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RESEARCH MEMORANDUM

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

I - STANDARD 18.75-INCH-DIAMETER JET NOZZLE

By Zelmar Barson and H. D. Wilsted

Lewis Flight Propulsion Laboratory
Cleveland, Ohio

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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SUMMARY

An altitude-chamber investigation was conducted at the NACA Lewis laboratory to determine the altitude performance characteristics of the British Rolls-Royce Nene II turbojet engine with a standard 18.75-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.

Because compressor pressure ratio and efficiency at high engine speeds decreased with increasing altitude at altitudes above 20,000 feet, engine-performance parameters could not be predicted for these altitudes from data taken at one particular altitude. 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. Engine performance at altitude was affected by compressor-performance variations caused by differences in atmospheric temperature and pressure with altitude. The data indicated that the net-thrust specific fuel consumption decreased with increasing altitude up to the tropopause (35,332 ft, based on NACA standard atmosphere), and thereafter increased with increasing altitude.

[redacted]

INTRODUCTION

Because of the design differences of the British Rolls-Royce Nene II engine as compared with similar American turbojet engines and because of the high sea-level rating, an altitude performance investigation of a Nene II engine was conducted in an altitude chamber at the NACA Lewis laboratory during 1948.

The effect of altitude and flight speed on the over-all engine performance, using the standard 18.75-inch-diameter jet nozzle, is presented herein. Results are presented for simulated conditions varying from sea level to an altitude of 60,000 feet and for ram-pressure ratios 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 1) was used to determine whether performance could be generalized; that is, whether data at one altitude and ram-pressure ratio could be used to predict performance at other conditions of altitude and ram-pressure ratio.

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 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 2), based on Rolls-Royce static test-bed data, is:

Rating	Jet thrust (lb)	Rotor 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.

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 frictionless 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 this 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, as shown in figure 4. The instrument ring also included 24 total-pressure probes, 14 static-pressure probes, and 4 wall static-pressure taps. This instrumentation was located approximately 18 inches downstream of the tail cone. In addition, the 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 a timer was synchronized by use of 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. 5 to 10, respectively). Jet thrust, net thrust, air consumption, and fuel consumption (figs. 5 to 8, respectively) decreased rapidly with increasing altitude, as would be expected with decreasing inlet-air density. Fuel-consumption data at an altitude of 60,000 feet were unavailable due to an instrument failure (fig. 8).

The net-thrust specific fuel consumption (fig. 9) decreased with increasing altitude until 30,000 feet was reached. This trend then reversed to give an increase as altitude continued to increase. The decreasing specific fuel consumption up to an altitude of 30,000 feet can be explained by figure 11, which is a cross plot (from plots of compressor pressure ratio from table I and engine speed from table II) of compressor pressure ratio against altitude. At any constant engine speed, the compressor pressure ratio is seen to increase with increasing altitude until the tropopause (35,332 ft, based on NACA standard atmosphere) is reached. This increase results from the increased compressor-tip Mach number with increasing altitude as the air temperature at the inlet to the engine decreases. The increasing compressor pressure ratio improves the engine cycle efficiency and at the same time tends to delay the drop in combustion efficiency that would otherwise result from decreasing pressure and temperature entering the combustion chambers as altitude is increased.

At altitudes above the tropopause, inlet-air temperature is constant and there is no compressor Mach number effect. At higher engine speeds, however, compressor pressure ratio decreased appreciably with increasing altitude. The compressor efficiency was found to follow exactly the same trends as the compressor pressure ratio for any constant tip Mach number. This decrease in compressor pressure ratio and efficiency combined with decreasing altitude pressure at altitudes above the tropopause resulted in decreased combustion and cycle efficiencies, thereby producing the reversal in specific-fuel-consumption trends with increasing altitude shown in figure 9. The indication that minimum specific fuel consumption occurred at the tropopause was independent of ram-pressure ratio.

The tail-pipe indicated gas temperature (fig. 10) at the lower engine speeds decreased rapidly with increasing altitude until the tropopause was reached. This decrease results, in part, from the decreased inlet-air temperature; in addition, it has been shown that compressor pressure ratio increases with increasing altitude up to the tropopause. This greater pressure ratio is then available for expansion across the turbine and the jet nozzle.

Because at the higher energy level at which the turbine operates an increase in pressure ratio makes available a greater enthalpy drop than that required by the increased compressor work, there will be an excess expansion pressure ratio across the turbine. The only way to match turbine and compressor work is to lower the energy level of the turbine by decreasing its inlet temperature, which results in decreased tail-pipe temperature as well. This condition exists until critical flow is established in the jet nozzle. At higher engine speeds in the critical-flow range, the entire increase in compressor pressure ratio is no longer available for expansion within the engine as there is a free-air expansion beyond the throat of the jet nozzle. The expansion ratio from the inlet to the throat of the jet nozzle is also fixed. In order to match the turbine to the compressor, it is then necessary to increase the energy level of the turbine thus increasing turbine-inlet and turbine-discharge temperatures.

Computed values of turbine efficiency (not included herein) were essentially unaffected by variations in altitude or ram-pressure ratio in the range of this investigation. Turbine efficiency therefore did not appear to contribute materially to performance variations resulting from changes in altitude and ram-pressure ratio.

Effect of ram-pressure ratio. - Performance data obtained at a simulated altitude of 30,000 feet at ram-pressure ratios from 1.00 to 2.70 are presented to show the effect of ram-pressure ratio on jet thrust, net thrust, air consumption (cooling air excluded), fuel consumption, net-thrust specific fuel consumption, and tail-pipe indicated gas temperature (figs. 12 to 17, respectively).

As would be expected with increasing air density at the engine inlet, an increase in ram-pressure ratio increased the jet thrust, air consumption, and fuel consumption (figs. 12, 14, and 15, respectively) throughout the range of engine speeds investigated, except that these trends apparently reversed for fuel consumption at low engine speeds (fig. 15). This reversal is in part due to a tendency for the engine to windmill; however, it can also be shown that combustion efficiency increases with increasing ram-pressure ratio and both these effects are more pronounced at low engine speeds. The break in the trend between ram-pressure ratios of 1.50 and 1.70 at the higher engine speeds was attributed to disparities in the data.

The net thrust (fig. 13) increased with increasing ram-pressure ratio for high engine speeds, but decreased with increasing ram-pressure ratio for low engine speeds. This decrease in net thrust results, of course, from an increase in inlet-air momentum $\frac{W_a V_p}{g}$ more rapid than the increase in jet thrust or discharge momentum. (See fig. 13 for values of flight velocity V_p corresponding to the various ram-pressure ratios investigated.) At the higher engine speeds, the more rapid increase in jet thrust overcomes the increasing inlet-air momentum, and the net thrust therefore increased with increasing ram-pressure ratio. This engine characteristic is desirable for high-speed flight, as the increasing thrust would partly offset the increasing airplane drag.

The net-thrust specific fuel consumption (fig. 16) increased with increasing ram-pressure ratio, directly reflecting the trends of the net-thrust and fuel-consumption curves. The break in fuel-consumption trends between ram-pressure ratios of 1.50 and 1.70, previously mentioned, is also shown. This increase in net-thrust specific fuel consumption with increasing ram-pressure ratio indicates a higher cost in fuel consumption for high-speed flight than would be expected from just the increased thrust requirements to overcome increasing airplane drag.

The tail-pipe indicated gas temperature (fig. 17), in general, decreased with increasing ram-pressure ratio. At low engine speeds, this decrease is due, in part, to the tendency of the engine to windmill. At all engine speeds, a temperature reduction caused by the increasing available energy as the turbine-inlet pressure is raised occurs. This characteristic was discussed in the section "Effect of Altitude."

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 1) to 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 altitude; any changes in component performance therefore lessen the possibility of generalizing to a single curve the data obtained at different altitudes.

Effect of altitude. - Typical corrected engine 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 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. 18 to 23, respectively).

As can be seen, the corrected values of jet thrust and net thrust (figs. 18 and 19) did not generalize, but decreased with increasing altitude. At the higher engine speeds, this decrease was attributed to the fact that the compressor pressure ratio and efficiency decreased as altitude increased as shown in figure 24. Because of the decrease in compressor pressure ratio and efficiency, a comparable decrease in air consumption would be expected, which also contributes to the decrease in thrust. The decrease in thrust with increasing altitude at lower engine speeds is, however, due to other causes. Examination of corrected tail-pipe pressure showed trends identical to the corrected jet-thrust trends, whereas the corrected turbine-inlet pressure did not decrease with increasing altitude at low engine speeds. Inasmuch as computed turbine efficiency showed little change with altitude, the decrease in thrust may be the result of proportionately larger pressure losses in the tail cone at high altitudes, where the tail-cone Reynolds number is lower.

From this altitude effect on compressor pressure ratio, it would be expected that the corrected air consumption would decrease with increasing altitude at the higher engine speeds. Although there was considerable scatter in the air-consumption data at high engine speeds, the mass of data (from table II) did show such a trend. Figure 20 shows that data at altitudes up to 20,000 feet fell on a single curve; whereas data at higher altitudes, in general, fell progressively lower at high engine speeds.

Corrected fuel consumption (fig. 21) generalized at a given ram-pressure ratio for altitudes up to 20,000 feet, but for higher altitudes increased with altitude throughout the range of engine speeds investigated. At low engine speeds, the increase is rapid and is due to the large drop in combustion efficiency with increasing altitude. At high engine speeds, the drop in combustion efficiency is much less, but it combines with the decrease in compressor pressure ratio and efficiency (fig. 24) to cause an increase in corrected fuel consumption.

The corrected net-thrust specific-fuel-consumption curves (fig. 22) reflect both the increase in corrected fuel consumption at the higher altitudes and low engine speeds and the decrease in corrected net thrust at altitude. The curves generalized for altitudes up to 20,000 feet, as would be expected from the net-thrust and fuel-consumption curves; as altitude was increased above 20,000 feet, however, the corrected net-thrust specific fuel consumption increased rapidly, especially at lower engine speeds. At higher ram-pressure ratios, the corrected net-thrust specific fuel consumption generalized at somewhat higher altitudes. At and below the engine speed for which the calculated net thrust becomes zero, the net-thrust specific fuel consumption is, of course, theoretically infinite. The corrected tail-pipe and tail-cone indicated gas temperatures appeared to generalize to a single curve for all altitudes at a given ram-pressure ratio (fig. 23). Tail-cone temperature, however, was consistently higher than tail-pipe temperature, as can be seen by a comparison of figures 23(a) and 23(b). This difference was attributed to the location and the number of thermocouples used in obtaining the two averages.

The decrease in compressor pressure ratio with increasing altitude shown in figure 24 is believed to be a Reynolds number effect. Performance investigations of centrifugal compressors and other full-scale engines at the Lewis laboratory have shown similar trends. It is not yet known to what extent, if any, these effects may be reduced by refinements in manufacture and design.

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 submerged. 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 submerged 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 throughout 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 1.00 to 2.70 are compared to show the effect of ram-pressure ratio on the corrected values of jet thrust, net thrust, air consumption, fuel consumption, net-thrust specific fuel consumption, and tail-pipe indicated gas temperature (figs. 25 to 30, respectively).

The corrected jet thrust (fig. 25(a)) did not generalize but increased almost linearly as ram-pressure ratio was increased. As previously discussed, however, it would be expected that pressures and temperatures throughout the engine would generalize when critical flow exists in the jet nozzle. At this condition, the static pressure in the jet-nozzle throat is equal to or greater than ambient static pressure, and the jet thrust is

$$F_j = \frac{W_g V_7}{g} + A_7(p_7 - p_0)$$

(All symbols are defined in the appendix.) If two different ram-pressure ratios, X and Y, are applied to the engine, both at the same corrected engine speed $N/\sqrt{\theta}$ and both causing critical flow in the jet nozzle, then

$$\left(\frac{W_g V_7}{g\delta}\right)_X = \left(\frac{F_j}{\delta}\right)_X - A_7\left(\frac{p_7 - p_0}{\delta}\right)_X$$

$$\left(\frac{W_g V_7}{g\delta}\right)_Y = \left(\frac{F_j}{\delta}\right)_Y - A_7\left(\frac{p_7 - p_0}{\delta}\right)_Y$$

Because it is assumed that conditions inside the engine can be generalized, these two equations are equal, and

$$\left(\frac{F_j}{\delta}\right)_X - \left(\frac{F_j}{\delta}\right)_Y = A_7\left[\left(\frac{p_7}{\delta}\right)_X - \left(\frac{p_0}{\delta}\right)_X - \left(\frac{p_7}{\delta}\right)_Y + \left(\frac{p_0}{\delta}\right)_Y\right]$$

Also

$$\left(\frac{p_7}{\delta}\right)_X = \left(\frac{p_7}{\delta}\right)_Y$$

Therefore,

$$\left(\frac{F_j + p_0 A_7}{\delta}\right)_X = \left(\frac{F_j + p_0 A_7}{\delta}\right)_Y$$

This parameter has been plotted (fig. 25(b)) and the data generalize very well for engine speeds and ram-pressure ratios at which there is critical flow in the jet nozzle. A similar plot has been used by Rolls-Royce Ltd. to generalize thrust data.

The corrected net thrust (fig. 26) also failed to generalize. This failure results both from the fact that jet thrust does not generalize without consideration of the excess pressure at the exit of the jet nozzle, and from the fact that the inlet-momentum term $\frac{W_a V_p}{g}$ is not generalized to a single value. If these two factors are taken into account, the corrected-net-thrust curve becomes similar to the corrected-jet-thrust-parameter curve of figure 25(b).

The corrected air consumption (fig. 27) appeared to increase as ram-pressure ratio was increased, but plots of data from table II at other altitudes (having somewhat less scatter) showed no trend with ram-pressure ratio. The trend of figure 27 was therefore attributed to an unusual scattering of the data, and the data as a whole indicated that corrected values of air consumption generalized to a single curve for all ram-pressure ratios investigated.

Corrected-fuel-consumption data (fig. 28) generalized very well at high engine speeds, where critical flow existed in the jet nozzle. At lower engine speeds, corrected fuel consumption decreased with increasing ram-pressure ratio. The corrected values of net-thrust specific fuel consumption should reflect the trends of corrected values of both net thrust and fuel consumption; inasmuch as the corrected net thrust did not generalize except at ram-pressure ratios above 1.30, a similar trend would be expected in the corrected net-thrust specific fuel consumption. The data shown in figure 29 did indicate such a generalization within the limitations of the ram-pressure-ratio effects on corrected fuel consumption. Fuel-consumption values were unavailable at a ram-pressure ratio of 1.00. The corrected tail-pipe indicated gas temperature (fig. 30) showed the same trends as the corrected fuel consumption; the data generalized to a single curve when critical flow was established in the jet nozzle. At low engine speeds, where critical flow did not exist in the jet nozzle, the corrected tail-pipe indicated gas temperature decreased with increasing ram-pressure ratio.

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 under simulated conditions of altitude from sea level to 60,000 feet and ram-pressure ratio from 1.00 to 3.50 (corresponding to flight Mach numbers from 0 to 1.47):

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

3. Engine performance at altitude was affected by compressor-performance variations caused by differences in atmospheric temperature and pressure. The data indicated that the net-thrust specific fuel consumption decreased with increasing altitude up to the tropopause (35,332 ft, based on NACA standard atmosphere), and thereafter increased with increasing altitude.

Lewis Flight Propulsion Laboratory,
National Advisory Committee for Aeronautics,
Cleveland, Ohio.

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 3

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 3. 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, by the following relation:

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

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.

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

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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), $T_{5,1}$ (°R)	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	29.55	29.53	1.00	534	6,056	624	36.05	1160	1240	850	1.589	22	1250	200	300	20	130	145	49
2	0	29.60	29.43	1.01	534	7,972	1287	52.48	1650	1234	800	2.098	22	1250	225	340	30	136	165	
3	0	29.55	29.43	1.00	536	9,972	2276	64.75	2490	1313	890	2.921	22	1240	300	400	34	150	185	
4	0	29.86	29.40	1.02	556	10,780	2753	68.86	2985	1406	970	3.182	20	1300	210	390	29	195	250	
5	0	29.58	29.43	1.01	536	10,776	2900	71.93	3085	1390	990	3.274	21	1250	325	410	34	160	200	
6	0	29.86	29.35	1.02	558	11,592	3571	77.15	3825	1505	1100	3.665	19	1300	460	500	30	202	280	
7	0	29.57	29.38	1.01	537	11,997	3746	79.87	3950	1507	1100	3.805	21	1250	500	560	34	175	235	
8	0	29.85	29.40	1.02	558	12,260	4517	83.99	4825	1633	1250	4.191	18	1300	710	725	32	200	270	
9	0	29.54	29.45	1.00	538	12,260	4545	87.18	4950	1648	1266	4.313	21	1250	780	780	34	185	265	
10	0	38.75	29.45	1.32	564	6,156	879	53.49	990	879	510	1.388	21	1600	180	250	23	150	150	52
11	0	38.70	29.40	1.32	561	8,008	1605	64.33	1390	1023	580	1.850	21	1600	235	350	28	170	289	
12	0	38.62	29.30	1.32	562	9,992	3025	82.18	2455	1176	750	2.654	20	1600	300	395	34	185	220	
13	0	38.60	29.40	1.31	562	10,800	3975	91.93	3325	1301	875	3.106	20	1600	390	430	36	190	230	
14	0	38.69	29.40	1.32	562	11,120	4613	95.94	3790	1349	925	3.314	19	1600	490	525	36	195	235	
15	10,000	20.61	20.58	1.00	486	5,996	501	27.54	910	1125	730	1.584	11	1000	[b]---	175	28	80	105	40
16	10,000	20.65	20.45	1.01	484	7,996	996	39.37	1270	1119	720	2.180	11	1000	200	300	32	90	115	
17	10,000	20.47	20.53	1.00	483	9,984	1854	51.10	1675	1255	880	3.148	10	1000	250	360	33	100	135	
18	10,000	20.46	20.62	.99	482	10,808	2409	56.42	2415	1333	930	3.657	10	980	270	380	33	115	160	
19	10,000	20.48	20.47	1.00	485	11,608	3060	62.63	3130	1475	1100	4.227	10	980	360	430	34	140	220	
20	10,000	20.56	20.77	.99	488	12,280	3770	67.41	3955	1623	1250	4.685	10	980	500	540	34	150	240	
21	10,000	26.69	20.63	1.29	520	6,012	612	37.73	710	865	460	1.411	10	1150	60	130	26	100	110	42
22	10,000	30.76	20.46	1.50	551	8,980	1851	60.84	1260	986	500	2.184	21	1300	200	300	32	165	185	122
23	10,000	30.86	20.46	1.51	551	10,004	2716	69.25	1900	1137	650	2.684	21	1300	300	400	33	180	210	
24	10,000	30.91	20.46	1.51	556	10,792	3530	75.63	2645	1277	850	3.121	24	1300	300	400	33	195	240	
25	10,000	30.56	20.46	1.49	560	11,608	4563	82.48	3640	1444	1026	3.658	24	1250	440	500	33	205	265	
26	10,000	34.22	19.95	1.72	565	7,984	1489	57.10	910	837	460	1.748	21	1490	160	290	27	165	178	51
27	10,000	34.15	20.63	1.66	562	8,108	1474	57.73	890	858	460	1.791	18	1300	180	205	30	157	170	
28	10,000	34.06	20.05	1.70	563	9,992	3079	72.67	1940	1124	675	2.604	20	1440	280	375	34	170	195	
29	10,000	34.02	20.48	1.66	558	9,988	3079	74.58	1940	1122	700	2.602	18	1300	275	360	34	175	205	
30	10,000	33.98	20.00	1.70	560	10,788	4113	81.71	2805	1262	848	3.081	20	1420	320	400	34	180	220	
31	10,000	34.13	20.10	1.70	562	11,624	5329	91.02	3950	1422	1000	3.630	19	1440	500	540	34	205	255	
32	20,000	17.58	13.75	1.28	480	8,020	880	34.43	750	931	525	2.085	15	900	98	145	30	85	100	28
33	20,000	17.54	13.75	1.28	484	9,992	1760	44.38	1360	1149	750	3.089	15	900	210	320	32	110	140	
34	20,000	17.56	13.70	1.28	482	10,788	2350	49.78	1945	1261	775	3.616	15	900	275	375	32	130	180	
35	20,000	17.64	13.70	1.29	484	11,544	2940	54.33	2555	1424	1060	4.155	15	900	300	400	32	140	195	
36	20,000	17.34	13.70	1.27	481	12,288	3660	57.78	3355	1623	1250	4.790	15	880	380	440	32	150	225	

