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Jack G. McArdle, Leonard Homyak,
and Allan S. Moore
Lewis Research Center
Cleveland, Ohio

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SUMMARY

The performance of a Lycoming YF-102 turbofan engine was measured in an outdoor test stand with a bellmouth inlet and seven exhaust-system configurations. The configurations consisted of three separate-flow systems of various fan and core nozzle sizes and four confluent-flow systems of various nozzle sizes and shapes. A Lycoming computer program provided good estimates of the engine performance and of thrust at maximum rating for each exhaust configuration. The internal performance of two different-shaped core nozzles for confluent-flow configurations was determined to be satisfactory. Pressure and temperature surveys were made with a traversing probe in the exhaust-nozzle flow for some confluent-flow configurations. The survey data at the mixing plane, plus the measured flow rates, were used to calculate the static-pressure variation along the exhaust-nozzle length. The computed pressures compared well with experimental wall static-pressure data. External-flow surveys were made, for some confluent-flow configurations, with a large fixed rake at various locations in the exhaust plume.

INTRODUCTION

As part of the NASA Quiet Short-Haul Research Aircraft (QSRA) Project, an airplane using the upper-surface-blowing propulsive lift concept has been built. The airplane is shown in figure 1. Its purpose is to conduct flight research into takeoff, approach, and landing problems. The airplane and its preliminary performance characteristics are described in references 1 and 2.

The QSRA is powered by four YF-102 engines manufactured by AVCO Corp. Lycoming Division, Stratford, Connecticut. The engines were built for use on the Northrup A-9A aircraft. At the conclusion of the A-9A program at Edwards Air Force Base, the YF-102 engines were obtained by NASA. Five of the engines were refurbished at the factory for use on QSRA. At the same time, some configuration changes (including addition of a core airbleed manifold) were made, as described in reference 3. One of these engines was sent to the NASA Lewis Research Center to be used in obtaining test data for designing the QSRA propulsion system and noise suppression treatment.

The NASA Lewis test program was planned to measure both the acoustic characteristics and the aerodynamic performance of the engine. The results of some of these tests are reported in references 4 to 6. The tests that assess the steady-state aerodynamic engine performance (for no airbleed or power extraction) are reported herein. Other tests, not reported, included engine acceleration and deceleration tests with core airbleed up to 14 percent of the core inlet airflow. The objectives of the steady-state tests were as follows:

(1) To gain NASA experience with engine performance and characteristics
(2) To test the engine with confluent-flow exhaust systems (few data were then available)
(3) To compare the measured performance with the performance estimated by the Lycoming engine-simulation computer program
(4) To provide design information for the QSRA

At the time the NASA Lewis test program was begun, the final QSRA configuration had not yet been determined. Consequently, both separate-flow and confluent-flow exhaust systems were tested. For convenience, economy, and ease in comparing results, the exhaust-system hardware was made up of simple round shapes that had effective flow areas in the range of interest for QSRA. All tests were performed with a bellmouth inlet on an outdoor static test stand. Engine performance parameters were measured over a full range of power settings. Flow surveys were made inside the engine and in the jet exhaust plume. Data are presented in graphs and tables.

APPARATUS

Engine

The Lycoming YF-102 engine (complete designation YF-102-LD-100 (QSRA updated), Lycoming Model ALF 502A) is a twin-spool turbofan powerplant. Illustrative sketches of the engine are shown in figure 2. The core engine consists of a combination seven-stage axial and single-stage centrifugal compressor driven by a two-stage axial turbine and an external atomizing combustor. An interstage bleed valve (ISBV) vents air from the sixth axial compressor stage, as required, to prevent compressor stall. This valve is open at low power settings and during rapid thrust transients and is automatically closed by a schedule in the fuel control. The front fan and one supercharging stage are driven by a two-stage, free coaxial power turbine through a 2.3-to-1 speed-reducing gear system. Maximum rating performance at sea-level static conditions with ideal inlet and exhaust systems is 33 360 newtons (7500 lb) thrust (minimum), 7600 rpm fan speed (maximum), and 6.2 bypass ratio (nominal). Maximum rating is defined by the manufacturer as the performance at 1194 K (1690° F) measured gas temperature (MGT) or at any of several other defined mechanical limits during off-design operation. The MGT is the average temperature sensed by 10 thermocouples spaced throughout the flow passage at the power turbine inlet.

Inlet System

The air inlet system used for all tests, shown in figures 3 and 4, consisted of a bellmouth and a transition section supported from the test stand and connected to the engine by a flexible joint. The bellmouth, previously used in another test program, was 193 centimeters (76 in.) in diameter at the inlet and had a straight exit section 112 centimeters (44 in.) in diameter. The transition section reduced the airflow passage to 101.6 centimeters (40 in.), the diameter of the engine inlet. The flexible joint included a soft neoprene seal and prevented transfer of large inlet system loads to the engine.

Separate-Flow Exhaust Systems

The separate-flow exhaust systems used for these tests (fig. 3) consisted of a core cowling, a core engine nozzle, and a fan nozzle. The core cowling was the same as that used on the A-9A airplane, except that it was shortened 13 centimeters (5 in.) for certain acoustic tests. The cowling was made of stainless-steel skin and frames and was mounted in cantilever fashion from a lip on the core engine.

The basic core nozzle was also the same as that used on the A-9A airplane. It consisted of a conical steel shell with a short straight section at the exit. A centerbody was attached to the shell by six flow-straightening vanes. The nozzle had a geometric exit area of 1361 square centimeters (210.9 in^2). For the smaller-core-nozzle configuration, the basic nozzle was made smaller by adding a conical insert at the aft end. The smaller nozzle had a geometric exit area of 1163 square centimeters (180.2 in^2).

The basic fan nozzle was a conical shell mounted from an engine flange aft of the frame assembly. The diameter of the basic nozzle was 99.9 centimeters (39.3 in.), which provided a geometric annular flow area of 3640 square centimeters (564 in^2). The smaller fan nozzle had the same wall angle as the basic nozzle but was 96.5 centimeters (38.0 in.) in diameter. The smaller fan nozzle provided 3230 square centimeters (500 in^2) of geometric annular flow area.

The basic separate-flow configuration (S-1) used the basic fan and core nozzles. These nozzles were approximately the sizes recommended by Lycoming for QSRA if the final design used a separate-flow exhaust system.

Confluent-Flow Exhaust Systems

The confluent-flow exhaust systems used for these tests (fig. 4) consisted of a core cowling, a core-engine nozzle, and a bypass-flow duct ending in an exhaust nozzle for the combined fan and core flows. The two configurations that used the same core nozzle are shown in figure 4(a). The core cowling was the same as that used for the separate-flow configurations, except that small scoops were installed over the existing ventilation ports at the forward end to force air into the engine space. Also, a 33-centimeter- (13-in.-) long aft skirt was added to the cowling to smooth the flow passage over the core nozzle.

The core nozzle is intended to diffuse the core flow in order to produce a satisfactory static-pressure match with the bypass flow at the mixing plane. To this end the basic nozzle consisted of a divergent cone attached to the shell of an A-9A core nozzle downstream of the straightening vanes. Although this resulted in a long nozzle, it was simple to fabricate and was expected to be aerodynamically successful because the flow would be fairly uniform before it began to diffuse. The exit diameter was 46.35 centimeters (18.25 in.), and the geometric exit area was 1687 square centimeters (261.5 in^2). The bypass-flow duct was made of steel extension and adapter spools and included a flexible joint near the engine mounting flange. The basic exhaust nozzle had a diameter of 78.2 centimeters (30.79 in.), which provided a geometric flow area of 4803 square centimeters (744.4 in^2). The geometric flow area in the bypass duct at the mixing plane was 4451 square centimeters (689.9 in^2).

The basic confluent-flow configuration (C-1) used the basic core and exhaust nozzles assembled as shown in figure 4(a). The nozzle areas, bypass-flow-duct area, and mixing length were approximately the same as those used for QSRA performance estimates if the final design used a confluent-flow exhaust system.

The larger exhaust nozzle, also shown in figure 4(a), had the same wall angle as the basic exhaust nozzle but had an exit diameter of 83.22 centimeters (32.80 in.), which provided a geometric flow area of 5453 square centimeters (845.2 in^2). The mixing length of this nozzle was only about half the mixing length of the basic nozzle.

The other confluent-flow configurations tested are shown in figure 4(b). The core cowling was the same as that for the configurations in figure 4(a), except that the aft skirt was not used. Two core nozzles are shown. The smaller core nozzle was the same as the basic core nozzle for the separate-flow configurations. The other nozzle was a short design intended to perform the same as the basic core nozzle. This nozzle consisted of a divergent conical outer steel shell with the straightening vanes and centerbody from the A-9A nozzle. The vanes were extended on both the inner and outer ends as required to mate to the new shell. The extensions were shaped and contoured by extrapolating the existing vane shape to the new radial length. No flow analyses were made to optimize the new vane contour. This nozzle had an exit diameter of 47.23 centimeters (18.59 in.), which provided a geometric flow area of 1752 square centimeters (271.5 in^2).

For the configurations shown in figure 4(b), the bypass-flow duct was the same as that in the basic confluent-flow configuration, except that a shorter adapter was used to give the same mixing length. Mixing-plane geometric flow areas and other pertinent information are included in the figure.

Instrumentation and Data Processing

The instrumentation used to measure engine steady-state performance is summarized in table I. The raw data for each test reading consisted of two scans of the complete instrument list. Most of the instrumentation was sampled once per scan (scan duration, ~15 sec), but net thrust and fan speed were sampled many times to obtain better average values. The raw data were recorded on the Lewis central data system and processed on a digital computer with a program specially written for these tests. The program averaged and listed the data; corrected results to standard-day temperature and pressure; and computed airflows, nozzle coefficients, and other performance parameters. The parameters used throughout this report are summarized in the appendix.

For some tests with the confluent-flow configurations, flow surveys were made with a traversing probe mounted from the bypass-flow duct either at the mixing plane (station 16) or at station 18. At either station, the probe could be located at the 90° or 135° circumferential position (aft, facing forward). The probe is shown in figure 5(a), and details of the pressure- and temperature-sensing elements are given in figure 5(b). Data from the probe, plus fan speed and probe position, were recorded while the probe was traversed slowly from the wall to the engine centerline and back to the wall again. The data were processed by a NASA Lewis computer program that collected data into "bins" spaced 0.64 centimeter (0.25 in.) apart, averaged like measurements in each bin, and then computed flow parameters from the averaged data. Fan speed was the grand average of all the fan speed measurements made during the whole traverse.

For some tests with the confluent-flow configurations, jet plume data were obtained with "super-rake." Super-rake is a large rake containing total-pressure, static-pressure, and total-temperature sensing elements mounted horizontally from a cart at a specified distance behind the engine. The super-rake on the mounting cart and in position for testing is shown in figures 6(a) and (b), and a schematic sketch of the rake is shown in figure 6(c). The data were processed by a NASA Lewis computer program, which averaged two scans of data at each super-rake station and then computed flow parameters from the averaged data.

At various places in this report, the data are identified by reading number. A typical identification is "007/045." The first number refers to the data-processing computer program, and the number after the slash mark identifies a particular data set. The computer program numbers are as follows:

Program 007 - Engine steady-state performance

Program 008 - Engine steady-state performance for acoustic tests

Program 009 - Traversing probe

Program 010 - Super-rake

Program 008 was a shortened version of 007 that accounted for removal of some instrumentation rakes for the acoustic tests.

Test Facility

All tests were conducted at the Vertical Lift Fan (VLF) Facility at the NASA Lewis Research Center. This facility is an outdoor, static engine test stand sheltered by a service building that is moved away on tracks before testing begins. The engine is shown ready for testing in figure 7. The engine was suspended beneath the thrust-measuring system, which can be pivoted around a vertical axis for operational convenience. Frameworks extending from the thrust-measuring system were used to mount inlet and exhaust ducts and other hardware separately from the engine. The engine centerline was 2.9 meters (9.5 ft) above the ground. The control room was about 150 meters (500 ft) from the engine.

PROCEDURE

For each configuration, the engine was run over a range of power settings from idle to as near 1194 K (1690° F) measured gas temperature (MGT) as feasible. Thus, the measured maximum performance depended on the ambient pressure and temperature at test time as well as on the configuration. All performance parameters have been corrected (or "referred") to standard-day ambient conditions so that valid comparisons can be made.

At preselected, corrected fan speeds, the engine was allowed to "steady out" for 2 minutes or longer. Data were taken when fan speed, which was affected by wind gusts and direction changes, was reasonably steady, as indicated by a strip-chart recorder in the control room. For all data, the wind speed was less than 3.6 meters per second (8 mph). The aerodynamic performance tests were intermixed with acoustic and other tests (e.g., tests reported in refs. 4 and 5). For many configurations and power settings the data were repeated so that different super-rake positions, traverses, etc., could be obtained at approximately the same fan speed.

RESULTS AND DISCUSSION

Method of Presentation

Experimental data. - All the important test results are listed in tables II to XIII. Typical results are also shown in graphical form and discussed in the text. The graphs were plotted from information in the tables. Measured and computed parameters, along with units, are summarized and defined in the appendix.

The engine with the basic confluent-flow configuration (C-1) was chosen as the baseline configuration. In this report, the performance of the engine with the other exhaust-system configurations generally is compared with this baseline.

Lycoming computer program. - For each configuration, the experimental performance is compared with the steady-state performance estimated for the same configuration by AVCO Lycoming program 10.12.113.25. This is an engine synthesis computer program usable for a large variety of inlet and exhaust systems over a wide range of flight conditions. The turbomachinery maps in the program were modified slightly from the standard model ALF 502 maps so they would represent more accurately the known performance of the particular engine used for these tests. Program input was as follows:

(1) Standard-day atmosphere: 10.132 N/cm^2 (14.696 lb/in^2) and 288.2 K (518.7° R)

(2) No inlet losses

(3) No power extraction or external airbleeds

(4) One-percent total-pressure loss in the bypass-flow duct, for confluent-flow configurations only. (This loss input adds to the duct loss (internally programmed) that occurs between the fan and the fan-nozzle mounting flange.)

(5) Effective flow areas and/or exhaust-system performance coefficients determined in the NASA Lewis test of that same configuration

The program output is a listing of the estimated performance at power settings from idle to maximum rating. Maximum rating is determined by reaching 1194 K (1690° F) MGT or by encountering any of several internally programmed mechanical limits for off-design operation. The program indicates when the interstage bleed valve (ISBV) is open but does not define a power setting at which it just begins to close.

Engine Performance

No serious mechanical problems or unusual operating behavior were encountered with the engine during this test program.

Basic confluent-flow configuration. - The performance of the engine with the basic confluent-flow configuration (C-1) is given in table II and in figures 8 to 16.

The variation of corrected thrust with corrected fan speed is shown in figure 8. The repeatability of the experimental data, which were taken on different test days, is very good. A dot-dashed line has been faired through the experimental data and is used herein as a baseline for comparison with the other configurations tested. The computer program provides a good estimate of the performance as shown by the dashed line in the figure. The largest difference between measured and estimated thrust, about 400 newtons (90 lb), occurred near maximum fan speed. The closure of the ISBV was not measured, but there is no reason to believe that it did not operate correctly within the predicted speed range.

The relation between corrected thrust and corrected MGT is shown in figure 9. The correction factor, $1/(\theta 1)^{1.022}$, is recommended by Lycoming. The estimated MGT was reasonably accurate at high power settings, but it tended to be greater than measured values at lower power settings. The thrust at the maximum performance rating for this configuration and for all the other configurations tested is discussed near the end of this section, Engine Performance.

The variation of corrected core-compressor speed with corrected fan speed is shown in figure 10. This graph shows that the estimated core speed was accurate, except near maximum power.

The corrected inlet airflow and the bypass ratio are shown as a function of corrected fan speed in figures 11 and 12, respectively. The measured airflow tended to be a little less than the nominal estimate but well within the ±3-percent allowable tolerance, except near idle power setting. The bypass ratio estimate was accurate at all power settings.

The measured total-pressure loss in the bypass-flow duct is shown in figure 13. Data from the other confluent-flow configurations tested are also included. The results seem to generalize well; the scatter was probably caused by configuration differences and the difficulty in measuring the average station-16 pressure accurately. (Only two fixed instrumentation rakes were used; see table I.) The pressure loss indicated by these results was approximated by the 1-percent total-pressure loss in the bypass-flow duct that was input to the Lycoming computer program.

The variation in corrected mixing-plane static pressure with corrected fan speed is shown in figure 14. The data plotted in this figure are a weighted average from station-6 and station-16 static-pressure instrumentation (table I). The data are in good agreement with the computer estimates, even though the static pressure measured during traverses varied throughout the mixing plane, as shown in detail in the section Internal-Flow Survey.

Figure 15 shows the free-skin temperature at various locations on the core cowling. The cowling skin was made from 0.081-centimeter- (0.032-in.-) thick 321 stainless steel. The increase in temperature at low fan speed was caused by the warm air vented under the cowling by the normal action of the ISBV.

As shown in figure 16, two of the six ventilating air scoops on the core cowling were specially instrumented with total-pressure sensing tubes. Although each scoop was in the wake of a strut on the fan frame, the pressure of the air entering the scoops was always greater than 92 percent of the fan discharge pressure.

Shorter-core-nozzle confluent-flow configuration. - Performance of the shorter-core-nozzle confluent-flow configuration (C-4) is given in table III and in figures 17 to 20. This configuration was designed to make the overall exhaust system shorter than the basic configuration while maintaining the same performance.

The variation of corrected thrust with corrected fan speed is shown in figure 17. The performance was almost identical to that of the basic configuration (dot-dashed line). The computer program provided a good estimate of the performance, as expected, because the flow areas and other program inputs were almost the same.

The similarity in performance with the basic confluent-flow configuration indicates that the basic and shorter-core-nozzle flow characteristics were essentially the same. As a further indication, the wall static pressures measured along the length of each nozzle are shown in figure 18. The data are presented as the ratio of wall pressure to measured total pressure at station 5 for various corrected fan speeds. They are plotted against nozzle geometric flow area in the plane containing the static-pressure tap. Similar station-5 rakes were used in both nozzles. For each nozzle, the wall pressures increased in the flow direction to the exit (except near the six vanes holding the centerbody). Separation would cause the measured wall pressure to become constant downstream of the separation point. Thus, no flow separation occurred in either nozzle, and the desired flow diffusion and static-pressure rise took place effectively.

The total pressure at the exits of the same two nozzles is given in figure 19. Data are presented as the ratio of the measured pressures at stations 6 and 5 and are shown as a function of corrected fan speed. The station-6 data were obtained during mixing-plane flow surveys, from which the area-weighted average total pressures were computed for this figure. The station-5 data were obtained from fixed rakes. However, the flow passages were not identical in the two nozzles forward of station 5, so the total-pressure losses (not measured in these tests) from the inlet to station 5 could be different. Hence, no direct comparison of losses for the whole nozzles can be made. On the basis of the data available, up to 2.5 percent loss was measured at high power setting. The basic nozzle appeared to have the greater loss, probably because of its longer length.

The corrected thrust specific fuel consumption for the shorter-core-nozzle confluent-flow configuration (C-4) is shown in figure 20. The shape of the curve is conventional. The best performance was attained at 20 000 newtons (4500 lb) corrected thrust and is 0.0105 g fuel/sec N thrust (0.37 lb fuel/hp lb thrust). The computer program estimates the performance very well at all power settings when the ISBV is closed. This is the only configuration for which a full set of reliable fuel-flow data were obtained.

Other confluent-flow configurations. - The performances of the larger-exhaust-nozzle confluent-flow configuration (C-5) and the smaller-core-nozzle confluent-flow configuration (C-6) are given in tables IV and V and figures 21 and 22, respectively. The corrected thrust for the larger exhaust nozzle, shown as a function of corrected fan speed in the figure, was significantly less than that for the basic confluent-flow configuration (C-1). The corrected thrust for the smaller core nozzle was a little better than that for the basic configuration. The computer program showed trends and estimated the performance reasonably well for both configurations.

Separate-flow configurations. - The performances of the basic separate-flow configuration (S-1), the smaller-core-nozzle separate-flow configuration (S-3), and the smaller-fan-nozzle separate-flow configuration (S-4) are given in tables VI to VIII and figures 23 to 25, respectively. As shown in the figures, for each configuration the corrected thrust at a given corrected fan speed was the same or slightly less than that for the basic confluent-flow configuration (C-1). The computer program predicted the direction of these trends but did not always accurately predict the magnitude of the changes. The largest difference between measured and estimated thrust occurred near maximum fan speed for separate-flow configurations S-1 and S-3; for each, the difference was 900 newtons (200 lb).

Thrust at maximum performance rating. - For the YF-102 engine the maximum rating is defined as the performance at 1194 K (2150° R, 1690° F) MGT or at some other limiting mechanical condition in the engine if that condition is reached at lesser MGT. For each configuration tested, the thrust at maximum rating for standard-day static conditions was determined by plotting corrected measured thrust against corrected measured MGT and reading the curve faired through these data at 1194 K corrected MGT (extrapolating, if necessary). Fan speed at maximum rating was found in a similar manner by plotting corrected fan speed against corrected MGT.

The experimental and estimated thrusts at maximum rating for standard-day static conditions for all the configurations tested are compared in figure 26. On this basis, the basic separate-flow configuration (S-1) produced the most thrust. The larger-exhaust-nozzle confluent-flow configuration (C-5) was next best, but that maximum thrust could be attained only on cold days because limiting mechanical fan speed was 7600 rpm. The smaller-fan-nozzle separate-flow configuration (S-4) had the next best performance; it provided about 300 newtons (70 lb) more thrust than the basic confluent-flow configuration. The differences in engine performance are attributed to changes in the core-fan speed match line caused by nozzle area changes as well as by differences in exhaust-system performance. The range of speed match covered in these tests is shown in figure 27. For the same fan speed, the core speed was lowest for the larger-exhaust-nozzle confluent-flow configuration (C-5) and was highest for the smaller-core-nozzle confluent-flow configuration (C-6).

It must be emphasized that the comparisons discussed herein refer to standard-day static performance only, since only outdoor test-stand data were obtained. The choice of an exhaust system for a particular application would be based on the performance at pertinent flight conditions and altitudes, as well as on ground performance.

Internal-Flow Survey

Internal-flow surveys were made with fixed rakes at station 13.2 and with a traversing probe at the mixing plane (station 16) and at station 18 for some of the confluent-flow configurations. The data are given in tables IX to XI and in figures 28 to 30. An index of the tabulated data is as follows:

Confluent-flow configuration	Table	Data taken at stations	Approximate fan speed, rpm
Basic (C-1)	IX(a), (b), (c)	13.2, 16, 18	3810
	IX(d), (e), (f)	13.2, 16, 18	4580
	IX(g), (h), (i)	13.2, 16, 18	5730
	IX(j), (k), (l)	13.2, 16, 18	7260
Shorter core nozzle (C-4)	X(a), (b), (c), (d)	16	3660, 4410, 5500, 6960
Larger exhaust nozzle (C-5)	XI(a), (b), (c)	18	4570, 6460, 7610

In these tables, available data have been averaged, where deemed appropriate, to show the most meaningful results. Thus, at stations 16 and 18, data from traverse surveys at 90° and 135° circumferential positions have been averaged for the tables, except where noted.

Typical flow-velocity data from the tables have been plotted for the basic confluent-flow configuration in figure 28. In the bypass duct the flow velocity was reasonably uniform across the station-13.2 annular area. At the mixing plane both the core and bypass flows can be recognized easily. The bypass flow had diffused somewhat at both the inner and outer walls, but the main body of the flow had about the same velocity as that at station 13.2. The core flow had a large velocity deficit at its center, probably caused by lower energy flow entering the nozzle from the turbine hub area at this speed, as well as by flow losses over the nozzle centerbody. At station 18 both flows had expanded to greater velocity. They probably had begun to mix because the velocity gradients have begun to disappear; however, the percentage of mixing was not computed.

Tables IX to XI show that an appreciable stream static-pressure gradient existed in the mixing plane. The magnitude of the gradient is shown in figure 29, in which the corrected static pressure is shown as a function of the duct radius in the mixing plane. The data are for the basic confluent-flow configuration at two corrected fan speeds. In this figure, the solid lines denote stream static pressure measured during traverses, and the symbols represent such measurements from fixed instrumentation. The static pressure increased from the centerline to the bypass duct wall. Most of the variation occurred in the core stream, and the increase was greater at high fan speed.

Wall static pressures were measured at several stations on the exhaust nozzle wall out to the exit. As part of the study of the confluent-flow systems, the stream static-pressure variation along the length of the exhaust nozzle was computed by the method given in reference 7. In this method, the core and bypass flows are treated as unmixed one-dimensional isentropic confluent flows in which the static pressure is uniform in planes normal to the streamlines. These planes were assumed to be normal to the nozzle axis for the computations shown herein. As shown in figure 29, the condition of uniform static pressure was not met exactly, especially in the core flow at high speeds. For the computations, the effective areas, flow rates, total pressures, and total temperatures measured in performance tests of the same configurations were used.

Results of the theoretical computations are compared with the experimental data in figure 30 for two configurations and two fan speeds. The theoretical stream static pressures compared reasonably well with the measured wall static pressures and were always less than the wall pressures, as expected for the converging passage. In the figure, experimental data and computed pressures also are shown for the bypass-flow duct upstream (negative downstream distance) of the mixing plane. The pressures were computed from isentropic one-dimensional flow relations and the flow coefficient at station 16. Agreement between the computed and measured pressures was not very good, probably because the flow coefficient was changing in the upstream duct.

External-Flow Surveys

External-flow surveys were made with the super-rake for some of the confluent-flow configurations. These data are shown in tables XII and XIII and in figures 31 and 32. An index of the tabulated data is as follows:

Confluent-flow configuration	Table	Data-plane distance from exit, cm	Approximate fan speed, rpm
Basic (C-1)	XII(a), (b), (c)	62, 152, 305	3800
	XII(d), (d), (f)	62, 152, 305	4580
	XII(g), (h), (i)	62, 152, 305	5700
	XII(j), (k)	152, 305	7210
Larger exhaust nozzle (C-5)	XIII(a), (b), (c)	152	4580, 6470, 7580

Typical jet-plume velocity data from the tables, along with data previously shown for station 18, are plotted in figure 31. The results show that the jet began to mix and dissipate soon after it left the nozzle. At 3 meters (10 ft) downstream, the high-velocity core remained, but the rest of the jet had spread considerably. The jet plume appeared to be asymmetric, or skewed to the engine centerline. This result appeared consistently in the external-flow survey data from this engine, but the reason is not known.

Typical super-rake data, in normalized form, are shown in figure 32 for a station 152 centimeters (5 ft) aft of the exhaust nozzle in the basic confluent-flow configuration. This figure shows that the skewed velocity pattern noted in the previous figure is related to the total-pressure, stream-static-pressure, and total-temperature gradients, all of which are asymmetric in the measurement plane. Other than asymmetry, the gradients seem to be of normal shape and expected magnitude for this type of jet exhaust.

SUMMARY OF RESULTS

The Lycoming YF-102 turbofan engine performed satisfactorily with each of the seven exhaust-system configurations tested. The three separate-flow systems were the basic, the smaller-core-nozzle, and the smaller-fan-nozzle configurations. The four confluent-flow configurations were the basic, the shorter-core-nozzle, and the smaller-core-nozzle configurations. The most important results of the test program are as follows:

1. An engine-synthesis computer program, supplied by Lycoming, provided good estimates of the engine performance and thrust at maximum performance rating for each configuration tested. Inputs necessary for the program include bypass-duct pressure loss (for confluent-flow configurations) and effective flow areas and/or exhaust-system performance coefficients. The largest difference between measured and estimated thrust, 900 newtons (200 lb), occurred for the basic separate-flow configuration near

maximum power. Performance data for all the configurations tested are given in comprehensive tables.

2. Two core nozzles for the confluent-flow systems, the basic nozzle and a shorter nozzle of significantly different design, were tested. Both gave satisfactory internal performance, based on wall static-pressure measurements and overall engine performance.

3. Internal-flow surveys were made, for some of the confluent-flow configurations, in the bypass-flow duct and in the exhaust nozzle. No unusual results were noted. The wall pressures in the nozzle were estimated satisfactorily by compound compressible flow computations. For these computations the flow model is based on the assumption of one-dimensional isentropic flow in both the core and bypass streams, with no mixing.

