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NACA

RESEARCH MEMORANDUM

for the

Air Materiel Command, Army Air Forces

PRELIMINARY RESULTS OF AN ALTITUDE-WIND-TUNNEL INVESTIGATION OF A TG-100A GAS TURBINE-PROPELLER ENGINE

II - WINDMILLING CHARACTERISTICS

By E. W. Conrad and J. D. Durham

Flight Propulsion Research Laboratory
Cleveland, Ohio

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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SUMMARY

An investigation has been conducted in the Cleveland altitude wind tunnel to determine the operational and performance characteristics of the TG-100A gas turbine-propeller engine. As a part of the investigation, windmilling characteristics were determined for a range of altitudes from 5000 to 35,000 feet, true airspeeds from 100 to 273 miles per hour, and propeller-blade angles from 4° to 46°.

The desirability of feathering the propeller of an inoperative engine was indicated by the high windmilling speeds and high drag values otherwise obtained. Extrapolation of the data showed that excessive windmilling speeds would be reached for propeller-blade angles from 5° to 41° at a true airspeed of 500 miles per hour. At an altitude of 35,000 feet, a true airspeed of 273 miles per hour, and a propeller-blade angle of 38°, the drag horsepower of the test installation was 585. When the propeller-blade angle was decreased to 6°, with a true airspeed in the tunnel of 255 miles per hour, the drag horsepower of the installation increased to 2647. For all conditions, maximum engine windmilling speed was obtained at propeller-blade angles between 10° and 16°. The application of generalizing factors to engine windmilling speed, air flow, and combustion-chamber pressure drop gave good results.

INTRODUCTION

At the request of the Air Materiel Command, Army Air Forces, an investigation has been conducted in the Cleveland altitude wind tunnel to determine the operational and performance characteristics of the TG-100A gas turbine-propeller engine. The performance characteristics are presented in reference 1.

As a part of the investigation, the windmilling characteristics were obtained for a range of altitudes from 5000 to 35,000 feet, true airspeeds from 100 to 273 miles per hour, and propeller-blade angles from 4° to 46°. The windmilling speed, the air flow, and the drag are presented for the range of simulated flight conditions investigated. Over-all pressure distributions through the engine and pressure surveys at each of the measuring stations are shown for the maximum windmilling speed at each simulated flight condition. A complete tabulation of the data is presented. No correction has been made for the tunnel blocking effects of the propeller.

INSTALLATION AND TEST PROCEDURE

Components of the TG-100A gas turbine-propeller engine include a 14-stage axial-flow compressor, nine cylindrical counterflow combustion chambers, and a single-stage turbine. Power is transmitted to the propeller by two stages of planetary gears having an over-all reduction ratio of 11.3513 to 1. A four-blade superhydromatic propeller (hub design 4260) 12 feet, 7 inches in diameter was used. Automatic and manual propeller controls and a blade-angle indicator were provided for this investigation. The blade-form curves for this propeller are shown in figure 1.

The engine was mounted in a specially designed wing nacelle installed in the 20-foot-diameter test section of the altitude wind tunnel (fig. 2.) Air was supplied to the engine by two ducts having openings in the leading edge of the wing, as shown in figure 3. Temperature and pressure measurements were obtained at eight stations along the path of air flow through the installation. A more complete description of the engine and test installation is given in reference 1.

Each series of conditions was obtained by varying the propeller-blade angle and maintaining constant altitude and true airspeed. The investigation was conducted at approximately NACA standard altitude conditions.

SYMBOLS

The following symbols are used in the calculations:

A cross-sectional area, square feet

D/q_0	windmilling drag coefficient, $\frac{\text{total drag of installation - streamline drag}}{\text{free-stream dynamic pressure}}$, square feet
D_t	total drag of installation, pounds
g	acceleration due to gravity, feet per second per second
H	enthalpy, Btu per pound
J	mechanical equivalent of heat, foot-pounds per Btu
N	engine speed, rpm
P	total pressure, pounds per square foot absolute
p	static pressure, pounds per square foot absolute
q_0	free-stream dynamic pressure, pounds per square foot
R	gas constant
shp	shaft horsepower (excluding friction horsepower and gear losses)
T_i	indicated temperature, °R
t	static temperature, °R
V_0	tunnel airspeed, feet per second
W_a	air flow, pounds per second
β	propeller-blade angle at 72-inch radius, degrees
γ	ratio of specific heats for air
δ	ratio of tunnel-test-section static pressure to pressure of NACA standard atmosphere at sea level
θ	ratio of tunnel-test-section absolute static temperature to absolute temperature of NACA standard atmosphere at sea level

Subscripts:

0	tunnel test section free air stream
1	wing-duct inlet

2	compressor inlet
3	compressor outlet
4	compressor-outlet elbow
5	turbine inlet
6	turbine outlet
7	exhaust-cone outlet
8	tail-pipe-nozzle outlet

The following parameters are generalized to NACA standard sea-level conditions:

$N/\sqrt{\theta}$	corrected engine speed, rpm
$(W_a \sqrt{\theta})/\delta$	corrected air flow, pounds per second
$(\Delta P)/\delta$	corrected total-pressure drop across combustion chambers, pounds per square foot

CALCULATIONS

The shaft horsepower delivered to the engine under windmilling conditions, excluding friction horsepower and gear losses, is approximated by the change in energy of the air flowing through the engine

$$shp = \frac{J}{550} W_{a,2} (H_8 - H_2) \tag{1}$$

where $W_{a,2}$ was obtained from the equation

$$W_{a,2} = A_2 P_2 \sqrt{\frac{2\gamma g}{(\gamma-1) R} \left[\frac{\left(\frac{P_2}{p_2}\right)^{\frac{\gamma-1}{\gamma}} - 1}{t_2} \right]} \tag{2}$$

The static temperature is given by the equation

$$t_2 = \frac{T_{1,2}}{0.85\left[\left(\frac{P_2}{p_2}\right)^{\frac{\gamma-1}{\gamma}} - 1\right] + 1}$$

The constant of 0.85 in equation (3) is the thermocouple impact recovery factor, which was experimentally determined. Air flows measured at the compressor inlet were used in the calculations because they were more consistent than measurements at the wing-duct inlets or the tail-pipe survey rake. Values of enthalpy used in equation (1) were obtained from reference 2.

RESULTS AND DISCUSSION

A complete tabulation of the windmilling data is presented in table I. Windmilling performance characteristics are presented in figures 4 to 12 and pressure surveys throughout the installation are shown in figures 13 to 19. No correction has been made for tunnel blocking effects. These effects are believed to be negligible at high propeller-blade angles, but data obtained at low blade angles may be affected.

Windmilling performance characteristics. - Engine windmilling speeds obtained at several airspeeds and altitudes are shown in figure 4 as a function of propeller-blade angle. A maximum windmilling speed of 13,100 rpm was obtained at an altitude of 35,000 feet, a true airspeed of 269 miles per hour, and a propeller-blade angle of 16° (fig. 4 (d)). For all simulated flight conditions, the maximum windmilling speeds were obtained at propeller-blade angles from 10° to 16°. The data in figure 4 were cross-plotted and extrapolated to determine the true airspeed at which the rated engine speed of 13,000 rpm would be obtained for any propeller-blade angle in the operating range of 4° to 46° (fig. 5). At a true airspeed of 500 miles per hour, the rated engine speed would be exceeded for all blade angles from about 5° to 41°. The desirability of feathering is evident.

Windmilling shaft horsepowers, as determined from the enthalpy rise of the air between the compressor inlet and the tail-pipe-nozzle outlet, are shown in figures 6 and 7 as functions of engine windmilling speed and propeller-blade angle, respectively. Gear losses, which vary from 20 horsepower at 4000 rpm to 100 horsepower at

13,000 rpm, are not included in the shaft horsepowers given. The different values of windmilling shaft horsepower at a given engine speed in figure 6 are the result of reduced engine air flow caused by high pressure losses across the propeller disk at low blade angles.

Maximum windmilling shaft horsepowers occurred in a range of propeller-blade angles from 10° to 16°. A value of 612 shaft horsepower was obtained at an altitude of 15,000 feet, a true airspeed of 209 miles per hour, and a propeller-blade angle of 12° (fig. 7(b)).

Air flow through the engine is given as a function of engine windmilling speed in figure 8. A plot of the same data in generalized form in figure 9 shows that the use of generalizing factors gives good results. Air flows obtained at windmilling conditions and at operating conditions are very nearly the same.

The corrected total-pressure drop across the combustion chambers as a function of corrected engine speed is shown in figure 10. These data also generalized very well.

The variation of windmilling-drag coefficient with propeller-blade angle is shown in figures 11 and 12 for various altitudes and airspeeds, respectively. Maximum values occurred at a blade angle of about 8°. For blade angles less than 12°, the windmilling-drag coefficients decreased with increasing altitude (fig. 11). The effect of change in airspeed was relatively small (fig. 12). At an altitude of 35,000 feet, a true airspeed of 273 miles per hour, and a propeller-blade angle of 38°, the windmilling-drag horsepower of the installation $\frac{D_t V_0}{550}$ was 585. When the blade angle was decreased to 6° with a true airspeed in the tunnel of only 255 miles per hour, the drag horsepower increased to 2647.

Pressure distribution. - Average total and static pressures throughout the engine are shown in figure 13 for a range of altitudes from 5000 to 35,000 feet. The data are shown for a propeller-blade angle of 12°, at which engine speeds near the maximum occurred for all flight conditions. The pressure distribution may be somewhat affected by variations in blade angle owing to differences in the blocking effect of the propeller. Engine windmilling speeds varied from 4100 to 13,000 rpm. Under all conditions, pressure drop occurred across the last few stages of the compressor. The number of compressor stages through which the pressure dropped decreased with increasing engine speed. Increases in total pressure indicated between stations 6 and 7 are attributed to misalinment of the air flow with respect to the instrumentation at the turbine outlet.

Detailed surveys at the measuring stations are shown in figures 14 to 19 for altitudes from 5000 to 35,000 feet and true airspeeds from 102 to 269 miles per hour. Data obtained at 5000 feet are presented for a propeller-blade angle of 10° and the data at other altitudes for a propeller-blade angle of 12°. These data represent engine windmilling speeds varying from 4100 to 13,000 rpm. Separation of the air flow on the inner side of the left-duct upper lip in figure 14 is indicated by the low total pressures at the top of rakes 1 to 4. Under power-on conditions this separation occurred at the right duct inlet. Separation in both cases was the result of misalinement of the duct upper lip with respect to the approaching streamlines. This misalinement was apparently caused by the rotational component of velocity imparted to the airstream in passing through the propeller disk. Separation occurred under windmilling conditions for propeller-blade angles between 4° and 20°. Large circumferential velocity gradients existed at the compressor outlet, with variations in impact pressure around the compressor outlet amounting to approximately 150 pounds per square foot. Inasmuch as the pressures measured at the turbine outlet in the windmilling investigation were unreliable, pressure surveys are not shown for that station. The average values, however, are included in table I.

A total-pressure distribution in the vertical plane at the tail-pipe-nozzle outlet was very uniform at low windmilling speeds, but at high speeds variations of 3 percent in the absolute values were found (fig. 19). At high engine speeds, somewhat higher total pressures were measured across the lower portion of the tail pipe.

SUMMARY OF RESULTS

An investigation of the windmilling characteristics of the TG-100A gas turbine-propeller engine was conducted in the Cleveland altitude wind tunnel for a range of altitudes from 5000 to 35,000 feet, true airspeeds from 100 to 273 miles per hour, and propeller-blade angles from 4° to 46°. The following results were obtained:

1. A windmilling speed of 13,000 rpm was obtained at an altitude of 35,000 feet, a true airspeed of 267 miles per hour, and a propeller-blade angle of 16°. Excessive engine speeds would be obtained under windmilling conditions for propeller-blade angles from about 5° to 41° at a true airspeed of 500 miles per hour.

2. The very high drag values obtained under windmilling conditions made the feathering of the propeller of an inoperative engine desirable. At an altitude of 35,000 feet, a true airspeed of 273 miles per hour,

and a propeller-blade angle of 38°, the drag horsepower of the test installation was 585. When the propeller-blade angle was decreased to 6°, with a true airspeed in the tunnel of 255 miles per hour, the drag horsepower of the installation increased to 2645.

3. For all conditions, maximum engine windmilling speed was obtained at propeller-blade angles between 10° and 16°.

4. Application of generalizing factors to engine windmilling speed, air flow, and combustion-chamber total-pressure drop gave good results.

5. The maximum windmilling shaft horsepower obtained (not including gear losses) was 612. This power was absorbed at an altitude of 15,000 feet, a true airspeed of 209 miles per hour, and a propeller-blade angle of 12°.

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REFERENCES

1. Saari, Martin J., and Wallner, Lewis E.: Preliminary Results of an Altitude-Wind-Tunnel Investigation of a TG-100 Gas Turbine-Propeller Engine. I - Performance Characteristics. NACA RM No. E7F10a, 1947.

2. Keenan, Joseph H., and Kaye, Joseph: Thermodynamic Properties of Air. John Wiley and Sons, Inc., 1945, pp. 3-33.

INDEX OF FIGURES

Figure 12. - Variation of windmilling-drag coefficient with propeller-blade angle for various true airspeeds.
Altitude, 15,000 feet.

Figure 13. - Variation of average total and static pressures through engine. Propeller-blade angle, 12°.
(a) Altitude, 5000 feet.
(b) Altitude, 15,000 feet.
(c) Altitude, 25,000 feet.
(d) Altitude, 35,000 feet.

Figure 14. - Distribution of total and static pressure at wing-duct inlet.
(a) Altitude, 5000 feet; propeller-blade angle, 10°.
(b) Altitude, 15,000 feet; propeller-blade angle, 12°.
(c) Altitude, 25,000 feet; propeller-blade angle, 12°.
(d) Altitude, 35,000 feet; propeller-blade angle, 12°.

Figure 15. - Distribution of total and static pressures at compressor inlet.
(a) Altitude, 5000 feet; propeller-blade angle, 10°.
(b) Altitude, 15,000 feet; propeller-blade angle, 12°.
(c) Altitude, 25,000 feet; propeller-blade angle, 12°.
(d) Altitude, 35,000 feet; propeller-blade angle, 12°.

Figure 16. - Distribution of total and static pressure at compressor outlet.
(a) Altitude, 5000 feet.
(b) Altitude, 15,000 feet.
(c) Altitude, 25,000 feet.
(d) Altitude, 35,000 feet.

Figure 17. - Distribution of total and static pressures at turbine-nozzle inlet.
(a) Altitude, 5000 feet.
(b) Altitude, 15,000 feet.
(c) Altitude, 25,000 feet.
(d) Altitude, 35,000 feet.

Figure 18. - Distribution of total and static pressures behind exhaust-cone outlet.
(a) Altitude, 5000 feet.
(b) Altitude, 15,000 feet.
(c) Altitude, 25,000 feet.
(d) Altitude, 35,000 feet.

Figure 19. - Distribution of total and static pressures at tail-pipe-nozzle outlet.
(a) Altitude, 5000 feet.
(b) Altitude, 15,000 feet.
(c) Altitude, 25,000 feet.
(d) Altitude, 35,000 feet.

TABLE I.- WINDMILLING DATA FOR

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	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
													Left duct inlet			Right duct inlet		
Run	Altitude (ft)	Tunnel static pressure, p_0 (lb/sq ft)	Tunnel indicated temperature, T_1 (°R)	Tunnel airspeed, V_0 (ft/sec)	Free-stream impact pressure, q_0 (lb/sq ft)	Blade angle, β (deg)	Engine windmilling speed, N (rpm)	Corrected windmilling speed, $N/\sqrt{\theta}$ (rpm)	Windmilling shaft horsepower	Air flow, $W_{a,2}$ (lb/sec)	Corrected air flow, $(W_{a,2}\sqrt{\theta})/\delta$ (lb/sec)	Windmilling drag coefficient, D/q_0 (sq ft)	Total pressure, P_1 (lb/sq ft abs.)	Static pressure, p_1 (lb/sq ft abs.)	Indicated temperature, $T_{i,1}$ (°R)	Total pressure, P_1 (lb/sq ft abs.)	Static pressure, p_1 (lb/sq ft abs.)	Indicated temperature, $T_{i,1}$ (°R)
1	5,000	1760	493	148	23	4	2,450	2,519	19.06	1.84	2.15	40.4	1771	1770	489	1776	1774	489
2	5,000	1760	493	148	22	6	4,050	4,163	46.10	3.20	3.74	58.9	1767	1764	490	1773	1770	490
3	5,000	1760	495	148	23	8	5,400	5,540	92.90	4.35	5.10	57.5	1765	1758	490	1772	1767	490
4	5,000	1760	496	148	23	10	5,600	5,740	120.3	5.07	5.95	48.7	1767	1760	490	1773	1768	490
5	5,000	1760	494	148	23	12	5,450	5,597	120.3	5.08	5.95	38.7	1772	1766	491	1776	1771	491
6	5,000	1760	497	148	23	16	5,100	5,222	99.1	4.37	5.13	28.3	1776	1770	491	1778	1774	491
7	5,000	1760	497	148	22	20	4,600	4,710	89.0	4.40	5.16	20.7	1779	1774	491	1780	1776	491
8	5,000	1760	495	148	22	24	4,200	4,309	67.1	4.00	4.69	14.9	1780	1776	492	1781	1778	492
9	5,000	1760	497	148	22	28	3,700	3,789	50.5	3.19	3.74	10.8	1781	1778	492	1781	1779	492
10	5,000	1760	497	148	22	32	3,350	3,430	46.1	3.20	3.76	8.09	1781	1779	492	1782	1780	492
11	5,000	1760	498	225	52	32	5,100	5,228	99.1	4.81	5.64	5.81	1809	1802	496	1810	1804	496
12	5,000	1760	501	221	51	28	5,700	5,825	134.8	5.45	6.41	11.0	1808	1799	498	1809	1802	498
13	5,000	1760	501	225	52	24	6,450	6,592	——	6.21	7.30	15.2	1808	1798	500	1808	1800	500
14	5,000	1760	502	221	51	20	7,100	7,249	252.0	6.93	8.16	21.6	1803	1790	501	1804	1794	501
15	5,000	1760	503	226	52	16	7,750	7,905	——	5.85	6.89	29.4	1798	1783	503	1801	1788	502
16	5,000	1760	509	223	51	12	8,200	8,315	——	——	——	40.4	1786	1769	509	1794	1780	509
17	5,000	1760	513	213	45	10	7,800	7,878	361.5	7.57	9.01	48.6	1774	1759	511	1785	1773	510
18	5,000	1760	513	195	39	8	7,000	7,063	278.5	6.53	7.78	59.6	1769	1757	512	1780	1770	512
19	5,000	1760	515	205	42	6	5,450	5,488	134.3	4.65	5.55	57.7	1775	1767	515	1785	1778	515
20	5,000	1760	513	220	49	4	4,200	4,242	86.1	3.48	4.14	45.9	1785	1778	512	1792	1788	512
21	15,000	1190	464	160	19	4	3,050	3,233	31.9	1.79	3.00	45.7	1198	1197	472	1202	1201	472
22	15,000	1190	479	157	18	6	4,200	4,381	33.4	2.17	3.70	55.9	1196	1193	482	1200	1198	482
23	15,000	1197	467	155	19	8	5,400	5,702	67.0	3.27	5.47	55.7	1202	1197	475	1207	1203	478
24	15,000	1190	461	154	18	10	5,800	6,165	93.7	3.51	5.87	49.0	1196	1191	468	1201	1197	469
25	15,000	1197	462	154	18	12	5,700	6,053	93.1	3.53	5.88	40.6	1206	1201	468	1210	1206	470
26	15,000	1190	464	155	18	16	5,350	5,671	96.6	3.03	5.08	29.6	1203	1198	469	1205	1201	469
27	15,000	1190	463	154	18	20	4,850	5,146	63.7	3.05	5.11	18.8	1205	1201	465	1206	1203	465
28	15,000	1190	462	154	18	24	4,400	4,673	48.9	2.45	4.10	15.0	1206	1203	465	1207	1204	465
29	15,000	1190	463	154	18	28	3,950	4,191	38.8	2.21	3.70	10.7	1206	1204	465	1207	1205	465
30	15,000	1190	463	154	18	32	3,500	3,714	26.7	1.81	3.30	8.2	1207	1205	466	1208	1205	466
31	15,000	1190	465	227	39	32	5,200	5,517	68.8	3.35	5.61	7.9	1226	1222	469	1227	1223	469
32	15,000	1190	465	231	40	28	5,900	6,260	104.3	4.35	7.29	10.9	1226	1219	469	1227	1222	469
33	15,000	1190	465	227	39	24	6,600	7,003	123.9	4.51	7.56	16.0	1225	1217	468	1226	1219	468
34	15,000	1190	465	227	39	20	7,200	7,640	175.2	5.11	8.56	22.3	1222	1212	468	1224	1216	468
35	15,000	1190	464	230	40	16	7,900	8,390	234.5	5.89	9.86	30.0	1217	1205	467	1221	1211	467
36	15,000	1190	464	227	39	12	8,200	8,708	276.2	6.24	10.45	40.7	1209	1196	467	1216	1206	467
37	15,000	1190	465	227	39	10	8,200	8,700	279.6	6.22	10.42	49.5	1204	1190	466	1213	1202	467
38	15,000	1197	465	227	40	8	7,500	7,958	221.4	5.38	8.96	56.2	1208	1197	468	1219	1209	469
39	15,000	1197	466	234	42	6	6,000	6,366	122.9	4.12	6.87	53.5	1212	1205	470	1221	1214	470
40	15,000	1190	465	231	40	4	4,000	4,244	57.4	2.47	4.14	41.9	1210	1206	470	1216	1212	470
41	15,000	1197	466	279	60	4	4,700	4,991	60.6	3.10	5.16	41.1	1230	1224	470	1235	1231	470
42	15,000	1190	465	279	59	6	6,900	7,335	142.5	4.83	8.08	51.5	1216	1205	471	1226	1218	472
43	15,000	1190	466	284	62	8	9,000	9,567	330.0	7.24	12.11	52.1	1211	1191	472	1224	1208	473
44	15,000	1190	467	300	69	10	10,400	11,045	527.5	9.00	15.07	44.5	1218	1190	472	1230	1207	474
45	15,000	1190	467	307	72	12	10,600	11,268	613.5	9.61	16.07	37.8	1227	1197	468	1235	1211	472
46	15,000	1190	466	279	60	16	9,500	10,089	463.5	7.95	13.31	30.1	1233	1211	468	1235	1217	468
47	15,000	1197	466	290	65	20	9,200	9.780	432.5	7.88	13.11	21.8	1252	1231	470	1251	1235	470
48	15,000	1190	467	297	68	24	8,600	9,133	——	7.02	11.75	16.0	1250	1233	471	1250	1235	471
49	15,000	1190	468	302	70	28	7,900	8,390	——	——	——	11.5	1256	1242	473	1257	1245	473
50	15,000	1197	468	302	71	28	7,950	8,443	272.3	6.36	10.59	11.4	1263	1249	472	1263	1251	472
51	15,000	——	468	——	—	32	7,150	——	——	——	——	——	——	——	474	——	——	474
52	25,000	781	432	183	18	4	3,150	3,465	28.2	1.51	3.72	41.2	789	788	439	792	791	439
53	25,000	781	434	184	18	6	4,300	4,717	33.8	1.88	4.64	48.4	788	786	439	792	790	439
54	25,000	788	435	172	16	8	5,400	5,913	——	.86	2.11	55.1	793	789	438	797	794	440
55	25,000	781	452	187	18	10	6,400	6,880	79.6	2.94	7.41	45.3	787	782	459	791	787	459
56	25,000	781	434	179	17	12	6,400	7,021	90.8	3.13	7.73	40.6	789	784	440	792	789	440
57	25,000	788	434	179	17	16	6,100	6,692	79.8	2.77	6.78	31.5	798	794	441	801	797	442
58	25,000	——	434	——	—	20	5,600	——	——	——	——	——	——	——	——	——	——	——
59	25,000	——	434	——	—	24	4,950	——	——	——	——	——	——	——	——	——	——	——
60	25,000	781	434	179	17	28	4,600	5,046	39.8	1.87	4.62	11.9	797	794	440	797	795	441
61	25,000	——	436	——	—	32	4,080	——	——	——	——	——	——	——	443	——	——	443
62	25,000	——	436	——	—	38	3,300	——	——	——	——	——	——	——	——	——	——	——
63	25,000	788	442	181	17	41.4	3,000	3,261	11.0	1.24	3.06	4.3	804	802	448	804	803	449
64	25,000	781	433	241	31	4	4,200	4,624	51.3	1.66	4.06	41.9	796	794	442	801	799	443

