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RESEARCH MEMORANDUM

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TURBINE PERFORMANCE CHARACTERISTICS OF A PYTHON TURBINE-PROPELLER ENGINE INVESTIGATED IN ALTITUDE WIND TUNNEL

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RESEARCH MEMORANDUM

TURBINE PERFORMANCE CHARACTERISTICS OF A PYTHON TURBINE-PROPELLER ENGINE INVESTIGATED IN ALTITUDE WIND TUNNEL

By John M. Farley and William R. Prince

SUMMARY

Performance of the turbine component of a Python turbine-propeller engine with four tail-pipe configurations was determined in the NACA Lewis altitude wind tunnel over a range of altitudes from 10,000 to 40,000 feet and engine speeds from 6800 to 8000 rpm. Fuel flow was varied at each engine speed to give full coverage of the operable engine range.

The relations of corrected turbine speed, corrected turbine enthalpy drop, pressure ratio, and efficiency were established on a turbine-characteristic plot. Turbine efficiency varied from approximately 83 to 86 percent, with the highest values being attained with the combined conditions of high turbine pressure ratio and high corrected turbine speed. Engine deterioration resulting from the accumulation of dirt on the compressor blades caused a shift in the turbine operating lines but had no apparent effect on the characteristic plot. Increasing the operating altitude or decreasing the exhaust-nozzle area, with constant corrected engine speed and corrected turbine speed, resulted in a decrease of turbine pressure ratio and corrected enthalpy drop but had little effect on the turbine efficiency.

INTRODUCTION

An investigation to evaluate the steady-state and dynamic performance characteristics of a Python turbine-propeller engine has been conducted in the NACA Lewis altitude wind tunnel. The investigation was conducted with four tail-pipe configurations at simulated altitudes from 10,000 to 40,000 feet with a cowl-inlet ram ratio of 1.025. The engine speed ranged from 6800 to 8000 rpm and the fuel flow was changed to give various powers at each speed. Instrumentation was installed in the engine to permit evaluation of component and over-all performance.

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Performance characteristics of the two-stage turbine operating as an integral component of the engine are presented herein. Typical results are graphically presented to show the effects of engine speed, altitude, and exhaust-nozzle area on turbine performance. All turbine-performance data are also presented in tabular form.

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INSTALLATION AND INSTRUMENTATION

Engine

The engine was mounted in a wing segment that extended across the 20-foot-diameter test section of the altitude wind tunnel (fig. 1).

The Python turbine-propeller engine has a nominal rating of 3670 shaft horsepower and 1150 pounds of jet thrust under static sea-level conditions at 8000 rpm and a tail-pipe gas temperature of approximately 1100° F (1560° R). The net dry weight of the engine without propeller is 3150 pounds and the maximum diameter is 54.5 inches.

A cross section of the engine is shown in figure 2. Air enters the engine through an annular cowling and is divided circumferentially into 11 convergent throats, which turn the air 180° into the compressor-inlet annulus. After passing forward through the 14-stage axial-flow compressor, the air is again turned 180° into 11 separate combustor-inlet ducts. From the combustors, which are arranged around the circumference of the compressor, the gas passes through the two rotors and two stator stages of the turbine, into the exhaust-cone section, and thence into the tail pipe. Mounted at the forward end of the compressor is a two-stage planetary-reduction gear, through which the engine drives two four-blade contrarotating propellers.

Turbine

Photographs of the turbine rotor and stator stages are presented in figures 3 and 4, respectively. The two-stage turbine delivers approximately 10,000 horsepower at sea-level rated conditions, with approximately 6000 horsepower being absorbed by the compressor. Both rotor stages are mounted on a common disk and

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the over-all turbine-rotor diameter varies from about 27.5 inches at the leading edge of the rotor first-stage blading to 30.09 inches at the trailing edge of the rotor second-stage blading. The blade sections vary from impulse type at the blade roots to reaction type at the tips. Cooling is provided for the turbine front and rear faces by air bled from the tenth and fifth stages of the compressor, respectively.

Instrumentation

Locations of the instrumentation stations for measuring temperatures and pressures through the engine are shown in figure 2. Details of the instrumentation at those stations used to determine the turbine performance are presented in figures 5 to 7. Turbine-inlet pressures were measured with mercury manometers and turbine-outlet and exhaust-nozzle-inlet pressures were measured with water manometers. All pressures were photographically recorded. Temperature measurements were made with chromel-alumel thermocouples and recorded on automatic flight recorders. Engine speed was measured by a stroboscopic tachometer. Fuel flows were measured by means of calibrated rotameters. Engine torque was measured with a built-in hydraulic torquemeter, which had been calibrated with a dynamometer by the manufacturer to give propeller shaft torque in terms of hydraulic pressure.

PROCEDURE

Investigations were conducted using four tail-pipe configurations. The standard configuration consisted of a 23-inch constant-diameter tail pipe, 66 inches long, with no exhaust nozzle. The other three configurations had a 24-inch-diameter, 66-inch long tail pipe with no exhaust nozzle, a 20-inch-diameter and a 22-inch-diameter exhaust nozzle, respectively.

With the standard tail-pipe configuration, data were taken at simulated altitudes of 10,000, 20,000, 30,000 and 40,000 feet. Full coverage of the engine operating range was obtained by varying fuel flow at each of several fixed engine speeds. At altitudes from 10,000 to 30,000 feet, data were taken for engine speeds between 8000 and 6800 rpm, the lower value being the flight idling speed.

At 40,000 feet, the engine speed was limited to a minimum of 7400 rpm to prevent reverse torque on the reduction gearing. With the other tail-pipe configurations, data were taken at simulated altitudes of 10,000, 30,000, and 40,000 feet at engine speeds of 8000, 7800, and 7600 rpm. The ratio of cowl-inlet total pressure to test-section static pressure was maintained at 1.025.

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At altitudes of 10,000 and 20,000 feet, cowl-inlet air temperatures corresponded to NACA standard air at a ram-pressure ratio of 1.025 and the test altitude. Above 20,000 feet the inlet temperature was held near -20° F, which was the minimum that could be easily maintained in the wind tunnel.

A standard power check was performed periodically. For this check, data were taken with different fuel flows at an engine speed of 8000 rpm, a pressure altitude of 10,000 feet, an inlet-air temperature of 60° F, and a ram-pressure ratio of 1.025.

Reduction-gear losses were calculated from a curve, furnished by the manufacturer, showing the ratio of gear horsepower to shaft horsepower as a function of shaft horsepower. This curve had been calculated by a measurement of the oil temperature rise in, and the oil flow through, the gearbox.

Methods used to determine the turbine performance from the experimental data are explained in the appendix.

RESULTS AND DISCUSSION

Turbine-performance data obtained over the range of simulated-flight conditions and with the standard configuration are plotted to show the variation of corrected turbine gas flow, corrected turbine-inlet temperature, corrected turbine enthalpy drop, turbine pressure ratio, and turbine efficiency with corrected turbine speed. The results with four tail-pipe configurations are presented in numerical form in tables I to V.

The variation of corrected turbine gas flow with corrected turbine speed at various altitudes for the standard tail-pipe configuration is shown in figure 8. The gas-flow parameter was constant for all conditions of engine speed, power, and altitude investigated. This observation indicates that the nozzles were choked and that the effective flow area was constant. The gas-flow parameter was unchanged for the other tail-pipe configurations (tables III to V).

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Turbine performance obtained with the standard tail-pipe configuration at altitudes of 10,000, 20,000, 30,000, and 40,000 feet is presented in figure 9. These curves and similar ones for the other tail-pipe configurations were used to make a turbine-characteristic plot, which shows contours of constant turbine efficiency and pressure ratio on coordinates of corrected turbine speed and corrected turbine enthalpy drop **(fig. 10)**. The turbine-efficiency contours were faired through data that had a scatter of approximately ±1 percent. Turbine performance is completely defined at any point on this composite plot. The satisfactory generalization of the data for various altitudes indicates, within the accuracy of the data, no effect of Reynolds number on the turbine performance.

The variation of turbine efficiency was small, from 83 to 86 percent, with the higher efficiency values occurring at the higher corrected turbine speeds, which correspond to conditions of high engine speed and low turbine-inlet temperature. The corrected turbine enthalpy drop varied almost directly with turbine pressure ratio **(fig. 10)**.

Engine deterioration. - During the early phase of the investigation, a loss of engine power was noted with an increase in engine operating time. This loss in power is associated with the accumulation of dust and oil on the compressor blades, which caused a reduction in mass flow and pressure ratio. The amount of dust that passed through the engine may have been greater during the wind-tunnel investigation than would have been encountered under actual flight conditions. The effect of this deterioration on the turbine operating conditions with the standard tail pipe installed on the engine is shown in **figure 11**. The turbine operating lines at an altitude of 10,000 feet and a corrected engine speed of about 8000 rpm for average engine times of 2.0 and 24.7 hours are shown **in figure 11(a)**. At all corrected turbine speeds, the corrected turbine enthalpy drop was reduced about 3 percent for this increase in operating time.

From curves such as those presented in **figure 11(a)**, a cross plot was made showing the effect of engine deterioration on corrected turbine enthalpy drop at a corrected turbine speed of 4400 rpm, for altitudes of 10,000, 20,000, 30,000, and 40,000 feet **(fig. 11(b))**. The data for 10,000 feet indicate that engine deterioration continued until about 30 hours of running time were accumulated. The decreased slopes of the other curves indicate that the effect of deterioration was reduced as the altitude was increased. It is noted, however, that the altitudes are not compared at

constant corrected engine speeds. At 10,000 feet, the corrected turbine enthalpy drop was reduced approximately 3 percent over the operation time from 0 to 25 hours, whereas at 30,000 feet the reduction was less than 1 percent. Data to determine the effect of engine deterioration at actual engine speeds other than 8000 rpm were unavailable.

The engine deterioration, illustrated in **figure 11**, which is attributed to changes in compressor performance, affects only the pressure levels through the engine and therefore would not alter the turbine-characteristic plot of **figure 10**. The data taken throughout the entire operating time of the engine showed no affect of deterioration on the gas-flow parameter.

Effect of engine speed. - Constant-speed operating lines for an altitude of 10,000 feet with the standard tail-pipe configuration are superimposed on the turbine-characteristic plot in **figure 12**. Reduction in the corrected engine speed from 8296 to 7006 rpm resulted in a reduction of the corrected turbine enthalpy drop from 39.3 to 31.0 Btu per pound of gas at a corrected turbine speed of 4300 rpm. Engine speed had little effect on turbine efficiency over the speed range investigated. The maximum effect occurred in the range of corrected turbine speeds above 4400 rpm, where a change in corrected engine speed from 8297 to 7006 rpm caused a drop in efficiency of approximately 2 percent. In general, the effect of engine speed on the turbine parameters was similar at the other altitudes (**figs. 9(b) to 9(d)**).

Effect of altitude. - The effects of altitude on the turbine operating lines at corrected engine speeds of 8400, 8000, and 7600 rpm with the standard tail-pipe configuration are shown in **figure 13**. Increasing altitude resulted in a decrease in corrected turbine enthalpy drop for a given corrected engine speed and corrected turbine speed. The effect of altitude was increased as the engine speed was reduced. With a corrected engine speed of 8400 rpm, corrected turbine enthalpy drop was reduced from 39.5 to 38.5 Btu per pound of gas for an increase in altitude from 10,000 to 40,000 feet at a corrected turbine speed of 4300 rpm. At a corrected engine speed of 8000 rpm, the reduction was from 37.8 to 36.2 Btu per pound of gas. The decrease in corrected turbine enthalpy drop with increase in altitude was due to the effect of altitude on the performance of the compressor, which changed the turbine operating conditions.

Although the altitude data presented were selected to minimize the effect of engine deterioration, it is probably not completely eliminated from **figure 13**.

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Effect of variations in tail-pipe configuration. - Turbine operating lines for the four tail-pipe configurations at an altitude of 10,000 feet and a corrected engine speed of 8000 rpm are superimposed on the turbine-characteristic plot in figure 14. These data were obtained at a cowl-inlet temperature of 60° F. Increasing the exhaust-nozzle diameter at a given corrected turbine speed resulted in an increase in turbine pressure ratio and turbine enthalpy drop. At all corrected turbine speeds, increasing the diameter from 20 to 24 inches resulted in an increase in corrected turbine enthalpy drop of approximately $5\frac{1}{2}$ percent.

SUMMARY OF RESULTS

The following turbine-performance results were obtained from an investigation of a Python turbine-propeller engine in the NACA Lewis altitude wind tunnel:

1. The turbine adiabatic efficiency varied from 83 to 86 percent over the range investigated. The higher efficiency values occurred at high turbine pressure ratios and high corrected turbine speeds.

2. Engine deterioration resulted in a shift of the turbine operating lines in the direction of lower turbine pressure ratios and lower turbine enthalpy drops but had no apparent effect on the turbine-characteristic plot.

3. With the standard tail-pipe configuration and a corrected turbine speed of 4300 rpm, changing the corrected engine speed from 8296 to 7006 rpm at an altitude of 10,000 feet resulted in a reduction of corrected turbine enthalpy drop from 39.3 to 31.0 Btu per pound of gas. The effect of engine speed on corrected turbine enthalpy was similar at the other altitudes. Changing altitude from 10,000 to 40,000 feet at a corrected engine speed of 8400 rpm reduced the corrected turbine enthalpy drop from 39.5 to 38.5 Btu per pound of gas.

4. Increasing the exhaust-nozzle diameter from 20 to 24 inches at a corrected turbine speed of 4300 rpm, a corrected engine speed of 8000 rpm, and an altitude of 10,000 feet resulted in an increase in corrected turbine enthalpy drop of approximately $5\frac{1}{2}$ percent.

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APPENDIX - METHODS OF CALCULATION

Symbols

The following are used in the calculations:

A	cross-sectional area, sq ft
C_p	specific heat at constant pressure, Btu/(lb)(°F)
C_T	thermal expansion ratio, ratio of hot area to cold area
ghp	gear horsepower
g	acceleration due to gravity, 32.2 ft/sec^2
H	enthalpy, Btu/lb gas flow
J	mechanical equivalent of heat, 778 ft-lb/Btu
N	engine speed, rpm
P	total pressure, lb/sq ft absolute
p	static pressure, lb/sq ft absolute
R	gas constant, 53.4 ft-lb/(lb)(°R)
shp	shaft horsepower
T	total temperature, °R
T_i	indicated temperature, °R
t	static temperature, °R
V	velocity, ft/sec
W_a	air flow, lb/sec
W_c	compressor-leakage air flow, lb/sec
W_f	fuel flow, lb/hr

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W_g gas flow, lb/sec

α thermocouple impact recovery factor, 0.85

γ ratio of specific heats

δ pressure correction factor, P/2116 (total pressure divided by NACA standard sea-level pressure)

η adiabatic efficiency

θ temperature correction factor, $\frac{\gamma T}{(1.4)(519)}$, product of γ and total temperature divided by product of γ and temperature for air at NACA standard sea-level conditions

ρ density, slugs/cu ft

Corrected parameters:

$N/\sqrt{\theta_1}$ corrected engine speed, rpm

$N/\sqrt{\theta_3}$ corrected turbine speed, rpm

T_3/θ_1 corrected turbine-inlet temperature, $^{\circ}R$

$\frac{W_{g,3}\sqrt{\theta_3}}{\delta_3\left(\frac{\gamma_3}{1.4}\right)}$ corrected turbine-inlet gas flow, lb/sec

$\frac{\Delta H_t}{\theta_3}$ corrected turbine enthalpy drop, Btu/lb gas

Subscripts:

t turbine

0 free stream

1 cowl inlet

2 burner inlet

3 turbine inlet

4 turbine outlet

5 exhaust-nozzle inlet

5a manufacturer's tail-pipe instrumentation

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Calculations

Total temperatures were calculated from thermocouple indicated temperatures with the equation

$$T = \frac{T_i \left(\frac{P}{p}\right)^{\frac{\gamma-1}{\gamma}}}{1 + \alpha\left[\left(\frac{P}{p}\right)^{\frac{\gamma-1}{\gamma}} - 1\right]} \tag{1}$$

Gas flow. - Gas flow was determined from pressure and temperature measurements at the exhaust-nozzle inlet (station 5) by use of the equation

$$W_{g,5} = g\rho_5 C_T A_5 V_5 = p_5 C_T A_5 \sqrt{\frac{\gamma_5 g}{Rt_5}} \sqrt{\frac{2}{\gamma_5 - 1}\left[\left(\frac{P_5}{p_5}\right)^{\frac{\gamma_5-1}{\gamma_5}} - 1\right]} \tag{2}$$

Gas flow at the turbine inlet was calculated by subtracting the measured values of turbine rear-face cooling air $W_{t,c}$ and compressor-outlet labyrinth leakage air $W_{c,l}$ (which was piped to the tail pipe behind the turbine) from the gas flow at station 5.

$$W_{g,3} = W_{g,5} - (W_{t,c} + W_{c,l}) \tag{3}$$

Turbine-inlet temperature. - In order to calculate turbine-inlet temperatures, the turbine power was assumed to equal the sum of the power absorbed by the compressor, the shaft horsepower measured by the torquemeter, and the power loss in the reduction gearing:

$$W_{g3}H_3 - W_{g,5}H_5 = (W_{a,2}H_2 - W_{a,1}H_1) + \frac{550\ (shp + gph)}{J} \tag{4}$$

Enthalpy at the turbine inlet was then

$$H_3 = \frac{W_{g,5}H_5 + (W_{a,2}H_2 - W_{a,1}H_1) + \frac{550\ (shp + ghp)}{J}}{W_{g,3}} \tag{5}$$

where

$$W_{a,2} = W_{g,3} - \frac{W_f}{3600}$$

$$W_{a,1} = W_{a,2} + W_c$$

Then

$$T_3 = H_3/C_p$$

Turbine efficiency. - Turbine adiabatic efficiency was calculated using the equation

$$\eta_t = \frac{1 - \frac{T_5}{T_3}}{1 - \left(\frac{P_4}{P_3}\right)^{\frac{\gamma_t - 1}{\gamma_t}}} \tag{6}$$

(The temperature at the exhaust-nozzle inlet T_5 was used instead of turbine-outlet temperature because temperature measurements at the turbine outlet were probably affected by radiation.) The values for γ_t were based on the fuel-air ratio and the average temperature of the gases flowing through the turbine.

