

ESD-TR-68-84
ESTI FILE COPY

ESD-TR-68-84

ESD RECORD COPY

RETURN TO
SCIENTIFIC & TECHNICAL INFORMATION DIVISION
(ESTI), BUILDING 1211

ESD ACCESSION LIST

ESTI Call No.

60770

Copy No.

of

cys.

Technical Note

1968-17

1 of 1

Pressure Distributions
on Sphere-Cone Radomes
in Uniform and Gradient Flows

R. D'Amato

W. R. Fanning

2 May 1968

Prepared under Electronic Systems Division Contract AF 19 (628)-5167 by

Lincoln Laboratory

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Lexington, Massachusetts



AD0670168

The work reported in this document was supported in part by the Northeast Radio Observatory Corporation under National Science Foundation Grant GP-5832 and in part by the U.S. Air Force under Contract AF 19(628)-5167.

This report may be reproduced to satisfy needs of U.S. Government agencies.

This document has been approved for public release and sale; its distribution is unlimited.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LINCOLN LABORATORY

PRESSURE DISTRIBUTIONS ON SPHERE-CONE RADOMES
IN UNIFORM AND GRADIENT FLOWS

R. D'AMATO
W. R. FANNING

Group 71

TECHNICAL NOTE 1968-17

2 MAY 1968

LEXINGTON

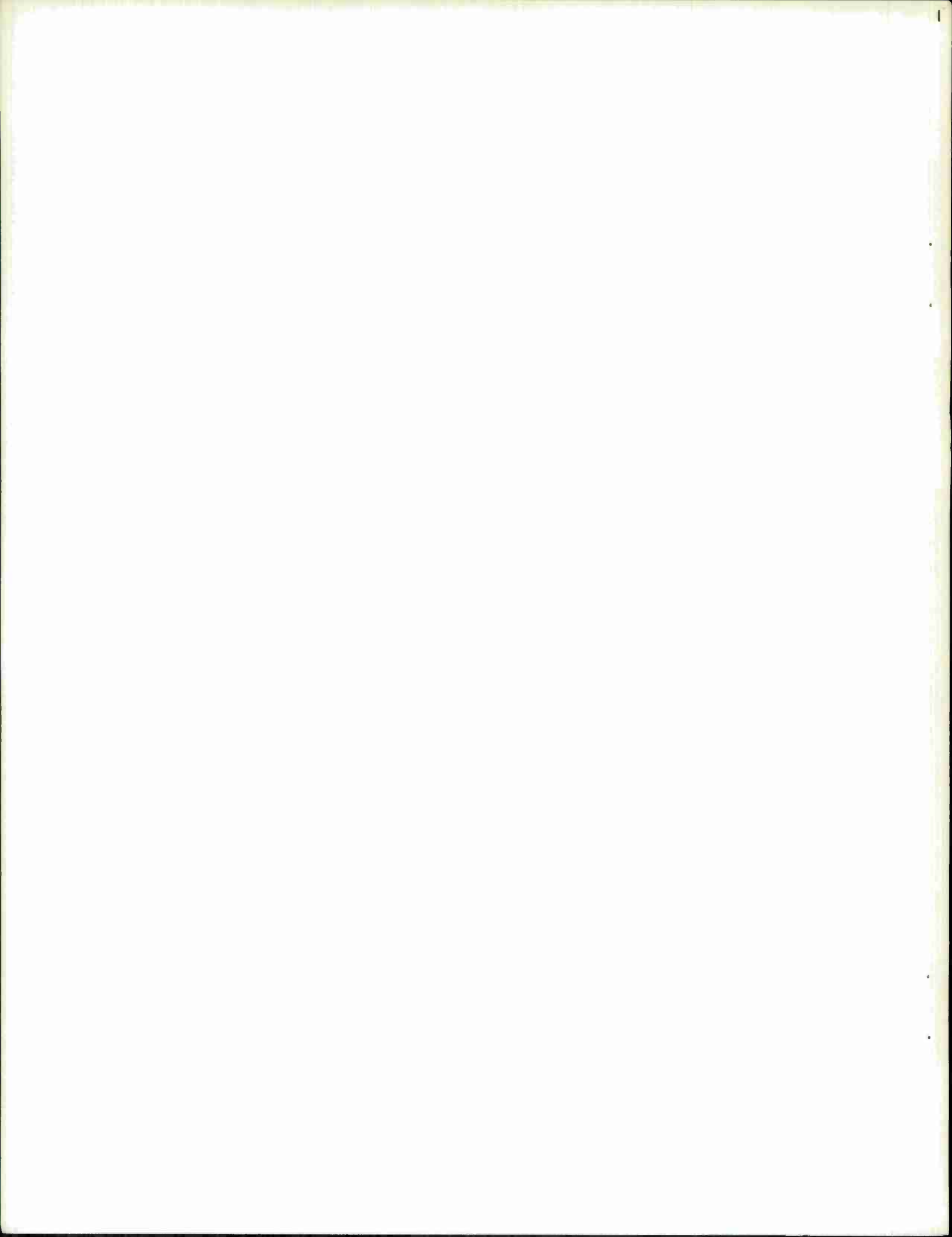
MASSACHUSETTS

ABSTRACT

A series of wind tunnel tests on two radome models, composed of truncated spheres on conical bases, in both a uniform and two power law gradient flow conditions are described in this report. The data from these tests is presented in the form of actual pressure coefficients and as Fourier coefficients which have been best-fitted to the experimental data.

Comparisons are presented to show the manner in which these pressure distributions vary from each other for the differing model and flow conditions.

Accepted for the Air Force
Franklin C. Hudson
Chief, Lincoln Laboratory Office



CONTENTS

Abstract	iii
List of Symbols	vi
I. Introduction	1
II. Description of the Models	1
III. Test Program	3
IV. Data Reduction and Results	6

LIST OF SYMBOLS

$A = \pi R^2$ = reference area

$$C_D = \frac{\text{Drag}}{q_{\text{ref}} A}$$

$$C_L = \frac{\text{Lift}}{q_{\text{ref}} A}$$

$$C_p = \frac{p - p_o}{q}$$

h = pressure head measured by manometer
or piezometer ring

K = constant

p = local pressure on model

p_o = static pressure

$$q = \frac{1}{2} \rho V^2 = \text{dynamic pressure}$$

R = radius of radome

S' = meridional distance measured from
top of radome

$$S = \frac{S'}{R}$$

V = wind velocity

Z = distance above ground plane

Z_o = reference height above ground plane

a = exponent

ρ = air density

θ = azimuth angle

ϕ = meridional angle

PRESSURE DISTRIBUTIONS ON SPHERE-CONE RADOMES IN UNIFORM AND GRADIENT FLOWS

I. INTRODUCTION

A series of tests has been conducted on two radome scale models in the M. I. T. Wright Brothers Wind Tunnel. The models were truncated spheres with conical base sections. Each of the models was tested in a uniform flow and two power law gradient flows with a velocity variation, V , as a function of height, Z , given by

$$V = V_0 \left(\frac{Z}{Z_0} \right)^a$$

where V_0 is a reference velocity at a reference height, Z_0 , above the ground plane. For these tests, a was equal to zero (uniform), one-sixth and one-fourth.

The purpose of these tests, which were carried out in support of the Northeast Radio Observatory Corporation (NEROC) Study Program, was to determine wind pressure distributions on large sphere-cone radomes in non-uniform gradient flows. At the time these tests were conducted, there was no existing data for the pressure distributions on this type radome in gradient flows.

This report briefly describes the models and the test conditions and presents the data that was obtained.

II. DESCRIPTION OF THE MODELS

The configurations of the two models tested are shown in Figure 1. The height of the two models was kept constant at 24-1/2 inches measured

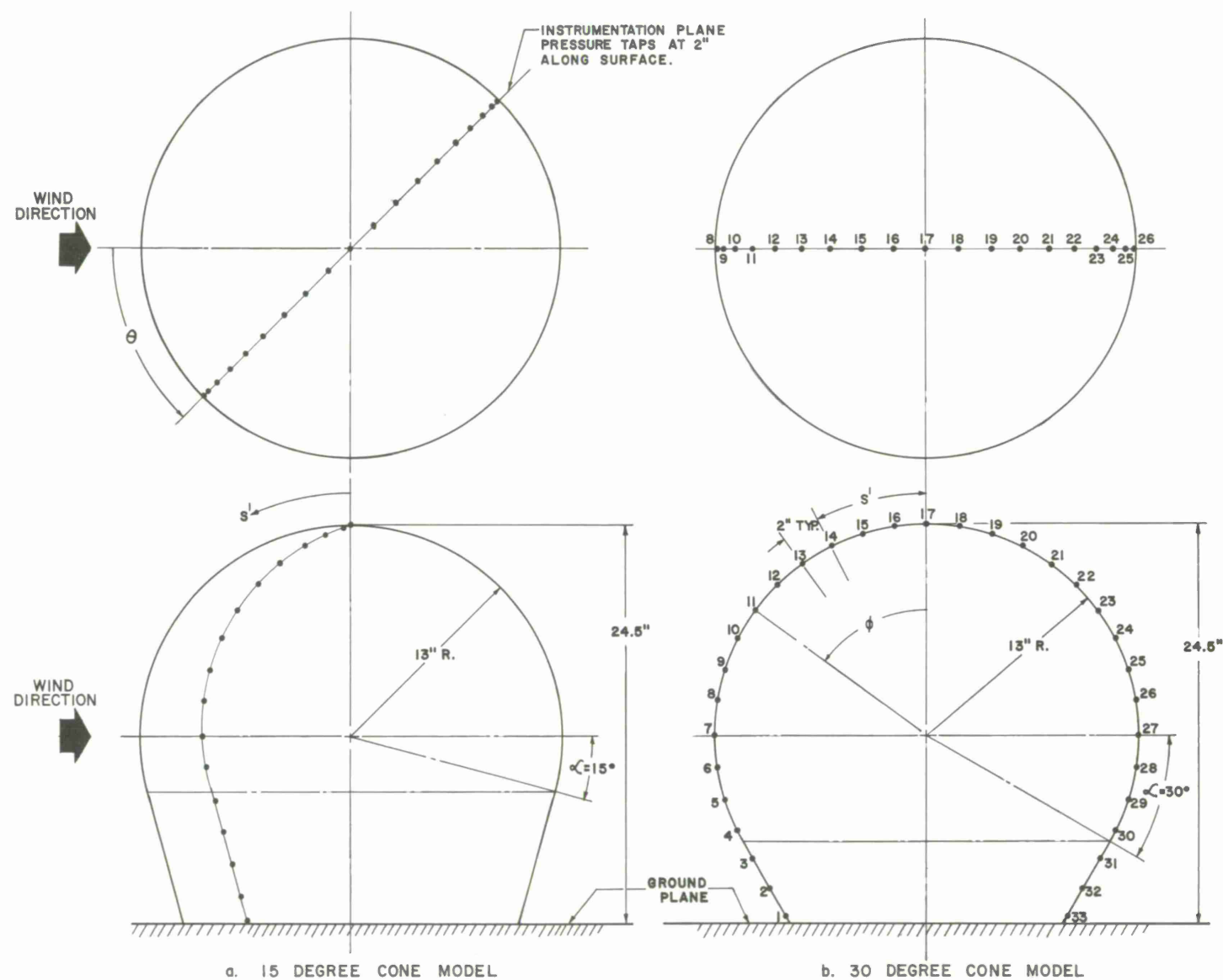


Fig. 1. Test models and instrumentation description.

from the mounting surface to the top of the model. The radius of the spherical portion of the model was 13 inches in both tests. The difference between the two models was in the relative proportion of the sphere to the cone section. In the first case, the sphere extended 15 degrees below the equator of the sphere and in the second case, 30 degrees below the equator. A conical section which was tangent to the sphere at the sphere-cone junction completed the base of the model. The height of the conical section was selected to keep the overall heights of the models the same.

The actual model construction (mahogany) consisted of a common spherical section which extended 15 degrees below the equator and two different base sections giving the two conical geometries. When assembled, each model was bolted to a metal plate that was, in turn, bolted to a splitter plate mounted in the tunnel. The model was sanded smooth and coated with clear lacquer. Figure 2 illustrates the model mounted on the splitter plate in the tunnel.

As shown in Figure 1, the models were instrumented with pressure taps on one complete great circle. The taps were spaced at intervals of approximately 2 inches of arc length along the surface for a total of 33 pressure taps on each model.

III. TEST PROGRAM

During these tests, the primary measurements consisted of pressure tap readings from the 33 taps mounted on the models. In order to obtain a complete pressure distribution, successive test runs were made with the instrumentation plane being rotated with respect to the wind direction as measured by the angle θ , shown in Figure 1. Indexing increments of 15

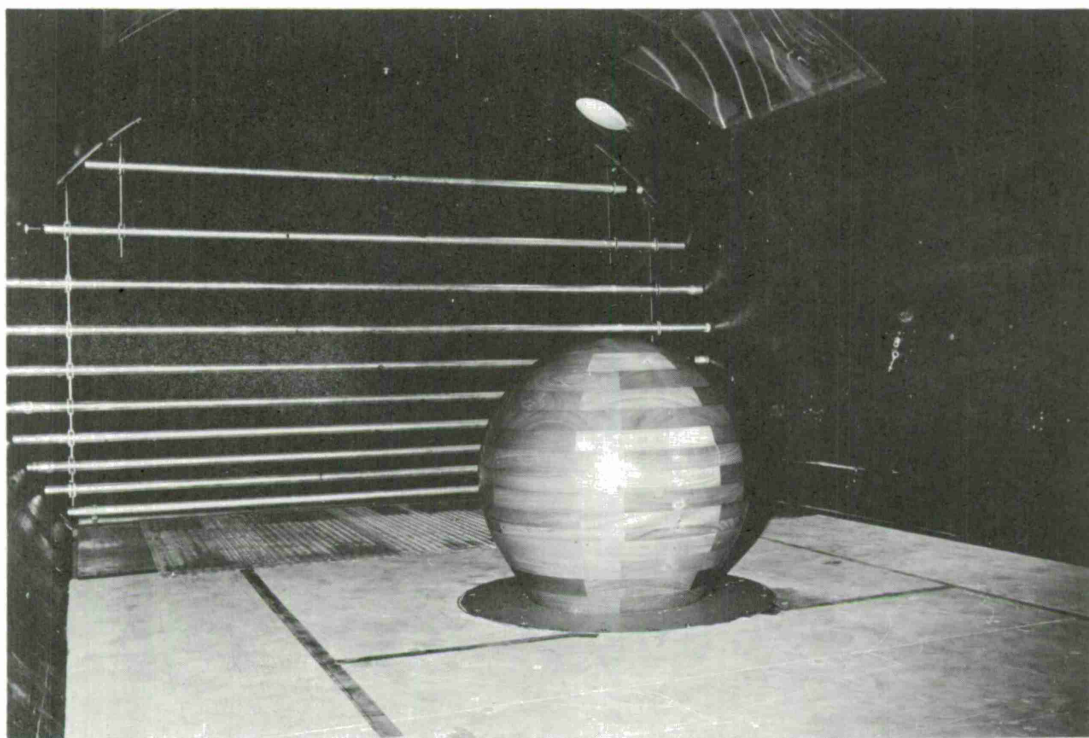


Fig. 2. Model in tunnel with $1/4$ power gradient fence.

degrees were used for intervals between 0 and 195° . The complete sphere-cone distribution was obtained with an overlap at one position ($\theta = 195^{\circ}$) for taps 1 - 16 and 18 - 33. Since the structure is rotationally symmetric, cross-correlation of the data can be performed at these points.

