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Report No. PWA-2600

Date: 30 June 1965

Volume 1

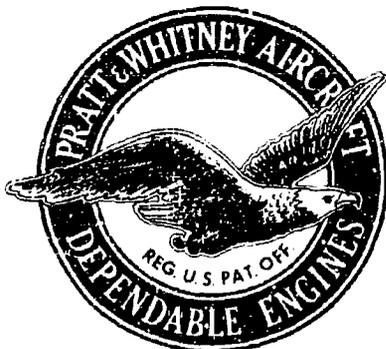
SUPERSONIC TRANSPORT AIRCRAFT ENGINE

PHASE D-B DEVELOPMENT PROGRAM

FINAL REPORT (U)

Prepared Under Contract FA-SS-65-18

Period Covered 1 January through 30 June 1965



PWA-E. H. Document Control  
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**Pratt & Whitney Aircraft** DIVISION OF UNITED AIRCRAFT CORPORATION

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PWA-2600

## FOREWORD

This report describes the work that was accomplished by Pratt & Whitney Aircraft during the period 1 January 1965 through 30 June 1965 in accordance with the requirements of contract FA-SS-65-18 entitled "Development of Supersonic Transport Engine - Phase II-B". The report is submitted to fulfill the requirements of Item 7, Section D of the contract work statement.

This report is classified as CONFIDENTIAL in compliance with the provisions of DD Form 254 dated 1 January 1965 provided for this contract.

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**INTRODUCTION**

The overall objectives of the program conducted under contract FA-SS-65-18 were to continue: the design of the STF 219 duct-heating turbofan engine, liaison with aircraft manufacturers to ensure optimum engine and ejector-reverser installation, and verification of major component performance by approximately full-scale component testing. This program was a continuation of the contractor's design and test effort on supersonic transport powerplants and was aimed at achieving further advances in engine design and component state-of-the-art over those submitted in the Phase II-A proposal for the supersonic transport engine.

In accordance with the requirements of contract FA-SS-65-18, the program was divided into 15 major fields of effort corresponding to the tasks listed in Section B of the contract work statement. These fields of effort included engine design in addition to research and development on compressors, primary combustion, turbines, augmentors, inlet and exhaust systems, noise reduction, controls and accessories, bearings and seals, and fuels and lubricants. Also, investigations were conducted on installation optimization, materials and manufacturing techniques, and supporting design considerations such as maintainability, reliability, and value engineering. A discussion of the work accomplished in each of these fields is presented in separate sections of this report in an order corresponding to the work statement items of the contract.

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ITEM 1

ITEM 1  
INSTALLATION COORDINATION



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## ITEM 1 - INSTALLATION COORDINATION

## OBJECTIVE

The Contractor continued to work with the airframe contractors to ensure optimum installation arrangements for the engine and ejector reverser in the airframe. Engine cycle studies were also included in this work.

A. INSTALLATION COORDINATION MEETINGS  
WITH AIRPLANE COMPANIES1. INSTALLATION COORDINATION WITH THE BOEING AIRPLANE  
COMPANYa. Introduction

Six coordination meetings were held between the Contractor and the Boeing Airplane Company during Phase IIB. The most significant topics discussed in the course of these meetings are summarized below:

- Performance. IBM performance decks for both turbofan and turbojet were given to Boeing. Changes were incorporated in these programs, at Boeing's request, to enable more efficient use to be made of their computer time.
- Ejector concepts. Improved mechanical and aerodynamic ejector concepts were studied, the most recent of which is a sliding shroud ejector (a fixed shroud ejector was used during Phase IIA).
- Noise. Information was exchanged several times, and Boeing witnessed a full-scale noise test in which a J57 afterburning engine, using a "boiler plate" SST type ejector, was run.
- Engine-to-inlet compatibility. Various constants for the Contractor's analog computer program for studying engine-to-inlet compatibility were supplied to Boeing for both the turbofan and turbojet.

- Turbine inlet temperature. The Contractor's turbine program was reviewed several times during Phase IIB. Data, hardware, and future planning were discussed.
- Weight. Weights were updated periodically. Weights for a specific installation were supplied to Boeing with each installation drawing.
- Engine-to-wing mating. A reduction in the base drag in the region between the engine and the wing at the wing trailing edge was made. Compatibility with Boeing's latest installation requirements was achieved.

The above items, with the exception of engine-to-wing mating, are covered in detail elsewhere in this report. This section of the report will, therefore, be devoted to a discussion of the engine-to-wing mating work done during Phase IIB.

#### b. Summary of Engine-to-Wing Mating Work

A reduction in base drag was accomplished by changing the shape of the ejector from round to octagonal, and by moving the ejector cant point aft relative to its Phase IIA position.

Figure 1-1 shows a comparison between the Phase IIA and Phase IIB configurations. Figure 1-2 shows the benefits obtained by moving the ejector cant point aft.

#### c. Nomenclature

The following nomenclature is used in describing the engine-to-wing mating work.

- Equivalent diameter. An octagonal ejector is used to eliminate base drag. As it is cumbersome to describe the size of an octagon, i. e., by dimensions across flats and corners, the terminology "equivalent diameter" or "equivalent round" has been adopted. This expression refers to the diameter of a round ejector which has the same geometric area as the particular octagonal ejector under discussion.
- Cant point. For all intents and purposes, the plane through which the ejector is canted intersects the engine center line at a point about which the ejector is a body of revolution. This point is called the ejector cant point. The location of

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the cant point influences the following:

- Ejector cant angle
- Position of the ejector relative to the wing.

#### d. Background

##### (1) Selection of Cant Point Location

For a given size engine and ejector combination, and for a given exhaust gas target point, it is advantageous to move the cant point aft. As the cant point moves aft, the ejector cant angle decreases while the ejector stays close to the trailing edge of the wing with very little interruption of internal wing structure. This is illustrated in Figure 1-2. It is desirable to have a decreased cant angle because of ejector internal aerodynamic and mechanical reasons. It is also desirable to have the ejector close to the wing because of the consequent reduction in base drag, and simpler wing mating.

In the course of studying how to obtain these desirable features, the ejector was canted in three different places. In Phase IIA the ejector was canted at the rear mount plane. Early in Phase IIB, the cant point was moved aft to the rear face of the turbofan primary nozzle to determine the effect on base drag and ejector cant angle. Later in Phase IIB, the cant point was moved slightly forward to a plane which passes through the throat of the fan nozzle (or the afterburner nozzle in a turbojet). This latter position assured symmetry downstream of the nozzle choke point. Boeing selected this cant point as the one which best suited their installation. In each of the foregoing cases, however, the canting results in some non-symmetry upstream of the cant point which will impose additional mechanical and aerodynamic complexity.

##### (2) Mounts, Tailflaps, and Inlet Extensions

As the installation progressed, the engine (and mounts) were moved rearward to reduce base drag. Finally, in order to get the variable exhaust nozzle (tailflaps) entirely out from under the wing where it could adversely effect base drag, the ejector was positioned relative to the wing such that the hinge point of the tailflaps was either in line with or aft of the wing trailing edge. Since the Boeing inlet position was fixed relative to the wing, the engine had to fill the space between the ejector (as positioned by the tailflap hinge point) and the inlet. The shorter turbofan required an extension or spacer between the engine inlet and the Boeing inlet, see Figure 1-1. The longer turbojets with full afterburners did not require an inlet extension and, in some cases, they were long enough to necessitate moving the tailflap hinge point aft of the wing trailing edge.

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### (3) Boeing's Installation Requirements

The differences between the installation drawings presented later in this section reflect the changes in Boeing's installation requirements as well as changes to the engine. As detailed design studies progressed, various aspects of the powerplant, including length and diameter, were revised. Close coordination with Boeing was essential to ensure that these revisions were compatible with the frequently changing airframe requirements.

The installation drawings were based on the latest Boeing requirements in the following areas:

- Wing contour. Wing cross section at the outbound nacelle location was provided by Boeing.
- Inlet position relative to the wing. This was changed as a function of the inlet flow field.
- Exhaust gas target point. This was fixed to be compatible with good cruise performance and by the location of the horizontal stabilizer.
- Permissible limits of mount locations. These limits were supplied by Boeing from time-to-time based on the latest wing configuration.
- Thrust reverser targeting requirements. Reverse thrust requirements and the possibility of re-ingestion were taken into consideration.
- Ejector position relative to the wing at the wing trailing edge. This position was varied, from time to time depending on its influence on the favorable interference effect between the engine and the wing.

As a rule, the inlet, the exhaust gas target point, and the position of the ejector variable tailflap hinge point were all fixed relative to the wing. The objective was to fit the engine to these points using extensions, canting, etc., in such a manner as to result in the minimum amount of interruption of wing internal structure.

### (4) Ejector Concepts

Improved aerodynamic and mechanical concepts were studied during

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Phase IIB. These studies resulted in the sliding shroud ejector (a fixed shroud ejector was used in Phase IIA). The sliding shroud ejector uses more efficiently the energy available from the engine and secondary air streams, and reduces the minimum wrap of the ejector around the engine. The sliding shroud ejector also has a higher L/D than the fixed shroud ejector. Its longer length for a given diameter, together with the translating shroud capability, has the potential for more flexibility in accommodating thrust reverser targeting. This ejector appears on the latest turbojet and turbofan installations.

#### (5) Afterburner Concepts

The afterburner for the turbojets progressed from a short, partial (acceleration) type unit with a Mach 2.0 limitation to a longer, full afterburner with Mach 2.7 capability (Boeing indicated that they required a Mach 2.7 or full afterburning capability). This primarily accounts for the increased length of the turbojet engines toward the latter part of Phase IIB.

#### (6) Flow Schedules and Turbine Inlet Temperature

Above Mach 2.0 on both the turbofan and the turbojet, the corrected engine airflow as a function of Mach number may be selected over a range of values. This flexibility gives Boeing an opportunity to choose the airflow schedule which results in the best match between engine and inlet. A "high", "base" and "low" flow schedule were offered. In Phase IIA, Boeing selected a base flow turbofan. In order to provide an opportunity for comparison of turbojets, all three flow schedules were offered in the latter part of this Phase. For each flow schedule, configurations for both the 2000°F and 2300°F turbine inlet temperatures were presented. Boeing could, therefore, examine the trades involved in starting initial service at the lower temperature with subsequent growth to the higher temperature within the same external envelope.

#### e. Discussion of STF 219B Turbofan Installations

The study of new ejector and installation concepts began with the Phase IIA configuration, (see Figure 1-3 ), which was a 600 lb/sec engine with a cylindrical ejector of 76.00 inch diameter. This arrangement produced a base drag area between the ejector and the wing trailing edge of approximately 425 sq. in.

The object of the new studies was to reduce this base drag area, thereby improving on the Phase IIA installation. Wing contour, mount location,

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and exhaust gas targeting information, as well as nacelle capture area and a 5° inlet angle relative to the horizontal reference datum, was supplied by Boeing and was used as the basis of these studies. An octagonal ejector was selected to further reduce the base drag area at the wing trailing edge. The flat side on top of the octagonal ejector offered possibilities of closer coupling to the wing surface than the circular section of the Phase IIA ejector.

A number of new arrangements of the engine and the octagonal ejector relative to the wing were investigated. These arrangements are summarized below.

- Figure 1-3 (Phase IIB configuration) shows how an octagonal ejector with the same equivalent area as the 76.00 inch diameter ejector of Phase IIA reduces the base drag area to 398 sq. in.
- As in Figure 1-3, Figure 1-4 shows an arrangement with the engine and ejector tangent to the wing. The rear engine mount plane was moved aft 40.00 inches (relative to its Phase IIA position) which required a 33.50 inch extension to the engine inlet case. The ejector was canted at an angle of 5° at the rear mount plane. The base drag area was reduced to 337 sq. in.
- Figure 1-5 shows an arrangement with the rear engine mount plane moved aft 30.00 inches. The ejector was canted 8° at the rear mount plane and the engine/ejector was inserted 4.00 inches into the wing. A 31.00 inch extension was required. The base drag area was reduced to 320 sq. in.
- Figure 1-6 shows an arrangement identical to Figure 1-5 except that the ejector cant point was moved aft to the primary nozzle plane. The cant angle is 6°. A 40.00 inch extension was required for this. The base drag area was reduced to 230 sq. in.
- Figure 1-7 shows an arrangement with the rear mount plane moved aft 40.00 inches and the ejector canted at 8° at the primary nozzle plane. The engine/ejector was inserted 4.00 inches into the wing. A 40.00 inch extension was required. The base drag area was reduced to 150 sq. in.



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ejector has a 78.00 inch equivalent diameter and was canted 10.00 inches forward of the primary nozzle plane. The ejector cant angle is  $10^{\circ} 55'$  and the configuration required a 36.98 inch extension.

The previous installation studies all involved fixed shroud ejector designs. A sliding shroud ejector was evolved in Phase IIB. This shroud makes more effective use of the energy in the engine and secondary air streams, reduces the minimum wrap of the ejector around the engine, and provides greater reverser targeting flexibility. On the turbofan, the shroud translates to three positions. The cruise position (blow-in doors closed) is the forward-most position. For take-off and up through the blow-in-door operating range, the shroud translates somewhat rearward relative to the cruise position. The shroud translates further rearward for reverse. The sliding shroud ejector is described in detail elsewhere in this report. Figure 1-14 shows a turbofan configuration which incorporates a sliding shroud ejector. Figure 1-14 also shows the most recent STF 219B accessory arrangement.

#### f. Discussion of STJ 227B Turbojet Installations

A 500 lb/sec afterburning turbojet engine installation was presented to Boeing for their initial Phase IIB studies. A number of new arrangements of the STJ 227B engine/ejector relative to the wing were investigated. The arrangements are summarized below. Two maximum turbine inlet temperatures were considered:  $2000^{\circ}\text{F}$  and  $2300^{\circ}\text{F}$ .

- Figure 1-15 shows an arrangement using an octagonal ejector of 75.00 inch equivalent diameter on a  $2300^{\circ}\text{F}$  turbine inlet temperature engine with partial augmentation. The inlet cowl was located 27.00 inches down from the horizontal reference line. Wing contour, reverser targeting, and the  $5^{\circ}$  inlet angle were supplied by Boeing and were used as the basis for these studies. The ejector was positioned so that the tailflap hinge line was aligned to and set tangent with the wing trailing edge. The ejector was canted at the rear engine mount plane with a  $10^{\circ} 15'$  angle required to hit Boeing's exhaust gas target point. This configuration required a 13.40 inch extension at the engine inlet.
- Figure 1-16 shows an arrangement identical to Figure 1-15 except that the ejector cant point was moved aft to the throat of the afterburner nozzle, which reduced the cant angle to  $7^{\circ} 40'$ . This required a 13.80 inch extension.

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The 2000 °F maximum turbine inlet temperature engine incorporated a full afterburner from its inception and was thus longer than the 2300 °F engine with partial augmentation. An 81.00 inch equivalent diameter ejector was used. Figure 1-17 shows an arrangement using this size octagonal ejector on a 2000 °F turbine inlet temperature engine. The ejector, canted at the rear engine mount plane, required a cant angle of 8° 25'. The overall length of the engine and ejector eliminated the need for an inlet extension.

Figure 1-18 shows an arrangement identical to Figure 1-17 except that the ejector was canted at the throat of the afterburner nozzle, which reduced the required cant angle to 6° 30'.

At this point in the program the engine size was increased to 525 lb/sec. Figure 1-19 shows an arrangement of this engine with a partial afterburner and its required 76.8 inch equivalent diameter ejector for turbine inlet temperature of 2300 °F. This configuration was positioned relative to the wing according to the latest Boeing data. A capture diameter of 56.18 inches located 27.75 inches down from the horizontal reference line with an inlet angle of 2° 15' was used. The ejector tail-flap hinge line was aligned with the wing trailing edge and with the upper surface of the octagonal ejector 3.00 inches above the wing upper surface at the wing trailing edge. The ejector was canted slightly forward of the afterburner nozzle throat at 10° 50'. A 21.00 inch inlet extension was required.

Figure 1-20 shows the corresponding arrangement for a fully augmented 2000 °F engine with its required 83.00 inch equivalent diameter ejector. The engine was positioned relative to the wing similar to that shown in Figure 1-19 except that the length of the engine moved the ejector tail-flap hinge line 35.00 inches aft of the wing trailing edge. The ejector was canted at a point 2.40 inches forward of the afterburner nozzle throat at 8°. No extension was required.

The previous installations all had fixed shroud ejectors. Later installations used the sliding shroud ejector. On the turbojet, the shroud translates such that it has one position for forward flight, and another for reverse. This ejector is described in detail elsewhere in this report. Six full afterburning turbojet configurations incorporating the sliding shroud ejector were presented to Boeing. These six configurations comprised a high, base, and low flow version of the 2000 °F and the 2300 °F engine. Each configuration was adjusted to its particular flow schedule and temperature for comparative purposes. As in the case of the turbofan, once the comparison has been completed and a selection made, one configuration may then evolve which permits growth from



## 2. INSTALLATION COORDINATION WITH THE LOCKHEED CALIFORNIA CORPORATION

### a. Introduction

Coordination meetings were held between the Contractor and the Lockheed California Corporation during Phase IIB. The most significant topics discussed in the course of these meetings are summarized below:

- Engine accessories. The Phase IIA arrangement was revised in order to relocate the accessories away from the bottom of the engine.
- Ejector. An octagonal blow-in-door ejector was studied as an alternative to the 12-sided design presented in Phase IIA.
- Engine cant and wing relationship. A study was made to determine the most desirable location for canting the engine as the result of Lockheed's request that the engine be canted 4° in a downward direction.
- Sonic boom. The size of the engine was changed in the light of the FAA's reduction in the sonic boom overpressure requirements.
- Turbojet installations. A number of installation sketches was prepared for various versions of the turbojet, which was reintroduced during Phase IIB.

### b. Accessory Study

Pratt & Whitney Aircraft restudied the accessory arrangement proposed in Phase IIA. This arrangement consisted of engine accessories driven by a gearbox located on the bottom of the engine and a power take-off gearbox located on top of the engine which supplied power to drive the airframe accessories. Lockheed requested that all engine accessories containing combustible fluids be moved from the bottom of the engine to reduce the danger of fire in the event of a collapsed landing gear or belly landing.

Figure 1-28 shows a revised arrangement with the engine accessories split into two groups. Those accessories requiring a power drive were mounted on the gearbox located on the left side of the engine at the engine horizontal center line. The remaining accessories were grouped at the same elevation on the opposite side of the engine. All accessories

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were removed from the bottom. This arrangement was rejected by Lockheed because the accessories in the upper quadrants interfered with their front engine mount structure. The arrangement also prevented ready access to the power take-off gearbox.

Continued study rejected the use of two separate towershafts and gearboxes for engine accessories because of internal gearing difficulties. A new arrangement (Figure 1-29) was devised with the engine-driven accessories located on the left side of the engine approximately 45° below the engine horizontal center line. The remaining accessories were located at the same level on the opposite side of the engine. Although this arrangement involved greater difficulty in removing the accessories from the bottom of the engine, the arrangement was generally acceptable for the 700 lb/sec engine size. When the size was reduced to 650 lb/sec this accessory arrangement became less attractive, as the units were crowded together in the reduced circumferential space. An alternate arrangement, Figure 1-30 evolved locating the engine accessory drive shaft on the right horizontal centerline, with the accessories grouped differently from Figure 1-28.

#### c. Octagonal Ejector

Early in Phase IIB Pratt & Whitney Aircraft studied the use of an octagonal blow-in-door ejector as an alternate to the circular door 12-sided design presented in Phase IIA. Figure 1-31 is a schematic drawing of the octagonal ejector sent to Lockheed. The octagonal ejector dominated studies during Phase IIB. All subsequent installation sketches sent to Lockheed represented some modification to this design. A detailed description of ejector studies is covered in the Ejector Reversers section of this report.

#### d. Engine Cant and Wing Relationship

During Phase IIB Lockheed moved both the inboard and outboard engines rearward on the wing approximately 5 to 6 feet. Concurrently, they requested that the engine be canted 4° downward. A study was made to determine the most desirable location for canting the engine, and a point just forward of the ejector was chosen. Figure 1-32 (outboard engine) and Figure 1-33 (inboard engine) show the STF219-L-700 engine installed in the Lockheed L-2000-4 wing with a 4° engine cant. This sketch indicated that the rearward relocation of the engine allowed the installation of the engine-ejector to significantly reduce wing blockage of the blow-in doors. During Phase IIA, the forward location of the engine placed the ejector in the thicker part of the wing and resulted in blockage of two blow-in doors.

PAGE NO 1-12

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Lockheed provided a sketch of a suggested flame arrester showing the general construction, frontal area, and desired pressure drop. The resulting study is shown on Figure 1-37. The flame arrestors were located immediately forward of the flapper valves. Their installation requires a mounting structure, attachment flanges, and accessibility for replacement of damaged units. The original study based on the 700 lbs/sec engine showed that the flame arrestors could be installed without difficulty and still provide the required area to maintain a minimum pressure drop.

Continued detail design of the engine and the reduction in engine size from 700 lbs/sec to 650 lbs/sec resulted in slightly less room for the flame arrestors. Similarly, continued ejector studies resulted in a tighter wrap between the engine and the ejector reducing still further the area available for the flame arrestors. A study was made of the entire secondary airflow passage from the engine inlet to the ejector throat because of these changes and the possible increase in secondary airflow to nearly 18 percent of the primary airflow.

Figure 1-38 shows that the minimum area available for secondary airflow occurs at the flame arrestors, flapper valves, and rear mount rings. Figure 1-39 shows more detail of these areas. This minimum area is now smaller than earlier studies showed. With an increase in secondary airflow and a corresponding increase in pressure drop, continued studies will be required in this area to provide a proper installation.

#### g. Turbojet Installations

The reintroduction of the turbojet engine during Phase IIB required updating of the Phase IIA installation. As a result, two preliminary installation drawings for a partial afterburning and a full afterburning turbojet were developed for the initial study (Figures 1-40 and 1-41). Subsequently, as the turbojet design evolved, a series of six installation sketches were prepared each showing the effect of turbine inlet temperature and airflow schedule selection on the size of the engine and ejector. Figure 1-42 presents a typical turbojet engine. The major dimensions and differences between each of the six engines are summarized on page 1-16. All versions of the turbojet are fully augmented and weights for each of the six engines were quoted.

Figure 1-43 shows external dimensions and a proposed accessory arrangement for the high temperature, base flow engine.

The 4° downward cant of the engine is required for the turbojet engine as well as the turbofan. Various combinations of engine positions relative to the L-2000-4 wing shape were tried. The current design has placed the cant in the turbojet engine slightly aft of the rear mount structure. All subsequent installation studies showed the cant at this location with an octagonal sliding shroud ejector.

The additional length of the turbojet engine plus the rearward movement of the engines relative to the wing makes it possible to install the engine in the L-2000-4 wing without blockage of any of the ejector blow-in doors. Reaching this optimum position requires setting the ejector higher into the wing and increasing the cant angle to approximately 6° (Figure 1-44). As seen in the figure, the engine rear mount ring appears to be in a favorable position for direct mounting to the wing.

An alternate scheme placed the top of the ejector flush with the top of the wing. This allowed full utilization of the blow-in doors and introduced the added feature of reduced cant angle. Unfortunately this arrangement lowered the engine relative to the wing sufficiently to eliminate a practical mounting installation.

Continued detail design of the engine will create further areas requiring coordination and revised installation techniques and procedures.

TABLE 1-1

PRINCIPAL INSTALLATION DIMENSIONS  
 FOR LOCKHEED CALIFORNIA CORPORATION  
 STJ227 TURBOJET ENGINE, 525 LBS./SEC. SIZE  
 TRANSLATING SHROUD EJECTOR, 4° CANT ANGLE

| Turbine<br>Inlet<br>Temp. (°F) | Airflow<br>Schedule | Inlet<br>Diameter (In.) | Overall<br>Length (In.) | Ejector<br>Equivalent<br>Diameter (In.) | Distance<br>Between<br>Mount Planes (In.) |
|--------------------------------|---------------------|-------------------------|-------------------------|---|---|
| 2000                           | High Flow           | 56.30                   | 307.32                  | 78.00                                   | 119.15                                    |
| 2000                           | Base Flow           | 56.30                   | 305.54                  | 75.00                                   | 119.15                                    |
| 2000                           | Low Flow            | 56.30                   | 303.56                  | 72.00                                   | 119.15                                    |
| 2300                           | High Flow           | 56.30                   | 299.54                  | 78.00                                   | 121.15                                    |
| 2300                           | Base Flow           | 56.30                   | 296.24                  | 75.00                                   | 121.15                                    |
| 2300                           | Low Flow            | 56.30                   | 296.26                  | 70.00                                   | 121.15                                    |

B. ENGINE CYCLE STUDIES

1. INTRODUCTION

Two engines were studied during Phase II B, the STF219, a non-mixed flow duct-heating turbofan, and the STJ227, an afterburning turbojet. The design parameters for these engines are presented in Table 1-2.

TABLE 1-2

Design Parameters of Afterburning Turbojet (STJ227) and Duct-Heating Turbofan (STF219) Engines

|                                      | <u>STJ227</u> |       | <u>STF219</u> |      |
|--------------------------------------|---------------|-------|---------------|------|
| Turbine Inlet Temperature (°F)       |               |       |               |      |
| Take-Off and Acceleration            | 2000          | 2300  | 2000          | 2300 |
| Cruise                               | 1900          | 2200  | 1900          | 2200 |
| Corrected Airflow (lb/sec)           |               |       |               |      |
| Nominal                              | 525           | 525   | 650           | 650  |
| Cruise (M <sub>0</sub> = 2.7)        | 372           | 372   | 308           | 308  |
| Over-All Pressure Ratio              | 9.3           | 9.3   | 11.9          | 11.9 |
| Fan Pressure Ratio                   |               |       | 2.7           | 2.7  |
| Bypass Ratio                         |               |       | 1.3           | 1.3  |
| Maximum Engine Diameter (inches)     | 75            | 75    | 81            | 81   |
| Engine Weight Including Ejector (lb) | 10470         | 10455 | 9560          | 9560 |

During Phase II A, the airframe manufacturers were supplied with sufficient information to permit them to make preliminary engine-aircraft performance estimates. At this time, both airframe manufacturers selected the STF219 engine. Boeing initially expressed an interest in the STJ227 engine with 25 percent augmentation, but this engine exceeded the limits for stable afterburner combustion above Mach 2, being specifically designed for augmentation during transonic operation from Mach 1.2 to Mach 1.8. Above Mach 2, the combustion chamber Mach number increased rapidly above the combustion stability limit and the combustion chamber inlet temperature dropped into the marginal auto-ignition range. However, during Phase II B, the sonic overpressure

limits were increased from 2.0 to 2.5 *pdf* for transonic acceleration and from 1.5 to 1.7 *pdf* for supersonic cruise. This shift resulted in the engine being sized for supersonic cruise rather than for transonic acceleration and made the STJ227 turbojet engine with full augmentation an attractive powerplant. Consequently, both engines were restudied.

The performance of the uninstalled engines at several critical flight conditions is shown in Table 1-3. The thrust specific fuel consumption over a wide range of power settings is shown in Figures 1-45 through 1-47. The effect of reoptimizing the STF219 engine is shown in Table 1-4 and Figures 1-48 through 1-50. Similar data for the STJ227 engine is presented in Table 1-5 and Figures 1-51 through 1-53. Detailed design information is presented in Section 2.

TABLE 1-3

Performance of Uninstalled  
STJ227 and STF219 Engines

|   | Afterburning Turbojet<br>STJ227 |       | Duct Heating Turbofan<br>STF219 |       |
|---|---------------------------------|-------|---------------------------------|-------|
|   |                                 |       |                                 |       |
| Take-Off Maximum Thrust (lb)  | 57000                           | 59800 | 52500                           | 57000 |
| Nominal Airflow Size (lb/sec)   | 525                             | 525   | 650                             | 650   |
| Cruise Turbine Inlet Temperature<br>(°F)                              | 1900                            | 2200  | 1900                            | 2200  |
| <u>Transonic Acceleration, Mach 1.2, at 45000 Ft</u>                  |                                 |       |                                 |       |
| Thrust (lb)   | 20600                           | 21400 | 18400                           | 19800 |
| Specific Fuel Consumption (lb/hr/lb)                                  | 1.91                            | 1.83  | 1.88                            | 1.84  |
| <u>Supersonic Cruise Mach 2.7 at 65000 Ft, Thrust = 9800 lb</u>       |                                 |       |                                 |       |
| Specific Fuel Consumption (lb/hr/lb)                                  | 1.44                            | 1.45  | 1.54                            | 1.48  |
| <u>Subsonic Part Throttle, Mach 0.9 at 36150 Ft, Thrust = 7500 lb</u> |                                 |       |                                 |       |
| Specific Fuel Consumption (lb/hr/lb)                                  | 1.05                            | 1.06  | 0.88                            | 0.91  |
| <u>Subsonic Part Throttle, Mach 0.6 at 15000 Ft, Thrust = 6500 lb</u> |                                 |       |                                 |       |
| Specific Fuel Consumption (lb/hr/lb)                                  | 1.25                            | 1.25  | 0.95                            | 0.96  |

Source: P-10

TABLE 1-4

Performance of STEAR Engine at Completion of Phase IIA  
and at Completion of Phase IIB

|   | Basic Engine |           | Initial Engine |           |
|---|--------------|-----------|----------------|-----------|
|   | Phase IIA    | Phase IIB | Phase IIA      | Phase IIB |
| Supersonic Cruise Turbine<br>inlet Temperature (°F)                   | 2200         | 2200      | 1900           | 1900      |
| Take-Off Maximum Thrust (lb)  | 56800        | 57000     | 52300          | 52500     |
| Airflow Size (lb/sec)   | 650          | 650       | 650            | 650       |
| Maximum Diameter (in)   | 79.7         | 81        | 79.7           | 81        |
| Engine Weight Including Ejector<br>(lb)                               | 9150         | 9560      | 9200           | 9560      |
| <u>Transonic Acceleration, Mach 1.2 at 45000 Ft</u>                   |              |           |                |           |
| Thrust (lb)   | 19700        | 19800     | 18300          | 18400     |
| Specific Fuel Consumption<br>(lb/hr/lb)                               | 1.84         | 1.84      | 1.88           | 1.88      |
| <u>Supersonic Cruise, Mach 2.7 at 65000 Ft, Thrust = 9800 lb</u>      |              |           |                |           |
| Specific Fuel Consumption<br>(lb/hr/lb)                               | 1.49         | 1.48      | 1.55           | 1.54      |
| <u>Subsonic Part Throttle, Mach 0.9 at 36150 Ft, Thrust = 7500 lb</u> |              |           |                |           |
| Specific Fuel Consumption<br>(lb/hr/lb)                               | 0.92         | 0.91      | 0.89           | 0.88      |
| <u>Subsonic Part Throttle, Mach 0.6 at 15000 Ft, Thrust = 6500 lb</u> |              |           |                |           |
| Specific Fuel Consumption<br>(lb/hr/lb)                               | 0.97         | 0.96      | 0.96           | 0.95      |

TABLE 1-5

Performance of STJ227 Engine at Completion of Phase IIA  
and at Completion of Phase IIB

|   | <u>Basic Engine</u><br><u>Phase IIA</u> | <u>Basic Engine</u><br><u>Phase IIB</u> | <u>Initial Engine</u><br><u>Phase IIB</u> |
|---|---|---|---|
| Supersonic Cruise Turbine<br>Inlet Temperature (°F)                   | 2200                                    | 2200                                    | 1900                                      |
| Take-Off Maximum Thrust (lb)  | 60600                                   | 59800                                   | 57000                                     |
| Airflow Size (lb/sec)   | 525                                     | 525                                     | 525                                       |
| Maximum Diameter (in)   | 78                                      | 75                                      | 75  |
| Engine Weight Including Ejector (lb)                                  | 9850                                    | 10455                                   | 10470                                     |
| <u>Transonic Acceleration, Mach 1.2 at 45000 Ft</u>                   |   |   |   |
| Thrust (lb)   | 21400                                   | 21400                                   | 20600                                     |
| Specific Fuel Consumption<br>(lb/ hr /lb)                             | 1.86                                    | 1.83                                    | 1.91                                      |
| <u>Supersonic Cruise, Mach 2.7 at 65000 Ft, Thrust 9800 lb</u>        |   |   |   |
| Specific Fuel Consumption<br>(lb/ hr /lb)                             | 1.50                                    | 1.45                                    | 1.44                                      |
| <u>Subsonic Part Throttle, Mach 0.9 at 36150 Ft, Thrust = 7500 lb</u> |   |   |   |
| Specific Fuel Consumption<br>(lb/ hr /lb)                             | 1.10                                    | 1.06                                    | 1.05                                      |
| <u>Subsonic Part Throttle, Mach 0.6 at 15000 Ft, Thrust = 6500 lb</u> |   |   |   |
| Specific Fuel Consumption<br>(lb/ hr /lb)                             | 1.33                                    | 1.25                                    | 1.25                                      |

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Particular emphasis during Phase IIB was placed on the augmentation systems, and IBM performance decks were provided to the airframe manufacturers to permit airframe-powerplant optimization with the fully augmented turbojet engine. In addition, a study of inflight thrust measurement techniques based on the STF219 engine was conducted.

## 2. AUGMENTATION SYSTEM STUDIES

The relaxation of the sonic boom overpressure limit permitted a re-optimization of the engine cycles, and, in particular, the augmentation systems. For the STF219 engine, the effect of reducing the amount of augmentation and the magnitude of the thrust discontinuity between un-augmented and minimum augmented operation were studied. For the STF227 engine, the effects of the turbine inlet temperature and engine air flow on augmentor performance were studied.

### a. STF219

Since the engines are now sized for supersonic cruise rather than for transonic acceleration, the fuel consumption during climb can be reduced by reducing the duct heater augmentation thrust and temperature. A reduction in the maximum augmentation thrust of 1 to 5 percent corresponds to an augmentation temperature reduction of 100 to 300°F and increases the aircraft range by 20 to 35 miles.

The Phase IIA evaluation indicated that the evaluating team considered the thrust discontinuity between non-augmented and minimum augmented thrust to be too great. Consequently, a study was conducted to determine the g loading applied to a passenger when the duct heaters on all four engines are lit simultaneously with several augmentation ratios. The results are plotted in Figure 1-54. The upper curve shows the g loading for the performance data presented during Phase IIA for which the fuel-air ratio for lighting was 0.01. For these conditions, the g loading would be only 0.05. However, studies conducted during Phase IIB have indicated that the minimum duct heating fuel-air ratio could be reduced to 0.008, thereby reducing the g loading to 0.04. Stable combustion has been demonstrated at much lower fuel-air ratios, and, with additional development, it would be possible to decrease the minimum fuel-air ratio to 0.003, corresponding to a maximum g loading of 0.01. The problem has been discussed with airframe manufacturers, however, and it was learned that passengers on present commercial jet aircraft experience a g loading of about 0.1, and, in some cases, they experience g loadings as high as 0.33. It appears, therefore, that the g loading produced during the SST

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flight will be significantly lower than that of current jet aircraft and, therefore, that there is little reason to develop a duct heater capable of ignition with a fuel-air ratio below 0.008.

b. STJ227

(1) Effect of Turbine Inlet Temperature

The engines were designed for operation with a turbine inlet temperature of 2200°F. However, initially the engines will probably be operated with a turbine inlet temperature of 1900°F, and, therefore, the effect of operating at the lower turbine inlet temperature must be considered. If the augmentation ratio or thrust increase is to be maintained at the lower turbine inlet temperature, the weight and maximum engine diameter are significantly increased. If the cycle pressure ratio is to remain unchanged, the turbine expansion ratio must be increased to provide the required compressor power. However, increasing the expansion ratio increases the turbine exit Mach number and the afterburner combustion chamber Mach number. Consequently, the engine diameter must be increased to provide acceptable afterburner inlet conditions. The effect of turbine inlet temperature on the maximum engine diameter is shown in Figure 1-55.

With a turbine inlet temperature of 1900°F, unaugmented thrust at cruise is marginal and the capability for augmentation during cruise at nonstandard temperatures or at off-design altitudes is desirable. The IBM decks supplied to the airframe manufacturers, therefore, provided performance, weight, and installation data for engines with augmentation limited to take-off and transonic operation; limited to take-off, acceleration, and supersonic cruise; or unlimited and used throughout the mission. Optimization studies conducted by the airframe manufacturers and based on these data resulted in the selection of the fully augmented version of the STJ227 engine.

(2) Effect of Supersonic Cruise Airflow

The engine corrected airflow at cruise affects the augmentor design in a manner similar to that of the turbine inlet temperature. In order to increase the airflow, the power output of the turbine must be increased, and, therefore, the expansion ratio must be increased. Consequently, the maximum engine diameter must be increased to satisfy the augmentor design criteria.

Continued reduction of the supersonic cruise airflow eventually results in the turbine power requirement being established at acceleration

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conditions rather than at cruise conditions. This effect is shown in Figure 1-56.

### 3. INFLIGHT PERFORMANCE MEASUREMENT SYSTEM

Inflight thrust measurement in supersonic vehicles is considerably more complicated than in subsonic vehicles. In subsonic vehicles, engine pressure ratio, speed, and exhaust temperature have been used in conjunction with a series of charts to indicate the performance and condition of the engine. These parameters provide an accurate method of determining the performance of engines with fixed nozzle geometry. For the more sophisticated engines required for the supersonic transport, however, these parameters are not adequate since the inlet, the exhaust nozzle, and the interference effects between the propulsion system and the airframe significantly affect the actual force applied to the vehicle. Consequently, thrust measurement will require the use of additional parameters in conjunction with a compact, light-weight (about 30 pounds) computer such as those currently being used in missile guidance systems. The parameters required are listed in Table 1-6 together with the measurement accuracy.

Table 1-6

#### Inflight Performance Measurement Parameters

| <u>Parameter</u>                                | <u>Accuracy<br/>(Percent)</u> |
|---|-------------------------------|
| $P_{am}$ , free stream static pressure          | $\pm 1.25$                    |
| $P_{t3}$ , fan discharge total pressure         | $\pm 1.25$                    |
| $P_{s3}$ , fan discharge static pressure        | $\pm 1.25$                    |
| $T_{t3}$ , fan discharge total temperature      | $\pm 1.0$                     |
| $(P_{t3} - P_{s3}) / P_{s3}$ *                  | $\pm 4.0$                     |
| $P_{t7}$ , gas generator total exhaust pressure | $\pm 1.0$                     |
| $A_{jduct}$ , duct exhaust nozzle throat area** | $\pm 3.0$                     |
| $W_f$ , engine fuel flow                        | $\pm 0.5$                     |

Notes:

\* This parameter may be obtained from engine control where it is used for duct exhaust nozzle positioning.

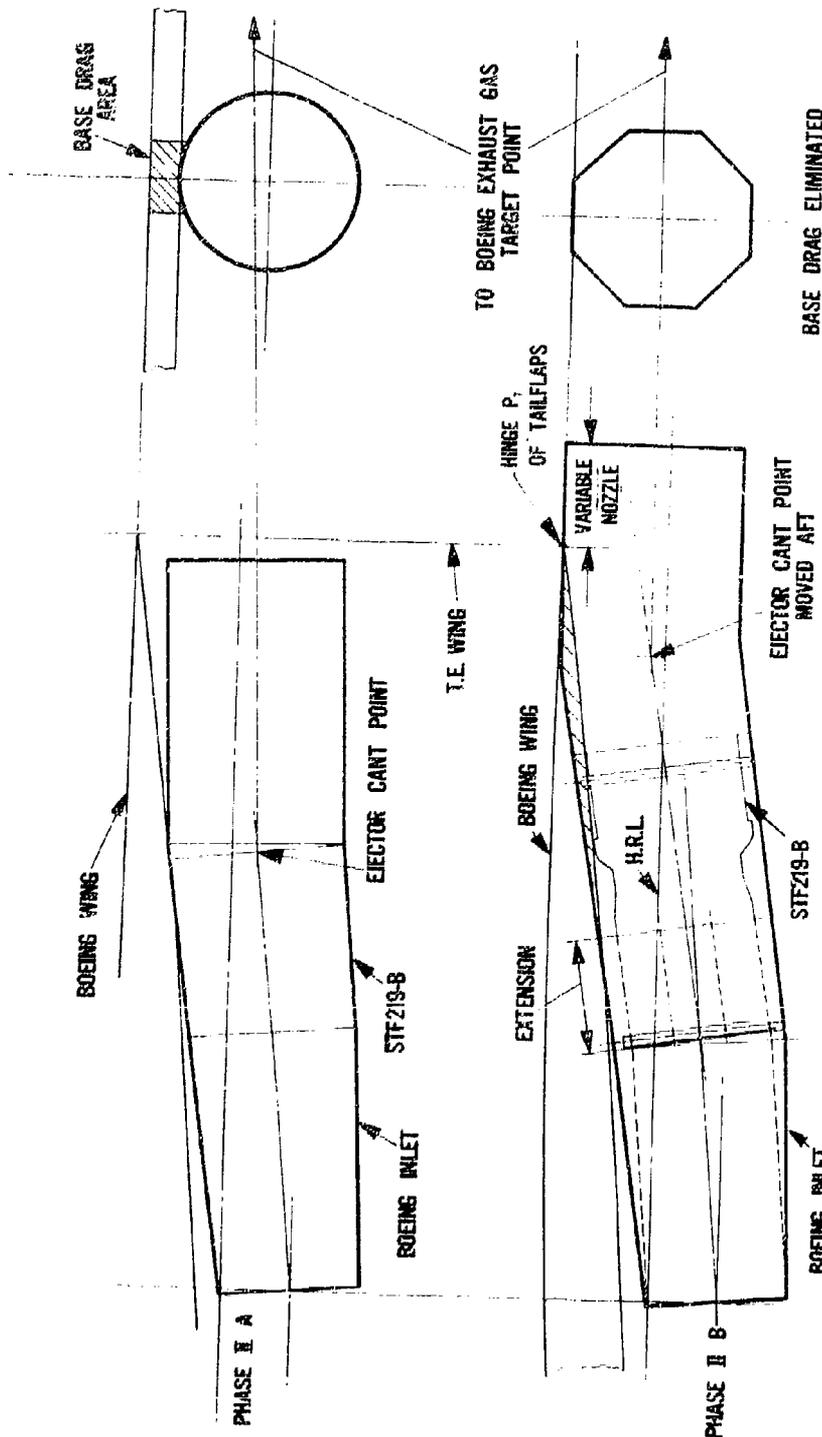
\*\* Direct measurement of  $A_{jduct}$  may not be required.

The thrust and thrust specific fuel consumption obtained from these measurements could be in error by as much as the arithmetical sum of the individual errors, but it is unlikely that all errors would be

at a maximum in the same direction. It is most probable that the error will be that predicted by the root-mean-square method of error summation. The probable error predicted by this method is shown in Table 1-7.

Table 1-7  
Probable Error in Inflight Performance  
Measurement

| <u>Flight Condition</u>           | <u>Power Setting</u> | <u>Probable Error (Percent)</u> |             |
|-----------------------------------|----------------------|---------------------------------|-------------|
|                                   |                      | <u>Total Thrust</u>             | <u>TSEC</u> |
| Sea-Level Take-Off                | Maximum Duct Heating | 3.0                             | 3.1         |
| Transonic Acceleration (Mach 1.2) | Maximum Duct Heating | 4.2                             | 4.3         |
| Supersonic Cruise (Mach 2.7)      | Partial Duct Heating |                                 | 12.3        |
| Subsonic Cruise (Mach 0.9)        | Part Throttle        |                                 | 5.5         |



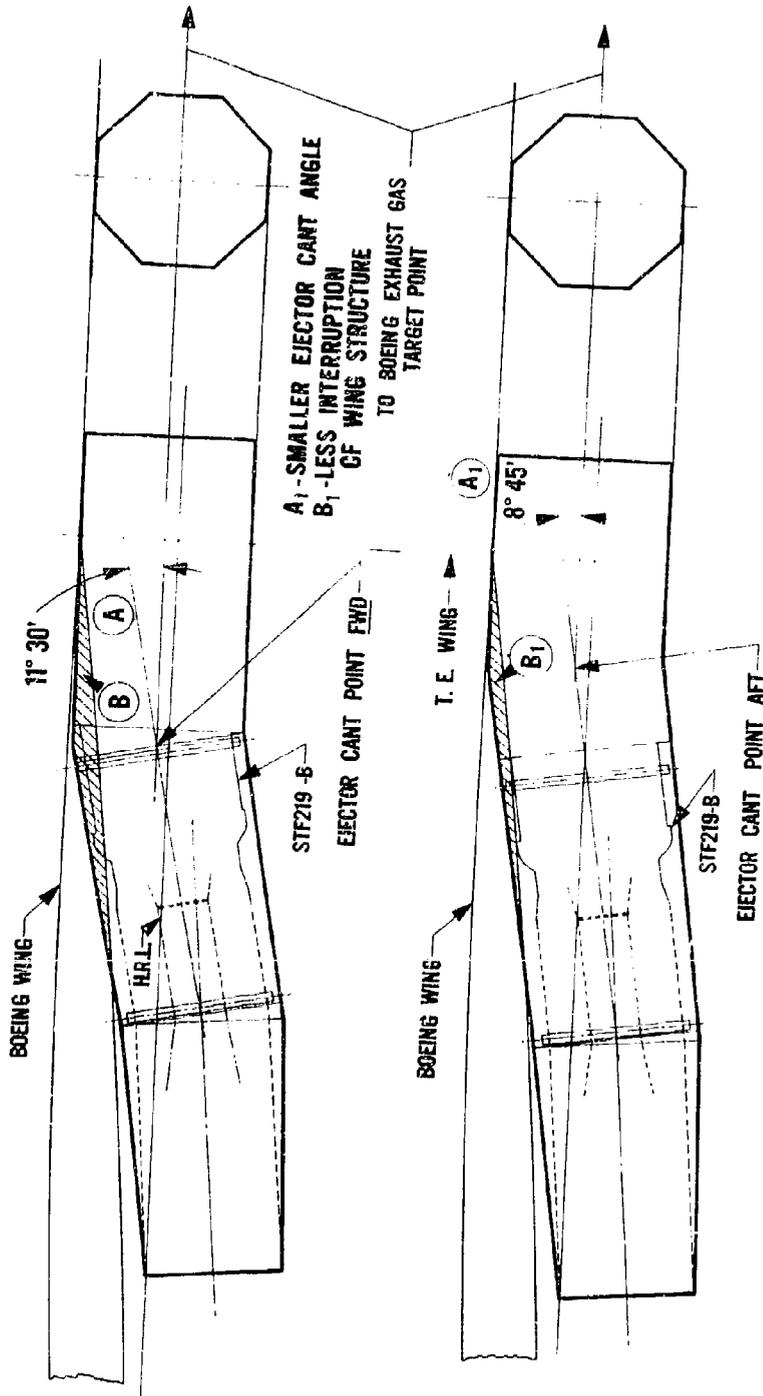
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BOEING INSTALLATION - SST

Figure 1-1

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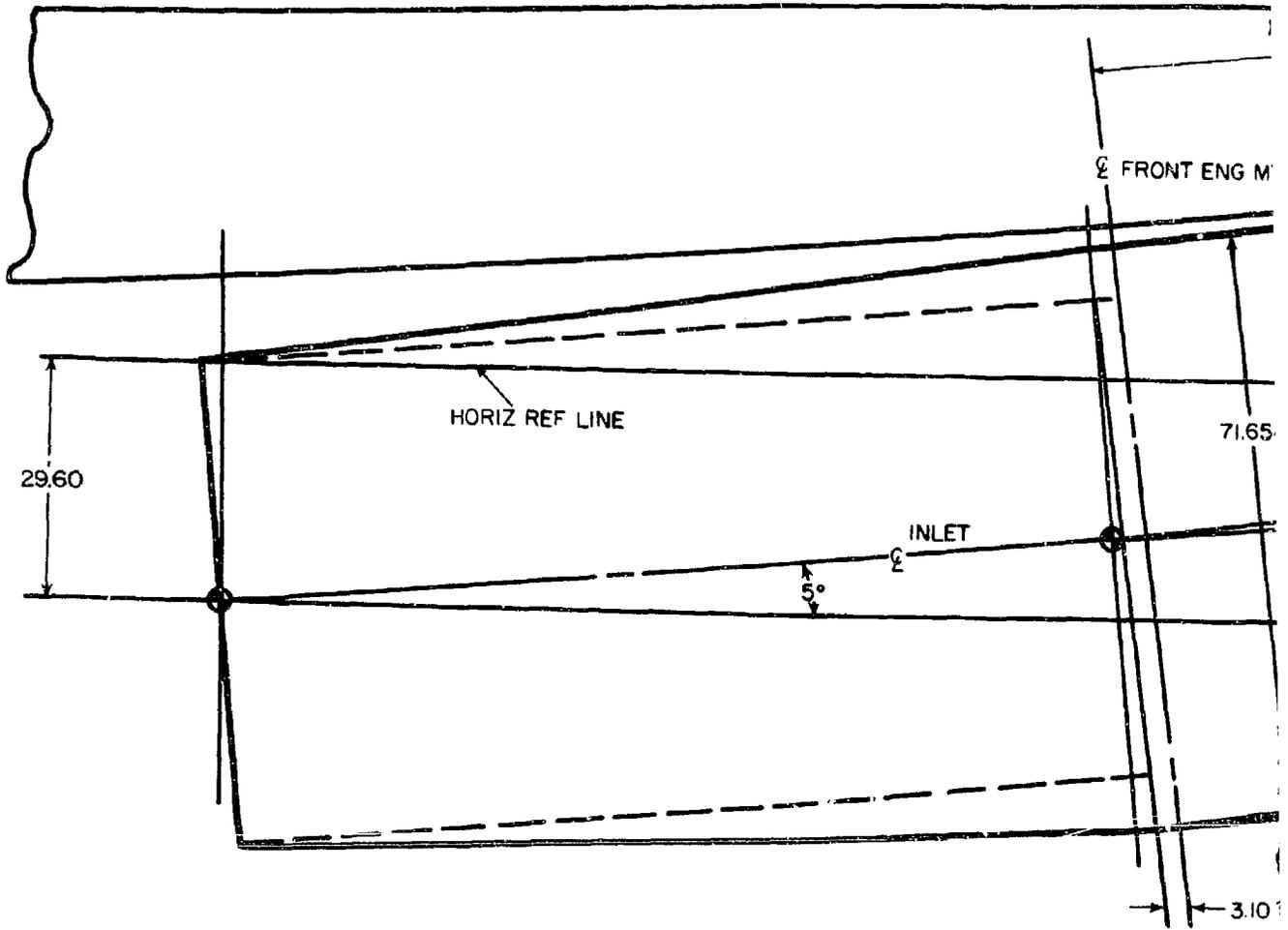
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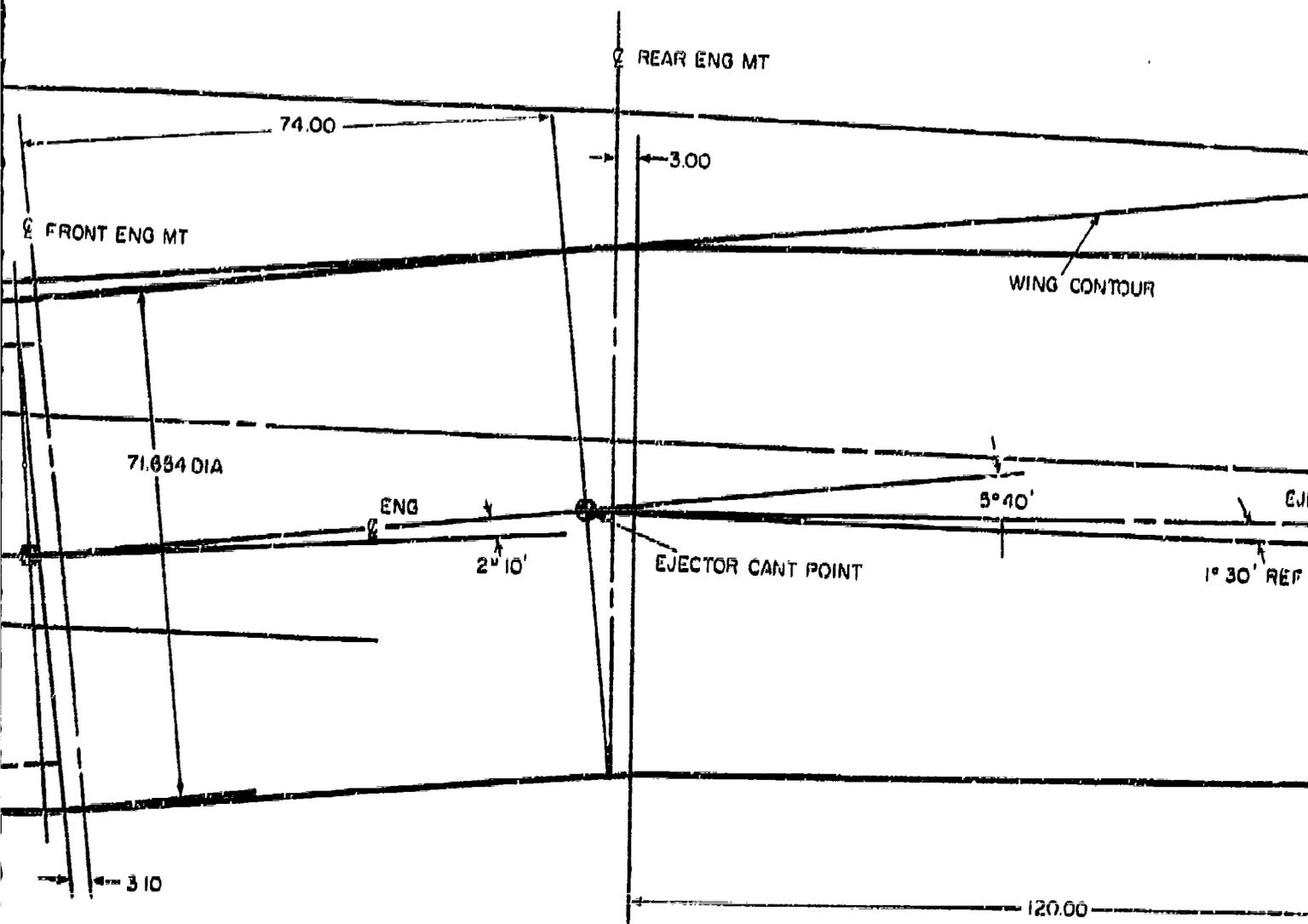
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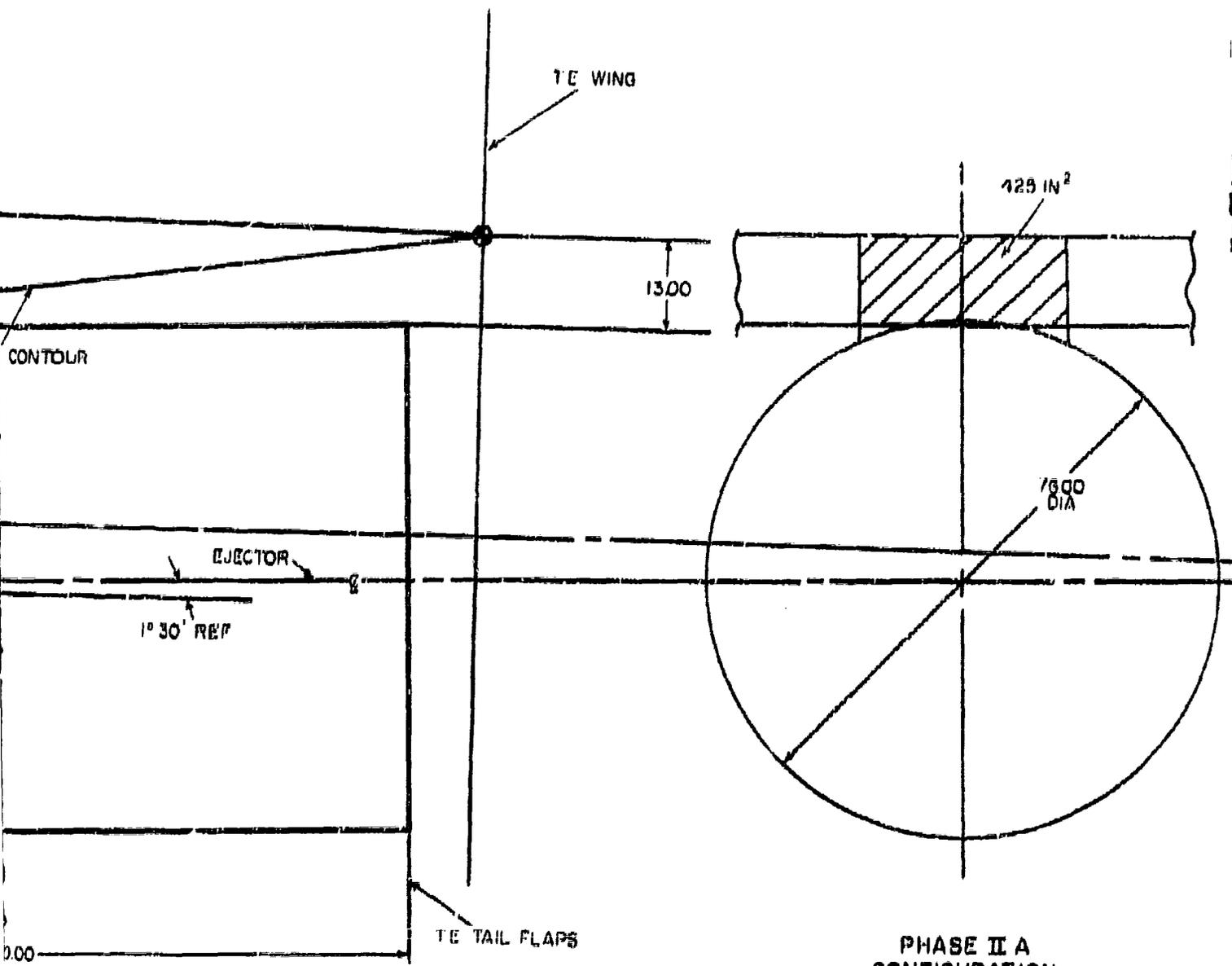
Figure 1-2

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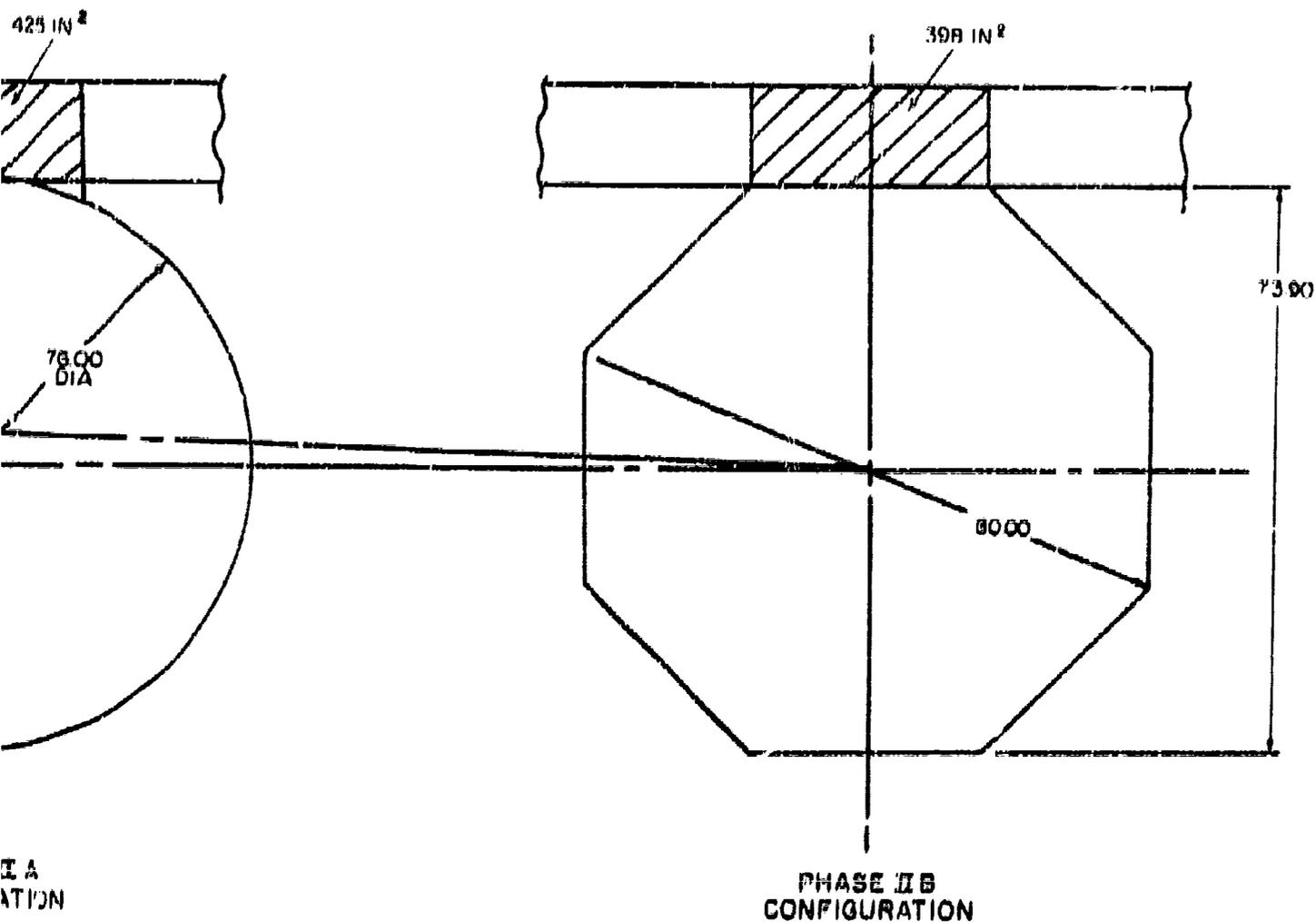
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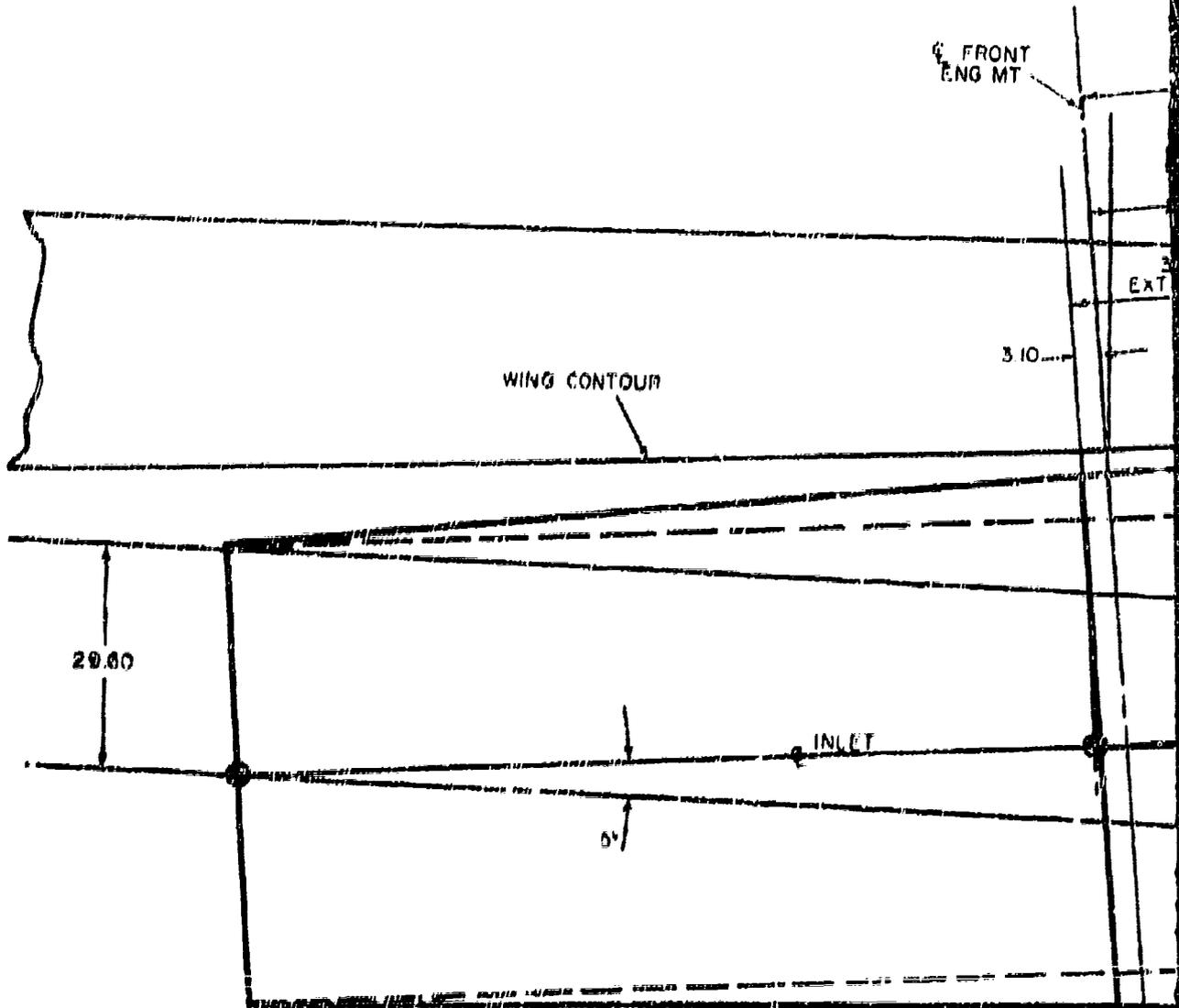
PHASE II A  
CONFIGURATION



ENGINE + EJECTOR TANGENT TO WING  
 EJECTOR CANTED AT REAR ENG. MOUNT PLANE  
 NOTE: ENGINE MOUNT PLANES ARE  
 NONPARALLEL & THE TAIL FLAPS  
 ARE FWD. OF THE WING  
 BASE DRAG AREA 425 in<sup>2</sup> (EQUIV. ROUND)  
 BASE DRAG AREA 398 in<sup>2</sup> (OCT.)

5T7219B 600 LBS. /SEC. TURBOFAN

Figure 1-3



FRONT  
ENG MT

114.00

E REAR MT  
ORIG. LOC

E REAR  
ENG MT

74.00

3.00

12

33.50  
EXTENSION

3.10

HRL

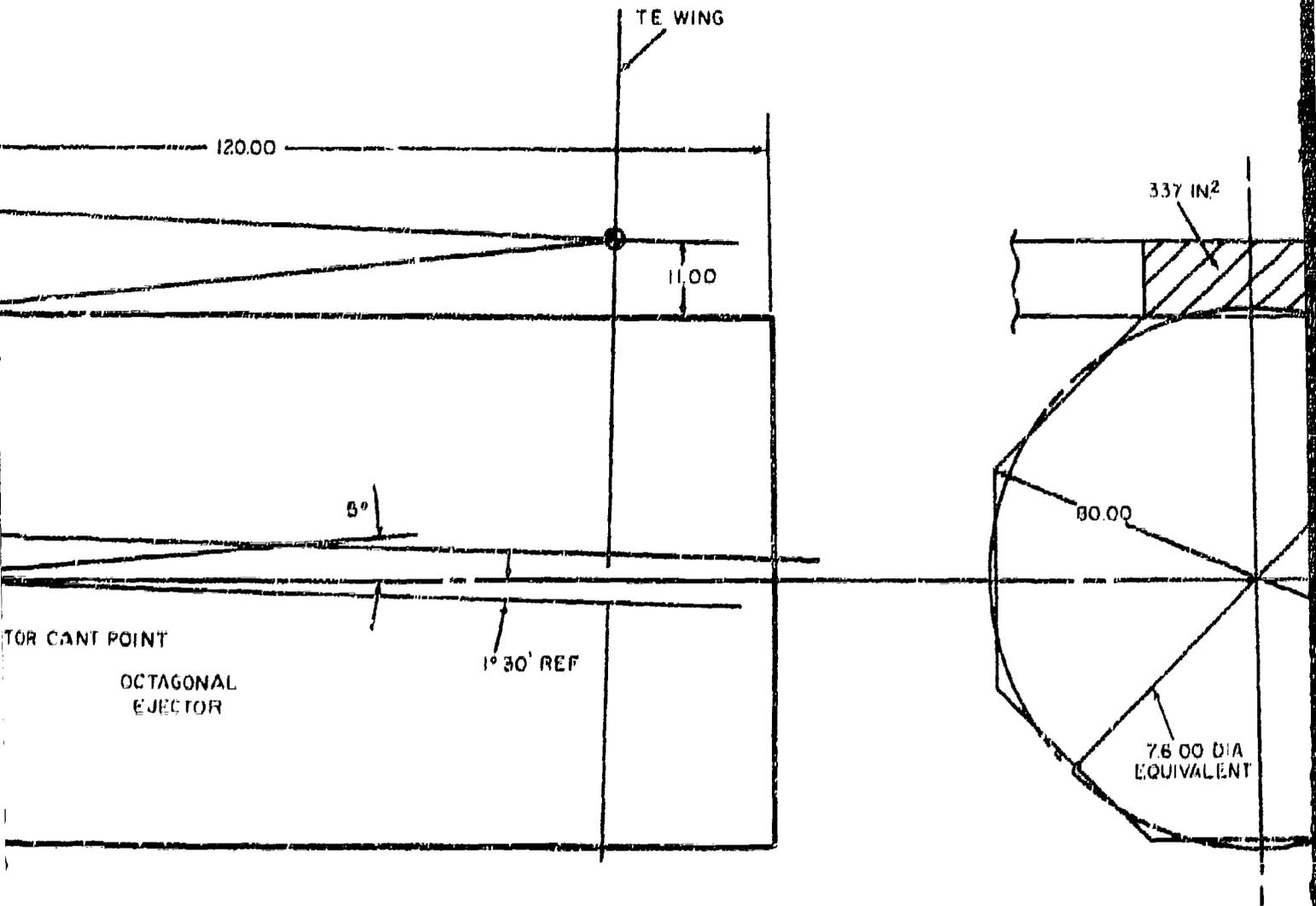
E ENG

1° 30'

EJECTOR CANT POINT

OCTAGONAL  
EJECTOR

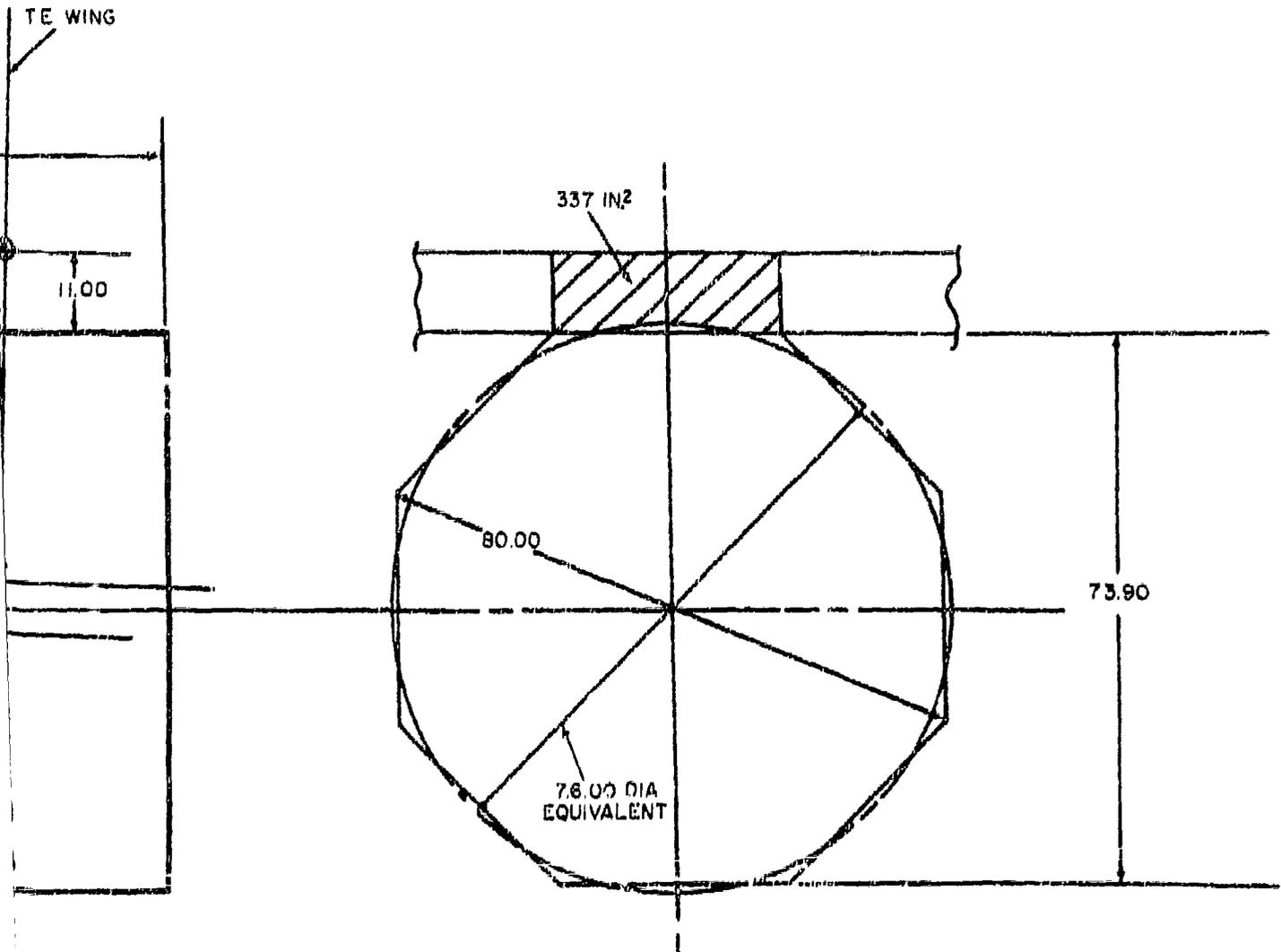
2



ARRANGEMENT SHOWING RE  
 MOVED AFT 40.00  
 ENGINE & EJECTOR ARE TA  
 EJECTOR CANTED AT REA  
 PLANE  
 ENGINE, MOUNT PLANES /  
 BASE DRAG AREA 337 in<sup>2</sup>

STF219B 600 LBS. /SEC

Figure 1



ARRANGEMENT SHOWING REAR ENG. MOUNT  
MOVED AFT 40.00  
ENGINE & EJECTOR ARE TANGENT TO WING  
EJECTOR CANTED AT REAR ENG. MOUNT  
PLANE  
ENGINE, MOUNT PLANES ARE NONPARALLEL  
BASE DRAG AREA 337 in<sup>2</sup>

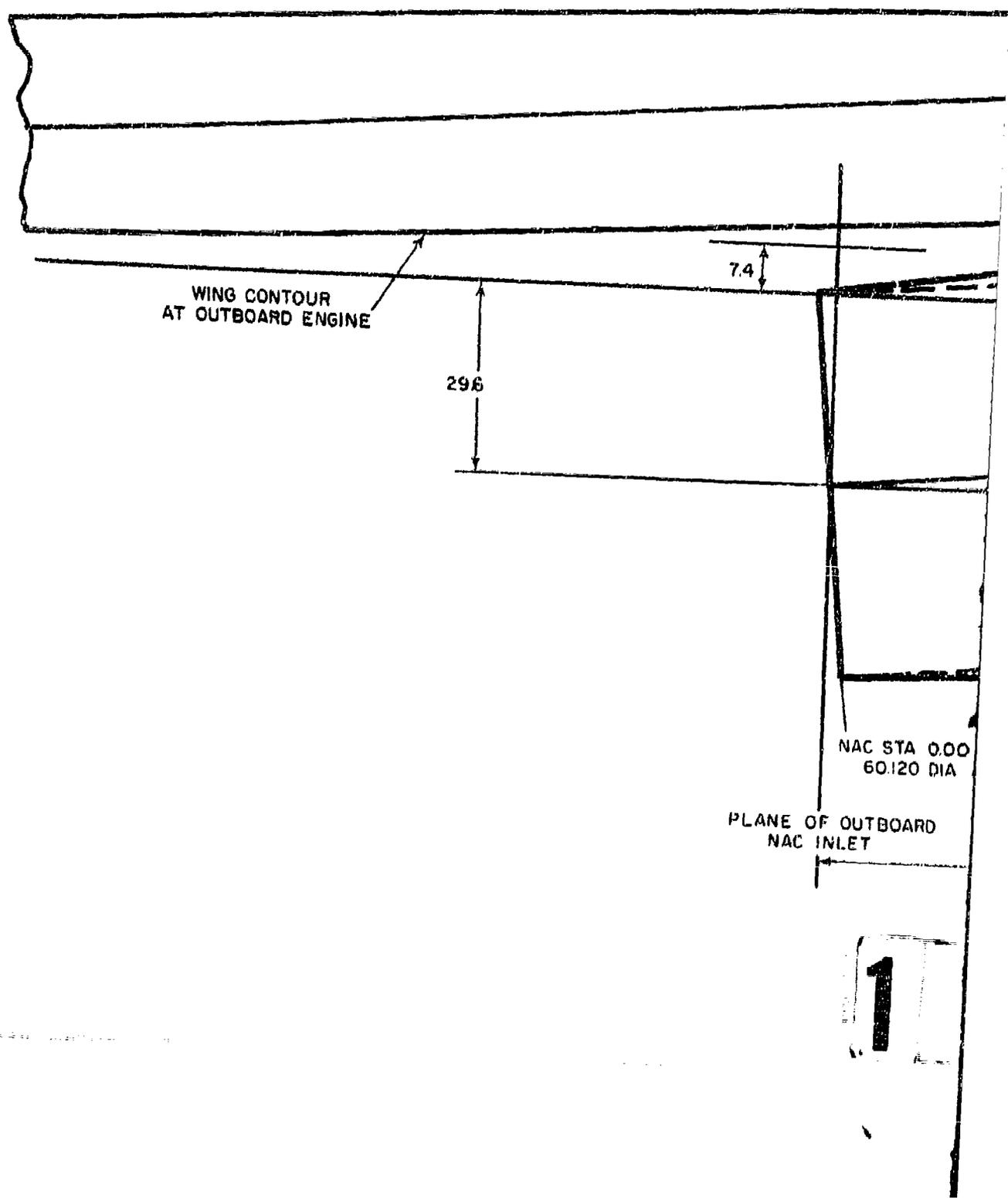
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STF219B 600 LBS./SEC. TURBOFAN

