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RESEARCH MEMORANDUM

PRELIMINARY RESULTS OF AN ALTITUDE-WIND-TUNNEL INVESTIGATION OF AN AXIAL-FLOW GAS TURBINE-PROPELLER ENGINE

I - PERFORMANCE CHARACTERISTICS

By Martin J. Saari and Lewis E. Wallner

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RESEARCH MEMORANDUM

PRELIMINARY RESULTS OF AN ALTITUDE-WIND-TUNNEL INVESTIGATION OF AN AXIAL-FLOW GAS TURBINE-PROPELLER ENGINE

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SUMMARY

A preliminary investigation of an axial-flow gas turbine-propeller engine has been conducted in the Cleveland altitude wind tunnel. Performance data were obtained for engine speeds from 8000 to 13,000 rpm at altitudes from 5000 to 35,000 feet and compressor-inlet ram-pressure ratios from 1.00 to 1.17. In order to conserve turbine life, the maximum exhaust-gas temperatures were limited to values from 50° to 100° F below the normal continuous temperature rating. A tabulation of performance data is presented together with curves of performance characteristics and a brief discussion of the results. A complete description of the instrumentation of the installation is given.

For a constant compressor-inlet ram-pressure ratio, the performance data obtained at different altitudes and engine speeds were generalized to standard sea-level conditions with reasonable accuracy. The specific fuel consumption at a given corrected engine speed decreased as the corrected shaft horsepower was increased. At a corrected engine speed of 13,000 rpm, the specific fuel consumption based on shaft horsepower decreased from 1.41 at a corrected shaft horsepower of 700 to 0.86 at a corrected shaft horsepower of 1800. At each altitude and engine speed an increase in shaft horsepower of 100 percent was accompanied by an increase in jet thrust of about 10 percent. When the engine speed was changed from 10,000 to 13,000 rpm at a constant turbine-inlet temperature, the jet thrust increased at a greater rate than the shaft horsepower. At a turbine-inlet temperature of 2000° R, this change in engine speed was accompanied by an increase in jet thrust of about 115 percent and an increase in shaft horsepower of 55 percent. In order to obtain an optimum ratio of shaft

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horsepower to the kinetic energy of the jet at operating conditions other than the design condition, a variable-area tail-pipe nozzle is required. An increase in compressor-inlet ram-pressure ratio from 1.00 to 1.13 did not appreciably affect the engine performance.

INTRODUCTION

An investigation has been conducted in the Cleveland altitude wind tunnel to determine the altitude performance and operational characteristics of an axial-flow gas turbine-propeller engine. Detailed pressure and temperature measurements were taken at eight stations in order to evaluate the over-all and component performance of the engine. Performance data were obtained at altitudes from 5000 to 35,000 feet and compressor-inlet ram-pressure ratios from 1.00 to 1.17, corresponding to airspeeds from 0 to 317 miles per hour. The engine was operated at speeds from 8000 to 13,000 rpm. The tunnel temperatures and pressures were maintained at approximately NACA standard altitude conditions.

A tabulation of performance data is presented together with performance characteristic curves. The effects of engine speed, altitude, and ram-pressure ratio on engine performance characteristics are shown and discussed. The data obtained at the several altitudes have been generalized and the methods employed in obtaining generalized performance curves are presented.

SYMBOLS

The following symbols are used in this report:

A	cross-sectional area, square feet
c_p	specific heat of gas at constant pressure, Btu per pound per °F
F_j	jet thrust, pounds
f/a	fuel-air ratio
g	acceleration due to gravity, feet per second per second
H	enthalpy, Btu per pound
J	mechanical equivalent of heat, foot-pounds per Btu

N	engine speed, rpm
P	total pressure, pounds per square foot absolute
p	static pressure, pounds per square foot absolute
R	gas constant
shp	shaft horsepower measured at torquemeter
ghp	horsepower loss in high-speed reduction gear
hp	shp + ghp
T	total temperature, °R
T_i	indicated temperature, °R
t	static temperature, °R
V	velocity, feet per second
W_a	air flow, pounds per second
W_f	fuel flow, pounds per hour
W_g	gas flow, pounds per second
W_f/shp	specific fuel consumption, pounds per shaft horsepower-hour
γ	ratio of specific heats for gases
δ	ratio of compressor-inlet total pressure to satic 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:

0	tunnel test-section air stream
1	wing-duct inlet
2	compressor inlet
3	compressor outlet

5	turbine inlet
8	tail-pipe-nozzle outlet

The data are generalized to NACA standard sea-level conditions by the following parameters:

F_j/δ	corrected jet thrust, pounds
$N/\sqrt{\theta}$	corrected engine speed, rpm
$(W_a\sqrt{\theta})/\delta$	corrected air flow, pounds per second
$W_f/(\delta\sqrt{\theta})$	corrected fuel flow, pounds per hour
$hp/(\delta\sqrt{\theta})$	corrected horsepower
T_5/θ	corrected turbine-inlet temperature

ENGINE, INSTALLATION, AND INSTRUMENTATION

Engine

The T31 gas turbine-propeller engine investigated has a 14-stage axial-flow compressor, nine cylindrical combustion chambers, a single-stage turbine, an exhaust cone, and a two-stage planetary reduction gear. A sectional drawing of the engine showing the location of these components is given in figure 1. The engine has a maximum over-all diameter of 37 inches and an over-all length of 116 inches with a straight exhaust cone and without a propeller. A tail pipe 96 inches in length and 14 inches in diameter was used in this investigation. The dry weight of the engine, including piping and all accessories, is approximately 1980 pounds.

The operating limits of the engine for static sea-level conditions as established by the manufacturer are:

Turbine speed, rpm:	
Maximum overspeed	13,300
Normal rated	13,000
Idling	10,000
Exhaust-gas temperatures (at exhaust-cone outlet), °F:	
Military rating 5 minutes	1265
Normal continuous rating	1170
Starting and acceleration	1600
Bearing temperatures, °F	250
Vibration, in.:	
At turbine frequency	0.004
At propeller frequency	0.025

Air enters the engine through a screened annular inlet surrounding the aft gear casing and passes into the first stage of the compressor through a set of inlet guide vanes. The air travels through the 14-stage compressor with a resultant increase in pressure and temperature. Small quantities of air are bled through the compressor casing from the fifth and sixth stator stages to cool the turbine wheel and pressurize the compressor balance piston chamber at the front of the compressor. Air is discharged from the compressor through two sets of guide vanes and turned 180° before entering the combustion chambers.

Most of the air flows directly into the combustion chambers and a small part is directed through the hollow turbine-nozzle vanes before entering the combustion zone. The combustion chambers are the counter-flow type and consist of an outer shell and a perforated inner liner. A duplex fuel nozzle is located in the dome of each combustion chamber. Spark plugs are installed in two of the combustion chambers and ignition in the other chambers is accomplished through cross-fire tubes. Quick-disconnect clamps connect the combustion chambers to the main frame.

Products of combustion leaving the combustion chambers pass through transition sections to the annular turbine-nozzle where the gases are accelerated. A large part of the energy of the high-velocity gases is absorbed by the turbine to drive the propeller shaft, the compressor, the reduction gears, and accessories. The gases are discharged from the turbine into an annular exhaust cone and through a tail pipe, where the remaining energy is utilized as jet thrust.

The turbine shaft passes through the compressor rotor and is supported by two journal-sleeve bearings. A splined sleeve coupling connects the turbine shaft with the reduction-gear assembly. The reduction gear consists of two planetary gear systems in series, with a speed reduction ratio of 11.3513:1. The ring gear of the high-speed stage is the floating type and its motion is restrained by six hydraulic pistons that provide a means of determining the shaft torque. The propeller shaft is connected to the low-speed planetary gear and is supported at the forward end by the main thrust ball bearing. Accessories are driven from a ring gear attached to the low-speed planetary cage.

Installation

The engine was installed in a streamline nacelle-wing combination, which was supported in the wind-tunnel test section by the tunnel balance frame. The axial center line of the nacelle coincided with the chord line of the wing and with the longitudinal center line of the tunnel test section. (See figs. 2 to 4.) The wing had an NACA 65,2-014 airfoil section with a chord length of 15 feet. Maximum diameter of the nacelle was 42.7 inches. When completely faired, the nacelle had a fineness ratio of 6.86. The engine was supported in the nacelle by two self-alining ball and socket mounts located on each side of the forward gear casing and by a tie bolt on the bottom of the turbine main frame.

The engine was equipped with a Hamilton-Standard four-blade super hydromatic propeller (hub design, 4260) that is 12 feet, 7 inches in diameter. The propeller included a self-contained governor assembly and a blade-angle indicating mechanism. The controls were modified to provide either manual or constant-speed operation of the propeller. The maximum rate of pitch change as rated by the manufacturer is 45° per second. In order to set accurately the test conditions, the propeller was operated by means of the manual control and restrictions were inserted in the control oil passages to reduce the manual rate of pitch change. For this investigation the low- and high-blade angle stops were set at 4° and 46°, respectively. The minimum flight blade angle stop was set at 12° and the feathering blade angle stop was set at 82°.

Air was supplied to the engine from the tunnel air stream through two wing ducts with leading-edge inlets in the propeller slipstream. The centers of the inlet were located along the wing span at about 80 percent of the propeller radius. (See figs. 4 and 5.) The air entering the wing ducts was turned 90° with the aid of guide vanes. A small part of the air was diverted from each duct for cooling the engine nacelle chamber. At the engine, the wing ducts were joined to form an annulus around the aft reduction-gear casing (fig. 6). This annulus was attached to the compressor-inlet flange. (See fig. 3.) Splitter plates were inserted vertically between the two halves of the annulus to reduce rotational flow.

Instrumentation

Pressure and temperature measurements were taken at eight stations throughout the installation. Details of the instrumentation installation at each measuring station are given in the appendix.

PROCEDURE

Performance characteristics of the engine were obtained at altitudes from 5000 to 35,000 feet, compressor-inlet ram-pressure ratios from 1.00 to 1.17, and a range of shaft horsepowers at engine speeds from 8000 to 13,000 rpm. In order to lengthen the turbine life, the engine was not operated at maximum power for any of the conditions presented.

Jet thrust was calculated from pressure and temperature measurements at the tail-pipe-nozzle outlet. Shaft horsepower was determined from torquemeter pressure measurements. The shaft power determined from the torquemeter pressure is greater than the propeller shaft power by an amount equal to the sum of the low-speed reduction gear loss and the power required to drive the accessories. The values of shaft horsepower presented in the uncorrected performance data were measured at the torquemeter. For the generalized data, however, the power loss in the high-speed reduction gear was added to the torquemeter power. Thus the corrected horsepower represents the total turbine power less the power required to drive the compressor.

Pressures were measured on water and mercury manometers and were photographically recorded. Temperatures were measured and recorded by two self-balancing potentiometers. The engine speed was determined with a tachometer and the exhaust-gas temperature for setting limiting test conditions was indicated by two thermocouples at station 7(fig. 1) that were connected in parallel to a temperature gage on the engine panel.

METHOD OF CALCULATIONS

Temperatures

The tail-pipe-nozzle outlet and compressor-inlet temperatures were calculated from the indicated temperature, using a thermocouple recovery factor of 0.85, and respective values of pressure, temperature, and ratio of specific heats.

$$T = \frac{T_1\left(\frac{P}{p}\right)^{\frac{\gamma-1}{\gamma}}}{1 + 0.85\left[\left(\frac{P}{p}\right)^{\frac{\gamma-1}{\gamma}} - 1\right]}$$

The turbine-inlet temperature was calculated from the enthalpy drop through the turbine and the enthalpy at the tail-pipe-nozzle outlet.

The enthalpy drop through the turbine included the power required to drive the compressor, the shaft power measured at the torquemeter, and the power loss in the high-speed reduction gear:

$$H_5 = \left[\frac{(\text{shp} + \text{ghp})\ 550}{W_g\ J}\right] + \left(H_3 - H_2\right) + H_8$$

$$T_5 = \frac{H_5}{c_{p,5}}$$

An integrated value of c_p was used in this equation. The gear horsepower used in calculating H_5 represents the power loss in the high-speed reduction gear and was estimated to vary from 50 horsepower at an engine speed of 13,000 rpm to 25 horsepower at 8000 rpm.

Velocity

The tunnel velocity was determined from the following relation:

$$V_0 = \sqrt{\frac{2\gamma g R_0 T_0}{\gamma-1}\left[1 - \left(\frac{p_0}{P_0}\right)^{\frac{\gamma-1}{\gamma}}\right]}$$

Thrust

The jet thrust of the engine was calculated from the following equation, which was derived in reference 1:

$$F_j = \frac{2\gamma_8}{\gamma_8-1} p_8 A_8 \left[\left(\frac{H_8}{p_8}\right)^{\frac{\gamma_8-1}{\gamma_8}} -1\right] + A_8 \left(p_8-p_0\right)$$

Air Flow

Engine air flow was determined from measurements of the compressor inlet and at the tail-pipe-nozzle outlet. The air flow presented in the tabulation data and used in the performance calculations was obtained from measurements at the compressor inlet because of more comprehensive instrumentation at that station. The air flow at the compressor inlet was calculated from the following relation:

$$W_{a,2} = p_2 A_2 \sqrt{\frac{2\gamma g}{(\gamma-1)\ R_2 t_2}} \sqrt{\left(\frac{P_2}{p_2}\right)^{\frac{\gamma-1}{\gamma}} -1}$$

Gas flow at the tail-pipe-nozzle outlet was obtained from the following relation:

$$W_g = p_8 A_8 \sqrt{\frac{2\gamma_8 g}{(\gamma_8-1)\ R_8\ t_8}} \sqrt{\left(\frac{P_8}{p_8}\right)^{\frac{\gamma_8-1}{\gamma_8}} -1}$$

The air flow was then found from

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

RESULTS AND DISCUSSION

Preliminary performance data are presented in table I. In the following sections, the effects of altitude, engine speed, and ram-pressure ratio on engine performance are discussed; generalized performance data and the methods employed in obtaining generalized performance curves are presented.

On several occasions oil entered the compressor air passage. Oil and dirt that adhered to the blades may have had some adverse effect on the compressor performance.

Altitude. - Performance data obtained at altitudes from 5000 to 35,000 feet, an engine speed of 13,000 rpm, and a compressor-inlet ram-pressure ratio of 1.00 are shown in figures 7 to 12. The calculated turbine-inlet temperature (fig. 7) increased linearly with shaft horsepower at each altitude. Using these values of turbine-inlet temperature, constant temperature contours are plotted in figures 8, 9, 11, and 12. From the data presented in these figures, the performance of the engine at an engine speed of 13,000 rpm and a ram-pressure ratio of 1.00 can be estimated for the range of altitudes investigated for turbine-inlet temperatures between 1700° and 2100° R.

At a given turbine-inlet temperature, the fuel flow decreased as the altitude was increased (fig. 8). The data shown in figure 9 indicate that the lowest specific fuel consumption at each turbine-inlet temperature occurred at an altitude of approximately 20,000 feet. The engine air flow remained constant at each altitude as the shaft horsepower was changed. (See fig. 10.) At constant turbine-inlet temperatures above 1900° R, the fuel-air ratio did not change appreciably with changes in altitude (fig. 11). At each altitude the jet thrust increased about 10 percent for an increase in shaft horsepower of 100 percent (fig. 12).

Engine speed. - The effect of engine speed on engine performance at an altitude of 5000 feet and a ram-pressure ratio of 1.00 is shown in figures 13 to 18. Constant temperature contours are plotted in figures 14, 15, 17, and 18, using the calculated values of turbine-inlet temperature in figure 13. With these contours superimposed on the data, the engine performance can be estimated for any engine speed at an altitude of 5000 feet and a ram-pressure ratio of 1.00.

The calculated turbine-inlet temperatures shown in figure 13 increase linearly with shaft horsepower at each engine speed. The temperature lines for constant engine speeds intersect owing to the change in the ratio of shaft horsepower to the kinetic energy of the jet as the engine speed is varied. The tail-pipe-nozzle area for this type of engine is so selected that the ratio of shaft horsepower to the kinetic energy of the jet gives optimum economy at the design operating conditions. In order to obtain an optimum ratio of shaft horsepower to jet thrust power for operating conditions other than the design condition, a variable-area tail-pipe nozzle is therefore required.

At each engine speed the fuel flow (fig. 14), the fuel-air ratio (fig. 17), and the jet thrust (fig. 18) increase linearly with shaft horsepower, whereas the air flow (fig. 16) remains constant as the shaft horsepower is changed. An increase in shaft horsepower reduced the specific fuel consumption at each engine speed (fig. 15). As the engine speed is raised at a constant turbine-inlet temperature, the rate of change in fuel flow with shaft horsepower decreases as the turbine-inlet temperature is increased (fig. 14). The significance of this relation is shown in figure 15, in which the specific fuel consumption at each engine speed decreases as the turbine-inlet temperature increases. At a turbine-inlet temperature of 2000° R, the specific fuel consumption was about 1.06 and was not noticeably changed by variations in engine speed. At a turbine-inlet temperature of 1700° R, however, the specific fuel consumption increased sharply from 1.52 at an engine speed of 10,000 rpm to 1.87 at 13,000 rpm.

An increase in engine speed at a constant turbine-inlet temperature reduced the fuel-air ratio at engine speeds up to 12,000 rpm (fig. 17). An increase in engine speed from 12,000 to 13,000 rpm did not change the fuel-air ratio in a manner consistent with the data obtained at lower speeds. The shaft horsepower, however, does not represent the total power output of the engine in that the kinetic energy of the jet is not included. As the engine speed was increased from 10,000 to 13,000 rpm at a constant turbine-inlet temperature, the jet thrust increased at a much greater rate than the shaft horsepower. (See fig. 18.) Because the change in shaft horsepower is small, the fuel-air ratios for engine speeds of 13,000 and 12,000 rpm are nearly the same (fig. 17).

Changing the engine speed from 10,000 to 13,000 rpm increased the jet thrust about 115 percent at each value of turbine-inlet temperature. The same increase in engine speed, however, resulted in an increase in shaft horsepower of only 7 percent at a turbine-inlet temperature of 1700° R and 55 percent at 2000° R (fig. 18).

Ram-pressure ratio. - The effect on engine performance of an increase in compressor-inlet ram-pressure ratio from 1.00 to 1.13 at an altitude of 25,000 feet and an engine speed of 13,000 rpm is shown in figures 19 to 24. The small change in ram-pressure ratio had no apparent effect on the relation between shaft horsepower and turbine-inlet temperature (fig. 19). An increase in ram-pressure ratio resulted in a slight decrease in fuel flow, specific fuel consumption, and fuel-air ratio (figs. 20, 21, and 23, respectively), whereas the jet thrust increased slightly (fig. 24). The increase in ram-pressure ratio did not appreciably change the air flow (fig. 22). Because of data scatter, the fuel-air ratios presented in figure 23 were obtained from faired values of fuel flow (fig. 20) and air flow (fig. 22).

Generalized engine performance. - The pressure and temperature factors δ and θ have been applied to the performance data to determine whether the engine performance obtained at several altitudes could be generalized. The generalized performance parameters used are corrected engine speed $N/\sqrt{\theta}$, corrected fuel flow $W_f/(\delta\sqrt{\theta})$, corrected air flow $(W_a\sqrt{\theta})/\delta$, corrected horsepower $hp/(\delta\sqrt{\theta})$, and corrected turbine-inlet temperature T_5/θ. These parameters were developed from concepts of flow similarity in reference 2.

The performance data obtained at several altitudes and engine speeds at a constant compressor-inlet ram-pressure ratio were generalized to standard sea-level conditions as shown in figures 25 to 34. Representative generalized data showing the variation of corrected fuel flow with corrected horsepower are presented in figure 25 for altitudes from 5000 to 35,000 feet, a compressor-inlet ram-pressure ratio of 1.00, and corrected engine speeds from 8200 to 14,200 rpm. Similar data showing the variation of corrected turbine-inlet temperature with corrected fuel flow for the same range of corrected engine speeds are given in figure 26. The generalized data presented in figures 25 and 26 were cross-plotted in figure 27, which shows the variation of corrected fuel flow with corrected engine speed for selected constant values of corrected horsepower and corrected turbine-inlet temperature.

The relation between corrected horsepower and corrected turbine-inlet temperature is presented in figure 28 for several corrected engine speeds. These values were cross-plotted in figure 29 to show the variation of corrected horsepower with corrected engine speed for constant corrected turbine-inlet temperatures. The reason for the decrease in corrected horsepower at the higher values of corrected engine speed has not been determined. A combination of the data in figures 27 and 29 gave two families of curves that show the variation of specific fuel consumption with corrected engine speed for constant corrected values of horsepower and turbine-inlet temperature (fig. 30). For a given engine speed, the specific fuel consumption decreased as the horsepower and turbine-inlet temperature increased.

At a corrected engine speed of 13,000 rpm, the specific fuel consumption based on shaft horsepower decreased from 1.41 at a corrected horsepower of 700 to 0.86 at 1800. At each constant corrected turbine-inlet temperature, the best fuel economy was obtained at a corrected engine speed of about 12,000 rpm. However, the specific fuel consumption based on shaft horsepower does not represent the over-all specific fuel consumption because the jet thrust has not been included.

The variation of corrected jet thrust with corrected horsepower and corrected turbine-inlet temperature for a range of corrected engine speeds is shown in figures 31 and 32, respectively. These data are cross-plotted in figure 33 to show the relation between corrected jet thrust and corrected engine speed for constant corrected values of horsepower and turbine-inlet temperature. The jet thrust increased as the engine speed and the horsepower were increased.

Corrected engine air flows obtained from measurements at the compressor inlet are shown in figure 34. These data were obtained at altitudes from 5000 to 35,000 feet at a compressor-inlet ram-pressure ratio of 1.00 for the range of shaft horsepowers investigated. The values of air flow calculated from pressure and temperature measurements at the tail-pipe-nozzle outlet were approximately 4 percent lower than those obtained from measurements at the compressor inlet.

SUMMARY OF RESULTS

An investigation of an axial-flow gas turbine-propeller engine in the Cleveland altitude wind tunnel at altitudes from 5000 to 35,000 feet, ram-pressure ratios from 1.00 to 1.13, and engine speeds from 8000 to 13,000 rpm gave the following results:

1. Performance data obtained at several altitudes and engine speeds for a constant compressor-inlet ram-pressure ratio were generalized to standard sea-level conditions with reasonable accuracy.

2. The specific fuel consumption at a given corrected engine speed decreased as the corrected horsepower increased. At a corrected engine speed of 13,000 rpm, the specific fuel consumption based on shaft horsepower decreased from 1.41 at a corrected horsepower of 700 to 0.86 at 1800.

3. At each altitude and engine speed, an increase in shaft horsepower of 100 percent was accompanied by an increase in jet thrust of about 10 percent. As the engine speed was increased from 10,000 to 13,000 rpm at a constant turbine-inlet temperature, the jet thrust increased at a greater rate than the shaft horsepower. At a turbine-inlet temperature of 2000° R, this change in engine speed was accompanied by increases of 115 percent in jet thrust and 55 percent in shaft horsepower.

4. In order to obtain an optimum ratio of shaft horsepower to the kinetic energy of the jet at operating conditions other than the design condition, a variable-area tail-pipe nozzle is required.

5. An increase in compressor-inlet ram-pressure ratio from 1.00 to 1.13 had little effect on the engine performance.

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APPENDIX - INSTRUMENTATION

Instrumentation was installed at eight measuring stations throughout the engine (fig. 1) to obtain the detailed pressure and temperature measurements from which the over-all and component engine performance could be calculated. Photographs and sectional drawings showing the instrumentation installed at each measuring station are presented in figures 35 to 41. The number of total- and static-pressure tubes and thermocouples installed at each station and the flow area at each station are given in table II. In addition to the pressure and temperature measurements taken at the eight stations, measurements were taken at other locations throughout the engine and installation.

Temperatures were measured with iron-constantan thermocouples at stations 1 to 4 and chromel-alumel thermocouples at the other stations. These temperatures were recorded on self-balancing potentiometers. Pressures were measured with water or mercury Alkazene manometers, depending upon the magnitude of the pressure at the measuring station, and were photographically recorded. Transverse vibrations of the engine in the horizontal and vertical planes were transmitted by vibration pickups located at the front bearing support, the front flange of the compressor, and the turbine flange. The vibration transmitters were connected to a vibration indicator in the control room through a selector switch.

REFERENCES

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2. Sanders, Newell D.: Performance Parameters for Jet-Propulsion Engines. NACA TN No. 1106, 1946.

TABLE I. - PERFORMANCE DATA

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Run	Altitude (ft)	Engine speed (rpm)	Shaft horsepower	Ram-pressure ratio, P_2/p_0	Tunnel velocity, V_0 (ft/sec)	Tunnel static pressure, p_0 (lb/sq ft)	Compressor-inlet temperature, T_2 (°R)	Fuel flow, W_f (lb/hr)	Specific fuel consumption, W_f/shp (lb/shp-hr)	Air flow, W_a (lb/sec)	Fuel-air ratio, f/a	Compressor pressure ratio	Turbine pressure ratio	Turbine-inlet temperature, T_5 (°R)	Tail-pipe temperature, T_8 (°R)	Jet thrust, F_j (lb)	Blade angle, β (deg)	Turbine cooling-air flow (lb/sec)	Balance-piston air flow (lb/sec)	Corrected engine speed, $N/\sqrt{\theta}$ (rpm)	Corrected horsepower, hp/$(\delta\sqrt{\theta})$	Corrected fuel flow, $W_f/(\delta\sqrt{\theta})$ (lb/hr)	Corrected air flow, $(W_a\sqrt{\theta})/\delta$ (lb/sec)	Corrected jet thrust, F_j/δ (lb)	Corrected turbine-inlet temperature, T_5/θ (°R)
1	5,000	13,000	425	0.99	211	1760	504	775	1.825	17.94	0.0120	4.72	3.62	1722	1366	352	13.3	0.10	0.02	13,190	583	951	21.38	426	1774
2	5,000	13,000	619	.99	210	1760	501	870	1.406	18.04	.0134	4.84	3.60	1795	1375	378	15.1	.10	.02	13,230	882	1067	21.42	456	1858
3	5,000	13,000	825	1.00	200	1760	496	970	1.175	18.46	.0146	5.00	4.02	1910	1454	388	16.3	.10	.02	13,300	1076	1192	21.69	466	1999
4	5,000	13,000	951	1.00	198	1670	502	1025	1.077	17.79	.0162	5.01	4.02	2015	1531	386	16.9	.10	.02	13,200	1226	1253	21.12	465	2081
5	5,000	13,000	1044	1.00	201	1767	497	1085	1.040	17.97	.0168	5.13	4.11	2025	1545	415	17.9	.10	.02	13,290	1339	1327	21.05	497	2118
6	5,000	12,000	334	1.00	193	1767	499	650	1.947	15.95	.0113	4.04	3.30	1628	1280	275	15.1	.10	.02	12,240	463	796	18.76	330	1695
7	5,000	12,000	482	1.00	192	1760	497	730	1.515	16.35	.0124	4.25	3.43	1708	1335	300	16.2	.10	.02	12,260	647	895	19.22	361	1785
8	5,000	12,000	636	1.00	183	1753	491	800	1.257	16.22	.0137	4.37	3.62	1775	1370	308	17.7	.11	.02	12,320	843	979	19.07	371	1874
9	5,000	12,000	824	1.00	169	1760	503	910	1.104	16.33	.0155	4.43	3.66	1970	1534	324	16.8	.11	.02	12,190	1042	1112	19.36	390	2058
10	5,000	11,000	308	.99	91	1760	494	562	1.824	13.53	.0115	3.46	2.95	1630	1311	200	5.6	.09	.02	11,270	431	697	15.98	242	1714
11	5,000	11,000	446	.99	92	1760	502	640	1.436	13.27	.0134	3.54	3.05	1718	1371	219	9.2	.10	.02	11,170	596	783	15.77	264	1775
12	5,000	11,000	591	1.00	110	1753	505	725	1.226	13.42	.0150	3.67	3.18	1840	1461	218	14.3	.10	.02	11,170	766	888	15.95	263	1900
13	5,000	11,000	739	1.00	130	1767	504	810	1.096	13.65	.0165	3.79	3.29	1882	1486	242		.10	.02	11,160	945	982	16.08	289	1959
14	5,000	10,000	209	1.00	136	1780		458	2.162			2.93					9.9	.09	.02						
15	5,000	10,000	302	1.00	149	1782	496	515	1.702	11.85	.0121	3.00	2.65	1621	1335	163	13.3	.08	.02	10,230	412	630	13.87	195	1697
16	5,000	10,000	403	1.00	101	1777	495	580	1.438	11.72	.0137	3.09	2.75	1717	1405	167	11.9	.08	.02	10,230	536	710	13.72	200	1796
17	5,000	10,000	513	1.00	102	1771	498	670	1.305	11.58	.0161	3.16	2.81	1897	1560	181	15.0	.09	.02	10,210	671	820	13.63	217	1980
18	5,000	8,050	57	1.00	81	1760	500	325	5.682	7.19	.0126	1.85	1.74	1562	1400	63	3.2	.05	.01	8,220	100	398	8.73	76	1627
19	5,000	8,100	85	1.00	92	1760	501	345	4.054	7.41	.0129	1.91	1.78	1605	1441	71	5.4	.05	.01	8,270	134	422	8.72	85	1671
20	5,000	8,000	114	1.00	92	1760	501	375	3.301	7.41	.0141	1.92	1.79	1680	1506	70	7.0	.06	.01	8,170	170	458	8.70	84	1747
21	5,000	8,050	144	1.00	101	1760	500	405	2.811	7.43	.0151	1.95	1.82	1740	1549	76	9.8	.06	.01	8,220	206	494	8.70	91	1818
22	15,000	13,000	352	1.00	230	1197	464	575	1.634	13.61	.0117	5.15	3.88	1690	1287	281	14.8	.07	.02	13,740	755	1078	22.83	499	1897
23	15,000	13,000	514	1.00	143	1190	570	645	1.254	13.28	.0135	5.25	4.09	1797	1360	297	16.9	.07	.02	13,660	1055	1206	22.51	529	1964
24	15,000	13,000	733	1.00	223	1190	470	765	1.044	13.16	.0162	5.43	4.24	1993	1505	306	18.8	.07	.02	13,662	1462	1422	22.25	543	2191
25	15,000	13,000	776	1.00	220	1190		778	.999																
26	15,000	13,000	849	1.00	209	1190		815	.960																
27	15,000	11,000	103	1.00	198	1190	461	325	3.155	10.77	.0084	3.67	3.08	1388	1106	153	12.9	.07	.01	11,665	268	612	18.05	272	1584
28	15,000	11,000	211	1.00	172	1190	465	385	1.820	10.55	.0101	3.75	3.15	1510	1196	159	13.2	.07	.01	11,610	469	721	17.78	282	1686
29	15,000	11,000	329	1.00	173	1190	465	445	1.354	10.55	.0117	3.91	3.28	1622	1276	175	15.6	.07	.01	11,610	691	834	17.76	311	1810
30	15,000	11,000	411	1.00	167	1197	459	495	1.205	10.88	.0126	3.85	3.26	1695	1325	180	16.8	.07	.01	11,700	846	929	18.04	317	1917
31	15,000	10,000	530	1.00	143	1197		570	1.076	10.60	.0149	4.20	3.58	1838	1435	196	17.6	.07	.02	11,765	1077	1078	17.52	346	2106
32	15,000	10,000	183	1.00	125	1190	460	355	1.940	8.44	.0117	3.11	2.72	1672	1287	111	9.2	.06	.02	10,620	411	671	14.15	198	1774
33	15,000	10,000	260	1.00	106	1190	465	400	1.538	8.16	.0136	3.20	2.82	1720	1405	115	10.4	.06	.01	10,590	554	754	13.72	205	1964
34	15,000	10,000	360	1.00	106	1190	463	475	1.319	8.05	.0164	3.27	2.88	1874	1523	122	14.4	.06	.01	10,590	734	893	13.49	216	2068
35	15,000	10,000	437	1.00	113	1197	462	550	1.259	7.85	.0195	3.36	2.99	2020	1634	130	17.8	.06	.01	10,600	877	1096	13.03	229	2270
36	15,000	10,000	172	1.06	342	1190	477	340	1.977	8.49	.0111	2.93	2.69	1540	1262	122	31.1	.06	.01	10,430	359	594	13.63	204	1675

