angle of attack and zero angle of sideslip. Tunnel velocity was then adjusted using the tunnel pitot (because it was equipped with a vernier manometer). As the attack or sideslip angle increased, drag due to the boom and test fixture increased and produced a lower velocity. The tunnel propeller pitch was then adjusted to restore velocity to the original value, again, using the tunnel pitot as the reference.

During low speed runs, the velocity reduction due to drag increases was minimal. At highest velocity, the effect was quite noticeable as may be seen by reviewing the tunnel velocities as the angle of attack was increased.

Each nose design was rigidly mounted on the boom body and set up at 0° angle of attack. Tunnel velocity was then raised to 25 knots nominal. Manometer readings for both the test boom and the test pitot were recorded. The angle of attack was then increased to 5°, 10°, 15° and 20°. For runs at 25 and 75 knots, angles of attack of 30° and 40° were also set up and the manometer readings recorded. (Note that since the nose was rigidly locked rather that being free to pivot as it normally would, the angles of attack were true relative to the boom nose.)

After manometer readings were recorded at all angles the boom was returned to zero angle and the tunnel velocity was then raised to 75 knots nominal and the procedure repeated. This was continued until each nose had been tested at all four velocities and all angles of attack.

Based on data recorded in the screening runs, calculations were made to determine the nose configuration that best met the specified requirements. This nose, SpaceAge Control part number 100475-1, was then mounted on the boom body on the test fixture with the gimbal free so the nose could move more normally. Then, with the boom at 0°, tunnel velocity was raised to 25 knots nominal. Manometer readings for the test boom and the test probe were recorded. The voltage readings from the first section of the dual potentiometers attached to the angle of attack and sideslip vanes were also recorded. The angle of attack was then increased to 10°, 20°, 30° and 40°, then -10°, -20°, -30° and -40° and the manometer and voltmeter readings were recorded for each. The tunnel velocity was then increased to 75, 150 and 200 knots nominal. At each velocity, manometer and voltmeter reading were recorded at each angle of attack.

After completion of all angle of attack runs, the boom was rotated about its longitudinal axis so the sideslip vane was uppermost. The entire procedure of recording manometer and voltmeter readings at all velocities and angles of sideslip was then repeated.

At all velocities and angles, the gimbaled nose was stable. The angle of attack and sideslip vanes were stable at all velocities and angles except when a vane was behind the boom body at high angles of attack. Some minor fluctuations were also noted when the vane was upstream of the boom at high angles and low velocities. This was apparently caused by wall proximity since the vane's fin, when upstream of the boom at 40° angle to the airstream, was within one inch of the tunnel test section access door.

TEST RESULTS All data was recorded on "Test Data Record Sheets" and calculated results are presented on "Data Analysis Sheets". Copies of these for all nose configuration screening runs (made with the nose locked) are included in the

Appendix to this report together with an explanation of the calculations used and a discussion of probable errors due to manometer reading errors. Other potential sources of error are considered to have much smaller effects and are therefore not discussed.

Figure 10 is a composite, plotting the performance accuracy of each experimental nose configuration at zero angle as "Error (Knots)" versus actual "Velocity (Knots)". The specification limits are the two converging lines noted "Limit". Only the 100551-1 air data boom (Run 220-4) was significantly out of tolerance at the zero angle.

Figures 11 through 14 plot "Error (Knots)" versus "Velocity (Knots)" for each boom at angles of attack of 0°, 5°, 10°, 15° and 20° at velocities from 25 knots to 200 knots and for angles of 30° and 40° for velocities of 25 and 75 knots (all velocities nominal).

Although all noses are relatively accurate at zero angle, both the 100550-1 air data boom (Run 220-3) and the 100551-1 air data boom (Run 220-4) move out of tolerance quite rapidly as the angle increases. The 100552-2 air data boom (Run 220-1) produces good results except at high angles of attack in the low and medium velocity ranges. The 100475-1 air data boom (Run 220-2) produces similar results except that the accuracy error magnitude at high angles and low and medium velocities is less than the 100552-2 air data boom. This is more clearly seen by comparing Data Analysis Sheets in the Appendix since the error magnitudes are beyond the ranges plotted in Figure 11 and 12.

Because of the better performance at the high angles and low to medium velocities (which are within helicopter operating envelopes), the 100475-1 air data boom was selected for further tests.

The qualification and calibration test were Runs 221-1 and 221-2. The Test Data Record Sheets and the Data Analysis Sheets follow this page and are discussed in the following paragraphs. These runs were made with the nose free to universally move through an approximate 42° included angle cone. Therefore, results up to 20° angle show approximately the same as the 0° angle results of the configuration test run on this nose (Run 220-2). Figures 15 and 16 present results for pitch angles up to ±40°. Figure 17 and 18 present data for yaw angles to ±40°. Note that only the extrapolated line is beyond the range expected due to manometer reading errors. Velocity errors are all within zero angle specification limits up to ±40°. This corresponds to approximately ±20° for the nose section and agrees with the results of the screening tests.

Using velocity errors for all angles up through ±30°, Tables 1 and 2 present statistical data where:

Velocity error	= X (from data analysis sheets)
Number of entries	= N
Summation of entries	= SX
Summation of the squares of all entries	= SX^2
Mean Error	= X
Standard Deviation	= SD
Upper 95% limit (UL)	= X + 2(SD)
Lower 95% limit (LL)	= X - 2(SD)

All values are shown as percentages and X, SD, UL and LL are also shown in knots. Figure 19 and 20 are plots of X, UL and LL (knots) versus velocity (knots) and also show the specification limit lines. The X values of Figures 19 and 20 should be used as calibration curves for the pitot for all angles of attack or sideslip up through ±30°. These curves may be combined and averaged since they are in such close agreement.

In Figure 21, X, UL and LL values are plotted from the data in Table 3. This combines both angle of attack and sideslip data and the X should be used as a calibration curve for angles of ±40°.

Finally, Figures 22 and 23 plot the angle of attack and sideslip vane potentiometer voltage readings from Runs 221-1 and 221-2. For a 28.000 VDC power input across the potentiometer, the voltage change per degree for a 340 ±5° potentiometer element is 0.0823 ±0.001 VDC/°. Since the calibration of the vanes is entirely dependent on the output of the power supply connected to it, no special attempt was made to closely control the voltage applied during the wind tunnel tests. Figures 22 and 23 do verify alignment, function and sensitivity of the pitch and yaw vane potentiometers.

Calibration of these vanes should be accomplished on the test aircraft while connected to the flight test power supply. A vane calibration fixture (100535) is clamped directly to the boom body and a sight is clamped on the vane fin. Using the

protractor segment on the vane calibration fixture, the fin sight is aligned with any desired angle and the potentiometer output voltage is noted. A plot of angular displacement versus output voltage is readily produced in this manner. Both potentiometers in two section units should be calibrated since minor alignment or electrical differences may exist.

TABLE 1: STATISTICAL ANALYSIS OF VELOCITY ERROR AT ALL ANGLES OF ATTACK THROUGH ± 30°

Variable	Unit of Measure	25 knots	75 knots	150 knots	200 knots
S X	%	1.17	- 1.90	- 0.30	- 1.50
S X^2	%	21.30	1.33	1.69	1.07
N	Units	7	7	7	7
X	%	0.17	- 0.27	- 0.04	- 0.21
X	Knots	0.04	- 0.20	- 0.06	- 0.34
SD	%	1.74	0.34	0.49	0.33
SD	Knots	0.44	0.26	0.74	0.53
UL	%	3.64	0.41	0.94	0.44
UL	Knots	0.91	0.31	1.41	0.71
LL	%	-3.31	- 0.95	- 1.02	- 0.87
LL	Knots	-0.83	- 0.71	- 1.53	- 1.41

TABLE 2: STATISTICAL ANALYSIS OF VELOCITY ERROR OF ALL ANGLES OF SIDESLIP THROUGH ±30°

Variable	Unit of Measure	25 knots	75 knots	150 knots	200 knots
S X	%	-5.30	- 2.20	- 2.00	- 1.50
S X^2	%	16.39	1.84	2.14	1.39
N	Units	7	7	7	7
X	%	-0.76	- 0.31	- 0.29	- 0.21
X	Knots	-0.19	- 0.23	- 0.44	- 0.71
SD	%	1.33	0.41	0.47	0.39
SD	Knots	0.33	0.31	0.71	0.63
UL	%	1.90	0.50	0.66	0.57
UL	Knots	0.48	0.38	0.99	0.92
LL	%	-3.42	- 1.12	- 1.23	- 1.00
LL	Knots	-0.86	- 0.84	- 1.85	- 1.62

TABLE 3: STATISTICAL ANALYSIS OF VELOCITY ERROR OF ANGLES OF ATTACK AND SIDESLIP THROUGH ± 40°

Variable	Unit of Measure	25 knots	75 knots	150 knots	200 knots
S X	%	7.30	10.70	15.60	13.90
S X^2	%	17.81	44.35	65.54	51.87
N	Units	4	4	4	4
X	%	1.83	2.68	3.90	3.48
X	Knots	0.46	2.01	5.85	5.50
SD	%	1.06	1.98	1.08	0.94
SD	Knots	0.27	1.49	1.62	1.49
UL	%	3.94	6.64	6.07	5.36
UL	Knots	0.99	4.98	9.11	8.47
LL	%	-0.29	- 1.29	1.73	1.59
LL	Knots	-0.07	- 0.97	2.60	2.51

APPENDIX

CALCULATIONS For pitot tubes, the pressure differences between the static and total or velocity orifices, may be used to calculate velocity of the flowing fluid using the equation:

(1) $V_o = SQRT(2g_c\Delta H)$

(2) $\Delta H = (P_t - P_s)/P_o$

therefore (3) $V_o = SQRT(2g_c((P_t - P_s)/P_o))$

where V_o = fluid velocity, ft/sec
g_c = gravitational constant, 32.174ft/sec²
P_t = total pressure, lb/ft²
P_s = static pressure, lb/ft²
P_o = fluid density, $lb/ft^3 = 0.0808\ lb/ft^3 \times 273.1° K/T_2 \times P_2/760$ mm Hg

where T_2 = fluid temperature, °K.
P_2 = fluid pressure, mm Hg.

To convert $(P_t - P_s)$ from inches of water to lb/ft² , multiply by 5.1977 (at 60° F). Substituting in (3):

(4) $Vo = SQRT(2 \times 32.174 \times ((P_t - P_s) \times 5.1977)/(0.0808 \times (273.1/T_2) \times (P_2/760)))$
$= 107.3 \times SQRT(((P_t - P_s)/P_2) \times T_2)$

Using equation (4) with atmospheric pressure readings in mm Hg, temperature in °K and pitot manometer readings in inches of water column, tunnel air velocity can be calculated in ft/sec.

This method has been used to calculate both the velocity at the test probe and the indicated velocity at the boom. The velocity error is the difference between the test probe and the boom velocities divided by the probe velocity.

The Data Analysis Sheets show the results of the tunnel tests. These results are the basis of the graphical accuracy plots presented in the body of this report.

POTENTIAL ERRORS At low velocities, the pitot pressure values are low and therefore possible manometer reading errors have significance. Slanted manometers were used for all pressure readings less than ten (10) inches of water column. These were graduated in 0.05 inch of water column and maximum reading errors were ±0.02 inch of water column. For higher pressure readings vertical manometers, graduated in 0.2-inch increments were used. Maximum reading errors on these were ±0.1 inch of water column.

