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Design of a Low Speed Fan Stage for Noise Suppression

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SUMMARY

This report describes the design of a low tip speed, moderate pressure rise fan stage for demonstration of noise reduction concepts. The fan rotor is a fixed-pitch configuration delivering a design pressure ratio of 1.378 at a specific flow of 43.1 lbm/sec/ft^2. Four exit stator configurations were provided to demonstrate the effectiveness of circumferential and axial sweep in reducing rotor-stator interaction tone noise. The fan stage design was combined with an axisymmetric inlet, conical convergent nozzle, and nacelle to form a powered fan-nacelle subscale model. This model has a 22-inch cylindrical flow path and employs a rotor with a 0.30 hub-to-tip radius ratio. The design is fully compatible with an existing NASA force balance and rig drive system.

The stage aerodynamic and structural design is described in detail. Three-dimensional (3-D) computational fluid dynamics (CFD) tools were used to define optimum airfoil sections for both the rotor and stators. A fan tone noise predictive system developed by Pratt & Whitney under contract to NASA was used to determine the acoustic characteristics of the various stator configurations. Parameters varied included rotor-to-stator spacing and vane leading edge sweep. The structural analysis of the rotor and stator are described herein. An integral blade and disk configuration was selected for the rotor. Analysis confirmed adequate low cycle fatigue life, vibratory endurance strength, and aeroelastic suitability. A unique load carrying stator arrangement was selected to minimize generation of tonal noise due to sources other than rotor-stator interaction. Analysis of all static structural components demonstrated adequate strength, fatigue life, and vibratory characteristics.

1.0 INTRODUCTION

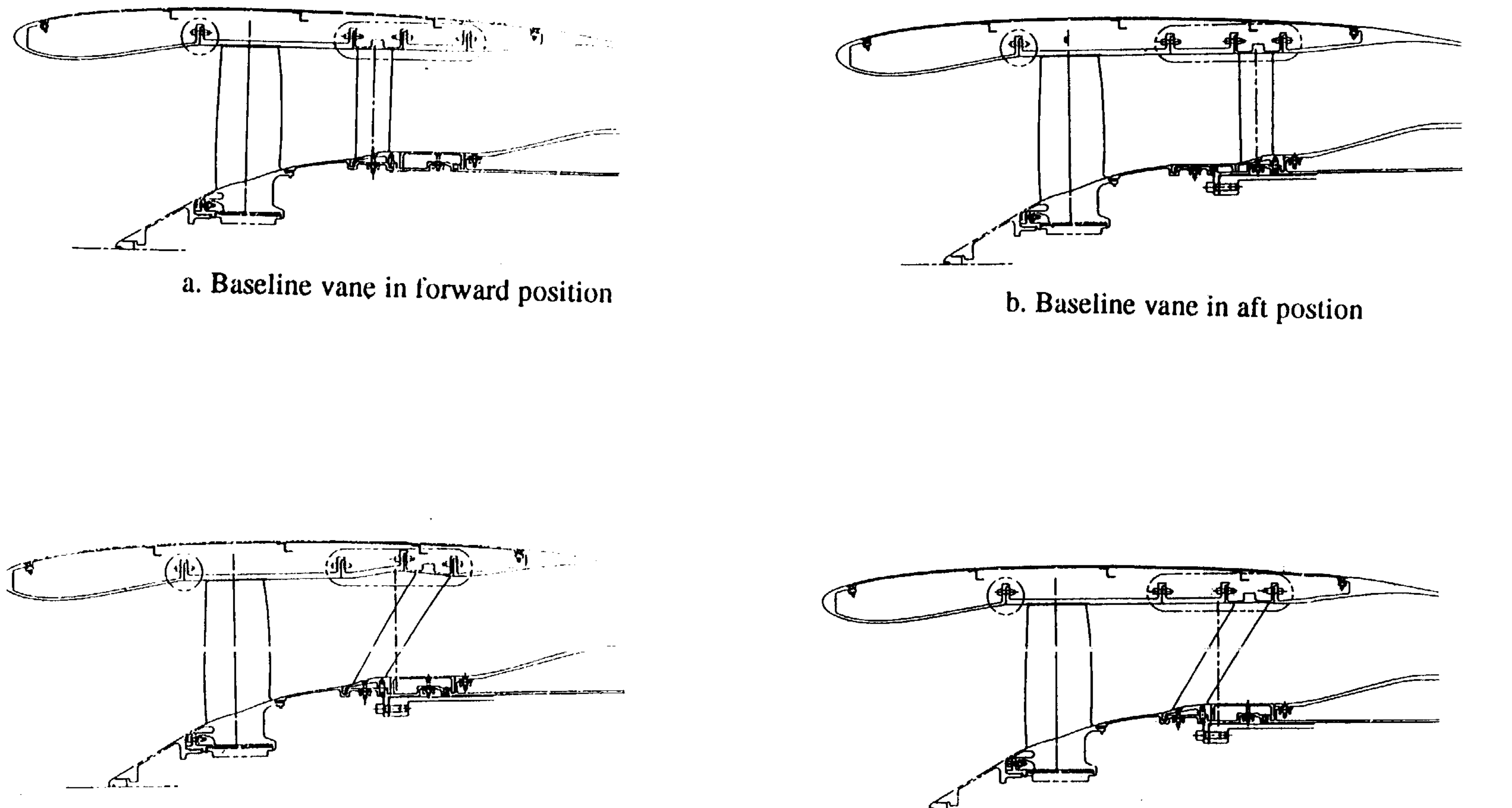
Since the late 1960s, there has been a continuous effort to lower community noise levels resulting from aircraft terminal operations. Current high bypass ratio engine technology is sufficient to allow certification of aircraft to Stage 3 of Federal Aviation Regulation (FAR) Part 36. As part of the natural evolutionary process, consideration of a reduced certification level is underway. In order to accommodate a growth plan, major reductions in propulsion system generated noise will be required for new aircraft/engine combinations to be certified to this more stringent noise standard. Under Task 5 of contract NAS3-25950, Allison Engine Company studied the engine component noise reductions required to produce a propulsion system for a twin engine aircraft producing certification levels 10 decibels (dB). below the current FAR 36 Stage 3 requirement. Early results of this study indicated a strong acoustic advantage in moving from a conventional six bypass ratio turbofan cycle to an ultrahigh bypass ratio cycle employing a low pressure ratio, low tip speed fan. However, cycle changes alone were not sufficient to produce flyover levels 10 dB below stage 3. Additional reductions required identification of innovative strategies for lowering the strength of dominant noise sources. Flyover time histories of perceived noise level produced under this contract indicated the predominant noise source was the fan during both the takeoff and approach segments of flight. Noise reduction studies based on this result identified bypass vane sweep as a potentially effective approach for reducing the pure tone portion of the fan noise field. Based on the results of these studies, a fan rig test program was proposed to the National Aeronautics and Space Administration (NASA) to demonstrate this concept. As a result of this proposal, a 22-inch diameter single-stage fan demonstrator has been designed. This report documents the aerodynamic and structural design of this stage.

2.0 RIG DESIGN FEATURES

The rig mechanical arrangement evolved from a set of requirements developed to meet the program technical objectives and to satisfy facility and operational needs. Specifically these requirements were:

- the rig must be compatible with existing NASA drive system
- no flow-path obstructions except rotor and stator allowable
- provisions must be made for multiple vane configurations
- vane configurational changes must be accomplished in the wind tunnel and not require removal of fan rotor

The final configuration, shown in Figure 1 , meets all design objectives and is fully compatible with the NASA drive rig. Based on acoustic analysis, four vane configurations will be tested. Removal of additional flow-path obstructions was required to isolate, as fully as possible, the acoustic impact of the vane geometry changes. As a result of this requirement, the stator must carry not only its normal aerodynamic loads, but also any nacelle generated loads. To accomplish this and allow vane changes without fan rotor removal, the vanes have been designed as a segmented ring with the airfoils providing a load path between flange rings on the inner and outer diameters. Loads are passed from the vane ring to a backbone support though a single shear pin and three radial fasteners in each segment. All outer flow-path pieces aft of the rotor are split axially to allow quick access to the vane fasteners for removal. Multiple attachment planes are provided to accommodate the four vane configurations to be tested. No provisions have been included for either a core rotor or a separate core flow stream.



a. Baseline vane in forward position

b. Baseline vane in aft postion

c. Axially swept vane

d. Swept and leaned vane

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Figure 1. Rig mechanical configuration.

3.0 AERODYNAMIC DESIGN

3.1 FAN STAGE AERODYNAMIC DESIGN

3.1.1 Baseline Stage Configuration And Vector Diagrams

The aerodynamic design point for the fan stage, as established during cycle optimization studies conducted during Task 5, is:

Tip Speed = 1000 ft/sec
Stage Pressure Ratio = 1.362
$W\sqrt{\theta}/\delta A = 43.1$ lbm/sec/ft^2

As shown in Figure 2, the final engine configuration of Task 5 employed a booster stage on the fan shaft to provide the required supercharging for the core compressor. Early in the rig design, it was decided both the booster stage and the core flow bifurcation would be eliminated. This produced two benefits. The first was a significant reduction in mechanical complexity, resulting in reduced fabrication costs. The second was the removal of additional noise sources, allowing a clear identification of the acoustic benefit of vane geometry variations. As a result of the very high bypass ratio cycle selected in the Task 5 engine study, a strong radial rotor exit total pressure gradient exists (Figure 3). This profile is also present in the rig design. The rig stage design pressure ratio was selected as the mass average of the 1.38 bypass and 1.21 core pressure of the original engine design, allowing for some loss through the rig stator. A schematic cross section of the baseline rig configuration is shown in Figure 4. As can be seen, a cylindrical outer flow-path contour was maintained through the stator exit. The requisite area ruling through the stage is introduced through the hub flow path as an integral part of the blading design. Curvature was used into and through the stator to keep the relatively low momentum fluid coming from the rotor hub energized. The rotor-to-stator axial gap is consistent with current Allison fans. Coordinates for the flow path of the baseline configuration are presented in Table 1.

The velocity vector diagrams were generated using the Allison axisymmetric streamline curvature design system. A listing for the aerodynamic design point is included in Appendix A. Some of the blade and vane inlet and exit profiles tabulated in Appendix A are plotted in Figures 5 and 6 Also shown are corresponding profiles from the NASA Stage 53 fan. The comparison is useful since the general character of the flow field through the two fans is similar. The NASA Stage 53 fan was designed for the same rotor pressure ratio and tip speed; it did not quite pump to design intent, hence, the profiles measured at design flow are shown in addition to those that represent design intent. The low noise fan (LNF) rotor is designed for a pressure profile of even greater skew and for higher throughflow velocities than found in the NASA Stage 53 fan. The rotor inlet is also set for a higher specific flow and lower inlet radius ratio (0.30). As a result, the inlet relative Mach number at the tip for the LNF is higher, 1.143, even though tip speeds are the same. Greater turning is required across the LNF blade tip but the blade is overall more lightly loaded.

Velocities at stator inlet, although subsonic, are relatively high toward the outer diameter due to the pressure profile from the rotor and the absence of a splitter. This, together with the thicknesses and camber required of these vane sections, made it impossible to design an entirely shock-free stator. Stator loading was reduced and performance enhanced by allowing closure of the discharge annulus to a Mach number of 0.59 (including blockage). The turning required through the baseline vane row is thus considerably less than was required through the NASA 53 fan stator.

3.1.2 Blade Design

The fan blade was designed as if destined for a commercial fan application to ensure as much realism was incorporated in its geometry as possible. The ultrahigh bypass ratio engine preliminary design cycle was

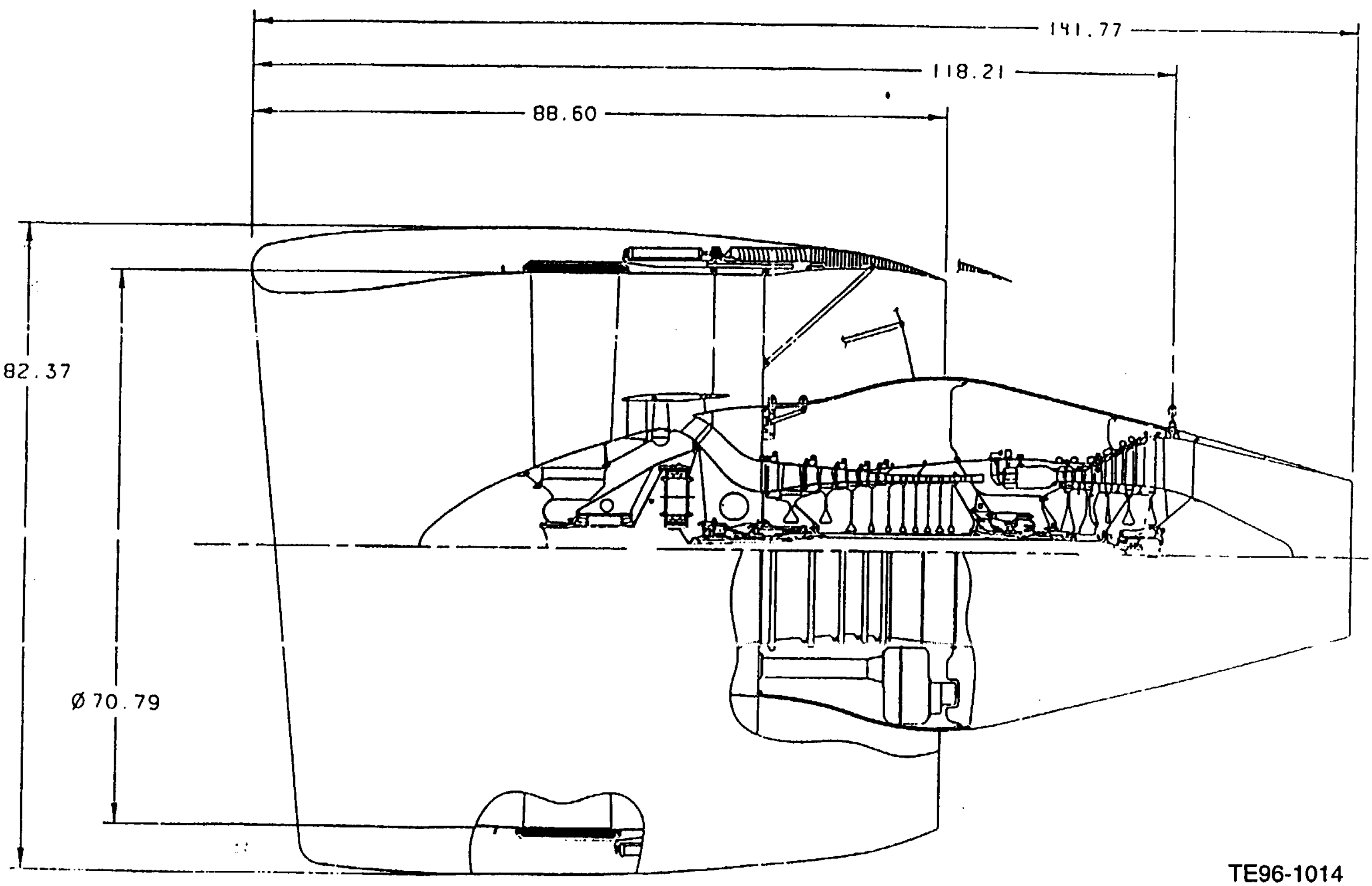

Figure 2. Final engine configuration – Task 5.

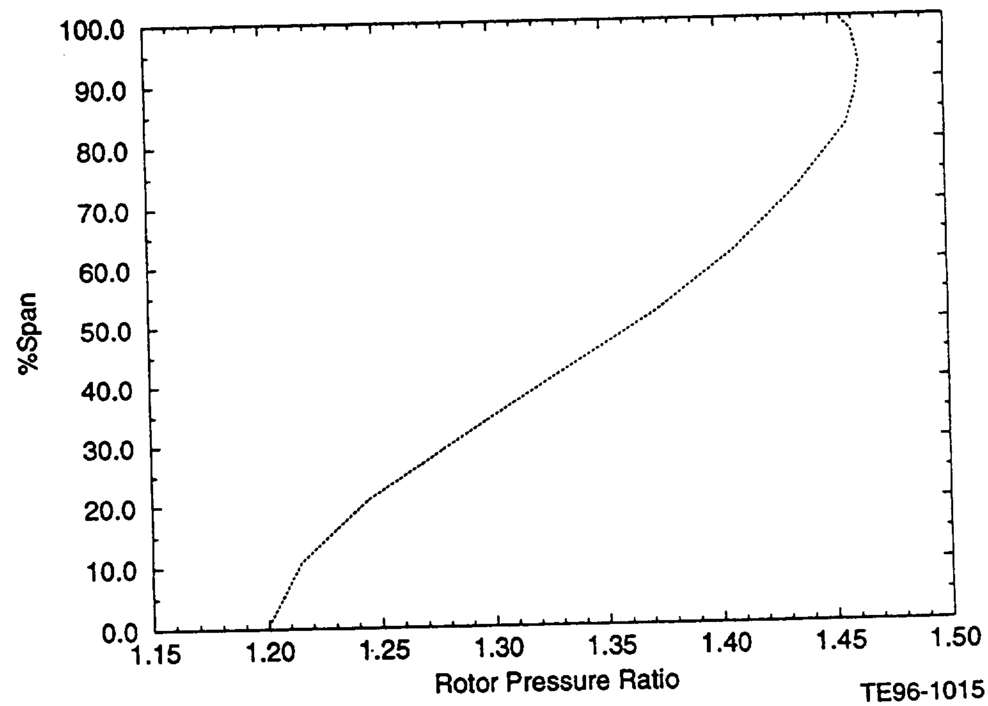

Figure 3. Rotor exit total pressure profile.

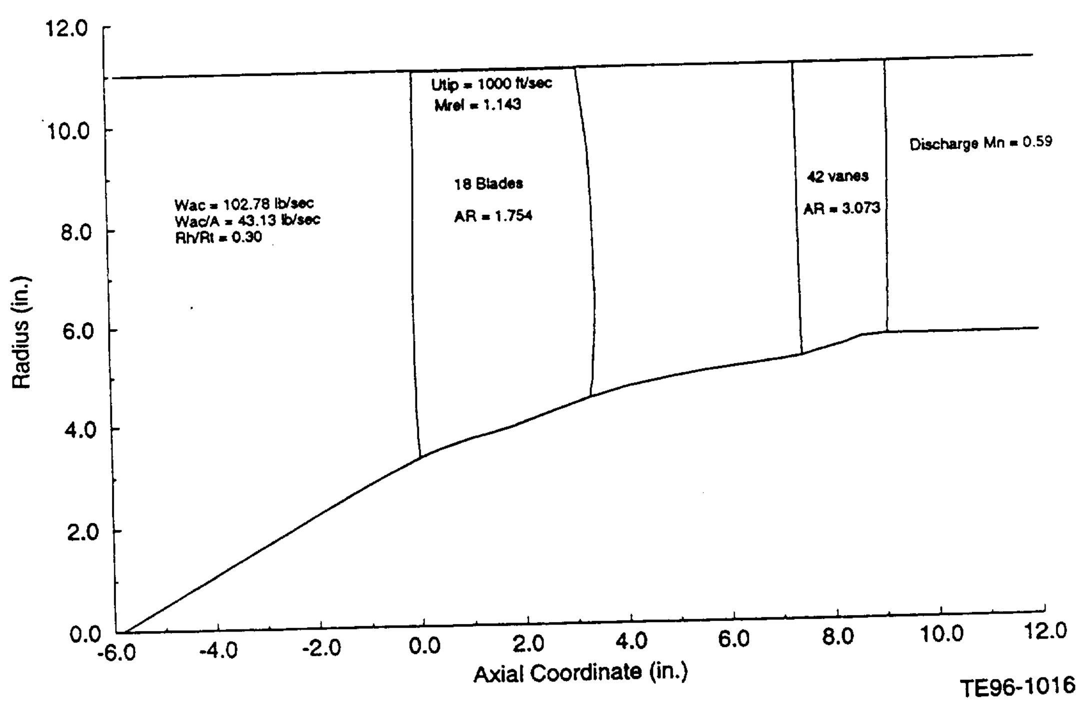

Figure 4. Baseline low noise fan schematic (meridional view).