37	15,000	10,000	248	1.06	345	1197	476	390	1.673	8.39	0.0129	2.98	2.77	1677	1370	125	32.3	0.06	0.01	10,440	489	676	13.35	208	1828
38	15,000	10,000	340	1.07	347	1197	476	460	1.353	8.41	.0152	3.09	2.92	1808	1473	137	33.0	.06	.01	10,440	646	796	13.35	227	1970
39	15,000	10,000	422	1.07	358	1190	473	525	1.244	8.41	.0173	3.21	3.01	1903	1545	148	33.7	.06	.01	10,470	791	913	13.36	246	2080
40	15,000	8,000	55	1.00	71	1197	462	250	4.529	5.66	.0123	2.04	1.88	1535	1367	52	1.8	.04	.01	8,480	150	472	9.46	92	1725
41	15,000	8,000	72	1.00	71	1190	462	260	3.611	5.50	.0131	2.05	1.89	1580	1401	56	3.7	.04	.01	8,480	185	490	9.24	100	1776
42	15,000	8,000	93	1.00	71	1190	462	290	3.125	5.50	.0146	2.08	1.92	1630	1445	58	5.7	.04	.01	8,480	222	546	9.22	103	1832
43	15,000	8,000	105	1.06	327	1190	476	275	2.624	5.60	.0136	1.99	1.93	1637	1444	71	36.1	.05	.01	8,352	227	480	8.98	119	1784
44	15,000	8,000	134	1.06	327	1197	477	305	2.269	5.47	.0155	2.01	1.96	1738	1527	71	36.3	.05	.01	8,344	275	528	8.73	118	1890
45	15,000	8,000	158	1.06	326	1197	475	335	2.115	5.50	.0169	2.05	2.01	1810	1570	69	36.8	.04	.01	8,360	318	582	8.75	115	1977
46	25,000	13,000	223	1.00	254	781	436	405	1.814	9.52	.0107	5.49	4.08	1657	1260	206	16.2	.04	.01	14,170	808	1198	23.69	558	1972
47	25,000	13,000	335	1.00	236	781	435	450	1.344	9.52	.0131	5.62	4.24	1742	1309	219	16.3	.05	.01	14,190	1140	1332	23.65	594	2078
48	25,000	13,000	461	.99	227	781	435	515	1.117	9.50	.0151	5.82	4.35	1910	1436	226	18.3	.05	.01	14,190	1520	1552	23.68	615	2280
49	25,000	13,000	522	1.00	229	781	434	540	1.035	9.45	.0159	5.85	4.43	1968	1477	231	19.4	.05	.01	14,220	1700	1603	23.43	626	2351
50	25,000	13,000	587	1.00	246	788	436	595	1.013	9.64	.0171	4.96	3.76	1998	1495	239	20.9	.05	.01	14,170	1860	1740	23.67	640	2380
51	25,000	13,000	234	1.09	437	788	468	400	1.712	9.34	.0119	5.15	4.03	1665	1264	221	29.8	.05	.01	13,732	744	1048	22.53	549	1845
52	25,000	13,000	394	1.08	437	781	466	470	1.191	9.66	.0135	5.35	4.32	1823	1365	235	31.0	.05	.01	13,761	1173	1240	22.37	587	2089
53	25,000	13,000	514	1.08	437	788	474	535	1.040	9.56	.0156	5.47	4.42	1936	1467	242	31.3	.05	.01	13,656	1458	1382	22.47	598	2120
54	25,000	13,000	638	1.07	434	781	466	605	.948	9.42	.0178	5.66	4.63	2237	1546	261	31.0	.05	.02	13,719	1808	1590	22.29	649	2490
55	25,000	13,000	384	1.12	504	781	499	455	1.186	9.03	.0140	5.02	4.22	1838	1389	229	34.0	.05	.01	13,259	1067	1118	21.37	553	1912
56	25,000	13,000	522	1.13	507	774	497	540	1.035	9.27	.0162	5.26	4.45	2006	1511	239	34.7	.05	.01	13,285	1420	1342	21.97	580	2090
57	25,000	13,000	631	1.13	510	788	490	595	.943	9.54	.0173	5.54	4.57	2078	1556	258	35.4	.05	.01	13,380	1660	1450	21.87	610	2200
58	25,000	10,000	71	1.00	152	774	422	238	3.352	6.22	.0106	3.30	2.80	1378	1111	81	9.5	.04	.01	11,100	318	721	15.25	221	1695
59	25,000	10,000	172	1.00	92	781	419	300	1.744	6.16	.0135	3.62	3.11	1672	1348	94	13.0	.04	.01	11,080	621	904	15.05	255	2070
60	25,000	10,000	118	1.09	387	781	451	235	4.519	6.44	.0101	3.11	2.85	1412	1135	92	33.6	.05	.01	10,730	407	629	14.97	229	1626
61	25,000	10,000	174	1.09	387	781	451	263	1.697	6.35	.0115	3.23	2.97	1553	1242	100	34.4	.04	.01	10,730	555	703	14.75	249	1788
62	25,000	10,000	261	1.09	385	781	450	320	1.029	6.19	.0144	3.38	3.11	1743	1371	104	35.7	.05	.01	10,740	789	855	14.35	259	2010
63	25,000	10,000	308	1.09	385	788	451	415	1.072	6.21	.0180	3.47	3.23	1850	1477	114	36.4	.05	.01	10,730	902	1094	14.23	280	2129
64	25,000	8,100	37	.99	39	788	435	200	4.986	4.07	.0136	2.14	1.97	1434	1256	38	5.2	.02	.01	8,870	181	593	10.05	105	1719
65	25,000	8,100	56	1.00	75	781	432	203	3.631	4.06	.0139	2.22	2.04	1523	1324	39	3.6	.03	.01	8,880	241	603	10.10	106	1830
66	25,000	8,000	97	1.00	75	781	428	246	2.541	3.86	.0177	2.32	2.14	1762	1521	41	12.0	.02	.01	8,860	364	734	9.40	111	2105
67	25,000	8,000	86	1.09	368	781	446	215	2.488	4.15	.0144	2.17	2.13	1562	1367	55	39.1	.03	.01	8,635	299	571	9.58	137	1842
68	25,000	8,000	122	1.09	370	781	445	253	2.067	3.78	.0165	2.25	2.21	1758	1504	56	39.8	.03	.01	8,640	396	681	8.72	139	2047
69	35,000	13,000	163	.99	229	493	435	285	1.753	5.91	.0134	5.68	4.15	1752	1319	140	13.6	.02	.01	14,200	1011	1362	23.51	608	2090
70	35,000	13,000	240	.99	238	486	438	318	1.324	5.82	.0152	5.89	4.32	1897	1430	143	16.7	.03	.01	14,151	1385	1520	23.47	627	2250
71	35,000	13,000	289	1.00	238	493	438	348	1.205	5.98	.0162	5.96	4.46	2006	1515	145	18.5	.03	.01	14,151	1591	1632	23.68	624	2377
72	35,000	13,000	340	1.00	242	493	437	373	1.098	5.97	.0174	6.10	4.60	2065	1552	151	19.1	.03	.01	14,167	1828	1747	23.56	649	2480
73	35,000	13,000	381	1.00	239	500	436	395	1.037	6.06	.0181	6.15	4.65	2080	1556	161	19.5	.03	.01	14,184	1995	1826	23.55	683	2479
74	35,000	13,000	155	1.07	429	493	457	272	1.758	6.21	.0122	5.39	4.19	1580	1168	151	29.1	.03	.01	13,858	874	1160	23.30	604	1797
75	35,000	13,000	252	1.08	429	493	457	318	1.261	6.24	.0142	5.62	4.44	1745	1287	157	30.2	.03	.01	13,858	1283	1350	23.33	626	1985
76	35,000	13,000	330	1.08	435	493	458	360	1.090	6.23	.0160	5.80	4.57	1900	1394	159	30.9	.03	.01	13,832	1613	1527	23.33	634	2150
77	35,000	13,000	432	1.08	436	493	455	480	.973	6.26	.0186	6.04	4.83	2040	1509	176	32.0	.03	.01	13,884	2038	1778	23.23	698	2326
78	35,000	13,000	422	1.08	436	508	454	425	1.001	6.30	.0186	5.93	4.71	2000	1484	191	32.5	.03	.01	13,897	1958	1755	22.88	742	2284
79	35,000	12,000	134	.98	143	493	430	250	1.860	5.38	.0129	5.13	3.94	1550	1159	123	6.4	.03	.01	13,188	858	1204	21.45	538	1874
80	35,000	12,000	209	.98	153	500	430	278	1.331	5.49	.0141	5.28	4.07	1638	1204	113	10.8	.03	.01	13,188	1197	1315	21.49	486	1970
81	35,000	12,000	276	.99	154	493	429	309	1.120	5.48	.0156	5.45	4.22	1897	1428	121	15.3	.03	.01	13,200	1530	1475	21.65	525	2298
82	35,000	12,000	341	.99	162	493	433	362	1.033	5.37	.0182	5.64	4.43	2033	1537	129	17.7	.03	.01	13,140	1828	1678	21.26	549	2438
83	35,000	10,050	163	1.16	506	493	450	223	1.370	4.49	.0138	3.40	3.28	1647	1301	77	42.2	.03	.01	10,800	781	884	15.43	284	1899
84	35,000	10,050	210	1.17	503	493	444	266	1.267	4.28	.0173	3.60	3.51	1868	1494	92	43.0	.03	.01	10,850	966	1053	14.53	337	2178

TABLE II. - SUMMARY OF INSTRUMENTATION

Location	Station	Area (sq in.)	Thermocouples	Pressure tubes		
				Total	Probe static	Wall static
Upper lip, left wing duct						17
Lower lip, left wing duct						15
Left wing-duct inlet	1	82.4	2	26	2	6
Right wing-duct inlet (fig. 35)	1	82.4	2	26	2	6
Wing cooling-air bleed, left forward		2.85	1	1		1
Wing cooling-air bleed, left aft		2.85	1	1		1
Wing cooling-air bleed, right forward		2.85	1	1		1
Wing cooling-air bleed, right aft		2.85	1	1		1
Compressor inlet (fig. 36)	2	94.7	6	15	6	9
Compressor stators	2,3					14
Balance piston cooling air ducts		.30	1	1		1
Compressor outlet (fig. 37)	3	48.5	9	12	2	5
Compressor-outlet elbow (fig. 37)	4		2	4	2	
Turbine inlet (fig. 38)	5	25.0		5		5
Turbine cooling-air baffles			6			
Turbine cooling-air ducts		.60	1	1		1
Turbine outlet (fig. 39)	6	79.0	9	9	3	3
Exhaust-cone outlet (fig. 40)	7	154.0	4	4		2
Tail-pipe surface	7,8					3
Tail-pipe outlet surface	8		2			4
Tail-pipe outlet rake (fig. 41)	8	154.0	6	16	3	
Fuselage			8			
Engine external			3			
Bearings			4			
Fuel supply			1			
Starter			1			

Station
1 Wing-duct inlet (fig. 5)
2 Compressor inlet
3 Compressor outlet
4 Compressor elbow
5 Turbine inlet
6 Turbine outlet
7 Exhaust-cone outlet
8 Tail-pipe-nozzle outlet

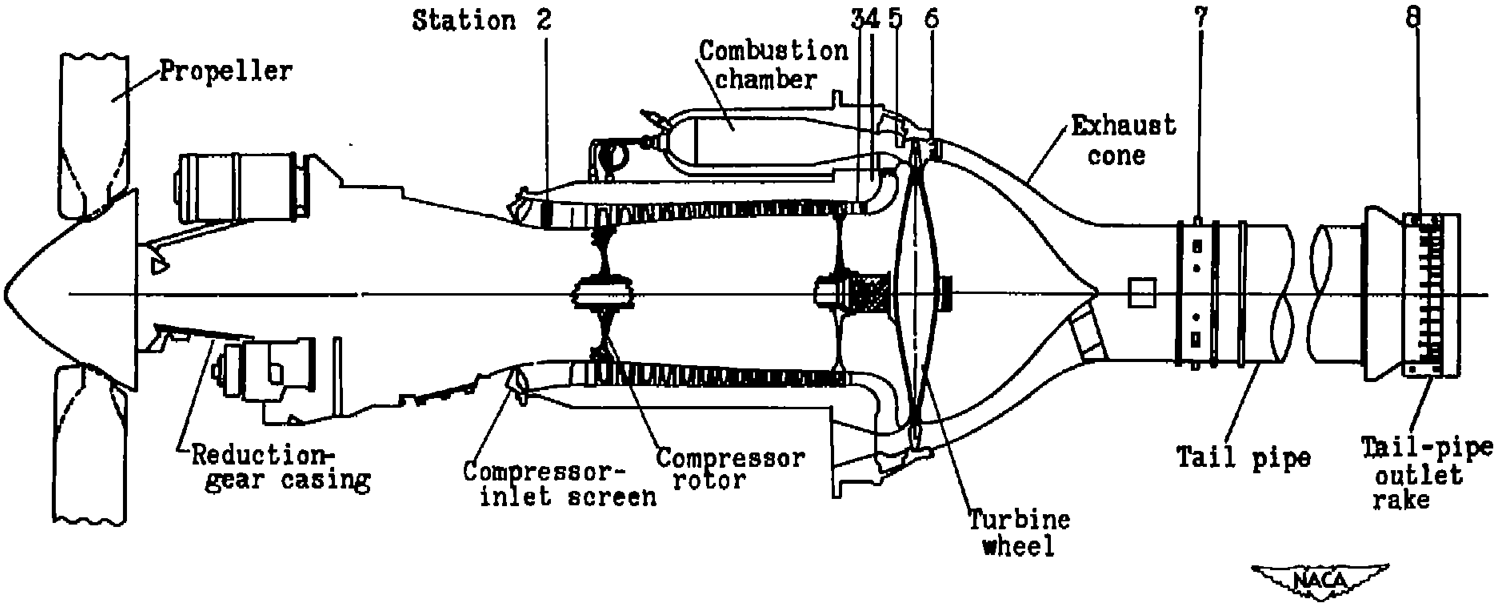

Station 2
3
4
5
6
7
8
Propeller
Combustion chamber
Exhaust cone
Reduction-gear casing
Compressor-inlet screen
Compressor rotor
Turbine wheel
Tail pipe
Tail-pipe outlet rake
NACA

Figure 1. - Side view of axial-flow gas turbine-propeller engine showing location of measuring stations.

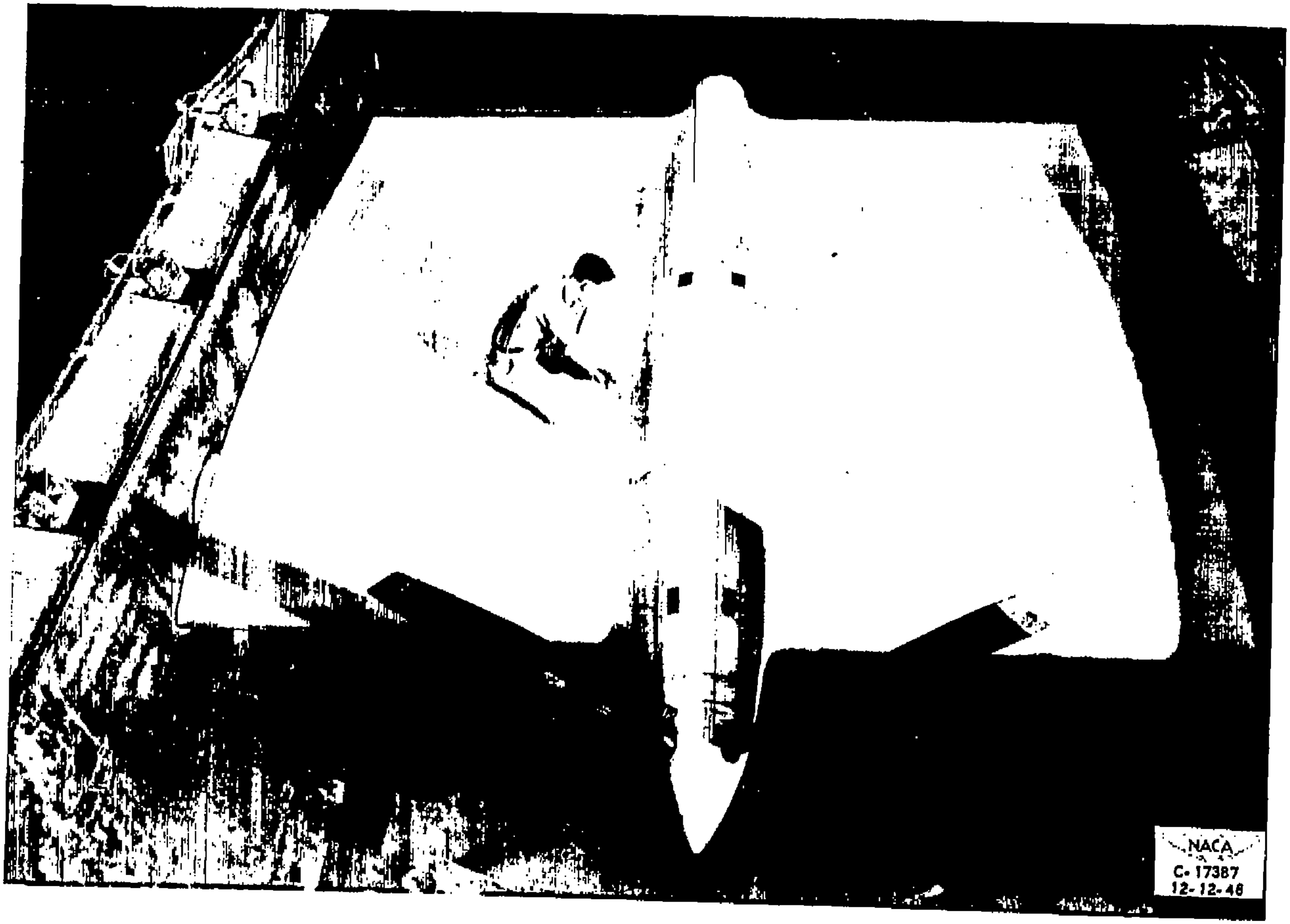
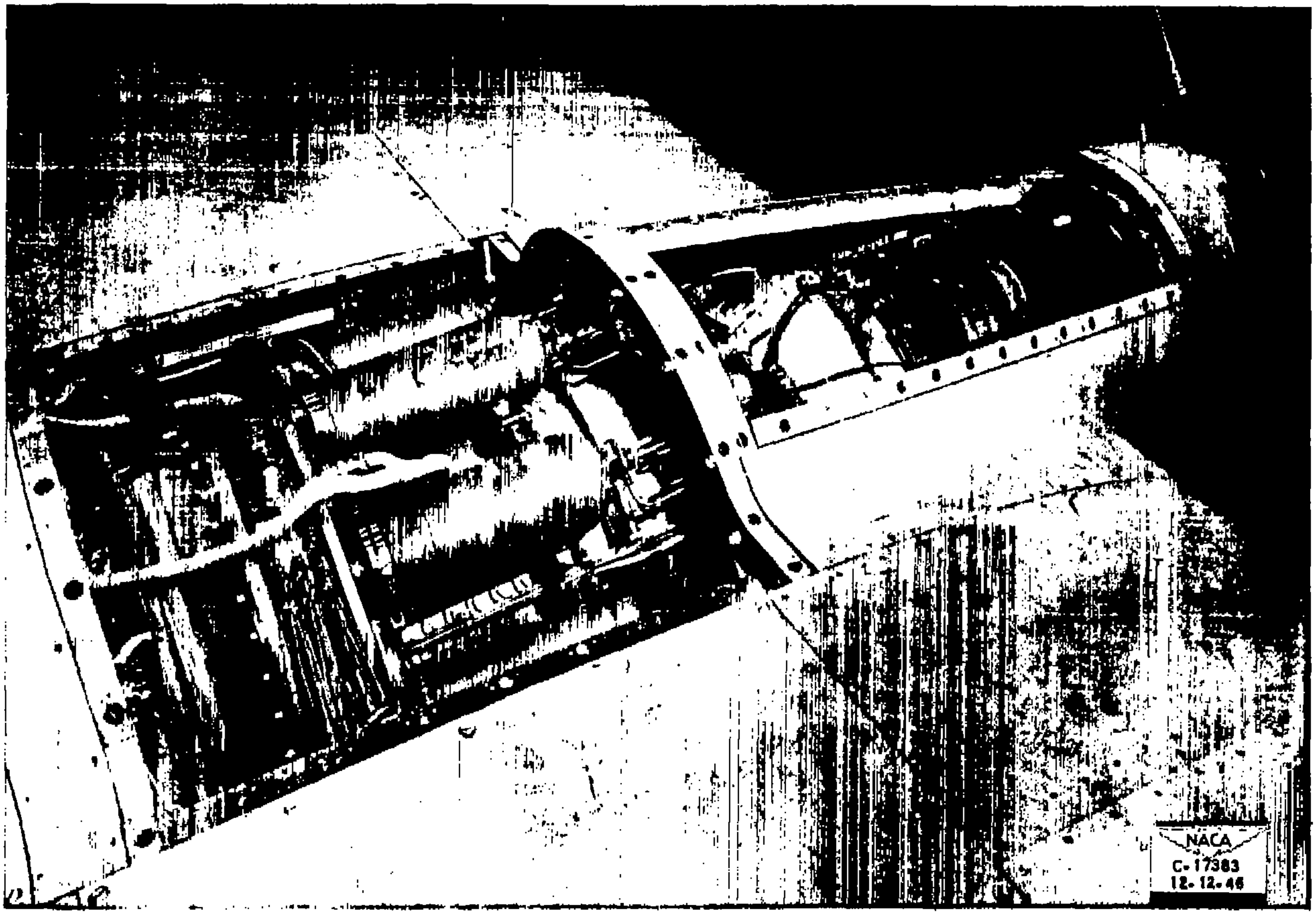

NACA
C-17387
12-12-48

Figure 2. - Top view of axial-flow gas turbine-propeller engine in altitude wind tunnel.



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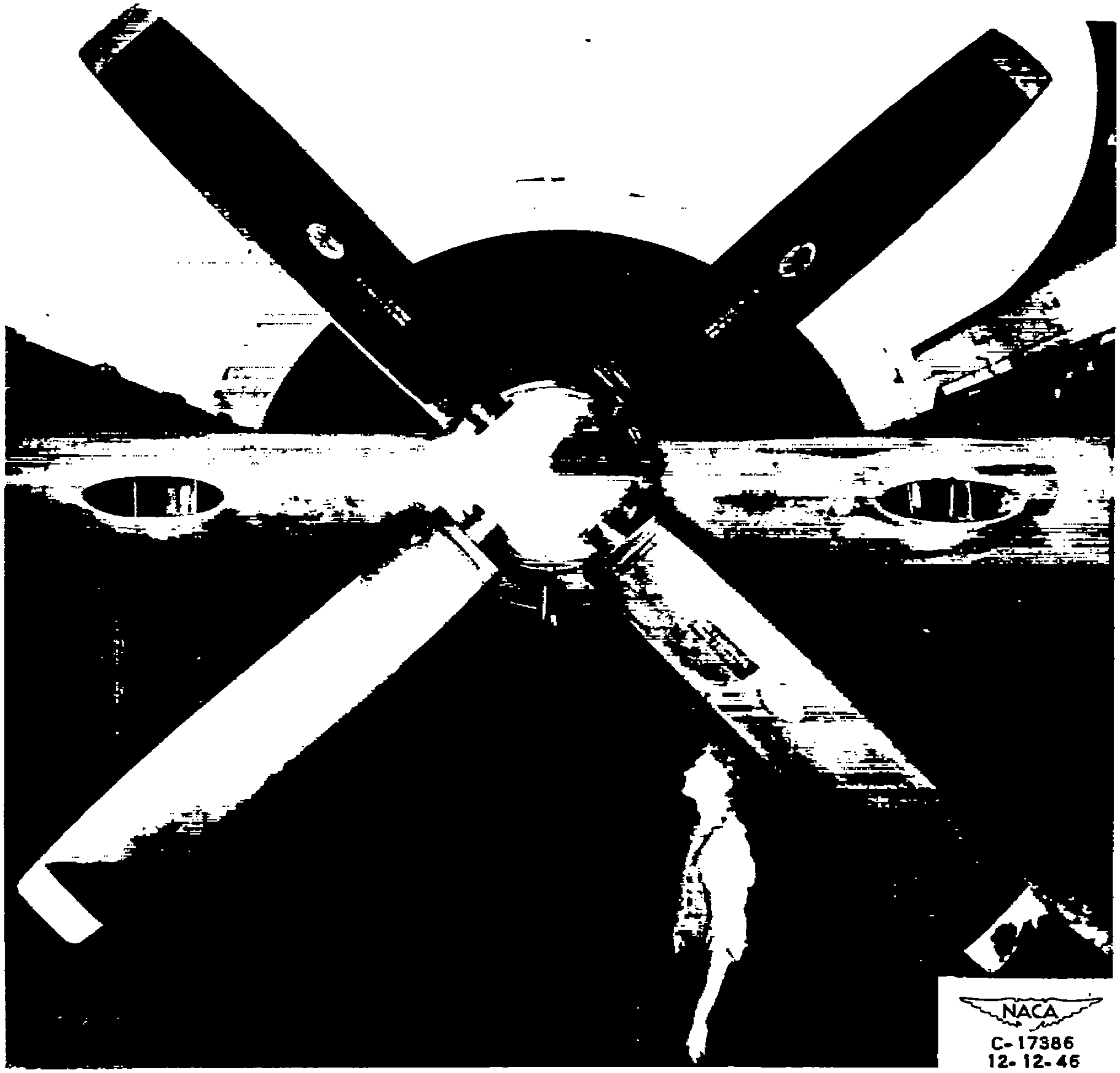
12-12-46

Figure 3. - Installation of axial-flow gas turbine-propeller engine in nacelle.



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12-12-46

Figure 4. - Front view of axial-flow gas turbine-propeller engine in altitude wind tunnel.