For all runs, the nominal tunnel speed was approximately 100 mph. In the case of the uniform flow tests, this velocity provides a good index of the overall flow conditions. For the gradient flow conditions, the 100 mph velocity represents the flow velocity near the top of the tunnel.

The velocity gradient for the non-uniform flow tests was produced by a series of horizontal parallel tubes upstream from the model. A view of this arrangement for the $1/4$ power gradient is shown in Figure 2. This scheme of producing a gradient flow in a wind tunnel is based on a method by C. F. Cowdrey¹. In general, the method gave very good results after careful adjustment of the tubular member spacings. Figures 3 and 4 are plots of the dynamic pressure variation as a function of distance above the ground plane. The velocity gradient was measured at three positions, two feet to the east and west of the centerline and on the centerline of the tunnel, to evaluate the uniformity of the flow field. It will be observed that the $1/4$ power gradient profile is more uniform than the $1/6$ power gradient profile. The reason for this has not been definitely established, although it was found that the flow is very sensitive to the exact spacing of the tubes. The overall accuracy of the gradients obtained in this program

¹Cowdrey, C. F., A Simple Method for the Design of Wind-Tunnel Velocity-Profile Grids, NPL Aero Note 1055, National Physical Laboratory, Teddington, England, May 1967.

compares quite favorably with that reported by Cowdrey in his work.

In addition to the 33 pressure taps on the model, several other pressure measurements were made including the following:

- a) The static as well as total pressure head on a pitot-static tube located approximately 8 inches below the ceiling of the tunnel. In the case of the uniform flow and $1/6$ power gradient tests, the pitot-static tube was approximately 50 inches upstream from the model. For the $1/4$ power gradient tests, the pitot-static tube was approximately 5 inches upstream from the model.
- b) The wall static pressure at the same streamwise location as the model using a piezometer ring.
- c) The total pressure in the settling section of the tunnel.

Alcohol having a specific gravity of 0.806 at 75°F was used in the manometers.

IV. DATA REDUCTION AND RESULTS

Data reduction was accomplished using a digital computer program. All of the direct readings taken in each run were punched on cards. The necessary calculations to compute the pressure coefficients were then carried out automatically and printed out in tabular form. This reduced data is presented in Tables 1 through 18 as a function of the azimuth position of the instrumentation plane (θ) with respect to the wind direction and the distance (S') along the surface of the model. Each pressure tap has a specific location, S' , on the model. The coordinates S' and θ are shown

in Figure 1. For convenience in scaling, the coordinate S' has been normalized with respect to the spherical radius, R .

The pressure coefficients, C_p , were calculated from

$$C_p = \frac{\Delta p}{q} = \frac{h_i - h_o}{K (h_{ref} - h_o)}$$

where h_i is the height of the i^{th} pressure tap on the model recorded by the manometer board.

h_o is the height of the wall static pressure tap on the manometer board as measured by the piezometer ring.

h_{ref} is the height of the reference total pressure tap on the manometer board.

q = dynamic pressure

K is a suitable constant defined below

The constant K was taken to be 1.0 for the uniform tests. For the gradient flow tests, the constant K was determined from Figures 3 and 4 at a height of 24-1/2 inches above the ground plane. In this way, the dynamic pressure at the top of the model was used as a reference. The value of h_{ref} was measured by the total head in the settling chamber for the uniform and 1/6 power gradient tests and by the total pressure of the pitot-static tube for the 1/4 power gradient tests.

The pressure coefficients presented in Tables 1 - 18 are the results for taps 1 - 17 and taps 17 - 33 separately as well as for the average of the corresponding taps in the two sets. If the model was exactly rotationally symmetric, the taps 1 - 17 would give results that are identical to the

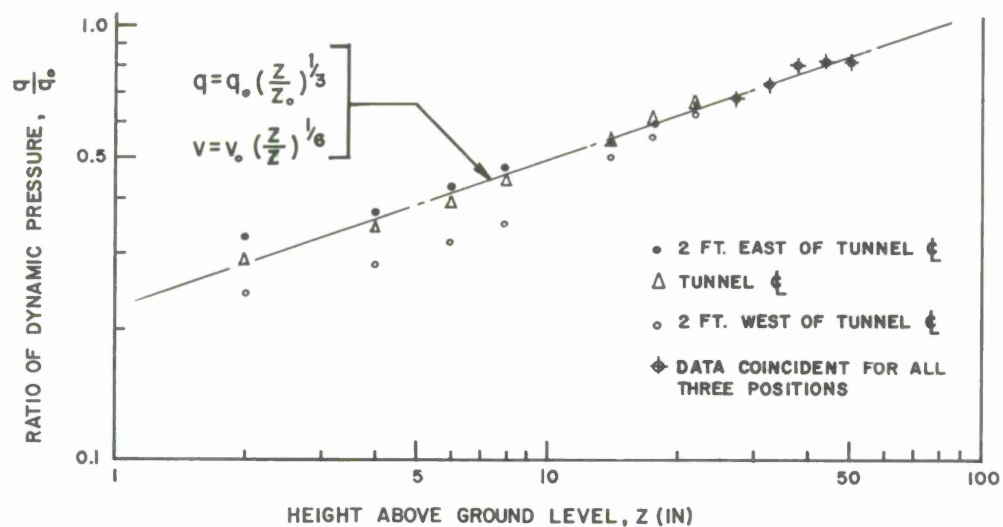


Fig. 3. Measured velocity gradient in tunnel without model for 1/6 power law.

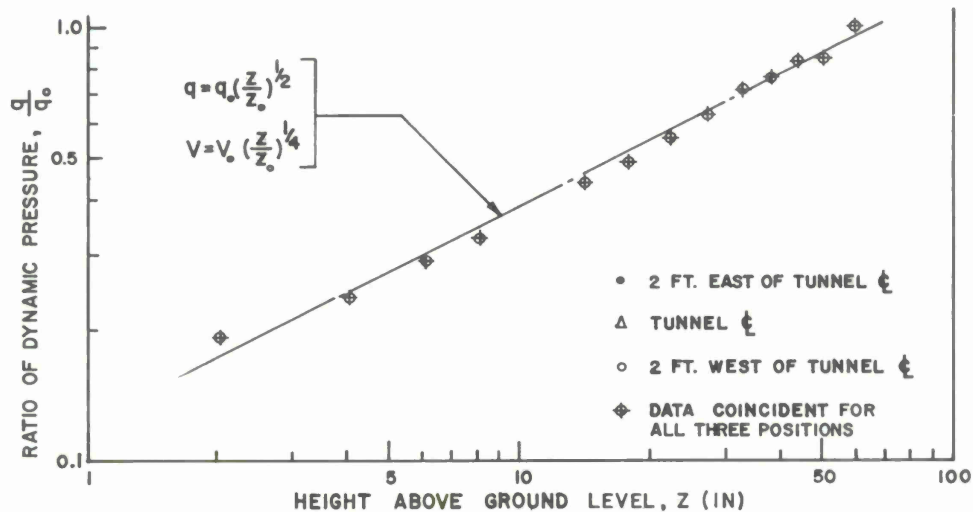


Fig. 4. Measured velocity gradient in tunnel without model for 1/4 power law.

taps 17 - 33, however, as can be seen, the two sets of taps do not give exactly identical results. These differences, however, are quite small with the worst variation in the pressure coefficient being on the order of ± 0.05 whereas most of the variations are within ± 0.02 of the average pressure coefficient. The differences could be caused by any combination of slight variations in the symmetry of the flow, roughness on the model around the pressure tap, and the aperture of the pressure tap itself. The variations noted are considered to be approximately the normal accuracy of wind tunnel experiments.

In addition to reducing the basic data into pressure coefficients, the data reduction program also fits the experimental data to a Fourier series of the form:

$$C_p(S) = C_{p0}(S) + C_{p1}(S) \cos \theta + \dots + C_{p5}(S) \cos 5 \theta$$

These Fourier coefficients are presented in Tables 19 to 24.

The fundamental and first harmonic coefficients are useful for computing the lift and drag on the models. The lift and drag coefficients C_L and C_D , respectively, for the 15 degree cone sphere model were computed from the following formulae:

$$C_L = \left(\frac{\Delta S'}{R} \right) \left(\frac{R_1}{R} \right) C_{p01} \cos 105^\circ + 2 \left(\frac{\Delta S'}{R} \right) \sum_{i=2}^4 C_{p0i} \left(\frac{R_i}{R} \right) \cos 105^\circ$$

$$+ 2 \left(\frac{\Delta S'}{R} \right) \sum_{i=5}^{16} C_{p0i} \cos \phi_i \sin \phi_i + \frac{1}{4} \left(\frac{\Delta S'}{R} \right)^2 C_{p017}$$

$$C_D = \frac{1}{2} \left(\frac{\Delta S'}{R} \right) \left(\frac{R_1}{R} \right) C_{p11} \sin 105^\circ + \left(\frac{\Delta S'}{R} \right) \sum_{i=2}^4 C_{p1i} \left(\frac{R_i}{R} \right) \sin 105^\circ$$

$$+ \left(\frac{\Delta S'}{R} \right) \sum_{i=5}^{16} C_{p1i} \sin^2 \phi_i$$

where the subscript i denotes the tap number, $\phi_i = \frac{S'}{R} \left(\frac{180}{\pi} \right)$ degrees, and R_i is the radius at the i^{th} pressure tap on the conical base. The values for $C_{p_{0i}}$ and $C_{p_{1i}}$ are the average values taken from Tables 19 through 24. Similar formulae were used for the 30 degree cone-sphere. The results of the calculation are shown in Table 25.

It will be noted that the lift coefficient for the 15 degree cone-sphere is consistently higher than for the 30 degree cone-sphere. On the other hand, the drag coefficient for the 30 degree cone-sphere is consistently higher than for the 15 degree cone-sphere. Both the lift and drag coefficients become progressively smaller as the exponent of the flow gradient increases (for uniform flow, the exponent is zero).

Finally, in Figures 5 through 8, comparisons are made of the pressure distribution with the instrumentation line parallel with the flow. In Figure 5, the two models in uniform flow are compared. In general, the differences between the pressure distributions is small, the greatest differences occurring on the leeward side of the model. In Figures 6 and 7, the two models are compared for the $1/6$ power and the $1/4$ power gradients, respectively. The differences in the pressure distributions for the two models are smaller than for the uniform flow case. Finally, in Figure 8, a comparison is presented of the pressure distributions for the uniform flow and two gradients on the 15 degree cone-sphere model. It will be noted that the maximum and minimum pressure coefficients decrease progressively as the exponent of the flow gradient increases. On the leeward side of the model ($S'/R < 0$), there is a considerable qualitative difference between the uniform flow and gradient flow pressure distributions. This difference is probably produced by the alteration in the boundary separation conditions produced by the gradient flow.

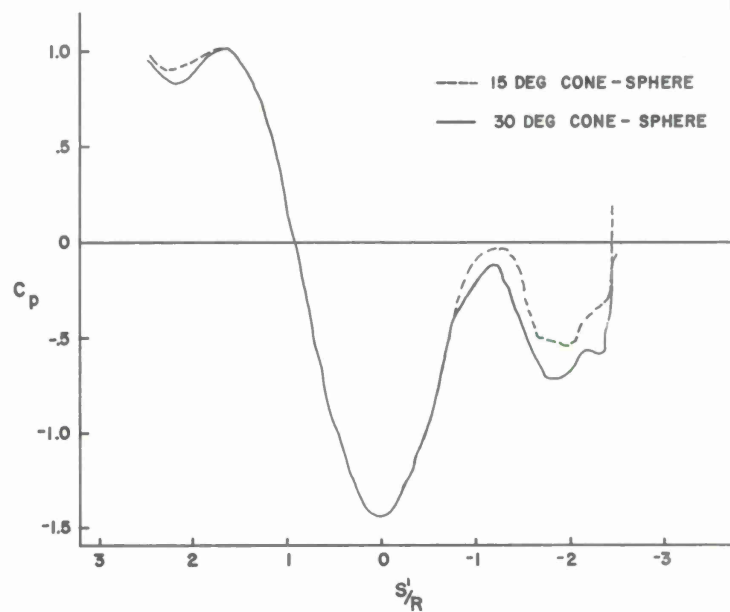


Fig. 5. Pressure distribution on both cone-sphere models for uniform flow at $\theta = 0$.

