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AN INVESTIGATION OF A FULL–SCALE ADVANCING BLADE CONCEPT ROTOR SYSTEM AT HIGH ADVANCE RATIO

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INTRODUCTION

Modern helicopters have been limited in high speed capability and cruise performance by stall of retreating blade and by compressibility effects of advancing blade. One technique for minimizing those adverse effects is to locate the rotor's total lift centroid on the advancing side of the rotor disk. The retreating blade lift requirements would then be greatly lessened, and the advancing blade would be operating at conditions favorable for better lift-to-drag ratios. This lift offset would result in a rolling moment across the hub. To achieve significant lift offset would necessitate a hingeless rotor system or large offset flapping hinge on an articulated rotor plus a means for countering the rolling moment (for trim) such as another rotor, a wing, or center-of-gravity offset etc.

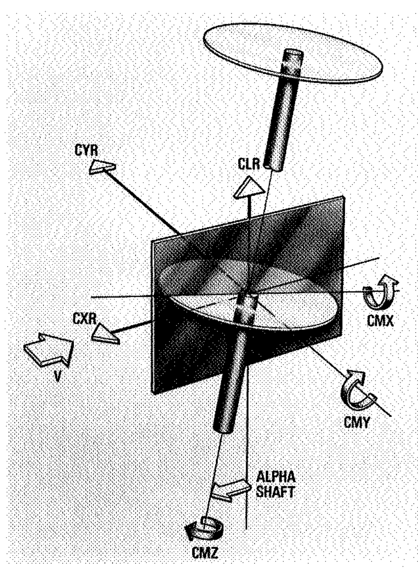
A rotor system has been built based upon this lift offset or advancing blade concept (ABC). This ABC rotor system featured two, counter rotating coaxial rotors utilizing blades that were very stiff in torsion and in flatwise and chordwise bending. Also, the blades were attached rigidly to the hubs with only a feathering bearing. The counter-rotating coaxial rotor arrangement resulted in cancellation of the hub moment below the rotating system, caused by the lift offset on the upper and lower rotors respectively.

An investigation was performed on the ABC rotor system in the 40- by 80-foot wind tunnel in June 1970. The program objectives were to demonstrate the system's performance capability, rotor loads, and to determine stability and control power derivatives over an advance ratio range of .2 to .9. Data were obtained over a range of lift and propulsive force, and are presented without discussion.

Overall noise data are presented in Appendix A.

NOTATION

Positive directions of forces and moments are shown in the following sketch.



$A_{1_{su}}$, $B_{1_{su}}$, $A_{1_{s\ell}}$, $B_{1_{s\ell}}$ coefficients in the representation of rotor-blade cyclic pitch for the upper and the lower rotors individually, that is, upper rotor $\theta_c = -A_{1_{su}} \cos \psi - B_{1_{su}} \sin \psi$,

lower rotor $\theta_c = -A_{1_{s\ell}} \cos \psi - B_{1_{s\ell}} \sin \psi$, deg.

A1S rotor system pitching moment control in deg,

$$\frac{A_{1_{su}} + A_{1_{s\ell}}}{2}$$

A1SP inter-rotor pitching moment control in deg,

$$\frac{A_{1_{su}} - A_{1_{s\ell}}}{2}$$

ALPHA SHAFT angle of rotor shaft from vertical, positive shaft tilted aft, deg

b number of blades

B1S rotor system rolling moment control in deg,

$$\frac{B_{1_{su}} - B_{1_{s\ell}}}{2}$$

B1SP inter-rotor rolling moment control in deg,

$$\frac{B_{1_{su}} + B_{1_{s\ell}}}{2}$$

$c_{.75R}$ blade chord at .75R, m

CLR rotor lift coefficient in wind-axis system, $\frac{\text{lift}}{\rho\ S\ (\Omega R)^2}$

CMX resultant rolling-moment coefficient about center of lower rotor in shaft-axis system,

$$\frac{\text{shaft axis rolling moment}}{\rho\ S\ (\Omega R)^2 R}$$

CMY resultant pitching-moment coefficient about center of lower rotor in shaft-axis system,

$$\frac{\text{shaft axis pitching moment}}{\rho \ \ S\ (\Omega R)^2 R}$$

CMZ resultant yawing-moment coefficient about center of lower rotor in shaft-axis system,

$$\frac{\text{shaft axis yawing moment}}{\rho \ \ S\ (\Omega R)^2 R}$$

CPO rotor profile-power coefficient,

$$CQR-(CLR)^2 \frac{\rho}{2(V/\Omega R)} - CXR \frac{V}{\Omega R}$$

CQR rotor total torque and total power coefficient

$$\frac{(\text{torque}) \ \ (\Omega)}{\rho\ S\ (\Omega R)^3}$$

CXR rotor propulsive-force coefficient in wind-axis system,

$$- \frac{\text{drag}}{\rho\ S\ (\Omega R)^2}$$

CYR rotor side-force coefficient in wind-axis system,

$$\frac{\text{side-force}}{\rho\ S\ (\Omega R)^2}$$

DELTA THETA half the difference in collective pitch between the upper and lower rotor blades, $\frac{\theta_u - \theta_\ell}{2}$, deg

L/D ratio of rotor lift to equivalent drag, $\frac{\text{lift}}{\text{drag} + (\text{torque})\ (\Omega/V)}$

$M_{(1.0)\ (90)}$ rotor-blade tip Mach number at the 90° azimuth position

R rotor radius, m

S reference area, $bRc_{.75R}$, m^2

T	free-stream temperature, ^{o}K
THETA	half the sum of the collective pitch of the upper and lower rotor blades, $\frac{\theta_u + \theta_\ell}{2}$, deg
V	free-stream velocity, m/sec
$\frac{V}{\Omega R}$, $\frac{V}{OR}$	advance ratio
ρ	air density, kg sec^2/m^4
Ω	rotor rotational speed, radians/sec
θ_c	cyclic pitch, deg
θ_ℓ	lower rotor blade collective at 0.75R, deg
θ_u	upper rotor blade collective at 0.75R, deg
ψ	rotor-blade azimuth angle measured from downwind position in direction of rotation for each rotor, deg

MODEL DESCRIPTION

The rotor system consisted of two, three bladed counter-rotating coaxial rotors. Dimensional information is listed below.

Rotor radius, m (ft)	6.098 (20)
Blade chord, m (ft)	
root	.5273 (1.73)
tip	.26365 (0.865)
Cutout radius, m (ft)	.7391 (2.425)
Rotor solidity, $\frac{S}{\pi R^2}$	0.111
Reference area, S, m^2 (ft^2)	
dual rotor	12.96 (139.5)
single rotor	6.48 (69.75)
Precone angle deg	
upper rotor	5
lower rotor	0
First mode bending frequency, cycle/sec	
flatwise	8.0
torsion	114.5

Blade chord length was linearly tapered between root and tip. Blade twist was non-linear and is shown in figure 1. Root airfoil section (at cutout radius) was NACA 0030 with linear taper in thickness ratio to a NACA 0006 section at the tip. The distance between the upper rotor and the lower rotor centers was .7622 m. (The upper rotor rotated counterclockwise and the lower rotor rotated clockwise as seen from above.)

Figure 2 is a general view of the rotor system installed in the wind tunnel test section. Rotor shaft angle-of-attack was remotely controlled using an extendable tail strut. Rotor power was provided by two 1521 metric HP variable frequency electric motors inside the faired body. The rotor was remotely controlled and monitored from the control room.

The single rotor test configuration consisted of the upper rotor plus simulated root end fittings in place of the lower rotor blades.

OPERATING PROCEDURES

For a given rotor rotational speed, tunnel speed was adjusted to maintain the desired advance ratio. At each shaft angle, the collective pitch and the inter-rotor moment controls were varied in accordance with a pre-test plan. The remaining controls were adjusted to "trim" the rotor system about all three axes. Data were than recorded. Collective pitch, B1SP or shaft angle was then changed and the above procedure repeated until a limit was reached in either structural loading, tunnel balance vibration or clearance between the upper and lower rotor blade tips. The clearance limit between blade tips was arbitrarily set at 10 inches.

Control power derivative data were obtained by varying one control at a time leaving the others fixed at their trim setting. Each control was deflected in both a positive and negative direction from its trimmed setting.

Single rotor data were accumulated with the controls set at the same position as in the dual rotor case.

Test conditions are illustrated in the rotor velocity diagram in figure 3.

DATA REDUCTION

Six-component forces and moments were measured by the wind-tunnel balance system. Tare corrections were applied to the balance data to account for forces and moments produced by the exposed model support struts, the faired body, and the rotating hub. The rotating hub tares included a simulated blade root end fittings out to .08125 R. The tares applied were based on wind-tunnel dynamic pressure, shaft angle and hub RPM.

Wind tunnel wall corrections were not applied to the data. There are a number of tunnel wall correction techniques which may be employed by the reader in analyzing the ABC rotor data. One type of wall correction which may be used is that based on a fixed wing being analogous to the rotor. The formulas for this type of correction are given below.

For the dual rotor configuration,

$$\Delta \text{ (ALPHA SHAFT)} = .593(\text{CLR})\left(\frac{1}{V/\Omega R}\right)^2$$

$$\Delta \text{ CXR} = -.01036(\text{CLR})^2 \left(\frac{1}{V/\Omega R}\right)^2$$

$$\Delta \text{ CMY} = -3.5(\Delta\text{CXR}) \text{ COS (ALPHA SHAFT)}/(2)(20)$$

For the single rotor configuration,

$$\Delta \text{ (ALPHA SHAFT)} = .331 \text{ (CLR)} \left(\frac{1}{V/\Omega R}\right)^2$$

$$\Delta \text{ CXR} = -.00577(\text{CLR})^2 \left(\frac{1}{V/\Omega R}\right)^2$$

$$\Delta \text{ CMY} = -3.5(\Delta\text{CXR}) \text{ COS (ALPHA SHAFT)}/(2)(20)$$

An example of the magnitude of this correction is shown below for two advance ratios, $\frac{V}{\Omega R}$ = .21 and .7, using two actual data points from tables 6 and 17.

	Wall Correction		Wall Correction	
	WITHOUT	WITH	WITHOUT	WITH
Table No.	6	6	17	17
Point No.	2	2	11	11
V/ΩR	.2127	.2127	.7025	.7025
ALPHA SHAFT	8.	9.71	4.	4.16
CLR	.130	.130	.1309	.1309
CXR	-.0199	-.0238	-.0214	-.0227
L/D	5.81	4.95	6.47	6.07
CPO	.00034	.00116	.01285	.01311
CQR	.000529	.000529	-.000805	-.000805
CMY	-.001895	-.001560	-.002578	-.002464

Force and moment data are referred to a point located at the center of the lower rotor hub. The force data are in the wind axis system and the moment data are in the shaft axes system. (These data are presented in Tables 1 through 20.) The control settings presented with the force and moment data are values hand recorded from meter readings.

Rotor power was determined from wattmeter readings of electrical power into the rotor drive motors. Motor plus transmission losses were determined by calibrations using the wind tunnel balance.

The rotor profile power coefficient is based on the assumption of uniform downwash distribution over the rotor disk.

"Trim" was established for the test program based upon 1P bending moments for the upper and lower rotors, electrically summed. Tunnel balance data indicate that roll trim was not achieved by a considerable margin. What was the cause of the discrepancy between the tunnel balance rolling moment data and the electrically summed 1P bending moments? The tunnel balance system was checked and found satisfactory. The tare configuration had no component that would contribute substantially to rolling moment with the rotors on and not contribute when the rotors were off. It appears that the rolling moment discrepancy was the result of instrumentation problems associated with the lower rotor slip ring assembly. The balance data presented herein is accurate, and although the rolling moment was not trimmed in the test, this does not indicate nor infer that trim could not have been achieved. A survey of the high advance ratio data indicates that L/D changes slightly as the out-of-trim rolling moment is reduced. In general, L/D increased as trim was approached.

RESULTS

Test results are presented in Tables 1 through 20 and organized in the following manner.

Table No.	Advance Ratio, $V/\Omega R$	ALPHA SHAFT
1	.212	-10,-8,-4
2		-4
3		-4,0
4		4
5		4,8
6		8
7	.355	-8,-4
8		-4,0,4,8
9	.467	-8
10		-8,-4
11		-4,0
12		0
13		0,4
14		8
15	.698	-4
16		-4,0,4
17		4
18	.910	-2,0
19*	.212	-8,0,8
20*	.351	-8,-4,0,4

*Tables 19 and 20 are single rotor test results.

