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RESEARCH MEMORANDUM

PERFORMANCE OF YJ73-GE-3 TURBOJET ENGINE IN ALTITUDE TEST CHAMBER

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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SUMMARY

The steady-state performance characteristics of the YJ73-GE-3 turbojet engine were determined in a Lewis altitude test chamber for a range of exhaust-nozzle areas at simulated altitudes from near sea level to 55,000 feet and flight Mach numbers from 0 to 1.2. The corresponding range of Reynolds number indices was from 0.96 to 0.12.

A method of performance calculation based on engine pumping characteristics is also presented. Engine performance calculated by this method is presented for a wide range of flight conditions.

The use of an exhaust-nozzle area sized to give rated conditions at sea level would permit operation near the point of minimum specific fuel consumption for a wide range of flight conditions, but would cause excessive exhaust-gas temperatures at rated speed at high altitudes.

At rated corrected speed with a choked exhaust nozzle (rated area), decreasing the Reynolds number index from 1.0 to 0.1 decreased the corrected air flow 5 percent and increased the corrected exhaust-gas temperature 120° R.

INTRODUCTION

The over-all performance of the YJ73-GE-3 turbojet engine was determined in an altitude chamber at the NACA Lewis laboratory and is presented herein along with the starting characteristics for two altitudes. Component performance for this engine is presented in reference 1. The YJ73-GE-3 differs from the YJ73-GE-1A turbojet engine reported in references 2 and 3 in that the first-stage turbine nozzle area is 10 percent less.

The J73 engines are provided with variable-position inlet guide vanes, which are closed at low engine speeds to avoid surge during rapid accelerations. Although the inlet guide vanes of the YJ73-GE-3 are normally closed with steady-state operation below 6800 rpm and open at higher speeds, the engine control was modified during the investigation to allow them to be open or closed at any speed. Because standard operation at cruise, normal, and military conditions is with open inlet guide vanes, most of the data presented herein were obtained with the inlet guide vanes in the open position. A limited amount of data was obtained with the vanes in the closed position.

Performance data were obtained over a range from about 70 to 100 percent of rated speed with several exhaust-nozzle areas at simulated altitudes from near sea level to 55,000 feet and flight Mach numbers from 0 to 1.2. The corresponding range of Reynolds number indices was from 0.96 to 0.12. One exhaust-nozzle area that gave approximately limiting exhaust-gas temperature at rated speed and sea-level static conditions was included. Additional data were obtained at 35,000 feet at a flight Mach number of 0.8 to show the effects of changes in inlet-air temperature on performance.

Data are presented in the form of engine performance maps at several flight conditions and in the form of engine pumping characteristics. Engine performance calculated from pumping characteristics is presented graphically for flight conditions from sea level to an altitude of 60,000 feet and from 0 to 1200 knots true flight speed. All experimental data are presented in both graphical and tabular form.

APPARATUS AND PROCEDURE

Engine

The engine, shown installed in the test chamber in figure 1, has an over-all length of 146.5 inches and diameter of 36.75 inches. It is equipped with 21 variable-position inlet guide vanes that rotate simultaneously through 30° from closed to open at 6800 rpm when speed is increasing and close at 6800 rpm when speed is decreasing. The open-position angle between the engine center line and a tangent to the vanes is 0° at the root and 13° at the tip.

The 12-stage axial-flow compressor has a pressure ratio of 7, a constant tip diameter of $32\frac{1}{8}$ inches, a first-stage hub-tip radius ratio of 0.455, a twelfth-stage hub-tip ratio of 0.880, and a tip Mach number of 0.997.

The combustor is cannular type, with ten tubular inner liners.

The first stage of the two-stage turbine has 40 stator vanes, while the second stage has 53. The rotor tip diameter of the first stage is $29\frac{1}{2}$ inches, and that of the second is $31\frac{1}{8}$ inches. The hub-tip radius ratios of the first and second stages are 0.73 and 0.64, respectively.

The manufacturer's performance ratings at standard sea-level static conditions are as follows:

Rated quantity	Military	Normal
Speed, rpm	7950	7615
Maximum specific fuel consumption, lb/(hr)(lb thrust)	0.917	0.887
Minimum jet thrust, lb	8920	7840
Air flow, lb/sec	142	----
Turbine-outlet temperature, $^{\circ}F$	1185	1085

Installation

Altitude test chamber. - A sketch of the altitude test chamber and some of its associated ducting is shown in figure 2. The test chamber is 14 feet in diameter and 20 feet long. The test bed on which the engine was mounted is connected by a linkage to a balance diaphragm for thrust measurement. A screen and honeycomb are installed in the chamber upstream of the test section to smooth and straighten the inlet-air flow. The front bulkhead, which incorporated a labyrinth seal around the front of the engine, prevented the flow of inlet air directly into the exhaust system and provided a means of maintaining a pressure difference across the engine. A bellmouth cowl was installed on the front bulkhead to obtain a uniform velocity profile at the inlet of the compressor.

Air supplied to the inlet section of the altitude chamber can be either refrigerated or heated dry air, or atmospheric air. 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 operate throttle valves automatically to maintain constant ram pressure ratio and exhaust pressure.

Instrumentation. - The locations of instrumentation stations throughout the engine together with schematic sketches of the instrumentation at the engine inlet and the exhaust-nozzle inlet are shown in figure 3. All pressures were measured with alkazene or mercury manometers and 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 with a calibrated rotameter.

Procedure

During the investigation the refrigeration system was changed to permit lower inlet-air temperatures, and at the same time the engine was overhauled. Therefore, the investigation was separated into two phases with the inlet-air temperatures varying from about 440° to 520° R for the first phase (before engine overhaul) and from about 380° to 440° R for the second phase (after engine overhaul).

Most of the engine performance data were obtained in the first phase and are presented in table I. The approximate flight conditions and corresponding Reynolds number indices obtained in this phase are shown in the following table:

Altitude, ft	Reynolds number index for flight Mach number, M, of -			
	0	0.4	0.8	1.2
0	0.96	----	---	----
15,000	----	----	0.88	----
25,000	----	----	.59	----
35,000	----	----	.39	0.58
45,000	----	----	.24	----
55,000	----	0.12	.15	----

The inlet-air total temperature and pressure and the static pressure in the test section surrounding the exhaust nozzle were maintained at approximately the desired altitude values except at the sea-level static condition. The average inlet total pressure of the data obtained at the sea-level static condition actually corresponded to a pressure altitude of about 2000 feet. In addition, the static pressure in the region surrounding the exhaust nozzle was slightly higher than the inlet total pressure, causing a slight reverse ram. The sea-level static condition was difficult to simulate in the altitude facility. The disparities at the sea-level static condition were due to this difficulty and were not normal experimental error. Although these difficulties prevent the direct presentation of the sea-level static data in the form of a performance map, the usefulness of the data for pumping characteristics is not affected.

Improvements in the refrigeration system permitted the use of colder inlet-air temperatures in the second phase of the program and thereby extended the range of the investigation to higher corrected engine speeds. The data obtained in the second phase are presented in table II. The approximate flight conditions and Reynolds number indices obtained in the second phase are shown in the following table:

Altitude, ft	Reynolds number index for flight Mach number, M, of -	
	0.4	0.8
35,000	-----	0.461
45,000	-----	.304
55,000	0.140	.176

The lower inlet-air temperatures obtained in the second phase resulted in higher Reynolds number indices for similar flight conditions. The effects of differences in Reynolds number indices and the performance changes accompanying the engine overhaul were reduced by graphical and analytical adjustments to the data obtained in the second phase. The magnitude of these adjustments was about 2 percent, which is of the same order as the variation that would be expected between production engines of any given model.

Data were obtained with four exhaust-nozzle areas at each flight condition. The physical details of the nozzle configurations are given in figure 4. The fixed exhaust nozzle with an area of 2.388 square feet (fig. 4(a)) was designed to give approximately limiting exhaust-gas temperature at sea-level static conditions and is referred to as the rated nozzle. A clamshell variable-area exahust nozzle (fig. 4(b)) was used to obtain the two intermediate areas of 2.514 and 2.694 square feet. The largest exhaust-nozzle area, 3.688 square feet, was obtained with a straight tail pipe attached to the outlet of the diffuser (fig. 4(c)). In order to extend the range of the investigation closer to compressor surge, an additional smaller-than-rated exhaust-nozzle area was used at the 35,000-foot altitude and 0.8 Mach number flight condition.

The inlet guide vanes were normally scheduled to begin opening or closing, depending on whether the engine was accelerating or decelerating, respectively, at 6800 rpm. The control was modified during the investigation to permit opening or closing the inlet guide vanes at any speed, thereby extending the speed range investigated with both inlet-guide-vane positions.

The fuel used was MIL-F-5624A, grade JP-4, with a lower heating value of 18,700 Btu per pound and a hydrogen-carbon ratio of 0.171.

The symbols and methods of experimental data reduction are given in appendixes A and B, respectively.

RESULTS AND DISCUSSION

Performance Maps

Performance maps are useful for the compact presentation of a large amount of altitude performance information. The performance maps for seven flight conditions with altitudes from 15,000 to 55,000 feet and Mach numbers from 0.43 to 1.23 are shown in figure 5. Only data obtained with open inlet guide vanes are shown. These data have been adjusted by the factors δ_a and θ_a to compensate for deviations from standard altitude pressures and temperatures. The deviations from altitude conditions were small except for some high-corrected-speed data taken at low inlet-air temperatures.

The exhaust-nozzle areas given on the performance maps are cold projected areas. As the discharge coefficients of exhaust nozzles vary with temperature, pressure ratio, and configuration, the effective flow areas will differ from the values shown on the performance maps. Curves to convert cold projected areas into effective areas can be found in a subsequent section.

At thrust levels below maximum, different values of specific fuel consumption may be obtained by varying the exhaust-nozzle area and engine speed simultaneously. In order to determine the best exhaust-nozzle-area schedule within the range investigated, the exhaust-nozzle areas corresponding to minimum specific fuel consumption for several thrust levels at each flight condition were obtained from figure 5 and plotted as a function of thrust in figure 6. For the high thrust levels (cruise and military) that would be employed over most of a normal flight plan, the exhaust-nozzle area for minimum specific fuel consumption varied from about 2.4 to 2.5 square feet. However, use of rated exhaust-nozzle area (2.388 sq ft) gave specific fuel consumptions within 2 percent of the minimum values.

Pumping Characteristics and Performance Prediction

Treatment of a turbojet engine as a pump (ref. 4) and presentation of its characteristics in terms of air flow, pressure ratio, and temperature ratio represent one of the most useful forms for performance calculation. One advantage of the use of pumping characteristics is that the engine performance can be determined apart from the effects of inlet and outlet ducting, so that the calculation of the effects of different ducting combinations on over-all engine performance is possible. The pumping characteristics, combustion efficiency, and exhaust ducting losses of the YJ73-GE-3 turbojet engine are presented in this section to aid performance calculation at any flight condition within the range of Reynolds number indices covered by the investigation. Sample problems illustrating the use of the curves presented in this section are given in appendix C.

Pumping characteristics with a range of exhaust-nozzle areas. - To simplify the presentation, data for one reference Reynolds number index were used to show the relation of corrected engine speed, engine temperature ratio, and engine pressure ratio. Curves are then given to provide correction to other Reynolds number indices. In order to obtain maximum ranges of corrected engine speed and engine temperature ratio, the 35,000-foot altitude and 0.8 Mach number flight condition was used as the reference. The Reynolds number index of this flight condition is 0.39.

The pumping characteristics at a Reynolds number index of 0.39 are shown in figure 7. The air-flow and pressure-ratio correction curves are shown in figure 8. The correction curve of air flow was found to be independent of temperature ratio and corrected speed, while the pressure-ratio correction curves were independent only of temperature ratio. To find the engine pressure ratio and corrected air flow at a given engine and flight condition, the following steps are used:

(1) From the desired inlet temperature, exhaust-gas temperature, and engine speed, find the engine temperature ratio and corrected engine speed.

(2) By using the engine temperature ratio, the corrected engine speed, and figure 7, find the engine pressure ratio and corrected air flow that would be obtained at a Reynolds number index of 0.39.

(3) Calculate the Reynolds number index from the total temperature and total pressure of the desired flight condition.

(4) From the corrected engine speed, the Reynolds number index, and figure 8, find the correction factors for engine pressure ratio and corrected air flow.

(5) Multiply the pressure ratio and corrected air flow obtained from step (2) by the correction factors from step (4).

The engine pressure ratio and corrected air flow obtained by the preceding method agree with faired experimental values within about 1 percent, except for the pressure ratios corresponding to the lowest temperature ratios at each speed, where slightly larger variations were found.

Pumping characteristics with fixed exhaust-nozzle area. - The pumping characteristics presented in figures 7 and 8 are suitable for engine performance calculations when a variable-area exhaust nozzle is trimmed to give a desired exhaust-gas temperature. However, use of figures 7 and 8 for an engine with a fixed-area exhaust nozzle would require trial-and-error solutions. In order to obtain direct solutions at approximately rated exhaust-nozzle area (2.388 sq ft), figure 9 was constructed. Figure 9 is limited in application to exhaust-nozzle pressure ratios greater than 2.5. For pressure ratios below about 2.5, the exhaust-nozzle discharge coefficient (fig. 10(a)) varies so that the use of the pumping characteristics of figures 7 and 8 and trial-and-error solutions would be required.

Reynolds number effects can be determined from figure 9. For a corrected speed of 7950 rpm, the corrected air flow decreased from 142 to 134.5 pounds per second and the temperature ratio increased from 3.1 to 3.4 when the Reynolds number index decreased from 1.0 to 0.1. The corrected-air-flow and temperature-ratio changes correspond to a 5-percent decrease and a 120° R (corrected temperature) increase, respectively.

Discharge coefficient. - For conditions in which the exhaust nozzle is unchoked or if discharge coefficient varies with pressure ratio, the variation of effective exhaust-nozzle area with exhaust-nozzle pressure ratio must be known to obtain a solution with figures 7 and 8. The discharge coefficients of the four exhaust nozzles used in this investigation were plotted against pressure ratio in figure 10 to permit calculation of effective area from cold projected area.

Combustion efficiency. - For the calculation of fuel flow, combustion efficiency must be known. Combustion efficiency is plotted in figure 11. The derivation of the correlating parameter, the product of air flow and exhaust-gas temperature, can be found in reference 5. Use of this curve with air flow and engine-inlet and exhaust-gas temperatures enables calculation of fuel flow and, hence, specific fuel consumption.

Exhaust ducting losses. - As was mentioned previously, the tail-pipe and exhaust-nozzle losses are not included in the engine pressure ratio. In order to permit calculation of thrust, the tail-pipe total-pressure loss and exhaust-nozzle effective velocity coefficient are presented in figures 12 and 13, respectively. The sharp rise of the tail-pipe total-pressure loss ratio at high values of turbine-outlet gas-flow parameter resulted from choking at the turbine outlet.

Thrust Correlation

Correlations of jet thrust with an exhaust-nozzle pressure-drop parameter are presented in references 6 and 7. Jet thrust correlations, when used in conjunction with pumping characteristics, may be used for thrust prediction. Correlations of jet thrust with exhaust-nozzle pressure drop obtained in this investigation are presented in figures 14 and 15. In figure 14 the thrusts for all four nozzle areas have been divided by effective area (discharge coefficient times projected area) to generalize thrusts to a single curve. Figure 15 is for the nozzle area that gives approximately rated temperature at sea-level static conditions. These correlations are limited in application to choked flow in the exhaust nozzle, which was assumed in the derivation of the correlating parameter.

Effect of Inlet Temperature on Performance

In order to determine the applicability of data at other inlet temperatures than were used during the investigation, data were obtained with inlet-air temperatures from 482° to 621° R at an altitude of 35,000 feet and a flight Mach number of 0.8. A fixed exhaust nozzle with an area of 2.37 square feet was used. The variations of corrected air flow, corrected net thrust, and corrected fuel flow with corrected engine speed for three inlet temperatures are shown in figures 16(a), (b), and (c), respectively. At a constant corrected speed, corrected air flow decreases slightly with increasing inlet temperature, while both corrected net thrust and corrected fuel flow increase with increasing inlet temperature. The variation of engine temperature ratio with engine pressure ratio for the three inlet temperatures is shown in figure 16(d). At constant corrected speed, the temperature ratio increased with inlet temperature. The pressure ratio also increased slightly with increasing inlet temperature.

The variation of the engine performance parameters with inlet temperature was due at least in part to changes in Reynolds number index associated with changes in inlet temperature. The range of Reynolds number index corresponding to the inlet-temperature variation was from 0.40 to 0.29. The change of performance variables for a Reynolds number index change from 0.40 to 0.29 was calculated from the pumping characteristics of figure 9 for a corrected speed of 7000 rpm. The results of these calculations and the corresponding information for variable-inlet-temperature data from figure 16 are shown in the following table:

	Corrected fuel flow	Corrected air flow	Temperature ratio	Pressure ratio	Corrected net thrust
Change due to Reynolds number effect, percent	2.6	-0.7	1.4	0	1.1
Total observed change, percent	9.6	-1.1	2.8	0.6	2.5

Comparison of the values indicates that much of the change of performance variables with inlet temperature can be charged to Reynolds number effects. Considering the accuracy of the data, correcting for inlet-temperature effects should not be necessary for corrected air flow, temperature ratio, pressure ratio, or corrected thrust over the range of temperatures investigated. In the case of corrected fuel flow, however, a significant difference of 7.0 percent exists between the total change of 9.6 percent and the change of 2.6 percent predicted for Reynolds number effects alone. The specific heat of the products of combustion of fuel and air increases with fuel-air ratio and temperature. Calculation showed that the increase in specific heat accounted for 5 of the 7-percent difference in corrected fuel flows. To predict fuel flows over wide ranges of inlet temperature, fuel flows should, therefore, be calculated from air flows, inlet and outlet temperatures, and combustion efficiencies, instead of from generalized fuel-flow plots. The recommended method of fuel-flow calculation was used for the predicted performance in the next section.

Calculated Performance from Pumping Characteristics

Predicted performance is included to facilitate estimations of airplane performance. Performance of the YJ73-GE-3 turbojet engine with a 2.388-square-foot exhaust-nozzle area was calculated from the pumping characteristics for a wide range of flight conditions and is plotted in figure 17. A standard NACA atmosphere and complete ram recovery were assumed. The accuracy of the calculated thrusts and fuel flows in figure 17 is within about 2 percent.

Because the discrepancies discussed previously in setting up the approximate sea-level static flight condition do not affect the data of figure 17(a), these data provide an accurate indication of actual sea-level capabilities of the YJ73-GE-3 turbojet engine with a fixed exhaust-nozzle area of 2.388 square feet. The thrust, air flow, and specific fuel consumption at rated speed and sea-level static flight conditions were 8800 pounds, 142 pounds per second, and 0.92 pound per hour per pound of thrust, respectively.

As mentioned before, errors in measuring temperatures and setting up the sea-level static flight condition resulted in the use of an exhaust-nozzle area (2.388 sq ft) that caused exhaust-gas temperatures to be about 25° R below the limiting value. The thrusts and fuel flows would have been slightly higher if the exhaust-nozzle area had been sized to give limiting exhaust-gas temperature. At rated speed and sea-level static conditions, the thrust and specific fuel consumption would have been about 8960 pounds and 0.93 pound per hour per pound of thrust, respectively.

Additional factors must be considered to determine the performance in an actual installation. The exhaust nozzle may be larger than that used here to give maximum performance with high ambient temperature. Another reason for increasing the exhaust-nozzle area could be the possible requirement that rated speed and exhaust-gas temperature be obtained simultaneously at static conditions with distorted and throttled inlet flow. Of course, inlet losses are present at all flight conditions and their effects should always be considered.

Altitude-Ignition Characteristics

The effect of fuel flow on altitude ignition was determined at altitudes of 35,000 and 45,000 feet with MIL-F-5624A, grade JP-4, fuel over a range of windmilling engine speeds (fig. 18). In order to determine whether ignition could be obtained for a given combination of fuel flow and windmilling engine speed, speed and fuel flow were maintained constant during the ignition period. Fuel temperature was about 60° F, and engine-inlet air temperature varied from 5° to -50° F at 35,000 feet but remained about constant at -35° F at 45,000 feet.

Results show that the minimum fuel flow required to obtain ignition increased with windmilling engine speed. To obtain ignition at windmilling speeds below 2500 rpm, a higher fuel flow was required at 45,000 that at 35,000 feet.

CONCLUDING REMARKS

The performance of the YJ73-GE-3 turbojet engine was determined over a wide range of flight conditions in an altitude test chamber. With an exhaust-nozzle area of 2.388 square feet, the performance at sea-level static conditions was: maximum thrust, 8800 pounds; air flow at rated speed, 142 pounds per second; specific fuel consumption at rated speed, 0.92 pound per hour per pound of thrust.

The use of an exhaust-nozzle area sized to give rated conditions at sea level would permit operation near the point of minimum specific fuel consumption for a wide range of flight conditions but would cause excessive exhaust-gas temperatures at rated speed at high altitudes.

At rated corrected speed and a choked exhaust nozzle (rated area), decreasing the Reynolds number index from 1.0 to 0.1 decreased the corrected air flow 5 percent and increased the corrected exhaust-gas temperature 120° R.

In order to predict fuel flows over wide ranges of inlet temperature, fuel flows should be calculated from air flows, inlet and outlet temperatures, and combustion efficiences, instead of from generalized fuel-flow plots.

Lewis Flight Propulsion Laboratory
National Advisory Committee for Aeronautics
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APPENDIX A

SYMBOLS

The following symbols are used in this report:

A	area, sq ft
B	thrust scale reading, lb
C_D	discharge coefficient, ratio of effective flow area to cold projected exhaust-nozzle area
C_V	effective-velocity coefficient, ratio of scale jet thrust to nozzle-inlet rake jet thrust
D	external drag of installation, lb
F_j	jet thrust, lb
F_n	net thrust, lb
g	dimensional constant, 32.2 ft/sec^2
M	Mach number
N	engine speed, rpm
P	total pressure, lb/sq ft abs
p	static pressure, lb/sq ft abs
R	gas constant, 53.3 ft-lb/(lb)($^{\circ}$R)
T	total temperature, $^{\circ}$R
t	static temperature, $^{\circ}$R
V	velocity, ft/sec or knots
W_a	air flow, lb/sec
W_f	fuel flow, lb/hr
W_g	gas flow, lb/sec

γ ratio of specific heats for gases

δ_a ratio of ambient absolute static pressure to absolute static pressure of NACA standard atmosphere at respective altitude

$\delta_{T,1}$ ratio of engine-inlet total pressure to absolute static pressure of NACA standard atmosphere at sea level

η_b combustion efficiency

θ_a ratio of absolute equivalent ambient static temperature to absolute static temperature of NACA standard atmosphere at respective altitude

$\theta_{T,1}$ ratio of absolute engine-inlet total temperature to absolute static temperature of NACA standard atmosphere at sea level

φ ratio of absolute viscosity of air at engine inlet to viscosity of NACA standard atmosphere at sea level

Subscripts:

a air

e equivalent

ef effective

f fuel

g gas

i indicated

j jet

N exhaust nozzle

r rake

s scale

0 free-stream conditions

1 engine inlet

3	compressor outlet
4	combustor inlet
5	turbine inlet
6	turbine outlet
7	exhaust-nozzle inlet

APPENDIX B

REDUCTION OF EXPERIMENTAL DATA

Flight Mach number. - The equivalent flight Mach number, with complete ram pressure recovery assumed, was calculated from the expression

$$M_{0,e} = \sqrt{\frac{2}{\gamma - 1}\left[\left(\frac{P_1}{p_0}\right)^{\frac{\gamma-1}{\gamma}} - 1\right]}$$

Equivalent temperature. - Equivalent static temperature was determined from ambient static pressure and engine-inlet total pressure and temperature:

$$t_{0,e} = \frac{T_1}{\left(\frac{P_1}{p_0}\right)^{\frac{\gamma-1}{\gamma}}}$$

Airspeed. - The following equation was used to calculate airspeed:

$$V_{0,e} = M_{0,e}\sqrt{\gamma g R t_{0,e}}$$

Temperature. - Total temperatures were determined from indicated temperatures with the following relation:

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

where 0.85 was taken as the recovery factor for the thermocouples used.

Air flow. - Air flow was determined from pressure and temperature measurements in the engine-inlet air duct and the following equation:

$$W_a = A_1 p_1 \sqrt{\frac{2g\gamma}{RT_1(\gamma - 1)}\left(\frac{P_1}{p_1}\right)^{\frac{\gamma-1}{\gamma}}\left[\left(\frac{P_1}{p_1}\right)^{\frac{\gamma-1}{\gamma}} - 1\right]}$$

Gas flow. - The total weight flow through the engine was calculated as follows:

$$W_g = W_{a,1} + \frac{W_f}{3600}$$

Exhaust-nozzle effective-velocity coefficient. - The velocity coefficient was calculated as the ratio of scale jet thrust to rake jet thrust. Scale jet thrust was obtained from the equation

$$F_{j,s} = B + \frac{W_{a,1}V_1}{g} + A_1(p_1 - p_0) + D$$

Rake jet thrust was calculated from gas flow and an effective-velocity parameter:

$$F_{j,r} = \frac{W_g}{g} V_{ef}$$

The effective velocity, which includes the effect of excess pressure not converted to velocity for supercritical pressure ratios, is given for an ideal convergent nozzle:

$$V_{ef} = V_N + \frac{A_N(p_N - p_0)}{W_g/g}$$

where V_N, A_N, and p_N are the velocity, the area, and the static pressure at the vena contracta. The term $V_{ef}/\sqrt{gRT_6}$ is called the effective-velocity parameter and is a function of exhaust-nozzle pressure ratio and the ratio of specific heats.

APPENDIX C

PERFORMANCE CALCULATION FROM PUMPING CHARACTERISTICS

Three methods of performance prediction based on pumping characteristics are presented to permit calculation of engine performance for most engine operating conditions.

Case A is for an engine with an exhaust nozzle of known area in which the exhaust-nozzle pressure ratio is high enough (well above critical) that the discharge coefficient is constant.

Case B is for an engine in which the exhaust-gas temperature is known, but the exhaust-nozzle area is not (e.g., where a control trims a variable-area exhaust nozzle for a desired temperature).

Case C is for an engine with an exhaust nozzle of known area when the exhaust-nozzle pressure ratio is low enough to change the discharge coefficient.

Case A

To demonstrate case A, a flight speed of 600 knots and an altitude of 15,000 feet are chosen as the flight condition. Rated engine speed and an exhaust-nozzle area of 2.388 square feet are assumed. The following quantities are known:

$$p_0 = 1193 \text{ lb/sq ft}$$

$$t_0 = 465^\circ \text{ R}$$

$$V_0 = 600 \text{ knots}$$

$$N = 7950 \text{ rpm}$$

From these quantities the following parameters may be calculated:

$$V_0 = 1013 \text{ ft/sec}$$

$$P_1 = 2149 \text{ lb/sq ft}$$

$$T_1 = 550^\circ \text{ R}$$

$$\delta_{T,1} = 1.016$$

$$\sqrt{\theta_{T,1}} = 1.030$$

$$\delta_{T,1}/\varphi\sqrt{\theta_{T,1}} = 0.940$$

$$N\sqrt{\theta_{T,1}} = 7718 \text{ rpm}$$

From figure 9,

$$W_a\sqrt{\theta_{T,1}}/\delta_{T,1} = 138.4 \text{ lb/sec}$$

$$P_6/P_1 = 2.11$$

$$T_7/T_1 = 2.94$$

and

$$W_a = 136.5 \text{ lb/sec}$$

$$P_6 = 4534 \text{ lb/sq ft}$$

$$T_7 = 1617^\circ \text{ R}$$

Fuel flow. - To calculate fuel flow and thereby obtain gas flow, the following steps are required:

$$W_aT_7 = (136.5)(1617)$$

$$= 221\times10^3$$

From figure 11,

$$\eta_b = 0.975$$

The engine temperature rise is

$$T_7 - T_1 = 1067^\circ \text{ R}$$

From reference 8,

$$(W_f/3600\ W_a)_{ideal} = 0.0149$$

Dividing by efficiency to obtain actual fuel-air ratio,

$$(W_f/3600\ W_a)_{actual} = 0.0153$$

The fuel flow is

$$W_f = 3600\ (W_a)(W_f/3600W_a)_{actual}$$

$$= 7520\ \text{lb/hr}$$

The gas flow is

$$W_g = W_a + (W_f/3600)$$

$$= 138.6\ \text{lb/sec}$$

Exhaust-nozzle-inlet pressure. - To calculate the exhaust-nozzle-inlet pressure P_7 the following steps are necessary:

$$W_g\sqrt{T_7}/P_6 = 1.229$$

From figure 12,

$$(P_6 - P_7)/P_6 = 0.0205$$

and

$$P_7 = P_6\left[1 - (P_6 - P_7)/P_6\right]$$

$$= 4441\ \text{lb/sq ft}$$

Thrust. - To calculate thrust the following steps are necessary:

$$P_7/p_0 = 3.723$$

Ratio of specific heats γ_7 for a fuel-air ratio of 0.0153 and a temperature of 1617° R is 1.334. From the exhaust-nozzle pressure ratio, the ratio of specific heats, and reference 9, the effective-velocity parameter $V_{ef}/\sqrt{gRT}$ can be found:

$$V_{ef}/\sqrt{gRT} = 1.472$$

The effective velocity is

$$V_{ef} = 1.472\sqrt{gRT_7}$$

$$= 2455\ \text{ft/sec}$$

The ideal or rake jet thrust is

$$F_{j,r} = V_{ef}W_g/g$$

$$= 10,570 \text{ lb}$$

From figure 13,

$$C_V = 0.986$$

The actual or scale jet thrust is

$$F_{j,s} = C_V F_{j,r}$$

$$= 10,420 \text{ lb}$$

Subtracting inlet momentum to get net thrust,

$$F_n = F_{j,s} - (V_0 W_a/g)$$

$$= 6126 \text{ lb}$$

Summary. - Summarizing the performance and rounding off numbers to give more realistic indications of accuracy,

$$T_7 = 1620^\circ \text{ R}$$

$$W_a = 137 \text{ lb/sec}$$

$$W_f = 7500 \text{ lb/hr}$$

$$F_n = 6100 \text{ lb}$$

Case B

To demonstrate case B, a flight speed of 600 knots and an altitude of 15,000 feet are chosen as the flight condition (the same as case A). For the engine, rated speed and limiting exhaust-gas temperature are assumed. The following quantities are known:

$$p_0 = 1193 \text{ lb/sq ft}$$

$$t_0 = 465^\circ \text{ R}$$

$$V_0 = 600 \text{ knots}$$

$$N = 7950 \text{ rpm}$$

$$T_7 = 1645^\circ \text{ R}$$

From these quantities the following parameters may be calculated:

$$V_0 = 1013 \text{ ft/sec}$$

$$P_1 = 2149 \text{ lb/sq ft}$$

$$T_1 = 550^\circ \text{ R}$$

$$\delta_{T,1} = 1.016$$

$$\sqrt{\theta_{T,1}} = 1.030$$

$$\delta_{T,1}/\varphi\sqrt{\theta_{T,1}} = 0.940$$

$$N/\sqrt{\theta_{T,1}} = 7718 \text{ rpm}$$

$$T_7/T_1 = 2.991$$

From figures 7 and 8, using the method outlined in the text,

$$W_a\sqrt{\theta_{T,1}}/\delta_{T,1} = 138.7 \text{ lb/sec}$$

$$P_6/P_1 = 2.172$$

and

$$W_a = 136.8 \text{ lb/sec}$$

$$P_6 = 4666 \text{ lb/sq ft}$$

Fuel flow. - To calculate fuel flow and thereby obtain gas flow, the following steps are required:

$$W_a T_7 = (136.8)(1645)$$

$$= 225\times 10^3$$

From figure 11,

$$\eta_b = 0.975$$

The engine temperature rise is

$$T_7 - T_1 = 1095^\circ \text{ R}$$

From reference 8,

$$(W_f/3600W_a)_{ideal} = 0.0154$$

Dividing by efficiency to obtain actual fuel-air ratio,

$$(W_f/3600W_a)_{actual} = 0.0158$$

The fuel flow is

$$W_f = 3600\ (W_a)(W_f/3600W_a)_{actual}$$

$$= 7780 \text{ lb/hr}$$

The gas flow is

$$W_g = W_a + (W_f/3600)$$

$$= 139.0 \text{ lb/sec}$$

Exhaust-nozzle-inlet pressure. - To calculate the exhaust-nozzle-inlet pressure P_7 the following steps are necessary:

$$W_g\sqrt{T_7}/P_6 = 1.208$$

From figure 12,

$$(P_6 - P_7)/P_6 = 0.0192$$

and

$$P_7 = P_6\left[1 - (P_6 - P_7)/P_6\right]$$

$$= 4576 \text{ lb/sq ft}$$

Thrust. - To calculate thrust the following steps are necessary:

$$P_7/p_0 = 3.836$$

and γ_7 for a fuel-air ratio of 0.0158 and a temperature of 1645° R is 1.332. From the exhaust-nozzle pressure ratio, the ratio of specific heats, and reference 9, the effective-velocity parameter $V_{ef}/\sqrt{gRT}$ can be found:

$$V_{ef}/\sqrt{gRT} = 1.484$$

The effective velocity is

$$V_{ef} = 1.484\sqrt{gRT_7}$$

$$= 2496 \text{ ft/sec}$$

The ideal or rake jet thrust is

$$F_{j,r} = V_{ef}W_g/g$$

$$= 10{,}780 \text{ lb}$$

From figure 13,

$$C_V = 0.987$$

The actual or scale jet thrust is

$$F_{j,s} = C_V F_{j,r}$$

$$= 10{,}640 \text{ lb}$$

Subtracting inlet momentum to get net thrust,

$$F_n = F_{j,s} - (V_0 W_a/g)$$

$$= 6335 \text{ lb}$$

Exhaust-nozzle area. - To find out whether the exhaust-gas temperature chosen is within the physical capabilities of the exhaust nozzle, calculation of the exhaust-nozzle area is necessary.