4. External-flow surveys were made, for some of the confluent-flow configurations, with a large fixed rake. The rake data showed that the jet plume was asymmetric - or skewed to the engine centerline - but otherwise showed expected pressure, temperature, and velocity gradients.

Lewis Research Center,
National Aeronautics and Space Administration
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769-02.

APPENDIX - SYMBOLS[1]

A geometric flow area (temperature corrected for core nozzles), cm^2 (in^2)

BARO ambient atmospheric pressure, N/cm^2 (lb/in^2)

CAEXIT for confluent-flow configurations, the sum of the theoretical area required for station-16 flow when it has expanded isentropically to BARO, plus the theoretical area required for station-6 flow when it has expanded to BARO, all divided by A18, dimensionless

CDENG core-nozzle discharge coefficient for separate-flow configurations,

$$\frac{W8}{BARO(A8)}\sqrt{\frac{2\gamma g}{R(\gamma - 1)(TT8)}\left[(H8)^{(\gamma-1)/\gamma} - 1\right](H8)^{(\gamma-1)/\gamma}}, \text{ dimensionless}$$

CDFAN fan-nozzle discharge coefficient for separate-flow configurations,

$$\frac{W13.2}{BARO(A18)}\sqrt{\frac{2\gamma g}{R(\gamma - 1)(TT13.2)}\left[(H18)^{(\gamma-1)/\gamma} - 1\right](H8)^{(\gamma-1)/\gamma}},$$

dimensionless

CFDUCT flow coefficient for bypass-flow duct at mixing plane for confluent-flow configurations,

$$\frac{W13.2}{PS16(A16)}\sqrt{\frac{2\gamma g}{R(\gamma - 1)(TT13.2)}\left[\left(\frac{PT16}{PS16}\right)^{(\gamma-1)/\gamma} - 1\right]\left(\frac{PT16}{PS16}\right)^{(\gamma-1)/\gamma}},$$

dimensionless

CFENG core-nozzle flow coefficient for confluent-flow configurations,

$$\frac{W6}{PS6(A6)}\sqrt{\frac{2\gamma g}{R(\gamma - 1)(TT5)}\left[\left(\frac{PT5}{PS6}\right)^{(\gamma-1)/\gamma} - 1\right]\left(\frac{PT5}{PS6}\right)^{(\gamma-1)/\gamma}}, \text{ dimensionless}$$

CVENG core-nozzle velocity coefficient for separate-flow configurations, dimensionless. (For these tests, CVENG was interpolated from the following: PT5/PS8 = 1.0, 1.2, 1.4; CVENG = 0.970, 0.976, 0.981.)

CVEXIT exhaust-nozzle velocity coefficient for confluent-flow configurations, $gFG/\left[W13.2(VIDFAN) + W6(VIDENG)\right]$, dimensionless

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[1]When numbers follow the symbols A, PS, PT, PW, TT, W, δ, and θ, the numbers refer to stations.

CVFAN fan-nozzle velocity coefficient for separate-flow configurations, $g\left[(FG) - (FGENG)\right]/W13.2(VIDFAN)$, dimensionless

FG gross thrust, FM + (Inlet momentum from headwind, if any), N (lb)

FGENG core-nozzle gross thrust for separate-flow configurations,

$$\frac{W8(CVENG)}{g}\sqrt{\frac{2\gamma gR(TT8)}{\gamma - 1}\left[1 - \left(\frac{PS8}{PT8}\right)^{(\gamma-1)/\gamma}\right]} + (PS8 - BARO)A8, \quad N\ (lb)$$

FGK1 corrected gross thrust, $FG/\delta 1$, N (lb)

FM measured thrust, N (lb)

FPR fan pressure ratio, PT13.2/PT12, dimensionless. (For these tests, assume that PT12 = PT1 = PT0.)

FTR fan temperature ratio, TT13.2/TT12, dimensionless. (For these tests, assume that TT12 = TT1 = TT0.)

g acceleration due to vravity, cm/sec^2 (ft/sec^2). (For these tests, $g = 980.7\ cm/sec^2$ ($32.174\ ft/sec^2$).)

HCPR core-compressor pressure ratio, PT3/PT2.1, dimensionless

H6 core-nozzle pressure ratio for confluent-flow configurations, PT5/BARO, dimensionless

H8 core-nozzle pressure ratio for separate-flow configurations, PT5/BARO, dimensionless

H16 bypass-flow pressure ratio for confluent-flow configurations, PT16/BARO, dimensionless

LCPR supercharger pressure ratio, PT2.1/PT1, dimensionless

NF fan speed, rpm

NFK1 fan speed corrected to engine inlet conditions, $NF/\sqrt{\theta 1}$, rpm

NG core-compressor speed, rpm

NGK1 core-compressor speed corrected to engine inlet conditions, $NG\sqrt{\theta 1}$, rpm

NGK2.1 core-compressor speed corrected to compressor inlet conditions, $NG\sqrt{\theta 2.1}$, rpm

PS static pressure, N/cm^2 (lb/in^2)

PS6 core-nozzle exhaust pressure for confluent-flow configurations, N/cm^2 (lb/in^2). (For these tests, PS6 was measured by the average of exit-plane wall static and lip static instrumentation.)

PS8 core-nozzle exhaust pressure for separate-flow configurations, N/cm^2 (lb/in^2). (For these tests, PS8 was measured by the average of exit-plane wall static and lip static instrumentation.)

PS8K1 core-nozzle exhaust pressure for separate-flow configurations corrected to engine inlet conditions, PS8/δ1, N/cm^2 (lb/in^2)

PS16 mixing-plane static pressure for confluent-flow configurations, N/cm^2 (lb/in^2). (For these tests, PS16 = $\left[3(PW16) + PS6\right]/4$, arbitrarily.)

PS16K1 mixing-plane static pressure for confluent-flow configurations, corrected to engine inlet conditions, PS16/δ1, N/cm^2 (lb/in^2)

PT total pressure, N/cm^2 (lb/in^2)

PW wall static pressure, N/cm^2 (lb/in^2)

R gas constant, evaluated at appropriate temperature and gas composition, J/g K (ft/^{o}R). (For these tests, R = 0.2871 J/g K (53.35 ft/^{o}R) for air near ambient temperature.)

TT total temperature, K (^{o}R). (For these tests, assume TT1 = TT0.)

T4.1K1 measured gas temperature corrected to engine inlet conditions, $TT4.1/(\theta 1)^{1.022}$, K (^{o}R)

VIDENG core-nozzle exhaust velocity if flow expanded isentropically to BARO, m/sec (ft/sec). (For confluent-flow configurations,

$$\text{VIDENG} = \sqrt{\frac{2\gamma gR(TT5)}{\gamma - 1}\left[1 - \left(\frac{1}{H6}\right)^{(\gamma-1)/\gamma}\right]}$$

For separate-flow configurations, replace H6 with H8.)

VIDFAN bypass-flow exhaust velocity if flow expanded isentropically to BARO, m/sec (ft/sec). (For confluent-flow configurations,

$$\text{VIDFAN} = \sqrt{\frac{2\gamma gR(TT13.2)}{\gamma - 1}\left[1 - \left(\frac{1}{H16}\right)^{(\gamma-1)/\gamma}\right]}$$

For separate-flow configurations, replace H16 with PT13.2/BARO.)

W gas flow rate, kg/sec (lb/sec)

WFUEL	fuel flow rate, g/sec (lb/hr)
WFUELK1	fuel flow rate corrected to engine inlet conditions, $WFUEL/(\delta 1)\sqrt{\theta 1}$, g/sec (lb/hr)
W1K1	inlet airflow corrected to engine inlet conditions, $W1\left(\sqrt{\theta 1}\right)/\delta 1$, kg/sec (lb/sec)
W2.1K1	core airflow corrected to engine inlet conditions, $W2.1\left(\sqrt{\theta 1}\right)/\delta 1$, kg/sec (lb/sec)
W2.1K2.1	core airflow corrected to core-compressor inlet conditions, $W2.1\left(\sqrt{\theta 2.1}\right)/\delta 2.1$, kg/sec (lb/sec)
W13.2	bypass flow rate, W1 - W2.1, kg/sec (lb/sec)
γ	ratio of specific heats, evaluated at appropriate temperature and gas composition, dimensionless. (For these tests, $\gamma = 1.4$ for air near ambient temperature.)
δ	ratio of pressure to standard-day pressure, dimensionless. (For these tests, $\delta 1 = \delta 0 = PT/10.132\ N/cm^2$ ($PT/14.696\ lb/in^2$).)
θ	ratio of total temperature to standard-day temperature, dimensionless. (For these tests, $\theta 1 = \theta 0 = TT/288.2\ K$ ($TT/518.7^{\circ}\ R$).)

REFERENCES

1. Cochrane, J. A.; and Boissevain, A. G.: Quiet, Short-Haul Research Aircraft - Current Status and Future Plans. AIAA Paper 78-1468, Aug. 1978.
2. Shovlin, M. D.; and Cochrane, J. A.: An Overview of the Quiet Short-Haul Research Aircraft Program. NASA TM-78545, 1978.
3. Engine Specification, YF102 (QSRA Updated) Lycoming Model No. ALF 502A Turbofan Engine. Specification No. 124.36D, AVCO Lycoming Division, 1976.
4. Clark, B. J.; McArdle, J. G.; and Homyak, L.: Measured and Predicted Noise of the AVCO-Lycoming YF102 Turbofan Engine. AIAA Paper 79-0641, Mar. 1979.
5. Gunnarson, D. W.; and McArdle, J. G.: Development and Test of an Inlet and Duct to Provide Airflow for a Wing Boundary Layer Control System. AIAA Paper 78-141, Jan. 1978.
6. Reshotko, M.; et al.: Core Noise Measurements on a YF102 Turbofan Engine. AIAA Paper 77-21, Jan. 1977.

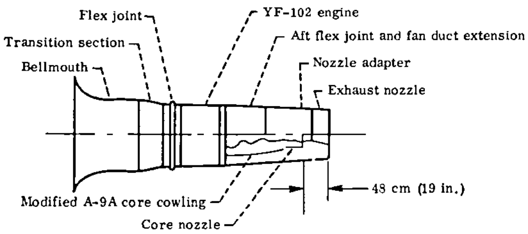
TABLE I. - ENGINE PERFORMANCE INSTRUMENTATION

Station	Total pressure	Wall static pressure	Lip static pressure	Total temperature	Wall temperature
	Number of sensing points				
0				6	
1		4			
2.1	[a]2	2		2	
3	1	1		2	
4.1				[b]1	
5	15	3		6	
6		3	2		2
8		3	6		2
13.2	40	4		20	
16	14	4		7	
18		3	1		
Core cowling					4
Aft length of bypass duct		12			
Aft length of core nozzle		8			
Miscellaneous (net thrust, fan speed, core speed, fuel flow rate, (core) inlet guide vane position, ambient atmospheric and wind conditions, and engine health measurements)					

[a]Two integrating rakes; each rake obtained a single pressure measurement from 10 sampling ports spaced across the flow passage.
[b]Single output from 10 thermocouples spaced throughout flow passage, all wired in parallel. This measurement is also called measured gas temperature (MGT).

TABLE II. - BASIC CONFLUENT-FLOW CONFIGURATION (C-1)

[Area at station 16, 4451 cm^2 (690 in^2); exhaust-nozzle area, 4803 cm^2 (744 in^2); core-nozzle area, 1687 cm^2 (262 in^2)]



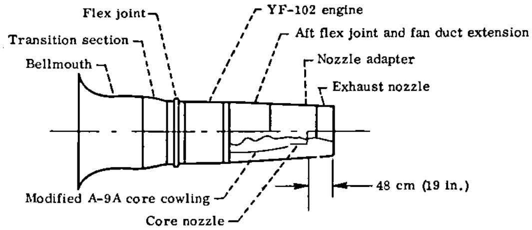
Reading	Fan speed corrected to engine inlet conditions, NFK1, rpm	Fan pressure ratio, FPR	Fan temperature ratio, FTR	Core compressor speed corrected to engine inlet conditions, NGK1, rpm	Core compressor speed corrected to compressor inlet conditions, NGK2.1, rpm	Supercharger pressure ratio, LCPR	Core compressor pressure ratio, HCPR	Measured gas temperature corrected to engine inlet conditions, T4.1K1		Corrected gross thrust, FGK1		Inlet airflow corrected to engine inlet conditions, W1K1		Core airflow corrected to engine inlet conditions, W2.1K1	
								K	°R	N	lb	kg/sec	lb/sec	kg/sec	lb/sec
7/046[a]	2741.2	1.0522	1.0200	12 896	12 705	1.0715	2.8970	707.33	1273.2	4 069	914.8	43.571	96.058	7.2843	16.059
7/047[a]	3812.9	1.1028	1.0343	14 647	14 246	1.1698	3.8822	722.28	1300.1	7 952.9	1787.9	60.885	134.23	8.4586	18.648
7/048[a]	4547.1	1.1526	1.0491	15 876	15 256	1.2481	4.5331	798.72	1437.7	11 570	2601.0	73.513	162.07	10.080	22.222
7/049[a]	5719.4	1.2569	1.0769	17 349	16 376	1.4192	5.4117	946.33	1703.4	19 097	4293.3	93.589	206.33	12.684	27.964
7/050[a]	6534.9	1.3529	1.1025	18 253	16 960	1.5724	5.9516	1066.1	1918.9	25 791	5798.0	107.75	237.54	14.813	32.658
7/051[a]	6728.8	1.3889	1.1105	18 526	17 150	1.6129	6.2889	1110.3	1998.5	28 246	6350.0	112.33	247.64	15.680	34.569
7/052[a]	7163.9	1.4427	1.1221	18 914	17 376	1.6740	6.5896	1167.4	2101.3	31 529	7088.0	118.51	261.27	16.505	36.388
7/057[b]	4547.1	1.1499	1.0477	15 799	15 218	1.2475	4.5088	793.94	1429.1	11 516	2588.9	72.801	160.50	10.077	22.215
7/066[b]	6476.5	1.3455	1.0982	18 201	16 941	1.5477	6.0351	1056.3	1901.4	25 352	5699.5	106.79	235.44	14.610	32.209
7/068[b]	7220.7	1.4422	1.1259	18 975	17 403	1.6925	6.5909	1172.9	2111.2	32 375	7278.3	119.04	262.43	16.838	37.121
7/070[b]	3794.5	1.1035	1.0338	14 664	14 283	1.1674	3.8856	722.61	1300.7	7 996.1	1797.6	61.221	134.97	8.5475	18.844
7/072[b]	5695.9	1.2557	1.0766	17 348	16 381	1.4122	5.4080	942.56	1696.6	18 931	4255.8	93.199	205.47	12.729	28.063

Reading	Core airflow corrected to core-compressor inlet conditions, W2.1K2.1		Fuel flow rate corrected to engine inlet conditions, WFUELK1		Core-nozzle pressure ratio, H6	Core-nozzle exhaust velocity if flow expanded isentropically to ambient atmospheric pressure, VIDENG		Core-nozzle flow coefficient, CFENG	Mixing-plane static pressure corrected to engine inlet conditions, PS16K1		Bypass-flow pressure ratio, H16	Bypass-flow exhaust velocity if flow expanded isentropically to ambient atmospheric pressure, VIDFAN		Exhaust nozzle velocity coefficient, CVEXIT	Sum of theoretical areas for station-16 and station-6 flows expanded isentropically to ambient atmospheric pressure, divided by area at station 18, CAEXIT
	kg/sec	lb/sec	g/sec	lb/hr		m/sec	ft/sec		N/cm^2	lb/in^2		m/sec	ft/sec		
7/046[a]	6.9005	15.213	-------	-------	1.0360	107.16	351.56	-------	10.317	14.964	1.0492	90.608	297.27	-------	-------
7/047[a]	7.4344	16.390	-------	-------	1.0634	153.63	504.05	0.88817	10.500	15.226	1.0972	126.37	414.60	0.99619	0.93342
7/048[a]	8.4037	18.527	-------	-------	1.0919	190.10	623.68	.93571	10.697	15.514	1.1461	153.31	502.99	.99888	.93933
7/049[a]	9.4692	20.876	-------	-------	1.1605	261.86	859.11	.96116	11.150	16.172	1.2452	196.49	644.65	.99956	.94239
7/050[a]	10.139	22.353	-------	-------	1.2326	324.43	1064.4	.97025	11.632	16.871	1.3423	229.16	751.85	.99278	.93944
7/051[a]	10.502	23.152	-------	-------	1.2713	352.68	1157.1	.94356	11.826	17.152	1.3756	238.96	784.00	.99138	.93752
7/052[a]	10.732	23.661	-------	-------	1.3179	387.52	1271.4	.93209	12.131	17.595	1.4282	253.64	832.15	.98176	.93574
7/057[b]	8.3855	18.487	-------	-------	1.0909	188.61	618.79	.93716	10.681	15.492	1.1432	152.20	499.36	1.0123	.93622
7/066[b]	10.141	22.358	-------	-------	1.2249	318.79	1045.9	.97801	11.594	16.815	1.3348	226.39	742.75	.99726	.93983
7/068[b]	10.847	23.914	-------	-------	1.3208	387.16	1270.2	.94315	12.149	17.621	1.4320	254.26	834.19	.99854	.93785
7/070[b]	7.5174	16.573	-------	-------	1.0629	152.81	501.34	.91249	10.501	15.230	1.0990	127.02	416.72	1.0041	.93345
7/072[b]	9.5531	21.061	-------	-------	1.1584	259.04	849.88	.9702	11.141	16.159	1.2454	196.43	644.46	.99369	.93850

[a]Inlet air temperature, 293 K (528° R); barometric pressure, 9.865 N/m^2 (14.308 psia).
[b]Inlet air temperature, 292 K (526° R); barometric pressure, 9.906 N/m^2 (14 368 psia).

TABLE III. - SHORTER-CORE-NOZZLE CONFLUENT-FLOW CONFIGURATION (C-4)

[Area at station 16, 4510 cm^2 (699 in^2); exhaust-nozzle area, 4803 cm^2 (744 in^2); core-nozzle area, 1752 cm^2 (272 in^2).]



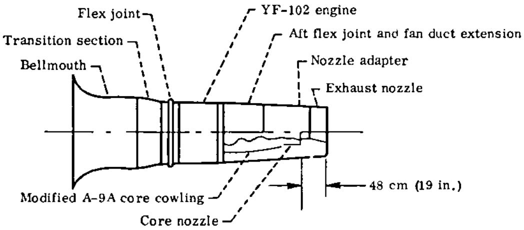
Reading[a]	Fan speed corrected to engine inlet conditions, NFK1, rpm	Fan pressure ratio, FPR	Fan temperature ratio, FTR	Core compressor speed corrected to engine inlet conditions, NGK1, rpm	Core compressor speed corrected to compressor inlet conditions, NGK2.1, rpm	Supercharger pressure ratio, LCPR	Core compressor pressure ratio, HCPR	Measured gas temperature corrected to engine inlet conditions, T4.1K1: K	T4.1K1: °R	Corrected gross thrust, FGK1: N	FGK1: lb	Inlet airflow corrected to engine inlet conditions, W1K1: kg/sec	W1K1: lb/sec	Core airflow corrected to engine inlet conditions, W2.1K1: kg/sec	W2.1K1: lb/sec
7/250	2944.4	1.0583	1.0212	13 379	13 161	1.0893	3.0951	714.83	1286.7	4 722.2	1061.6	46.842	103.27	7.8898	17.394
7/252	3791.1	1.1007	1.0328	14 564	14 171	1.1615	3.9000	720.11	1296.2	7 895.6	1775.0	61.054	134.60	8.2953	18.288
7/253	4527.4	1.1507	1.0475	15 775	15 180	1.2529	4.5063	792.94	1427.3	11 483	2581.5	73.555	162.16	10.154	22.385
7/255	5653.9	1.2488	1.0745	17 217	16 249	1.4100	5.4001	938.22	1688.8	18 494	4157.7	92.619	204.19	12.586	27.748
7/256	6467.5	1.3442	1.0987	18 201	16 921	1.5628	5.9572	1056.4	1901.5	25 551	5744.2	107.02	235.94	14.796	32.620
7/257	6822.4	1.3912	1.1093	18 574	17 153	1.6237	6.2735	1114.6	2006.3	28 628	6435.9	112.85	248.79	15.693	34.598
7/258	7196.0	1.4454	1.1252	18 976	17 392	1.6999	6.5795	1179.6	2123.2	32 307	7263.0	119.39	263.20	16.902	37.263
7/259	7426.9	1.4782	1.1328	19 233	17 534	1.7496	6.7863	1218.9	2194.0	34 447	7744.1	122.61	270.30	17.652	38.915
7/261	3764.9	1.0984	1.0316	14 529	14 146	1.1669	3.8283	718.39	1293.1	7 744.4	1741.0	60.446	133.26	8.4423	18.612
7/263	5702.6	1.2545	1.0751	17 310	16 328	1.4182	5.4084	943.72	1698.7	18 964	4263.2	93.408	205.93	12.662	27.914
7/265	6839.2	1.3952	1.1113	18 614	17 171	1.6308	6.3116	1119.4	2014.9	28 756	6464.6	113.26	249.69	15.792	34.816
7/268	7450.7	1.4816	1.1344	19 272	17 568	1.7556	6.7799	1226.4	2207.6	34 368	7726.3	123.14	271.47	17.813	39.271

Reading[a]	Core airflow corrected to core-compressor inlet conditions, W2.1K2.1: kg/sec	W2.1K2.1: lb/sec	Fuel flow rate corrected to engine inlet conditions, WFUELK1: g/sec	WFUELK1: lb/hr	Core-nozzle pressure ratio, H6	Core-nozzle exhaust velocity if flow expanded isentropically to ambient atmospheric pressure, VIDENG: m/sec	VIDENG: ft/sec	Core-nozzle flow coefficient, CFENG	Mixing-plane static pressure corrected to engine inlet conditions, PS16K1: N/cm^2	PS16K1: lb/in^2	Bypass-flow pressure ratio, H16	Bypass-flow exhaust velocity if flow expanded isentropically to ambient atmospheric pressure, VIDFAN: m/sec	VIDFAN: ft/sec	Exhaust nozzle velocity coefficient, CVEXIT	Sum of theoretical areas for station-16 and station-6 flows expanded isentropically to ambient atmospheric pressure, divided by area at station 18, CAEXIT
7/250	7.3636	16.234	68.506	543.71	1.0367	114.60	375.97	-------	10.351	15.013	1.0560	92.891	304.76	-------	-------
7/252	7.3396	16.181	88.379	701.43	1.0609	145.28	476.64	0.87561	10.510	15.243	1.0953	120.26	394.62	1.0130	0.94466
7/253	8.4218	18.567	123.11	977.10	1.0897	180.84	593.30	.93704	10.709	15.532	1.1414	145.54	477.78	1.0048	.95176
7/255	9.4579	20.851	195.18	1549.1	1.1517	244.23	801.28	.95676	11.154	16.178	1.2353	185.19	607.59	.99920	.95113
7/256	10.184	22.452	271.32	2153.4	1.2186	302.49	992.41	.99724	11.645	16.889	1.3323	217.18	712.54	1.0077	.94778
7/257	10.466	23.073	317.22	2517.7	1.2632	335.92	1102.1	.95931	11.924	17.294	1.3797	230.76	757.09	.99918	.94074
7/258	10.850	23.918	363.28	2883.2	1.3107	367.68	1206.3	.97656	12.239	17.751	1.4325	244.95	803.63	.99796	.94389
7/259	11.067	24.398	396.26	3145.0	1.3419	386.49	1268.0	.98808	12.449	18.055	1.4653	252.92	829.78	.99993	.94115
7/261	7.4308	16.382	86.175	683.94	1.0601	143.86	471.99	.89104	10.502	15.232	1.0938	119.00	390.43	1.0117	.94403
7/263	9.4647	20.866	200.42	1590.7	1.1547	246.96	810.23	.95995	11.174	16.206	1.2399	186.76	612.73	1.0056	.95071
7/265	10.497	23.142	314.50	2496.1	1.2669	338.79	1111.5	.95719	11.931	17.304	1.3825	231.52	759.59	.99506	.94153
7/268	11.131	24.539	399.89	3173.8	1.345	387.10	1270.0	.99243	12.475	18.094	1.4707	254.36	834.51	.98747	.94132

[a]Inlet air temperature, 271 K (488° R); barometric pressure, 9.902 N/m^2 (14.362 psia).

TABLE IV. - LARGER-EXHAUST-NOZZLE CONFLUENT-FLOW CONFIGURATION (C-5)

[Area at station 16, 4451 cm^2 (690 in^2); exhaust-nozzle area, 5453 cm^2 (845 in^2); core-nozzle area, 1687 cm^2 (262 in^2).]



Reading	Fan speed corrected to engine inlet conditions, NFK1, rpm	Fan pressure ratio, FPR	Fan temperature ratio, FTR	Core compressor speed corrected to engine inlet conditions, NGK1, rpm	Core compressor speed corrected to compressor inlet conditions, NGK2.1, rpm	Supercharger pressure ratio, LCPR	Core compressor pressure ratio, HCPR	Measured gas temperature corrected to engine inlet conditions, T4.1K1		Corrected gross thrust, FGK1		Inlet airflow corrected to engine inlet conditions, W1K1		Core airflow corrected to engine inlet conditions, W2.1K1	
								K	°R	N	lb	kg/sec	lb/sec	kg/sec	lb/sec
7/109[a]	2790.4	1.0502	1.0187	12 916	12 718	1.0766	2.8971	699.89	1259.8	4 168.9	937.21	45.351	99.982	7.3750	16.259
7/110[a]	3758.6	1.0904	1.0307	14 426	14 041	1.1662	3.7878	711.72	1281.1	7 559.3	1699.4	62.768	138.38	8.2962	18.290
7/111[a]	4547.0	1.1356	1.0439	15 620	15 031	1.2497	4.3850	777.67	1399.8	11 005	2474.0	76.344	168.31	9.9096	21.847
7/112[a]	5677.5	1.2249	1.0683	16 999	16 054	1.4158	5.1783	910.5	1638.9	17 931	4031.1	96.116	211.90	12.398	27.333
7/113[a]	6447.6	1.3025	1.0899	17 804	16 553	1.5507	5.7261	1014.89	1826.8	23 137	5201.5	109.13	240.58	14.237	31.387
7/114[a]	6856.1	1.3472	1.1024	18 173	16 755	1.6268	5.9755	1070.3	1926.5	26 375	5929.4	115.40	254.42	15.230	33.576
7/115[a]	7518.9	1.4089	1.1247	18 831	17 141	1.7669	6.3658	1162.4	2092.3	31 928	7177.6	124.93	275.42	17.174	37.863
8/051[b]	3767.4	------	------	14 418	14 034	1.1655	3.7848	710.22	1278.4	7 532.2	1693.3	63.090	139.09	8.3012	18.301
8/052[b]	4475.7	------	------	15 617	15 048	1.2396	4.4032	777.50	1399.5	11 025	2478.5	75.795	167.10	9.7990	21.603
8/053[b]	5680.7	------	------	17 070	16 117	1.4145	5.2127	915.17	1647.3	18 060	4060.2	96.818	213.43	12.462	27.473
8/054[b]	6457.4	------	------	17 858	16 604	1.5506	5.7440	1020.2	1836.3	23 600	5305.6	110.078	242.68	14.312	31.553
8/055[b]	7492.0	------	------	18 780	17 082	1.7526	6.3464	1157.9	2084.3	31 410	7061.2	124.84	275.23	17.050	37.588

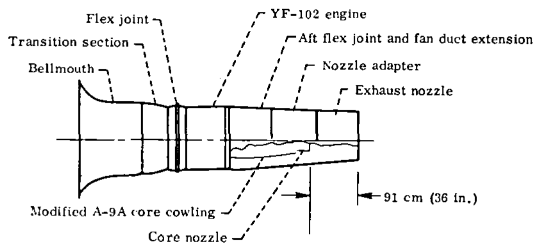
Reading	Core airflow corrected to core-compressor inlet conditions, W2.1K2.1		Fuel flow rate corrected to engine inlet conditions, WFUELK1		Core-nozzle pressure ratio, H6	Core-nozzle exhaust velocity if flow expanded isentropically to ambient atmospheric pressure, VIDENG		Core-nozzle flow coefficient, CFENG	Mixing-plane static pressure corrected to engine inlet conditions, PS16K1		Bypass-flow pressure ratio, H16	Bypass-flow exhaust velocity if flow expanded isentropically to ambient atmospheric pressure, VIDFAN		Exhaust nozzle velocity coefficient, CVEXIT	Sum of theoretical areas for station-16 and station-6 flows expanded isentropically to ambient atmospheric pressure, divided by area at station 18, CAEXIT
	kg/sec	lb/sec	g/sec	lb/hr		m/sec	ft/sec		N/cm^2	lb/in^2		m/sec	ft/sec		
7/109[a]	6.9567	15.337	-------	-------	1.0219	91.206	299.24	-------	10.237	14.848	1.0463	87.587	287.36	------	-------
7/110[a]	7.3083	16.112	-------	-------	1.0434	126.32	414.44	0.88297	10.312	14.956	1.0856	118.36	388.32	1.0135	0.92062
7/111[a]	8.2404	18.167	-------	-------	1.0627	156.08	512.07	.92810	10.409	15.097	1.1271	143.40	470.48	.99758	.93441
7/112[a]	9.2723	20.442	-------	-------	1.1035	208.59	684.36	.96919	10.621	15.404	1.2103	182.30	598.10	1.0078	.93775
7/113[a]	9.8743	21.769	-------	-------	1.1423	253.05	830.22	.99680	10.824	15.699	1.2848	210.11	639.33	.98516	.93537
7/114[a]	10.154	22.386	-------	-------	1.1785	286.22	939.05	.95005	10.954	15.888	1.3305	224.99	738.15	.98237	.92121
7/115[a]	10.657	23.494	-------	-------	1.2391	334.30	1096.8	.92561	11.183	16.220	1.3874	246.61	795.80	1.0023	.92574
8/051[b]	7.3174	16.132	-------	-------	1.0439	------	-------	-------	------	------	------	------	------	-------	-------
8/052[b]	8.2037	18.086	-------	-------	1.0622	------	-------	-------	------	------	------	------	------	-------	-------
8/053[b]	9.3304	20.570	-------	-------	1.1054	------	-------	-------	------	------	------	------	------	-------	-------
8/054[b]	9.9269	21.885	-------	-------	1.1460	------	-------	-------	------	------	------	------	------	-------	-------
8/055[b]	10.689	23.566	-------	-------	1.2367	------	-------	-------	------	------	------	------	------	-------	-------

[a]Inlet air temperature, 291 K (524° R); barometric pressure, 9.925 N/m^2 (14.396 psia).