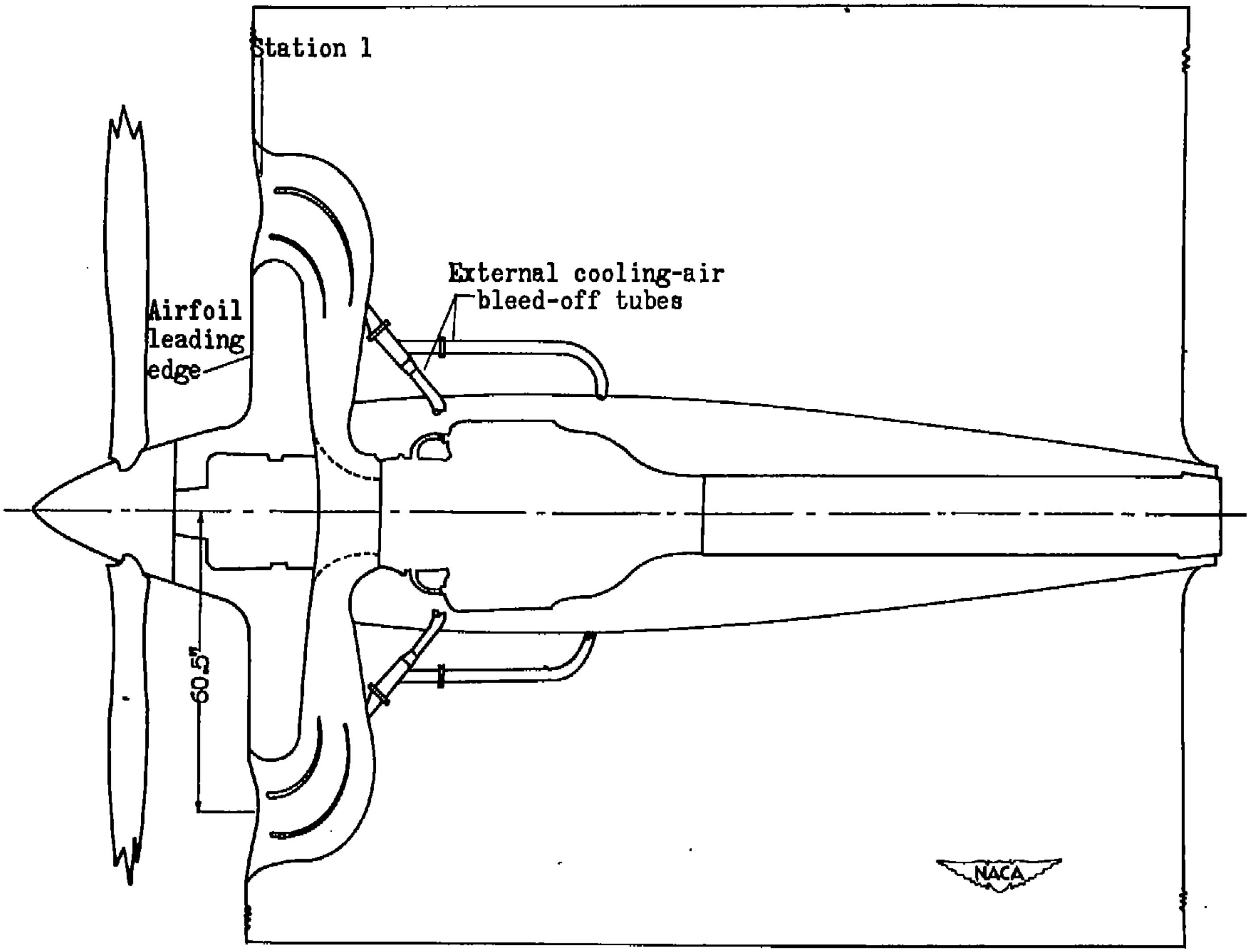
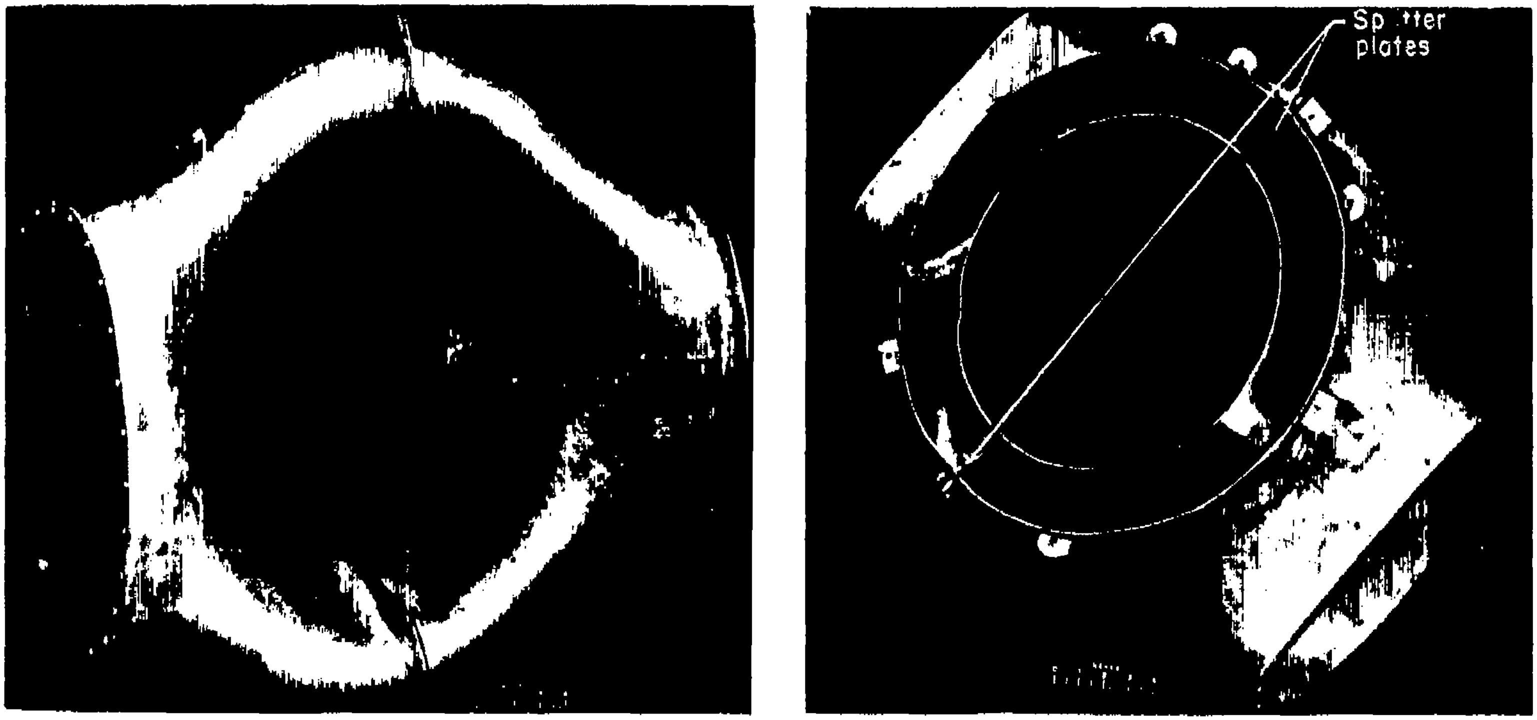

Station 1
External cooling-air bleed-off tubes
Airfoil leading edge
60.5"
NACA

Figure 5. - Sketch of axial-flow gas turbine-propeller engine installation showing location of wing ducts and inlets.


Splitter plates

(a) Front view.

(b) Rear view.

Figure 6. - Induction duct annulus.

NACA
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2-6-47

781

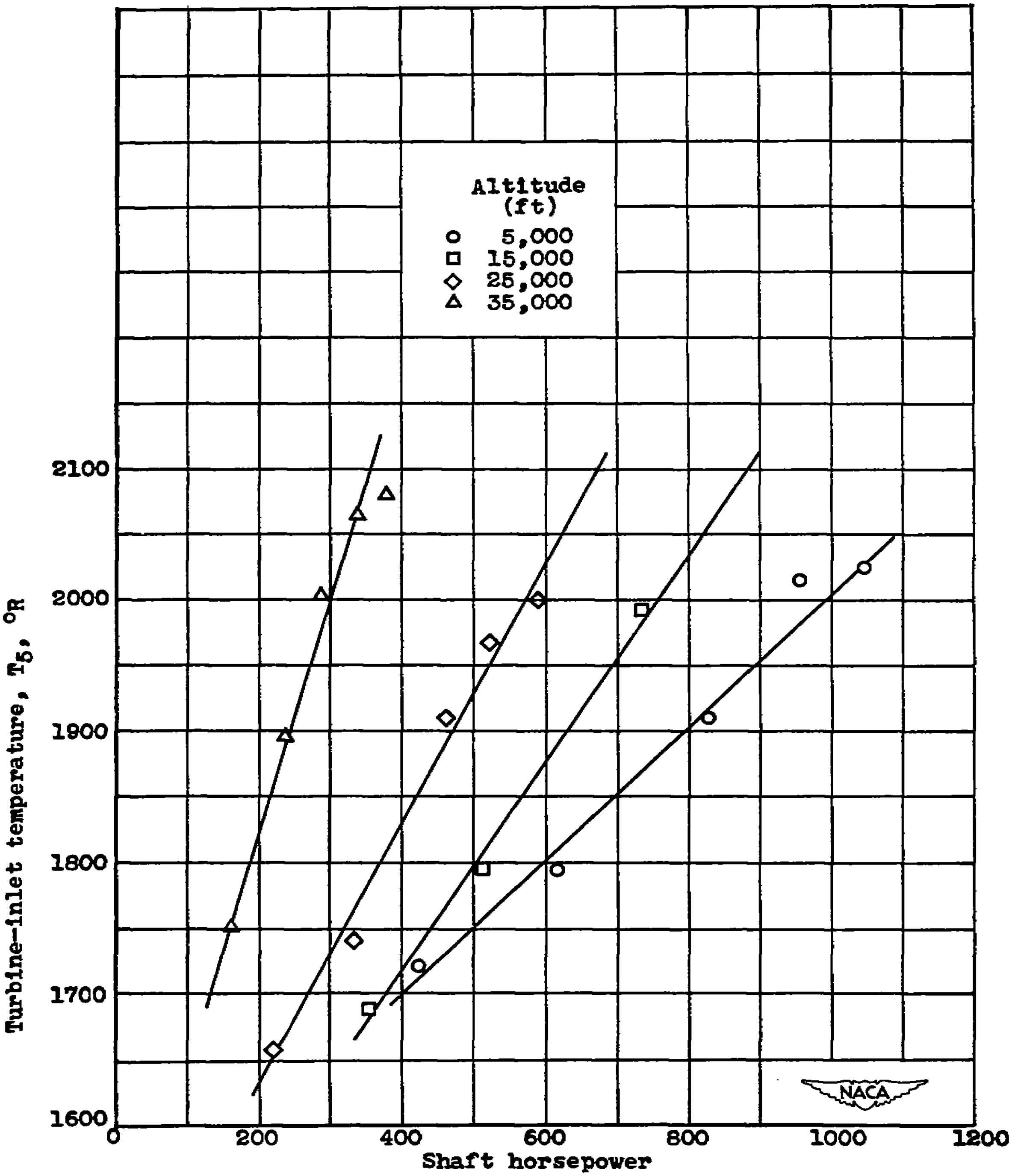


Figure 7.- Effect of shaft horsepower and altitude on turbine-inlet temperature. Engine speed, 13,000 rpm; compressor-inlet ram-pressure ratio, 1.00.

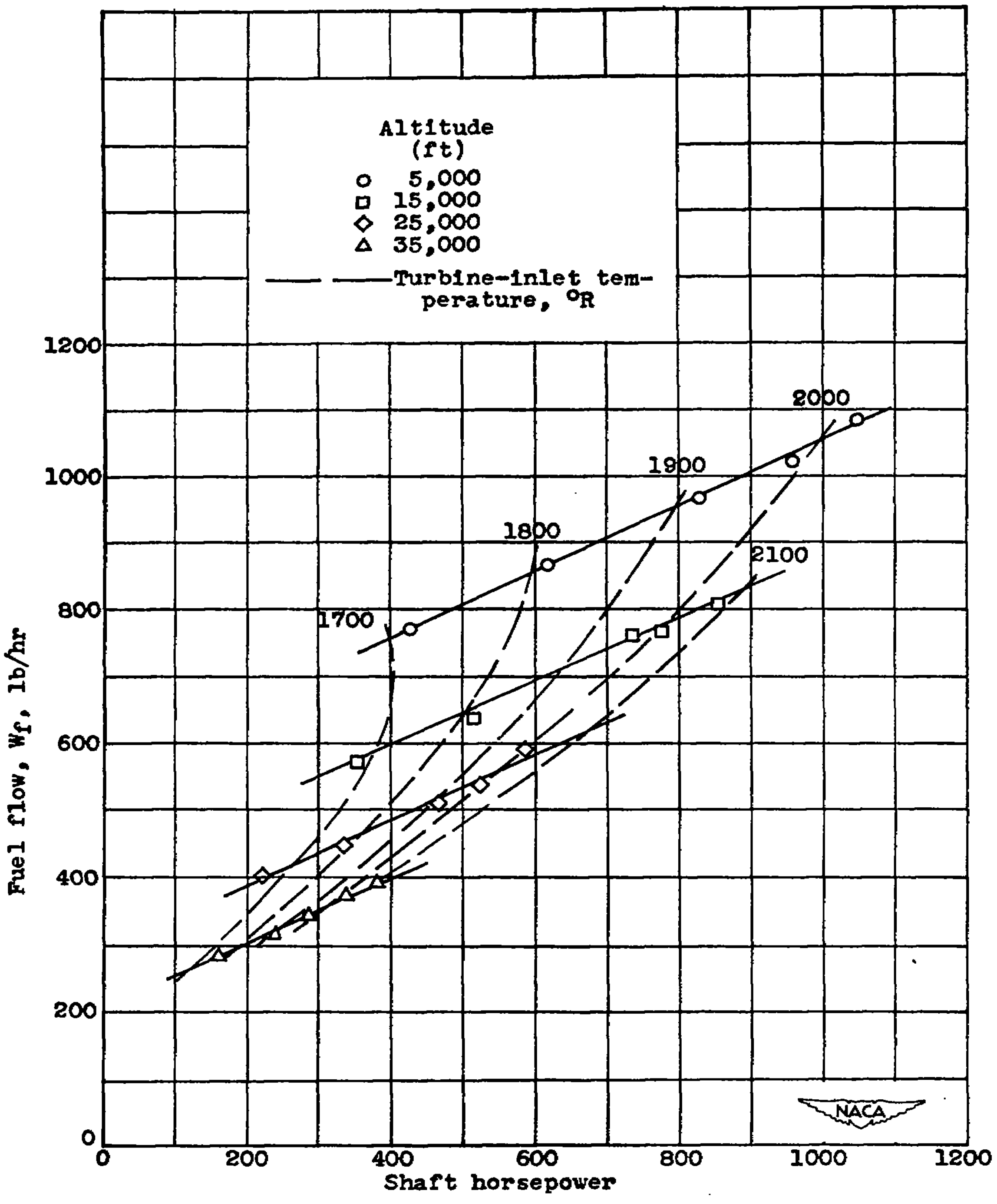


Figure 8.- Effect of shaft horsepower and altitude on engine fuel flow. Engine speed, 13,000 rpm; compressor-inlet ram-pressure ratio, 1.00.

781

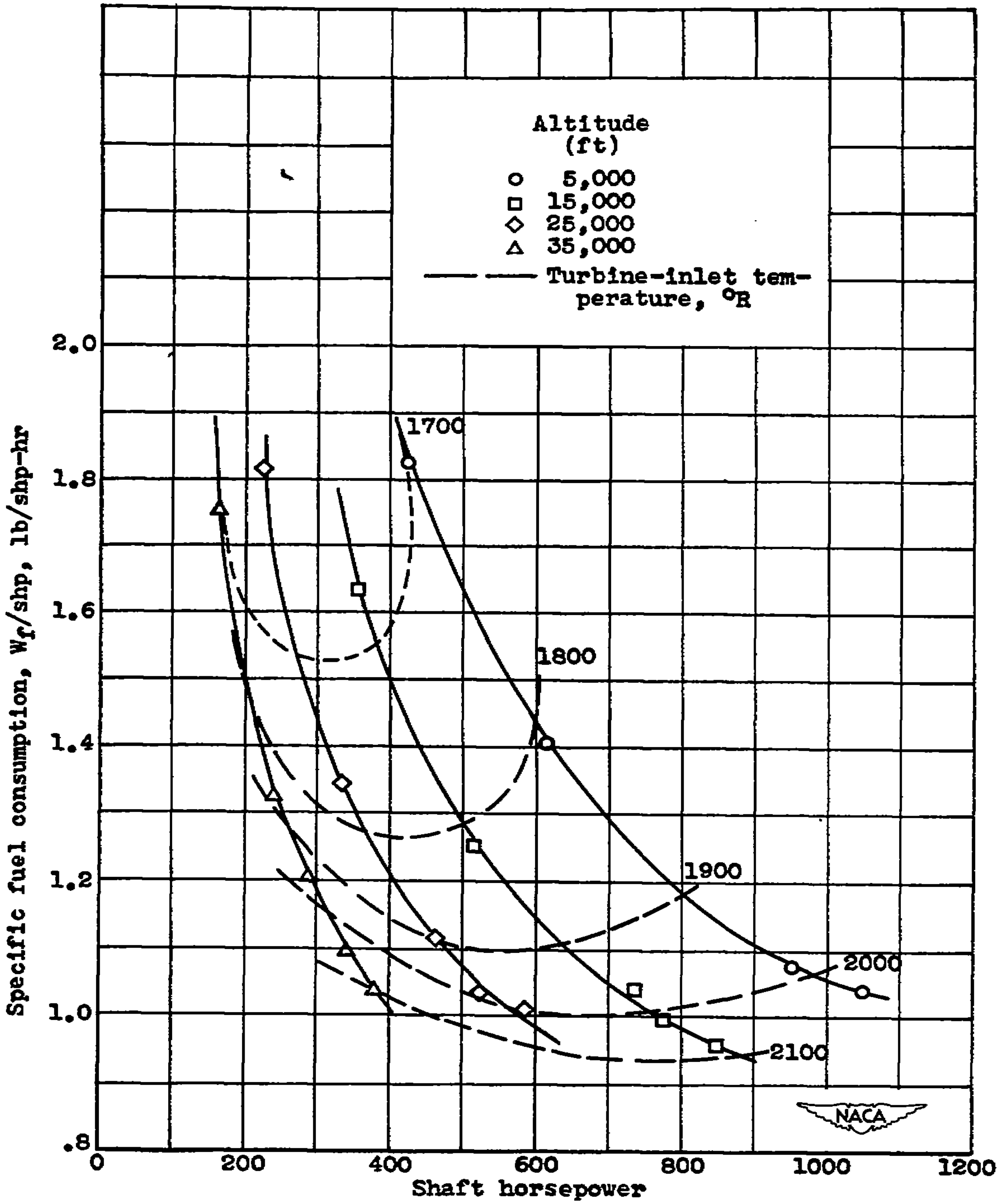


Figure 9.- Effect of shaft horsepower and altitude on specific fuel consumption. Engine speed, 13,000 rpm; compressor-inlet ram-pressure ratio, 1.00.

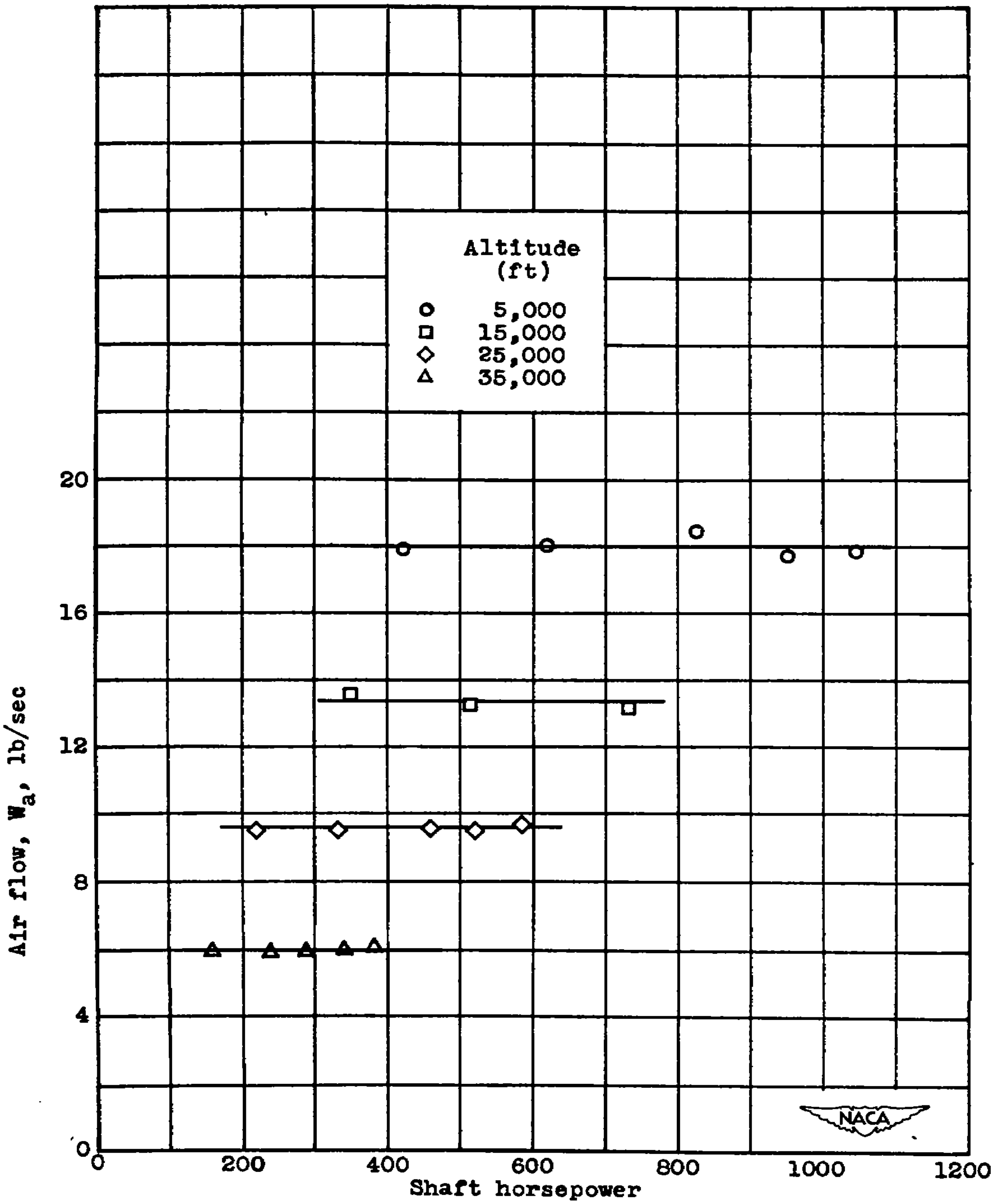


Figure 10.- Effect of shaft horsepower and altitude on engine air flow. Engine speed, 13,000 rpm; compressor-inlet ram-pressure ratio, 1.00.

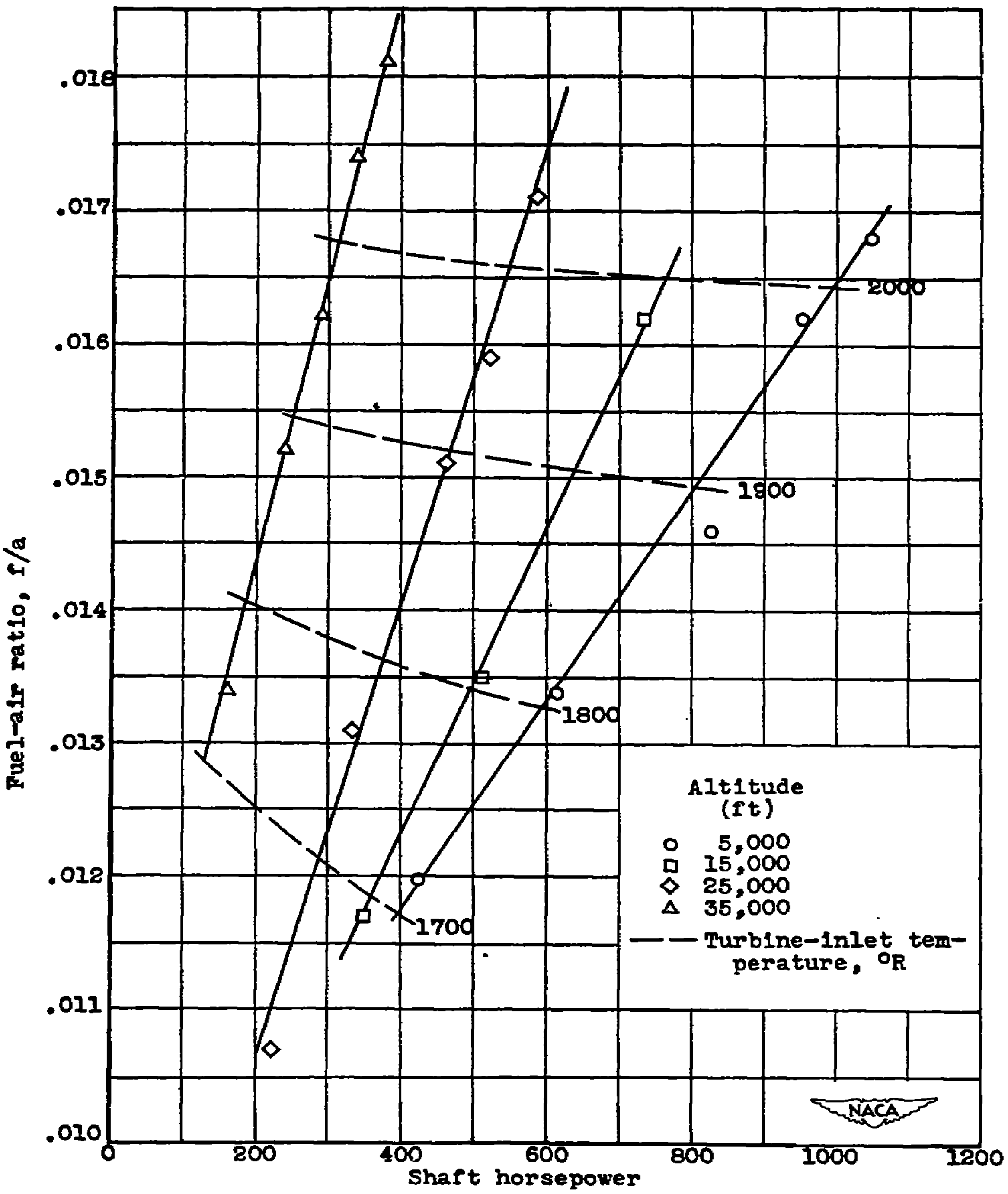


Figure 11.- Effect of shaft horsepower and altitude on fuel-air ratio. Engine speed, 13,000 rpm; compressor-inlet ram pressure ratio, 1.00.

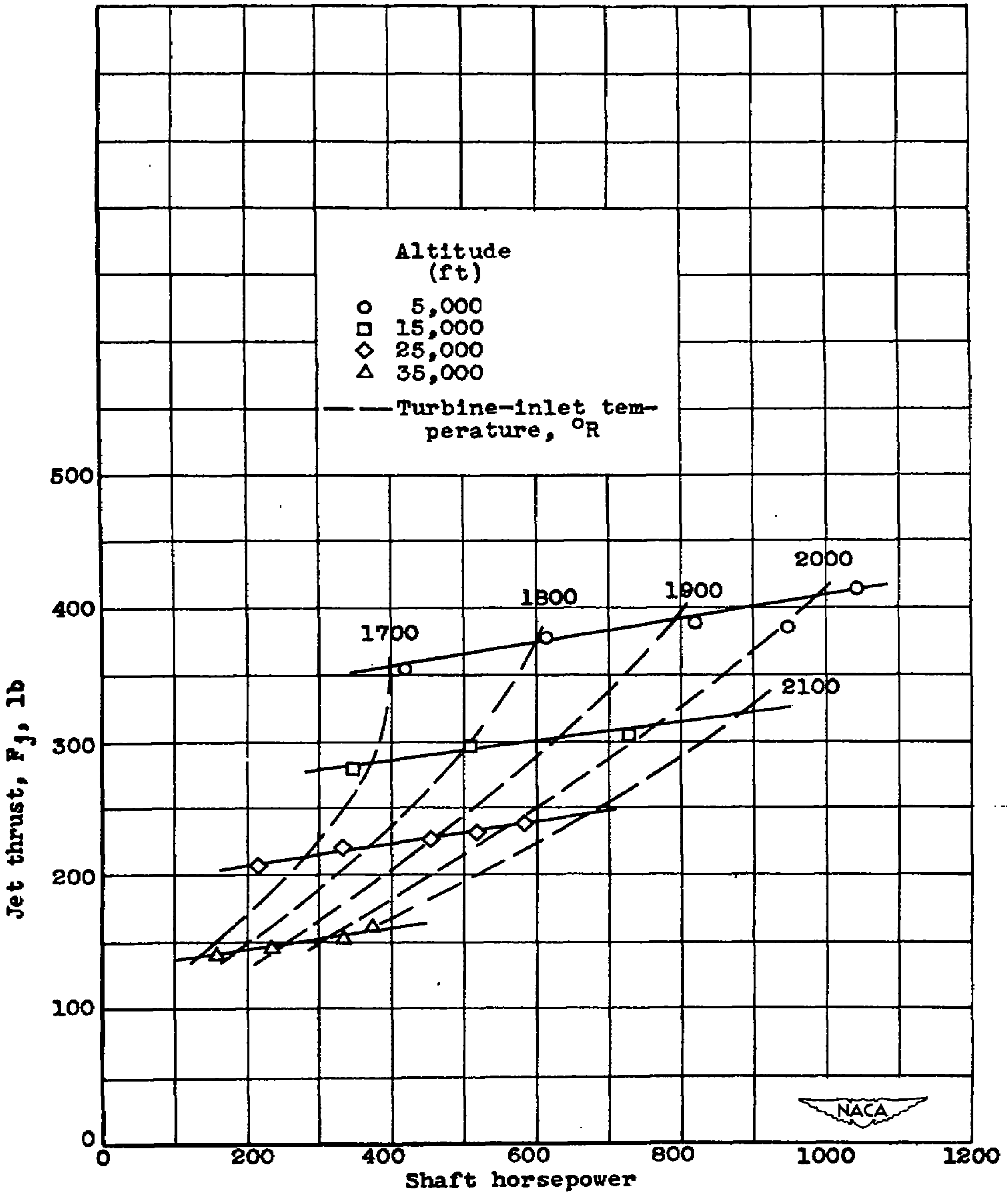


Figure 12.- Effect of shaft horsepower and altitude on jet thrust. Engine speed, 13,000 rpm; compressor-inlet ram-pressure ratio, 1.00.

