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RESEARCH MEMORANDUM

ALTITUDE COMPONENT PERFORMANCE OF THE YJ73-GE-3 TURBOJET ENGINE

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NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS

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SUMMARY

An investigation to determine the altitude performance characteristics of the YJ73-GE-3 turbojet engine was conducted in an altitude chamber of the NACA Lewis laboratory. The engine was equipped with variable inlet guide vanes. The component performance was determined at two positions of the inlet guide vanes over a range of engine speeds, exhaust-nozzle areas, and flight conditions. The range of flight conditions covered corresponds to a variation in compressor Reynolds number index from 0.96 to 0.12.

A reduction in Reynolds number index over approximately the range indicated resulted in a decrease in the corrected air flow of $4\frac{1}{2}$ percent and in compressor efficiency of 6 percent. By operating the engine with the inlet guide vanes closed, the compressor steady-state performance was improved at corrected engine speeds below 6300 rpm. For example, at a corrected engine speed of 5600 rpm, the compressor efficiency was raised from 0.73 to 0.82 as the inlet guide vanes were moved from the open to the closed position. At rated engine conditions at a flight Mach number of 0.8, the combustion efficiency varied from 0.98 to 0.96 as altitude was varied from sea level to 55,000 feet. Within the range of this investigation, turbine efficiency varied about 4 percent. About half this variation is due to the effect of turbine-inlet Reynolds number, while the remaining half is due to changes in the turbine operating point.

INTRODUCTION

An investigation to determine the altitude performance and operational characteristics of the YJ73-GE-3 turbojet engine was conducted in an altitude chamber of the NACA Lewis laboratory. As part of this investigation, the performance of the components operating in the engine was obtained and is presented herein. The engine discussed herein is the production version of the J73 and is identical with the engine discussed in references 1 and 2 (YJ73-GE-1A), except that the turbine stator area is about 9 percent lower. Both engines are equipped with variable inlet guide vanes to avoid compressor surge during acceleration at low engine speed. The component performance is shown for operating conditions that occur over a range of engine speeds at four fixed exhaust-nozzle areas with the inlet guide vanes in both the open and closed positions. Simulated flight conditions varied from altitudes of approximately sea level to 55,000 feet and flight Mach numbers from zero to 1.2 (corresponding to a Reynolds number index range from 0.96 to 0.12). All data were taken with the inlet screens retracted. 3167

APPARATUS

Installation and Instrumentation

The altitude-chamber test section in which the engine was installed is 14 feet in diameter and 20 feet long (fig. 1). A photograph of the engine installed in the test chamber is shown in figure 2. The platform on which the engine was rigidly mounted is connected by a linkage to a balance-pressure diaphragm for measuring engine thrust. A honeycomb is installed in the chamber upstream of the test section to straighten and smooth the flow of the inlet air. The front bulkhead, which incorporates a labyrinth seal around the forward end of the engine, prevents the flow of combustion air directly into the engine compartment and exhaust system and provides a means of maintaining a pressure difference across the engine. A bellmouth cowl was installed on the front bulkhead just ahead of the engine to obtain a smooth flow of air into the compressor.

Air supplied to the inlet section of the altitude chamber can be either heated or refrigerated. Exhaust gases from the jet nozzle pass through an exhaust section, a primary cooler, an exhaust header, and a secondary cooler before entering the exhauster system. The inlet and exhaust pressure controls were designed to automatically maintain constant the desired ram pressure ratio and exhaust pressure.

The location of the instrumentation stations throughout the engine is shown in the cross-sectional sketch of figure 3. Also shown on this figure is a table giving the number of pressure tubes, wall static orifices, and thermocouples at each station. All pressures were measured by means of alkazene or mercury manometers and were photographically recorded. Temperatures were measured with iron-constantan and chromel-alumel thermocouples and were recorded by self-balancing potentiometers. Engine speed was measured by a chronometric tachometer and fuel flow by means of a calibrated rotameter.

Engine

At static sea-level conditions the YJ73-GE-3 turbojet engine has the following ratings:

	Military	Normal
Engine speed, rpm	7950	7615
Exhaust-gas temperature, °F	1185	1085
Thrust, lb (screens retracted)	8920	7840
Specific fuel consumption, lb/(hr)(lb thrust)	0.917	0.887

Compressor-outlet leakage and bleed air are used to provide a balance piston force at the front of the compressor and to cool the turbine disks and the first-stage turbine stator. This air is eventually returned to the main air stream before it passes through the exhaust nozzle.

The standard fixed-area conical exhaust nozzle has a nominal diameter of 21 inches. This nozzle was sized to give limiting exhaust-gas temperature at rated engine speed at static sea-level conditions. In addition, three larger exhaust nozzles were also installed on the engine during the program. The largest exhaust nozzle used had an exit area slightly larger than the turbine-outlet area.

Compressor

The 12-stage axial-flow compressor is shown in figure 4(a). The 21 variable inlet guide vanes rotate simultaneously through an angle of 30° from the open to the closed position. In the open position, the angles between the engine center line and a line tangent to the leading and trailing edges of the guide-vane airfoil sections at the root and the tip are 0° and 13°, respectively. The inlet guide vanes change position at an engine speed of 6800 rpm, going from the closed to the open position as speed is increased. The rate at which this change is made is independent of engine characteristics.

The significant compressor design parameters are:

Blade-tip diameter (constant), in. . . . . $32\frac{1}{8}$
Rotor hub-tip radius ratio
  First stage 0.46
  Last stage 0.88

At an engine speed of 7950 rpm and compressor pressure ratio of 7.0 (static sea level),

Air flow, lb/sec	[1]143
Air flow per sq ft of frontal area	25.4
Compressor efficiency	[1]0.81
Compressor-inlet tip Mach number	0.997

Combustor

The combustor used in this engine is of the cannular type, consisting of an annular space containing 10 can-type liners (fig. 4(b)) that are connected to the turbine-inlet annulus by transition sections. Two spark-plug-type ignitors, located in liners diametrically opposite, are employed for engine starting. Large elliptical cross-over tubes between liners are used to facilitate flame propagation during high-altitude starting. Fuel is supplied to a dual-element fuel nozzle in each combustor primary zone. A fuel-flow divider ahead of the fuel nozzles determines the division of the fuel to the small and large orifices of each fuel nozzle.

The maximum combustor flow area, which is an annular area, is 5.3 square feet and results at rated conditions in an average reference velocity of about 95 feet per second in the combustor primary zone.

Turbine

The two-stage axial-flow turbine rotor is shown in figure 4(c). The significant turbine design parameters are:

Blade-tip diameter, in.	
First stage	$29\frac{1}{2}$
Second stage	$31\frac{1}{8}$
Hub-tip radius ratio	
First stage	0.73
Second stage	0.64
Average radial tip clearance, in.	0.05
Rated turbine-inlet temperature, $^{\circ}$R	2020
Rated corrected turbine speed, rpm	4040
Design corrected work, Btu/lb	28.5
Design corrected weight flow, lb/sec	42

[1]From manufacturer's compressor-rig tests.

The first-stage turbine stator contains internal passages through which cooling air from the compressor leakage is passed. The second-stage turbine stator blades increase in height from leading to trailing edge by an amount corresponding to the previously mentioned change in turbine tip diameter between the two stages.

PROCEDURE

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A temporary limitation in the refrigeration system occurred during the period of this investigation when most of the data were obtained, and thus the inlet-air temperatures were confined to a range between 60° and -20° F. Limited data were taken later when it became possible to obtain inlet temperatures of -80° F and below. The preponderance of the data (given in table I) were obtained in the earlier period, and the later data (table II) were undertaken only to extend the data to higher values of corrected engine speed.

The following table indicates the range over which the earlier data were obtained with four different exhaust nozzles:

Nominal pressure altitude, ft	Nominal flight Mach number, M_0	Average Reynolds number index	Nominal engine-speed range, rpm	Inlet-guide-vane position
Sea-level	0	0.96	5500-7950	Open
	0	.96	3600-7950	Closed
15,000	0.8	0.88	5500-7950	Open
25,000	0.8	0.59	5500-7950	Open
35,000	1.2	0.58	5500-7950	Open
	.8	.39	5500-7950	Open
	.8	.40	4500-7950	Closed
45,000	0.8	0.24	5500-7950	Open
55,000	0.8	0.15	5500-7950	Open
	.4	.12	5500-7950	Open

The later data were taken only at altitudes of 35,000 feet and above with the inlet guide vanes open. Although the flight conditions of these data correspond to the data listed above, the Reynolds number indices differ, inasmuch as these data were taken at a considerably lower inlet-air temperature.

The fuel used throughout the investigation was MIL-F-5624A, grade JP-4, with a lower heating value of 18,700 Btu per pound and a hydrogen-carbon ratio of 0.168. The symbols and methods of calculation used in this report are given in appendixes A and B, respectively.

RESULTS AND DISCUSSION

The performance is presented herein for each component over a range of operating conditions as an independent component and also as a component operating in the engine. The data in this report are presented for various values of Reynolds number index, not altitude and Mach number. In order to correlate these data with flight conditions, the variation of Reynolds number index with altitude and flight Mach number for standard NACA conditions is shown in figure 5.

Compressor Performance

Performance maps. - The compressor performance is presented by showing lines of constant corrected engine speed (compressor Mach number) and compressor efficiency on coordinates of compressor pressure ratio and corrected air flow. Performance maps with the inlet guide vanes in the closed position are presented in figures 6(a) and (b) at the two Reynolds number indices for which complete data were obtained, namely, 0.96 and 0.40. Within the accuracy of the data, a given corrected engine speed resulted in only one compressor pressure ratio for corrected engine speeds of 6000 rpm or lower. The peak compressor efficiency occurred at a corrected engine speed of 6000 rpm and decreased from 0.82 to 0.79 as Reynolds number index decreased from 0.96 to 0.40. This same change in Reynolds number index had little or no effect on corrected air flow.

With the inlet guide vanes in the open position, data were taken over a sufficient range of Reynolds number indices to define clearly the Reynolds number effect. Performance is presented in the compressor map (fig. 6(c)) at Reynolds number index of 0.39 and in figure 7, which shows the variation of corrected air flow and compressor efficiency with Reynolds number index for constant values of corrected engine speed and compressor pressure ratio. Data at Reynolds number index of 0.39 were selected for figure 6(c) because of the high corrected engine speed data that were available. A peak compressor efficiency of slightly over 0.84 occurred at a corrected engine speed of about 7100 rpm and a compressor pressure ratio of 5.5. At rated corrected engine speed, the compressor efficiency decreased to 0.81 and the corrected air flow was about 141 pounds per second. Within the range of exhaust-nozzle areas used to obtain the data, variation in compressor pressure ratio at a given corrected engine speed resulted in small changes in compressor efficiency of the order of 0.02 or less. At corrected engine speeds above 7000 rpm, variations in pressure ratio had little effect on corrected air flow; while at speeds below 7000 rpm, the corrected air flow increased as pressure ratio was reduced.

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Effect of Reynolds number. - The effects of Reynolds number on compressor efficiency and corrected air flow are presented in figure 7. A careful examination of the data obtained at Reynolds number indices other than 0.39 has shown these curves to be valid for open-inlet-guide-vane operation at all compressor pressure ratios at corrected engine speeds of 6800 rpm and above. For a given corrected engine speed and compressor pressure ratio, the ordinates of figure 7 give the ratio of the compressor efficiency and corrected air flow at any Reynolds number index to the compressor efficiency and corrected air flow at a Reynolds number index of 0.39. Thus, the corrected air flow and compressor efficiency can be obtained for a Reynolds number index of 0.39 (fig. 6(c)) and corrected to any desired Reynolds number index (fig. 7) within the range investigated.

The effects of Reynolds number as shown in figure 7 are to reduce the compressor efficiency about 6 percent and the corrected air flow about $4\frac{1}{2}$ percent as Reynolds number index is decreased from 0.96 to 0.12. The decreases in compressor efficiency and corrected air flow with Reynolds number index are small until Reynolds number index is reduced below 0.5.

Comparison of compressor performance with inlet guide vanes in open and closed positions. - A comparison of the performance with open and closed inlet guide vanes is presented in figure 8 at a Reynolds number index of 0.96. In this figure, compressor pressure ratio, efficiency, and corrected air flow for the rated exhaust-nozzle area are shown as functions of corrected engine speed. Also shown are the pressure-ratio stall lines for the two inlet-guide-vane positions. The range of corrected engine speeds over which the inlet guide vanes will change position is also indicated. It can readily be seen that, at low corrected engine speeds (below 6300 rpm), an improvement in the steady-state compressor performance may be obtained by operating with the inlet guide vanes in the closed position; at corrected engine speeds above 6300 rpm, the opposite is true. At a corrected engine speed of 5600 rpm, for example, changing the inlet guide vanes from the open to the closed position resulted in no change in pressure ratio, an increase in corrected air flow from 70 to 72 pounds per second, and an increase in compressor efficiency from 0.73 to 0.82. The surge lines indicate about the same margin of acceleration (in terms of pressure ratio) for either guide-vane position. Consideration of the steady-state performance and surge lines would indicate that, in general, a lower switch-over speed than that provided would be advantageous. Engine acceleration characteristics, which are beyond the scope of this report, are not completely determined by the variables shown in figure 8, however. No final selection of switch-over point should be made, therefore, without consideration of acceleration characteristics.

Performance maps for compressor operating as part of engine. - In order to identify the compressor performance with engine operating conditions, lines of constant corrected turbine-inlet temperature are superimposed in figure 9 on the compressor maps obtained at Reynolds number indices of 0.96 and 0.12, the limits over which the investigation was conducted. Also superimposed on each map is a line showing the mode of operation with rated exhaust-nozzle area.

At a Reynolds number index of 0.96 (fig. 9(a)), with the engine operated at rated corrected engine speed and exhaust-nozzle area, the compressor pressure ratio was 7.0, the corrected air flow 143 pounds per second, the compressor efficiency 0.82, and the corrected turbine-inlet temperature 2020° R. As Reynolds number index was reduced to 0.12 (fig. 9(b)), at the same corrected engine speed and exhaust-nozzle area, the compressor pressure ratio remained at 7.0, the corrected air flow and compressor efficiency decreased to 136 pounds per second and 0.78, respectively, and the corrected turbine-inlet temperature was raised to 2180° R. As noted previously, the reductions in corrected air flow and compressor efficiency are due to Reynolds number effects on the compressor. A similar effect on the turbine performance will be shown in a later section. These Reynolds number effects were of such magnitude and direction that a constant compressor pressure ratio and an increased corrected turbine-inlet temperature resulted. 3167

For both Reynolds number indices, the operating line for rated exhaust-nozzle area passed through the region of maximum compressor efficiency.

Pressure loss through the compressor-outlet diffuser. - The loss in total pressure in the diffuser between the compressor and combustor may be expressed in terms of total-pressure loss ratio (pressure loss divided by inlet pressure). Over the entire range of this investigation this total-pressure loss ratio was about 0.6 percent.

Combustor Performance

Combustion efficiency. - As shown in reference 3, combustion efficiency for several combustors correlates with combustor-inlet conditions P_4T_3/V_b. Combustion efficiency is presented as a function of P_4T_3/V_b in figure 10. Over the range that the combustor operated in this engine, the fuel distribution and fuel-air ratio were found to have negligible effect on this correlation. An auxiliary scale of $W_{a,1}T_7$, which is proportional to P_4T_3/V_b, is also shown, because it is considered a more practical parameter insofar as engine operation

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is concerned. The combustion efficiency was constant at 0.98 above P_4T_3/V_b of 35,000 ($W_{a,1}T_7$ of 52,500). A decrease in combustion parameter below this value resulted in a decrease in combustion efficiency to 0.83 at P_4T_3/V_b of 6000. Thus, at rated engine conditions and a flight Mach number of 0.8, the combustion efficiency remained at 0.98 up to an altitude of about 37,000 feet (P_4T_3/V_b of 35,000) and decreased to 0.96 at an altitude of 55,000 feet (P_4T_3/V_b of 23,000).

Combustor total-pressure loss. - The combustor total-pressure loss ratio is presented as a function of combustor temperature ratio in figure 11. Data for all Reynolds number indices fall along a single curve. The pressure loss ratio decreased from 0.075 to 0.037 as combustor temperature ratio increased from 1.0 to 2.2 (approximately the combustor temperature ratio at rated conditions).

Combustor-outlet temperature distribution. - The data presented in figure 12 are typical temperature profiles at the turbine outlet. Previous investigations have indicated that turbine-outlet profiles reflect the combustor-outlet profiles, although in somewhat diminished magnitude. The turbine-outlet station is used, because no reliable temperature measurements were available at the combustor outlet. There were no consistent effects of altitude, flight Mach number, engine speed, or temperature level on the combustor temperature distribution. The data of figure 12 indicate that the radial temperature distribution with which the rotor would be concerned is relatively flat. However, the circumferential temperature variations are of considerable magnitude, amounting to 12 percent above the average (probably more ahead of the turbine). Therefore, near rated temperatures the local temperature may be more than 200° F above the average. Although this circumferential unbalance is unimportant insofar as the rotor is concerned, it could be detrimental to the stator life. No adverse effects on stator life were observed during the testing reported herein, which included over 170 hours of engine operation at various conditions without engine overhaul.

Turbine Performance

Performance map.- The performance of the turbine is presented in terms of corrected enthalpy drop and turbine gas-flow parameter with lines of constant corrected turbine speed, turbine pressure ratio, and turbine efficiency. Data for compressor Reynolds number indices of 0.96 and 0.88 were combined to construct the map shown in figure 13. For these compressor Reynolds number indices, the turbine Reynolds number index varied nominally from 0.90 to 1.50. A check showed that turbine Reynolds number had a negligible effect over this range of turbine Reynolds number indices. Therefore, the map of figure 13 was constructed from all data that fell within this turbine Reynolds number index range. Because of the variable inlet guide vanes used on this engine, it was possible to obtain turbine performance over a much wider range of enthalpy drop (at a constant corrected turbine speed) than is usually possible in engine performance evaluations.

At rated static sea-level conditions, the turbine operated at a corrected turbine speed of 4040 rpm and a corrected enthalpy drop of 30.0 Btu per pound. This operating point on the map of figure 13 (which approximates the static sea-level condition) corresponded to a turbine pressure ratio of 2.96, a corrected turbine gas flow of 43.0 pounds per second, and a turbine efficiency of 0.87. From the turbine weight-flow parameter, it may be determined that increasing the corrected turbine speed from 3900 to 4600 rpm resulted in about a $2\frac{1}{2}$-percent reduction in the corrected turbine gas flow. Thus, the critical turbine flow area decreased as corrected turbine speed was increased, which indicated that the critical turbine flow area was downstream of the first-stage stator (ref. 4). 3167

The peak turbine efficiency, which was slightly over 0.87 for the data shown in figure 13, occurred at a corrected turbine speed of about 4150 rpm. Over the entire range of turbine operation in figure 13, the efficiency varied less than 0.02. At any given corrected turbine speed, changing the turbine pressure ratio had no discernible effect on corrected gas flow or efficiency within the range investigated.

Effect of Reynolds number. - The effect of turbine Reynolds number on turbine efficiency and corrected turbine gas flow at a given corrected turbine speed and pressure ratio is presented in figure 14. The reference Reynolds number index of 1.50 was used so that figures 13 and 14 could be used together in determining turbine performance. The trends shown in figure 14 are valid over the range of turbine operating conditions presented in figure 13. The effect of reducing the turbine Reynolds number from 1.50 to 0.15 was to decrease the corrected turbine gas flow 2 percent and the turbine efficiency $2\frac{1}{2}$ percent.

Altitude Performance of Components at Rated Conditions

The variation of component performance with altitude at a flight Mach number of 0.8 is presented in figure 15 for rated engine conditions (rated exhaust-nozzle area and either limiting engine speed or exhaust-gas temperature). Increasing altitude from sea level to 55,000 feet results in an increase in corrected engine speed from 7480 to 8610 rpm and a decrease in Reynolds number from 1.31 to 0.17. The corrected engine speed of 8610 rpm is reached at the tropopause and remains constant as altitude is raised above this value. Compressor efficiency decreased from 0.842 to 0.768 as altitude was increased from sea level to the tropopause. Practically all of this decrease resulted from the increased corrected engine speed, while the effect of Reynolds number up to the tropopause was negligible. As altitude was increased to 55,000 feet, a further reduction of compressor efficiency to 0.753 occurred entirely because of Reynolds number effects. As can be seen in figure 15, the reduction in compressor efficiency would have been greater (to 0.744), except that it was necessary to reduce the engine speed in order to maintain turbine temperature limits.

The corrected air flow increased from 134.9 to 146.7 pounds per second as altitude was raised to the tropopause (assuming that corrected air flow is constant above a Reynolds number index of 0.96, i.e., fig. 7). This increase is due to the increase in corrected engine speed, which overshadowed the relatively small decrease associated with Reynolds number. As altitude was increased beyond the tropopause to an altitude of 55,000 feet, the corrected air flow was reduced to 142.9 pounds per second because of the effect of Reynolds number and the previously mentioned reduction in engine speed.

An increase in the altitude from sea level to 55,000 feet resulted in a small decrease in combustion efficiency from 0.98 to 0.96. This reduction, of course, would increase if lower values of flight Mach number or engine speed were considered, inasmuch as combustion efficiency is primarily a function of the combustor pressure level.

Turbine efficiency decreased from about 0.870 to 0.854 as altitude was raised from sea level to 55,000 feet. Over the range through which the turbine operates in the engine, turbine efficiency is a function only of corrected turbine speed and turbine Reynolds number (figs. 13 and 14). Because the corrected turbine speed remained nearly constant for rated engine conditions, the decrease in turbine efficiency resulted only from a decrease in turbine Reynolds number.

CONCLUDING REMARKS

Performance of the components of the YJ73-GE-3 engine was determined over a wide range of engine operating conditions and flight conditions. The effect of Reynolds number on the compressor performance at a constant corrected engine speed and compressor pressure ratio with the inlet guide vanes open was to reduce the corrected air flow $4\frac{1}{2}$ percent and the compressor efficiency 6 percent as Reynolds number index decreased from 0.96 to 0.12. At corrected engine speeds below 6300 rpm, the compressor performance can be improved by operating with the inlet guide vanes in the closed position. At a corrected engine speed of 5600 rpm, the compressor efficiency is raised from 0.73 to 0.82 as the inlet guide vanes move from the open to the closed position.

At rated engine conditions at a flight Mach number of 0.8, as altitude was increased from sea level to 55,000 feet, the compressor efficiency was reduced about 11 percent and the corrected air flow was raised about 6 percent primarily because of the effects of increased corrected engine speed. 3167

The combustion efficiency remained at 0.98 at values of P_4T_3/V_b of 35,000 and above, which corresponds to rated engine conditions at an altitude of 37,000 feet or less and a flight Mach number of 0.8. At the same engine and flight conditions at an altitude of 55,000 feet, the combustion efficiency was 0.96. At all Reynolds number indices the combustor total-pressure loss ratio was 0.037 for rated engine conditions.

Over the range of engine conditions investigated, at any given compressor Reynolds number index the turbine efficiency and the corrected turbine gas flow varied about 2 percent. As the turbine-inlet Reynolds number index was decreased from 1.50 to 0.15 at constant corrected turbine speed and turbine pressure ratio, the corrected turbine gas flow and the turbine efficiency decreased 2 and $2\frac{1}{2}$ percent, respectively. At rated engine conditions, as altitude was increased from sea level to 55,000 feet at 0.8 flight Mach number, a reduction in turbine efficiency of 2 percent was due only to the decrease in turbine Reynolds number.

Lewis Flight Propulsion Laboratory
National Advisory Committee for Aeronautics
Cleveland, Ohio, April 16, 1954

APPENDIX A

SYMBOLS

The following symbols are used in this report:

A	cross-sectional area, sq ft
g	acceleration due to gravity, 32.174 ft/sec^2
H	total enthalpy of air or gas mixture, Btu/lb
M	Mach number
N	engine speed, rpm
P	total pressure, lb/sq ft abs
p	static pressure, lb/sq ft abs
R	gas constant, 53.4 ft-lb/(lb)($^{\circ}$R)
Re	Reynolds number
T	total temperature, $^{\circ}$R
V	velocity, ft/sec
V_{cr}	critical velocity, $\sqrt{\frac{2\gamma}{\gamma + 1} gRT}$, ft/sec
W_a	air flow, lb/sec
W_f	fuel flow, lb/hr
W_g	gas flow, lb/sec
β	function of γ, $\frac{1.4}{\gamma}\left[\frac{\left(\frac{\gamma + 1}{2}\right)^{\frac{\gamma}{\gamma - 1}}}{\left(\frac{1.4 + 1}{2}\right)^{\frac{1.4}{1.4 - 1}}}\right]$
γ	ratio of specific heats

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

η efficiency

θ temperature-correction factor $(V_{cr}/1018)^2$ (squared ratio of critical velocity to critical velocity at NACA standard sea-level conditions)

λ $\frac{Am + B}{m + 1}$, $\frac{\text{Btu}}{\text{lb of fuel}}$ (as defined in ref. 5)

μ absolute viscosity, lb-sec/sq ft

ρ density, $\text{lb-sec}^2/\text{ft}^4$

ϕ viscosity-correction factor $\mu/3.719\times10^{-7}$ (viscosity divided by NACA standard sea-level viscosity)

Subscripts:

a air

b combustor

c compressor

g gas mixture

i indicated

t turbine

0 free-stream conditions

1 engine or compressor inlet

3 compressor outlet, compressor diffuser inlet

4 combustor inlet, compressor diffuser outlet

5 turbine inlet, combustor outlet

6 turbine outlet, tail-pipe diffuser inlet

7 exhaust-nozzle inlet, tail-pipe diffuser outlet

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APPENDIX B

METHODS OF CALCULATION

Temperature. - Total temperatures were calculated from indicated temperatures by the following relation:

$$T = \frac{T_i\left(\frac{P}{p}\right)^{\frac{\gamma - 1}{\gamma}}}{1 + 0.85\left[\left(\frac{P}{p}\right)^{\frac{\gamma - 1}{\gamma}} - 1\right]} \tag{1}$$

where 0.85 is the impact recovery factor for the type of thermocouple used.