37	20,000	20.71	13.56	1.53	503	9,000	1435	45.10	1000	959	490	2.382	26	925	150	230	30	135	165	123
38	20,000	20.66	13.66	1.51	503	10,008	2131	51.25	1510	1122	660	2.958	26	900	250	350	30	145	185	
39	20,000	20.61	13.46	1.53	506	10,820	2819	57.07	2125	1259	840	3.462	26	925	275	380	31	155	205	
40	20,000	20.76	13.66	1.52	504	11,592	3678	62.66	2925	1439	870	4.055	26	925	325	430	31	170	255	
41	20,000	20.66	13.76	1.50	506	12,296	4375	67.14	3790	1625	1250	4.567	26	910	450	515	31	180	260	
42	20,000	23.30	13.83	1.69	521	8,012	1082	41.49	625	816	410	1.841	10	1050	60	125	31	120	135	43
43	20,000	23.21	13.83	1.68	521	8,040	1099	41.67	630	815	420	1.861	10	1050	60	125	31	120	135	
44	20,000	23.19	13.78	1.68	524	10,008	2391	55.53	1475	1112	700	2.828	10	1040	225	350	32	145	175	
45	20,000	23.12	13.78	1.68	524	10,784	3076	61.52	2090	1257	840	3.298	10	1040	300	390	32	160	200	
46	20,000	27.56	13.56	2.03	554	9,416	2147	57.06	1150	979	500	2.306	24	1150	200	275	31	180	200	120
47	20,000	27.34	13.54	2.02	548	9,548	2359	59.02	----	992	520	2.414	18	1175	200	300	32	165	190	
48	20,000	27.34	13.54	2.02	542	9,532	2382	59.71	----	966	520	2.424	19	1175	200	300	32	155	185	
49	20,000	27.34	13.64	2.00	550	9,472	2421	60.56	----	966	510	2.455	19	1175	200	300	32	145	180	
50	20,000	27.56	13.76	2.00	557	10,008	2729	61.89	1595	1098	600	2.625	24	1175	260	350	31	180	210	
51	20,000	27.56	13.66	2.02	559	10,788	3566	67.85	2305	1259	825	3.063	24	1175	300	410	31	195	240	
52	20,000	27.61	13.66	2.02	562	11,596	4602	75.22	3195	1435	1000	3.614	24	1175	370	450	31	210	265	
53	20,000	27.61	13.86	1.99	563	12,252	5595	79.95	4200	1608	1200	4.111	24	1175	575	610	31	220	290	
54	20,000	29.99	13.40	2.24	562	9,996	3184	65.88	1625	1096	660	2.591	21	1300	240	350	29	190	220	50
55	20,000	30.02	13.35	2.25	563	10,789	3997	73.12	2400	1263	840	3.061	20	1300	300	390	31	198	236	
56	20,000	29.98	12.65	2.37	563	11,616	5435	80.64	3425	1426	1000	3.622	18	1300	400	450	32	205	255	
57	20,000	29.87	13.45	2.22	564	12,312	6353	86.79	4610	1610	1200	4.161	18	1300	680	700	33	205	265	
58	30,000	8.84	8.94	.99	428	8,120	461	18.80	----	1058	550	2.420	18	425	25	75	25	125	150	116
59	30,000	8.89	8.94	.99	428	9,016	686	23.41	----	1025	625	2.906	18	425	75	125	26	120	210	
60	30,000	8.94	8.84	1.01	426	10,016	992	25.70	----	1160	700	3.726	18	430	125	200	26	110	165	
61	30,000	8.94	8.84	1.01	424	10,768	1261	29.11	----	1256	860	4.282	18	420	200	295	27	110	175	
62	30,000	8.94	8.84	1.01	426	11,588	1616	29.90	----	1454	1100	4.708	20	425	200	350	27	115	200	
63	30,000	9.04	8.84	1.02	427	12,218	1808	31.29	----	1688	1250	5.018	18	425	250	375	28	130	235	
64	30,000	11.40	9.10	1.25	440	8,012	600	24.31	634	859	500	2.210	18	710	---	90	28	115	120	20
65	30,000	11.20	9.05	1.24	438	10,012	1380	32.39	1130	1109	750	3.454	18	700	---	240	29	80	120	
66	30,000	11.25	9.05	1.24	439	10,784	1740	34.16	1496	1271	920	3.940	18	710	---	320	30	100	140	
67	30,000	11.25	9.10	1.23	439	11,584	2230	36.75	1945	1480	1120	4.580	18	720	---	360	30	115	190	
68	30,000	11.25	8.95	1.26	440	12,240	2575	38.63	2370	1641	1350	4.954	18	720	---	390	30	125	215	
69	30,000	13.35	8.85	1.51	465	9,112	1080	31.70	844	938	500	2.640	22	700	100	150	29	100	120	108
70	30,000	13.25	8.95	1.48	464	9,952	1563	36.61	1160	1091	650	3.218	22	650	200	275	29	110	140	
71	30,000	13.30	8.95	1.49	465	10,804	2081	40.01	1620	1250	825	3.818	22	650	250	360	29	122	160	
72	30,000	13.35	8.95	1.49	465	11,588	2611	42.76	2180	1459	1075	4.380	22	.675	300	375	29	140	205	
73	30,000	13.20	8.75	1.51	465	12,320	3161	44.73	2840	1654	1300	4.958	22	650	300	400	29	148	225	
74	30,000	15.04	8;80	1.71	483	7,984	805	29.25	560	785	390	1.955	11	810	---	50	27	100	115	56
75	30,000	14.79	8.78	1.68	480	7,988	790	29.16	568	781	390	1.968	10	810	---	60	28	100	120	
76	30,000	15.06	8.90	1.69	482	9,992	1803	39.97	1216	1076	700	3.069	10	810	180	280	31	110	140	
77	30,000	15.13	8.73	1.73	480	9,988	1805	40.31	1224	1079	700	3.065	10	820	190	280	31	110	140	
78	30,000	15.18	8.80	1.72	482	10,788	2395	44.30	1726	1248	900	3.654	10	810	250	360	31	125	165	
79	30,000	15.11	8.85	1.71	481	11,596	2980	47.65	2250	1438	1060	4.236	10	810	280	380	32	135	200	
80	30,000	15.25	8.80	1.73	482	12,260	3674	51.05	2900	1602	1250	4.728	10	820	300	420	32	145	215	
81	30,000	17.80	8.76	2.03	502	8,860	1311	38.03	788	864	475	2.238	18	810	75	130	28	136	165	102
82	30,000	17.75	8.85	2.01	502	9,984	2100	45.01	1276	1083	675	2.935	18	810	200	300	30	140	175	
83	30,000	17.80	8.85	2.01	504	10,808	2712	48.51	1804	1256	835	3.442	18	810	245	360	30	150	190	
84	30,000	17.80	8.75	2.03	505	11,604	3467	54.32	2550	1434	1075	4.054	18	810	300	390	30	165	230	
85	30,000	17.65	8.75	2.02	502	12,280	4159	56.10	3275	1626	1265	4.597	18	810	350	425	30	170	240	

[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.

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

NACA

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), $T_{5,1}$ (°R)	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)	aAccumulative engine time (hr)
86	30,000	19.69	9.07	2.17	517	9,112	1640	42.55	905	898	525	2.317	26	910	110	180	29	150	180	82
87	30,000	20.00	8.87	2.26	520	10,008	2558	48.18	1320	1094	725	2.809	26	910	215	325	30	150	180	
88	30,000	19.94	8.92	2.24	520	10,768	2994	52.62	1885	1250	875	3.316	26	910	260	370	30	155	200	
89	30,000	20.02	8.77	2.28	519	11,568	3827	56.86	2640	1426	1075	3.878	26	910	300	405	30	168	220	
90	30,000	19.94	8.77	2.27	520	12,280	4551	60.41	3490	1623	1275	4.409	26	910	390	475	30	180	250	
91	30,000	22.99	9.03	2.55	540	8,212	1377	42.38	610	746	360	1.826	11	1025	36	80	29	140	150	44
92	30,000	22.92	8.92	2.57	542	10,004	2725	53.66	1466	1096	690	2.702	11	1050	225	340	30	162	195	
93	40,000	7.25	5.45	1.33	421	8,930	597	18.82	512	902	500	2.855	28	375	b---	75	24	120	180	112
94	40,000	7.15	5.45	1.31	424	9,984	886	21.93	752	1066	650	3.569	28	375	75	110	24	110	150	
95	40,000	7.15	5.45	1.31	423	10,832	1145	24.02	1016	1232	850	4.182	28	375	125	200	25	110	155	
96	40,000	7.10	5.55	1.28	427	11,568	1448	24.51	1344	1446	1065	4.735	29	350	205	320	27	120	210	
97	40,000	8.45	5.55	1.52	442	8,984	700	21.27	598	912	490	2.730	22	475	15	75	26	110	150	109
98	40,000	8.30	5.55	1.50	444	9,992	1042	24.24	808	1080	650	3.380	22	475	45	150	27	105	140	
99	40,000	8.25	5.65	1.46	445	10,752	1346	26.50	1100	1217	800	3.996	22	475	175	250	27	110	145	
100	40,000	8.25	5.65	1.46	443	11,568	1708	27.55	1498	1474	1050	4.581	22	475	220	350	27	118	175	
101	40,000	8.20	5.55	1.48	444	11,896	1827	27.30	1654	1558	1175	4.804	22	475	220	350	27	130	200	
102	40,000	9.59	5.50	1.74	462	10,028	1200	26.44	840	1091	700	3.214	15	650	95	140	28	100	135	27
103	40,000	9.72	5.50	1.77	461	10,772	1560	28.35	1194	1255	880	3.763	15	650	190	282	28	105	145	
104	40,000	9.56	5.55	1.72	462	11,600	1940	29.51	1640	1470	1175	4.358	15	650	220	340	29	115	168	
105	40,000	9.55	5.50	1.74	464	12,288	2250	29.36	1915	1674	1365	4.821	15	650	280	385	29	120	180	
106	40,000	11.08	5.38	2.06	480	8,204	695	23.09	432	766	360	2.027	11	700	---	25	27	100	120	38
107	40,000	11.25	5.13	2.19	480	8,992	1034	25.94	590	877	510	2.401	10	710	---	75	28	105	130	
108	40,000	11.11	5.35	2.08	482	10,008	1473	29.98	910	1084	700	3.075	10	700	80	170	28	110	145	
109	40,000	11.19	5.20	2.15	482	10,808	1930	32.48	1300	1256	900	3.635	10	700	200	300	29	125	170	
110	40,000	11.18	5.20	2.15	480	11,588	2355	34.80	1780	1453	1150	4.194	10	750	220	350	29	130	185	
111	40,000	12.80	5.55	2.31	499	9,204	1198	29.36	845	927	500	2.452	18	620	90	100	27	130	155	100
112	40,000	12.70	5.55	2.29	500	10,012	1639	32.65	1080	1098	700	2.993	18	625	125	200	28	135	165	
113	40,000	12.70	5.45	2.33	500	10,800	2082	35.40	1345	1255	850	3.498	18	610	200	315	26	160	220	
114	40,000	12.80	5.55	2.31	502	11,672	2606	36.88	1890	1480	1100	4.057	18	615	250	360	27	170	235	
115	40,000	12.70	5.55	2.29	498	12,268	3022	39.81	2570	1641	1290	4.569	18	615	290	390	27	180	260	
116	40,000	14.99	5.57	2.69	520	9,008	1394	32.64	702	898	525	2.229	26	710	75	105	25	160	190	81
117	40,000	14.78	5.47	2.70	520	9,988	1857	35.78	1006	1095	710	2.806	26	715	150	210	27	158	185	
118	40,000	14.74	5.47	2.70	521	10,812	2382	38.79	1460	1277	925	3.333	26	710	225	335	27	165	210	
119	40,000	14.90	5.52	2.70	524	11,600	2934	41.90	2005	1466	1110	3.650	26	710	250	370	27	175	230	

120	40,000	19.59	5.39	3.60	564	9,452	1970	40.69	775	972	510	2,268	27	850	100	160	26	180	200	124
121	40,000	19.44	5.39	3.61	563	9,976	2362	43.99	1050	1091	610	2.576	27	850	175	260	27	180	210	
122	40,000	19.29	5.48	3.52	566	10,796	2978	47.14	1610	1267	800	3,052	27	850	250	350	25	200	250	
123	50,000	4.45	3.35	1.33	424	8,504	297	11.06	390	870	460	2.681	29	260	---	20	24	115	160	113
124	50,000	4.25	3.45	1.23	425	10,140	548	13.38	508	1104	725	3.694	30	250	---	35	25	110	155	
125	50,000	4.45	3.45	1.29	425	10,828	691	14.95	656	1235	875	4.130	30	250	---	75	25	110	160	
126	50,000	4.45	3.35	1.33	424	11,536	858	14.70	840	1460	1075	4.519	30	250	50	150	24	120	185	
127	50,000	4.45	3.35	1.33	427	11,980	977	15.25	978	1568	1275	4.811	30	285	115	190	25	135	220	
128	50,000	5.25	3.45	1.52	441	9,472	506	14.06	462	974	575	2.998	22	240	---	25	25	110	145	110
129	50,000	5.00	3.45	1.45	441	10,008	619	14.45	584	1063	700	3.448	22	245	---	50	25	110	150	
130	50,000	5.15	3.35	1.54	442	10,776	800	16.02	698	1250	850	3.934	22	245	25	100	25	120	160	
131	50,000	5.15	3.35	1.54	441	11,652	1051	16.94	956	1480	1060	4.554	22	220	100	190	25	130	185	
132	50,000	7.36	2.75	2.68	482	8,844	718	17.20	396	851	500	2.370	10	600	---	25	25	120	145	101
133	50,000	7.85	3.45	2.28	500	9,072	685	17.39	426	896	500	2.381	18	425	---	25	23	155	195	
134	50,000	7.16	2.80	2.56	484	9,000	736	16.96	408	890	500	2.439	10	600	---	25	25	125	150	
135	50,000	7.41	2.70	2.74	480	9,504	918	18.87	500	980	600	2.769	10	600	---	50	26	120	155	
136	50,000	7.85	3.45	2.26	507	10,032	960	19.90	584	1104	700	2.949	18	425	20	75	25	165	215	
137	50,000	7.85	3.45	2.28	502	10,780	1252	22.20	828	1213	850	3.446	18	425	90	145	24	165	220	
138	50,000	7.85	3.45	2.28	502	11,552	1539	22.85	1146	1439	1050	3.972	18	425	175	265	25	170	235	
139	50,000	7.85	3.46	2.28	496	11,624	1588	23.31	1200	1485	1110	4.051	18	410	190	280	24	175	245	
140	50,000	9.08	3.97	2.29	522	12,272	2031	27.11	1676	1671	1390	4.569	26	475	250	360	24	180	245	
141	50,000	9.28	3.67	2.53	518	9,012	784	20.27	482	910	525	2.231	26	475	---	35	21	165	205	82
142	50,000	9.30	3.37	2.76	524	9,560	981	20.87	558	1016	640	2.529	26	490	20	65	24	160	190	
143	50,000	9.14	3.42	2.67	526	9,940	1093	21.84	630	1084	710	2.737	26	485	50	75	24	160	190	
144	50,000	9.30	3.72	2.50	521	10,000	1118	22.54	664	1106	725	2.826	26	485	35	85	24	160	195	
145	50,000	9.35	3.77	2.48	522	10,788	1438	24.74	942	1287	900	3.344	26	490	120	175	25	160	200	
146	50,000	9.19	3.42	2.69	524	10,860	1477	24.75	948	1284	915	3.348	26	490	115	175	25	160	200	
147	50,000	9.32	3.72	2.51	524	11,596	1802	26.65	1308	1484	1175	3.891	26	480	200	310	25	170	215	
148	50,000	9.18	3.67	2.50	519	11,612	1805	26.23	1308	1478	1175	3.905	26	490	200	320	25	170	220	
149	50,000	12.08	3.28	3.68	562	9,468	1226	26.25	560	954	525	2.296	27	575	50	70	19	190	220	126
150	50,000	12.08	3.28	3.68	564	9,992	1458	27.15	665	1092	625	2.536	28	575	75	110	21	190	225	
151	60,000	2.69	2.04	1.32	444	9,484	236	7.04	---	994	625	3.065	20	200	---	---	19	145	210	115
152	60,000	2.74	1.94	1.41	442	10,520	357	8.49	---	1145	800	3.657	20	200	15	15	19	165	250	
153	60,000	2.64	2.04	1.29	442	11,016	409	8.45	---	1311	925	3.989	20	200	25	30	20	175	270	
154	60,000	2.69	2.04	1.32	442	11,620	483	8.62	---	1479	1200	4.357	20	200	25	40	20	170	275	
155	60,000	2.74	2.04	1.34	440	12,520	572	8.74	---	1714	1500	4.777	20	200	50	75	22	160	255	
156	60,000	4.15	2.25	1.84	478	9,128	353	9.74	304	923	525	2.443	18	290	---	10	22	150	195	104
157	60,000	4.25	2.15	1.98	481	10,016	497	11.29	386	1092	700	3.106	18	290	---	25	22	165	225	
158	60,000	4.35	2.15	2.02	483	10,736	646	12.32	486	1236	860	3.483	18	290	---	50	18	170	245	
159	60,000	4.30	2.05	2.10	487	11,528	807	13.11	682	1453	1075	4.107	18	280	35	90	23	165	245	
160	60,000	4.25	2.15	1.98	483	12,280	940	13.39	866	1654	1375	4.482	18	290	75	150	22	152	195	
161	60,000	5.18	2.02	2.56	503	9,032	428	11.75	318	908	535	2.359	26	315	--	25	21	160	190	83
162	60,000	4.97	2.12	2.34	502	10,024	599	12.58	414	1106	725	2.960	26	310	--	50	25	150	185	
163	60,000	5.01	2.17	2.31	501	10,800	761	13.88	560	1273	915	3.507	26	310	20	75	25	155	195	
164	60,000	4.92	2.27	2.17	499	11,628	948	14.49	784	1489	1200	4.069	26	310	50	120	28	172	240	
165	60,000	5.77	2.17	2.66	522	8,976	458	12.07	336	908	525	2.225	26	330	--	10	22	155	183	79
166	60,000	5.67	2.12	2.68	528	9,964	648	13.33	410	1100	735	2.768	27	330	--	25	22	160	187	
167	60,000	5.64	2.27	2.49	520	10,844	867	14.81	600	1290	975	3.351	27	350	50	75	25	165	195	

[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.

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_{61}	Corr. T_{61}/θ	Corr. $T_{5,1}/\theta$
1	0	1.00	5,972	5,972	633	633	4681	633	633	37.04	37.04	1159	1159	1.831	1.831	1205	1205	1273
2	0	1.00	7,862	7,862	1247	1247	5295	1247	1247	54.08	54.08	1654	1654	1.326	1.326	1209	1209	1234
3	0	1.00	9,815	9,815	2313	2313	6361	2313	2313	66.84	66.84	2491	2491	1.077	1.077	1276	1276	1312
4	0	1.00	10,415	10,415	2702	2702	6750	2702	2702	71.03	71.03	2935	2935	1.086	1.086	1333	1333	1365
5	0	1.00	10,606	10,606	2947	2947	6995	2947	2947	74.27	74.27	3086	3086	1.047	1.047	1351	1351	1409
6	0	1.00	11,178	11,178	3541	3541	7589	3541	3541	80.06	80.06	3761	3761	1.062	1.062	1415	1415	1466
7	0	1.00	11,437	11,437	3765	3765	7813	3765	3765	82.89	82.89	3955	3955	1.050	1.050	1456	1456	1507
8	0	1.00	11,823	11,823	4497	4497	8545	4497	4497	86.64	86.64	4735	4735	1.053	1.053	1524	1524	1596
9	0	1.00	12,043	12,043	4619	4619	8667	4619	4619	90.19	90.19	4942	4942	1.070	1.070	1589	1589	1649
10	0	1.30	6,126	5,902	893	687	3801	-267	-205	55.64	42.83	1001	742	∞	∞	882	819	902
11	0	1.30	7,993	7,700	1583	1218	4532	195	150	64.15	51.22	1412	1046	7.239	6.974	1030	956	972
12	0	1.30	9,963	9,598	2989	2299	5413	1189	915	83.20	66.43	2501	1853	2.103	2.026	1175	1091	1122
13	0	1.30	10,769	10,375	3995	3073	6187	1986	1528	92.86	74.15	3374	2500	1.698	1.636	1295	1201	1233
14	0	1.30	11,089	10,682	4493	3456	6570	2417	1859	95.99	76.65	3794	2812	1.569	1.512	1342	1246	1279
15	10,000	1.00	5,979	6,196	501	728	4776	501	728	27.63	38.75	907	1367	1.812	1.878	1118	1201	1271
16	10,000	1.00	7,988	8,280	1004	1459	5507	1004	1459	39.34	55.17	1278	1926	1.273	1.320	1135	1220	1286
17	10,000	1.00	9,986	10,349	1858	2702	6750	1858	2702	51.23	71.85	1879	2832	1.011	1.048	1235	1327	1375
18	10,000	1.00	10,819	11,215	2404	3495	7543	2404	3495	56.24	78.88	2412	3636	1.003	1.040	1331	1430	1492
19	10,000	1.00	11,584	12,008	3076	4472	8520	3076	4472	63.08	88.50	3140	4732	1.021	1.058	1468	1578	1669
20	10,000	1.00	12,217	12,664	3770	5481	9529	3770	5481	67.48	94.67	3898	5875	1.034	1.072	1606	1726	1819
21	10,000	1.30	6,018	6,006	611	683	3797	-181	-202	37.90	42.47	710	792	∞	∞	861	858	903
22	10,000	1.50	8,902	8,710	1862	1805	4504	243	236	61.75	61.15	1257	1191	5.159	5.048	971	928	904
23	10,000	1.50	9,916	9,703	2698	2615	5314	864	837	69.95	69.27	1896	1797	2.193	2.146	1120	1071	1046
24	10,000	1.50	10,656	10,427	3482	3375	6074	1479	1433	76.39	75.65	2592	2458	1.754	1.715	1247	1192	1223
25	10,000	1.50	11,418	11,172	4624	4482	7181	2404	2330	84.70	83.88	3602	3415	1.498	1.466	1398	1338	1376
26	10,000	1.70	7,976	7,662	1501	1284	3665	-263	-225	58.29	51.90	938	771	∞	∞	841	776	853
27	10,000	1.70	8,108	7,789	1539	1316	3697	-244	-209	68.91	52.45	888	729	∞	∞	848	782	839
28	10,000	1.70	9,982	9,589	3160	2703	5084	900	770	74.64	66.47	1990	1636	2.210	2.123	1123	1036	1046
29	10,000	1.70	10,027	9,632	3231	2764	5145	911	779	75.63	68.23	1993	1637	2.186	2.100	1132	1044	1079
30	10,000	1.70	10,809	10,383	4233	3620	6001	1690	1446	83.90	74.71	2892	2376	1.708	1.641	1268	1170	1209
31	10,000	1.70	11,624	11,166	5456	4666	7047	2633	2252	93.16	82.96	4045	3323	1.535	1.475	1423	1313	1346
32	20,000	1.30	8,039	8,337	903	1512	4626	203	340	34.83	56.20	752	1306	3.700	3.857	927	996	1055
33	20,000	1.30	9,974	10,344	1806	3022	6136	895	1496	45.43	73.30	1380	2396	1.545	1.602	1146	1232	1297
34	20,000	1.30	10,796	11,191	2405	4025	7139	1382	2314	50.91	82.18	1978	3428	1.430	1.482	1201	1357	1329
35	20,000	1.30	11,528	11,950	2974	4978	8092	1862	3116	55.37	89.34	2606	4521	1.400	1.451	1420	1526	1629
36	20,000	1.30	12,310	12,760	3811	6379	9493	2614	4375	59.60	98.16	3484	6045	1.333	1.382	1629	1751	1845
37	20,000	1.50	8,998	9,143	1409	2044	4743	277	402	44.81	65.97	1015	1495	3.660	3.718	963	994	985
38	20,000	1.50	10,009	10,167	2122	3078	5777	830	1205	51.11	72.99	1520	2239	1.830	1.859	1122	1158	1186
39	20,000	1.50	10,799	10,969	2788	4044	6743	1348	1955	57.02	81.42	2121	3125	1.573	1.598	1254	1294	1336
40	20,000	1.50	11,582	11,764	3633	5270	7969	2062	2991	62.20	88.82	2894	4267	1.406	1.427	1436	1462	1370
41	20,000	1.50	12,260	12,453	4372	6342	9041	2673	3877	67.30	96.10	3774	5564	1.413	1.435	1614	1667	1754

