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RESEARCH MEMORANDUM

ALTITUDE-CHAMBER PERFORMANCE OF BRITISH ROLLS-ROYCE NENE II ENGINE

II - 18.41-INCH-DIAMETER JET NOZZLE

By J. C. Armstrong, H. D. Wilsted
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NATIONAL ADVISORY COMMITTEE
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SUMMARY

An altitude-chamber investigation was conducted to determine the altitude performance characteristics of the British Rolls-Royce Nene II turbojet engine with an 18.41-inch-diameter jet nozzle. Results are presented for simulated altitudes from sea level to 60,000 feet and for ram-pressure ratios from 1.00 to 3.50 (corresponding to flight Mach numbers from 0 to 1.47, assuming 100-percent ram-pressure recovery).

Typical performance-data plots are presented to show graphically the effects of altitude and flight ram-pressure ratio. Conventional correction methods were applied to the data to determine the possibility of generalizing each performance parameter to a single curve. A complete tabulation of corrected and uncorrected engine-performance parameters is presented. A comparison of performance with the 18.75- and 18.41-inch-diameter jet nozzles is made to show the effect of small changes in nozzle size under simulated-flight conditions.

The investigation showed that engine performance obtained at one altitude could not be used to predict performance at other altitudes for altitudes above 20,000 feet. Performance at or below 20,000 feet could, however, be predicted from sea-level data or data obtained at any altitude in this range for any particular ram-pressure ratio. For varying ram-pressure ratios, performance can be predicted from other ram-pressure-ratio data only for conditions for which critical flow exists in the jet nozzle.

In comparison with the standard 18.75-inch-diameter jet nozzle, the 18.41-inch-diameter nozzle gave somewhat lower values of net-thrust specific fuel consumption at engine speeds below 11,000 rpm

at a simulated altitude of 30,000 feet and a ram-pressure ratio of 1.30. Above 11,000 rpm this trend was reversed. Jet thrust, net thrust, fuel consumption, and tail-pipe indicated gas temperature generally increased when the smaller nozzle was used.

INTRODUCTION

Because the British Rolls-Royce Nene II engine is different in design from similar United States turbojet engines and has a high sea-level rating, the Nene engine was investigated in an altitude chamber at the NACA Lewis laboratory during 1948.

The effect on altitude performance of a small change in jet-nozzle size is of interest, particularly with reference to engine specific fuel consumption, because aircraft range is directly affected. At altitude, a jet nozzle smaller than standard can be used at cruise conditions without exceeding allowable temperatures; at a given flight condition, a smaller jet nozzle should give higher thrust and possibly lower specific fuel consumption.

In order to determine the change in altitude performance resulting from a small change in jet-nozzle size, three different jet-nozzle diameters (18.75, 18.41, and 18.00 in.) were used in this investigation of the Nene II engine.

The effects of altitude and flight speed on the over-all engine performance using the standard 18.75-inch-diameter jet nozzle are presented in reference 1. The over-all engine performance using an 18.41-inch-diameter jet nozzle is presented herein. Results are presented for simulated-flight conditions varying in altitude from sea level to 60,000 feet and in ram-pressure ratio from 1.00 to 3.50. These ram-pressure ratios correspond to flight Mach numbers from 0 to 1.47, assuming 100-percent ram-pressure recovery. The conventional method of reducing data to sea-level conditions (reference 2) was used to determine whether the performance parameters could be generalized to a single curve; that is, whether data obtained at one altitude and ram-pressure ratio can be used to predict performance at other conditions of altitude and ram-pressure ratio. Also, a comparison of engine performance with these two different jet-nozzle diameters is presented for a simulated-flight condition of 30,000 feet at a ram-pressure ratio of 1.30.

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DESCRIPTION OF POWER PLANT

A cutaway view of the British Rolls-Royce Nene II power plant, which is a through-flow turbojet engine having nine combustion chambers, is shown in figure 1. The engine incorporates a single-stage double-entry centrifugal compressor (tip diameter, 28.80 in.) driven by a single-stage reaction turbine (tip diameter, 24.53 in.). The turbine-nozzle area is 126 square inches and the standard jet-nozzle area is 276 square inches. The dry engine weight is approximately 1720 pounds (starting panel and generator included) and the maximum diameter (cold) is 49.50 inches, giving an effective frontal area of 13.36 square feet.

The sea-level engine performance (reference 3), based on Rolls-Royce static test-bed data with the standard 18.75-inch-diameter jet nozzle, is:

Rating	Jet thrust (lb)	Engine speed (rpm)	Specific fuel consumption (lb/(hr)(lb thrust))
Take-off	5000	12,250	1.04
Military	5000	12,250	1.04
Max. cruise	4000	11,500	1.02
Idle	120	2,600	----

From these values it can be seen that the rated military thrust per unit weight of engine is 2.91 pounds thrust per pound weight, and the rated military thrust per unit of frontal area is 374 pounds thrust per square foot. The maximum allowable tail-cone gas temperature is 1365° F with the standard 18.75-inch-diameter jet nozzle.

A sea-level acceptance run of the engine with minimum research instrumentation installed showed a thrust of 5110 pounds and a specific fuel consumption of 1.01 pounds per hour per pound of thrust at an engine speed of 12,261 rpm.

APPARATUS AND PROCEDURE

Altitude Test Chamber

The engine was installed in an altitude test chamber 10 feet in diameter and 60 feet long (schematically shown in fig. 2). The inlet section of the chamber (surrounding the engine) was separated from the exhaust section by a steel bulkhead; the engine tail pipe passed through the bulkhead by means of a low-friction seal. The seal was composed of three floating asbestos-board rings so mounted on the tail pipe as to allow thermal expansion in both radial and axial directions, as well as a reasonable amount of lateral movement to prevent binding.

Engine thrust was measured by a balanced-pressure-diaphragm-type thrust indicator outside the test chamber, connected by a linkage to the frame on which the engine was mounted in the chamber.

An A.S.M.E. type flat-plate orifice mounted in a straight run of 42-inch-diameter pipe at the approach to the test chamber was provided for measuring engine air consumption. Because of the large variation in atmospheric conditions investigated, however, considerable difficulty was encountered with condensation in the orifice differential-pressure lines despite repeated attempts to remedy the situation. The engine air consumption was therefore calculated from engine pressure and temperature measurements in the tail pipe, as described in the appendix.

The ram-air pressure was controlled by a main, electrically operated butterfly valve in the 42-inch air-supply line, bypassed by a 12-inch, pneumatically operated V-port valve. Air was supplied by either a combustion-air (moist, room-temperature) system or a refrigerated-air (dry, cooled) system at temperatures near those desired. Final control of air temperature was accomplished by means of a set of electric heaters in the bypass line immediately preceding the entrance to the test chamber. The air entered the test chamber, passed through a set of straightening vanes, and then entered the engine cowl. The purpose of the cowl was to prevent circulation of heated air from the region of the tail pipe and combustion chambers directly into the aft inlet of the compressor. This heated air was therefore mixed with the cooler air supply before entering the compressor.

The exhaust jet was discharged into a diffusing elbow mounted in the exhaust section of the chamber. This elbow ducted the gases into a dry-type primary cooler. Control of the exhaust pressure was obtained by means of a main, electrically operated butterfly valve, bypassed by a 20-inch, pneumatically operated butterfly valve. The gases then passed through a dry-type secondary cooler and thence into the system exhausters.

Instrumentation

Compressor-inlet temperature and total pressure were measured by eight probes, each consisting of an iron-constantan thermocouple and a total-pressure tube. Four probes were equally spaced around the periphery of the front compressor-inlet screen, and four around the back screen, (station 2, fig. 3). Control of ram pressure and temperature was based on the averaged readings of the eight probes. Compressor-discharge pressures were measured at the exit of compressor-discharge elbows 1, 4, and 7 by seven total-pressure tubes in each elbow.

Engine tail-pipe temperatures at station 6 were measured by means of 25 chromel-alumel, stagnation-type thermocouples located in an instrument ring. The instrument ring also included 24 total-pressure probes, 14 static-pressure probes, and 4 wall static-pressure taps. (See fig. 4, reference 1.) This instrumentation was located approximately 18 inches downstream of the tail cone. In addition, four Nene engine standard tail-cone thermocouples supplied by Rolls-Royce Ltd. were mounted in the tail cone and were used for engine-control purposes.

All pressures, including the thrust-indicator-diaphragm pressure, were instantaneously recorded by photographing the manometer panel. Temperatures were recorded by two self-balancing, scanning potentiometers, which required about 3 minutes to record all engine temperatures. Pressure and temperature instrumentation was also located at other stations throughout the engine; measurements from this instrumentation are not reported.

Engine speed was measured by means of an impulse counter, which operated on the frequency of an alternating-current three-phase generator mounted on the accessory case of the engine. Action of the counter and the timer was synchronized by a single mechanism.

Fuel consumption was measured by a calibrated variable-area-orifice flow meter, which allowed near full-scale readings for various ranges of fuel flow by changing the orifice flow area.

With the exception of air consumption, performance data were generally reproducible within 2 percent. Air-consumption data scattered appreciably at high engine speeds and was reproducible only to within 5 percent with a few points showing even greater scatter.

Procedure

Performance characteristics of the engine were obtained over a range of engine speeds at simulated altitudes from sea level to 60,000 feet and ram-pressure ratios from 1.00 to 3.50. Inlet-air temperatures were, in general, held to within 3° F of NACA standard values corresponding to the simulated-altitude and ram-pressure-ratio conditions. Compressor-inlet total pressures were held at values corresponding to the simulated flight conditions, assuming 100-percent ram-pressure recovery.

RESULTS AND DISCUSSION

A summary of performance and operational data obtained at simulated-altitude conditions is presented in table I. Altitude data corrected for small variations in compressor-inlet pressure and temperature settings and for variations in exhaust-pressure settings are summarized in table II. Table II also includes the data corrected to conditions of NACA standard sea-level static pressure and temperature at the compressor inlet.

Simulated Flight Performance

Effect of altitude. - Typical performance data from table II, obtained at a ram-pressure ratio of 1.30 and simulated altitudes from sea level to 60,000 feet, are presented to show the effect of altitude on jet thrust, net thrust, air consumption (cooling air excluded), fuel consumption, net-thrust specific fuel consumption, and tail-pipe indicated gas temperature (figs. 4 to 9, respectively). The trends shown are identical to those discussed in reference 1; that is, a rapid decrease in jet thrust, net thrust, air consumption, and fuel consumption with increasing altitude and a decrease in specific fuel consumption up to an altitude of approximately 30,000 feet, after which this trend reversed to give an increase in specific fuel consumption as altitude continued to increase. This reversal, as discussed in reference 1, is a result of decreasing inlet temperature, which increases the compressor Mach number thereby producing an increase in the compressor pressure ratio and cycle efficiency. The reversal therefore apparently takes place at the tropopause (35,332 ft based on NACA standard atmosphere). The specific-fuel-consumption curves are computed from values obtained from the faired-in fuel-consumption and net-thrust curves; any discrepancies that occur between the fuel-consumption and net-thrust data and the faired curves are carried over to the specific-fuel-consumption curves. The data points therefore in many cases do not fall on the faired curve. The tail-pipe indicated gas temperature (fig. 9) at engine speeds below 10,800 rpm decreased rapidly with increasing altitude to about 40,000 feet, after which there was no further change with altitude. At the engine speeds above 10,800 rpm, there was a reversal in this trend, with tail-pipe temperature increasing with increasing altitude. This reversal in trend takes place at lower engine speeds for ram-pressure ratios greater than 1.30, and at higher engine speeds for lower ram-pressure ratios.

Effect of ram-pressure ratio. - Performance data obtained at a simulated altitude of 30,000 feet and at ram-pressure ratios from 1.30 to 3.00 are presented to show the effect of ram-pressure ratio on jet thrust, net thrust, air consumption, fuel consumption, net-thrust specific fuel consumption, and tail-pipe indicated gas temperature (figs. 10 to 15, respectively).

As would be expected with increasing air density at the engine inlet, an increase in ram-pressure ratio generally increased jet thrust, air consumption, and fuel consumption throughout the range of engine speeds investigated. The net thrust increased with increasing ram-pressure ratio for high engine speeds, but decreased with increasing ram-pressure ratio for low engine speeds. For the data shown in figure 11 (30,000 ft altitude), the reversal in trend occurred at approximately 10,000 rpm. The net-thrust specific fuel consumption increased with increasing ram-pressure ratio. The curve for a ram-pressure ratio of 1.50 coincides with the curve for a ram-pressure ratio of 1.70; however, this coincidence is attributable to a slightly high value of fuel consumption for a ram-pressure ratio of 1.50, as indicated by figure 13. The tail-pipe indicated gas temperature, in general, decreased slightly with increasing ram-pressure ratio. (fig. 15). This decrease was small and somewhat inconsistent and could well be interpreted as data scatter at the higher engine speeds. As would be expected, an appreciable decrease in temperature occurred at the lower engine speeds, where there was a tendency for the engine to windmill.

These trends with varying ram-pressure ratio are identical to those discussed in greater detail in reference 1.

Generalized Performance

Performance data varying in altitude from sea level to 60,000 feet and in ram-pressure ratio from 1.00 to 3.50 were reduced in the conventional manner (reference 2) to NACA standard sea-level conditions. The development of this method of generalizing data involves the concept of flow similarity and the application of dimensional analysis to the performance of turbojet engines. In this development, the efficiencies of engine components are considered to be unaffected by changes in flight conditions.

Effect of altitude. - Typical sea-level corrected engine performance data (table II) obtained at a ram-pressure ratio of 1.30 and simulated altitudes from sea level to 60,000 feet are compared to show the effect of altitude on the corrected values of jet thrust, net thrust, air consumption, fuel consumption, net-thrust specific fuel consumption, tail-pipe indicated gas temperature, and tail-cone indicated gas temperature (figs. 16 to 21, respectively).

The corrected values of jet thrust and net thrust (figs. 16 and 17) did not generalize but decreased with increasing altitude for all altitudes above 20,000 feet. This decrease was attributed, in part, to the decrease in compressor pressure ratio and efficiency as altitude was increased, as discussed in reference 1. Because of the decrease in compressor pressure ratio, a comparable decrease in air consumption would be expected. Although there is an appreciable scatter in the data, a decrease in air consumption with increasing altitude is indicated (fig. 18). The data for 50,000 feet indicate an appreciable decrease at a corrected engine speed of 13,300 rpm after a peak air consumption at 12,800 rpm. This trend and similar trends indicated by other high-altitude data in reference 1 are attributed to scatter in the data at high altitude, where small errors in reading instrumentation are appreciable percentages of the absolute values. Corrected fuel consumption (fig. 19) increased only a small amount with increasing altitude at high values of corrected engine speed. At low engine speeds, the fuel consumption increased very rapidly with increasing altitude. The corrected net-thrust-specific-fuel-consumption curves (fig. 20) generalized up to an altitude of 20,000 feet. Above 20,000 feet the corrected specific fuel consumption increased with increasing altitude. The corrected tail-pipe and tail-cone indicated gas temperature (fig. 21) generalized at all engine speeds. The difference between tail-pipe and tail-cone temperatures is attributed to the differences in the location and the number of thermocouples used.

The failure of the altitude data to generalize to single curves for each parameter for altitudes above 20,000 feet is in agreement with the results of the investigation using the standard 18.75-inch jet nozzle (reference 1).

Effect of ram-pressure ratio. - The conventional method of generalizing data was specifically developed to adjust for changes in the pressure and the temperature of the atmosphere in which the engine is operating. Variations in ram-pressure ratio (flight speed) change the performance characteristics by effectively changing the compression ratio of the engine. In general, the increased operating pressure with increasing ram-pressure ratio raises the total expansion pressure ratio of the engine (from turbine inlet to jet-nozzle throat) until critical flow is established in the jet nozzle. After critical flow is established, the expansion pressure ratio of the engine remains constant with increasing ram-pressure ratio. The engine is then effectively operating in an atmosphere having a static pressure equal to the pressure existing in the jet-nozzle throat, and is operating at a constant effective ram-pressure ratio. The effective ram-pressure ratio is then equal to the ratio of the compressor-inlet total pressure to the jet-nozzle-throat static pressure. With critical flow in the jet nozzle, generalization of flow characteristics within the engine should be possible within the limitations discussed in connection with altitude effects.

Typical performance data obtained at a simulated altitude of 30,000 feet and ram-pressure ratios from 1.30 to 3.00 are compared to show the effect of ram-pressure ratio on the corrected values of jet thrust, jet-thrust parameter $\frac{F_j + p_0 A_7}{\delta}$, (reference 1), net thrust, air consumption, fuel consumption, net-thrust specific fuel consumption, and tail-pipe indicated gas temperature (figs. 22 to 27, respectively). (The symbols are defined in the appendix.)

The corrected jet thrust (fig. 22(a)) did not generalize but the corrected jet-thrust parameter (fig. 22(b)) generalized for all conditions for which the jet nozzle was choked. The corrected net thrust of figure 23 appears to generalize at the higher speeds; however, examination of plots of the data of table II at other altitudes shows that the data for ram-pressure ratios lower than 1.30 do not generalize. Although the corrected air consumption of figure 24 generalized, the jet thrust did not generalize and thus, there is apparently no reason to expect the net thrust to generalize. At higher flight speeds (ram-pressure ratios), however, the momentum of the incoming air is greater at a given mass flow; this larger quantity, when subtracted from the higher jet-thrust values of figure 22, causes the corrected net thrust to generalize for ram-pressure ratios above 1.30. Corrected fuel consumption generalized at the high engine speeds when critical flow existed in the jet nozzle (fig. 25). At lower engine speeds, the fuel consumption decreased with increasing ram-pressure ratio. The corrected net-thrust specific fuel consumption (fig. 26) showed reasonable agreement for ram-pressure ratios above 1.30. Examination of plots of the data of table II at other altitudes show appreciably lower values of specific fuel consumption at a ram-pressure ratio of 1.00. The corrected tail-pipe indicated gas temperature (fig. 27) also generalized to a single curve for engine speeds at which critical flow existed in the jet nozzle. At lower engine speeds, the corrected tail-pipe indicated gas temperature decreased with increasing ram-pressure ratio.

Effect of Jet-Nozzle Area on Performance

A rational examination of the effect of jet-nozzle area on engine performance, neglecting secondary effects, indicates that a reduction in jet-nozzle area increases the resistance to flow through the nozzle, thus raising the tail-pipe pressure. Because, from considerations of typical centrifugal-compressor performance, the compressor pressure ratio remains nearly constant for small changes in air flow, the higher tail-pipe pressure caused by a reduction in jet-nozzle area results in a decreased expansion pressure ratio across the turbine. In order to maintain the required turbine power output, it is then necessary to raise the turbine-inlet temperature, which results in an increased tail-pipe temperature as well. The engine air consumption is essentially proportional to the turbine-inlet pressure and inversely proportional to the square root of the turbine-inlet temperature. Because the turbine-inlet pressure, as previously explained, remains nearly constant and the turbine-inlet temperature rises, a small decrease in air consumption would be expected. This decrease would cause the turbine-inlet temperature to rise slightly at the same fuel flow used with the larger jet nozzle, but an increase in fuel flow to the engine is probably necessary to attain the turbine-inlet temperature required by the smaller jet nozzle. The higher tail-pipe pressure caused by a reduction in jet-nozzle area results in an increase in jet-nozzle-throat velocity in the subcritical flow range, or in a greater excess of nozzle-throat static pressure over ambient static pressure in the critical flow range. In either case, the jet thrust for a given gas flow would increase. Because the jet-nozzle-throat velocity varies directly as the square root of the tail-pipe temperature and the engine air consumption varies inversely as the square root of the turbine-inlet temperature, these effects tend to cancel each other and should not have much effect on the jet thrust. The net result should therefore be an increase in jet thrust due to the higher tail-pipe pressure.

Performance parameters at a simulated altitude of 30,000 feet and a ram-pressure ratio of 1.30 using the 18.41-inch-diameter jet nozzle are compared with the engine performance using the standard nozzle (18.75-in. diameter) data from reference 1 (figs. 28 to 33). The decrease in area of 3.5 percent showed the expected trends, causing a small increase in jet thrust, net thrust, and tail-pipe indicated gas temperature over the entire speed range. At an engine speed of 12,000 rpm these increases amount to approximately 4, 5, and 3 percent, respectively. Fuel consumption (fig. 31) also increased over most of the speed range (about 9 percent at an engine speed of 12,000 rpm). Air consumption, because of the scatter in the data, was obtained from the faired curves of figure 24 herein and figure 27 of reference 1. These data show the expected decrease in air consumption when using the smaller jet nozzle, (approximately 1 percent at an engine speed of 12,000 rpm). The net-thrust specific fuel consumption (fig. 32) was somewhat lower for the smaller nozzle at engine speeds below 11,000 rpm (about 5 percent lower at an engine speed of 10,000 rpm); above 11,000 rpm the smaller nozzle gave a slightly higher specific fuel consumption (about 3 percent higher at an engine speed of 12,000 rpm).

SUMMARY OF RESULTS

The following results were obtained from an altitude-chamber investigation of the performance of a British Rolls-Royce Nene II turbojet engine using an 18.41-inch-diameter jet nozzle:

1. Engine-performance parameters could not be predicted for altitudes above 20,000 feet from data obtained at one particular altitude, because of a progressive decrease in compressor pressure ratio and efficiency at high engine speeds at altitudes above 20,000 feet.

2. At a given altitude, performance data at any ram-pressure ratio for which critical flow existed in the jet nozzle could be used to predict performance at any other ram-pressure ratio in the critical flow range within the limits of this investigation.

3. In comparison with the standard 18.75-inch-diameter jet nozzle, the 18.41-inch-diameter jet nozzle (a decrease in area of approximately 3.5 percent) indicated a slightly lower value of net-thrust specific fuel consumption at engine speeds below 11,000 rpm (5 percent lower at an engine speed of 10,000 rpm) at a simulated altitude of 30,000 feet and a ram-pressure ratio of 1.30. At engine

speeds above 11,000 rpm, the smaller nozzle indicated a slightly higher specific fuel consumption. Jet thrust, net thrust, fuel consumption, and tail-pipe indicated gas temperature all increased slightly when the smaller nozzle was used (approximately 4, 5, 9, and 3 percent, respectively), whereas air consumption showed a small decrease (about 1 percent).

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APPENDIX - CALCULATIONS

Symbols

A	area, sq ft
D	diameter, ft
F	thrust, lb
g	acceleration due to gravity, 32.2 ft/sec^2
H	enthalpy, Btu/lb
J	mechanical equivalent of heat, 778 ft-lb/Btu
K	thrust constant
M	Mach number
N	engine speed, rpm
P	absolute total pressure, lb/sq ft
p	absolute static pressure, lb/sq ft
R	gas constant, 53.3 ft-lb/(lb)($^{\circ}$F)
T	total temperature, $^{\circ}$R
t	static temperature, $^{\circ}$R
V	velocity, ft/sec
W_a	air consumption, lb/sec
W_f	fuel consumption, lb/hr
W_g	gas flow, lb/sec
γ	ratio of specific heats
δ	ratio of compressor-inlet absolute total pressure to absolute static pressure of NACA standard atmosphere at sea level

θ ratio of compressor-inlet absolute total temperature to absolute static temperature of NACA standard atmosphere at sea level

Subscripts:

b barometer

d thrust-measuring diaphragm

i indicated

j jet

n net

p airplane

s seal

Station notation (fig. 3):

0 free stream

2 compressor inlet

3 compressor discharge

5 tail cone (turbine discharge)

6 tail pipe (upstream of jet nozzle)

7 jet-nozzle outlet (throat)

Methods of Calculation

Thrust. - Thrust was determined from the altitude-chamber thrust indicator (by multiplying the diaphragm pressure by a constant) with an added correction factor to account for the pressure differential across the tail-pipe seal. The relation used was

$$F_j = F_i + A_s(P_2 - p_0)$$

where

$$F_i = K(p_d - p_b)$$

and the seal area

$$A_s = \frac{\pi D_s^2}{4}$$

<u>Air consumption.</u> - Engine air consumption was calculated from measurements of temperature and total and static pressure in the tail pipe. Total-pressure profiles across the tail pipe were plotted for each data point; the profiles were then read at eight points, so selected as to divide the tail-pipe area into four equal concentric, annular areas. The following formula was then applied to each of the four areas:

$$W_g = \frac{p_6 A}{R t_6} \sqrt{2gJ\Delta H}$$

where

A 1/4 × tail-pipe area (cold)

ΔH enthalpy difference between total- and static-pressure conditions, determined from reference 4

The static temperature in the formula was calculated from the indicated temperature by the following relation:

$$t_6 = \frac{T_{6,i}}{1 + 0.8\left(\frac{T_6}{t_6} - 1\right)}$$

where the temperature ratio was determined from the tail-pipe total-to-static pressure ratio by means of reference 4. The factor 0.8 is the selected average value of thermocouple recovery factor based on instrument calibrations.

The engine air consumption was then determined by adding the gas flows through the four annular areas and subtracting the fuel flow:

$$W_a = W_g - \frac{W_f}{3600}$$

Simulated flight speed. - The simulated flight speed at which the engine was operated was determined from the following relation:

$$V_p = \sqrt{2gR \frac{\gamma}{\gamma-1} t_0 \left[\left(\frac{P_2}{p_0}\right)^{\frac{\gamma-1}{\gamma}} - 1\right]}$$

where γ was assumed to be 1.40.

