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RESEARCH MEMORANDUM

for the

Air Research and Development Command, U. S. Air Force

INVESTIGATION OF A PROTOTYPE IROQUOIS TURBOJET ENGINE IN AN ALTITUDE TEST CHAMBER

COORD. NO. AF-P-6

By John E. McAulay and Donald E. Groesbeck

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ABSTRACT

Operation of the original engine configuration disclosed a severe compressor stall problem at high altitude, which was largely attributed to a radial flow distortion entering the high-pressure compressor. Engine modifications for eliminating or alleviating the stall problem were investigated. These included use of variable high-pressure compressor inlet guide vanes, increased turbine-stator areas, and minor alterations in both the low- and high-pressure compressor rotors.

INDEX HEADINGS

Engines, Turbojet	3.1.3
Combustion - Turbine Engines	3.5.2.2
Compressors - Axial Flow	3.6.1.1
Turbines - Axial Flow	3.7.1.1

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SUMMARY

An altitude investigation was conducted to determine the performance and operating characteristics of a prototype Iroquois turbojet engine. Steady-state engine data were obtained over a range of Reynolds number indices from 1.00 to 0.17, inlet-air temperatures from -40° to 340° F, and simulated Mach numbers from 0.9 to 2.3. In addition, engine-operating limits, including transient and steady-state compressor stall, were obtained.

Operation of the original engine configuration disclosed a severe compressor-stall problem at high altitude, which markedly reduced the engine-operating range and raised serious doubts as to the practical ability of the engine to operate at Reynolds number indices below 0.45 at moderate-to-high corrected engine speeds. Examination of the component data disclosed that the reduced engine-operating range was a result of a decrease in the high-pressure compressor stall margin, which was largely due to a severe radial-flow distortion entering the compressor. Engine modifications for eliminating or alleviating the stall problem were investigated. These included use of variable high-pressure compressor-inlet guide vanes, increased turbine-stator areas, and minor alterations in both the low- and high-pressure compressor rotors. To the degree that they were used, these engine modifications did not produce an engine configuration that was completely stall-free over the desired range of flight conditions. The use of the modifications, however, did establish that an increased turbine-stator area greatly alleviates the stall problem and that compressor modifications short of complete redesign are, at best, hopeful solutions to the problem.

INTRODUCTION

An investigation was conducted in an altitude test chamber of the NACA Lewis laboratory at the request of the Air Research Development Command, U. S. Air Force in order to evaluate the performance and operating characteristics of a prototype twin-spool Iroquois turbojet engine. The

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evaluation of the original engine configuration revealed a severe compressor stall problem at high altitude, which resulted in reduced engine-operating limits at high altitudes and low inlet-air temperatures. In an effort to increase the compressor stall margin and thereby extend the operating range of the engine, the engine manufacturer developed two engine modifications. The first modified engine (A) included a set of variable guide vanes at the inlet of the high-pressure compressor and also included turbine-stators of increased area. A second modified engine (B) was also investigated that incorporated the same changes as the first engine modification, and also included minor alterations in the compressor.

Performance and operating limits of the engines were investigated over a range of Reynolds number indices from 1.00 to 0.17, inlet-air temperatures from -40° to 340° F, and simulated flight Mach numbers from 0.9 to 2.3. Data are presented herein that give the operating limits of the original engine configuration and that show how seriously these reduced limits affect the engine performance and operating characteristics. The data are then examined in order to determine the reason for the reduced engine operating limits. Finally, the effects of the modifications on the engine operating limits and performance are evaluated.

All the steady-state engine data obtained are presented in tabular form. Symbols and methods of performance calculation used in this report are given in appendixes A and B, respectively.

APPARATUS

Engine and Installation

The fully developed Iroquois turbojet engine is a two-spool engine designed to produce 20,000 pounds of thrust, without afterburning, at static sea-level conditions. A prototype version of the engine, shown installed in the altitude test chamber in figure 1, was investigated at the Lewis Laboratory. The prototype engine was expected to deliver about 90 percent of the rated thrust of the fully developed engine. Maximum allowable high- and low-pressure rotor speeds were 7800 and 5740 rpm, respectively. The limiting exhaust-gas temperature was 1735° R as measured by 25 thermocouples located immediately downstream of the turbine. The relation between this temperature measurement and what is considered a more accurate measurement of exhaust-gas temperature, which was measured by 20 thermocouples located in a more favorable place further downstream in the afterburner, is shown in figure 2.

The basic engine consists of a three-stage axial-flow low-pressure compressor of transonic design driven by a single-stage turbine, a seven-stage axial-flow high-pressure compressor driven by a two-stage turbine, an annular vaporizing combustion chamber, an afterburner with a fully

modulated convergent exhaust nozzle, and an ejector, which was rendered ineffective for this investigation. The dry weight of the complete engine was approximately 4500 pounds.

Original engine configuration. - Two engines were investigated (AX 102/1B and AX 103/1) that were basically the same and are classified as engines of the original configuration. One, the AX 102/1B, had shroud cutouts in the first- and third-stage compressor-rotor blade tips in which a plastic shroud ring was fitted. In addition, the fourth-stage rotor blades (high-pressure compressor-inlet stage) had a 0.4-inch piece cut from the blade tips to increase the natural frequency of the blades above the excitation frequency in the high engine speed range. The AX 103/1 engine did not have the shroud cut-outs and employed full-length fourth-stage rotor blades.

Modified engine configuration A. - The modified engine configuration A was represented by engine AX 103/2 and differed from the original engine configuration (AX 103/1) in the following respects:

(1) Increased turbine stator areas in order to reduce the engine-operating pressure ratio

(a) First- and second-stage areas increased $3\frac{1}{2}$ percent

(b) Third-stage area increased 5 percent

(2) Friable plastic coating on the first- and second-stator tip seals to reduce clearance

(3) Addition of variable guide vanes at the high-pressure compressor inlet to increase the mass-flow capacity, to reduce velocity profile entering the high-pressure compressor, and to give another degree of freedom in operation of the engine (additional details of guide vanes given in fig. 3).

(The guide vanes used were originally designed for purposes other than what has been mentioned and were employed as a possible "quick fix.")

Modified engine configuration B. - The modified configuration B was represented by engine AX 102/3C and differed from the modified engine configuration A as follows:

(1) The first-stage rotor blades were restaggered -3° and given an increase in twist varying linearly from 0° at a station approximately 20 percent of the blade height to 5° at the blade tip. This modification was intended to: (a) increase the blade root pressure ratio and (b) decrease the blade tip pressure ratio while maintaining the same weight flow.

(2) The third-stage rotor blades were completely redesigned with a thickened root, thinned tip, tapered chord, and changed profile. The purpose of the rotor blade redesign was to strengthen the blades.

(3) The high-pressure compressor blade tip clearances were reduced by means of plastic on the stator spacers.

The altitude test chamber in which the engine was installed permitted the simulation of a wide range of flight conditions by proper control of valves, which allowed the engine-inlet and exhaust pressures to be set at the desired values. Modulation of gas-fired heaters or use of an expansion turbine produced the required inlet-air temperature at the engine inlet.

Instrumentation

A summary of the steady-state instrumentation installed in the engine is given in figure 4. The pressures were recorded by a digital automatic multiple-pressure recorder. The temperatures were recorded by self-balancing automatic digital potentiometers. Engine thrust was measured by the facility balance system.

Engine vibration was monitored by pickups mounted on the low pressure, high pressure, and turbine bearing housings and on the rear frame. Compressor blade stresses were measured by strain gages on the rotor blades of the first and third stages using a slipring arrangement. The stresses were permanently recorded and were also visually monitored.

Pressure transducers were also used to record the transient variation of pressures in the first, fourth, and ninth stages of the high-pressure compressor.

PROCEDURE

The following table gives the conditions at which steady-state engine performance data were obtained. Generally, each constant exhaust-nozzle area operating line was established by obtaining four to six data points. Except in one instance in which limited data were obtained at an inlet temperature of 240° F and over (in table IV), the measured exhaust-nozzle areas presented in this report are applicable to a tailpipe configuration, which consisted of instrumentation rakes at the turbine outlet and nozzle inlet and no flameholder.

Configuration	Nominal Reynolds number index	High-pressure compressor-inlet guide vane angle, deg	Simulated altitude, ft	Simulated Mach number	Nominal inlet air temperature, °F	Number of constant nozzle-area operating lines
Original	1.09		Sea level	0	85 to 105	1
↓	.45		35,000	.9	15	4
↓	↓		38,500	.9	-40	2
↓	↓		58,000	2.0	240	2
↓	.37		50,000	1.5	106	1
↓	.17		55,000	.9	15	2 plus additional single points
Modified engine A	0.37	-5	42,000	0.9	-40	3
↓	↓	0	↓	↓	↓	3
↓	↓	5	↓	↓	↓	1 plus additional single points
↓	.17	-5	58,000	↓	↓	3
↓	↓	0	↓	↓	↓	3
↓	↓	5	↓	↓	↓	3
↓	↓	5	55,000	↓	15	individual points
Modified engine B	1.00	0	14,000	0.9	45 to 60	3
↓	.65	0	24,000	.9	40	4
↓	.37	0	66,000	2.3	340	1 data point
↓	↓	5	42,000	.9	-40	4
↓	↓	0	↓	↓	↓	4
↓	↓	-5	↓	↓	↓	4
↓	↓	0	58,000	2.0	240	1
↓	.27	0	47,500	.9	-40	4
↓	.17	0	58,000	.9	-40	1 data point

The pertinent engine performance is given in tables I to IV.

In addition to the steady-state data taken, engine-stall data were obtained. Engine quasi steady-state stall points were obtained, in general, wherever stall occurred within the engine operating envelope.

These data were obtained by slowly changing the engine speed or nozzle area until stall occurred, at which time pertinent data were obtained. Fuel-flow stall was obtained on each of the three engine configurations at the following conditions:

Configuration	Reynolds number index	Simulated altitude, ft	Simulated flight Mach number	Nominal inlet air temperature, °F	Guide vane angle, deg
Original	0.45	38,500	0.9	15	--
Modified A	.37	42,000	↓	-40	-5
Modified B	.37	42,000	↓	-40	0

At the flight conditions given in the preceding table, the high-pressure rotor speed was set at several initial engine speeds between 6200 and 7800 rpm. At these speeds, step increases in engine fuel flow were made. The size of these steps was increased in small increments until compressor stall was encountered.

RESULTS AND DISCUSSION

Original Engine Configuration

Steady-state operating limits. - The steady-state operating limits of the original engine configuration are shown in figure 5 on coordinates of exhaust-nozzle area and high-pressure rotor speed. The operating limits for two engines shown on this figure (see APPARATUS), were obtained at engine-inlet conditions corresponding to Reynolds number indices of 0.45 (fig. 5(a)) and 0.17 (fig. 5(b)) at a simulated flight Mach number of 0.9.

The engine-operating limit curves presented in figure 5(a) for a Reynolds number index of 0.45 indicate that rated engine conditions were not always attained. Rated engine conditions are defined as an engine operating point at which limiting values of high-pressure rotor speed and exhaust-gas temperature are reached. The AX 103/1 engine either stalled at low inlet-air temperatures (-40° F) or reached limiting exhaust-gas temperature and vibration at moderate inlet-air temperatures (15° F) before rated engine conditions were obtained. At an inlet temperature of 15° F, the AX 102/1B engine did reach rated conditions on several occasions but on one occasion it was unable to do so because compressor stall occurred. The occurrence of stall on this occasion, although it was only encountered during one run, is an indication that the compressor stall margin is quite small. A description of the operational limits of the original engine configuration would not be complete without pointing out that in the same Reynolds number index range as that shown in

figure 5(a) but at conditions simulating Mach numbers from 1.5 to 2.0 the compressor stall margin was large and the engine handling characteristics were satisfactory.

Operation of the original engine configuration (AX 103/1) was also restricted by excessive low-pressure compressor blade stresses and engine vibration (fig. 5). These blade stress and engine vibration limits, which were set at absolute maximums of 20,000 pounds per square inch and 8 mils, respectively, for steady-state operation, are associated with the proximity of compressor stall, particularly of the low-pressure compressor.

The data of figure 5(b), which correspond to an altitude of about 56,000 feet at a Mach number of 0.9 at standard inlet-air temperatures, show that there was a large reduction in the operable range of the engine at low engine-inlet Reynolds numbers as compared with the higher Reynolds numbers (fig. 5(a)). Inasmuch as the limits shown in figure 5(b) were obtained at an inlet-air temperature of 15° F, it can readily be seen that rated engine conditions at a Reynolds number index of 0.17 are unattainable except at high inlet-air temperatures (well above 15° F) because compressor stall is a function, among other things, of corrected speed.

Effect of engine-operating limits on maximum attainable thrust. - The manner in which reduced engine-operating limits affect thrust is shown in figure 6. For rated exhaust-nozzle area, the ratio of the maximum attainable net thrust to the maximum thrust that would have been possible if stall-free engine operation existed is shown as a function of the inlet-air temperature for Reynolds number indices of 0.45 and 0.17 at a Mach number of 0.9 for the AX 102/1B engine. At a Reynolds number index of 0.45, the thrust penalty is small and only occurs at inlet-air temperatures below -20° F. (This assumes that the stall line of the AX 102/1B engine was the same as that for the AX 103/1 engine corrected for inlet temperature.) However, at a Reynolds number index of 0.17, the thrust loss becomes quite severe; for example, at the standard inlet-air temperature for Mach 0.9, the thrust loss is about 26 percent.

Engine transient operating margin. - Restriction of the steady-state operating limits and the resultant thrust penalties (figs. 5 and 6) do not in themselves complete the description of the consequences incurred by compressor stall. While the engine may operate in the ranges described in figure 5, a small variation in the method of engine operation or variation in flow entering the engine would drastically curtail engine operation over and above that shown in figures 5 and 6. Consequently, the engine fuel-flow stall margin was determined in order to provide a means of quantitatively measuring the compressor stall margin and, therefore, to measure the ability of the engine to operate satisfactorily even in the presence of variations such as those previously described.

The data given in figure 7 (AX 103/1 engine) show the relation between the steady-state operating line and the engine stall line in terms of fuel flow and high-pressure rotor speed for a Reynolds number index of 0.45 at a Mach number of 0.9 and an inlet air temperature of 15° F. The extrapolation of the stall line was possible because of later steady-state data at an inlet-air temperature of -40° F that disclosed the location of the intersection of the operating line and the stall line (fig. 5(a)). At a high-pressure rotor speed of 96 percent of rated (7490 rpm), a fuel step increase to rated fuel flow would result in compressor stall; therefore, there is very little stall margin available for engine acceleration. Consequently, although the engine is operable at this flight condition, extreme care would have to be taken in setting the acceleration schedule. In addition, nonuniform flow conditions at the engine inlet might markedly reduce the small margin available with uniform inlet flow conditions.

Fuel-step stall data were not taken at a Reynolds number index of 0.17 because a number of random compressor stalls did occur within the steady-state operating envelope shown in figure 5(b). This, along with the small stall margin shown by the data of figure 7, signified that little could be learned by the fuel-step method at low Reynolds number indices. The operating experiences encountered up to this point in the program demonstrated that the original engine configuration was inoperable from a practical viewpoint at Reynolds number indices appreciably below 0.45 and at inlet-air temperatures in the vicinity of those encountered in the tropopause at Mach numbers near 0.9.

One additional piece of information that exemplifies the seriousness of the compressor stall problem was the difficulty in unstalling the compressor once stall had been encountered. This was particularly true at high altitudes where careful throttle manipulation was necessary in order for the compressor to recover from stall without combustor blowout occurring.

Component performance and its relationship to compressor stall problem. - Up to this point in the discussion, the results of altitude operation of the engine have been considered. In order to understand the reasons for the engine behavior it is necessary to study the individual engine components. Since high-pressure compressor stall posed the most serious restriction on engine operation, high-pressure compressor performance is presented in figure 8. The curves shown on this figure represent data obtained from the original engine configuration at Reynolds number indices of 0.45 and 0.17 and also represent data from the manufacturer's rig at an equivalent Reynolds number index of about 0.2. The rig-compressor efficiency data were chosen to be comparable with the engine data at a Reynolds number index of 0.17 as far as the rotor speed - pressure ratio relationship is concerned.

It is immediately obvious that there is a wide disagreement between the engine-compressor and the rig-compressor data. In order to simplify this discussion the effect of changing Reynolds number on the stall line is considered negligible as would be indicated by an extrapolation of the two engine compressor stall lines. This is also borne out by past experience, which has disclosed little or no shift of the stall line with Reynolds number on compressor map coordinates (ref. 1).

The engine-compressor data exhibit a sizable reduction of the pressure ratio of the stall line and airflow of the constant-rotor-speed lines over that of the rig compressor. In searching for an explanation for these differences, the flow conditions entering the high-pressure compressor were examined. The flow entering the rig compressor was essentially uniform. However, the flow entering the engine compressor had a severe radial total-pressure distortion. A typical example of this distortion is shown in figure 9 in which the variation of the ratio of local total pressure to over-all average total pressure across the high-pressure compressor inlet annulus is presented. The four radial rakes used in obtaining the data of figure 9 exhibited very little circumferential variation. Past studies of the effect of compressor-inlet distortion on performance demonstrate that the disagreement between the rig- and engine-compressor data in figure 8 might well be attributed to the type and magnitude of distortion depicted in figure 9.

Other effects of the flow distortion entering the engine high-pressure compressor besides those already mentioned are the positive slope of the constant rotor speed lines and the lower efficiency of the compressor. The positive slope of the constant speed lines is in agreement with an observed trend toward reduced distortion as the high-pressure compressor pressure ratio is increased at a constant corrected speed. The reduced efficiency of the high-pressure engine compressor as compared to that of the rig compressor can be attributed largely to the wide range of angles of attack over which the radial distortion forces the first stage of the high-pressure compressor to operate.

Although, as previously stated, there is no discernible effect of Reynolds number on the high-pressure compressor stall line, variation in the Reynolds number does result in a shift of the constant speed line to lower airflow and of the constant nozzle-area operating line to a higher pressure ratio so that at a Reynolds number index of 0.17, the high-pressure compressor stall margin is practically zero. Data obtained by the engine manufacturer indicated that the Reynolds number effect on the compressor was aggravated by the flow distortion.

To continue the study of the component performance, data for the low-pressure compressor are presented in figure 10. The agreement between the rig- and engine-compressor data is in general quite good. Furthermore, the effect of Reynolds number on the stall line and constant speed

lines is, for practical purposes, nonexistent. The shift in the operating line can be traced directly to the Reynolds number effect on the high-pressure compressor. In turn, this movement of the operating line on the low-pressure compressor map is the reasons for the change in low-pressure compressor efficiency with Reynolds number. The rig-compressor efficiency data were chosen to be comparable with the engine data at a Reynolds number index of 0.45, as far as a speed-airflow relation is concerned.

To complete the study of the component performance, the over-all compressor, combustor, and turbine efficiencies are plotted as functions of corrected high-pressure rotor speed in figure 11 for Reynolds number indices of 0.9, 0.45, and 0.17 for the rated exhaust-nozzle area operating lines. These data show that the combustor and turbine efficiencies are relatively high. However, the over-all compressor efficiency reflects the low efficiency of the high-pressure compressor shown in figure 8.

A summary of the study of the component performance of the original engine configuration leads to the following conclusions:

(1) The effect of nonuniform flow entering the high-pressure compressor markedly reduces the stall margin and efficiency. In addition, the flow distortion results in a more severe Reynolds number effect than would otherwise be present.

(2) The turbine and combustor perform at a high level of efficiency.

(3) As a result of the small stall margin of the high-pressure compressor, particularly above rated corrected high-pressure rotor speed, the engine operates dangerously near stall even at low altitudes.

Consequently, when the steady-state operating line is shifted toward the stall line as the Reynolds number is decreased, the limited high-speed stall margin becomes increasingly small and stall is encountered at low rotor speeds until high-speed engine operation becomes impossible.

At this point in the investigation it was decided that two basic approaches could be taken to improve the stall margin and consequently increase the engine-operating range and improve handling characteristics:

(a) Raise the stall line by modifying or redesigning the high-pressure compressor or improving the flow distribution out of the low-pressure compressor

(b) Lower the operating line by increasing the turbine stator areas or improving the component efficiencies.

These approaches were attempted in varying degrees by the engine manufacturer and are exemplified by the modified A and B engine configurations. It is noteworthy to mention that the modifications reported herein were necessarily of the quick fix variety.

Modified Engine Configurations A and B and Comparison with the Original Engine Configuration

In order to simplify the discussion on the modified engine configurations, both of which used the variable high-pressure compressor inlet guide vanes, the effect of the guide vanes on engine performance and operating limits is discussed using the data from the modified B configuration. The effect of the guide vanes was very similar for both modified engine configurations. The three engine configurations are then compared.

Effect of high-pressure compressor inlet guide vanes. - The effect of changing the guide vane angle on the operating limits of the engine is presented in figure 12 for a Reynolds number index of 0.37, inlet-air temperature of -40° F, and a flight Mach number of 0.9. The same coordinates used previously for this purpose are employed, namely exhaust-nozzle area and high-pressure rotor speed. As the guide vane angle is changed from -5° to 5°, the high-pressure rotor speed at which low-pressure rotor speed limit, limiting exhaust-gas temperature, or high-pressure-compressor stall was reached generally increased. This is primarily due to a change in the speed ratio between the low-pressure and high-pressure rotors as can be observed from noting the position of the limiting (constant) low-pressure rotor speed lines.

The effect of guide vane angle on the engine performance is shown in figure 13 in which net thrust and specific fuel consumption are plotted as functions of high-pressure rotor speed for altitudes of 40,000 and 50,000 feet at Mach numbers of 0.9 and 1.5, respectively. The engine performance was calculated from engine pumping characteristics obtained at a Reynolds number index of 0.37 with a choked exhaust nozzle. The curves of figure 13 are plotted for the exhaust-nozzle area that corresponds to the rated area for the particular flight condition under consideration. The data indicate that for a given high-pressure rotor speed there is little to choose from guide vane angles between -5° and 5°, insofar as performance is concerned. This would not be the case if the guide vane angle range was extended beyond these limits. Sea-level tests by the manufacturer showed that guide vane angles greater than 5° resulted in a significant loss in engine performance.

Comparison of engine steady-state limits for the three engine configurations. - In comparing the performance and operating limits of the three engine configurations, high-pressure compressor inlet guide vane

angles of -5° and 0° were chosen for the modified A and B engine configurations, respectively. These angles were selected because it appeared they would give near-optimum engine performance over a wide range of flight conditions and also their operating limits were quite comparable at a Reynolds number index of 0.37. The operating limits of the three configurations are compared in figure 14 on a nozzle area - high-pressure rotor speed basis for Reynolds number indices between 0.45 and 0.17. In the case of the original engine configuration (AX 103/1), the lowest operating limits were used. At Reynolds number indices of 0.45 to 0.37 (fig. 14(a)) the operating limits of all configurations were about the same if the engine vibration limits of the original engine configuration were neglected. However, at a lower index (fig. 14(b)) there was a marked difference. In this case, the operating limit curves for the original and modified engine A configurations are given for an index of 0.17. The modified engine B configuration was essentially inoperable at a Reynolds number index of 0.17 and so the operating limits for an index of 0.27 are presented. Thus, the modified engine A configuration was clearly superior in terms of engine operating limits in the lower Reynolds number index range.

Comparison of fuel-flow stall margin for the three engine configurations. - The fuel-flow stall margins of the three engine configurations are presented in figure 15 on coordinates of corrected engine fuel flow and corrected high-pressure rotor speed. The data used to establish the curves were obtained at a Reynolds number index of 0.45, Mach number of 0.9, and rated exhaust-nozzle area. Below a corrected high-pressure rotor speed of about 8100 rpm, the stall margin of the modified engine A configuration was best. Above this speed the modified engine B had the largest stall margin. The improved stall margin of the modified engine configurations over that of the original engine configuration was largely due to the lowering of the steady-state operating lines, which came about as a result of the increased turbine-stator areas.

Comparison of the performance of the three engine configurations. - The net thrust and specific fuel consumption are shown as functions of high-pressure rotor speed in figure 16 for altitudes of 40,000 and 50,000 feet at Mach numbers of 0.9 and 1.5, respectively. The data used to obtain these curves were calculated as previously described regarding the data of figure 13. Within the accuracy of the data there was no appreciable difference in the performance of the three engines with the exception of the slightly higher specific fuel consumption of the modified engine B configuration at part engine speed. Calculation of the performance of the modified engine B configuration for standard sea-level static conditions resulted in a thrust of 17,600 pounds and a specific fuel consumption of 0.98 with the variable high-pressure guide vanes set at an angle of 0°.

Effect of engine configuration change on component performance. - The over-all compressor and turbine efficiencies of the three engine configurations are presented in figure 17 as a function of corrected high-pressure rotor speed for rated exhaust-nozzle areas and Reynolds number indices of 0.17 and 0.45 to 0.37. These data show no appreciable change in the compressor and turbine efficiencies as a result of any of the engine modifications.

It will be recalled that examination of the high-pressure compressor characteristics for the original engine configuration showed that flow distortion entering the compressor was the prime reason for the reduced stall margin and, consequently, for the narrow engine operating limits as compared with the stall margin predicted on the basis of rig-compressor tests. Inasmuch as an effort was made to reduce the magnitude of this distortion, the curves of figure 18 are presented to disclose what success was achieved. This figure gives the percent of total-pressure distortion entering the high-pressure compressor as a function of corrected high-pressure rotor speed for the three engine configurations for rated nozzle areas at Reynolds number indices of 0.45 to 0.37 and a Mach number of 0.9. At high corrected speeds, the flow distortion entering the compressor was lowest for the modified engine B configuration and highest for the original engine configuration. At low and intermediate corrected rotor speeds the original and modified engine A configurations had about the same distortion with the modified engine B configuration having a slightly lower distortion. These changes in distortion can be attributed to a shift in the engine operating line on the low-pressure compressor map and to modifications in the low-pressure compressor.

In order to determine whether any noticeable effect of the change in distortion can be observed on the high-pressure compressor stall line, a comparison of the high-pressure compressor stall lines for the three engine configurations on compressor map coordinates is presented in figure 19. As has been pointed out previously, there was no discernible effect of Reynolds number on the stall line. It is somewhat difficult to perceive any effect of the change in distortion on the stall line except possibly at the high speed portion of the curves where the stall line of the modified engine B configuration showed improvement over the other configurations. (This is particularly true when considering the stall line on a fuel-flow basis (fig. 15).) It is important to point out that drawing conclusions from the comparison of stall lines obtained from different physical compressors, even those of the same model, can lead to erroneous decisions, as has been borne out by past experience. Consequently, stall lines of several engines that are alike may differ in magnitude by as much as the variations shown in figure 19.

Now that the high-pressure compressor stall lines of the three engine configurations have been presented and compared, the remaining

consideration is the relation of the steady-state operating line to the stall lines, that is, the stall margin. This is accomplished in figure 20, which presents the stall region and rated nozzle operating lines for the three engine configurations. Stall for all three configurations is represented by a shaded area. The curves of figure 20(a) present the stall margin at Reynolds number indices of 0.45 to 0.37. Figure 20(b) is a similar representation for an index of 0.17. The shift in the steady-state operating lines toward the region of stall as Reynolds number index is decreased is quite apparent.