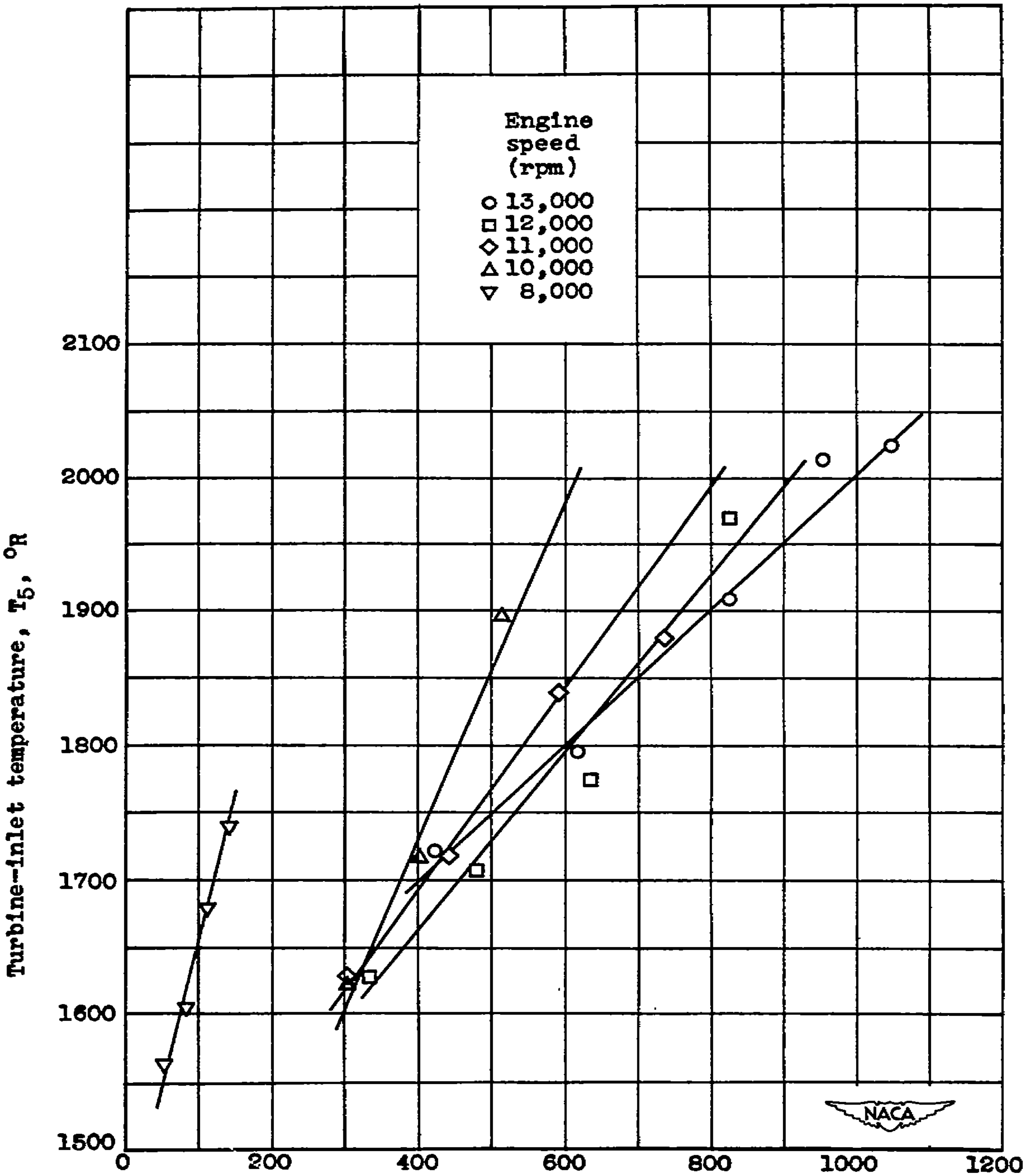


Figure 13.- Effect of shaft horsepower and engine speed on turbine-inlet temperature. Altitude, 5000 feet; compressor-inlet ram-pressure ratio, 1.00.

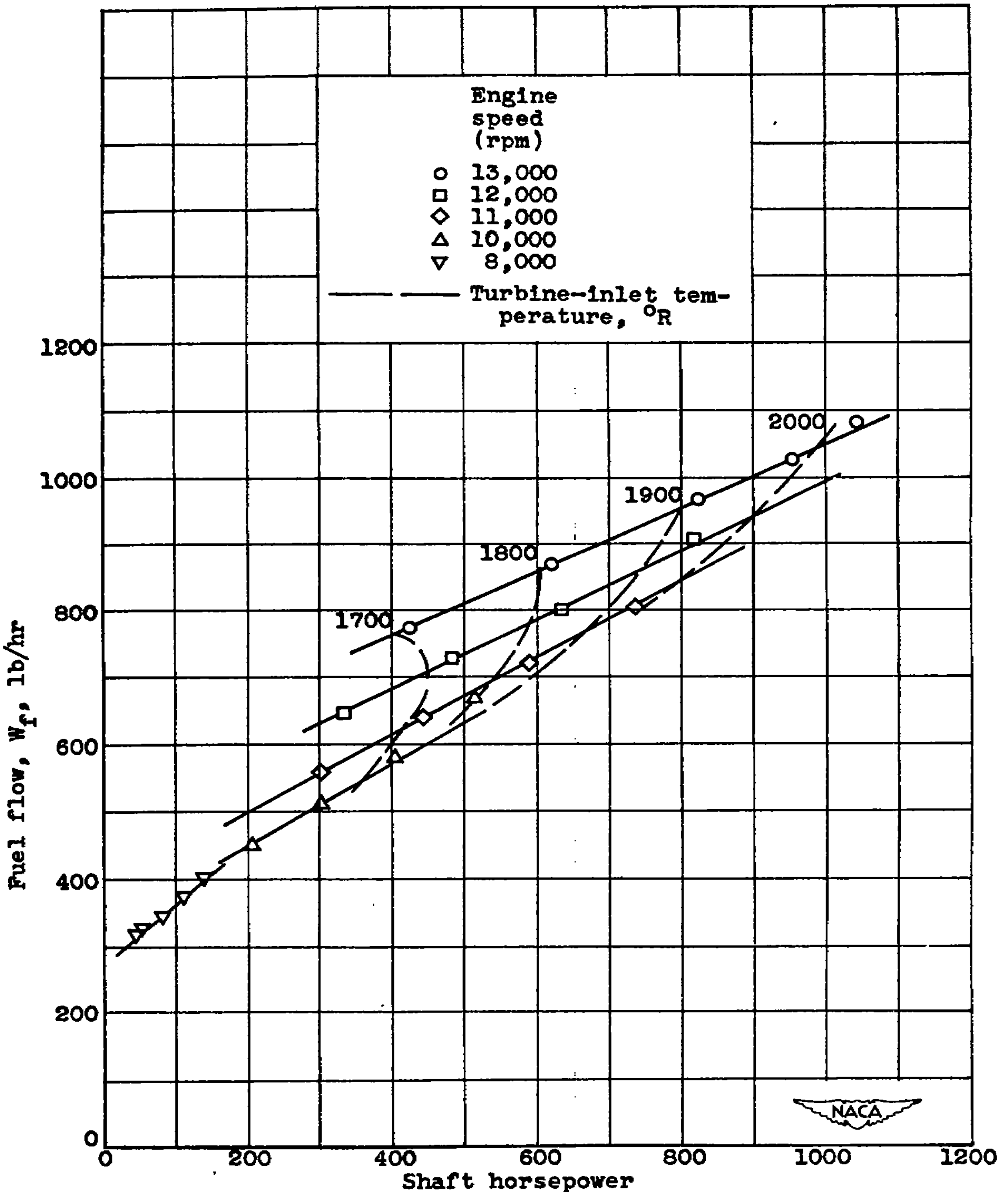


Figure 14.- Effect of shaft horsepower and engine speed on fuel flow. Altitude, 5000 feet; compressor-inlet ram-pressure ratio, 1.00.

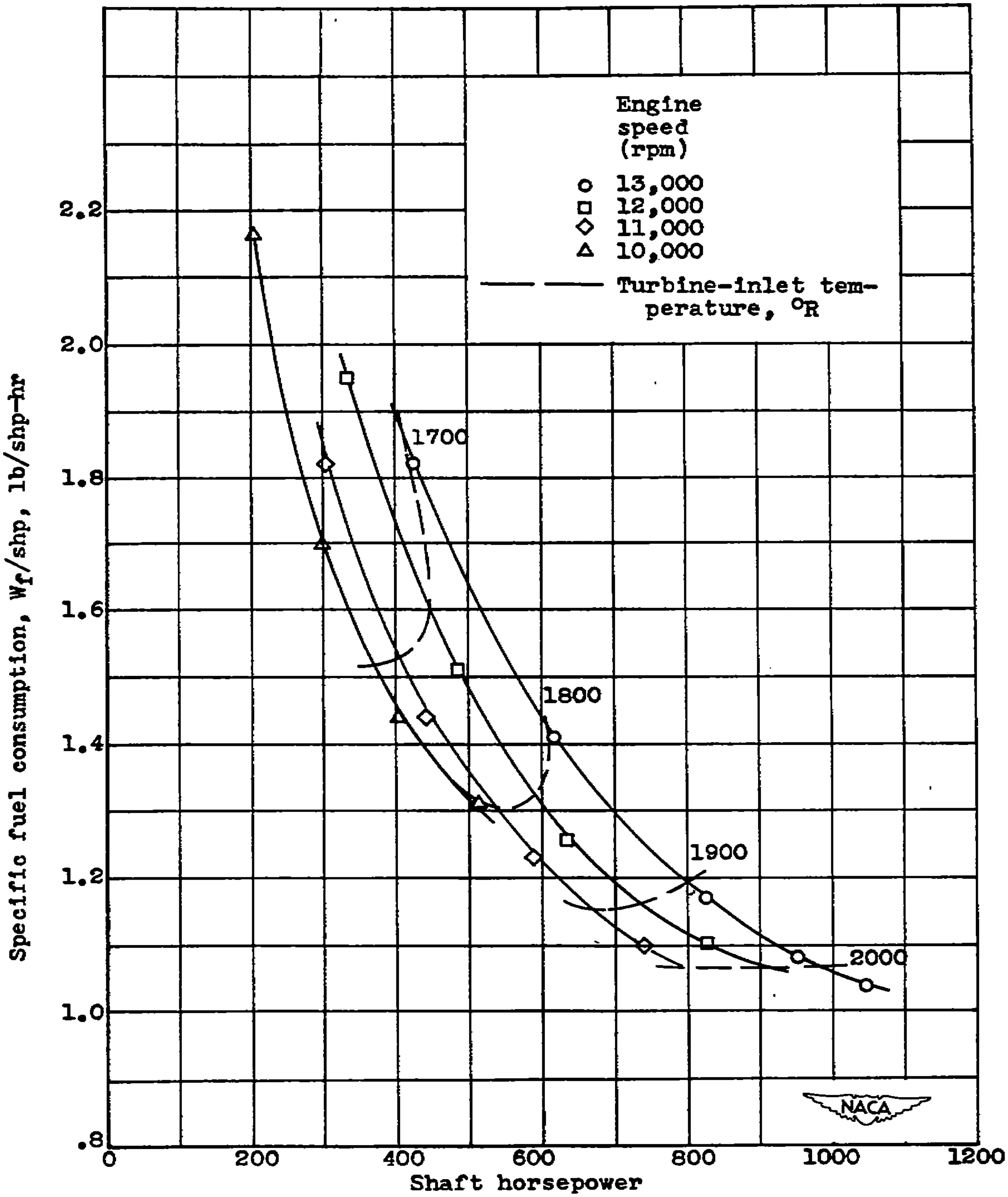


Figure 15.- Effect of shaft horsepower and engine speed on specific fuel consumption. Altitude, 5000 feet; compressor-inlet ram-pressure ratio, 1.00.

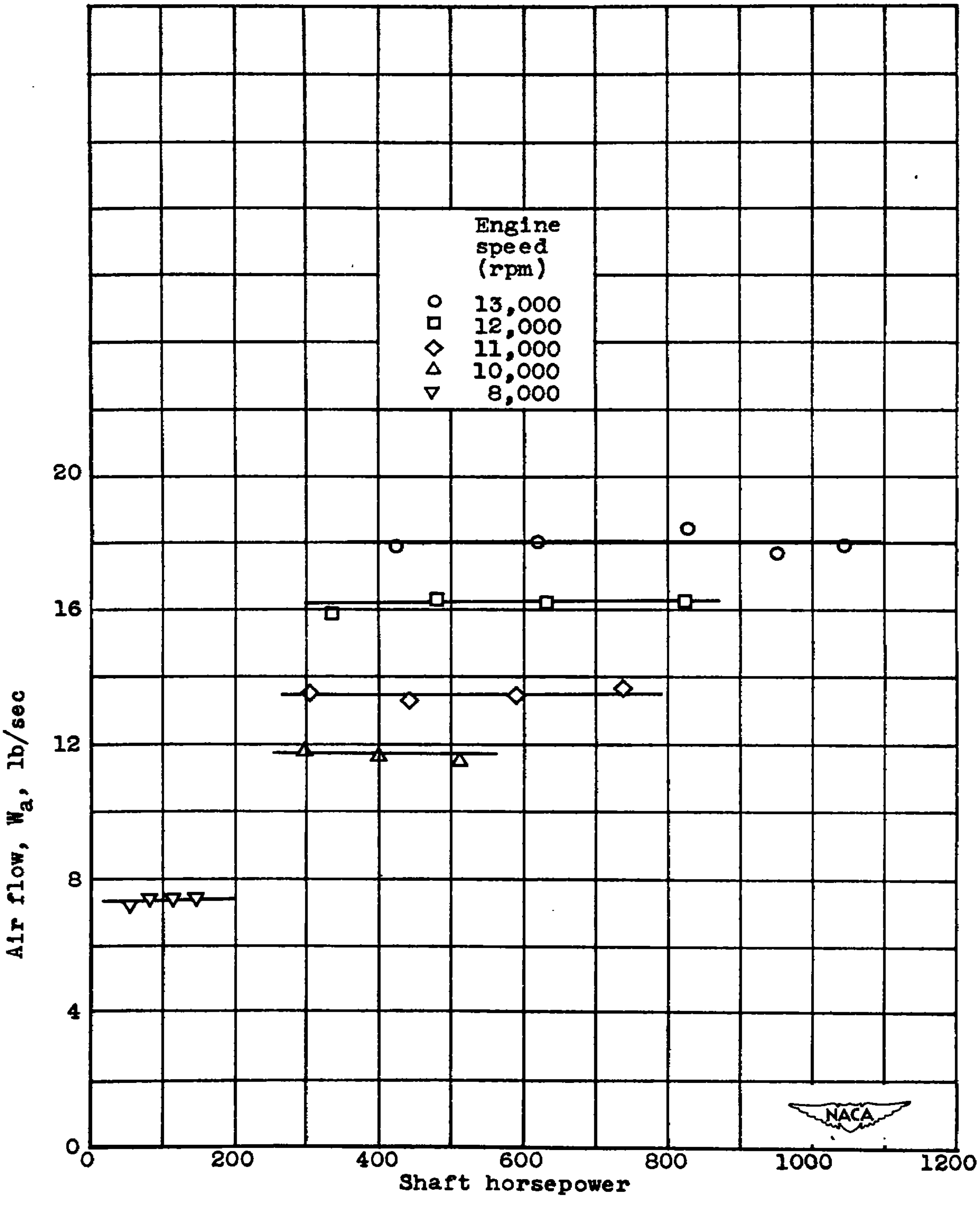


Figure 16.- Effect of shaft horsepower and engine speed on engine air flow. Altitude, 5000 feet; compressor-inlet ram-pressure ratio, 1.00.

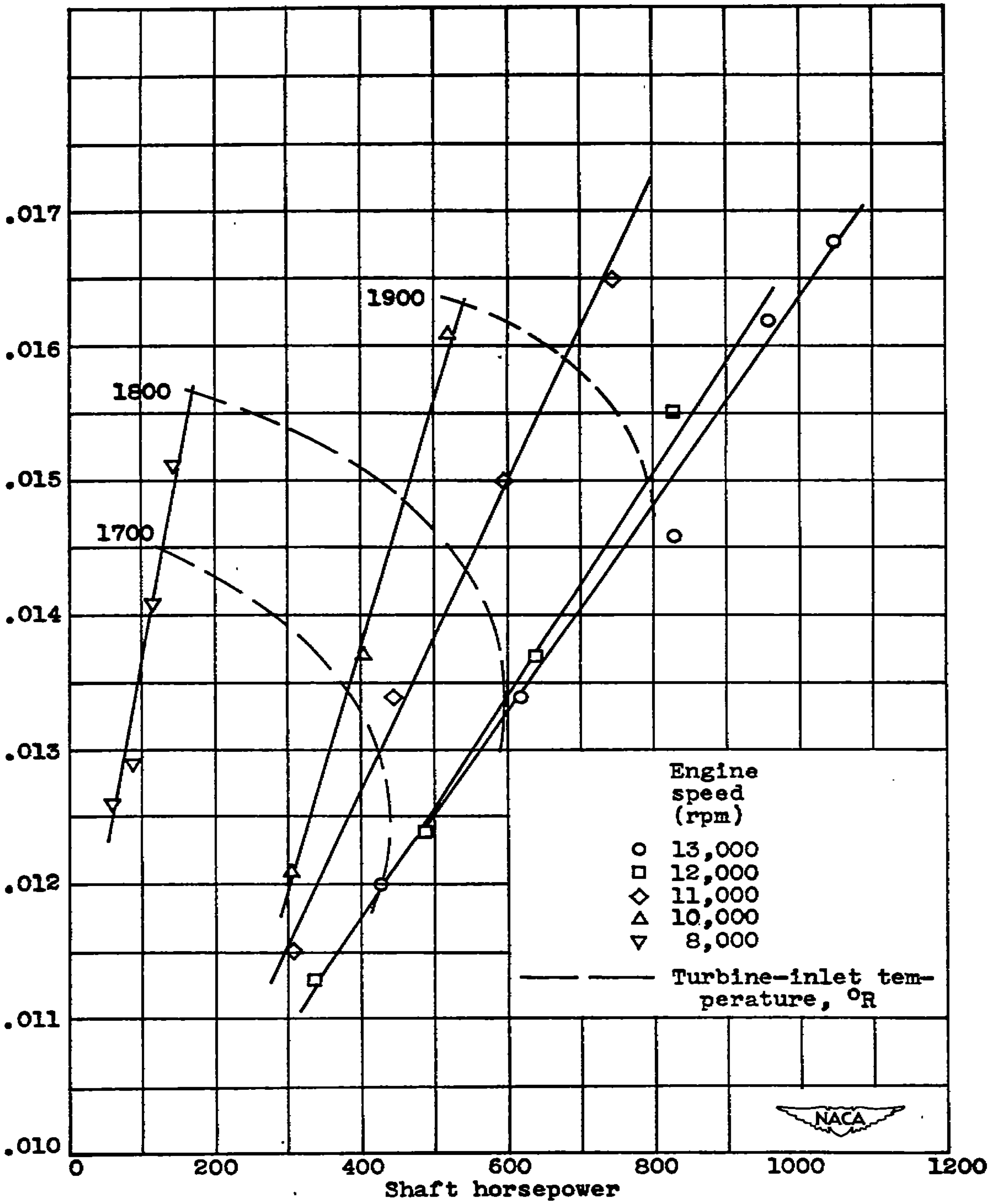


Figure 17.- Effect of shaft horsepower and engine speed on fuel-air ratio. Altitude, 5000 feet; compressor-inlet ram-pressure ratio, 1.00.

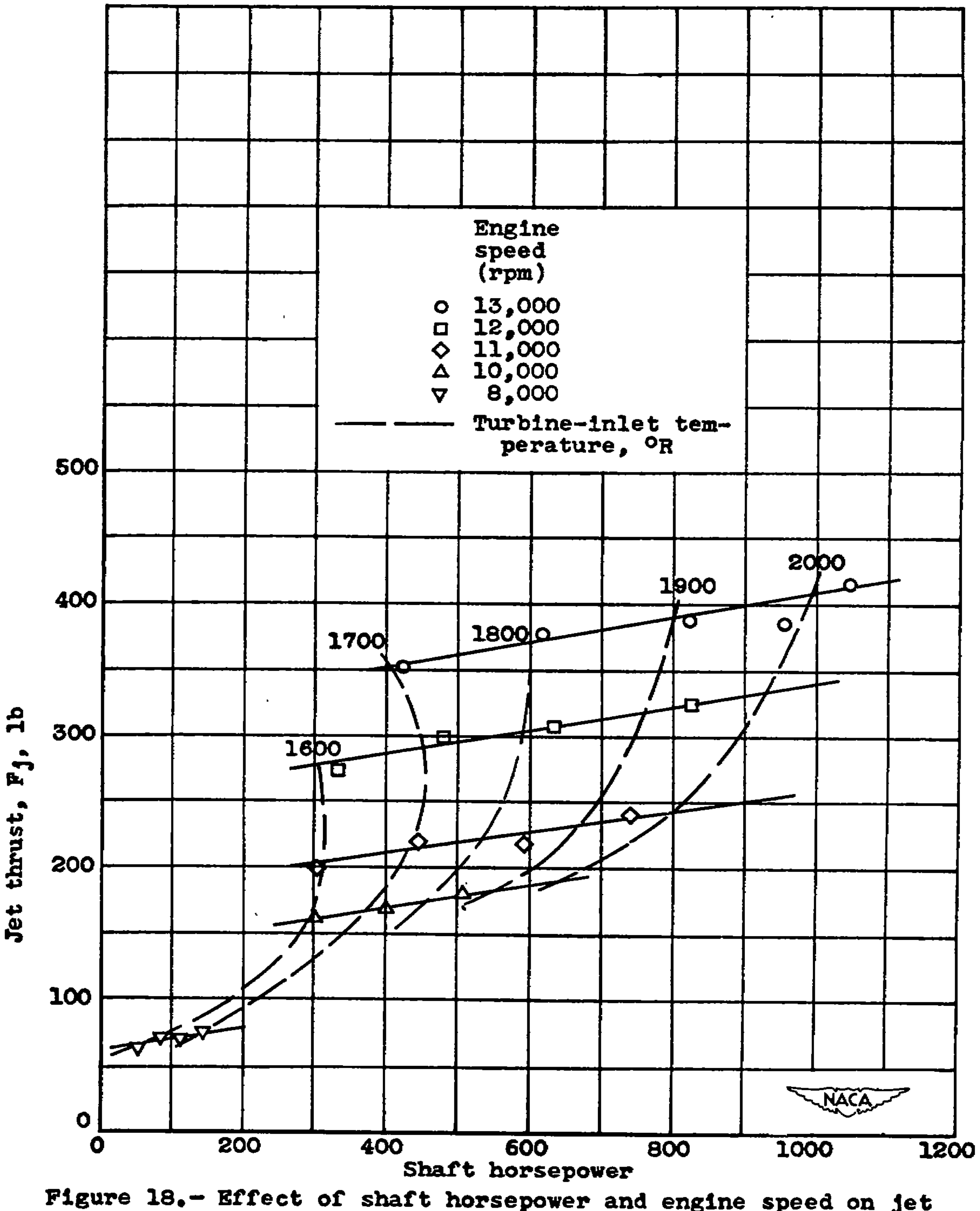


Figure 18.- Effect of shaft horsepower and engine speed on jet thrust. Altitude, 5000 feet; compressor-inlet ram-pressure ratio, 1.00.

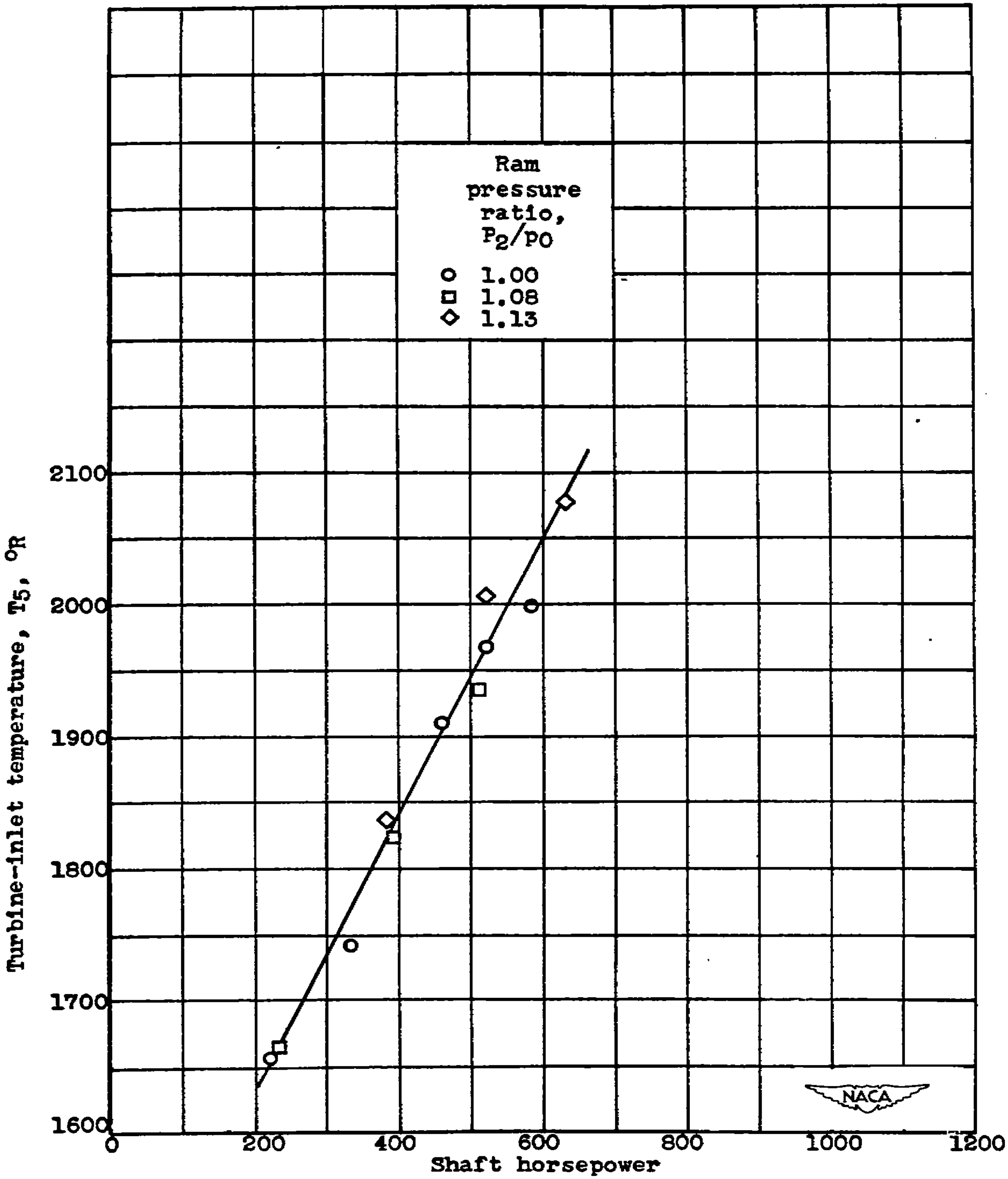


Figure 19.- Effect of shaft horsepower and compressor-inlet ram-pressure ratio on turbine-inlet temperature. Engine speed, 13,000 rpm; altitude, 25,000 feet.

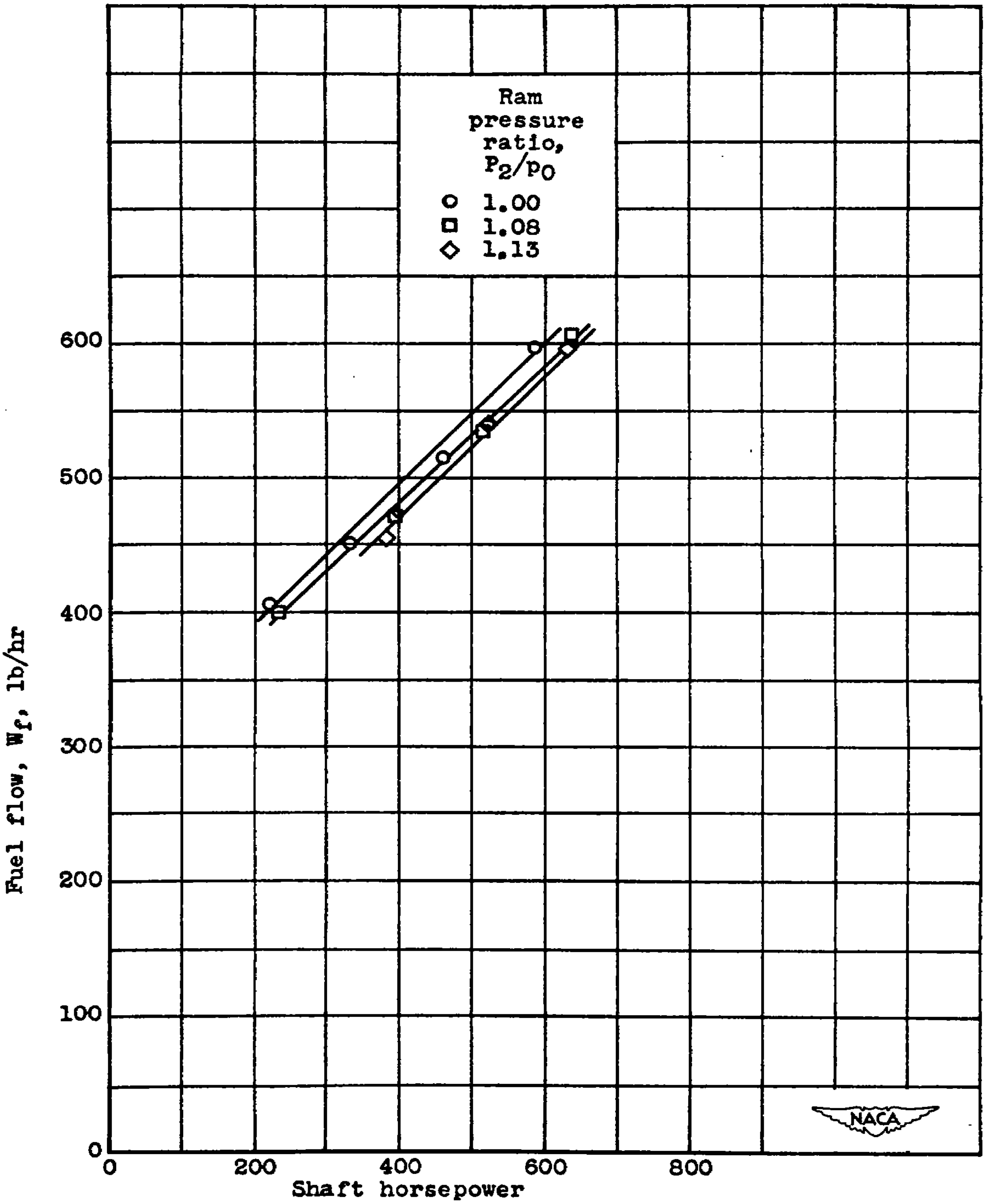


Figure 20.- Effect of shaft horsepower and compressor-inlet ram-pressure ratio on fuel flow. Engine speed, 13,000 rpm; altitude, 25,000 feet.