Net thrust. - Net thrust was calculated from jet thrust by subtracting the momentum of the free-stream air approaching the engine inlet, according to the relation

$$F_n = F_j - \frac{W_a V_p}{g}$$

where V_p is the simulated flight speed as previously calculated.

Flight Mach number. - The flight Mach number was calculated from the compressor-inlet total pressure, assuming 100-percent ram-pressure recovery, by the following relation:

$$M_p = \sqrt{\frac{2}{\gamma-1} \left[\left(\frac{P_2}{p_0}\right)^{\frac{\gamma-1}{\gamma}} - 1\right]}$$

where γ was assumed to be 1.40.

REFERENCES

1. Barson, Zelmar, and Wilsted, H. D.: Altitude-Chamber Performance of British Rolls-Royce Nene II Engine. I - Standard 18.75-Inch-Diameter Jet Nozzle. NACA RM E9I23, 1949.

2. Bollay, William: Performance Variation of Gas Turbines and Jet Propulsion Units with Atmospheric Inlet Conditions. Power Plant Memo. No. 1, Bur. Aero., Navy Dept., March 3, 1943.

3. Anon.: Rolls-Royce Nene II Performance and Installation Data. TSD 57, Dec. 1947.

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

TABLE I - PERFORMANCE AND OPERATIONAL DATA OBTAINED AT SIMULATED-ALTITUDE CONDITIONS

Point	Altitude (ft)	Compressor-inlet total pressure, P_2 (in. Hg abs.)	Exhaust static pressure, p_0 (in. Hg abs.)	Ram-pressure ratio, P_2/p_0	Compressor-inlet total temperature, T_2 (°R)	Engine speed, N (rpm)	Jet thrust, F_j (lb)	Air consumption, W_a (lb/sec)	Fuel consumption, W_f (lb/hr)	Tail-pipe indicated gas temperature, $T_{6,1}$ (°R)	Tail-cone indicated gas temperature (Rolls-Royce thermocouples) $T_{5,1}$ (°F)	Compressor pressure ratio, P_3/P_2	Fuel-supply pressure (lb/sq in. gage)	Fuel-pump-discharge pressure (lb/sq in. gage)	Main-fuel-manifold pressure (lb/sq in. gage)	Pilot-fuel-manifold pressure (lb/sq in. gage)	Oil-pump-discharge pressure (lb/sq in. gage)	Oil inlet temperature (°F)	Rear-bearing temperature (°F)	[a]Accumulative engine time (hr)
1	0	29.94	30.02	1.00	562	6,040	643	34.54	1250	1323	900	1.509	15	1200	200	325	19	140	150	73
2	0	30.00	30.02	1.00	562	7,960	1129	48.95	1745	1301	860	1.978	15	1280	280	380	26	150	175	
3	0	29.91	29.94	1.00	562	10,012	2329	62.39	2640	1400	1000	2.804	18	1300	350	420	35	140	170	
4	0	29.86	29.89	1.00	562	10,812	2926	67.92	3210	1474	1060	3.204	18	1300	360	420	32	180	225	
5	0	29.92	29.89	1.00	561	11,580	3669	73.94	3950	1581	1190	3.624	18	1300	500	550	32	190	270	
6	0	38.91	29.99	1.30	564	8,040	1692	65.12	1535	1055	600	1.888	20	1620	220	350	30	165	180	75
7	0	38.85	29.80	1.30	561	7,924	1619	64.42	1520	1040	600	1.843	20	1600	220	325	30	165	185	141
8	0	39.00	29.90	1.30	558	9,020	2344	75.22	2025	1124	700	2.238	20	1600	300	400	30	170	200	
9	0	37.10	29.70	1.25	563	10,004	3015	76.94	2695	1258	825	2.679	20	1500	300	390	30	180	220	
10	10,000	26.50	20.51	1.29	520	6,392	718	36.60	845	914	500	1.497	22	1100	100	150	28	120	130	90
11	10,000	26.62	20.46	1.30	519	8,052	1276	47.47	1145	1001	600	1.961	22	1200	200	300	32	120	140	
12	10,000	26.58	20.56	1.29	521	10,000	2438	59.76	2070	1214	850	2.861	22	1200	250	390	33	150	190	
13	10,000	26.64	20.66	1.29	523	10,804	3140	67.67	2715	1330	950	3.321	22	1175	250	400	32	170	220	
14	10,000	26.58	20.46	1.30	520	11,600	4202	75.64	3700	1496	1150	3.929	22	1200	450	500	32	180	240	
15	10,000	26.55	20.46	1.30	521	12,292	5082	79.13	4865	1685	1325	4.438	22	1200	700	750	32	190	270	
16	10,000	33.98	20.49	1.66	558	9,968	3126	73.47	2030	1148	720	2.629	20	1400	280	380	29	190	230	75
17	10,000	34.05	20.59	1.65	561	10,824	4178	82.88	2965	1298	900	3.108	19	1400	320	400	31	200	250	
18	10,000	33.92	20.74	1.64	560	11,588	5394	89.37	4085	1463	1050	3.641	18	1400	520	600	34	200	250	
19	10,000	35.05	20.45	1.71	564	9,084	2342	66.16	1430	999	560	2.173	20	1420	230	330	33	125	195	140
20	10,000	35.00	20.65	1.70	564	9,980	3254	76.64	2145	1155	710	2.613	20	1420	300	400	33	190	215	
21	10,000	35.00	20.45	1.71	562	10,824	4386	85.20	3125	1316	900	3.095	20	1420	370	450	33	200	245	
22	10,000	33.45	19.95	1.68	567	11,600	5279	87.65	4050	1489	1100	3.591	20	1420	530	580	33	210	265	
23	20,000	17.51	13.76	1.27	480	7,984	924	34.76	850	946	550	2.105	14	800	100	180	30	85	100	67
24	20,000	17.57	13.76	1.28	482	9,992	1876	45.11	1499	1185	800	3.159	14	800	200	340	31	110	140	
25	20,000	17.36	13.81	1.26	481	10,820	2443	48.78	2065	1343	950	3.727	14	800	250	370	31	120	160	
26	20,000	17.40	13.76	1.26	484	11,596	3079	52.45	2765	1516	1140	4.259	14	800	300	400	31	140	195	
27	20,000	17.52	13.76	1.27	484	12,140	3680	56.38	3415	1675	1320	4.687	13	800	400	450	31	150	230	
28	20,000	23.16	13.56	1.71	522	9,040	1681	46.85	1080	972	600	2.266	20	1000	180	250	30	150	170	88
29	20,000	23.07	13.61	1.70	521	10,020	2481	53.65	1665	1162	800	2.840	20	1050	230	350	20	155	190	
30	20,000	23.13	13.66	1.69	522	10,800	3207	59.79	2315	1323	950	3.311	20	1050	250	375	31	165	210	
31	20,000	23.18	13.66	1.70	520	11,608	4091	65.26	3180	1489	1125	3.891	20	1050	350	425	31	175	230	
32	20,000	23.08	13.76	1.68	520	12,220	4834	68.67	4070	1666	1300	4.368	20	1050	500	575	32	180	250	
33	20,000	29.99	13.74	2.18	562	9,040	2282	57.49	1070	936	520	2.118	19	1300	190	260	30	170	190	74
34	20,000	30.07	13.79	2.18	562	9,984	3218	66.21	1740	1125	700	2.610	19	1300	300	380	33	175	195	
35	20,000	30.11	13.64	2.21	562	10,776	4161	71.91	2550	1289	880	3.073	18	1300	320	400	33	180	220	
36	20,000	30.13	13.65	2.21	562	11,616	5324	79.32	3670	1476	1040	3.627	18	1300	400	480	33	200	240	
37	30,000	11.48	8.68	1.32	447	8,656	860	27.24	720	940	520	2.550	15	550	80	120	25	120	155	132
38	30,000	11.58	8.78	1.32	446	10,008	1429	32.91	1075	1144	725	3.408	15	550	180	260	27	110	145	
39	30,000	11.63	8.58	1.36	447	10,776	1917	36.04	1540	1306	900	3.988	15	550	220	340	28	110	153	
40	30,000	11.73	8.78	1.34	446	11,596	2419	38.45	2135	1539	1200	4.590	15	550	280	380	28	125	190	
41	30,000	11.58	8.88	1.30	447	12,072	2671	39.60	2510	1665	1325	5.001	15	550	300	400	28	135	220	
42	30,000	13.38	8.78	1.52	466	8,828	1064	30.53	840	942	520	2.528	15	620	95	140	28	93	118	131
43	30,000	13.38	8.78	1.52	468	10,000	1649	36.51	1224	1142	720	3.277	15	620	200	300	29	110	140	
44	30,000	13.43	8.68	1.55	467	10,800	2195	38.48	1676	1302	900	3.794	15	620	230	350	29	123	165	
45	30,000	13.53	8.78	1.54	465	11,592	2794	42.79	2350	1569	1175	4.458	15	620	290	390	29	140	205	
46	30,000	13.33	8.68	1.54	460	12,084	3177	44.28	2545	1664	1305	4.880	15	620	310	420	29	150	228	
47	30,000	15.14	8.81	1.72	482	9,088	1329	34.96	865	955	550	2.527	14	725	100	170	31	130	175	68
48	30,000	15.12	8.86	1.71	484	9,980	1860	39.77	1166	1118	750	3.092	14	740	200	300	29	130	160	
49	30,000	15.23	8.76	1.74	482	10,808	2456	43.72	1745	1312	920	3.710	14	730	250	350	29	130	170	
50	30,000	15.04	8.81	1.71	482	11,640	3093	45.46	2445	1537	1150	4.307	13	725	300	390	30	135	185	
51	30,000	15.04	8.91	1.69	482	12,204	3566	48.83	3020	1664	1325	4.741	13	720	350	400	30	150	230	
52	30,000	17.83	8.78	2.03	504	8,988	1505	39.81	896	926	500	2.371	20	800	100	180	30	125	150	136
53	30,000	17.78	8.78	2.02	502	9,068	1540	38.79	916	937	500	2.411	20	800	120	180	29	125	155	
54	30,000	17.83	8.68	2.05	501	9,904	2149	44.79	1328	1108	700	2.933	20	800	200	300	29	135	170	
55	30,000	17.58	8.78	2.00	504	9,948	2104	44.75	1260	1109	700	2.936	22	800	200	300	28	150	200	
56	30,000	18.08	8.88	2.04	501	10,664	2776	48.14	1876	1269	860	3.414	20	810	250	350	29	150	190	
57	30,000	17.83	8.88	2.01	504	11,520	3466	51.01	2590	1469	1125	3.984	20	800	300	410	29	170	230	
58	30,000	20.09	8.82	2.28	520	7,920	1093	37.28	664	751	325	1.790	21	900	75	100	29	120	140	77
59	30,000	20.08	8.85	2.27	517	8,976	1670	41.71	890	915	550	2.228	20	900	100	170	28	150	170	87
60	30,000	20.08	8.95	2.24	520	10,012	2439	47.26	1395	1151	800	2.816	20	925	200	325	29	160	190	
61	30,000	19.95	8.80	2.27	522	10,784	3108	50.84	1985	1322	950	3.301	20	900	250	375	29	170	210	
62	30,000	19.84	8.71	2.28	524	11,640	3918	55.66	2835	1510	1150	3.922	20	900	300	400	29	170	240	
63	30,000	19.84	8.91	2.23	520	12,232	4498	58.17	3515	1680	1325	4.339	20	900	400	475	29	180	260	

[a]Average representing time in altitude chamber. Approximately 22 hr had been accumulated at time of installation in altitude chamber.

NACA

TABLE I - PERFORMANCE AND OPERATIONAL DATA OBTAINED AT SIMULATED-ALTITUDE - Concluded

Point	Altitude (ft)	Compressor-inlet total pressure, P_2 (in. Hg abs.)	Exhaust static pressure, P_0 (in. Hg abs.)	Ram-pressure ratio, P_2/P_0	Compressor-inlet total temperature, T_2 (°R)	Engine speed, N (rpm)	Jet thrust, F_j (lb)	Air consumption, W_a (lb/sec)	Fuel consumption, W_f (lb/hr)	Tail-pipe indicated gas temperature, $T_{6,1}$ (°R)	Tail-cone indicated gas temperature (Rolls-Royce thermocouples) $T_{5,1}$ (°F)	Compressor pressure ratio, P_3/P_2	Fuel-supply pressure (lb/sq in. gage)	Fuel-pump-discharge pressure (lb/sq in. gage)	Main-fuel-manifold pressure (lb/sq in. gage)	Pilot-fuel-manifold pressure (lb/sq in. gage)	Oil-pump-discharge pressure (lb/sq in. gage)	Oil inlet temperature (°F)	Rear-bearing temperature (°F)	[a]Accumulative engine time (hr)
64	30,000	24.16	8.81	2.74	552	9,132	2140	49.04	905	939	500	2.189	18	1040	160	220	30	160	180	139
65	30,000	24.21	8.81	2.75	542	9,156	2224	50.05	950	947	500	2.234	15	1020	170	240	31	145	165	
66	30,000	24.16	8.91	2.71	549	9,984	2954	53.68	1450	1135	675	2.694	18	1040	260	360	30	165	195	
67	30,000	24.11	8.91	2.71	552	10,808	3730	58.66	2200	1316	900	3.162	18	1040	300	400	29	190	230	
68	30,000	24.06	8.81	2.73	552	11,580	4626	63.95	3030	1490	1100	3.672	18	1040	350	450	29	200	255	
69	30,000	24.16	9.31	2.60	556	12,264	5444	68.19	4000	1685	1300	4.164	18	1040	510	580	29	210	280	
70	30,000	25.88	9.04	2.86	562	10,012	3175	56.73	1510	1124	700	2.609	20	1120	200	310	24	200	235	75
71	30,000	25.96	8.89	2.92	562	11,620	4926	68.08	2915	1476	1100	2.648	19	1100	350	400	29	205	260	
72	40,000	7.28	5.48	1.33	428	8,300	516	17.11	500	899	500	2.482	15	390	[b]---	80	28	110	145	132
73	40,000	7.28	5.48	1.33	426	8,992	671	17.98	550	973	600	2.853	15	390	---	70	25	100	130	
74	40,000	7.48	5.48	1.36	425	9,992	977	21.84	715	1135	725	3.500	15	400	80	130	26	100	135	
75	40,000	7.23	5.58	1.30	427	10,812	1191	22.91	1010	1320	950	4.137	16	390	150	230	26	110	160	
76	40,000	7.48	5.48	1.36	424	11,552	1591	24.24	1410	1531	1200	4.695	16	390	220	330	26	115	180	
77	40,000	9.40	5.30	1.77	460	9,040	947	23.00	628	947	525	2.628	22	480	50	80	27	100	130	128
78	40,000	9.50	5.50	1.73	461	10,008	1293	25.93	795	1129	705	3.242	20	480	100	150	26	112	148	
79	40,000	9.60	5.40	1.78	462	10,784	1681	28.70	1120	1310	900	3.812	20	480	200	280	26	120	160	
80	40,000	9.50	5.50	1.73	459	11,600	2070	29.98	1630	1536	1145	4.432	20	480	240	350	26	140	210	
81	40,000	11.06	5.61	1.97	480	8,940	1002	25.57	700	929	550	2.431	14	570	50	100	26	130	170	69
82	40,000	11.16	5.61	1.99	482	9,988	1459	29.26	910	1122	750	3.100	14	580	100	180	28	125	160	
83	40,000	11.12	5.56	2.00	483	10,800	1877	31.76	1265	1315	950	3.687	14	580	200	300	28	130	170	
84	40,000	11.18	5.56	2.01	482	11,604	2377	33.77	1800	1534	1200	4.262	14	580	250	360	28	140	200	
85	40,000	11.15	5.56	2.00	484	12,012	2596	34.76	2085	1665	1325	4.556	14	580	260	380	28	150	215	
86	40,000	14.72	5.52	2.67	522	9,916	1861	34.73	1010	1113	725	2.764	24	710	150	205	27	157	193	78
87	40,000	14.75	5.54	2.66	520	10,800	2418	38.69	1518	1316	925	3.340	24	710	220	325	28	160	200	
88	40,000	14.75	5.57	2.65	520	11,584	3023	41.29	2095	1516	1145	3.902	24	710	280	385	28	170	220	
89	40,000	14.78	5.55	2.66	520	9,060	1389	31.13	708	939	600	2.246	20	700	25	110	27	140	160	85
90	40,000	14.86	5.55	2.68	521	9,960	1940	34.95	1084	1145	800	2.812	20	700	175	240	27	150	180	
91	40,000	14.82	5.60	2.64	520	10,784	2452	37.85	1534	1340	1000	3.317	20	700	200	350	27	170	210	
92	40,000	14.77	5.60	2.64	521	11,560	3000	40.73	2105	1536	1250	3.846	20	700	250	390	27	170	230	
93	40,000	19.14	5.56	3.44	563	9,980	2492	41.46	1294	1132	700	2.606	14	850	200	280	26	180	210	70
94	50,000	4.68	3.38	1.38	428	9,324	510	12.36	438	1043	650	2.949	16	280	---	40	26	125	180	133
95	50,000	4.68	3.28	1.43	424	9,988	607	13.21	502	1134	725	3.361	16	290	---	50	26	115	165	
96	50,000	4.68	3.38	1.38	428	10,772	754	14.37	672	1307	900	3.915	16	280	60	85	26	115	170	
97	50,000	4.68	3.18	1.47	428	11,600	978	15.51	918	1530	1125	4.543	16	280	100	170	26	120	180	
98	50,000	4.68	3.28	1.43	428	12,096	1088	15.37	1120	1723	1325	4.848	17	280	170	250	26	130	205	
99	50,000	6.00	3.30	1.82	457	8,960	581	14.91	396	922	512	2.550	20	330	---	20	22	140	185	129
100	50,000	5.90	3.30	1.79	460	10,004	809	16.48	542	1119	725	3.254	20	330	---	35	24	130	170	
101	50,000	6.00	3.40	1.76	461	10,740	1031	17.83	752	1293	900	3.783	20	330	40	120	24	130	175	
102	50,000	5.80	3.30	1.76	461	11,624	1244	18.83	1068	1540	1175	4.431	20	320	160	220	24	140	200	
103	50,000	7.32	3.46	2.12	482	9,100	683	17.11	555	944	550	2.520	14	400	---	50	24	135	170	70
104	50,000	7.20	3.36	2.14	482	10,040	974	19.05	660	1135	750	3.121	14	400	50	80	25	130	165	
105	50,000	7.34	3.41	2.15	481	10,828	1262	20.99	885	1329	960	3.706	14	400	100	180	26	130	170	
106	50,000	7.38	3.46	2.13	482	11,600	1508	22.23	1160	1542	1225	4.215	14	400	200	300	26	140	190	
107	50,000	9.18	3.72	2.47	522	8,268	551	17.66	358	802	405	1.889	26	500	50	12	18	163	197	79
108	50,000	9.15	3.72	2.46	520	10,000	1135	22.35	684	1129	755	2.867	25	500	75	100	22	175	225	
109	50,000	9.16	3.77	2.43	509	10,828	1500	24.60	1004	1322	950	3.421	25	495	130	210	21	185	255	
110	50,000	9.24	3.77	2.45	519	11,628	1814	25.68	1315	1539	1205	3.899	25	495	205	315	22	190	265	
111	50,000	9.23	3.50	2.64	520	9,020	858	20.00	484	935	600	2.271	20	500	---	45	22	160	195	86
112	50,000	9.12	3.50	2.61	520	9,984	1170	21.75	688	1149	800	2.829	20	475	---	100	24	160	195	
113	50,000	9.27	3.50	2.65	520	10,788	1539	24.11	996	1342	1000	3.327	20	480	---	200	24	165	210	
114	50,000	9.20	3.55	2.59	522	11,588	1867	25.22	1378	1557	1300	3.874	20	490	200	350	24	180	240	
115	50,000	11.98	3.66	3.27	562	10,016	1505	26.23	860	1142	750	2.626	14	600	50	130	18	190	235	71
116	60,000	3.08	2.08	1.48	434	9,324	329	8.05	308	1075	625	2.906	17	210	---	12	22	140	215	134
117	60,000	2.83	2.08	1.36	432	9,972	330	7.73	320	1153	700	3.283	17	200	---	10	22	140	210	
118	60,000	2.88	2.08	1.38	434	10,752	423	9.45	398	1310	900	3.847	18	200	---	30	22	140	205	
119	60,000	2.88	2.08	1.38	436	11,608	542	9.21	556	1541	1120	4.441	18	200	---	60	22	145	210	
120	60,000	2.78	1.98	1.40	441	12,200	601	9.52	664	1717	1325	4.673	18	200	60	90	22	150	230	
121	60,000	3.88	2.18	1.78	460	8,836	239	9.14	370	916	500	2.497	20	250	---	20	23	95	135	135
122	60,000	3.68	2.08	1.77	460	9,984	446	10.24	400	1134	725	3.242	20	250	---	30	23	115	150	
123	60,000	3.78	2.08	1.82	462	10,836	602	11.29	506	1329	940	3.836	20	250	---	60	23	125	160	
124	60,000	3.68	2.08	1.77	460	11,600	735	11.35	678	1540	1160	4.375	20	250	70	100	23	85	190	
125	60,000	3.68	1.98	1.86	462	12,088	824	11.74	818	1726	1325	4.698	20	250	95	140	23	150	215	

[a]Average representing time in altitude chamber. Approximately 22 hr had been accumulated at time of installation in altitude chamber.

[b]Dashes indicate that values are unknown.

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TABLE II - PERFORMANCE DATA ADJUSTED TO STANDARD ALTITUDE AND CORRECTED TO STANDARD SEA-LEVEL ATMOSPHERIC CONDITIONS
(Adjusted for variations in ram-pressure ratio)