From figure 10(a),

$$C_D = 0.985$$

(The exhaust-nozzle area is expected to be smaller than 2.388 square feet, because a higher value of T_7 was used in case B than in case A. Therefore, fig. 10(a) is used.)

Using the total-to-static pressure ratio at the exit of the exhaust nozzle, the ratio of specific heats, and reference 9, the exhaust-nozzle area can be found:

Static-pressure parameter = 0.801

$$A_N = \frac{(W_g)(\sqrt{T_7})(0.801)}{1.010(C_D)(p_N)(\sqrt{g/R})}$$

$$= 2.366 \text{ sq ft}$$

(The value 1.010 was an approximate correction for thermal expansion used for all experimental data.)

Summarizing the performance and rounding off numbers to give more realistic indications of accuracy,

$$W_a = 137 \text{ lb/sec}$$

$$W_f = 7800 \text{ lb/hr}$$

$$F_n = 6300 \text{ lb}$$

$$A_N = 2.37 \text{ sq ft}$$

Case C

The similarity of the mathematical steps in cases B and C makes a numerical example of case C unnecessary. The differences between the two methods are: for case B the exhaust-gas temperature is known, while for case C it is unknown; for case B the exhaust-nozzle area is unimportant (except that it should fall within the geometrical limitations), while for case C the exhaust-nozzle area is known and is one of the factors affecting exhaust-gas temperature.

The solution of case C is accomplished as follows:

(1) Assume an exhaust-gas temperature.

(2) Solve for exhaust-nozzle area (using the steps given in case B).

(3) Assume new values of exhaust-gas temperature and solve for exhaust-nozzle area until either the desired value of area is obtained or until sufficient points have been obtained to cross-plot for performance at the desired exhaust-nozzle area.

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TABLE I. - ENGINE PERFORMANCE DATA.

(a) Inlet guide vanes open.

Run	Approximate altitude, ft	Reynolds number index, $\frac{\delta_{T,1}}{\varphi\sqrt{\theta_{T,1}}}$	Tail-pipe static pressure, p_0, $\frac{lb}{sq\ ft\ abs}$	Flight Mach number, M_0	Equivalent ambient-air static temperature, $t_{0,e}$, °R	Engine-inlet total temperature, T_1, °R	Engine-inlet total pressure, P_1, $\frac{lb}{sq\ ft\ abs}$	Turbine-inlet total temperature, T_5, °R	Turbine-outlet total temperature, T_6, °R	Turbine-outlet total pressure, P_6, $\frac{lb}{sq\ ft\ abs}$	Tail-pipe total temperature, °R: Actual, T_7	Tail-pipe total temperature, °R: Adjusted, T_7/θ_a	Tail-pipe total temperature, °R: Corrected, $T_7/\theta_{T,1}$	Tail-pipe total pressure, P_7, $\frac{lb}{sq\ ft\ abs}$	Engine speed, rpm: Actual, N	Engine speed, rpm: Adjusted, $N/\sqrt{\theta_a}$	Engine speed, rpm: Corrected, $N/\sqrt{\theta_{T,1}}$
Exhaust-nozzle area, 2.388 sq ft																	
1	0	0.922	2035	0	522	514	1932	2030	1691	4416	1632	1623	1648	4315	7955	7932	7993
2		.925	2043	0	522	514	1942	1967	1624	4280	1572	1563	1588	4184	7792	7769	7830
3		.926	2037	0	522	515	1944	1810	1470	3949	1444	1436	1456	3840	7409	7388	7438
4		.938	2039	0	520	515	1970	1560	1248	3269	1247	1245	1257	3197	6680	6673	6706
5		.959	2041	0	518	516	2014	1430	1247	2477	1212	1214	1219	2452	5498	5503	5514
6	15,000	0.862	1186	0.803	448	506	1813	2018	1654	4146	1613	1674	1655	4045	7922	8073	8023
7		.864	1187	.806	448	507	1819	1790	1446	3672	1419	1473	1456	3564	7413	7554	7508
8		.861	1176	.812	448	507	1812	1458	1161	2807	1148	1192	1176	2738	6686	6813	6764
9		.871	1189	.798	451	509	1809	1443	1157	2788	1142	1177	1165	2724	6670	6770	6735
10		.861	1176	.811	450	509	1811	1063	846	1718	839	867	856	1684	5502	5590	5556
11		.867	1183	.802	454	512	1806	1067	850	1702	848	868	860	1668	5498	5564	5536
12	25,000	0.577	769	0.818	443	502	1193	2028	1635	2766	1623	1575	1678	2692	7953	7835	8086
13		.575	775	.803	446	504	1185	1958	1581	2639	1558	1502	1605	2576	7795	7654	7910
14		.575	782	.800	447	504	1192	1790	1441	2409	1422	1368	1465	2347	7417	7275	7527
15		.575	766	.816	446	505	1185	1464	1175	1843	1152	1111	1185	1812	6688	6567	6780
16		.575	774	.811	447	506	1192	1055	844	1124	840	808	862	1100	5494	5389	5564
17	35,000	0.578	494	1.21	394	509	1209	2020	1637	2763	1618	1618	1650	2688	7953	7953	8031
18		.575	494	1.20	395	509	1201	1963	1583	2667	1560	1556	1591	2585	7792	7782	7868
19		.576	491	1.21	394	510	1206	1790	1450	2424	1424	1424	1450	2347	7420	7420	7485
20		.576	494	1.20	395	510	1204	1460	1165	1842	1149	1146	1170	1797	6682	6673	6741
21		.578	486	1.22	395	512	1209	930	718	946	722	720	732	921	5492	5485	5530
22		.362	492	.804	445	502	753	2033	1661	1738	1628	1441	1683	1694	7951	7482	8084
23		.362	485	.809	444	502	746	1960	1610	1684	1568	1391	1621	1638	7788	7336	7919
24		.367	490	.805	442	499	750	1900	1551	1628	1505	1342	1565	1585	7631	7207	7782
25		.362	490	.809	444	502	753	1800	1486	1544	1431	1270	1480	1502	7420	6990	7544
26		.367	481	.822	440	499	749	1663	1328	1394	1319	1182	1372	1355	7097	6719	7237
27		.362	502	.788	447	503	756	1478	1183	1180	1170	1031	1207	1146	6670	6262	6765
28		.367	492	.803	443	500	752	1220	957	901	955	850	991	876	6013	5671	6126
29		.362	492	.798	447	504	748	1083	867	699	866	763	892	686	5492	5156	5573
30	45,000	0.220	301	0.799	443	499	458	2020	1658	1057	1614	1433	1679	1029	7845	7393	8000
31		.223	304	.806	445	503	466	1990	1635	1048	1590	1404	1641	1020	7782	7312	7905
32		.225	307	.794	443	499	465	1940	1597	1021	1540	1366	1602	993	7653	7208	7804
33		.220	295	.819	444	503	458	1830	1490	944	1452	1287	1498	916	7405	6970	7522
34		.220	300	.804	443	500	459	1710	1379	872	1361	1208	1413	846	7106	6695	7240
35		.221	296	.818	444	503	459	1500	1211	723	1188	1052	1226	701	6867	6274	6772
36		.224	307	.800	443	500	468	1330	1049	626	1051	932	1091	607	6265	5899	6383
37		.225	310	.795	447	503	470	1140	896	445	912	803	941	435	5564	5220	5652
38	55,000	0.139	195	0.791	458	515	294	2000	1644	625	1603	1376	1616	604	7629	7069	7659
39		.137	189	.808	457	516	290	1897	1546	578	1519	1308	1528	561	7407	6875	7429
40		.135	185	.818	457	518	287	1770	1459	534	1413	1215	1416	519	7178	6657	7185
41		.138	194	.791	460	518	293	1605	1303	466	1284	1096	1287	453	6828	6308	6835
42		.137	192	.792	460	518	290	1300	1057	322	1037	885	1039	316	6011	5554	6017
43		.100	192	.417	501	518	216	1971	1637	454	1582	1242	1585	441	7506	6651	7514
44		.101	195	.417	499	517	220	1907	1597	439	1532	1205	1538	428	7345	6514	7359
45		.101	195	.418	499	517	220	1803	1494	395	1446	1138	1452	384	7080	6280	7093
46		.101	196	.403	501	517	219	1643	1350	355	1320	1036	1325	347	6678	5915	6691
47		.101	198	.399	501	517	221	1590	1366	264	1317	1033	1322	260	6002	5316	6013

TABLE I. - CONTINUED. ENGINE PERFORMANCE DATA.

(a) Continued. Inlet guide vanes open.

Run	Air flow, lb/sec: Actual, W_a	Air flow: Adjusted, $\frac{W_a\sqrt{\theta_a}}{\delta_a}$	Air flow: Corrected, $\frac{W_a\sqrt{\theta_{T,1}}}{\delta_{T,1}}$	Combustion efficiency, η_b	Combustion parameter, W_aT_7	Fuel flow, lb/hr: Actual, W_f	Fuel flow: Adjusted, $\frac{W_f}{\delta_a\sqrt{\theta_a}}$	Fuel flow: Corrected, $\frac{W_f}{\delta_{T,1}\sqrt{\theta_{T,1}}}$	Rake jet thrust $F_{j,r}$, lb	Scale jet thrust, lb: Actual, $F_{j,s}$	Scale jet thrust: Adjusted, $F_{j,s}/\delta_a$	Scale jet thrust: Corrected, $\frac{F_{j,s}}{\delta_{T,1}}$	Scale net thrust, lb: Actual, $F_{n,s}$	Scale net thrust: Adjusted, $F_{n,s}/\delta_a$	Scale net thrust: Corrected, $\frac{F_{n,s}}{\delta_{T,1}}$	Net thrust specific fuel consumption, $\frac{lb/hr}{lb\ thrust}$: Actual, $W_f/F_{n,s}$	Net thrust specific fuel consumption: Adjusted, $\frac{W_f}{F_{n,s}\sqrt{\theta_a}}$	Net thrust specific fuel consumption: Corrected, $\frac{W_f}{F_{n,s}\sqrt{\theta_{T,1}}}$	Engine temperature ratio, T_7/T_1	Engine pressure ratio, P_6/P_1
Exhaust-nozzle area, 2.388 sq ft																				
1	131.3	136.9	143.1	0.988	21.4	7480	7757	8230	8228	8181	8508	8958	8181	8508	8958	0.915	0.912	0.919	3.175	2.285
2	129.7	134.7	140.7	.979	20.4	6980	7210	7645	7800	7771	8051	8470	7771	8051	8470	.898	.895	.901	3.058	2.200
3	123.1	128.3	133.5	.979	17.8	5740	5947	6267	6725	6669	6929	7256	6669	6929	7256	.860	.858	.864	2.804	2.030
4	107.1	111.3	114.6	.992	13.4	3820	3961	4119	4628	4535	4707	4871	4535	4707	4871	.843	.842	.846	2.421	1.660
5	64.6	66.9	67.7	.982	7.83	2210	2294	2330	1796	1764	1829	1854	1764	1829	1854	1.252	1.253	1.256	2.349	1.230
6	124.0	122.4	142.9	0.977	20.0	7050	7226	8332	9343	9215	9270	10754	6002	6038	7004	1.175	1.197	1.190	3.188	2.286
7	117.3	115.7	134.7	.991	16.6	5330	5458	6278	7913	7698	7736	8953	4650	4673	5408	1.146	1.168	1.161	2.804	2.018
8	100.8	100.5	116.4	.995	11.6	3120	3223	3687	5447	5265	5339	6150	2028	2665	3070	1.187	1.210	1.201	2.264	1.550
9	99.5	98.3	115.3	.981	11.4	3080	3135	3639	5377	5186	5202	6068	2616	2624	3061	1.177	1.195	1.189	2.244	1.544
10	66.3	66.2	76.7	.981	5.56	1054	1085	1243	2053	1896	1923	2215	160	162	187	6.588	6.693	6.653	1.648	.948
11	62.5	62.3	72.8	.974	5.38	1023	1043	1207	1959	1828	1843	2142	200	202	234	5.115	5.176	5.150	1.656	.943
12	82.1	85.1	143.3	0.989	13.3	4680	4708	8442	6257	5237	6368	11064	4084	4170	7245	1.146	1.129	1.165	3.233	2.32
13	80.1	82.6	141.0	.968	12.5	4340	4317	7866	5880	5811	5887	10378	3741	3790	6681	1.160	1.139	1.177	3.091	2.23
14	76.7	78.5	134.1	.981	10.9	3540	3486	6377	5177	5057	5077	8976	3081	3093	5469	1.149	1.127	1.166	2.821	2.02
15	66.2	69.1	116.5	.960	7.62	2150	2163	3888	3612	3507	3595	6256	1771	1815	3159	1.214	1.192	1.231	2.281	1.555
16	42.3	43.7	74.1	.967	3.55	680	676	1222	1297	1146	1162	2034	42	43	75	16.19	15.88	16.39	1.660	.943
17	82.2	82.8	142.4	0.983	13.3	4650	4687	8220	6927	6763	6817	11835	3762	3792	6584	1.236	1.236	1.248	3.179	2.283
18	80.3	81.0	140.1	.985	12.5	4280	4308	7615	6600	6441	6493	11349	3517	3545	6197	1.217	1.215	1.229	3.065	2.212
19	76.7	77.8	133.5	.977	10.9	3530	3579	6250	5915	5755	5836	10100	2949	2990	5175	1.197	1.197	1.208	2.792	2.010
20	65.8	66.4	114.7	.992	7.56	2050	2063	3633	4250	4117	4150	7234	1715	1729	3013	1.195	1.193	1.205	2.253	1.530
21	43.3	44.4	75.2	1.004	3.12	415	425	731	1654	1497	1534	2620	----	----	----	-----	-----	-----	1.410	.783
22	51.6	65.5	142.7	.976	8.41	3000	2857	8571	3921	3950	3997	11100	2616	2246	7351	1.147	1.079	1.166	3.243	2.31
23	50.2	54.7	139.9	.955	7.86	2800	2709	7940	3712	3714	3814	10533	2411	2476	6838	1.161	1.094	1.180	3.124	2.26
24	50.1	53.9	138.5	.964	7.53	2600	2495	7482	3577	3546	3603	10003	2256	2292	6364	1.152	1.088	1.175	3.016	2.171
25	48.8	52.6	134.9	.971	6.89	2300	2201	6571	3330	3326	3379	9346	2060	2093	5789	1.117	1.052	1.136	2.851	2.053
26	46.1	50.4	127.8	.974	6.08	1900	1862	5474	2922	2897	2998	8184	1687	1746	4766	1.126	1.066	1.148	2.643	1.862
27	41.3	43.6	113.7	.940	4.83	1410	1313	4009	2232	2242	2224	6275	1195	1185	3345	1.180	1.108	1.199	2.326	1.56
28	34.9	37.5	96.5	.934	3.34	800	764	2294	1444	1449	1466	4007	550	557	1548	1.455	1.372	1.482	1.910	1.198
29	25.6	27.6	71.4	.984	2.22	438	416	1257	777	800	810	2263	142	144	402	3.085	2.896	3.131	1.718	.935
30	30.9	33.5	139.9	0.927	4.98	1870	1803	8810	2332	2365	2419	10926	1575	1611	7277	1.187	1.119	1.210	3.234	2.31
31	31.1	33.5	138.9	.952	4.94	1781	1695	8215	2311	2338	2368	10617	1533	1553	6961	1.162	1.092	1.180	3.161	2.25
32	30.7	32.7	137.2	.955	4.73	1668	1576	7741	2222	2219	2226	10099	1436	1440	6535	1.162	1.094	1.185	3.086	2.196
33	29.1	32.3	132.4	.938	4.23	1456	1431	6833	2013	2054	2144	9489	1289	1346	5955	1.130	1.064	1.148	2.887	2.06
34	28.3	30.9	128.2	.953	3.86	1258	1217	5909	1826	1809	1858	8339	1079	1108	4974	1.166	1.098	1.188	2.722	1.90
35	25.3	28.0	115.1	.967	3.01	880	862	4121	1407	1384	1441	6380	719	748	3315	1.224	1.152	1.243	2.362	1.574
36	22.9	24.4	101.5	.972	2.40	620	586	2856	1073	1078	1081	4874	491	492	2220	1.263	1.189	1.287	2.102	1.338
37	16.3	17.2	72.2	.829	1.48	375	350	1715	512	557	547	2481	134	133	603	2.799	2.626	2.843	1.813	.947
38	17.9	18.9	128.3	0.908	2.87	1080	979	7793	1305	1309	1282	9409	847	830	6090	1.275	1.181	1.280	3.113	2.122
39	17.3	18.8	125.5	.906	2.62	953	894	6971	1203	1191	1204	8687	738	746	5380	1.292	1.199	1.296	2.944	1.992
40	16.6	18.4	122.0	.925	2.34	790	756	5832	1087	1079	1114	7958	638	658	4606	1.238	1.148	1.239	2.728	1.861
41	15.5	16.5	111.5	.930	1.98	620	564	4482	887	----	----	----	---	---	----	-----	-----	-----	2.479	1.590
42	11.1	12.0	81.2	.883	1.16	310	285	2263	450	452	450	3296	164	163	1194	1.893	1.749	1.895	2.002	1.110
43	12.8	14.4	124.8	.887	2.02	770	679	7537	814	806	802	7881	624	621	6104	1.233	1.093	1.234	3.054	2.098
44	12.6	13.9	121.2	.906	1.93	705	612	6800	770	752	737	7240	573	561	5514	1.231	1.092	1.233	2.963	1.997
45	11.8	13.0	113.0	.903	1.70	600	521	5782	652	649	636	6242	481	472	4630	1.246	1.105	1.248	2.797	1.795
46	10.9	11.9	104.7	.915	1.43	466	402	4509	530	499	486	4819	350	341	3380	1.331	1.179	1.334	2.553	1.620
47	7.2	7.8	68.4	.844	.94	332	284	3185	245	---	---	----	---	---	----	-----	-----	-----	2.547	1.195

TABLE I. - CONTINUED. ENGINE PERFORMANCE DATA.

(a) Continued. Inlet guide vanes open.

Run	Approximate altitude, ft	Reynolds number index, $\frac{\delta_{T,1}}{\varphi\sqrt{\theta_{T,1}}}$	Tail-pipe static pressure, p_0, $\frac{lb}{sq\ ft\ abs}$	Flight Mach number, M_0	Equivalent ambient-air static temperature, $t_{0,e}$, °R	Engine-inlet total temperature, T_1, °R	Engine-inlet total pressure, P_1, $\frac{lb}{sq\ ft\ abs}$	Turbine-inlet total temperature, T_5, °R	Turbine-outlet total temperature, T_6, °R	Turbine-outlet total pressure, P_6, $\frac{lb}{sq\ ft\ abs}$	Tail-pipe total temperature, °R			Tail-pipe total pressure, P_7, $\frac{lb}{sq\ ft\ abs}$	Engine speed, rpm		
											Actual, T_7	Adjusted, T_7/θ_a	Corrected, $T_7/\theta_{T,1}$		Actual, N	Adjusted, $N/\sqrt{\theta_a}$	Corrected, $N/\sqrt{\theta_{T,1}}$
Exhaust-nozzle area, 2.514 sq ft																	
48	0	0.942	2060	0	514	505	1943	1940	1596	4218	1533	1548	1576	4140	7945	7985	8055
49		.938	2052	0	514	506	1937	1880	1535	4115	1483	1498	1522	4034	7790	7829	7889
50		.947	2058	0	514	506	1952	1763	1413	3855	1392	1406	1428	3775	7417	7454	7512
51		.942	2048	0	514	506	1942	1760	1400	3832	1386	1403	1425	3756	7409	7446	7504
52		.955	2048	0	512	506	1969	1527	1221	3261	1220	1237	1252	3208	6665	6712	6750
53		.956	2052	0	513	507	1972	1530	1224	3271	1224	1239	1253	3220	6670	6710	6748
54		.984	2065	0	509	507	2036	1433	1237	2513	1214	1238	1243	2494	5489	5544	5553
55		.984	2061	0	510	508	2034	1450	1252	2520	1232	1254	1259	2496	5489	5538	5548
56	15,000	0.828	1058	0.840	441	503	1679	1930	1549	3740	1500	1581	1548	3657	7941	8155	8066
57		.890	1183	.806	445	503	1812	1930	1552	3873	1496	1563	1544	3790	7939	8114	8064
58		.885	1171	.808	443	501	1797	1850	1492	3749	1452	1525	1504	3666	7794	7989	7933
59		.885	1171	.808	442	500	1798	1693	1351	3446	1326	1395	1377	3364	7422	7615	7562
60		.897	1193	.799	444	501	1816	1415	1116	2721	1106	1158	1146	2680	6699	6853	6818
61		.897	1198	.799	445	502	1823	1050	836	1720	832	869	860	1699	5473	5593	5565
62	25,000	0.582	777	0.806	442	499	1191	1925	1531	2563	1513	1473	1574	2504	7947	7842	8104
63		.584	780	.809	444	502	1200	1853	1482	2503	1456	1410	1506	2443	7790	7667	7921
64		.580	780	.806	443	501	1195	1703	1350	2276	1332	1292	1380	2217	7415	7302	7547
65		.582	784	.803	443	500	1198	1415	1111	1798	1113	1081	1155	1766	6678	6580	6804
66		.581	779	.804	443	500	1192	1080	844	1140	855	830	887	1127	5530	5449	5634
67	35,000	0.583	473	1.23	388	505	1193	1907	1524	2529	1500	1523	1542	2460	7968	8024	8078
68		.583	468	1.24	386	505	1193	1833	1458	2451	1440	1470	1480	2378	7786	7864	7893
69		.583	469	1.24	387	506	1194	1670	1323	2218	1315	1339	1349	2166	7413	7480	7508
70		.580	478	1.22	392	510	1198	1373	1076	1684	1068	1073	1087	1646	6678	6691	6737
71		.581	493	1.21	399	515	1208	895	682	868	690	681	696	848	5432	5398	5453
72		.373	494	.806	441	498	757	1930	1553	1636	1524	1362	1588	1601	7945	7511	8111
73		.430	483	.815	391	443	747	1897	1517	1746	1498	1510	1756	1702	7945	7977	8599
74		.371	498	.798	444	500	757	1853	1510	1579	1454	1292	1509	1548	7788	7340	7935
75		.430	491	.808	394	445	754	1753	1418	1633	1377	1377	1606	1588	7625	7625	8234
76		.371	492	.809	441	499	756	1715	1357	1449	1346	1202	1400	1418	7402	6994	7548
77		.428	490	.806	395	446	751	1500	1187	1401	1177	1174	1370	1365	6947	6938	7494
78		.370	502	.792	445	501	759	1435	1126	1126	1130	1000	1171	1102	6670	6276	6789
79		.362	486	.808	444	502	746	1067	847	682	856	759	885	674	5432	5116	5523
80	45,000	0.263	310	0.973	396	446	469	1920	1554	1069	1519	1507	1768	1044	7945	7912	8571
81		.263	309	.792	397	447	467	1773	1433	1001	1398	1383	1623	974	7619	7579	8209
82		.230	304	.813	438	496	469	1917	1554	1009	1508	1353	1577	987	7941	7522	8123
83		.225	296	.820	437	496	460	1860	1512	964	1460	1312	1527	943	7795	7390	7974
84		.226	294	.830	437	497	462	1715	1363	878	1345	1210	1404	859	7390	7010	7552
85		.269	316	.788	397	446	476	1523	1211	858	1198	1187	1394	835	6932	6899	7478
86		.224	295	.821	438	497	459	1443	1121	693	1134	1018	908	675	6667	6316	6813
87		.227	306	.800	442	498	466	1093	879	435	870	774	907	725	5504	5193	5619
88	55,000	0.160	193	0.793	407	458	292	1963	1595	643	1554	1501	1761	629	7953	7815	8466
89		.140	193	.793	441	496	292	2017	1610	630	1604	1429	1678	619	7983	7536	8166
90		.157	186	.795	407	459	283	1830	1483	595	1443	1391	1632	581	7627	7494	8110
91		.140	190	.802	440	496	290	1940	1534	602	1537	1373	1608	590	7771	7344	7949
92		.138	187	.808	440	497	287	1797	1400	543	1423	1271	1486	533	7384	6979	7545
93		.155	184	.809	408	462	283	1543	1232	490	1219	1174	1369	476	6860	6732	7271
94		.138	184	.820	439	498	286	1490	1155	417	1176	1053	1225	409	6646	6288	6785
95		.134	182	.813	441	499	281	1147	923	265	918	881	955	263	5528	5218	5637
96		.124	197	.455	442	460	227	2007	1637	503	1595	1418	1799	492	7951	7497	8446
97		.123	192	.475	441	461	224	1893	1540	479	1499	1336	1688	468	7642	7174	8108
98		.105	189	.478	475	497	221	2030	1633	479	1609	1331	1680	469	7926	7209	8099
99		.105	190	.485	475	497	223	2037	1636	478	1623	1343	1694	468	7884	7171	8056
100		.104	187	.487	474	496	220	1990	1592	463	1586	1315	1659	451	7742	7049	7919
101		.107	193	.467	797	224	224	1880	1476	436	1496	1235	1562	428	7436	6756	7599
102		.124	195	.471	443	463	227	1660	1336	406	1315	1167	1474	394	6996	6590	7407
103		.106	192	.460	477	497	222	1555	1259	347	1236	1018	1290	341	6634	6022	6779
104		.105	177	.584	466	498	223	1373	1129	269	1105	932	1151	266	6112	5613	6240
105		.105	187	.539	472	499	228	1377	1156	257	1125	937	1170	257	5786	5280	5900

TABLE I. - CONTINUED. ENGINE PERFORMANCE DATA.

(a) Continued. Inlet guide vanes open.

Run	Air flow, lb/sec: Actual, W_a	Air flow: Adjusted, $\frac{W_a\sqrt{\theta_a}}{\delta_a}$	Air flow: Corrected, $\frac{W_a\sqrt{\theta_{T,1}}}{\delta_{T,1}}$	Combustion efficiency, η_b	Combustion parameter, W_aT_7	Fuel flow, lb/hr: Actual, W_f	Fuel flow: Adjusted, $\frac{W_f}{\delta_a\sqrt{\theta_a}}$	Fuel flow: Corrected, $\frac{W_f}{\delta_{T,1}\sqrt{\theta_{T,1}}}$	Rake jet thrust $F_{j,r}$ lb	Scale jet thrust, lb: Actual, $F_{j,s}$	Scale jet thrust: Adjusted, $F_{j,s}/\delta_a$	Scale jet thrust: Corrected, $\frac{F_{j,s}}{\delta_{T,1}}$	Scale net thrust, lb: Actual, $F_{n,s}$	Scale net thrust: Adjusted, $F_{n,s}/\delta_a$	Scale net thrust: Corrected, $\frac{F_{n,s}}{\delta_{T,1}}$	Net thrust specific fuel consumption, $\frac{lb/hr}{lb\ thrust}$: Actual, $W_f/F_{n,s}$	Net thrust specific fuel consumption: Adjusted, $\frac{W_f}{F_{n,s}\sqrt{\theta_a}}$	Net thrust specific fuel consumption: Corrected, $\frac{W_f}{F_{n,s}\sqrt{\theta_{T,1}}}$	Engine temperature ratio, T_7/T_1	Engine pressure ratio, P_6/P_1
Exhaust-nozzle area, 2.514 sq ft																				
48	134.3	137.2	144.2	0.975	20.6	7075	7302	7811	7766	7792	8003	8485	7792	8003	8485	0.909	0.913	0.921	3.036	2.171
49	131.3	134.7	141.6	.965	19.5	6600	6839	7299	7355	7373	7602	8051	7373	7602	8051	.895	.900	.906	2.931	2.124
50	125.8	128.7	134.6	.984	17.5	5585	5770	6131	6848	6493	6675	7038	6493	6675	7038	.861	.865	.873	2.751	1.975
51	125.0	128.5	134.4	.973	17.4	5585	5798	6165	6425	6450	6663	7031	6450	6663	7031	.867	.871	.878	2.745	1.973
52	108.1	110.9	114.7	.965	13.2	3875	4031	4219	4519	4516	4665	4855	4516	4665	4855	.878	.883	.890	2.411	1.656
53	108.6	111.3	115.2	.973	13.3	3875	4019	4207	4555	4540	4681	4871	4540	4681	4871	.853	.857	.864	2.414	1.659
54	65.5	66.5	67.3	.986	7.95	2270	2350	2386	1800	1827	1873	1898	1827	1873	1898	1.243	1.256	1.259	2.394	1.234
55	63.3	64.4	65.2	.965	7.80	2300	2383	2418	1766	1766	1814	1832	1766	1814	1832	1.304	1.316	1.317	2.425	1.239
56	119.6	131.4	148.2	0.938	17.9	6320	7321	8089	8680	8637	9743	10883	5422	6116	6832	1.166	1.197	1.183	2.982	2.228
57	125.0	123.3	143.7	.973	18.7	6320	6511	7498	8872	8705	8775	10167	5469	5513	6388	1.156	1.181	1.194	2.974	2.137
58	123.2	122.5	142.6	.968	17.9	5970	6235	7158	8540	8390	8549	9883	5200	4299	6126	1.148	1.177	1.168	2.898	2.086
59	117.7	116.9	136.0	.967	15.6	4925	5149	5906	7532	7388	7528	8696	4344	4427	5113	1.134	1.153	1.155	2.652	1.917
60	103.1	100.8	118.1	.994	11.4	2990	3059	3545	5358	5146	5146	5995	2502	2502	2915	1.195	1.222	1.216	2.208	1.498
61	67.0	65.3	76.5	1.023	5.57	1012	1030	1195	2039	1891	1883	2195	171	170	199	5.918	6.048	6.017	1.657	.944
62	82.3	84.2	143.4	0.974	12.4	4250	4179	7702	5880	5787	5845	10283	3664	3701	6511	1.160	1.145	1.183	3.032	2.152
63	81.5	83.4	141.4	.967	11.9	3980	3941	7134	5664	5557	5590	9797	3439	3460	6063	1.157	1.139	1.176	2.900	2.086
64	77.4	79.1	134.7	.972	10.3	3240	3210	5840	4946	4845	4874	8580	2844	2861	5037	1.139	1.122	1.159	2.659	1.905
65	67.9	69.0	117.7	.997	7.56	2000	1973	3599	3551	3370	3373	5951	1622	1624	2864	1.233	1.215	1.256	2.226	1.501
66	44.3	45.3	77.2	1.040	3.79	710	705	1284	1404	1318	1329	2339	176	177	312	4.034	3.975	4.110	1.710	.956
67	81.1	84.8	142.0	0.960	12.2	4160	4411	7482	6492	6424	6764	11396	3429	3611	6083	1.213	1.221	1.230	2.970	2.120
68	79.9	84.2	139.9	.958	11.5	3840	4127	6906	6235	6261	6662	11107	3298	3509	5851	1.164	1.176	1.180	2.851	2.054
69	77.0	81.1	134.8	.988	10.1	3070	3289	5509	5616	5396	5731	9562	2537	2694	4496	1.210	1.221	1.225	2.599	1.858
70	65.7	68.3	115.1	.986	7.02	1772	1850	3157	3991	3872	4035	6838	1444	1505	2550	1.227	1.229	1.238	2.094	1.406
71	40.3	41.0	70.4	.984	2.78	338	339	594	1371	1285	1298	2251	----	----	----	-----	-----	-----	1.340	.719
72	52.0	55.4	142.4	.965	7.93	2750	2621	7847	3742	3648	3677	10196	2308	2326	6451	1.192	1.127	1.217	3.060	2.161
73	55.5	57.0	145.2	.969	8.31	2970	3074	9107	4038	4055	4181	11488	2692	2775	7626	1.103	1.107	1.194	3.381	2.337
74	57.5	54.6	141.2	.954	7.48	2550	2403	7262	3562	3487	3487	9746	2170	2170	6065	1.175	1.107	1.197	2.908	2.086
75	54.9	55.6	142.5	.983	7.55	2550	2586	7727	3739	3714	3766	10421	2373	2406	6659	1.075	1.075	1.161	3.094	2.166
76	49.4	52.9	135.7	.976	6.65	2100	2008	5994	3192	3091	3128	8652	1812	1834	5072	1.159	1.095	1.182	2.697	1.917
77	50.3	51.2	131.4	.958	5.92	1843	1870	5603	2993	2991	3039	8429	1763	1791	4968	1.045	1.044	1.127	2.639	1.866
78	42.0	44.3	115.1	.970	4.75	1308	1221	3712	2181	2076	2059	5788	1007	999	2808	1.299	1.222	1.322	2.255	1.484
79	24.6	26.8	68.7	.872	2.11	470	454	1355	738	719	737	2039	80	83	2283	5.839	5.500	5.937	1.705	.914
80	34.4	34.3	143.7	0.980	5.22	1870	1850	9102	2499	2459	2443	11093	1633	1622	7368	1.145	1.140	1.235	3.406	2.279
81	33.4	33.5	140.5	.954	4.67	1636	1622	7987	2277	2255	2248	10217	1452	1447	6579	1.127	1.121	1.214	3.128	2.144
82	32.2	34.4	142.0	.945	4.86	1718	1648	7929	2306	2255	2284	10175	1420	1438	7929	1.210	1.146	1.238	3.040	2.150
83	31.1	34.1	139.7	.928	4.53	1595	1573	7505	2174	2135	2220	9821	1324	1377	7505	1.205	1.142	1.233	2.944	2.095
84	30.3	33.4	135.7	.960	4.07	1309	1301	6126	1966	1895	1986	8679	1095	1148	6126	1.195	1.134	1.221	2.706	1.900
85	31.1	30.4	128.0	.951	3.72	1183	1148	5673	1825	1803	1757	8014	1060	1033	4712	1.116	1.111	1.204	2.686	1.803
86	26.0	28.7	117.4	.998	2.95	798	789	3759	1385	----	----	----	----	----	3759	-----	-----	-----	2.282	1.510
87	16.3	17.4	72.6	.839	1.42	343	326	1590	494	500	504	2271	82	83	1590	4.183	3.947	4.271	1.747	.934
88	20.8	21.0	142.0	0.967	3.24	1183	1150	9138	1527	1437	1422	10427	930	920	6748	1.272	12.50	1.354	3.393	2.204
89	20.0	21.0	141.6	.983	3.20	1131	1056	8384	1471	1420	1405	10291	912	903	6609	1.240	1.171	1.268	3.234	2.160
90	20.0	20.9	141.0	.956	2.89	1003	1012	7989	1367	1287	1322	9640	798	820	5977	1.257	1.235	1.337	3.144	2.106
91	19.3	20.6	138.0	.980	2.97	1023	972	7636	1378	1332	1339	9720	837	841	6108	1.222	1.155	1.250	3.099	2.080
92	18.3	19.7	131.7	.975	2.60	852	822	6419	1210	1171	1196	8634	700	715	5162	1.217	1.150	1.244	2.863	1.890
93	18.1	19.1	127.5	.967	2.20	685	698	5432	1069	987	1025	7385	537	557	4018	1.276	1.252	1.352	2.639	1.733
94	15.7	17.2	113.8	.976	1.85	523	514	3951	839	---	----	----	---	----	----	-----	-----	-----	2.361	1.460
95	9.0	10.0	66.7	.746	.83	242	240	1858	297	328	344	2470	93	98	700	2.602	2.456	2.653	1.840	.943
96	16.0	16.5	140.6	.963	2.55	948	867	9395	1073	1023	918	9545	790	688	7371	1.199	1.131	1.274	3.467	2.218
97	15.6	16.5	139.0	.966	2.33	842	786	8453	1005	947	947	8961	710	706	6718	1.186	1.110	1.258	3.252	2.142
98	14.7	16.4	138.1	.928	2.37	890	818	8705	986	973	984	9316	739	747	7076	1.204	1.095	1.230	3.237	2.170
99	14.9	16.4	138.0	.952	2.41	881	805	8543	993	980	985	9299	741	745	7031	1.189	1.082	1.215	3.266	2.143
100	14.7	16.5	138.3	.966	2.33	830	772	8166	948	932	952	8964	694	709	6675	1.196	1.089	1.223	3.198	2.104
101	14.0	15.2	129.3	.984	2.09	705	634	6805	847	815	807	7698	598	592	5649	1.179	1.071	1.205	3.010	1.945
102	14.4	14.9	126.4	.969	1.89	615	567	6007	771	711	696	6629	494	484	4606	1.245	1.173	1.318	2.840	1.789
103	11.6	12.7	108.3	.902	1.44	458	414	4461	549	528	525	5033	350	348	3336	1.309	1.188	1.338	2.487	1.563
104	9.6	11.2	88.8	.852	1.06	325	322	3148	363	---	---	----	---	---	----	-----	-----	-----	2.219	-----
105	8.4	9.4	76.7	.861	.95	295	275	2792	287	---	---	----	---	---	----	-----	-----	-----	2.255	1.128

TABLE I. - CONTINUED. ENGINE PERFORMANCE DATA.