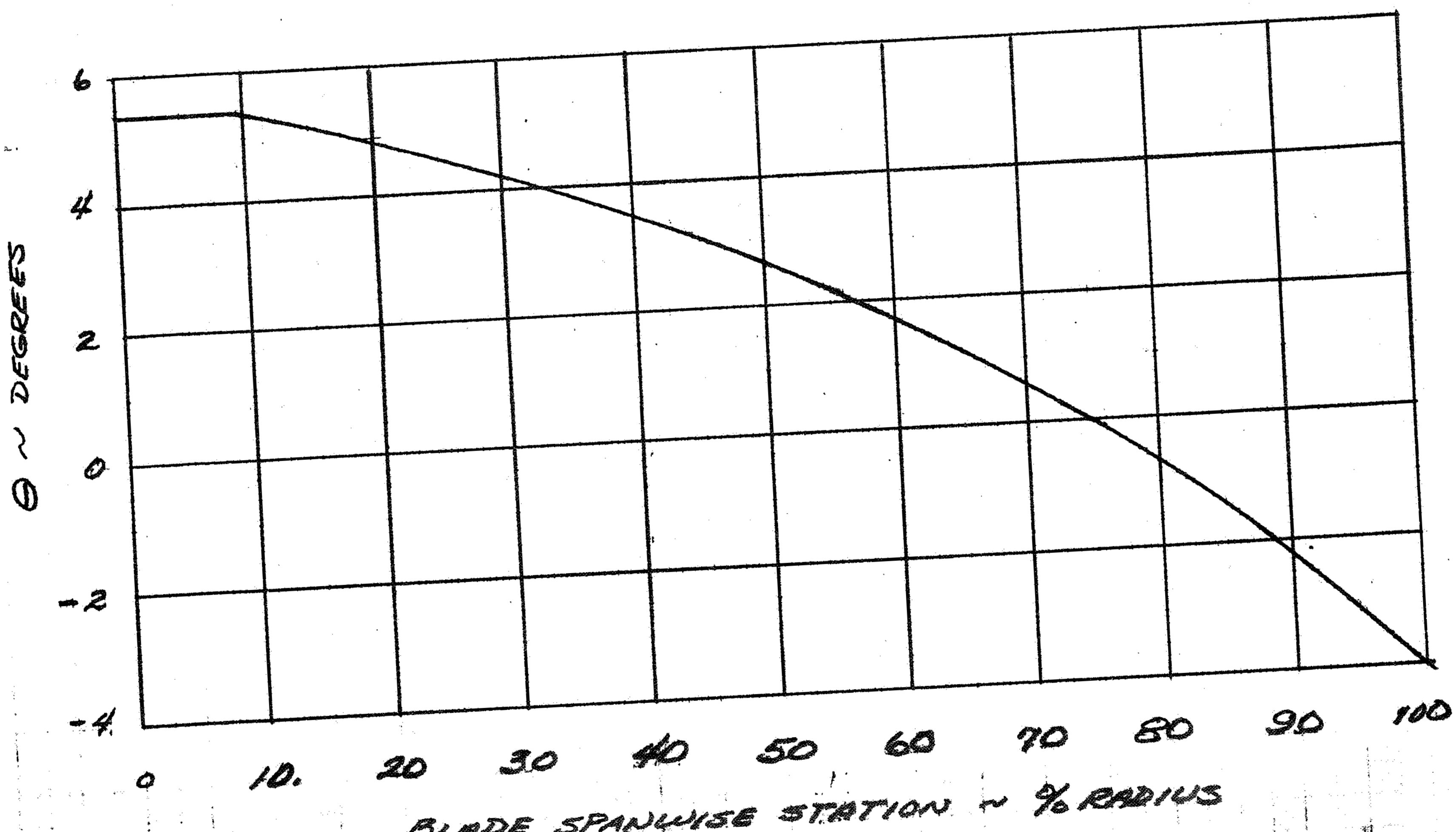


FIGURE 1 ABC ROTOR TWIST DISTRIBUTION

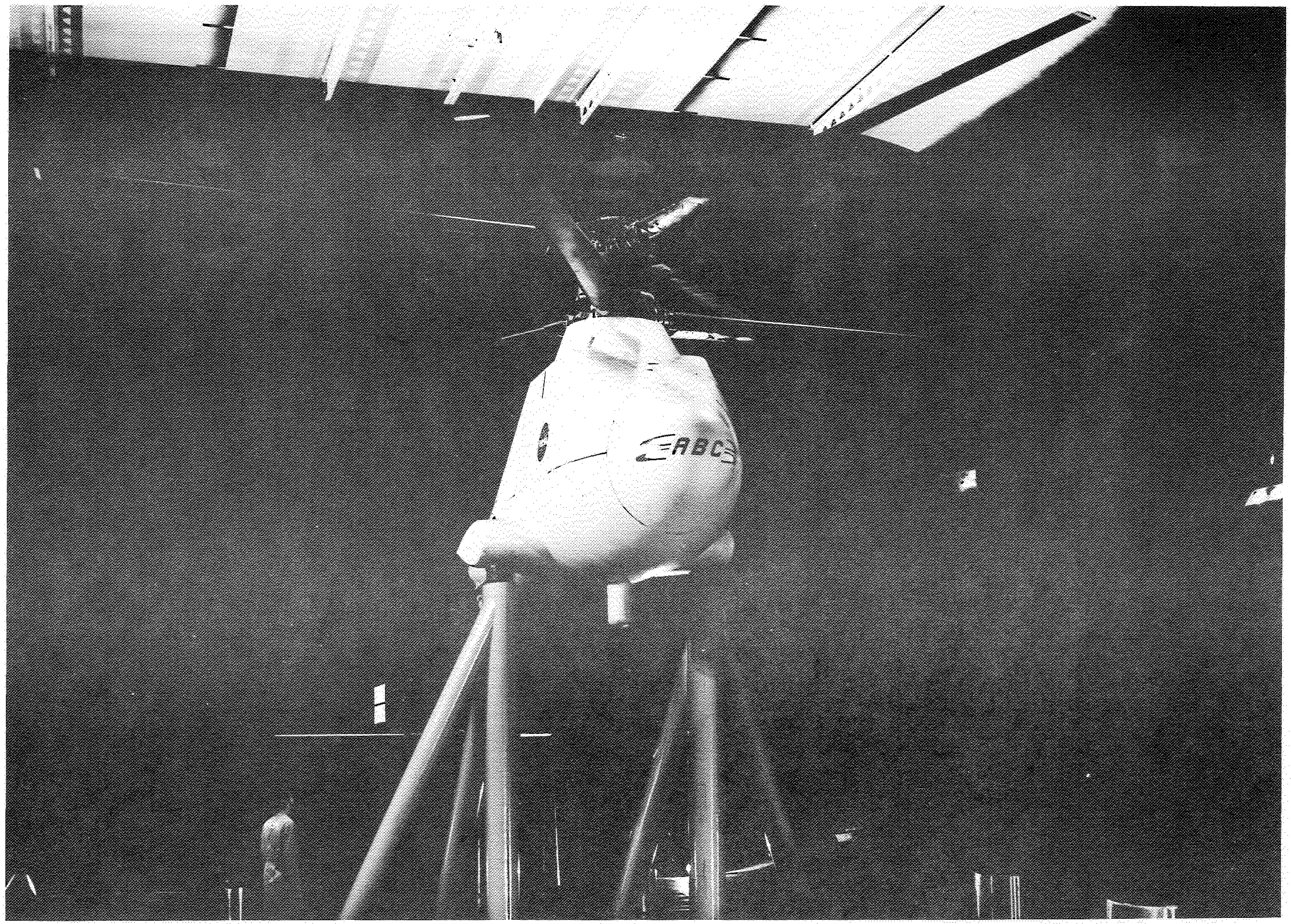


FIGURE 2 GENERAL VIEW OF ROTOR SYSTEM

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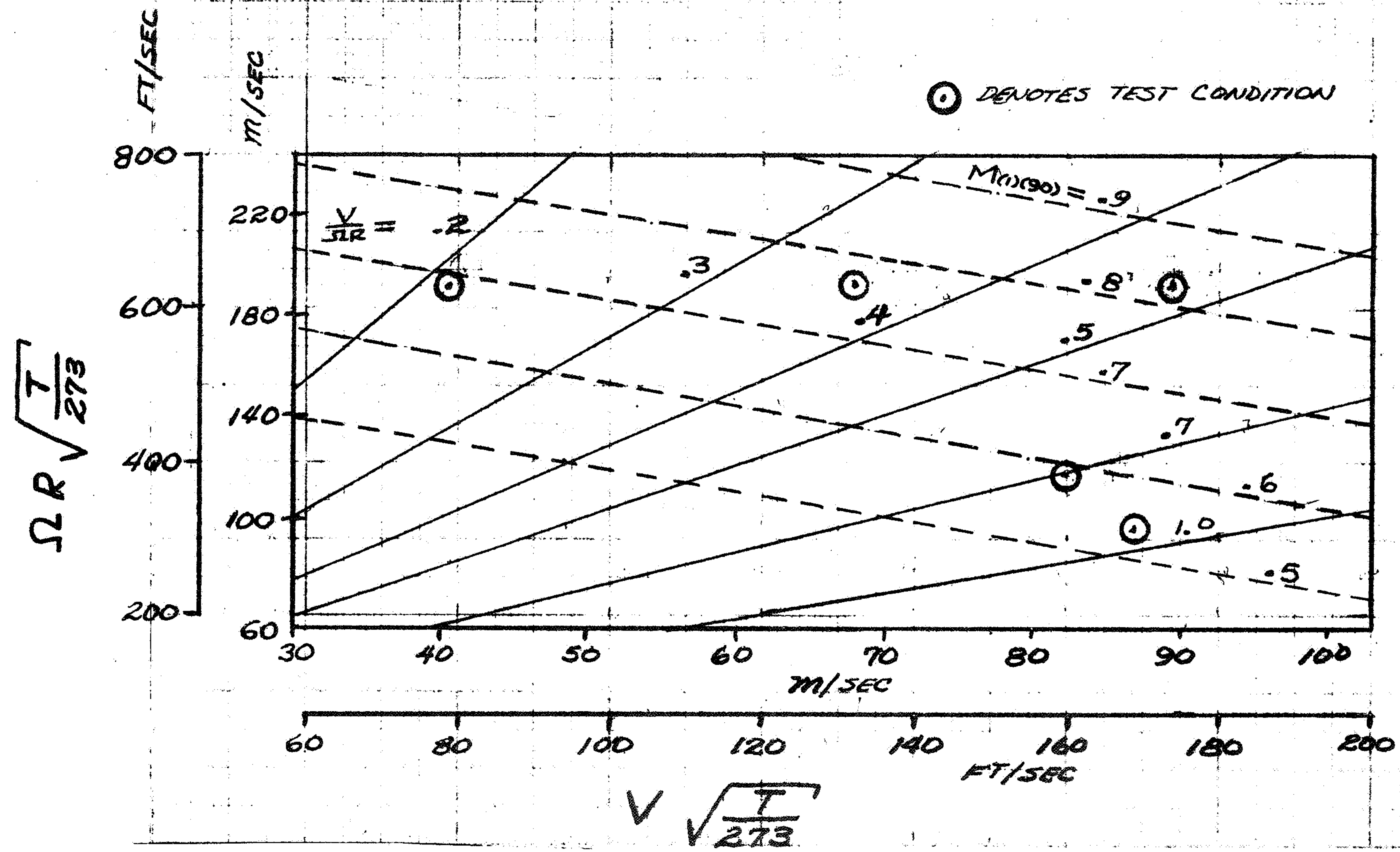


Figure 3 Rotor Velocity Diagram

TEST 362.0 RUN 5

TABLE No. 1

A B C ROTOR V/OR = 0.21 , M(1.0)(90) = 0.69

WIND AXES FORCES, SHAFT AXES MOMENTS

PT	THETA	ALPHA SHAFT	B1SP	B1S	A1SP	A1S	DELTA THETA	L/D	CLR	CXR	CQR	CPO	CYR	CMX	CMY	CMZ
1	10.0	-10.0	4.2	0.1	0.4	-3.2	0.2	4.84	0.09387	0.014395	0.0071485	0.0017915	-0.000410	-0.001772	0.000667	0.000604
2	12.0	-10.0	4.2	0.0	0.4	-4.5	0.2	4.13	0.11940	0.017888	0.0098987	0.0023743	-0.001246	-0.002914	0.001458	0.000768
3	14.0	-10.0	4.4	0.2	0.5	-5.9	0.3	3.23	0.14815	0.021926	0.0143932	0.0040005	-0.001737	-0.003185	0.000917	0.001217
4	12.0	-8.0	6.0	-0.4	0.4	-4.0	-0.4	3.98	0.11923	0.016219	0.0097829	0.0026225	-0.000500	-0.002820	0.000542	-0.000220
5	12.0	-8.0	4.0	-0.3	0.4	-5.2	-0.4	3.99	0.13228	0.015656	0.0103249	0.0024222	-0.000954	-0.002593	0.000312	-0.000126
6	14.0	-8.0	4.0	-0.3	0.5	-6.6	-0.4	3.07	0.15953	0.017772	0.0148197	0.0043966	-0.001484	-0.003663	0.000612	0.000180
7	10.0	-8.0	4.0	-0.5	0.4	-3.8	-0.5	4.78	0.10316	0.012688	0.0072651	0.0017892	-0.000389	-0.002425	0.000168	-0.000336
8	10.0	-8.0	2.0	-0.5	0.4	-5.2	-0.5	4.62	0.11396	0.012216	0.0078071	0.0018160	-0.001097	-0.003112	-0.000041	-0.000171
9	12.0	-8.0	2.0	-0.3	0.5	-6.4	-0.4	3.66	0.14495	0.014559	0.0114874	0.0028994	-0.001412	-0.002892	0.000478	0.000069
10	10.0	-4.0	6.0	1.5	0.5	-3.7	2.2	3.36	0.10503	0.007775	0.0082327	0.0036913	-0.001048	-0.004027	0.000535	0.003283
11+	10.0	-4.0	3.9	1.4	0.6	-4.9	2.2	3.73	0.11828	0.006597	0.0081172	0.0030551	-0.002938	-0.004612	-0.000390	0.002870
12*	10.0	-4.0	3.9	2.8	0.7	-5.1	2.2	3.65	0.11773	0.007108	0.0083103	0.0031666	-0.000600	0.002325	-0.000861	0.002716
13*	10.0	-4.0	4.0	-0.7	0.4	-4.5	1.5	3.95	0.12045	0.005819	0.0076911	0.0026582	-0.004867	-0.010258	0.000357	0.001943
14*	10.0	-4.0	3.9	1.5	0.6	-3.6	2.1	3.64	0.11638	0.005139	0.0078457	0.0032037	-0.001618	-0.003968	0.006358	0.003138
15*	10.0	-4.0	4.0	1.7	0.6	-6.3	2.8	3.52	0.11972	0.007971	0.0088524	0.0034002	-0.004336	-0.002681	-0.007009	0.003391
16*	10.0	-4.0	4.0	0.8	0.5	-4.8	5.6	2.09	0.10431	0.004290	0.0114871	0.0077263	-0.008349	-0.016407	-0.006874	0.008891
17*	10.0	-4.0	4.0	0.8	0.6	-4.8	-2.4	4.07	0.11956	0.006225	0.0075361	0.0024721	0.005234	0.008332	-0.001048	-0.002379

+ DENOTES 'TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

* DENOTES 'OUT OF TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

TEST 362.0 RUN 6

TABLE No. 2

A B C ROTOR V/OR = 0.21 , M(1.0)(90) = 0.69

WIND AXES FORCES, SHAFT AXES MOMENTS

PT	THETA	ALPHA SHAFT	B1SP	B1S	A1SP	A1S	DELTA THETA	L/D	CLR	CXR	CQR	CPO	CYR	CMX	CMY	CMZ
1	7.9	-4.0	4.0	2.5	0.7	-3.4	4.5	2.88	0.08348	0.004384	0.0069886	0.0042245	-0.002566	-0.006967	0.000205	0.005127
2	10.0	-4.0	3.9	1.5	0.6	-4.8	2.3	3.66	0.11849	0.006599	0.0081333	0.0030233	-0.002677	-0.005235	0.000401	0.003189
3	12.0	-4.0	3.9	0.7	0.5	-6.1	0.9	3.43	0.14918	0.007578	0.0108478	0.0034251	-0.002300	-0.003792	0.000712	0.001828
4	7.9	-4.0	1.9	0.7	0.5	-4.5	1.8	5.08	0.10175	0.003434	0.0049271	0.0014710	-0.003483	-0.002651	0.000552	0.001386
5+	10.0	-4.0	2.0	0.9	0.6	-5.8	1.6	4.00	0.13282	0.004805	0.0080596	0.0024251	-0.004066	-0.004361	0.000562	0.002162
6*	10.0	-4.0	2.0	1.4	0.5	-6.0	0.0	4.23	0.13549	0.005620	0.0079440	0.0019268	0.001147	0.003360	-0.000278	0.000012
7*	10.0	-4.0	2.0	-1.5	0.3	-6.0	0.0	4.11	0.13486	0.005126	0.0080207	0.0021609	-0.004509	-0.008813	-0.000343	0.000604
8*	10.0	-4.0	1.9	0.8	0.5	-4.6	1.6	3.78	0.13144	0.003421	0.0080197	0.0027348	-0.002893	-0.004318	0.006578	0.002350
9*	10.0	-4.0	2.1	0.8	0.5	-7.2	1.5	3.92	0.13312	0.006888	0.0086317	0.0025216	-0.004517	-0.003106	-0.006559	0.001887
10*	9.9	-4.0	2.0	0.8	0.5	-5.8	3.2	3.15	0.12466	0.004900	0.0093562	0.0042214	-0.006902	-0.009226	-0.002473	0.004734
11*	10.0	-4.0	2.0	0.2	0.4	-6.0	0.0	4.30	0.13545	0.005444	0.0077912	0.0018113	-0.001579	-0.002319	0.000020	0.000315

+ DENOTES 'TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

* DENOTES 'OUT OF TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

TEST 362.0 RUN 7

TABLE No. 3

A B C ROTOR V/OR = 0.21 , M(1.0)(90) = 0.69

WIND AXES FORCES, SHAFT AXES MOMENTS

PT	THETA	ALPHA SHAFT	B1SP	B1S	A1SP	A1S	DELTA THETA	L/D	CLR	CXR	CQR	CPO	CYR	CMX	CMY	CMZ
1	10.0	-4.0	2.0	-0.3	0.4	-5.6	-0.1	4.50	0.13577	0.004873	0.0074338	0.0015794	-0.001888	-0.003337	0.001624	0.000204
2	12.0	-4.0	2.0	-0.1	0.5	-7.2	0.0	3.40	0.16205	0.005520	0.0113152	0.0032862	-0.002213	-0.003980	0.000498	0.000600
3	10.0	0.0	6.0	-0.2	0.3	-4.2	-0.1	4.08	0.12499	0.000521	0.0066189	0.0024278	-0.001058	-0.002904	-0.000359	-0.000039
4	8.0	0.0	4.0	-0.2	0.4	-4.0	-0.2	5.61	0.11171	-0.001108	0.0040242	0.0010271	-0.001226	-0.002747	-0.000510	-0.000372
5	10.0	0.0	4.0	0.2	0.4	-5.5	-0.1	4.46	0.14267	-0.001583	0.0064962	0.0015410	-0.001090	-0.001863	-0.000241	-0.000100
6	12.0	0.0	4.0	0.4	0.6	-7.0	-0.1	3.30	0.17047	-0.001971	0.0105965	0.0034627	-0.001698	-0.003752	-0.000348	0.000362
7	6.0	0.0	2.0	-0.4	0.4	-3.8	-0.2	6.39	0.09286	-0.002056	0.0026552	0.0008460	-0.001110	-0.002555	0.000144	-0.000364
8	8.0	0.0	2.0	0.0	0.4	-5.4	-0.2	5.32	0.12748	-0.002555	0.0045904	0.0009316	-0.001488	-0.002034	-0.000362	-0.000149
9	10.0	0.0	2.0	0.0	0.5	-6.6	-0.1	4.25	0.15182	-0.003586	0.0068744	0.0016543	-0.002188	-0.003328	-0.000254	0.000078
10	12.0	0.0	2.0	1.0	0.6	-7.5	-0.1	3.07	0.17716	-0.005457	0.0112073	0.0042484	-0.000992	-0.002196	0.000942	0.000186
11	8.0	0.0	0.1	0.2	0.5	-6.3	-0.2	4.73	0.13390	-0.004342	0.0051112	0.0013776	-0.001846	-0.002201	0.000261	0.000033