Point	Altitude (ft)	Ram-pressure ratio	Engine speed (rpm)		Jet thrust (lb)			Net thrust (lb)		Air consumption (lb/sec)		Fuel consumption (lb/hr)		Net-thrust specific fuel consumption (lb/(hr)(lb thrust))		Indicated gas temperature (°R)		
																Tail-pipe		Tail-cone
		P_2/p_0	Alt. N	Corr. $N/\sqrt{\theta}$	Alt. F_j	Corr. F_j/δ	Parameter $\frac{F_j + p_0A_7}{\delta}$	Alt. F_n	Corr. F_n/δ	Alt. W_a	Corr. $W_a\sqrt{\theta}/\delta$	Alt. W_f	Corr. $W_f/\delta\sqrt{\theta}$	Alt. W_f/F_n	Corr. $W_f/F_n\sqrt{\theta}$	Alt. $T_{6,i}$	Corr. $T_{6,i}/\theta$	Corr. $T_{5,i}/\theta$
1	0	1.00	5,808	5,808	641	641	4,554	641	641	35.81	35.81	1198	1198	1.869	1.869	1223	1223	1257
2	0	1.00	7,646	7,646	1126	1126	5,039	1126	1126	50.80	50.80	1671	1671	1.484	1.484	1200	1200	1218
3	0	1.00	9,618	9,618	2327	2327	6,240	2327	2327	64.88	64.88	2534	2534	1.089	1.089	1292	1292	1347
4	0	1.00	10,386	10,386	2929	2929	6,842	2929	2929	70.78	70.78	3087	3087	1.054	1.054	1361	1361	1404
5	0	1.00	11,135	11,135	3673	3673	7,586	3673	3673	76.97	76.97	3802	3802	1.035	1.035	1463	1463	1526
6	0	1.30	8,009	7,716	1689	1299	4,309	277	214	65.23	52.09	1526	1131	5.486	5.285	1047	971	976
7	0	1.30	7,909	7,619	1626	1251	4,261	226	174	64.81	51.75	1522	1128	6.729	6.483	1037	962	981
8	0	1.30	9,029	8,698	2346	1805	4,815	719	554	75.21	60.05	2029	1504	2.818	2.715	1128	1046	1079
9	0	1.30	9,966	9,601	3188	2452	5,462	1421	1092	81.67	65.21	2757	2043	1.941	1.870	1228	1139	1166
10	10,000	1.30	6,399	6,386	720	805	3,815	-46	-51	36.69	41.12	848	947	∞	∞	905	901	947
11	10,000	1.30	8,068	8,052	1283	1435	4,445	289	323	47.64	53.40	1154	1288	3.996	3.988	1005	1001	1060
12	10,000	1.30	10,000	9,980	2475	2768	5,778	1212	1355	60.50	67.80	2071	2312	1.709	1.706	1209	1204	1300
13	10,000	1.30	10,783	10,761	3162	3536	6,546	1737	1943	68.22	76.45	2733	3051	1.573	1.570	1324	1319	1399
14	10,000	1.30	11,611	11,588	4226	4727	7,737	2640	2952	75.98	85.15	3725	4158	1.411	1.408	1499	1493	1607
15	10,000	1.30	12,292	12,267	5112	5717	8,727	3449	3858	79.62	89.23	4893	5462	1.419	1.416	1685	1678	1778
16	10,000	1.70	10,017	9,622	3277	2803	5,105	995	851	75.41	67.15	2083	1712	2.096	2.013	1153	1064	1094
17	10,000	1.70	10,835	10,408	4346	3718	6,020	1782	1524	84.72	75.44	3037	2496	1.705	1.638	1296	1196	1253
18	10,000	1.70	11,610	11,153	5694	4871	7,173	2896	2477	92.45	82.32	4203	3454	1.451	1.394	1464	1351	1394
19	10,000	1.70	9,066	8,709	2322	1986	4,288	323	276	66.05	58.82	1436	1180	4.452	4.275	1002	924	943
20	10,000	1.70	9,960	9,568	3243	2774	5,076	928	794	76.43	68.06	2133	1753	2.297	2.207	1152	1063	1076
21	10,000	1.70	10,824	10,398	4379	3746	6,048	1805	1544	85.02	75.71	3144	2584	1.742	1.673	1317	1215	1256
22	10,000	1.70	11,555	11,100	5512	4715	7,017	2725	2331	92.09	82.00	4196	3448	1.541	1.480	1479	1364	1429
23	20,000	1.30	8,002	8,299	946	1583	4,593	230	385	35.61	57.46	850	1476	3.697	3.834	937	1008	1077
24	20,000	1.30	9,994	10,365	1921	3214	6,224	996	1667	46.01	74.23	1500	2603	1.506	1.562	1182	1271	1352
25	20,000	1.30	10,834	11,236	2546	4260	7,270	1533	2565	50.39	81.31	2101	3646	1.370	1.421	1342	1444	1516
26	20,000	1.30	11,574	12,004	3192	5342	8,352	2108	3528	53.92	87.00	2826	4905	1.340	1.390	1512	1626	1716
27	20,000	1.30	12,117	12,567	3793	6347	9,357	2630	4401	57.87	93.38	3476	6032	1.322	1.371	1670	1796	1909
28	20,000	1.70	9,040	9,022	1682	2152	4,454	310	397	47.06	60.35	1095	1399	3.530	3.523	971	967	1055
29	20,000	1.70	10,020	10,000	2530	3238	5,540	950	1216	54.22	69.53	1683	2149	1.771	1.767	1162	1157	1255
30	20,000	1.70	10,800	10,778	3251	4161	6,463	1498	1917	60.19	77.18	2330	2976	1.556	1.553	1321	1316	1403
31	20,000	1.70	11,619	11,596	4119	5271	7,573	2206	2823	65.65	84.18	3204	4092	1.453	1.450	1491	1485	1580
32	20,000	1.70	12,232	12,208	4924	6301	8,603	2898	3709	69.50	89.12	4118	5259	1.421	1.418	1670	1663	1756
33	20,000	2.30	9,083	8,684	2445	2313	4,014	177	167	60.77	60.14	1124	1017	6.370	6.090	945	864	905
34	20,000	2.30	10,032	9,591	3462	3275	4,976	862	815	69.65	68.93	1840	1664	2.136	2.042	1137	1039	1071
35	20,000	2.30	10,828	10,352	4425	4186	5,887	1616	1529	75.21	74.43	2679	2423	1.658	1.585	1301	1189	1236
36	20,000	2.30	11,671	11,158	5661	5356	7,057	2578	2439	82.60	81.74	3859	3490	1.497	1.431	1491	1363	1385
37	30,000	1.30	8,626	9,327	849	2202	5,212	317	822	27.64	66.27	734	2058	2.316	2.504	942	1101	1148
38	30,000	1.30	9,984	10,796	1416	3671	6,681	779	2019	33.04	79.22	1071	3002	1.374	1.486	1138	1331	1379
39	30,000	1.30	10,738	11,611	1864	4834	7,844	1174	3045	35.81	85.87	1519	4258	1.293	1.398	1301	1521	1584
40	30,000	1.30	11,568	12,509	2328	6035	9,044	1607	4167	37.37	89.60	2085	5845	1.297	1.403	1536	1796	1937
41	30,000	1.30	12,029	13,007	2670	6922	9,932	1905	4938	39.73	95.25	2500	7008	1.312	1.419	1653	1933	2072
42	30,000	1.50	8,793	9,316	1047	2352	4,961	311	699	30.37	64.40	847	2015	2.721	2.883	939	1054	1096
43	30,000	1.50	9,940	10,531	1638	3680	6,289	753	1692	36.53	77.45	1217	2895	1.615	1.711	1132	1271	1314
44	30,000	1.50	10,746	11,385	2142	4811	7,420	1222	2744	37.99	80.55	1664	3960	1.362	1.443	1294	1452	1516
45	30,000	1.50	11,559	12,246	2722	6115	8,724	1702	3823	42.15	89.37	2328	5541	1.369	1.450	1560	1751	1825
46	30,000	1.50	12,116	12,836	3132	7035	9,644	2068	4645	43.92	93.13	2527	6013	1.221	1.294	1672	1877	1991
47	30,000	1.70	9,059	9,427	1327	2630	4,932	347	687	35.09	66.82	872	1798	2.515	2.617	954	1033	1093
48	30,000	1.70	9,928	10,331	1850	3666	5,968	738	1463	39.79	75.77	1163	2398	1.575	1.639	1107	1199	1297
49	30,000	1.70	10,775	11,212	2414	4783	7,086	1198	2373	43.50	82.82	1723	3552	1.439	1.497	1305	1413	1486
50	30,000	1.70	11,604	12,075	3108	6159	8,461	1830	3625	45.75	87.12	2451	5053	1.340	1.394	1528	1655	1734
51	30,000	1.70	12,166	12,660	3582	7098	9,400	2210	4378	49.12	93.53	3016	6219	1.366	1.421	1655	1792	1922
52	30,000	2.00	8,971	9,121	1478	2490	4,446	192	324	39.75	65.86	890	1524	4.627	4.704	923	954	989
53	30,000	2.00	9,069	9,220	1528	2574	4,530	279	470	38.63	64.01	912	1562	3.269	3.323	937	969	993
54	30,000	2.00	9,915	10,080	2124	3579	5,535	683	1151	44.56	73.84	1331	2280	1.949	1.981	1111	1148	1202
55	30,000	2.00	9,929	10,095	2129	3586	5,542	661	1114	45.35	75.14	1272	2179	1.923	1.955	1105	1142	1195
56	30,000	2.00	10,676	10,854	2702	4552	6,508	1177	1982	47.18	78.17	1834	3142	1.559	1.585	1272	1315	1367
57	30,000	2.00	11,499	11,691	3436	5789	7,745	1794	3022	50.80	84.18	2570	4402	1.433	1.457	1464	1513	1632
58	30,000	2.30	7,936	7,912	1115	1634	3,335	-238	-348	37.75	55.48	669	978	∞	∞	755	750	783
59	30,000	2.30	9,021	8,994	1705	2498	4,199	192	282	42.22	62.04	897	1311	4.663	4.649	925	919	1014
60	30,000	2.30	10,032	10,002	2509	3676	5,377	790	1157	47.99	70.52	1416	2069	1.793	1.788	1156	1148	1256
61	30,000	2.30	10,784	10,752	3210	4703	6,404	1351	1979	51.89	76.26	2032	2969	1.504	1.500	1323	1314	1402
62	30,000	2.30	11,629	11,594	4038	5917	7,618	1982	2904	57.40	84.35	2931	4282	1.479	1.475	1507	1497	1596
63	30,000	2.30	12,257	12,220	4675	6850	8,551	2539	3720	59.62	87.61	3643	5322	1.434	1.430	1694	1682	1786

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TABLE II - PERFORMANCE DATA ADJUSTED TO STANDARD ALTITUDE AND CORRECTED TO STANDARD SEA-LEVEL ATMOSPHERIC CONDITIONS - Concluded
(Adjusted for variations in ram-pressure ratio)

Point	Altitude (ft)	Ram-pressure ratio	Engine speed (rpm)		Jet thrust (lb)			Net thrust (lb)		Air consumption (lb/sec)		Fuel consumption (lb/hr)		Net-thrust specific fuel consumption (lb/(hr)(lb thrust))		Indicated gas temperature (°R)		
																Tail-pipe		Tail-cone
		P_2/p_0	Alt. N	Corr. $N/\sqrt{\theta}$	Alt. F_j	Corr. F_j/δ	Parameter $\frac{F_j + p_0A_7}{\delta}$	Alt. F_n	Corr. F_n/δ	Alt. W_a	Corr. $W_a\sqrt{\theta}/\delta$	Alt. W_f	Corr. $W_f/\delta\sqrt{\theta}$	Alt. W_f/F_n	Corr. $W_f/F_n\sqrt{\theta}$	Alt. $T_{6,1}$	Corr. $T_{6,1}/\theta$	Corr. $T_{5,1}/\theta$
64	30,000	2.70	9,096	8,857	2122	2635	4,084	172	215	49.02	62.81	894	1086	5.187	5.051	931	883	903
65	30,000	2.70	9,201	8,959	2182	2722	4,171	229	286	49.34	63.22	947	1150	4.130	4.021	955	906	919
66	30,000	2.70	9,965	9,703	2929	3655	5,104	819	1022	53.33	68.33	1427	1734	1.743	1.697	1131	1073	1073
67	30,000	2.70	10,766	10,483	3704	4621	6,070	1392	1737	58.42	74.85	2170	2636	1.559	1.518	1305	1238	1279
68	30,000	2.70	11,524	11,221	4589	5725	7,174	2049	2556	64.20	82.26	3009	3656	1.469	1.430	1475	1399	1465
69	30,000	2.70	12,169	11,849	5430	6775	8,224	2722	3396	68.45	87.70	3954	4803	1.452	1.414	1658	1573	1643
70	30,000	3.00	10,022	9,618	3312	3720	5,024	857	962	58.52	68.49	1547	1667	1.806	1.733	1127	1038	1071
71	30,000	3.00	11,631	11,162	5084	5710	7,014	2163	2429	69.65	81.51	2992	3225	1.384	1.328	1480	1363	1440
72	40,000	1.30	8,255	9,140	503	2088	5,098	183	760	16.99	63.70	503	2312	2.747	3.041	901	1105	1179
73	40,000	1.30	8,964	9,925	660	2741	5,751	325	1348	17.83	66.86	546	2510	1.682	1.862	975	1195	1301
74	40,000	1.30	9,973	11,042	923	3832	6,842	526	2182	21.11	79.14	697	3202	1.325	1.467	1139	1396	1457
75	40,000	1.30	10,767	11,921	1183	4912	7,922	753	3126	22.86	85.71	999	4592	1.327	1.469	1309	1604	1714
76	40,000	1.30	11,543	12,780	1498	6218	9,228	1059	4398	23.31	87.38	1358	6242	1.282	1.419	1533	1879	2037
77	40,000	1.70	9,013	9,603	847	2690	4,992	220	699	22.96	68.41	638	2157	2.897	3.086	945	1073	1116
78	40,000	1.70	9,968	10,620	1215	3858	6,160	509	1617	25.86	77.06	790	2671	1.551	1.652	1120	1271	1312
79	40,000	1.70	10,728	11,430	1513	4803	7,105	737	2339	28.43	84.71	1092	3692	1.481	1.578	1301	1477	1533
80	40,000	1.70	11,578	12,335	1989	6315	8,617	1179	3742	29.69	88.47	1615	5461	1.369	1.459	1530	1737	1815
81	40,000	2.00	8,927	9,293	1006	2715	4,671	196	530	25.62	66.40	689	1934	3.505	3.649	926	1004	1092
82	40,000	2.00	9,953	10,361	1448	3906	5,862	528	1423	29.14	75.50	904	2539	1.714	1.784	1115	1208	1303
83	40,000	2.00	10,751	11,192	1871	5047	7,003	866	2336	31.80	82.40	1258	3534	1.452	1.512	1304	1413	1515
84	40,000	2.00	11,563	12,037	2349	6338	8,294	1289	3476	33.57	87.00	1782	5003	1.381	1.438	1524	1652	1787
85	40,000	2.00	11,945	12,435	2578	6954	8,910	1478	3986	34.83	90.25	2062	5792	1.396	1.453	1647	1785	1914
86	40,000	2.70	9,906	9,886	1897	3791	5,240	532	1064	35.29	70.67	1023	2040	1.921	1.917	1112	1106	1178
87	40,000	2.70	10,811	10,789	2465	4928	6,377	949	1896	39.23	78.56	1539	3070	1.622	1.619	1320	1313	1382
88	40,000	2.70	11,595	11,572	3082	6161	7,610	1466	2931	41.79	83.70	2124	4237	1.449	1.446	1521	1513	1602
89	40,000	2.70	9,069	9,051	1415	2829	4,278	193	385	31.62	63.33	717	1431	3.724	3.717	941	936	1057
90	40,000	2.70	9,960	9,940	1956	3910	5,359	592	1183	35.29	70.67	1092	2178	1.845	1.841	1146	1140	1255
91	40,000	2.70	10,795	10,773	2501	4999	6,448	1018	2035	38.35	76.81	1557	3106	1.529	1.526	1343	1336	1456
92	40,000	2.70	11,560	11,537	3062	6121	7,570	1460	2919	41.42	82.96	2130	4249	1.459	1.456	1538	1530	1703
93	40,000	3.50	9,971	9,578	2529	3900	5,018	666	1027	42.05	67.51	1305	1934	1.960	1.883	1130	1043	1069
94	50,000	1.30	9,274	10,268	473	3165	6,175	249	1669	11.87	71.79	433	3207	1.735	1.921	1048	1285	1366
95	50,000	1.30	9,980	11,050	545	3648	6,658	306	2046	12.72	76.88	490	3628	1.601	1.773	1145	1403	1465
96	50,000	1.30	10,714	11,862	692	4635	7,645	432	2895	13.80	83.45	644	4769	1.488	1.647	1297	1590	1654
97	50,000	1.30	11,537	12,774	868	5812	8,822	592	3960	14.70	88.85	863	6395	1.459	1.615	1521	1865	1932
98	50,000	1.30	12,031	13,320	980	6562	9,572	709	4746	14.42	87.19	1064	7887	1.501	1.662	1712	2099	2174
99	50,000	1.70	8,963	9,549	446	2282	4,584	52	266	14.42	69.29	402	2192	7.735	8.241	931	1057	1113
100	50,000	1.70	9,975	10,627	703	3596	5,898	255	1307	16.37	78.65	536	2925	2.101	2.238	1117	1268	1342
101	50,000	1.70	10,696	11,396	917	4691	6,993	438	2243	17.51	84.12	730	3983	1.667	1.776	1283	1456	1531
102	50,000	1.70	11,577	12,334	1187	6073	8,376	665	3404	19.09	91.71	1071	5841	1.610	1.715	1527	1734	1841
103	50,000	2.00	9,068	9,440	620	2696	4,652	112	488	16.05	67.10	536	2428	4.779	4.975	942	1021	1093
104	50,000	2.00	10,005	10,415	901	3922	5,878	323	1406	18.30	76.50	636	2880	1.968	2.049	1132	1227	1308
105	50,000	2.00	10,801	11,244	1145	4984	6,940	521	2266	19.77	82.65	822	3722	1.577	1.642	1328	1439	1537
106	50,000	2.00	11,559	12,033	1362	5926	7,882	709	3085	20.66	86.35	1068	4838	1.505	1.567	1532	1660	1814
107	50,000	2.70	8,259	8,243	578	1864	3,313	-116	-373	17.95	57.96	347	1119	∞	∞	801	797	860
108	50,000	2.70	10,010	9,990	1205	3882	5,331	326	1052	22.71	73.33	691	2221	2.115	2.111	1133	1127	1213
109	50,000	2.70	10,956	10,934	1569	5057	6,506	614	1979	24.69	79.74	1042	3350	1.696	1.693	1355	1348	1438
110	50,000	2.70	11,651	11,628	1879	6054	7,503	877	2826	25.90	83.63	1334	4292	1.522	1.519	1557	1549	1675
111	50,000	2.70	9,033	9,015	872	2809	4,258	96	309	20.07	64.81	488	1568	5.084	5.074	944	939	1064
112	50,000	2.70	9,999	9,979	1207	3889	5,338	351	1130	22.14	71.48	700	2250	1.995	1.991	1154	1148	1259
113	50,000	2.70	10,805	10,783	1552	5001	6,450	619	1996	24.11	77.85	1002	3224	1.618	1.615	1348	1341	1459
114	50,000	2.70	11,577	11,554	1912	6163	7,612	922	2971	25.61	82.70	1398	4496	1.515	1.512	1561	1553	1755
115	50,000	3.00	9,795	9,622	1256	3645	4,949	309	896	23.11	68.27	734	2091	2.376	2.334	1071	1034	1097
116	60,000	1.30	9,210	10,197	277	2990	6,000	139	1501	7.33	71.47	292	3495	2.104	2.329	1082	1326	1338
117	60,000	1.30	9,871	10,929	314	3385	6,395	170	1838	7.61	74.22	315	3767	1.851	2.049	1138	1395	1404
118	60,000	1.30	10,621	11,759	388	4184	7,194	213	2303	9.26	90.25	380	4545	1.782	1.973	1282	1572	1631
119	60,000	1.30	11,438	12,664	502	5418	8,428	333	3598	8.95	87.28	530	6329	1.589	1.759	1500	1839	1886
120	60,000	1.30	11,954	13,235	572	6174	9,184	391	4225	9.59	93.51	649	7758	1.658	1.836	1657	2031	2111
121	60,000	1.70	8,810	9,386	209	1722	4,024	-26	-212	8.58	66.51	357	3142	∞	∞	920	1044	1093
122	60,000	1.70	9,954	10,605	429	3539	5,841	151	1251	10.14	78.62	399	3508	2.632	2.804	1131	1284	1342
123	60,000	1.70	10,780	11,485	553	4566	6,868	256	2116	10.87	84.25	482	4245	1.883	2.006	1320	1498	1578
124	60,000	1.70	11,565	12,322	711	5868	8,170	405	3341	11.21	86.89	666	5858	1.645	1.753	1531	1738	1828
125	60,000	1.70	12,025	12,812	773	6381	8,683	461	3809	11.41	88.42	795	6998	1.724	1.837	1708	1939	2005

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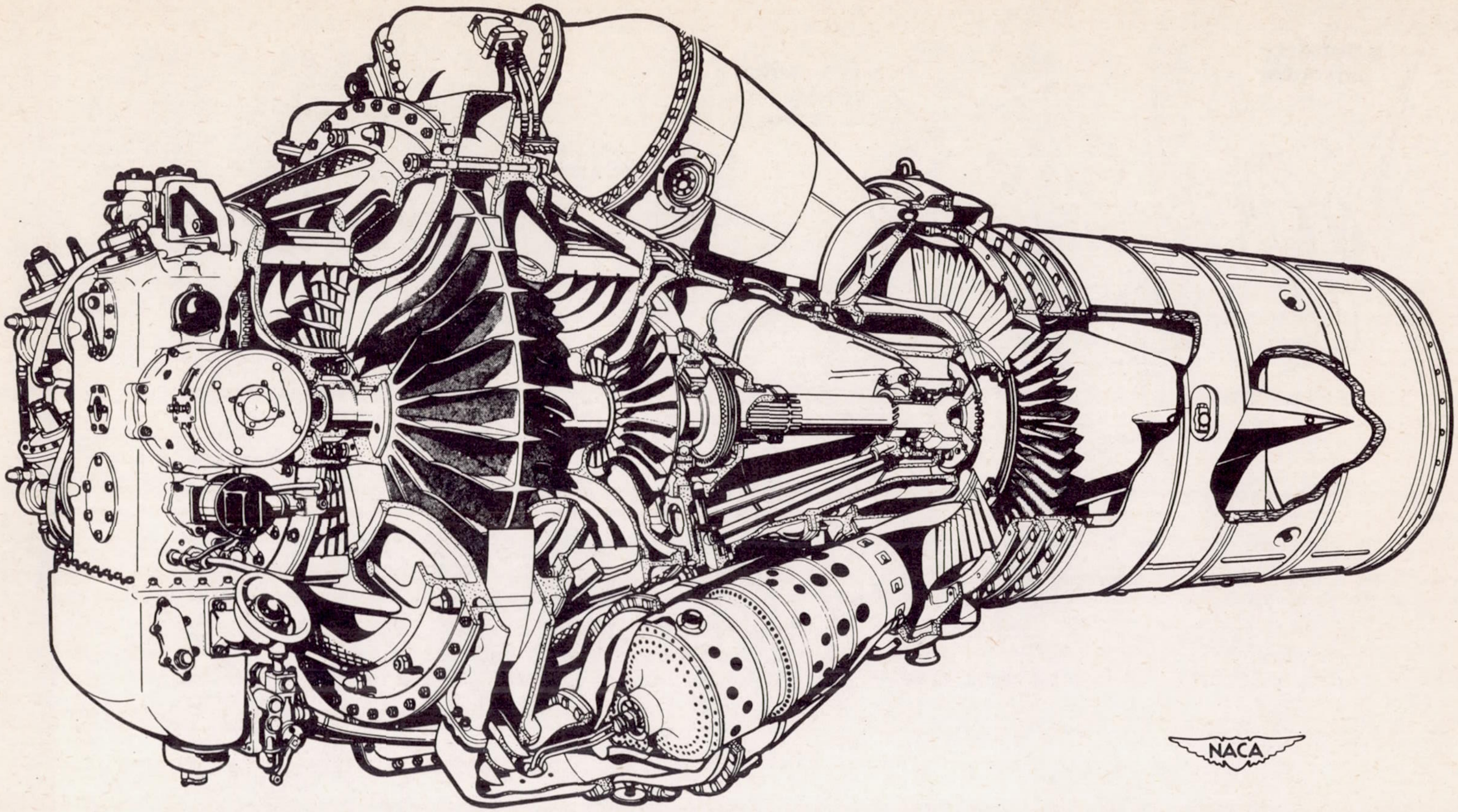

Figure 1. - Cutaway view of British Rolls-Royce Nene II turbojet engine. (Photographed from Rolls-Royce Manual on Nene engine.)

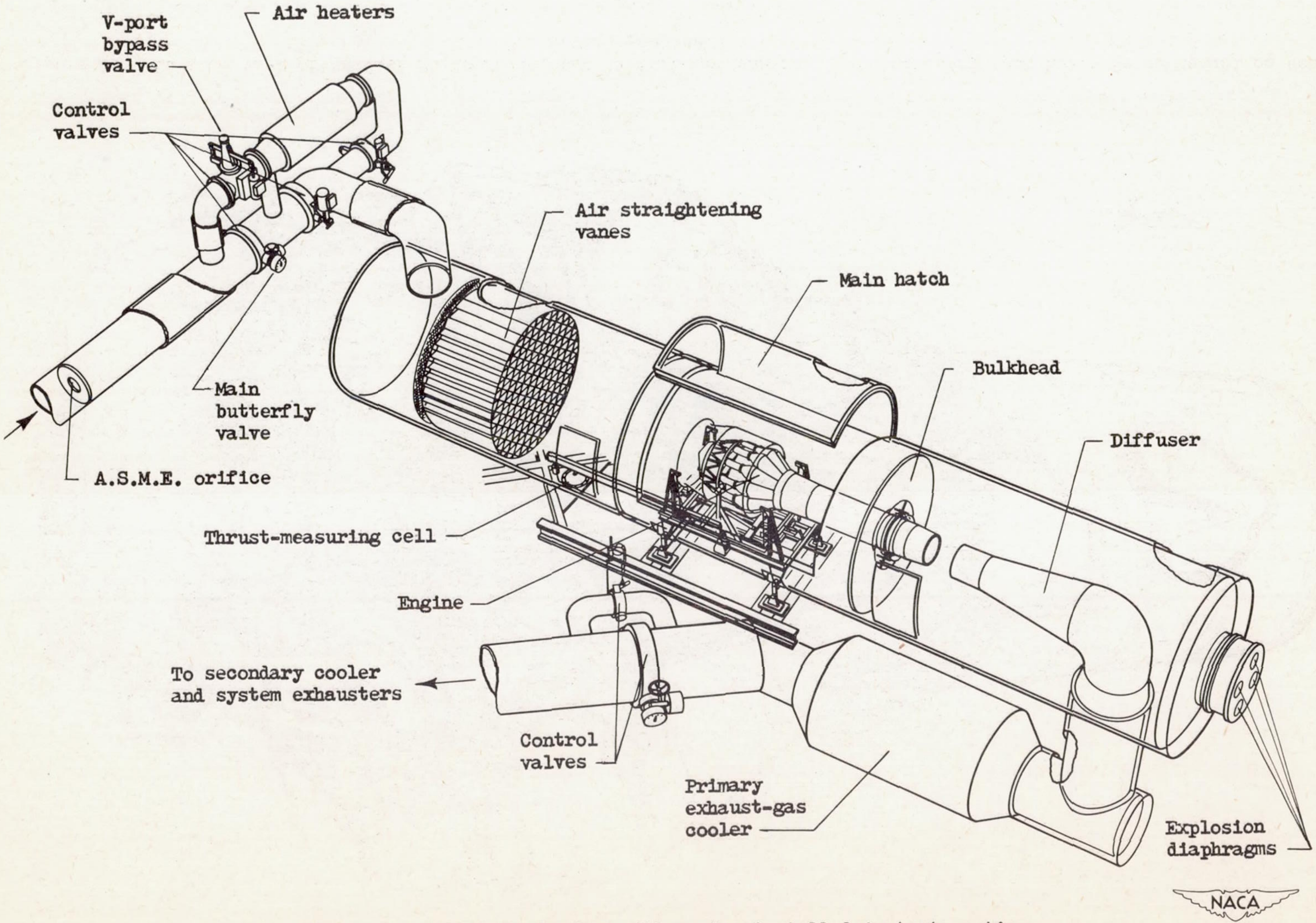

Figure 2. - Altitude chamber with engine installed in test section.