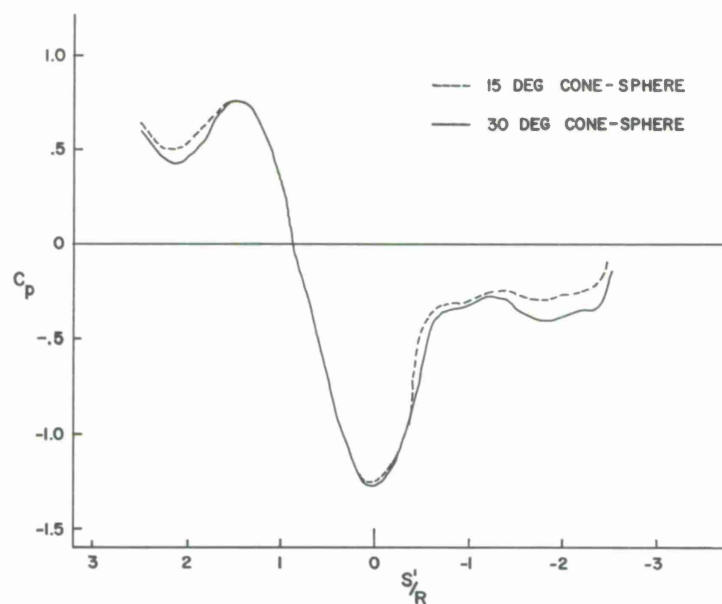


Fig. 6. Pressure distribution on both cone-sphere models for $1/6$ power gradient flow at $\theta = 0$.

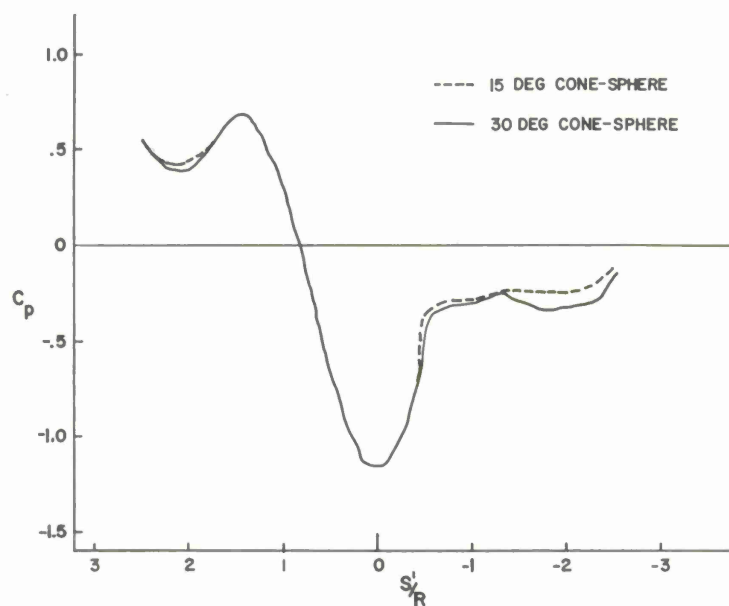


Fig. 7. Pressure distribution on both cone-sphere models for $1/4$ power gradient flow at $\theta = 0$.

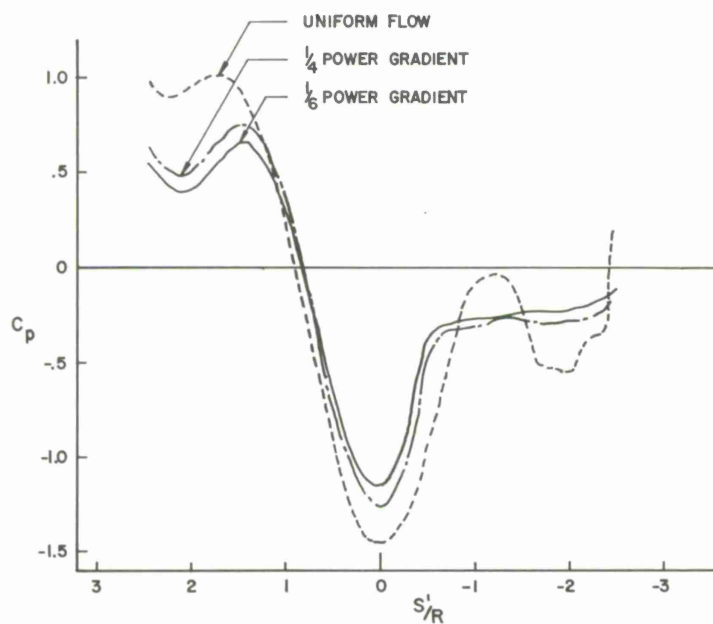


Fig. 8. Pressure distribution on 15-degree cone-sphere for uniform flow and $1/6$ and $1/4$ power gradients at $\theta = 0$.

TABLE 1

TUNNEL REFERENCE=
15.00 DEGREE CONE
UNIFORM FLOW 12/10/67

IN. ALCOHOL

TAPS 1 TO 17

TAP	S/THETA	C.	15.	30.	45.	60.	75.	90.	105.	120.	135.	150.	165.	180.	THETA/S	TAP
1	2.4615	0.98	0.77	0.20	-0.53	-1.13	-1.20	-0.50	-0.34	-0.37	-0.55	-0.62	-0.21	0.20	2.4615	1
2	2.3077	0.90	0.70	0.17	-0.51	-1.06	-1.22	-0.54	-0.36	-0.43	-0.58	-0.67	-0.56	-0.37	2.3077	2
3	2.1538	0.92	0.72	0.22	-0.44	-1.01	-1.25	-0.91	-0.36	-0.45	-0.58	-0.65	-0.56	-0.40	2.1538	3
4	2.0000	0.95	0.70	0.25	-0.36	-0.95	-1.27	-1.13	-0.45	-0.55	-0.57	-0.63	-0.63	-0.54	2.0000	4
5	1.8462	1.00	0.82	0.35	-0.28	-0.87	-1.24	-1.20	-0.69	-0.57	-0.62	-0.59	-0.58	-0.52	1.8462	5
6	1.6923	1.01	0.85	0.40	-0.22	-0.81	-1.20	-1.25	-0.90	-0.57	-0.66	-0.59	-0.55	-0.50	1.6923	6
7	1.5385	0.96	0.81	0.37	-0.22	-0.80	-1.20	-1.30	-1.06	-0.53	-0.58	-0.58	-0.51	-0.29	1.5385	7
8	1.3846	0.83	0.70	0.30	-0.25	-0.81	-1.21	-1.33	-1.17	-0.69	-0.42	-0.47	-0.37	-0.08	1.3846	8
9	1.2308	0.63	0.60	0.16	-0.35	-0.85	-1.22	-1.35	-1.22	-0.82	-0.40	-0.27	-0.18	-0.03	1.2308	9
10	1.0769	0.34	0.24	-0.07	-0.50	-0.94	-1.27	-1.38	-1.27	-0.94	-0.56	-0.25	-0.11	-0.05	1.0769	10
11	0.9231	0.02	-0.05	-0.32	-0.66	-1.02	-1.30	-1.40	-1.31	-1.05	-0.74	-0.42	-0.21	-0.15	0.9231	11
12	0.7692	-0.34	-0.39	-0.59	-0.86	-1.13	-1.34	-1.42	-1.36	-1.22	-0.91	-0.66	-0.47	-0.40	0.7692	12
13	0.6154	-0.66	-0.70	-0.84	-1.02	-1.20	-1.35	-1.41	-1.38	-1.29	-1.04	-0.87	-0.74	-0.69	0.6154	13
14	0.4615	-0.99	-1.00	-1.09	-1.19	-1.30	-1.39	-1.42	-1.40	-1.34	-1.27	-1.09	-0.98	-0.96	0.4615	14
15	0.3077	-1.23	-1.24	-1.29	-1.33	-1.39	-1.42	-1.44	-1.43	-1.40	-1.36	-1.30	-1.28	-1.28	0.3077	15
16	0.1538	-1.41	-1.40	-1.43	-1.43	-1.44	-1.45	-1.45	-1.44	-1.44	-1.43	-1.41	-1.40	-1.40	0.1538	16
17	0.0	-1.45	-1.45	-1.47	-1.46	-1.46	-1.46	-1.45	-1.45	-1.45	-1.45	-1.44	-1.45	-1.45	0.0	17

TUNNEL REFERENCE=
15.00 DEGREE CCNE
UNIFORM FLOW 12/18/67

IN.ALCCHOL

TABLE 2

TAPS 17 TO 33

TAP	S/THETA	C.	15.	30.	45.	60.	75.	90.	105.	120.	135.	150.	165.	180.	THETA/S	TAP
33	2.4615	0.98	0.77	0.17	-0.57	-1.14	-1.09	-0.45	-0.34	-0.37	-0.55	-0.65	-0.25	0.18	2.4615	33
32	2.3077	0.92	0.71	0.17	-0.51	-1.06	-1.13	-0.45	-0.35	-0.44	-0.59	-0.67	-0.52	-0.33	2.3077	32
31	2.1538	0.93	0.73	0.20	-0.47	-1.04	-1.20	-0.82	-0.38	-0.45	-0.59	-0.66	-0.57	-0.40	2.1538	31
30	2.0000	0.95	0.78	0.27	-0.38	-0.97	-1.23	-1.08	-0.45	-0.55	-0.59	-0.64	-0.62	-0.54	2.0000	30
29	1.8462	0.99	0.82	0.33	-0.30	-0.89	-1.21	-1.17	-0.70	-0.59	-0.62	-0.59	-0.58	-0.55	1.8462	29
28	1.6923	1.00	0.84	0.37	-0.26	-0.85	-1.21	-1.25	-0.92	-0.61	-0.67	-0.59	-0.55	-0.53	1.6923	28
27	1.5385	0.96	0.80	0.37	-0.22	-0.80	-1.18	-1.28	-1.04	-0.53	-0.59	-0.59	-0.51	-0.26	1.5385	27
26	1.3846	0.83	0.68	0.27	-0.29	-0.85	-1.21	-1.33	-1.16	-0.65	-0.44	-0.48	-0.34	-0.07	1.3846	26
25	1.2308	0.63	0.45	0.12	-0.39	-0.89	-1.24	-1.36	-1.23	-0.81	-0.39	-0.27	-0.13	-0.02	1.2308	25
24	1.0769	0.35	0.22	-0.10	-0.54	-0.98	-1.28	-1.38	-1.27	-0.92	-0.54	-0.24	-0.08	-0.04	1.0769	24
23	0.9231	0.02	-0.08	-0.35	-0.71	-1.07	-1.31	-1.40	-1.32	-1.03	-0.72	-0.40	-0.19	-0.14	0.9231	23
22	0.7692	-0.32	-0.40	-0.59	-0.87	-1.14	-1.32	-1.40	-1.34	-1.15	-0.84	-0.61	-0.42	-0.38	0.7692	22
21	0.6154	-0.70	-0.77	-0.92	-1.12	-1.31	-1.43	-1.46	-1.39	-1.27	-1.06	-0.89	-0.75	-0.72	0.6154	21
20	0.4615	-1.01	-1.05	-1.12	-1.24	-1.34	-1.41	-1.44	-1.42	-1.34	-1.26	-1.10	-1.18	-1.00	0.4615	20
19	0.3077	-1.25	-1.27	-1.30	-1.36	-1.41	-1.43	-1.45	-1.44	-1.39	-1.35	-1.31	-1.27	-1.27	0.3077	19
18	0.1538	-1.38	-1.38	-1.39	-1.41	-1.42	-1.42	-1.42	-1.42	-1.41	-1.40	-1.39	-1.37	-1.38	0.1538	18
17	0.0	-1.45	-1.45	-1.44	-1.45	-1.45	-1.45	-1.45	-1.46	-1.46	-1.46	-1.47	-1.45	-1.45	0.0	17

TUNNEL REFERENCE=
15.00 DEGREE CONE
UNIFORM FLOW 12/18/67

IN. ALCCOL

TABLE 3

AVERAGE OF TWO TAPS

TAP S/THETA	0.	15.	30.	45.	60.	75.	90.	105.	120.	135.	150.	165.	180.	THETA/S TAP
1 33 2.4615	C.98	C.77	0.15	-0.55	-1.13	-1.15	-0.48	-0.34	-0.37	-0.55	-0.64	-0.23	0.19	2.4615 1 33
2 32 2.3077	C.91	C.71	0.17	-0.51	-1.06	-1.18	-0.49	-0.36	-0.43	-0.58	-0.67	-0.54	-0.35	2.3077 2 32
3 31 2.1538	C.92	C.73	0.21	-0.45	-1.02	-1.23	-0.87	-0.37	-0.45	-0.59	-0.66	-0.57	-0.40	2.1538 3 31
4 30 2.0000	0.95	C.78	0.28	-0.37	-0.96	-1.25	-1.11	-0.45	-0.55	-0.58	-0.64	-0.62	-0.54	2.0000 4 30
5 29 1.8462	C.99	C.82	0.34	-0.29	-0.88	-1.22	-1.19	-0.69	-0.58	-0.62	-0.59	-0.58	-0.53	1.8462 5 29
6 28 1.6923	1.01	C.84	0.38	-0.24	-0.83	-1.21	-1.25	-0.91	-0.59	-0.67	-0.59	-0.55	-0.52	1.6923 6 28
7 27 1.5385	C.96	C.80	0.37	-0.22	-0.80	-1.19	-1.29	-1.05	-0.53	-0.58	-0.59	-0.51	-0.28	1.5385 7 27
8 26 1.3846	C.83	C.69	0.28	-0.27	-0.83	-1.21	-1.33	-1.17	-0.67	-0.43	-0.48	-0.35	-0.08	1.3846 8 26
9 25 1.2308	C.63	C.58	0.14	-0.37	-0.87	-1.23	-1.35	-1.22	-0.81	-0.40	-0.27	-0.16	-0.03	1.2308 9 25
10 24 1.0769	C.35	C.23	-0.06	-0.52	-0.96	-1.27	-1.38	-1.27	-0.93	-0.55	-0.24	-0.10	-0.05	1.0769 10 24
11 23 0.9231	C.02	-0.07	-0.33	-0.68	-1.05	-1.31	-1.40	-1.32	-1.04	-0.73	-0.41	-0.20	-0.14	0.9231 11 23
12 22 0.7692	-0.33	-0.40	-0.59	-0.86	-1.13	-1.33	-1.41	-1.35	-1.18	-0.88	-0.63	-0.45	-0.39	0.7692 12 22
13 21 0.6154	-0.68	-0.73	-0.88	-1.07	-1.26	-1.39	-1.44	-1.38	-1.28	-1.05	-0.88	-0.75	-0.71	0.6154 13 21
14 20 0.4615	-1.00	-1.03	-1.11	-1.21	-1.32	-1.40	-1.43	-1.41	-1.34	-1.26	-1.09	-1.08	-0.98	0.4615 14 20
15 19 0.3077	-1.24	-1.25	-1.30	-1.35	-1.40	-1.43	-1.44	-1.43	-1.40	-1.35	-1.31	-1.28	-1.27	0.3077 15 19
16 18 0.1538	-1.39	-1.39	-1.41	-1.42	-1.43	-1.43	-1.43	-1.43	-1.43	-1.41	-1.40	-1.39	-1.39	0.1538 16 18
17 17 0.0	-1.45	-1.45	-1.46	-1.46	-1.46	-1.45	-1.45	-1.45	-1.46	-1.46	-1.46	-1.45	-1.45	0.0 17 17