[b]Inlet air temperature, 292 K (525° R); barometric pressure, 9.874 N/m^2 (14.322 psia).

TABLE V. - SMALLER-CORE-NOZZLE CONFLUENT-FLOW CONFIGURATION (C-6)

[Area at station 16, 4927 cm^2 (764 in^2); exhaust-nozzle area, 4803 cm^2 (744 in^2); core-nozzle area, 1361 cm^2 (211 in^2).]



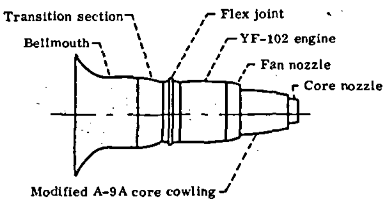
Reading	Fan speed corrected to engine inlet conditions, NFK1, rpm	Fan pressure ratio, FPR	Fan temperature ratio, FTR	Core compressor speed corrected to engine inlet conditions, NGK1, rpm	Core compressor speed corrected to compressor inlet conditions, NGK2.1, rpm	Supercharger pressure ratio, LCPR	Core compressor pressure ratio, HCPR	Measured gas temperature corrected to engine inlet conditions, T4.1K1		Corrected gross thrust, FGK1		Inlet airflow corrected to engine inlet conditions, W1K1		Core airflow corrected to engine inlet conditions, W2.1K1	
								K	°R	N	lb	kg/sec	lb/sec	kg/sec	lb/sec
7/241[a]	2886.5	1.0562	1.0211	13 248	13 208	1.0830	3.0271	718.67	1293.6	4 603.9	1035.0	47.038	103.70	7.646	16.856
7/242[a]	3762.3	1.0953	1.0323	14 523	14 130	1.1663	3.8460	723.72	1302.7	7 870.2	1769.3	61.729	136.09	8.427	18.578
7/243[a]	4561.2	1.1436	1.0466	15 877	15 275	1.2483	4.5483	803.17	1445.7	11 838	2661.4	75.001	165.35	10.080	22.223
7/244[a]	5647.6	1.2382	1.0725	17 351	16 384	1.4036	5.4513	948.83	1707.9	18 857	4239.3	93.875	206.96	12.603	27.785
7/245[a]	6444.2	1.3252	1.0959	18 295	17 009	1.5333	6.1552	1071.22	1928.2	25 545	5742.7	107.28	236.51	14.777	32.578
7/246[a]	6459.7	1.3279	1.0980	18 324	17 040	1.5505	6.1052	1074.33	1933.8	25 947	5833.2	108.05	238.20	14.942	32.942
7/248[a]	7138.3	1.4187	1.1209	19 113	17 548	1.6661	6.7280	1193.78	2148.4	32 444	7293.6	119.34	263.09	16.860	37.170
7/249[a]	7372.6	1.4484	1.1302	19 361	17 681	1.7172	6.8767	1232.94	2219.3	34 443	7743.1	122.75	270.61	17.660	38.933
8/180[b]	3761.1	------	------	14 521	14 134	1.1648	3.8339	725.5	1305.9	7 846.2	1763.9	61.385	135.33	8.373	18.460
8/181[b]	4487.3	------	------	15 710	15 135	1.2413	4.4855	798.44	1437.2	11 390	2560.6	73.564	162.18	9.9396	21.913
8/183[b]	5638.3	------	------	17 239	16 291	1.4082	5.3850	945.56	1702.0	18 699	4203.6	93.195	205.46	12.637	27.860
8/184[b]	6408.6	------	------	18 197	16 941	1.5399	6.0201	1064.2	1915.5	25 235	5673.0	106.96	235.81	14.666	32.334

Reading	Core airflow corrected to core-compressor inlet conditions, W2.1K2.1		Fuel flow rate corrected to engine inlet conditions, WFUELK1		Core-nozzle pressure ratio, H6	Core-nozzle exhaust velocity if flow expanded isentropically to ambient atmospheric pressure, VIDENG		Core-nozzle flow coefficient, CFENG	Mixing-plane static pressure corrected to engine inlet conditions, PS16K1		Bypass-flow pressure ratio, H16	Bypass-flow exhaust velocity if flow expanded isentropically to ambient atmospheric pressure, VIDFAN		Exhaust nozzle velocity coefficient, CVEXIT	Sum of theoretical areas for station-16 and station-6 flows expanded isentropically to ambient atmospheric pressure, divided by area at station 18, CAEXIT
	kg/sec	lb/sec	g/sec	lb/hr		m/sec	ft/sec		N/cm^2	lb/in^2		m/sec	ft/sec		
7/241[a]	7.179	15.827	-------	-------	1.0462	130.01	426.55	1.0768	10.348	15.009	1.0537	92.513	303.52	0.97641	0.95138
7/242[a]	7.427	16.373	-------	-------	1.0838	172.01	564.33	.88523	10.481	15.202	1.0910	119.44	391.67	.99058	.94007
7/243[a]	8.393	18.504	-------	-------	1.1259	216.21	709.36	.90803	10.680	15.490	1.1386	146.44	480.45	.99570	.94056
7/244[a]	9.509	20.964	-------	-------	1.2104	289.82	950.84	.93724	11.098	16.096	1.2269	185.18	607.54	.99069	.94261
7/245[a]	10.366	22.854	-------	-------	1.2963	354.54	1163.2	.97160	11.555	16.759	1.3140	215.27	706.27	.99635	.93897
7/246[a]	10.363	22.846	-------	-------	1.3000	356.62	1170.0	.97585	11.567	16.777	1.3136	215.15	705.88	1.0026	.94648
7/248[a]	11.022	24.300	-------	-------	1.4134	425.99	1397.6	.94806	12.080	17.521	1.4099	242.79	796.55	.99135	.93126
7/249[a]	11.262	24.828	-------	-------	1.4553	444.58	1458.6	.93926	12.260	17.781	1.4446	251.65	825.63	.98311	.92499
8/150[b]	7.385	16.281	88.812	704.87	------	------	------	-------	------	------	------	------	------	-------	-------
8/181[b]	8.3116	18.324	121.44	963.79	------	------	------	-------	------	------	------	------	------	-------	-------
8/183[b]	9.4964	20.936	200.02	1587.5	------	------	------	-------	------	------	------	------	------	-------	-------
8/184[b]	10.230	22.554	276.99	2198.4	------	------	------	-------	------	------	------	------	------	-------	-------

[a]Inlet air temperature, 279 K (503° R); barometric pressure, 9.830 N/m^2 (14.258 psia).
[b]Inlet air temperature, 295 K (531° R); barometric pressure, 9.807 N/m^2 (14.224 psia).

TABLE VI. - BASIC SEPARATE-FLOW CONFIGURATION (S-1)

[Fan-nozzle area, 3640 cm^2 (564 in^2); core-nozzle area, 1361 cm^2 (211 in^2).]



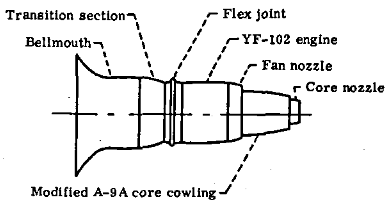
Reading	Fan speed corrected to engine inlet conditions, NFK1, rpm	Fan pressure ratio, FPR	Fan temperature ratio, FTR	Core compressor speed corrected to engine inlet conditions, NGK1, rpm	Core compressor speed corrected to compressor inlet conditions, NGK2.1, rpm	Supercharger pressure ratio, LCPR	Core compressor pressure ratio, HCPR	Measured gas temperature corrected to engine inlet conditions, T4.1K1		Corrected gross thrust, FGK1		Inlet airflow corrected to engine inlet conditions, W1K1		Core airflow corrected to engine inlet conditions, W2.1K1	
								K	°R	N	lb	kg/sec	lb/sec	kg/sec	lb/sec
7/018[a]	7136.0	1.4053	1.1190	18 711	17 168	1.6768	6.3593	1136.2	2045.1	30 457	6846.9	119.85	264.23	16.223	35.766
7/020[a]	6788.6	1.3517	1.1038	18 210	16 837	1.6191	5.9433	1073.4	1932.1	26 665	5994.6	112.56	248.15	15.090	33.267
7/021[a]	6048.6	1.2804	1.0844	17 421	16 346	1.4695	5.5850	985.50	1773.9	21 360	4801.9	101.88	224.61	13.249	29.208
7/022[a]	5287.7	1.2066	1.0644	16 680	15 862	1.3468	5.0534	885.94	1594.7	15 971	3590.4	88.650	195.44	11.522	25.402
7/023[a]	3794.3	1.0950	1.0332	14 583	14 183	1.1643	3.7816	716.67	1295.4	7 419.2	1667.9	61.643	135.90	8.2926	18.282
7/024[a]	2724.9	1.0469	1.0186	12 813	12 629	1.0715	2.7918	703.06	1265.5	3 621.8	814.21	44.975	99.153	7.1604	15.786
7/026[b]	3867.8	------	------	14 634	14 232	1.1728	3.8895	724.61	1304.3	7 922.7	1781.1	63.421	139.82	8.5062	18.753
7/031[b]	7228.6	------	------	18 749	17 166	1.7000	6.3230	1142.8	2057.0	31 078	6986.6	120.44	265.53	16.549	36.484
7/033[b]	6423.7	------	------	18 002	16 744	1.5406	5.8618	1033.6	1860.4	24 378	5480.4	108.04	238.18	14.321	31.573
8/023[c]	5576.9	------	------	17 035	16 112	1.3916	5.1558	911.44	1640.6	17 441	3920.9	92.515	203.96	12.145	26.776
8/024[c]	4453.2	------	------	15 626	15 074	1.2361	4.3506	781.28	1406.3	10 745	2415.5	73.468	161.97	9.7500	21.495
8/039[d]	6905.9	------	------	18 445	16 991	1.6316	6.2164	1103.8	1986.8	28 481	6402.7	115.85	255.40	15.622	34.441

Reading	Core airflow corrected to core-compressor inlet conditions, W2.1K2.1		Fuel flow rate corrected to engine inlet conditions, WFUELK1		Core-nozzle pressure ratio, H8	Core-nozzle exhaust velocity if flow expanded isentropically to ambient atmospheric pressure, VIDENG		Core-nozzle discharge coefficient, CDENG	Core-nozzle flow coefficient, CFENG	Core-nozzle exhaust-pressure corrected to engine inlet conditions, PS8K1		Bypass-flow exhaust velocity if flow expanded isentropically to ambient atmospheric pressure, VIDFAN		Fan-nozzle velocity coefficient, CVFAN	Fan-nozzle discharge coefficient, CDFAN
	kg/sec	lb/sec	g/sec	lb/hr		m/sec	ft/sec			N/cm²	lb/in²	m/sec	ft/sec		
7/018[a]	10.545	23.247	------	------	1.2619	357.5	1173.0	0.86754	0.93919	10.639	15.431	250.53	821.95	0.97979	0.93609
7/020[a]	10.079	22.220	------	------	1.2189	321.75	1055.6	.85514	.94497	10.609	15.387	235.04	771.12	.98318	.94611
7/021[a]	9.6084	21.183	------	------	1.1595	271.44	890.55	.85255	.95515	10.501	15.231	211.47	693.81	.97748	.97080
7/022[a]	8.9965	19.834	------	------	1.1167	224.36	736.08	.82477	.93286	10.412	15.101	183.37	601.62	.97553	.97240
7/023[a]	7.3228	16.144	------	------	1.0571	148.18	486.16	.78031	.88354	10.264	14.886	126.54	415.16	.94662	.97356
7/024[a]	6.7798	14.947	------	------	1.0256	100.64	330.20	------	------	10.166	14.744	89.639	294.09	------	.97320
7/026[b]	7.4575	16.441	------	------	1.0588	148.40	486.87	.78728	.88436	10.258	14.878	------	------	------	------
7/031[b]	10.632	23.440	------	------	1.2587	363.29	1191.9	.90542	.98847	10.677	15.486	------	------	------	------
7/033[b]	9.9949	22.035	------	------	1.1820	291.93	957.76	.88334	.98079	10.535	15.279	------	------	------	------
8/023[c]	9.2279	20.344	------	------	1.1266	234.67	769.92	------	------	------	------	------	------	------	------
8/024[c]	8.1760	18.025	------	------	1.0797	177.22	581.42	------	------	------	------	------	------	------	------
8/039[d]	10.394	22.914	------	------	1.2311	332.35	1090.4	------	------	------	------	------	------	------	------

[a]Inlet air temperature, 302 K (543° R); barometric pressure, 9.834 N/m^2 (14.263 psia).
[b]Inlet air temperature, 296 K (533° R); barometric pressure, 9.927 N/m^2 (14.398 psia).
[c]Inlet air temperature, 299 K (539° R); barometric pressure, 9.824 N/m^2 (14.249 psia).
[d]Inlet air temperature, 297 K (534° R); barometric pressure, 9.871 N/m^2 (14.317 psia).

TABLE VII. - SMALLER-CORE-NOZZLE SEPARATE-FLOW CONFIGURATION (S-3)

[Fan-nozzle area, 3640 cm^2 (564 in^2); core-nozzle area, 1163 cm^2 (180 in^2).]



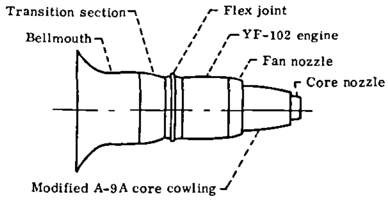
Reading	Fan speed corrected to engine inlet conditions, NFK1, rpm	Fan pressure ratio, FPR	Fan temperature ratio, FTR	Core compressor speed corrected to engine inlet conditions, NGK1, rpm	Core compressor speed corrected to compressor inlet conditions, NGK2.1, rpm	Supercharger pressure ratio, LCPR	Core compressor pressure ratio, HCPR	Measured gas temperature corrected to engine inlet conditions, T4.1K1		Corrected gross thrust, FGK1		Inlet airflow corrected to engine inlet conditions, W1K1		Core airflow corrected to engine inlet conditions, W2.1K1	
								K	°R	N	lb	kg/sec	lb/sec	kg/sec	lb/sec
7/231[a]	3773.6	1.0948	1.0315	14 517	14 127	1.1691	3.8355	718.56	1293.4	7 776.4	1748.2	61.675	135.97	8.4658	18.664
7/232[a]	4538.1	1.1416	1.0451	15 749	15 161	1.2483	4.4845	790.33	1422.6	11 409	2564.9	74.574	164.41	10.086	22.236
7/234[a]	5699.6	1.2392	1.0723	17 274	16 287	1.4177	5.3958	941.17	1694.1	18 858	4239.4	94.873	209.16	12.679	27.953
7/235[a]	6424.6	1.3194	1.0933	18 104	16 851	1.5550	5.9083	1046.9	1884.4	24 678	5547.8	107.98	238.06	14.751	32.520
7/236[a]	6800.2	1.3613	1.1057	18 499	17 082	1.6225	6.2466	1101.6	1982.9	27 892	6270.4	114.14	251.63	15.700	34.602
7/237[a]	7211.3	1.4119	1.1195	18 898	17 301	1.7078	6.4882	1164.5	2096.1	31 558	7094.5	120.82	266.36	16.886	37.228
7/239[a]	7611.9	1.4487	1.1330	19 226	17 456	1.7908	6.6977	1220.9	2197.7	34 393	7731.9	125.21	276.04	17.978	39.634
8/175[b]	3813.4	------	------	14 552	14 155	1.1713	3.8476	720.61	1297.1	7 929.9	1782.5	62.310	137.37	8.4935	18.725
8/176[b]	4549.2	------	------	15 762	15 168	1.2511	4.4823	792.28	1426.1	11 542	2594.8	74.856	165.03	10.067	22.193
8/177[b]	5680.4	------	------	17 190	16 226	1.4190	5.3125	935.33	1683.6	18 709	4206.0	94.497	208.33	12.760	28.130
8/178[b]	6515.6	------	------	18 171	16 871	1.5640	5.9751	1058.3	1904.9	25 527	5738.7	109.28	240.93	14.771	32.565
8/179[b]	7369.2	------	------	19 046	17 369	1.7242	6.6460	1196.1	2153.0	32 947	7406.7	122.69	270.49	17.189	37.895

Reading	Core airflow corrected to core-compressor inlet conditions, W2.1K2.1		Fuel flow rate corrected to engine inlet conditions, WFUELK1		Core-nozzle pressure ratio, H8	Core-nozzle exhaust velocity if flow expanded isentropically to ambient atmospheric pressure, VIDENG		Core-nozzle discharge coefficient, CDENG	Core-nozzle flow coefficient, CFENG	Core-nozzle exhaust-pressure corrected to engine inlet conditions, PS8K1		Bypass-flow exhaust velocity if flow expanded isentropically to ambient atmospheric pressure, VIDFAN		Fan-nozzle velocity coefficient, CVFAN	Fan-nozzle discharge coefficient, CDFAN
	kg/sec	lb/sec	g/sec	lb/hr		m/sec	ft/sec			N/cm²	lb/in²	m/sec	ft/sec		
7/231[a]	7.4407	16.404	-------	-------	1.0677	152.05	498.85	0.85120	0.90888	10.231	14.838	120.02	393.77	0.99039	0.97140
7/232[a]	8.3933	18.504	-------	-------	1.0996	189.88	622.98	.87439	.93119	10.277	14.905	145.69	477.98	.98381	.97092
7/234[a]	9.4855	20.912	-------	-------	1.1676	256.14	840.34	.90284	.95650	10.373	15.045	186.67	612.42	.98947	.96778
7/235[a]	10.191	22.468	-------	-------	1.2335	311.69	1022.6	.93818	.98637	10.453	15.160	213.30	699.80	.98134	.96199
7/236[a]	10.476	23.096	-------	-------	1.2810	343.69	1127.6	.92902	.97042	10.497	15.225	225.76	740.67	.98248	.96188
7/237[a]	10.800	23.810	-------	-------	1.3434	384.32	1260.9	.93241	.96725	10.550	15.301	239.58	786.02	.97578	.95854
7/239[a]	11.057	24.377	-------	-------	1.4011	415.59	1363.5	.93499	.96445	10.595	15.367	249.41	818.29	.97457	.95451
8/175[b]	7.4552	16.436	-------	-------	1.0684	157.82	517.78	-------	-------	------	------	------	------	-------	-------
8/176[b]	8.3615	18.434	-------	-------	1.0999	195.66	641.92	-------	-------	------	------	------	------	-------	-------
8/177[b]	9.5259	21.001	-------	-------	1.1657	261.75	858.77	-------	-------	------	------	------	------	-------	-------
8/178[b]	10.172	22.425	-------	-------	1.2400	325.66	1069.1	-------	-------	------	------	------	------	-------	-------
8/179[b]	10.932	24.100	-------	-------	1.3681	409.77	1344.4	-------	-------	------	------	------	------	-------	-------

[a]Inlet air temperature, 272 K (490° R); barometric pressure, 9.926 N/m^2 (14.396 psia).
[b]Inlet air temperature, 287 K (517° R); barometric pressure, 9.875 N/m^2 (14.322 psia).

TABLE VIII. - SMALLER-FAN-NOZZLE SEPARATE-FLOW CONFIGURATION (S-4)

[Fan-nozzle area, 3230 cm^2 (500 in^2); core-nozzle area, 1361 cm^2 (211 in^2).]



Reading	Fan speed corrected to engine inlet conditions, NFK1, rpm	Fan pressure ratio, FPR	Fan temperature ratio, FTR	Core compressor speed corrected to engine inlet conditions, NGK1, rpm	Core compressor speed corrected to compressor inlet conditions, NGK2.1, rpm	Supercharger pressure ratio, LCPR	Core compressor pressure ratio, HCPR	Measured gas temperature corrected to engine inlet conditions, T4.1K1		Corrected gross thrust, FGK1		Inlet airflow corrected to engine inlet conditions, W1K1		Core airflow corrected to engine inlet conditions, W2.1K1	
								K	°R	N	lb	kg/sec	lb/sec	kg/sec	lb/sec
7/038[a]	7155.7	1.4663	1.1329	18 911	17 635	1.6812	6.5517	1165.7	2098.2	31 798	7148.4	115.38	254.36	16.590	36.575
7/039[a]	6744.3	1.4117	1.1192	18 558	17 147	1.6173	6.2779	1111.9	2001.4	28 042	6304.1	109.39	241.16	15.741	34.702
7/040[a]	6456.2	1.3585	1.1067	18 139	16 845	1.5492	5.9514	1053.4	1896.1	24 784	5571.6	102.89	226.84	14.481	31.927
7/041[a]	5740.6	1.2688	1.0829	17 326	16 326	1.4233	5.3796	946.89	1704.4	18 791	4224.3	90.392	199.28	12.715	28.031
7/042[a]	4509.4	1.1585	1.0516	15 829	15 234	1.2451	4.5105	798.56	1437.4	11 366	2555.2	71.132	156.82	10.033	22.120
7/043[a]	3823.8	1.1084	1.0369	14 677	14 271	1.1711	3.8795	726.28	1307.3	7 953	1788.0	59.607	131.41	8.5724	18.899
7/044[a]	2753.4	1.0544	1.0202	12 903	12 706	1.0745	2.8652	707.39	1273.3	4 100	921.7	43.788	96.535	7.3745	16.258
8/040[b]	7150.2	------	------	18 915	17 337	1.6756	6.6263	1165.7	2098.3	31 435	7066.8	115.29	254.17	16.523	36.427
8/041[b]	6409.5	------	------	18 142	16 870	1.5452	5.9439	1050.4	1890.8	24 509	5509.8	102.91	226.87	14.497	31.961
8/042[b]	5687.0	------	------	17 321	16 334	1.4120	5.3939	945.39	1701.7	18 654	4193.5	90.387	199.27	12.596	27.770
8/043[b]	4567.0	------	------	15 852	15 244	1.2484	4.5397	801.22	1442.2	11 478	2580.4	71.708	158.09	9.9745	21.990
8/044[b]	3742.4	------	------	14 597	14 206	1.1625	3.8649	722.44	1300.4	7 696.8	1730.3	59.021	130.12	8.3706	18.454

Reading	Core airflow corrected to core-compressor inlet conditions, W2.1K2.1		Fuel flow rate corrected to engine inlet conditions, WFUELK1		Core-nozzle pressure ratio, H8	Core-nozzle exhaust velocity if flow expanded isentropically to ambient atmospheric pressure, VIDENG		Core-nozzle discharge coefficient, CDENG	Core-nozzle flow coefficient, CFENG	Core-nozzle exhaust-pressure corrected to engine inlet conditions, PS8K1		Bypass-flow exhaust velocity if flow expanded isentropically to ambient atmospheric pressure, VIDFAN		Fan-nozzle velocity coefficient, CVFAN	Fan-nozzle discharge coefficient, CDFAN
	kg/sec	lb/sec	g/sec	lb/hr		m/sec	ft/sec			N/cm²	lb/in²	m/sec	ft/sec		
7/038[a]	10.765	23.733	-------	-------	1.2747	363.23	1191.7	0.87230	0.93847	10.633	15.422	263.27	863.75	1.0001	0.97400
7/039[a]	10.533	23.222	-------	-------	1.2330	331.74	1088.4	.87947	.95442	10.566	15.323	248.97	816.82	.98920	.97486
7/040[a]	10.066	22.192	-------	-------	1.1953	298.85	980.49	.85802	.93892	10.511	15.245	234.00	767.72	.99534	.97895
7/041[a]	9.4778	20.895	-------	-------	1.1389	245.47	805.34	.85326	.94378	10.417	15.108	204.97	672.48	.99184	.97948
7/042[a]	8.3729	18.459	-------	-------	1.0824	180.76	593.03	.81850	.91030	10.300	14.939	159.89	524.66	.99016	.98481
7/043[a]	7.5287	16.598	-------	-------	1.0587	148.76	488.05	.79984	.88752	10.247	14.862	133.15	436.83	.98845	.98628
7/044[a]	6.9694	15.365	-------	-------	1.0270	102.07	334.86	1.0092	1.0819	10.166	14.744	101.19	331.99	.96707	.98365
8/040[b]	10.758	23.718	-------	-------	1.2750	363.35	1192.1	-------	-------	------	------	------	------	-------	-------
8/041[b]	10.090	22.245	-------	-------	1.1948	298.13	978.12	-------	-------	------	------	------	------	-------	-------
8/042[b]	9.4601	20.856	-------	-------	1.1373	243.87	800.11	-------	-------	------	------	------	------	-------	-------
8/043[b]	8.3089	18.318	-------	-------	1.0840	182.44	598.57	-------	-------	------	------	------	------	-------	-------
8/044[b]	7.3985	16.311	-------	-------	1.0568	146.02	479.07	-------	-------	------	------	------	------	-------	-------

[a]Inlet air temperature, 294 K (529° R); barometric pressure, 9.939 N/m^2 (14.416 psia).
[b]Inlet air temperature, 293 K (527° R); barometric pressure, 9.936 N/m^2 (14 411 psia).

TABLE IX. - RAKE AND TRAVERSING-PROBE EXHAUST-SYSTEM FLOW DATA FOR BASIC CONFLUENT-FLOW CONFIGURATION (C-1)

(a) Readings 007/75 and 007/82 averaged; data at station 13.2; fan speed, 3815 rpm; inlet air temperature, 291.0 K (523.9° R); barometric pressure, 9.9239 N/cm^2 (14.394 psia); wall static pressure, 10.304 N/cm^2 (14.945 psia); total temperature, 300.8 K (541.4° R).