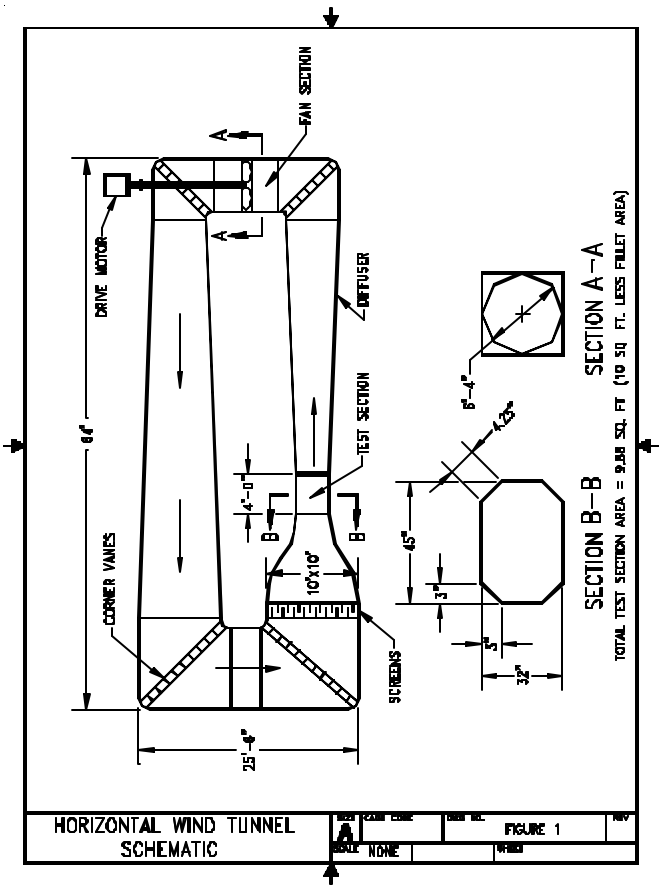
Velocity errors corresponding to these manometer reading errors are tabulated below.

Velocity (knots)	Reading Error (inch H_2O)	Error (%)	Velocity Error (knots)
25	±0.02	±2.5	±0.63
75	±0.02	±0.6	±0.42
150	±0.02	±0.1	±0.21
167	±0.02	±0.1	±0.19
150	±0.10	±0.7	±1.05
167	±0.10	±0.6	±0.95

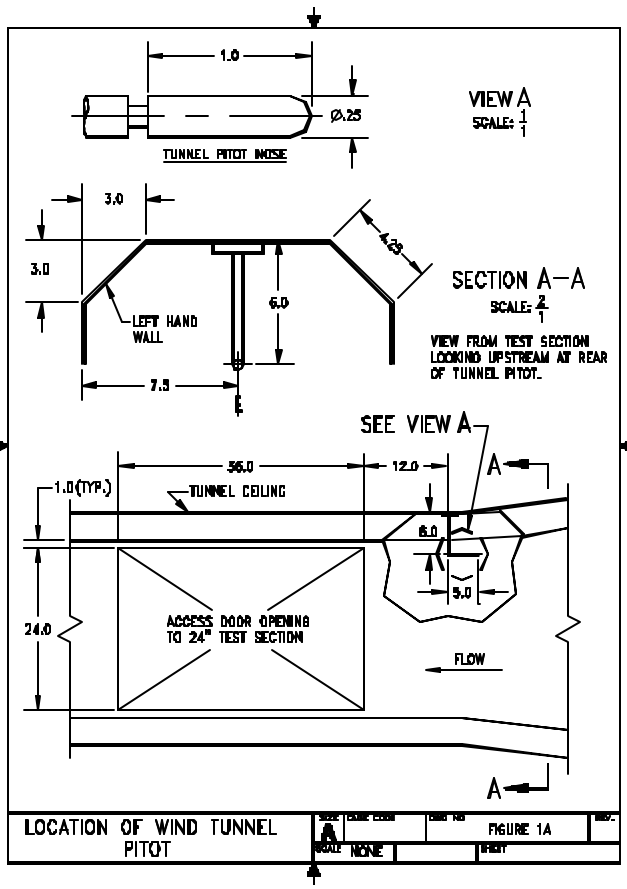
Since the vertical manometers were used only for total head pressures at 150 knots or more and the slanted manometers were used for all static head pressures and total head pressures below 150 knots, maximum errors due to manometer readings are:

Velocity (knots)	Static (knots)	Total (knots)	Total Velocity Error (knots)
25	±0.63	±0.63	±1.26
75	±0.42	±0.42	±0.84
150	±0.21	±0.70	±1.05
167	±0.19	±0.60	±0.95

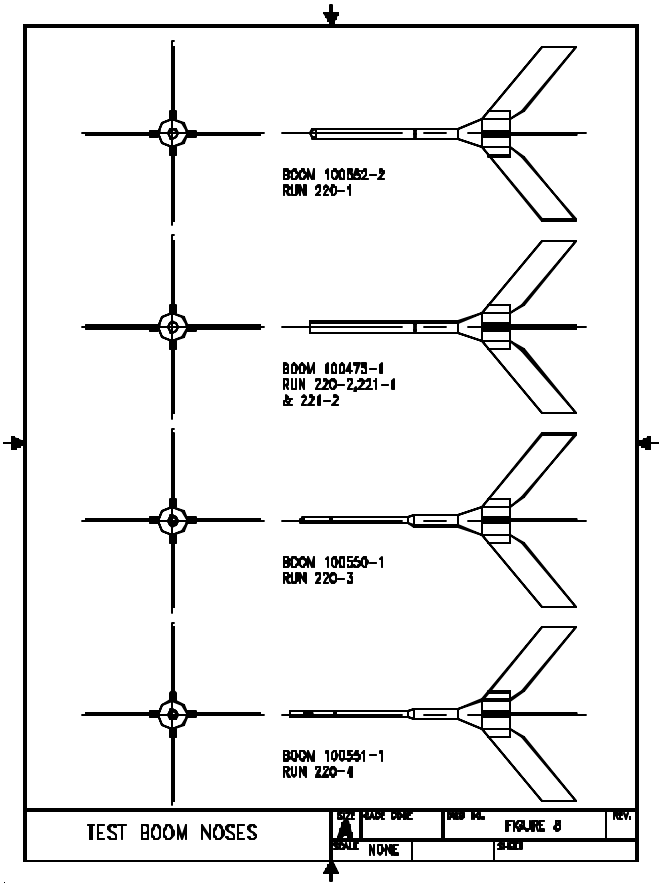
From this it is apparent that the maximum manometer reading errors produce deviations less than half the permissible pitot deviation and of approximately the same magnitude as the actual pitot deviation. The consistency of the pitot deviations indicate that actual manometer reading errors were less than the maximum probable errors and that pitot performance is therefore well within the permissible envelope.



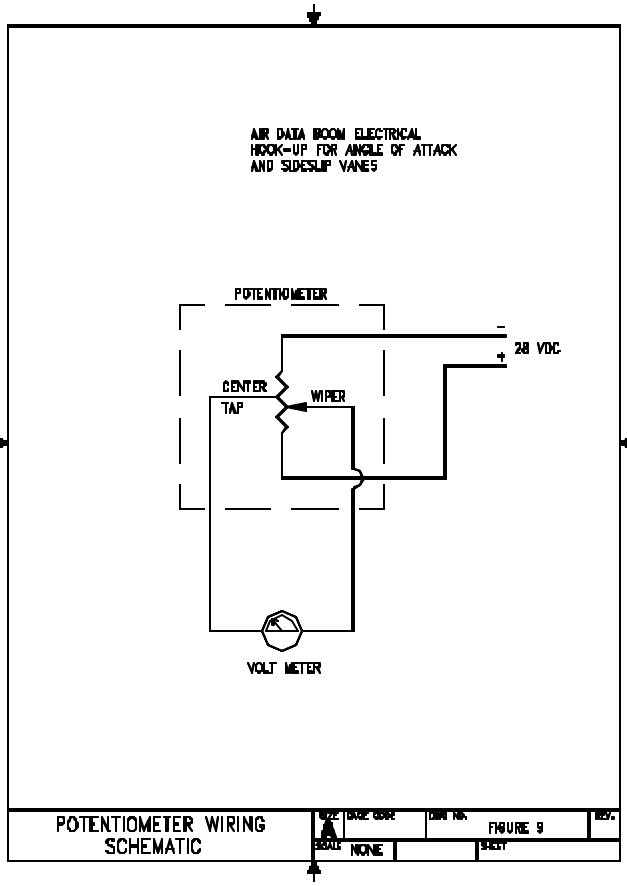
HORIZONTAL WIND TUNNEL SCHEMATIC — FIGURE 1



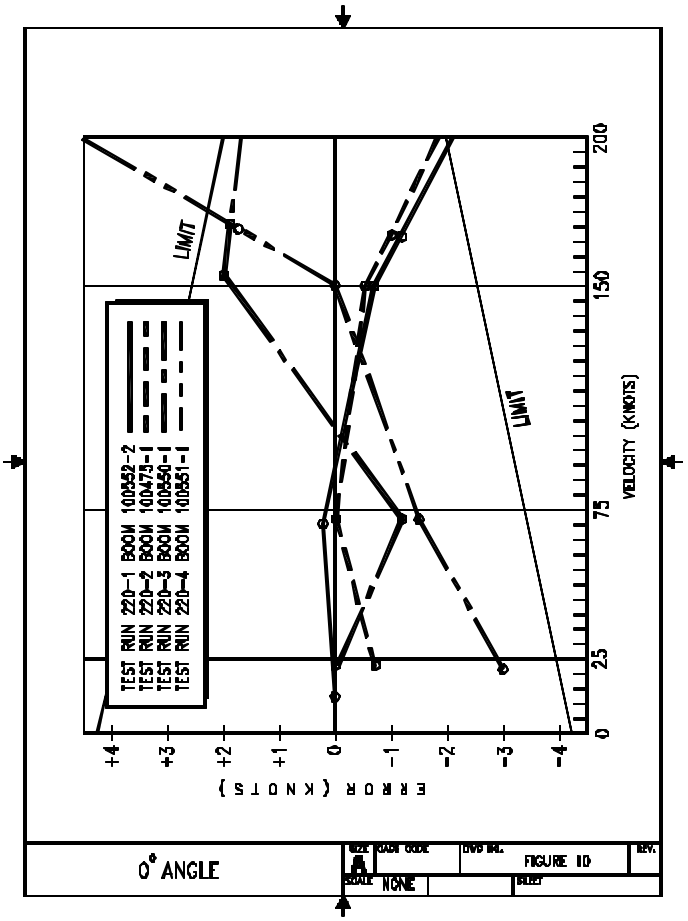
LOCATION OF WIND TUNNEL PITOT — FIGURE 1A