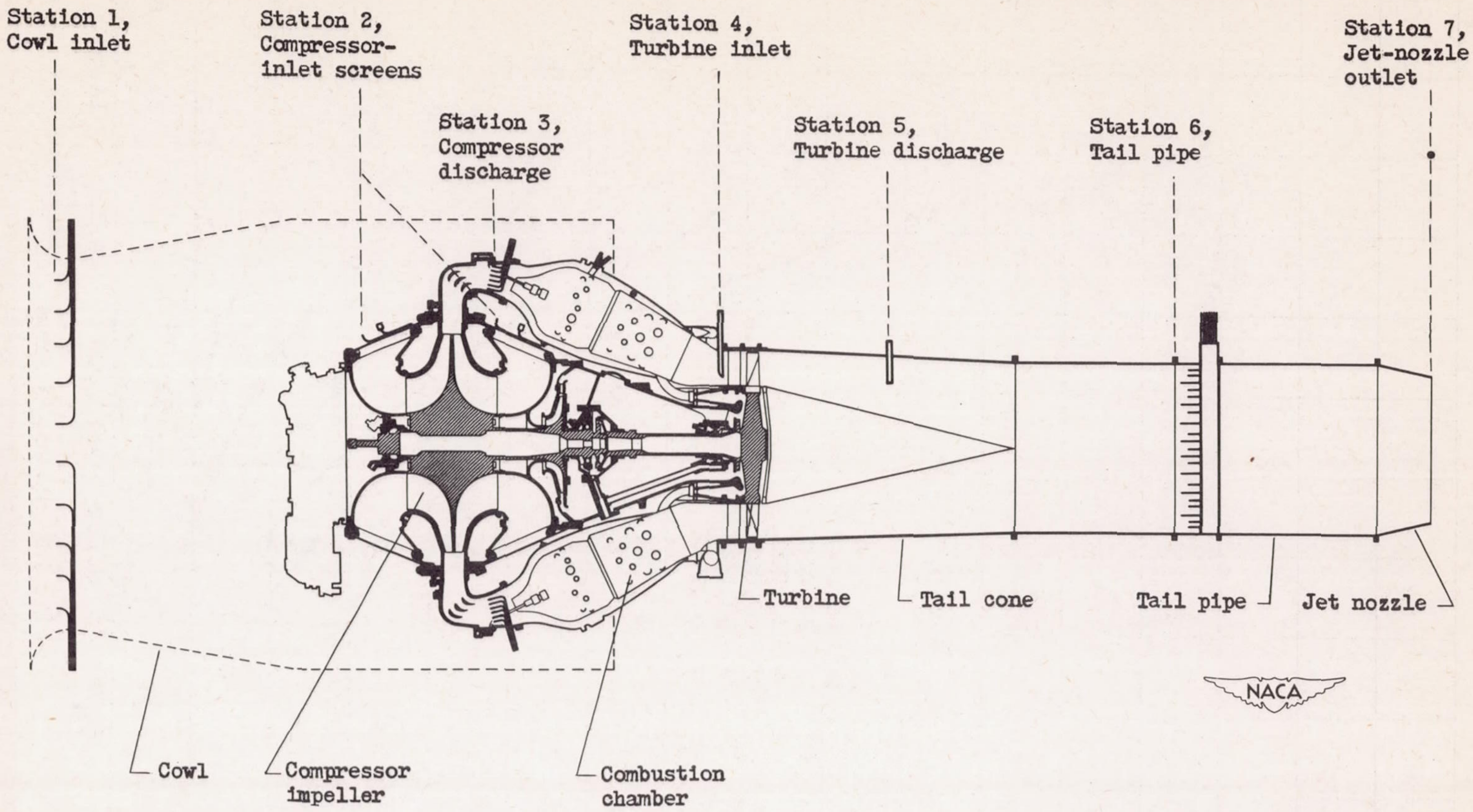

Figure 3. - Sectional side view of British Rolls-Royce Nene II engine showing instrumentation stations.

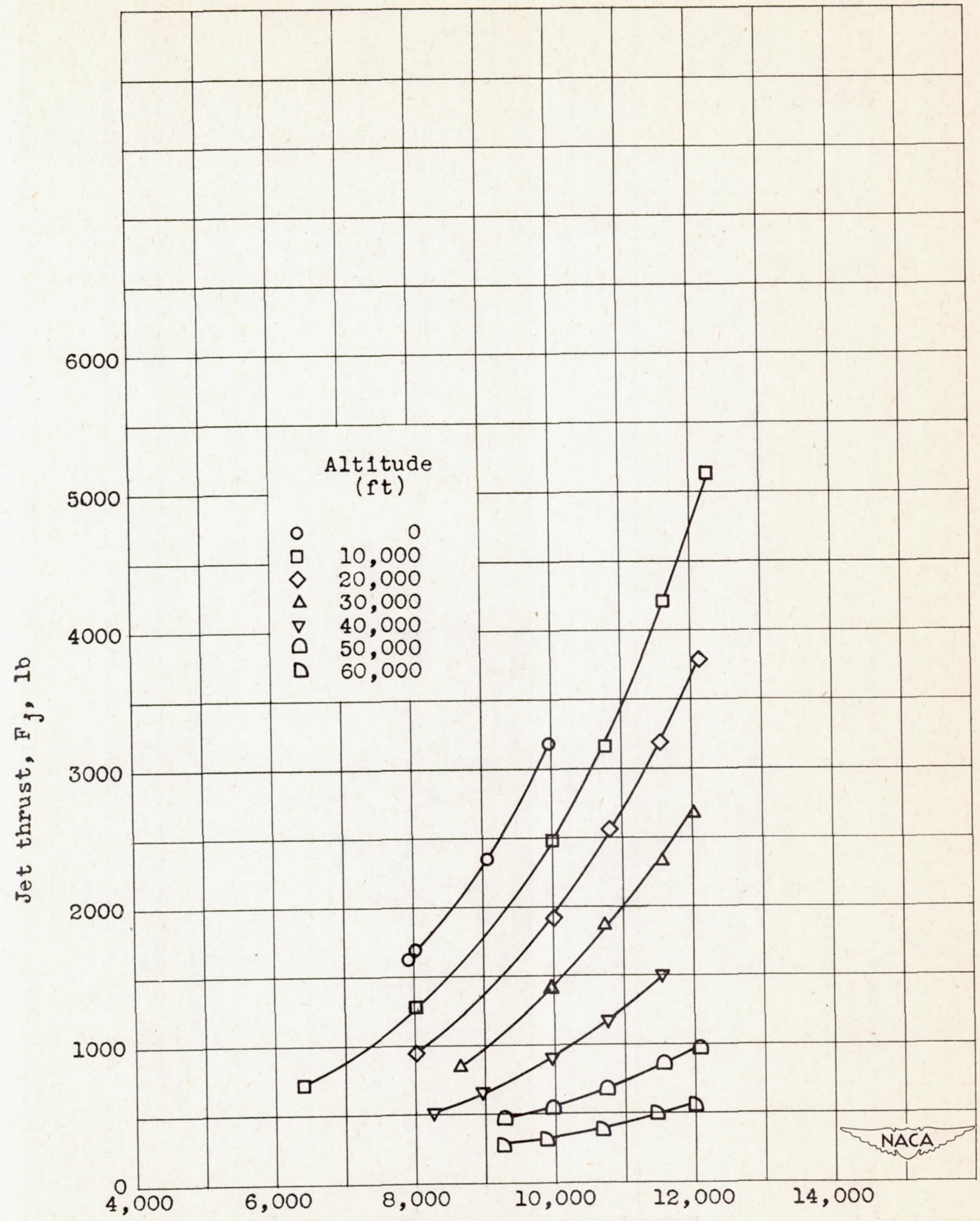

Figure 4. - Effect of altitude on jet thrust. Ram-pressure ratio, 1.30.

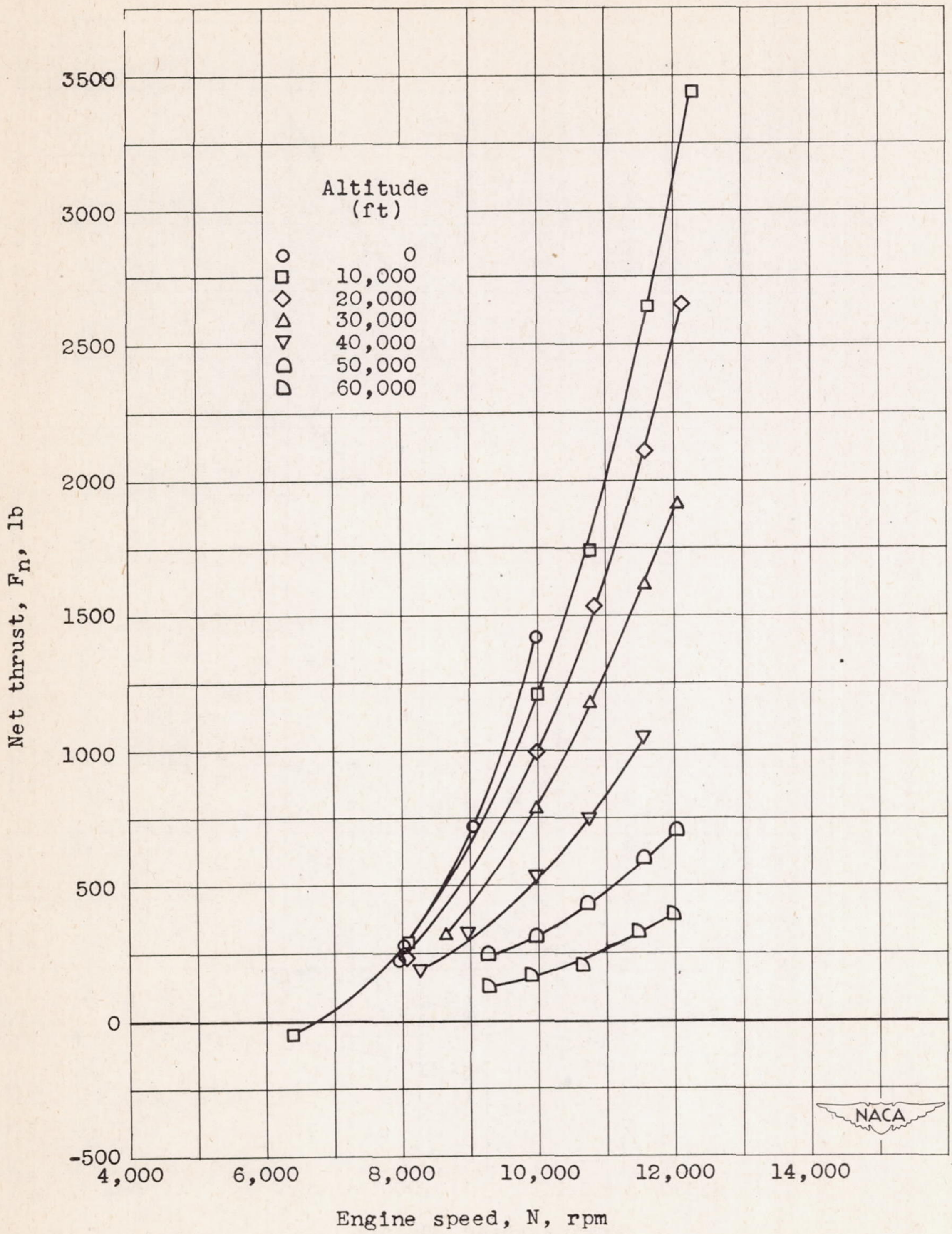

Figure 5. - Effect of altitude on net thrust. Ram-pressure ratio, 1.30.

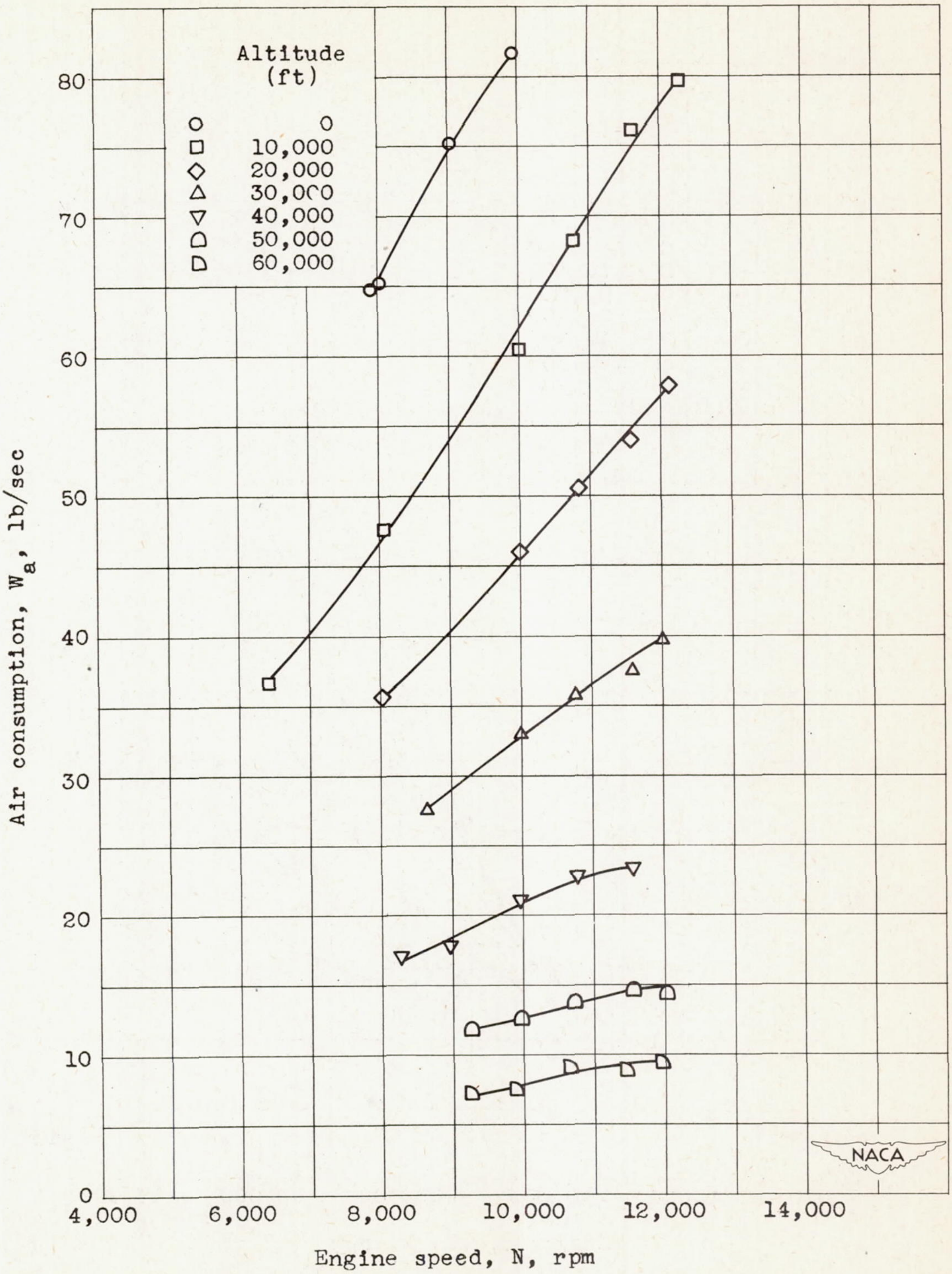

Figure 6. - Effect of altitude on air consumption. Ram-pressure ratio, 1.30.

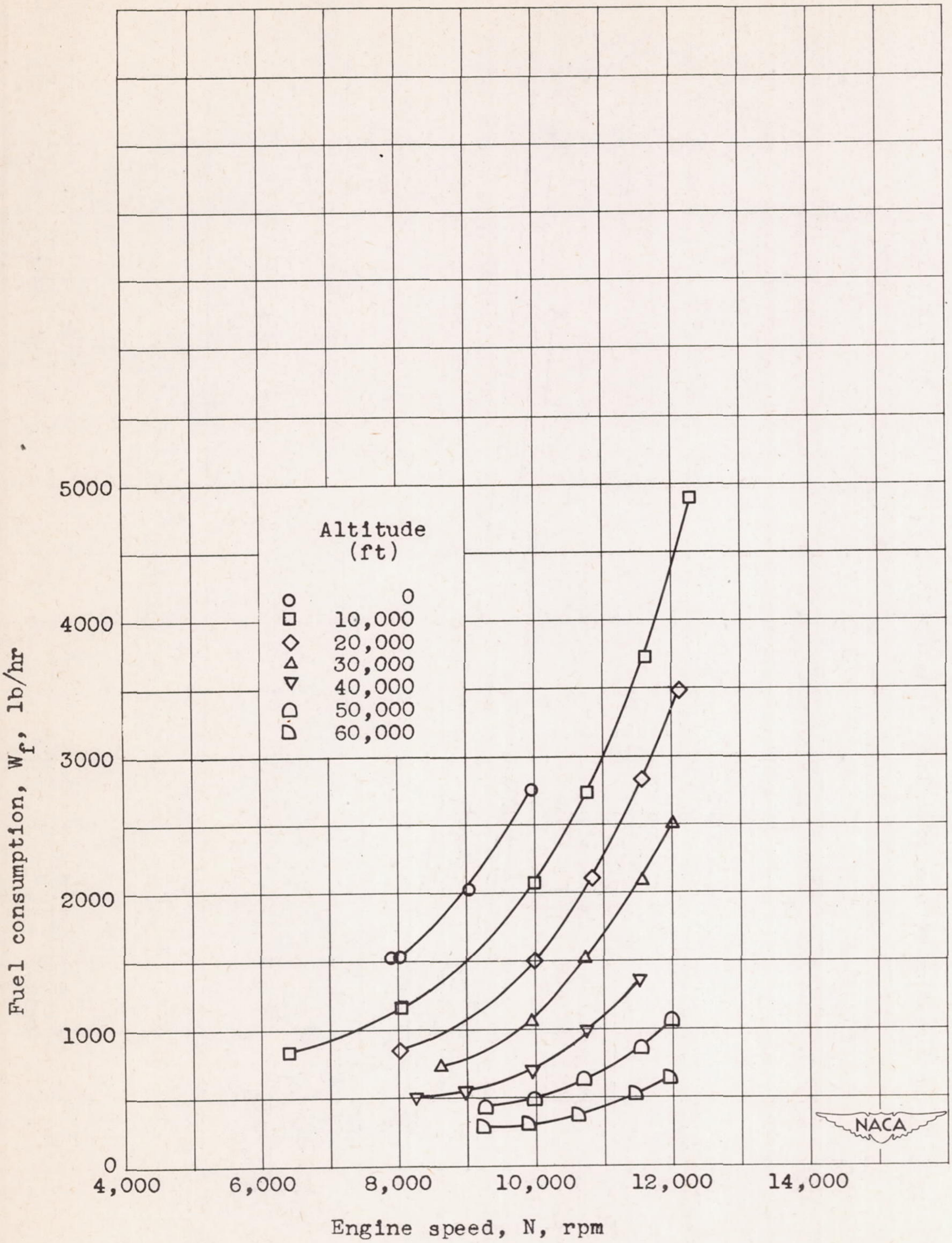

Figure 7. - Effect of altitude on fuel consumption. Ram-pressure ratio, 1.30.

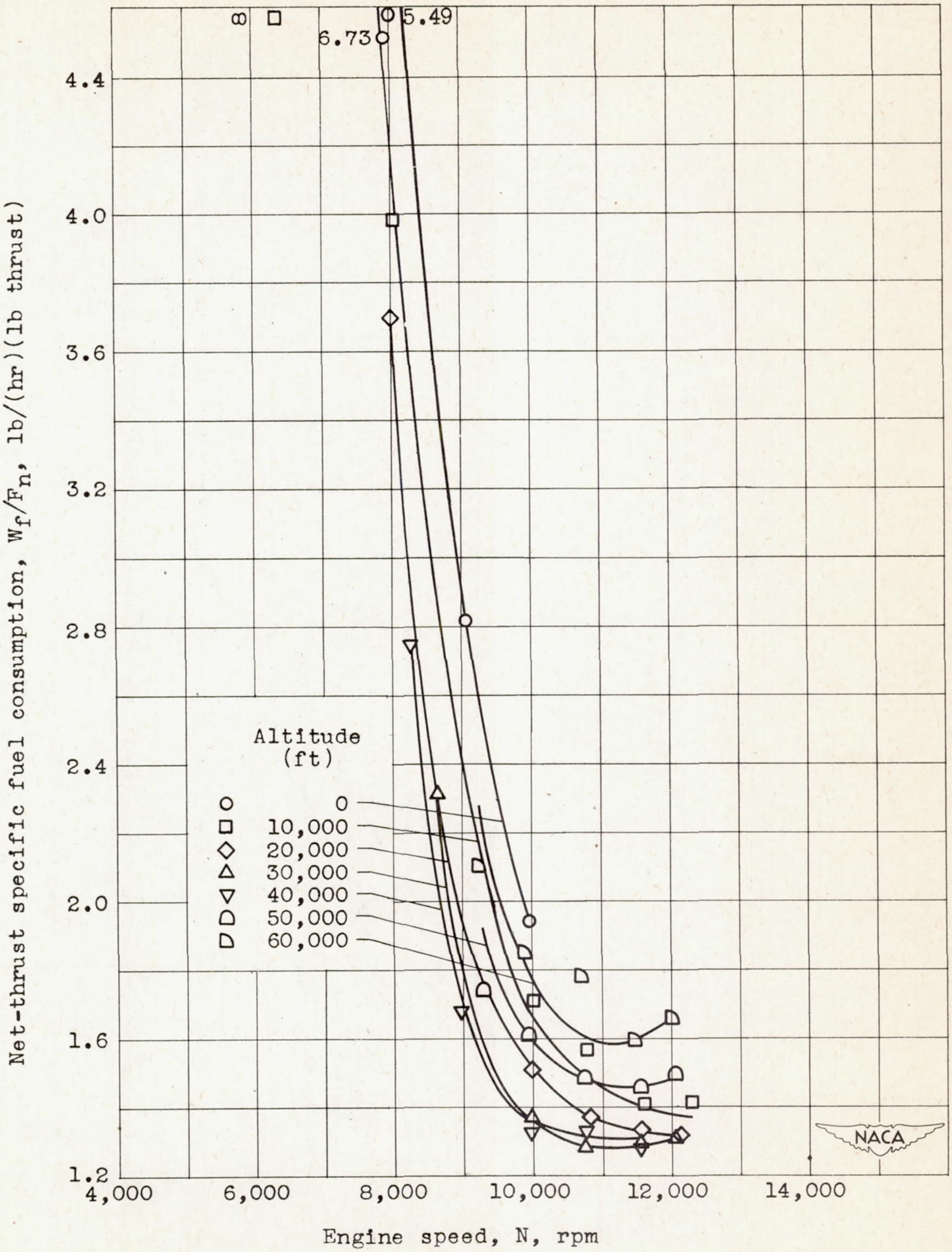

Figure 8. - Effect of altitude on net-thrust specific fuel consumption. Ram-pressure ratio, 1.30.

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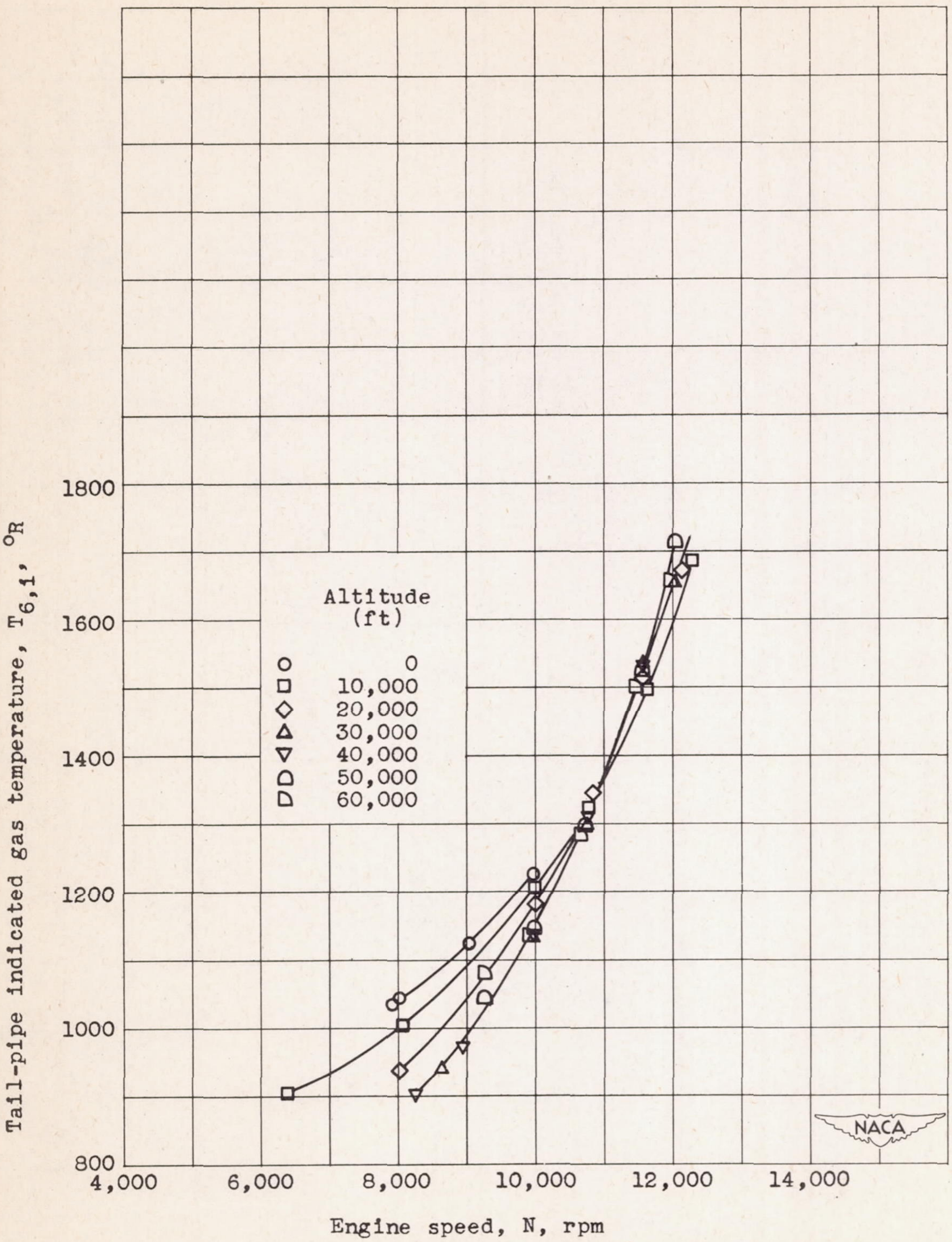

Figure 9. - Effect of altitude on tail-pipe indicated gas temperature. Ram-pressure ratio, 1.30.