(a) Continued. Inlet guide vanes open.

Run	Approximate altitude, ft	Reynolds number index, $\delta_{T,1}/\varphi\sqrt{\theta_{T,1}}$	Tail-pipe static pressure, p_0, lb/sq ft abs	Flight Mach number, M_0	Equivalent ambient-air static temperature, $t_{0,e}$, °R	Engine-inlet total temperature, T_1, °R	Engine-inlet total pressure, P_1, lb/sq ft abs	Turbine-inlet total temperature, T_5, °R	Turbine-outlet total temperature, T_6, °R	Turbine-outlet total pressure, P_6, lb/sq ft abs	Tail-pipe total temperature, °R			Tail-pipe total pressure, P_7, lb/sq ft abs	Engine speed, rpm		
											Actual, T_7	Adjusted, T_7/θ_a	Corrected, $T_7/\theta_{T,1}$		Actual, N	Adjusted, $N/\sqrt{\theta_a}$	Corrected, $N/\sqrt{\theta_{T,1}}$
Exhaust-nozzle area, 2.694 sq ft																	
106	0	0.938	2053	0	514	505	1933	1807	1445	3851	1403	1417	1442	3762	7955	7995	8065
107		.942	2059	0	514	505	1942	1750	1400	3772	1358	1372	1396	3664	7788	7827	7895
108		.942	2050	0	513	505	1944	1640	1304	3547	1272	1287	1308	3458	7420	7465	7522
109		.958	2056	0	511	505	1976	1455	1151	3083	1148	1166	1180	3032	6686	6739	6778
110		.978	2035	0	513	506	2004	1360	1163	2424	1140	1154	1170	2403	5498	5531	5568
111	15,000	0.888	1180	0.805	445	503	1806	1736	1384	3458	1333	1393	1375	3363	7953	8128	8078
112		.888	1183	.802	447	504	1805	1680	1334	3343	1292	1344	1331	3247	7786	7942	7901
113		.890	1191	.798	447	504	1812	1550	1210	3061	1194	1242	1230	2981	7415	7563	7525
114		.891	1188	.803	448	506	1815	1315	1011	2420	1005	1043	----	2382	6678	6805	6763
115		.890	1194	.795	450	507	1810	1010	791	1585	798	824	817	1562	5411	5498	5475
116	25,000	0.585	775	0.814	445	504	1197	1750	1382	2283	1347	1302	1387	2206	7949	7814	8067
117		.585	774	.813	445	504	1195	1700	1327	2202	1307	1263	1346	2135	7795	7662	7910
118		.585	776	.811	445	504	1195	1560	1209	2011	1199	1159	1235	1965	7411	7285	7521
119		.580	769	.815	446	505	1189	1323	1013	1580	1015	979	----	1552	6674	6553	6766
120		.585	778	.811	448	507	1198	1015	788	1045	801	769	820	1029	5445	5334	5509
121	35,000	0.596	486	1.22	384	498	1207	1773	1387	2321	1366	1402	1423	2236	7955	8058	8121
122		.591	479	1.22	---	499	1200	1707	1332	2244	1317	1351	1370	2167	7794	7895	7948
123		.582	468	1.24	382	500	1195	1577	1216	2049	1216	1254	1262	1987	7441	7553	7581
124		.582	477	1.23	386	503	1199	1300	990	1583	992	1013	1024	1535	6686	6753	6791
125		.579	482	1.21	391	506	1188	867	649	860	670	665	677	835	5470	5492	5540
126		.427	478	.816	392	444	497	1770	1396	1558	1373	1381	1605	1506	7964	7988	8611
127		.427	482	.812	392	444	490	1627	1290	1468	1255	1260	1467	1416	7619	7634	8238
128		.370	498	.799	447	504	758	1763	1412	1441	1354	1193	1395	1395	7953	7466	8071
129		.368	485	.809	439	497	746	1685	1340	1311	1297	1163	1354	1292	7794	7380	7964
130		.370	503	.793	448	504	761	1703	1346	1394	1309	1151	1348	1348	7792	7307	7907
131		.371	495	.803	440	497	757	1570	1232	1301	1207	1080	1260	1264	7420	7019	7582
132		.370	498	.798	447	504	757	1573	1226	1259	1212	1068	1248	1224	7400	6947	7510
133		.428	480	.813	391	443	485	1393	1069	1246	1067	1074	1251	1204	6930	6951	7501
134		.376	502	.806	441	498	769	1324	1016	1036	1016	908	1059	1016	6669	6305	6809
135		.370	501	.794	444	500	759	1010	796	674	800	710	830	664	5428	5113	5530
136	45,000	0.267	298	0.828	390	443	467	1790	1417	973	1388	1400	1627	940	7964	8000	8620
137		.269	306	.819	391	443	475	1653	1312	920	1278	1286	1498	889	7614	7637	8241
138		.267	298	.826	391	444	466	1613	1273	897	1248	1255	1459	866	7506	7529	8115
139		.229	307	.809	441	499	472	1793	1406	897	1390	1238	1446	869	7930	7484	8087
140		.230	314	.795	444	500	476	1800	1409	903	1396	1236	1449	875	7905	7438	8054
141		.227	302	.813	441	499	466	1750	1363	870	1356	1209	1410	844	7795	7362	7949
142		.227	308	.802	443	500	470	1730	1358	864	1339	1188	1390	837	7775	7322	7922
143		.223	301	.806	443	500	461	1620	1261	789	1254	1113	1302	768	7420	6992	7560
144		.267	301	.809	392	443	463	1413	1096	778	1093	1096	1281	750	6924	6934	7494
145		.226	309	.794	444	500	468	1355	1040	629	1046	926	1086	615	6674	6279	6800
146		.229	320	.778	449	503	477	1060	845	427	839	735	866	415	5472	5121	5558
147	55,000	0.132	179	0.815	439	497	277	1860	1503	549	1442	1291	1505	531	7970	7541	8144
148		.148	188	.795	441	497	285	1767	1422	529	1366	1217	1426	513	7771	7336	7941
149		.138	195	.786	443	498	293	1647	1319	502	1274	1130	1328	487	7449	7016	7605
150		.138	198	.777	444	498	295	1327	1044	379	1021	904	1064	366	6547	6159	6684
151		.135	192	.777	445	499	286	1173	919	270	922	814	959	266	5786	5437	5900
152		.103	193	.388	483	498	214	1925	1562	421	1506	1225	1569	408	7938	7161	8104
153		.125	193	.430	479	497	219	1837	1484	409	1432	1175	1495	396	7714	6987	7883
154		.118	200	.422	481	498	226	1697	1368	385	1324	1082	1380	373	7369	6661	7523
155		.112	204	.475	476	498	238	1433	1230	367	1197	988	1247	357	6915	6283	7060
156		.110	202	.370	487	500	222	1410	1155	300	1121	905	1164	293	6348	5702	6468

TABLE I. - CONTINUED. ENGINE PERFORMANCE DATA.

(a) Continued. Inlet guide vanes open.

Run	Air flow, lb/sec			Combustion efficiency, η_b	Combustion parameter, W_aT_7	Fuel flow, lb/hr			Rake jet thrust, $F_{j,r}$, lb	Scale jet thrust, lb			Scale net thrust, lb			Net thrust specific fuel consumption, $\frac{lb/hr}{lb\ thrust}$			Engine temperature ratio, T_7/T_1	Engine pressure ratio, P_6/P_1
	Actual, W_a	Adjusted, $\frac{W_a\sqrt{\theta_a}}{\delta_a}$	Corrected, $\frac{W_a\sqrt{\theta_{T,1}}}{\delta_{T,1}}$			Actual, W_f	Adjusted, $\frac{W_f}{\delta_a\sqrt{\theta_a}}$	Corrected, $\frac{W_f}{\delta_{T,1}\sqrt{\theta_{T,1}}}$		Actual, $F_{j,s}$	Adjusted, $F_{j,s}/\delta_a$	Corrected, $\frac{F_{j,s}}{\delta_{T,1}}$	Actual, $F_{n,s}$	Adjusted, $F_{n,s}/\delta_a$	Corrected, $\frac{F_{n,s}}{\delta_{T,1}}$	Actual, $W_f/F_{n,s}$	Adjusted, $\frac{W_f}{F_{n,s}\sqrt{\theta_a}}$	Corrected, $\frac{W_f}{F_{n,s}\sqrt{\theta_{T,1}}}$		
Exhaust-nozzle area, 2.694 sq ft																				
106	133.2	136.7	143.9	0.963	18.7	6125	6347	6799	6890	6941	7156	7600	6941	7156	7600	0.883	0.887	0.895	2.778	1.992
107	131.7	134.7	141.6	.958	17.9	5750	5941	6354	6545	6584	6768	7177	6584	6768	7177	.873	.877	.885	2.689	1.942
108	125.6	128.9	134.8	.959	16.0	4890	5076	5394	5765	5830	6017	6343	5830	6017	6343	.840	.844	.852	2.519	1.825
109	108.9	111.1	115.0	.962	12.5	3500	3631	3800	4117	4151	4271	4446	4151	4271	4446	.843	.847	.855	2.273	1.560
110	68.1	70.4	71.1	.988	7.76	2100	2197	2246	1704	1721	1790	1817	1721	1790	1817	1.220	1.225	1.234	2.253	1.210
111	124.8	123.5	144.1	0.941	16.6	5380	5559	6405	7992	7877	7964	9232	4650	4701	5450	1.157	1.182	1.175	2.650	1.915
112	122.8	121.3	141.8	.957	15.9	4930	5069	5864	7615	7557	7617	8857	4388	4423	5143	1.124	1.146	1.141	2.563	1.852
113	117.7	115.6	135.5	.973	14.1	4030	4119	4777	6728	6543	6556	7642	3517	3524	4108	1.147	1.169	1.163	2.369	1.689
114	101.0	99.5	116.2	.998	10.2	2390	2445	2822	4668	----	----	----	----	----	----	-----	-----	-----	1.986	1.333
115	63.9	62.7	73.6	1.016	5.09	852	865	1008	1677	1532	1531	1791	----	----	----	-----	-----	-----	1.574	.876
116	82.5	85.0	143.7	0.972	11.1	3500	3485	6280	5251	5203	5271	9199	3045	3085	5384	1.149	1.129	1.166	2.673	1.907
117	80.8	83.4	141.1	.962	10.6	3290	3279	5913	5056	4970	5040	8802	2857	2897	5060	1.152	1.132	1.169	2.593	1.843
118	77.2	79.5	134.7	.971	9.25	2665	2651	4790	4447	4331	4383	7670	2320	2348	4109	1.149	1.129	1.166	2.379	1.683
119	66.7	69.4	117.2	1.006	6.77	1615	1619	2914	3116	----	----	----	----	----	----	-----	-----	-----	2.010	1.329
120	42.3	43.6	73.9	1.006	3.39	579	572	1035	1137	1020	1029	1801	----	----	----	-----	-----	-----	1.580	.872
121	82.9	83.9	142.4	0.984	11.3	3580	3718	6407	6169	6073	6225	10642	3055	3131	5355	1.172	1.187	1.197	2.743	1.923
122	82.3	84.5	142.2	.990	10.8	3310	3487	5951	5981	5788	6020	10204	2778	2889	4898	1.192	1.207	1.216	2.639	1.870
123	78.4	82.1	136.2	.981	9.53	2770	2991	4998	5379	4923	5238	8719	2030	2160	3595	1.365	1.385	1.391	2.432	1.715
124	67.7	70.0	117.7	.992	6.71	1573	1658	2820	3871	3735	3899	6592	1246	1301	2199	1.262	1.275	1.282	1.972	1.320
125	43.1	44.3	75.8	.995	2.84	309	320	557	1441	1297	1340	2310	----	----	----	-----	-----	-----	1.304	.724
126	54.8	56.9	144.8	.964	7.52	2590	2707	8006	3696	3738	3895	10687	2391	2491	6836	1.083	1.086	1.171	3.092	2.105
127	54.1	55.7	142.4	.967	6.78	2200	2278	6774	3396	3395	3507	9669	2071	2139	5898	1.062	1.064	1.148	2.827	1.976
128	51.7	55.1	142.3	.934	2.62	2300	2159	6517	3317	3224	3224	9001	1893	1893	5285	1.215	1.141	1.233	2.687	1.901
129	50.8	55.1	140.9	.941	6.59	2095	2037	6071	3120	3167	3253	8982	1854	1904	5258	1.130	1.070	1.155	2.610	1.76
130	50.6	53.5	138.7	.997	2.59	2100	1950	5928	3133	3046	3016	8471	1752	1735	4872	1.199	1.124	1.217	2.597	1.832
131	48.7	51.8	133.3	.953	5.88	1758	1673	5021	2828	2789	2806	7795	1537	1546	4296	1.144	1.082	1.169	2.429	1.72
132	48.4	51.6	133.3	.960	2.50	1718	1613	4873	2766	2697	2697	7538	1454	1454	4064	1.182	1.110	1.200	2.405	1.663
133	50.6	52.3	133.4	.972	5.39	1573	1607	4770	2729	2688	2790	7677	1449	1504	4138	1.065	1.068	1.153	2.409	1.682
134	43.4	45.6	117.1	1.006	4.41	1069	1003	3003	2031	----	----	----	----	----	----	-----	-----	-----	2.040	1.348
135	24.9	26.3	68.1	.866	1.99	405	379	1150	670	684	680	1907	49	49	137	8.265	7.786	8.421	1.600	.884
136	34.8	35.8	145.7	0.968	4.83	1666	1730	8170	2362	2304	2382	10439	1438	1487	6516	1.159	1.164	1.254	3.133	2.084
137	34.3	34.4	141.2	.982	4.38	1432	1446	6905	2165	2120	2135	9445	1275	1284	5680	1.123	1.126	1.215	2.885	1.937
138	33.9	35.0	142.4	.991	42.3	1330	1379	6530	2113	2073	2143	9413	1229	1271	5581	1.082	1.085	1.170	2.811	1.925
139	31.8	33.8	139.8	.973	4.42	1437	1360	6570	2077	2053	2059	9204	1230	1234	5514	1.168	1.02	1.191	2.786	1.900
140	31.5	32.8	137.4	.979	4.40	1420	1311	6431	2048	2059	2020	9152	1255	1231	5578	1.131	1.064	1.152	2.792	1.897
141	31.6	34.1	140.7	.995	4.29	1335	1286	6182	2025	1983	2023	9005	1162	1185	5277	1.149	1.085	1.172	2.717	1.868
142	31.3	33.2	138.4	.958	4.19	1338	1260	6137	1972	1855	1855	8351	1050	1050	4727	1.274	1.200	1.298	2.678	1.838
143	29.3	31.8	132.0	.977	3.67	1097	1057	5130	1734	1683	1722	7725	927	948	4255	1.183	1.115	1.205	2.508	1.710
144	31.2	31.9	131.8	.969	3.41	1004	1029	4966	1702	1687	1726	7710	925	946	4227	1.085	1.087	1.174	2.467	1.680
145	25.7	27.2	113.9	.990	2.69	675	633	3109	1207	----	----	----	----	----	----	-----	-----	-----	2.092	1.344
146	17.4	17.9	75.8	.877	1.46	312	281	1406	461	434	418	1925	----	----	----	-----	-----	-----	1.668	.895
147	19.1	21.5	142.4	0.933	2.75	954	963	7447	1291	1259	1343	9618	763	814	5829	1.250	1.183	1.277	2.901	1.980
148	19.0	20.4	137.7	.919	2.59	882	846	6692	1209	1156	1174	8583	674	685	5004	1.309	1.236	1.338	2.748	1.855
149	18.3	19.1	129.7	.920	2.33	755	692	5530	1084	1050	1028	7583	588	576	4247	1.276	1.202	1.303	2.558	1.710
150	14.8	15.2	104.2	.886	1.51	415	377	3039	654	----	----	----	---	---	----	-----	-----	-----	2.050	1.285
151	10.5	11.1	75.8	.895	.96	232	217	1751	324	343	341	2538	82	82	607	2.829	2.658	2.885	1.848	.944
152	14.3	15.7	138.6	.935	2.15	770	687	7773	847	835	826	8256	630	623	6229	1.222	1.102	1.248	3.024	1.965
153	14.1	15.4	133.1	.916	2.02	710	636	7010	797	802	794	7749	600	594	5797	1.183	1.072	1.209	2.881	1.870
154	13.8	14.6	126.9	.935	1.83	600	518	5735	704	697	666	6526	502	479	4700	1.195	1.080	1.220	2.659	1.703
155	13.8	14.2	119.8	.929	1.65	498	424	4520	631	605	566	5379	388	363	3450	1.284	1.167	1.311	2.404	1.50
156	10.5	11.1	98.3	.872	1.18	360	306	3496	385	385	364	3670	354	240	2421	1.417	1.273	1.444	2.242	1.352

TABLE I. - CONTINUED. ENGINE PERFORMANCE DATA.

(a) Continued. Inlet guide vanes open.

Run	Approximate altitude, ft	Reynolds number index, $\frac{\delta_{T,1}}{\varphi\sqrt{\theta_{T,1}}}$	Tail-pipe static pressure, p_0, lb/sq ft abs	Flight Mach number, M_0	Equivalent ambient-air static temperature, $t_{0,e}$, °R	Engine-inlet total temperature, T_1, °R	Engine-inlet total pressure, P_1, lb/sq ft abs	Turbine-inlet total temperature, T_5, °R	Turbine-outlet total temperature, T_6, °R	Turbine-outlet total pressure, P_6, lb/sq ft abs	Tail-pipe total temperature, °R: Actual, T_7	Tail-pipe total temperature, °R: Adjusted, T_7/θ_a	Tail-pipe total temperature, °R: Corrected, $T_7/\theta_{T,1}$	Tail-pipe total pressure, P_7, lb/sq ft abs	Engine speed, rpm: Actual, N	Engine speed, rpm: Adjusted, $N/\sqrt{\theta_a}$	Engine speed, rpm: Corrected, $N/\sqrt{\theta_{T,1}}$
Exhaust-nozzle area, 3.688 sq ft																	
157	0	1.051	2053	0	512	503	1933	1573	1193	3171	1174	1190	1212	2988	7949	8005	8074
158		.941	2054	0	511	503	1937	1523	1145	2969	1139	1157	1175	2750	7778	7840	7900
159		.959	2060	0	509	501	1957	1427	1062	2825	1064	1085	1102	2664	7411	7485	7543
160		.970	2057	0	508	501	1976	1260	958	2514	945	966	979	2447	6667	6740	6786
161		1.000	2057	0	502	500	2024	1223	1016	2239	999	1033	1037	2221	5489	5582	5592
162		.992	2057	0	504	502	2025	1223	1019	2235	998	1028	1032	2215	5492	5574	5584
163		.985	2051	0	505	504	2037	1263	1128	2150	1114	1145	1147	2140	4593	4657	4661
164	15,000	0.899	1191	0.793	442	497	1802	1550	1171	2821	1158	1218	1209	2418	7926	8132	8099
165		.899	1190	.795	441	497	1804	1500	1130	2753	1120	1180	1169	2360	7790	8000	7960
166		.892	1178	.812	442	500	1816	1385	1031	2544	1026	1079	1065	2178	7424	7617	7564
167		.920	1255	.786	450	505	1885	1385	1030	2581	1025	1059	1054	2213	7411	7530	7513
168		.880	1201	.792	451	507	1815	1170	851	1942	853	879	873	1756	6701	6802	6780
169		.911	1193	.798	438	494	1815	863	641	1432	649	689	682	1392	5504	5669	5642
170	25,000	0.653	794	0.803	415	468	1213	1557	1181	1937	1167	1209	1294	1694	7926	8069	8347
171		.647	788	.802	416	469	1203	1503	1133	1904	1122	1160	1242	1634	7797	7930	8202
172		.635	786	.800	421	475	1198	1373	1026	1723	1022	1043	1117	1478	7407	7481	7742
173		.607	786	.800	433	488	1197	1153	849	1349	852	846	906	1221	6653	6630	6861
174		.602	796	.800	440	496	1213	867	667	908	673	658	704	891	5328	5267	5450
175	35,000	0.594	494	1.232	383	499	1208	1160	853	1314	856	881	890	1120	6687	6781	6819
176		.585	483	1.239	384	502	1205	1158	850	1283	853	875	882	1091	6653	6739	6765
177		.579	492	1.223	389	506	1201	875	626	879	640	648	657	790	5843	5878	5918
178		.429	487	.807	395	446	747	1585	1208	1274	1193	1190	1389	1093	7956	7946	8583
179		.431	491	.804	395	446	751	1520	1152	1238	1139	1136	1326	1062	7795	7785	8409
180		.432	492	.804	395	446	753	1385	1036	1141	1031	1028	1200	979	7420	7410	8004
181		.437	489	.812	390	442	754	1177	864	947	866	875	1017	821	6686	6719	7245
182		.434	491	.804	391	442	751	830	612	621	621	626	729	599	5492	5514	5951
183	45,000	0.258	293	0.821	396	449	456	----	1216	774	1201	1192	1388	664	7956	7926	8554
184		.279	332	.780	406	455	496	----	1217	814	1202	1163	1371	704	7958	7830	8499
185		.278	333	.777	405	454	496	----	1171	784	1158	1122	1323	677	7776	7660	8314
186		.278	333	.781	405	454	498	----	1062	736	1056	1023	1208	635	7384	7274	7895
187		.266	304	.802	394	445	464	----	877	576	879	877	1025	506	6685	6676	7219
188		.268	291	.830	386	439	457	----	641	401	650	662	768	386	5598	5648	6087
189	55,000	0.188	254	0.705	703	468	354	----	1293	544	1273	1174	1411	477	7958	7644	8380
190		.189	249	.719	728	469	351	----	1230	526	1212	1121	1342	461	7786	7487	8191
191		.189	250	.719	720	470	349	----	1121	482	1109	1020	1224	423	7386	7086	7762
192		.189	255	.693	706	472	352	----	905	405	903	823	993	372	6670	6369	6995
193		.189	249	.719	722	472	348	----	793	453	797	730	877	411	6252	5984	6556
194		.158	259	.399	417	467	289	----	1353	425	1329	1153	1476	383	8006	7457	8440
195		.153	254	.388	404	465	282	----	1232	401	1214	1058	1354	367	7640	7132	8071
196		.153	254	.377	403	464	280	----	1098	362	1086	946	1213	333	7197	6718	7612
197		.152	253	.381	396	463	280	----	929	316	924	806	1120	305	6506	6080	6888

TABLE I. - CONTINUED. ENGINE PERFORMANCE DATA.

(a) Concluded. Inlet guide vanes open.

Run	Air flow, lb/sec			Combustion efficiency, η_b	Combustion parameter, W_aT_7	Fuel flow, lb/hr			Rake jet thrust $F_{j,r}$, lb	Scale jet thrust, lb			Scale net thrust, lb			Net thrust specific fuel consumption, $\frac{lb/hr}{lb\ thrust}$			Engine temperature ratio, T_7/T_1	Engine pressure ratio, P_6/P_1
	Actual, W_a	Adjusted, $\frac{W_a\sqrt{\theta_a}}{\delta_a}$	Corrected, $\frac{W_a\sqrt{\theta_{T,1}}}{\delta_{T,1}}$			Actual, W_f	Adjusted, $\frac{W_f}{\delta_a\sqrt{\theta_a}}$	Corrected, $\frac{W_f}{\delta_{T,1}\sqrt{\theta_{T,1}}}$		Actual, $F_{j,s}$	Adjusted, $F_{j,s}/\delta_a$	Corrected, $\frac{F_{j,s}}{\delta_{T,1}}$	Actual, $F_{n,s}$	Adjusted, $F_{n,s}/\delta_a$	Corrected, $\frac{F_{n,s}}{\delta_{T,1}}$	Actual, $W_f/F_{n,s}$	Adjusted, $\frac{W_f}{F_{n,s}\sqrt{\theta_a}}$	Corrected, $\frac{W_f}{F_{n,s}\sqrt{\theta_{T,1}}}$		
Exhaust-nozzle area, 3.688 sq ft																				
157	133.8	137.0	144.2	0.969	15.7	4430	4599	4927	5030	4498	4637	4925	4498	4637	4925	0.985	0.993	1.001	2.334	1.640
158	131.7	134.6	141.6	.988	15.0	4070	4226	4514	4326	4213	4339	4601	4213	4339	4601	.966	.974	.982	2.267	1.533
159	127.4	129.4	135.3	.988	13.6	3440	3565	3785	3789	3694	3789	3992	3694	3789	3992	.932	.941	.948	2.124	1.444
160	110.4	112.3	116.1	.967	10.4	2440	2538	2660	2563	2554	2628	2735	2554	2628	2735	.956	.968	.974	1.886	1.273
161	70.7	71.5	72.5	.983	7.06	1715	1795	1826	1131	1125	1158	1176	1125	1158	1176	1.525	1.550	1.554	1.998	1.104
162	71.5	72.5	73.5	.979	7.14	1715	1791	1822	1123	1114	1146	1164	1114	1146	1164	1.540	1.547	1.560	1.988	1.103
163	48.2	49.1	49.4	.961	5.37	1462	1530	1542	604	588	607	611	588	607	611	2.490	2.520	2.525	2.210	1.057
164	126.2	123.3	145.0	0.981	14.6	4110	4225	4931	6329	5939	5951	6972	2733	2738	3209	1.504	1.543	1.537	2.330	1.565
165	124.3	121.4	142.7	.965	13.9	3840	3956	4603	6033	5742	5759	6735	2579	2587	3025	1.489	1.529	1.522	2.254	1.526
166	119.6	118.1	136.7	.966	12.3	3080	3201	3656	5287	4877	4940	5682	1765	1788	2056	1.745	1.790	1.778	2.052	1.401
167	122.7	114.8	136.0	.995	12.6	3040	2936	3461	5221	4925	4682	5531	1810	1721	2033	1.680	1.707	1.703	2.030	1.369
168	102.4	100.2	118.0	1.001	8.73	1666	1680	1965	3284	3015	2995	3518	393	390	458	4.239	4.303	4.289	1.682	1.070
169	73.9	71.7	84.1	1.000	4.79	545	561	651	1336	1227	1227	1431	----	----	----		-----	-----	1.314	.789
170	89.0	86.4	147.4	0.998	10.4	3000	3018	5515	4628	4401	4351	7680	2184	2159	3811	1.374	1.399	1.447	2.494	1.627
171	86.2	84.4	144.2	.974	9.68	2780	2816	5144	4311	4117	4101	7242	1969	1962	3463	1.412	1.436	1.485	2.392	1.583
172	83.0	82.1	140.3	.964	8.49	2240	2260	4137	3708	3491	3486	6165	1414	1412	2497	1.584	1.600	1.656	2.152	1.438
173	70.7	70.9	121.2	.977	6.03	1238	1232	2257	2433	2227	2224	3937	434	433	767	2.853	2.843	2.942	1.746	1.127
174	42.2	42.1	72.0	.955	2.84	363	354	648	665	625	616	1090	----	----	----	-----	-----	-----	1.357	.7486
175	68.8	70.7	118.2	1.032	5.89	1110	1173	1983	3203	2960	3084	5186	433	451	759	2.564	2.600	2.615	1.715	1.088
176	67.5	70.1	116.5	.994	5.75	1121	1196	2002	3111	2893	3046	5080	400	421	702	2.803	2.839	2.850	1.699	1.065
177	52.4	53.9	91.2	.913	3.35	354	369	632	1646	1413	1462	2490	----	----	----	-----	-----	-----	1.265	.732
178	55.7	57.1	146.3	.990	6.65	2030	2074	6204	3018	2904	2975	8238	1547	1583	4383	1.312	1.310	1.415	2.675	1.705
179	55.5	56.4	145.0	.982	6.32	1870	1894	5685	2874	2746	2784	7738	1395	1415	3931	1.341	1.339	1.447	2.554	1.648
180	54.3	55.1	141.6	.991	5.60	1532	1548	4644	2536	2433	2462	6837	1110	1123	3119	1.380	1.378	1.489	2.312	1.515
181	49.7	50.3	128.7	1.004	4.30	980	1003	2980	1860	1751	1783	4913	537	547	1507	1.825	1.834	1.978	1.959	1.256
182	35.0	35.3	90.9	.958	2.17	304	313	938	699	686	696	1933	----	----	----	-----	-----	-----	1.405	.827
183	----	----	-----	----	----	1270	1330	6336	----	1755	1875	8143	916	963	4250	1.386	1.381	1.490	2.675	1.697
184	----	----	-----	----	----	----	----	----	----	1760	1633	7508	920	854	3930	-----	-----	-----	2.65	1.641
185	----	----	-----	----	----	----	----	----	----	1709	1581	7291	863	798	3684	-----	-----	-----	2.55	1.581
186	----	----	-----	----	----	----	----	----	----	1501	1388	6378	669	618	2843	-----	-----	-----	2.33	1.478
187	----	----	-----	----	----	650	658	3201	----	1051	1065	4793	343	348	1564	1.895	1.895	2.046	1.975	1.241
188	----	----	-----	----	----	252	269	1267	----	489	517	2264	----	----	----	-----	-----	-----	1.481	.878
189	----	----	-----	----	----	----	----	----	----	1069	824	6557	582	448	3482	-----	-----	-----	2.72	1.538
190	----	----	-----	----	----	----	----	----	----	1059	812	6377	548	420	3300	-----	-----	-----	2.59	1.497
191	----	----	-----	----	----	----	----	----	----	----	----	----	----	----	----	-----	-----	-----	2.37	1.378
192	----	----	-----	----	----	----	----	----	----	636	476	3827	223	167	1342	-----	-----	-----	1.92	1.152
193	----	----	-----	----	----	----	----	----	----	----	----	----	----	----	----	-----	-----	-----	1.70	1.300
194	----	----	-----	----	----	----	----	----	----	706	521	5169	458	413	3352	-----	-----	-----	2.85	1.471
195	----	----	-----	----	----	----	----	----	----	611	459	4591	393	359	2953	-----	-----	-----	2.61	1.424
196	----	----	-----	----	----	----	----	----	----	493	371	3723	290	284	740	-----	-----	-----	2.35	1.292
197	----	----	-----	----	----	----	----	----	----	----	----	----	----	----	----	-----	-----	-----	2.01	1.130

TABLE I. - CONTINUED. ENGINE PERFORMANCE DATA.