Reynolds number index. - For a given corrected engine or turbine speed, Reynolds number index varies linearly with Reynolds number and is defined as the ratio of Reynolds number at any condition to Reynolds number at standard sea-level conditions:

$$\text{Re index} = \frac{\delta}{\phi\sqrt{\theta}} \tag{2}$$

Air flow. - Air flow was determined from pressure and temperature measurements at the engine inlet (station 1) by the following equation:

$$W_{a,1} = g\rho_1 A_1 V_1 = p_1 A_1 \sqrt{\left(\frac{2\gamma_1}{\gamma_1 - 1}\right)\left(\frac{g}{RT_1}\right)\left(\frac{P_1}{p_1}\right)^{\frac{\gamma_1 - 1}{\gamma_1}}\left[\left(\frac{P_1}{p_1}\right)^{\frac{\gamma_1 - 1}{\gamma_1}} - 1\right]} \tag{3}$$

The various compressor-outlet bleed and leakage flows were determined to be about 2 percent of the inlet-air flow. Although portions of the flow reenter ahead of the turbine (after station 5) and between turbine stages, this flow was ignored insofar as station 6 is concerned. However, the entire bleed and leakage flow has reentered the mainstream flow before passing through the exhaust nozzle. The air or gas flows at the various stations were calculated by the following equations:

$$W_{a,3} = W_{a,1} \tag{4}$$

$$W_{g,5} = 0.98W_{a,1} + \frac{W_f}{3600} \tag{5}$$

$$W_{g,7} = W_{a,1} + \frac{W_f}{3600} \tag{6}$$

Compressor efficiency. - Compressor efficiency was calculated by use of the tables in reference 6 and neglecting water-vapor corrections. Using known values of compressor-inlet and -outlet total pressure and temperature, compressor efficiency was determined from the following expression: 3167

$$\eta_c = \frac{H_{3,isentropic} - H_1}{H_{3,actual} - H_1} \tag{7}$$

Combustion parameter. - Combustion parameter P_4T_3/V_b is most easily calculated by assuming that the burner-inlet Mach number is low enough that total and static values of temperature and pressure are nearly equal. Thus, it can be shown that

$$\frac{P_4T_3}{V_b} = \left(\frac{A_b}{R}\right) \frac{P_4^2}{W_{a,4}} \tag{8}$$

where A_b is the maximum combustor flow area and is equal to approximately 5.3 square feet; and V_b, which is not a real velocity at the combustor inlet, is used according to criteria previously established in order that various combustors could be compared on a fair basis.

Combustion efficiency. - Combustion efficiency is defined as the ratio of the actual enthalpy rise of the gas while passing through the engine to the theoretical increase in enthalpy that would result from complete combustion of the fuel:

$$\eta_b = \frac{H_{a,7} + \frac{W_f}{3600W_{a,1}} \lambda_7 - H_{a,1}}{18,700 \frac{W_f}{3600W_{a,1}}} \tag{9}$$

where 18,700 Btu per pound is the lower heating value of the fuel.

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Turbine-inlet total temperature. - Turbine-inlet temperature was calculated by the use of temperature-enthalpy tables and the following equation:

$$H_{g,5} = \frac{W_{a,1}\left(H_{a,3} - H_{a,1}\right)}{W_{g,5}} + H_{a,7} \tag{10}$$

The difference in the fuel-air ratios between stations 5 and 7 is negligible with respect to calculation involving equation (10).

Turbine efficiency. - Turbine efficiency was obtained from the relation

$$\eta_t = \frac{1 - T_7/T_5}{1 - \left(\frac{P_6}{P_5}\right)^{\frac{\gamma_t - 1}{\gamma_t}}} \tag{11}$$

where γ_t is based on $\frac{T_5 + T_7}{2}$ and fuel-air ratio.

REFERENCES

1. Campbell, Carl E., and Sobolewski, Adam E.: Altitude-Chamber Investigation of J73-GE-1A Turbojet Engine Component Performance. NACA RM E53I08, 1953.

2. Campbell, Carl E., and Conrad, E. William: Altitude Performance Characteristics of the J73-GE-1A Turbojet Engine. NACA RM E53I25, 1953.

3. Childs, J. Howard: Preliminary Correlation of Efficiency of Aircraft Gas-Turbine Combustors for Different Operating Conditions. NACA RM E50F15, 1950.

4. Berkey, William E., Rebeske, John J., Jr., and Forrette, Robert E.: Performance Evaluation of Reduced-Chord Rotor Blading as Applied to J73 Two-Stage Turbine. I - Over-All Performance with Standard Rotor Blading at Inlet Conditions of 35 Inches of Mercury Absolute and 700° R. NACA RM E52G31, 1953.

5. Turner, L. Richard, and Bogart, Donald: Constant-Pressure Combustion Charts Including Effects of Diluent Addition. NACA Rep. 937, 1949. (Supersedes NACA TN's 1086 and 1655.)

6. Amorosi, A.: Gas Turbine Gas Charts. Res. Memo. No. 6-44 (Navships 250-330-6), Bur. Ships, Navy Dept., Dec. 1944.

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TABLE 1. - PERFORMANCE DATA

(a) Inlet guide vanes open.

Run	Compressor Reynolds number index, $\frac{\delta_1}{\varphi_1\sqrt{\theta_1}}$	Altitude-exhaust pressure, p_0, lb/sq ft	Flight Mach number, M_0	Equivalent ambient-air static temperature, t_0, °R	Engine-inlet total temperature, T_1, °R	Engine-inlet total pressure, P_1, lb/sq ft abs	Compressor-inlet total pressure, P_2, lb/sq ft abs	Compressor-outlet total temperature, T_3, °R	Compressor-outlet total pressure, P_3, lb/sq ft abs	Combustor-inlet total pressure, P_4, lb/sq ft abs	Turbine-inlet total temperature, T_5, °R	Turbine-inlet total pressure, P_5, lb/sq ft abs	Turbine-outlet total temperature, T_6, °R	Turbine-outlet total pressure, P_6, lb/sq ft abs	Tail-pipe total temperature, T_7, °R	Tail-pipe total pressure, P_7, lb/sq ft abs
Exhaust-nozzle area, 2.388 sq ft																
1	0.922	2035	0	522	514	1932	1899	979	13616	13427	2030	12990	1691	4416	1632	4315
2	.925	2043	0	522	514	1942	1913	963	13173	12952	1967	12565	1624	4280	1572	4184
3	.926	2037	0	522	515	1944	1917	926	12022	11865	1810	11462	1470	3949	1444	3840
4	.938	2039	0	520	515	1970	1951	858	9578	9516	1560	9139	1248	3269	1247	3197
5	.959	2041	0	518	516	2014	2007	859	5587	5575	1430	5340	1247	2477	1212	2452
6	.862	1186	.803	448	506	1813	1785	969	12794	12668	2018	12189	1654	4146	1613	4045
7	.864	1187	.806	448	507	1819	1797	919	11328	11241	1790	10796	1446	3672	1419	3564
8	.861	1176	.812	448	507	1812	1794	846	8781	8728	1458	8358	1161	2807	1148	2738
9	.871	1189	.798	451	509	1809	1792	846	8733	8677	1443	8314	1157	2788	1142	2724
10	.861	1176	.811	450	509	1811	1803	844	4911	4887	1063	4605	846	1718	839	1684
11	.867	1183	.802	454	512	1806	1802	734	4793	4774	1067	4515	850	1702	848	1668
12	.577	769	.818	443	502	1193	1172	967	8515	8424	2028	8119	1635	2766	1623	2692
13	.575	775	.803	446	504	1185	1167	954	8150	8078	1958	7764	1581	2639	1558	2576
14	.575	782	.800	447	504	1192	1175	916	7425	7363	1790	7079	1441	2409	1422	2347
15	.575	766	.816	446	505	1185	1174	844	5826	5785	1464	5551	1175	1843	1152	1812
16	.575	774	.811	447	506	1192	1187	728	3162	3146	1055	2984	844	1124	840	1100
17	.578	494	1.21	394	509	1209	1189	974	8487	8419	2020	8090	1637	2763	1618	2688
18	.575	494	1.20	395	509	1201	1184	958	8173	8108	1963	7798	1583	2667	1560	2585
19	.576	411	1.21	394	510	1206	1191	921	7485	7426	1790	7136	1450	2424	1424	2347
20	.576	494	1.20	395	510	1204	1192	848	5769	5732	1460	5493	1165	1842	1849	1797
21	.578	486	1.22	395	512	1209	1205	726	3056	3031	930	2848	718	946	722	921
22	.362	492	.804	445	502	753	742	970	5353	5315	2033	5106	1661	1738	1628	1694
23	.362	485	.809	444	502	746	737	954	5190	5151	1960	4953	1610	1684	1568	1638
24	.367	490	.805	442	499	750	740	934	5039	4997	1900	4804	1551	1628	1505	1585
25	.362	490	.809	444	502	753	743	917	4770	4739	1800	4536	1486	1544	1431	1502
26	.367	481	.822	440	499	749	739	882	4331	4315	1663	4133	1328	1394	1319	1355
27	.362	502	.788	447	503	756	749	844	3653	3622	1478	3474	1183	1180	1170	1146
28	.367	492	.803	443	500	752	748	773	2781	2776	1220	2632	957	901	955	876
29	.362	492	.798	447	504	748	746	729	1974	1961	1083	1863	867	699	866	686
30	.220	301	.799	443	499	458	453	963	3263	3240	2020	3113	1658	1057	1614	1029
31	.223	304	.806	445	503	466	459	960	3231	3206	1990	3079	1635	1048	1590	1020
32	.225	307	.794	443	499	465	460	945	3143	3114	1940	2998	1597	1021	1590	993
33	.220	295	.819	444	503	458	452	922	2940	2915	1830	2803	1490	944	1452	916
34	.220	300	.804	443	500	459	454	891	2700	2686	1710	2577	1379	872	1361	846
35	.221	296	.818	444	503	459	454	846	2282	2260	1500	2171	1211	723	1188	701
36	.224	307	.800	443	500	468	465	804	1950	1943	1330	1861	1049	626	1051	607
37	.225	310	.795	447	503	470	468	739	1270	1265	1140	1201	896	445	912	435
38	.139	195	.791	458	515	294	292	965	1890	1876	2000	1806	1644	625	1603	604
39	.137	189	.808	457	516	290	286	943	1755	1744	1897	1672	1546	578	1519	561
40	.135	185	.818	457	518	287	284	919	1649	1642	1770	1572	1459	534	1413	519
41	.138	194	.791	460	518	293	290	883	1445	1440	1605	1374	1303	466	1284	453
42	.137	192	.792	460	518	290	288	800	932	929	1300	884	1057	322	1037	316
43	.100	192	.417	501	518	216	214	961	1365	1359	1971	1305	1637	454	1582	441
44	.101	195	.417	499	517	220	217	945	1360	1312	1907	1258	1597	439	1532	428
45	.101	195	.418	499	517	220	218	918	1202	1196	1803	1148	1494	395	1446	384
46	.101	196	.403	501	517	219	218	876	1042	1032	1643	987	1350	355	1320	347
47	.101	198	.399	501	517	221	220	821	673	670	1590	641	1366	264	1317	260

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TABLE I. - Continued. PERFORMANCE DATA

(a) Continued. Inlet guide vanes open.

Engine speed, N, rpm	Corrected engine speed, $\frac{N}{\sqrt{\theta_1}}$, rpm	Compressor-inlet tip Mach number, M_c	Engine air flow, $W_{a,1}$, lb/sec	Corrected air flow, $W_{a,1}\frac{\sqrt{\theta_1}}{\delta_1}$, lb/sec	Compressor pressure ratio, P_3/P_1	Compressor efficiency, η_c	Compressor-discharge pressure-loss ratio, $(P_3-P_4)/P_3$	Combustor pressure-loss ratio, $\frac{P_4-P_5}{P_4}$	Combustion efficiency, η_b	Combustion parameter, $\frac{P_4T_3}{V_b}\times 10^{-4}$	Combustion parameter, $W_{a,1}T_7\times 10^{-4}$	Turbine Reynolds number index $\frac{\delta_5}{\varphi_5\sqrt{\theta_5}}$	Corrected turbine speed, $\frac{N}{\sqrt{\theta_5}}$, rpm	Corrected turbine gas flow, $\frac{W_{g,5}\sqrt{\theta_5}}{\delta_5}\beta$, lb/sec	Turbine efficiency, η_t	Corrected turbine enthalpy drop, $\Delta H_t/\theta_5$, $\frac{Btu}{lb\text{-}sec}$	Turbine pressure ratio, P_5/P_6	Run
Exhaust-nozzle area, 2.388 sq ft																		
7955	7993	1.002	131.3	143.1	7.048	0.814	0.014	0.033	0.988	13.9	21.4	1.23	4079	43.0	0.850	29.7	2.941	1
7792	7830	.982	129.7	140.7	6.783	.824	.017	.030	.979	13.1	20.4	1.17	4054	43.2	.867	29.8	2.936	2
7409	7438	.933	123.1	133.5	6.184	.847	.013	.034	.979	11.6	17.8	1.21	4016	43.0	.865	29.4	2.903	3
6680	6706	.841	107.1	114.6	4.862	.850	.007	.040	.992	8.56	13.4	1.16	3890	43.2	.862	28.5	2.796	4
5498	5514	.691	64.6	67.7	2.774	.715	.002	.042	.982	4.87	7.83	.74	3346	42.6	.843	21.8	2.156	5
7922	8023	1.006	124.0	142.9	7.057	.807	.010	.038	.977	14.3	20.0	1.15	4075	43.2	.872	30.0	2.940	6
7413	7508	.942	117.3	134.7	6.228	.833	.008	.040	.991	10.9	16.6	1.17	4051	43.1	.877	30.0	2.940	7
6686	6764	.848	100.8	116.4	4.846	.845	.006	.042	.995	7.65	11.6	1.14	4024	42.9	.857	30.0	2.978	8
6670	6735	.845	99.5	115.3	4.828	.853	.006	.042	.981	7.66	11.4	1.15	4042	42.3	.839	30.7	2.982	9
5502	5556	.697	66.3	76.7	2.712	.752	.005	.058	.981	3.65	5.56	.93	3883	43.3	.887	27.0	2.680	10
5498	5536	.694	62.5	72.8	2.654	.742	.004	.055	.974	3.69	5.38	.91	3875	41.8	.874	26.8	2.653	11
7953	8086	1.014	82.1	143.3	7.137	.804	.011	.036	.989	8.74	13.3	.77	4080	43.1	.868	30.0	2.935	12
7795	7910	.992	80.1	141.0	6.878	.813	.009	.039	.968	8.25	12.5	.76	4064	43.1	.879	30.0	2.942	13
7417	7527	.944	76.7	134.1	6.229	.833	.008	.039	.981	7.16	10.9	.77	4040	43.1	.874	30.0	2.939	14
6688	6780	.850	66.2	116.5	4.912	.851	.007	.040	.960	5.12	7.62	.76	4015	42.5	.852	30.0	3.012	15
5494	5564	.698	42.3	74.1	2.653	.729	.005	.052	.967	2.37	3.55	.59	3893	42.5	.868	27.0	2.655	16
7953	8031	1.007	82.2	142.4	7.020	.806	.008	.039	.983	8.73	13.3	.76	4088	43.2	.864	29.8	2.928	17
7792	7868	.987	80.3	140.1	8.805	.817	.008	.038	.985	8.29	12.5	.76	4058	43.1	.884	30.4	2.935	18
7420	7485	.938	76.7	133.5	6.206	.840	.008	.039	.977	7.28	10.9	.77	4044	42.7	.863	29.7	2.944	19
6682	6741	.845	65.8	114.7	4.792	.845	.006	.042	.992	5.05	7.56	.75	4019	42.6	.858	30.0	2.982	20
5492	5530	.693	43.3	75.2	2.528	.724	.008	.060	1.004	2.15	3.12	.66	4129	42.5	.845	29.4	3.010	21
7951	8084	1.014	51.6	142.7	7.109	.796	.007	.039	.976	5.54	8.42	.48	4070	43.2	.866	30.0	2.938	22
7788	7919	.993	50.2	139.9	6.957	.814	.008	.038	.955	5.35	7.86	.48	4060	43.3	.862	30.0	2.941	23
7631	7782	.976	50.1	138.5	6.719	.821	.008	.039	.964	5.05	7.53	.49	4038	42.8	.887	29.7	2.951	24
7420	7544	.946	48.8	134.9	6.335	.832	.007	.043	.971	4.66	6.98	.49	4031	42.9	.869	30.0	2.938	25
7097	7237	.908	46.1	127.8	5.782	.842	.004	.042	.974	4.09	6.08	.48	4005	42.6	.857	29.0	2.965	26
6670	6765	.848	41.3	113.7	4.832	.831	.009	.041	.940	3.22	4.83	.47	3990	42.6	.853	29.6	2.944	27
6013	6126	.768	34.9	96.5	3.698	.827	.002	.052	.934	2.23	3.34	.44	3977	43.1	.866	29.2	2.921	28
5492	5573	.699	25.6	71.4	2.639	.715	.007	.050	.984	1.52	2.22	.37	3843	41.8	.853	27.0	2.665	29
7845	8000	1.003	30.9	139.9	7.124	.799	.007	.039	.927	3.44	4.98	.29	4030	42.2	.871	29.9	2.946	30
7782	7905	.991	31.1	138.9	6.933	.802	.008	.040	.952	3.35	4.94	.31	4028	42.5	.873	30.0	2.939	31
7653	7804	.979	30.7	137.2	6.759	.805	.009	.037	.955	3.19	4.73	.30	4007	42.6	.886	29.8	2.936	32
7405	7522	.943	29.1	132.4	6.419	.833	.009	.038	.938	2.95	4.23	.29	3990	41.8	.871	29.7	2.968	33
7106	7240	.908	28.3	128.2	5.882	.834	.005	.041	.953	2.58	3.86	.29	3960	42.6	.853	29.6	2.955	34
6867	6772	.849	25.3	115.1	4.972	.847	.009	.039	.967	2.04	3.01	.29	3959	42.2	.838	29.5	3.003	35
6265	6383	.800	22.9	101.5	4.167	.824	.004	.042	.972	1.67	2.40	.28	3980	41.8	.836	30.0	2.973	36
5564	5652	.834	16.3	72.2	2.702	.698	.004	.051	.829	.99	1.48	.22	3801	42.4	.846	26.9	2.699	37
7629	7659	.960	17.9	128.3	6.420	.793	.007	.037	.908	1.99	2.87	.17	3940	42.0	.871	29.3	2.889	38
7407	7429	.932	17.3	125.5	6.050	.803	.006	.041	.906	1.78	2.62	.17	3924	42.4	.879	29.2	2.893	39
7178	7185	.901	16.6	122.0	5.748	.828	.004	.043	.925	1.65	2.34	.17	3931	41.7	.850	29.4	2.944	40
6828	6835	.857	15.5	111.5	4.932	.812	.004	.046	.930	1.36	1198	.16	3921	42.1	.827	29.4	2.948	41
6011	6017	.755	11.1	81.2	3.212	.722	.003	.048	.883	.78	1.16	.13	3829	42.1	.858	27.9	2.745	42
7506	7514	.942	12.8	124.8	6.308	.803	.004	.040	.887	1.46	2.02	.12	3906	41.1	.869	29.2	2.874	43
7345	7359	.923	12.6	121.2	5.987	.796	.003	.041	.906	1.38	1.93	.12	3879	41.3	.862	29.2	2.865	44
7080	7093	.889	11.8	113.0	5.564	.798	.005	.040	.903	1.23	1.70	.12	3845	41.0	.848	28.8	2.906	45
6678	6691	.839	10.9	104.7	4.756	.800	.010	.044	.915	.99	1.43	.12	3794	41.8	.859	28.2	2.780	46
6002	6013	.754	7.2	68.4	3.045	.633	.005	.043	.844	.63	.94	.08	3464	42.0	.849	24.5	2.428	47

TABLE I. - Continued. PERFORMANCE DATA

(a) Continued. Inlet guide vanes open.

Run	Compressor Reynolds number index, $\frac{\delta_1}{\varphi_1\sqrt{\theta_1}}$	Altitude-exhaust pressure, p_0, lb/sq ft	Flight Mach number, M_0	Equivalent ambient-air static temperature, t_0, °R	Engine-inlet total temperature, T_1, °R	Engine-inlet total pressure, P_1, lb/sq ft abs	Compressor-inlet total pressure, P_2, lb/sq ft abs	Compressor-outlet total temperature, T_3, °R	Compressor-outlet total pressure, P_3, lb/sq ft abs	Combustor-inlet total pressure, P_4, lb/sq ft abs	Turbine-inlet total temperature, T_5, °R	Turbine-inlet total pressure, P_5, lb/sq ft abs	Turbine-outlet total temperature, T_6, °R	Turbine-outlet total pressure, P_6, lb/sq ft abs	Tail-pipe total temperature, T_7, °R	Tail-pipe total pressure, P_7, lb/sq ft abs
Exhaust-nozzle area, 2.514 sq ft																
48	0.942	2060	0	514	505	1943	1910	963	13473	13272	1940	12839	1596	4218	1533	4140
49	.938	2052	0	514	506	1937	1907	949	13077	12919	1880	12478	1535	4115	1483	4034
50	.947	2058	0	514	506	1952	1930	916	12092	11966	1763	11516	1412	3855	1392	3775
51	.942	2048	0	514	506	1942	1859	914	12029	11928	1760	11473	1400	3832	1386	3756
52	.955	2048	0	512	506	1969	1909	846	9691	9609	1527	9246	1221	3261	1220	3208
53	.956	2052	0	513	507	1972	1911	846	9734	9638	1530	9278	1224	3271	1224	3220
54	.984	2065	0	509	507	2036	2015	750	5682	5668	1433	5433	1237	2513	1214	2494
55	.984	2061	0	510	508	2034	2014	750	5629	5613	1450	5378	1252	2520	1232	2496
56	.828	1058	.840	441	503	1679	1638	959	12302	12241	1930	11780	1549	3740	1500	3657
57	.890	1183	.806	445	503	1812	1776	958	12553	12418	1930	11963	1552	3873	1496	3790
58	.885	1171	.808	443	501	1797	1763	942	12194	12069	1850	11627	1492	3749	1452	3666
59	.885	1171	.808	442	500	1798	1771	906	11177	11085	1693	10638	1351	3446	1326	3364
60	.897	1193	.799	444	501	1816	1765	836	8805	8739	1415	8373	1116	2721	1106	2680
61	.897	1198	.799	445	502	1823	1812	723	4900	4879	1050	4616	836	1720	832	1699
62	.582	777	.806	442	499	1191	1172	956	8295	8226	1925	7914	1531	2563	1513	2504
63	.584	780	.809	444	502	1200	1181	943	8772	8011	1853	7696	1482	2503	1456	2443
64	.580	780	.806	443	501	1195	1181	908	7333	7279	1703	6992	1350	2276	1332	2217
65	.582	784	.803	443	500	1198	1187	836	5801	5770	1415	5520	1111	1798	1113	1766
66	.581	779	.804	443	500	1192	1187	727	3308	3287	1080	3111	844	1140	855	1127
67	.583	473	1.23	388	505	1193	1174	961	8311	8239	1907	7915	1524	2529	1500	2460
68	.583	468	1.24	386	505	1193	1174	944	7994	7956	1833	7648	1458	2451	1440	2378
69	.583	469	1.24	387	506	1194	1179	911	7349	7333	1670	6991	1323	2218	1315	2166
70	.580	478	1.22	392	510	1198	1185	840	5849	5826	1373	5566	1076	1684	1068	1646
71	.581	493	1.21	399	515	1208	1204	722	2835	2809	895	2637	682	868	690	848
72	.373	494	.806	441	498	757	746	958	5304	5267	1930	5061	1553	1636	1524	1601
73	.430	483	.815	391	443	747	734	897	5683	5651	1897	5436	1517	1746	1498	1702
74	.371	498	.798	444	500	757	747	945	5107	5073	1853	4871	1510	1579	1454	1548
75	.430	491	.808	394	445	754	741	863	5317	5289	1753	5085	1418	1633	1377	1588
76	.371	492	.809	441	499	756	747	904	4674	4646	1715	4465	1357	1449	1346	1418
77	.428	490	.806	395	446	751	740	802	4563	4538	1500	4355	1187	1401	1177	1365
78	.370	502	.792	445	501	759	752	837	3649	3625	1435	3470	1126	1126	1130	1102
79	.362	486	.808	444	502	746	744	720	1925	1917	1067	1815	847	682	856	674
80	.263	310	.973	396	446	469	461	903	3487	3463	1920	3340	1554	1089	1519	1044
81	.263	309	.792	397	447	467	461	869	3273	3246	1773	3123	1433	1001	1398	974
82	.230	304	.813	438	496	469	464	959	3266	3243	1917	3114	1554	1009	1508	987
83	.225	296	.820	437	496	460	456	942	3161	3141	1860	3010	1512	964	1460	943
84	.226	294	.830	437	497	462	458	904	2888	2869	1715	2752	1363	878	1345	859
85	.209	316	.788	397	446	476	470	805	2801	2783	1523	2677	1211	858	1198	835
86	.224	295	.821	438	497	459	455	835	2272	2260	1443	2167	1121	693	1134	675
87	.227	306	.800	442	498	466	464	927	1223	1216	1093	1144	879	435	870	725
88	.160	193	.793	407	458	292	288	925	2298	2284	1963	2201	1595	643	1554	629
89	.140	193	.793	441	496	292	289	972	2060	2045	2017	1966	1610	630	1604	619
90	.157	186	.795	407	459	283	278	893	1971	1961	1830	1884	1483	595	1443	581
91	.140	190	.802	440	496	290	288	951	1963	1952	1940	1871	1534	602	1537	590
92	.138	187	.808	440	497	287	284	914	1778	1767	1797	1691	1400	543	1423	533
93	.155	184	.809	408	462	283	279	823	1712	1701	1543	1635	1232	490	1219	476
94	.138	184	.820	439	498	286	284	840	1359	1356	1490	1294	1155	417	1176	409
95	.134	182	.813	441	499	281	282	735	762	755	1147	719	923	265	918	263
96	.124	197	.455	442	460	227	222	934	1684	1681	2007	1616	1637	503	1595	492
97	.123	192	.475	441	461	224	221	905	1553	1550	1893	1489	1540	479	1499	468
98	.105	189	.478	475	497	221	218	971	1543	1538	2030	1479	1633	479	1609	469
99	.105	190	.485	475	497	223	220	970	1539	1536	2037	1479	1636	478	1623	468
100	.104	187	.487	474	496	220	217	957	1501	1497	1990	1435	1592	463	1586	451
101	.107	193	.467	476	497	224	222	925	1381	1376	1880	1325	1476	436	1496	428
102	.124	195	.471	443	463	227	224	845	1314	1311	1660	1259	1336	406	1315	394
103	.106	192	.460	477	497	222	220	851	1062	1061	1555	1014	1259	347	1236	341
104	.105	177	.584	466	498	223	222	789	796	790	1373	759	1129	269	1105	266
105	.105	187	.539	472	499	228	227	773	694	686	1377	663	1156	257	1125	257

TABLE I. - Continued. PERFORMANCE DATA

(a) Continued. Inlet guide vanes open.