+ DENOTES 'TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

* DENOTES 'OUT OF TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

TEST 362.0 RUN 8

TABLE No. 4

A B C ROTOR V/OR = 0.21 , M(1.0)(90) = 0.69

WIND AXES FORCES, SHAFT AXES MOMENTS

PT	THETA	ALPHA SHAFT	B1SP	B1S	A1SP	A1S	DELTA THETA	L/D	CLR	CXR	CQR	CPO	CYR	CMX	CMY	CMZ
1	8.0	4.0	6.0	-0.1	0.3	-3.2	-0.2	4.51	0.11920	-0.008271	0.0039106	0.0020268	-0.000666	-0.001332	0.000901	-0.000052
2+	8.0	4.0	4.0	0.0	0.4	-4.4	-0.2	5.04	0.13204	-0.010503	0.0033423	0.0010441	-0.000868	-0.001033	0.000095	-0.000090
3*	8.0	4.0	3.9	1.7	0.6	-4.4	-0.2	4.91	0.13203	-0.010715	0.0034611	0.0012246	0.002133	0.005385	0.000326	0.000192
4*	8.0	4.0	4.0	-1.7	0.2	-4.4	-0.2	4.99	0.12996	-0.010802	0.0032635	0.0011938	-0.004309	-0.009183	0.000313	-0.000406
5*	8.0	4.0	3.9	0.0	0.4	-3.1	-0.2	4.94	0.13025	-0.012343	0.0029920	0.0012186	-0.000611	-0.000966	0.007475	0.000014
6*	8.0	4.0	4.1	0.0	0.4	-5.9	-0.2	5.07	0.13176	-0.008143	0.0038643	0.0011734	-0.001083	-0.001259	-0.008074	-0.000102
7*	8.0	4.0	4.0	0.0	0.3	-4.4	1.5	4.59	0.12921	-0.010297	0.0038238	0.0016911	-0.004214	-0.006487	0.000033	0.001295
8*	8.0	4.0	4.0	0.1	0.3	-4.4	-1.5	4.88	0.13109	-0.010435	0.0035069	0.0012771	0.001664	0.002262	0.000129	-0.000828
9	10.0	4.0	4.0	0.7	0.3	-5.8	0.2	4.02	0.15653	-0.012014	0.0057647	0.0019881	-0.001382	-0.002067	0.000285	0.000774
10	6.0	4.0	4.0	0.0	0.2	-3.0	0.0	6.22	0.10060	-0.008329	0.0016852	0.0008590	-0.001052	-0.001497	-0.000197	-0.000235
11+	6.0	4.0	1.9	-0.1	0.2	-4.3	0.0	6.36	0.11186	-0.009903	0.0016454	0.0005208	-0.001885	-0.002901	-0.000125	-0.000067
12*	6.0	4.0	2.0	1.7	0.3	-4.2	0.0	6.37	0.11124	-0.009789	0.0016485	0.0005520	0.001568	0.005578	0.000017	0.000022
13*	6.0	4.0	2.0	-1.4	0.1	-4.3	0.0	6.19	0.11207	-0.010256	0.0016883	0.0006599	-0.004106	-0.008694	-0.000179	-0.000196
14*	6.0	4.0	1.9	0.1	0.3	-2.7	0.0	6.41	0.11125	-0.012034	0.0011325	0.0004711	-0.000965	-0.000993	0.008313	-0.000170
15*	6.0	4.0	2.2	0.1	0.2	-5.6	0.0	6.20	0.11168	-0.007984	0.0021646	0.0006750	-0.001558	-0.001481	-0.007419	0.000041
16*	6.0	4.0	2.0	0.1	0.3	-4.3	1.5	5.83	0.11080	-0.010203	0.0018865	0.0008889	-0.003940	-0.005120	-0.000698	0.000283
17*	6.0	4.0	2.0	0.1	0.3	-4.3	-1.5	6.32	0.10945	-0.009447	0.0016881	0.0006116	0.001709	0.002233	-0.000485	-0.000408
18	8.0	4.0	2.0	0.2	0.3	-5.5	0.1	5.11	0.14470	-0.012991	0.0032751	0.0006109	-0.002212	-0.002772	0.000737	0.000283
19+	10.0	4.0	2.2	0.2	0.3	-6.8	0.0	3.88	0.16846	-0.014961	0.0060927	0.0019525	-0.002816	-0.004133	-0.000022	0.000549
20*	10.0	4.0	2.0	2.6	0.5	-6.8	0.0	3.70	0.16626	-0.015029	0.0064505	0.0025691	0.002036	0.004182	0.000320	0.000055
21*	10.0	4.0	2.0	-1.1	0.2	-6.8	0.0	3.70	0.16933	-0.015477	0.0064896	0.0023958	-0.005706	-0.009134	-0.000565	0.000991
22*	10.0	4.0	1.8	1.0	0.4	-5.6	0.0	3.66	0.16859	-0.017483	0.0060921	0.0024296	-0.000670	-0.001320	0.007042	0.000760
23*	10.0	4.0	2.1	1.0	0.3	-8.1	0.0	3.74	0.16877	-0.013131	0.0069272	0.0024545	-0.001947	-0.001905	-0.006304	0.000301

+ DENOTES 'TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

* DENOTES 'OUT OF TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

TEST 362.0 RUN 9

TABLE No. 5

A B C ROTOR V/OR = 0.21 , M(1.0)(90) = 0.69

WIND AXES FORCES, SHAFT AXES MOMENTS

PT	THETA	ALPHA SHAFT	B1SP	B1S	A1SP	A1S	DELTA THETA	L/D	CLR	CXR	CQR	CPO	CYR	CMX	CMY	CMZ
1	4.0	4.0	2.0	-0.1	0.1	-2.8	-0.2	7.39	0.08067	-0.007666	0.0006961	0.0006583	-0.000916	-0.001196	0.000648	-0.000248
2+	10.0	4.0	2.0	0.5	0.3	-6.5	0.0	3.79	0.16984	-0.015733	0.0061945	0.0020371	-0.002109	-0.002983	0.001856	0.000599
3*	10.1	4.0	2.0	0.5	0.3	-6.5	1.5	3.37	0.16643	-0.014795	0.0073738	0.0032969	-0.005156	-0.006427	-0.000185	0.002964
4*	10.0	4.0	2.0	0.7	0.3	-6.5	-1.5	3.72	0.16706	-0.015695	0.0062342	0.0023431	0.001580	0.000261	0.001529	-0.001381
5	6.0	4.0	-0.1	0.3	0.2	-5.1	0.0	5.80	0.12034	-0.012003	0.0018695	0.0006822	-0.001701	-0.001830	0.001788	0.000042
6	8.0	4.0	0.0	0.3	0.2	-6.5	0.1	4.41	0.15185	-0.015147	0.0041105	0.0013292	-0.002981	-0.003425	0.000803	0.000376
7	4.6	8.0	4.0	-0.3	0.2	-2.1	-0.8	6.62	0.08606	-0.014382	-0.0002953	0.0008221	-0.001121	-0.001344	0.000633	-0.000264
8	6.0	8.0	4.0	0.1	0.2	-3.4	0.0	5.87	0.11732	-0.018043	0.0004176	0.0006979	-0.000984	-0.000765	0.000367	0.000157
9+	8.0	8.0	4.0	0.2	0.2	-4.7	0.1	4.52	0.14756	-0.021882	0.0023020	0.0013199	-0.001835	-0.002746	0.000946	0.000665
10*	8.0	8.0	3.8	2.3	0.4	-4.7	0.1	4.27	0.14924	-0.022106	0.0027345	0.0016591	0.002212	0.005668	0.001182	0.001334
11*	8.0	8.0	4.0	-1.3	0.1	-4.7	0.1	4.52	0.14647	-0.022008	0.0022233	0.0013399	-0.004815	-0.009455	0.000853	0.000195
12*	8.0	8.0	3.9	0.3	0.3	-3.5	0.1	4.27	0.14473	-0.023207	0.0022622	0.0016761	-0.001159	-0.002265	0.006921	0.000912
13*	8.0	8.0	4.1	0.3	0.2	-6.3	0.1	4.52	0.14954	-0.019596	0.0028868	0.0013000	-0.002260	-0.002259	-0.007591	0.000558
14*	8.0	8.0	4.0	0.4	0.3	-4.8	1.5	4.13	0.14507	-0.021246	0.0029649	0.0020104	-0.004282	-0.007047	0.000672	0.001855
15*	8.0	8.0	4.0	0.4	0.3	-4.7	-1.5	4.50	0.14320	-0.021423	0.0022192	0.0014537	0.001949	0.003330	0.000476	-0.000445

+ DENOTES 'TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

* DENOTES 'OUT OF TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

TEST 362.0 RUN 10

TABLE A5.6

A B C ROTOR V/OR = 0.21 , M(1.0)(90) = 0.69

WIND AXES FORCES, SHAFT AXES MOMENTS

PT	THETA	ALPHA SHAFT	B1SP	B1S	A1SP	A1S	DELTA THETA	L/D	CLR	CXR	CQR	CPO	CYR	CMX	CMY	CMZ
1	4.0	8.0	2.0	-0.2	0.1	-3.4	-0.2	6.65	0.09777	-0.015884	-0.0002520	0.0006484	-0.001326	-0.001867	-0.000163	-0.000171
2	6.0	8.0	2.0	0.3	0.2	-5.0	-0.1	5.81	0.13021	-0.019922	0.0005286	0.0003406	-0.001477	-0.001315	-0.001895	0.000100
3+	8.0	8.0	2.0	0.2	0.3	-6.0	-0.1	4.50	0.15991	-0.024757	0.0022849	0.0008353	-0.002719	-0.003356	-0.000536	0.000499
4*	8.0	8.0	2.0	2.1	0.4	-6.0	-0.1	4.31	0.15967	-0.024659	0.0026363	0.0012203	0.001086	0.004005	-0.000580	0.000684
5*	8.0	8.0	2.0	-1.4	0.2	-6.0	0.0	4.28	0.16053	-0.025287	0.0025974	0.0012568	-0.005795	-0.009470	-0.000927	0.000495
6*	8.0	8.0	1.9	0.4	0.3	-4.7	-0.1	4.39	0.15796	-0.026660	0.0019726	0.0010748	-0.001488	-0.002128	0.006475	0.000703
7*	8.0	8.0	2.2	0.5	0.2	-7.5	-0.1	4.43	0.16141	-0.022190	0.0030265	0.0009130	-0.003037	-0.003037	-0.009005	0.000475
8*	8.0	8.0	2.1	0.4	0.3	-6.0	1.5	4.10	0.15573	-0.023712	0.0030265	0.0017077	-0.005545	-0.006245	-0.001541	0.001809
9*	8.0	8.0	2.0	0.4	0.3	-6.1	-1.5	4.50	0.15766	-0.024530	0.0022461	0.0009957	0.001246	0.001277	-0.000659	-0.000381
10	10.0	8.0	1.9	1.9	0.4	-7.0	0.1	3.28	0.18298	-0.028531	0.0057979	0.0031188	-0.001363	-0.000792	-0.000688	0.001119
11	10.0	8.0	4.0	1.0	0.3	-6.3	0.1	3.51	0.17216	-0.024523	0.0051835	0.0026206	-0.001325	-0.001527	-0.000389	0.001376
12	6.0	8.0	4.0	0.0	0.2	-3.6	0.0	5.69	0.11638	-0.017774	0.0005645	0.0007894	-0.001491	-0.001783	-0.000279	0.000016
13	4.0	8.0	0.0	0.3	0.4	-4.4	-0.1	6.45	0.10792	-0.017354	-0.0001342	0.0004943	-0.001303	-0.000999	-0.000675	-0.000029
14	6.0	8.0	0.0	0.4	0.4	-5.7	0.0	5.14	0.14097	-0.022749	0.0009914	0.0005866	-0.002526	-0.002528	-0.000895	0.000268
15	8.0	8.0	0.0	1.2	0.6	-6.6	0.0	3.91	0.16818	-0.028085	0.0031653	0.0017350	-0.002408	-0.001123	-0.000074	0.000561

+ DENOTES 'TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

* DENOTES 'OUT OF TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

TEST 362.0 RUN 11

TABLE No. 7

A B C ROTOR V/OR = 0.36 , M(1.0)(90) = 0.76

WIND AXES FORCES, SHAFT AXES MOMENTS

PT	THETA	ALPHA SHAFT	B1SP	B1S	A1SP	A1S	DELTA THETA	L/D	CLR	CXR	CQR	CPO	CYR	CMX	CMY	CMZ
1	12.0	-8.0	7.9	0.0	-0.5	-2.8	0.1	6.45	0.09490	0.009555	0.0086361	0.0038319	0.000389	-0.004859	0.004438	0.001031
2	12.0	-8.0	5.9	0.1	0.3	-5.0	0.1	7.32	0.11861	0.010800	0.0095781	0.0035459	-0.000598	-0.006061	-0.000106	0.000970
3	10.0	-8.0	4.0	0.0	-0.3	-4.9	0.1	8.49	0.10171	0.007692	0.0069600	0.0026155	-0.000985	-0.005828	0.000074	0.001083
4	12.0	-8.0	4.0	0.0	-0.3	-6.2	0.1	6.62	0.13893	0.010065	0.0110681	0.0044752	-0.001943	-0.006846	0.001513	0.001375
5	10.0	-8.0	2.0	0.1	-0.3	-5.8	0.0	7.13	0.11962	0.006690	0.0083297	0.0037180	-0.002687	-0.008243	0.002316	0.001407
6	8.0	-4.0	4.0	0.0	-0.3	-4.1	0.0	9.04	0.09880	0.001743	0.0044951	0.0023495	-0.001574	-0.005162	0.000434	0.000370
7	8.0	-4.0	6.0	0.0	-0.2	-2.7	0.0	7.85	0.07450	0.001387	0.0038632	0.0025033	-0.000590	-0.002914	0.001193	0.000643
8	10.0	-4.0	6.0	0.0	-0.2	-4.5	0.1	8.02	0.11343	0.003370	0.0062362	0.0030310	-0.001663	-0.005385	0.000507	0.000612
9	12.0	-4.0	8.0	0.3	-0.2	-5.3	0.2	6.52	0.12996	0.005947	0.0092022	0.0044516	-0.001759	-0.004871	0.000325	0.001236
10	12.0	-4.0	6.0	0.4	-0.3	-6.1	0.1	6.67	0.15120	0.004262	0.0095620	0.0044742	-0.001793	-0.004405	0.002173	0.000999
11	10.0	-4.0	4.0	0.0	-0.2	-5.7	0.1	7.91	0.13682	0.002462	0.0070222	0.0032244	-0.002622	-0.007246	0.001564	0.000871
12	12.0	-4.0	4.0	-0.5	-0.3	-7.2	0.2	5.80	0.16841	0.001868	0.0110064	0.0059222	-0.003575	-0.008429	0.002160	0.001724
13	8.0	-4.0	2.0	-0.5	-0.3	-5.3	0.0	8.26	0.11874	0.000748	0.0053828	0.0029190	-0.003780	-0.007863	0.001060	0.000894