Table I.
Flow-path coordinates for LNF3.

Tip contour is a straigh line of radius 11.00000 in.

HUB

	Z	R	
Spinner nose	-5.7500	0.0000	
	-5.5000	0.211325	
	-5.0000	0.5000	— straight line
	-1.5000	2.520756	— segment*
	-1.0000	2.8000	
Rotor LE	0.0000	3.3000	
	0.4000	3.4770	
	1.0000	3.6700	
	1.4000	3.7700	
	1.8000	3.8900	stack axis ≡ 1.5584
	2.2000	4.0400	
Rotor TE	3.2940	4.4330	
	4.0000	4.6350	
	5.0000	4.8450	
	5.6000	4.9420	
	5.8000	4.9750	
	6.0000	4.9850	
	7.0000	5.1200	
Stator LE	7.4120	5.1930	
	7.8000	5.3000	
	8.2000	5.4100	stack axis ≡ 8.2518
	8.6000	5.5500	
Stator TE	9.0930	5.6000	
	10.0000	5.6000	— straight line
	11.0000	5.6000	— segment

* $R = mZ + b$
where: $m = \tan 30$ deg
$B = 3.3867513$

assumed, including an 85% speed takeoff condition, so part-speed performance could be considered. Analytically, the blade demonstrates over 16% surge margin at design speed. Leading edge thickness (Figure 7) was selected consistent with current bird strike criteria. Trailing edge thickness was set equal to leading edge thickness everywhere except near the hub, where a blunter leading edge was employed to improve the hub inlet flow field. Blade chord varies linearly such that the tip is 45% longer than the hub. The spanwise distribution of maximum thickness-to-chord is also shown and ranges from 2.75% at the tip to 9.42% at the hub. The locations of maximum thickness for each section (not shown) were shifted from a uniform 50% chord to improve passage area qualities. Geometric properties are tabulated in Appendix A.

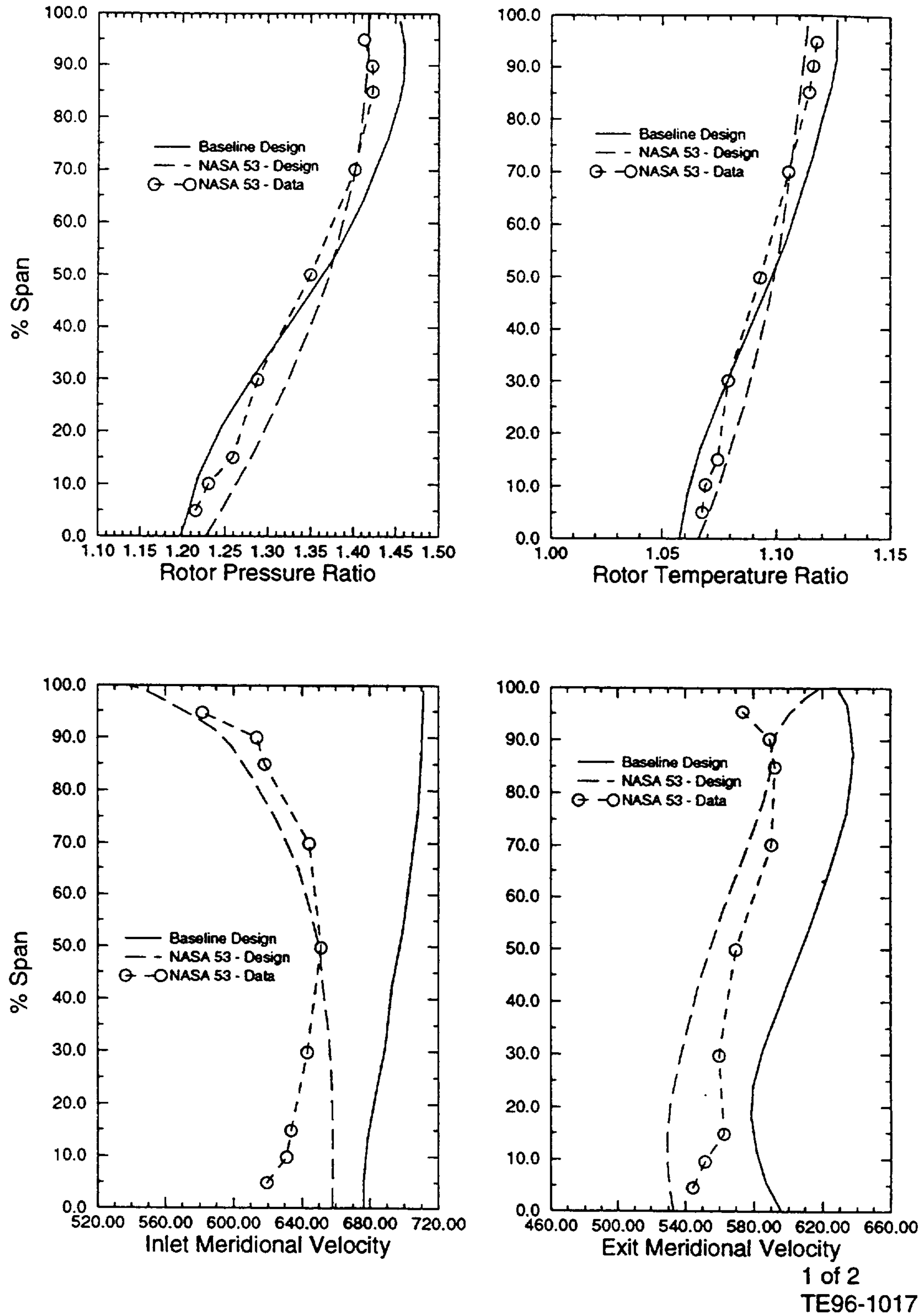

Figure 5. Low noise fan rotor design point profiles (1 of 2).

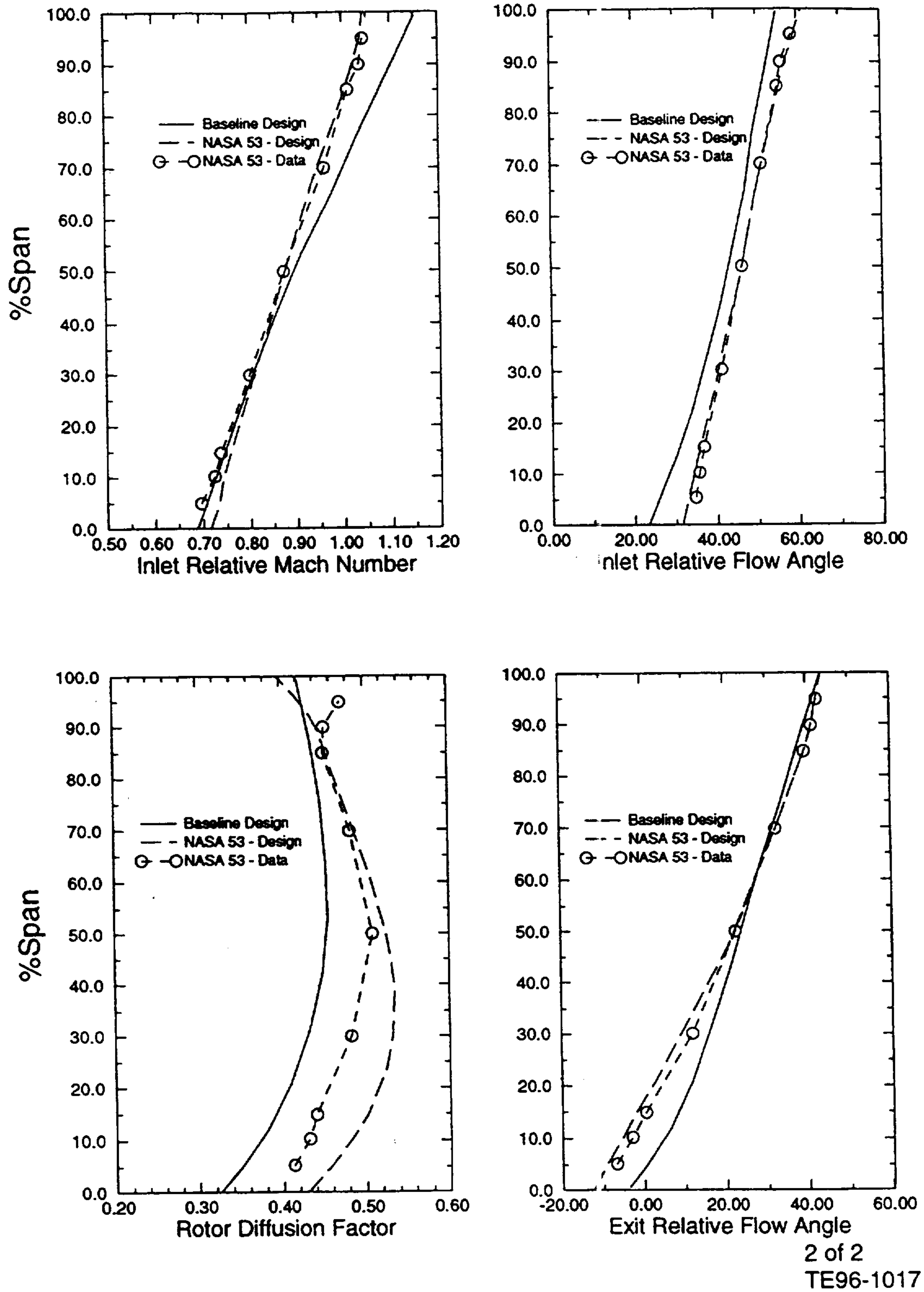

Figure 5. Low noise fan rotor design point profiles (2 of 2).

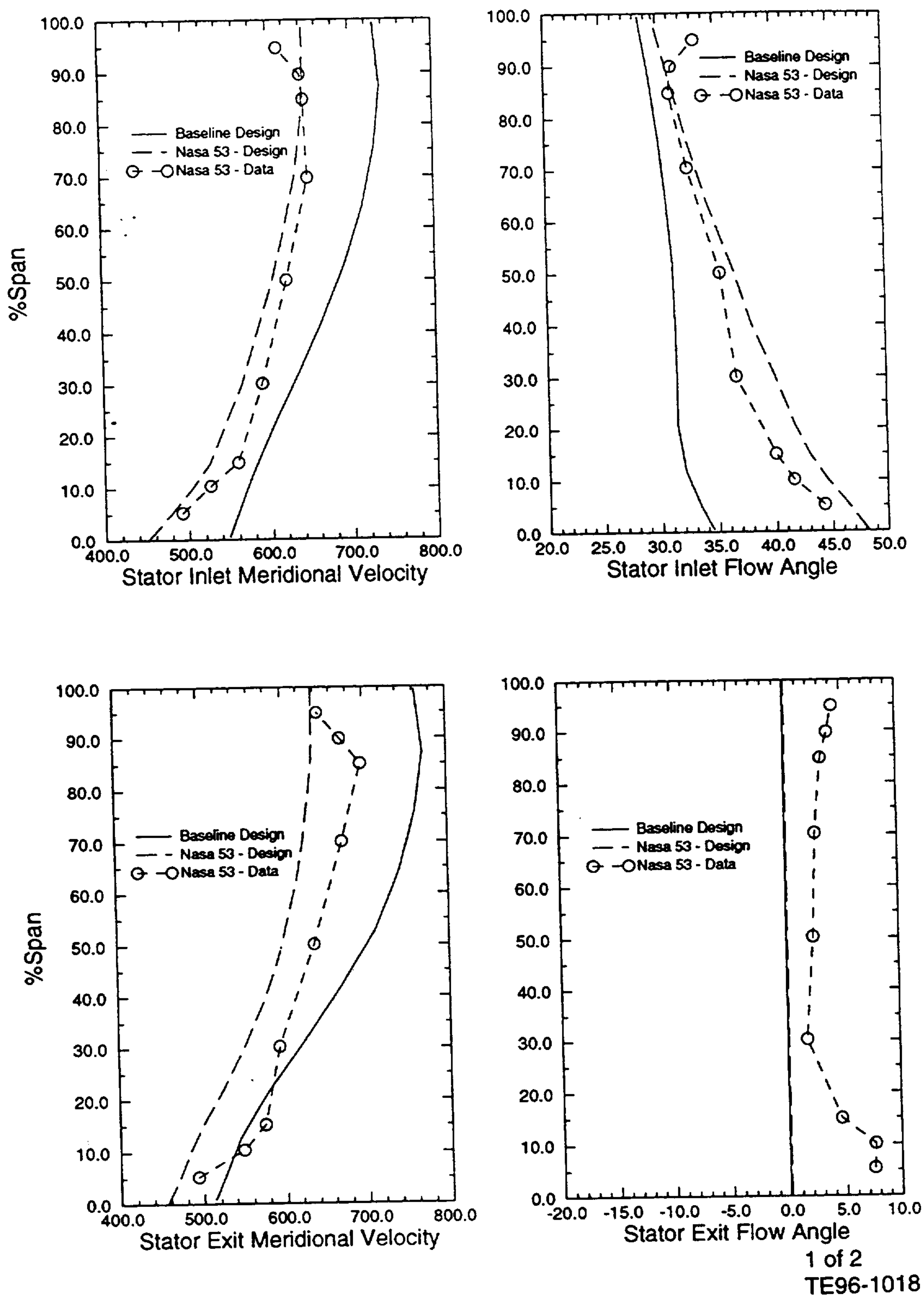

Figure 6. Low noise fan baseline stator design point profiles (1 of 2).

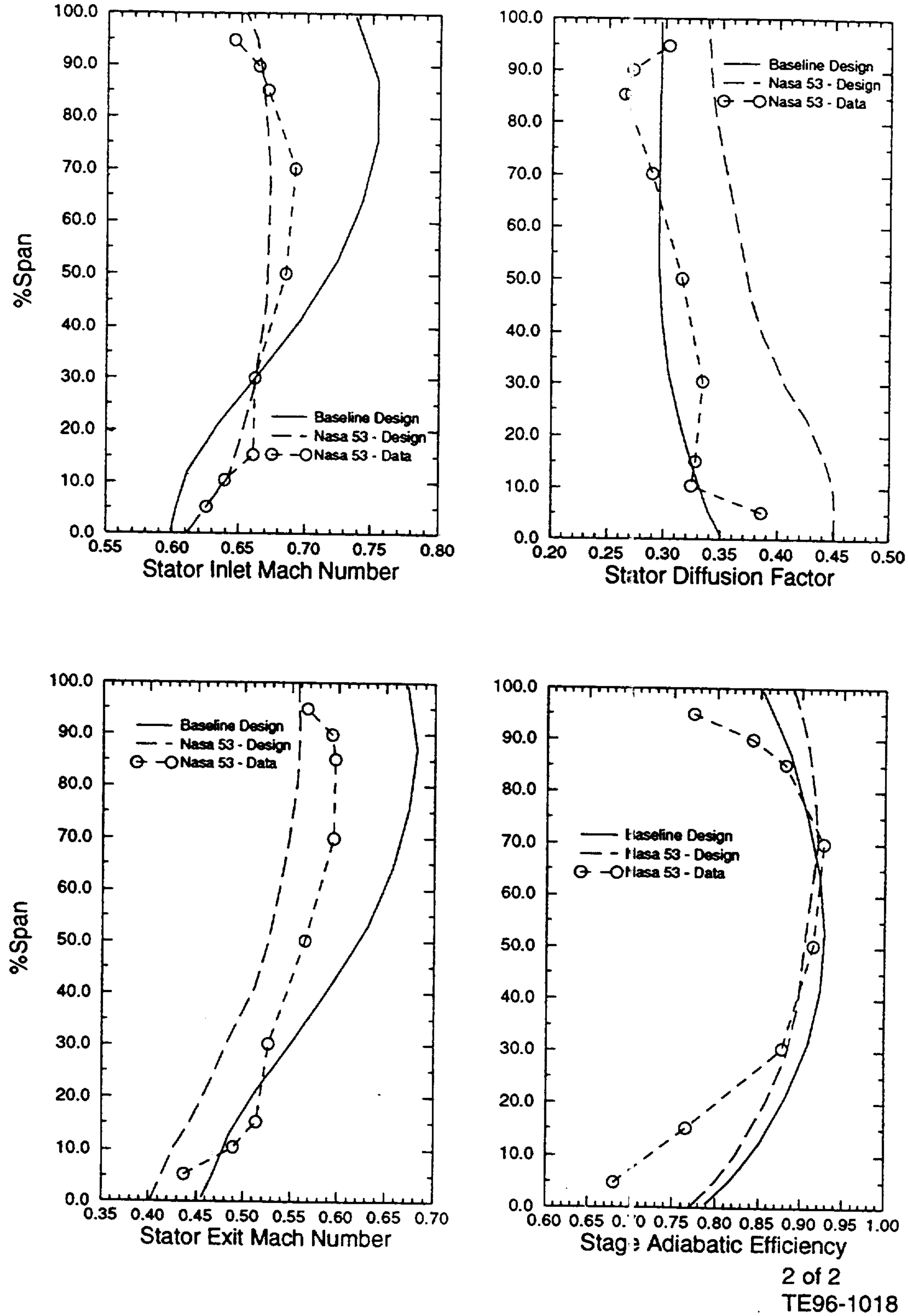

Figure 6. Low noise fan baseline stator design point profiles (2 of 2).

Preliminary design of the blading was carried out assuming multiple-circular-arc (MCA) airfoil sections. Given the low tip speed of this fan, an MCA blade was acceptable for studying the effects of changes in aspect ratio, maximum thickness, and spanwise chord distributions on surge margin and mechanical integrity. The final blade is made up of sections of aerodynamically-optimized meanlines with near-sinusoidal thickness distributions. Viscous computational analysis was used extensively to obtain the desired match of the blade passages with the design intent flow field. The transonic sections were tailored for the design speed shock structure permitting the largest excursion in flow range to stall with acceptable performance.

The spanwise distribution of incidence angles to which the blade sections were set, shown as the solid line in Figure 8 evolved from several considerations. One was the decision to design to relatively tight throats (3.5% throat margin) to favor operating line performance. In the portion of the blade with supersonic inlet relative flow, another consideration was to observe the first captured Mach wave rule. This is a rule-of-thumb setting a critical incidence off the suction surface at a point halfway between the leading edge and the point of emanation of the first captured Mach wave to a minimum of 1.5 degrees, to ensure flow-handling capability. A third consideration involved the meanlines of all sections which were carefully shaped to produce acceptable surface Mach number distributions devoid of local peaks or spikes. This could be done over the outer half of the blade only by straightening the meanlines forward of the throat locations and forcing the bulk of the turning aft (Figure 9). Where possible, the subsonic sections were tailored for shock-free (design point) operation. Optimum chordwise loading distributions were achieved by keeping meanline curvature well forward and closing the leading edge. All this led to incidences considerably smaller than employed in the design of the NASA Stage 53 rotor.