Engine speed, N, rpm	Corrected engine speed, $N/\sqrt{\theta_1}$, rpm	Compressor-inlet tip Mach number, M_c	Engine air flow, $W_{a,1}$, lb/sec	Corrected air flow, $W_{a,1}\frac{\sqrt{\theta_1}}{\delta_1}$, lb/sec	Compressor pressure ratio, P_3/P_1	Compressor efficiency, η_c	Compressor-discharge pressure-loss ratio, $(P_3-P_4)/P_3$	Combustor pressure-loss ratio, $\frac{P_4-P_5}{P_4}$	Combustion efficiency, η_b	Combustion parameter, $\frac{P_4T_3}{V_b}\times 10^{-4}$	Combustion parameter, $W_{a,1}T_7\times 10^{-4}$	Turbine Reynolds number index, $\frac{\delta_5}{\varphi_5\sqrt{\theta_5}}$	Corrected turbine speed, $\frac{N}{\sqrt{\theta_5}}$, rpm	Corrected turbine gas flow, $\frac{W_{g,5}\sqrt{\theta_5}}{\delta_5}\beta$, lb/sec	Turbine efficiency, η_t	Corrected turbine enthalpy drop, $\Delta H_t/\theta_5$, $\frac{Btu}{lb-sec}$	Turbine pressure ratio, P_5/P_6	Run
Exhaust-nozzle area, 2.514 sq ft																		
7945	8055	1.010	134.3	144.2	6.934	0.805	0.015	0.033	0.975	13.3	20.6	1.26	4160	43.5	0.877	30.8	3.044	48
7790	7889	1.002	131.3	141.6	6.751	.819	.012	.034	.965	12.9	19.5	1.27	4143	43.0	.879	30.6	3.032	49
7417	7512	.942	125.8	134.6	6.195	.834	.010	.038	.984	11.5	17.5	1.27	4069	43.1	.876	30.1	2.987	50
7409	7504	.941	125.0	134.4	6.194	.839	.008	.038	.973	11.5	17.4	1.26	4067	42.9	.877	30.2	2.994	51
6665	6750	.846	108.1	114.7	4.922	.852	.008	.038	.965	8.64	13.2	1.19	3921	42.6	.852	28.7	2.835	52
6670	6748	.846	108.6	115.2	4.936	.860	.010	.037	.973	8.66	13.3	1.19	3919	42.8	.848	28.7	2.836	53
5489	5553	.696	65.5	67.3	2.791	.711	.003	.042	.986	4.96	7.95	.76	3339	42.5	.844	21.7	2.162	54
5489	5548	.696	63.3	85.2	2.767	.705	.003	.042	.965	5.04	7.80	.74	3311	41.8	.843	21.5	2.134	55
7941	8066	1.011	119.6	148.2	7.327	.835	.005	.038	.938	12.7	17.9	1.17	4203	41.7	.859	31.0	3.150	56
7939	8064	1.011	125.0	143.7	6.928	.806	.011	.037	.973	12.5	18.7	1.18	4200	42.9	.879	31.0	3.089	57
7794	7933	.995	123.2	142.6	6.786	.818	.010	.037	.968	12.0	17.9	1.21	4179	42.9	.876	31.0	3.102	58
7422	7562	.948	117.7	136.0	6.216	.835	.008	.040	.967	10.6	15.6	1.22	4155	42.7	.872	31.0	3.087	59
6699	6818	.855	103.1	118.1	4.849	.846	.008	.042	.994	7.50	11.4	1.17	4090	43.1	.855	30.0	3.077	60
5473	5565	.698	67.0	76.5	2.688	.741	.004	.054	1.023	3.60	5.57	.94	3884	43.4	.869	27.0	2.684	61
7947	8104	1.016	82.3	143.4	6.965	.800	.008	.038	.974	8.33	12.4	.79	4181	43.0	.884	31.0	3.087	62
7790	7921	.993	81.5	141.4	6.727	.852	.008	.039	.967	7.97	11.9	.80	4172	42.9	.864	31.0	3.075	63
7415	7547	.946	77.4	134.7	6.136	.828	.007	.039	.972	6.93	10.3	.80	4137	42.9	.880	31.2	3.072	64
6678	6804	.853	67.9	117.7	4.842	.841	.005	.043	.997	4.96	7.56	.78	4080	43.1	.837	30.6	3.070	65
5530	5634	.707	44.3	77.2	2.775	.744	.006	.054	1.040	2.47	3.79	.61	3875	43.2	.863	27.0	2.729	66
7968	8078	1.013	81.1	142.0	6.966	.811	.009	.039	.960	8.47	12.2	.80	4210	42.17	.868	31.0	3.130	67
7786	7893	.990	79.9	139.9	6.701	.822	.005	.039	.958	8.02	11.5	.81	4195	42.1	.870	31.0	3.120	68
7413	7508	.946	77.0	134.8	6.155	.842	.002	.047	.988	7.06	10.1	.82	4175	42.2	.839	31.4	3.152	69
6678	6737	.845	65.7	115.1	4.882	.881	.004	.045	.986	5.23	7.02	.82	4141	40.6	.822	31.1	3.305	70
5432	5453	.684	40.3	70.4	2.347	.685	.009	.061	.984	1.98	2.78	.63	4162	42.0	.854	29.9	3.038	71
7945	8111	1.017	52.0	142.4	7.007	.797	.007	.039	.965	5.40	7.93	.50	4173	42.6	.867	30.9	3.093	72
7945	8599	1.078	55.5	145.2	7.608	.762	.006	.038	.969	5.82	8.31	.55	4209	42.0	.860	30.9	3.113	73
7788	7935	.995	57.5	141.2	6.746	.806	.007	.040	.954	4.53	7.48	.51	4171	42.8	.880	31.3	3.085	74
7625	8234	1.033	54.9	142.5	7.052	.792	.005	.039	.983	5.16	7.55	.56	4198	42.4	.863	30.9	3.114	75
7402	7548	.947	49.4	135.7	6.183	.835	.006	.039	.976	4.42	6.65	.50	4118	43.0	.868	30.6	3.082	76
6947	7494	.940	50.3	131.4	6.076	.841	.006	.040	.958	4.14	5.92	.58	4125	41.8	.845	30.7	3.108	77
6670	6789	.851	42.0	115.1	4.808	.838	.007	.043	.970	3.17	4.75	.48	4051	42.7	.836	30.2	3.082	78
5432	5523	.693	24.6	68.7	2.580	.715	.004	.053	.872	1.51	2.11	.36	3828	41.0	.839	26.3	2.661	79
7945	8571	1.075	34.9	143.7	7.435	.750	.007	.036	.980	3.53	5.22	.33	4184	42.5	.854	30.8	3.124	80
7619	8209	1.029	33.4	140.5	7.009	.784	.008	.038	.954	3.19	4.67	.34	4170	42.4	.853	30.9	3.124	81
7941	8123	1.018	32.2	142.0	6.964	.785	.007	.040	.945	3.31	4.86	.31	4187	42.7	.880	31.4	3.086	82
7795	7974	1.000	31.1	139.7	6.872	.809	.006	.042	.928	3.21	4.53	.31	4165	41.9	.874	31.1	3.122	83
7390	7552	.947	30.3	135.7	6.251	.833	.007	.041	.960	2.75	4.07	.31	4111	42.7	.859	30.8	3.135	84
6932	7478	.938	31.1	128.0	5.884	.815	.006	.038	.951	2.52	3.72	.35	4086	42.3	.838	30.2	3.120	85
6667	6813	.854	26.0	117.4	4.950	.848	.005	.041	.998	1.99	2.95	.30	4036	42.5	.831	30.2	3.127	86
5504	5619	.704	16.3	72.6	2.624	.689	.006	.059	.839	.92	1.42	.22	3836	43.6	.879	27.2	2.630	87
7953	8466	1.062	20.8	142.0	7.898	.781	.006	.036	.967	2.54	3.24	.21	4144	39.6	.802	30.9	3.423	88
7983	8166	1.024	20.0	141.6	7.055	.670	.007	.039	.983	2.12	3.20	.19	4109	43.1	.846	30.7	3.121	89
7627	8110	1.017	20.0	141.0	6.977	.779	.005	.039	.956	1.95	2.89	.20	3161	42.8	.849	30.7	3.167	90
7771	7949	.997	19.3	138.0	6.769	.784	.006	.042	.980	1.99	2.97	.19	4069	43.0	.852	30.5	3.108	91
7384	7545	.946	18.3	131.7	6.195	.808	.006	.043	.975	1.73	2.60	.19	4016	43.0	.841	30.1	3.114	92
6860	7271	.912	18.1	127.5	6.056	.857	.006	.039	.967	1.62	2.20	.21	4017	40.5	.787	30.1	3.337	93
6646	6785	.851	15.7	113.8	4.752	.811	.002	.046	.976	1.19	1.85	.17	3958	43.6	.825	29.6	3.103	94
5528	5687	.707	9.0	66.7	2.712	.694	.009	.048	.746	.64	.83	.13	3766	39.6	.840	26.6	2.913	95
7951	8446	1.059	16.0	140.6	7.425	.744	.002	.039	.963	1.79	2.55	.15	4098	42.0	.830	30.6	3.212	96
7642	8108	1.017	15.6	139.0	6.945	.761	.002	.039	.966	1.56	2.33	.15	4053	42.9	.852	30.4	3.108	97
7926	8099	1.016	14.7	138.1	6.982	.769	.003	.038	.928	1.62	2.37	.14	4062	42.1	.866	30.4	3.087	98
7884	8056	1.010	14.9	138.0	6.995	.773	.002	.037	.953	1.61	2.41	.14	4031	42.9	.847	30.2	3.094	99
7742	7919	.993	14.7	138.3	6.823	.778	.003	.041	.966	1.54	2.33	.14	4006	43.2	.841	30.1	3.100	100
7436	7599	.953	14.0	129.3	6.165	.782	.004	.037	.984	1.37	2.09	.14	3955	43.1	.851	30.0	3.039	101
6996	7407	.929	13.4	126.4	5.791	.785	.002	.040	.969	1.21	1.89	.15	3952	43.5	.831	29.7	3.101	102
6634	6779	.850	11.6	108.3	4.784	.786	.001	.044	.902	.98	1.44	.13	3873	42.2	.852	29.3	2.922	103
6112	6240	.782	9.6	88.8	3.590	.748	.008	.039	.852	.66	1.06	.11	3792	43.4	.819	27.2	2.822	104
5786	5900	.740	8.4	76.7	3.044	.681	.012	.036	.861	.56	.95	.10	3585	43.9	.830	25.6	2.580	105

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TABLE I. - Continued. PERFORMANCE DATA

(a) Continued. Inlet guide vanes open.

Run	Compressor Reynolds number index, $\frac{\delta_1}{\varphi_1\sqrt{\theta_1}}$	Altitude-exhaust pressure, p_0, lb/sq ft	Flight Mach number, M_0	Equivalent ambient-air static temperature, t_0, °R	Engine-inlet total temperature, T_1, °R	Engine-inlet total pressure, P_1, lb/sq ft abs	Compressor-inlet total pressure, P_2, lb/sq ft abs	Compressor-outlet total temperature, T_3, °R	Compressor-outlet total pressure, P_3, lb/sq ft abs	Combustor-inlet total pressure, P_4, lb/sq ft abs	Turbine-inlet total temperature, T_5, °R	Turbine-inlet total pressure, P_5, lb/sq ft abs	Turbine-outlet total temperature, T_6, °R	Turbine-outlet total pressure, P_6, lb/sq ft abs	Tail-pipe total temperature, T_7, °R	Tail-pipe total pressure, P_7, lb/sq ft abs
Exhaust-nozzle area, 2.694 sq ft																
106	0.938	2053	0	514	505	1933	1901	956	13079	12896	1807	12449	1445	3851	1403	3762
107	.942	2059	0	514	505	1942	1912	942	12664	12537	1750	12084	1400	3772	1358	3664
108	.942	2050	0	513	505	1944	2114	909	11740	11627	1640	11177	1304	3547	1272	3458
109	.958	2056	0	5111	505	1976	1957	844	9605	9557	1455	9169	1151	3083	1148	3032
110	.978	2035	0	513	506	2004	1997	747	5727	5709	1360	5457	1163	2424	1140	2403
111	.888	1180	.805	445	503	1806	1771	949	12106	11994	1736	11526	1384	3458	1333	3363
112	.888	1183	.802	447	504	1805	1771	933	11697	11590	1680	11111	1334	3343	1292	3247
113																
111	.888	1180	.805	445	503	1806	1771	949	12106	11994	1736	11526	1384	3458	1333	3363
112	.888	1183	.802	447	504	1805	1771	933	11697	11590	1680	11111	1334	3343	1292	3247
113	.890	1191	.798	447	504	1812	1785	899	10695	10604	1550	10174	1210	3061	1194	2981
114	.891	1188	.803	448	506	1815	1794	832	8432	8383	1315	7981	1011	2420	1005	2382
115	.890	1194	.795	450	507	1810	1800	720	4578	4553	1010	9275	791	1585	798	1562
116	.585	775	.814	445	504	1197	1172	950	7955	7905	1750	7581	1382	2283	1347	2206
117	.585	774	.813	445	504	1195	1172	935	7702	7645	1700	7331	1327	2202	1307	2135
118	.585	776	.811	445	504	1195	1177	901	7050	6996	1560	6709	1209	2011	1199	1965
119	.580	769	.815	446	505	1189	1173	832	5529	5508	1323	5244	1013	1580	1015	1552
120	.585	778	.811	448	507	1198	1192	721	3068	1015	3048	2877	788	1045	801	1029
121	.596	486	1.22	384	498	1207	1187	946	8120	8080	1773	7741	1387	2321	1366	2236
122	.591	479	1.22	384	499	1200	1181	931	7891	7882	1707	7537	1332	2244	1317	2167
123	.582	468	1.24	382	500	1195	1179	899	7234	7165	1577	6863	1216	2049	1216	1987
124	.582	477	1.23	386	503	1199	1186	829	5650	5622	1300	5349	990	1583	992	1535
125	.579	482	1.21	391	506	1188	1072	714	2996	2970	867	2786	649	860	670	835
126	.427	478	.816	392	444	497	727	891	5449	5426	1770	5217	1396	1558	1373	1506
127	.427	482	.812	392	444	490	731	855	5137	5109	1627	4902	1290	1468	1255	1416
128	.370	498	.799	447	504	758	744	952	5010	4981	1763	4774	1412	1441	1354	1395
129	.368	485	.809	439	497	746	738	928	4905	4865	1685	4675	1340	1311	1297	1292
130	.370	503	.793	448	504	761	748	938	4843	4812	1703	4613	1346	1394	1309	1348
131	.371	495	.803	440	497	757	751	897	4514	4480	1570	4284	1232	1301	1207	1264
132	.370	498	.798	447	504	757	745	905	4442	4406	1573	4232	1226	1259	1212	1224
133	.428	480	.813	391	443	485	731	792	4368	4336	1393	4165	1069	1246	1067	1204
134	.376	502	.806	441	498	769	761	826	3566	3553	1324	3380	1016	1036	1016	1016
135	.370	501	.794	444	500	759	757	716	1936	1926	1010	1820	796	674	800	664
136	.267	298	.828	390	443	467	459	892	3395	3377	1790	3234	1417	973	1388	940
137	.269	306	.819	391	443	475	468	857	3210	3195	1653	3064	1312	920	1278	889
138	.267	298	.826	391	444	466	459	848	3141	3126	1613	2995	1273	897	1248	866
139	.229	307	.809	441	499	472	468	950	3112	3094	1793	2961	1406	897	1390	869
140	.230	314	.795	444	500	476	472	951	3128	3111	1800	2976	1409	903	1396	875
141	.227	302	.813	441	499	466	461	938	3039	3020	1750	2895	1363	870	1356	844
142	.227	308	.802	443	500	470	466	932	3000	2982	1730	2849	1358	864	1339	837
143	.223	301	.806	443	500	461	458	902	2761	2737	1620	2627	1261	789	1254	768
144	.267	301	.809	392	443	463	457	796	2734	2722	1413	2605	1096	778	1093	750
145	.226	309	.794	444	500	468	464	833	2176	2159	1355	2059	1040	629	1046	615
146	.229	320	.778	449	503	477	477	727	1204	1196	1060	1135	845	427	839	415
147	.132	179	.815	439	497	277	266	962	1945	1936	1860	1850	1503	549	1442	531
148	.148	188	.795	441	497	285	274	942	1882	1880	1767	1782	1422	529	1366	513
149	.138	195	.786	443	498	293	283	912	1762	1749	1647	1672	1319	502	1274	487
150	.138	198	.777	444	498	295	289	825	1301	1294	1327	1233	1044	379	1021	366
151	.135	192	.777	445	499	286	285	757	851	843	1173	804	919	270	922	266
152	.103	193	.388	483	498	214	207	968	1445	1442	1925	1370	1562	421	1506	408
153	.125	193	.430	479	497	219	212	946	1401	1397	1837	1340	1484	409	1432	396
154	.118	200	.422	481	498	226	219	913	1301	1289	1697	1237	1368	385	1324	373
155	.112	204	.475	476	498	238	233	868	1217	1211	1433	1161	1230	367	1197	357
156	.110	202	.370	487	500	222	219	819	913	906	1410	867	1155	300	1121	293

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TABLE I. - Continued. PERFORMANCE DATA

(a) Continued. Inlet guide vanes open.

Engine speed, N, rpm	Corrected engine speed, $\frac{N}{\sqrt{\theta_1}}$, rpm	Compressor-inlet tip Mach number, M_c	Engine air flow, $W_{a,1}$, lb/sec	Corrected air flow, $W_{a,1}\frac{\sqrt{\theta_1}}{\delta_1}$ lb/sec	Compressor pressure ratio, P_3/P_1	Compressor efficiency, η_c	Compressor-discharge pressure-loss ratio, $(P_3-P_4)/P_3$	Combustor pressure-loss ratio, $\frac{P_4-P_5}{P_4}$	Combustion efficiency, η_b	Combustion parameter, $\frac{P_4T_3}{V_b}\times 10^{-4}$	Combustion parameter, $W_{a,1}T_7\times 10^{-4}$	Turbine Reynolds number index, $\frac{\delta_5}{\phi_5\sqrt{\theta_5}}$	Corrected turbine speed, $\frac{N}{\sqrt{\theta_5}}$, rpm	Corrected turbine gas flow, $\frac{W_{g,5}\sqrt{\theta_5}}{\delta_5}\beta$, lb/sec	Turbine efficiency, η_t	Corrected turbine enthalpy drop, $\Delta H_t/\theta_5$, $\frac{Btu}{lb-sec}$	Turbine pressure ratio, P_5/P_6	Run
Exhaust-nozzle area, 2.694 sq ft																		
7955	8065	1.011	133.2	143.9	6.766	0.804	0.014	0.035	0.963	12.6	18.7	1.31	4314	42.8	0.879	32.3	3.233	106
7788	7895	.990	131.7	141.6	6.521	.810	.010	.036	.958	12.1	17.9	1.34	4289	42.8	.880	32.5	3.204	107
7420	7522	.943	125.6	134.8	6.039	.832	.001	.039	.959	10.9	16.0	1.33	4220	42.6	.884	32.0	3.152	108
6686	6778	.850	108.9	115.0	4.861	.845	.005	.041	.962	8.49	12.5	1.25	4034	42.2	.851	30.1	2.974	109
5498	5568	.698	68.1	71.1	2.858	.733	.003	.044	.988	4.84	7.76	.81	3426	42.8	.841	22.9	2.251	110
7953	8078	1.013	124.8	144.1	6.703	.804	.009	.039	.941	11.7	16.6	1.29	4399	42.3	.885	33.0	3.333	111
7786	7901	.991	122.8	141.8	6.480	.821	.009	.041	.957	11.1	15.9	1.28	4373	42.4	.877	33.0	3.323	112
7415	7525	.944	117.7	135.5	5.902	.836	.009	.041	.973	9.67	14.1	1.30	4332	42.5	.859	33.0	3.323	113
6678	6763	.848	101.0	116.2	4.646	.848	.006	.048	.998	7.04	10.2	1.22	4229	42.5	.864	32.0	3.298	114
5411	5475	.687	63.9	73.6	2.529	.722	.006	.057	1.016	3.29	5.09	.90	3913	43.5	.870	27.0	2.710	115
7949	8067	1.017	82.5	143.7	6.646	.802	.006	.041	.972	7.67	11.1	.84	4378	42.7	.880	33.0	3.321	116
7795	7910	.992	80.8	141.1	6.445	.814	.007	.041	.962	7.32	10.6	.84	4354	42.6	.877	33.0	3.329	117
7411	7521	.943	77.2	134.7	5.900	.832	.008	.041	.971	6.42	9.25	.86	4316	42.4	.865	33.0	3.337	118
6674	6766	.848	66.7	117.2	4.650	.846	.004	.048	1.006	4.60	6.77	.80	4213	42.9	.851	31.0	3.319	119
5445	5509	.691	42.3	73.9	2.561	.725	.007	.056	1.006	2.22	3.39	.60	3929	43.2	.863	28.0	2.753	120
7955	8121	1.018	82.9	142.4	6.727	.871	.005	.042	.984	7.97	11.3	.85	4352	42.4	.876	33.0	3.336	121
7794	7948	.997	82.3	142.2	6.576	.815	.001	.044	.990	7.64	10.8	.86	4346	42.3	.865	32.9	3.359	122
7441	7581	.951	78.4	136.2	6.054	.835	.010	.042	.981	6.33	9.53	.86	4313	42.4	.856	32.9	3.349	123
6686	6791	.852	67.7	117.7	4.712	.855	.005	.049	.992	4.73	6.71	.83	4255	41.7	.852	32.4	3.380	124
5470	5540	.695	43.1	75.8	2.522	.735	.009	.062	.995	2.07	2.84	.78	4253	41.7	.850	30.9	3.239	125
7964	8611	1.080	54.8	144.8	7.364	.758	.004	.039	.964	5.44	7.52	.57	4361	41.5	.856	32.7	3.349	126
7619	8238	1.033	54.1	142.4	6.914	.791	.006	.040	.967	4.89	6.78	.59	4348	41.6	.861	32.6	3.339	127
7953	8071	1.012	51.7	142.3	6.609	.796	.006	.042	.934	4.85	2.62	.52	4363	42.5	.886	33.0	3.313	128
7794	7964	.999	50.8	140.9	6.575	.814	.008	.039	.941	4.72	6.59	.54	4372	41.8	.834	33.2	3.566	129
7792	7907	.992	50.6	138.7	6.364	.802	.006	.041	.997	4.63	2.59	.53	4347	42.5	.884	33.0	3.309	130
7420	7582	.951	48.7	133.3	5.963	.820	.008	.044	.953	4.17	5.88	.54	4309	42.1	.873	33.0	3.293	131
7400	7510	.942	48.4	133.3	5.868	.818	.008	.040	.960	4.06	2.50	.53	4292	42.4	.854	33.0	3.361	132
6930	7501	.941	50.6	133.4	5.895	.835	.007	.039	.972	3.76	5.39	.60	4269	42.1	.859	32.2	3.342	133
6669	6809	.854	43.4	117.1	4.637	.831	.004	.049	1.006	2.94	4.41	.51	4207	43.4	.861	31.9	3.263	134
5428	5530	.693	24.9	68.1	2.551	.707	.005	.055	.866	1.51	1.99	.38	3928	40.1	.866	27.6	2.701	135
7964	8620	1.081	34.8	145.7	7.270	.748	.005	.042	.968	3.52	4.83	.35	4338	42.8	.863	32.4	3.323	136
7614	8241	1.033	34.3	141.2	6.758	.773	.005	.041	.982	3.01	4.38	.36	4313	42.6	.860	32.4	3.330	137
7506	8115	1.018	33.9	142.4	6.740	.793	.005	.042	.991	2.92	42.3	.36	4301	42.5	.851	32.2	3.339	138
7930	8087	1.014	31.8	139.8	6.593	.782	.006	.043	.973	3.05	4.42	.32	4317	42.7	.868	32.7	3.301	139
7905	8054	1.010	31.5	137.4	6.571	.782	.005	.043	.979	3.11	4.40	.32	4294	42.2	.869	32.6	3.296	140
7795	7949	.997	31.6	140.7	6.521	.797	.006	.041	.995	2.92	4.29	.32	4293	42.8	.861	32.6	3.328	141
7775	7922	.993	31.3	138.4	6.383	.801	.006	.045	.958	2.87	4.19	.32	4308	42.9	.869	32.4	3.297	142
7420	7560	.948	29.3	132.0	5.989	.824	.009	.040	.977	2.59	3.67	.32	4292	42.0	.853	32.1	3.330	143
6924	7494	.940	31.2	131.8	5.905	.826	.004	.043	.969	2.40	3.41	.37	4237	41.9	.832	32.1	3.348	144
6674	6800	.853	25.7	113.9	4.650	.821	.003	.051	.990	1.85	2.69	.31	4163	42.6	.845	31.7	3.273	145
5472	5558	.697	17.4	75.8	2.524	.678	.007	.054	.877	.83	1.46	.23	3867	46.0	.885	27.4	2.658	146
7970	8144	1.028	19.1	142.4	7.022	.786	.005	.044	.933	1.99	2.75	.19	4262	41.8	.861	33.0	3.369	147
7771	7941	.996	19.0	137.7	6.604	.791	.001	.052	.919	1.88	2.59	.19	4259	42.0	.863	33.0	3.368	148
7449	7605	.954	18.3	129.7	6.014	.797	.007	.044	.920	1.69	2.33	.20	4227	41.7	.857	32.0	3.331	149
6547	6684	.838	14.8	104.2	4.410	.800	.005	.047	.886	1.14	1.51	.19	4124	40.7	.855	31.0	3.253	150
5786	5900	.740	10.5	75.8	2.976	.704	.009	.046	.895	.69	.96	.14	3899	41.3	.836	29.0	2.978	151
7938	8104	1.016	14.3	138.6	6.752	.760	.002	.050	.935	1.47	2.15	.19	4176	42.4	.862	32.0	3.254	152
7714	7883	.989	14.1	133.1	6.397	.765	.003	.041	.916	1.41	2.02	.19	4149	41.8	.863	32.0	3.277	153
7369	7523	.943	13.8	126.9	5.757	.771	.009	.040	.935	1.21	1.83	.19	4118	43.2	.858	31.0	3.213	154
6915	7060	.885	13.8	119.8	5.113	.793	.005	.041	.929	1.08	1.65	.21	4202	42.4	.637	33.0	3.164	155
6348	6468	.811	10.5	98.3	4.113	.776	.008	.043	.872	.79	1.18	.12	3885	43.3	.846	29.0	2.890	156