TABLE I - PERFORMANCE DATA OF PYTHON TURBINE

Run	Altitude (ft)	Tunnel static pressure p_0 (lb/sq ft abs.)	Engine speed N (rpm)	Fuel flow W_f (lb/hr)	Shaft horse-power shp	Cowl-inlet total pressure P_1 (lb/sq ft abs.)	Cowl-inlet total temperature T_1 (°R)	Turbine-inlet total pressure P_3 (lb/sq ft abs.)	Turbine-inlet total temperature, T_3 (°R)	Turbine-outlet total pressure P_4 (lb/sq ft abs.)	Turbine-outlet static pressure p_4 (lb/sq ft abs.)	Turbine-outlet total temperature, T_4 (°R)
1	10,000	1451	8006	2330	2578	1492	485	7762	1957	1760	1580	1435
2		1454	8006	2170	2398	1494	485	7608	1884	1739	1557	1362
3		1455	8006	2055	2139	1495	483	7533	1830	1734	1562	1325
4		1448	8006	1645	1419	1488	484	7130	1641	1699	1555	1179
5		1456	8006	1125	410	1497	479	6662	1372	1677	1574	988
6		1453	7806	2240	2491	1491	489	7341	1986	1725	1548	1472
7		1437	7806	2080	2316	1475	486	7184	1894	1694	1527	1394
8		1451	7806	1920	2085	1489	488	7095	1820	1694	1541	1329
9		1449	7806	1510	1317	1487	484	6779	1598	1678	1543	1157
10		1446	7806	1010	316	1485	490	6213	1362	1667	1553	991
11		1450	7606	2060	2289	1488	485	6969	1907	1691	1532	1417
12		1448	7606	1975	2139	1486	484	6925	1853	1685	1535	1364
13		1451	7606	1820	1924	1489	488	6815	1790	1674	1536	1317
14		1448	7606	1420	1165	1485	486	6450	1555	1658	1536	1136
15		1440	7606	900	241	1479	482	5985	1291	1629	1546	947
16		1451	7406	1880	1978	1489	488	6557	1864	1665	1531	1398
17		1444	7406	1810	1852	1481	487	6484	1813	1654	1525	1353
18		1457	7406	1660	1641	1494	490	6399	1737	1660	1538	1291
19		1449	7406	1310	1045	1486	493	6072	1543	1636	1530	1144
20		1451	7406	910	289	1487	487	5742	1298	1620	1549	968
21		1453	7205	1675	1658	1489	490	6155	1775	1641	1526	1339
22		1452	7205	1600	1524	1489	490	6101	1727	1637	1579	1301
23		1448	7205	1470	1314	1485	486	6043	1641	1632	1525	1229
24		1452	7205	1220	889	1489	487	5818	1492	1625	1532	1114
25		1439	7205	875	302	1475	491	5435	1303	1599	1531	982
26		1447	6805	1400	1235	1486	490	5437	1658	1597	1510	1275
27		1455	6802	1360	1148	1493	491	5474	1622	1606	1519	1250
28		1452	6805	1220	965	1490	490	5323	1535	1597	1516	1173
29		1454	6805	1050	686	1493	489	5254	1427	1602	1526	1091
30		1449	6805	810	307	1487	487	5007	1282	1594	1530	984
31	20,000	965	8006	1810	2013	993	456	5456	2053	1214	1058	1543
32		973	8006	1680	1883	1000	456	5407	1973	1203	1053	1454
33		975	8006	1550	1699	1002	455	5316	1885	1187	1045	1337
34		968	8006	1265	1204	994	455	5017	1703	1155	1036	1234
35		972	8006	840	361	998	454	4587	1416	1131	1047	1039
36		969	7806	1675	1891	996	456	5251	1989	1195	1045	1482
37		976	7806	1555	1740	1003	457	5189	1908	1178	1041	1397
38		976	7806	1420	1545	1002	457	5080	1820	1173	1038	1331
39		971	7806	1385	1522	998	453	5075	1778	1160	1031	1293
40		969	7806	1125	1024	995	454	4808	1597	1151	1032	1162
41		975	7806	750	292	1000	452	4431	1347	1125	1042	990
42		970	7606	1515	1701	996	456	4985	1913	1159	1027	1420
43		979	7606	1430	1565	1005	461	4913	1856	1157	1034	1375
44		969	7606	1420	1565	995	456	4913	1833	1147	1023	1352
45		977	7606	1315	1392	1003	457	4870	1758	1149	1032	1291
46		966	7606	1065	949	992	455	4612	1580	1129	1026	1159
47		968	7606	717	296	994	455	4280	1324	1109	1031	982
48		971	7406	1415	1556	997	454	4704	1864	1139	1023	1398
49		965	7406	1345	1444	990	452	4648	1814	1129	1016	1350
50		971	7406	1250	1303	997	450	4633	1720	1130	1023	1275
51		966	7406	1010	883	992	454	4378	1562	1114	1023	1162
52		973	7406	680	272	997	452	4095	1286	1105	1035	968
53		968	7205	1285	1345	994	454	4423	1811	1118	1016	1367
54		966	7205	1270	1308	992	456	4353	1823	1114	1016	1357
55		964	7205	1250	1262	990	458	4330	1790	1115	1013	1359

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PROPELLER ENGINE WITH STANDARD TAIL-PIPE CONFIGURATION

Tail-pipe total pressure P_{5a} (lb/sq ft abs.)	Tail-pipe indicated temperature T_{5a} (°R)	Exhaust-nozzle-inlet total pressure P_5 (lb/sq ft abs.)	Exhaust-nozzle-inlet static pressure p_5 (lb/sq ft abs.)	Exhaust-nozzle-inlet total temperature T_5 (°R)	Corrected engine speed $N/\sqrt{\theta_1}$ (rpm)	Corrected turbine speed $N/\sqrt{\theta_3}$ (rpm)	Corrected turbine gas flow (lb/sec)	Corrected turbine enthalpy drop $\Delta H_t/\theta_3$ (Btu/lb gas)	Corrected turbine-inlet temperature T_3/θ_1 (°R)	Turbine pressure ratio P_3/P_4	Turbine efficiency η_t (percent)	Average engine time (hr)	Run
1641	1454	1636	1478	1452	8278	4254	22.00	39.32	2094	4.410	84.3	3.2	1
1631	1390	1630	1478	1389	8278	4328	22.05	39.52	2016	4.375	85.3	3.2	2
1623	1344	1625	1477	1352	8302	4387	21.81	38.86	1966	4.344	84.9	3.2	3
1608	1198	1602	1465	1206	8286	4614	22.12	38.15	1760	4.197	86.1	3.2	4
1655	1009	1584	1467	1012	8334	5016	21.67	36.15	1487	3.973	85.7	3.2	5
1625	1470	1620	1476	1486	8040	4119	22.07	38.31	2108	4.256	84.3	13.1	6
1596	1408	1597	1458	1410	8064	4210	21.92	38.47	2023	4.241	84.5	13.1	7
1599	1345	1603	1471	1352	8056	4289	21.86	38.29	1936	4.188	85.2	13.1	8
1592	1174	1583	1462	1186	8079	4557	21.75	37.15	1713	4.040	85.3	13.1	9
1627	1004	1555	1456	1014	8032	4906	21.24	35.12	1443	3.772	85.9	13.1	10
1602	1424	1602	1470	1435	7865	4089	22.06	37.40	2041	4.121	84.0	13.9	11
1593	1383	1598	1469	1391	7872	4145	21.98	37.18	1987	4.110	84.1	13.9	12
1590	1324	1591	1470	1341	7849	4212	21.54	37.09	1904	4.071	84.5	13.9	13
1579	1163	1570	1460	1160	7857	4498	21.66	36.40	1661	3.890	85.8	13.9	14
1602	961	1543	1451	960	7895	4901	21.14	34.71	1390	3.674	87.3	13.9	15
1584	1391	1585	1470	1416	7643	4023	21.68	35.78	1982	3.938	82.9	14.6	16
1576	1361	1575	1462	1374	7643	4078	21.60	36.03	1932	3.920	83.6	14.6	17
1585	1301	1582	1472	1313	7621	4158	21.98	36.01	1840	3.855	84.4	14.6	18
1574	1161	1564	1459	1166	7599	4393	22.34	35.19	1624	3.711	84.8	14.6	19
1593	981	1546	1460	978	7643	4763	21.31	33.81	1383	3.544	86.1	14.6	20
1572	1343	1567	1467	1358	7414	4005	21.44	34.71	1880	3.751	83.3	14.8	21
1570	1310	1565	1465	1322	7414	4057	21.42	34.55	1829	3.727	82.8	14.8	22
1564	1236	1558	1460	1249	7443	4153	21.54	34.36	1752	3.703	84.7	14.8	23
1579	1130	1557	1459	1134	7436	4340	22.34	33.93	1590	3.580	84.8	14.8	24
1557	986	1526	1448	989	7407	4622	21.12	32.70	1377	3.399	86.4	14.8	25
1540	1288	1541	1456	1292	7002	3906	22.11	32.24	1756	3.405	82.6	17.6	26
1550	1258	1550	1463	1264	6996	3945	22.12	32.03	1715	3.408	82.2	17.6	27
1548	1188	1546	1457	1192	7002	4046	23.02	31.88	1626	3.333	83.4	17.6	28
1565	1098	1535	1460	1106	7009	4188	21.40	31.26	1515	3.280	84.0	17.6	29
1538	985	1527	1453	990	7023	4402	22.22	30.56	1366	3.141	86.4	17.6	30
1126	1528	1101	983	1539	8542	4152	21.96	39.26	2344	4.494	82.6	19.6	31
1126	1446	1105	989	1461	8542	4238	22.00	39.51	2246	4.495	84.2	19.6	32
1116	1374	1102	991	1389	8550	4328	21.92	39.47	2150	4.479	84.4	19.6	33
1077	1238	1079	980	1252	8550	4539	21.83	38.81	1943	4.344	85.3	19.6	34
1073	1028	1072	977	1041	8558	4942	23.11	36.75	1619	4.056	85.5	19.6	35
1119	1465	1095	986	1479	8329	4115	22.04	38.85	2264	4.394	84.4	20.2	36
1118	1394	1098	991	1410	8321	4197	22.16	38.91	2167	4.405	85.0	20.2	37
1113	1331	1092	990	1345	8321	4291	21.94	38.76	2067	4.331	84.8	20.2	38
1094	1300	1086	985	1309	8360	4333	21.97	38.98	2037	4.375	85.1	20.2	39
1070	1174	1071	979	1175	8345	4557	21.86	38.05	1826	4.177	85.8	20.2	40
1074	978	1069	977	989	8360	4931	22.88	36.20	1547	3.939	86.8	20.2	41
1103	1406	1084	984	1427	8116	4085	22.12	38.18	2177	4.301	83.7	20.9	42
1097	1364	1089	993	1384	8070	4143	22.09	38.17	2090	4.246	84.0	20.9	43
1088	1345	1078	983	1362	8116	4165	21.83	38.25	2086	4.283	84.5	20.9	44
1085	1290	1082	989	1305	8108	4247	21.77	37.87	1997	4.238	84.3	20.9	45
1061	1156	1057	975	1172	8123	4464	21.36	37.05	1802	4.085	85.0	20.9	46
1064	965	1051	971	979	8123	4845	22.44	35.33	1510	3.859	85.9	20.9	47
1083	1391	1074	984	1405	7917	4025	21.96	37.12	2131	4.130	83.0	21.5	48
1070	1346	1064	977	1364	7932	4078	21.83	37.10	2083	4.117	83.2	21.5	49
1068	1276	1068	983	1288	7954	4179	21.68	37.10	1984	4.100	83.6	21.5	50
1054	1156	1050	974	1167	7917	4369	21.66	35.89	1786	3.930	84.8	21.5	51
1073	955	1044	976	961	7932	4781	21.81	34.49	1477	3.706	85.4	21.5	52
1061	1356	1059	980	1377	7702	3970	21.95	35.65	2070	3.956	82.5	22.0	53
1057	1374	1054	977	1392	7688	3957	21.79	35.32	2075	3.908	82.0	22.0	54
1051	1351	1052	975	1364	7666	3992	21.96	35.49	2028	3.883	82.5	22.0	55

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TABLE I - PERFORMANCE DATA OF PYTHON TURBINE-PROPELLER

Run	Altitude (ft)	Tunnel static pressure p_0 (lb/sq ft abs.)	Engine speed N (rpm)	Fuel flow W_f (lb/hr)	Shaft horse-power shp	Cowl-inlet total pressure P_1 (lb/sq ft abs.)	Cowl-inlet total temperature T_1 (°R)	Turbine-inlet total pressure P_3 (lb/sq ft abs.)	Turbine-inlet total temperature, T_3 (°R)	Turbine-outlet total pressure P_4 (lb/sq ft abs.)	Turbine-outlet static pressure p_4 (lb/sq ft abs.)	Turbine-outlet total temperature, T_4 (°R)
56	20,000	963	7205	1225	1246	988	458	4318	1779	1108	1012	1349
57		971	7205	1150	1134	997	455	4346	1711	1118	1023	1286
58		972	7205	925	773	997	456	4149	1518	1104	1026	1151
59		965	7205	645	249	989	454	3865	1286	1089	1026	987
60		973	6805	940	816	1000	455	3838	1568	1087	1018	1223
61		964	6805	875	720	994	454	3779	1507	1079	1013	1172
62		964	6805	800	582	990	455	3691	1431	1071	1009	1115
63		970	6805	595	255	995	454	3557	1251	1077	1025	986
64	30,000	626	8006	1265	1376	645	437	3651	2078	806	691	1570
65		626	8006	1170	1303	643	438	3574	2005	793	684	1509
66		628	8006	1085	1173	645	437	3508	1925	784	683	1445
67		627	8006	885	869	644	436	3358	1731	757	672	1294
68		621	8006	575	266	637	436	3007	1435	730	670	1086
69		627	7806	1160	1287	643	438	3482	2025	787	681	1531
70		626	7806	1095	1215	643	438	3470	1940	779	677	1462
71		625	7806	983	1077	642	437	3395	1825	761	670	1370
72		623	7806	815	773	640	437	3241	1656	743	665	1250
73		619	7806	570	336	636	436	2958	1428	722	663	1082
74		624	7606	1050	1173	641	439	3337	1927	759	669	1468
75		630	7606	1020	1114	645	438	3349	1886	767	675	1432
76		628	7606	935	1016	644	444	3221	1810	746	664	1381
77		622	7606	774	742	639	440	3081	1631	732	661	1252
78		618	7606	540	276	634	437	2858	1366	711	658	1075
79		628	7406	960	1052	644	437	3149	1864	747	665	1435
80		626	7406	910	995	643	437	3088	1814	738	661	1403
81		625	7406	845	889	641	436	3081	1715	732	660	1319
82		626	7406	720	664	643	438	2965	1567	726	663	1220
83		623	7406	525	302	640	437	2803	1373	714	664	1065
84		626	7205	840	870	643	437	2965	1737	728	660	1363
85		626	7205	805	824	642	435	2985	1696	727	661	1323
86		625	7205	765	761	642	435	2933	1635	723	659	1279
87		623	7205	665	573	640	436	2848	1521	717	659	1198
88		623	7205	500	288	639	436	2667	1350	705	661	1058
89		623	6805	670	580	640	441	2585	1581	702	654	1296
90		624	6805	635	551	640	436	2578	1538	701	655	1252
91		630	6805	595	481	647	440	2562	1492	706	662	1216
92		624	6805	525	366	641	438	2501	1400	699	658	1136
93		629	6805	472	262	645	439	2466	1332	701	664	1076
94	40,000	396	8006	755	799	406	441	2231	2050	500	431	1649
95		396	8006	720	764	406	443	2198	2015	494	429	1616
96		392	8006	660	671	403	441	2157	1908	482	424	1535
97		390	8006	560	507	400	439	2042	1754	471	418	1412
98		389	8006	410	232	399	446	1908	1519	458	418	1235
99		397	7806	700	745	407	434	2152	1976	492	431	1599
100		394	7806	670	699	404	436	2113	1924	483	424	1560
101		391	7806	630	632	399	437	2087	1850	472	419	1491
102		395	7806	400	237	404	438	1890	1512	461	424	1231
103		391	7606	620	626	402	438	2013	1889	470	418	1545
104		394	7606	590	593	406	438	1998	1835	472	421	1504
105		391	7606	550	515	402	442	1956	1764	463	416	1450
106		398	7606	490	426	408	439	1937	1670	468	424	1370
107		390	7606	100	253	400	439	1820	1518	452	417	1266
108		394	7406	520	491	405	442	1857	1742	458	417	1472
109		393	7406	470	415	404	442	1816	1667	458	417	1390
110		394	7406	390	268	406	444	1763	1497	453	418	1266

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ENGINE WITH STANDARD TAIL-PIPE CONFIGURATION - Concluded

Tail-pipe total pressure P_{5a} (lb/sq ft abs.)	Tail pipe indicated temperature T_{5a} (°R)	Exhaust-nozzle-inlet total pressure P_5 (lb/sq	Exhaust-nozzle-inlet static pressure p_5 (lb/sq	Exhaust-nozzle-inlet total temperature T_5 (°R)	Corrected engine speed $N/\sqrt{\theta_1}$ (rpm)	Corrected turbine speed $N/\sqrt{\theta_3}$ (rpm)	Corrected turbine gas flow (lb/sec)	Corrected turbine enthalpy drop $\Delta H_t/\theta_3$ (Btu/lb gas)	Corrected turbine-inlet temperature T_3/θ_1 (°R)	Turbine pressure ratio P_3/P_4	Turbine efficiency η_t (percent)	Average engine time (hr)	Run
1050	1346	1050	974	1356	7666	4003	21.92	35.52	2016	3.897	82.2	22.0	56
1058	1278	1058	981	1296	7695	4073	21.87	35.10	1952	3.887	83.4	22.0	57
1048	1138	1047	979	1145	7688	4309	21.41	35.03	1728	3.758	84.8	22.0	58
1064	964	1030	970	973	7702	4651	21.54	33.18	1470	3.549	84.6	22.0	59
1038	1209	1039	980	1208	7268	4008	21.44	32.82	1789	3.531	82.7	22.5	60
1032	1156	1032	973	1159	7275	4082	21.85	32.56	1723	3.502	83.1	22.5	61
1029	1104	1031	968	1100	7268	4183	22.80	32.51	1632	3.446	83.9	22.5	62
1053	954	1026	976	962	7275	4451	21.09	31.39	1430	3.303	84.1	22.5	63
737	1543	718	638	1545	8727	4140	21.78	39.74	2468	4.530	83.9	26.2	64
733	1478	713	637	1486	8719	4211	21.70	39.87	2376	4.507	83.9	26.2	65
728	1414	712	638	1420	8727	4288	21.81	39.83	2286	4.474	84.8	26.2	66
706	1263	703	635	1262	8735	4503	21.78	39.53	2060	4.436	86.3	26.2	67
683	1051	684	625	1052	8735	4912	22.27	36.85	1708	4.119	86.0	26.2	68
729	1501	710	638	1505	8501	4083	21.65	39.16	2400	4.424	84.6	26.7	69
724	1431	709	636	1437	8501	4165	21.81	39.38	2299	4.454	84.2	26.7	70
717	1330	703	635	1340	8509	4284	21.58	39.65	2167	4.461	85.1	26.7	71
695	1216	694	631	1211	8509	4484	21.72	39.18	1967	4.362	85.6	26.7	72
679	1048	676	623	1044	8516	4801	21.49	37.07	1700	4.097	86.8	26.7	73
718	1435	701	634	1434	8268	4072	21.72	38.53	2278	4.397	83.7	27.1	74
720	1390	705	638	1399	8283	4111	21.65	38.69	2235	4.366	84.3	27.1	75
710	1330	699	636	1340	8222	4191	21.84	38.65	2116	4.318	84.4	27.1	76
689	1208	687	629	1203	8260	4399	21.76	38.08	1924	4.209	85.3	27.1	77
675	1026	673	621	1006	8291	4775	21.90	36.12	1622	4.020	85.5	27.1	78
711	1384	698	636	1391	8073	4025	21.99	37.97	2214	4.216	84.2	27.6	79
703	1349	693	634	1355	8073	4078	21.95	37.71	2154	4.184	83.9	27.6	80
693	1265	690	632	1272	8080	4187	21.82	37.29	2041	4.209	84.6	27.6	81
688	1170	685	632	1167	8065	4362	21.58	36.92	1857	4.084	83.9	27.6	82
678	1020	676	626	1016	8073	4637	21.99	35.72	1631	3.926	85.5	27.6	83
690	1306	687	633	1306	7853	4048	21.60	36.87	2063	4.073	83.2	28.0	84
689	1269	686	632	1269	7868	4094	21.58	36.83	2023	4.106	83.7	28.0	85
687	1216	684	632	1221	7868	4162	21.48	36.85	1951	4.057	84.1	28.0	86
681	1143	676	629	1136	7861	4304	21.03	36.17	1810	3.972	84.3	28.0	87
673	1009	673	626	1011	7861	4546	22.13	34.31	1607	3.783	84.3	28.0	88
671	1228	668	628	1207	7383	3994	21.26	34.03	1861	3.682	83.3	28.5	89
670	1188	668	628	1173	7424	4043	21.24	33.94	1831	3.678	83.1	28.5	90
675	1158	673	634	1138	7390	4102	21.20	33.64	1760	3.629	83.4	28.5	91
667	1078	667	628	1068	7411	4224	21.35	32.77	1659	3.578	83.3	28.5	92
678	1010	673	631	1019	7397	4323	22.59	31.84	1575	3.518	82.5	28.5	93
463	1526	450	401	1517	8687	4163	22.15	39.84	2413	4.462	85.2	31.6	94
458	1475	447	400	1498	8662	4196	22.04	39.19	2361	4.449	84.0	31.6	95
450	1388	441	397	1410	8687	4304	21.65	39.43	2245	4.475	84.4	31.6	96
442	1285	435	394	1290	8703	4475	21.82	38.88	2074	4.335	85.5	31.6	97
427	1124	425	391	1121	8638	4785	21.19	37.39	1768	4.166	84.5	31.6	98
457	1464	446	402	1470	8540	4130	22.36	39.20	2363	4.370	85.7	30.4	99
451	1419	441	399	1425	8516	4181	21.62	39.39	2290	4.375	85.1	30.4	100
444	1349	436	395	1365	8509	4259	21.56	39.21	2197	4.422	84.6	30.4	101
432	1111	430	397	1120	8501	4674	21.10	36.64	1792	4.100	84.5	30.4	102
443	1386	435	395	1413	8283	4109	21.85	38.02	2238	4.283	83.2	32.0	103
443	1348	438	398	1361	8283	4163	22.23	38.30	2174	4.233	85.3	32.0	104
438	1291	432	395	1308	8245	4242	21.68	38.16	2071	4.225	85.1	32.0	105
442	1225	438	401	1243	8268	4351	21.99	37.36	1974	4.139	84.2	32.0	106
427	1124	423	392	1131	8268	4549	21.09	36.12	1795	4.027	84.1	32.0	107
435	1294	431	397	1310	8028	4154	21.78	36.73	2046	4.055	83.4	32.8	108
434	1235	430	396	1251	8028	4239	22.26	36.21	1957	3.965	84.5	32.8	109
427	1118	424	396	1122	8006	4459	20.86	35.72	1750	3.892	84.0	32.8	110