TUNNEL REFERENCE=
30.00 DEGREE CCNE
UNIFORM FLOW 12/18/67

IN. ALCOHOL

TABLE 4

TAPS 1 TO 17

TAP	S/THETA	0.	15.	30.	45.	60.	75.	90.	105.	120.	135.	150.	165.	180.	THETA/S	TAP
1	2.4615	0.95	0.73	0.15	-0.47	-0.79	-0.91	-0.53	-0.41	-0.51	-0.51	-0.58	-0.32	-0.09	2.4615	1
2	2.3077	0.87	0.67	0.17	-0.40	-0.81	-1.03	-0.46	-0.41	-0.51	-0.57	-0.65	-0.64	-0.58	2.3077	2
3	2.1538	0.85	0.68	0.24	-0.32	-0.77	-1.06	-0.70	-0.45	-0.54	-0.59	-0.65	-0.64	-0.58	2.1538	3
4	2.0000	0.90	0.74	0.32	-0.23	-0.72	-1.06	-0.94	-0.48	-0.64	-0.62	-0.65	-0.68	-0.69	2.0000	4
5	1.8462	0.97	0.82	0.40	-0.17	-0.71	-1.09	-1.07	-0.62	-0.74	-0.68	-0.63	-0.68	-0.73	1.8462	5
6	1.6923	1.00	0.86	0.45	-0.13	-0.65	-1.09	-1.15	-0.78	-0.69	-0.69	-0.64	-0.64	-0.64	1.6923	6
7	1.5385	0.97	0.82	0.42	-0.15	-0.72	-1.12	-1.22	-0.96	-0.61	-0.63	-0.65	-0.64	-0.47	1.5385	7
8	1.3846	0.83	0.71	0.34	-0.20	-0.75	-1.14	-1.28	-1.10	-0.63	-0.46	-0.57	-0.54	-0.24	1.3846	8
9	1.2308	0.63	0.53	0.20	-0.30	-0.81	-1.17	-1.31	-1.18	-0.80	-0.41	-0.32	-0.25	-0.09	1.2308	9
10	1.0769	0.35	0.26	-0.03	-0.46	-0.91	-1.22	-1.35	-1.24	-0.92	-0.56	-0.25	-0.14	-0.07	1.0769	10
11	0.9231	0.02	-0.04	-0.28	-0.63	-1.01	-1.26	-1.38	-1.30	-1.05	-0.73	-0.42	-0.23	-0.16	0.9231	11
12	0.7692	-0.35	-0.40	-0.58	-0.85	-1.13	-1.32	-1.41	-1.35	-1.22	-0.91	-0.67	-0.45	-0.41	0.7692	12
13	0.6154	-0.67	-0.69	-0.82	-1.00	-1.21	-1.33	-1.40	-1.37	-1.29	-1.05	-0.88	-0.77	-0.70	0.6154	13
14	0.4615	-1.03	-0.95	-1.07	-1.17	-1.30	-1.36	-1.41	-1.40	-1.35	-1.27	-1.08	-0.99	-0.96	0.4615	14
15	0.3077	-1.23	-1.22	-1.27	-1.32	-1.39	-1.41	-1.43	-1.43	-1.40	-1.34	-1.29	-1.30	-1.29	0.3077	15
16	0.1538	-1.43	-1.39	-1.41	-1.43	-1.45	-1.44	-1.45	-1.45	-1.45	-1.42	-1.41	-1.42	-1.41	0.1538	16
17	0.0	-1.45	-1.42	-1.46	-1.45	-1.48	-1.45	-1.46	-1.45	-1.46	-1.44	-1.44	-1.47	-1.46	0.0	17

TUNNEL REFERENCE=
30.00 DEGREE CCNE
UNIFORM FLOW 12/18/67

IN. ALCOHOL

TABLE 5

TAPS 17 TO 33

TAP	S/THETA	C.	15.	30.	45.	60.	75.	90.	105.	120.	135.	150.	165.	180.	THETA/S TAP
33	2.4615	0.95	0.74	0.11	-0.68	-0.72	-0.47	-0.44	-0.42	-0.45	-0.50	-0.49	-0.28	-0.12	2.4615 33
32	2.3077	0.87	0.67	0.14	-0.53	-0.75	-0.72	-0.40	-0.43	-0.49	-0.58	-0.64	-0.61	-0.55	2.3077 32
31	2.1538	0.85	0.67	0.17	-0.46	-0.78	-0.87	-0.72	-0.46	-0.53	-0.60	-0.66	-0.63	-0.57	2.1538 31
30	2.0000	0.90	0.73	0.27	-0.32	-0.72	-0.95	-0.93	-0.47	-0.61	-0.62	-0.66	-0.66	-0.67	2.0000 30
29	1.8462	0.97	0.80	0.34	-0.27	-0.74	-1.03	-1.07	-0.62	-0.70	-0.67	-0.63	-0.64	-0.72	1.8462 29
28	1.6923	1.01	0.84	0.37	-0.23	-0.75	-1.10	-1.17	-0.88	-0.68	-0.74	-0.64	-0.62	-0.73	1.6923 28
27	1.5385	0.97	0.80	0.37	-0.21	-0.74	-1.10	-1.22	-0.98	-0.55	-0.72	-0.64	-0.56	-0.47	1.5385 27
26	1.3846	0.84	0.68	0.27	-0.28	-0.80	-1.17	-1.29	-1.11	-0.62	-0.57	-0.57	-0.41	-0.25	1.3846 26
25	1.2308	0.63	0.45	0.12	-0.38	-0.86	-1.20	-1.33	-1.19	-0.77	-0.42	-0.32	-0.17	-0.12	1.2308 25
24	1.0769	0.34	0.22	-0.11	-0.54	-0.97	-1.26	-1.37	-1.24	-0.92	-0.50	-0.23	-0.10	-0.22	1.0769 24
23	0.9231	0.02	-0.09	-0.35	-0.70	-1.06	-1.30	-1.39	-1.28	-1.02	-0.69	-0.38	-0.20	-0.34	0.9231 23
22	0.7692	-0.32	-0.40	-0.59	-0.86	-1.13	-1.32	-1.39	-1.32	-1.14	-0.82	-0.57	-0.41	-0.33	0.7692 22
21	0.6154	-0.72	-0.79	-0.93	-1.13	-1.32	-1.43	-1.45	-1.37	-1.27	-1.04	-0.87	-0.74	-0.52	0.6154 21
20	0.4615	-1.03	-1.08	-1.14	-1.25	-1.36	-1.43	-1.44	-1.40	-1.35	-1.24	-1.09	-1.02	-0.95	0.4615 20
19	0.3077	-1.25	-1.28	-1.28	-1.35	-1.41	-1.44	-1.44	-1.42	-1.40	-1.34	-1.29	-1.25	-1.20	0.3077 19
18	0.1538	-1.38	-1.40	-1.38	-1.39	-1.42	-1.42	-1.42	-1.41	-1.42	-1.39	-1.37	-1.35	-1.31	0.1538 18
17	0.0	-1.46	-1.47	-1.44	-1.44	-1.46	-1.45	-1.46	-1.45	-1.48	-1.45	-1.46	-1.43	-1.45	0.0 17

TUNNEL REFERENCE=
30.00 DEGREE CCNE
UNIFORM FLCW 12/18/67

IN. ALCCOL

TABLE 6

AVERAGE OF TWO TAPS

TAP S/THETA	0.	15.	30.	45.	60.	75.	90.	105.	120.	135.	150.	165.	180.	THETA/S TAP
1 33 2.4615	0.95	0.73	0.13	-0.58	-0.76	-0.69	-0.49	-0.41	-0.48	-0.51	-0.53	-0.30	-0.10	2.4615 1 33
2 32 2.3077	0.87	0.67	0.16	-0.47	-0.78	-0.87	-0.43	-0.42	-0.50	-0.57	-0.64	-0.62	-0.57	2.3077 2 32
3 31 2.1538	0.85	0.67	0.20	-0.39	-0.78	-0.97	-0.71	-0.45	-0.54	-0.59	-0.65	-0.64	-0.57	2.1538 3 31
4 30 2.0000	0.90	0.74	0.30	-0.27	-0.72	-1.00	-0.94	-0.48	-0.63	-0.62	-0.65	-0.67	-0.68	2.0000 4 30
5 29 1.8462	0.97	0.81	0.37	-0.22	-0.72	-1.06	-1.07	-0.62	-0.72	-0.67	-0.63	-0.66	-0.72	1.8462 5 29
6 28 1.6923	1.01	0.85	0.41	-0.18	-0.72	-1.10	-1.16	-0.83	-0.68	-0.71	-0.64	-0.63	-0.68	1.6923 6 28
7 27 1.5385	0.97	0.81	0.40	-0.18	-0.73	-1.11	-1.22	-0.97	-0.58	-0.67	-0.65	-0.60	-0.47	1.5385 7 27
8 26 1.3846	0.84	0.70	0.31	-0.24	-0.77	-1.15	-1.28	-1.11	-0.63	-0.52	-0.57	-0.48	-0.24	1.3846 8 26
9 25 1.2308	0.63	0.51	0.16	-0.34	-0.84	-1.19	-1.32	-1.18	-0.79	-0.41	-0.32	-0.21	-0.11	1.2308 9 25
10 24 1.0769	0.35	0.24	-0.07	-0.50	-0.94	-1.24	-1.36	-1.24	-0.92	-0.53	-0.24	-0.12	-0.15	1.0769 10 24
11 23 0.9231	0.02	-0.06	-0.31	-0.67	-1.03	-1.28	-1.38	-1.29	-1.04	-0.71	-0.40	-0.21	-0.25	0.9231 11 23
12 22 0.7692	-0.33	-0.40	-0.58	-0.85	-1.13	-1.32	-1.40	-1.33	-1.18	-0.86	-0.62	-0.45	-0.37	0.7692 12 22
13 21 0.6154	-0.69	-0.74	-0.87	-1.06	-1.26	-1.38	-1.43	-1.37	-1.28	-1.04	-0.88	-0.75	-0.61	0.6154 13 21
14 20 0.4615	-1.03	-1.04	-1.11	-1.21	-1.33	-1.40	-1.43	-1.40	-1.35	-1.26	-1.09	-1.01	-0.95	0.4615 14 20
15 19 0.3077	-1.24	-1.25	-1.27	-1.33	-1.40	-1.42	-1.44	-1.42	-1.40	-1.34	-1.29	-1.28	-1.25	0.3077 15 19
16 18 0.1538	-1.41	-1.40	-1.40	-1.41	-1.44	-1.43	-1.43	-1.43	-1.44	-1.40	-1.39	-1.39	-1.36	0.1538 16 18
17 17 0.0	-1.45	-1.45	-1.45	-1.45	-1.47	-1.45	-1.46	-1.45	-1.47	-1.45	-1.45	-1.45	-1.45	0.0 17 17

TUNNEL REFERENCE=
15.00 DEGREE CCNE
1/6 POWER GRADIENT 12/18/67

IN. ALCCFCL

TABLE 7

TAPS 1 TO 17

TAP	S/THETA	0.	15.	30.	45.	60.	75.	90.	105.	120.	135.	150.	165.	180.	THETA/S	TAP
1	2.4615	0.64	0.52	0.18	-0.32	-0.73	-0.88	-0.59	-0.27	-0.23	-0.24	-0.25	-0.18	-0.10	2.4615	1
2	2.3077	0.52	0.42	0.09	-0.35	-0.71	-0.87	-0.59	-0.25	-0.25	-0.27	-0.28	-0.25	-0.23	2.3077	2
3	2.1538	0.48	0.40	0.08	-0.33	-0.70	-0.87	-0.68	-0.23	-0.24	-0.28	-0.29	-0.28	-0.26	2.1538	3
4	2.0000	0.53	0.42	0.11	-0.31	-0.68	-0.87	-0.76	-0.26	-0.27	-0.29	-0.30	-0.28	-0.26	2.0000	4
5	1.8462	0.60	0.49	0.18	-0.25	-0.63	-0.85	-0.79	-0.35	-0.28	-0.30	-0.31	-0.30	-0.28	1.8462	5
6	1.6923	0.68	0.58	0.25	-0.16	-0.55	-0.85	-0.86	-0.49	-0.30	-0.32	-0.32	-0.31	-0.29	1.6923	6
7	1.5385	0.76	0.65	0.30	-0.15	-0.58	-0.87	-0.92	-0.63	-0.30	-0.32	-0.32	-0.32	-0.27	1.5385	7
8	1.3846	0.75	0.64	0.30	-0.15	-0.59	-0.89	-0.97	-0.73	-0.33	-0.32	-0.33	-0.31	-0.24	1.3846	8
9	1.2308	0.65	0.54	0.23	-0.21	-0.63	-0.92	-1.01	-0.81	-0.38	-0.31	-0.33	-0.32	-0.25	1.2308	9
10	1.0769	0.45	0.35	0.07	-0.33	-0.71	-0.98	-1.07	-0.91	-0.49	-0.31	-0.32	-0.31	-0.30	1.0769	10
11	0.9231	0.18	0.10	-0.13	-0.48	-0.80	-1.03	-1.11	-0.98	-0.64	-0.33	-0.31	-0.31	-0.31	0.9231	11
12	0.7692	-0.14	-0.20	-0.35	-0.66	-0.92	-1.10	-1.15	-1.06	-0.81	-0.45	-0.33	-0.33	-0.33	0.7692	12
13	0.6154	-0.46	-0.50	-0.63	-0.81	-0.99	-1.11	-1.15	-1.09	-0.93	-0.65	-0.43	-0.35	-0.35	0.6154	13
14	0.4615	-0.79	-0.81	-0.88	-0.98	-1.09	-1.16	-1.17	-1.14	-1.04	-0.88	-0.73	-0.60	-0.55	0.4615	14
15	0.3077	-1.04	-1.03	-1.07	-1.12	-1.16	-1.20	-1.21	-1.19	-1.14	-1.06	-1.00	-0.94	-0.91	0.3077	15
16	0.1538	-1.23	-1.21	-1.22	-1.23	-1.23	-1.23	-1.22	-1.22	-1.21	-1.19	-1.18	-1.16	-1.16	0.1538	16
17	0.0	-1.26	-1.26	-1.26	-1.26	-1.26	-1.25	-1.24	-1.24	-1.24	-1.23	-1.24	-1.24	-1.24	0.0	17