(b) Inlet guide vanes closed.

Run	Approximate altitude, ft	Reynolds number index, $\frac{\delta_{T,1}}{\varphi\sqrt{\theta_{T,1}}}$	Tail-pipe static pressure, p_0, lb/sq ft abs	Flight Mach number, M_0	Equivalent ambient-air static temperature, $t_{0,e}$, °R	Engine-inlet total temperature, T_1, °R	Engine-inlet total pressure, P_1, lb/sq ft abs	Turbine-inlet total temperature, T_5, °R	Turbine-outlet total temperature, T_6, °R	Turbine-outlet total pressure, P_6, lb/sq ft abs	Tail-pipe total temperature, °R			Tail-pipe total pressure, P_7, lb/sq ft abs	Engine speed, rpm		
											Actual, T_7	Adjusted, T_7/θ_a	Corrected, $T_7/\theta_{T,1}$		Actual, N	Adjusted, $N/\sqrt{\theta_a}$	Corrected, $N/\sqrt{\theta_{T,1}}$
Exhaust-nozzle area, 2.388 sq ft																	
1	0	0.950	2048	0	521	517	1997	1507	1252	2972	1246	1241	1251	2899	7091	7078	7104
2		.949	2038	0	521	518	2000	1340	1114	2632	1108	1104	1110	2588	6019	6008	6025
3		.949	2043	0	522	520	2020	1240	1102	2380	1070	1064	1068	2357	5015	5000	5010
4		.950	2038	0	521	520	2028	1263	1151	2212	1135	1131	1133	2202	4081	4073	4077
5		.951	2034	0	520	519	2027	1253	1184	2161	1170	1168	1170	2153	3604	3600	3604
6	15,000	0.861	1164	0.821	449	509	1811	1347	1054	2285	1056	1094	1077	2228	7083	7210	7152
7		.861	1166	.813	450	509	1800	1203	938	2043	938	969	957	2000	6538	6643	6602
8		.860	1153	.819	450	510	1789	967	765	1636	769	794	783	1597	5502	5590	5550
9	35,000	0.362	500	0.796	456	514	759	1400	1096	984	1102	952	1113	958	7087	6587	7121
10		.358	495	.794	455	512	750	1243	978	866	972	842	986	845	6540	6085	6585
11		.362	495	.803	455	514	757	1107	875	769	873	756	882	752	5985	5569	6014
12		.360	497	.797	455	513	755	990	786	689	793	687	803	673	5447	5068	5479
Exhaust-nozzle area, 2.514 sq ft																	
13	0	0.948	2055	0	521	517	1995	1767	1432	3162	1421	1416	1427	3086	7945	7930	7960
14		.950	2059	0	521	517	2000	1727	1387	3136	1385	1378	1389	3056	7782	7767	7797
15		.952	2061	0	521	517	2005	1620	1303	3045	1304	1299	1309	2968	7415	7401	7429
16		.953	2058	0	521	517	2008	1450	1182	2840	1185	1180	1190	2788	6670	6657	6683
17		.963	2051	0	519	517	2027	1250	1105	2388	1078	1078	1082	2371	5032	5032	5042
18	35,000	0.400	491	0.802	418	472	750	1615	1280	1104	1265	1192	1392	1073	7945	7714	8332
19		.399	494	.802	420	474	754	1550	1230	1079	1221	1145	1337	1050	7797	7552	8158
20		.398	494	.800	423	477	753	1430	1122	1010	1122	1045	1221	984	7415	7156	7734
21		.387	496	.800	429	484	756	1243	978	914	972	893	1042	894	6735	6454	6974
22		.375	498	.798	439	495	757	917	739	651	742	666	778	638	5146	4875	5269
Exhaust-nozzle area, 2.694 sq ft																	
23	35,000	0.432	489	0.808	394	446	751	1515	1182	1045	1170	1168	1362	1012	7949	7943	8575
24		.432	499	.793	396	446	755	1450	1129	1007	1119	1113	1303	973	7780	7758	8393
25		.432	495	.796	396	446	751	1334	1027	965	1025	1020	1193	934	7409	7391	7992
26		.432	499	.790	396	446	753	1147	872	862	876	870	1020	839	6670	6649	7195
27		.419	481	.804	396	447	736	910	704	706	711	708	825	690	5532	5519	5961
Exhaust-nozzle area, 3.688 sq ft																	
28	0	0.954	2073	0	522	518	2021	1455	1138	2475	1120	1114	1122	2409	7943	7920	7951
29		.960	2080	0	521	517	2027	1420	1106	2454	1089	1085	1093	2398	7777	7762	7792
30		.959	2074	0	520	516	2022	1340	1049	2418	1035	1033	1041	2370	4403	7396	7425
31		.964	2077	0	518	515	2030	1240	980	2357	968	970	976	2322	6663	6670	6689
32		.972	2070	0	516	514	2039	1150	951	2260	941	947	950	2233	5723	5740	5751
33	35,000	0.407	487	0.809	412	466	749	1333	990	796	986	943	1098	723	7964	7788	8404
34		.399	482	.815	415	470	745	1280	944	771	943	895	1041	704	7793	7593	8189
35		.418	483	.815	403	457	747	1160	850	742	850	831	966	685	7424	7341	7912
36		.408	491	.812	413	467	757	970	711	657	717	684	797	627	6598	6444	6956
37		.408	494	.808	414	468	759	970	709	659	715	680	793	630	6534	6375	6881
38		.407	489	.813	412	467	755	867	641	607	649	621	721	587	5937	5806	6259

TABLE I. - CONCLUDED. ENGINE PERFORMANCE DATA.

(b) Concluded. Inlet guide vanes closed.

Run	Air flow, lb/sec			Combustion efficiency, η_b	Combustion parameter, W_aT_7	Fuel flow, lb/hr			Rake jet thrust, $F_{j,r}$, lb	Scale jet thrust, lb			Scale net thrust, lb			Net thrust specific fuel consumption, $\frac{lb/hr}{lb\ thrust}$			Engine temperature ratio, T_7/T_1	Engine pressure ratio, P_6/P_1
	Actual, W_a	Adjusted, $\frac{W_a\sqrt{\theta_a}}{\delta_a}$	Corrected, $\frac{W_a\sqrt{\theta_{T,1}}}{\delta_{T,1}}$			Actual, W_f	Adjusted, $\frac{W_f}{\delta_a\sqrt{\theta_a}}$	Corrected, $\frac{W_f}{\delta_{T,1}\sqrt{\theta_{T,1}}}$		Actual, $F_{j,s}$	Adjusted, $F_{j,s}/\delta_a$	Corrected, $\frac{F_{j,s}}{\delta_{T,1}}$	Actual, $F_{n,s}$	Adjusted, $F_{n,s}/\delta_a$	Corrected, $\frac{F_{n,s}}{\delta_{T,1}}$	Actual, $W_f/F_{n,s}$	Adjusted, $\frac{W_f}{F_{n,s}\sqrt{\theta_a}}$	Corrected, $\frac{W_f}{F_{n,s}\sqrt{\theta_{T,1}}}$		
Exhaust-nozzle area, 2.388 sq ft																				
1	91.7	94.9	97.0	0.980	11.4	3300	3402	3504	3542	3463	3577	3671	----	----	----	-----	-----	-----	2.410	1.488
2	77.4	80.5	81.8	.968	8.58	2260	2341	2394	2348	2317	2405	2451	----	----	----	-----	-----	-----	2.139	1.316
3	59.5	61.8	62.4	1.012	6.36	1534	1585	1606	1381	1337	1385	1401	----	----	----	-----	-----	-----	2.058	1.178
4	40.3	42.0	42.1	.930	4.58	1280	1326	1334	708	645	670	673	----	----	----	-----	-----	-----	2.183	1.091
5	33.5	34.9	35.0	.916	3.92	1150	1195	1201	514	483	502	504	----	----	----	-----	-----	-----	2.254	1.066
6	84.9	85.5	98.3	0.980	8.96	2270	2368	2677	3902	3743	3837	4372	1493	1530	1744	1.213	1.235	1.225	2.075	1.262
7	78.7	79.2	91.7	.956	7.38	1660	1725	1971	3124	3055	3125	3593	986	1009	1160	1.684	1.711	1.700	1.843	1.135
8	64.2	65.4	75.3	.960	4.91	800	842	954.7	1814	1718	1778	2032	21	22	25	38.09	38.70	38.42	1.508	0.914
9	35.3	37.8	97.8	0.964	3.88	1022	946	2863	1659	1647	1640	4592	734	731	2046	1.392	1.294	1.399	2.144	1.296
10	33.2	35.8	92.9	.961	3.22	750	702	2130	1363	1307	1315	3687	451	454	1272	1.663	1.547	1.674	1.898	1.155
11	29.8	32.2	82.8	1.008	2.60	498	466	1399	1036	995	1001	2781	218	219	609	2.284	2.125	2.295	1.698	1.016
12	25.5	27.4	71.0	.933	2.02	360	336	1015	732	682	683	1912	22	22	62	16.36	15.22	16.46	1.546	0.913
Exhaust-nozzle area, 2.514 sq ft																				
13	94.8	97.8	100.4	0.974	13.5	4330	4452	4602	4090	4158	4283	4412	----	----	----	-----	-----	-----	2.749	1.585
14	94.3	97.2	99.6	.978	13.1	4100	4207	4347	3960	4057	4171	4292	----	----	----	-----	-----	-----	2.675	1.568
15	93.2	95.9	98.2	.986	12.2	3620	3711	3827	3654	3728	3829	3933	----	----	----	-----	-----	-----	2.522	1.519
16	87.5	90.1	92.1	.994	10.4	2830	2903	2989	2986	3033	3118	3197	----	----	----	-----	-----	-----	2.292	1.414
17	57.5	59.3	59.9	1.048	6.20	1470	1517	1538	1306	1371	1415	1431	----	----	----	-----	-----	-----	2.085	1.178
18	38.4	40.1	103.4	0.980	4.86	1514	1490	4477	2113	2065	2094	5825	1105	1120	3117	1.370	1.330	1.437	2.680	1.472
19	38.5	40.0	103.2	.993	4.70	1405	1372	4125	2041	1761	1775	4941	801	807	2248	1.754	1.699	1.835	2.576	1.431
20	37.1	38.7	99.9	.975	4.16	1171	1139	3432	1809	1747	1761	4909	817	824	2296	1.433	1.383	1.495	2.352	1.341
21	35.6	37.3	96.2	.987	3.46	837	805	2426	1501	1463	1469	4095	+564	566	+1579	+1.484	1.422	+1.537	2.008	1.209
22	24.0	25.4	65.6	.864	1.78	322	305	921.6	585	583	583	1629	-29	-29	-81	-11.0	-10.52	-11.37	1.499	.860
Exhaust-nozzle area, 2.694 sq ft																				
23	39.5	40.3	103.2	0.977	4.62	1410	1434	4286	2.020	1773	1805	4996	807	822	2274	1.747	1.746	1.885	2.623	1.391
24	39.0	39.1	101.4	.963	4.37	1310	1303	3961	1875	1733	1730	4858	795	793	2228	1.648	1.643	1.778	2.509	1.334
25	40.2	40.5	105.0	.979	4.12	1132	1136	3441	1804	1732	1742	4881	763	768	2150	1.484	1.480	1.601	2.298	1.285
26	37.0	37.0	96.3	.992	3.24	750	747	2273	1391	1387	1384	3897	500	499	1405	1.500	1.495	1.618	1.964	1.145
27	30.7	31.8	81.8	.948	2.18	402	415	1245	875.7	847	877	2435	99	102	285	4.061	4.052	4.376	1.591	.9592
Exhaust-nozzle area, 3.688 sq ft																				
28	98.4	100.7	102.9	1.002	11.0	2840	2891	2976	2319	2321	2370	2430	----	----	----	-----	-----	-----	2.162	1.225
29	98.0	99.9	102.1	.986	10.7	2700	2741	2824	2219	2234	2272	2332	----	----	----	-----	-----	-----	2.106	1.211
30	96.2	98.2	100.3	.995	9.95	2380	2425	2497	2055	2079	2121	2175	----	----	----	-----	-----	-----	2.006	1.196
31	90.2	91.8	93.6	.977	8.73	1990	2030	2082	1703	1714	1747	1786	----	----	----	-----	-----	-----	1.880	1.161
32	75.3	76.7	77.8	.983	7.09	1533	1571	1599	1161	1147	1172	1191	----	----	----	-----	-----	-----	1.831	1.108
33	39.3	41.1	105.1	0.979	3.87	990	990	2951	1384	1294	1324	3656	312	319	881	3.173	3.103	3.348	2.116	1.063
34	39.0	41.3	105.3	.985	3.67	888	894	2650	1315	1229	1270	3490	244	252	693	3.639	3.546	3.824	2.006	1.035
35	39.0	40.6	103.6	.966	3.31	745	759	2249	1200	1133	1168	3210	161	166	456	4.627	4.575	4.931	1.860	.9933
36	36.2	37.6	96.1	.922	2.60	452	448	1332	862.0	806	817	2253	----	----	----	-----	-----	-----	1.535	.8679
37	36.3	37.5	96.1	.969	2.60	430	423	1262	859.4	824	831	2297	----	----	----	-----	-----	-----	1.528	.8682
38	33.4	34.8	88.8	.938	2.17	303	302	895	654.8	654	666	1833	----	----	----	-----	-----	-----	1.390	.8040

TABLE II. - ENGINE PERFORMANCE DATA OBTAINED AFTER ENGINE OVERHAUL.

Run	Approximate altitude, ft	Reynolds number index, $\delta_{T,1}/\sqrt{\theta_{T,1}}$	Tail-pipe static pressure, p_0, lb/sq ft abs	Flight Mach number, M_0	Equivalent ambient air static temperature, $t_{0,e}$, °R	Engine-inlet total temperature, T_1, °R	Engine-inlet total pressure, P_1, lb/sq ft abs	Turbine-inlet total temperature, T_5, °R	Turbine-outlet total temperature, T_6, °R	Turbine-outlet total pressure, P_6, lb/sq ft abs	Tail-pipe total temperature, °R: Actual, T_7	Adjusted, T_7/θ_a	Corrected, $T_7/\theta_{T,1}$	Tail-pipe total pressure, P_7, lb/sq ft abs	Engine speed, rpm: Actual, N	Adjusted, $N/\sqrt{\theta_a}$	Corrected, $N/\sqrt{\theta_{T,1}}$
Exhaust-nozzle area, 2.388 sq ft																	
1	35,000	0.470	475	0.821	358	406	739	2010	1610	2046	1615	1778	2064	1991	7975	8366	9016
2		.475	478	.819	366	415	742	2018	1612	2009	1617	1742	2023	1955	7958	8260	8900
3		.453	484	.813	383	434	747	1987	1621	1947	1600	1646	1914	1909	7943	8054	8687
4		.480	481	.819	363	412	747	----	1533	----	----	----	----	----	7763	8089	8713
5		.442	481	.820	385	437	748	1913	1547	1880	1529	1564	1816	1837	7748	7833	8444
6		.489	485	.813	360	408	749	----	1466	----	----	----	----	----	7589	7938	8560
7		.436	482	.815	388	440	745	1800	1442	1754	1437	1459	1694	1716	7424	7476	8063
8		.489	483	.824	357	406	754	1753	1392	1845	1400	1546	1789	1796	7363	7739	8324
9		.488	480	.817	362	410	744	1617	1263	1666	1285	1398	1627	1626	6992	7293	7867
10		.439	492	.799	390	440	749	1455	1148	1356	1154	1166	1361	1322	6547	6580	7110
11		.418	478	.809	399	451	735	1083	858	736	871	860	1003	719	5267	5234	5650
12	45,000	0.340	291	0.826	328	373	455	2007	1618	1329	1607	1925	2235	1296	7941	8695	9367
13		.344	298	.815	324	367	461	1920	1548	1299	1540	1868	2178	1269	7773	8558	9244
14		.334	303	.803	322	364	463	1837	1472	1262	1466	1789	2091	1234	7589	8386	9063
15		.338	293	.813	325	368	452	1737	1386	1186	1386	1676	1954	1158	7362	8098	8742
16		.341	298	.804	330	373	456	1587	1262	1108	1266	1508	1761	1078	6998	7635	8254
17		.267	297	.797	391	441	451	2017	1693	1182	1621	1629	1908	1153	7947	7963	8621
18		.261	287	.822	389	442	447	1975	1605	1165	1580	1596	1855	1139	7835	7874	8490
19		.276	299	.809	388	439	460	1780	1438	1056	1422	1440	1681	1031	7365	7409	8008
20		.274	311	.792	393	442	470	1497	1192	837	1189	1189	1396	817	6619	6619	7173
21		.271	308	.793	396	446	466	1070	859	422	872	865	1015	413	5038	5019	5435
22	55,000	0.206	181	0.829	337	383	284	2037	1651	814	1640	1912	2222	791	7877	8507	9169
23		.205	182	.820	338	384	283	1890	1539	769	1520	1768	2054	752	7608	8201	8844
24		.215	194	.794	340	383	294	1797	1460	737	1437	1661	1947	720	7405	7960	8619
25		.212	190	.806	339	383	291	1620	1310	681	1294	1500	1753	665	6935	7469	8072
26		.163	175	.841	387	442	278	2067	1690	738	1660	1687	1949	722	7990	8054	8658
27		.166	177	.837	389	444	280	1975	1606	715	1584	1600	1852	696	7748	7787	8377
28		.156	178	.832	394	448	280	1833	1484	652	1466	1462	1698	636	7358	7348	7919
29		.160	186	.802	413	464	284	1510	1218	485	1209	1156	1353	470	6542	6397	6919
30		.160	194	.784	411	461	291	1227	978	288	998	976	1124	280	5502	3080	5838
31		.161	197	.409	370	382	221	1990	1653	579	1597	1696	2170	563	7651	7888	8918
32		.156	189	.417	369	382	213	1797	1486	543	1438	1531	1954	527	7256	7488	8458
33		.160	197	.409	370	382	221	1737	1372	518	1358	1442	1846	504	6988	7205	8145
34		.128	192	.438	425	441	219	2037	1686	545	1639	1516	1929	531	7814	7514	8477
35		.127	188	.466	424	442	218	1883	1544	504	1512	1401	1775	490	7435	7158	8057
36		.133	198	.438	429	445	226	1550	1274	398	1257	1152	1466	387	6536	6256	7058
37		.127	196	.434	432	448	223	1510	1251	247	1273	1158	1474	243	5453	5201	5869
Exhaust-nozzle area, 2.514 sq ft																	
38	55,000	0.180	185	0.800	369	416	282	1897	1487	707	1502	1600	1874	684	7924	8178	8851
39		.177	179	.823	366	415	279	1860	1460	677	1469	1578	1838	664	7835	8117	8762
40		.178	183	.808	367	415	281	1697	1328	542	1332	1430	1670	517	7403	7662	8279
41		.178	184	.802	368	415	281	1385	1111	510	1082	1156	1354	490	6549	6765	7324
42		.178	183	.804	367	414	280	1140	904	371	885	948	1110	359	5752	5953	6440
43		.154	190	.792	419	471	287	1990	1586	686	1583	1485	3.361	666	7930	7680	8325
44		---	186	.799	----	---	283	----	1572	659	----	----	-----	639	7756	----	----
45		.168	201	.736	402	446	288	1757	1419	589	1386	1355	3.108	571	7373	7290	7954
46		.168	197	.768	406	454	291	1500	1191	489	1191	1153	2.623	474	6636	6529	7095
47		.141	198	.415	399	413	223	1953	1554	---	1548	1525	1946	---	7964	7904	8927
48		.142	198	.431	398	413	225	1867	1517	532	1482	1463	1863	507	7765	7716	8704
49		.140	193	.444	397	413	221	1740	1394	505	1379	1365	1733	486	7420	7382	8317
50		.137	188	.450	397	413	216	1523	1230	440	1211	1199	1522	424	6721	6687	7534
51		.134	186	.453	399	415	214	1297	1041	339	1029	1014	1287	327	5953	5908	6657
Exhaust-nozzle area, 2.694 sq ft																	
52	55,000	.180	174	.843	355	405	277	1817	1403	676	1422	1574	1823	651	7952	8366	9003
53		.179	175	.838	356	406	277	1737	1330	646	1357	1498	1734	622	7780	8177	8796
54		.180	180	.824	361	410	281	1579	1228	591	1229	1338	1556	564	7369	7693	8291
55		.172	173	.831	364	414	272	1337	1044	487	1036	1119	1299	457	6585	6842	7373
56		.170	180	.810	376	425	277	995	795	216	779	814	951	207	5388	5507	5954
57		.143	198	.408	392	405	222	1825	1426	502	1428	1432	1831	480	7924	7932	8971

TABLE II. - CONCLUDED. ENGINE PERFORMANCE DATA OBTAINED AFTER ENGINE OVERHAUL.

Run	Air flow, lb/sec: Actual, W_a	Air flow: Adjusted, $\frac{W_a\sqrt{\theta_a}}{\delta_a}$	Air flow: Corrected, $\frac{W_a\sqrt{\theta_{T,1}}}{\delta_{T,1}}$	Combustion efficiency, η_b	Combustion parameter, W_aT_7	Fuel flow, lb/hr: Actual, W_f	Fuel flow: Adjusted, $\frac{W_f}{\delta_a\sqrt{\theta_a}}$	Fuel flow: Corrected, $\frac{W_f}{\delta_{T,1}\sqrt{\theta_{T,1}}}$	Rake jet thrust $F_{j,r}$, lb	Scale jet thrust, lb: Actual, $F_{j,s}$	Scale jet thrust: Adjusted, $F_{j,s}/\delta_a$	Scale jet thrust: Corrected, $\frac{F_{j,s}}{\delta_{T,1}}$	Scale net thrust, lb: Actual, $F_{n,s}$	Scale net thrust: Adjusted, $F_{n,s}/\delta_a$	Scale net thrust: Corrected, $\frac{F_{n,s}}{\delta_{T,1}}$	Net thrust specific fuel consumption, $\frac{lb/hr}{lb\ thrust}$: Actual, $W_f/F_{n,s}$	Net thrust specific fuel consumption: Adjusted, $\frac{W_f}{F_{n,s}\sqrt{\theta_a}}$	Net thrust specific fuel consumption: Corrected, $\frac{W_f}{F_{n,s}\sqrt{\theta_{T,1}}}$	Engine temperature ratio, T_7/T_1	Engine pressure ratio, P_6/P_1
Exhaust-nozzle area, 2.388 sq ft																				
1	59.7	59.6	151.1	1.993	9.64	3630	3989	11750	4760	3537	3707	10126	2124	2226	6081	1.709	1.793	1.932	3.978	2.769
2	58.8	59.0	149.8	1.982	9.50	3590	3884	11450	4659	4667	4863	13310	3265	3402	9312	1.105	1.141	1.229	3.896	2.708
3	57.3	58.2	148.4	.981	9.17	3400	3548	10534	4480	2350	2426	6658	961	989	2723	3.538	3.588	3.869	3.687	2.606
4	59.6	59.2	150.4	1.025	9.16	3290	3547	10461	----	----	----	----	----	----	----	-----	-----	-----	-----	-----
5	56.8	58.1	147.4	.978	8.68	3140	3286	9681	4295	2341	2431	6623	949	982	2685	3.309	3.345	3.606	3.499	2.513
6	58.3	57.3	146.1	1.001	8.56	3040	3265	9686	----	----	----	----	----	----	----	-----	-----	-----	-----	-----
7	54.8	56.2	143.3	.995	7.87	2700	2809	8328	3932	2247	2329	6381	908	938	2579	2.974	2.995	3.230	3.266	2.354
8	57.9	56.8	143.6	1.009	8.10	2800	3035	8883	4148	4177	4306	11721	2805	2892	7871	1.005	1.049	1.129	3.448	2.447
9	55.4	55.2	140.1	.998	7.12	2350	2545	7520	3697	3672	3812	10443	2359	2449	6709	.9983	1.039	1.121	3.134	2.239
10	47.1	47.5	122.6	.971	5.44	1658	1686	5087	2731	1793	1819	5065	660	668	1865	2.512	2.525	2.728	2.623	1.810
11	24.8	26.0	66.4	.914	2.16	539	558	1665	831	1668	1743	4802	106	110	305	5.095	5.063	5.466	1.931	1.001
12	38.2	36.95	150.8	0.961	6.15	2450	2840	13441	3079	3152	3335	14660	2280	2412	10604	1.075	1.177	1.268	4.308	2.921
13	38.8	36.45	149.8	.979	5.98	2300	2617	12554	3030	3067	3171	14078	2200	2275	10098	1.045	1.151	1.243	4.196	2.818
14	38.7	35.57	147.9	.972	5.67	2150	2417	11733	2910	2946	2996	13463	2098	2134	9588	1.025	1.133	1.224	4.027	2.726
15	37.5	35.83	147.8	.984	5.20	1900	2196	10562	2719	2739	2879	12821	1902	1999	8903	.999	1.099	1.186	3.766	2.624
16	36.1	34.21	142.0	.945	4.57	1650	1861	9030	2438	2484	2568	11526	1681	1738	7800	.982	1.071	1.158	3.394	2.430
17	33.8	35.0	146.3	.956	5.48	2100	2182	10689	2653	2703	2807	12682	1891	1961	8873	1.111	1.113	1.205	3.676	2.621
18	33.6	35.9	146.9	.935	5.31	2050	2210	10517	2616	2661	2863	12597	1831	1965	8668	1.120	1.126	1.214	3.575	2.606
19	33.0	33.8	139.7	.956	4.70	1675	1736	8378	2337	2314	2392	10644	1512	1557	6955	1.108	1.175	1.205	3.239	2.296
20	29.0	29.3	120.5	.960	3.45	1085	1096	5293	1692	1107	1122	4984	414	418	1864	2.621	2.621	2.840	2.690	1.781
21	14.0	14.1	59.0	.819	1.22	343	342	1680	403	1020	1020	4623	683	683	3102	5.022	5.003	5.417	1.955	.9056
22	22.9	22.35	146.5	0.932	3.75	1550	1765	13443	1862	1904	2009	14187	1373	1449	10230	1.129	1.219	1.314	4.282	2.866
23	23.2	22.60	149.4	.937	3.53	1400	1583	12169	1789	1760	1846	13160	1226	1286	9167	1.142	1.231	1.328	3.958	2.717
24	22.9	20.94	141.4	.947	3.29	1250	1323	10471	1663	1648	1622	11861	1138	1120	8190	1.098	1.180	1.278	3.752	2.507
25	22.3	20.80	139.3	.937	2.88	1050	1136	8887	1508	1450	1457	10543	946	951	6878	1.110	1.195	1.292	3.379	2.340
26	20.7	22.4	145.1	.907	3.43	1400	1540	11548	1668	1730	1891	13169	1210	1320	9211	1.157	1.166	1.254	3.756	2.655
27	20.3	21.8	141.7	.911	3.21	1270	1377	10377	1578	1636	1765	12363	1126	1215	8509	1.125	1.134	1.220	3.568	2.554
28	19.3	20.8	135.7	.903	2.83	1079	1156	8776	1405	1447	1557	10935	961	1031	7262	1.123	1.122	1.209	3.272	2.329
29	15.7	16.4	110.3	.892	1.89	629	632	4957	905	671	693	5000	283	291	2109	2.223	2.174	2.351	2.605	1.708
30	8.9	8.9	60.8	.718	.89	315	313	2430	304	192	189	1396	----	----	----	-----	-----	-----	2.165	.9897
31	17.1	16.1	140.4	.903	2.73	1150	1150	12835	1211	1207	1170	11557	1002	971	9594	1.148	1.184	1.338	4.181	2.620
32	16.3	16.0	138.8	.932	2.34	911	950	10548	1079	1093	1105	10858	894	904	8881	1.019	1.052	1.188	3.764	2.549
33	16.1	15.2	132.6	.976	2.19	811	811	9052	999	986	956	9441	792	768	7583	1.024	1.056	1.194	3.555	2.344
34	15.8	16.4	140.9	.935	2.59	1017	973	10660	1120	1156	1150	11169	938	933	9063	1.084	1.042	1.176	3.717	2.489
35	14.9	15.7	133.4	.891	2.25	888	869	9340	985	1042	1059	10114	824	837	7998	1.078	1.078	1.168	3.421	2.312
36	12.5	12.6	108.4	.901	2.83	540	499	5460	640	665	641	6226	492	475	4607	1.098	1.098	1.186	2.825	1.761
37	5.7	5.8	49.9	.719	.72	318	296	3248	171	179	174	1699	101	98	958	3.149	3.149	3.389	2.842	1.108
Exhaust-nozzle area, 2.514 sq ft																				
38	21.9	21.9	146.9	0.902	3.28	1308	1393	10963	1627	1599	1650	11999	1087	1122	8157	1.203	1.241	1.344	3.611	2.508
39	22.0	22.6	148.3	.911	3.23	1258	1390	10670	1618	1550	1654	11755	1023	1092	7758	1.230	1.274	1.376	3.540	2.427
40	21.5	21.6	144.4	.951	2.86	1012	1094	8522	1371	1368	1428	10301	862	900	6491	1.174	1.215	1.313	3.217	1.929
41	18.1	18.2	122.1	.876	1.96	658	706	5541	1014	972	1009	7319	547	568	4119	1.203	1.243	1.345	2.607	1.815
42	15.2	15.3	102.5	.831	1.34	405	438	3427	649	594	620	4489	238	248	1799	1.702	1.762	1.906	2.138	1.325
43	20.4	21.5	142.9	.913	3.22	1250	1217	9675	1533	1418	1425	10455	916	921	6754	1.365	1.322	1.433	3.361	2.390
44	----	----	-----	----	----	1169	----	----	----	1251	----	9354	----	----	----	-----	-----	-----	-----	2.329
45	19.9	19.3	135.5	.963	2.76	955	897	7569	1300	1331	1265	9779	884	840	6495	1.080	1.068	1.165	3.108	2.045
46	17.1	16.9	116.5	.939	2.04	650	620	5053	961	986	956	7169	582	564	4232	1.117	1.099	1.194	2.623	1.680
47	17.0	16.5	143.5	.946	2.62	1012	996	10764	----	1093	1054	10371	879	848	8341	1.151	1.142	1.290	3.748	-----
48	16.6	16.1	139.3	.924	2.46	952	913	10035	1078	1046	1009	9837	829	800	7796	1.148	1.141	1.287	3.588	2.364
49	16.0	15.9	136.6	.907	2.21	832	819	8930	991	969	959	9278	753	745	7210	1.105	1.099	1.239	3.339	2.285
50	14.9	15.2	129.8	.938	1.80	608	615	6676	813	748	760	7327	545	554	5339	1.116	1.110	1.251	2.932	2.037
51	12.0	12.4	105.9	.863	1.23	405	413	4478	511	213	219	2106	48	49	475	8.438	8.375	9.436	2.480	1.584
Exhaust-nozzle area, 2.694 sq ft																				
52	22.4	23.4	151.0	0.902	3.18	1238	1430	10707	1621	1591	1747	12154	1050	1153	8021	1.179	1.240	1.335	3.511	2.440
53	22.7	23.6	153.5	.949	3.08	1115	1278	9630	1583	1517	1655	11588	970	1058	7410	1.149	1.208	1.299	3.342	2.332
54	22.0	22.3	147.1	.939	2.70	922	1021	7811	1398	1331	1412	10022	807	856	6077	1.143	1.193	1.286	2.998	2.103
55	18.9	20.0	131.0	.959	1.95	623	715	5426	1027	696	768	5414	240	265	1867	2.596	2.697	2.907	2.502	1.790
56	11.1	11.6	77.0	.562	.87	329	357	2777	211	337	358	2574	70	74	535	4.700	4.803	5.194	1.832	.780
57	17.1	16.5	143.8	.925	2.44	928	896	10014	1060	1049	1012	9999	839	809	7997	1.106	1.107	1.252	3.526	2.261

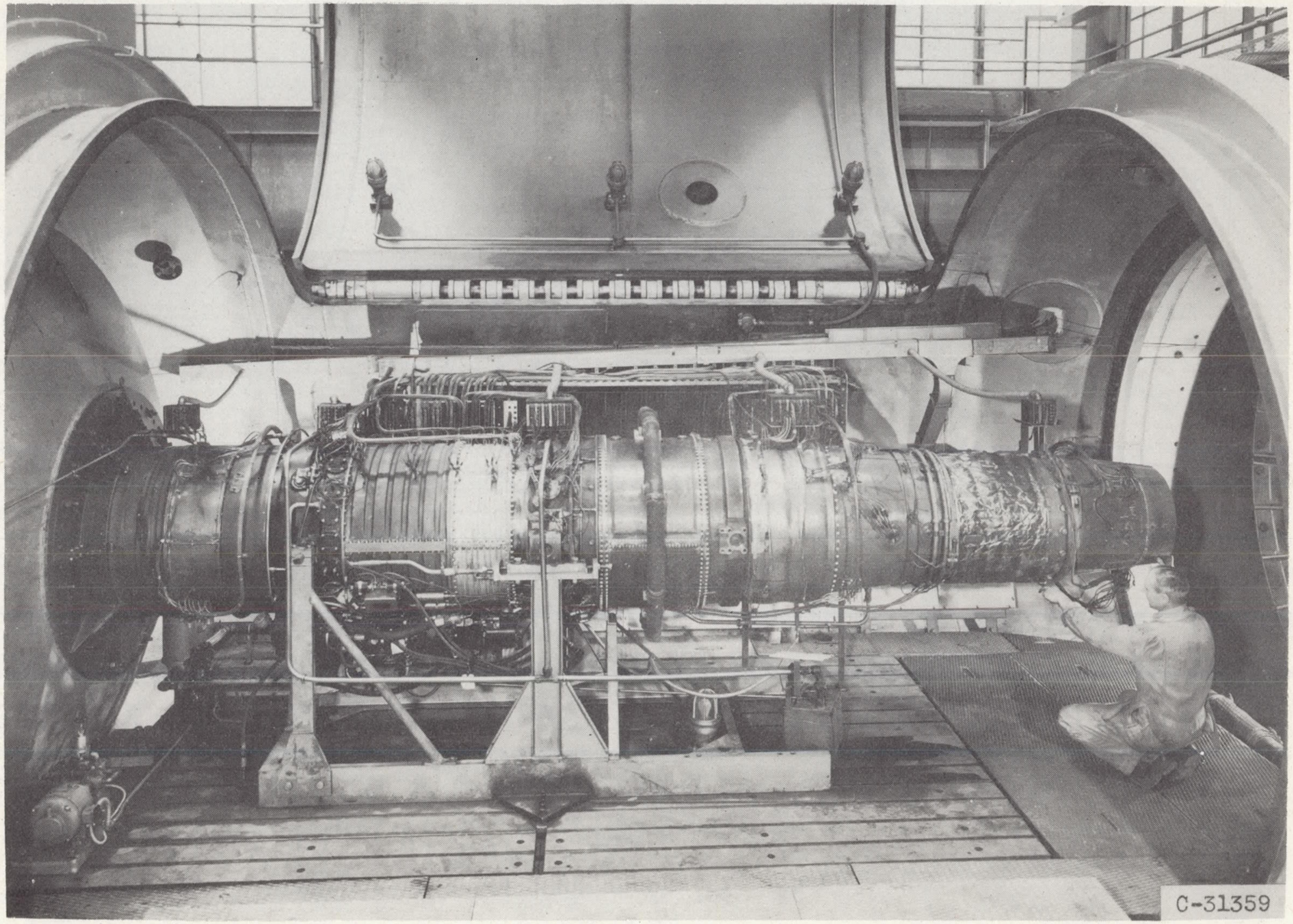


Figure 1. - Installation of YJ73-GE-3 turbojet engine in altitude chamber.