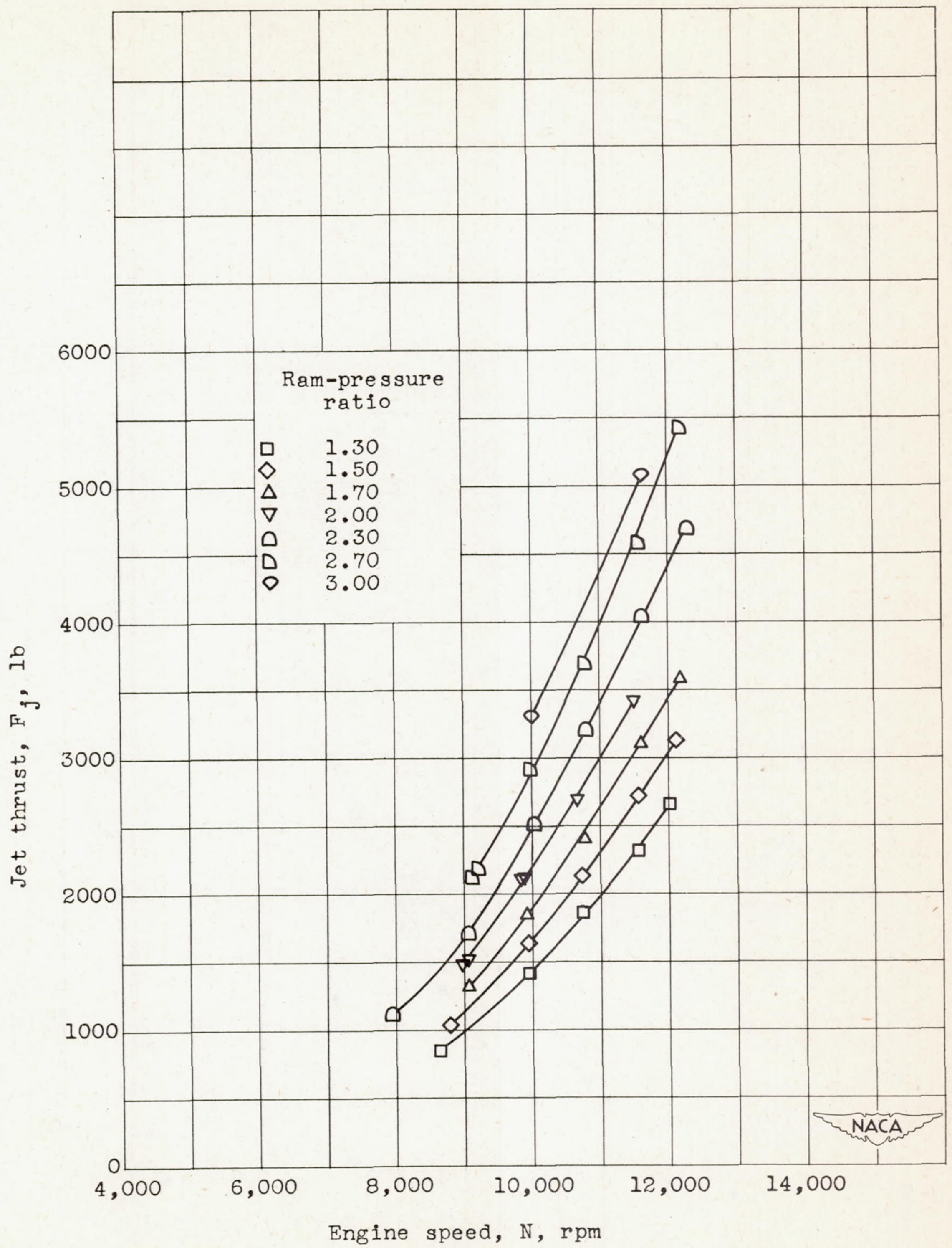

Figure 10. - Effect of ram-pressure ratio on jet thrust. Altitude, 30,000 feet.

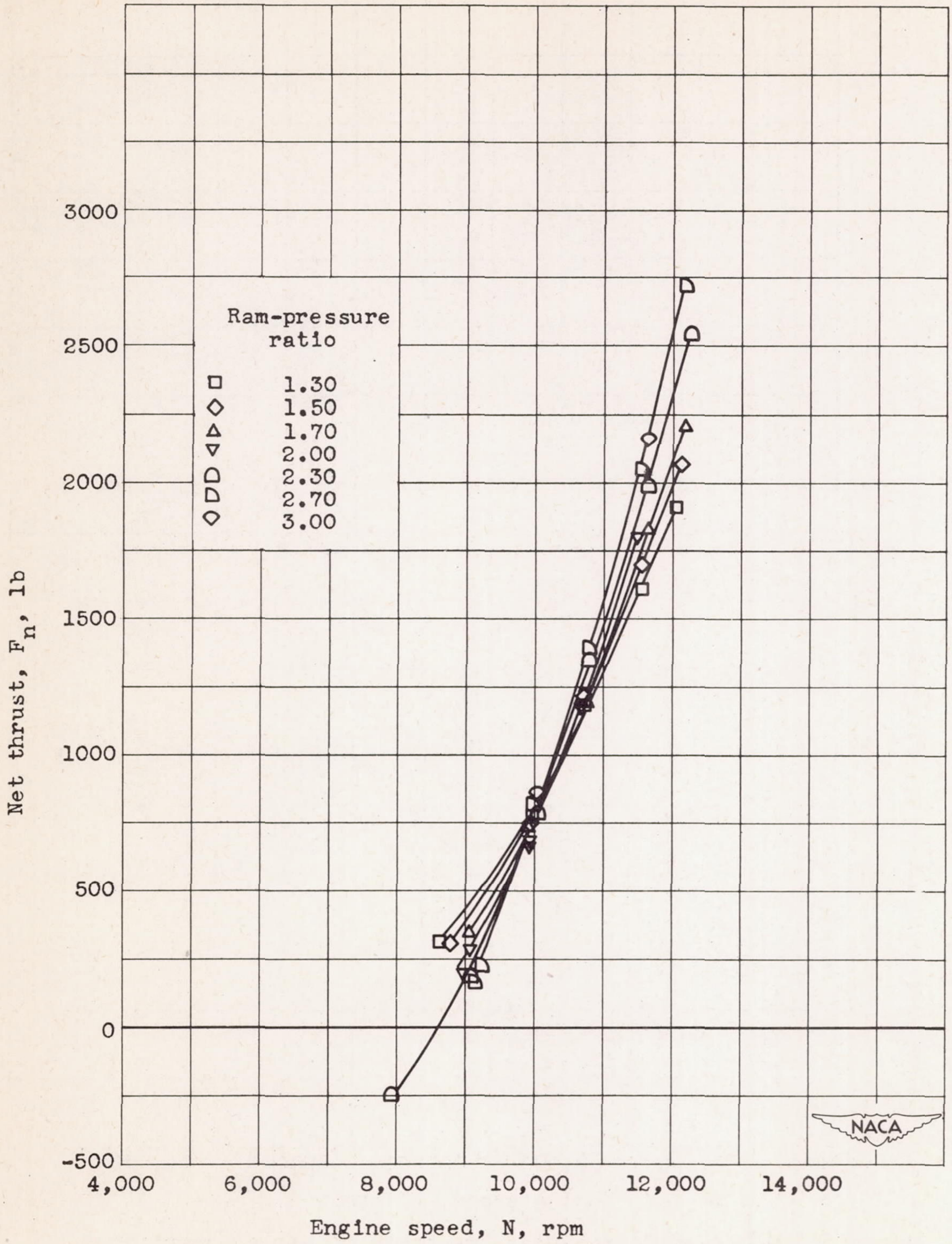

Figure 11. - Effect of ram-pressure ratio on net thrust. Altitude, 30,000 feet.

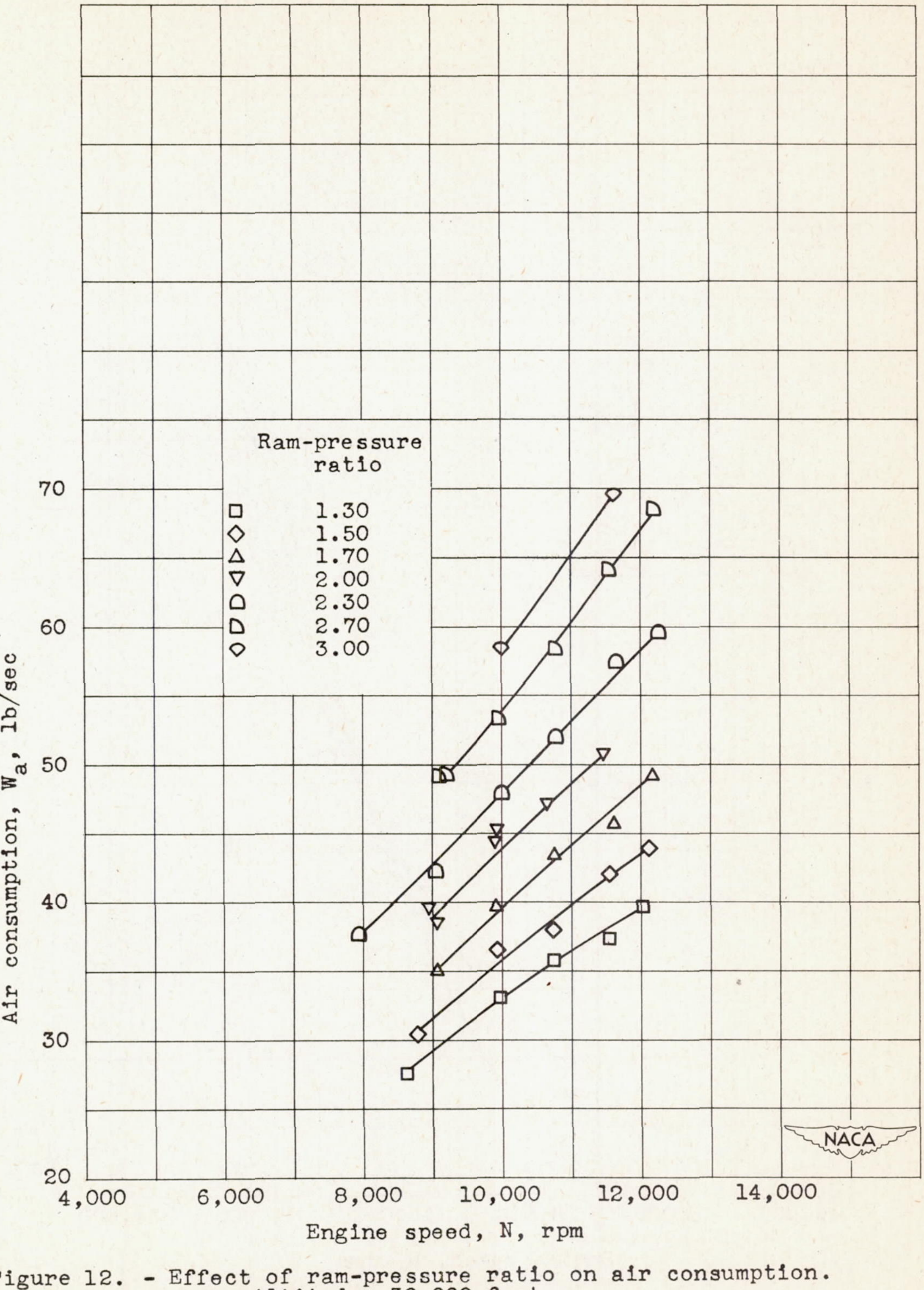

Figure 12. - Effect of ram-pressure ratio on air consumption. Altitude, 30,000 feet.

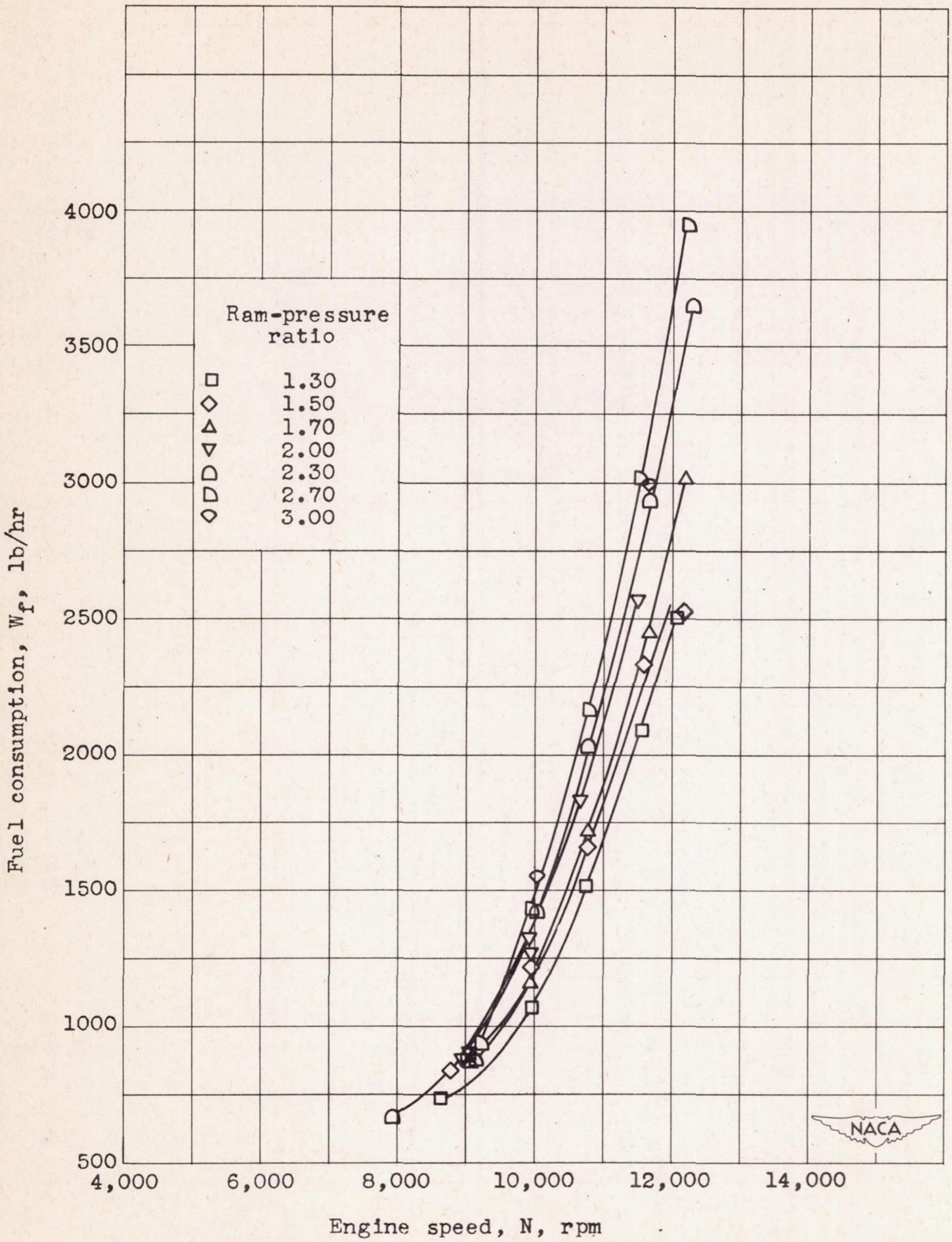

Figure 13. - Effect of ram-pressure ratio on fuel consumption. Altitude, 30,000 feet.

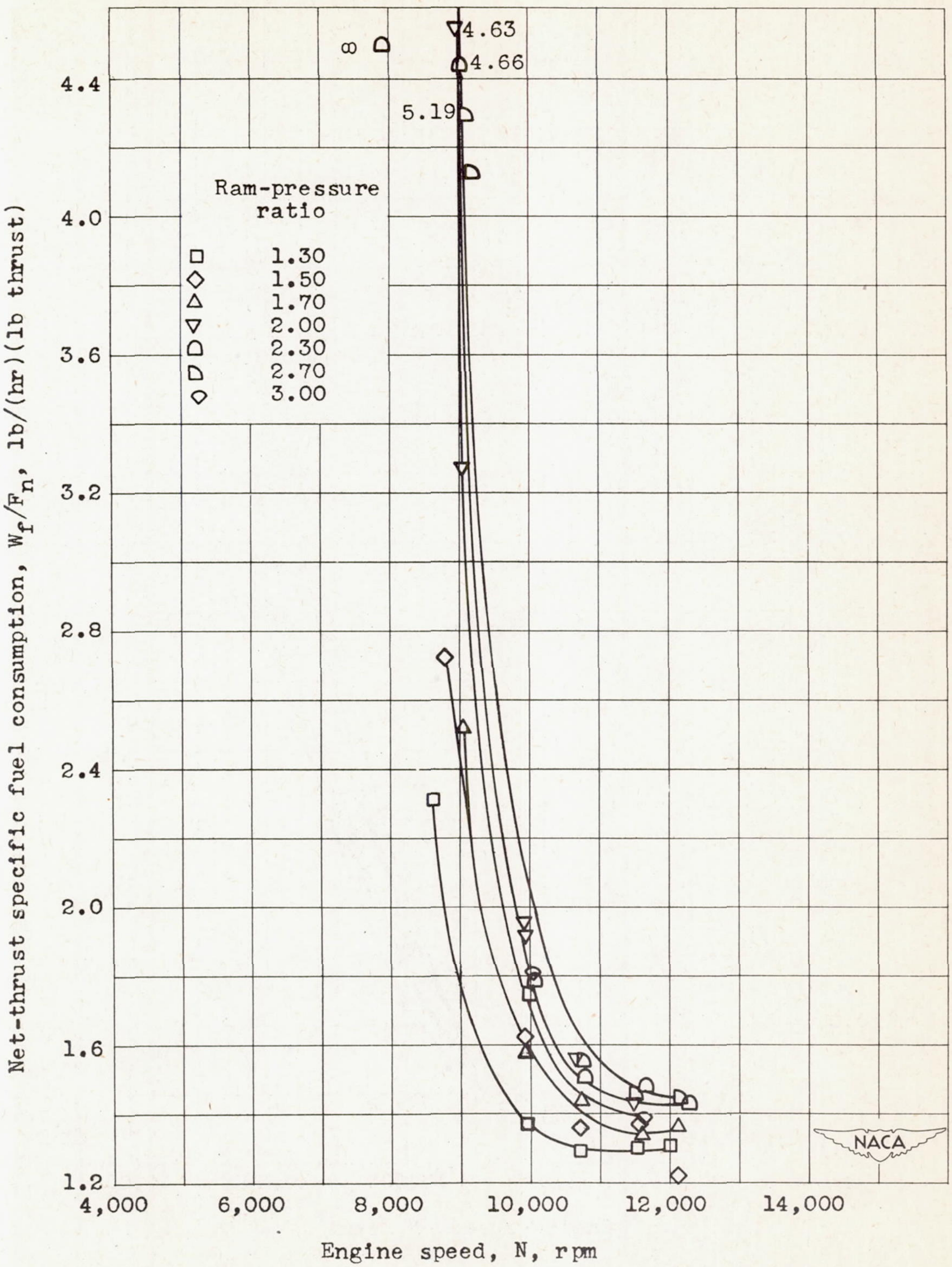

Figure 14. - Effect of ram-pressure ratio on net-thrust specific fuel consumption. Altitude, 30,000 feet.

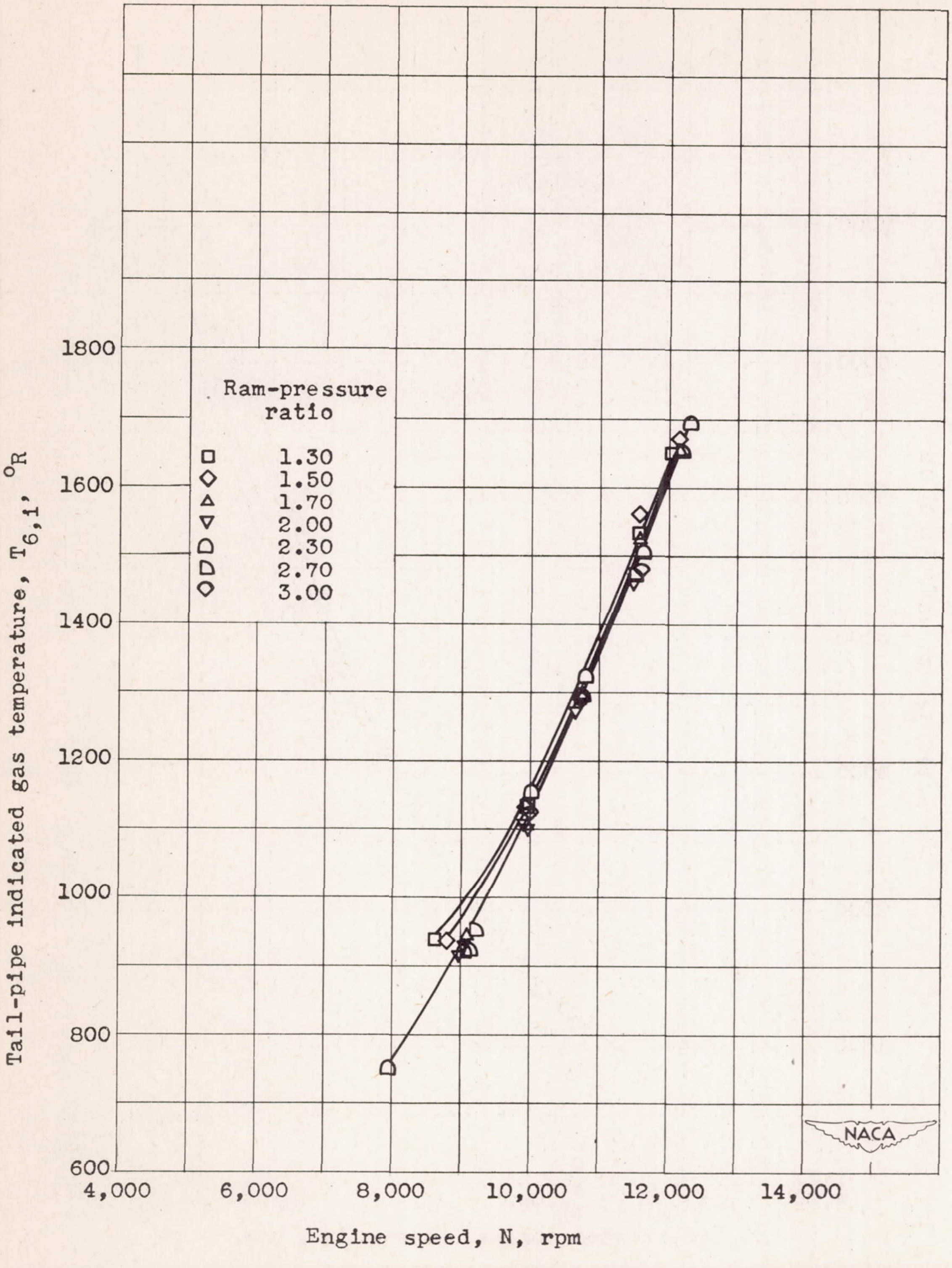

Figure 15. - Effect of ram-pressure ratio on tail-pipe indicated gas temperature. Altitude, 30,000 feet.

