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RM-E7D25

Preliminary results of an altitude-wind-tunnel investigation of a TG-100A gas turbine-propeller engine II - Windmilling characteristics

National Advisory Committee for Aeronautics, Washington, D. C.

U.S. Eng. Restr. Aug'47 54 photos, tables, graphs

The windmilling characteristics of the TG-100A propeller turbojet engine were investigated in the wind tunnel for a range of altitudes from 5000 to 35,000 ft, true airspeeds from 100 to 273 mph, and propeller-blade angles from 4° to 46°. A windmilling speed of 13,000 rpm was obtained at maximum altitude, near maximum airspeed, and a propeller-blade angle of 16°. Excessive engine speeds would be obtained at an airspeed of 300 mph and blade angles from about 5° to 41°. Drag hp increased to 2647 with blade angle decreased to 6° and airspeed of 255 mph. Maximum engine windmilling speed for all conditions was obtained with blade angles between 10° and 16°. Maximum shaft hp was 612.

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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

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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

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 275 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 275 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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INDEX OF FIGURES

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-100A gas turbine-propeller engine in altitude wind tunnel.

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

Figure 4. - Variation of engine windmilling speed with propeller-blade angle and approximate true airspeed.
(a) Altitude, 5000 feet.
(b) Altitude, 15,000 feet.
(c) Altitude, 25,000 feet.
(d) Altitude, 35,000 feet.

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.
(a) Altitude, 5000 feet.
(b) Altitude, 15,000 feet.
(c) Altitude, 25,000 feet.
(d) Altitude, 35,000 feet.

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.

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, $T_{1,1}$ (°R)	Total pressure, P_1 (lb/sq ft abs.)	Static pressure, p_1 (lb/sq ft abs.)	Indicated temperature, $T_{1,1}$ (°R)
1	5,000	1760	423	148	93	4	2,480	2,519	12.08	1.84	2.15	40.4	1771	1770	482	1776	1774	422
2	5,000	1760	423	148	22	8	4,080	4,163	48.10	3.20	3.74	68.9	1757	1764	490	1773	1770	490
3	5,000	1760	425	149	23	8	5,400	5,548	82.90	4.35	5.10	57.5	1765	1752	420	1772	1757	490
4	5,000	1760	425	149	93	10	5,600	5,740	120.3	5.07	5.96	46.7	1757	1760	420	1773	1758	490
5	5,000	1760	424	149	23	12	5,450	5,527	190.3	5.05	5.95	32.7	1772	1766	491	1775	1771	421
6	5,000	1760	427	149	23	16	5,100	5,222	29.1	4.37	5.13	26.3	1776	1770	421	1778	1774	421
7	5,000	1760	427	148	22	20	4,600	4,710	82.0	4.40	5.15	20.7	1772	1774	421	1780	1779	421
8	5,000	1760	425	148	22	24	4,200	4,302	57.1	4.00	4.69	14.2	1750	1776	422	1781	1772	422
9	5,000	1760	427	148	22	28	3,700	3,782	50.5	3.12	3.74	10.2	1721	1778	422	1781	1772	422
10	5,000	1760	427	148	22	32	3,350	3,460	45.1	3.20	3.75	8.09	1781	1772	422	1782	1760	422
11	5,000	1760	428	225	92	32	5,100	5,228	99.1	4.51	5.44	5.81	1802	1802	426	1810	1804	426
12	9,000	1760	501	221	81	28	5,700	5,825	134.5	5.45	5.41	11.0	1808	1722	498	1809	1802	498
13	9,000	1760	501	225	82	24	5,450	6,522	------	6.21	7.30	15.2	1808	1798	500	1808	1800	500
14	5,000	1760	502	221	81	20	7,100	7,249	252.0	6.93	8.15	21.5	1803	1790	501	1804	1724	501
15	5,000	1760	503	226	82	16	7,750	7,905	------	8.88	6.22	22.4	1798	1723	503	1801	1782	502
16	5,000	1760	509	223	81	12	8,200	8,315	------	------	------	40.4	1786	1782	502	1794	1780	502
17	5,000	1760	513	213	46	10	7,600	7,878	351.5	7.57	8.01	48.5	1774	1752	511	1785	1773	510
18	5,000	1760	513	195	32	8	7,000	7,063	278.5	5.53	7.78	59.5	1752	1757	512	1790	1770	519
19	9,000	1760	515	208	42	6	5,480	5,488	134.3	4.65	5.55	57.7	1775	1767	515	1785	1772	515
20	5,000	1760	513	220	46	4	4,200	4,242	86.1	3.46	4.14	45.2	1725	1778	512	1792	1786	512
21	15,000	1190	464	150	19	4	3,080	3,233	31.2	1.76	3.00	45.7	1198	1127	472	1202	1201	472
22	15,000	1190	479	157	18	8	4,200	4,361	33.4	2.17	3.70	55.9	1196	1183	482	1200	1196	482
23	15,000	1197	457	155	16	8	9,400	8,702	57.0	3.27	9.47	58.7	1202	1197	475	1207	1203	478
24	15,000	1190	461	154	18	10	5,800	5,165	23.7	3.51	5.67	49.0	1198	1121	468	1201	1197	452
25	15,000	1197	482	154	18	12	9,700	8,063	93.1	3.53	5.28	40.6	1206	1201	468	1210	1206	470
26	15,000	1190	464	155	12	18	5,350	5,971	96.6	3.03	9.06	22.5	1203	1198	469	1205	1201	469
27	15,000	1190	463	154	18	20	4,850	5,146	63.7	3.05	5.11	18.6	1205	1201	465	1208	1203	466
28	15,000	1190	462	154	18	24	4,400	4,973	48.2	2.45	4.10	15.0	1206	1203	465	1207	1204	465
29	15,000	1190	453	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	453	154	18	32	3,500	3,714	26.7	1.61	3.30	8.2	1207	1205	466	1208	1205	466
31	15,000	1190	465	227	32	32	9,200	5,917	68.8	3.35	5.61	7.2	1296	1222	469	1227	1223	452
32	15,000	1190	455	251	40	98	5,200	5,260	104.3	4.35	7.22	10.2	1225	1212	469	1227	1222	469
33	15,000	1190	468	227	32	24	6,600	7,003	123.2	4.51	7.55	16.0	1225	1217	468	1225	1212	468
34	15,000	1190	468	227	39	20	7,200	7,540	175.2	5.11	2.55	22.3	1222	1212	462	1224	1215	468
35	15,000	1190	454	230	40	16	7,900	8,390	234.5	5.22	2.66	30.0	1217	1205	467	1221	1211	457
36	15,000	1120	454	227	32	12	8,200	2,708	278.2	6.24	10.45	40.7	1202	1196	467	1216	1206	467
37	15,000	1190	465	227	32	10	2,200	6,700	272.6	6.22	10.42	49.5	1204	1190	466	1213	1202	467
38	15,000	1197	465	227	40	8	7,500	7,985	221.4	5.38	0.26	56.2	1208	1127	468	1212	1209	452
39	15,000	1197	466	234	49	8	6,000	6,365	122.2	4.12	9.27	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	41.2	1210	1206	470	1216	1212	470
41	15,000	1197	465	272	60	4	4,700	4,991	80.5	3.10	5.15	41.1	1230	1224	470	1235	1231	470
42	15,000	1190	465	272	52	6	6,900	7,335	142.5	4.83	8.08	51.5	1216	1205	471	1226	1212	472
43	15,000	1190	466	284	82	8	2,000	2,567	330.0	7.24	12.11	52.1	1211	1191	472	1224	1208	473
44	15,000	1190	457	300	62	10	10,400	11,045	527.5	9.00	15.07	44.5	1218	1190	472	1230	1207	474
45	15,000	1190	457	307	72	12	10,600	11,266	513.5	2.61	16.07	37.2	1227	1197	468	1235	1211	472
46	15,000	1190	465	276	60	15	2,500	10,062	453.5	7.98	13.31	30.1	1233	1211	468	1235	1217	468
47	15,000	1197	466	290	68	20	2,200	2,760	432.5	7.88	13.11	21.8	1232	1231	470	1251	1235	470
48	15,000	1190	467	297	82	24	8,600	2,133	------	7.02	11.78	18.0	1260	1233	471	1250	1235	471
49	15,000	1190	468	302	70	28	7,900	6,390	------	------	------	11.9	1255	1242	473	1257	1245	473
50	15,000	1197	468	302	71	28	7,950	5,443	272.5	5.36	10.52	11.4	1243	1242	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	786	432	722	721	439
53	25,000	781	434	184	18	6	4,300	4,717	33.6	1.88	4.64	48.4	788	786	439	792	790	439
54	25,000	782	435	172	16	8	5,400	5,913	------	.86	2.11	55.1	793	789	438	797	724	440
55	25,000	781	452	187	18	10	6,400	6,880	72.5	2.94	7.41	45.3	787	782	439	791	787	439
56	25,000	781	434	179	17	12	8,400	7,081	90.5	3.13	7.73	40.5	789	784	440	792	788	440
57	25,000	788	434	179	17	16	8,100	8,692	79.8	2.77	5.78	31.5	798	794	441	801	767	442
58	25,000	-----	434	----	--	20	8,600	------	------	------	------	------	------	------	------	------	------	------
59	25,000	-----	434	----	--	24	4,950	------	------	------	------	------	------	------	------	------	------	------
60	25,000	781	434	179	17	28	4,600	5,045	39.8	1.57	4.62	11.2	797	794	440	797	795	441
61	25,000	-----	435	----	--	32	4,080	------	------	------	------	------	------	------	443	------	------	443
62	99,000	-----	436	----	--	38	3,300	------	------	------	------	------	------	------	------	------	------	------
63	25,000	788	442	181	17	41.4	3,000	3,251	11.0	1.24	3.06	4.3	804	802	448	804	803	446
64	25,000	781	433	241	31	4	4,200	4,624	51.3	1.66	4.08	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_0 (lb/sq ft abs.)	Static pressure, p_s (lb/sq ft abs.)	Indicated temperature, $t_{i,2}$ (°R)	Total pressure, p_0 (lb/sq ft abs.)	Static pressure, p_s (lb/sq ft abs.)	Indicated temperature, $t_{i,3}$ (°R)	Total pressure, p_0 (lb/sq ft abs.)	Static pressure, p_s (lb/sq ft abs.)	Indicated temperature, $t_{i,4}$ (°R)	Total pressure, p_0 (lb/sq ft abs.)	Static pressure, p_s (lb/sq ft abs.)	Total pressure, p_0 (lb/sq ft abs.)	Static pressure, p_s (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	1800	1740	1760	515	1760	1760	520	1760	1759	517
1769	1763	490	1886	1894	519	1922	1912	515	1895	1894	1707	1755	530	1760	1760	532	1760	1757	530
1764	1753	490	2066	2011	537	2083	2058	537	2017	2006	1678	1755	550	1754	1760	552	1753	1756	553
1766	1752	491	2112	2056	544	2088	2084	543	2059	2043	1672	1755	558	1754	1760	560	1755	1759	562
1769	1755	492	2107	2043	545	2081	2083	542	2042	2020	1675	1756	558	1754	1760	561	1755	1760	560
1772	1761	493	2042	1997	537	2029	2017	536	1999	1988	1687	1755	551	1754	1760	559	1755	1761	559
1775	1765	492	1993	1959	530	1983	1976	530	1957	1950	1699	1753	544	1752	1753	551	1755	1752	550
1777	1769	493	1950	1923	525	1943	1938	524	1921	1914	1709	1753	539	1754	1753	542	1755	1752	540
1778	1773	494	1914	1892	520	1906	1901	519	1885	1884	1712	1753	535	1752	1753	540	1755	1751	538
1779	1774	494	1884	1868	515	1882	1880	515	1868	1869	1717	1752	530	1751	1750	536	1754	1753	530
1804	1791	496	2087	2006	537	2044	2035	537	2007	1990	1691	1770	551	1755	1753	556	1770	1756	558
1801	1785	496	2133	2069	551	2117	2102	550	2077	2065	----	1773	566	1759	1753	570	1777	1756	571
1799	1778	500	2166	2175	569	2137	2222	560	2182	2164	----	1777	582	1771	1753	589	1774	1755	590
1792	1766	501	2360	2281	588	2357	2330	585	2092	2070	----	1782	600	1771	1753	606	1774	1754	600
1785	1756	502	2546	2414	602	2503	2475	604	2419	2397	----	1790	617	1790	1755	612	1774	1752	615
1775	----	509	2581	2506	620	2607	2574	612	2512	2491	----	----	633	1795	1756	642	----	1756	644
1766	1755	510	2536	2414	615	2497	2475	617	2423	2395	----	1787	631	1774	1757	649	1771	1757	646
1767	1745	512	2360	2250	600	2318	2305	599	2256	2238	1689	1775	610	1765	1757	636	1763	1755	630
1777	1755	515	2074	2015	564	2041	2049	557	2023	2013	1672	1761	586	1760	1757	599	1761	1755	595
1787	1779	515	1956	1924	550	1946	1945	546	1928	1919	1704	1755	565	1760	1757	565	1761	1757	560
1790	1784	478	1284	1258	503	1264	1254	503	1257	1253	1169	1189	520	1190	1190	530	1190	1190	521
1197	1193	465	1318	1298	515	1316	1310	514	1295	1290	1151	1189	530	1190	1190	530	1189	1190	530
1202	1194	460	1413	1373	526	1406	1388	524	1377	1372	1140	1190		1197	1197	540	1198	1195	545
1195	1185	472	1462	1417	529	1449	1436	527	1410	1405	1125	1189	545	1192	1190	550	1194	1189	550
1204	1194	472	1462	1417	529	1444	1440	525	1421	1409	1135	1204	541	1199	1197	549	1201	1197	550
1199	1197	472	1420	1384	524	1412	1405	521	1384	1376	1138	1197	----	1194	1190	545	1198	1191	540
1202	1195	469	1377	1349	510	1371	1363	509	1349	1345	1143	1197	538	1194	1190	530	1194	1191	537
1203	1198	469	1341	1321	507	1338	1331	501	1317	1314	1152	1194	520	1194	1194	526	1194	1192	521
1204	1200	470	1313	1298	498	1310	1307	470	1296	1289	1160	1194	515	1195	1194	520	1193	1192	511
1205	1202	469	1291	1277	494	1293	1289	494	1275	1274	1167	1192	510	1194	1194	512	1193	1192	510
1273	1214	470	1414	1383	514	1408	1401	514	1381	1373	1140	1199	530	1196	1194	530	1197	1193	529
1223	1209	470	1486	1432	526	1476	1461	524	1437	1428	1125	1201	540	1196	1194	540	1198	1194	540
1216	1202	470	1563	1510	466	1547	1549	540	1524	1514	1112	1206	551	1197	1194	550	1200	1193	556
1215	1193	469	1696	1609	585	1573	1655	567	1619	1600	1097	1211	565	1208	1201	569	1201	1193	570
1208	1181	459	1822	1717	572	1792	1767	574	1726	1707	1085	1216	581	1202	1190	585	1202	1191	590
1201	1171	469	1869	1774	582	1864	1831	585	1787	1763	1080	1220	590	1202	1190	598	1201	1189	600
1197	1157	469	1896	1777	584	1887	1831	588	1788	1761	1075	1219	592	1204	1187	600	1199	1187	602
1208	1188	470	1738	1663	569	1713	1694	569	1661	1639	1094	1214	590	1202	1194	590	1202	1195	590
1214	1201	473	1498	1445	537	1486	1472	536	1453	1440	1124	1200	557	1197	1194	560	1197	1193	560
1212	1207	472	1380	1298	507	1317	1310	508	1302	1298	1164	1190	577	1190	1187	540	1190	1188	535
1221	1224	474	1368	1340	511	1345	1339	509	1342	1334	1150	1197	559	1197	1187	531	1198	1188	530
1216	1198	474	1603	1533	549	1569	1567	551	1542	1526	1098	1199	561	1197	1187	560	1198	1185	560
1204	1162	475	2086	1940	606	2040	2011	610	1984	1974	1136	1232	609	1204	1187	600	1200	1184	615
1199	1132	476	2636	2436	657	2566	2524	663	2453	2415	1130	1291	641	1220	1187	646	1212	1186	650
1201	1125	474	2786	2590	669	2776	2679	676	2604	2549	1160	1310	647	1236	1187	650	1222	1188	660
1212	1162	466	2580	2186	628	2294	2264	630	2197	2162	1159	1262	622	1219	1194	538	1210	1192	639
1232	1184	470	2256	2098	617	2204	2160	620	2110	2078	1163	1260	617	1295	1197	630	1218	1201	630
1238	1197	472	2064	1935	600	2023	1993	603	1940	1916	1123	1236	599	1218	1201	520	1210	1196	615
1244	----	473	1663	1760	580	1653	1608	582	1767	1743	----	----	561	1209	1197	602	----	1198	601
1251	1221	473	1673	1766	578	1845	1817	580	1775	1752	1094	1230	585	1218	1208	598	1216	1206	598
----	1235	474	1715	1652	560	1594	1673	561	1630	1620	1113	1221	570	----	----	582	1213	----	583
791	789	445	834	829	475	837	837	475	830	827	785	780	490	781	781	500	781	780	490
790	788	445	880	867	480	878	873	479	869	858	783	781	496	781	781	498	780	779	491
793	792	445	954	928	494	950	947	494	930	923	749	789	510	788	788	510	789	788	508
798	776	461	1019	976	526	1011	1005	528	981	974	729	788	540	783	781	540	783	780	540
797	776	445	1034	994	514	1025	1020	514	995	986	728	789	527	783	781	530	784	781	529
796	797	446	1007	974	510	1003	992	510	977	967	740	795	524	790	788	530	791	788	524
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
794	790	446	----	----	485	----	----	488	----	----	784	786	501	783	781	508	784	785	500
----	----	448	----	----	480	----	----	479	----	----	----	----	491	----	----	497	----	----	490
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
805	801	454	848	838	471	846	841	478	836	837	776	789	480	790	792	480	790	790	475
792	791	449	874	861	488	878	869	483	869	868	756	788	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)	Normal static pressure, p_0 (lb/sq ft)	Tunnel indicated temperature, T_i (°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 (lb/sec)	Corrected air flow, $(W_a \sqrt{\theta})/\delta$ (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	22,000	781	431	234	30	5	5,060	5,879	78.7	2.77	5.60	53.4	793	787	432	799	795	440
66	25,000	761	433	241	31	8	7,500	8,368	140.9	3.95	9.72	52.9	790	781	439	799	791	440
67	25,000	721	441	237	30	10	8,300	9,058	170.4	4.40	10.93	45.5	794	784	445	800	791	446
68	25,000	781	440	237	30	12	9,400	9,173	203.2	4.25	11.31	39.7	796	785	445	802	793	445
69	25,000	781	442	234	22	15	5,100	8,829	175.2	4.91	10.46	32.5	800	791	445	804	797	442
70	25,000	----	440	---	--	20	7,250	------	-----	----	------	-----	---	---	444	---	---	445
71	25,000	----	438	---	--	24	6,700	------	-----	----	------	-----	---	---	---	---	---	---
72	25,000	788	440	237	30	28	6,100	6,661	82.5	2.89	5.51	11.2	815	810	445	815	812	445
73	25,000	----	435	---	--	39	5,400	------	-----	----	------	-----	---	---	---	---	---	---
74	22,000	----	435	---	--	38	4,800	------	-----	----	------	-----	---	---	---	---	---	---
75	25,000	781	433	241	31	41	4,000	4,404	37.3	1.93	4.75	6.96	810	807	436	810	809	438
76	25,000	774	435	306	50	4	4,800	5,066	35.8	2.07	5.14	38.1	803	800	447	806	803	443
77	25,000	781	436	304	50	5	7,300	8,023	106.7	3.76	9.27	49.3	804	794	444	813	806	445
78	25,000	781	437	304	50	8	9,050	9,955	-----	2.75	8.77	52.7	799	784	443	810	798	445
79	25,000	781	438	310	52	10	10,400	11,450	278.2	4.92	19.11	45.1	800	779	448	811	798	444
80	25,000	774	436	307	50	12	10,500	11,540	398.0	5.68	18.62	35.5	802	777	446	807	782	446
81	25,000	761	437	304	50	14	10,400	11,440	461.5	5.70	18.50	34.5	809	787	445	816	798	445
82	25,000	----	438	---	--	15	10,200	------	-----	----	------	-----	---	---	---	---	---	---
83	25,000	----	434	---	--	20	2,550	------	-----	----	------	-----	---	---	---	---	---	---
84	25,000	781	434	296	46	24	8,600	9,477	334.4	5.58	15.13	12.6	823	810	440	824	813	440
85	22,000	----	433	---	--	32	7,000	------	-----	----	------	-----	---	---	---	---	---	---
86	25,000	----	439	---	--	38	2,750	------	-----	----	------	-----	---	---	---	---	---	---
87	22,000	761	431	302	50	46	4,400	4,975	-----	----	------	3.8	829	823	437	829	827	437
88	35,000	500	417	160	9	4	1,700	1,901	-----	----	------	-----	506	506	423	506	506	418
89	35,000	493	418	152	8	8	3,000	3,350	-----	----	------	-----	497	496	422	499	499	420
90	35,000	----	417	---	--	8	3,000	------	-----	----	------	-----	---	---	---	---	---	---
91	35,000	----	418	---	--	10	3,500	------	-----	----	------	-----	---	---	---	---	---	---
92	35,000	493	415	151	8	12	4,100	4,600	38.2	1.53	5.09	-----	497	496	418	498	498	418
93	35,000	500	418	141	7	15	4,400	4,940	34.5	1.38	5.10	-----	504	503	418	505	505	413
94	35,000	493	414	151	8	20	4,250	4,770	19.3	.75	9.98	-----	498	497	415	429	498	415
95	35,000	----	414	---	--	24	4,000	------	-----	----	------	-----	---	---	---	---	---	---
96	35,000	493	414	151	18	28	3,650	4,100	91.2	1.08	4.13	-----	489	498	417	500	499	415
97	35,000	----	413	---	--	32	3,600	------	-----	----	------	-----	---	---	---	---	---	---
98	35,000	493	413	151	--	46	2,200	2,470	19.5	.60	3.05	-----	500	500	415	500	500	412
99	35,000	493	420	228	18	4	3,050	3,410	-----	----	------	33.8	504	504	423	505	504	423
100	35,000	493	420	228	18	8	4,100	4,570	18.2	.50	3.07	38.8	501	500	423	505	503	423
101	35,000	----	420	---	--	8	5,500	------	-----	----	------	-----	---	---	---	---	---	---
102	35,000	----	419	---	--	10	7,400	------	-----	----	------	-----	---	---	---	---	---	---
103	35,000	493	419	219	17	12	7,500	8,360	66.1	2.40	9.21	39.7	501	497	420	504	501	421
104	35,000	493	418	234	19	15	7,600	8,420	101.7	2.67	8.68	29.9	503	497	420	507	502	420
105	35,000	493	418	227	18	20	7,000	7,280	148.8	3.96	13.14	23.0	506	501	420	508	504	420
106	35,000	----	418	---	--	24	8,350	------	-----	----	------	-----	---	---	---	---	---	---
107	35,000	----	417	---	--	32	8,100	------	-----	----	------	-----	---	---	---	---	---	---
108	35,000	493	418	227	18	46	3,100	3,490	18.8	.81	3.10	3.11	510	509	420	510	510	420
109	35,000	500	433	332	32	4	4,700	5,196	35.5	1.56	5.05	-----	522	520	435	523	519	435
110	35,000	493	434	333	36	8	7,600	8,288	89.9	2.36	10.92	-----	509	508	434	512	511	434
111	35,000	486	434	333	38	8	9,750	10,774	184.0	3.83	15.09	-----	498	488	434	508	498	434
112	35,000	493	434	331	36	10	10,700	11,824	273.4	4.51	17.91	-----	507	490	431	516	503	434
113	35,000	493	434	331	36	12	11,200	19,378	317.2	4.90	19.03	-----	511	493	435	518	503	434
114	35,000	493	432	334	39	15	11,200	19,410	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	10,787	228.5	3.93	18.20	-----	525	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	54	4	5,600	5,233	74.7	2.01	7.75	-----	527	520	440	528	519	437
120	35,000	493	439	375	49	8	6,600	9,477	140.4	3.35	13.09	-----	511	501	443	523	513	443
121	35,000	493	440	365	45	8	10,700	11,770	958.0	4.59	17.91	-----	507	489	441	520	506	443
122	35,000	493	440	375	48	10	12,300	13,542	411.3	5.48	21.36	-----	519	499	442	523	508	444
123	35,000	493	442	392	53	12	13,000	14,300	489.0	5.86	22.53	-----	519	494	444	527	507	445
124	35,000	493	442	402	53	15	13,100	14,410	598.3	5.94	23.18	-----	528	506	446	534	513	445
125	35,000	493	442	325	54	20	12,400	13,640	451.2	5.85	22.06	-----	533	509	446	537	517	445
126	35,000	----	439	---	--	24	11,550	------	-----	----	------	-----	---	---	---	---	---	---
127	35,000	500	436	298	56	32	9,425	10,458	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	11.27	-----	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 rake			Turbine inlet		Turbine outlet			Exhaust-cone outlet			Tail-pipe nozzle outlet		
Total pressure, P_0 (lb/sq ft abs.)	Static pressure, p_0 (lb/sq ft abs.)	Indicated temperature, $T_{1,2}$ (°R)	Total pressure, P_0 (lb/sq ft abs.)	Static pressure, p_0 (lb/sq ft abs.)	Indicated temperature, $T_{1,3}$ (°R)	Total pressure, P_0 (lb/sq ft abs.)	Static pressure, p_0 (lb/sq ft abs.)	Indicated temperature, $T_{1,4}$ (°R)	Total pressure, P_0 (lb/sq ft abs.)	Static pressure, p_0 (lb/sq ft abs.)	Total pressure, P_0 (lb/sq ft abs.)	Static pressure, p_0 (lb/sq ft abs.)	Indicated temperature, $T_{1,6}$ (°R)	Total pressure, P_7 (lb/sq ft abs.)	Static pressure, p_7 (lb/sq ft abs.)	Indicated temperature, $T_{1,7}$ (°R)	Total pressure, P_8 (lb/sq ft abs.)	Static pressure, p_8 (lb/sq ft abs.)	Indicated temperature, $T_{1,8}$ (°R)
794	785	445	----	----	505	----	----	506	----	----	730	784	525	781	781	529	781	778	530
799	771	444	1168	1119	535	1168	1158	540	----	1113	712	794	547	785	778	548	784	778	553
799	787	449	1305	1233	551	1291	1254	565	1231	1213	708	803	560	790	781	561	787	779	570
799	785	447	1329	1243	557	1305	1255	570	1258	1236	709	809	566	793	778	577	788	780	580
794	774	450	1275	1196	593	1251	1232	586	1208	1185	712	806	555	790	781	572	789	781	578
----	----	447	----	----	548	----	----	547	----	----	----	----	554	----	----	570	----	----	570
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811	803	447	1024	987	517	1015	1006	515	988	981	744	797	551	793	792	540	795	791	540
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809	808	443	874	859	477	877	859	477	888	857	761	784	492	783	781	500	785	786	490
804	799	451	897	880	487	898	884	487	880	876	755	775	480	774	774	503	774	775	498
804	788	448	1130	1089	533	1116	1101	535	1078	1066	714	798	536	781	778	530	788	777	531
794	785	445	1478	1368	560	1445	1419	567	1379	1358	724	820	570	783	778	550	787	776	570
788	755	445	1920	1776	634	1572	1541	641	1798	1769	757	854	603	808	781	610	----	778	612
781	727	446	1850	1808	641	1699	1669	649	1816	1784	752	845	609	809	781	620	797	773	621
791	738	448	1936	1783	637	1886	1855	----	1801	1771	755	856	604	808	781	620	804	781	620
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812	763	441	1429	1336	574	1399	1376	578	1341	1390	758	859	568	789	784	590	802	785	590
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827	----	440	927	901	487	898	898	484	884	879	----	----	501	788	784	516	----	787	510
808	----	438	518	514	488	521	521	488	518	512	----	----	474	497	490	474	----	500	470
499	488	442	533	521	493	529	527	490	564	553	457	493	530	493	493	540	492	496	547
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488	496	432	550	546	474	554	558	473	548	543	475	494	500	493	493	510	493	493	518
504	501	486	571	560	478	572	570	470	560	557	482	499	496	500	500	505	500	500	500
488	497	486	556	548	499	566	556	487	546	545	477	494	490	493	493	500	494	494	490
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
499	497	487	538	535	489	542	546	481	535	534	481	494	480	493	493	485	494	494	480
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500	499	489	515	515	489	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
505	502	432	548	540	478	553	553	475	536	536	476	491	490	493	493	499	493	492	490
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499	499	428	788	780	523	780	729	595	724	714	450	487	530	497	493	479	497	492	531
500	488	426	770	758	524	781	754	525	733	725	481	504	530	500	500	537	497	493	536
503	476	426	716	685	514	713	704	514	687	683	471	----	524	497	493	534	518	494	530
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509	508	430	531	531	465	538	538	463	529	528	485	496	400	496	493	490	496	496	481
512	518	444	572	590	486	574	570	485	563	500	477	497	507	496	493	510	497	496	510
510	498	440	739	695	532	727	722	534	700	590	445	498	540	491	488	540	490	488	540
494	467	436	1060	980	599	1040	1021	605	990	973	440	515	582	488	479	578	493	490	586
498	456	437	1310	1210	640	1275	1250	646	1218	1204	472	535	608	497	486	610	506	487	618
498	450	436	1427	1316	658	1391	1353	667	1324	1302	474	545	620	500	490	625	510	490	629
500	451	434	1456	1346	660	1418	1394	669	1355	1325	479	549	619	506	493	630	512	493	630
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
513	499	435	1128	1045	605	1100	1081	619	1045	1031	457	533	587	504	493	600	506	495	600
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
526	523	436	586	567	502	581	577	500	566	564	475	497	529	497	486	549	496	496	540
526	519	447	606	588	515	605	596	515	588	584	459	488	539	486	485	536	486	489	550
516	492	445	850	817	573	864	849	577	827	814	441	507	571	490	486	565	481	486	573
500	450	445	1222	1178	645	1250	1222	663	1190	1172	456	533	611	497	486	609	503	486	615
464	433	445	1528	1505	705	1586	1555	717	1514	1490	497	555	658	507	486	664	513	486	666
496	425	446	1781	1647	734	1737	1705	745	1689	1630	517	586	690	519	493	690	519	486	686
500	427	445	1836	1699	736	1790	1757	761	1710	1662	528	593	683	519	493	704	523	492	706
508	445	445	1719	1585	715	1675	1648	726	1568	1573	512	578	650	515	493	678	501	495	680
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
541	514	443	1098	1020	611	1074	1050	615	1029	1007	525	540	598	518	507	615	515	504	615
539	525	442	829	780	562	815	803	565	782	769	455	515	569	502	493	582	501	497	585