TEST 362.0 RUN 12

TABLE No. 8

A B C ROTOR V/OR = 0.36 , M(1.0)(90) = 0.76

WIND AXES FORCES, SHAFT AXES MOMENTS

PT	THETA	ALPHA SHAFT	B1SP	B1S	A1SP	A1S	DELTA THETA	L/D	CLR	CXR	CQR	CPO	CYR	CMX	CMY	CMZ
1	8.0	-4.0	4.0	0.4	-0.1	-4.5	0.9	8.77	0.10426	0.001652	0.0048313	0.0025508	-0.001943	-0.003232	0.000375	0.000587
2	8.0	-4.0	6.0	0.5	-0.1	-0.8	1.0	7.95	0.08127	0.001757	0.0042487	0.0025917	-0.001057	-0.001238	0.000507	0.000597
3	8.0	0.0	6.1	0.5	-0.2	-4.1	1.0	8.46	0.11623	-0.003763	0.0035439	0.0027713	-0.001902	-0.002269	-0.000174	0.000528
4	6.0	0.0	4.0	0.3	-0.1	-3.6	0.8	9.40	0.09384	-0.004254	0.0020299	0.0021603	-0.001963	-0.002719	0.000361	0.000222
5	8.0	0.0	4.0	0.6	-0.1	-5.6	0.9	8.78	0.13777	-0.005162	0.0037296	0.0025838	-0.001966	-0.001974	0.000447	0.000489
6	10.0	0.0	4.0	0.3	-0.2	-7.2	0.9	6.27	0.16940	-0.007109	0.0070338	0.0050447	-0.003679	-0.005519	0.000646	0.001066
7	6.0	0.0	2.0	0.2	-0.2	-7.2	0.8	9.01	0.11298	-0.005035	0.0026554	0.0024359	-0.002800	-0.004283	-0.001257	0.000337
8	8.0	0.0	2.0	0.2	-0.2	-7.1	0.8	7.03	0.15640	-0.007487	0.0052260	0.0040404	-0.003855	-0.005511	0.000158	0.000954
9	6.0	0.0	0.0	-0.4	-0.3	-6.2	0.7	7.95	0.12884	-0.007413	0.0031117	0.0031261	-0.004728	-0.007401	0.001412	0.000798
10	6.0	4.0	4.0	0.3	-0.3	-4.6	0.4	9.50	0.12300	-0.012420	0.0001847	0.0021915	-0.002587	-0.003099	-0.000037	0.000343
11	4.0	4.0	2.0	0.2	-0.2	-4.2	0.6	10.33	0.10232	-0.011000	-0.0003864	0.0018517	-0.002423	-0.003072	-0.000323	0.000163
12	6.0	4.0	2.0	0.1	-0.4	-6.5	0.3	9.11	0.14571	-0.014886	0.0003900	0.0023233	-0.004143	-0.006270	-0.000701	0.000454
13	2.0	4.0	0.0	0.0	-0.3	-4.2	0.3	9.45	0.08643	-0.010120	-0.0003462	0.0020671	-0.002430	-0.004068	0.000129	0.000104
14	4.0	4.0	0.0	0.0	-0.3	-6.0	0.4	9.91	0.12867	-0.014077	-0.0003885	0.0020046	-0.003407	-0.005378	0.000361	0.000311
15	4.0	8.0	4.0	0.2	-0.3	-4.3	0.4	6.49	0.11941	-0.019492	-0.0003891	0.0042625	-0.002271	-0.004174	-0.000756	0.000105
16	2.0	8.0	2.0	0.1	-0.3	-4.0	0.2	6.12	0.10246	-0.017717	-0.0003486	0.0042781	-0.001778	-0.002722	-0.000323	0.000022
17	4.0	8.0	2.0	0.2	-0.2	-5.8	0.2	6.46	0.14357	-0.023344	-0.0003905	0.0046528	-0.002745	-0.004527	-0.000551	0.000182
18	6.0	8.0	2.0	-0.2	-0.3	-7.4	0.5	6.37	0.17559	-0.028547	-0.0003492	0.0048722	-0.004842	-0.007914	-0.001115	0.001072
19	1.0	8.0	0.0	0.0	-0.8	-3.7	-3.8	5.97	0.09764	-0.017345	-0.0003498	0.0042695	-0.002778	-0.005020	-0.000177	-0.000140
20	2.0	8.0	0.0	0.6	-1.0	-4.4	-2.5	6.27	0.11865	-0.019919	-0.0003498	0.0044793	-0.001837	-0.004280	-0.000439	-0.000168
21	4.0	8.0	0.0	0.8	-1.3	-5.8	-3.5	6.31	0.15825	-0.026206	-0.0003918	0.0049024	-0.002462	-0.005956	-0.000713	0.000339

+ DENOTES 'TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

* DENOTES 'OUT OF TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

TEST 362.0 RUN 13

TABLE NO. 9

A B C ROTOR V/OR = 0.46 , M(1.0)(90) = 0.82

WIND AXES FORCES, SHAFT AXES MOMENTS

PT	THETA	ALPHA SHAFT	B1SP	B1S	A1SP	A1S	DELTA THETA	L/D	CLR	CXR	CQR	CPQ	CYR	CMX	CMY	CMZ
1	12.1	-8.0	8.2	0.3	-0.1	-4.8	0.3	7.13	0.08958	0.006162	0.0081222	0.0044230	-0.001447	-0.003220	-0.000363	0.001503
2	12.1	-8.0	8.0	0.4	-0.1	-4.8	0.3	6.71	0.09094	0.004430	0.0082485	0.0052162	-0.000554	-0.002086	0.001430	0.001245
3	14.1	-8.0	8.0	0.2	-0.1	-7.1	0.3	6.63	0.14380	0.006692	0.0131600	0.0075817	-0.002555	-0.005713	0.001773	0.001758
4	15.0	-8.0	8.0	-0.2	-0.1	-8.0	0.3	5.95	0.15991	0.006950	0.0156819	0.0093984	-0.003185	-0.007507	0.000639	0.002392
5+	14.0	-8.0	10.0	0.2	-0.1	-5.6	0.3	6.35	0.10950	0.006681	0.0111076	0.0065717	-0.002092	-0.005622	0.000859	0.001816
6*	14.0	-8.0	10.0	0.8	-0.1	-5.6	0.3	6.18	0.10755	0.006805	0.0112551	0.0067097	0.000275	0.000087	0.000052	0.001422
7*	14.0	-8.0	10.0	-0.2	-0.1	-5.6	0.3	6.08	0.10676	0.006573	0.0112469	0.0068263	-0.003018	-0.008022	-0.000018	0.002021
8*	14.0	-8.0	10.0	0.5	-0.1	-4.8	0.3	6.08	0.10681	0.005771	0.0109269	0.0068734	-0.000696	-0.002601	0.005643	0.001839
9*	14.0	-8.0	10.0	0.5	-0.1	-5.9	0.3	6.18	0.10618	0.006823	0.0112414	0.0067093	-0.001023	-0.002639	-0.002455	0.001774

+ DENOTES 'TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

* DENOTES 'OUT OF TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

TEST 362.0 RUN 14

Table No. 10

A R C ROTOR V/OR = 0.46 , M(1.0)(90) = 0.82

WIND AXES FORCES, SHAFT AXES MOMENTS

PT	THETA	ALPHA SHAFT	B1SP	B1S	A1SP	A1S	DELTA THETA	L/D	CLR	CXR	CQR	CPO	CYR	CMX	CMY	CMZ
1	12.0	-8.0	8.0	-0.1	0.0	-4.5	0.0	6.26	0.08774	0.003337	0.0080255	0.0055586	-0.001803	-0.002380	0.001902	0.001430
2	12.0	-8.0	6.0	-0.2	-0.1	-6.0	0.0	7.10	0.12055	0.003890	0.0096893	0.0061461	-0.002094	-0.002694	0.002835	0.001075
3	15.0	-8.0	0.0	-0.1	0.0	-6.2	0.0	6.22	0.13137	0.008169	0.0136436	0.0077815	-0.002183	-0.004892	0.002544	0.001483
4	12.0	-4.0	0.0	0.0	-0.1	-4.7	0.0	5.90	0.10055	0.000887	0.0083566	0.0067390	-0.002384	-0.002439	0.001491	0.001772
5+	12.0	-4.0	8.0	0.0	0.0	-6.2	0.0	7.08	0.13749	-0.000346	0.0089365	0.0068610	-0.003093	-0.003750	0.003008	0.001342
6*	12.0	-4.0	7.9	0.6	0.0	-6.1	0.0	7.28	0.14002	-0.000463	0.0088076	0.0067067	-0.000345	0.000534	0.003860	0.001043
7*	12.0	-4.0	8.0	-0.5	-0.1	-6.2	0.0	6.88	0.13765	-0.000763	0.0090155	0.0071292	-0.004201	-0.006881	0.002720	0.001455
8*	12.0	-4.0	8.0	0.1	0.0	-5.9	0.0	7.29	0.13895	-0.000839	0.0085456	0.0066536	-0.002383	-0.002639	0.005783	0.001398
9	14.0	-4.0	8.1	-0.3	0.0	-8.3	0.0	5.64	0.17765	-0.001247	0.0141276	0.0109614	-0.002285	-0.005121	0.001623	0.001875

\+ DENOTES 'TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

* DENOTES 'OUT-OF TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

TEST 362.0 RUN 15

TABLE No. 11

A B C ROTOR V/OR = 0.46 , M(1.0)(90) = 0.82

WIND AXES FORCES, SHAFT AXES MOMENTS

PT	THETA	ALPHA SHAFT	B1SP	B1S	A1SP	A1S	DELTA THETA	L/D	CLR	CXR	CQR	CPO	CYR	CMX	CMY	CMZ
1	10.0	-4.0	6.0	-0.2	-0.1	-5.0	-0.1	7.63	0.11952	-0.001046	0.0067767	0.0055510	-0.002819	-0.003295	0.001638	0.001252
2	12.0	-4.0	6.0	-0.5	0.0	-7.0	-0.1	6.26	0.16149	-0.002279	0.0109399	0.0088918	-0.003941	-0.005115	0.000979	0.001753
3	10.0	-4.0	8.0	-0.2	-0.2	-2.9	-0.1	6.20	0.08420	-0.001139	0.0058170	0.0055078	-0.002758	-0.003145	0.002060	0.001673
4	8.0	-4.0	4.0	-0.6	-0.1	-4.6	-0.2	7.54	0.10244	-0.002676	0.0051036	0.0051082	-0.004247	-0.005747	0.001306	0.001560
5	6.0	0.0	4.0	-0.8	-0.2	-4.0	-0.2	7.03	0.10032	-0.008545	0.0026671	0.0054420	-0.003762	-0.005339	0.000626	0.000337
6	8.0	0.0	4.0	-0.8	-0.1	-6.2	-0.1	7.30	0.14871	-0.009987	0.0048323	0.0068329	-0.004625	-0.005694	0.001517	0.000731
7	6.0	0.0	2.0	-0.7	-0.1	-6.0	-0.2	7.38	0.12789	-0.009676	0.0035618	0.0061141	-0.004245	-0.005769	-0.001022	0.000540
8	6.0	0.0	6.0	-0.5	-0.1	-2.3	-0.2	5.24	0.06616	-0.007082	0.0025825	0.0053611	-0.002992	-0.001936	-0.000899	0.000769
9+	8.0	0.0	6.1	-0.5	-0.1	-4.7	-0.2	7.70	0.11713	-0.007130	0.0037723	0.0054685	-0.003484	-0.004460	-0.000685	0.000583
10*	8.0	0.0	6.0	0.2	-0.1	-4.7	-0.1	7.75	0.11977	-0.007354	0.0037787	0.0055067	-0.002087	-0.000031	0.000311	0.000766
11*	8.0	0.0	6.0	-0.9	-0.2	-4.8	-0.2	7.68	0.12039	-0.007584	0.0037786	0.0055934	-0.004971	-0.007587	0.000411	0.000450

+ DENOTES 'TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

* DENOTES 'OUT OF TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

TEST 362.0 RUN 17

TABLE No. 12

A B C ROTOR V/OR = 0.46 , M(1.0)(90) = 0.82

WIND AXES FORCES, SHAFT AXES MOMENTS

PT	THETA	ALPHA SHAFT	B1SP	B1S	A1SP	A1S	DELTA THETA	L/D	CLR	CXR	COR	CPO	CYR	CMX	CMY	CMZ
1+	8.0	0.0	6.0	-0.3	-2.5	-5.5	-0.2	7.98	0.11562	-0.006935	0.0034645	0.0050255	-0.002286	-0.005398	0.000178	0.000934
2*	8.0	0.0	6.0	-0.3	-2.6	-5.2	-0.2	7.61	0.11709	-0.007398	0.0036664	0.0054009	-0.002263	-0.005111	0.002586	0.000935
3*	8.0	0.0	6.0	-0.3	-2.7	-6.0	-0.2	7.33	0.11495	-0.006364	0.0042834	0.0056170	-0.002719	-0.005258	-0.004075	0.001005
4	10.0	0.0	6.0	-0.4	-3.7	-6.2	-0.1	6.99	0.14823	-0.008246	0.0059404	0.0070648	-0.003008	-0.006270	0.000498	0.001088
5	10.0	0.0	8.0	0.2	-3.0	-5.9	-0.1	6.53	0.11862	-0.005058	0.0060319	0.0066659	-0.001716	-0.002520	-0.002389	0.001316
6	8.0	0.0	7.9	-0.1	-2.0	-3.2	-0.2	4.73	0.06904	-0.005109	0.0043774	0.0061600	-0.000996	-0.002428	-0.001674	0.001308

+ DENOTES 'TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

* DENOTES 'OUT OF TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

TEST 362.0 RUN 18

TABLE No. 13

A B C ROTOR V/OR = 0.46 , M(1.0)(90) = 0.82

WIND AXES FORCES, SHAFT AXES MOMENTS

PT	THETA	ALPHA SHAFT	B1SP	B1S	A1SP	A1S	DELTA THETA	L/D	CLR	CXR	CQR	CPO	CYR	CMX	CMY	CMZ
1	6.0	0.0	6.1	-0.5	0.0	-2.9	-0.2	5.73	0.06789	-0.006072	0.0026771	0.0049374	-0.001943	-0.004607	-0.000732	0.001047
2+	6.0	4.0	6.2	-0.5	0.0	-4.9	-0.2	7.05	0.11032	-0.012955	0.0012466	0.0057779	-0.003155	-0.006238	-0.003243	0.000453
3*	6.0	4.0	6.0	0.0	0.0	-5.2	-0.2	7.59	0.11888	-0.013685	0.0009127	0.0055462	-0.001020	-0.002309	-0.001512	0.000690
4*	6.0	4.0	5.8	-0.1	-0.1	-5.2	-0.2	7.17	0.11989	-0.014215	0.0011562	0.0060027	-0.004805	-0.009699	-0.001739	0.000292
5*	6.0	4.0	5.9	-0.4	0.0	-4.9	-0.2	7.38	0.12088	-0.014516	0.0008662	0.0058504	-0.002573	-0.005230	0.001165	0.000507
6	6.0	4.0	6.0	-0.4	0.0	-5.8	-0.2	7.10	0.11921	-0.013454	0.0015439	0.0060904	-0.003325	-0.004939	-0.005931	0.000792
7	8.0	4.0	6.0	-0.7	0.0	-7.4	-0.2	6.84	0.16515	-0.018315	0.0026781	0.0078245	-0.004499	-0.009018	-0.001085	0.000873
8	4.0	4.0	4.0	-0.7	0.0	-4.6	-0.3	7.17	0.09903	-0.012875	0.0004365	0.0052304	-0.003240	-0.005995	-0.002868	0.000398
9	6.0	4.0	4.0	-0.7	-0.2	-6.4	-0.2	7.57	0.14523	-0.016749	0.0011253	0.0063701	-0.004446	-0.007988	-0.000948	0.000697
10	2.0	4.0	2.0	-0.61	-0.1	-3.7	-0.3	6.41	0.07931	-0.011539	0.0003883	0.0050244	-0.002363	-0.004110	-0.002014	0.000514
11+	4.0	4.0	2.0	-0.9	-0.3	-5.9	-0.3	7.83	0.12978	-0.015843	0.0003411	0.0056457	-0.004524	-0.008863	-0.001807	0.000240
12*	4.0	4.0	2.0	-0.3	-0.2	-5.6	-0.2	7.63	0.12881	-0.015508	0.0006390	0.0058185	-0.001951	-0.004964	-0.002802	0.000427
13*	4.0	4.0	2.0	-0.9	-0.2	-5.7	-0.3	7.30	0.12606	-0.015674	0.0007395	0.0060939	-0.006451	-0.012449	-0.002913	0.000302
14*	4.0	4.0	2.0	-0.8	-0.2	-5.2	-0.3	7.69	0.12901	-0.016138	0.0002927	0.0057620	-0.004283	-0.008389	0.001007	0.000374
15*	4.0	4.0	2.0	-0.8	-0.2	-6.0	-0.3	7.58	0.12749	-0.014798	0.0009413	0.0058620	-0.004142	-0.007731	-0.005318	0.000428
16	2.0	4.0	0.0	-1.0	-0.2	-4.8	-0.3	7.28	0.10607	-0.013943	0.0002942	0.0054082	-0.003812	-0.008237	-0.002326	0.000442