Distance from wall, cm	Total pressure, N/cm^2	Mach number	Velocity, m/sec
0.432	10.778	0.2543	87.84
1.270	10.856	.2756	95.10
2.184	10.943	.2943	101.4
3.658	10.975	.3016	103.9
6.071	10.976	.3018	104.0
9.144	10.976	.3017	104.0
11.30	10.996	.3062	105.4
12.75	10.993	.3056	105.2
13.87	10.982	.3030	104.4
15.22	10.510	.2625	90.64

(b) Readings 009/13 and 009/20 averaged; data at station 16; fan speed, 3802 rpm; inlet air temperature, 291.0 K (523.8° R); barometric pressure, 9.9239 N/cm^2 (14.394 psia).

Distance from engine centerline, cm	Total pressure, N/cm^2	Stream static pressure, N/cm^2	Total temperature, K	Mach number	Velocity, m/sec
0.010	10.267	10.210	654.4	0.0944	47.75
2.550	10.280	10.210	656.4	.1003	50.78
5.090	10.320	10.210	659.7	.1190	60.46
7.630	10.366	10.214	663.0	.1471	74.77
10.18	10.416	10.219	665.3	.1674	85.18
12.72	10.472	10.221	669.7	.1945	99.23
15.26	10.529	10.222	676.7	.2088	106.2
17.80	10.556	10.235	681.9	.2133	109.6
20.34	10.523	10.245	676.9	.1988	101.7
22.88	10.435	10.264	567.6	.1534	71.92
23.51	10.435	10.269	433.4	.1502	61.63
25.42	10.709	10.265	320.7	.2471	88.10
27.96	10.921	10.263	303.9	.2994	103.7
30.50	10.957	10.263	301.3	.3074	105.9
33.04	10.952	10.261	301.0	.3068	105.7
35.58	10.957	10.261	301.0	.3078	106.0
38.12	10.917	10.264	301.1	.2983	102.8
40.66	10.840	10.263	300.9	.2807	96.79
43.20	10.764	10.269	301.2	.2603	89.92
43.83	10.740	10.269	301.2	.2537	87.72

(c) Readings 009/28 and 009/35 averaged; data at station 18; fan speed, 3772 rpm; inlet air temperature, 287.1 K (516.8° R); barometric pressure, 9.9780 N/cm^2 (14.472 psia).

Distance from engine centerline, cm	Total pressure, N/cm^2	Stream static pressure, N/cm^2	Total temperature, K	Mach number	Velocity, m/sec
0.040	10.415	10.039	648.4	0.2324	116.7
2.580	10.445	10.037	653.4	.2420	121.9
5.120	10.489	10.036	656.8	.2550	128.7
7.660	10.531	10.035	660.3	.2665	134.8
10.20	10.557	10.033	656.8	.2738	138.1
12.74	10.577	10.034	648.4	.2786	139.6
15.28	10.603	10.034	621.2	.2848	139.8
17.82	10.649	10.030	532.6	.2956	134.8
20.36	10.714	10.024	407.6	.3108	124.2
22.90	10.864	10.014	319.9	.3432	121.5
25.44	11.028	10.005	294.3	.3754	127.3
27.98	11.051	9.9983	292.7	.3808	128.7
30.52	11.037	9.9914	291.6	.3796	128.1
33.06	11.025	9.9818	291.6	.3794	128.0
35.60	10.974	9.9677	291.6	.3730	125.9
38.14	10.790	9.9528	292.7	.3414	115.7
38.78	10.705	9.9549	292.7	.3238	109.4

(d) Readings 007/076 and 007/087 averaged; data at station 13.2; fan speed, 4618 rpm; inlet air temperature, 290.9 K (523.7° R); barometric pressure, 9.9256 N/cm^2 (14.396 psia); wall static pressure, 10.523 N/cm^2 (15.262 psia); total temperature, 305.3 K (549.5° R).

Distance from wall, cm	Total pressure, N/cm^2	Mach number	Velocity, m/sec
0.432	11.219	0.3040	105.5
1.270	11.351	.3308	114.6
2.184	11.466	.3523	121.9
3.658	11.532	.3642	125.9
6.071	11.518	.3616	125.0
9.144	11.525	.3629	125.5
11.30	11.542	.3658	126.4
12.75	11.542	.3659	126.5
13.87	11.548	.3670	126.8
15.22	11.296	.3200	110.9

(e) Readings 009/014 and 009/026 averaged; data at station 16; fan speed, 4611 rpm; inlet air temperature, 291.2 K (524.1° R); barometric pressure, 9.9256 N/cm^2 (14.396 psia).

Distance from engine centerline, cm	Total pressure, N/cm^2	Stream static pressure, N/cm^2	Total temperature, K	Mach number	Velocity, m/sec
0.010	10.480	10.388	696.8	0.1140	59.36
2.550	10.500	10.388	701.4	.1259	65.60
5.090	10.540	10.386	706.6	.1460	76.43
7.630	10.604	10.390	711.1	.1720	90.16
10.18	10.691	10.396	711.1	.2035	106.7
12.72	10.767	10.404	714.2	.2249	118.1
15.26	10.863	10.405	721.9	.2527	133.2
17.80	10.865	10.417	725.2	.2499	132.0
20.34	10.831	10.435	725.6	.2338	123.5
22.88	10.752	10.467	636.6	.1984	98.34
23.51	10.748	10.473	487.6	.1918	82.82
25.42	11.108	10.463	319.2	.2938	104.3
27.96	11.424	10.461	306.7	.3572	123.7
30.50	11.498	10.460	305.5	.3674	126.9
33.04	11.498	10.463	305.4	.3699	127.8
35.58	11.471	10.463	305.1	.3652	126.2
38.12	11.463	10.463	305.1	.3637	125.6
40.55	11.364	10.462	305.6	.3459	119.7
43.20	11.158	10.472	305.9	.3027	105.1
43.83	11.115	10.472	305.9	.2931	101.8

(f) Readings 009/029 and 009/036 averaged; data at station 18; fan speed, 4537 rpm; inlet air temperature, 286.9 K (516.5° R); barometric pressure, 9.9780 N/cm^2 (14.472 psia).

Distance from engine centerline, cm	Total pressure, N/cm^2	Stream static pressure, N/cm^2	Total temperature, K	Mach number	Velocity, m/sec
0.040	10.643	10.074	682.0	0.2846	146.1
2.580	10.655	10.075	689.4	.2876	148.3
5.120	10.729	10.074	695.0	.3052	157.9
7.660	10.818	10.072	698.9	.3253	168.5
10.20	10.861	10.069	698.8	.3350	173.4
12.74	10.884	10.067	689.0	.3399	174.8
15.28	10.943	10.066	637.8	.3511	173.9
17.82	11.000	10.058	500.4	.3617	159.3
20.36	11.133	10.049	365.7	.3860	145.6
22.90	11.406	10.034	310.0	.4321	149.6
25.44	11.564	10.020	297.8	.4570	154.9
27.98	11.600	10.010	295.6	.4638	156.5
30.52	11.569	9.9983	295.6	.4614	155.7
33.06	11.571	9.9829	295.6	.4640	156.6
35.60	11.464	9.9616	295.6	.4521	152.7
38.14	11.144	9.9382	295.6	.4074	138.1
38.78	10.993	9.9425	295.4	.3800	129.0

TABLE IX. - Concluded.

(g) Readings 007/077 and 007/083 averaged; data at station 13.2; fan speed, 5754 rpm; inlet air temperature, 291.1 K (524.0° R); barometric pressure, 9.9256 N/cm^2 (14.396 psia); wall static pressure, 10.991 N/cm^2 (15.941 psia); total temperature, 313.7 K (564.7° R).

Distance from wall, cm	Total pressure, N/cm^2	Mach number	Velocity, m/sec
0.432	12.133	0.3784	132.5
1.270	12.398	.4185	146.0
2.184	12.571	.4424	154.1
3.658	12.607	.4471	155.6
6.071	12.588	.4446	154.8
9.144	12.538	.4378	152.5
11.30	12.527	.4364	152.1
12.75	12.539	.4380	152.6
13.87	12.507	.4336	151.1
15.22	12.197	.3886	135.9

(h) Readings 009/015 and 009/021 averaged; data at station 16; fan speed, 5760 rpm; inlet air temperature, 291.1 K (524.0° R); barometric pressure, 9.9256 N/cm^2 (14.396 psia).

Distance from engine centerline, cm	Total pressure, N/cm^2	Stream static pressure, N/cm^2	Total temperature, K	Mach number	Velocity, m/sec
0.010	11.006	10.747	771.1	0.1885	102.5
2.550	10.978	10.742	774.0	.1791	97.64
5.090	11.057	10.757	790.0	.2025	111.4
7.630	11.270	11.763	798.1	.2604	143.3
10.18	11.330	10.785	793.6	.2711	148.8
12.72	11.360	10.801	792.1	.2750	150.9
15.26	11.512	10.796	810.3	.3110	172.2
17.80	11.490	10.812	817.3	.3026	168.3
20.34	11.389	10.840	817.0	.2699	150.3
22.88	11.377	10.900	732.4	.2527	133.9
23.51	11.325	10.907	549.1	.2334	105.8
25.42	11.821	10.896	337.8	.3433	124.9
27.96	12.339	10.896	316.6	.4253	148.9
30.50	12.489	10.890	314.3	.4470	155.7
33.04	12.530	10.892	314.0	.4522	157.4
35.58	12.545	10.890	314.0	.4544	158.1
38.12	12.541	10.899	314.1	.4541	158.0
40.66	12.444	10.893	315.0	.4402	153.6
43.20	12.135	10.898	315.3	.3950	138.4
43.83	12.048	10.898	315.2	.3812	133.6

(i) Readings 009/030 and 009/037 averaged; data at station 18; fan speed, 5696 rpm; inlet-air temperature, 286.8 K (516.1° R); barometric pressure, 9.9780 N/cm^2 (14.472 psia).

Distance from engine centerline, cm	Total pressure, N/cm^2	Stream static pressure, N/cm^2	Total temperature, K	Mach number	Velocity, m/sec
0.040	11.246	10.137	758.2	0.3940	211.1
2.580	11.289	10.151	759.3	.3986	213.7
5.120	11.392	10.157	774.0	.4147	224.2
7.660	11.481	10.156	785.0	.4290	233.2
10.20	11.534	10.146	788.4	.4388	238.8
12.74	11.536	10.135	779.9	.4404	238.7
15.28	11.611	10.134	714.6	.4513	234.2
17.82	11.670	10.125	540.8	.4579	207.9
20.36	11.835	10.108	392.7	.4802	186.4
22.90	12.267	10.079	324.2	.5378	188.6
25.44	12.544	10.056	305.6	.5713	193.8
27.98	12.630	10.037	304.3	.5827	197.1
30.52	12.672	10.016	302.6	.5898	198.8
33.06	12.674	9.9876	302.6	.5938	200.0
35.60	12.581	9.9463	302.6	.5895	198.7
38.14	12.032	9.9024	304.3	.5347	181.7
38.78	11.845	9.9160	304.3	.5096	173.6

(j) Readings 007/080 and 007/086 averaged; data at station 13.2; fan speed, 7294 rpm; inlet air temperature, 291.1 K (524.2° R); barometric pressure, 9.9273 N/cm^2 (14.398 psia); wall static pressure, 12.036 N/cm^2 (17.457 psia); total temperature, 328.0 K (590.4° R).

0.432	13.932	0.4619	164.2
1.270	14.275	.4998	177.1
2.184	14.550	.5277	186.4
3.658	14.676	.5399	190.5
6.071	14.613	.5338	188.5
9.144	14.482	.5209	184.2
11.30	14.391	.5117	181.1
12.75	14.377	.5103	180.6
13.87	14.315	.5039	178.4
15.22	13.904	.4587	163.1

(k) Readings 009/018 and 009/025 averaged; data at station 16; fan speed, 7282 rpm; inlet air temperature, 291.1 K (524.2° R); barometric pressure, 9.9273 N/cm^2 (14.398 psia).

0.010	11.814	11.421	904.2	0.2238	131.6
2.550	12.124	11.462	914.7	.2954	174.0
5.090	12.825	11.603	935.2	.3890	230.3
7.630	13.114	11.667	935.9	.4195	247.9
10.18	13.053	11.689	940.6	.4087	242.3
12.72	13.044	11.692	959.6	.4067	243.6
15.26	12.930	11.693	976.5	.3903	235.9
17.80	12.654	11.739	982.3	.3346	203.5
20.34	12.676	11.792	979.5	.3261	198.1
22.88	12.794	11.848	936.9	.3388	201.7
23.51	12.848	11.871	716.4	.3418	175.9
25.42	13.249	11.888	351.4	.3966	146.6
27.96	13.946	11.882	329.9	.4838	172.0
30.50	14.222	11.874	328.0	.5144	181.8
33.04	14.416	11.868	327.5	.5349	188.6
35.58	14.478	11.884	328.3	.5394	190.2
38.12	14.504	11.908	328.9	.5386	190.3
40.66	14.449	11.836	331.0	.5354	189.8
43.20	13.957	11.898	331.7	.4828	172.1
43.83	13.884	11.898	331.7	.4750	169.5

(l) Readings 009/033 and 009/040 averaged; data at station 18; fan speed, 7244 rpm; inlet air temperature, 287.5 K (517.6° R); barometric pressure, 9.9666 N/cm^2 (14.470 psia).

0.040	12.777	10.303	935.5	0.5745	334.3
2.580	12.908	10.329	952.6	.5945	349.4
5.120	13.201	10.325	956.4	.6155	361.7
7.660	13.204	10.293	953.6	.6197	363.5
10.20	13.078	10.245	953.2	.6133	359.9
12.74	13.015	10.232	912.5	.6081	349.6
15.28	13.061	10.253	794.0	.6071	326.7
17.82	13.141	10.252	641.9	.6124	297.4
20.36	13.318	10.230	490.5	.6282	267.6
22.90	13.707	10.205	361.6	.6639	242.3
25.44	14.276	10.166	322.7	.7143	244.8
27.98	15.589	10.126	320.5	.7422	252.6
30.52	14.735	10.089	319.4	.7567	256.6
33.06	14.764	10.029	320.6	.7649	259.6
35.60	14.677	9.9266	322.8	.7694	261.8
38.14	13.885	9.8446	325.5	.7188	247.3
38.78	13.483	9.8639	325.5	.6834	236.1

TABLE X. - TRAVERSING-PROBE EXHAUST-SYSTEM FLOW DATA FOR SHORTER-CORE-NOZZLE CONFLUENT-FLOW CONFIGURATION (C-4)

[Data at station 16.]

(a) Readings 009/054 and 009/073 averaged; fan speed, 3658 rpm; inlet air temperature, 270.8 K (487.5° R); barometric pressure, 9.8987, N/cm² (14.357 psia).

Distance from engine centerline, cm	Total pressure, N/cm²	Stream static pressure, N/cm³	Total temperature, K	Mach number	Velocity, m/sec
0.386	10.284	10.228	607.1	0.0890	43.50
2.926	10.301	10.229	607.8	.1010	49.30
5.466	10.327	10.228	607.9	.1184	57.76
8.006	10.376	10.227	610.1	.1455	71.08
10.55	10.432	10.224	614.3	.1720	84.20
13.09	10.470	10.221	622.8	.1880	92.61
15.63	10.517	10.221	633.1	.2047	101.5
18.17	10.570	10.224	539.8	.2215	110.3
20.71	10.586	10.220	632.4	.2276	112.7
23.25	10.444	10.243	500.3	.1679	74.63
25.79	10.751	10.242	291.3	.2622	88.94
28.33	10.796	10.242	284.5	.2730	91.48
30.87	10.798	10.242	283.1	.2734	91.37
33.41	10.839	10.240	282.0	.2853	95.19
35.95	10.891	10.239	280.7	.2983	99.26
38.49	10.893	10.239	279.8	.2989	99.29
41.03	10.842	10.238	279.7	.2873	95.51
43.57	10.656	10.243	279.8	.2385	79.49
44.20	10.607	10.243	279.8	.2238	74.68

(b) Readings 009/066 and 009/075 averaged; fan speed, 4408 rpm; inlet air temperature, 270.8 K (487.4° R); barometric pressure, 9.9022 N/cm² (14.362 psia).

Distance from engine centerline, cm	Total pressure, N/cm²	Stream static pressure, N/cm²	Total temperature, K	Mach number	Velocity, m/sec
0.386	10.488	10.424	644.0	0.0941	47.31
2.926	10.529	10.420	647.1	.1228	61.73
5.466	10.557	10.418	648.0	.1382	69.46
8.006	10.360	10.415	648.4	.1729	86.82
10.55	10.728	10.415	651.8	.2090	105.1
13.09	10.773	10.409	662.9	.2251	114.0
15.63	10.798	10.405	673.9	.2342	119.4
18.17	10.887	10.410	678.7	.2576	131.7
20.71	10.909	10.410	672.7	.2634	134.1
23.25	10.724	10.444	540.2	.1954	90.28
25.79	11.177	10.436	297.1	.3123	106.6
28.33	11.257	10.436	289.1	.3278	110.3
30.87	11.245	10.432	287.8	.3258	109.4
33.41	11.301	10.429	286.7	.3395	113.8
35.95	11.389	10.428	285.1	.3570	119.3
38.49	11.411	10.428	283.9	.3611	120.4
41.03	11.334	10.430	284.0	.3469	115.8
43.57	11.055	10.437	284.3	.2880	96.89
44.20	10.957	10.439	284.3	.2640	88.60

(c) Readings 009/068 and 009/076 averaged; fan speed, 5498 rpm; inlet air temperature, 270.7 K (487.2° R); barometric pressure, 9.9035 N/cm² (14.364 psia)

0.386	10.914	10.819	709.0	0.1140	59.77
2.926	11.017	10.835	711.4	.1533	80.39
5.466	11.128	10.835	714.1	.1985	104.1
8.006	11.206	10.830	717.6	.2252	118.2
10.55	11.293	10.825	722.2	.2510	132.1
13.09	11.405	10.815	736.0	.2811	145.1
15.63	11.460	10.800	755.9	.2975	159.6
18.17	11.526	10.796	763.4	.3131	168.6
20.71	11.526	10.825	755.6	.3065	164.3
23.25	11.287	10.877	585.4	.2315	111.2
25.79	11.935	10.852	303.3	.3674	126.2
28.33	12.104	10.852	296.8	.3935	133.5
30.87	12.088	10.846	296.1	.3912	132.5
33.41	12.173	10.844	295.4	.4066	137.6
35.95	12.329	10.835	293.8	.4326	145.8
38.49	12.433	10.840	291.5	.4469	149.9
41.03	12.360	10.840	291.8	.4372	146.9
43.57	11.938	10.853	292.7	.3714	125.6
44.20	11.844	10.863	292.7	.3535	119.8

(d) Readings 009/071 and 009/080 averaged; fan speed, 6960 rpm; inlet air temperature, 271.1 K (488.0° R); barometric pressure, 9.9035 N/cm² (14.364 psia).

0.386	12.442	11.712	852.6	0.3021	171.4
2.926	12.749	11.823	846.0	.3360	189.5
5.466	12.842	11.818	853.0	.3536	200.0
8.006	12.850	11.787	857.0	.3616	206.0
10.55	13.076	11.751	882.9	.4034	231.1
13.09	12.826	11.713	890.7	.3715	214.2
15.63	12.584	11.694	902.5	.3314	192.6
18.17	12.618	11.714	906.7	.3356	195.5
20.71	12.768	11.796	905.5	.3453	200.9
23.25	12.654	11.892	697.6	.3016	156.8
25.79	13.441	11.853	318.6	.4225	148.0
28.33	13.768	11.844	311.8	.4627	159.8
30.87	13.767	11.843	312.0	.4604	159.0
33.41	13.858	11.832	311.4	.4739	163.4
35.95	14.104	11.819	310.2	.5067	174.2
38.49	14.381	11.808	307.7	.5379	183.8
41.03	14.318	11.817	307.8	.5312	181.7
43.57	13.684	11.843	308.9	.4592	158.5
44.20	13.515	11.855	308.9	.4366	151.0

TABLE XI. - TRAVERSING-PROBE EXHAUST-SYSTEM FLOW DATA FOR LARGER-EXHAUST-NOZZLE CONFLUENT-FLOW CONFIGURATION (C-5)

[Data at station 18, 90° position.]

(a) Reading 009/043; fan speed, 4567 rpm; inlet air temperature, 290.1 K (522.2° R); barometric pressure, 9.9187 N/cm² (14.386 psia).

Distance from engine centerline cm	Total pressure, N/cm²	Stream static pressure, N/cm²	Total temperature, K	Mach number	Velocity, m/sec
0.068	10.231	10.005	681.7	0.18176	93.38
2.608	10.263	10.004	692.0	.19469	100.7
5.148	10.314	10.001	695.2	.21336	110.5
7.688	10.384	10.000	700.4	.23639	122.7
10.23	10.490	9.9973	701.6	.26735	138.7
12.77	10.545	9.9932	700.2	.28334	146.8
15.31	10.594	9.9918	695.2	.29503	152.2
17.85	10.607	9.9863	621.2	.29827	146.0
20.39	10.629	9.9856	446.2	.30156	126.0
22.93	10.995	9.9808	334.5	.37480	135.4
25.47	11.275	9.9711	306.6	.42294	145.8
28.01	11.303	9.9628	303.8	.42879	147.1
30.55	11.285	9.9532	303.3	.42770	146.6
33.09	11.255	9.9422	303.0	.42495	145.6
35.63	11.196	9.9270	302.9	.41844	143.4
38.17	11.019	9.9056	303.1	.39328	135.1
40.71	10.647	9.8932	300.0	.32574	111.9
41.34	9.9022	9.8946	299.2	.03311	11.47

(b) Reading 009/045; fan speed, 6458 rpm; inlet air temperature, 290.1 K (522.2° R); barometric pressure, 9.9222 N/cm² (14.391 psia).

Distance from engine centerline cm	Total pressure, N/cm²	Stream static pressure, N/cm²	Total temperature, K	Mach number	Velocity, m/sec
0.068	10.891	10.092	803.7	0.33886	186.6
2.608	11.088	10.101	813.8	.37527	207.4
5.148	11.287	10.116	824.5	.40759	226.2
7.688	11.251	10.126	828.4	.39973	222.4
10.23	11.222	10.110	832.9	.39790	222.0
12.77	11.185	10.082	816.4	.39639	219.1
15.31	11.327	10.062	768.9	.42287	226.9
17.85	11.320	10.068	659.7	.41842	209.1
20.39	11.377	10.092	526.4	.42057	188.8
22.93	12.022	10.076	366.7	.50943	190.4
25.47	12.552	10.052	323.9	.57284	200.1
28.01	12.801	10.030	318.7	.60120	207.6
30.55	12.888	10.009	317.0	.61237	210.7
33.09	12.917	9.9856	316.6	.61812	212.4
35.63	12.843	9.9456	316.9	.61598	211.8
38.17	12.469	9.8884	318.2	.58563	202.5
40.71	11.598	9.8594	309.5	.48757	167.9
41.34	9.8794	9.8587	309.3	.05476	19.27

(c) Reading 009/047; fan speed, 7612 rpm; inlet air temperature, 289.9 K (521.9° R); barometric pressure, 0.0222 N/cm² (14.391 psia).

Distance from engine centerline cm	Total pressure, N/cm²	Stream static pressure, N/cm²	Total temperature, K	Mach number	Velocity, m/sec
0.068	11.498	10.154	894.8	0.43575	250.7
2.608	11.848	10.173	904.7	.48366	278.7
5.148	12.130	10.198	916.2	.51697	298.9
7.688	12.306	10.190	931.8	.53999	314.1
10.23	12.150	10.159	941.7	.52577	307.7
12.77	11.879	10.129	921.2	.49503	287.4
15.31	11.806	10.129	883.9	.48456	276.2
17.85	11.920	10.145	859.6	.49692	279.3
20.39	12.254	10.154	730.7	.53423	277.4
22.93	12.611	10.162	474.8	.56702	239.0
25.47	13.442	10.129	344.0	.64964	231.7
28.01	13.759	10.094	331.7	.68087	237.7
30.55	13.932	10.062	329.4	.69862	242.5
33.09	13.917	10.028	327.5	.70117	242.6
35.63	13.846	9.9684	327.5	.70210	242.9
38.17	13.452	9.8828	239.3	.67911	236.2
40.71	12.377	9.8105	319.6	.58627	203.1
41.34	9.8842	9.8036	316.2	.10818	38.49

TABLE XII. - SUPER-RAKE JET PLUME DATA FOR BASIC CONFLUENT-FLOW CONFIGURATION (C-1)

(a) Reading 010/016; data at 62 cm (2.0 ft) aft of station 18; fan speed, 3822 rpm; inlet air temperature, 291.6 K (524.9° R); barometric pressure, 9.9084 N/cm² (14.371 psia).

Super-rake station	Total pressure, N/cm²	Stream static pressure, N/cm²	Total temperature, K	Mach number	Velocity, m/sec
1	9.9084	9.9084	291.7	0	0
3	9.9084	9.9077	│	.0054	1.833
5	9.9077	9.9077	│	0	0
7	9.9084	9.9077	│	.0095	3.262
9	9.9091	9.9084	↓	.0105	3.589
11	9.9084	9.9077	291.8	.0098	3.348
13	9.9084	│	│	.0105	3.590
15	9.9084	│	│	.0093	3.176
17	9.9077	│	│	0	0
19	9.9077	│	↓	0	0
21	9.9070	↓	291.8	0	0
23	9.9070	9.9063	291.9	.0079	2.700
25	9.9056	9.9049	292.0	.0107	3.668
27	9.9228	9.8966	293.4	.0614	21.06
29	10.232	9.8966	297.5	.2187	75.22
31	10.861	9.9222	299.3	.3620	123.8
33	10.958	9.9477	301.2	.3745	128.4
35	10.841	9.9732	301.2	.3476	119.4
37	10.603	9.9766	320.4	.2963	105.3
39	10.507	9.9780	439.6	.2736	113.7
41	10.438	9.9794	609.4	.2569	125.1
43	10.387	9.9801	633.3	.2422	120.2
45	10.441	9.9773	657.0	.2586	130.5
47	10.496	9.9780	658.9	.2729	137.9
49	10.550	9.9787	632.0	.2862	141.6
51	10.599	9.9794	550.8	.2968	137.5
53	10.755	9.9787	473.6	.3304	142.0
55	10.991	9.9739	396.5	.3758	147.5
57	11.027	9.9504	311.0	.3863	134.5
59	10.667	9.9125	301.3	.3255	112.0
61	10.021	9.8980	300.6	.1333	46.23
63	9.9125	9.9022	298.5	.0386	13.38
65	9.9125	9.9070	296.4	.0282	9.723
67	9.9118	9.9111	293.0	.0120	4.109
69	9.9118	9.9118	292.3	0	0
71	9.9118	9.9118	292.6	│	│
73	9.9084	9.9084	292.5	│	│
75	│	│	292.6	│	│
77	│	│	292.6	│	│
79	│	│	292.3	│	│
81	│	│	292.2	│	│
83	│	│	292.2	│	│
85	↓	↓	292.2	↓	↓

(b) Reading 010/009; data at 152 cm (5.0 ft) aft of station 18; fan speed, 3801 rpm; inlet air temperature, 292.0 K (525.6° R); barometric pressure, 9.9049 N/cm² (14.366 psia).