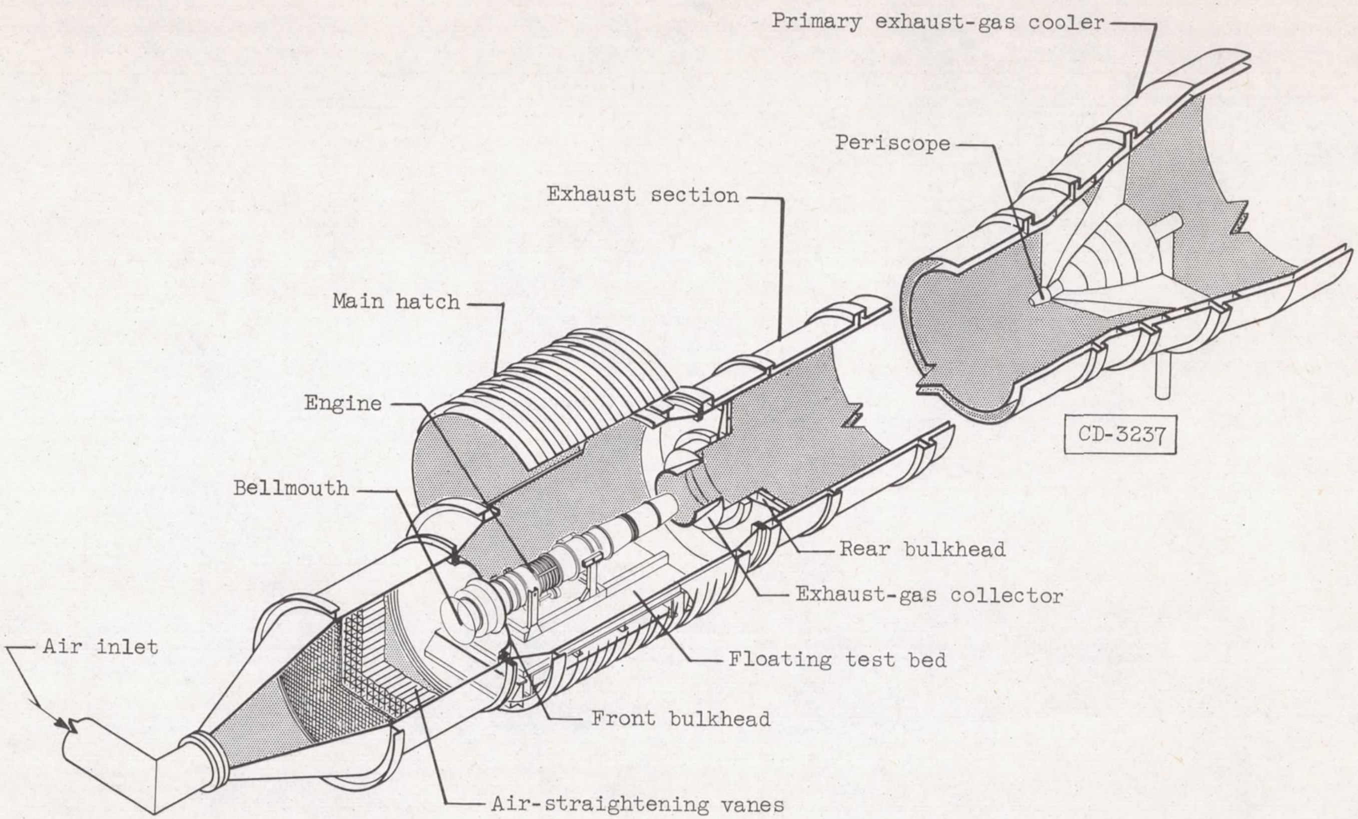
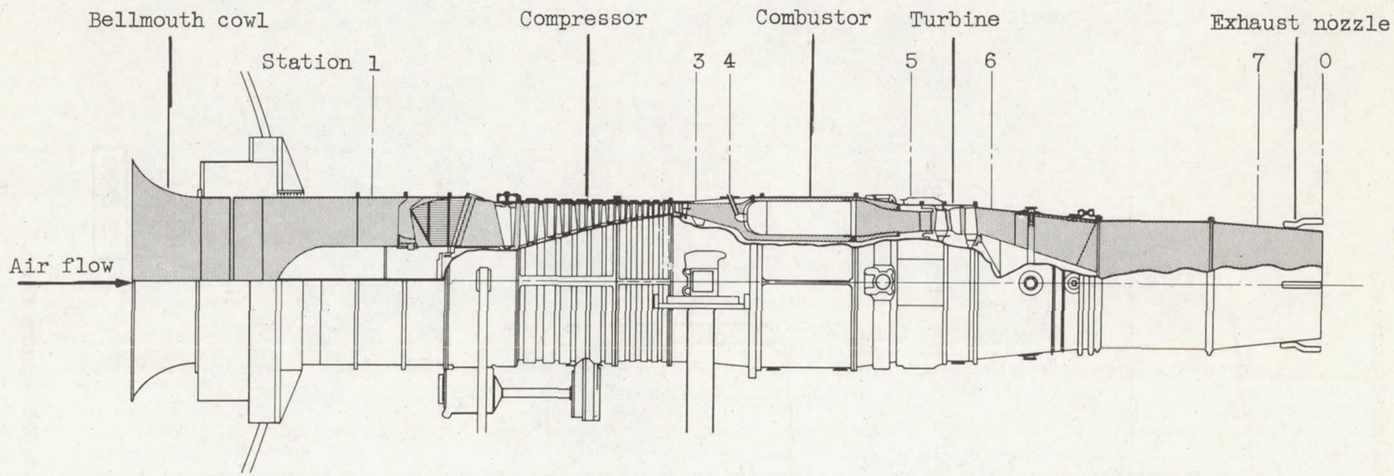
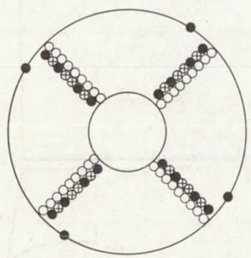


Figure 2. - Schematic diagram of altitude test chamber with engine installed in test section.

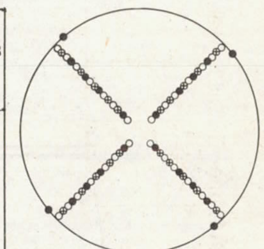




o Total pressure
● Static pressure
⊕ Thermocouple

Station 1

Station	Location	Total-pressure tubes	Static-pressure tubes	Wall static-pressure orifices	Thermo-couples
0	Tail-pipe region	0	4	0	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

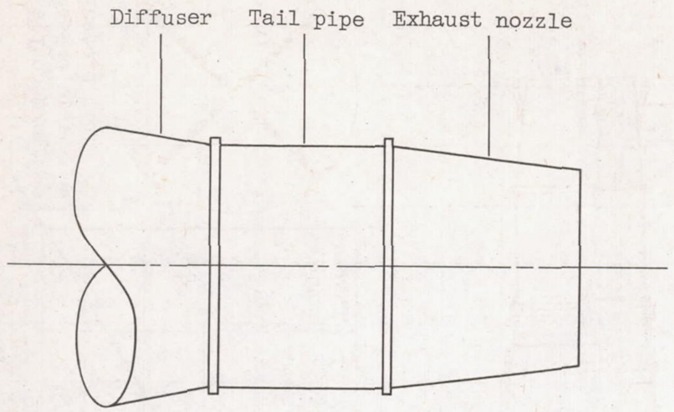


o Total pressure
● Static pressure
⊕ Thermocouple

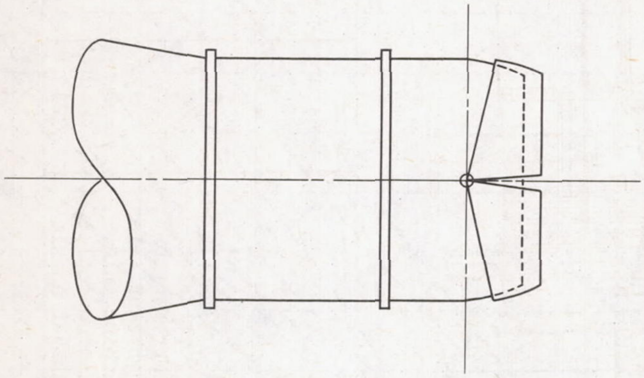
Station 7

CD-3657

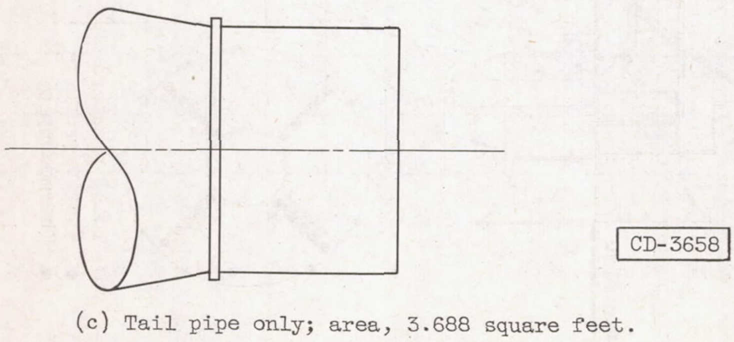
Figure 3. - Cross section of turbojet engine installation showing instrumentation stations.



(a) Fixed conical nozzle; area, 2.388 square feet.

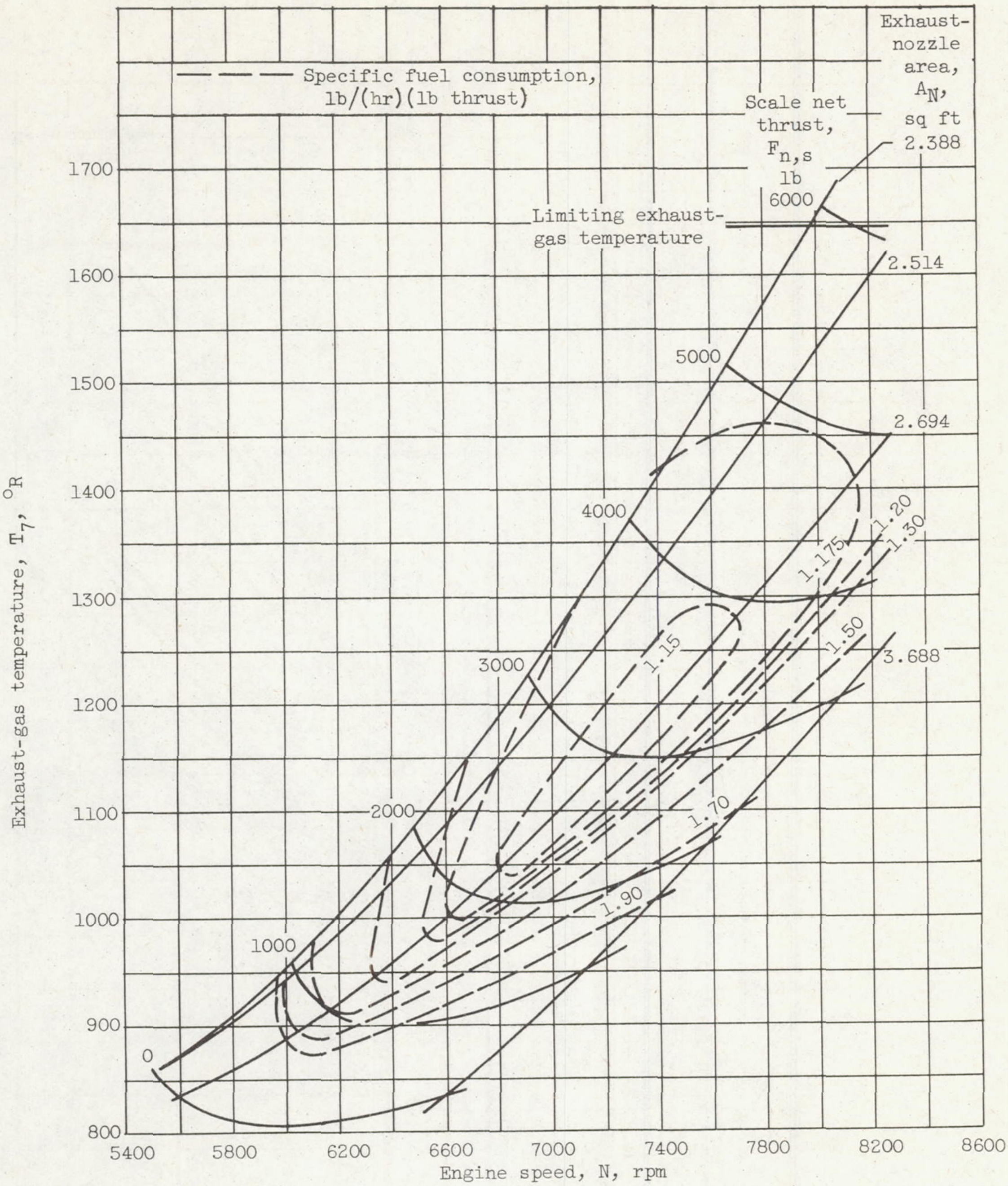


(b) Clamshell-type nozzle; area, 2.514 and 2.694 square feet (two positions).



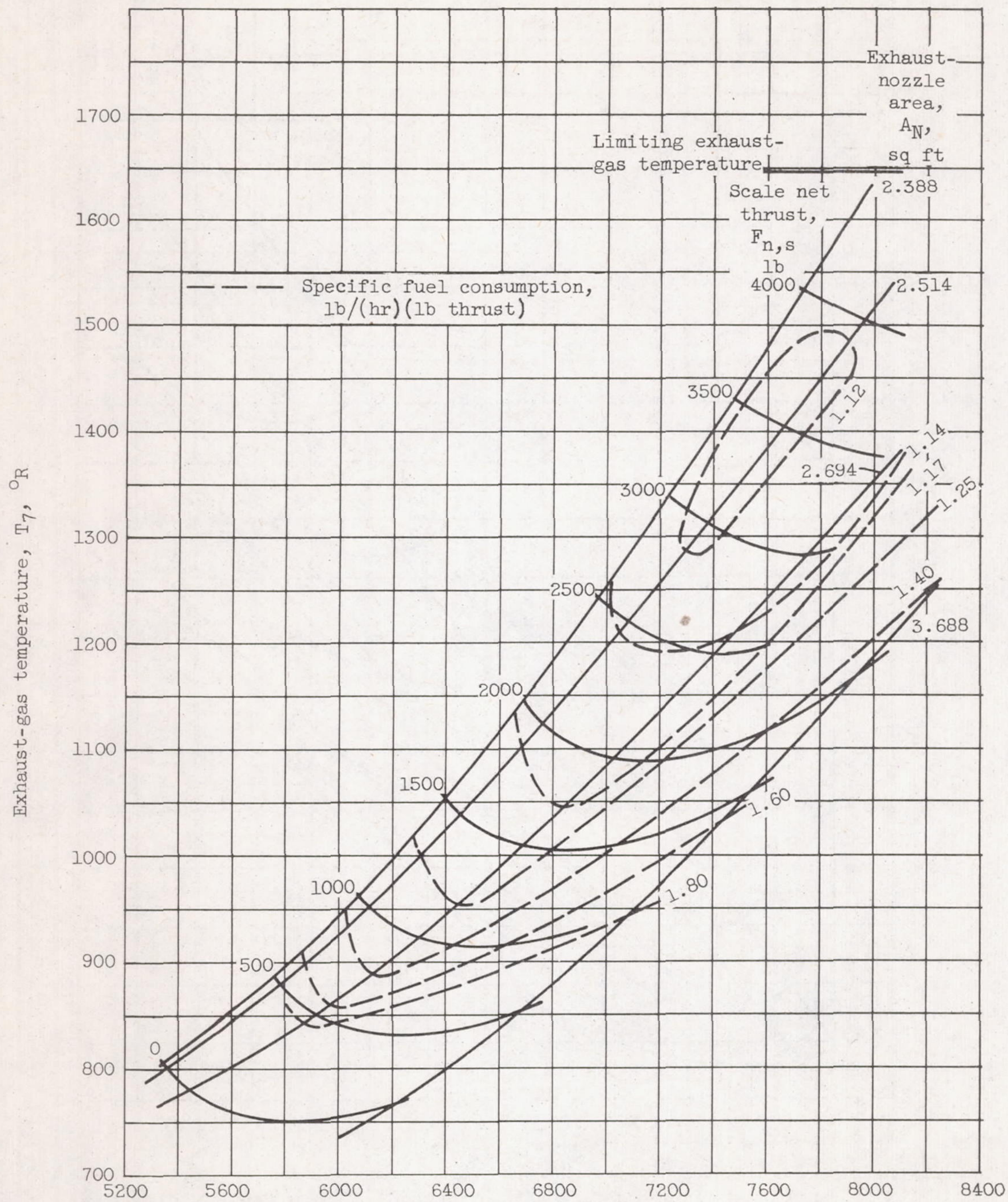
(c) Tail pipe only; area, 3.688 square feet.

Figure 4. - Sketch of exhaust nozzles.



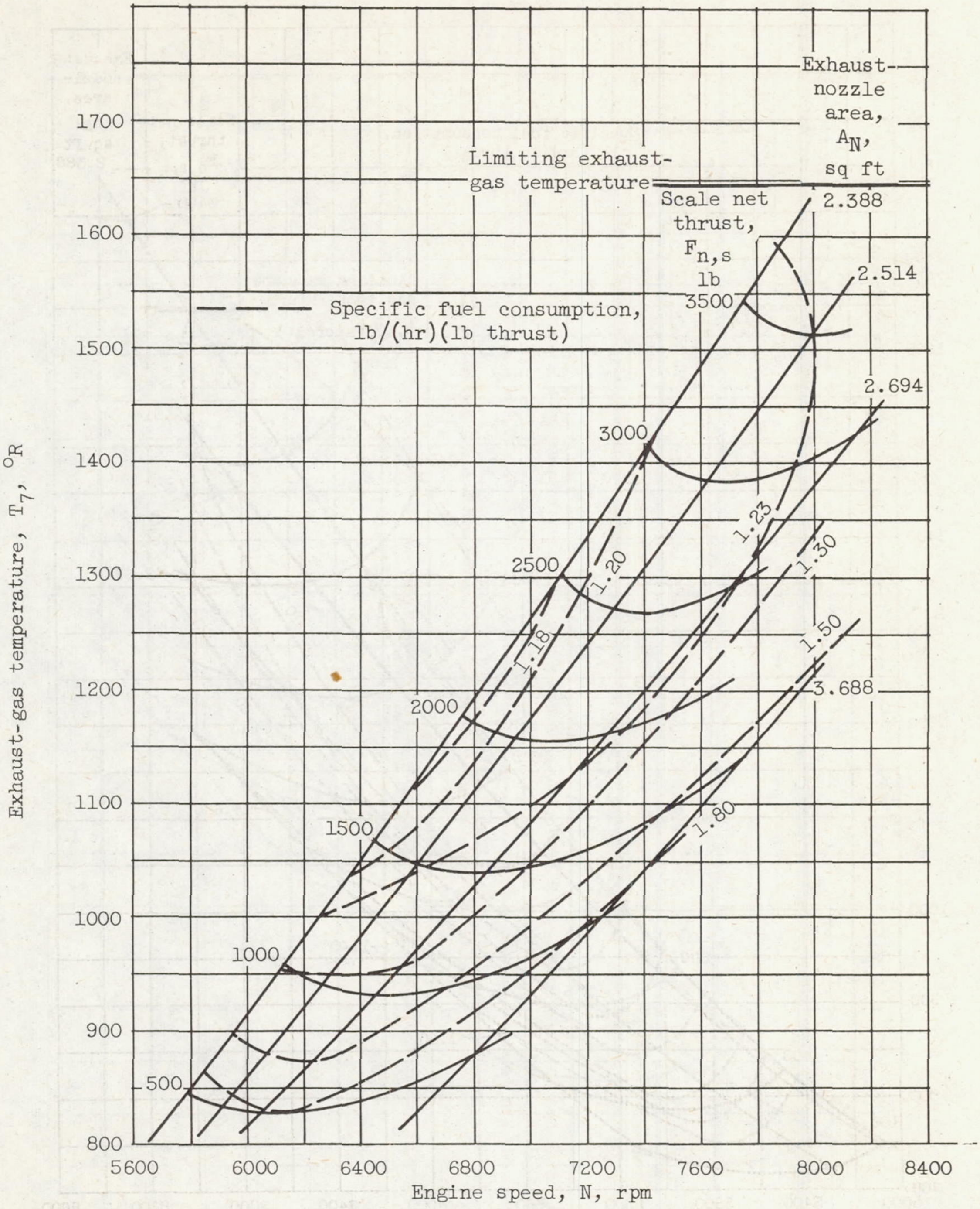
(a) Reynolds number index, 0.88; altitude, 15,000 feet; flight Mach number, 0.803.

Figure 5. - Engine performance maps.



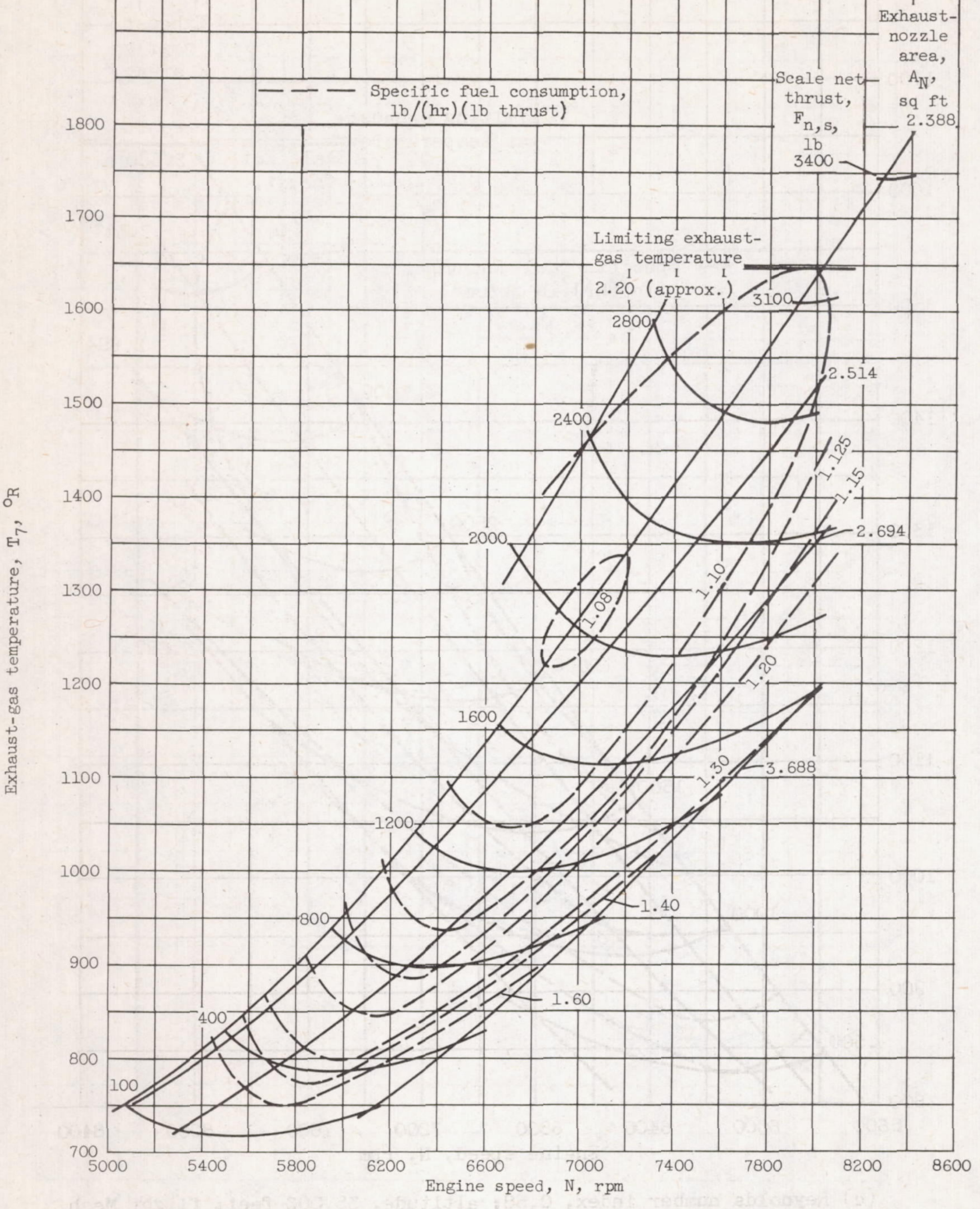
(b) Reynolds number index, 0.59; altitude, 25,000 feet; flight Mach number, 0.804.

Figure 5. - Continued. Engine performance maps.



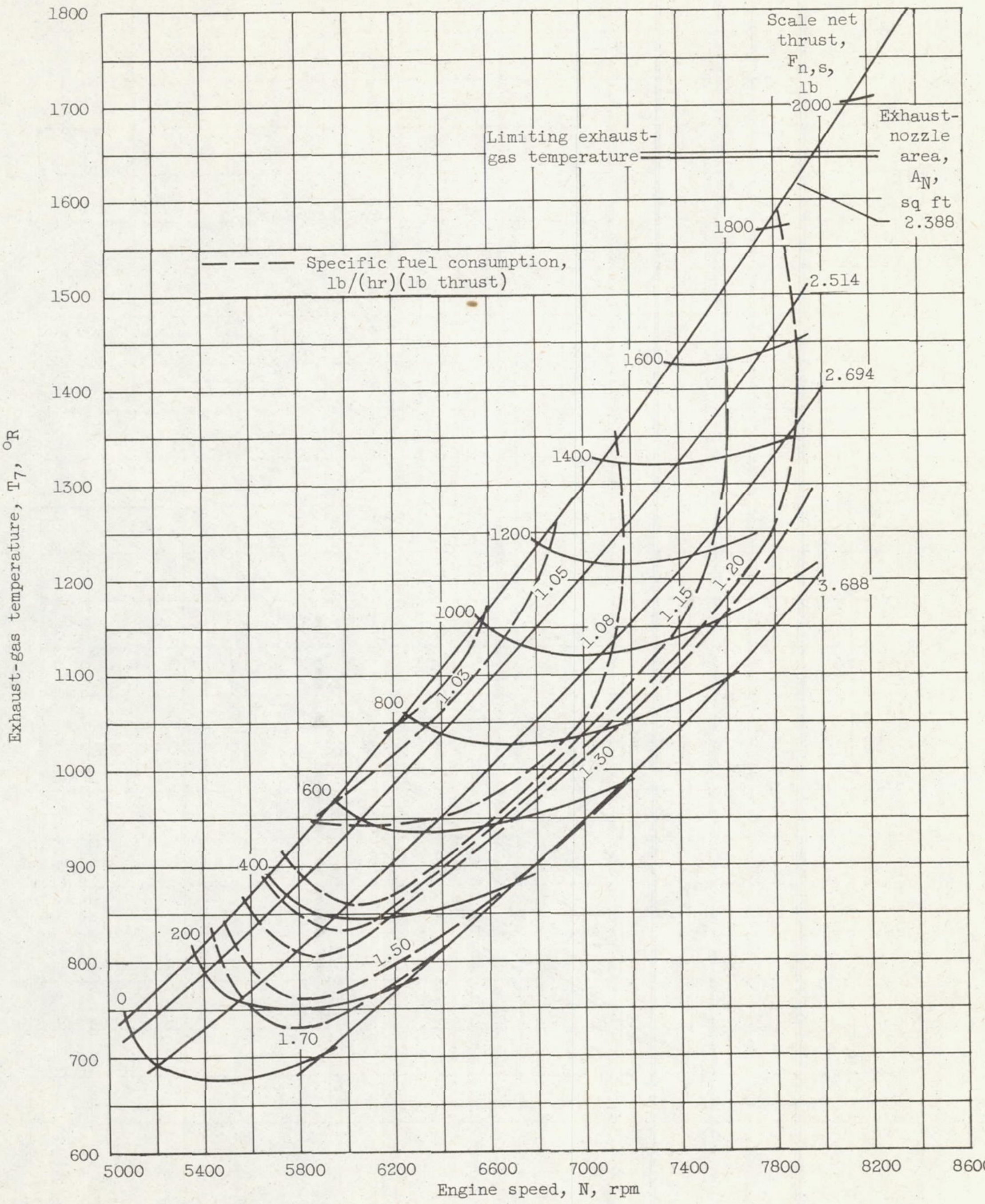
(c) Reynolds number index, 0.58; altitude, 35,000 feet; flight Mach number, 1.23.

Figure 5. - Continued. Engine performance maps.



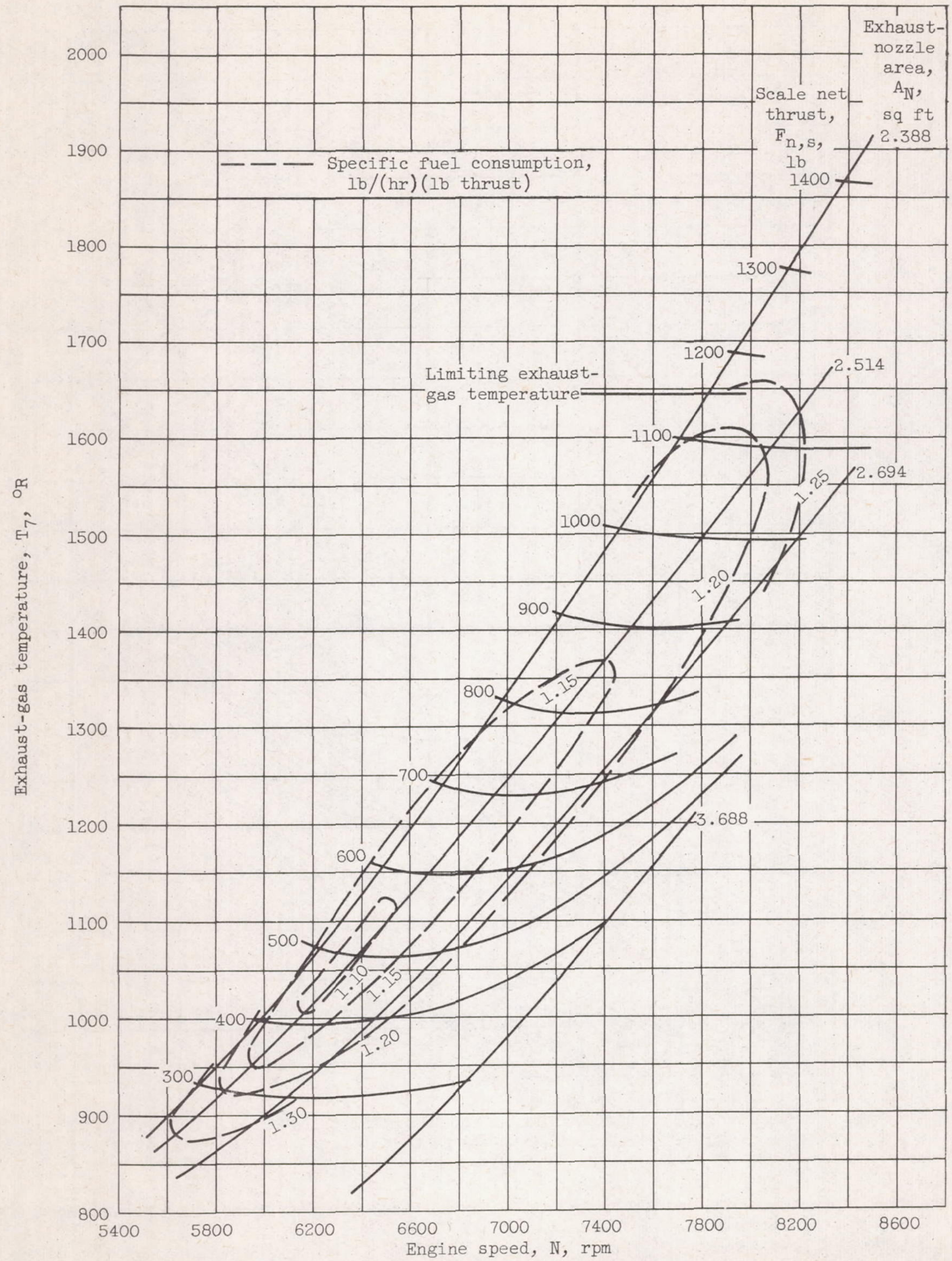
(d) Reynolds number index, 0.39; altitude, 35,000 feet, flight Mach number, 0.805.