TABLE I. - Continued. PERFORMANCE DATA

(a) Continued. Inlet guide vanes open.

Run	Compressor Reynolds number index, $\frac{\delta_1}{\varphi_1\sqrt{\theta_1}}$	Altitude-exhaust pressure, p_0, lb/sq ft	Flight Mach number, M_0	Equivalent ambient-air static temperature, t_0, °R	Engine-inlet total temperature, T_1, °R	Engine-inlet total pressure, P_1, lb/sq ft abs	Compressor-inlet total pressure, P_2, lb/sq ft abs	Compressor-outlet total temperature, T_3, °R	Compressor-outlet total pressure, P_3, lb/sq ft abs	Combustor-inlet total pressure, P_4, lb/sq ft abs	Turbine-inlet total temperature, T_5, °R	Turbine-inlet total pressure, P_5, lb/sq ft abs	Turbine-outlet total temperature, T_6, °R	Turbine-outlet total pressure, P_6, lb/sq ft abs	Tail-pipe total temperature, T_7, °R	Tail-pipe total pressure P_7, lb/sq ft abs
Exhaust-nozzle area, 3.688 sq ft																
157	1.051	2053	0	512	503	1933	1891	938	12378	12267	1573	11775	1193	3171	1174	2988
158	.941	2051	0	511	503	1937	1911	923	11852	11750	1523	11274	1145	2969	1139	2750
159	.959	2060	0	509	501	1957	1935	891	10992	10884	1427	10445	1062	2825	1064	2664
160	.970	2057	0	508	501	1976	1958	827	9010	8974	1260	8533	958	2514	945	2447
161	1.000	2057	0	502	500	2024	2017	734	5646	5615	1223	5352	1016	2239	999	2221
162	.992	2057	0	504	502	2025	2017	735	5628	5602	1223	5335	1019	2235	998	2215
163	.985	2051	0	505	504	2037	2035	666	3974	3964	1263	3794	1128	2150	1114	2140
164	.899	1191	.793	442	497	1802	1772	927	11491	11416	1550	10933	1171	2821	1158	2418
165	.899	1190	.795	441	497	1804	1776	914	11191	11121	1500	10651	1130	2753	1120	2360
166	.892	1178	.812	442	500	1816	1793	883	10370	10300	1385	9859	1031	2544	1026	2178
167	.920	1255	.786	450	505	1885	2049	887	9637	9566	1385	9138	1030	2581	1025	2213
168	.880	1201	.792	451	507	1815	1797	827	8001	7969	1170	7531	851	1942	853	1756
169	.911	1193	.798	438	494	1815	1807	705	5058	5027	863	4721	641	1432	649	1392
170	.653	794	..803	415	468	1213	1194	895	7945	7884	1557	7570	1181	1937	1167	1694
171	.647	788	.802	416	469	1203	1185	884	7730	7681	1503	7348	1133	1904	1122	1634
172	.635	786	.800	421	475	1198	1181	855	7032	6966	1373	6677	1026	1723	1022	1478
173	.607	786	.800	433	488	1197	1185	797	5529	5515	1153	5228	849	1349	852	1221
174	.602	796	.800	440	496	1213	1209	691	2852	2832	867	2661	667	908	673	891
175	.594	494	1.232	383	499	1208	1196	813	5403	5381	1160	5087	853	1314	856	1120
176	.585	483	1.239	384	502	1205	1192	813	5319	5299	1158	5009	850	1283	853	1091
177	.579	492	1.223	389	506	1201	1194	744	3697	3668	875	3444	626	879	640	790
178	.429	487	.807	395	446	747	732	881	5198	5162	1585	4943	1208	1274	1193	1093
179	.431	491	.804	395	446	751	736	862	5041	5014	1520	4799	1152	1238	1139	1062
180	.432	492	.804	395	446	753	739	828	4692	4661	1385	4461	1036	1141	1031	979
181	.437	489	.812	390	442	754	741	762	3913	3896	1177	3710	864	947	866	821
182	.434	491	.804	391	442	751	747	654	2368	2353	830	2208	612	621	621	599
183	.258	293	.821	396	449	456	435	---	----	----	----	----	1216	774	1201	664
184	.279	332	.780	406	455	496	488	---	----	----	----	----	1217	814	1202	704
185	.278	333	.777	405	454	496	490	---	----	----	----	----	1171	784	1158	677
186	.278	333	.781	405	454	498	492	---	----	----	----	----	1062	736	1056	635
187	.266	304	.802	394	445	464	441	---	----	----	----	----	877	576	879	506
188	.268	291	.830	386	439	457	447	---	----	----	----	----	641	401	650	386
189	.188	254	.705	703	468	354	349	---	----	----	----	----	1293	544	1273	477
190	.189	249	.719	728	469	351	348	---	----	----	----	----	1230	526	1212	461
191	.189	250	.719	720	470	349	346	---	----	----	----	----	1121	482	1109	423
192	.189	255	.693	706	472	352	349	---	----	----	----	----	905	405	903	372
193	.189	249	.719	722	472	348	346	---	----	----	----	----	793	453	797	411
194	.158	259	.399	417	467	289	289	---	----	----	----	----	1353	425	1329	383
195	.153	254	.388	404	465	282	280	---	----	----	----	----	1232	401	1214	367
196	.153	254	.377	403	464	280	278	---	----	----	----	----	1098	362	1086	333
197	.152	253	.381	396	463	280	278	---	----	----	----	----	929	316	924	305

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TABLE I. - Continued. PERFORMANCE DATA

(a) Concluded. Inlet guide vanes open.

Engine speed, N, rpm	Corrected engine speed, $\frac{N}{\sqrt{\theta_1}}$, rpm	Compressor-inlet tip Mach number, M_c	Engine air flow, $W_{a,1}$, lb/sec	Corrected air flow, $W_{a,1}\frac{\sqrt{\theta_1}}{\delta_1}$, lb/sec	Compressor pressure ratio, P_3/P_1	Compressor efficiency, η_c	Compressor-discharge pressure-loss ratio, $(P_3-P_4)/P_3$	Combustor pressure-loss ratio, $\frac{P_4-P_5}{P_4}$	Combustion efficiency, η_b	Combustion parameter, $\frac{P_4 T_3}{V_b}\times 10^{-4}$	Combustion parameter, $W_{a,1}T_7\times 10^{-4}$	Turbine Reynolds number index, $\frac{\delta_5}{\varphi_5\sqrt{\theta_5}}$	Corrected turbine speed, $\frac{N}{\sqrt{\theta_5}}$, rpm	Corrected turbine gas flow, $\frac{W_{g,5}\sqrt{\theta_5}}{\delta_5}\beta$, lb/sec	Turbine efficiency, η_t	Corrected turbine enthalpy drop, $\Delta H_t/\theta_5$, $\frac{Btu}{lb\text{-}sec}$	Turbine pressure ratio, P_5/P_6	Run
Exhaust-nozzle area, 3.688 sq ft																		
7949	8074	1.012	133.8	144.2	6.404	0.800	0.009	0.040	0.969	11.4	15.7	1.48	4610	42.1	0.880	35.9	3.713	157
7778	7900	.991	131.7	141.6	6.119	.802	.009	.041	.988	10.6	15.0	1.46	4586	42.5	.860	35.8	3.798	158
7411	7543	.946	127.4	135.3	5.617	.813	.010	.040	.988	9.41	13.6	1.44	4513	42.8	.874	35.3	3.697	159
6667	6786	.851	110.4	116.1	4.560	.830	.004	.049	.967	7.38	10.4	1.40	4307	42.7	.893	33.4	3.394	160
5489	5592	.701	70.7	72.5	2.790	.725	.005	.047	.983	4.51	7.06	.90	3599	43.0	.878	24.5	2.391	161
5492	5584	.700	72.5	73.5	2.779	.729	.005	.048	.979	4.44	7.14	.90	3601	43.6	.883	24.4	2.387	162
4593	4661	.584	48.2	49.4	1.951	.654	.003	.043	.961	3.30	5.37	.62	2965	42.1	.833	16.4	1.765	163
7926	8099	1.016	126.2	145.0	6.377	.798	.007	.042	.981	10.4	14.6	1.39	4627	42.4	.852	36.0	3.876	164
7790	7960	.998	124.3	142.7	6.203	.808	.007	.042	.965	10.1	13.9	1.41	4625	42.1	.852	36.0	3.868	165
7424	7564	.949	119.6	136.7	5.710	.836	.007	.043	.966	8.97	12.3	1.44	4582	41.9	.859	35.8	3.876	166
7411	7513	.942	122.7	136.0	5.112	.778	.007	.045	.995	7.55	12.6	1.33	4580	46.4	.912	35.7	3.541	167
6701	6780	.850	102.4	118.0	4.408	.829	.004	.055	1.001	6.28	8.73	1.34	4519	43.1	.877	35.7	3.877	168
5504	5642	.708	73.9	84.1	2.787	.796	.006	.061	1.000	3.46	4.79	1.18	4290	42.1	.871	31.4	3.297	169
7926	8347	1.047	89.0	147.4	6.550	.773	.008	.040	.998	6.92	10.4	.96	4619	43.3	.852	36	3.837	170
7797	8202	1.029	86.2	144.2	6.426	.788	.006	.043	.974	6.79	9.68	.96	4625	42.4	.854	35	3.860	171
7407	7742	.971	83.0	140.3	5.870	.817	.009	.042	.964	5.78	8.49	.97	4592	42.8	.848	35	3.874	172
6653	6861	.860	70.7	121.2	4.619	.863	.003	.052	.977	4.26	6.03	.95	4520	42.5	.844	35	3.876	173
5328	5450	.683	42.2	72.0	2.351	.702	.007	.060	.955	1.88	2.84	.66	4143	42.8	.858	29	2.931	174
6687	6819	.855	68.8	118.2	4.473	.864	.004	.055	1.032	4.26	5.89	.91	4530	42.6	.850	35.3	3.871	175
6653	6765	.848	67.5	116.5	4.414	.848	.004	.055	.994	4.21	5.75	.90	4511	42.5	.849	35.0	3.905	176
5843	5918	.742	52.4	91.2	3.078	.802	.008	.061	.913	2.60	3.35	.84	4522	41.3	.843	35.0	3.918	177
7956	8583	1.076	55.7	146.3	6.959	.754	.007	.042	.990	4.84	6.65	.62	4598	41.9	.836	35	3.880	178
7795	8409	1.054	55.5	145.0	6.712	.769	.005	.043	.982	4.58	6.32	.62	4599	42.1	.842	35	3.876	179
7420	8004	1.004	54.3	141.6	6.231	.797	.007	.043	.991	4.05	5.60	.65	4583	42.1	.842	36	3.909	180
6686	7245	.909	49.7	128.7	5.190	.827	.004	.048	1.004	3.09	4.30	.66	4499	42.6	.851	35.4	3.917	181
5492	5951	.746	35.0	90.9	3.153	.811	.006	.062	.958	1.60	2.17	.58	4362	41.8	.859	32.7	3.555	182
7956	8554	1.073	-----	-----	-----	-----	-----	-----	-----	-----	-----	----	----	----	-----	----	-----	183
7958	8499	1.066	-----	-----	-----	-----	-----	-----	-----	-----	-----	----	----	----	-----	----	-----	184
7776	8314	1.043	-----	-----	-----	-----	-----	-----	-----	-----	-----	----	----	----	-----	----	-----	185
7384	7895	.990	-----	-----	-----	-----	-----	-----	-----	-----	-----	----	----	----	-----	----	-----	186
6685	7219	.905	-----	-----	-----	-----	-----	-----	-----	-----	-----	----	----	----	-----	----	-----	187
5598	6087	.763	-----	-----	-----	-----	-----	-----	-----	-----	-----	----	----	----	-----	----	-----	188
7958	8380	1.051	-----	-----	-----	-----	-----	-----	-----	-----	-----	----	----	----	-----	----	-----	189
7786	8191	1.027	-----	-----	-----	-----	-----	-----	-----	-----	-----	----	----	----	-----	----	-----	190
7386	7762	.973	-----	-----	-----	-----	-----	-----	-----	-----	-----	----	----	----	-----	----	-----	191
6670	6995	.877	-----	-----	-----	-----	-----	-----	-----	-----	-----	----	----	----	-----	----	-----	192
6252	6556	.822	-----	-----	-----	-----	-----	-----	-----	-----	-----	----	----	----	-----	----	-----	193
8006	8440	1.058	-----	-----	-----	-----	-----	-----	-----	-----	-----	----	----	----	-----	----	-----	194
7640	8071	1.012	-----	-----	-----	-----	-----	-----	-----	-----	-----	----	----	----	-----	----	-----	195
7197	7612	.955	-----	-----	-----	-----	-----	-----	-----	-----	-----	----	----	----	-----	----	-----	196
6506	6888	.864	-----	-----	-----	-----	-----	-----	-----	-----	-----	----	----	----	-----	----	-----	197

TABLE I. - Continued. PERFORMANCE DATA

(b) Inlet guide vanes closed.

Run	Compressor Reynolds number index, $\frac{\delta_1}{\varphi_1\sqrt{\theta_1}}$	Altitude-exhaust pressure, p_0, lb/sq ft	Flight Mach number, M_0	Equivalent ambient-air static temperature, t_0, °R	Engine-inlet total temperature, T_1, °R	Engine-inlet total pressure, P_1, lb/sq ft abs	Compressor-inlet total pressure, P_2, lb/sq ft abs	Compressor-outlet total temperature, T_3, °R	Compressor-outlet total pressure, P_3, lb/sq ft abs	Combustor-inlet total pressure, P_4, lb/sq ft abs	Turbine-inlet total temperature, T_5, °R	Turbine-inlet total pressure, P_5, lb/sq ft abs	Turbine-outlet total temperature, T_6, °R	Turbine-outlet total pressure, P_6, lb/sq ft abs	Tail-pipe total temperature, T_7, °R	Tail-pipe total pressure, P_7, lb/sq ft abs
Exhaust-nozzle area, 2.388 sq ft																
1	0.950	2048	0	521	517	1997	1986	845	8285	8226	1507	7892	1252	2972	1246	2899
2	.949	2038	0	521	518	2000	1993	772	6575	6555	1340	6263	1114	2632	1108	2588
3	.949	2043	0	522	520	2020	2018	702	4848	4842	1240	4616	1102	2380	1070	2357
4	.950	2038	0	521	520	2028	2028	638	3527	3516	1263	3379	1151	2212	1135	2202
5	.951	2034	0	520	519	2027	2027	614	3135	3111	1253	3023	1184	2161	1170	2153
6	.861	1164	0.821	449	509	1811	1801	822	7157	7079	1347	6799	1054	2285	1056	2228
7	.861	1166	.813	450	509	1800	1792	783	6355	6324	1203	6015	938	2043	938	2000
8	.860	1153	.819	450	510	1789	1782	707	4564	4542	967	4275	765	1636	769	1597
9	.362	500	.796	456	514	759	755	837	3059	3033	1400	2912	1096	984	1102	958
10	.358	495	.794	455	512	750	746	793	2675	2667	1243	2535	978	866	972	845
11	.362	495	.803	455	514	757	754	754	2294	2281	1107	2160	875	769	873	752
12	.360	497	.797	455	513	755	753	712	1879	1873	990	1766	786	689	793	673
Exhaust-nozzle area, 2.514 sq ft																
13	0.948	2055	0	521	517	1995	1981	907	9295	9225	1767	8858	1432	3162	1421	3086
14	.950	2059	0	521	517	2000	2199	894	9147	9070	1727	8708	1387	3136	1385	3056
15	.952	2061	0	521	517	2005	1990	865	8691	8649	1620	8306	1303	3045	1304	2968
16	.953	2058	0	521	517	2008	1998	814	7717	7696	1450	7384	1182	2840	1185	2788
17	.963	2051	0	519	517	2027	2022	701	4901	4893	1250	4652	1105	2388	1078	2371
18	.400	491	0.802	418	472	750	745	858	3605	3587	1615	3436	1280	1104	1265	1073
19	.399	494	.802	420	474	754	748	845	3523	3504	1550	3359	1230	1079	1221	1050
20	.398	494	.800	423	477	753	748	814	3285	3264	1430	3129	1122	1010	1122	984
21	.387	496	.800	429	484	756	751	772	2903	2895	1243	2764	978	914	972	894
22	.375	498	.798	439	495	757	755	670	1737	1725	917	1623	739	651	742	638
Exhaust-nozzle area, 2.694 sq ft																
23	0.432	489	0.808	394	446	751	746	829	3644	3617	1515	3465	1182	1045	1170	1012
24	.432	499	.793	396	446	755	750	810	3511	3483	1450	3338	1129	1007	1119	973
25	.432	495	.796	396	446	751	746	776	3423	3402	1334	3261	1027	965	1025	934
26	.432	499	.790	396	446	753	749	721	2911	2900	1147	2761	872	862	876	839
27	.419	481	.804	396	447	736	734	647	2174	2172	910	2046	704	706	711	690
Exhaust-nozzle area, 3.688 sq ft																
28	0.954	2073	0	522	518	2021	2005	886	8605	8541	1455	8166	1138	2475	1120	2409
29	.960	2080	0	521	517	2027	2012	872	8460	8413	1420	8051	1106	2454	1089	2398
30	.959	2074	0	520	516	2022	2008	844	8092	8033	1340	7678	1049	2418	1035	2370
31	.964	2077	0	518	515	2030	2020	798	7273	7244	1240	6897	980	2357	968	2322
32	.972	2070	0	516	514	2039	2032	733	5825	5813	1150	5510	951	2260	941	2233
33	.407	487	0.809	412	466	749	742	834	3341	3315	1333	3158	990	796	986	723
34	.399	482	.815	415	470	745	740	820	3250	3232	1280	3083	944	771	943	704
35	.418	483	.815	403	457	747	742	775	3103	3080	1160	2944	850	742	850	685
36	.408	491	.812	413	467	757	753	724	2632	2621	970	2477	711	657	717	627
37	.408	494	.808	414	468	759	754	726	2643	2638	970	2487	709	659	715	630
38	.407	489	.813	412	467	755	751	688	2266	2257	867	2123	641	607	649	587

TABLE I. - Concluded. PERFORMANCE DATA

(b) Concluded. Inlet guide vanes closed.