TABLE II - ENGINE PERFORMANCE DETERIORATION DATA OF PYTHON

Run	Altitude (ft)	Tunnel static pressure p_0 (lb/sq ft abs.)	Engine speed N (rpm)	Fuel flow W_f (lb/hr)	Shaft horse-power shp	Cowl-inlet total pressure P_1 (lb/sq	Cowl-inlet total temper-ature T_1 (°R)	Turbine-inlet total pressure P_3 (lb/sq	Turbine-inlet total tempera-ture, T_3 (°R)	Turbine-outlet total pressure P_4 (lb/sq	Turbine-outlet static pressure p_4 (lb/sq	Turbine-outlet total tempera-ture, T_4 (°R)
1	10,000	1466	8006	2320	2589	1505	518	7509	2052	1756	1568	1533
2		1453	8006	2100	2246	1492	518	7275	1936	1716	1547	1416
3		1458	8006	1850	1831	1497	520	7086	1807	1703	1552	1318
4		1460	8006	1560	1328	1498	522	6795	1684	1686	1550	1222
5		1458	8006	2320	2510	1498	517	7367	2068	1739	1560	1552
6		1447	8006	2100	2195	1485	514	7215	1938	1706	1545	1434
7		1455	8006	1870	1831	1494	525	7038	1845	1694	1550	1355
8		1450	8006	1580	1374	1488	520	6801	1695	1679	1544	1234
9		1459	8006	1195	595	1497	510	6503	1482	1668	1564	1073
10		1466	8006	2290	2488	1503	523	7261	2082	1734	1555	1568
11		1457	8006	2020	2116	1496	517	7090	1936	1705	1542	1441
12		1452	8006	1600	1363	1490	520	6712	1714	1677	1541	1267
13		1458	8006	1100	349	1496	517	6264	1448	1663	1559	1064
14		1450	8006	2010	2039	1488	521	6932	1962	1694	1536	1471
15		1456	8006	1610	1376	1494	520	6658	1738	1676	1545	1292
16		1452	8006	1155	554	1489	519	6208	1503	1446	1548	1111
17	20,000	975	8006	1730	1922	1002	451	5505	1973	1222	1067	1437
18		971	8006	1610	1790	997	449	5404	1906	1194	1051	1373
19		969	8006	1475	1556	996	450	5272	1794	1175	1042	1290
20		969	8006	1265	1146	995	450	5059	1667	1155	1042	1186
21		968	8006	885	469	995	451	4675	1423	1129	1042	1027
22	30,000	625	8006	1230	1345	643	441	3615	2042	800	687	1534
23		631	8006	1130	1237	648	442	3585	1958	793	686	1455
24		624	8006	1045	1107	641	441	3486	1883	772	675	1394
25		623	8006	870	824	641	440	3324	1717	751	669	1273
26		629	8006	610	306	646	443	3063	1460	737	676	1097
27	40,000	390	8006	745	768	400	442	2196	2044	489	420	1597
28		387	8006	725	746	397	438	2184	2006	487	418	1578
29		386	8006	665	678	397	439	2138	1925	477	413	1514
30		387	8006	570	526	398	441	2060	1780	466	409	1392
31		396	8006	450	300	407	440	1973	1583	465	419	1243

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TURBINE-PROPELLER ENGINE WITH STANDARD TAIL-PIPE CONFIGURATION

Tail-pipe total pressure P_{5a} (lb/sq ft abs.)	Tail-pipe indicated temperature T_{5a} (°R)	Exhaust-nozzle-inlet total pressure P_5 (lb/sq ft abs.)	Exhaust-nozzle-inlet static pressure p_5 (lb/sq ft abs.)	Exhaust-nozzle-inlet total temperature T_5 (°R)	Corrected engine speed $N/\sqrt{\theta_1}$ (rpm)	Corrected turbine speed $N/\sqrt{\theta_3}$ (rpm)	Corrected turbine gas flow (lb/sec)	Corrected turbine enthalpy drop $\Delta H_t/\theta_3$ (Btu/lb gas)	Corrected turbine-inlet temperature T_3/θ_1 (°R)	Turbine pressure ratio P_3/P_4	Turbine efficiency η_t (percent)	Average engine time (hr)	Run
1647	1551	1638	1490	1531	8014	4161	21.90	38.91	2056	4.276	85.1	2.0	1
1613	1440	1616	1475	1439	8014	4274	22.03	38.69	1940	4.240	85.5	2.0	2
1605	1345	1607	1476	1344	7998	4413	21.86	38.23	1803	4.161	85.3	2.0	3
1603	1245	1594	1474	1252	7983	4559	21.62	37.53	1674	4.030	85.8	2.0	4
1632	1558	1627	1483	1552	8022	4146	21.98	38.27	2076	4.236	84.2	6.3	5
1605	1451	1608	1469	1448	8046	4272	22.03	38.51	1957	4.229	84.5	6.3	6
1602	1370	1603	1474	1374	7960	4370	21.76	37.94	1823	4.155	85.3	6.3	7
1593	1254	1585	1464	1258	7998	4544	21.67	37.58	1692	4.051	85.9	6.3	8
1634	1094	1580	1467	1096	8078	4837	21.84	36.48	1508	3.899	87.1	6.3	9
1638	1560	1628	1488	1570	7976	4131	21.97	37.83	2065	4.187	83.7	16.1	10
1611	1446	1610	1476	1453	8022	4274	21.97	37.75	1944	4.158	84.1	16.1	11
1588	1271	1585	1464	1284	7998	4523	21.83	36.99	1711	4.002	84.7	16.1	12
1617	1083	1568	1466	1084	8022	4891	21.53	34.87	1454	3.767	85.5	16.1	13
1598	1465	1597	1467	1476	7991	4247	22.17	37.44	1954	4.092	84.7	24.7	14
1591	1296	1586	1467	1305	7998	4493	21.90	36.69	1735	3.973	84.5	24.7	15
1601	1120	1561	1457	1127	8006	4806	21.80	35.17	1503	3.772	85.7	24.7	16
1131	1466	1114	993	1457	8590	4236	22.10	39.76	2270	4.505	84.8	4.5	17
1121	1403	1104	987	1404	8606	4307	22.23	39.59	2203	4.526	84.5	4.5	18
1098	1324	1094	985	1314	8598	4431	22.01	39.70	2069	4.487	85.2	4.5	19
1077	1215	1079	982	1221	8598	4583	21.56	38.60	1923	4.380	85.2	4.5	20
1072	1031	1066	976	1036	8590	4930	22.24	37.52	1638	4.141	86.8	4.5	21
733	1529	716	637	1510	8687	4172	21.96	40.03	2403	4.519	84.8	9.3	22
737	1445	719	643	1444	8679	4252	21.77	39.98	2299	4.521	84.7	9.3	23
721	1383	709	635	1382	8687	4332	22.01	39.84	2216	4.516	85.3	9.3	24
697	1264	700	633	1256	8695	4521	21.82	39.32	2025	4.426	85.5	9.3	25
695	1083	692	635	1071	8670	4873	21.75	37.19	1710	4.156	85.4	9.3	26
454	1523	442	395	1515	8679	4170	21.82	39.64	2400	4.491	84.6	10.1	27
451	1494	440	393	1487	8719	4207	21.87	39.64	2377	4.485	84.1	10.1	28
446	1415	435	391	1419	8703	4288	21.65	39.74	2276	4.482	85.0	10.1	29
437	1315	433	395	1310	8687	4445	21.04	39.39	2095	4.421	84.7	10.1	30
436	1186	436	400	1166	8695	4693	21.38	38.12	1867	4.243	84.8	10.1	31

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TABLE III - PERFORMANCE DATA OF PYTHON TURBINE-

Run	Altitude (ft)	Tunnel static pressure p_0 (lb/sq ft abs.)	Engine speed N (rpm)	Fuel flow W_f (lb/hr)	Shaft horsepower shp	Cowl-inlet total pressure P_1 (lb/sq ft abs)	Cowl-inlet total temperature T_1 (°R)	Turbine-inlet total pressure P (lb/sq ft abs.)	Turbine-inlet total temperature, T_3 (°R)	Turbine-outlet total pressure P_4 (lb/sq ft abs.)	Turbine-outlet static pressure p_4 (lb/sq ft abs.)	Turbine-outlet total temperature, T_4 (°R)
1	10,000	1457	8006	2180	2017	1495	522	7001	2030	1803	1669	1548
2		1477	8006	2140	1971	1514	522	7069	2034	1828	1693	1551
3		1454	8006	1910	1665	1491	515	6885	1876	1788	1661	1413
4		1457	8006	1600	1133	1493	525	6540	1738	1759	1649	1303
5		1457	8006	1200	1460	1495	517	6256	1531	1740	1646	1136
6		1450	8006	2180	2079	1487	492	7301	1959	1833	1680	1466
7		1455	8006	1990	1801	1492	488	7200	1845	1826	1681	1376
8		1450	8006	1460	909	1487	483	6770	1570	1781	1657	1154
9		1451	7806	2120	2033	1488	488	7047	1933	1810	1664	1459
10		1451	7806	2010	1889	1487	490	6961	1886	1800	1660	1419
11		1447	7806	1820	1618	1485	483	6900	1761	1788	1655	1320
12		1450	7806	1820	1585	1487	487	6864	1774	1788	1657	1330
13		1448	7806	1390	847	1485	486	6478	1541	1754	1641	1141
14		1450	7606	1890	1727	1486	489	6600	1847	1765	1640	1403
15		1449	7606	1790	1603	1486	486	6536	1789	1758	1637	1354
16		1449	7606	1655	1377	1486	486	6464	1702	1750	1633	1278
17		1448	7606	1280	748	1485	487	6127	1506	1726	1625	1120
18	30,000	626	8006	1200	1201	643	444	3574	2055	834	746	1552
19		628	8006	1130	1110	644	444	3514	1985	829	743	1493
20		625	8006	985	903	641	441	3390	1857	816	737	1384
21		632	8006	985	903	648	445	3421	1844	821	745	1372
22		626	8006	765	519	642	445	3196	1632	795	731	1207
23		630	8006	685	351	646	445	3119	1549	789	734	1121
24		629	7806	1090	1094	645	441	3400	1968	820	737	1490
25		628	7806	1050	1026	644	445	3372	1932	815	736	1459
26		624	7806	1000	982	641	438	3352	1867	807	730	1390
27		632	7806	925	847	648	443	3309	1781	808	737	1325
28		626	7806	910	835	642	442	3260	1792	801	730	1336
29		627	7806	710	483	643	439	3098	1562	786	726	1158
30		629	7806	665	390	645	444	3040	1530	780	728	1111
31		629	7606	1025	1011	645	443	3229	1940	801	726	1472
32		630	7606	970	935	646	442	3226	1862	801	730	1404
33		628	7606	955	913	644	442	3207	1856	796	725	1399
34		632	7606	880	803	647	439	3177	1757	793	727	1297
35		629	7606	850	748	646	444	3120	1735	790	724	1303
36		629	7606	690	504	646	445	2991	1573	777	721	1164
37		632	7606	680	369	648	441	2973	1501	781	728	1159
38	40,000	392	8006	785	753	403	438	2250	2098	530	469	1639
39		391	8006	720	683	401	437	2198	2025	522	463	1560
40		389	8006	605	554	401	438	2103	1857	509	457	1396
41		391	8006	520	412	402	436	2039	1723	502	456	1270
42		393	7606	650	615	404	440	2036	1967	505	455	1514
43		392	7606	610	560	402	439	1996	1918	500	453	1468
44		395	7606	560	482	406	436	1985	1810	501	456	1372
45		396	7606	530	437	408	436	1970	1733	500	457	1302

2019

PROPELLER ENGINE WITH A 20-INCH-DIAMETER EXHAUST NOZZLE

Tail-pipe total pressure P_{5a} (lb/sq ft abs.)	Tail-pipe indicated temperature T_{5a} (°R)	Exhaust-nozzle-inlet total pressure P_5 (lb/sq ft abs.)	Exhaust-nozzle-inlet static pressure p_5 (lb/sq ft abs.)	Exhaust-nozzle-inlet total temperature T_5 (°R)	Corrected engine speed $N/\sqrt{\theta_1}$ (rpm)	Corrected turbine speed $N/\sqrt{\theta_3}$ (rpm)	Corrected turbine gas flow (lb/sec)	Corrected turbine enthalpy drop $\Delta H_t/\theta_3$ (Btu/lb gas)	Corrected turbine-inlet temperature T_3/θ_1 (°R)	Turbine pressure ratio P_3/P_4	Turbine efficiency η_t (percent)	Average engine time (hr)	Run
1719	1561	1719	1618	1554	7983	4181	22.03	36.22	2018	3.883	83.3	44.3	1
1745	1550	1744	1638	1557	7983	4176	22.47	35.80	2022	3.867	83.5	44.3	2
1708	1425	1711	1607	1420	8038	4335	22.80	36.38	1891	3.851	85.3	44.3	3
1696	1318	1686	1588	1322	7958	4493	23.00	35.31	1717	3.718	84.7	44.3	4
1715	1158	1655	1574	1158	8022	4765	21.66	34.29	1537	3.595	86.1	44.3	5
1733	1475	1736	1627	1478	8222	4252	22.23	36.86	2067	3.983	85.2	46.4	6
1732	1384	1735	1623	1389	8262	4370	22.51	36.96	1962	3.943	85.3	46.4	7
1720	1168	1692	1590	1173	8302	4709	22.76	35.79	1687	3.801	86.3	46.4	8
1717	1469	1719	1617	1464	8056	4172	21.96	36.58	2056	3.893	85.2	46.8	9
1711	1431	1712	1611	1429	8032	4219	22.16	36.32	1998	3.867	84.9	46.8	10
1700	1325	1706	1601	1329	8095	4356	22.71	36.21	1892	3.859	85.0	46.8	11
1701	1338	1706	1602	1341	8056	4339	22.79	36.46	1891	3.839	85.3	46.8	12
1705	1164	1670	1577	1157	8064	4633	22.46	35.55	1646	3.693	86.6	46.8	13
1686	1416	1689	1594	1409	7834	4149	22.40	35.31	1960	3.739	84.7	47.2	14
1678	1366	1684	1588	1360	7857	4219	23.33	35.96	1911	3.718	85.8	47.2	15
1670	1295	1676	1581	1292	7857	4309	22.67	35.36	1818	3.694	85.1	47.2	16
1694	1149	1643	1564	1139	7849	4563	21.79	34.47	1605	3.550	86.8	47.2	17
789	1533	781	723	1545	8654	4159	22.06	38.21	2402	4.285	83.4	58.0	18
782	1479	777	722	1492	8654	4227	21.94	38.21	2320	4.239	83.3	58.0	19
764	1384	765	714	1383	8687	4361	21.54	38.26	2185	4.154	85.7	58.0	20
770	1377	773	720	1379	8646	4372	22.09	37.73	2151	4.167	84.1	58.0	21
747	1211	751	702	1220	8646	4628	22.19	37.07	1903	4.020	84.4	58.0	22
753	1153	749	699	1160	8646	4740	22.82	35.82	1807	3.953	83.7	58.0	23
776	1479	771	718	1482	8470	4137	21.86	37.84	2316	4.146	83.9	58.2	24
769	1450	768	715	1449	8430	4172	22.00	37.40	2253	4.137	84.4	58.2	25
760	1389	761	710	1397	8501	4240	21.70	37.67	2212	4.154	84.4	58.2	26
761	1334	763	713	1333	8446	4332	21.93	37.28	2086	4.095	84.4	58.2	27
753	1340	754	707	1338	8462	4322	21.49	37.47	2104	4.070	85.3	58.2	28
739	1165	745	698	1166	8485	4605	22.41	36.44	1847	3.941	85.0	58.2	29
746	1143	744	695	1149	8438	4649	23.28	35.53	1788	3.897	83.9	58.2	30
759	1455	757	709	1469	8237	4059	21.80	36.87	2273	4.031	83.8	58.5	31
756	1398	759	709	1404	8245	4136	22.47	36.74	2186	4.027	84.0	58.5	32
752	1388	752	706	1399	8245	4143	21.26	36.71	2179	4.029	84.2	58.5	33
750	1306	752	706	1319	8268	4249	21.58	36.66	2077	4.006	84.6	58.5	34
745	1301	746	703	1307	8222	4273	21.22	36.25	2028	3.949	84.2	58.5	35
734	1175	739	695	1178	8214	4471	22.05	35.74	1835	3.849	85.5	58.5	36
749	1143	739	695	1133	8253	4574	22.22	34.86	1767	3.807	83.6	58.5	37
498	1569	491	453	1587	8719	4118	22.21	37.74	2486	4.245	82.6	61.3	38
495	1516	486	450	1522	8727	4187	22.09	38.15	2405	4.211	84.0	61.3	39
475	1376	476	443	1381	8719	4358	21.86	38.35	2200	4.132	86.1	61.3	40
470	1271	462	441	1276	8735	4516	20.75	37.93	2051	4.062	86.9	61.3	41
478	1479	474	443	1493	8260	4031	21.80	36.51	2320	4.032	83.3	62.2	42
471	1438	470	440	1453	8268	4078	21.90	36.38	2267	3.992	83.7	62.2	43
471	1350	470	442	1366	8298	4193	21.36	36.62	2155	3.962	84.1	62.2	44
469	1289	470	442	1303	8298	4278	21.44	36.36	2063	3.940	84.7	62.2	45