The predicted surface distributions of isentropic Mach number and associated passage Mach number contours for the near-tip, pitch, and near-hub sections of the blade are shown in Figures 10, 11, and 12. The near-tip section was fashioned to produce a single, oblique shock pulled well back into the passage and impinging on the suction surface just ahead of the region of greatest curvature. The suction surface Mach number rises smoothly to a peak of about 1.35. The pitch section, shown in Figure 11, was shaped to operate shock free. Maximum thickness was brought forward to the mouth and curvature was distributed over a larger portion of the section to flatten the forward portion of the suction surface velocity distribution.

Area-ruling of the hub flow path was an integral part of the design of the near-hub sections. Due to thickness, the hub was found to be quite insensitive to incidence and local meanline changes. Modification of the hub flow path improved the loading distributions. The intent was to force the section loading forward without allowing the hub to overpump (due to greatly increased camber). Several iterations were required, with the final outcome shown in Figure 12.

The rotor deviation angles, shown in Figure 8 were set by augmenting calculated NASA 2-D rule deviations with the empirically-estimated corrections plotted in Figure 13. These corrections have been established through comparisons of computational and measured results from other Allison compressor stages, as well as published reports. The computational results suggest, for the deviation distribution chosen, there is sufficient camber in the blading to produce the desired pressure profile. The velocity vectors for the near-tip, pitch, and near-hub sections reveal a healthy flow field with no trace of incipient separation (Figure 14).

The static or manufactured blade geometry producing the desired blade shape at design speed was determined by subtracting the predicted deflection of the blade due to centrifugal and aerodynamic loading

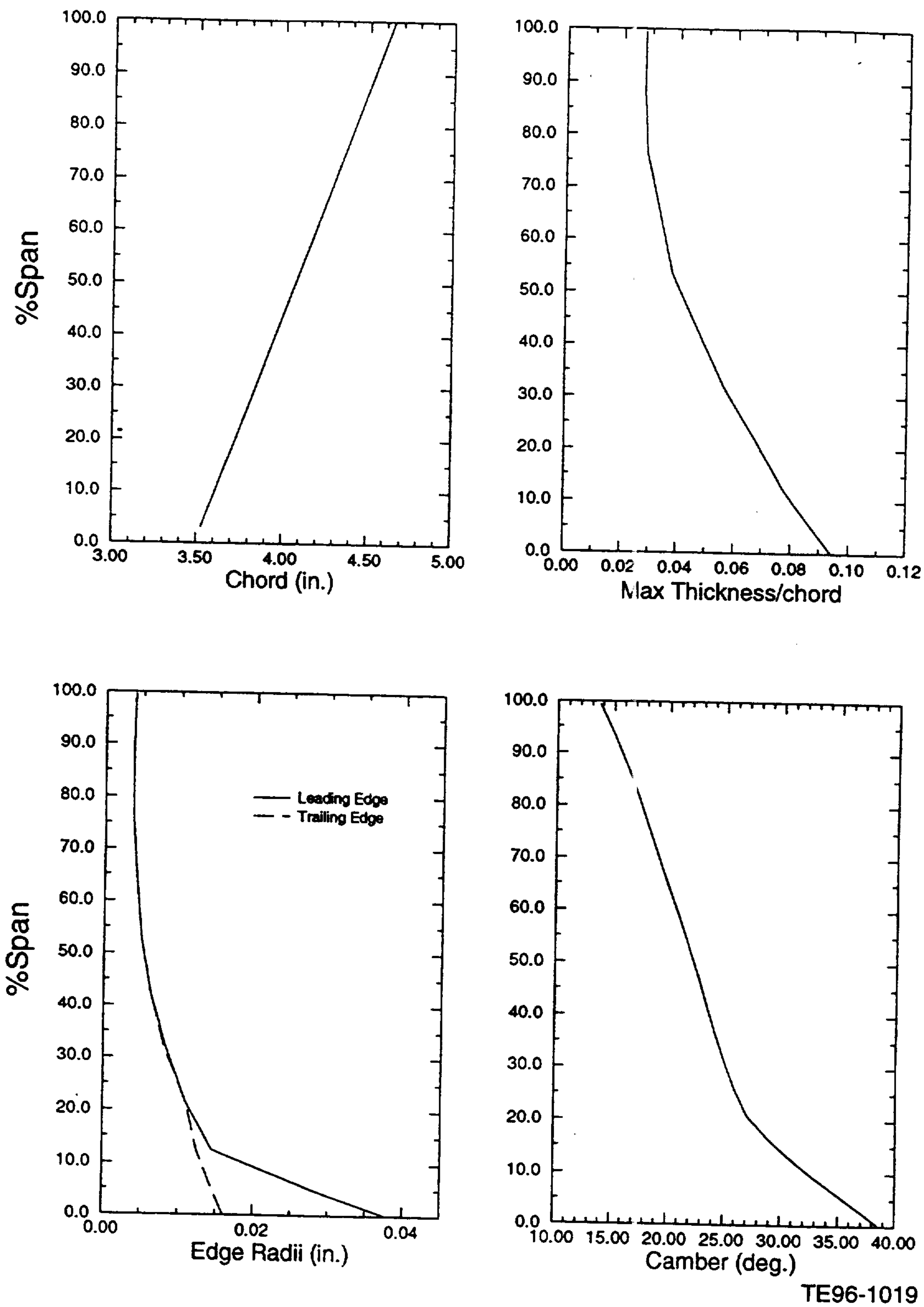

Figure 7. Rotor blade geometric parameters.

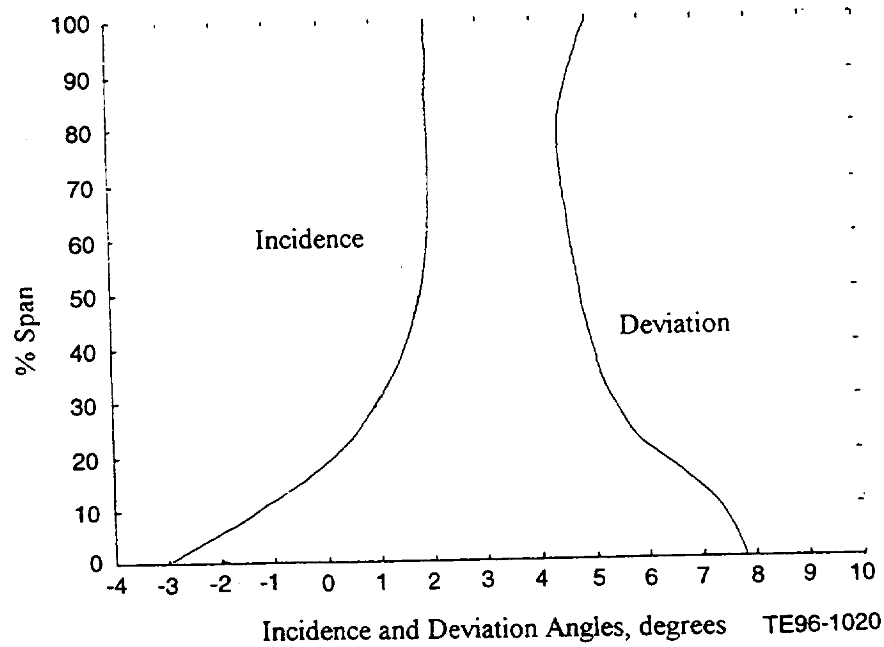

Figure 8. Incidence and deviation angles (degrees).

applied at the design point. These deflections were determined using an Allison proprietary finite element structural analysis procedure. Airfoil sections are defined on planes normal to the stack axis. The stack axis is a radial line passing through the center of gravity of each conical section. The leading edge shapes are elliptical. The blading opens with speed by as much as 2 deg in stagger at the tip, due mostly to flexibility of the leading edge. Associated with this movement in the blade-to-blade view, which clearly affects flow handling and pumping capacity, is the radial growth of the tip, with its consequences on clearance effects.

3.1.3 Baseline Fan Vane Design

A view of the baseline stator design, fan configuration No. 1 (FC1), is shown in Figure 14. Unlike the rotor, the stators are unique to the 22-in. NASA rig vehicle because none could be directly scaled-up for use in a high bypass turbofan. In an engine, separate stator assemblies would be required for the bypass and core flow streams. Neither of these assemblies would necessarily reproduce a section of the rig stators, due to the presence of the flow splitter. Nevertheless, the stators are crucial components of the rig tests. The baseline stator must deliver the same performance and allow no more noise in the acoustic test vehicle than would the bypass stator in a representative commercial turbofan.

The dominant feature of the stator flow field is its nonuniform, high-velocity inlet (Figure 6). The baseline stator is relatively lightly loaded and does not have to affect a large amount of turning, so the emphasis during its design was on minimizing total pressure loss. As a result, the vane design process primarily involved the selection of an incidence distribution. For any given incidence, neither meanline shape, maximum thickness, nor section thickness distribution had any appreciable effect on performance. Therefore, simple double circular arc sections with maximum thickness located just forward of mid-chord were employed.

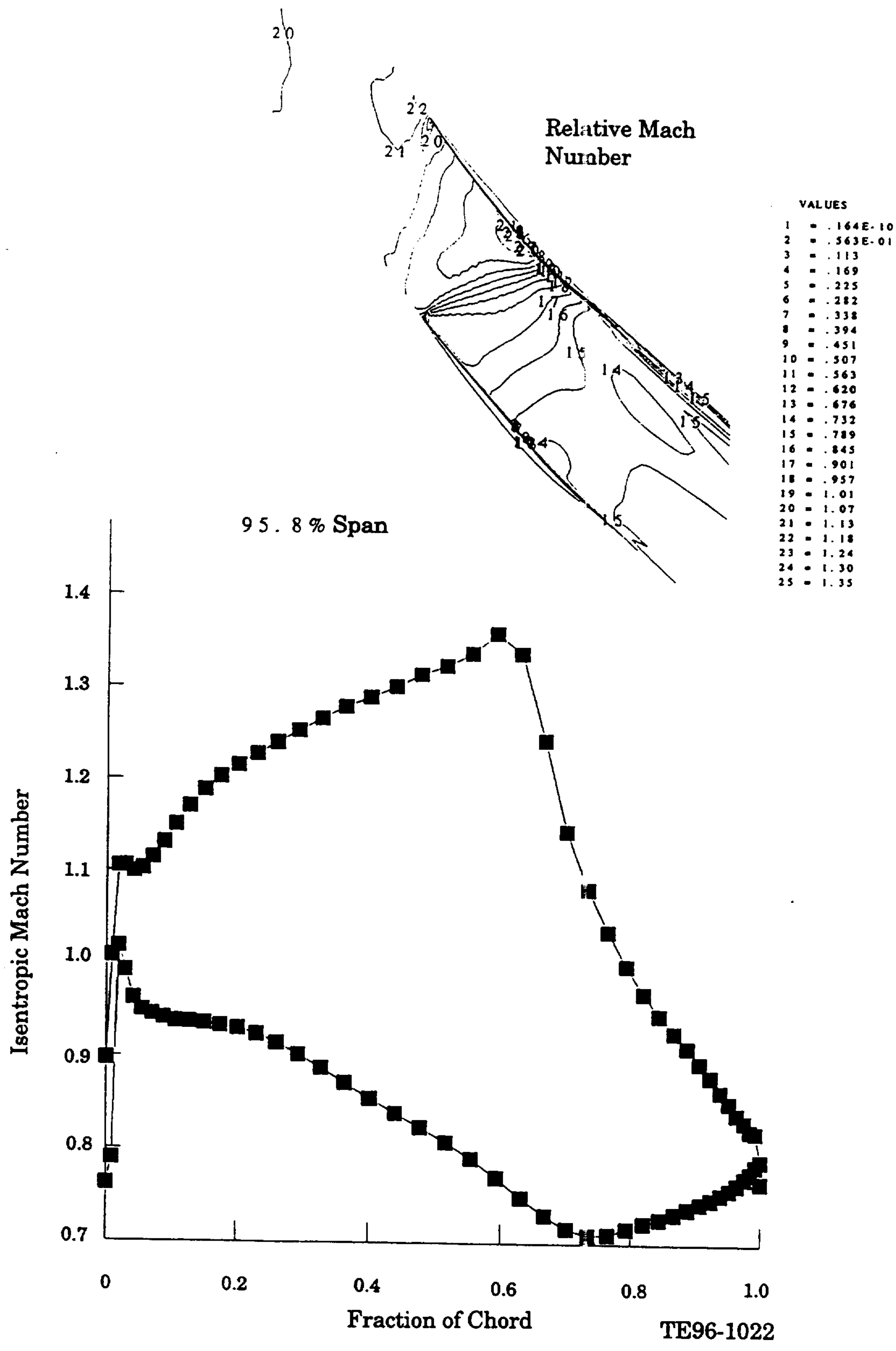

Figure 9. Blade near-tip Mach number distribution.

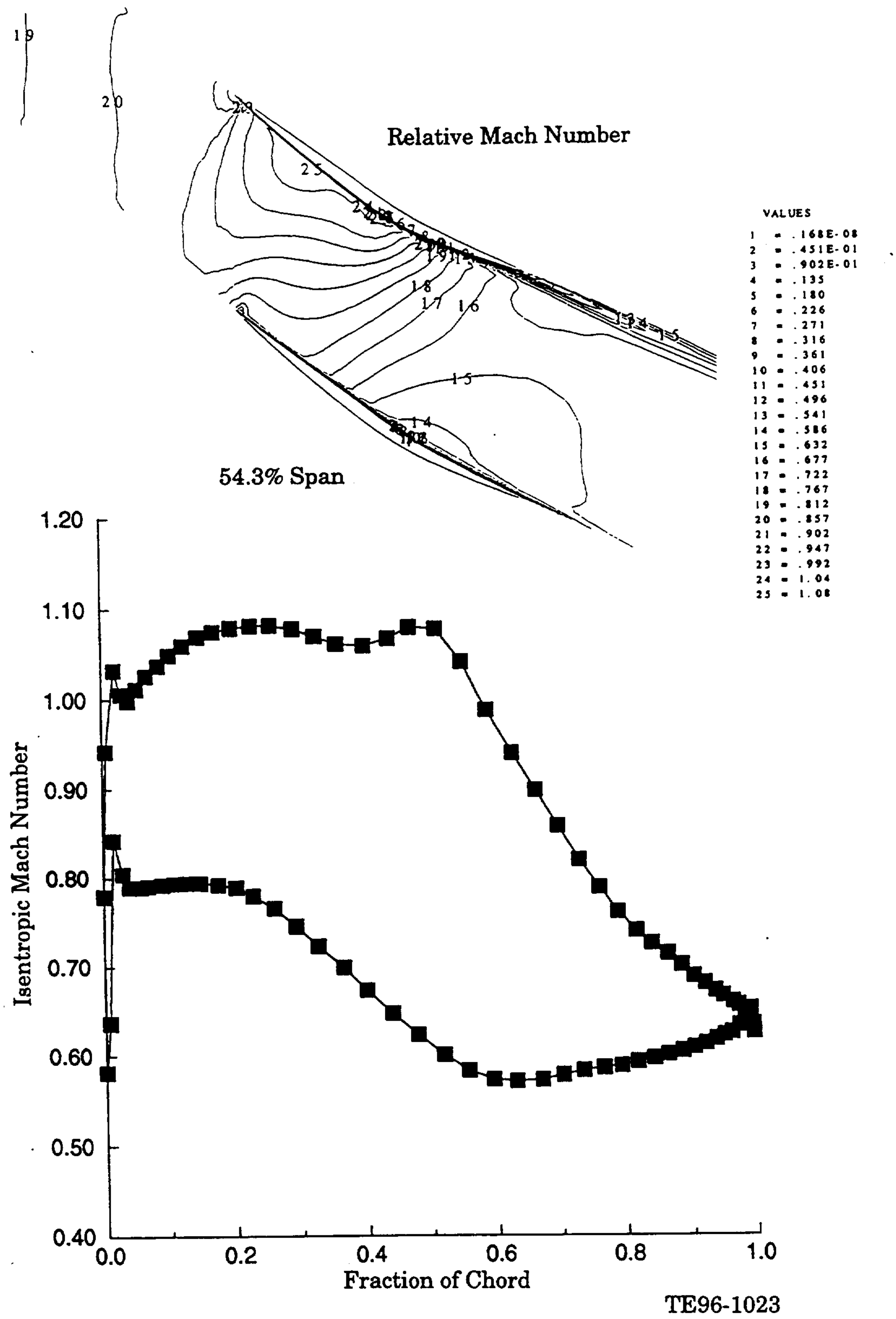

Figure 10. Blade pitch section Mach number distribution.

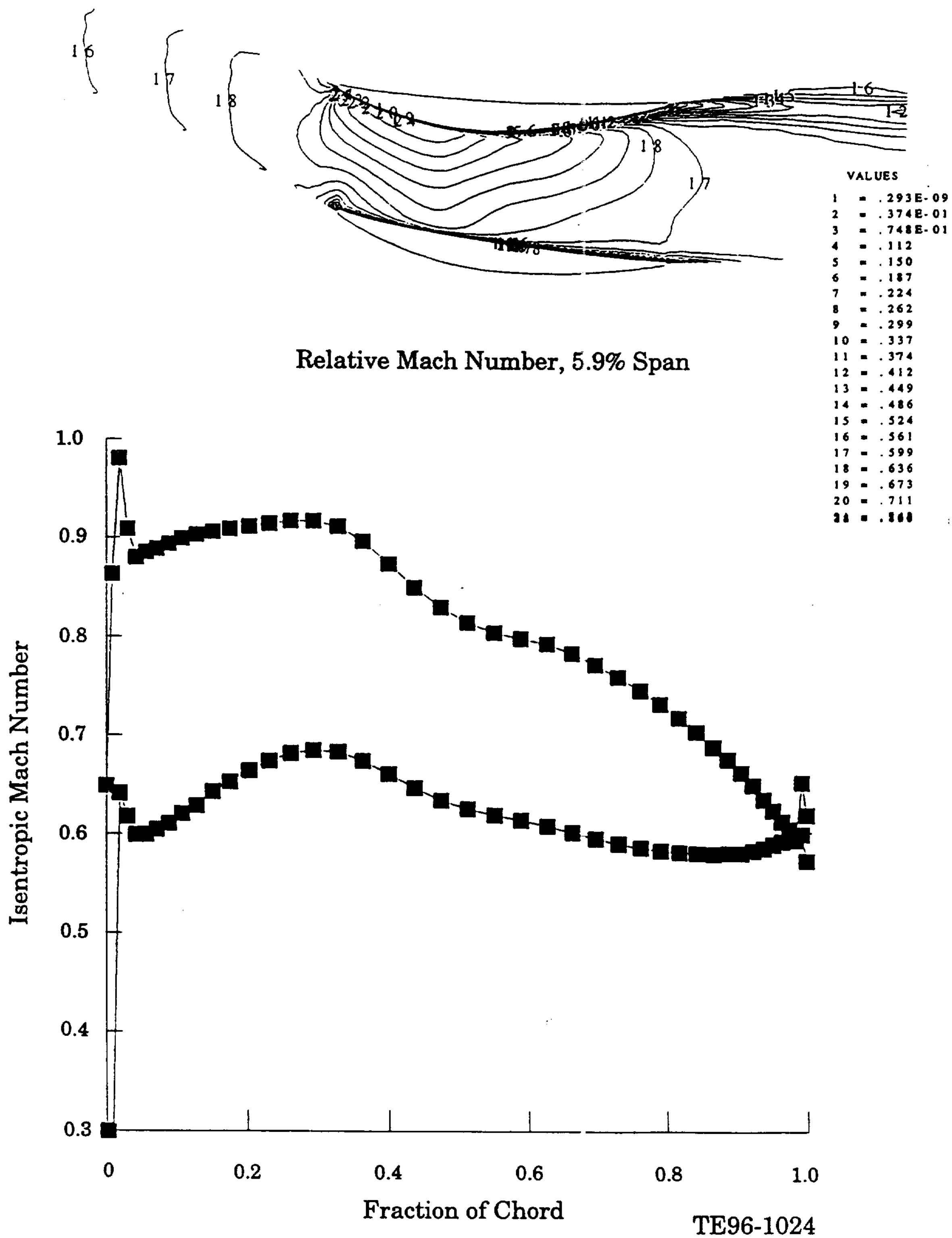

Figure 11. Blade near-hub Mach number distribution.