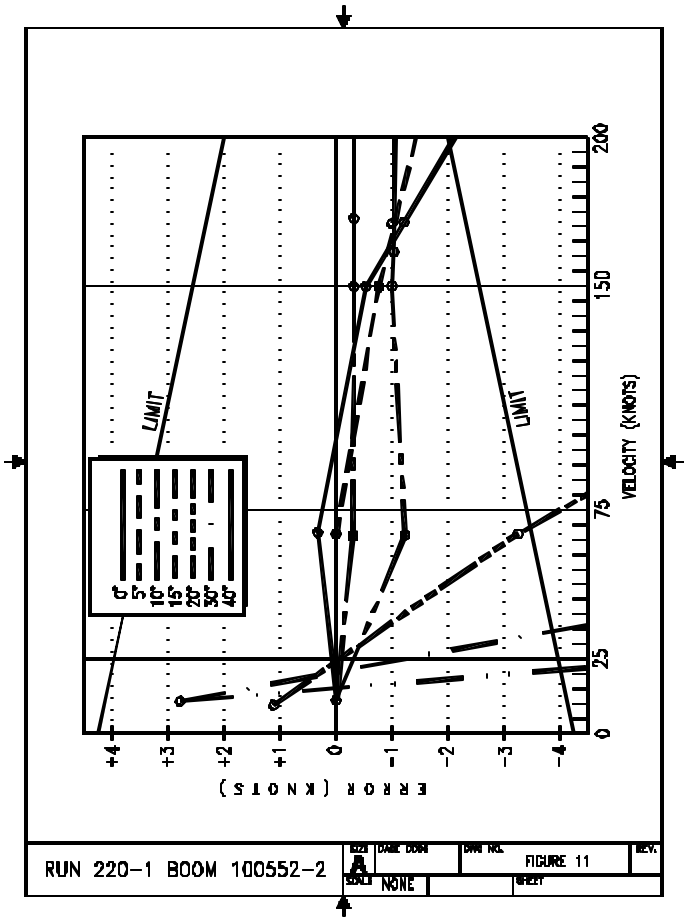


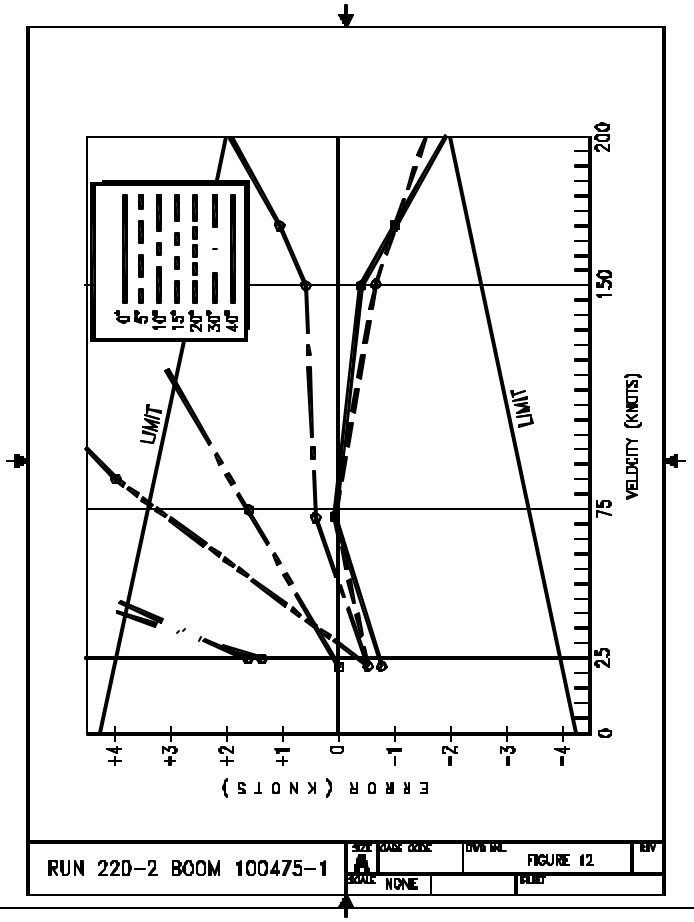
TEST BOOM NOSES — FIGURE 8

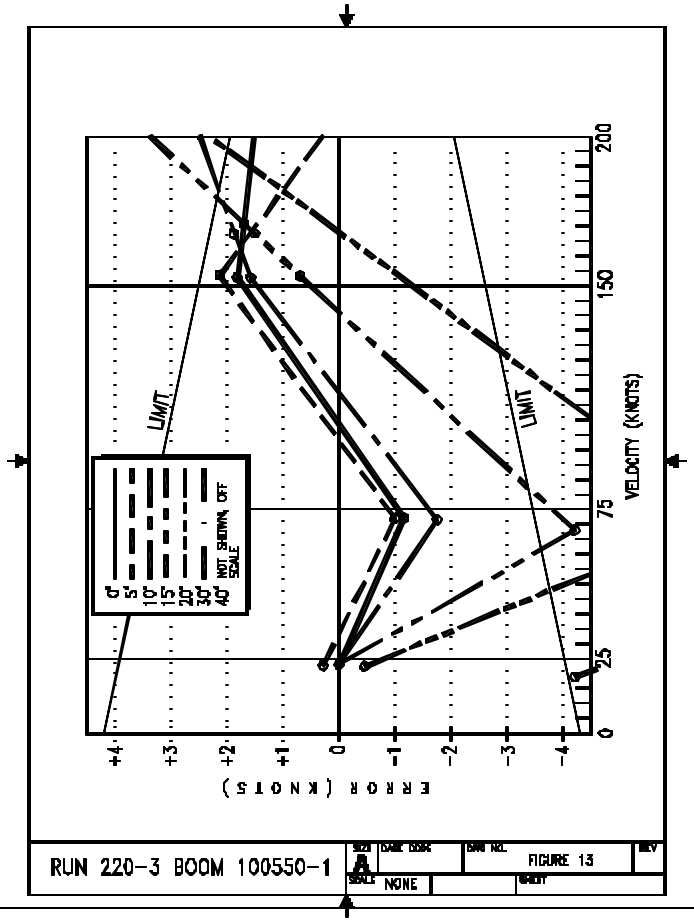


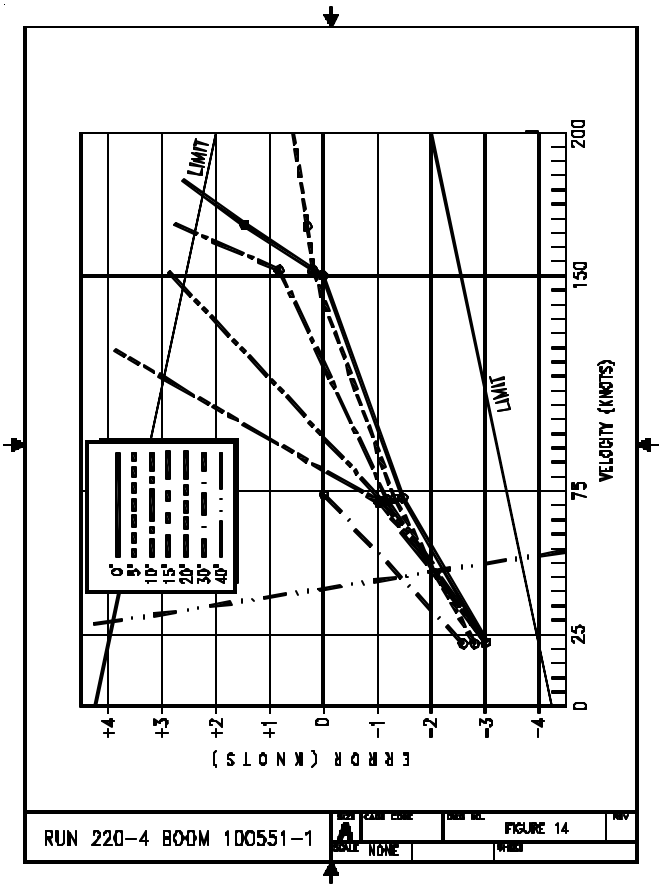
POTENTIOMETER WIRING SCHEMATIC — FIGURE 9


LIMIT
LIMIT
TEST RUN 220-1 BOOM 100552-2
TEST RUN 220-2 BOOM 100475-1
TEST RUN 220-3 BOOM 100550-1
TEST RUN 220-4 BOOM 100551-1
VELOCITY (KNOTS)
ERROR (KNOTS)
0° ANGLE
FIGURE 10


LIMIT
LIMIT
0°
5°
10°
15°
20°
30°
40°
VELOCITY (KNOTS)
ERROR (KNOTS)
RUN 220-1 BOOM 100552-2
FIGURE 11


LIMIT
LIMIT
0°
5°
10°
15°
20°
30°
40°
VELOCITY (KNOTS)
ERROR (KNOTS)
RUN 220-2 BOOM 100475-1
FIGURE 12


LIMIT
LIMIT
0°
5°
10°
15°
20°
30°
40°
NOT SHOWN, OFF SCALE
VELOCITY (KNOTS)
ERROR (KNOTS)
RUN 220-3 BOOM 100550-1
FIGURE 13



RUN 220-4 BOOM 100551-1 — FIGURE 14

RUN NO. 221-1 | BOOM NO. 100475-1 | DATE FEB. 21, 1974

BAROMETER: START 767.2 mm hg COMPLETE 767.3 mm hg

TEMPERATURE: START 68°F COMPLETE 86°F

NOTES: SWIVEL HEAD FREE, PITCH VANE UP, YAW VANE TO THE LEFT POSITIVE PITCH TO RIGHT.

STATIC 0 IS 6.00 FOR ALL SPEEDS. TOTAL 0 IS 6.00 FOR 25 & 75, 30.5 FOR 150 & 200.

TEMP °F	NOMINAL TEST SPEED KNOTS	TUNNEL PRESSURE ΔP CM H_2O	TUNNEL PRESSURE ΔP IN H_2O	TEST PROBE PRESSURES Pt	TEST PROBE PRESSURES Ps	TEST BOOM PRESSURES Pt	TEST BOOM PRESSURES Ps	PITCH ANGLE DEGREES	YAW ANGLE DEGREES	P-VANE INDICATED VOLTS	Y-VANE INDICATED VOLTS
68°	25	1.05	.41	6.42	6.03	6.42	6.02	0°	0°	0	0
	"	"		6.42	6.02	6.42	6.02	10°	"	.77	"
	"	"		6.42	6.02	6.42	6.01	20°	"	1.55	"
	"	"		6.42	6.02	6.42	6.00	30°	"	2.37	"
	"	"		6.42	6.02	6.41	5.98	40°	"	3.20	"
	"	"		6.42	6.02	6.41	6.01	-10°	"	-.78	"
	"	"		6.42	6.02	6.41	6.02	-20°	"	-1.80	"
	"	"		6.42	6.02	6.41	6.01	-30°	"	-2.45	"
	"	"		6.41	6.02	6.41	6.00	-40°	"	-3.20	~
68°	75	9.05	3.58	9.44	5.88	9.45	6.02	0°	0°	.09	0
	"	"		9.45	6.00	9.46	6.03	10°	"	.72	"
	"	"		9.46	6.00	9.46	6.02	20°	"	1.86	"
	"	"		9.46	6.00	9.46	5.97	30°	"	2.55	"
	"	"		9.50	6.02	9.50	5.69	40°	"	3.22	.1-.3
	"	"		9.45	6.01	9.45	6.05	-10°	"	-.84	0
	"	"		9.47	6.02	9.47	6.05	-20°	"	-1.87	"
	"	"		9.48	6.01	9.47	6.03	-30°	"	-2.52	"
	"	"		9.50	6.01	9.48	6.00	-40°	"	-3.33	~

~INDICATES OSCILLATIONS OR INSTABILITY

DATA ANALYSIS SHEET — SHEET 1 OF 2

RUN NO. 221-1 | BOOM NO. 100475-1 | DATE FEB. 21, 1974

BAROMETER: START 767.2 mm hg COMPLETE 767.3 mm hg

TEMPERATURE: START 68°F COMPLETE 86°F

NOTES: SWIVEL HEAD FREE, PITCH VANE UP, YAW VANE TO THE LEFT POSITIVE PITCH TO RIGHT.

STATIC 0 IS 6.00 FOR ALL SPEEDS. TOTAL 0 IS 6.00 @ 25 & 75, 30.5 FOR 150 & 200.

TEMP °F	NOMINAL TEST SPEED KNOTS	TUNNEL PRESSURE ΔP CM H_2O	TUNNEL PRESSURE ΔP IN H_2O	TEST PROBE PRESSURES Pt	TEST PROBE PRESSURES Ps	TEST BOOM PRESSURES Pt	TEST BOOM PRESSURES Ps	PITCH ANGLE DEGREES	YAW ANGLE DEGREES	P-VANE INDICATED VOLTS	Y-VANE INDICATED VOLTS
72°	150	37.0	14.57	16.35	5.55	16.35	5.67	0°	0°	.09	0
	"	"		16.2	5.68	16.2	5.83	10°	"	.89	- 02
	"	"		16.2	5.62	16.2	5.80	20°	"	1.54	- 05
	"	"		16.1	5.85	16.1	5.52	30°	"	2.40	~
	"	"		16.1	5.88	16.2	4.27	40°	"	3.22	~
	"	"		16.25	5.88	16.25	5.78	-10°	"	-.83	0
	"	"		16.2	5.80	16.2	5.77	-20°	"	-1.84	05
	"	"		16.1	5.68	16.15	5.37	-30°	"	-2.51	05
77°	"	38.37	14.32	16.2	5.80	16.3	4.08	-40°	"	-3.35	~
81°	200	45.45	17.89	13.0	5.40	13.0	5.52	0°	0°	.12	.02
	"	44.08	17.34	13.45	5.59	13.45	5.73	10°	"	.58	-.05
	"	43.88	17.28	13.55	5.50	13.55	5.67	20°	"	1.52	-.07
	"	40.65	16.00	14.8	5.81	14.8	5.81	30°	"	2.38	-.12
	"	37.77	14.87	15.8	5.67	15.85	4.20	40°	"	3.20	~
84°	"	43.55	17.07	13.7	5.56	13.75	5.70	-10°	"	-.83	0
	"	42.04	16.88	14.2	5.69	14.26	5.71	-20°	"	-1.66	.04
	"	36.61	14.41	15.5	5.62	15.5	5.35	-30°	"	-2.49	.02
86°	"	35.10	13.82	16.6	5.82	16.75	4.27	-40°	"	-3.31	~

~INDICATES OSCILLATIONS OR INSTABILITY

DATA ANALYSIS SHEET — SHEET 2 OF 2

RUN NO. 221-1 | BOOM NO. 100475-1 | DATE FEB. 21, 1974

NOTES:

	ANGLE OF ATTACK	TEST PROBE DATA ΔPt	TEST PROBE DATA ΔPs	TEST PROBE DATA TOTAL ΔP	TEST PROBE DATA VEL. FPS	TEST PROBE DATA VEL. KNOTS	TEST BOOM DATA ΔPt	TEST BOOM DATA ΔPs	TEST BOOM DATA TOTAL ΔP	TEST BOOM DATA VEL. FPS	TEST BOOM DATA VEL. KNOTS	VEL. ERROR %
NOMINAL SPEED 25 KNOTS TUNNEL ΔP 1.41 IN H_2O 24.17 KNOTS	0°	.42	.03	39	41.47	24.33	.42	.02	.40	42.00	24.86	1.24
	10°	.42	.02	.40	42.00	24.86	.42	.02	.40	42.00	24.86	0
	20°	.42	.02	.40	42.00	24.86	.42	.01	.41	42.52	25.17	1.23
	30°	.42	.02	40	42.00	24.86	.42	0	.42	43.03	25.47	2.3
	40°	.42	.02	40	42.00	24.86	.41	- 02	.43	43.54	25.78	2.3
	-10°	.42	.02	40	42.00	24.86	.41	.01	.40	42.00	24.86	0
	-20°	.42	.02	.40	42.00	24.86	.41	.02	.39	41.47	24.55	-3.6
	-30°	.42	.02	.40	42.00	24.86	.41	.01	.40	42.00	24.86	0
	-40°	.41	.02	.39	41.47	24.55	.41	0	.41	42.52	25.17	2.4
NOMINAL SPEED 75 KNOTS TUNNEL ΔP 9.41 IN H_2O 24.17 KNOTS	0°	3.44	-.02	3.45	123.53	73.13	3.45	.02	3.43	122.99	72.81	-.4
	10°	3.45	0	3.45	123.35	73.02	3.48	.05	3.41	122.43	72.80	-.5
	20°	3.45	0	3.45	123.35	73.02	3.45	.03	3.41	122.43	72.80	-.5
	30°	3.46	0	3.45	123.35	73.02	3.48	-.03	3.48	124.08	73.44	.5
	40°	3.50	.02	3.48	123.88	73.34	3.50	-.31	3.81	129.62	76.74	4.4
	-10°	3.45	.01	3.44	123.17	72.91	3.45	.05	3.40	122.45	72.48	-.5
	-20°	3.47	.02	3.45	123.35	73.02	3.47	.05	3.42	122.81	72.70	-.4
	-30°	3.48	.01	3.45	123.35	73.02	3.47	.03	3.44	123.17	72.81	-.1
	-40°	3.50	.01	3.48	124.06	73.44	3.48	0	3.48	123.58	73.34	-.1
NOMINAL SPEED 150 KNOTS TUNNEL ΔP 37.0 CM H_2O 14.57 IN H_2O 48.41 KNOTS	0°	14.15	-.45	14.60	254.61	150.73	14.15	-.33	14.48	253.67	150.11	-.4
	10°	14.30	- 32	14.62	254.79	150.83	14.30	-.17	14.47	253.48	150.06	-.5
	20°	14.30	- 38	14.68	255.31	151.14	14.30	-.20	14.50	255.88	151.48	.2
	30°	14.40	-.37	14.77	256.09	151.60	14.40	-.48	14.88	257.04	152.17	.3
	40°	14.40	-.32	14.72	255.66	151.30	14.30	-1.73	16.03	266.79	157.94	4.2
	-10°	14.26	-.32	14.57	254.35	150.57	14.26	-.22	14.47	253.48	150.06	-.3
	-20°	14.30	-.40	14.70	255.48	151.24	14.30	-.23	14.53	254.00	150.37	-.5
	-30°	14.40	-.32	14.72	255.66	151.30	14.35	- 65	14.98	257.91	152.68	.9
	-40°	14.30	- 20	14.50	252.86	151.68	14.20	-1.92	16.12	267.54	158.38	4.3

DATA ANALYSIS SHEET — SHEET 1 OF 2

RUN NO. 221-1 | BOOM NO. 100475-1 | DATE FEB 21, 1974

NOTES:

NOMINAL SPEED 200 KNOTS TUNNEL ΔP=13.95 - 17.88 IN. H2O 14.47-18.38 KNOTS

	ANGLE OF ATTACK	TEST PROBE DATA ΔPt	ΔPs	TOTAL ΔP	VEL. FPS	VEL. KNOTS	TEST BOOM DATA ΔPt	ΔPs	TOTAL ΔP	VEL. FPS	VEL. KNOTS	VEL. ERROR %
	0°	17.50	-.60	18.10	285.88	169.24	17.50	-.48	17.98	284.94	168.68	-.3
	10°	17.05	-.41	17.46	280.78	166.22	17.05	-.27	17.32	279.66	165.53	-.4
	20°	16.85	-.50	17.45	280.70	166.18	16.95	-.53	17.28	279.33	165.36	-.4
	30°	16.70	-.39	16.08	280.54	166.67	15.70	-.38	16.09	280.54	150.57	0
	40°	14.70	-.33	15.03	260.61	154.22	14.85	-1.80	16.45	272.84	161.34	4.4
	-10°	16.80	-.42	17.22	279.64	165.54	16.75	-.30	17.05	278.25	164.72	-.4
	-20°	16.30	-.41	16.71	275.48	163.07	16.25	-.29	16.54	274.08	162.24	-.5
	-30°	15.00	-.38	15.38	264.27	156.45	14.90	-.65	15.55	265.73	157.31	.5
	-40°	13.90	-.18	14.08	253.32	149.96	13.75	-1.73	15.40	264.93	156.83	4.5

DWG NO. DATA ANALYSIS SHEET | REV. | SIZE A | CAGE CODE | SCALE NONE | SHEET 2 OF 2

RUN NO. 221-2 | BOOM NO. 100475-1 | DATE FEB. 21, 1974

BAROMETER: START 767.2 mm hg | COMPLETE 767.2 mm hg

TEMPERATURE: START 80°F | COMPLETE 92°F

NOTES: SWIVEL HEAD FREE, YAW VANE UP, PITCH VANE TO RIGHT POSITIVE YAW TO LEFT (BOOM INVERTED).

STATIC 0 IS 6.00 FOR ALL SPEEDS. TOTAL 0 IS 6.00 @25 & 75, 30.5 FOR 150 & 200.

TEMP °F	NOMINAL TEST SPEED KNOTS	TUNNEL PRESSURE ΔP CM H_2O	IN H_2O	TEST PROBE PRESSURES Pt	Ps	TEST BOOM PRESSURES Pt	Ps	PITCH ANGLE DEGREES	YAW ANGLE DEGREES	P-VANE INDICATED VOLTS	Y-VANE INDICATED VOLTS
80°	25	1.05	.41	6.40	6.02	6.40	6.03	0°	0°	.08	.085
	"	"		6.40	6.02	6.40	6.03	"	10°	.11	-.71
	"	"		6.40	6.02	6.40	6.03	"	20°	.15	-1.53
	"	"		6.40	6.02	6.40	6.03	"	30°	25	-2.52
	"	"		6.40	6.02	6.40	6.03	"	40°	~	-3.18
	"	"		6.40	6.02	6.40	6.03	"	-10°	.04	.67
	"	"		6.40	6.02	6.40	6.03	"	-20°	0	1.51
	"	"		6.40	6.02	6.42	6.02	"	-30°	~	2.38
	"	"		6.40	6.02	6.41	5.89	"	-40°	~	3.18
79°	75	8.05	3.56	9.45	5.88	9.45	6.03	0°	0°	.05	.085
	"	"		9.48	6.00	9.48	6.03	"	10°	.10	-.71
	"	"		9.45	6.00	9.45	6.03	"	20°	16	-1.80
	"	"		9.48	6.00	9.50	6.01	"	30°	20	-2.46
	"	"		9.54	6.02	9.53	5.85	"	40°	25	-3.24
	"	"		9.45	6.00	9.47	6.04	"	-10°	0	.78
	"	"		9.45	6.00	9.47	6.05	"	-20°	0	1.80
	"	"		9.47	6.00	9.45	5.85	"	-30°	0	2.48
79°	"	"		9.51	6.02	9.50	5.85	"	-40°	~	3.25

~ INDICATES OSCILLATIONS OR INSTABILITY

DWG NO. DATA ANALYSIS SHEET | REV. | SIZE A | CAGE CODE | SCALE NONE | SHEET 1 OF 2

RUN NO. 221-2 | BOOM NO. 100475-1 | DATE FEB. 21, 1974

BAROMETER: START 767.2 mm hg | COMPLETE

TEMPERATURE: START 79°F | COMPLETE 92°F

NOTES: SWIVEL HEAD FREE, YAW VANE UP, PITCH VANE TO RIGHT POSITIVE YAW TO LEFT (BOOM INVERTED)

STATIC 0 IS 6.00 FOR ALL SPEEDS. TOTAL 0 IS 6.00 @25 & 75, 30.5 FOR 150 & 200.

TEMP °F	NOMINAL TEST SPEED KNOTS	TUNNEL PRESSURE Pt	Ps	TEST PROBE PRESSURES Pt	Ps	TEST BOOM PRESSURES Pt	Ps	PITCH ANGLE DEGREES	YAW ANGLE DEGREES	P-VANE INDICATED VOLTS	Y-VANE INDICATED VOLTS
79°	150	37.0	14.57	16.3	5.58	16.3	5.70	0°	0°	.02	-.11
	"	"		16.15	5.69	16.15	5.85	"	10°	.07	-.84
	"	"		16.15	5.60	16.15	5.80	"	20°	17	-1.48
	"	"		16.1	5.64	16.1	5.68	"	30°	.23	-2.30
	"	"		16.1	5.86	16.2	4.80	"	40°	.34	-3.13
	"	"		16.15	5.87	16.2	5.81	"	-10°	0	.74
	"	"		16.15	5.85	16.2	5.78	"	-20°	0	1.61
	"	"		16.15	5.68	16.2	5.37	"	-30°	0	2.40
89°	"	35.35	13.81	16.65	5.79	16.75	4.16	"	-40°	.08	3.19
89°	200	44.32	17.45	13.5	5.45	13.5	5.55	0°	0°	.03	-.03
	"	42.96	16.91	13.86	5.60	13.85	5.75	"	10°	06	-.63
	"	43.08	16.96	13.85	5.55	13.85	5.70	"	20°	.14	-1.44
	"	39.78	15.68	15.00	5.60	15.00	5.70	"	30°	.23	-2.29
	"	38.88	14.82	16.05	5.65	16.15	4.80	"	40°	.38	-3.11
91°	"	42.87	16.80	14.0	5.60	14.0	5.71	"	-10°	0	.75
	"	41.6	16.34	14.4	5.60	14.5	5.72	"	-20°	0	1.66
	"	38.16	16.02	15.6	5.68	15.7	5.33	"	-30°	05	2.57
91°	"	34.77	15.69	15.8	5.80	17.0	4.67	"	-40°	09	3.18

~ INDICATES OSCILLATIONS OR INSTABILITY

DWG NO. DATA ANALYSIS SHEET | REV. | SIZE A | CAGE CODE | SCALE NONE | SHEET 2 OF 2

RUN NO. 221-2 | BOOM NO. 100475-1 | DATE FEB. 21, 1974

NOTES:

NOMINAL SPEED 75 KNOTS TUNNEL ΔP=3.41 IN. H_2O 25-43 KNOTS

NOMINAL SPEED 150 KNOTS TUNNEL ΔP=13.36 IN H_2O 74.91 KNOTS

NOMINAL SPEED 139 KNOTS TUNNEL ΔP=11.44 IN H_2O 14.47-111.84 KNOTS

	ANGLE OF ATTACK	TEST PROBE DATA ΔPt	ΔPs	TOTAL ΔP	VEL. FPS	VEL. KNOTS	TEST BOOM DATA ΔPt	ΔPs	TOTAL ΔP	VEL. FPS	VEL. KNOTS	VEL. ERROR %
	0°	.40	.02	.38	41.38	24.50	.40	.03	.37	40.84	24.17	-1.3
	10°	.40	.02	.38	41.38	24.50	.40	.03	.37	40.84	24.17	-1.3
	20°	.40	.02	.38	41.38	24.50	.40	.03	.37	40.84	24.17	-1.3
	30°	.40	.02	.38	41.38	24.50	.40	.03	.37	40.84	24.17	-1.3
	40°	.40	.02	.38	41.38	24.50	.40	.02	.38	41.38	24.50	0
	-10°	.40	.02	.38	41.38	24.50	.40	.03	.37	40.84	24.17	-1.5
	-20°	.40	.02	.38	41.38	24.50	.40	.03	.37	40.84	24.17	-1.3
	-30°	.40	.02	.38	41.38	24.50	.42	.02	.40	42.48	25.13	2.5
	-40°	.40	.02	.38	41.38	24.50	.41	-.01	.42	43.51	25.18	2.6
	0°	3.45	-.02	3.47	124.92	73.95	3.45	03	3.42	124.02	73.42	-.7
	10°	3.48	0	3.48	124.74	73.85	3.48	.05	3.41	123.84	73.31	-.7
	20°	3.45	0	3.45	124.56	73.74	3.45	.05	3.40	123.68	73.20	-.7
	30°	3.48	0	3.48	125.10	74.05	3.50	.01	3.48	125.28	74.17	.1
	40°	3.54	.02	3.52	125.82	74.84	3.55	-.15	3.68	128.85	76.18	1.7
	-10°	3.45	0	3.45	124.56	73.74	3.47	.04	3.43	124.20	73.53	-.2
	-20°	3.45	0	3.45	124.56	73.74	3.47	.05	3.42	124.02	73.42	-.4
	-30°	3.47	0	3.47	124.92	73.95	3.45	-.05	3.50	125.46	74.27	.4
	-40°	3.51	.02	3.49	125.28	74.17	3.50	-.35	3.85	131.59	77.90	4.7
	0°	14.20	-.42	14.62	256.43	151.80	14.20	-.30	14.50	255.37	151.18	-.4
	10°	14.35	-.31	14.66	256.78	152.01	14.35	-.15	14.50	255.37	151.18	-.3
	20°	14.38	-.40	14.78	257.56	152.48	14.55	-.20	14.55	255.81	151.44	-.6
	30°	14.40	-.37	14.77	257.74	152.58	14.40	-.02	14.72	257.30	152.32	-.1
	40°	14.40	-.34	14.74	257.48	152.42	14.30	-1.10	15.40	263.18	155.80	2.1
	-10°	14.33	-.33	14.66	256.96	152.11	14.30	-.19	14.49	255.28	151.15	-.6
	-20°	14.35	-.35	14.70	257.13	152.22	14.30	-.21	14.51	255.48	151.23	-.6
	-30°	14.35	-.32	14.67	256.86	152.06	14.30	-.83	14.93	259.13	153.40	.8
	-40°	13.85	-.21	14.06	253.85	150.25	13.75	-1.84	15.59	267.30	158.24	5.0

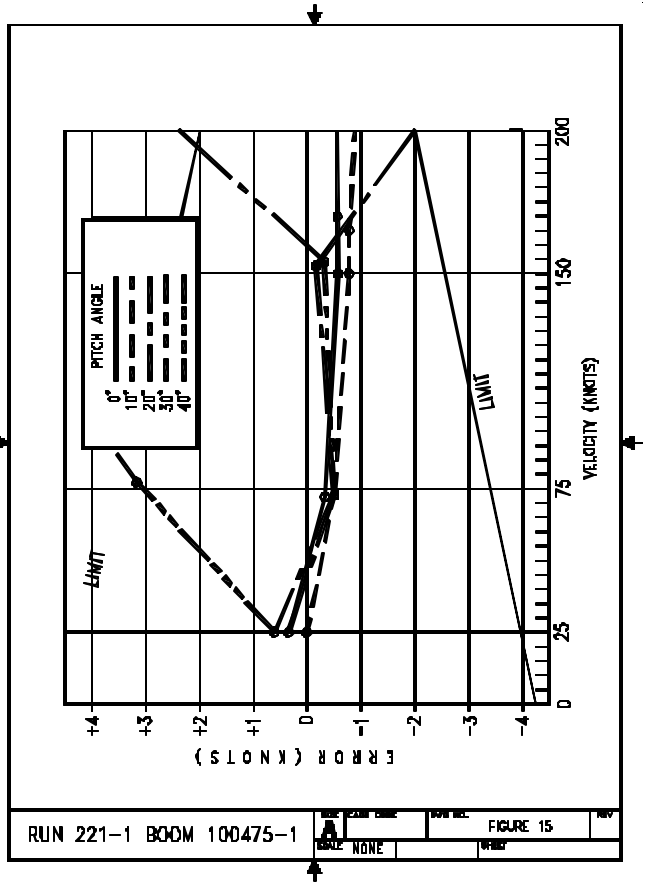
DWG NO. DATA ANALYSIS SHEET | REV. | SIZE A | CAGE CODE | SCALE NONE | SHEET 1 OF 2

RUN NO. 221-2 | BOOM NO. 100475-1 | DATE FEB 21, 1974

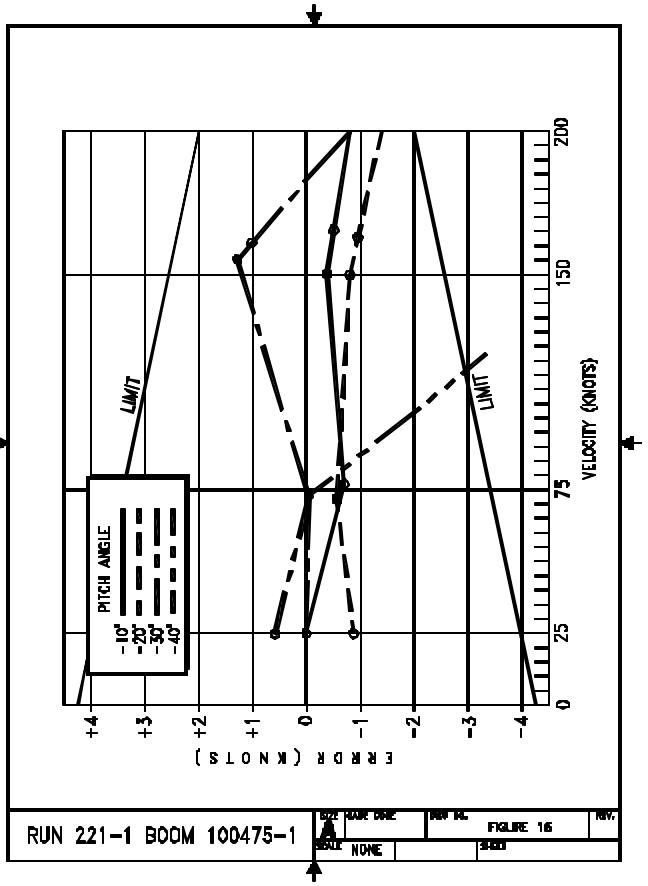
NOTES:

	ANGLE OF ATTACK	TEST PROBE DATA ΔPt	ΔPs	TOTAL ΔP	VEL FPS	VEL KNOTS	TEST BOOM DATA ΔPt	ΔPs	TOTAL ΔP	VEL FPS	VEL KNOTS	VEL ERROR K
NOMINAL SPEED 200 KNOTS TUNNEL ΔP=13.89-17.45 IN. H2O 144.7-177.46 KNOTS	0°	17.00	-.55	17.55	283.61	167.88	17.00	-.45	17.45	282.80	167.42	-.2
	10°	16.85	-.40	17.05	279.54	165.49	16.85	-.25	16.90	278.31	164.76	-.4
	20°	16.85	-.45	17.10	279.95	165.73	16.85	-.30	16.85	278.72	165.00	-.4
	30°	15.50	-.40	15.90	269.85	159.81	15.50	-.30	15.80	269.10	159.30	-.3
	40°	14.52	-.35	14.80	260.44	154.18	14.35	-1.10	15.45	266.10	157.53	2.1
	-10°	16.50	-.40	16.90	276.51	165.05	16.50	-.29	16.79	277.90	164.51	-.3
	-20°	16.10	-.40	16.50	275.48	163.08	16.00	-.29	16.29	273.73	162.05	-.6
	-30°	14.90	-.38	15.25	264.85	156.78	14.80	-.67	15.47	266.75	157.91	.7
	-40°	13.70	-.20	13.90	253.06	149.81	13.50	-1.53	14.93	261.39	154.74	3.1

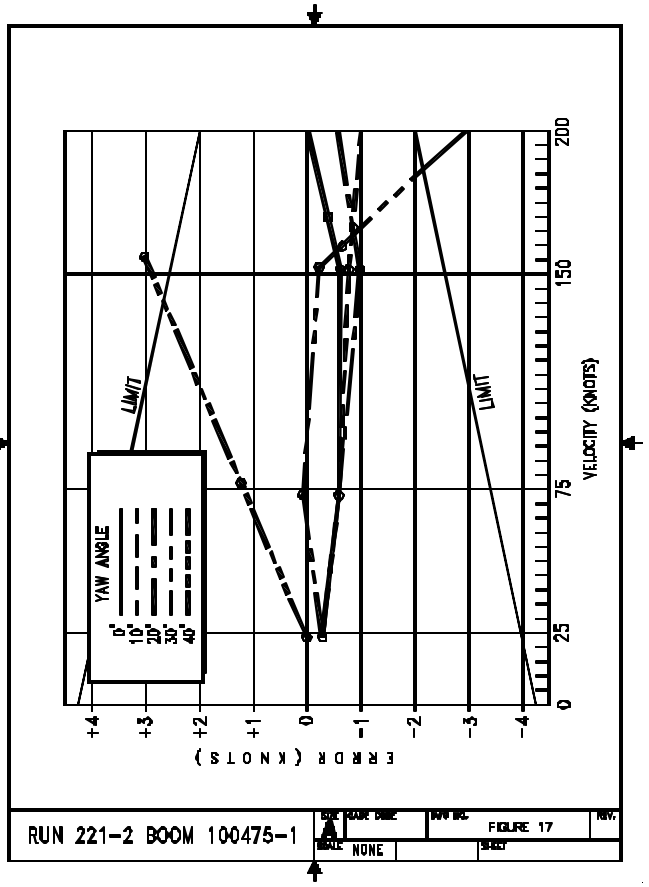
DATA ANALYSIS SHEET | SIZE A | SCALE NONE | SHEET 2 OF 2



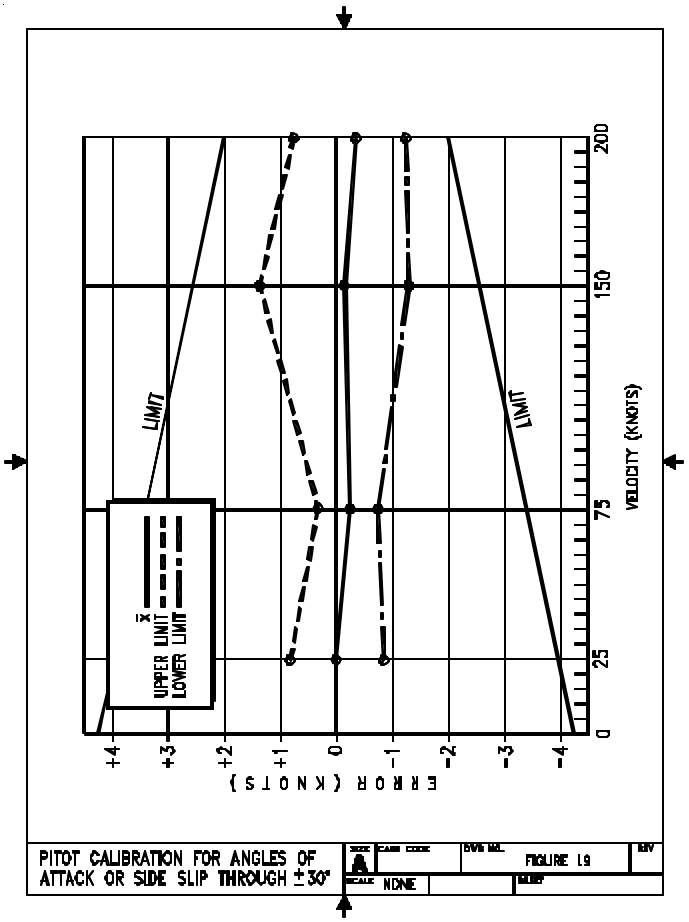
RUN 221-1 BOOM 100475-1 | SIZE A | SCALE NONE | FIGURE 15