+ DENOTES 'TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

* DENOTES 'OUT OF TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

TEST 362.0 RUN 19

Table No. 14

A B C ROTOR V/OR = 0.46 , M(1.0)(90) = 0.82

WIND AXES FORCES, SHAFT AXES MOMENTS

PT	THETA	ALPHA SHAFT	B1SP	B1S	A1SP	A1S	DELTA THETA	L/D	CLR	CXR	CQR	CPQ	CYR	CMX	CMY	CMZ
1	2.0	8.0	4.0	-0.5	-0.2	-3.7	-0.3	5.47	0.09713	-0.018693	-0.0004283	0.0069665	-0.001158	-0.004887	-0.001922	-0.000396
2+	4.0	8.0	4.0	-0.7	-0.1	-6.2	-0.3	6.11	0.14810	-0.025195	-0.0004336	0.0084211	-0.002975	-0.008413	-0.003252	-0.000363
3*	4.0	8.0	4.0	0.2	-0.2	-6.2	-0.3	6.09	0.14806	-0.025251	-0.0004351	0.0084650	0.000844	-0.002016	-0.003696	-0.000065
4*	4.0	8.0	4.0	-1.5	-0.3	-6.1	-0.3	5.86	0.14669	-0.025988	-0.0004361	0.0089314	-0.006132	-0.012030	-0.002430	-0.000536
5*	4.0	8.0	4.0	-0.7	-0.2	-6.0	-0.3	5.82	0.15033	-0.026797	-0.0004378	0.0092357	-0.003305	-0.008605	-0.001165	-0.000419
6*	4.0	8.0	4.2	-0.7	-0.3	-7.0	-0.3	6.20	0.14778	-0.024771	-0.0004395	0.0084394	-0.003069	-0.008383	-0.007955	-0.000463
7	1.0	8.0	2.0	-0.5	-0.2	-4.6	-0.3	5.69	0.10827	-0.019978	-0.0004425	0.0074288	-0.001851	-0.006625	-0.001574	-0.000722
8	2.0	8.0	2.0	-1.0	-0.3	-5.7	-0.3	5.77	0.13265	-0.023928	-0.0004443	0.0086496	-0.002942	-0.009187	-0.002247	-0.000862
9	3.1	8.0	2.1	-0.9	-0.3	-6.6	-0.3	5.76	0.15541	-0.027939	-0.0004458	0.0097257	-0.003065	-0.009493	-0.002649	-0.000446
10	1.1	8.0	0.0	-0.7	-0.3	-6.4	-0.3	5.79	0.13636	-0.024523	-0.0004473	0.0088076	-0.002039	-0.007763	-0.002598	-0.000476

+ DENOTES 'TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

* DENOTES 'OUT OF TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

TEST 362.0 RUN 20

TABLE No. 15

A B C ROTOR V/OR = 0.70 , M(1.0)(90) = 0.58

WIND AXES FORCES, SHAFT AXES MOMENTS

PT	THETA	ALPHA SHAFT	B1SP	B1S	A1SP	A1S	DELTA THETA	L/D	CLR	CXR	CQR	CPO	CYR	CMX	CMY	CMZ
8	12.0	-4.0	8.0	-1.1	0.0	-6.4	-0.2	7.65	0.13908	-0.012723	0.0037974	0.0111299	-0.000449	-0.016775	0.003793	0.000728
9	14.0	-4.0	8.0	-1.1	-0.1	-8.2	-0.2	8.58	0.19719	-0.014709	0.0057555	0.0128783	-0.002861	-0.019638	0.003624	0.001136
10	8.0	-4.0	6.0	-0.9	0.0	-4.0	-0.4	4.42	0.06580	-0.012717	0.0015065	0.0100123	0.003267	-0.010029	-0.000667	0.000012
11	10.0	-4.0	6.0	-1.5	-0.2	-6.0	-0.3	8.06	0.12598	-0.013455	0.0015119	0.0096350	-0.001356	-0.019773	0.000392	0.000722
12	12.0	-4.0	6.0	-1.7	-0.4	-7.7	-0.2	10.27	0.18092	-0.015445	0.0015148	0.0097183	-0.004419	-0.024359	0.001641	0.001413
13	8.0	-4.0	4.0	-1.4	-0.2	-5.4	-0.3	6.49	0.11075	-0.013193	0.0026910	0.0108915	-0.000020	-0.015593	-0.000692	0.000649
14	10.0	-4.0	4.0	-1.9	-0.2	-7.2	-0.3	7.74	0.16857	-0.015670	0.0042606	0.0129024	-0.004724	-0.024998	0.000515	0.000862
15	5.0	-4.0	2.0	-1.7	-0.2	-4.6	-0.4	5.84	0.09337	-0.013810	0.0015247	0.0104484	-0.000912	-0.017528	-0.000542	0.000643
16	8.0	-4.0	2.0	-1.7	-0.3	-6.7	-0.3	7.59	0.15214	-0.015625	0.0030986	0.0121916	-0.003132	-0.024308	-0.000452	0.000604
17	6.0	-4.0	0.0	-1.9	-0.2	-5.5	-0.4	6.47	0.13224	-0.016011	0.0031038	0.0129100	-0.003088	-0.023627	0.001300	0.000856

TEST 362.0 RUN 21

TABLE No. 16

A B C ROTOR V/OR = 0.70 , M(1.0)(90) = 0.58

WIND AXES FORCES, SHAFT AXES MOMENTS

PT	THETA	ALPHA SHAFT	B1SP	B1S	A1SP	A1S	DELTA THETA	L/D	CLR	CXR	CQR	CPO	CYR	CMX	CMY	CMZ
1	8.0	-4.0	6.0	-0.2	0.0	-4.0	0.9	4.01	0.06823	-0.012407	0.0032363	0.0115684	0.001779	-0.009316	-0.000189	0.000552
2	8.0	0.0	6.1	-0.3	0.1	-5.8	0.8	6.59	0.14124	-0.016275	0.0036287	0.0134839	-0.000867	-0.013854	0.000587	-0.000944
3	10.0	0.0	6.0	-0.9	0.1	-7.5	0.8	7.30	0.19314	-0.020709	0.0040290	0.0156278	-0.006660	-0.021339	0.000247	-0.001098
4+	6.0	0.0	4.0	-0.8	0.2	-5.7	0.7	6.34	0.12408	-0.015448	0.0028738	0.0124120	-0.004631	-0.014701	-0.001805	-0.001349
5*	6.0	0.0	3.8	-0.3	0.3	-5.7	0.7	6.62	0.12994	-0.015487	0.0028788	0.0123330	-0.001371	-0.005862	-0.000870	-0.000787
6*	6.0	0.0	4.2	-1.7	0.0	-5.7	0.7	5.56	0.11353	-0.016288	0.0028834	0.0131952	-0.006366	-0.026094	-0.004333	-0.000815
7*	6.0	0.0	3.9	-0.9	0.2	-4.9	0.7	6.58	0.12806	-0.016460	0.0021038	0.0123071	-0.001897	-0.013924	0.005203	-0.001045
8*	6.0	0.0	4.1	-1.0	0.1	-6.7	0.7	6.70	0.12397	-0.014365	0.0028889	0.0116910	-0.002369	-0.014637	-0.010637	-0.000435
9	8.0	0.0	4.1	-1.0	0.1	-7.3	0.7	7.40	0.17900	-0.019507	0.0032859	0.0143866	-0.006435	-0.021164	-0.001277	-0.000751
10	4.0	0.0	2.0	-1.0	0.1	-5.4	0.6	5.97	0.10956	-0.015319	0.0021100	0.0117983	-0.002353	-0.014906	-0.002498	-0.000872
11	6.0	0.0	2.0	-1.2	-0.1	-7.0	0.6	6.74	0.16043	-0.019630	0.0028981	0.0145067	-0.006161	-0.024072	-0.003070	-0.001280
12	2.0	0.0	0.0	-0.9	0.0	-5.1	0.5	5.58	0.10139	-0.015678	0.0017247	0.0118223	-0.002342	-0.013862	-0.000839	-0.001391
13	4.0	0.0	0.1	-1.0	-0.1	-6.5	0.6	6.92	0.15235	-0.019530	0.0017248	0.0134858	-0.004465	-0.018547	-0.000646	-0.000918
14	4.0	0.0	4.0	-0.7	0.1	-4.0	0.6	4.37	0.07030	-0.013601	0.0017277	0.0108120	-0.002901	-0.007535	-0.002316	-0.000590
15+	4.0	4.0	4.0	-1.0	0.0	-5.6	0.6	6.33	0.14164	-0.022141	0.0001540	0.0140099	-0.004225	-0.016389	-0.000630	-0.002304
16*	4.0	4.0	3.9	-0.1	0.1	-5.6	0.6	6.61	0.14689	-0.021995	0.0001540	0.0137903	-0.002016	-0.004131	-0.000024	-0.002678
17*	3.9	4.0	-0.1	-5.6	0.5	1.0	1.5	6.24	0.14216	-0.023689	-0.0006344	0.0142657	-0.005561	-0.025162	-0.001752	-0.003075

+ DENOTES 'TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

* DENOTES 'OUT OF TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

TEST 362.0 RUN 22

TABLE NO. 17

A B C ROTOR V/OR = 0.70, M(1.0)(90) = 0.58

WIND AXES FORCES, SHAFT AXES MOMENTS

PT	THETA	ALPHA SHAFT	B1SP	B1S	A1SP	A1S	DELTA THETA	L/D	CLR	CXR	CQR	CPO	CYR	CMX	CMY	CMZ
6+	4.0	4.0	4.0	-1.1	-0.5	-5.3	-0.1	6.76	0.13789	-0.020992	-0.0004175	0.0126318	-0.005727	-0.013532	-0.002211	-0.002444
7*	4.0	4.0	3.9	-1.1	-0.5	-4.4	-0.1	6.58	0.14386	-0.022985	-0.0007973	0.0136717	-0.005016	-0.014751	0.005941	-0.002300
8*	4.0	4.0	4.1	-1.1	-0.6	-6.3	-0.1	6.49	0.13097	-0.020252	-0.0000414	0.0127014	-0.004122	-0.015050	-0.012347	-0.002412
9	6.0	4.0	4.1	-1.4	-0.6	-6.6	0.0	6.94	0.18669	-0.026405	0.0003377	0.0160263	-0.005767	-0.024157	-0.002615	-0.002436
10	2.0	4.0	4.1	-0.6	-0.4	-3.6	-0.1	4.44	0.07786	-0.017576	-0.0000416	0.0117870	0.000157	-0.006238	-0.003775	-0.001410
11	2.0	4.0	2.0	-1.2	-0.5	-5.0	-0.1	6.47	0.13089	-0.021367	-0.0008045	0.0128520	-0.005037	-0.014257	-0.002578	-0.001918
12	4.0	4.0	2.1	-1.5	-0.6	-6.6	-0.1	6.84	0.17770	-0.027138	-0.0008057	0.0157179	-0.006778	-0.024272	-0.006084	-0.002384
13	2.0	4.0	0.0	-1.5	-0.6	-6.2	-0.1	6.66	0.16559	-0.026546	-0.0011922	0.0153256	-0.007348	-0.022857	-0.004569	-0.002664

\+ DENOTES 'TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

* DENOTES 'OUT OF TRIM' POINT FOR DETERMINING CONTROL POWER DERIVATIVES

TEST 362.0 RUN 23

TABLE No. 18

A B C ROTOR V/OR = 0.91 , M(1.0)(90) = 0.53

WIND AXES FORCES, SHAFT AXES MOMENTS

PT	THETA	ALPHA SHAFT	B1SP	B1S	A1SP	A1S	DELTA THETA	L/D	CLR	CXR	CQR	CPO	CYR	CMX	CMY	CMZ
1	2.0	0.0	2.0	-0.8	-0.2	-3.4	-0.3	2.99	0.05984	-0.018900	0.0010339	0.0180736	-0.003037	-0.046554	0.008986	0.001570
2	4.0	0.0	2.0	-1.7	-0.4	-5.2	-0.2	5.90	0.11320	-0.018840	0.0003164	0.0166660	-0.010858	-0.047744	-0.001068	0.000262
3	6.0	0.0	2.0	-1.7	-0.3	-6.7	-0.2	7.66	0.18190	-0.023400	0.0003169	0.0195345	-0.014219	-0.053705	-0.004702	-0.001306
4	2.0	0.0	0.0	-1.1	-0.3	-4.7	-0.3	5.22	0.09253	-0.018180	-0.0004123	0.0155871	-0.007405	-0.061148	-0.006898	-0.000189

TEST 362.0 RUN 25

TABLE No. 19

A B C ROTOR V/OR = 0.21 , M(1.0)(90) = 0.69

WIND AXES FORCES, SHAFT AXES MOMENTS

PT	THETA	ALPHA SHAFT	B1SP	B1S	A1SP	A1S	DELTA THETA	L/D	CLR	CXR	CQR	CPO	CYR	CMX	CMY	CMZ
9	10.0	-8.0	2.2	-0.6	0.6	-3.7	-0.5	4.98	0.11824	0.014717	0.0081430	0.0013624	-0.007690	-0.008780	-0.001020	0.007842
10	12.0	-8.0	2.5	-0.3	0.5	-4.9	-0.4	4.11	0.14350	0.018106	0.0112284	0.0019984	-0.012955	-0.015462	-0.001349	0.010917
11	14.0	-8.0	2.4	-0.4	0.5	-6.2	-0.4	3.06	0.17041	0.019566	0.0160273	0.0042893	-0.020997	-0.025525	0.001702	0.015361
12	6.0	0.0	1.3	-0.6	0.7	-7.2	-0.2	5.91	0.10606	-0.003719	0.0030062	0.0008355	-0.005858	-0.006209	0.005101	0.002950
13	8.0	0.0	1.3	-0.2	0.7	-4.8	-0.2	5.33	0.13782	-0.002281	0.0049821	0.0004709	-0.012114	-0.016929	-0.002621	0.005193
14	10.0	0.0	1.4	-0.1	0.6	-5.8	-0.2	4.67	0.16920	-0.003354	0.0069528	0.0001547	-0.018783	-0.024825	-0.002148	0.007865
15	12.0	0.0	1.4	0.5	0.6	-7.0	-0.1	3.19	0.18805	-0.004773	0.0114567	0.0031872	-0.025076	-0.028931	-0.001797	0.011863
16	8.0	0.0	2.3	-0.5	0.7	-3.6	-0.2	5.25	0.12758	-0.001643	0.0047946	0.0008739	-0.007129	-0.004715	-0.000201	0.004750
17	10.0	0.0	2.3	-0.1	0.6	-5.2	-0.1	4.56	0.15983	-0.001713	0.0070465	0.0007016	-0.014071	-0.016461	-0.000808	0.007741
18	12.1	0.0	2.3	0.0	0.6	-6.8	-0.1	3.25	0.18084	-0.001138	0.0115511	0.0032312	-0.021423	-0.023400	-0.000398	0.011777
19	6.0	8.0	1.4	0.0	0.4	-4.5	-0.2	5.31	0.14289	-0.021553	0.0011352	0.0003711	-0.011279	-0.013047	-0.007457	0.001372
20	8.0	8.0	1.3	-0.1	0.4	-5.5	-0.1	4.32	0.17188	-0.026827	0.0027351	0.0006382	-0.017320	-0.020068	-0.004360	0.003268
21	10.0	8.0	1.4	-0.1	0.4	-6.5	0.1	3.14	0.19120	-0.030150	0.0064953	0.0032659	-0.023645	-0.027870	0.000187	0.006796