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TABLE IV - PERFORMANCE DATA OF PYTHON TURBINE-

Run	Altitude (ft)	Tunnel static pressure p_0 (lb/sq ft abs.)	Engine speed N (rpm)	Fuel flow W_f (lb/hr)	Shaft horse-power shp	Cowl-inlet total pressure P_1 (lb/sq ft abs.)	Cowl-inlet total temperature T_1 (°R)	Turbine-inlet total pressure P_3 (lb/sq ft abs.)	Turbine-inlet total temperature, T_3 (°R)	Turbine-outlet total pressure P_4 (lb/sq ft abs.)	Turbine-outlet static pressure p_4 (lb/sq ft abs.)	Turbine-outlet total temperature, T_4 (°R)
1	10,000	1452	8006	2190	2209	1488	522	6941	2072	1722	1580	1578
2		1455	8006	1900	1813	1493	521	6765	1895	1712	1580	1433
3		1451	8006	1180	507	1489	518	6184	1497	1664	1570	1106
4		1456	8006	2410	2572	1495	493	7441	2080	1770	1601	1574
5		1454	8006	2255	2266	1493	499	7246	2017	1752	1593	1524
6		1452	8006	2190	2266	1490	487	7336	1941	1757	1592	1446
7		1450	7806	2190	2265	1488	487	7069	1969	1736	1580	1486
8		1451	7806	1980	1977	1488	486	6950	1864	1720	1577	1387
9		1452	7806	1780	1557	1490	489	6760	1758	1708	1577	1308
10		1443	7806	1350	881	1481	484	6423	1521	1677	1564	1121
11		1451	7606	1940	1916	1489	489	6613	1888	1698	1566	1425
12		1453	7606	1820	1733	1490	488	6525	1808	1692	1567	1364
13		1446	7606	1650	1475	1483	487	6406	1724	1678	1561	1289
14		1449	7606	1300	858	1487	485	6146	1513	1665	1562	1121
15	30,000	631	8006	1225	1291	647	448	3541	2102	808	709	1587
16		624	8006	1225	1133	641	441	3578	2057	805	706	1567
17		631	8006	1050	1042	647	444	3462	1915	789	699	1428
18		627	8006	1030	995	644	445	3427	1887	783	694	1409
19		629	8006	890	833	646	444	3320	1756	776	695	1294
20		628	8006	695	484	644	444	3142	1557	757	692	1137
21		627	7806	1090	1144	644	444	3392	1975	786	695	1493
22		623	7806	1000	1037	640	443	3328	1884	770	685	1412
23		625	7806	900	881	641	442	3253	1779	765	687	1319
24		623	7806	700	506	639	443	3069	1567	747	683	1153
25		624	7606	1015	1054	640	442	3233	1927	764	682	1458
26		627	7606	980	989	645	441	3225	1860	766	686	1392
27		628	7606	865	830	645	442	3140	1740	763	686	1292
28		627	7606	630	471	643	441	2947	1506	741	683	1109
29	40,000	391	8006	750	764	402	442	2204	2059	503	439	1568
30		395	8006	665	654	405	443	2146	1939	497	439	1457
31		393	8006	630	589	403	443	2115	1874	491	434	1405
32		394	8006	575	496	405	442	2077	1781	486	434	1323
33		398	7606	660	671	408	438	2057	1921	490	437	1481
34		399	7606	600	593	408	440	2009	1855	484	435	1404
35		390	7606	490	465	400	444	1929	1740	470	426	1276
36		394	7606	500	459	404	440	1941	1736	476	432	1297
37		389	7606	360	253	399	439	1803	1504	458	424	1096

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PROPELLER ENGINE WITH A 22-INCH-DIAMETER EXHAUST NOZZLE

Tail-pipe total pressure P_{5a} (lb/sq ft abs.)	Tail-pipe indicated temperature T_{5a} (°R)	Exhaust-nozzle-inlet total pressure P_5 (lb/sq ft abs.)	Exhaust-nozzle-inlet static pressure p_5 (lb/sq ft abs.)	Exhaust-nozzle-inlet total temperature T_5 (°R)	Corrected engine speed $N/\sqrt{\theta_1}$ (rpm)	Corrected turbine speed $N/\sqrt{\theta_3}$ (rpm)	Corrected turbine gas flow (lb/sec)	Corrected turbine enthalpy drop $\Delta H_t/\theta_3$ (Btu/lb gas)	Corrected turbine-inlet temperature T_3/θ_1 (°R)	Turbine pressure ratio P_3/P_4	Turbine efficiency η_t (percent)	Average engine time (hr)	Run
1633	1565	1634	1532	1572	7983	4142	21.87	36.80	2060	4.031	84.2	65.4	1
1626	1429	1626	1527	1435	7991	4318	22.05	36.62	1887	3.952	84.1	65.4	2
1643	1125	1582	1500	1130	8014	4817	21.62	34.67	1500	3.716	84.6	65.4	3
1670	1563	1667	1549	1570	8214	4133	22.09	37.72	2190	4.204	83.5	67.1	4
1651	1528	1653	1541	1529	8166	4194	22.00	37.14	2098	4.136	82.6	67.1	5
1652	1455	1654	1541	1456	8262	4270	21.87	38.08	2068	4.175	84.2	67.1	6
1641	1490	1641	1534	1488	8056	4137	22.10	37.31	2098	4.072	83.9	68.6	7
1628	1400	1631	1528	1399	8064	4242	21.80	37.17	1991	4.041	85.0	68.6	8
1622	1321	1627	1523	1321	8040	4359	22.54	36.71	1866	3.958	84.9	68.6	9
1613	1143	1598	1500	1136	8079	4663	22.67	35.89	1631	3.830	86.0	68.6	10
1615	1434	1617	1522	1433	7834	4109	21.86	35.88	2004	3.895	84.4	68.9	11
1612	1374	1614	1520	1374	7849	4193	22.11	35.87	1923	3.856	83.7	68.9	12
1601	1303	1606	1509	1303	7849	4285	22.76	35.72	1837	3.818	84.7	68.9	13
1615	1145	1590	1501	1139	7865	4552	22.60	34.72	1619	3.691	85.9	68.9	14
751	1581	739	678	1579	8614	4114	22.16	38.63	2435	4.382	82.8	63.1	15
747	1551	736	673	1557	8687	4157	22.14	37.42	2421	4.445	80.1	63.1	16
743	1418	734	676	1427	8654	4297	22.09	38.36	2238	4.388	83.3	63.1	17
734	1395	728	672	1406	8646	4328	21.80	38.41	2201	4.377	83.1	63.1	18
722	1296	722	670	1299	8654	4473	21.76	38.43	2053	4.278	84.9	63.1	19
709	1140	712	662	1149	8654	4729	22.27	37.51	1820	4.151	84.9	63.1	20
739	1479	729	671	1485	8438	4130	22.33	38.07	2309	4.316	82.5	63.5	21
728	1394	720	665	1404	8446	4222	22.19	38.15	2207	4.322	83.7	63.5	22
717	1314	716	665	1321	8462	4334	21.91	38.25	2089	4.252	84.4	63.5	23
700	1156	703	656	1165	8446	4597	21.94	36.75	1836	4.108	83.9	63.5	24
727	1439	716	663	1451	8238	4069	22.28	37.50	2263	4.232	82.6	63.8	25
727	1383	720	668	1395	8246	4135	22.15	37.49	2189	4.210	83.1	63.8	26
712	1294	713	666	1297	8238	4265	21.73	37.44	2043	4.115	84.8	63.8	27
697	1116	702	657	1122	8246	4559	22.15	36.36	1772	3.977	84.4	63.8	28
465	1538	457	419	1536	8679	4155	22.17	39.03	2418	4.362	84.3	70.5	29
466	1444	459	422	1442	8670	4272	22.57	38.66	2272	4.318	84.6	70.5	30
461	1393	455	420	1389	8670	4342	22.14	38.65	2195	4.308	85.1	70.5	31
455	1324	452	419	1318	8679	4443	21.93	38.66	2091	4.274	84.9	70.5	32
464	1445	456	423	1453	8283	4078	21.96	36.72	2276	4.198	81.9	73.2	33
458	1374	453	422	1396	8260	4145	21.79	37.35	2188	4.151	83.2	73.2	34
440	1271	441	412	1274	8222	4268	21.88	39.20	2034	4.104	89.1	73.2	35
445	1291	446	416	1300	8260	4273	21.95	36.64	2048	4.078	83.9	73.2	36
431	1108	434	407	1104	8268	4565	22.38	37.50	1778	3.928	88.5	73.2	37

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TABLE V - PERFORMANCE DATA OF PYTHON TURBINE-

Run	Altitude (ft)	Tunnel static pressure P_0 (lb/sq ft abs.)	Engine speed N (rpm)	Fuel flow W_f (lb/hr)	Shaft horse-power shp	Cowl-inlet total pressure P_1 (lb/sq ft abs.)	Cowl-inlet total temperature T_1 (°R)	Turbine-inlet total pressure P_3 (lb/sq ft abs.)	Turbine-inlet total temperature, T_3 (°R)	Turbine-outlet total pressure P_4 (lb/sq ft abs.)	Turbine-outlet static pressure P_4 (lb/sq ft abs.)	Turbine-outlet total temperature, T_4 (°R)
1	10,000	1447	8006	2190	2367	1485	523	7032	2062	1674	1509	1552
2		1445	8006	1860	1892	1483	515	6869	1863	1652	1507	1382
3		1448	8006	1500	1258	1486	516	6574	1670	1642	1512	1225
4		1453	8006	1095	448	1491	523	6146	1469	1625	1526	1081
5		1451	8006	2400	2741	1490	492	7507	2058	1714	1526	1532
6		1448	8006	2255	2538	1487	492	7368	1990	1694	1515	1477
7		1448	8006	1580	1387	1486	493	6826	1651	1661	1516	1204
8		1451	8006	1105	460	1489	489	6425	1395	1630	1529	1008
9		1450	7806	2200	2463	1488	493	7086	1984	1673	1510	1489
10		1453	7806	2090	2297	1490	484	7116	1890	1679	1516	1401
11		1446	7806	2100	2275	1484	485	7024	1914	1670	1509	1422
12		1454	7806	2090	2275	1491	484	7120	1890	1675	1517	1401
13		1452	7806	1910	2021	1489	494	6888	1837	1657	1512	1359
14		1457	7806	1520	1353	1490	494	6558	1629	1643	1515	1200
15		1454	7806	1015	366	1491	488	6132	1358	1621	1530	988
16		1452	7606	1960	2115	1489	488	6717	1875	1657	1508	1407
17		1453	7606	1860	1948	1490	489	6635	1826	1646	1510	1363
18		1447	7606	1680	1668	1483	486	6532	1712	1632	1505	1269
19		1455	7606	1390	1130	1492	488	6295	1547	1631	1515	1140
20		1453	7606	985	380	1490	484	5924	1328	1613	1528	974
21		1446	7606	970	357	1483	482	5944	1320	1606	1520	963
22		1452	7406	910	325	1489	487	5635	1310	1599	1526	969
23		1453	7205	1610	1560	1490	488	5949	1736	1611	1504	1328
24		1456	7205	1520	1427	1493	486	5829	1673	1612	1509	1271
25		1451	7205	1430	1285	1487	487	5811	1621	1601	1502	1225
26		1443	7205	1210	916	1480	484	5657	1480	1588	1499	1114
27		1449	7205	880	322	1485	485	5340	1299	1587	1520	973
28	30,000	629	8006	1240	1359	645	439	3608	2064	789	675	1541
29		624	8006	1170	1291	641	438	3535	1979	773	665	1465
30		624	8006	1060	1155	641	438	3461	1880	758	659	1374
31		628	8006	870	845	644	437	3316	1695	742	658	1222
32		625	8006	590	302	641	436	3024	1430	720	657	1024
33		627	7806	1150	1270	644	439	3469	1988	774	667	1480
34		626	7806	1080	1198	643	437	3429	1914	761	662	1412
35		626	7806	1030	1105	641	437	3374	1840	751	657	1347
36		630	7806	785	768	646	437	3222	1630	737	658	1174
37		629	7806	570	283	645	437	2956	1385	721	661	990
38		627	7606	1090	1211	643	436	3314	1953	758	661	1460
39		627	7606	1010	1120	642	436	3268	1880	748	658	1390
40		627	7606	980	1066	643	435	3255	1827	742	656	1346
41		625	7606	800	820	641	435	3134	1652	728	652	1208
42		624	7606	545	357	640	435	2873	1396	710	652	1002
43		627	7205	950	937	643	435	2953	1783	719	649	1338
44		631	7205	860	896	647	435	2967	1748	722	653	1310
45		627	7205	800	834	642	434	2918	1687	714	648	1251
46		627	7205	650	599	642	435	2815	1523	711	652	1121
47		628	7205	495	272	644	432	2671	1320	702	654	952
48	40,000	391	8006	750	764	402	436	2232	2033	491	417	1541
49		389	8006	640	683	401	433	2143	1900	476	411	1409
50		394	8006	660	671	406	437	2150	1880	478	415	1388
51		391	8006	550	472	402	436	2080	1734	465	408	1277
52		393	8006	400	232	402	433	1925	1513	453	411	1093
53		390	7606	600	582	401	436	2009	1839	454	408	1386
54		390	7606	535	504	402	441	1949	1747	455	405	1304
55		389	7606	400	334	399	437	1846	1534	446	404	1115
56		391	7606	290	141	400	438	1738	1329	440	408	951

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PROPELLER ENGINE WITH A 24-INCH-DIAMETER EXHAUST NOZZLE

Tail-pipe total pressure P_{5a} (lb/sq ft abs.)	Tail-pipe indicated temperature T_{5a} (°R)	Exhaust-nozzle inlet total pressure P_5 (lb/sq ft abs.)	Exhaust-nozzle inlet static pressure p_5 (lb/sq ft abs.)	Exhaust-nozzle inlet total temperature T_5 (°R)	Corrected engine speed $N/\sqrt{\theta_1}$ (rpm)	Corrected turbine speed $N/\sqrt{\theta_3}$ (rpm)	Corrected turbine gas flow (lb/sec)	Corrected turbine enthalpy drop $\Delta H_t/\theta_3$ (Btu/lb gas)	Corrected turbine-inlet temperature T_3/θ_1 (°R)	Turbine pressure ratio P_3/P_4	Turbine efficiency η_t (percent)	Average engine time (hr)	Run
1579	1551	1575	1463	1556	7976	4150	22.14	37.62	2046	4.201	83.1	34.7	1
1557	1381	1561	1457	1391	8038	4349	21.82	37.96	1877	4.158	84.8	34.7	2
1555	1239	1559	1455	1243	8030	4577	22.59	37.25	1680	4.004	85.9	34.7	3
1604	1101	1541	1456	1102	7976	4855	21.66	35.19	1457	3.782	84.9	34.7	4
1613	1535	1598	1468	1536	8222	4155	22.62	38.80	2171	4.380	84.1	35.8	5
1596	1480	1585	1465	1484	8222	4220	22.04	38.75	2099	4.349	84.1	35.8	6
1564	1215	1568	1456	1221	8214	4601	22.72	37.79	1738	4.110	85.6	35.8	7
1604	1031	1545	1453	1029	8246	4979	21.70	36.47	1481	3.942	86.2	35.8	8
1586	1490	1580	1466	1494	8009	4121	22.21	37.84	2089	4.236	82.9	36.5	9
1584	1415	1582	1468	1413	8079	4213	22.12	38.00	2027	4.238	83.6	36.5	10
1576	1436	1573	1462	1433	8071	4190	22.00	37.98	2048	4.206	84.1	36.5	11
1583	1415	1582	1469	1413	8079	4213	22.12	37.85	2027	4.251	83.6	36.5	12
1557	1370	1570	1456	1373	8001	4270	22.60	37.66	1930	4.157	84.5	36.5	13
1560	1215	1563	1459	1217	8001	4515	22.69	36.70	1711	3.991	84.7	36.5	14
1605	1006	1540	1457	1008	8056	4913	21.67	35.24	1444	3.783	86.5	36.5	15
1567	1418	1568	1466	1417	7849	4122	22.07	36.81	1994	4.054	83.0	37.0	16
1562	1373	1564	1466	1376	7834	4175	21.98	36.72	1938	4.031	83.8	37.0	17
1553	1285	1554	1456	1283	7857	4302	22.15	37.00	1828	4.002	84.6	37.0	18
1556	1160	1556	1459	1157	7849	4506	22.74	36.12	1645	3.860	85.3	37.0	19
1594	999	1535	1457	993	7872	4835	21.64	34.54	1424	3.673	86.0	37.0	20
1591	988	1528	1449	983	7895	4851	21.71	34.55	1421	3.701	86.5	37.0	21
1568	991	1525	1456	989	7643	4738	21.07	33.44	1396	3.524	85.8	37.3	22
1546	1336	1549	1461	1333	7436	4048	22.34	34.40	1846	3.693	82.6	37.6	23
1547	1286	1549	1464	1278	7443	4117	22.63	34.56	1787	3.659	83.8	37.6	24
1550	1239	1540	1456	1237	7436	4177	22.73	34.53	1727	3.630	84.2	37.6	25
1547	1136	1525	1445	1126	7457	4359	22.61	33.86	1587	3.562	84.7	73.6	26
1543	994	1516	1452	989	7450	4630	21.35	32.21	1390	3.365	85.9	73.6	27
718	1538	702	637	1535	8703	4150	22.01	39.60	2440	4.573	83.2	39.8	28
710	1469	695	632	1459	8719	4234	21.98	39.92	2345	4.573	84.3	39.8	29
704	1383	693	630	1376	8719	4335	22.34	39.93	2228	4.566	85.2	39.8	30
690	1248	688	634	1233	8727	4549	21.74	39.69	2013	4.469	86.1	39.8	31
670	1045	675	627	1045	8735	4921	22.20	37.50	1702	4.200	85.5	39.8	32
710	1485	695	635	1473	8485	4117	21.82	39.52	2350	4.482	84.4	40.3	33
720	1418	693	633	1412	8509	4192	22.08	39.78	2273	4.506	84.5	40.3	34
703	1356	692	632	1350	8509	4270	22.43	39.78	2185	4.493	85.1	40.3	35
687	1200	687	636	1185	8509	4515	21.74	39.28	1936	4.372	86.7	40.3	36
673	1018	678	631	1012	8509	4870	22.41	37.23	1645	4.100	86.4	40.3	37
704	1459	690	634	1456	8298	4046	21.94	38.98	2325	4.372	83.6	40.7	38
701	1395	690	633	1392	8298	4118	22.57	38.61	2238	4.369	84.8	40.7	39
701	1356	690	634	1350	8306	4172	22.45	38.83	2180	4.387	84.3	40.7	40
683	1224	681	632	1213	8306	4371	21.82	38.55	1971	4.305	85.3	40.7	41
665	1028	671	626	1024	8306	4727	22.41	36.73	1665	4.046	86.1	40.7	42
685	1339	679	633	1338	7868	4001	22.22	37.07	2127	4.107	83.8	41.3	43
687	1314	682	637	1313	7868	4036	21.94	36.70	2085	4.109	82.9	41.3	44
677	1259	676	632	1258	7882	4103	21.98	37.09	2017	4.087	84.5	41.3	45
670	1143	670	631	1131	7868	4301	21.45	36.26	1817	3.959	85.8	41.3	46
666	978	670	629	975	7897	4598	22.93	35.50	1586	3.805	87.1	41.3	47
442	1519	435	394	1519	8735	4178	22.18	38.92	2420	4.546	81.9	42.4	48
440	1401	429	392	1397	8767	4314	21.90	39.83	2277	4.502	84.9	42.4	49
445	1378	435	397	1379	8727	4335	22.23	39.90	2233	4.498	85.3	42.4	50
435	1278	429	394	1277	8735	4500	21.85	38.70	2064	4.473	83.5	42.4	51
421	1116	424	393	1110	8767	4791	22.07	37.84	1813	4.249	84.8	42.4	52
435	1371	427	393	1373	8298	4159	22.36	37.98	2189	4.330	82.6	42.7	53
431	1295	425	393	1299	8253	4259	22.12	37.60	2056	4.284	83.4	42.7	54
416	1133	417	390	1124	8291	4527	21.40	38.04	1822	4.139	86.8	42.7	55
413	965	418	390	969	8283	4835	23.05	36.80	1575	3.950	88.2	42.7	56