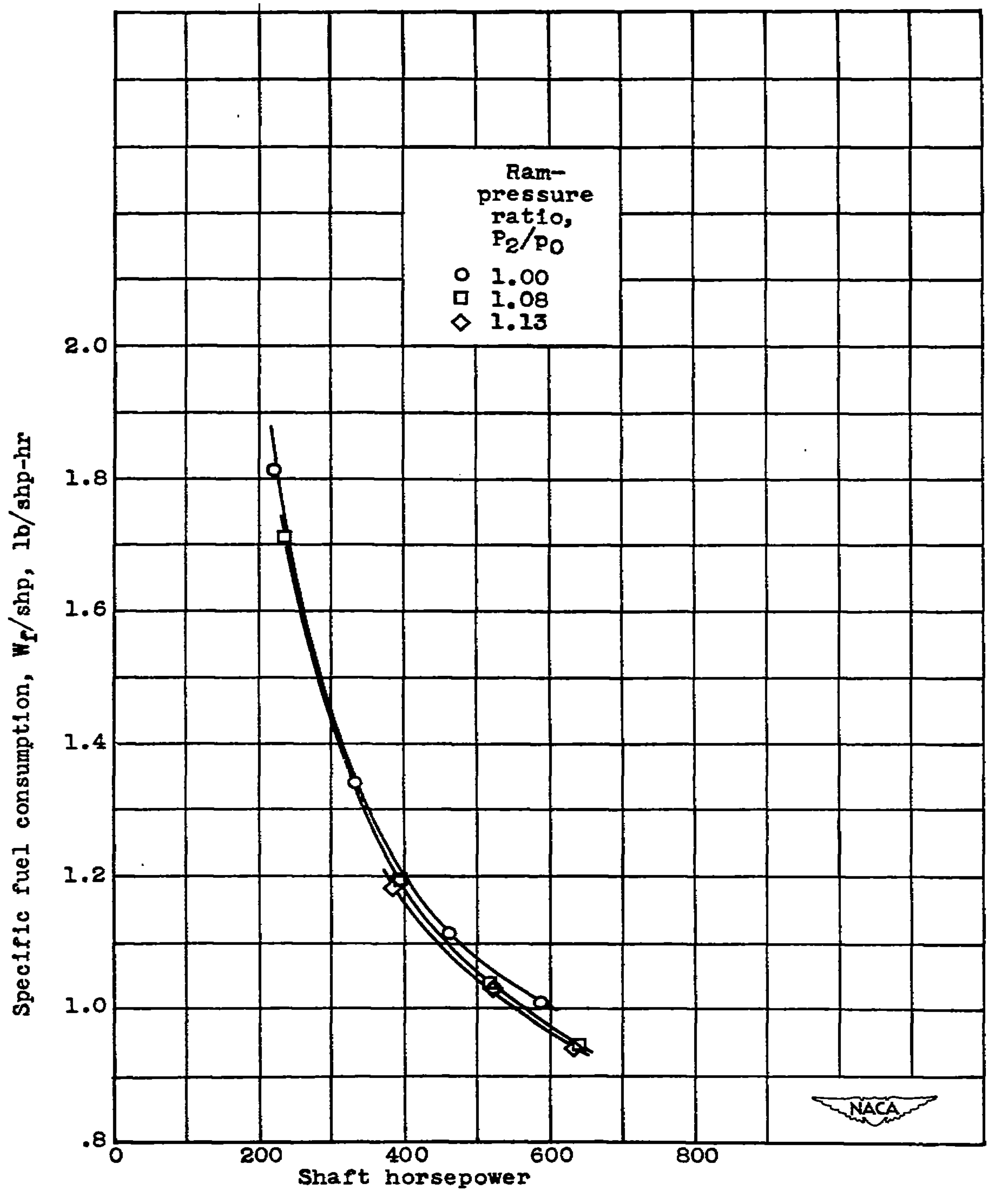


Figure 21.- Effect of shaft horsepower and compressor-inlet ram-pressure ratio on specific fuel consumption. Engine speed, 13,000 rpm; altitude, 25,000 feet.

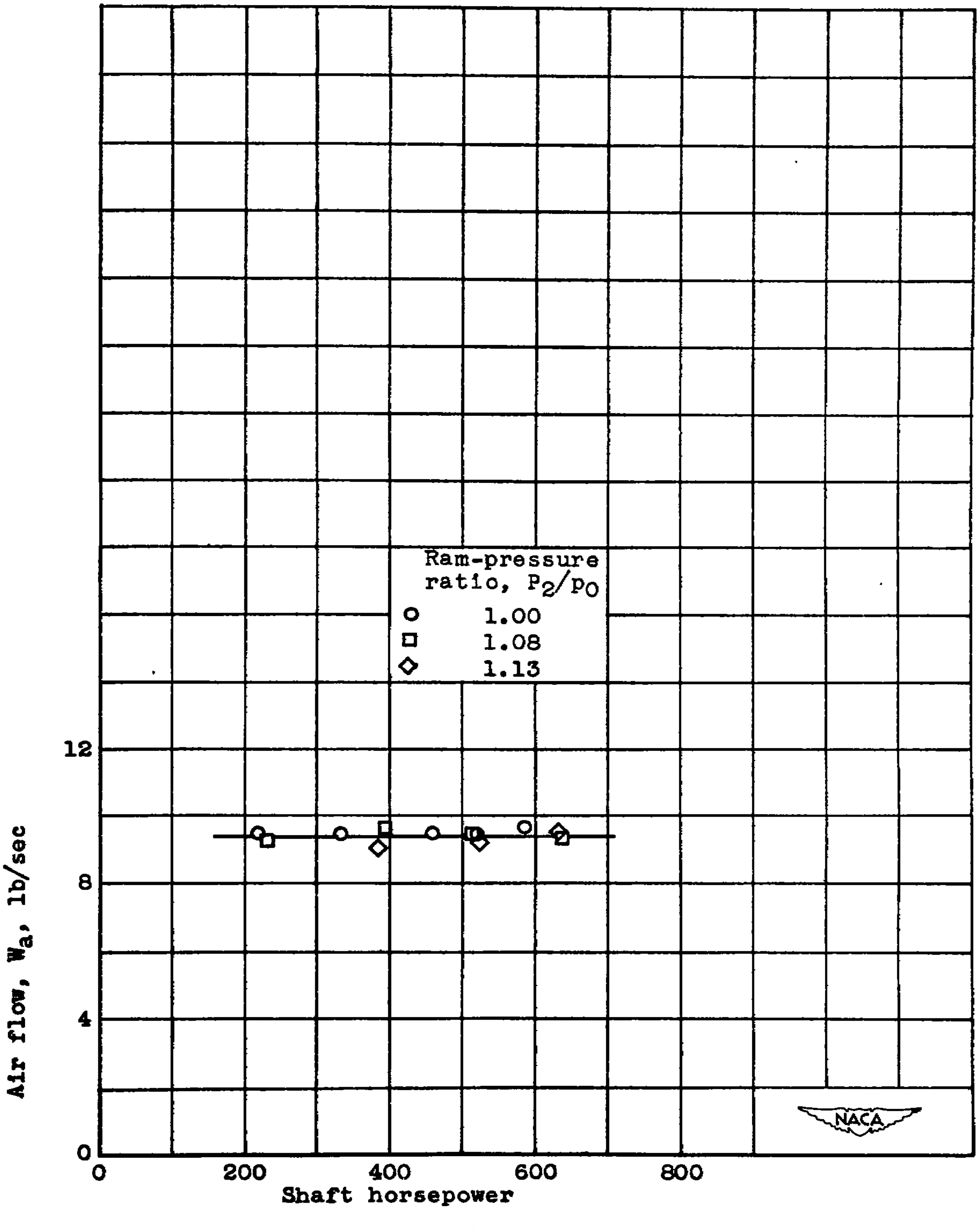


Figure 22.- Effect of shaft horsepower and compressor-inlet ram-pressure ratio on engine air flow. Engine speed, 13,000 rpm; altitude, 25,000 feet.

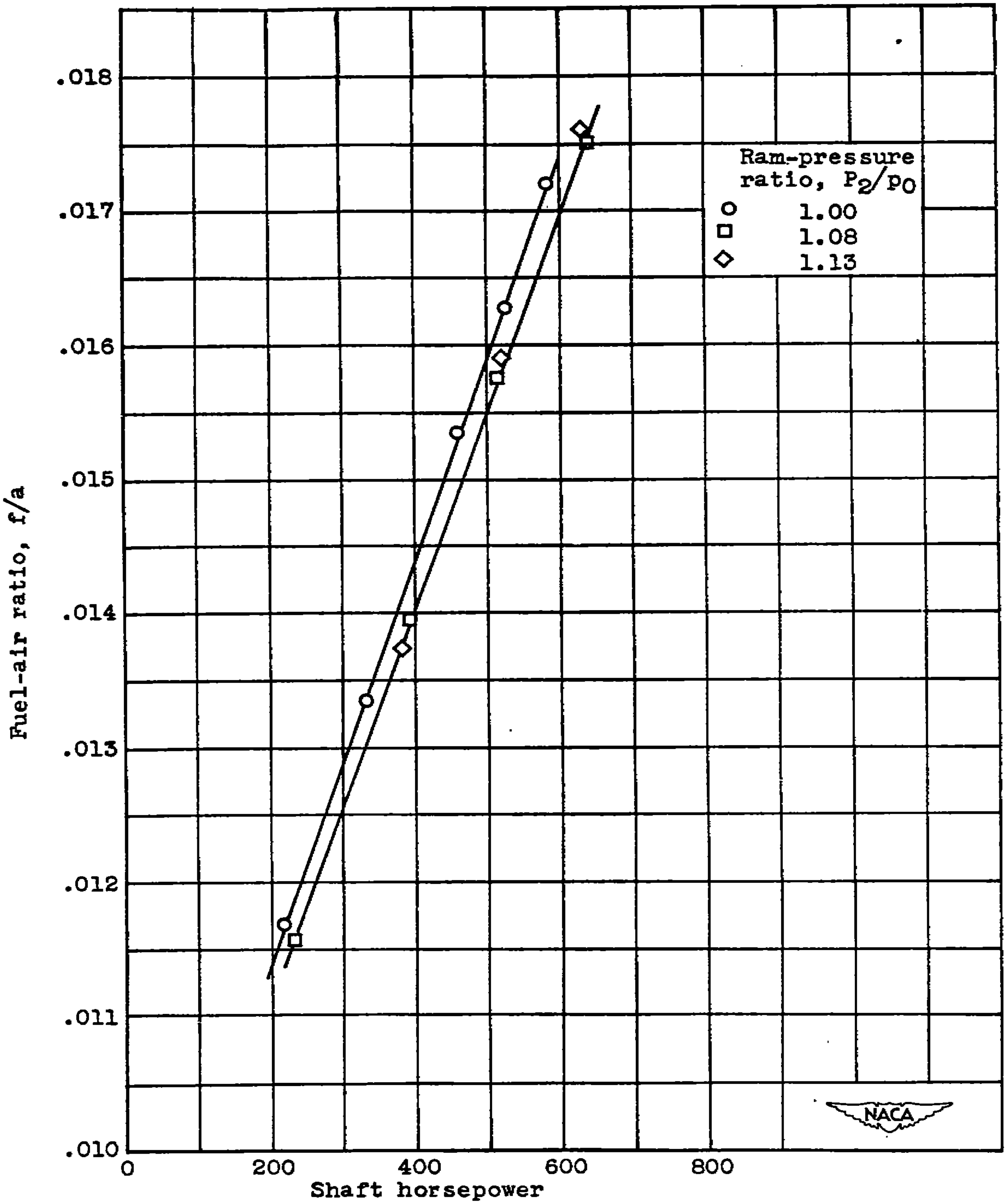


Figure 23.- Effect of shaft horsepower and compressor-inlet ram-pressure ratio on fuel-air ratio. Engine speed, 13,000 rpm; altitude, 25,000 feet.

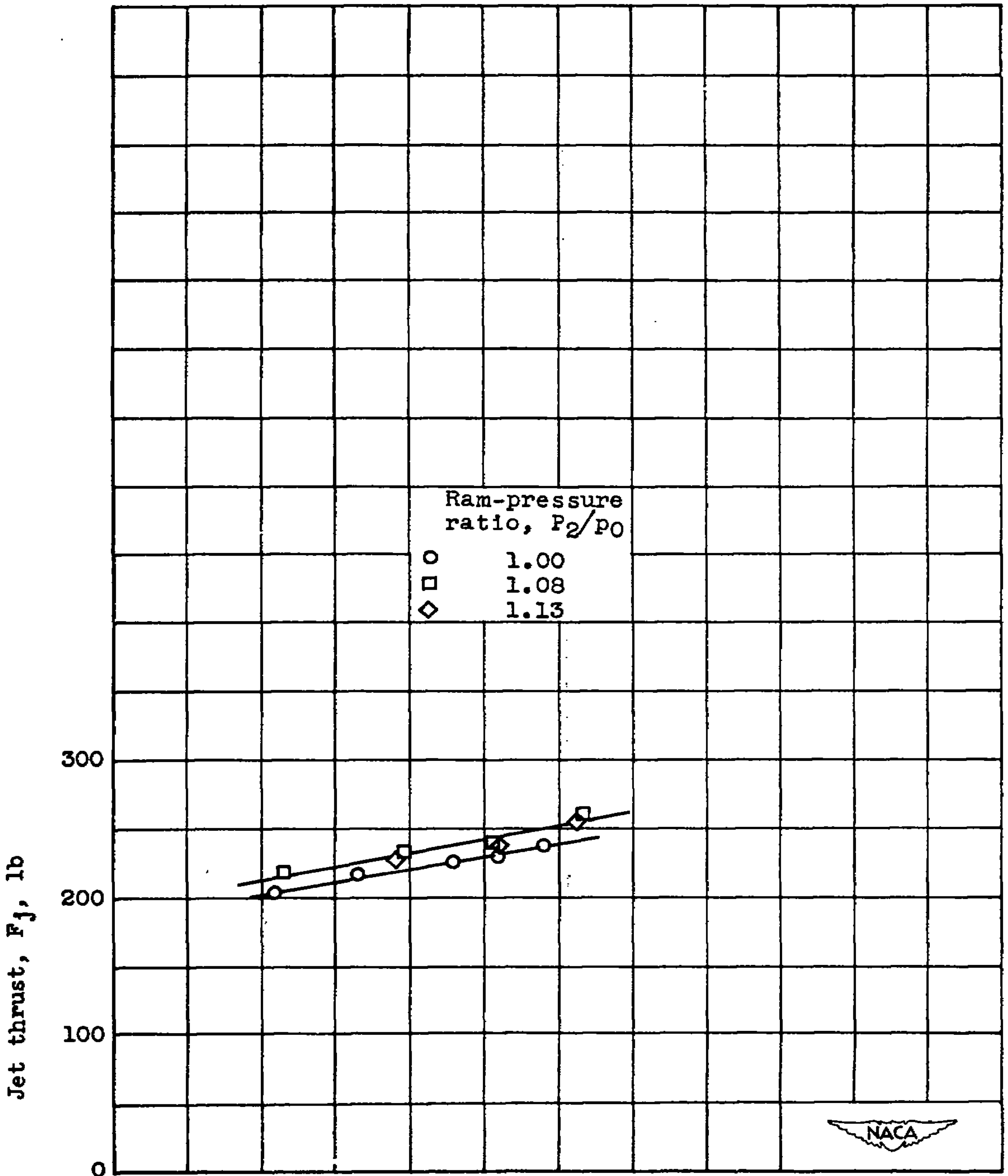


Figure 24.- Effect of shaft horsepower and compressor-inlet ram-pressure ratio on jet thrust. Engine speed, 13,000 rpm; altitude, 25,000 feet.

781

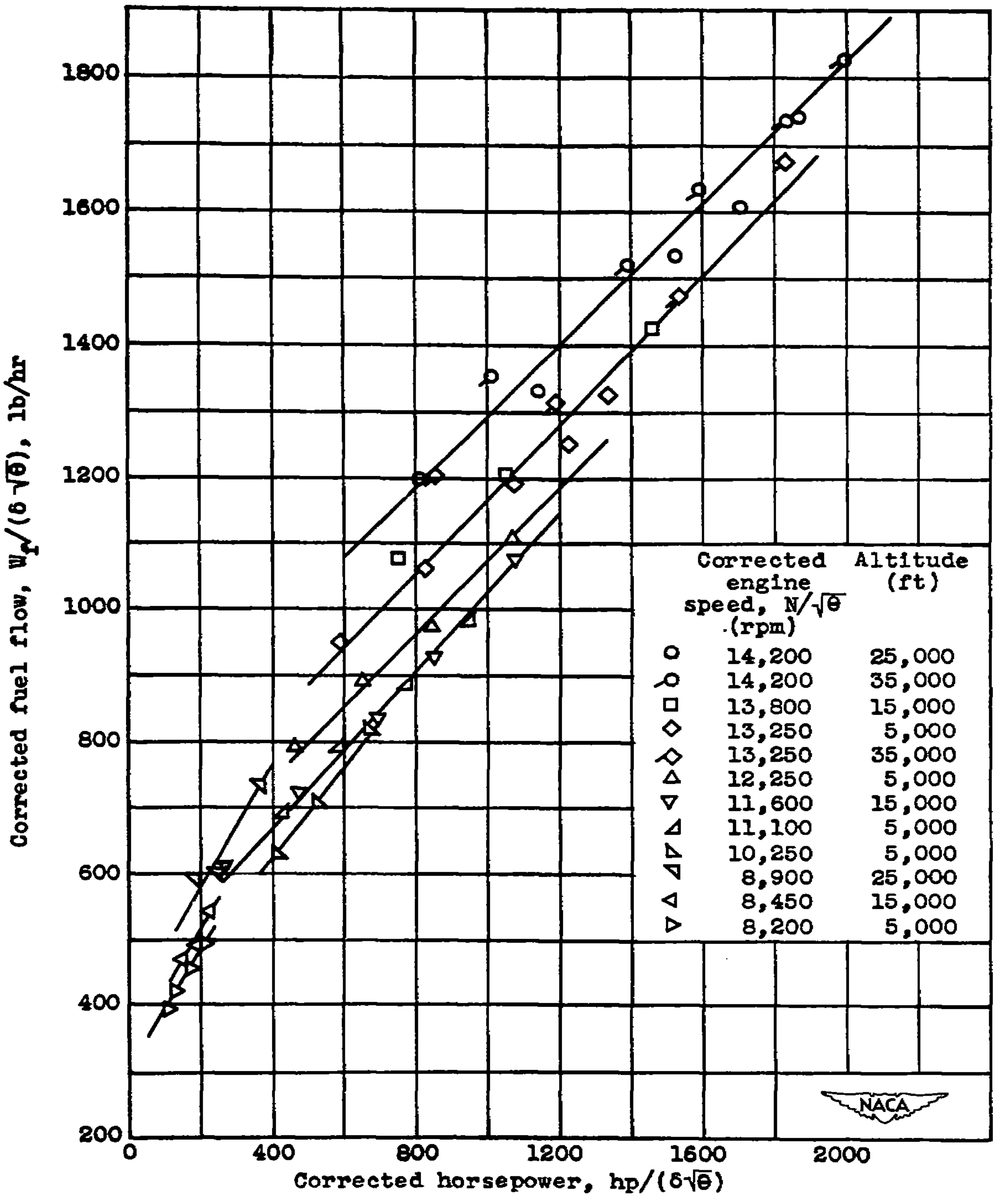


Figure 25.- Effect of corrected horsepower and corrected engine speed on corrected fuel flow. Compressor-inlet ram-pressure ratio, 1.00.

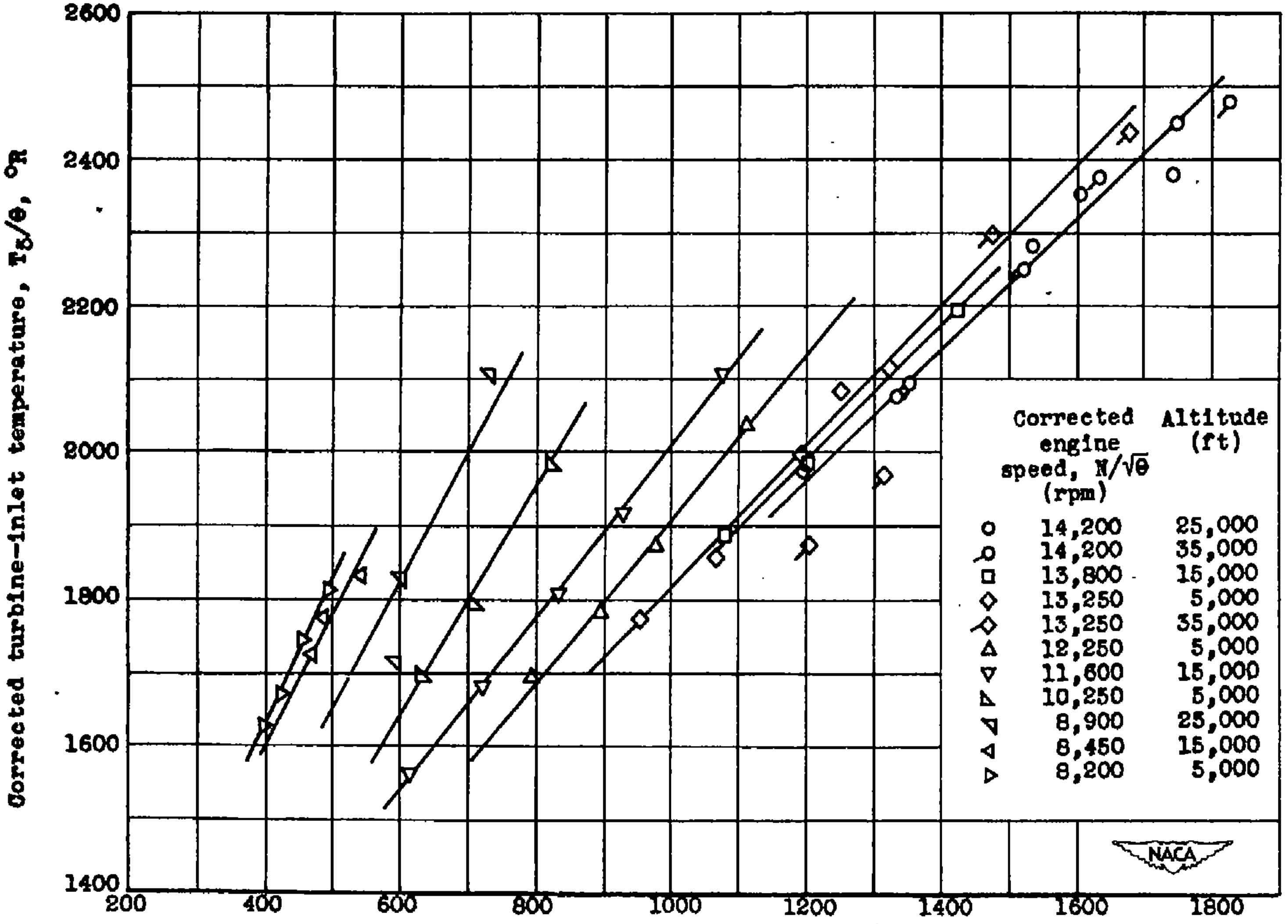


Figure 26.- Effect of corrected fuel flow and corrected engine speed on corrected turbine-inlet temperature. Compressor—inlet ram-pressure ratio, 1.00.

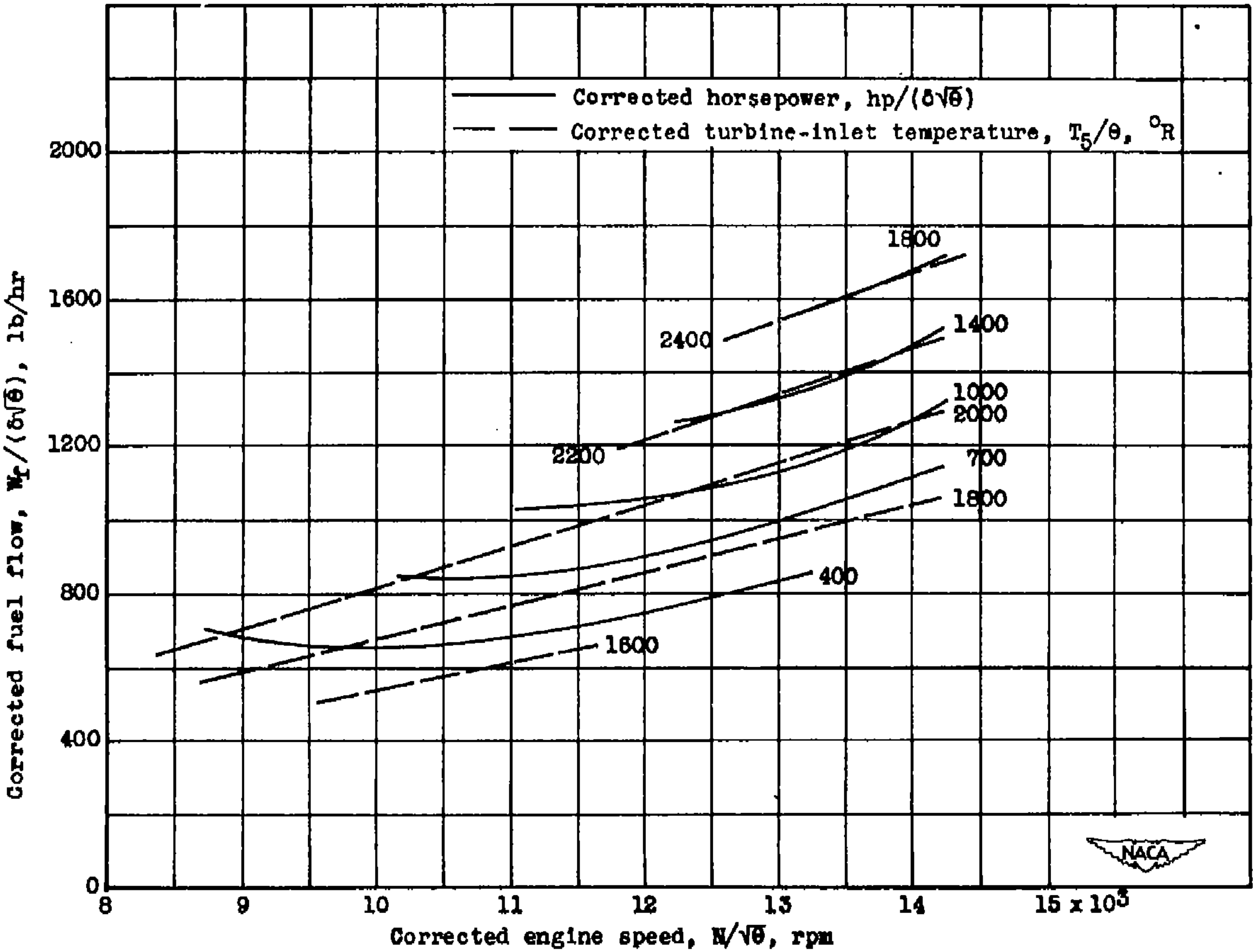


Figure 27.- Effect of corrected engine speed and corrected horsepower on corrected fuel flow. Compressor-inlet ram-pressure ratio, 1.00.

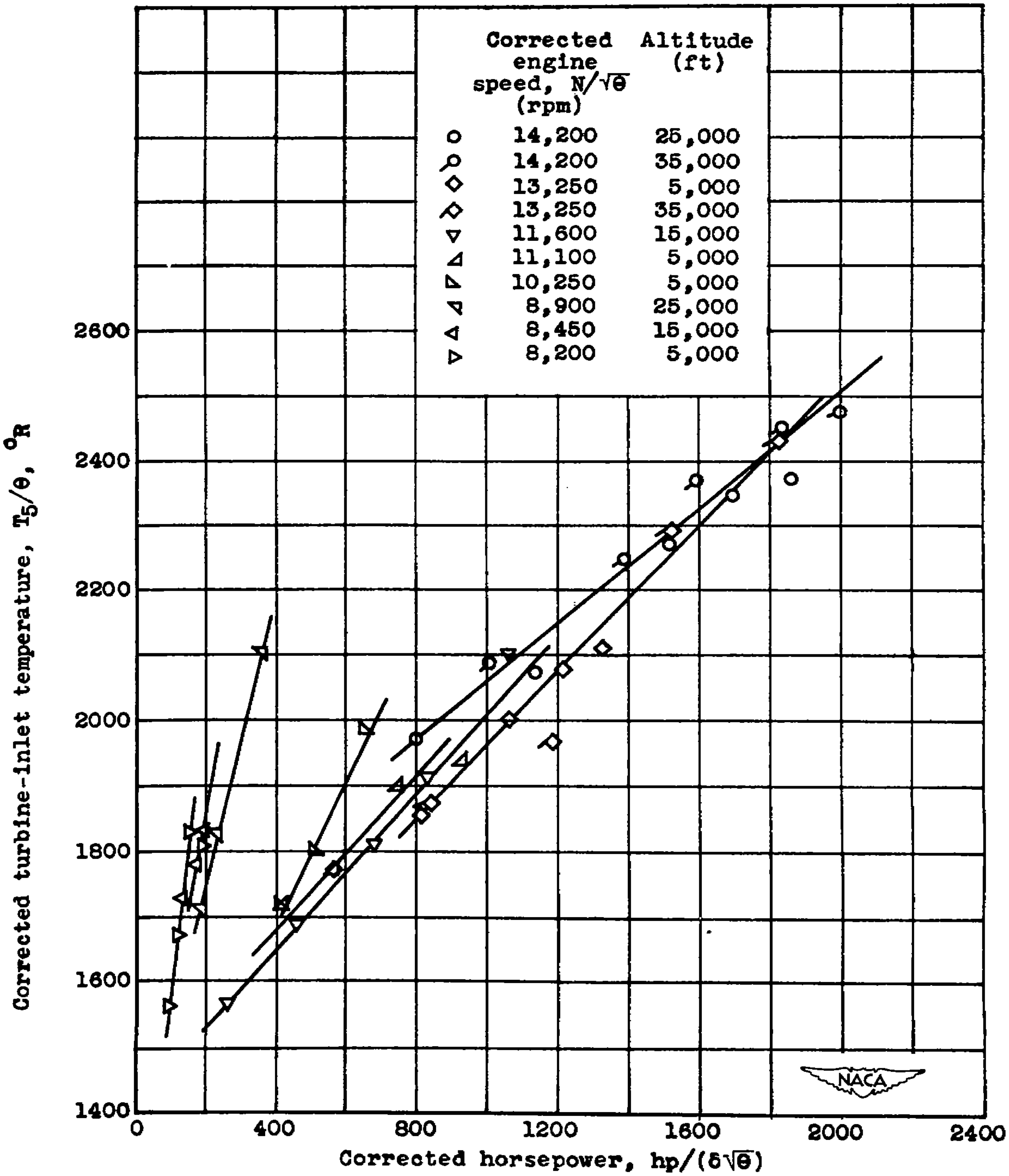


Figure 28.- Effect of corrected horsepower and corrected engine speed on corrected turbine-inlet temperature. Compressor-inlet ram-pressure ratio, 1.00.