TG-100 GAS TURBINE-PROPELLER ENGINE

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
Compressor inlet			Compressor outlet			Compressor-outlet elbow			Turbine inlet		Turbine outlet			Exhaust-cone outlet			Tail-pipe-nozzle outlet		
Total pressure, P_2 (lb/sq ft abs.)	Static pressure, p_2 (lb/sq ft abs.)	Indicated temperature, $T_{i,2}$ (°R)	Total pressure, P_3 (lb/sq ft abs.)	Static pressure, p_3 (lb/sq ft abs.)	Indicated temperature, $T_{i,3}$ (°R)	Total pressure, P_4 (lb/sq ft abs.)	Static pressure, p_4 (lb/sq ft abs.)	Indicated temperature, $T_{i,4}$ (°R)	Total pressure, P_5 (lb/sq ft abs.)	Static pressure, p_5 (lb/sq ft abs.)	Total pressure, P_6 (lb/sq ft abs.)	Static pressure, p_6 (lb/sq ft abs.)	Indicated temperature, $T_{i,6}$ (°R)	Total pressure, P_7 (lb/sq ft abs.)	Static pressure, p_7 (lb/sq ft abs.)	Indicated temperature, $T_{i,7}$ (°R)	Total pressure, P_8 (lb/sq ft abs.)	Static pressure, p_8 (lb/sq ft abs.)	Indicated temperature, $T_{i,8}$ (°R)
1773	1772	490	1826	1817	504	1823	1820	505	1817	1808	1740	1760	513	1760	1760	520	1760	1759	517
1769	1763	490	1926	1894	519	1922	1912	515	1895	1894	1707	1758	530	1760	1760	532	1760	1757	530
1764	1763	490	2066	2011	537	2053	2035	537	2017	2006	1676	1762	550	1764	1760	552	1763	1758	553
1766	1752	491	2112	2056	544	2098	2084	543	2059	2043	1672	1765	558	1764	1760	560	1765	1759	562
1769	1755	492	2107	2043	542	2081	2063	542	2042	2029	1676	1766	558	1764	1760	561	1765	1760	560
1772	1761	493	2042	1997	537	2029	2017	535	1999	1988	1687	1765	551	1764	1760	559	1765	1761	559
1775	1765	492	1993	1959	530	1983	1975	530	1957	1950	1699	1763	544	1762	1763	551	1765	1762	550
1777	1769	493	1950	1923	525	1943	1933	524	1927	1914	1709	1763	539	1764	1763	542	1765	1762	542
1778	1773	494	1914	1892	520	1908	1901	519	1893	1886	1719	1763	532	1762	1763	540	1765	1762	538
1779	1774	494	1884	1868	515	1882	1880	515	1866	1862	1727	1762	530	1762	1760	536	1764	1763	530
1804	1791	496	2057	2008	537	2044	2035	537	2007	1999	1691	1770	551	1765	1763	556	1770	1766	558
1801	1785	498	2133	2069	551	2117	2102	550	2077	2062	----	1773	566	1769	1763	570	1772	1766	571
1799	1778	500	2266	2175	569	2237	2222	568	2182	2164	----	1777	582	1771	1763	539	1774	1765	590
1792	1766	501	2360	2281	585	2357	2330	585	2092	2070	----	1782	600	1771	1763	606	1774	1764	608
1785	1766	502	2545	2414	602	2503	2475	604	2429	2397	----	1790	617	1790	1798	622	1774	1762	625
1775	----	509	2651	2505	620	2607	2574	622	2519	2491	----	----	633	1792	1830	642	----	1759	644
1768	1735	510	2536	2414	616	2497	2475	617	2423	2395	----	1787	631	1774	1757	649	1771	1757	648
1767	1743	512	2350	2252	600	2318	2302	599	2256	2238	1689	1772	618	1765	1757	636	1765	1755	630
1777	1765	515	2074	2016	568	2061	2049	567	2023	2013	1675	1761	584	1758	1757	599	1761	1755	593
1787	1779	513	1958	1924	550	1948	1943	548	1928	1919	1704	1759	565	1760	1757	585	1761	1757	580
1200	1198	478	1264	1258	503	1264	1264	503	1257	1253	1169	1199	520	1190	1190	530	1190	1188	521
1197	1193	485	1318	1296	515	1316	1310	514	1295	1290	1151	1189	530	1190	1190	530	1189	1188	530
1202	1194	480	1413	1373	526	1406	1398	524	1377	1372	1140	1200		1197	1197	540	1198	1195	540
1195	1185	472	1462	1417	529	1449	1436	527	1418	1405	1125	1199	542	1192	1190	550	1194	1189	550
1204	1194	472	1462	1417	529	1444	1440	526	1421	1409	1135	1204	541	1199	1197	549	1201	1197	550
1199	1192	472	1420	1384	524	1412	1405	521	1384	1376	1136	1197	----	1194	1190	565	1195	1191	560
1202	1195	469	1377	1349	510	1371	1363	509	1349	1345	1143	1195	528	1194	1190	530	1194	1191	527
1203	1198	469	1341	1321	502	1338	1331	501	1317	1314	1152	1194	520	1194	1194	526	1194	1192	520
1204	1200	470	1313	1298	498	1310	1307	470	1296	1289	1160	1194	513	1195	1194	520	1193	1192	511
1205	1202	469	1291	1277	494	1293	1289	494	1275	1274	1168	1192	510	1194	1194	512	1193	1192	510
1223	1214	470	1418	1383	514	1408	1401	514	1381	1373	1140	1199	530	1195	1194	530	1197	1195	529
1223	1209	470	1486	1432	526	1476	1461	524	1437	1428	1125	1201	540	1195	1194	540	1198	1194	540
1218	1202	470	1583	1510	468	1567	1549	540	1524	1514	1112	1206	551	1197	1194	550	1200	1193	556
1213	1193	469	1696	1609	555	1673	1655	557	1619	1602	1097	1211	566	1206	1201	569	1201	1193	570
1208	1181	469	1822	1717	572	1792	1767	574	1725	1707	1085	1216	581	1202	1190	585	1202	1191	590
1201	1171	469	1889	1774	582	1854	1831	585	1787	1763	1080	1220	590	1202	1190	598	1201	1189	600
1197	1167	469	1895	1777	584	1857	1831	586	1788	1761	1078	1219	592	1204	1187	600	1199	1187	602
1206	1183	470	1738	1653	569	1713	1694	569	1661	1639	1094	1214	580	1202	1194	590	1202	1193	590
1214	1201	473	1498	1445	537	1486	1472	536	1453	1440	1124	1200	552	1197	1194	560	1197	1193	560
1212	1207	472	1320	1298	507	1317	1310	508	1302	1296	1154	1190	527	1190	1187	540	1190	1188	530
1231	1224	474	1369	1340	511	1366	1359	509	1342	1338	1150	1197	529	1197	1197	531	1198	1195	530
1216	1198	474	1603	1533	549	1589	1567	551	1542	1525	1098	1199	561	1192	1187	560	1198	1185	569
1204	1162	475	2086	1940	608	2040	2011	610	1954	1926	1136	1232	609	1204	1187	608	1200	1184	615
1199	1132	475	2636	2436	657	2565	2524	663	2453	2415	1130	1291	641	1220	1187	646	1212	1186	650
1201	1125	474	2796	2590	669	2775	2679	675	2604	2559	1160	1310	647	1236	1197	660	1222	1188	660
1212	1162	468	2350	2186	626	2294	2264	630	2197	2162	1159	1262	622	1218	1194	638	1210	1192	639
1232	1184	470	2256	2098	617	2204	2169	620	2110	2078	1163	1260	617	1225	1197	630	1218	1201	630
1235	1197	472	2064	1935	600	2023	1993	603	1940	1916	1123	1236	599	1215	1201	520	1210	1196	618
1244	----	473	1863	1760	580	1833	1806	582	1767	1743	----	----	581	1209	1197	602	----	1198	601
1251	1221	473	1873	1766	578	1843	1817	580	1775	1752	1094	1230	586	1216	1208	598	1215	1205	599
----	1235	474	1715	1632	560	1694	1673	561	1638	1620	1113	1221	570	----	----	582	1213	----	583
791	789	445	834	829	473	837	837	475	830	827	765	780	490	781	781	500	781	780	490
790	786	445	880	867	480	878	873	479	859	858	753	781	496	781	781	498	780	779	491
793	792	445	956	928	494	950	947	494	930	923	749	789	510	788	788	510	789	796	508
786	776	461	1019	976	528	1011	1003	528	981	974	729	786	540	783	781	540	783	780	540
787	776	445	1036	994	514	1025	1020	514	998	988	728	789	527	783	781	530	784	781	529
796	787	446	1007	974	510	1003	992	510	977	967	740	795	524	790	788	530	791	789	524
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
794	790	446	----	----	485	----	----	485	----	----	754	784	501	783	781	508	784	783	500
----	----	448	----	----	480	----	----	479	----	----	----	----	491	----	----	497	----	----	490
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
803	801	454	845	835	471	846	841	472	838	837	776	789	480	790	792	480	790	790	475
798	795	449	874	861	493	875	869	493	859	858	756	782	520	781	781	539	780	780	538

TABLE I.- CONCLUDED. WINDMILLING DATA

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
													Left duct inlet			Right duct inlet		
Run	Altitude (ft)	Tunnel static pressure, P_0 (lb/sq ft)	Tunnel indicated temperature, T_1 (°R)	Tunnel airspeed, V_0 (ft/sec)	Free-stream impact pressure, q_0 (lb/sq ft)	Blade angle, β (deg)	Engine windmilling speed, N (rpm)	Corrected windmilling speed, $N/\sqrt{\theta}$ (rpm)	Windmilling shaft horsepower	Air flow, $W_{a,2}$ (lb/sec)	Corrected air flow, $(W_{a,2}\sqrt{\theta})/\delta$ (lb/sec)	Windmilling drag coefficient, D/q_0 (sq ft)	Total pressure, P_1 (lb/sq ft abs.)	Static pressure, p_1 (lb/sq ft abs.)	Indicated temperature, $T_{i,1}$ (°R)	Total pressure, P_1 (lb/sq ft abs.)	Static pressure, p_1 (lb/sq ft abs.)	Indicated temperature, $T_{i,1}$ (°R)
65	25,000	781	431	234	30	6	6,050	6,679	76.7	2.77	6.80	53.4	793	787	439	799	795	440
66	25,000	781	433	241	31	8	7,600	8,368	140.9	3.95	9.72	52.9	790	781	439	799	791	440
67	25,000	781	441	237	30	10	8,300	9,055	170.4	4.40	10.93	46.5	794	784	445	800	791	446
68	25,000	781	440	237	30	12	8,400	9,173	203.2	4.56	11.31	39.7	796	785	445	802	793	445
69	25,000	781	442	234	29	16	8,100	8,829	176.2	4.21	10.46	32.5	800	791	448	804	797	448
70	25,000	—	440	—	—	20	7,550	—	—	—	—	—	—	—	444	—	—	445
71	25,000	—	439	—	—	24	6,700	—	—	—	—	—	—	—	—	—	—	—
72	25,000	788	440	237	30	28	6,100	6,661	85.5	2.69	6.61	11.2	815	810	445	816	812	445
73	25,000	—	435	—	—	32	5,400	—	—	—	—	—	—	—	—	—	—	—
74	25,000	—	435	—	—	38	4,500	—	—	—	—	—	—	—	—	—	—	—
75	25,000	781	433	241	31	41	4,000	4,404	37.3	1.93	4.75	4.26	810	807	438	810	809	438
76	25,000	774	435	306	50	4	4,600	5,069	36.8	2.07	5.14	38.1	803	800	447	806	803	445
77	25,000	781	438	304	50	6	7,300	8,023	105.7	3.76	9.27	49.3	804	794	444	813	805	445
78	25,000	781	437	304	50	8	9,050	9,955	—	2.75	6.77	52.7	799	784	443	810	798	445
79	25,000	781	436	310	52	10	10,400	11,450	278.5	4.92	12.11	45.1	800	779	442	811	792	444
80	25,000	774	438	307	50	12	10,500	11,540	398.0	6.68	16.62	38.5	802	777	446	807	789	446
81	25,000	781	437	304	50	14	10,400	11,440	401.5	6.70	16.50	34.6	809	787	445	816	798	445
82	25,000	—	435	—	—	16	10,200	—	—	—	—	—	—	—	—	—	—	—
83	25,000	—	434	—	—	20	9,550	—	—	—	—	—	—	—	—	—	—	—
84	25,000	781	434	296	48	24	8,600	9,477	334.4	6.56	16.13	15.6	823	810	440	824	813	440
85	25,000	—	433	—	—	32	7,000	—	—	—	—	—	—	—	—	—	—	—
86	25,000	—	432	—	—	38	5,750	—	—	—	—	—	—	—	—	—	—	—
87	25,000	781	431	302	50	46	4,400	4,875	—	—	—	3.2	829	825	437	829	827	437
98	35,000	500	417	160	9	4	1,700	1,901	—	—	—	—	506	506	423	505	506	418
89	35,000	493	418	152	8	6	3,000	3,350	—	—	—	—	497	496	422	499	499	420
90	35,000	—	417	—	—	8	3,000	—	—	—	—	—	—	—	—	—	—	—
91	35,000	—	416	—	—	10	3,600	—	—	—	—	—	—	—	—	—	—	—
92	35,000	493	415	151	8	12	4,100	4,600	35.2	1.33	5.09	—	497	496	418	499	498	418
93	35,000	500	415	141	7	16	4,400	4,940	34.8	1.35	5.10	—	504	503	418	505	505	416
94	35,000	493	414	151	8	20	4,250	4,770	19.3	.78	2.98	—	498	497	415	499	498	415
95	35,000	—	414	—	—	24	4,000	—	—	—	—	—	—	—	—	—	—	—
96	35,000	493	414	151	18	28	3,650	4,100	21.2	1.08	4.13	—	499	498	417	500	499	415
97	35,000	—	413	—	—	32	3,300	—	—	—	—	—	—	—	—	—	—	—
98	35,000	493	413	151	—	46	2,200	2,470	12.5	.80	3.05	—	500	500	415	500	500	412
99	35,000	493	420	228	18	4	3,050	3,410	—	—	—	35.2	504	504	423	505	504	423
100	35,000	493	420	228	18	6	4,100	4,570	18.2	.80	3.07	38.6	501	500	423	505	503	423
101	35,000	—	420	—	—	8	6,500	—	—	—	—	—	—	—	—	—	—	—
102	35,000	—	419	—	—	10	7,400	—	—	—	—	—	—	—	—	—	—	—
103	35,000	493	419	219	17	12	7,500	8,380	86.1	2.40	9.21	39.7	501	497	420	504	501	421
104	35,000	493	418	234	19	16	7,500	8,420	101.7	2.67	2.88	29.9	503	497	420	507	502	420
105	35,000	493	418	227	18	20	7,000	7,280	145.5	3.95	15.14	23.0	506	501	420	508	504	420
106	35,000	—	418	—	—	24	6,350	—	—	—	—	—	—	—	—	—	—	—
107	35,000	—	417	—	—	32	5,100	—	—	—	—	—	—	—	—	—	—	—
108	35,000	493	416	227	18	46	3,100	3,480	16.5	.81	3.10	3.11	510	509	420	510	510	420
109	35,000	500	433	332	39	4	4,700	5,198	35.6	1.58	6.05	—	522	520	435	523	519	435
110	35,000	493	434	335	39	6	7,500	8,288	89.9	2.36	10.22	—	509	502	434	518	511	434
111	35,000	486	434	333	38	8	9,750	10,774	184.0	3.83	15.09	—	498	486	434	508	498	434
112	35,000	493	434	331	38	10	10,700	11,824	273.4	4.61	17.91	—	507	490	431	516	503	434
113	35,000	493	434	331	38	12	11,200	12,376	317.2	4.90	19.03	—	511	493	433	518	503	434
114	35,000	493	432	334	39	16	11,200	12,410	342.5	5.10	19.76	—	516	497	434	522	507	434
115	35,000	—	431	—	—	20	10,500	—	—	—	—	—	—	—	—	—	—	—
116	35,000	493	430	334	39	24	9,700	10,767	222.5	3.93	15.20	—	526	513	431	527	517	431
117	35,000	—	429	—	—	32	7,900	—	—	—	—	—	—	—	—	—	—	—
118	35,000	493	428	324	37	46	4,800	5,342	53.7	1.39	5.36	—	528	525	429	528	527	430
119	35,000	493	434	423	64	4	5,600	6,233	74.7	2.01	7.75	—	527	520	440	525	519	437
120	35,000	493	439	375	49	6	8,600	9,477	140.4	3.36	13.09	—	511	501	443	523	513	443
121	35,000	493	440	365	46	8	10,700	11,770	258.0	4.59	17.91	—	507	489	441	520	506	443
122	35,000	493	440	372	48	10	12,300	13,542	411.3	5.48	21.36	—	512	489	442	523	505	444
123	35,000	493	442	392	53	12	13,000	14,300	489.0	5.85	22.83	—	519	494	444	527	507	445
124	35,000	493	442	402	56	16	13,100	14,410	525.3	5.94	23.18	—	528	502	446	534	513	446
125	35,000	493	442	395	54	20	12,400	13,640	451.2	5.65	22.05	—	533	509	445	537	517	445
126	35,000	—	439	—	—	24	11,550	—	—	—	—	—	—	—	—	—	—	—
127	35,000	500	435	395	56	32	9,425	10,452	236.7	4.01	15.30	—	553	539	442	554	543	442
128	35,000	493	434	402	57	38	8,000	8,880	140.2	2.94	11.37	—	546	537	440	548	541	440

FOR TG-100 GAS TURBINE-PROPELLER ENGINE

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
Compressor inlet			Compressor outlet			Compressor outlet elbow			Turbine inlet		Turbine outlet			Exhaust-cone outlet			Tail-pipe-nozzle outlet		
Total pressure, P_2 (lb/sq ft abs.)	Static pressure, p_2 (lb/sq ft abs.)	Indicated temperature, $T_{i,2}$ (°R)	Total pressure, P_3 (lb/sq ft abs.)	Static pressure, p_3 (lb/sq ft abs.)	Indicated temperature, $T_{i,3}$ (°R)	Total pressure, P_4 (lb/sq ft abs.)	Static pressure, p_4 (lb/sq ft abs.)	Indicated temperature, $T_{i,4}$ (°R)	Total pressure, P_5 (lb/sq ft abs.)	Static pressure, p_5 (lb/sq ft abs.)	Total pressure, P_6 (lb/sq ft abs.)	Static pressure, p_6 (lb/sq ft abs.)	Indicated temperature, $T_{i,6}$ (°R)	Total pressure, P_7 (lb/sq ft abs.)	Static pressure, p_7 (lb/sq ft abs.)	Indicated temperature, $T_{i,7}$ (°R)	Total pressure, P_8 (lb/sq ft abs.)	Static pressure, p_8 (lb/sq ft abs.)	Indicated temperature, $T_{i,8}$ (°R)
794	785	448	—	—	508	—	—	506	—	—	730	784	526	781	781	529	781	778	530
789	771	444	1185	1119	538	1168	1158	540	—	1113	710	794	547	785	778	548	784	778	553
789	767	448	1305	1223	561	1281	1264	565	1231	1213	708	803	560	790	781	561	787	779	570
789	765	447	1329	1243	567	1306	1285	570	1252	1236	709	809	568	793	778	577	789	780	580
794	774	450	1273	1195	563	1251	1232	565	1202	1185	712	806	566	790	781	572	789	781	578
—	—	447	—	—	545	—	—	547	—	—	—	—	554	—	—	570	—	—	570
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
811	803	447	1024	987	517	1015	1006	515	988	981	744	797	531	793	792	540	793	791	540
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
809	805	443	874	859	477	877	869	477	858	857	761	784	492	785	781	500	785	785	490
804	799	451	897	880	487	896	894	487	880	876	756	775	460	774	774	503	774	773	499
804	788	448	1130	1069	533	1116	1101	533	1076	1066	714	792	536	781	778	530	782	777	531
794	785	445	1476	1366	580	1445	1419	587	1379	1358	724	820	570	793	778	560	787	776	570
786	758	445	1920	1776	634	1872	1841	641	1788	1759	757	854	603	806	781	610	—	778	612
781	727	446	1950	1808	641	1899	1869	649	1816	1784	752	846	609	809	781	620	797	773	621
791	738	445	1936	1793	637	1886	1855	—	1801	1771	756	856	604	806	781	620	804	781	620
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
812	763	441	1429	1336	574	1399	1376	578	1341	1320	758	859	568	799	784	590	802	785	590
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
827	—	440	927	881	487	898	898	584	884	879	—	—	501	788	784	519	—	787	510
505	—	436	515	514	459	521	521	458	515	515	—	—	474	497	490	474	—	500	470
498	498	442	523	521	493	529	527	490	524	523	487	493	530	493	493	540	492	492	547
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
498	495	432	550	542	474	554	553	473	543	543	478	494	500	493	493	510	493	493	518
504	501	429	571	560	472	572	570	470	560	557	482	499	495	500	500	506	500	500	500
498	497	428	556	549	469	556	556	467	549	546	477	494	490	493	493	500	494	494	490
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
499	497	427	538	535	459	542	542	461	535	534	481	494	480	493	493	485	494	494	480
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
500	499	429	515	515	452	521	521	452	517	514	489	494	471	493	493	475	494	494	470
504	—	434	527	524	474	528	528	474	525	521	—	—	499	493	493	510	—	492	500
503	502	432	548	540	472	553	553	473	538	538	478	491	490	493	493	499	493	492	490
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
499	489	426	762	720	523	750	739	526	724	714	450	457	530	497	493	479	497	492	531
500	488	426	770	728	624	761	754	525	733	725	451	504	530	500	500	537	497	493	536
503	476	426	716	685	514	713	704	514	687	683	471	—	524	497	493	534	515	494	530
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
509	508	430	531	531	465	535	535	463	529	528	486	495	480	495	493	490	495	495	481
522	518	444	572	560	486	574	570	485	563	560	477	497	507	498	493	510	497	496	510
510	498	440	739	695	532	727	722	534	700	690	445	498	540	491	486	540	490	488	540
494	467	439	1060	980	599	1040	1021	605	990	973	440	515	582	488	479	579	493	480	585
496	456	437	1310	1210	640	1278	1260	646	1218	1204	472	538	609	497	486	610	506	487	612
496	450	436	1427	1316	658	1391	1363	667	1324	1302	474	546	620	500	490	625	510	490	629
500	451	434	1456	1346	660	1418	1394	669	1353	1328	479	549	619	506	493	630	512	493	630
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
513	486	435	1125	1043	606	1100	1081	612	1046	1031	457	533	587	504	493	600	509	495	600
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
526	523	436	585	567	502	581	577	500	569	564	476	497	529	497	486	549	496	496	540
526	519	447	606	588	516	605	598	515	588	584	459	488	539	486	486	556	486	486	550
512	492	446	880	817	573	864	849	577	827	814	441	507	571	490	486	568	491	486	573
500	460	445	1282	1178	645	1250	1222	653	1190	1172	468	533	611	497	486	609	503	486	615
494	433	445	1628	1505	705	1586	1556	717	1514	1490	497	565	658	507	486	664	513	488	665
496	425	446	1781	1647	734	1737	1708	746	1659	1630	517	586	690	519	493	690	519	489	695
500	427	446	1836	1699	738	1790	1757	751	1710	1682	525	593	693	519	493	704	523	492	705
508	445	445	1719	1593	715	1676	1648	726	1599	1573	512	575	650	518	493	678	521	495	680
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
541	514	443	1098	1020	611	1074	1060	615	1029	1007	525	540	595	518	507	615	516	504	613
539	525	442	829	780	562	815	803	565	782	769	456	513	569	502	493	582	501	497	585