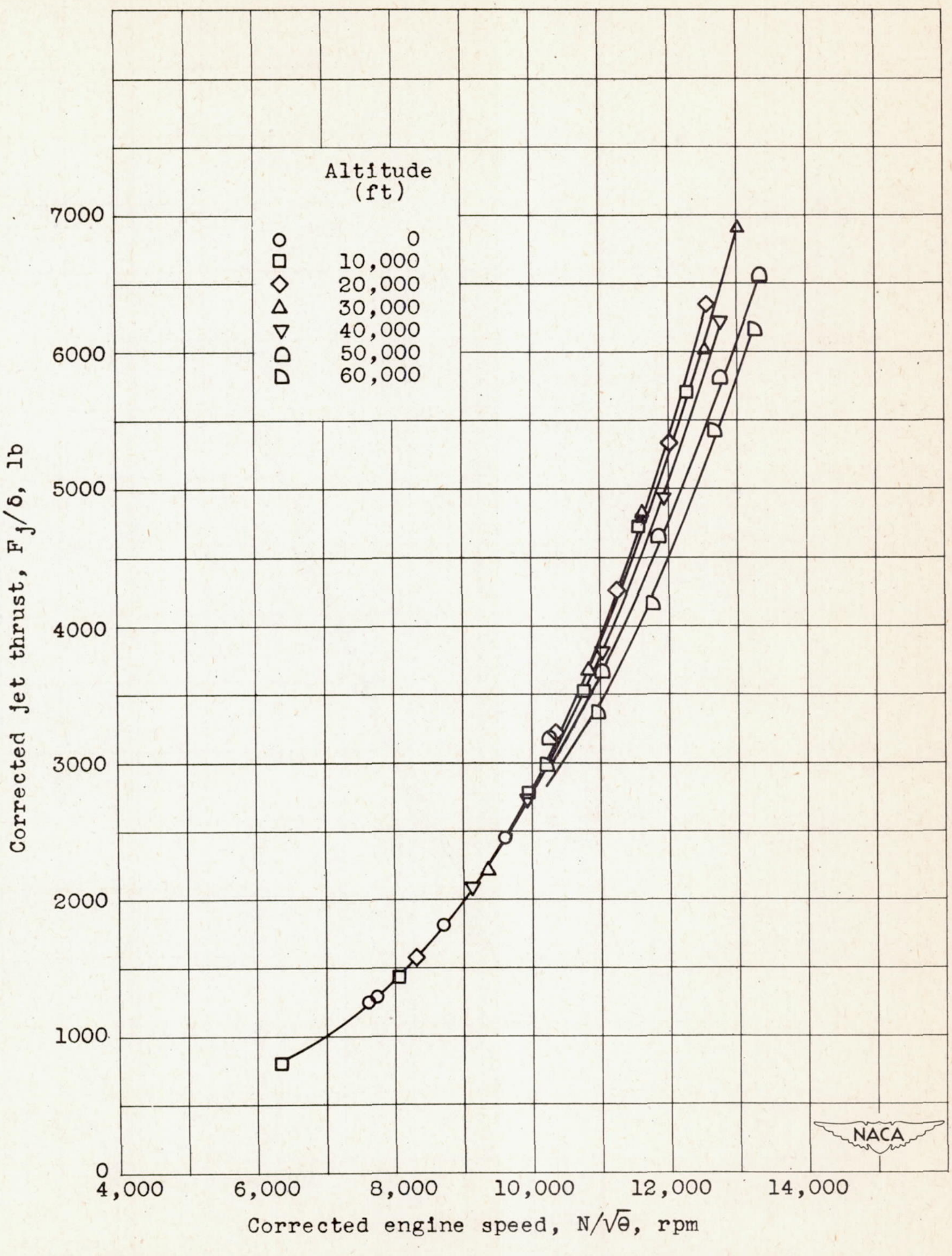

Figure 16. - Effect of altitude on corrected jet thrust. Ram-pressure ratio, 1.30.

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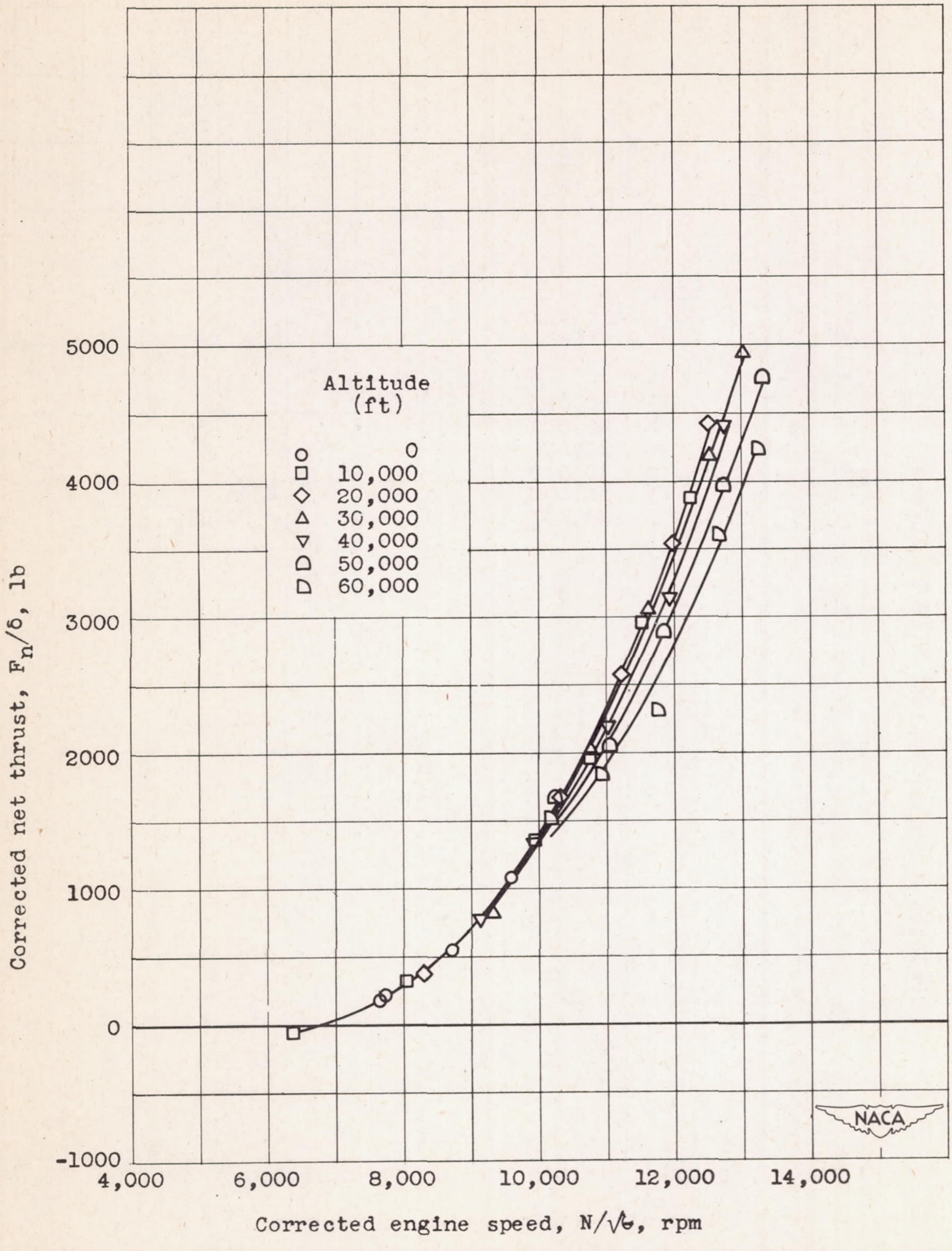

Figure 17. - Effect of altitude on corrected net thrust.
Ram-pressure ratio, 1.30.

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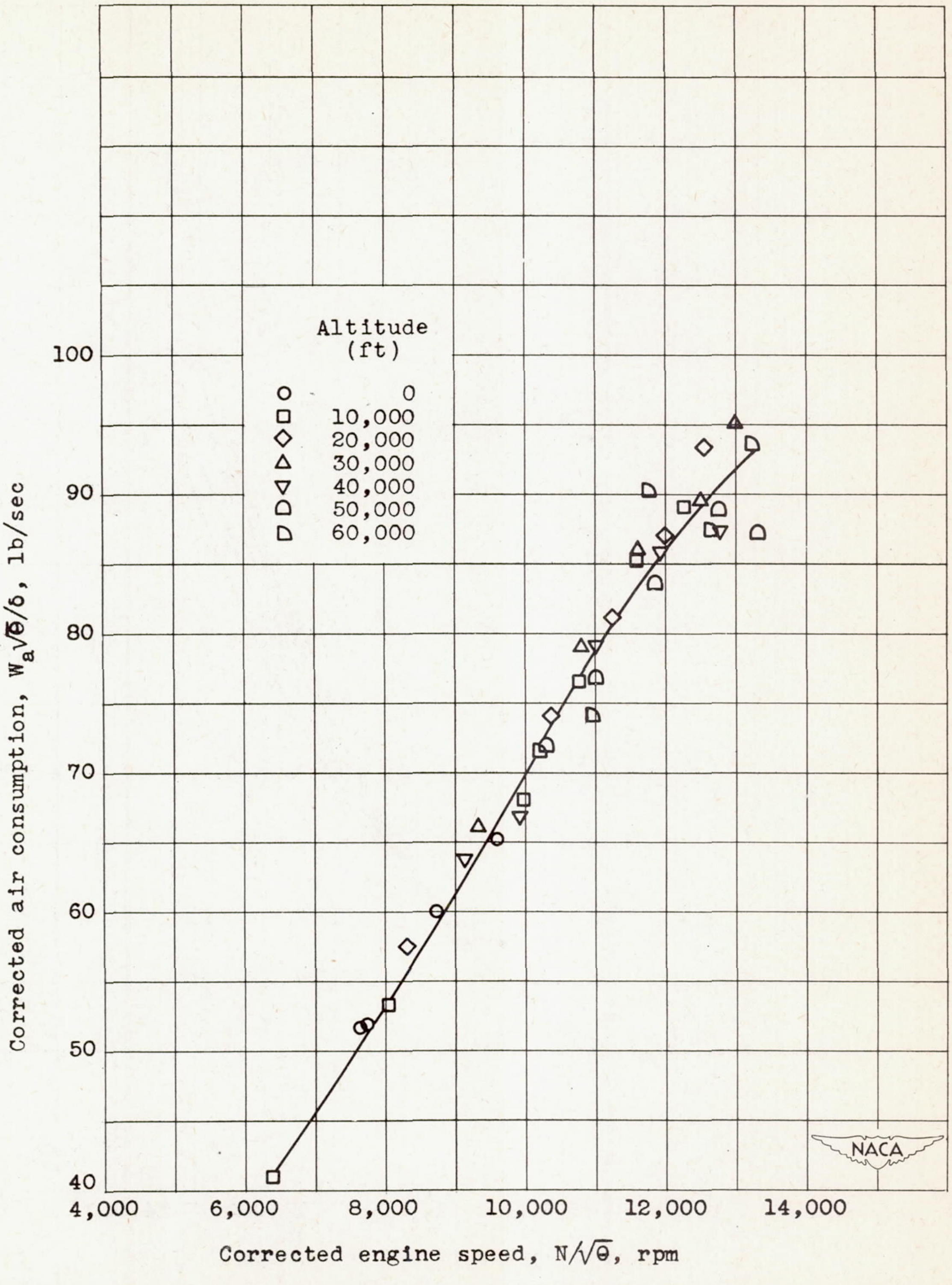


Figure 18. - Effect of altitude on corrected air consumption. Ram-pressure ratio, 1.30.

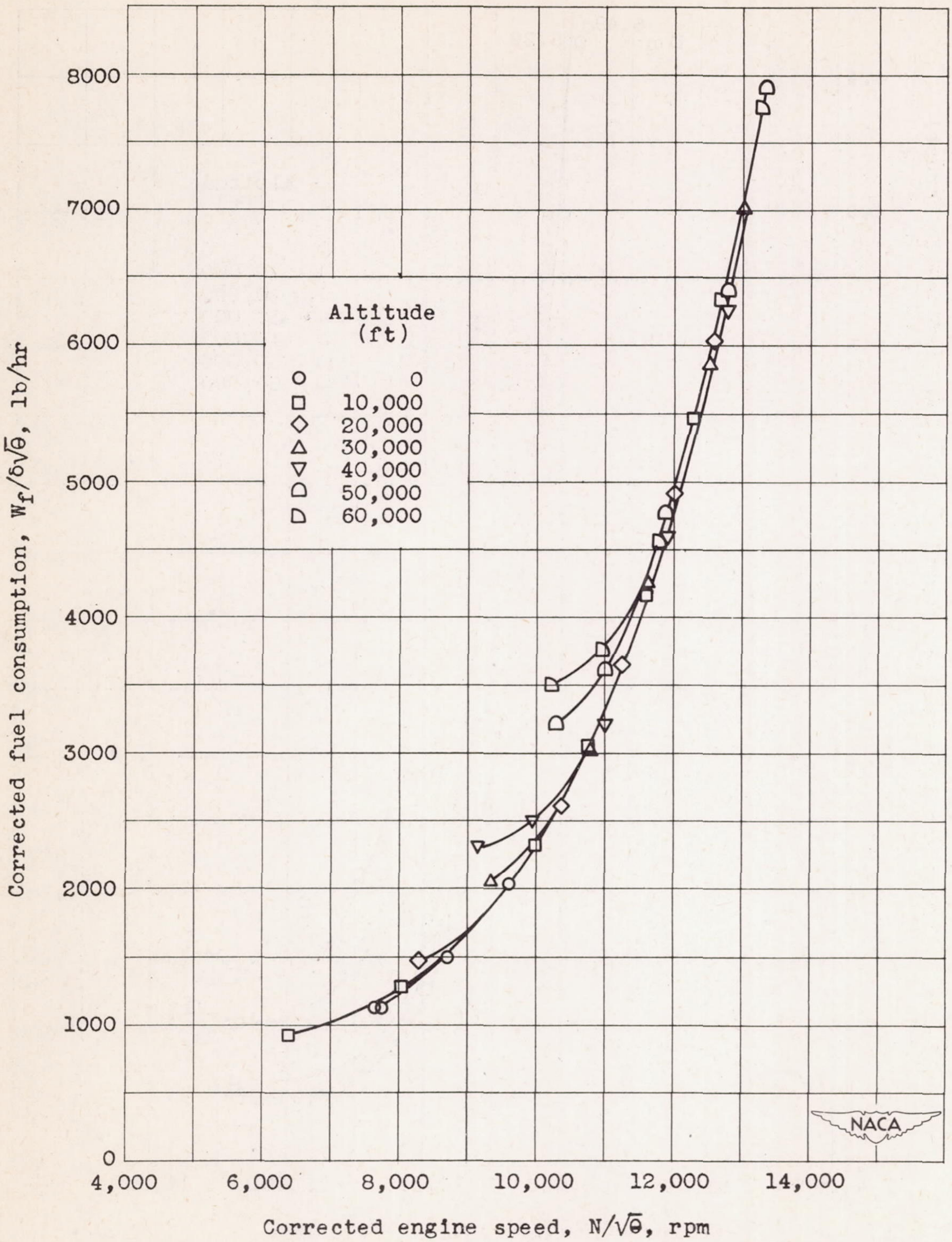


Figure 19. - Effect of altitude on corrected fuel consumption. Ram-pressure ratio, 1.30.

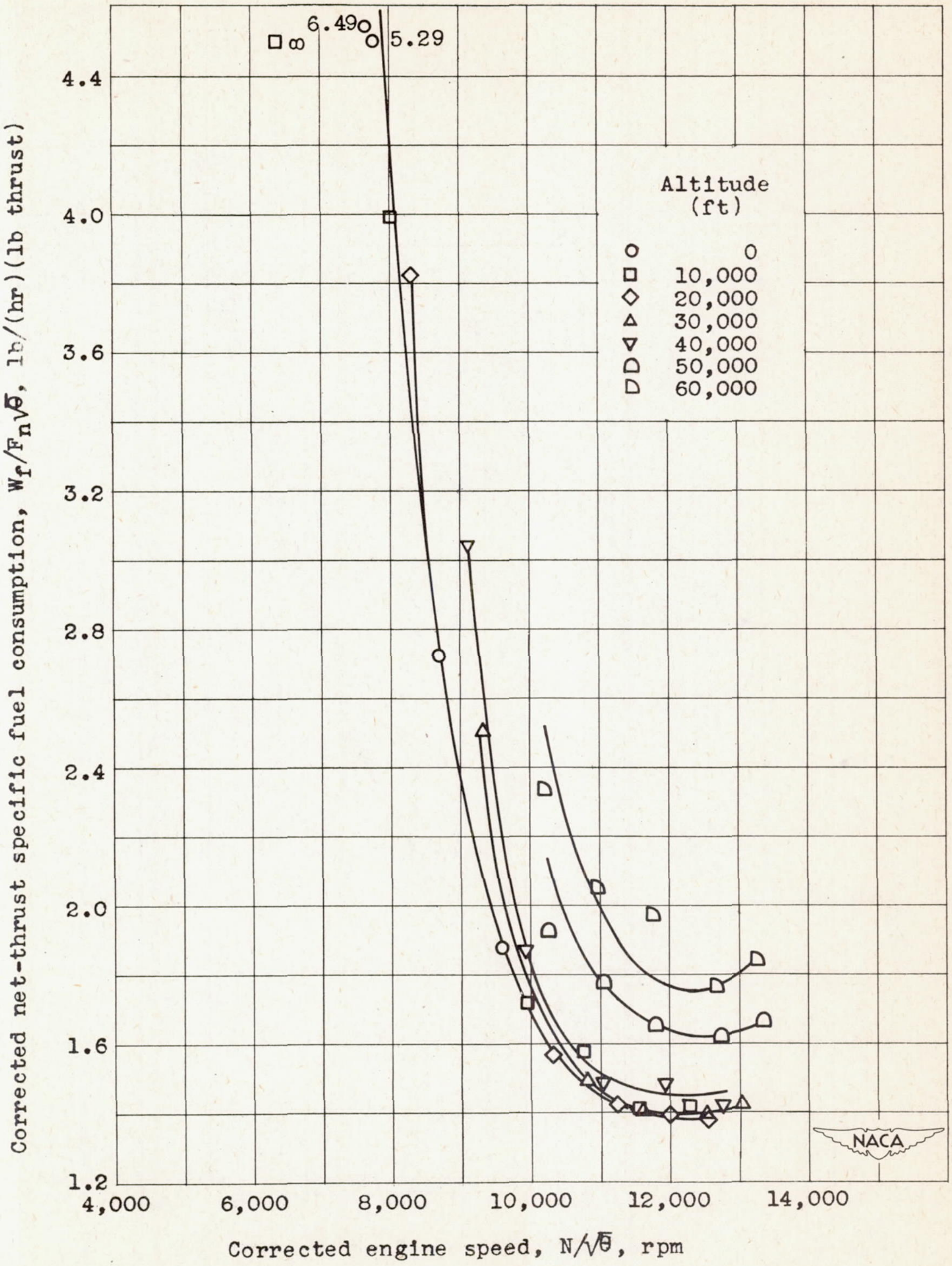
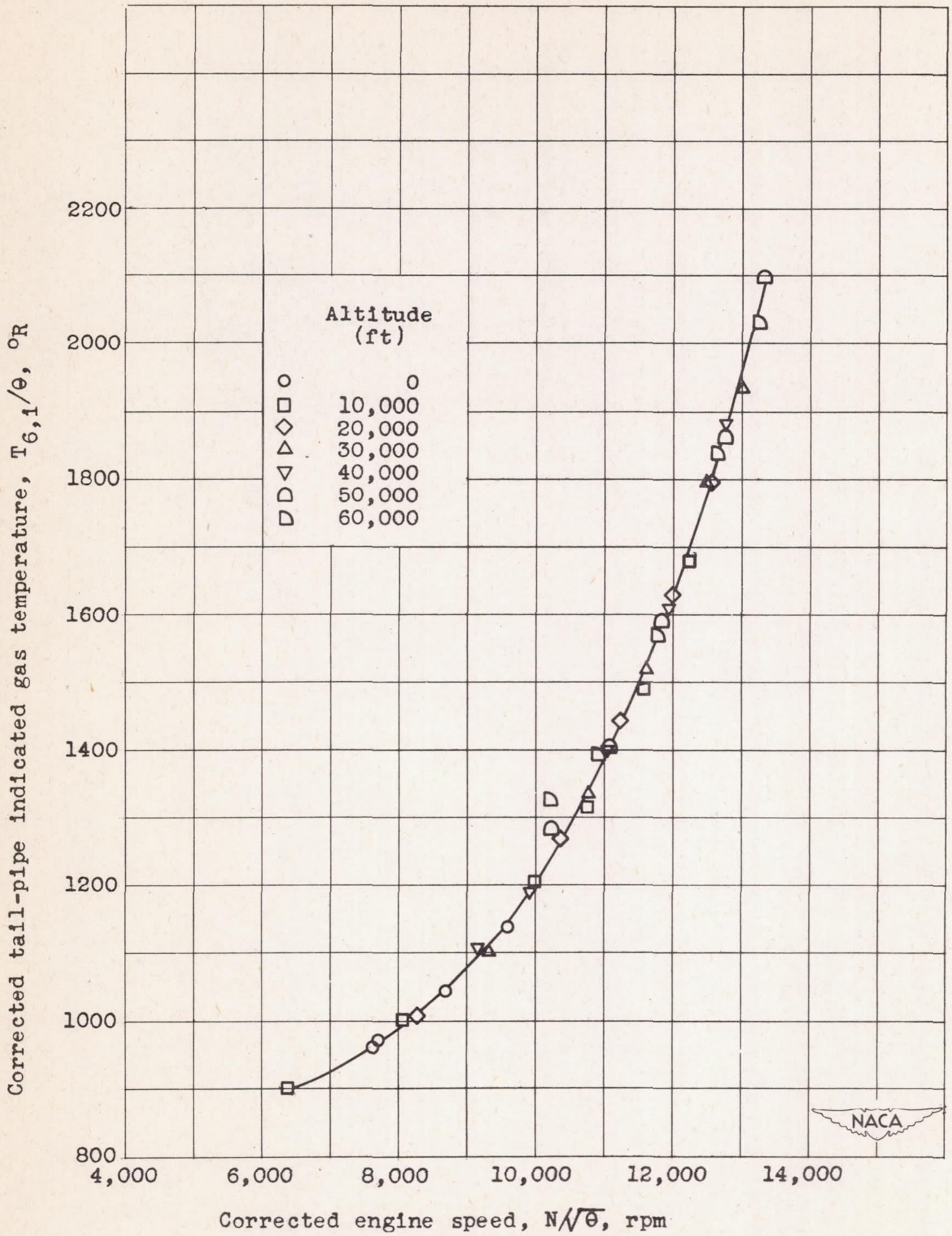
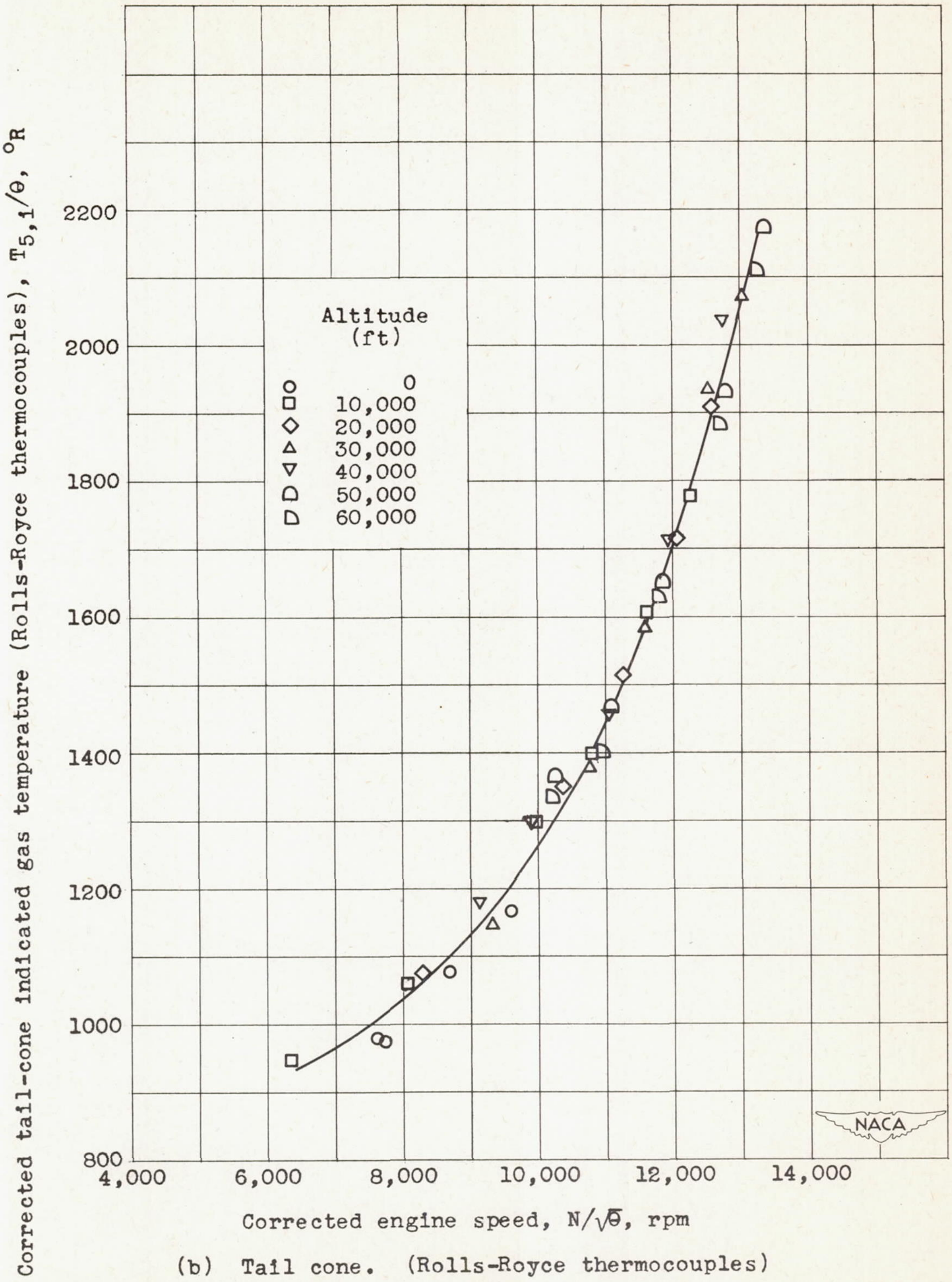


Figure 20. - Effect of altitude on corrected net-thrust specific fuel consumption. Ram-pressure ratio, 1.30.