Engine speed, N, rpm	Corrected engine speed, $\frac{N}{\sqrt{\theta_1}}$, rpm	Compressor-inlet tip Mach number, M_c	Engine air flow, $W_{a,1}$, lb/sec	Corrected air flow, $W_{a,1}\frac{\sqrt{\theta_1}}{\delta_1}$, lb/sec	Compressor pressure ratio, P_3/P_1	Compressor efficiency, η_c	Compressor-discharge pressure-loss ratio, $(P_3-P_4)/P_3$	Combustor pressure-loss ratio, $\frac{P_4-P_5}{P_4}$	Combustion efficiency, η_b	Combustion parameter, $\frac{P_4T_3}{V_b}\times 10^{-4}$	Combustion parameter, $W_{a,1}T_7\times 10^{-4}$	Turbine Reynolds number index, $\frac{\delta_5}{\varphi_5\sqrt{\theta_5}}$	Corrected turbine speed, $\frac{N}{\sqrt{\theta_5}}$, rpm	Corrected turbine gas flow, $\frac{W_{g,5}\sqrt{\theta_5}}{\delta_5}\beta$, lb/sec	Turbine efficiency, η_t	Corrected turbine enthalpy drop, $\Delta H_t/\theta_5$, $\frac{Btu}{lb\text{-}sec}$	Turbine pressure ratio, P_5/P_6	Run
Exhaust-nozzle area, 2.388 sq ft																		
7091	7104	0.891	91.7	97.0	4.149	0.785	0.007	0.041	0.980	7.47	11.4	1.02	4201	42.1	0.777	28.1	2.655	1
6019	6025	.756	77.4	81.8	3.288	.822	.003	.045	.968	5.62	8.58	.94	3812	42.0	.846	24.9	2.380	2
5015	5010	.628	59.5	62.4	2.400	.813	.001	.047	1.012	3.99	6.36	.76	3295	42.2	.846	19.0	1.939	3
4081	4077	.511	40.3	42.1	1.739	.754	.003	.039	.930	3.10	4.58	.62	2659	39.4	.958	14.4	1.528	4
3604	3604	.452	33.5	35.0	1.547	.726	.008	.028	.916	2.92	3.92	.50	2357	36.4	.783	9.8	1.399	5
7083	7152	.897	84.9	98.3	3.952	.778	.011	.040	.980	5.97	8.96	1.01	4474	42.8	.863	30.7	2.975	6
6538	6602	.828	78.7	91.7	3.531	.802	.005	.049	.956	5.14	7.38	1.03	4356	42.1	.868	29.8	2.944	7
5502	5550	.696	64.2	75.3	2.551	.791	.005	.059	.960	3.25	4.91	.93	4064	42.9	.875	26.2	2.613	8
7087	7121	.893	35.3	97.8	4.030	.772	.009	.040	.964	2.64	3.88	.42	4352	42.1	.857	30.4	2.959	9
6540	6585	.826	33.2	92.9	3.567	.792	.003	.050	.961	2.17	3.22	.42	4291	42.9	.869	29.7	2.927	10
5985	6014	.754	29.8	82.8	3.030	.795	.006	.053	1.008	1.77	2.60	.41	4145	42.4	.858	28.3	2.809	11
5447	5479	.687	25.5	71.0	2.489	.763	.003	.057	.933	1.39	2.02	.38	3979	41.8	.866	26.1	2.563	12
Exhaust-nozzle area, 2.514 sq ft																		
7945	7960	0.998	94.8	100.4	4.659	0.725	0.008	0.040	0.974	9.08	13.5	0.98	4354	42.3	0.860	28.6	2.801	13
7782	7797	.978	94.3	99.6	4.574	.740	.008	.040	.978	8.82	13.1	.98	4314	42.2	.878	28.3	2.777	14
7415	7429	.932	93.2	98.2	4.335	.768	.005	.040	.986	8.02	12.2	1.00	4240	42.3	.863	27.8	2.728	15
6670	6683	.838	87.5	92.1	3.843	.810	.003	.041	.994	6.85	10.4	1.02	4024	42.1	.832	26.2	2.600	16
5032	5042	.632	57.5	59.9	2.418	.804	.002	.049	1.048	4.21	6.20	.76	3293	40.7	.844	19.3	1.948	17
7945	8332	1.045	38.4	103.4	4.807	.689	.005	.042	.980	3.39	4.86	.42	4550	42.1	.860	30.9	3.112	18
7797	8158	1.023	38.5	103.2	4.672	.708	.004	.027	.993	3.23	4.70	.43	4555	26.9	.632	30.7	4.880	19
7415	7734	.970	37.1	99.9	4.363	.737	.006	.041	.975	2.91	4.16	.44	4507	41.7	.842	30.3	3.098	20
6735	6974	.875	35.6	96.2	3.840	.783	.003	.045	.987	2.38	3.46	.45	4384	42.2	.848	29.6	3.024	21
5146	5269	.661	24.0	65.6	2.295	.753	.007	.059	.864	1.25	1.78	.38	3898	41.2	.848	24.7	2.493	22
Exhaust-nozzle area, 2.694 sq ft																		
7949	8575	1.075	39.5	103.2	4.852	.661	.007	.042	.977	3.35	4.62	.45	4693	41.4	.853	32.6	3.316	23
7780	8393	1.052	39.0	101.4	4.650	.674	.008	.042	.963	3.15	4.37	.46	4703	41.5	.849	32.3	3.315	24
7409	7992	1.002	40.2	105.0	4.558	.732	.006	.042	.979	2.91	4.12	.51	4659	41.8	.838	31.8	3.380	25
6670	7195	.902	37.0	96.3	3.866	.763	.004	.048	.992	2.30	3.24	.50	4544	42.0	.869	31.1	3.203	26
5532	5961	.748	30.7	81.8	2.954	.809	.001	.072	.948	1.56	2.18	.48	4207	52.6	-----	28.3	2.289	27
Exhaust-nozzle area, 3.688 sq ft																		
7943	7951	0.997	98.4	102.9	4.258	0.715	0.007	0.044	1.002	7.51	11.0	1.12	4787	42.8	0.857	32.7	3.299	28
7777	7792	.977	98.0	102.1	4.174	.727	.006	.043	.986	7.31	10.7	1.13	4743	42.7	.870	32.3	3.281	29
4403	7425	.931	96.2	100.3	4.002	.760	.007	.044	.995	6.79	9.95	1.14	4639	42.6	.861	31.6	3.176	30
6663	6689	.839	90.2	93.6	3.583	.797	.004	.048	.977	5.89	8.73	1.13	4340	42.8	.875	29.3	2.927	31
5723	5751	.721	75.3	77.8	2.857	.817	.002	.052	.983	4.54	7.09	1.00	3893	42.9	.847	24.7	2.438	32
7964	8404	1.054	39.3	105.1	4.461	.672	.008	.047	.979	2.83	3.87	.48	5053	42.3	.846	36.3	3.967	33
7793	8189	1.027	39.0	105.3	4.362	.698	.006	.046	.985	2.71	3.67	.49	5041	42.1	.846	35.8	3.998	34
7424	7912	.992	39.0	103.6	4.154	.719	.007	.044	.966	2.46	3.31	.53	5030	41.8	.853	35.6	3.968	35
6598	6956	.872	36.2	96.1	3.477	.777	.004	.055	.922	1.92	2.60	.54	4862	41.9	.844	34.1	3.771	36
6534	6881	.863	36.3	96.1	3.482	.774	.002	.057	.969	1.94	2.60	.54	4815	41.9	.850	34.2	3.774	37
5937	6259	.785	33.4	88.8	3.001	.777	.004	.059	.938	1.54	2.17	.53	4620	42.5	.849	32.7	3.498	38

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TABLE II. - PERFORMANCE DATA OBTAINED AFTER ENGINE OVERHAUL WITH COLD INLET-AIR TEMPERATURES

[Inlet guide vanes open.]

Run	Compressor Reynolds number index, $\frac{\delta_1}{\varphi_1\sqrt{\theta_1}}$	Altitude-exhaust pressure, p_0, lb/sq ft	Flight Mach number, M_0	Equivalent ambient-air static temperature, t_0, °R	Engine-inlet total temperature, T_1, °R	Engine-inlet total pressure, P_1, $\frac{lb}{sq\ ft\ abs}$	Compressor-outlet total temperature, T_3, °R	Compressor-outlet total pressure, P_3, $\frac{lb}{sq\ ft\ abs}$	Turbine-inlet total temperature, T_5, °R	Turbine-inlet total pressure, P_5, $\frac{lb}{sq\ ft\ abs}$	Turbine-outlet total temperature, T_6, °R	Turbine-outlet total pressure, P_6, $\frac{lb}{sq\ ft\ abs}$	Tail-pipe total temperature, T_7, °R	Tail-pipe total pressure, P_7, $\frac{lb}{sq\ ft\ abs}$
Exhaust-nozzle area, 2.388 sq ft														
1	0.470	475	0.821	358	406	739	865	6163	2010	5919	1610	2046	1615	1991
2	.475	478	.819	366	415	742	873	6046	2018	5810	1612	2009	1617	1955
3	.453	484	.813	383	434	747	891	5920	1987	5672	1621	1947	1600	1909
4	.480	481	.819	363	412	747	848	----	----	----	1533	----	----	----
5	.442	481	.820	385	437	748	874	5730	1913	5501	1547	1880	1529	1837
6	.489	485	.813	360	408	749	827	----	----	----	1466	----	----	----
7	.436	482	.815	388	440	745	847	5347	1800	5136	1442	1754	1437	1716
8	.489	483	.824	357	406	754	802	5580	1753	5390	1392	1845	1400	1796
9	.488	480	.817	362	410	744	776	5067	1617	4867	1263	1666	1285	1626
10	.439	492	.799	390	440	749	772	4136	1455	3951	1148	1356	1154	1322
11	.418	478	.809	399	451	735	667	1961	1083	1860	858	736	871	719
12	.340	291	.826	328	373	455	829	4032	2007	3873	1618	1329	1607	1296
13	.344	298	.819	324	367	461	805	3926	1920	3781	1548	1299	1540	1269
14	.334	303	.803	322	364	463	781	3968	1837	3814	1472	1262	1466	1234
15	.338	293	.813	325	368	452	764	3617	1737	3487	1386	1186	1386	1158
16	.341	298	.804	330	373	456	730	3375	1587	3262	1262	1108	1266	1078
17	.267	297	.797	391	441	451	899	3606	2017	3467	1693	1182	1621	1153
18	.261	287	.822	389	442	447	890	3547	1975	3411	1605	1165	1580	1139
19	.276	299	.809	388	439	460	842	3243	1780	3104	1438	1056	1422	1031
20	.274	311	.792	393	442	470	784	2597	1497	2474	1192	837	1189	817
21	.271	308	.793	396	446	466	645	1068	1070	1028	859	422	872	413
22	.206	181	.829	337	383	284	843	2467	2037	2369	1651	814	1640	791
23	.205	182	.820	338	384	283	808	2340	1890	2252	1539	769	1520	752
24	.215	194	.794	340	383	294	788	2267	1797	2184	1460	737	1437	720
25	.212	190	.806	339	383	291	747	2075	1620	2001	1310	681	1294	665
26	.163	175	.841	387	442	278	911	2280	2067	2189	1690	738	1660	722
27	.166	177	.837	389	444	280	890	2192	1975	2108	1606	715	1584	696
28	.156	178	.832	394	448	280	860	2008	1833	1930	1484	652	1466	636
29	.160	186	.802	413	464	284	799	1482	1510	1426	1218	485	1209	470
30	.160	194	.784	411	461	291	701	773	1227	740	978	288	998	280
31	.161	197	.409	370	382	221	832	1766	1990	1708	1653	579	1597	563
32	.156	189	.417	369	382	213	783	1644	1797	1593	1486	543	1438	527
33	.160	197	.409	370	382	221	808	1562	1737	1508	1372	518	1358	504
34	.128	192	.438	425	441	219	901	1661	2037	1596	1686	545	1639	531
35	.127	188	.466	424	442	218	865	1549	1883	1489	1544	504	1512	490
36	.133	198	.438	429	445	226	786	1176	1550	1138	1274	398	1257	387
37	.127	196	.434	432	448	223	712	601	1510	572	1251	247	1273	243
Exhaust-nozzle area, 2.514 sq ft														
38	0.180	185	0.800	369	416	282	866	2289	1897	2209	1487	707	1502	684
39	.177	179	.823	366	415	279	855	2234	1860	2132	1460	677	1469	664
40	.178	183	.808	367	415	281	814	1975	1697	1891	1328	542	1332	517
41	.178	184	.802	368	415	281	743	1657	1385	1564	1111	510	1082	490
42	.178	183	.804	367	414	280	671	1187	1140	1119	904	371	885	359
43	.154	190	.792	419	471	287	931	2173	1990	2092	1586	686	1583	666
44	----	186	.799	---	---	283	---	2082	----	1995	1572	659	----	639
45	.168	201	.736	402	446	288	856	1889	1757	1803	1419	589	1386	571
46	.168	197	.768	406	454	291	800	1545	1500	1484	1191	489	1191	474
47	.141	198	.415	399	413	223	873	----	1953	----	1554	---	1548	---
48	.142	198	.431	398	413	225	852	1709	1867	1653	1517	532	1482	507
49	.140	193	.444	397	413	221	819	1599	1740	1558	1394	505	1379	486
50	.137	188	.450	397	413	216	761	1381	1523	1346	1230	440	1211	424
51	.134	186	.453	399	415	214	697	1031	1297	1004	1041	339	1029	327
Exhaust-nozzle area, 2.694 sq ft														
52	0.180	174	0.843	355	405	277	851	2305	1817	2211	1403	676	1422	651
53	.179	175	.838	356	406	277	833	2212	1737	2127	1330	646	1357	622
54	.180	180	.824	361	410	281	796	2035	1579	1945	1228	591	1229	564
55	.172	173	.831	364	414	272	738	1664	1337	1590	1044	487	1036	457
56	.170	180	.810	376	425	277	644	856	995	825	795	216	779	207
57	.143	198	.408	392	405	222	854	1741	1825	1666	1426	502	1428	480

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TABLE II. - Concluded. PERFORMANCE DATA OBTAINED AFTER ENGINE OVERHAUL WITH COLD INLET-AIR TEMPERATURES

[Inlet guide vanes open.]

Engine speed, N, rpm	Corrected engine speed, $N/\sqrt{\theta_1}$, rpm	Compressor-inlet tip Mach number, M_c	Engine air flow, $W_{a,1}$, lb/sec	Corrected air flow, $W_{a,1}\frac{\sqrt{\theta_1}}{\delta_1}$, lb/sec	Compressor pressure ratio, P_3/P_1	Compressor efficiency, η_c	Compressor-discharge and combustor pressure-loss ratio, $\frac{P_3-P_5}{P_3}$	Combustion efficiency, η_b	Combustion parameter, $\frac{P_4T_3}{V_b}\times 10^{-4}$	Combustion parameter, $W_{a,1}T_7\times 10^{-4}$	Turbine Reynolds number index, $\frac{\delta_5}{\varphi_5\sqrt{\theta_5}}$	Corrected turbine speed, $\frac{N}{\sqrt{\theta_5}}$, rpm	Corrected turbine gas flow, $\frac{W_{g,5}\sqrt{\theta_5}}{\delta_5}\beta$, lb/sec	Turbine efficiency, η_t	Corrected turbine enthalpy drop, $\Delta H_t/\theta_5$, $\frac{Btu}{lb\text{-}sec}$	Turbine pressure ratio, P_5/P_6	Run
Exhaust-nozzle area, 2.388 sq ft																	
7975	9016	1.131	59.7	151.1	8.340	0.734	0.040	0.933	6.44	9.64	0.56	4108	42.8	0.862	30	2.893	1
7958	8900	1.116	58.8	149.8	8.148	.740	.039	.982	6.30	9.50	.55	4091	43.0	.874	29	2.892	2
7943	8687	1.089	57.3	148.4	7.925	.761	.042	.981	6.19	9.17	.55	4113	42.6	.850	29	2.913	3
7763	8713	1.093	59.6	150.4	-----	-----	-----	1.025	----	9.16	----	----	----	-----	--	-----	4
7748	8444	1.059	56.8	147.4	7.660	.785	.040	.978	5.85	8.68	.55	4089	42.6	.864	30	2.926	5
7589	8560	1.073	58.3	146.1	-----	-----	-----	1.001	----	8.56	----	----	----	-----	--	-----	6
7424	8063	1.011	54.8	143.3	7.177	.814	.040	.995	5.28	7.87	.55	4034	42.6	.859	29	2.928	7
7363	8324	1.044	57.9	143.6	7.401	.789	.034	1.009	5.45	8.10	.59	4053	42.3	.854	29	2.921	8
6992	7867	.987	55.4	140.1	6.810	.815	.040	.998	4.69	7.12	.58	4002	42.9	.857	29	2.921	9
6547	7110	.892	47.1	122.6	5.522	.834	.045	.971	3.67	5.44	.54	3945	42.5	.851	29	2.914	10
5267	5650	.709	24.8	66.4	2.688	.676	.052	.914	1.57	2.16	.36	3686	40.5	.875	26	2.527	11
7941	9367	1.175	38.2	150.8	8.862	.706	.039	.961	4.30	6.15	.37	4097	41.9	.868	29	2.915	12
7773	9244	1.159	38.8	149.8	8.516	.706	.037	.979	4.02	5.98	.38	4092	42.5	.858	29	2.910	13
7589	9063	1.137	38.7	147.9	8.570	.739	.039	.972	4.12	5.67	.40	4082	41.0	.840	29	3.022	14
7362	8742	1.096	37.5	147.8	8.002	.754	.036	.984	3.64	5.20	.39	4069	42.2	.852	29	2.940	15
6998	8254	1.035	36.1	142.0	7.401	.806	.034	.945	3.19	4.57	.40	4040	41.3	.838	28	2.944	16
7947	8621	1.081	33.8	146.3	7.996	.775	.039	.956	3.89	5.48	.33	4085	41.5	.853	29	2.933	17
7835	8490	1.065	33.6	146.9	7.935	.790	.038	.935	3.79	5.31	.33	4070	41.5	.867	29	2.928	18
7365	8008	1.004	33.0	139.7	7.050	.809	.043	.956	3.22	4.70	.34	4025	42.2	.852	29	2.939	19
6619	7173	.899	29.0	120.5	5.526	.812	.047	.960	2.36	3.45	.33	3936	42.4	.840	29	2.956	20
5038	5435	.682	14.0	59.0	2.292	.598	.038	.819	.82	1.22	.20	3548	41.3	.857	24	2.436	21
7877	9169	1.150	22.9	146.5	8.687	.709	.040	.932	2.69	3.75	.22	4032	41.3	.856	29	2.910	22
7608	8844	1.109	23.2	149.4	8.269	.748	.038	.937	2.39	3.53	.23	4037	43.5	.843	29	2.928	23
7405	8619	1.081	22.9	141.4	7.711	.749	.037	.947	2.270	3.29	.23	4029	41.9	.845	29	2.963	24
6935	8072	1.012	22.3	139.3	7.131	.793	.036	.937	1.96	2.88	.24	3967	42.1	.839	29	2.939	25
7990	8658	1.086	20.7	145.1	8.201	.771	.040	.907	2.55	3.43	.20	4063	40.7	.853	30	2.966	26
7748	8377	1.050	20.3	141.7	7.829	.791	.038	.911	2.40	3.21	.20	4025	40.5	.853	29	2.948	27
7358	7919	.993	19.3	135.7	7.171	.816	.039	.903	2.11	2.83	.20	3963	40.4	.846	29	2.960	28
6542	6919	.868	15.7	110.3	5.218	.832	.038	.892	1.42	1.89	.20	3870	39.9	.820	28	2.940	29
5502	5838	.732	8.9	60.8	2.656	.621	.043	.718	1.68	.89	.12	3634	39.2	.837	25	2.569	30
7651	8918	1.118	17.1	140.4	7.991	.686	.033	.903	1.85	2.73	.16	3960	43.6	.856	29	2.950	31
7256	8458	1.061	16.3	138.8	7.718	.754	.031	.932	1.68	2.34	.18	3946	42.0	.851	29	2.933	32
6988	8145	1.021	16.1	132.6	7.068	.671	.035	.976	1.53	2.19	.17	3862	43.0	.926	31	2.911	33
7814	8477	1.063	15.8	140.9	7.584	.747	.039	.935	1.76	2.59	.15	3998	42.4	.854	29	2.928	34
7435	8057	1.010	14.9	133.4	7.106	.780	.039	.891	1.63	2.25	.15	3952	41.0	.843	29	2.954	35
6536	7058	.885	12.5	108.4	5.204	.784	.032	.901	1.12	2.83	.15	3820	40.5	.799	27	2.860	36
5453	5869	.736	5.7	49.9	2.695	.556	.048	.719	.65	.72	.07	3229	36.2	.812	22	2.316	37
Exhaust-nozzle area, 2.514 sq ft																	
7924	8851	1.110	21.9	146.9	8.117	0.753	0.035	0.902	2.42	3.28	0.22	4196	40.8	0.851	31	3.124	38
7835	8762	1.099	22.0	148.3	8.007	.762	.046	.911	2.30	3.23	.22	4192	41.9	.850	31	3.150	39
7403	8279	1.038	21.5	144.4	7.028	.773	.043	.951	1.84	2.86	.22	4139	43.9	-----	30	3.489	40
6549	7324	.918	18.1	122.1	5.897	.834	.056	.876	1.53	1.96	.18	4041	40.2	.857	30	3.067	41
5752	6440	.808	15.2	102.5	4.239	.823	.057	.831	.94	1.34	.20	3929	42.6	.862	29	3.017	42
7930	8325	1.044	20.4	142.9	7.571	.795	.037	.913	2.35	3.22	.20	4106	41.1	.858	30	3.050	43
7756	----	-----	----	-----	7.357	-----	.030	-----	----	----	----	----	----	-----	--	3.028	44
7373	7954	.997	19.9	135.5	6.559	.769	.031	.963	1.82	2.76	.20	4052	43.5	.861	30	3.061	45
6636	7095	.890	17.1	116.5	5.309	.800	.031	.939	1.41	2.04	.20	3939	41.8	.825	29	3.035	46
7964	8927	1.119	17.0	143.5	-----	-----	-----	.946	----	2.62	----	4163	----	-----	30	-----	47
7765	8704	1.091	16.6	139.3	7.596	.735	.033	.924	1.78	2.46	.17	4147	40.9	.844	30	3.108	48
7420	8317	1.043	16.0	136.6	7.235	.772	.026	.907	1.62	2.21	.17	4098	40.3	.843	30	3.085	49
6721	7534	.945	14.9	129.8	6.394	.830	.025	.938	1.30	1.80	.18	3962	40.3	.817	29	3.059	50
5953	6657	.835	12.0	105.9	4.818	.836	.026	.863	.90	1.23	.16	3793	39.6	.824	28	3.962	51
Exhaust-nozzle area, 2.694 sq ft																	
7952	9003	1.129	22.4	151.0	8.321	.751	.041	.902	2.40	3.18	.23	4301	40.7	.850	32	3.271	52
7780	8796	1.103	22.7	153.5	7.986	.766	.038	.949	2.18	3.08	.24	4299	41.9	.845	32	3.293	53
7369	8291	1.040	22.0	147.1	7.242	.807	.044	.939	1.91	2.70	.25	4265	42.1	.840	31	3.291	54
6585	7373	.925	18.9	131.0	6.118	.867	.045	.959	1.49	1.95	.24	4135	40.4	.837	31	3.265	55
5388	5954	.747	11.1	77.0	3.090	.738	.036	.562	.67	.87	.18	3930	39.8	-----	28	3.820	56
7924	8971	1.125	17.1	143.8	7.842	.719	.043	.925	1.80	2.44	.18	4276	41.3	.842	32	3.319	57

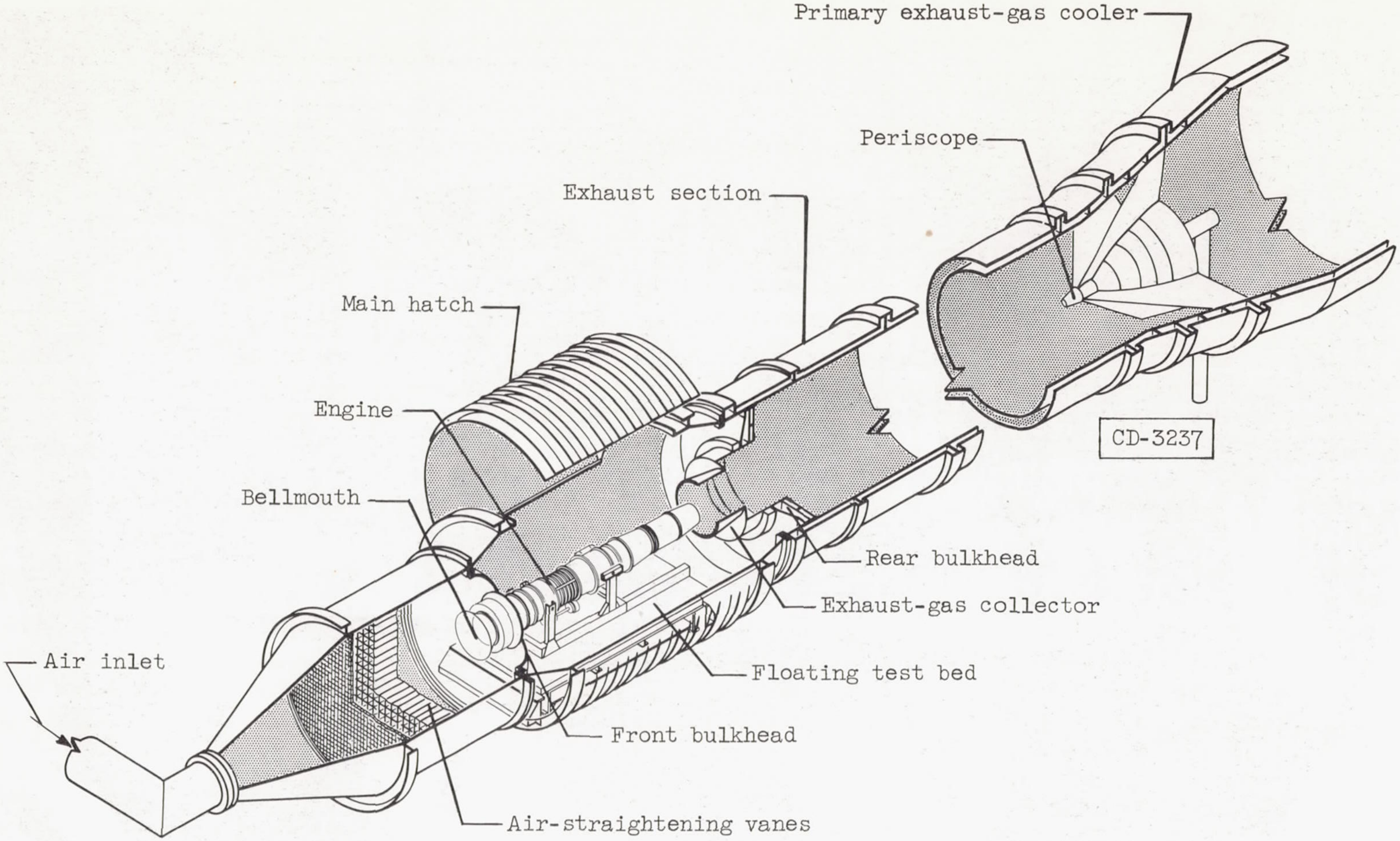

Figure 1. - Schematic diagram of altitude test chamber.