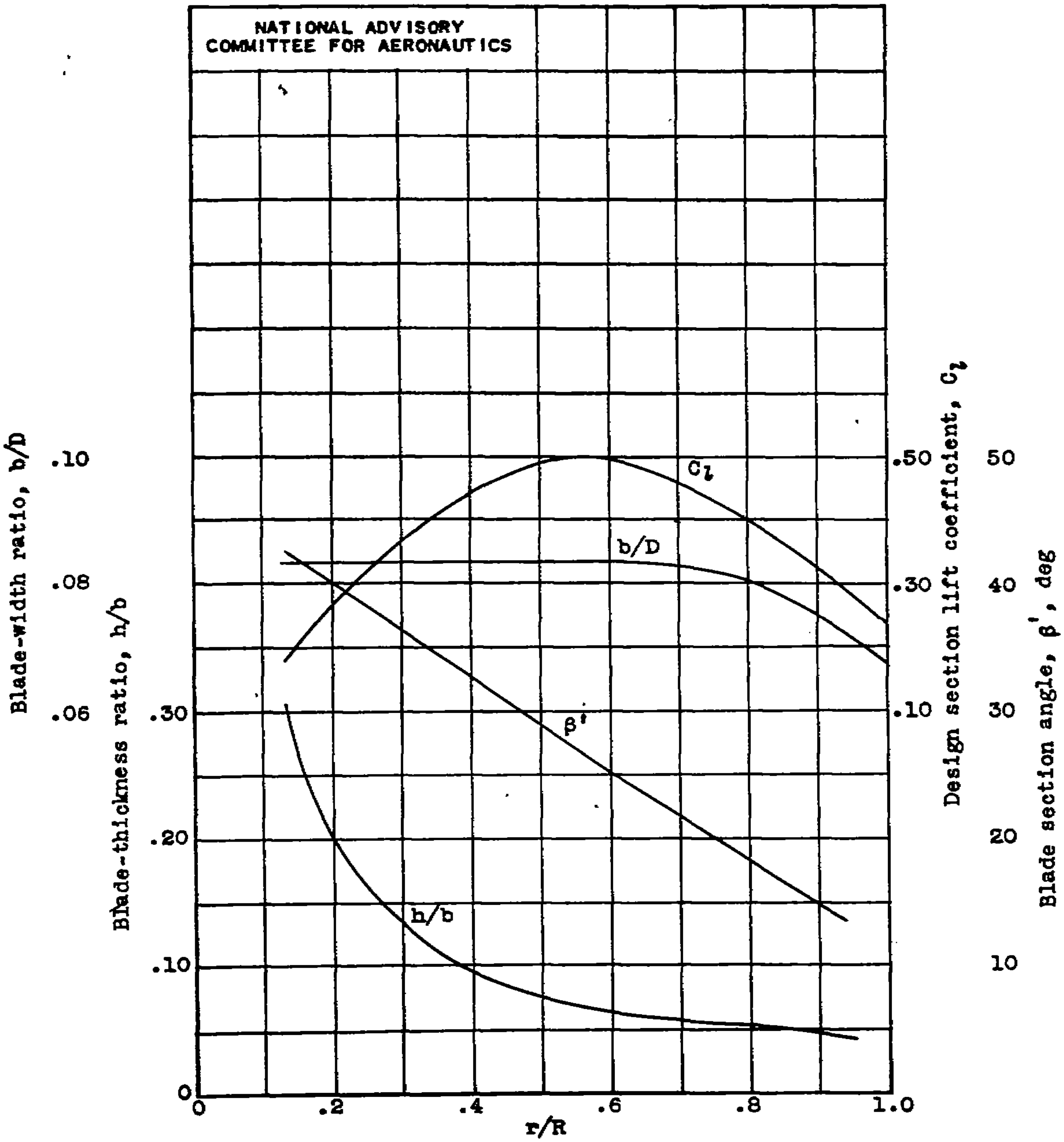


Figure 1. - Blade-form curves for Hamilton-Standard 4260 four-blade propeller. b, section chord; D, propeller diameter; h, section thickness; R, radius to tip; r, section radius.

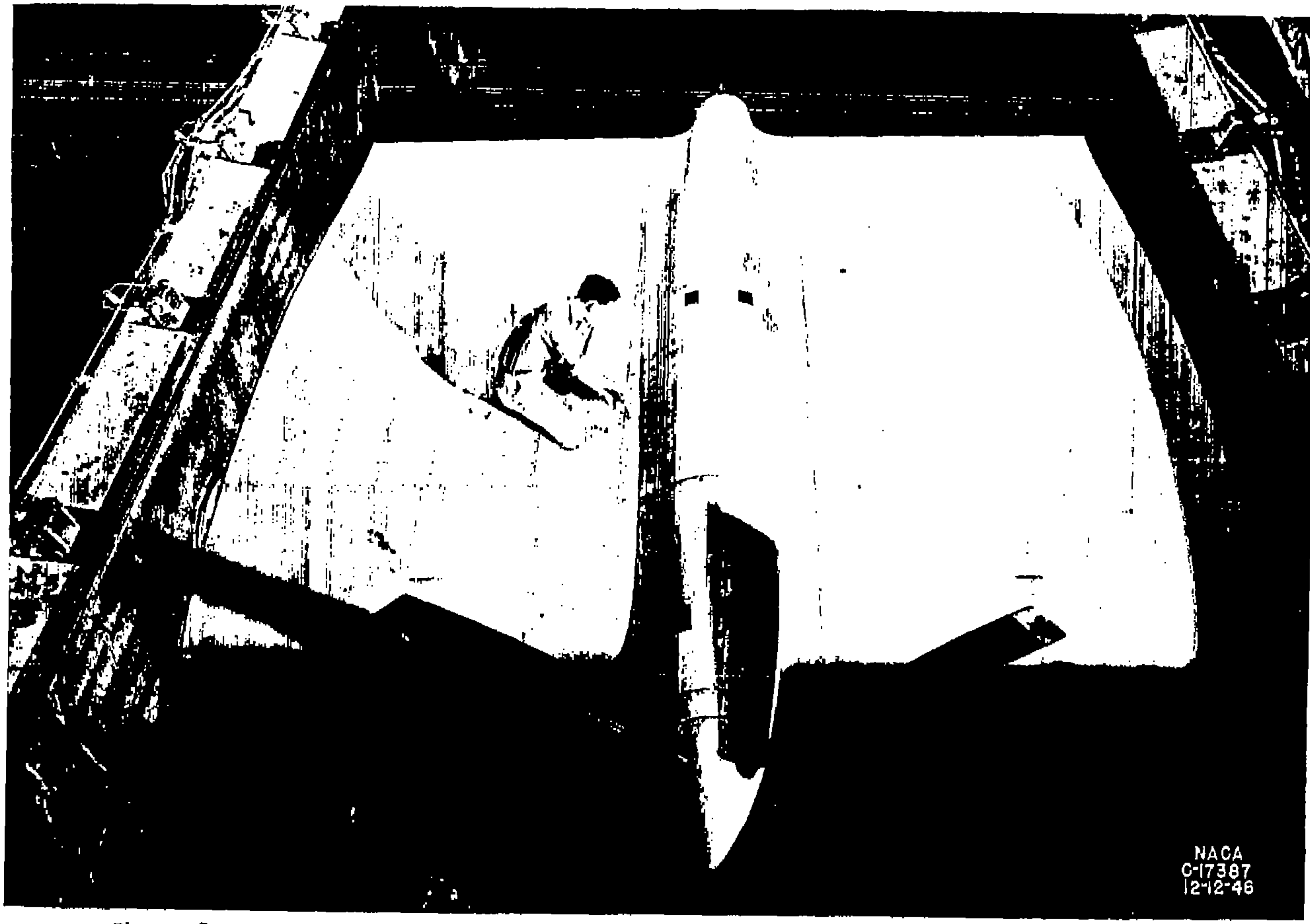


Figure 2. - Installation of TG-100 gas turbine-propeller engine in altitude wind tunnel.

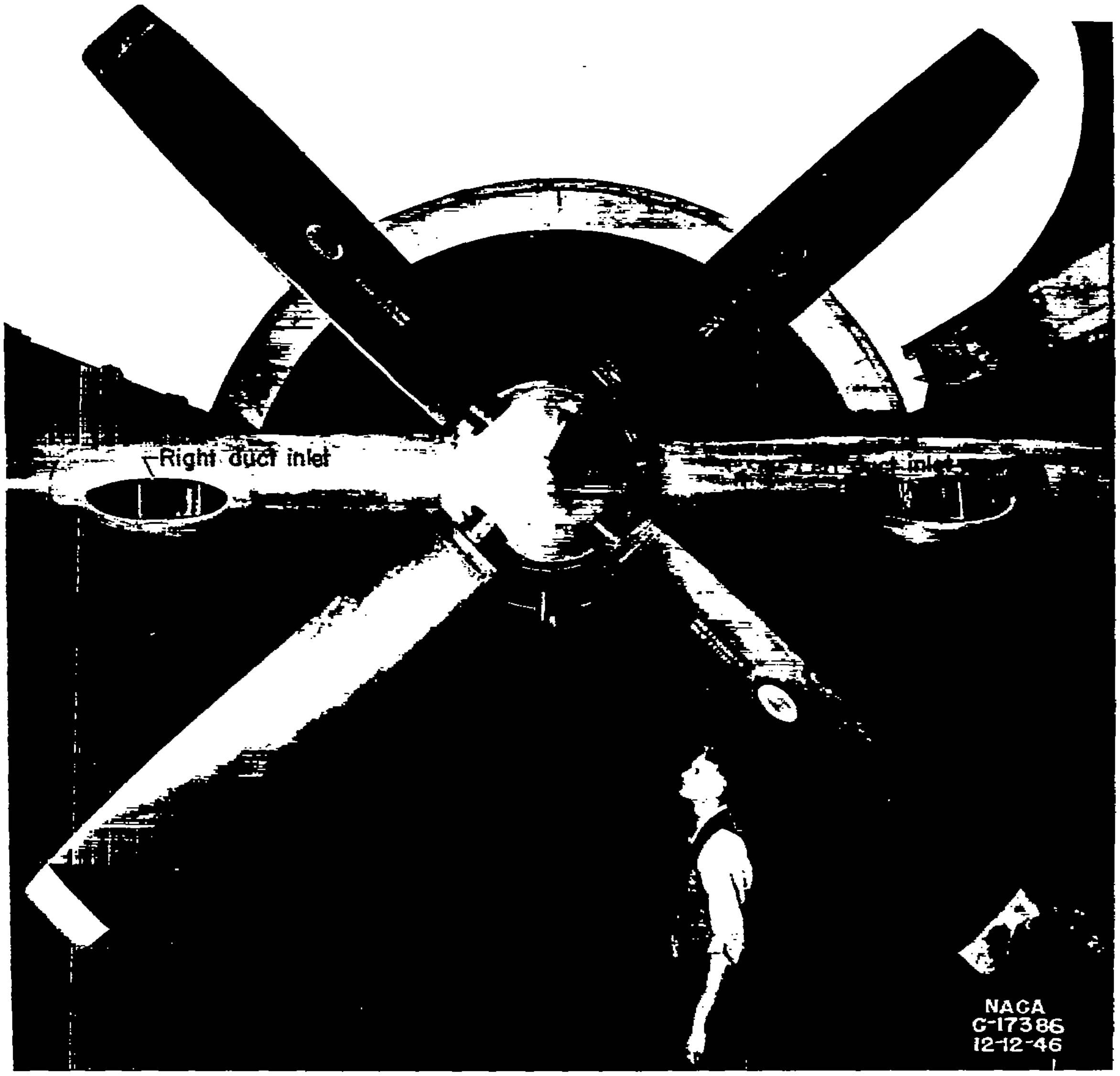


Figure 3. - Installation of TG-100 gas turbine-propeller engine showing wing duct inlets.

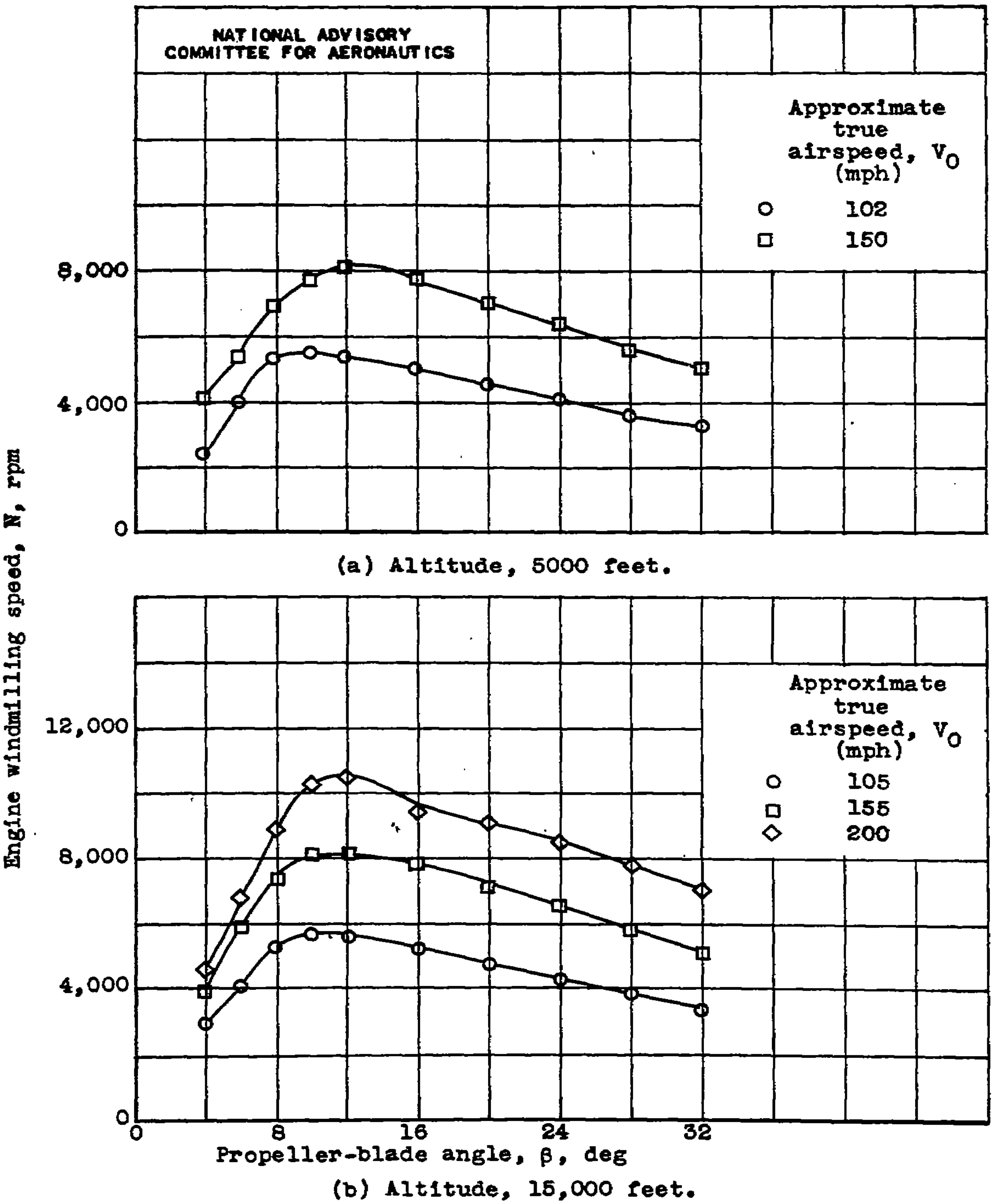


Figure 4. - Variation of engine windmilling speed with propeller-blade angle and approximate true airspeed.

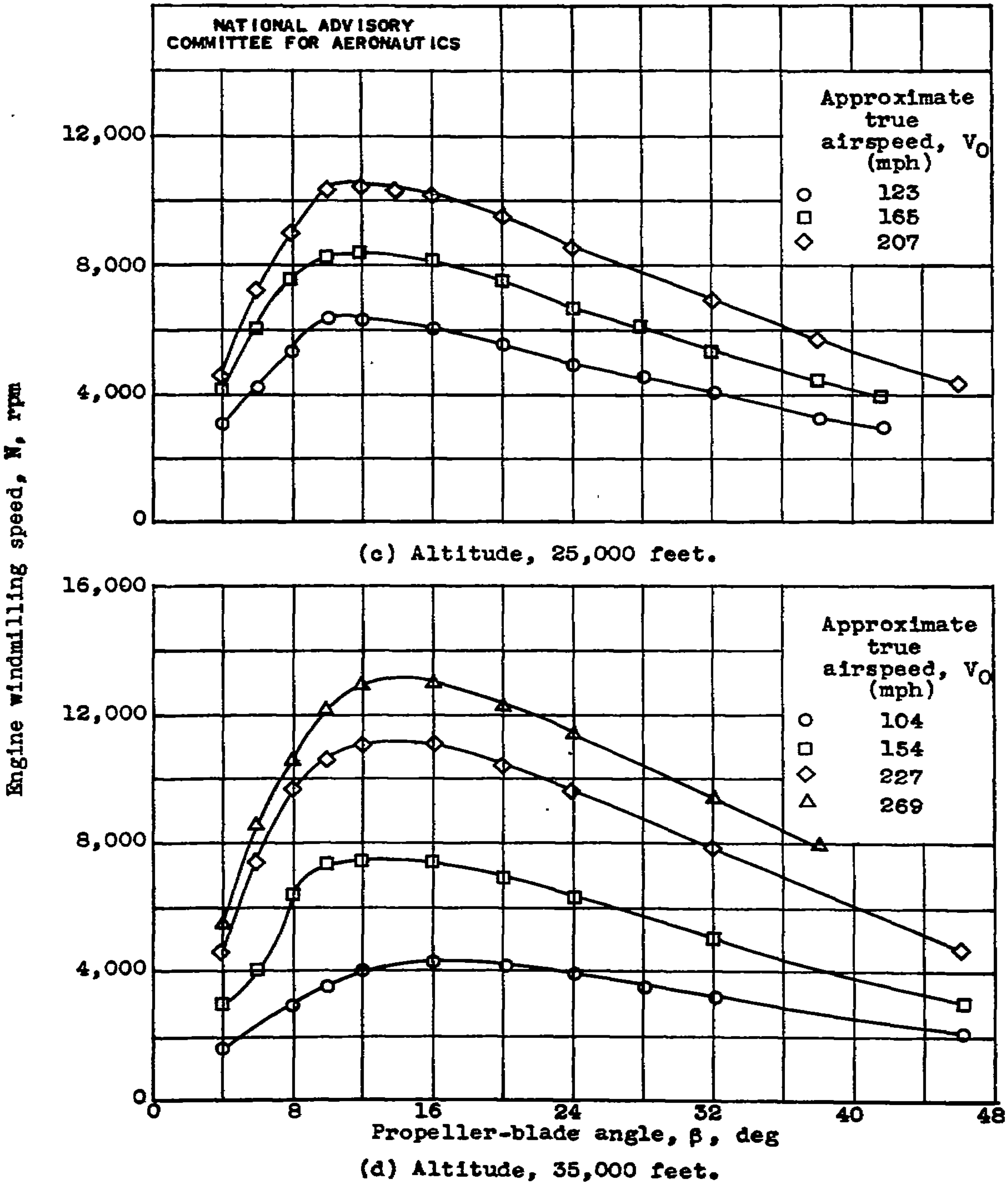


Figure 4. - Concluded. Variation of engine windmilling speed with propeller-blade angle and approximate true airspeed.

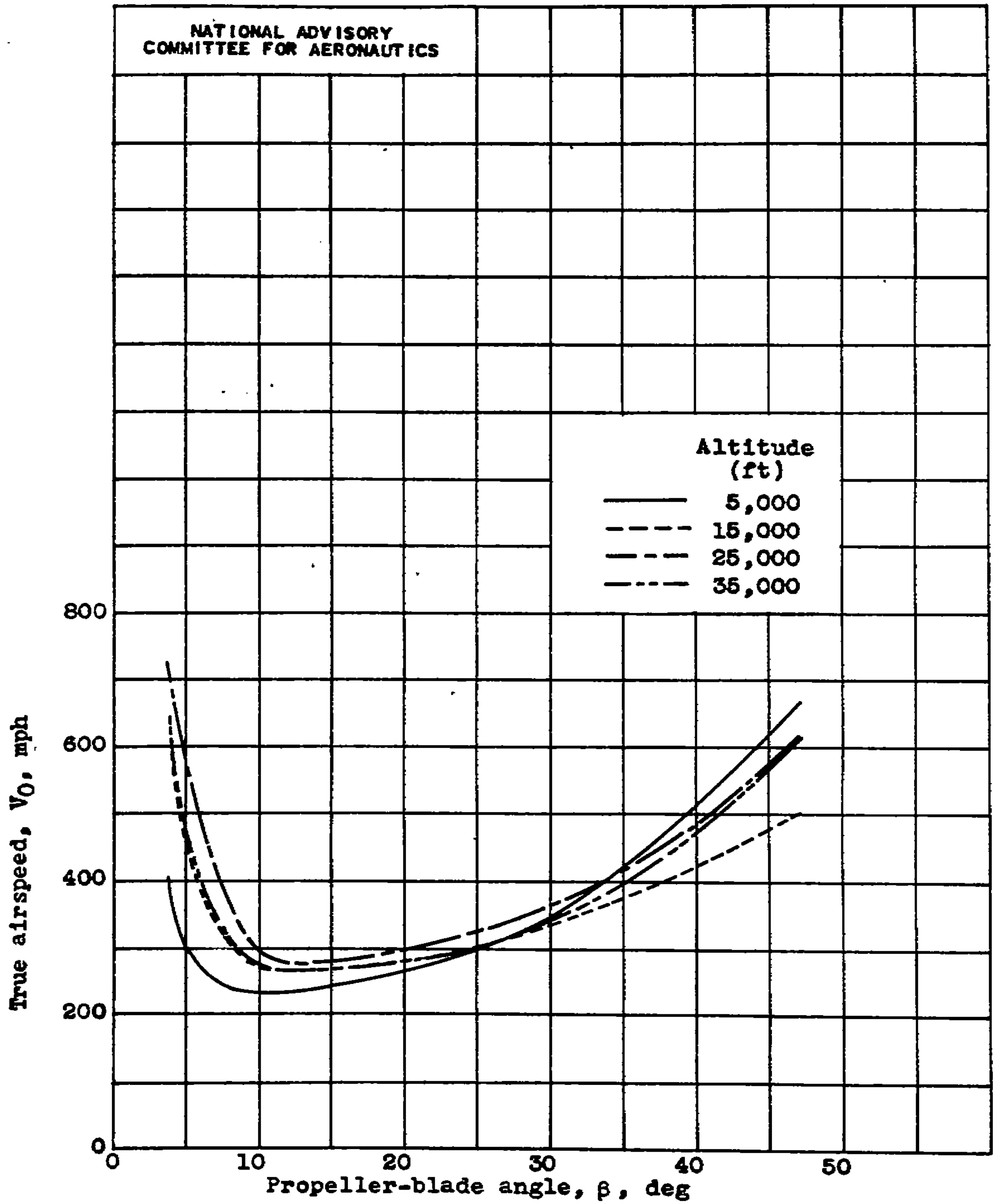


Figure 5. - Relation between true airspeed and propeller-blade angle at engine speed of 13,000 rpm. (Data cross-plotted and extrapolated from fig. 4.)