(a) Tail pipe.

Figure 21. - Effect of altitude on corrected indicated gas temperatures. Ram-pressure ratio, 1.30.



(b) Tail cone. (Rolls-Royce thermocouples)

Figure 21. - Concluded. Effect of altitude on corrected indicated gas temperatures. Ram-pressure ratio, 1.30.

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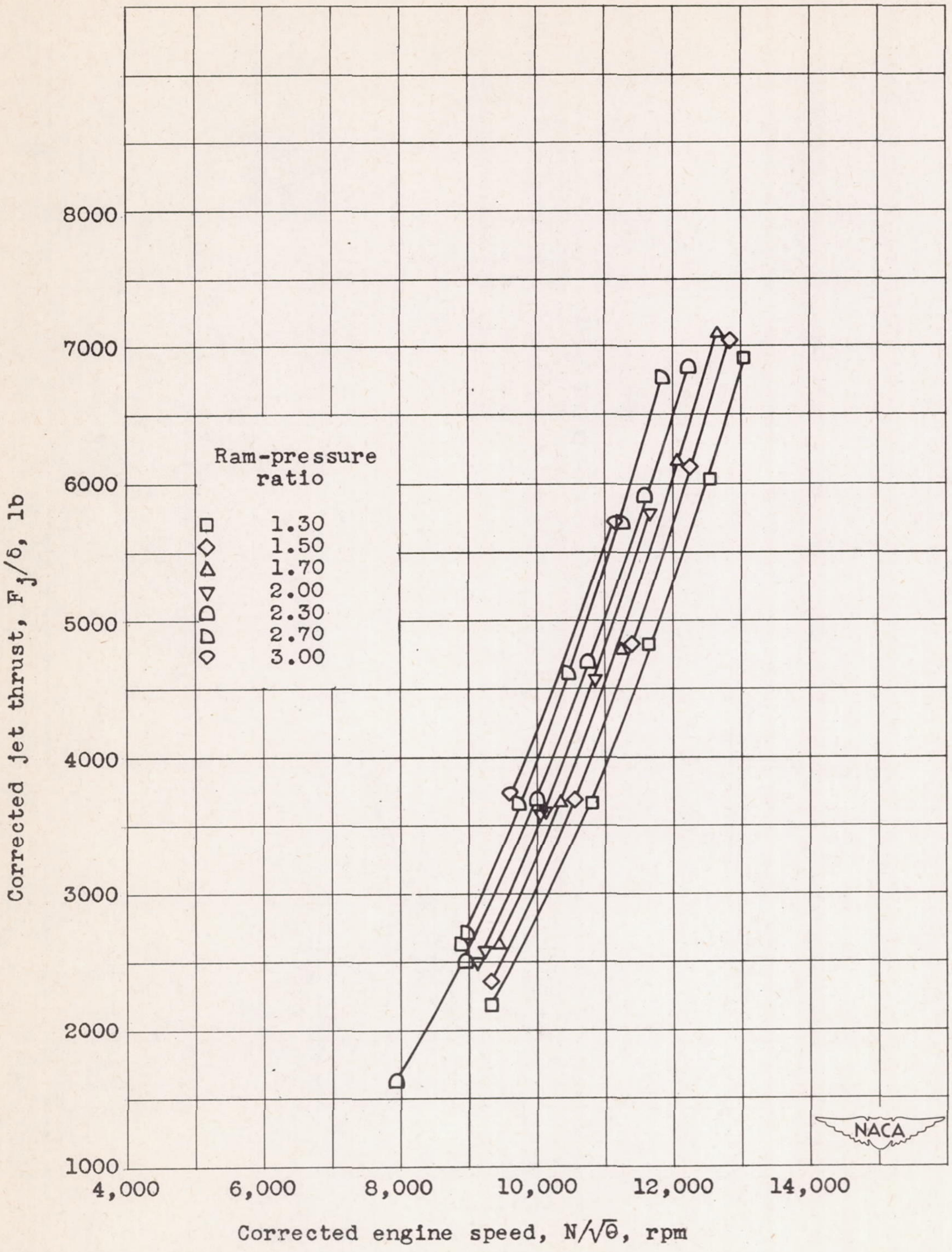
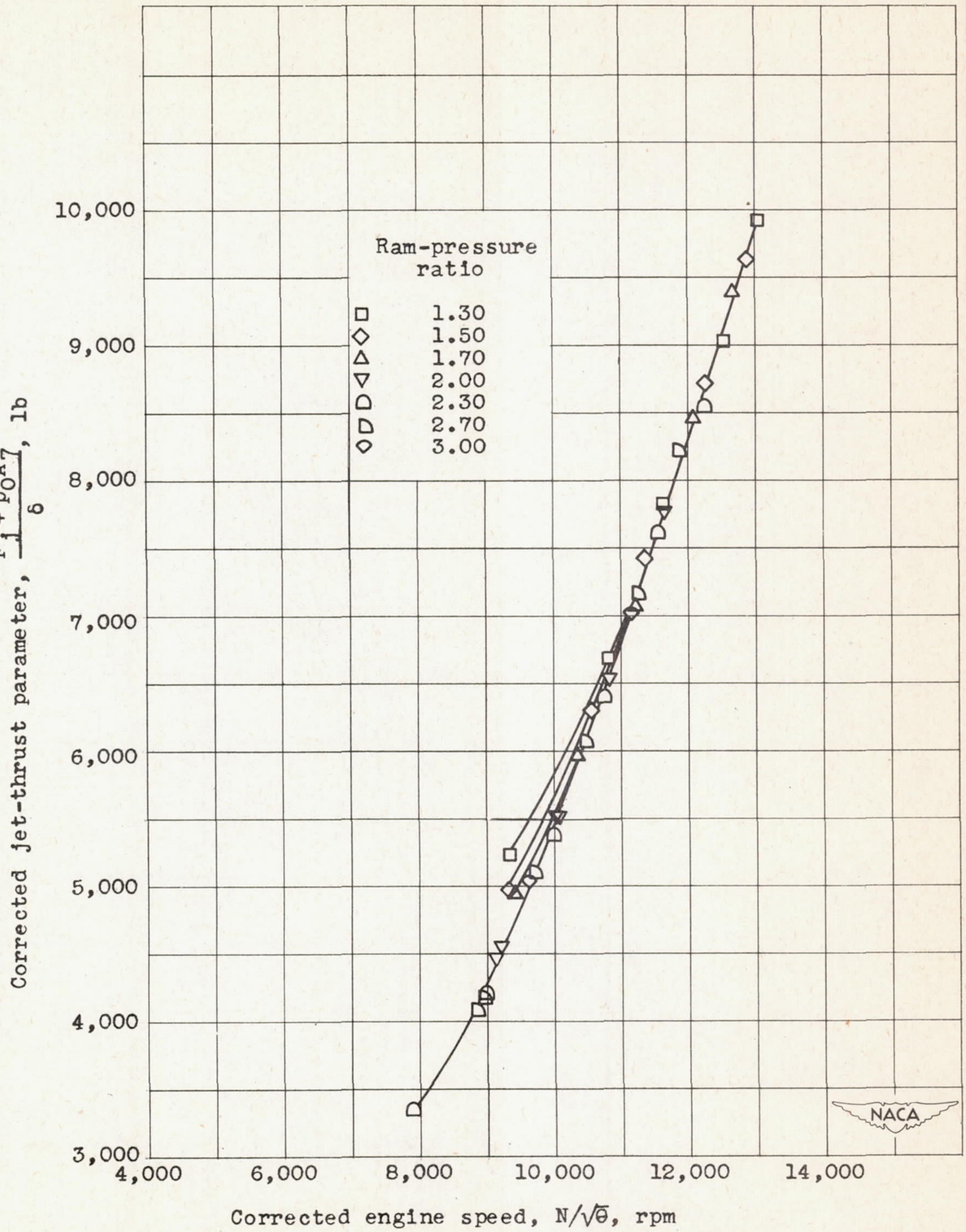


(a) Corrected jet thrust, F_j/δ.

Figure 22. - Effect of ram-pressure ratio on corrected jet thrust. Altitude, 30,000 feet.



(b) Corrected jet-thrust parameter, $\frac{F_j + p_0A_7}{\delta}$

Figure 22. - Concluded. Effect of ram-pressure ratio on corrected jet thrust. Altitude, 30,000 feet.

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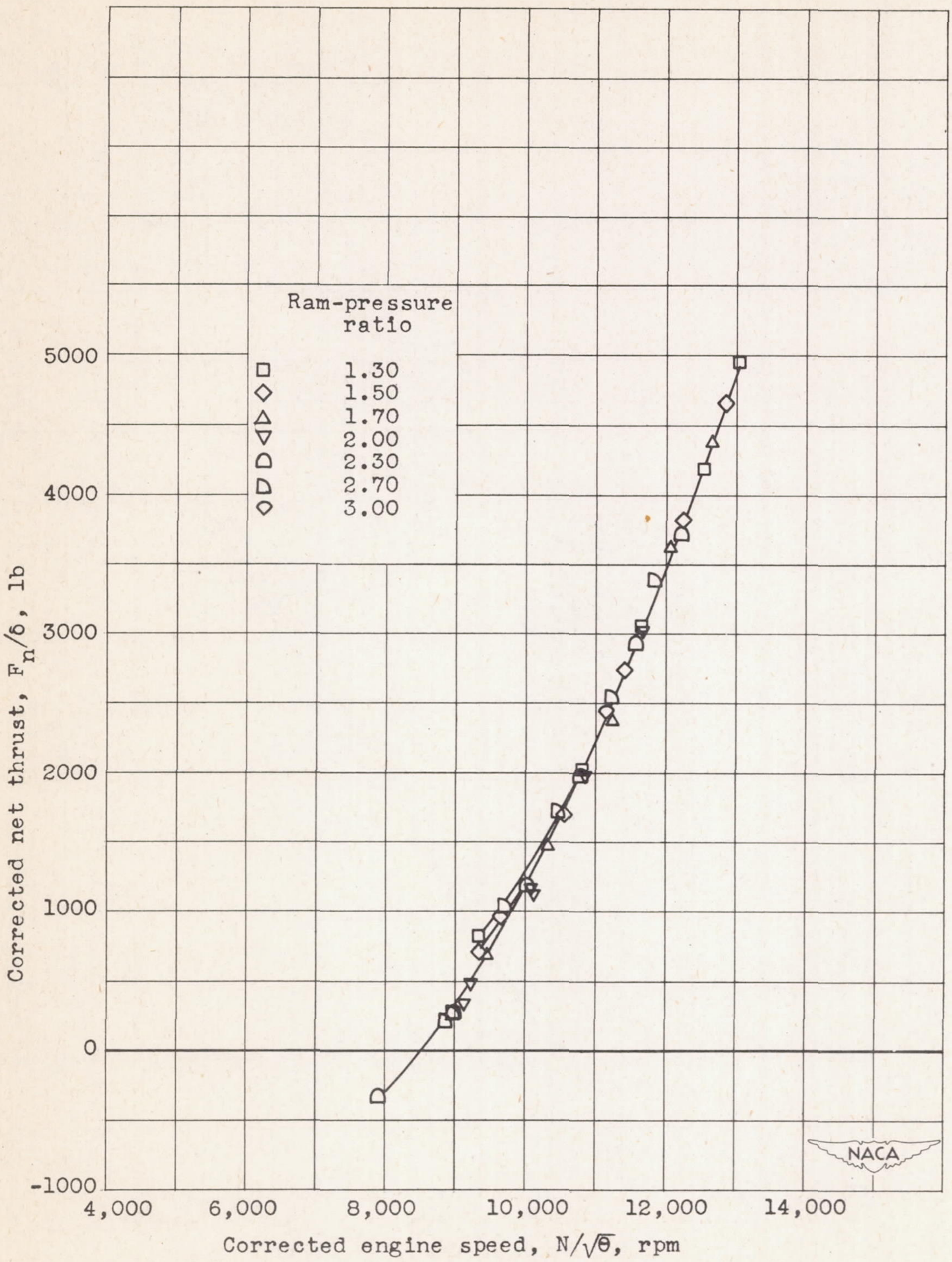

Figure 23. - Effect of ram-pressure ratio on corrected net thrust. Altitude, 30,000 feet.

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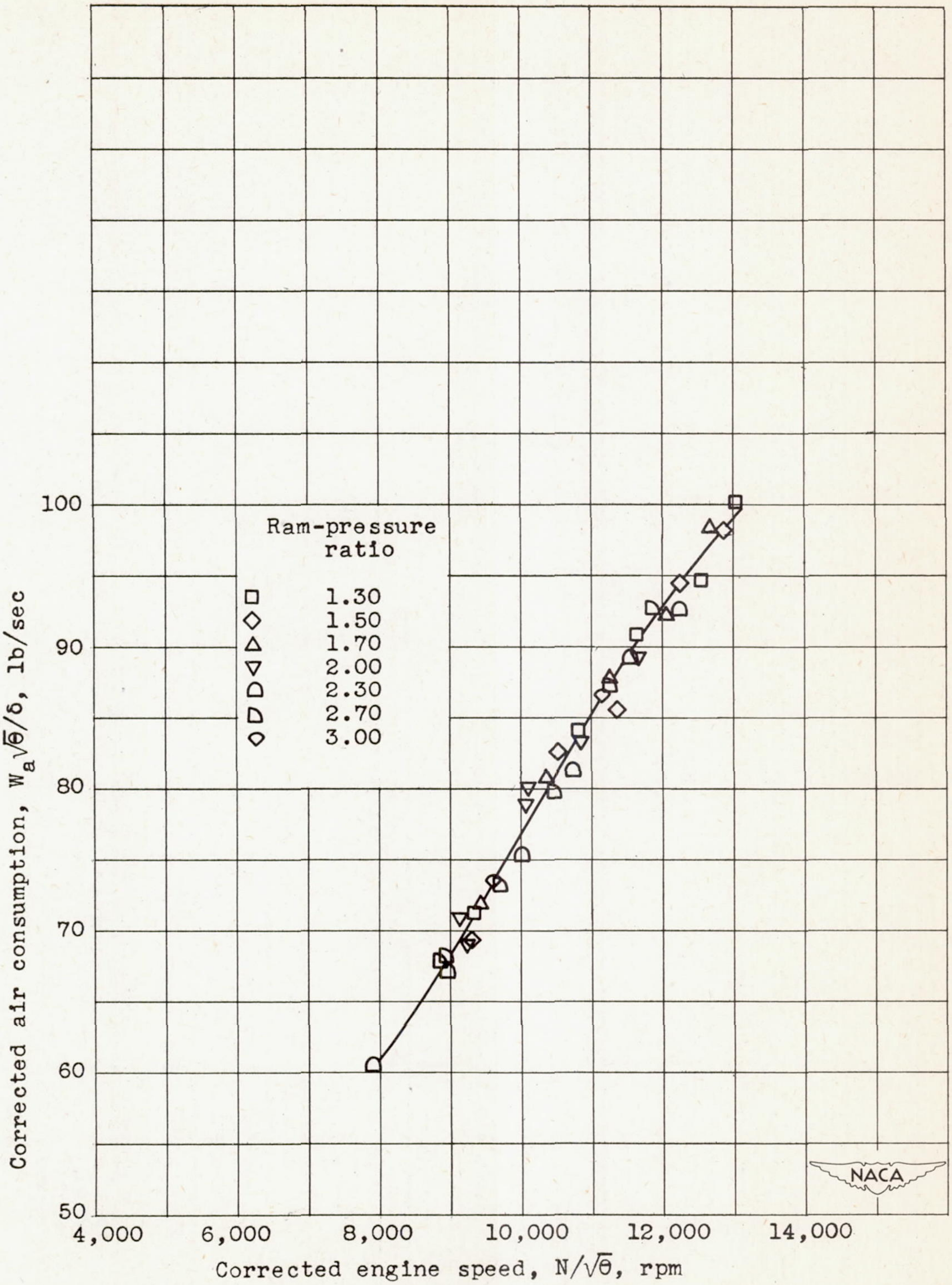

Figure 24. - Effect of ram-pressure ratio on corrected air consumption. Altitude, 30,000 feet.

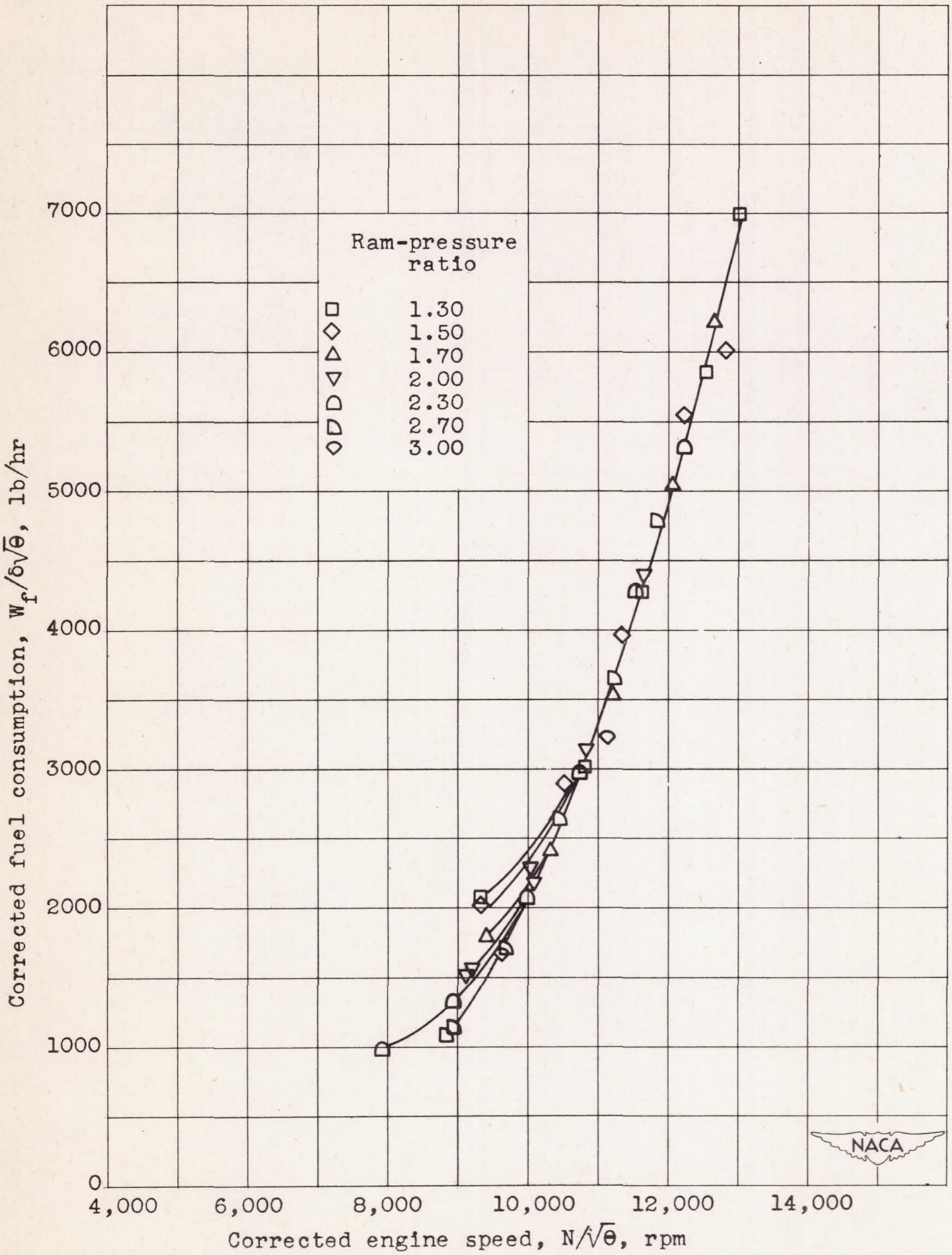

Figure 25. - Effect of ram-pressure ratio on corrected fuel consumption. Altitude, 30,000 feet.

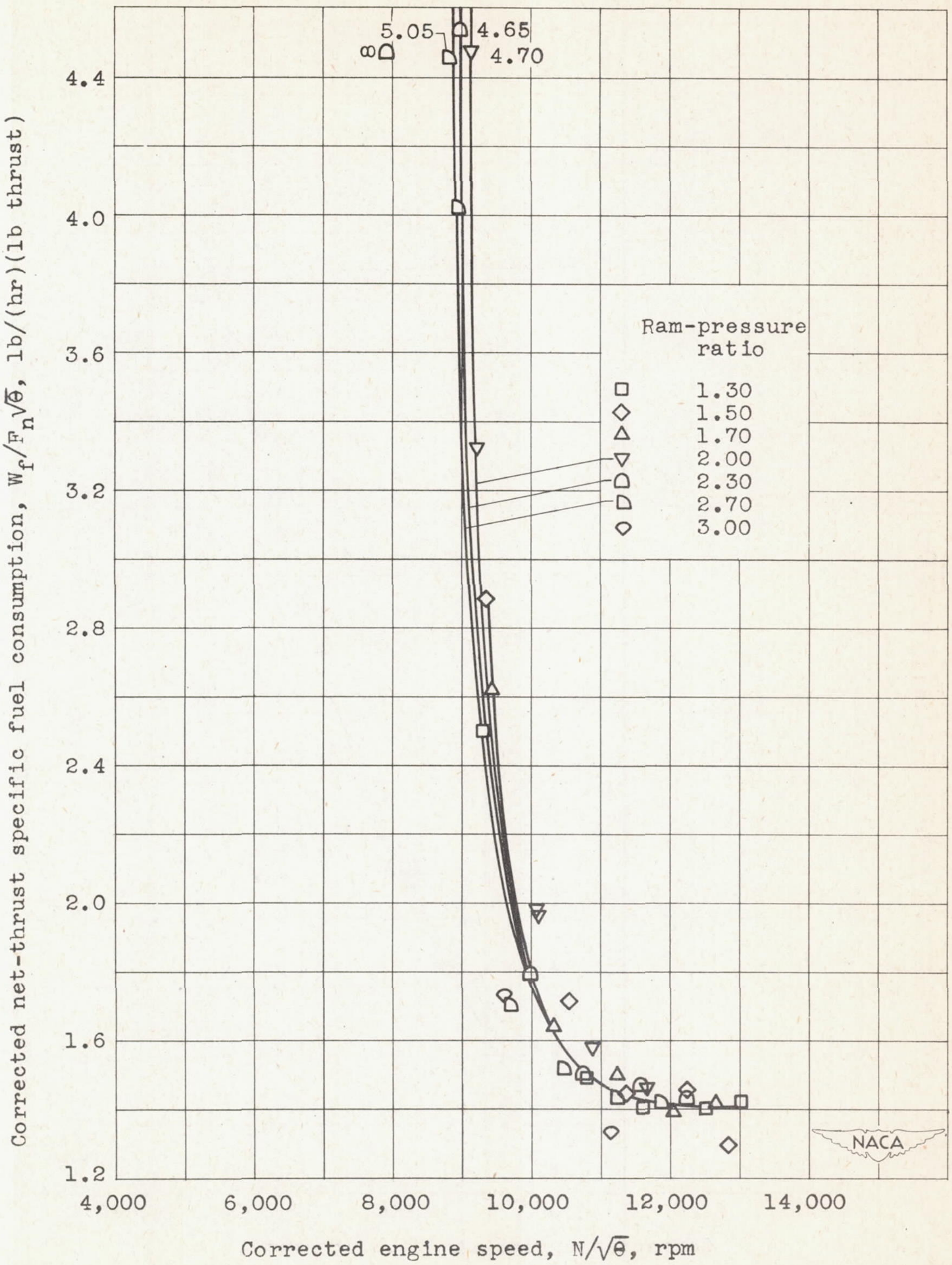

Figure 26. - Effect of ram-pressure ratio on corrected net-thrust specific fuel consumption. Altitude, 30,000 feet.