Super-rake station	Total pressure, N/cm²	Stream static pressure, N/cm²	Total temperature, K	Mach number	Velocity, m/sec
1	9.9049	9.9042	292.4	0	1.499
3	│	│	292.3	0	0
5	│	│	292.4	0	0
7	│	↓	292.3	0	0
9	│	9.9042	292.3	.0072	2.485
11	↓	9.9042	292.3	.0114	3.894
13	9.9056	9.9035	292.5	.0153	5.246
15	9.9035	9.9035	292.5	0	0
17	9.9035	9.9035	292.4	0	0
19	9.9022	9.9028	292.5	0	0
21	9.9022	9.8987	293.0	.0209	7.155
23	9.9166	9.8891	293.7	.0624	21.42
25	9.9890	9.8794	294.8	.1254	43.08
27	10.101	9.8739	296.2	.1808	62.13
29	10.335	9.8787	298.4	.2550	87.69
31	10.683	9.9070	299.7	.3303	113.3
33	10.852	9.9353	301.0	.3576	122.7
35	10.756	9.9635	309.5	.3326	115.9
37	10.601	9.9704	354.7	.2977	111.2
39	10.518	9.9739	456.3	.2778	117.6
41	10.458	9.9766	571.1	.2626	124.0
43	10.398	9.9780	611.1	.2460	120.0
45	10.467	9.9712	651.8	.2666	134.0
47	10.535	9.9739	639.3	.2837	141.1
49	10.603	9.9739	564.6	.2994	140.2
51	10.669	9.9745	483.1	.3132	136.0
53	10.811	9.9690	429.4	.3434	140.5
55	10.917	9.9546	375.7	.3662	140.2
57	10.756	9.9187	318.6	.3425	121.0
59	10.430	9.8856	302.4	.2781	96.16
61	10.125	9.8760	298.6	.1890	65.20
63	9.9780	9.8829	297.7	.1172	40.45
65	9.9180	9.8898	296.8	.0639	22.04
67	9.9063	9.8966	294.8	.0363	12.50
69	9.9070	9.9015	293.3	.0274	9.404
71	9.9063	9.9028	292.9	.0226	7.758
73	9.9063	9.9028	292.5	.0228	7.825
75	9.9063	9.9028	292.5	.0223	7.650
77	9.9063	9.9042	292.5	.0188	6.447
79	9.9070	9.9042	292.3	.0200	6.867
81	9.9077	9.9049	292.1	.0213	7.300
83	9.9070	9.9049	292.1	.0165	5.654
85	9.9070	9.9049	292.1	.0170	5.850

(c) Reading 010/002; data at 305 cm (10.0 ft) aft of station 18; fan speed, 3744 rpm; inlet air temperature, 293.4 K (528.1° R); barometric pressure, 9.9084 N/cm² (14.371 psia).

Super-rake station	Total pressure, N/cm²	Stream static pressure, N/cm²	Total temperature, K	Mach number	Velocity, m/sec
1	9.9077	9.9084	294.0	0	0
3	9.9084	9.9084	293.9	│	│
5	9.9070	9.9077	294.0	│	│
7	9.9063	9.9070	294.0	↓	↓
9	9.9084	9.9070	294.2	.0142	4.872
11	9.9056	9.9063	294.4	0	0
13	9.9022	9.9001	294.9	.0191	6.562
15	9.9077	9.8966	295.2	.0392	13.51
17	9.9132	9.8946	295.8	.0519	17.86
19	9.9353	9.8891	296.4	.0817	28.16
21	9.9449	9.8870	297.4	.0913	31.52
23	9.9877	9.8760	298.4	.1270	43.88
25	10.032	9.8684	299.8	.1538	53.24
27	10.163	9.8753	302.1	.2030	70.40
29	10.290	9.8808	305.8	.2418	84.20
31	10.386	9.8973	209.2	.2636	92.17
33	10.512	9.9139	312.7	.2909	102.1
35	10.598	9.9304	328.4	.3066	110.2
37	10.583	9.9470	358.9	.2994	112.5
39	10.538	9.9559	411.7	.2870	115.4
41	10.487	9.9642	484.4	.2726	118.9
43	10.436	9.9656	546.1	.2593	119.8
45	10.497	9.9422	608.4	.2824	137.2
47	10.558	9.9366	591.0	.2984	142.9
49	10.620	9.9304	526.2	.3131	141.7
51	10.652	9.9242	456.9	.3207	135.5
53	10.659	9.9255	409.8	.3214	128.7
55	10.635	9.9242	362.7	.3163	119.4
57	10.524	9.9201	335.5	.2920	106.2
59	10.432	9.9139	318.4	.2708	96.11
61	10.231	9.9077	309.1	.2147	72.29
63	10.169	9.9049	306.8	.1944	67.94
65	10.926	9.9028	304.5	.1333	46.48
67	9.9704	9.9001	301.2	.1004	34.86
69	9.9401	9.9008	299.2	.0749	25.95
71	9.9118	9.9022	297.5	.0377	13.02
73	9.9104	9.9015	296.9	.0353	12.20
75	9.9125	9.9022	296.1	.0386	13.32
77	9.9097	9.9035	295.4	.0294	10.11
79	9.9091	9.9049	294.6	.0260	8.933
81	9.9084	9.9063	294.1	.0194	6.680
83	9.9070	9.9070	293.8	0	0
85	9.9097	9.9077	293.5	.0152	5.202

TABLE XII. - Continued.

(d) Reading 010/017; data at 62 cm (2.0 ft) aft of station 18; fan speed, 4580 rpm; inlet air temperature, 291.0 K (523.8° R); barometric pressure, 9.9049 N/cm² (14.366 psia).

Super-rake station	Total pressure, N/cm²	Stream static pressure, N/cm²	Total temperature, K	Mach number	Velocity, m/sec
1	9.9046	9.9048	291.7	0	0
3	9.9049	9.9049		0	0
5	9.9053	9.9048		0.0044	1.526
7	9.9049	9.9048		.0024	.816
9	9.9056	9.9046		.0065	2.234
11	9.9046	9.9048		0	0
13	9.9046	9.9049		0	0
15	9.9049	9.9048		.0024	.816
17	9.9053	9.9048		.0044	1.526
19	9.9049	9.9048		.0024	.816
21	9.9042	9.9048		0	0
23	9.9046	9.9037	↓	.0061	2.080
25	9.9038	9.9018	293.0	.0092	3.160
27	9.9284	9.8939	293.9	.0705	24.20
29	10.397	9.8939	300.0	.2674	92.11
31	11.342	9.9008	302.8	.4452	152.2
33	11.456	9.9490	305.0	.4537	155.5
35	11.249	10.004	305.6	.4130	142.2
37	10.904	10.008	331.1	.3526	126.9
39	10.594	10.011	476.7	.3283	141.6
41	10.707		651.1	.3150	157.8
43	10.638		674.4	.2995	152.8
45	10.697		697.8	.3132	162.2
47	10.756		697.8	.3260	168.7
49	10.818		652.8	.3360	168.4
51	11.004	↓	594.4	.3734	178.5
53	11.156	10.008	485.0	.3938	170.5
55	11.521	9.9973	375.6	.4555	173.1
57	11.542	9.9766	308.3	.4643	160.4
59	10.983	9.9284	305.6	.3828	132.1
61	10.056	9.9801	303.9	.1493	52.03
63	9.9073	9.8904	300.0	.0284	9.158
65	9.9073	9.9042	297.8	.0113	3.908
67	9.9077	9.9034	293.3	.0133	4.555
69	9.9077	9.9032	292.2	.0136	4.655
71	9.9073	9.9032		.0131	4.472
73	9.9073	9.9035		.0125	4.282
75	9.9077	9.9048		.0109	3.742
77	9.9073	9.9051		.0097	3.316
79		9.9042		.0113	3.873
81		9.9035		.0125	4.282
83		9.9035		.0125	4.282
85	↓	9.9048	↓	.0102	3.512

(e) Reading 010/010; data at 152 cm (5.0 ft) aft of station 18; fan speed, 4589 rpm; inlet air temperature, 292.0 K (525.6° R); barometric pressure, 9.9049 N/cm² (14.366 psia).

Super-rake station	Total pressure, N/cm²	Stream static pressure, N/cm²	Total temperature, K	Mach number	Velocity, m/sec
1	9.9056	9.9042	292.7	0.0120	4.107
3	9.9049	9.9042	292.7	.0137	4.682
5	9.9049	9.9042	292.7	.0100	3.436
7	9.9042	9.9042	292.6	0	0
9	9.9049	9.9035	292.7	.0138	4.742
11	9.9049	9.9042	292.7	.0118	4.037
13	9.9049	9.9042	292.8	.0112	3.824
15	9.9042	9.9028	292.7	.0140	4.801
17	9.9042	9.9008	292.8	.0217	7.423
19	9.9042	9.8980	293.0	.0295	10.12
21	9.9028	9.8932	294.0	.0372	12.79
23	9.9166	9.8780	295.1	.0749	25.76
25	9.9766	9.8656	297.1	.1266	43.63
27	10.174	9.8656	299.6	.2101	72.55
29	10.627	9.8760	300.5	.3254	118.9
31	11.169	9.9160	303.0	.4162	142.7
33	11.365	9.9559	305.6	.4393	150.9
35	11.142	9.9959	315.8	.3974	139.2
37	10.936	10.006	371.3	.3594	136.8
39	10.839	10.008	488.3	.3411	148.7
41	10.742	10.010	617.3	.3223	157.4
43	10.666	10.011	658.6	.3058	154.1
45	10.763	10.011	699.8	.3275	169.7
47	10.852	10.018	683.9	.3442	176.3
49	10.949	10.018	596.3	.3619	173.4
51	11.091	10.019	514.7	.3863	172.1
53	11.276	10.008	450.6	.4180	174.2
55	11.484	9.9835	368.1	.4525	170.3
57	11.237	9.9304	313.7	.4244	147.9
59	10.734	9.8753	305.1	.3474	120.1
61	10.221	9.8574	301.7	.2282	78.97
63	9.9890	9.8704	300.4	.1308	45.35
65	9.9173	9.8836	299.1	.0689	24.20
67	9.9028	9.8960	296.3	.0316	10.88
69	9.9042	9.9001	293.9	.0241	8.264
71	9.9042	9.9022	293.2	.0165	5.666
73	9.9042	9.9042	292.0	0	0
75	9.9049	9.9049	292.4	0	0
77	9.9056	9.9049	292.7	.0103	3.517
79	9.9056	9.9049	292.5	.0069	2.370
81	9.9049	9.9056	292.4	0	0
83	9.9056	9.9063	292.4	0	0
85	9.9070	9.9056	292.4	.0120	4.105

(f) Reading 010/003; data at 305 cm (10.0 ft) aft of station 18; fan speed, 4554 rpm; inlet air temperature, 293.1 K (527.6° R); barometric pressure, 9.9084 N/cm² (14.371 psia).

Super-rake station	Total pressure, N/cm²	Stream static pressure, N/cm²	Total temperature, K	Mach number	Velocity, m/sec
1	9.9084	9.9084	293.7	0	0
3	9.9056	9.9084	293.6		
5	9.9049	9.9084	293.7		
7	9.9056	9.9063	293.7	↓	↓
9	9.9077	9.9015	293.9	.0311	10.68
11	9.9035	9.9008	294.0	.0178	6.105
13	9.8994	9.8987	294.7	.0044	1.505
15	9.9028	9.8932	295.0	.0374	12.88
17	9.9097	9.8911	295.8	.0517	17.80
19	9.9539	9.8836	296.5	.1010	34.80
21	9.9911	9.8711	297.4	.1314	45.32
23	10.020	9.8629	298.6	.1506	52.01
25	10.116	9.8615	300.4	.1914	66.24
27	10.194	9.8629	302.6	.2180	75.61
29	10.529	9.8746	306.4	.3042	105.7
31	10.584	9.8973	310.2	.3113	108.8
33	10.867	9.9201	314.0	.3637	127.4
35	10.947	9.9422	327.9	.3738	133.7
37	10.976	9.9746	357.3	.3726	139.1
39	10.878	9.9884	416.4	.3522	142.0
41	10.783	9.9939	503.3	.3331	147.4
43	10.710	9.9994	580.9	.3174	150.5
45	10.802	9.9766	657.0	.3427	172.2
47	10.894	9.9725	644.0	.3614	179.6
49	10.985	9.9690	567.6	.3779	176.6
51	11.036	9.9649	488.2	.3666	168.0
53	11.049	9.9559	423.9	.3898	158.0
55	10.967	9.9380	374.6	.3784	144.6
57	10.836	9.9111	341.2	.3597	131.4
59	10.621	9.8836	321.4	.3226	114.6
61	10.423	9.8684	310.7	.2807	98.33
63	10.274	9.8698	308.2	.2405	84.06
65	10.121	9.8704	305.7	.1899	66.26
67	10.033	9.8711	302.2	.1528	53.09
69	9.9490	9.8794	299.8	.1002	34.69
71	9.9242	9.8870	298.5	.0738	26.53
73	9.9097	9.8925	297.3	.0499	17.24
75	9.9084	9.8960	296.4	.0423	14.60
77	9.9063	9.8973	295.5	.0351	12.10
79	9.9084	9.9008	294.7	.0333	11.46
81	9.9056	9.9035	294.0	.0169	5.821
83	9.9077	9.9035	293.7	.0233	8.019
85	9.9077	9.9063	293.4	.0126	4.312

TABLE XII. - Continued.

(g) Reading 010/018; data at 62 cm (2.0 ft) aft of station 18; fan speed, 5740 rpm; inlet air temperature, 291.6 K (524.8° R); barometric pressure, 9.9084 N/cm² (14.371 psia).

Super-rake station	Total pressure, N/cm²	Stream static pressure, N/cm²	Total temperature, K	Mach number	Velocity, m/sec
1	9.9084	9.9084	291.4	0	0
3	9.9084				
5	9.9077				
7	9.9084				
9	9.9084				
11	9.9077				
13			291.6		
15		9.9077	291.6		
17		9.9077	291.6		
19	9.9070	9.9077	291.6		
21	9.9070	9.9070	291.8		
23	9.9063	9.9063	291.9		
25	9.9042	9.9015	292.0	.0213	7.299
27	9.9780	9.8746	296.0	.1223	42.08
29	10.814	9.8725	396.2	.3633	125.7
31	12.384	9.9401	310.3	.5699	194.8
33	12.469	10.008	314.4	.5698	196.1
35	12.067	10.075	314.0	.5146	178.0
37	11.539	10.086	347.0	.4432	162.2
39	11.419	10.092	503.5	.4260	187.3
41	11.335	10.097	675.6	.4146	210.1
43	11.291	10.095	728.9	.4089	206.8
45	11.382	10.100	783.3	.4232	230.0
47	11.473	10.099	779.0	.4375	236.8
49	11.564	10.099	726.7	.4505	235.6
51	11.746	10.099	751.0	.4765	252.7
53	11.972	10.092	488.3	.5023	216.2
55	12.548	10.077	383.3	.5695	216.4
57	12.618	10.016	315.4	.5844	201.1
59	11.636	9.9111	314.2	.4846	168.2
61	10.145	9.8677	311.8	.1995	70.28
63	9.9049	9.8808	306.4	.0591	20.69
65	9.9098	9.8939	301.1	.0479	16.64
67	9.9111	9.9070	294.0	.0246	8.436
69	9.9104	9.9097	292.9	.0120	4.108
71	9.9118		293.1	.0172	5.908
73	9.9118		293.1	.0158	5.410
75	9.9118		293.1	.0173	5.913
77	9.9111		293.2	.0142	4.863
79			292.8	.0142	4.850
81		9.9104	292.6	.0109	3.748
83		9.9104	292.6	.0044	1.499
85	9.9118	9.9097	292.6	.0161	5.509

(h) Reading 010/011; data at 152 cm (5.0 ft) aft of station 18; fan speed, 5738 rpm; inlet air temperature, 292.1 K (525.8° R); barometric pressure, 9.9049 N/cm² (14.366 psia).

Super-rake station	Total pressure, N/cm²	Stream static pressure, N/cm²	Total temperature, K	Mach number	Velocity, m/sec
1	9.9035	9.9056	292.6	0	0
3	9.9035	9.9049			
5	9.9042	9.9049			
7	9.9035	9.9049			
9	9.9049	9.9049	292.6		
11	9.9049	9.9042	292.4	.0076	2.596
13	9.9028	9.9028	292.6	0	0
15	9.9035	9.9022	292.5	.0147	5.028
17	9.9022	9.9008	292.6	.0155	5.301
19	9.9035	9.8960	293.0	.0335	11.50
21	9.9035	9.8870	294.0	.0492	16.92
23	9.9670	9.8718	296.2	.1170	40.27
25	10.046	9.8477	298.9	.1691	58.40
27	10.462	9.8318	302.6	.2994	103.4
29	11.089	9.8463	307.8	.4159	143.7
31	11.888	9.9173	310.3	.5169	177.4
33	12.233	9.9884	312.8	.5466	188.1
35	11.908	10.059	323.6	.4973	174.9
37	11.566	10.075	388.0	.4492	173.6
39	11.466	10.083	525.4	.4352	196.2
41	11.376	10.088	668.7	.4227	213.0
43	11.302	10.090	724.9	.4114	215.6
45	11.432	10.096	781.4	.4317	234.1
47	11.562	10.094	751.5	.4514	239.8
49	11.693	10.092	650.6	.4686	232.2
51	11.815	10.090	606.3	.4847	231.9
53	12.084	10.072	508.0	.5194	227.5
55	12.428	10.037	386.4	.5620	214.4
57	12.082	9.9484	320.8	.5346	185.6
59	11.227	9.8532	312.1	.4361	151.5
61	10.484	9.8249	307.2	.3062	106.5
63	10.111	9.8456	305.0	.1955	68.12
65	9.9318	9.8670	302.8	.0969	33.65
67	9.8973	9.8804	298.5	.0357	12.37
69	9.8973	9.8973	295.4	0	0
71	9.8994	9.9008	293.9		
73	9.8994	9.9015	292.8		
75	9.9015	9.9022	292.6		
77	9.9015	9.9035	292.4		
79	9.9022	9.9042	292.3		
81	9.8994	9.9035	292.1		
83	9.9015	9.9042	292.0		
85	9.9049	9.9049	292.1		

(i) Reading 010/004; data at 305 cm (10.0 ft) aft of station 18; fan speed, 5636 rpm; inlet air temperature, 293.1 K (527.6° R); barometric pressure, 9.9084 N/cm² (14.371 psia).

Super-rake station	Total pressure, N/cm²	Stream static pressure, N/cm²	Total temperature, K	Mach number	Velocity, m/sec
1	9.9077	9.9077	293.9	0	0
3	9.9056	9.9084	294.0	0	0
5	9.9097	9.9063	294.0	.0238	8.163
7	9.9063	9.9056	294.2	.0090	3.100
9	9.9063	9.9035	294.6	.0186	6.383
11	9.9049	9.8966	295.0	.0346	11.90
13	9.9077	9.8856	295.7	.0564	19.43
15	9.9422	9.8773	296.5	.0967	32.28
17	9.9339	9.8718	297.4	.0946	32.64
19	10.004	9.8635	298.6	.1420	49.04
21	10.066	9.8594	300.6	.1724	59.71
23	10.146	9.8442	302.3	.2082	72.18
25	10.214	9.8312	304.9	.2625	91.20
27	10.657	9.8470	308.4	.3379	117.6
29	10.841	9.8615	313.7	.3707	129.7
31	11.089	9.8787	318.4	.4101	144.1
33	11.309	9.9173	323.2	.4377	154.6
35	11.591	9.9628	341.9	.4707	170.5
37	11.616	10.003	381.4	.4679	179.0
39	11.513	10.030	454.4	.4498	187.8
41	11.390	10.044	553.3	.4308	198.1
43	11.318	10.050	637.8	.4201	206.9
45	11.421	10.060	722.2	.4356	227.4
47	11.524	10.059	708.9	.4510	233.0
49	11.626	10.046	621.1	.4664	226.0
51	11.721	10.038	532.0	.4789	215.2
53	11.707	10.023	461.9	.4783	200.8
55	11.656	9.9752	402.0	.4779	187.5
57	11.369	9.9159	355.6	.4470	165.5
59	11.065	9.8636	330.6	.4092	146.5
61	10.776	9.8249	316.7	.3660	128.7
63	10.483	9.8236	313.4	.3063	107.6
65	10.129	9.8394	310.1	.2040	71.69
67	10.094	9.8511	305.0	.1870	65.20
69	9.9801	9.8615	302.3	.1308	45.48
71	9.9201	9.8739	300.5	.0817	28.35
73	9.9167	9.8842	298.5	.0411	14.20
75	9.8973	9.8925	295.9	.0264	9.114
77	9.9035	9.8973	295.1	.0299	10.30
79	9.9028	9.9008	295.1	.0173	5.944
81	9.8994	9.9035	294.2	0	0
83	9.8994	9.9035	293.7	0	0
85	9.9035	9.9063	293.3	0	0

TABLE XII. - Concluded.

(j) Reading 010/014; data at 152 cm (5.0 ft) aft of station 18; fan speed, 7210 rpm; inlet air temperature, 292.3 K (526.1° R); barometric pressure, 9.9049 N/cm^2 (14.366 psia).

Super-rake station	Total pressure, N/cm^2	Stream static pressure, N/cm^2	Total temperature, K	Mach number	Velocity, m/sec
1	9.9042	9.9028	292.2	0.0169	5.803
3	9.9070	9.9028	↓	.0228	7.821
5	9.9042	9.9077		0	0
7	9.9063	9.9056		.0100	3.433
9	9.9049	9.9022		.0192	6.574
11	9.9049	9.9028		.0174	5.946
13	9.9042	9.9028	292.4	.0145	4.971
15	9.9008	9.8987	292.6	.0162	5.560
17	9.8953	9.8891	293.0	.0305	10.48
19	9.9104	9.8725	294.2	.0742	25.50
21	9.8849	9.8504	296.1	.0707	24.36
23	9.9525	9.7863	299.2	.1553	53.70
25	10.337	9.7284	304.2	.2961	102.6
27	10.848	9.7277	311.6	.3979	138.6
29	11.949	9.7629	321.2	.5455	190.2
31	12.998	9.9015	330.3	.6366	222.8
33	13.126	10.039	339.4	.6317	224.3
35	13.255	10.178	393.1	.6273	239.7
37	13.187	10.219	522.6	.6181	271.7
39	12.952	10.260	701.9	.5939	301.7
41	12.790	10.294	835.6	.5753	318.2
43	12.720	10.305	862.8	.5670	318.6
45	12.842	10.313	892.7	.5792	330.6
47	12.964	10.307	877.5	.5933	335.4
49	13.086	10.289	782.9	.6055	323.7
51	13.268	10.276	645.8	.6216	302.5
53	13.598	10.214	541.8	.6570	292.6
55	13.667	10.099	437.7	.6740	270.0
57	13.267	9.9456	360.8	.6556	239.3
59	12.338	9.7650	331.5	.5883	207.5
61	11.118	9.6733	320.0	.4508	158.3
63	10.292	9.7277	316.1	.2852	100.7
65	10.019	9.7822	312.2	.1852	65.32
67	9.9504	9.8360	305.2	.1286	44.92
69	9.8963	9.8711	300.4	.0590	20.46
71	9.8932	9.8849	298.2	.0353	12.22
73	9.8987	9.8925	295.5	.0309	10.63
75	9.9042	9.8953	292.8	.0360	12.34
77	9.9042	9.8987	292.4	.0267	9.165
79	9.9077	9.9008	293.0	.0319	10.95
81	9.9063	9.9001	292.7	.0288	9.889
83	9.9070	9.9008	292.6	.0307	10.52
85	9.9070	9.9022	292.5	.0266	9.117

(k) Reading 010/007; data at 305 cm (10.0 ft) aft of station 18; fan speed, 7204 rpm; inlet air temperature, 293.9 K (529.1° R); barometric pressure, 9.9084 N/cm^2 (14.371 psia).

Super-rake station	Total pressure, N/cm^2	Stream static pressure, N/cm^2	Total temperature, K	Mach number	Velocity, m/sec
1	9.9035	9.9084	294.1	0	0
3	9.9042	9.9049	294.4	0	0
5	9.9028	9.8870	295.1	.0481	16.56
7	9.9022	9.8877	295.9	.0454	15.65
9	9.9098	9.8966	297.2	.0435	15.02
11	9.9580	9.8835	298.4	.1037	35.86
13	9.9552	9.8636	300.2	.1153	39.98
15	9.9939	9.8601	302.4	.1390	48.33
17	10.010	9.8408	305.2	.1563	54.56
19	10.124	9.8070	308.3	.2137	74.81
21	10.288	9.7976	312.8	.2655	93.42
23	10.448	9.7594	317.2	.3139	110.9
25	10.803	9.7256	324.4	.3905	138.8
27	11.060	9.7450	334.5	.4295	154.5
29	11.391	9.7834	348.9	.4716	172.6
31	11.966	9.8525	360.1	.5350	197.7
33	12.495	9.9208	371.4	.5847	218.2
35	12.703	9.9890	409.0	.5976	233.6
37	12.926	10.052	463.2	.6125	254.0
39	12.932	10.095	536.8	.6093	271.6
41	12.916	10.131	621.7	.6049	287.5
43	12.900	10.158	687.8	.6013	302.3
45	13.016	10.176	753.9	.6124	321.3
47	13.133	10.152	747.5	.6266	345.7
49	13.249	10.129	670.6	.6385	315.8
51	13.217	10.107	573.5	.6358	291.8
53	13.101	10.040	499.0	.6316	271.1
55	12.800	9.9663	424.5	.6104	242.6
57	12.266	9.8994	383.2	.5630	213.9
59	11.753	9.8367	356.3	.5113	188.4
61	11.238	9.7980	339.1	.4474	161.8
63	10.868	↓	333.4	.3882	139.8
65	10.520		327.7	.3207	114.8
67	10.274		319.3	.2612	92.88
69	10.120	9.8305	313.0	.2042	72.07
71	10.005	9.8374	309.1	.1555	54.63
73	9.9546	9.8553	305.9	.1199	41.96
75	9.9098	9.8760	303.5	.0698	24.32
77	9.9132	9.8842	301.0	.0647	22.49
79	9.9028	9.8932	299.0	.0379	13.13
81	9.9008	9.9001	257.2	.0118	4.069
83	9.9042	9.9042	296.0	0	0
85	9.9111	9.9070	294.8	.0251	8.645

TABLE XIII. - SUPER-RAKE JET PLUME DATA FOR LARGER-EXHAUST-NOZZLE CONFLUENT-FLOW CONFIGURATION (C-5)

[Data at 152 cm (5.0 ft) aft of station 18; barometric pressure, 9.9256 N/cm^2 (14.396 psia).]

(a) Reading 010/022; fan speed, 4577 rpm; inlet air temperature, 291.4 K (524.5° R).

Super-rake station	Total pressure, N/cm^2	Stream static pressure, N/cm^2	Total temperature, K	Mach number	Velocity, m/sec
1	9.9249	9.9256	292.3	0	0
3	9.9249	9.9256	↓	↓	↓
5	9.9249	9.9249	↓	↓	↓
7	9.9242	9.9242	↓	↓	↓
9	9.9256	9.9249	↓	0.0066	2.248
11	9.9242	9.9242	292.4	0	0
13	9.9180	9.9235	292.3	↓	↓
15	9.9187	9.9242	292.3	↓	↓
17	9.9180	9.9235	292.3	↓	↓
19	9.9180	9.9215	292.4	↓	↓
21	9.9200	9.9173	293.0	.0210	7.195
23	9.9539	9.9034	294.0	.0805	27.62
25	10.026	9.8939	295.5	.1380	47.44
27	10.199	9.8870	297.5	.2112	72.67
29	10.608	9.9008	300.3	.3158	108.6
31	10.984	9.9346	301.7	.3817	130.9
33	11.280	9.9684	303.1	.4243	145.3
35	11.092	10.002	308.8	.3875	134.4
37	10.727	10.008	344.1	.3168	116.5
39	10.521	10.008	459.3	.2701	114.8
41	10.443	10.007	625.0	.2503	123.4
43	10.381	10.007	654.4	.2323	117.2
45	10.429	9.9952	684.3	.2502	128.8
47	10.476	↓	684.9	.2633	135.3
49	10.523	↓	672.7	.2755	140.5
51	10.564	↓	606.7	.2851	138.3
53	10.745	10.002	553.3	.3239	150.1
55	11.087	9.9973	466.1	.3890	165.2
57	11.240	9.9753	350.0	.4170	153.6
59	11.032	9.9325	309.4	.3905	135.5
61	10.588	9.8980	303.4	.3118	107.8
63	10.217	9.8994	302.3	.2131	73.88
65	10.021	9.9008	301.1	.1314	45.59
67	9.5180	9.9022	297.8	.0846	29.25
69	9.9291	9.9132	295.5	.0478	16.47
71	9.9277	9.9180	294.4	.0373	12.82
73	9.9297	9.9194	293.3	.0381	13.06
75	9.9284	9.9201	293.2	.0345	11.85
77	9.9297	9.9194	293.0	.0374	12.84
79	9.9284	9.9208	292.7	.0340	11.62
81	9.9291	9.9208	292.5	.0355	12.18
83	9.9291	9.9201	292.6	.0357	12.25
85	9.9297	9.9229	292.6	.0305	10.47

(b) Reading 010/024; fan speed, 6469 rpm; inlet air temperature, 291.1 K (524° R).