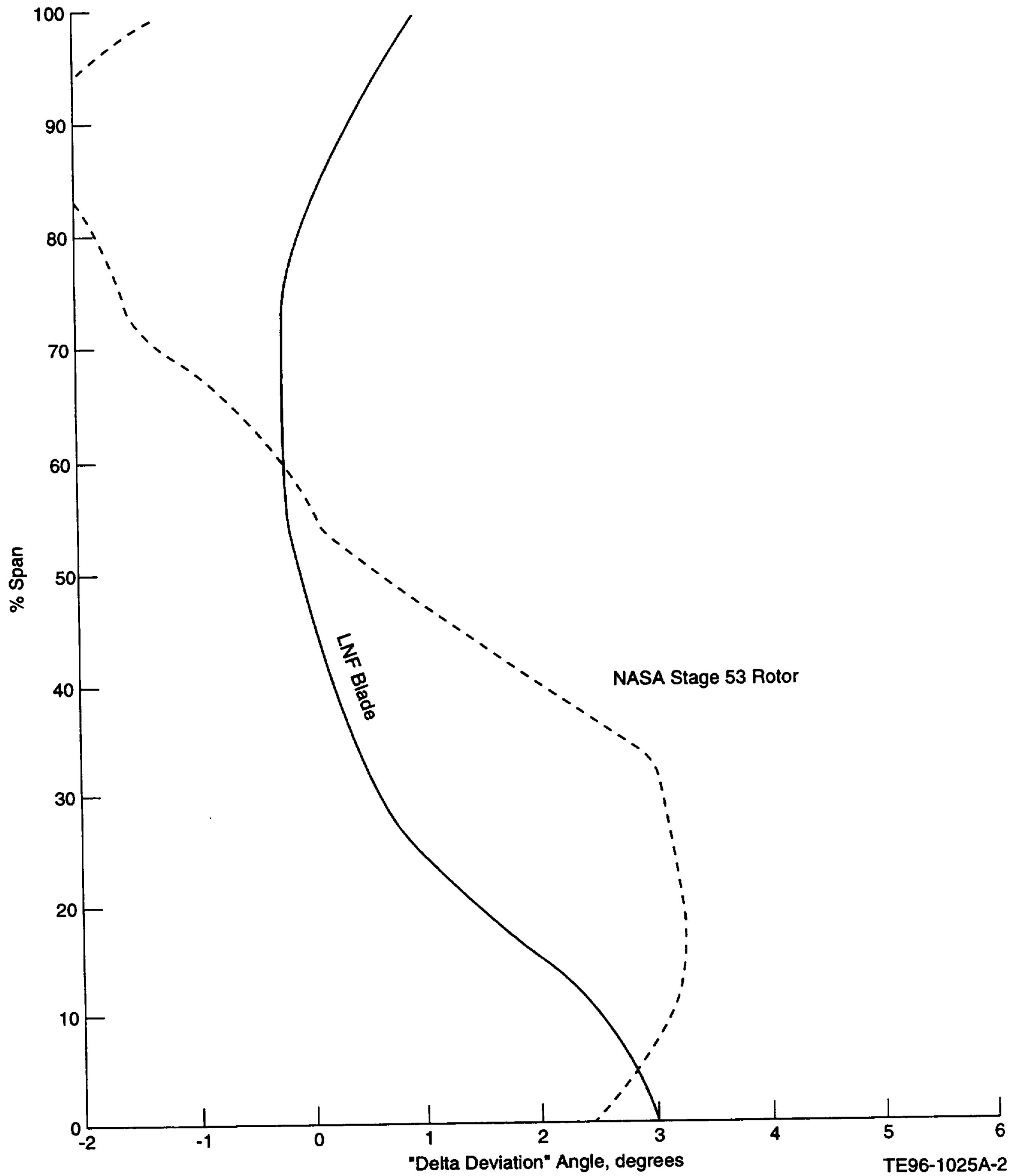

Figure 12. Empirical modifications to the rotor deviation profile.

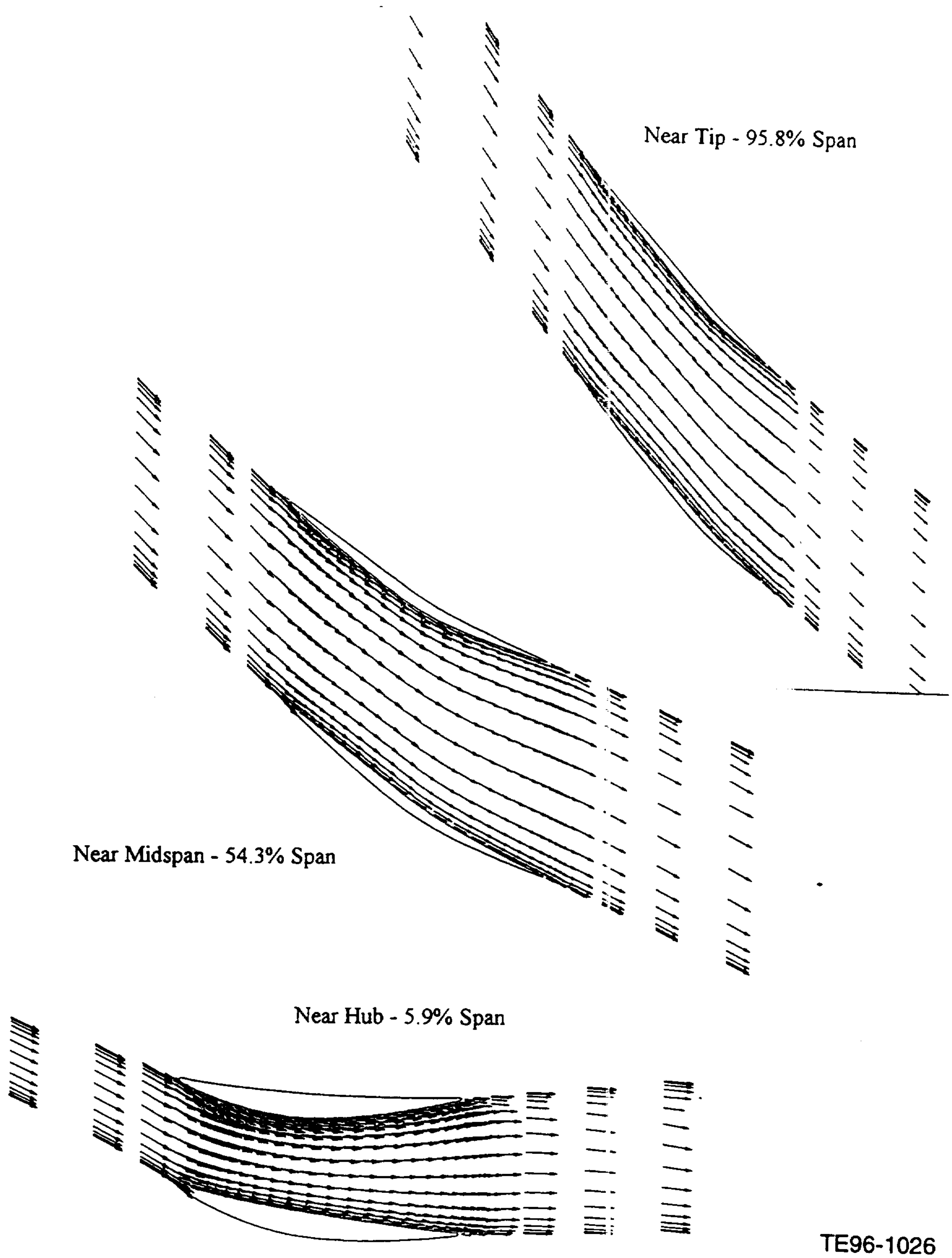

Figure 13. Rotor passage velocity vectors.

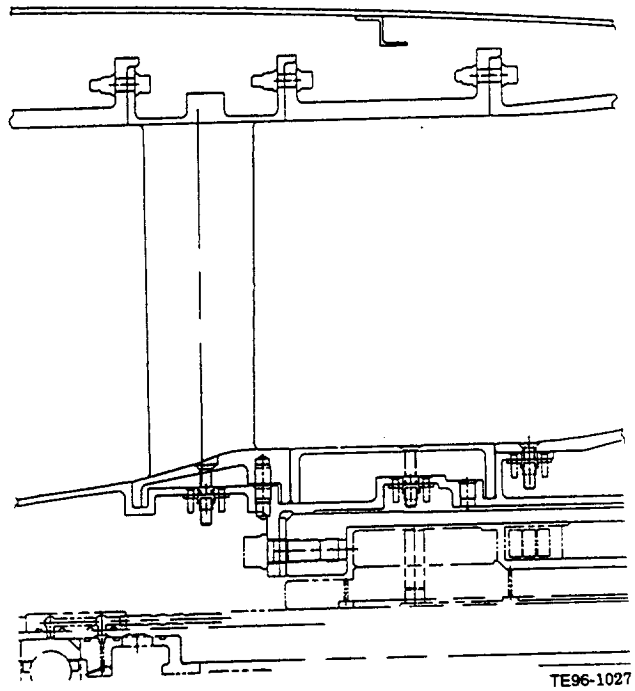

Figure 14. Baseline vane arrangement.

A wide range of incidence levels were examined in an effort to optimize velocity distributions about the vane sections and to minimize suction surface velocity peaks, but it became apparent there were basically only two solutions. These solutions are represented in Figure 15 by the "A" and "B" incidence distributions. The leading edge (at design flow) could either be A) optimally aligned with or set closed relative to the incoming flow, which invariably produced supersonic velocities over the forward third of the outer sections or B) set open relative to the incoming flow to produce velocity distributions with reduced trailing edge loading. All attempts to combine the two types radially forced the outer sections toward "A"-type distributions.

A "B"-type design was finally chosen for FC1. The design offered reduced suction surface Mach number peaks in exchange for increased leading edge loading. It was felt the more open leading edges would not be a liability in this stage, given the large axial gap between the rotor and stator. Deviation was reduced for the "B"-type vane, as shown in Figure 15, while throats were not excessive. The deviation angle profile was adjusted to remove all swirl as would be required of a bypass stator.

The surface isentropic Mach number distributions and associated passage Mach number contours are shown in Figures 16, 17, and 18 for the near outer diameter, pitch, and near inner diameter "B" vane sections. The inner diameter flow path was contoured through the vane, as it was through the blade, to help balance the loading distributions of the near-hub sections.

The mechanical properties of the baseline vane are tabulated in Appendix A. These properties were retained in designing the alternative vanes. Most have constant spanwise distributions; e.g. maximum thickness-to-chord is 5% and chord is 1.81 in.

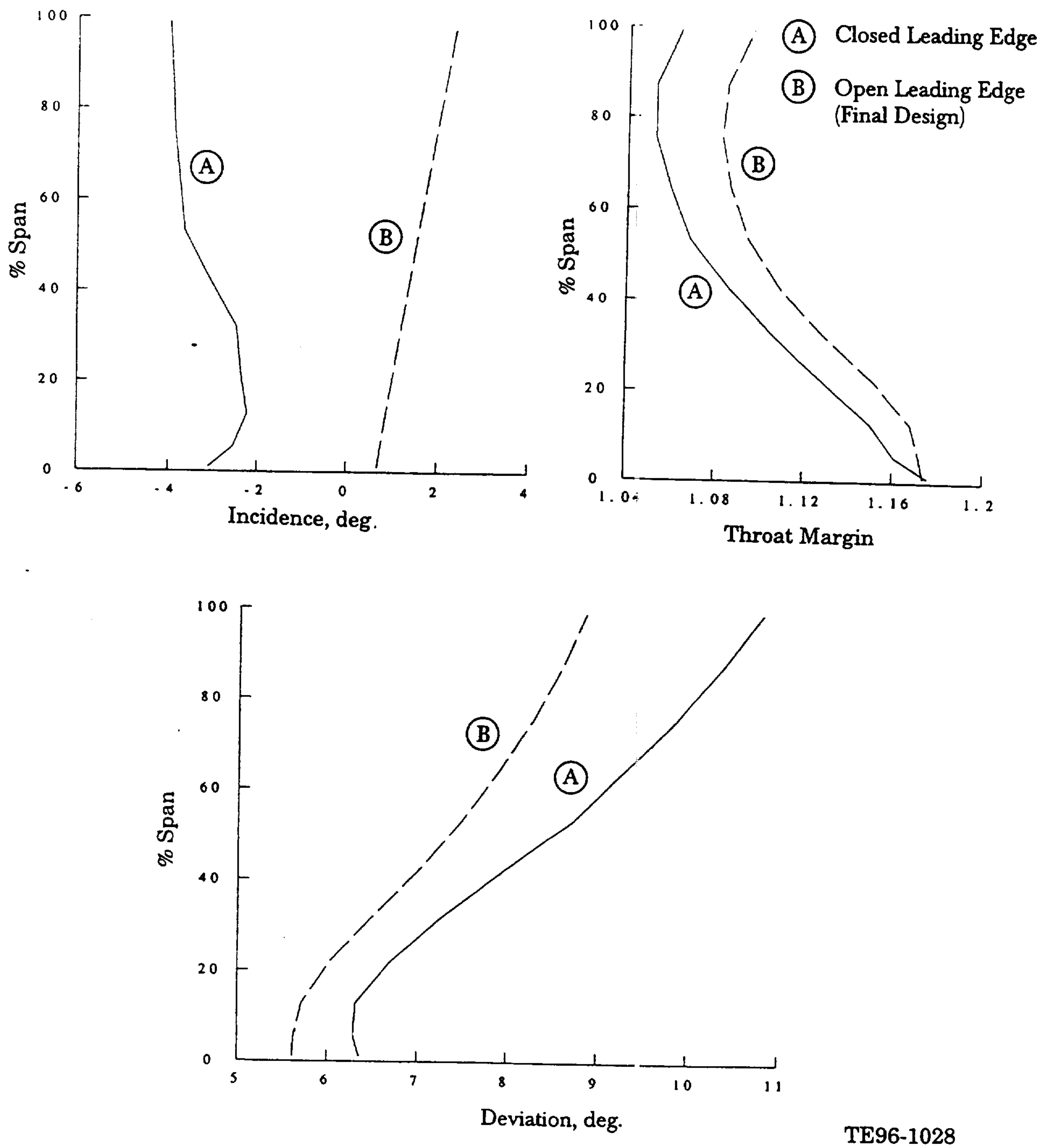

Figure 15. Baseline stator incidence, deviation, and throat margin.

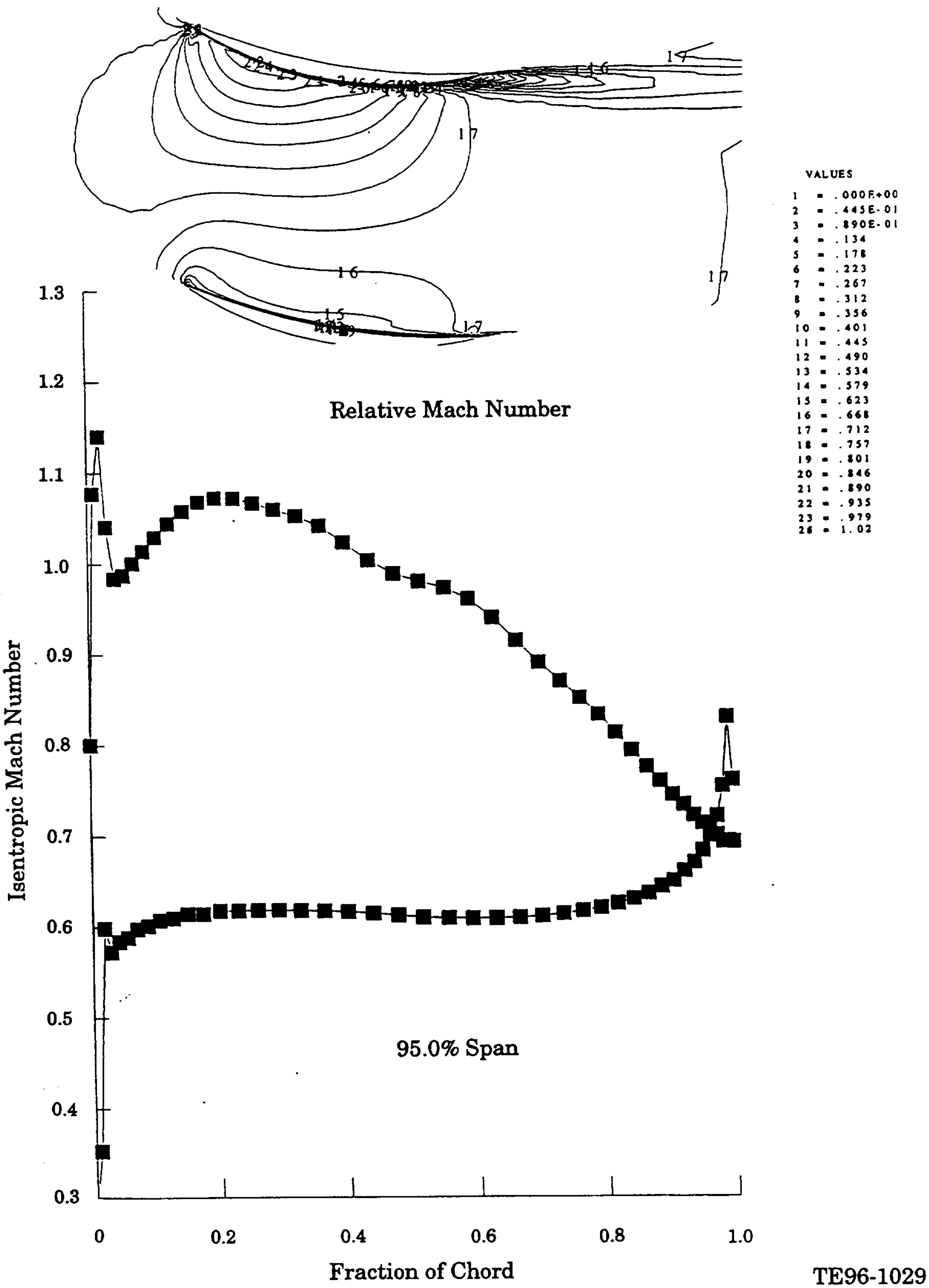

Figure 16. Baseline stator near-tip Mach number distribution.