RUN 221-1 BOOM 100475-1 | SIZE A | SCALE NONE | FIGURE 16



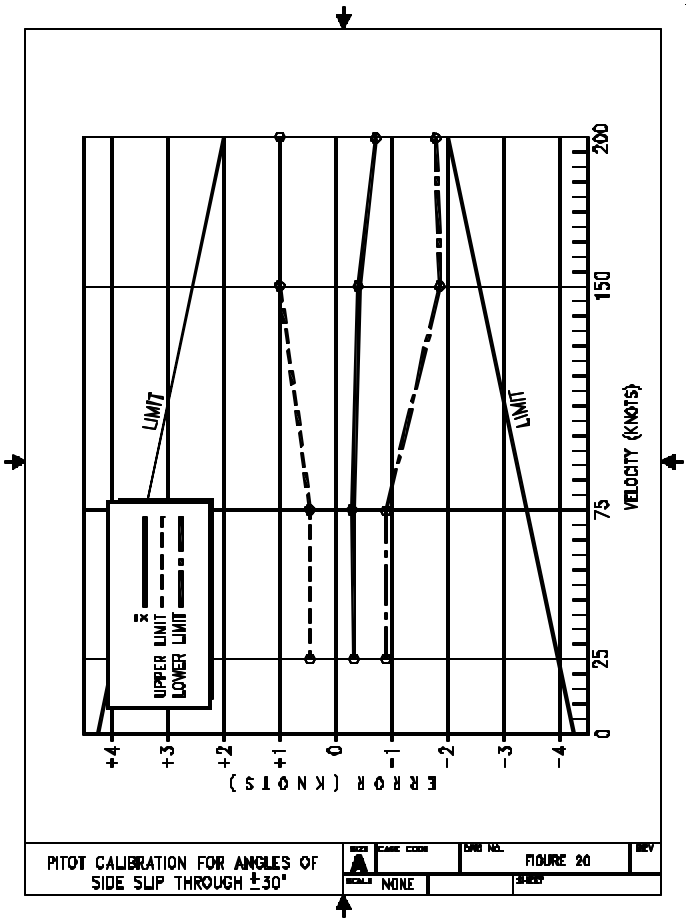
RUN 221-2 BOOM 100475-1 | SIZE A | SCALE NONE | FIGURE 17



PITOT CALIBRATION FOR ANGLES OF ATTACK OR SIDE SLIP THROUGH ±30°

FIGURE 19

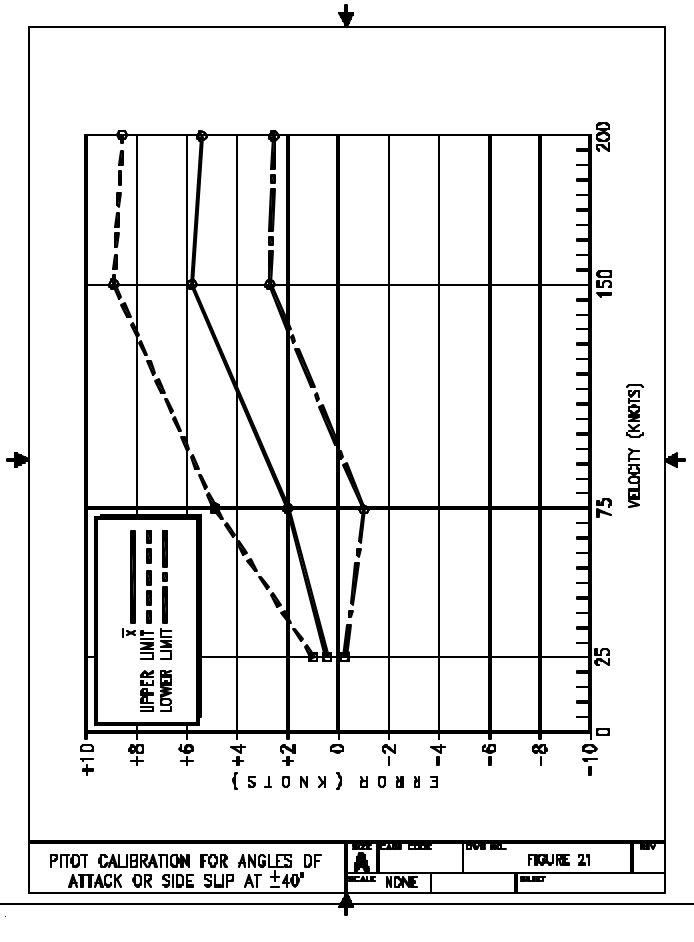
SCALE NONE



PITOT CALIBRATION FOR ANGLES OF SIDE SLIP THROUGH ±30°

FIGURE 20

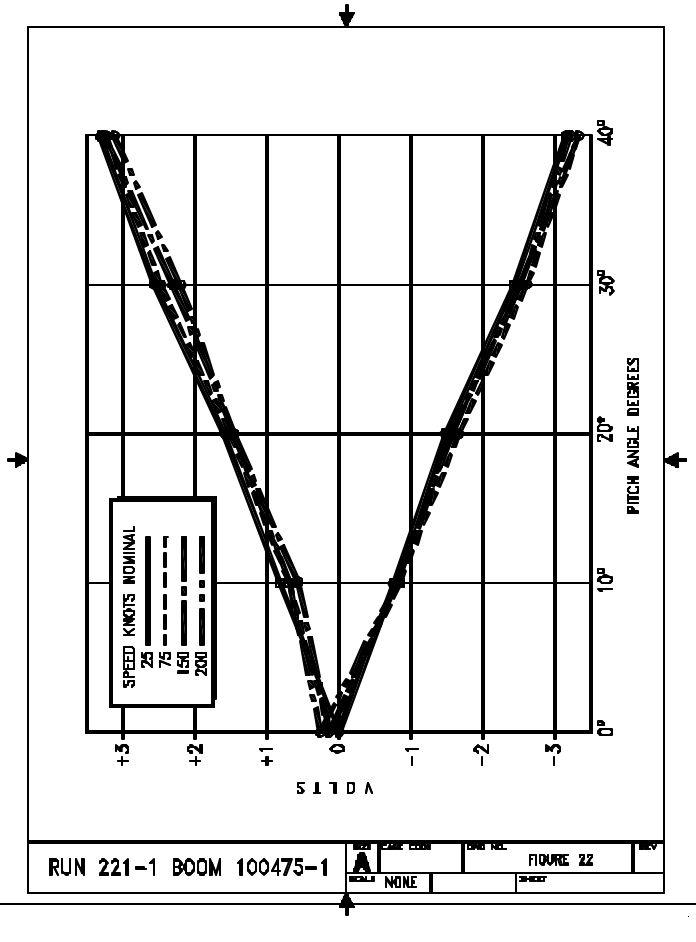
SCALE NONE



PITOT CALIBRATION FOR ANGLES OF ATTACK OR SIDE SLIP AT ±40°

FIGURE 21

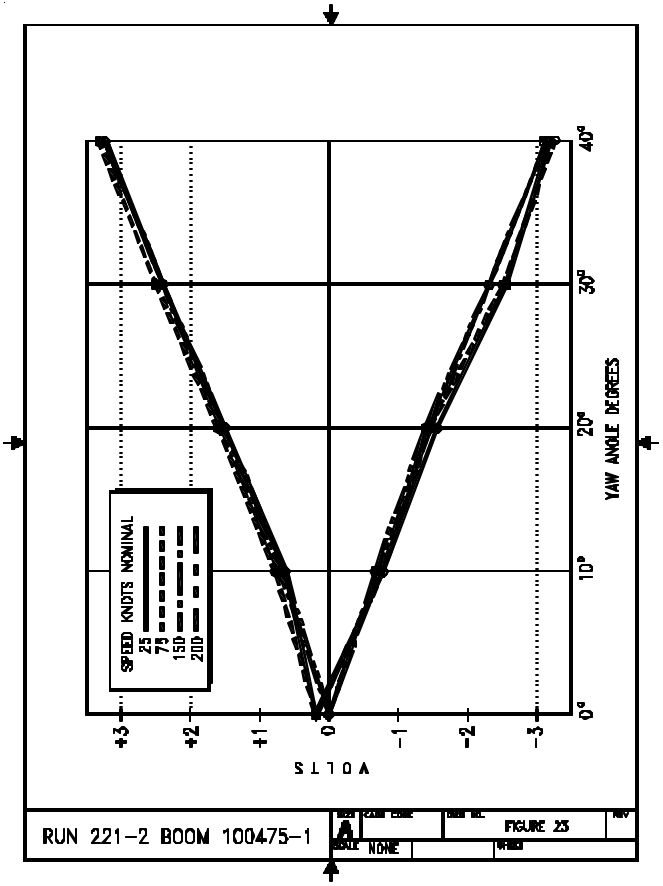
SCALE NONE



RUN 221-1 BOOM 100475-1

FIGURE 22

SCALE NONE



RUN 221-2 BOOM 100475-1 — SIZE A — CAGE CODE — DWG NO. FIGURE 23 — REV — SCALE NONE — SHEET

RUN NO. 220-1 — BOOM NO. 100552-2 — DATE FEB. 20, 1974

BAROMETER: START 766.0 mm hg — COMPLETE 766.3 mm hg

TEMPERATURE: START 64°F — COMPLETE 72° F

NOTES: SWIVEL HEAD LOCKED STRAIGHT AHEAD.

STATIC 0 IS 4.20 FOR 25 & 75 AND 7.50 FOR 150 & 200.

TOTAL 0 IS 3.00 FOR 25 & 75 AND 24.80 FOR 150 & 200.

TEMP °F	NOMINAL TEST SPEED KNOTS	TUNNEL PRESSURE ΔP CM H_2O	TUNNEL PRESSURE ΔP IN H_2O	TEST PROBE PRESSURES Pt	TEST PROBE PRESSURES Ps	TEST BOOM PRESSURES Pt	TEST BOOM PRESSURES Ps	PITCH ANGLE DEGREES	YAW ANGLE DEGREES	P-VANE INDICATED VOLTS	Y-VANE INDICATED VOLTS
72°	25	1.05	.41	5.10	4.20	5.10	4.20	0°	0°	0	—
	"	"		5.10	4.20	5.10	4.20	5°	"	.34	—
	"	"		5.10	4.20	5.10	4.20	10°	"	.74	—
	"	"		5.10	4.20	5.10	4.20	15°	"	1.11	—
	"	"		5.10	4.20	5.09	4.20	20°	"	1.50	—
	"	"		5.10	4.20	2.95	4.20	30°	"	2.37	—
	"	"		5.10	4.20	2.80	4.35	40°	"	3.25	—
72°	75	8.05	3.56	8.15	4.20	8.20	4.23	0°	0°	0	—
	"	"		8.08	4.20	8.11	4.25	5°	"	.34	—
	"	"		8.07	4.20	8.09	4.20	10°	"	.75	—
	"	"		8.07	4.20	5.87	4.10	15°	"	1.17	—
	"	"		8.08	4.20	5.53	3.91	20°	"	1.80	—
	"	"		8.14	4.23	4.52	3.48	30°	"	2.44	—
	"	"		8.17	4.28	3.00	3.14	40°	"	3.27	—
70°	150	37.0	14.57	10.80	7.08	10.8	7.30	0°	0°	0	—
	"	"		10.2	7.20	10.2	7.37	5°	"	.34	—
	"	"		10.1	7.24	10.4	7.05	10°	"	.74	—
	"	"		10.2	7.23	11.2	6.53	15°	"	1.17	—
	"	"		10.1	7.23	12.5	5.88	20°	"	1.80	—
71°	200	45.15	18.17	6.8	6.88	6.8	7.12	0°	0°	0	
	"	45.00	17.74	7.2	7.04	7.2	7.25	5°	"	.22	
	"	44.80	17.58	7.2	7.10	7.5	6.80	10°	"	.75	
	"	44.8	17.64	7.28	7.07	8.4	6.30	15°	"	1.14	
	"	44.2	17.40	7.4	7.07	10.0	5.64	20°	"	1.80	