42	20,000	1.70	8,012	7,996	1099	1406	3787	-110	-141	41.49	53.21	622	794	∞	∞	811	808	862
43	20,000	1.70	8,040	8,024	1116	1428	3809	-112	-145	42.13	54.02	626	800	∞	∞	810	807	871
44	20,000	1.70	9,978	9,958	2432	3112	5493	799	1023	56.03	.1.86	1490	1904	1.865	1.861	1105	1101	1149
45	20,000	1.70	10,751	10,730	3138	4016	6397	1317	1686	62.49	80.14	2102	2685	1.596	1.593	1250	1245	1287
46	20,000	2.00	9,343	9,115	2108	2294	4318	180	196	57.19	63.78	1134	1203	6.291	6.138	971	923	905
47	20,000	2.00	9,529	9,297	2350	2557	4581	347	378	59.39	66.23	[a]----	----	-----	-----	989	940	929
48	20,000	2.00	9,560	9,327	2373	2582	4606	358	389	59.79	66.68	----	----	-----	-----	973	925	959
49	20,000	2.00	9,812	9,578	2440	2655	4679	420	457	59.93	66.83	----	----	-----	-----	995	946	950
50	20,000	2.00	9,902	9,660	2727	2967	4991	621	676	62.51	69.71	1578	1674	2.539	2.477	1076	1023	988
51	20,000	2.00	10,663	10,393	3544	3855	5879	1236	1345	68.49	76.38	2269	2407	1.835	1.790	1230	1169	1193
52	20,000	2.00	11,417	11,130	4563	4965	6989	1994	2170	76.22	85.00	3119	3311	1.564	1.526	1394	1325	1348
53	20,000	2.00	12,052	11,758	5573	6063	8067	2839	3089	81.09	90.43	4099	4351	1.444	1.409	1559	1482	1530
54	20,000	2.30	10,044	9,602	3362	3180	4940	776	734	69.25	68.53	1747	1680	2.251	2.152	1102	1007	1029
55	20,000	2.30	10,829	10,353	4232	4003	5763	1372	1298	76.56	75.76	2563	2310	1.862	1.760	1264	1155	1198
56	20,000	2.30	11,661	11,148	5676	5370	7130	2514	2379	84.69	83.80	3592	3249	1.429	1.366	1443	1319	1361
57	20,000	2.30	12,347	11,804	6817	6449	8209	3416	3231	91.12	90.17	4847	4384	1.419	1.357	1615	1476	1522
58	30,000	1.00	7,970	8,947	468	1543	5592	468	1543	19.19	57.60	----	----	-----	-----	1011	1274	1216
59	30,000	1.00	8,844	9,928	681	2296	6345	681	2296	23.87	71.66	----	----	-----	-----	980	1235	1311
60	30,000	1.00	9,848	11,055	981	3507	7356	981	3507	26.92	77.80	----	----	-----	-----	1130	1423	1423
61	30,000	1.00	10,614	11,913	1252	4217	8266	1252	4217	29.33	88.04	----	----	-----	-----	1220	1537	1616
62	30,000	1.00	11,396	12,790	1594	5369	9418	1594	5369	30.20	90.67	----	----	-----	-----	1406	1771	1901
63	30,000	1.00	12,009	13,478	1756	5918	9967	1756	5918	31.32	93.99	----	----	-----	-----	1623	2044	2071
64	30,000	1.30	8,048	8,701	615	1695	4710	141	386	24.80	58.93	621	1742	4.402	4.760	870	1017	1102
65	30,000	1.30	10,080	10,899	1443	3740	6856	804	2083	33.17	79.82	1157	3243	1.440	1.557	1140	1332	1424
66	30,000	1.30	10,843	11,726	1826	4732	7847	1150	2979	35.09	84.12	1546	4328	1.344	1.453	1306	1527	1626
67	30,000	1.30	11,649	12,596	2355	6102	9217	1630	4225	37.59	90.10	2019	5657	1.238	1.339	1525	1780	1868
68	30,000	1.30	12,295	13,293	2689	6068	10085	1925	4990	39.61	94.95	2472	6928	1.284	1.388	1686	1971	2140
69	30,000	1.50	9,087	9,627	1069	2401	5100	300	674	31.74	67.29	845	2009	2.814	2.961	934	1047	1071
70	30,000	1.50	9,915	10,504	1581	3551	6250	684	1537	37.02	78.48	1176	2801	1.722	1.823	1088	1220	1242
71	30,000	1.50	10,781	11,415	2095	4705	7404	1119	2514	40.27	85.39	1618	3848	1.446	1.531	1244	1395	1434
72	30,000	1.50	11,564	12,243	2606	5853	8552	1568	3522	42.85	90.86	2172	5167	1.386	1.467	1452	1628	1715
73	30,000	1.50	12,300	13,023	3179	7141	9840	2085	4683	45.18	95.80	2850	6779	1.368	1.448	1647	1848	1966
74	30,000	1.70	7,953	8,276	812	1610	3992	-11	-22	29.47	56.14	563	1161	∞	∞	784	849	918
75	30,000	1.70	7,982	8,306	814	1614	3998	-20	-39	29.63	56.82	574	1184	∞	∞	775	839	914
76	30,000	1.70	9,904	10,368	1814	3595	5977	608	1363	40.29	76.74	1224	2524	1.780	1.852	1071	1159	1249
77	30,000	1.70	9,901	10,366	1791	3551	5933	666	1321	40.26	76.68	1216	2507	1.824	1.898	1078	1167	1254
78	30,000	1.70	10,760	11,194	2372	4702	7084	1132	2244	44.37	84.51	1709	3524	1.509	1.570	1242	1344	1464
79	30,000	1.70	11,578	12,045	2975	5896	8278	1646	3259	47.61	90.65	2240	4618	1.361	1.416	1434	1552	1640
80	30,000	1.70	12,226	12,722	3518	6972	9354	2109	4179	50.43	96.02	2848	5872	1.350	1.406	1598	1730	1846
81	30,000	2.00	8,859	9,008	1286	2167	4192	62	105	37.85	62.72	785	1345	12.60	12.81	869	898	972
82	30,000	2.00	9,983	10,150	2107	3550	5575	646	1089	45.17	74.84	1280	2193	1.981	2.014	1082	1119	1173
83	30,000	2.00	10,706	10,967	2706	4559	6584	1139	1919	48.46	80.31	1792	3070	1.574	1.600	1251	1293	1333
84	30,000	2.00	11,509	11,765	3445	5804	7829	1686	2840	54.40	90.13	2522	4320	1.496	1.521	1426	1474	1577
85	30,000	2.00	12,279	12,465	4162	7012	9037	2336	3935	56.50	93.61	3280	5619	1.404	1.428	1625	1680	1763

[a]Dashes indicate that values are unknown.

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
			Alt.	Corr.	Alt.	Corr.	Parameter	Alt.	Corr.	Alt.	Corr.	Alt.	Corr.	Alt.	Corr.	Alt.	Corr.	Corr.
		P_2/p_0	N	$N/\sqrt{\theta}$	F_j	F_j/δ	$\frac{F_j + p_0A_7}{\delta}$	F_n	F_n/δ	W_a	$W_a\sqrt{\theta}/\delta$	W_f	$W_f/\delta\sqrt{\theta}$	W_f/F_n	$W_f/F_n\sqrt{\theta}$	T_{61}	T_{61}/θ	$T_{5,i}/\theta$
86	30,000	2.30	9,157	9,130	1754	2570	4351	173	254	44.11	64.85	951	1388	5.481	5.465	897	890	979
87	30,000	2.30	10,028	9,998	2418	3542	5303	662	970	49.01	72.05	1353	1977	2.043	2.037	1101	1092	1183
88	30,000	2.30	10,789	10,757	3100	4541	6302	1178	1724	53.66	78.86	1939	2835	1.647	1.642	1258	1248	1332
89	30,000	2.30	11,605	11,568	3935	5764	7525	1862	2728	57.84	85.00	2656	3938	1.448	1.444	1437	1426	1535
90	30,000	2.30	12,305	12,268	4697	6881	8642	2488	3646	61.65	90.57	3570	5215	1.433	1.429	1631	1620	1732
91	30,000	2.70	8,269	8,051	1443	1801	3301	-286	-357	43.71	56.01	619	755	∞	∞	745	707	778
92	30,000	2.70	10,053	9,789	2904	3624	5124	687	857	56.05	71.83	1558	1893	2.269	2.209	1107	1050	1102
93	40,000	1.30	8,951	9,910	580	2406	5520	230	955	18.56	69.64	625	2872	2.716	3.007	913	1118	1190
94	40,000	1.30	9,985	11,053	883	3665	6779	467	1938	22.11	82.90	757	3478	1.621	1.795	1065	1306	1380
95	40,000	1.30	10,846	11,998	1147	4760	7874	691	2867	24.23	90.84	1027	4715	1.487	1.645	1233	1512	1607
96	40,000	1.30	11,528	12,754	1484	6158	9272	1013	4205	25.00	93.72	1363	6262	1.346	1.489	1434	1758	1854
97	40,000	1.50	8,979	9,741	681	2449	5148	188	675	20.85	69.17	588	2297	3.138	3.404	915	1077	1128
98	40,000	1.50	9,958	10,803	1050	3778	6477	473	1702	24.39	80.91	804	3139	1.700	1.844	1072	1262	1297
99	40,000	1.50	10,710	11,619	1377	4953	7652	740	2665	26.91	89.25	1110	4331	1.500	1.627	1207	1421	1471
100	40,000	1.50	11,542	12,521	1741	6265	8964	1079	3881	28.01	92.89	1518	5926	1.408	1.527	1467	1727	1769
101	40,000	1.50	11,856	12,862	1862	6699	9398	1203	4328	27.86	92.41	1681	6559	1.397	1.516	1547	1821	1911
102	40,000	1.70	9,981	10,634	1175	3723	6104	458	1452	26.20	78.04	817	2765	1.786	1.903	1079	1226	1303
103	40,000	1.70	10,729	11,435	1489	4728	7109	705	2231	28.81	85.86	1147	3881	1.633	1.740	1244	1413	1509
104	40,000	1.70	11,542	12,301	1910	6064	8445	1091	3466	29.99	89.32	1605	5428	1.469	1.566	1455	1652	1837
105	40,000	1.70	12,188	12,989	2194	6966	9347	1335	4240	31.45	95.68	1863	6301	1.394	1.486	1653	1877	2046
106	40,000	2.00	8,196	8,531	679	1833	3857	-49	-132	23.05	59.76	436	1225	∞	∞	769	833	892
107	40,000	2.00	8,983	9,350	978	2640	4664	171	462	25.55	66.24	583	1639	3.408	3.548	880	953	1059
108	40,000	2.00	9,977	10,385	1452	3919	5943	504	1361	30.01	77.80	904	2541	1.794	1.867	1077	1167	1249
109	40,000	2.00	10,774	11,215	1872	5053	7077	854	2304	32.23	83.55	1275	3581	1.492	1.553	1248	1352	1464
110	40,000	2.00	11,575	12,049	2270	6125	8149	1182	3188	34.44	89.28	1780	5001	1.506	1.569	1459	1581	1751
111	40,000	2.30	9,197	9,386	1197	2808	4568	174	407	29.24	67.26	844	2020	4.863	4.963	927	964	998
112	40,000	2.30	10,002	10,200	1647	3863	5625	497	1165	32.84	75.55	1069	2557	2.151	2.195	1096	1140	1204
113	40,000	2.30	10,789	11,002	2081	4884	6644	836	1960	35.59	81.88	1340	3207	1.603	1.635	1251	1303	1360
114	40,000	2.30	11,637	11,867	2594	6087	7847	1304	3068	36.86	84.80	1880	4505	1.442	1.473	1469	1550	1615
115	40,000	2.30	12,282	12,525	3037	7127	8887	1640	3847	39.92	91.83	2377	5693	1.459	1.479	1642	1710	1824
116	40,000	2.70	9,017	8,999	1297	2593	4092	36	72	32.63	65.36	709	1413	19.66	19.62	901	898	983
117	40,000	2.70	10,008	9,978	1882	3763	5262	483	967	36.23	72.57	1022	2036	2.109	2.105	1098	1093	1168
118	40,000	2.70	10,822	10,790	2424	4845	6344	864	1726	40.43	80.97	1489	2970	1.724	1.721	1278	1272	1379
119	40,000	2.70	11,565	11,542	2947	5890	7389	1318	2634	42.20	84.53	2008	4005	1.524	1.521	1449	1442	1554

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120	40,000	3.50	9,435	9,063	1953	3011	4168	138	213	40.96	65.76	786	1165	8.693	5.469	968	894	892
121	40,000	3.50	9,976	9,583	2328	3590	4747	378	585	44.01	70.65	1071	1586	2.822	2.711	1089	1006	987
122	40,000	3.50	10,765	10,341	2984	4601	5758	874	1348	47.64	76.47	1623	2405	1.856	1.783	1258	1162	1156
123	50,000	1.30	8,598	9,520	293	1963	5077	84	565	11.09	67.12	400	2965	4.748	5.257	878	1075	1136
124	50,000	1.30	10,129	11,206	581	3887	7001	315	2108	14.11	85.39	582	3862	1.656	1.832	1093	1338	1437
125	50,000	1.30	10,822	11,973	700	4687	7801	417	2791	15.05	90.98	659	4877	1.578	1.748	1232	1510	1632
126	50,000	1.30	11,537	12,764	845	5659	8775	570	3817	14.60	88.38	842	6231	1.475	1.632	1458	1787	1879
127	50,000	1.30	11,946	13,216	968	6479	9593	679	4548	15.31	92.64	980	7258	1.443	1.596	1557	1908	2111
128	50,000	1.50	9,478	10,282	493	2859	5558	168	972	13.75	73.56	455	2867	2.718	2.949	975	1148	1220
129	50,000	1.50	10,014	10,864	651	3779	6478	296	1719	15.01	80.31	556	3389	1.818	1.972	1084	1276	1367
130	50,000	1.50	10,770	11,684	792	4595	7294	413	2399	16.00	85.61	694	4371	1.680	1.822	1248	1469	1540
131	50,000	1.50	11,640	12,627	1038	6023	8722	639	3709	16.86	90.22	949	5976	1.486	1.612	1482	1744	1791
132	50,000	2.30	8,993	9,177	731	2767	4527	100	378	18.04	66.93	425	1639	4.260	4.347	890	926	1034
133	50,000	2.30	9,056	9,242	694	2627	4387	79	298	17.59	65.24	430	1658	8.470	5.582	894	930	996
134	50,000	2.30	9,1?3	9,320	777	2940	4700	134	506	18.37	68.14	458	1767	3.482	3.492	927	964	1029
135	50,000	2.30	9,683	9,882	917	3468	5228	235	849	19.77	73.33	526	2029	2.342	2.390	1024	1065	1146
136	50,000	2.30	9,946	10,150	968	3664	5424	260	984	20.23	75.04	583	2249	2.240	2.286	1086	1130	1187
137	50,000	2.30	10,747	10,960	1265	4787	6547	480	1817	22.43	83.20	829	3197	1.728	1.750	1204	1254	1354
138	50,000	2.30	11,497	11,724	1562	5912	7672	756	2854	23.08	85.62	1150	4437	1.523	1.555	1428	1487	1561
139	50,000	2.30	11,658	11,889	1611	6097	7857	792	2997	23.40	86.81	1211	4673	1.528	1.556	1490	1552	1643
140	50,000	2.30	11,989	12,235	1776	6720	8480	931	3524	24.16	39.52	1423	5518	1.536	1.566	1590	1656	1634
141	50,000	2.70	9,039	9,021	809	2607	4106	23	70	20.36	65.75	493	1536	22.70	22.66	917	912	987
142	50,000	2.70	9,531	9,512	972	3134	4633	165	529	20.90	67.51	551	1770	3.353	3.346	1012	1006	1089
143	50,000	2.70	9,901	9,881	1122	3616	5115	250	833	22.33	72.12	637	2047	2.462	2.457	1076	1070	1155
144	50,000	2.70	10,000	9,980	1148	3701	5200	277	890	22.56	72.85	666	2142	2.412	2.407	1109	1102	1180
145	50,000	2.70	10,778	10,756	1484	4783	6282	536	1726	24.54	70.24	922	2964	1.721	1.718	1290	1284	1357
146	50,000	2.70	10,838	10,806	1496	4823	6322	528	1698	25.08	80.97	956	3074	1.814	1.810	1277	1271	1361
147	50,000	2.70	11,561	11,538	1855	5980	7479	834	2686	26.43	85.36	1258	4044	1.500	1.506	1481	1474	1624
148	50,000	2.70	11,635	11,612	1861	5998	7497	851	2744	26.12	84.36	1280	4115	1.503	1.499	1475	1468	1625
149	50,000	3.50	9,468	9,095	1193	2967	4124	26	64	26.36	68.24	575	1374	22.35	21.47	954	881	910
150	50,000	3.50	9,973	9,580	1414	3516	4672	206	515	27.24	70.53	690	1648	3.331	3.200	1088	1005	998
151	60,000	1.30	9,267	10,200	240	2585	5699	99	1072	7.45	72.62	[a]---	---	---	---	954	1168	1275
152	60,000	1.30	10,304	11,400	343	3697	6811	177	1913	8.78	85.62	---	---	---	---	1101	1360	1485
153	60,000	1.30	10,791	11,938	431	4653	7767	261	2816	9.04	88.15	---	---	---	---	1257	1539	1626
154	60,000	1.30	11,380	12,599	491	5295	8409	320	3450	9.08	88.54	---	---	---	---	1418	1738	1951
155	60,000	1.30	12,094	13,380	570	6146	9260	401	4527	8.96	87.31	---	---	---	---	1650	2022	2076
156	60,000	2.00	9,137	9,611	381	2672	4696	64	448	10.04	67.64	306	2231	4.784	4.980	920	997	1064
157	60,000	2.00	9,994	10,403	500	3508	5532	142	996	11.34	76.40	386	2815	2.715	2.826	1087	1178	1251
158	60,000	2.00	10,692	11,129	630	4420	6444	247	1732	12.12	81.70	473	3456	1.913	1.995	1226	1328	1418
159	60,000	2.00	11,432	11,900	779	5464	7488	363	2547	13.16	88.67	673	4012	1.853	1.929	1433	1553	1641
160	60,000	2.00	12,229	12,729	951	6666	8690	523	3669	13.52	91.13	866	6323	1.655	1.723	1535	1772	1859
161	60,000	2.30	8,909	9,184	381	2322	4082	-7	-40	11.08	66.17	305	1887	∞	∞	912	949	1039
162	60,000	2.30	9,987	10,192	585	3567	5527	148	904	12.48	74.61	408	2540	2.759	2.816	1100	1144	1225
163	60,000	2.30	10,779	10,992	745	4540	6300	269	1636	13.60	81.31	549	3417	2.046	2.089	1268	1319	1424
164	60,000	2.30	11,628	11,858	976	5954	7714	474	2861	14.34	85.77	765	4756	1.612	1.644	1478	1539	1716
165	60,000	2.70	8,967	8,949	457	2376	3875	-10	-52	12.08	62.95	334	1729	∞	∞	908	905	979
166	60,000	2.70	9,905	9,885	663	3443	4942	135	697	13.66	71.16	414	2144	3.082	3.076	1088	1082	1175
167	60,000	2.70	10,865	10,833	911	4732	6231	327	1606	15.10	78.67	601	3111	1.838	1.834	1298	1292	1437

[a]Dashes indicate values are unknown.

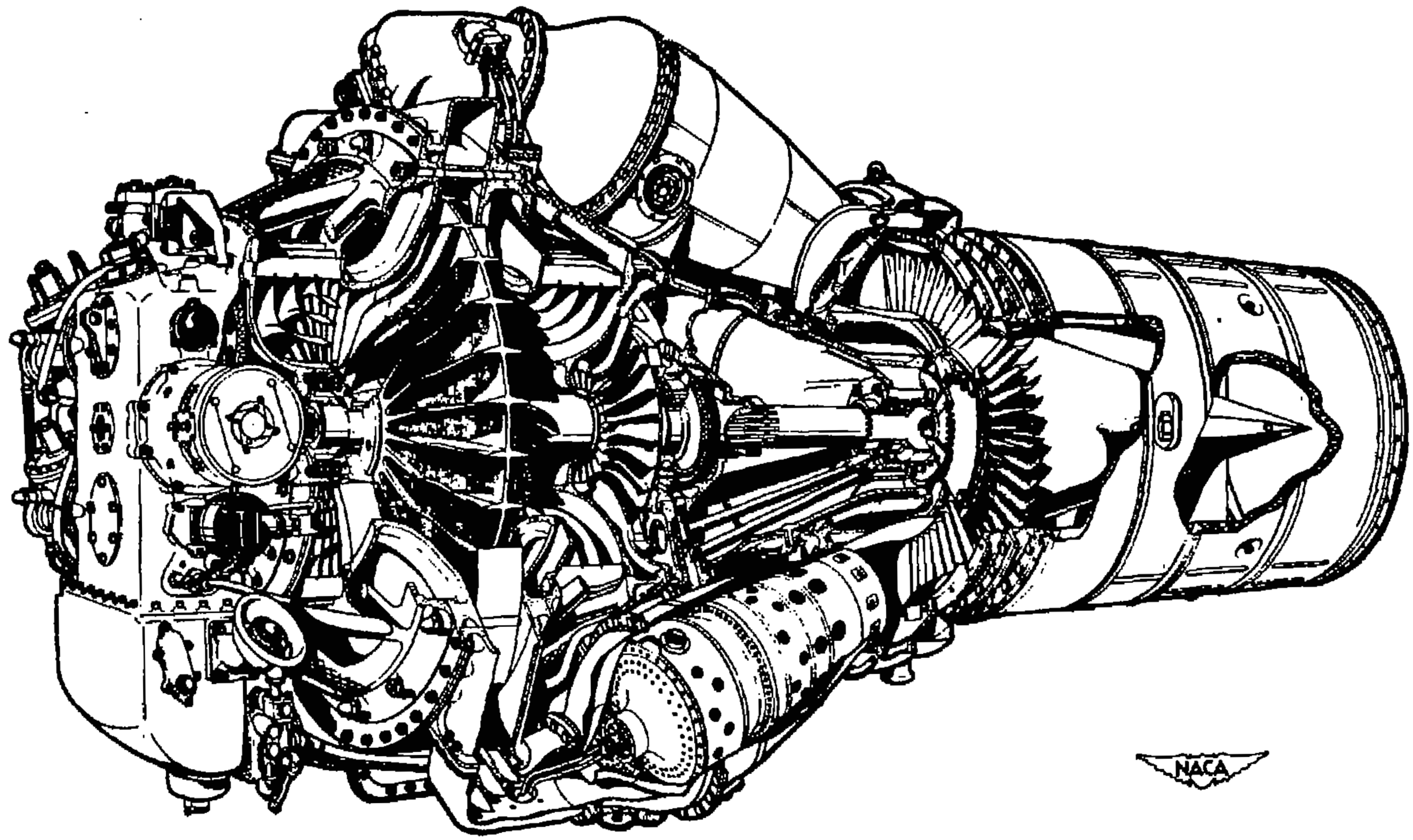


Figure 1. - Cutaway view of British Rolls-Royce Nene II turbojet engine. (Photographed from Rolls-Royce Manual on Nene engine.)

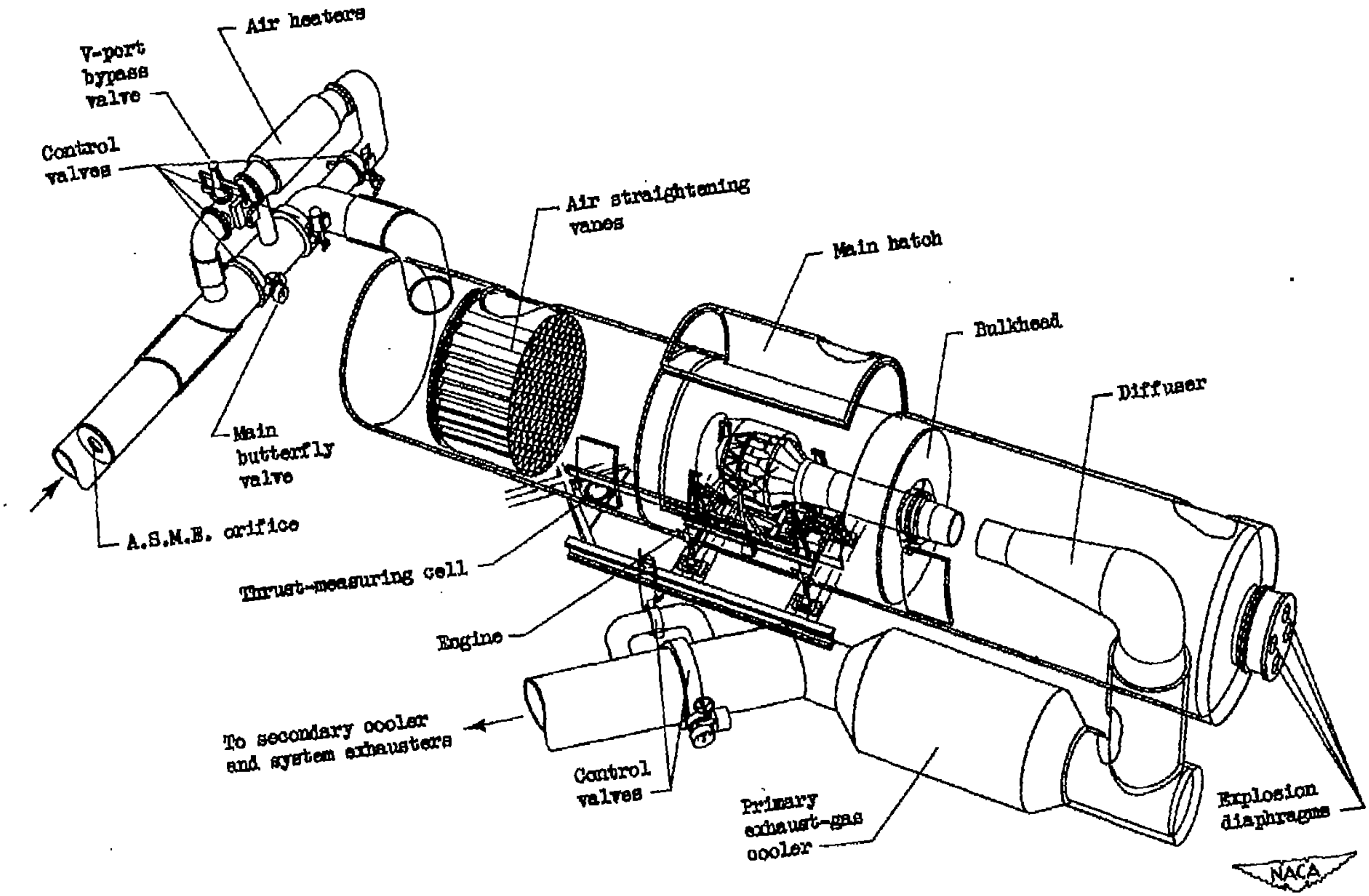


Figure 2. - Altitude chamber with engine installed in test section.