There does remain a question as to why the operating lines of the modified A and B configurations were not more in agreement. Since the component efficiencies (fig. 17) were essentially the same, the only apparent reason would be that the turbine flow areas were not the same even though they were intended to be.

Summing up the discussion in connection with figures 19 and 20, it becomes apparent that of the changes investigated the only positive method of improving the stall margin, barring complete redesign of the compressor, is by opening the turbine-stator areas and thereby lowering the operating line.

CONCLUDING REMARKS

An investigation of the prototype Iroquois turbojet engine in an altitude test chamber disclosed a severe stall problem in the high-pressure compressor at low Reynolds numbers and low inlet-air temperatures. Consequently, the operating range of the original engine configuration was severely restricted below Reynolds number indices of 0.45 at moderate and high corrected rotor speeds. The reduced operating range resulted in high thrust penalties. For example, at standard conditions at an altitude of 56,000 feet and Mach number of 0.9 the maximum possible net thrust was 26 percent below that available without compressor stall. In contrast, the engine exhibited a large operating margin at simulated Mach numbers of 1.5 and 2.0 at altitudes of 50,000 to 60,000 feet (inlet-air temperatures between 100° and 250° F and Reynolds number indices of approximately 0.4).

Examination of the component data of the original engine configuration revealed that the small stall margin of the high-pressure compressor, when it was operating as an integral part of the engine, was basically due to the radial flow distortion at its inlet. This and an accompanying Reynolds number effect on the high-pressure compressor resulted in the curtailed engine operation at altitude.

As a consequence, the manufacturer produced engine modifications that included variable high-pressure compressor inlet guide vanes, increased turbine-stator areas, and other modifications of a lesser nature. The effect of these modifications was, in general, beneficial but inadequate as far as engine operating limits were concerned. These modifications were incorporated without penalizing the engine performance.

The analysis of the component performance of the three engine configurations disclosed that of the modifications employed, opening the turbine-stator areas was the most effective modification and the one requiring the least amount of development. In addition, a practical reduction of the flow distortion entering the high-pressure compressor still appears to offer profitable stall margin improvement.

Lewis Flight Propulsion Laboratory
National Advisory Committee for Aeronautics
Cleveland, Ohio, June 13, 1958

APPENDIX A

SYMBOLS

A	area, sq ft
B	thrust scale force, lb
C_d	flow coefficient, ratio of actual to ideal
C_V	velocity coefficient, ratio of scale jet thrust to ideal jet thrust
F_j	jet thrust, lb
F_n	net thrust, lb
g	acceleration due to gravity, 32.17 ft/sec^2
h	enthalpy, Btu/lb
K	thermocouple constant, 106
M	Mach number
N	engine speed, rpm
P	total pressure, lb/sq ft abs
p	static pressure, lb/sq ft abs
R	gas constant, 53.4 ft-lb/(lb)($^{\circ}$R)
T	total temperature, $^{\circ}$R
t	static temperature, $^{\circ}$R
V	velocity, ft/sec
w_a	airflow, lb/sec
w_f	fuel flow, lb/sec
w_g	gas flow, lb/sec
γ	ratio of specific heats

δ ratio of total pressure to static pressure of NACA standard atmosphere at sea level

η efficiency

θ ratio of total temperature to static temperature of NACA standard atmosphere at sea level

φ ratio of viscosity to the viscosity of NACA standard atmosphere at sea level

$\frac{\delta}{\varphi\sqrt{\theta}}$ Reynolds number index, $P(T+216)/5.7738\ T^2$

Subscripts:

a air

ac actual

av average

C compressor

e engine

eff effective

g gas

HP high pressure

he heat exchanger

i indicated

id ideal

LP low pressure

l leakage

max maximum

min minimum

N nozzle throat

s scale

T turbine

tp turbine pump

x Venturi station (approximately 7 ft upstream of engine inlet, station 1)

0 free stream

1 engine inlet, low-pressure compressor inlet

2 low-pressure compressor outlet

2-1 high-pressure compressor inlet

3 high-pressure compressor outlet

4 high-pressure turbine inlet

5 high-pressure turbine outlet, low-pressure turbine inlet

6 low-pressure turbine outlet

9 exhaust-nozzle inlet

APPENDIX B

METHODS OF CALCULATION

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

$$M_0 = \sqrt{\frac{2}{\gamma_1 - 1}\left[\left(\frac{P_1}{p_0}\right)^{\frac{\gamma_1 - 1}{\gamma_1}} - 1\right]} \qquad (1)$$

Flight speed. - The following equation was used to calculate flight speed:

$$V_0 = M_0 \sqrt{\gamma_1 g R T_1 \left(\frac{p_0}{P_1}\right)^{\frac{\gamma_1 - 1}{\gamma_1}}} \qquad (2)$$

Exhaust-gas temperature. - Total temperatures at the exhaust-nozzle inlet were determined from indicated temperatures by correcting the indicated temperatures for recovery (ref. 2) and radiation (ref. 3) as follows:

$$T = T_i + \Delta T_{radiation} + \Delta T_{recovery} \qquad (3)$$

Airflow. - The airflow was calculated at the Venturi station as follows

$$w_{a,1} = C_d p_x A_x \sqrt{\frac{2\gamma_1 g}{(\gamma_1 - 1) R T_1}\left(\frac{P_x}{p_x}\right)^{\frac{\gamma_1 - 1}{\gamma_1}}\left[\left(\frac{P_x}{p_x}\right)^{\frac{\gamma_1 - 1}{\gamma_1}} - 1\right]} \qquad (4)$$

where

$$C_d = 0.994$$

The airflows and gas flows at the various stations throughout the engine were calculated as follows:

$$w_{a,2} = w_{a,1} \qquad (5)$$

$$w_{a,2-1} = w_{a,2} + 0.32\ w_{a,he} \tag{6}$$

where $w_{a,he}$ was calculated in the same manner as $w_{a,1}$

$$w_{a,3} = w_{a,1} - 0.68\ w_{a,he} \tag{7}$$

$$w_{a,4} = w_{a,1} - 0.68\ w_{a,he} - w_{a,l} - w_{a,tp} \tag{8}$$

where $w_{a,l}$ and $w_{a,tp}$ were originally measured and then each was assumed to equal 0.0138 $w_{a,1}$

$$w_{a,6} = w_{a,4} \tag{9}$$

$$w_{a,9} = w_{a,1} - w_{a,tp} \tag{10}$$

$$w_{g,4} = w_{a,4} + w_f \tag{11}$$

$$w_{g,6} = w_{g,4} \tag{12}$$

$$w_{g,9} = w_{a,9} + w_f \tag{13}$$

Scale thrust. - Engine scale thrusts were calculated as follows:

$$F_{j,s} = B + A_{seal}\ (P_x - p_{tank}) \tag{14}$$

$$F_{n,s} = F_{j,s} - \frac{w_{a,1}}{g} V_0 \tag{15}$$

Ideal thrust. - Ideal engine thrusts were calculated as follows:

$$F_{j,id} = \frac{w_{g,9}}{g} V_N + A_N\ (p_N - p_0) \tag{16}$$

$$= \frac{w_{g,9}}{g} V_{eff} \tag{17}$$

where

$$V_{eff} = V_N + \frac{A_N(p_N - p_0)}{\frac{w_{g,9}}{g}} \tag{18}$$

and where $V_{eff}/\sqrt{gRT_9}$ is defined in reference 4.

Velocity coefficient. - Velocity coefficient is defined as the ratio of scale jet thrust to ideal jet thrust

$$C_V = \frac{F_{j,s}}{F_{j,id}} \tag{19}$$

Specific fuel consumption. - The net specific fuel consumption is defined and calculated as follows:

$$\frac{w_f}{F_{n,s}} = \frac{w_f}{C_V F_{j,id} - \frac{w_{a,1}}{g} V_0} \tag{20}$$

Compressor efficiency. - The compressor efficiencies are calculated as follows:

$$\eta_C(\text{over-all}) = \frac{h_a\Big]_1^{3'} + \frac{w_{a,he}}{w_{a,3}} h_a\Big]_1^{he'} - 0.32 \frac{w_{a,he}}{w_{a,3}} h_a\Big]_1^{2'}}{h_a\Big]_1^{3} + \frac{w_{a,he}}{w_{a,3}} h_a\Big]_1^{he} - 0.32 \frac{w_{a,he}}{w_{a,3}} h_a\Big]_1^{2}} \tag{21}$$

where primed values are isentropic

$$\eta_{C,LP} = \frac{h_a\Big]_1^{2'}}{h_a\Big]_1^{2}} \tag{22}$$

$$\eta_{C,HP} = \frac{h_a\Big]_2^{3'} + \frac{w_{a,he}}{w_{a,3}} h_a\Big]_2^{he'}}{h_a\Big]_2^{3} + \frac{w_{a,he}}{w_{a,3}} h_a\Big]_2^{he}} \tag{23}$$

Engine combustion efficiency. - The engine combustion efficiency is calculated as follows:

$$\eta_e = \frac{(w_f/w_a)_{9,id}}{(w_f/w_a)_{9,ac}} \tag{24}$$

where

$$\left(\frac{w_f}{w_a}\right)_{9,ac} = \frac{w_f}{w_{a,9}} \tag{25}$$

and

$$\left(\frac{w_f}{w_a}\right)_{9,id} = \frac{h_a\Big]_{1'}^{9}}{h_C - \frac{Am + B}{m + 1}\Big]_{540^\circ R}^{9}} \tag{26}$$

Equation (26) is defined in reference 5, and tables of equation (26) are given in reference 6.

Turbine-inlet temperature. - The turbine-inlet temperature (or combustor-outlet temperature) is calculated as follows:

$$T_4 = T_3 + T\Big]_3^4 \tag{27}$$

where

$$T\Big]_3^4 = f\left[\left(\frac{w_f}{w_a}\right)_{id} \text{ and } T_3\right] \tag{28}$$

Turbine efficiency. - Turbine efficiency is calculated as follows:

$$\eta_T = \frac{h_g\Big]_6^4}{h_g\Big]_{6'}^4} \tag{29}$$

The low and high pressure turbine efficiencies are not presented because of the inability to accurately measure P_5.

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TABLE I. - PERFORMANCE DATA OF ORIGINAL ENGINE CONFIGURATION

[(a) AX 102/1B engine.]

Run	Altitude, ft	Mach number, M_0	Reynolds number index, $\delta_1/\varphi_1\sqrt{\theta_1}$	Exhaust-nozzle area, A_N, sq in.	High-pressure rotor speed, N_{HP}, rpm	Low-pressure rotor speed, N_{LP}, rpm	Engine-inlet temperature, T_1, °R	Low-pressure compressor-outlet temperature, T_2, °R	High-pressure compressor-outlet temperature, T_3, °R	Turbine-inlet temperature, T_4, °R	Exhaust-gas temperature, T_9, °R	Engine-inlet total pressure, P_1, lb/sq ft abs	Low-pressure compressor-outlet total pressure, P_2, lb/sq ft abs	High-pressure compressor-outlet total pressure, P_3, lb/sq ft abs	Turbine-inlet total pressure, P_4, lb/sq ft abs	Turbine-outlet total pressure, P_6, lb/sq ft abs	Exhaust-nozzle inlet total pressure, P_9, lb/sq ft abs
1	Sea level	0	0.857	680	7032	4373	568	640	953	1777	1423	2036	3085	9,905	9,070	3292	3170
2			.870	681	7216	4597	564	650	983	1878	1484	2054	3232	10,781	9,889	3511	3369
3			.840	679	7401	4707	579	670	1019	1926	1523	2047	3285	11,215	10,339	3643	3499
4			.911	681	7604	4982	544	648	1015	2042	1609	2048	3554	13,168	12,242	4190	4016
5			.906	682	7796	5230	546	656	1039	2145	1685	2045	3657	13,992	13,088	4451	4265
6	35,000	0.9	.432	674	7004	4641	485	577	894	1740	1359	838	1452	5,123	4,695	1569	1498
7			.432	679	7010	4747	486	579	896	1747	1356	840	1447	5,126	4,698	1565	1494
8			.432	681	7198	4892	485	583	918	1835	1436	838	1499	5,548	5,101	1707	1629
9			.430	681	7403	5046	484	588	944	1943	1531	831	1538	6,001	5,536	1858	1772
10			.431	681	7599	5240	483	593	971	2067	1629	831	1583	6,437	5,967	2000	1909
11			.434	682	7755	5384	482	597	999	2143	1703	835	1613	6,772	6,287	2127	2037
12			.445	754	6264	4495	470	554	791	1332	1038	827	1335	3,577	3,235	977	915
13			.450	826	7173	5689	473	615	933	1716	1287	844	1667	5,436	4,994	1398	1269
14	55,000	.9	.165	649	6249	4043	483	549	807	1476	1170	319	474	1,378	1,256	438	420
15			.169	649	6944	4585	478	563	887	1845	1462	322	538	1,904	1,776	623	598
16			.165	680	6251	4247	479	552	806	1426	1116	314	487	1,402	1,261	415	394
17			.169	679	6289	4254	477	552	812	1446	1128	320	496	1,439	1,311	434	413
18			.166	682	6509	4473	478	560	835	1544	1208	315	510	1,579	1,432	468	445
19			.169	678	6687	4612	477	565	857	1626	1272	321	533	1,717	1,585	519	494
20			.166	682	6708	4637	477	566	859	1645	1290	314	529	1,723	1,573	512	487
21			.166	680	6905	4787	476	572	883	1751	1373	313	548	1,850	1,699	557	529
22			.169	681	7203	5035	477	579	927	1921	1512	320	583	2,141	1,998	664	632
23			.168	698	6271	4311	477	555	811	1437	1116	319	496	1,414	1,284	417	396
24			.171	699	7265	5144	474	583	930	1921	1503	321	604	2,188	2,044	661	627
25			.168	727	7568	5706	470	604	986	2084	1616	313	647	2,496	2,334	729	688
26			.172	774	7076	5507	471	600	918	1727	1314	322	627	2,050	1,894	552	513
27			.170	778	7309	5750	473	613	959	1874	1427	319	626	2,248	2,084	606	562
28			.171	793	7180	5692	471	610	941	1799	1360	318	633	2,116	1,957	561	516
29			.172	815	7176	5762	473	616	942	1781	1348	322	655	2,147	1,984	561	509

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TABLE I. - Continued. PERFORMANCE DATA OF ORIGINAL ENGINE CONFIGURATION

[(a) Concluded. AX 102/1B engine.]

Run	Exhaust or free-stream static pressure, p_0, lb/sq ft abs	Engine fuel flow, w_f, lb/sec	Engine-inlet air-flow, $w_{a,1}$, lb/sec	Corrected engine-inlet high-pressure rotor speed, $N_{HP}/\sqrt{\theta_1}$, rpm	Corrected high-pressure rotor speed, $N_{HP}/\sqrt{\theta_2}$, rpm	Corrected low-pressure rotor speed, $N_{LP}/\sqrt{\theta_1}$, rpm	Corrected engine-inlet airflow, $w_{a,1}\sqrt{\theta_1}/\delta_1$, lb/sec	Corrected high-pressure compressor airflow, $w_{a,2-1}\sqrt{\theta_2}/\delta_2$, lb/sec	Scale jet thrust, $F_{j,s}$, lb	Scale net thrust, $F_{n,s}$, lb	Net specific fuel consumption, $w_f/F_{n,s}$, lb/(hr)(lb of thrust)	Velocity coefficient, C_V	Exhaust-nozzle flow coefficient, $C_{d,N}$	Over-all compressor efficiency, η_C	Low-pressure compressor efficiency, $\eta_{C,LP}$	High-pressure compressor efficiency, $\eta_{C,HP}$	Engine combustion efficiency, η_e	Over-all turbine efficiency, η_T
1	2036	2.208	184.93	6723	6335	4181	201.06	141.12	7,955	7,875	1.009	0.969	0.902	0.831	-----	0.789	0.972	0.888
2	2041	2.502	196.90	6918	6449	4407	211.61	144.69	9,124	8,463	1.064	.964	.906	.803	0.914	.787	.984	.918
3	2040	2.740	200.36	7009	6515	4453	218.76	146.94	9,984	9,479	1.041	.987	.897	.809	.927	.788	-----	.918
4	2052	3.469	232.08	7426	6801	4865	245.53	154.92	3,064	10,364	.956	.983	.919	.796	.892	.783	.996	.936
5	2044	3.897	241.70	7598	6936	5097	256.63	157.63	14,537	14,307	.981	.976	.929	.796	.899	.779	.988	.929
6	497	1.162	96.86	7245	6639	4801	236.57	149.27	6,173	3,467	1.207	.976	.970	.793	.901	.778	.989	.907
7	501	1.166	96.40	7244	6638	4905	235.22	149.30	6,172	3,491	1.203	.984	.961	.790	.882	.783	.972	.920
8	500	1.349	102.10	7446	6791	5061	249.37	153.10	6,891	4,056	1.197	.978	.980	.790	.902	.777	.980	.907
9	497	1.571	106.94	7666	6958	5225	263.18	156.92	7,708	4,746	1.192	.982	.956	.787	.893	.774	.977	.892
10	492	1.801	112.24	7877	7109	5432	275.94	160.88	8,572	5,437	1.193	.983	.986	.775	.884	.759	.992	.901
11	489	2.005	115.78	8047	7234	5587	282.90	163.22	9,229	5,968	1.209	.973	.964	.763	.863	.752	.985	.892
12	503	.602	80.40	6583	6064	4724	195.72	131.91	3,134	971	2.232	.900	.984	.730	.823	-----	.983	.809
13	502	1.158	103.82	7513	6587	5959	248.48	143.87	5,874	3,020	1.380	.960	.970	.714	.715	.763	.982	.906
14	184	.263	27.71	6478	6073	4191	177.62	127.71	1,380	592	1.601	.964	.917	.769	.885	.751	.965	.862
15	195	.488	35.29	7236	6664	4778	222.96	144.93	2,290	1,328	1.324	.951	.954	.767	.893	.745	.971	.900
16	177	.252	28.69	6507	6057	4421	185.73	129.02	1,375	542	1.675	.939	.965	.778	.883	.761	.947	.857
17	188	.265	29.50	6560	6094	4437	187.05	130.18	1,428	603	1.580	.945	.959	.762	.871	.749	.956	.874
18	182	.318	31.36	6782	6265	4661	202.40	135.66	1,642	752	1.521	.939	.969	.777	.867	.759	.948	.866
19	186	.369	33.67	6975	6405	4811	212.78	139.93	1,896	943	1.407	.941	.978	.766	.850	.760	.970	.877
20	180	.375	33.22	6997	6419	4837	214.46	139.31	1,890	942	1.433	.950	.967	.777	.861	.766	.954	.860
21	185	.437	34.92	7210	6576	4998	225.97	144.55	2,135	1,166	1.347	.965	.970	.767	.860	.754	.958	.877
22	184	.568	38.92	7513	6821	5252	246.45	149.58	2,671	1,564	1.308	.954	.965	.756	.871	.738	.973	.890
23	188	.252	29.00	6541	6065	4497	184.37	128.66	1,354	545	1.663	.938	.950	.753	-----	.749	.977	.872
24	184	.574	39.86	7602	6854	5382	251.45	148.44	2,706	1,572	1.314	.948	.968	.751	.846	.734	.982	.889
25	180	.712	43.78	7953	7014	5996	281.68	154.83	3,216	1,977	1.297	.955	.971	.727	.804	.728	.975	.904
26	189	.460	38.92	7428	6582	5781	244.72	141.66	2,274	1,191	1.390	.950	.972	.727	.759	.747	.961	.894
27	185	.550	41.17	7656	6724	6023	260.64	145.46	2,622	1,463	1.352	.950	.975	.717	.764	.736	.975	.902
28	186	.491	39.53	7538	6624	5975	250.21	143.52	2,370	1,267	1.394	.949	.975	.711	.731	.744	.973	.907
29	187	.487	40.45	7516	6590	6035	253.73	142.64	2,316	1,181	1.485	.919	.979	.717	.741	.750	.983	.892

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TABLE I. - Continued. PERFORMANCE DATA OF ORIGINAL ENGINE CONFIGURATION

[(b) AX 103/1 engine.]

Run	Altitude, ft	Mach number, M_0	Reynolds number index, $\delta_1/\varphi_1\sqrt{\theta_1}$	Exhaust-nozzle area, A_N, sq in.	High-pressure rotor speed, N_{HP}, rpm	Low-pressure rotor speed, N_{LP}, rpm	Engine-inlet temperature, T_1, °R	Low-pressure compressor-outlet temperature, T_2, °R	High-pressure compressor-outlet temperature, T_3, °R	Turbine-inlet temperature, T_4, °R	Exhaust-gas temperature, T_9, °R	Engine-inlet total pressure, P_1, lb/sq ft abs	Low-pressure compressor-outlet total pressure, P_2, lb/sq ft abs	High-pressure compressor-outlet total pressure, P_3, lb/sq ft abs	Turbine-inlet total pressure, P_4, lb/sq ft abs	Turbine-outlet total pressure, P_6, lb/sq ft abs	Exhaust-nozzle inlet total pressure, P_9, lb/sq ft abs
30	35,000	0.9	0.446	649	6252	3977	474	540	791	1415	1109	839	1266	3875	3503	1231	1184
31			.449	648	6608	4261	473	548	836	1605	1261	841	1348	4576	4185	1472	1420
32			.439	649	6631	4279	474	549	835	1601	1260	825	1328	4539	4159	1463	1412
33			.447	648	6915	4476	474	556	872	1770	1401	840	1403	5207	4797	1702	1642
34			.447	649	7204	4695	474	561	907	1924	1539	840	1462	5892	5452	1940	1873
35			.448	649	7559	5019	473	572	953	2137	1708	839	1530	6673	6209	2216	2147
36			.449	654	7587	5129	471	575	963	2140	1712	837	1550	6838	6388	2258	2184
37			.446	677	6260	4159	474	547	794	1376	1061	838	1299	3843	3455	1147	1099
38			.446	678	6584	4434	475	557	833	1512	1182	841	1376	4440	4046	1337	1279
39			.447	671	6988	4745	473	565	882	1741	1358	839	1477	5358	4919	1650	1581
40			.448	675	7350	5076	473	576	932	1957	1535	840	1568	6336	5851	1960	1881
41			.449	684	7620	5413	471	588	970	2090	1650	838	1631	6910	6401	2158	2073
42			.445	711	6251	4316	474	554	796	1335	1023	837	1317	3773	3372	1073	1020
43			.447	707	6705	4700	473	567	850	1549	1186	838	1431	4646	4229	1342	1275
44			.447	705	6993	4932	473	575	887	1695	1306	837	1514	5284	4829	1548	1473
45			.447	713	7319	5279	473	587	930	1866	1445	838	1626	6198	5704	1823	1731
46			.445	745	6244	4484	473	561	799	1313	996	835	1337	1317	3305	1008	951
47			.447	747	6507	4772	473	572	831	1420	1079	839	1415	4210	3783	1135	1068
48			.448	751	6723	4974	473	581	859	1507	1148	839	1479	4606	4163	1250	1175
49			.446	754	6939	5169	473	589	887	1619	1226	836	1541	5077	4623	1381	1298
50	38,500		.444	650	6592	4285	420	494	781	1598	1256	710	1216	4636	4280	1492	1441
51			.445	650	6805	4452	419	497	805	1719	1357	710	1241	5073	4689	1649	1593
52			.445	650	7004	4614	420	503	833	1821	1438	712	1286	5521	5110	1803	1742
53			.448	650	7117	4703	419	504	847	1893	1500	715	1289	5633	5225	1863	1804
54			.448	679	6640	4524	421	504	792	1567	1214	720	1283	4731	4337	1432	1373
55			.446	676	6897	4729	422	512	824	1697	1320	719	1321	5223	4822	1605	1541
56			.446	684	7099	4973	421	519	854	1818	1418	717	1363	5659	5231	1746	1678
57			.443	683	7288	5185	422	527	882	1929	1509	714	1379	5959	5518	1842	1774
58			.444	679	7403	5259	421	527	894	1994	1565	713	1389	6154	5735	1930	1860
59	50,000	1.8	.448	650	6992	4422	706	791	1093	1760	1392	1400	1975	5140	4579	1609	1551
60	58,000	2.0	.445	650	7184	4583	704	795	1117	1877	1488	1385	2010	5608	5021	1764	1700
61			.451	650	7411	4730	701	798	1144	2015	1604	1395	2074	6167	5569	1976	1905
62			.444	649	7580	4887	704	806	1180	2172	1736	1382	2113	6732	6155	2188	2108
63			.449	673	7003	4629	703	798	1096	1720	1344	1395	2015	5116	4543	1510	1446
64			.442	674	7214	4786	707	808	1124	1822	1428	1383	2043	5479	4880	1625	1556
65			.448	682	7404	4944	703	809	1149	1942	1526	1391	2117	6093	5480	1828	1751
66			.442	680	7615	5087	707	818	1175	2049	1616	1383	2154	6481	5855	1966	1880
67			.448	683	7760	5217	705	825	1202	2145	1689	1396	2227	6968	6317	2122	2032
68	50,000	1.5	.373	677	6511	4312	572	653	915	1479	1146	895	1313	3386	3067	1013	970
69			.373	681	6512	4304	572	650	912	1479	1149	895	1313	3458	3068	1015	974
70			.373	676	6772	4522	571	657	944	1614	1257	892	1366	3933	3526	1169	1120
71			.369	677	7108	4772	572	667	987	1792	1403	884	1420	4503	4087	1367	1311
72			.373	680	7383	4967	567	670	1019	1940	1522	885	1490	5095	4660	1568	1505
73			.367	689	7601	5150	579	693	1066	2041	1595	892	1545	5463	5023	1669	1600
74			.371	684	7616	5164	571	682	1052	2057	1618	888	1546	5530	5084	1698	1627
75			.370	682	7700	5255	567	680	1066	2149	1697	877	1560	5879	5442	1828	1755
76	55,000	.9	.166	650	6295	4081	482	549	807	1477	1166	319	479	1423	1291	449	431
77			.168	649	6397	4168	481	552	818	1533	1213	322	492	1506	1371	476	457
78			.168	649	6540	4285	481	555	836	1610	1275	322	505	1609	1470	512	493
79			.168	649	6702	4413	480	559	857	1710	1351	322	519	1738	1596	556	534
80			.169	649	6779	4459	480	560	864	1745	1382	323	526	1789	1646	575	554
81			.169	679	6283	4231	477	552	805	1446	1132	319	490	1427	1288	426	408
82			.170	679	6457	4402	477	558	826	1521	1186	322	510	1556	1414	464	445
83			.170	680	6619	4563	477	564	849	1606	1254	323	529	1694	1547	507	484
84			.170	682	6907	4789	477	572	884	1755	1370	322	556	1909	1756	579	553
85			.169	683	7124	4942	476	577	911	1861	1460	320	575	2081	1920	634	607
86			.170	685	7230	5013	476	580	927	1923	1510	322	591	2193	2024	669	640

TABLE I. - Concluded. PERFORMANCE DATA OF ORIGINAL ENGINE CONFIGURATION

[(b) Concluded. AX 103/1 engine.]