— INDICATES NO READING

SIZE A — CAGE CODE — DWG NO. DATA ANALYSIS SHEET — REV. — SCALE NONE — SHEET 1 OF 2

RUN NO. 220-1 — BOOM NO. 100552-2 — DATE FEB. 20, 1974

NOTES:

	ANGLE OF ATTACK	TEST PROBE DATA ΔPt	ΔPs	TOTAL ΔP	VEL. FPS	VEL. KNOTS	TEST BOOM DATA ΔPt	ΔPs	TOTAL ΔP	VEL. FPS	VEL. KNOTS	VEL. ERROR %
NOMINAL SPEED 25 KNOTS TUNNEL ΔP=1.41 IN. H_2O 74.0 KNOTS	0°	.10	0	.10	20.93	12.39	.10	0	.10	20.93	12.39	0
	5°	.10	0	.10	20.93	12.39	.10	0	.10	20.93	12.39	0
	10°	.10	0	.10	20.93	12.39	.10	0	.10	20.93	12.39	0
	15°	.10	0	.10	20.93	12.39	.10	0	.10	20.93	12.39	0
	20°	.10	0	.10	20.83	12.39	.11	0	.11	21.96	13.00	4.8
	30°	.10	0	.10	20.83	12.39	.08	0	.08	23.48	13.90	10.8
	40°	.10	0	.10	20.93	12.39	.20	.15	.05	23.49	13.90	10.8
NOMINAL SPEED 75 KNOTS TUNNEL ΔP=9.39 IN. H_2O 74.0 KNOTS	0°	3.15	0	3.15	117.71	69.68	3.20	.03	3.17	118.09	69.90	.3
	5°	3.08	0	3.08	116.40	68.81	3.11	.03	3.08	116.40	68.81	0
	10°	3.07	0	3.07	116.21	68.79	3.09	0	3.09	116.59	69.02	.33
	15°	3.07	0	3.07	116.21	68.79	2.87	-.10	2.97	114.30	67.68	-1.6
	20°	3.08	0	3.08	116.40	68.81	2.53	-.28	2.82	111.38	65.85	-4.3
	30°	3.14	.03	3.11	116.86	69.24	1.52	-.72	2.24	99.26	58.78	-15.15
	40°	3.17	.05	3.12	117.15	69.35	0	-1.06	1.06	88.28	40.42	-41.71
NOMINAL SPEED 150 KNOTS TUNNEL ΔP=37.0 IN. H_2O 151.34 KNOTS	0°	14.30	-.42	14.72	255.34	151.16	14.30	-.30	14.60	254.30	150.54	-.4
	5°	14.40	-.30	14.70	253.16	151.06	14.40	-.13	14.53	253.68	150.17	-.5
	10°	14.50	-.28	14.78	255.89	151.36	14.20	-.45	14.65	254.73	150.80	-.5
	15°	14.40	-.27	14.67	254.80	150.90	13.40	-.87	14.27	252.28	149.35	-1.0
	20°	14.50	-.27	14.77	256.77	151.41	12.10	-.182	15.62	245.61	145.40	-7.9
NOMINAL SPEED 200 KNOTS TUNNEL ΔP=17.20-17.20 IN. H_2O 181.6-181.61 KNOTS	0°	17.80	-.62	18.42	286.60	168.87	17.80	-.38	18.18	284.73	168.56	-.5
	5°	17.40	-.45	17.85	282.15	167.02	17.40	-.28	17.65	280.56	166.08	-.5
	10°	17.40	-.40	17.80	281.74	166.79	17.10	-.60	17.70	280.94	166.32	-.2
	15°	17.35	-.43	17.78	281.58	166.69	16.20	-1.20	17.40	278.55	164.90	-1.0
	20°	17.40	-.43	17.83	280.39	165.99	14.60	-1.86	16.46	270.92	160.39	-5.3

SIZE A — CAGE CODE — DWG NO. DATA ANALYSIS SHEET — REV. — SCALE NONE — SHEET 2 OF 2

RUN NO. 220-2 — BOOM NO. 100475-1 — DATE FEB. 20, 1974

BAROMETER: START 768.3 mm hg — COMPLETE 767.0 mm hg

TEMPERATURE: START 68°F — COMPLETE 80° F

NOTES: SWIVEL HEAD LOCKED STRAIGHT AHEAD.

STATIC 0 IS 7.80 @ 25 AND 6.00 @ 75, 150, & 200

TOTAL 0 IS 7.80 @ 25 AND 6.00 @ 75, AND 24.6 @ 150 & 200.

TEMP °F	NOMINAL TEST SPEED KNOTS	TUNNEL PRESSURE ΔP CM H_2O	TUNNEL PRESSURE ΔP IN H_2O	TEST PROBE PRESSURES Pt	TEST PROBE PRESSURES Ps	TEST BOOM PRESSURES Pt	TEST BOOM PRESSURES Ps	PITCH ANGLE DEGREES	YAW ANGLE DEGREES	P-VANE INDICATED VOLTS	Y-VANE INDICATED VOLTS
	25	1.05	.41	7.88	7.50	7.80	7.33	0°	0°	.05	—
	"	"		7.89	7.51	7.90	7.38	5°	"	.41	—
	"	"		7.89	7.51	7.90	7.53	10°	"	.81	—
	"	"		7.89	7.51	7.90	7.52	15°	"	1.18	—
	"	"		7.90	7.51	7.91	7.53	20°	"	1.60	—
	"	"		7.88	7.51	7.90	7.47	30°	"	2.57	—
	"	"		7.91	7.51	7.88	7.44	40°	"	3.16	—
	75	9.00	3.56	9.45	5.95	9.49	6.00	0°	0°	—	—
	"	"		9.45	5.97	9.50	6.01	5°	"	.37	—
	"	"		9.46	5.97	9.50	5.97	10°	"	.78	—
	"	"		9.48	5.97	9.51	5.84	15°	"	1.18	—
	"	"		9.48	5.98	9.51	5.63	20°	"	1.6	—
	"	"		9.52	6.01	9.43	5.09	30°	"	2.50	—
	"	"		9.57	6.03	9.05	4.59	40°	"	3.25	—
	150	37.0	14.57	10.3	5.72	10.3	5.82	0°	0°	-.03	—
	"	"		10.15	5.73	10.15	5.88	5°	"	.31	—
	"	"		10.15	5.76	10.15	5.82	10°	"	.75	—
	"	"		10.15	5.78	10.16	5.80	15°	"	1.18	—
	"	"		10.15	5.75	10.25	4.24	20°	"	1.60	—
	200	45.85	18.05	7.0	5.43	7.0	5.82	0°	0°	-0.03	—
	"	44.57	17.55	7.3	5.57	7.3	5.78	5°	"	.28	—
	"	44.17	17.38	7.45	5.64	7.45	5.42	10°	"	.76	—
	"	44.44	17.50	7.40	5.63	7.40	4.73	15°	"	1.14	—
	"	43.95	17.30	7.55	5.62	7.65	3.80	20°	"	1.60	—

— INDICATES NO READING

SIZE A — CAGE CODE — DWG NO. DATA ANALYSIS SHEET — REV. — SCALE NONE — SHEET 1 OF 2

RUN NO. 220-2 | BOOM NO. 100475-1 | DATE FEB 20, 1974

NOTES:

	ANGLE OF ATTACK	TEST PROBE DATA ΔPt	ΔPs	TOTAL ΔP	VEL. FPS	VEL. KNOTS	TEST BOOM DATA ΔPt	ΔPs	TOTAL ΔP	VEL. FPS	VEL. KNOTS	VEL. ERROR %
NOMINAL SPEED 25 KNOTS TUNNEL ΔP=.41 IN. H_2O 25.1 KNOTS	0°	.39	0	.39	41.48	24.58	.40	.03	.37	40.40	23.92	-2.6
	5°	.39	.01	.38	40.95	24.24	.40	.05	.37	40.40	23.92	-1.3
	10°	.39	.01	.38	40.85	24.24	.40	.03	.37	40.40	23.92	-1.3
	15°	.39	.01	.38	40.85	24.24	.40	.02	.38	40.85	24.24	0
	20°	.40	.01	.39	41.48	24.55	.41	.03	.38	40.95	24.24	-1.3
	30°	.39	.01	.38	40.95	24.24	.40	-.03	.43	45.55	25.79	6.4
	40°	.41	.01	.40	42.01	24.87	.39	-.06	.45	44.54	26.38	6.1
NOMINAL SPEED 75 KNOTS TUNNEL ΔP=3.46 IN. H_2O 74.44 KNOTS	0°	3.45	-.05	3.50	124.67	73.81	3.49	0	3.49	124.49	73.70	0.1
	5°	3.45	-.03	3.48	124.32	73.60	3.50	.01	3.49	124.49	73.70	-0.1
	10°	3.46	-.03	3.49	124.49	73.70	3.50	-.03	3.53	125.21	74.12	0.6
	15°	3.48	-.03	3.51	124.85	73.91	3.51	-.16	3.67	127.66	75.57	2.2
	20°	3.48	-.02	3.50	124.67	73.81	3.51	-.37	3.88	131.27	77.71	5.3
	30°	3.52	.01	3.51	124.85	73.81	3.43	-.91	4.34	138.83	82.19	11.2
	40°	3.57	.03	3.54	125.38	74.22	3.05	-1.41	4.46	140.74	83.32	12.3
NOMINAL SPEED 150 KNOTS TUNNEL ΔP=14.57 IN. H_2O 151.08 KNOTS	0°	14.3	-.28	14.58	255.29	151.13	14.5	-.18	14.48	254.41	150.61	-0.3
	5°	14.45	-.27	14.72	258.51	151.85	14.445	-.12	14.57	255.20	151.08	-0.5
	10°	14.45	-.24	14.69	256.26	151.70	14.445	-.38	14.83	257.46	152.42	0.5
	15°	14.45	-.25	14.70	256.33	151.75	14.445	-1.00	15.45	282.78	155.57	2.5
	20°	14.45	-.25	14.70	256.33	151.75	14.35	-1.78	16.11	288.35	158.86	4.7
NOMINAL SPEED 200 KNOTS TUNNEL ΔP=17.49-18.06 IN. H_2O 185-178 KNOTS	0°	17.6	-.37	18.17	286.24	169.45	17.6	-.38	17.98	284.74	168.57	-0.5
	5°	17.3	-.43	17.73	282.75	167.39	17.3	-.24	17.54	281.23	166.49	-0.5
	10°	17.15	-.36	17.51	280.89	166.38	17.15	-.38	17.73	282.75	167.39	0.6
	15°	17.2	-.37	17.57	281.48	166.83	17.2	-1.27	18.47	288.58	170.85	2.5
	20°	17.08	-.38	17.43	280.35	165.97	16.85	-2.10	18.05	285.08	173.51	4.5

SIZE A | CAGE CODE | DWG NO. DATA ANALYSIS SHEET | REV.
SCALE NONE | SHEET 2 OF 2

RUN NO. 220-5 | BOOM NO. 100550-1 | DATE FEB. 20, 1974

BAROMETER: START 767.2 mm hg COMPLETE 782.7 mm hg
TEMPERATURE: START 71°F COMPLETE 79.4°F
NOTES: SWIVEL HEAD LOCKED STRAIGHT AHEAD.
STATIC 0 IS 5.88 FOR ALL SPEEDS.
TOTAL 0 IS 6.02 FOR 25 & 75 AND 24.80 FOR 150 & 200.