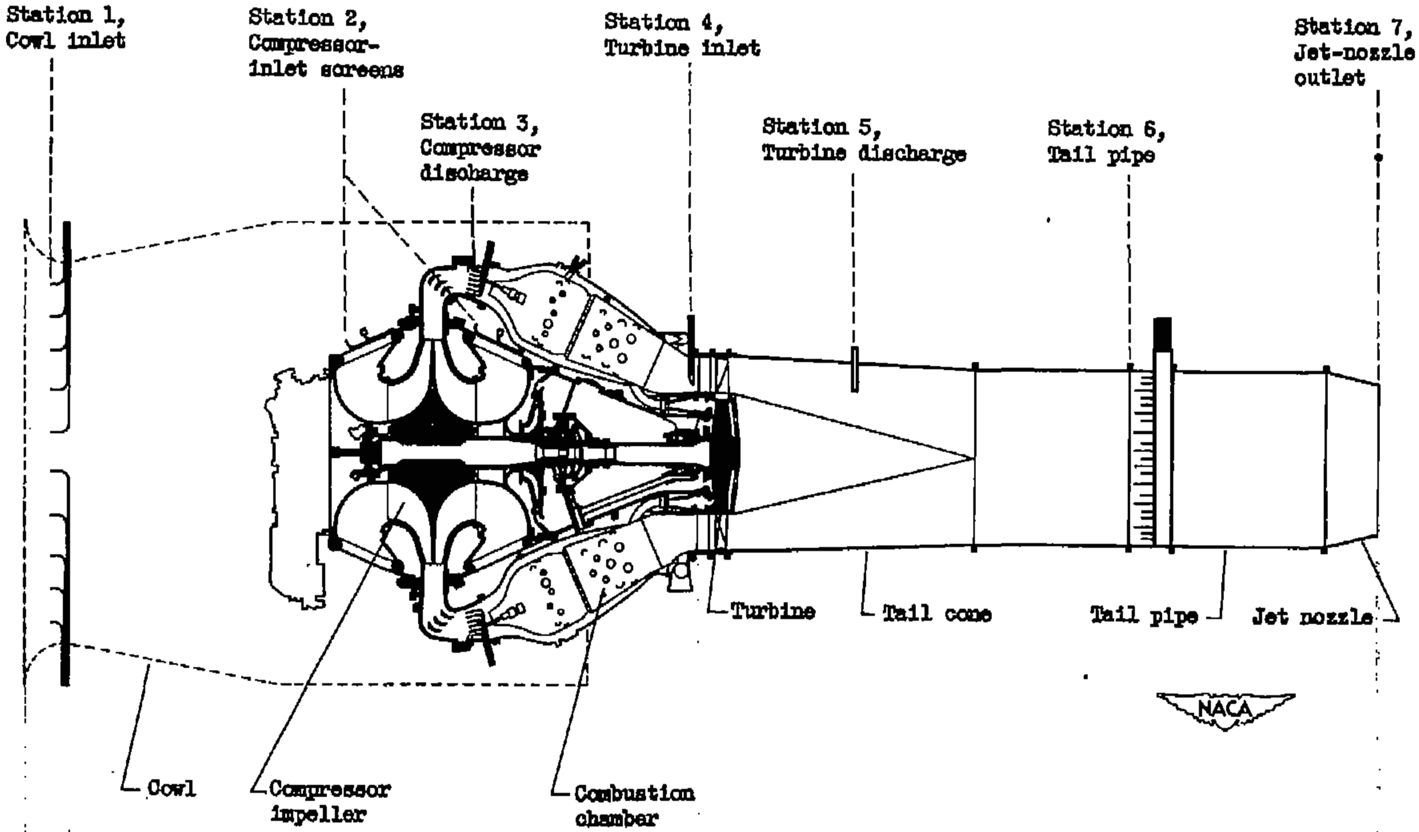
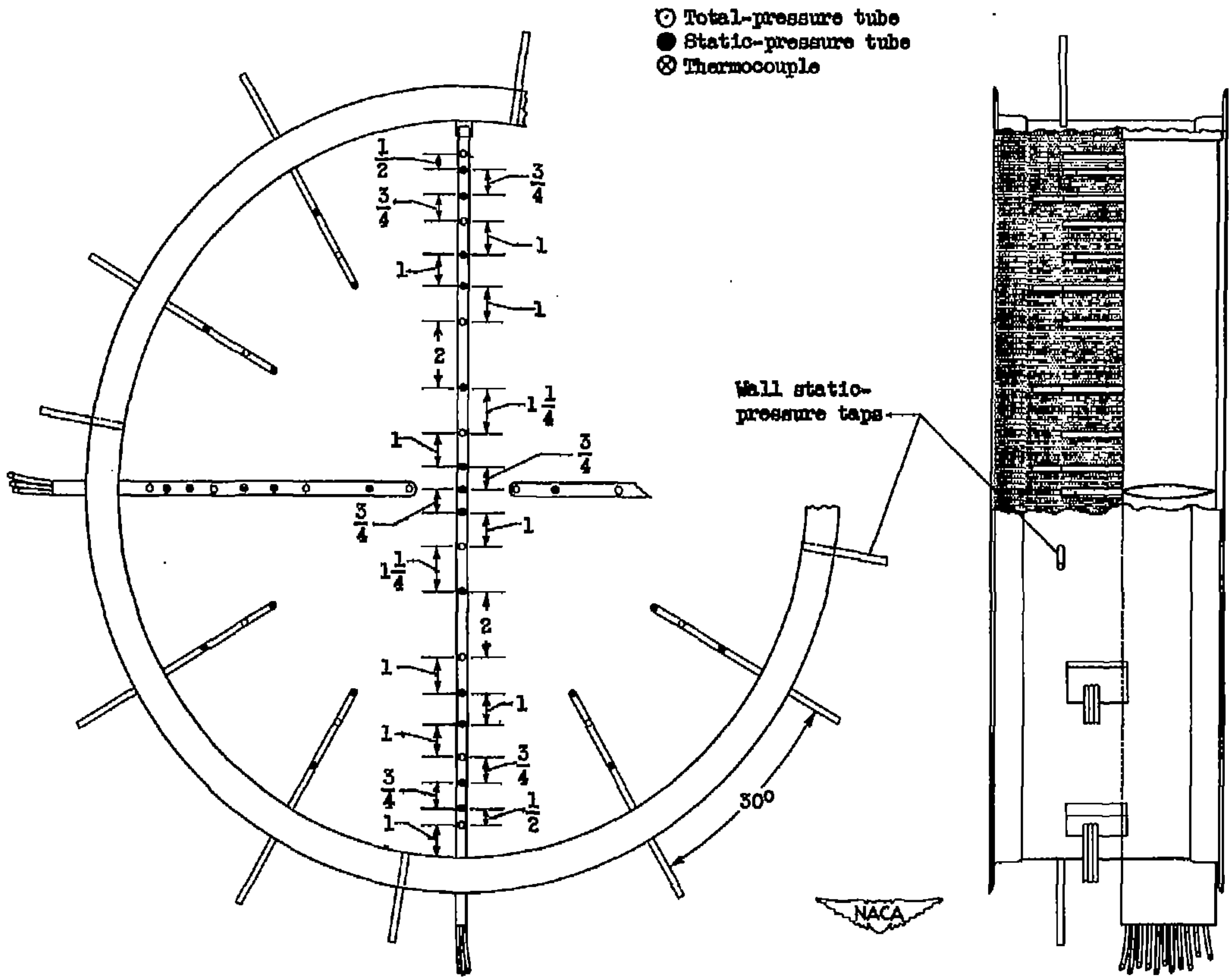
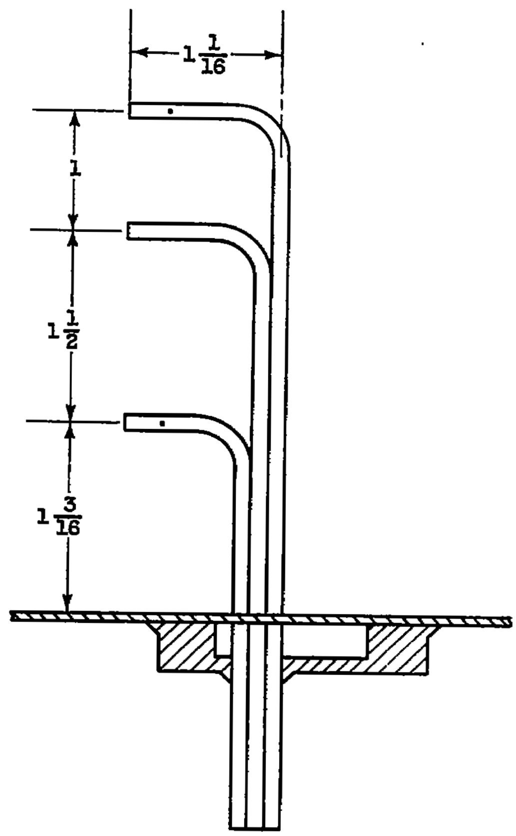


Figure 3. - Sectional side view of British Rolls-Royce Nene II engine showing instrumentation stations.

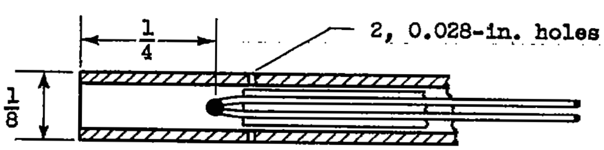


(a) Pressure-probe and thermocouple locations.

Figure 4. - Tail-pipe instrumentation details. (All dimensions given in inches.)



(b) Probe detail.



(c) Thermocouple detail.

Figure 4. - Concluded. Tail-pipe instrumentation details. (All dimensions given in inches.)

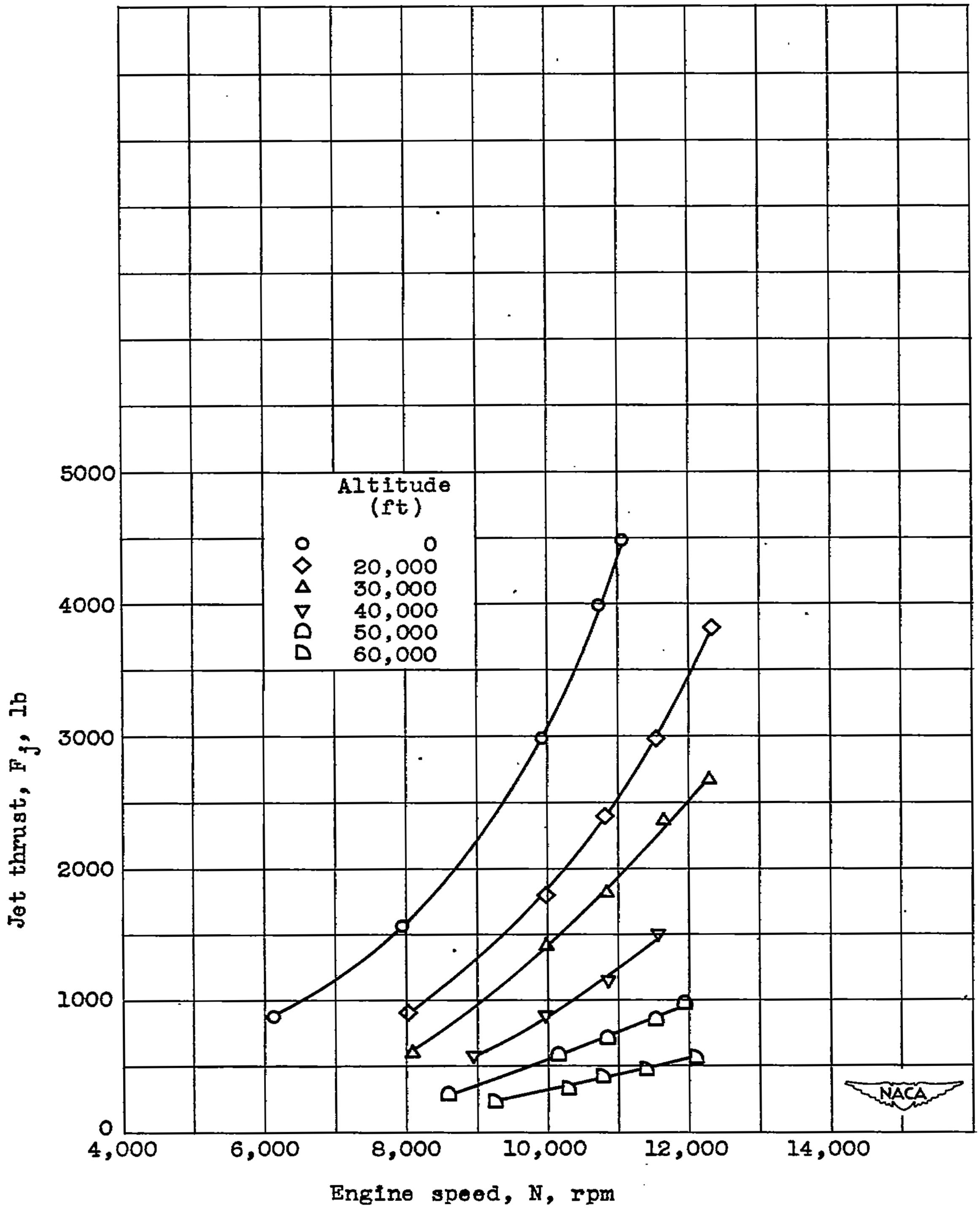


Figure 5. - Effect of altitude on jet thrust. Ram-pressure ratio, 1.30.

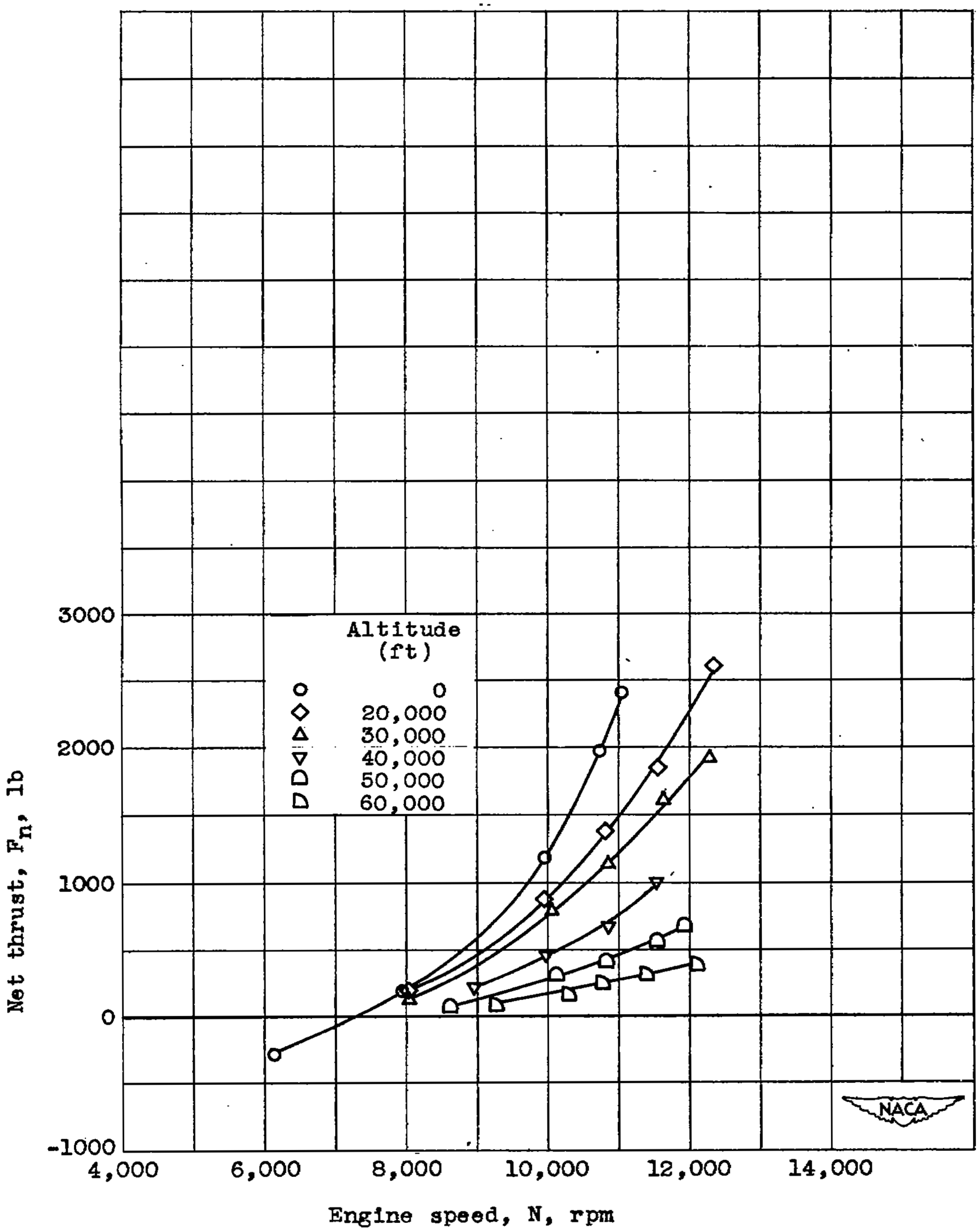


Figure 6. - Effect of altitude on net thrust. Ram-pressure ratio, 1.30.

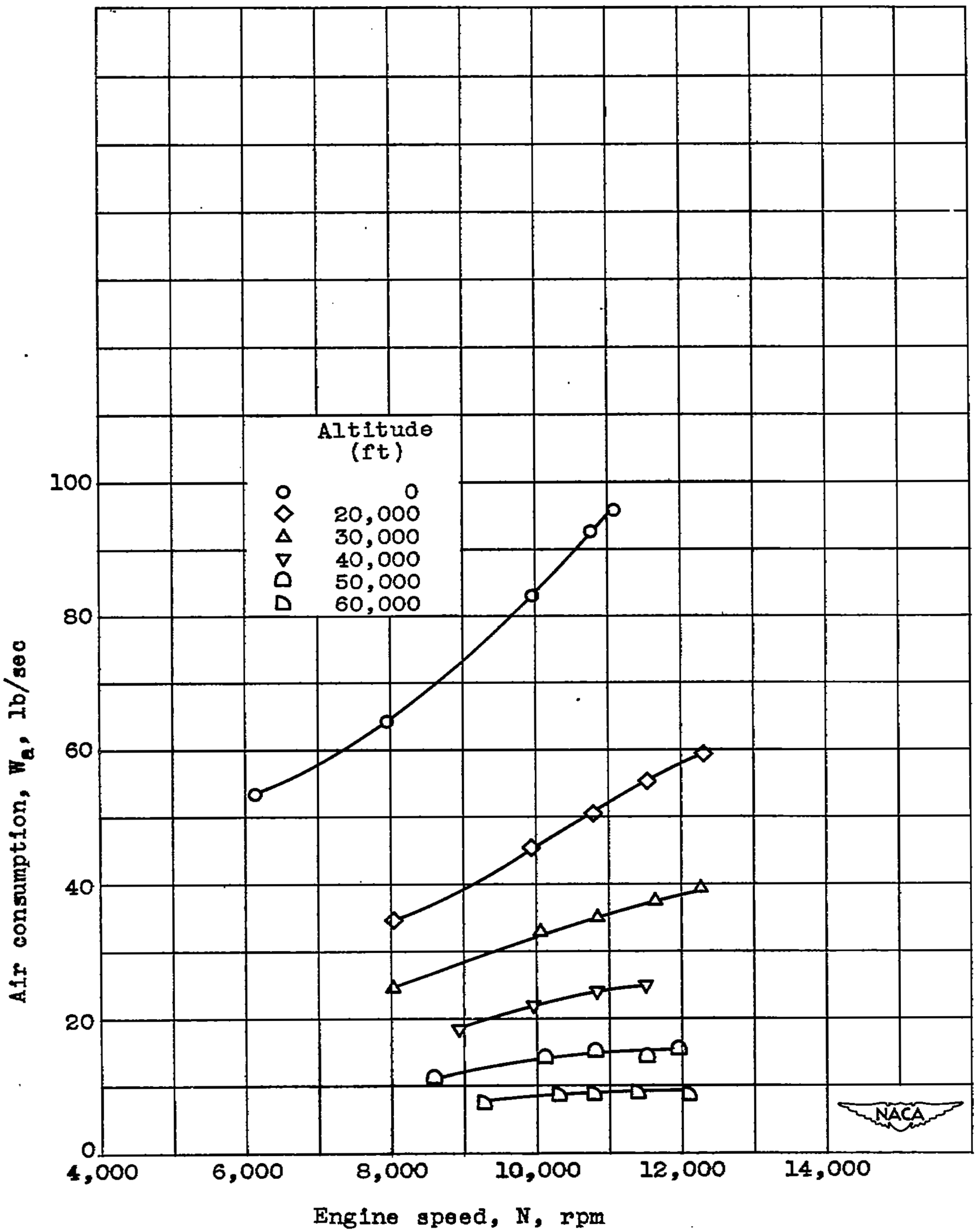


Figure 7. - Effect of altitude on air consumption. Ram-pressure ratio, 1.30.