TEST 362.0 RUN 24

TABLE No. 20

A B C ROTOR V/OR = 0.35 , M(1.0)(90) = 0.76

WIND AXES FORCES, SHAFT AXES MOMENTS

PT	THETA	ALPHA SHAFT	B1SP	B1S	A1SP	A1S	DELTA THETA	L/D	CLR	CXR	CQR	CPO	CYR	CMX	CMY	CMZ
15	10.0	-8.0	4.0	-0.2	-4.7	-0.5	0.1	9.14	0.12554	0.009599	0.0081999	0.0023376	-0.015469	-0.031598	0.003169	0.009640
16	8.0	-4.0	3.9	-0.2	-4.5	-0.5	0.0	9.10	0.10801	0.003628	0.0054585	0.0023425	-0.013110	-0.024001	-0.003929	0.006357
17	10.0	-4.0	4.0	-0.2	-5.6	-0.4	0.1	8.26	0.15259	0.002463	0.0073775	0.0028427	-0.021809	-0.037056	0.003442	0.008842
18	12.0	-4.0	4.0	-0.7	-7.1	-0.5	0.2	5.70	0.18210	0.001395	0.0117370	0.0060204	-0.032869	-0.049103	0.002504	0.013558
19	6.0	0.0	2.0	-0.3	-6.8	-0.5	0.0	8.18	0.12017	-0.002563	0.0042765	0.0029081	-0.019074	-0.037383	-0.013263	0.005626
20	8.0	0.0	1.9	-0.3	-6.6	-0.5	0.0	7.28	0.16493	-0.008062	0.0051491	0.0037167	-0.028766	-0.045843	-0.000709	0.007242
21	6.0	0.0	4.0	-0.2	-0.1	-3.8	0.0	9.44	0.10655	-0.004606	0.0023615	0.0022083	-0.011413	-0.017823	-0.000386	0.003377
22	8.0	0.0	3.9	0.3	-0.1	-5.8	0.0	9.21	0.14211	-0.003722	0.0041158	0.0022366	-0.018883	-0.029378	-0.004192	0.005705
23	10.0	0.0	3.7	-0.2	-0.1	-7.5	0.0	6.47	0.18217	-0.006930	0.0074554	0.0046523	-0.031004	-0.044579	-0.000897	0.009204
24	4.0	4.0	1.8	-0.4	0.0	-4.2	0.0	8.96	0.11800	-0.012911	0.0000891	0.0023982	-0.014917	-0.026690	-0.000383	0.000696
25	6.0	4.0	1.9	-0.4	-0.1	6.4	0.0	7.73	0.16208	-0.016198	0.0016671	0.0031618	-0.026331	-0.042466	-0.004141	0.003362

APPENDIX A

HELICOPTER NOISE DATA

Paul T. Soderman

Appendix A

Helicopter noise was measured with ½ inch condenser microphones in the wind tunnel at locations shown in figure A1. The microphones were shielded by aerodynamically shaped nose cones. The data were recorded on magnetic tape and later analyzed using a 6%* bandwidth spectrum analyzer.

Table A1 shows the over-all sound pressure levels for the three microphones for various test conditions. Figure A2-A8 are typical narrow band frequency spectrums. The dips in the centers of the graphs are due to the analyzer mechanism and are not due to the noise characteristics. Figures A2 and A3 are background noise spectrums and Figures A4-A8 include the helicopter noise. Figures A9 and A10 show the noise from a 48 ft. diameter, two-bladed rotor tested in the 40- by 80-Foot Wind Tunnel previously. The data were taken from Full-Scale Helicopter Rotor Noise Measurements In Ames 40- by 80-Foot Wind Tunnel, Bell Helicopter Co., Report no. 576-099-052, Aug. 29, 1967. During the Bell test the microphone was located midway between microphones 1 and 2 shown in figure A1.

All data are presented uncorrected. It is estimated that the noise levels are approsimately 7 db higher than free field levels because of the reverberant field due to the wind tunnel walls. Also, the noise generation of the helicopter in hover condition was undoubtedly affected by the wake recirculation due to the wind tunnel walls.

*filter bandwidth = 6% of center frequency

TABLE A1

Over All SPL, dB ref. .0002 ubar

Data Pt.	Mic. 1	Mic. 2	Mic. 3	
				RUN 1 $q=0$
—	79	—	—	background noise, $q=0$ RPM = 0
1	110	—	108	
2	110	—	—	
3	106	—	106	
4	110	—	—	
				RUN 2 $q=0$
1	110	—	109	
2	115	—	113	
3	115	—	—	
4	111	—	110	
5	111	—	110	
6	111	—	110	
7	110	—	110	
8	116	—	116	Dist. between blades decreased
9	111	—	110	
10	110	—	—	
11	111	—	—	
12	111	—	—	
13	114	—	—	
14	117	—	—	

OASPL , dB

Data Pt.	MIC.1	MIC. 2	MIC.3	
1	124	–	–	RUN 11
2	122	–	–	
3	121	–	–	
4	123	–	–	
5	123	–	–	
6	120	–	–	
7	121	–	–	
8	–	–	–	
9	–	–	–	
10	125	–	–	
11	124	–	–	
12	126	–	124	
13	123	–	–	
1	–	–	126	RUN 13
2	–	–	127	
3	–	–	129	
4	–	–	129	
5	–	–	128	
6	–	–	128	
7	–	–	128	
8	–	–	128	

OA SPL, dB

Data Pt.	MIC 1	MIC 2	MIC 3	
9	–	–	129	RUN 13
1	–	–	126	RUN 14
2	–	–	127	
3	–	–	128	
4	–	–	128	
5	–	–	128	
6	–	–	128	
7	–	–	128	
8	–	–	128	
9	–	–	129	
1	–	–	127	RUN 15
2	–	–	128	
3	–	–	126	
4	–	–	126	
5	–	–	127	
6	–	–	128	
7	–	–	128	
8	–	–	126	
9	–	–	127	
10	–	–	127	
11	–	–	127	

OA SPL, dB

Data pt.	MIC. 1	MIC. 2	MIC. 3		
1	–	–	–	RUN 21	
2	120	–	120		
3	120	–	121		
4	121	–	120		
5	121	–	120		
6	121	–	120		
7	122	–	120		
8	121	–	121		
9	122	–	120		
10	122	–	120		
11	122	–	120		
12	122	–	120		
13	121	–	120		
14	121	–	120		
15	121	–	120		
16	121	–	120		
17	121	–	120		
1	104	–	103	RUN 22	NO WIND
2	105	–	105		NO WIND
6	121	–	121		WIND ON

OA SPL, dB

Data Pt.	Mic. 1	Mic. 2	Mic. 3			
8	121	—	121	RUN 22		
9	120	—	121			
10	120	—	120			
11	120	—	121			
12	120	—	121			
13	120	—	121			
14	118	—	115			
1	120	120	122	RUN 23		
2	121	120	119			
3	—	119	—			
4	120	119	122			
				RUN 24 Single Rotor		ΩR
2	98	—	—	$\alpha = -4^\circ$, $\delta = 0$,	$\frac{C_{LR}}{\sigma} = .0384$	122
3	98	—	—		.0524	
4	99	—	—		.0720	
5	100	—	—		.1008	
6	100	—	—		.1234	
7	102	—	—		.1478	
8	103	—	—		.1584	
9	105	—	—		.0222	
10	107	—	—		.0362	

OA SPL, dB

RUN 24 (CONT'D)

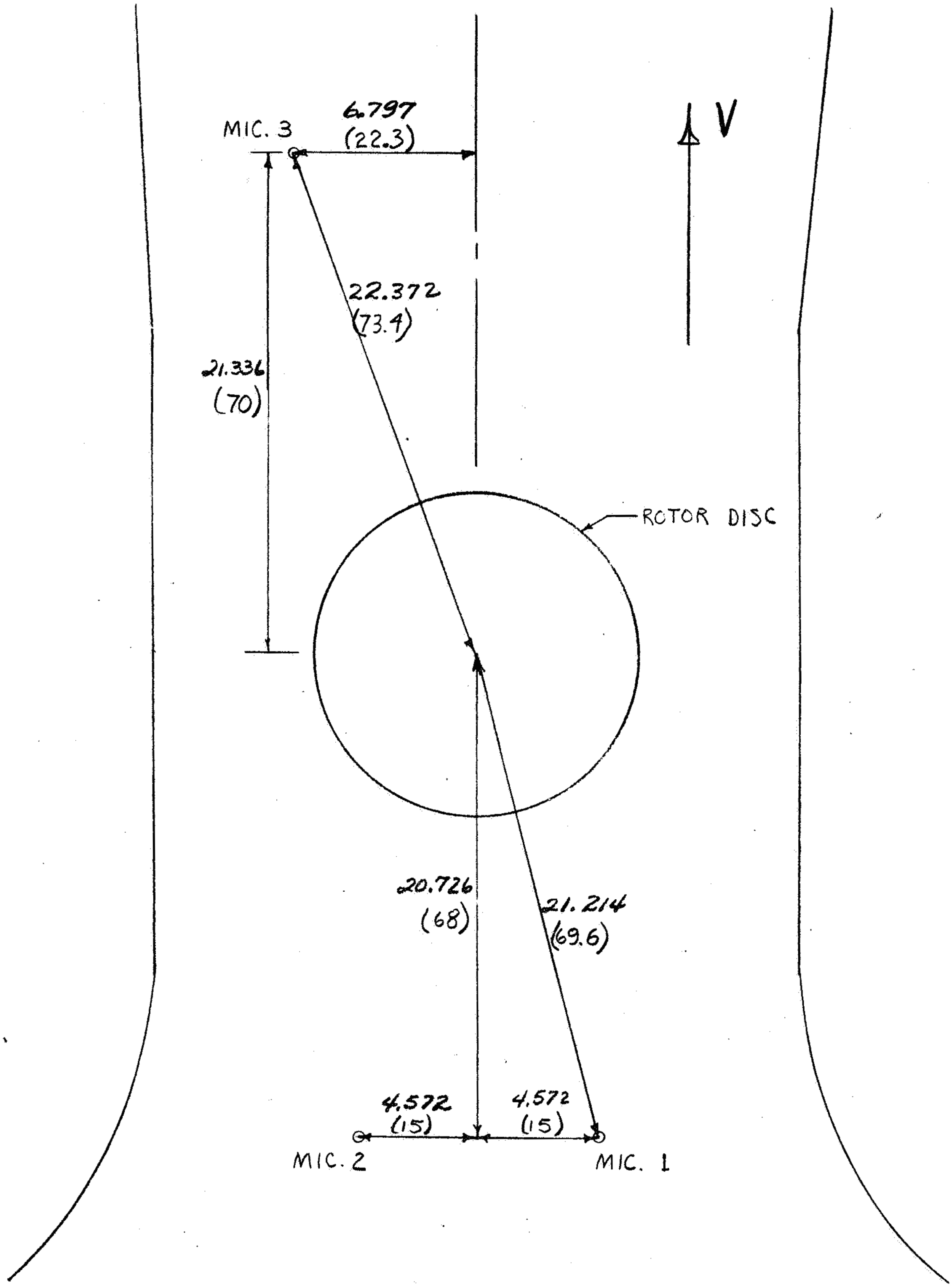
Data pt.	mic. 1	mic. 2	mic. 3		C_{LR}/σ	ΩR
11	112	—	—	$\alpha = -4$, $\theta = 0$	.0836	198
12	113	—	—		.1102	198
15	120	—	—			
16	119	119	—			
17	121	—	—			
18	123	—	—			
19	122	122	—			
20	123	—	—			
21	120	—	—			
22	120	—	—			
23	125	—	—			
24	121	—	—			
25	123	—	—			
26	100	—	—	$\alpha = -4$, $\theta = 0$	.0209	198
27	100	—	—		.0335	
28	103	—	—		.0541	
29	103	—	—		.0618	
30	108	—	—		.1032	
31	113	—	—		.1270	
32	116	—	—		.1404	
33	120	—	—		.1591	

OA SPL, dB

RUN 28 ROTOR OFF TARE RUNS

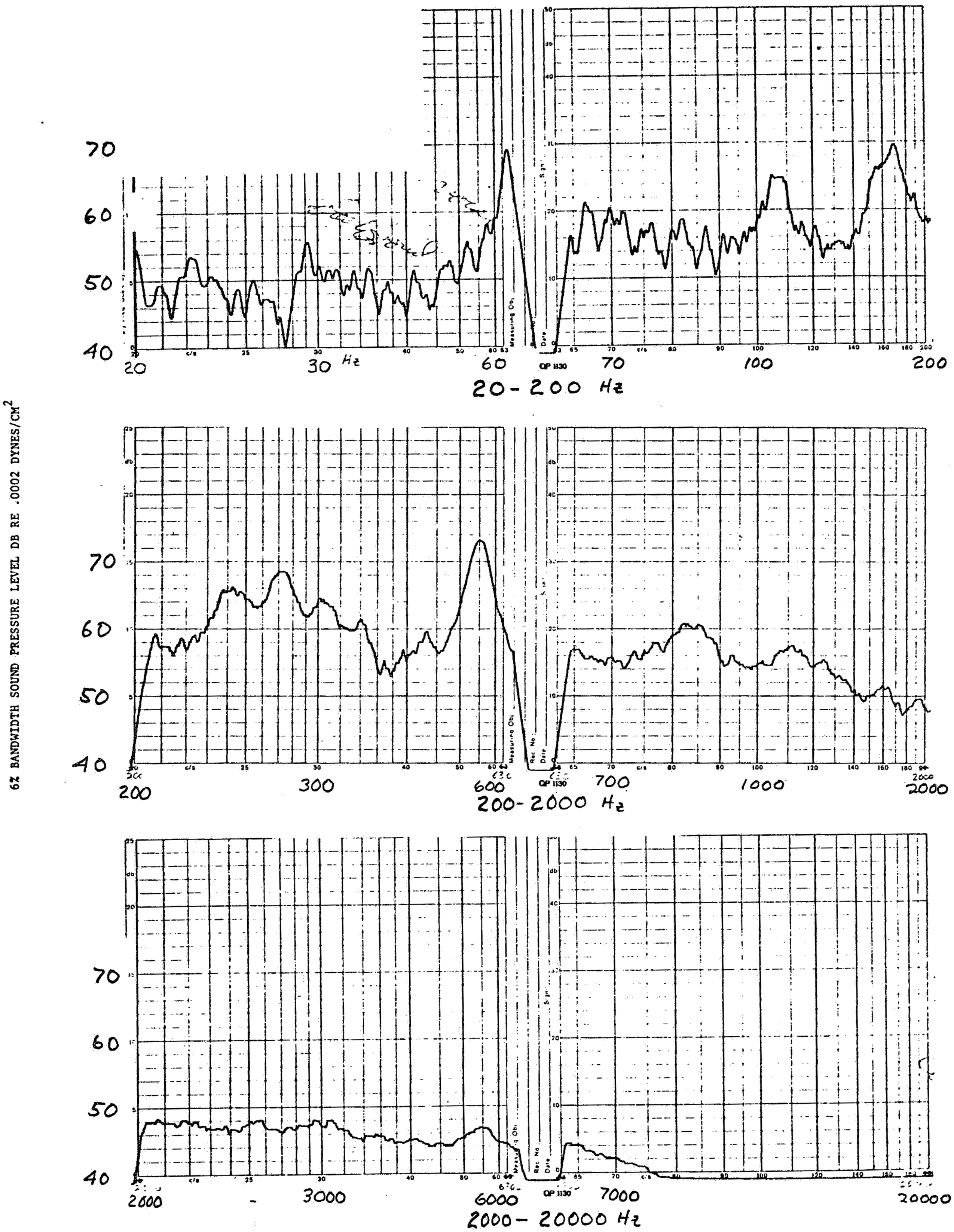
Data pt.	mic. 1	mic. 2	mic. 3	α	$V/\Omega R$ *
–	92	–	–	Background noise Tunnel motors in idle	
1	104	106	–		
2	102		–	−10°	.21
3	–	106	–	−8°	.21
4	–	106	–	−6°	.21
8	101	–	–	+2°	.21
–	117	–	–	−10°	.35
–	–	115	–	−8°	.35
–	117	–	–	0	.35
–	–	121	–	−6	.50
–	–	125	121	−4	.50
–	122	–	–	−2	.50
–	–	–	121	0	.50
–	120	–	–	−4	.70
–	120	–	119	−2	.70
–	120	–	–	0	.43

* Rotor off. Ω is hub rotational speed.