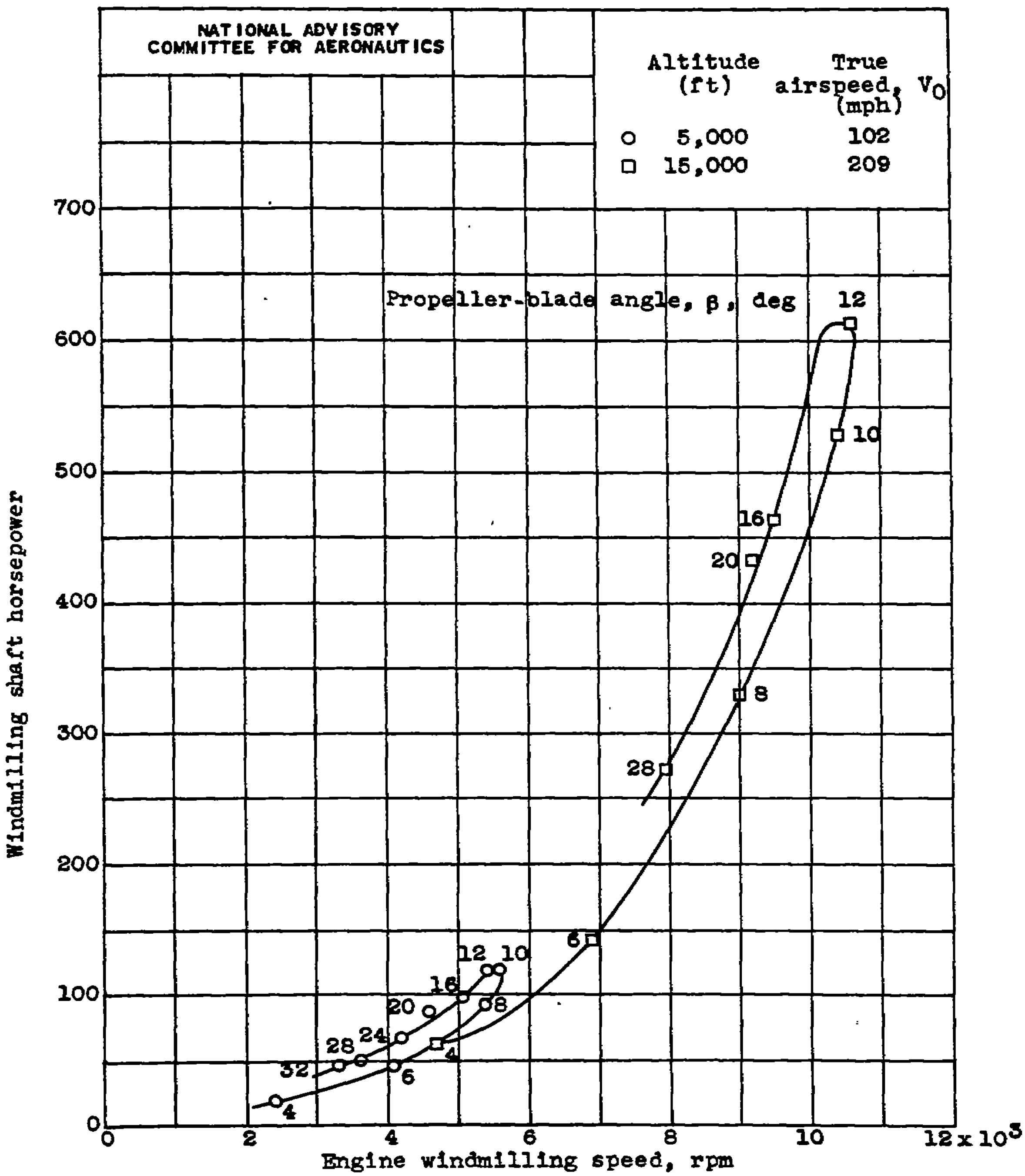


Figure 6. - Variation of windmilling shaft horsepower with engine speed for various propeller-blade angles.

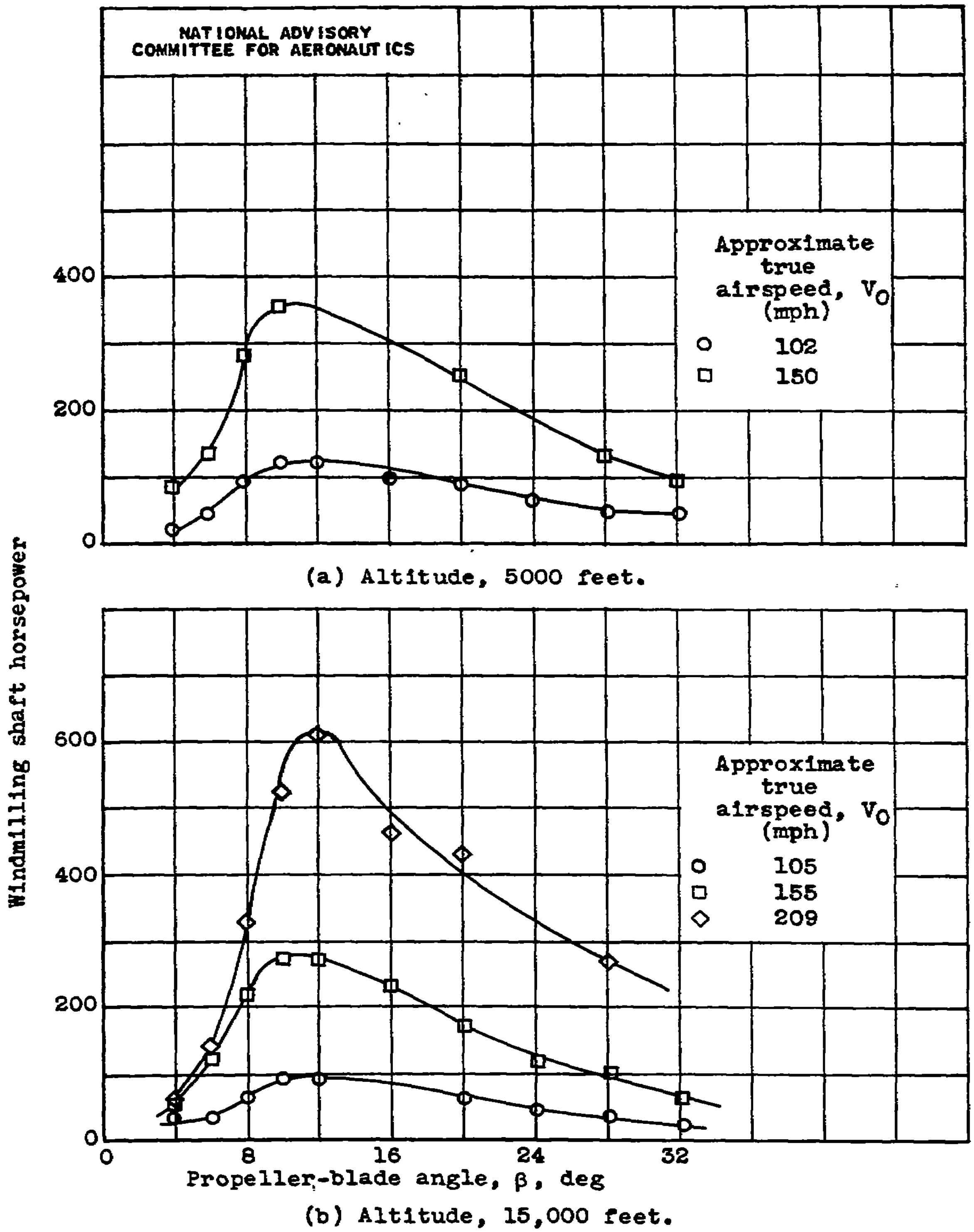


Figure 7. - Variation of windmilling shaft horsepower with propeller-blade angle.

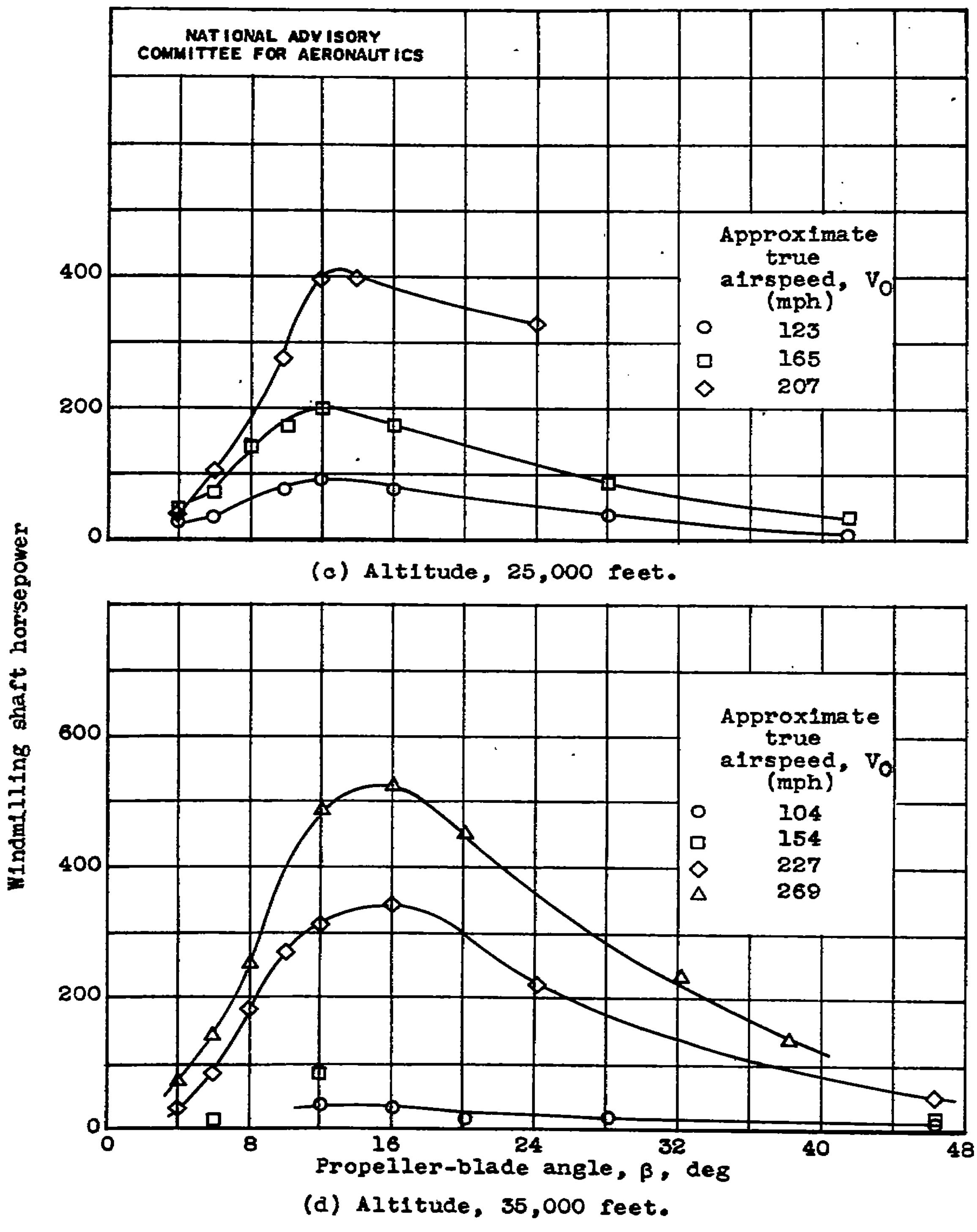


Figure 7. - Concluded. Variation of windmilling shaft horsepower with propeller-blade angle.

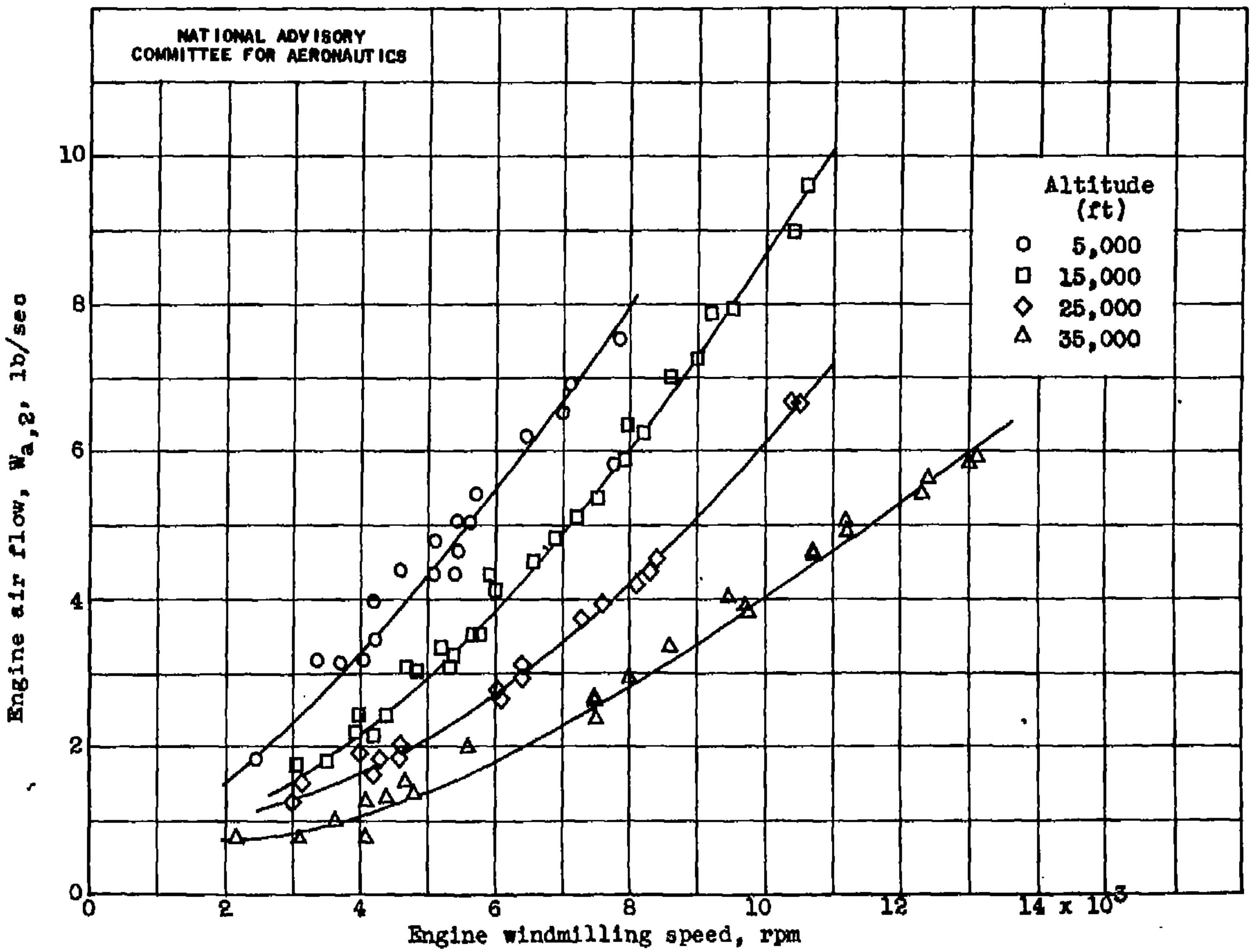


Figure 8. - Variation of engine air flow with engine windmilling speed.

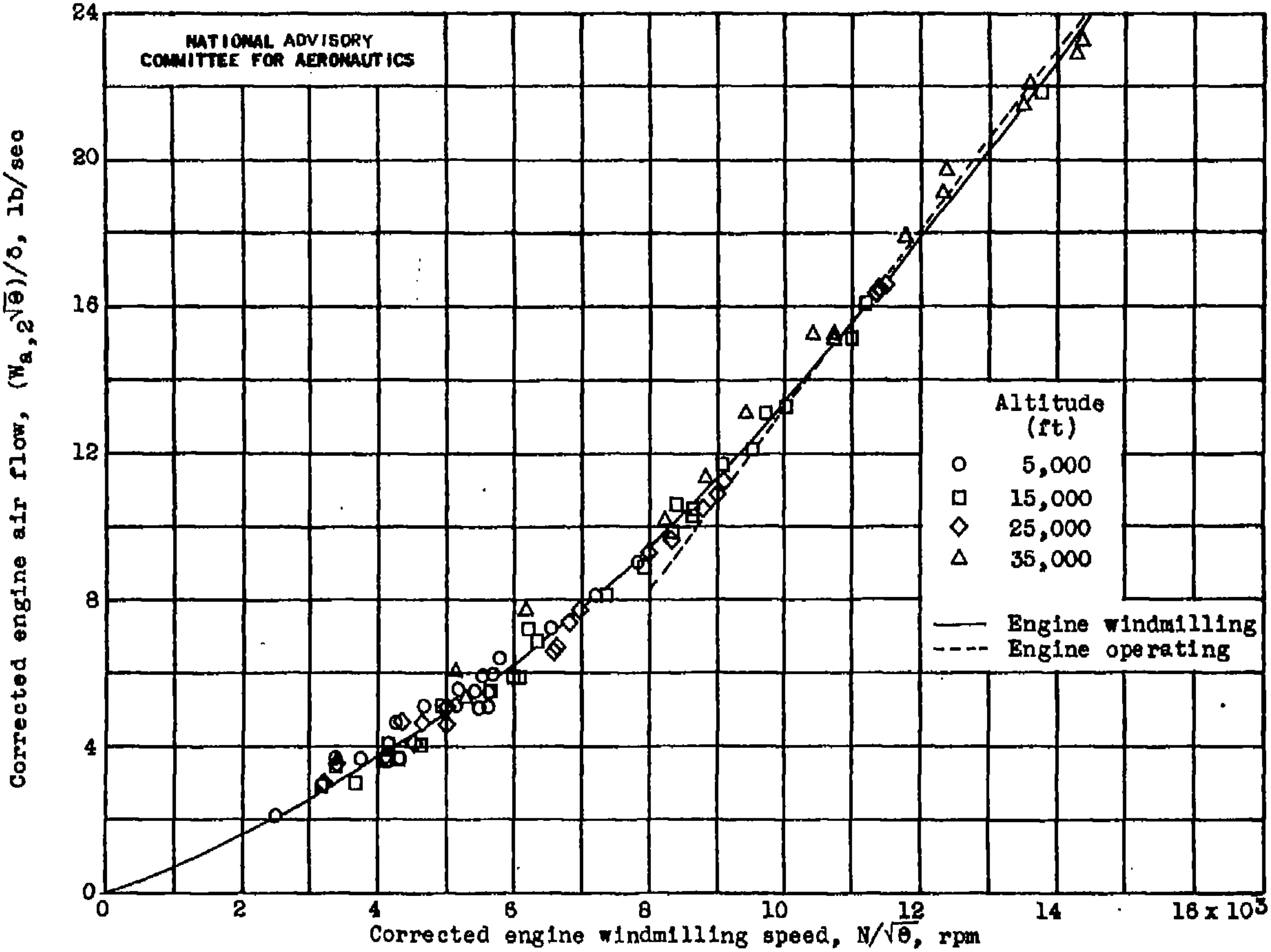


Figure 9. - Variation of corrected engine air flow with corrected engine windmilling speed.

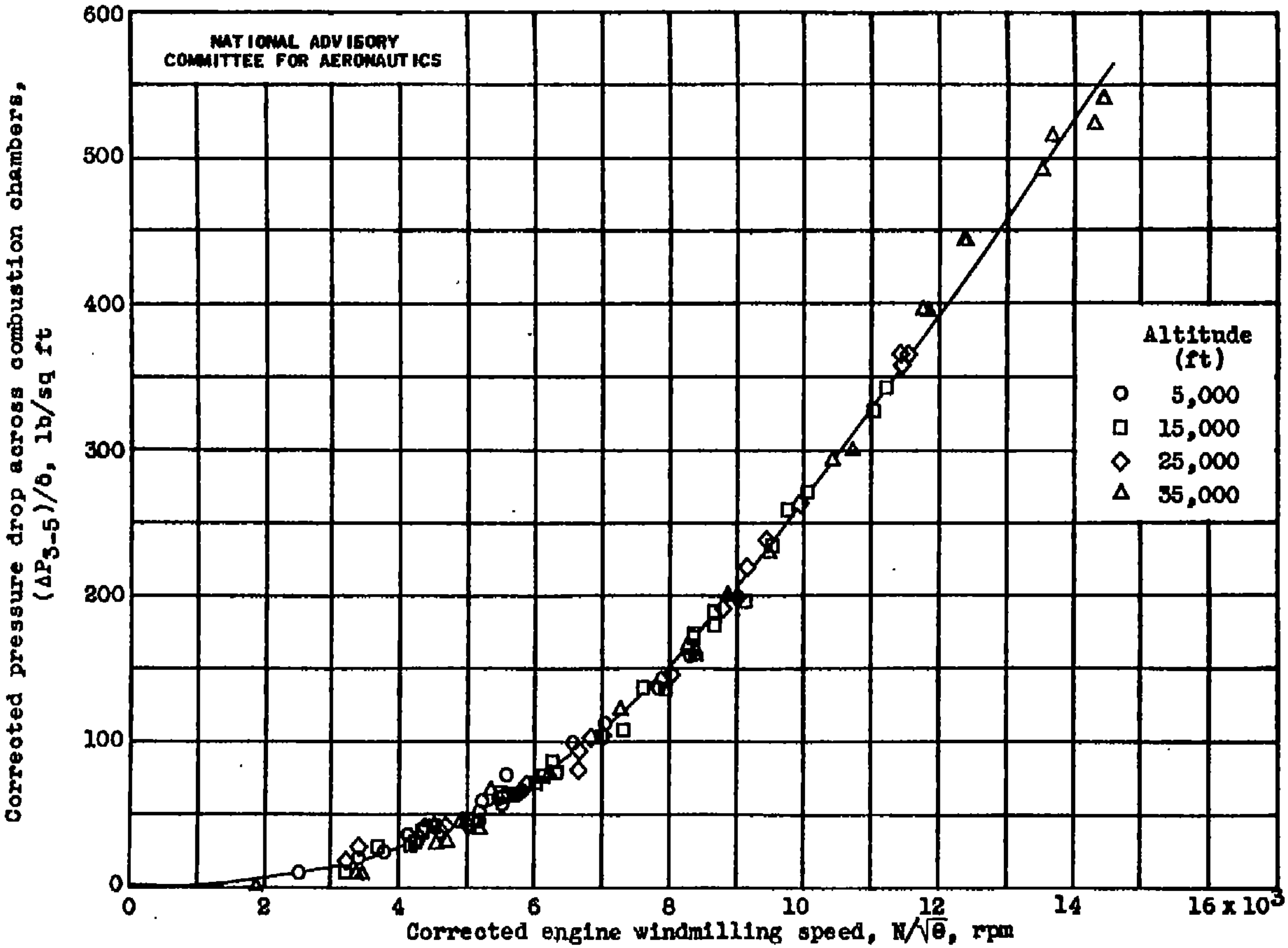


Figure 10. - Variation of corrected pressure drop across combustion chambers with corrected engine windmilling speed.