Figure 5. - Continued. Engine performance maps.



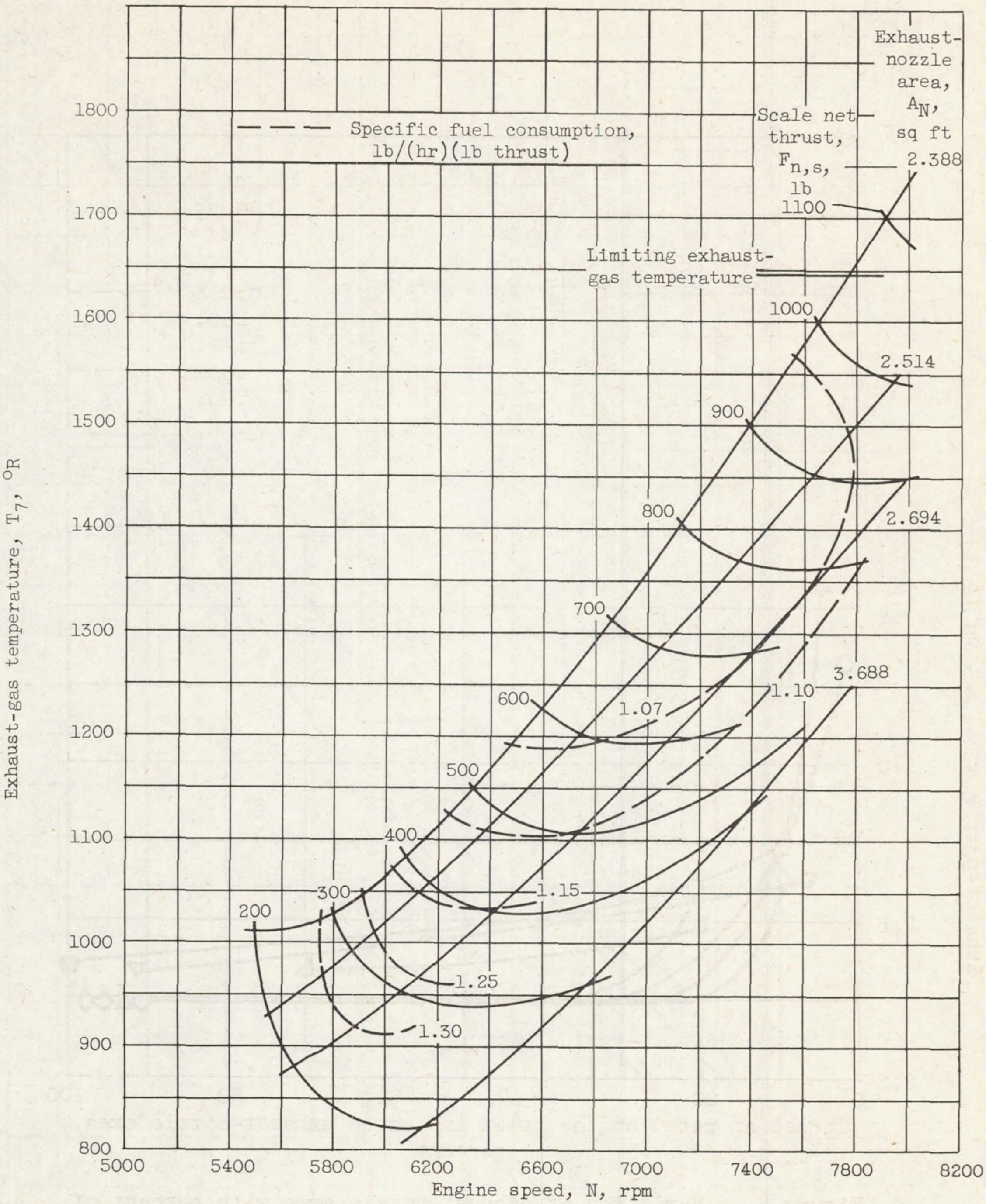
(e) Reynolds number index, 0.24; altitude, 45,000 feet; flight Mach number, 0.805.

Figure 5. - Continued. Engine performance maps.



(f) Reynolds number index, 0.15; altitude, 55,000 feet; flight Mach number, 0.79.

Figure 5. - Continued. Engine performance maps.



(g) Reynolds number index, 0.12; altitude, 55,000 feet; flight Mach number, 0.43.

Figure 5. - Concluded. Engine performance maps.

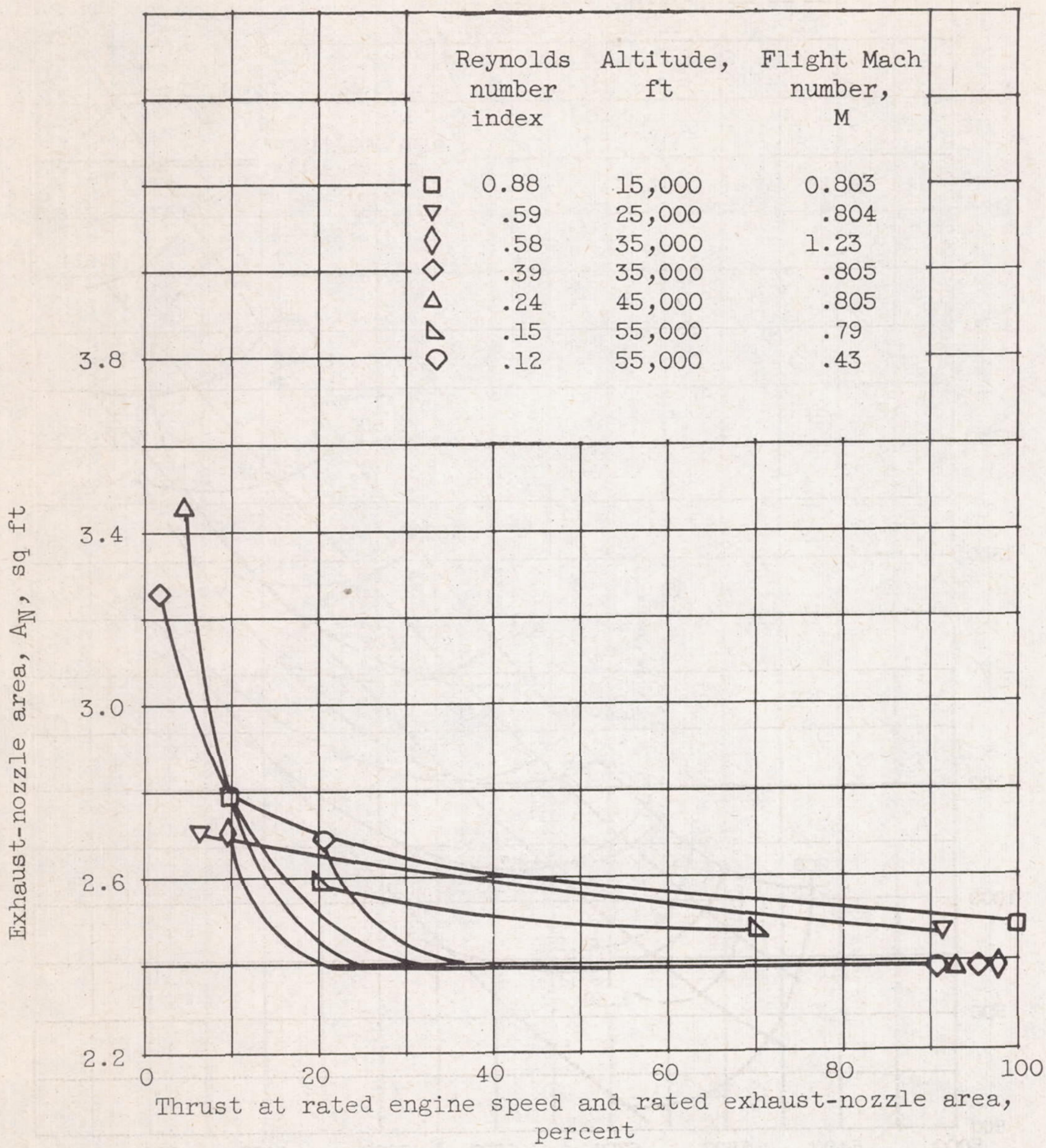
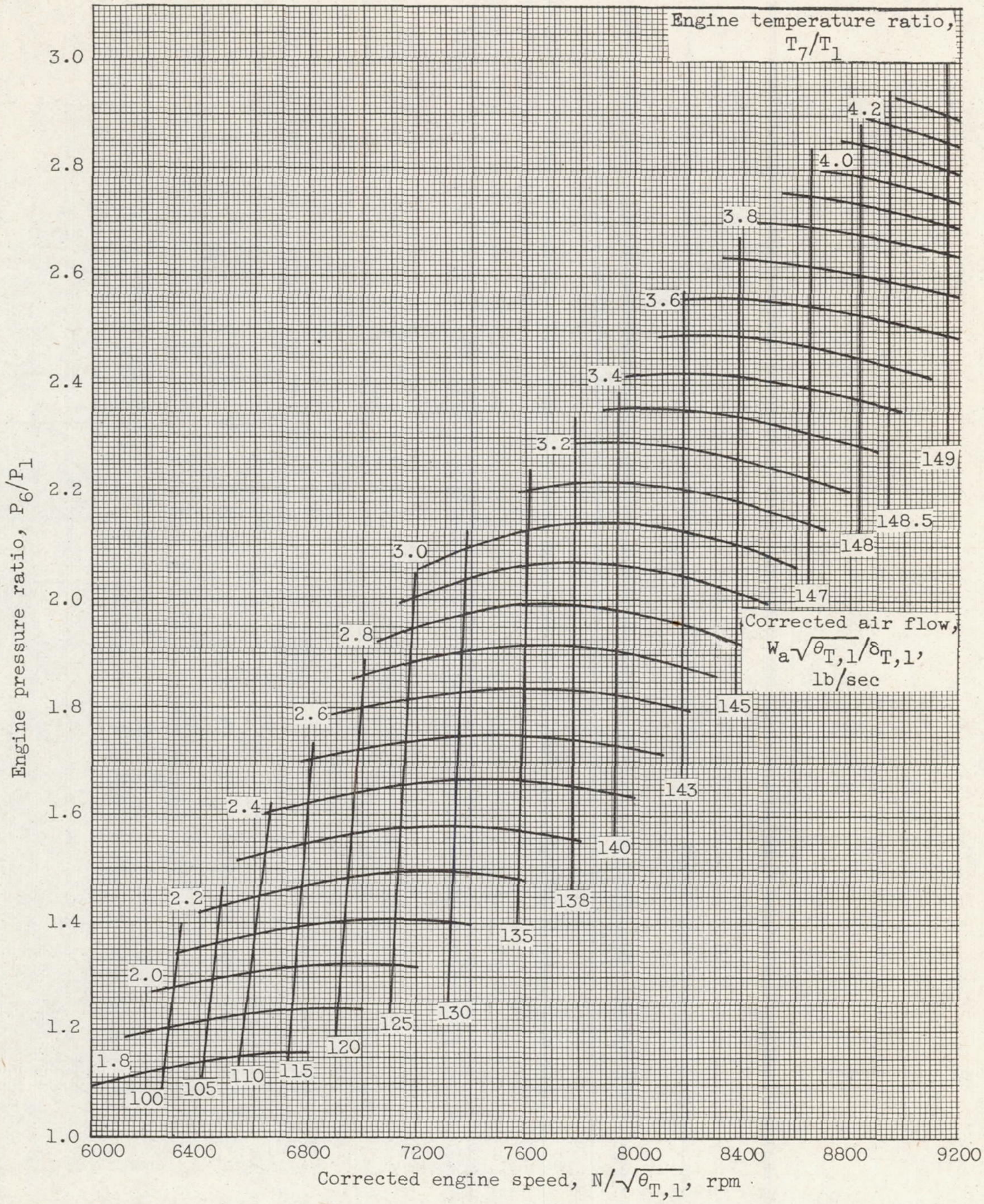


Figure 6. - Variation of exhaust-nozzle area with percent of maximum thrust for minimum specific fuel consumption.



Engine 7. - Engine pumping characteristics. Reynolds number index, 0.39; altitude, 35,000 feet; flight Mach number, 0.805.

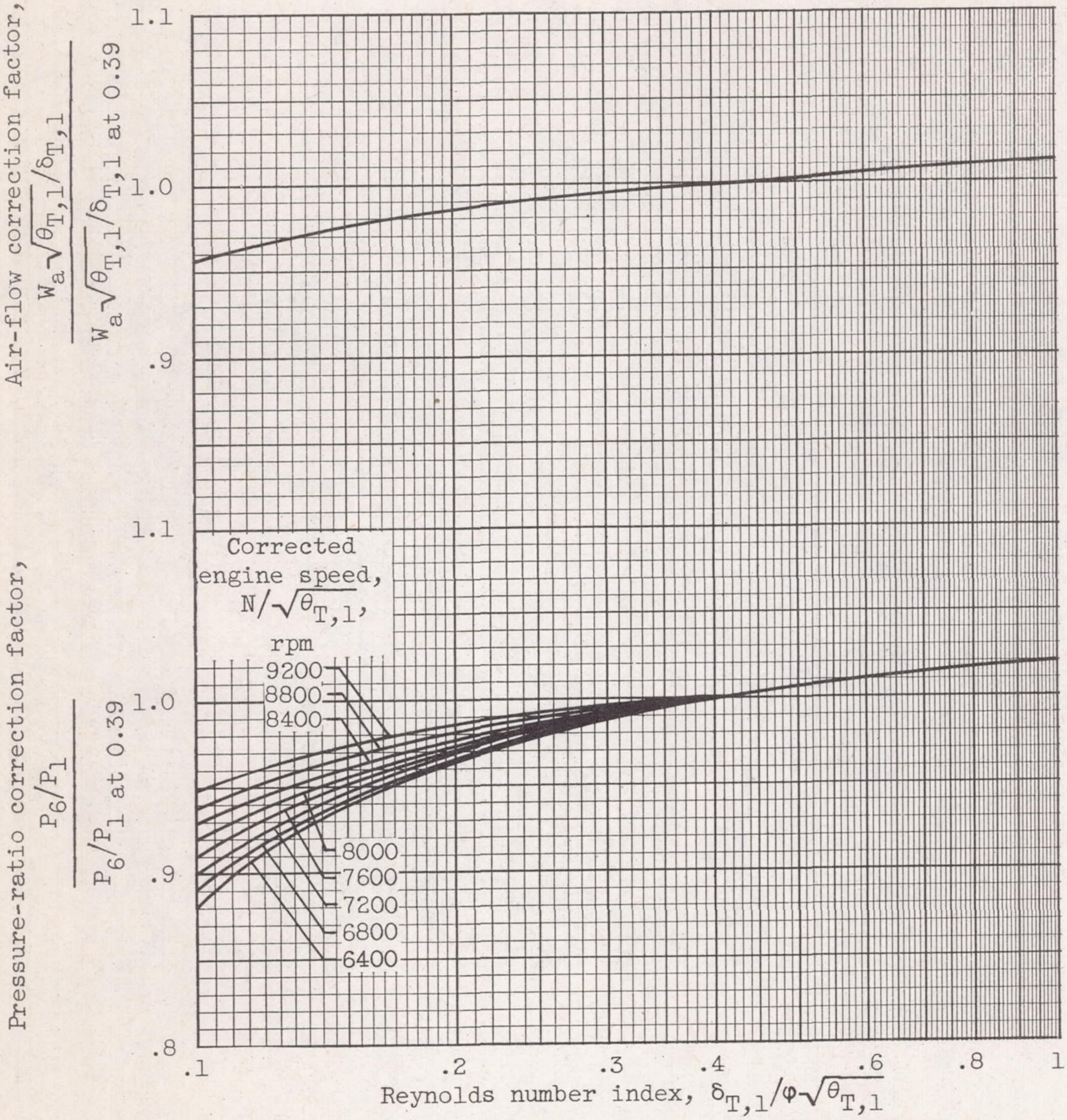


Figure 8. - Engine air-flow and pressure-ratio corrections for range of Reynolds number index.

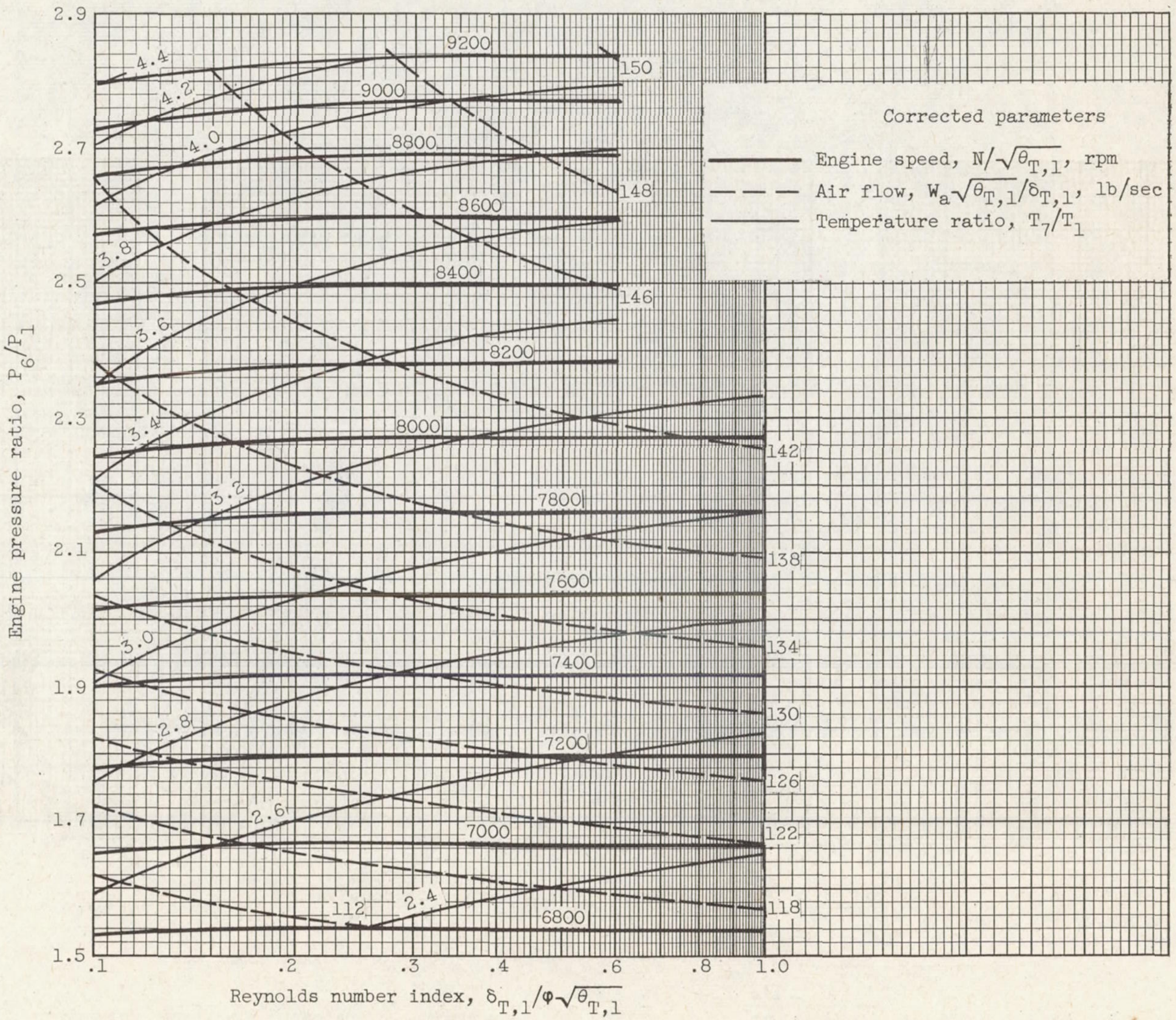
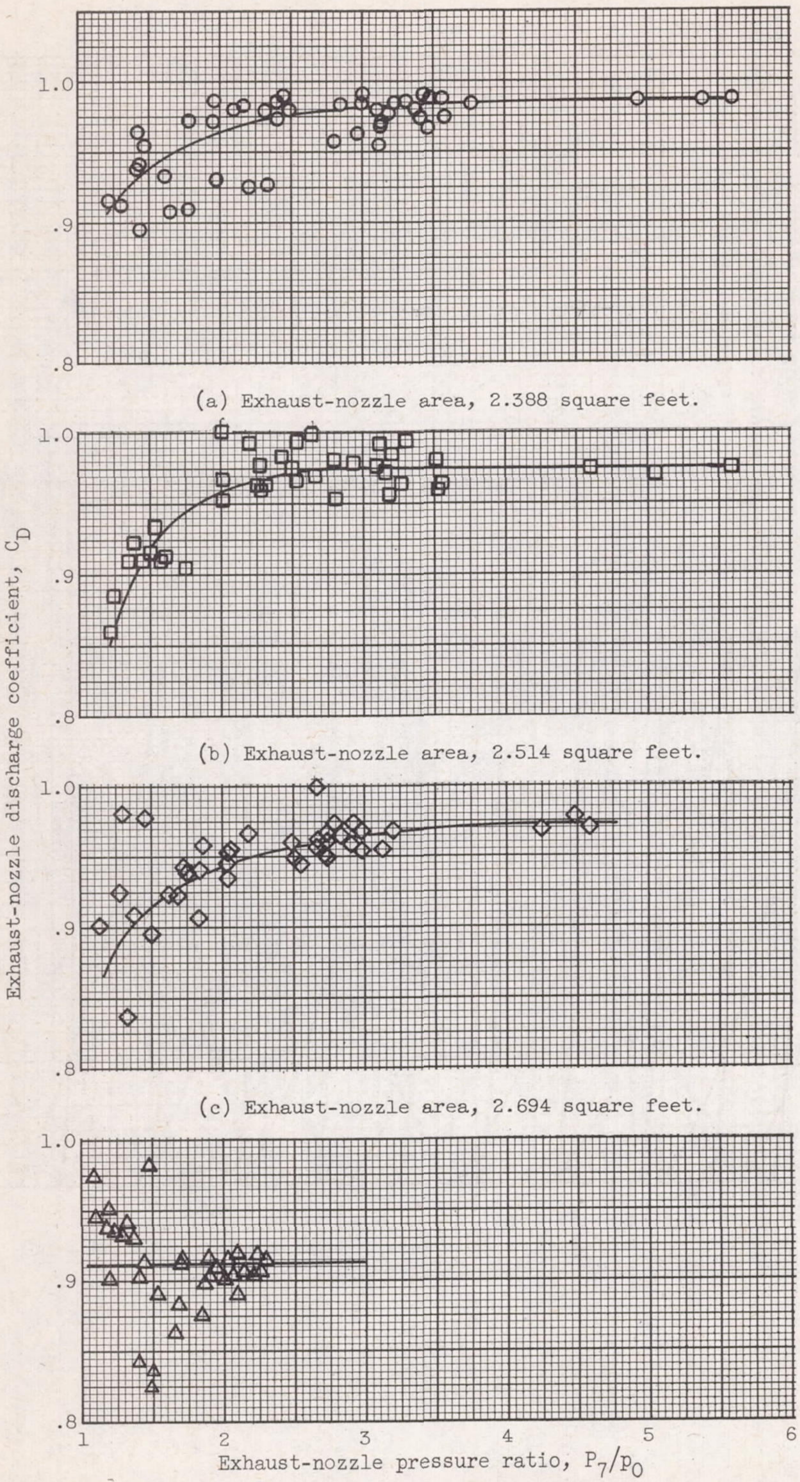


Figure 9. - Engine pumping characteristics with exhaust-nozzle area of 2.388 square feet.



(a) Exhaust-nozzle area, 2.388 square feet.

(b) Exhaust-nozzle area, 2.514 square feet.

(c) Exhaust-nozzle area, 2.694 square feet.

(d) Exhaust-nozzle area, 3.688 square feet.

Figure 10. - Exhaust-nozzle discharge coefficient.

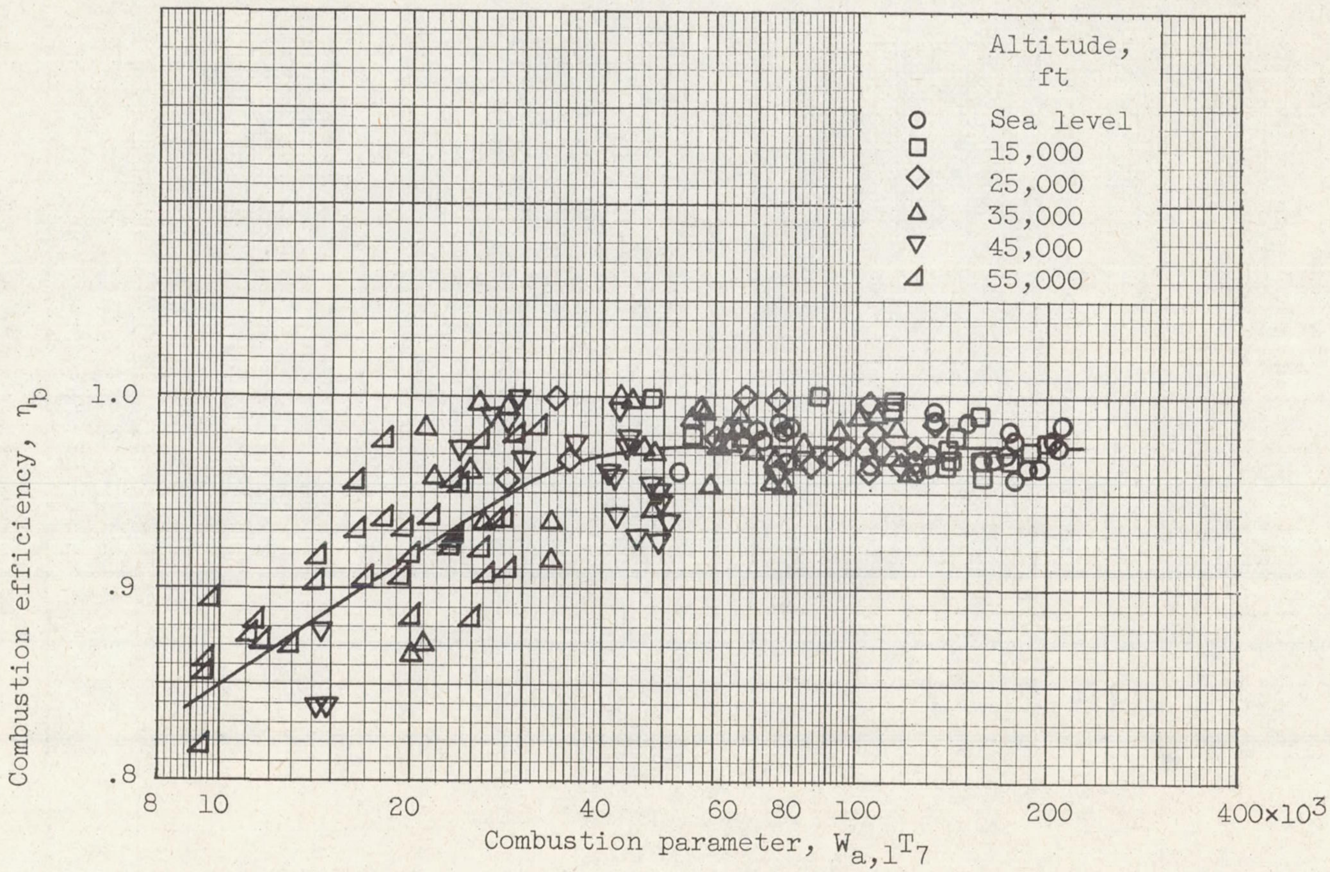


Figure 11. - Variation of combustion efficiency with combustion parameter.

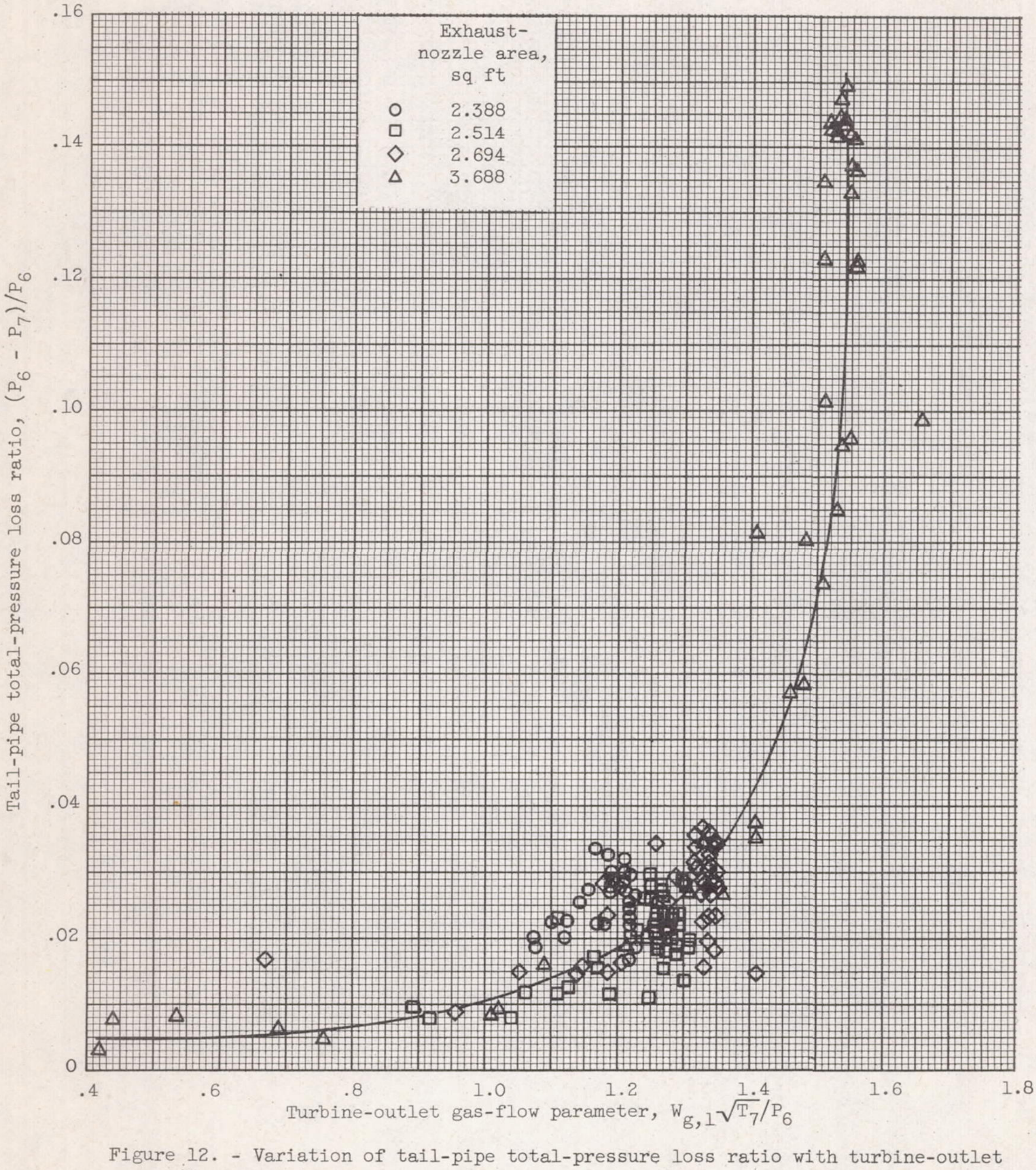


Figure 12. - Variation of tail-pipe total-pressure loss ratio with turbine-outlet gas-flow parameter.