Run	Exhaust or free-stream static pressure, p_0, lb/sq ft abs	Engine fuel flow, w_f, lb/sec	Engine-inlet air-flow, $w_{a,1}$, lb/sec	Corrected engine inlet high-pressure rotor speed, $N_{HP}/\sqrt{\theta_1}$, rpm	Corrected high-pressure rotor speed, $N_{HP}/\sqrt{\theta_2}$, rpm	Corrected low-pressure rotor speed, $N_{LP}/\sqrt{\theta_1}$, rpm	Corrected engine-inlet airflow, $w_{a,1}\sqrt{\theta_1}/\delta_1$, lb/sec	Corrected high-pressure compressor airflow, $w_{a,2-1}\sqrt{\theta_2}/\delta_2$, lb/sec	Scale jet thrust, $F_{j,s}$, lb	Scale net thrust, $F_{n,s}$, lb	Net specific fuel consumption, $W_f/F_{n,s}$, lb/(hr)(lb of thrust)	Velocity coefficient, C_V	Exhaust-nozzle flow coefficient, $C_{d,N}$	Over-all compressor efficiency, η_C	Low-pressure compressor efficiency, $\eta_{C,LP}$	High-pressure compressor efficiency, $\eta_{C,HP}$	Engine combustion efficiency, η_e	Over-all turbine efficiency, η_T
30	505	0.692	80.86	6542	6129	4161	194.87	138.12	4112	1910	1.305	0.970	0.949	0.812	0.896	0.802	0.978	0.897
31	498	.965	90.84	6922	6431	4463	218.20	146.93	5400	2892	1.201	.972	.953	.802	.909	.785	.989	.910
32	500	.964	89.89	6938	6447	4478	220.32	147.63	5313	2878	1.206	.969	.946	.815	.921	.798	.977	.905
33	509	1.248	99.04	7235	6681	4683	238.37	154.95	6513	3829	1.173	.972	.952	.805	.912	.790	.994	.905
34	502	1.569	107.25	7538	6929	4912	258.19	161.83	7730	4787	1.180	.971	.950	.804	.934	.778	.996	.877
35	498	2.000	116.17	7918	7199	5257	279.58	169.12	9239	6034	1.193	.978	.950	.784	.893	.771	.997	.913
36	501	2.065	117.77	7964	7208	5384	283.65	169.62	9384	6168	1.205	.976	.940	.774	.872	.767	.983	.903
37	498	.636	80.66	6550	6098	4352	194.75	135.17	3891	1670	1.371	.972	.955	.801	.867	.796	.978	.899
38	511	.851	89.39	6882	6355	4635	215.26	142.79	4912	2494	1.228	.981	.961	.799	.875	.793	.984	.865
39	500	1.232	102.44	7320	6697	4971	246.77	153.47	6568	3753	1.182	.970	.971	.798	.902	.782	.990	.913
40	500	1.669	114.27	7699	6973	5317	274.96	162.89	8293	5152	1.166	.977	.966	.793	.896	.780	.994	.908
41	506	1.988	120.72	7999	7159	5682	290.50	167.17	9256	5986	1.196	.973	.949	.768	.843	.768	.990	.908
42	497	.586	80.18	6541	6050	4516	193.67	133.45	3650	1436	1.470	.975	.954	.784	.818	.796	.984	.888
43	503	.896	93.35	7024	6415	4923	225.03	144.66	5096	2545	1.267	.967	.968	.784	.830	.792	.985	.905
44	502	1.154	102.19	7325	6644	5166	246.61	150.67	6265	3473	1.196	.972	.969	.782	.855	.779	.989	.914
45	497	1.526	113.28	7666	6882	5529	273.07	157.14	7763	4640	1.184	.974	.954	.787	.865	.783	.979	.908
46	503	.556	78.91	6540	6006	4697	190.91	130.25	3381	1232	1.624	.983	.948	.765	.773	.795	.972	.888
47	498	.711	86.87	6816	6198	4998	209.28	136.70	4162	1767	1.448	.973	.966	.766	.770	.798	.974	.883
48	506	.854	93.16	7042	6354	5210	224.28	141.41	4817	2284	1.346	.973	.969	.759	.769	.792	.974	.881
49	502	1.028	99.40	7268	6513	5414	240.19	145.80	5597	2883	1.284	.972	.966	.761	.774	.798	.969	.910
50	416	1.069	91.50	7328	6757	4763	245.25	155.81	5861	3454	1.116	.971	.952	.819	.943	.795	.966	.900
51	421	1.272	97.14	7574	6954	4955	259.99	162.51	6646	4119	1.118	.972	.953	.811	.930	.792	.970	.907
52	414	1.459	102.85	7786	7114	5129	274.93	167.03	7464	4742	1.113	.974	.952	.802	.932	.779	.979	.913
53	417	1.551	103.01	7921	7222	5234	274.04	167.06	7694	4980	1.126	.974	.942	.780	.906	.761	.985	.915
54	416	1.024	94.97	7372	6738	5023	251.40	154.72	5849	3319	1.116	.968	.972	.803	.912	.783	.982	.910
55	413	1.246	101.09	7649	6944	5244	268.42	161.21	6746	4038	1.116	.967	.969	.794	.892	.783	.983	.913
56	412	1.457	106.12	7882	7099	5522	282.14	165.11	7592	4757	1.108	.979	.960	.775	.867	.769	.988	.912
57	419	1.632	108.69	8082	7232	5750	290.28	168.54	8077	5216	1.131	.972	.963	.757	.831	.761	.993	.911
58	420	1.761	110.94	8219	7346	5839	296.49	170.76	8532	5629	1.130	.977	.963	.750	.834	.750	.994	.909
59	245	.899	94.75	5995	5664	3791	167.08	125.66	7095	1920	1.685	.963	.954	.794	.848	.793	.987	.890
60	248	1.107	99.91	6168	5804	3935	177.74	130.58	7871	2443	1.636	.967	.952	.808	.857	.811	.972	.894
61	238	1.358	107.88	6377	5977	4070	190.24	136.90	8883	2988	1.636	.953	.955	.807	.856	.810	.998	.905
62	242	1.659	112.90	6506	6083	4195	201.32	141.29	9555	3397	1.758	.931	.943	.813	.878	.811	.989	.901
63	255	.834	95.06	6017	5648	3977	167.81	124.15	6902	1756	1.709	.967	.972	.778	.809	.789	.994	.890
64	250	.995	99.05	6181	5782	4101	176.85	128.42	7520	2135	1.678	.965	.971	.789	.813	.805	.984	.897
65	250	1.221	106.24	6362	5930	4248	188.10	132.93	8538	2774	1.585	.971	.949	.798	.834	.806	.989	.898
66	240	1.433	111.19	6525	6066	4359	198.58	137.56	9180	3095	1.667	.954	.957	.806	.847	.815	.984	.896
67	242	1.640	117.43	6658	6155	4476	207.44	141.11	9902	3483	1.695	.944	.954	.794	.826	.807	.989	.908
68	241	.531	69.75	6201	5804	4107	173.10	126.44	4324	1194	1.601	.961	.971	.758	.813	.762	1.001	.892
69	240	.527	69.63	6203	5819	4100	172.86	126.16	4364	1235	1.554	.968	.962	.779	.841	.779	1.001	.887
70	244	.710	76.16	6456	6019	4311	189.53	133.13	5118	1717	1.490	.963	.967	.793	.856	.791	.985	.889
71	243	.965	83.28	6771	6270	4546	209.39	141.06	6161	2443	1.422	.970	.957	.799	.870	.797	.972	.901
72	242	1.237	91.38	7063	6498	4752	228.34	147.85	7268	3200	1.392	.975	.953	.795	.879	.785	.967	.909
73	245	1.382	95.54	7197	6578	4876	239.30	151.59	7904	3608	1.379	.982	.948	.785	.858	.784	.970	.920
74	237	1.404	96.76	7261	6644	4923	241.90	152.27	8012	3660	1.381	.969	.959	.795	.878	.787	.999	.901
75	240	1.594	100.00	7367	6727	5028	252.16	155.71	8582	4132	1.389	.972	.947	.799	.893	.788	.988	.918
76	190	.272	28.88	6532	6120	4234	184.69	131.51	1428	628	1.559	.937	.953	.782	.887	.771	.960	.872
77	190	.300	30.02	6645	6203	4330	190.02	133.42	1587	750	1.442	.951	.955	.782	.874	.774	.971	.874
78	192	.344	31.89	6793	6324	4451	201.64	138.45	1765	882	1.403	.940	.967	.781	.890	.768	.984	.880
79	190	.397	33.33	6969	6458	4589	210.80	141.31	1996	1066	1.341	.950	.961	.778	.890	.765	.982	.897
80	190	.420	34.09	7049	6526	4637	214.97	142.71	2095	1142	1.326	.949	.962	.780	.899	.761	.987	.894
81	191	.258	29.45	6553	6092	4414	187.03	131.35	1391	582	1.598	.938	.969	.769	.828	.782	.986	.861
82	192	.302	31.51	6736	6228	4592	198.83	135.89	1603	733	1.481	.942	.974	.770	.829	.776	.982	.863
83	192	.351	33.12	6904	6349	4759	208.31	138.43	1824	908	1.392	.949	.969	.769	.832	.774	.978	.882
84	190	.443	36.28	7205	6579	4996	228.87	145.28	2217	1206	1.324	.948	.972	.768	.849	.765	.984	.903
85	192	.521	38.30	7439	6756	5160	242.75	148.93	2499	1449	1.293	.951	.965	.763	.860	.755	.983	.891
86	192	.570	40.11	7549	6839	5235	252.75	152.09	2695	1593	1.287	.946	.974	.760	.869	.746	.994	.893

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TABLE II. - PERFORMANCE DATA OF ENGINE CONFIGURATION A

[AX 103/2 engine.]

Run	Altitude, ft	Mach number, M_0	Reynolds number index, $\delta_1/\varphi_1\sqrt{\theta_1}$	Inlet guide vane angle, deg	Exhaust-nozzle area, A_N, sq in.	High-pressure rotor speed, N_{HP}, rpm	Low-pressure rotor speed, N_{LP}, rpm	Engine-inlet temperature, T_1, °R	Low-pressure compressor-outlet temperature, T_2, °R	High-pressure compressor-outlet temperature, T_3, °R	Turbine inlet temperature, T_4, °R	Exhaust-gas temperature, T_9, °R	Engine-inlet total pressure, P_1, lb/sq ft abs	Low-pressure compressor-outlet total pressure, P_2, lb/sq ft abs	High-pressure compressor-outlet total pressure, P_3, lb/sq ft abs	Turbine-inlet total pressure, P_4, lb/sq ft abs	Turbine-outlet total pressure, P_6, lb/sq ft abs	Exhaust-nozzle inlet total pressure, P_9, lb/sq ft abs
1	------	---	0.364	-5	649	6244	3935	428	487	747	1450	1146	598	940	3152	2857	1024	989
2	------	---	.367		681	6484	4269	426	498	776	1512	1181	600	1012	3542	3221	1093	1050
3	------	---	.371		681	6760	4505	420	498	800	1647	1292	594	962	4103	3752	1277	1227
4	------	---	.369		680	6994	4688	425	511	836	1772	1394	600	1101	4459	4101	1404	1350
5	------	---	.370		682	7307	4999	423	517	875	1949	1542	598	1126	4873	4530	1555	1498
6	------	---	.376		708	7720	5505	420	533	931	2145	1694	603	1190	5371	5015	1681	1614
7	------	---	.367		717	6504	4469	428	509	783	1470	1132	603	1045	3526	3193	1025	977
8	------	---	.362		718	6838	4753	427	517	821	1625	1257	592	1102	4095	3746	1208	1152
9	------	---	.369		720	7110	5054	425	524	857	1776	1379	600	1167	4687	4307	1394	1330
10	------	---	.367		716	7410	5324	423	530	896	1960	1534	594	1163	5007	4643	1520	1456
11	------	---	.368		719	7736	5629	423	541	940	2132	1674	596	1183	5318	4940	1624	1556
12	------	---	.369		717	7745	5617	423	540	939	2146	1690	596	1190	5319	4950	1636	1567
13	------	---	.375		732	7660	5691	421	540	930	2071	1619	602	1212	5351	4969	1601	1528
14	------	---	.361		754	6610	4759	430	524	800	1482	1130	596	1078	3577	3223	987	931
15	------	---	.364		754	6875	4977	428	529	833	1610	1231	598	1147	4097	3727	1145	1080
16	------	---	.365		752	7180	5348	426	537	875	1781	1368	595	1204	4730	4329	1344	1271
17	------	---	.367		754	7439	5699	426	548	913	1927	1488	598	1226	5102	4702	1450	1373
18	------	---	.370		778	7310	5733	423	550	898	1842	1408	598	1262	5028	4595	1373	1287
19	------	---	.367	0	681	6613	4311	423	496	780	1542	1206	593	1010	3621	3292	1122	1077
20	------	---	.368		685	6932	4537	422	503	814	1690	1327	593	1063	4130	3788	1292	1243
21	------	---	.367		679	7210	4741	422	509	846	1838	1452	591	1090	4506	4163	1438	1383
22	------	---	.369		683	7497	5022	422	517	882	1993	1581	595	1137	4901	4555	1580	1523
23	------	---	.373		687	7754	5269	421	525	914	2115	1678	599	1179	5217	4867	1671	1611
24	------	---	.369		718	6610	4515	423	505	782	1484	1144	596	1054	3665	3319	1068	1017
25	------	---	.368		717	6890	4725	422	512	815	1620	1251	593	1100	4103	3746	1212	1156
26	------	---	.368		717	7195	5009	423	521	854	1781	1385	595	1152	4602	4224	1378	1317
27	------	---	.369		718	7490	5273	422	529	891	1941	1519	594	1179	4960	4588	1506	1440
28	------	---	.368		728	7789	5640	421	541	929	2066	1613	592	1211	5245	4876	1581	1507
29	------	---	.366		724	7797	5571	423	540	934	2100	1648	592	1206	5239	4861	1594	1525
30	------	---	.373		757	6550	4691	422	514	781	1424	1080	602	1083	3564	3209	976	919
31	------	---	.373		758	6766	4873	420	517	805	1523	1158	597	1132	3938	3568	1089	1027
32	------	---	.374		757	7010	5101	420	525	836	1649	1261	599	1186	4390	4001	1231	1161
33	------	---	.373		759	7255	5405	420	534	870	1774	1360	597	1231	4804	4400	1353	1278
34	------	---	.375		762	7566	5705	420	544	908	1917	1476	600	1251	5138	4706	1454	1374
35	------	---	.371		795	7300	5761	420	548	881	1771	1346	594	1278	4940	4527	1331	1242
36	------	---	.369	5	668	7777	4948	422	518	901	2106	1682	594	1147	4882	4552	1601	1545
37	------	---	.368		668	7796	4976	421	519	903	2115	1689	591	1144	4909	4583	1617	1560
38	------	---	.372		688	7816	5061	421	524	908	2086	1654	598	1176	4929	4593	1580	1521
39	------	---	.368		756	6628	4687	422	514	784	1440	1094	593	1071	3563	3212	981	924
40	------	---	.369		757	6892	4900	422	521	814	1555	1186	595	1132	3959	3600	1104	1041
41	------	---	.369		758	7230	5210	421	532	854	1703	1302	594	1193	4474	4086	1248	1178
42	------	---	.370		759	7500	5412	421	539	885	1827	1404	594	1233	4781	4399	1351	1276
43	------	---	.368		763	7797	5716	421	552	926	1975	1521	591	1276	5107	4702	1446	1366
44	------	---	.370		797	7618	5761	421	557	910	1872	1427	595	1296	4966	4549	1340	1248
45	55,000	0.9	.172		649	6279	3863	471	532	782	1438	1140	321	472	1399	1259	450	435
46			.173		687	7792	5105	469	574	961	2108	1670	320	605	2420	2246	765	735
47			.170		761	7832	5745	470	606	986	2025	1560	317	655	2493	2300	701	661
48			.168		797	5870	4028	480	550	762	1181	902	321	469	1134	986	308	290
49			.170		795	6170	4387	477	561	796	1302	991	322	500	1313	1152	349	326
50			.169		797	6540	4783	478	575	837	1429	1083	321	536	1547	1376	404	372
51			.171		798	6759	4987	478	584	864	1523	1155	326	567	1707	1535	452	415
52			.168		801	7246	5407	476	601	925	1766	1350	318	610	2064	1872	551	508
53			.170		833	7499	5720	472	610	959	1876	1431	318	654	2291	2092	606	546
54			.168		915	5160	3257	480	524	677	920.9	722	321	415	826	707	240	229
55			.168		1040	6777	5196	478	596	876	1530	1151	320	574	1724	1546	434	331

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TABLE II. - Continued. PERFORMANCE DATA OF ENGINE CONFIGURATION A

[AX 103/2 engine.]

Run	Exhaust or free-stream static pressure, p_0, lb/sq ft abs	Engine fuel flow, w_f, lb/sec	Engine-inlet air-flow, $w_{a,1}$, lb/sec	Corrected engine inlet high-pressure rotor speed, $N_{HP}/\sqrt{\theta_1}$, rpm	Corrected high-pressure rotor speed, $N_{HP}/\sqrt{\theta_2}$, rpm	Corrected low-pressure rotor speed, $N_{LP}/\sqrt{\theta_1}$, rpm	Corrected engine-inlet airflow, $w_{a,1}\sqrt{\theta_1}/\delta_1$, lb/sec	Corrected high-pressure compressor airflow, $w_{a,2-1}\sqrt{\theta_2}/\delta_2$, lb/sec	Scale jet thrust, $F_{j,s}$, lb	Scale net thrust, $F_{n,s}$, lb	Net specific fuel consumption, $w_f/F_{n,s}$, lb/(hr)(lb of thrust)	Velocity coefficient, C_V	Exhaust-nozzle flow coefficient, $C_{d,N}$	Over-all compressor efficiency, η_C	Low-pressure compressor efficiency, $\eta_{C,LP}$	High-pressure compressor efficiency, $\eta_{C,HP}$	Engine combustion efficiency, η_e	Over-all turbine efficiency, η_T
1	285	0.655	66.87	6875	6446	4333	214.71	145.83	4068	2007	1.175	0.976	0.957	0.811	1.00	0.785	0.967	0.887
2	308	.7580	73.99	7157	6620	4712	236.56	151.61	4519	2352	1.160	.970	.968	.800	.955	.767	.975	.895
3	289	.985	81.72	7514	6901	5007	261.80	159.59	5604	3145	1.128	.980	.959	.808	.973	.769	.966	.897
4	304	1.155	86.19	7729	7048	5181	274.88	164.43	6158	3613	1.151	.971	.960	.793	.937	.764	.975	.898
5	293	1.408	90.88	8094	7307	5537	290.47	170.47	7004	4273	1.186	.965	.960	.761	.895	.741	.987	.895
6	257	1.70	95.73	8582	7618	6120	302.35	172.57	8127	5022	1.219	.979	.950	.706	.798	.708	.994	.907
7	305	.711	74.25	7162	6568	4921	236.81	148.90	4382	2183	1.173	.978	.967	.786	.903	.766	.969	.892
8	302	.945	82.45	7539	6851	5240	267.54	158.12	5392	2964	1.148	.974	.963	.793	.923	.767	.964	.900
9	296	1.189	90.20	7857	7076	5585	287.91	164.41	6455	3749	1.142	.976	.957	.779	.899	.757	.974	.904
10	280	1.427	92.74	8208	7333	5897	298.39	170.51	7222	4369	1.176	.975	.956	.743	.838	.738	.987	.899
11	277	1.664	94.58	8569	7577	6235	303.34	172.77	7813	4880	1.228	.974	.955	.703	.777	.713	.984	.913
12	256	1.68	94.74	8579	7593	6222	303.45	171.98	8043	4969	1.219	.982	.958	.704	.789	.710	.988	.908
13	275	1.62	96.23	8504	7510	6318	304.48	171.37	7835	4824	1.207	.978	.955	.709	.788	.719	.981	.907
14	299	.713	74.44	7262	6578	5228	240.39	146.94	4369	2143	1.198	.982	.967	.770	.842	.768	.964	.891
15	289	.911	82.81	7571	6810	5480	266.10	154.21	5359	2831	1.158	.980	.971	.769	.868	.755	.971	.922
16	281	1.18	91.42	7925	7059	5903	294.54	163.50	6540	3719	1.146	.979	.965	.760	.856	.751	.979	.909
17	279	1.39	95.19	8211	7239	6290	304.99	168.76	7243	4281	1.167	.979	.971	.731	.770	.744	.991	.898
18	273	1.29	95.29	8097	7101	6351	304.67	164.63	6986	4000	1.160	.980	.975	.738	.795	.755	.984	.901
19	310	.800	74.69	7325	6765	4776	240.44	152.91	4696	2541	1.134	.981	.962	.797	.950	.762	.969	.898
20	303	1.014	82.02	7688	7041	5031	263.78	160.72	5633	3235	1.129	.976	.959	.792	.945	.759	.981	.896
21	303	1.231	86.18	7996	7281	5257	278.38	165.65	6353	3840	1.154	.975	.957	.777	.930	.746	.978	.898
22	306	1.463	90.38	8314	7511	5569	290.07	167.87	7108	4475	1.177	.976	.951	.752	.905	.698	.982	.899
23	293	1.679	93.24	8608	7709	5851	296.61	168.47	7746	4945	1.222	.981	.953	.723	.865	.704	.966	.908
24	311	.754	76.92	7322	6701	5001	246.62	152.35	4582	2362	1.149	.974	.967	.798	.913	.773	.971	.886
25	307	.944	83.17	7641	6937	5240	267.44	159.04	5416	3007	1.130	.975	.967	.785	.906	.765	.973	.904
26	307	1.179	89.00	7970	7181	5549	285.80	163.76	6339	3749	1.132	.979	.959	.773	.897	.751	.979	.904
27	298	1.403	92.55	8307	7419	5847	297.22	167.74	7073	4337	1.165	.977	.956	.743	.852	.733	.987	.899
28	298	1.594	94.48	8648	7629	6262	304.34	168.63	----	4481	1.281	-----	.951	.709	.788	.727	.973	.937
29	280	1.614	93.52	8636	7644	6170	301.64	167.45	7668	4794	1.212	.979	.950	.707	.813	.702	.980	.910
30	313	.679	75.68	7264	6582	5203	240.04	147.29	4208	2021	1.209	.973	.969	.773	.838	.816	.963	.895
31	302	.825	81.32	7521	6779	5417	259.45	151.79	4994	2608	1.139	.986	.966	.774	.870	.761	.962	.905
32	293	1.012	88.00	7792	6970	5670	279.69	157.96	5857	3216	1.133	.979	.969	.768	.864	.758	.975	.907
33	291	1.200	93.36	8065	7153	6009	297.78	162.90	----	3500	1.234	-----	.968	.753	.848	.747	.983	.907
34	292	1.402	95.80	8410	7390	6342	304.04	165.97	----	4017	1.256	-----	.961	.721	.793	.733	.980	.908
35	290	1.238	95.19	8115	7104	6404	305.29	162.06	----	3516	1.268	-----	.965	.751	.804	.766	.957	.903
36	310	1.542	87.85	8625	7785	5487	281.99	161.97	7092	4562	1.217	.971	.961	.720	.911	.677	.994	.905
37	315	1.559	87.65	8655	7796	5525	282.49	162.09	7132	4647	1.208	.977	.951	.718	.891	.687	.988	.907
38	313	1.525	88.82	8668	7777	5620	283.21	160.61	7080	4528	1.212	.972	.949	.708	.871	.680	.993	.907
39	316	.690	75.45	7351	6660	5198	242.67	148.29	4221	2080	1.194	.974	.968	.775	.845	.774	.966	.895
40	316	.846	82.18	7643	6826	5434	263.48	153.89	4990	2651	1.149	.973	.976	.768	.859	.758	.983	.899
41	316	1.065	88.18	8027	7141	5784	283.15	158.33	5864	3361	1.141	.977	.972	.753	.841	.749	.976	.906
42	313	1.241	91.20	8327	7360	6009	292.41	159.46	6449	3841	1.163	.976	.966	.732	.829	.727	.975	.902
43	311	1.433	94.13	8657	7560	6347	303.37	161.02	7046	4349	1.186	.975	.966	.702	.790	.705	.986	.905
44	311	1.292	93.85	8458	7353	6397	300.50	158.72	6614	3916	1.188	.968	.976	.710	.772	.728	.989	.906
45	191	.268	29.72	6591	6201	4055	186.92	134.93	1453	640	1.508	.934	.964	.786	.901	.768	.979	.874
46	192	.726	43.04	8197	7409	5370	270.22	158.35	3212	2040	1.280	.954	.962	.735	.889	.706	.988	.905
47	193	.694	45.06	8230	7248	6037	286.41	157.57	3158	1948	1.283	.959	.973	.720	.797	.726	.971	.901
48	195	.147	25.87	6104	5702	4188	163.95	120.31	805	100	5.291	.935	.950	.732	.784	.740	.966	.872
49	194	.193	28.56	6436	5934	4576	180.05	125.67	1058	277	2.501	.936	.945	.734	.763	.751	.998	.869
50	192	.264	32.35	6815	6213	4984	204.85	134.72	1388	498	1.907	.926	.971	.747	.777	.767	.978	.873
51	195	.322	35.05	7043	6372	5196	218.51	138.99	1655	690	1.678	.927	.976	.741	.773	.763	.978	.881
52	191	.467	39.70	7566	6734	5646	252.72	148.20	2293	1206	1.392	.936	.978	.738	.777	.759	1.002	.886
53	191	.558	43.16	7864	6917	5998	273.59	151.57	2665	1490	1.349	.942	.982	.724	.781	.740	1.005	.893
54	192	.082	20.58	5365	5135	3387	130.54	105.52	370.7	-196	-----	.897	.935	.750	.828	.741	.784	.826
55	190	.318	34.87	7062	6324	5414	221.23	137.82	1392	426	2.688	.906	.962	.732	.736	.775	.977	.877

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TABLE II. - Continued. PERFORMANCE DATA OF ENGINE CONFIGURATION A

[AX 103/2 engine.]