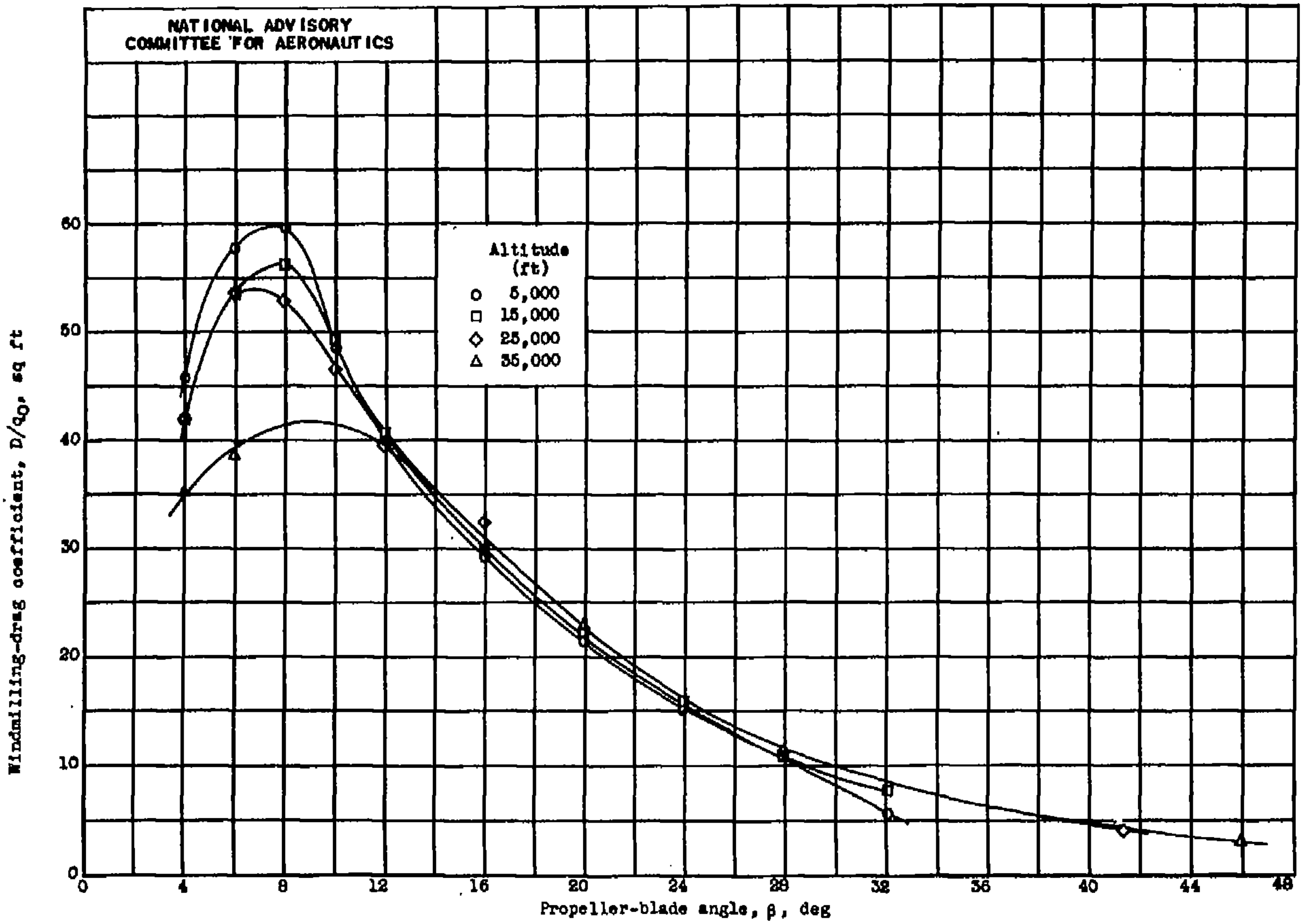


Figure 11. - Variation of windmilling-drag coefficient with propeller-blade angle for several altitudes. True airspeed, 153 miles per hour.

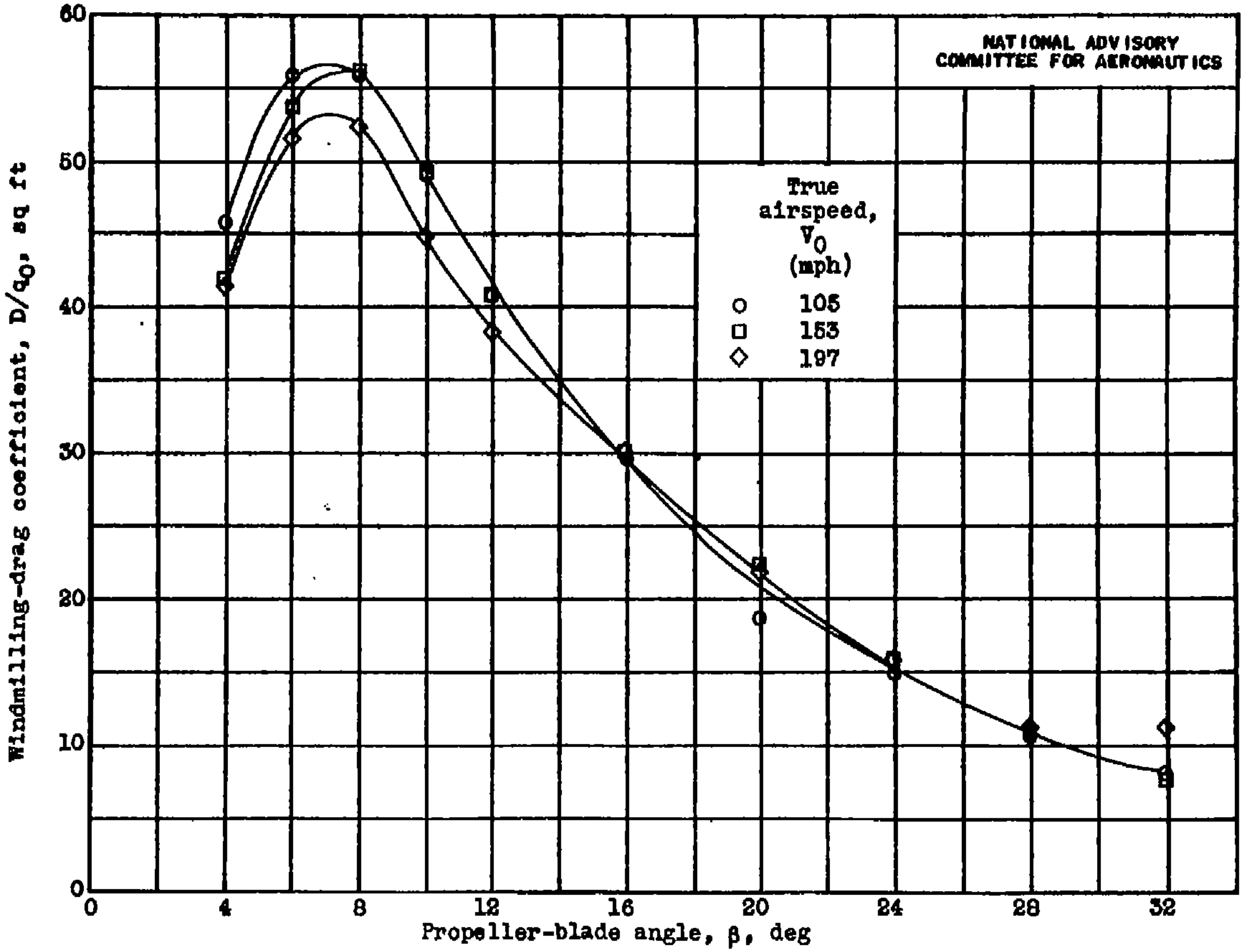
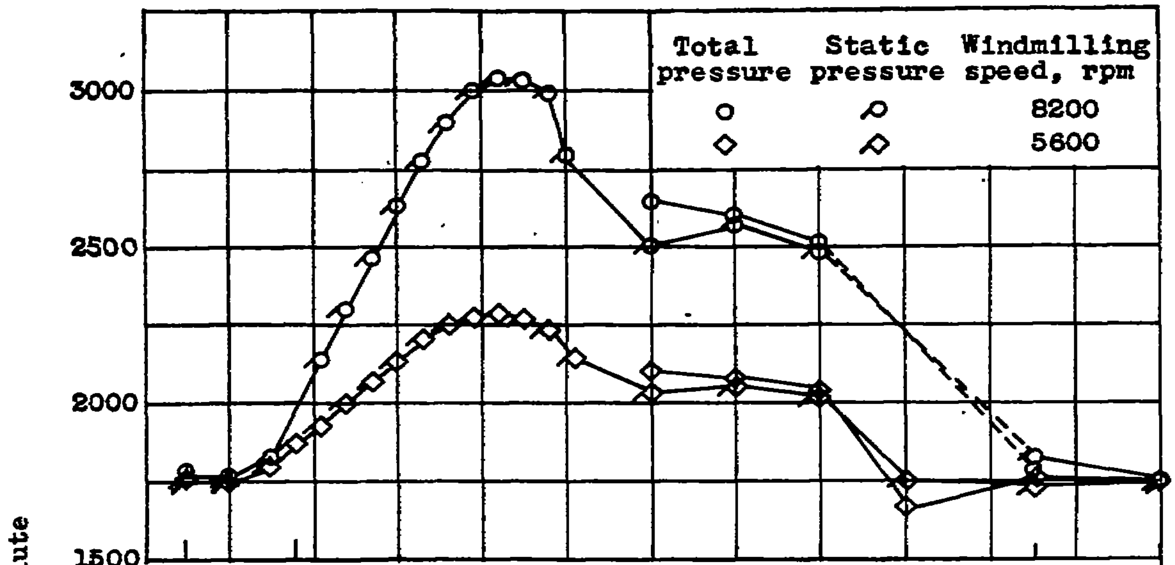
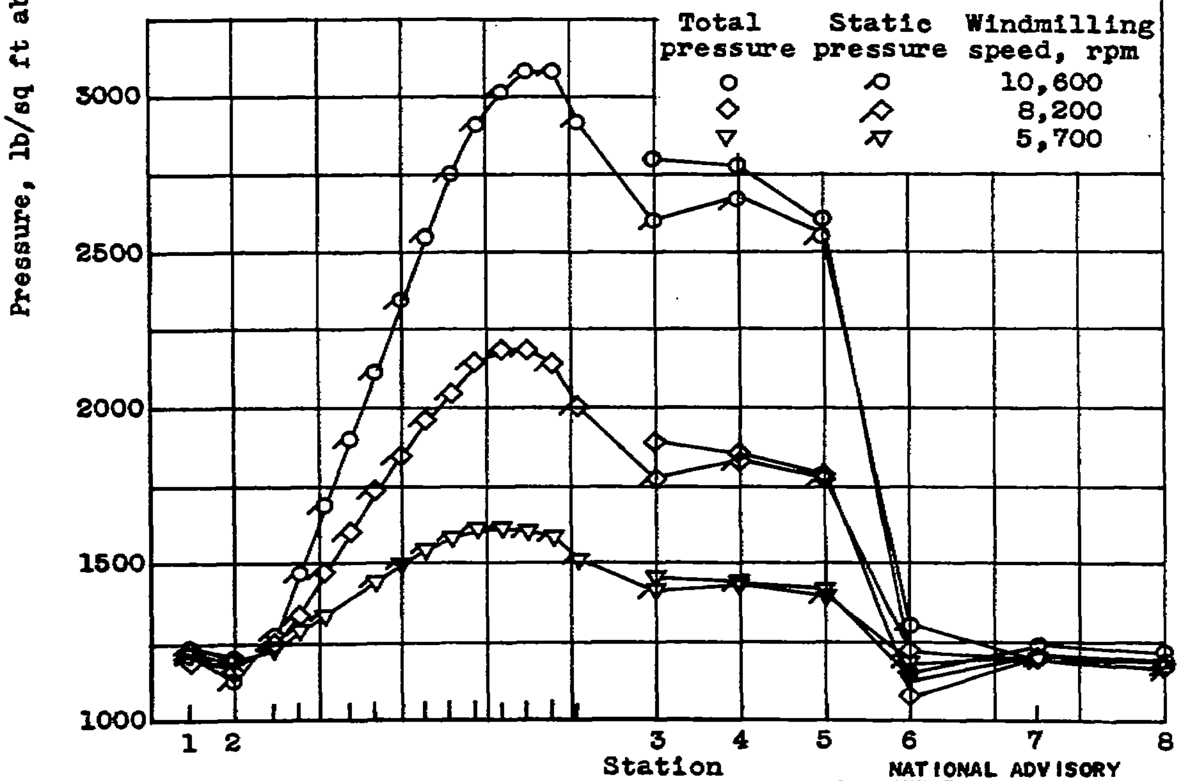


Figure 12. - Variation of windmilling-drag coefficient with propeller-blade angle for various true airspeeds. Altitude, 15,000 feet.



(a) Altitude, 5000 feet.



(b) Altitude, 15,000 feet.

Figure 13. - Variation of average total and static pressures through engine. Propeller-blade angle, 12°.

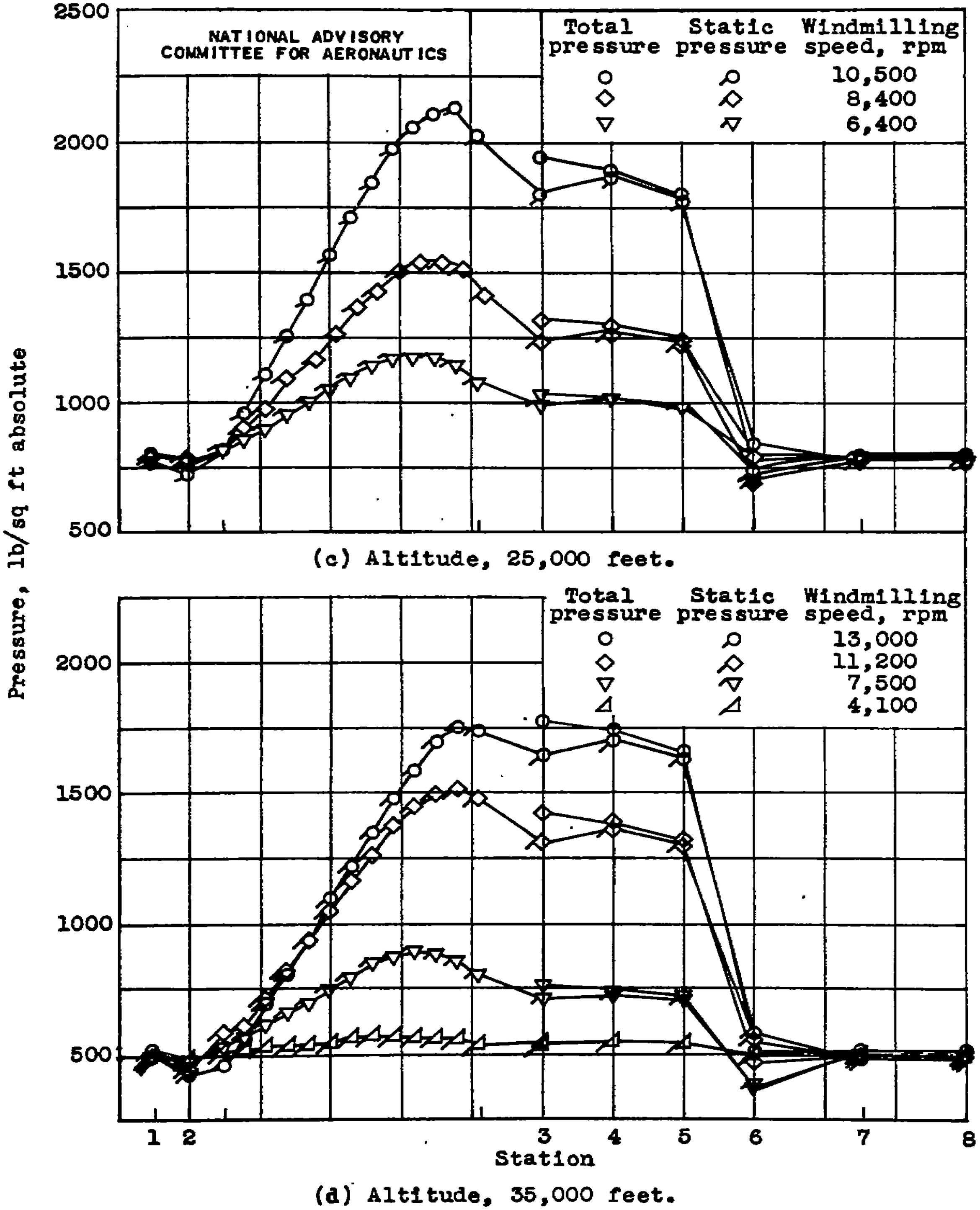


Figure 13. – Concluded. Variation of average total and static pressures through engine. Propeller-blade angle, 12°.

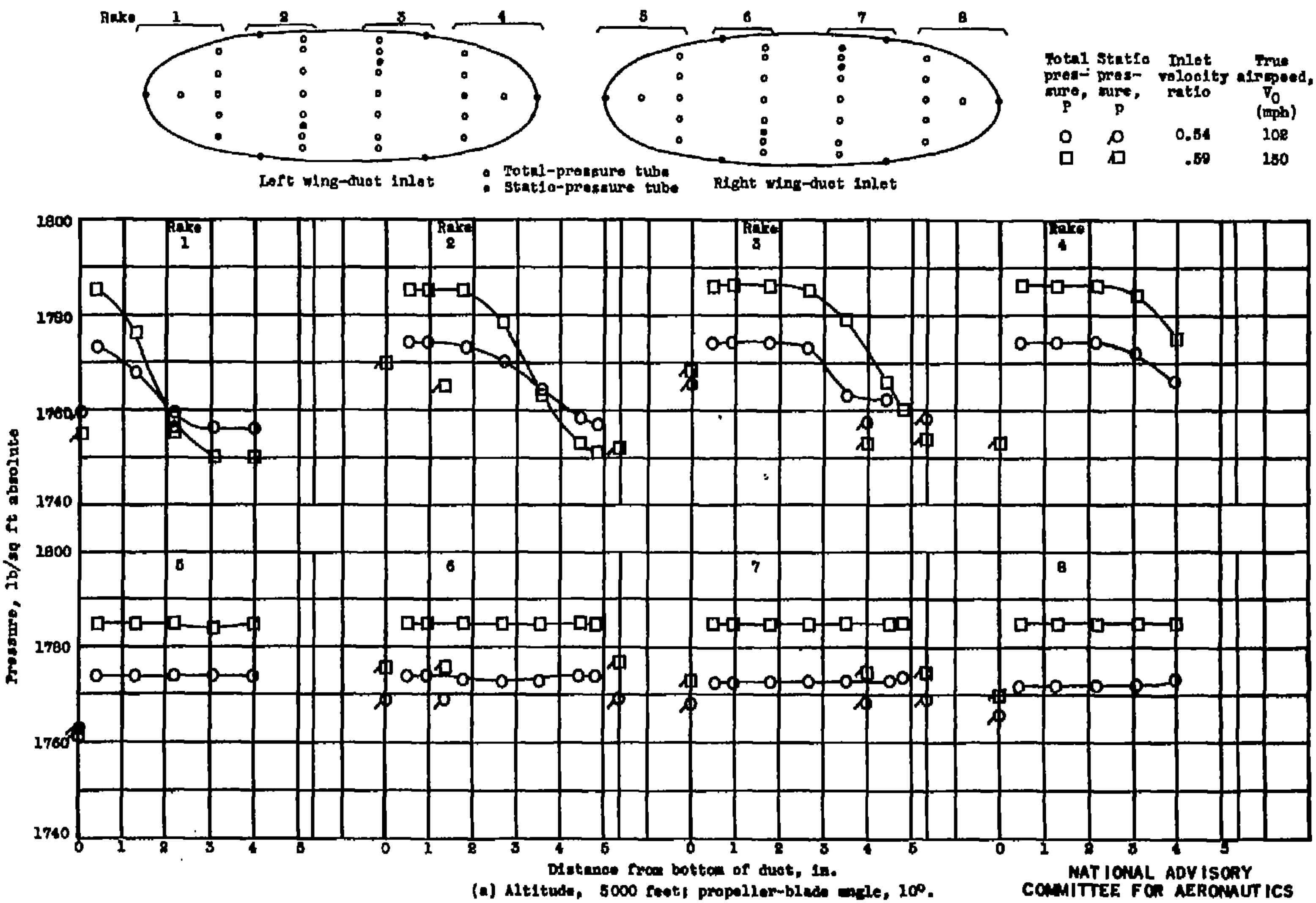


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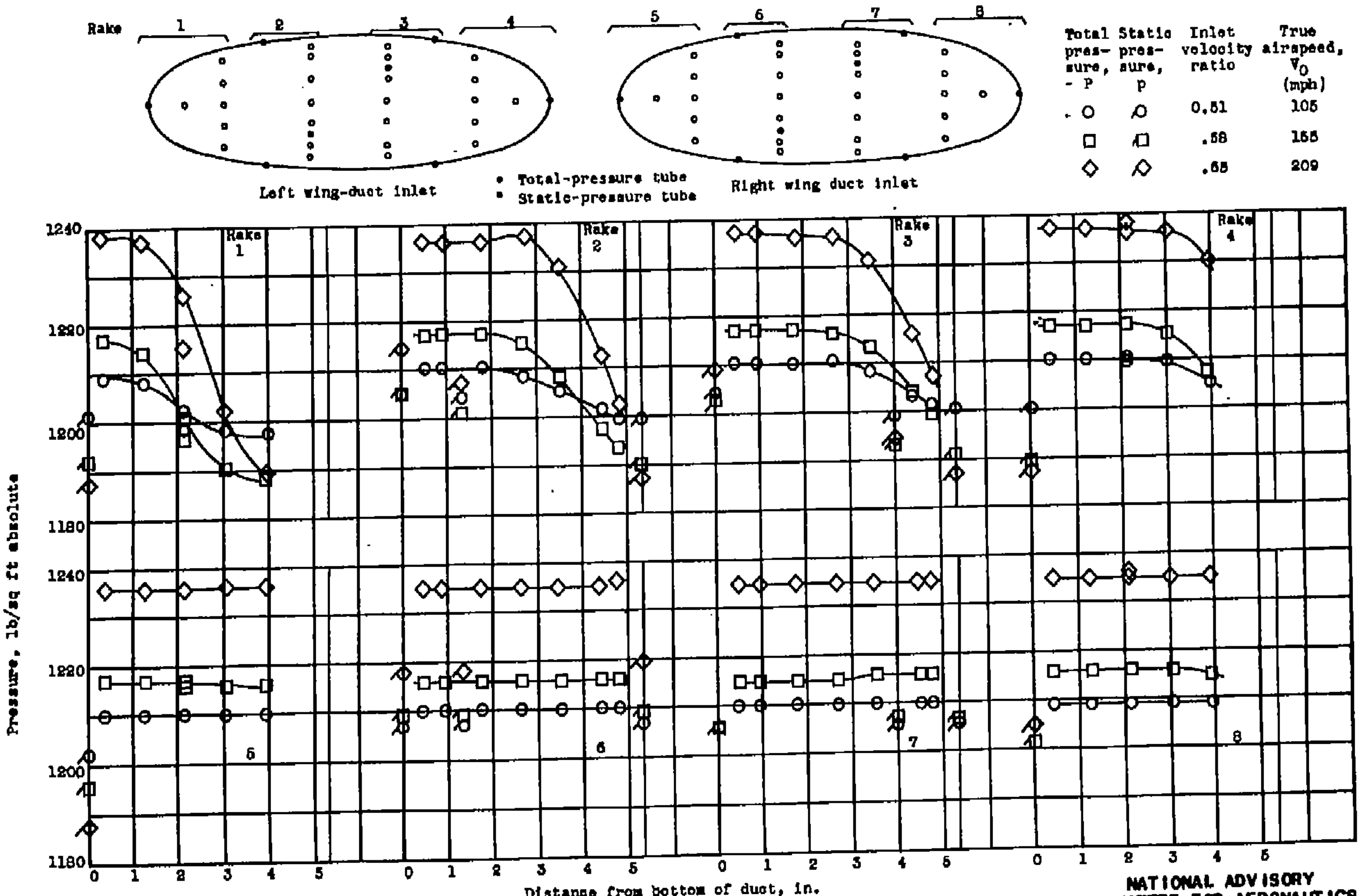
Figure 14. - Distribution of total and static pressures at wing-duct inlet.