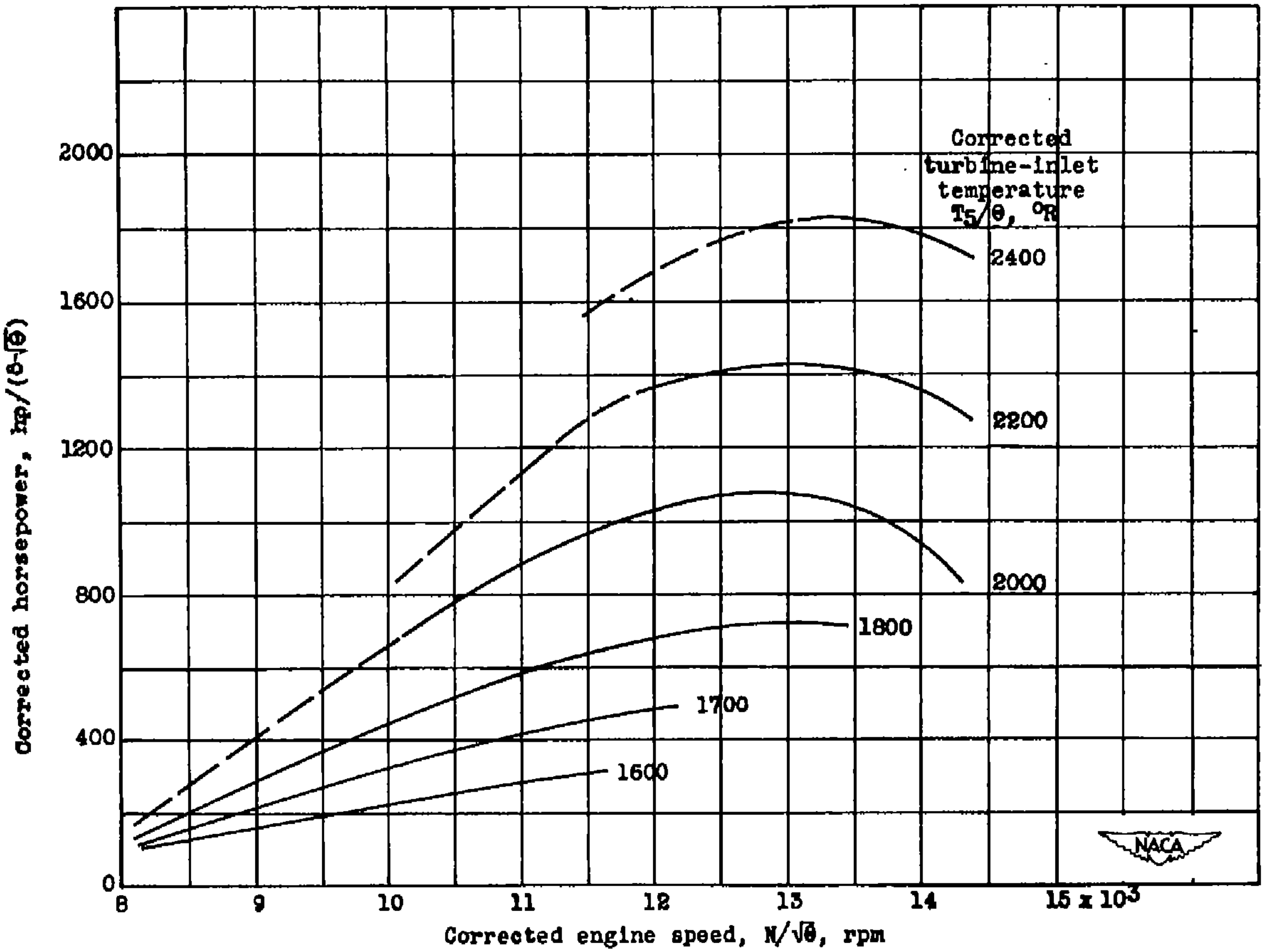


Figure 29.- Effect of corrected engine speed and corrected turbine-inlet temperature on corrected horsepower. Compressor-inlet ram-pressure ratio, 1.00. (Dashed portion of curves extrapolated.)

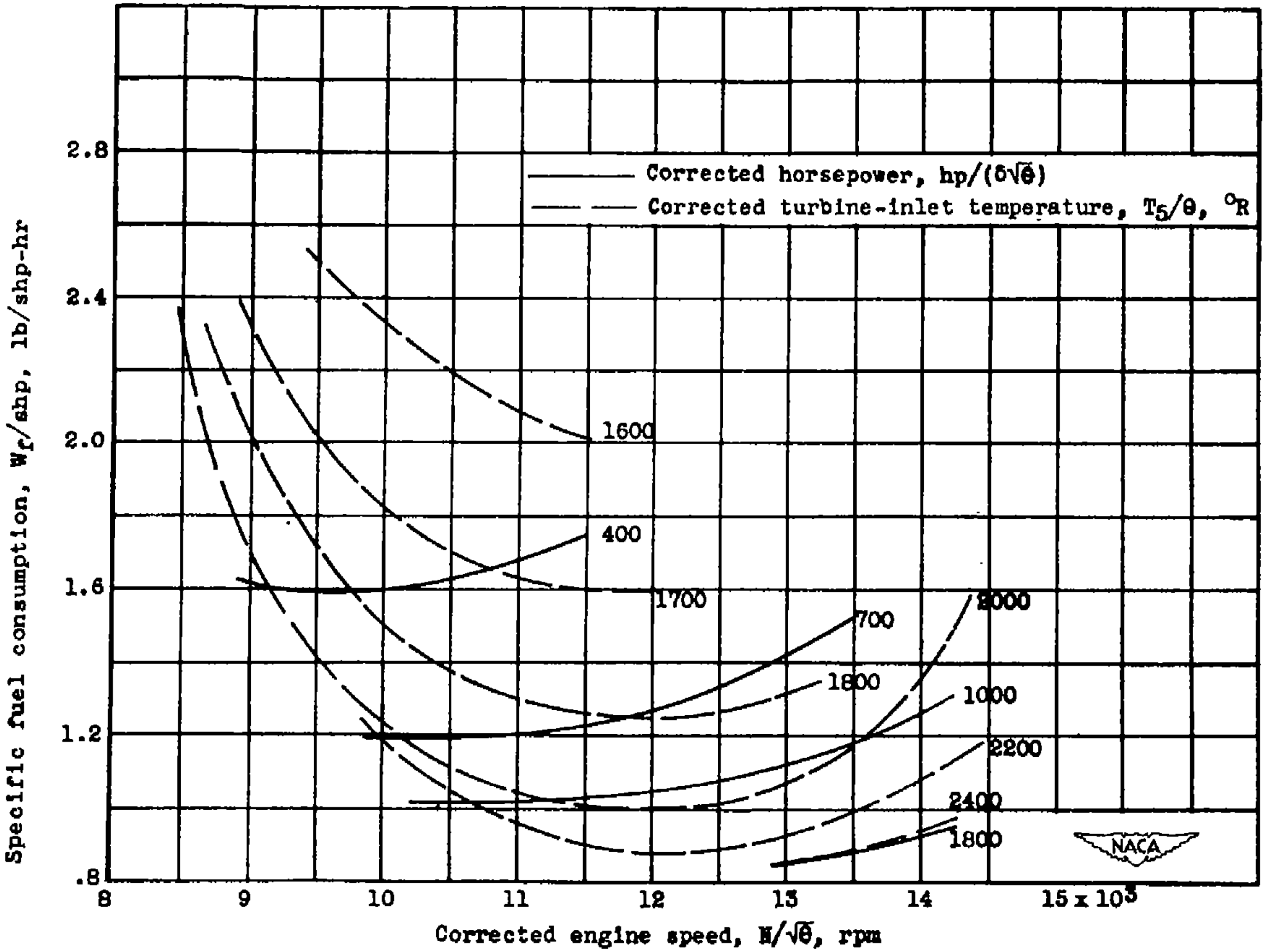


Figure 30.- Effect of corrected engine speed, corrected horsepower, and corrected turbine-inlet temperature on specific fuel consumption. Compressor-inlet ram-pressure ratio, 1.00.

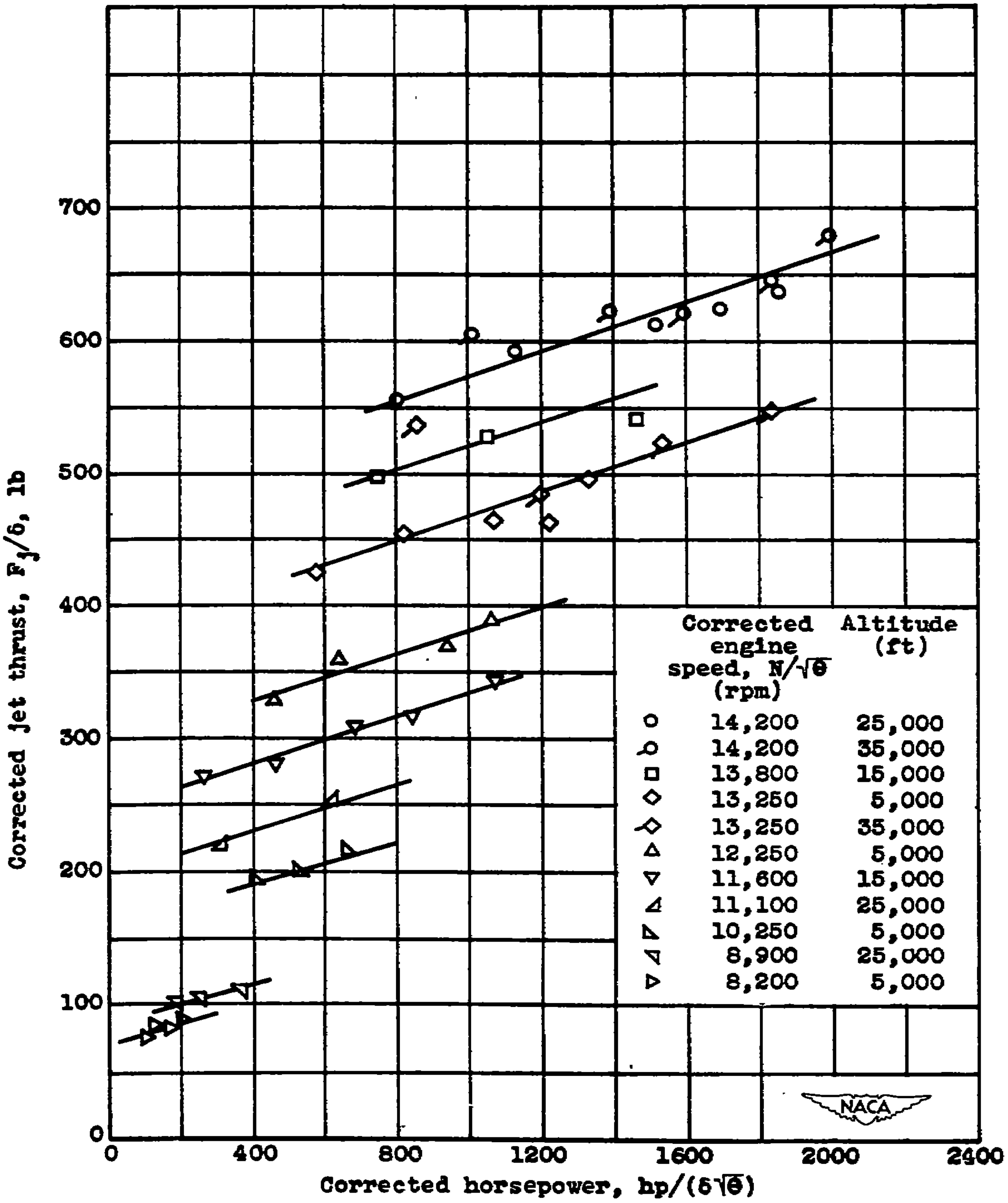


Figure 31.- Effect of corrected horsepower and corrected engine speed on corrected jet thrust. Compressor-inlet ram-pressure ratio, 1.00.

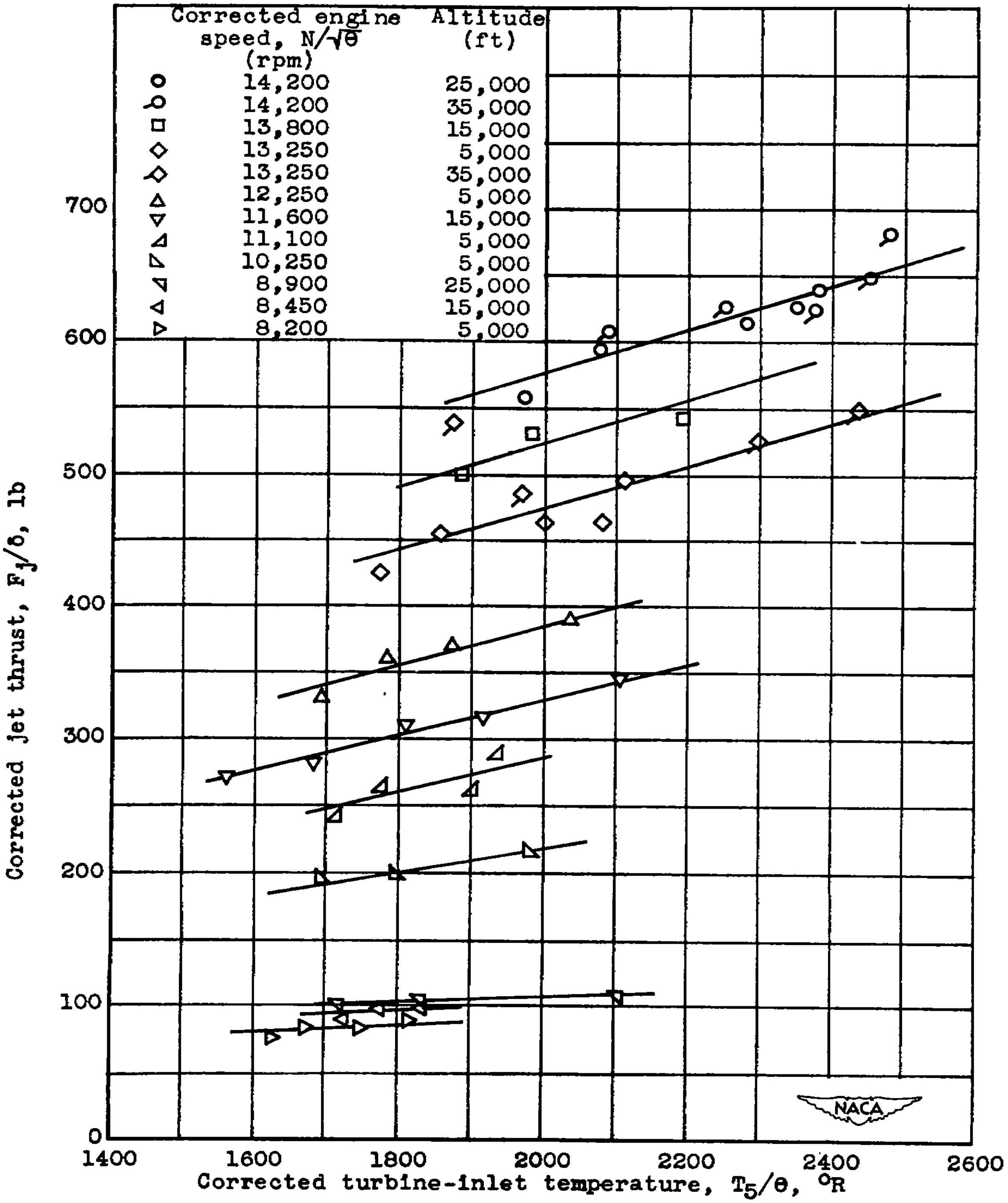


Figure 32.- Effect of corrected turbine-inlet temperature and corrected engine speed on corrected jet thrust. Compressor-inlet ram-pressure ratio, 1.00.

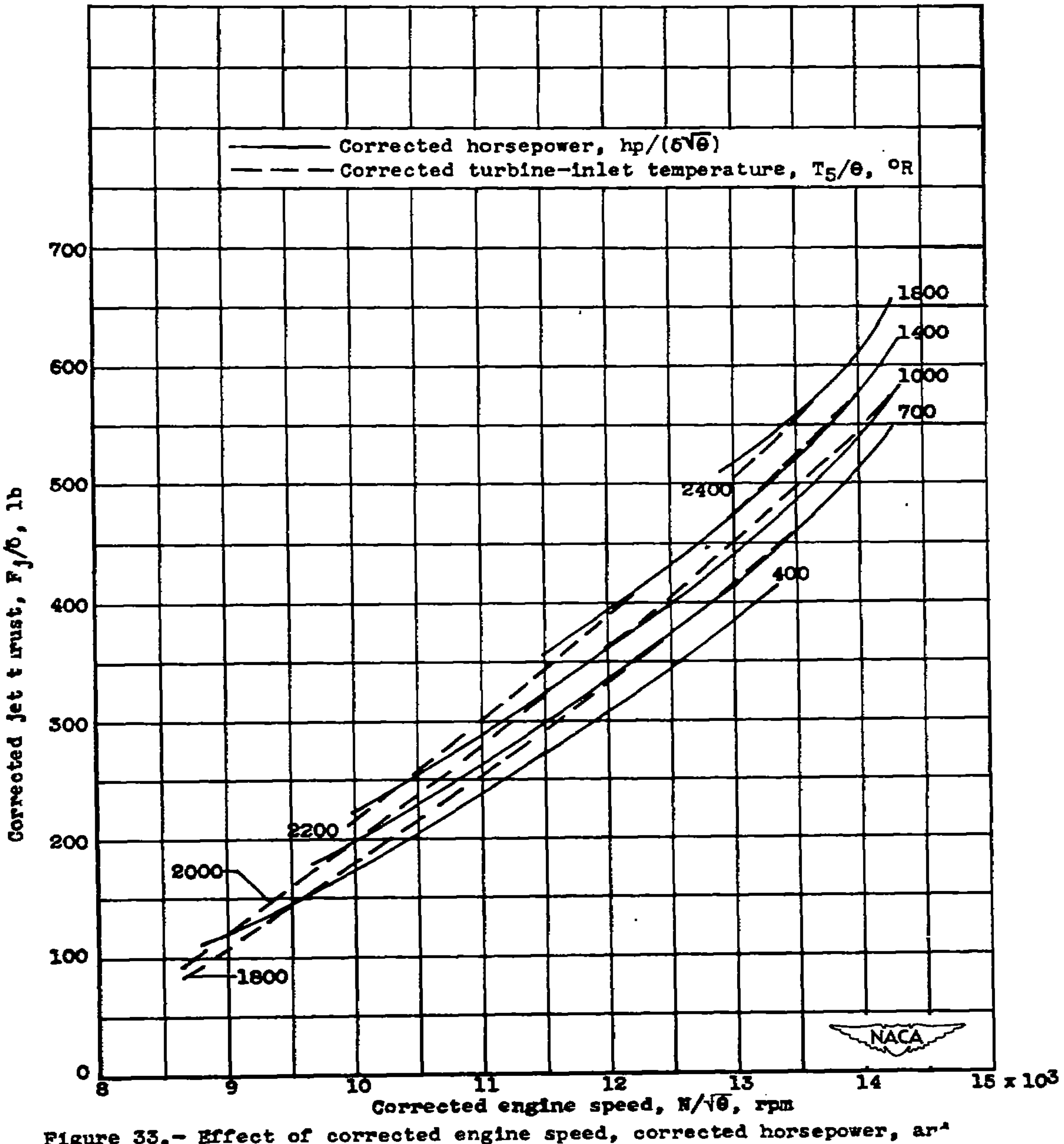


Figure 33.- Effect of corrected engine speed, corrected horsepower, and corrected turbine-inlet temperature on corrected jet thrust. Compressor-inlet ram-pressure ratio, 1.00.

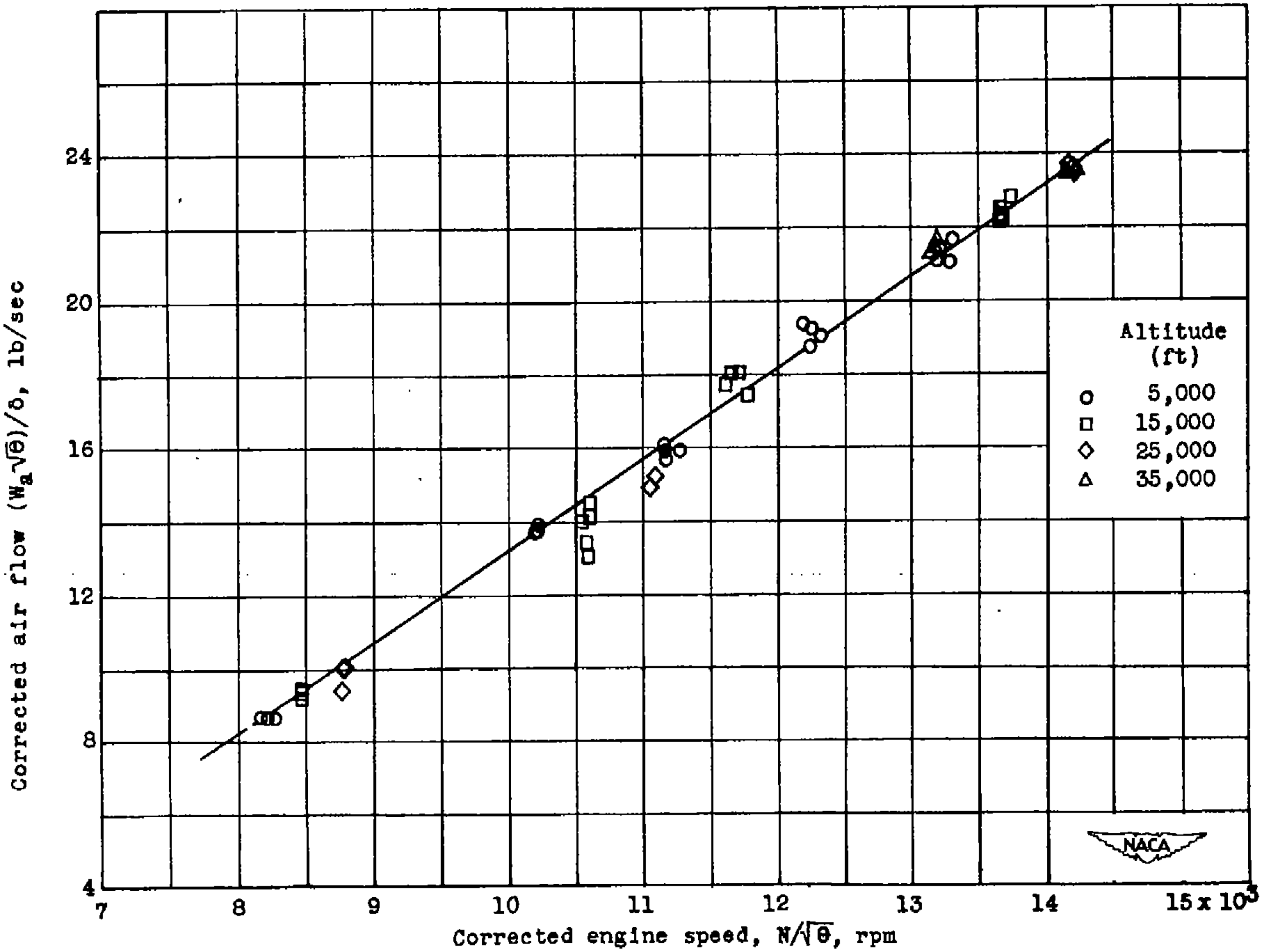
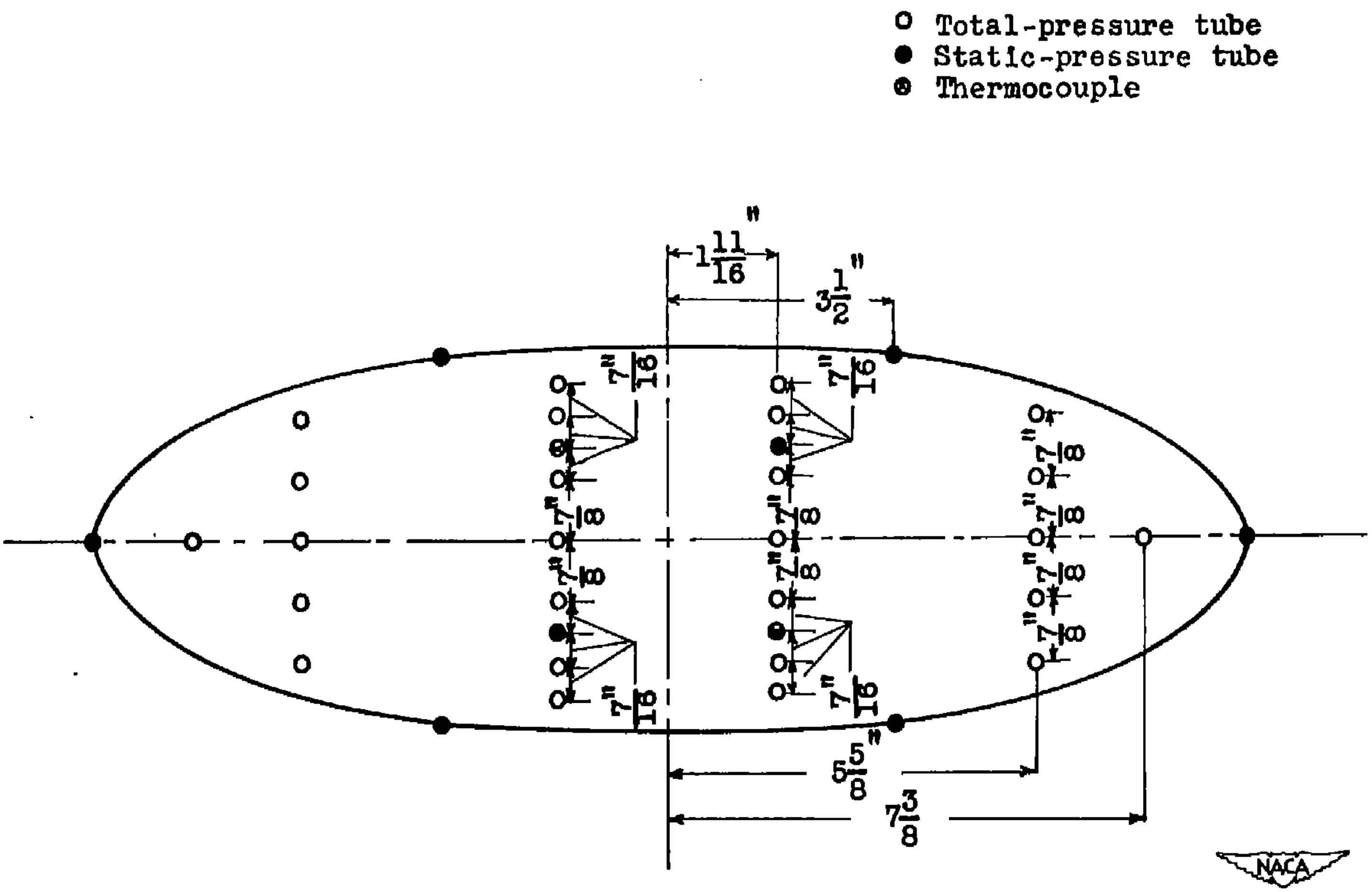
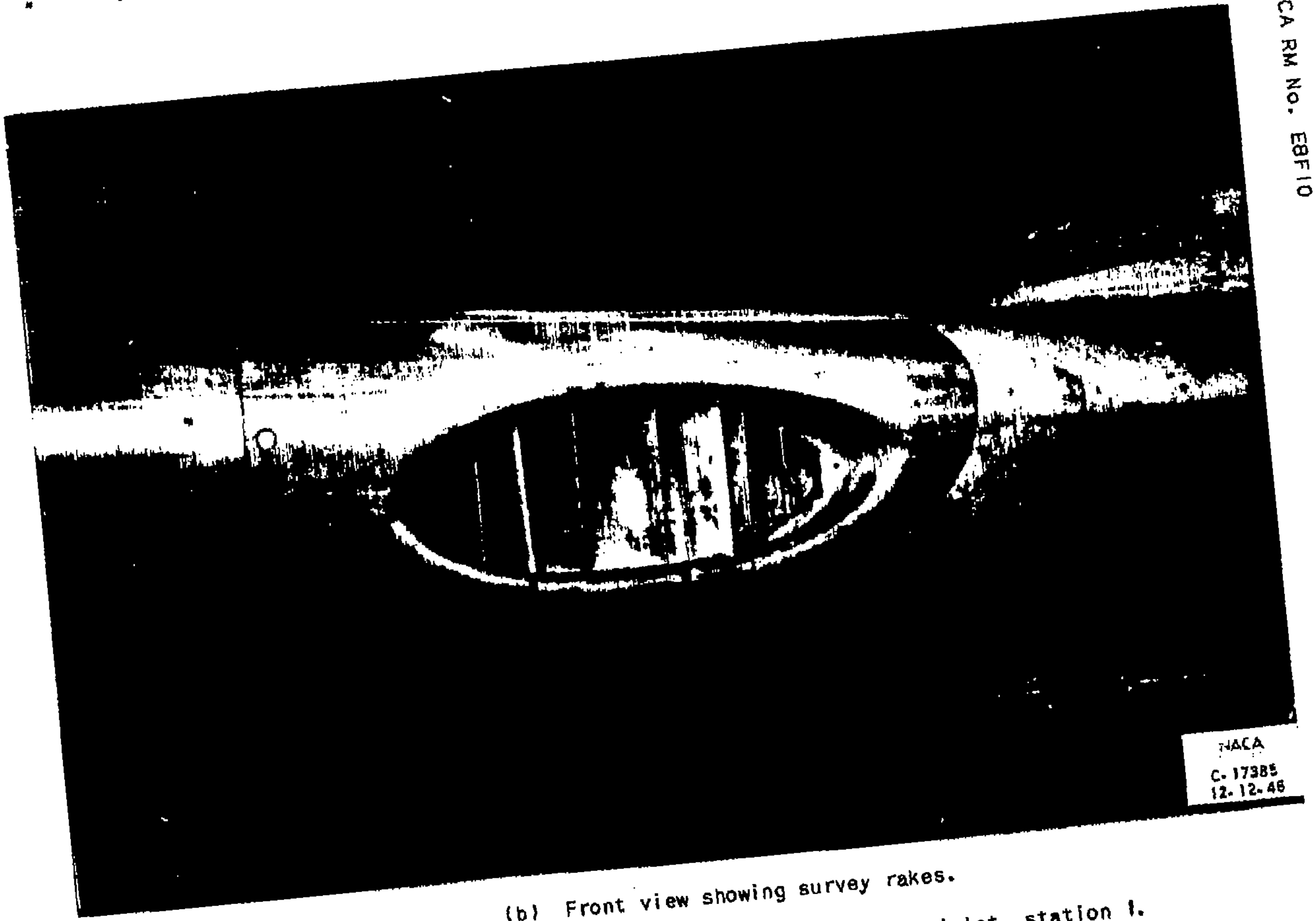


Figure 34.- Effect of corrected engine speed and altitude on corrected engine air flow. Compressor-inlet ram-pressure ratio, 1.00.