Run	Altitude, ft	Mach number, M_0	Reynolds number index, $\delta_1/\varphi_1\sqrt{\theta_1}$	Inlet guide vane angle, deg	Exhaust-nozzle area, A_N, sq in.	High-pressure rotor speed, N_{HP}, rpm	Low-pressure rotor speed, N_{LP}, rpm	Engine-inlet temperature, T_1, °R	Low-pressure compressor-outlet temperature, T_2, °R	High-pressure compressor-outlet temperature, T_3, °R	Turbine inlet temperature, T_4, °R	Exhaust-gas temperature, T_9, °R	Engine-inlet total pressure, P_1, lb/sq ft abs	Low-pressure compressor-outlet total pressure, P_2, lb/sq ft abs	High-pressure compressor-outlet total pressure, P_3, lb/sq ft abs	Turbine-inlet total pressure, P_4, lb/sq ft abs	Turbine-outlet total pressure, P_6, lb/sq ft abs	Exhaust-nozzle inlet total pressure, P_9, lb/sq ft abs
56	58,000	0.9	0.169	-5	649	6647	4275	422	492	794	1706	1360	273	463	1765	1624	584	564
57			.170		679	6308	4179	422	490	754	1459	1142	274	449	1490	1351	456	437
58			.172		678	6436	4277	421	492	768	1521	1192	277	464	1595	1456	493	472
59			.170		678	6606	4351	425	500	786	1586	1246	277	474	1697	1553	527	505
60			.172		679	6614	4420	420	495	789	1609	1264	276	479	1750	1602	542	520
61			.173		681	6745	4529	420	498	804	1676	1319	278	496	1877	1724	585	561
62			.173		680	6876	4669	419	500	825	1777	1404	276	510	2012	1855	633	608
63			.171		701	6246	4234	426	497	753	1410	1096	280	558	1454	1315	430	410
64			.172		699	6377	4295	425	499	761	1436	1113	280	466	1532	1389	454	433
65			.169		704	7037	5045	422	516	849	1787	1394	273	533	2157	1987	651	622
66			.172		718	6724	4633	421	506	802	1601	1242	277	498	1777	1624	527	502
67			.173		721	6784	4779	420	511	816	1642	1272	277	515	1879	1717	550	524
68			.172		722	6920	4904	420	514	834	1719	1336	275	525	1986	1823	588	559
69			.172		719	7045	4973	421	517	843	1754	1364	276	531	2068	1899	614	586
70			.173		718	7090	5135	418	518	858	1827	1423	276	543	2179	2007	650	621
71			.172		717	7330	5256	422	527	883	1913	1497	277	553	2265	2093	682	651
72			.172		758	6437	4672	421	511	776	1449	1109	276	487	1574	1420	431	406
73			.173		757	6618	4813	420	511	798	1532	1173	278	506	1708	1548	473	444
74			.173		758	6760	4949	420	521	818	1599	1224	277	523	1817	1659	507	476
75			.170		751	6833	5017	423	523	828	1636	1257	274	531	1904	1744	534	503
76			.172		758	6914	5105	420	525	837	1675	1287	275	541	1955	1792	551	518
77			.172		759	7130	5362	419	534	869	1794	1382	275	565	2177	2000	613	577
78			.173		763	7323	5725	419	545	905	1924	1483	276	583	2378	2189	673	635
79			.172		752	7496	5728	422	546	916	1972	1527	276	581	2409	2223	692	654
80			.173	0	680	6424	4234	422	493	763	1499	1175	278	462	1562	1425	483	463
81			.174		680	6600	4358	421	496	782	1567	1227	280	480	1710	1567	531	509
82			.173		680	6814	4528	420	500	806	1675	1317	277	494	1867	1717	585	561
83			.172		680	7024	4720	420	506	833	1797	1417	275	509	2019	1866	638	613
84			.172		681	7140	4831	420	509	848	1846	1455	275	519	2114	1957	664	638
85			.173		718	6792	4707	420	508	808	1631	1267	277	510	1854	1700	551	525
86			.173		720	7218	5180	419	520	865	1848	1440	276	548	2213	2040	658	628
87			.173		718	7010	4902	419	513	835	1731	1348	277	529	2030	1865	607	579
88			.173		722	7414	5372	419	527	892	1952	1527	276	555	2314	2142	695	663
89			.177		759	6618	4825	420	514	791	1500	1148	279	507	1702	1549	468	439
90			.174		755	6813	4982	419	518	818	1601	1226	277	531	1869	1707	523	491
91			.173		757	7046	5206	418	526	849	1719	1320	276	553	2049	1880	577	543
92			.174		762	7270	5511	417	536	881	1833	1409	276	575	2248	2065	633	596
93			.173		759	7453	5727	418	543	906	1935	1494	276	583	2374	2189	674	637
94			.170	5	650	6440	4045	426	489	756	1503	1189	277	444	1516	1383	489	471
95			.173		676	6350	4086	421	489	748	1453	1140	277	442	1428	1296	440	423
96			.172		681	6500	4234	422	494	765	1500	1174	277	461	1555	1417	478	458
97			.171		680	6693	4371	423	498	784	1577	1238	276	474	1683	1542	522	501
98			.171		682	6887	4485	422	501	806	1667	1309	276	488	1809	1664	566	543
99			.172		681	7116	4641	422	507	831	1776	1400	277	504	1952	1802	615	591
100			.171		718	6804	4634	422	508	800	1589	1233	276	497	1750	1602	520	495
101			.172		721	7344	5078	421	523	867	1844	1438	276	540	2107	1945	629	600
102			.171		726	7593	5288	421	531	897	1961	1532	275	557	2245	2075	671	641
103			.174		719	7794	5418	421	536	921	2063	1618	280	570	2348	2179	710	679
104			.169		727	7840	5541	423	542	929	2061	1612	273	572	2366	2189	707	674
105			.172		758	6889	4916	422	517	820	1607	1235	277	522	1822	1664	511	481
106			.172		755	7089	5133	420	527	845	1691	1296	276	545	1987	1823	558	524
107			.172		757	7301	5311	420	535	870	1787	1373	276	563	2118	1947	597	563
108			.171		758	7480	5502	421	541	895	1879	1448	275	577	2241	2065	633	596
109			.172		762	7780	5756	420	553	929	2011	1555	275	596	2378	2201	677	638
110			.173		754	7790	5673	421	548	929	2030	1575	278	592	2384	2204	689	652
111			.174		777	7666	5743	420	553	919	1949	1500	278	605	2361	2174	653	613

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TABLE II. - Concluded. PERFORMANCE DATA OF ENGINE CONFIGURATION A
[AX 103/2 engine.]

Run	Exhaust or free-stream static pressure, p_0, lb/sq ft abs	Engine fuel flow, w_f, lb/sec	Engine-inlet air-flow, $w_{a,1}$, lb/sec	Corrected engine inlet high-pressure rotor speed, $N_{HP}/\sqrt{\theta_1}$, rpm	Corrected high-pressure rotor speed, $N_{HP}/\sqrt{\theta_2}$, rpm	Corrected low-pressure rotor speed, $N_{LP}/\sqrt{\theta_1}$, rpm	Corrected engine-inlet airflow, $w_{a,1}\sqrt{\theta_1}/\delta_1$, lb/sec	Corrected high-pressure compressor airflow, $w_{a,2-1}\sqrt{\theta_2}/\delta_2$, lb/sec	Scale jet thrust, $F_{j,s}$, lb	Scale net thrust, $F_{n,s}$, lb	Net specific fuel consumption, $w_f/F_{n,s}$, lb/(hr)(lb of thrust)	Velocity coefficient, C_V	Exhaust-nozzle flow coefficient, $C_{d,N}$	Over-all compressor efficiency, η_C	Low-pressure compressor efficiency, $\eta_{C,LP}$	High-pressure compressor efficiency, $\eta_{C,HP}$	Engine combustion efficiency, η_e	Over-all turbine efficiency, η_T
56	161	0.457	34.36	7372	6827	4741	240.56	152.96	2309	1411	1.166	0.983	0.947	0.793	0.988	0.753	0.947	0.890
57	166	.314	30.90	6996	6492	4634	214.95	141.57	1697	905	1.248	.974	.956	.785	.941	.754	.935	.884
58	165	.354	32.70	7146	6610	4749	225.33	145.36	1889	1042	1.222	.969	.959	.782	.944	.750	.944	.885
59	169	.393	34.37	7300	6731	4809	237.86	150.88	2080	1206	1.172	.976	.964	.793	.945	.763	.956	.887
60	163	.415	35.04	7352	6772	4913	242.12	151.15	2138	1227	1.218	.955	.963	.787	.960	.748	.949	.886
61	162	.468	37.01	7498	6886	5035	253.57	154.83	2407	1431	1.177	.970	.960	.787	.969	.734	.951	.888
62	164	.532	38.98	7675	7026	5197	268.15	158.86	2648	1638	1.169	.961	.967	.782	.992	.732	.974	.889
63	166	.290	30.71	6894	6383	4673	210.46	138.89	1640	836.4	1.249	.997	.957	.779	.907	.755	.932	.869
64	166	.311	32.58	7047	6503	4746	223.13	145.10	1742	890	1.258	.965	.975	.785	.906	.767	.949	.881
65	163	.577	40.79	7804	7057	5595	285.22	161.56	2862	1808	1.150	.988	.953	.789	.947	.753	.926	.899
66	164	.410	36.12	7465	6810	5144	248.87	151.76	2207	1267	1.162	.979	.962	.769	.907	.743	.963	.893
67	172	.445	37.38	7541	6837	5312	257.26	152.33	2275	1345	1.191	.964	.963	.766	.897	.742	.955	.893
68	168	.498	39.00	7692	6953	5451	269.53	156.55	2506	1519	1.181	.964	.963	.763	.903	.735	.961	.894
69	162	.529	40.21	7822	7058	5522	277.63	160.02	2716	1659	1.149	.977	.965	.769	.903	.744	.963	.896
70	170	.586	41.52	7901	7097	5721	286.19	161.94	2837	1798	1.174	.963	.963	.757	.896	.734	.962	.899
71	163	.636	42.35	8129	7274	5829	292.26	163.44	3076	1964	1.166	.973	.964	.747	.879	.725	.974	.893
72	167	.313	32.73	7147	6487	5187	225.69	141.38	1691	852	1.323	.965	.962	.757	.821	.762	.947	.875
73	166	.364	34.98	7357	6669	5350	239.94	145.34	1943	1041	1.258	.965	.968	.750	.864	.733	.959	.888
74	165	.409	36.69	7514	6747	5501	252.05	148.76	2149	1201	1.227	.967	.967	.744	.821	.743	.958	.892
75	169	.444	37.57	7569	6807	5557	261.53	150.51	2292	1343	1.190	.980	.960	.764	.879	.748	.939	.889
76	166	.468	38.59	7686	6874	5674	267.22	152.01	2391	1404	1.201	.967	.963	.750	.854	.739	.954	.892
77	166	.558	41.72	7935	7029	5968	288.34	158.38	2767	1699	1.184	.963	.969	.744	.870	.740	.969	.892
78	166	.659	44.20	8150	7146	6372	304.04	164.82	3122	1989	1.193	.963	.965	.724	.788	.738	.970	.900
79	169	.687	44.08	8313	7308	6352	304.30	164.75	3213	2094	1.182	.974	.963	.723	.805	.729	.968	.896
80	165	.340	32.79	7124	6591	4696	224.85	146.51	1841	986	1.240	.956	.970	.783	.929	.755	.962	.883
81	165	.395	34.82	7328	6751	4839	237.00	150.13	2078	1168	1.217	.960	.959	.784	.936	.753	.943	.893
82	167	.467	36.95	7574	6942	5033	254.30	155.38	2354	1409	1.192	.958	.962	.785	.950	.749	.952	.892
83	166	.546	38.79	7808	7114	5246	268.09	159.46	2640	1647	1.195	.959	.959	.773	.937	.739	.956	.896
84	167	.584	40.04	7937	7210	5370	277.17	161.87	2800	1780	1.181	.962	.964	.769	.940	.735	.962	.897
85	167	.438	37.39	7551	6865	5233	256.85	153.66	2274	1316	1.198	.956	.962	.774	.907	.748	.964	.892
86	167	.600	41.88	8033	7212	5765	288.61	162.06	2871	1803	1.198	.953	.964	.756	.899	.730	.965	.895
87	168	.516	39.72	7802	7051	5456	272.84	158.09	2589	1580	1.175	.962	.958	.766	.909	.739	.961	.894
88	166	.666	42.83	8252	7362	5979	295.34	164.51	3112	2018	1.189	.964	.961	.734	.859	.717	.972	.892
89	165	.359	35.47	7357	6650	5364	238.81	147.32	1920	984	1.315	.953	.976	.763	.812	.759	.949	.878
90	167	.423	37.62	7582	6820	5545	258.11	149.99	2211	1251	1.218	.962	.967	.755	.950	.740	.954	.891
91	167	.503	40.19	7852	6999	5801	276.83	154.88	2555	1534	1.180	.966	.970	.744	.853	.730	.967	.896
92	165	.592	42.75	8110	7154	6149	294.01	160.07	2907	1809	1.178	.967	.968	.731	.819	.730	.967	.899
93	168	.667	44.16	8305	7287	6381	304.16	163.98	3134	2019	1.189	.966	.970	.720	.796	.723	.969	.896
94	166	.337	31.13	7108	6634	4465	215.74	144.07	1813	1005	1.206	.980	.953	.801	.981	.766	.934	.885
95	168	.292	30.47	7050	6542	4537	209.40	141.62	1602	823	1.279	.953	.977	.764	.896	.747	.988	.874
96	169	.334	32.43	7209	6663	4696	223.60	145.43	1794	969	1.241	.954	.969	.780	.918	.753	.966	.885
97	166	.389	34.13	7414	6833	4842	236.17	149.43	2037	1159	1.208	.963	.960	.786	.944	.755	.950	.889
98	168	.444	35.93	7638	7038	4974	248.51	154.00	2254	1339	1.194	.959	.958	.775	.945	.740	.960	.893
99	168	.516	37.64	7892	7200	5146	259.75	156.23	2519	1558	1.193	.962	.957	.765	.935	.732	.961	.894
100	169	.400	35.56	7546	6878	5139	245.54	149.80	2104	1204	1.196	.966	.957	.771	.906	.765	.958	.894
101	167	.569	40.12	8154	7316	5638	277.42	157.84	2739	1716	1.193	.962	.964	.738	.876	.714	.972	.892
102	166	.646	41.36	8430	7507	5872	286.24	159.03	2981	1922	1.211	.963	.957	.718	.855	.700	.971	.896
103	169	.720	42.23	8653	7670	6016	287.42	159.43	3196	2113	1.227	.971	.961	.696	.825	.682	.966	.903
104	166	.727	42.23	8673	7668	6137	296.03	159.75	3221	2147	1.219	.979	.953	.706	.840	.690	.950	.907
105	166	.408	36.76	7640	6902	5452	252.95	148.79	2170	1220	1.205	.968	.965	.750	.880	.726	.973	.887
106	166	.475	39.28	7880	7035	5706	271.32	153.81	2436	1431	1.195	.961	.975	.743	.844	.734	.970	.899
107	166	.540	40.94	8116	7191	5904	282.65	156.42	2659	1608	1.208	.954	.974	.730	.827	.726	.973	.901
108	167	.606	41.96	8305	7326	6110	290.77	157.18	2883	1813	1.203	.966	.969	.722	.828	.714	.964	.898
109	167	.696	43.18	8648	7537	6399	298.88	158.31	3153	2051	1.222	.970	.963	.695	.781	.701	.963	.895
110	164	.706	43.07	8649	7581	6298	295.17	158.45	3209	2083	1.221	.973	.958	.695	.797	.692	.966	.907
111	158	.656	43.52	8522	7427	6384	297.98	157.22	3116	1944	1.215	.966	.973	.702	.785	.708	.975	.890

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TABLE III. - PERFORMANCE DATA OF ENGINE CONFIGURATION B

[AX 102/3C engine.]

Run	Altitude, ft	Mach number, M_0	Reynolds number index, $\delta_1/\varphi_1\sqrt{\theta_1}$	Inlet guide vane angle, deg	Exhaust-nozzle area, A_N, sq in.	High-pressure rotor speed, N_{HP}, rpm	Low-pressure rotor speed, N_{LP}, rpm	Engine-inlet temperature, T_1, °R	Low-pressure compressor-outlet temperature, T_2, °R	High-pressure compressor-outlet temperature, T_3, °R	Turbine inlet temperature, T_4, °R	Exhaust-gas temperature, T_9, °R	Engine-inlet total pressure, P_1, $\frac{lb}{sq\ ft}$ abs	Low-pressure compressor-outlet total pressure, P_2, $\frac{lb}{sq\ ft}$ abs	High-pressure compressor-outlet total pressure, P_3, $\frac{lb}{sq\ ft}$ abs	Turbine-inlet total pressure, P_4, $\frac{lb}{sq\ ft}$ abs	Turbine-outlet total pressure, P_6, $\frac{lb}{sq\ ft}$ abs	Exhaust-nozzle inlet total pressure, P_9, $\frac{lb}{sq\ ft}$ abs
1	14,000	0.9	0.989	0	649	5779	3363	510	557	762	1236	986	2047	2731	6,509	5,828	2218	2145
2			.983		649	6179	3721	515	571	811	1406	1111	2060	2906	7,837	7,032	2612	2522
3			1.007		649	6987	4379	505	582	898	1831	1449	2056	3287	11,602	10,660	3961	3811
4			.972		650	6991	4342	518	592	904	1814	1436	2051	3224	11,048	10,126	3767	3623
5			.999		651	7313	4629	507	592	938	1999	1590	2051	3426	12,953	11,981	4423	4256
6			.993		677	5819	3502	509	560	767	1209	956	2049	2793	6,633	5,897	2134	2053
7			1.003		676	6273	3970	505	571	818	1404	1097	2048	3043	8,438	7,593	2633	2508
8			1.000		680	6586	4231	508	581	855	1535	1195	2058	3193	9,651	8,692	3028	2889
9			.989		677	6993	4551	512	596	909	1754	1370	2057	3393	11,483	10,503	3624	3462
10			.994		679	7398	4860	509	604	956	1966	1543	2050	3589	13,548	12,292	4334	4141
11			1.009		678	7577	4967	503	606	974	2077	1634	2050	3689	14,645	13,137	4650	4451
12			.981		716	5839	3591	514	570	775	1191	925	2049	2829	6,562	5,791	2013	1926
13			.981		716	6636	4419	516	598	869	1519	1168	2060	3284	9,533	8,518	2832	2678
14			.977		719	7158	4896	516	617	941	1798	1387	2053	3611	12,171	11,065	3653	3454
15			.900		721	7765	5370	549	669	1048	2112	1645	2047	3820	14,134	12,979	4288	4059
16	24,500		.639		649	5786	3388	507	555	764	1254	999	1312	1760	4,172	3,819	1446	1397
17			.650		649	6373	3907	502	564	826	1520	1208	1317	1945	5,810	5,216	1927	1856
18			.649		649	6895	4285	501	577	888	1799	1439	1312	2076	7,236	6,607	2463	2372
19			.652		649	7424	4668	502	589	951	2108	1693	1321	2247	9,026	8,318	3118	3013
20			.646		681	5810	3525	501	553	761	1217	957	1307	1802	4,362	3,852	1380	1325
21			.653		679	6509	4183	501	573	841	1509	1186	1320	2049	6,157	5,518	1909	1822
22			.656		677	7075	4624	498	586	909	1812	1429	1316	2244	7,978	7,272	2538	2424
23			.659		681	7709	5099	497	604	985	2154	1706	1318	2445	10,072	9,267	3266	3129
24			.657		719	5793	3618	500	555	763	1192	927	1325	1849	4,379	3,854	1330	1269
25			.656		714	6484	4323	499	577	840	1469	1135	1320	2091	6,033	5,372	1773	1679
26			.658		718	7091	4847	497	596	916	1756	1365	1317	2338	8,008	7,245	2404	2269
27			.657		719	7779	5469	497	620	1007	2135	1675	1314	2585	10,494	9,614	3194	3030
28			.649		758	6595	4655	503	596	865	1487	1134	1318	2158	6,170	5,498	1718	1586
29			.648		756	6998	4994	503	608	911	1651	1262	1317	2332	7,409	6,688	2075	1936
30			.652		760	7385	5336	501	620	964	1856	1430	1318	2548	8,888	8,076	2529	2362
31			.655		762	7718	5730	498	634	1010	2065	1590	1313	2726	10,442	9,537	3000	2803
32	42,000		.366	-5	649	5846	3621	426	479	704	1311	1040	597	885	2,609	2,358	861	829
33			.365		649	6126	3850	426	485	736	1436	1140	597	929	3,011	2,739	992	954
34			.365		649	6426	4081	426	491	770	1595	1269	596	977	3,498	3,213	1166	1121
35			.367		649	6725	4300	424	498	806	1763	1408	595	1028	4,000	3,691	1352	1304
36			.365		649	6949	4472	425	503	835	1908	1527	595	822	4,386	4,061	1498	1446
37			.364		678	5820	3715	427	483	704	1257	983	596	894	2,517	2,266	791	756
38			.367		679	6299	4147	426	494	756	1454	1139	599	994	3,265	2,969	1018	971
39			.367		683	6805	4569	424	507	820	1724	1356	595	1085	4,192	3,860	1324	1264
40			.371		680	7195	4954	420	513	867	1959	1556	595	1131	4,905	4,531	1581	1516
41			.364		681	7473	5171	427	527	909	2117	1689	595	1145	5,173	4,810	1683	1618
42			.363		715	5798	3844	429	490	704	1209	938	598	908	2,433	2,182	721	683
43			.367		717	6414	4404	427	507	777	1475	1141	602	1039	3,374	3,066	996	939
44			.368		720	6910	4870	423	518	840	1736	1348	594	1155	4,396	4,039	1322	1249
45			.365		720	7377	5432	425	536	909	2026	1590	594	1185	5,170	4,788	1574	1497
46			.369		721	7596	5610	424	541	937	2139	1687	599	1202	5,401	5,028	1661	1582
47			.365		729	7620	5695	426	549	942	2141	1685	595	1202	5,381	4,988	1629	1548
48			.368		757	6818	4938	427	527	833	1636	1255	603	1159	4,004	3,665	1140	1064
49			.368		760	7006	5157	426	532	858	1730	1331	600	1219	4,435	4,072	1262	1177
50			.372		760	7206	5541	422	542	893	1875	1446	600	1265	5,076	4,681	1457	1361
51			.371		758	7363	5745	422	547	917	1978	1533	598	1252	5,238	4,837	1512	1419
52			.366	0	649	5799	3559	426	478	694	1260	996	598	875	2,524	2,273	828	798
53			.366		649	5834	3605	426	479	700	1290	1022	597	881	2,585	2,334	848	816
54			.366		649	6183	3848	425	484	737	1459	1160	595	928	3,059	2,786	1018	979
55			.367		649	6627	4207	425	495	788	1676	1334	597	1006	3,792	3,489	1268	1221
56			.368		649	6902	4388	424	500	819	1828	1464	597	1042	4,227	3,916	1442	1392

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TABLE III. - Continued. PERFORMANCE DATA OF ENGINE CONFIGURATION B

[AX 102/3C engine.]