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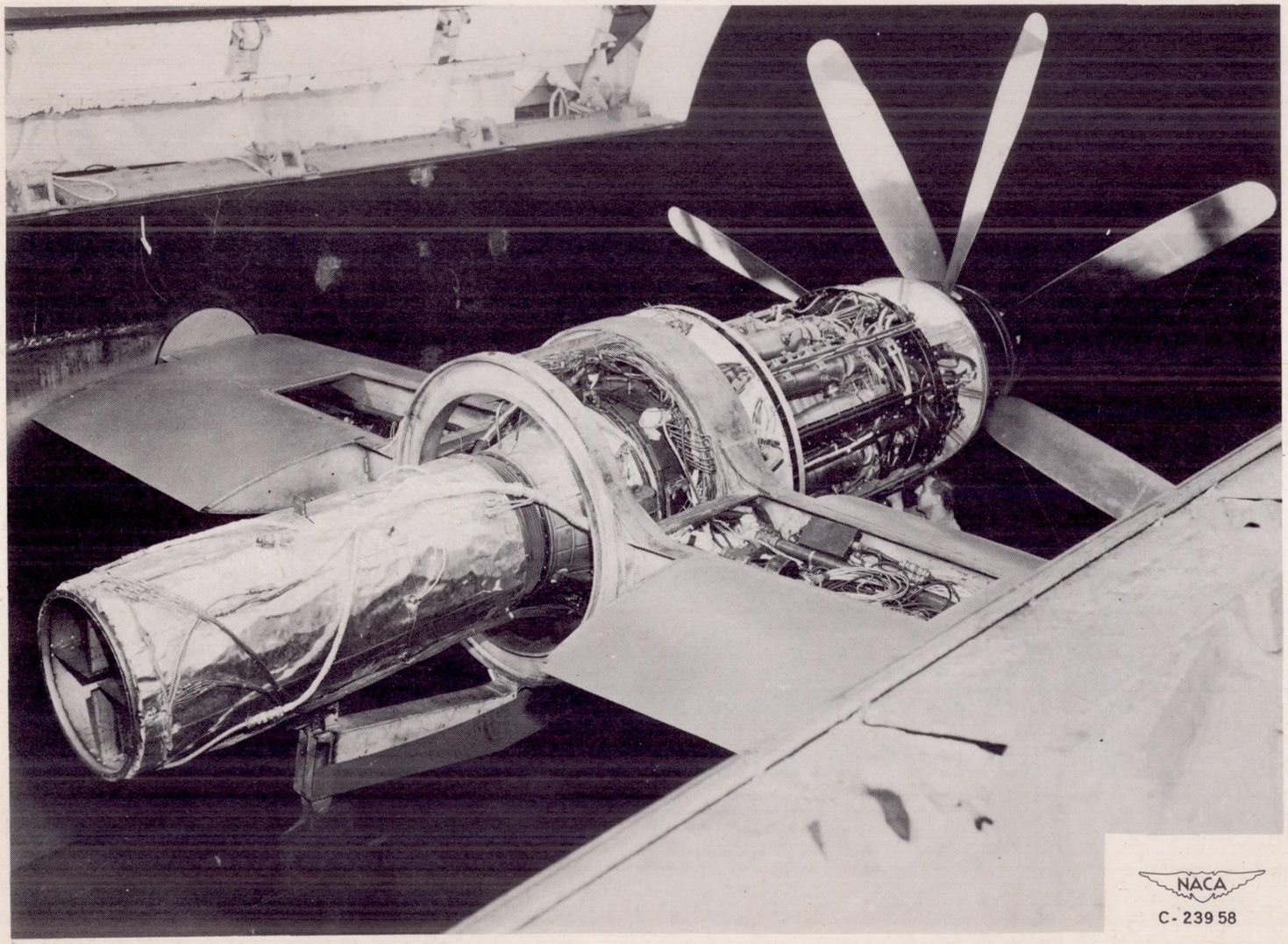

Figure 1. - Installation of Python turbine-propeller engine in altitude wind tunnel (cowling removed).

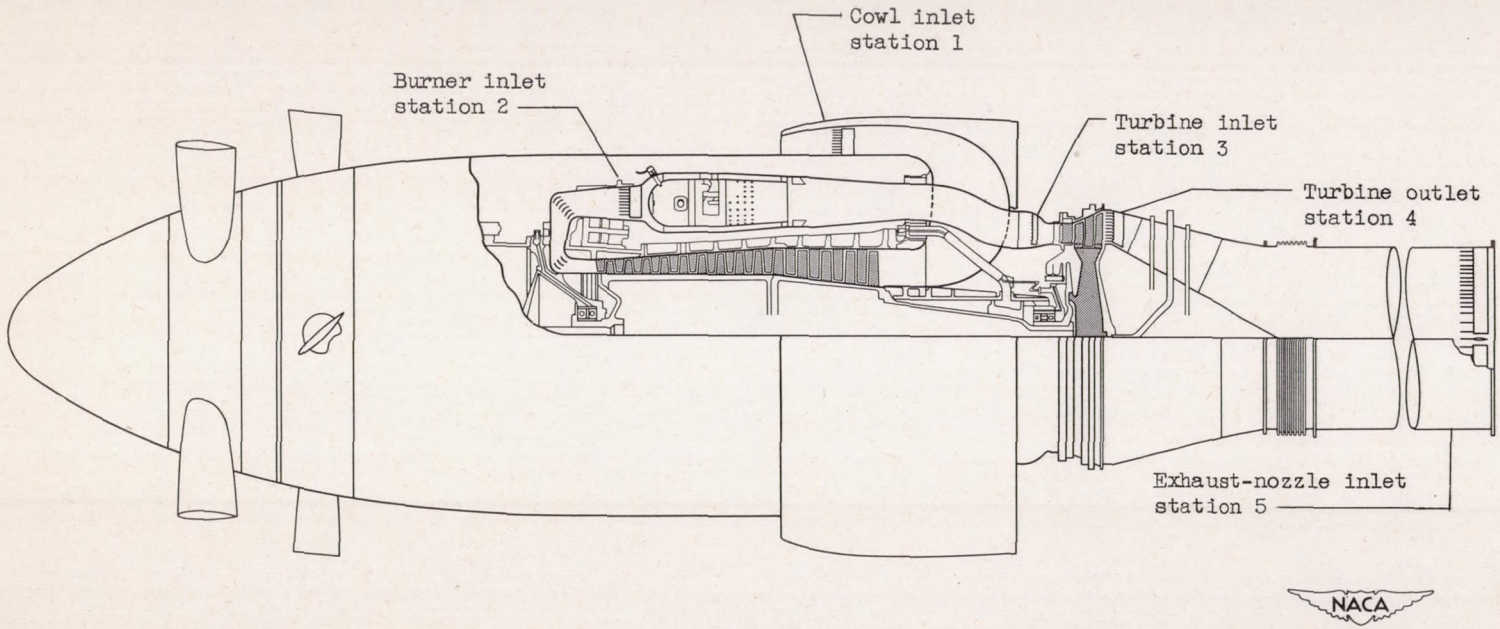

Figure 2. - Cross section of Python turbine-propeller engine showing measuring stations.

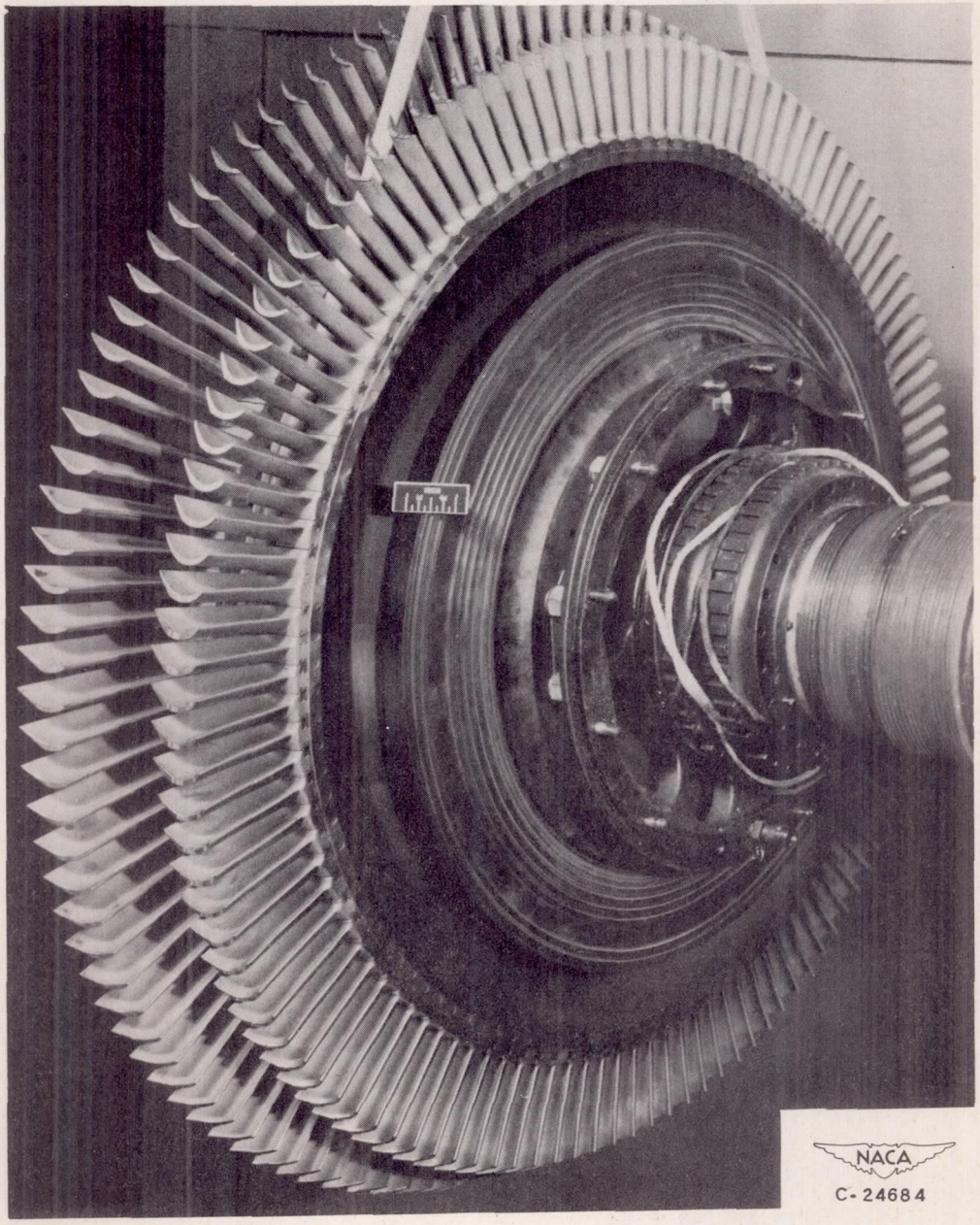

Figure 3. - Turbine rotor of Python turbine-propeller engine.

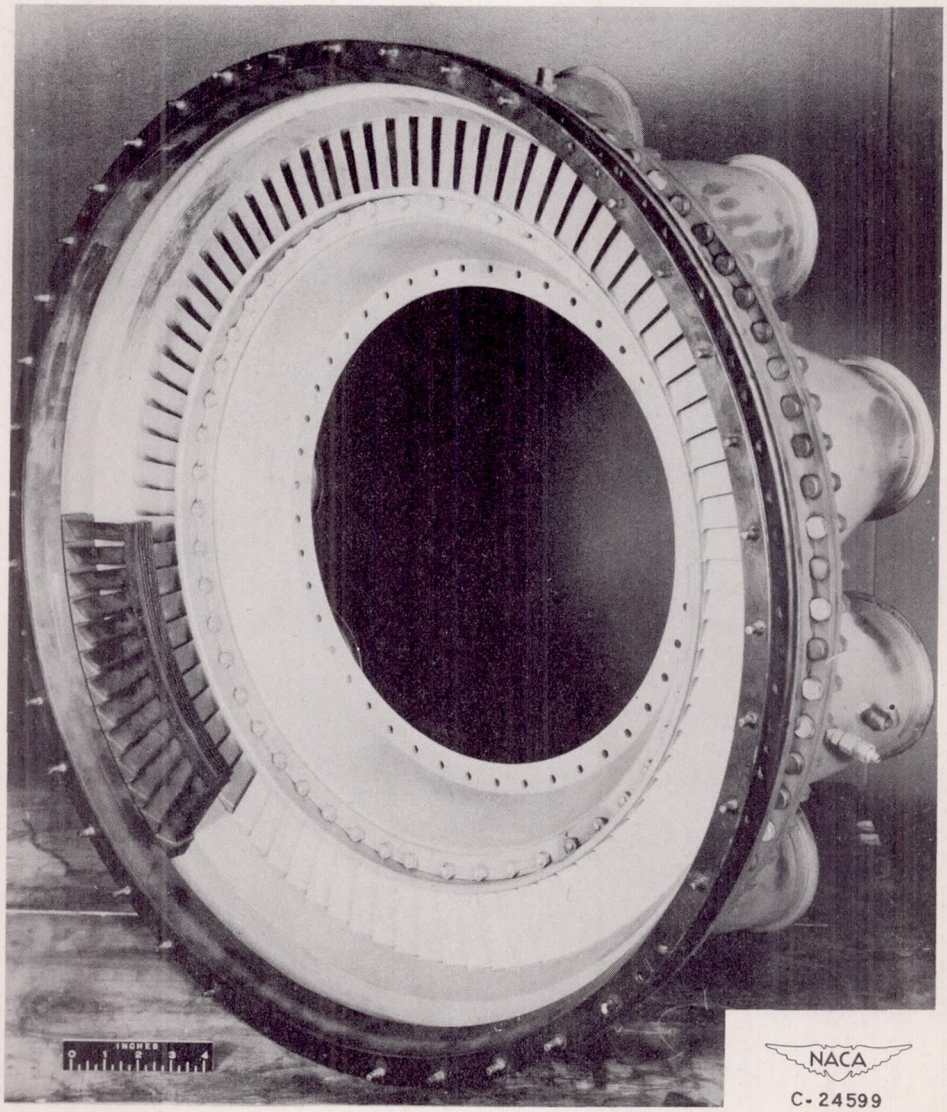

Figure 4. - First-stage turbine stator and segment of second-stage stator. Python turbine-propeller engine.