○ Total-pressure tube
● Static-pressure tube
⊗ Thermocouple
1 11/16"
3 1/2"
7/16"
7/8"
5 5/8"
7 3/8

(a) Location of instrumentation.

Figure 35.- Instrumentation at wing-duct inlet, station 1.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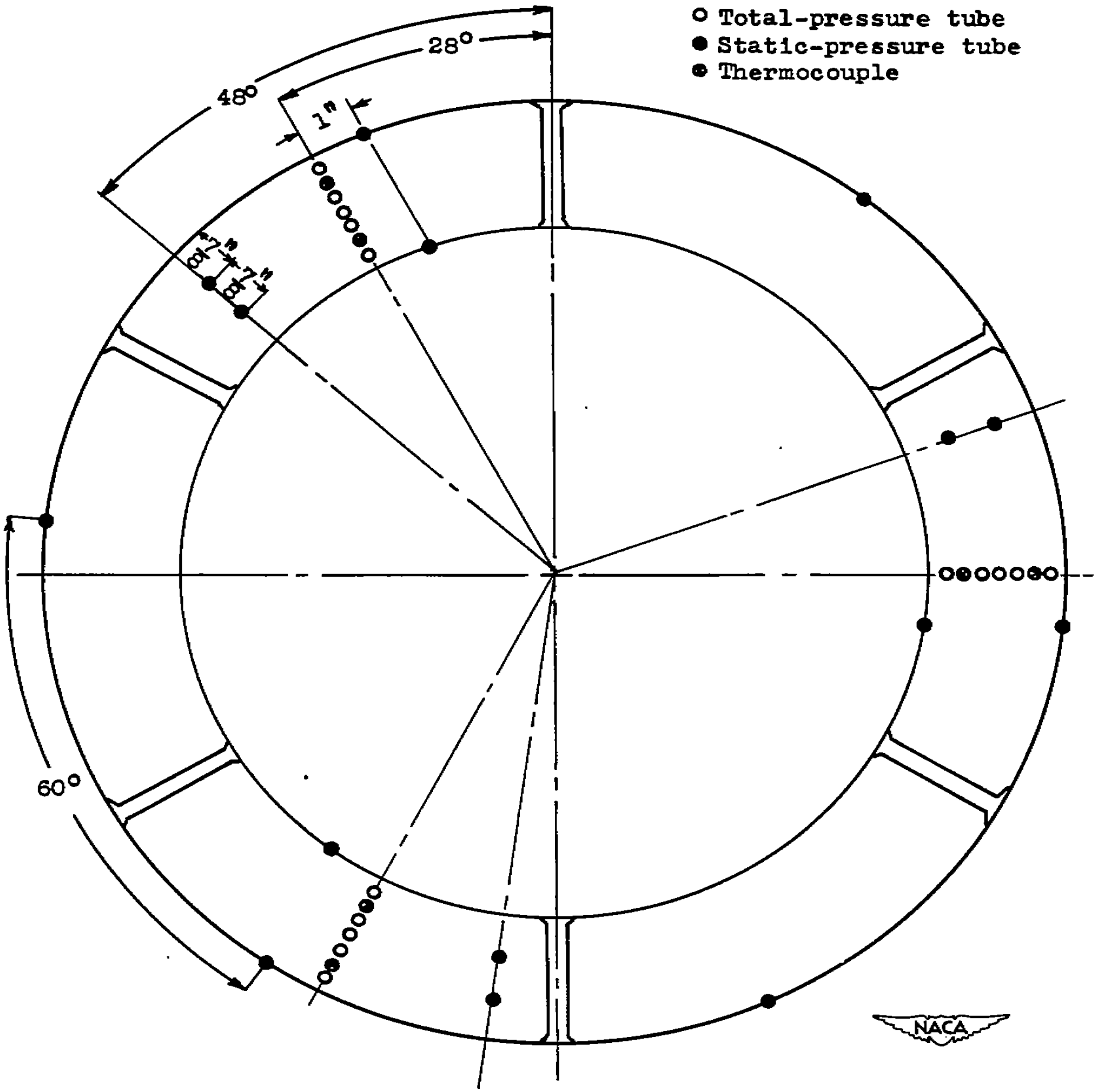
C-17385
12-12-46

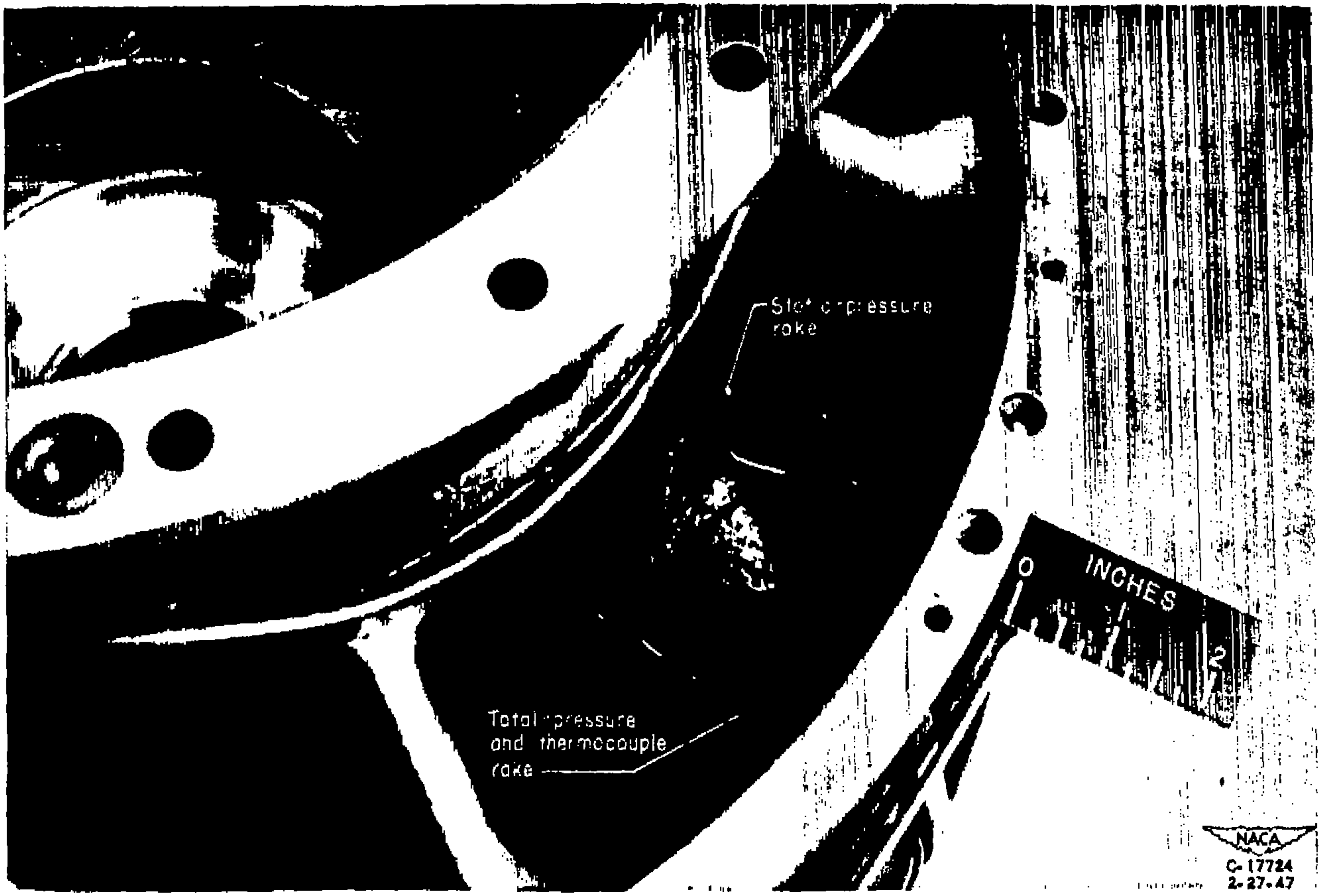
(b) Front view showing survey rakes.

Figure 35. - Concluded. Instrumentation at wing-duct inlet, station 1.


○ Total-pressure tube
● Static-pressure tube
⊕ Thermocouple
28°
48°
1"
7/8"
7/8"
60°
NACA

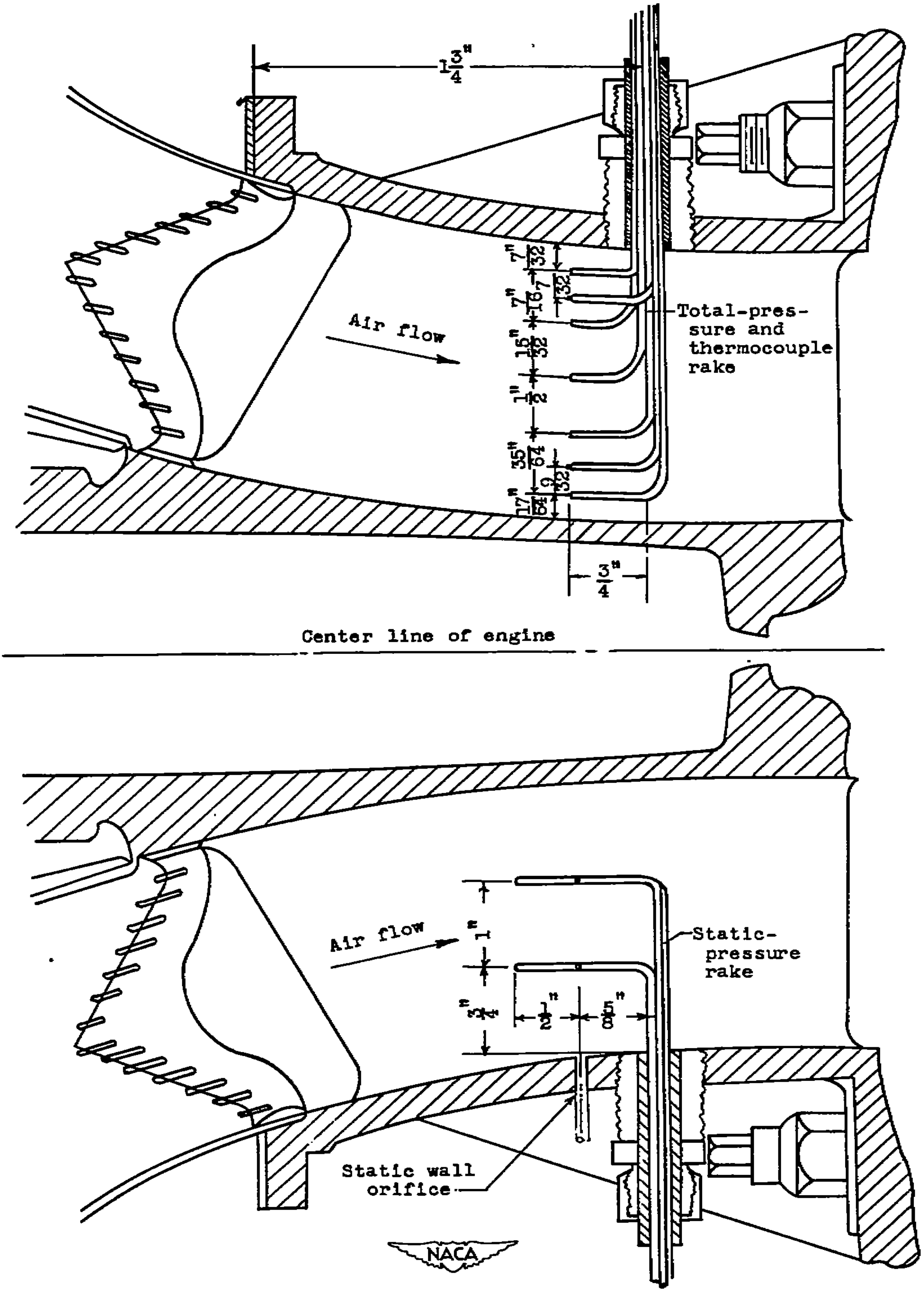
(a) Location of instrumentation.

Figure 36.- Instrumentation at compressor inlet, station 2.


Static-pressure rake
Total-pressure and thermocouple rake
0
INCHES
1
2
NACA
C-17724
2-27-47

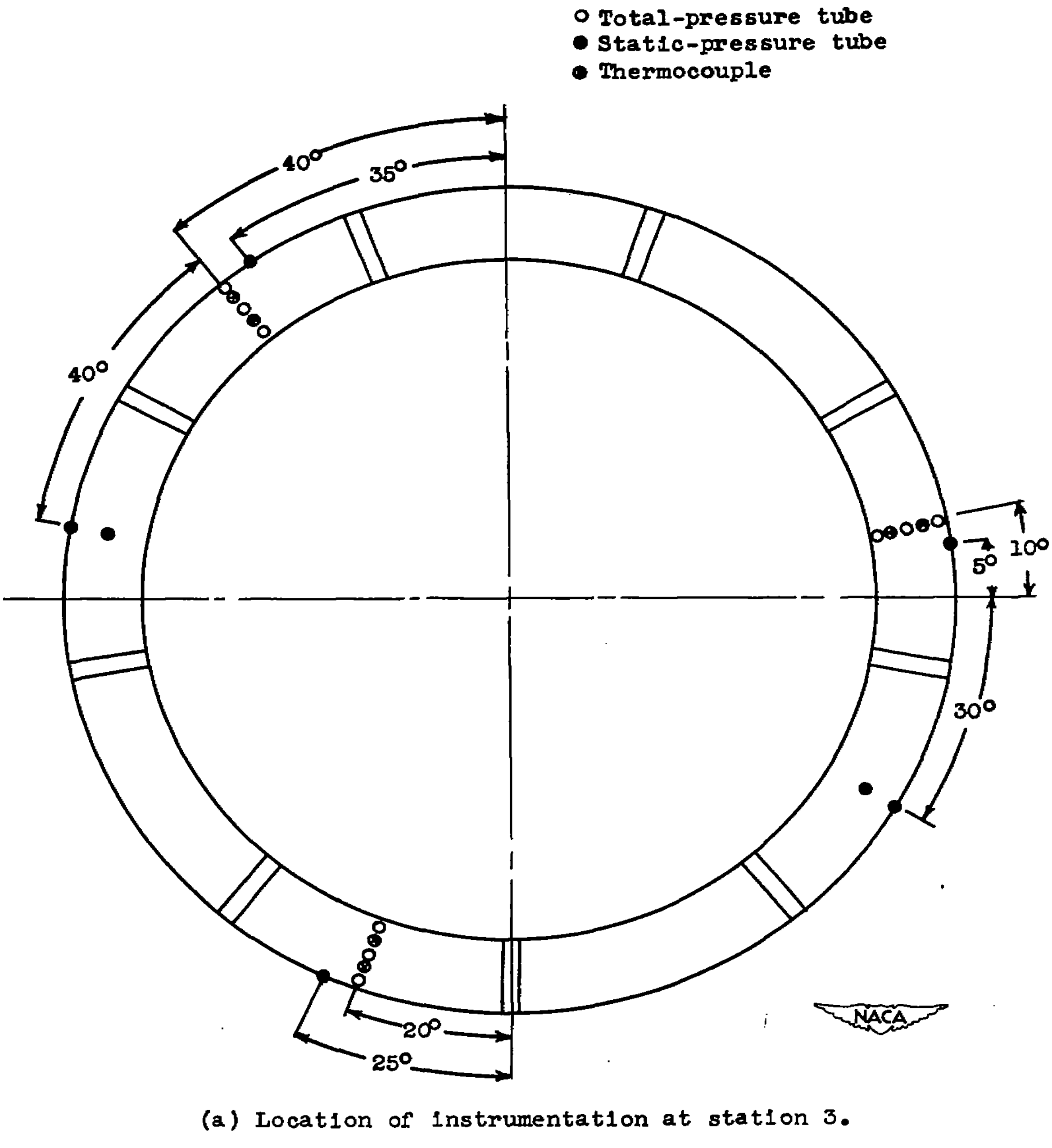
(b) Installation of pressure and temperature rakes.

Figure 36. - Continued. Instrumentation at compressor inlet, station 2.


1 3/4"
7/32"
7/32"
7/16"
15/32"
1/2"
35/64"
9/32"
17/64"
3/4"
Air flow
Total-pressure and thermocouple rake
Center line of engine
Air flow
1"
3/4"
1/2"
5/8"
Static-pressure rake
Static wall orifice

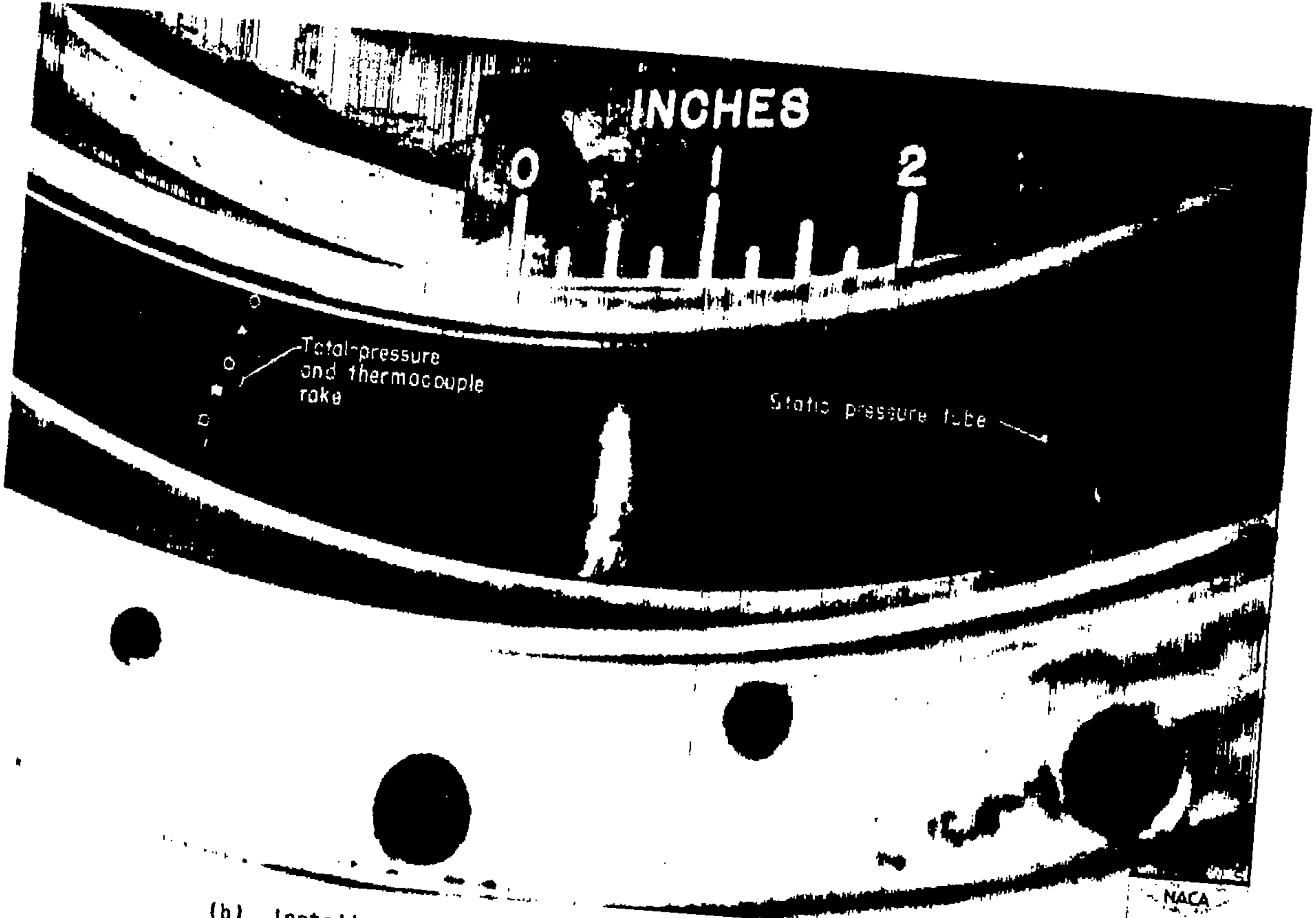
(c) Detail sketch of total-pressure, static-pressure, and thermocouple rakes.

Figure 36.- Concluded. Instrumentation at compressor inlet, station 2.


○ Total-pressure tube
● Static-pressure tube
● Thermocouple
40°
35°
40°
10°
5°
30°
20°
25°

(a) Location of instrumentation at station 3.

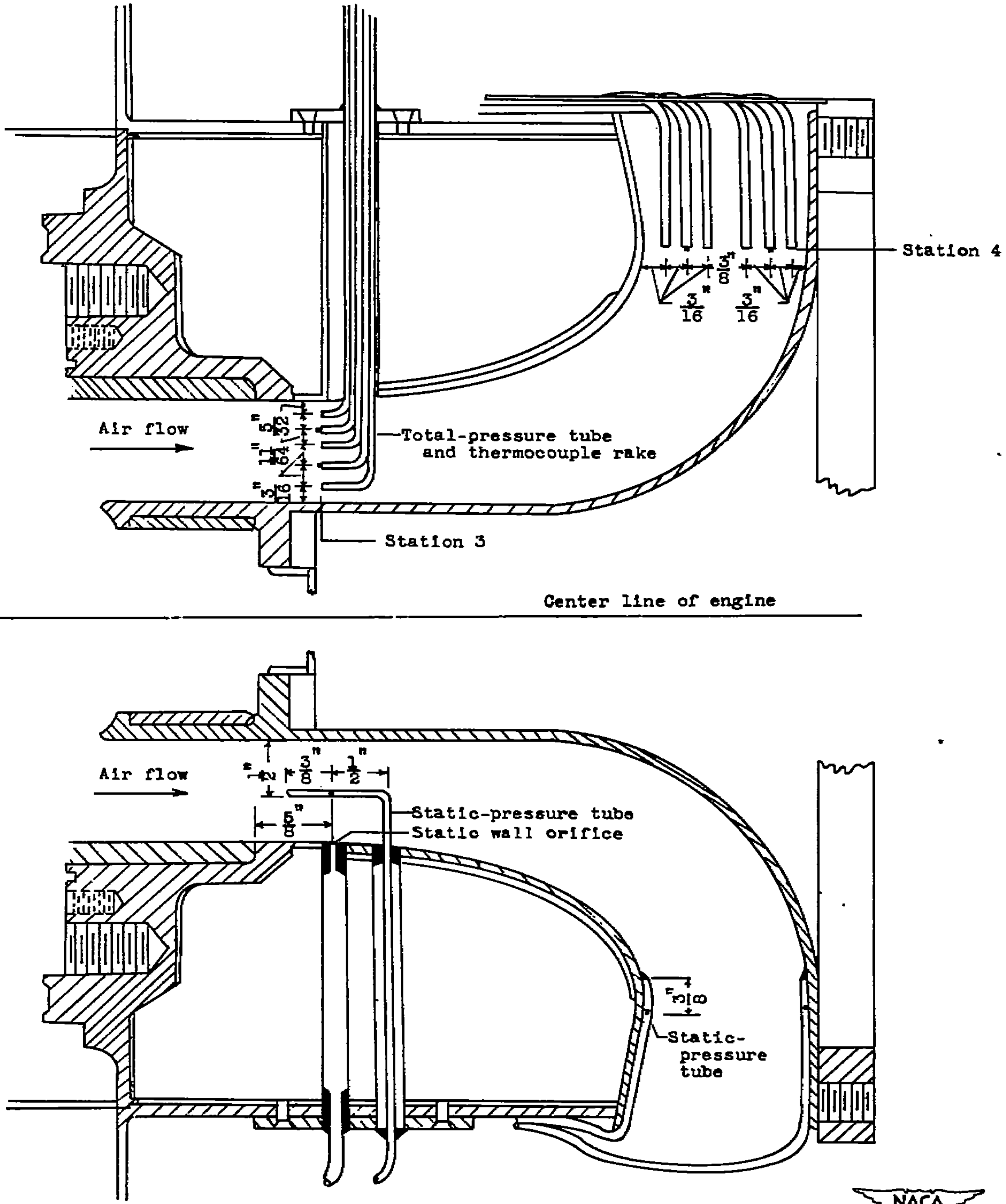
Figure 37.- Instrumentation at compressor outlet, station 3, and compressor elbow, station 4.


INCHES
0
1
2
Total-pressure and thermocouple rake
Static pressure tube

NACA
C-17725
1-27-47

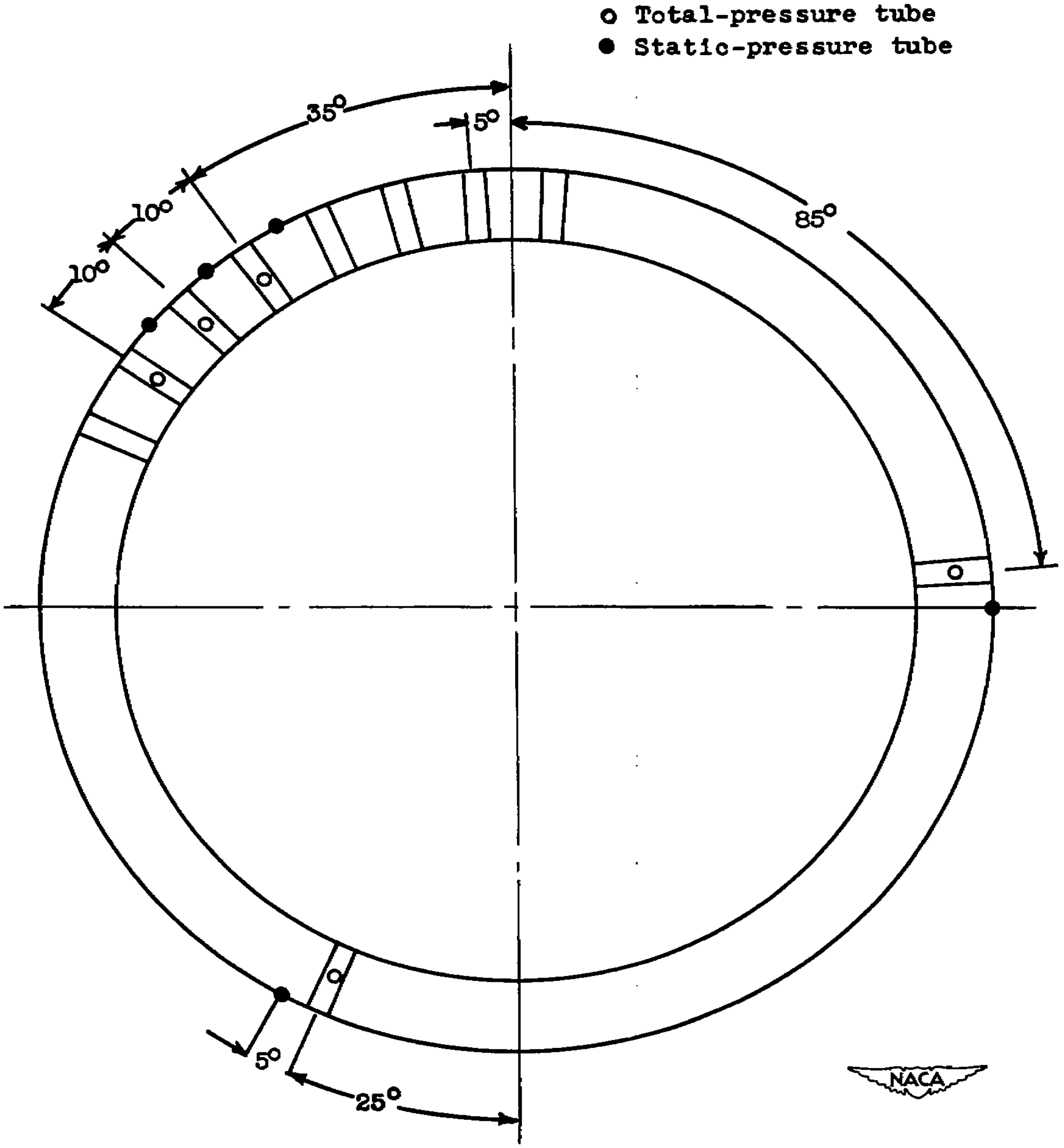
(b) Installation of pressure and temperature rakes at station 3.