Figure 1-4

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PRATT & WHITNEY AIRCRAFT



WING CONTOUR  
AT OUTBOARD ENGINE

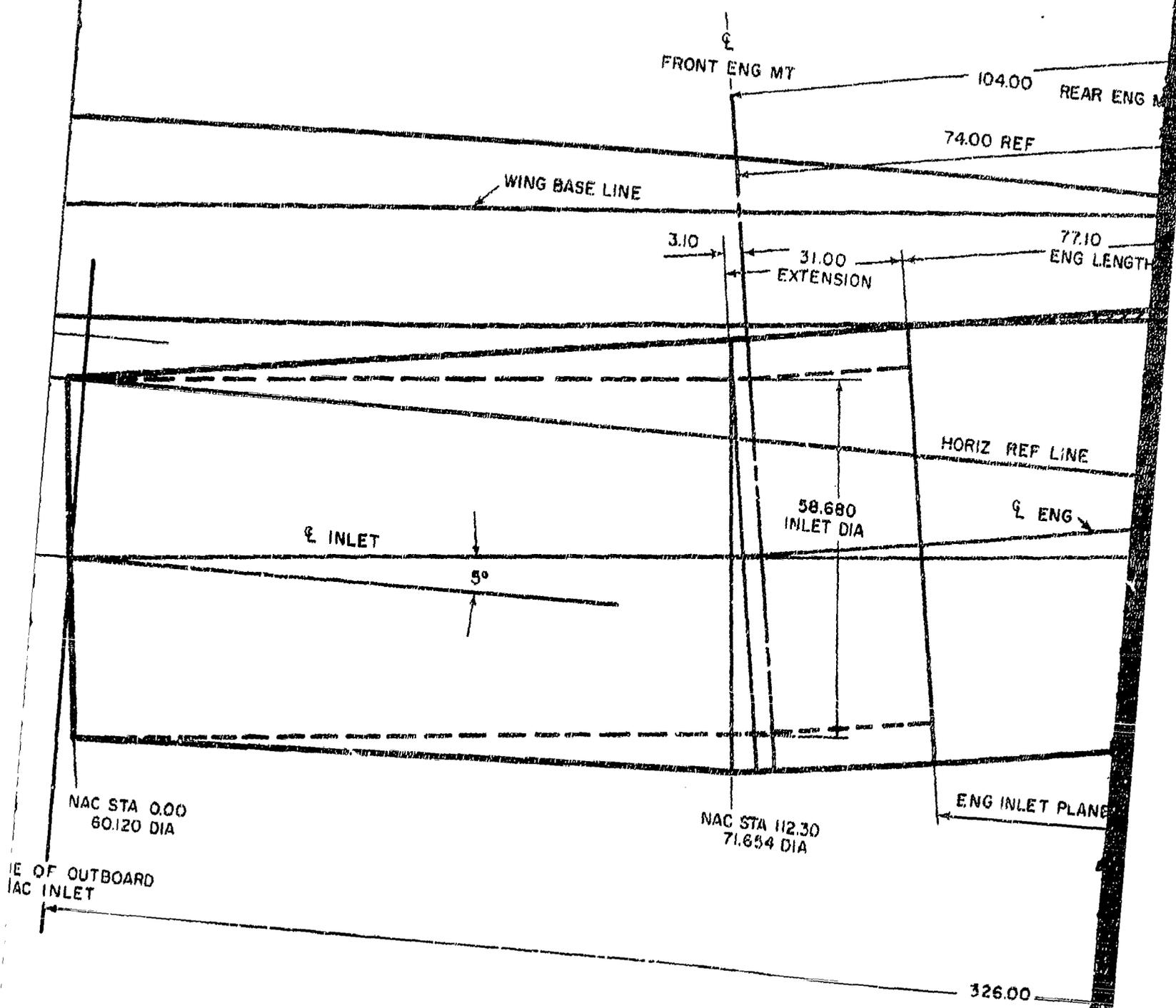
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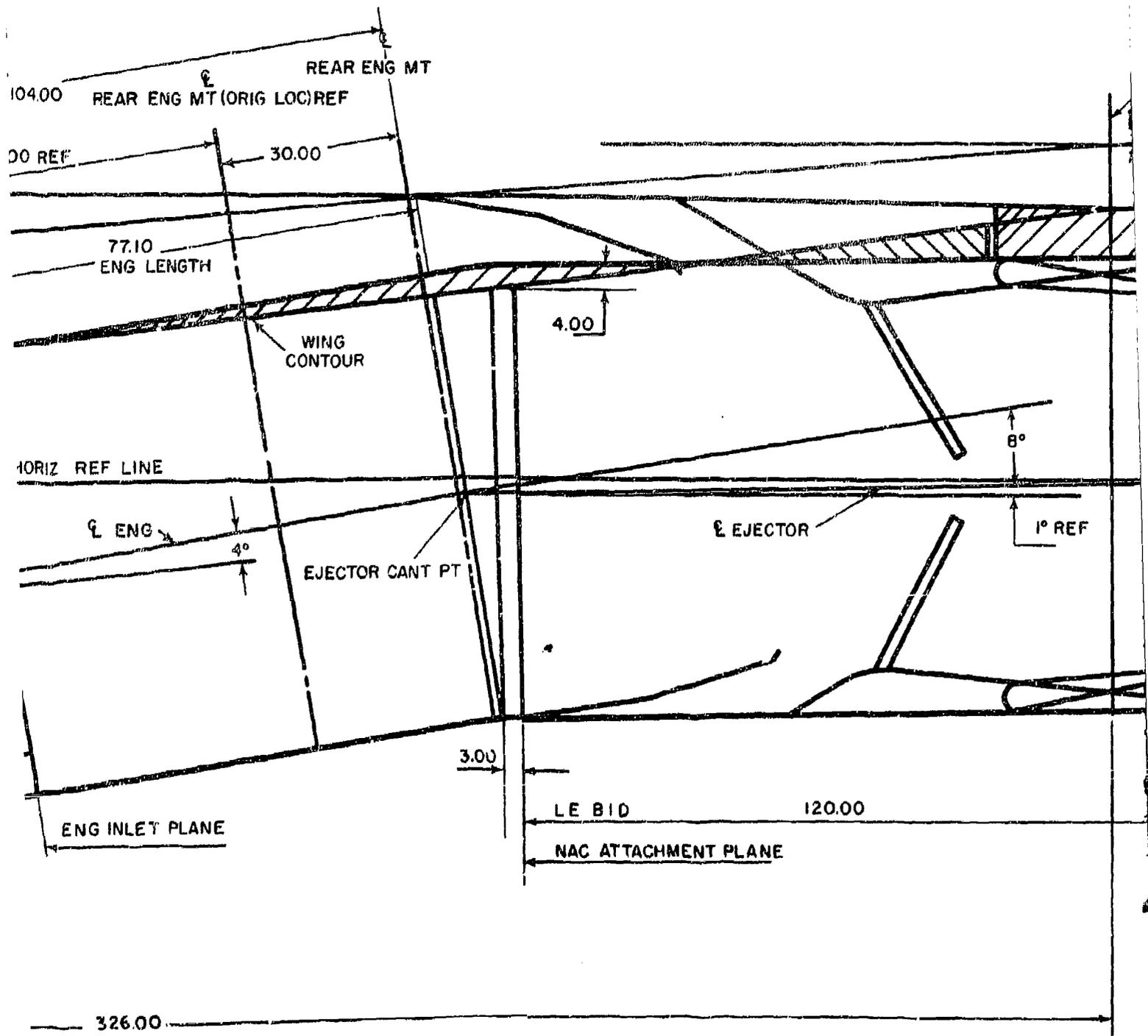
PLANE OF OUTBOARD  
NAC INLET

1

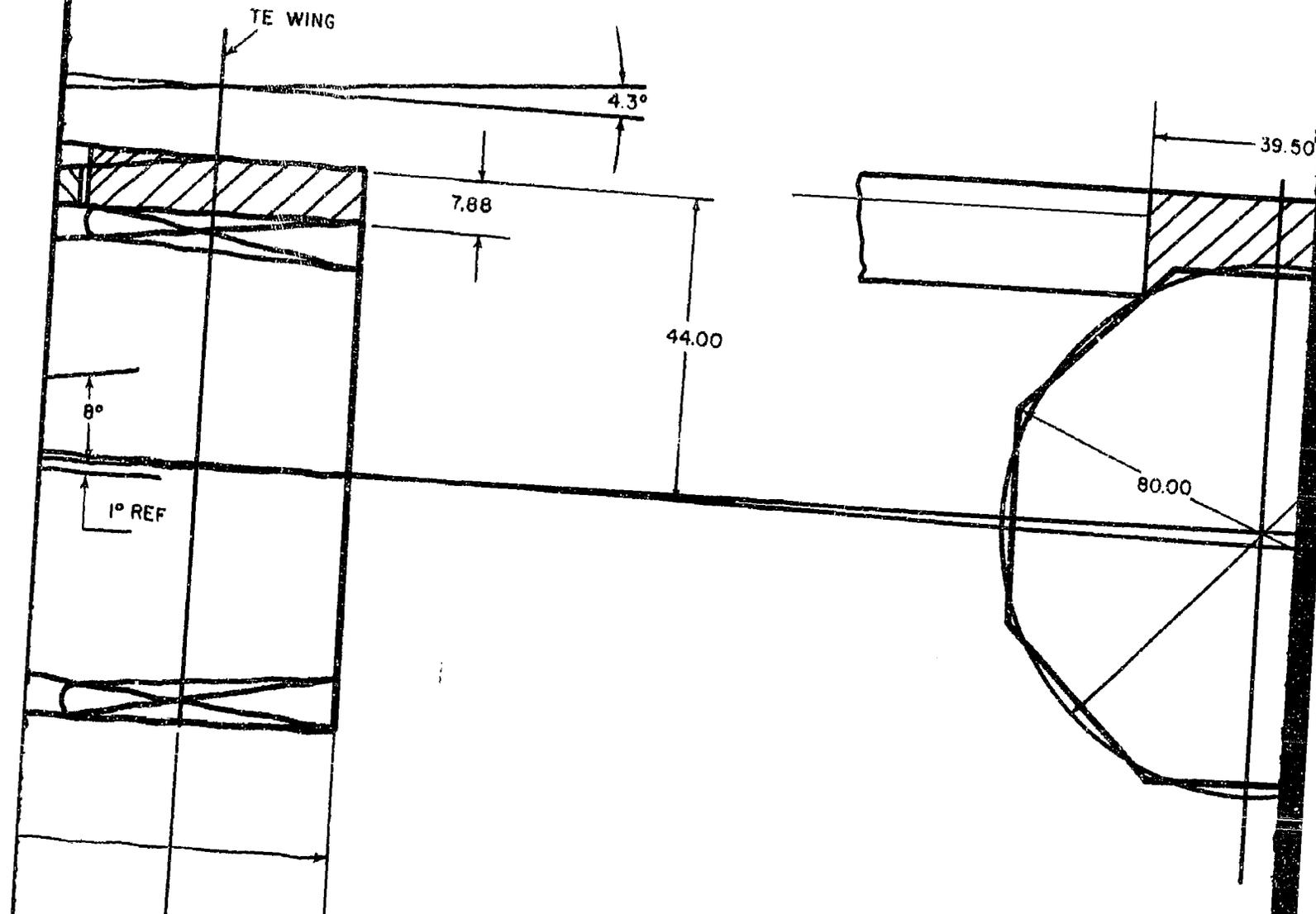


IE OF OUTBOARD  
 IAC INLET

2



CON

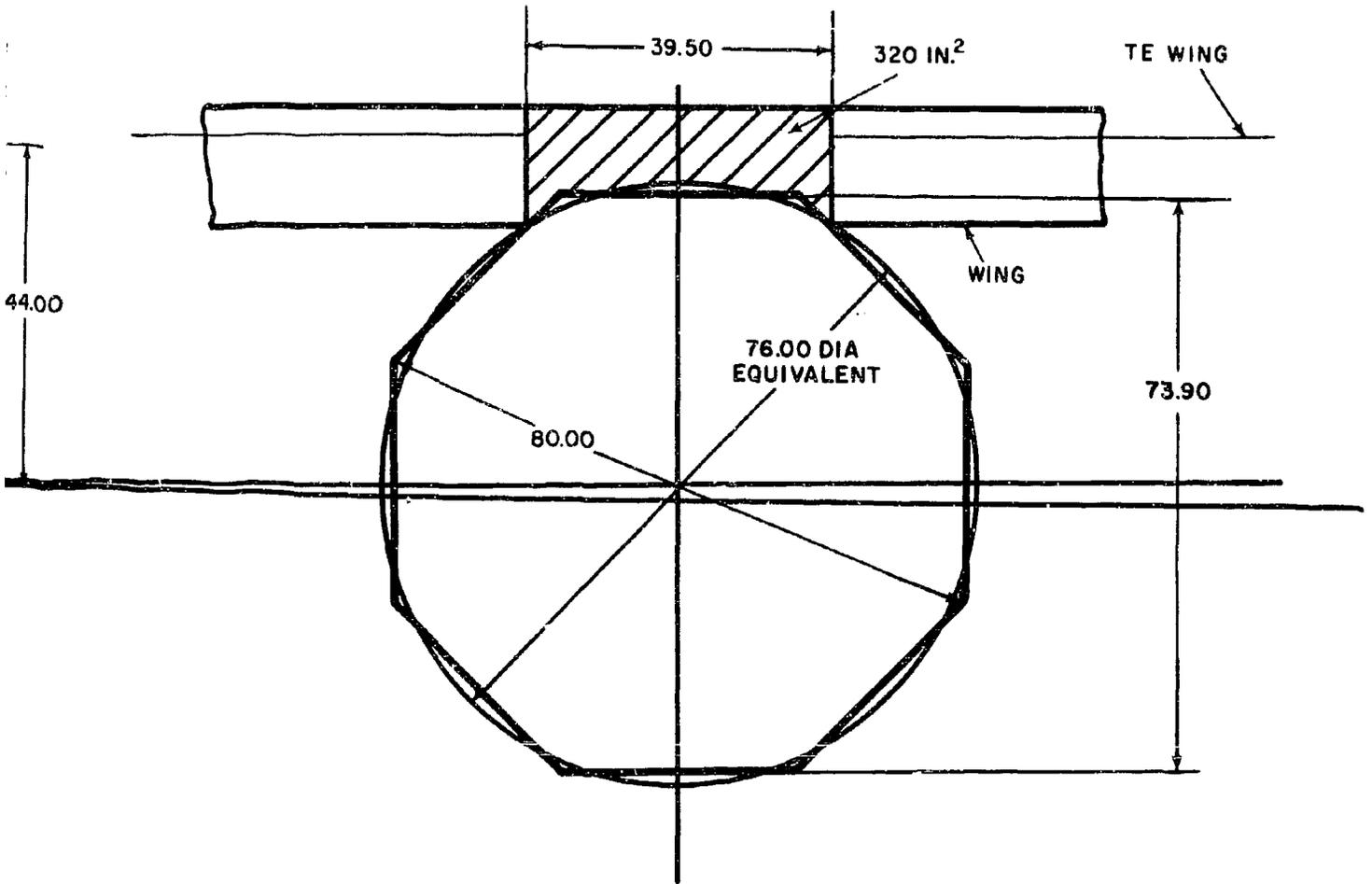


EJECTOR CANTED AT REAR MOUNT PLANE  
ARRANGEMENT MOVING REAR ENG. MOUNT  
30.00 AFT. & INSERTING ENG. 4.00 INTO  
WING

STF219B 600 I

CO

4

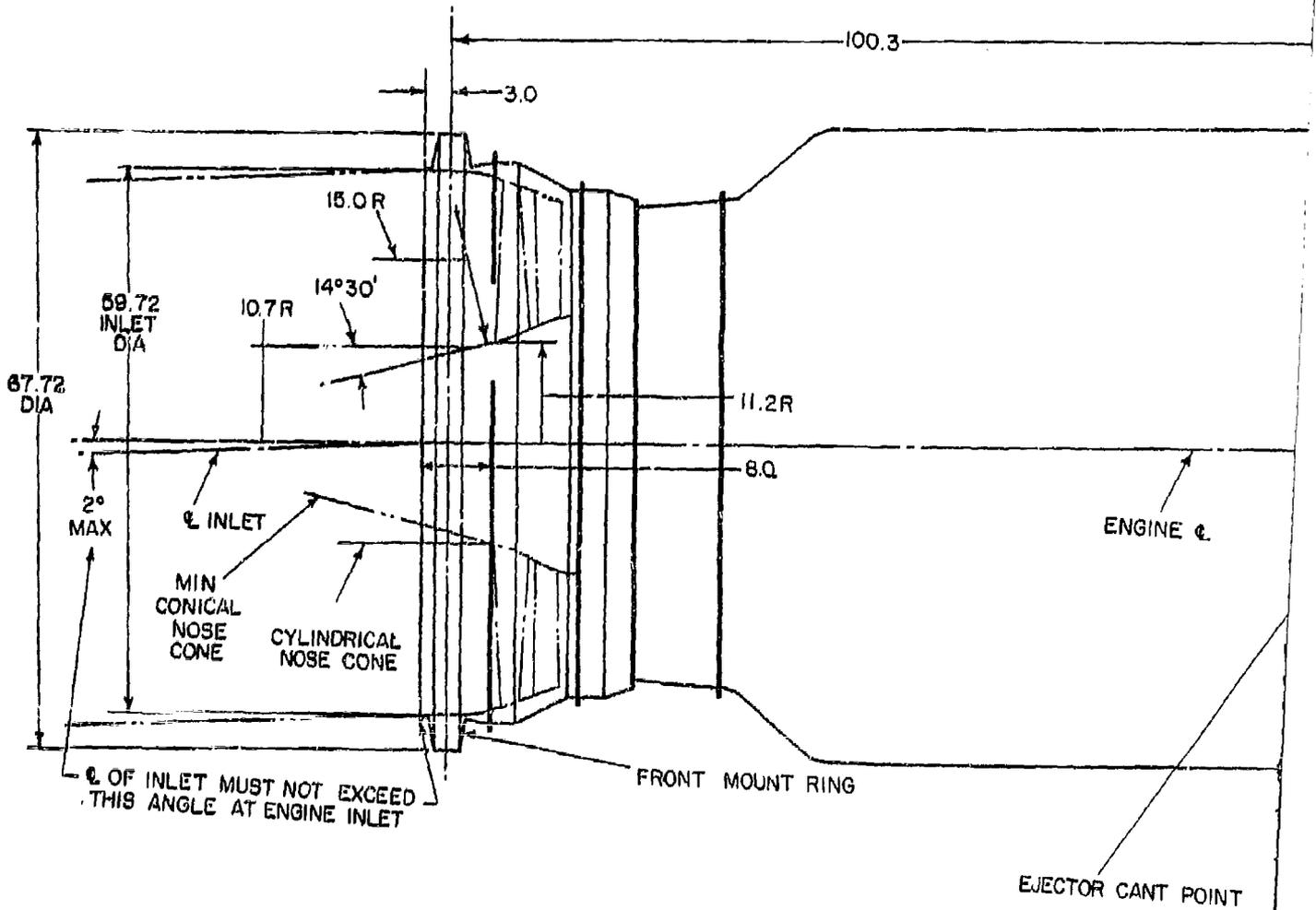


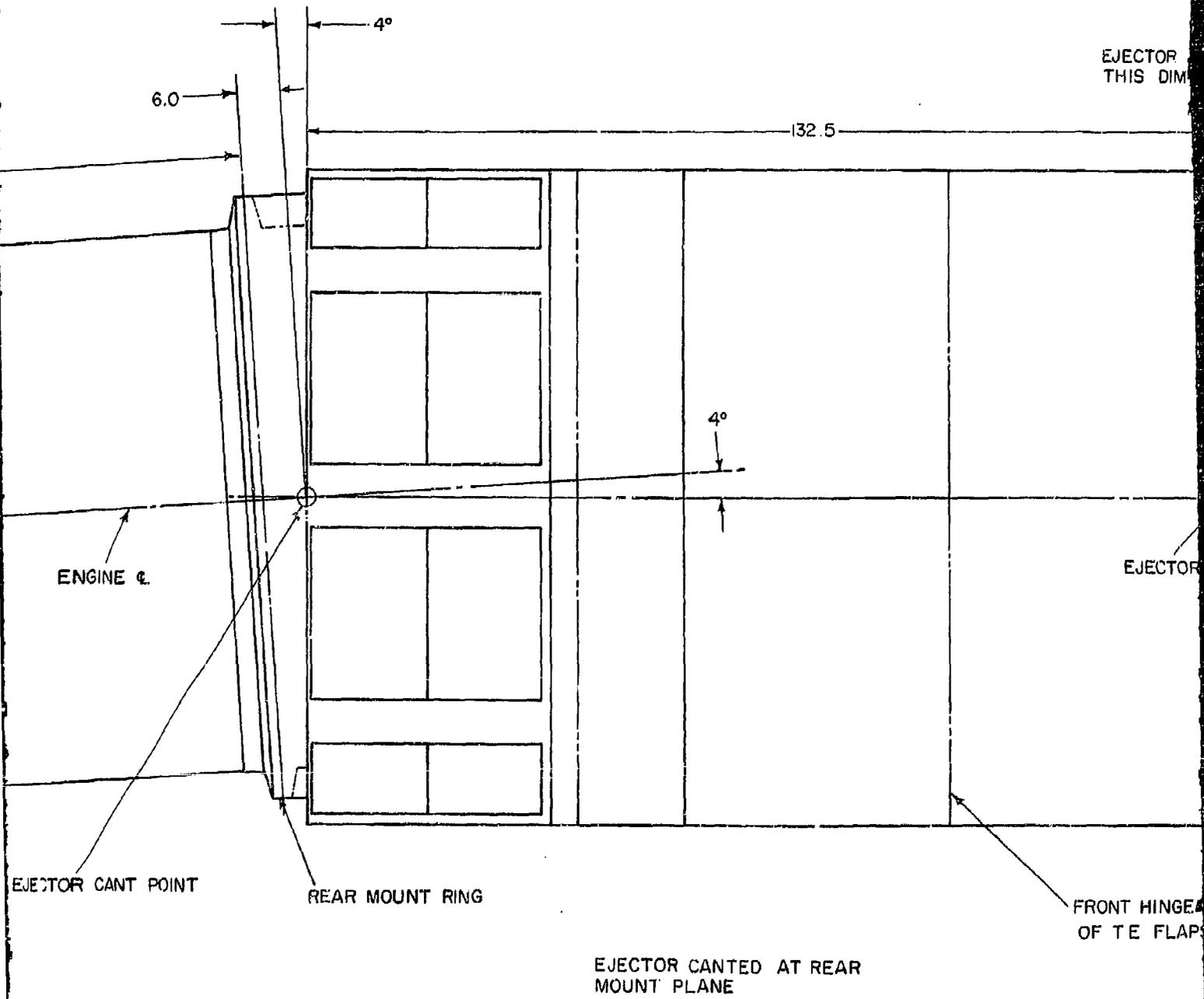
EJECTOR CANTED AT REAR MOUNT PLANE  
ARRANGEMENT MOVING REAR ENG. MOUNT  
30.00 AFT. & INSERTING ENG. 4.00 INTO  
WING

STF219B 600 LBS./SEC. TURBOFAN

Figure 1-5

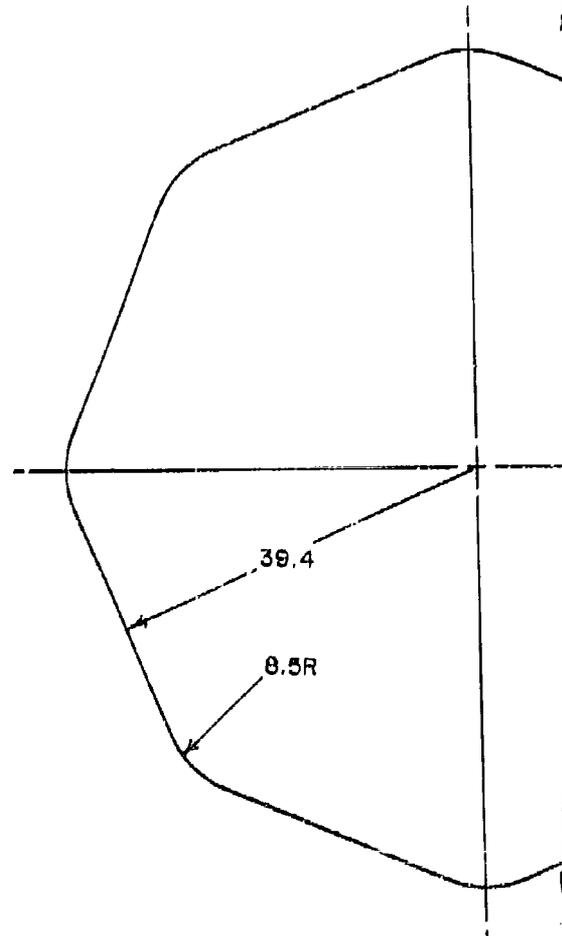
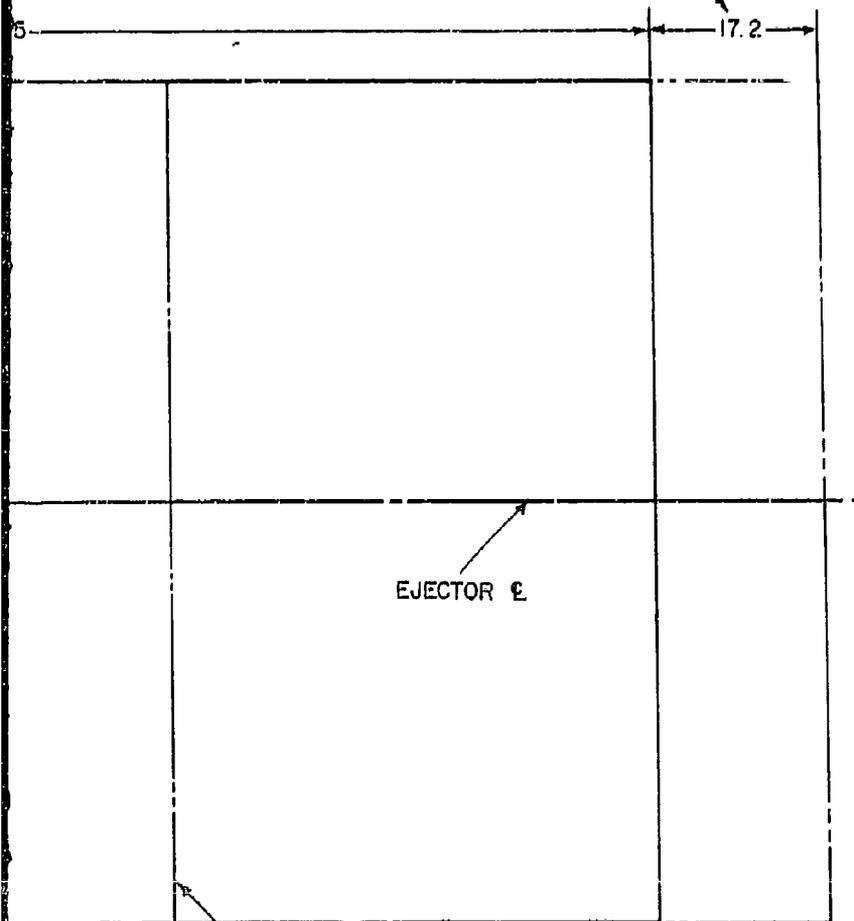
5





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EJECTOR TRANSLATES REARWARD  
THIS DIM DURING REVERSE THRUST



STF219B 600 LBS./SEC. TURBOFAN

Figure 1-6

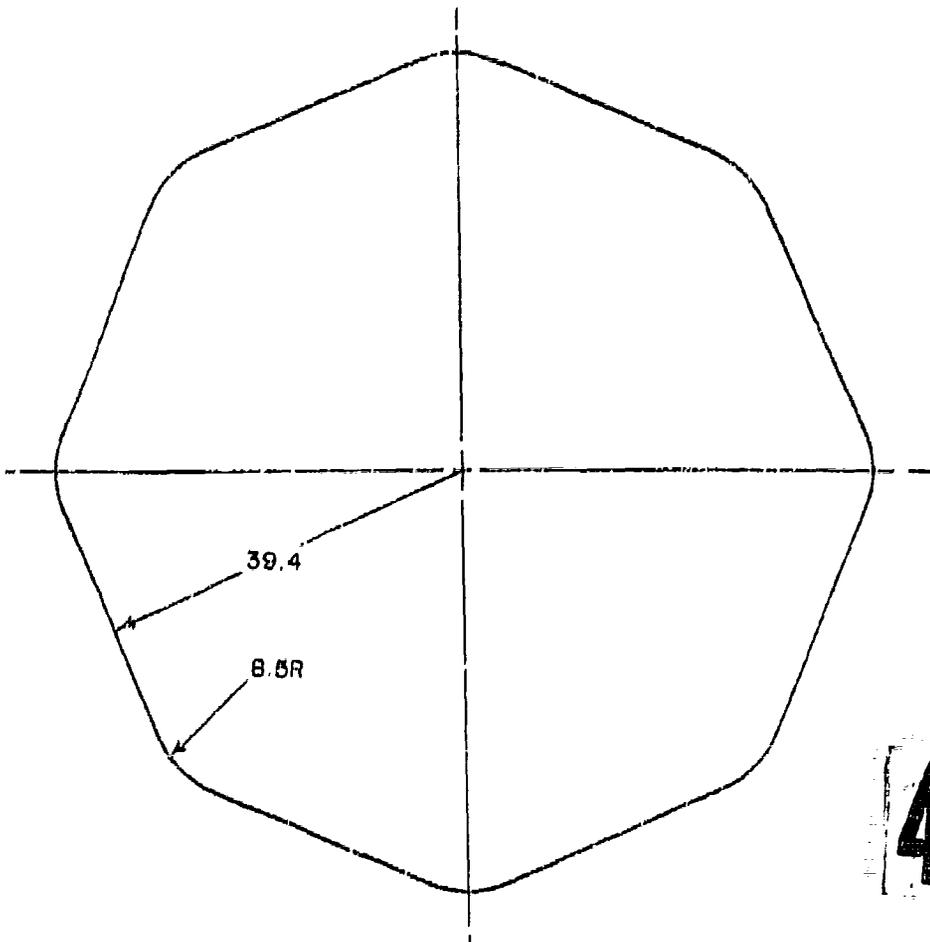
CONFIDENTIAL

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PWA-2600

ATES REARWARD  
REVERSE THRUST

17.2



4

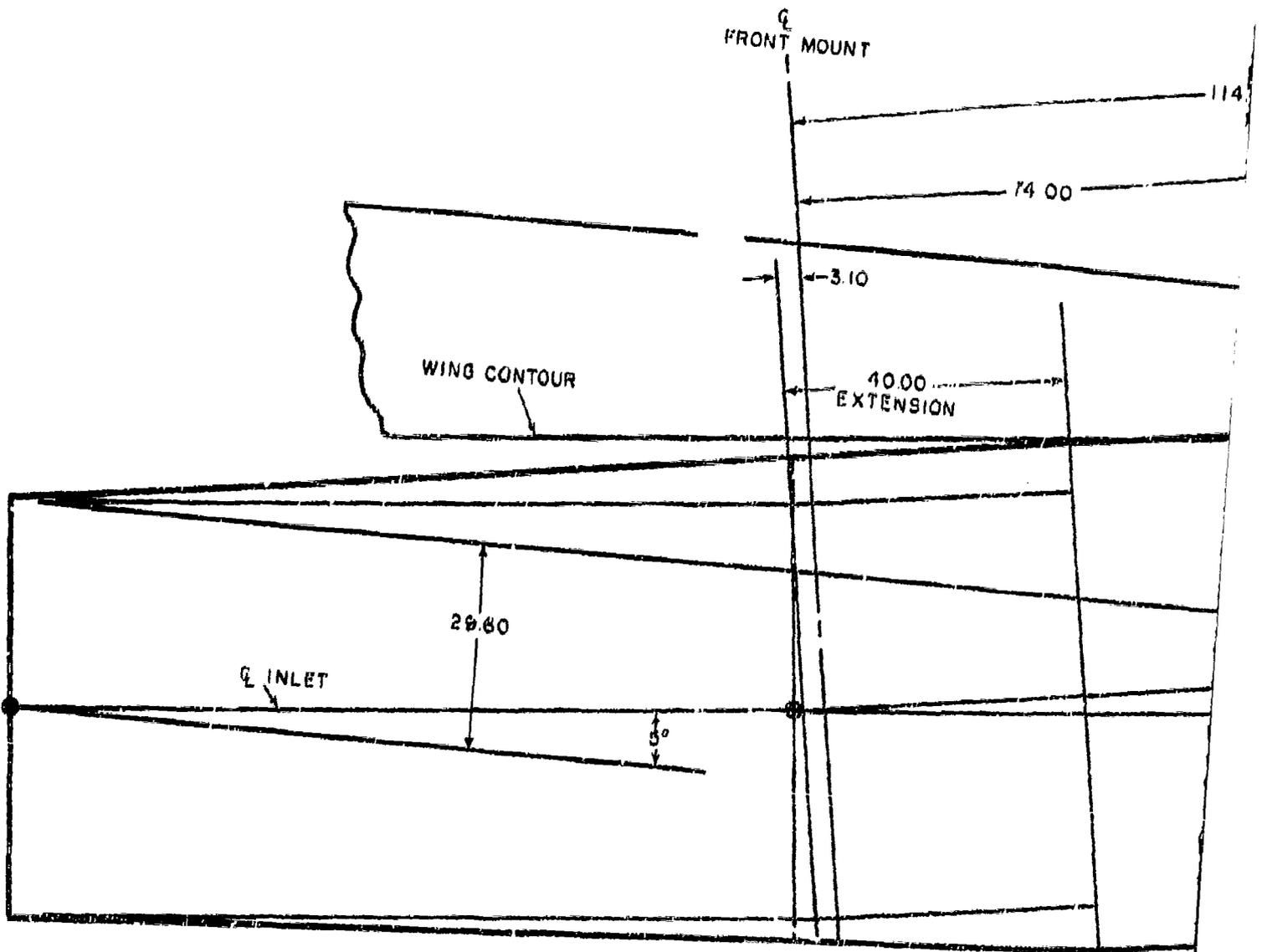
STF219B 600 LBS./SEC. TURBOFAN

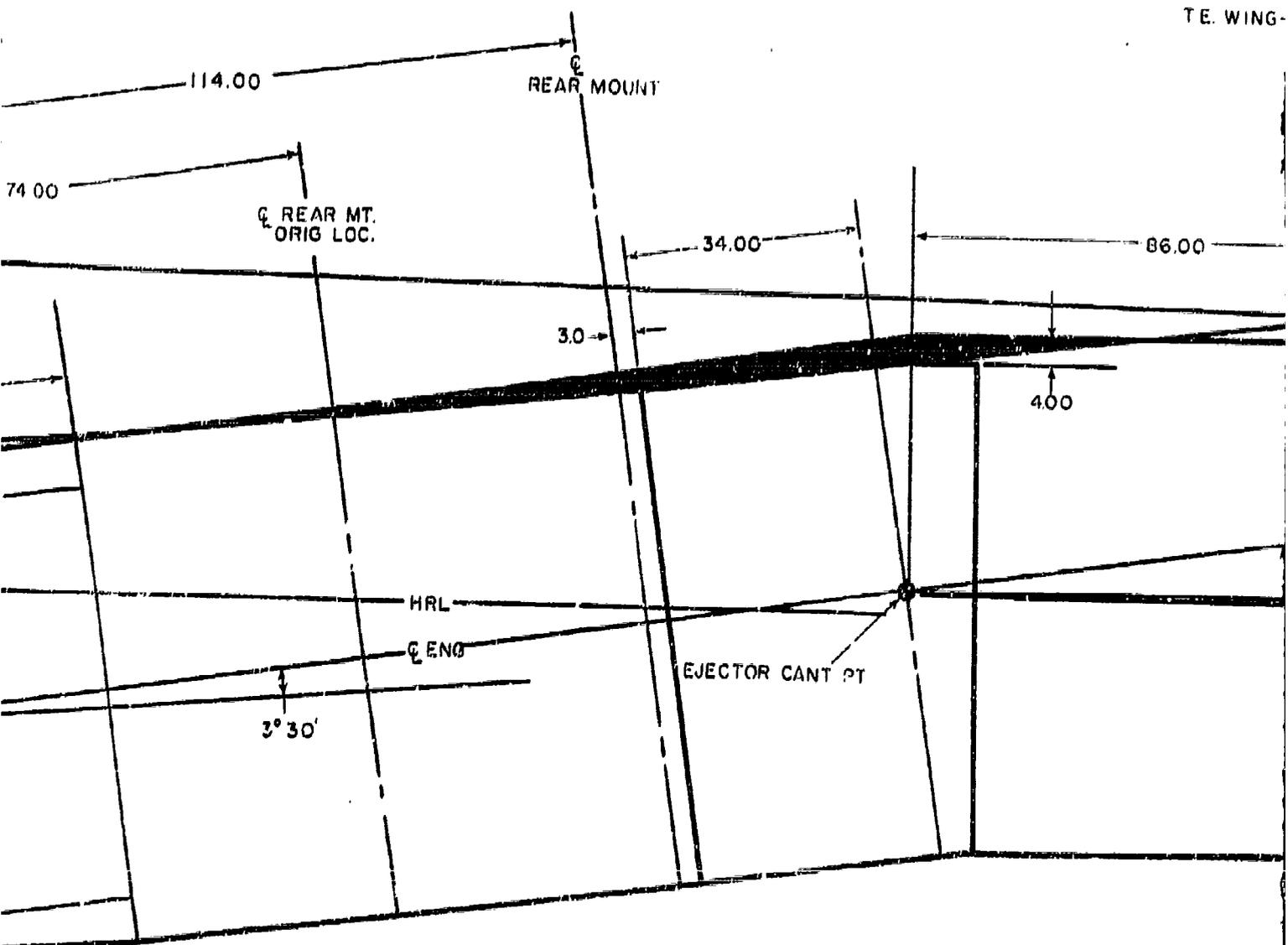
Figure 1-6

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CONFIDENTIAL - SECURITY INFORMATION  
UNCLASSIFIED EXCEPT WHERE SHOWN  
OTHERWISE

PRATT & WHITNEY AIRCRAFT

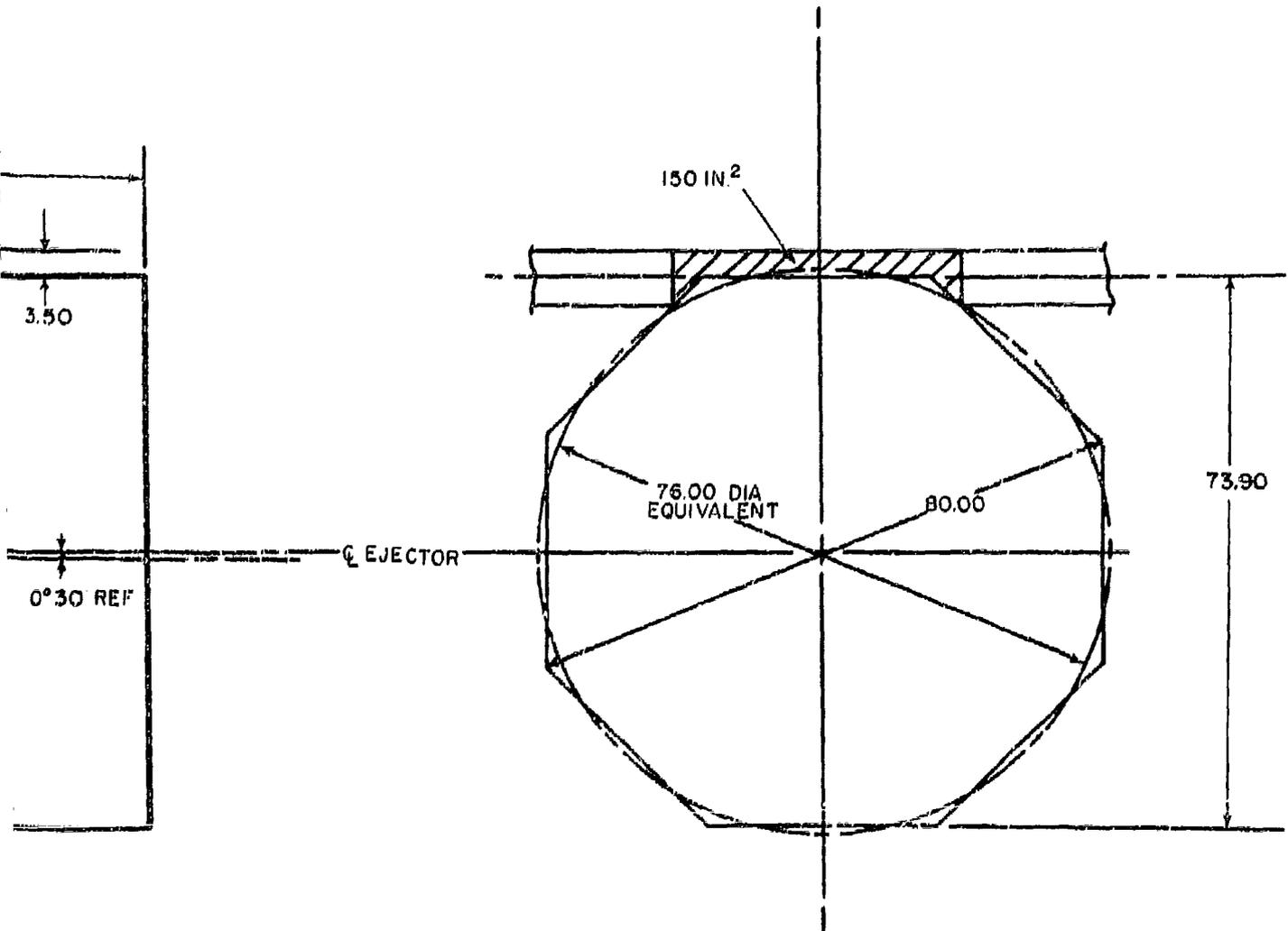






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PWA-2600



ARRANGEMENT MOVING REAR ENG. MT AFT  
40.00 & INSERTING ENG. 4.00 INTO WING  
EJECTOR CANTED AT NOZZLE PLANE  
ENG. MOUNT PLANES ARE PARALLEL.  
BASE DRAG AREA = 150 in<sup>2</sup>

STF219B 600 LBS./SEC. TURBOFAN

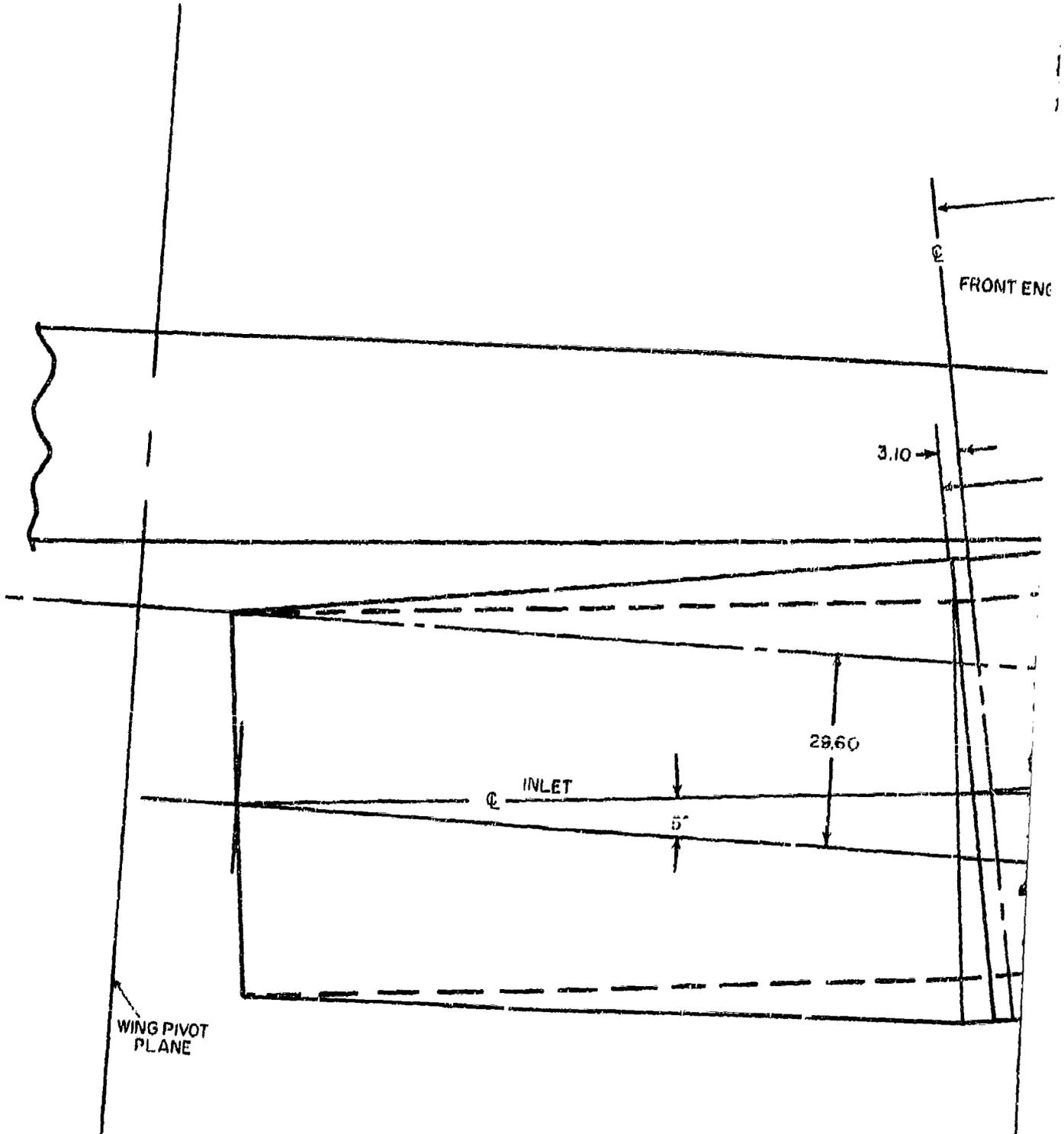
Figure 1-7

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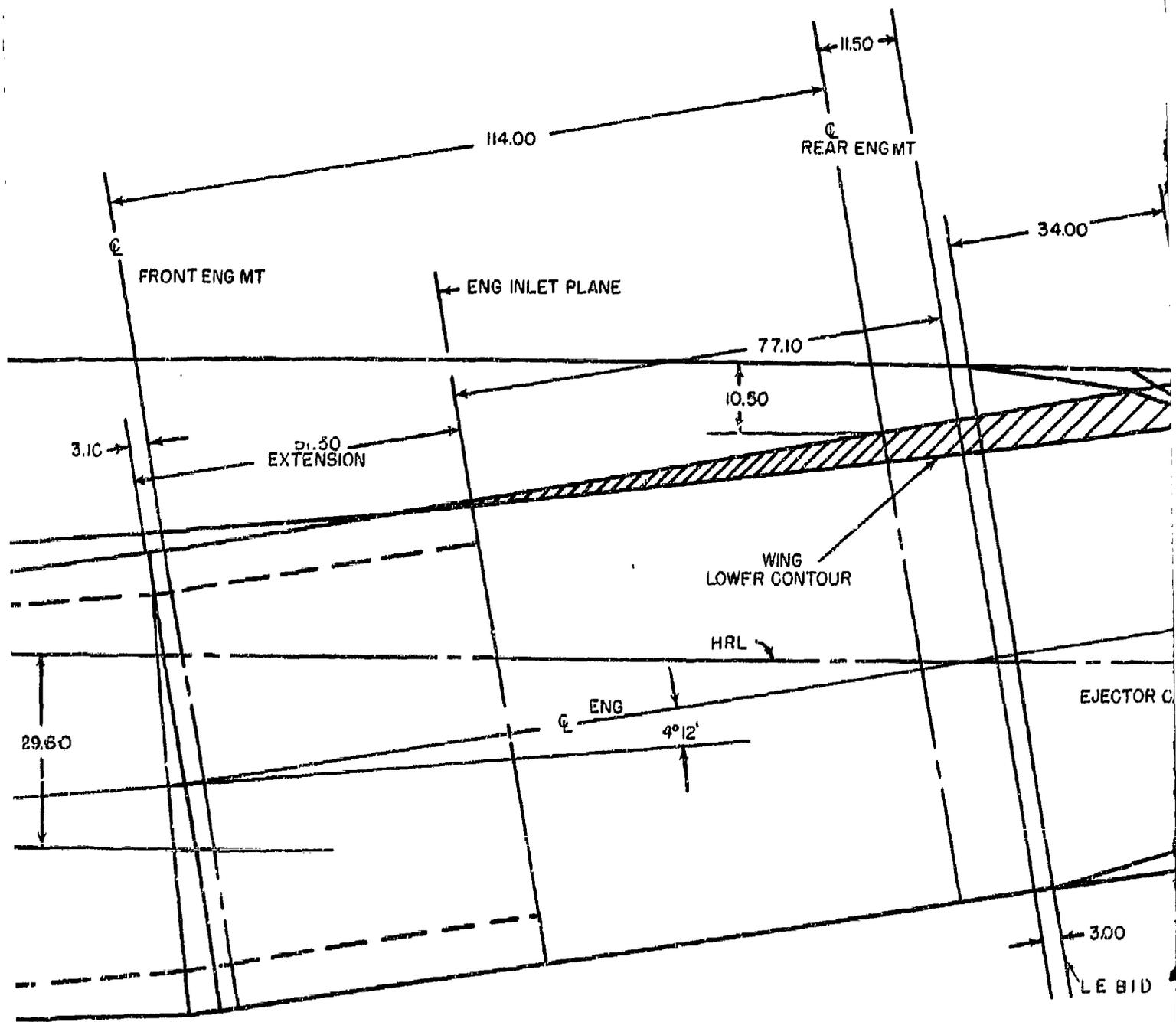
UNCLASSIFIED AT 2 YEAR INTERVAL  
DECLASSIFIED AFTER 10 YEARS  
DATE 08/08/01 BY 60324  
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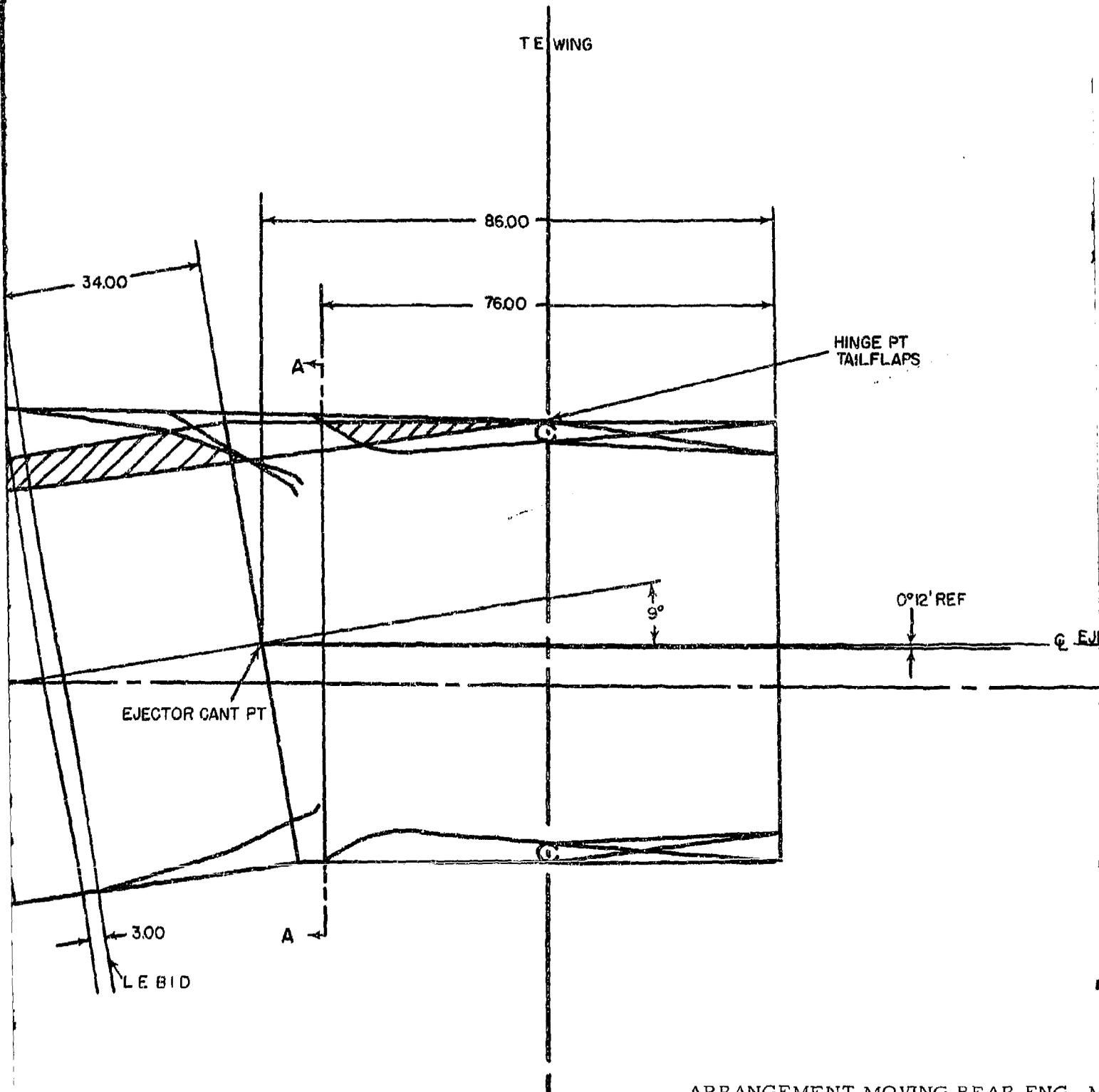
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PRATT & WHITNEY AIRCRAFT

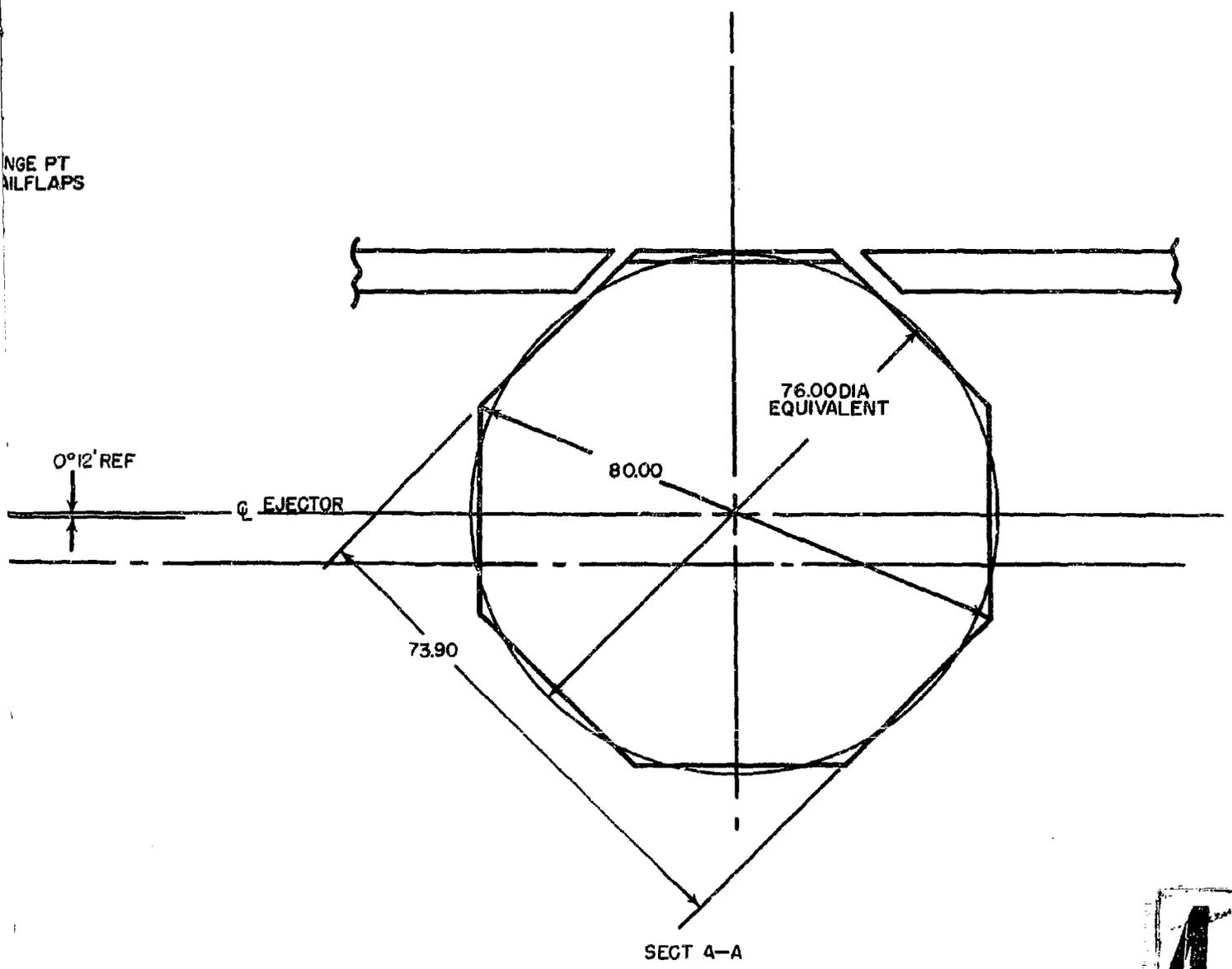


1





ARRANGEMENT MOVING REAR ENG. M  
 40.00 AFT & SETTING EJECTOR TAIL F  
 AT T. E. OF WING  
 EJECTOR CANTED AT NOZZLE PLANE



ENGINE PT  
TAILFLAPS

0°12' REF

EJECTOR

76.00 DIA  
EQUIVALENT

80.00

73.90

SECT 4-A

4

MOVING REAR ENG. MT.  
EJECTOR TAIL FLAPS  
NOZZLE PLANE

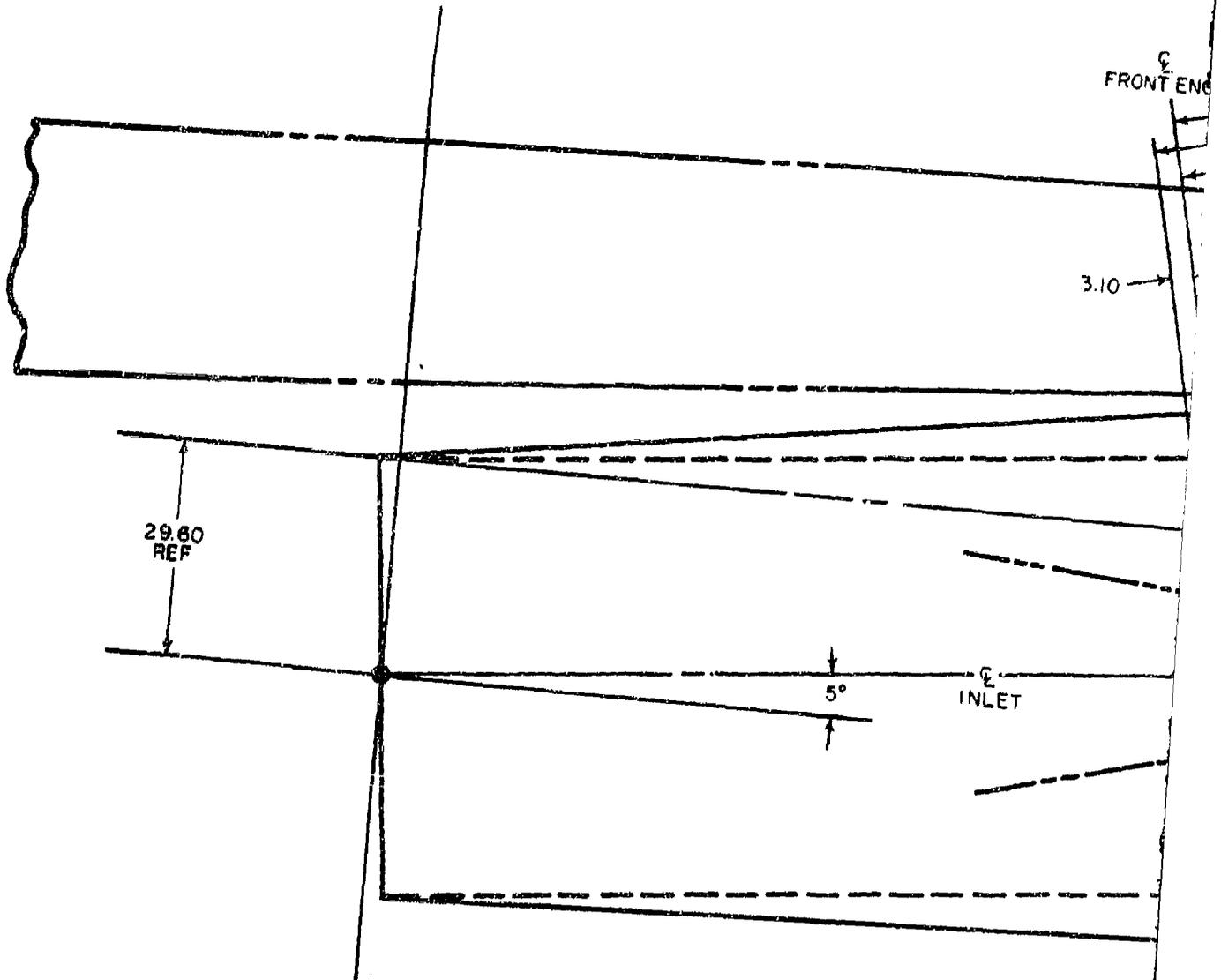
STF219B 600 LBS./SEC. TURBOFAN

Figure 1-8

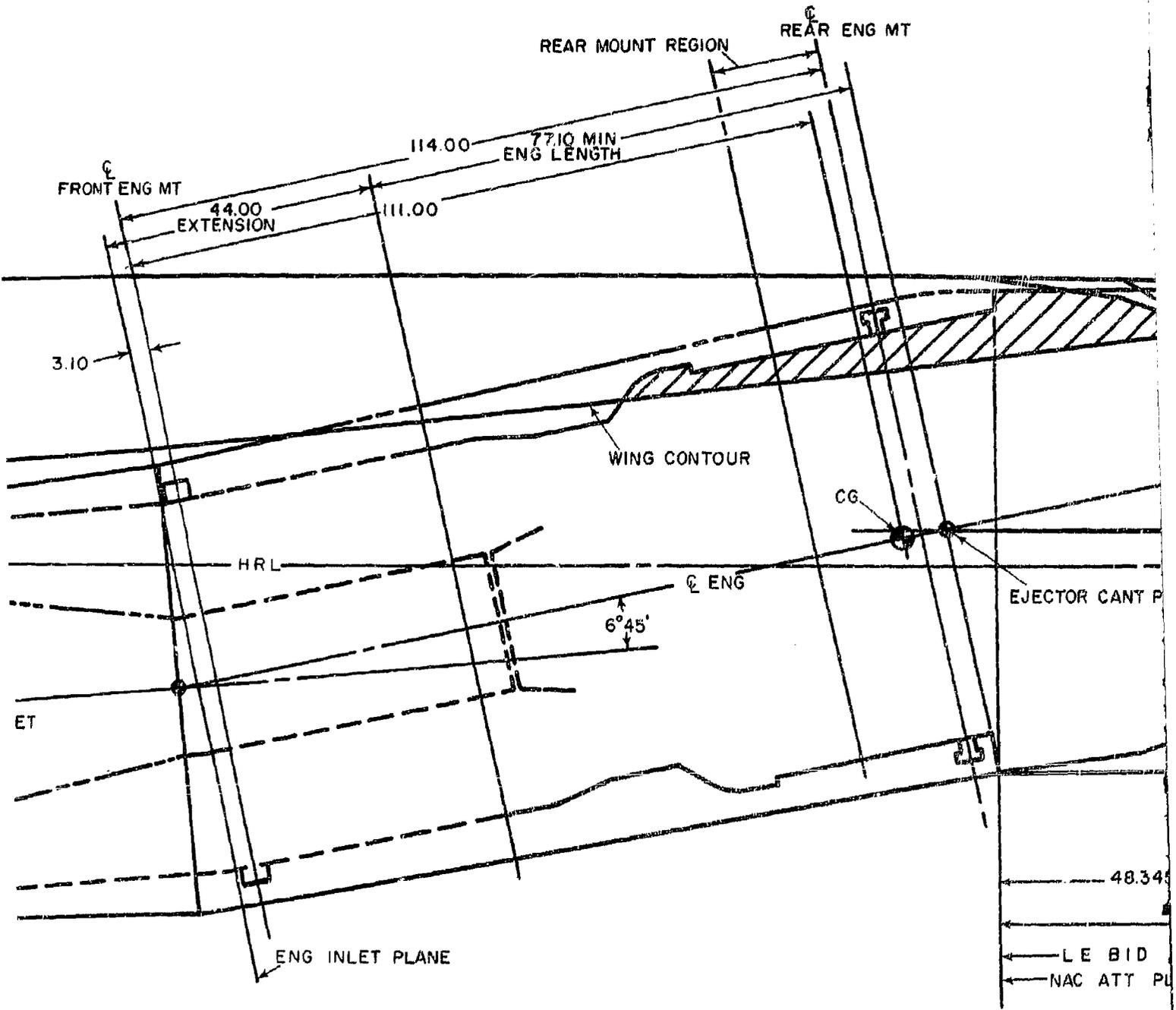
CLASSIFIED BY 3 YEAR INTERVALS  
DECLASSIFIED AFTER 12 YEARS  
DDO GPO 196110

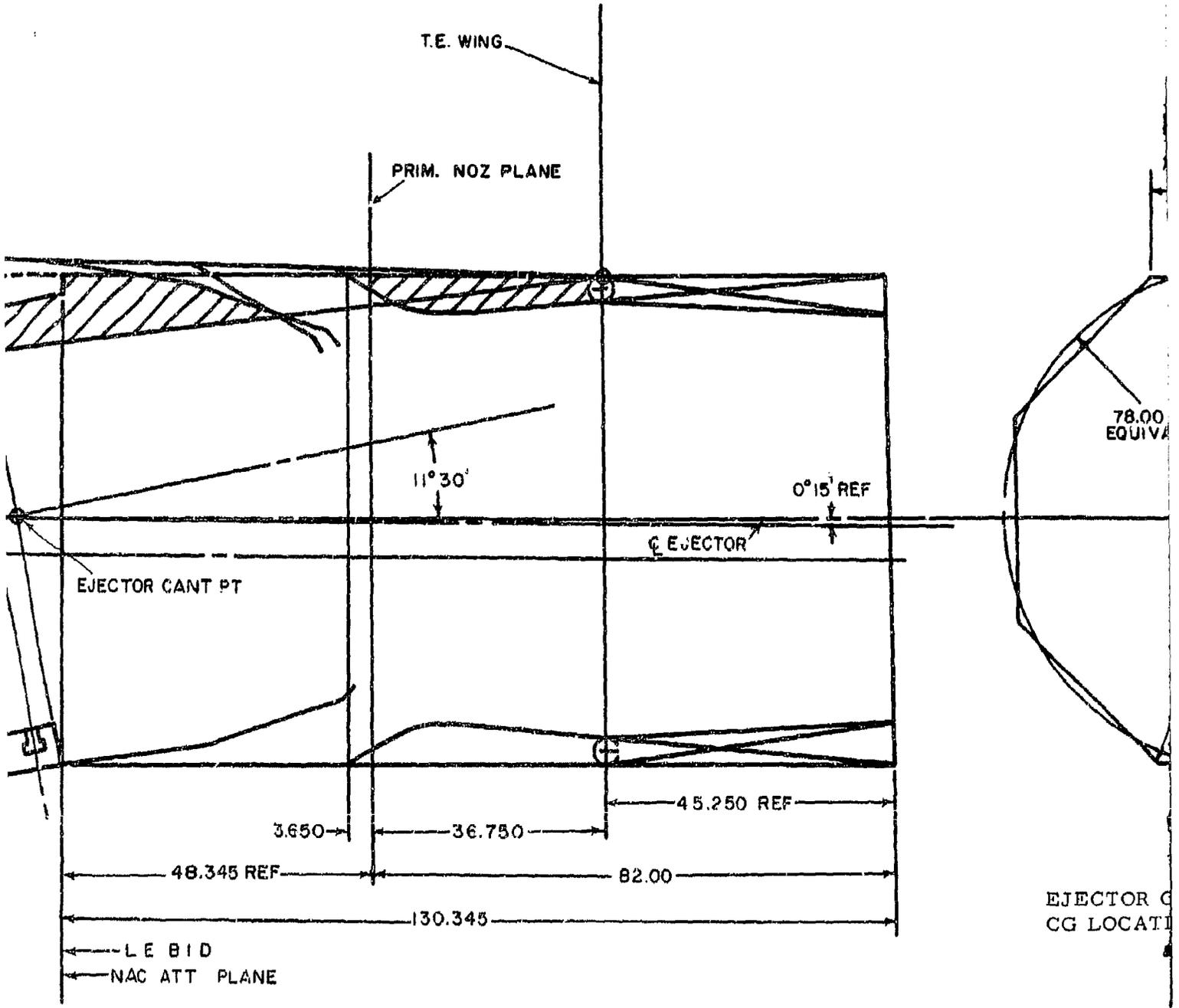
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PRATT & WHITNEY AIRCRAFT



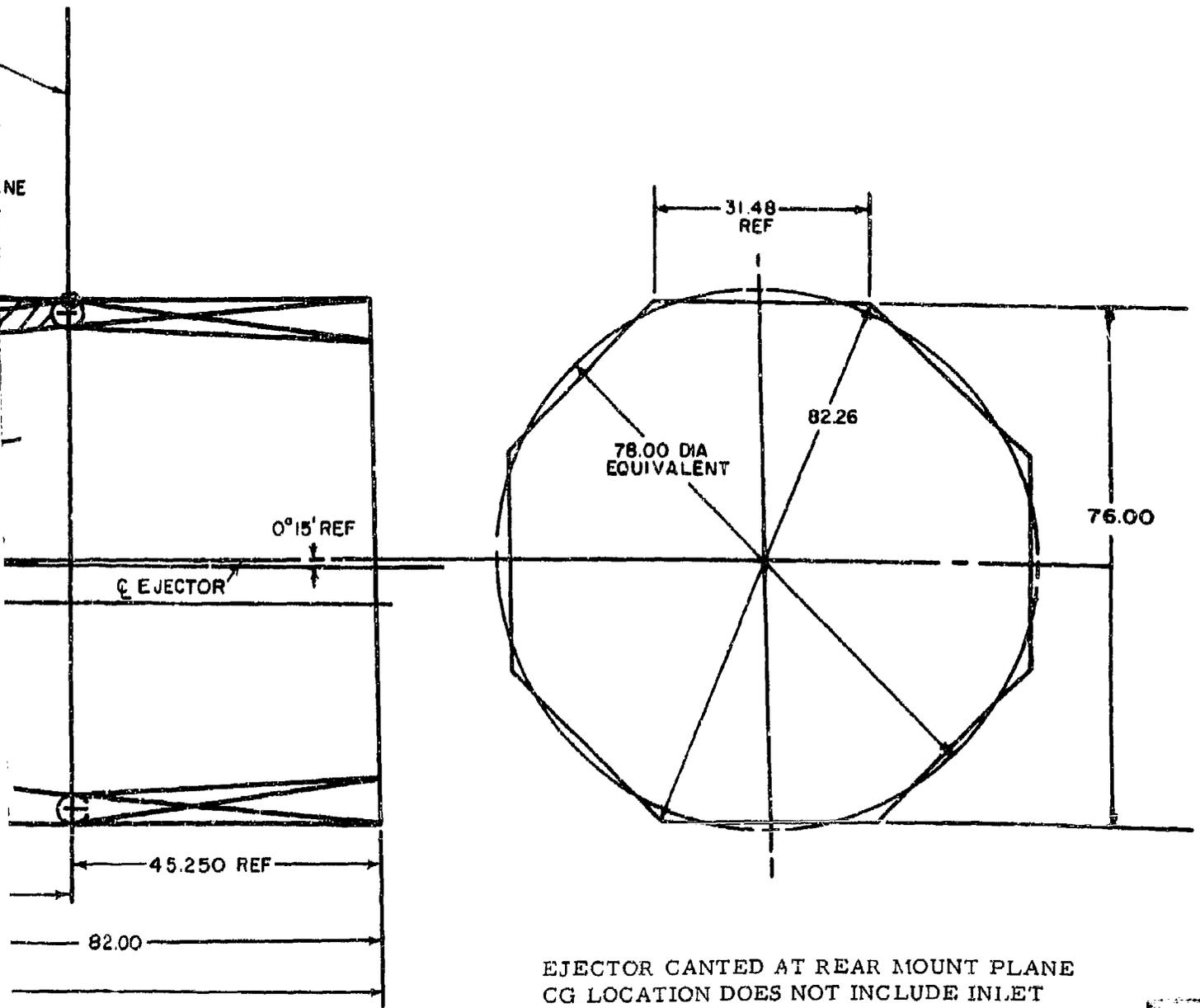
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STF219B 600 LBS. /S

Figure



EJECTOR CANTED AT REAR MOUNT PLANE  
CG LOCATION DOES NOT INCLUDE INLET

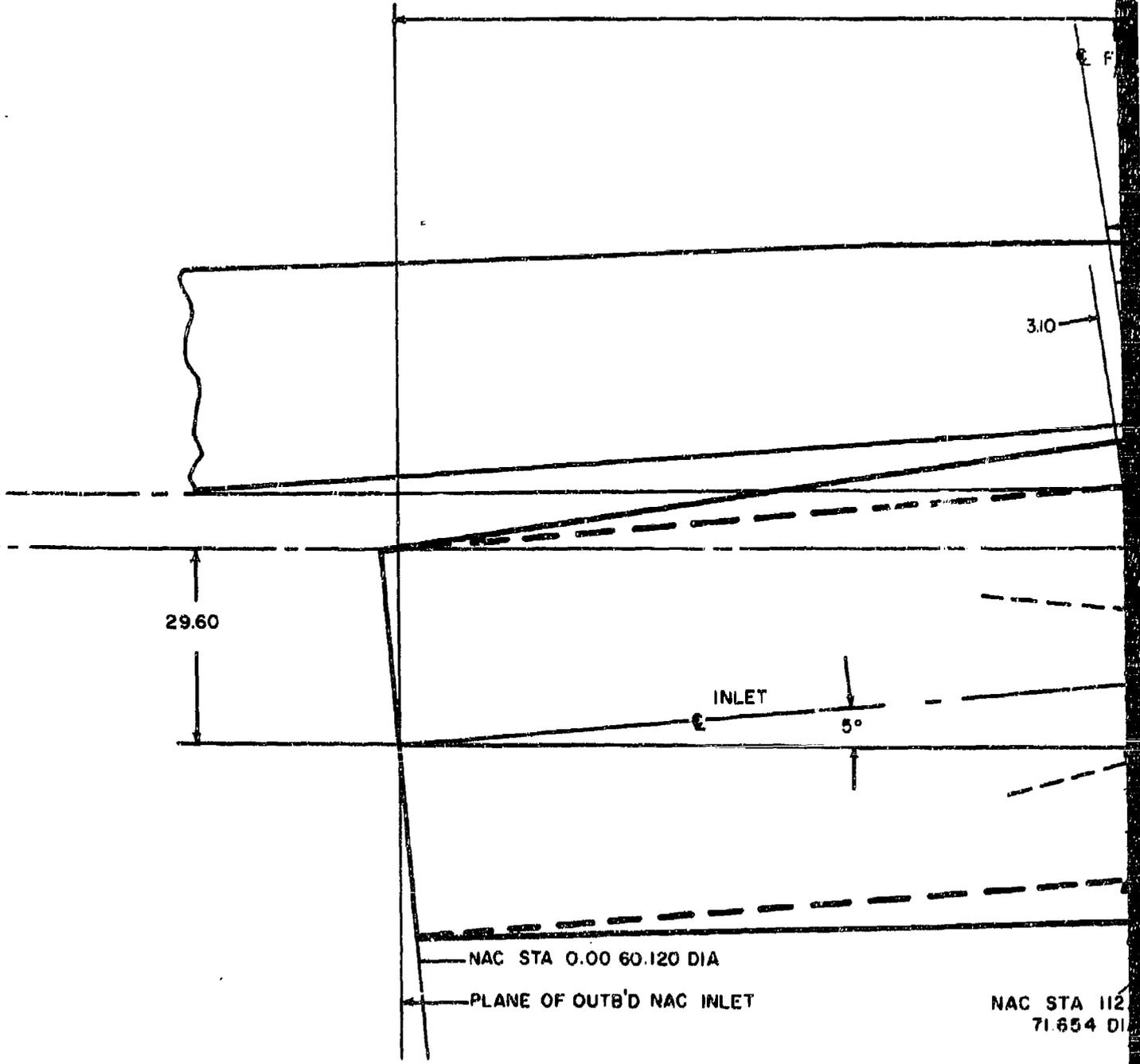
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STF219B 600 LBS. /SEC. TURBOFAN

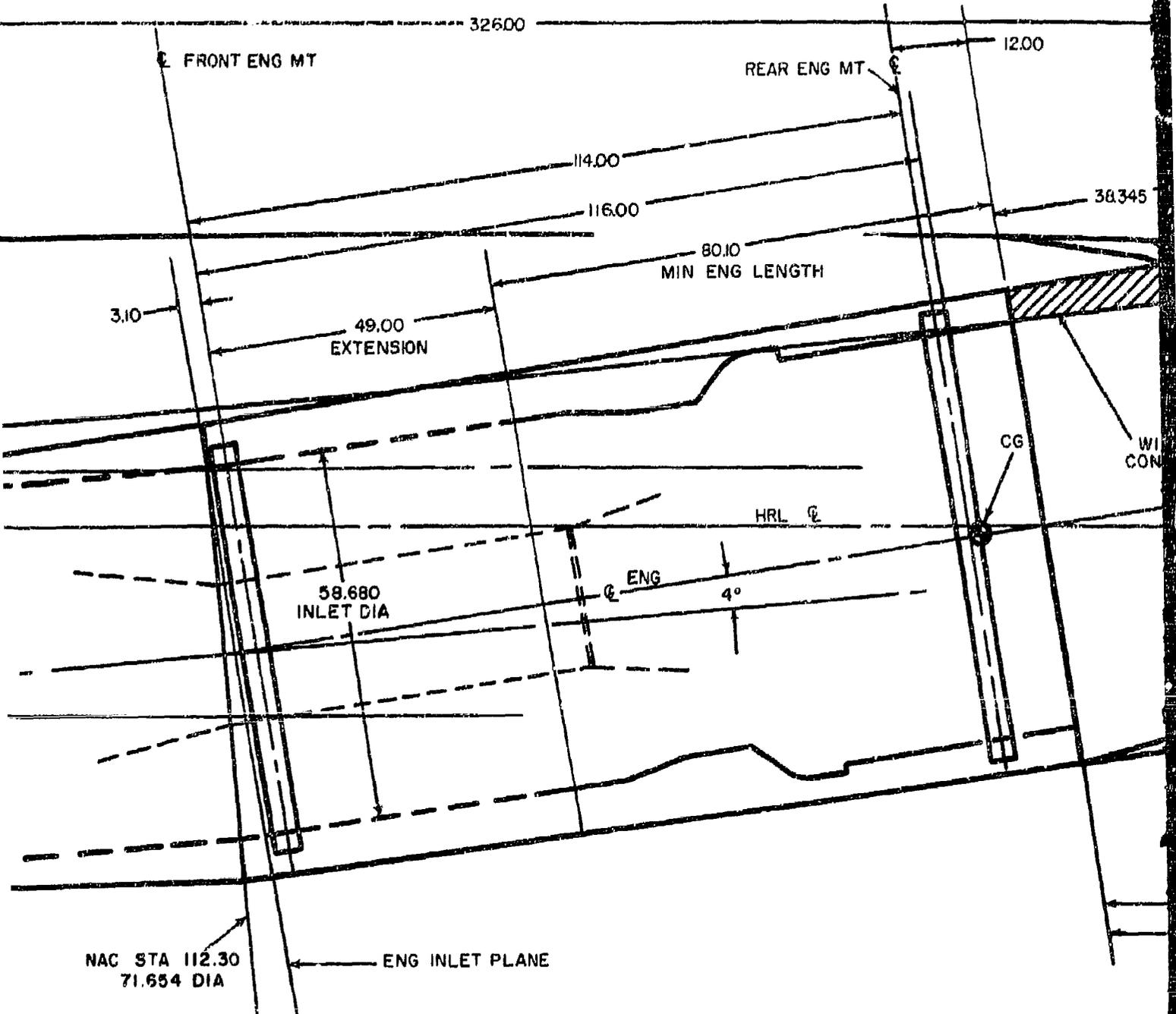
Figure 1-9

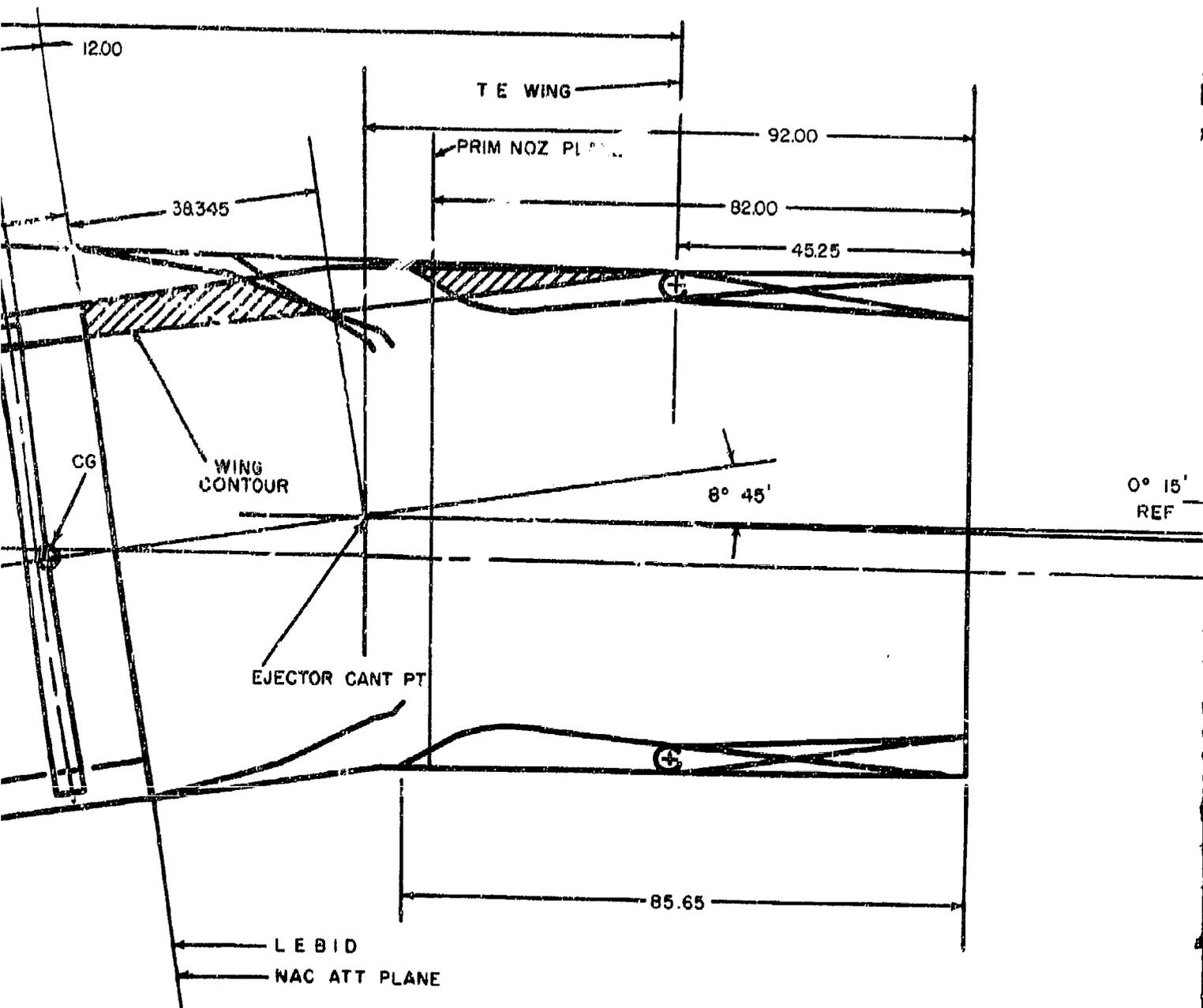
DOWNGRADED AT 5 YEAR INTERVALS  
DECLASSIFIED AFTER 12 YEARS  
GDD UN 8200 10

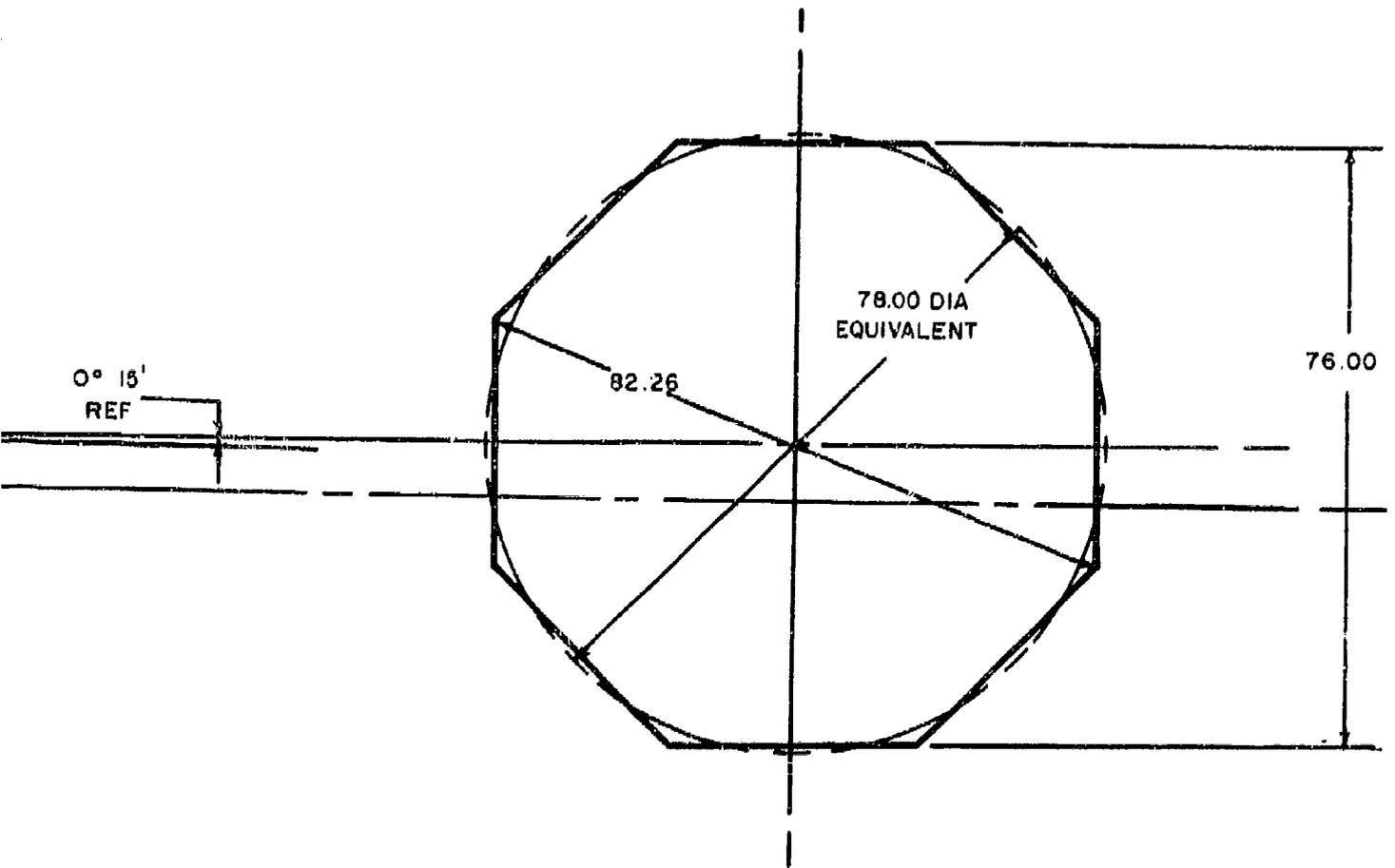
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LAW.