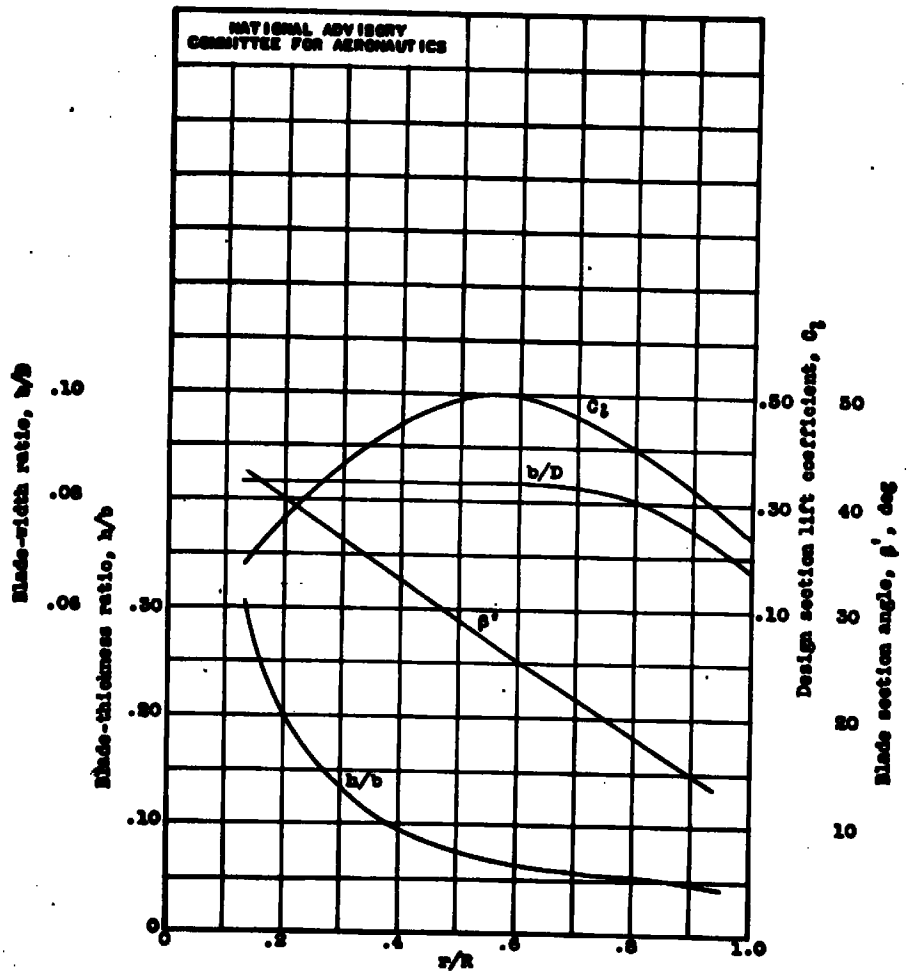


Figure 1. - Blade-form curves for Hamilton-Standard 4260 four-blade propeller. b, section chord; D, propeller diameter; h, section thickness; R, radius to tip; r, section radius.

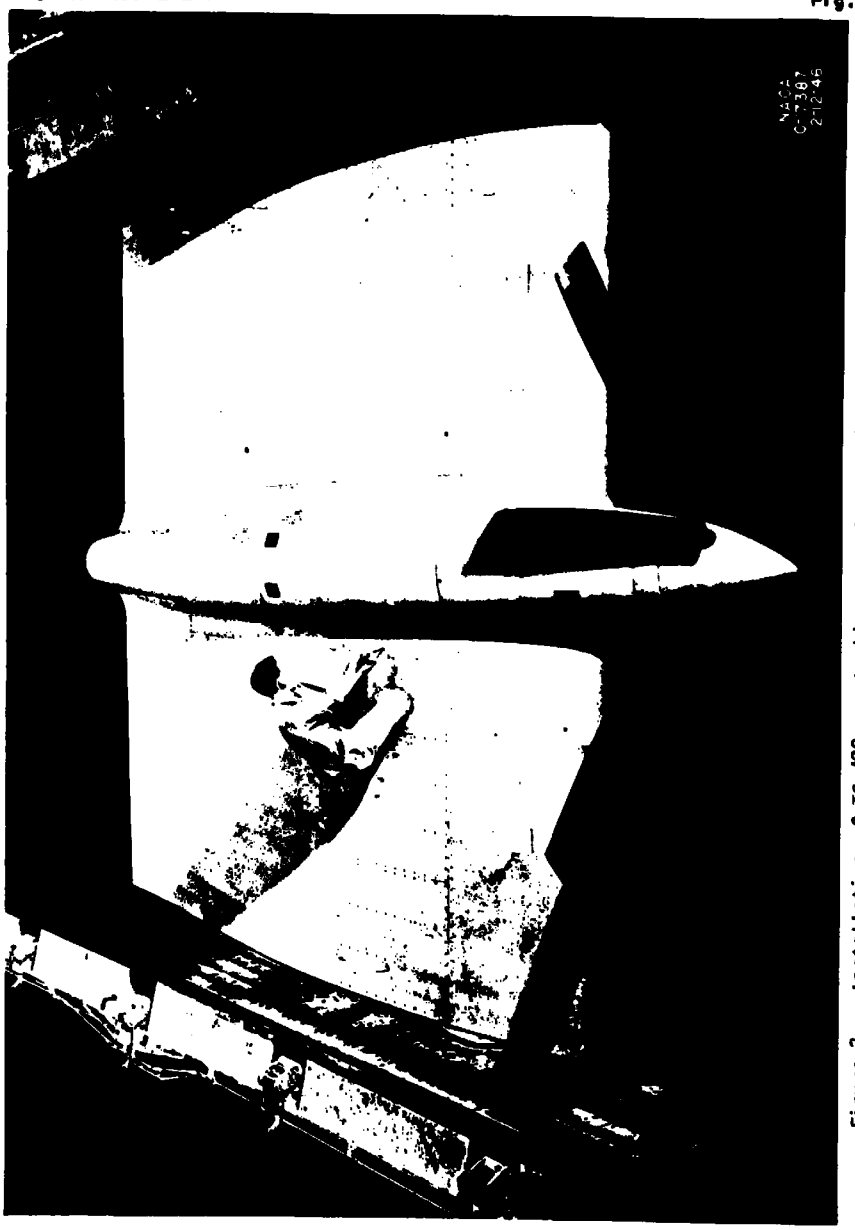


Figure 2. - Installation of TG-100 gas turbine-propeller engine in altitude wind tunnel.