(b) Altitude, 15,000 feet; propeller-blade angle, 12°.

Figure 14. - Continued. Distribution of total and static pressure at wing-duct inlet.

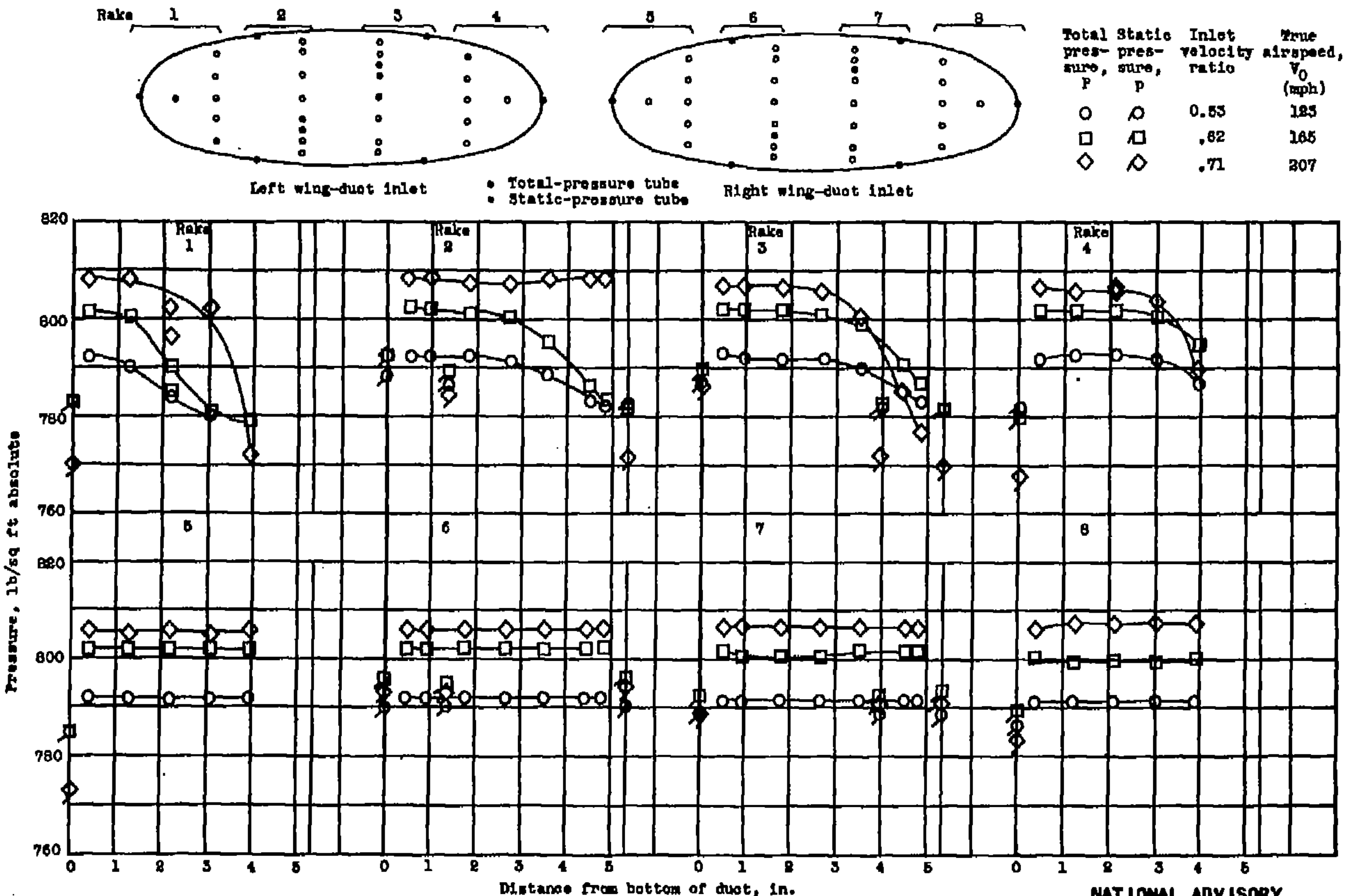


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Figure 14. - Continued. Distribution of total and static pressure at wing-duct inlet.

Fig. 14c

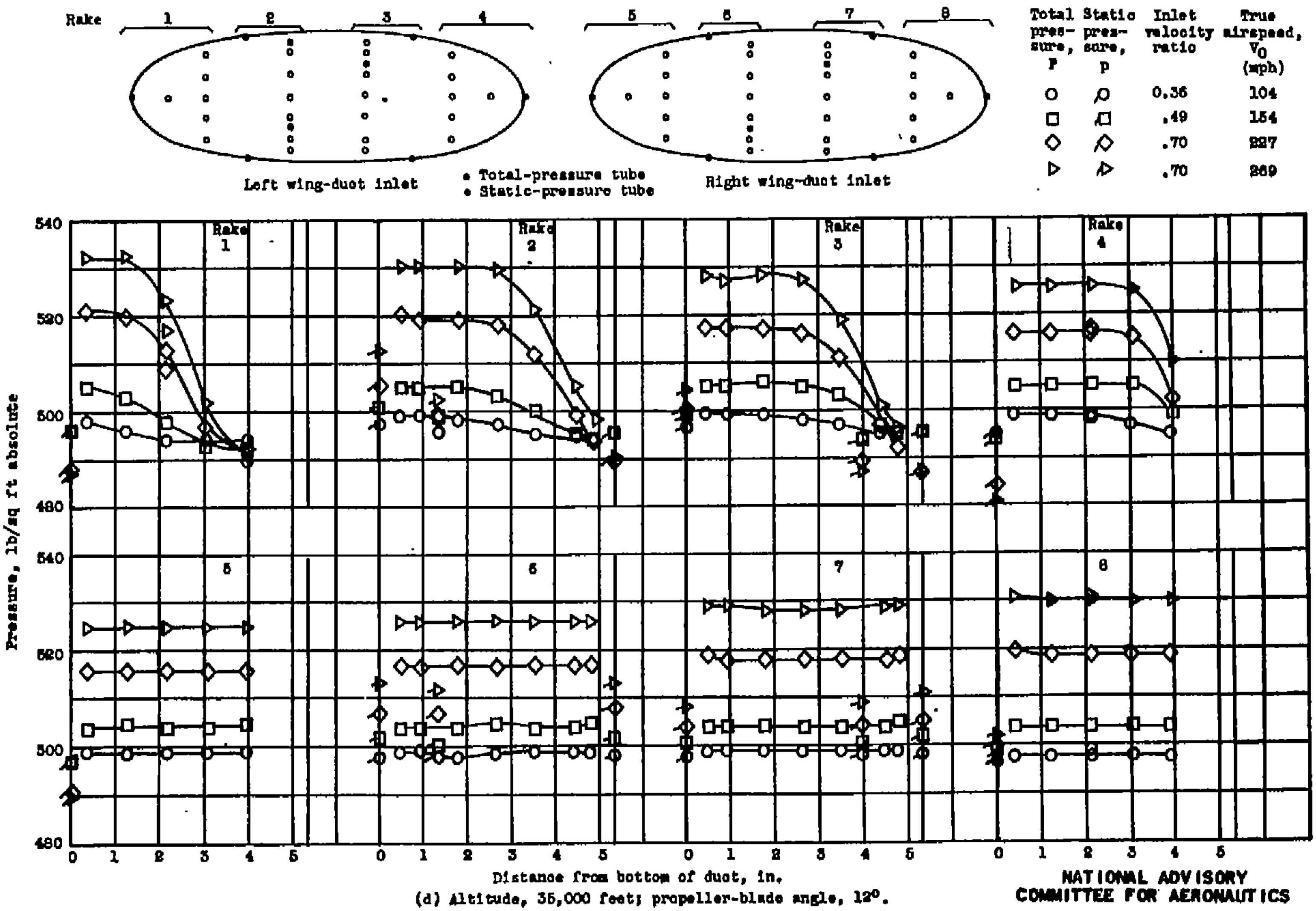

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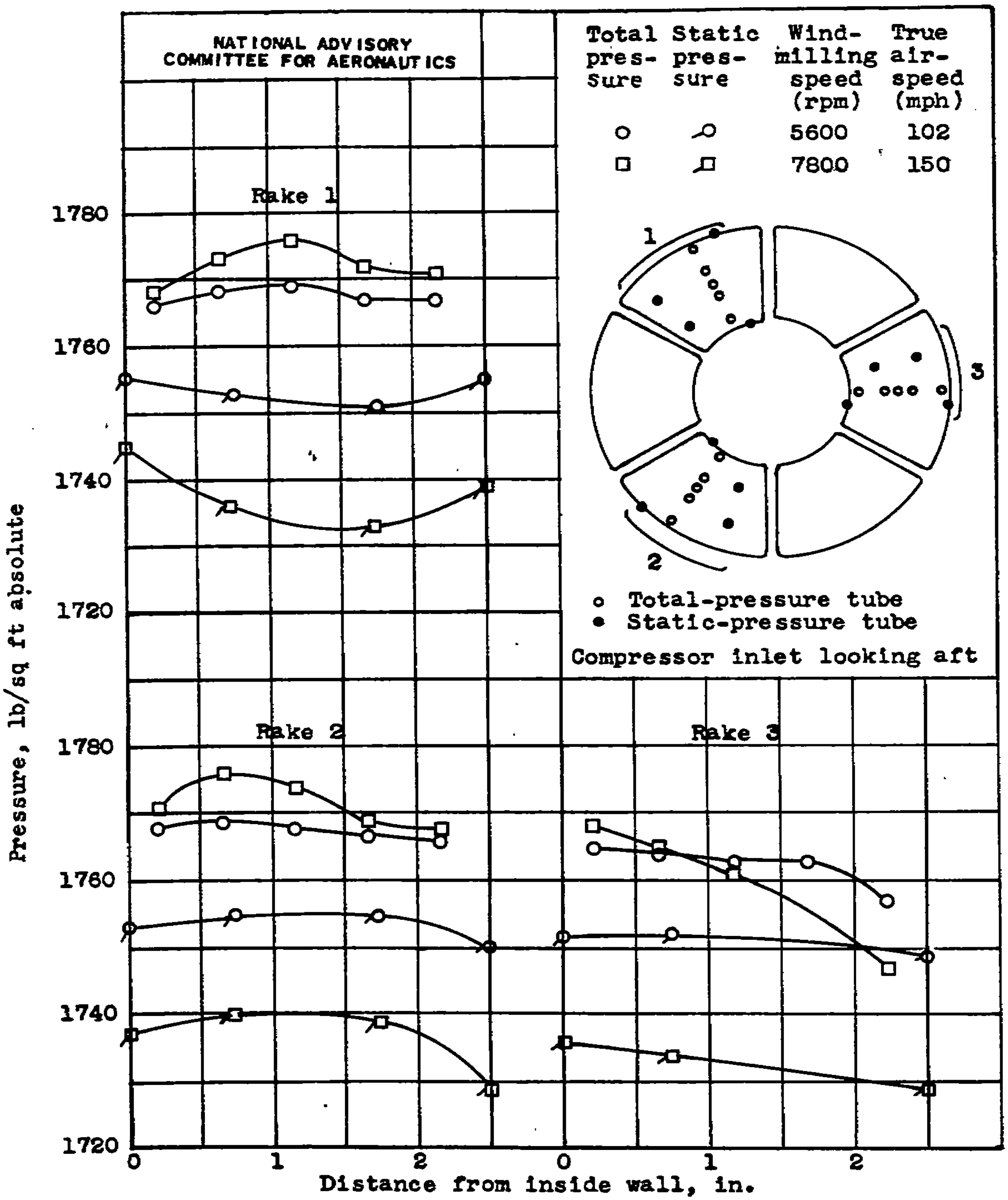
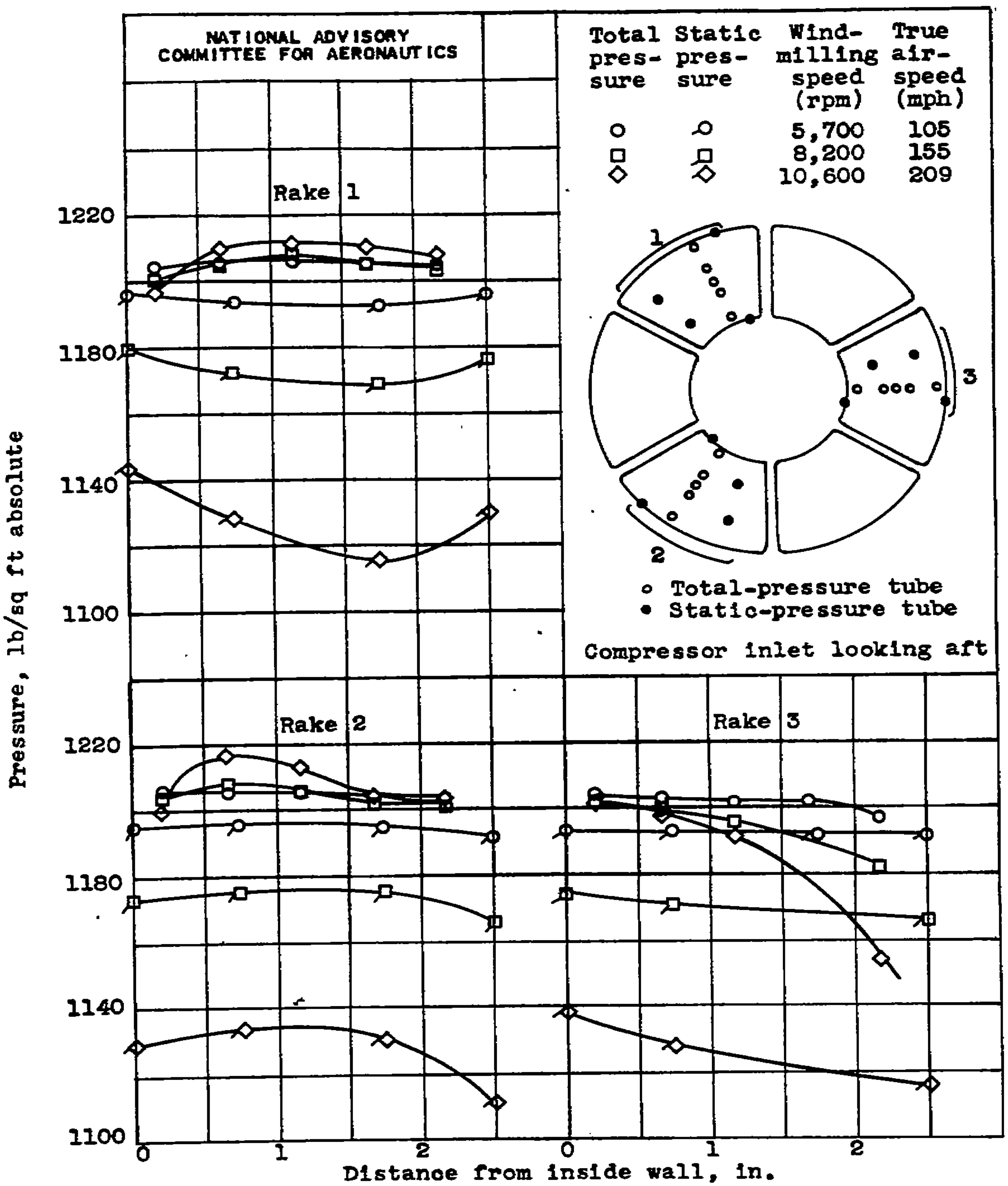
Figure 14. – Concluded. Distribution of total and static pressure at wing-duct inlet.



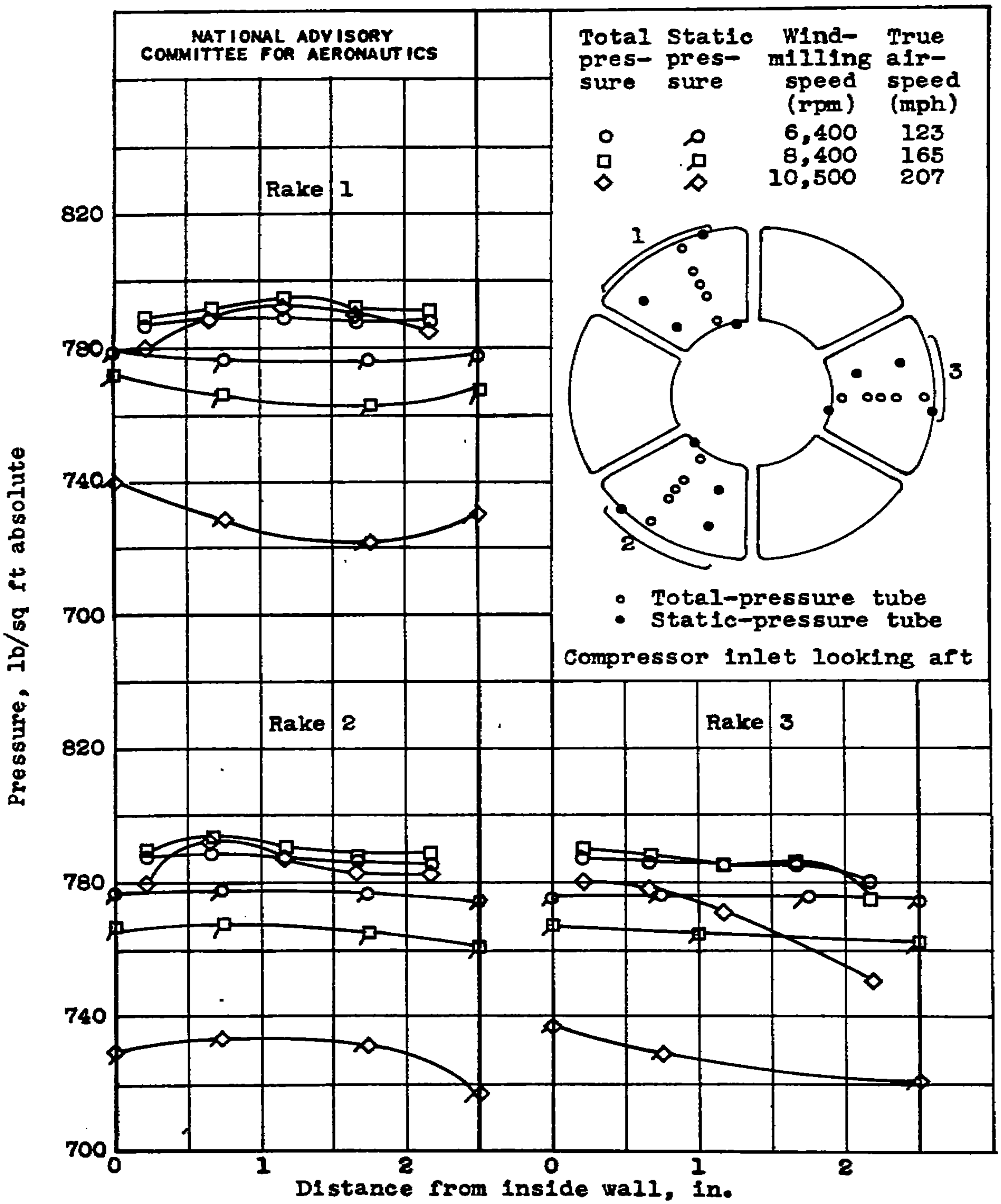
(a) Altitude, 5000 feet; propeller-blade angle, 10°.

Figure 15. - Distribution of total and static pressures at compressor inlet.



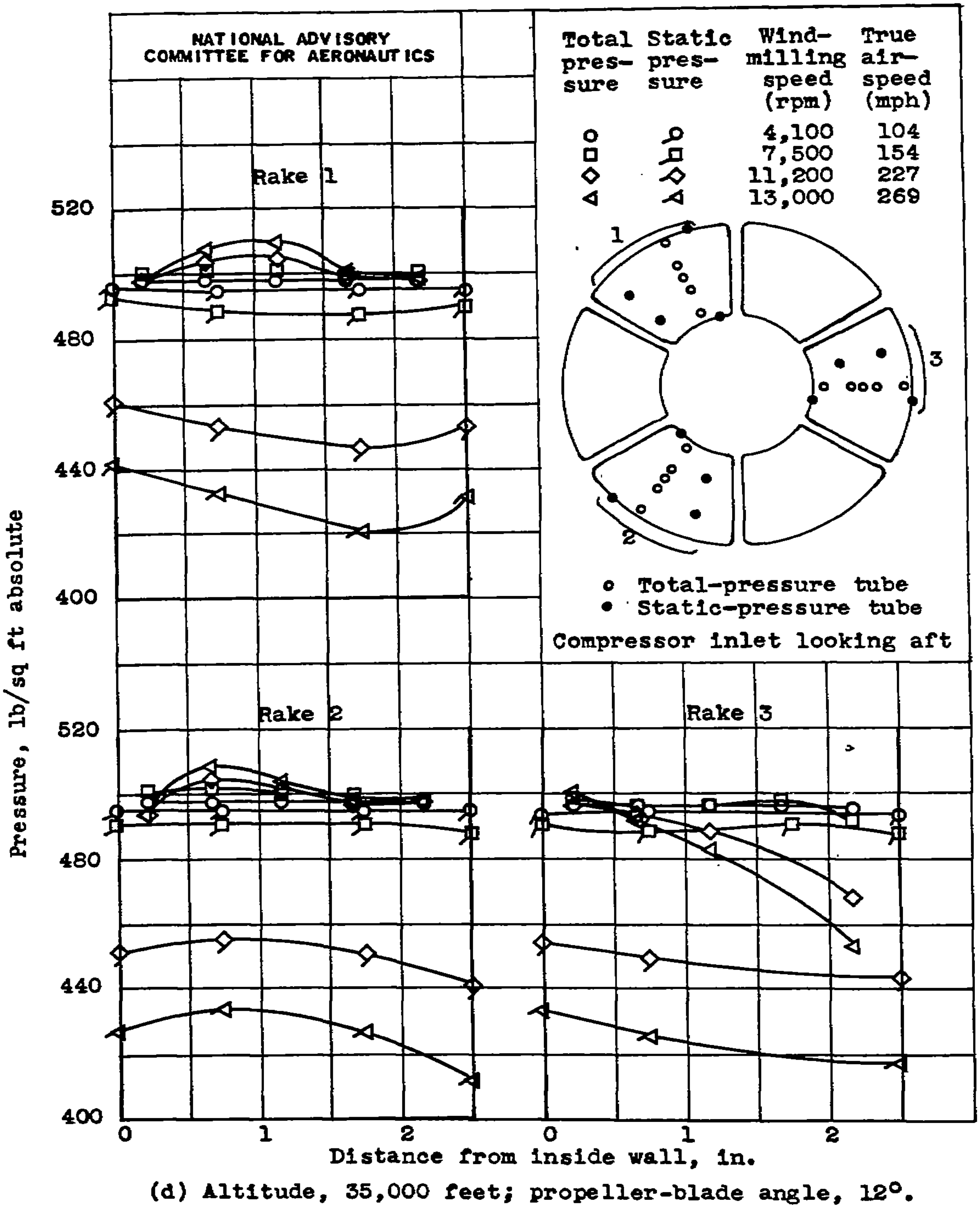
(b) Altitude, 15,000 feet; propeller-blade angle, 12°.