Run	Exhaust or free-stream static pressure, p_0, lb/sq ft abs	Engine fuel flow, w_f, lb/sec	Engine-inlet airflow, $w_{a,1}$, lb/sec	Corrected engine-inlet high-pressure rotor speed, $N_{HP}/\sqrt{\theta_1}$, rpm	Corrected high-pressure rotor speed, $N_{HP}/\sqrt{\theta_2}$, rpm	Corrected low-pressure rotor speed, $N_{LP}/\sqrt{\theta_1}$, rpm	Corrected engine-inlet airflow, $w_{a,1}\sqrt{\theta_1}/\delta_1$, lb/sec	Corrected high-pressure compressor airflow, $w_{a,2-1}\sqrt{\theta_2}/\delta_2$, lb/sec	Scale jet thrust, $F_{j,s}$, lb	Scale net thrust, $F_{n,s}$, lb	Net specific fuel consumption, $w_f/F_{n,s}$, lb/(hr)(lb of thrust)	Velocity coefficient, C_V	Exhaust-nozzle flow coefficient, $C_{d,N}$	Over-all compressor efficiency, η_C	Low-pressure compressor efficiency, $\eta_{C,LP}$	High-pressure compressor efficiency, $\eta_{C,HP}$	Engine combustion efficiency, η_e	Over-all turbine efficiency, η_T
1	1216	0.931	150.42	5830	5578	3392	154.15	118.63	6,024	1,720	1.949	0.974	0.918	0.793	0.930	0.760	1.000	0.882
2	1209	1.338	168.44	6203	5891	3735	172.38	128.03	8,125	3,233	1.490	.979	.929	.806	.950	.773	1.000	.914
3	1234	2.880	223.64	7083	6598	4440	227.05	154.05	14,878	8,572	1.210	.979	.943	.813	.940	.787	1.005	.952
4	1232	2.676	212.57	6997	6544	4446	219.05	148.88	13,852	7,785	1.238	.981	.938	.822	.963	.789	.998	.950
5	1241	3.535	240.76	7399	6848	4684	245.51	160.55	17,420	10,666	1.193	.980	.954	.806	.940	.777	1.020	.940
6	1227	.888	153.12	5876	5602	3536	156.57	121.18	5,808	1,463	2.185	.980	.928	.784	.922	.752	1.000	.871
7	1212	1.416	180.96	6360	5981	4025	184.42	132.99	8,569	3,400	1.499	.972	.957	.800	-----	-----	1.000	.897
8	1242	1.852	199.04	6657	6225	4276	202.47	140.71	10,616	5,012	1.330	.980	.953	.807	.930	.778	.986	.926
9	1237	2.598	223.84	7040	6526	4582	228.74	150.95	14,001	7,655	1.222	.984	.966	.811	.936	.782	1.002	.928
10	1245	3.543	250.91	7471	6859	4908	256.51	161.17	17,780	10,752	1.186	.984	.964	.800	.929	.776	1.010	.946
11	1239	4.015	261.57	7697	7015	5045	265.81	163.83	19,177	11,862	1.219	.966	.965	.789	-----	-----	1.025	.953
12	1223	.810	151.01	5867	5571	3608	155.18	119.54	5,344	1,024	2.848	.986	.921	.772	.885	.749	.995	.895
13	1233	1.700	196.73	6656	6182	4432	201.52	137.68	9,926	4,305	1.422	.975	.950	.793	.895	.776	1.003	.924
14	1224	2.750	235.97	7178	6565	4911	242.55	152.38	14,790	9,123	1.085	.976	.968	.796	.893	.775	1.019	.940
15	1251	-----	253.40	7550	6839	5221	269.40	160.91	18,331	11,002	-----	.982	.964	.791	.889	.779	-----	.930
16	794	.626	95.91	5854	5595	3428	152.84	119.58	3,903	1,211	1.861	.984	.905	.769	.923	.736	.988	.884
17	805	1.132	118.29	6480	6113	3973	186.91	134.66	6,347	3,075	1.325	.984	.928	.814	.952	.783	.982	.896
18	811	1.765	137.71	7018	6539	4362	218.21	148.37	8,983	5,219	1.217	.982	.929	.807	.923	.784	.994	.915
19	812	2.647	160.29	7549	6969	4747	252.61	161.93	12,346	7,939	1.200	.986	.931	.811	.945	.778	1.003	.934
20	802	.586	98.39	5915	5629	3588	156.56	119.78	3,703	995	2.121	.983	.922	.790	.926	.759	1.000	.882
21	800	1.159	126.18	6625	6195	4258	198.76	137.02	6,623	3,109	1.342	.979	.955	.807	.930	.780	.990	.883
22	815	1.916	151.81	7222	6658	4721	239.03	152.61	9,839	5,707	1.209	.974	.958	.809	.930	.781	1.001	.911
23	810	2.942	177.29	7879	7146	5211	278.48	166.70	13,813	8,960	1.182	.983	.950	.795	.895	.773	1.015	.934
24	806	.552	101.27	5902	5602	3687	158.76	120.73	3,539	3,638	2.718	.973	.933	.771	.907	.740	1.020	.885
25	796	1.054	125.97	6612	6149	4409	198.05	135.32	6,171	6,321	1.430	.976	.960	.795	.898	.766	1.006	.898
26	840	1.810	155.01	7246	6617	4954	243.72	150.73	9,426	5,337	1.221	.972	.961	.793	.893	.773	1.004	.915
27	802	3.002	185.60	7949	7117	5589	292.45	166.63	14,231	14,488	1.186	.982	.962	.780	.860	.771	1.012	.913
28	798	1.066	128.28	6699	6154	4729	202.71	135.58	6,099	6,194	1.525	.985	.974	.769	.817	.765	1.006	.901
29	805	1.512	145.94	7108	6465	5074	230.77	143.97	8,169	8,315	1.318	.982	.965	.782	.848	.773	.981	.911
30	806	2.111	167.16	7517	6757	5432	263.64	151.95	10,896	11,071	1.210	.984	.965	.775	.870	.757	1.000	.911
31	802	2.804	187.61	7879	6983	5850	296.25	162.25	13,626	13,932	1.193	.978	.964	.779	.848	.771	1.007	.931
32	361	.472	57.25	6452	6084	3996	183.83	131.76	2,826	2,873	1.258	.980	.928	.801	.959	.769	.975	.878
33	359	.614	63.40	6761	6337	4250	203.75	139.73	3,495	3,585	1.190	.975	.939	.805	.976	.768	.972	.881
34	357	.810	70.82	7093	6607	4505	227.75	149.48	4,390	4,518	1.144	.972	.945	.812	.996	.768	.983	.895
35	356	1.045	77.36	7441	6866	4757	248.59	156.27	5,312	5,465	1.138	.972	.940	.799	.970	.760	.984	.901
36	361	1.242	82.26	7679	7058	4942	264.91	162.87	6,043	6,133	1.137	.974	.940	.795	.976	.752	.996	.911
37	364	.424	56.83	6416	6032	4096	183.08	130.11	2,553	2,624	1.385	.973	.940	.783	.941	.750	.972	.881
38	365	.662	68.66	6953	6456	4578	219.78	142.68	3,782	3,884	1.176	.974	.955	.802	.977	.758	.975	.884
39	356	1.046	81.87	7529	6885	5055	263.24	158.00	5,414	5,617	1.109	.982	.955	.795	.959	.756	.980	.900
40	356	1.411	91.19	7998	7237	5507	291.84	169.79	6,845	6,962	1.131	.971	.959	.772	-----	.744	1.005	.896
41	352	1.614	92.48	8239	7416	5701	298.12	172.44	7,434	7,484	1.162	.979	.950	.751	-----	.732	1.002	.902
42	359	.371	55.83	6378	5967	4228	179.54	126.53	2,329	2,373	1.524	.982	.944	.767	.893	.742	.998	.864
43	353	.657	70.68	7068	6491	4853	225.51	142.46	3,909	4,002	1.161	.977	.963	.773	.903	.745	1.014	.886
44	353	1.062	85.61	7656	6917	5396	275.23	156.98	5,920	5,849	1.096	.978	.956	.778	-----	.740	1.002	.910
45	358	1.504	93.91	8152	7259	6002	302.63	170.75	7,161	7,321	1.142	.978	.958	.745	.835	.742	1.000	.897
46	360	1.671	95.77	8401	7440	6205	305.84	172.09	7,584	7,793	1.177	.973	.953	.715	.800	.720	1.004	.900
47	357	1.656	95.45	8411	7409	6286	307.42	172.91	7,542	7,618	1.177	.976	.957	.716	.772	.733	1.006	.902
48	366	.895	80.50	7513	6766	5442	256.22	148.36	4,847	4,965	1.158	.976	.965	.750	.878	.723	.993	.903
49	362	1.027	86.60	7735	6920	5693	276.63	152.31	5,594	5,727	1.101	.977	.964	.755	.904	.719	1.024	.897
50	357	1.311	95.41	7991	7052	6145	303.26	163.32	6,761	6,908	1.103	.979	.962	.747	.835	.741	1.010	.905
51	358	1.376	96.76	8166	7172	6371	308.83	167.94	7,106	7,293	1.076	.974	.968	.726	.796	.735	1.068	.900
52	356	.436	56.76	6401	6042	3929	182.03	132.00	2,699	2,759	1.290	.978	.935	.807	.944	.780	.969	.880
53	355	.461	57.14	6439	6072	3979	183.54	131.95	2,806	2,850	1.260	.985	.932	.807	.950	.778	.967	.873
54	357	.639	64.31	6833	6402	4252	207.05	141.84	3,630	3,720	1.170	.976	.936	.810	-----	.772	.977	.892
55	357	.930	75.06	7324	6786	4649	240.65	154.62	4,914	5,053	1.131	.973	.945	.811	.977	.773	.984	.901
56	360	1.170	80.84	7636	7032	4855	258.93	161.39	5,775	5,913	1.140	.977	.940	.800	.964	.763	.975	.904

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TABLE III. - Continued. PERFORMANCE DATA OF ENGINE CONFIGURATION B

[AX 102/3C engine.]

Run	Altitude, ft	Mach number, M_0	Reynolds number index, $\delta_1/\varphi_1\sqrt{\theta_1}$	Inlet guide vane angle, deg	Exhaust-nozzle area, A_N, sq in.	High-pressure rotor speed, N_{HP}, rpm	Low-pressure rotor speed, N_{LP}, rpm	Engine-inlet temperature, T_1, $^{\circ}R$	Low-pressure compressor-outlet temperature, T_2, $^{\circ}R$	High-pressure compressor-outlet temperature, T_3, $^{\circ}R$	Turbine inlet temperature, T_4, $^{\circ}R$	Exhaust-gas temperature, T_9, $^{\circ}R$	Engine-inlet total pressure, P_1, $\frac{lb}{sq\ ft}$ abs	Low-pressure compressor-outlet total pressure, P_2, $\frac{lb}{sq\ ft}$ abs	High-pressure compressor-outlet total pressure, P_3, $\frac{lb}{sq\ ft}$ abs	Turbine-inlet total pressure, P_4, $\frac{lb}{sq\ ft}$ abs	Turbine-outlet total pressure, P_6, $\frac{lb}{sq\ ft}$ abs	Exhaust-nozzle inlet total pressure, P_9, $\frac{lb}{sq\ ft}$ abs
57	42,000	0.9	0.367	0	677	5818	3695	426	482	695	1225	959	599	898	2529	2269	786	752
58			.369		680	6305	4141	423	491	750	1444	1126	596	987	3270	2974	1008	960
59			.367		681	6812	4529	423	505	813	1700	1337	594	1080	4137	3803	1309	1250
60			.364		679	7318	4937	426	520	877	1983	1577	594	1128	4864	4516	1575	1512
61			.365		681	7568	5151	426	526	909	2118	1689	596	1152	5161	4807	1679	1614
62			.353		718	5830	3844	440	503	716	1203	930	602	907	2411	2154	710	672
63			.360		717	6403	4386	431	509	774	1446	1118	597	1025	3295	2985	968	914
64			.365		718	6913	4834	426	520	833	1702	1325	595	1143	4309	3959	1291	1221
65			.368		721	7393	5346	422	532	897	1976	1548	593	1185	5065	4686	1543	1467
66			.366		719	7704	5553	425	542	937	2143	1690	596	1203	5326	4938	1639	1562
67			.366		726	7723	5660	424	545	943	2153	1694	594	1214	5363	4989	1630	1550
68			.365		738	7731	5733	426	549	945	2132	1671	596	1229	5376	4992	1612	1527
69			.361		753	6406	4557	435	523	784	1424	1089	606	1046	3204	2890	901	840
70			.365		757	6756	4914	430	529	827	1594	1221	603	1148	3918	3574	1104	1029
71			.368		763	7047	5215	425	534	858	1727	1327	599	1228	4584	4207	1295	1210
72			.373		758	7240	5520	420	538	885	1857	1433	597	1257	5054	4653	1442	1352
73			.374		760	7445	5730	419	543	910	1962	1519	597	1254	5264	4854	1510	1416
74			.365	5	649	5818	3551	426	476	691	1250	990	595	872	2521	2271	822	791
75			.366		649	6161	3824	426	484	727	1399	1109	597	927	2983	2711	984	946
76			.372		649	6235	3856	426	485	735	1439	1143	607	948	3099	2843	1031	991
77			.367		649	6447	4031	425	489	760	1551	1234	598	965	3421	3137	1136	1092
78			.369		649	6714	4204	423	492	788	1689	1348	597	1011	3830	3526	1291	1243
79			.369		650	7005	4398	422	499	821	1842	1476	595	1043	4262	3946	1444	1395
80			.371		652	7197	4537	422	502	840	1932	1552	598	1078	4519	4192	1535	1481
81			.362		679	5843	3711	429	484	698	1209	944	597	894	2483	2223	765	731
82			.364		678	6508	4235	429	501	772	1504	1176	600	1011	3439	3134	1076	1025
83			.364		680	7188	4698	428	514	847	1829	1445	598	1113	4448	4094	1429	1369
84			.365		682	7750	5109	427	528	914	2134	1702	598	1183	5066	4727	1650	1582
85			.369		718	5814	3840	423	483	692	1164	898	597	918	2504	2238	731	691
86			.362		720	6403	4346	428	505	764	1413	1090	594	1025	3288	2977	961	907
87			.362		720	6910	4734	427	517	821	1643	1275	593	1118	4109	3767	1230	1162
88			.364		718	7374	5120	425	528	875	1888	1476	593	1189	4802	4435	1457	1382
89			.369		721	7803	5472	423	540	931	2120	1668	597	1243	5313	4937	1636	1556
90			.365		755	6292	4436	428	511	759	1353	1031	600	1020	3070	2761	855	797
91			.364		758	6804	4888	429	527	822	1563	1191	600	1149	3905	3562	1099	1025
92			.371		757	7208	5310	422	534	868	1780	1370	599	1249	4774	4380	1363	1276
93			.373		759	7620	5720	421	547	922	2003	1552	599	1285	5275	4873	1528	1434
94	48,000		.276	0	649	5803	3577	425	476	695	1286	1019	449	657	1909	1713	625	602
95			.273		649	6141	3843	428	487	736	1440	1144	449	692	2235	2024	735	706
96			.269		649	6440	4052	434	500	780	1621	1290	450	727	2564	2343	861	830
97			.276		649	6673	4241	424	495	792	1716	1363	448	760	2897	2667	970	934
98			.277		677	5783	3701	424	480	693	1226	957	450	673	1906	1701	588	562
99			.277		679	6206	4061	424	490	739	1394	1087	449	728	2364	2130	727	893
100			.282		681	6541	4352	418	496	782	1601	1251	448	785	2831	2585	887	846
101			.277		680	7020	4729	422	512	841	1849	1456	447	834	3403	3136	1083	1037
102			.275		680	7307	4993	425	522	879	2004	1587	447	852	3674	3396	1182	1135
103			.276		719	7301	5241	422	530	880	1924	1504	445	888	3713	3423	1119	1064
104			.278		721	7611	5581	421	539	924	2114	1661	446	905	3995	3698	1222	1163
105			.278		754	6357	4541	422	509	766	1412	1076	448	772	2421	2167	676	632
106			.281		758	6689	4834	418	513	803	1570	1199	448	844	2924	2646	823	770
107			.276		758	7012	5203	423	533	854	1736	1330	447	908	3375	3079	954	893
108			.280		760	7367	5733	419	545	906	1959	1513	446	940	3910	3613	1115	1047
109	58,000		.166		717	7256	5199	430	537	889	1947	1525	275	551	2240	2068	678	643

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TABLE III. - Concluded. PERFORMANCE DATA OF ENGINE CONFIGURATION B

[AX 102/3C engine.]

Run	Exhaust or free-stream static pressure, p_0, lb/sq ft abs	Engine fuel flow, w_f, lb/sec	Engine-inlet air-flow, $w_{a,1}$, lb/sec	Corrected engine-inlet high-pressure rotor speed, $N_{HP}/\sqrt{\theta_1}$, rpm	Corrected high-pressure rotor speed, $N_{HP}/\sqrt{\theta_2}$, rpm	Corrected low-pressure rotor speed, $N_{LP}/\sqrt{\theta_1}$, rpm	Corrected engine-inlet airflow, $w_{a,1}\sqrt{\theta_1}/\delta_1$, lb/sec	Corrected high-pressure compressor airflow, $w_{a,2-1}\sqrt{\theta_2}/\delta_2$, lb/sec	Scale jet thrust, $F_{j,s}$, lb	Scale net thrust, $F_{n,s}$, lb	Net specific fuel consumption, $w_f/F_{n,s}$, lb/(hr)(lb of thrust)	Velocity coefficient, C_V	Exhaust-nozzle flow coefficient, $C_{d,N}$	Over-all compressor efficiency, η_C	Low-pressure compressor efficiency, $\eta_{C,LP}$	High-pressure compressor efficiency, $\eta_{C,HP}$	Engine combustion efficiency, η_e	Over-all turbine efficiency, η_T
57	346	0.413	58.06	6421	6036	4078	185.80	132.12	2678	2718	1.323	0.985	0.954	0.805	0.936	0.776	0.977	0.870
58	358	.656	69.02	6984	6481	4587	221.15	144.43	3799	3896	1.171	.975	.965	.808	.966	.770	.976	.888
59	353	1.013	81.42	7545	6906	5016	262.03	157.56	5398	5540	1.112	.974	.957	.800	.962	.759	.986	.902
60	362	1.415	89.67	8077	7311	5449	289.24	168.53	6782	6858	1.134	.976	.953	.772	-----	.744	1.000	.894
61	356	1.607	91.89	8353	7516	5685	295.47	170.07	7313	7415	1.176	.972	.948	.746	-----	.724	1.001	.904
62	363	.353	55.62	6331	5924	4175	180.15	128.01	2251	2309	1.599	.975	.948	.774	.869	.758	1.006	.874
63	356	.627	69.63	7024	6467	4811	224.80	142.43	3767	3839	1.163	.981	.964	.787	.924	.755	1.005	.883
64	355	1.006	84.89	7632	6906	5337	273.52	157.38	5547	5699	1.086	.973	.962	.791	-----	.758	1.017	.897
65	362	1.411	93.43	8199	7301	5929	300.82	169.11	6969	7122	1.105	.978	.956	.745	.841	.739	1.020	.901
66	358	1.635	94.94	8513	7538	6136	305.21	170.87	7502	7706	1.166	.974	.957	.715	.808	.715	1.019	.905
67	365	1.620	95.32	8542	7537	6260	307.00	170.37	7505	7711	1.145	.973	.963	.708	.796	.711	1.037	.901
68	362	1.640	95.44	8533	7518	6328	306.99	169.16	7486	7538	1.172	.979	.954	.711	.797	.713	1.003	.906
69	354	.585	68.68	6995	6382	4976	219.57	139.57	3489	3596	1.276	.970	.971	.756	.836	.748	1.010	.888
70	358	.837	80.16	7425	6692	5400	256.01	149.28	4733	4864	1.156	.973	.977	.761	.878	.738	1.007	.895
71	376	1.082	89.28	7787	6947	5763	285.34	156.15	5844	5970	1.106	.979	.962	.768	.887	.744	.998	.896
72	357	1.305	95.37	8051	7112	6138	303.93	163.61	6691	6851	1.111	.977	.964	.754	.844	.746	1.003	.898
73	362	1.416	97.07	8286	7279	6377	309.02	167.69	7089	7262	1.104	.976	.966	.730	.798	.737	1.029	.898
74	355	.429	56.02	6421	6074	3919	180.37	130.23	2646	2705	1.302	.978	.928	.818	.984	.782	.961	.869
75	356	.594	63.76	6800	6380	4221	204.77	140.67	3449	3554	1.196	.970	.939	.823	.954	.785	.965	.883
76	360	.637	66.01	6882	6449	4256	208.57	142.64	3681	3795	1.175	.970	.942	.816	-----	.777	.979	.880
77	359	.769	69.68	7125	6642	4455	223.24	148.43	4241	4331	1.135	.979	.941	.816	.976	.781	.974	.890
78	359	.956	75.57	7437	6895	4657	241.78	154.26	5016	5136	1.123	.977	.940	.808	.996	.765	.982	.900
79	360	1.179	81.27	7768	7144	4877	260.48	161.98	5801	5975	1.141	.971	.945	.794	.953	.760	.986	.896
80	359	1.314	84.25	7982	7318	5032	269.04	162.83	6284	6465	1.150	.972	.947	.785	-----	.744	.991	.895
81	355	.391	57.05	6427	6050	4081	183.99	130.58	2486	2567	1.422	.969	.952	.800	.957	.764	.977	.873
82	360	.721	72.10	7158	6624	4658	231.34	148.59	4102	4262	1.164	.963	.967	.806	.960	.769	.989	.902
83	354	1.187	84.60	7915	7223	5173	272.06	160.28	6003	6074	1.130	.978	.947	.786	.969	.741	.982	.906
84	362	1.589	90.30	8545	7683	5633	289.73	162.97	7187	7362	1.176	.976	.938	.725	.911	.694	1.008	.903
85	364	.366	58.44	6442	6024	4255	186.90	130.02	2377	2428	1.485	.979	.951	.794	.924	.765	.983	.868
86	366	.619	70.22	7050	6493	4785	227.11	143.11	3686	3763	1.171	.980	.963	.800	.938	.765	.987	.882
87	367	.942	81.98	7615	6924	5217	265.35	159.90	5162	5248	1.095	.984	.952	.796	.945	.759	.986	.899
88	371	1.238	89.85	8148	7311	5658	290.12	161.71	6357	6534	1.082	.973	.954	.767	.908	.735	1.037	.898
89	365	1.587	94.41	8646	7650	6063	301.95	164.23	7410	7583	1.140	.977	.949	.716	.843	.698	1.025	.909
90	360	.522	67.10	6927	6342	4884	214.99	138.49	3226	3295	1.268	.979	.968	.766	.846	.758	1.015	.885
91	356	.798	80.10	7484	6752	5377	256.65	148.86	4672	4783	1.119	.977	.966	.768	.892	.740	1.015	.908
92	360	1.165	82.13	7994	7107	5889	293.60	158.39	6174	6343	1.103	.973	.963	.761	.882	.737	1.009	.903
93	361	1.484	96.75	8458	7423	6349	302.93	163.72	7160	7353	1.142	.974	.964	.718	.815	.712	1.010	.904
94	269	.331	42.27	6412	6058	3953	180.28	130.75	2019	2077	1.293	.972	.934	.804	.960	.773	.993	.877
95	265	.446	47.00	6761	6338	4231	201.08	139.49	2612	2667	1.171	.979	.942	.806	.953	.776	.996	.879
96	270	.594	51.29	7043	6562	4431	220.77	147.04	3208	3276	1.146	.979	.934	.806	.970	.767	.988	.905
97	275	.736	56.65	7383	6833	4692	241.88	155.06	3740	3848	1.149	.972	.944	.808	.975	.770	.972	.911
98	268	.312	42.87	6398	6013	4095	182.38	130.20	1925	1962	1.386	.981	.942	.804	.926	.779	.953	.878
99	267	.460	50.24	6866	6387	4493	214.07	142.30	2667	2743	1.219	.972	.955	.815	.953	.784	.952	.885
100	268	.644	57.45	7288	6691	4849	243.29	152.18	3530	3643	1.130	.969	.961	.792	.931	.761	.990	.911
101	266	.919	64.31	7785	7068	5244	274.59	163.07	4569	4703	1.142	.971	.956	.788	.915	.762	.982	.910
102	272	1.086	67.40	8074	7286	5518	288.84	168.83	5081	5244	1.163	.969	.959	.769	.887	.747	.990	.906
103	271	1.035	69.16	8097	7225	5812	296.35	166.99	5014	5152	1.144	.973	.964	.763	.853	.754	.985	.898
104	272	1.225	71.44	8451	7469	6195	305.33	170.93	5517	5730	1.191	.963	.960	.724	.800	.728	1.000	.910
105	274	.445	51.56	7050	6421	5036	219.79	140.71	2582	2647	1.255	.975	.961	.759	.817	.756	.995	.895
106	258	.630	59.41	7453	6728	5387	251.89	148.94	3535	3614	1.161	.978	.960	.769	.874	.745	.977	.909
107	264	.803	66.20	7767	6919	5765	283.10	157.01	4285	4430	1.132	.967	.975	.764	.865	.749	1.003	.910
108	271	1.060	72.35	8199	7189	6381	308.21	167.48	5189	5380	1.138	.965	.973	.735	.790	.749	1.018	.899
109	165	.626	41.11	7972	7134	5712	288.36	161.22	2972	3080	1.183	.965	.958	.765	.885	.742	.982	.892

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TABLE IV. - HIGH INLET AIR TEMPERATURE DATA (AX 102/3C ENGINE)

[Exhaust-nozzle areas for tailpipe configuration with turbine-outlet rakes, single total-pressure rake at exhaust-nozzle inlet and flameholder.]

Run	Reynolds number index, $\delta_1/\varphi_1\sqrt{\theta_1}$	Exhaust-nozzle area, A_N, sq in.	High-pressure rotor speed, N_{HP}, rpm	Low-pressure rotor speed, N_{LP}, rpm	Engine-inlet temperature, T_1, ^{o}R	Low-pressure compressor-outlet temperature, T_2, ^{o}R	High-pressure compressor-outlet temperature, T_3, ^{o}R	Exhaust-gas temperature, T_9, ^{o}R	Engine-inlet total pressure, P_1, $\frac{lb}{sq\ ft}$ abs	Low-pressure compressor-outlet total pressure, P_2, $\frac{lb}{sq\ ft}$ abs	High-pressure compressor-outlet total pressure, P_3, $\frac{lb}{sq\ ft}$ abs	Turbine-inlet total pressure, P_4, $\frac{lb}{sq\ ft}$ abs	Turbine-outlet total pressure, P_6, $\frac{lb}{sq\ ft}$ abs	Exhaust-nozzle inlet total pressure, P_9, $\frac{lb}{sq\ ft}$ abs
1	0.381	720	7784	5242	699	816	1192	1678	1174	1899	5791	5204	1728	1614
2	.375	742	7000	4685	696	791	1090	1302	1150	1672	4093	3606	1175	1093
3	.379	723	7210	4823	696	794	1114	1405	1163	1747	4538	4026	1312	1218
4	.383	719	7420	4997	696	802	1140	1500	1174	1810	4982	4443	1454	1354
5	.379	727	7604	5148	696	807	1167	1592	1162	1843	5330	4777	1575	1464
6	.382	724	6977	4630	696	787	1079	1282	1171	1698	4139	3641	1190	1108
7	.403	722	7580	5035	758	867	1217	1564	1371	2060	5478	4880	1625	1517
8	.386	722	7600	5054	784	893	1249	1591	1370	2029	5299	4714	1584	1482
9	.375	721	7625	5051	806	907	1252	1582	1375	2030	5243	4663	1561	1460

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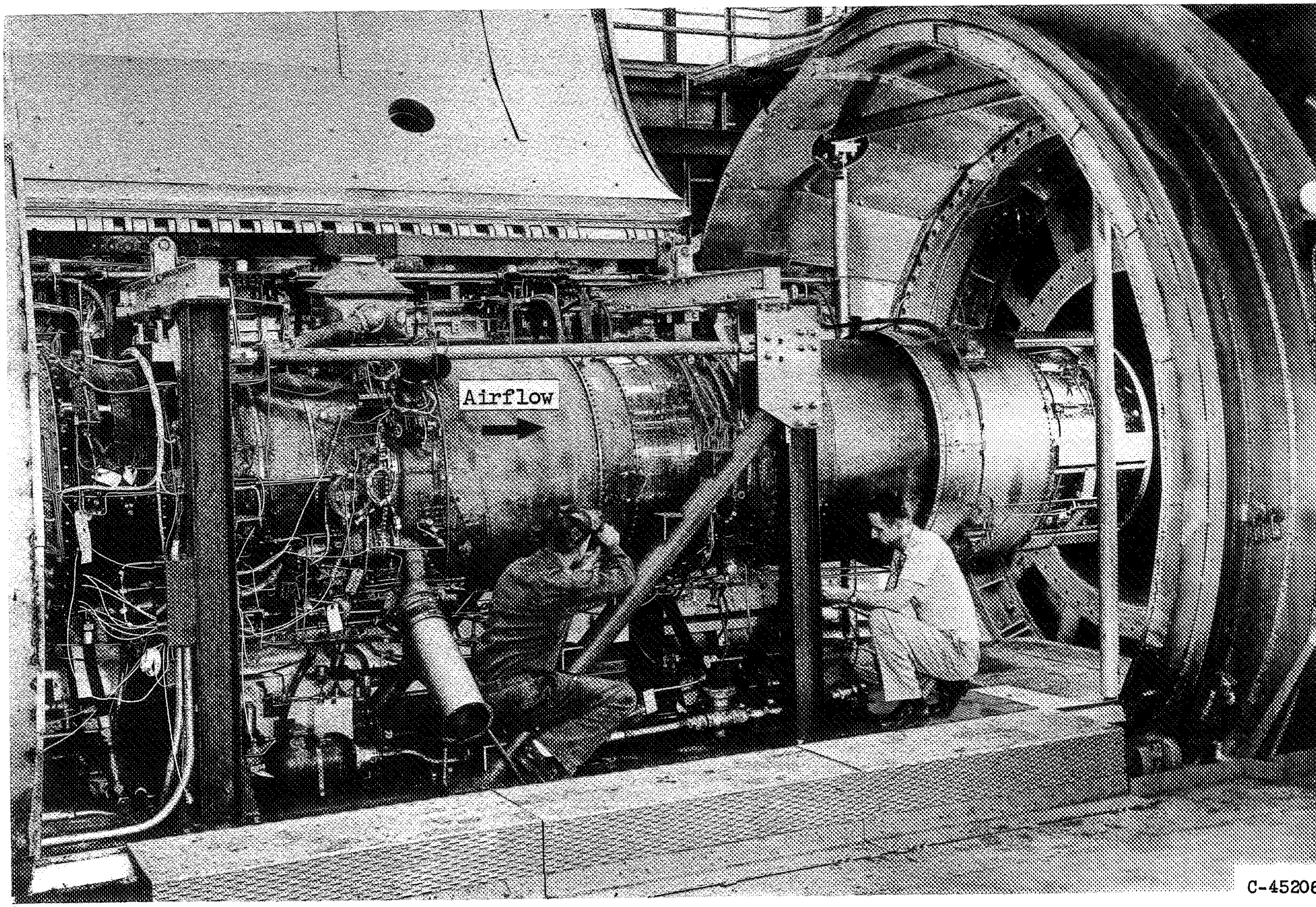

Figure 1. - Prototype Iroquois turbojet engine installed in altitude test chamber.