TEMP °F	NOMINAL TEST SPEED KNOTS	TUNNEL PRESSURE ΔP CM H_2O	IN H_2O	TEST PROBE PRESSURES Pt	Ps	TEST BOOM PRESSURES Pt	Ps	PITCH ANGLE DEGREES	YAW ANGLE DEGREES	P-VANE INDICATED VOLTS	Y-VANE INDICATED VOLTS
71°	25	1.05	.41	6.38	5.97	6.38	5.97	0°	0°	.08	—
	"	"		6.38	5.98	6.38	5.97	5°	"	.40	—
	"	"		6.38	5.97	6.37	5.96	10°	"	.74	—
	"	"		6.38	5.97	6.37	5.96	15°	"	1.17	—
	"	"		6.38	5.97	6.36	5.95	20°	"	1.62	—
	"	"		6.38	5.97	6.25	5.98	30°	"	2.38	—
	"	"		6.38	5.97	6.18	5.88	40°	"	3.20	—
72°	75	8.05	3.56	8.41	5.86	9.40	5.88	0°	0°	-.03	—
	"	"		9.45	5.89	9.42	5.98	5°	"	.32	—
	"	"		9.45	5.90	9.39	5.95	10°	"	.74	—
	"	"		9.45	5.90	9.11	5.95	15°	"	1.18	—
	"	"		9.45	5.80	8.80	5.91	20°	"	1.61	—
	"	"		9.48	5.93	7.83	5.30	30°	"	2.45	—
	"	"		9.80	6.97	6.47	4.78	40°	"	3.27	—
73°	150	37.0	14.57	10.85	6.86	10.66	6.14	0°	0°	-.07	—
	"	"		10.2	5.67	10.29	5.14	5°	"	.29	—
	"	"		10.2	5.70	10.5	5.12	10°	"	.73	—
	"	"		10.2	5.67	11.45	4.45	15°	"	1.17	—
	"	"		10.2	5.67	12.8	3.45	20°	"	1.62	—
79°	200	45.74	18.01	7.17	5.35	7.17	5.01	0°	0°	-.03	—
	"	44.20	17.43	7.4	5.52	7.5	5.13	5°	"	.28	—
	"	43.88	17.28	7.45	5.58	7.85	4.70	10°	"	.70	—
	"	44.10	17.38	7.48	5.57	8.90	3.81	15°	"	1.14	—
	"	43.8	17.24	7.6	5.56	10.6	2.67	20°	"	1.60	—

— INDICATES NO READING

SIZE A | CAGE CODE | DWG NO. DATA ANALYSIS SHEET | REV.
SCALE NONE | SHEET 1 OF 2

RUN NO 220-3 | BOOM NO. 100550-1 | DATE FEB. 20, 1974

NOTES:

	ANGLE OF ATTACK	TEST PROBE DATA ΔPt	ΔPs	TOTAL ΔP	VEL. FPS	VEL. KNOTS	TEST BOOM DATA ΔPt	ΔPs	TOTAL ΔP	VEL. FPS	VEL. KNOTS	VEL. ERROR %
NOMINAL SPEED 25 KNOTS TUNNEL ΔP=.41 IN. H_2O 24.58 KNOTS	0°	.36	-.01	.37	40.49	23.97	.38	-.01	.37	40.49	23.97	0
	5°	.36	0	.36	39.94	23.64	.36	-.01	.37	40.49	23.97	1.3
	10°	.36	-.01	.37	40.49	23.97	.39	-.02	.37	40.49	23.97	0
	15°	.36	-.01	.37	40.49	23.97	.35	-.02	.37	40.49	23.97	0
	20°	.36	-.01	.37	40.49	23.87	.34	-.02	.36	39.94	23.64	-1.5
	30°	.36	-.01	.37	40.49	23.87	.23	-.02	.25	33.28	19.70	-17.86
	40°	.36	-.01	.37	40.49	23.97	.17	-.02	.19	29.20	17.18	-28.32
NOMINAL SPEED 75 KNOTS TUNNEL ΔP=3.46 IN. H_2O 74.53 KNOTS	0°	3.39	-.12	3.51	124.82	73.95	3.38	-.02	3.40	122.94	72.78	-1.5
	5°	3.43	-.08	3.52	125.09	74.05	3.40	-.02	3.42	123.31	72.89	-1.4
	10°	3.43	-.08	3.51	124.82	73.95	3.33	-.02	3.35	122.04	72.24	-2.3
	15°	3.43	-.08	3.51	124.82	73.85	3.08	-.02	3.11	117.58	69.61	-5.9
	20°	3.43	-.08	3.51	124.82	73.85	2.78	-.07	2.85	112.58	66.65	-10.0
	30°	3.48	-.05	3.51	124.82	73.85	1.81	-.68	2.49	105.21	62.28	-15.88
	40°	3.48	-.01	3.49	124.56	73.74	.45	-1.23	1.68	86.42	51.18	-30.62
NOMINAL SPEED 150 KNOTS TUNNEL ΔP=14.57 IN. H_2O 151.34 KNOTS	0°	14.25	-.42	14.67	256.56	151.56	14.25	-.84	15.08	259.66	153.71	1.5
	5°	14.40	-.31	14.71	258.37	151.77	14.35	-.84	15.19	260.52	154.22	1.5
	10°	14.40	-.28	14.68	258.10	151.61	14.10	-.88	14.98	258.54	153.05	.8
	15°	14.40	-.31	14.71	258.37	151.77	13.35	-1.53	14.88	257.84	152.64	.5
	20°	14.40	-.31	14.71	258.37	151.77	11.80	-2.85	14.33	255.03	149.79	-1.3
NOMINAL SPEED 200 KNOTS TUNNEL ΔP=17.74-18.31 IN. H_2O 186-188 KNOTS	0°	17.45	-.63	18.08	286.17	168.41	17.43	-.97	18.40	288.35	171.00	.8
	5°	17.20	-.45	17.66	282.98	167.02	17.10	-.88	17.98	286.30	168.99	.8
	10°	17.15	-.40	17.55	282.10	167.00	16.65	-1.28	17.93	285.14	168.80	1.0
	15°	17.15	-.41	17.56	282.18	167.05	15.70	-2.17	17.87	284.66	168.51	.8
	20°	17.00	-.42	17.42	281.08	165.38	14.00	-3.81	17.81	280.14	165.86	-.5

SIZE A | CAGE CODE | DWG NO. DATA ANALYSIS SHEET | REV.
SCALE NONE | SHEET 2 OF 2

RUN NO 220-4 | BOOM NO. 100551-1 | DATE FEB. 20, 1974

BAROMETER: START 767.2 mm hg COMPLETE 787.2 mm hg
TEMPERATURE: START 73.5°F COMPLETE 79°F
NOTES: SWIVEL HEAD LOCKED STRAIGHT AHEAD.
STATIC 0 IS 6.00 FOR ALL SPEEDS
TOTAL 0 IS 6.04 FOR 25 & 75 AND 24.80 FOR 150 & 200.

TEMP °F	NOMINAL TEST SPEED KNOTS	TUNNEL PRESSURE ΔP CM H_2O	IN H_2O	TEST PROBE PRESSURES Pt	Ps	TEST BOOM PRESSURES Pt	Ps	PITCH ANGLE DEGREES	YAW ANGLE DEGREES	P-VANE INDICATED VOLTS	Y-VANE INDICATED VOLTS
75°	25	1.05	.41	6.43	6.00	6.43	6.09	0°	0°	.074	—
	"	"		6.43	6.00	6.43	6.08	5°	"	.47	—
	"	"		6.44	6.00	6.43	6.08	10°	"	.72	—
	"	"		6.44	6.00	6.43	6.08	15°	"	1.17	—
	"	"		6.44	6.00	6.43	6.08	20°	"	1.61	—
	"	"		6.44	6.00	6.44	6.08	30°	"	2.37	—
	"	"		6.44	6.00	6.25	6.08	40°	"	3.18	—
76°	75	9.08	3.66	9.49	5.93	9.49	6.07	0°	0°	—	—
	"	"		9.49	5.95	9.48	6.07	5°	"	.35	—
	"	"		9.50	5.98	9.48	6.07	10°	"	.75	—
	"	"		9.51	5.96	9.50	6.07	15°	"	1.18	—
	"	"		9.52	5.98	9.51	6.08	20°	"	1.62	—
	"	"		9.53	5.98	9.50	5.95	30°	"	2.45	—
	"	"		9.60	6.03	7.87	5.02	40°	"	3.25	—
77°	150	37.0	14.57	10.4	5.70	10.4	5.88	0°	0°	-.029	—
	"	"		10.2	5.72	10.2	5.88	5°	"	.29	—
	"	"		10.25	5.70	10.25	5.80	10°	"	.73	—
	"	"		10.15	5.73	10.15	5.08	15°	"	1.16	—
	"	"		10.15	5.72	10.15	4.45	20°	"	1.62	—
78°	200	45.48	17.91	7.1	5.43	7.1	5.15	0°	0°	-.025	—
	"	44.18	17.38	7.5	5.58	7.5	5.15	5°	"	.28	—
	"	43.81	17.25	7.65	5.65	7.65	5.11	10°	"	.78	—
	"	43.97	17.31	7.55	5.61	7.55	4.80	15°	"	1.14	—
	"	43.47	17.11	7.75	5.81	7.75	4.35	20°	"	1.66	—

— INDICATES NO READING

SIZE A | CAGE CODE | DWG NO. DATA ANALYSIS SHEET | REV.
SCALE NONE | SHEET 1 OF 2

RUN NO. 220-4 | BOOM NO. 100551-1 | DATE FEB. 20, 1974

NOTES:

	ANGLE OF ATTACK	TEST PROBE DATA ΔPt	ΔPs	TOTAL ΔP	VEL. FPS	VEL. KNOTS	TEST BOOM DATA ΔPt	ΔPs	TOTAL ΔP	VEL. FPS	VEL. KNOTS	VEL. ERROR %
NOMINAL SPEED 25 KNOTS TUNNEL ΔP=.41 IN. H2O 28.23 KNOTS	0°	.39	0	.39	41.67	24.67	.39	.09	.30	36.54	21.63	-12.3
	5°	.39	0	.39	41.67	24.67	.39	.08	.31	37.15	21.99	-10.8
	10°	.40	0	.40	42.20	24.89	.39	.08	.31	37.15	21.99	-12.0
	15°	.40	0	.40	42.20	24.89	.39	.08	.31	37.15	21.99	-12.0
	20°	.40	0	.40	42.20	24.89	.39	.08	.31	37.15	21.98	-12.0
	30°	.40	0	.40	42.20	24.89	.40	.08	.32	37.74	22.34	-10.0
	40°	.40	0	.40	42.20	24.89	.21	.06	.15	24.05	14.24	42.78
NOMINAL SPEED 75 KNOTS TUNNEL ΔP=3.61 IN. H2O 74.49 KNOTS	0°	3.45	-.07	3.52	125.40	74.24	3.45	.07	3.38	122.88	72.75	-2.0
	5°	3.45	-.05	3.50	125.05	74.07	3.44	.07	3.37	122.70	72.64	-1.9
	10°	3.46	-.04	3.50	125.05	74.07	3.45	.07	3.38	122.88	72.75	-1.8
	15°	3.47	-.04	3.51	125.22	74.13	3.46	.07	3.39	123.06	72.85	-1.7
	20°	3.48	-.04	3.52	125.40	74.24	3.47	.06	3.41	123.43	73.07	-1.6
	30°	3.49	-.02	3.51	125.22	74.13	3.46	-.05	3.51	125.22	74.13	0
	40°	3.56	.03	3.53	125.58	74.34	1.83	-.98	2.81	112.04	66.33	-10.8
NOMINAL SPEED 150 KNOTS TUNNEL ΔP=14.67 IN. H2O 151.28 KNOTS	0°	14.20	-.30	14.50	254.95	150.93	14.20	-.31	14.51	255.03	150.98	0
	5°	14.40	-.28	14.68	256.52	151.86	14.40	-.32	14.72	256.87	152.07	.1
	10°	14.35	-.30	14.65	256.28	151.71	14.35	-.40	14.75	257.13	152.22	.3
	15°	14.45	-.27	14.72	256.87	152.07	14.45	-.92	15.37	262.48	155.39	2.2
	20°	14.45	-.28	14.73	256.98	152.12	14.45	-1.55	16.00	267.81	158.54	4.2
NOMINAL SPEED 240 KNOTS TUNNEL ΔPs=17.01-17.41 IN. H2O 184.29-186.04 KNOTS	0°	17.50	-.57	18.07	285.13	168.80	17.50	-.85	18.35	287.33	170.10	.8
	5°	17.10	-.41	17.51	280.68	166.16	17.10	-.85	17.95	284.18	168.24	.1
	10°	16.95	-.35	17.30	278.99	165.16	16.95	-.89	17.84	283.31	167.72	1.6
	15°	17.05	-.38	17.44	280.11	165.85	17.05	-1.20	18.25	286.85	169.85	2.3
	20°	16.85	-.39	17.24	278.80	164.87	16.85	-1.65	18.50	288.50	170.79	3.6

SIZE A | CAGE CODE | DWG NO. DATA ANALYSIS SHEET | REV

SCALE NONE | SHEET 2 OF 2