Figure 37. - Continued. Instrumentation at compressor outlet, station 3, and compressor elbow, station 4.


Station 4
3/8"
3/16"
3/16"
Air flow
5/32"
11/64"
3/16"
Total-pressure tube and thermocouple rake
Station 3
Center line of engine
Air flow
1/2"
3/8"
1/2"
5/8"
Static-pressure tube
Static wall orifice
3/8"
Static-pressure tube

(c) Detail sketch of instrumentation at stations 3 and 4.

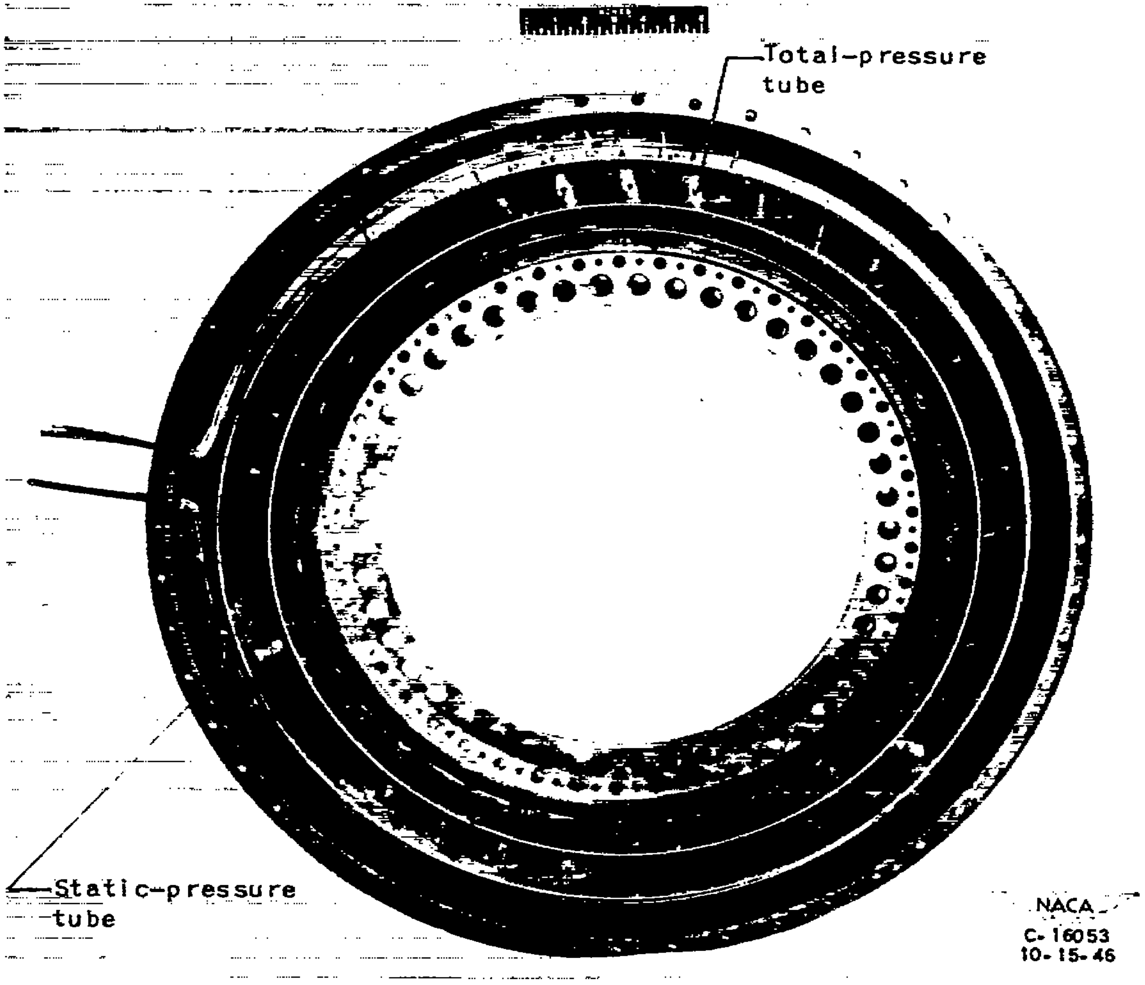
Figure 37.- Concluded. Instrumentation at compressor outlet, station 3, and compressor elbow, station 4.


○ Total-pressure tube
● Static-pressure tube
35°
5°
85°
10°
10°
5°
25°
NACA

(a) Location of instrumentation looking aft.

Figure 38.- Instrumentation at turbine inlet, station 5.

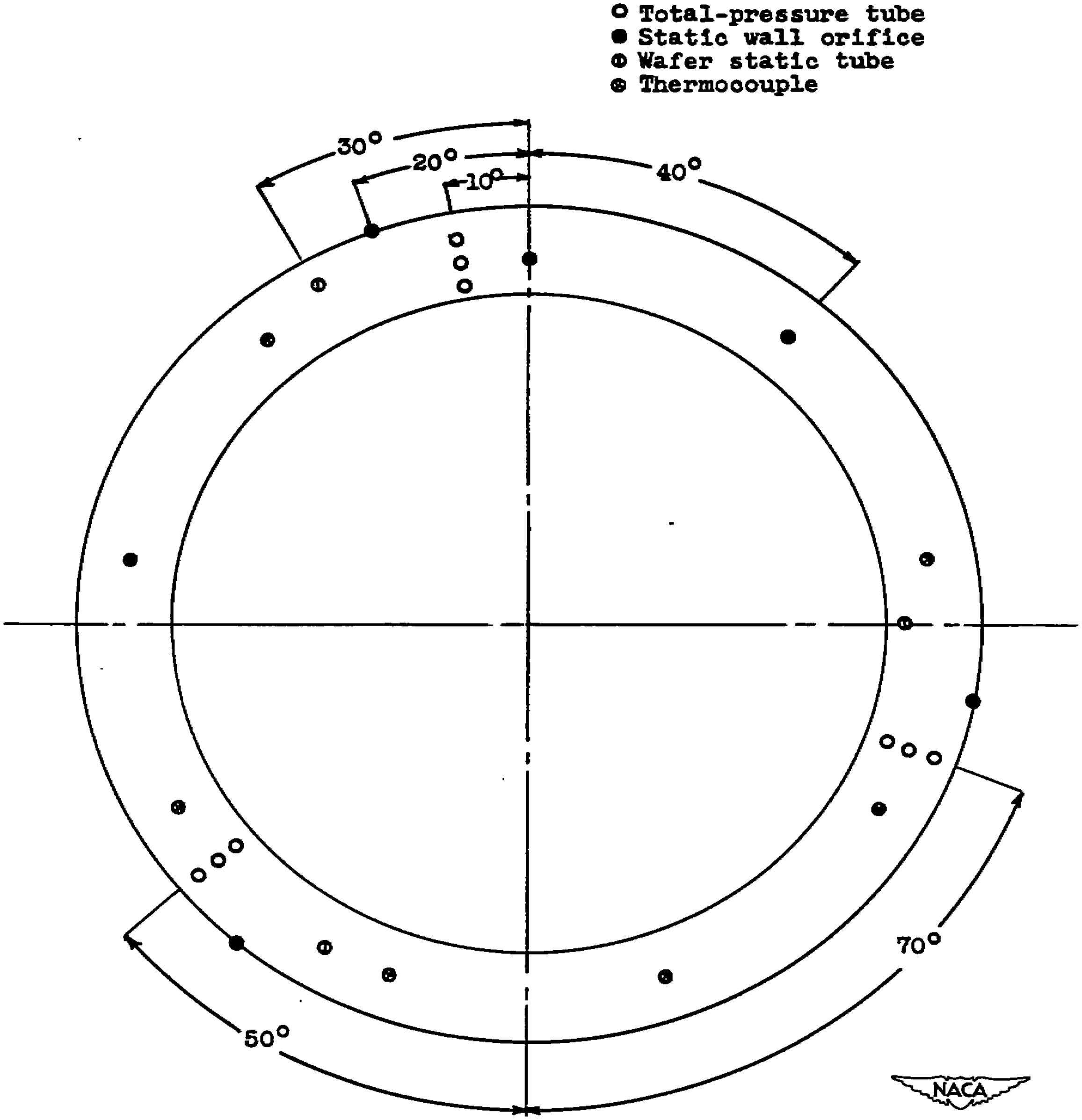
781


Total-pressure tube
Static-pressure tube
NACA
C-16053
10-15-46

(b) Installation of total-and static-pressure tubes.

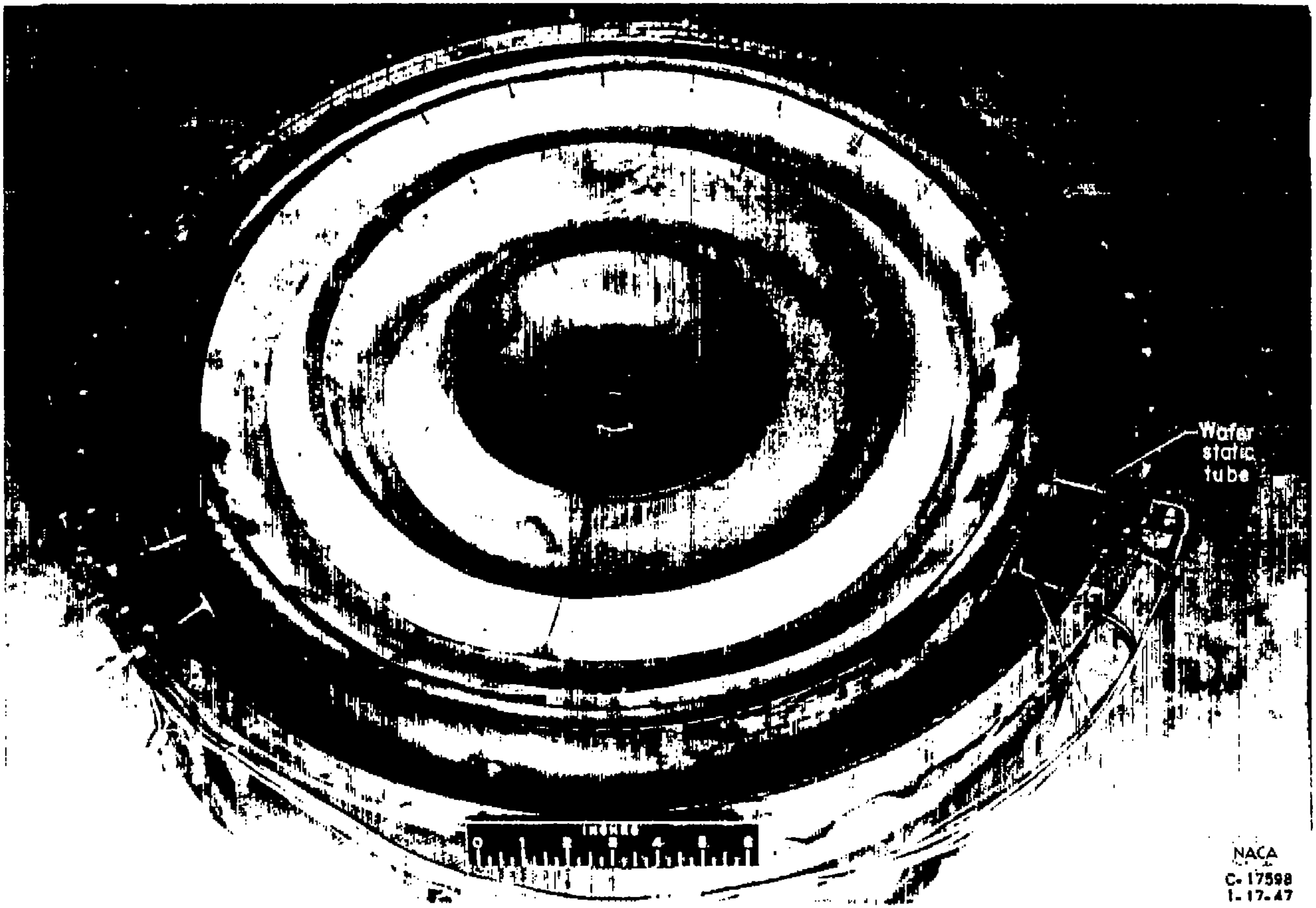
Figure 38. - Concluded. Instrumentation at turbine inlet, station 5.

781


○ Total-pressure tube
● Static wall orifice
⦶ Wafer static tube
⊗ Thermocouple
30°
20°
10°
40°
50°
70°
NACA

(a) Location of instrumentation looking aft.

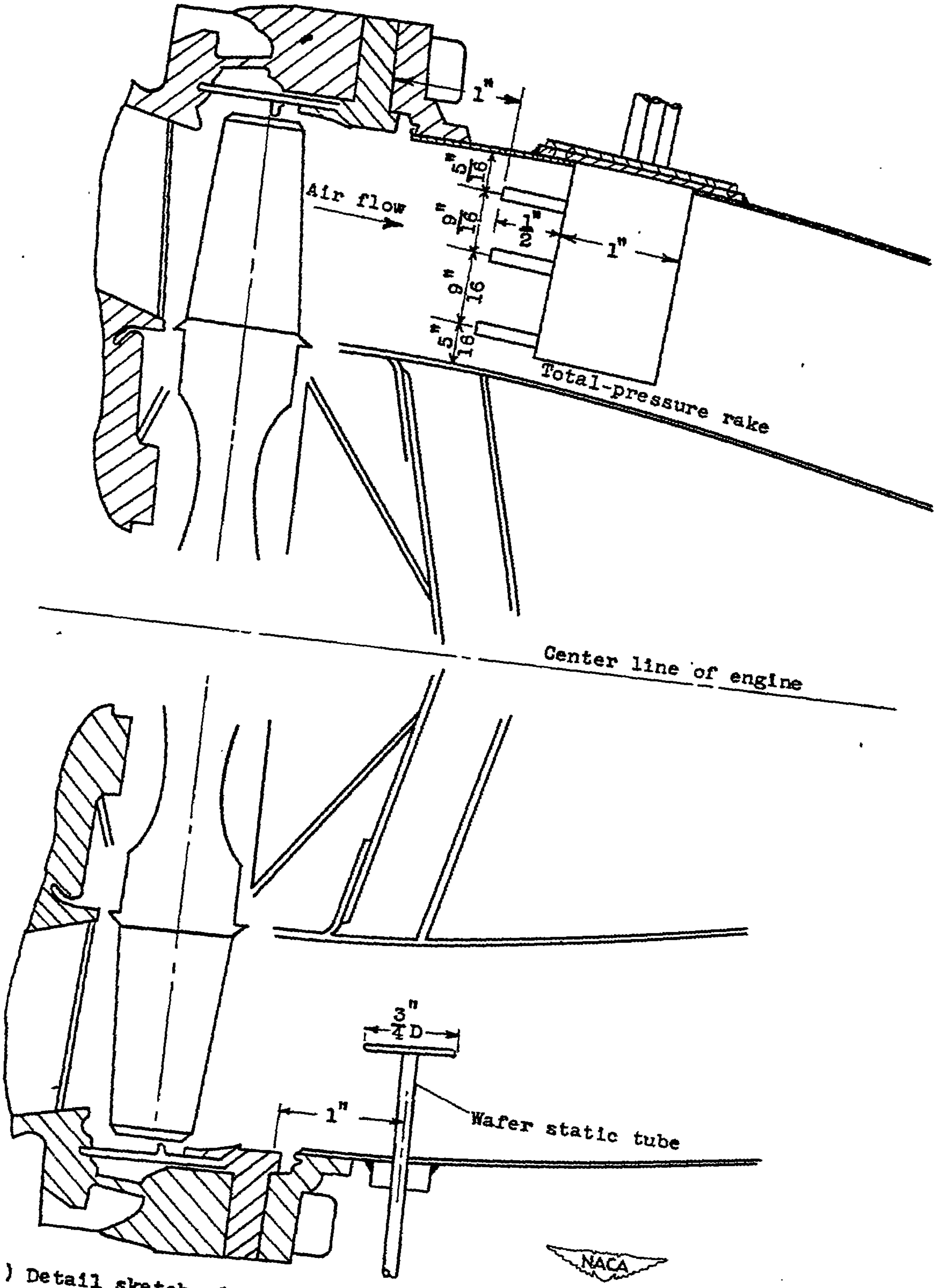
Figure 39.- Instrumentation at turbine outlet, station 6.


Wafer static tube
INCHES
0
1
2
3
4
5
6

NACA
C-17598
1-17-47

(b) Installation of total-pressure rakes and static-pressure tubes.

Figure 39. - Continued. Instrumentation at turbine outlet, station 6.


1"
Air flow
5"/16
9"/16
1/2"
1"
9"/16
5"/16
Total-pressure rake
Center line of engine
3"/4 D
1"
Wafer static tube
NACA

(c) Detail sketch of total-pressure rake and wafer static tube.
Figure 39.- Concluded. Instrumentation at turbine outlet, station 6.

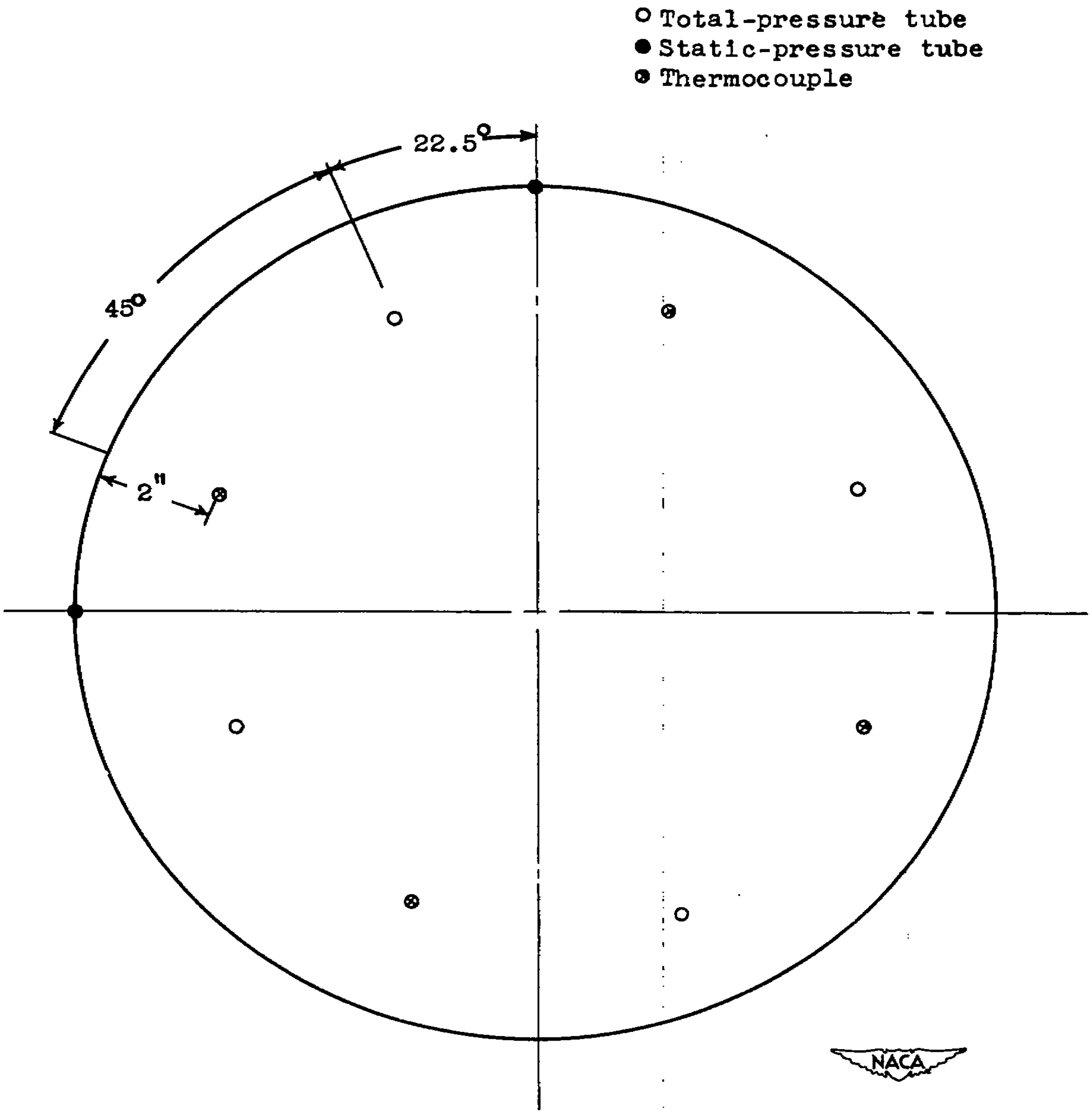
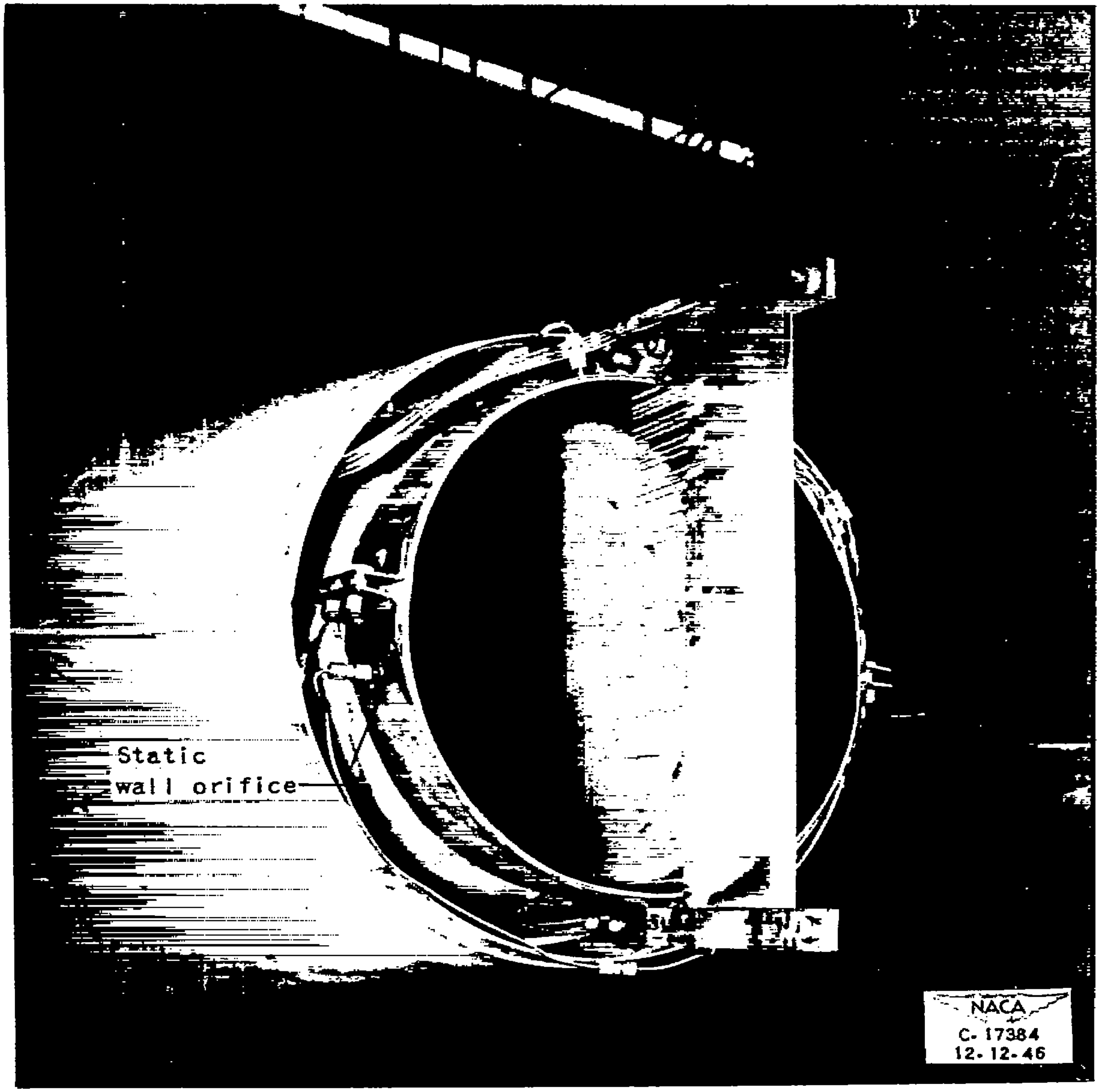

○ Total-pressure tube
● Static-pressure tube
⊗ Thermocouple
22.5°
45°
2"
NACA

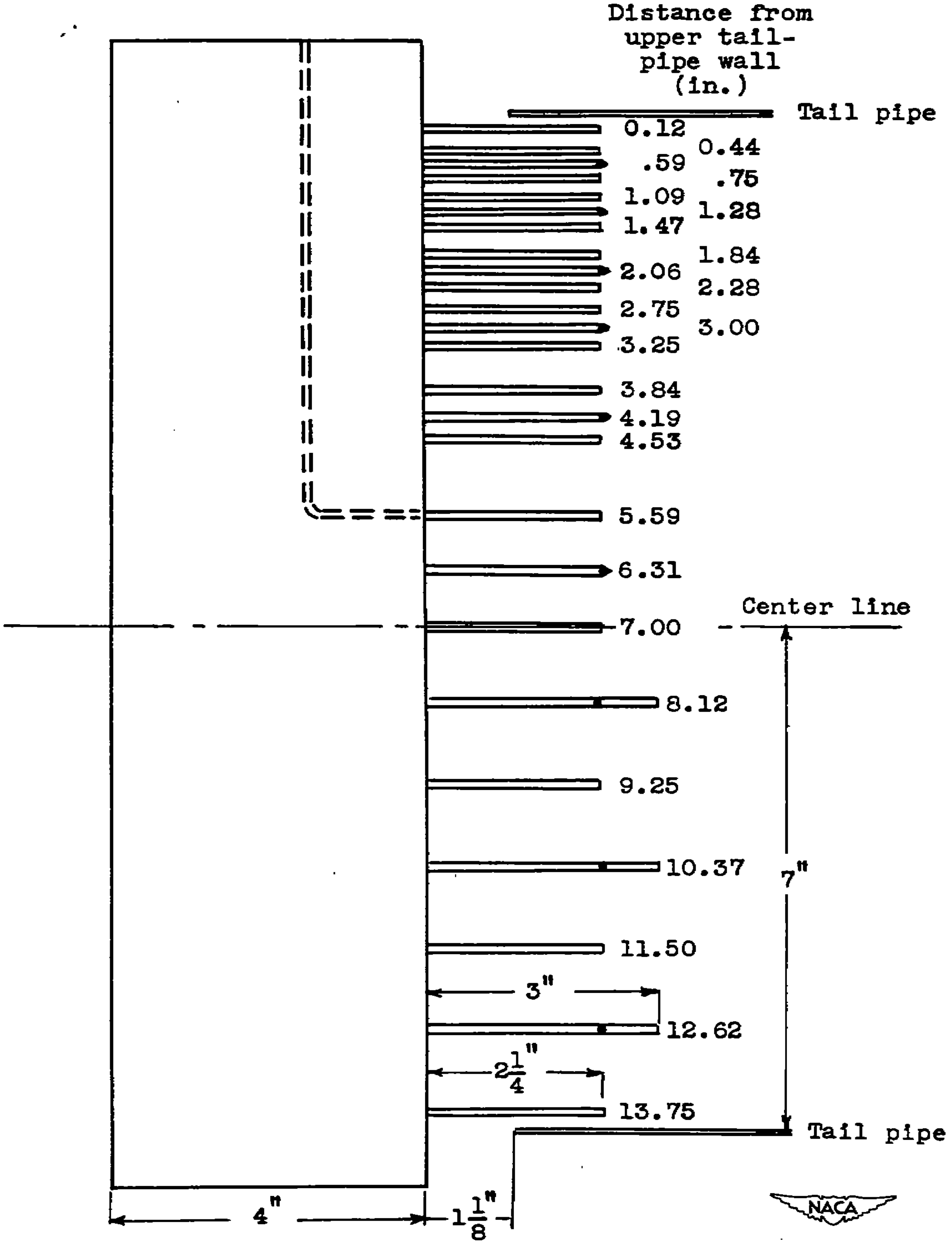
Figure 40.- Location of instrumentation at exhaust-cone outlet, station 7.

781


Static
wall orifice
NACA
C-17384
12-12-46

(a) Installation of tail-pipe-outlet rake.

Figure 41. - Instrumentation at tail-pipe-nozzle outlet, station 8.


Distance from upper tail-pipe wall (in.)
Tail pipe
0.12
0.44
.59
.75
1.09
1.28
1.47
1.84
2.06
2.28
2.75
3.00
3.25
3.84
4.19
4.53
5.59
6.31
Center line
7.00
8.12
9.25
10.37
7"
11.50
3"
12.62
$2\frac{1}{4}$"
13.75
Tail pipe
4"
$1\frac{1}{8}$"

(b) Detail sketch of tail-pipe-outlet rake.

Figure 41.- Concluded. Instrumentation at tail-pipe-nozzle outlet, station 8.

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