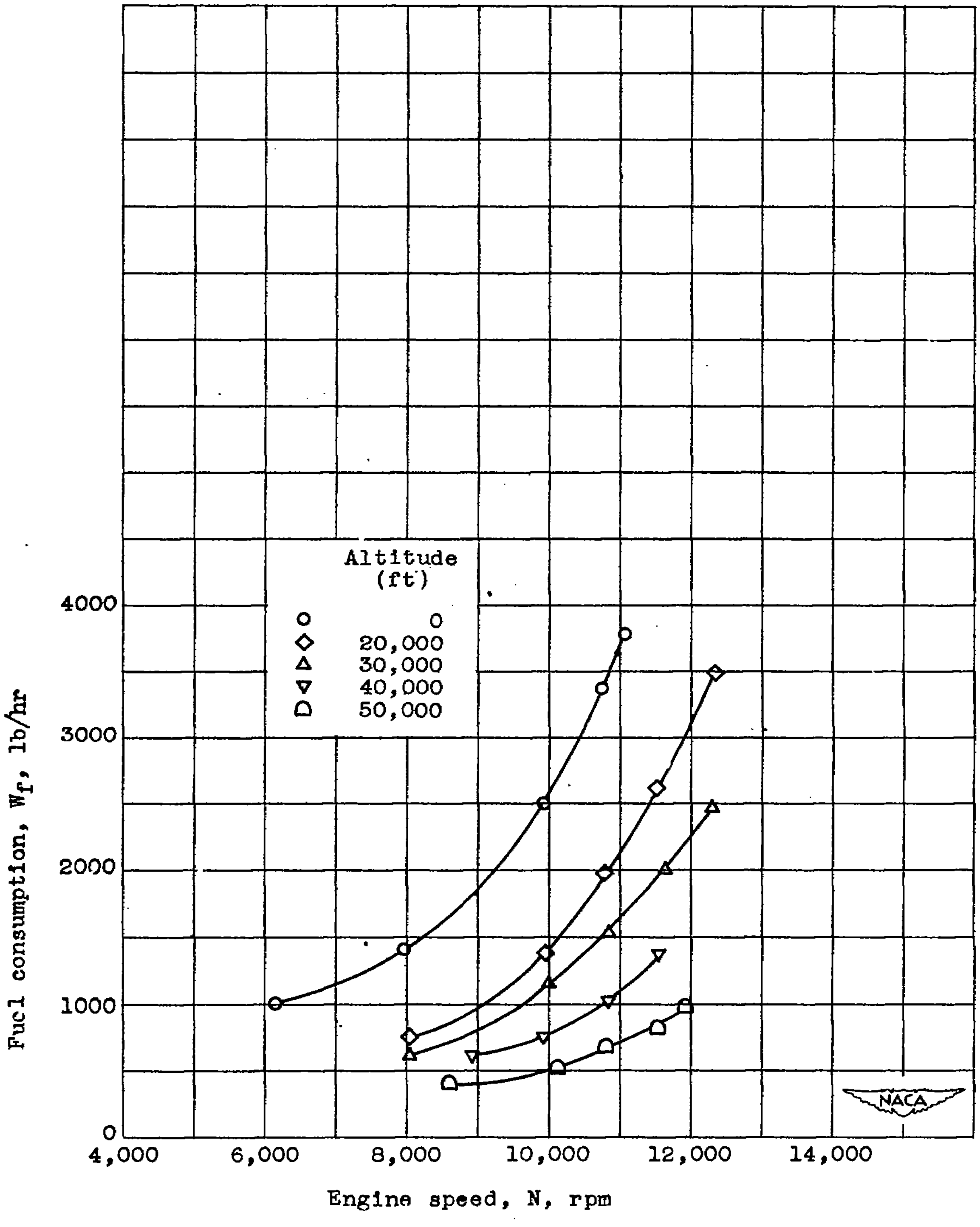


Figure 8. - Effect of altitude on fuel consumption. Ram-pressure ratio, 1.30.

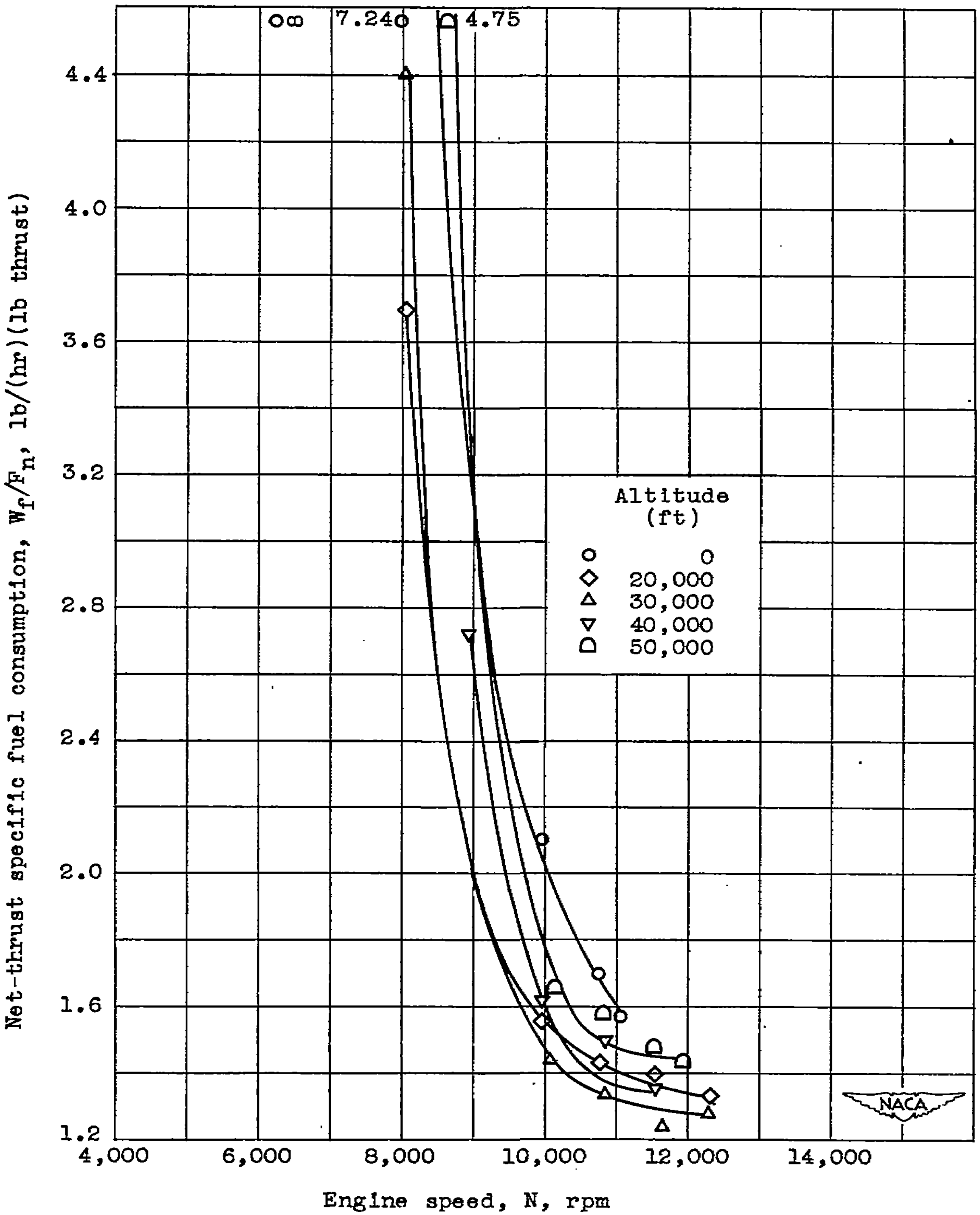


Figure 9. - Effect of altitude on net-thrust specific fuel consumption. Ram-pressure ratio, 1.30.

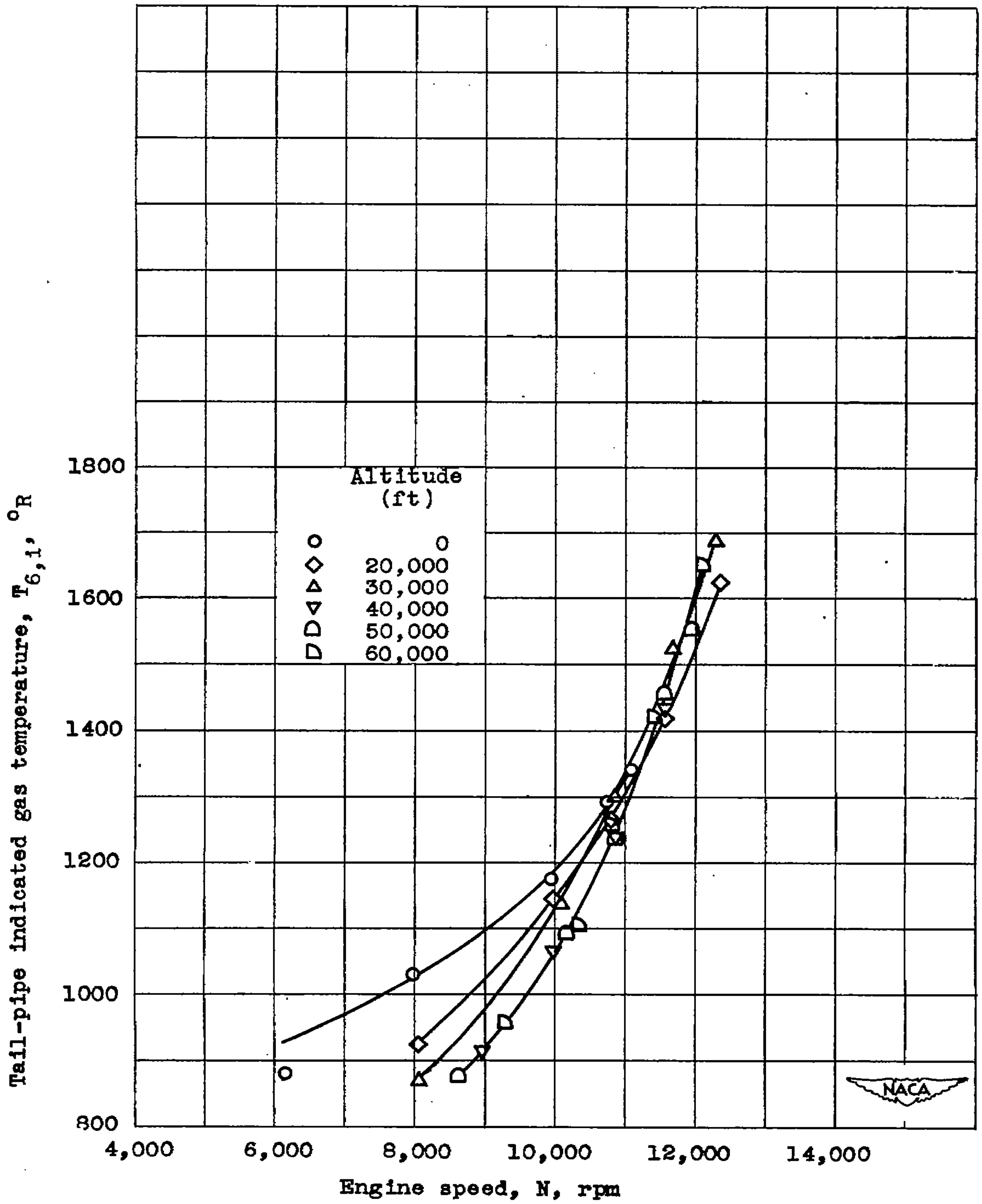


Figure 10. - Effect of altitude on tail-pipe indicated gas temperature. Ram-pressure ratio, 1.30.

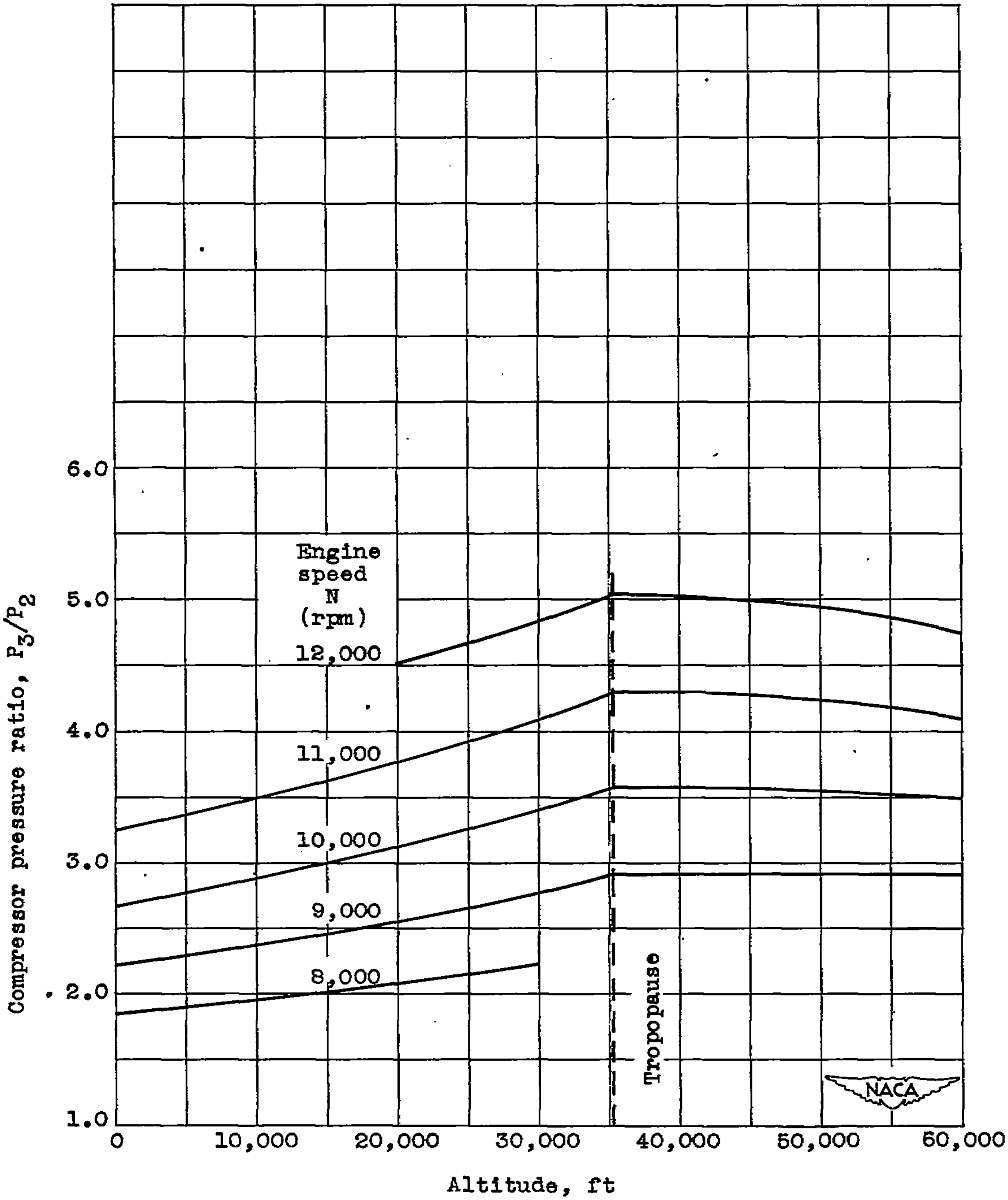


Figure 11. - Effect of altitude on compressor pressure ratio at various engine speeds. Ram-pressure ratio, 1.30.

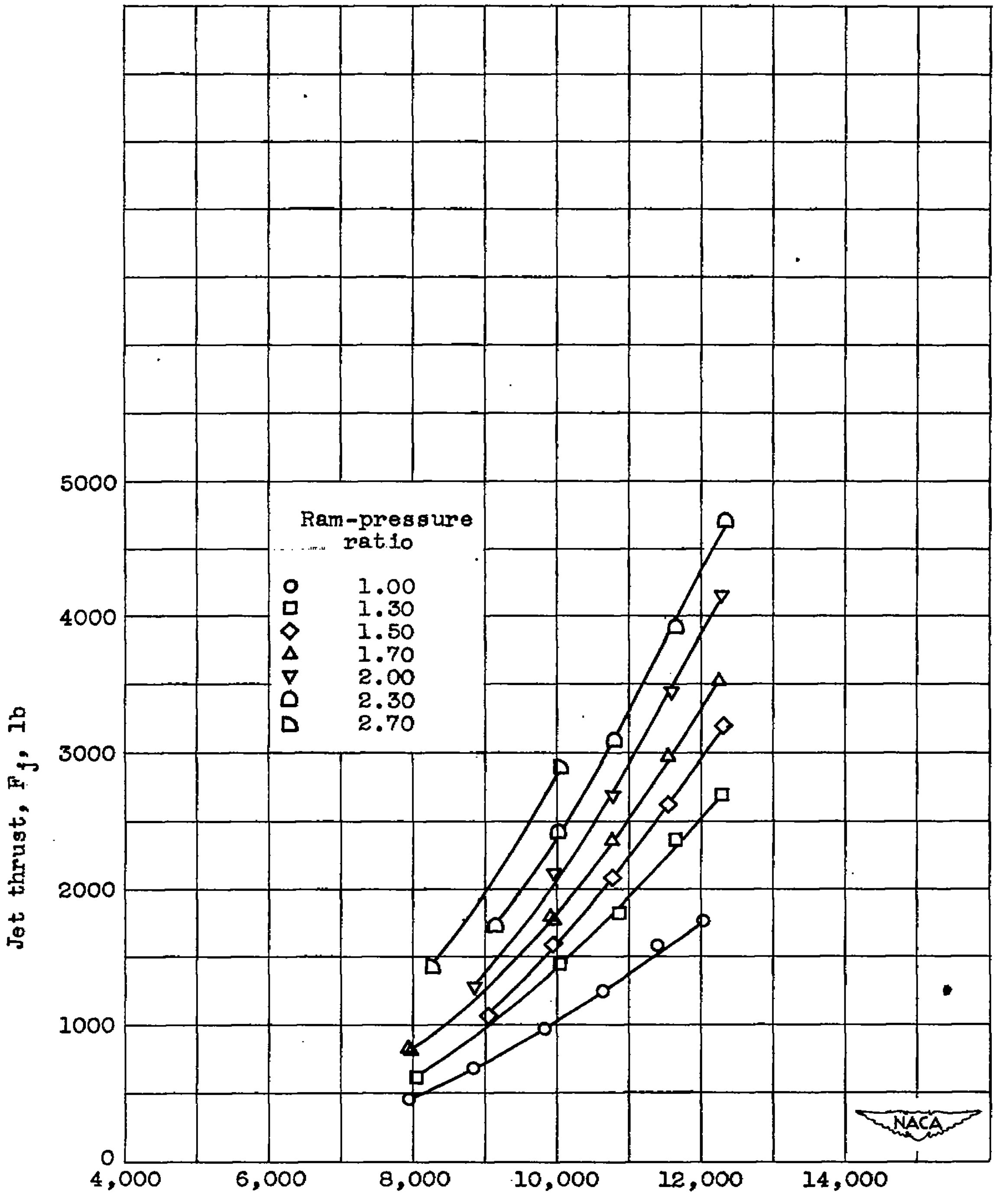


Figure 12. - Effect of ram-pressure ratio on jet thrust. Altitude, 30,000 feet.

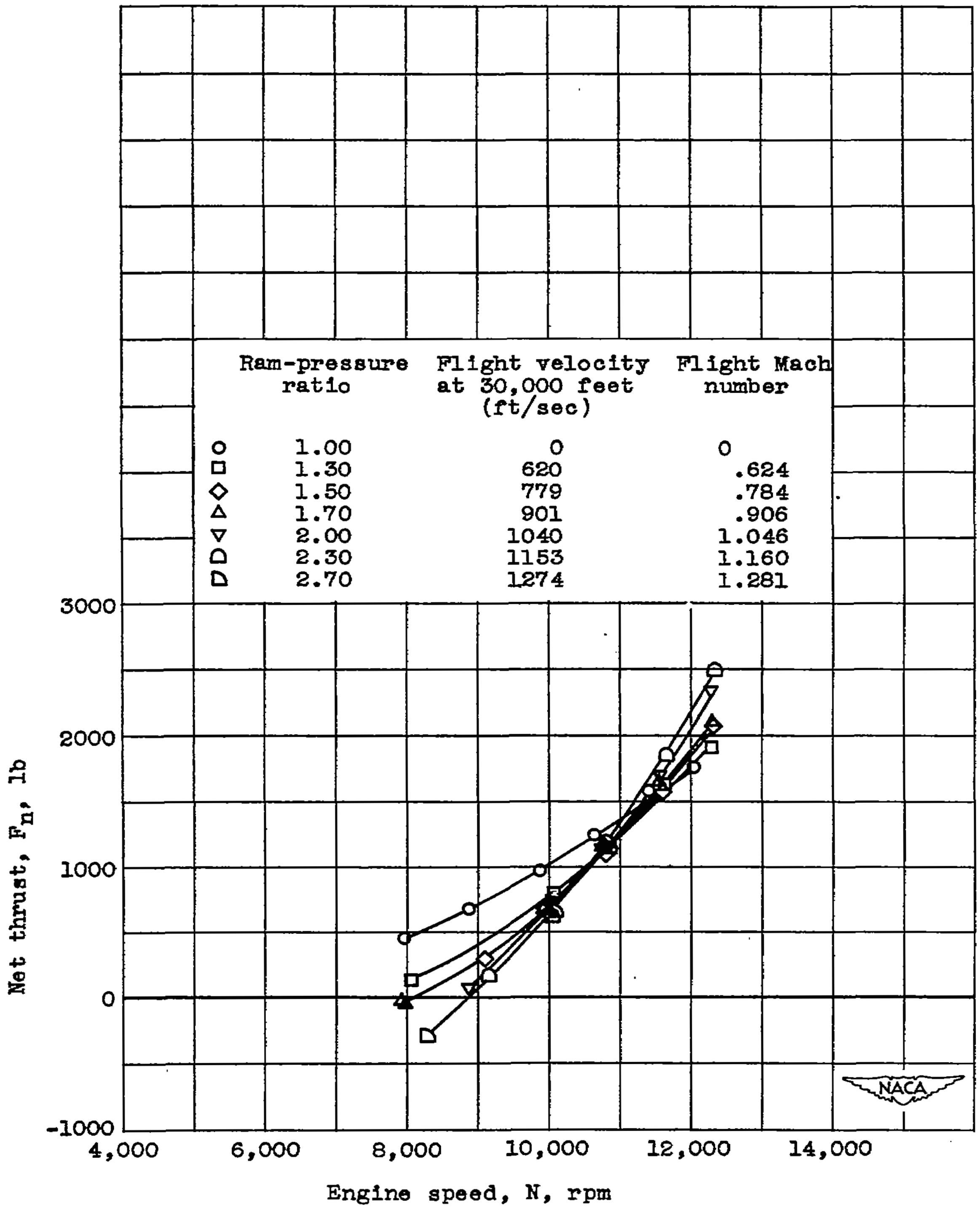


Figure 13. - Effect of ram-pressure ratio on net thrust. Altitude, 30,000 feet.

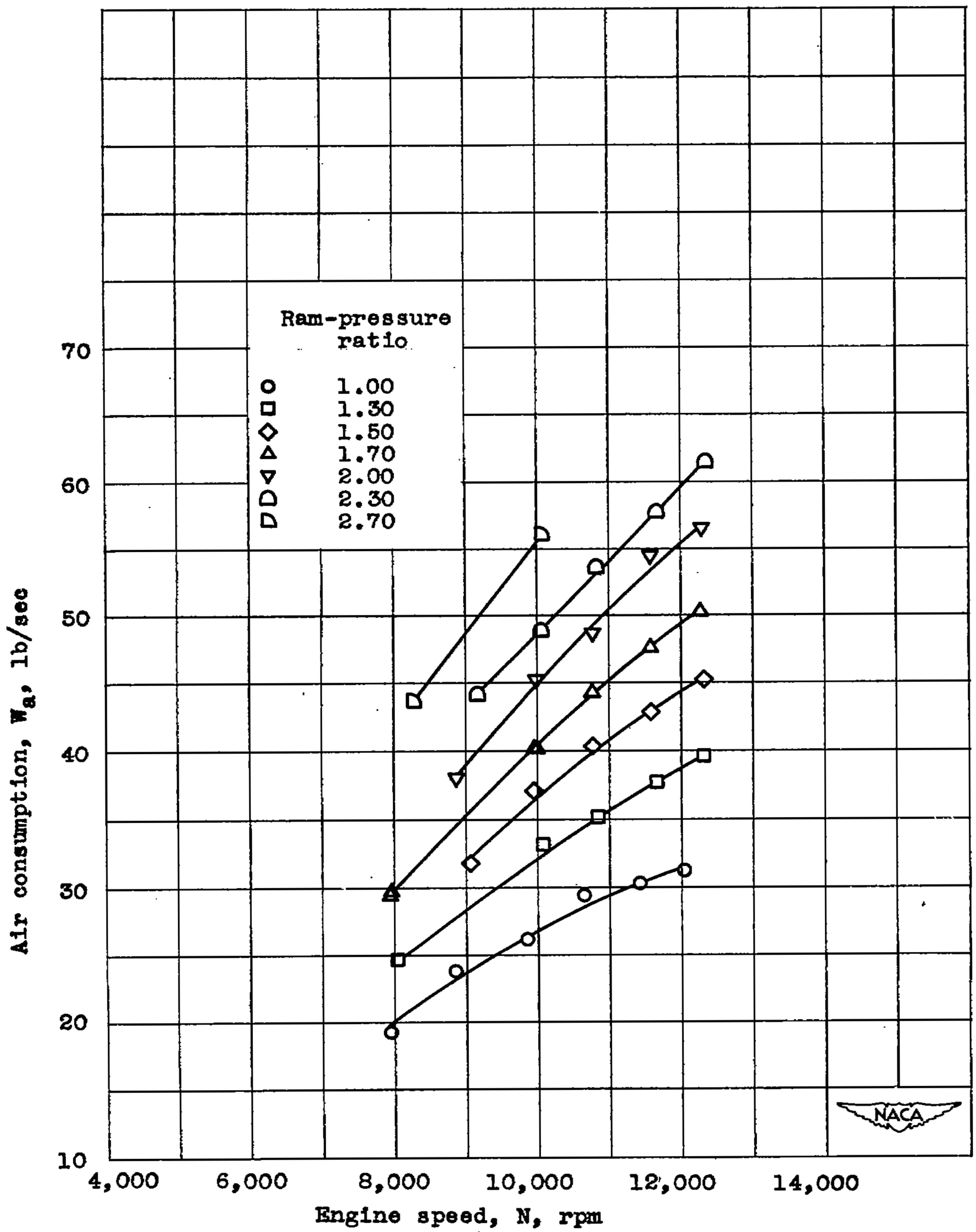


Figure 14. - Effect of ram-pressure ratio on air consumption. Altitude, 30,000 feet.