TUNNEL REFERENCE=
15.00 DEGREE CCNE
1/6 POWER GRACIENT 12/18/67

IN. ALCCOL

TABLE 8

TAPS 17 TO 33

TAP	S/THETA	0.	15.	30.	45.	60.	75.	90.	105.	120.	135.	150.	165.	180.	THETA/S TAP
33	2.4615	0.63	0.46	0.09	-0.38	-0.78	-0.90	-0.57	-0.26	-0.23	-0.25	-0.26	-0.19	-0.10	2.4615 33
32	2.3077	0.51	0.38	0.06	-0.35	-0.71	-0.83	-0.54	-0.25	-0.25	-0.28	-0.28	-0.25	-0.22	2.3077 32
31	2.1538	0.48	0.35	0.03	-0.27	-0.73	-0.88	-0.64	-0.23	-0.25	-0.28	-0.29	-0.28	-0.26	2.1538 31
30	2.0000	0.51	0.35	0.07	-0.33	-0.70	-0.88	-0.74	-0.26	-0.27	-0.29	-0.30	-0.28	-0.26	2.0000 30
29	1.8462	0.58	0.45	0.15	-0.27	-0.65	-0.86	-0.79	-0.33	-0.28	-0.31	-0.31	-0.30	-0.28	1.8462 29
28	1.6923	0.68	0.52	0.20	-0.23	-0.63	-0.86	-0.86	-0.48	-0.30	-0.33	-0.33	-0.31	-0.30	1.6923 28
27	1.5385	0.75	0.61	0.26	-0.17	-0.58	-0.86	-0.85	-0.62	-0.30	-0.33	-0.33	-0.31	-0.27	1.5385 27
26	1.3846	0.74	0.61	0.25	-0.19	-0.62	-0.91	-0.96	-0.73	-0.32	-0.32	-0.33	-0.31	-0.25	1.3846 26
25	1.2308	0.64	0.52	0.19	-0.25	-0.66	-0.94	-1.01	-0.81	-0.37	-0.32	-0.33	-0.32	-0.26	1.2308 25
24	1.0765	0.44	0.33	0.05	-0.36	-0.74	-0.99	-1.06	-0.90	-0.48	-0.32	-0.33	-0.32	-0.31	1.0765 24
23	0.9231	0.18	0.10	-0.15	-0.50	-0.83	-1.06	-1.11	-0.97	-0.63	-0.34	-0.32	-0.32	-0.32	0.9231 23
22	0.7692	-0.12	-0.19	-0.38	-0.65	-0.91	-1.08	-1.12	-1.02	-0.77	-0.43	-0.33	-0.33	-0.32	0.7692 22
21	0.6154	-0.48	-0.55	-0.70	-0.90	-1.09	-1.21	-1.22	-1.13	-0.95	-0.68	-0.44	-0.35	-0.35	0.6154 21
20	0.4615	-0.79	-0.82	-0.91	-1.01	-1.13	-1.19	-1.21	-1.16	-1.06	-0.90	-0.73	-0.62	-0.58	0.4615 20
19	0.3077	-1.03	-1.05	-1.08	-1.13	-1.19	-1.23	-1.22	-1.20	-1.17	-1.08	-1.01	-0.95	-0.95	0.3077 19
18	0.1538	-1.16	-1.17	-1.18	-1.18	-1.20	-1.19	-1.19	-1.18	-1.18	-1.16	-1.13	-1.12	-1.13	0.1538 18
17	0.0	-1.24	-1.24	-1.24	-1.23	-1.24	-1.24	-1.24	-1.25	-1.26	-1.26	-1.26	-1.26	-1.26	0.0 17

TUNNEL REFERENCE=
15.00 DEGREE CCNE
1/6 POWER GRADIENT 12/18/67

IN. ALCOHOL

TABLE 9

AVERAGE OF TWO TAPS

TAP	S/THETA	0.	15.	30.	45.	60.	75.	90.	105.	120.	135.	150.	165.	180.	THETA/S	TAP	
1	33	2.4615	0.63	0.49	0.14	-0.35	-0.75	-0.89	-0.58	-0.27	-0.23	-0.25	-0.26	-0.18	-0.10	2.4615	1 33
2	32	2.3077	0.52	0.40	0.07	-0.35	-0.71	-0.85	-0.57	-0.25	-0.25	-0.28	-0.28	-0.25	-0.23	2.3077	2 32
3	31	2.1538	0.48	0.38	0.05	-0.35	-0.71	-0.87	-0.66	-0.23	-0.25	-0.28	-0.29	-0.28	-0.26	2.1538	3 31
4	30	2.0000	0.52	0.41	0.09	-0.32	-0.69	-0.88	-0.75	-0.26	-0.27	-0.29	-0.30	-0.28	-0.26	2.0000	4 30
5	29	1.8462	0.59	0.47	0.16	-0.26	-0.64	-0.86	-0.79	-0.34	-0.28	-0.30	-0.31	-0.30	-0.28	1.8462	5 29
6	28	1.6923	0.68	0.55	0.23	-0.19	-0.61	-0.86	-0.86	-0.49	-0.30	-0.32	-0.32	-0.31	-0.30	1.6923	6 28
7	27	1.5385	0.75	0.63	0.28	-0.16	-0.58	-0.87	-0.90	-0.63	-0.30	-0.32	-0.33	-0.31	-0.27	1.5385	7 27
8	26	1.3846	0.74	0.62	0.28	-0.17	-0.60	-0.90	-0.96	-0.73	-0.32	-0.32	-0.33	-0.31	-0.25	1.3846	8 26
9	25	1.2308	0.65	0.53	0.21	-0.23	-0.64	-0.93	-1.01	-0.81	-0.37	-0.32	-0.33	-0.32	-0.26	1.2308	9 25
10	24	1.0769	0.45	0.34	0.06	-0.34	-0.72	-0.99	-1.06	-0.90	-0.49	-0.32	-0.32	-0.31	-0.30	1.0769	10 24
11	23	0.9231	0.18	0.10	-0.14	-0.49	-0.82	-1.04	-1.11	-0.98	-0.64	-0.34	-0.32	-0.31	-0.32	0.9231	11 23
12	22	0.7692	-0.13	-0.20	-0.38	-0.65	-0.91	-1.09	-1.13	-1.04	-0.79	-0.44	-0.33	-0.33	-0.32	0.7692	12 22
13	21	0.6154	-0.47	-0.52	-0.66	-0.85	-1.04	-1.16	-1.19	-1.11	-0.94	-0.66	-0.44	-0.35	-0.35	0.6154	13 21
14	20	0.4615	-0.79	-0.82	-0.89	-0.99	-1.11	-1.17	-1.19	-1.15	-1.05	-0.89	-0.73	-0.61	-0.57	0.4615	14 20
15	19	0.3077	-1.03	-1.04	-1.08	-1.13	-1.18	-1.22	-1.21	-1.20	-1.16	-1.07	-1.00	-0.95	-0.93	0.3077	15 19
16	18	0.1538	-1.20	-1.19	-1.20	-1.21	-1.21	-1.21	-1.20	-1.20	-1.19	-1.17	-1.16	-1.14	-1.15	0.1538	16 18
17	17	0.0	-1.25	-1.25	-1.25	-1.24	-1.25	-1.24	-1.24	-1.24	-1.25	-1.24	-1.25	-1.25	-1.25	0.0	17 17

TABLE 10

TUNNEL REFERENCE=
30.00 DEGREE CCNE
1/6 POWER GRADIENT 12/1E/67

TAPS 1 TO 17

TAP	S/THETA	0.	15.	30.	45.	60.	75.	90.	105.	120.	135.	150.	165.	180.	THETA/S	TAP
1	2.4615	0.59	0.46	0.10	-0.25	-0.51	-0.60	-0.41	-0.32	-0.31	-0.33	-0.33	-0.22	-0.13	2.4615	1
2	2.3077	0.48	0.38	0.07	-0.33	-0.53	-0.65	-0.34	-0.29	-0.33	-0.35	-0.38	-0.37	-0.35	2.3077	2
3	2.1538	0.43	0.34	0.06	-0.30	-0.54	-0.67	-0.48	-0.28	-0.33	-0.35	-0.38	-0.37	-0.35	2.1538	3
4	2.0000	0.43	0.36	0.08	-0.26	-0.53	-0.72	-0.62	-0.30	-0.38	-0.38	-0.39	-0.38	-0.37	2.0000	4
5	1.8462	0.55	0.46	0.17	-0.21	-0.53	-0.75	-0.73	-0.38	-0.40	-0.41	-0.40	-0.40	-0.40	1.8462	5
6	1.6923	0.68	0.58	0.28	-0.14	-0.50	-0.77	-0.81	-0.53	-0.40	-0.42	-0.40	-0.39	-0.38	1.6923	6
7	1.5385	0.75	0.64	0.33	-0.11	-0.52	-0.82	-0.89	-0.67	-0.38	-0.41	-0.41	-0.38	-0.35	1.5385	7
8	1.3846	0.74	0.64	0.33	-0.12	-0.55	-0.85	-0.95	-0.78	-0.40	-0.39	-0.41	-0.37	-0.28	1.3846	8
9	1.2308	0.64	0.55	0.25	-0.18	-0.60	-0.90	-1.01	-0.88	-0.48	-0.36	-0.36	-0.34	-0.27	1.2308	9
10	1.0769	0.44	0.36	0.08	-0.30	-0.65	-0.97	-1.08	-0.95	-0.60	-0.35	-0.33	-0.32	-0.30	1.0769	10
11	0.9231	0.18	0.11	-0.13	-0.45	-0.79	-1.02	-1.13	-1.03	-0.74	-0.42	-0.33	-0.32	-0.33	0.9231	11
12	0.7692	-0.15	-0.20	-0.38	-0.65	-0.91	-1.09	-1.17	-1.11	-0.90	-0.57	-0.37	-0.35	-0.35	0.7692	12
13	0.6154	-0.47	-0.50	-0.63	-0.80	-0.99	-1.12	-1.18	-1.14	-0.99	-0.77	-0.52	-0.40	-0.38	0.6154	13
14	0.4615	-0.80	-0.81	-0.88	-0.98	-1.10	-1.17	-1.20	-1.18	-1.10	-0.96	-0.81	-0.70	-0.65	0.4615	14
15	0.3077	-1.05	-1.04	-1.08	-1.12	-1.18	-1.21	-1.23	-1.23	-1.18	-1.13	-1.05	-1.00	-0.98	0.3077	15
16	0.1538	-1.23	-1.22	-1.24	-1.23	-1.26	-1.24	-1.25	-1.26	-1.25	-1.23	-1.22	-1.20	-1.21	0.1538	16
17	0.0	-1.28	-1.27	-1.28	-1.27	-1.28	-1.27	-1.27	-1.27	-1.27	-1.27	-1.26	-1.26	-1.27	0.0	17

TABLE 11

TUNNEL REFERENCE=
30.00 DEGREE CONE
1/6 POWER GRADIENT 12/18/67

TAPS 17 TO 33

TAP	S/THETA	0.	15.	30.	45.	60.	75.	90.	105.	120.	135.	150.	165.	180.	THETA/S	TAP
33	2.4615	0.58	0.45	0.05	-0.48	-0.57	-0.36	-0.30	-0.27	-0.28	-0.30	-0.27	-0.19	-0.14	2.4615	33
32	2.3077	0.48	0.37	0.03	-0.40	-0.54	-0.42	-0.32	-0.27	-0.30	-0.34	-0.35	-0.35	-0.35	2.3077	32
31	2.1538	0.43	0.32	0.01	-0.35	-0.58	-0.58	-0.47	-0.27	-0.31	-0.35	-0.37	-0.35	-0.35	2.1538	31
30	2.0000	0.46	0.34	0.07	-0.33	-0.55	-0.64	-0.60	-0.29	-0.37	-0.37	-0.38	-0.37	-0.38	2.0000	30
29	1.8462	0.54	0.43	0.13	-0.29	-0.57	-0.72	-0.74	-0.35	-0.40	-0.40	-0.38	-0.38	-0.41	1.8462	29
28	1.6923	0.66	0.54	0.21	-0.22	-0.55	-0.77	-0.83	-0.50	-0.40	-0.42	-0.38	-0.38	-0.40	1.6923	28
27	1.5385	0.75	0.60	0.27	-0.17	-0.54	-0.79	-0.88	-0.62	-0.38	-0.40	-0.38	-0.36	-0.35	1.5385	27
26	1.3846	0.74	0.60	0.26	-0.20	-0.60	-0.85	-0.95	-0.75	-0.39	-0.38	-0.38	-0.35	-0.30	1.3846	26
25	1.2308	0.64	0.51	0.18	-0.26	-0.65	-0.92	-1.02	-0.83	-0.45	-0.36	-0.35	-0.32	-0.28	1.2308	25
24	1.0769	0.45	0.33	0.03	-0.38	-0.74	-0.98	-1.07	-0.92	-0.58	-0.35	-0.33	-0.32	-0.31	1.0769	24
23	0.9231	0.21	0.09	-0.17	-0.52	-0.84	-1.05	-1.12	-1.00	-0.71	-0.40	-0.33	-0.33	-0.33	0.9231	23
22	0.7692	-0.13	-0.20	-0.40	-0.67	-0.93	-1.09	-1.14	-1.04	-0.83	-0.53	-0.36	-0.34	-0.35	0.7692	22
21	0.6154	-0.50	-0.56	-0.71	-0.93	-1.11	-1.23	-1.25	-1.16	-1.00	-0.75	-0.50	-0.39	-0.40	0.6154	21
20	0.4615	-0.81	-0.83	-0.93	-1.05	-1.15	-1.21	-1.23	-1.18	-1.10	-0.96	-0.81	-0.68	-0.68	0.4615	20
19	0.3077	-1.04	-1.07	-1.11	-1.18	-1.22	-1.25	-1.25	-1.22	-1.19	-1.12	-1.05	-1.00	-1.01	0.3077	19
18	0.1538	-1.19	-1.19	-1.21	-1.23	-1.23	-1.23	-1.21	-1.19	-1.20	-1.18	-1.16	-1.15	-1.16	0.1538	18
17	0.0	-1.27	-1.26	-1.26	-1.27	-1.27	-1.27	-1.27	-1.27	-1.28	-1.27	-1.28	-1.27	-1.28	0.0	17