NAC STA 112  
71.654 DI







EJECTOR CANTED 10.00 FWD. OF PRIMARY  
NOZZLE PLANE  
CG LOCATION DOES NOT INCLUDE INLET

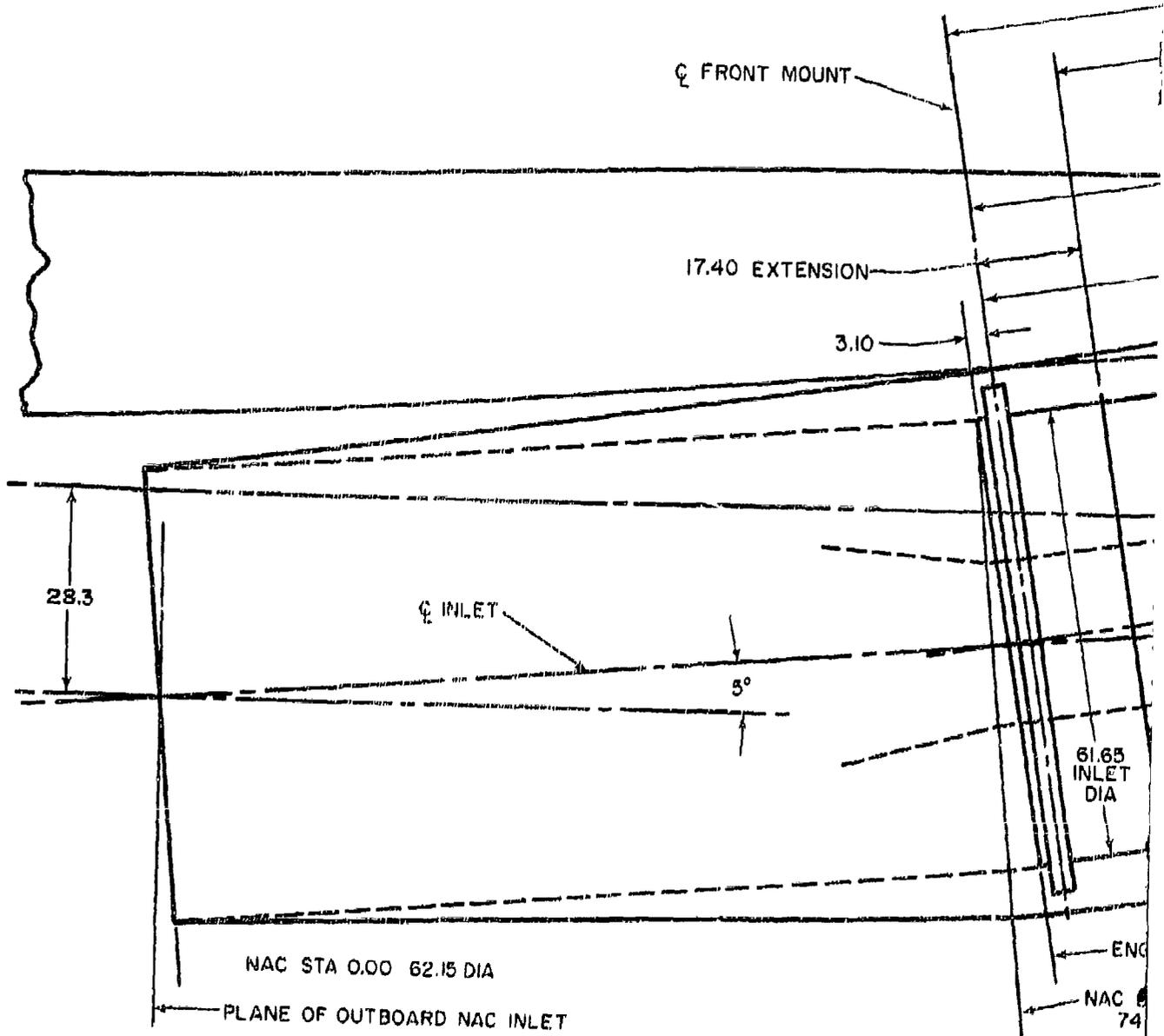
STF219B 600 LBS./SEC. TURBOFAN

Figure 1-10

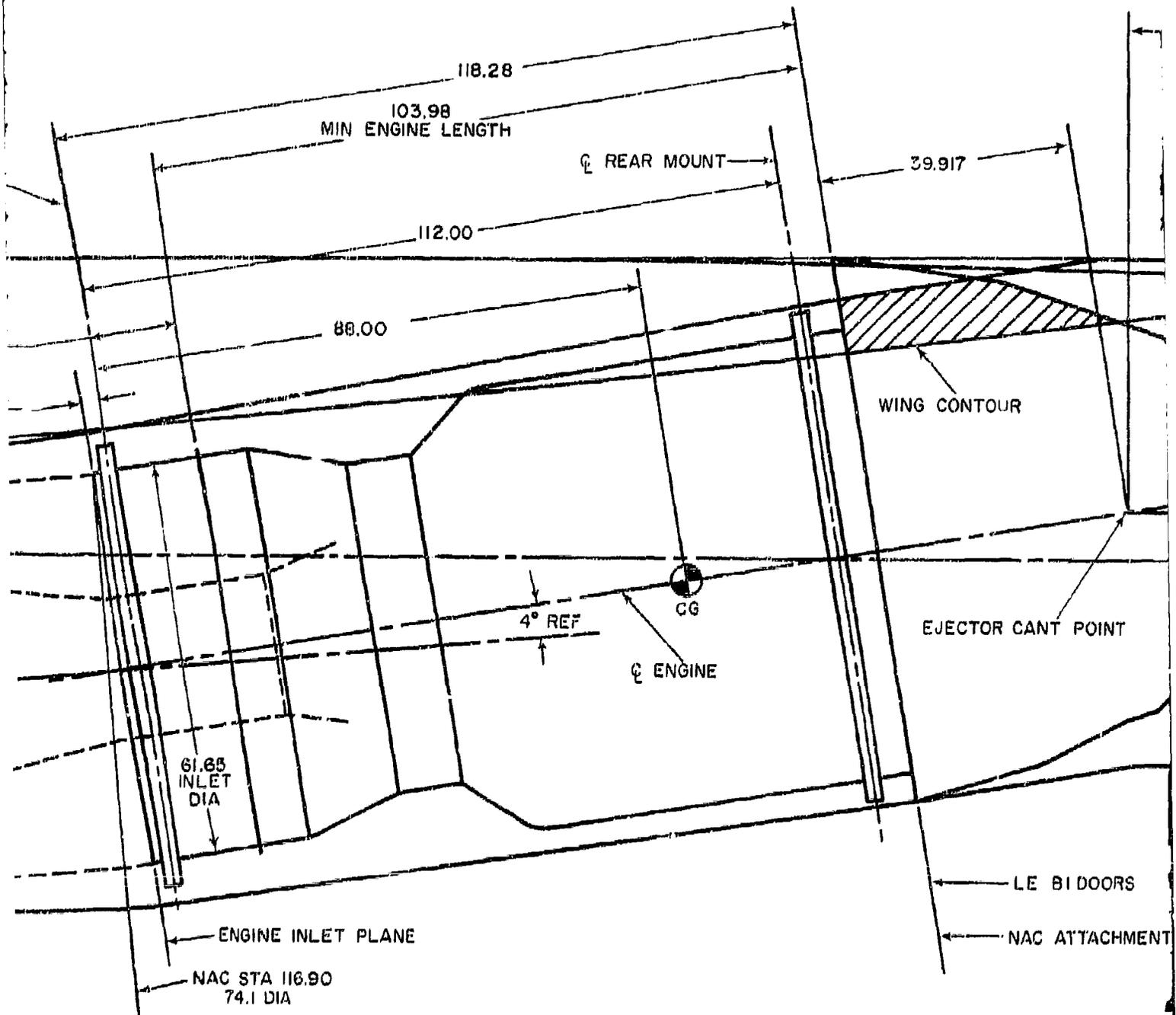
4

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DECLASSIFIED UNDER 25 USC  
552A  
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PROPERTY OF THE AIR FORCE SYSTEMS COMMAND AND IS  
CLASSIFIED "SECRET" IN ACCORDANCE WITH THE  
DECLASSIFICATION AND CONTROL OF INFORMATION ACT  
UNLESS OTHERWISE SPECIFIED BY LAW

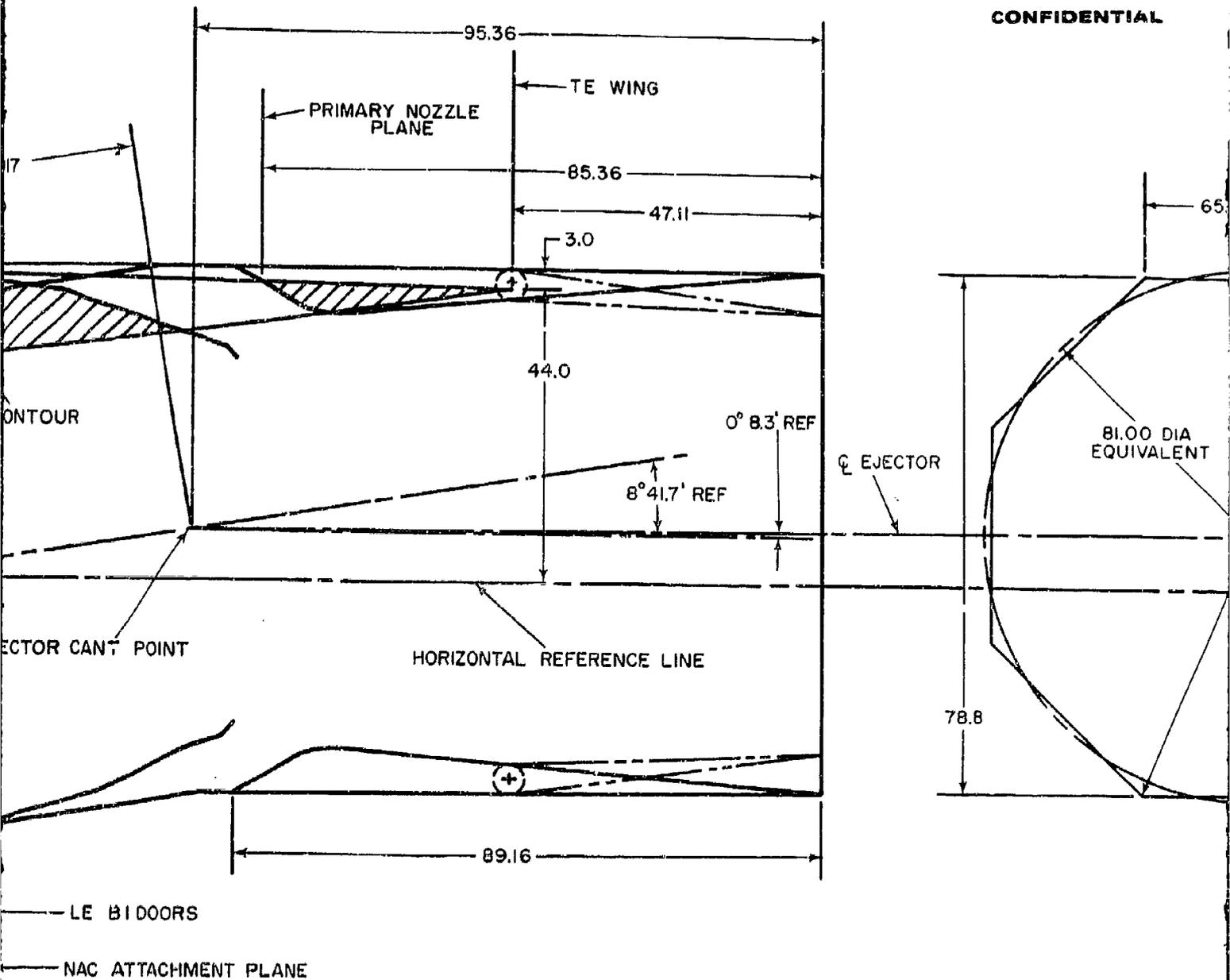
PRATT & WHITNEY AIRCRAFT



1



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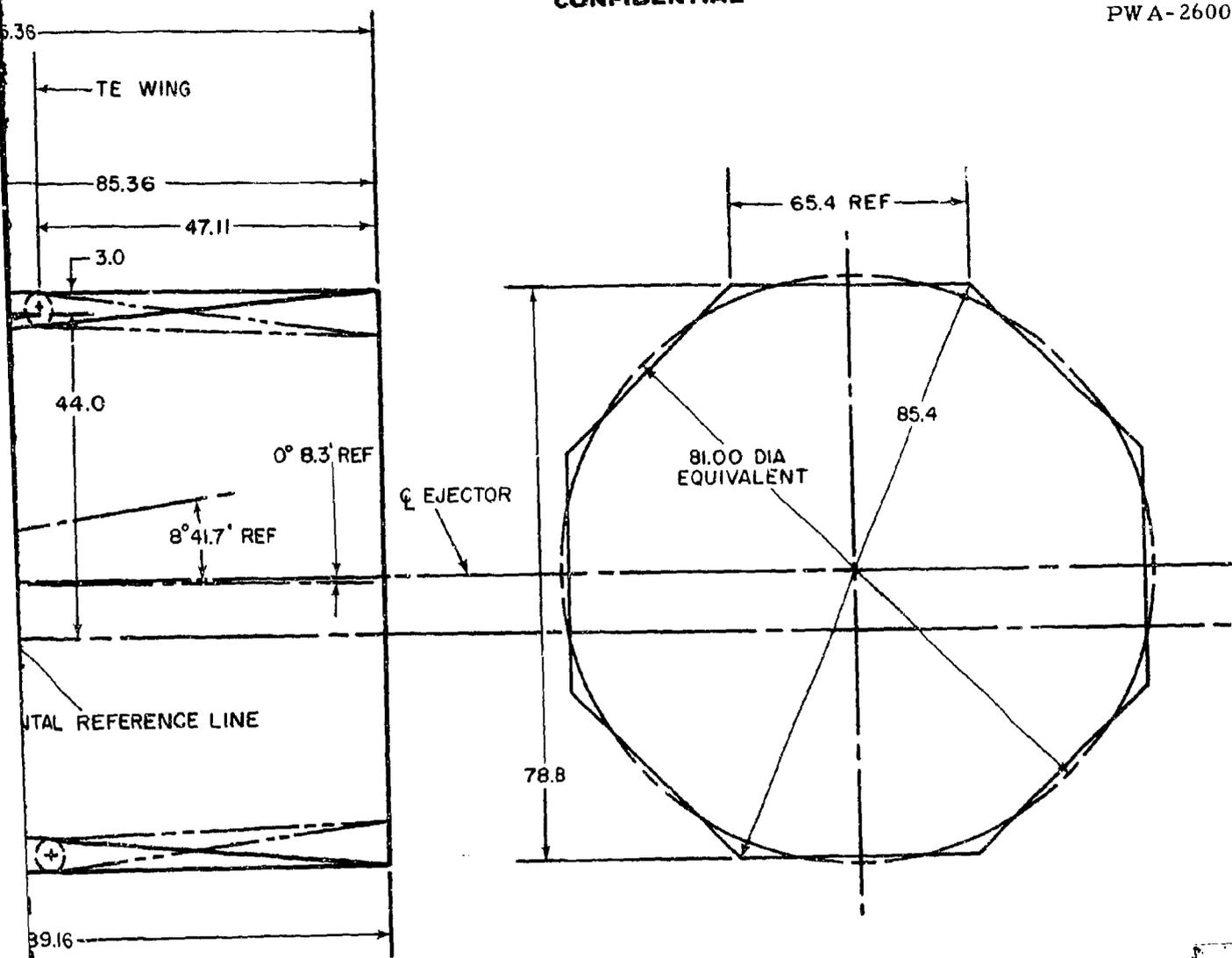
CG LOCATION DOES NOT INCLUDE INLET

EJECTOR CAN  
NOZZLE PL/  
CG LOCATION

STF219 650 LBS./SEC. TURF

Figure 1-11

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CG LOCATION DOES NOT INCLUDE INLET

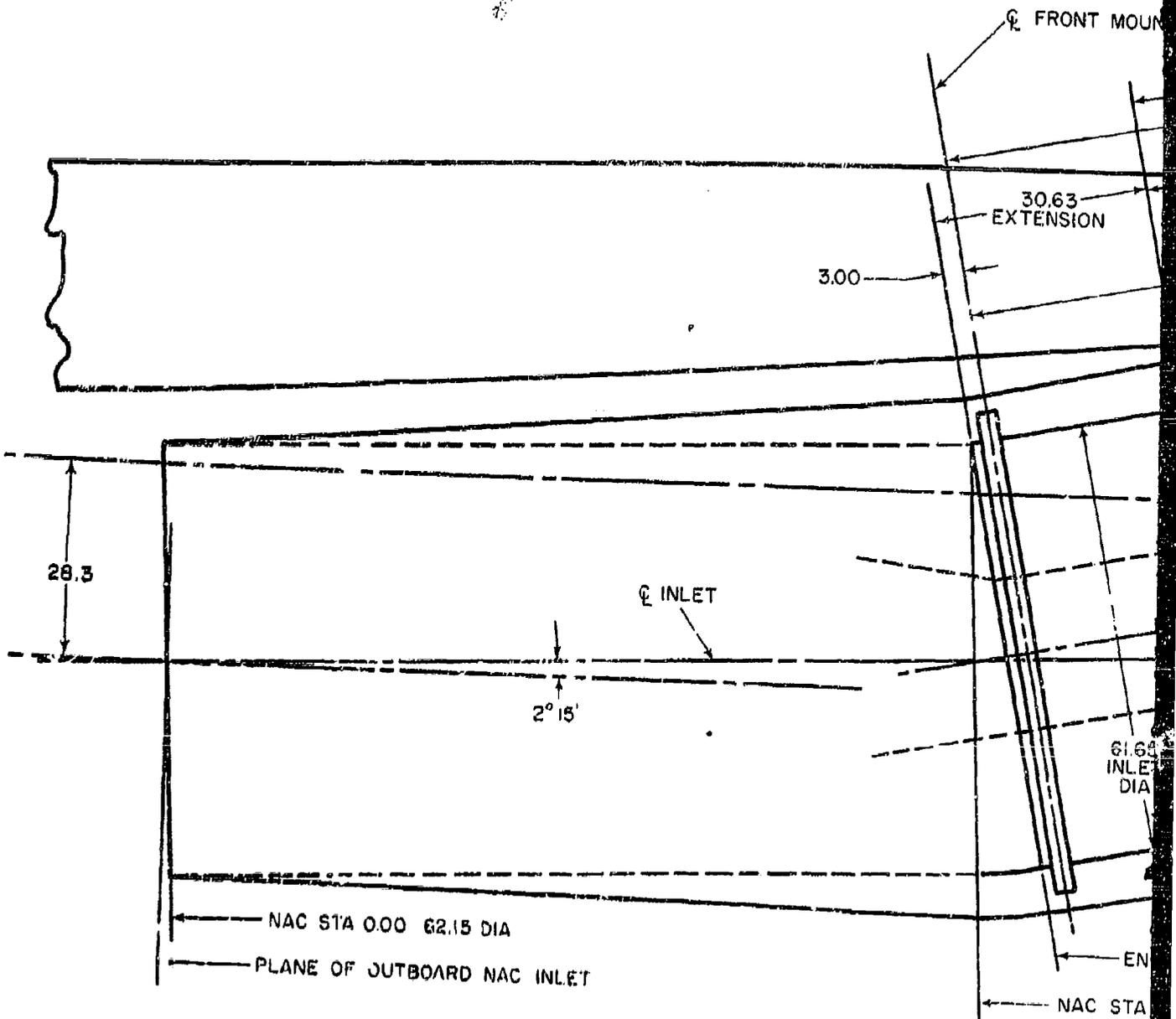
EJECTOR CANTED 10.00 FWD. OF PRIMARY NOZZLE PLANE  
CG LOCATION DOES NOT INCLUDE INLET

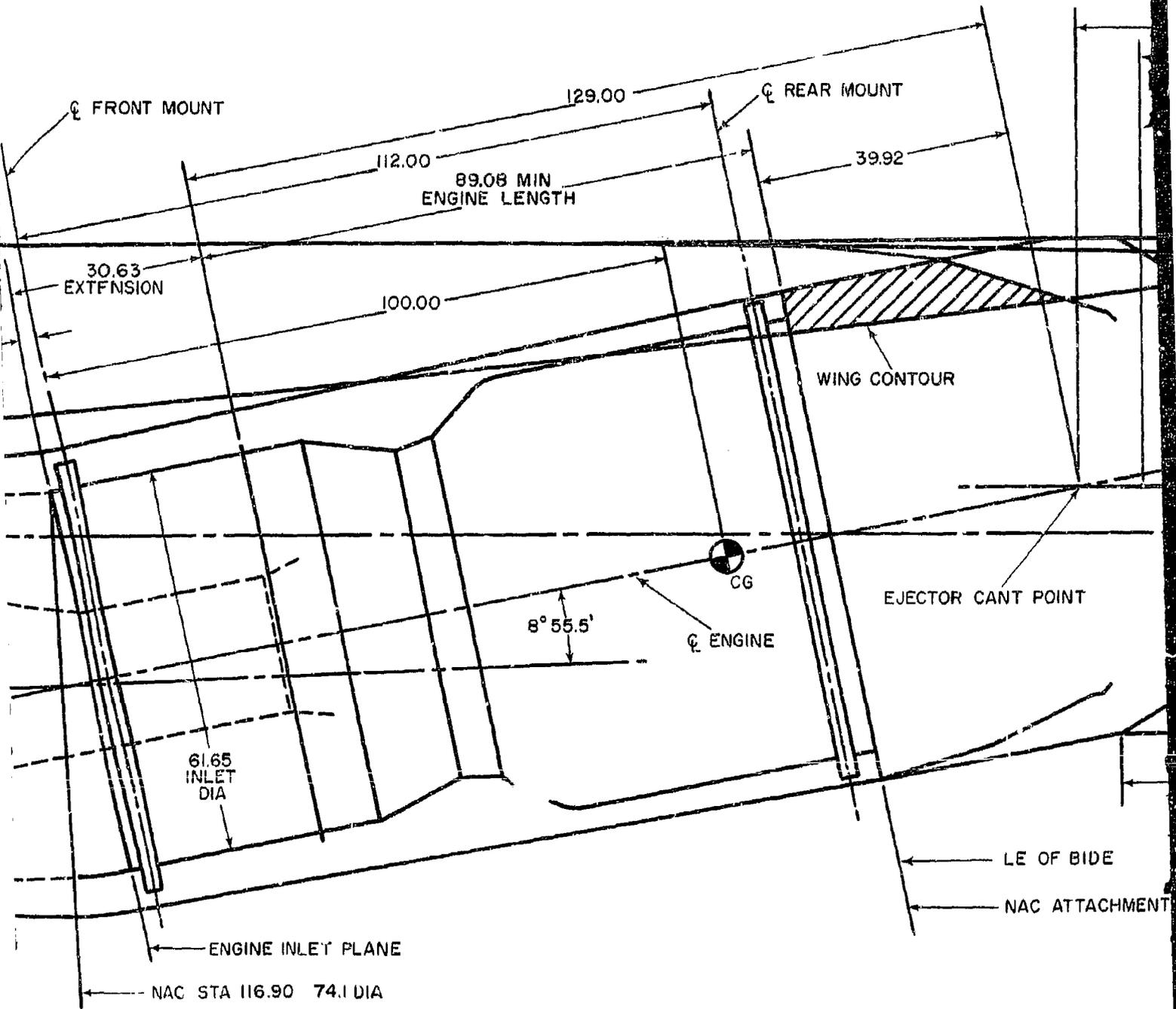
STF219 650 LBS./SEC. TURBOFAN

Figure 1-11

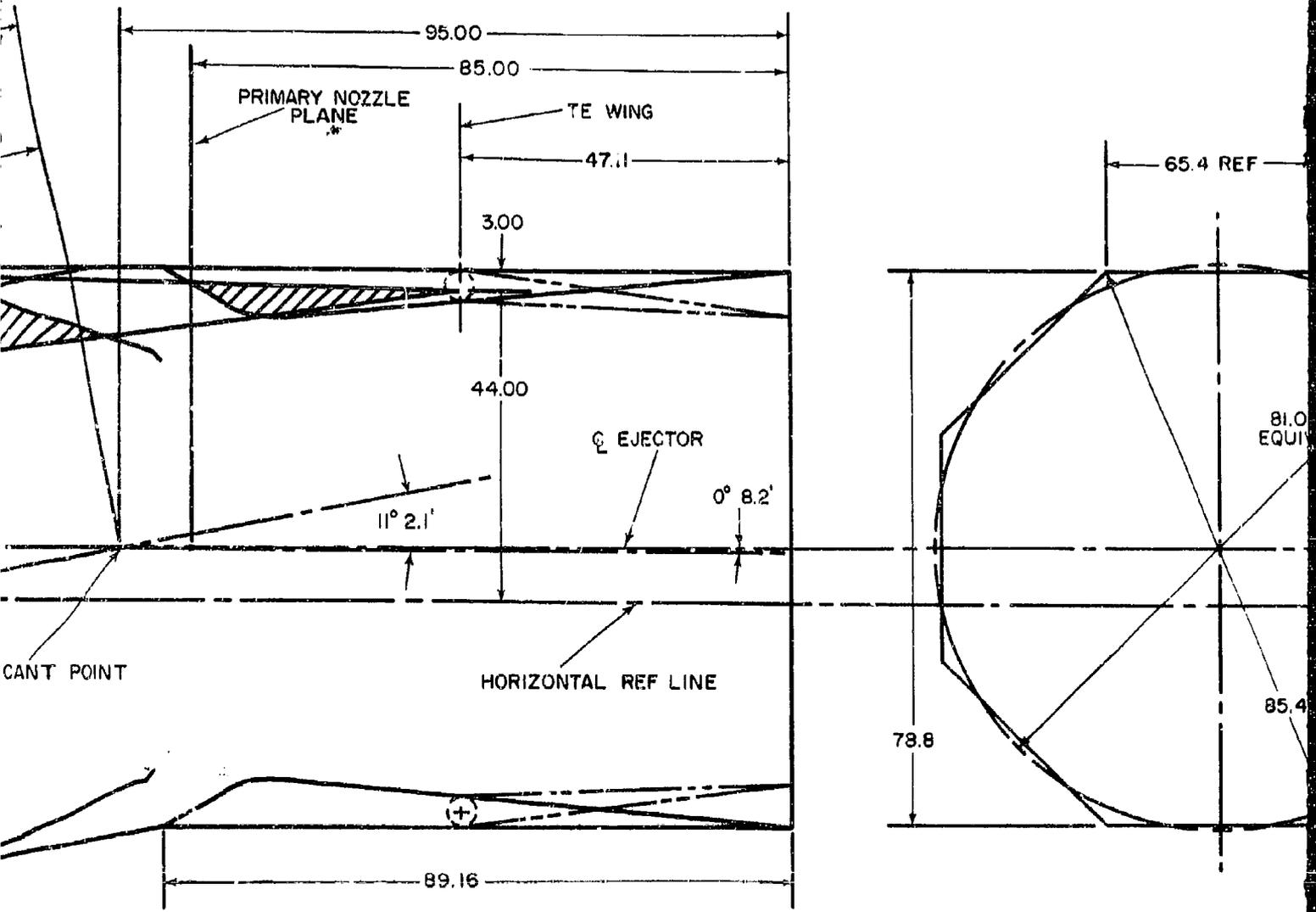
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DECLASSIFIED AFTER 15 YEARS  
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4





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EJECTOR CANTED 10.00 FWD.  
NOZZLE PLANE  
CG LOCATION DOES NOT INCLUDE

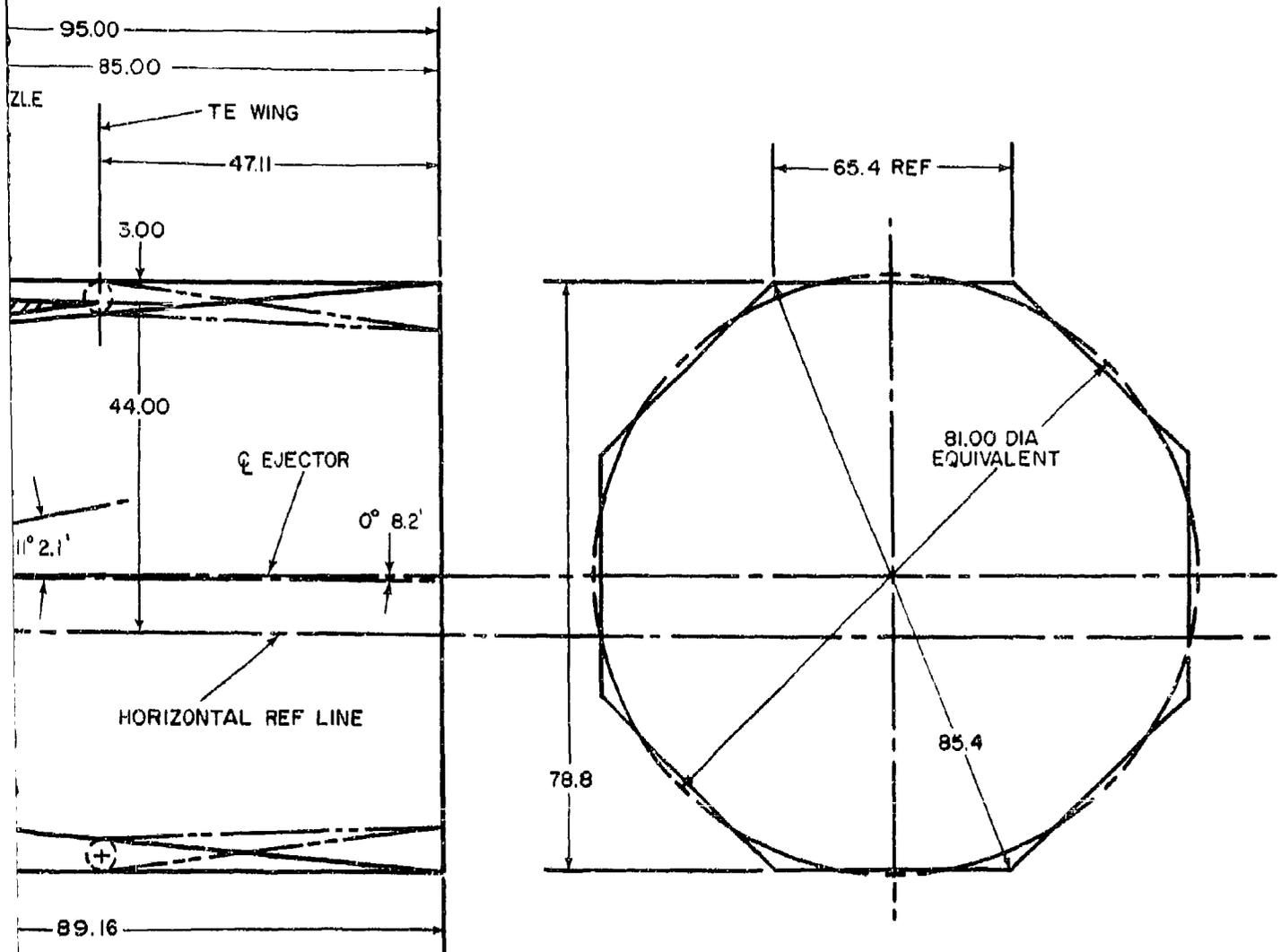
CG LOCATION DOES NOT INCLUDE INLET

STF219 650 LBS./SEC. TURBOFAN

Figure 1-12

CONFIDENTIAL

3



EJECTOR CANTED 10.00 FWD. OF PRIMARY  
NOZZLE PLANE  
CG LOCATION DOES NOT INCLUDE INLET

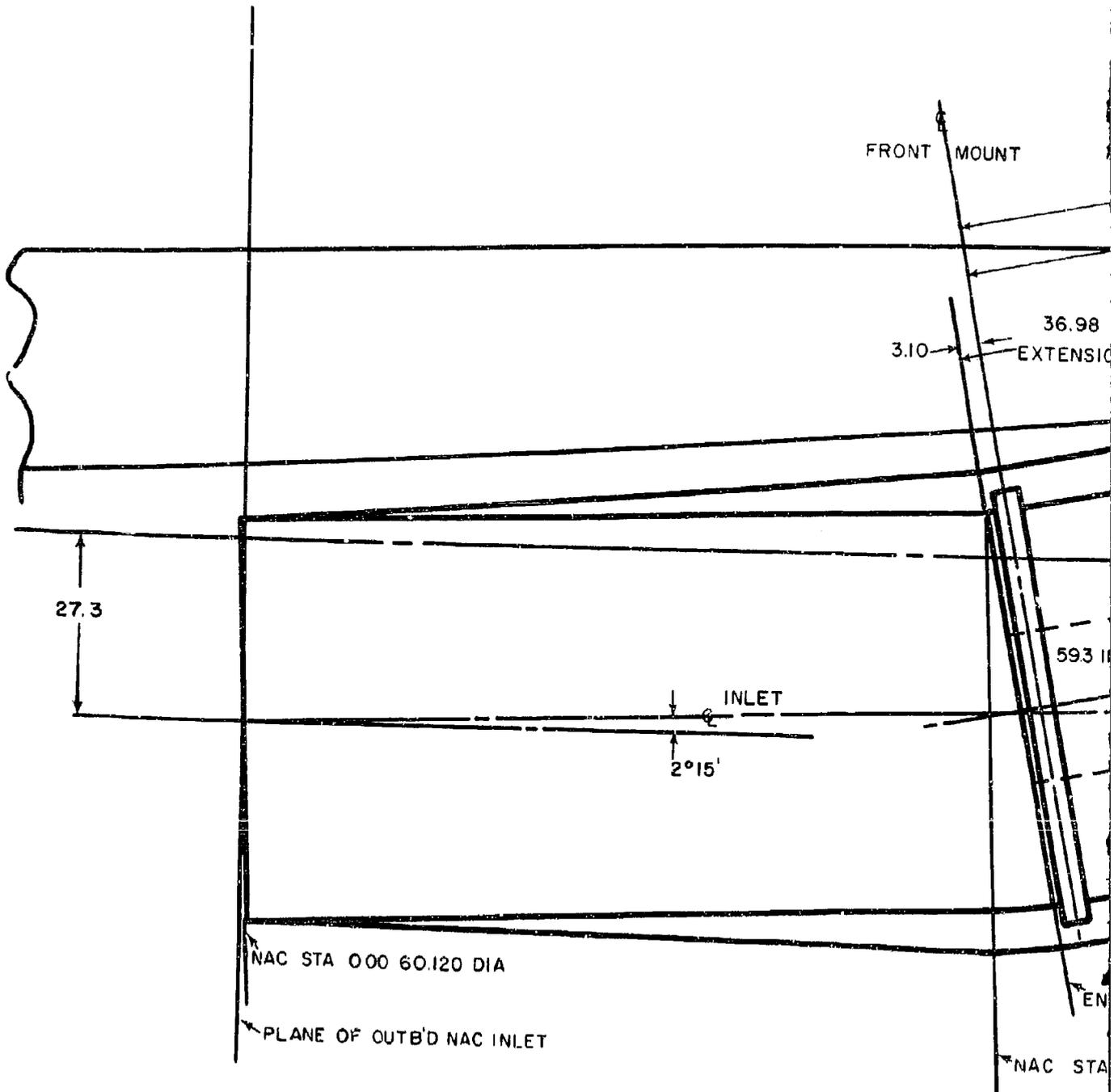
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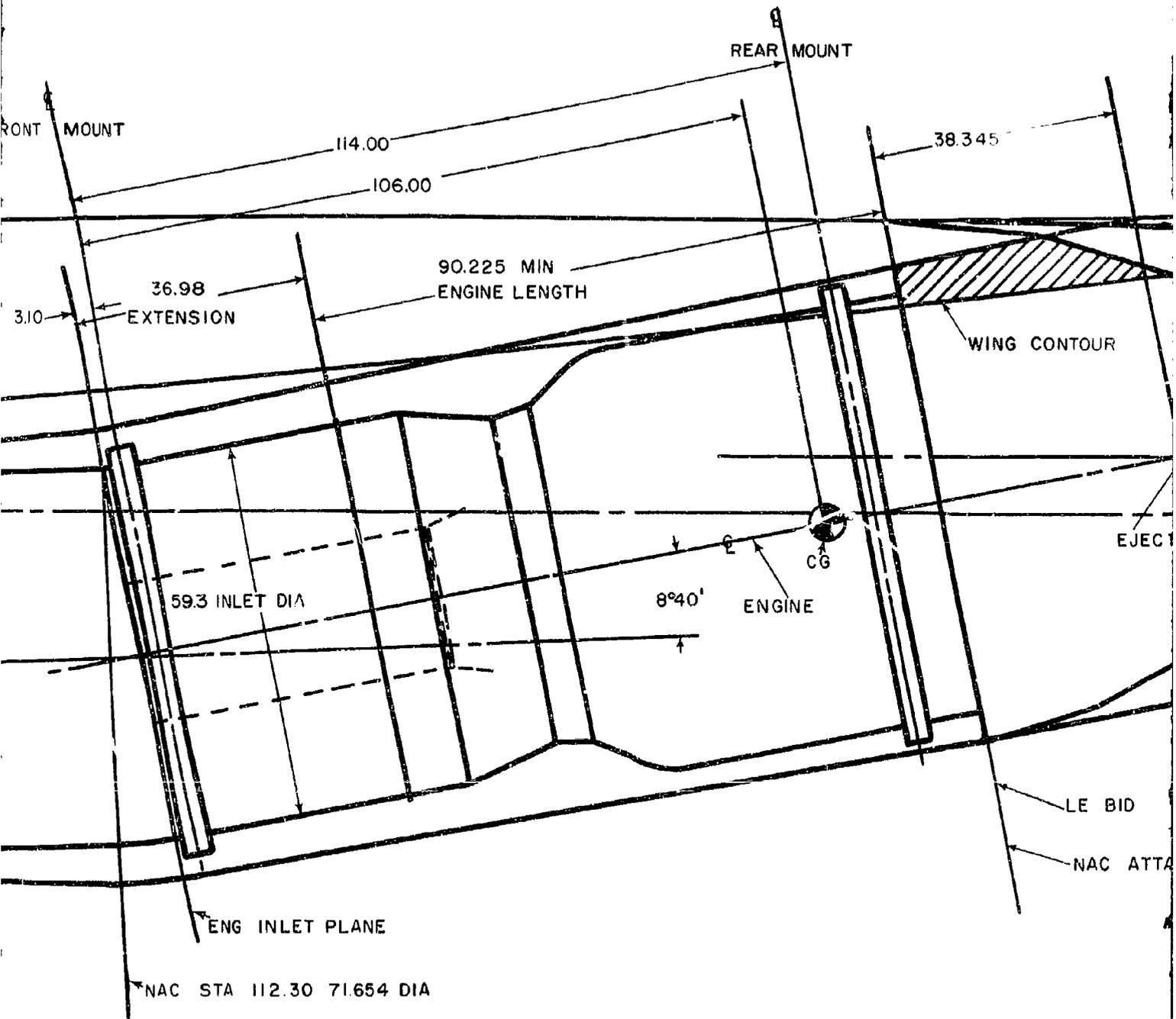
STF219 650 LBS./SEC. TURBOFAN

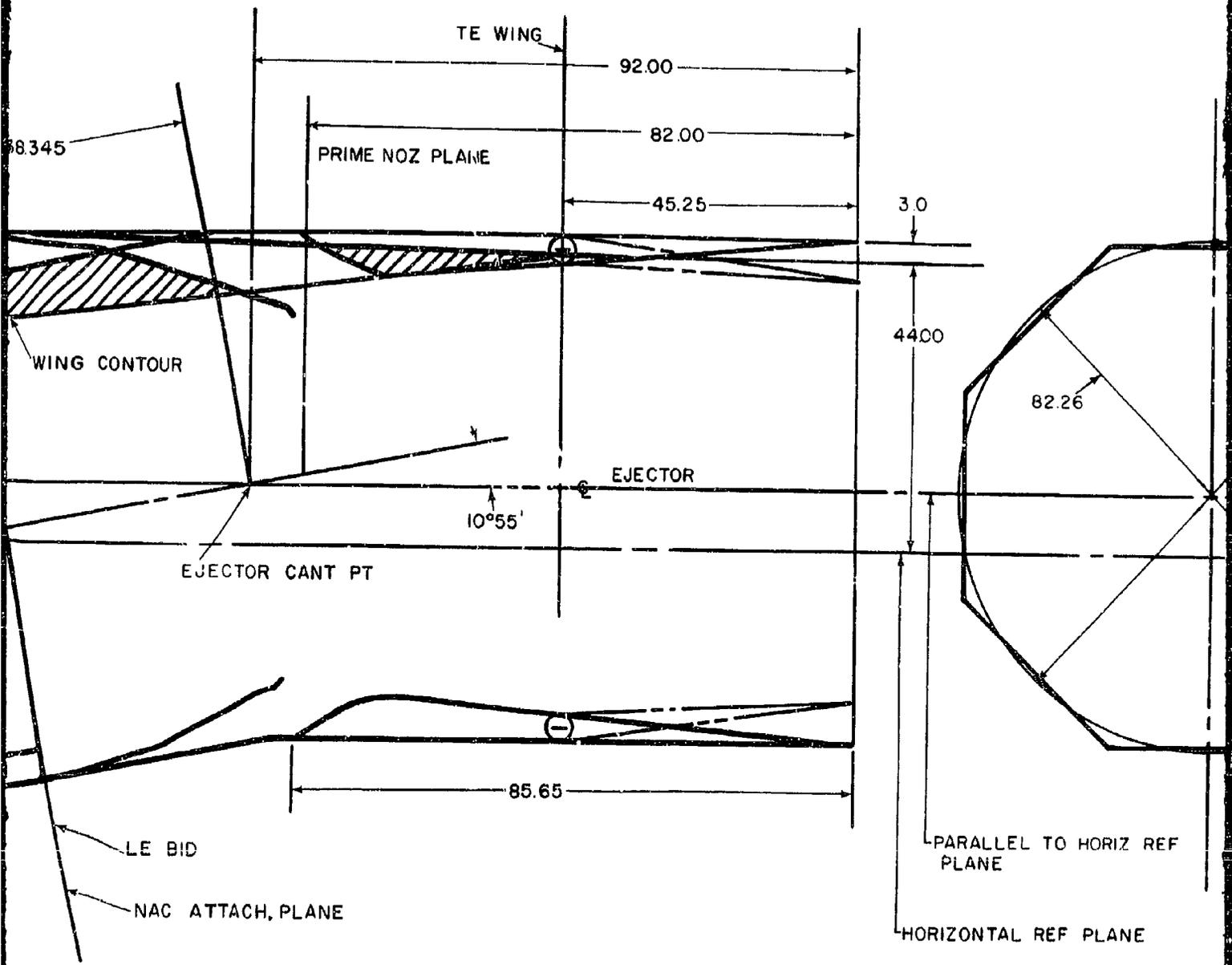
Figure 1-12

REPRODUCED AT THE NATIONAL ARCHIVES  
SERIALS ACQUISITION DIVISION  
11-15-80

4







EJECTOR CANTED 10  
NOZZLE PLANE  
CG LOCATION DOES N

STF219 600 LBS./SEC. TURF

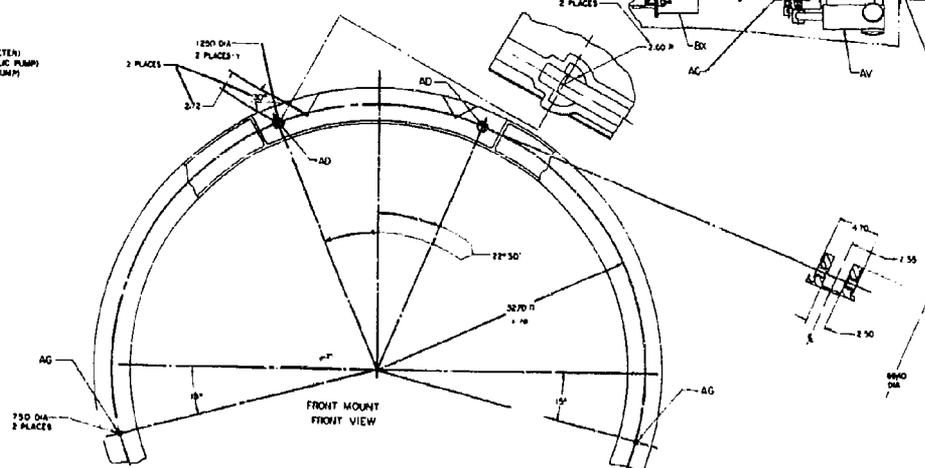
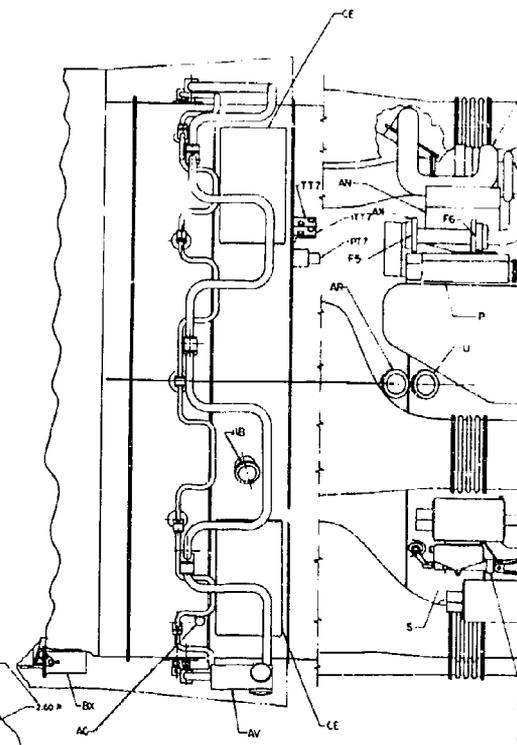
Figure 1-13



PRATT & WHITNEY AIRCRAFT

| ZONES   |      | ACCESSORY DRIVE PADS                             |
|---------|------|--|
| 11-1-1  | A    | POWER 120 AMP                                    |
| 11-1-2  | B    | TACHOMETER INTS PAD (DU) (4475 20000 RPM)        |
| 11-1-3  | C    | TACHOMETER INTS PAD (DU) (4475 20000 RPM)        |
| 11-1-4  | D    | HYDRAULIC PUMP (TWO) (AS 4658)                   |
| ZONES   |      | FUEL DRAIN                                       |
| 11-2-1  | FD1  | COMBUSTION CHAMBER FUEL DRAIN                    |
| 11-2-2  | FD2  | DUMP VALVE DRAIN (GAS GENERATOR)                 |
| 11-2-3  | FD4  | DUMP VALVE DRAIN (DUCT HEATER ZONE I)            |
| 11-2-4  | FD4A | DUMP VALVE DRAIN (DUCT HEATER ZONE II)           |
| ZONES   |      | FUEL PRESSURE                                    |
| 11-3-1  | FP1  | FUEL PUMP INLET PRESSURE                         |
| 11-3-2  | FP3  | CHECK VALVE FUEL PRESSURE                        |
| ZONES   |      | FUEL FLOW  |
| 11-4-1  | F1   | FUEL PUMP & DUCT HEATER PUMP SUPPLY INLET        |
| 11-4-2  | F2   | MAIN FUEL FLOWMETER SUPPLY INLET                 |
| 11-4-3  | F3   | MAIN FUEL FLOWMETER SUPPLY OUTLET                |
| 11-4-4  | F5   | DUCT HEATER FLOWMETER SUPPLY INLET               |
| 11-4-5  | F6   | DUCT HEATER FLOWMETER SUPPLY OUTLET              |
| ZONES   |      | FUEL VENT  |
| 11-5-1  | FV2  | FUEL PUMP OUTLET VENT                            |
| ZONES   |      | OIL BREATHER                                     |
| 11-6-1  | LO2  | MAIN OIL OVERBOARD BREATHER                      |
| ZONES   |      | OIL DRAIN  |
| 11-7-1  | LD1  | OIL TANK DRAIN                                   |
| 11-7-2  | LD3  | OIL TANK OVERBOARD DRAIN                         |
| 11-7-3  | LD3  | OIL DUMP OVERBOARD DRAIN                         |
| 11-7-4  | LD3  | GEARBOX MAIN OIL DRAIN                           |
| 11-7-5  | LD7  | OIL STRAINER DRAIN                               |
| ZONES   |      | OIL FLOW   |
| 11-8-1  | L1   | OIL TANK REMOTE FILLER                           |
| 11-8-2  | L2   | OIL TANK MANUAL FILL                             |
| ZONES   |      | OIL PRESSURE                                     |
| 11-9-1  | LP1  | PRESSURE FOR TRANSDUCER                          |
| 11-9-2  | LP4  | OIL FILTER INLET PRESSURE                        |
| 11-9-3  | LP6  | OIL FILTER OUTLET PRESSURE                       |
| ZONES   |      | OIL TEMPERATURE                                  |
| 11-10-1 | LT1  | MAIN OIL TEMPERATURE                             |
| ZONES   |      | OIL VENT   |
| 11-11-1 | LV3  | OIL PRESSURE TRANSMITTER VENT                    |
| ZONES   |      | SEAL DRAIN                                       |
| 11-12-1 | SD1  | FUEL CONTROL SEAL DRAIN                          |
| 11-12-2 | SD2  | FUEL PUMP SEAL DRAIN                             |
| 11-12-3 | SD3  | ACCESSORY DRIVE OVERBOARD DRAIN (TACHOMETER)     |
| 11-12-4 | SD4  | ACCESSORY DRIVE OVERBOARD DRAIN (HYDRAULIC PUMP) |
| 11-12-5 | SD5  | ACCESSORY DRIVE OVERBOARD DRAIN (FUEL PUMP)      |
| 11-12-6 | SD9  | HYDRAULIC PUMP SEAL DRAIN                        |
| 11-12-7 | SUM  | DUCT HEATER FUEL PUMP SEAL DRAIN                 |
| ZONES   |      | TEMPERATURE SENSING                              |
| 11-13-1 | TT7  | TURBINE EXIT TEMPERATURE (AVERAGE)               |
| 11-13-2 | TT7  | TURBINE EXIT TEMPERATURE (INDIVIDUAL)            |
| ZONES   |      | PRESSURE SENSING                                 |
| 11-14-1 | PT7  | TURBINE EXIT PRESSURE                            |

| ZONES    |    | MISCELLANEOUS   |
|----------|----|---|
| 11-15-1  | F  | OIL TANK  |
| 11-15-2  | F  | GAS GENERATOR FOR FUEL PUMP   |
| 11-15-3  | G  | FUEL PUMP/FUEL FILTER (GAS GENERATOR)                               |
| 11-15-4  | H  | FUEL PUMP/FILTER (BYPASS RANGE FOR REMOVAL)                         |
| 11-15-5  | J  | DUCT HEATER FUEL PUMP   |
| 11-15-6  | K  | HYDRAULIC PUMP  |
| 11-15-7  | L  | OIL PUMP  |
| 11-15-8  | M  | OIL FILTER  |
| 11-15-9  | N  | FUEL OIL COOLER (GAS GENERATOR)                                     |
| 11-15-10 | P  | FUEL OIL COOLER (DUCT HEATER)                                       |
| 11-15-11 | Q  | GEARBOX   |
| 11-15-12 | S  | AUTOMATIC RESTART SWITCH  |
| 11-15-13 | T  | BREATHING PRESSURE VALVE  |
| 11-15-14 | U  | HIGH PRESSURE BLEED PAD   |
| 11-15-15 | V  | UNITIZED CONTROL FUEL ALUMINUM TANK & HOUSING                       |
| 11-16-1  | AG | EXHAUST (GAS GENERATOR)   |
| 11-16-2  | AB | WATER PLUG (GAS GENERATOR) LEAK SPACE FOR REMOVAL                   |
| 11-16-3  | AC | WATER PLUG (DUCT HEATER) LEAK SPACE FOR REMOVAL                     |
| 11-16-4  | AD | ENGINE FRONT MOUNTING PROVISIONS                                    |
| 11-16-5  | AE | ENGINE REAR MOUNT PROVISIONS  |
| 11-16-6  | AF | FUEL RETURN TO SUPPLEMENTARY COOLING                                |
| 11-16-7  | AH | GROUND HANDLING HOLES (FRONT MOUNT)                                 |
| 11-16-8  | AJ | POWER CONTROL LEVER (20° ANGLE OF TRAVEL)                           |
| 11-16-9  | AK | SOFT OFF LEVER (90° ANGLE OF TRAVEL)                                |
| 11-16-10 | AL | APPROACH VELOCITY CONTROL LEVER (90° ANGLE OF TRAVEL)               |
| 11-16-11 | AM | WASH HOSE OR SMOKE POSITION RESET LEVER (90° ANGLE OF TRAVEL)       |
| 11-16-12 | AN | AIR TURBINE VALVE (DUCT HEATER FUEL PUMP)                           |
| 11-16-13 | AP | IGNITION EXHAUST ELECTRICAL COHN (GAS GENERATOR)                    |
| 11-16-14 | AS | THERMAL SHUT (LOW FLOW)   |
| 11-16-15 | AT | AEROYNAMIC BRAKE CONTROL AIR SUPPLY COHN                            |
| 11-16-16 | AV | DUCT NOZZLE POSITION FEEDBACK                                       |
| 11-16-17 | AW | CHECK B DUMP VALVE (DUCT HEATER ZONE I)                             |
| 11-16-18 | AX | GAS GENERATOR FUEL FLOWMETER MOUNTING PROVISIONS                    |
| 11-16-19 | AY | DUCT HEATER FUEL FLOWMETER MOUNTING PROVISIONS                      |
| 11-16-20 | AZ | FUEL CONTROL FUEL FILTER BAY SPACE FOR REMOVAL                      |
| 11-16-21 | BA | CHECK B DUMP VALVE (LOW FLOW VALVE (GAS GENERATOR FUEL))            |
| 11-16-22 | BB | CHECK B DUMP VALVE FILTER   |
| 11-16-23 | BC | NOZZLE POSITION INDICATOR MOUNTING PROVISIONS                       |
| 11-16-24 | BD | REVERSE POSITION INDICATOR ELECTRICAL COHN                          |
| 11-16-25 | BE | HYDRAULIC RETURN PLATE  |
| 11-16-26 | BF | VIBRATION MOUNT (SPACE RESERVED FOR GROUP PROVIDED BY AIRFRAME MFG) |
| 11-17-1  | EP | SECONDARY AIR BYPASS DUCTS  |
| 11-17-2  | ER | FUEL FILTER PRESSURE ELECTRICAL CONNECTION                          |
| 11-17-3  | ES | FUEL VALVE TEMPERATURE SENSOR                                       |
| 11-17-4  | ET | OIL SCVENOR PUMP-BREARME COMPARTMENT                                |
| 11-17-5  | EV | HYDRAULIC DISCHARGE FILTER  |
| 11-17-6  | EX | DUCT NOZZLE ACTUATORS (8 REQD)                                      |
| 11-17-7  | CA | AEROYNAMIC BRAKE ACTUATORS  |
| 11-17-8  | CC | THRUST REVERSING ACTUATION (2 REQD)                                 |
| 11-17-9  | CD | GAS GENERATOR ACCESS DOORS  |
| 11-17-10 | CE | EXHAUST (DUCT HEATER)   |
| 11-17-11 | CF | IGNITION EXHAUST ELECTRICAL COHN (GAS GENERATOR)                    |



5.00 D.4

15 D.4  
8 HOLES  
EQUALLY SPACED

1.75 D.4  
6.000 D.4

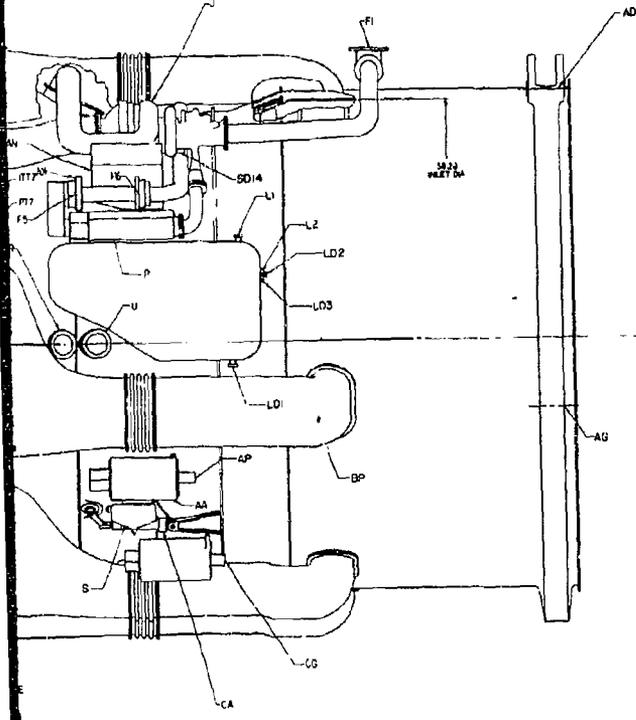
**LIMIT LOADS FOR PILEY PLANGE**

M = MOMENT IN PLANE CONTAINING ENGINE AXIS  
 H = LOAD PERPENDICULAR TO ENGINE AXIS  
 P = AXIAL LOAD

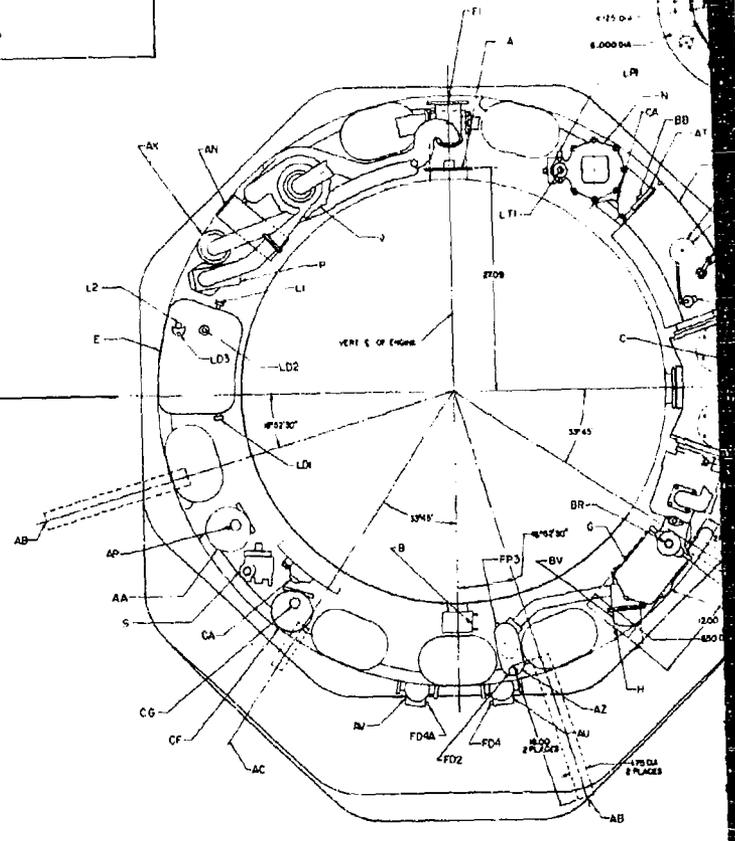


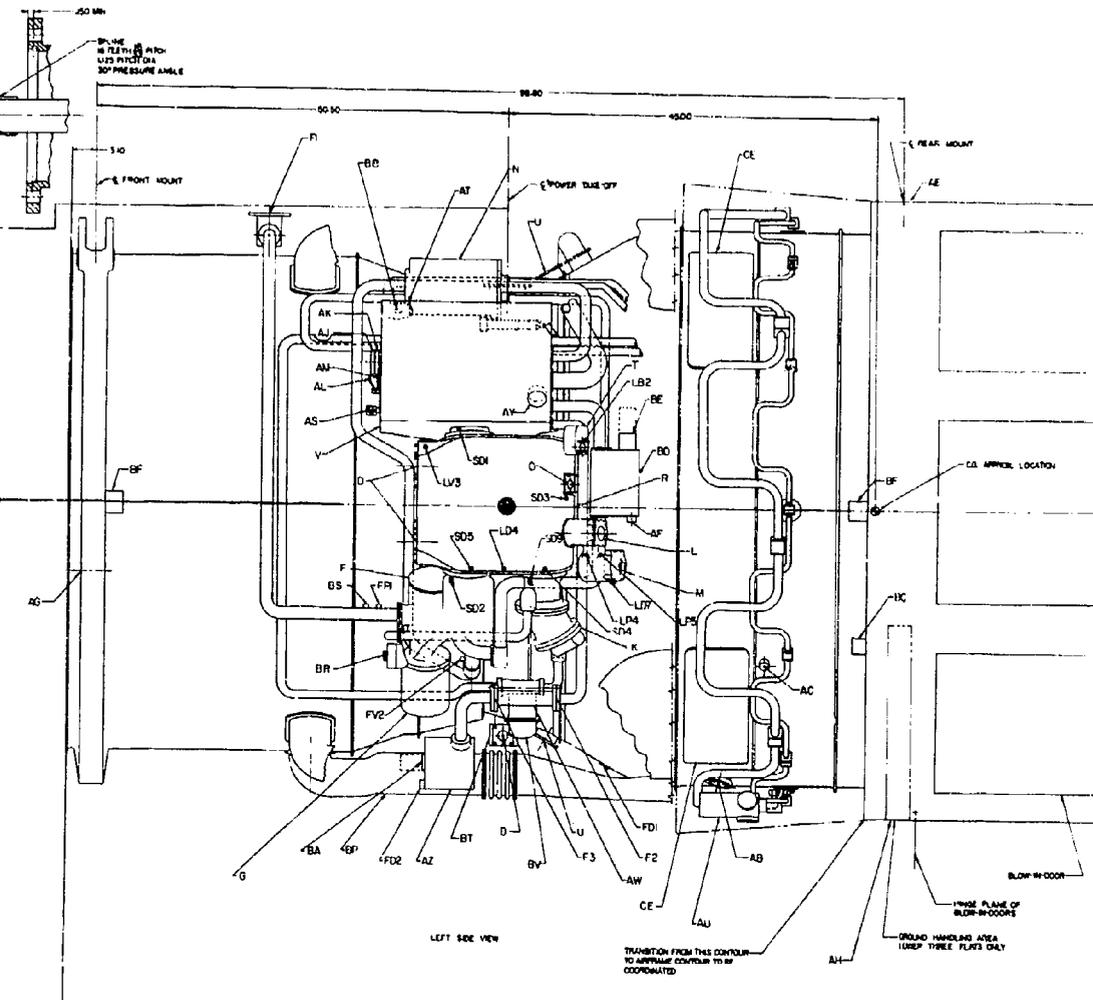
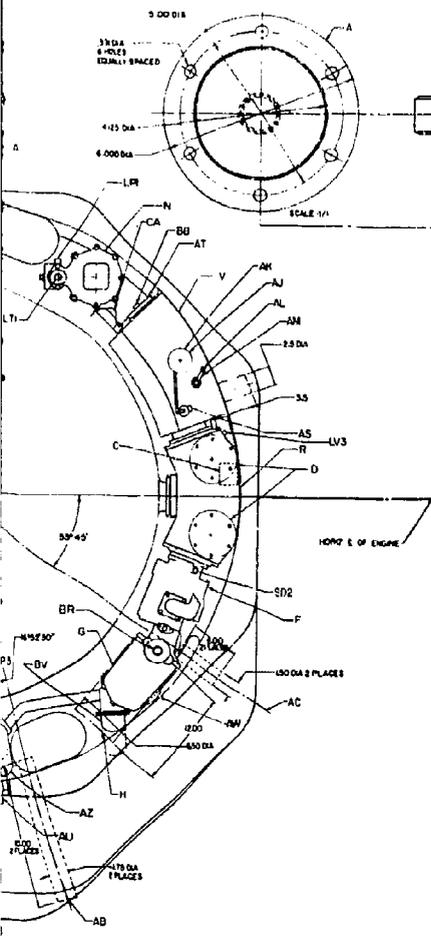
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 H =  
 P =

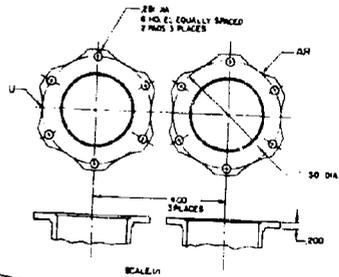
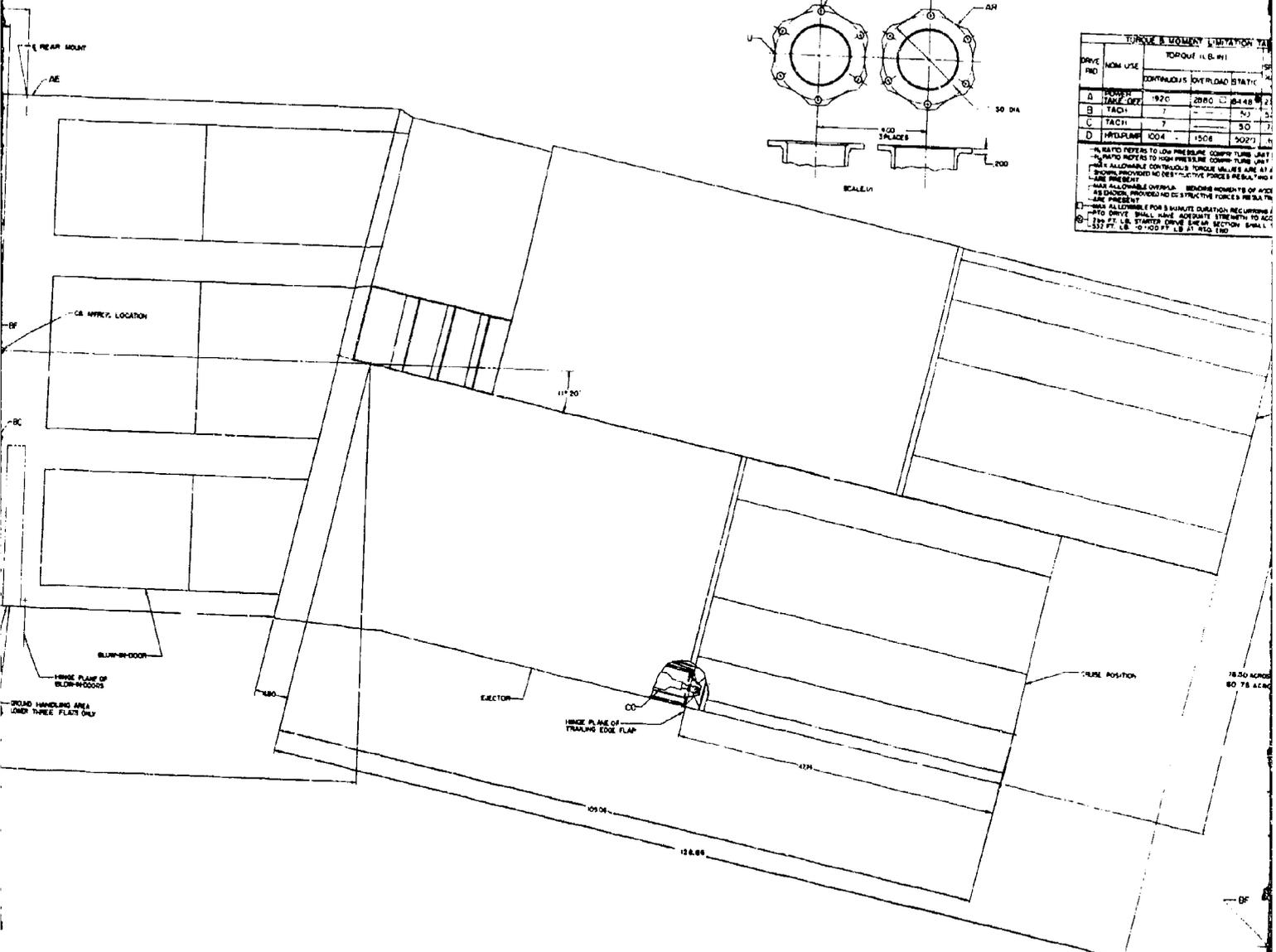
MIN NO BOLTS



RIGHT SIDE VIEW



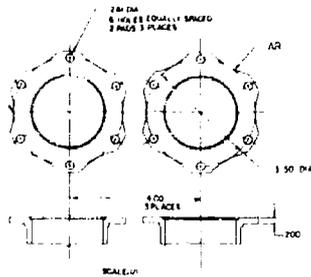




| TORQUE & MOMENT LIMITATION |                | TOP OUT (L.B.W.) |                 |
|----------------------------|----------------|------------------|-----------------|
| DRIVE NO.                  | HOW USE        | CONTINUOUS       | OVERLOAD STATIC |
| A                          | POWER TAKE OFF | 1920             | 2880 LBS        |
| B                          | TACH           | 7                | 50              |
| C                          | TACH           | 7                | 30              |
| D                          | HYDRAULIC      | 1004             | 1508            |

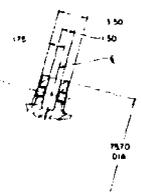
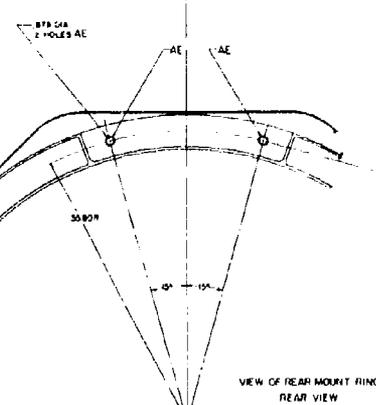
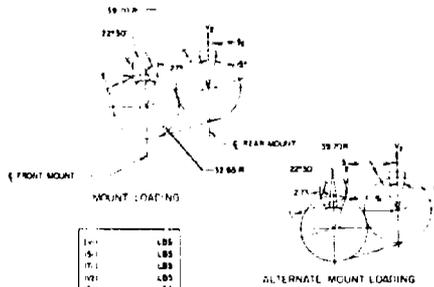
\*ALWAYS REFER TO LOW PRESSURE COMP. TUBE UNIT  
 \*RATIO APPLIES TO HIGH PRESSURE COMP. TUBE UNIT  
 \*ALLOWABLE CONTINUOUS TORQUE VALUES ARE AS SHOWN PROVIDED NO DESTRUCTIVE FORCES RESULT AND ARE PRESENT  
 \*ARE ALLOWABLE OVERLOADS - RESERVE MOMENTS OF INERTIA INDICATED PROVIDED NO DESTRUCTIVE FORCES RESULT AND ARE PRESENT  
 \*ARE ALLOWABLE FOR 3 MINUTE DURATION INCLUDING PHOTO DRIVE SHALL HAVE ADEQUATE STRENGTH TO ACC 100 LBS. STARTS DRIVE SECTION SHALL BE 337 FT. LB. @ 1000 FT. LB. AT 100 RPM

PROPOSED TURN



| DRIVE No. | NO. OF USE | TORQUE (L.B.FOOT) |          |        | SPEED (RPM) | REDUCTION RATIO | ROTATION (ENGINE AND) | OVERHUNG MOMENT (L.B.IN) |
|-----------|------------|-------------------|----------|--------|-------------|-----------------|-----------------------|--------------------------|
|           |            | CONTINUOUS        | OVERLOAD | STATIC |             |                 |                       |                          |
| A         | START      | 1970              | 2890     | 8440   | 2,524       | 1/2             | CCW                   |                          |
| B         | TACH       | 7                 |          | 50     | 50R         | 1/2             | CCW                   |                          |
| C         | TACH       | 7                 |          | 50     | 50R         | 1/2             | CCW                   |                          |
| D         | INTEGRAL   | 100R              | 151R     | 5420   | 500         | 1/2             | CW                    |                          |