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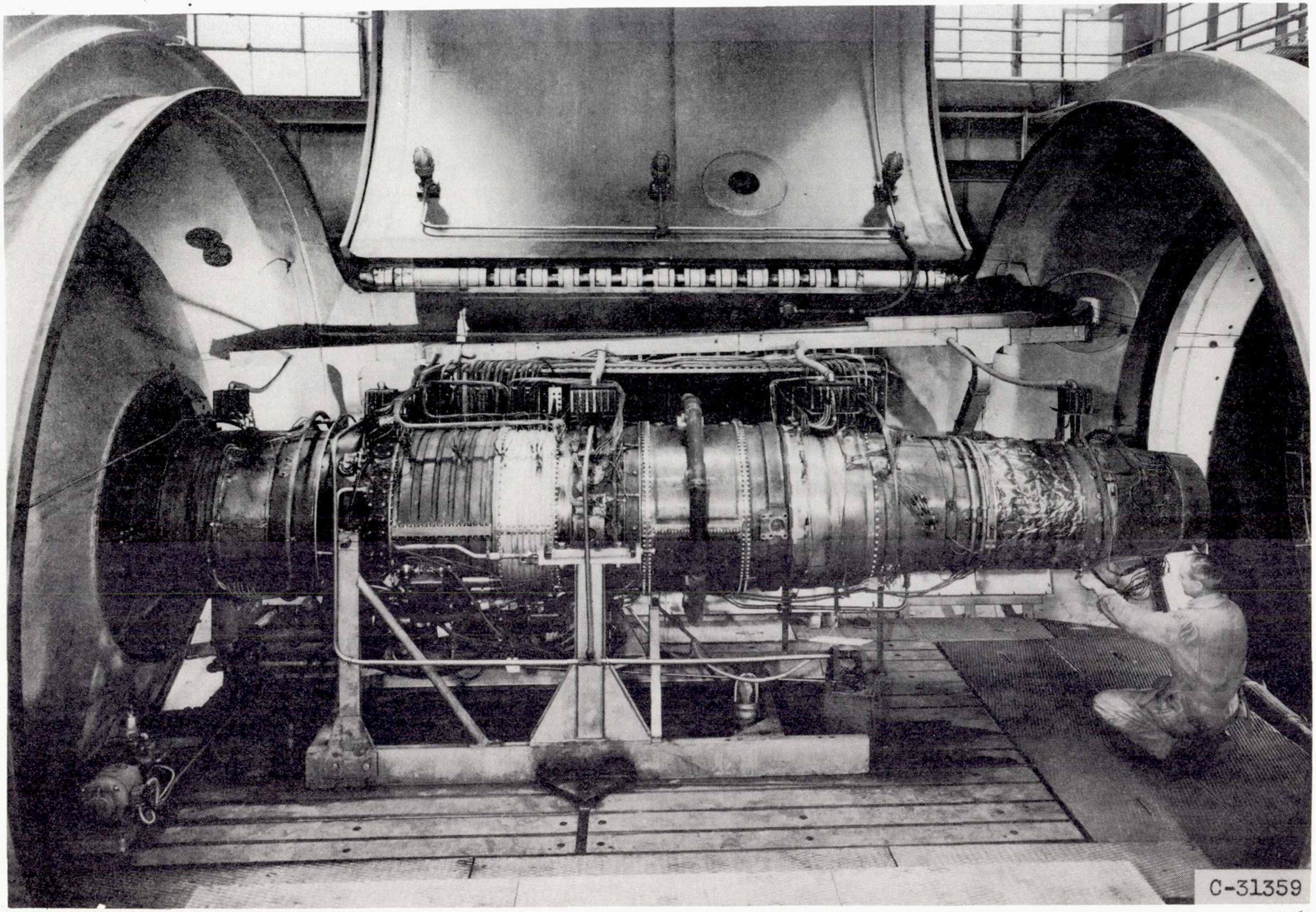

Figure 2. - Installation of YJ73-GE-3 turbojet engine in altitude test chamber.

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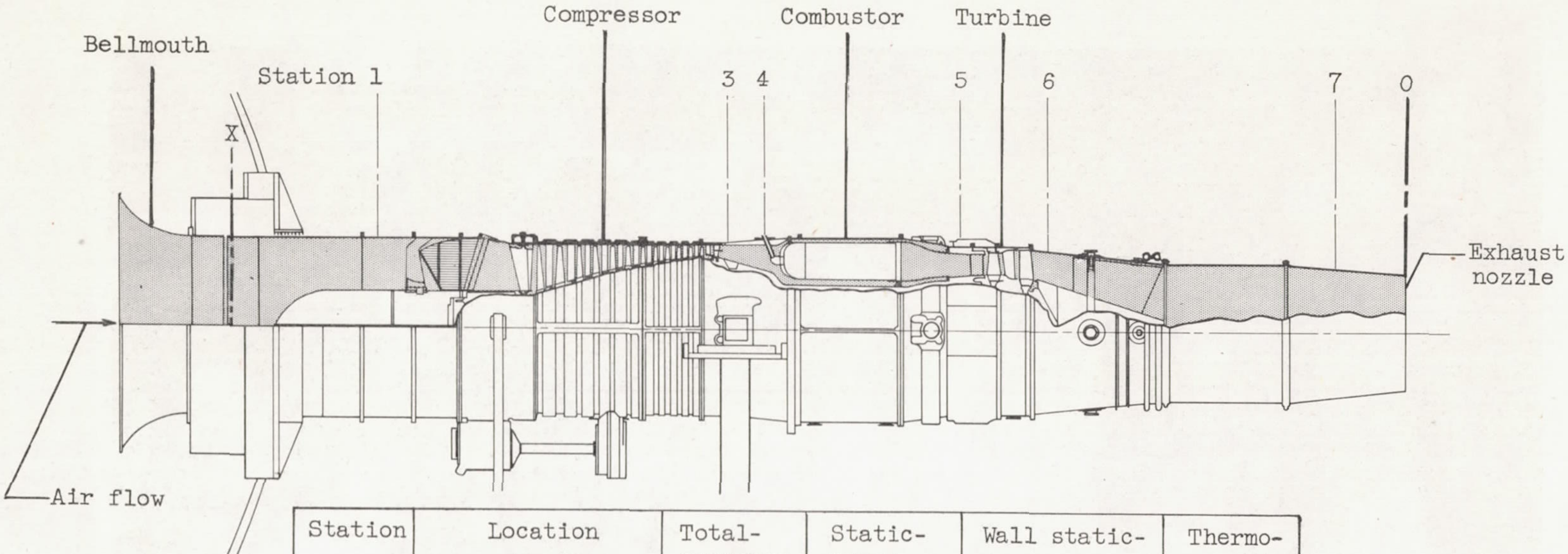

Station	Location	Total-pressure tubes	Static-pressure tubes	Wall static-pressure orifices	Thermo-couples
X	Inlet duct	0	0	4	0
1	Engine inlet	36	16	4	16
3	Compressor outlet	20	4	5	6
4	Combustor inlet	5	0	0	0
5	Turbine inlet	9	0	0	0
6	Turbine outlet	24	0	8	20
7	Exhaust nozzle	28	16	4	20
0	Altitude chamber	0	4	0	0

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Figure 3. - Cross section of YJ73-GE-3 turbojet engine showing location of instrumentation.

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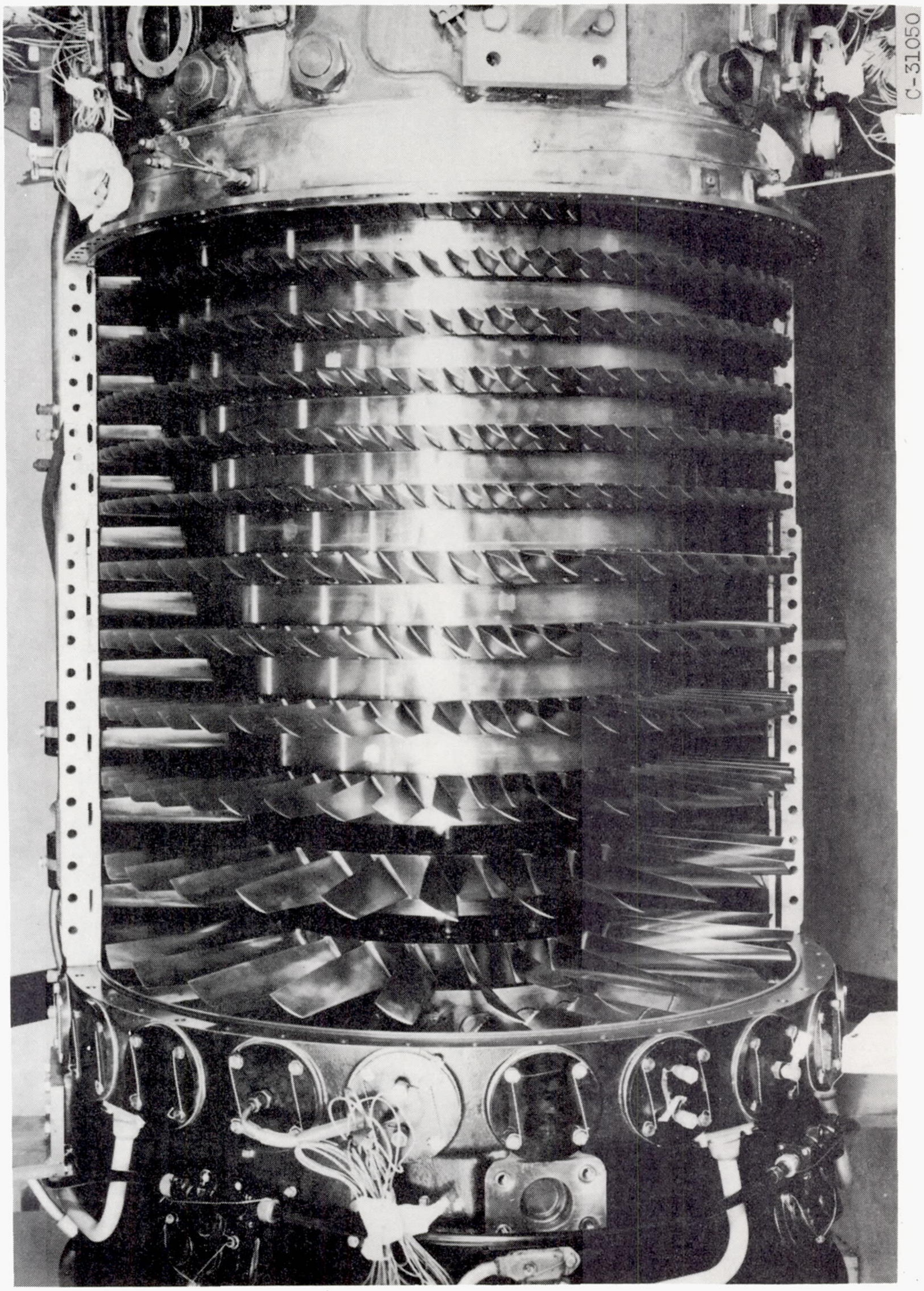

(a) Compressor rotor.

Figure 4. - Components of YJ73-GE-3 engine.

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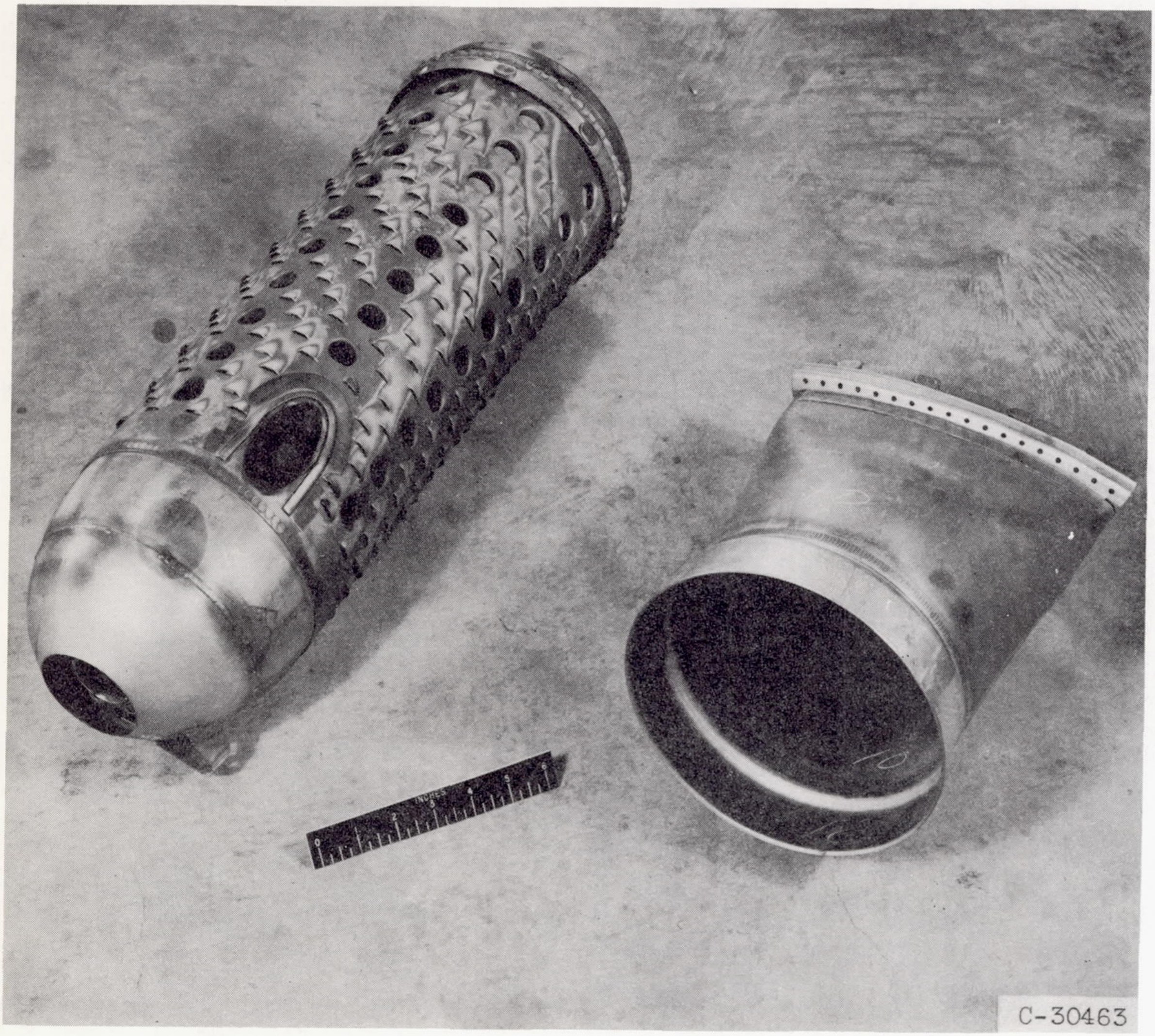

(b) Combustor liner and transition section.

Figure 4. - Continued. Components of YJ73-GE-3 engine.

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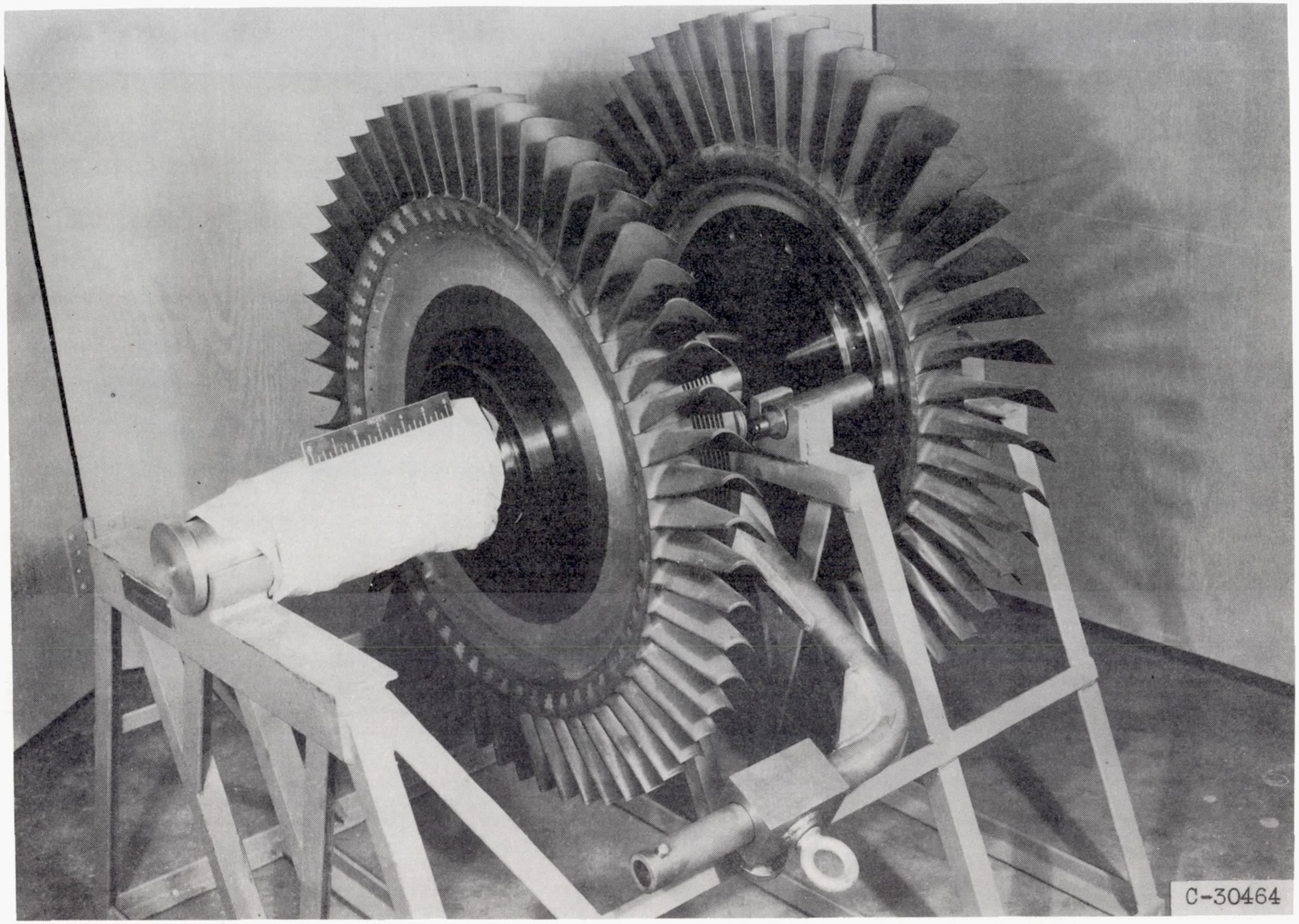

(c) Turbine rotor.

Figure 4. - Concluded. Components of YJ73-GE-3 engine.

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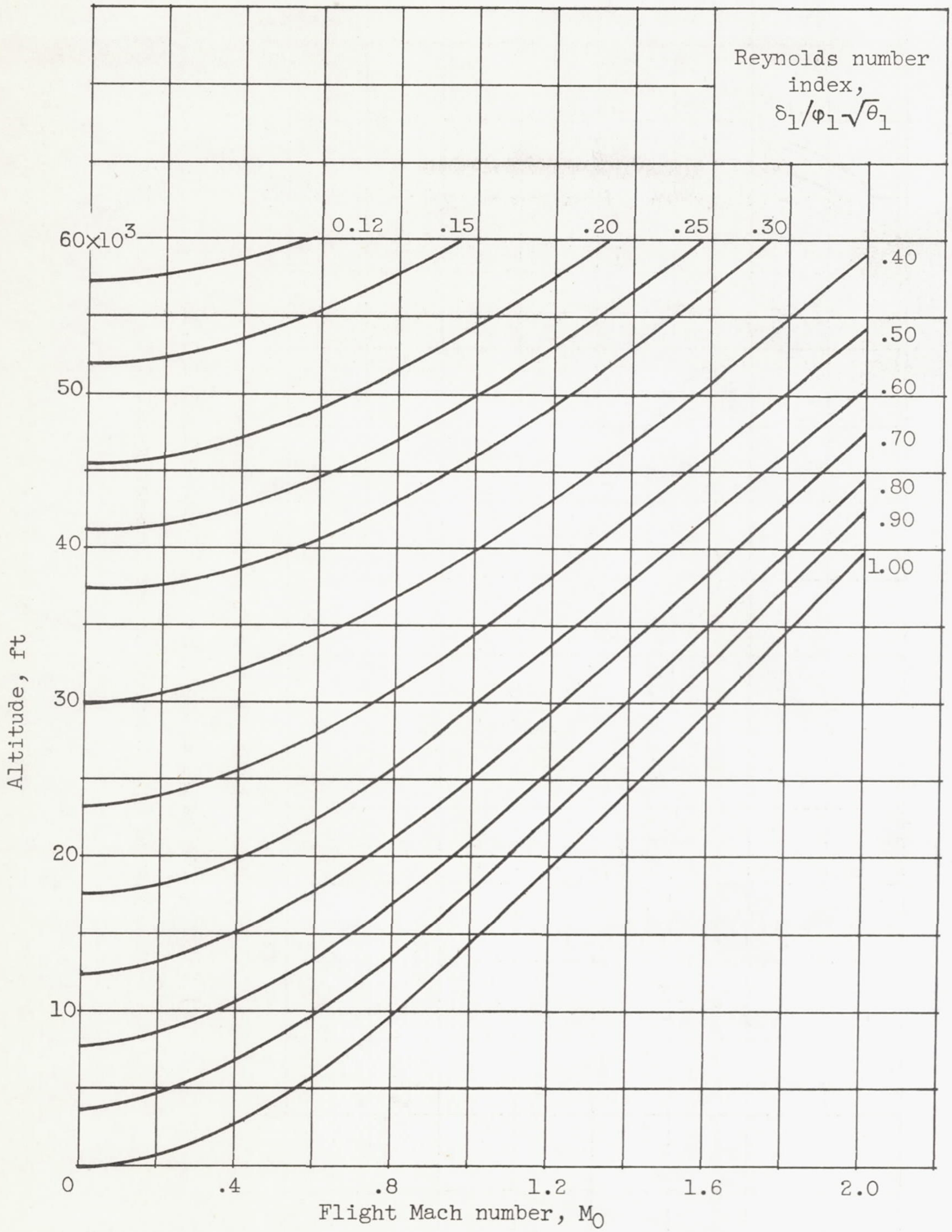

Figure 5. - Variation of Reynolds number index with altitude and flight Mach number at standard NACA conditions.

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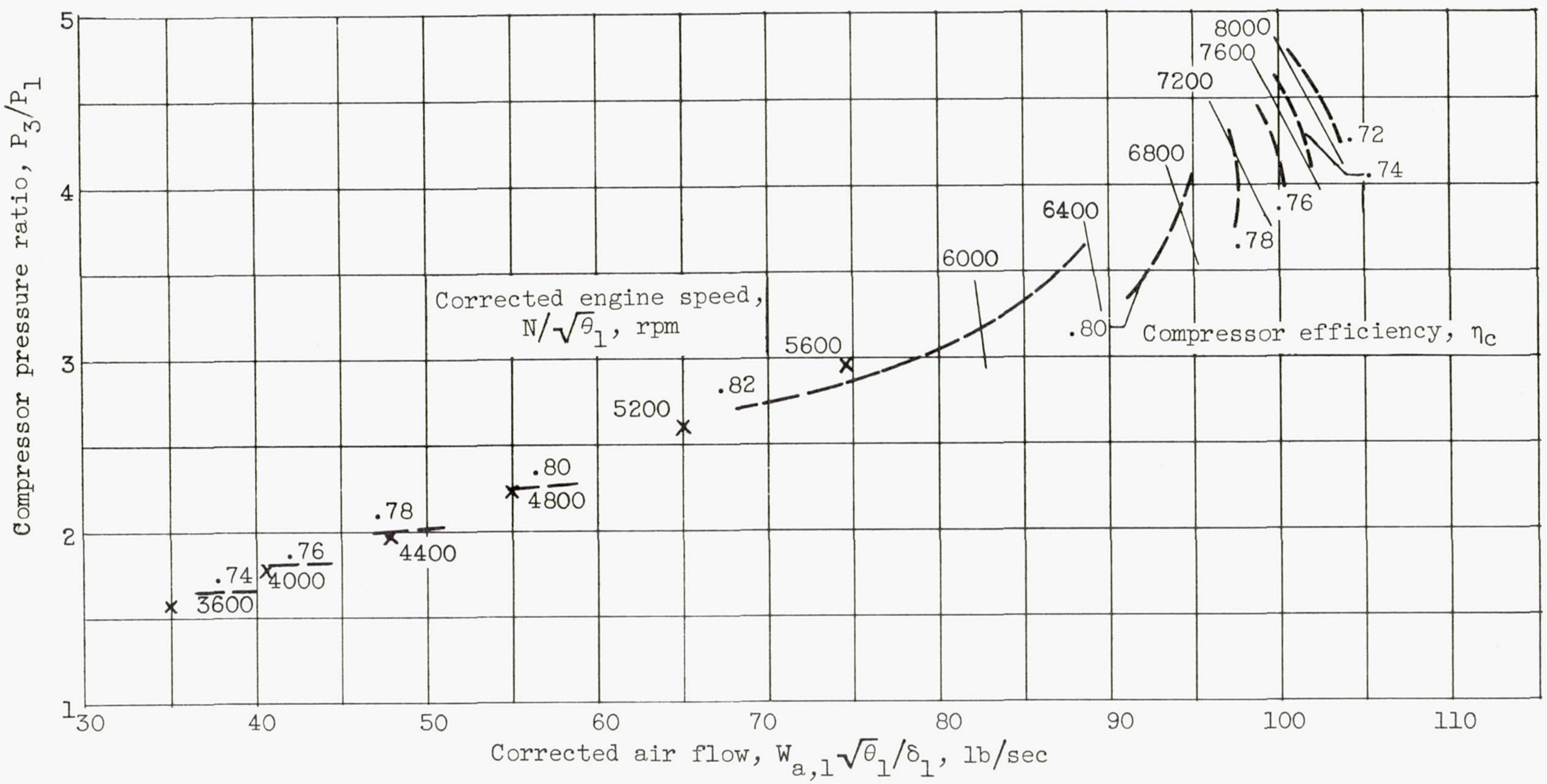

(a) Inlet guide vanes closed; Reynolds number index, 0.96.