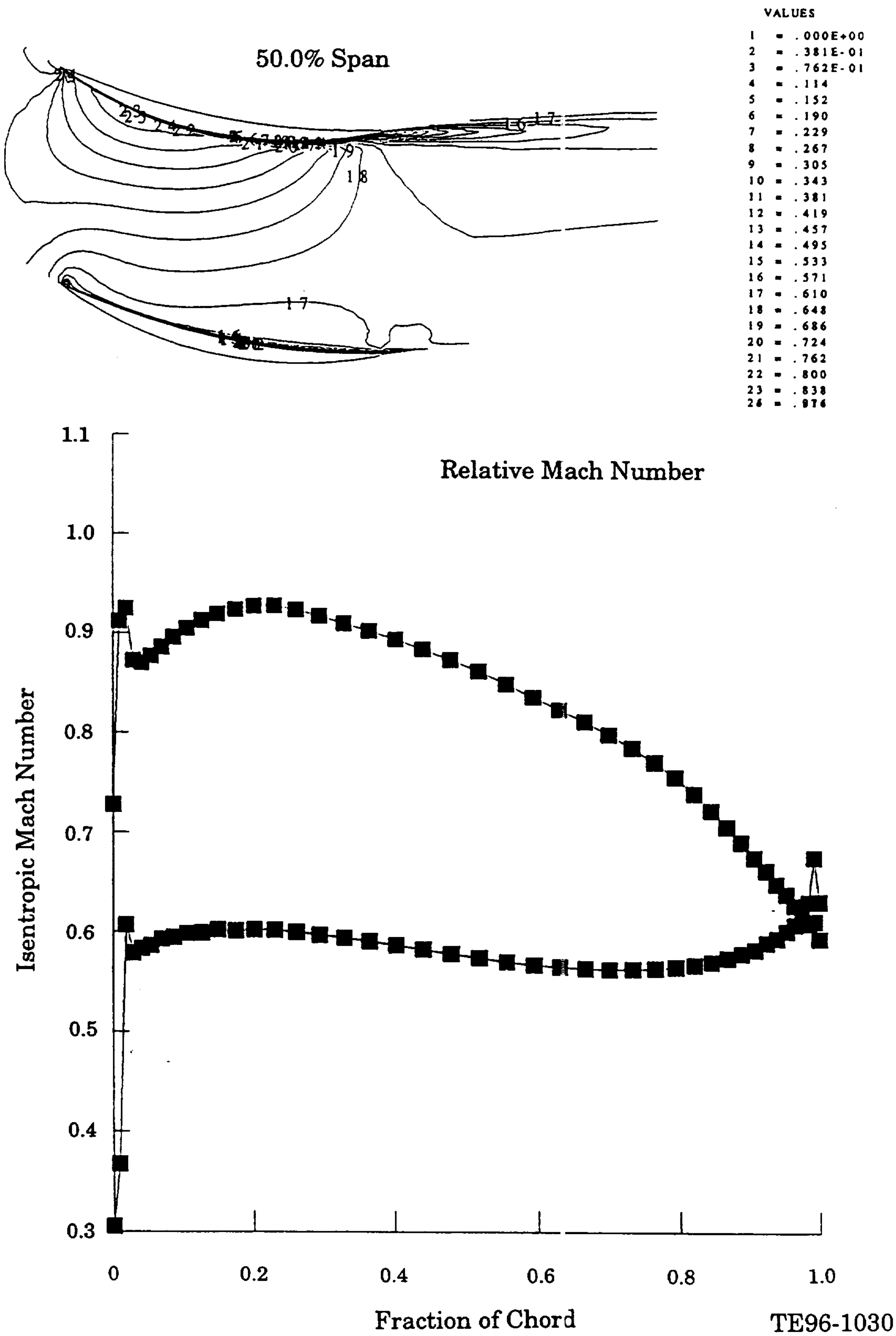

Figure 17. Baseline stator midspan Mach number distribution.

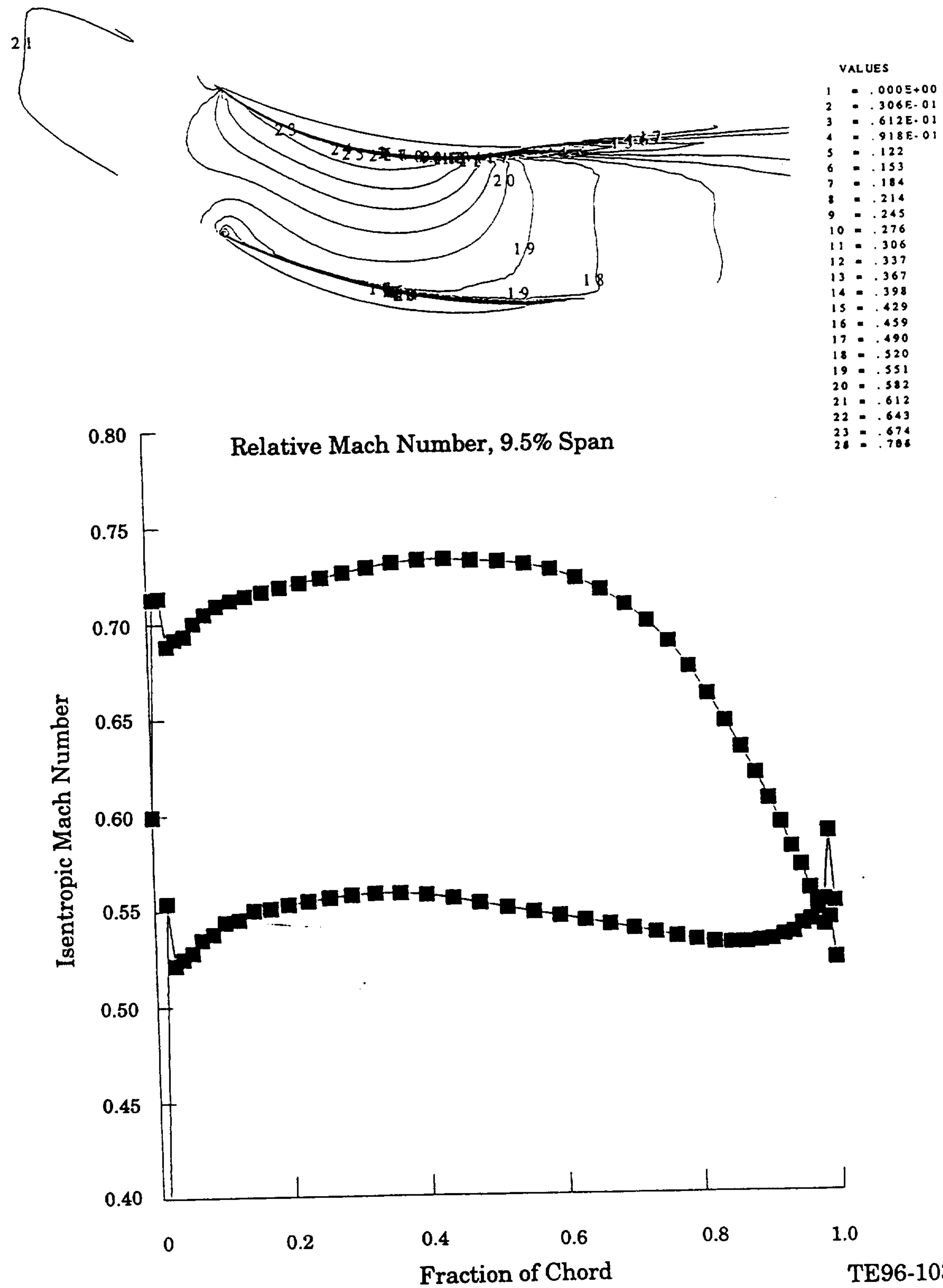

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Figure 18. Baseline stator near-hub Mach number distribution.

3.1.4 Fan Stage Analysis

3.1.4.1 Predicted Map

The predicted 100% and 85% speedline characteristics for the low noise fan (LNF) rotor are a composite of analytical and empirical considerations (Figure 19). The shaded circles in the figure represent analysis results at various backpressures for 100% and 85% corrected speed. No attempt was made to include the untwist characteristics of the blade with speed or throttling. To model the indicated aerodynamic design point, the code was run to an "equivalent" design point just over 1% higher in flow and pressure ratio. This was done in light of prior experience with the code to be explained in section 3.1.4.2 below. The background speedlines result from scaling the experimentally-derived map of the NASA Stage 53 rotor to the fan rotor design point and are included for reference to trends only. The speedline scaled from the NASA 53 data roughly corresponds to the computationally predicted behavior of the current design. The design intent surge margin of 15% was obtained. The associated contours of predicted efficiency are also shown with the NASA Stage 53 rotor data, scaled for flow, in the background. These data were more difficult to assess. The computational procedure, at least for high speed machines, typically predicts efficiencies 2 to 3 points higher than are actually attained; this has been assumed a function of computational limits preventing running the code with sufficiently dense grids to accurately reproduce profile drag due to skin friction. Therefore, the predicted efficiency has been modified to better fit the available data. In general, the modified efficiency follows the trends predicted by the code, but reduced at the design condition to correspond to the value obtained from the axisymmetric streamline curvature procedure. Additionally, the rate of efficiency loss beyond the peak has been increased from the computational predictions to mirror the NASA Stage 53 data.

3.1.4.2 Off-Design Performance

The LNF rotor, though part of a research vehicle to be built for acoustics testing, was designed to standards allowing it to be scaled-up directly for use in a large turbofan engine. For that reason, an effort was made to ensure the blade would also demonstrate good off-design performance. It was analyzed along the operating line, near stall, and at an unthrottled condition at both 100% and 85% speed. Figures 20 through 27 show how the LNF rotor is expected to throttle at design speed.

The changes occuring in the total pressure and loss profiles of the rotor with throttling are shown in Figure 20. The long dashed line labeled "ADP-BD76" is the design intent profile from the axisymmetric streamline curvature design code. The three other lines are the profiles predicted by the numerical solution at the three points along the design speedline highlighted in the map of Figure 19. The CFD solution characteristically indicates a stronger hub and a weaker tip than seems to develop in reality, so the profile labeled "ADP-Dawes" was selected as the one to use for the detailed design of the blade. Here again, the analysis of the NASA Stage 53 rotor flow field proved useful. The differences between the BD76 and computational profiles for that machine were considered in establishing the LNF design profile. The unthrottled and near-stall pressure profiles indicate pumping at the hub (which would deliver the core flow in the turbofan) remains unchanged while the bypass portion of the blade, from 20% span to the tip, throttles proportionately with radius. Losses increase with throttling in a consistent manner except, curiously, at the near-tip near stall where they apparently decrease. The changes in throughflow velocities are reflected in the profiles of inlet relative Mach number and air angles (Figure 21). As the blade tip throttles, it maintains flow, while the fraction of flow through the hub decreases. The hub incidence increases 5-6 degrees while the tip increases only 2-3 degrees. The discharge air angles remain little changed over virtually the entire blade span, another indication there is sufficient camber in the blade and the turning can be sustained without a breakdown in the flow field right up to stall.

The predicted changes in surface Mach number distributions and passage Mach number contours for the near-tip, pitch, and near-hub sections with throttling are shown in Figures 22 through 27. Most noticeable

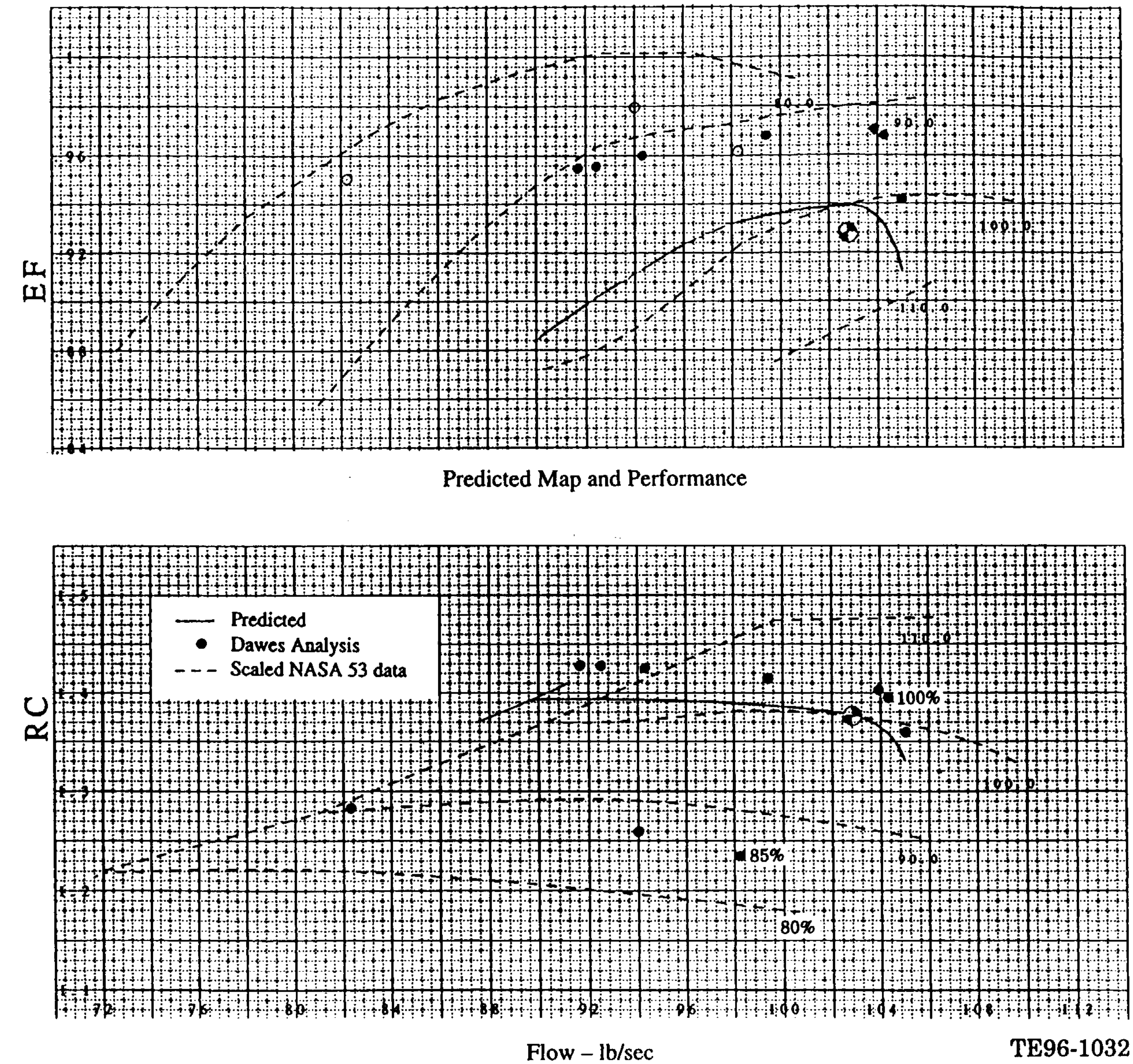

Figure 19. Predicted rotor-only performance map.

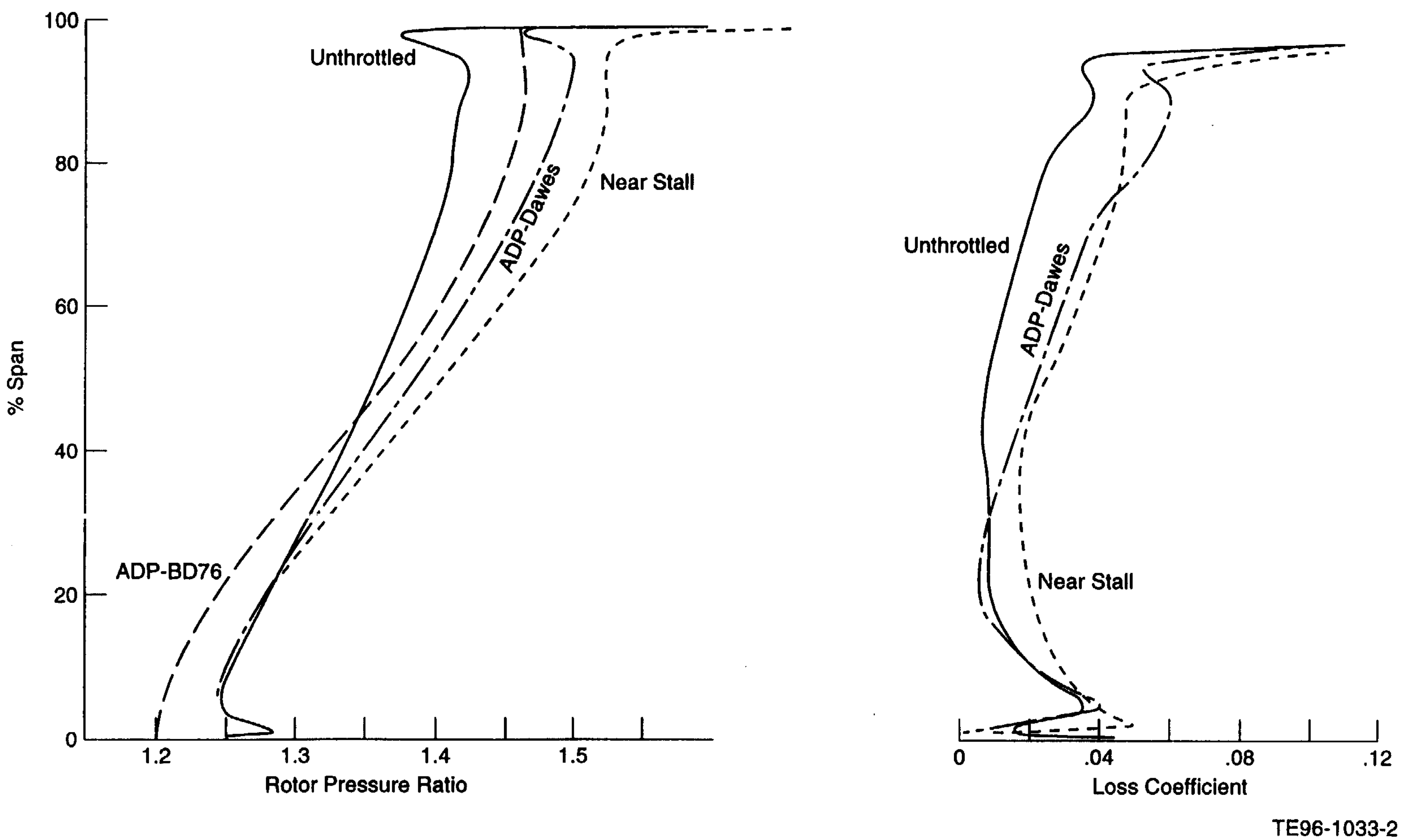

Figure 20. Effect of throttling on rotor pressure rise and loss at design speed.