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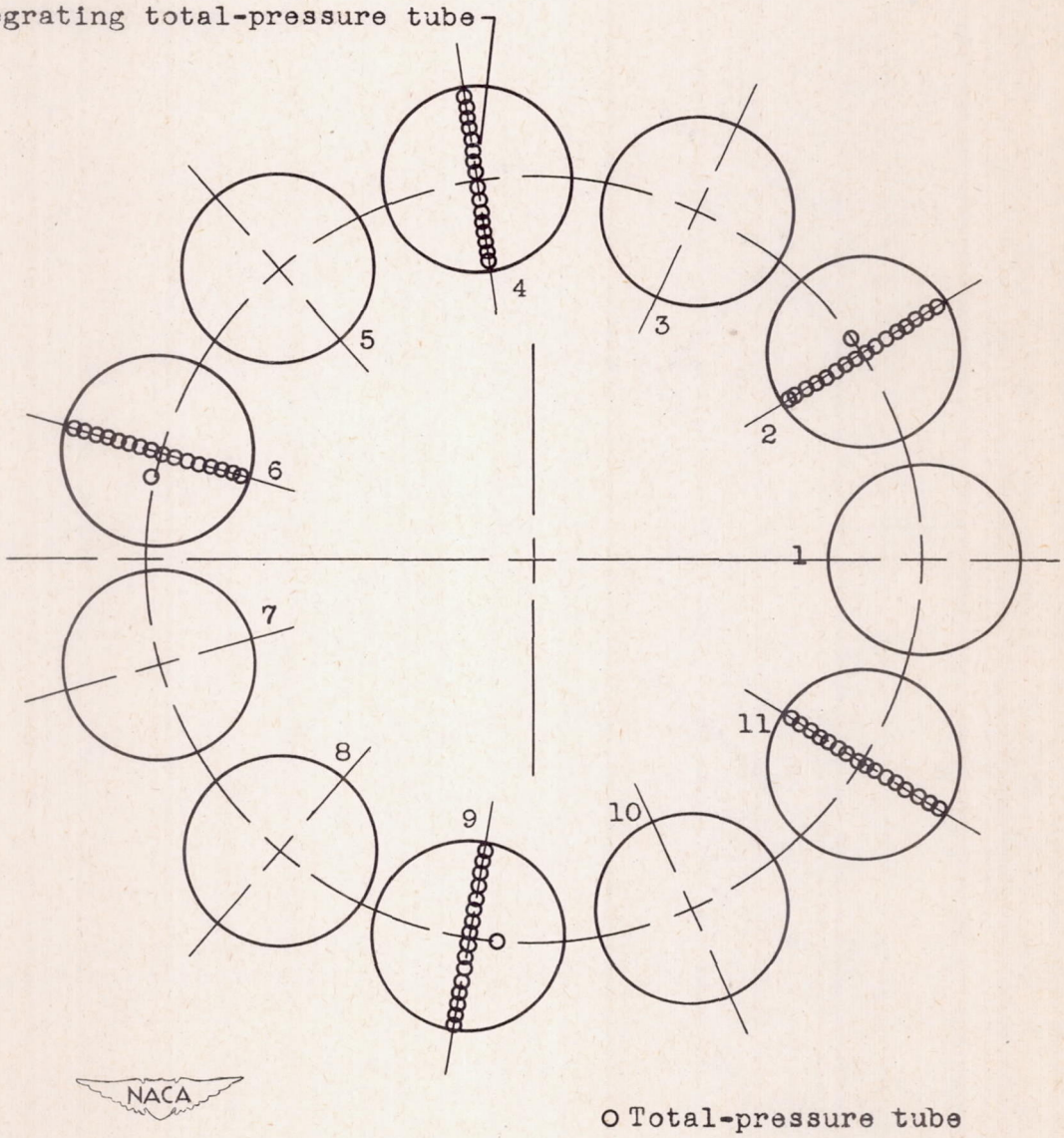
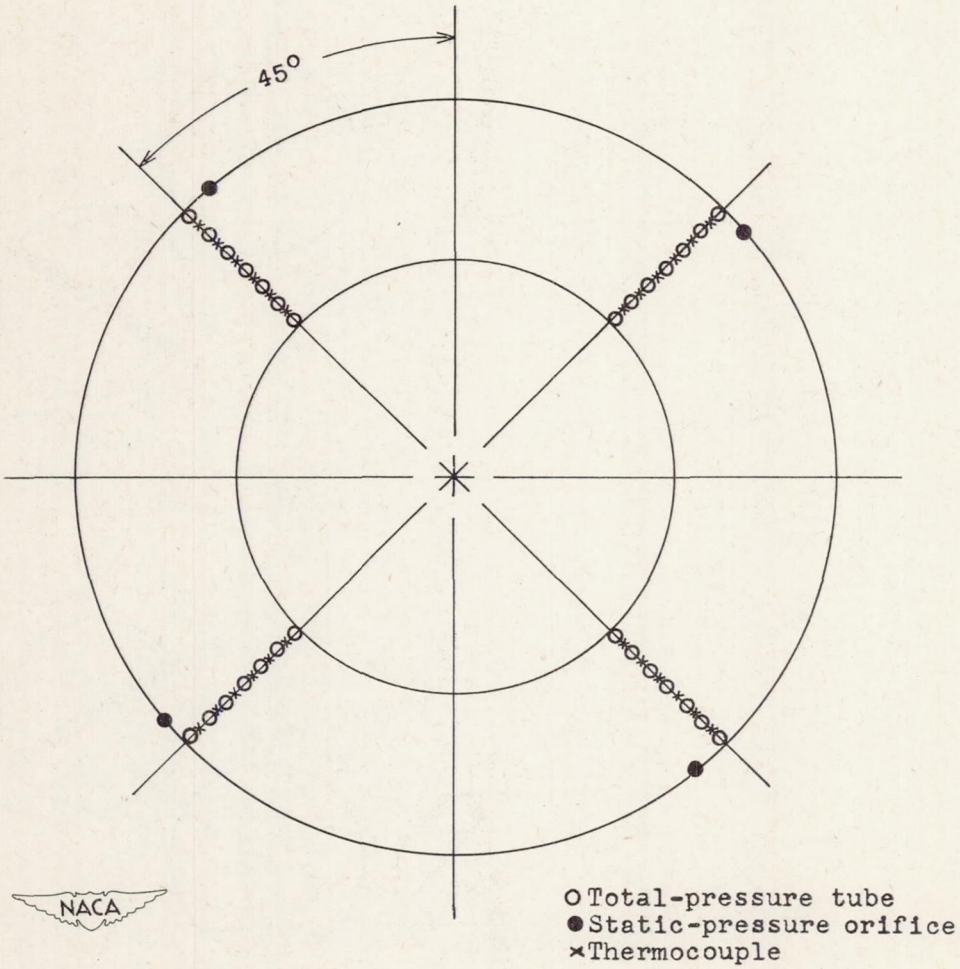
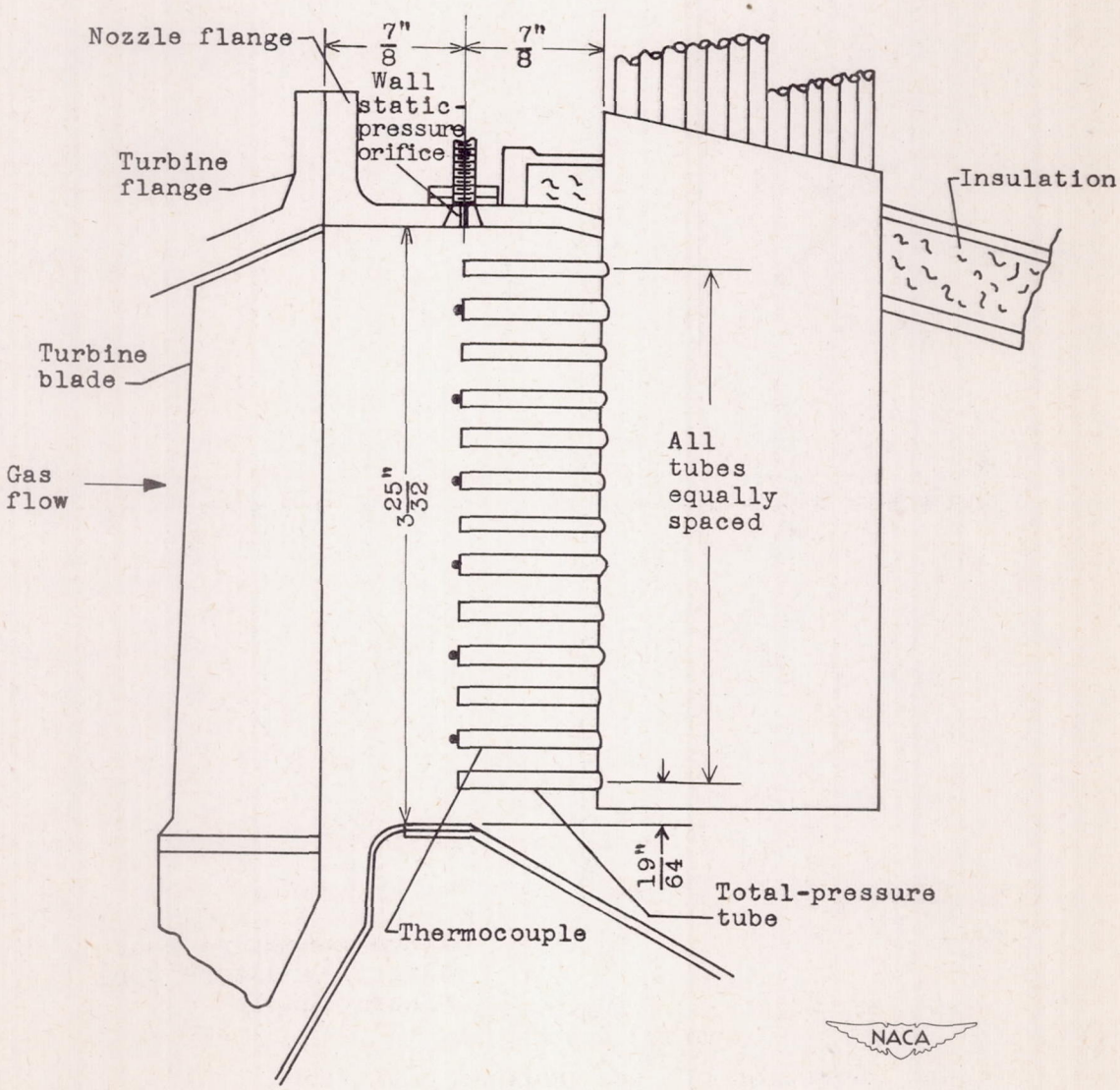


Figure 5. - Location of instrumentation at turbine inlet, station 3, 3 inches upstream of turbine flange. View looking downstream.



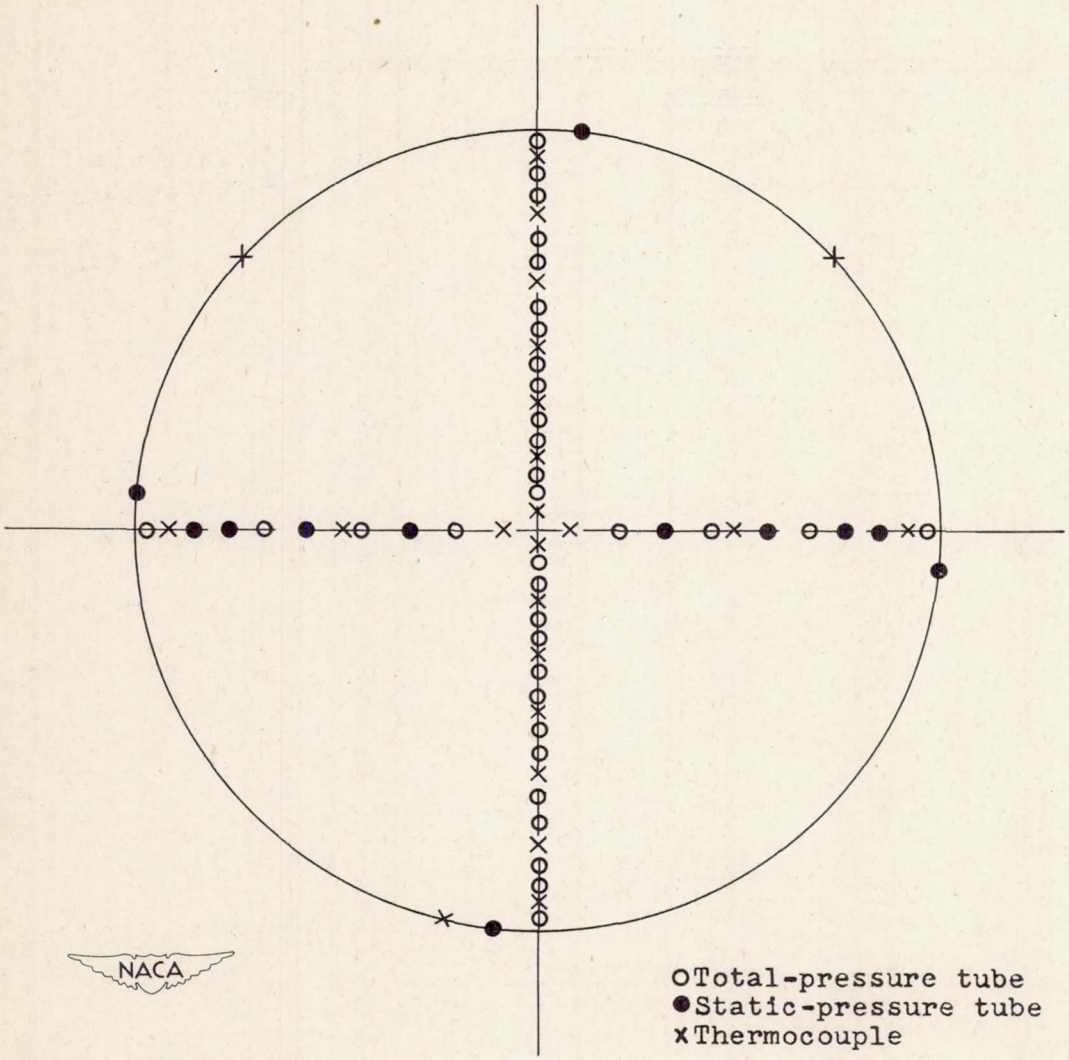
(a) Location of instrumentation. View looking downstream.

Figure 6. - Instrumentation at turbine outlet, station 4, 7/8 inch downstream of turbine flange.



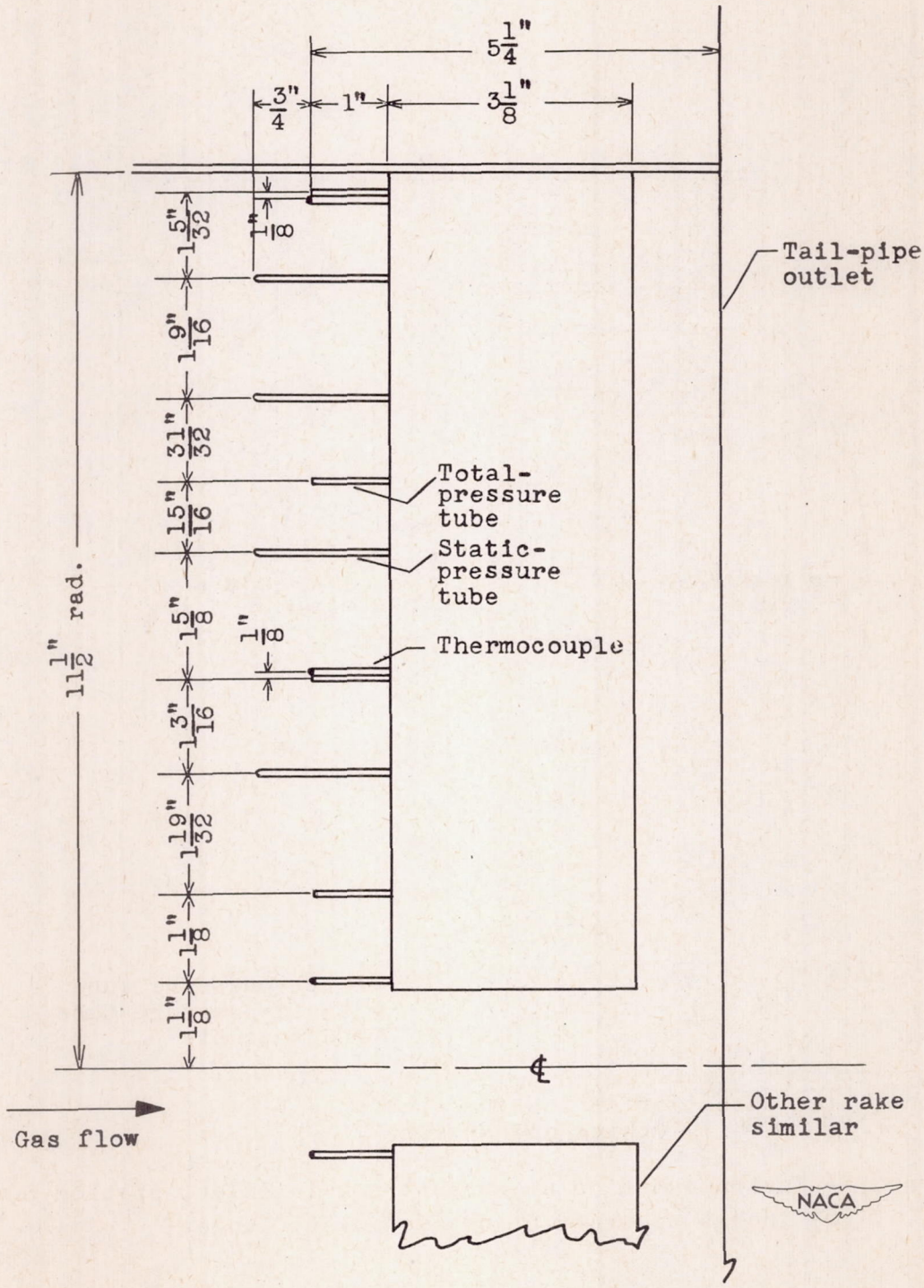
(b) Detail sketch of pressure and temperature survey.

Figure 6. - Concluded. Instrumentation at turbine outlet, station 4, 7/8 inch downstream of turbine flange.



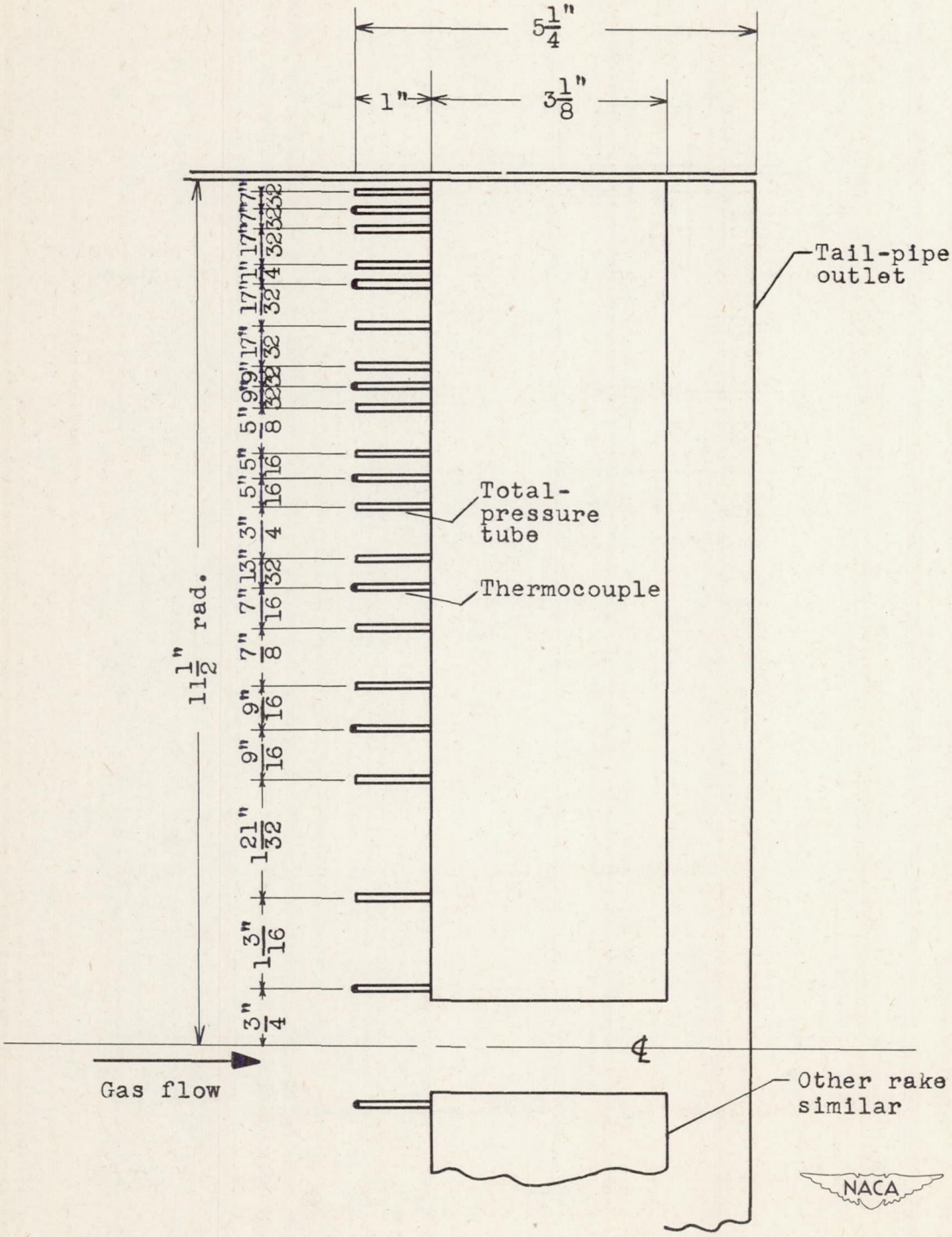
(a) Location of instrumentation. View looking downstream.

Figure 7. - Instrumentation at exhaust-nozzle inlet, station 5, $5\frac{1}{4}$ inches upstream of nozzle-inlet flange.



(b) Detail sketch of horizontal survey rake.

Figure 7. - Continued. Instrumentation at exhaust-nozzle inlet, station 5, $5\frac{1}{4}$ inches upstream of tail-pipe outlet.



(c) Detail sketch of vertical survey rake.

Figure 7. - Concluded. Instrumentation at exhaust-nozzle inlet, station 5, $5\frac{1}{4}$ inches upstream of tail-pipe outlet.