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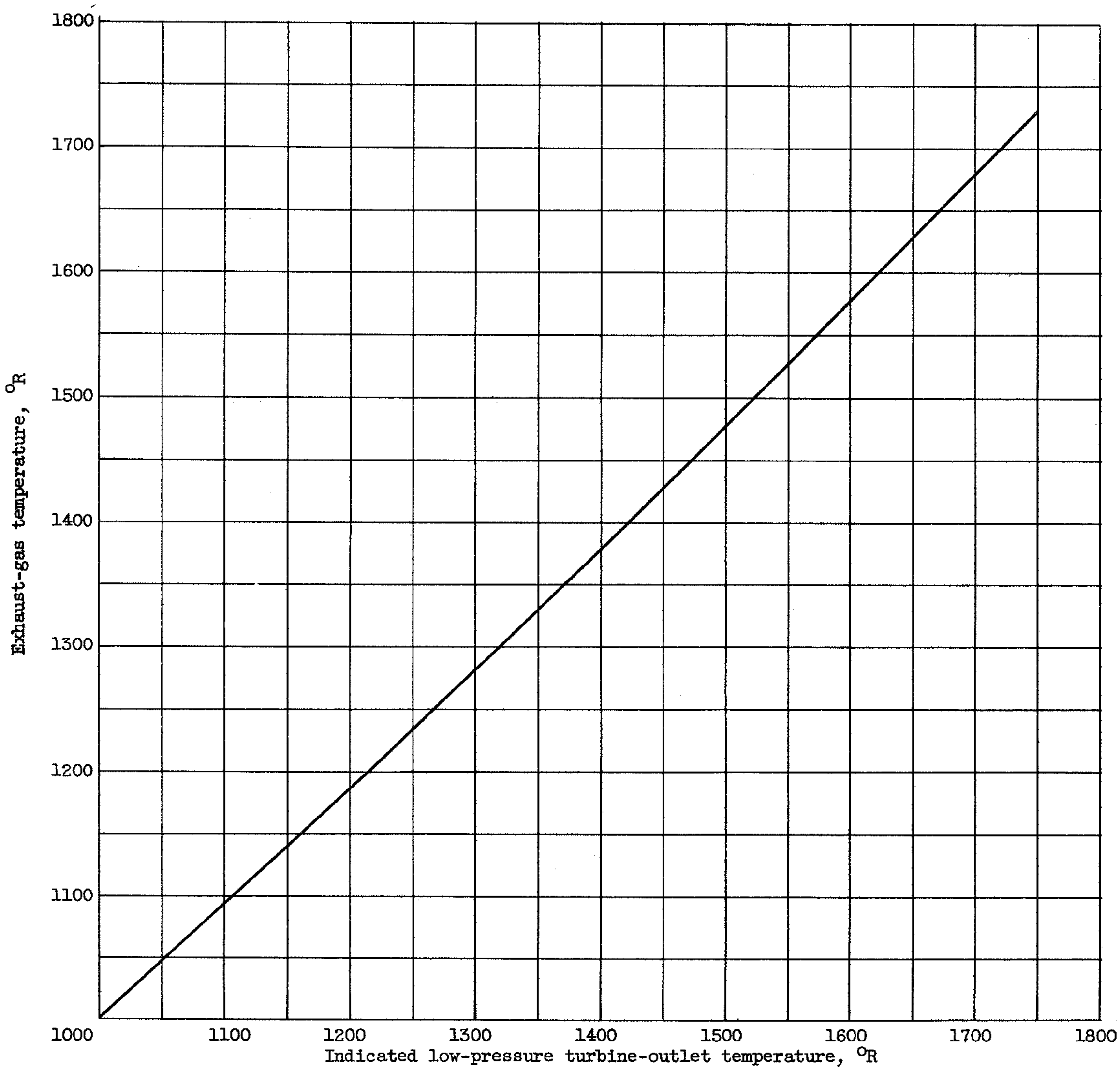

Figure 2. - Relation between indicated turbine-outlet temperature and exhaust-gas temperature.

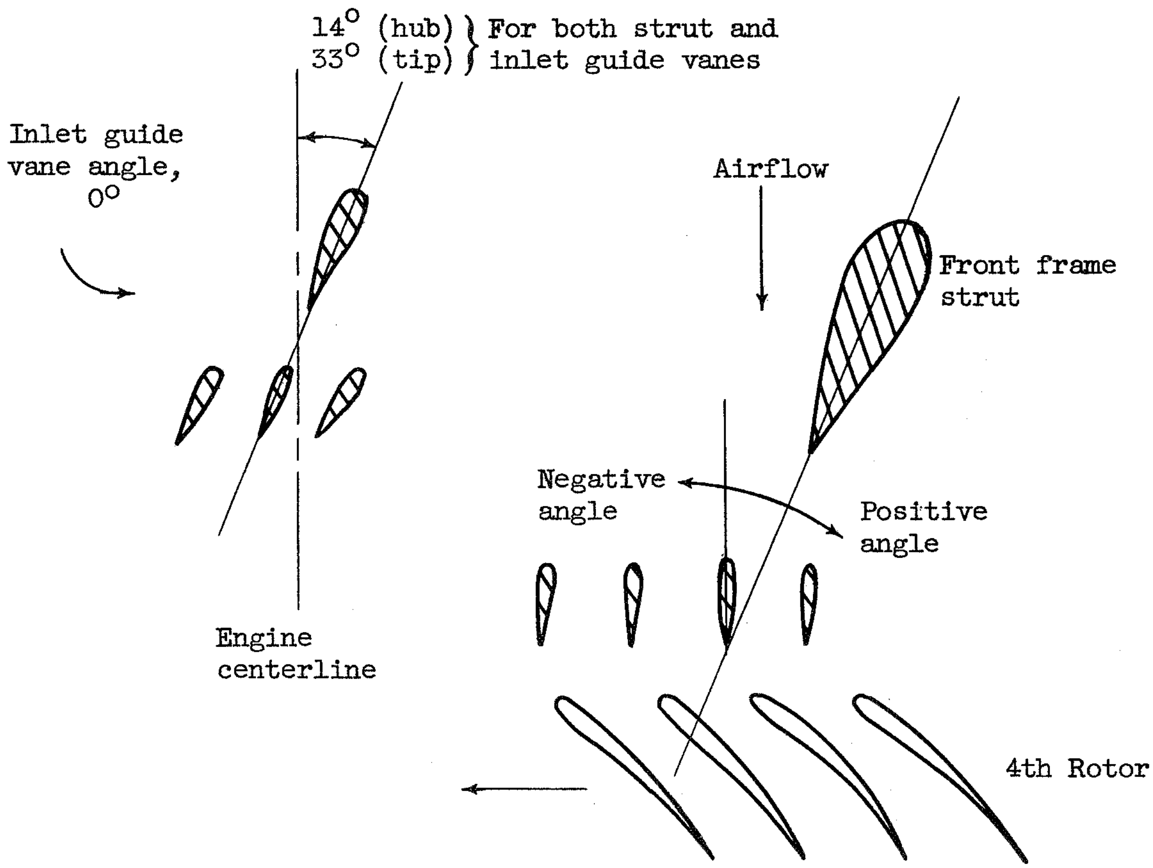

Figure 3. - Schematic diagram of variable high-pressure compressor-inlet guide vanes and adjacent stages.

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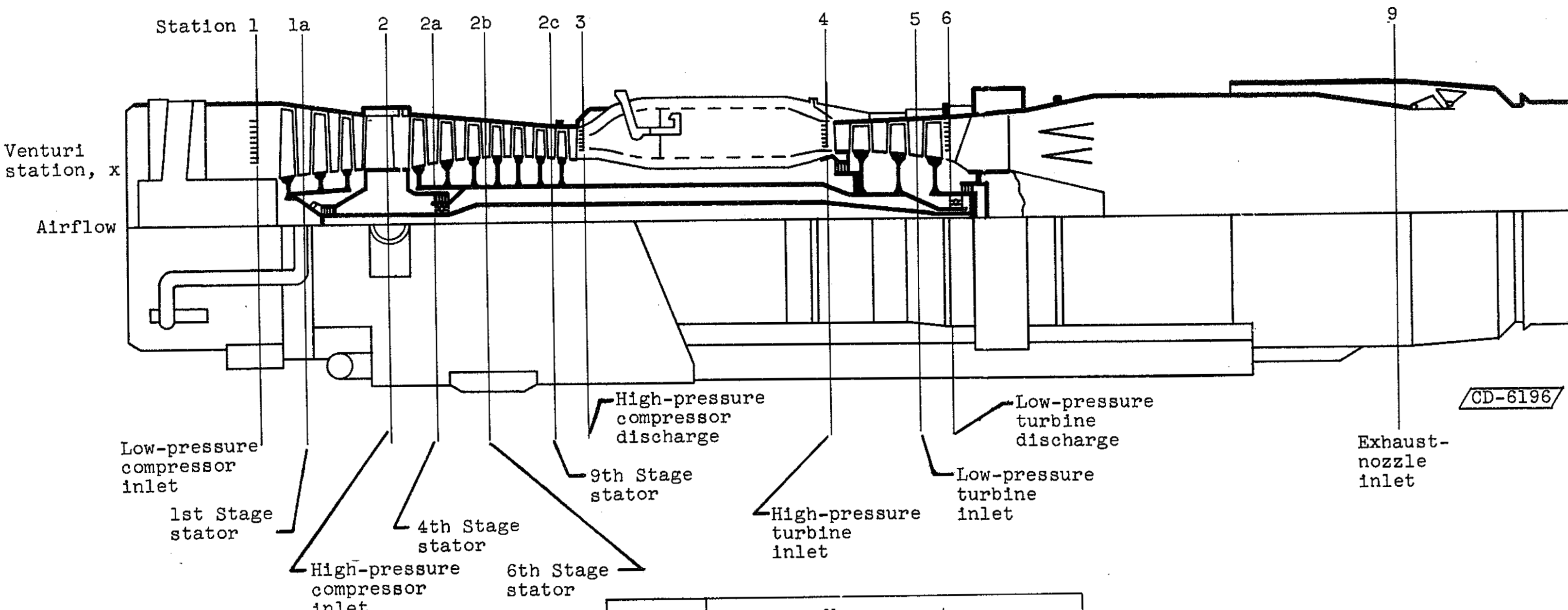

Station	Measurements		
	Total pressure	Static pressure	Total temperature
x		8	
1	20	4	10
1a	5	2	5
2	20	4	20
2a	5	2	5
2b	5	1	5
2c			
3	20		20
4	10		
5	10		
6	25		25
9	20	4	20

Figure 4. - Schematic diagram of Iroquois turbojet engine showing steady-state instrumentation stations.

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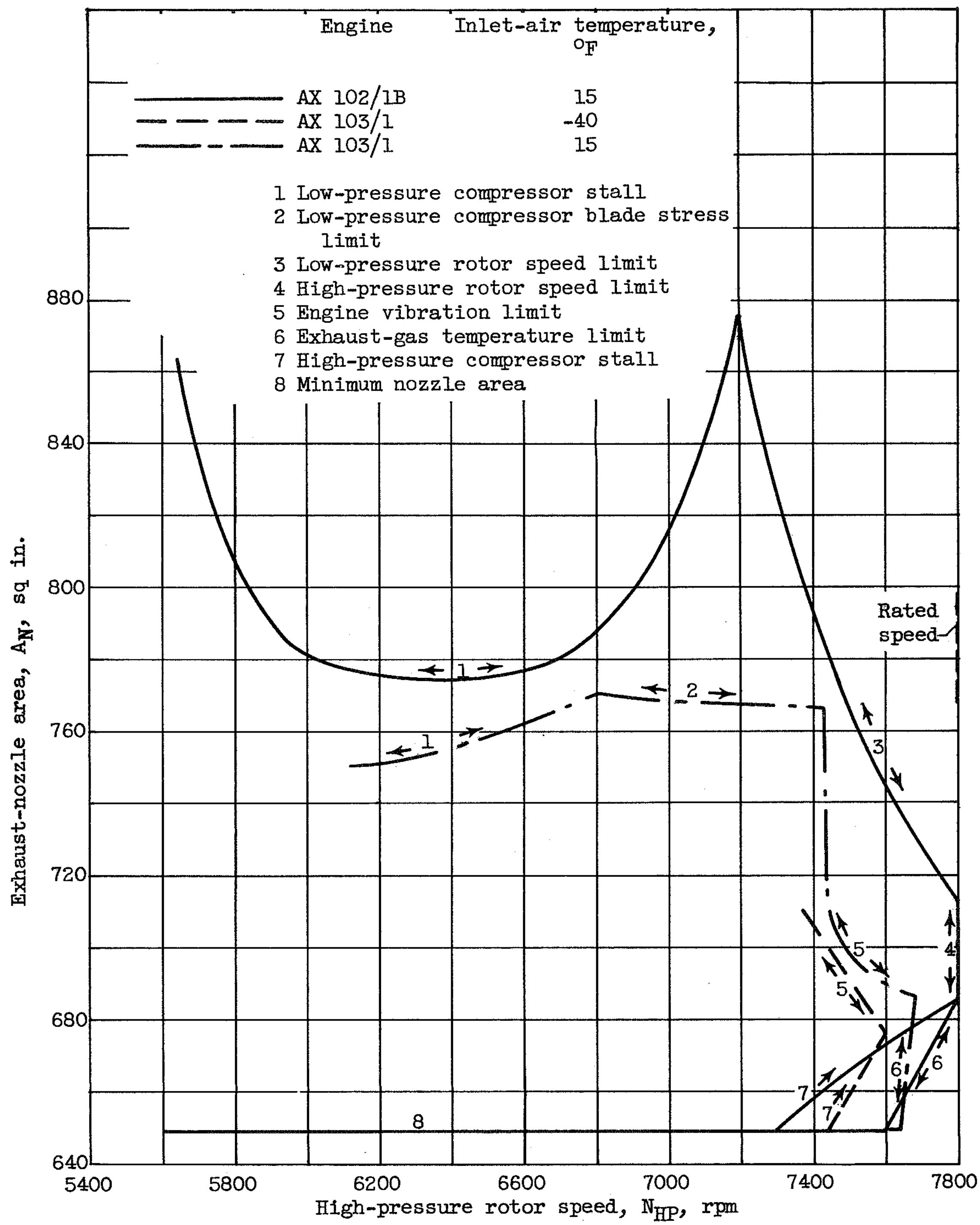
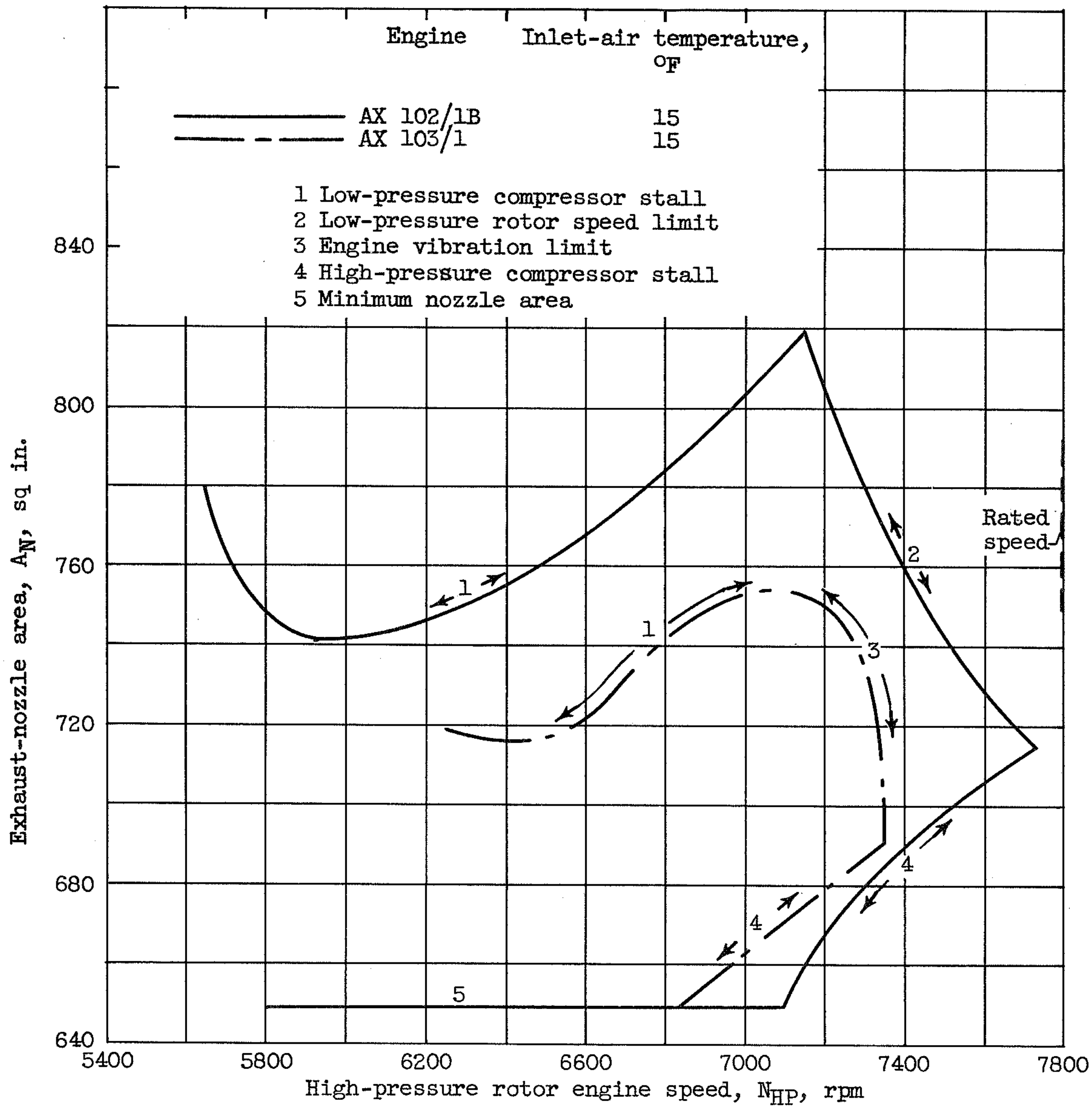


(a) Reynolds number index, 0.45.

Figure 5. - Operating limits of original engine configuration at simulated flight Mach number of 0.9.



(b) Reynolds number index, 0.17.

Figure 5. - Concluded. Operating limits of original engine configuration at simulated flight Mach number of 0.9.

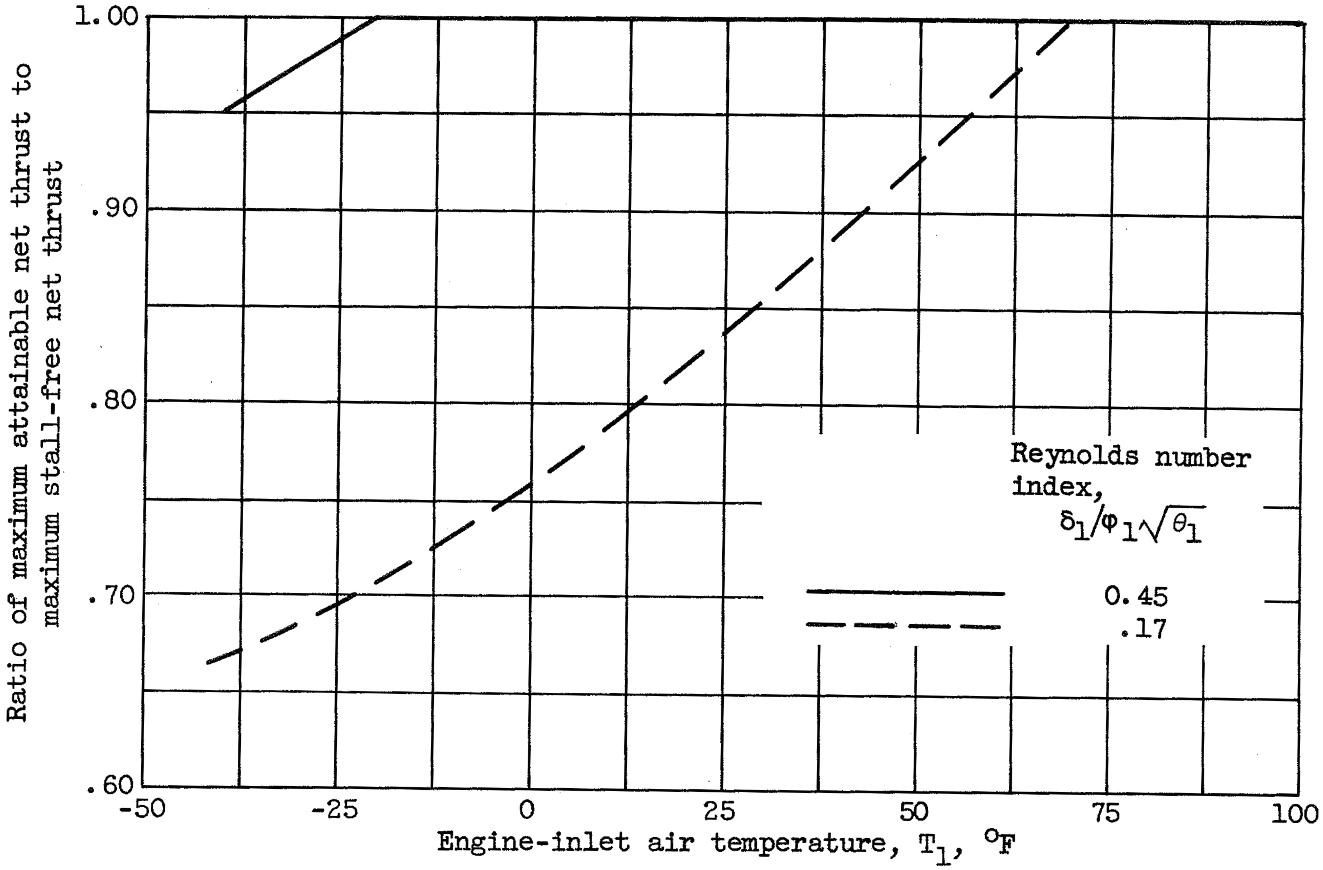


Figure 6. - Net thrust loss of original engine configuration due to presence of compressor stall. Simulated Mach number, 0.9.

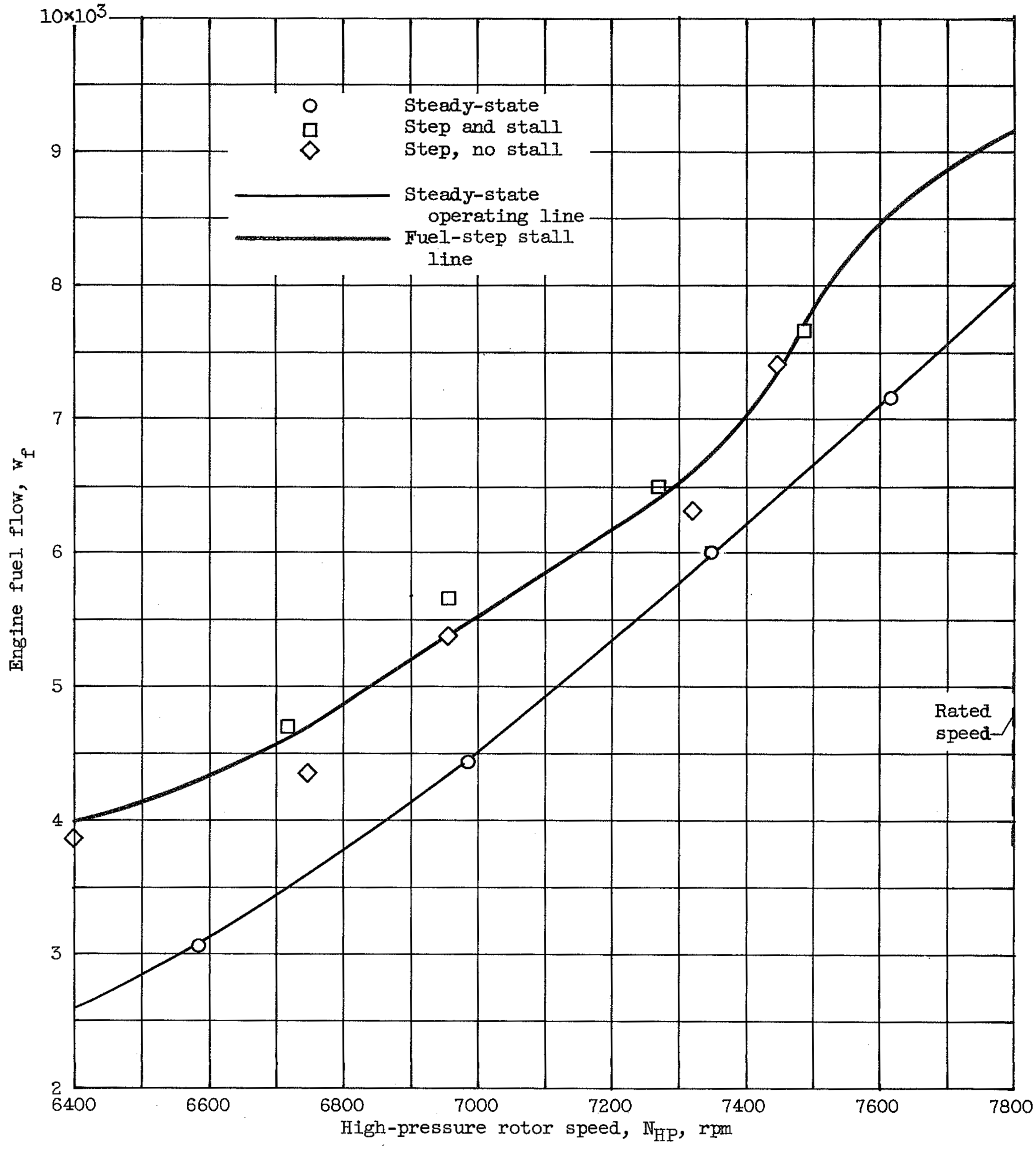


Figure 7. - Original engine configuration fuel-flow stall margin. Reynolds number index, 0.45; simulated flight Mach number, 0.9; inlet-air temperature, 15° F; rated exhaust-nozzle area.