Figure 15. - Continued. Distribution of total and static pressures at compressor inlet.



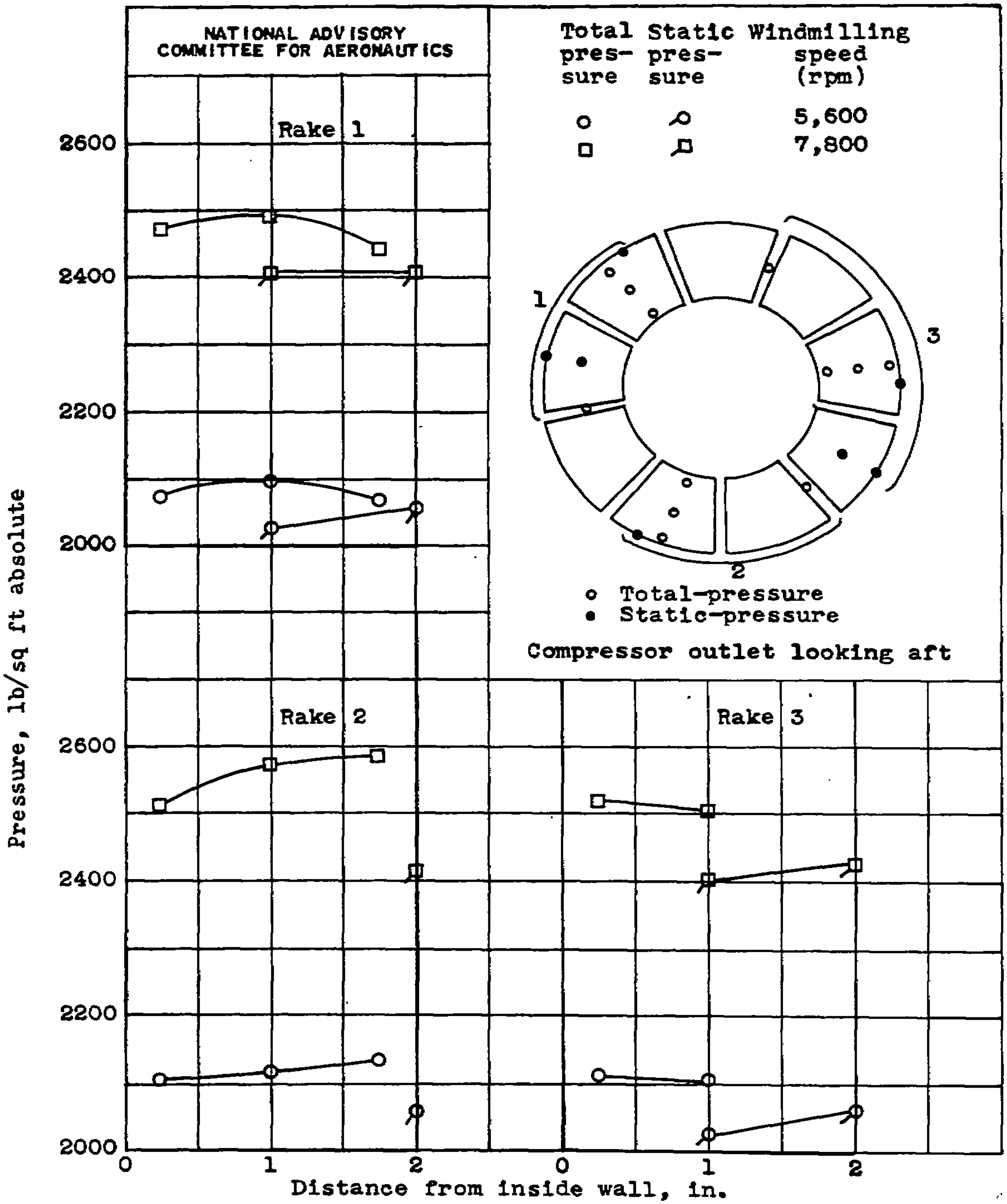
(c) Altitude, 25,000 feet; propeller-blade angle, 12°.

Figure 15. - Continued. Distribution of total and static pressures at compressor inlet.



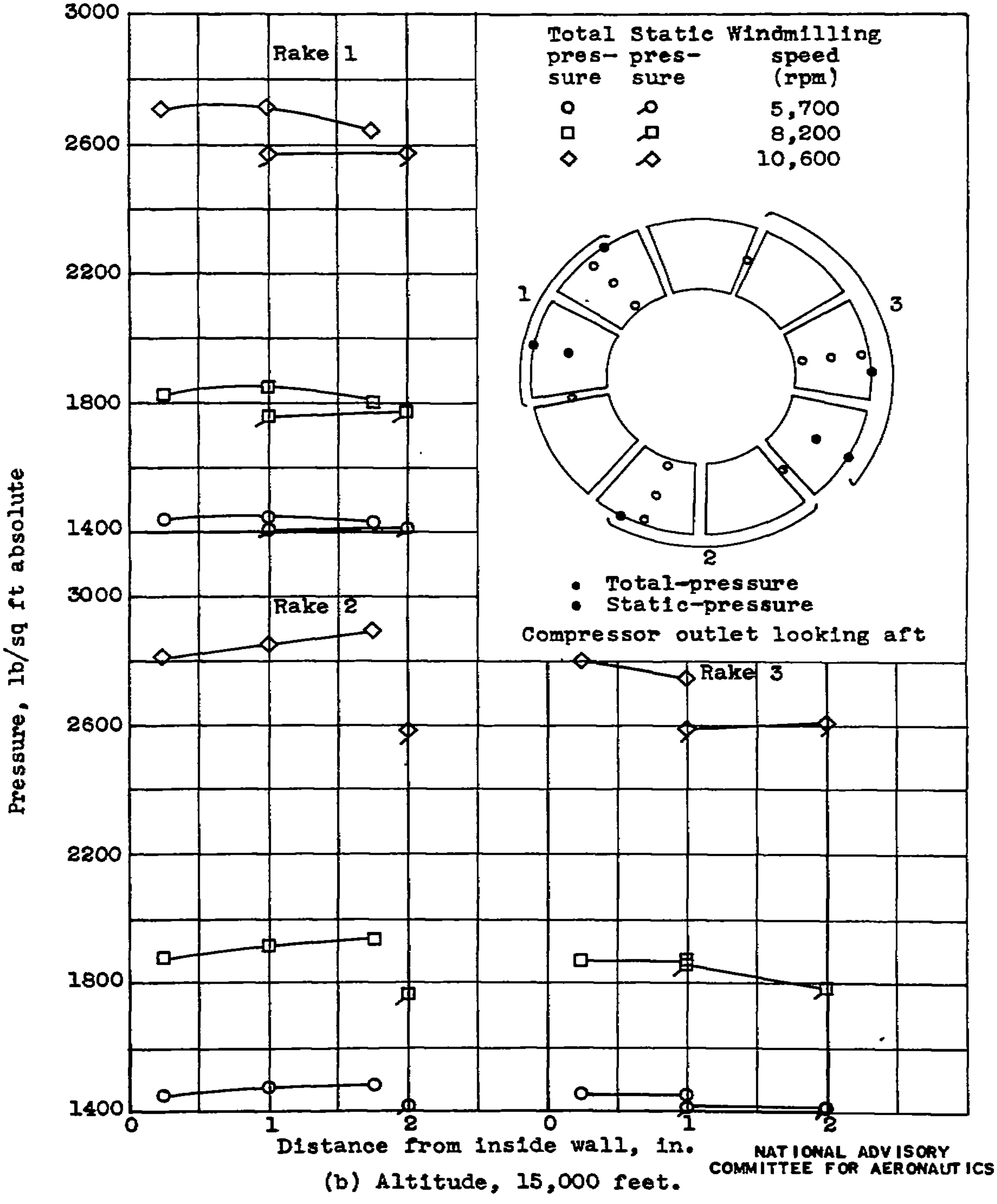
(d) Altitude, 35,000 feet; propeller-blade angle, 12°.

Figure 15. – Concluded. Distribution of total and static pressures at compressor inlet.



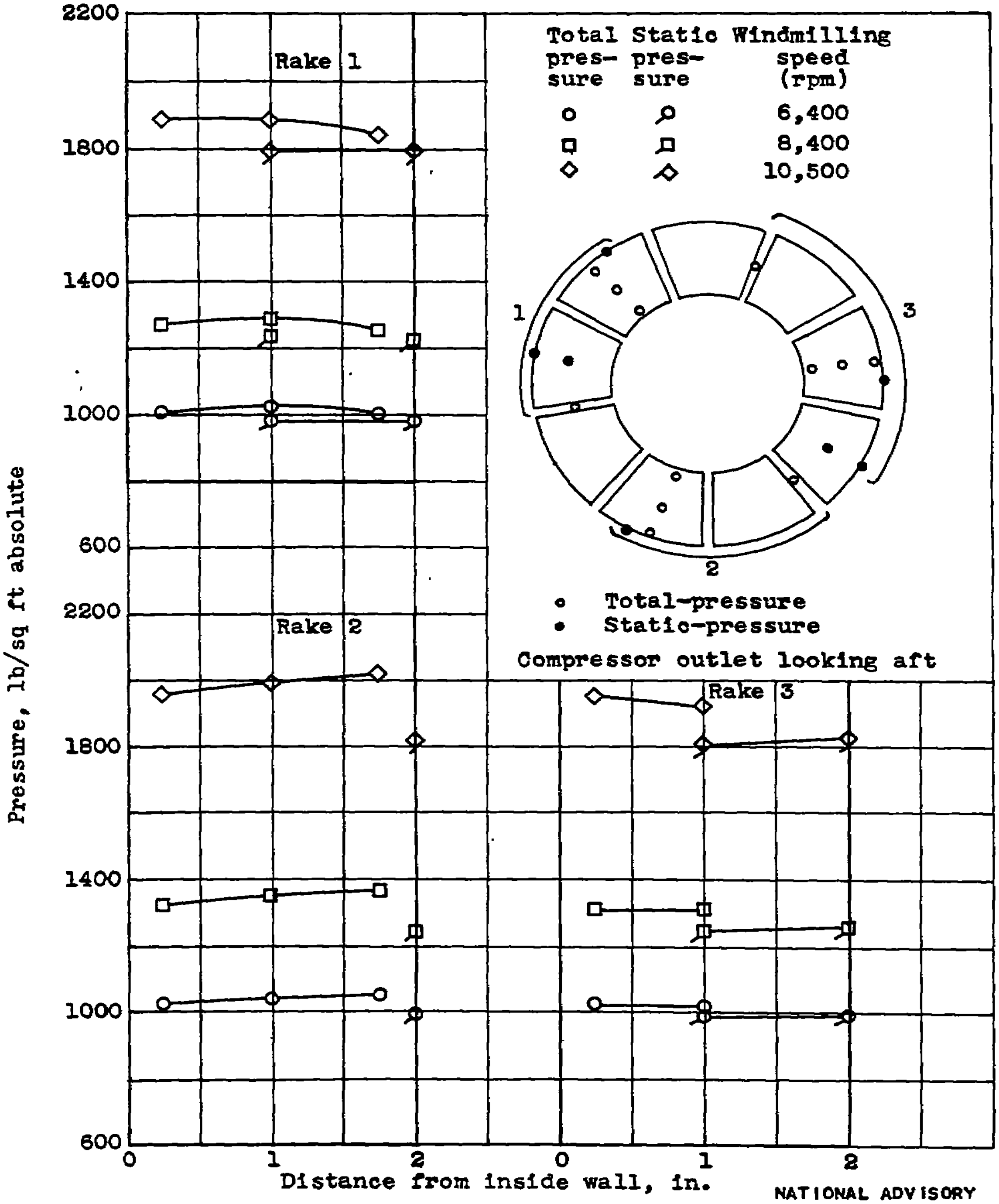
(a) Altitude, 5000 feet.

Figure 16. - Distribution of total and static pressures at compressor outlet.



(b) Altitude, 15,000 feet.

Figure 16. – Continued. Distribution of total and static pressures at compressor outlet.



(c) Altitude, 25,000 feet.

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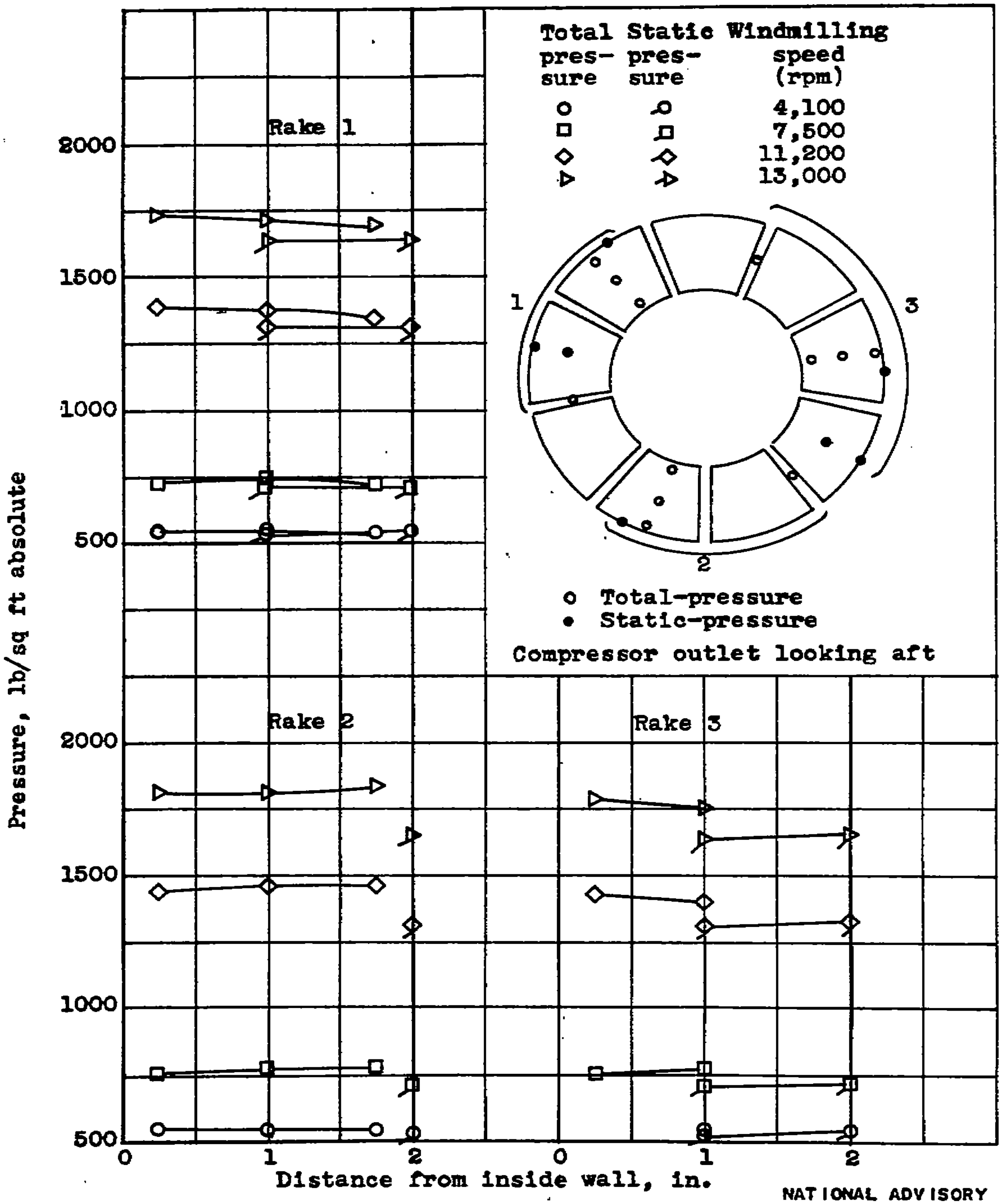
Figure 16. – Continued. Distribution of total and static pressures at compressor outlet.



(d) Altitude, 35,000 feet.

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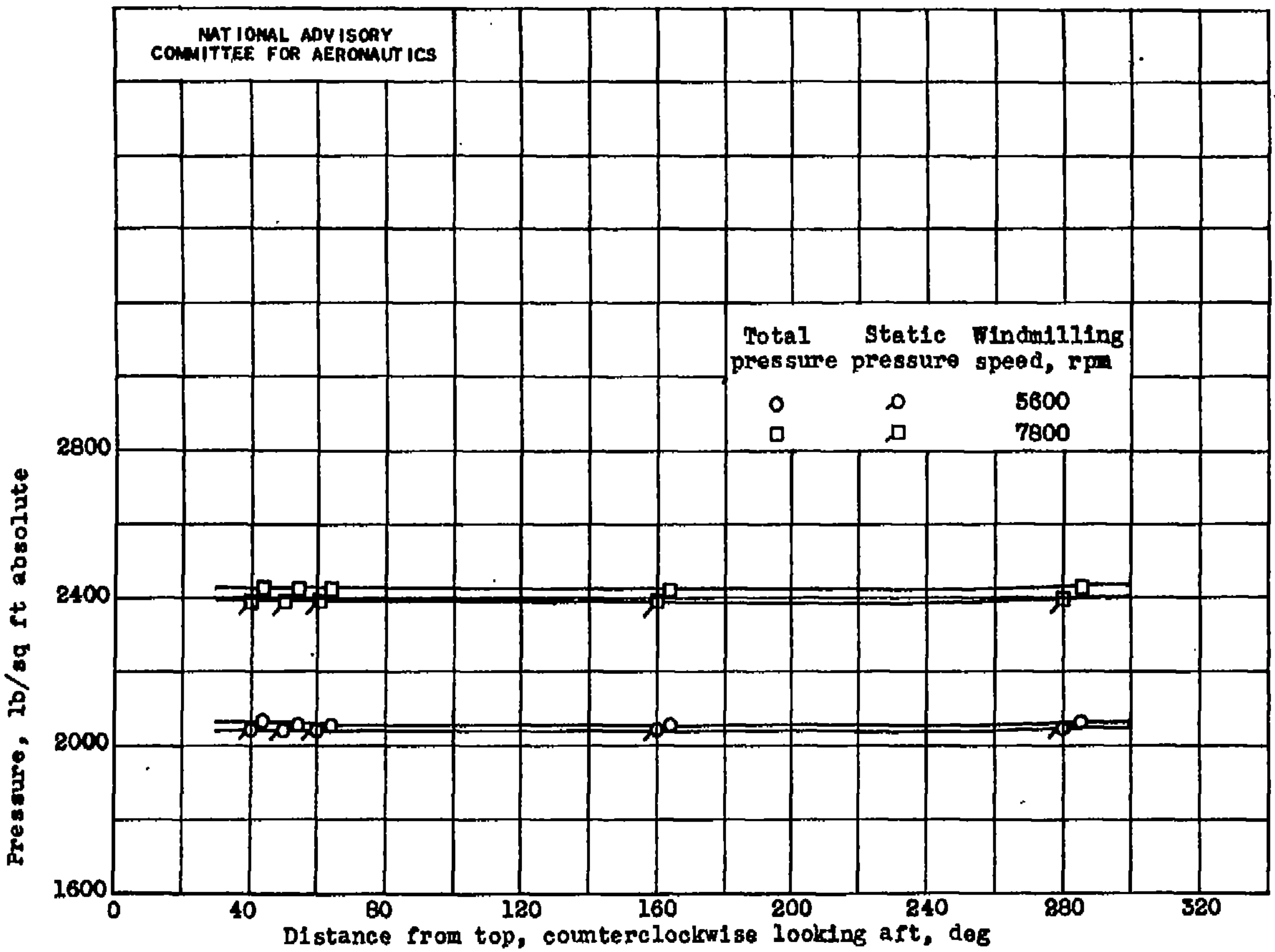
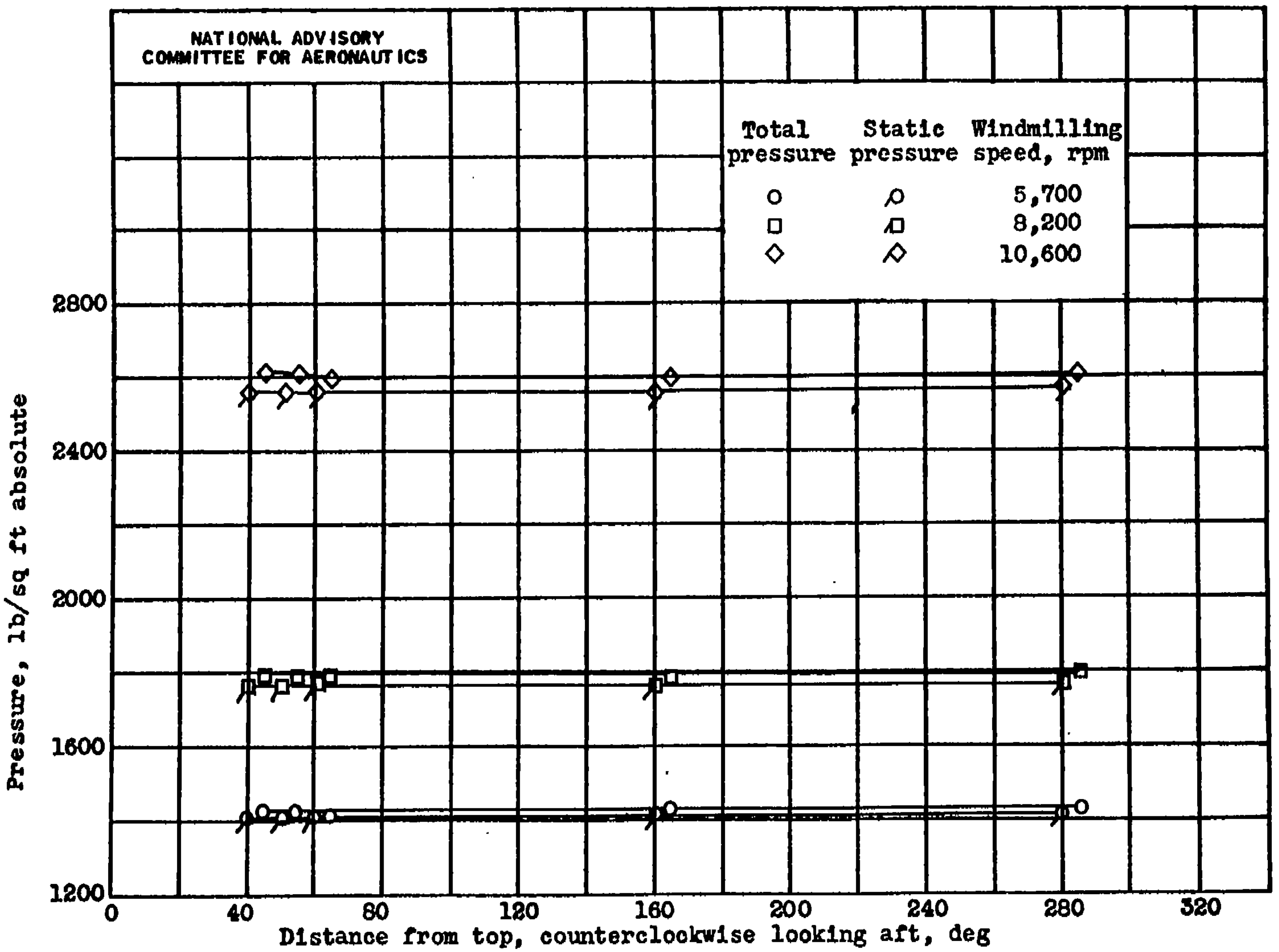
Figure 16. - Concluded. Distribution of total and static pressures at compressor outlet.