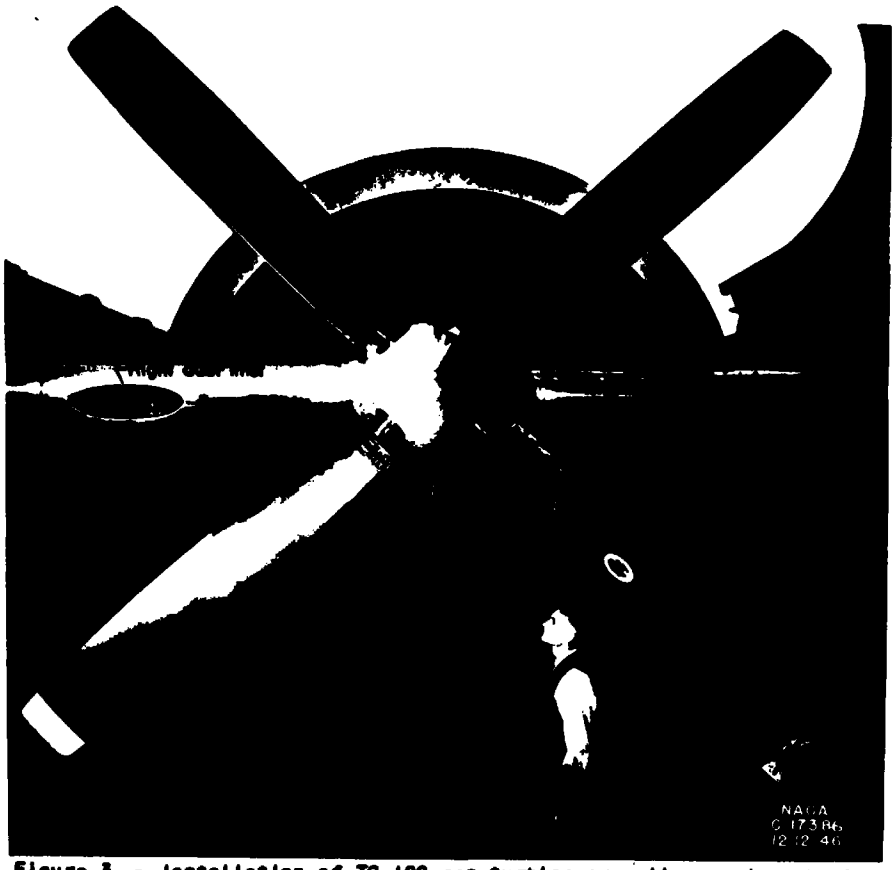


Figure 3. - Installation of TG-100 gas turbine-propeller engine showing wing duct inlets.

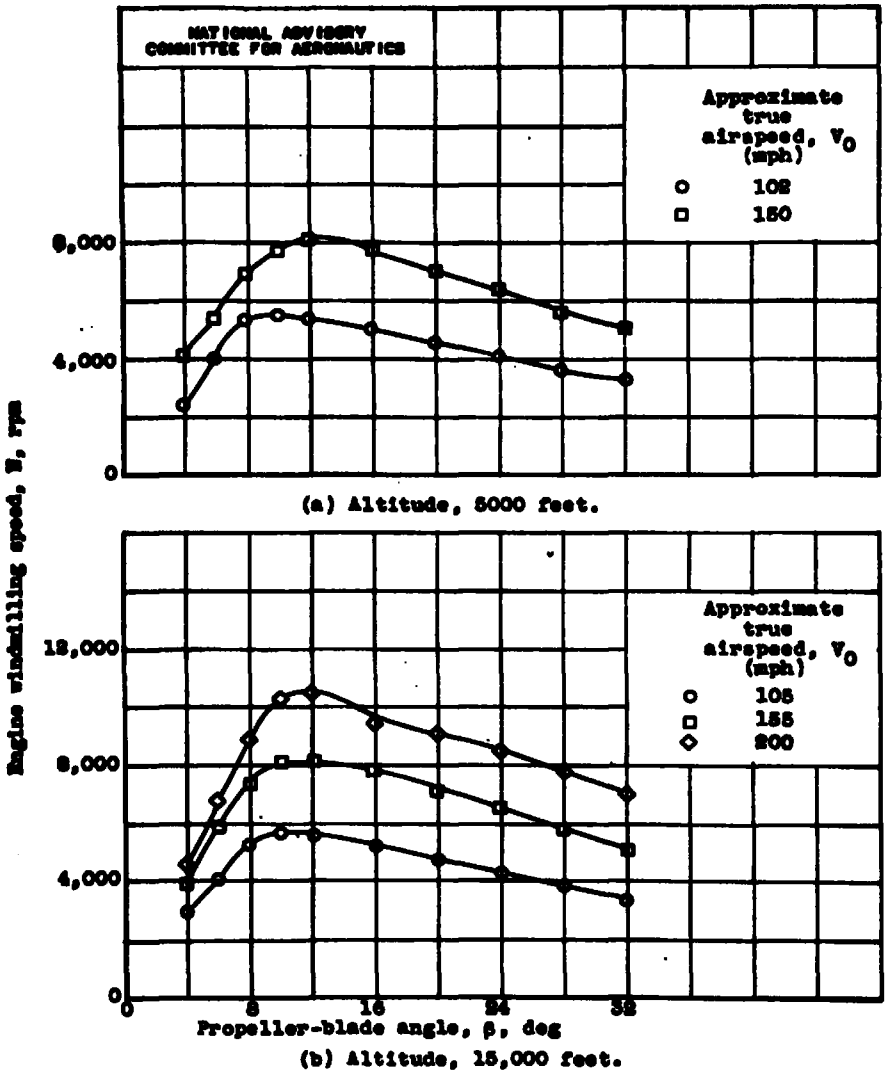
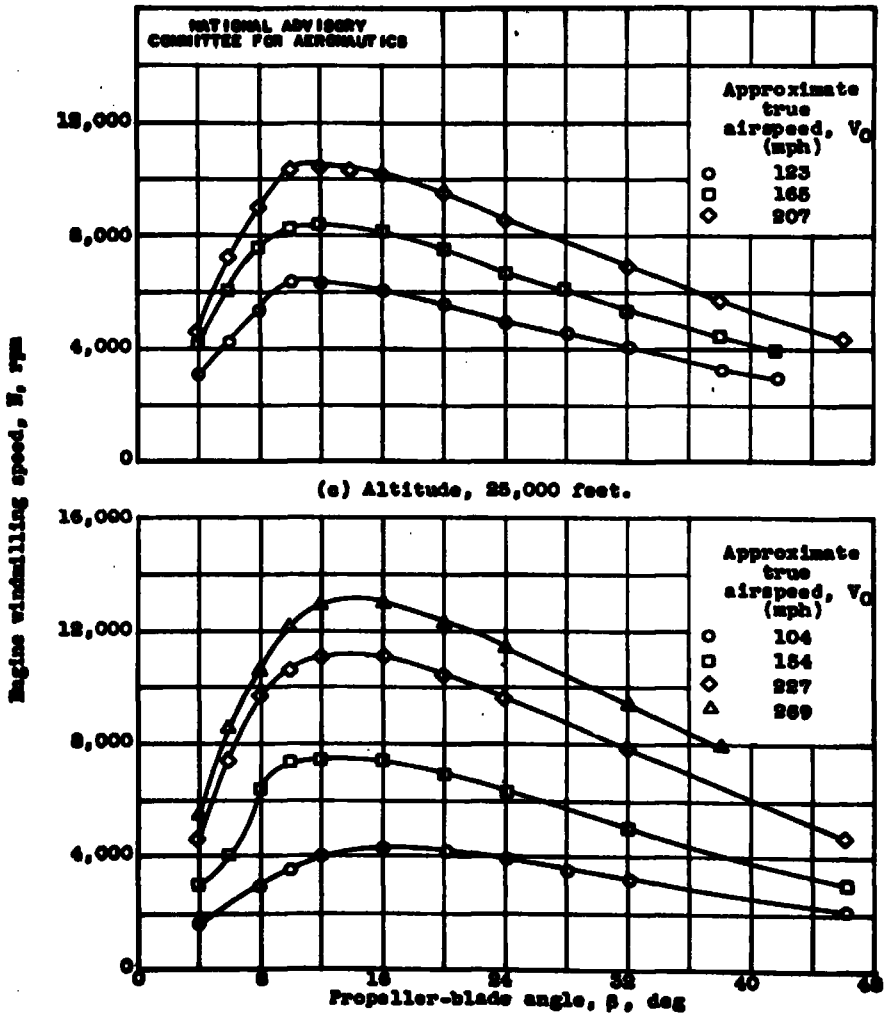


Figure 4. - Variation of engine windmilling speed with propeller-blade angle and approximate true airspeed.



(c) Altitude, 25,000 feet.

(d) Altitude, 35,000 feet.

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

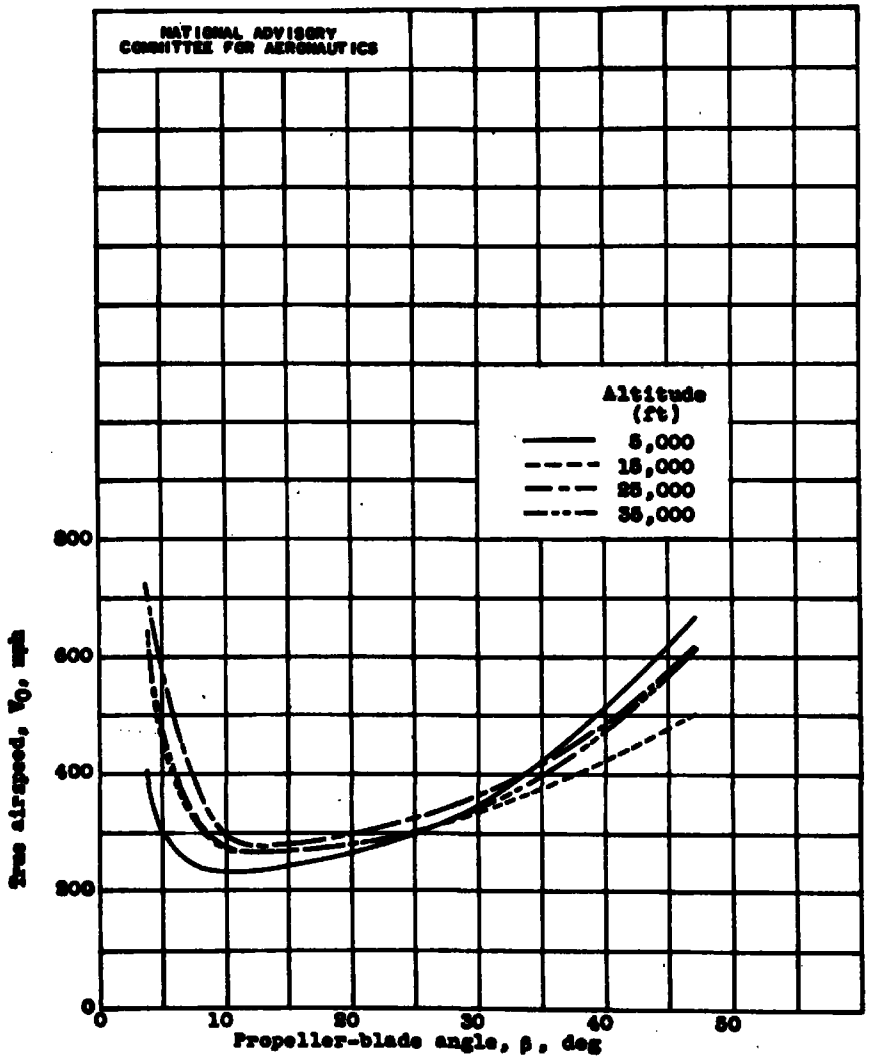


Figure 5. - Relation between true airspeed and propeller-blade angle at engine speed of 13,000 rpm. (Data cross-plotted and extrapolated from fig. 4.)

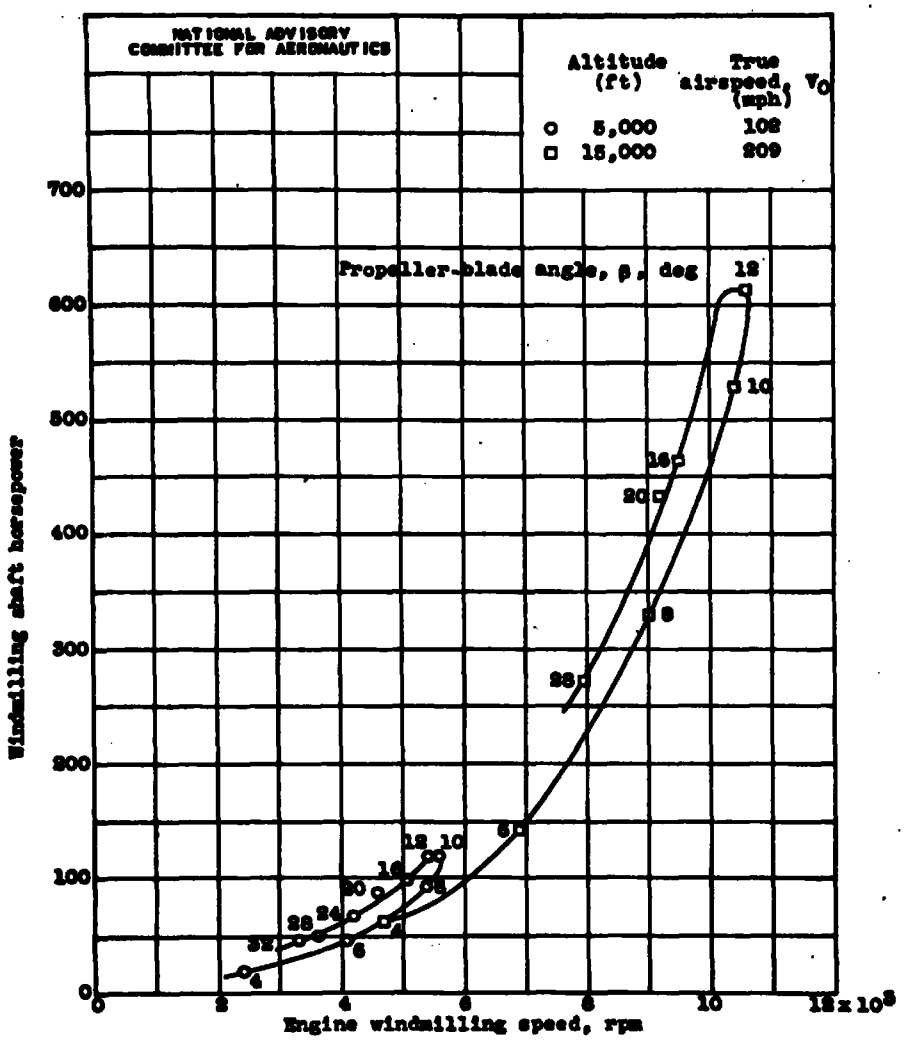


Figure 6. - Variation of windmilling shaft horsepower with engine speed for various propeller-blade angles.