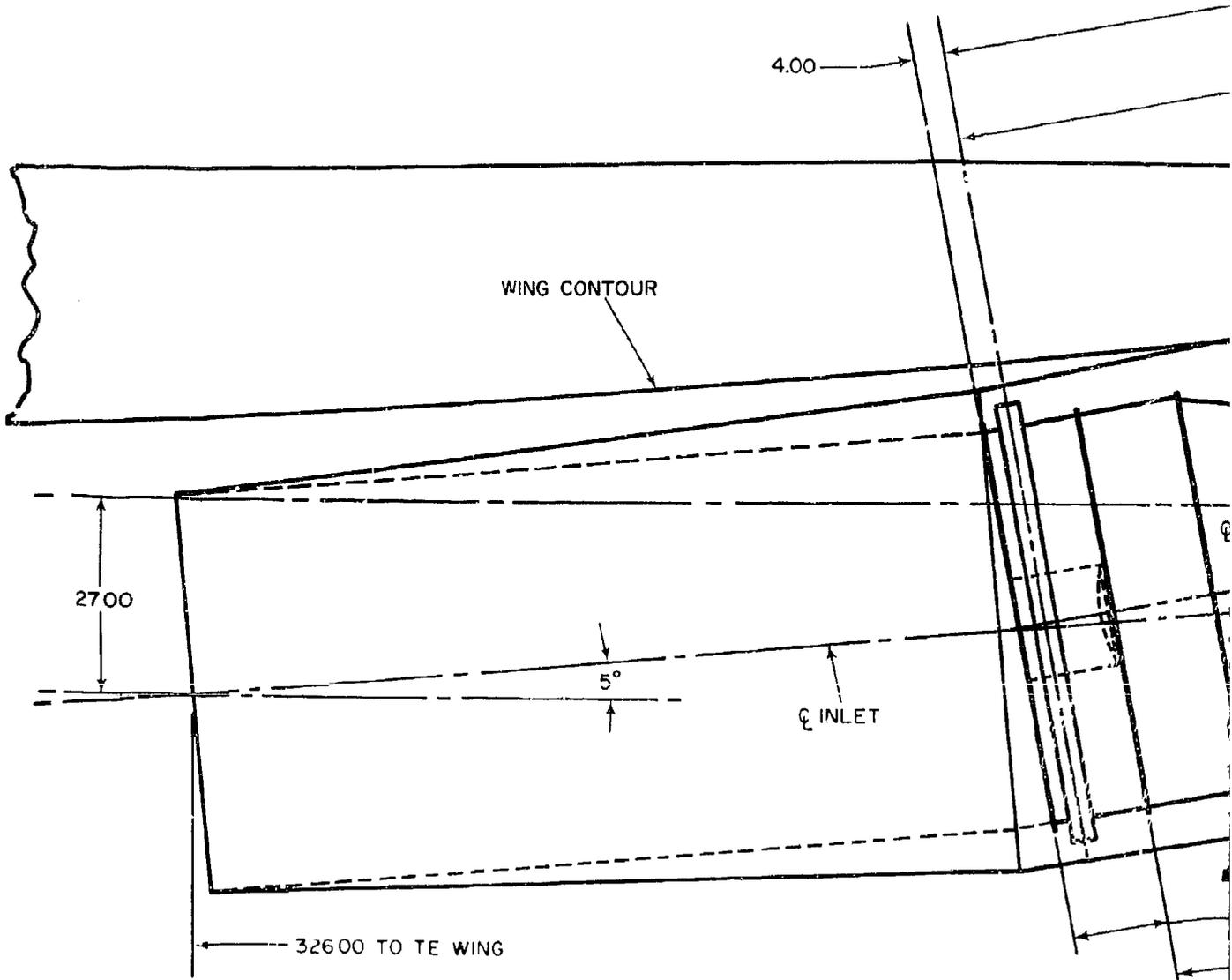
- MAX. TORQUE REFERS TO LOW PRESSURE COMPRESSOR UNIT SPEED  
 - MAX. TORQUE REFERS TO HIGH PRESSURE COMPRESSOR UNIT SPEED  
 - MAX. ALLOWABLE CONTINUOUS TORQUE VALUES ARE AT ANY ENGINE SPEED UNLESS OTHERWISE SPECIFIED  
 - MAX. ALLOWABLE OVERHUNG MOMENT VALUES OF ACCESSORIES ABOUT DRIVE PRO FZ OF ARE AS SHOWN PROVIDED NO DESTRUCTIVE FORCES RESULT FROM ACCESS VIBRATION ARE PRESENT  
 - MAX. ALLOWABLE OVERHUNG MOMENT VALUES OF ACCESSORIES ABOUT DRIVE PRO FZ OF ARE AS SHOWN PROVIDED NO DESTRUCTIVE FORCES RESULT FROM ACCESS VIBRATION ARE PRESENT  
 - MAX. ALLOWABLE FOR 8 MINUTE DURATION REQUIRE AT 4 HR INTERVALS MIN  
 - PRO DRIVE SHALL HAVE ADEQUATE STRENGTH TO ACCOMMODATE A MAX TORQUE EQUAL TO 1.5 TIMES THE STARTER ONLY REAR SECTION SHALL FAIL AT A STATIC TORQUE EQUAL TO 1.5 TIMES THE MAXIMUM TORQUE AT 1/2 RPM END

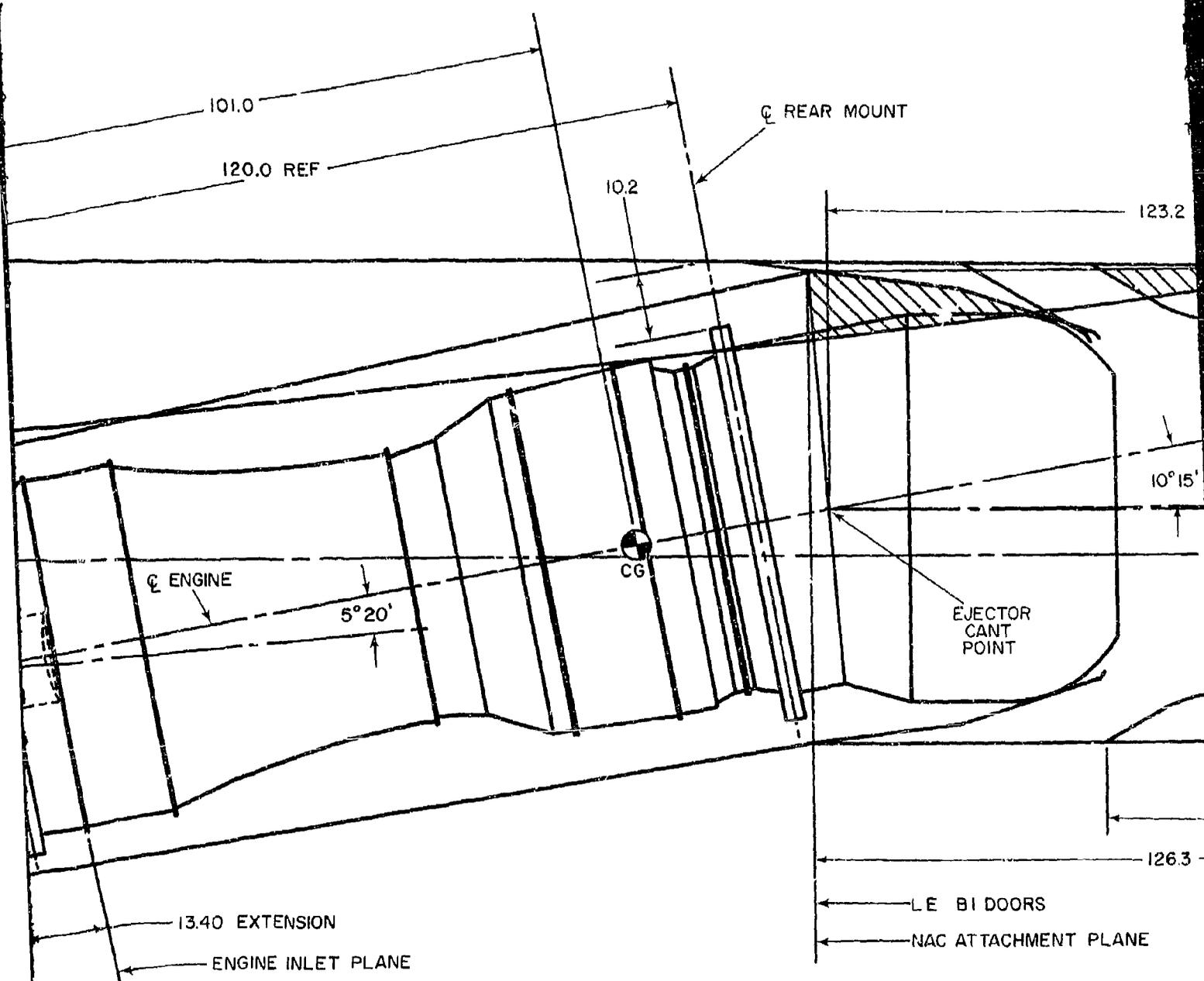


PROPOSED TURBOFAN ACCESSORY ARRANGEMENT

Figure 1-14

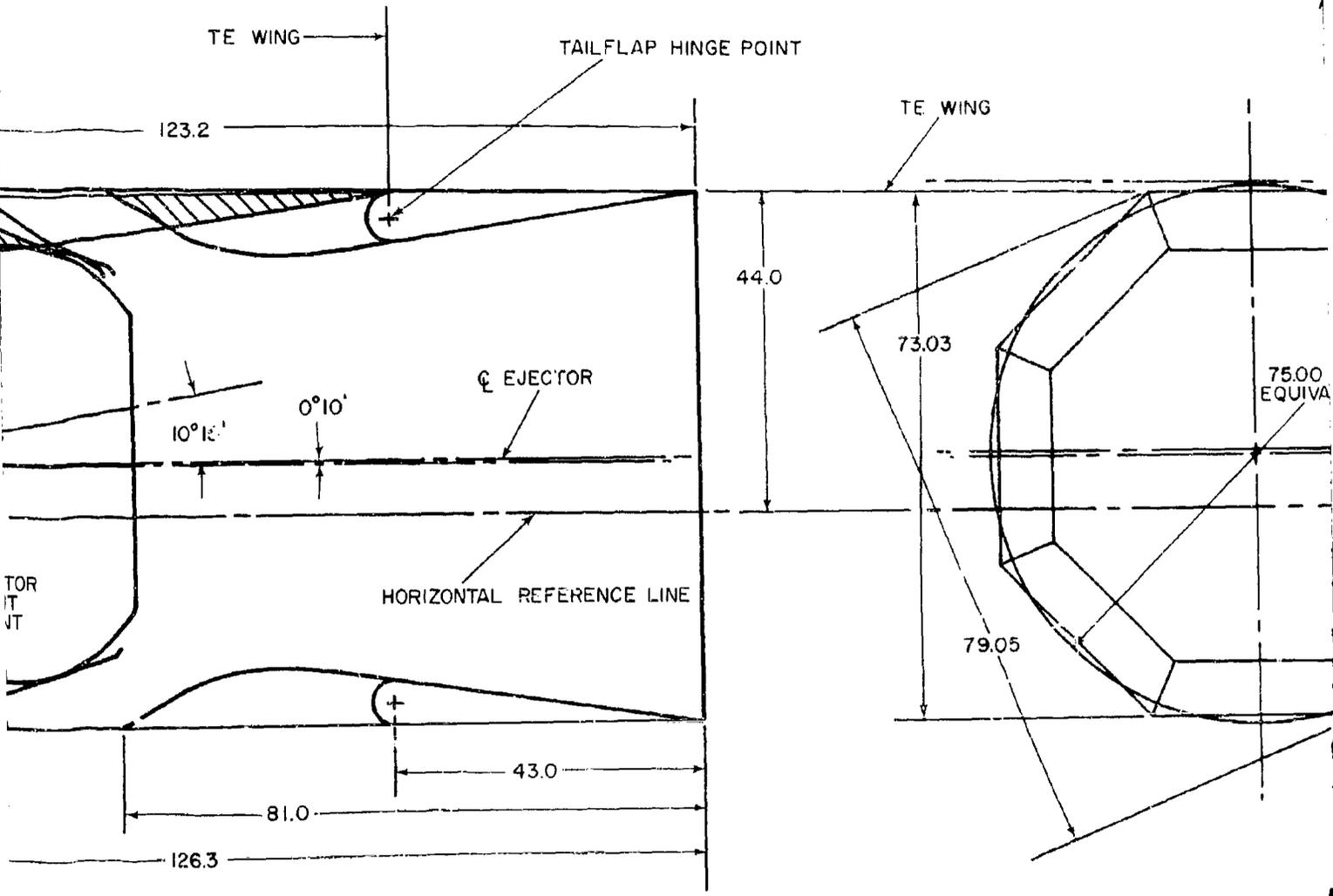
APPROVED BY: [Signature]  
 DATE: [Date]  
 TITLE: [Title]





2300°F MAX. TURBINE I  
 EJECTOR CANTED AT R  
 CG LOCATION DOES NOT

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DOORS  
MOUNT PLANE

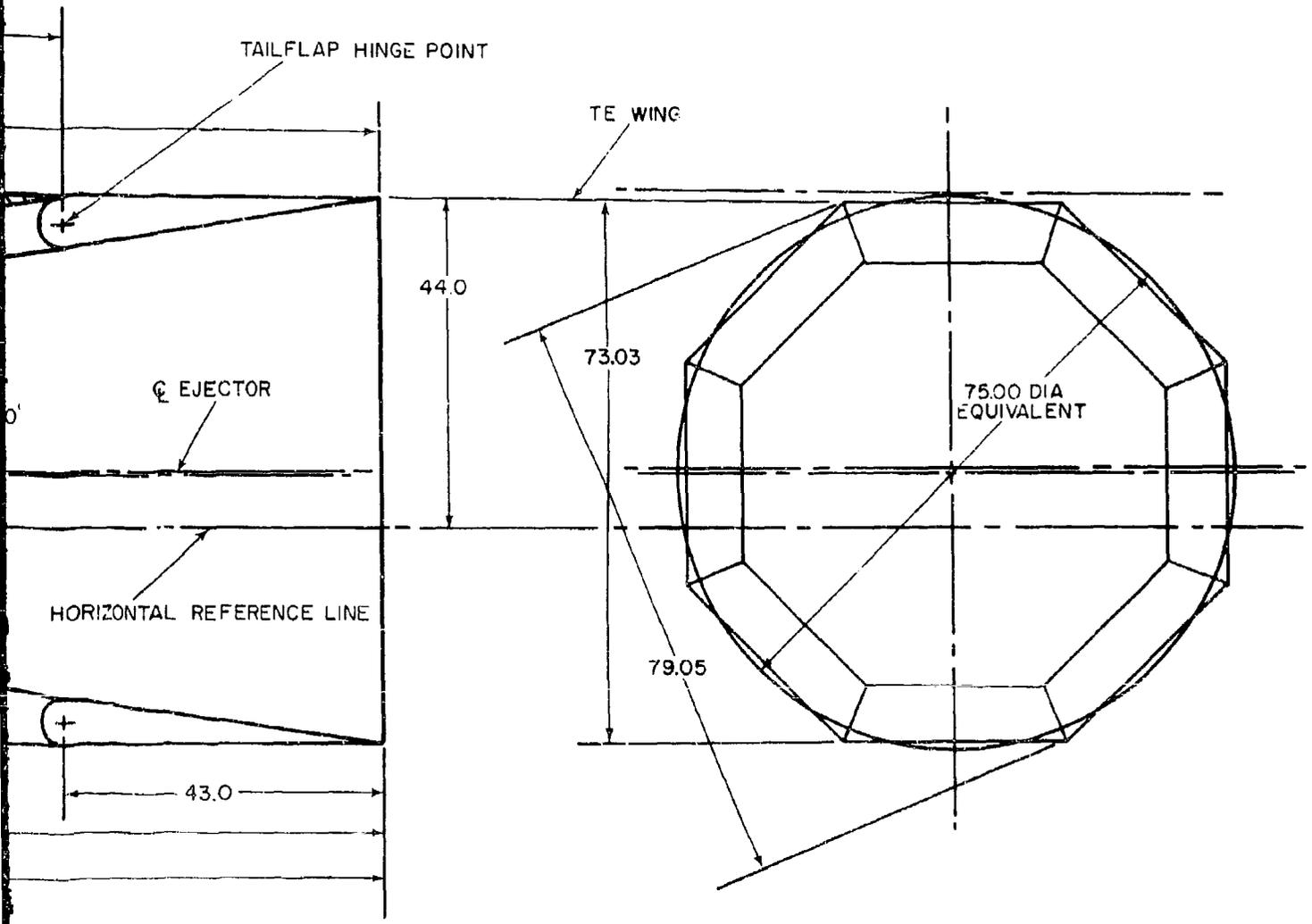
CG LOCATION DOES NOT INCLUDE THE INLET

MAX. TURBINE INLET TEMP.  
CANTED AT REAR MOUNT PLANE  
LOCATION DOES NOT INCLUDE THE INLET

STJ227 500 LBS./SEC. TURBOJET

Figure 1-15

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CG LOCATION DOES NOT INCLUDE THE INLET

TEMP. MOUNT PLANE  
SIDE THE INLET

STJ227 500 LBS./SEC. TURBOJET

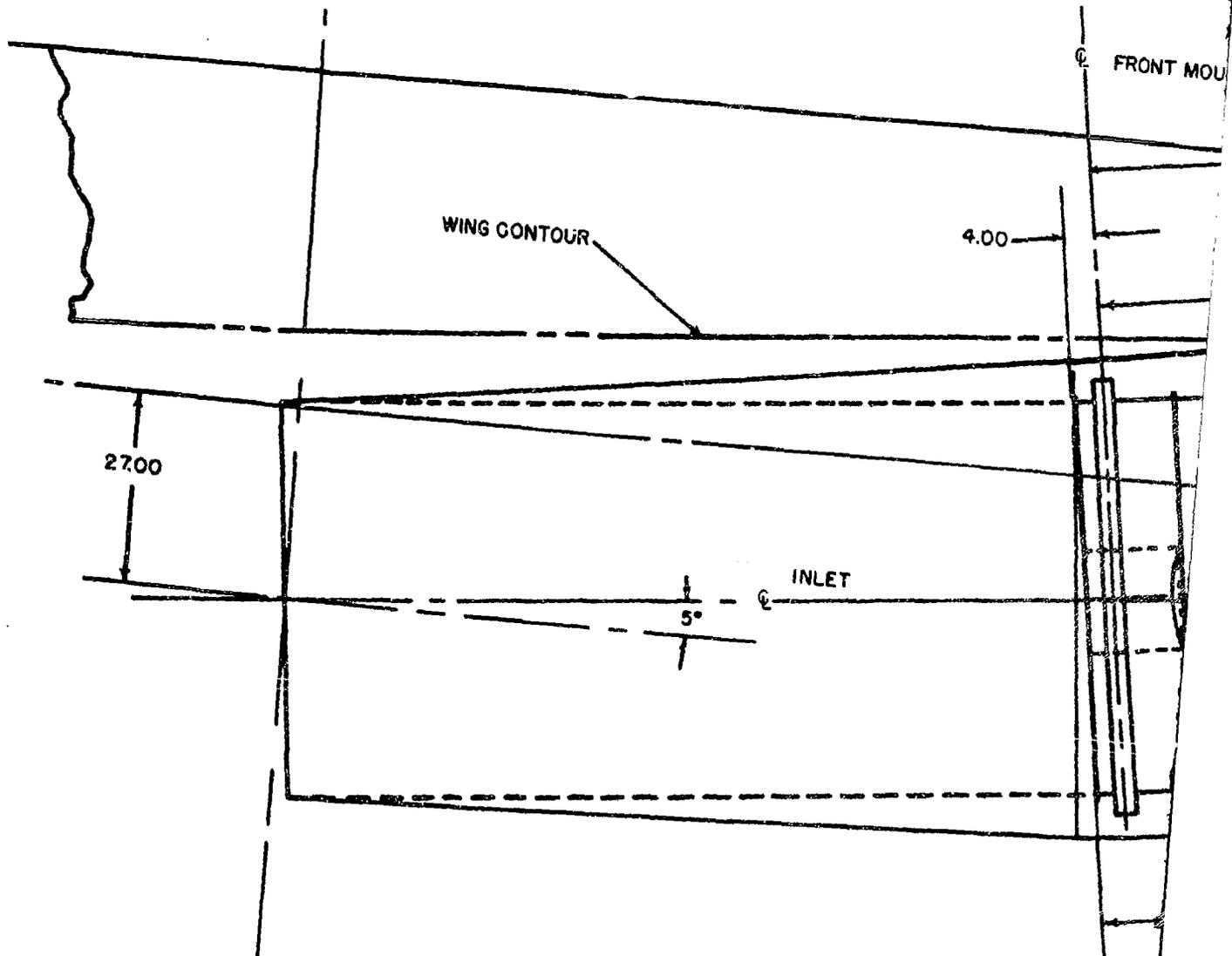
Figure 1-15

4

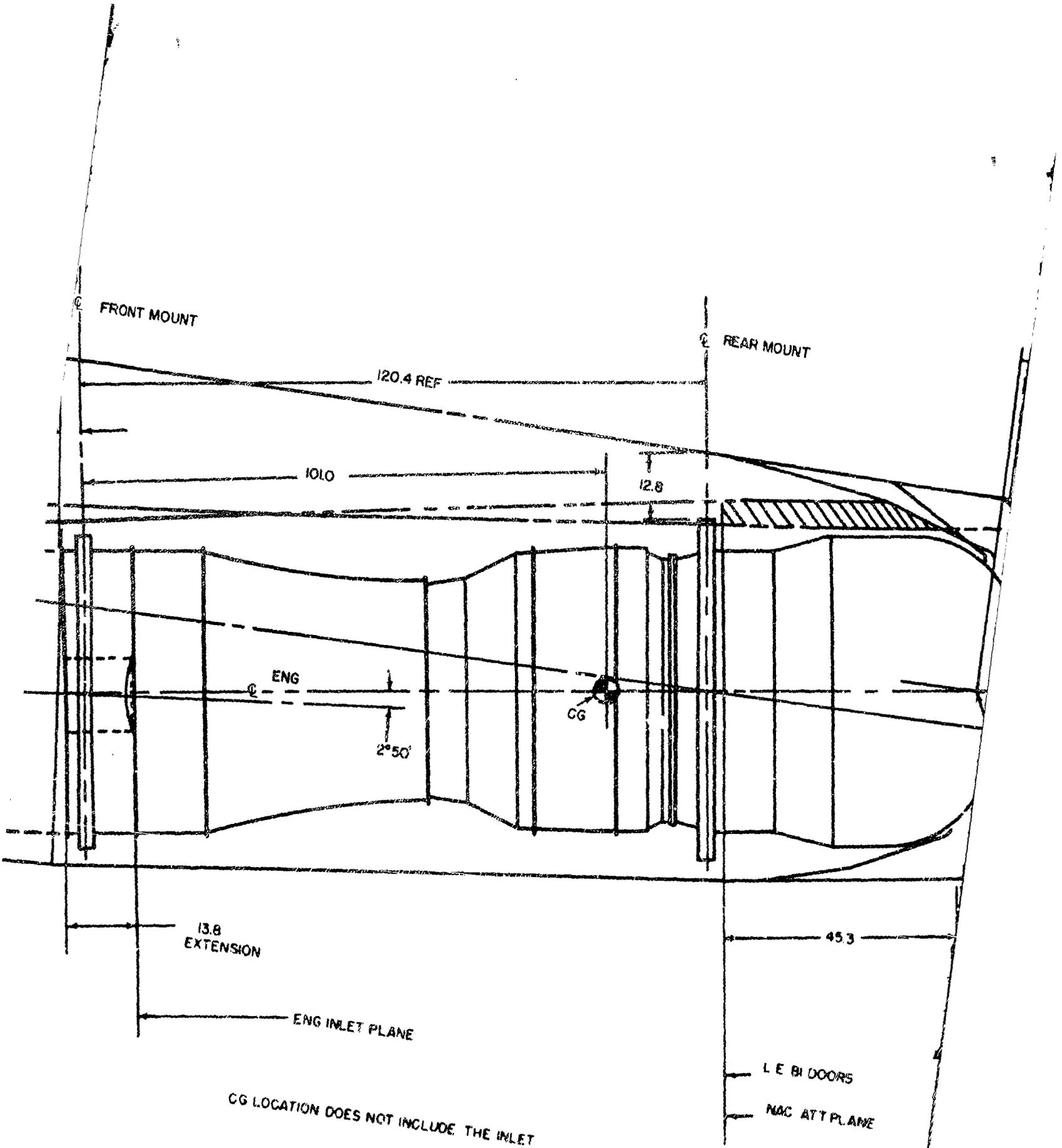
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 DATE 01/18/2010

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PRATT & WHITNEY AIRCRAFT

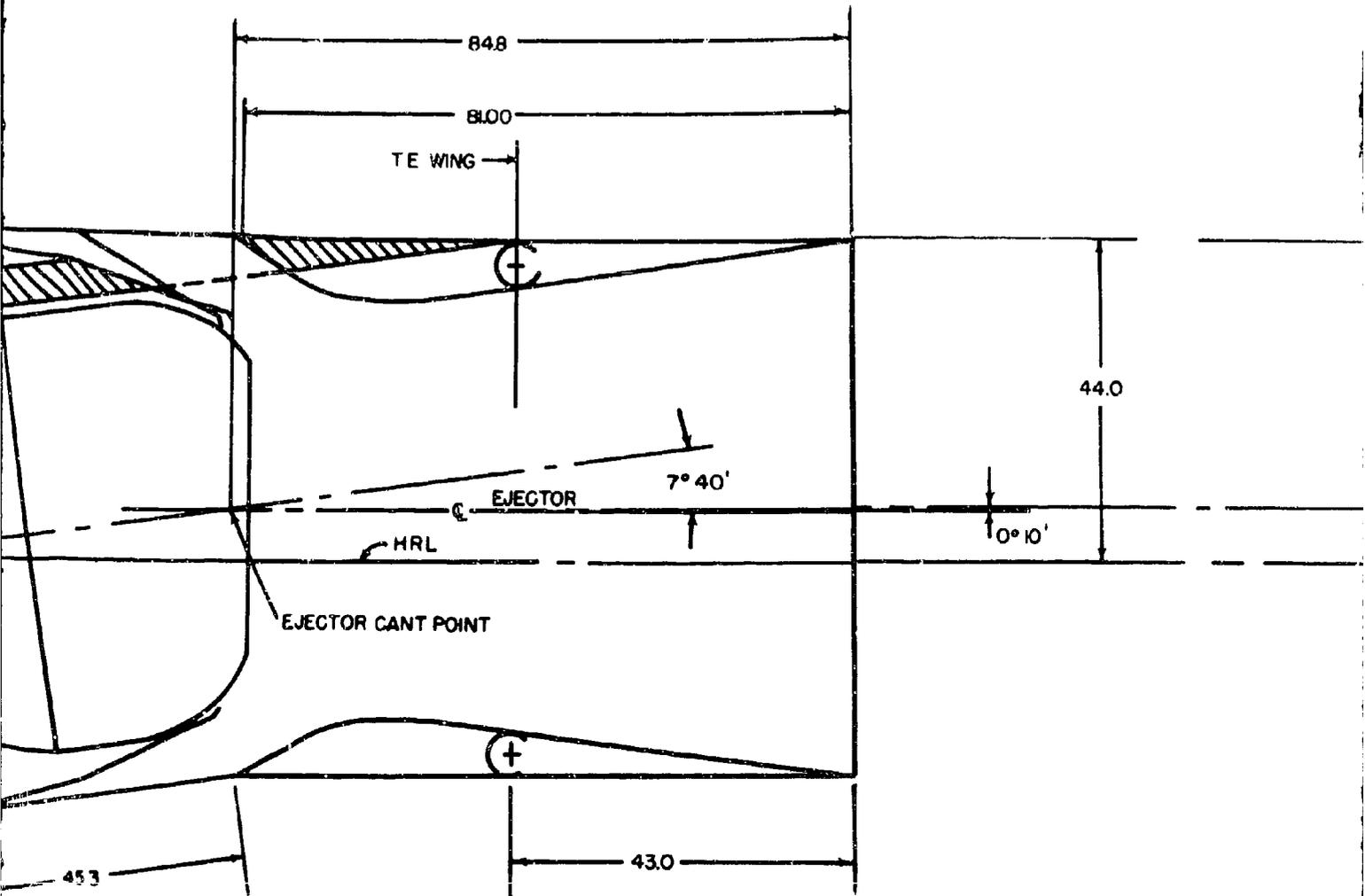


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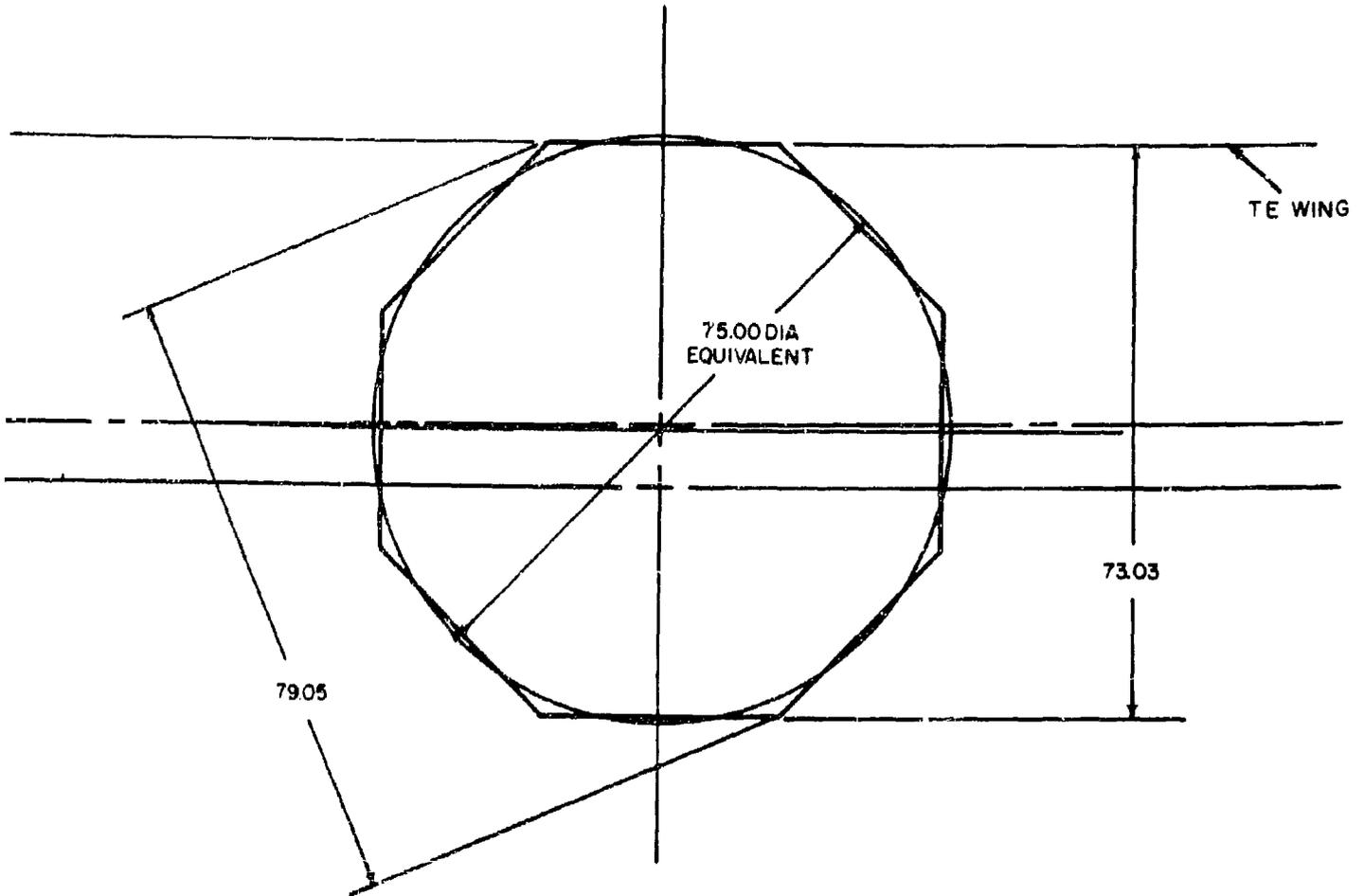


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E BI DOORS  
 NAC ATT PLANE



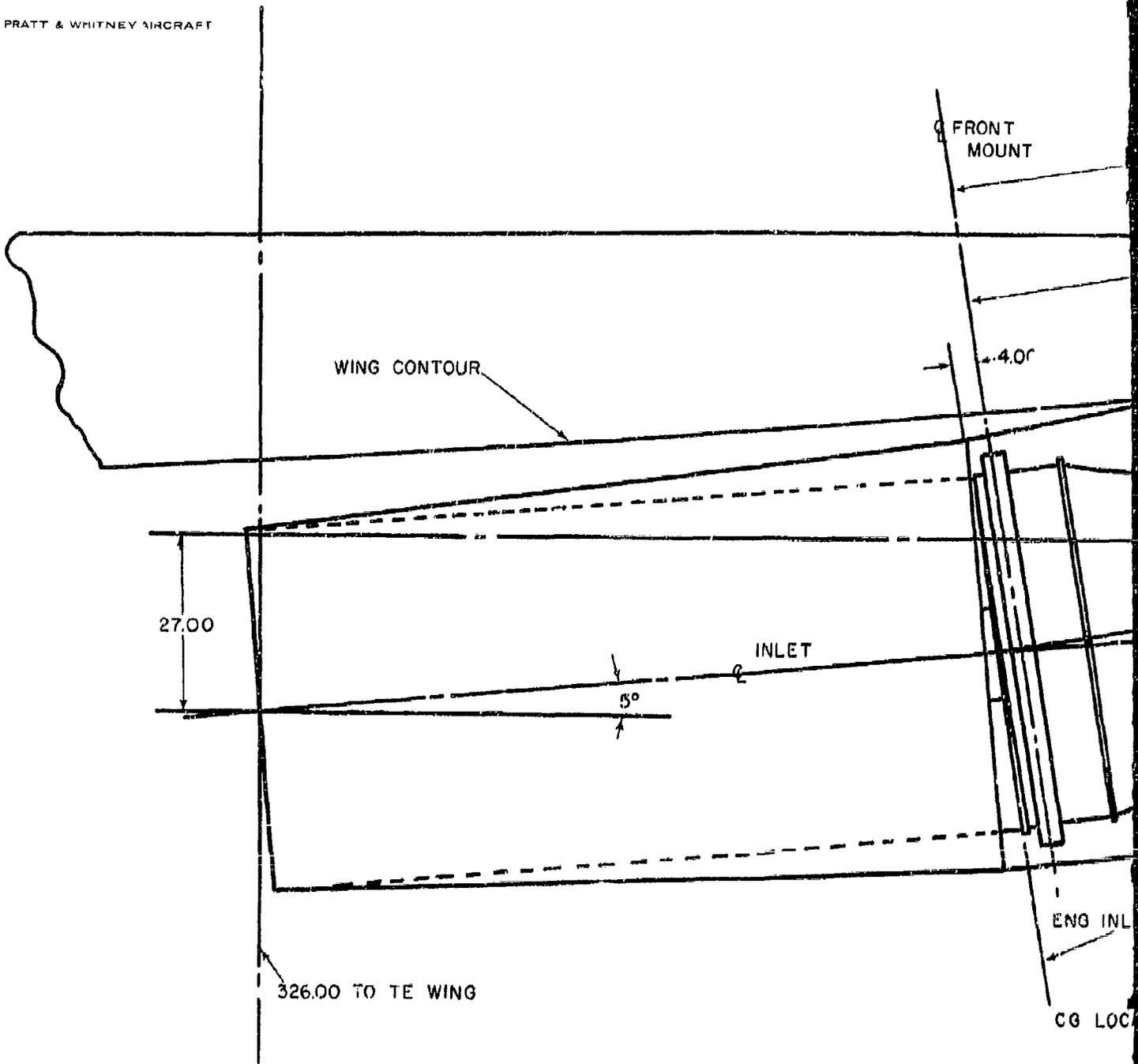
2300°F MAX. TURBINE INLET  
TEMPERATURE  
EJECTOR CANTED AT PRIMARY  
NOZZLE PLANE

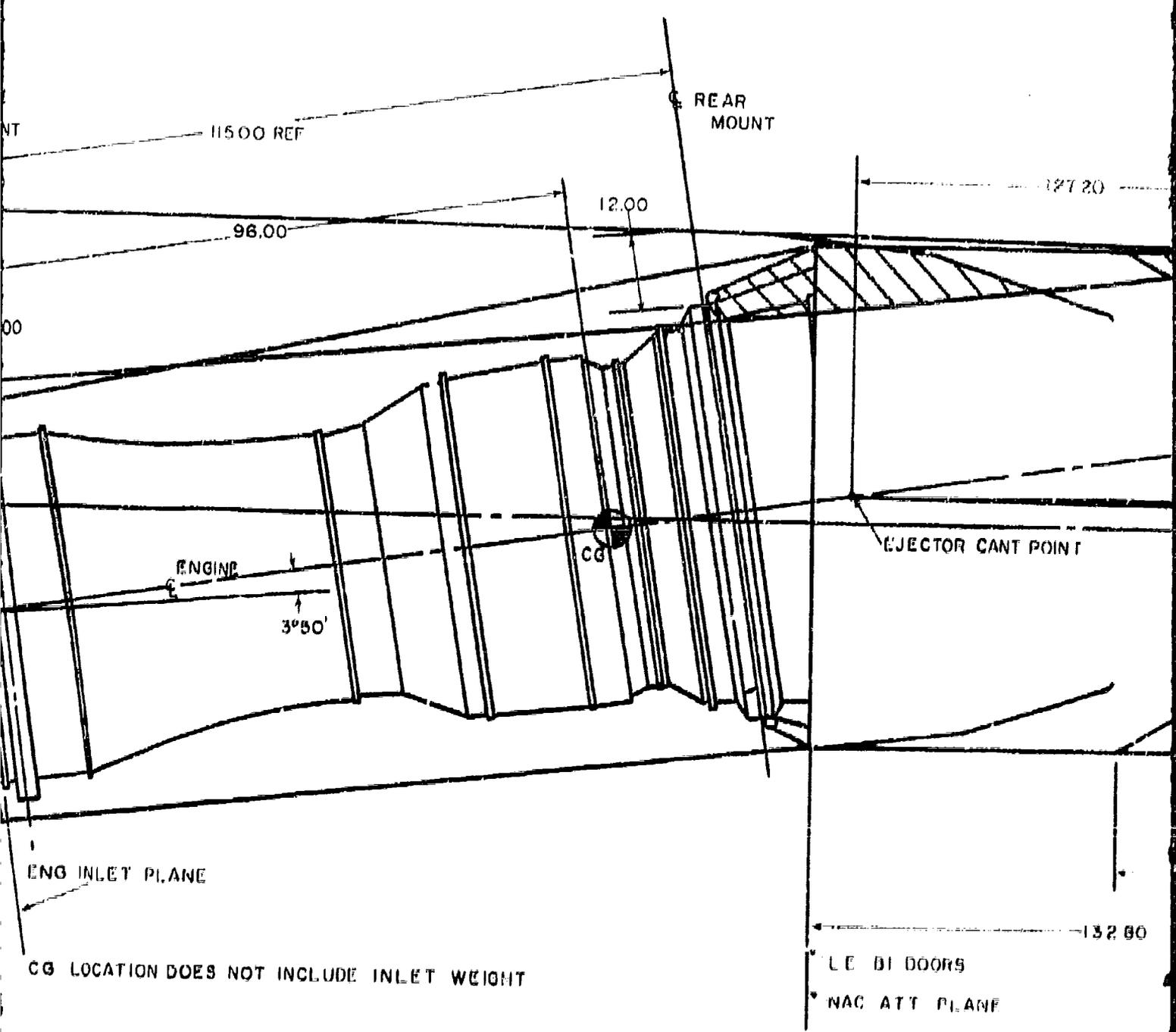
STJ227 500 LBS./SEC. TURBOJET

Figure 1-16

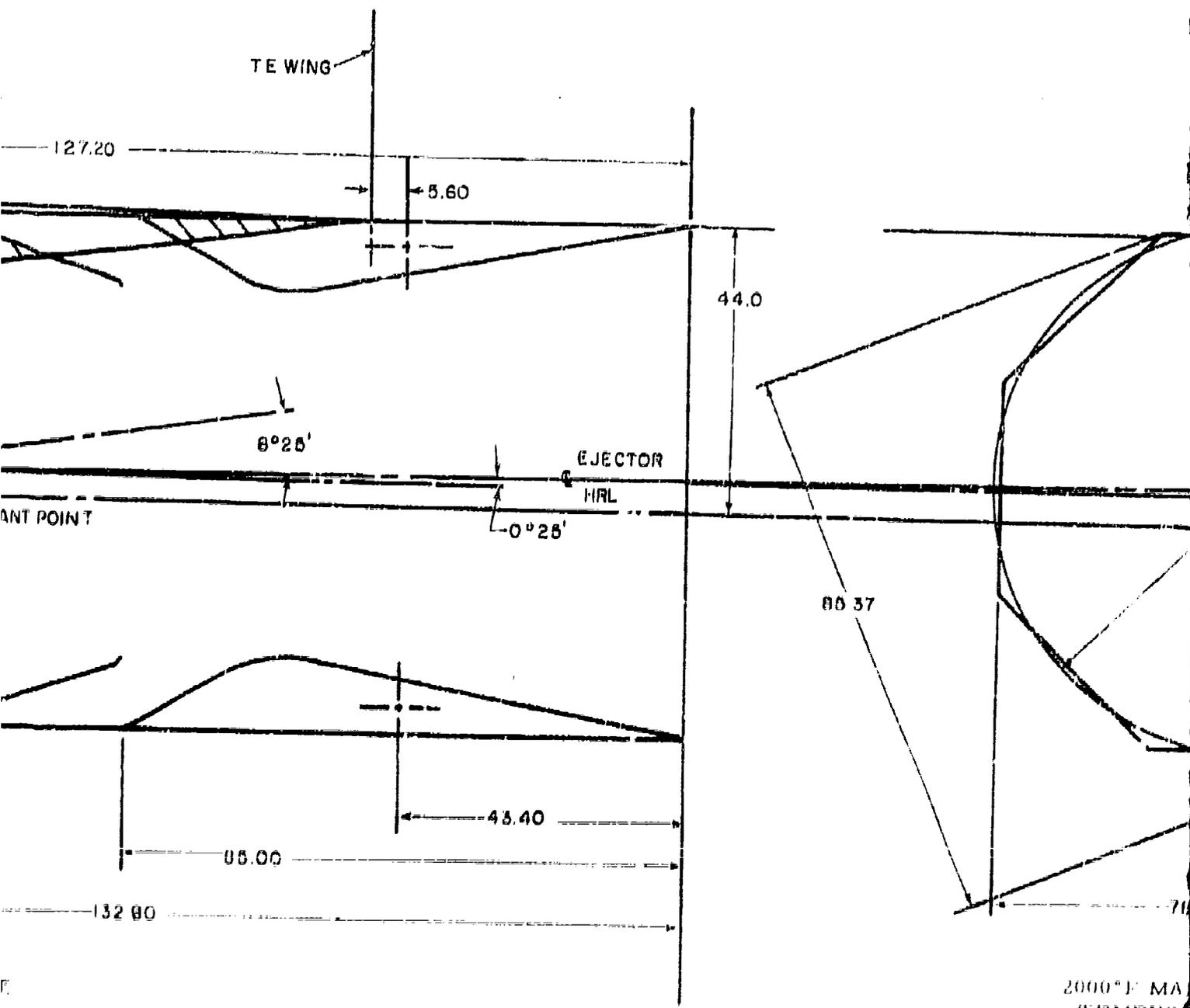
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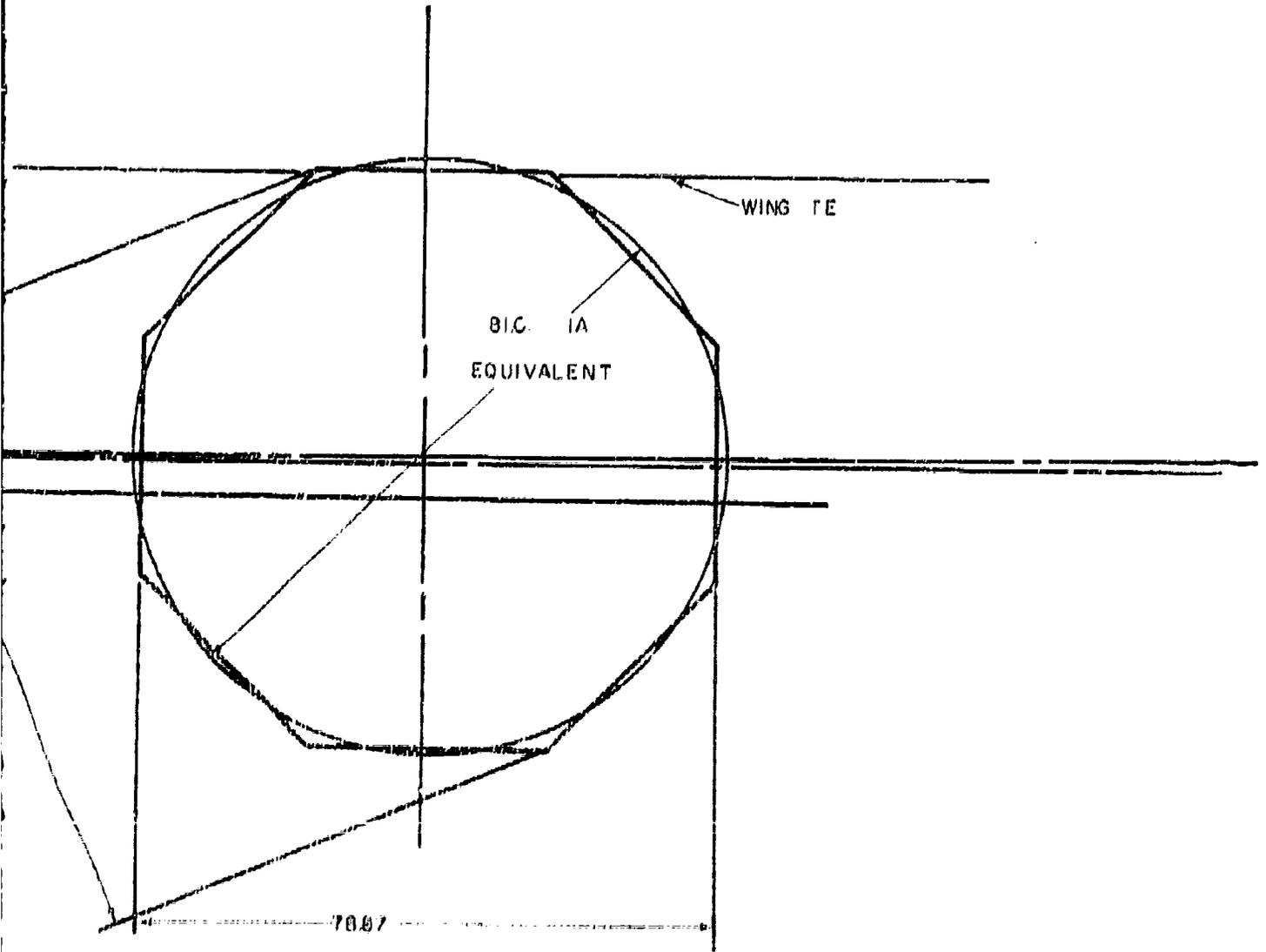




CG LOCATION DOES NOT INCLUDE INLET WEIGHT



2000°F MA  
 TEMPER  
 EJECTOR  
 MOUNT 19



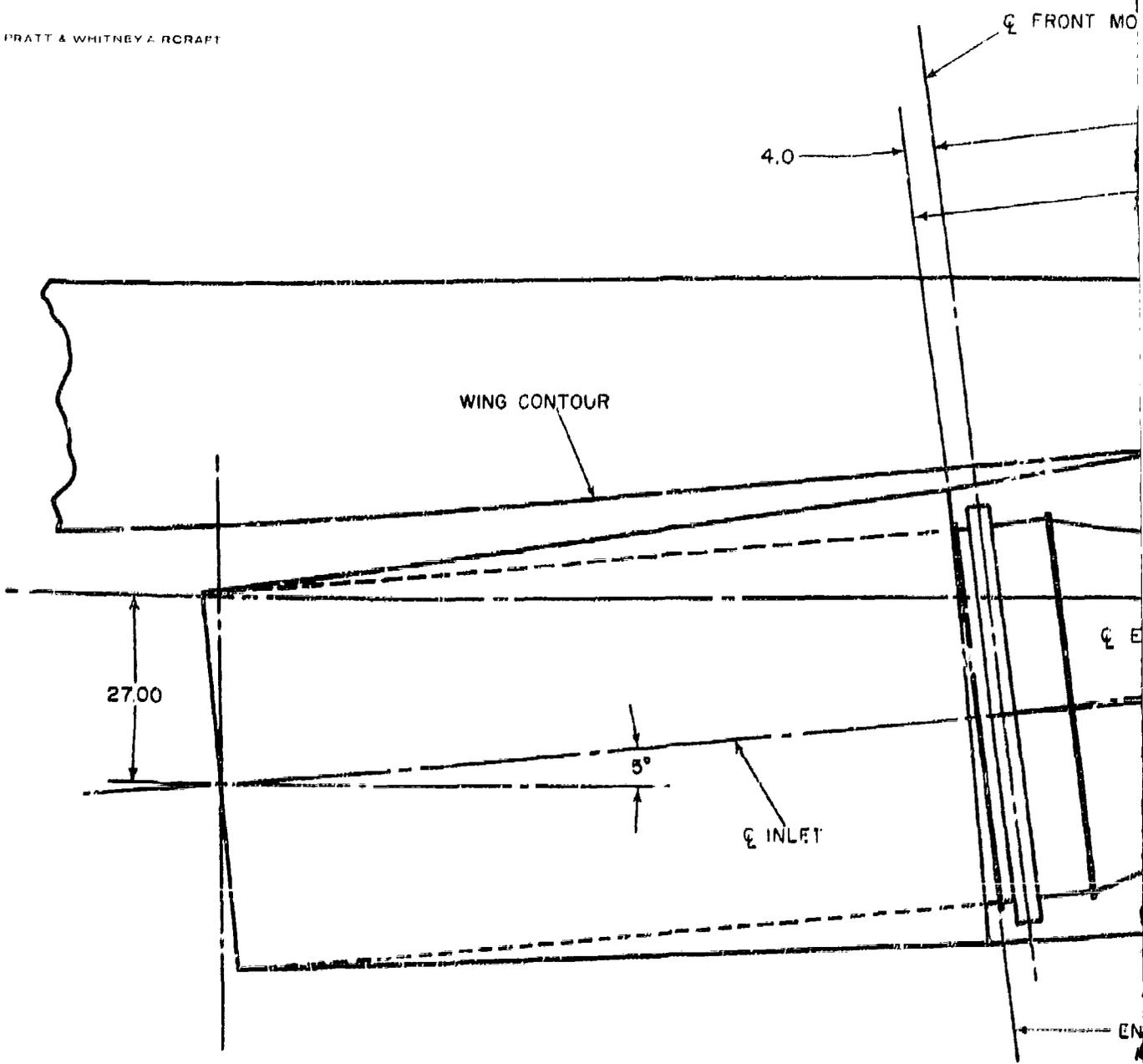
2000°F MAX. TURBINE INLET  
TEMPERATURE  
EJECTOR CENTERED AT REAR  
MOUNT PLANE

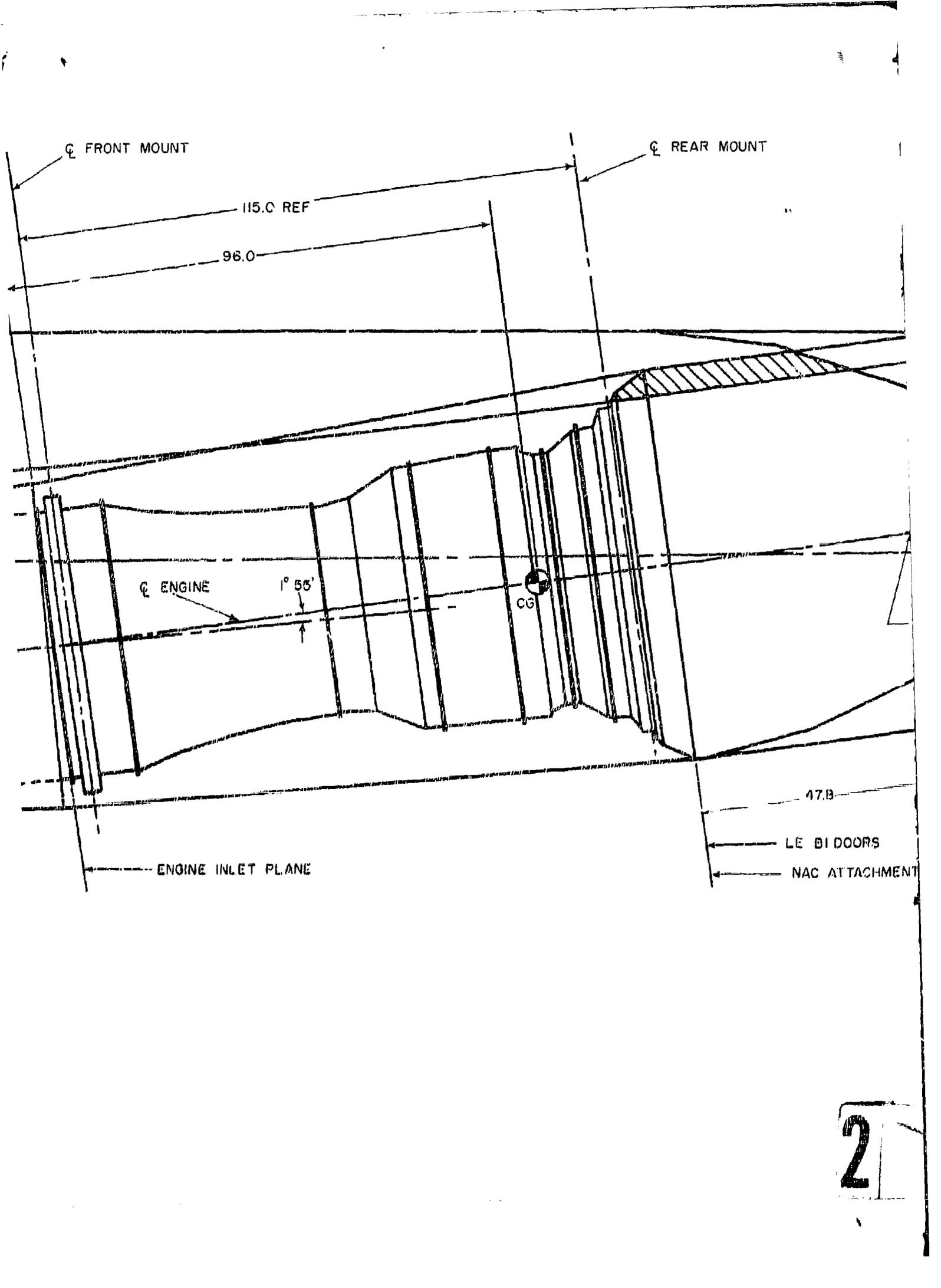
STJ227 500 LBS./SEC. TURBOJET

Figure 1-17

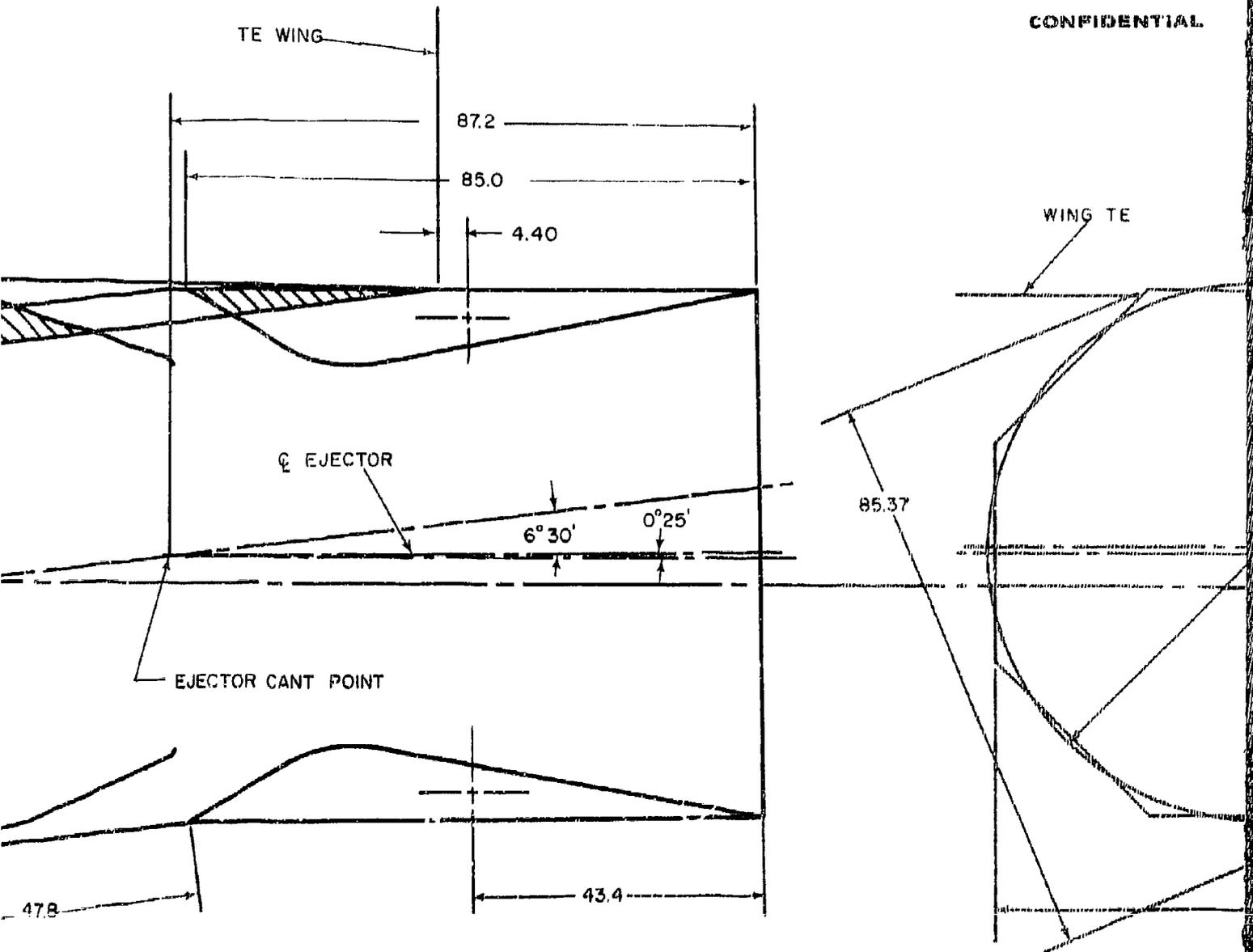


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E 81 DOORS  
NAC ATTACHMENT PLANE

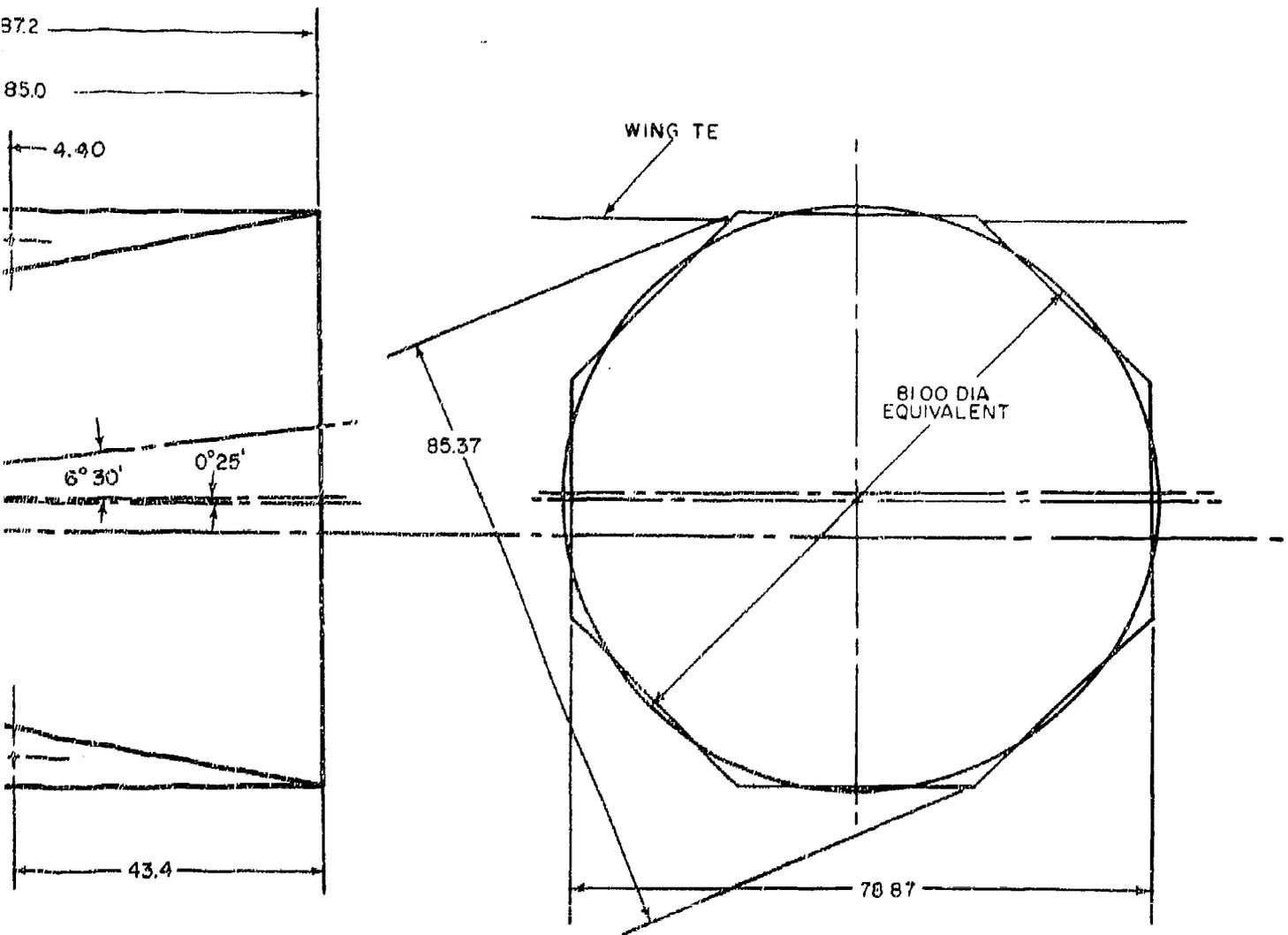
CG LOCATION DOES NOT INCLUDE INLET WEIGHT

2000°F MAX TU  
TEMPERATUR  
EJECTOR CANT  
NOZZLE PLAN

STJ227 500 LBS./SEC. TU

Figure 1-18

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CG LOCATION DOES NOT INCLUDE INLET WEIGHT

2000°F MAX. TURBINE INLET  
TEMPERATURE  
EJECTOR CANTED AT PRIMARY  
NOZZLE PLANE

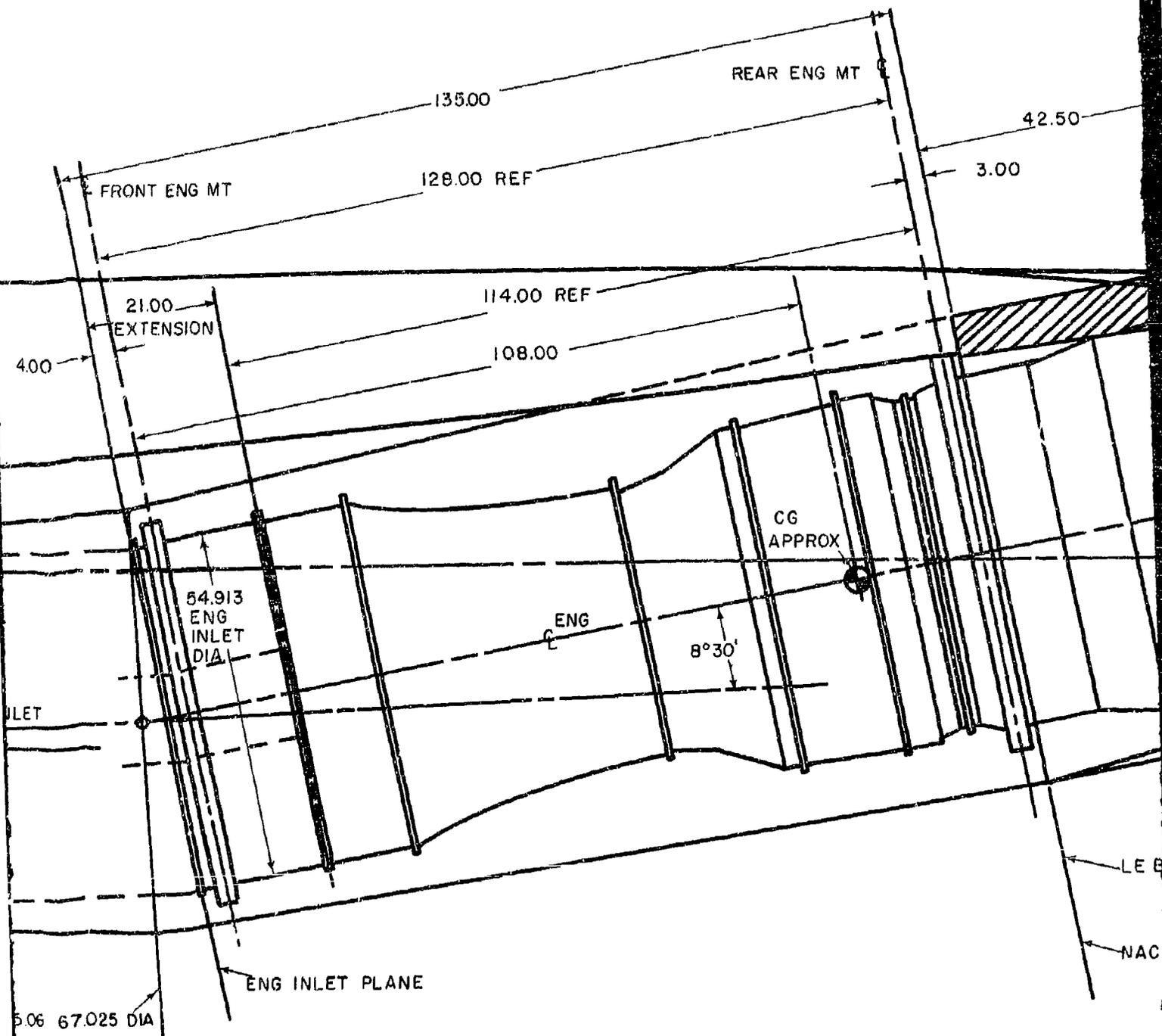
STJ227 500 LBS./SEC. TURBOJET

Figure 1-18

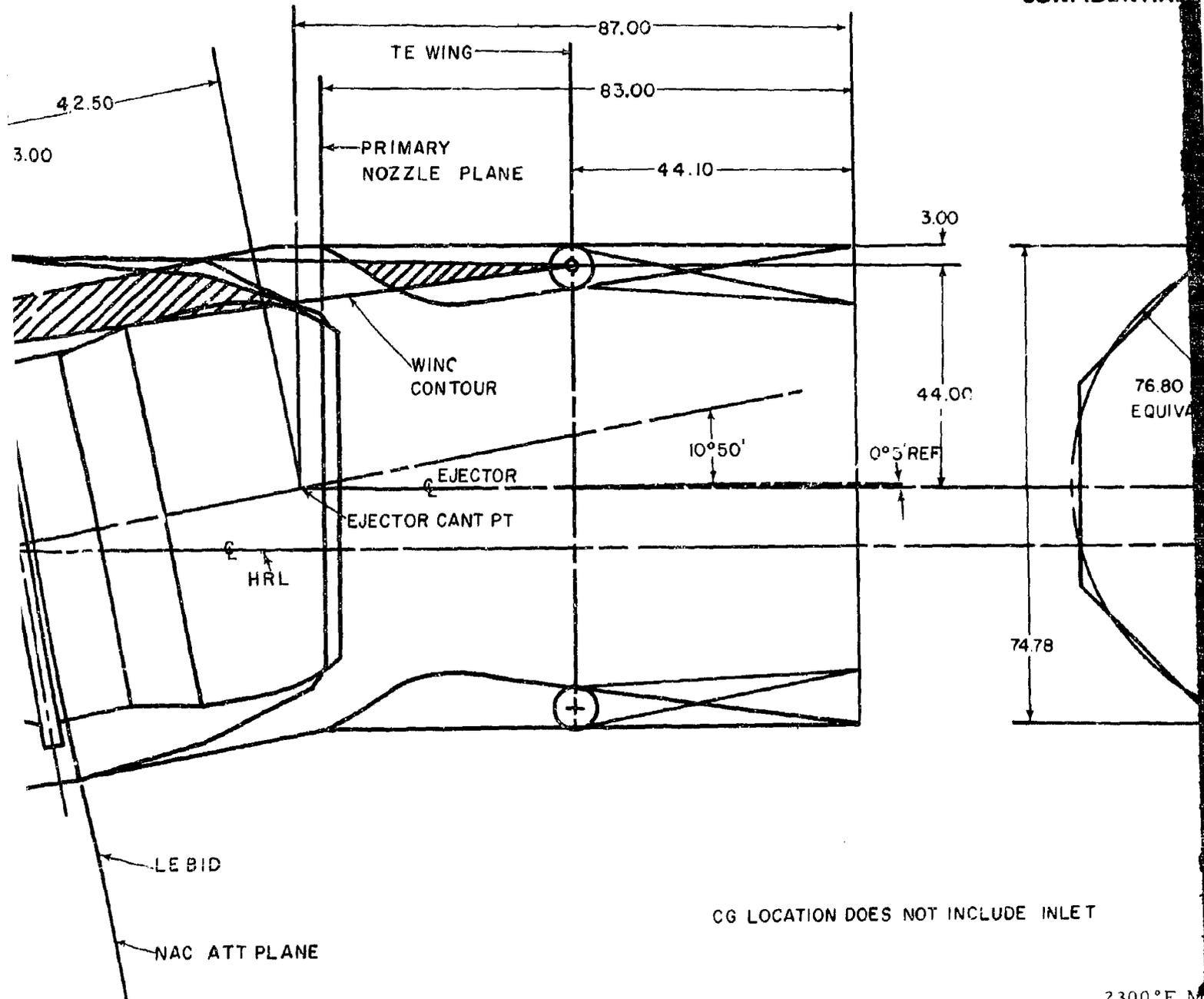
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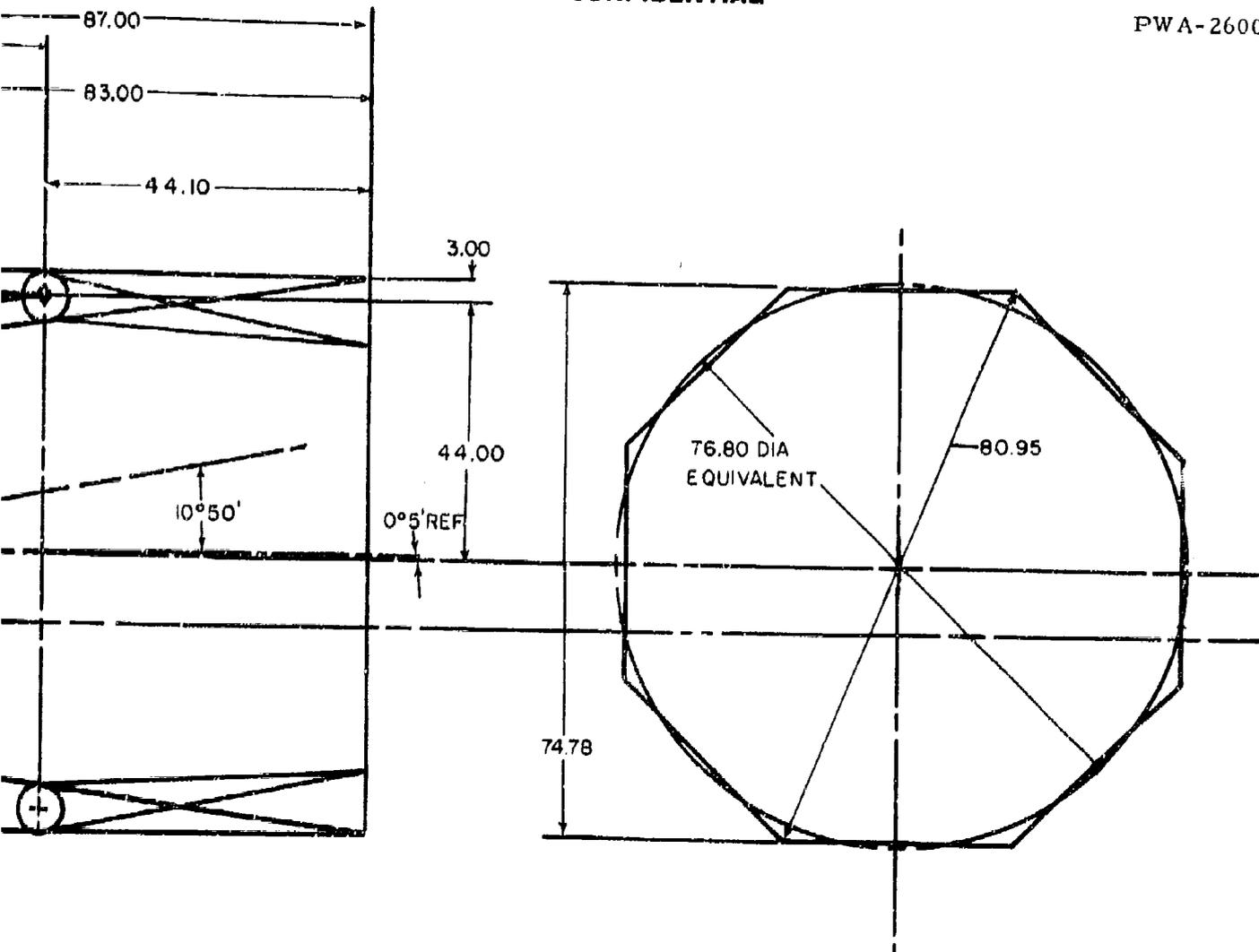
2300 °F M  
TEMPE  
EJECTOR  
PRIMAR  
\*NOTE:

STJ227 525 LBS. /SEC.