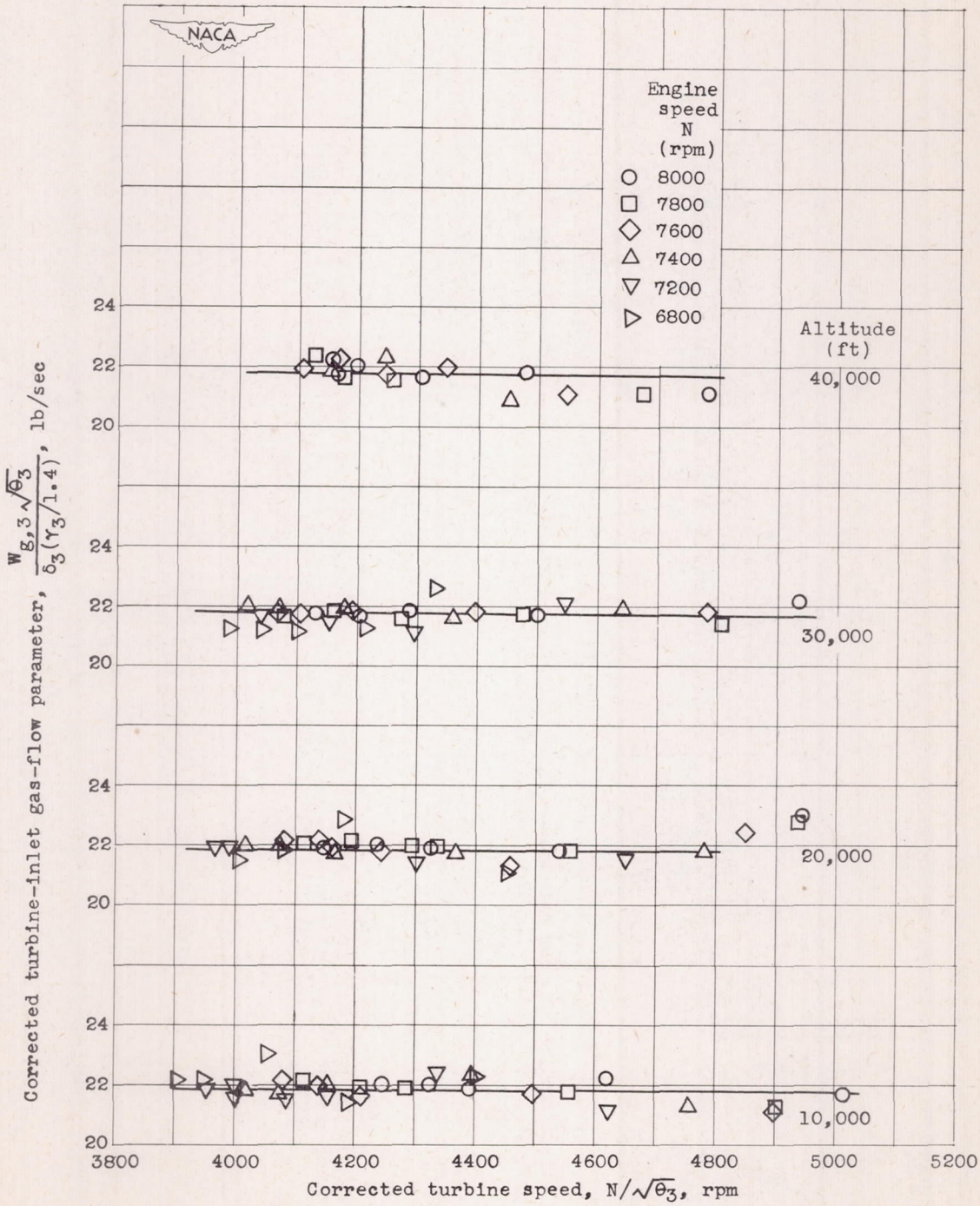
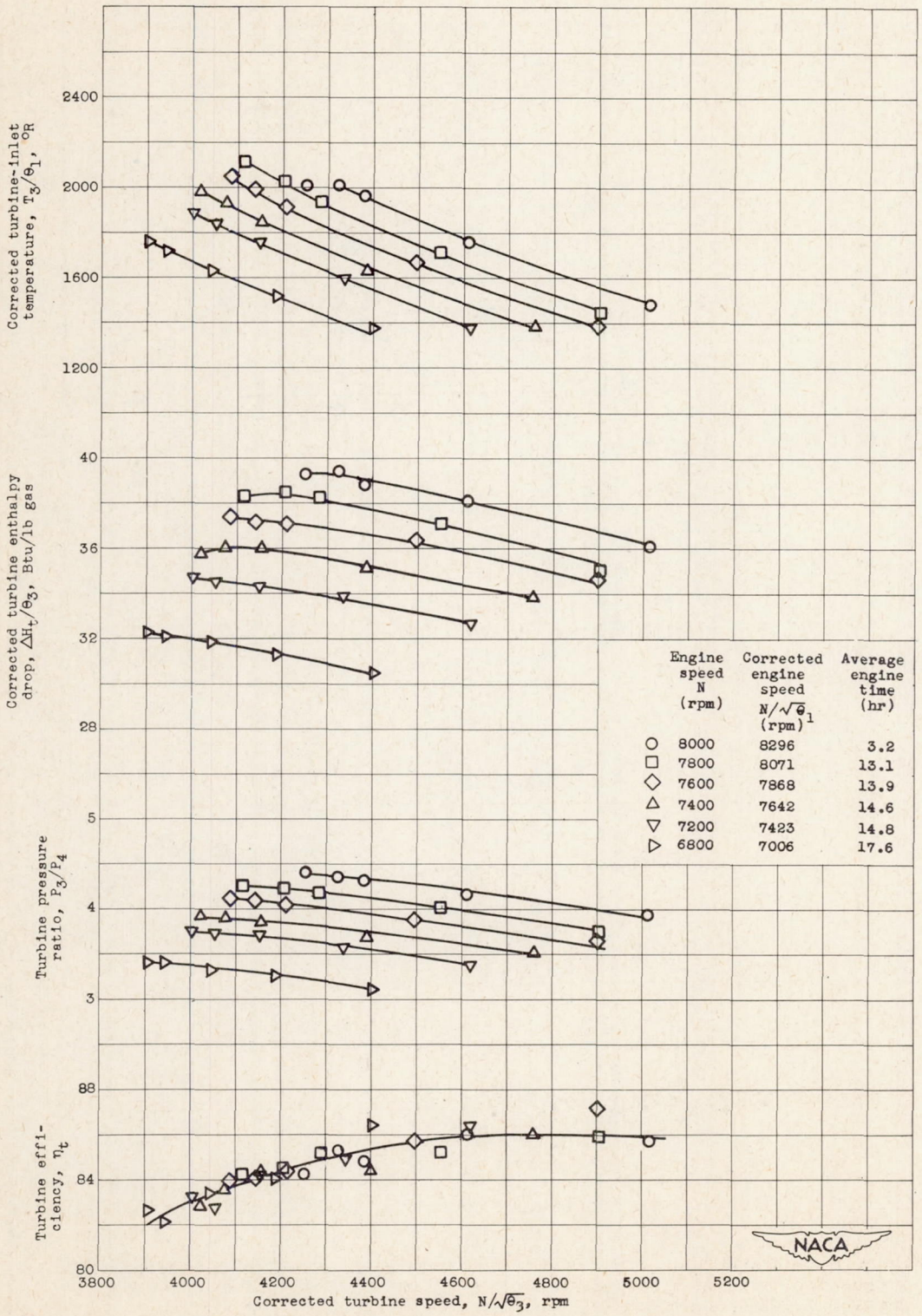
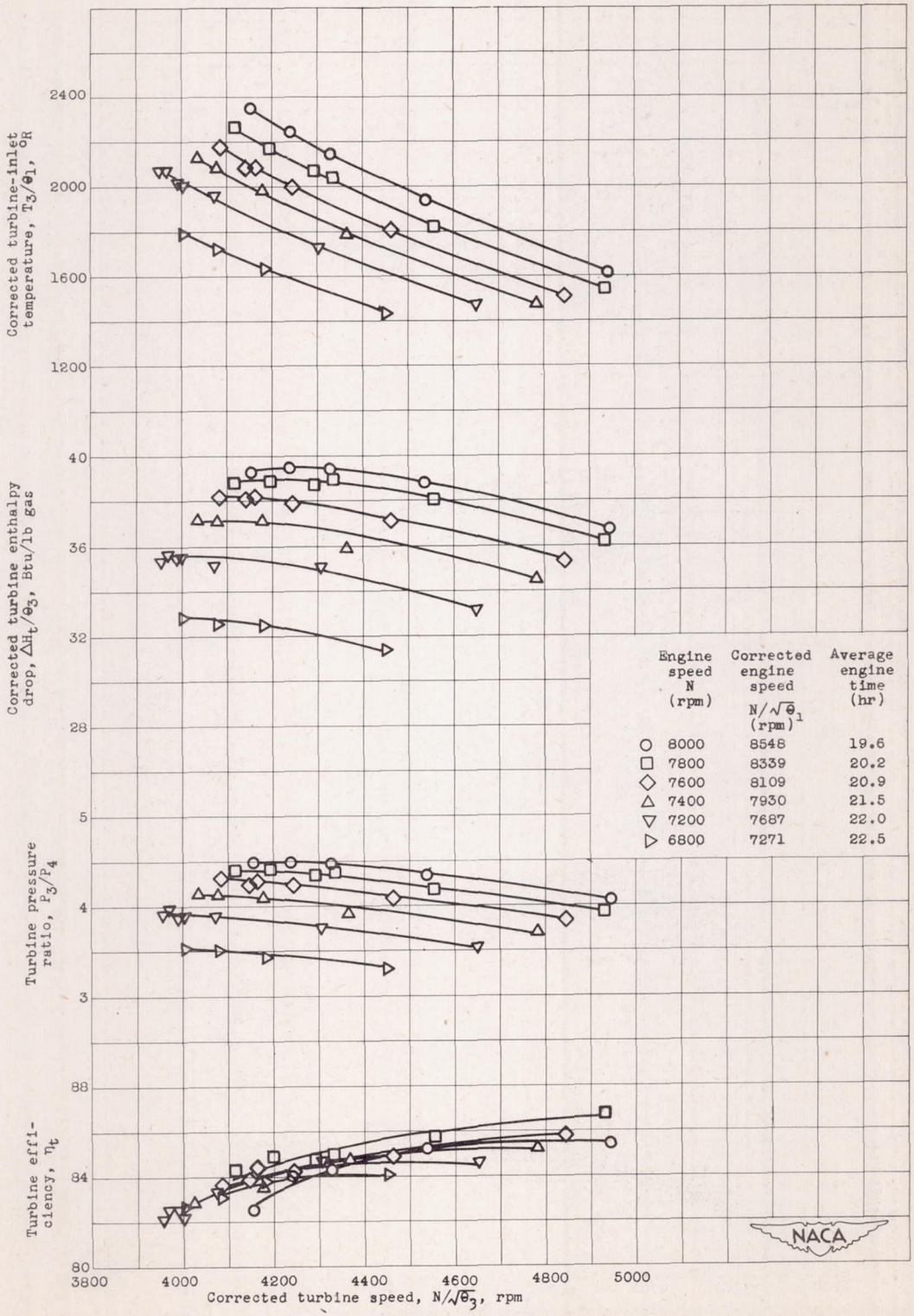


Figure 8. - Variation of corrected turbine-inlet gas-flow parameter with corrected turbine speed at various altitudes. Cowl-inlet pressure ratio, 1.025; standard tail-pipe configuration.



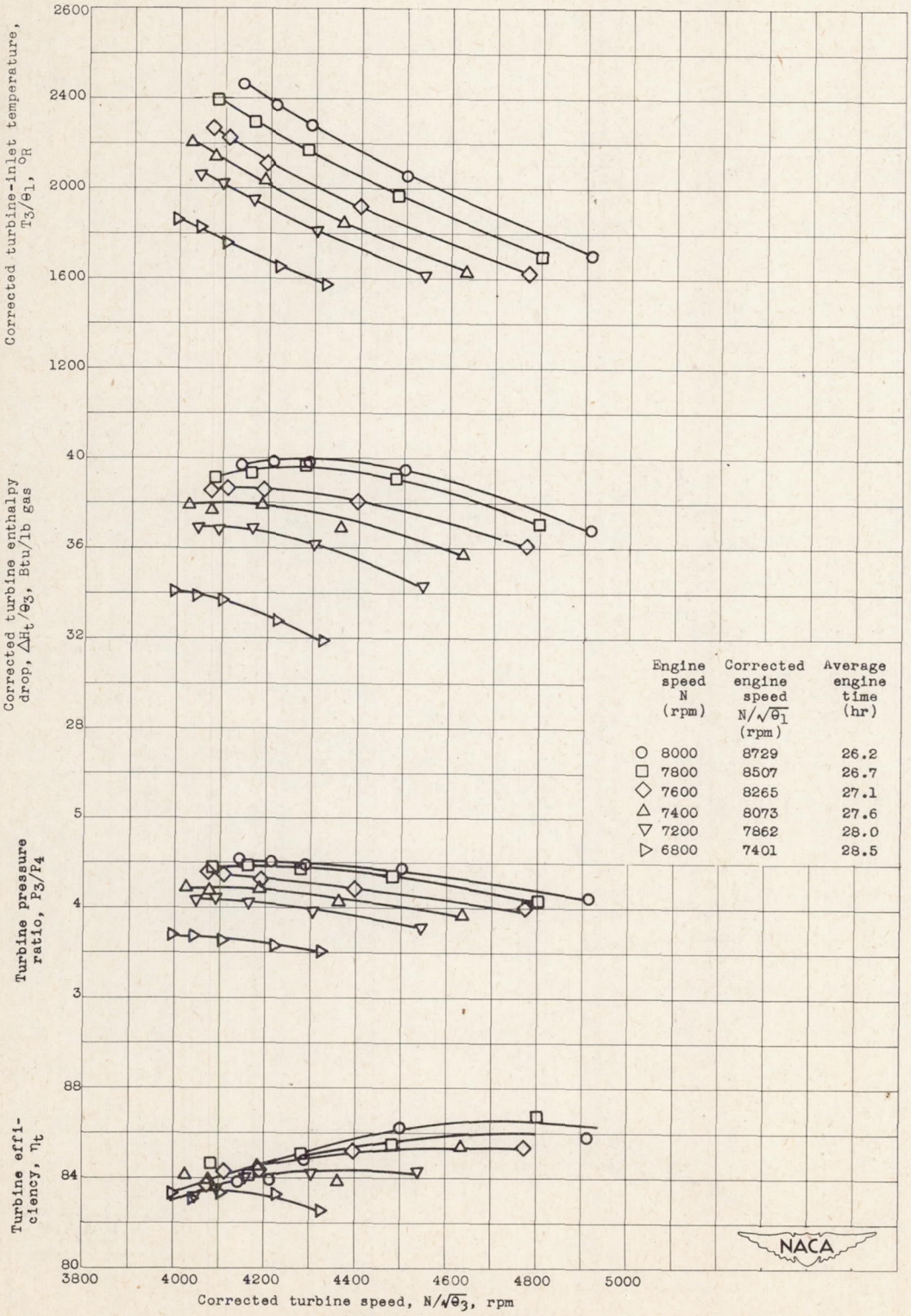
(a) Altitude, 10,000 feet.

Figure 9. - Variation of basic turbine-performance parameters with engine speed and corrected turbine speed. Cowl-inlet pressure ratio, 1.025; standard tail-pipe configuration.



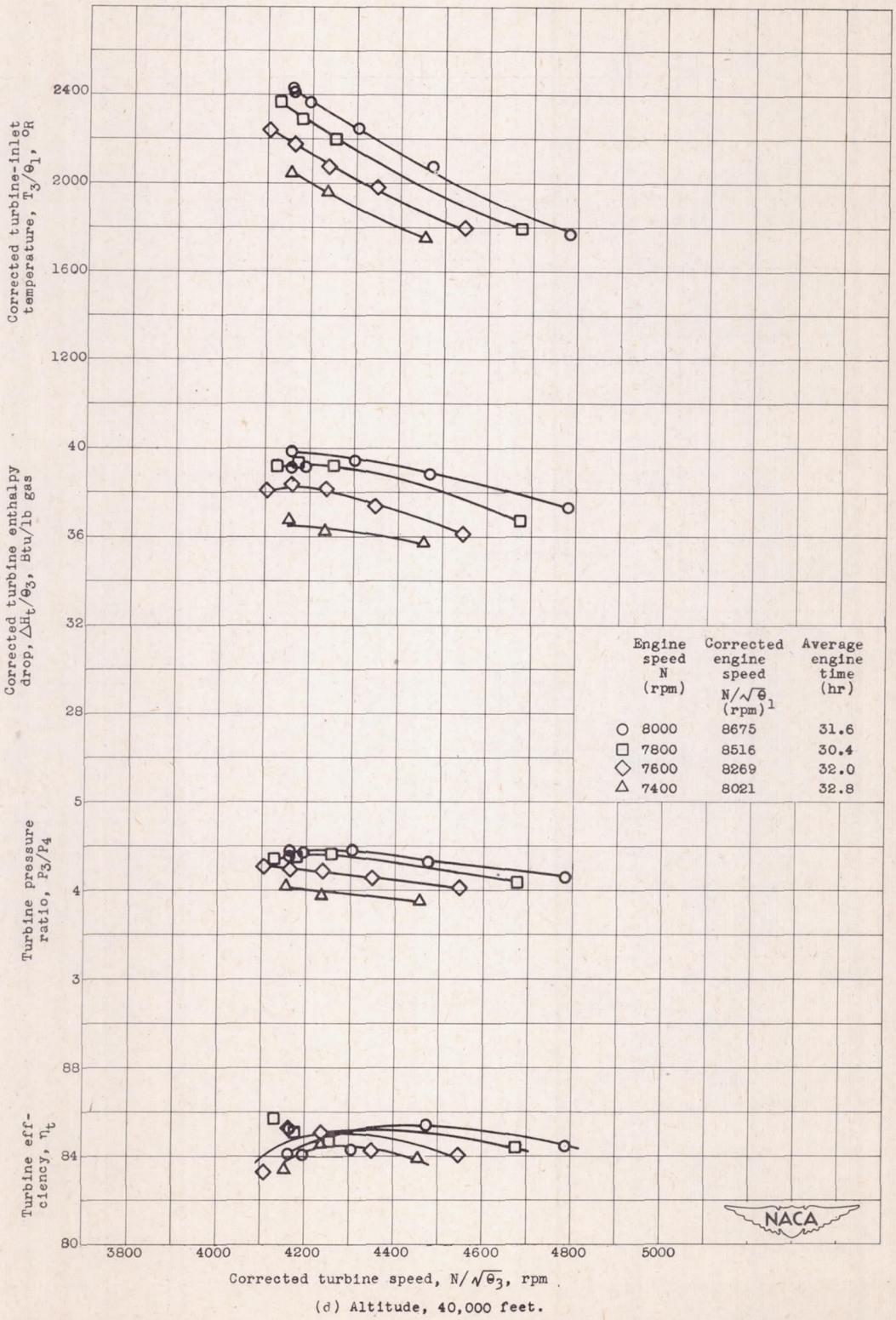
(b) Altitude, 20,000 feet.

Figure 9. - Continued - Variation of basic turbine-performance parameters with engine speed and corrected turbine speed. Cowl-inlet pressure ratio, 1.025; standard tail-pipe configuration.



(c) Altitude, 30,000 feet.

Figure 9. - Continued - Variation of basic turbine-performance parameters with engine speed and corrected turbine speed. Cowl-inlet pressure ratio, 1.025; standard tail-pipe configuration.



(d) Altitude, 40,000 feet.

Figure 9. - Concluded - Variation of basic turbine-performance parameters with engine speed and corrected turbine speed. Cowl-inlet pressure ratio, 1.025; standard tail-pipe configuration.