Figure 6. - Compressor performance maps.

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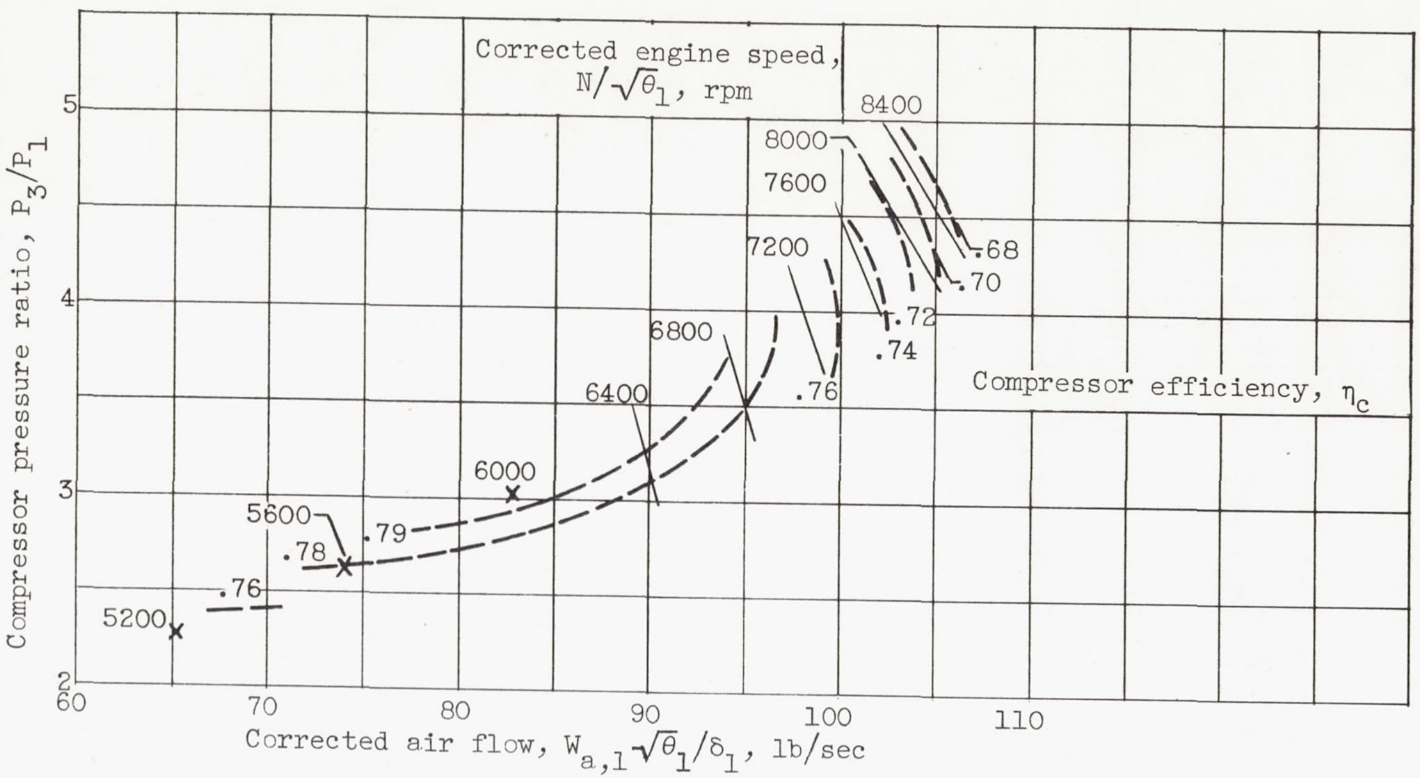

(b) Inlet guide vanes closed; Reynolds number index, 0.40.

Figure 6. - Continued. Compressor performance maps.

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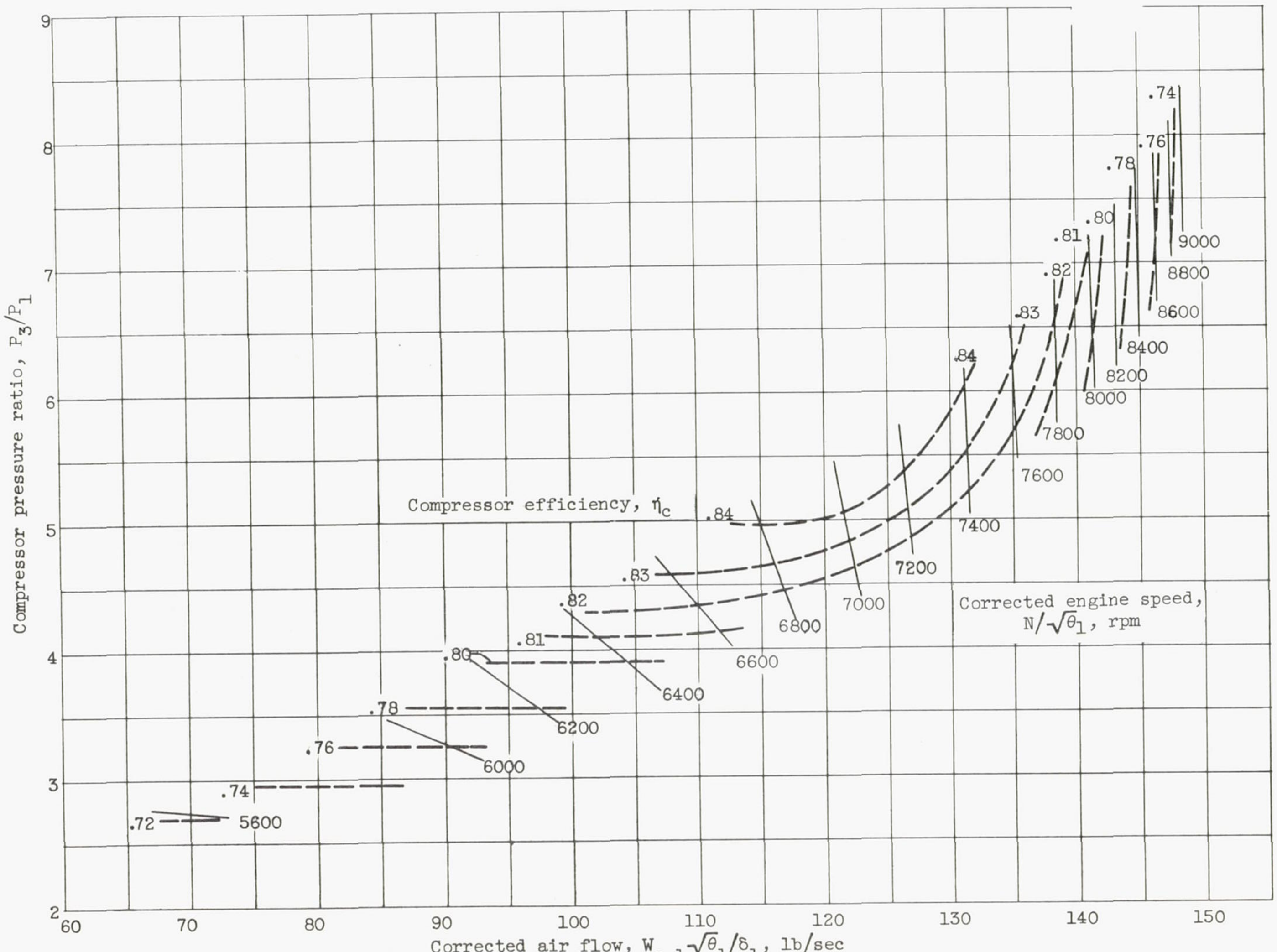

(c) Inlet guide vanes open; Reynolds number index, 0.39.

Figure 6. - Concluded. Compressor performance maps.

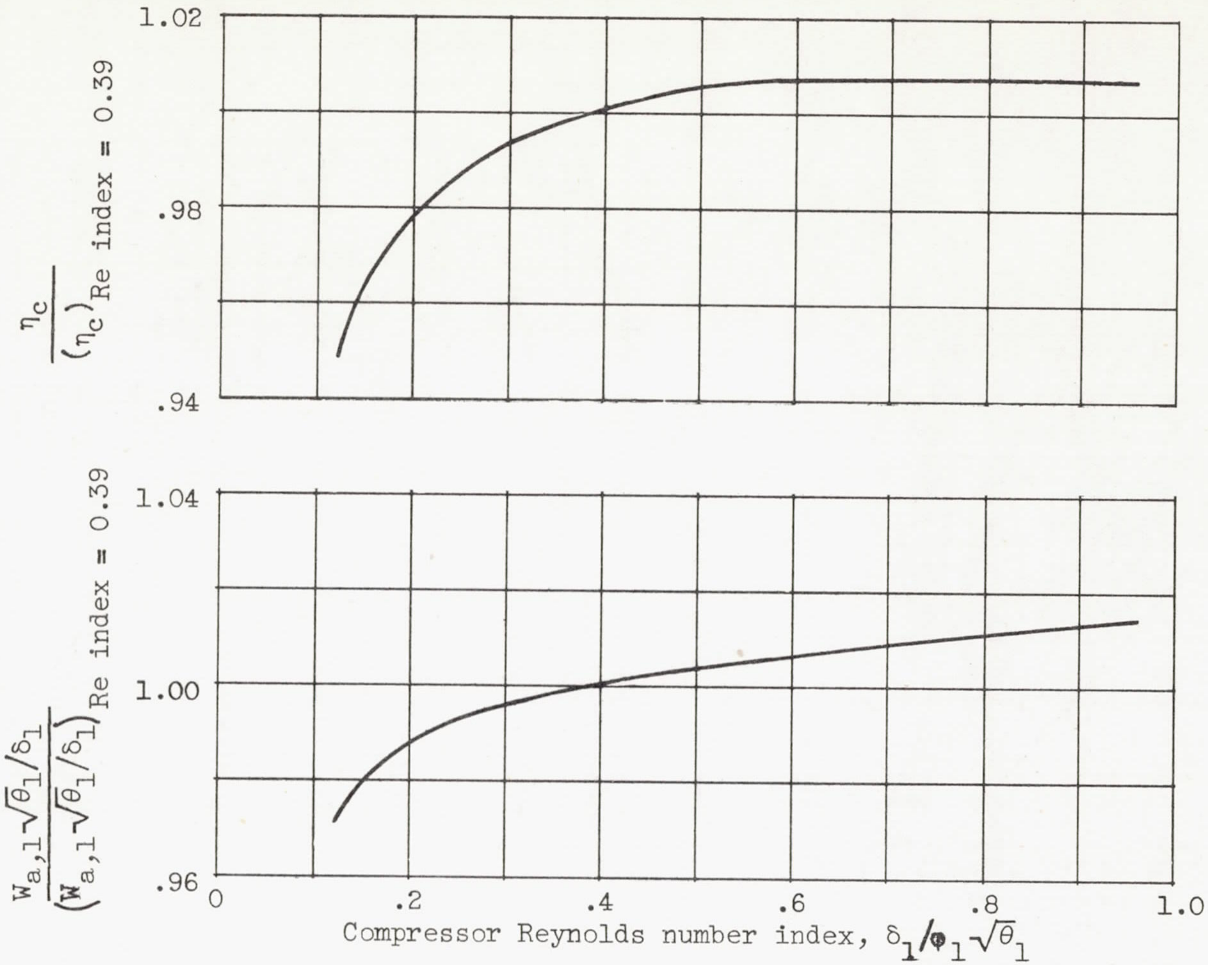

Figure 7. - Effect of compressor Reynolds number index on compressor efficiency and corrected air flow. Inlet guide vanes open. Applicable at all compressor pressure ratios at corrected engine speeds of 6800 rpm and above.

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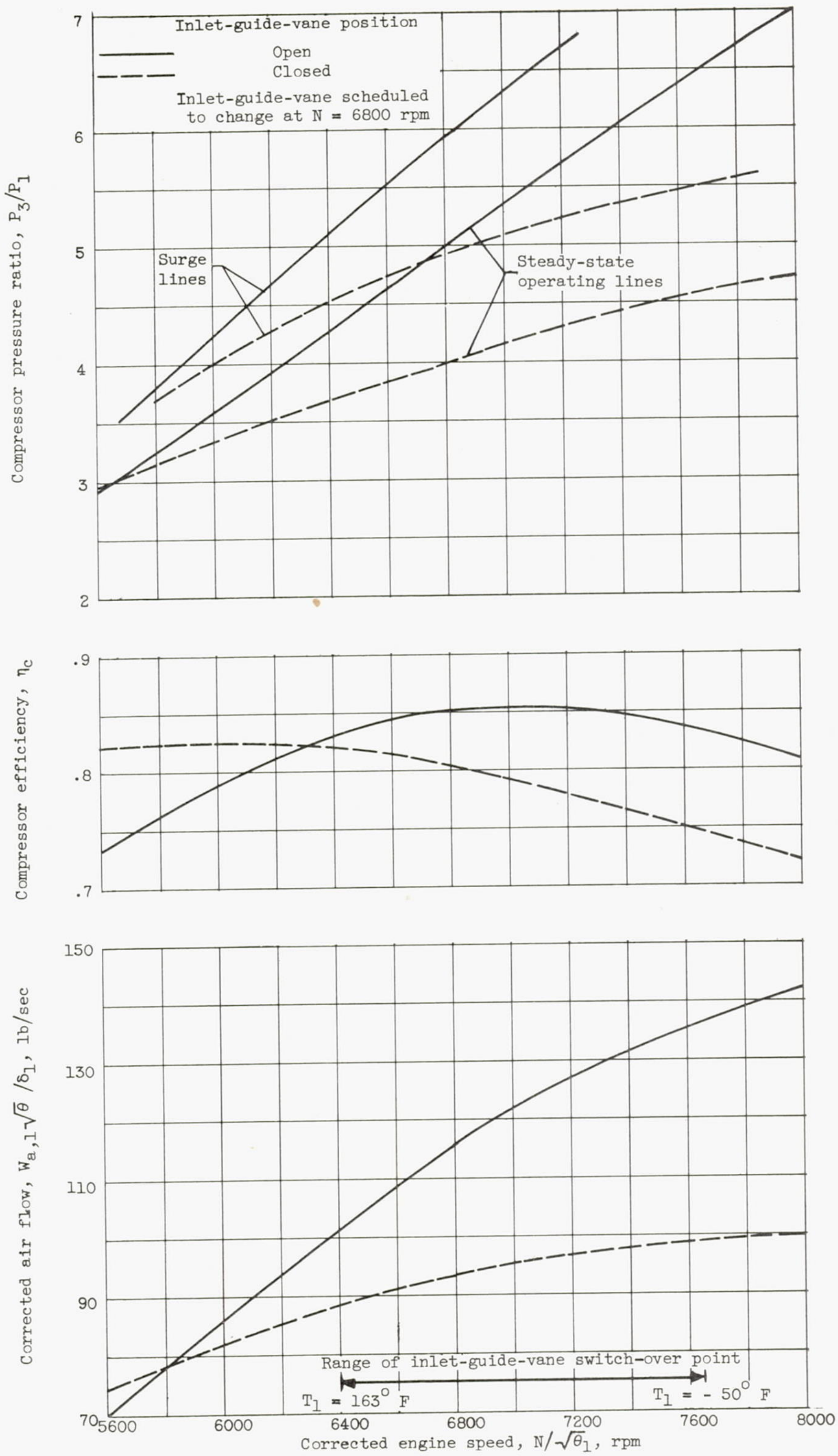

Figure 8. - Effect of inlet-guide-vane position on compressor pressure ratio, efficiency, and corrected air flow for rated exhaust-nozzle area. Reynolds number index, 0.96.

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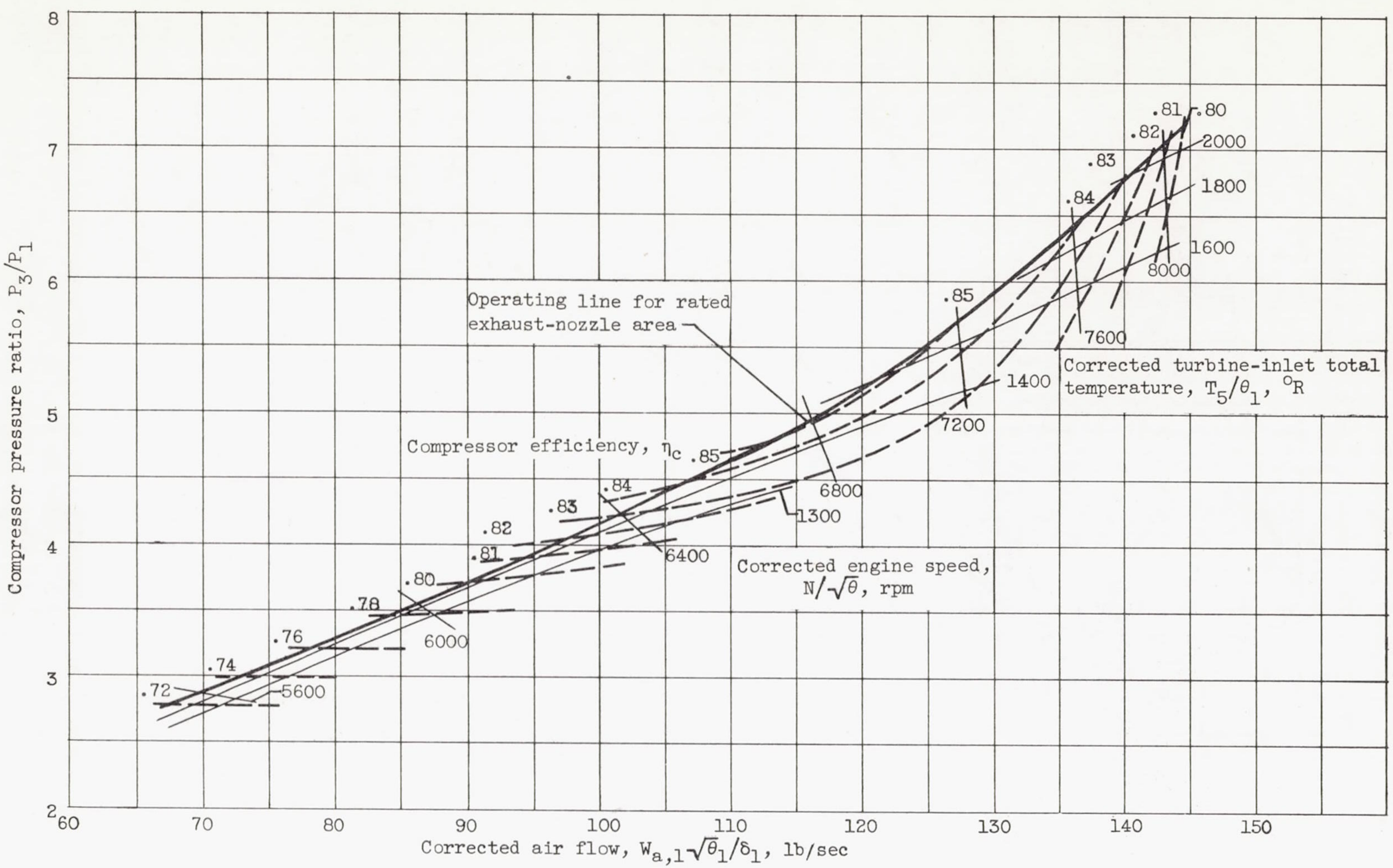

(a) Reynolds number index, 0.96.

Figure 9. - Compressor performance map showing lines of constant corrected turbine-inlet temperature. Inlet guide vanes open.

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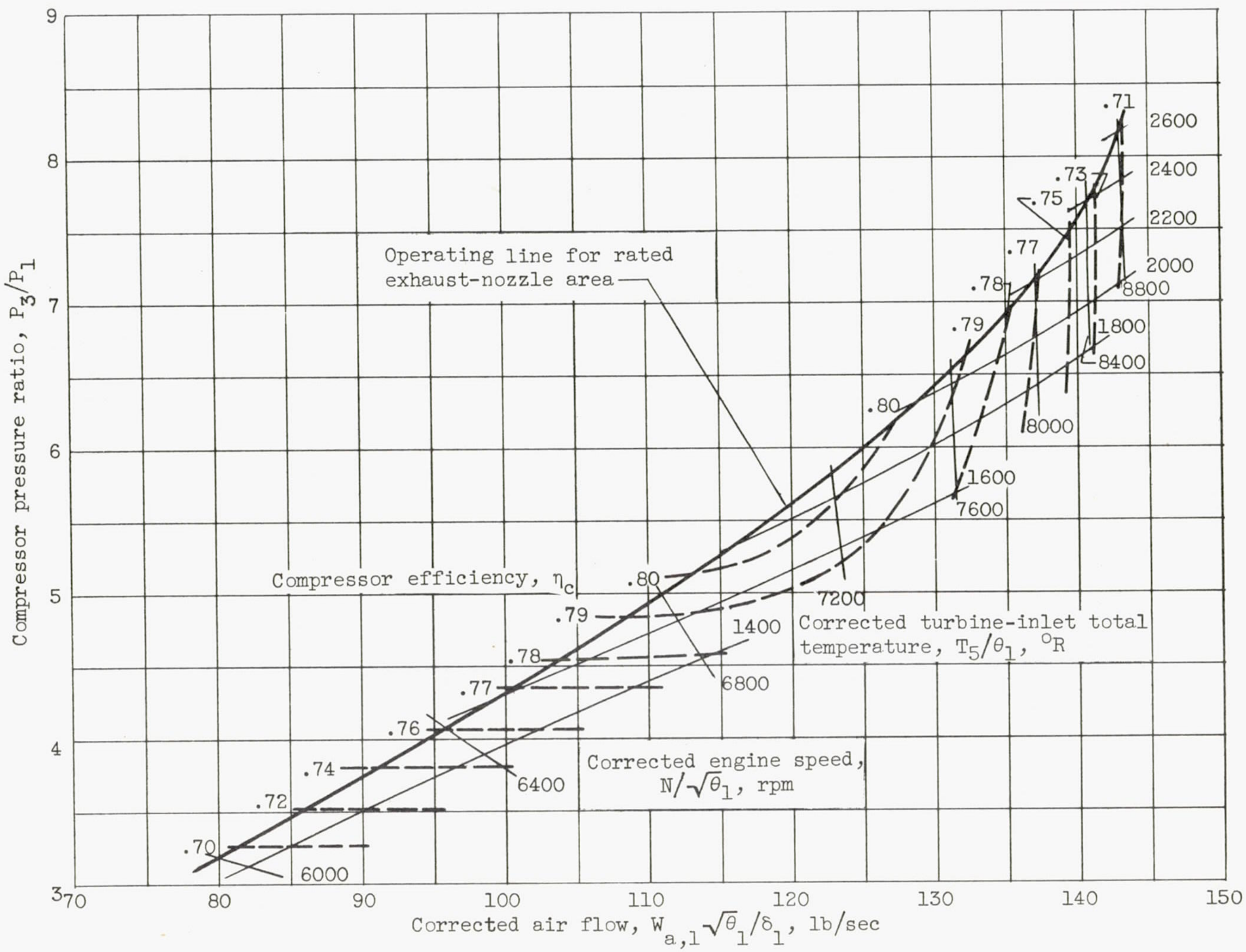

(b) Reynolds number index, 0.12.

Figure 9. - Concluded. Compressor performance map showing lines of constant corrected turbine-inlet temperature. Inlet guide vanes open.