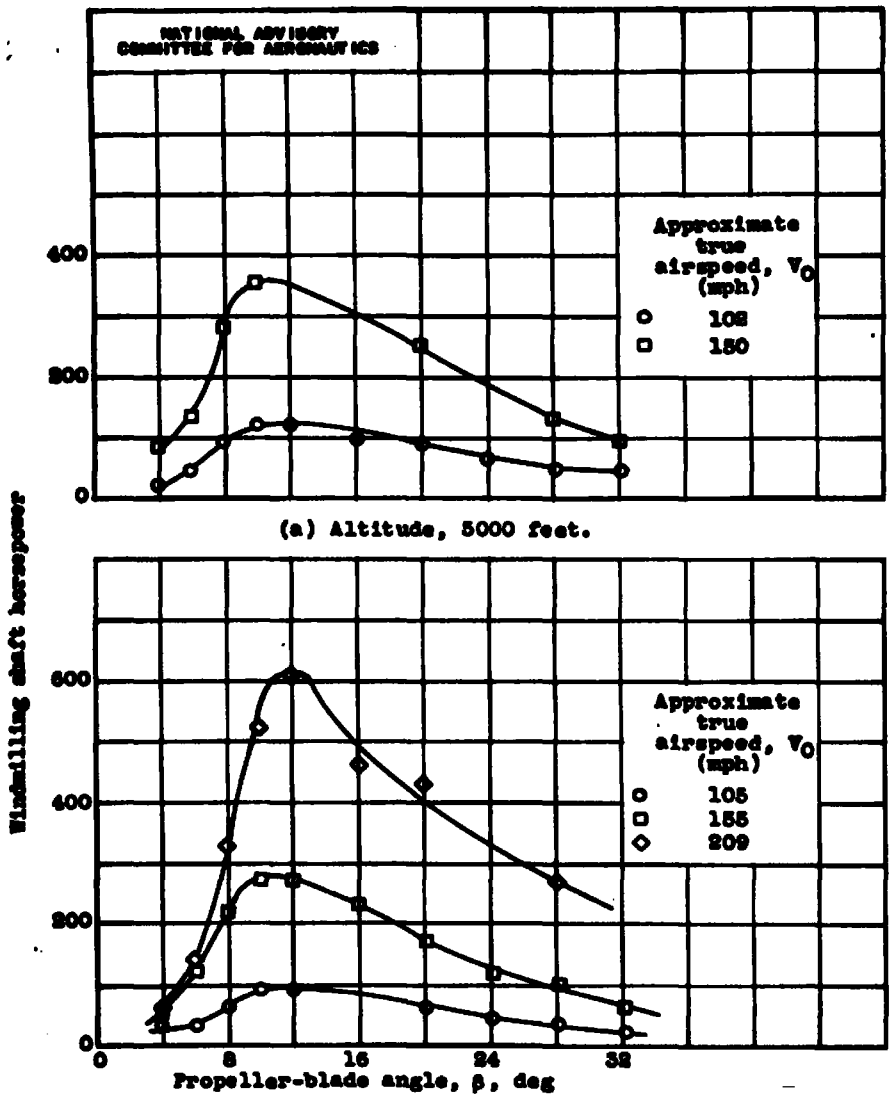
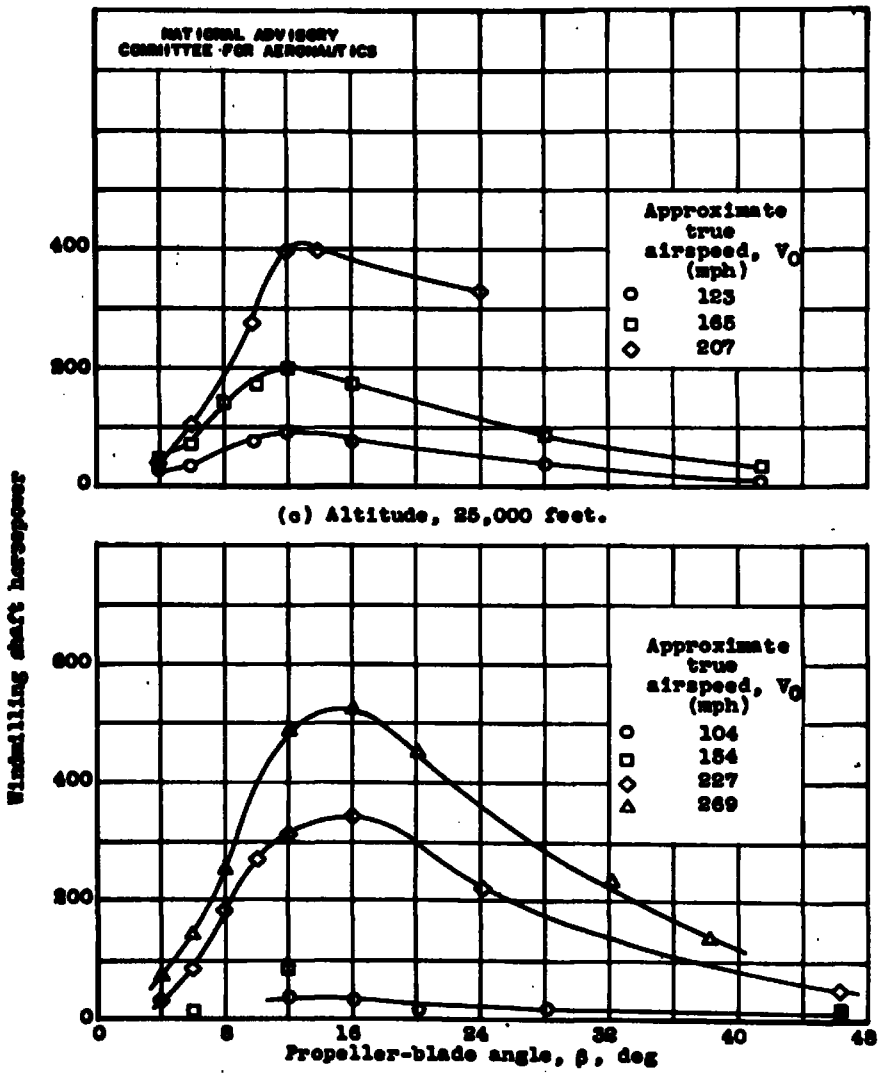


Figure 7. - Variation of windmilling shaft horsepower with propeller-blade angle.



(c) Altitude, 25,000 feet.

(d) Altitude, 35,000 feet.

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

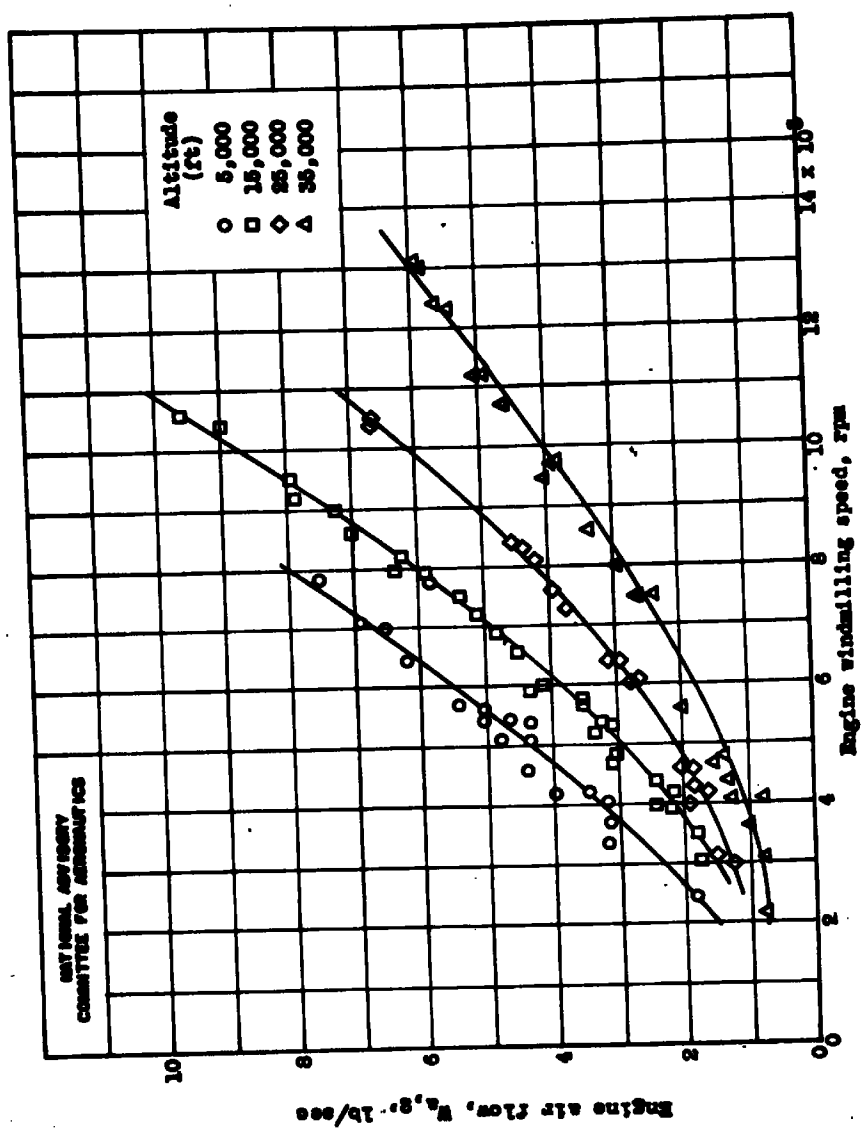


Figure 8. - Variation of engine air flow with engine windmilling speed.

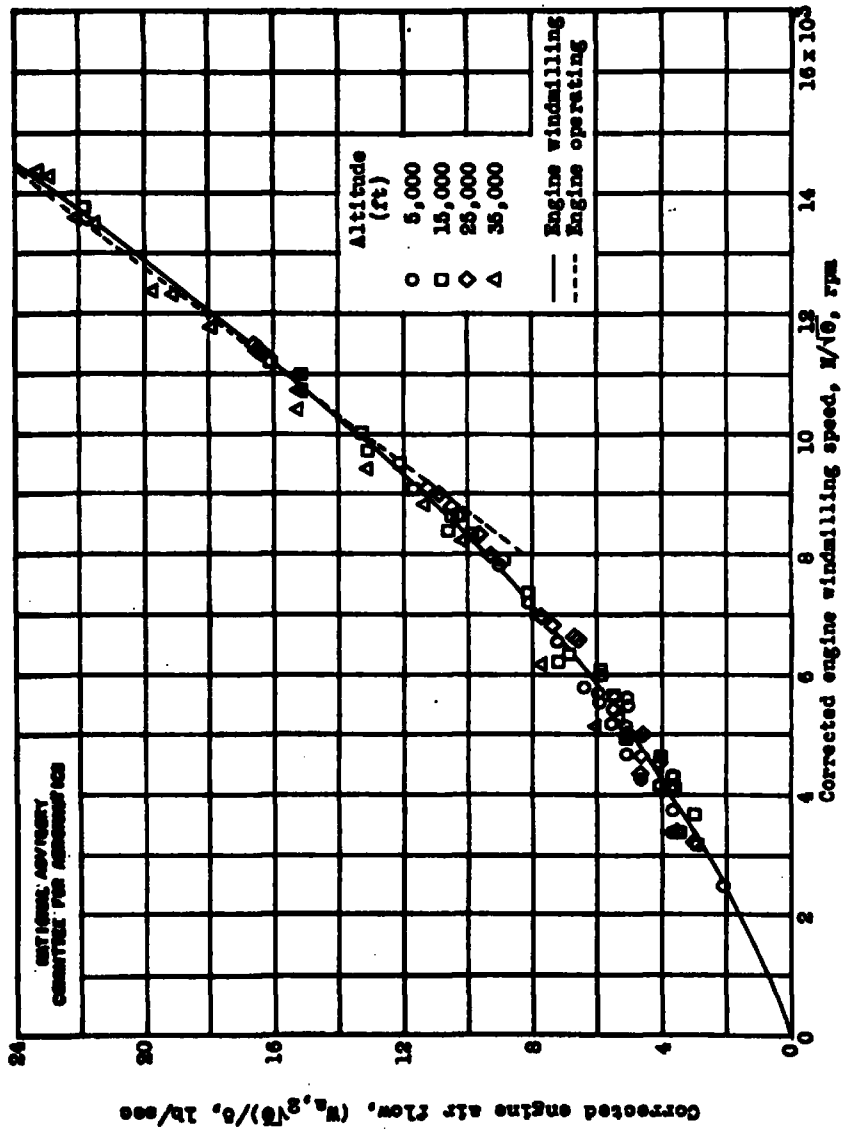


Figure 9. - Variation of corrected engine air flow with corrected engine windmilling speed.

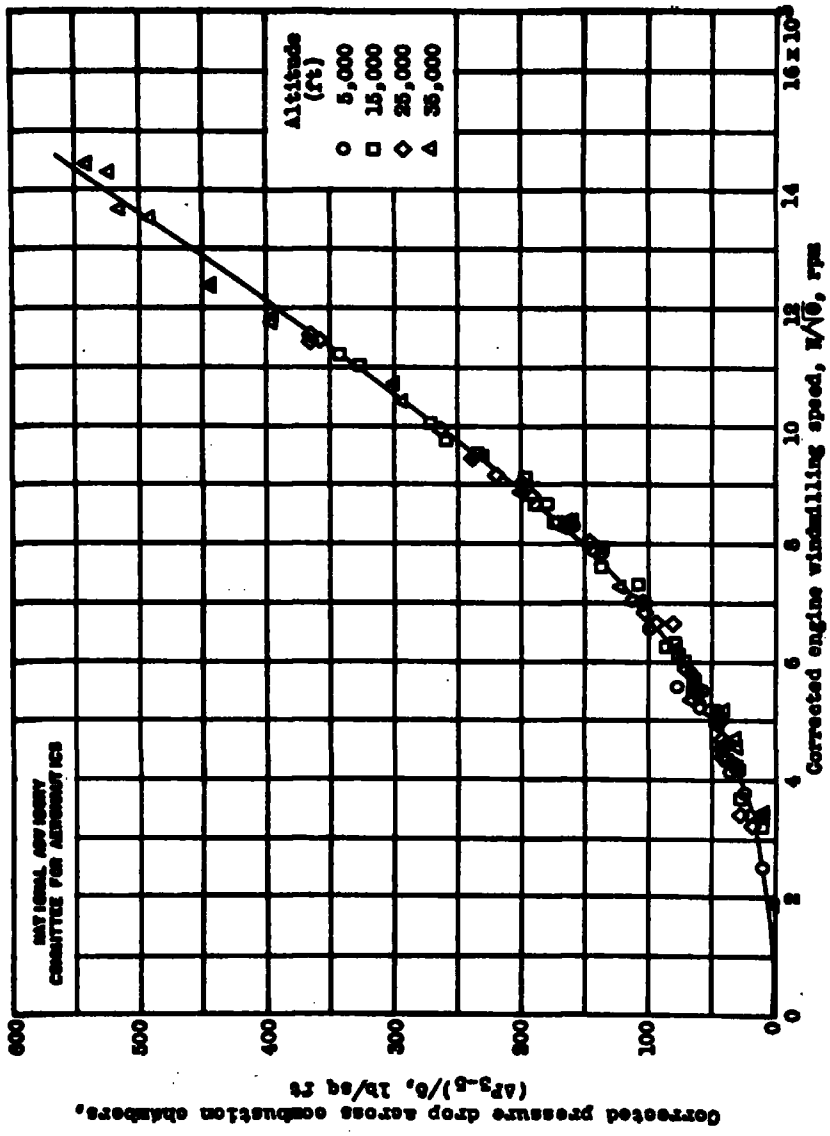


Figure 10. - Variation of corrected pressure drop across combustion chambers with corrected engine windmilling speed.

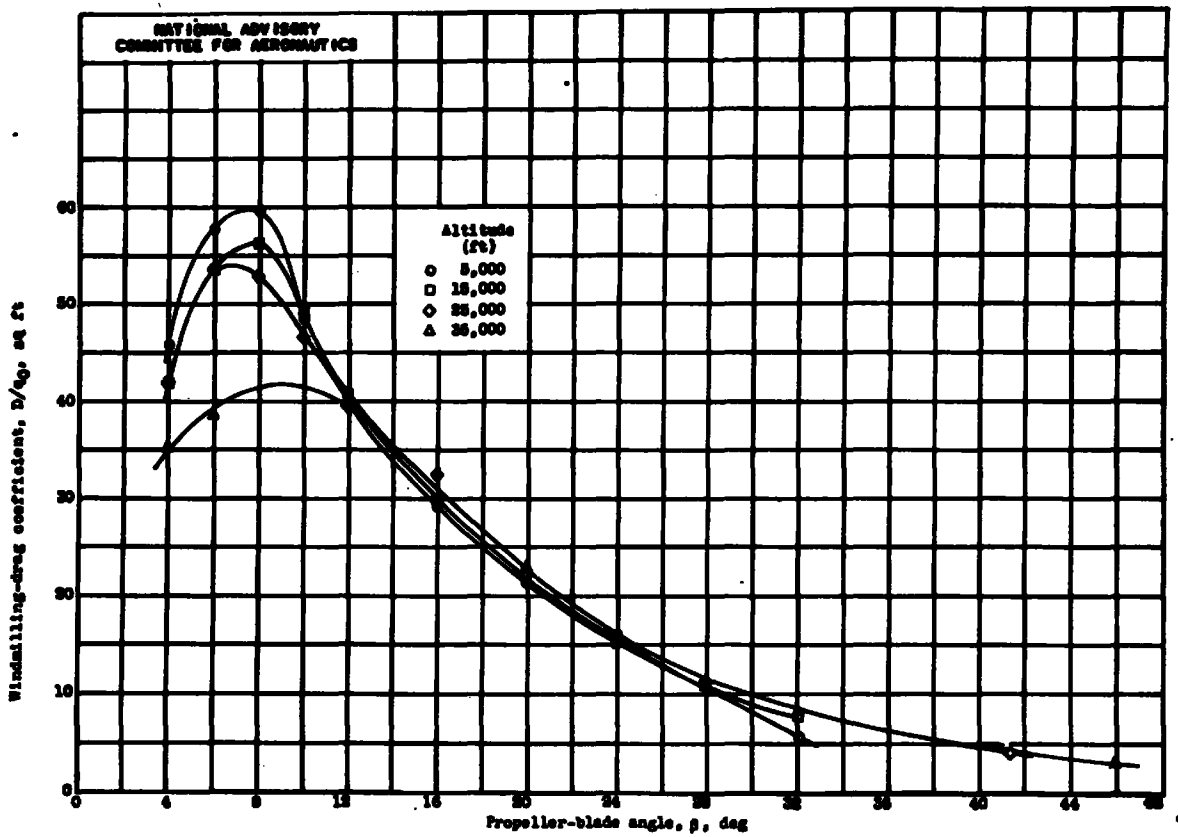


Figure 11. - Variation of windmilling-drag coefficient with propeller-blade angle for several altitudes. True airspeed, 153 miles per hour.