Figure 1-19

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3



CG LOCATION DOES NOT INCLUDE INLET

2300°F MAXIMUM TURBINE INLET  
 TEMPERATURE  
 EJECTOR CANTED 4.00 FWD. OF  
 PRIMARY NOZZLE PLANE  
 \*NOTE: CG LOCATION DOES NOT  
 INCLUDE INLET

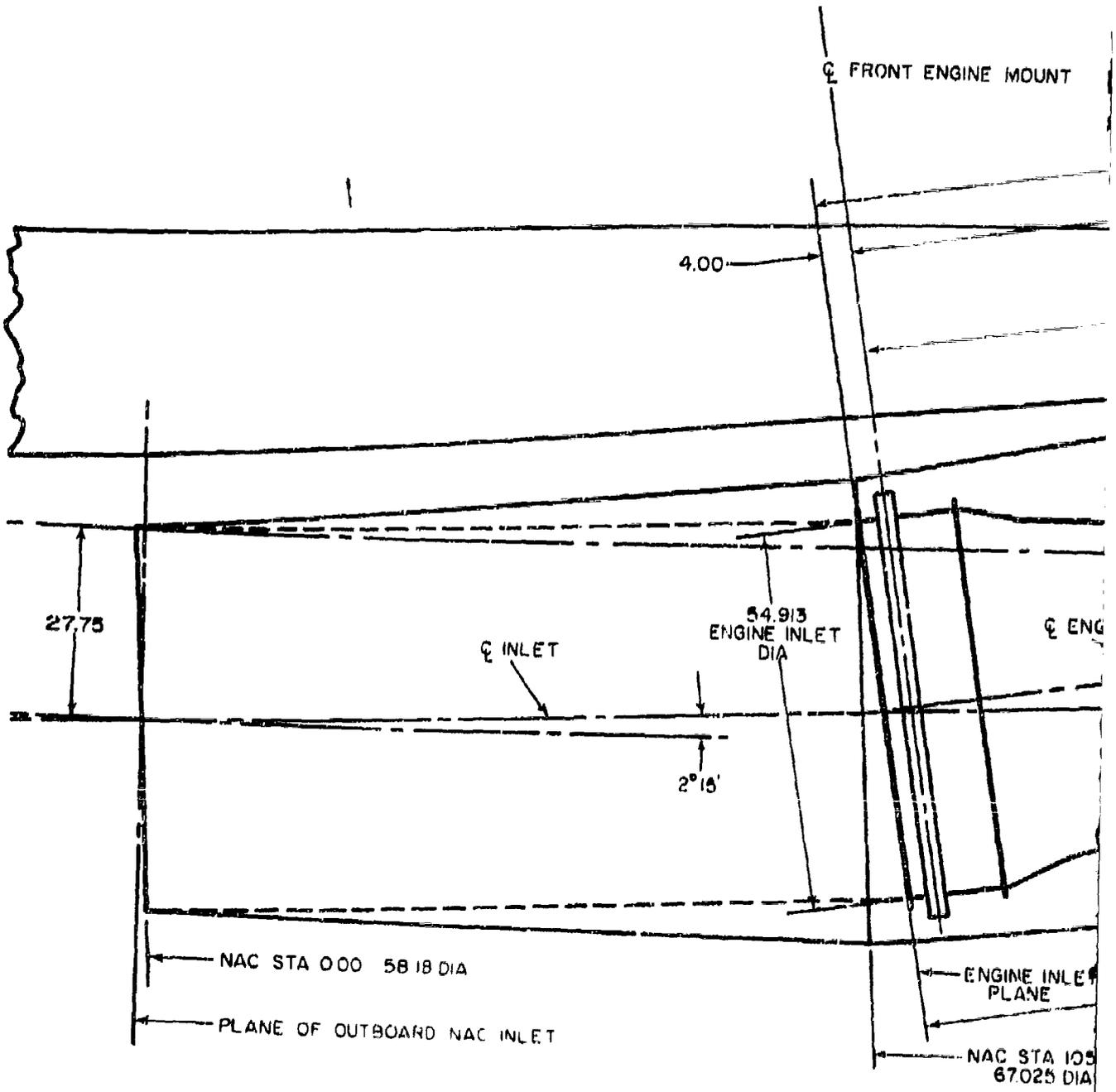
STJ227 525 LBS./SEC. TURBOJET

Figure 1-19

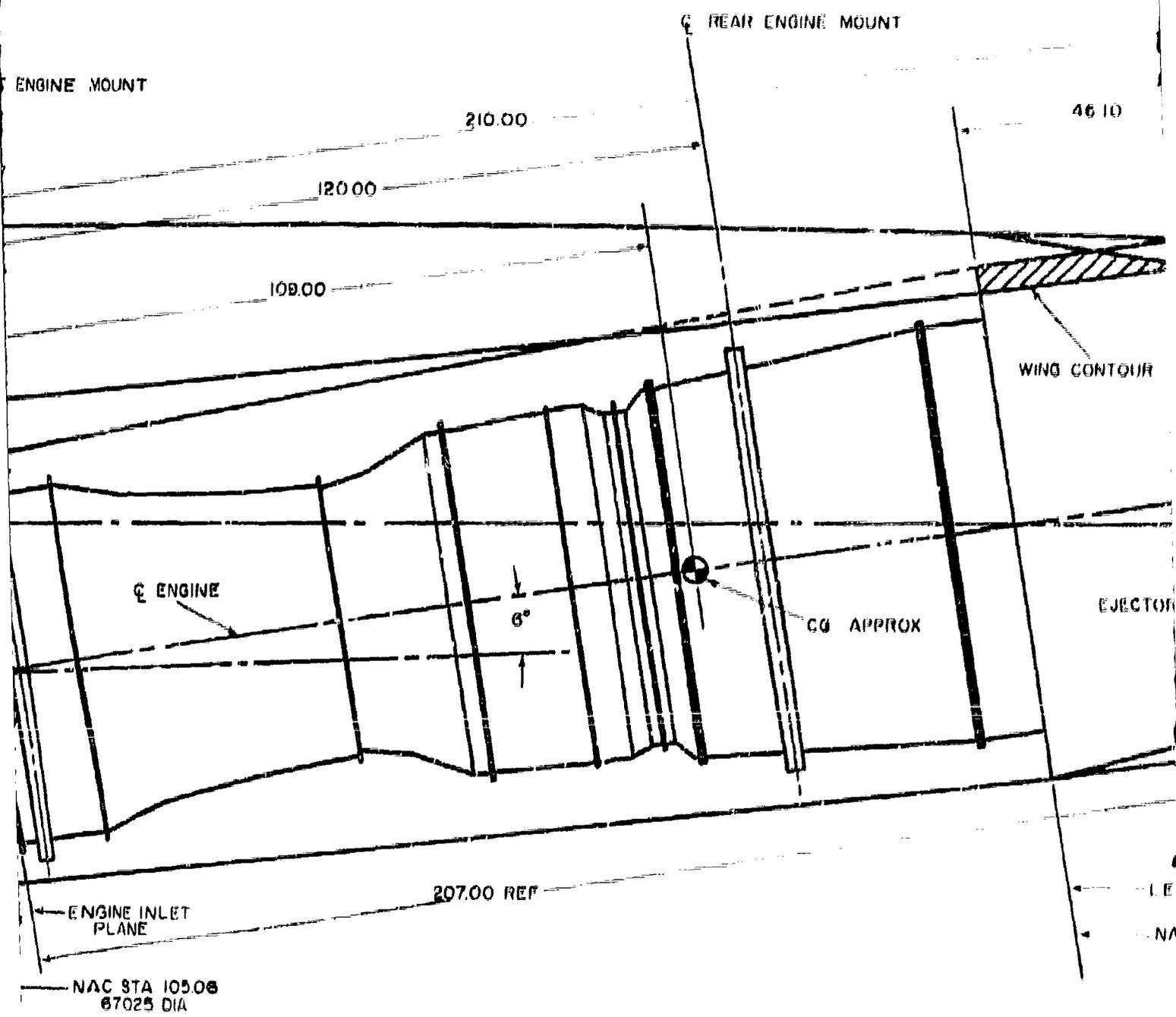
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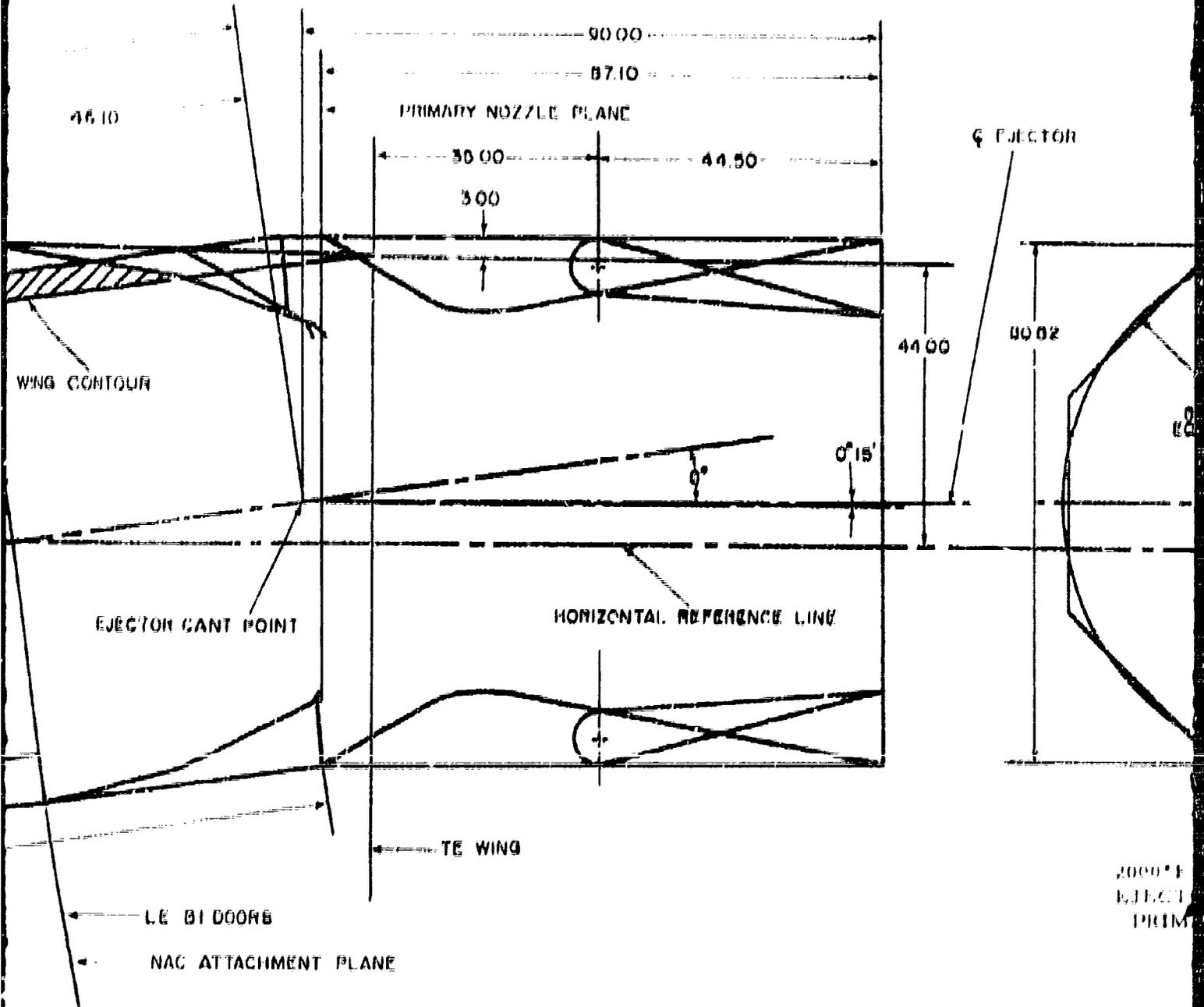
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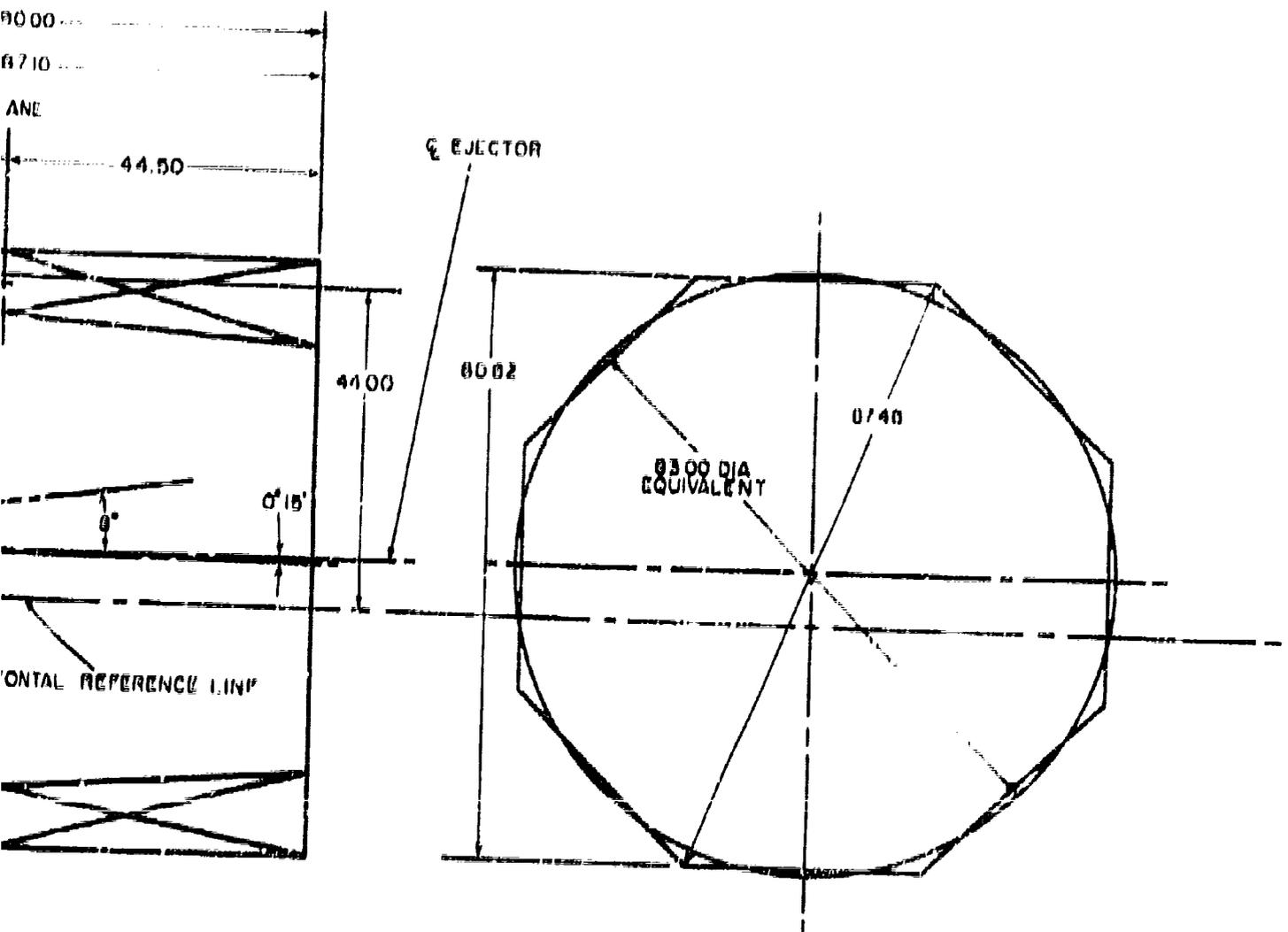
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2000°F MAXIMUM TURBINE INLET  
EJECTOR CANTED 2.40° FWD OF  
PRIMARY NOZZLE PLANE

SLJ227 525 LBS./SEC. TURBOJET

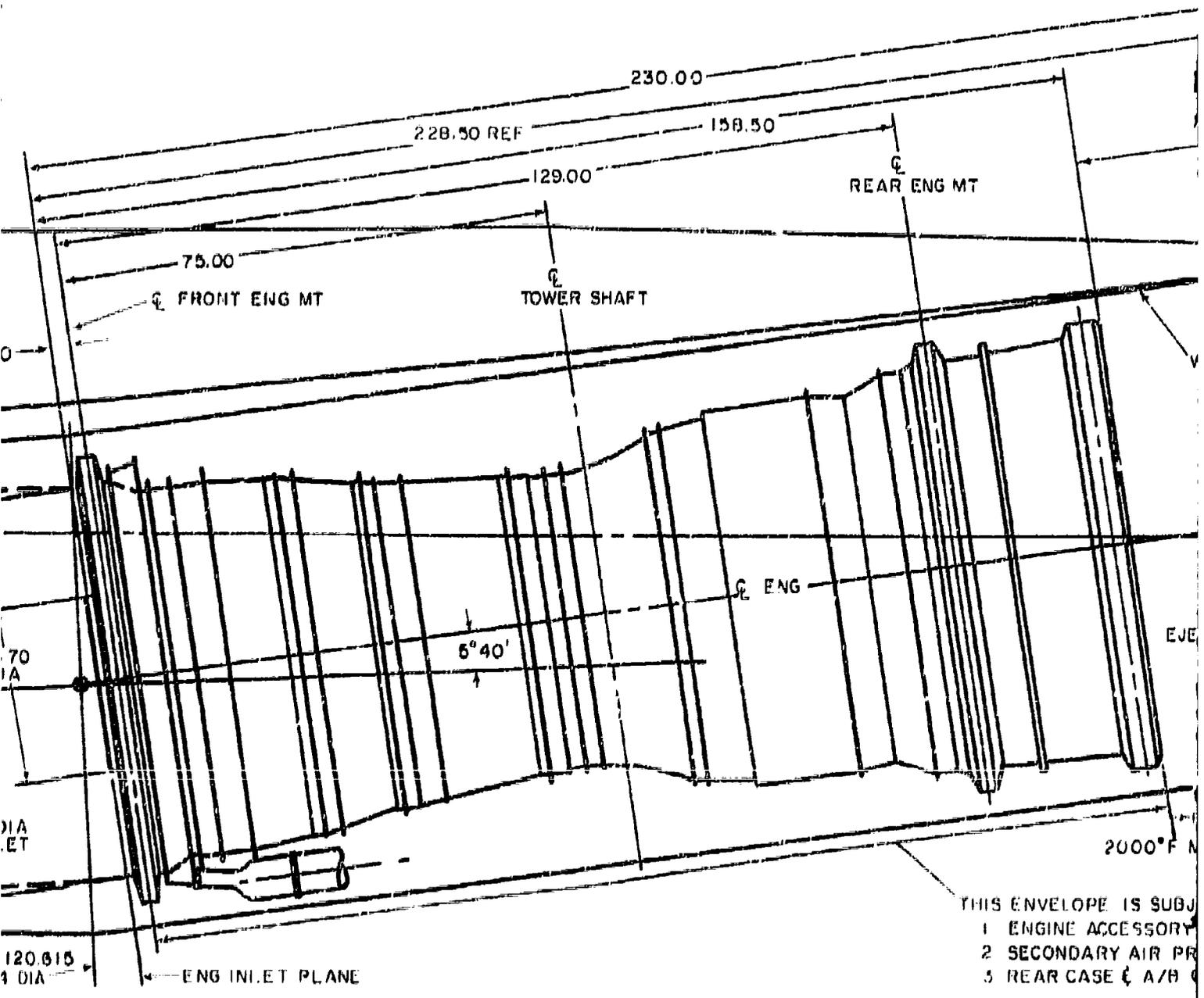
Figure 1-20

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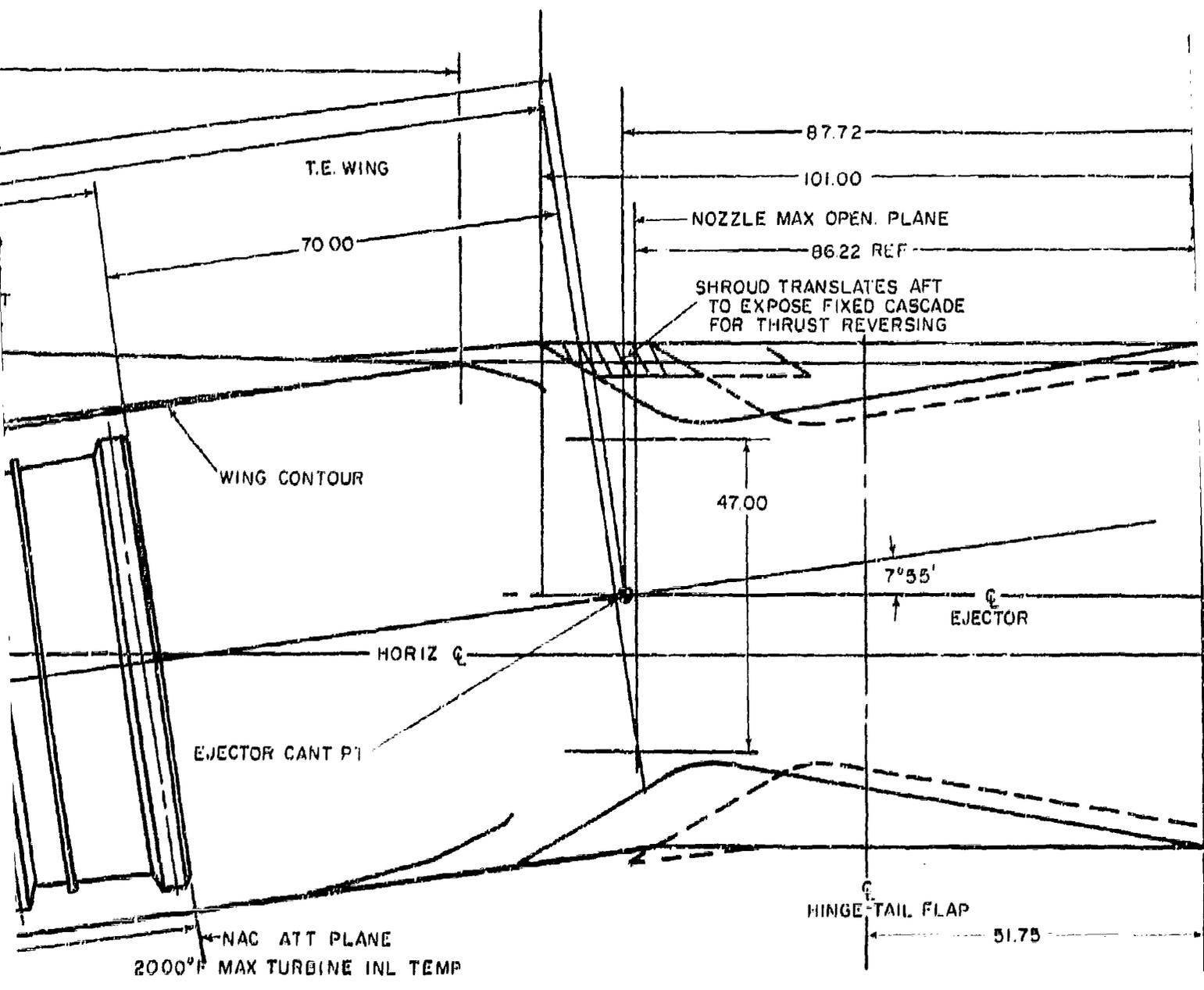


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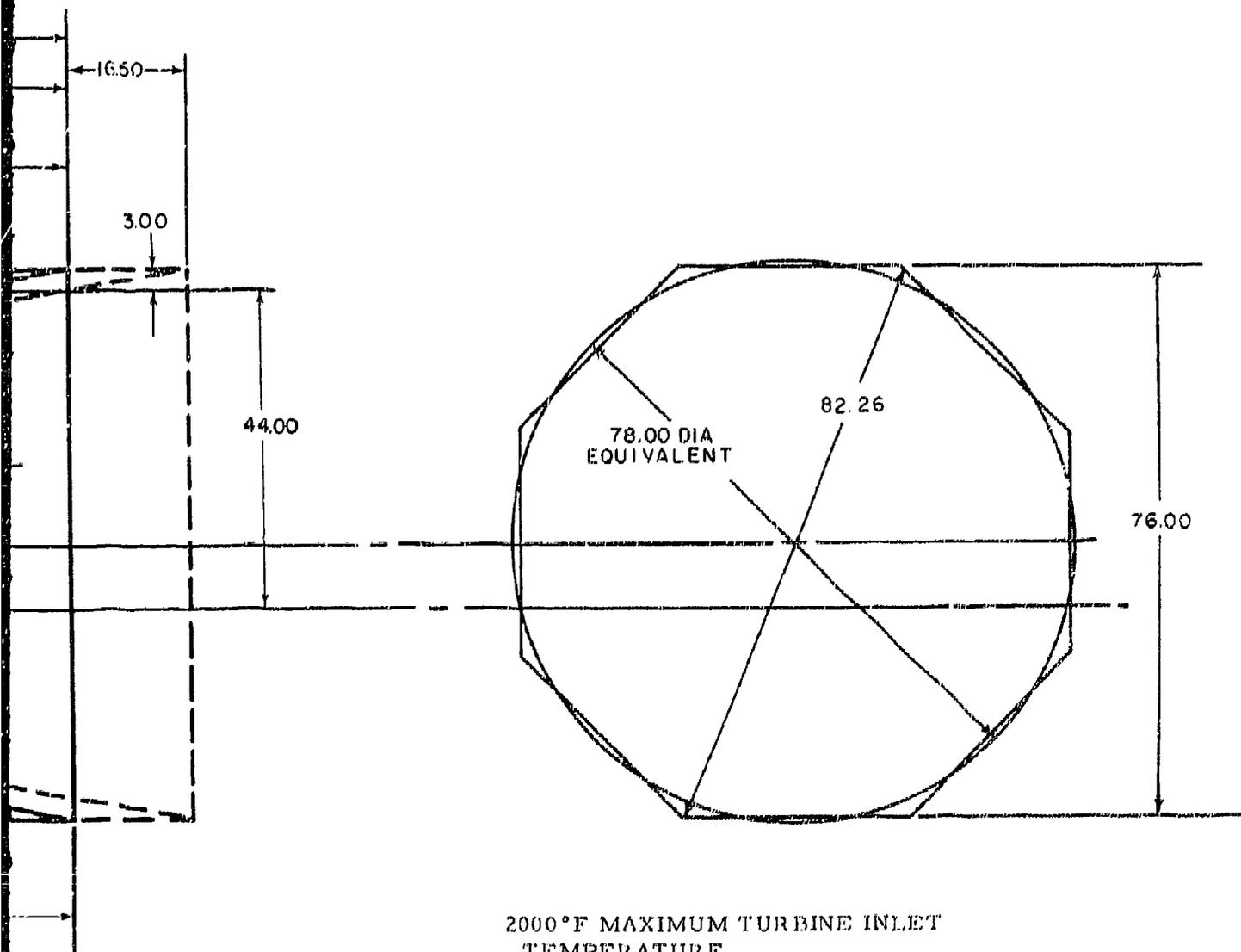


THIS ENVELOPE IS SUBJ  
 1 ENGINE ACCESSORY  
 2 SECONDARY AIR PR  
 3 REAR CASE  $\phi$  A/H

2



1 ENVELOPE IS SUBJECT TO CHANGE FOR:  
 2 ENGINE ACCESSORY ARRANGEMENT  
 3 SECONDARY AIR PROVISIONS FOR EJECTOR  
 4 REAR CASE & A/O COOLING PROVISIONS



2000°F MAXIMUM TURBINE INLET  
TEMPERATURE  
EJECTOR CANTED 1.50 FWD. OF  
PRIMARY NOZZLE PLANE

THIS ENVELOPE IS SUBJECT TO CHANGE FOR:

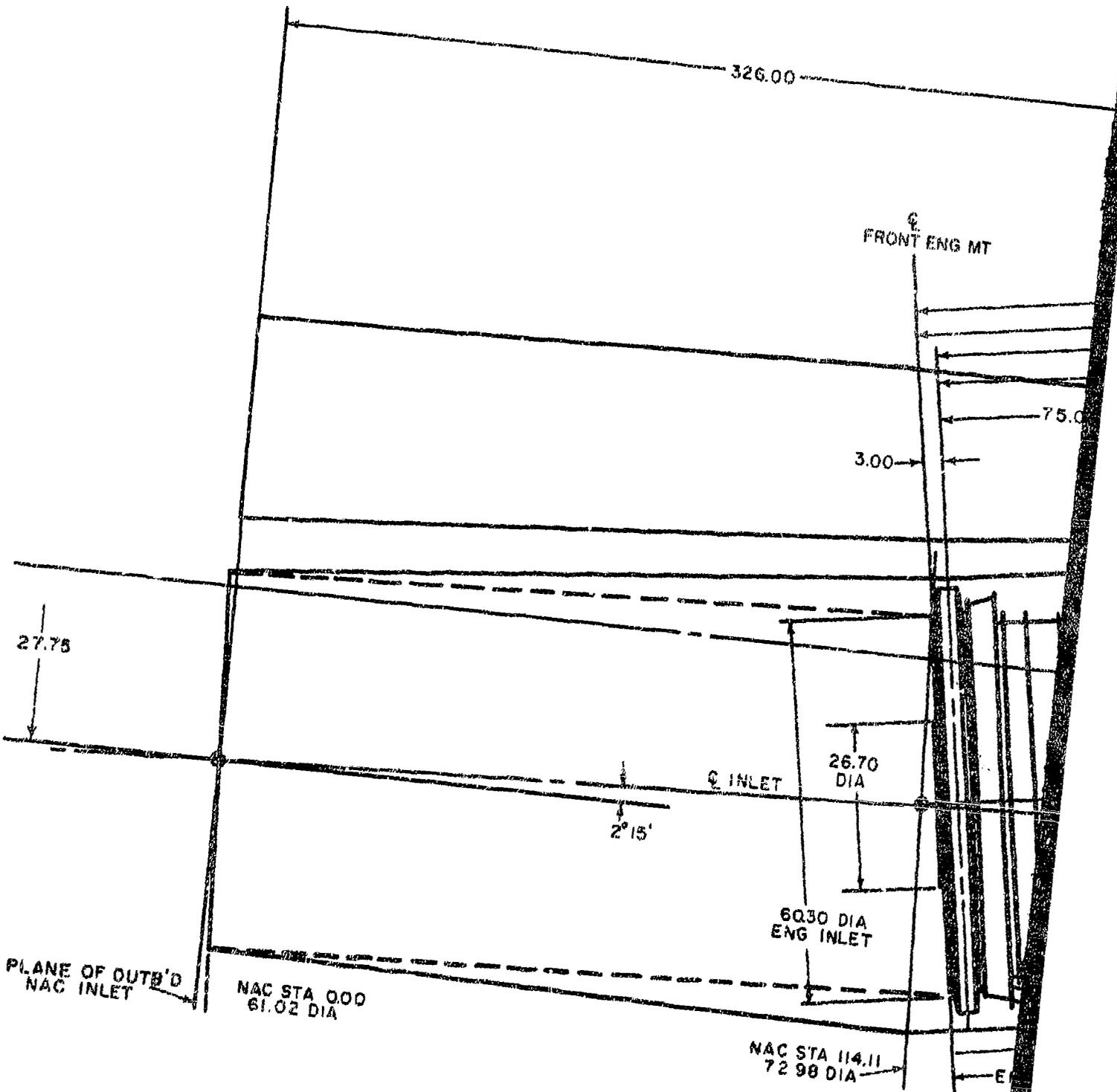
1. ENGINE ACCESSORY ARRANGEMENT
2. SECONDARY AIR PROVISIONS FOR EJECTOR
3. REAR CASE & A/B COOLING PROVISIONS

STJ227, 525 LBS./SEC. (HIGH FLOW) TURBOJET

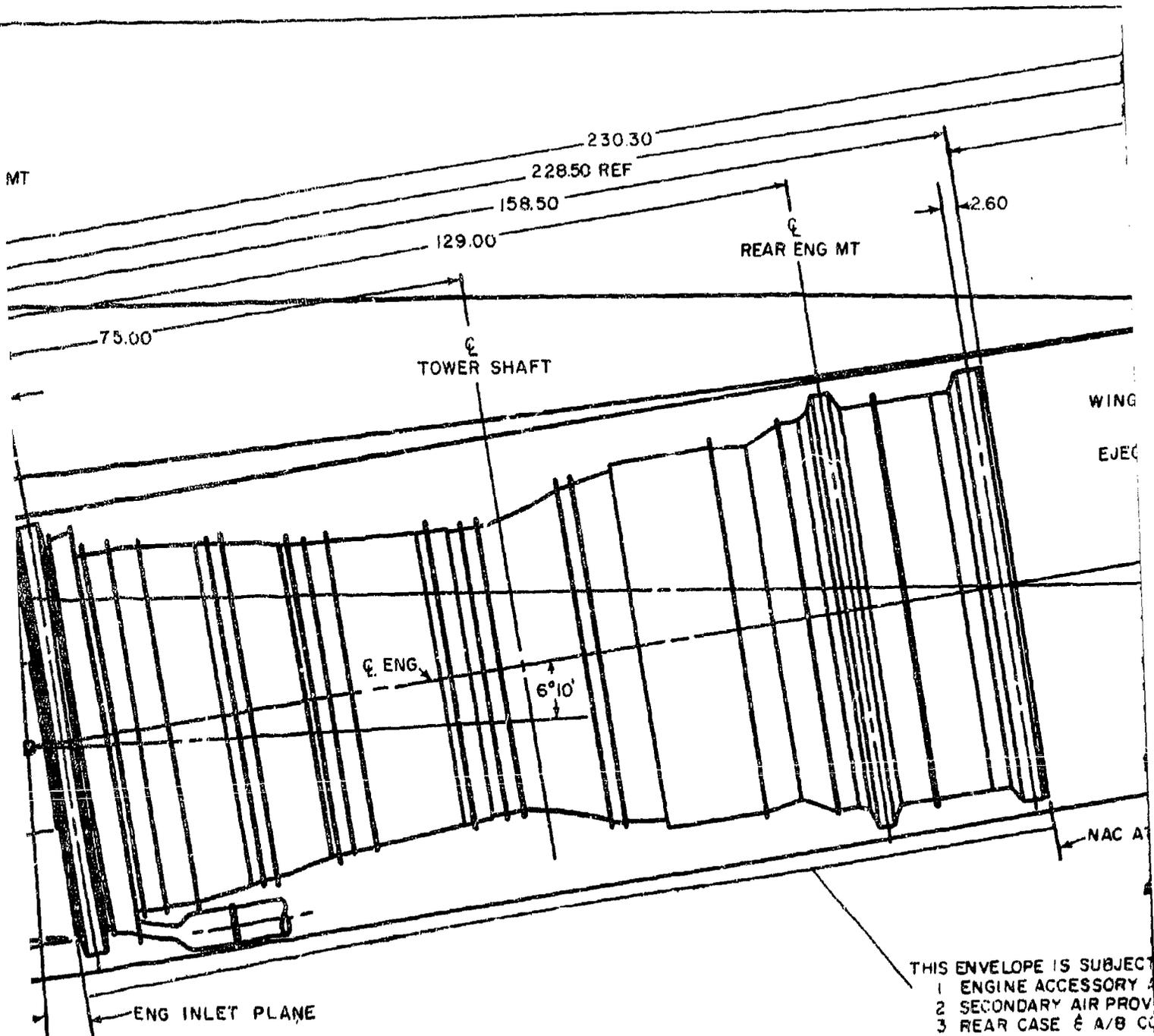
Figure 1-21

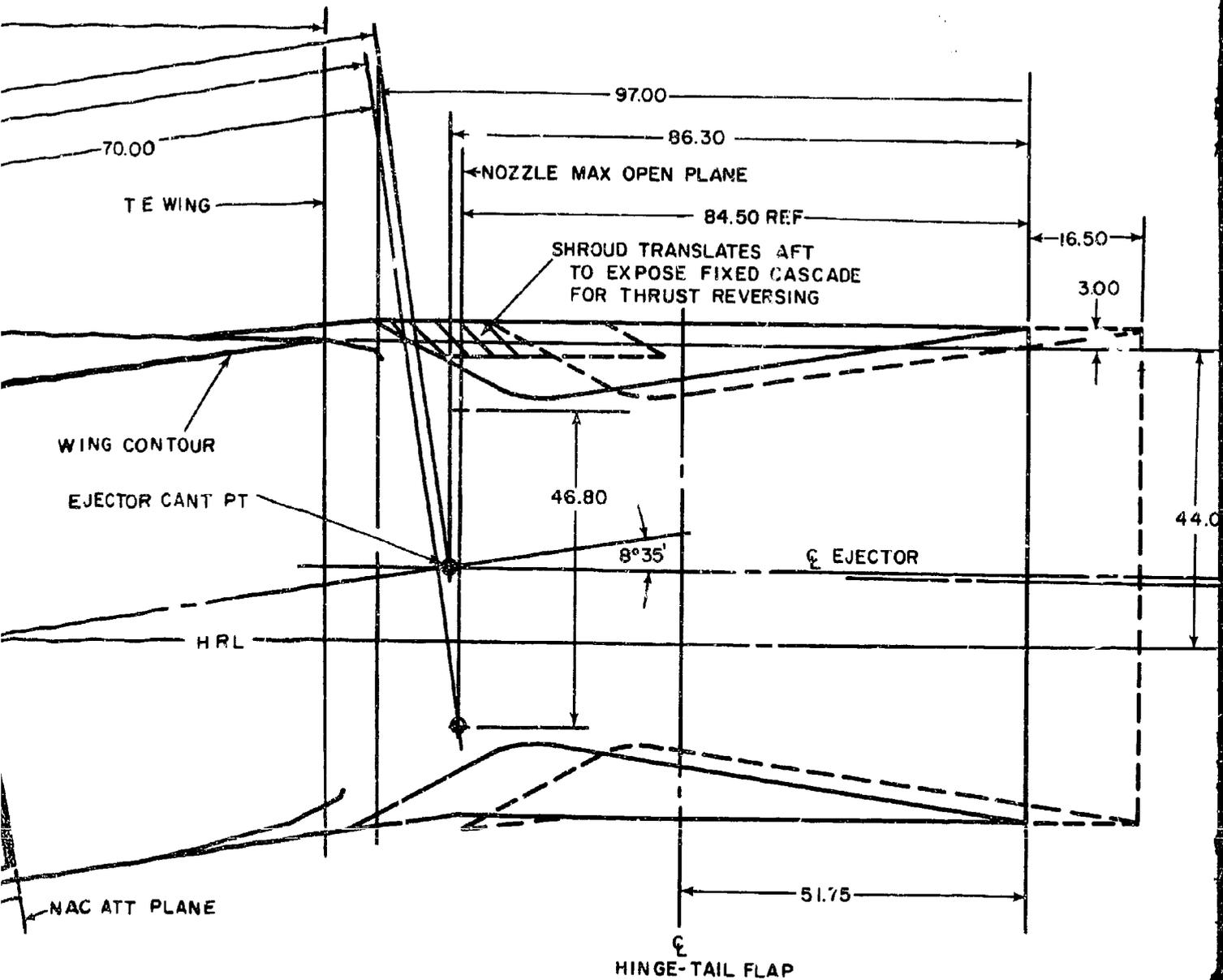
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OR THE SECRETARY OF THE SPACE FORCE

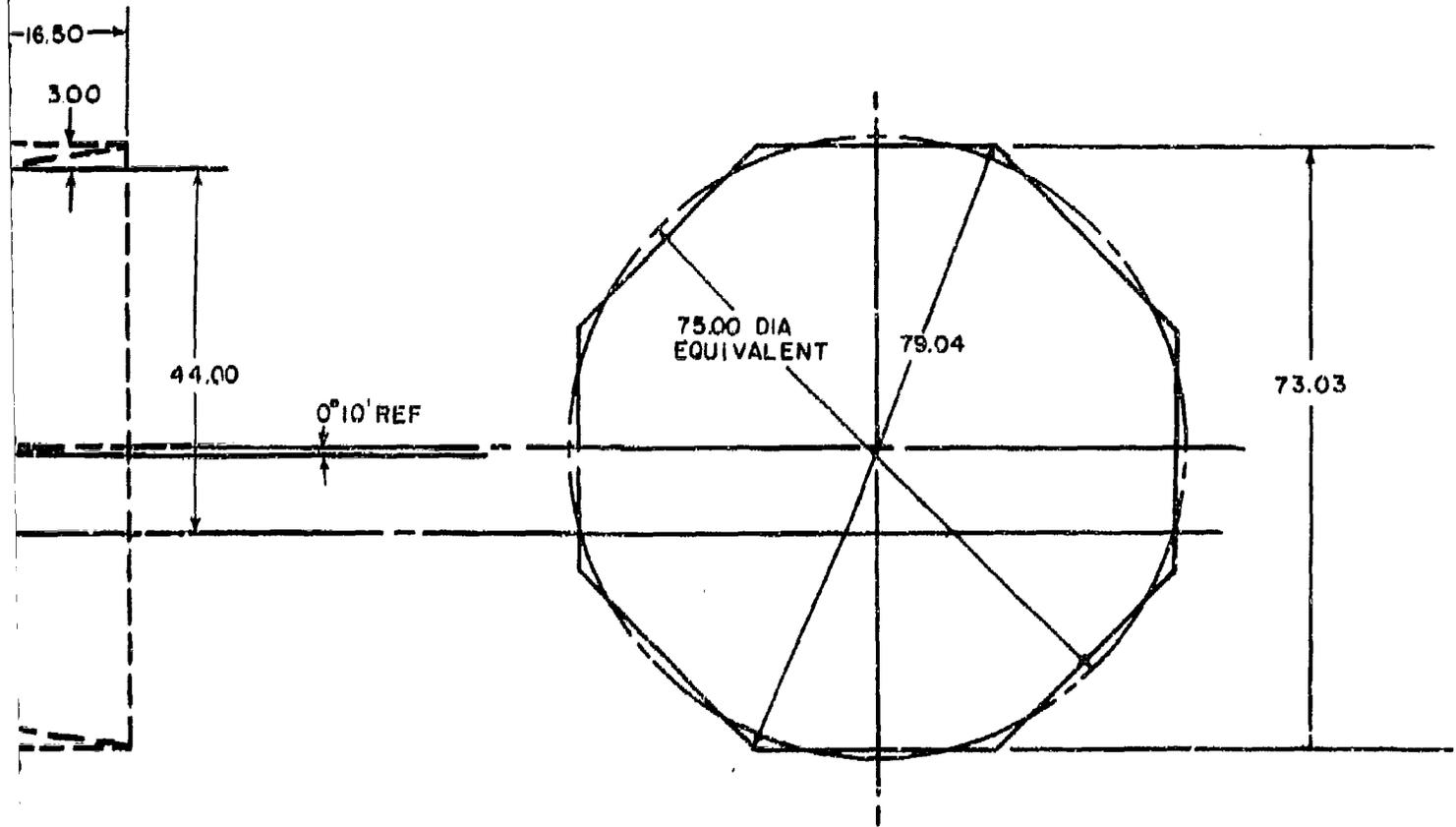


1





IS SUBJECT TO CHANGE FOR  
 NECESSARY ARRANGEMENT  
 AIR PROVISION FOR EJECTOR  
 SE E A/B COOLING PROVISION



2000°F TURBINE INLET TEMPERATURE  
L. H. SIDE VIEW OUTBOARD POD  
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1. ENGINE ACCESSORY ARRANGEMENT  
2. SECONDARY AIR PROVISION FOR EJECTOR  
3. REAR CASE AND A/B COOLING PROVISION

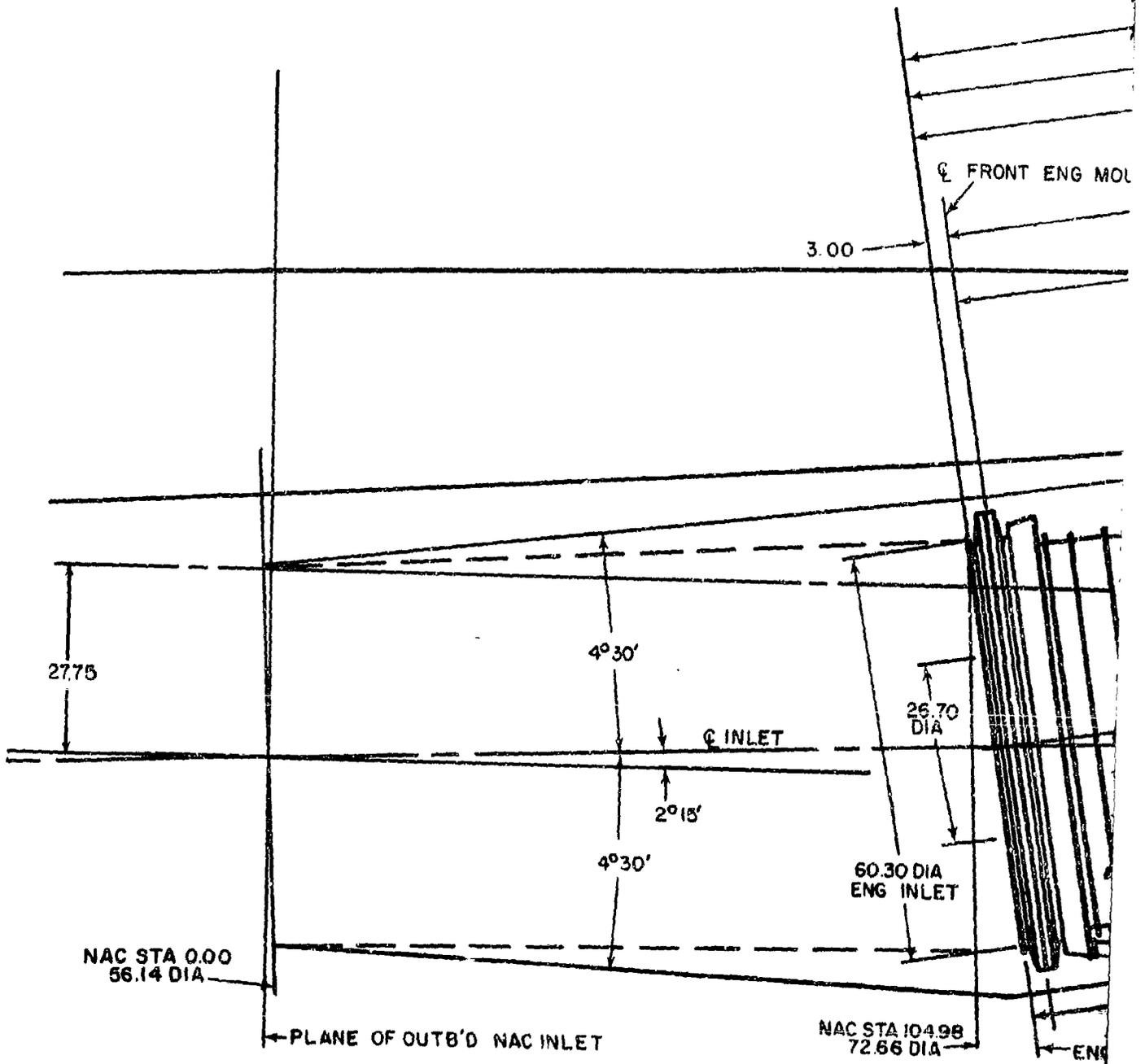
STJ227, 525 LBS./SEC. (I-ASE FLOW) TURBOJET

Figure 1-22

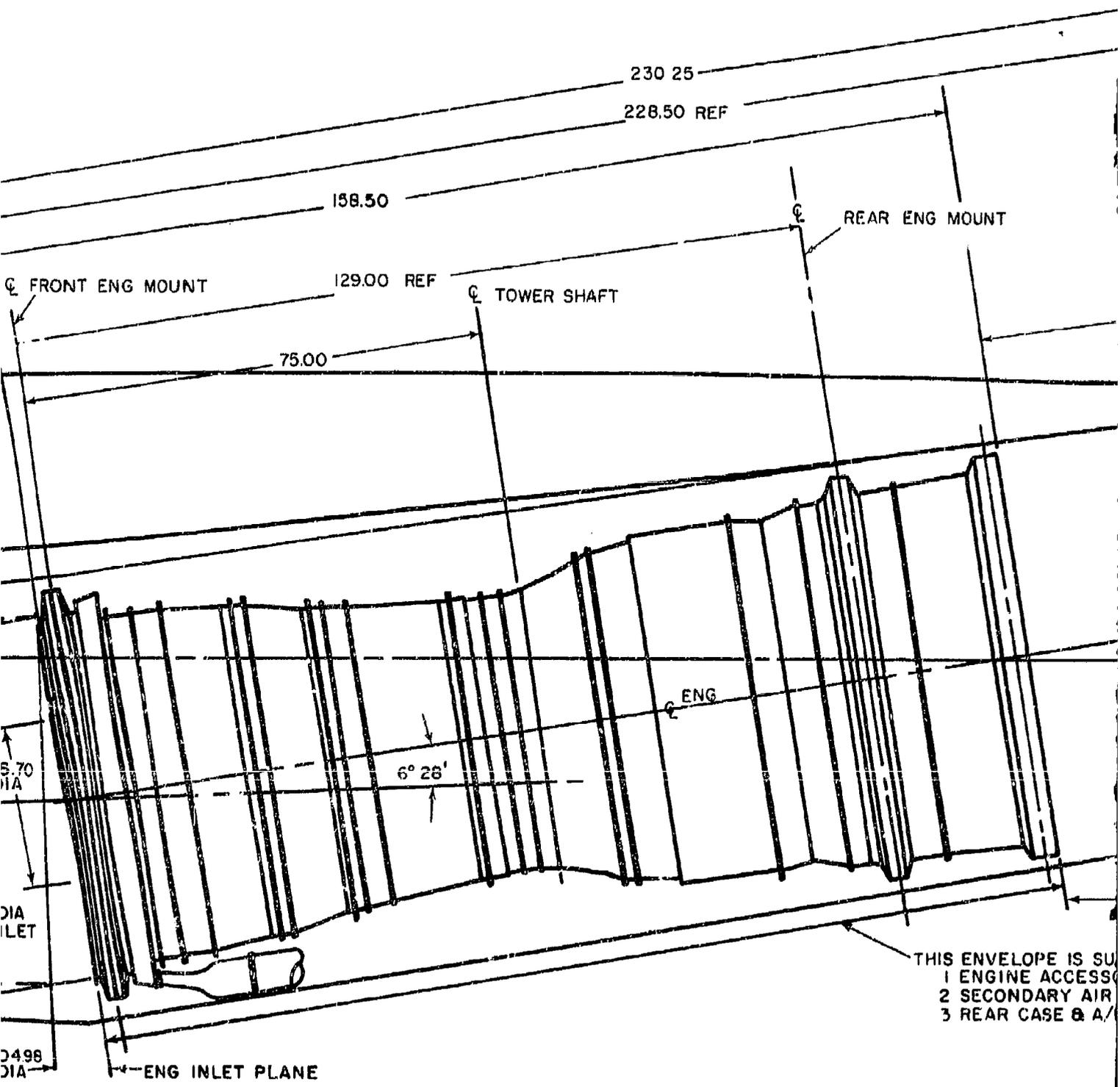


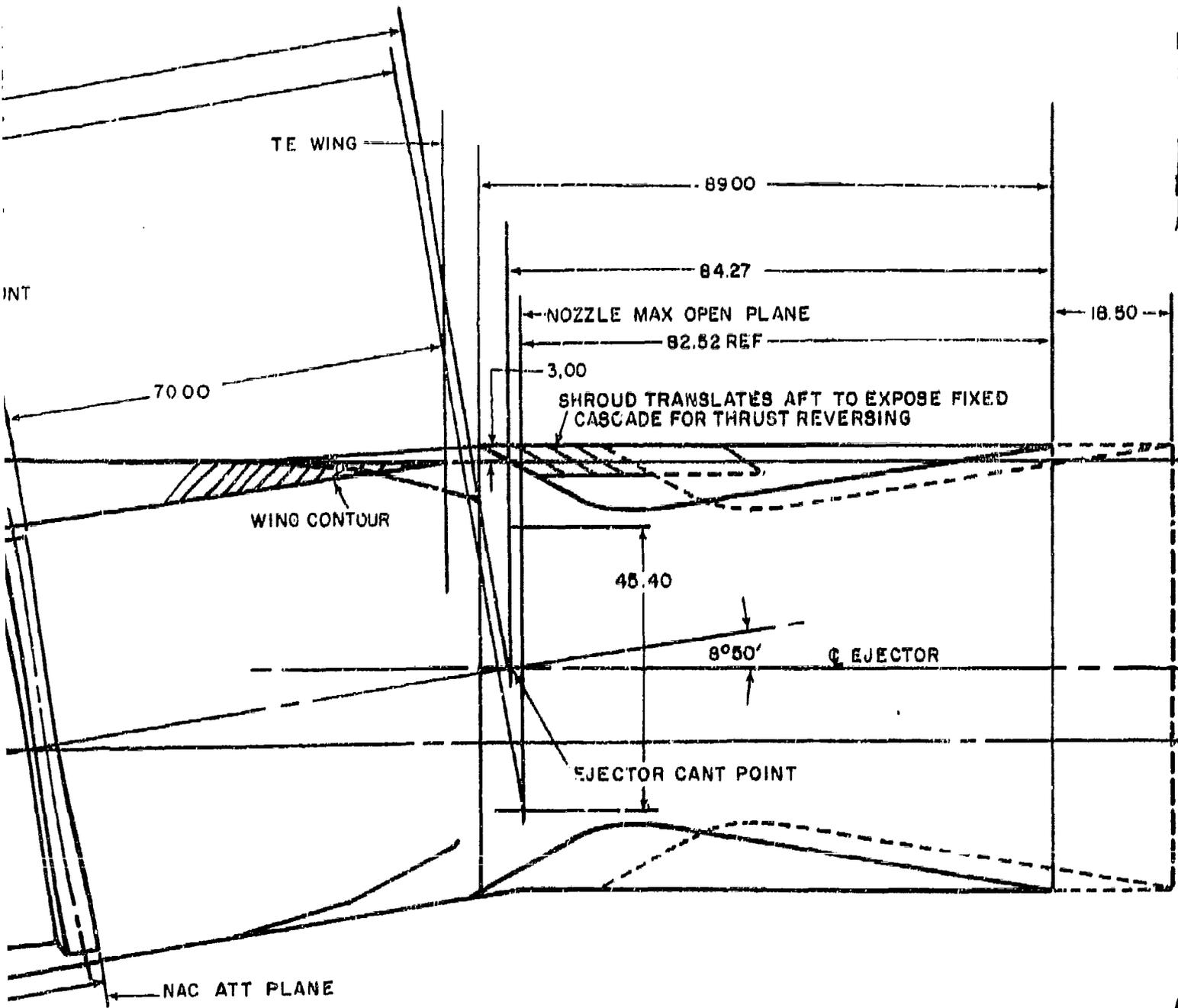
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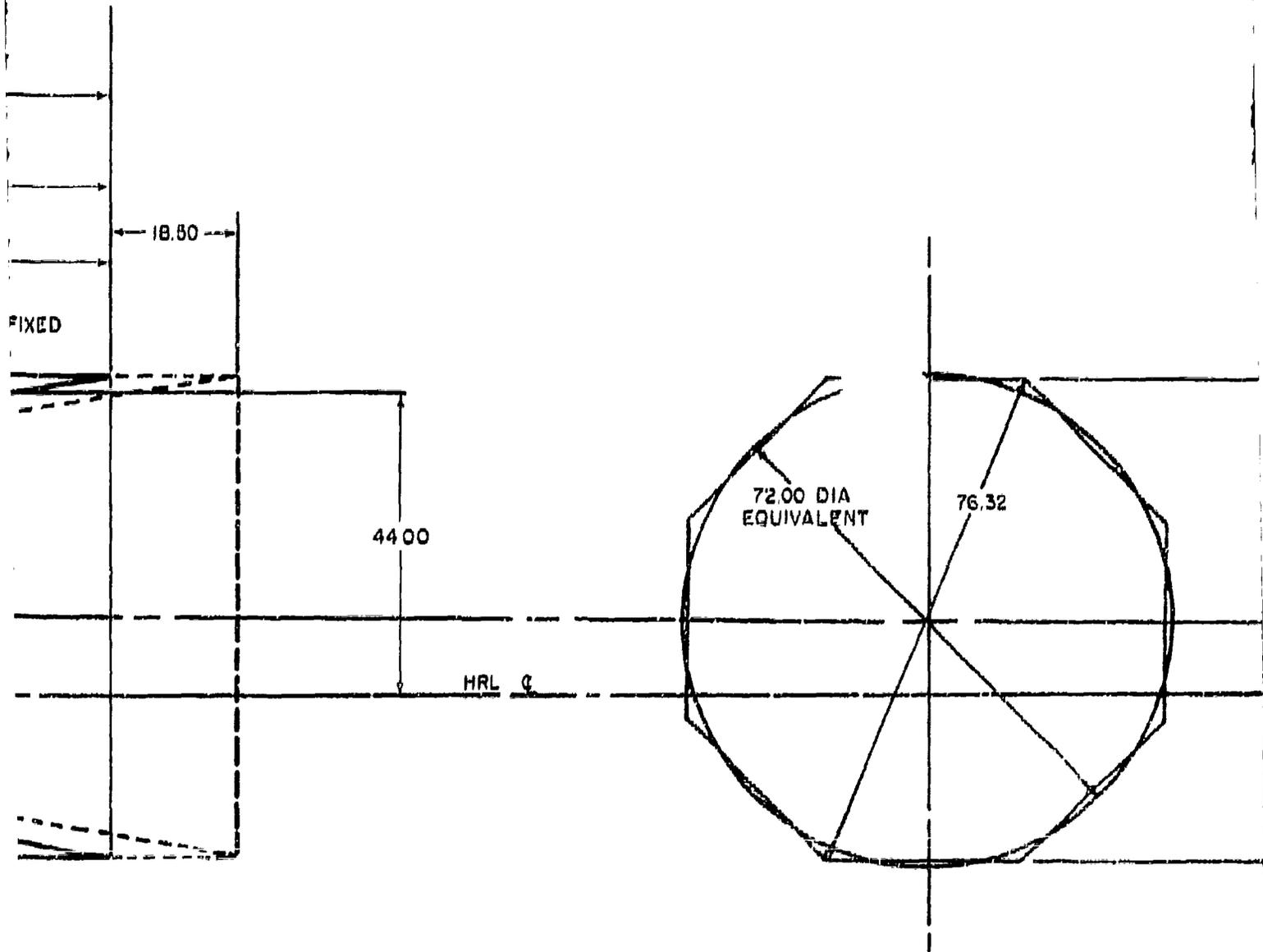
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 ENGINE ACCESSORY ARRANGEMENT  
 SECONDARY AIR PROVISIONS FOR EJECTOR  
 REAR CASE & A/B COOLING PROVISIONS

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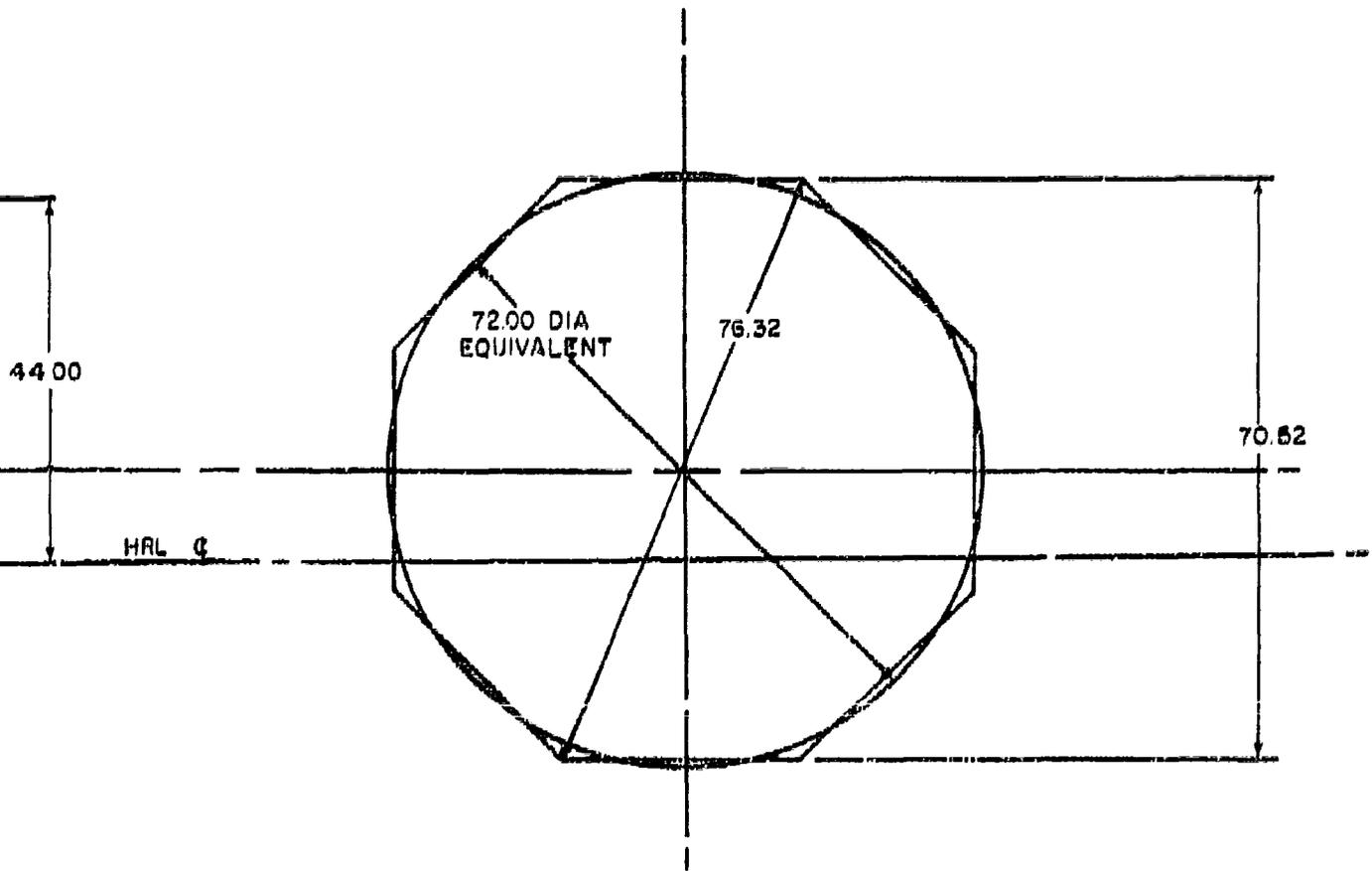


2000°F TURBINE INLET TEMPERATURE  
THIS ENVELOPE IS SUBJECT TO CHANGE FOR:  
1. ENGINE ACCESSORY ARRANGEMENT  
2. SECONDARY A/R PROVISIONS FOR EJECTOR  
3. REAR CASE & A/B COOLING PROVISIONS

STJ227, 525 LBS./SEC. (LOW FLOW) TURBOJET

Figure 1-23

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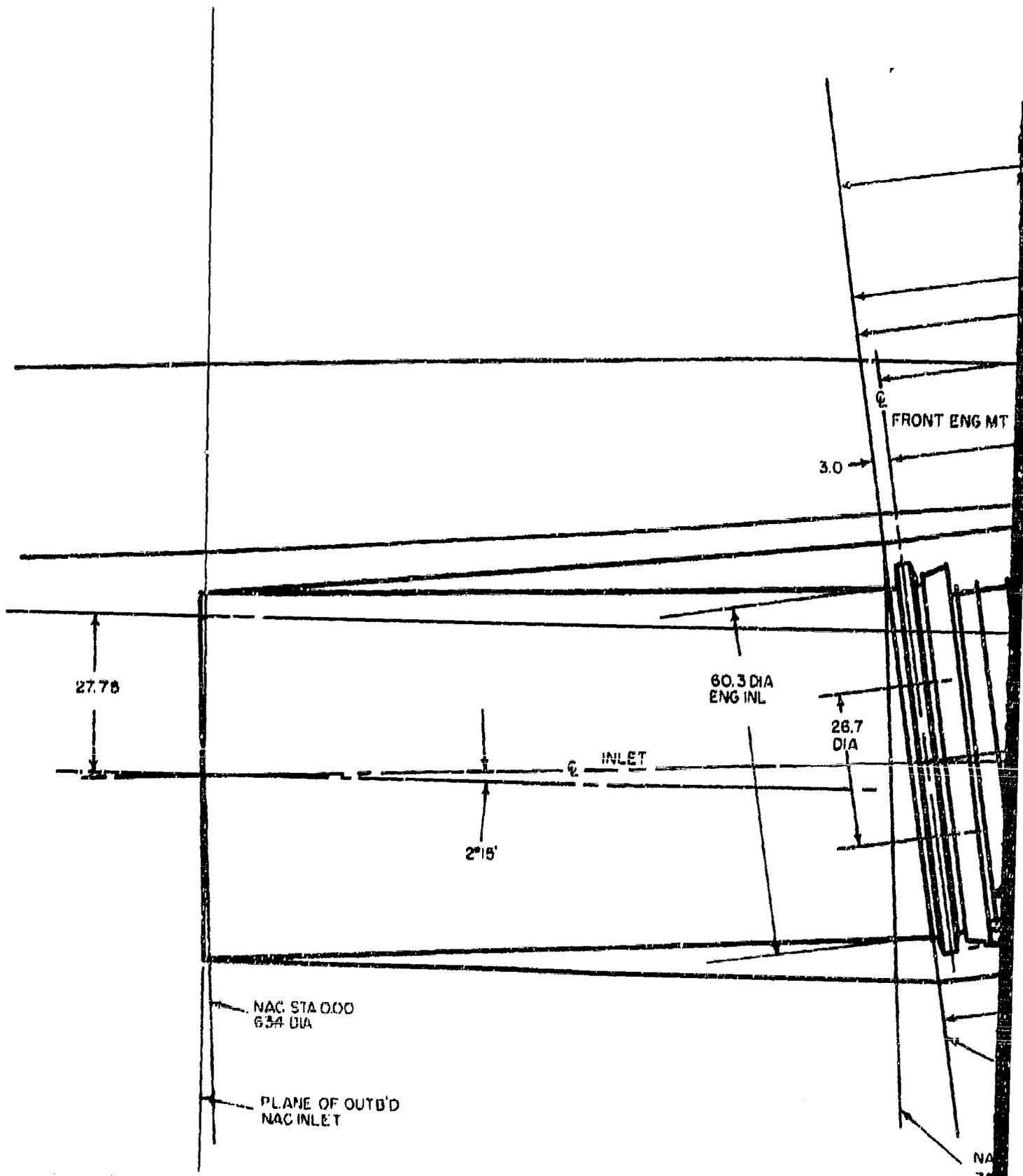
2000°F TURBINE INLET TEMPERATURE  
THIS ENVELOPE IS SUBJECT TO CHANGE FOR:  
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2. SECONDARY A/R PROVISIONS FOR EJECTOR  
3. REAR CASE & A/B COOLING PROVISIONS

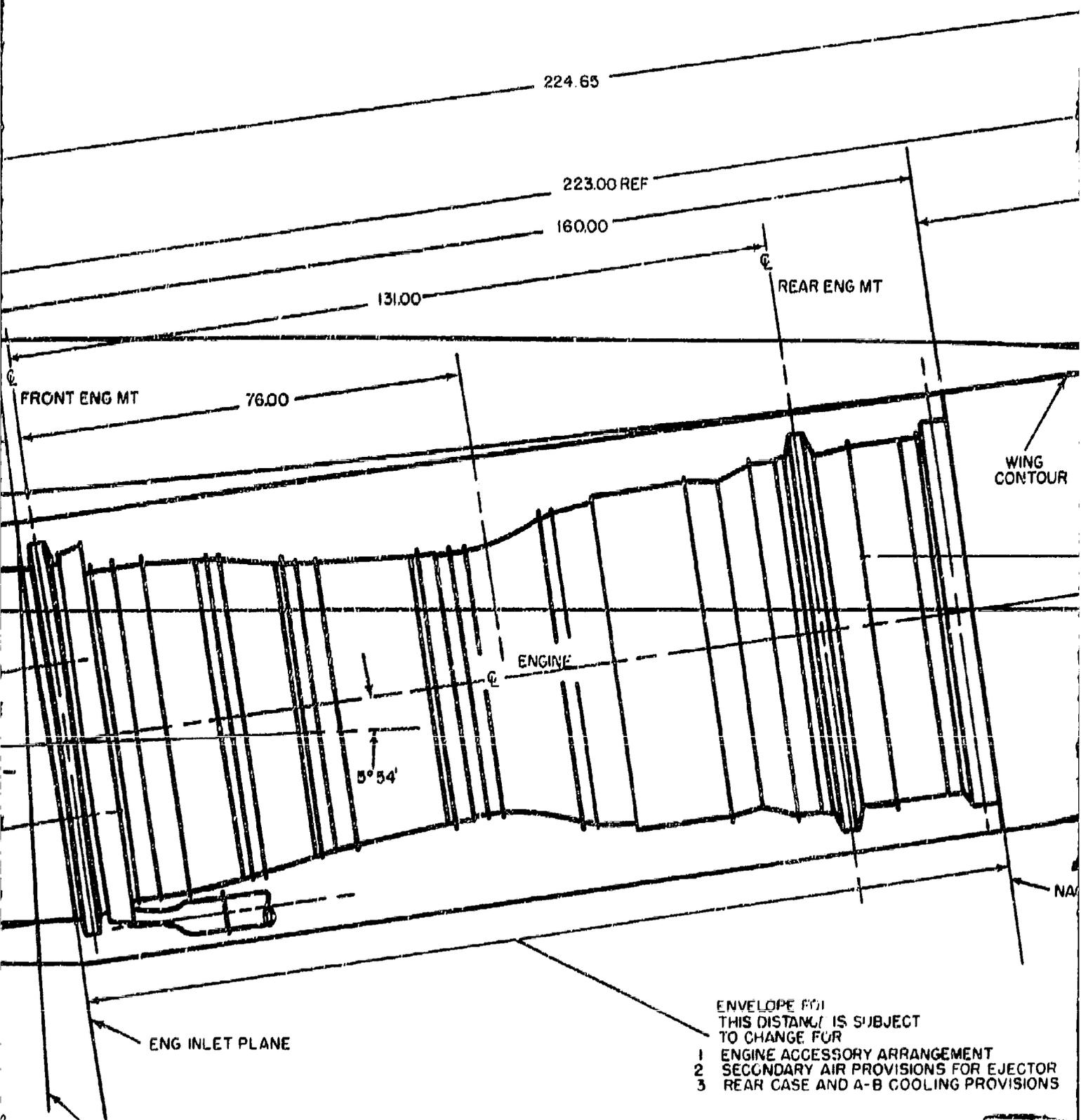
STJ227, 525 LBS./SEC. (LOW FLOW) TURBOJET

Figure 1-23

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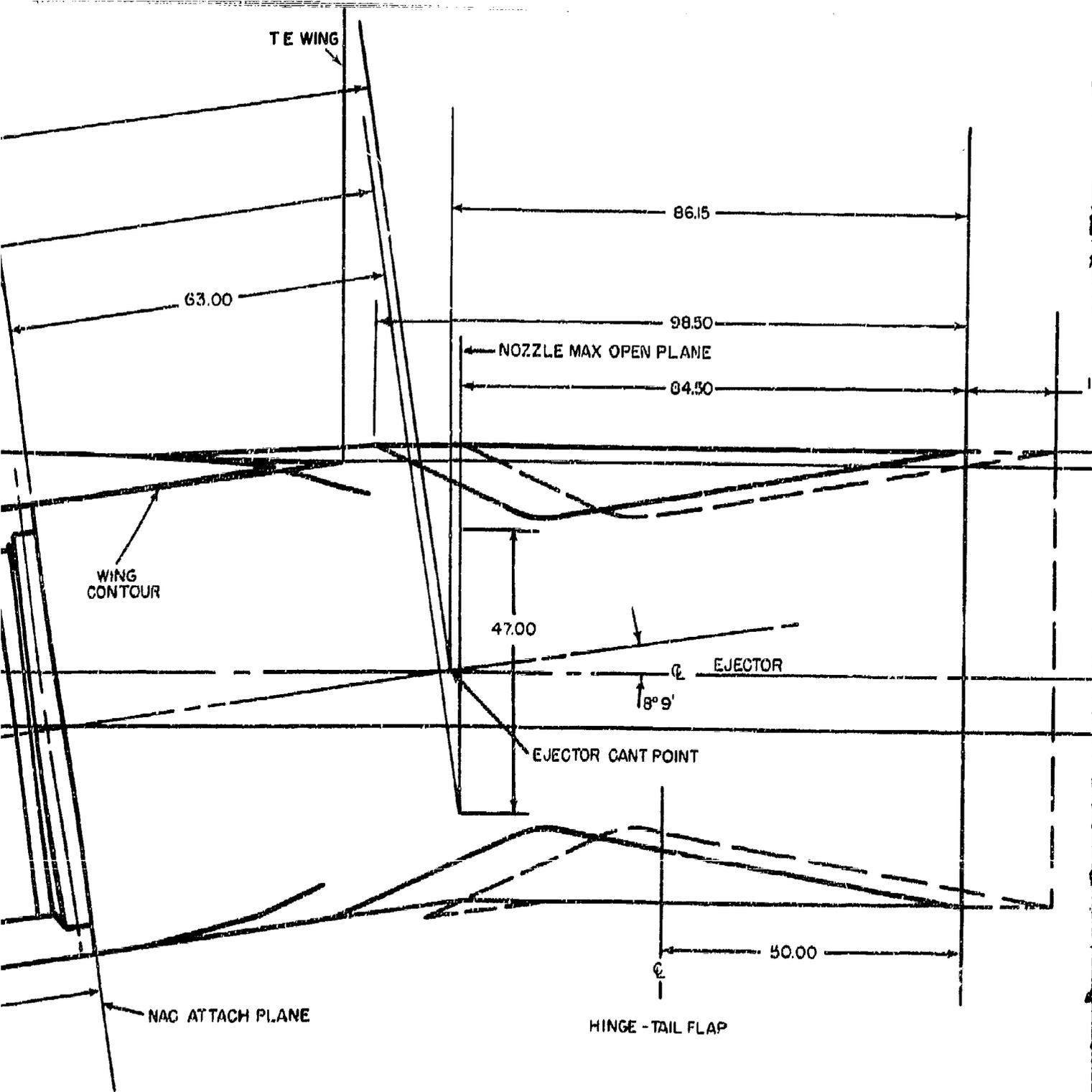




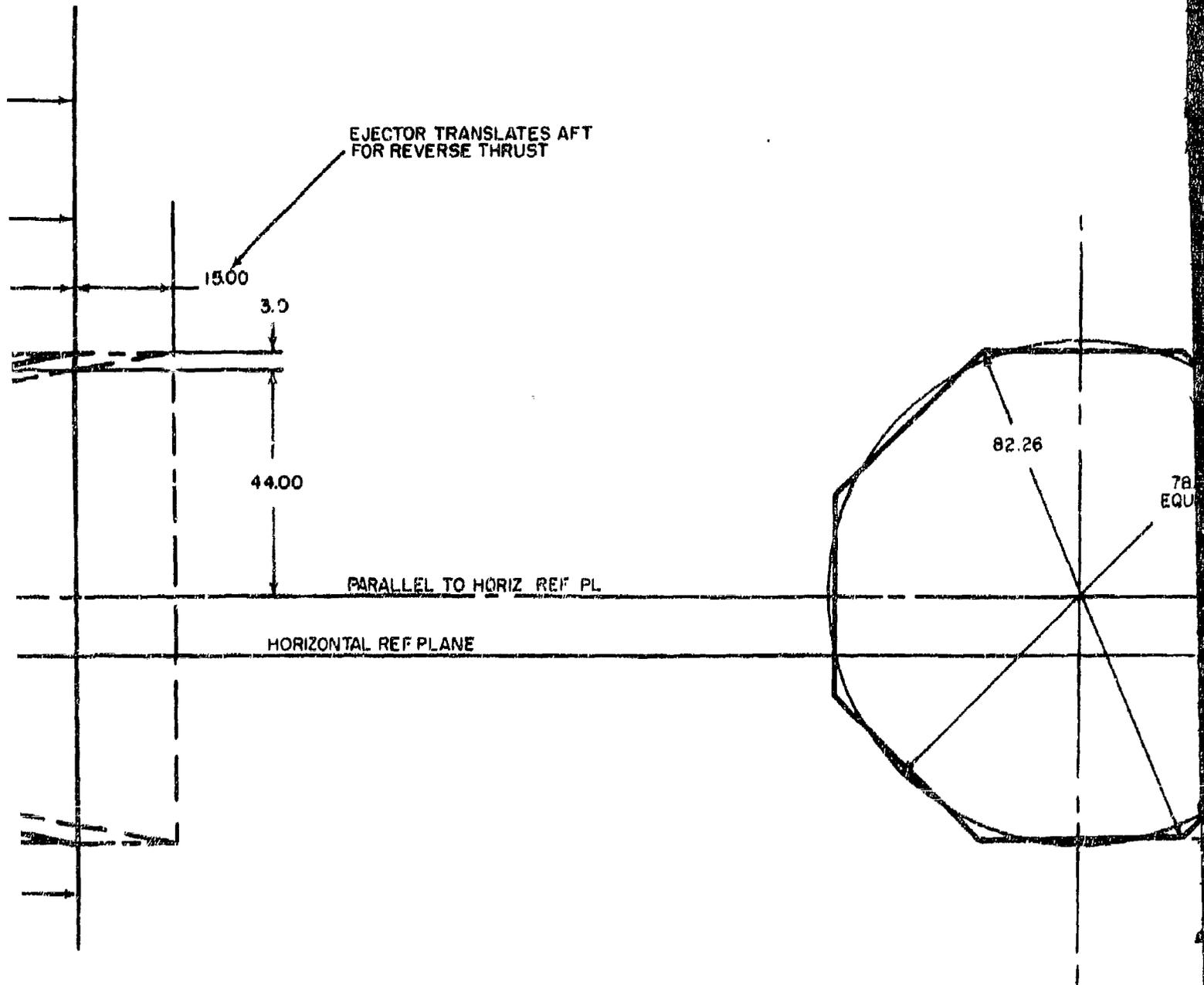
ENVELOPE FOR THIS DISTANCE IS SUBJECT TO CHANGE FOR

- 1 ENGINE ACCESSORY ARRANGEMENT
- 2 SECONDARY AIR PROVISIONS FOR EJECTOR
- 3 REAR CASE AND A-B COOLING PROVISIONS

2



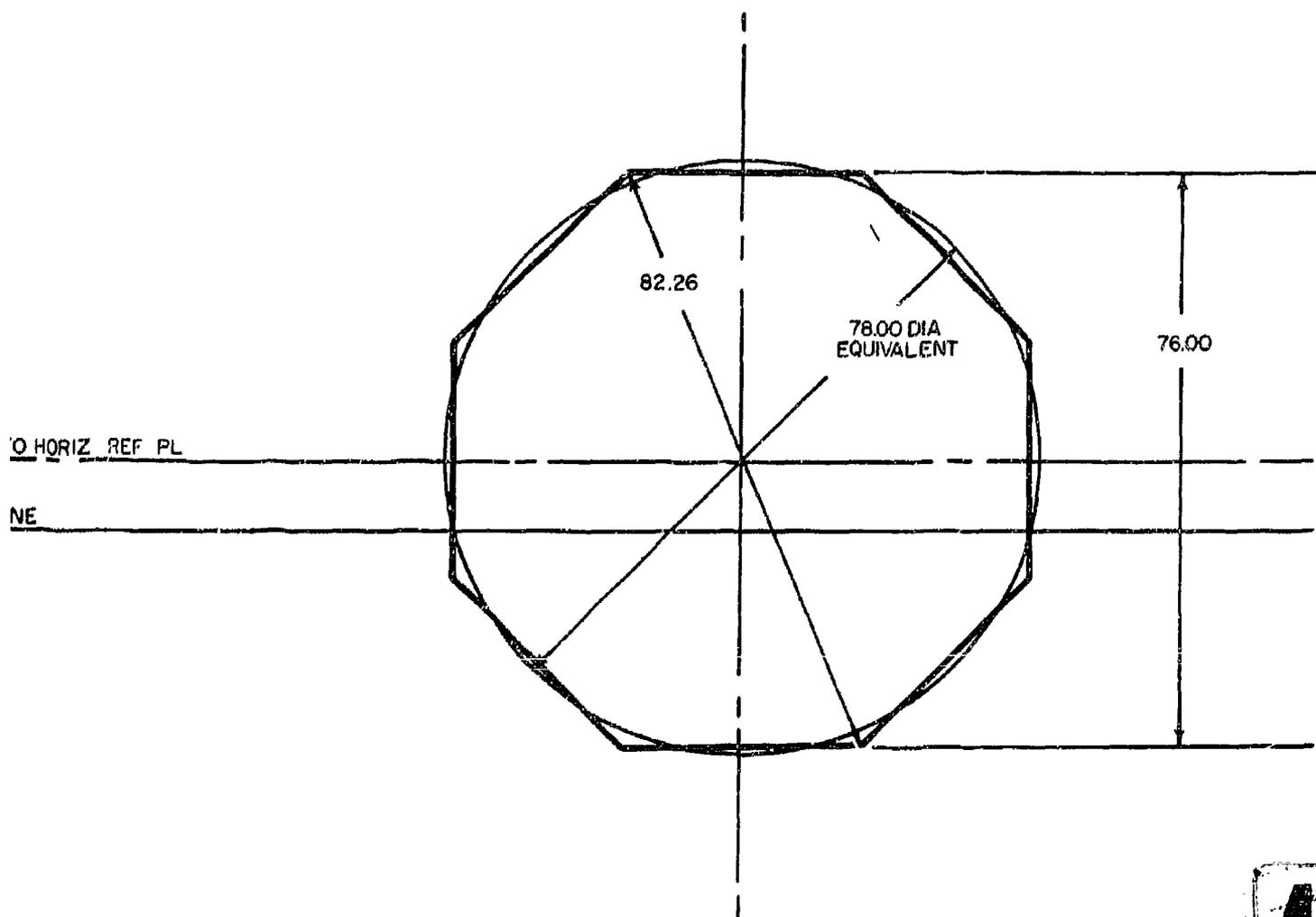
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 OLING PROVISIONS



2300°F TURBINE INLET TEMPERATURE  
STJ227, 525 LBS./SEC. (HIGH FLOW)

Figure 1-24

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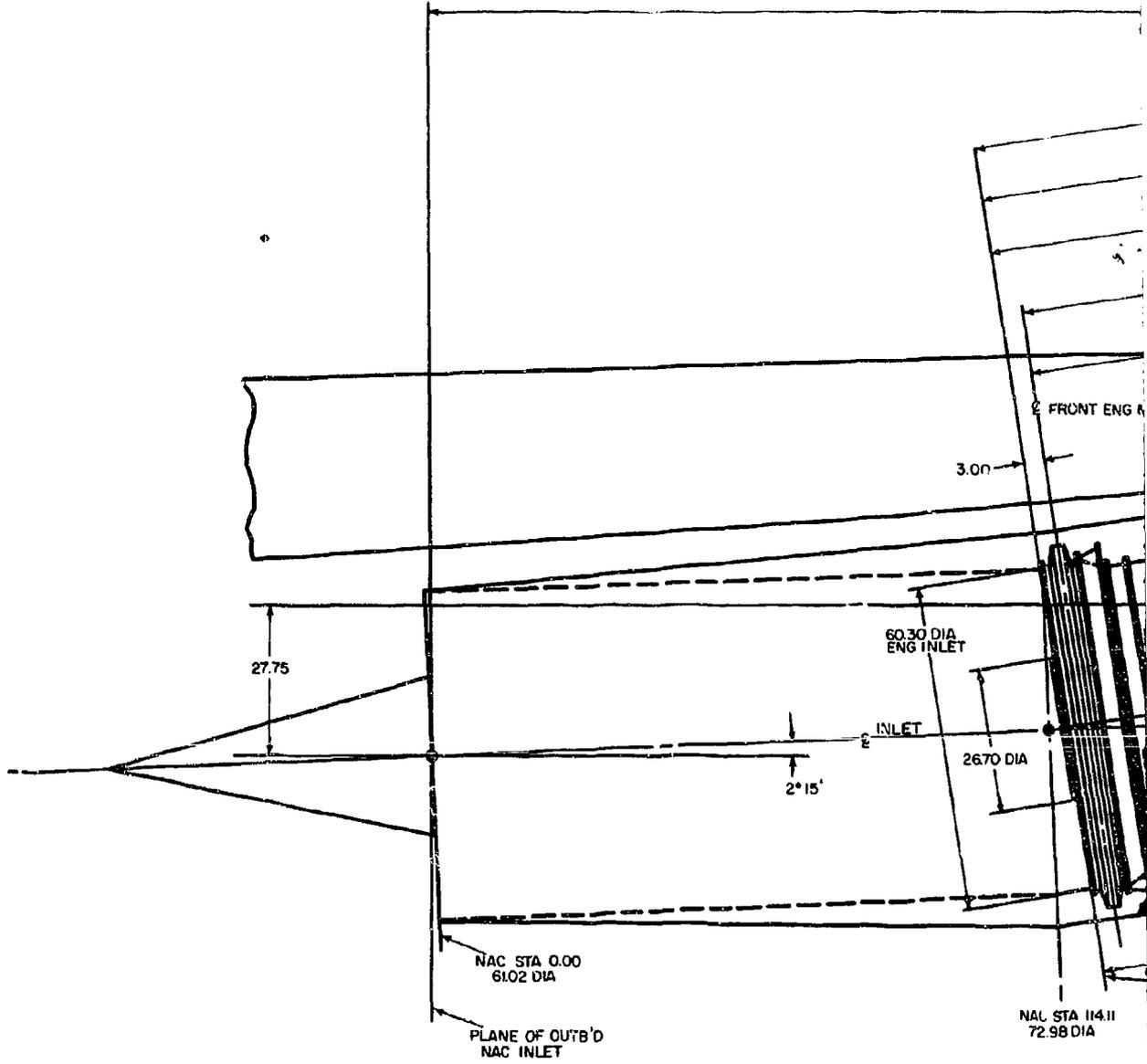
2300°F TURBINE INLET TEMPERATURE  
STJ227, 525 LBS./SEC. (HIGH FLOW) TURBOJET