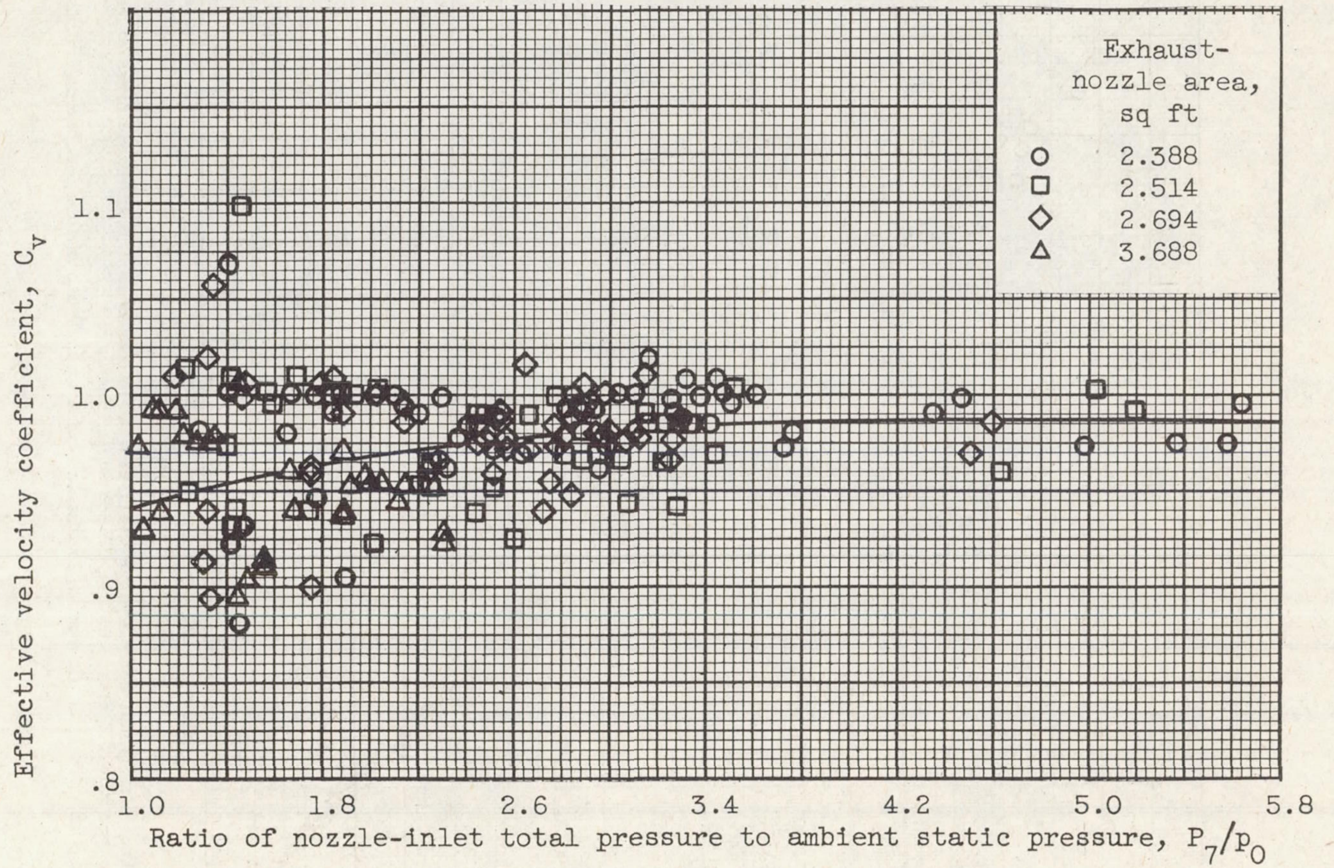


Figure 13. - Variation of effective velocity coefficient with exhaust-nozzle pressure ratio.

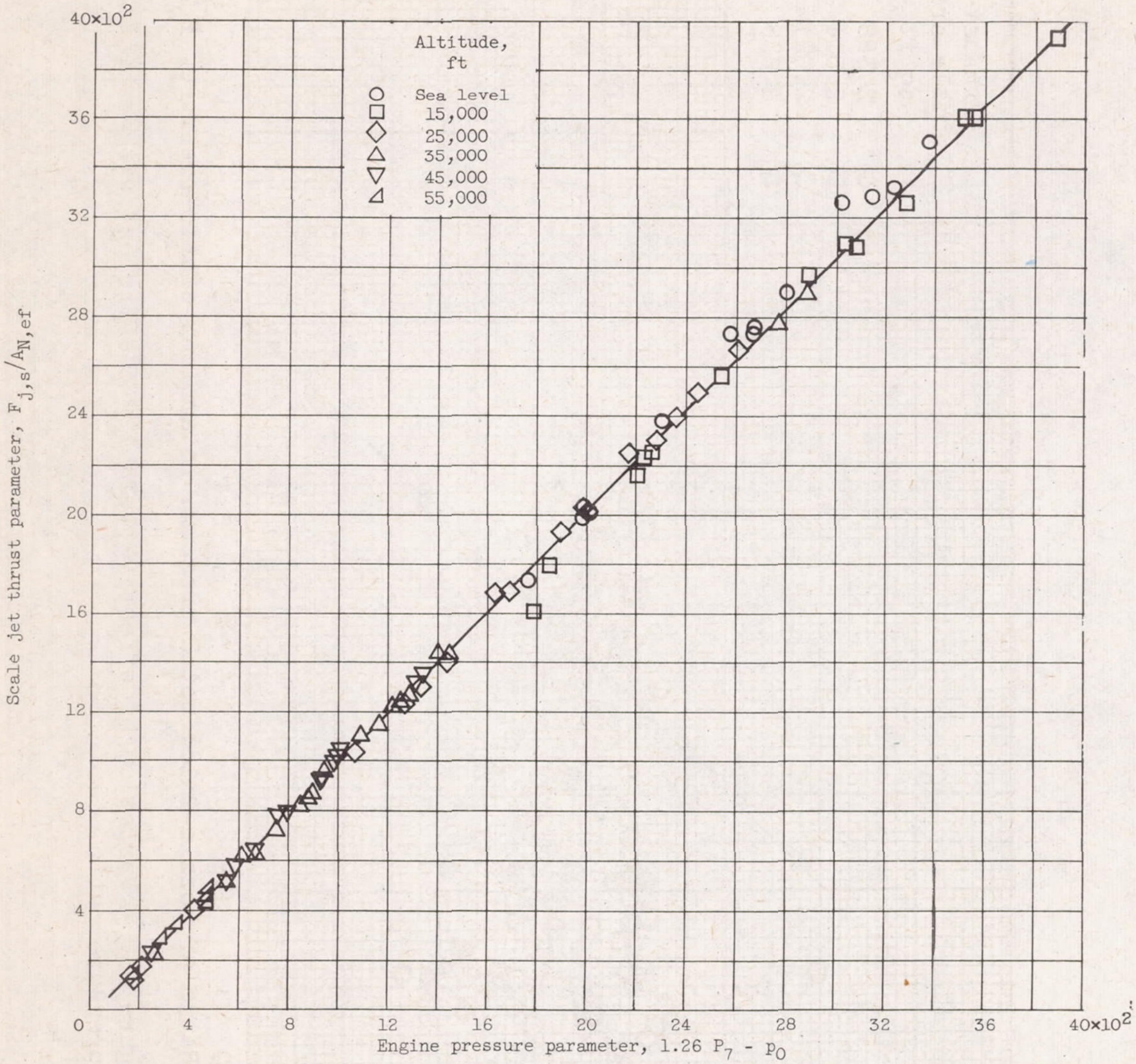


Figure 14. - Jet thrust correlation for all exhaust-nozzle areas. Four nozzle areas at each altitude: 2.388, 2.514, 2.694, and 3.688 square feet.

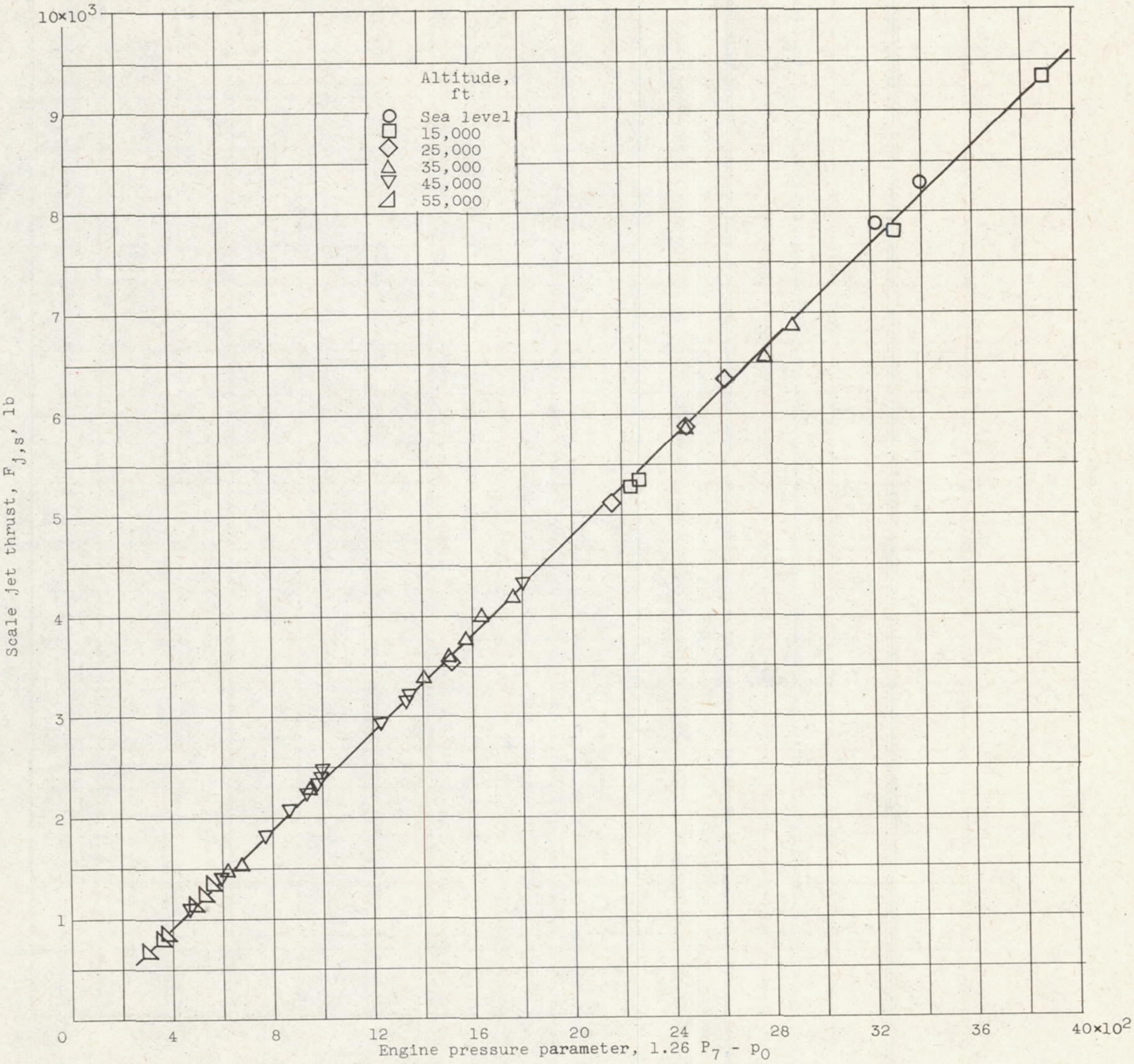
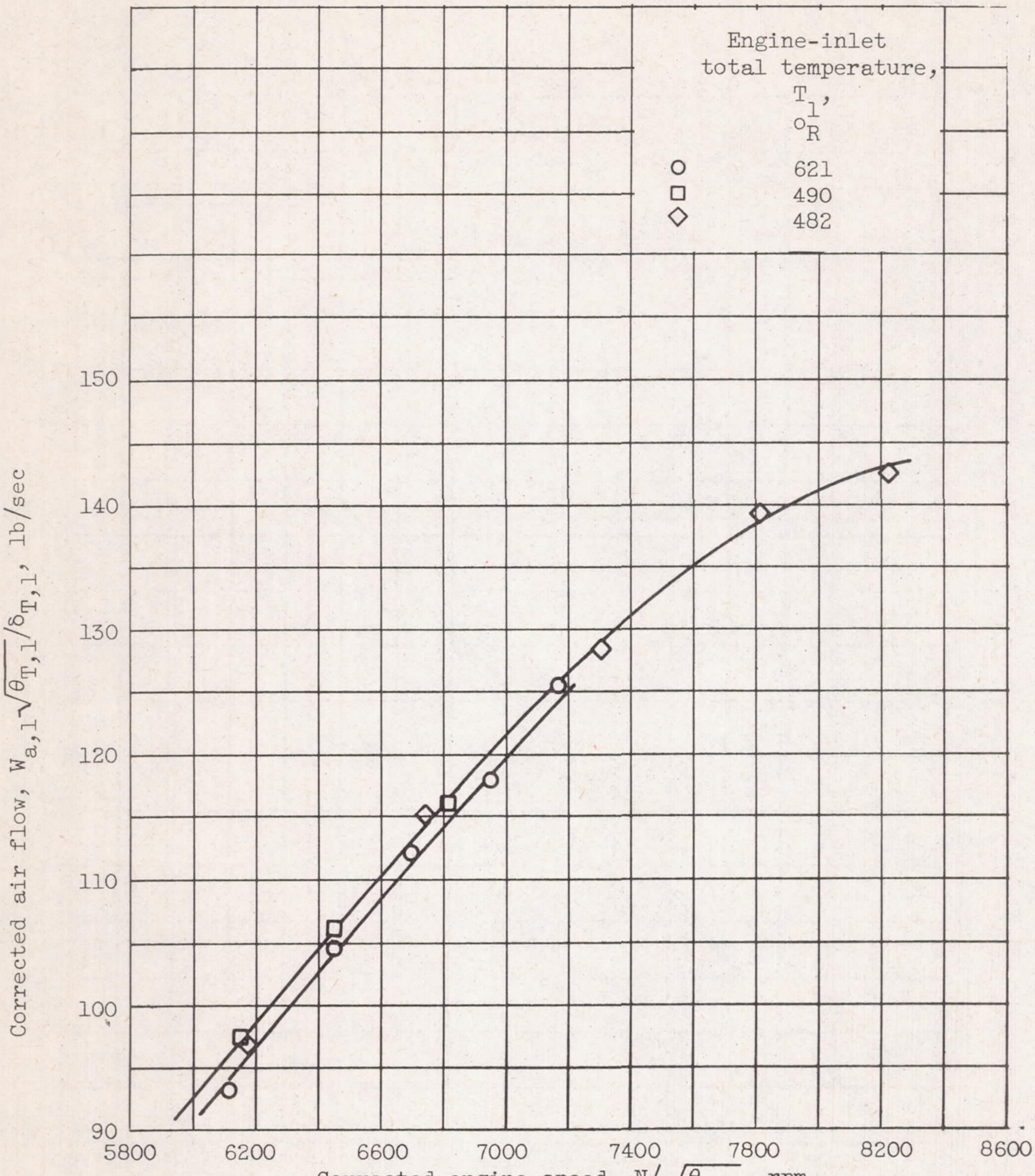
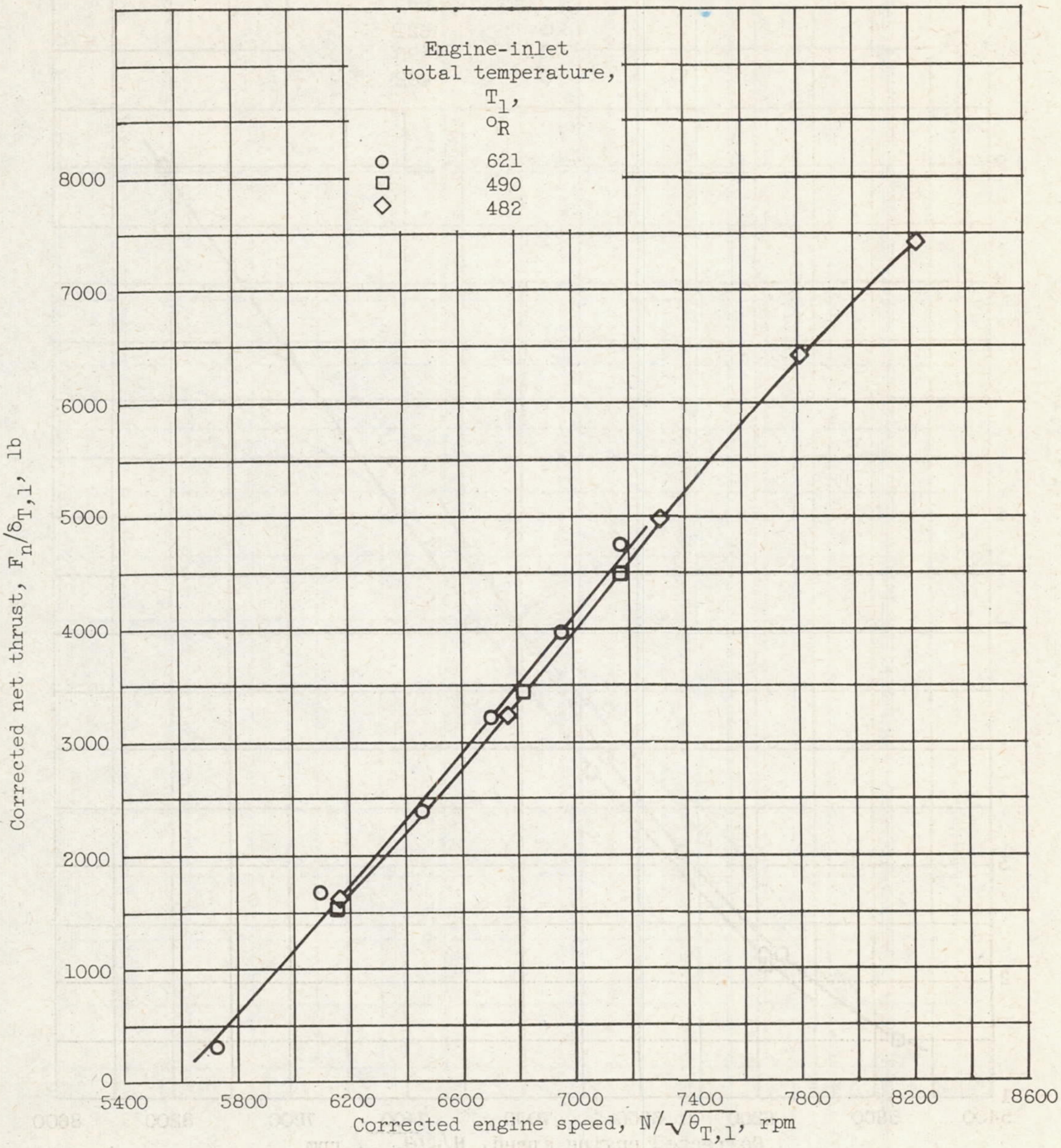


Figure 15. - Jet thrust correlation for an exhaust-nozzle area of 2.388 square feet.



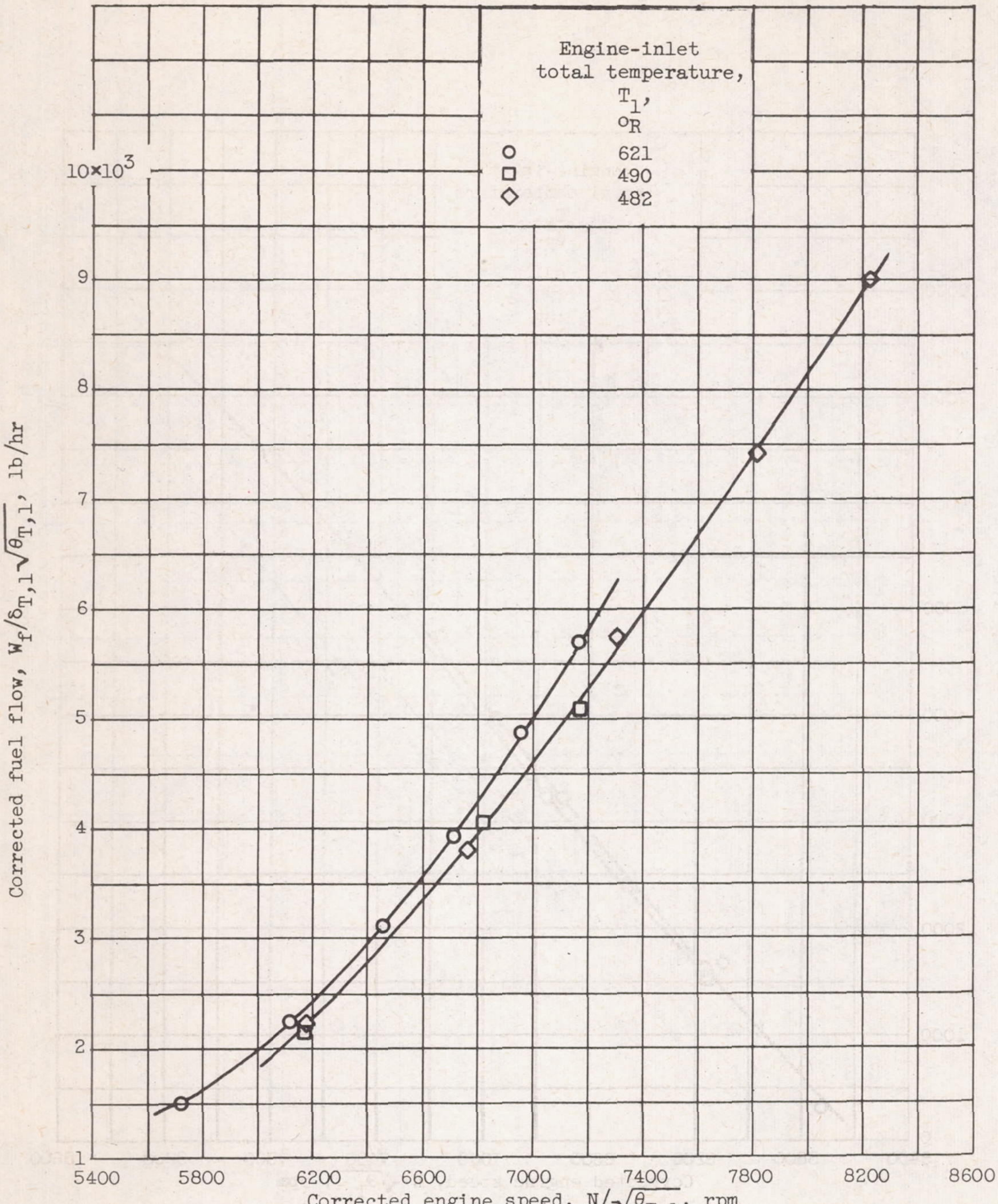
(a) Corrected air flow.

Figure 16. - Effects of inlet temperature. Altitude, 35,000 feet; flight Mach number, 0.8; exhaust-nozzle area, 2.37 square feet.



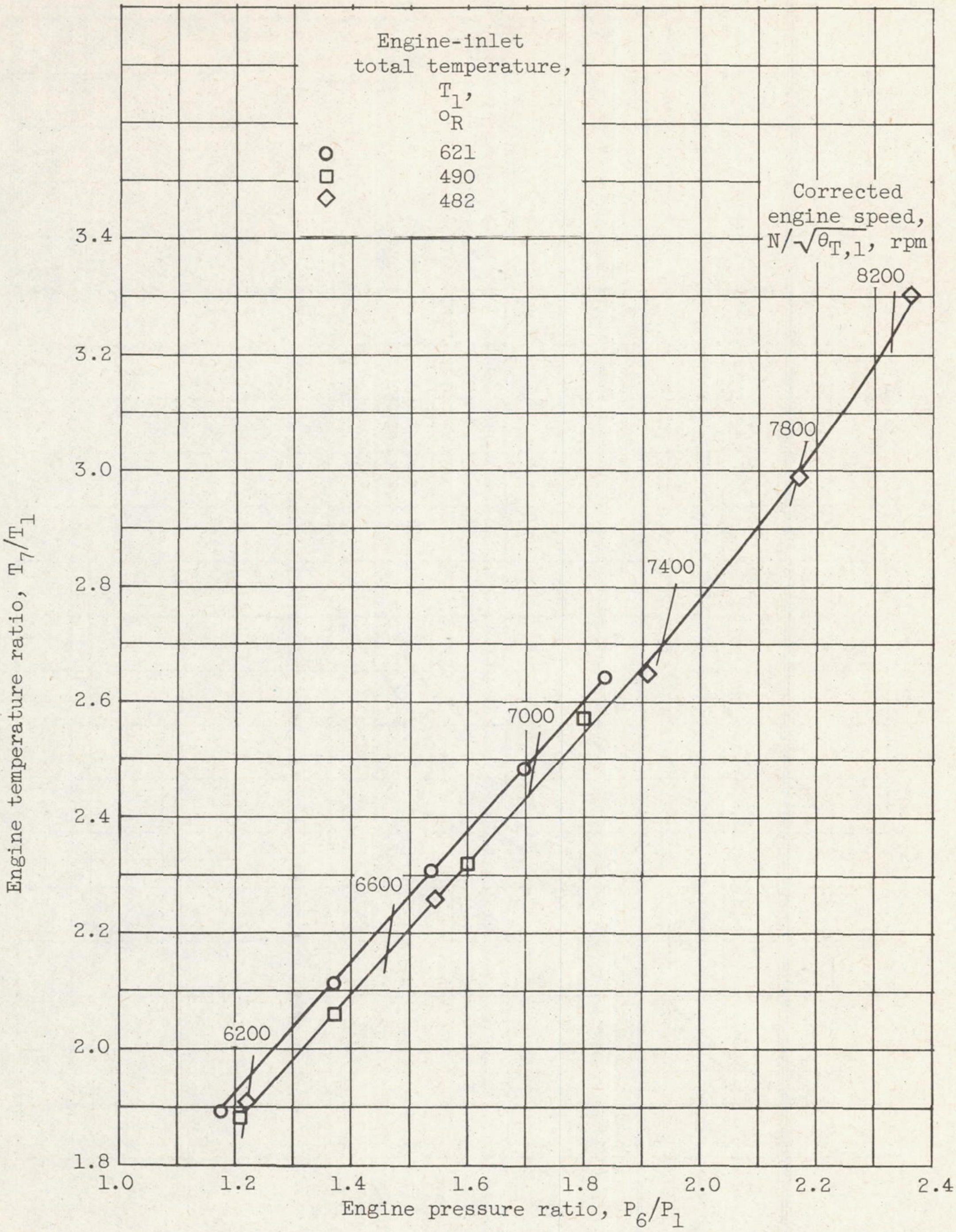
(b) Corrected net thrust.

Figure 16. - Continued. Effects of inlet temperature. Altitude, 35,000 feet; flight Mach number, 0.8; exhaust-nozzle area, 2.37 square feet



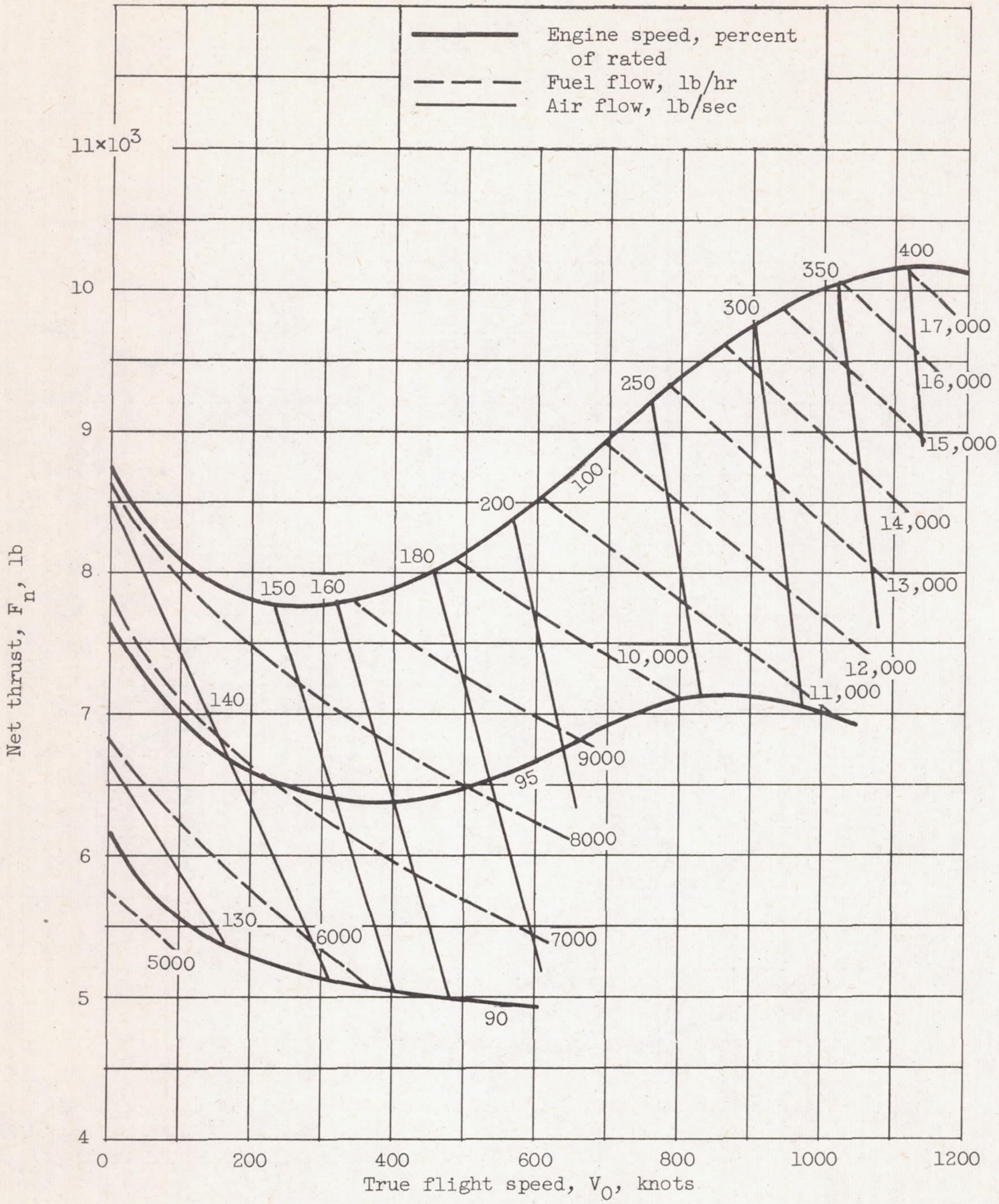
(c) Corrected fuel flow.

Figure 16. - Continued. Effects of inlet temperature. Altitude, 35,000 feet; flight Mach number, 0.8; exhaust-nozzle area, 2.37 square feet.



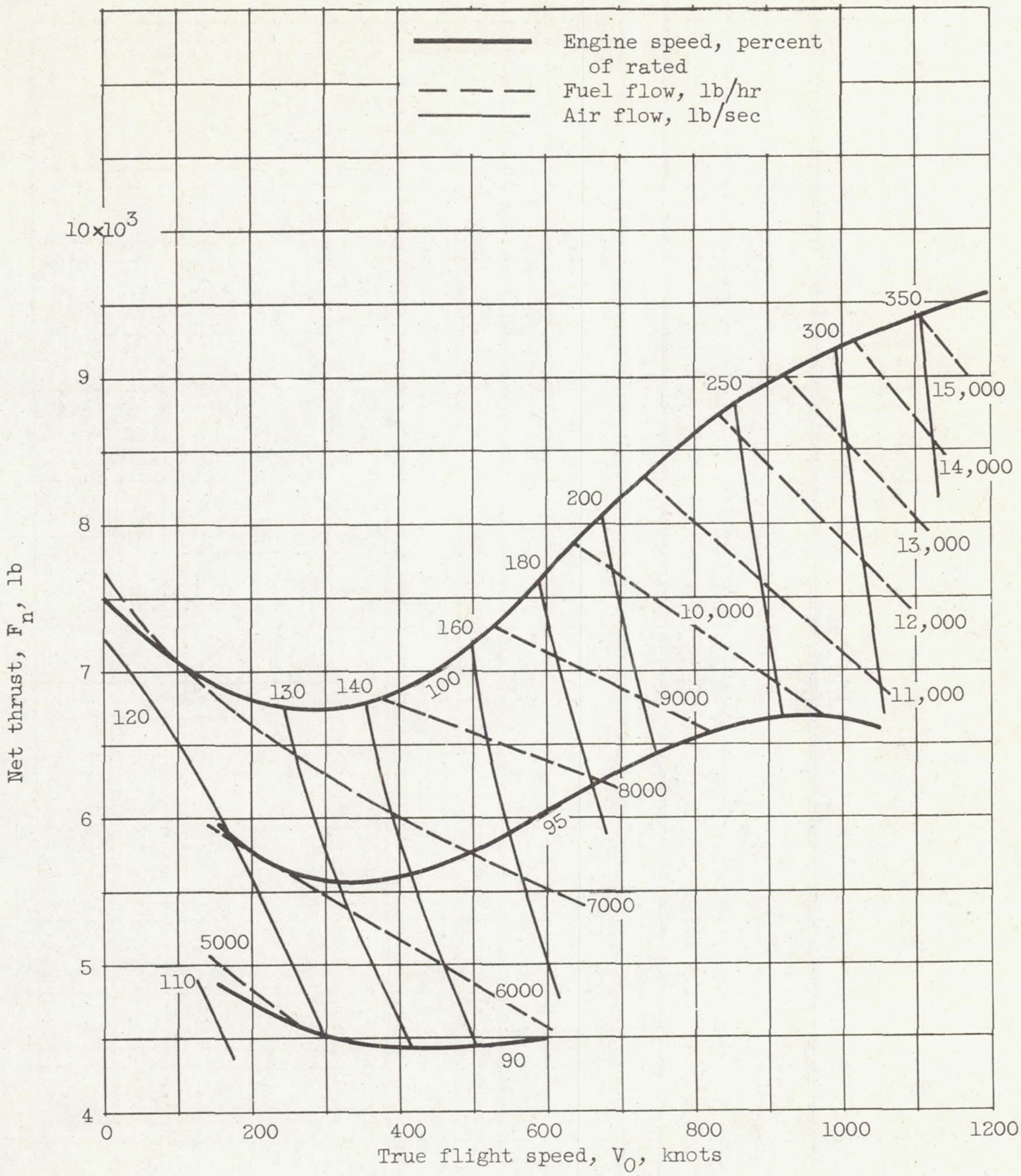
(d) Variation of engine temperature ratio with engine pressure ratio.