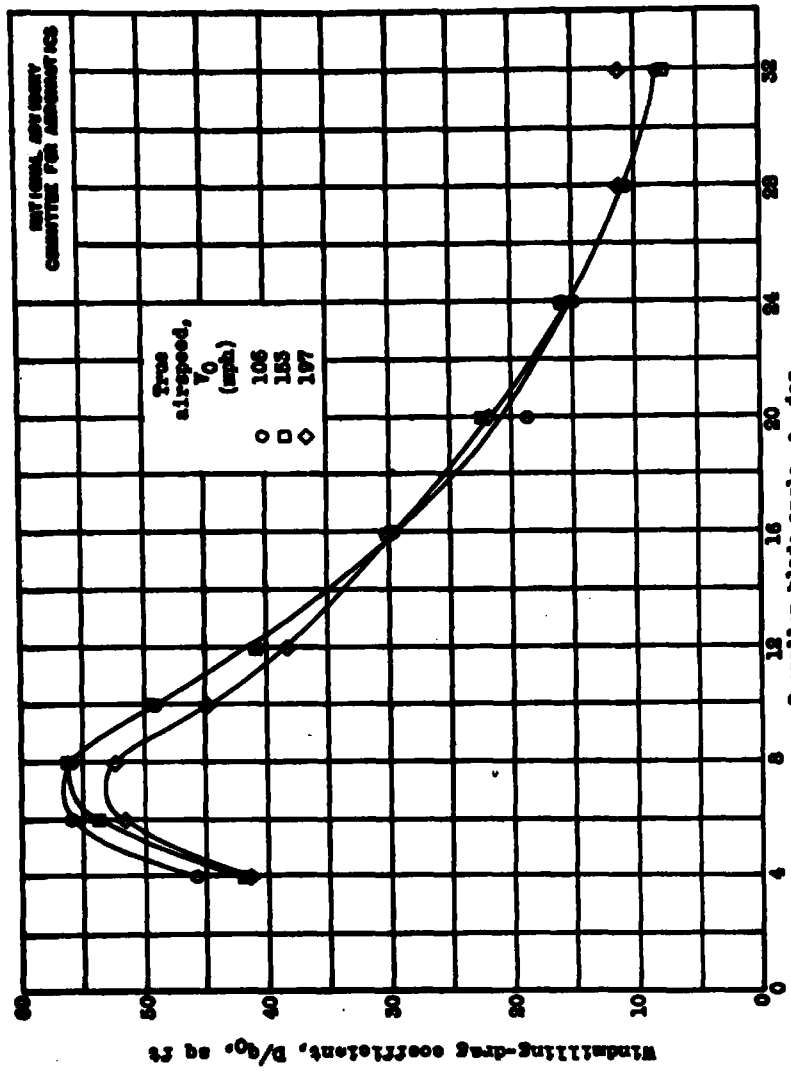


Figure 12. - Variation of windmilling-drag coefficient with propeller-blade angle for various true airspeeds. Altitude, 15,000 feet.

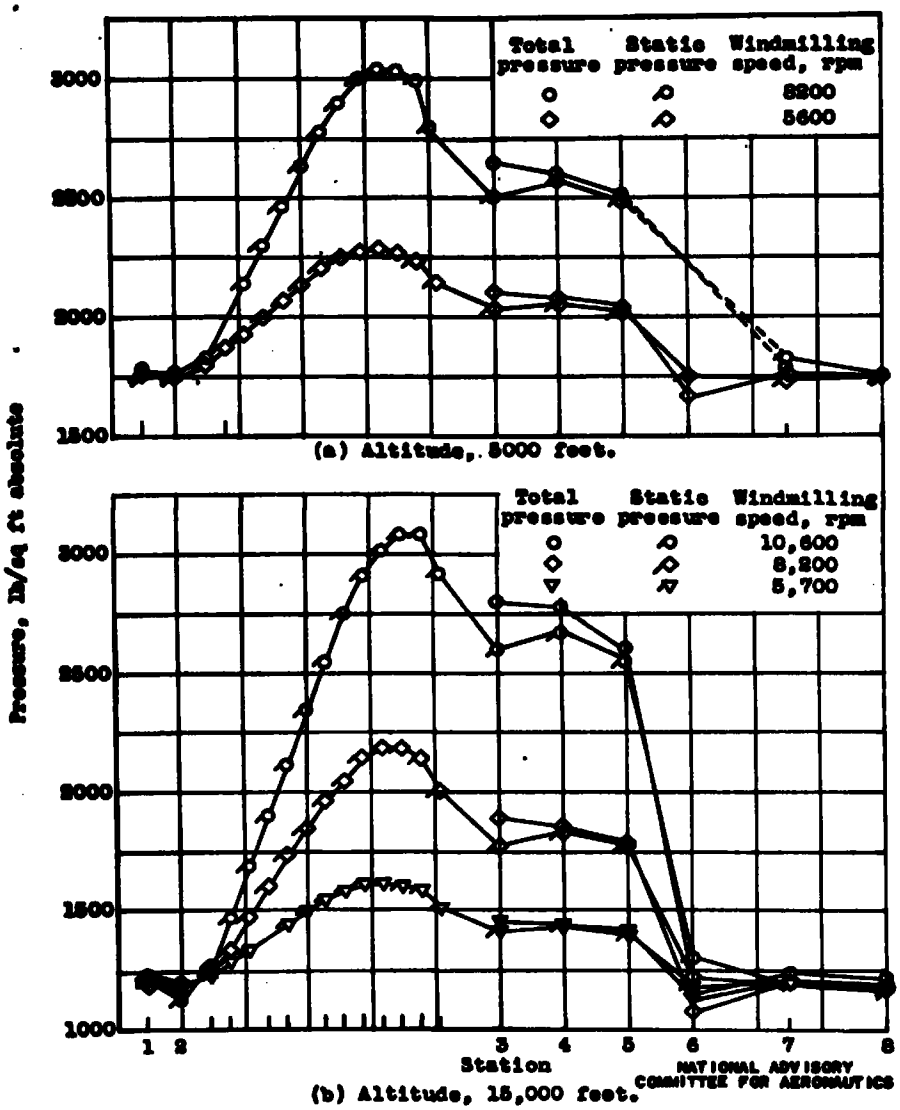


Figure 13. - Variation of average total and static pressures through engine. Propeller-blade angle, 12°.

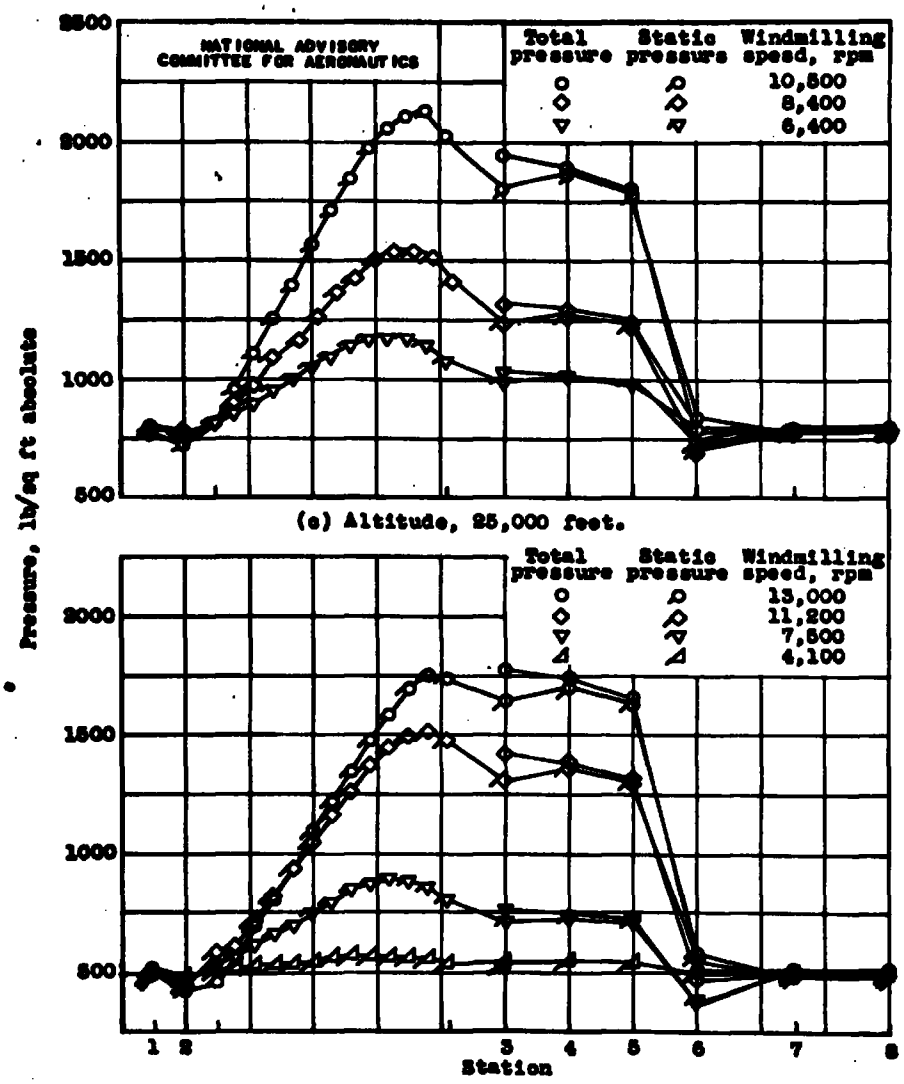
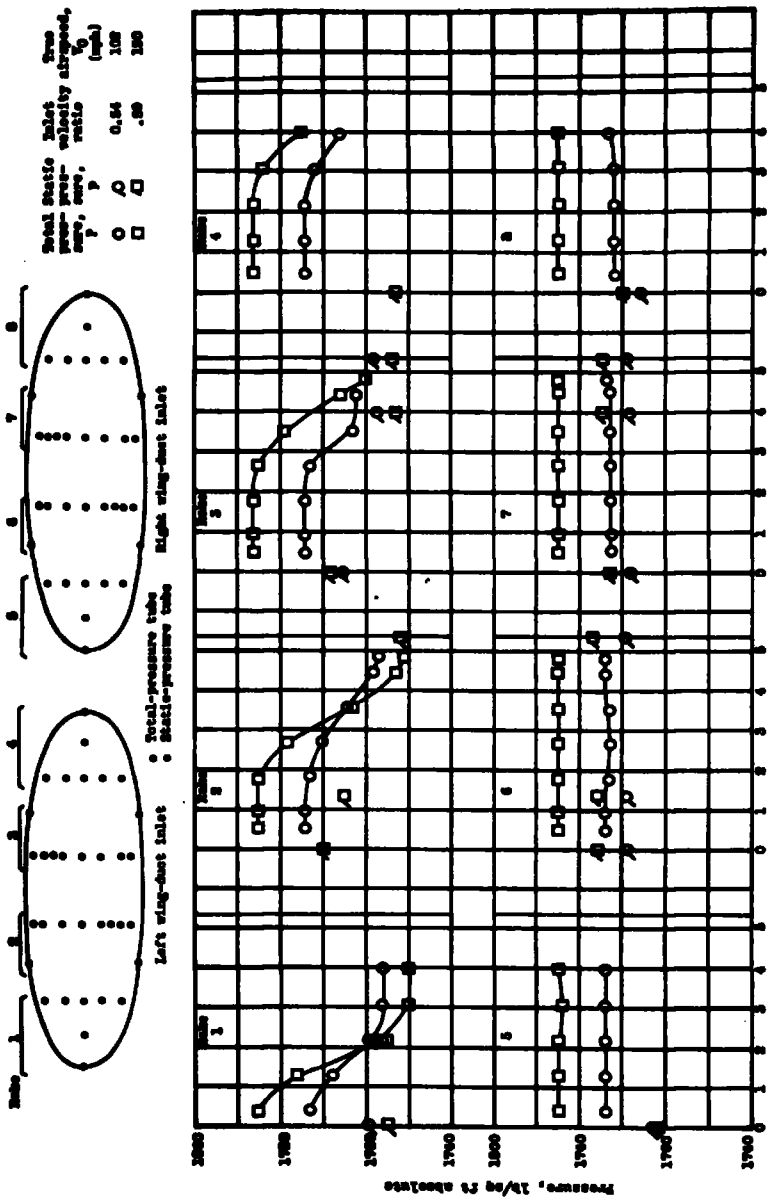
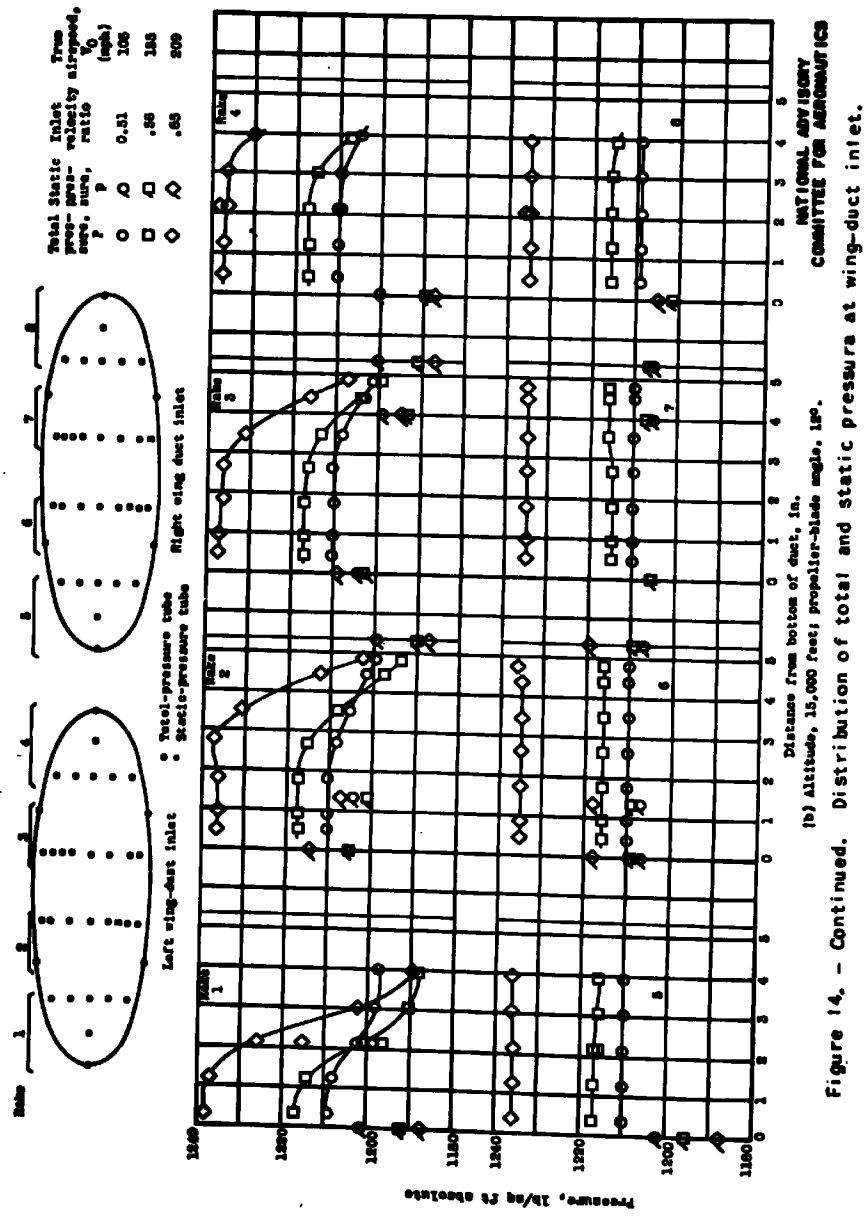


Figure 13. - Concluded. Variation of average total and static pressures through engine. Propeller-blade angle, 12°.



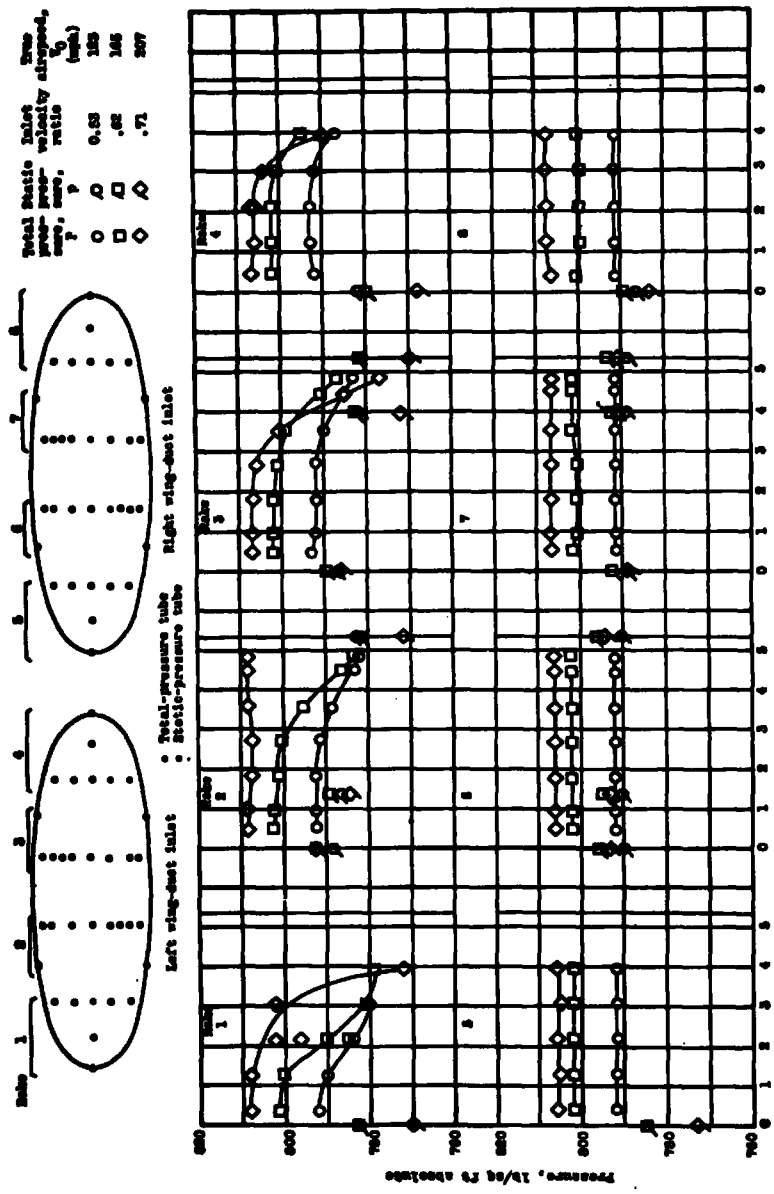
(a) Altitude, 8000 feet; propeller-blade angle, 16°.