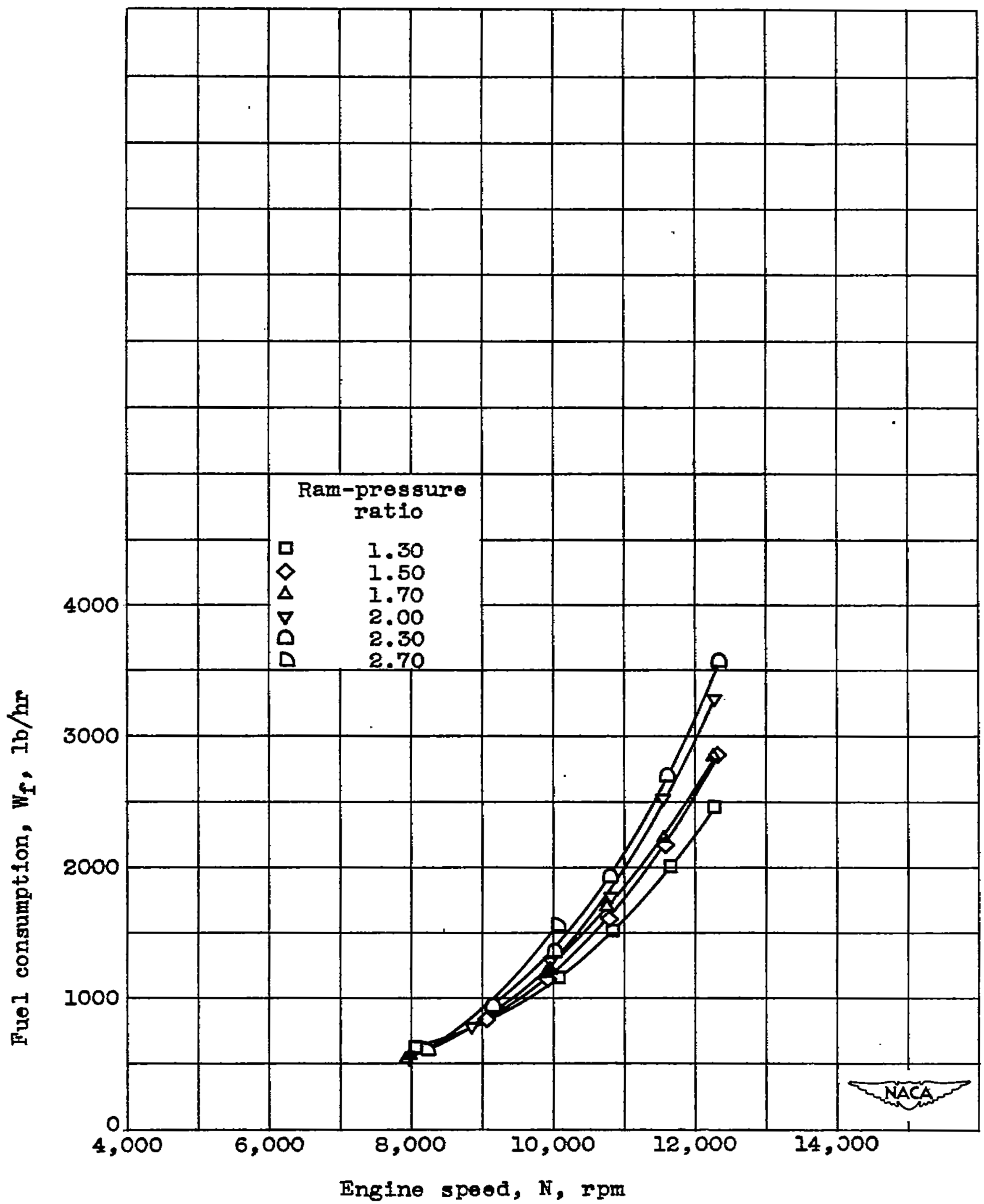


Figure 15. - Effect of ram-pressure ratio on fuel consumption. Altitude, 30,000 feet.

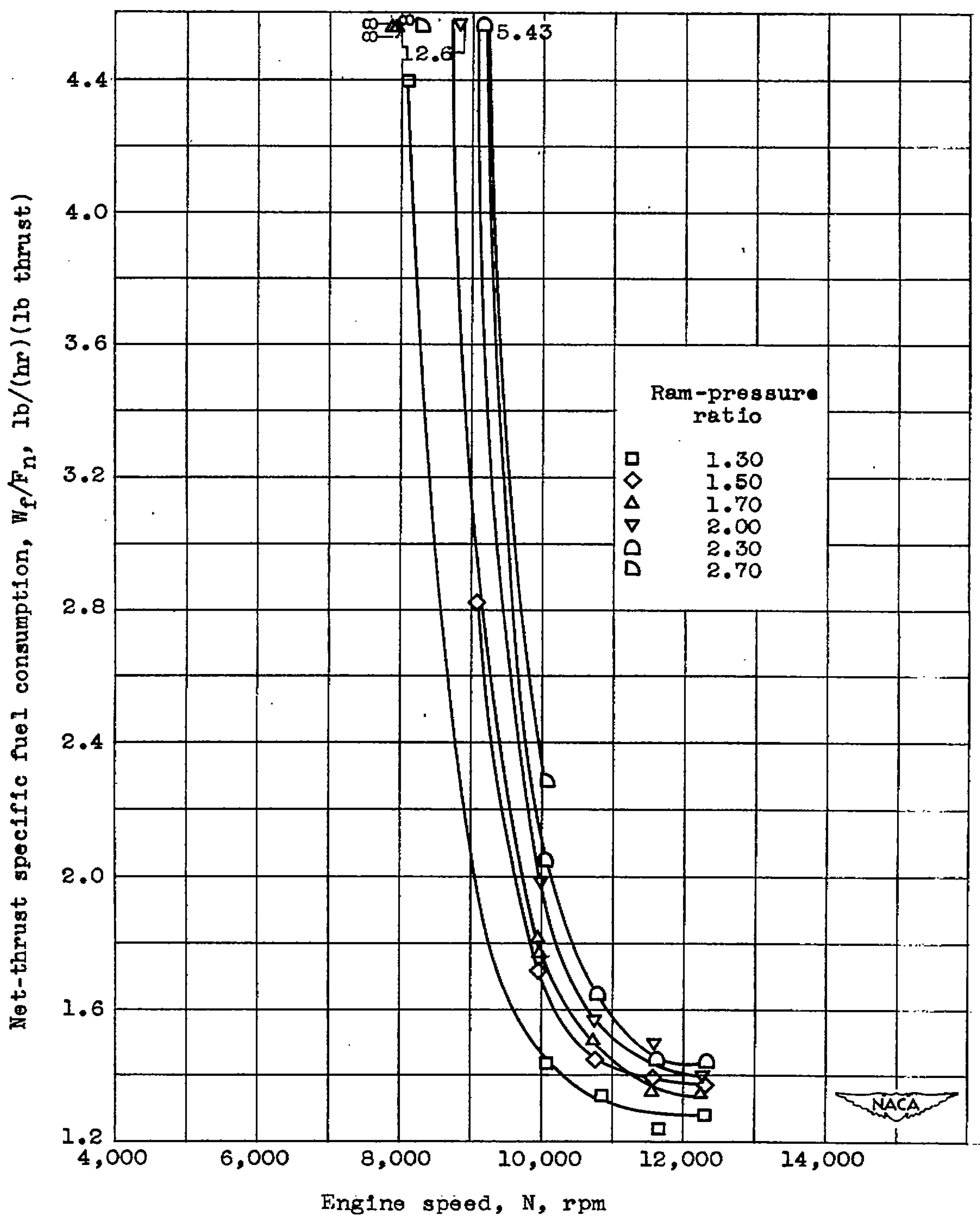


Figure 16. - Effect of ram-pressure ratio on net-thrust specific fuel consumption. Altitude, 30,000 feet.

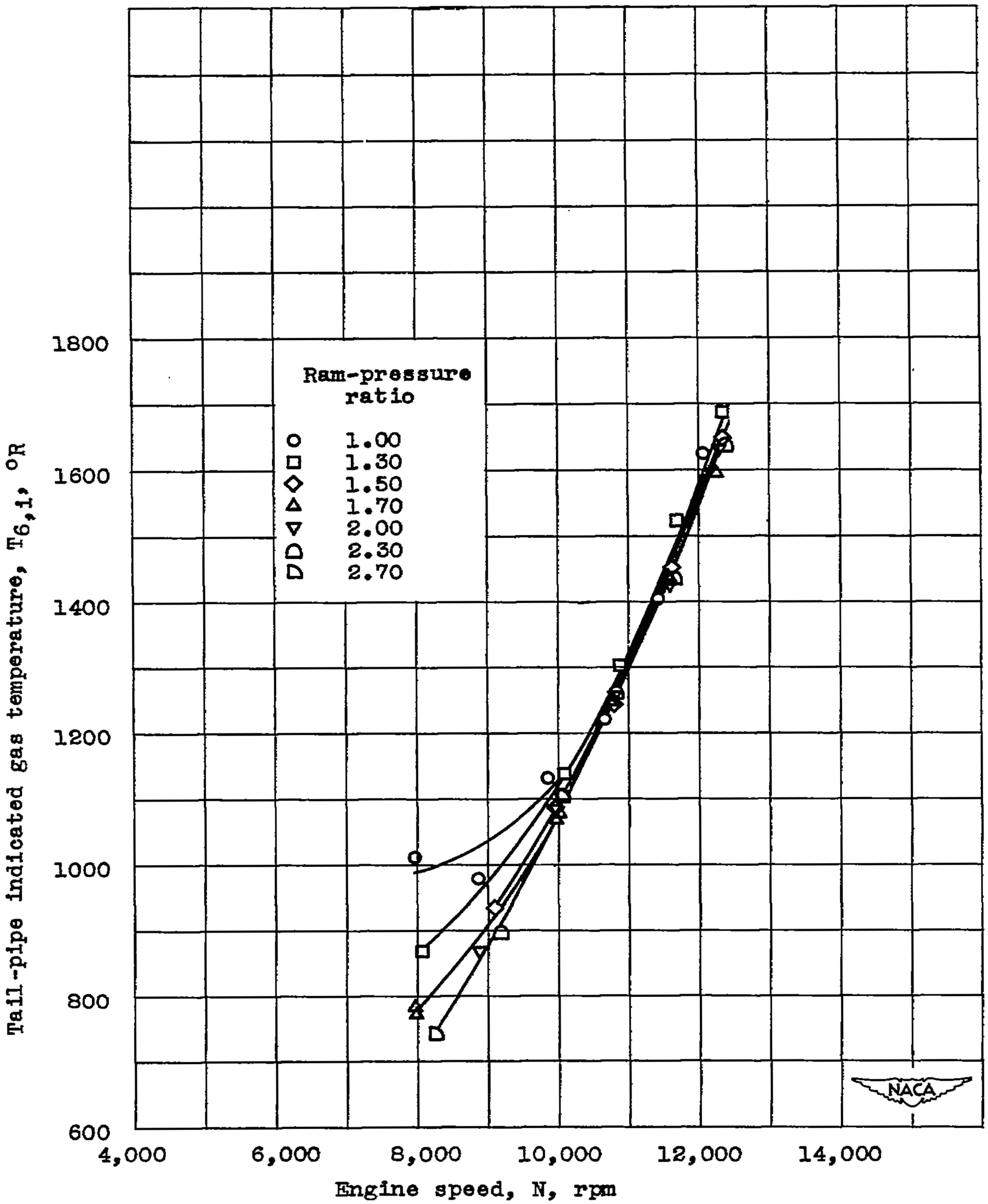


Figure 17. - Effect of ram-pressure ratio on tail-pipe indicated gas temperature. Altitude, 30,000 feet.

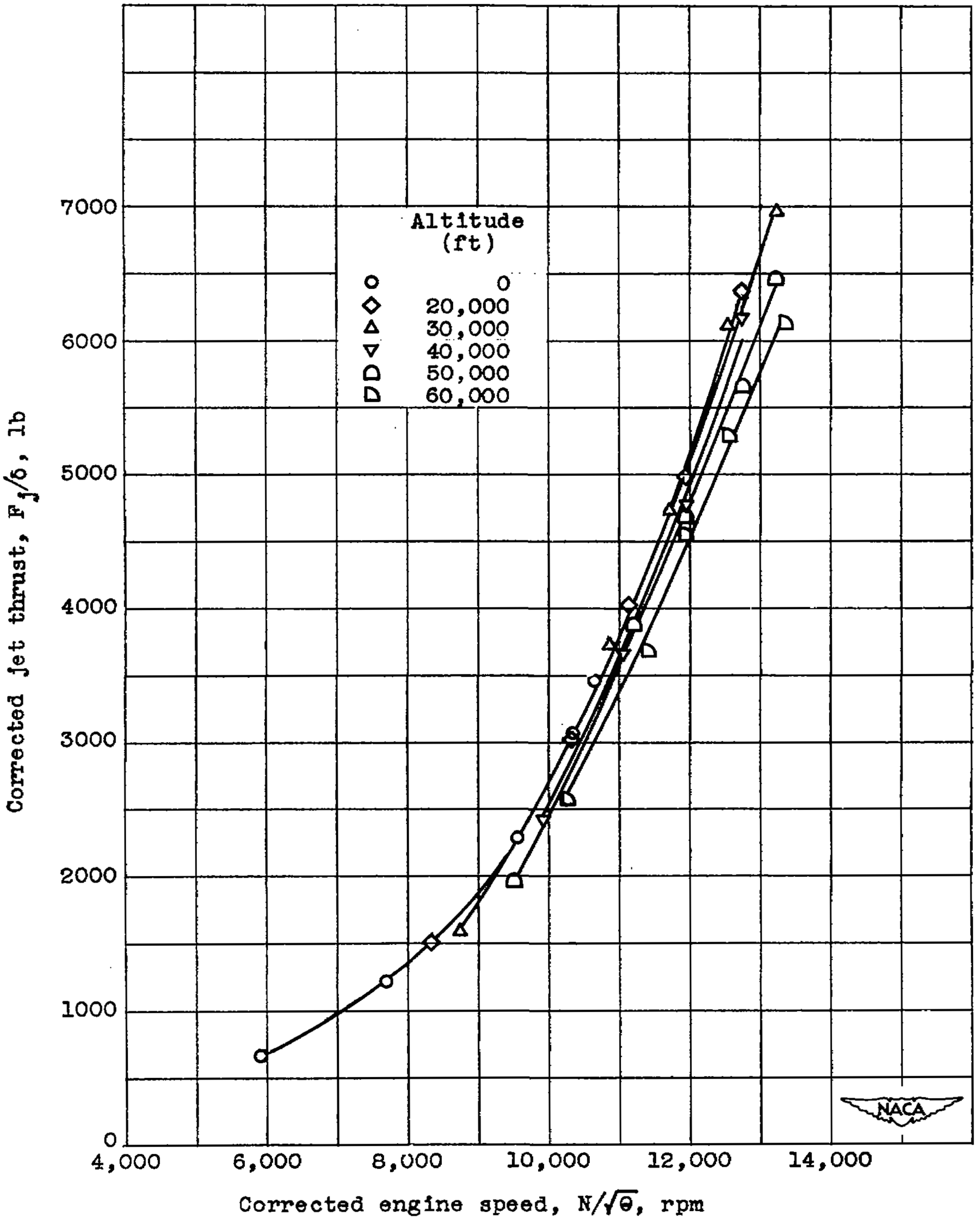


Figure 18. - Effect of altitude on corrected jet thrust. Ram-pressure ratio, 1.30.

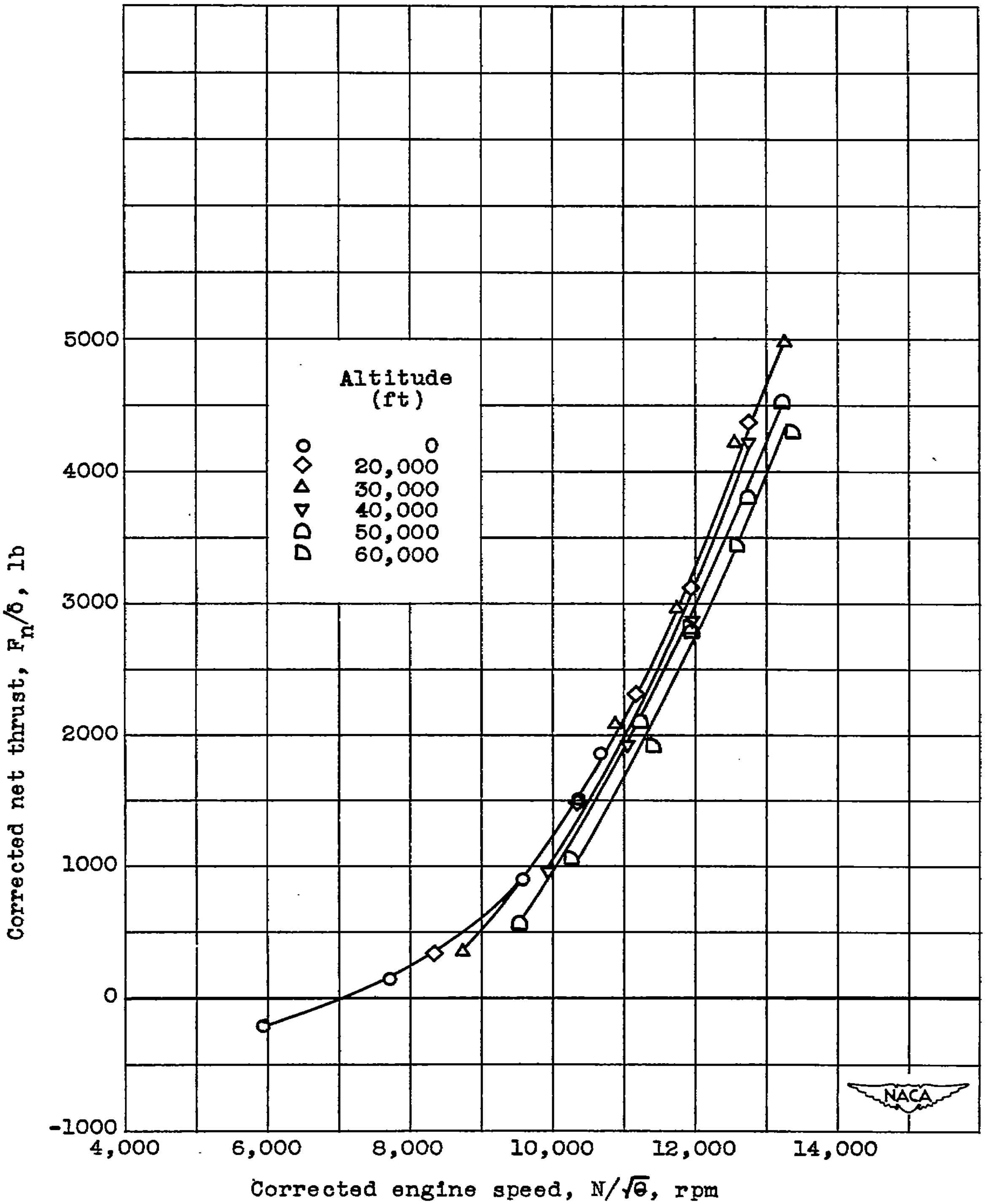


Figure 19. - Effect of altitude on corrected net thrust.
Ram-pressure ratio, 1.30.

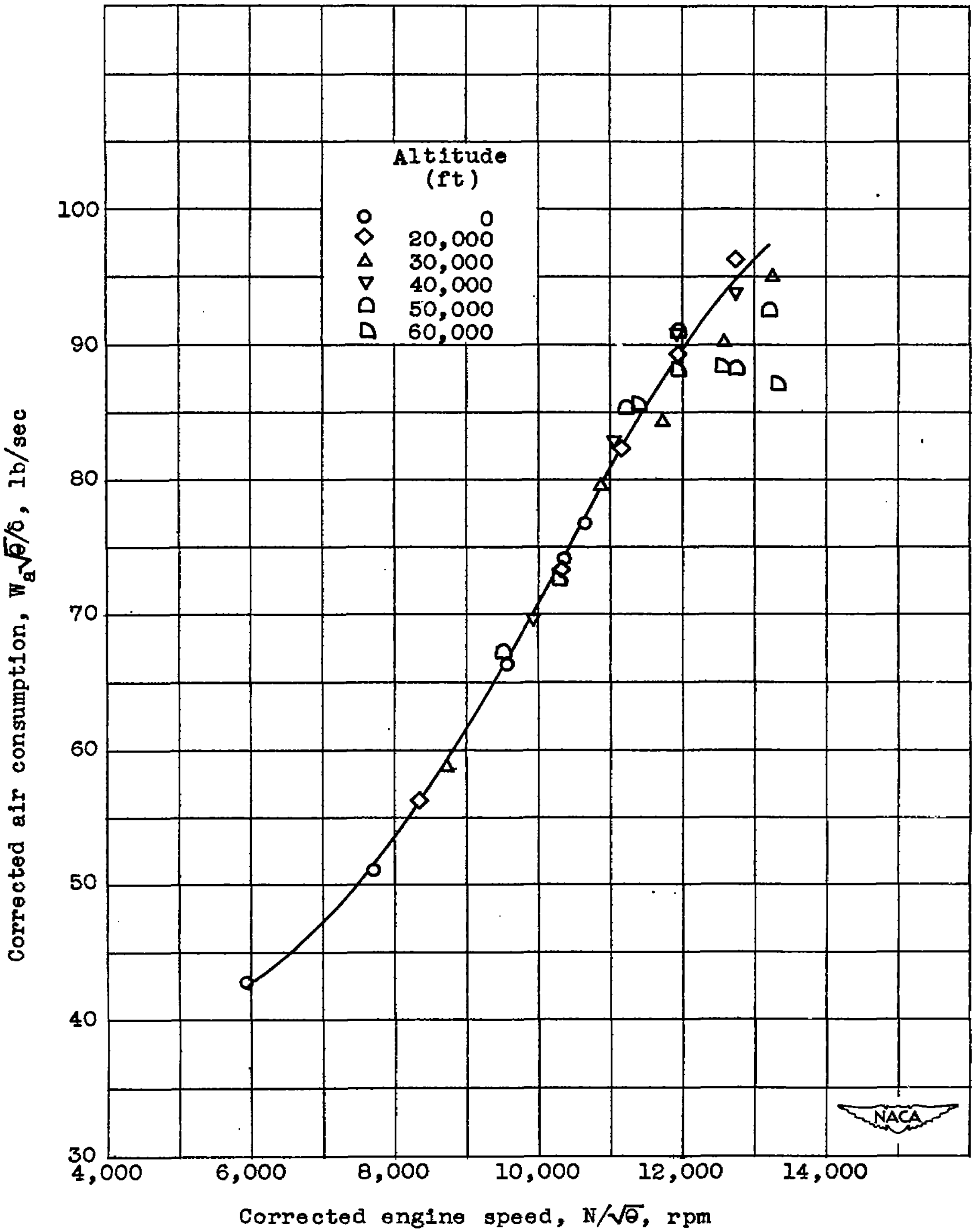


Figure 20. - Effect of altitude on corrected air consumption. Ram-pressure ratio, 1.30.