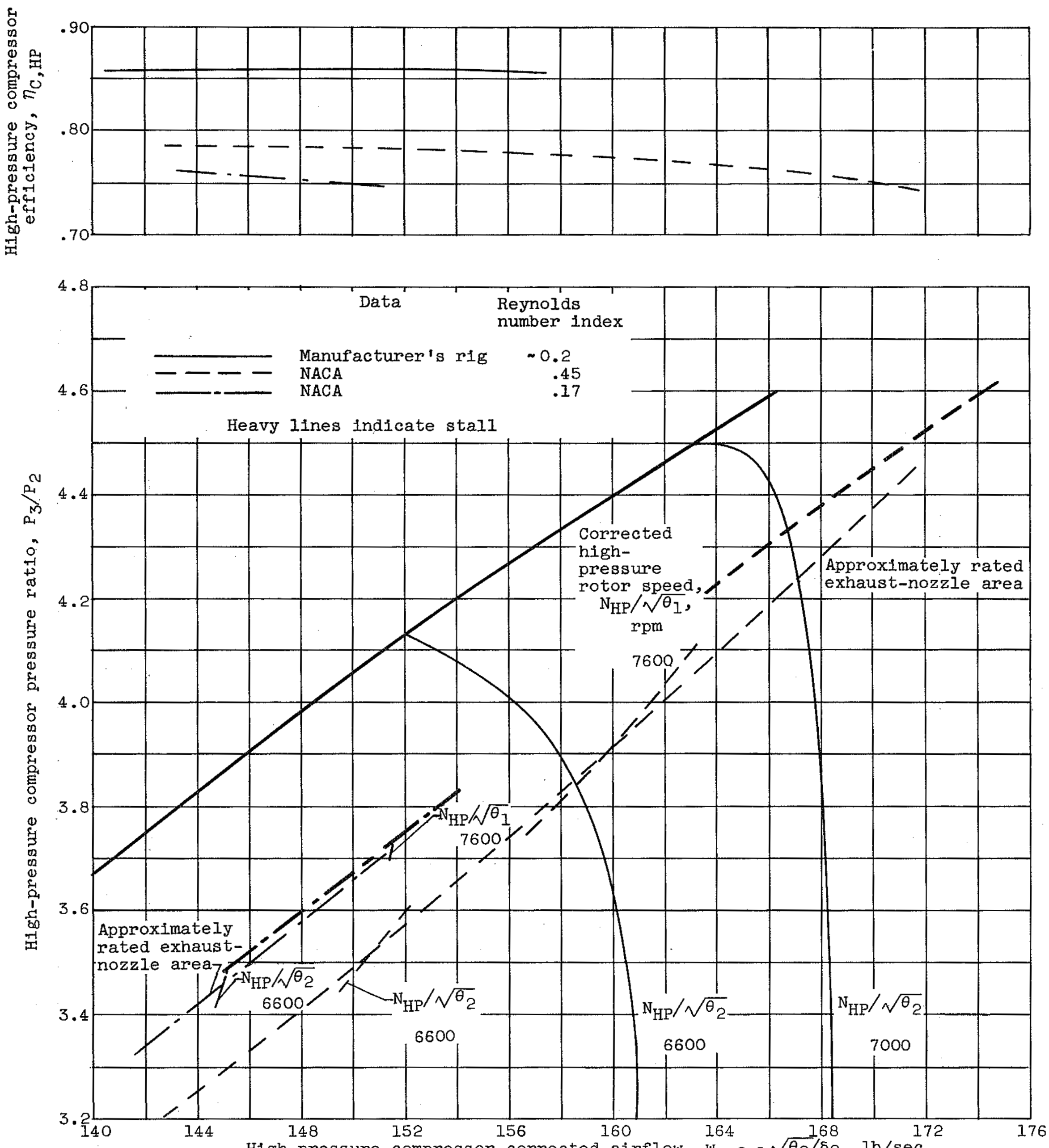


Figure 8. - Original engine configuration high-pressure compressor performance.

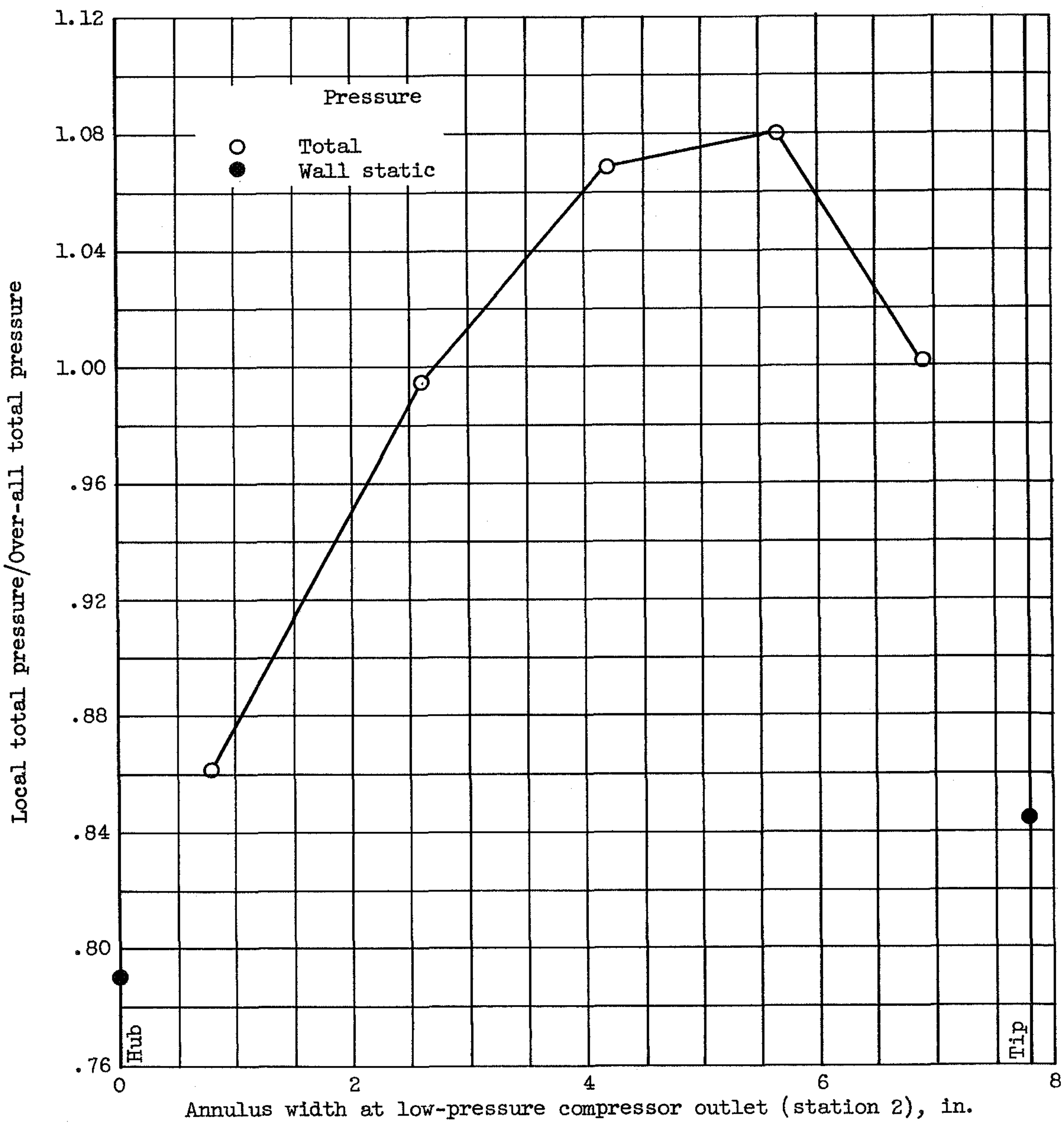


Figure 9. - Typical pressure variation at low-pressure compressor outlet for original engine configuration.

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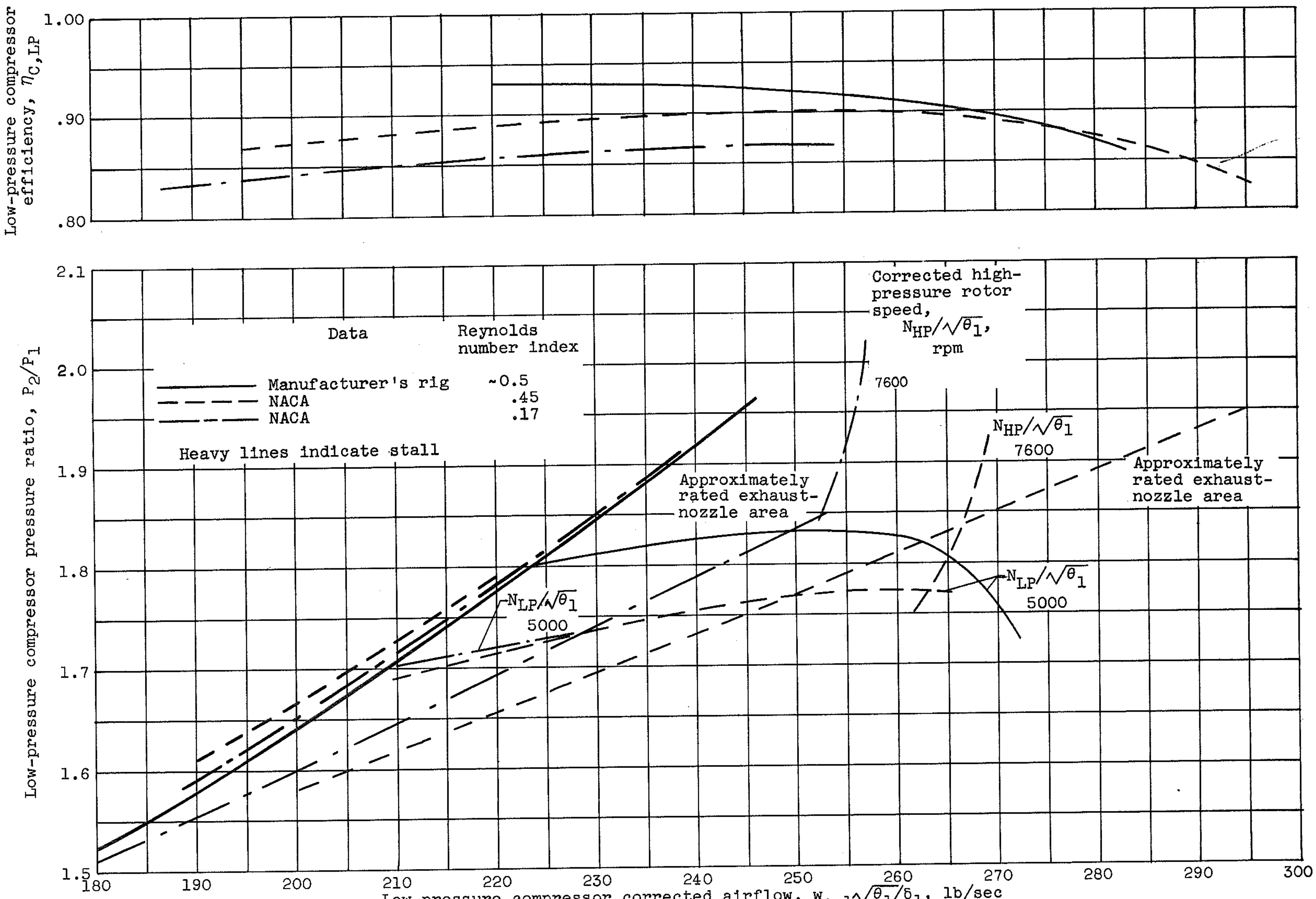

Figure 10. - Original engine configuration low-pressure compressor performance.

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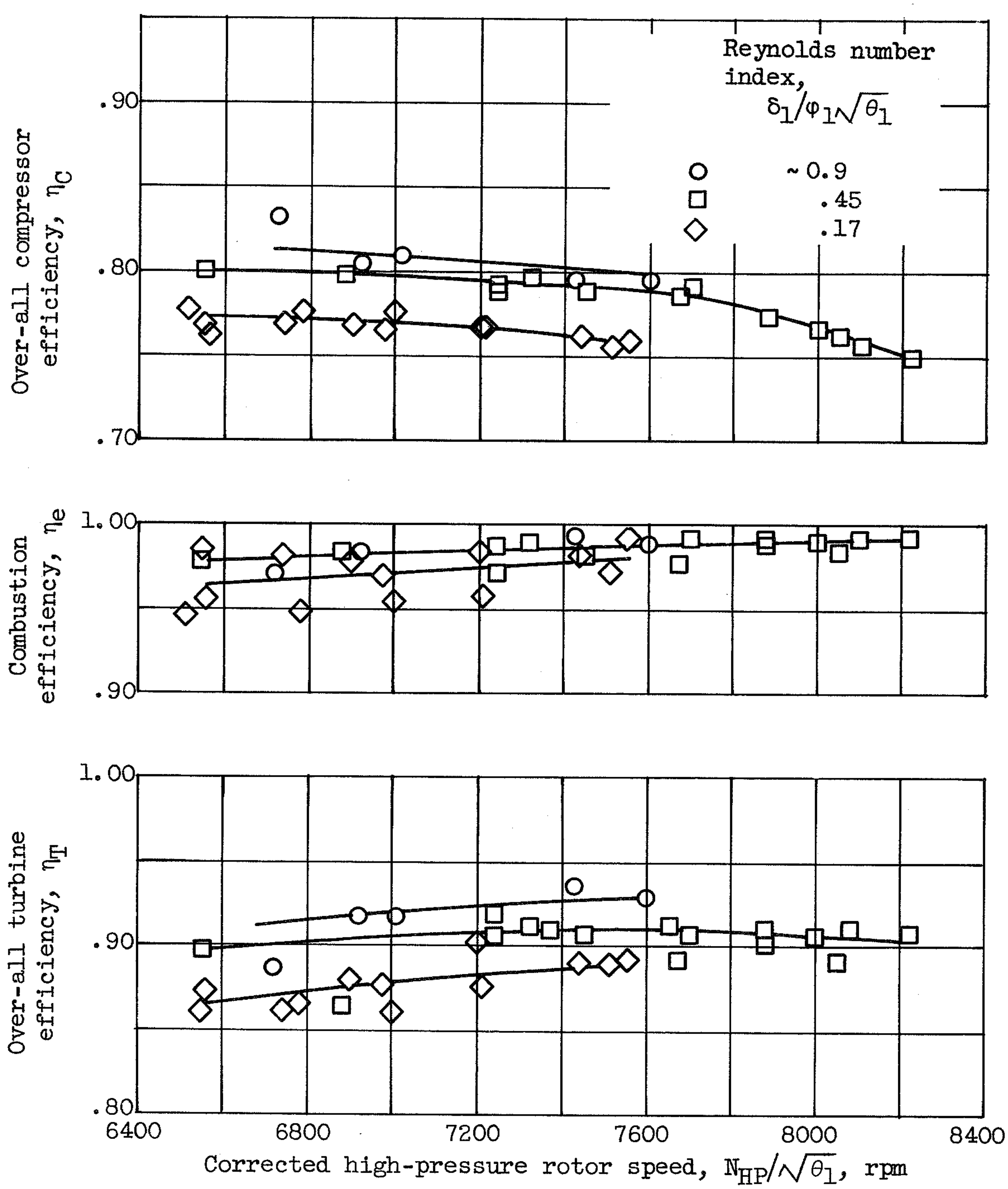


Figure 11. - Component efficiencies of original engine configuration for rated exhaust-nozzle area.

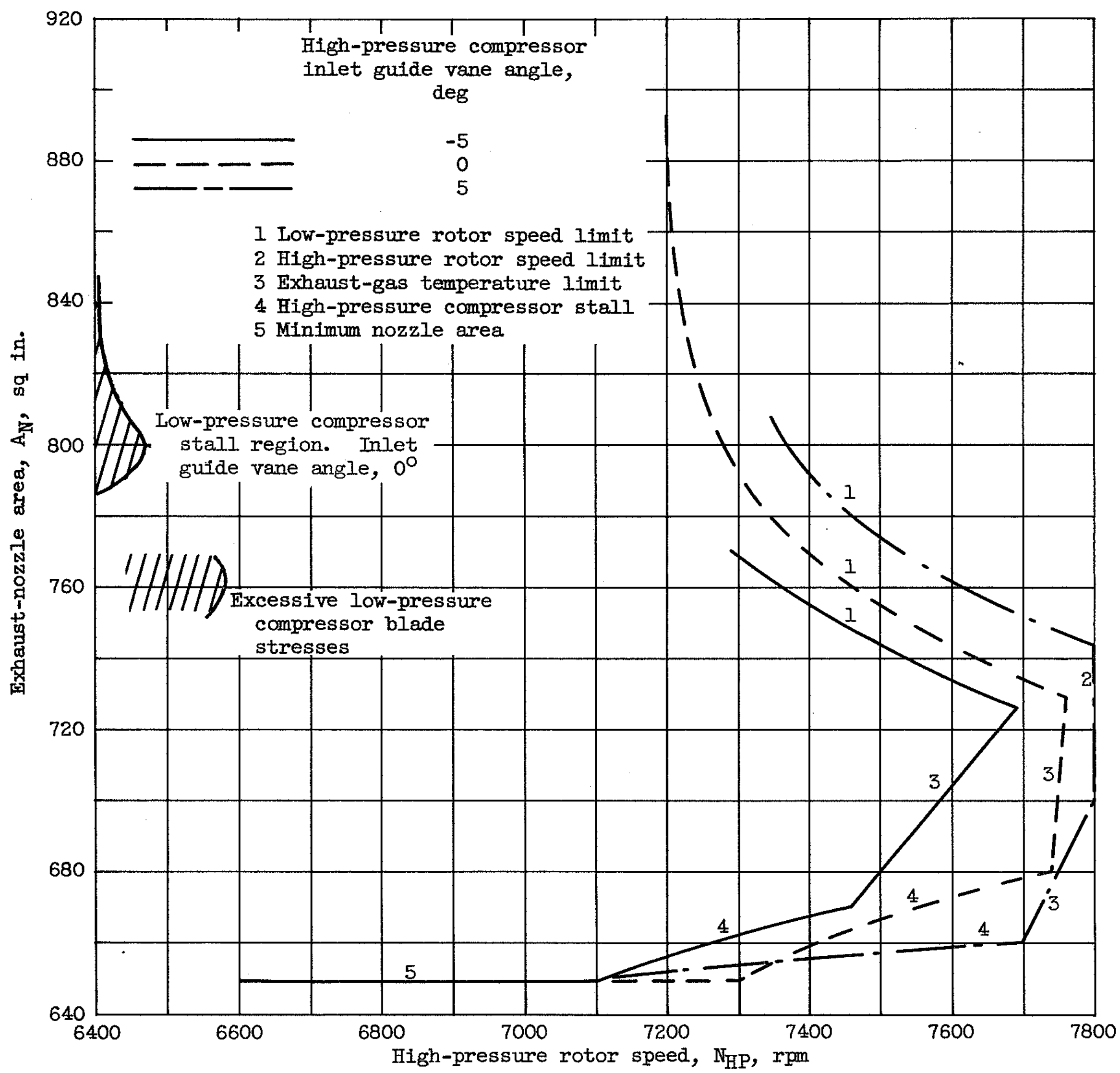


Figure 12. - Effect of high-pressure compressor-inlet guide vane angle on operating limits of modified B engine configuration. Reynolds number index, 0.37; inlet air temperature, -40° F; simulated flight Mach number, 0.9.

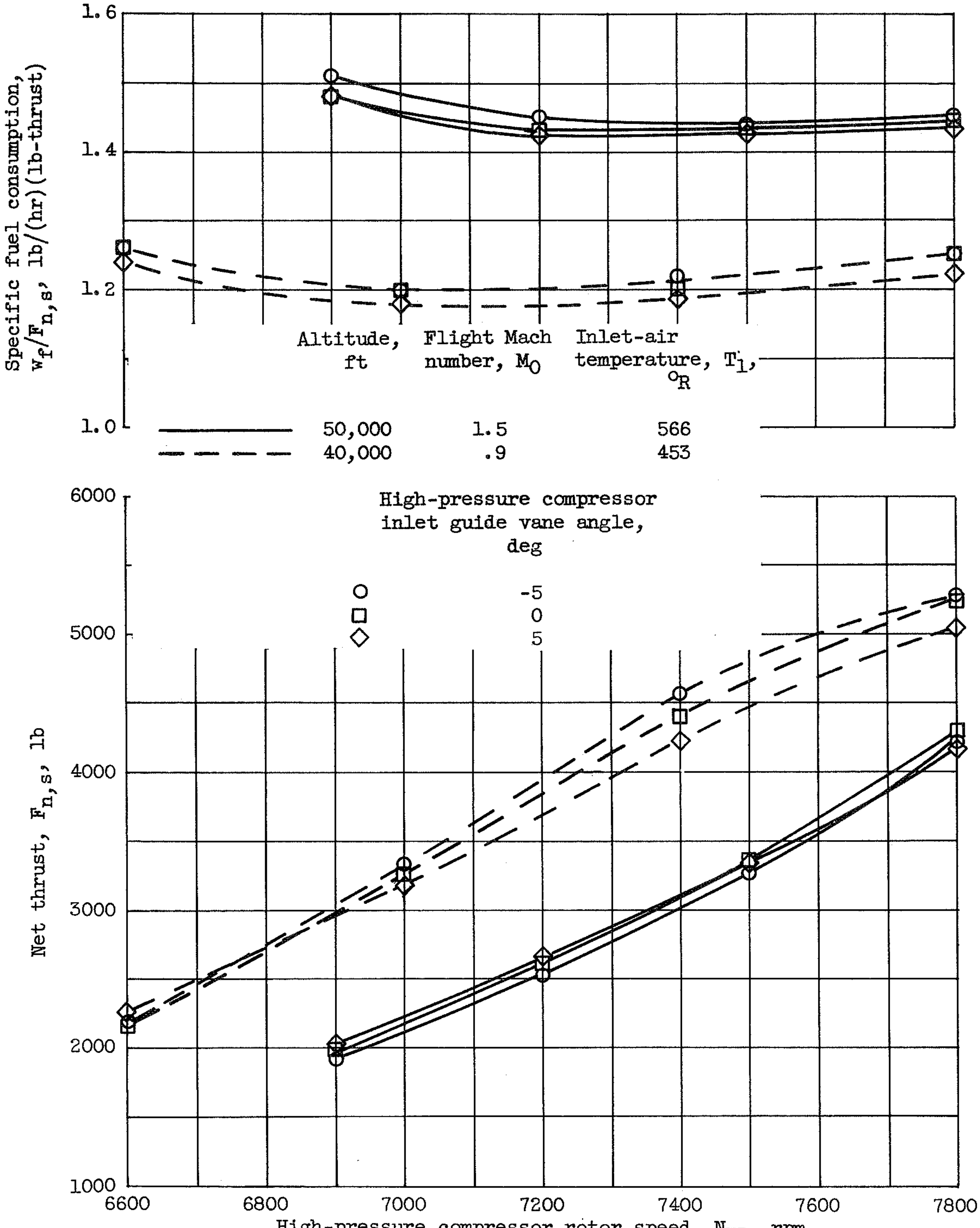
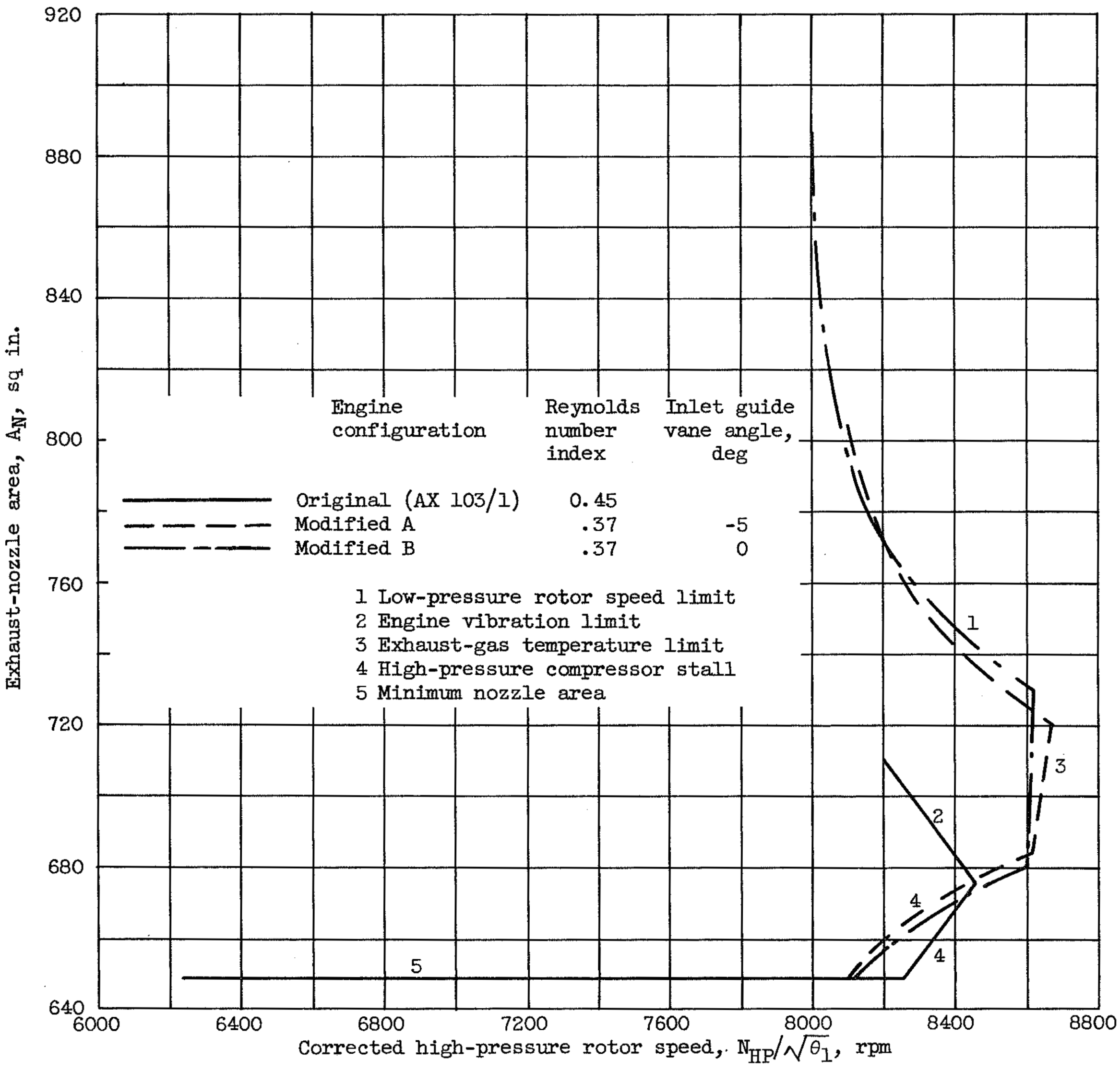
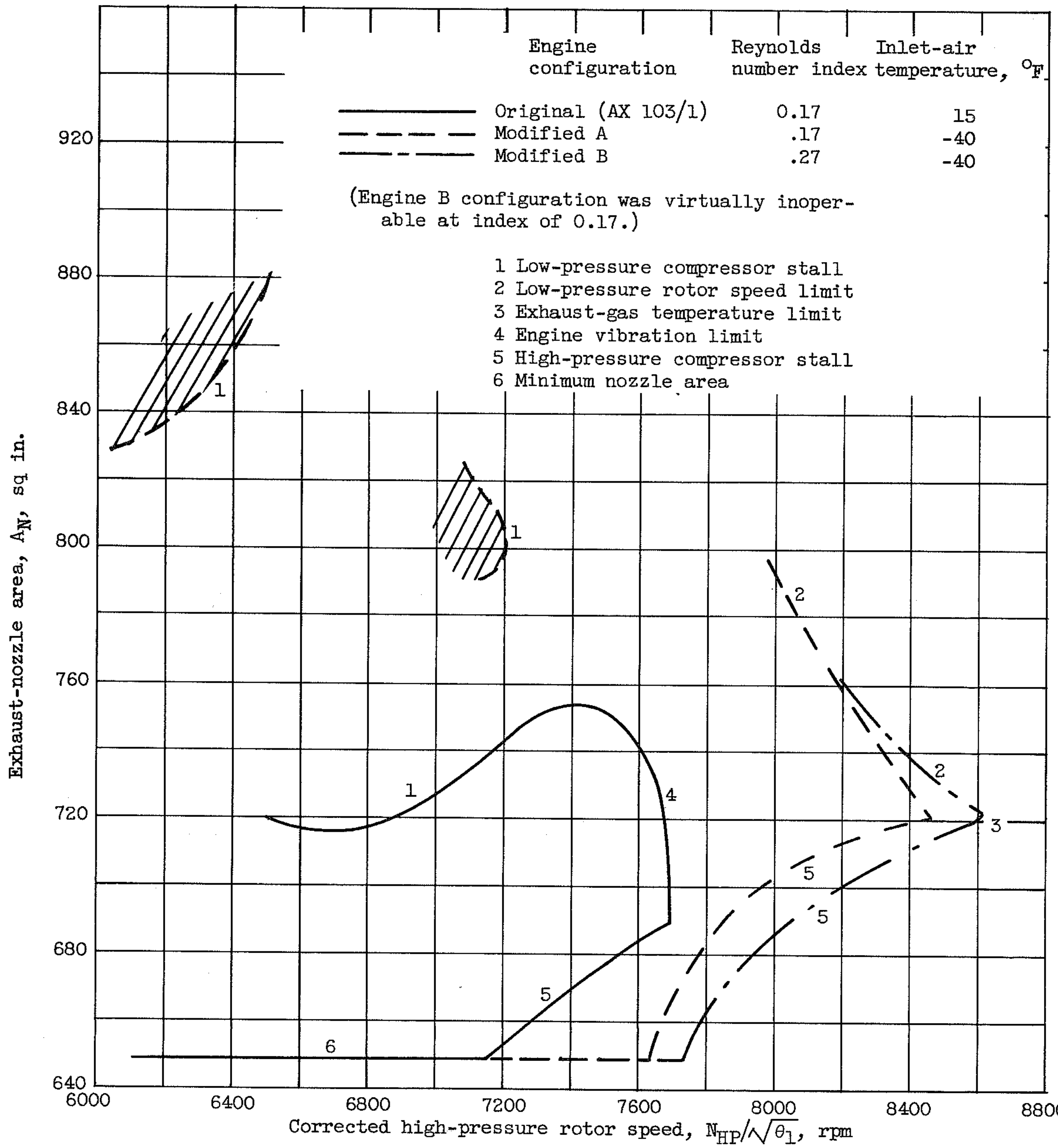


Figure 13. - Effect of high-pressure compressor inlet guide vane angle on performance of modified B engine configuration. Reynolds number index, 0.37; rated exhaust-nozzle area.