Super-rake station	Total pressure, N/cm^2	Stream static pressure, N/cm^2	Total temperature, K	Mach number	Velocity, m/sec
1	9.9249	9.9256	292.9	0	0
3	9.9256	9.9249	↓	.0116	3.962
5	9.9242	9.9249	↓	0	0
7	9.9256	9.9256	↓	0	0
9	9.9235	9.9249	292.1	0	0
11	9.9270	9.9249	↓	.0188	6.442
13	9.9249	9.9242	↓	.0076	2.595
15	9.9249	9.9235	↓	.0148	5.080
17	9.9228	9.9201	292.2	.0214	7.340
19	9.9228	9.9173	292.4	.0286	9.799
21	9.9173	9.9077	293.6	.0376	12.92
23	9.9759	9.8815	296.3	.1167	40.18
25	10.163	9.8511	299.9	.2115	73.06
27	10.706	9.8491	304.5	.3475	120.0
29	11.424	9.8829	310.6	.4601	159.1
31	12.405	9.9573	313.3	.5698	195.7
33	12.739	10.032	316.0	.5949	204.7
35	12.125	10.106	327.0	.5172	182.5
37	11.550	10.118	393.1	.4398	171.2
39	11.331	10.119	527.6	.4076	183.6
41	11.238	10.119	657.8	.3945	197.7
43	11.217	10.117	730.0	.3924	206.5
45	11.237	10.116	802.4	.3970	218.5
47	11.195	10.118	799.2	.4000	219.7
49	11.276	10.119	752.8	.4023	219.1
51	11.455	10.121	754.8	.4306	229.7
53	11.713	10.117	671.1	.4676	235.2
55	12.390	10.110	492.2	.5495	236.4
57	12.772	10.073	362.6	.5931	218.6
59	12.293	9.9677	322.5	.5560	194.1
61	11.357	9.8760	316.0	.4516	157.6
63	10.558	9.8801	313.4	.3096	108.7
65	10.142	9.8842	310.9	.1924	67.67
67	9.9559	9.8877	304.3	.0992	34.63
69	9.9242	9.9111	299.4	.0437	15.15
71	9.9270	9.9208	269.8	.0299	10.32
73	9.9263	9.9249	294.1	.0147	5.042
75	9.9256	9.9256	293.6	0	0
77	9.9270	9.9256	293.1	.0105	3.598
79	9.9263	9.9270	292.7	0	0
81	9.9270	9.9270	292.4	0	0
83	9.9263	9.9263	292.6	0	0
85	9.9270	9.9263	292.4	.0087	2.998

(c) Reading 010/027; fan speed, 7578 rpm; inlet air temperature, 290.9 K (523.7° R).

Super-rake station	Total pressure, N/cm^2	Stream static pressure, N/cm^2	Total temperature, K	Mach number	Velocity, m/sec
1	9.9270	9.9236	292.0	0.0211	7.222
3	9.9263	9.9215	↓	.0253	8.668
5	9.9263	9.9215	↓	.0270	9.232
7	9.9270	9.9222	↓	.0260	8.892
9	9.9263	9.9222	292.1	.0244	8.304
11	9.9277	9.9208	292.1	.0309	10.59
13	9.9277	9.9208	292.2	.0313	10.72
15	9.9263	9.9201	292.2	.0303	10.38
17	9.9235	9.9173	292.3	.0297	10.16
19	9.9249	9.9091	292.8	.0473	16.22
21	9.9249	9.8932	293.5	.0674	23.11
23	10.011	9.8642	299.0	.1456	50.35
25	10.304	9.8387	304.1	.2580	89.58
27	11.018	9.8387	311.1	.4057	141.0
29	12.124	9.8960	319.9	.5469	109.3
31	13.292	9.9911	325.2	.6525	226.2
33	13.331	10.086	330.5	.6446	225.5
35	12.681	10.181	368.2	.5698	212.1
37	12.415	10.197	506.7	.5406	236.0
39	12.171	10.210	709.7	.5139	264.4
41	12.095	10.219	867.6	.5059	286.6
43	11.916	10.222	880.4	.4821	275.6
45	11.979	10.226	893.3	.4901	281.9
47	12.042	10.224	894.9	.4987	286.9
49	12.106	10.221	857.7	.5067	285.4
51	12.257	10.219	768.9	.5242	280.0
53	12.539	10.206	669.4	.5568	277.5
55	13.066	10.190	570.2	.6113	280.5
57	13.645	10.119	452.2	.6694	264.5
59	13.145	9.9856	342.0	.6398	227.9
61	11.808	9.8656	326.3	.5137	181.2
63	10.838	9.8684	322.5	.3688	130.9
65	10.243	9.8711	318.7	.2306	82.01
67	9.9966	9.8739	309.5	.1332	46.87
69	9.9332	9.9022	302.3	.0669	23.29
71	9.9291	9.9134	298.5	.0468	16.18
73	9.9297	9.9208	294.6	.0353	12.13
75	9.9297	9.9242	293.8	.0232	9.677
77	9.9270	9.9242	293.0	.0188	6.453
79	9.9297	9.9242	292.4	.0288	9.856
81	9.9304	9.9249	292.0	.0265	6.453
83	9.9297	9.9256	292.1	.0242	8.273
85	9.9297	9.9256	291.9	.0251	8.620

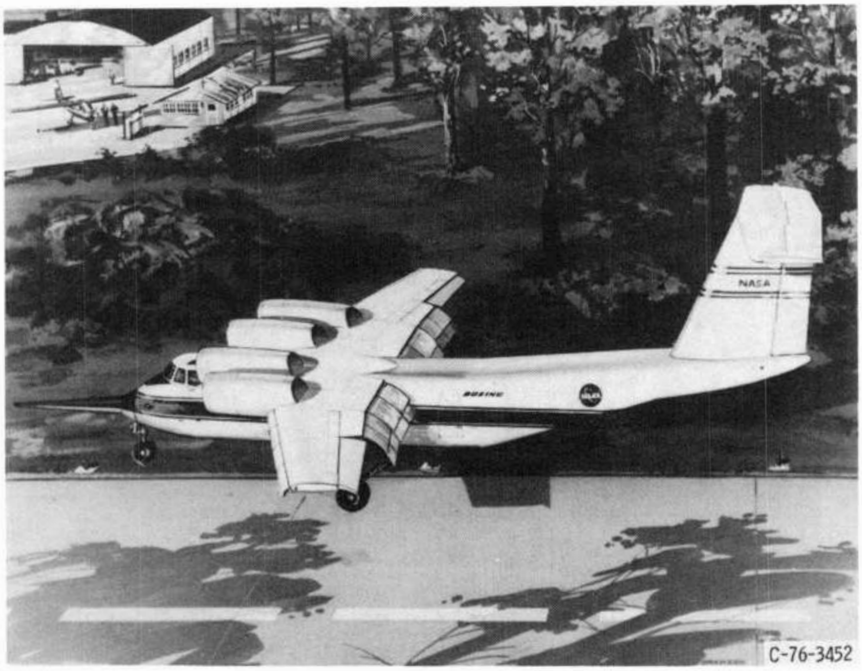
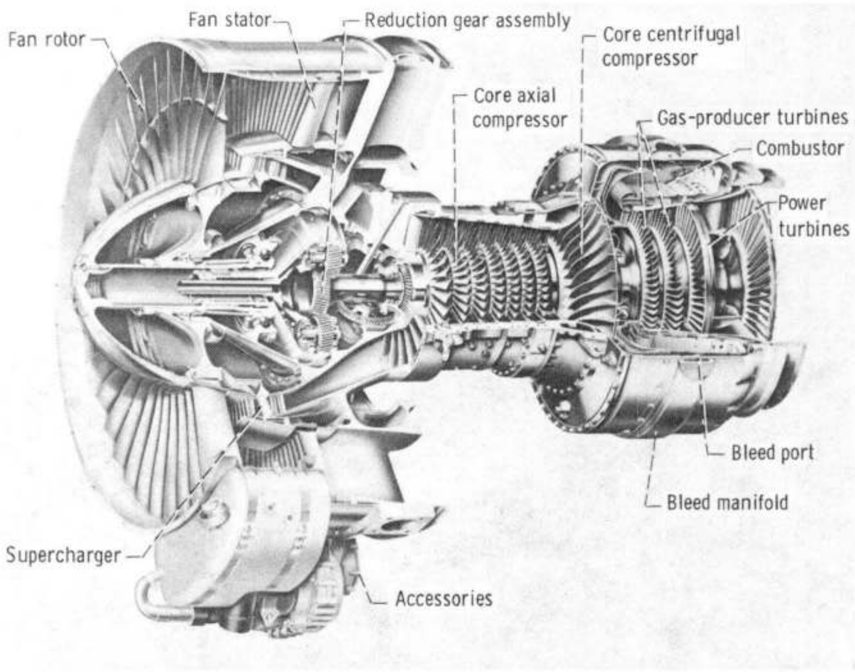
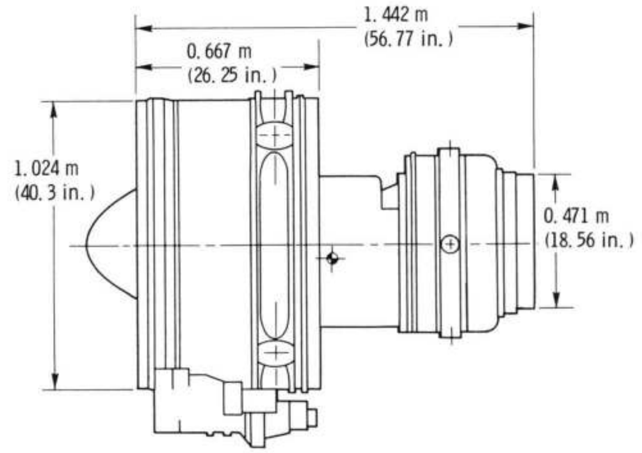


Figure 1. - Artist's sketch of QSRA in approach configuration.

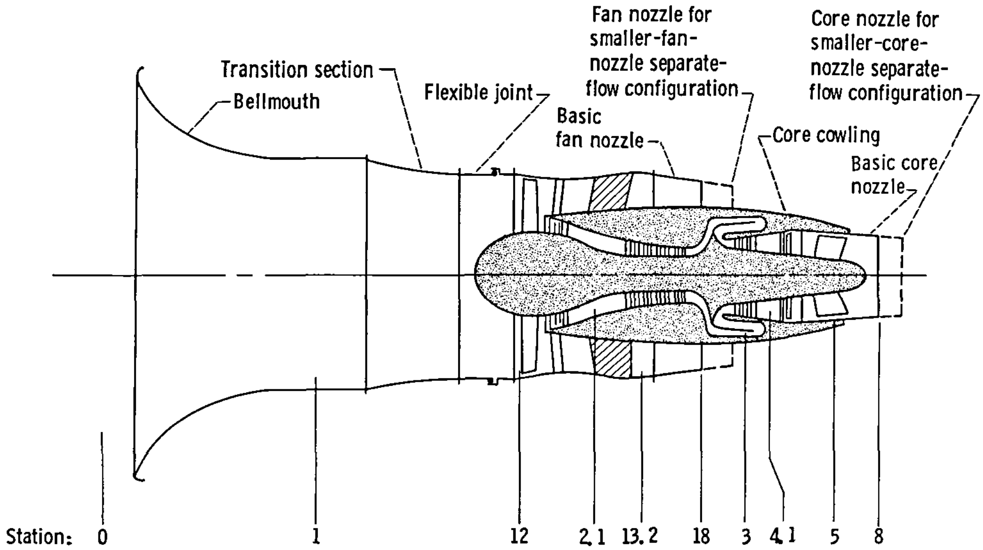


(a) Cutaway illustration.



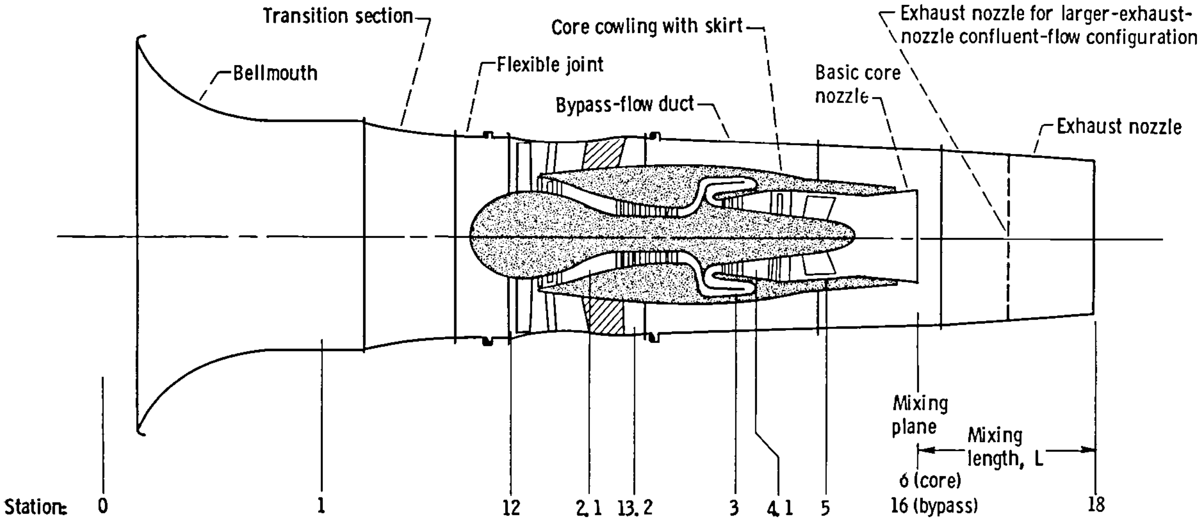
(b) Side envelope.

Figure 2. - Lycoming YF-102 turbofan engine.



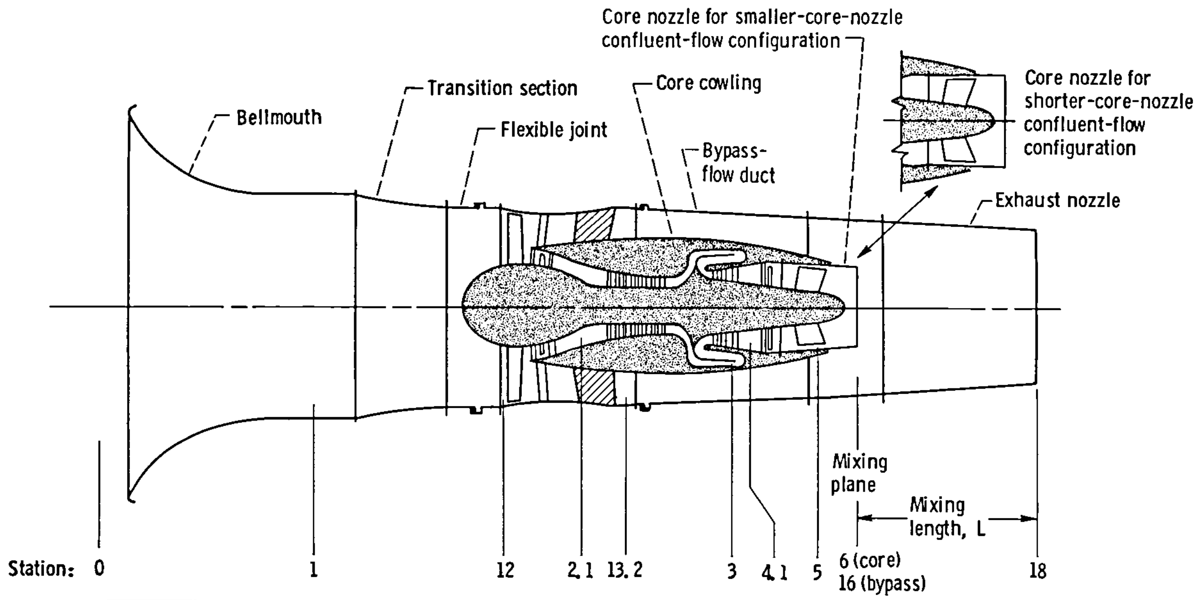
Separate-flow configuration	Core-nozzle area		Fan-nozzle area	
	cm^2	in^2	cm^2	in^2
Basic (S-1)	1361	210.9	3640	564
Smaller core nozzle (S-3)	1163	180.2	3640	564
Smaller fan nozzle (S-4)	1361	210.9	3230	500

Figure 3. - Separate-flow configurations.



Confluent-flow configuration	Core-nozzle area		Exhaust-nozzle area		Bypass-flow-duct area at mixing plane		Mixing length, L	
	cm^2	in^2	cm^2	in^2	cm^2	in^2	cm^2	in^2
Basic (C-1)	1687	261.5	4803	744.4	4451	689.9	91.4	36.0
Larger exhaust nozzle (C-5)	1687	261.5	5453	845.2	4451	689.9	47.5	18.7

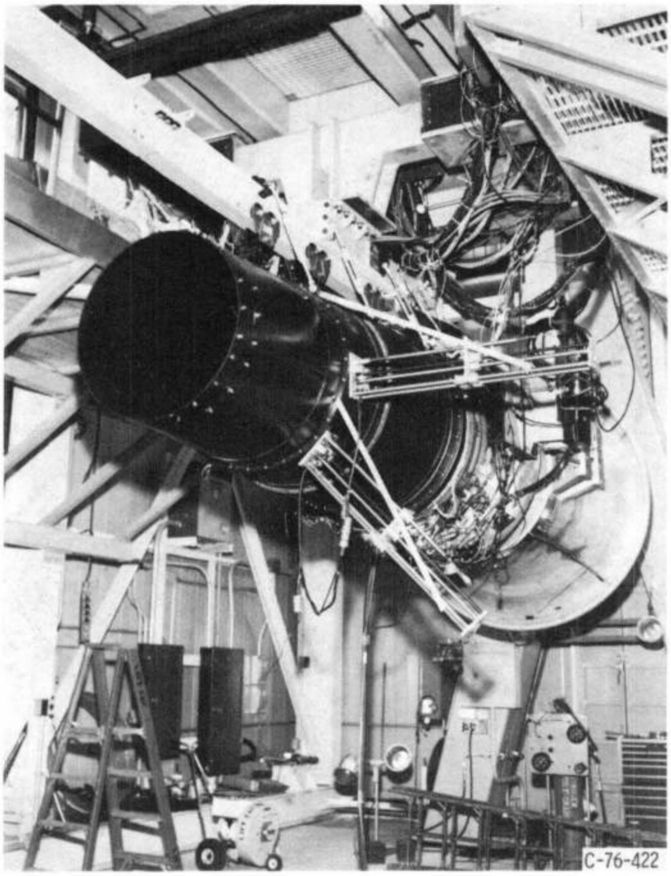
(a) Configuration using basic core nozzle.



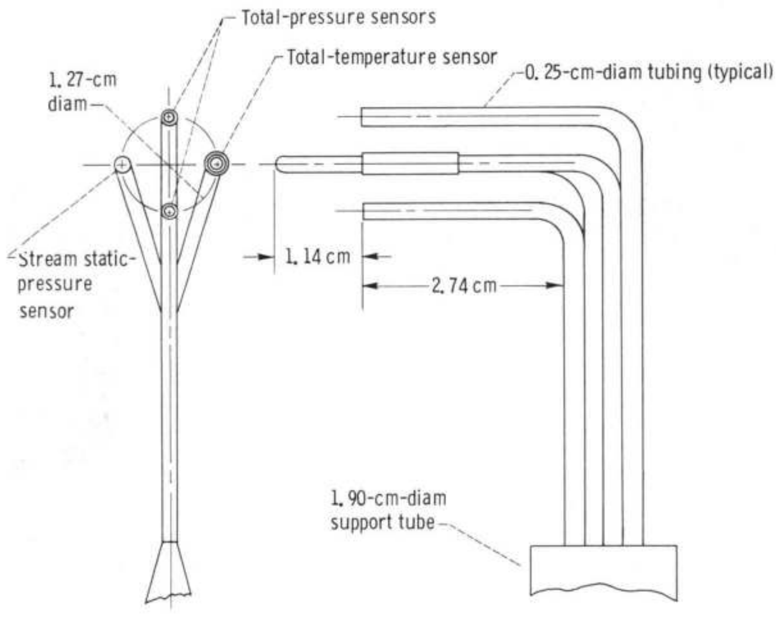
Confluent-flow configuration	Core-nozzle area		Exhaust-nozzle area		Bypass-flow-duct area at mixing plane		Mixing length, L	
	cm^2	in^2	cm^2	in^2	cm^2	in^2	cm^2	in^2
Shorter core nozzle (C-4)	1752	271.5	4803	744.4	4510	699.0	91.4	36.0
Smaller core nozzle (C-6)	1361	210.9	4803	744.4	4927	763.7	91.4	36.0

(b) Other confluent-flow configurations.

Figure 4. - Confluent-flow configurations.



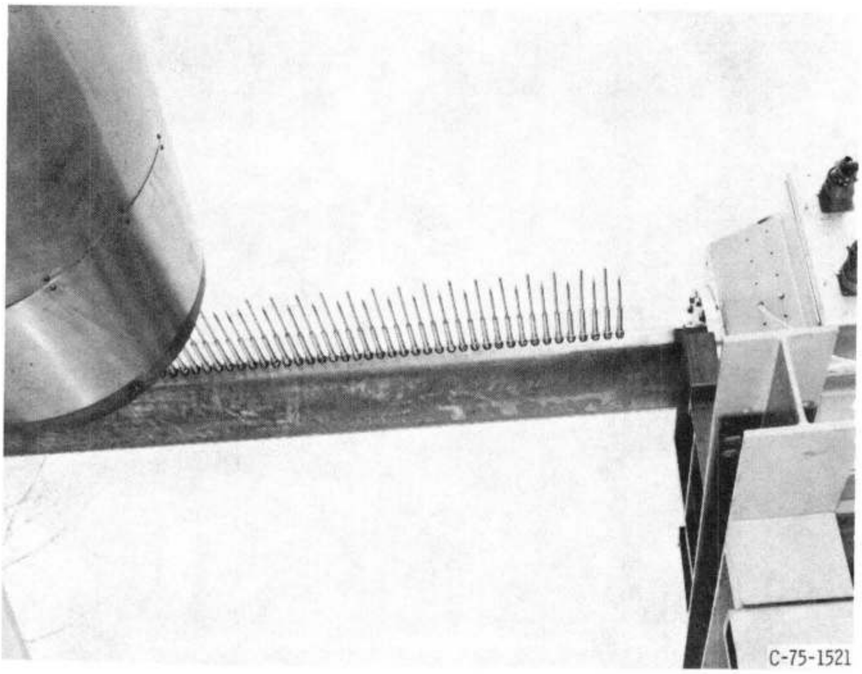
(a) Probes mounted at mixing plane.



(b) Probe details.

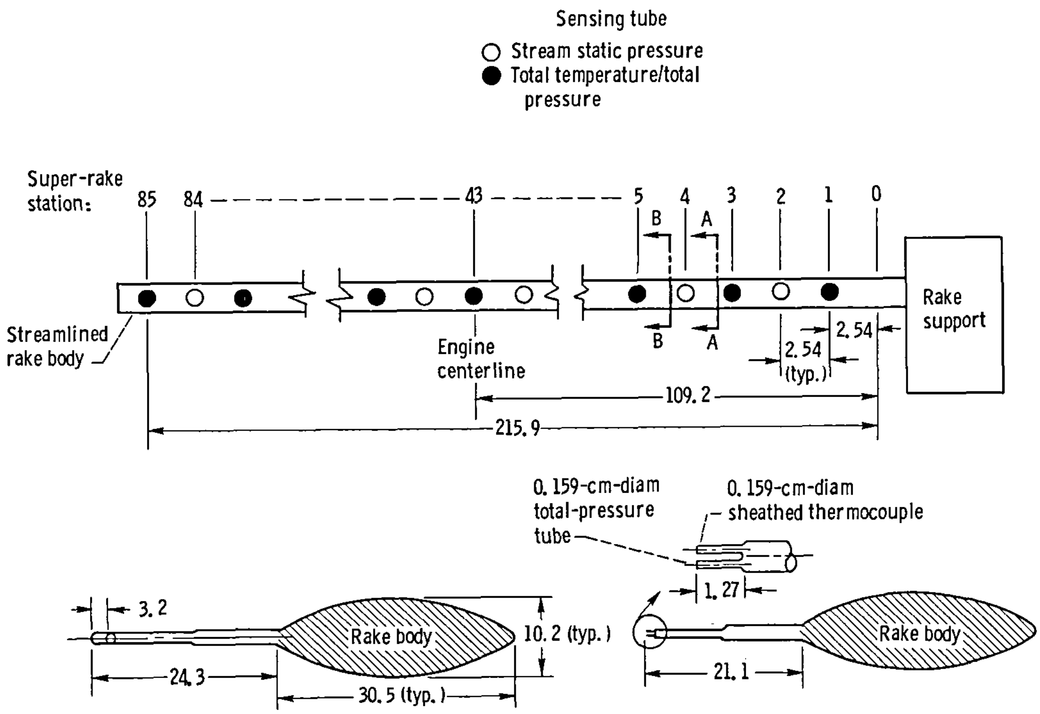
Figure 5. - Traversing probe for internal-flow surveys.

(a) On mounting cart.



(b) In position for testing.

Figure 6. - Super-rake used for external (jet plume) flow surveys.



Section A-A: Typical of all stream-static-pressure sensing tubes (42 tubes total)

Section B-B: Typical of all total-temperature/total-pressure sensing tubes (43 pairs total)

(c) Schematic drawing (all dimensions in centimeters.)

Figure 6. - Concluded.

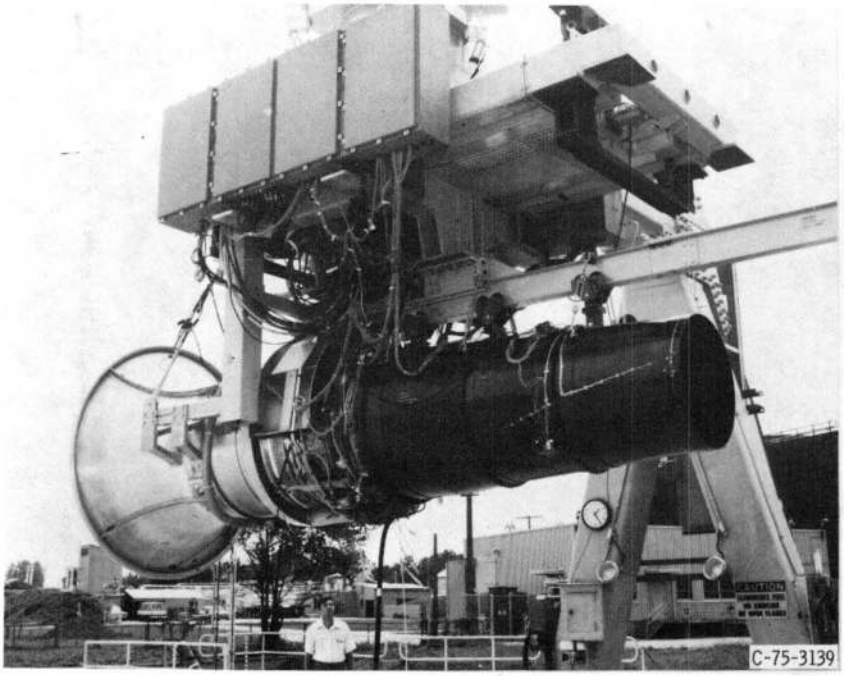


Figure 7. - YF-102 engine with basic confluent-flow configuration exhaust system ready for testing at Vertical Lift Facility.