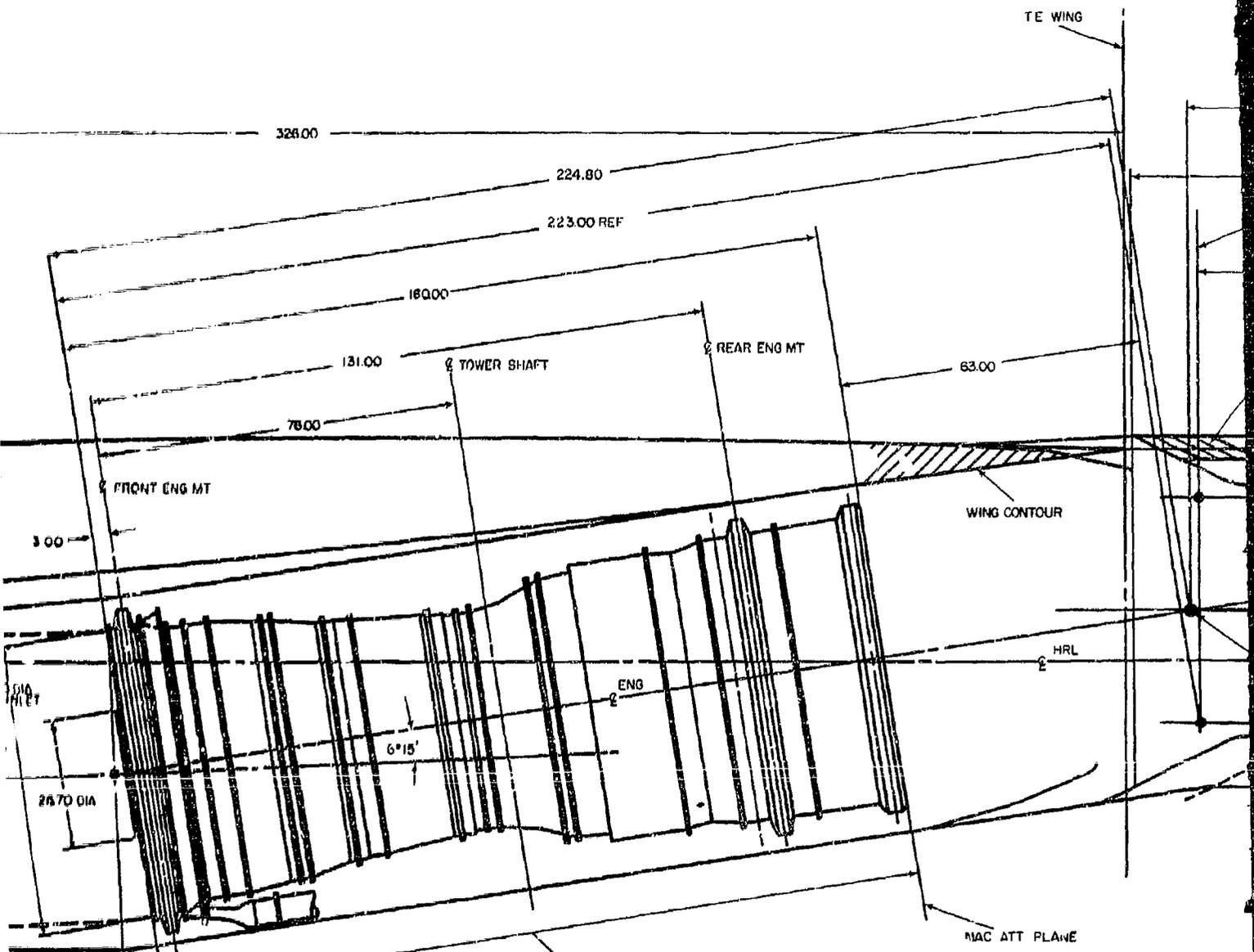
Figure 1-24

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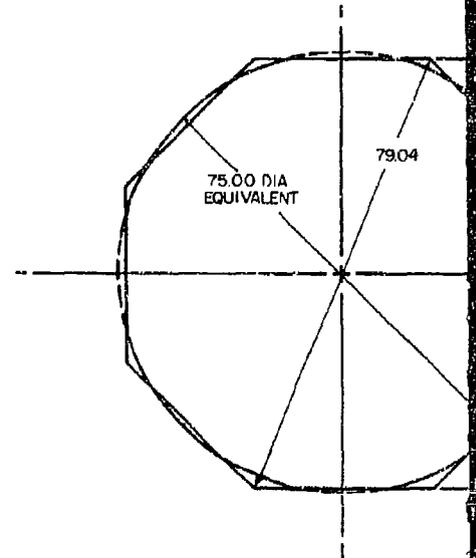
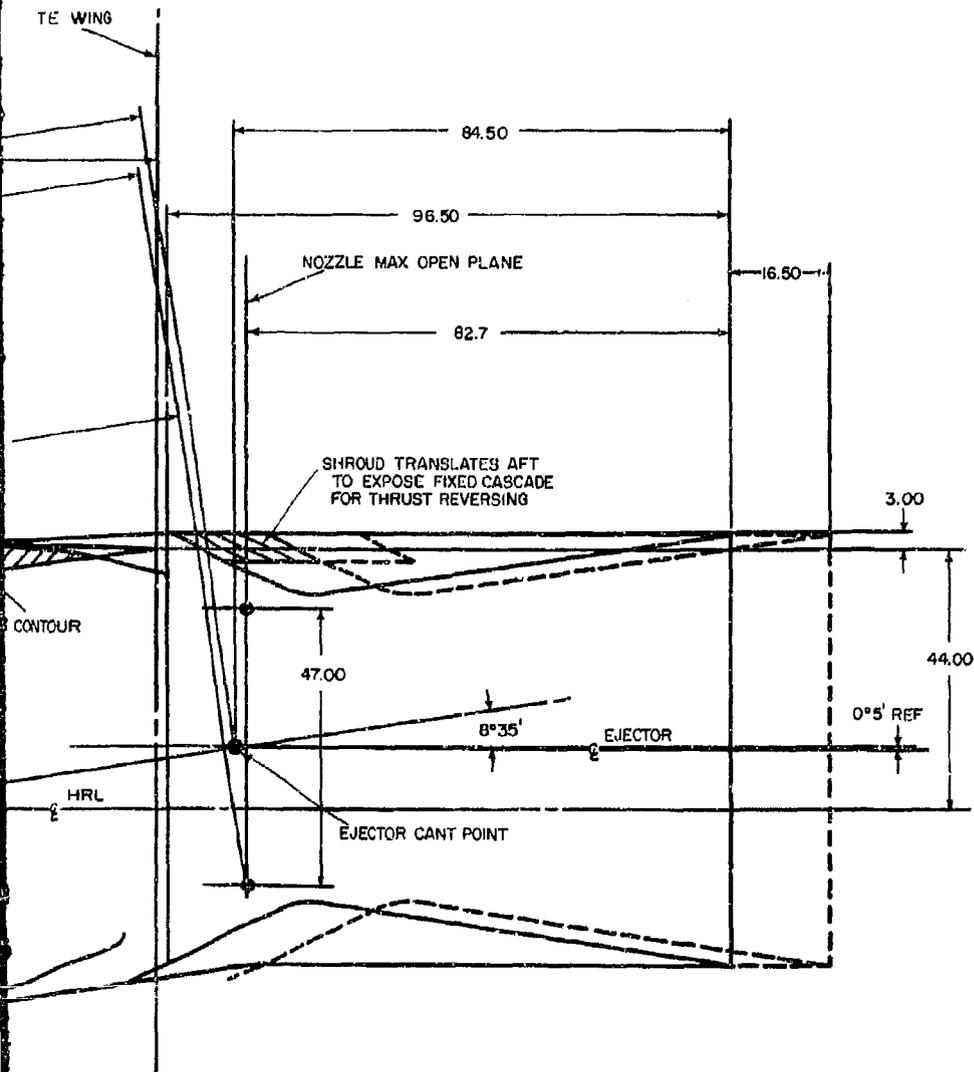




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72.00 DIA

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 1 ENGINE ACCESSORY ARRANGEMENT  
 2 SECONDARY AIR PROVISIONS FOR EJECTOR  
 3 REAR CASE & A/B COOLING PROVISIONS

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2300°F TURBINE INLET TEMPERAT  
THIS ENVELOPE IS SUBJECT TO CH  
1. ENGINE ACCESSORY ARRANGEM  
2. SECONDARY AIR PROVISIONS FO  
3. REAR CASE & A/B COOLING PRO

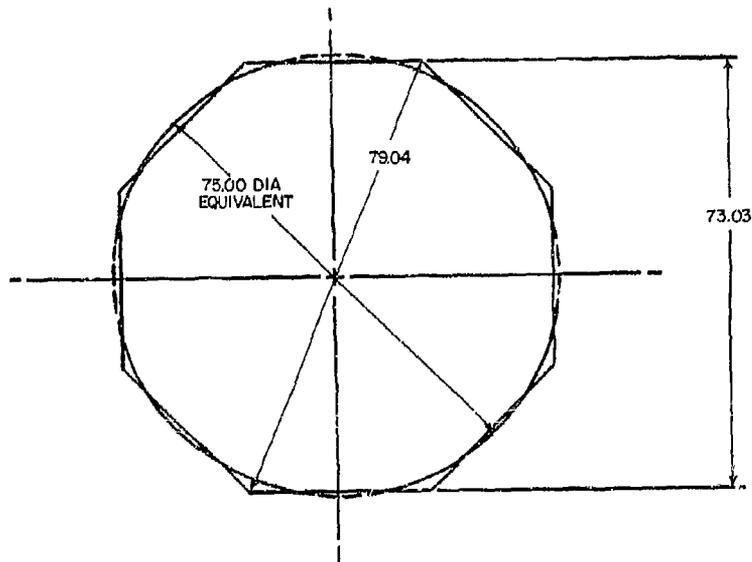
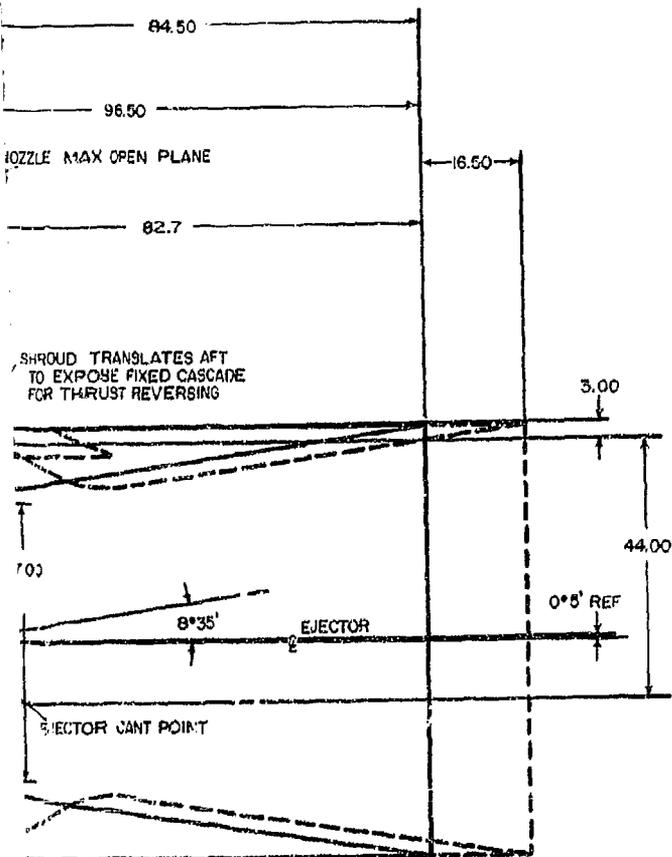
STJ227, 525 LBS./SEC. (BASE FLOW) TURBOJET

Figure 1-25

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PWA-2600



2300°F TURBINE INLET TEMPERATURE  
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1. ENGINE ACCESSORY ARRANGEMENT  
2. SECONDARY AIR PROVISIONS FOR EJECTOR  
3. REAR CASE & A/B COOLING PROVISIONS

STJ227, 525 LBS./SEC. (BASE FLOW) TURBOJET

Figure 1-25

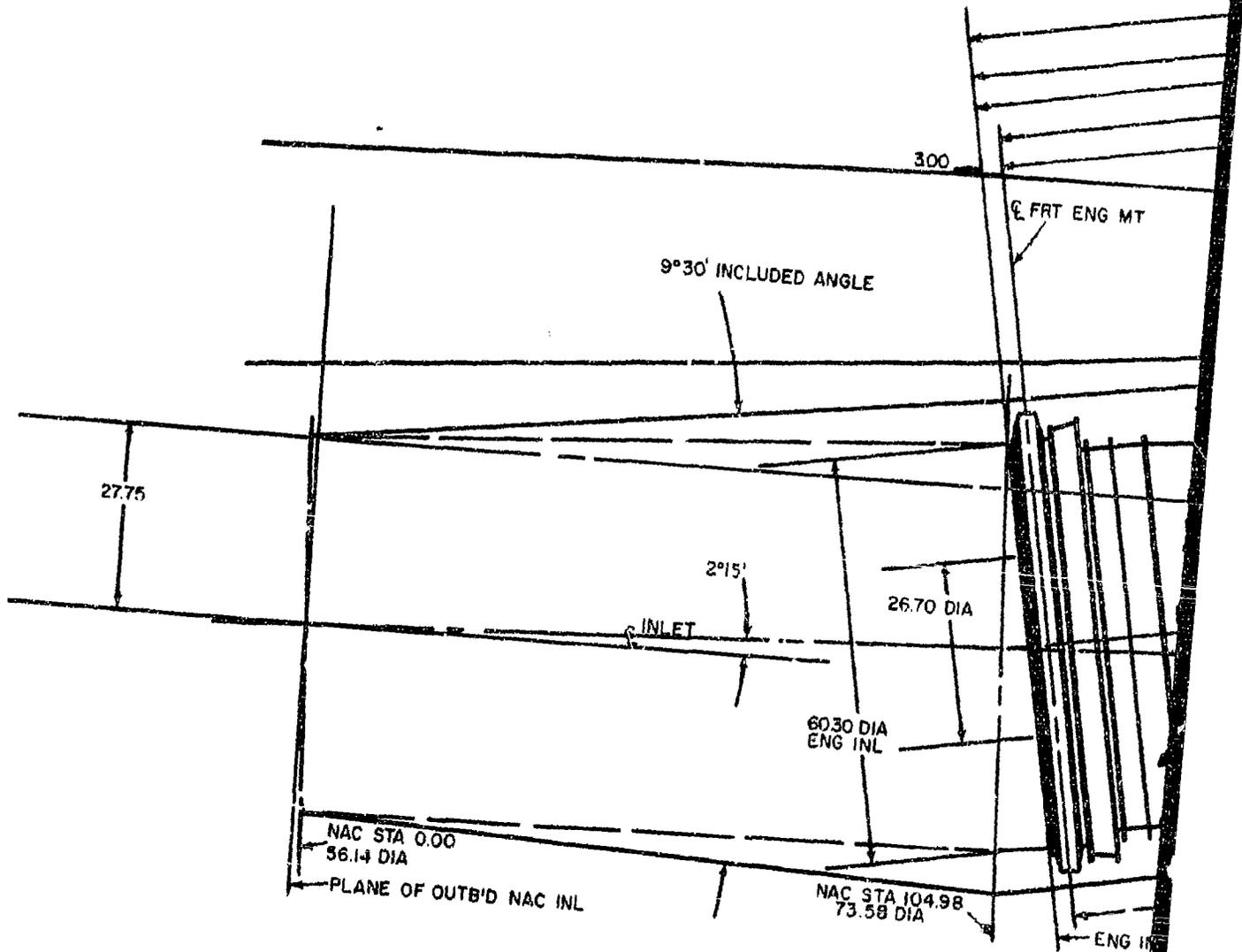
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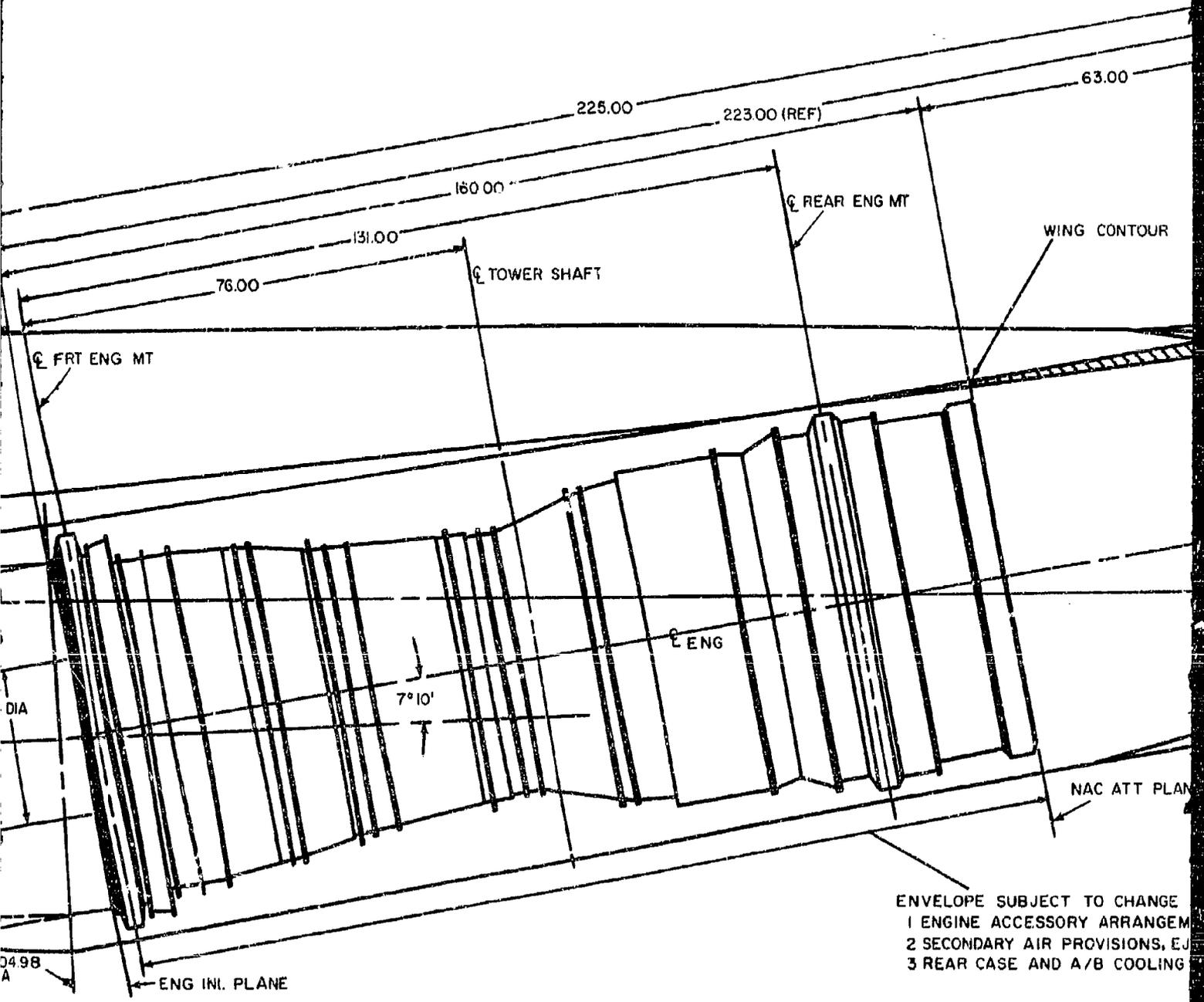
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GPO 1975 O-300-10

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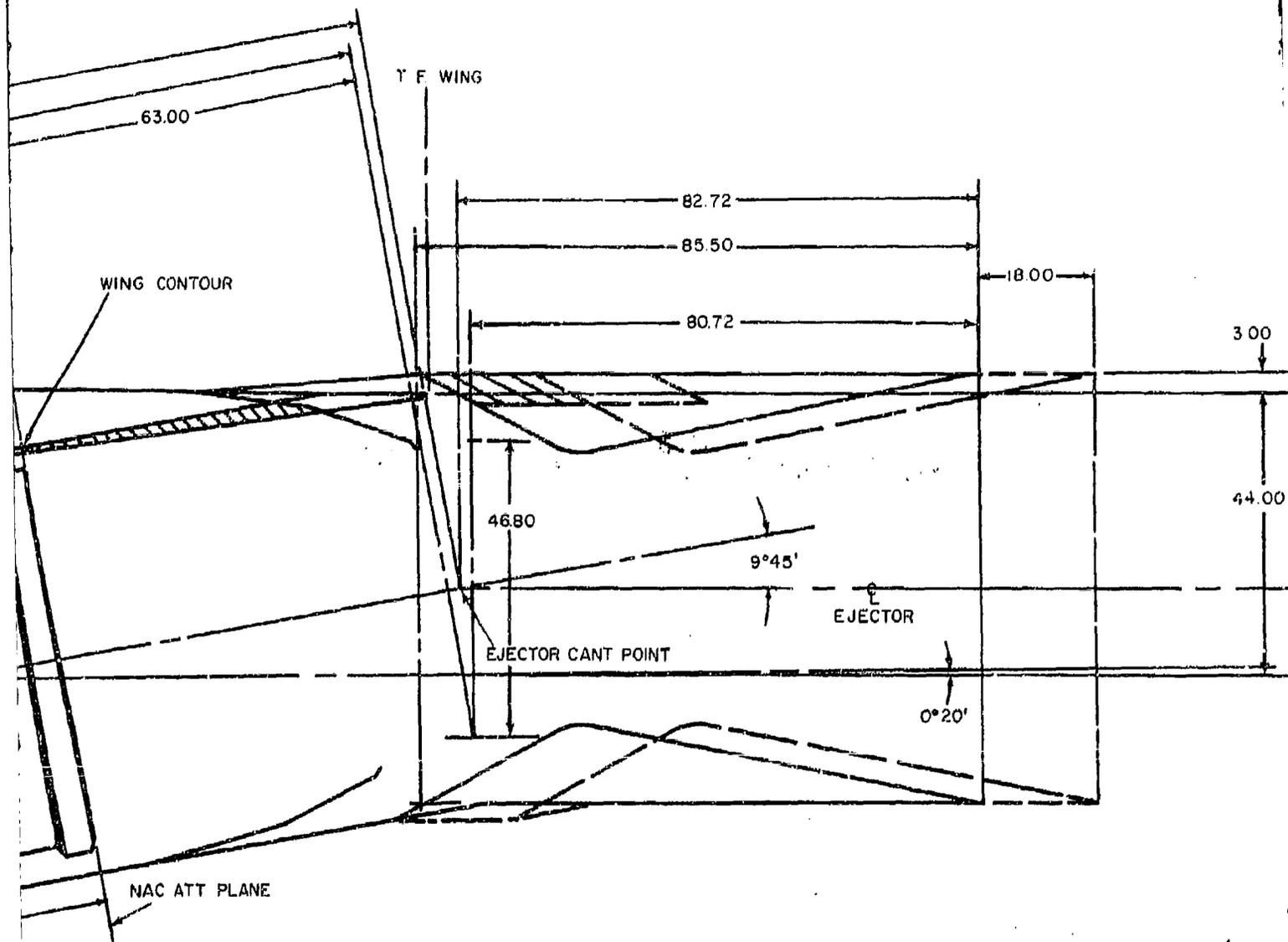
4

PRATT & WHITNEY AIRCRAFT





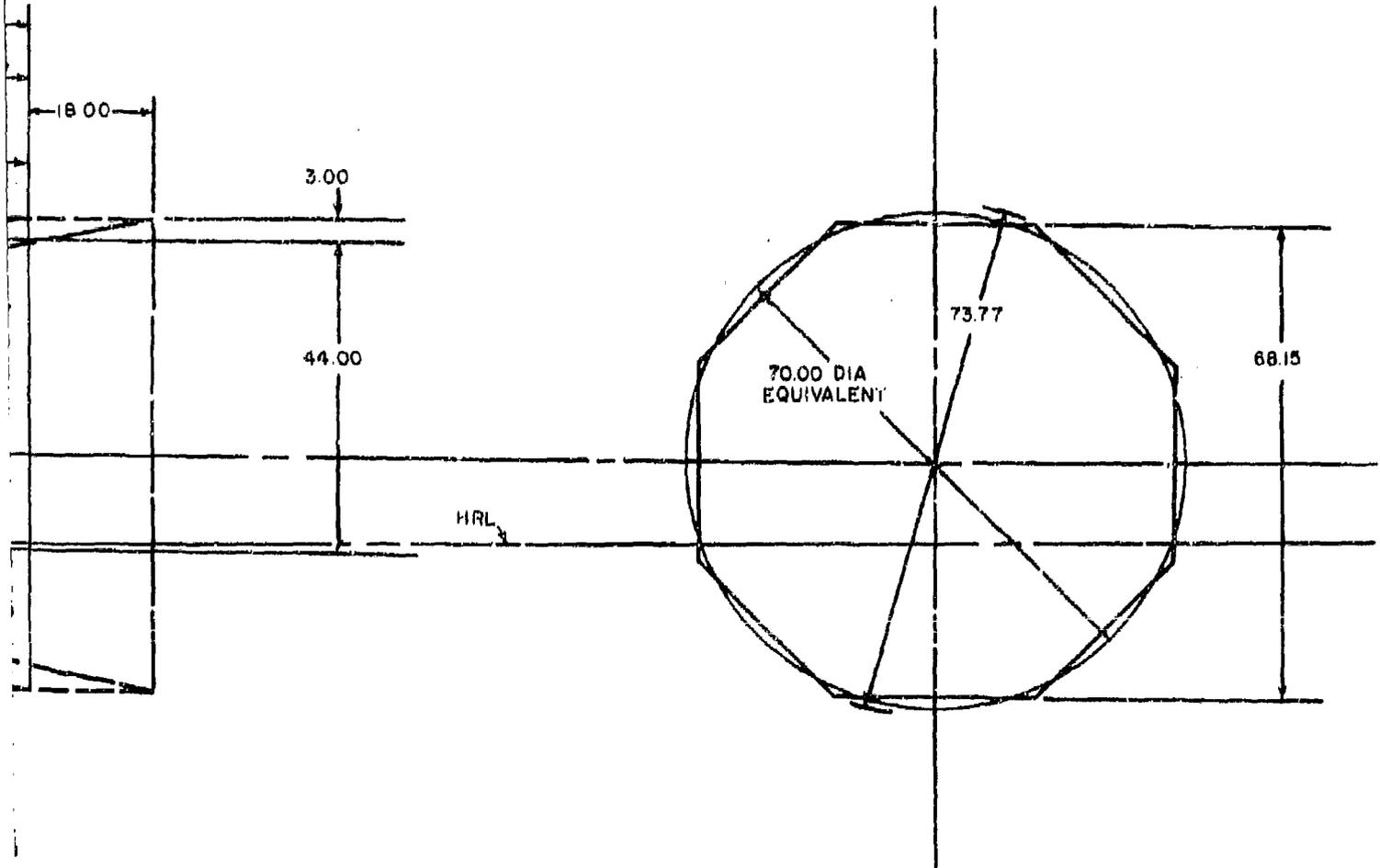
ENVELOPE SUBJECT TO CHANGE  
 1 ENGINE ACCESSORY ARRANGEM  
 2 SECONDARY AIR PROVISIONS, EJ  
 3 REAR CASE AND A/B COOLING



BE SUBJECT TO CHANGE  
 IE ACCESSORY ARRANGEMENT  
 IDARY AIR PROVISIONS, EJECTOR  
 CASE AND A/B COOLING PROVISIONS

CONFIDENTIAL

PWA-2600



STJ227, 525 LBS./SEC. (LOW FLOW) TURBOJET

Figure 1-26

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4

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DATE OF REPRODUCTION  
BY THE NATIONAL ARCHIVES  
ON REQUEST AFTER 2008

PRATT & WHITNEY AIRCRAFT

**ACCESSORY DRIVE SHAFTS**

POWER TAKEOFF  
 BOOMERGA LITE AND H-1 (AND BOOMERGA)  
 HYDRAULIC PUMP (TWO 141 4483)

**FUEL DRAIN**

COMBUSTION CHAMBER FUEL DRAIN  
 CLAMP VALVE DRAIN (ZONE I)  
 CLAMP VALVE DRAIN (AIR ZONE I)  
 CLAMP VALVE DRAIN (AIR ZONE II)  
 AFTERBURNER COMBUSTION CHAMBER FUEL DRAIN

**FUEL PRESSURE**

FUEL PUMP RELIEF PRESSURE  
 CHECK VALVE FUEL PRESSURE OUTLET PRESSURE

**FUEL FLOW**

FUEL PUMP & AFTERBURNER FUEL SUPPLY METER  
 MAIN FUEL FLOWMETER SUPPLY METER  
 MAIN FUEL FLOWMETER SUPPLY OUTLET  
 AFTERBURNER FLOWMETER SUPPLY METER  
 AFTERBURNER LOWPRESSURE SUPPLY OUTLET

**FUEL VENT**

FUEL PUMP OUTLET VENT

**PRESSURE SENSING**

FURNACE EXIT PRESSURE

**OL BREATHER**

MAIN OL OVERPRESSURE BREATHER

**OL DRAIN**

OL MAIN DRAIN  
 OL MAIN OVERFLOW DRAIN  
 OL OL OVERFLOW DRAIN  
 MAIN OL DRAIN  
 OL STRAINER DRAIN

**OL FLOW**

OL MAIN FLOW METER  
 OL MAIN FLOW METER

**OL PRESSURE**

PRESSURE FOR TRANSMITTER  
 OL FILTER INLET PRESSURE  
 OL FILTER OUTLET PRESSURE

**OL TEMPERATURE**

MAIN OL TEMPERATURE

**OL VENT**

OL PRESSURE TRANSMITTER VENT

**DEAL DRAIN**

FUEL CONTROL DEAL DRAIN  
 FUEL PUMP DEAL DRAIN  
 HYDRAULIC PUMP DEAL DRAIN  
 AFTERBURNER FUEL PUMP DEAL DRAIN

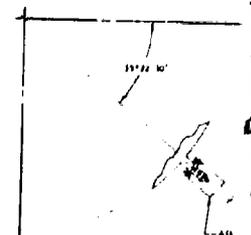
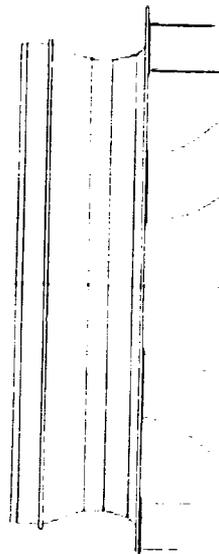
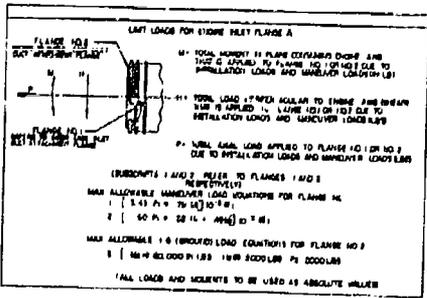
**TEMPERATURE SENSING**

FURNACE EXIT TEMPERATURE (AUX)  
 FURNACE EXIT TEMPERATURE (NORMAL)

**MISCELLANEOUS**

- 101-01-01 MAIN FUEL PUMP
- 101-01-02 FUEL PUMP FUEL FILTER (141 4483)
- 101-01-03 FUEL PUMP FUEL FILTER (LOW SPACE FOR REMOVAL)
- 101-01-04 AFTERBURNER FUEL PUMP
- 101-01-05 HYDRAULIC PUMP
- 101-01-06 OL PUMP
- 101-01-07 OL FILTER
- 101-01-08 FUEL OL COOLER (AUX)
- 101-01-09 FUEL OL COOLER (NORMAL)
- 101-01-10 GASKET
- 101-01-11 AUTOMATIC RESTART SWITCH
- 101-01-12 BREATHER PRESSURE SENSING VALVE
- 101-01-13 MAIN FUEL CONTROL
- 101-01-14 AFTERBURNER FUEL CONTROL

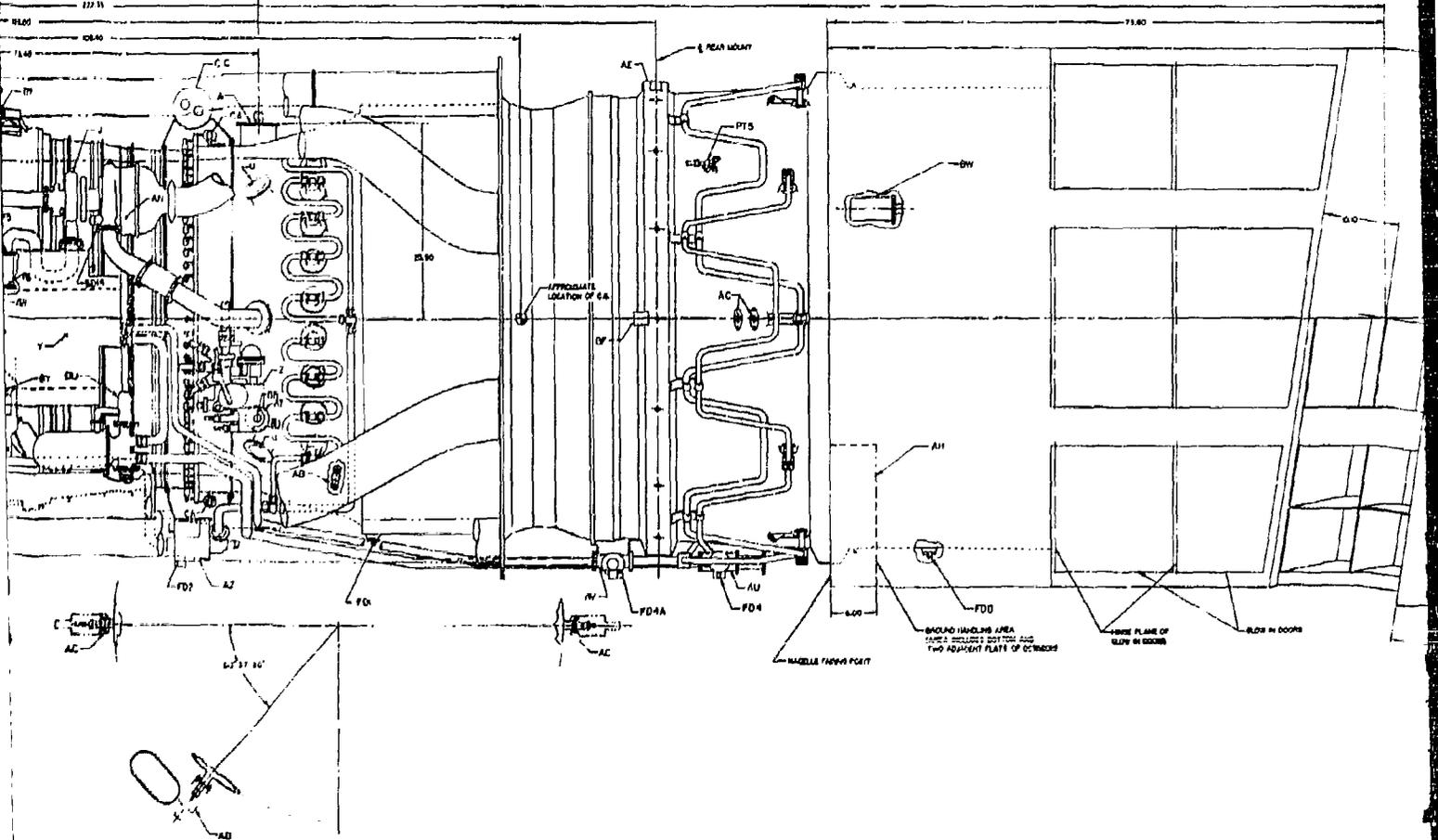
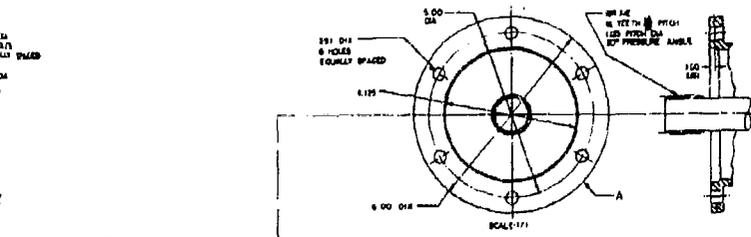
- 101-01-15 EXHAUST NOZZLE CONTROL
- 101-01-16 THERMAL PROTECTION FLUX
- 101-01-17 EXHAUST FUEL METERING VALVE FOR REMOVAL
- 101-01-18 EXHAUST FUEL (AFTERBURNER) METER SHAFT FOR REMOVAL
- 101-01-19 EXHAUST FUEL METERING THERMOPILE
- 101-01-20 EXHAUST FUEL METERING PRESSURE
- 101-01-21 FUEL RETURN TO SUPPLEMENTARY COOLING
- 101-01-22 GROUND HANDLING VALVE (RIGHT MOUNT)
- 101-01-23 GROUND HANDLING VALVE (LEFT MOUNT)
- 101-01-24 POWER CONTROL LEVER (DOWNWARD OF TRAVEL)
- 101-01-25 STOP OFF LEVER (UPWARD OF TRAVEL)
- 101-01-26 APPROACH VELOCITY CONTROL LEVER (UPWARD OF TRAVEL)
- 101-01-27 MACH NO ON SIGHT POSITION METER LEVER (UPWARD OF TRAVEL)
- 101-01-28 AIR FURNISH VALVE (AFTERBURNER FUEL PUMP)
- 101-01-29 METER (EXHAUST ELECTRICAL DOWN)
- 101-01-30 THERMAL SHUT OFF (NO)
- 101-01-31 AUTOMATIC DRIVE CONTROL AIR SUPPLY COIL
- 101-01-32 EXHAUST NOZZLE FEEDBACK
- 101-01-33 OIL COOL FLOW METER (AFTERBURNER ZONE I)
- 101-01-34 OIL COOL FLOW METER (AFTERBURNER ZONE II)
- 101-01-35 GAS EXHAUSTOR FUEL FLOWMETER
- 101-01-36 MAIN FUEL FLOWMETER
- 101-01-37 AFTERBURNER FUEL FILTER (LOW SPACE FOR REMOVAL)
- 101-01-38 MODEL OVERPRESSURE CHECK VALVE (MAIN FUEL)
- 101-01-39 OL LINE
- 101-01-40 NOZZLE POSITION INDICATOR MOUNTING BRACKET
- 101-01-41 METER POSITION INDICATOR (EXHAUST ELECTRICAL)
- 101-01-42 THERMOPILE FUEL PRESSURE VALVE
- 101-01-43 VENTURON METER (SPACE RESERVED FOR FLOW)
- 101-01-44 CONTROL CABLE FUEL CONTROL
- 101-01-45 EXHAUST AIR SHUT OFF VALVE
- 101-01-46 FUEL FLOW TEMPERATURE SENSOR
- 101-01-47 OL OILLINE TEMPERATURE SENSOR WITH AFTERBURNER MALL
- 101-01-48 HYDRAULIC RETURN FILTER
- 101-01-49 EXHAUST NOZZLE ACTUATOR
- 101-01-50 STOP OFF BLEED DOOR ACTUATOR
- 101-01-51 FUEL FLOW METER ACTUATOR
- 101-01-52 ALGEBRAIC BRIDGE ACTUATOR
- 101-01-53 EXHAUST METER
- 101-01-54 EXHAUST METER (AFTERBURNER)



VIEW 14 MAIN FUEL PUMP  
 (SEE FIG. 14)





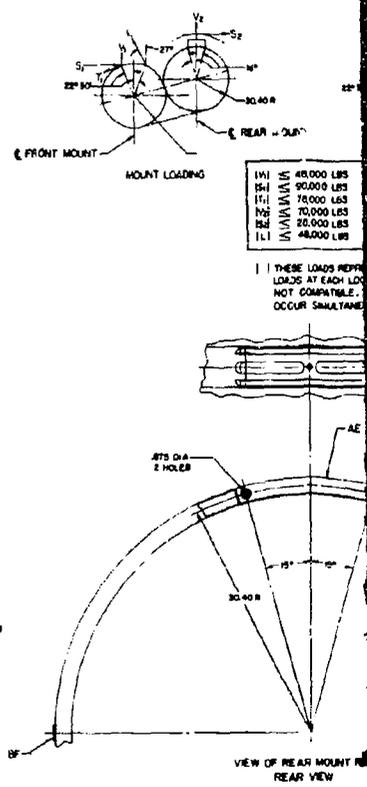
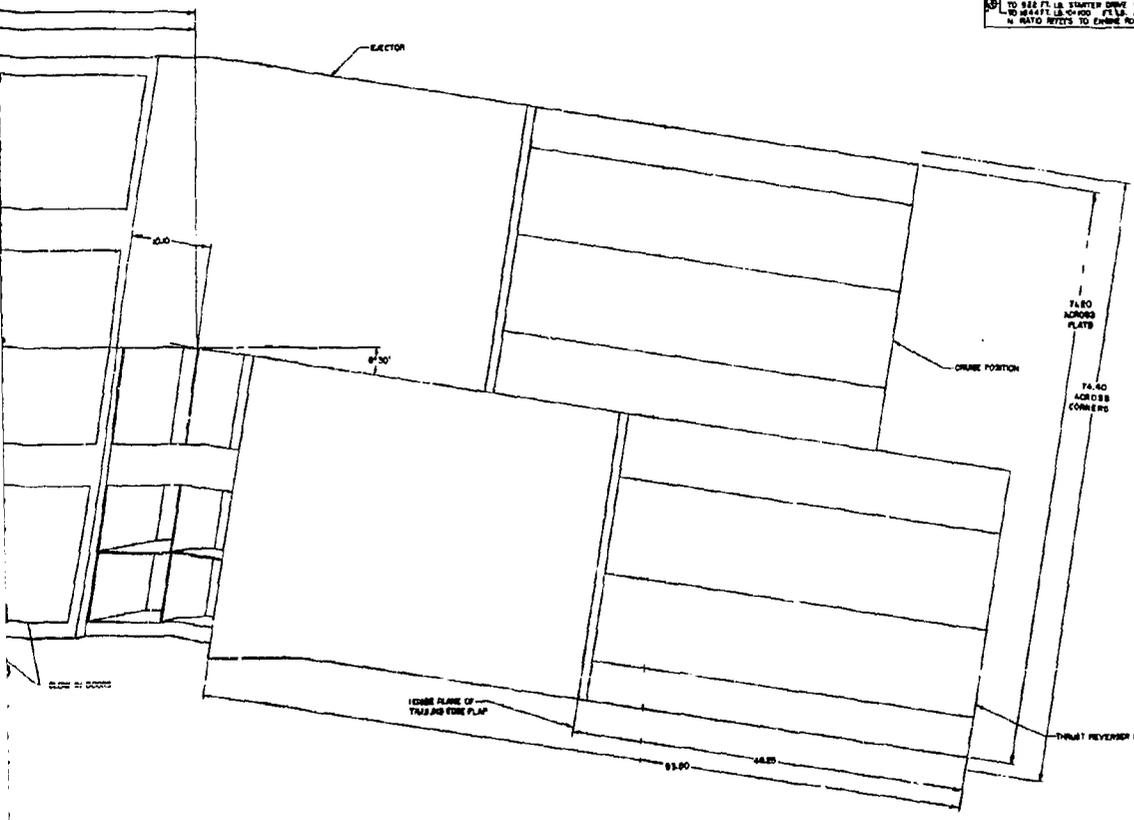


VIEW OF MAIN ENGINE  
LOOKING FORWARD

TORQUE & MOMENT LIMITATION TABLE-ACCESS DRIVES

| DRIVE<br>FRD | NOMINAL<br>USE  | TORQUE (L.B.-IN.) |          |        | SPEED<br>RPM | ROTATION<br>(FACING<br>ENGINE<br>END) | + G<br>OVERLOAD<br>% (1.1 - 1.4<br>L.D. P.) |
|--------------|-----------------|-------------------|----------|--------|--------------|---------------------------------------|---|
|              |                 | CONTINUOUS        | OVERLOAD | STATIC |              |                                       |   |
| A            | TURBO<br>ACCESS | 2334              | 3500     | 24200  | 2,940        | CCW                                   |   |
| B            | PACK            | 7                 | 50       | 762    | 4            | CCW                                   |   |
| C            | HYDRAID         | 948               | 1420     | 1730   | 980          | CCW                                   |   |

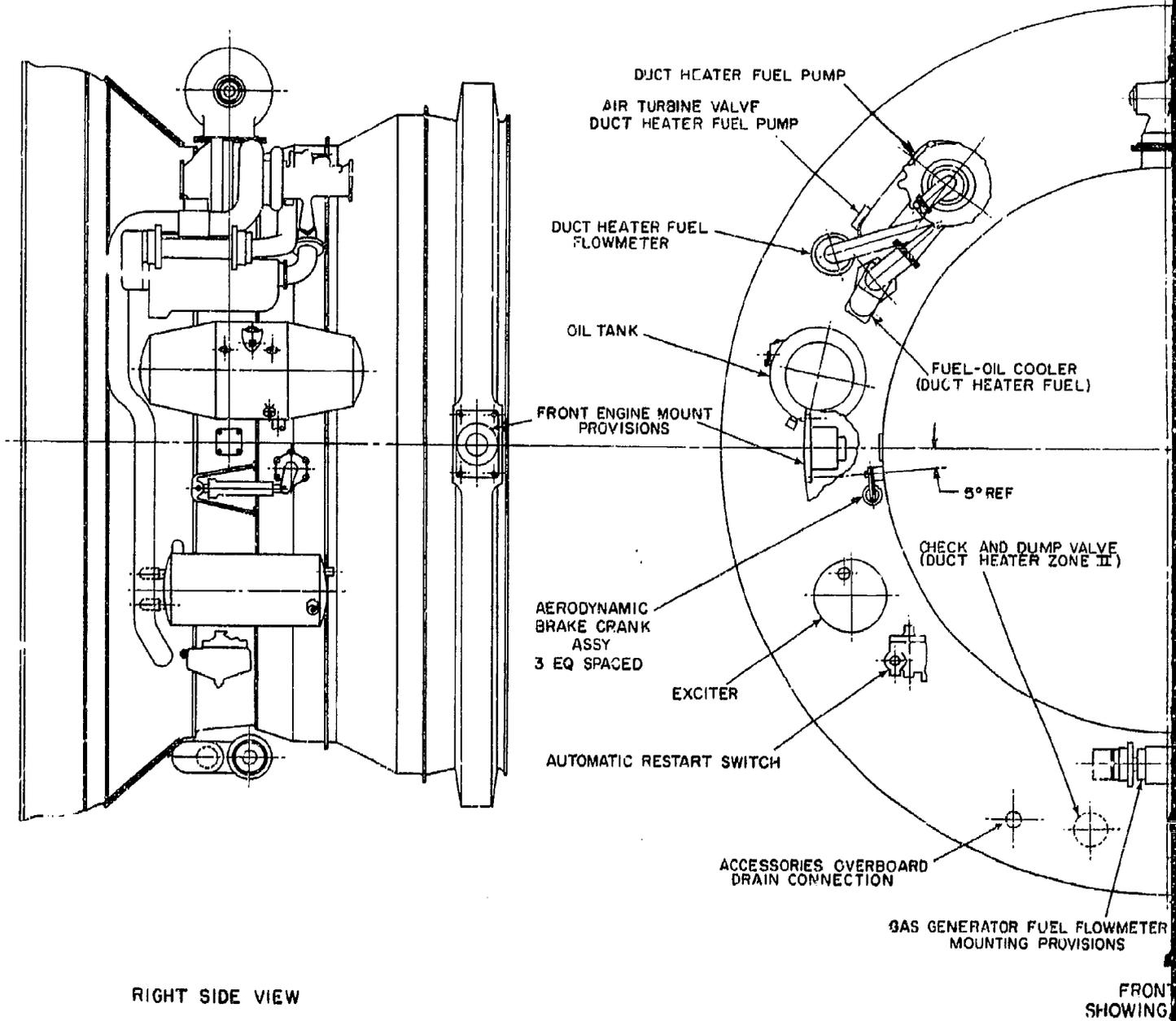
MAX ALLOWABLE CONTINUED TORQUE VALUES ARE 50 PER CENT ENGINE SPEED UNLESS OTHERWISE SPECIFIED. NO DESTRUCTIVE FORCES RESULTING FROM ACCESS OPERATIONAL POSITION ARE PERMITTED.  
 MAX ALLOWABLE OVERLOAD BEYOND MOMENTS OF ACCELERATION ABOUT DRIVE AND CG ARE AS SHOWN PROVIDED NO DESTRUCTIVE FORCES RESULT FROM ACCESS OPERATION ARE PERMITTED.  
 MAX ALLOWABLE FOR 5 MINUTE DUMP ON RELOADING AT 400 RPM INTERVALS OR P.T.O. DRIVE SHALL HAVE ADEQUATE STRENGTH TO ACCOMMODATE A MAX TORQUE EQUAL TO 842 FT. LB. SIMILAR DRIVE BEARING SECTION SHALL FAIL AT A STATIC TORQUE EQUIV TO 842 FT. LB. WHEN P.T.O. IS AT 400 RPM.  
 MAX ALLOWABLE FOR 5 MINUTE DUMP ON RELOADING AT 400 RPM INTERVALS OR P.T.O. DRIVE SHALL HAVE ADEQUATE STRENGTH TO ACCOMMODATE A MAX TORQUE EQUAL TO 842 FT. LB. WHEN P.T.O. IS AT 400 RPM.



PROPOSED TURBOJET ACCESSOR

Figure 1-27

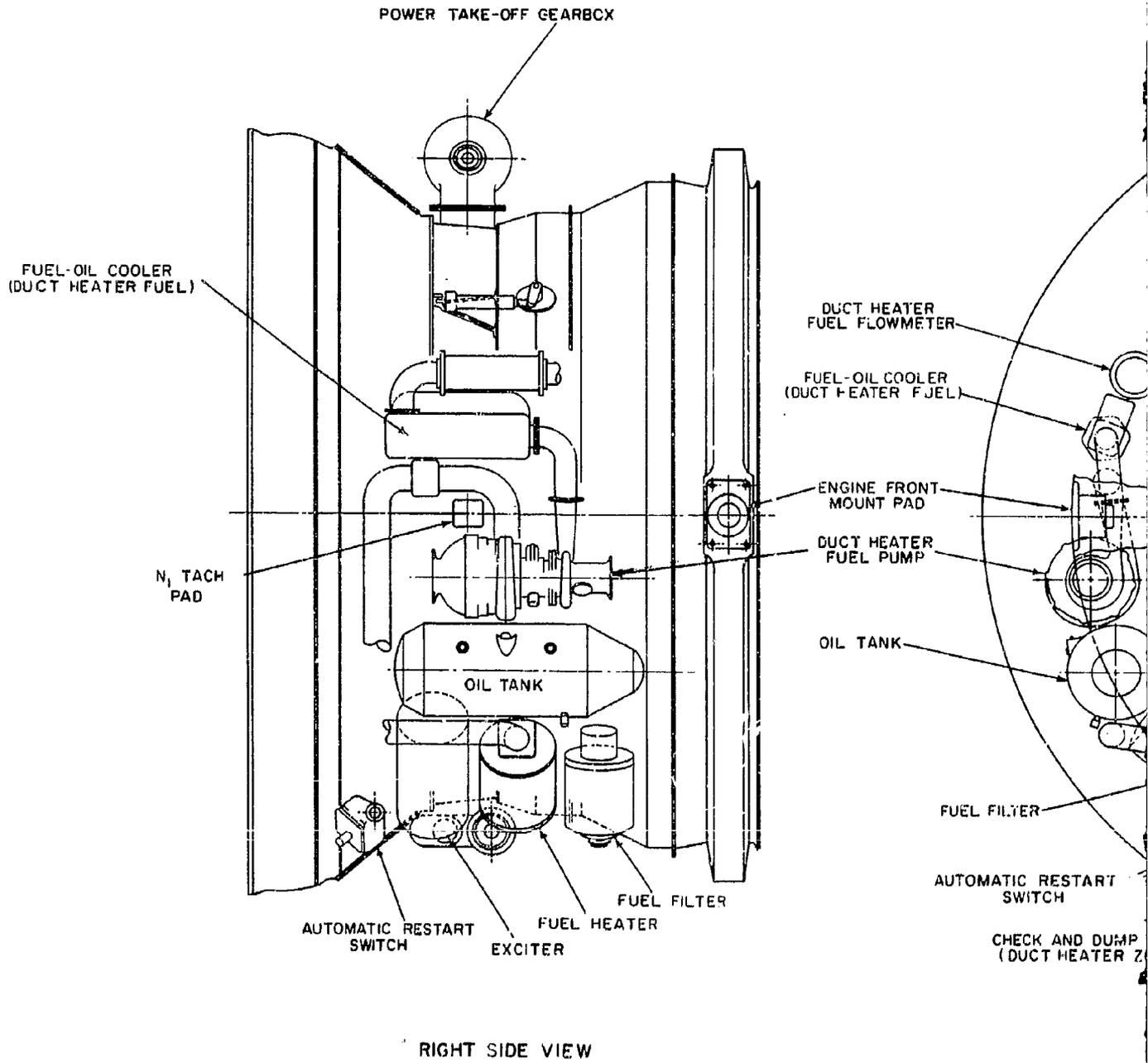


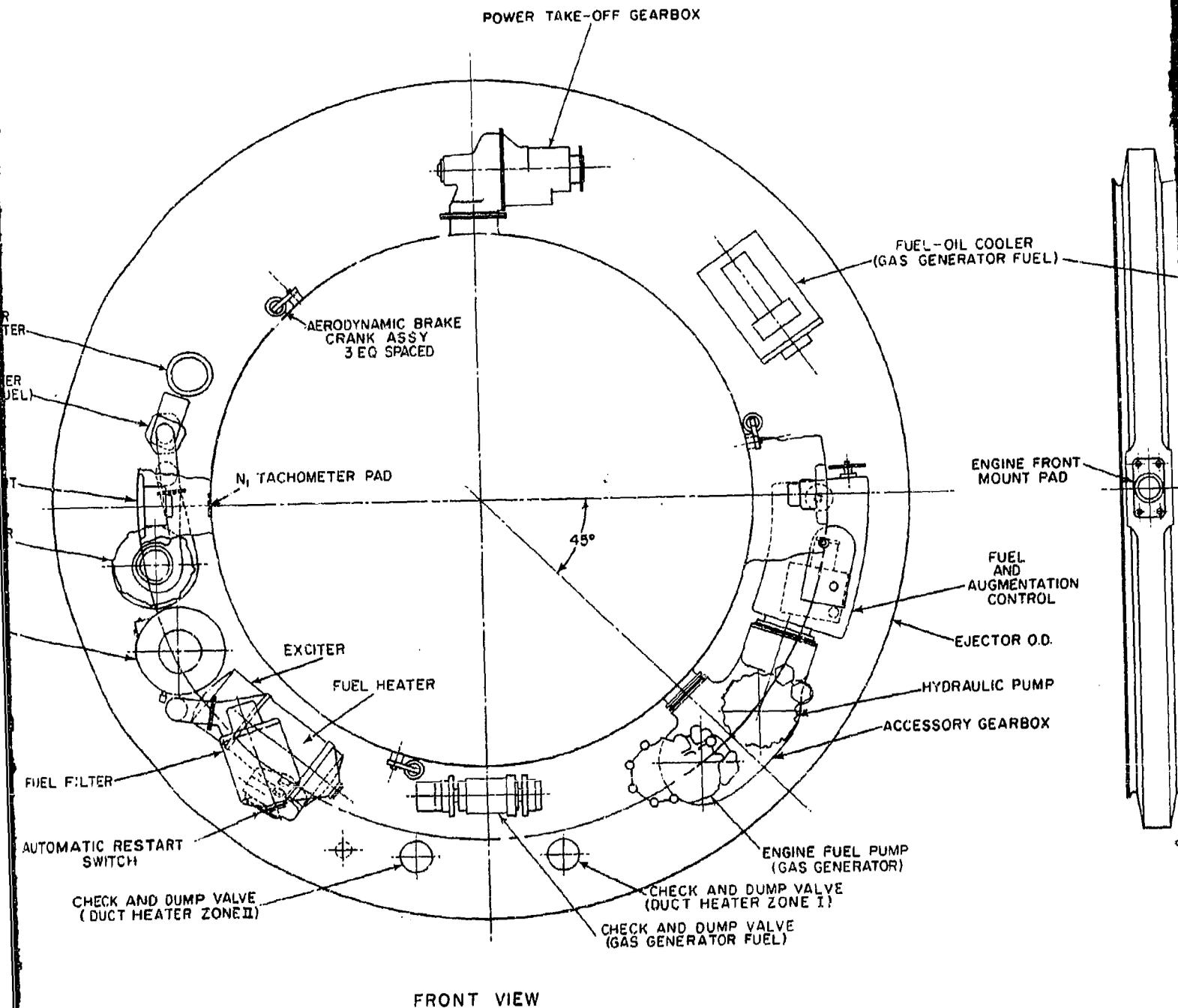


RIGHT SIDE VIEW

FRONT SHOWING

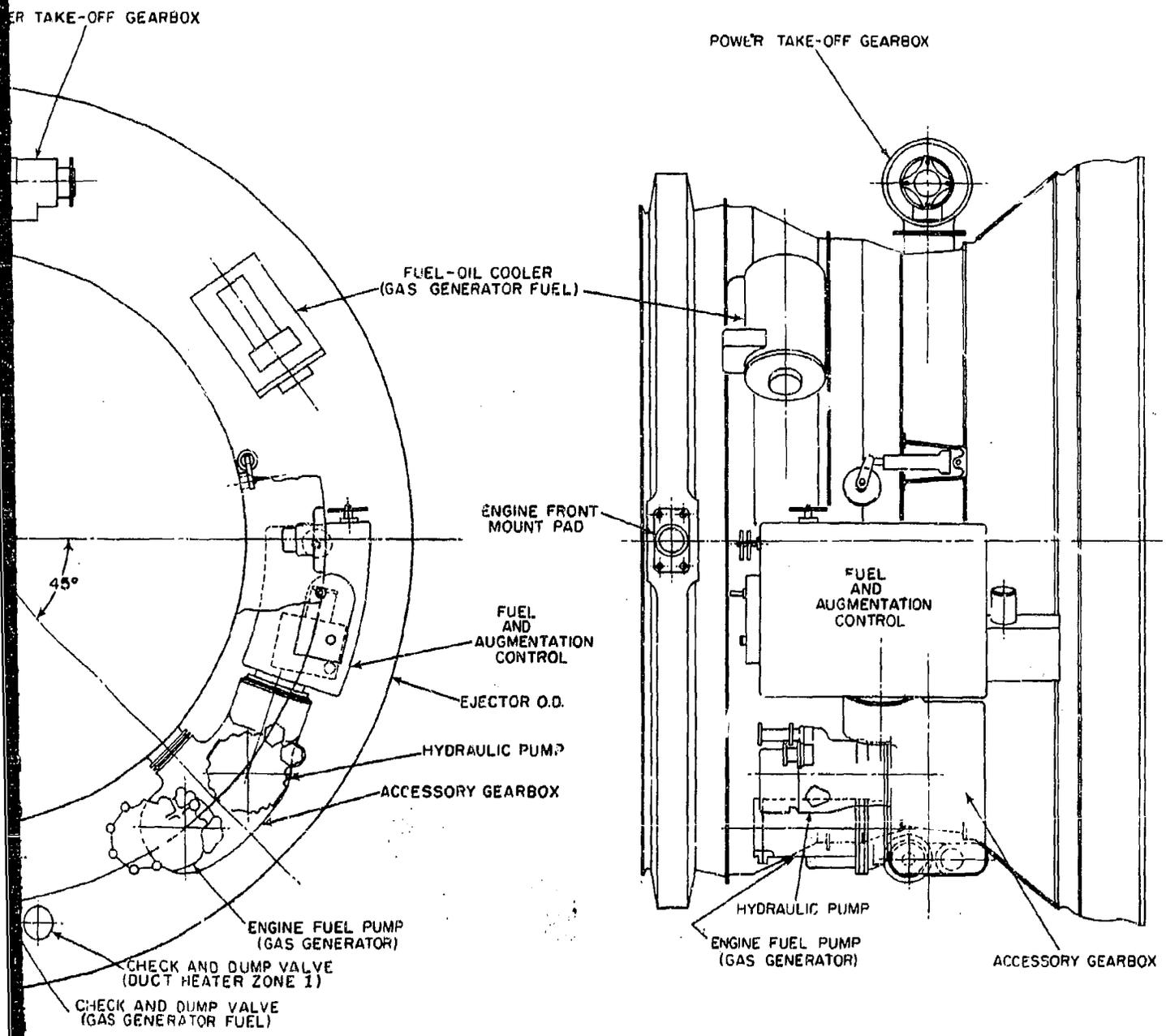






REVISED ACCESSORY ARRANGEMENT MOUNT STRUCTURE AT

Figure 1-20



LEFT SIDE VIEW

REVISED ACCESSORY ARRANGEMENT MAKING ROOM FOR MOUNT STRUCTURE AT TOP OF ENGINE

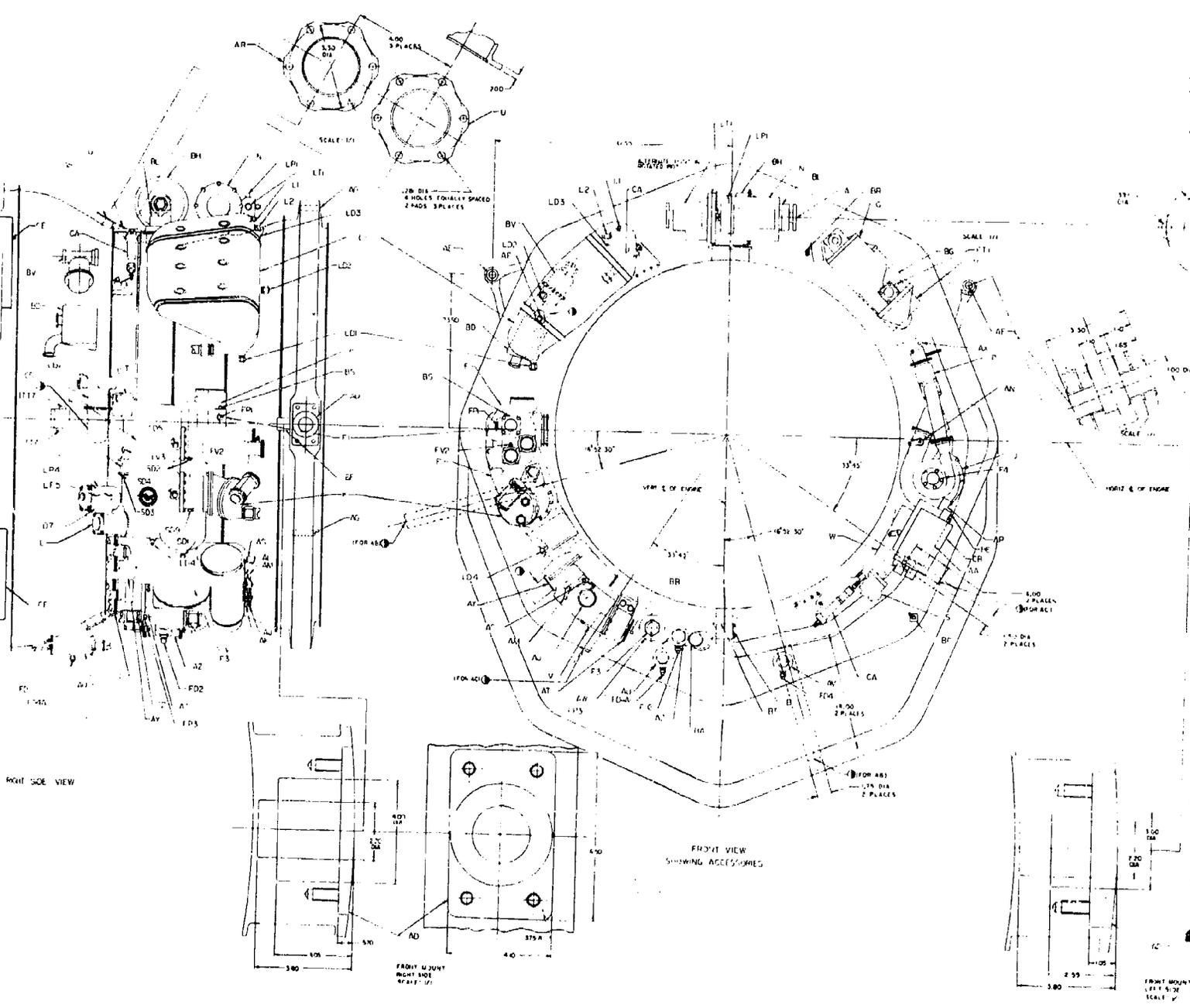
Figure 1-29

3

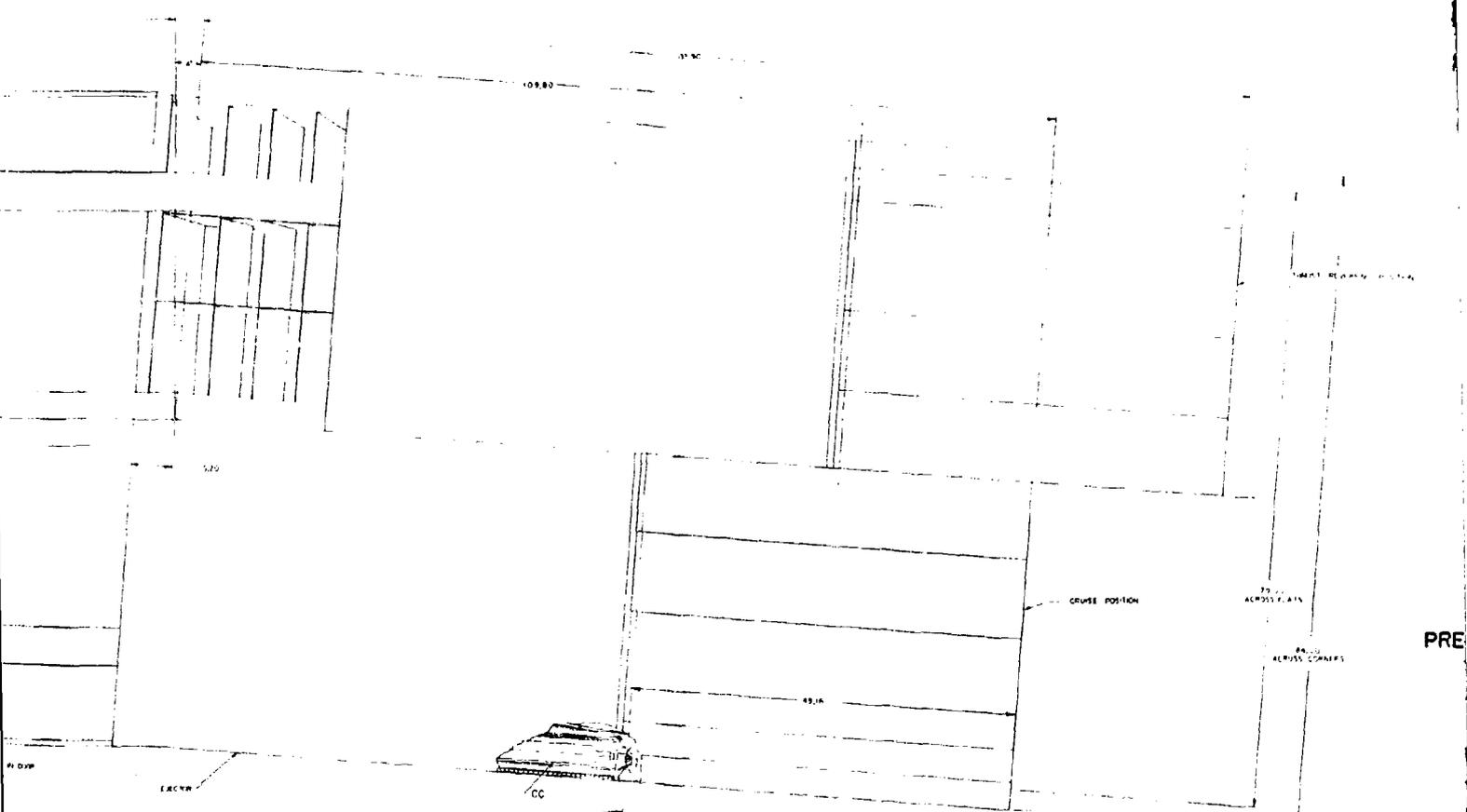
REPLACEMENT AT 5 YEAR INTERVALS  
REPLACEMENT AFTER 10 YEARS  
100 000 0000

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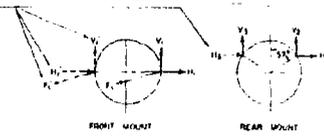




| TYPE | TORQUE & MOMENT LIMITATION TABLE ACCESSORY |        | SPEED DATA | ROTATION | T/R |
|------|--|--------|------------|----------|-----|
|      | CONTINUOUS OVERLOAD                        | STATIC |            |          |     |
| A    | 2360                                       | 2540   | 2040 RPM   | CCW      |     |
| B    |  |        | 50 RPM     | CCW      |     |
| C    |  |        | 742 RPM    | CCW      |     |

NOTES: (1) FOR MILITARY COMPRESSION TURBOFAN USE WITH SPEED LIMITER TO MAINTAIN COMPRESSOR SURVEILLANCE WITH SPEED LIMITER. (2) CONTINUOUS LOADS ARE AT ANY ENGINE SPEED UNLESS OTHERWISE SHOWN. PROVIDE AND INDICATE FORCES IMPOSED FROM ACCESSORY OPERATION. (3) MAXIMUM MOMENTS OF ACCESSORIES ABOUT ONLY TWO POINTS ARE AS SHOWN. PROVIDE NO DESTRUCTIVE FORCES RESULTING FROM ACCESSORY OPERATION. (4) MAX ALLOWABLE FOR TWO MINUTES DURATION REQUIRING AT FOUR HOUR INTERVALS. (5) ALL DIMENSIONS SHALL HAVE ADEQUATE STRENGTH TO ACCOMMODATE MAXIMUM TORQUE. (6) FROM THE 7/16" STAMPER DRIVE SHAFT SECTION SHALL BE AT A STATIC TORQUE LOAD TO USE 17 LBS. C 400 FT LBS AT 1710 RPM.

| LIMIT LOADS FOR MULTI ALIGNED       |  |
|-------------------------------------|--|
| MAXIMUM LOADS                       |  |
| MOMENT IN PLANE CONTAINING ENG AXIS |  |
| LOAD PERPENDICULAR TO ENG AXIS      |  |
| MAXIMUM LOAD 140 LBS                |  |



|                 |                  |
|-----------------|------------------|
| N1 ≤ 47,400 LBS | N2 ≤ 45,000 LBS  |
| N3 ≤ 32,800 LBS | N4 ≤ 32,800 LBS  |
| N5 ≤ 72,000 LBS | N6 ≤ 72,000 LBS  |
| N7 ≤ 55,800 LBS | N8 ≤ 52,800 LBS  |
| N9 ≤ 52,800 LBS | N10 ≤ 55,400 LBS |

THESE LOADS REPRESENT THE MAX LOADS AT EACH LOCATION AND ARE NOT SIMULTANEOUS. THEY DO NOT OCCUR SIMULTANEOUSLY.

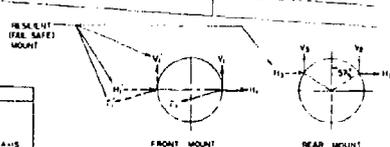
- (1) MIN SPACE FOR REMOVAL
- (2) DIMENSIONS FOR TIME POS OF FEATURES SHOWN
- (3) CENTERLINE OF CASE CONTAINING SUCH FE
- (4) UNLESS OTHERWISE INDICATED
- (5) ALL DIMENSIONS SHOWN ARE NOMINAL UNLESS
- (6) ALL DIMENSIONS GIVEN FOR ROOM TEMPERATURE

PROPOSED TURBOFAN ACCESSORY ARRANGEMENT

Figure 1-30



PRELIMINARY INSTALLATION DWG  
PRINTED JUNE 23, 1965



| LIMIT LOADS FOR INLET FLANGE     |  |
|----------------------------------|--|
| P-LEVEL LOADS                    |  |
| MOMENT IN PLANE                  |  |
| CONTAINING ENG AXIS              |  |
| M-LOAD PERPENDICULAR TO ENG AXIS |  |
| P-1 400 LBS                      |  |
| M-1 1500 FT LBS                  |  |
| M-2 600 LBS                      |  |
| MAX WT LOAD 140 LBS              |  |

|                               |                               |
|-------------------------------|-------------------------------|
| $N_1 \leq 47,400 \text{ LBS}$ | $N_2 \leq 45,100 \text{ LBS}$ |
| $H_1 \leq 32,800 \text{ LBS}$ | $H_2 \leq 32,800 \text{ LBS}$ |
| $M_1 \leq 72,000 \text{ LBS}$ | $M_2 \leq 72,000 \text{ LBS}$ |
| $M_3 \leq 55,000 \text{ LBS}$ | $M_4 \leq 50,800 \text{ LBS}$ |
| $M_5 \leq 52,800 \text{ LBS}$ |                               |
| $M_6 \leq 55,400 \text{ LBS}$ |                               |

|| THESE LOADS REPRESENT THE MAX LOADS AT EACH LOCATION AND ARE NOT COMPATIBLE. THEY DO NOT OCCUR SIMULTANEOUSLY.