(a) Reynolds number index, 0.45 to 0.37.

Figure 14. - Variation of engine operating limits with engine configuration change. Simulated flight Mach number, 0.9; inlet-air temperature, -40° F.



(b) Reynolds number index, 0.17.

Figure 14. - Concluded. Variation of engine operating limits with engine configuration change. Simulated flight Mach number, 0.9.

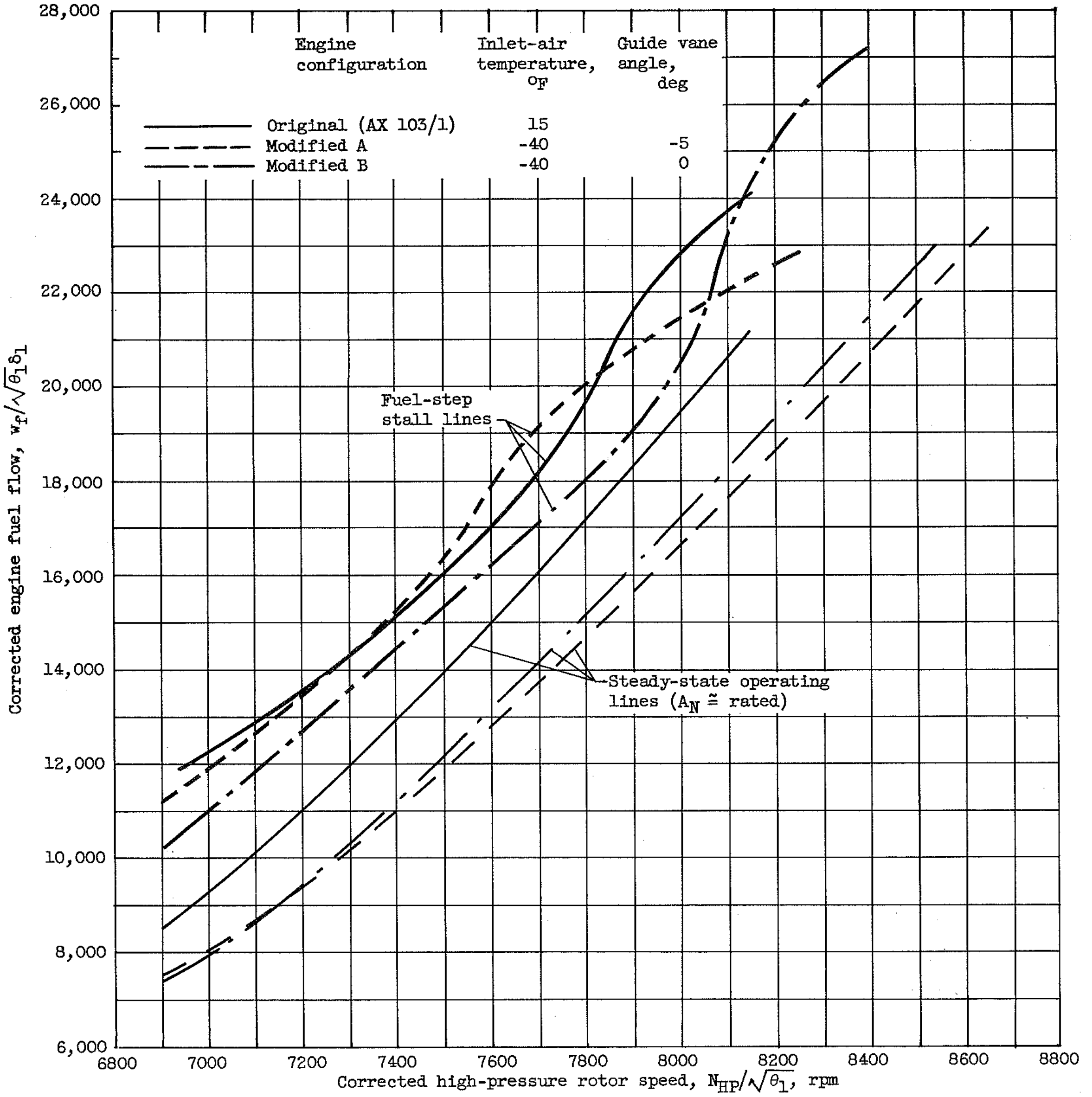


Figure 15. - Variation of engine fuel flow stall margin with engine configuration change. Reynolds number index, 0.45; simulated flight Mach number, 0.9.

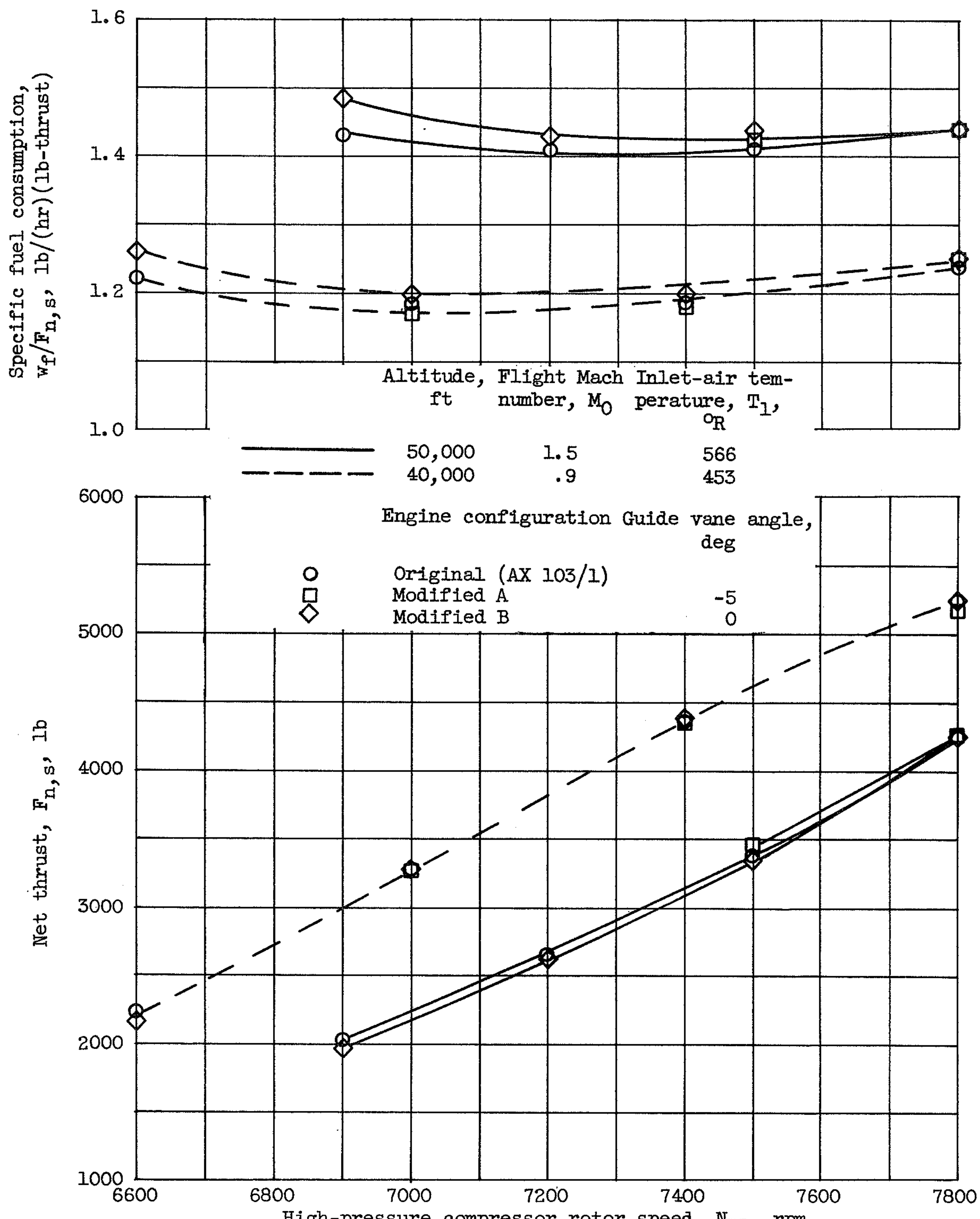
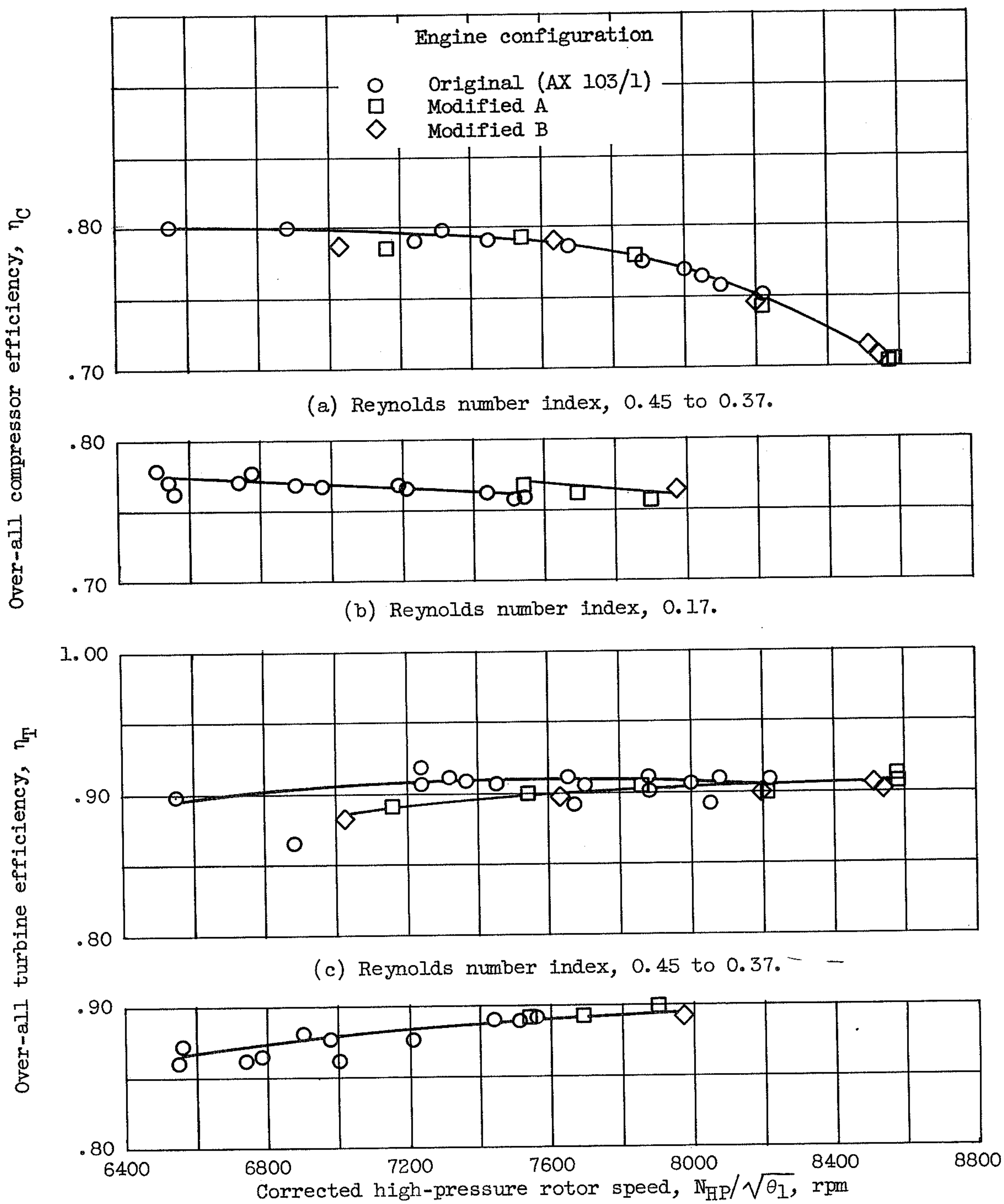


Figure 16. - Variation of engine performance with engine configuration change.



(a) Reynolds number index, 0.45 to 0.37.

(b) Reynolds number index, 0.17.

(c) Reynolds number index, 0.45 to 0.37.

(d) Reynolds number index, 0.17.

Figure 17. - Variation of over-all compressor and turbine efficiencies for three engine configurations.

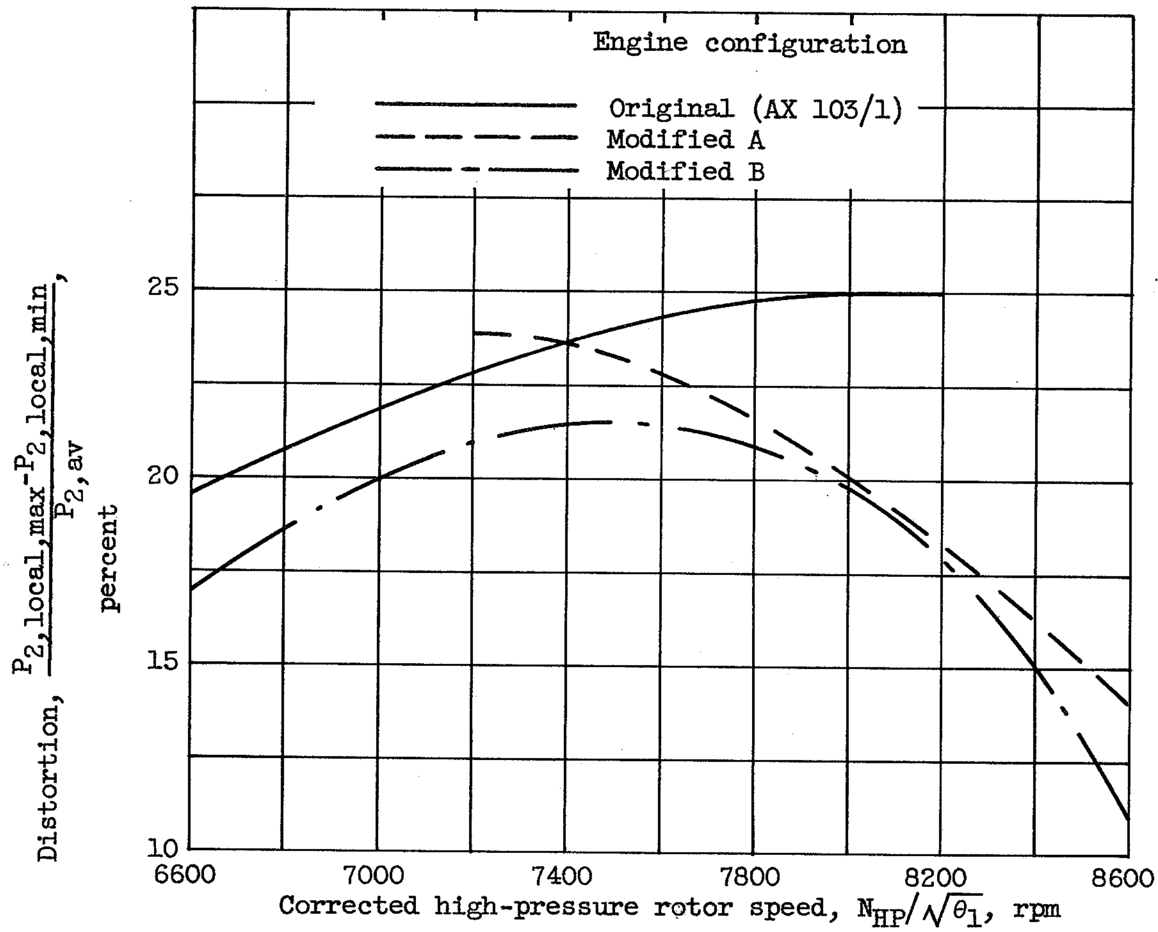


Figure 18. - Variation of high-pressure compressor inlet distortion with high-pressure rotor speed for a rated area operating line. Reynolds number index, 0.37 to 0.45; flight Mach number, 0.9.

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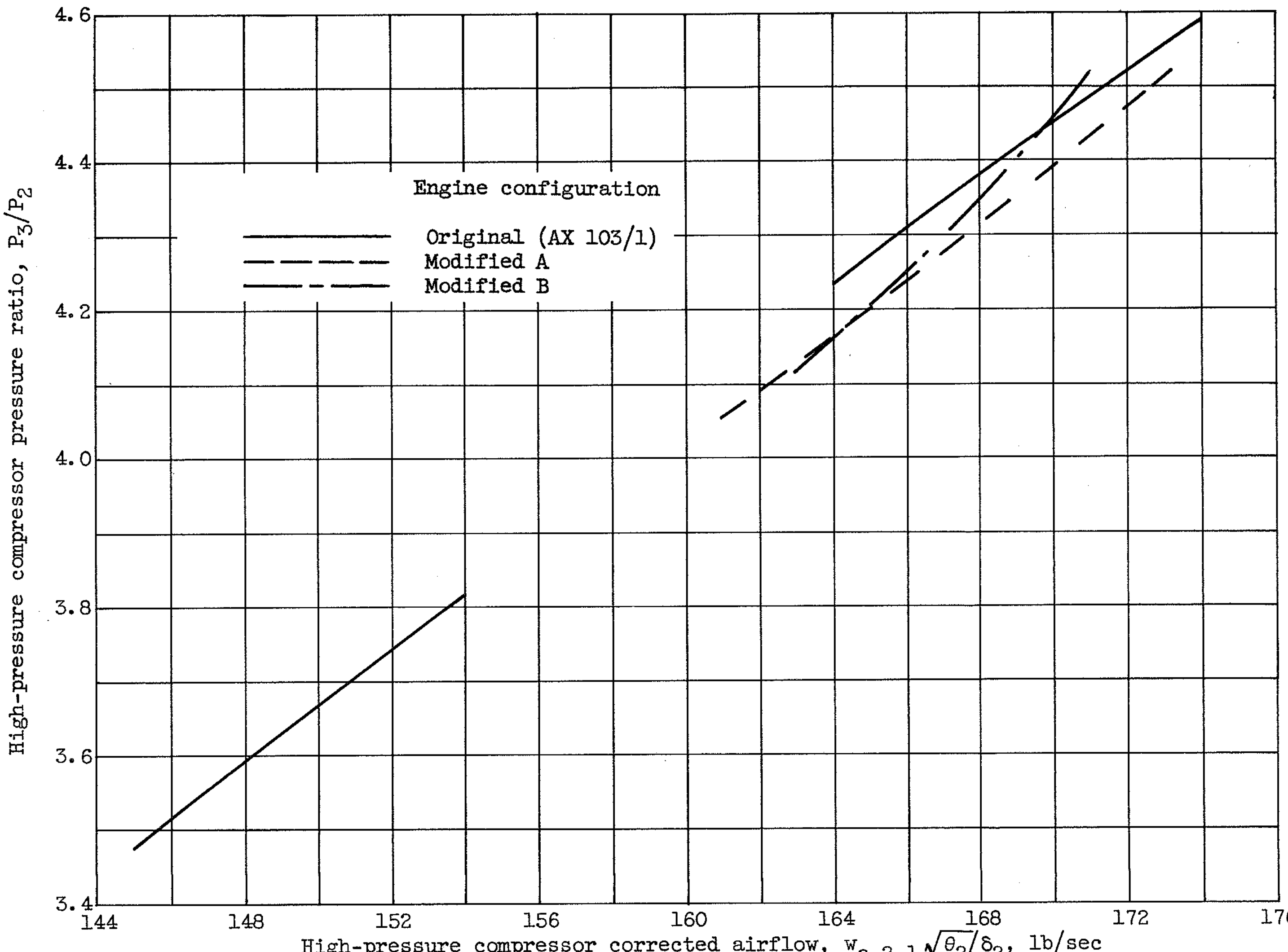

Figure 19. - Variation of high-pressure compressor stall line with engine configuration change. Reynolds number index range, 0.45 to 0.17.

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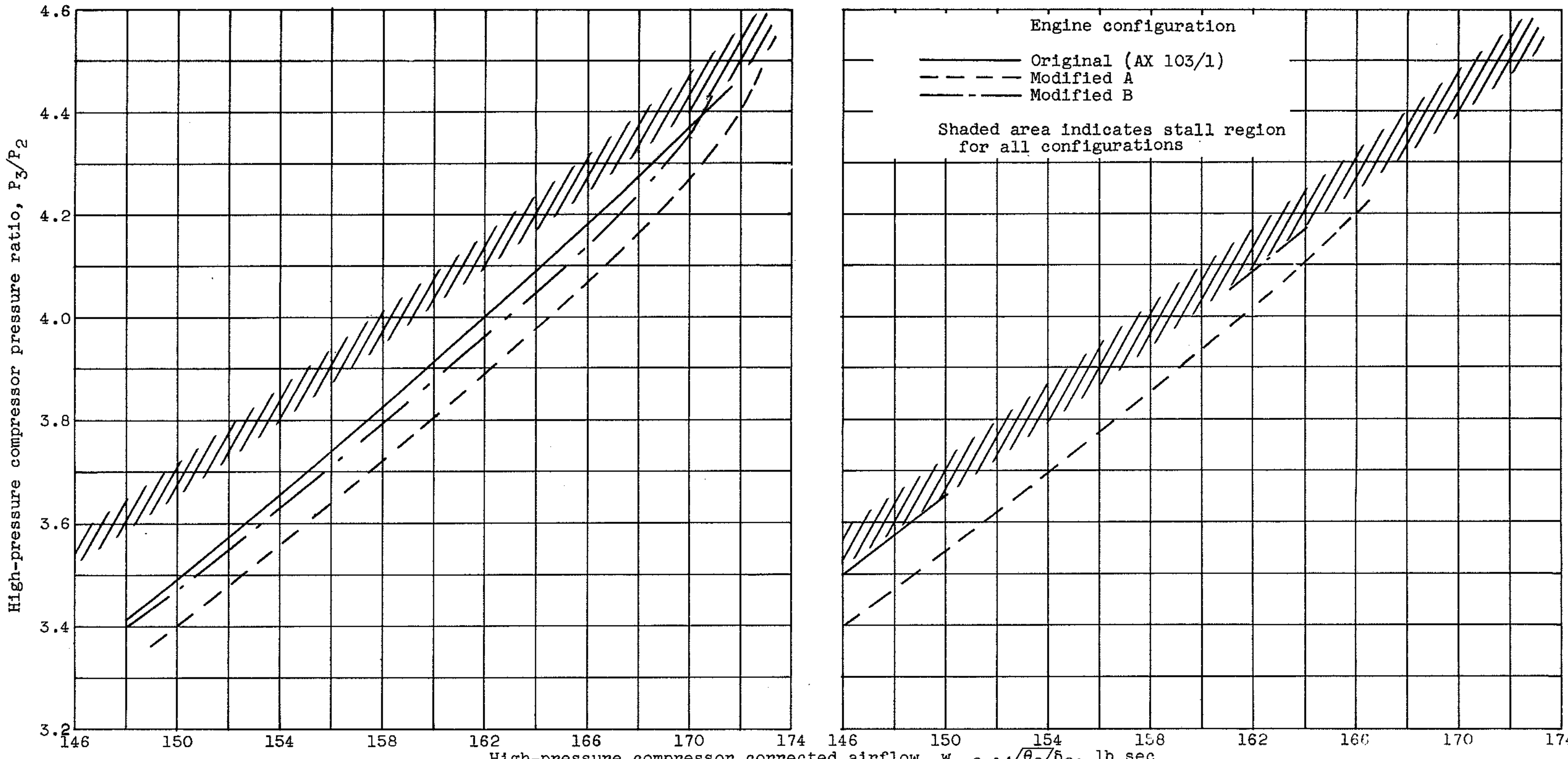

(a) Reynolds number index, 0.45 to 0.37.

(b) Reynolds number index, 0.17.

Figure 20. - Variation of high-pressure compressor stall margin with engine configuration change.

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Restriction/Classification Cancelled

INVESTIGATION OF A PROTOTYPE IROQUOIS TURBOJET ENGINE IN AN ALTITUDE TEST CHAMBER

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June 13, 1958
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