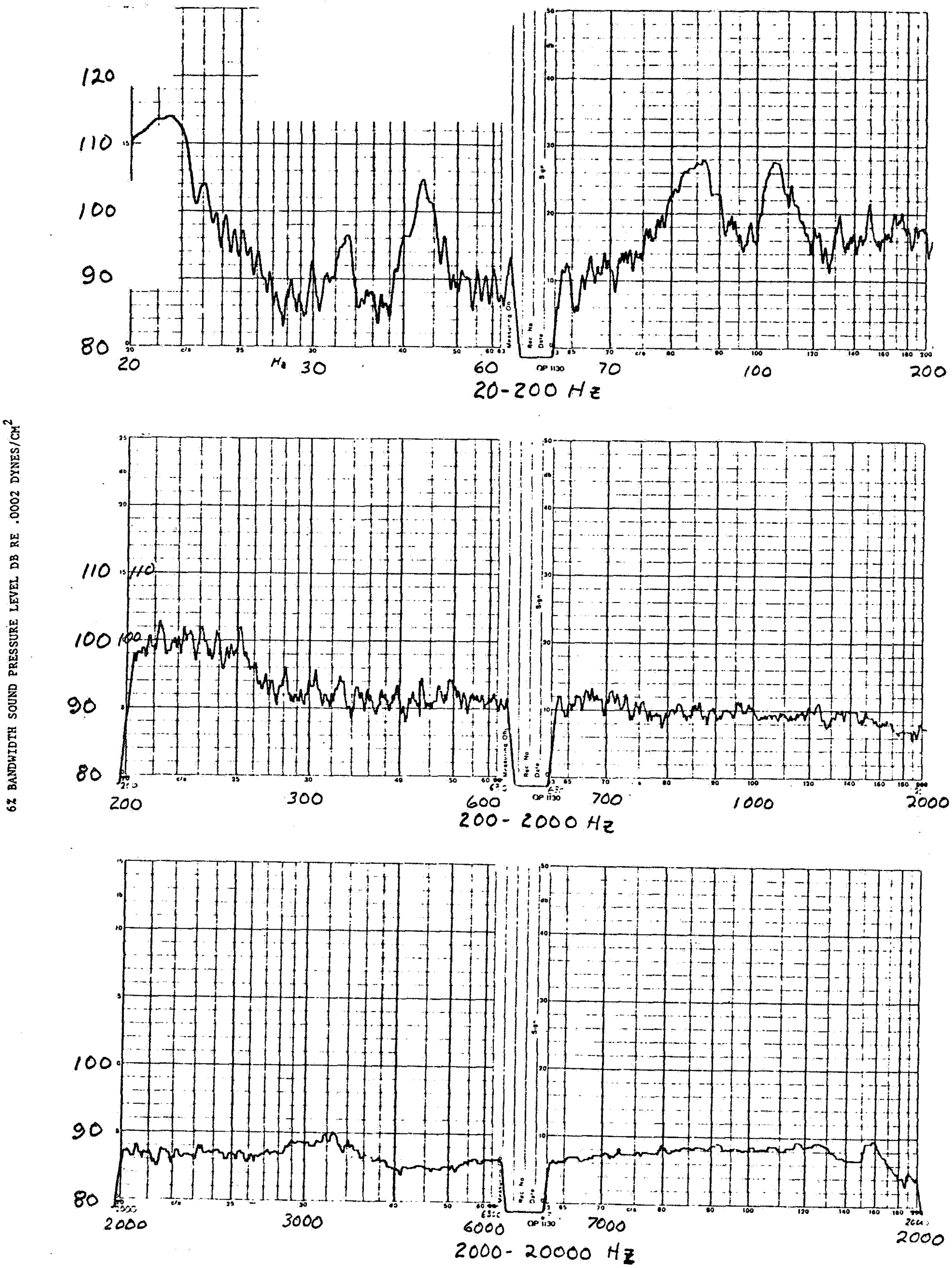
DIMENSIONS IN METERS (FEET)

Figure A1.- Microphone locations relative to the rotor.



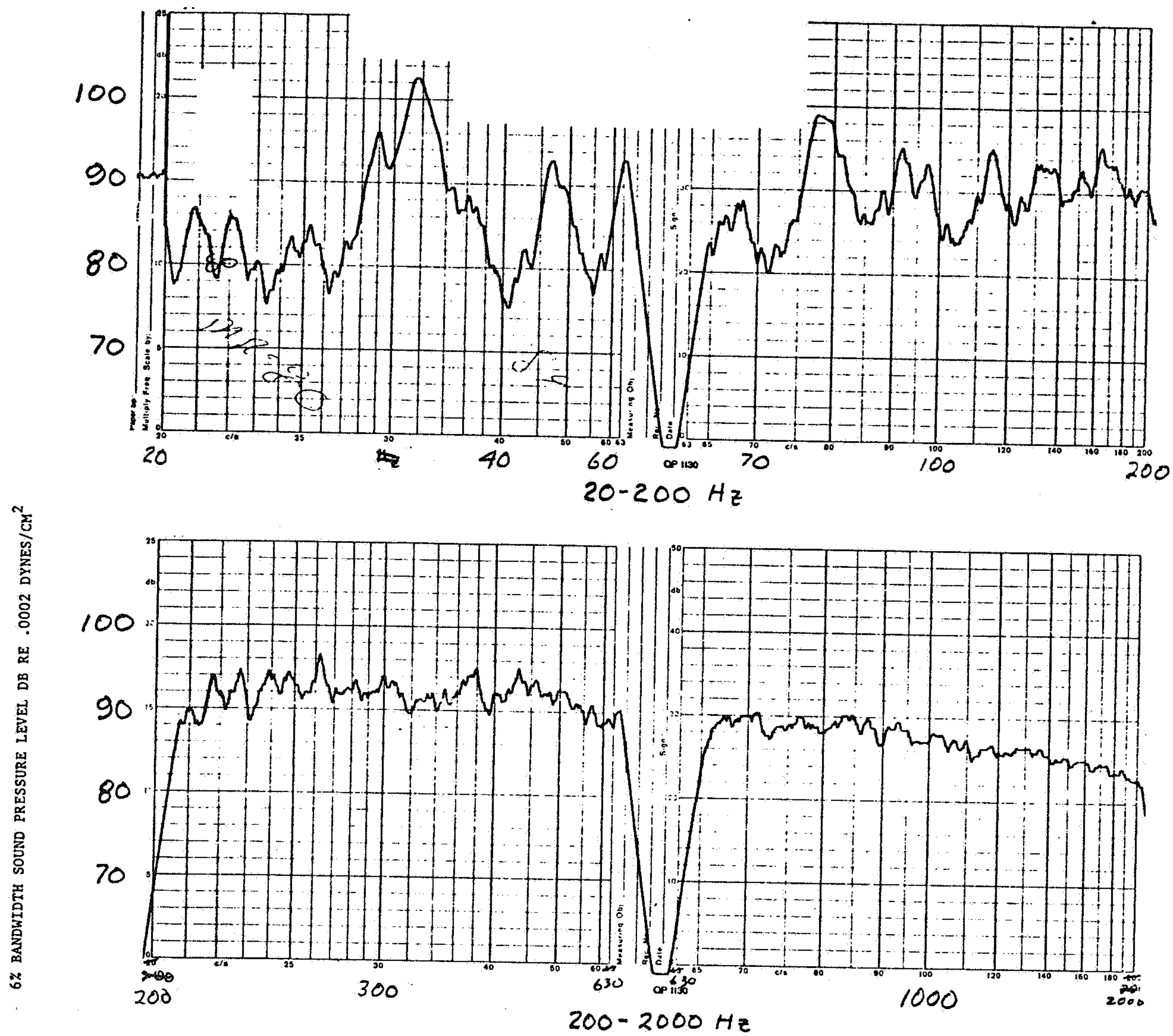
Run No. 1 RPM = 0 Mic. No. 1

Figure A2 - Background noise spectrum, q = 0.



Run No. 29 Mic. No. 1
Delta Pt. 1

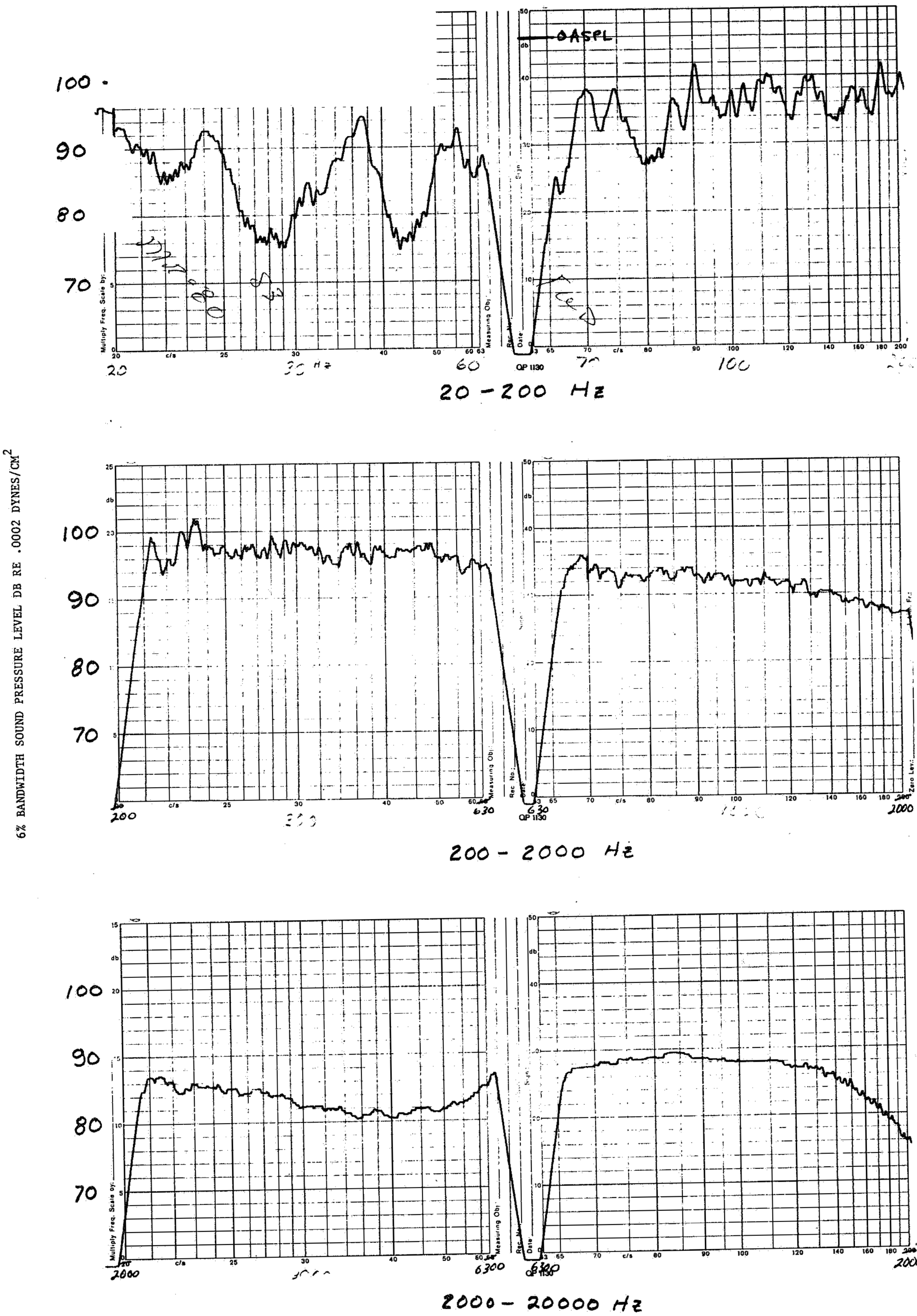
Figure A3- Background noise spectrum with the rotor removed from the model, $q=2872\ N/m^2$ (60 psf)



Run No. 2 RPM = 310 Mic. No. 3

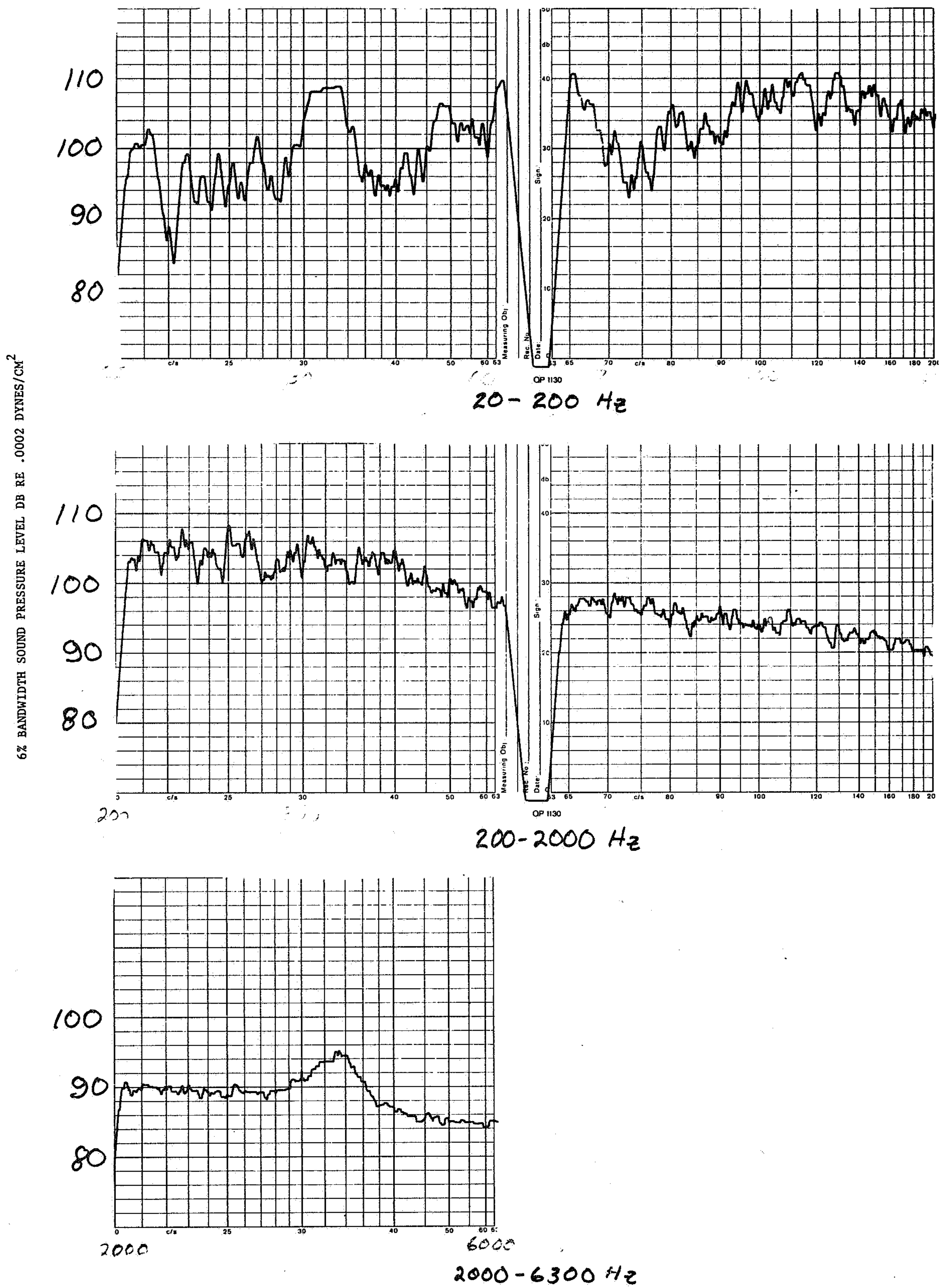
Delta Pt. 9 $q = 0$ $\alpha = 2^{\circ}$, $\theta = 5^{\circ}$

Figure A4- Noise spectrum with both rotors operating.



Run No. 2	RPM = 351	Mic. No. 1
Delta Pt. 3	q = 0	$\alpha = 0^{o}$, $\theta = 3^{o}$

Figure A5- Noise spectrum with both rotors operating.