- ① MIN SPACE FOR REMOVAL
- ② DETAILS FOR THE POS OF FEATURES SHOWN ARE CENTERLINES OF CASE CONTAINING SUCH FEATURES UNLESS OTHERWISE INDICATED
- ③ ALL DIMENSIONS SHOWN ARE NOMINAL UNLESS OTHERWISE SPECIFIED
- ④ ALL DIMENSIONS GIVEN FOR ROOM TEMPERATURE UNLESS OTHERWISE NOTED

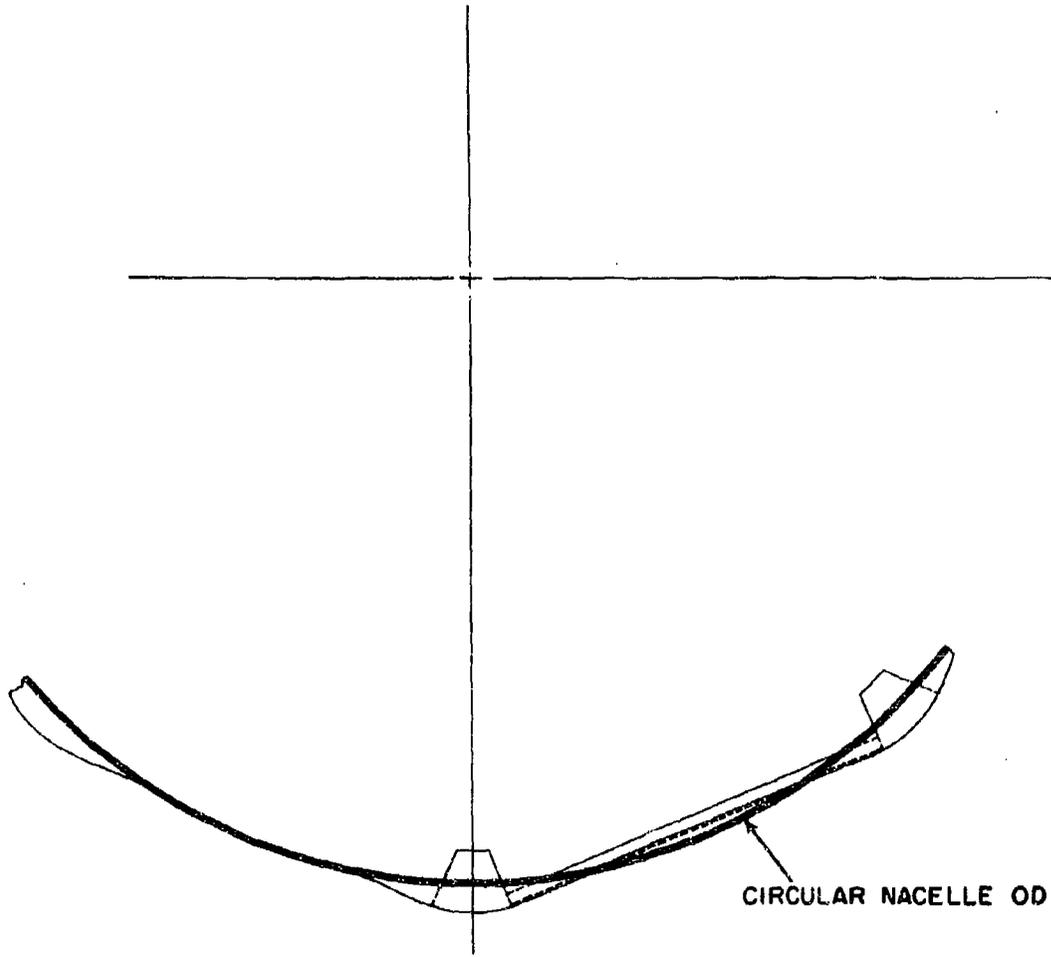
PROPOSED TURBOFAN ACCESSORY ARRANGEMENT

Figure 1-30

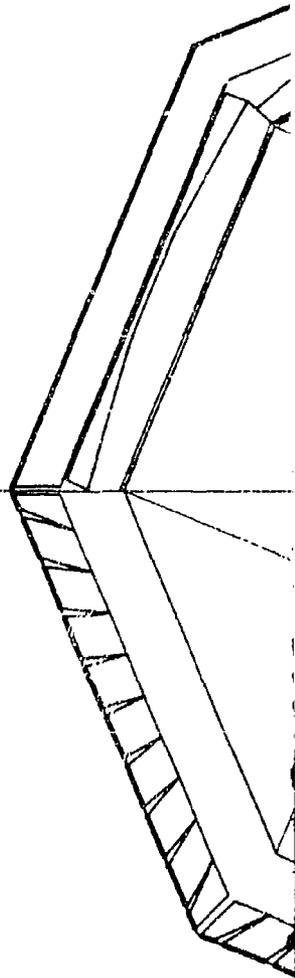
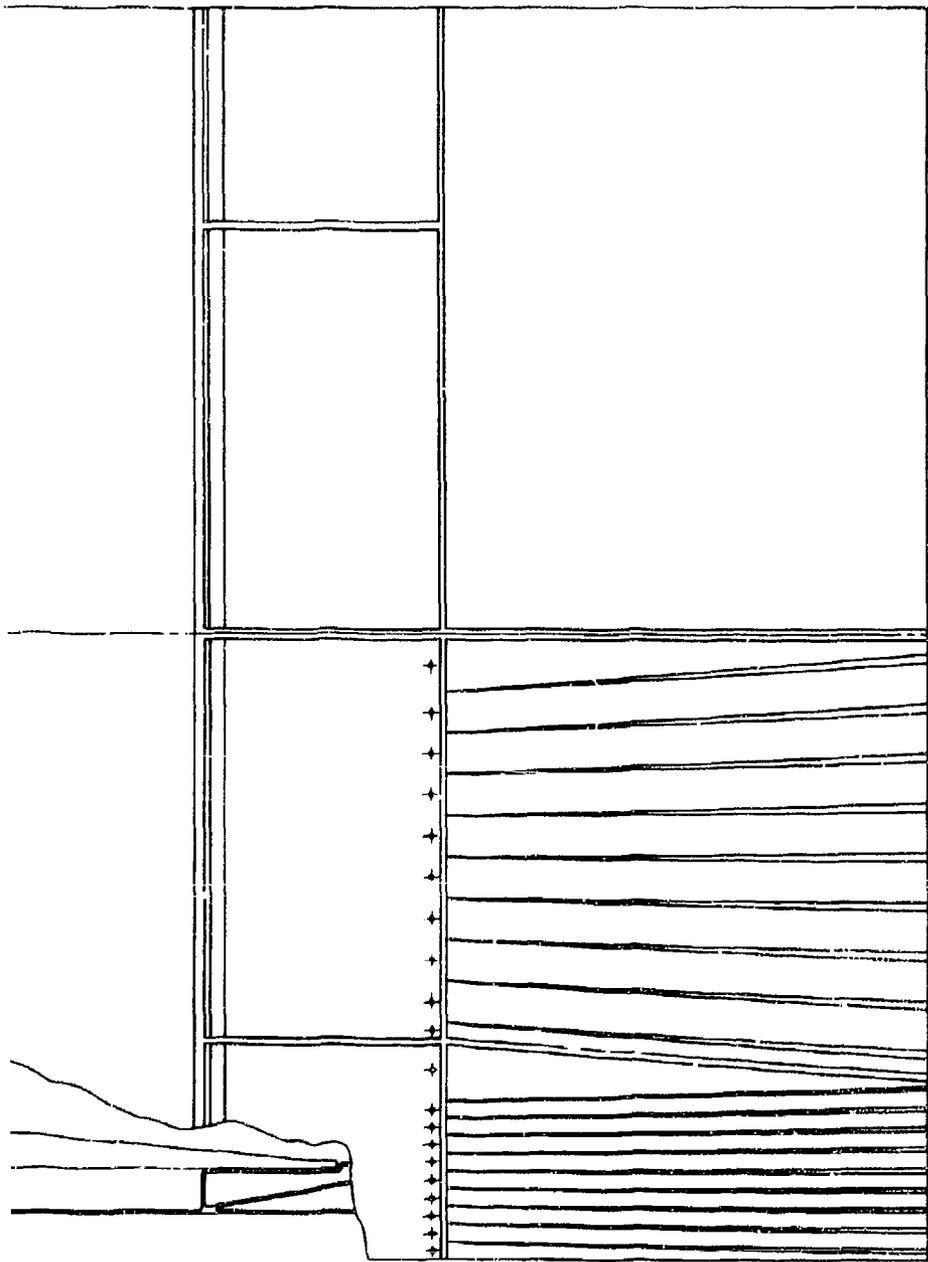
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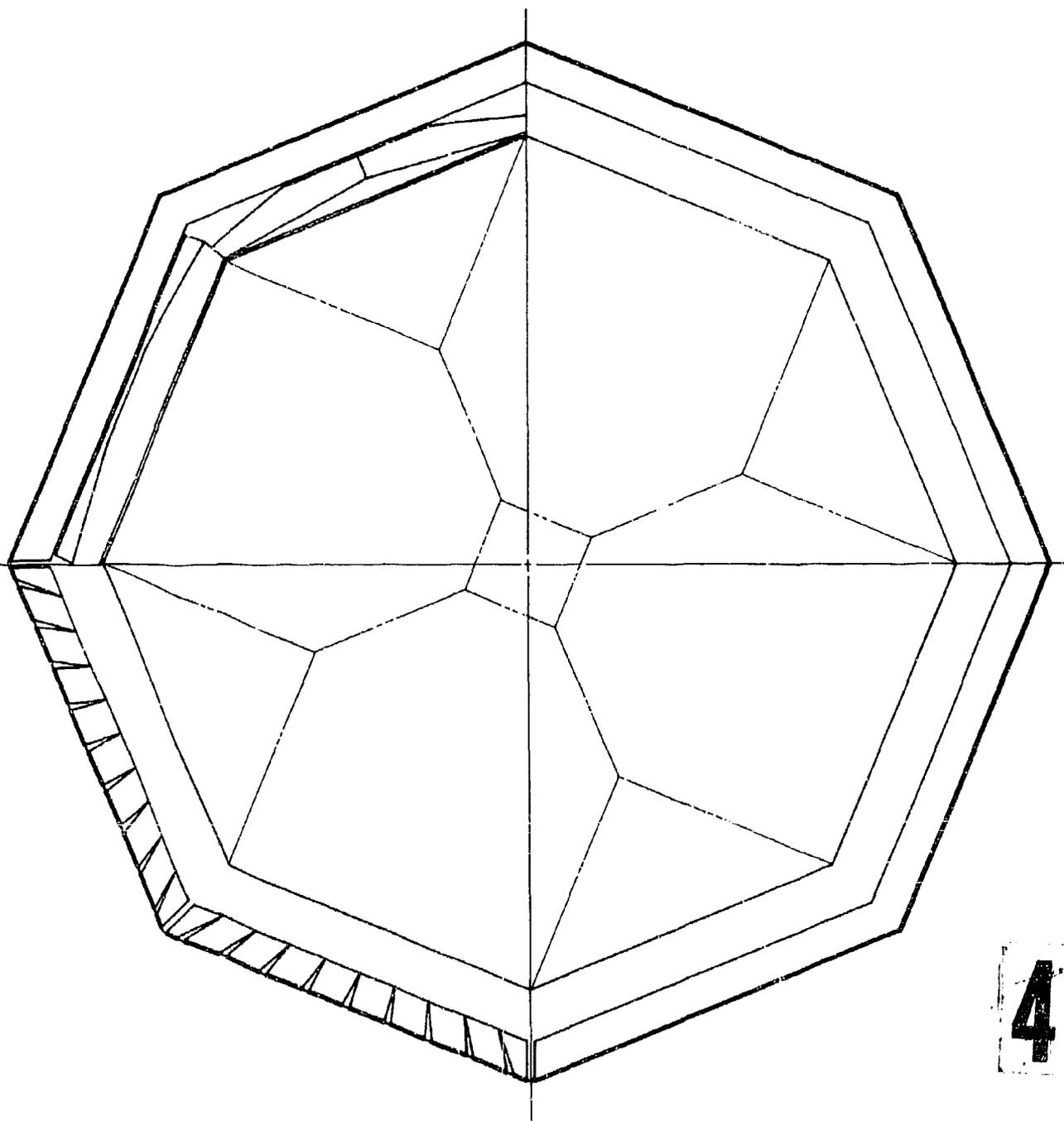
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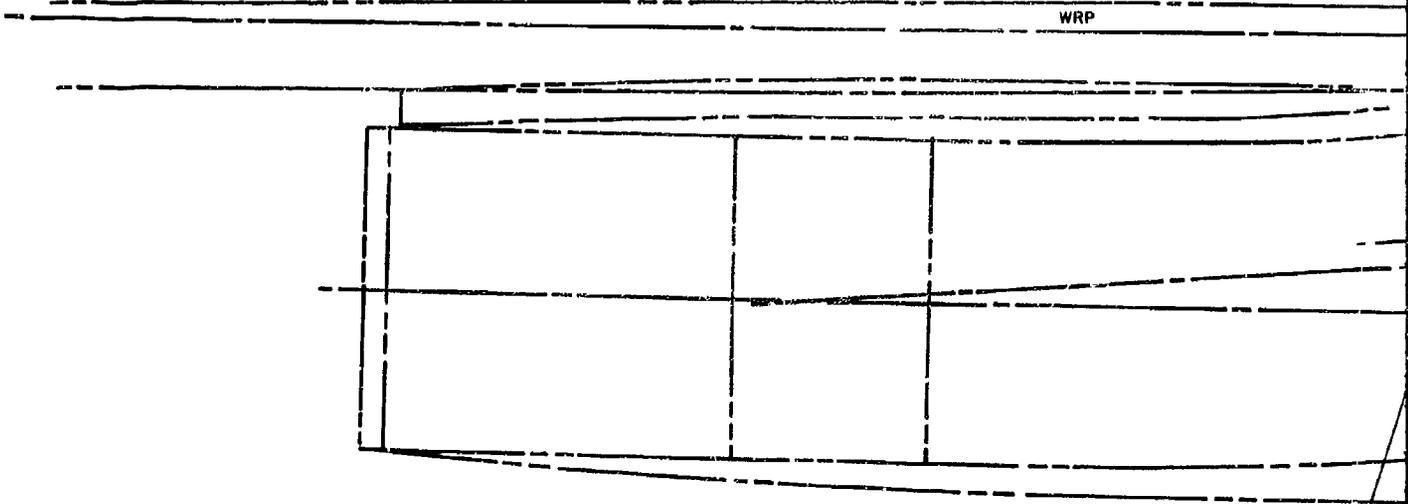
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SCHEMATIC OF OCTAGONAL EJECTOR

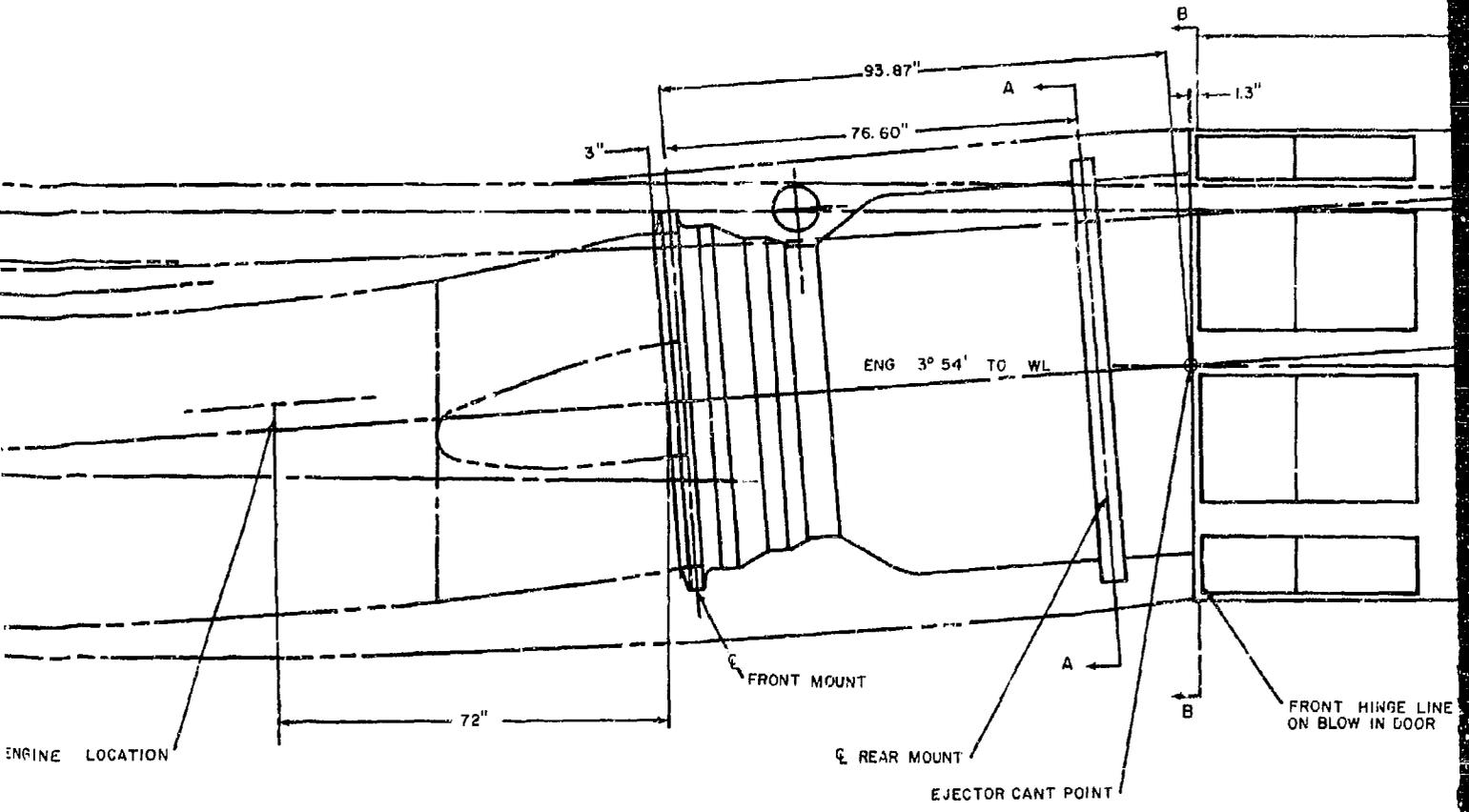
Figure 1-31

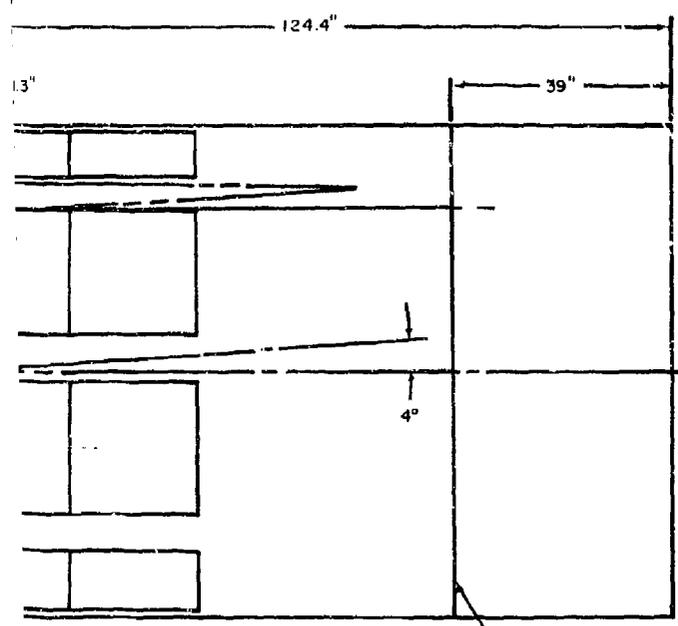
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PRATT & WHITNEY AIRCRAFT



PRESENT ENGINE LOCATION

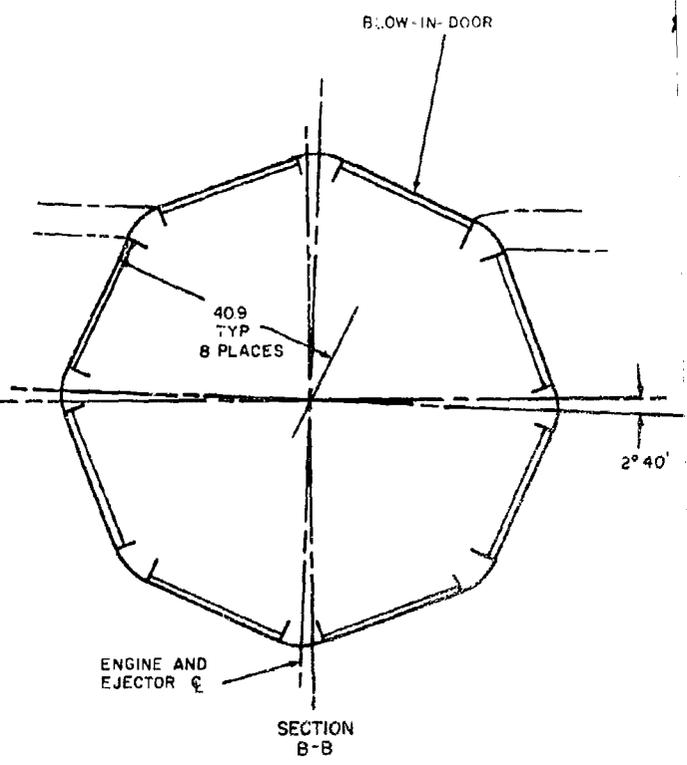




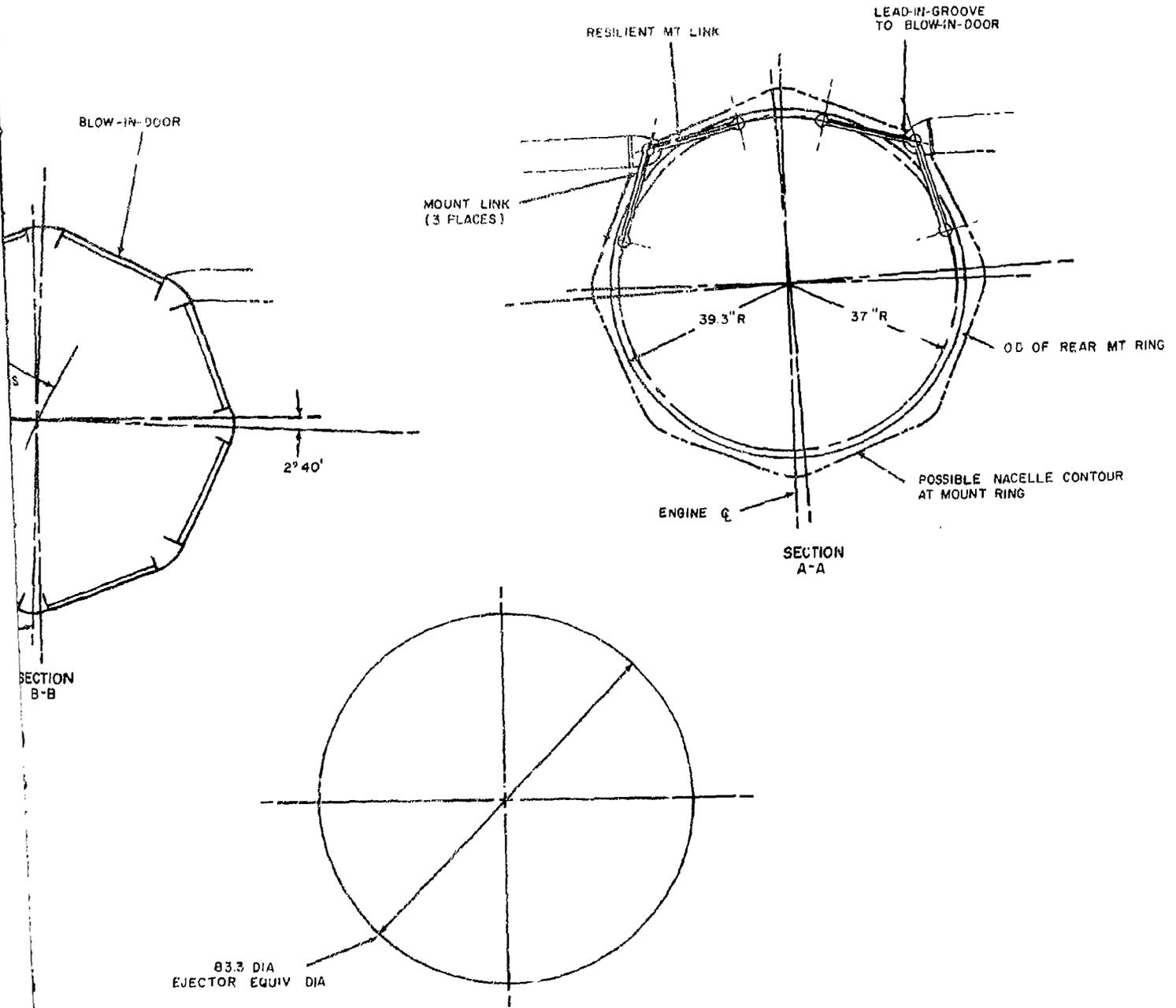
FRONT HINGE LINE ON BLOW IN DOOR

FRONT HINGE LINE ON TAIL FEATHERS

EJECTOR CANTED AT REAR MOUNT PLANE



83.3 DIA EJECTOR EQUIV DIA

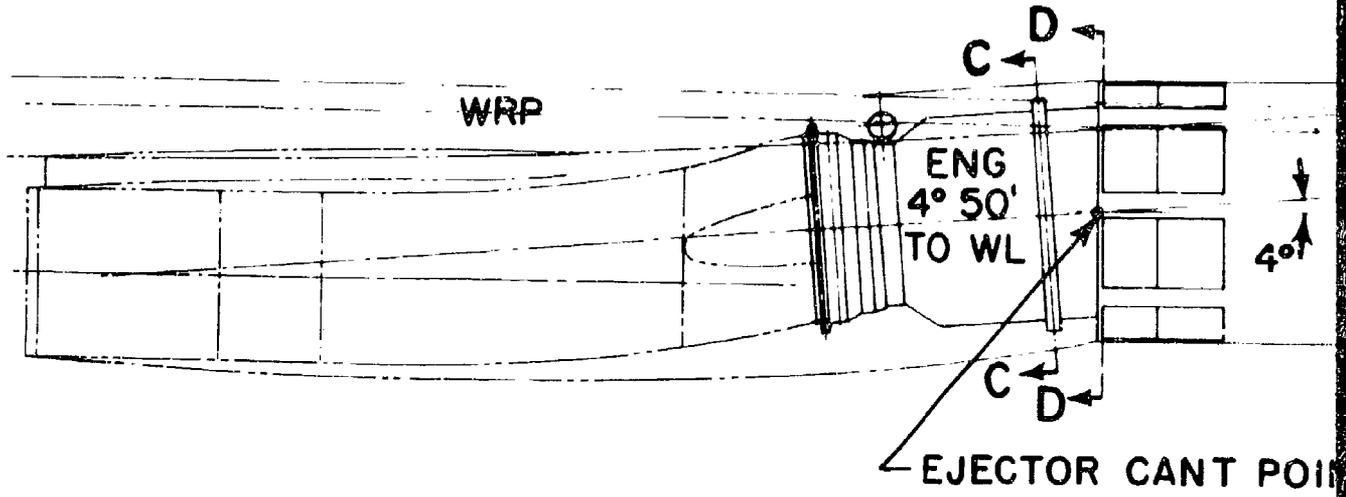


STF219L 700 LB/SEC TURBOFAN OUTBOARD ENGINE

Figure 1-32

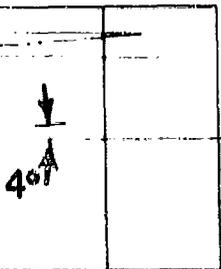
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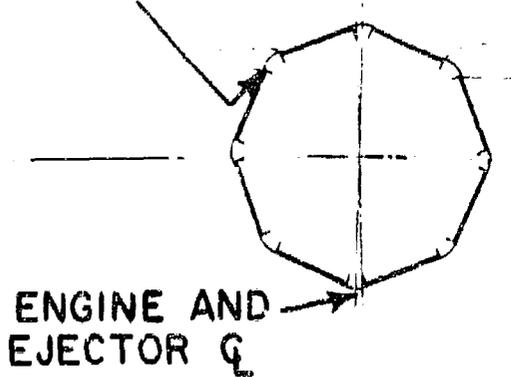


LINE UP BLOW-IN-DOORS  
WITH WING LIKE THIS

SECTION C-C

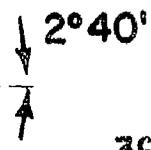
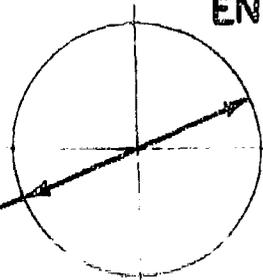


POINT



SECTION D-D

83.3 DIA  
EJECTOR EQUIV DIA



2°40'



ENGINE CL

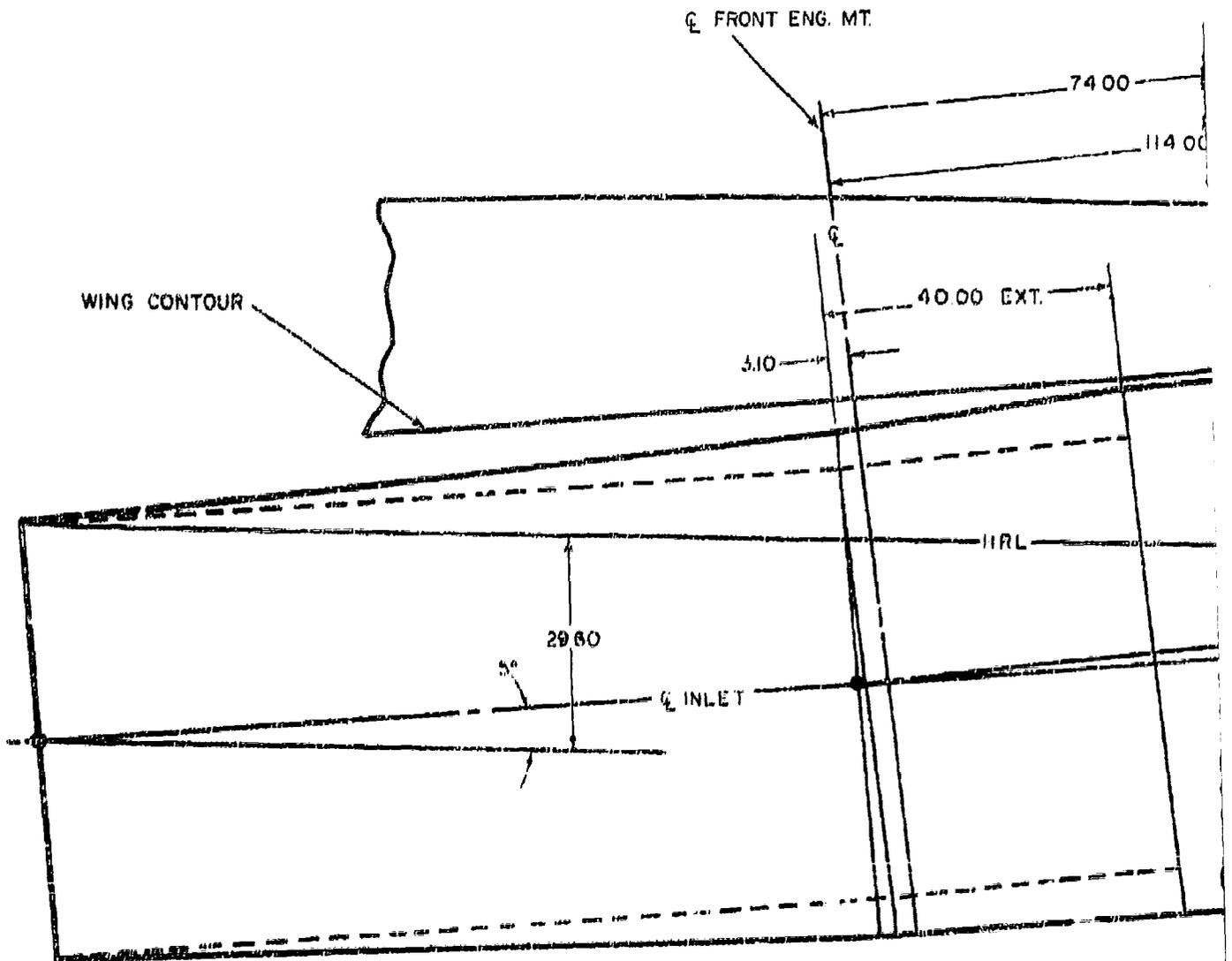
POSSIBLE  
NACELLE  
CONTOUR  
AT  
MOUNT  
RING

2

STF219L 700 L.B/SEC TURBOFAN INBOARD ENGINE

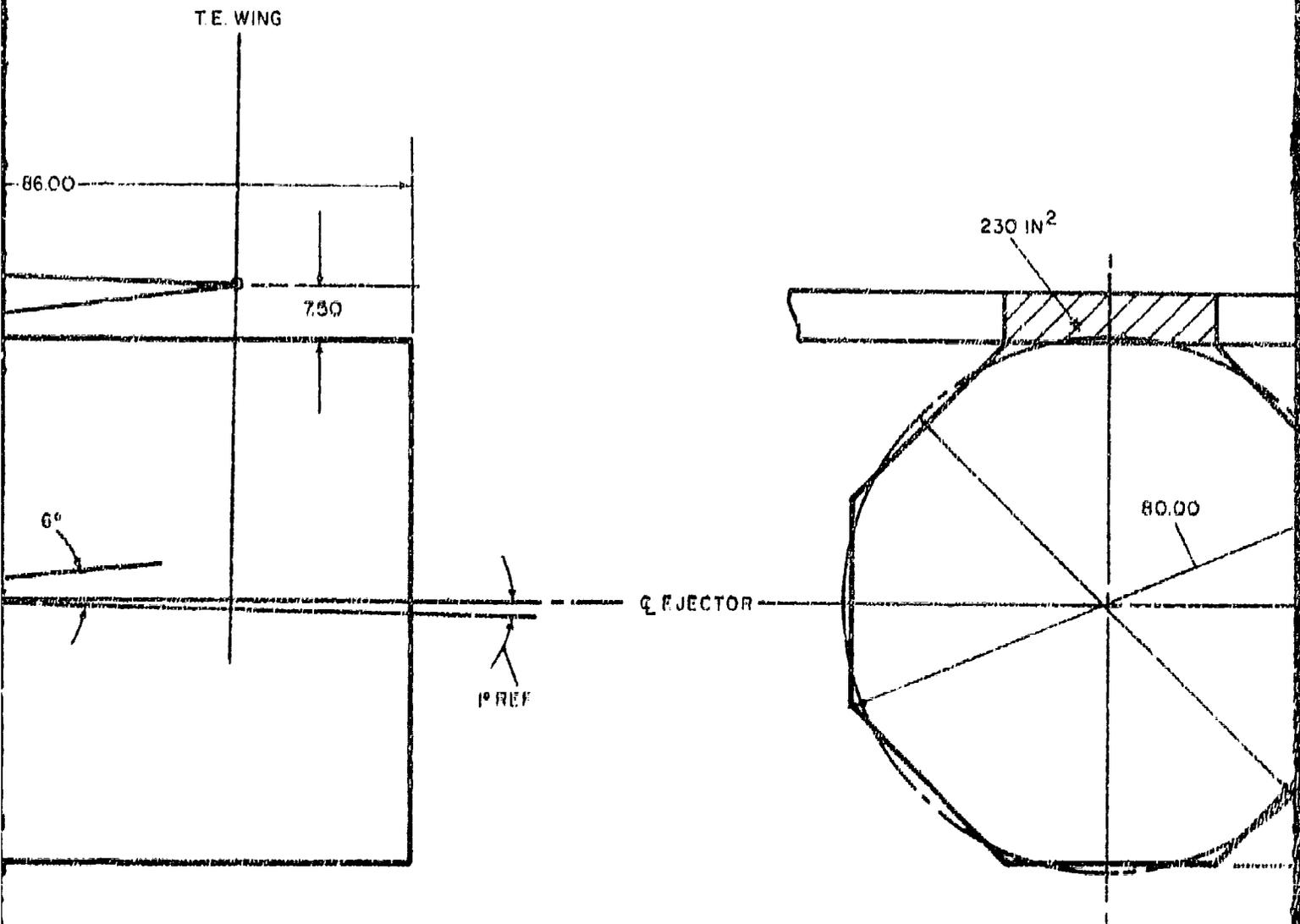
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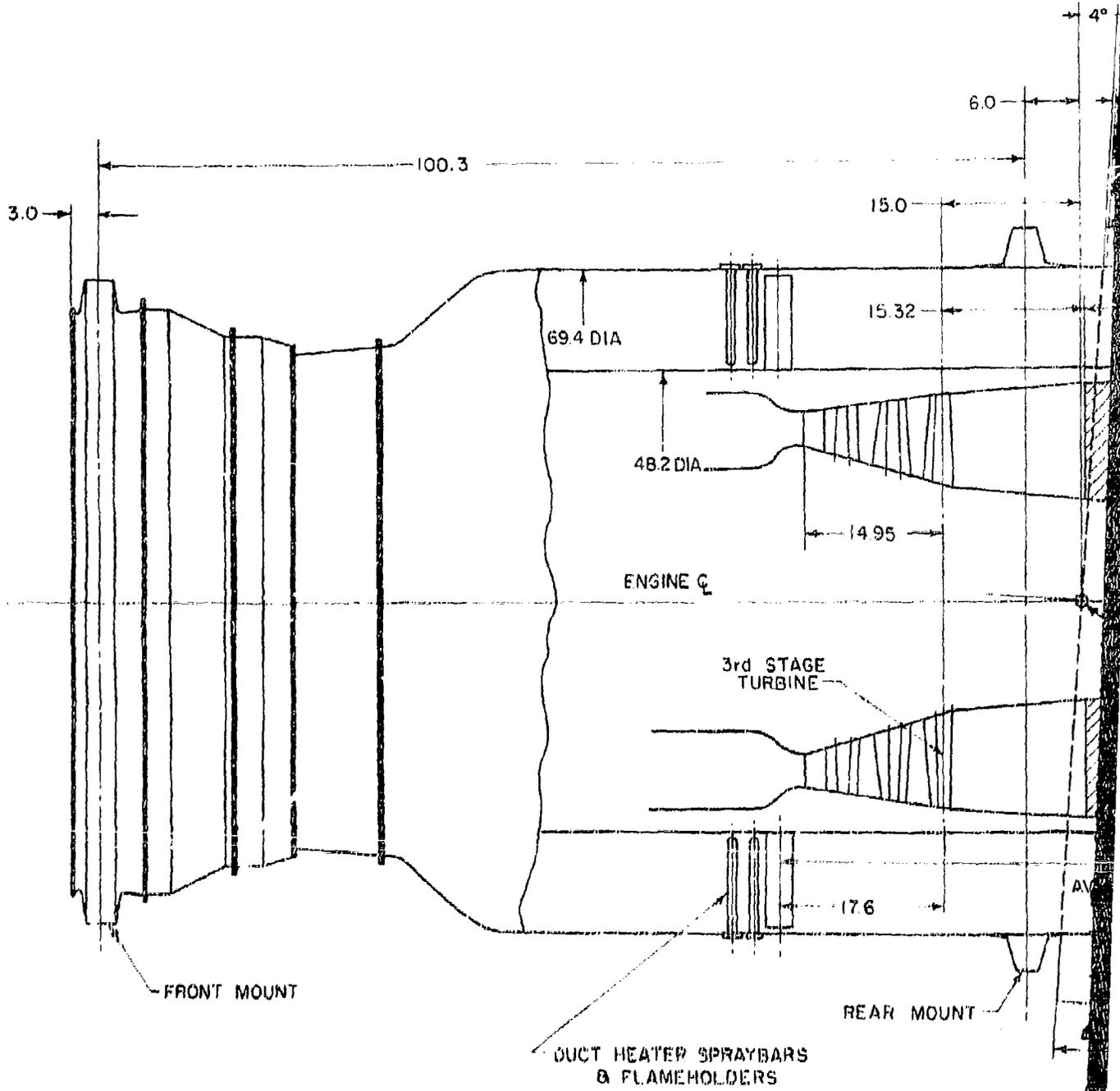
ARRANGEMENT SHOWING REAR ENGL.  
MOVED AFT 40.00  
ENGINE & EJECTOR ARE TANGENT TO  
EJECTOR CANTED AT NOZZLE PLANE  
ENGL. MOUNT PLANES ARE PARALLEL  
BASE DRAG AREA 230 in<sup>2</sup>

5TF219L 650 LB/SEC TURBOFAN

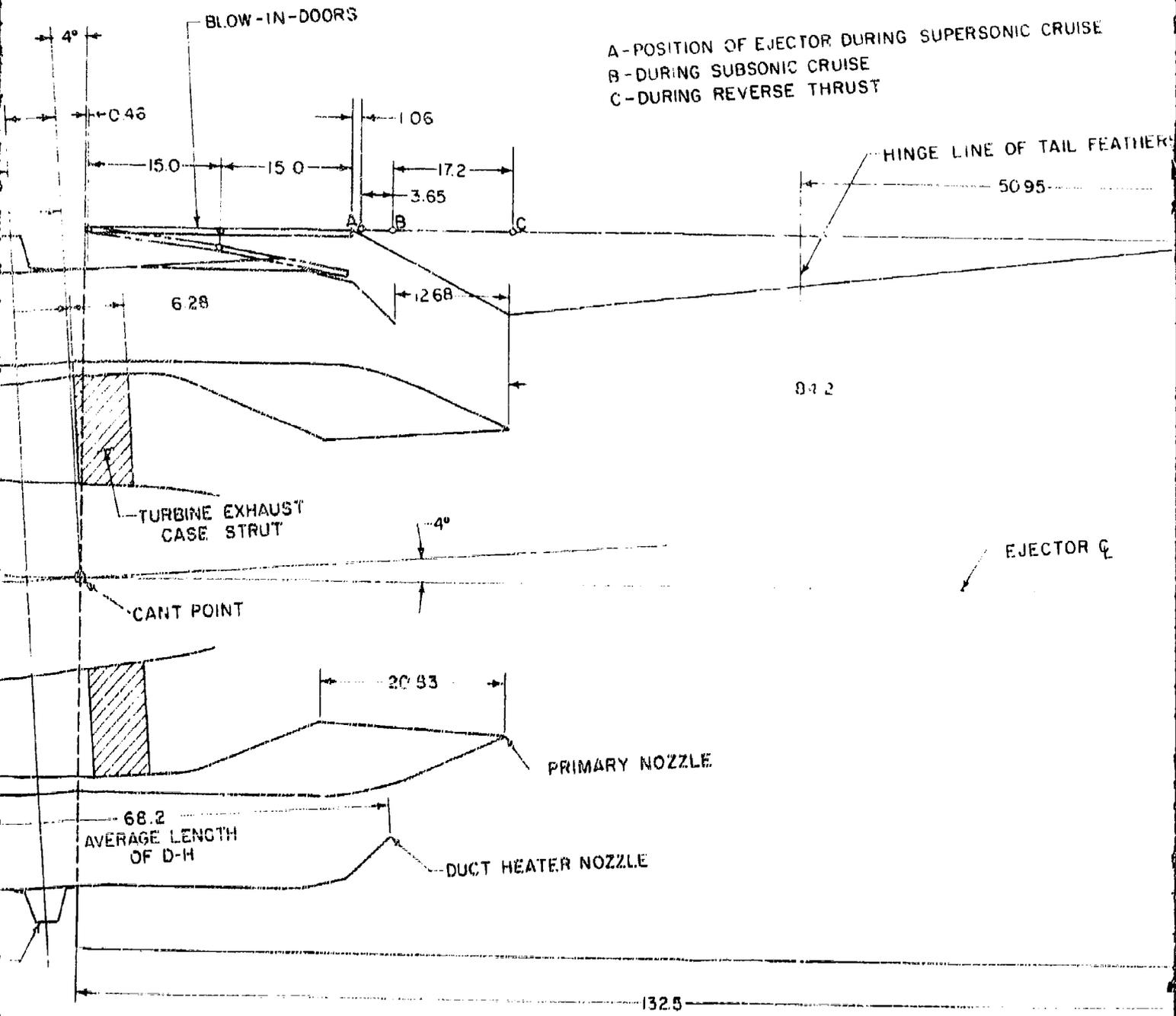
Figure 1-14

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SECTION A-A

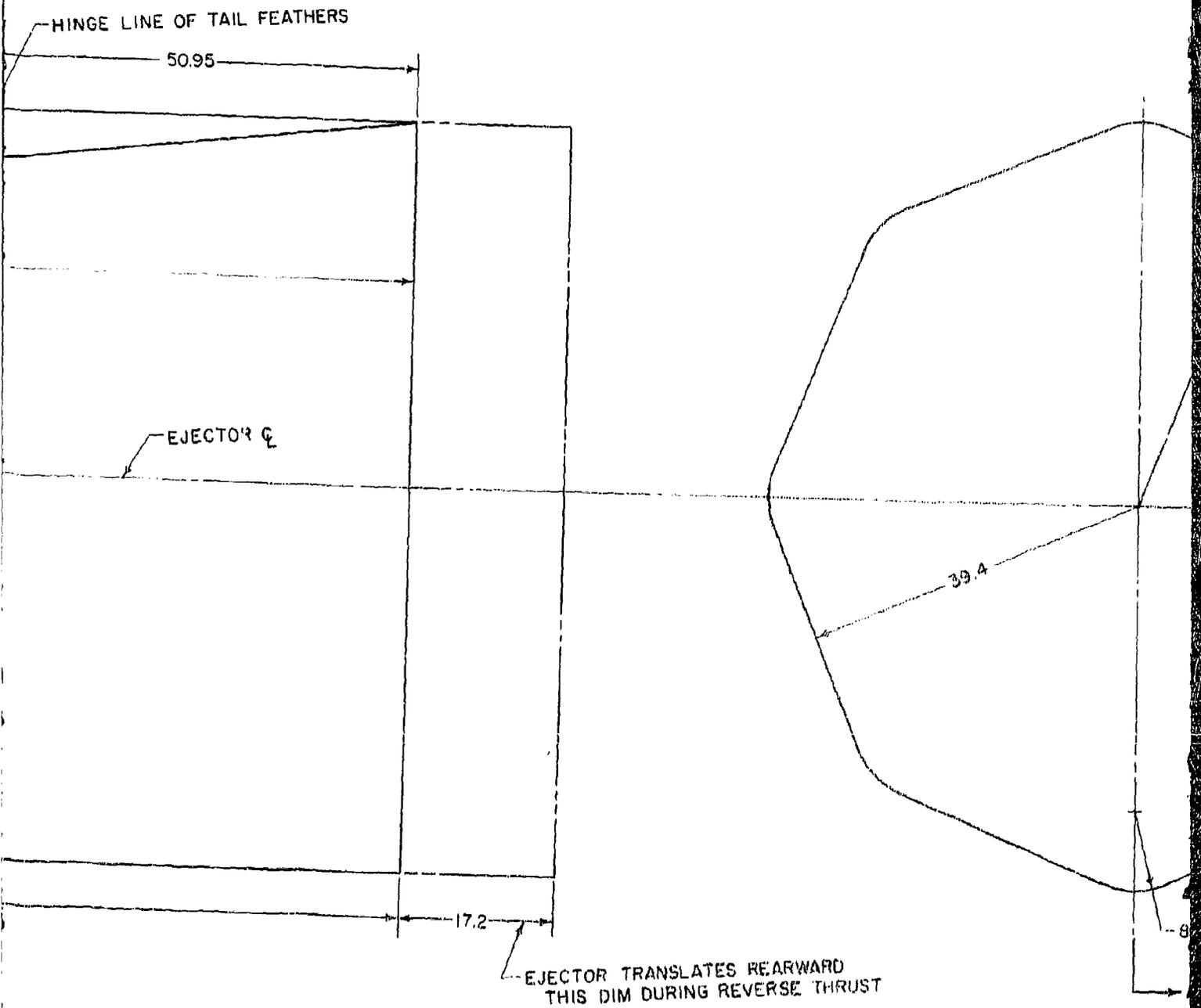


A-POSITION OF EJECTOR DURING SUPERSONIC CRUISE  
 B-DURING SUBSONIC CRUISE  
 C-DURING REVERSE THRUST

SECTION A-A

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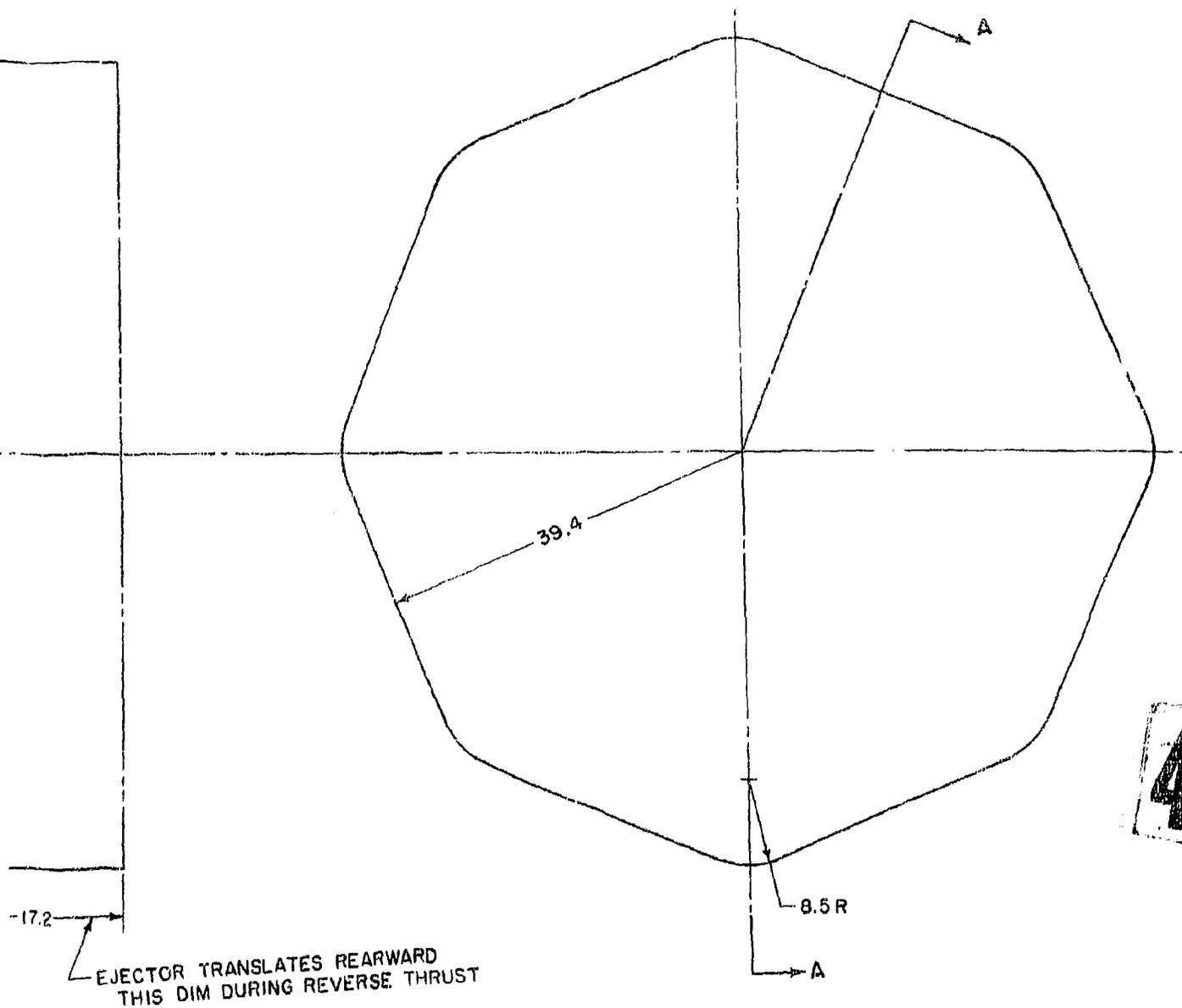
DURING SUPERSONIC CRUISE  
CRUISE  
CRUISE



STF219L 650 LB/SEC TURBOFAN  
ENGINE/EJECTOR RELATION

Figure 1-35

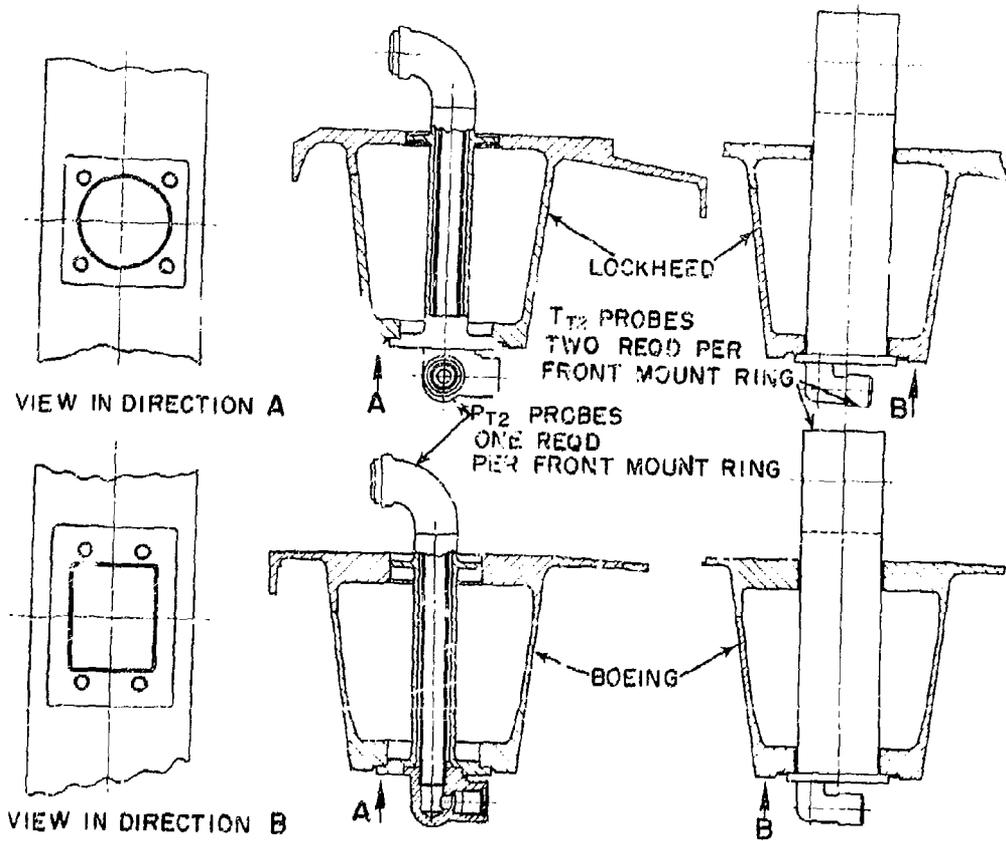
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STF219L 650 LB/SEC TURBOFAN SHOWING  
ENGINE/EJECTOR RELATIONSHIP

Figure 1-35

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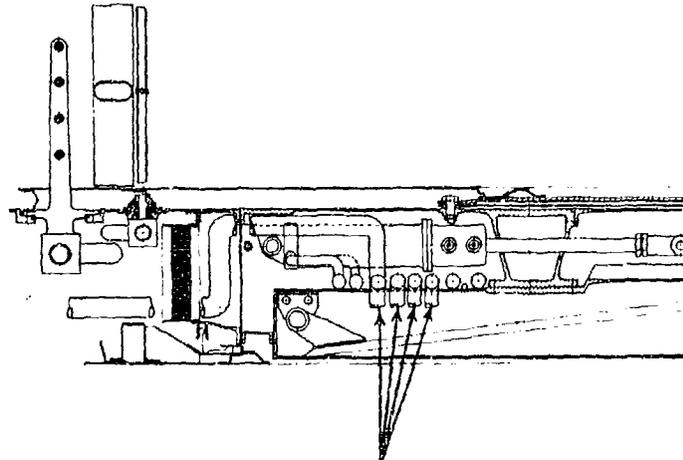


INLET PRESSURE AND TEMPERATURE PROBES FOR  
BIASING ENGINE FUEL CONTROL

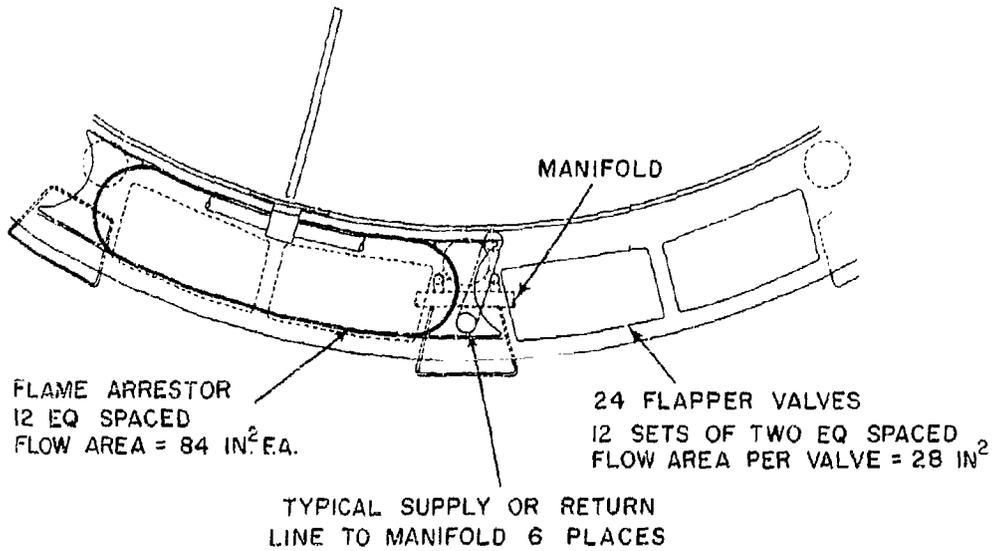
Figure 1-36

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SUPPLY AND RETURN LINES  
TO REVERSER ACTUATOR  
TYP 12 PLACES

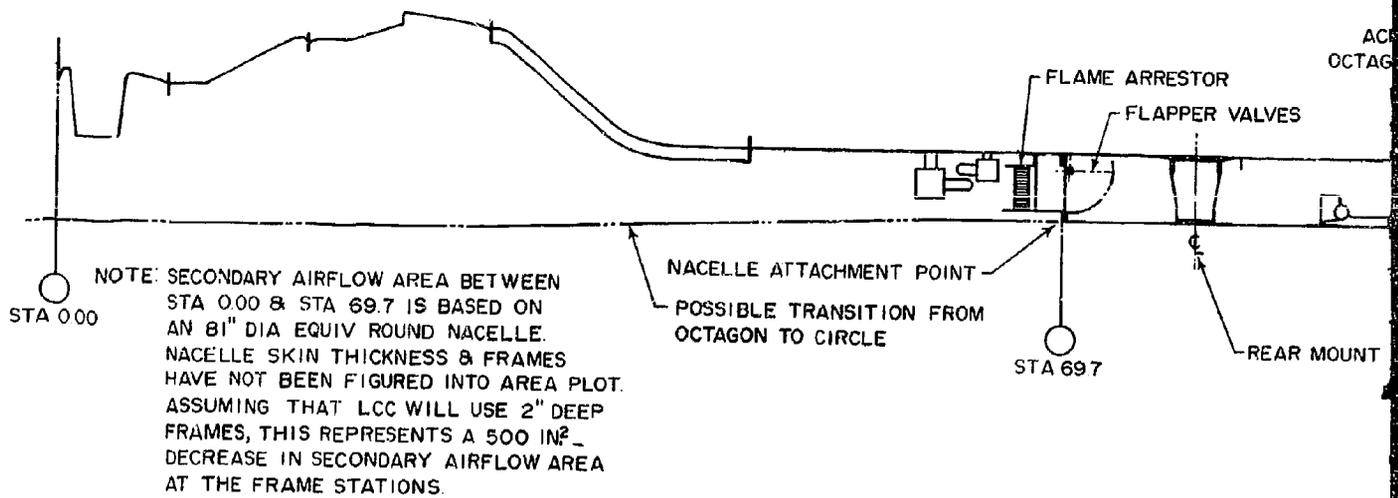
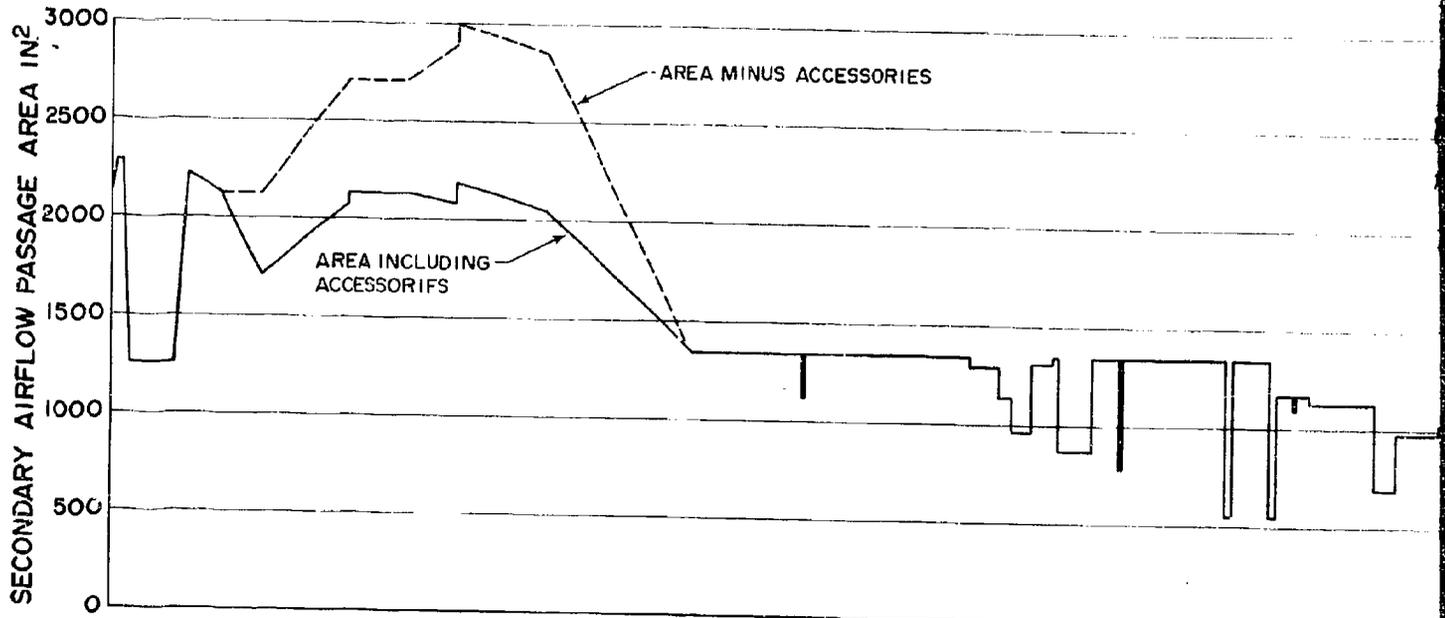


ARRANGEMENT OF FLAME ARRESTORS  
IN SECONDARY AIR PASSAGE

Figure 1-37

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DECLASSIFIED AFTER 15 YEARS  
GPO: 1964 O-350-70

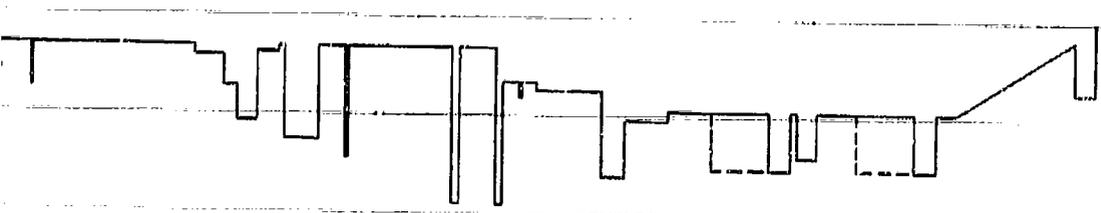
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NOTE: SECONDARY AIRFLOW AREA BETWEEN STA 000 & STA 69.7 IS BASED ON AN 81" DIA EQUIV ROUND NACELLE. NACELLE SKIN THICKNESS & FRAMES HAVE NOT BEEN FIGURED INTO AREA PLOT. ASSUMING THAT LCC WILL USE 2" DEEP FRAMES, THIS REPRESENTS A 500  $\text{in}^2$  DECREASE IN SECONDARY AIRFLOW AREA AT THE FRAME STATIONS.

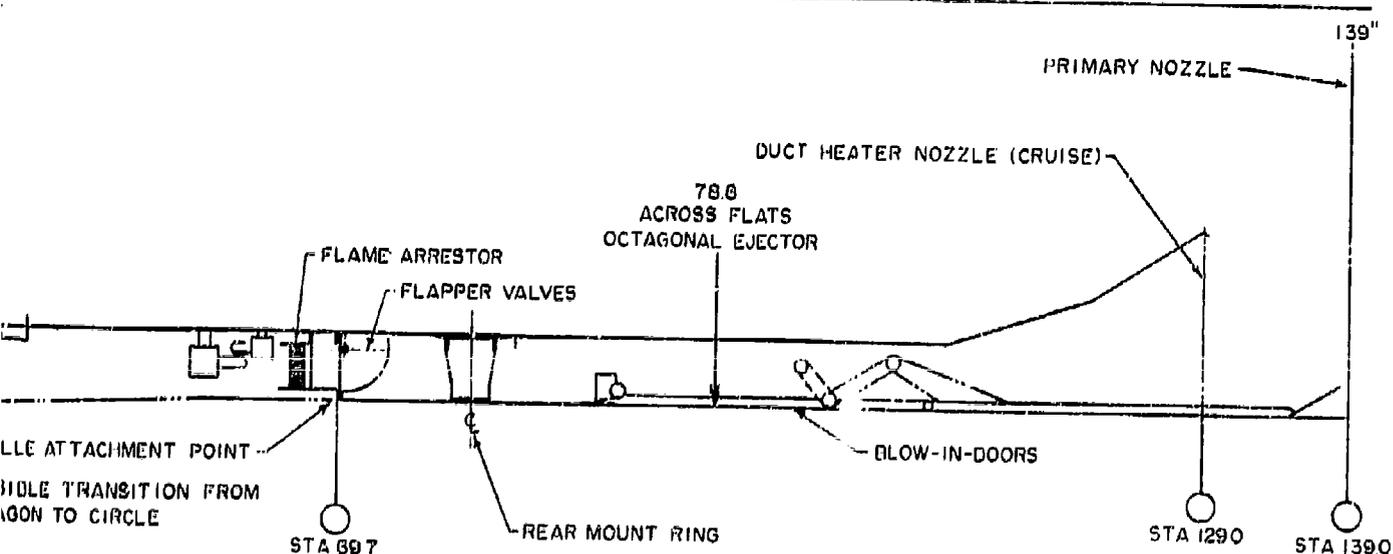
SECONDARY AIRFL

ACCESSORIES



| Mo  | AREA | % PRESS LOSS |
|-----|------|--------------|
| 0.3 | 920  | 5%           |
| 0.5 | 608  | 15%          |
| 0.6 | 537  | 20%          |
| 0.7 | 494  | 25%          |

BASED ON MAX  
SECONDARY AIRFLOW  
FROM COORD SHEET  
547

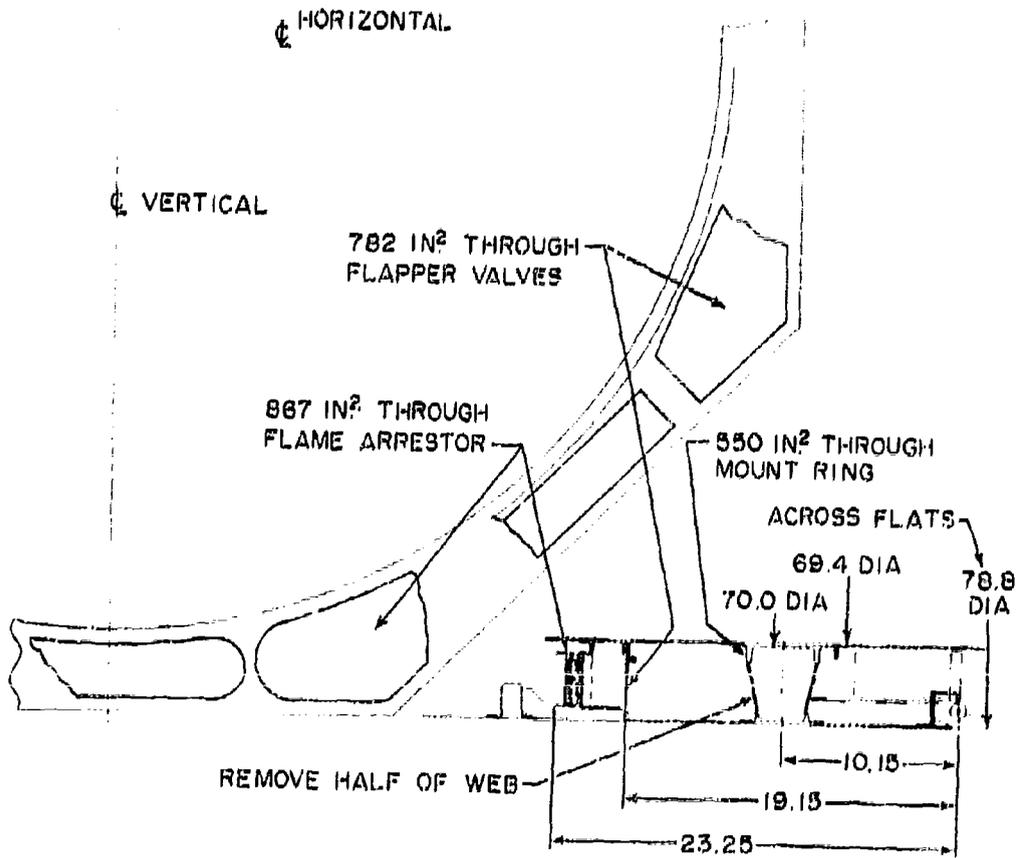


SECONDARY AIRFLOW PASSAGE GENERAL ARRANGEMENT

Figure 1-38

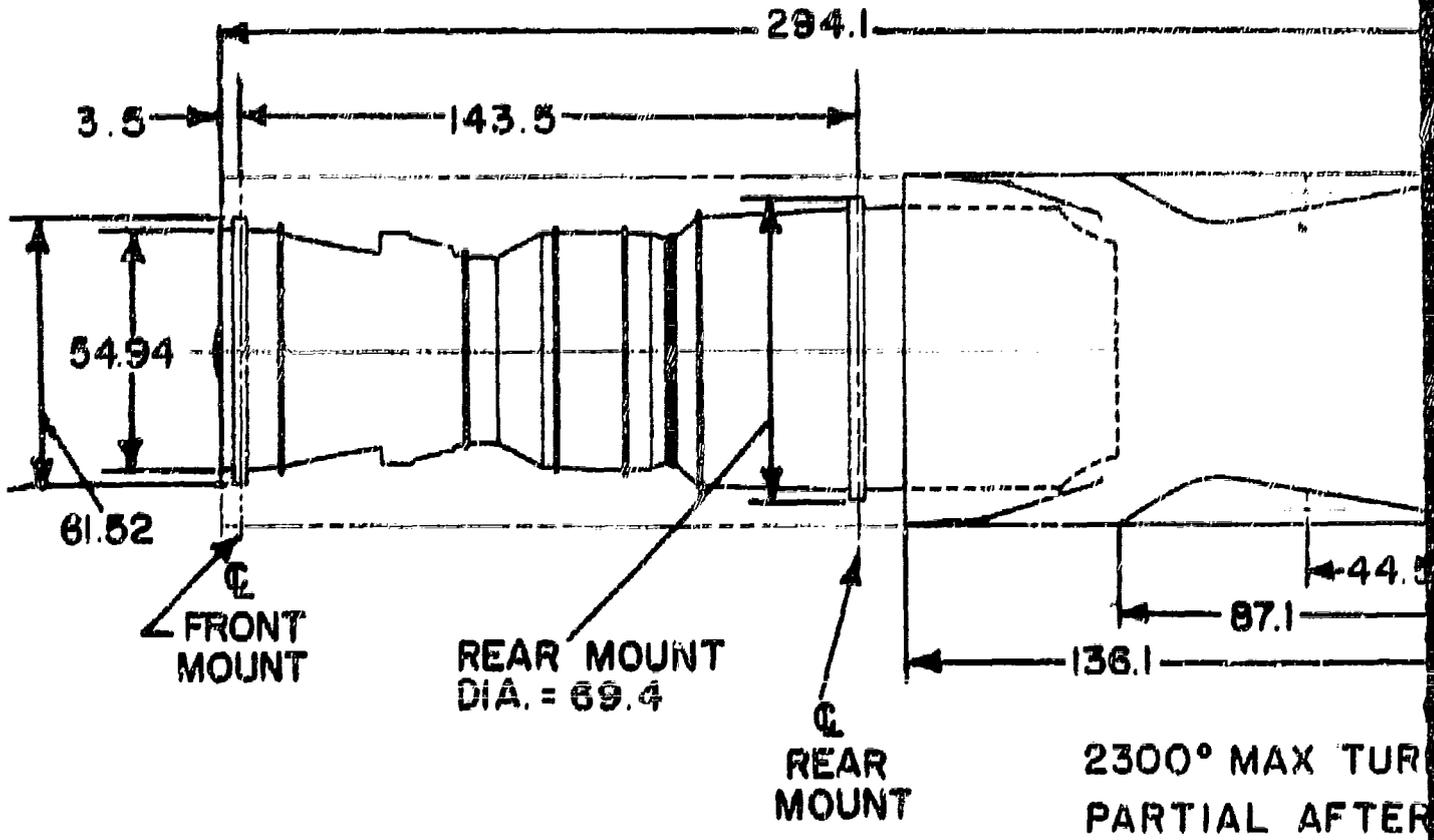
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DETAILS OF SECONDARY AIRFLOW PASSAGE

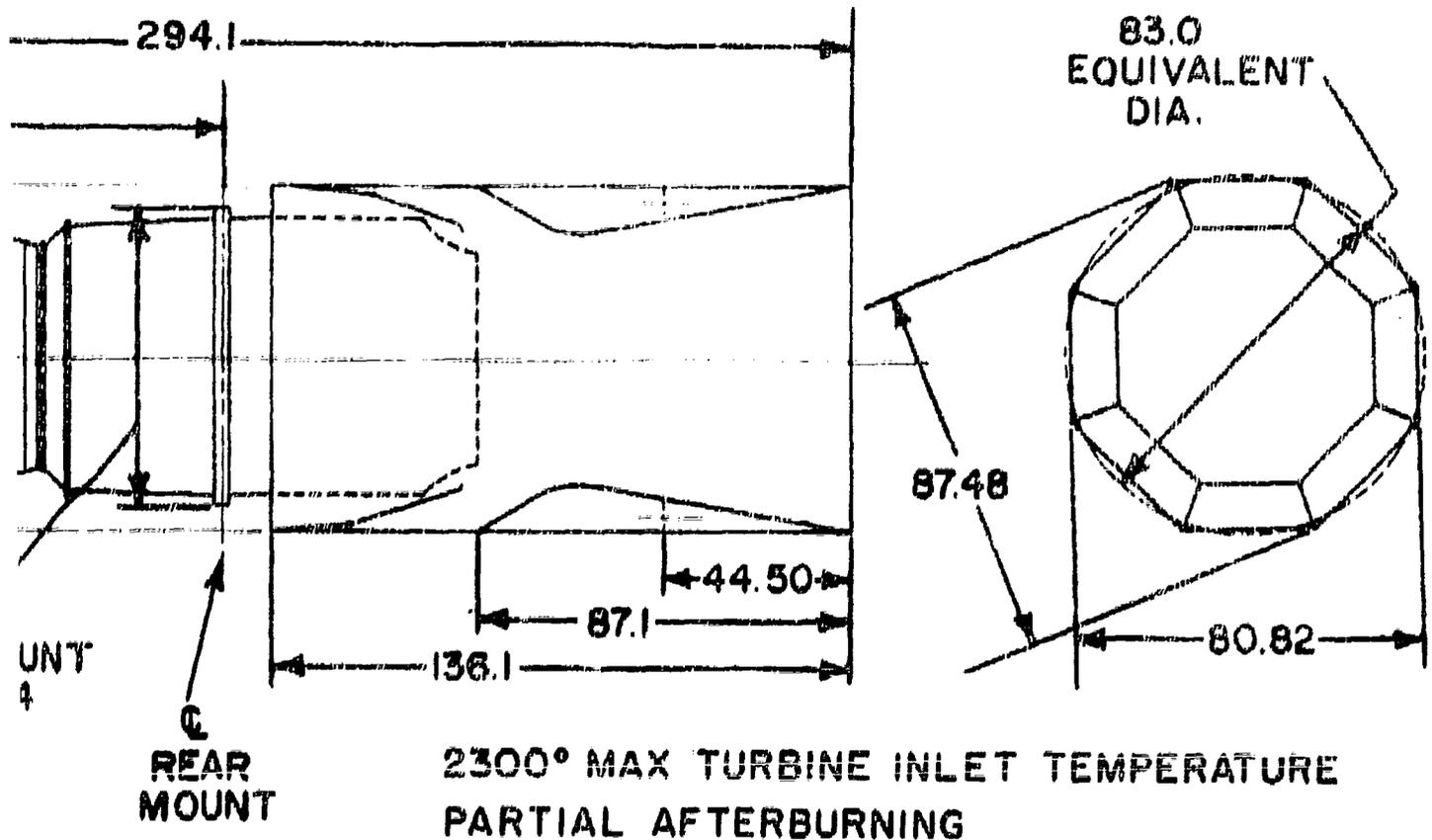
Figure 1-39



STJ227 525 LB

Fig.