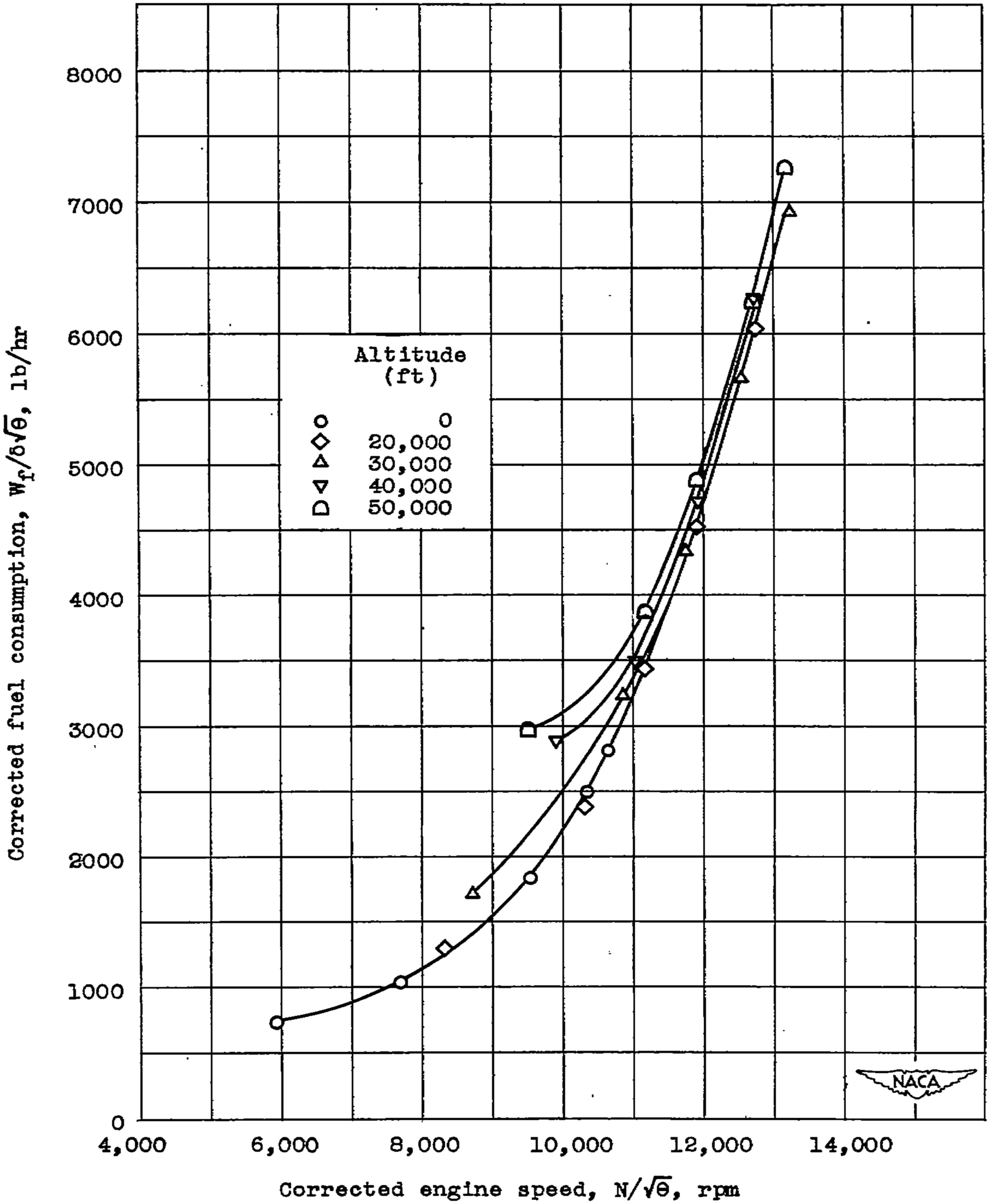


Figure 21. - Effect of altitude on corrected fuel consumption. Ram-pressure ratio, 1.30.

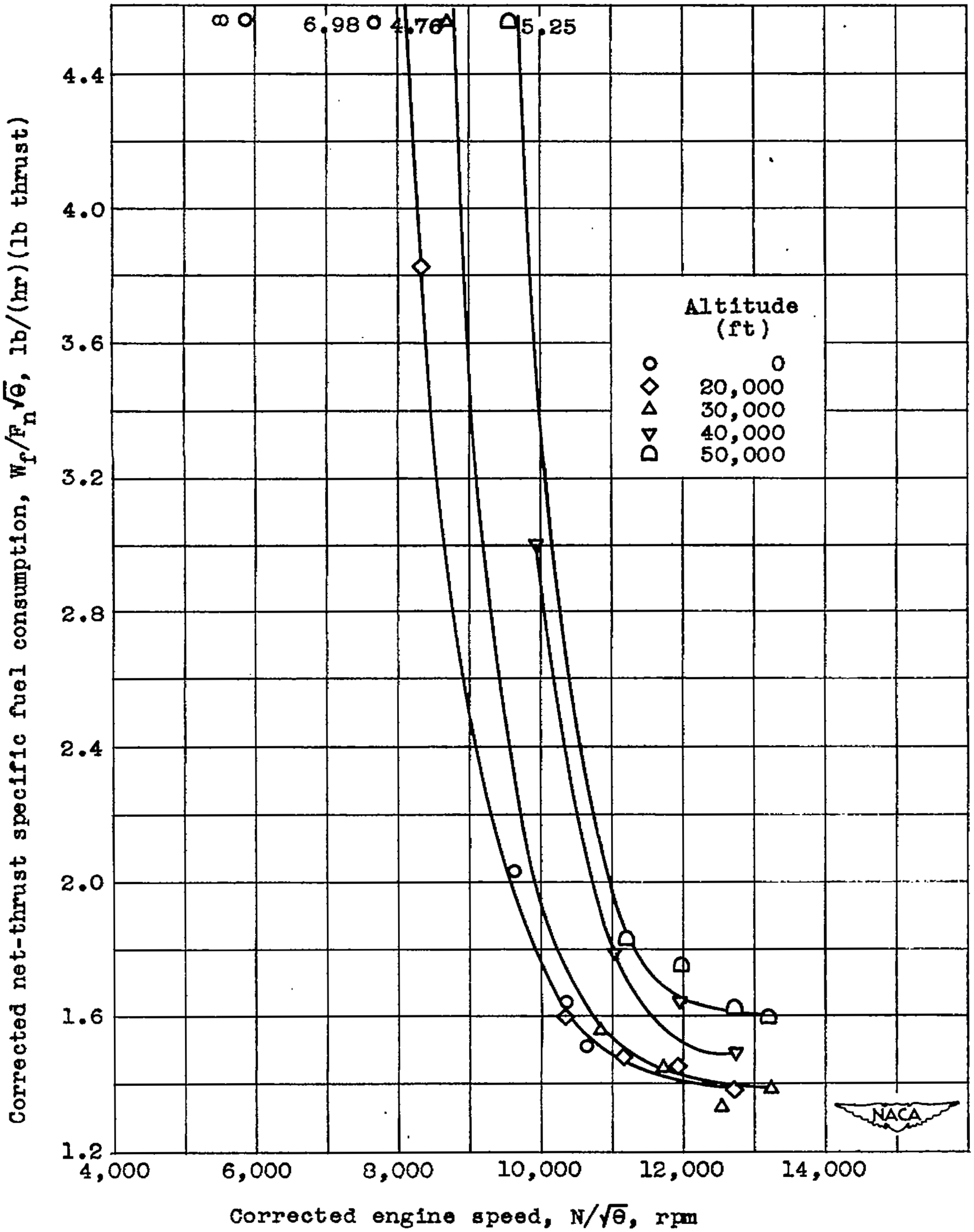
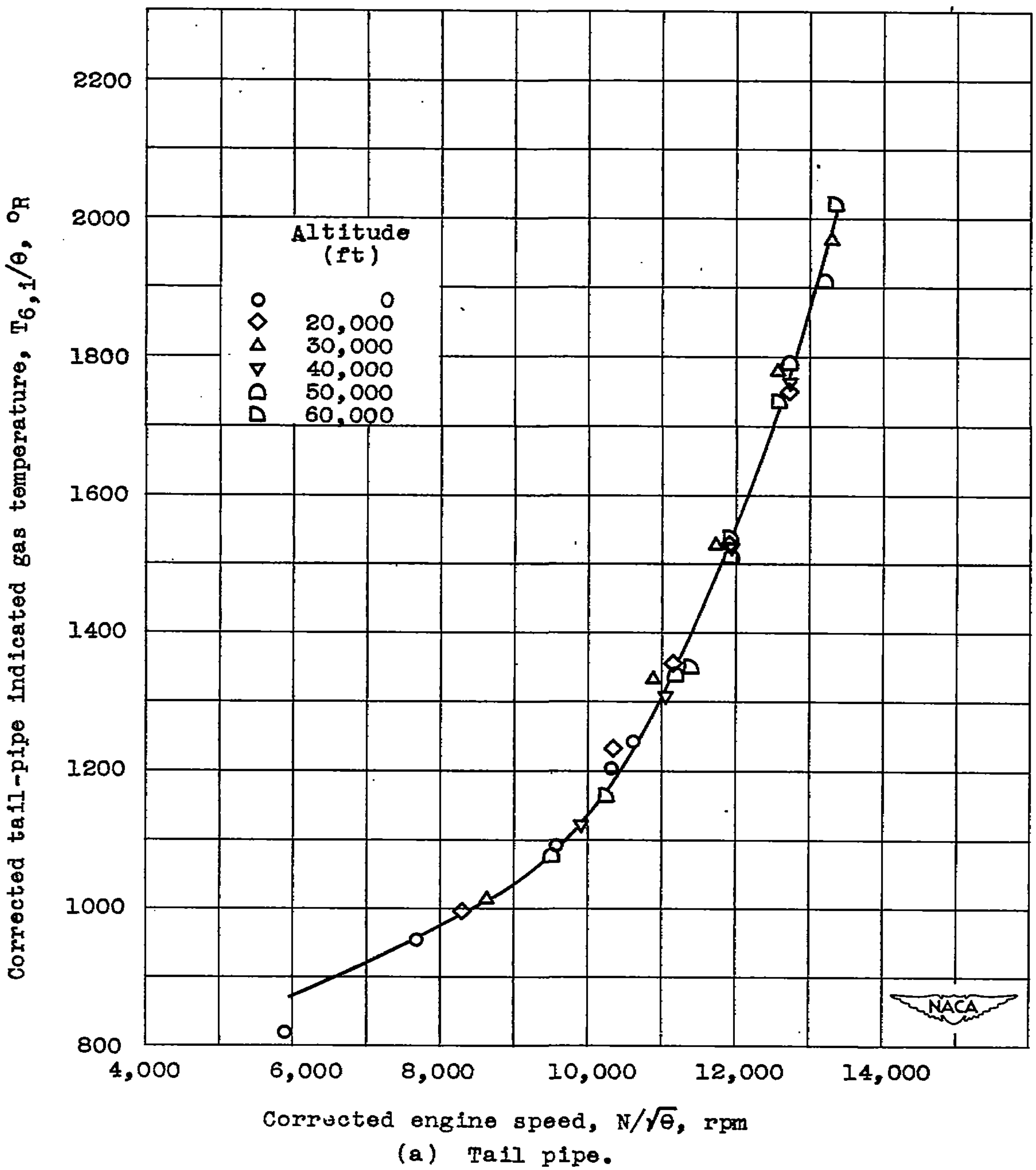
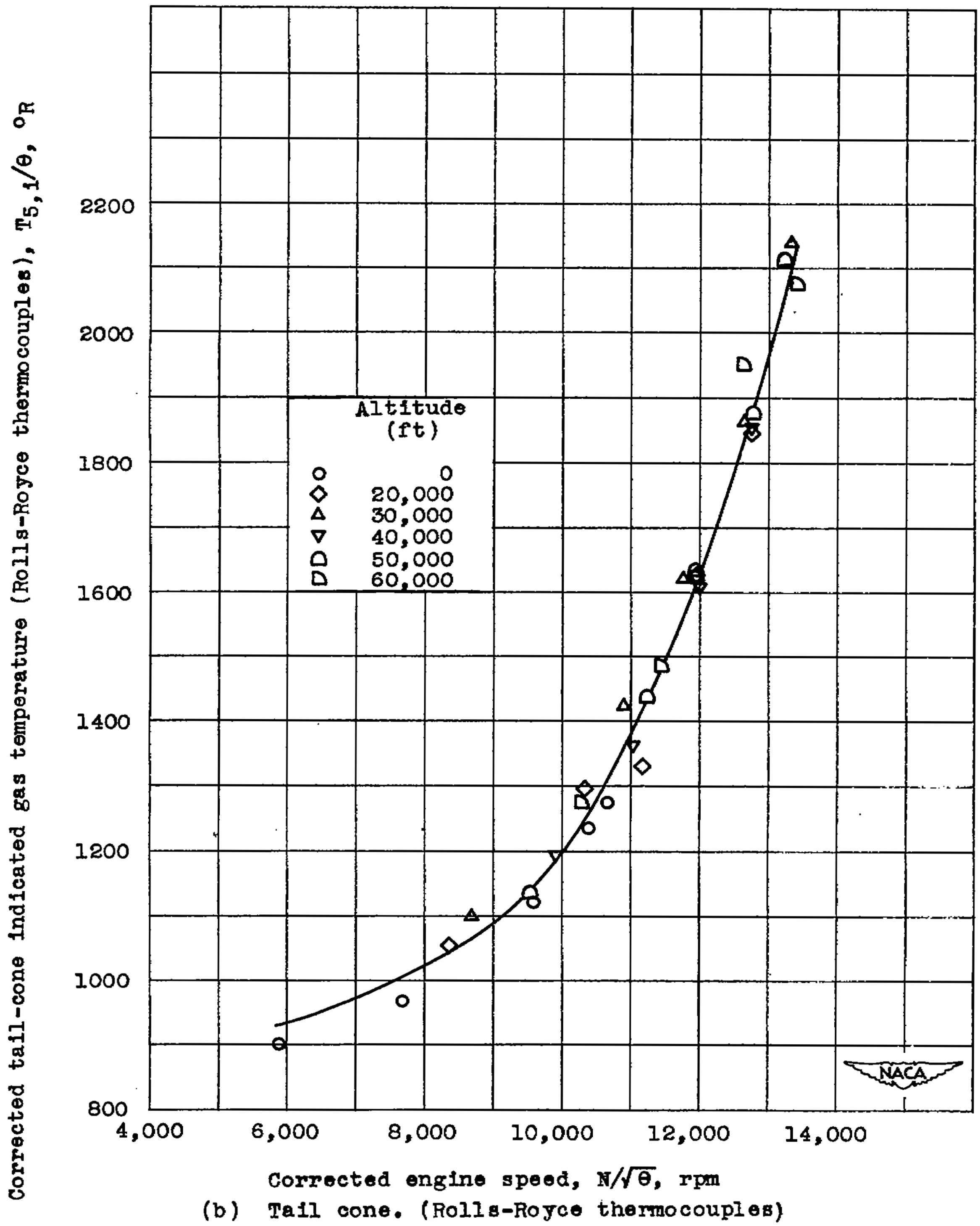


Figure 22. - Effect of altitude on corrected net-thrust specific fuel consumption. Ram-pressure ratio, 1.30.



(a) Tail pipe.

Figure 23. - Effect of altitude on corrected indicated gas temperatures. Ram-pressure ratio, 1.30.



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

Figure 23. - Concluded. Effect of altitude on corrected indicated gas temperatures. Ram-pressure ratio, 1.30.

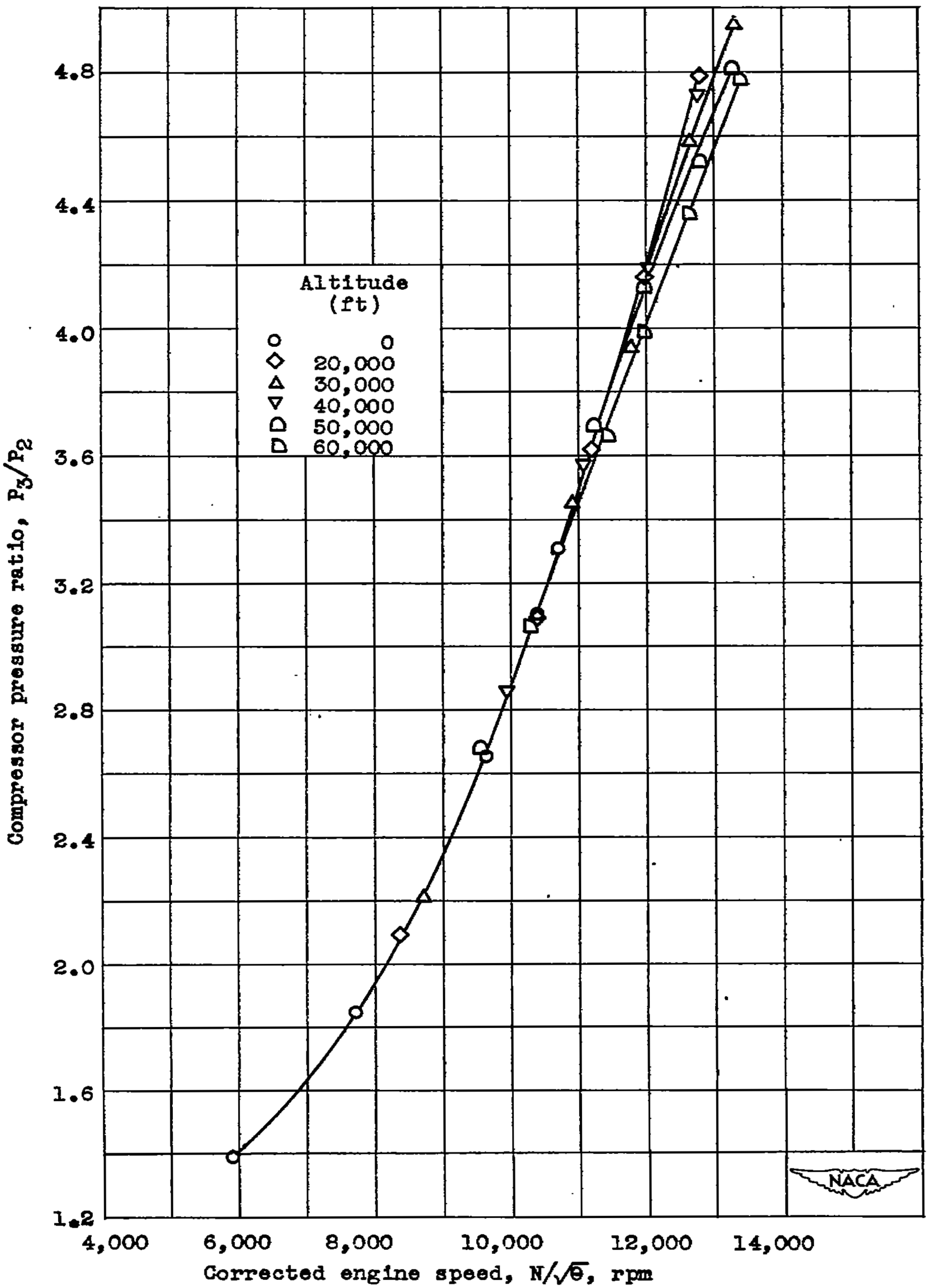
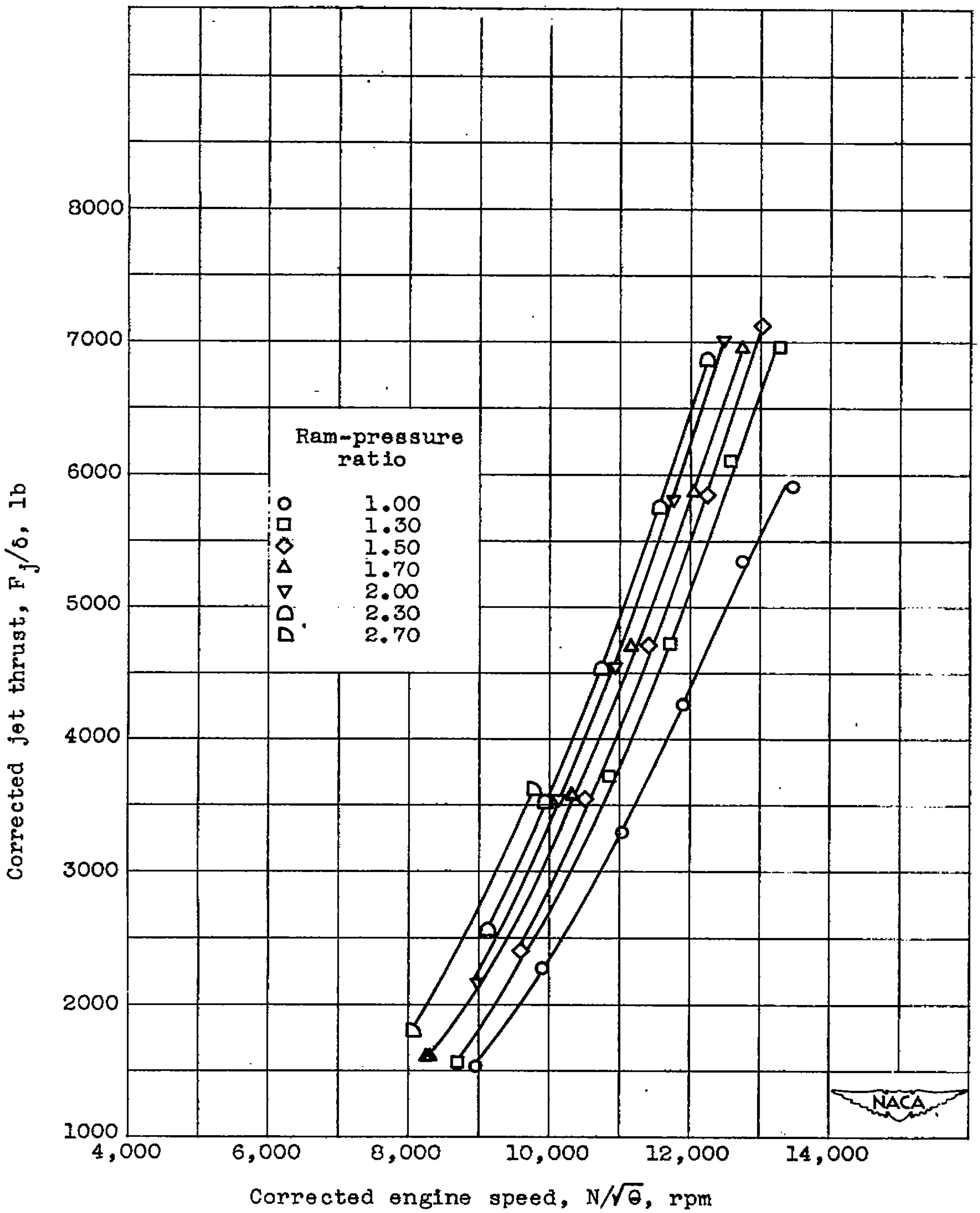
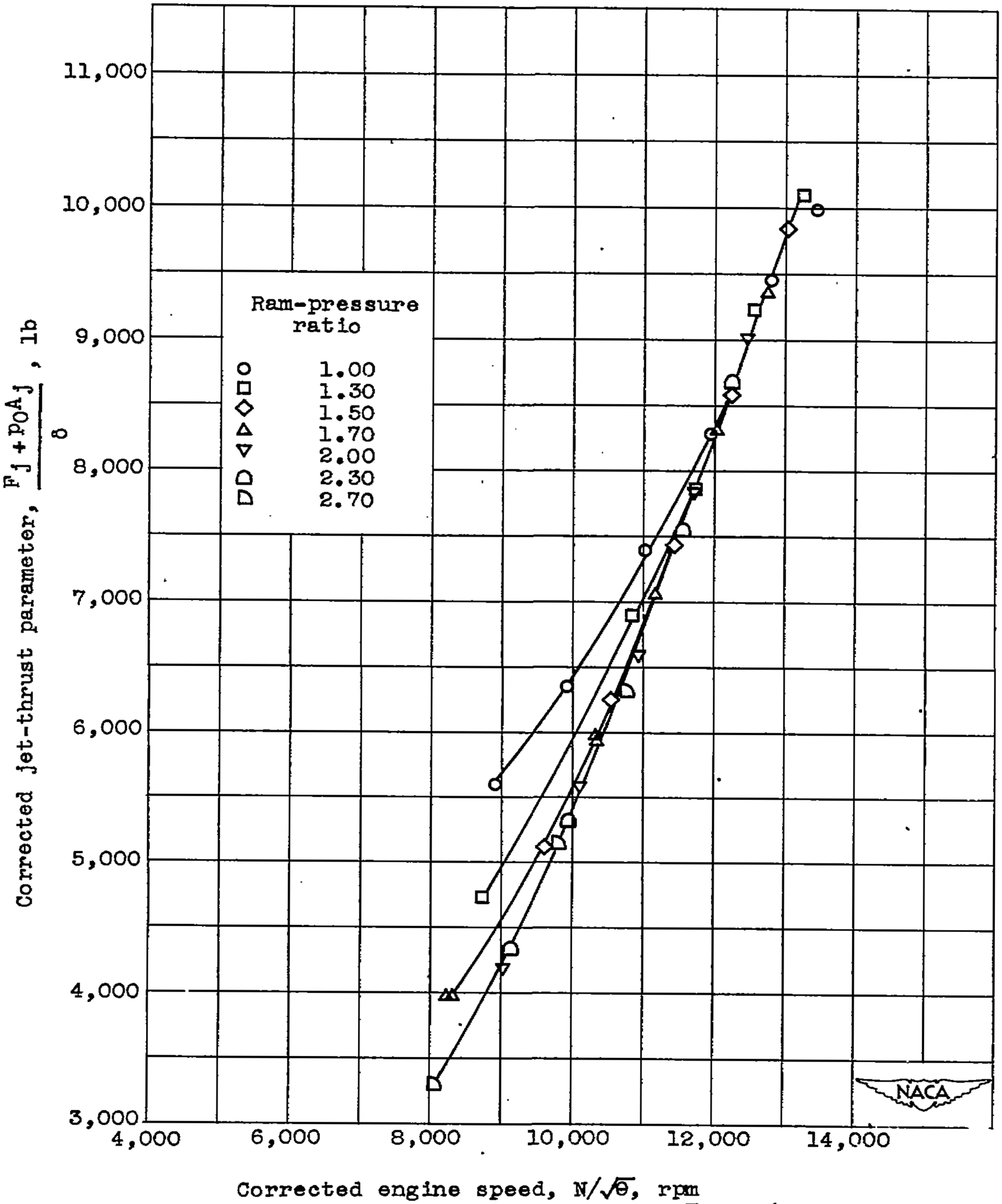