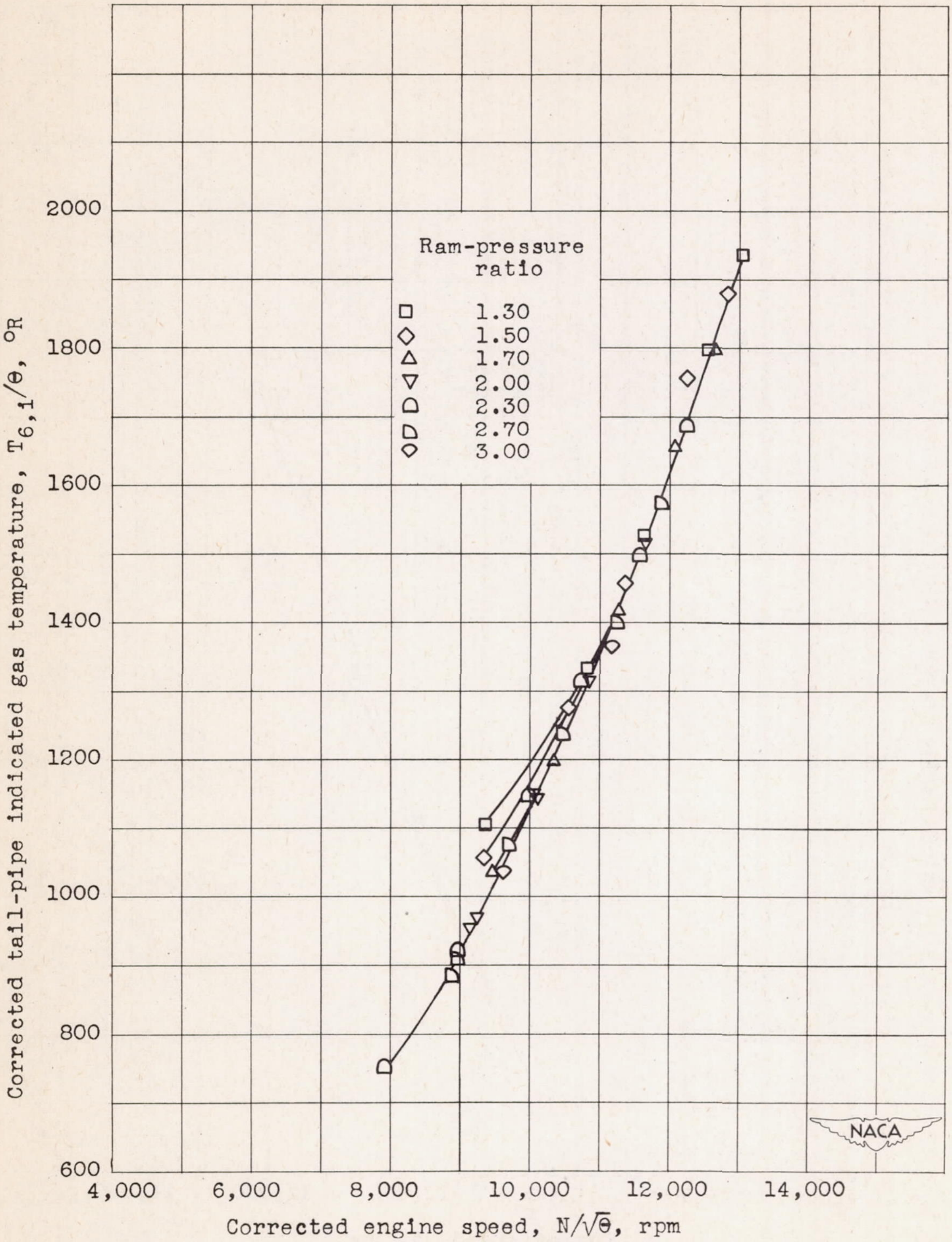

Figure 27. - Effect of ram-pressure ratio on corrected tail-pipe indicated gas temperature. Altitude, 30,000 feet.

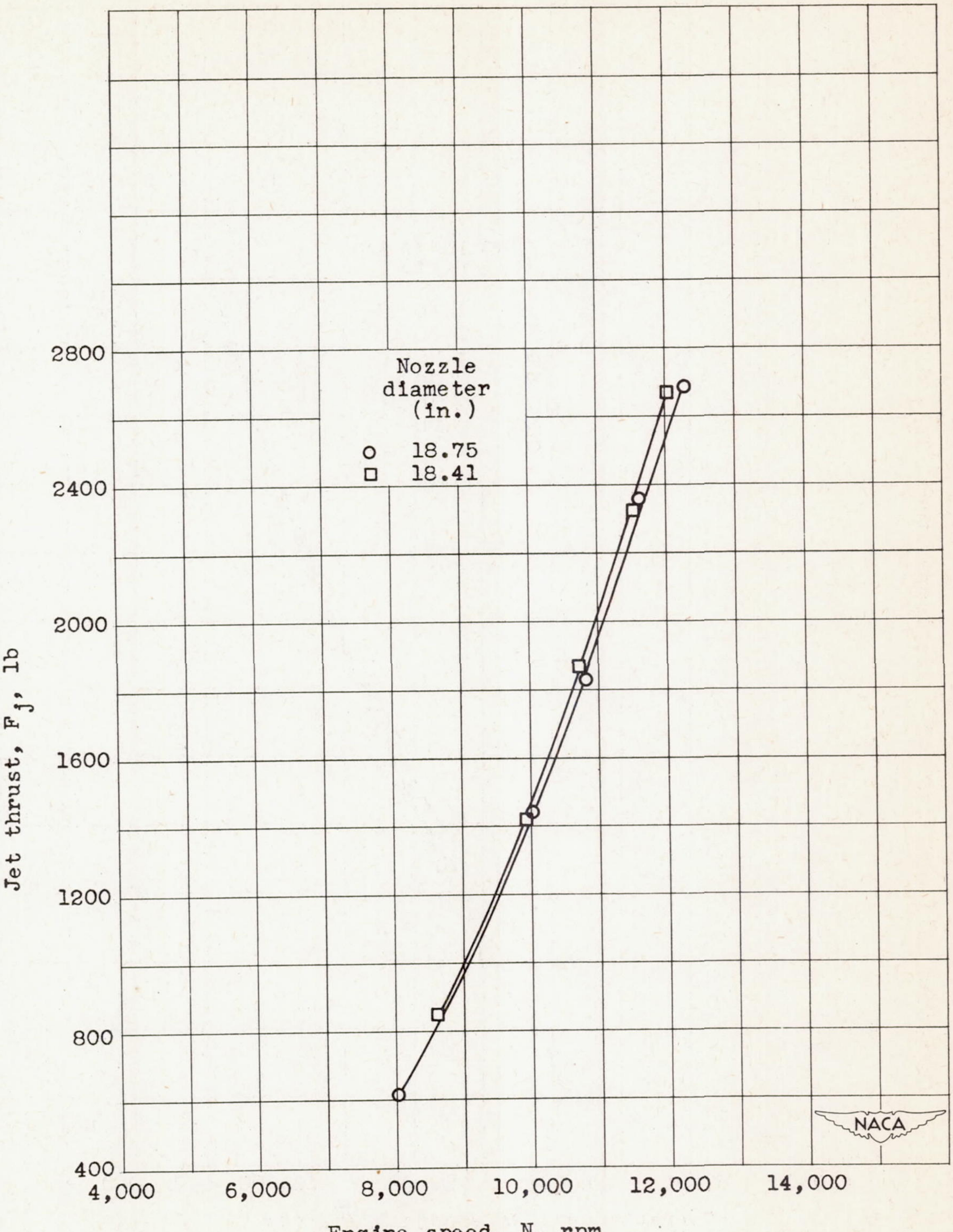

Figure 28. - Effect of jet-nozzle size on jet thrust. Altitude, 30,000 feet; ram-pressure ratio, 1.30.

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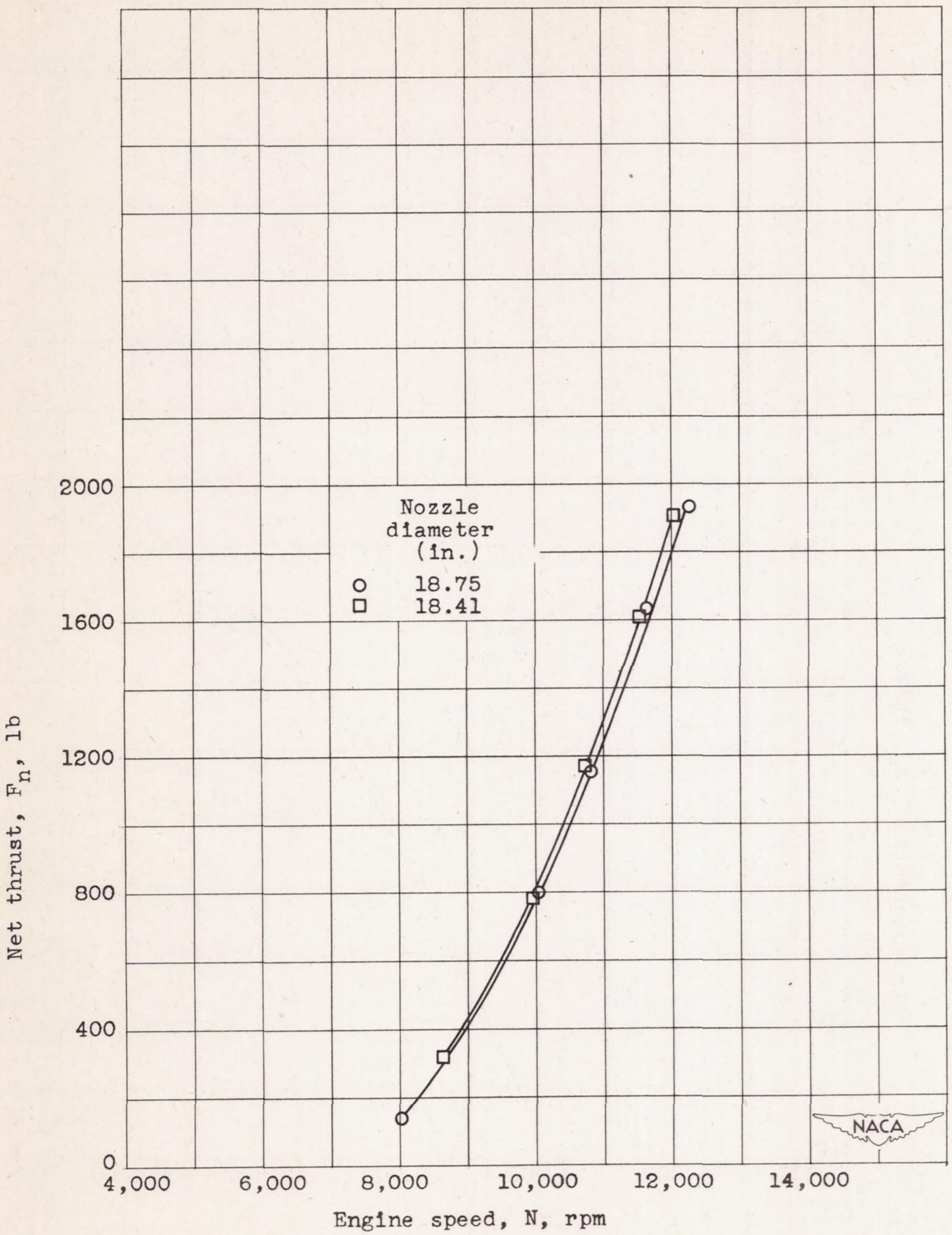

Figure 29. - Effect of jet-nozzle size on net thrust. Altitude, 30,000 feet; ram-pressure ratio, 1.30.

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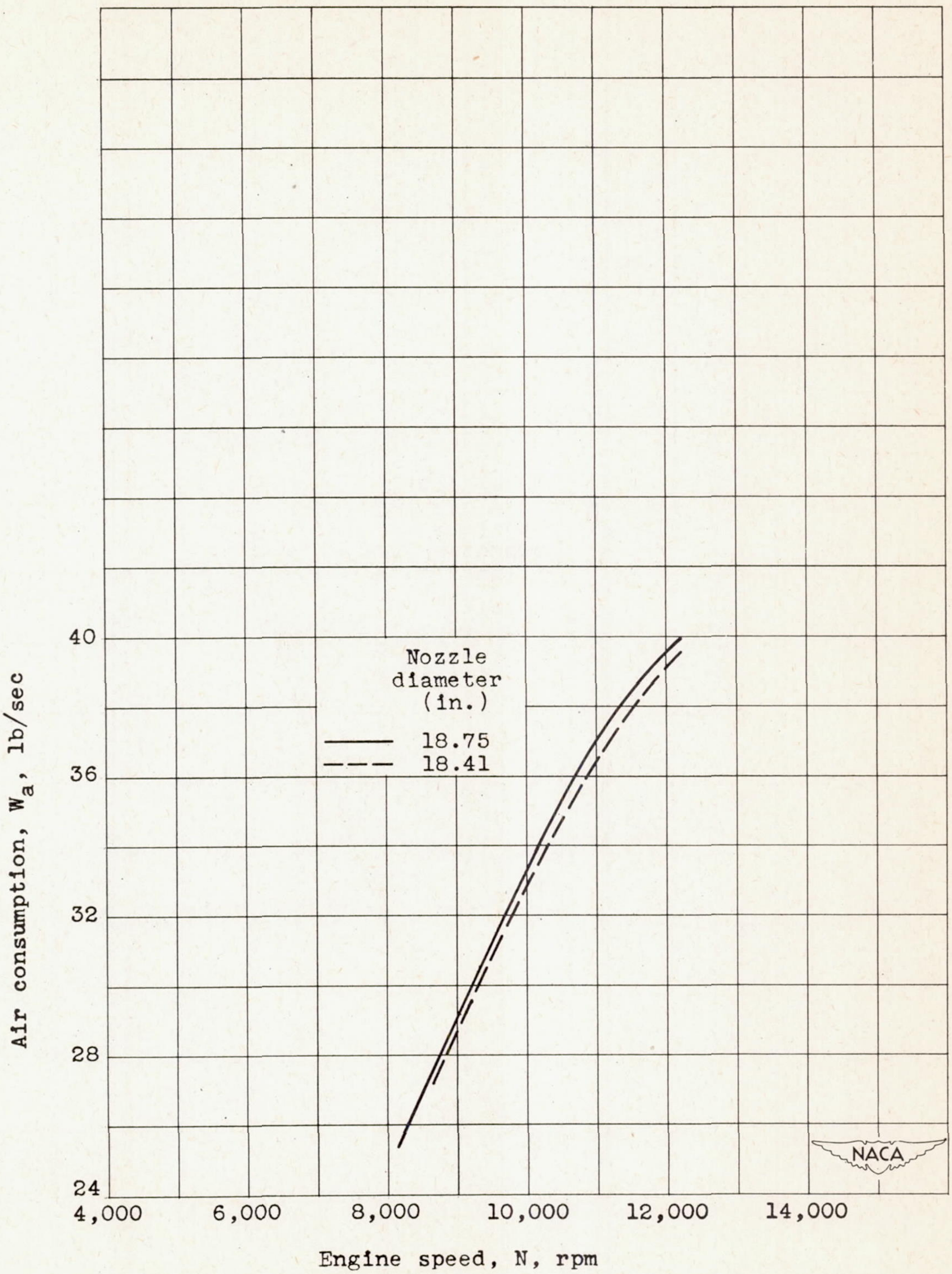

Figure 30. - Effect of jet-nozzle size on air consumption. Altitude, 30,000 feet; ram-pressure ratio, 1.30.

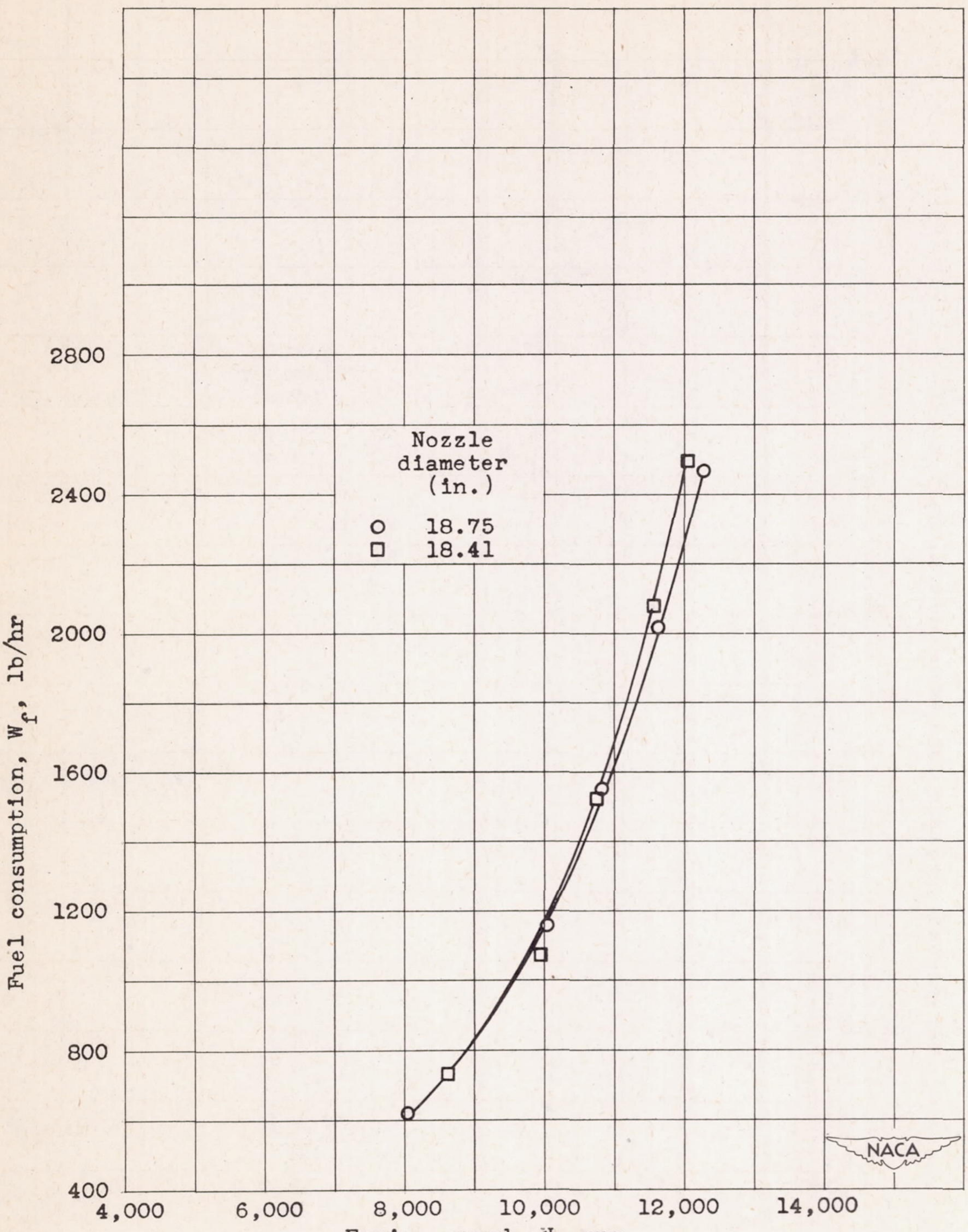

Figure 31. - Effect of jet-nozzle size on fuel consumption. Altitude, 30,000 feet; ram-pressure ratio, 1.30.

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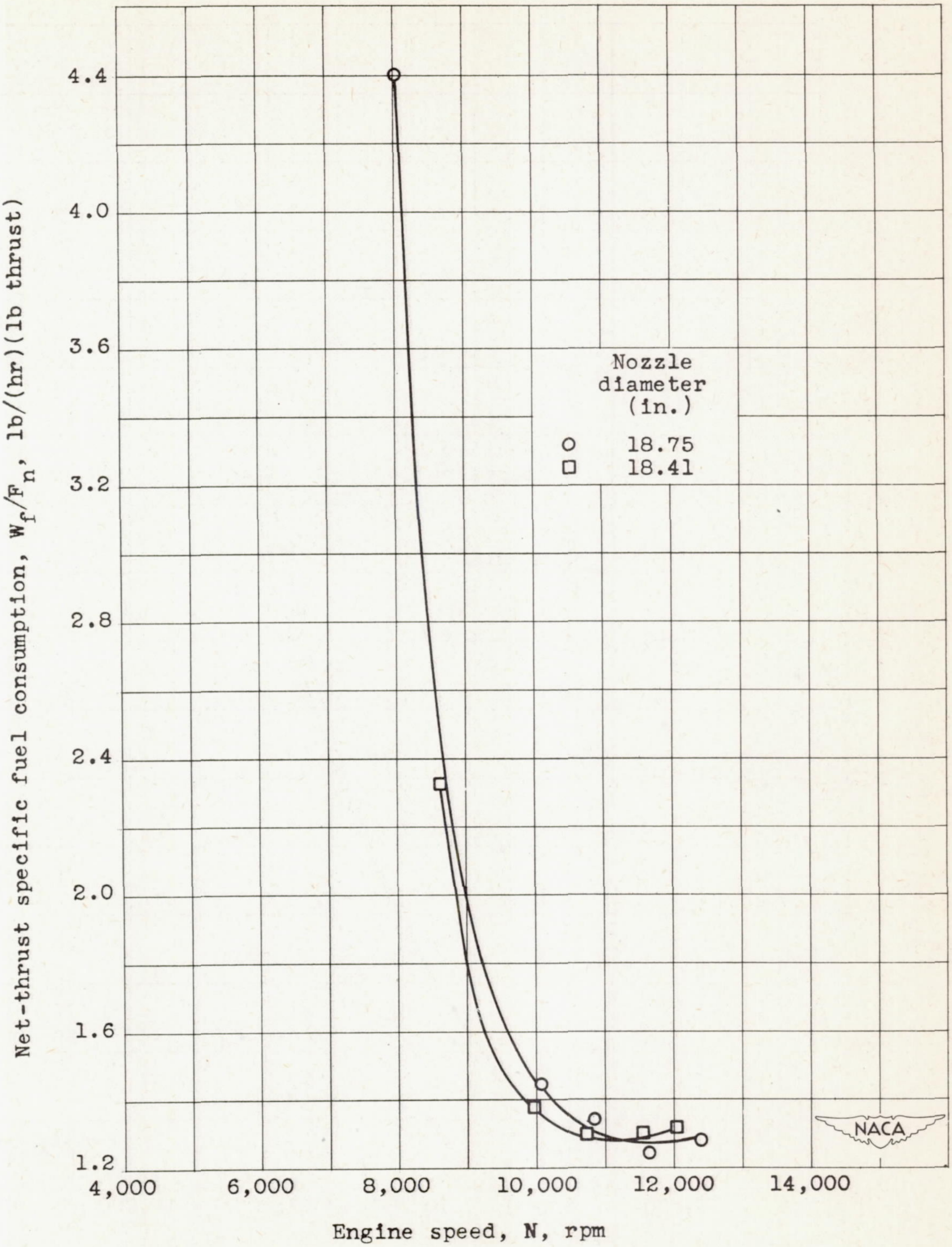

Figure 32. - Effect of jet-nozzle size on net-thrust specific fuel consumption. Altitude, 30,000 feet; ram-pressure ratio, 1.30.

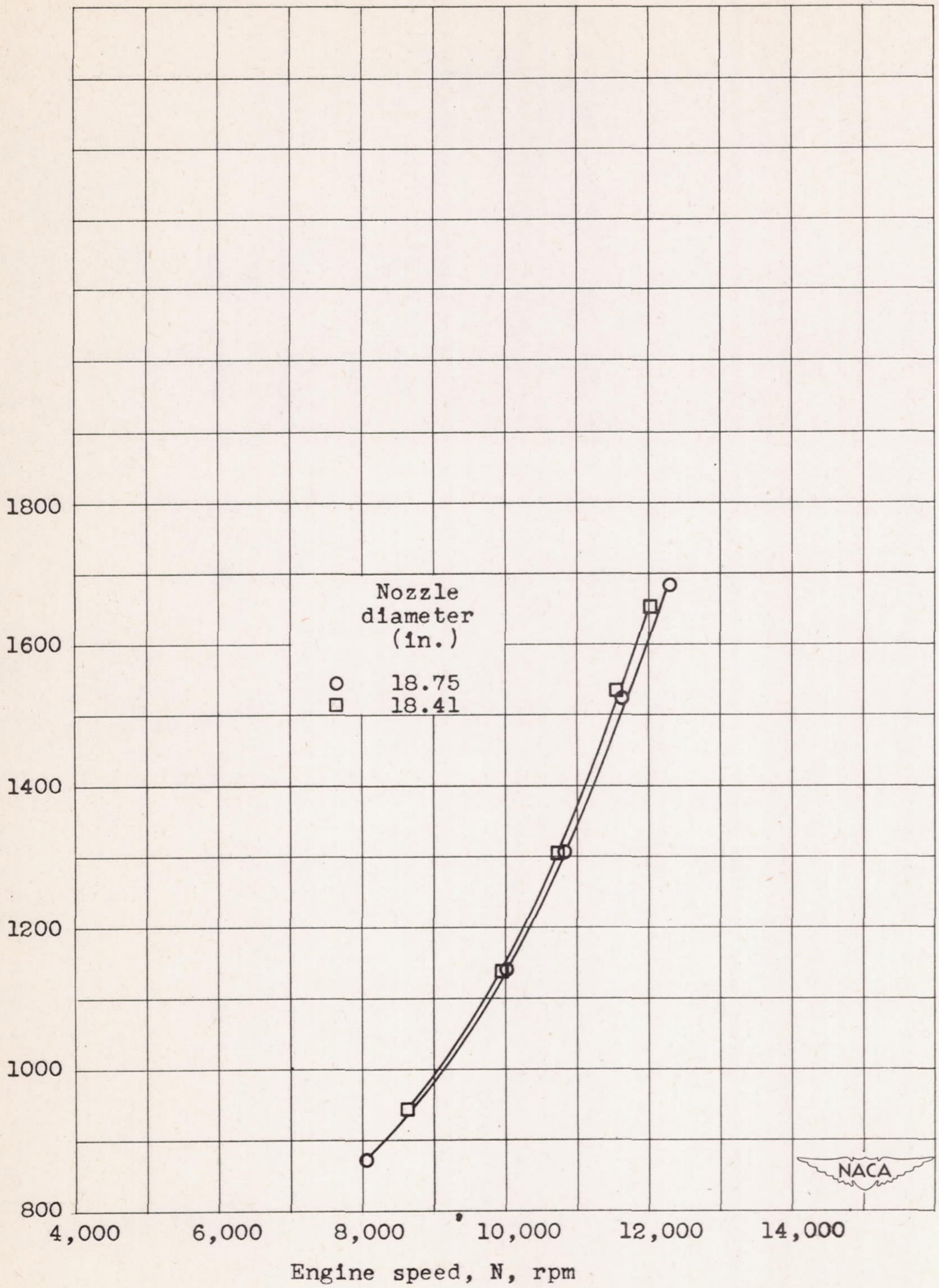

Figure 33. - Effect of jet-nozzle size on tail-pipe indicated gas temperature. Altitude, 30,000 feet; ram-pressure ratio, 1.30.