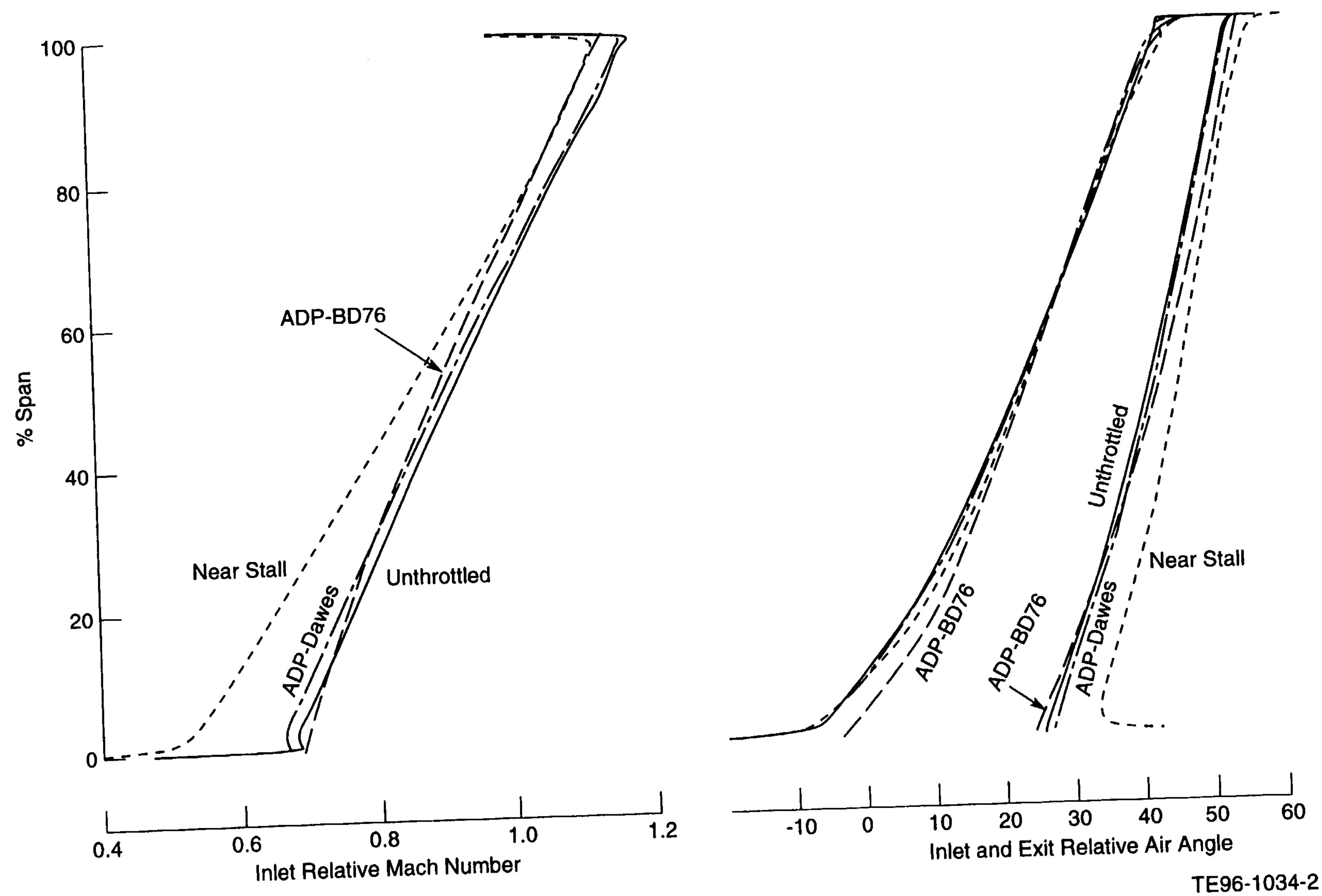

Figure 21. Effect of throttling on rotor Mach number and air angles at design speed.

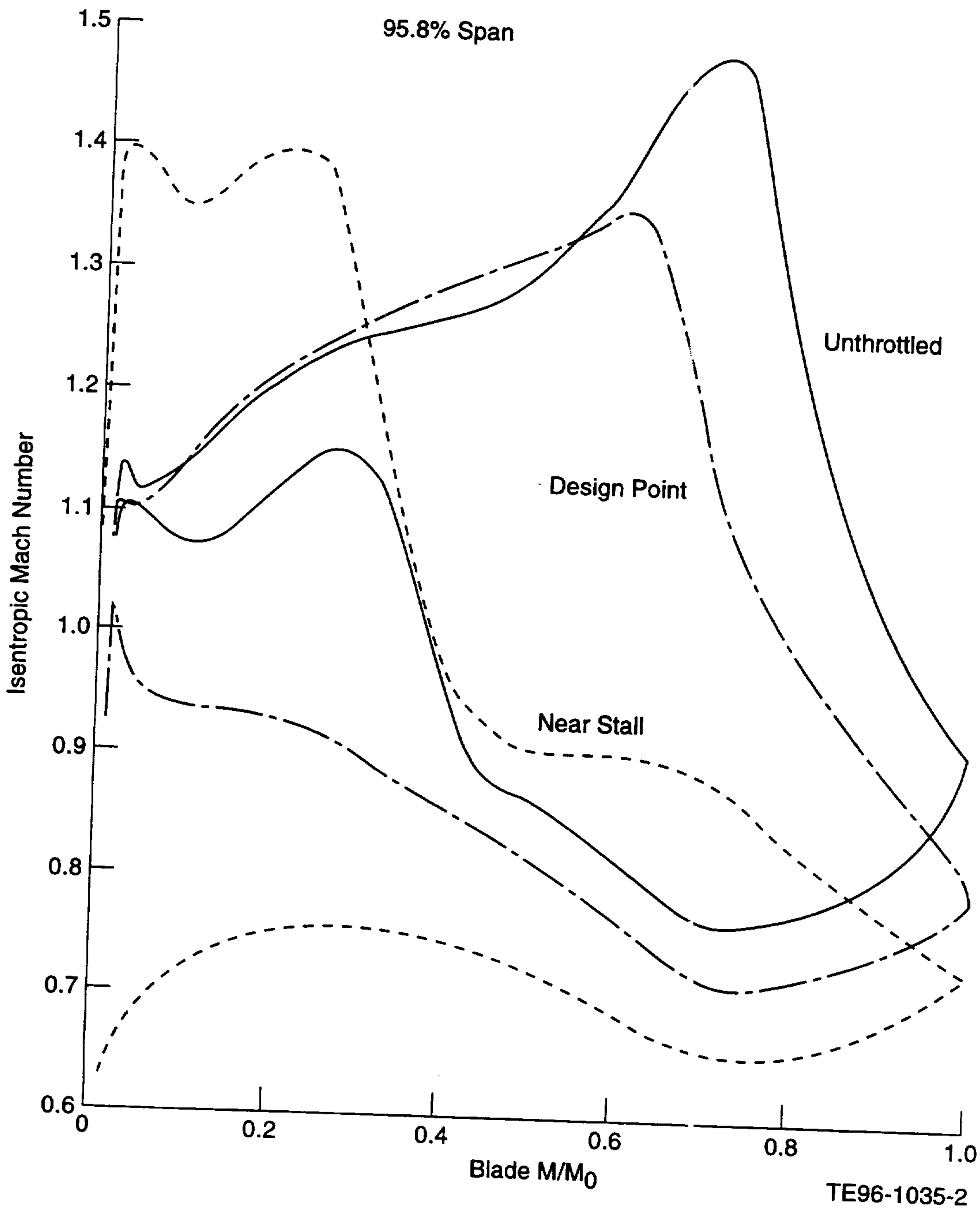

Figure 22. Effect of throttling on blade surface Mach number — near tip section.

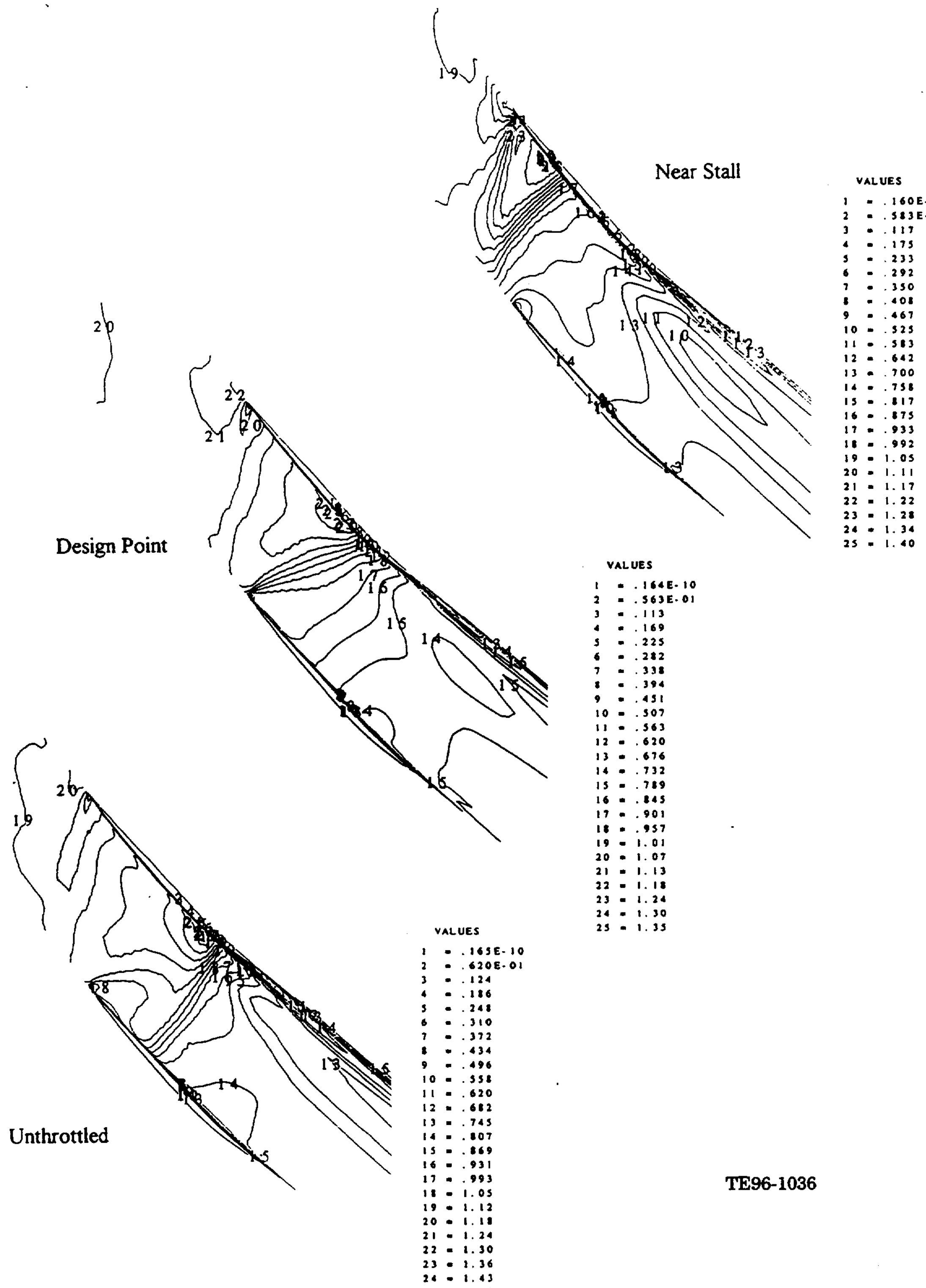

Figure 23. Effect of throttling on blade passage Mach number — near-tip section.

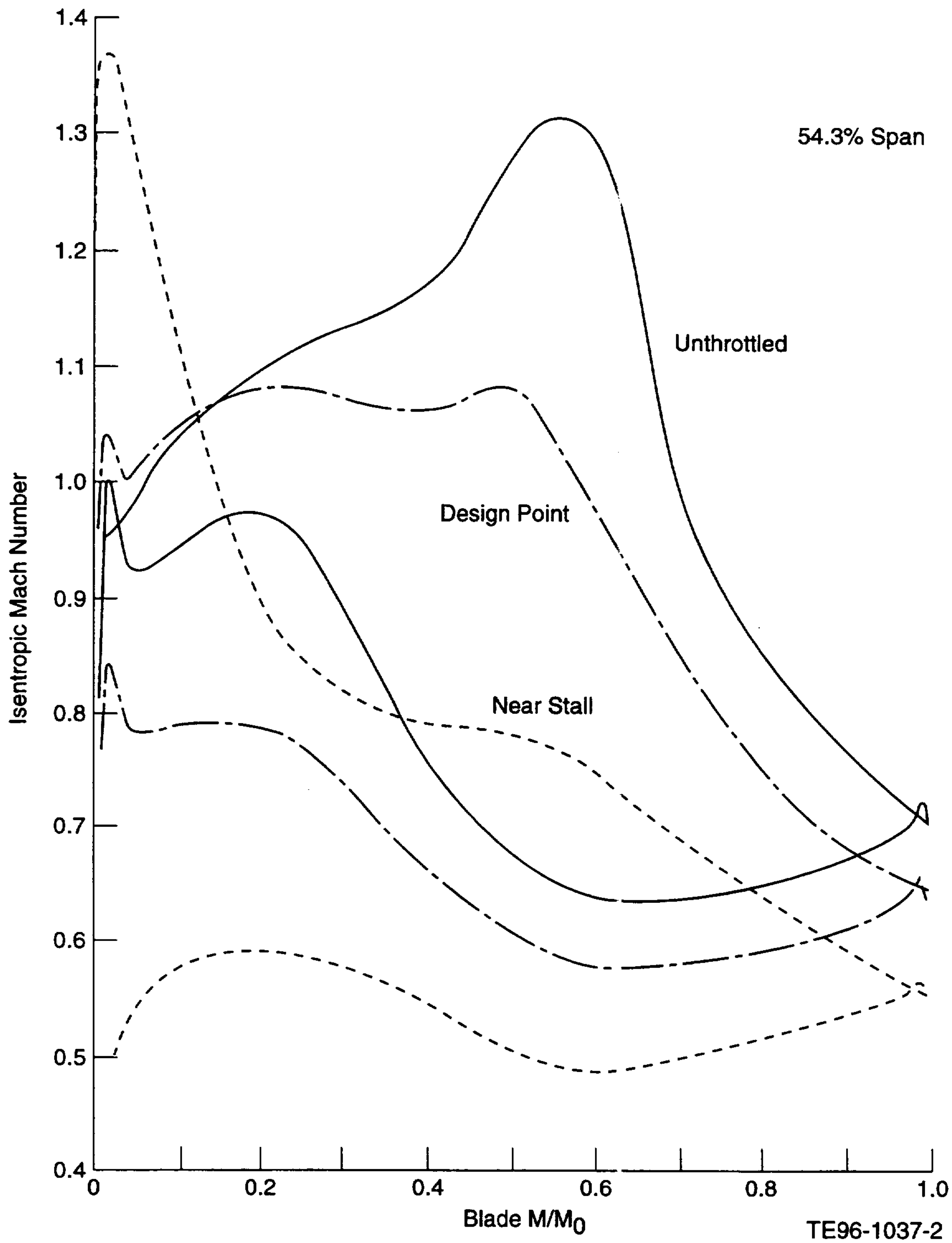

Figure 24. Effect of throttling on blade surface Mach number — midspan section.

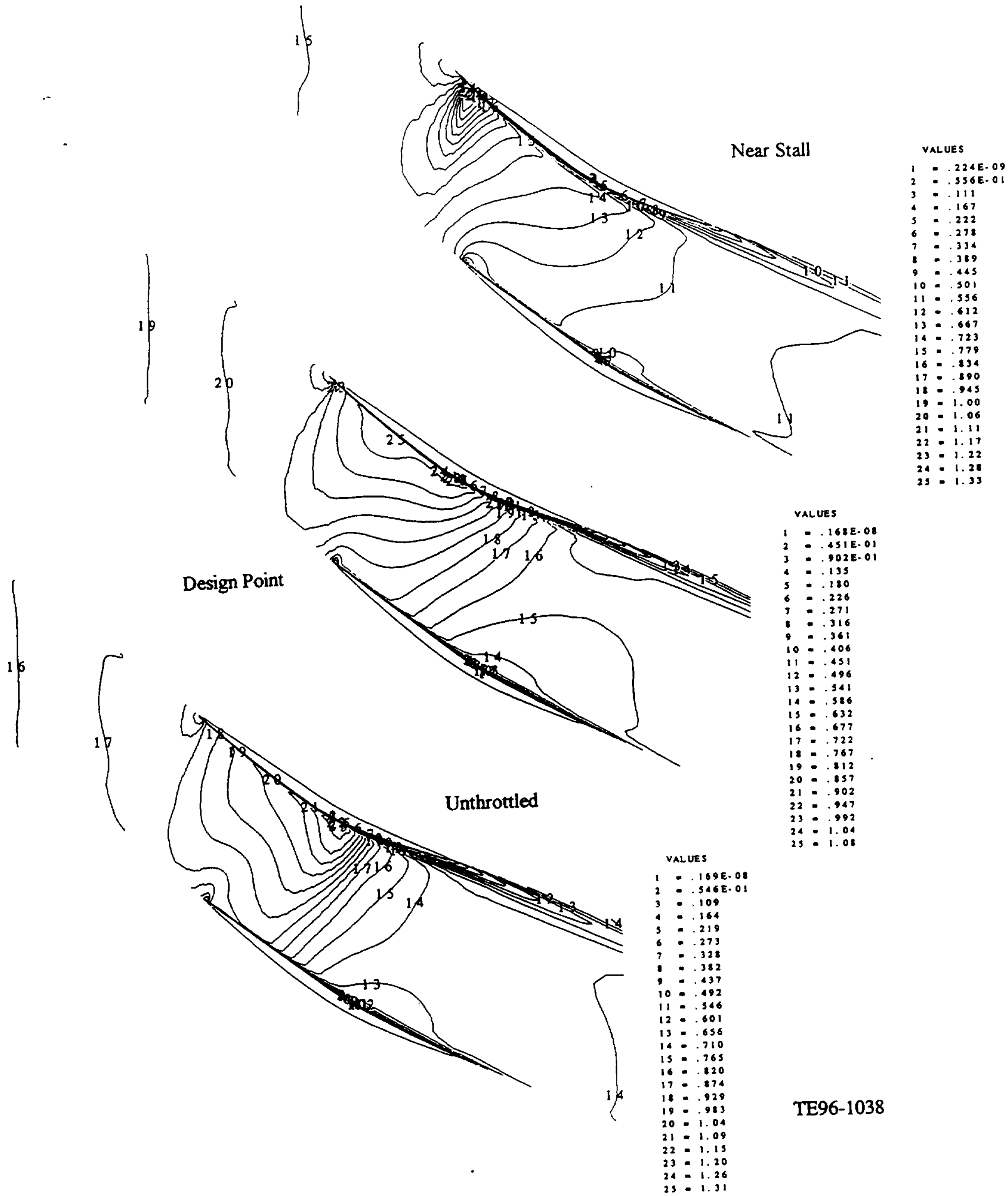

Figure 25. Effect of throttling on blade passage Mach number — midspan section.

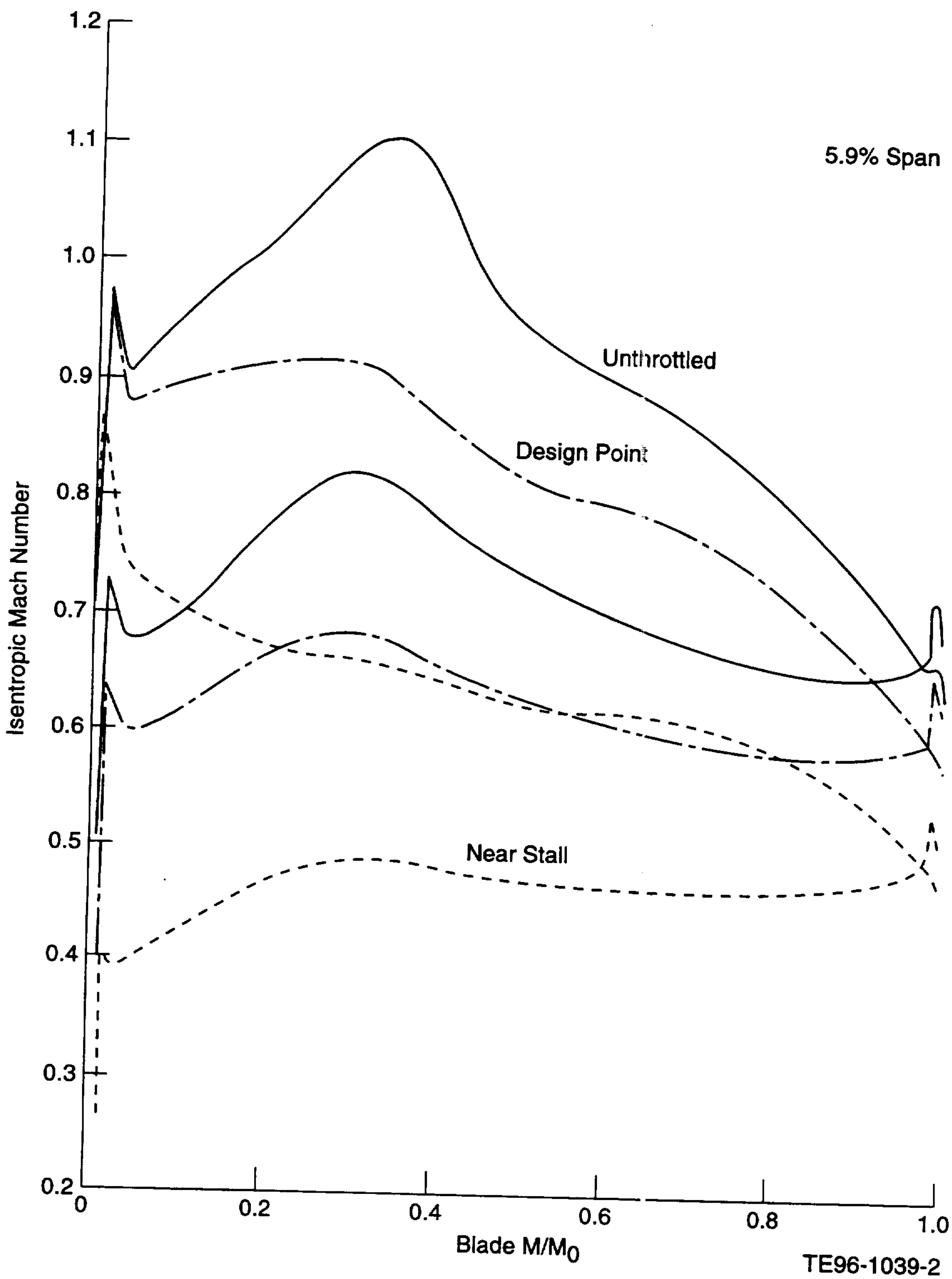

Figure 26. Effect of throttling on blade surface Mach number — near-hub section.