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



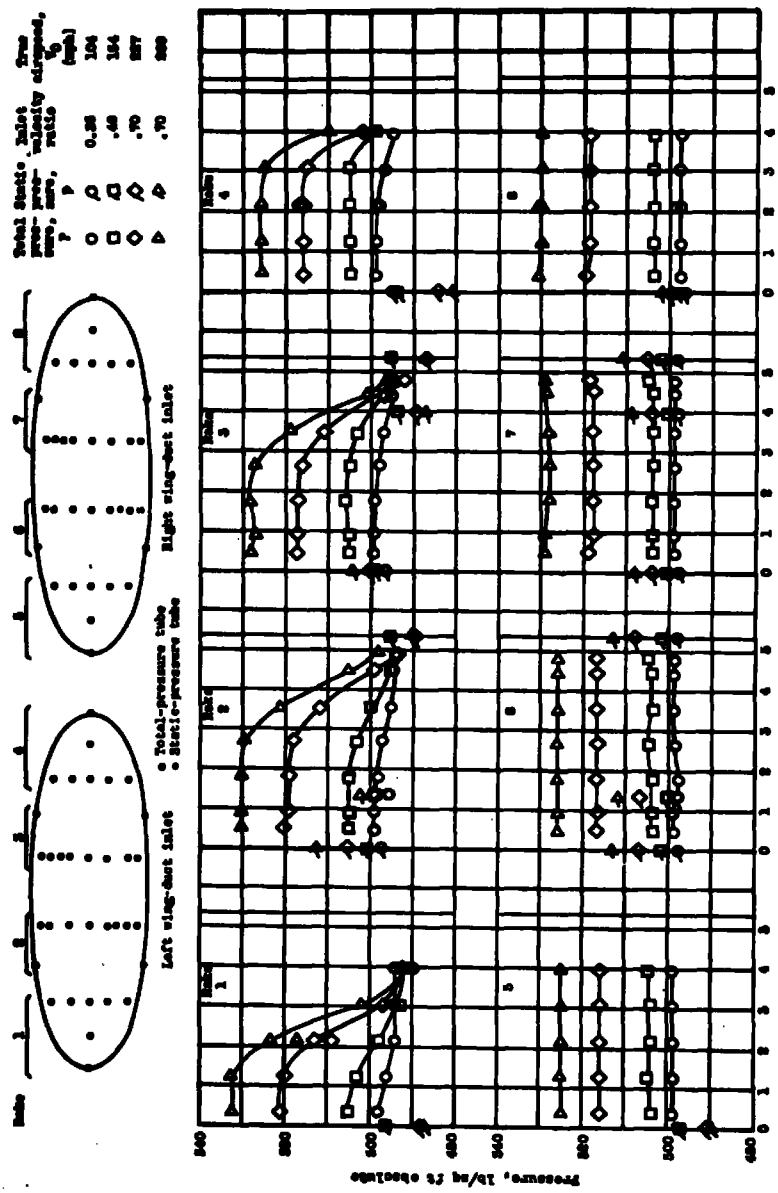
(b) Altitude, 15,000 feet; propeller-blade angle, 12°.

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



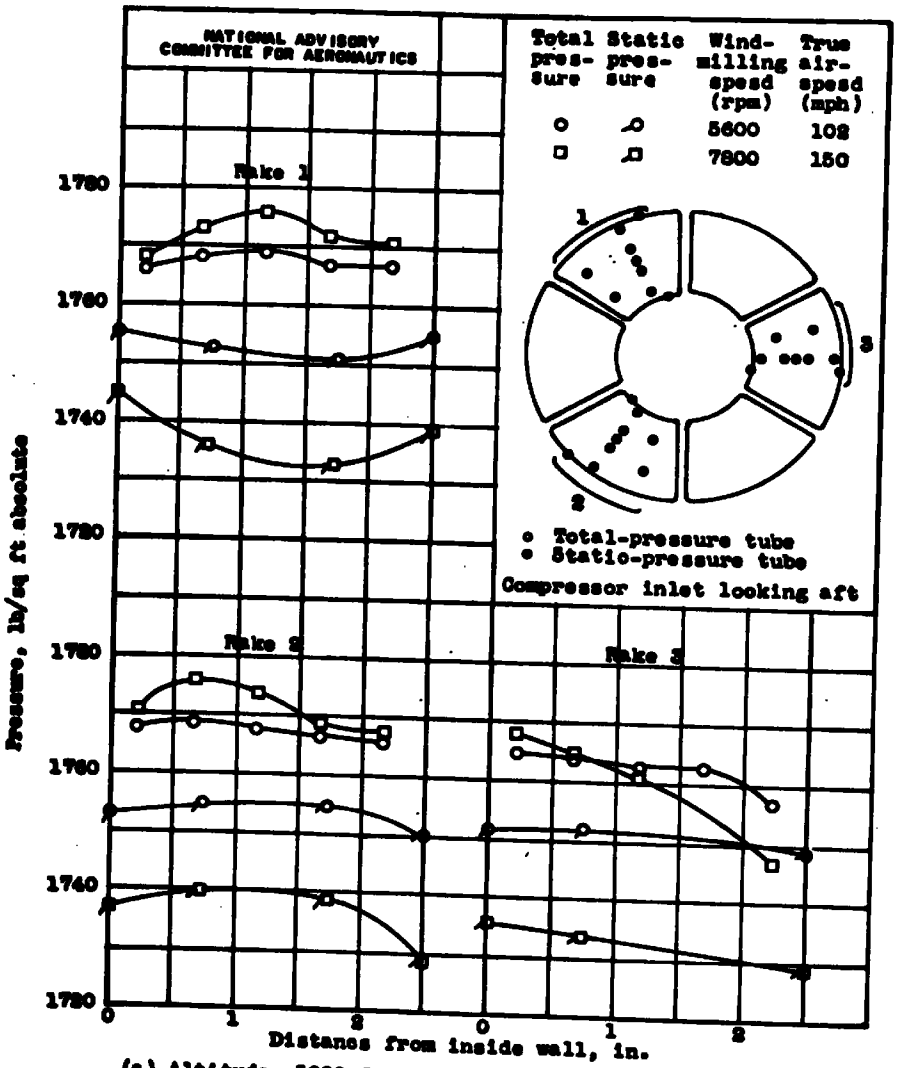
(c) Altitude, 25,000 feet; propeller-blade angle, 12°.

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



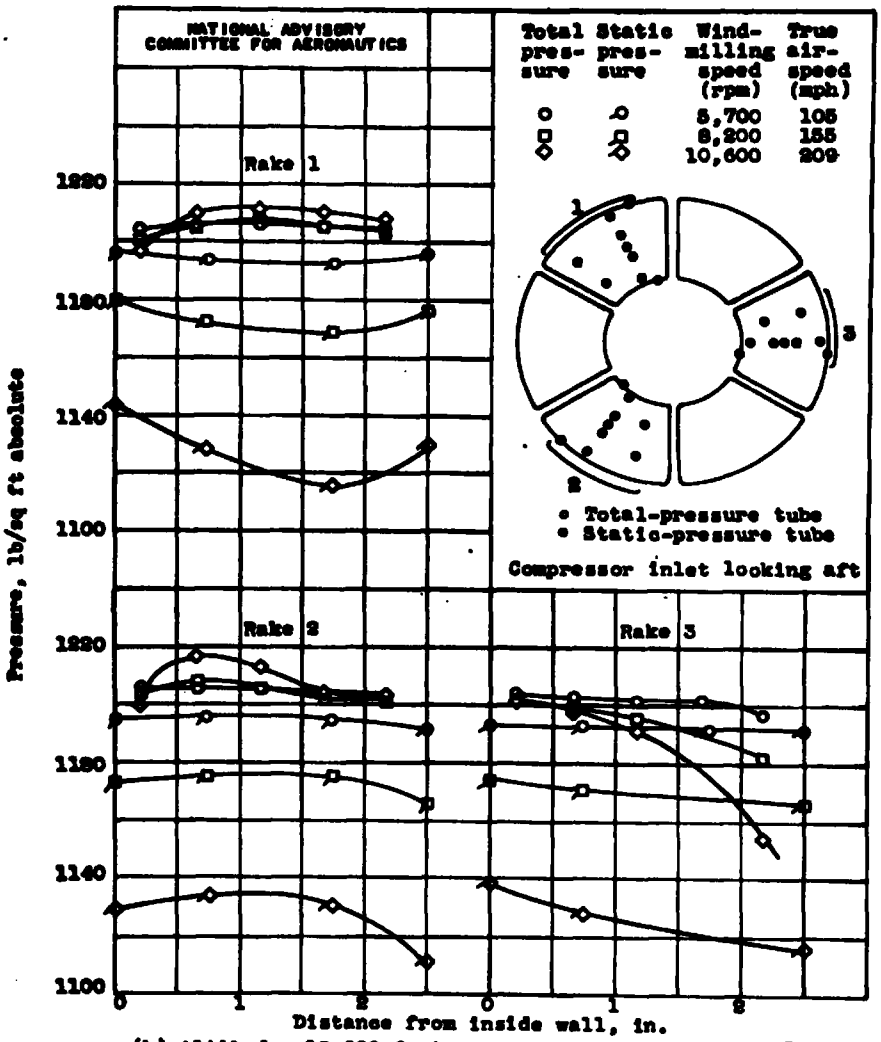
(d) Altitude, 35,000 feet; propeller-blade angle, 15°.

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



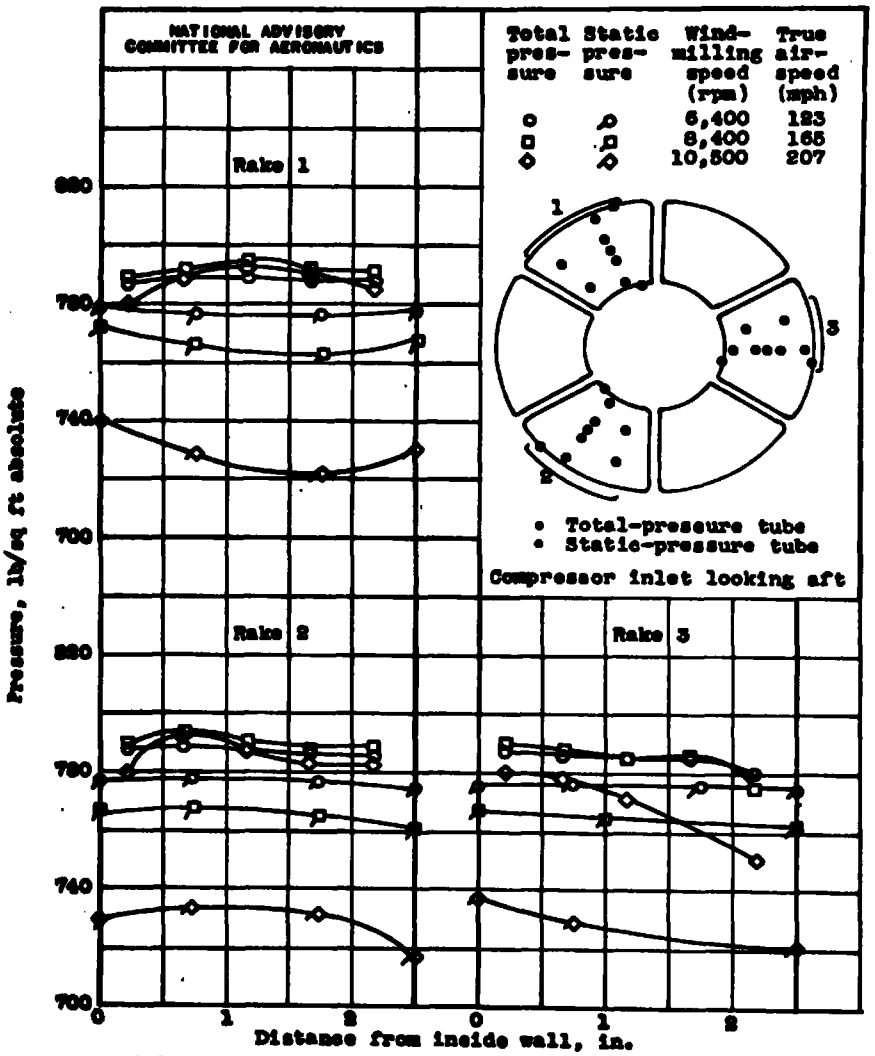
(a) Altitude, 8000 feet; propeller-blade angle, 10°.

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



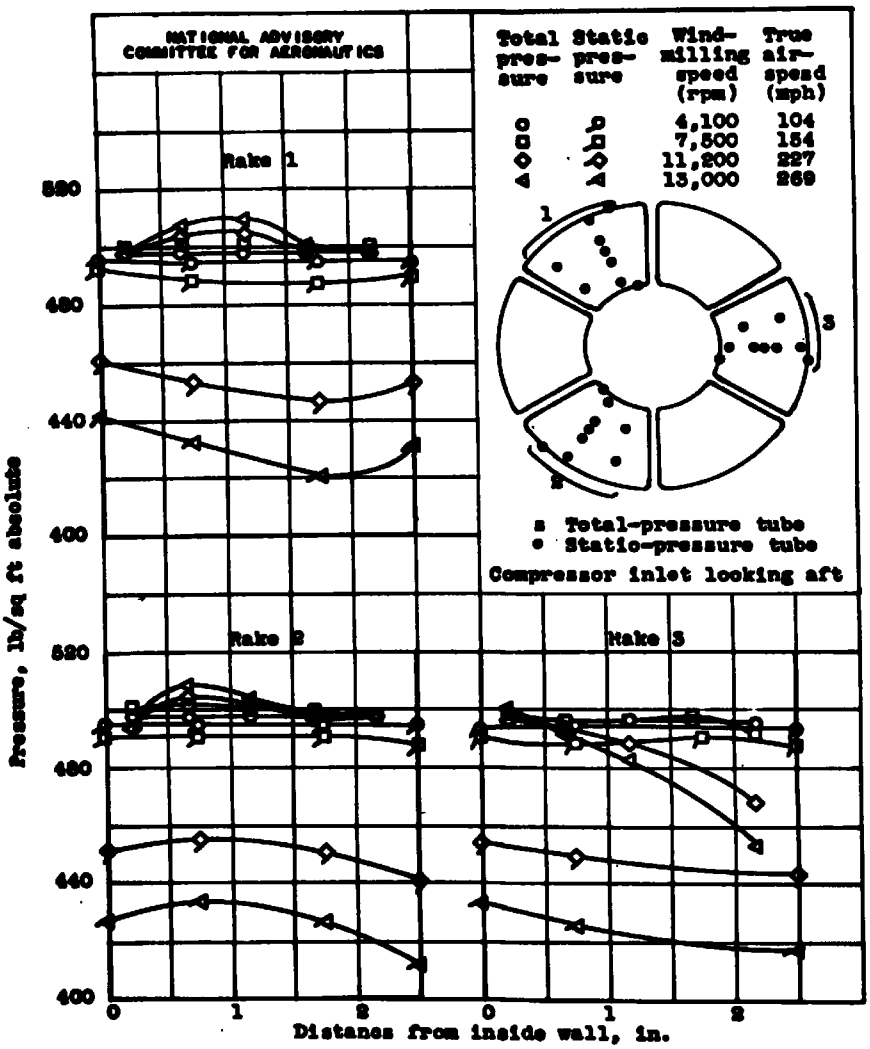
(b) Altitude, 15,000 feet; propeller-blade angle, 12°.

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



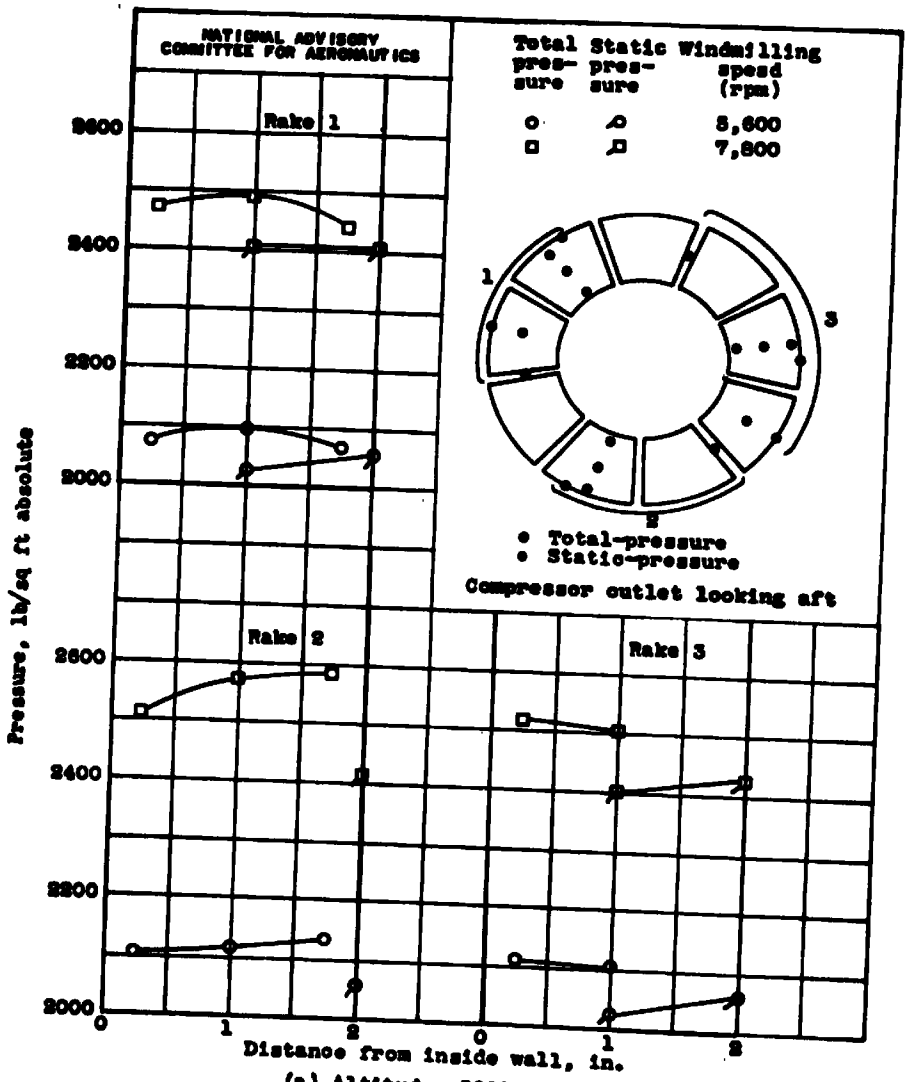
(c) Altitude, 25,000 feet; propeller-blade angle, 18°.