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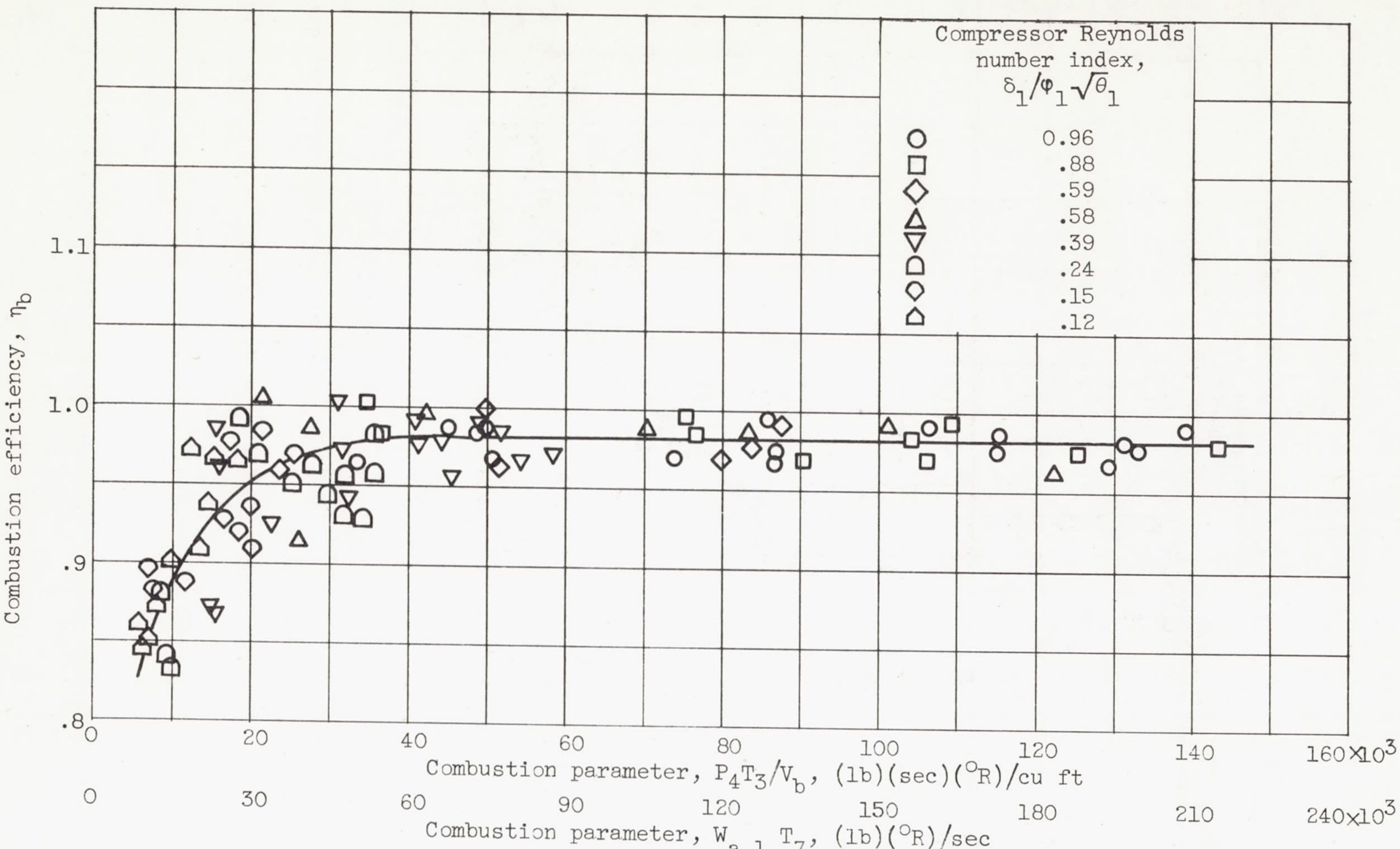

Figure 10. - Variation of combustion efficiency with combustion parameters.

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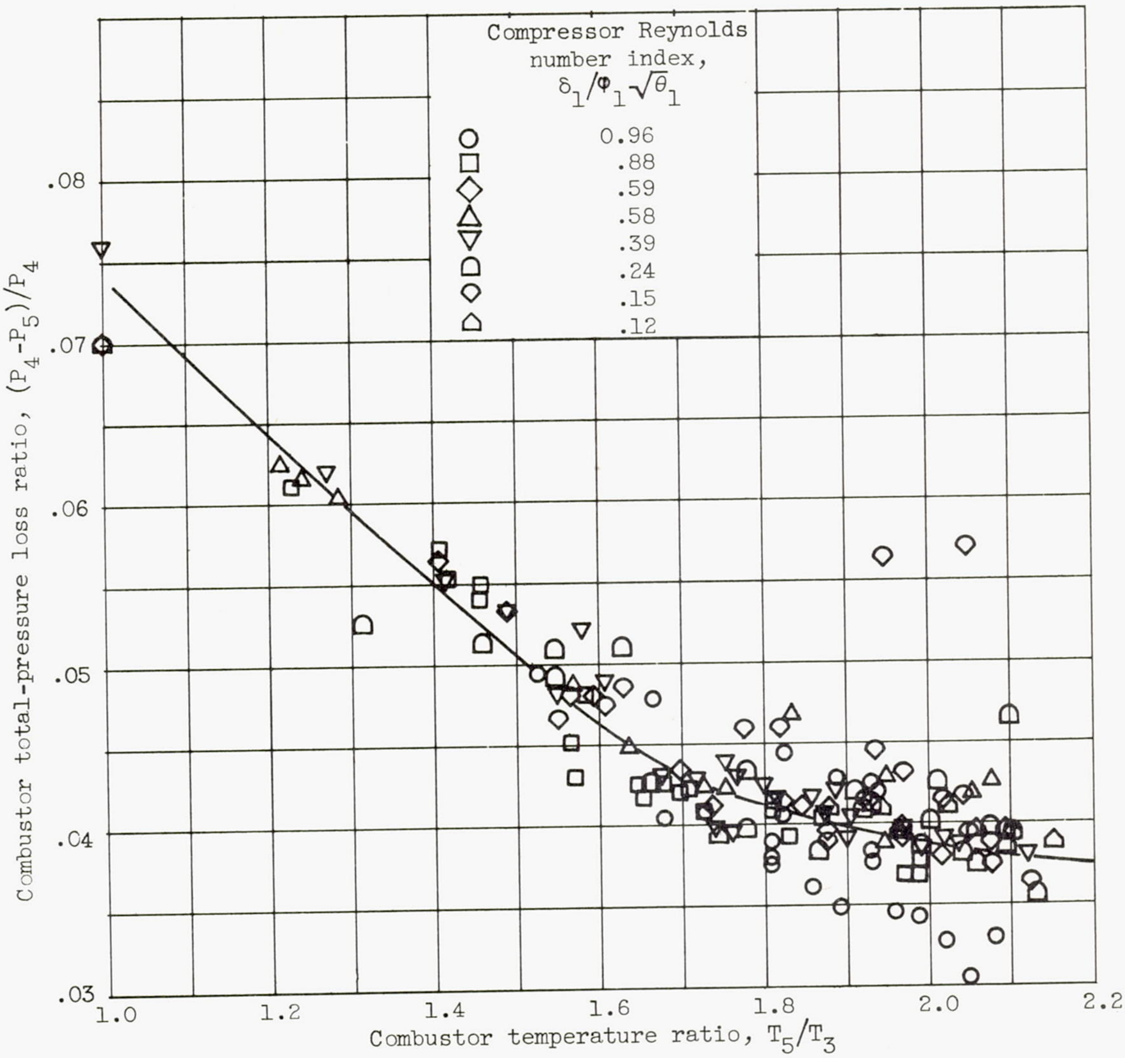

Figure 11. - Variation of combustor total-pressure loss ratio with combustor temperature ratio.

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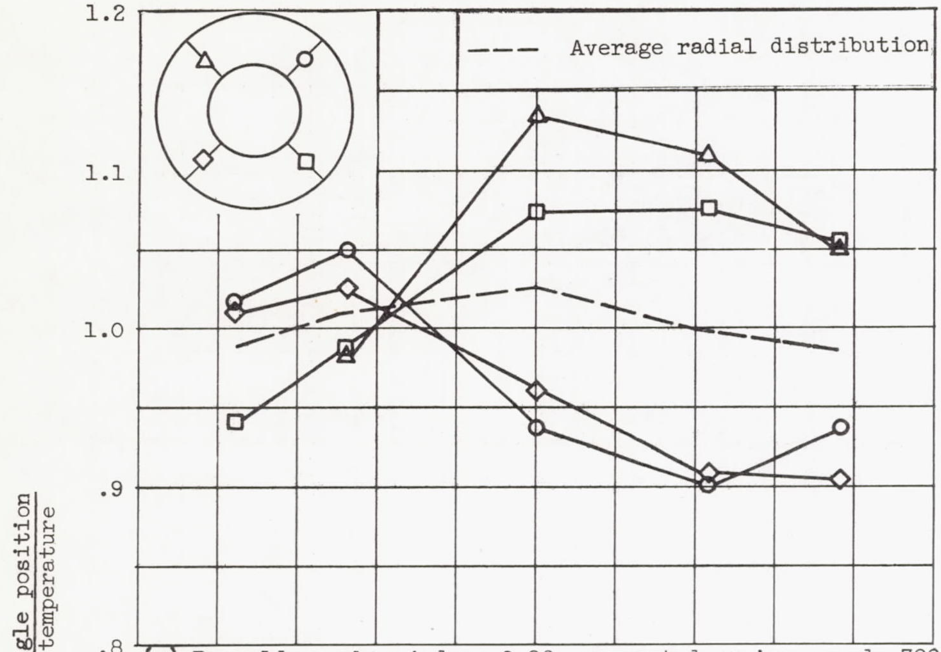
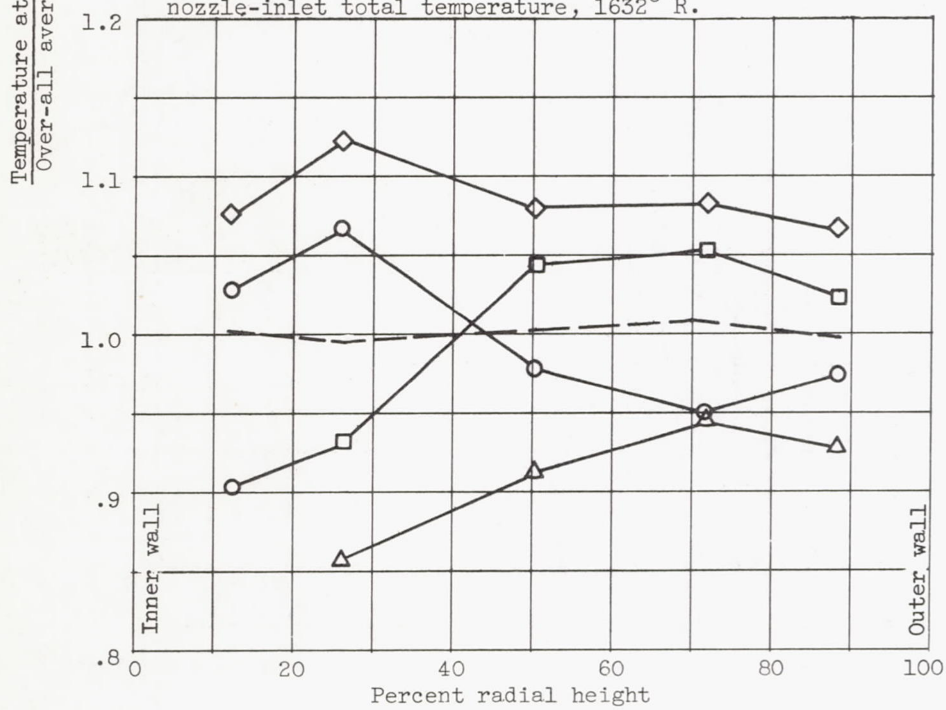


(a) Reynolds number index, 0.96; corrected engine speed, 7993 rpm; turbine-outlet total temperature, 1691° R; exhaust-nozzle-inlet total temperature, 1632° R.



(b) Reynolds number index, 0.12; corrected engine speed, 7514 rpm; turbine-outlet total temperature, 1637° R; exhaust-nozzle-inlet total temperature, 1582° R.

Figure 12. - Typical total-temperature profiles at turbine outlet, station 6.

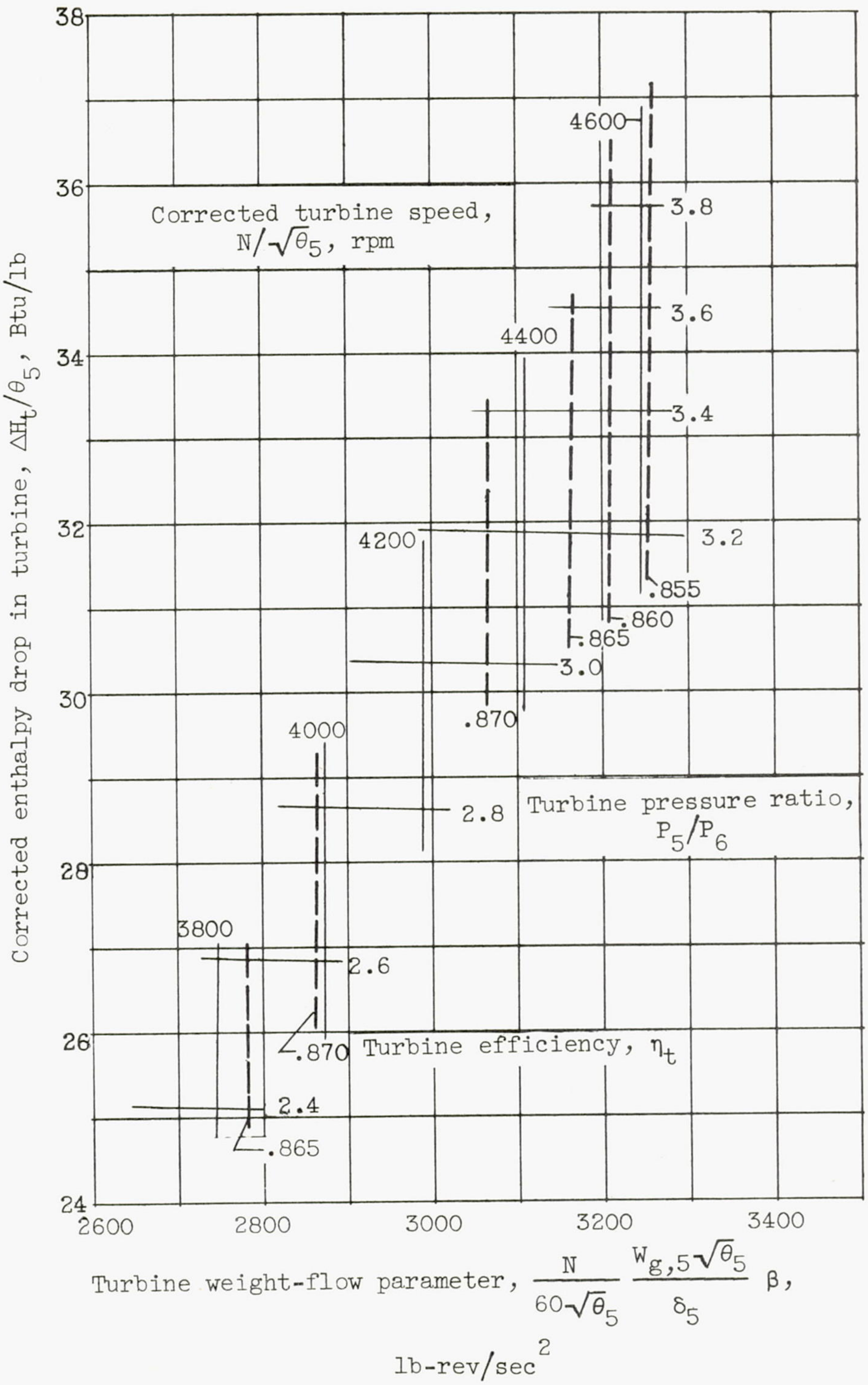


Figure 13. - Turbine performance map. Compressor Reynolds number indices of 0.96 and 0.88. Turbine Reynolds number indices varied as shown in tables I and II.

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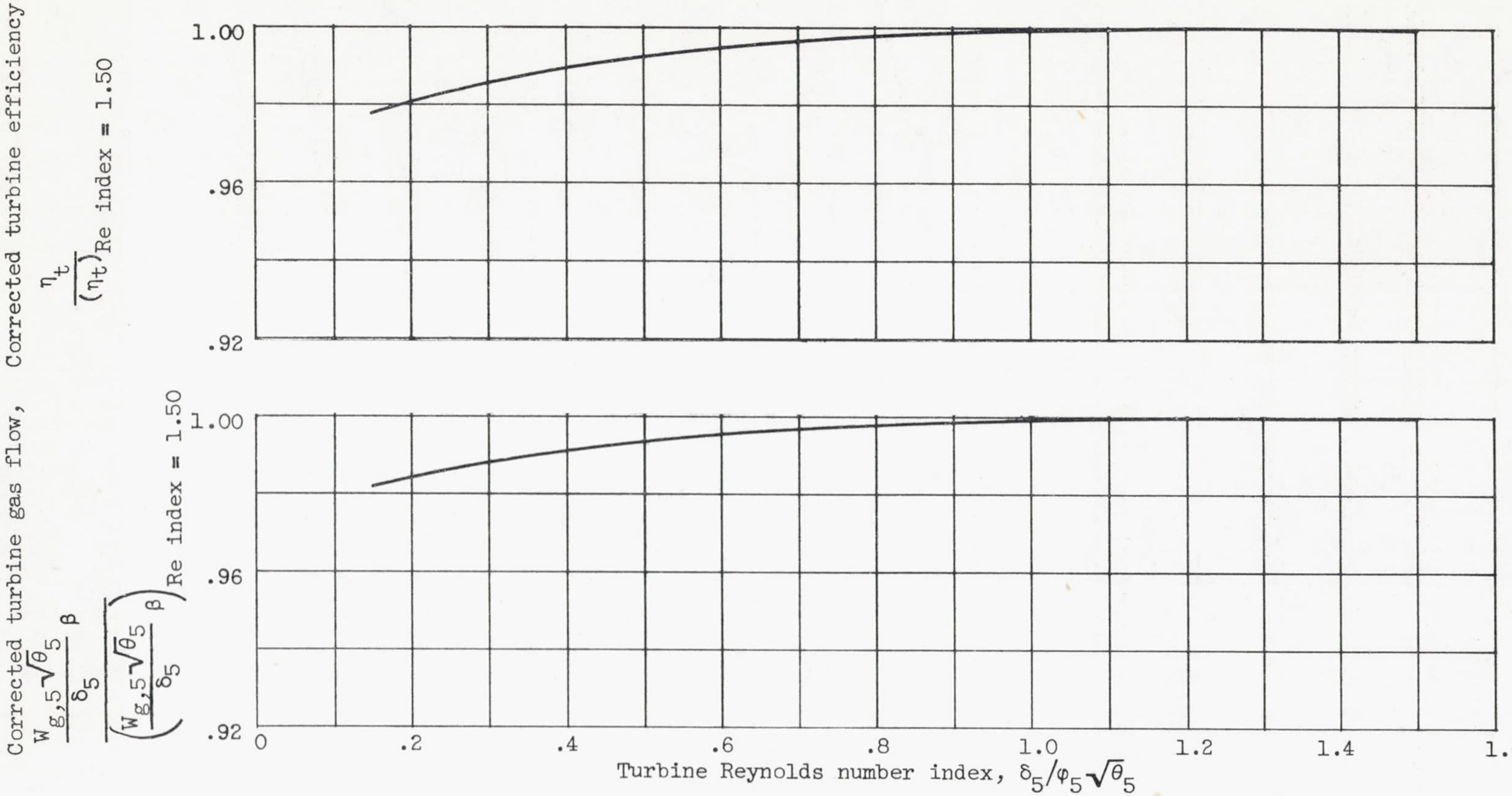

Figure 14. - Effect of turbine Reynolds number index on turbine efficiency and corrected turbine gas flow.

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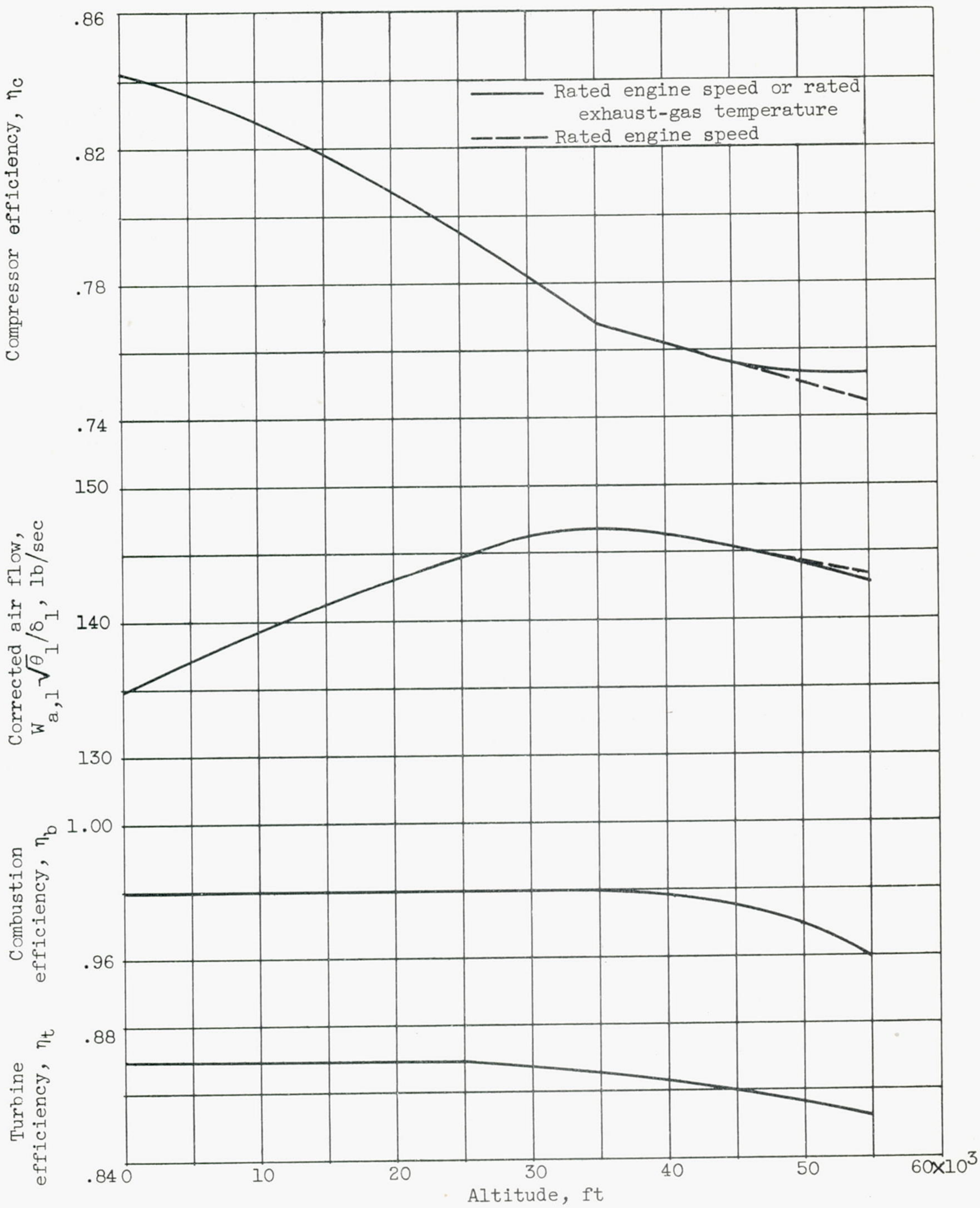

Figure 15. - Variation of compressor, combustor, and turbine efficiency and corrected air flow with altitude at rated engine conditions. Flight Mach number, 0.8.

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ALTITUDE COMPONENT PERFORMANCE OF THE YJ73-GE-3 TURBOJET ENGINE

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hjk - 4/15/54

Engines, Turbojet 3.1.3

Combustion Research, General 3.5.1

Compressors - Axial Flow 3.6.1.1

Turbines - Axial Flow 3.7.1.1

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Abstract

An investigation to determine the altitude performance characteristics of the YJ73-GE-3 turbojet engine was conducted in an altitude chamber of the NACA Lewis laboratory. The engine was equipped with variable inlet guide vanes. The component performance was determined at two positions of the inlet guide vanes over a range of engine speeds, exhaust-nozzle areas, and flight conditions. The range of flight conditions covered corresponds to a variation in compressor Reynolds number index from 0.96 to 0.12.

A reduction in Reynolds number index over approximately the range indicated resulted in a decrease in the corrected air flow of $4\frac{1}{2}$ percent and in compressor efficiency of 6 percent. By operating the engine with the inlet guide vanes closed, the compressor steady-state performance was improved at corrected engine speeds below 6300 rpm. For example, at a corrected engine speed of 5600 rpm, the compressor efficiency was raised from 0.73 to 0.82 as the inlet guide vanes were moved from the open to the closed position. At rated engine conditions at a flight Mach number of 0.8, the combustion efficiency varied from 0.98 to 0.96 as altitude was varied from sea level to 55,000 feet. Within the range of this investigation, turbine efficiency varied about 4 percent. About half this variation is due to the effect of turbine-inlet Reynolds number, while the remaining half is due to changes in the turbine operating point.

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