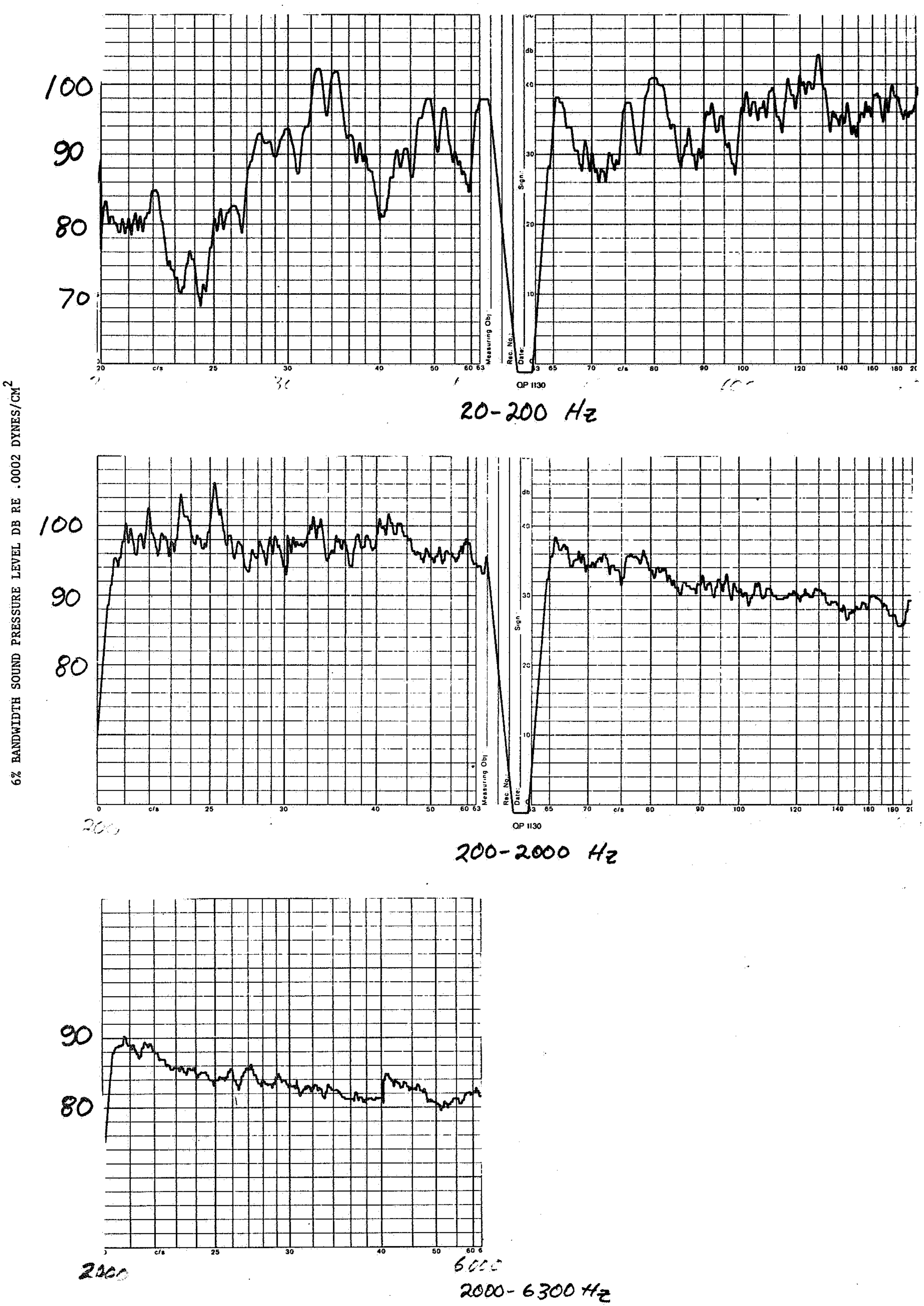


q=3062 N/m^2 (64 psf)

Run No. 11 RPM = 310 Mic. No. 1

Delta Pt. 12 $\alpha = -4^{\circ}$, $\theta = 12^{\circ}$

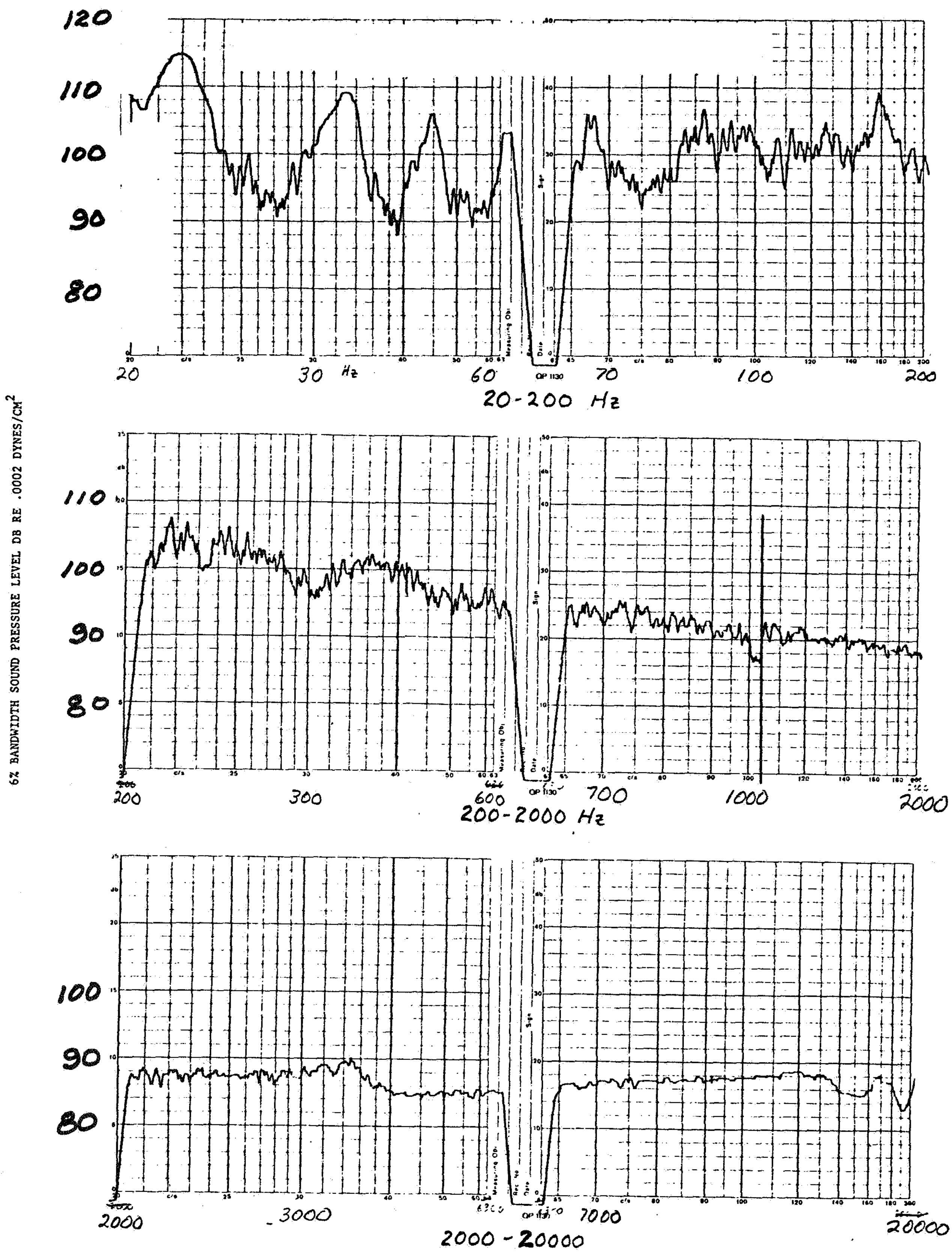
Figure A6 - Noise spectrum with both rotors operating.



Run No. 24 RPM = 310 Mic. No. 2

Delta Pt. 12 $q = 0$ $\alpha = -4^{\circ}$, $\theta = 10^{\circ}$

Figure A7 - Noise spectrum with one rotor removed from the model.

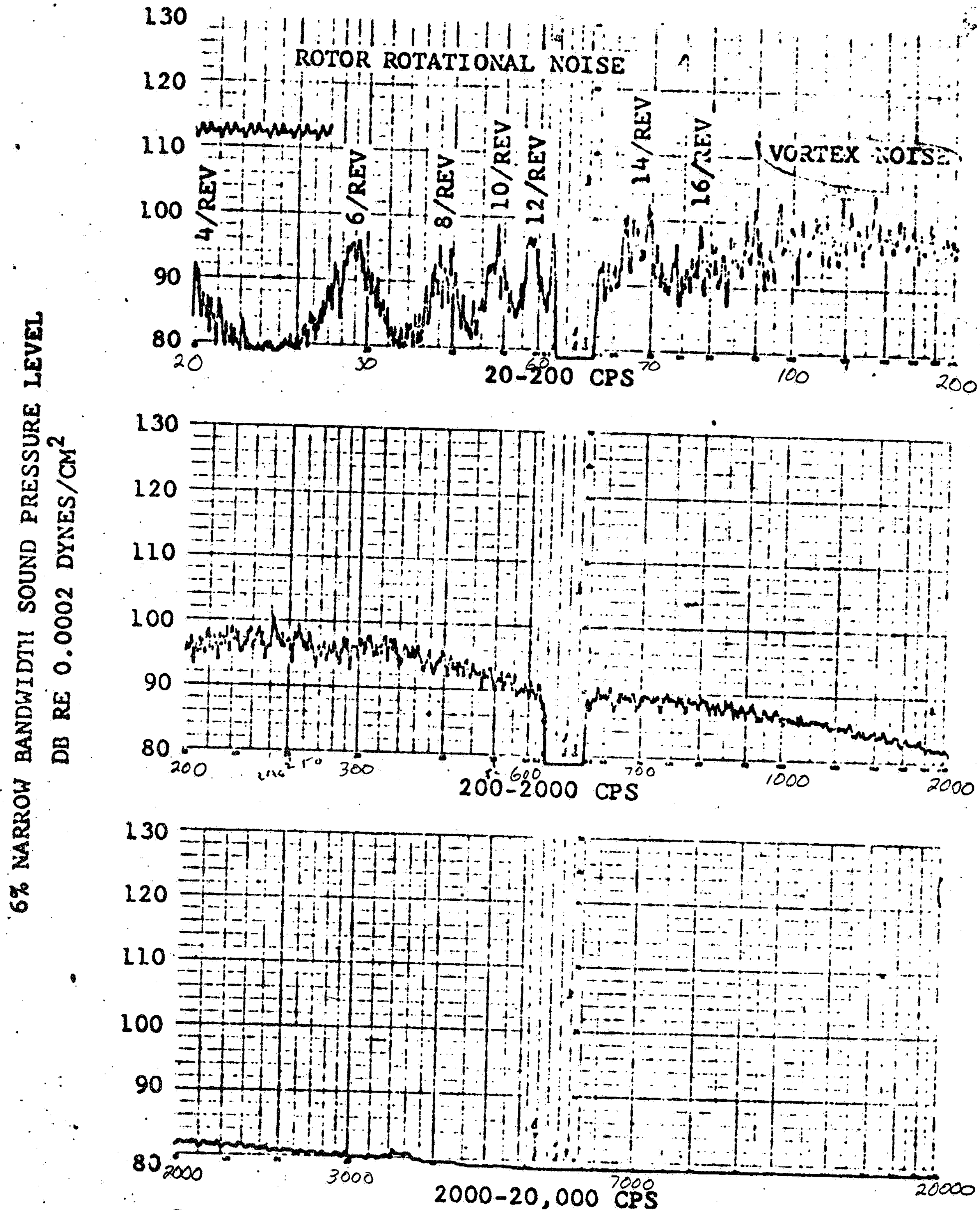


Run No. 24 RPM = 311 Mic. No. 1

Delta Pt. 21 q= 2823 N/ m^2 $\alpha = 0^o$, $\theta = 6^o$

(59 psf)

Figure A8- Noise spectrum with one rotor removed from the model.



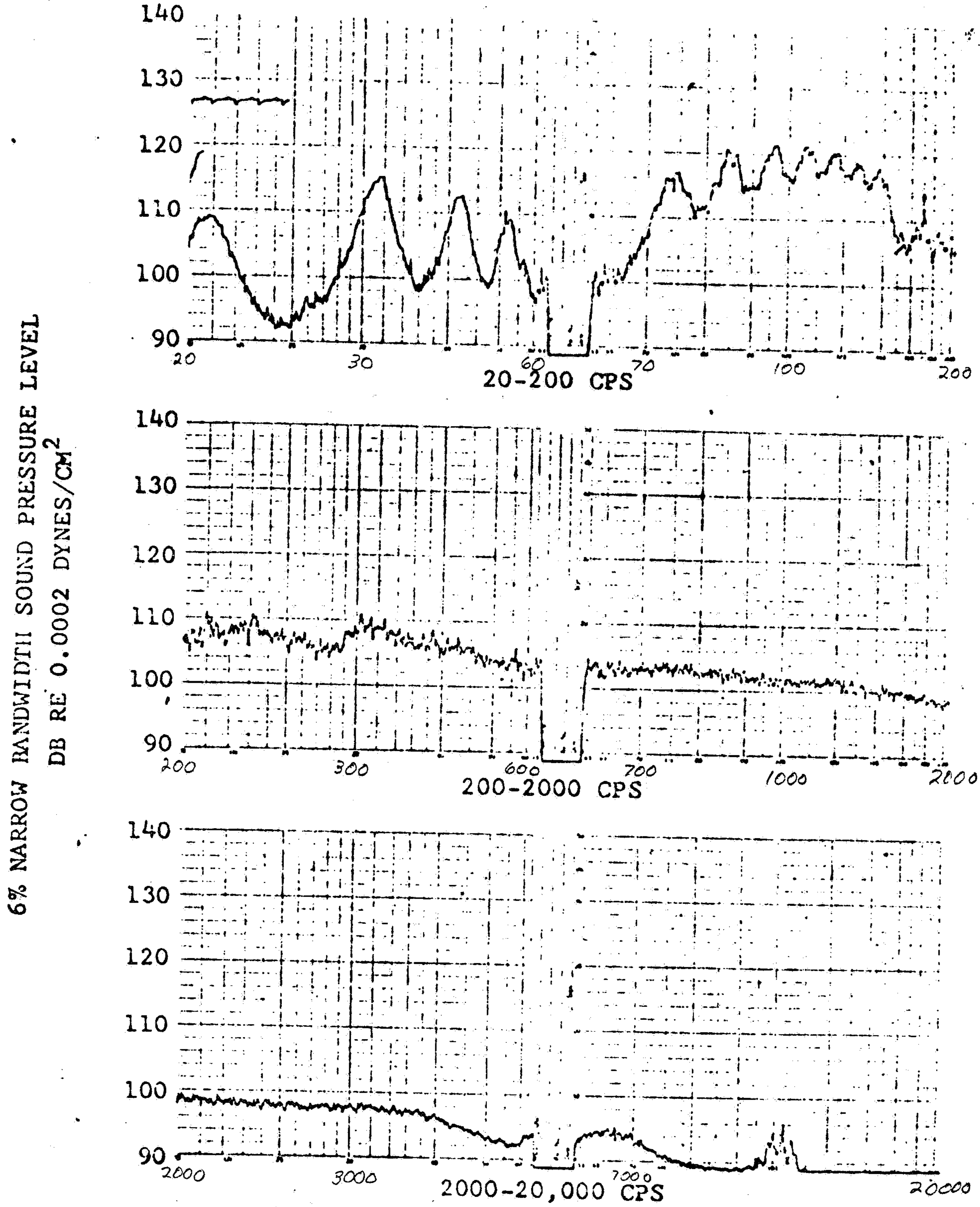
Run Number 2
Delta Point 1

$M_{(1.0,90.)} = .65$ $\qquad q = 0$

$\mu = 0$ $\qquad \alpha_{TPP} = -10^{\circ}$

RPM $= 290$ $\qquad \theta_G = 12^{\circ}$

Figure A9- Thin-tipped rotor noise spectrum for hover condition, Bell rotor.



Run Number 18 $M_{(1.0,90.)}$ = .90 q = 54

Delta Point 5 μ = .27 α_{TPP} = -9°

RPM = 314 θ_G = 16.25°

Figure A10- Rotor noise spectrum, Bell rotor, standard blades.