TABLE 12

TUNNEL REFERENCE=
30.00 DEGREE CCNE
1/6 POWER GRADIENT 12/18/67

IN. ALCOHOL

AVERAGE OF TWO TAPS

TAP S/THETA	0.	15.	30.	45.	60.	75.	90.	105.	120.	135.	150.	165.	180.	THETA/S TAP
1 33 2.4615	C.59	C.45	C.07	-0.42	-0.54	-0.48	-0.36	-0.30	-0.30	-0.31	-0.30	-0.21	-0.14	2.4615 1 33
2 32 2.3077	C.48	C.37	C.05	-0.36	-0.53	-0.53	-0.33	-0.28	-0.32	-0.34	-0.36	-0.36	-0.35	2.3077 2 32
3 31 2.1538	C.43	C.33	0.04	-0.35	-0.56	-0.63	-0.47	-0.28	-0.32	-0.35	-0.38	-0.36	-0.35	2.1538 3 31
4 30 2.0000	0.45	C.35	C.08	-0.29	-0.54	-0.68	-0.61	-0.29	-0.37	-0.38	-0.39	-0.38	-0.37	2.0000 4 30
5 29 1.8462	C.55	C.44	C.15	-0.25	-0.55	-0.74	-0.73	-0.36	-0.40	-0.40	-0.39	-0.39	-0.40	1.8462 5 29
6 28 1.6923	C.67	C.56	C.24	-0.18	-0.53	-0.77	-0.82	-0.51	-0.40	-0.42	-0.39	-0.38	-0.39	1.6923 6 28
7 27 1.5385	C.75	C.62	C.30	-0.14	-0.53	-0.80	-0.89	-0.65	-0.38	-0.40	-0.39	-0.37	-0.35	1.5385 7 27
8 26 1.3846	C.74	C.62	C.29	-0.16	-0.57	-0.85	-0.95	-0.76	-0.39	-0.38	-0.39	-0.36	-0.29	1.3846 8 26
9 25 1.2308	C.64	C.53	0.22	-0.22	-0.63	-0.91	-1.01	-0.85	-0.46	-0.36	-0.36	-0.33	-0.27	1.2308 9 25
10 24 1.0769	C.45	C.34	0.05	-0.34	-0.71	-0.97	-1.08	-0.94	-0.59	-0.35	-0.33	-0.32	-0.31	1.0769 10 24
11 23 0.9231	C.19	C.10	-0.15	-0.49	-0.81	-1.04	-1.13	-1.01	-0.73	-0.41	-0.33	-0.32	-0.33	0.9231 11 23
12 22 0.7692	-0.14	-0.20	-0.35	-0.66	-0.92	-1.09	-1.16	-1.08	-0.86	-0.55	-0.36	-0.34	-0.35	0.7692 12 22
13 21 0.6154	-0.48	-0.53	-0.67	-0.86	-1.05	-1.17	-1.21	-1.15	-1.00	-0.76	-0.51	-0.39	-0.39	0.6154 13 21
14 20 0.4615	-0.80	-0.82	-0.91	-1.01	-1.13	-1.19	-1.21	-1.18	-1.10	-0.96	-0.81	-0.69	-0.67	0.4615 14 20
15 19 0.3077	-1.05	-1.05	-1.09	-1.15	-1.20	-1.23	-1.24	-1.22	-1.18	-1.12	-1.05	-1.00	-0.99	0.3077 15 19
16 18 0.1538	-1.21	-1.21	-1.22	-1.23	-1.24	-1.24	-1.23	-1.23	-1.23	-1.20	-1.19	-1.18	-1.19	0.1538 16 18
17 17 0.0	-1.27	-1.26	-1.27	-1.27	-1.28	-1.27	-1.27	-1.27	-1.28	-1.27	-1.27	-1.26	-1.27	0.0 17 17

TABLE 13

TUNNEL REFERENCE=
15.00 DEGREE CCNE
1/4 POWER GRACIENT 12/18/67

TAPS 1 TO 17

TAP	S/THETA	C.	15.	30.	45.	60.	75.	90.	105.	120.	135.	150.	165.	180.	THETA/S	TAP
1	2.4615	0.55	0.43	0.11	-0.20	-0.65	-0.80	-0.57	-0.24	-0.20	-0.21	-0.22	-0.17	-0.13	2.4615	1
2	2.3077	0.46	0.34	0.04	-0.24	-0.66	-0.80	-0.57	-0.23	-0.22	-0.24	-0.23	-0.21	-0.18	2.3077	2
3	2.1538	0.41	0.30	0.03	-0.33	-0.64	-0.79	-0.62	-0.22	-0.21	-0.24	-0.24	-0.24	-0.23	2.1538	3
4	2.0000	0.45	0.32	0.05	-0.30	-0.62	-0.80	-0.69	-0.24	-0.22	-0.24	-0.24	-0.24	-0.23	2.0000	4
5	1.8462	0.52	0.41	0.12	-0.24	-0.58	-0.78	-0.73	-0.30	-0.24	-0.25	-0.26	-0.25	-0.23	1.8462	5
6	1.6923	0.55	0.48	0.19	-0.15	-0.54	-0.78	-1.06	-0.43	-0.24	-0.24	-0.27	-0.26	-0.24	1.6923	6
7	1.5385	0.65	0.54	0.24	-0.18	-0.54	-0.77	-0.84	-0.54	-0.25	-0.27	-0.28	-0.27	-0.24	1.5385	7
8	1.3846	0.65	0.55	0.26	-0.18	-0.54	-0.81	-0.88	-0.64	-0.27	-0.27	-0.29	-0.28	-0.24	1.3846	8
9	1.2308	0.58	0.45	0.15	-0.19	-0.60	-0.84	-0.92	-0.71	-0.30	-0.27	-0.29	-0.28	-0.24	1.2308	9
10	1.0769	0.41	0.32	0.06	-0.30	-0.65	-0.90	-0.98	-0.80	-0.38	-0.27	-0.29	-0.29	-0.27	1.0769	10
11	0.9231	0.17	0.09	-0.12	-0.43	-0.73	-0.95	-1.02	-0.87	-0.51	-0.29	-0.29	-0.29	-0.29	0.9231	11
12	0.7692	-0.13	-0.15	-0.35	-0.60	-0.84	-1.00	-1.06	-0.94	-0.81	-0.35	-0.30	-0.30	-0.29	0.7692	12
13	0.6154	-0.42	-0.46	-0.58	-0.76	-0.92	-1.03	-1.07	-0.98	-0.80	-0.52	-0.34	-0.30	-0.30	0.6154	13
14	0.4615	-0.72	-0.74	-0.81	-0.91	-1.00	-1.07	-1.08	-1.02	-0.91	-0.75	-0.57	-0.45	-0.41	0.4615	14
15	0.3077	-0.95	-0.96	-0.99	-1.02	-1.07	-1.10	-1.11	-1.07	-1.02	-0.95	-0.87	-0.80	-0.77	0.3077	15
16	0.1538	-1.11	-1.11	-1.11	-1.12	-1.12	-1.13	-1.12	-1.10	-1.09	-1.05	-1.06	-1.05	-1.04	0.1538	16
17	0.0	-1.14	-1.13	-1.14	-1.15	-1.14	-1.14	-1.14	-1.13	-1.13	-1.14	-1.13	-1.14	-1.13	0.0	17

TABLE 14

TUNNEL REFERENCE= IN.ALCCPOL
 15.00 DEGREE CCNE
 1/4 POWER GRADIENT 12/18/67

TAPS 17 TO 33

TAP	S/THETA	C.	15.	30.	45.	60.	75.	90.	105.	120.	135.	150.	165.	180.	THETA/S	TAP
33	2.4615	0.56	0.45	0.14	-0.27	-0.64	-0.78	-0.54	-0.24	-0.20	-0.21	-0.22	-0.18	-0.13	2.4615	33
32	2.3077	0.46	0.37	0.09	-0.28	-0.62	-0.74	-0.54	-0.27	-0.22	-0.23	-0.23	-0.21	-0.18	2.3077	32
31	2.1538	0.42	0.33	0.05	-0.31	-0.65	-0.80	-0.64	-0.23	-0.21	-0.24	-0.24	-0.24	-0.23	2.1538	31
30	2.0000	0.45	0.37	0.10	-0.23	-0.55	-0.77	-0.68	-0.26	-0.22	-0.24	-0.24	-0.24	-0.23	2.0000	30
29	1.8462	0.51	0.41	0.15	-0.21	-0.56	-0.75	-0.73	-0.30	-0.23	-0.25	-0.27	-0.24	-0.23	1.8462	29
28	1.6923	0.55	0.49	0.21	-0.18	-0.55	-0.78	-0.75	-0.43	-0.24	-0.26	-0.27	-0.26	-0.24	1.6923	28
27	1.5385	0.66	0.56	0.27	-0.14	-0.52	-0.78	-0.82	-0.54	-0.26	-0.27	-0.28	-0.27	-0.24	1.5385	27
26	1.3846	0.66	0.55	0.25	-0.16	-0.55	-0.82	-0.88	-0.64	-0.27	-0.27	-0.28	-0.28	-0.24	1.3846	26
25	1.2308	0.58	0.47	0.18	-0.21	-0.59	-0.86	-0.92	-0.72	-0.30	-0.27	-0.28	-0.29	-0.25	1.2308	25
24	1.0769	0.41	0.30	0.04	-0.32	-0.67	-0.90	-1.00	-0.80	-0.38	-0.28	-0.28	-0.25	-0.28	1.0769	24
23	0.9231	0.17	0.08	-0.14	-0.45	-0.75	-0.96	-1.01	-0.87	-0.51	-0.29	-0.28	-0.25	-0.30	0.9231	23
22	0.7692	-0.11	-0.15	-0.35	-0.59	-0.82	-0.97	-1.02	-0.90	-0.64	-0.35	-0.30	-0.30	-0.30	0.7692	22
21	0.6154	-0.42	-0.45	-0.62	-0.79	-0.97	-1.06	-1.08	-1.00	-0.80	-0.52	-0.34	-0.31	-0.30	0.6154	21
20	0.4615	-0.73	-0.76	-0.84	-0.94	-1.07	-1.08	-1.10	-1.04	-0.92	-0.76	-0.59	-0.46	-0.39	0.4615	20
19	0.3077	-0.95	-0.95	-1.01	-1.06	-1.09	-1.12	-1.11	-1.08	-1.03	-0.95	-0.87	-0.81	-0.78	0.3077	19
18	0.1538	-1.07	-1.08	-1.08	-1.10	-1.09	-1.09	-1.08	-1.07	-1.05	-1.03	-1.01	-1.00	-0.99	0.1538	18
17	0.0	-1.13	-1.14	-1.13	-1.14	-1.13	-1.13	-1.14	-1.14	-1.14	-1.15	-1.14	-1.13	-1.14	0.0	17

TABLE 15

TUNNEL REFERENCE= IN. ALCCFOL
 15.00 DEGREE CCNE
 1/4 POWER GRADIENT 12/18/67

AVERAGE OF TWO TAPS

TAP S/THETA	0.	15.	30.	45.	60.	75.	90.	105.	120.	135.	150.	165.	180.	THETA/S TAP
1 33 2.4615	0.56	0.44	0.12	-0.28	-0.65	-0.79	-0.56	-0.24	-0.20	-0.21	-0.22	-0.17	-0.13	2.4615 1 33
2 32 2.3077	0.46	0.35	0.06	-0.31	-0.64	-0.77	-0.56	-0.23	-0.22	-0.23	-0.23	-0.21	-0.18	2.3077 2 32
3 31 2.1538	0.41	0.31	0.04	-0.32	-0.64	-0.80	-0.63	-0.22	-0.21	-0.24	-0.24	-0.24	-0.23	2.1538 3 31
4 30 2.0000	0.45	0.34	0.08	-0.26	-0.61	-0.79	-0.69	-0.25	-0.22	-0.24	-0.24	-0.24	-0.23	2.0000 4 30
5 29 1.8462	0.51	0.41	0.14	-0.23	-0.57	-0.77	-0.73	-0.30	-0.23	-0.25	-0.26	-0.24	-0.23	1.8462 5 29
6 28 1.6923	0.59	0.48	0.20	-0.18	-0.55	-0.78	-0.92	-0.43	-0.24	-0.25	-0.27	-0.26	-0.24	1.6923 6 28
7 27 1.5385	0.66	0.55	0.25	-0.16	-0.53	-0.77	-0.83	-0.54	-0.25	-0.27	-0.28	-0.27	-0.24	1.5385 7 27
8 26 1.3846	0.66	0.55	0.26	-0.17	-0.54	-0.82	-0.88	-0.64	-0.27	-0.27	-0.28	-0.28	-0.24	1.3846 8 26
9 25 1.2308	0.58	0.48	0.19	-0.20	-0.59	-0.85	-0.92	-0.72	-0.30	-0.27	-0.28	-0.29	-0.25	1.2308 9 25
10 24 1.0769	0.41	0.31	0.05	-0.31	-0.66	-0.90	-0.99	-0.80	-0.38	-0.28	-0.29	-0.29	-0.27	1.0769 10 24
11 23 0.9231	0.17	0.09	-0.13	-0.44	-0.74	-0.95	-1.01	-0.87	-0.51	-0.29	-0.29	-0.29	-0.29	0.9231 11 23
12 22 0.7692	-0.12	-0.19	-0.35	-0.60	-0.83	-0.99	-1.04	-0.92	-0.72	-0.35	-0.30	-0.30	-0.29	0.7692 12 22
13 21 0.6154	-0.42	-0.47	-0.60	-0.77	-0.94	-1.05	-1.08	-0.99	-0.80	-0.52	-0.34	-0.31	-0.30	0.6154 13 21
14 20 0.4615	-0.73	-0.75	-0.82	-0.92	-1.01	-1.07	-1.09	-1.03	-0.92	-0.76	-0.58	-0.45	-0.40	0.4615 14 20
15 19 0.3077	-0.95	-0.96	-1.00	-1.04	-1.08	-1.11	-1.11	-1.08	-1.02	-0.95	-0.87	-0.80	-0.78	0.3077 15 19
16 18 0.1538	-1.09	-1.10	-1.10	-1.11	-1.11	-1.11	-1.10	-1.09	-1.07	-1.04	-1.04	-1.02	-1.02	0.1538 16 18
17 17 0.0	-1.13	-1.13	-1.14	-1.14	-1.13	-1.13	-1.14	-1.13	-1.13	-1.14	-1.14	-1.13	-1.13	0.0 17 17