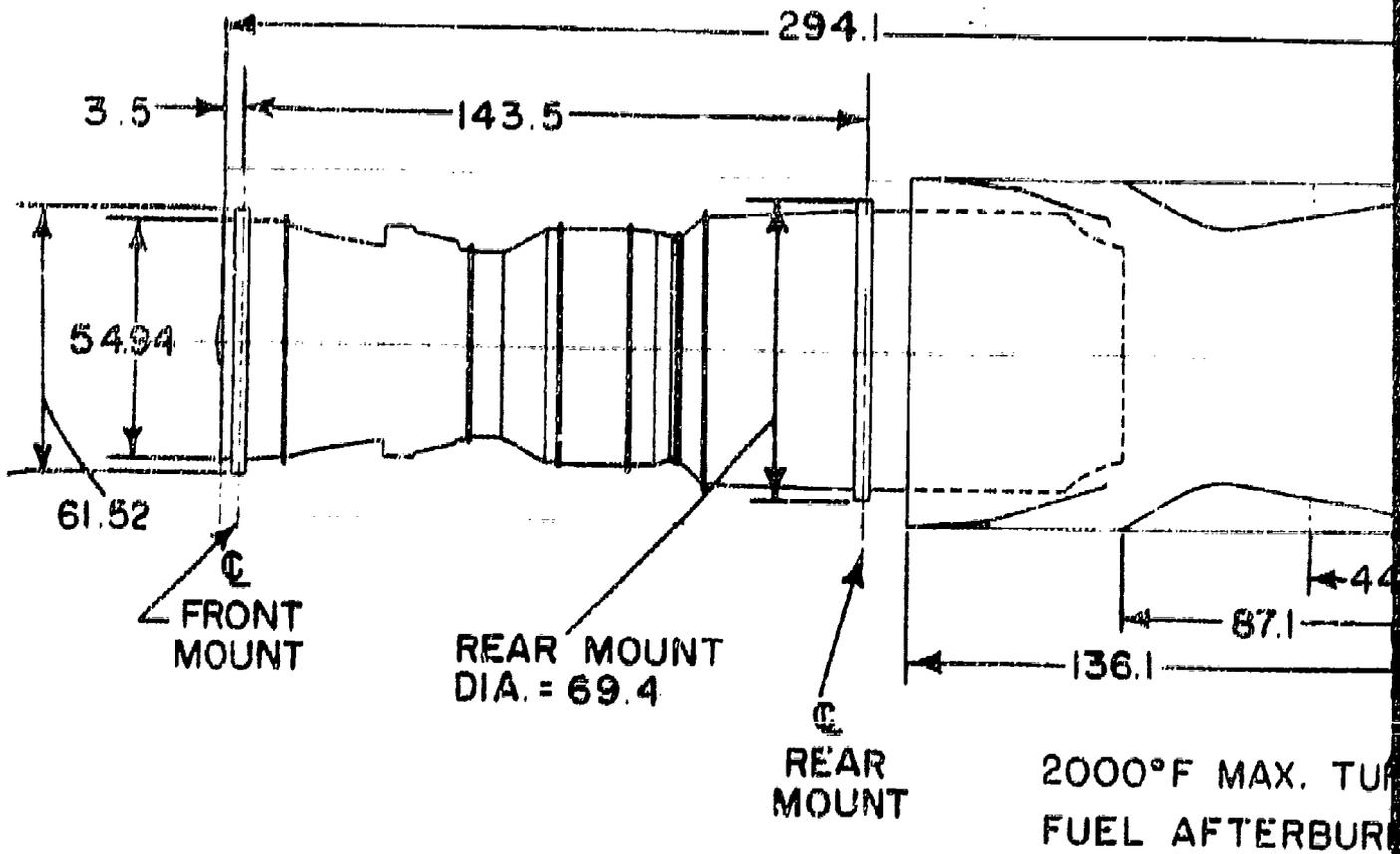




BTJ227 525 LB/SEC TURBOJET

Figure 1-40

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DATE 10-19-60

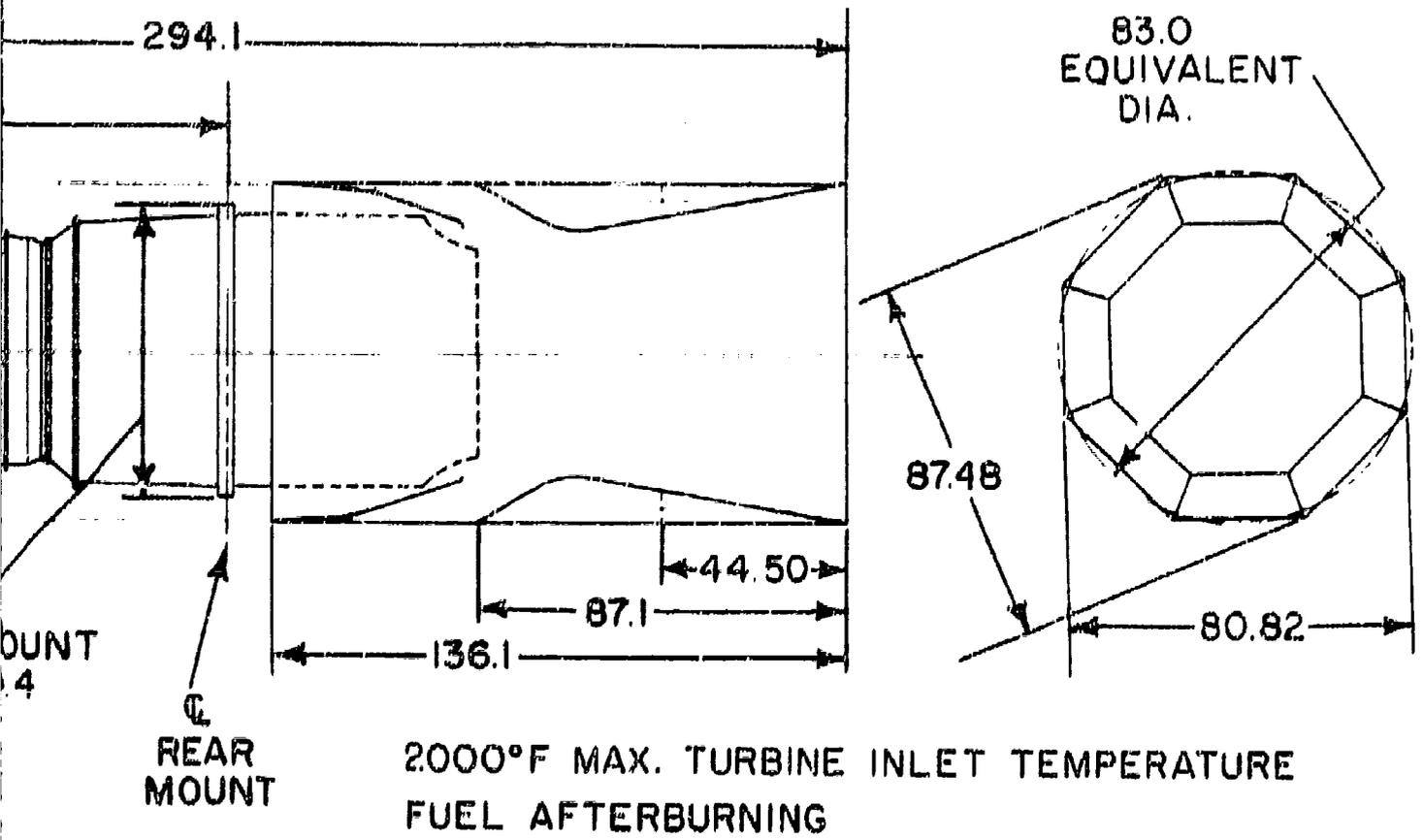


STJ227 525 1

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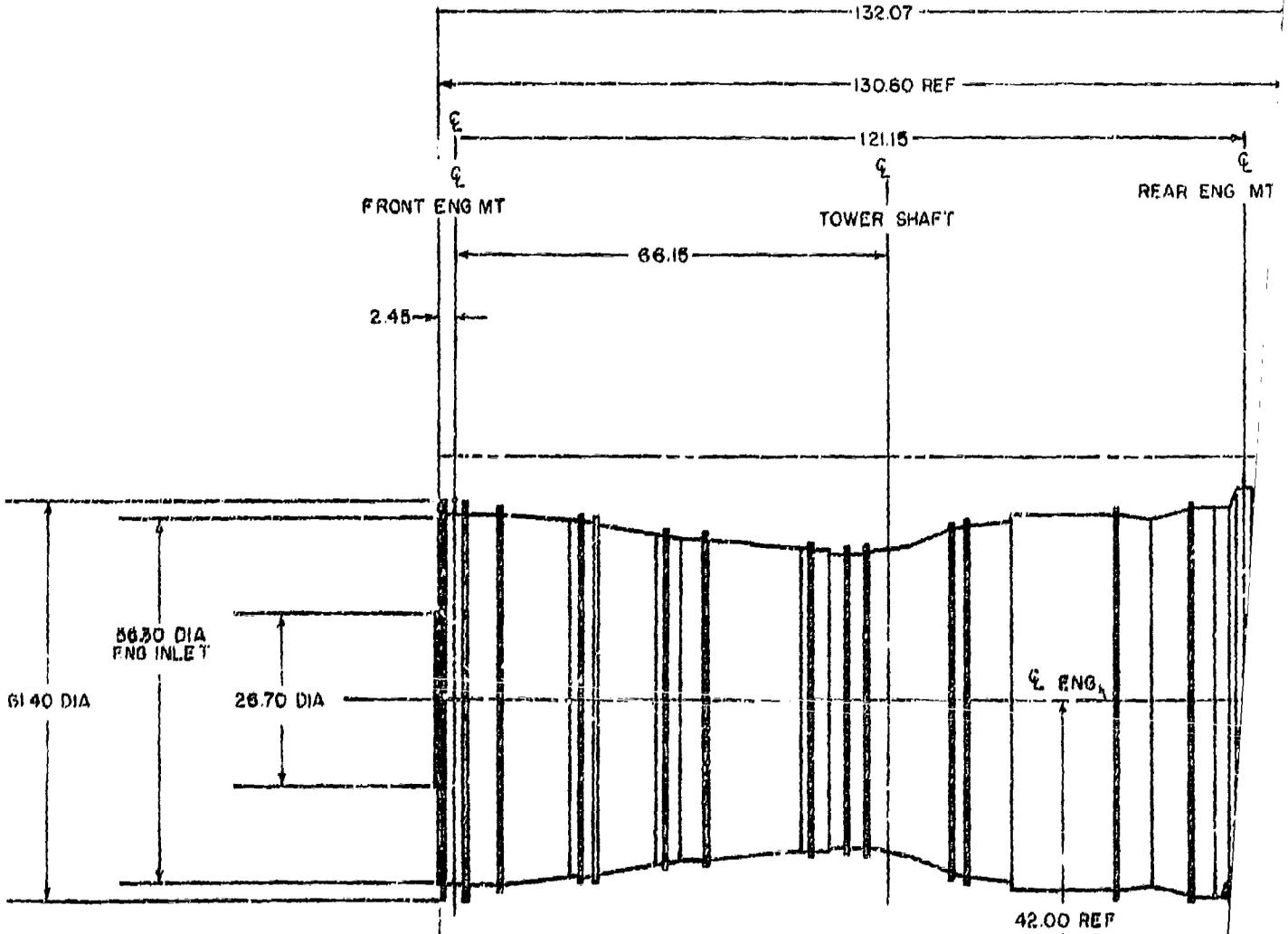
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STJ227 525 LB/SEC TURBOJET

Figure 1-41

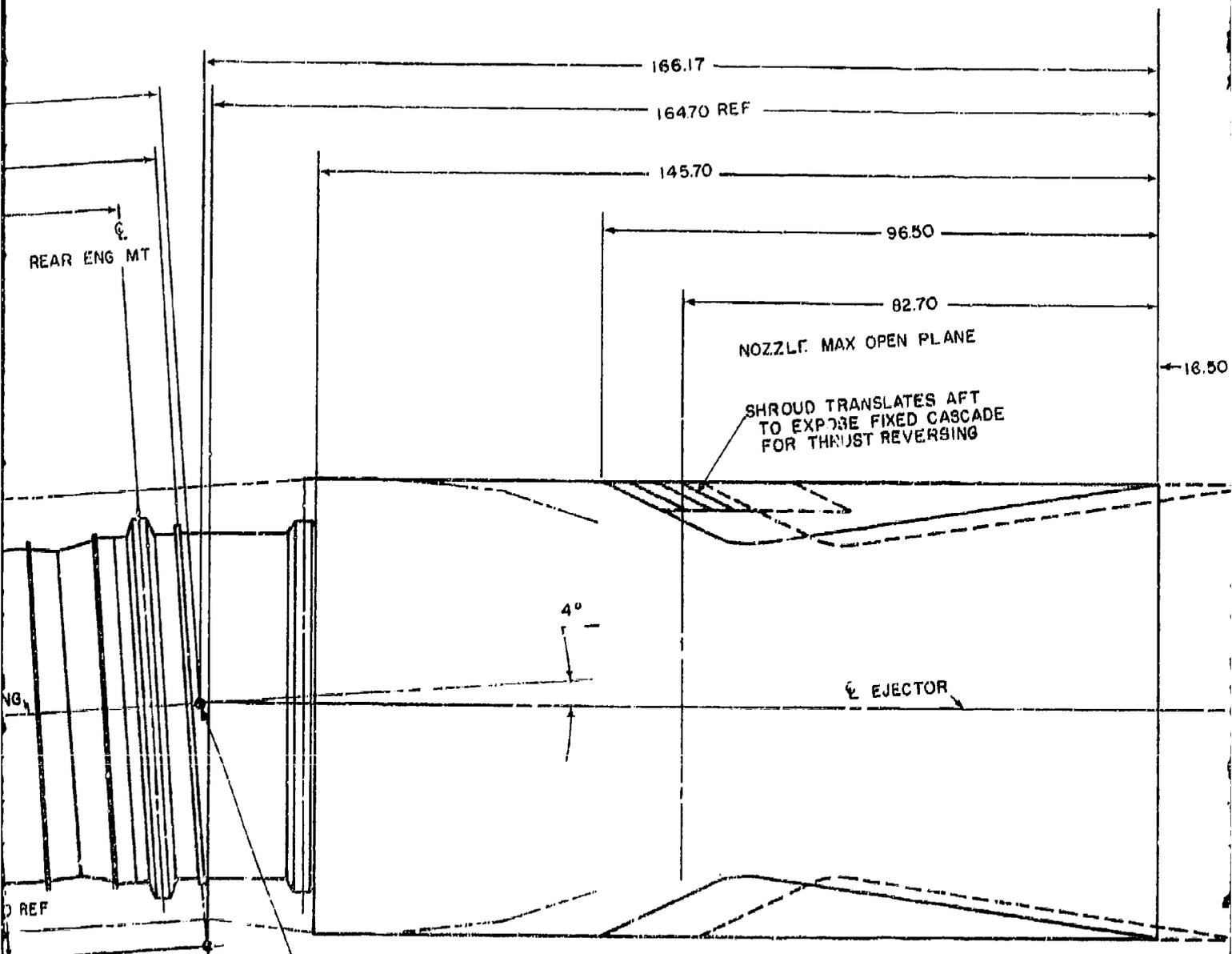
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PRATT & WHITNEY AIRCRAFT



THIS ENVELOPE SUBJECT TO CHANGE FOR:  
1. ENGINE ACCESSORY ARRANGEMENT  
2. SECONDARY AIR PROVISIONS FOR E.J.  
3. REAR CASE & A/B COOLING PROVIS

1

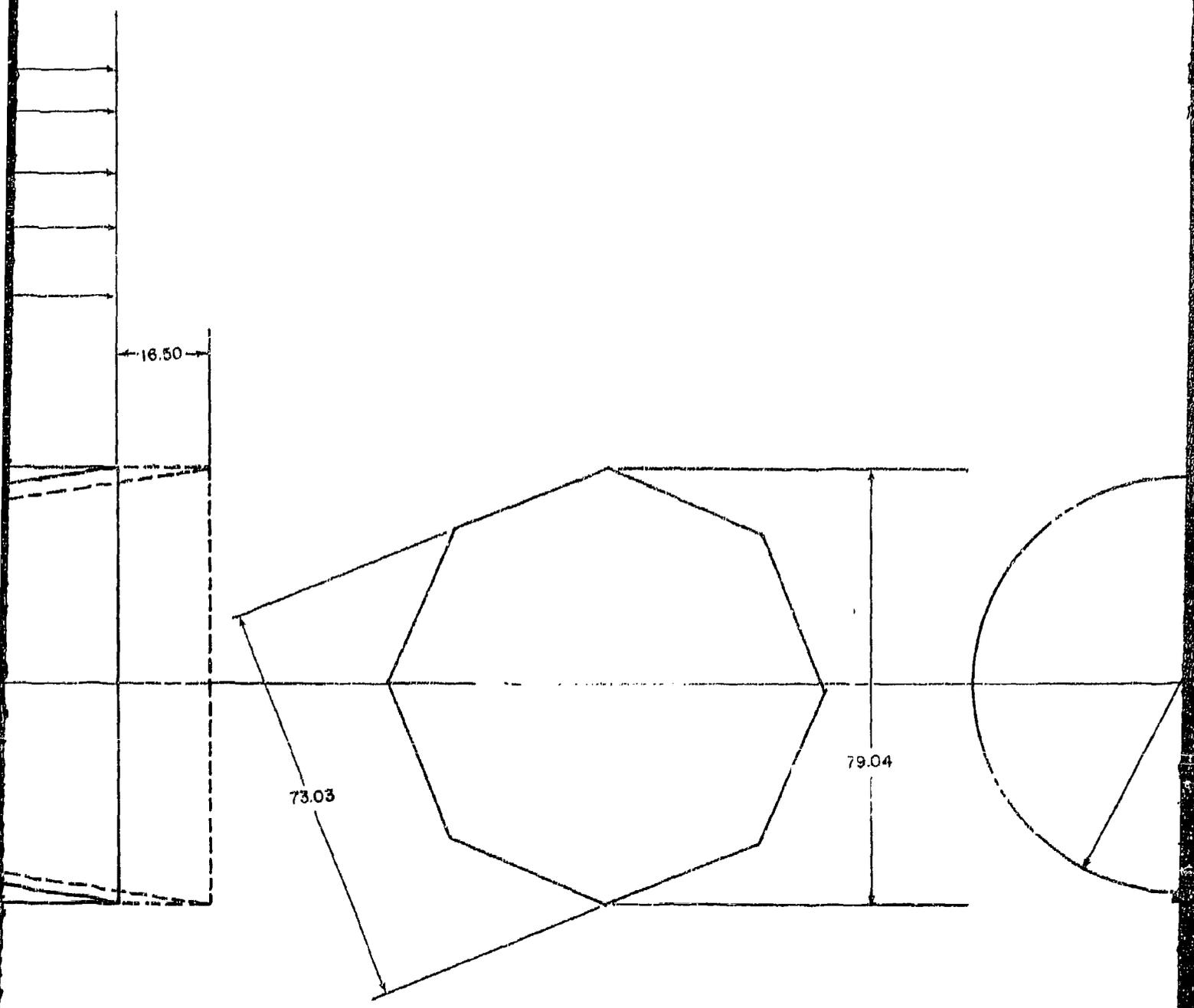


TO CHANGE FOR:  
 ARRANGEMENT  
 DIVISIONS FOR EJECTOR  
 COOLING PROVISIONS

— EJECTOR CANT POINT

2

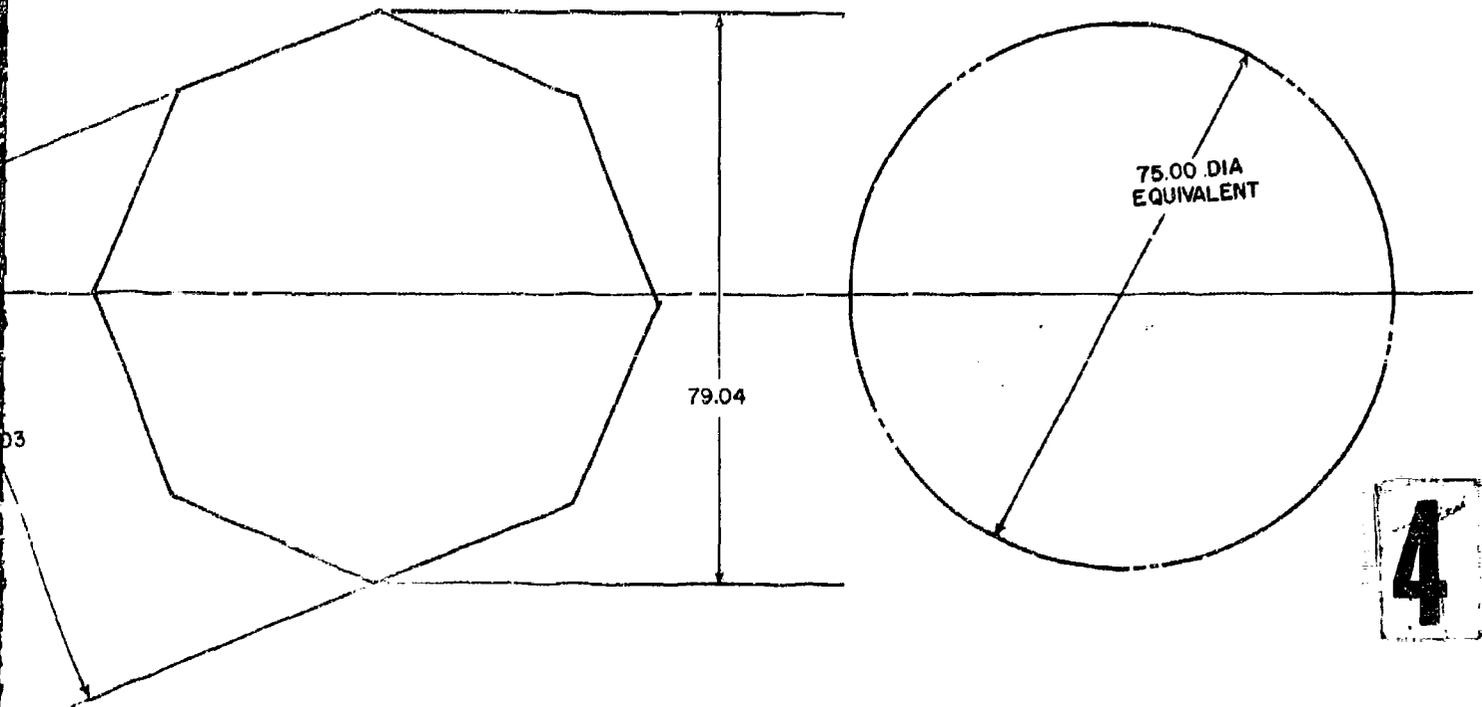
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TYPICAL TURBOJET ENGINE. FULL AFTERBU

Figure 1-42

CONFIDENTIAL



4

TYPICAL TURBOJET ENGINE. FULL AFTERBURNING.

Figure 1-42

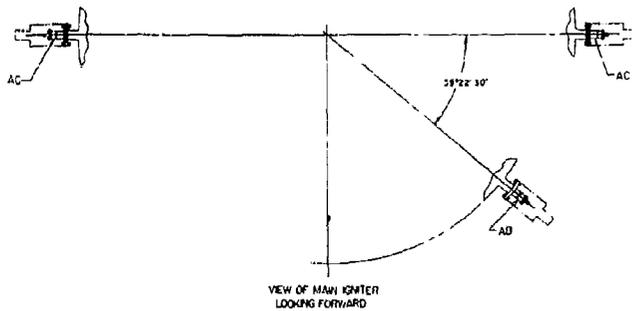
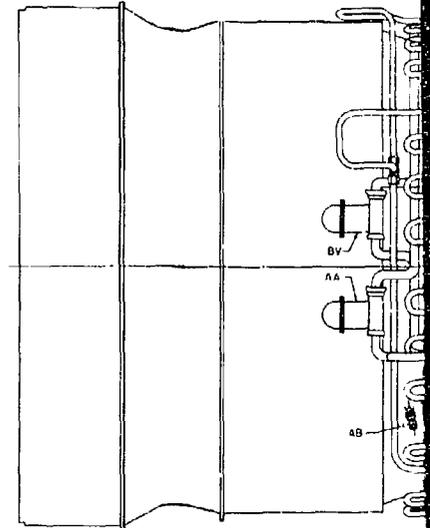
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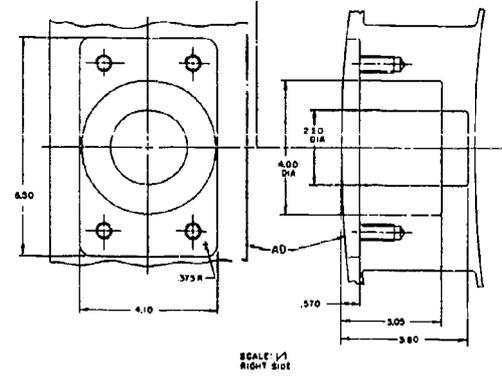
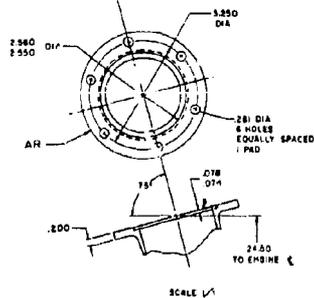
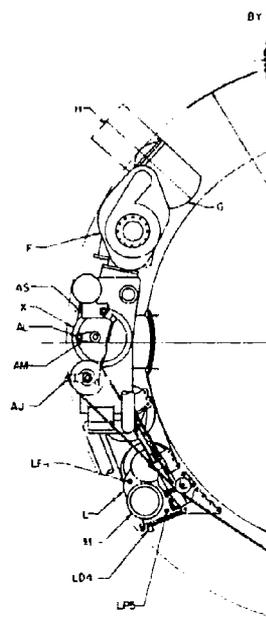
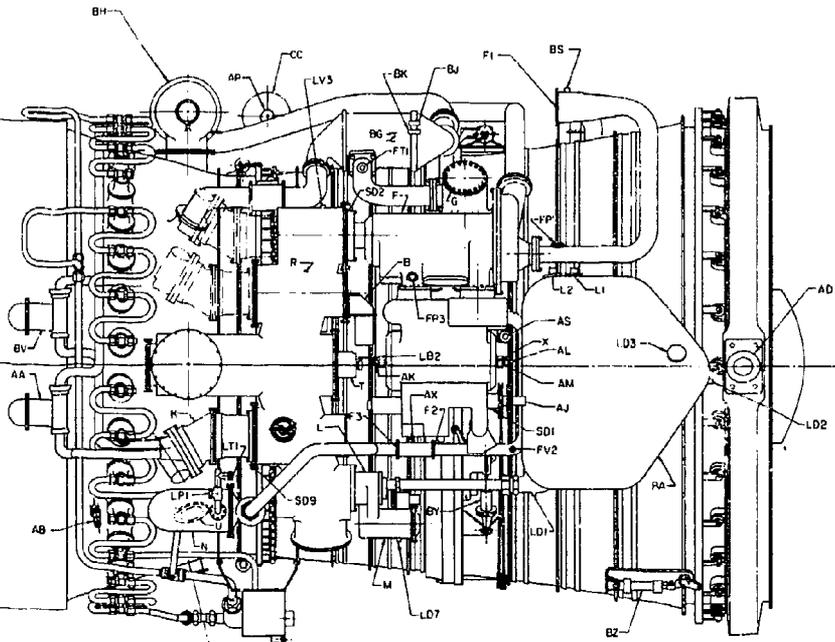
PRATT & WHITNEY AIRCRAFT

| ZONE                    | ACCESSORY DRIVE PADS                                       | ZONE |
|-------------------------|--|------|
| 257, 277, 302           | A POWER TAKEOFF TACHOMETER MOUNTING PAD WITH HAND ROOSTERS | 21A  |
|                         | FUEL DRAIN   | AG   |
| 17C                     | FD1 COMBUSTION CHAMBER FUEL DRAIN                          | AH   |
| 18C                     | FD2 DUMP VALVE DRAIN (MAIN)                                | AJ   |
| 18C                     | FD3 DUMP VALVE DRAIN (AFTERBURNER) ZONE I                  | AK   |
| 18C                     | FD4 DUMP VALVE DRAIN (AFTERBURNER) ZONE 2                  | AL   |
| 18C                     | FD5 AFTERBURNER COMBUSTION CHAMBER FUEL DRAIN              | AM   |
|                         | FUEL PRESSURE  | AN   |
| 191                     | FP1 FUEL PUMP INLET PRESSURE                               | AP   |
| 302                     | FP3 DUMP VALVE FUEL PRESSURE (OUTLET PRESSURE)             | AR   |
|                         | FUEL FLOW  | AS   |
| 187, 307                | F1 FUEL PUMP & AFTERBURNER PUMP SUPPLY INLET               | AT   |
| 300                     | F2 MAIN FUEL FLOWMETER SUPPLY INLET                        | AV   |
| 300                     | F3 MAIN FUEL FLOWMETER SUPPLY OUTLET                       | AW   |
| 187                     | F4 AFTERBURNER FLOWMETER SUPPLY INLET                      | AX   |
| 180                     | F5 AFTERBURNER FLOWMETER SUPPLY OUTLET                     | AY   |
|                         | FUEL VENT  | AZ   |
| 290                     | FV2 FUEL PUMP OUTLET VENT                                  | BA   |
|                         | FUEL TEMPERATURE   | BB   |
| 302                     | FT1 HEATER OUTLET FUEL TEMPERATURE                         | BC   |
|                         | OIL BREATHER   | BD   |
| 300                     | LB2 MAIN OIL OVERBOARD BREATHER                            | BE   |
|                         | OIL DRAIN  | BF   |
| 28C                     | LD1 OIL MAIN DRAIN   | BG   |
| 28D                     | LD2 OIL TANK OVERFLOW DRAIN                                | BH   |
| 29D                     | LD3 OIL CUP OVERFLOW DRAIN                                 | BI   |
| 29C                     | LD4 GEARBOX MAIN OIL DRAIN                                 | BJ   |
| 30C                     | LD7 OIL STRAINER DRAIN                                     | BK   |
|                         | OIL FLOW   | BL   |
| 28E                     | LL OIL TANK NEGATIVE FILL                                  | BM   |
| 28E                     | L2 OIL TANK MANUAL FILL                                    | BN   |
|                         | OIL PRESSURE   | BO   |
| 210                     | LP1 PRESSURE FOR TRANSMITTER                               | BP   |
| 22C                     | LP2 OIL FILTER INLET PRESSURE—PROVISIONS FOR PRESSURE      | BQ   |
| 22C                     | LP3 OIL FILTER OUTLET PRESSURE—DIFFERENTIAL                | BR   |
|                         | OIL TEMPERATURE  | BS   |
| 310                     | LT1 MAIN OIL TEMPERATURE                                   | BT   |
|                         | OIL VENT   | BU   |
| 207                     | LV3 OIL PRESSURE TRANSMITTER VENT                          | BV   |
|                         | SEAL DRAIN   | BW   |
| 280                     | SD1 FUEL CONTROL SEAL DRAIN                                | BX   |
| 302                     | SD2 FUEL PUMP SEAL DRAIN                                   | BY   |
| 300                     | SD3 HYDRAULIC PUMP SEAL DRAIN                              | BZ   |
| 180                     | SD14 AFTERBURNER FUEL PUMP SEAL DRAIN                      | CA   |
|                         | TEMPERATURE SENSING  | CB   |
| 200                     | TT5 TURBINE EXIT TEMPERATURE (AVERAGE)                     | CC   |
| 200                     | TT5 TURBINE EXIT TEMPERATURE (INDIVIDUAL)                  |      |
|                         | PRESSURE SENSING   |      |
| 187                     | PTS TURBINE EXIT PRESSURE                                  |      |
|                         | MISCELLANEOUS  |      |
| 24E, 30E                | F MAIN FUEL PUMP   |      |
| 22E, 30E                | G FUEL PUMP FUEL FILTER DRAIN                              |      |
| 24E                     | H FUEL PUMP FILTER (MIN SPACE FOR REMOVAL)                 |      |
| 181, 22E                | J AFTERBURNER FUEL PUMP                                    |      |
| 310                     | K HYDRAULIC PUMP   |      |
| 24C, 30D                | L OIL PUMP   |      |
| 24C, 30C                | M OIL FILTER   |      |
| 31C                     | N FUEL OIL COOLER (MAIN)                                   |      |
| 18C, 22C                | P FUEL OIL COOLER (AFTERBURNER)                            |      |
| 30E                     | Q GEARBOX  |      |
| 30D                     | R AUTOMATIC RESTART SWITCH                                 |      |
| 30D                     | T BREATHER PRESSURIZING VALVE                              |      |
| 181, 189, 31C           | U HIGH PRESSURE BLEED PAD                                  |      |
| 24D, 29D                | X MAIN FUEL CONTROL  |      |
| 17D, 21D                | Y AFTERBURNER FUEL CONTROL                                 |      |
| 17D                     | Z EXHAUST NOZZLE CONTROL                                   |      |
| 32D                     | AA HYDRAULIC DISCHARGE FILTER                              |      |
| 300, 34B, 17C, 20C, 24D | AB HEATER PLUG (MAIN)                                      |      |
| 200, 31B, 18B           | AC HEATER PLUG (AFTERBURNER)                               |      |
| 71B, 24E, 24A, 18E      | AD ENGINE FRONT MOUNTING PROVISIONS                        |      |
| 17E, 18E, 18E           | AE ENGINE REAR MOUNTING PROVISIONS                         |      |
| 207                     | AF FUEL RETURN TO SUPPLEMENTARY CLOSING                    |      |

|                         |    |  |
|-------------------------|----|--|
| 21A                     | AG | GROUND HANDLING INDEX (FRONT MOUNT)                                  |
| 12C                     | AH | LAND HANDLING AREA (REAR)  |
| 28D                     | AJ | POWER CONTROL LEVER (90° ANGLE OF TRAVEL)                            |
| 30D                     | AK | SHUT OFF LEVER (90° ANGLE OF TRAVEL)                                 |
| 28D                     | AL | APPROACH VELOCITY CONTROL LEVER (90° ANGLE OF TRAVEL)                |
| 28D, 29D                | AM | MACH NO. ON SMOKE POSITION RESET LEVER (90° ANGLE OF TRAVEL)         |
| 28E                     | AN | AIR TURBINE VALVE AFTERBURNER FUEL PUMP                              |
| 31F                     | AP | IGNITION EXCITER ELECTRICAL CONN.                                    |
| 31B                     | AR | THERMAL ANTI-ICING PAD   |
| 24E, 28D                | AS | AEROHYDRAULIC BRAKE CONTROL AIR SUPPLY CONN.                         |
| 17D                     | AT | EXHAUST NOZZLE FEEDBACK  |
| 18C                     | AU | CHECK & DUMP VALVE (AFTERBURNER ZONE I)                              |
| 18C                     | AV | CHECK & DUMP VALVE (AFTERBURNER ZONE II)                             |
| 180                     | AW | MAIN FUEL FLOWMETER MOUNTING PROVISIONS                              |
| 30D                     | AX | AFTERBURNER FUEL FLOWMETER MOUNTING PROVISIONS                       |
| 22E, 18E                | AY | FUEL CONTROL FUEL FILTER (MIN SPACE FOR REMOVAL)                     |
| 18C, 22C                | AZ | WOODRILL BYPASS CHECK & DUMP LOW OIL VALVE (MAIN)                    |
| 28D                     | BA | OIL TANK   |
| 17D                     | BB | NOZZLE POSITION INDICATOR MOUNTING PROVISIONS                        |
| 20D                     | BC | REVERSE POSITION INDICATOR CONN. (ELECTRICAL)                        |
| 17C                     | BD | THERMOSTAT, FUEL BYPASS VALVE  |
| 4A, 22B, 140, 20B       | BF | VIBRATION MOUNT (SPACE RESERVED FOR PICKUP PROVIDED BY AIRFRAME MFG) |
| 20E                     | BG | FUEL HEATER  |
| 177, 247, 31F           | BH | POWER TAKEOFF DEARBON  |
| 307                     | BI | FUEL HEATER VALVE ELECTRICAL CONN.                                   |
| 187                     | BJ | FUEL HEATER VALVE POSITION INDICATOR (ELECTRICAL)                    |
| 187                     | BK | POWER TAKEOFF DECOUPLER  |
| 187, 247                | BL | POWER TAKEOFF DECOUPLER ACTUATING SHAFT                              |
| 24D                     | BN | CONTROL CABLE—FUEL CONTROL   |
| 187, 287                | BS | FUEL INLET TEMPERATURE SENSOR  |
| 18D                     | BU | AFTERBURNER FUEL OIL COOLER THERMOSTATIC BYPASS VALVE                |
| 310                     | BV | HYDRAULIC RETURN FILTERS   |
| 18E                     | BW | EXHAUST NOZZLE ACTUATORS   |
| 23D, 28D, 187, 257, 30C | BY | STARTING BLEED DOOR ACTUATORS  |
| 20E, 29C                | BZ | INLET GUIDE VANE ACTUATORS   |
| 18C, 187                | CA | AEROHYDRAULIC BRAKE ACTUATORS  |
| 20D                     | CB | EXCITER (MAIN)   |
| 187, 307                | CC | EXCITER (AFTERBURNER)  |



VIEW OF MAIN HEATER  
LOOKING FORWARD

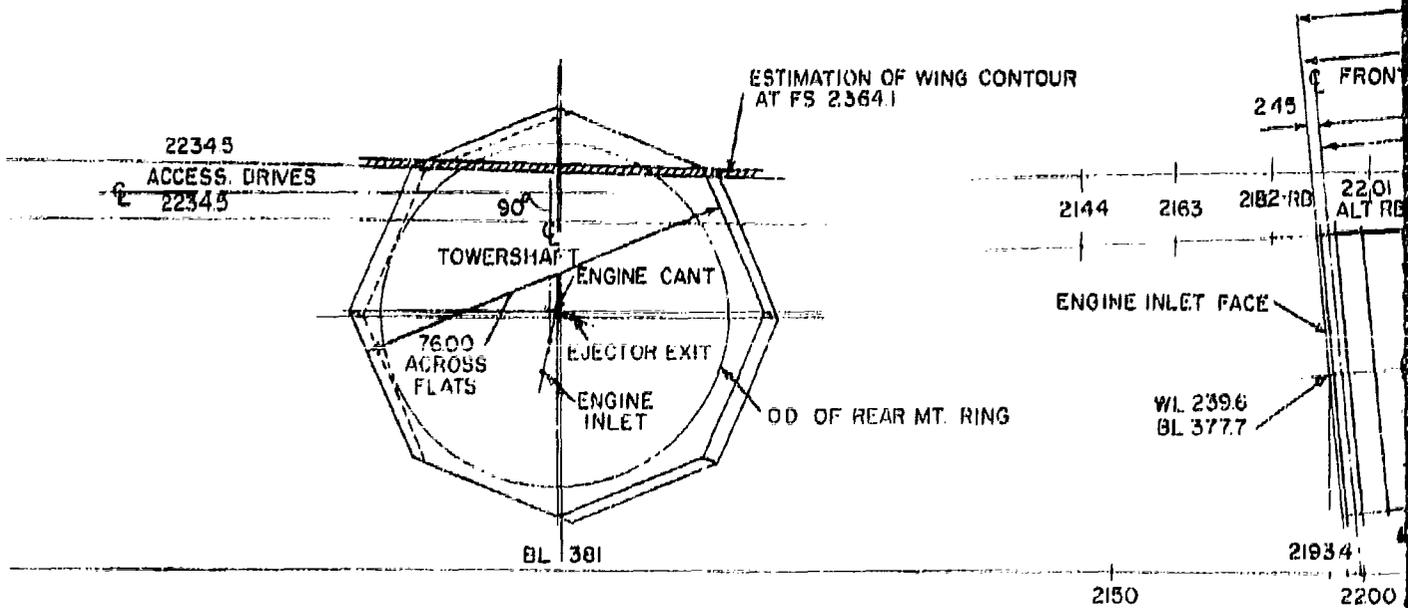
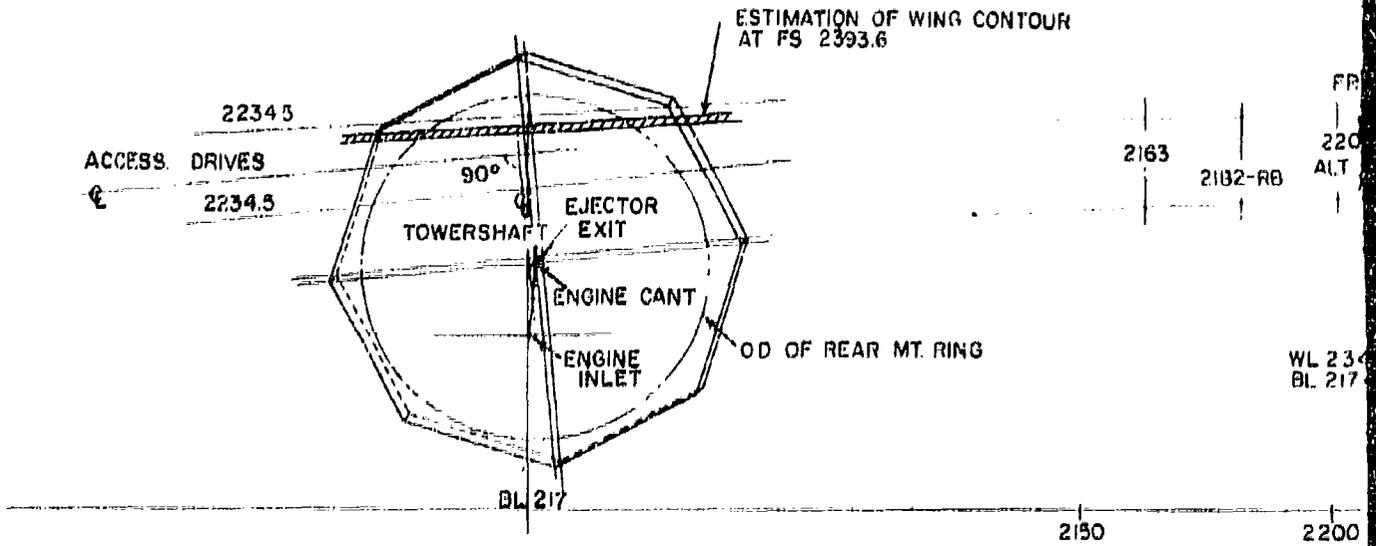


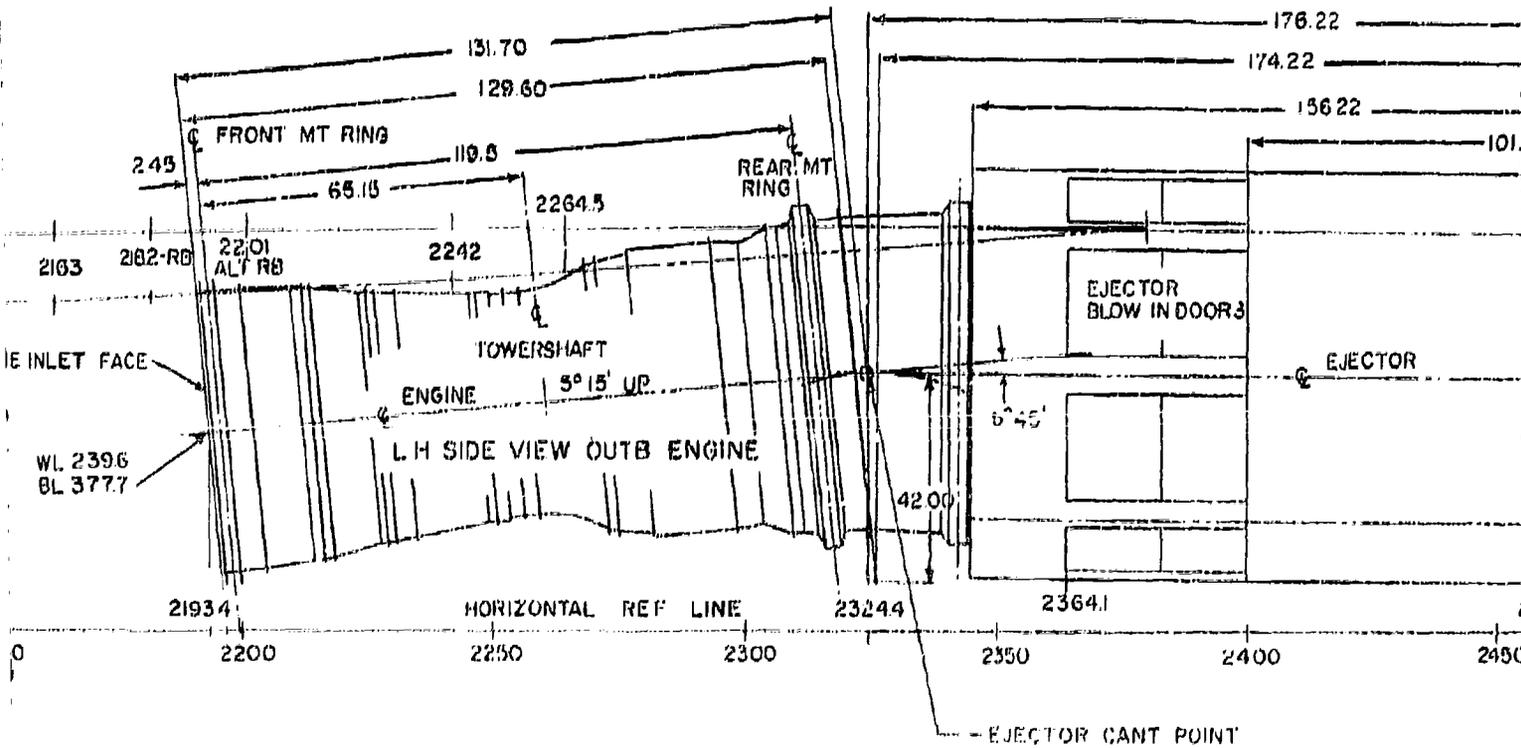
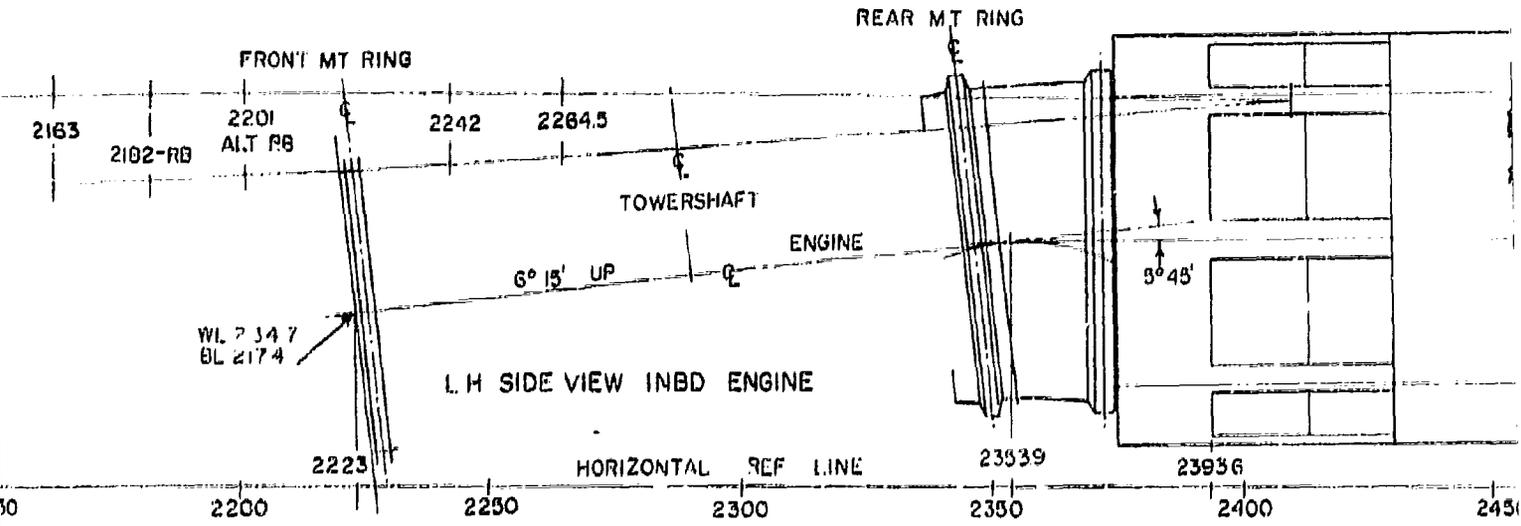






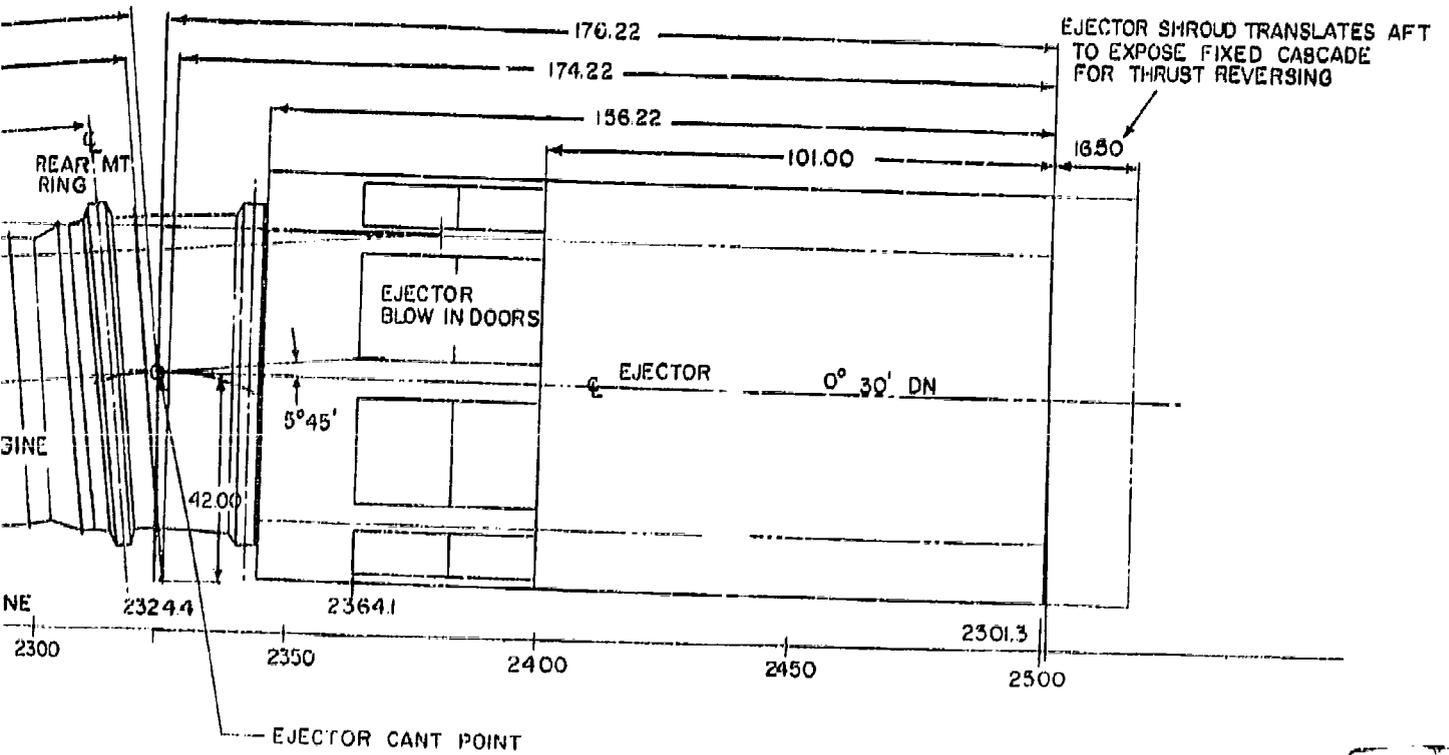
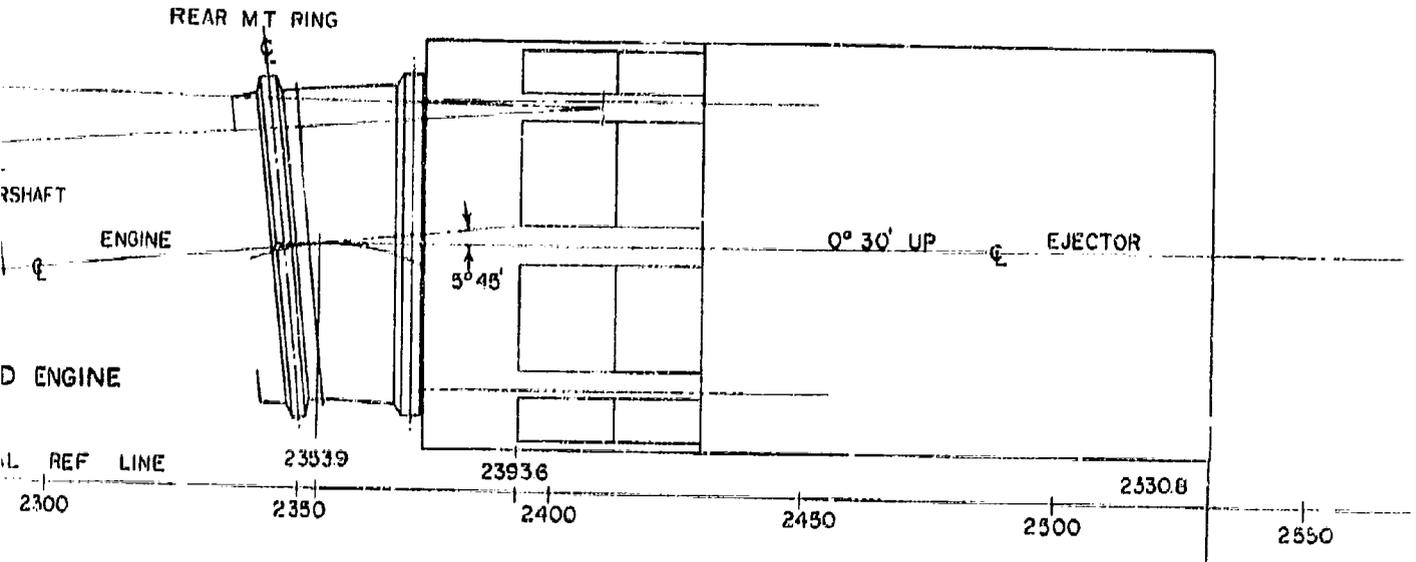






TYPICAL TURBOJET INST  
EFFECT OF INCREASE

Figure 1



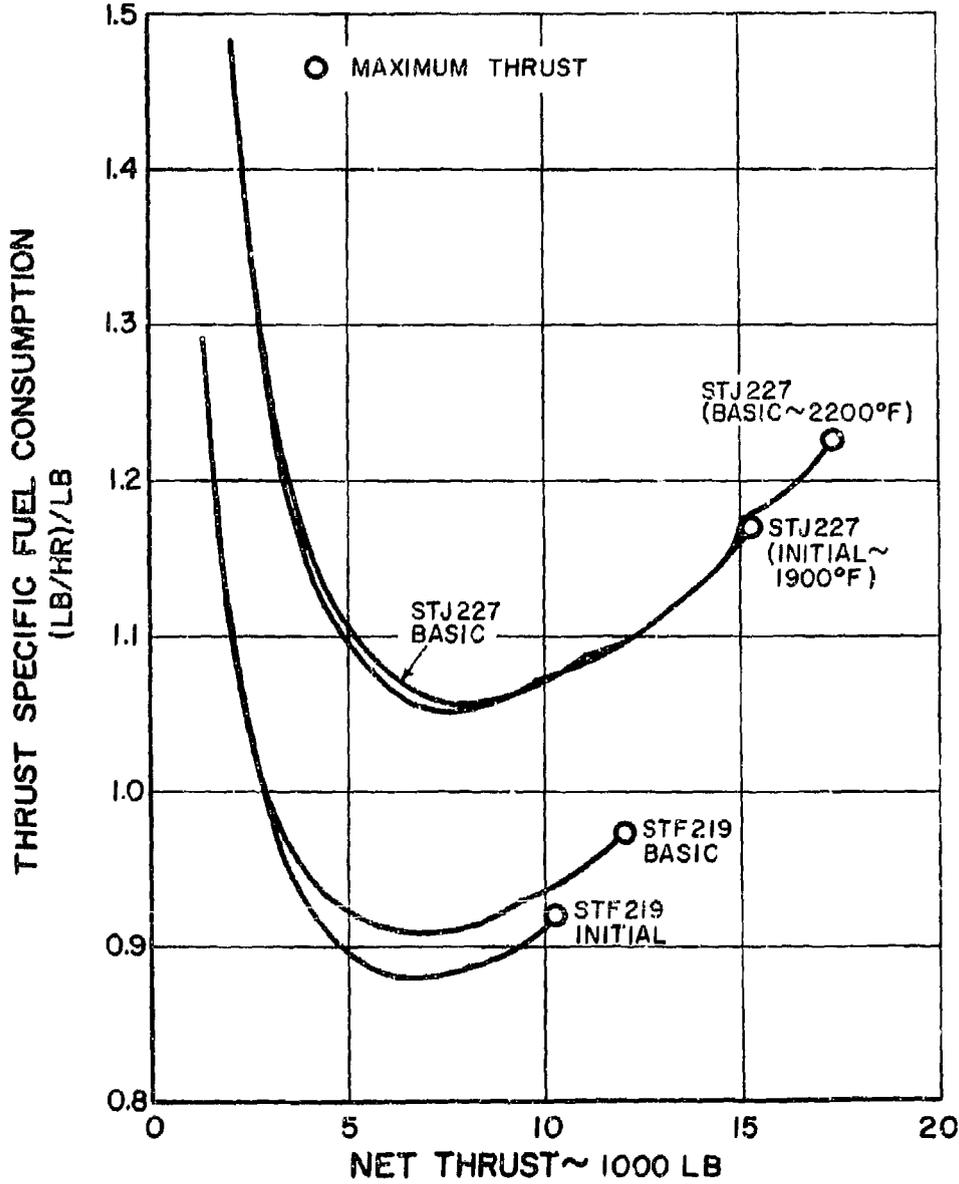
TYPICAL TURBOJET INSTALLATION SHOWING EFFECT OF INCREASED CANT ANGLE

Figure 1-44

3



U S STANDARD ATMOSPHERE - 1962 (GEOM)  
 RAM RECOVERY PER MIL-E-5008B  
 36,150 FT PHASE II B M<sub>0</sub> 0.9



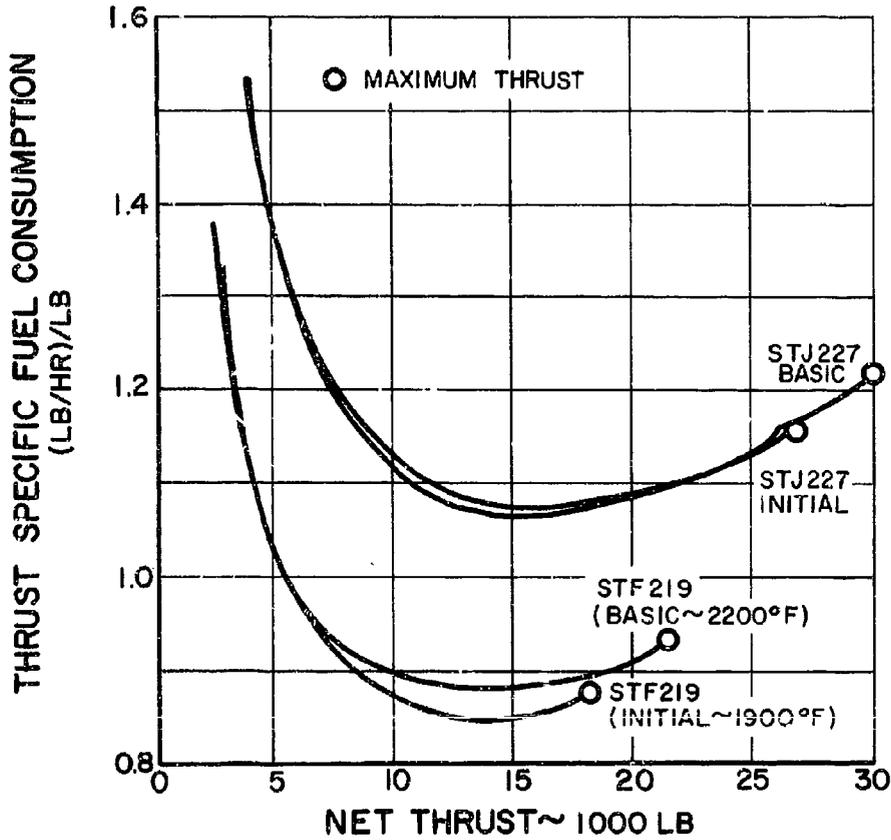
ESTIMATED PERFORMANCE OF STF219 AND STJ227 ENGINES  
 AT MACH 0.9 AT 36,150 FEET

Figure 1-46

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U.S. STANDARD ATMOSPHERE-1962 (GEOM)  
 RAM RECOVERY PER MIL-E-5008B  
 15,000 FT PHASE II B MN 0.6



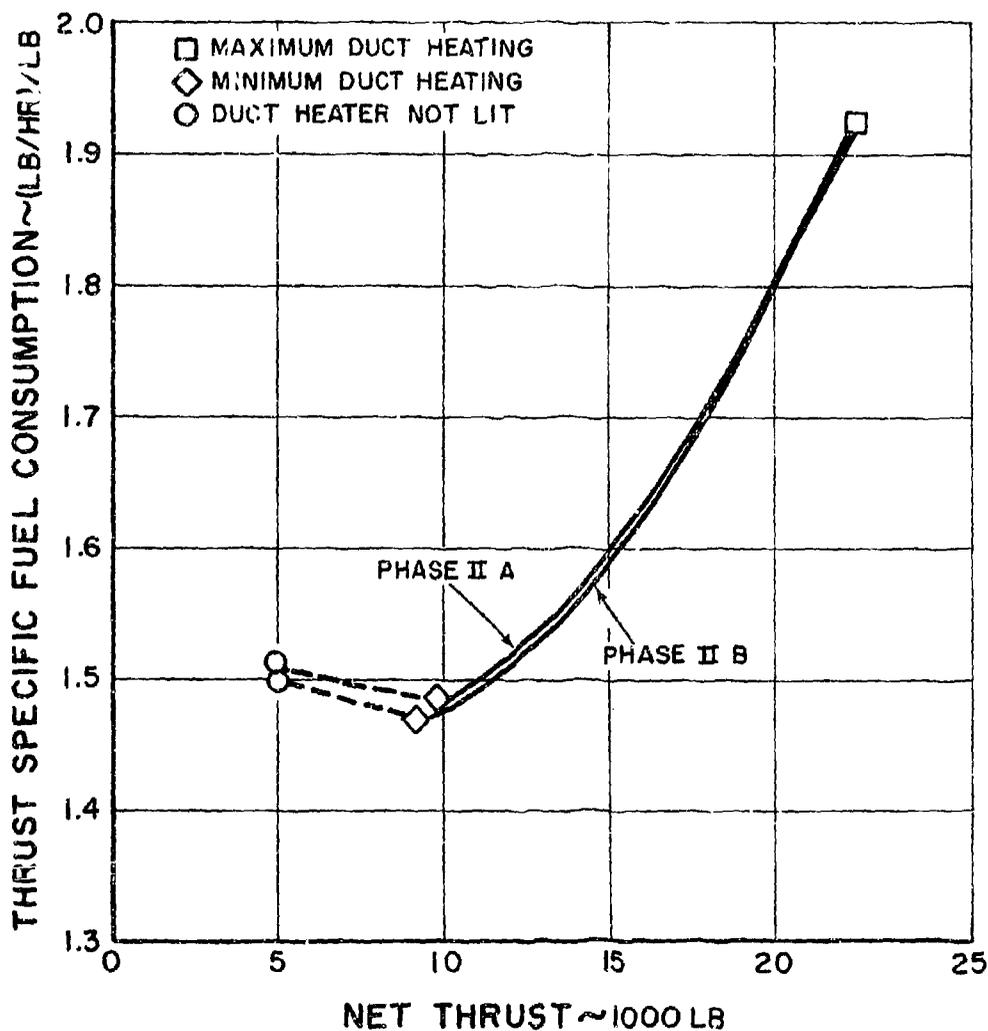
ESTIMATED PERFORMANCE OF STF219 AND STJ227 ENGINES  
 AT MACH 0.6 AT 15,000 FEET

Figure 1-47

DOWNGRADED AT 2 YEAR INTERVALS  
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US STANDARD ATMOSPHERE - 1962 (GEOM)  
RAM RECOVERY PER MIL-E-5008B  
DESIGN TURBINE INLET TEMPERATURE 2200°F  
65,000 FT Mn 2.7



ESTIMATED PERFORMANCE OF STF219 ENGINE AFTER PHASE IIA AND AFTER PHASE IIB AT MACH 2,7 AT 65,000 FEET

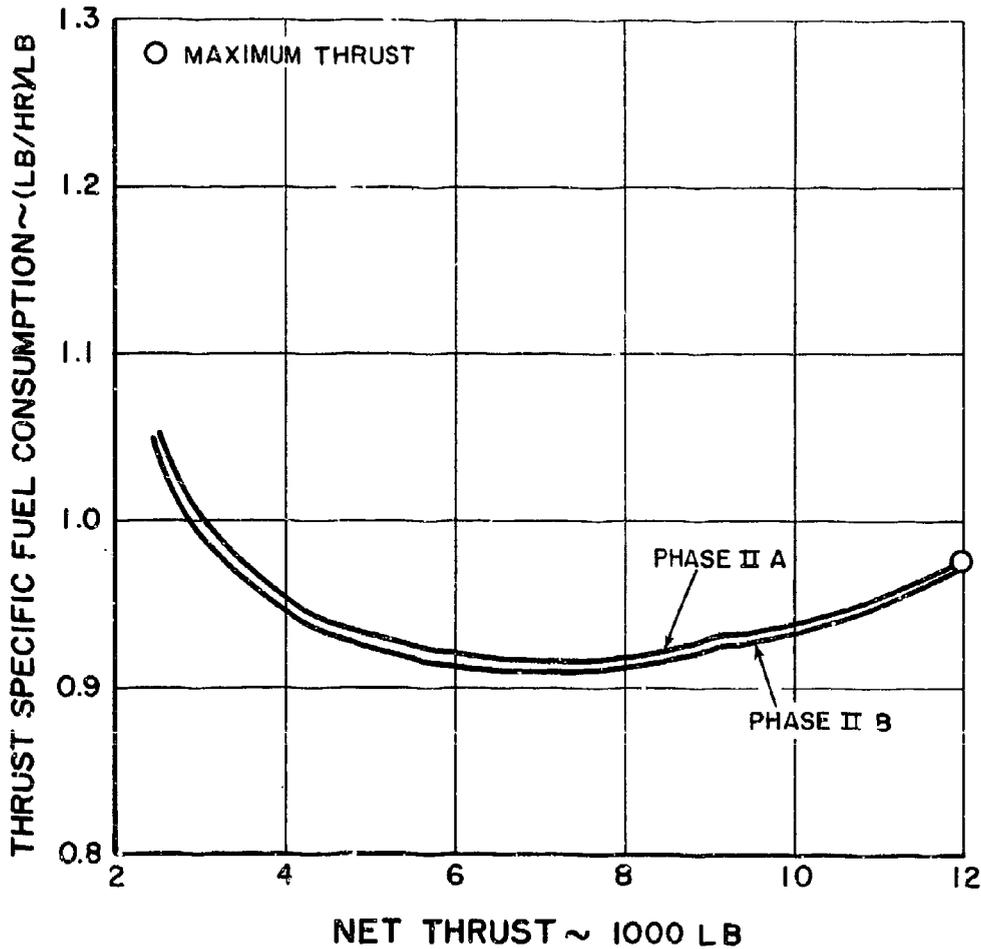
Figure 1-48

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DOWNGRADED AT 3 YEAR INTERVALS  
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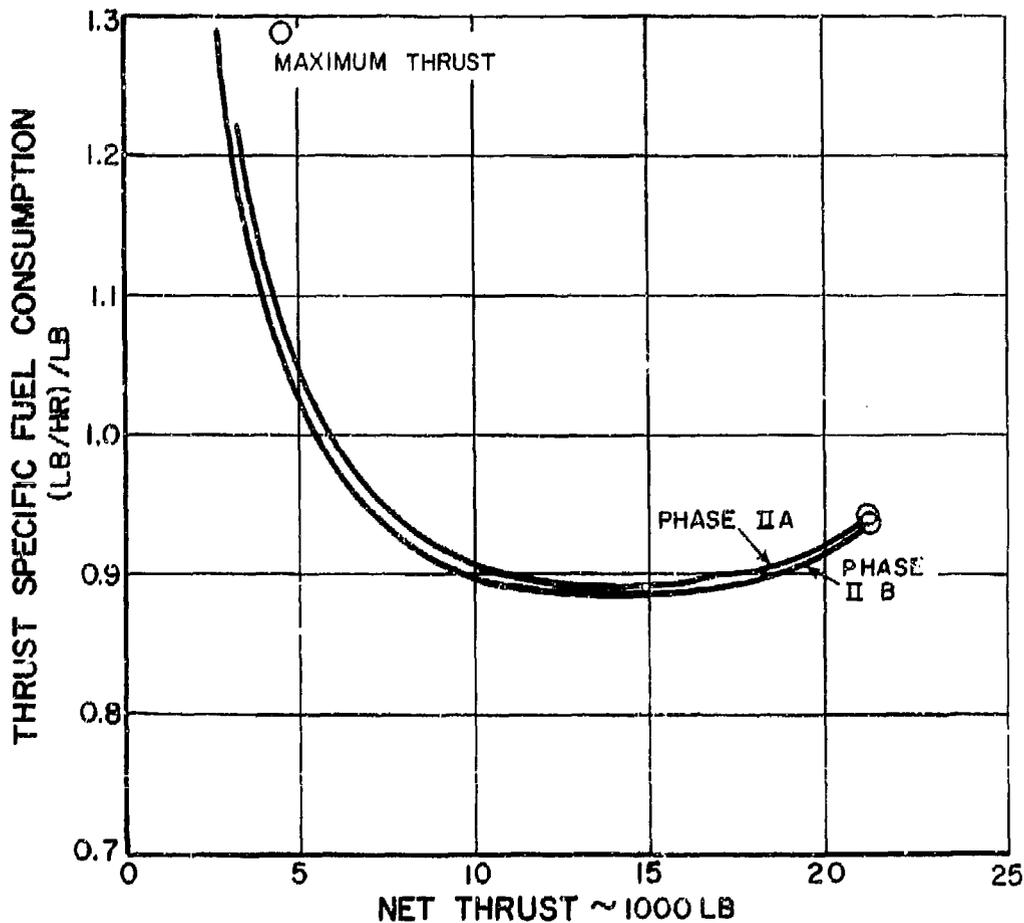
U S STANDARD ATMOSPHERE - 1962 (GEOM)  
 RAM RECOVERY PER MIL-E-5008 B  
 DESIGN TURBINE INLET TEMPERATURE 2300°F  
 36,150 FT Mn 0.9



ESTIMATED PERFORMANCE OF ST/F219 ENGINE AFTER PHASE IIA AND AFTER PHASE IIB AT MACH 0.9 AT 36,150 FEET

Figure 1-49

US STANDARD ATMOSPHERE - 1962 (GEOM)  
 RAM RECOVERY PER MIL-E-5008 B  
 DESIGN TURBINE INLET TEMPERATURE - 2300°F  
 15,000FT Mn 0.6



ESTIMATED PERFORMANCE OF STF219 ENGINE AFTER PHASE IIA  
 AND AFTER PHASE IIB AT MACH 0.6 AT 15,000 FEET

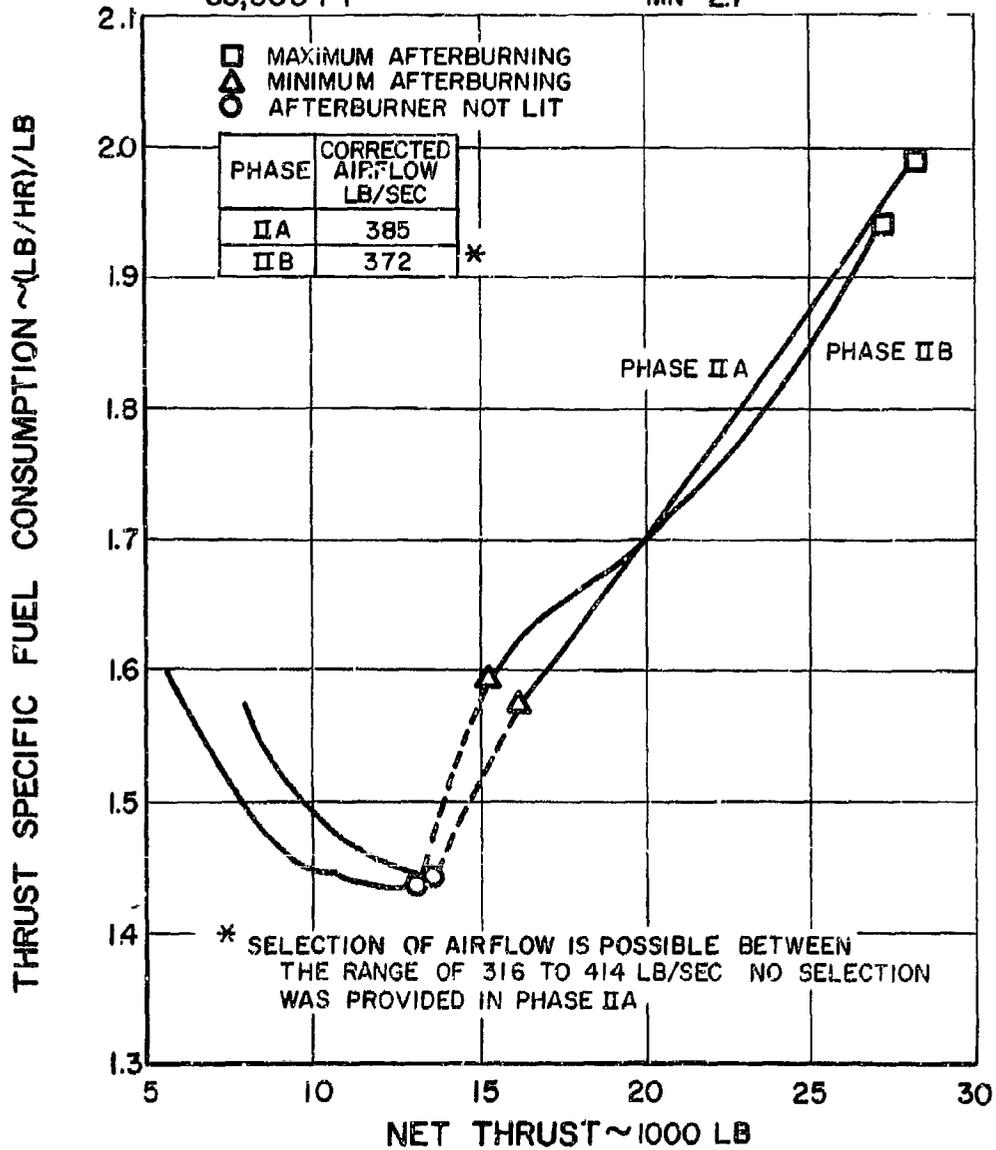
Figure 1-50

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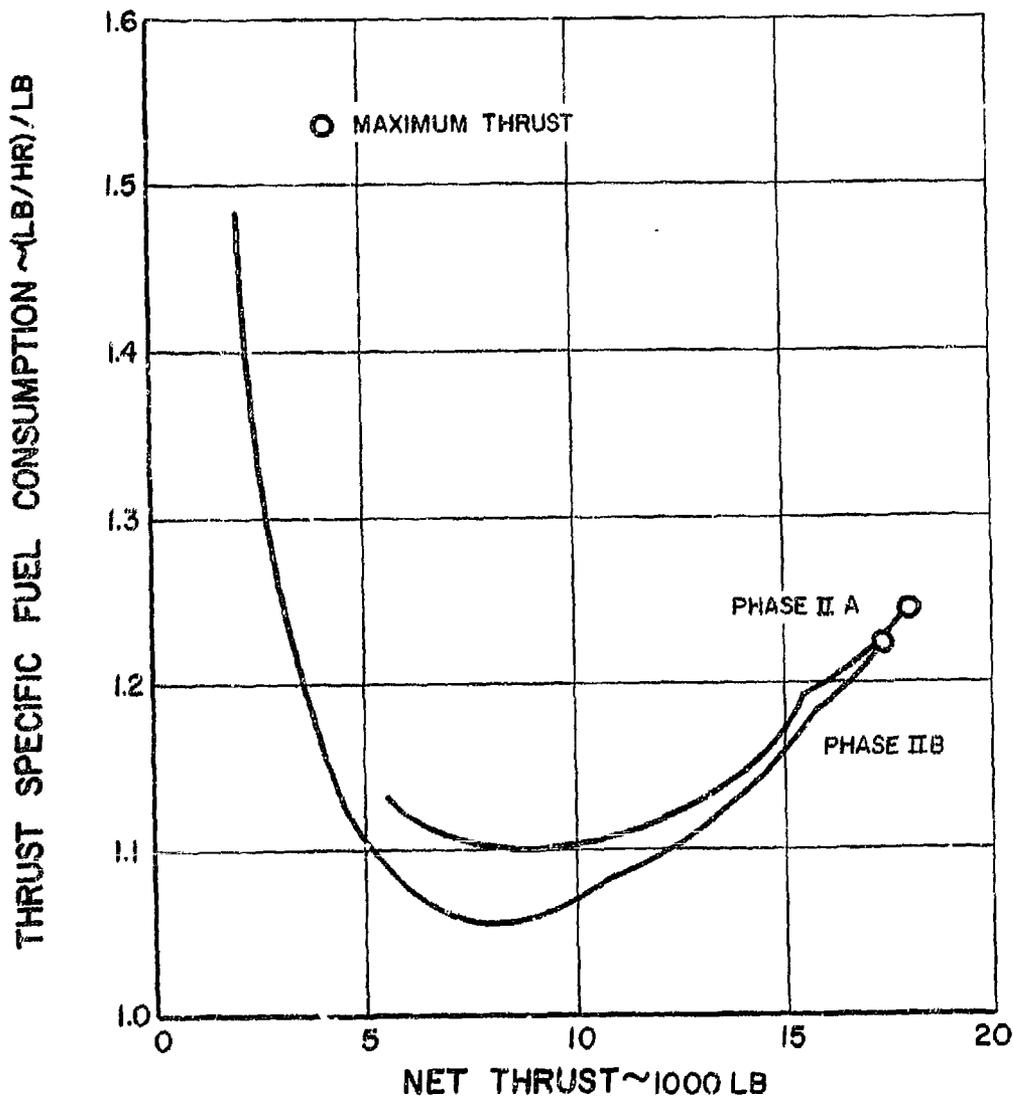
US STANDARD ATMOSPHERE - 1962 (GEOM)  
 RAM RECOVERY PER MIL-E-5008B  
 DESIGN TURBINE INLET TEMPERATURE 2200°F  
 65,000 FT MN 2.7



ESTIMATED PERFORMANCE OF STJ227 ENGINE AFTER PHASE II A AND AFTER PHASE II B AT MACH 2.7 AT 65,000 FEET

Figure 1-51

U S STANDARD ATMOSPHERE - 1962 (GEOM)  
 RAM RECOVERY PER MIL-E-5008B  
 DESIGN TURBINE INLET TEMPERATURE 2300°F  
 36,150 FT Mn 0.9



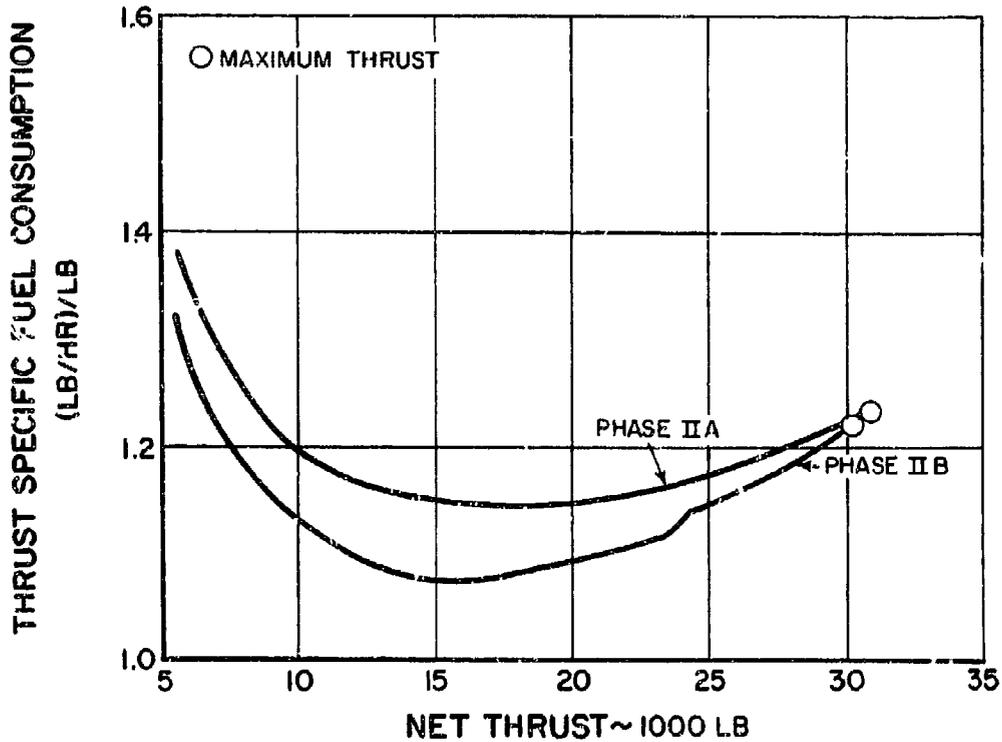
ESTIMATED PERFORMANCE OF STJ227 ENGINE AFTER PHASE IIA AND AFTER PHASE IIB AT MACH 0.9 AT 36,150 FEET

Figure 1-52

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US STANDARD ATMOSPHERE -1962 (GEOM)  
 RAM RECOVERY PER MIL-E-5008B  
 DESIGN TURBINE INLET TEMPERATURE = 2300°F  
 15,000 FT MN 0.6



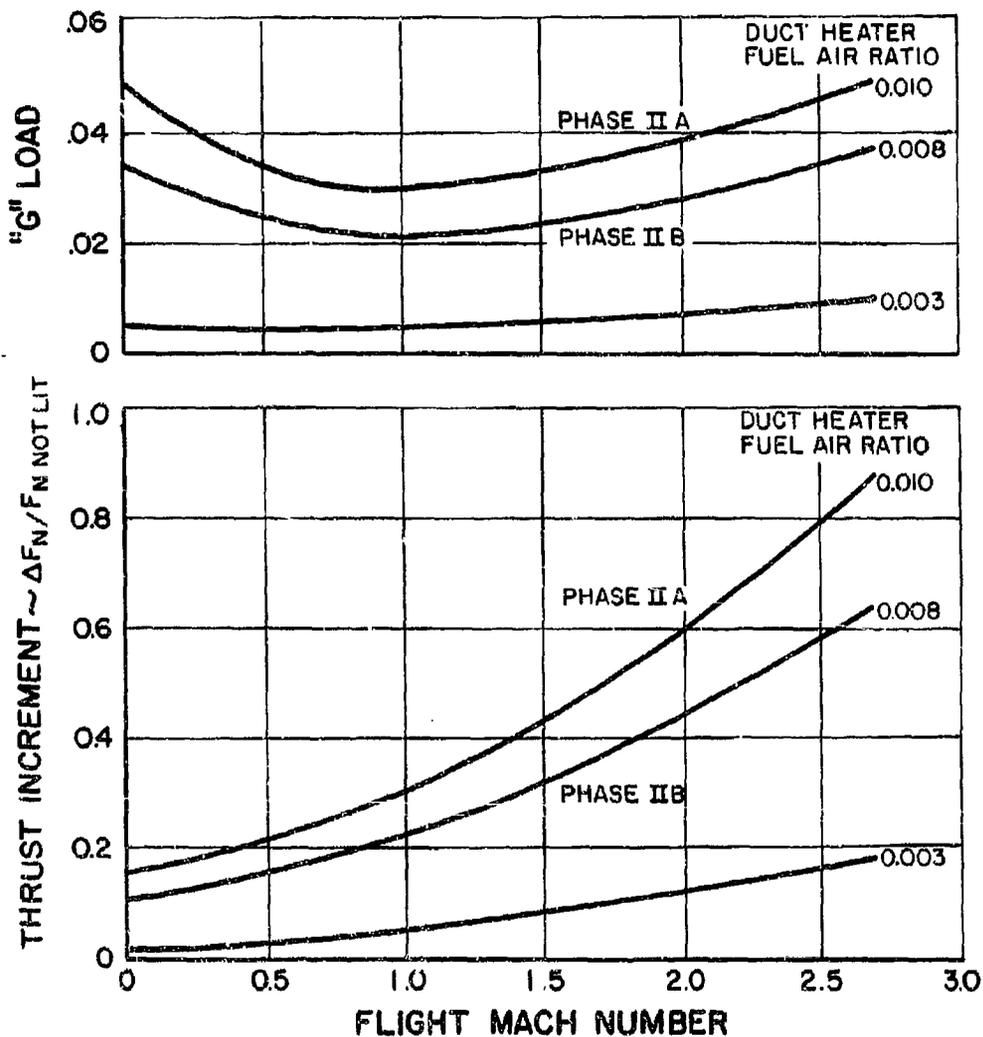
ESTIMATED PERFORMANCE OF STJ227 ENGINE AFTER PHASE IIA AND AFTER PHASE IIB AT MACH 0.6 AT 15,000 FEET

Figure 1-53

CONFIDENTIAL

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U.S. STANDARD ATMOSPHERE - 1962 (GEOM)  
 RAM RECOVERY PER MIL - E - 5008 B  
 TOGW = 450,000 LBS

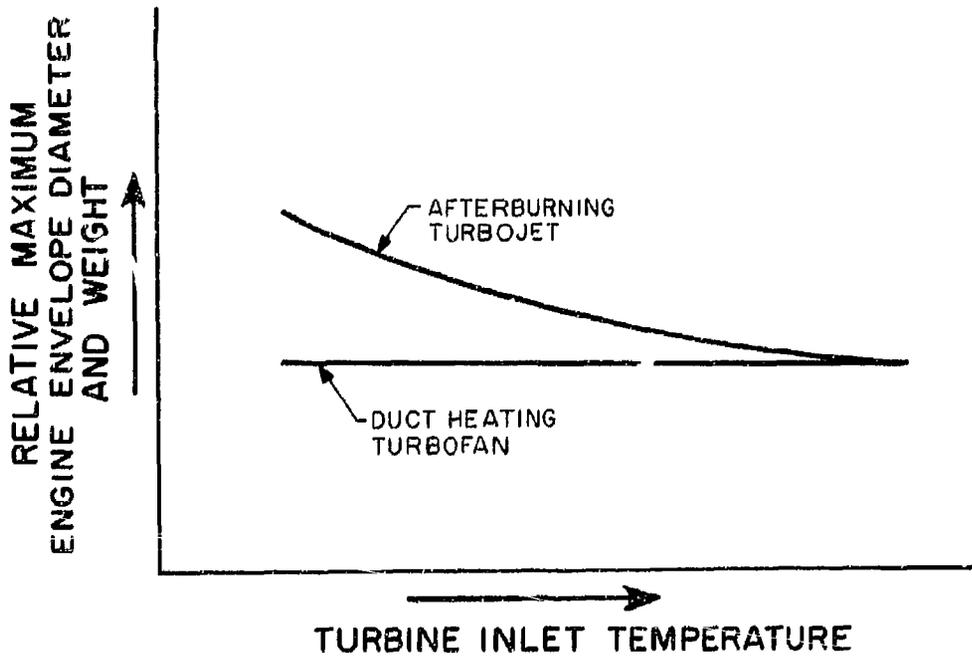


LOADING AND THRUST INCREMENT PRODUCED BY LIGHTING DUCT HEATER OF STF219 ENGINE

Figure 1-54

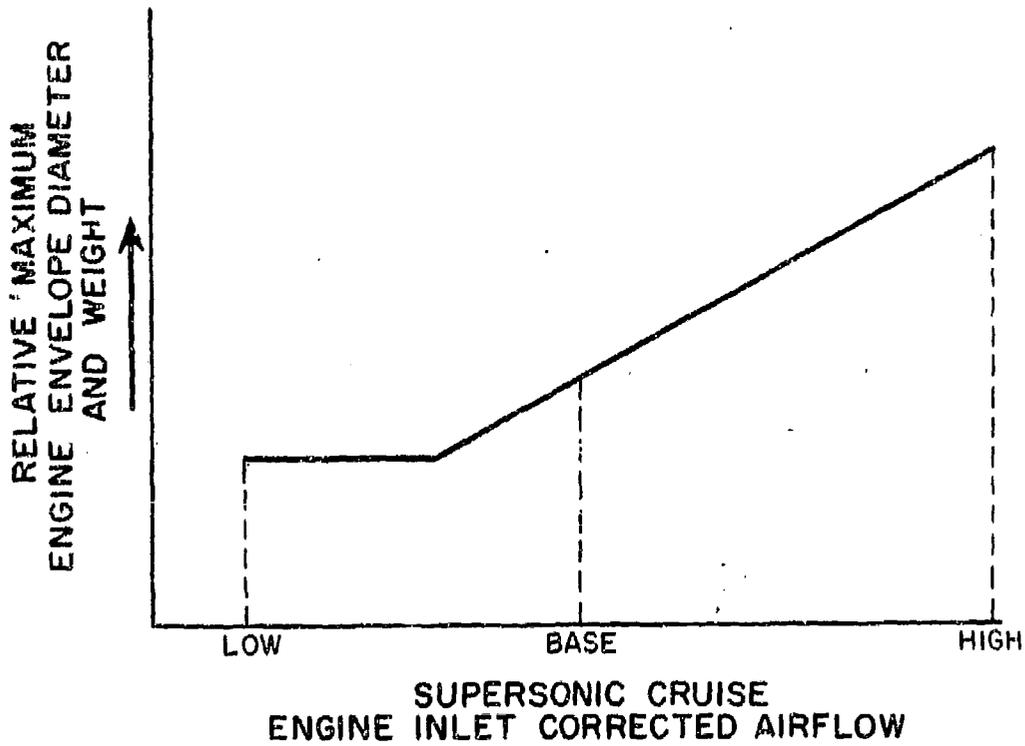
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 THEREIN.



EFFECT OF TURBINE INLET TEMPERATURE ON ENGINE WEIGHT AND MAXIMUM DIAMETER

Figure 1-55



EFFECT OF ENGINE SUPERSONIC CRUISE INLET AIRFLOW  
ON ENGINE WEIGHT AND MAXIMUM DIAMETER

Figure 1-56

ORIGINATED AT 3 YEAR INTERVALS  
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