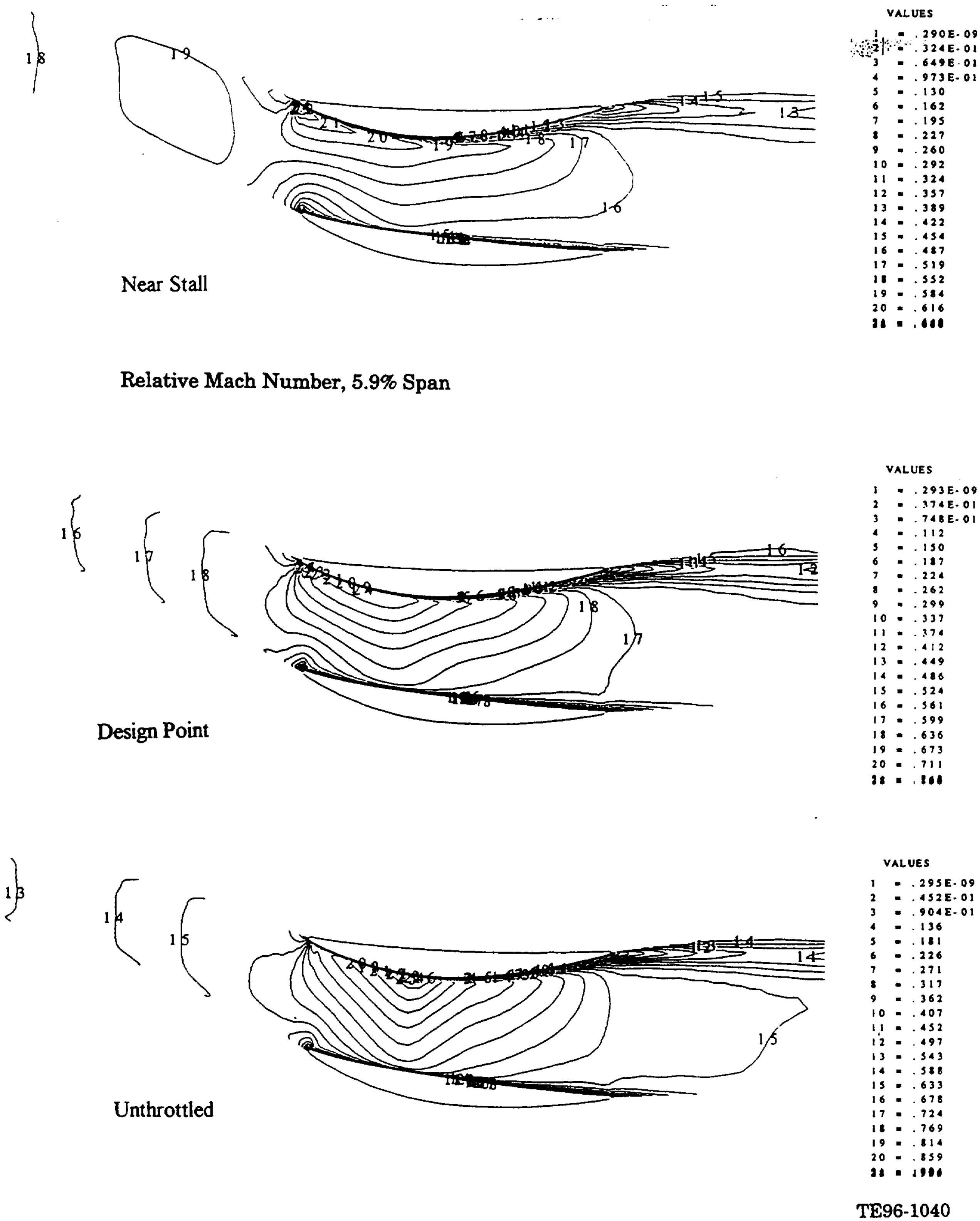

Figure 27. Effect of throttling on blade passage Mach number — near-hub section.

is the movement of the shock near the tip. It migrates from within the passage, as an over-expansion normal shock (probably a reflection from the suction surface of a very weak leading edge oblique shock) to a strong, started oblique leading edge shock to an unstarted, though still stable, normal position to a final, (not shown) unstable interaction with the pressure side bow waves from the neighboring blade. It is the ability of 3-D codes to reproduce shock system geometries and reveal the effects on performance of shock structures that make them such powerful design tools. Note the problem of suction side peakiness, discussed earlier, cannot be avoided in the unthrottled condition. The shock is far enough aft that it impinges on the blade in the region of greatest curvature. A vestige of the near-tip flow field can still be seen in the pitch passages, though it was possible to design the pitch section for shock-free operation at the design point. The hub experiences the largest change in flow level and not surprisingly, becomes the pinch point with decreasing backpressure. The surface Mach number distributions illustrate the rationale for the selection of incidences discussed earlier. The progression from negative to design to larger incidences with throttling is apparent.

Once a blade shape acceptable at design speed was defined, it was analyzed at 85% speed, which was defined as takeoff speed in the ultrahigh bypass engine cycle. At this speed, the blade tip inlet runs to just under Mach 1.0. Obviously, the nominal operating line condition at this speed is particularly important from a noise production standpoint. The surface Mach number distributions and passage Mach number contours predicted for the near-tip, pitch, and near-hub sections at the takeoff point are shown in Figures 28, 29, and 30. Notably, even the outermost section operates shock free.

Incidence levels are uniformly higher than at design speed. The near-tip and pitch sections also exhibit a pronounced reacceleration bump in their suction surface Mach number distributions. This is produced by the large local curvature in each section, discussed earlier, that is in turn one consequence of designing to relatively tight throat margins.

3.1.5 Additional Vane Designs

The NASA test plan calls for the acoustic evaluation of four distinct configurations. Each is characterized by a different stator; the rotor design described earlier is common to all. The baseline fan includes the radial vane already described. The second configuration of the fan, designated FC2 and shown in Figure 1b, results from repositioning the baseline stator further downstream and increases the rotor-to-stator axial gap. Although the vanes are placed in a slightly different flow field, as modeled in Appendix B, the stator assembly itself remains unchanged. The third and fourth fan configurations, however, necessitated the design of two new stator vanes and associated flow-path modifications. For fan configuration No. 3 (FC3) the stator of the baseline fan is replaced with a vane whose leading edge lies at a 30 degree angle from vertical. The fourth fan, FC4, replaces this stator with another made up of vanes that are both swept and leaned. These latter two stator designs are described below.

3.1.5.1 Axially Swept Vane Design

From an acoustic study conducted by NASA, it was determined that among a candidate set of purely swept shapes, a vane swept 30 degrees aft offered the best potential for noise reduction. A stator with this amount of sweep was designed so the radial vane stator of FC1 could be replaced, requiring only one additional spoolpiece to recomplete the outer casing. That the extra spoolpiece was required in any case proved fortuitous since it was found during design of the swept vane that the outer flow path could not be kept of constant radius. A meridional view of the swept vane fan, FC3, is shown in Figure 1c. Not only is the vane highly swept but the casing forward of and through the vane includes a substantial bulge. The incorporations of sweep so increased throughflow velocities that changes in airfoil sections alone were not enough to produce satisfactory outboard vane passage designs; careful area-ruling of the flow-path annulus had to be considered at the same time. Several casing and hub wall contours were analyzed to optimize the final flow-path geometry.

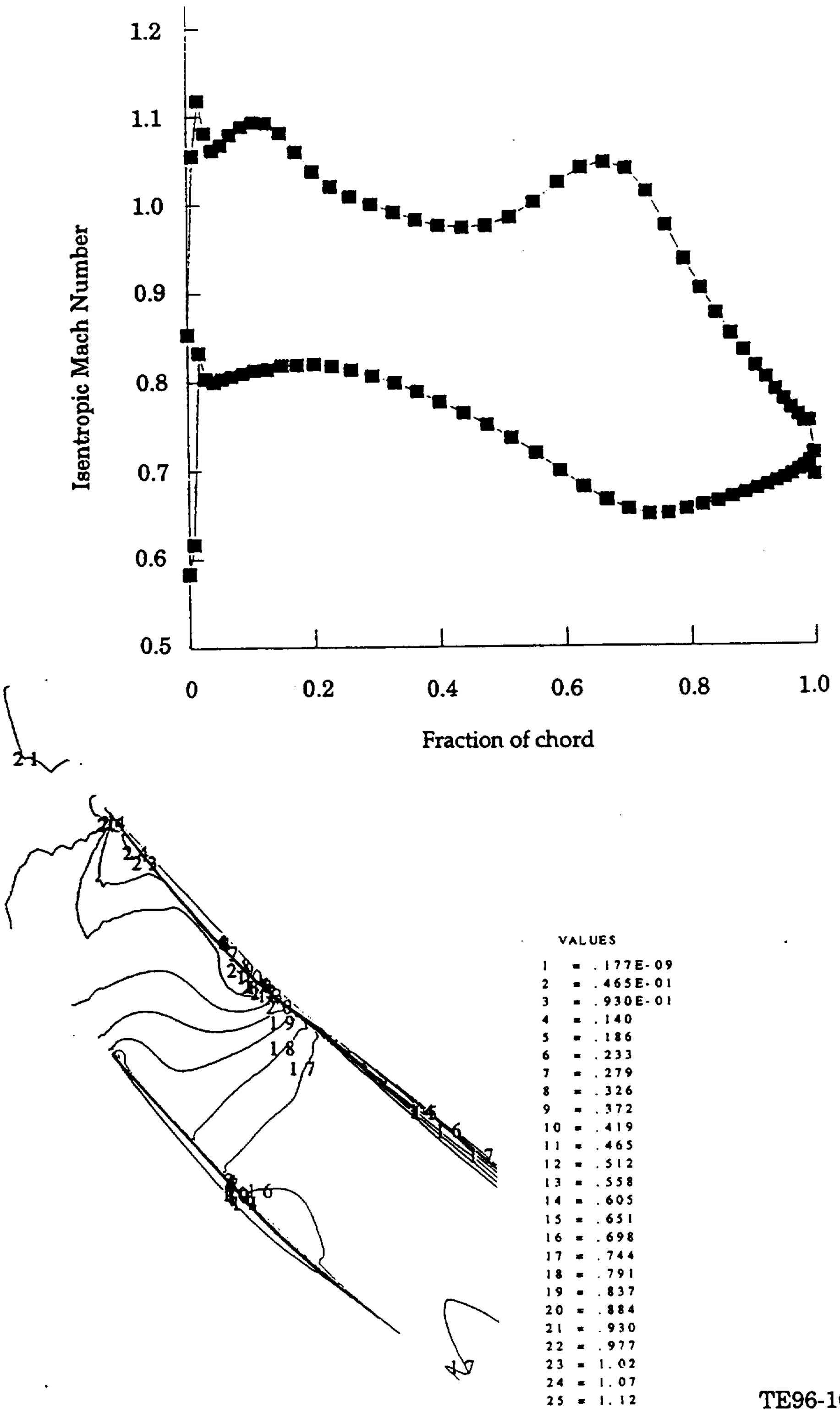

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Figure 28. Rotor blade Mach number distribution at simulated takeoff speed — near-tip section.

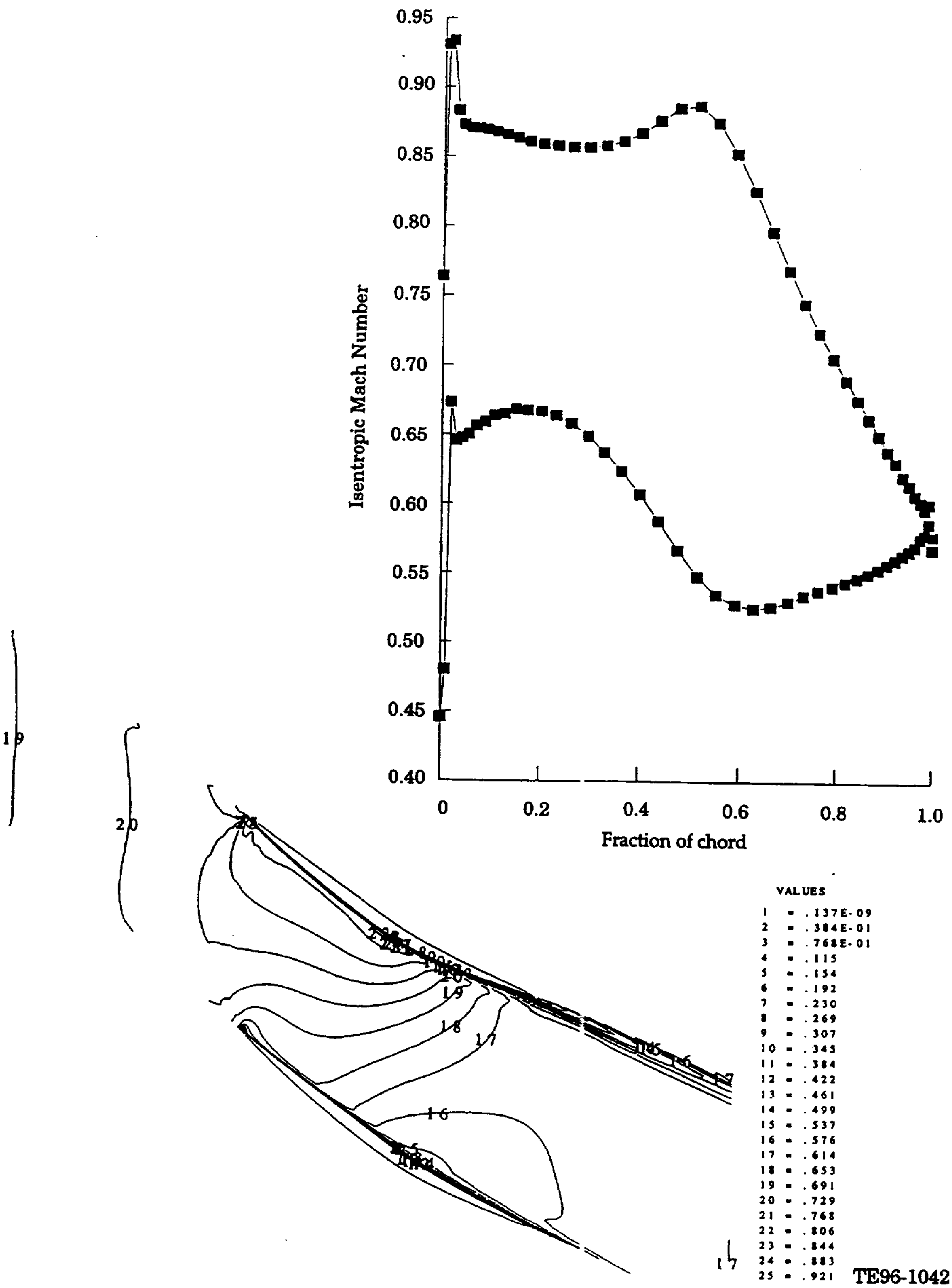
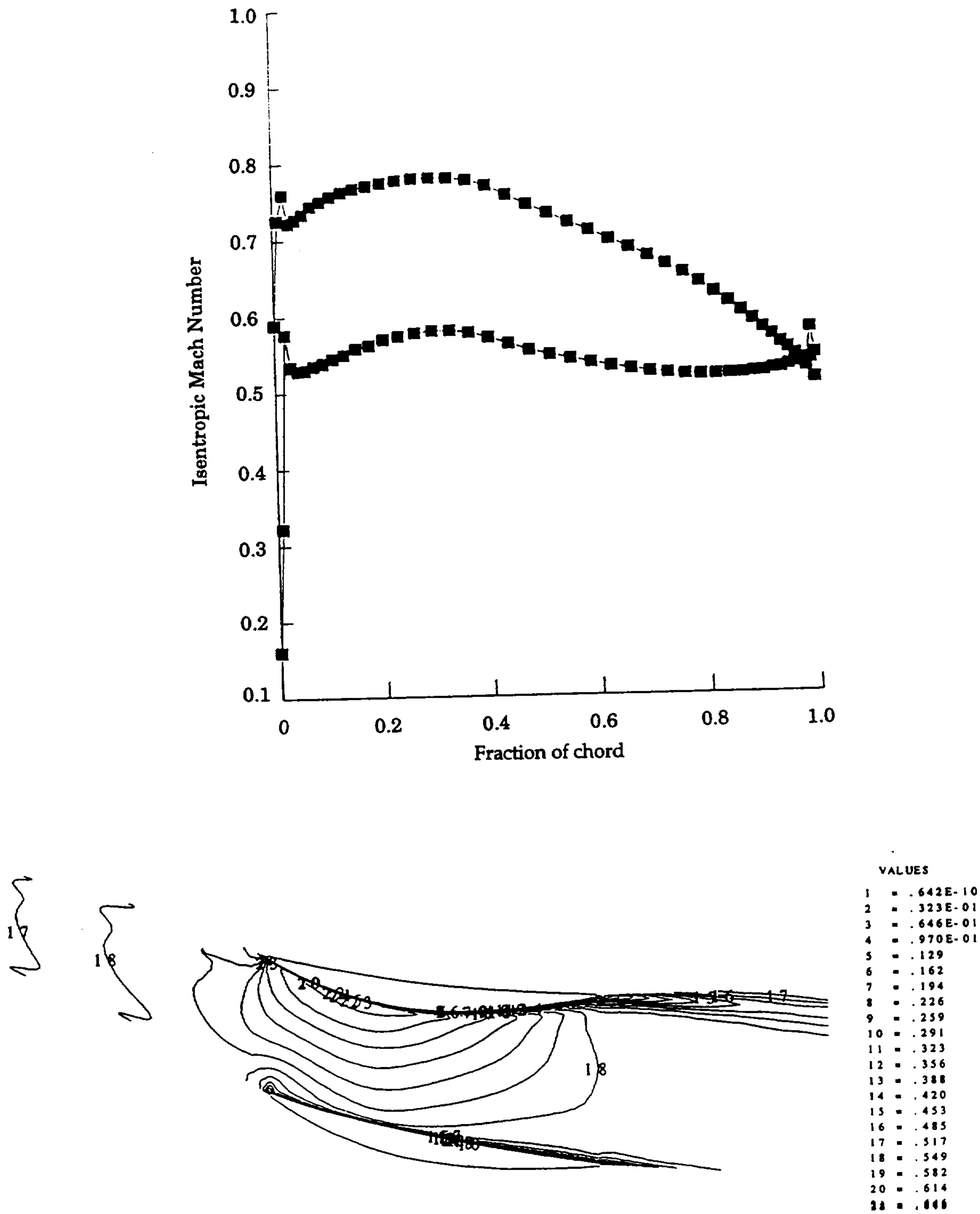


Figure 29. Rotor blade Mach number distribution at simulated takeoff speed — midspan section.