TABLE 16

TUNNEL REFERENCE= IN. ALCCFCL
 30.00 DEGREE CCNE
 1/4 POWER GRACIENT 12/18/67

TAPS 1 TO 17

TAP	S/THETA	0.	15.	30.	45.	60.	75.	90.	105.	120.	135.	150.	165.	180.	THETA/S	TAP
1	2.4615	0.53	0.40	0.05	-0.34	-0.46	-0.53	-0.36	-0.29	-0.28	-0.29	-0.26	-0.20	-0.13	2.4615	1
2	2.3077	0.44	0.22	0.03	-0.30	-0.48	-0.57	-0.30	-0.27	-0.28	-0.30	-0.31	-0.32	-0.31	2.3077	2
3	2.1538	0.39	0.30	0.02	-0.29	-0.45	-0.62	-0.42	-0.26	-0.28	-0.30	-0.31	-0.32	-0.31	2.1538	3
4	2.0000	0.38	0.30	0.04	-0.25	-0.45	-0.65	-0.54	-0.27	-0.32	-0.32	-0.32	-0.33	-0.32	2.0000	4
5	1.8462	0.47	0.38	0.11	-0.22	-0.45	-0.69	-0.66	-0.34	-0.35	-0.35	-0.32	-0.34	-0.35	1.8462	5
6	1.6923	0.60	0.45	0.22	-0.14	-0.47	-0.71	-0.73	-0.46	-0.34	-0.35	-0.34	-0.34	-0.34	1.6923	6
7	1.5385	0.68	0.57	0.27	-0.12	-0.45	-0.76	-0.81	-0.60	-0.33	-0.35	-0.34	-0.34	-0.31	1.5385	7
8	1.3846	0.68	0.57	0.27	-0.12	-0.50	-0.79	-0.87	-0.70	-0.35	-0.34	-0.34	-0.34	-0.27	1.3846	8
9	1.2308	0.60	0.45	0.20	-0.20	-0.54	-0.83	-0.92	-0.78	-0.40	-0.32	-0.32	-0.32	-0.25	1.2308	9
10	1.0769	0.41	0.22	0.05	-0.29	-0.64	-0.90	-0.98	-0.87	-0.52	-0.32	-0.31	-0.30	-0.29	1.0769	10
11	0.9231	0.20	0.10	-0.13	-0.43	-0.73	-0.92	-1.03	-0.95	-0.66	-0.35	-0.31	-0.31	-0.31	0.9231	11
12	0.7692	-0.13	-0.15	-0.27	-0.60	-0.84	-1.01	-1.08	-1.01	-0.80	-0.48	-0.32	-0.32	-0.32	0.7692	12
13	0.6154	-0.43	-0.46	-0.60	-0.76	-0.93	-1.06	-1.10	-1.05	-0.91	-0.68	-0.42	-0.35	-0.35	0.6154	13
14	0.4615	-0.73	-0.75	-0.84	-0.92	-1.03	-1.09	-1.11	-1.09	-1.00	-0.86	-0.70	-0.60	-0.54	0.4615	14
15	0.3077	-0.98	-0.98	-1.04	-1.06	-1.11	-1.14	-1.14	-1.14	-1.09	-1.02	-0.94	-0.91	-0.89	0.3077	15
16	0.1538	-1.13	-1.14	-1.17	-1.16	-1.17	-1.17	-1.16	-1.16	-1.15	-1.14	-1.11	-1.12	-1.11	0.1538	16
17	0.0	-1.17	-1.16	-1.20	-1.19	-1.19	-1.18	-1.17	-1.18	-1.18	-1.17	-1.16	-1.18	-1.18	0.0	17

TABLE 17

TUNNEL REFERENCE= IN. ALCCFCL
 30.00 DEGREE CCNE
 1/4 POWER GRACIENT 12/18/67

TAPS 17 TC 33

TAP	S/THETA	C.	15.	20.	45.	60.	75.	90.	105.	120.	135.	150.	165.	180.	THETA/S	TAP
33	2.4615	C.52	C.42	C.C9	-C.38	-0.52	-0.37	-0.27	-0.26	-0.26	-0.27	-0.25	-0.17	-0.14	2.4615	33
32	2.3077	0.44	C.35	C.C8	-C.30	-0.46	-0.39	-0.25	-0.24	-0.27	-0.30	-0.31	-0.29	-0.30	2.3077	32
31	2.1538	C.38	C.32	C.C6	-C.29	-0.48	-0.54	-0.38	-0.24	-0.27	-0.30	-0.33	-0.29	-0.30	2.1538	31
30	2.0000	0.38	C.32	C.C8	-C.26	-0.45	-0.58	-0.53	-0.27	-0.32	-0.33	-0.34	-0.32	-0.32	2.0000	30
29	1.8462	C.47	C.41	C.15	-C.19	-0.47	-0.62	-0.63	-0.33	-0.35	-0.35	-0.35	-0.32	-0.34	1.8462	29
28	1.6923	0.59	C.50	C.22	-0.16	-0.45	-0.70	-0.73	-0.47	-0.35	-0.37	-0.25	-0.32	-0.33	1.6923	28
27	1.5385	C.67	C.57	C.28	-0.13	-0.45	-0.73	-0.79	-0.58	-0.33	-0.35	-0.35	-0.32	-0.30	1.5385	27
26	1.3846	C.67	C.56	C.25	-C.16	-0.53	-0.79	-0.87	-0.69	-0.34	-0.34	-0.35	-0.32	-0.26	1.3846	26
25	1.2308	C.58	C.48	C.18	-C.22	-0.55	-0.84	-0.92	-0.78	-0.39	-0.33	-0.33	-0.30	-0.25	1.2308	25
24	1.0769	C.41	C.30	C.C4	-C.33	-0.66	-0.90	-0.98	-0.86	-0.50	-0.32	-0.33	-0.30	-0.28	1.0769	24
23	0.9231	0.17	C.08	-C.15	-C.46	-0.76	-0.96	-1.03	-0.92	-0.63	-0.35	-0.33	-0.30	-0.30	0.9231	23
22	0.7692	-0.12	-C.15	-C.26	-0.61	-0.85	-1.03	-1.04	-0.97	-0.75	-0.46	-0.33	-0.31	-0.32	0.7692	22
21	0.6154	-C.44	-C.45	-C.61	-C.81	-0.98	-1.09	-1.11	-1.05	-0.89	-0.65	-0.44	-0.34	-0.34	0.6154	21
20	0.4615	-C.76	-C.75	-0.85	-C.96	-1.06	-1.13	-1.14	-1.09	-1.00	-0.87	-0.71	-0.57	-0.55	0.4615	20
19	0.3077	-C.98	-1.00	-1.02	-1.08	-1.12	-1.16	-1.15	-1.14	-1.08	-1.02	-0.96	-0.85	-0.89	0.3077	19
18	0.1538	-1.11	-1.12	-1.11	-1.13	-1.14	-1.14	-1.11	-1.11	-1.11	-1.09	-1.08	-1.05	-1.05	0.1538	18
17	0.0	-1.18	-1.18	-1.16	-1.17	-1.18	-1.18	-1.17	-1.18	-1.19	-1.19	-1.20	-1.16	-1.17	0.0	17

TABLE 18

TUNNEL REFERENCE=
30.00 DEGREE CCNE
1/4 POWER GRADIENT 12/18/67

AVERAGE OF TWO TAPS

TAP S/THETA	C.	15.	30.	45.	60.	75.	90.	105.	120.	135.	150.	165.	180.	THETA/S TAP
1 33 2.4615	C.53	C.41	0.07	-0.36	-0.49	-0.45	-0.32	-0.27	-0.27	-0.28	-0.26	-0.18	-0.14	2.4615 1 33
2 32 2.3077	C.44	C.34	0.06	-0.30	-0.47	-0.48	-0.27	-0.26	-0.27	-0.30	-0.31	-0.31	-0.30	2.3077 2 32
3 31 2.1538	C.35	C.31	0.04	-0.29	-0.48	-0.58	-0.40	-0.25	-0.28	-0.30	-0.32	-0.31	-0.31	2.1538 3 31
4 30 2.0000	C.38	C.21	0.06	-0.26	-0.49	-0.62	-0.54	-0.27	-0.32	-0.32	-0.33	-0.32	-0.32	2.0000 4 30
5 29 1.8462	C.47	C.35	0.13	-0.20	-0.48	-0.66	-0.64	-0.34	-0.35	-0.35	-0.34	-0.33	-0.34	1.8462 5 29
6 28 1.6923	C.60	C.49	0.22	-0.15	-0.48	-0.70	-0.73	-0.46	-0.35	-0.36	-0.34	-0.33	-0.34	1.6923 6 28
7 27 1.5385	C.67	C.57	0.27	-0.13	-0.49	-0.74	-0.80	-0.59	-0.33	-0.35	-0.35	-0.33	-0.30	1.5385 7 27
8 26 1.3846	C.67	C.57	0.26	-0.14	-0.51	-0.79	-0.87	-0.69	-0.35	-0.34	-0.35	-0.33	-0.27	1.3846 8 26
9 25 1.2308	C.59	C.48	0.19	-0.21	-0.57	-0.84	-0.92	-0.78	-0.40	-0.32	-0.33	-0.31	-0.25	1.2308 9 25
10 24 1.0769	0.41	C.32	0.04	-0.31	-0.65	-0.90	-0.98	-0.86	-0.51	-0.32	-0.32	-0.30	-0.29	1.0769 10 24
11 23 0.9231	C.18	C.09	-0.14	-0.45	-0.75	-0.94	-1.03	-0.94	-0.64	-0.35	-0.32	-0.30	-0.31	0.9231 11 23
12 22 0.7692	-0.12	-0.19	-0.36	-0.60	-0.84	-1.02	-1.06	-0.99	-0.77	-0.47	-0.33	-0.32	-0.32	0.7692 12 22
13 21 0.6154	-0.43	-0.48	-0.61	-0.79	-0.96	-1.07	-1.11	-1.05	-0.90	-0.66	-0.43	-0.35	-0.34	0.6154 13 21
14 20 0.4615	-0.74	-0.77	-0.85	-0.94	-1.04	-1.11	-1.13	-1.09	-1.00	-0.86	-0.70	-0.59	-0.54	0.4615 14 20
15 19 0.3077	-0.98	-0.99	-1.03	-1.07	-1.12	-1.15	-1.14	-1.14	-1.09	-1.02	-0.95	-0.90	-0.89	0.3077 15 19
16 18 0.1538	-1.12	-1.13	-1.14	-1.15	-1.15	-1.15	-1.14	-1.14	-1.13	-1.11	-1.10	-1.09	-1.08	0.1538 16 18
17 17 0.0	-1.17	-1.17	-1.18	-1.18	-1.18	-1.18	-1.17	-1.18	-1.18	-1.18	-1.18	-1.17	-1.17	0.0 17 17

15.00 DEGREE CONE
UNIFORM FLOW 12/18/67

TABLE 19

HARMONIC NO.

S	0	1	2	3	4	5
2.46	-0.32379	0.24717	0.55764	0.40611	0.28585	-0.20381
2.31	-0.38920	0.34837	0.45746	0.44410	0.19810	-0.15639
2.15	-0.41671	0.37514	0.52818	0.44265	0.11215	-0.16002
2.00	-0.43825	0.43885	0.58290	0.42744	0.03487	-0.13394
1.85	-0.43743	0.47830	0.64869	0.36506	-0.00569	-0.09585
1.69	-0.44660	0.50947	0.69858	0.31557	-0.03431	-0.07237
1.54	-0.43655	0.46691	0.73173	0.27706	-0.05775	-0.06584
1.38	-0.44822	0.35826	0.78470	0.21202	-0.07188	-0.02795
1.23	-0.47096	0.23140	0.82140	0.14867	-0.06609	0.01886
1.08	-0.57684	0.11045	0.77191	0.07207	-0.04358	0.01804
0.92	-0.71666	0.05153	0.67479	0.02540	-0.01425	0.00349
0.77	-0.88112	0.02625	0.53004	-0.00062	-0.00305	0.00737
0.62	-1.06686	0.00413	0.37595	0.00337	-0.00004	0.00536
0.46	-1.22229	0.01311	0.21216	-0.00500	0.00493	-0.00056
0.31	-1.34974	0.00871	0.09488	0.00533	0.00068	0.00220
0.15	-1.41318	-0.00282	0.02229	-0.00016	0.00350	0.00012
0.0	-1.45400	-0.00000	0.00209	-0.00000	0.00359	-0.00000

30.00 DEGREE CCNE
UNIFORM FLOW 12/18/67

TABLE 20

HARMONIC NO.