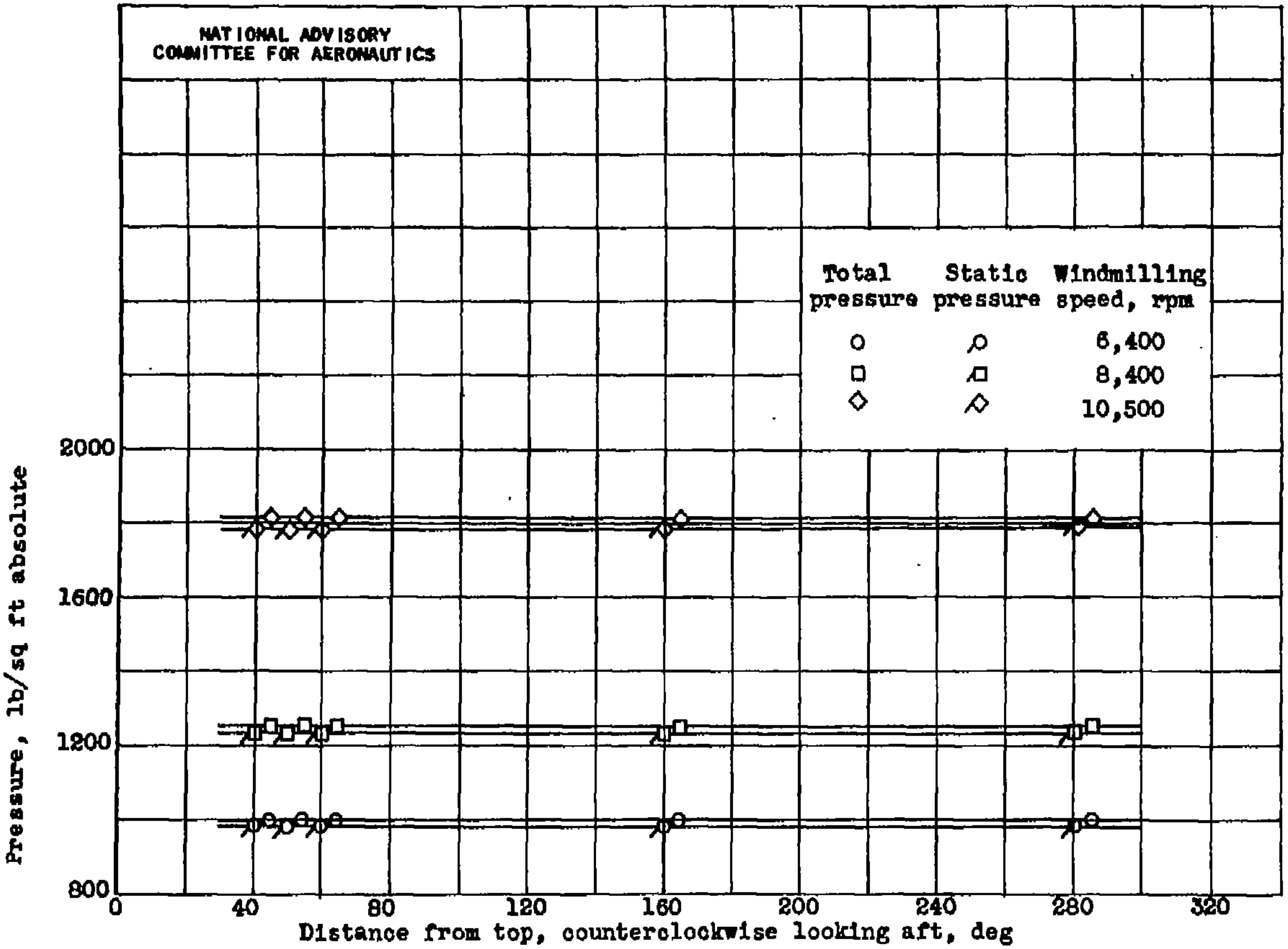
(a) Altitude, 5000 feet.

Figure 17. - Distribution of total and static pressures at turbine-nozzle inlet.



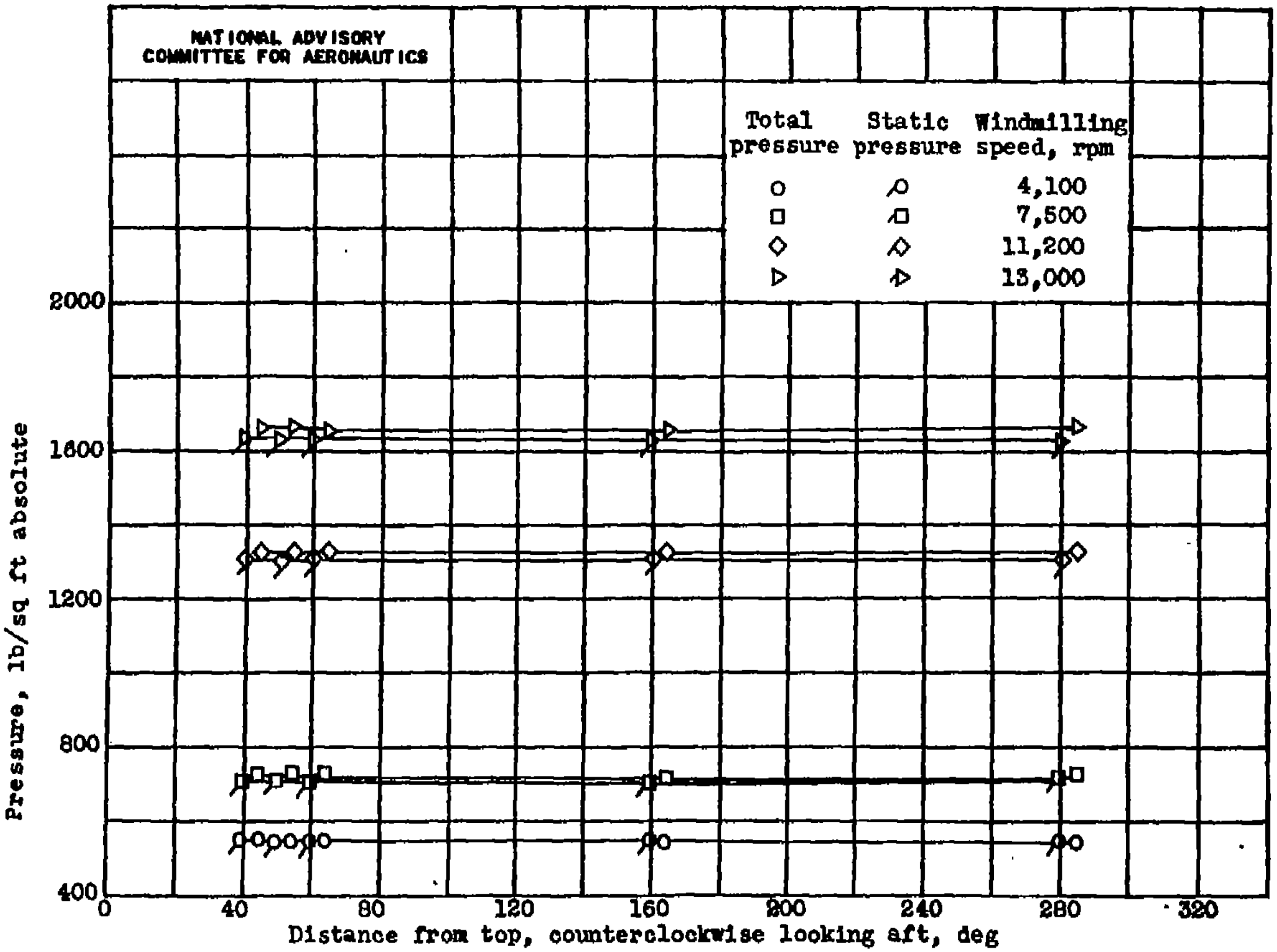
(b) Altitude, 15,000 feet.

Figure 17. – Continued. Distribution of total and static pressures at turbine-nozzle inlet.



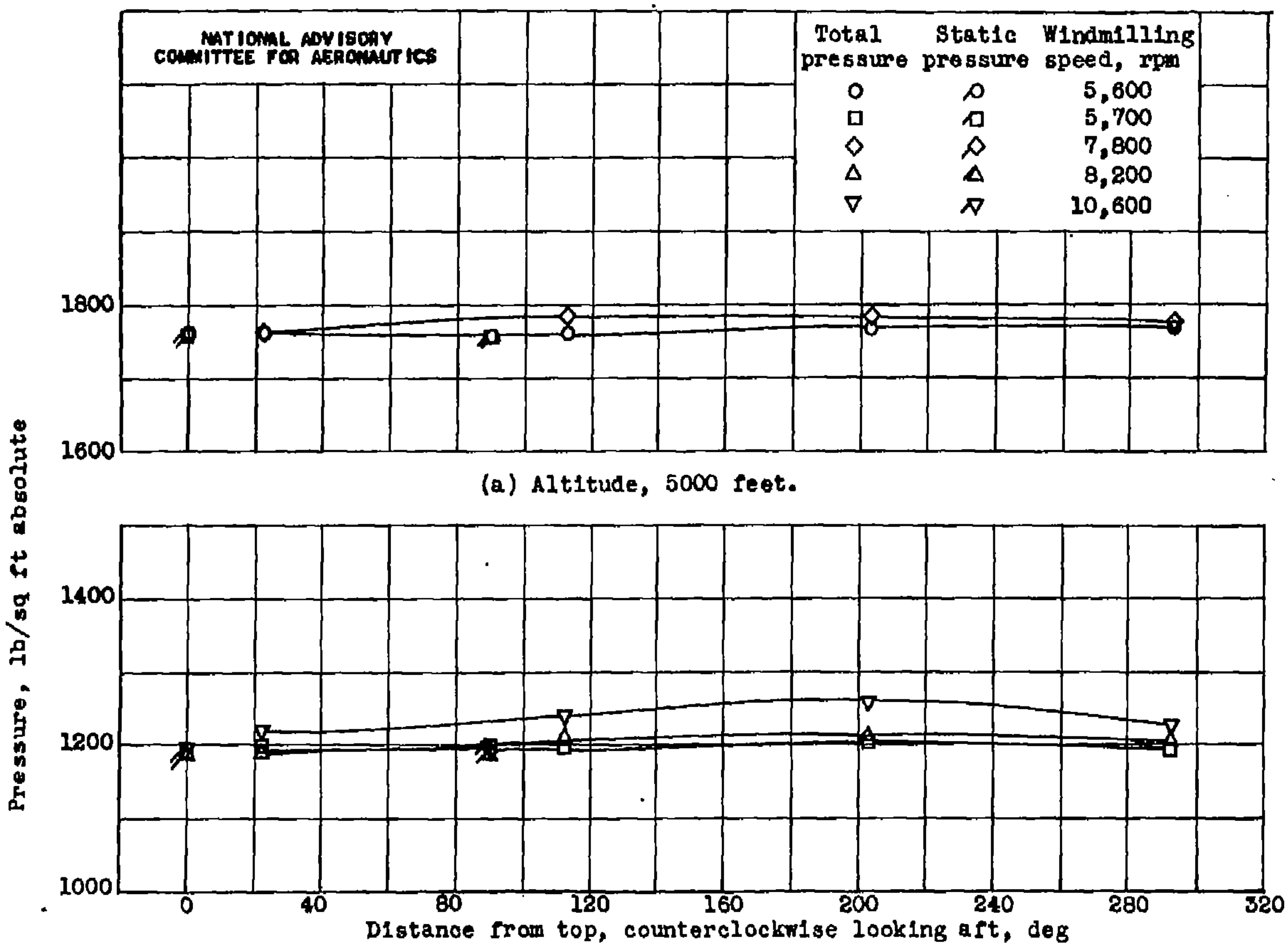
(c) Altitude, 25,000 feet.

Figure 17. - Continued. Distribution of total and static pressures at turbine-nozzle inlet.



(d) Altitude, 35,000 feet.

Figure 17. – Concluded. Distribution of total and static pressures at turbine-nozzle inlet.



(a) Altitude, 5000 feet.

(b) Altitude, 15,000 feet.

Figure 18. - Distribution of total and static pressures behind exhaust-cone outlet.

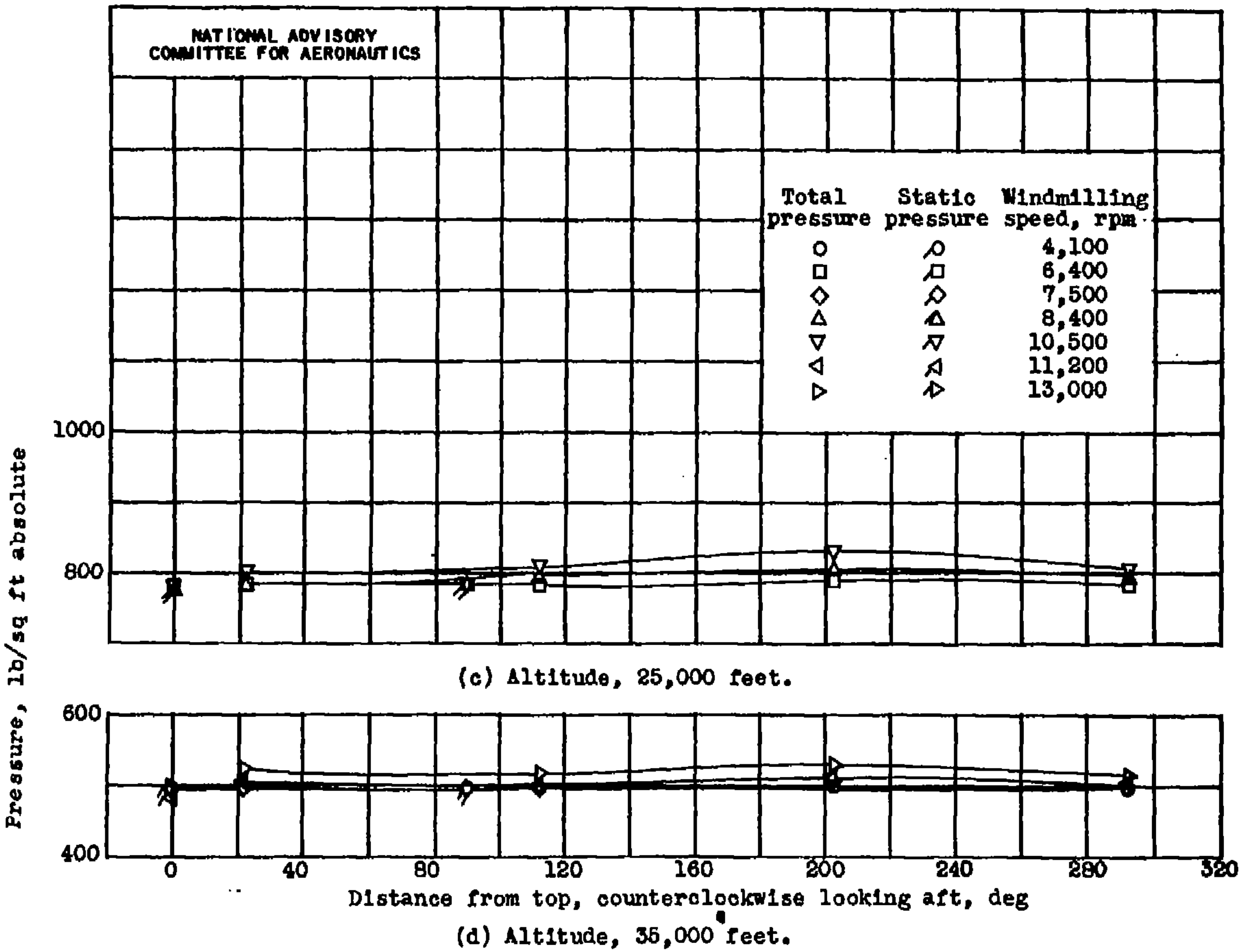
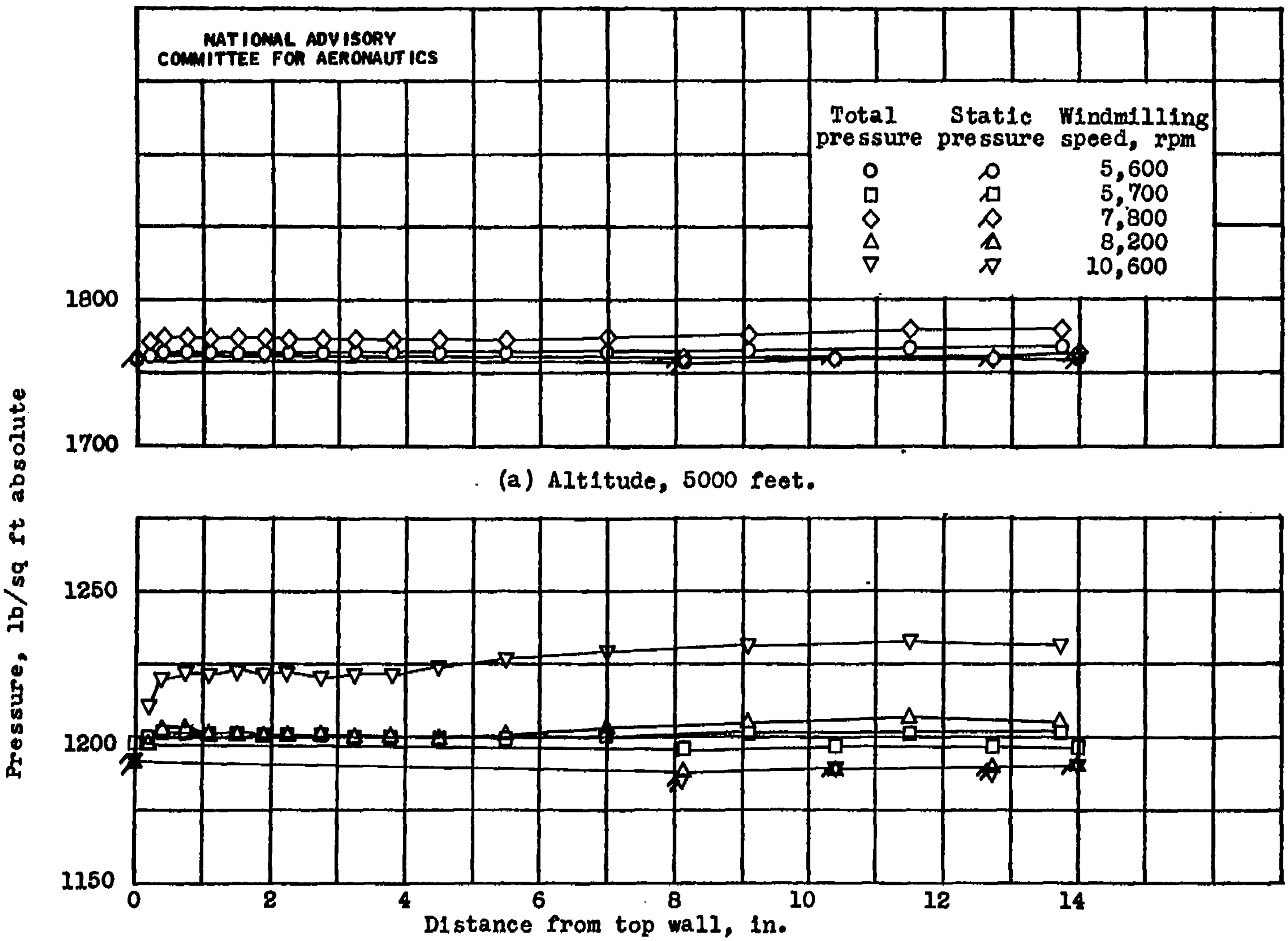


Figure 18. - Concluded. Distribution of total and static pressures behind exhaust-cone outlet.



(a) Altitude, 5000 feet.

(b) Altitude, 15,000 feet.

Figure 19. - Distribution of total and static pressures at tail-pipe-nozzle outlet.

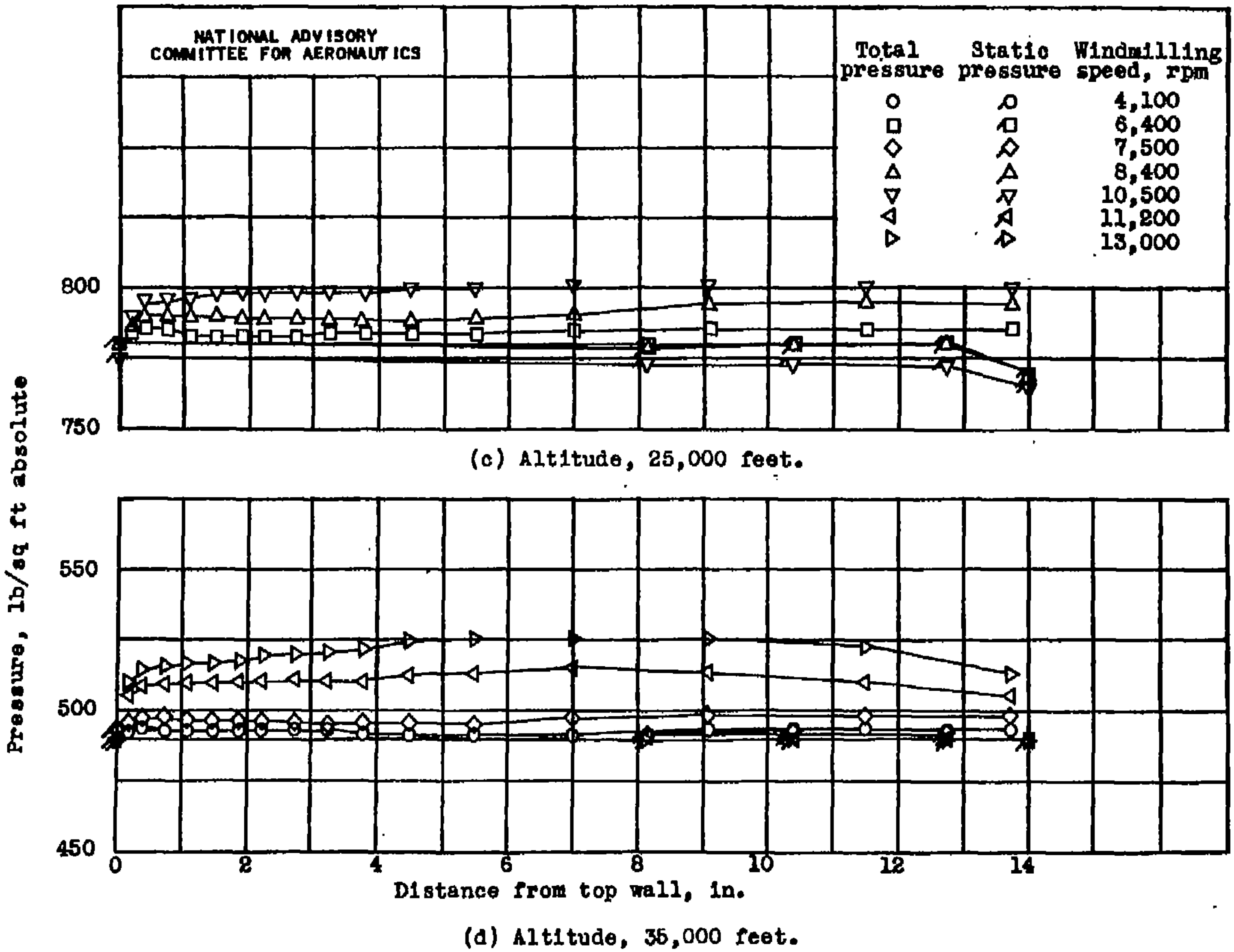


Figure 19. - Concluded. Distribution of total and static pressures at tail-pipe-nozzle outlet.