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



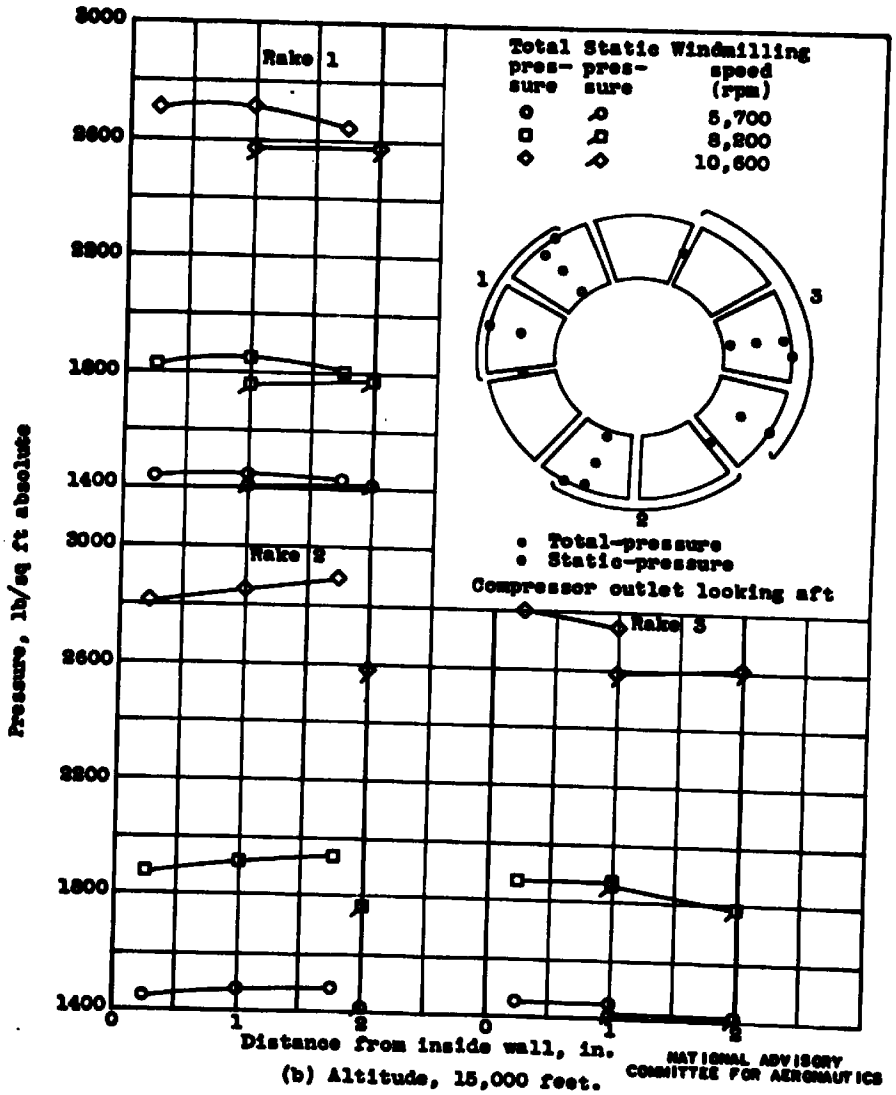
(d) Altitude, 35,000 feet; propeller-blade angle, 12°.

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



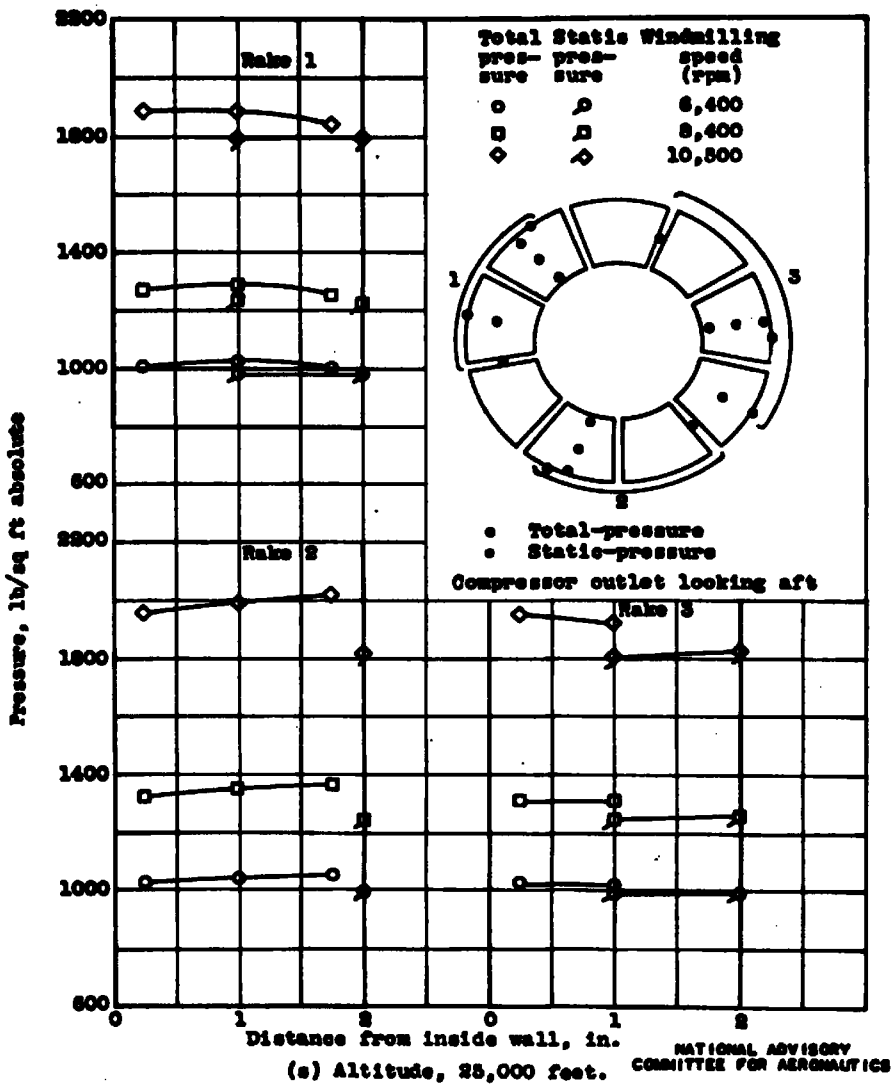
(a) Altitude, 5000 feet.

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



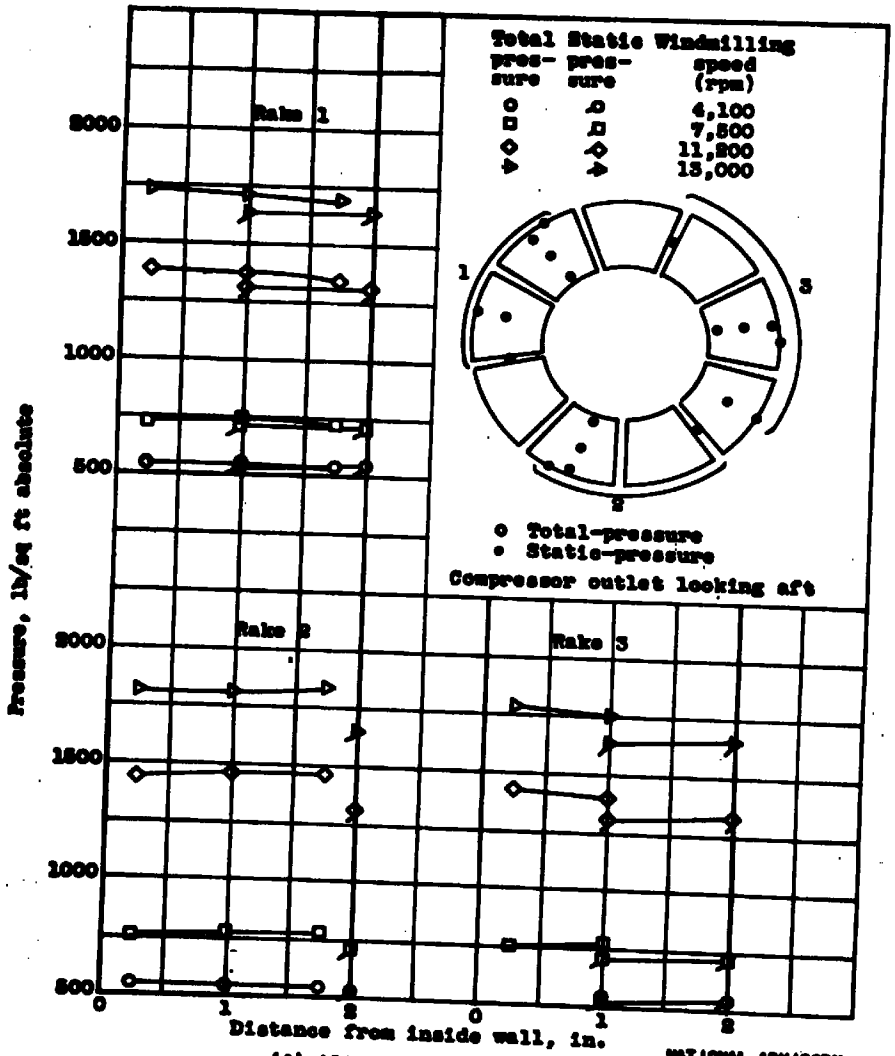
(b) Altitude, 15,000 feet.

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



(e) Altitude, 25,000 feet.

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



(d) Altitude, 35,000 feet.

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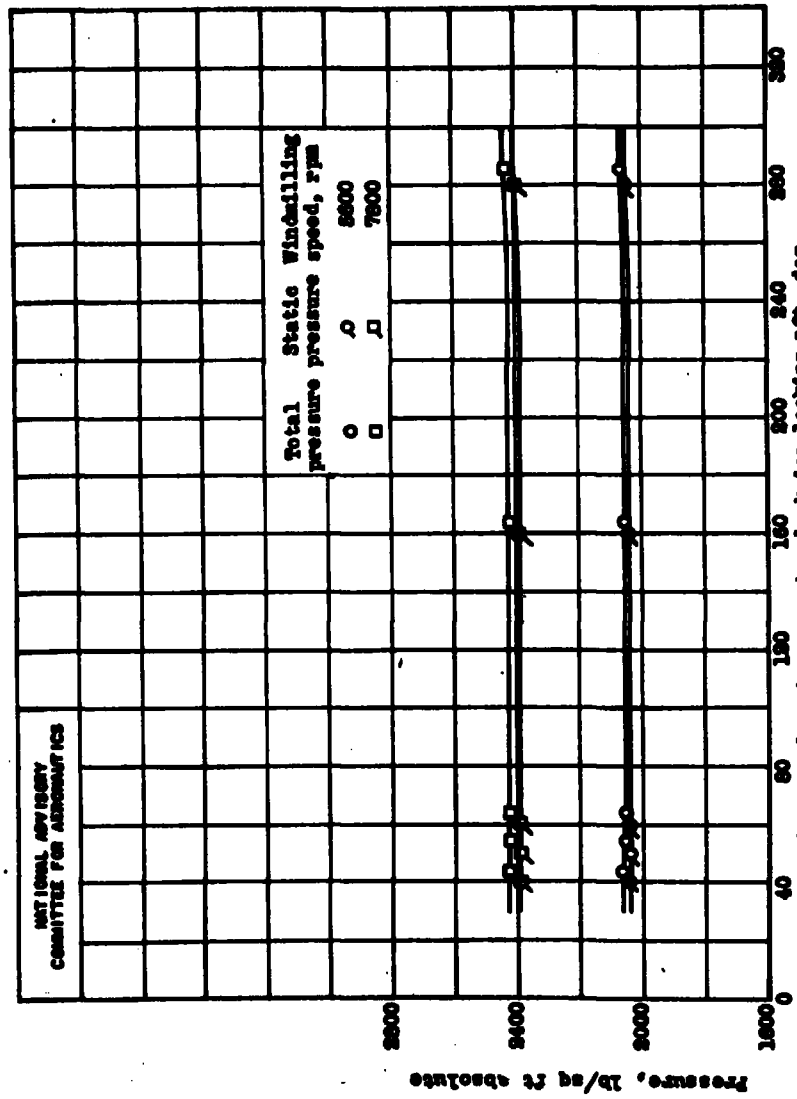
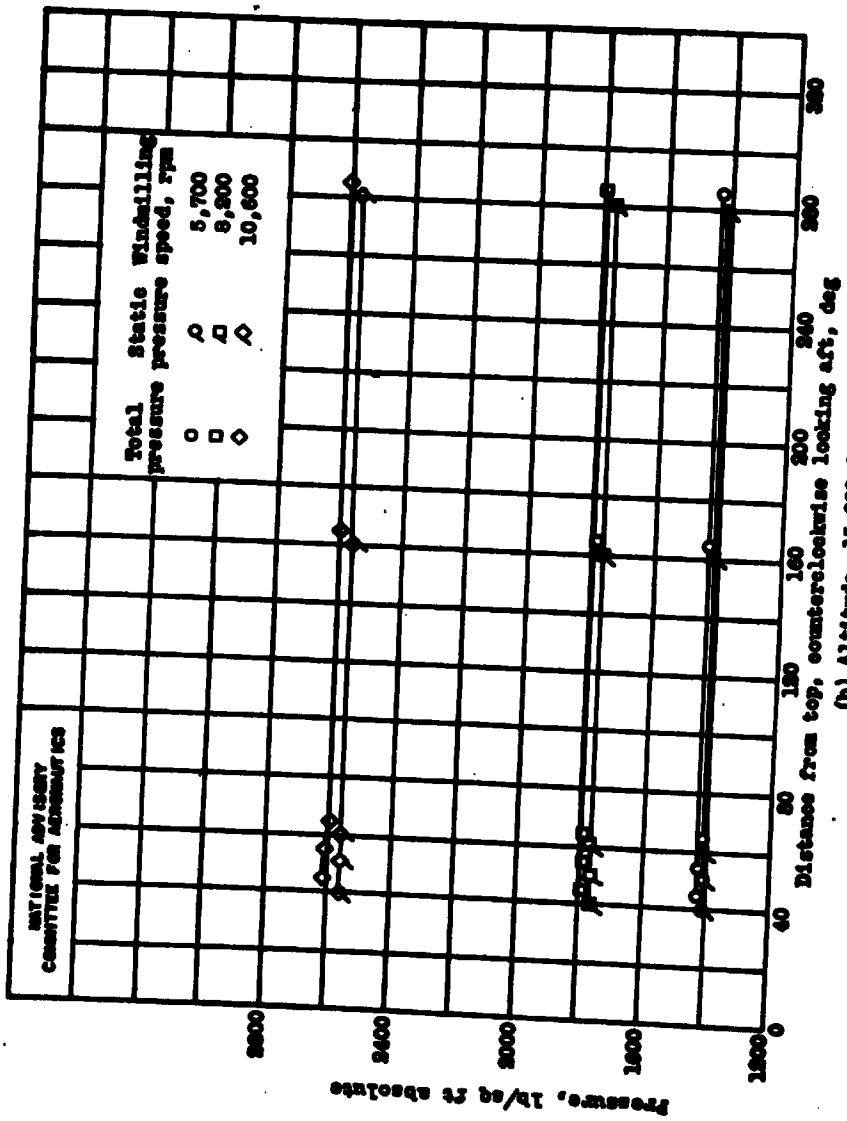
Figure 16. - Concluded. Distribution of total and static pressures at compressor outlet.



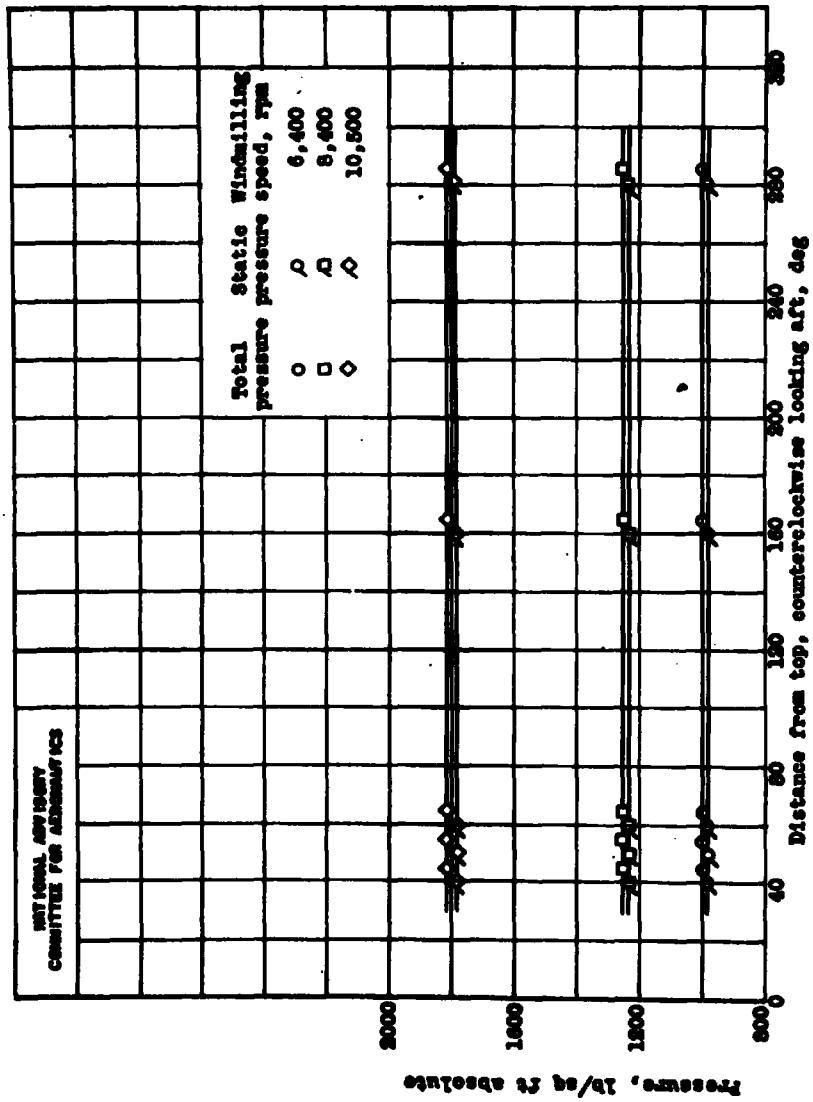
(a) Altitude, 5000 feet.