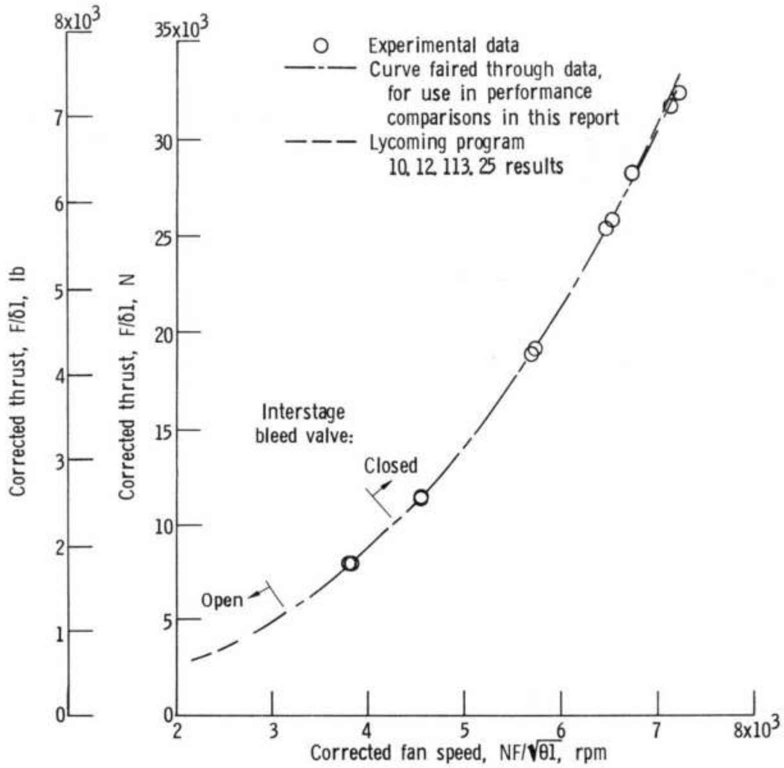


Figure 8. - Thrust performance for basic confluent-flow configuration (C-1).

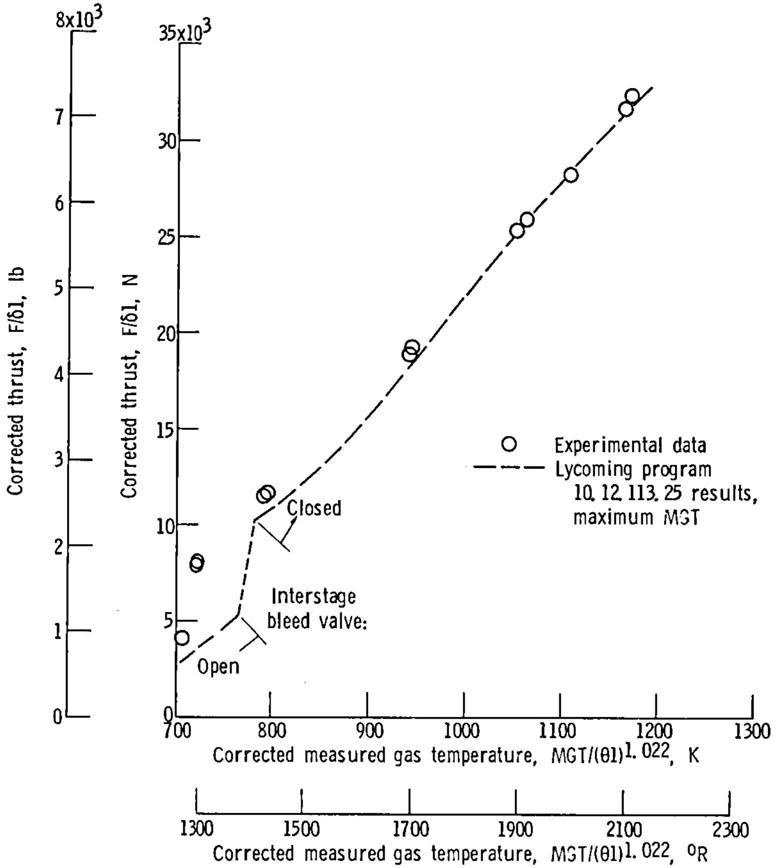


Figure 9. - Measured gas temperature for basic confluent-flow configuration (C-1).

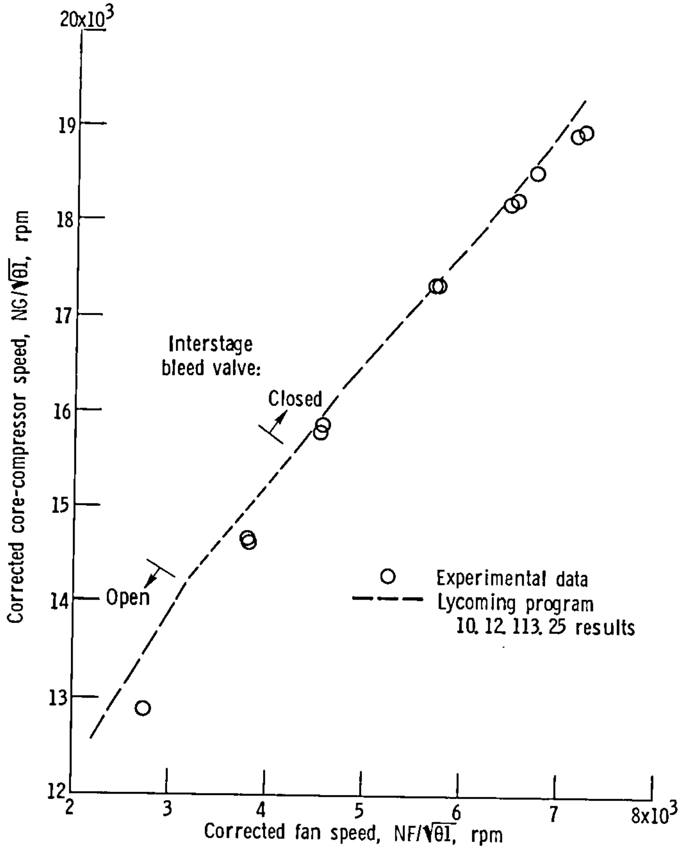


Figure 10. - Core-compressor speed for basic confluent-flow configuration (C-1).

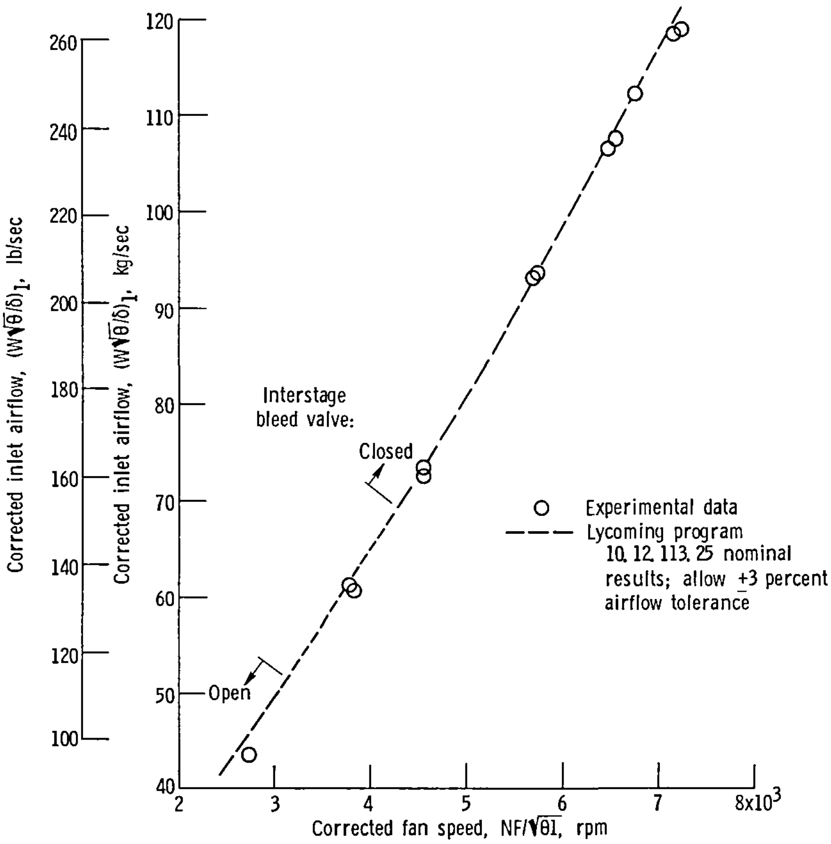


Figure 11. - Inlet airflow for basic confluent-flow configuration (C-1).

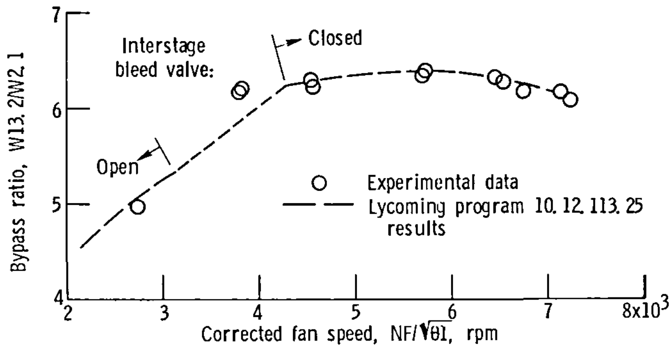


Figure 12. - Bypass ratio for basic confluent-flow configuration (C-1).

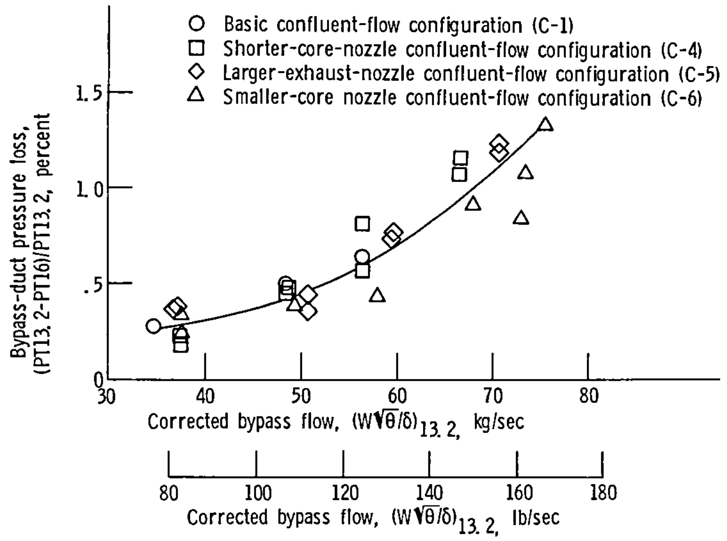


Figure 13. - Bypass-duct pressure loss for all confluent-flow configurations.

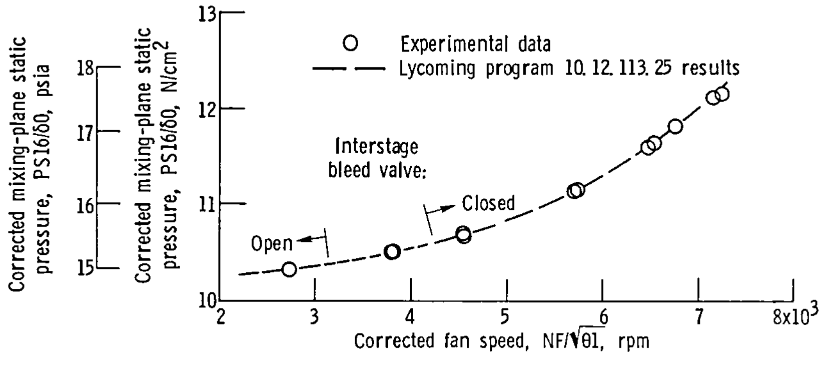


Figure 14. - Mixing-plane static pressure for basic confluent-flow configuration (C-1). (PS16 is a weighted average of static pressures measured by instrumentation at stations 6 and 16.)

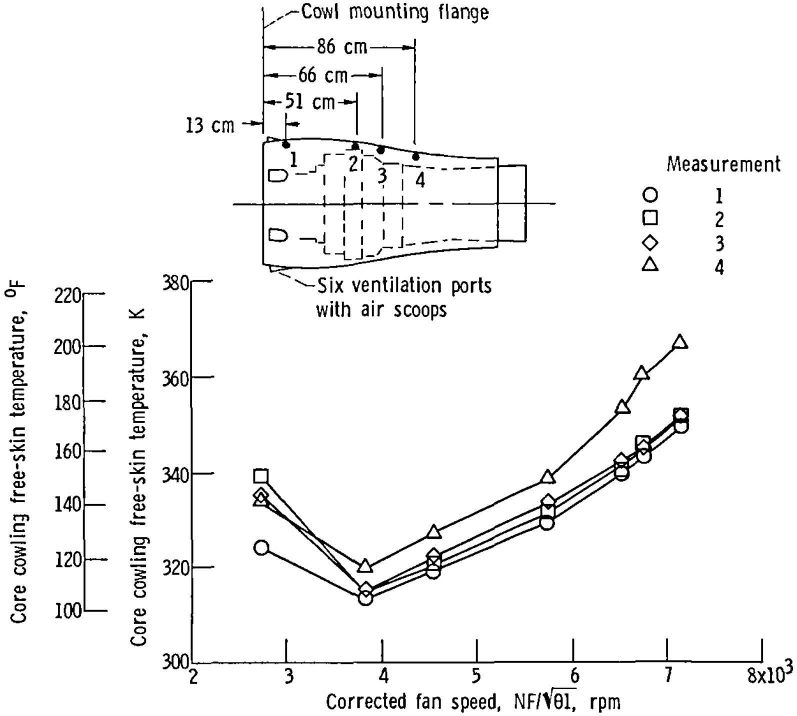


Figure 15. - Core cowling free-skin temperature for basic confluent-flow configuration (C-1).

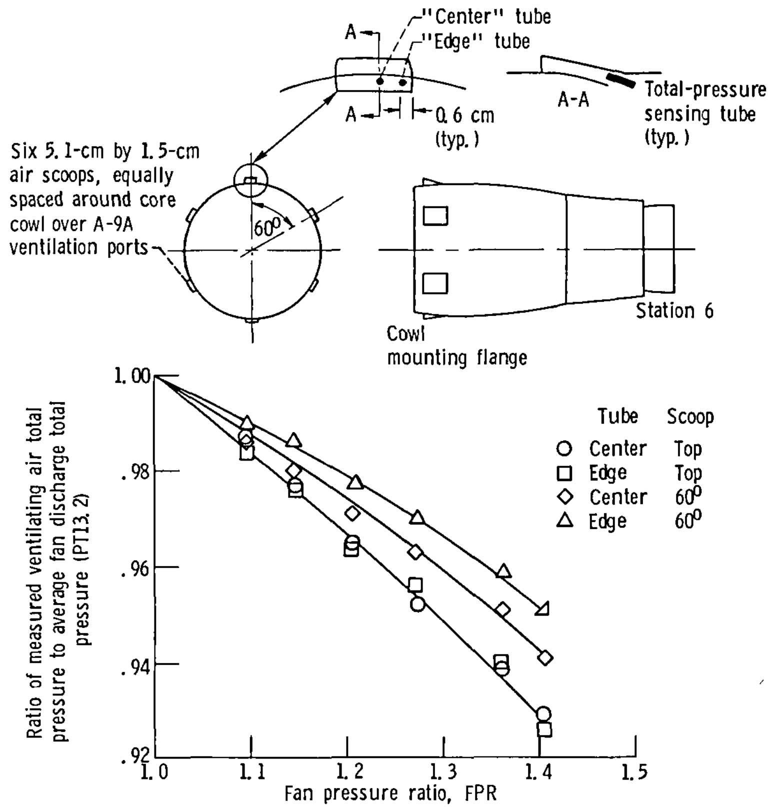


Figure 16. - Core cowling ventilating air incoming pressure for basic confluent-flow configuration (C-1).

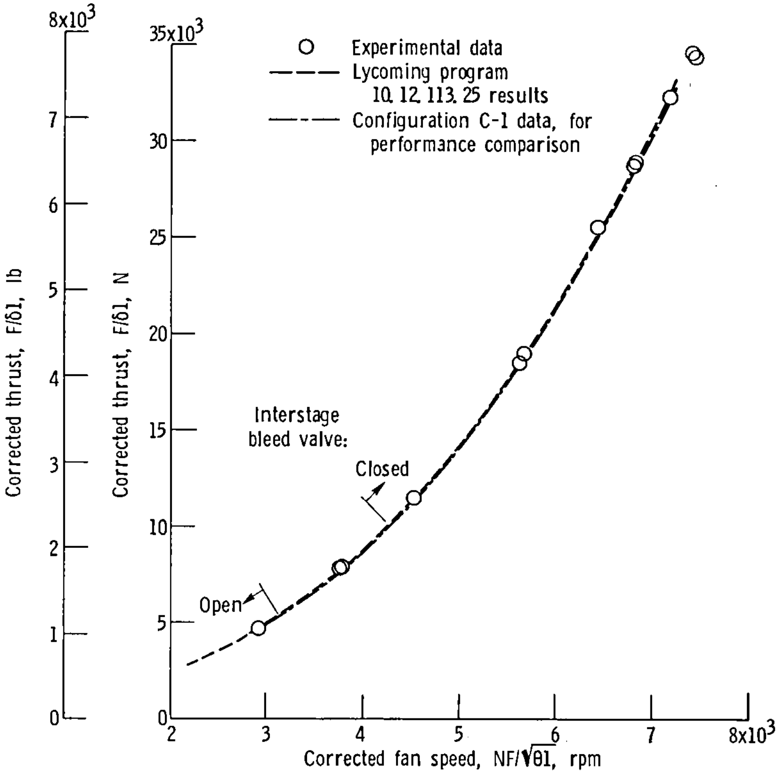
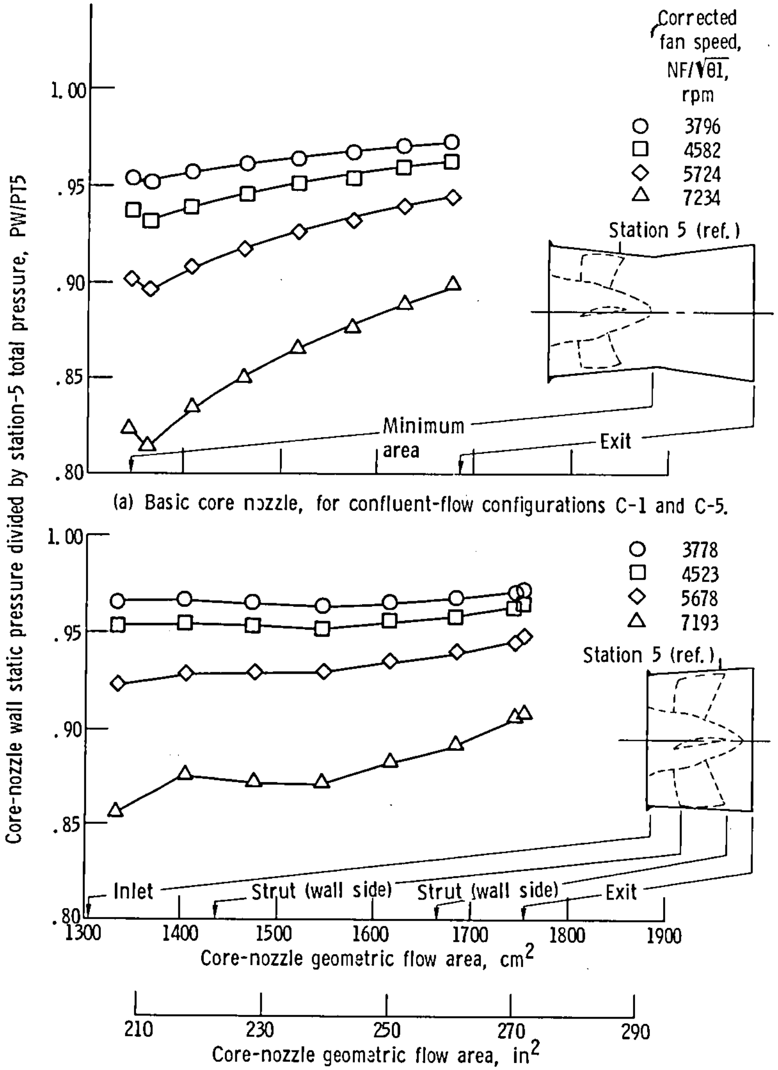


Figure 17. - Thrust performance for shorter-core-nozzle confluent-flow configuration (C-4).



(a) Basic core nozzle, for confluent-flow configurations C-1 and C-5.

(b) Shorter core nozzle, for confluent-flow configuration C-4.

Figure 18. - Variation of wall static pressure along nozzle for core nozzles in confluent-flow configurations C-1, C-4, and C-5.

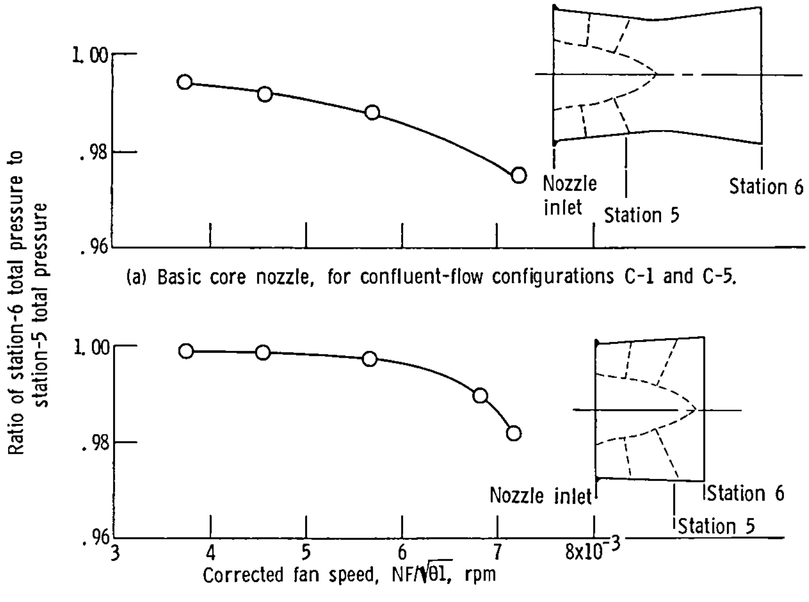


Figure 19. - Total-pressure in exit plane of core nozzles for confluent-flow configurations. (Station-5 data are from rakes. Station-6 data are area-weighted average of traverses at 90° and 135° circumferential position.)

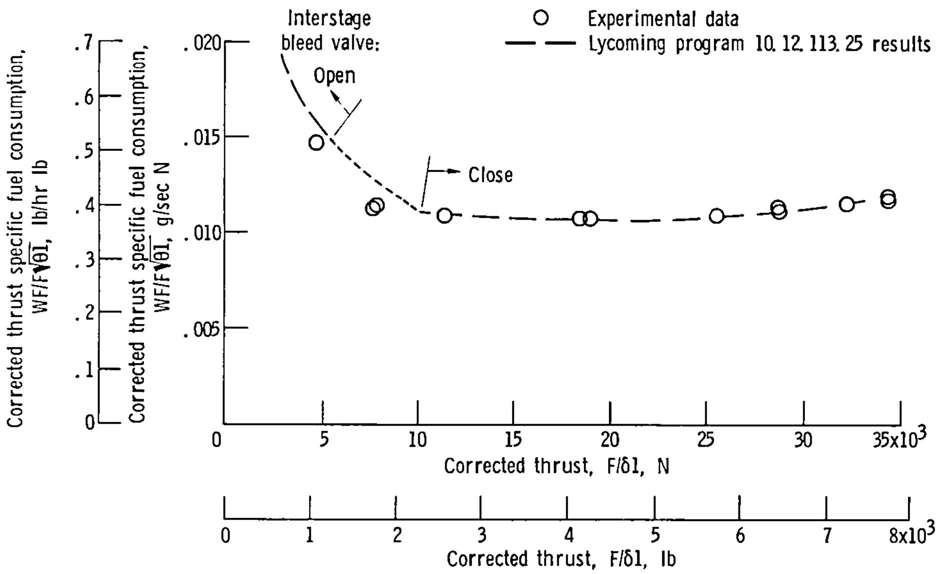


Figure 20. - Thrust specific fuel consumption for shorter-core-nozzle confluent-flow configuration (C-4).

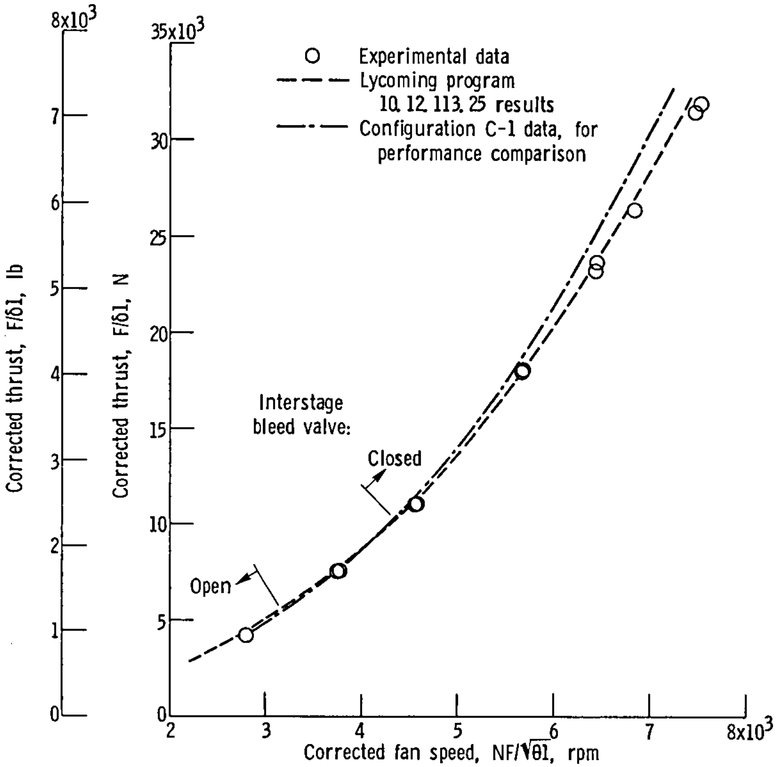


Figure 21. - Thrust performance for larger-exhaust-nozzle confluent-flow configuration (C-5).

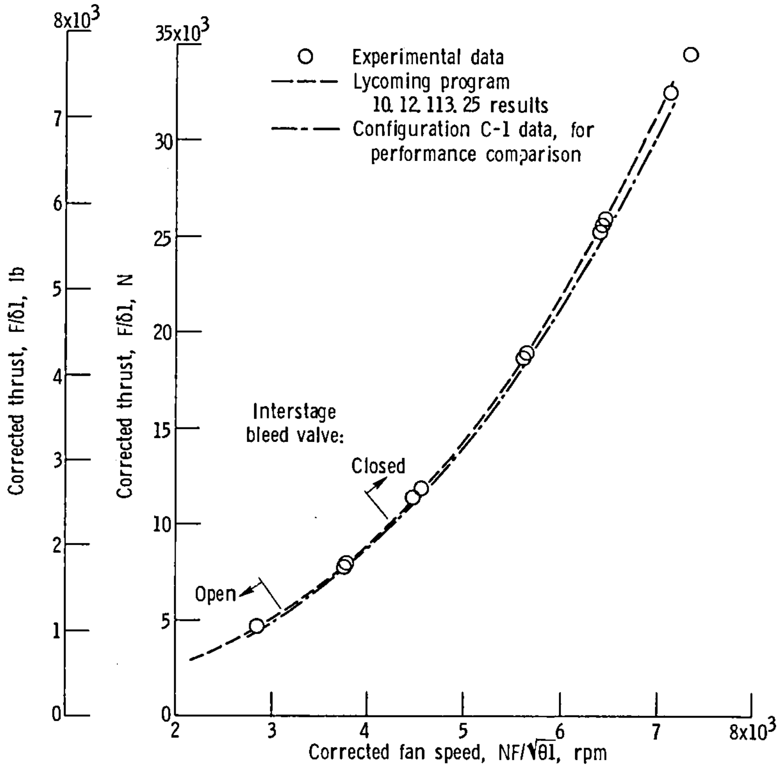


Figure 22. - Thrust performance of smaller-core-nozzle confluent-flow configuration (C-6).