S	0	1	2	3	4	5
2.46	-0.28851	0.30576	0.44381	0.29620	0.25110	-0.02276
2.31	-0.36065	0.41298	0.35589	0.35870	0.17071	-0.04865
2.15	-0.39144	0.43536	0.42394	0.35025	0.10046	-0.07498
2.00	-0.40366	0.50764	0.47974	0.33433	0.03493	-0.07712
1.85	-0.42260	0.55642	0.56110	0.31416	0.00693	-0.06380
1.69	-0.43691	0.57887	0.62741	0.29053	-0.02387	-0.05500
1.54	-0.43804	0.53802	0.66455	0.27083	-0.04722	-0.06383
1.38	-0.45372	0.42408	0.71678	0.22538	-0.06949	-0.03777
1.23	-0.47209	0.25183	0.77045	0.14722	-0.07459	0.01000
1.08	-0.56866	0.12603	0.74749	0.08281	-0.05514	0.02699
0.92	-0.70908	0.06499	0.65598	0.03324	-0.02507	0.01213
0.77	-0.87478	0.02287	0.52671	-0.00117	-0.00415	0.00554
0.62	-1.06071	-0.00591	0.37667	-0.00468	0.00793	-0.00382
0.46	-1.21657	-0.00765	0.22140	-0.01863	0.01112	-0.00912
0.31	-1.34236	0.00738	0.09754	0.00203	-0.00152	-0.00188
0.15	-1.41091	-0.00711	0.02521	-0.00296	0.00188	-0.00229
0.0	-1.45489	-0.00000	0.00429	0.0	0.00214	-0.00000

TABLE 21

15.00 DEGREE CCNE
1/6 POWER GRADIENT 12/18/67

HARMONIC NO.

S	0	1	2	3	4	5
2.46	-0.23846	0.14257	0.42326	0.31374	0.06753	-0.09843
2.31	-0.26368	0.14456	0.36197	0.29496	0.05176	-0.08611
2.15	-0.28259	0.14301	0.36142	0.30187	0.02959	-0.09427
2.00	-0.28387	0.16709	0.39182	0.29167	0.01160	-0.09345
1.85	-0.27406	0.21741	0.41903	0.27898	-0.00736	-0.08067
1.69	-0.27430	0.27242	0.47321	0.26382	-0.03373	-0.06184
1.54	-0.27119	0.30886	0.52166	0.25182	-0.05101	-0.04329
1.38	-0.29257	0.30685	0.55523	0.24151	-0.06524	-0.03345
1.23	-0.33518	0.27097	0.55755	0.22372	-0.07749	-0.01792
1.08	-0.41544	0.19667	0.54458	0.19127	-0.08788	0.00607
0.92	-0.51310	0.09716	0.51783	0.14595	-0.08569	0.02584
0.77	-0.62656	-0.00798	0.46504	0.08351	-0.06338	0.03567
0.62	-0.77846	-0.10342	0.40419	0.01451	-0.01913	0.02191
0.46	-0.94084	-0.09430	0.25833	-0.01835	0.00557	-0.00255
0.31	-1.10030	-0.04465	0.12088	-0.00731	0.00164	0.00043
0.15	-1.18887	-0.02453	0.02092	-0.00046	0.00255	0.00148
0.0	-1.24542	-0.00000	-0.00177	-0.00000	-0.00092	-0.00000

TABLE 22

30.00 DEGREE CONE
1/6 POWER GRADIENT 12/18/67

HARMONIC NO.

S	0	1	2	3	4	5
2.46	-0.20502	0.17975	0.29475	0.21207	0.14557	-0.00301
2.31	-0.24451	0.21628	0.22919	0.22406	0.10423	-0.01525
2.15	-0.27351	0.20139	0.25632	0.22621	0.06832	-0.04135
2.00	-0.28800	0.23087	0.29387	0.21660	0.03355	-0.05316
1.85	-0.29583	0.28059	0.36074	0.22781	0.00961	-0.05406
1.69	-0.28819	0.33808	0.43472	0.22176	-0.01556	-0.04347
1.54	-0.28628	0.36334	0.49581	0.22226	-0.03895	-0.03424
1.38	-0.30722	0.35039	0.53853	0.21579	-0.05484	-0.02562
1.23	-0.35044	0.29823	0.56073	0.19530	-0.07006	-0.00754
1.08	-0.42991	0.21485	0.55559	0.16490	-0.07769	0.01772
0.92	-0.53192	0.12035	0.52839	0.11963	-0.07133	0.03355
0.77	-0.65505	0.01786	0.47236	0.05809	-0.04714	0.03563
0.62	-0.81300	-0.06993	0.40398	-0.00059	-0.00583	0.01306
0.46	-0.97869	-0.05536	0.24695	-0.01498	0.00811	0.00018
0.31	-1.13126	-0.02375	0.11403	-0.00354	0.00398	-0.00005
0.15	-1.21570	-0.01621	0.02150	0.00021	0.00313	0.00077
0.0	-1.27170	-0.00000	0.00192	-0.00000	0.00218	-0.00000

15.00 DEGREE CONE
1/4 POWER GRADIENT 12/18/67

TABLE 23

HARMONIC NO.

S	0	1	2	3	4	5
2.46	-0.21166	0.13653	0.37785	0.27717	0.04097	-0.08325
2.31	-0.23643	0.11884	0.33919	0.26355	0.03603	-0.07836
2.15	-0.25797	0.11268	0.33219	0.26819	0.01189	-0.08183
2.00	-0.25081	0.13988	0.35222	0.25562	-0.00654	-0.08005
1.85	-0.24195	0.17852	0.37983	0.24769	-0.01726	-0.07266
1.69	-0.25238	0.22458	0.44999	0.24059	-0.06230	-0.05617
1.54	-0.24142	0.26338	0.46575	0.23160	-0.05099	-0.04071
1.38	-0.26160	0.26810	0.49632	0.22794	-0.06813	-0.03053
1.23	-0.29954	0.23810	0.50146	0.21628	-0.07950	-0.02072
1.08	-0.37157	0.17126	0.49128	0.18939	-0.08915	-0.00088
0.92	-0.45910	0.08091	0.46170	0.14917	-0.08613	-0.01811
0.77	-0.56503	-0.01704	0.41855	0.08196	-0.06573	0.03662
0.62	-0.68565	-0.11893	0.36848	0.03099	-0.03635	0.02967
0.46	-0.83115	-0.14082	0.26173	-0.02241	0.00624	-0.00033
0.31	-0.99026	-0.07532	0.12250	-0.00781	0.00436	0.00025
0.15	-1.07854	-0.03928	0.02371	0.00184	-0.00076	0.00129
0.0	-1.13591	-0.00000	0.00005	-0.00000	0.00200	-0.00000

TABLE 24

30.00 DEGREE CCNE
1/4 POWER GRADIENT 12/18/67

HARMONIC NO.

S	0	1	2	3	4	5
2.46	-0.18387	0.16276	C.27039	0.19219	0.12457	-0.00265
2.31	-0.20829	0.19290	C.20871	C.19699	0.08960	-0.01588
2.15	-0.23438	0.17965	C.23312	C.20111	0.05508	-0.04054
2.00	-0.25572	0.19572	C.26463	C.19347	0.02710	-0.04809
1.85	-0.25889	0.24439	C.32185	0.19624	0.00554	-0.04823
1.69	-0.25579	0.29530	C.39351	0.20112	-0.02056	-0.04209
1.54	-0.25683	0.32197	C.45131	C.20467	-0.04008	-0.03311
1.38	-0.27868	0.31581	C.49064	0.19970	-0.05562	-0.02366
1.23	-0.31923	C.27052	C.50930	0.18534	-0.06604	-0.00751
1.08	-0.39388	0.19785	C.50432	0.15637	-0.07405	0.01323
0.92	-0.48646	C.10966	C.48014	0.11611	-0.06915	0.03303
0.77	-0.59877	C.00920	C.43342	0.06250	-0.05222	0.03116
0.62	-0.73209	-0.07412	C.37531	C.00325	-0.01233	0.01908
0.46	-0.89298	-0.08090	C.24331	-C.02003	0.01047	-0.00184
0.31	-1.04423	-0.04337	C.11080	-0.00645	0.00206	0.00100
0.15	-1.12726	-0.02321	C.02061	0.00082	0.00398	0.00198
0.0	-1.17796	-0.00000	C.00142	-0.00000	0.00380	-0.00000

TABLE 25

LIFT AND DRAG COEFFICIENTS DETERMINED FROM
INTEGRATION OF THE PRESSURE DISTRIBUTION COEFFICIENTS

Model and Test	C_L	C_D
15° Sphere-Cone - Uniform Flow	0.742	0.490
30° Sphere-Cone - Uniform Flow	0.667	0.549
15° Sphere-Cone - 1/6 Power Flow	0.569	0.294
30° Sphere-Cone - 1/6 Power Flow	0.540	0.361
15° Sphere-Cone - 1/4 Power Flow	0.508	0.245
30° Sphere-Cone - 1/4 Power Flow	0.499	0.319

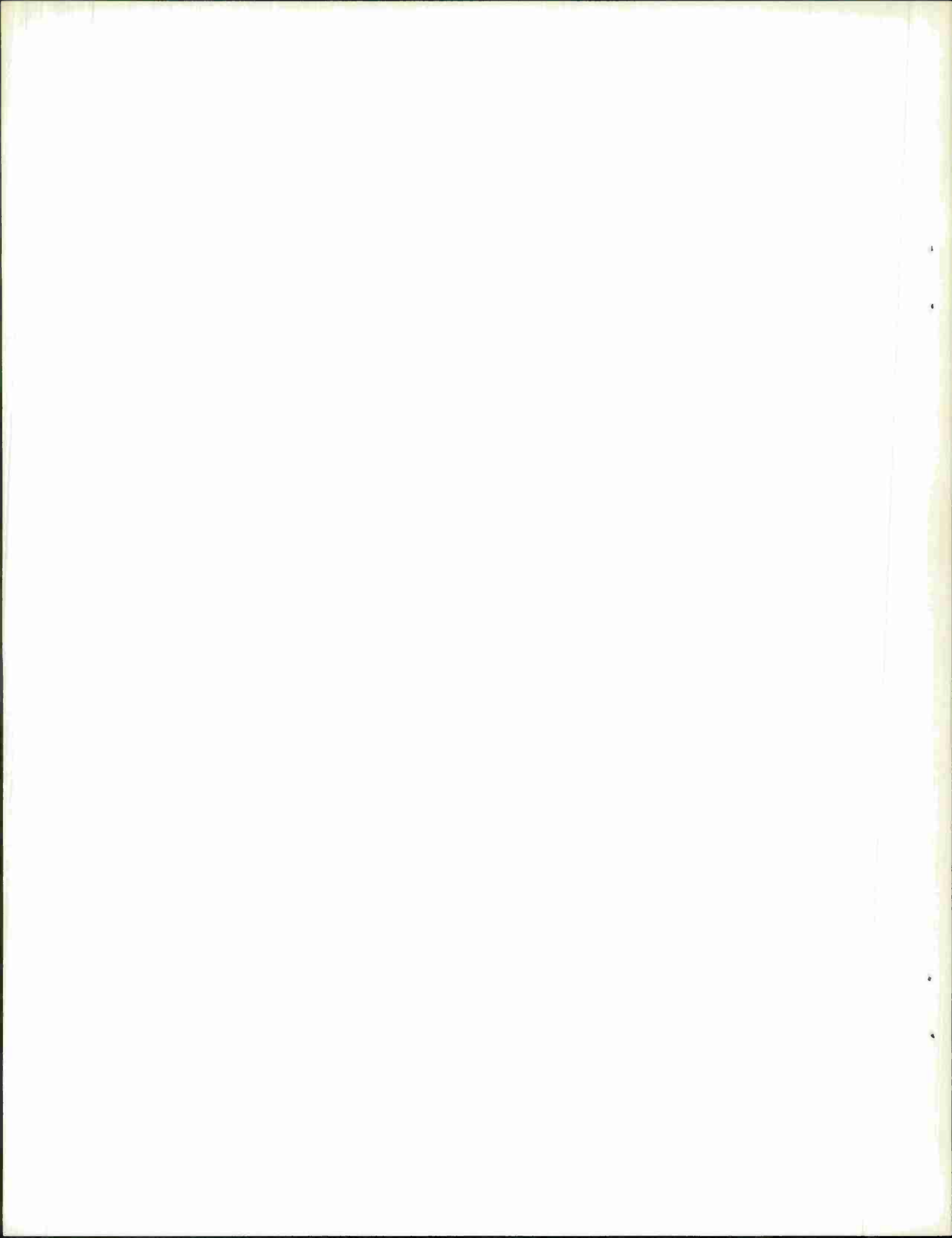
ACKNOWLEDGMENTS

The wind tunnel tests described in this report were carried out by Prof. J. Bicknell and Mr. S. D. Lewis of the M. I. T. Department of Aeronautics and Astronautics in support of the NEROC Study Program supported by the National Science Foundation (Grant GP-5832) and the participating institutions.

The authors are grateful for the suggestions by Prof. Bicknell and Mr. Lewis regarding the data reduction.

The gradient flow fence used in these tests was suggested by Mr. C. Scruton of the National Physical Laboratory, Teddington, England.

DOCUMENT CONTROL DATA - R&D		
<i>(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)</i>		
1. ORIGINATING ACTIVITY (Corporate author) Lincoln Laboratory, M.I.T.		2a. REPORT SECURITY CLASSIFICATION Unclassified
		2b. GROUP None
3. REPORT TITLE Pressure Distributions on Sphere-Cone Radomes in Uniform and Gradient Flows		
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Technical Note		
5. AUTHOR(S) (Last name, first name, initial) D'Amato, Richard Fanning, William R.		
6. REPORT DATE 2 May 1968	7a. TOTAL NO. OF PAGES 46	7b. NO. OF REFS None
8a. CONTRACT OR GRANT NO. AF 19(628)-5167	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Note 1968-17	
b. PROJECT NO. 649L	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) ESD-TR-68-84	
c.		
d.		
10. AVAILABILITY/LIMITATION NOTICES This document has been approved for public release and sale; its distribution is unlimited.		
11. SUPPLEMENTARY NOTES None	12. SPONSORING MILITARY ACTIVITY Air Force Systems Command, USAF	
13. ABSTRACT A series of wind tunnel tests on two radome models, composed of truncated spheres on conical bases, in both a uniform and two power law gradient flow conditions are described in this report. The data from these tests is presented in the form of actual pressure coefficients and as Fourier coefficients which have been best-fitted to the experimental data. Comparisons are presented to show the manner in which these pressure distributions vary from each other for the differing model and flow conditions.		
14. KEY WORDS sphere-cone radomes wind tunnel tests pressure distributions lift and drag coefficients		



Printed by
United States Air Force
L. G. Hanscom Field
Bedford, Massachusetts