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



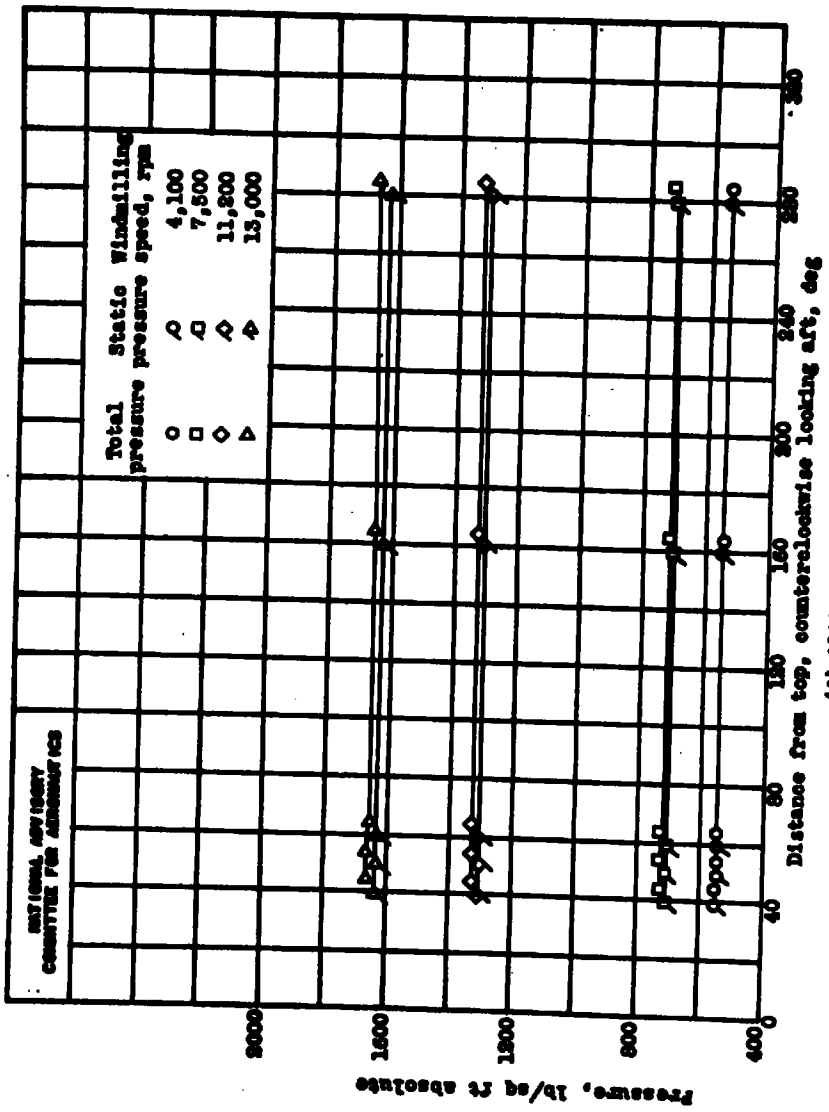
(b) Altitude, 15,000 feet.

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



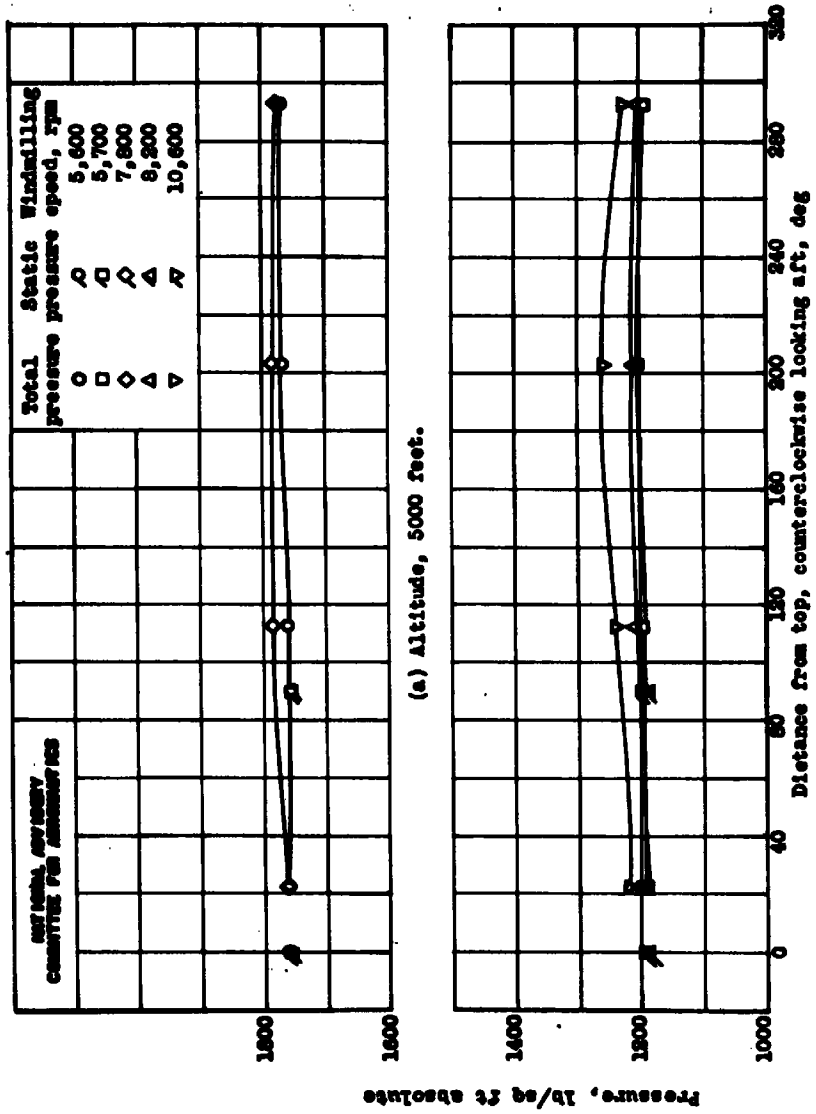
(c) Altitude, 25,000 feet.

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



(d) Altitude, 35,000 feet.

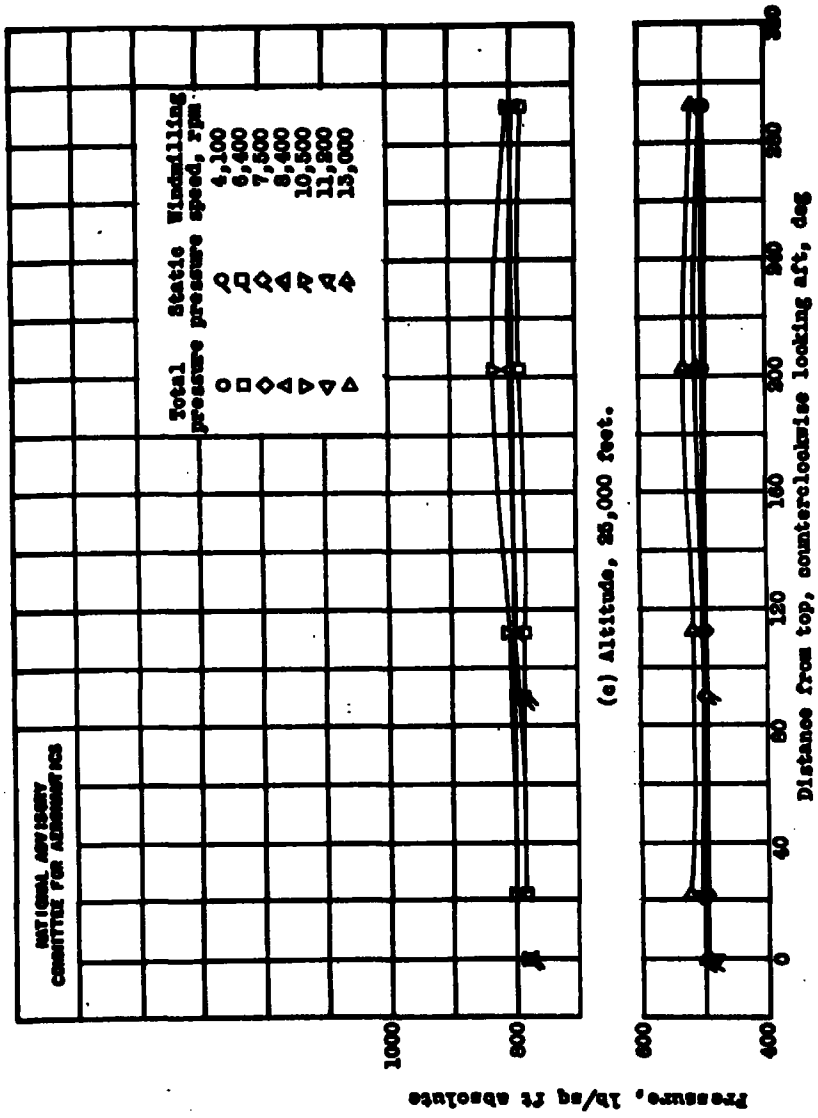
Figure 17. - Concluded. Distribution of total and static pressures at turbine-nozzle inlet.



(a) Altitude, 5000 feet.

(b) Altitude, 15,000 feet.

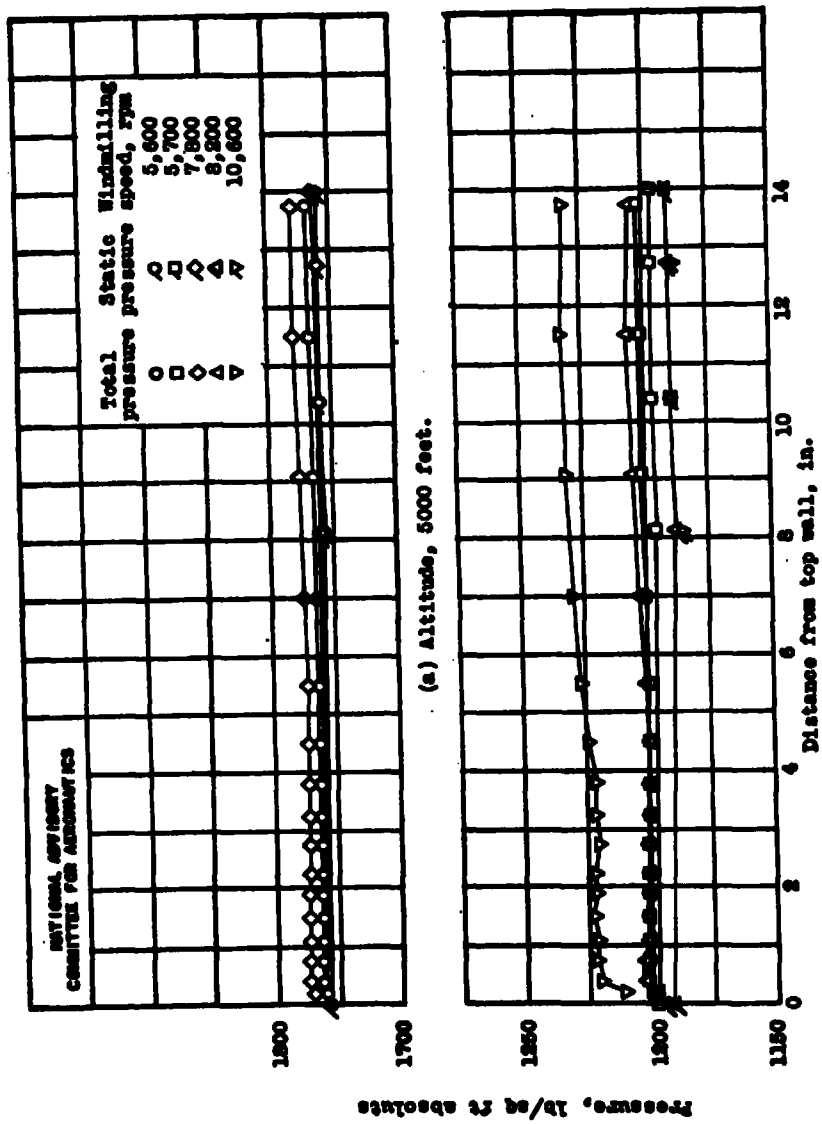
Figure 18. - Distribution of total and static pressures behind exhaust-cone outlet.



(c) Altitude, 25,000 feet.

(d) Altitude, 35,000 feet.

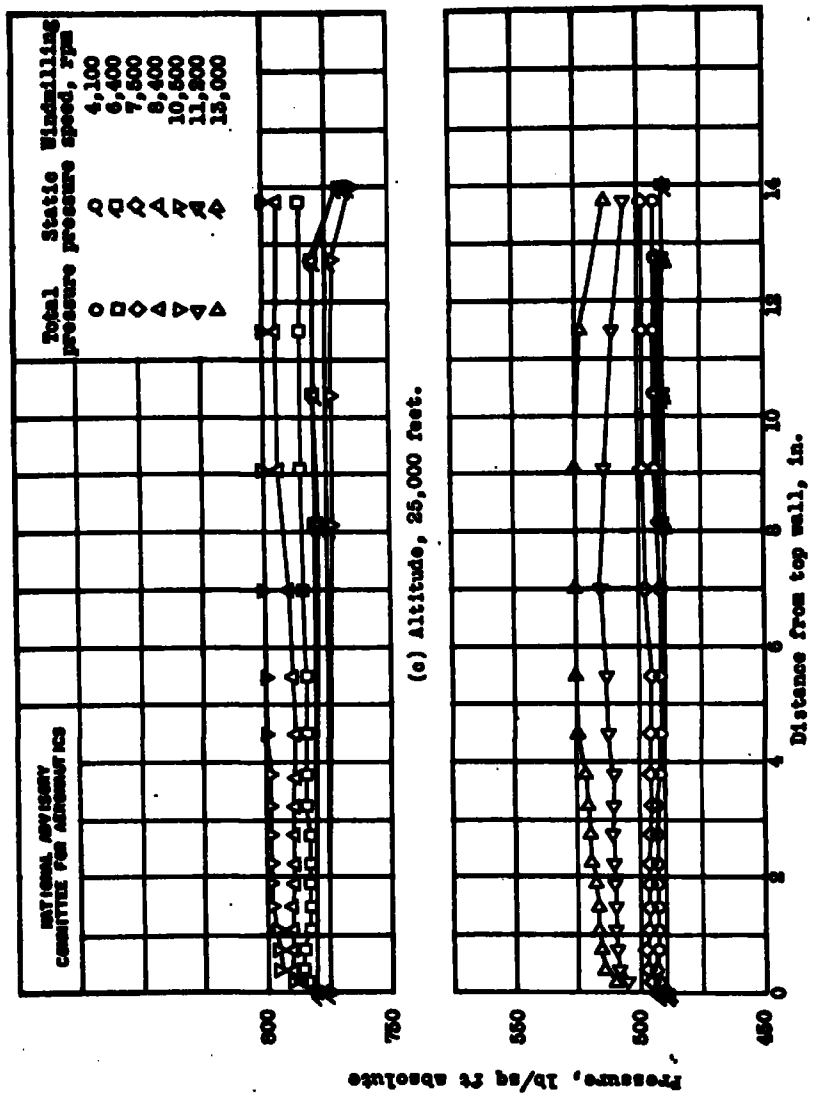
Figure 18. - Concluded. Distribution of total and static pressures behind exhaust-cone outlet.



(a) Altitude, 5000 feet.

(b) Altitude, 15,000 feet.

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



(c) Altitude, 25,000 feet.

(d) Altitude, 35,000 feet.

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

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TSDIN FORM 69 A (13 MAR 47)

Conrad, E. W.
Durham, J. D.

AUTHOR(S)

[redacted] over

DIVISION: Power Plants, Jet and Turbine (5)
SECTION: Performance (16)
CROSS REFERENCES: Propeller turbojets - Performance (75476.28); Propeller blades - Pitch distribution (75459); TG-100A (75476.28)

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ABSTRACT

The windmilling characteristics of the TG-100A propeller turbojet engine were investigated in the wind tunnel for a range of altitudes from 5000 to 35,000 ft, true airspeeds from 100 to 273 mph, and propeller-blade angles from 4° to 46°. A windmilling speed of 13,000 rpm was obtained at maximum altitude, near maximum airspeed, and a propeller-blade angle of 16°. Excessive engine speeds would be obtained at an airspeed of 500 mph and blade angles from about 5° to 41°. Drag hp increased to 2647 with blade angle decreased to 6° and airspeed of 255 mph. Maximum engine windmilling speed for all conditions was obtained with blade angles between 10° and 16°. Maximum shaft hp was 612.

NOTE: Requests for copies of this report must be addressed to: N.A.C.A., Washington, D.C.

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BY John P. Moore USCO

DATE 15 Feb. 1951

Cauth: Ltr fr NACA dtd 11 Mar 54

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Auth: NACA Research Abstracts & Reclassification Notice No. 104 dd 3 Aug 56

TSDIN FORM 69 A (19 Oct 47)

Conrad, E. W.
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AUTHOR(S)

DIVISION: Power Plants, Jet and Turbine (5)
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