Figure 16. - Concluded. Effects of inlet temperature. Altitude, 35,000 feet; flight Mach number, 0.8; exhaust-nozzle area, 2.37 square feet.



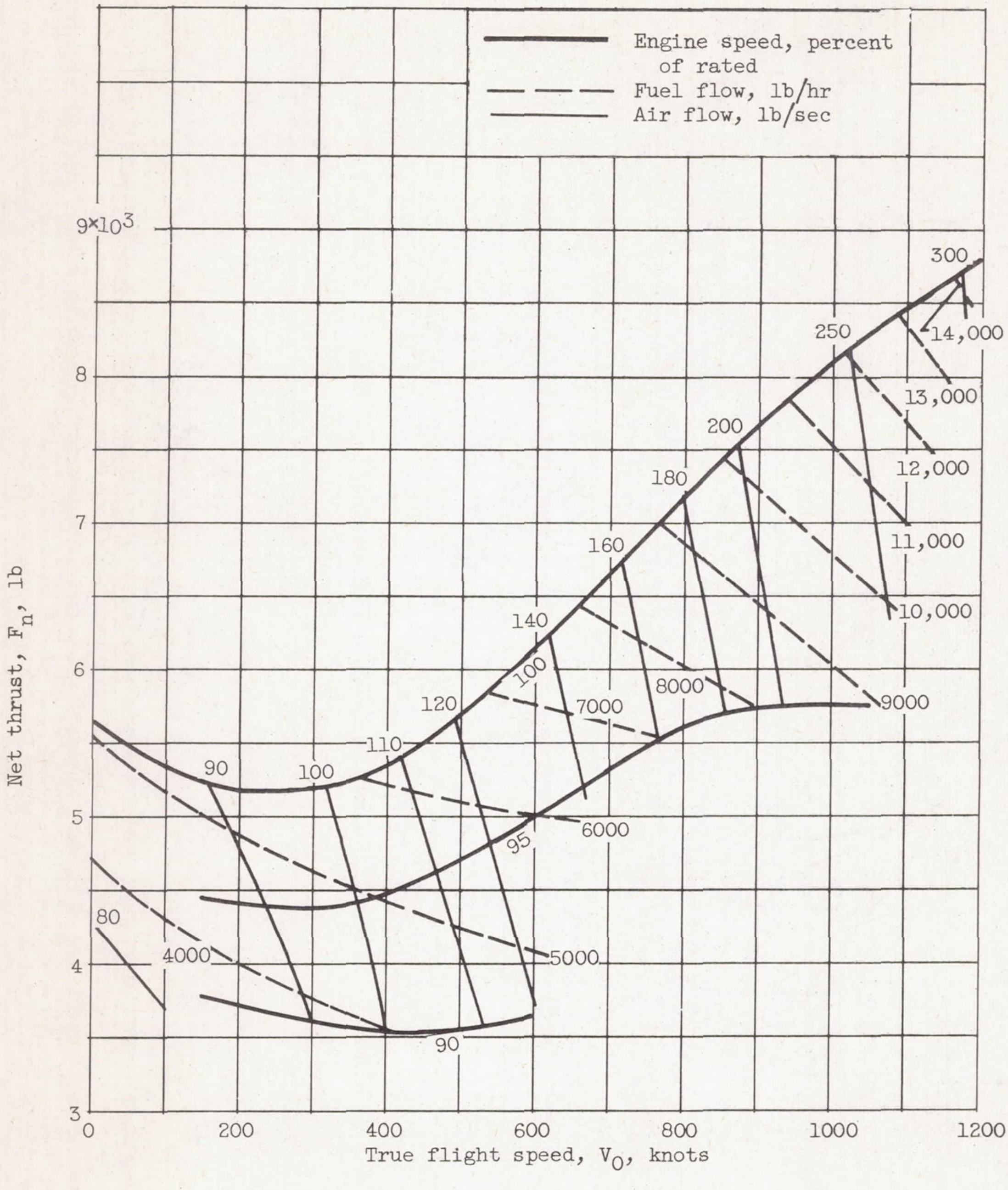
(a) Altitude, sea level.

Figure 17. - Predicted performance from pumping characteristics. Exhaust-nozzle area, 2.388 square feet. Standard NACA atmosphere and complete ram recovery assumed.



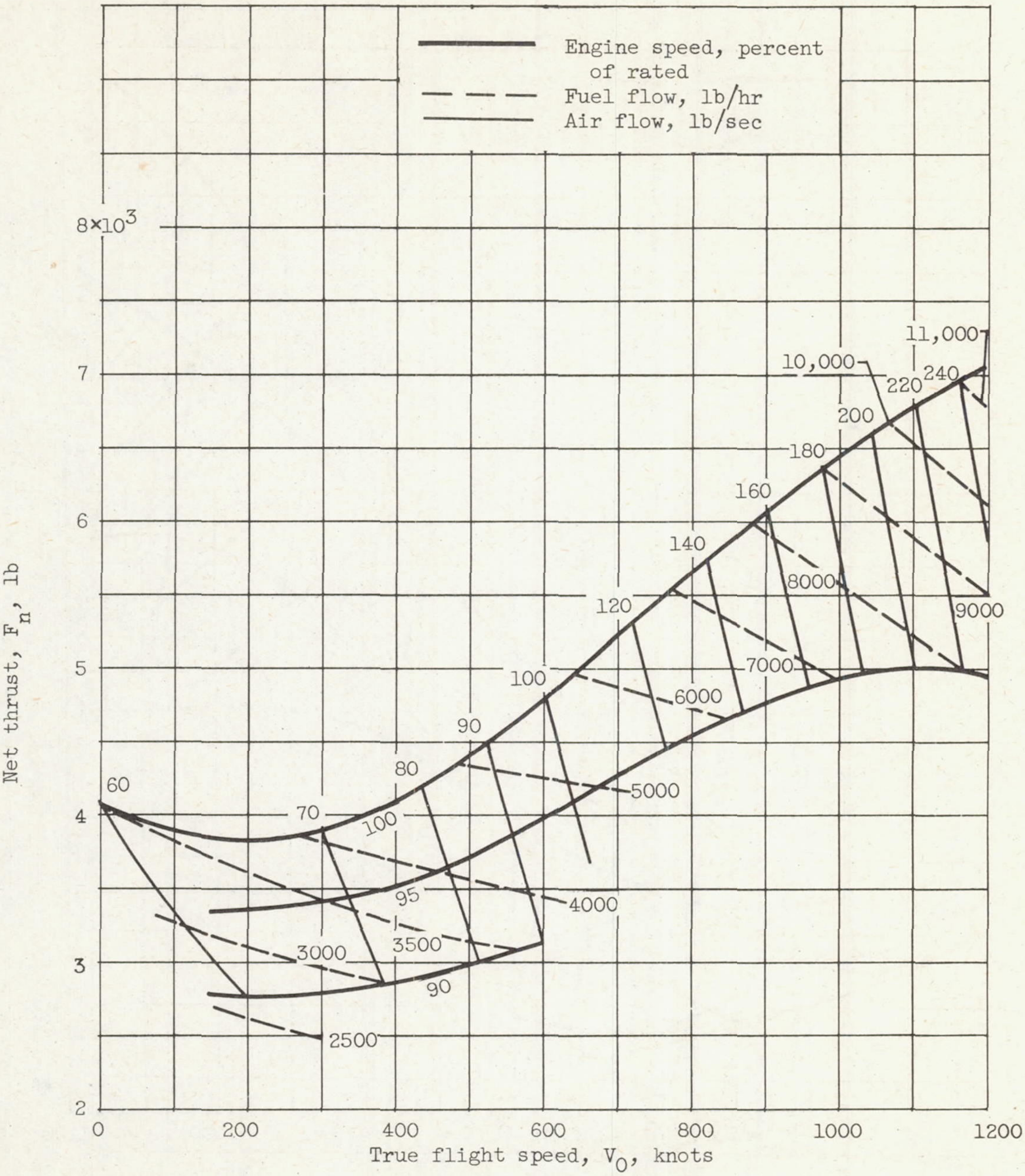
(b) Altitude, 5000 feet.

Figure 17. - Continued. Predicted performance from pumping characteristics. Exhaust-nozzle area, 2.388 square feet. Standard NACA atmosphere and complete ram recovery assumed.



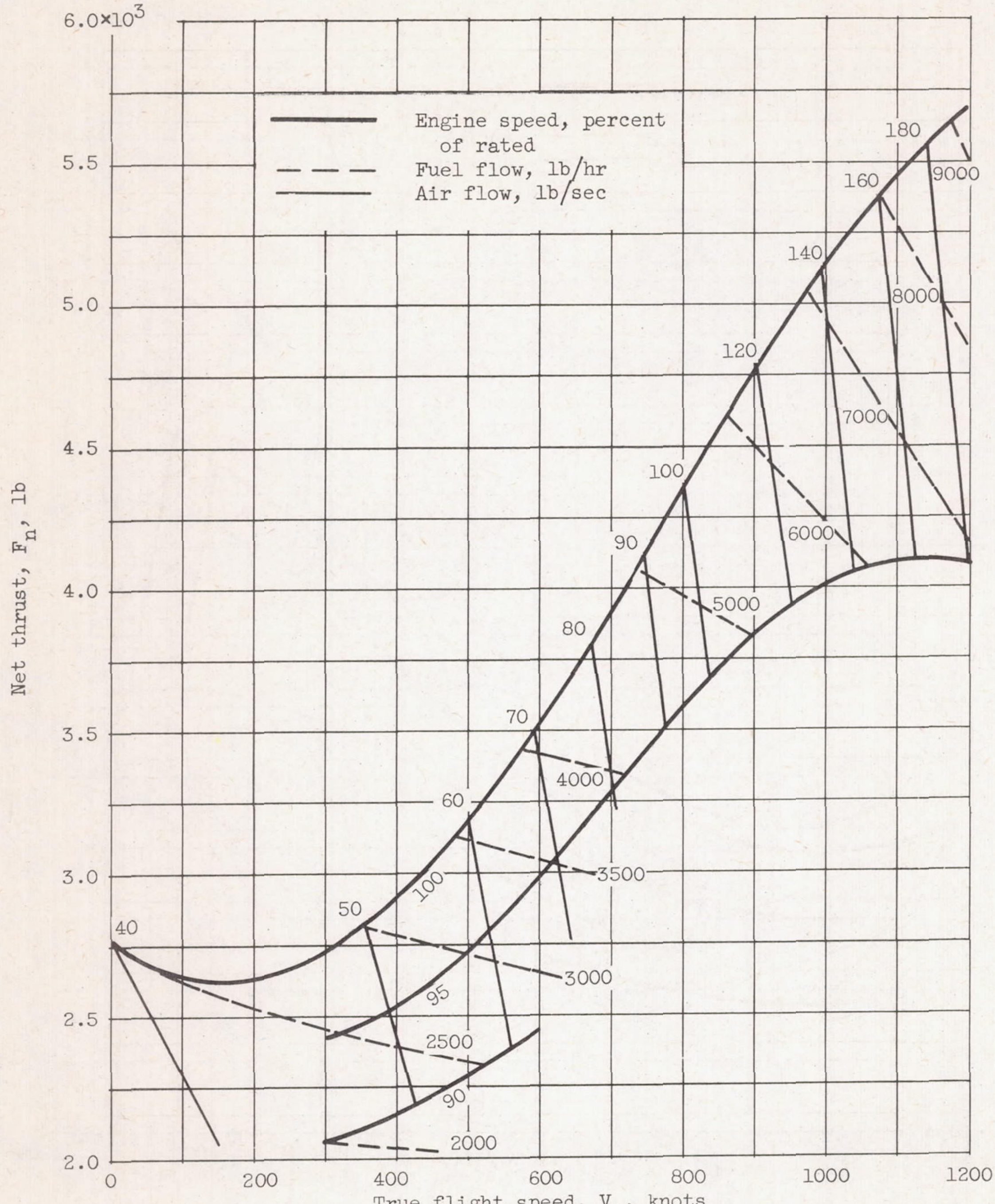
(c) Altitude, 15,000 feet.

Figure 17. - Continued. Predicted performance from pumping characteristics. Exhaust-nozzle area, 2.388 square feet. Standard NACA atmosphere and complete ram recovery assumed.



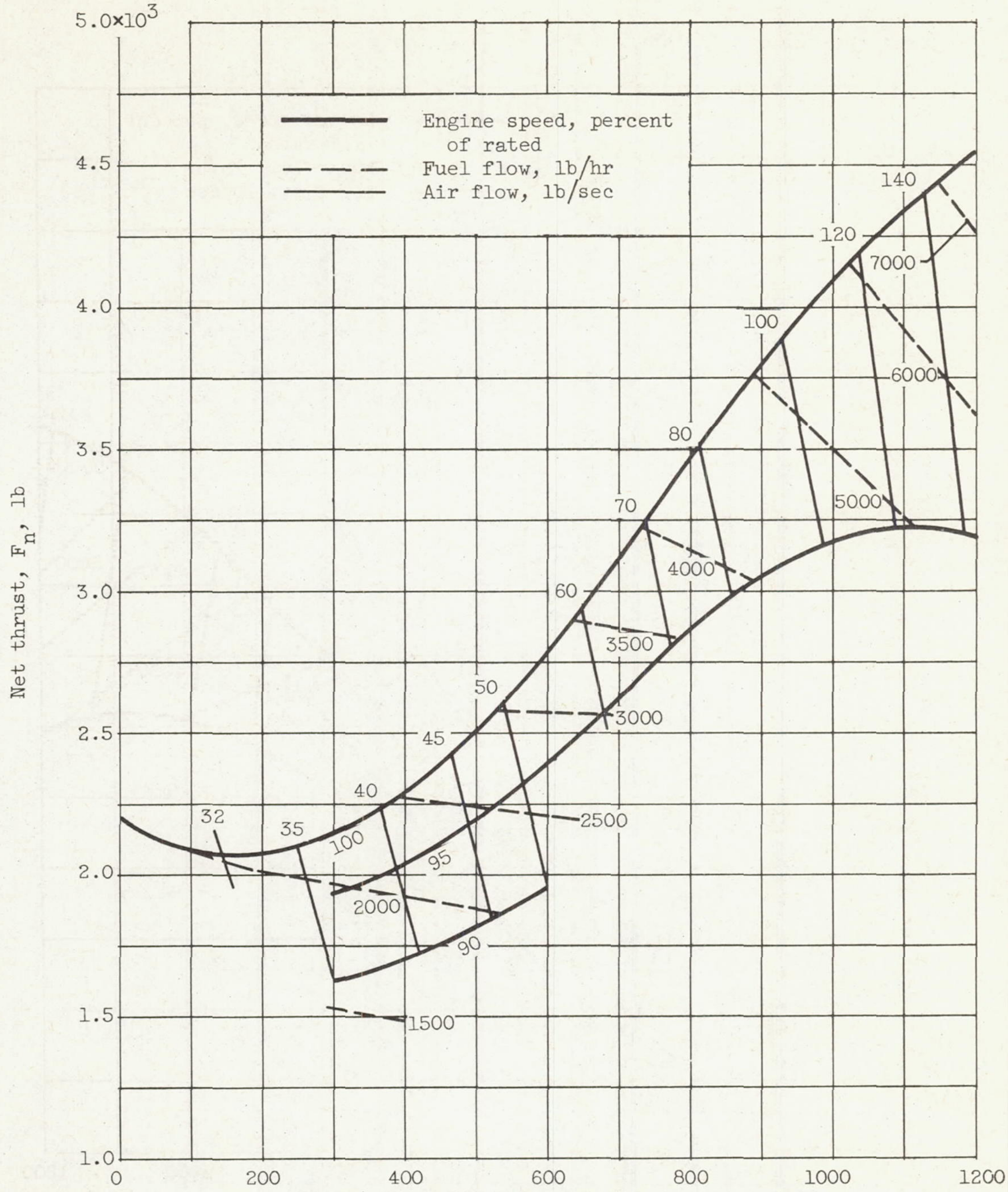
(d) Altitude, 25,000 feet.

Figure 17. - Continued. Predicted performance from pumping characteristics. Exhaust-nozzle area, 2.388 square feet. Standard NACA atmosphere and complete ram recovery assumed.



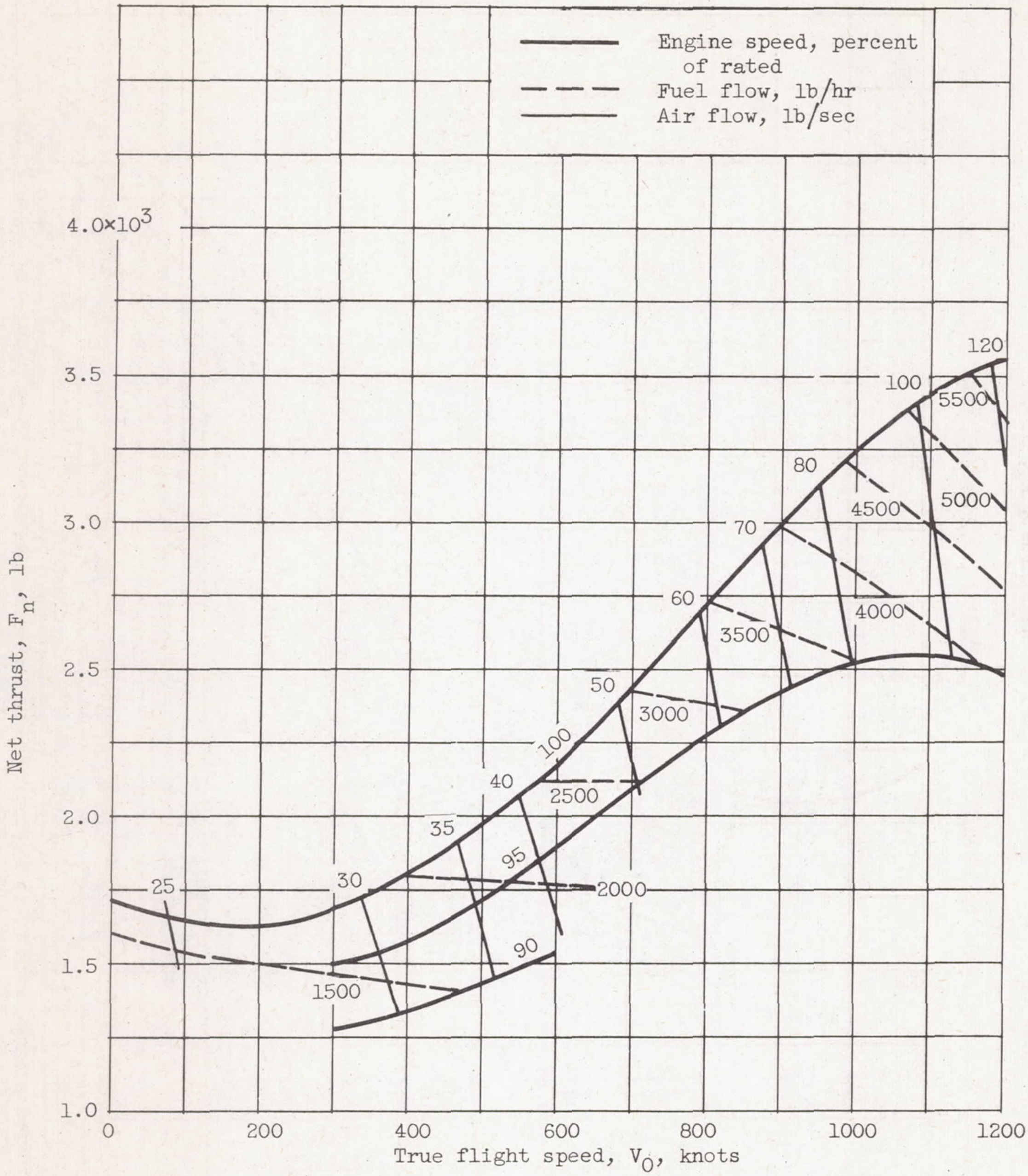
(e) Altitude, 35,000 feet.

Figure 17. - Continued. Predicted performance from pumping characteristics. Exhaust-nozzle area, 2.388 square feet. Standard NACA atmosphere and complete ram recovery assumed.



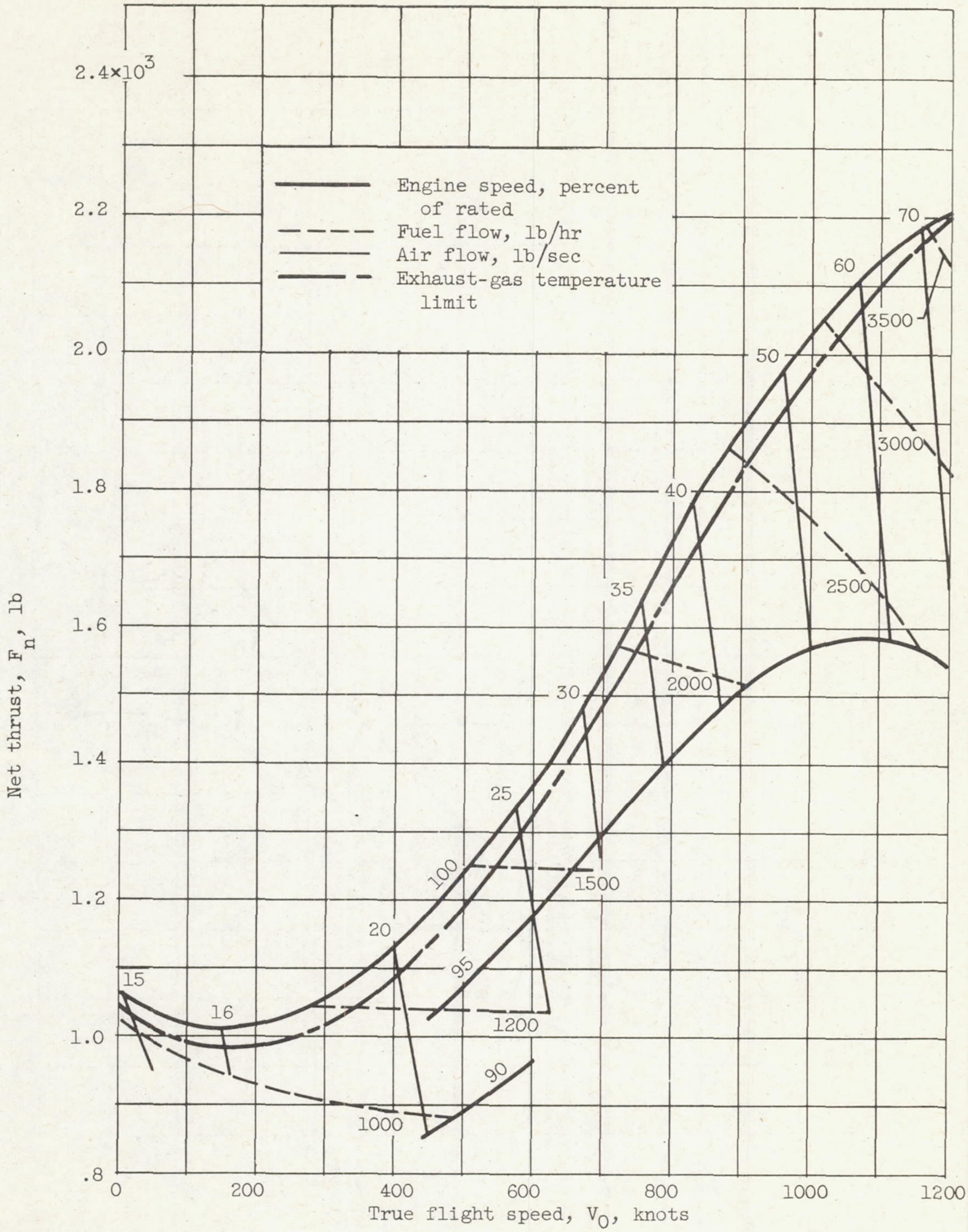
(f) Altitude, 40,000 feet.

Figure 17. - Continued. Predicted performance from pumping characteristics. Exhaust-nozzle area, 2.388 square feet. Standard NACA atmosphere and complete ram recovery assumed.



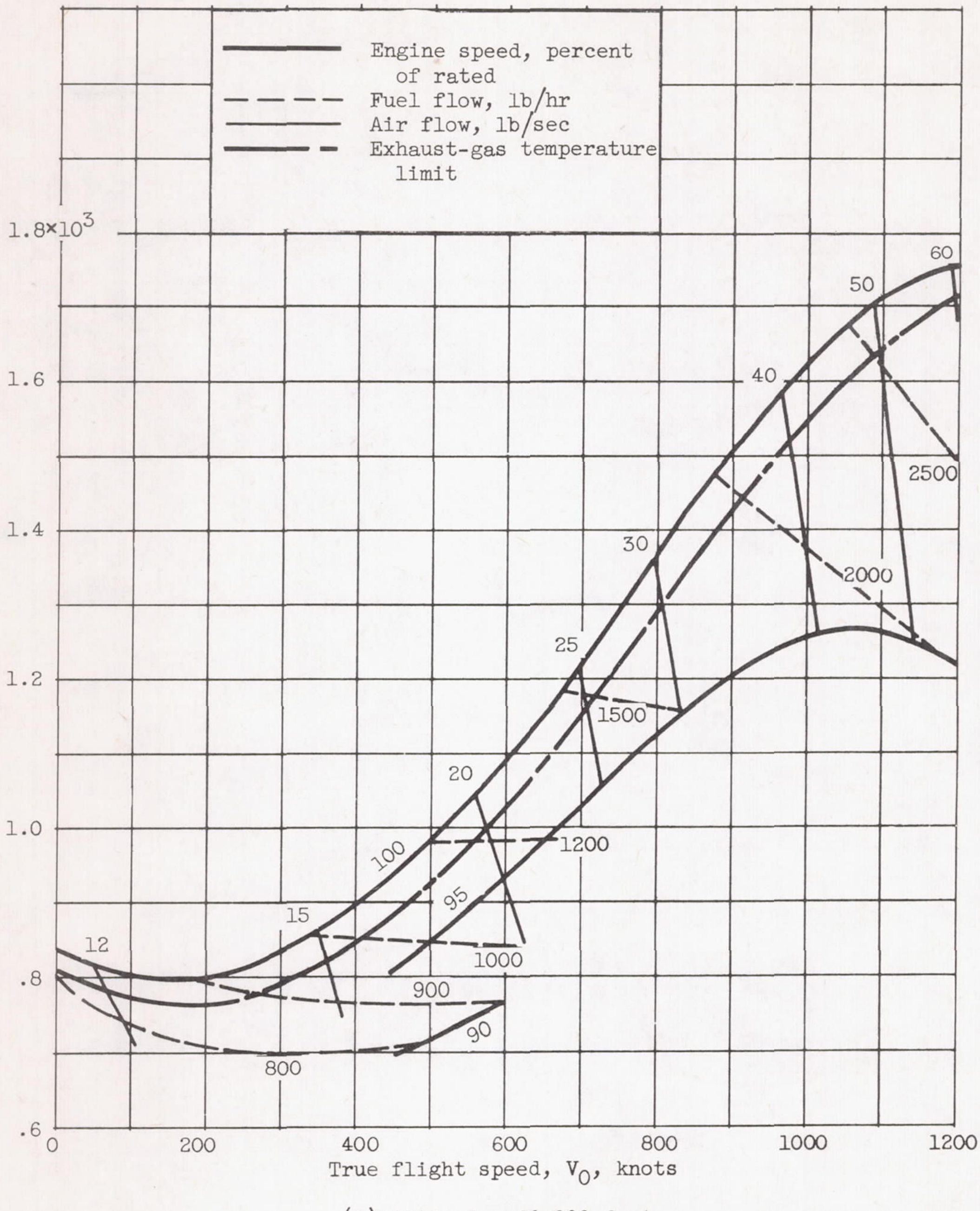
(g) Altitude, 45,000 feet.

Figure 17. - Continued. Predicted performance from pumping characteristics. Exhaust-nozzle area, 2.388 square feet. Standard NACA atmosphere and complete ram recovery assumed.



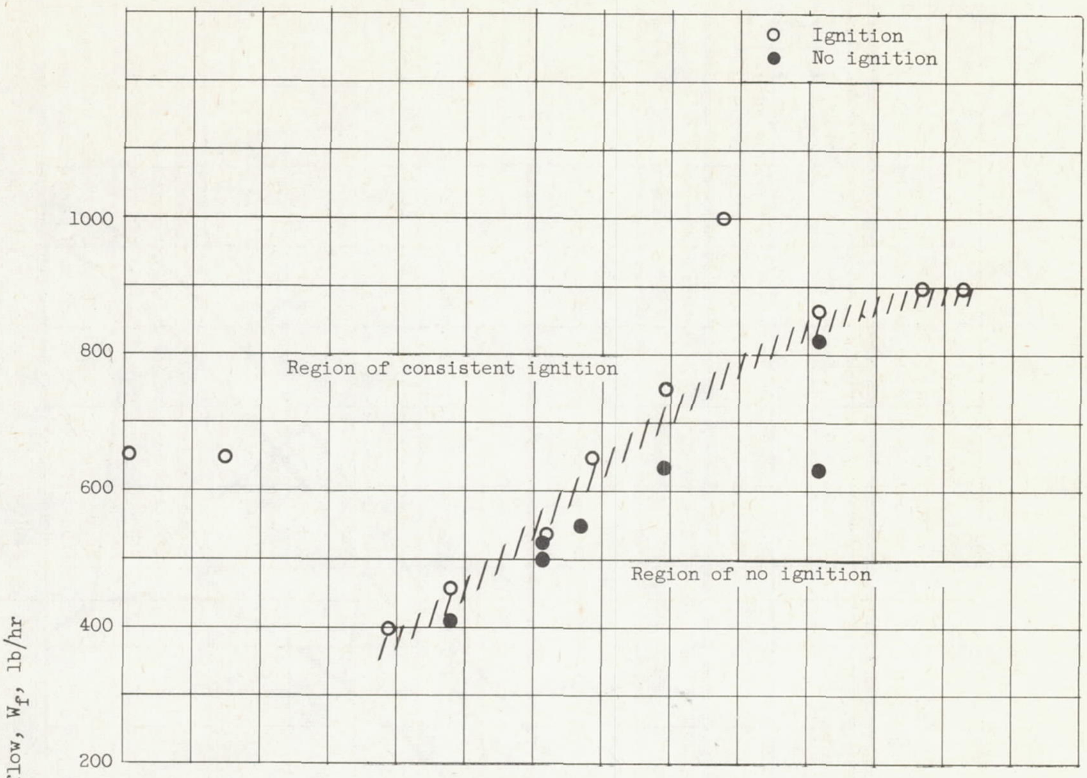
(h) Altitude, 55,000 feet.

Figure 17. - Continued. Predicted performance from pumping characteristics. Exhaust-nozzle area, 2.388 square feet. Standard NACA atmosphere and complete ram recovery assumed.

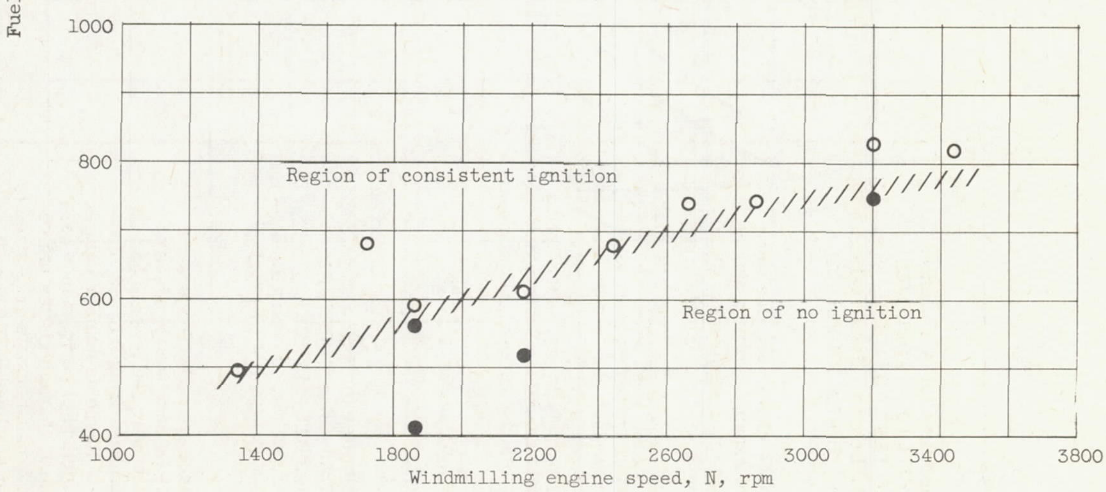


(i) Altitude, 60,000 feet.

Figure 17. - Concluded. Predicted performance from pumping characteristics. Exhaust-nozzle area, 2.388 square feet. Standard NACA atmosphere and complete ram recovery assumed.



(a) Altitude, 35,000 feet.



(b) Altitude, 45,000 feet.

Figure 18. - Effect of fuel flow on altitude-ignition characteristics. Fuel temperature, approximately 60° F; engine-inlet air temperature, 5° to -50° F.