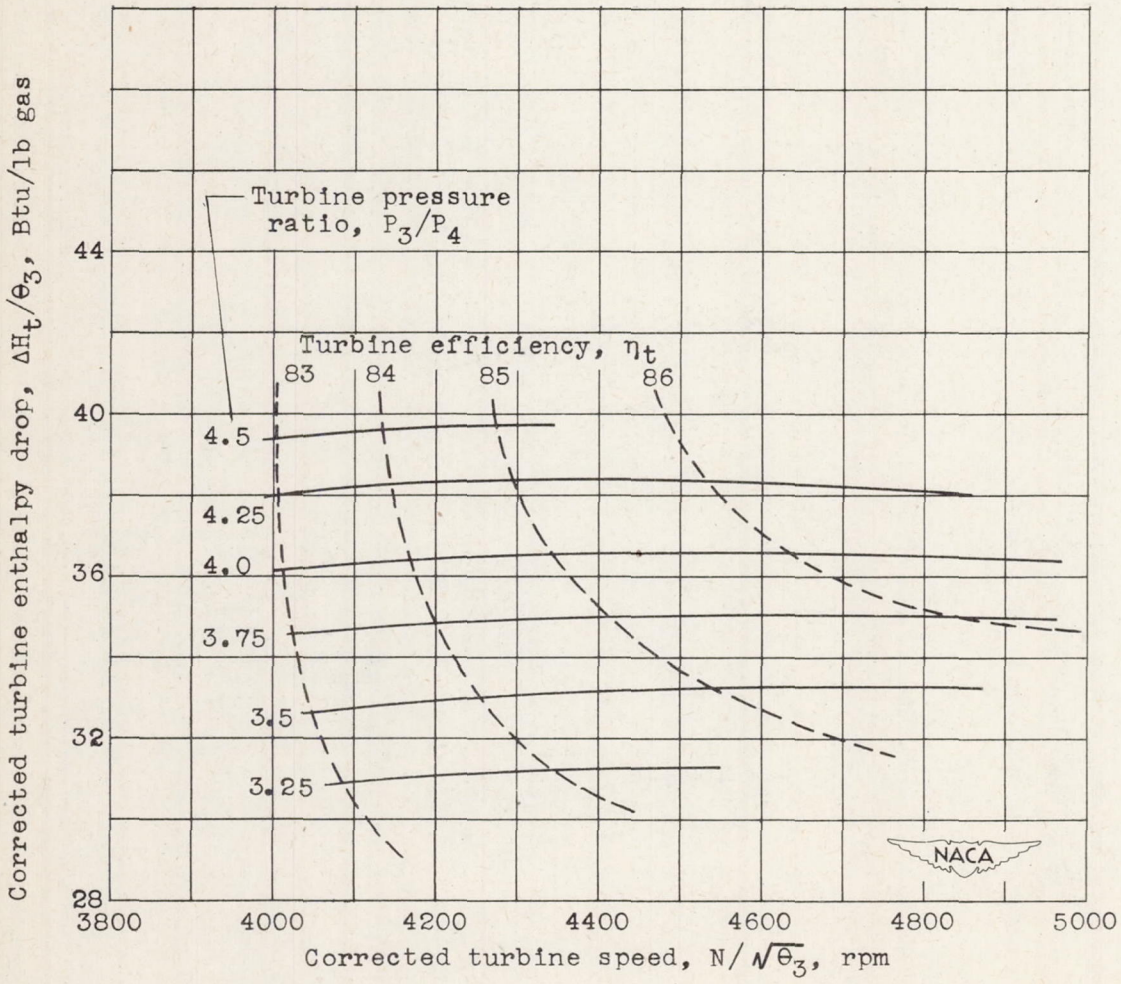
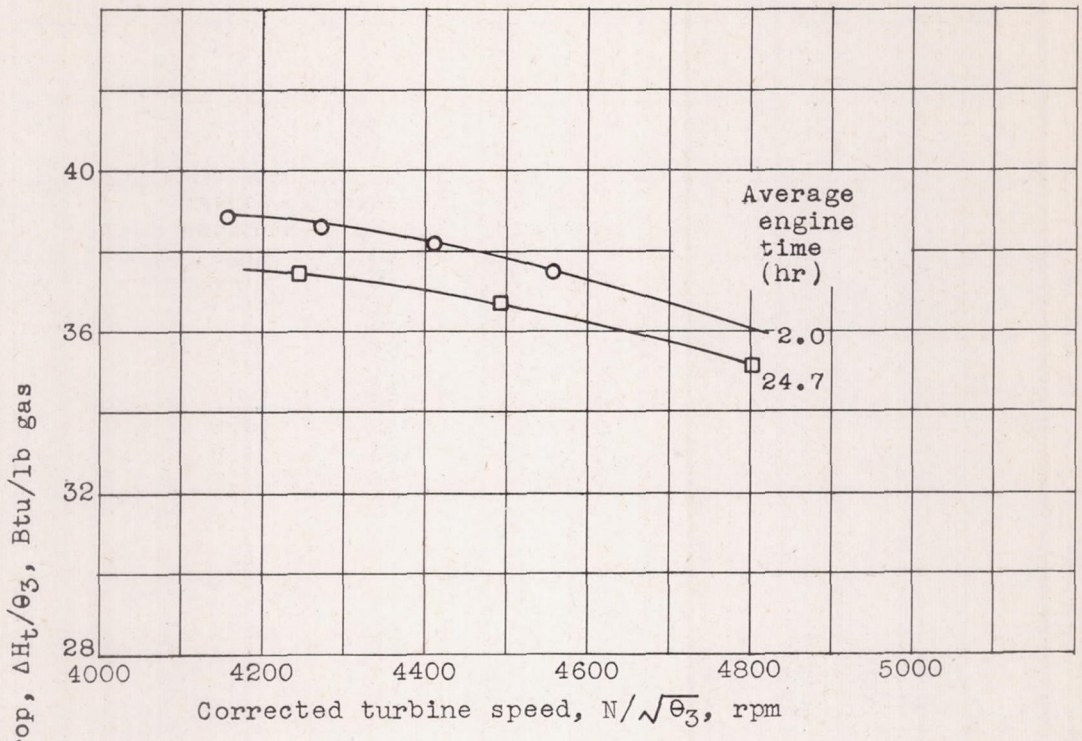
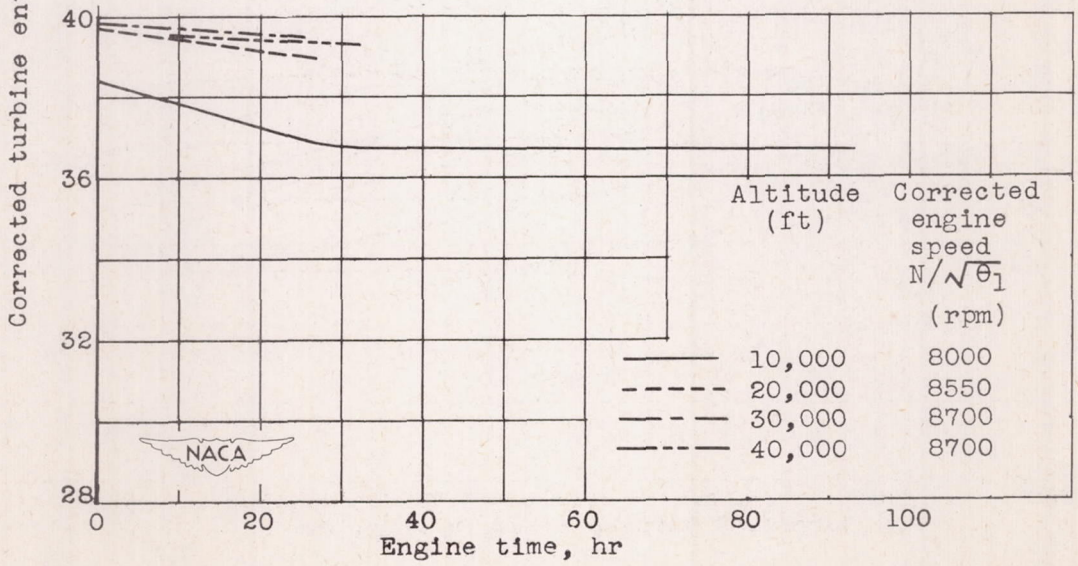


Figure 10. - Turbine-characteristic plot.



(a) Effect of engine deterioration on turbine operating lines at altitude of 10,000 feet. Corrected engine speed, $N/\sqrt{\theta_1}$, 8000 rpm.



(b) Variation in effect of engine deterioration with with altitude at corrected turbine speed of 4400 rpm. Engine speed, N, 8000 rpm.

Figure 11. - Effect of engine deterioration on turbine performance. Cowl-inlet pressure ratio, 1.025; standard tail-pipe configuration.

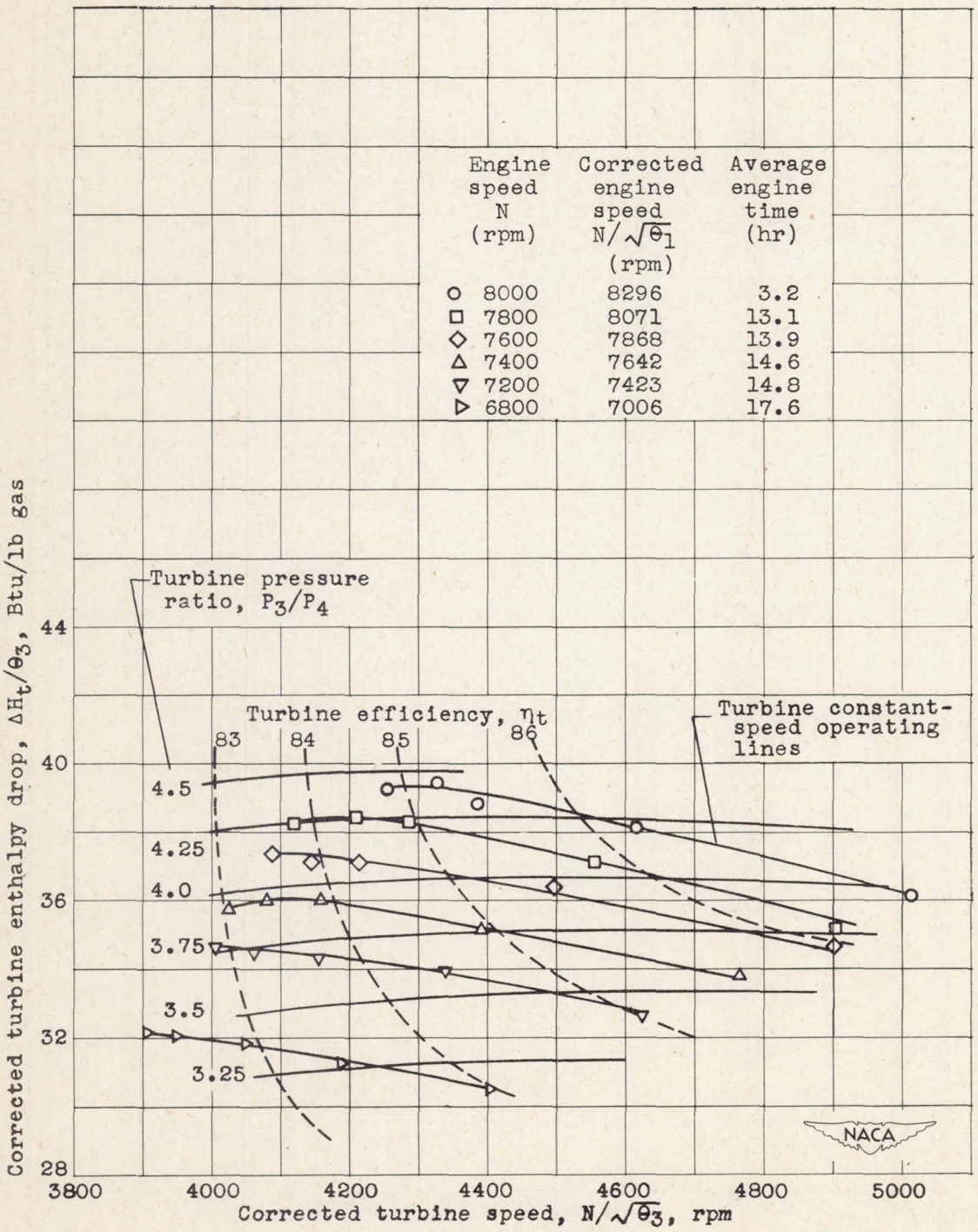


Figure 12. - Turbine operating lines at constant engine speed. Altitude, 10,000 feet; cowl-inlet pressure ratio, 1.025; standard tailpipe configuration.

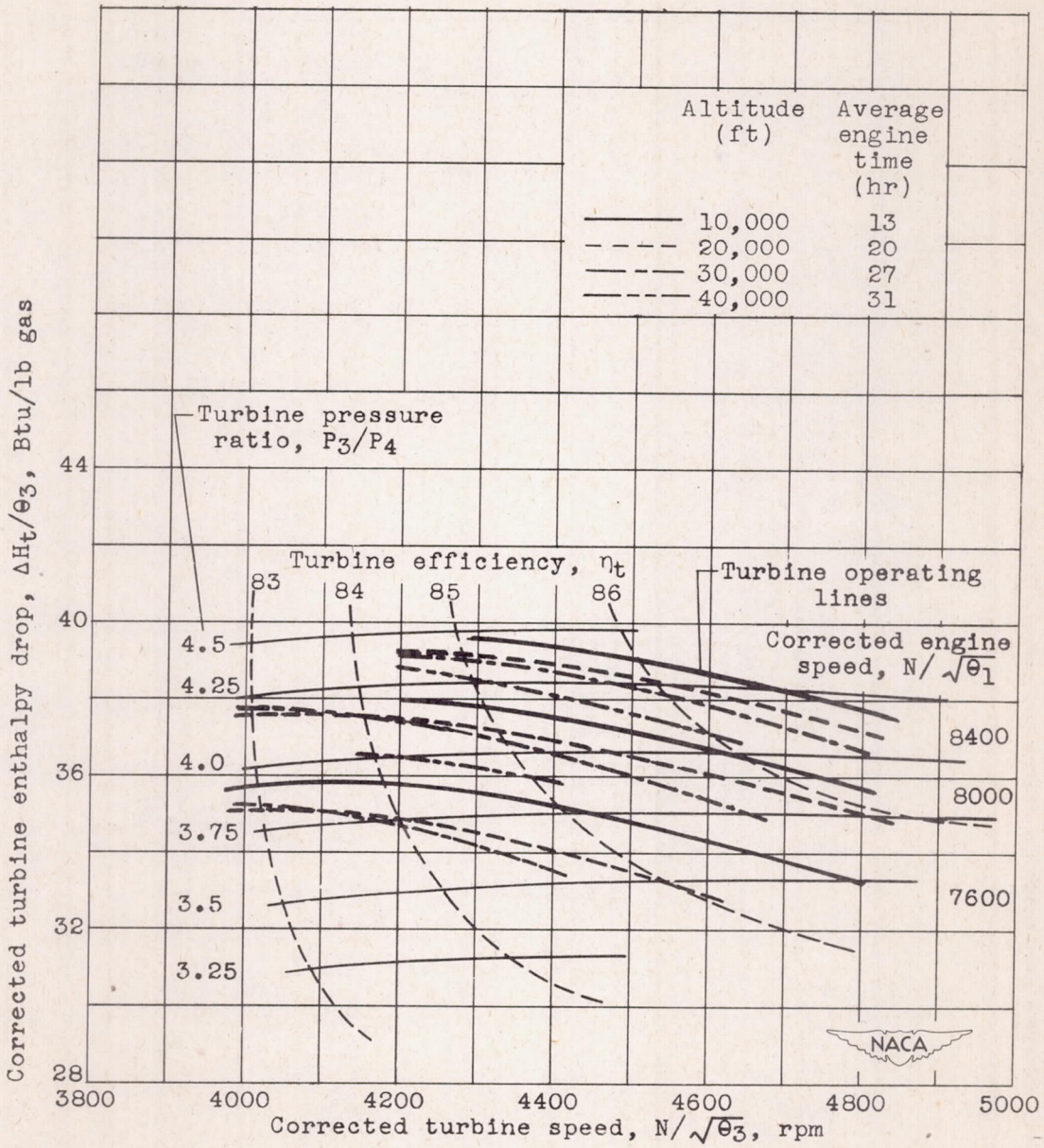


Figure 13. - Effect of altitude on turbine operating lines at several engine speeds. Cowl-inlet pressure ratio, 1.025; standard tail-pipe configuration.

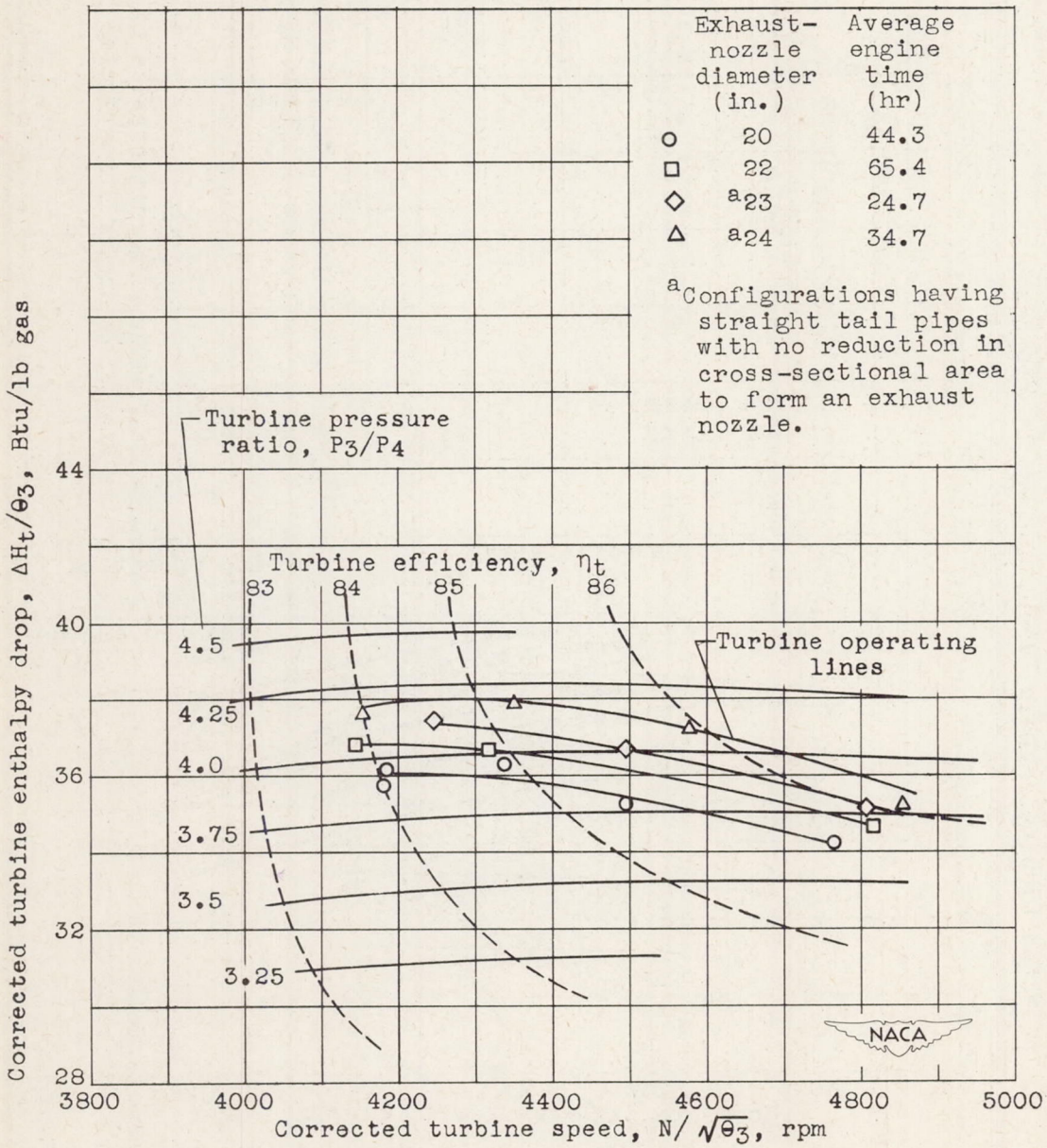


Figure 14. - Effect of tail-pipe configuration on turbine operating lines at altitude of 10,000 feet. Cowl-inlet pressure ratio, 1.025; corrected engine speed, 8000 rpm.

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