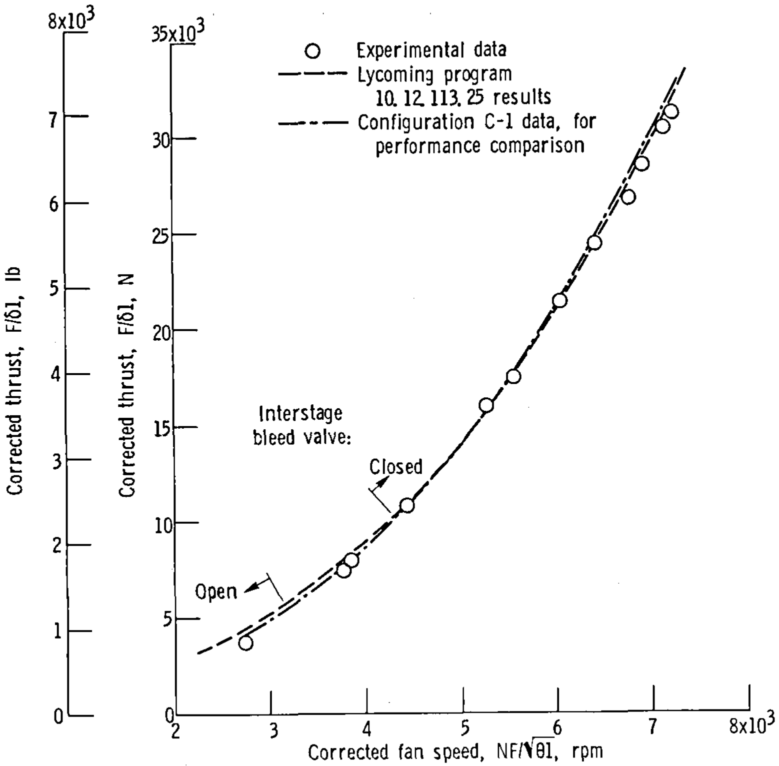


Figure 23. - Thrust performance of basic separate-flow configuration (S-1).

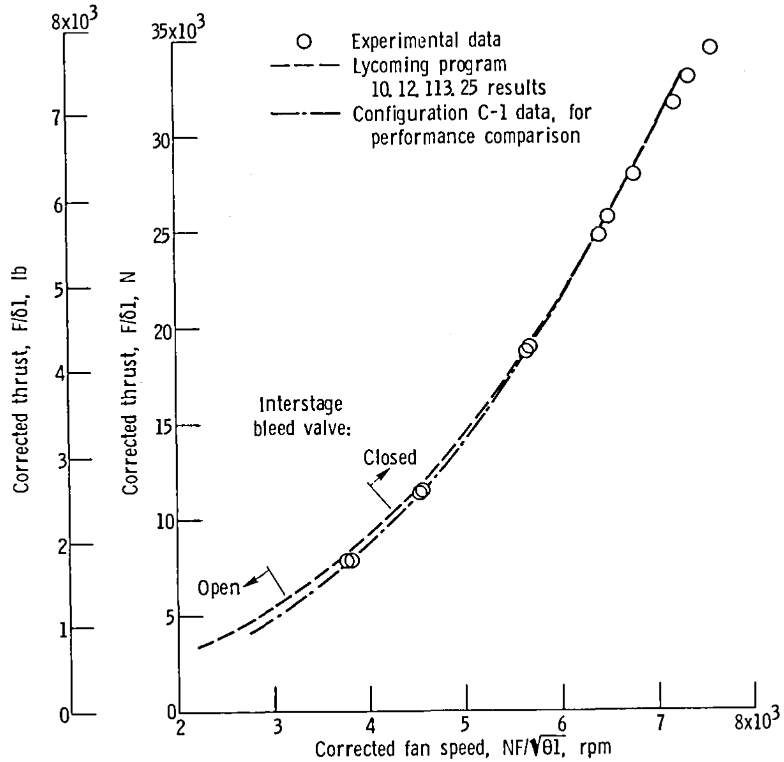


Figure 24. - Thrust performance of smaller-core-nozzle separate-flow configuration (S-3).

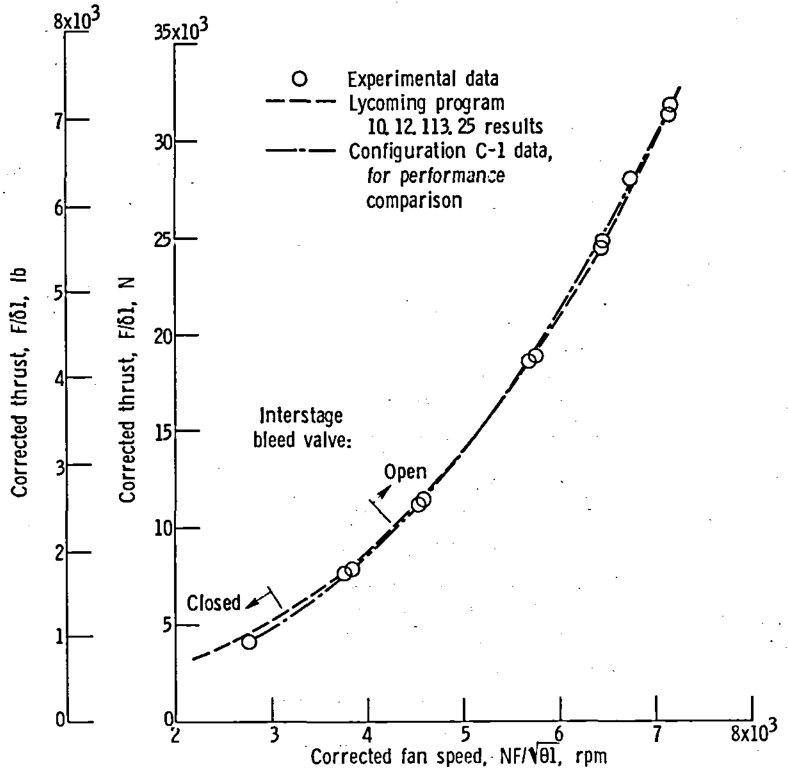


Figure 25. - Thrust performance of smaller-fan-nozzle separate-flow configuration (S-4).

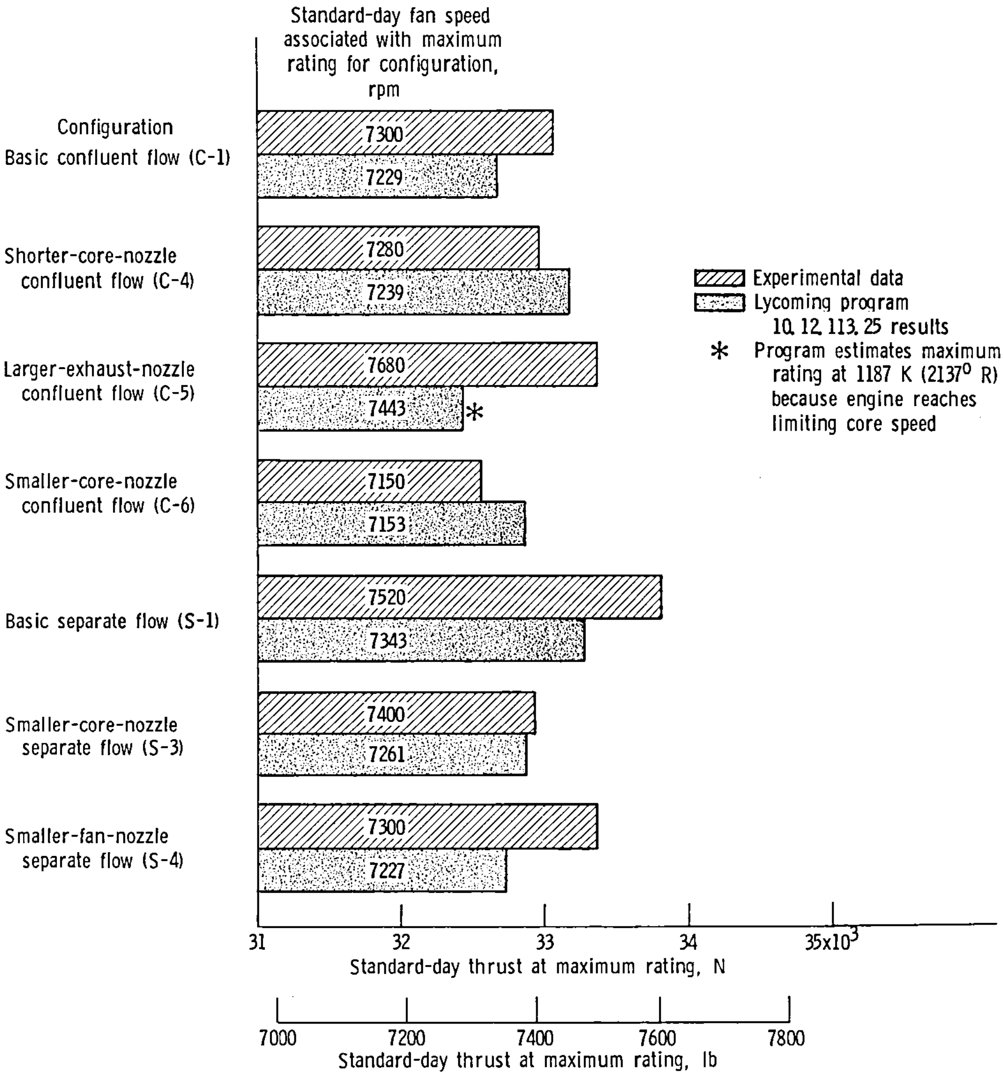


Figure 26. - Comparison of standard-day static thrusts at maximum performance rating for all configurations tested.

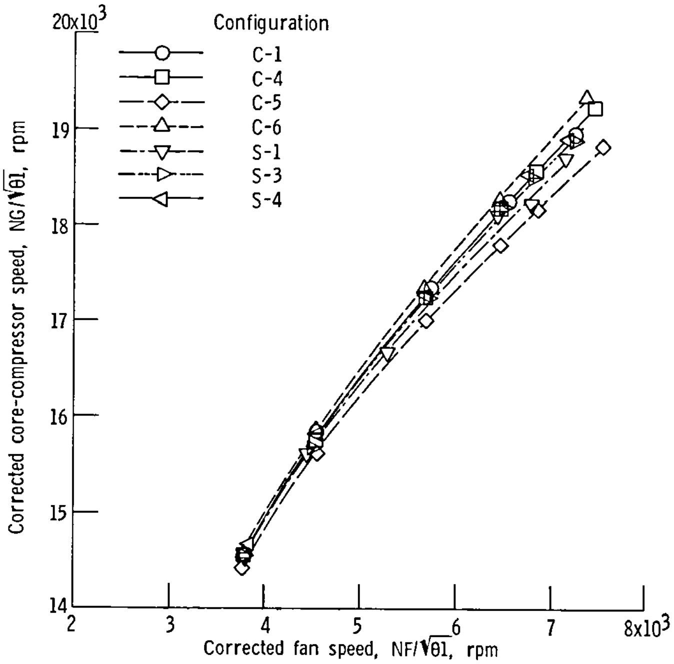
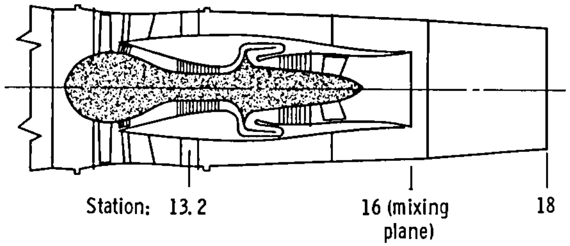


Figure 27. - Speed match lines for all configurations tested.



Station	Corrected fan speed, NF/$\sqrt{\theta 1}$, rpm	Data method
13.2	4596	Average of two readings of fixed instrumentation in bypass duct
16 (mixing plane)	4588	Average of probe traverses at 90^0 and 135^0 circumferential positions
18	4543	Average of probe traverses at 90^0 and 135^0 circumferential positions

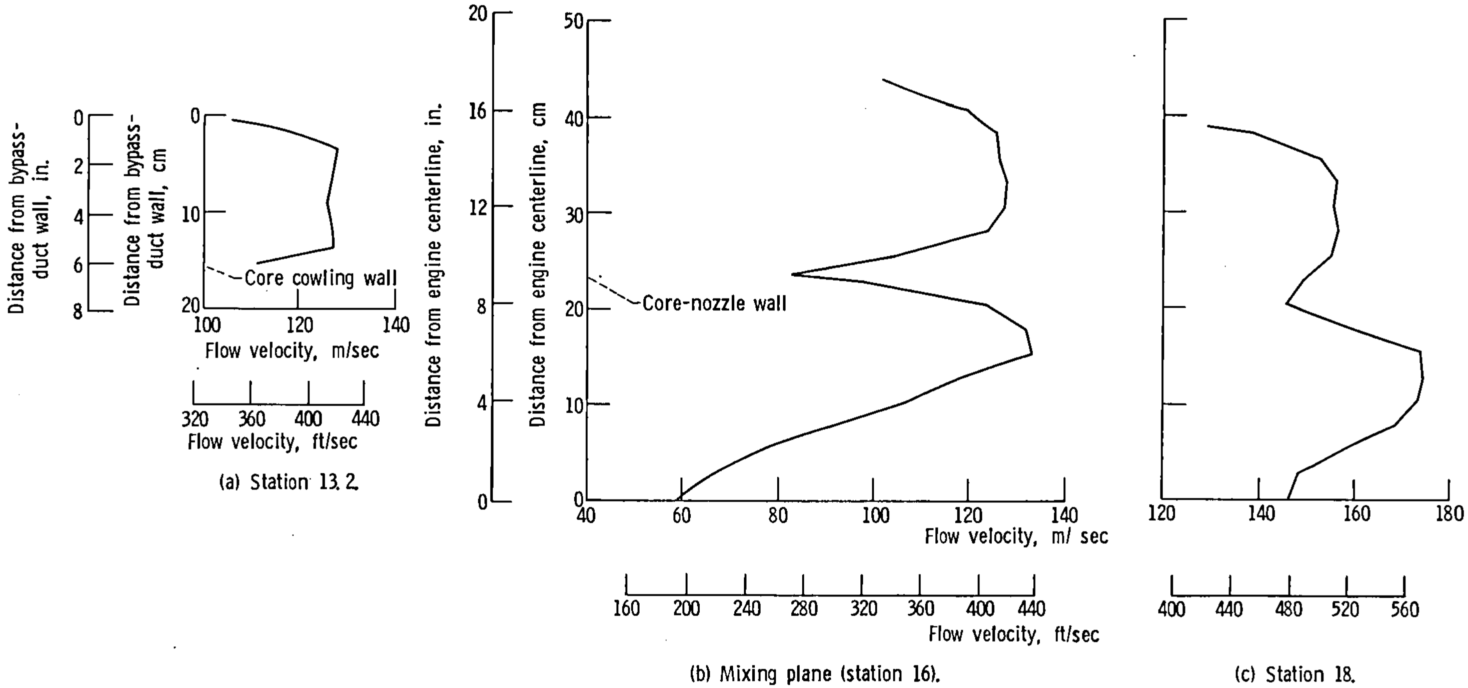


Figure 28. - Typical flow velocities from internal flow surveys. Results shown for basic confluent-flow configuration (C-1).

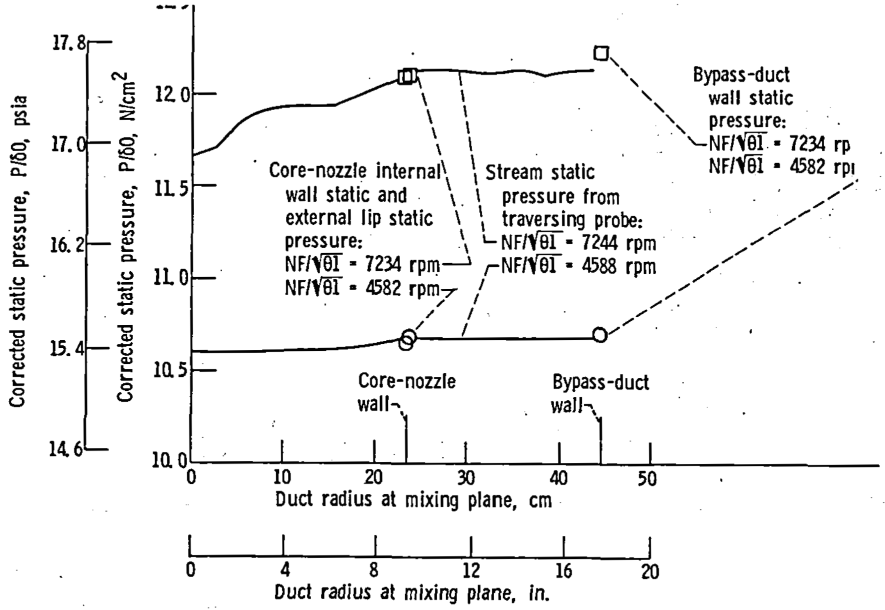


Figure 29. - Variation of static pressure in mixing plane. Results shown for basic confluent-flow configuration (C-1).

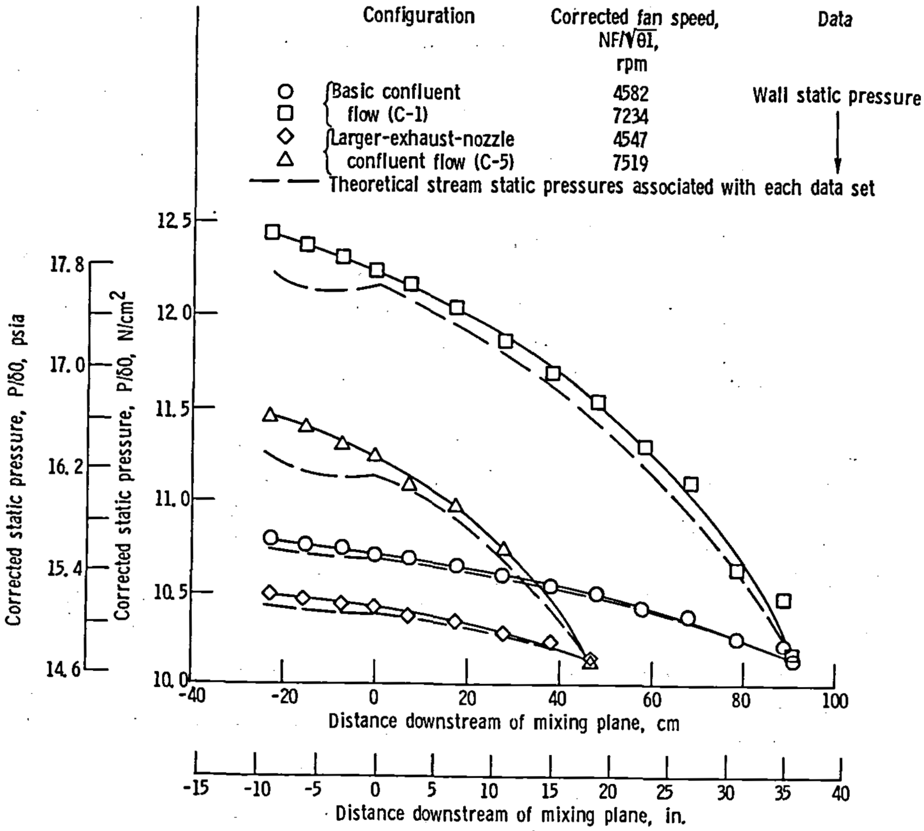
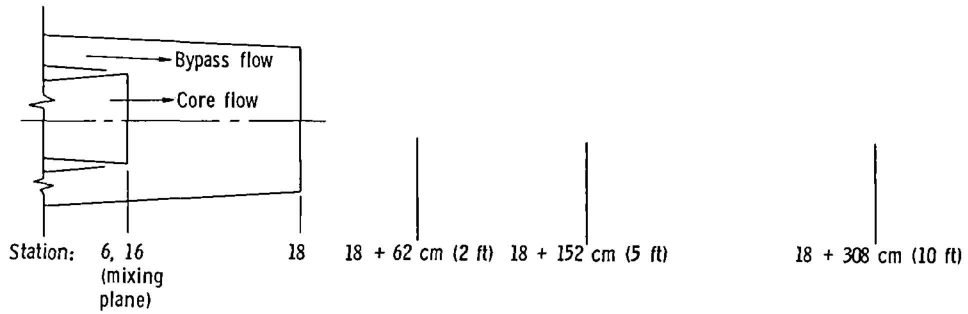
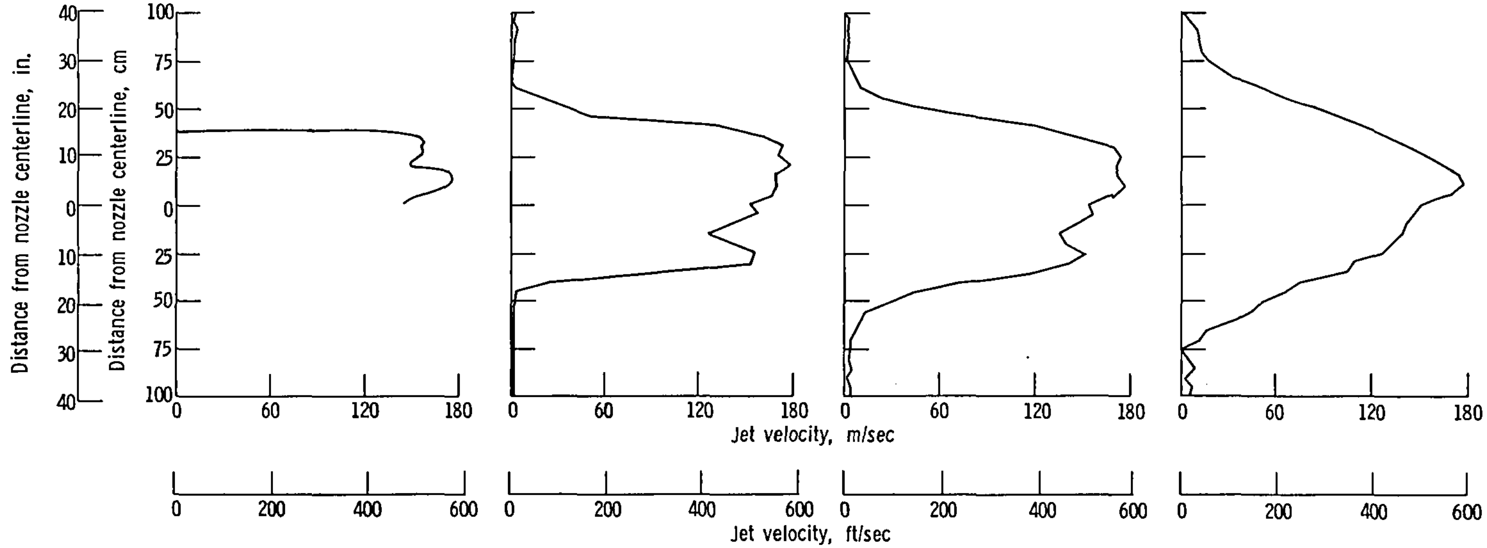


Figure 30. - Comparison of experimental and theoretical static pressures in exhaust nozzle for confluent-flow configurations.



Station	Corrected fan speed, $NF/\sqrt{\theta 1}$, rpm	Data method
18	4543	Average of probe traverses from centerline to wall, at 90° and 135° locations
18 + 62 cm	4547	Super-rake
18 + 152 cm	4526	Super-rake
18 + 308 cm	4509	Super-rake



(a) Station 18. (b) Station 18 + 62 cm. (c) Station 18 + 152 cm. (d) Station 18 + 308 cm.

Figure 31. - Typical jet-plume velocities from external-flow surveys. Results shown for basic confluent-flow configuration (C-1).

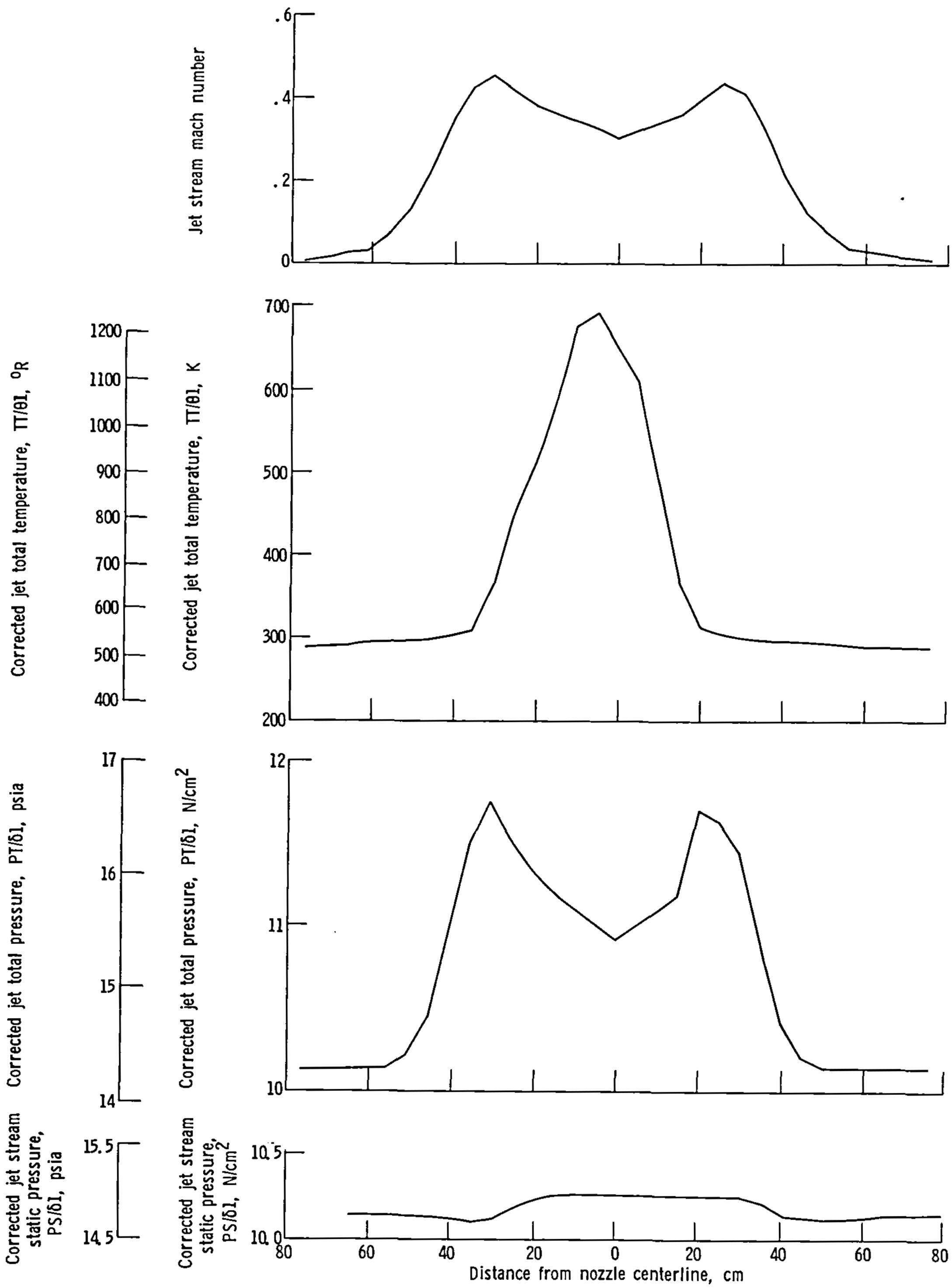


Figure 32. - Typical super-rake pressure and temperature data. Results shown for basic confluent-flow configuration (C-1); fan speed, 4580 rpm; station, 152 cm (5 ft) downstream of exhaust nozzle exit.

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15. Supplementary Notes

16. Abstract

The performance of a Lycoming YF-102 turbofan engine was measured in an outdoor test stand with a bellmouth inlet and seven exhaust-system configurations. The configurations consisted of three separate-flow systems of various fan and core nozzle sizes and four confluent-flow systems of various nozzle sizes and shapes. A Lycoming computer program provided good estimates of the engine performance and of thrust at maximum rating for each exhaust configuration. The internal performance of two different-shaped core nozzles for confluent-flow configurations was determined to be satisfactory. Pressure and temperature surveys were made with a traversing probe in the exhaust-nozzle flow for some confluent-flow configurations. The survey data at the mixing plane, plus the measured flow rates, were used to calculate the static-pressure variation along the exhaust-nozzle length. The computed pressures compared well with experimental wall static-pressure data. External-flow surveys were made, for some confluent-flow configurations, with a large fixed rake at various locations in the exhaust plume.

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