Figure 24. - Effect of altitude on compressor pressure ratio. Ram-pressure ratio, 1.30.



(a) Corrected jet thrust, F_j/δ.

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



(b) Corrected jet-thrust parameter, $\frac{F_j + p_0 A_j}{\delta}$

Figure 25. - Concluded. Effect of ram-pressure ratio on corrected jet thrust. Altitude, 30,000 feet.

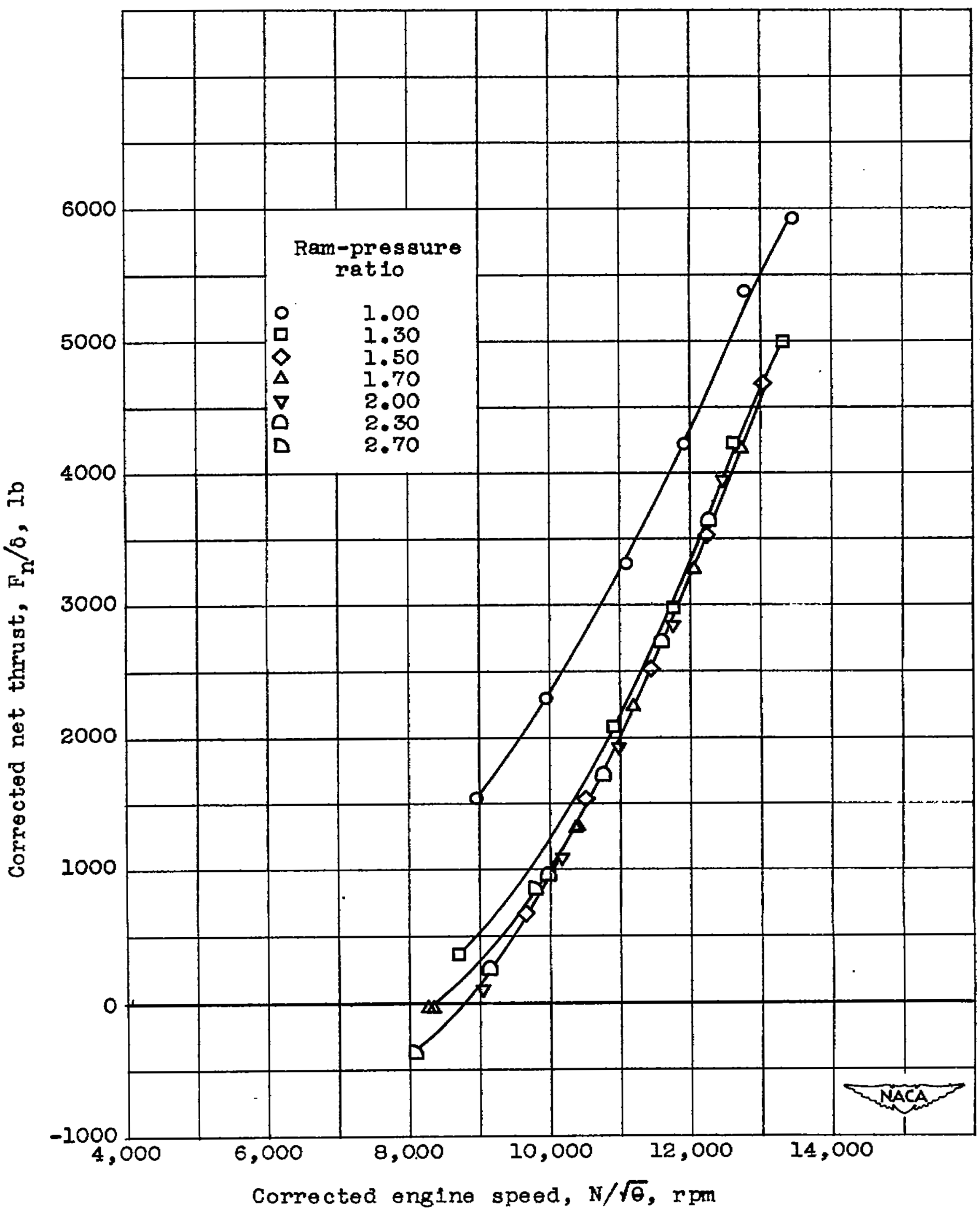


Figure 26. - Effect of ram-pressure ratio on corrected net thrust. Altitude, 30,000 feet.

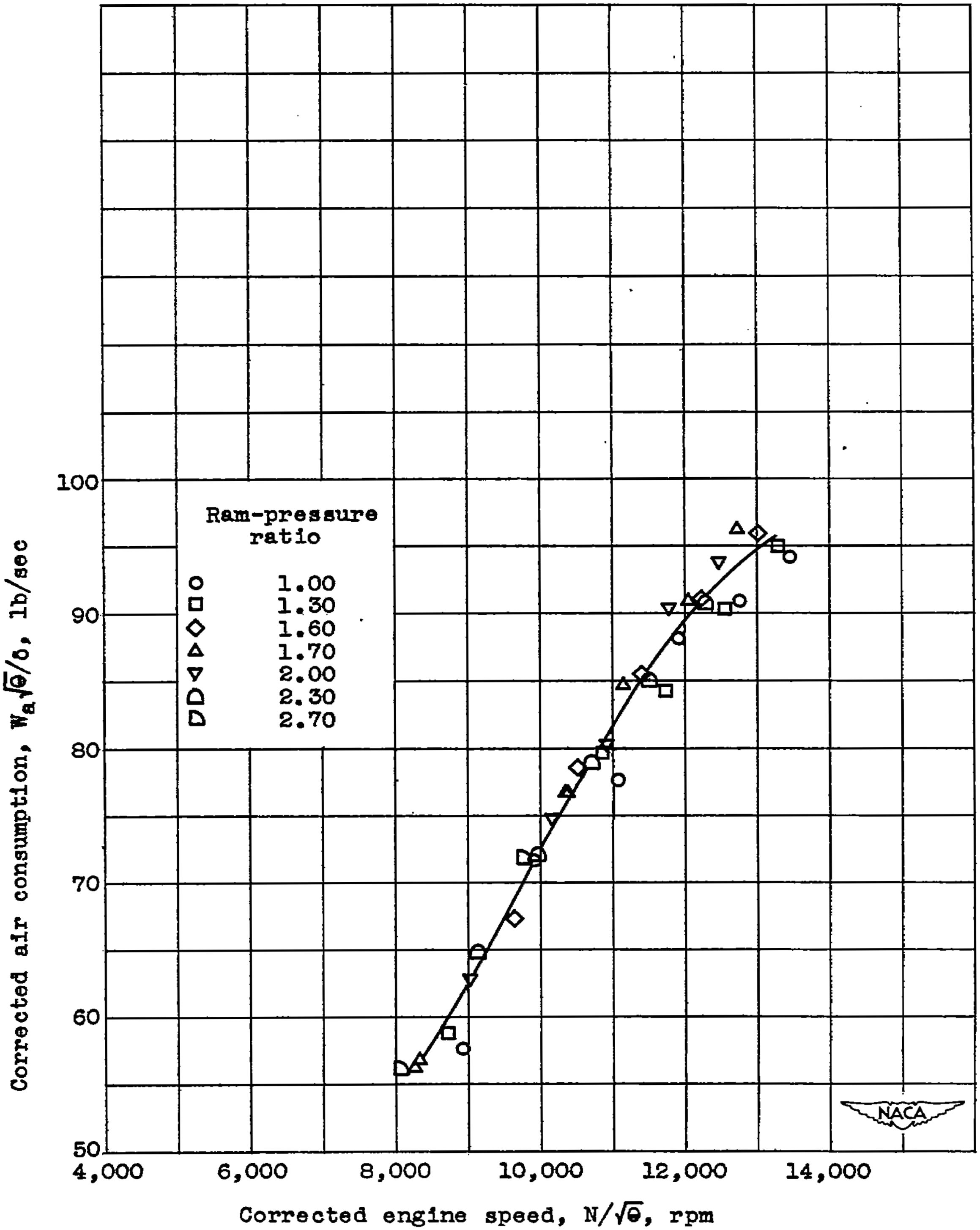


Figure 27. - Effect of ram-pressure ratio on corrected air consumption. Altitude, 30,000 feet.

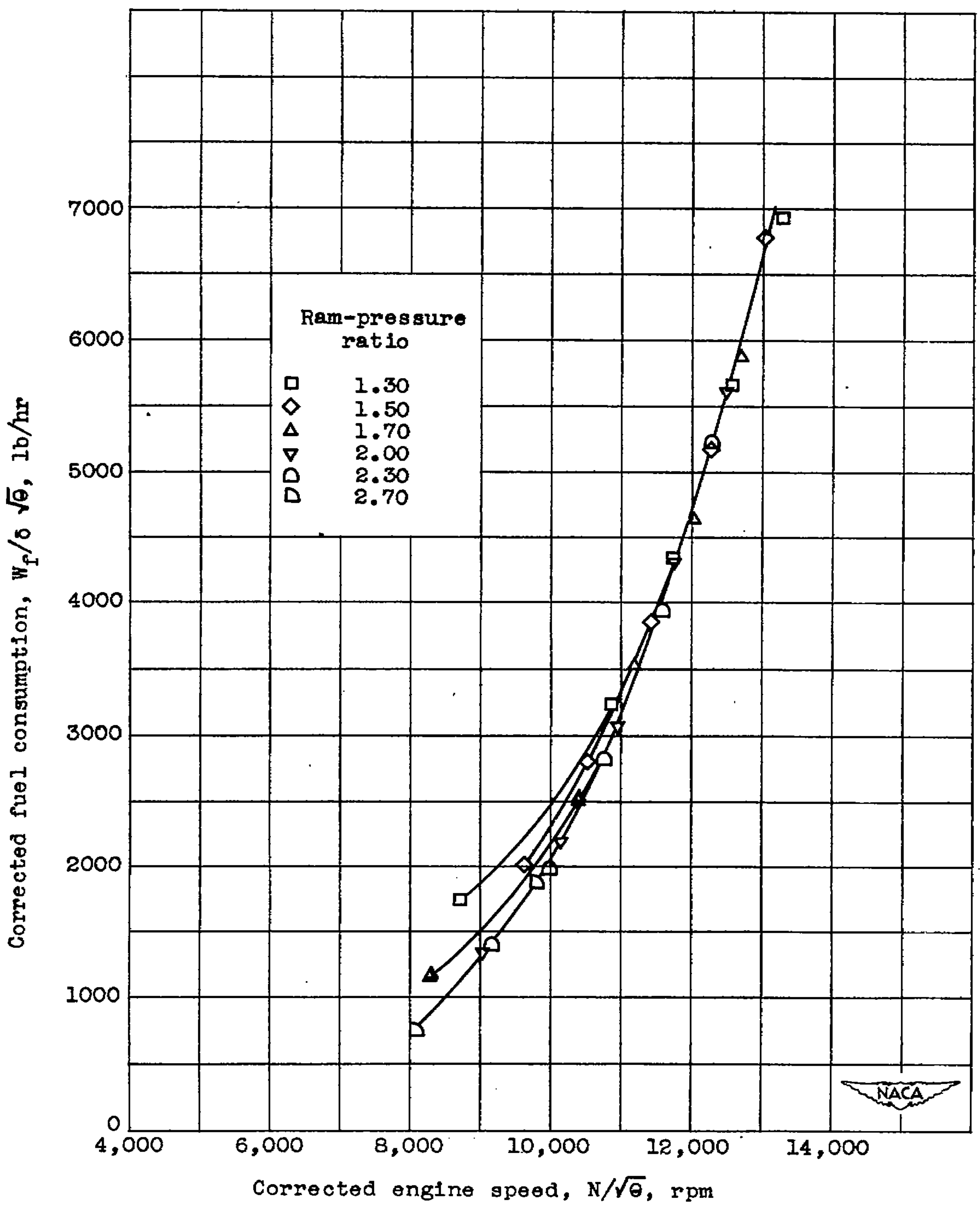


Figure 28. - Effect of ram-pressure ratio on corrected fuel consumption. Altitude, 30,000 feet.

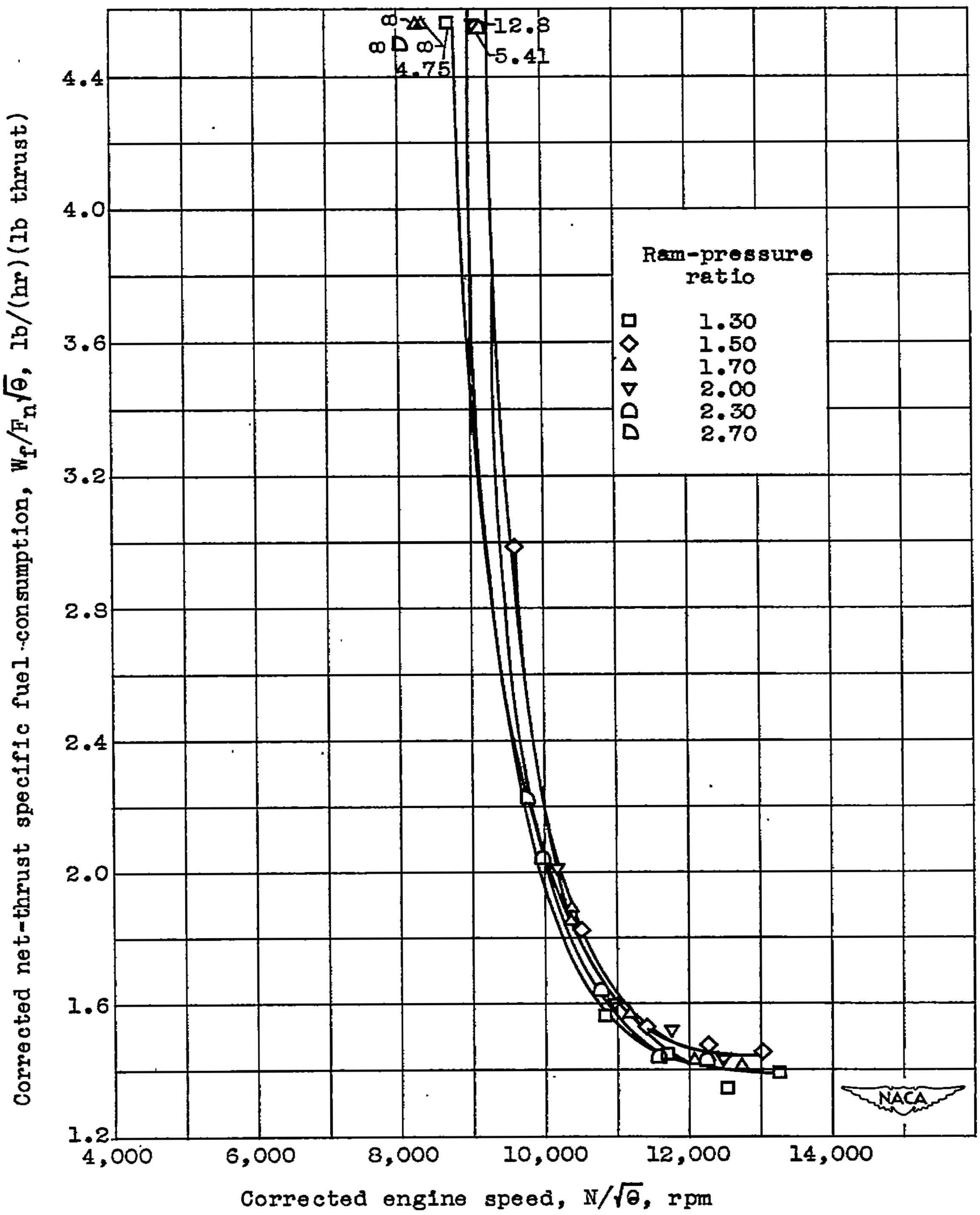


Figure 29. - Effect of ram-pressure ratio on corrected net-thrust specific fuel consumption. Altitude, 30,000 feet.

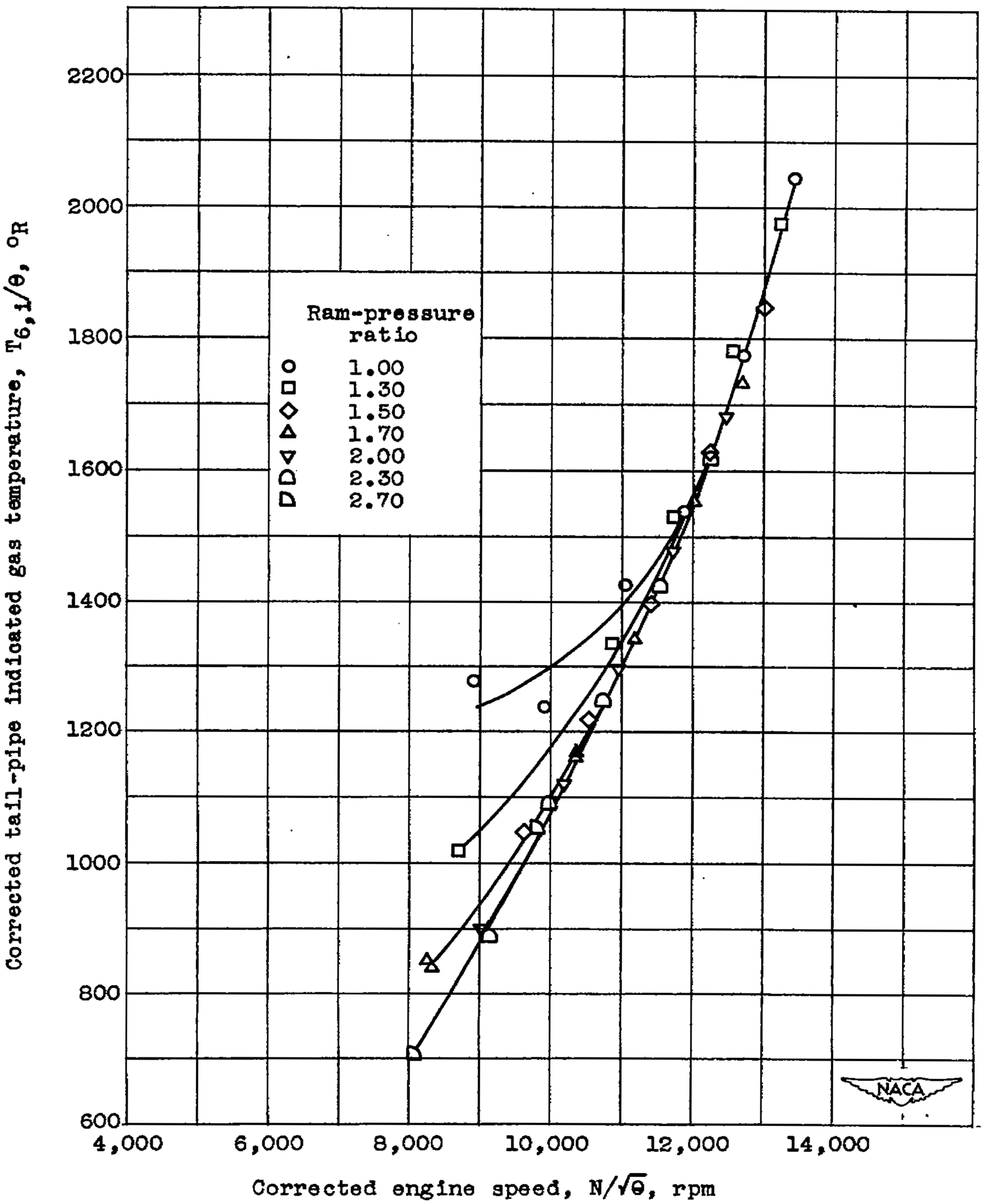


Figure 30.- Effect of ram-pressure ratio on corrected tail-pipe indicated temperature. Altitude, 30,000 feet.