TE96-1043

Figure 30. Rotor blade Mach number distribution at simulated takeoff speed — near-hub section.

The design objective was a swept stator with the same kind of velocity distributions over the vane surfaces as were obtained with the baseline vane. All of the physical properties of the baseline vane, i.e. maximum and edge thicknesses, chord, location of maximum thickness, etc, were preserved in both this and the following swept vane designs. Double circular arc sections were employed as before although, due to the sweep, deviation angles increased. Since the outer diameter bulge not only reduced the level but also flattened the shape of the throughflow velocity profile, incidences were adjusted accordingly. Profiles of these parameters are shown in Figure 31 compared with those for the radial vane, *at the respective vane edges.* The surface isentropic Mach number distributions and associated passage Mach number contours are shown in Figures 32, 33, and 34 for the near-tip, midspan, and near-hub sections shown for the baseline vane. A listing detailing FC3 conditions at the aerodynamic design point is included in Appendix C.

3.1.5.2 Swept and tangentially Tilted Vane Design

The NASA acoustic study referred to previously indicates a potential for further noise reduction by adding lean (tangential tilt) to a swept vane. The study suggests a vane leaned 30 degrees suction-side down (toward the I.D.) with the lean, like the sweep, incorporated so the vane edges remain straight (viewed along engine centerline) offers the largest benefit. The FC4 vane was designed for this degree of stack axis lean. The final geometry is shown in Figure 1d. Noticeably absent is the large bulge in the O.D. flow path required in FC3. Referring to Figure 35, it can be observed that vane lean increases the flow blockage, producing a proportional increase in throughflow velocity, but tends to reduce the migration of flow toward the outer flow path compared to the simple swept design. As a result, flow-path contouring upstream of the leading edge is not required. Deviation shows a strong sensitivity to loading. In the outboard sections, increased loading produces an increase in inlet-to-discharge velocity ratio; as a result, deviation angle increases. For the inboard sections, increased loading results in a decrease in section velocity ratio; as a result, the deviation angle decreases.

As for FC3, the design objective for the swept and leaned vane was to reproduce velocity distributions over its surfaces as much like those obtained for the radial vane as possible. Section incidences were adapted to help achieve this. The resultant distributions for the usual three sample sections are shown in Figures 36, 37, and 38. A listing detailing FC4 conditions at the aerodynamic design point is included in Appendix D.

3.2 NACELLE AERODYNAMIC DESIGN

This nacelle design was developed to meet the basic operational requirements of an isolated nacelle configuration for subsonic/transonic application having an advanced turbofan inlet and a separate flow exhaust system. Since the test vehicle includes no provisions for a separate core flowstream, the primary or core nozzle was truncated and replaced by the propulsion rig metering strut housing the powered drive. Thus, the inlet flow equals the fan nozzle exit flow, unlike a turbofan flight nacelle where the inlet flow splits into the fan and the core flow and exits separately from the two exhaust nozzles.

3.2.1. Inlet Aerodynamic Requirements

Inlet Dimensions

Both inlet and exhaust systems are sized for maximum inlet corrected flow of 102.78 lb. At this flow rate, the inlet throat area is designed for maximum average Mach number at the throat (M_{th}); to be equal to or below 0.75. At this flow condition, the fan operates at maximum specific flow of 43.5 lb/ft^2. This value is consistent with current Allison Engine Company fan design criteria.

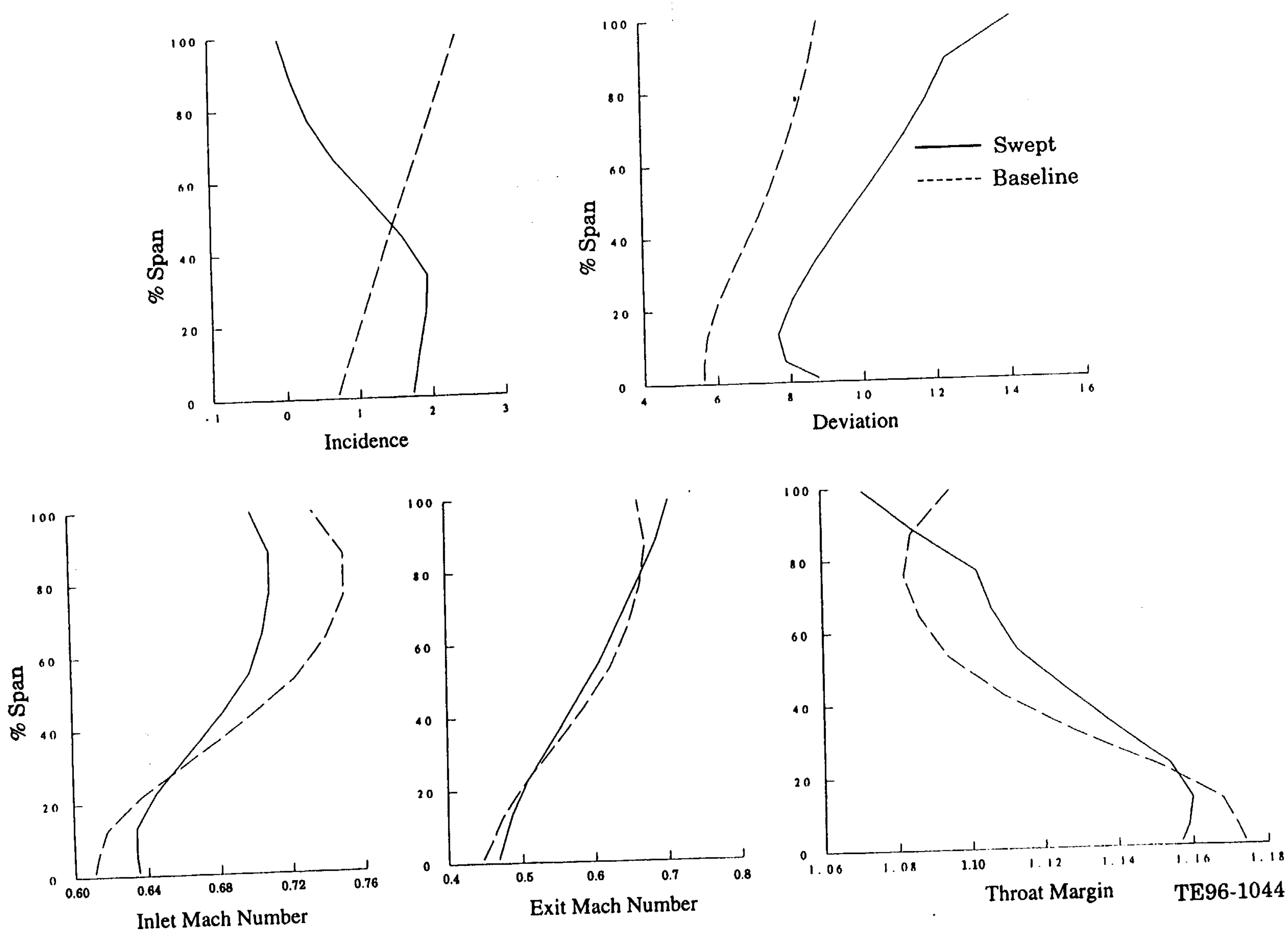


Figure 31. Swept vane design point incidence, deviation, throat margin, and Mach number profiles.

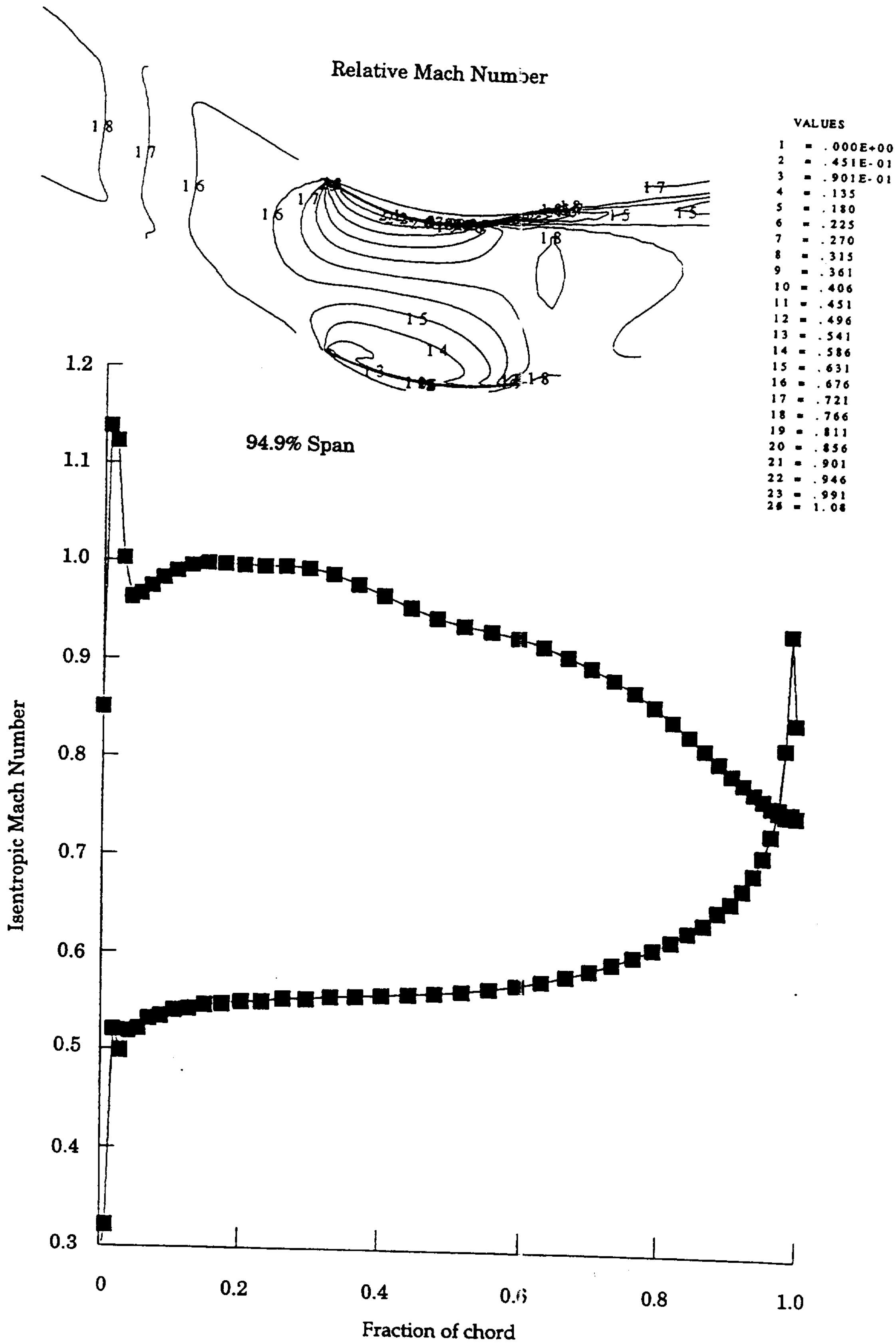


Figure 32. Swept vane design point Mach number distributions — near-tip section.

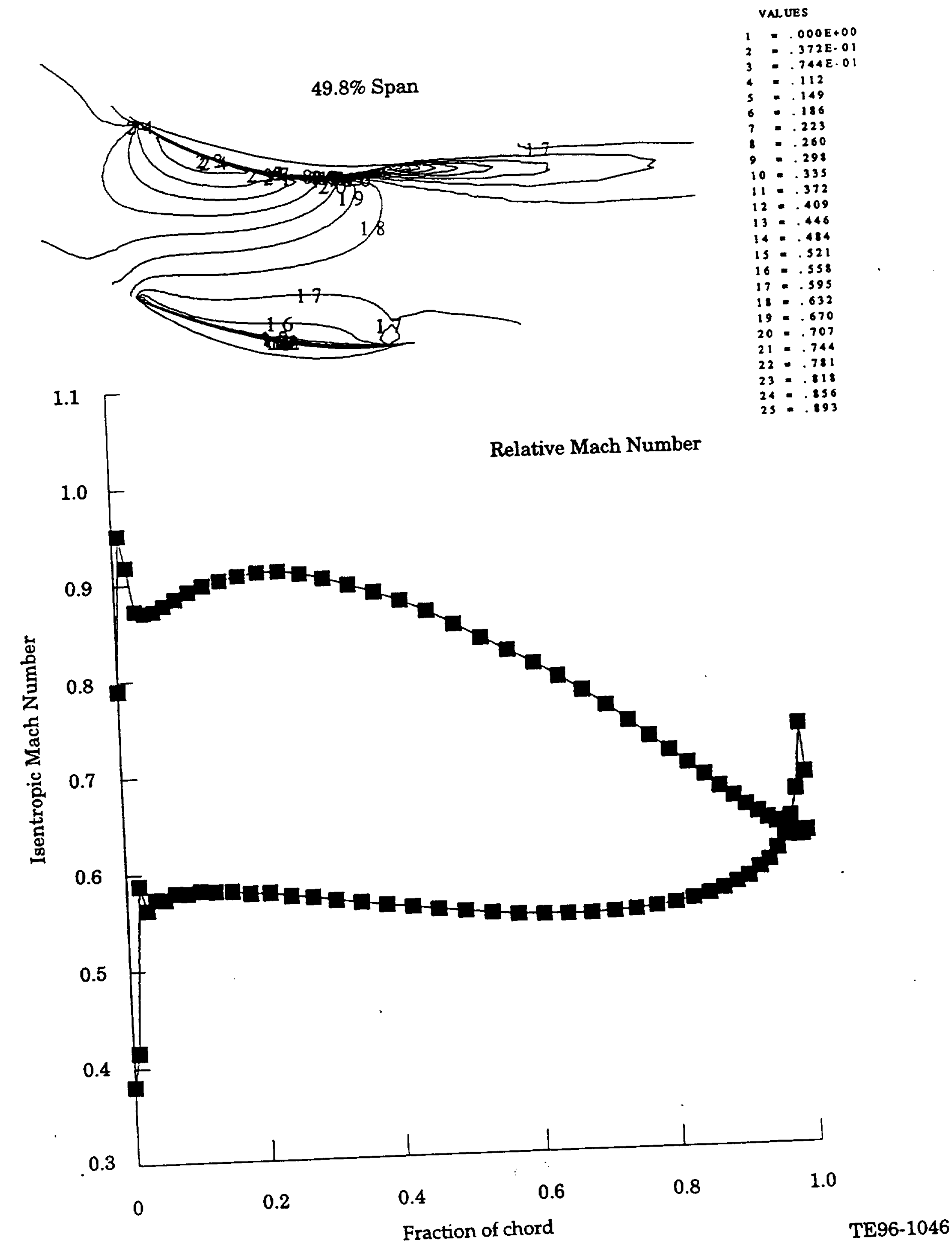
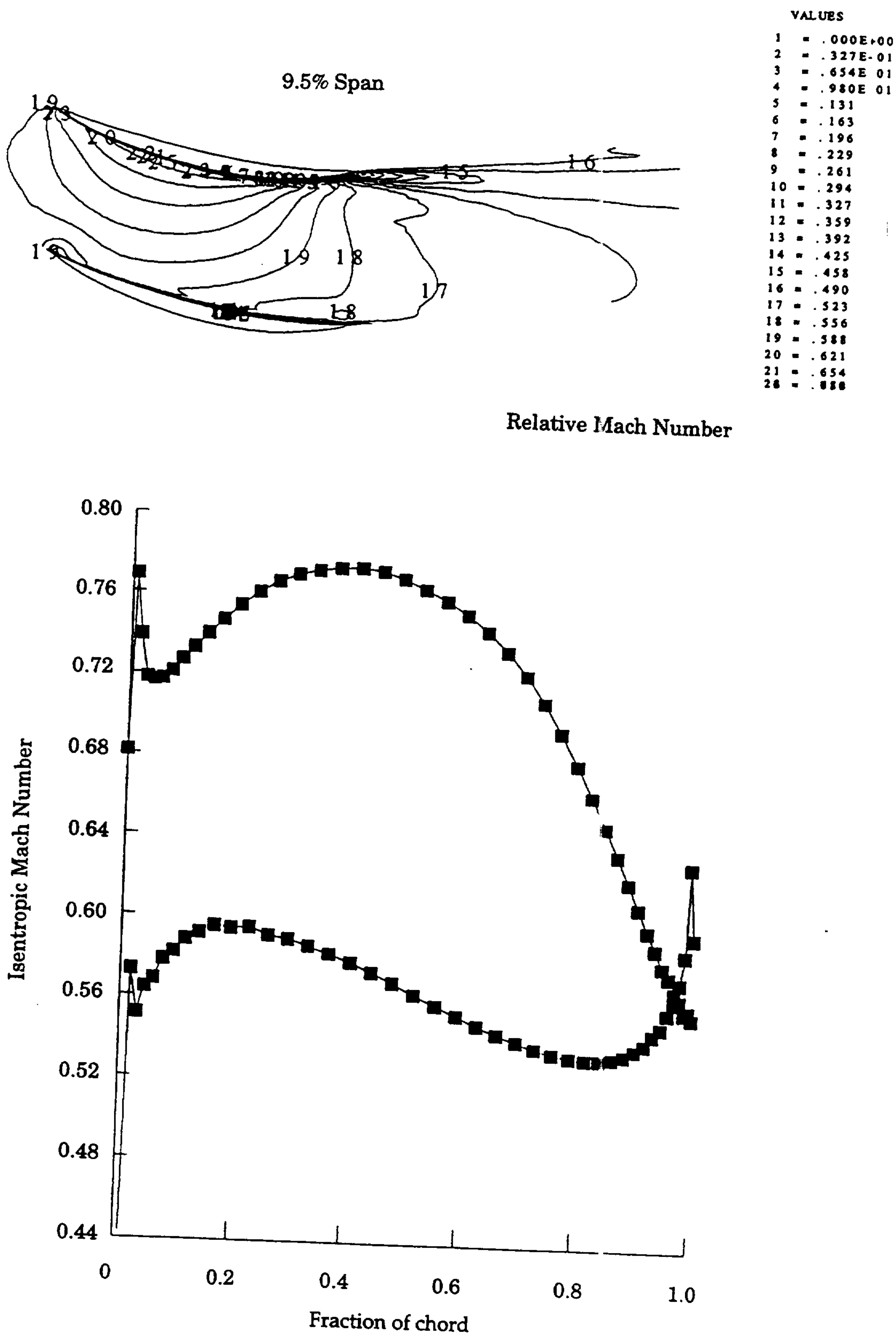


Figure 33. Swept vane design point Mach number distributions — midspan section.



TE96-1047

Figure 34. Swept vane design point Mach number distributions — near-hub section.

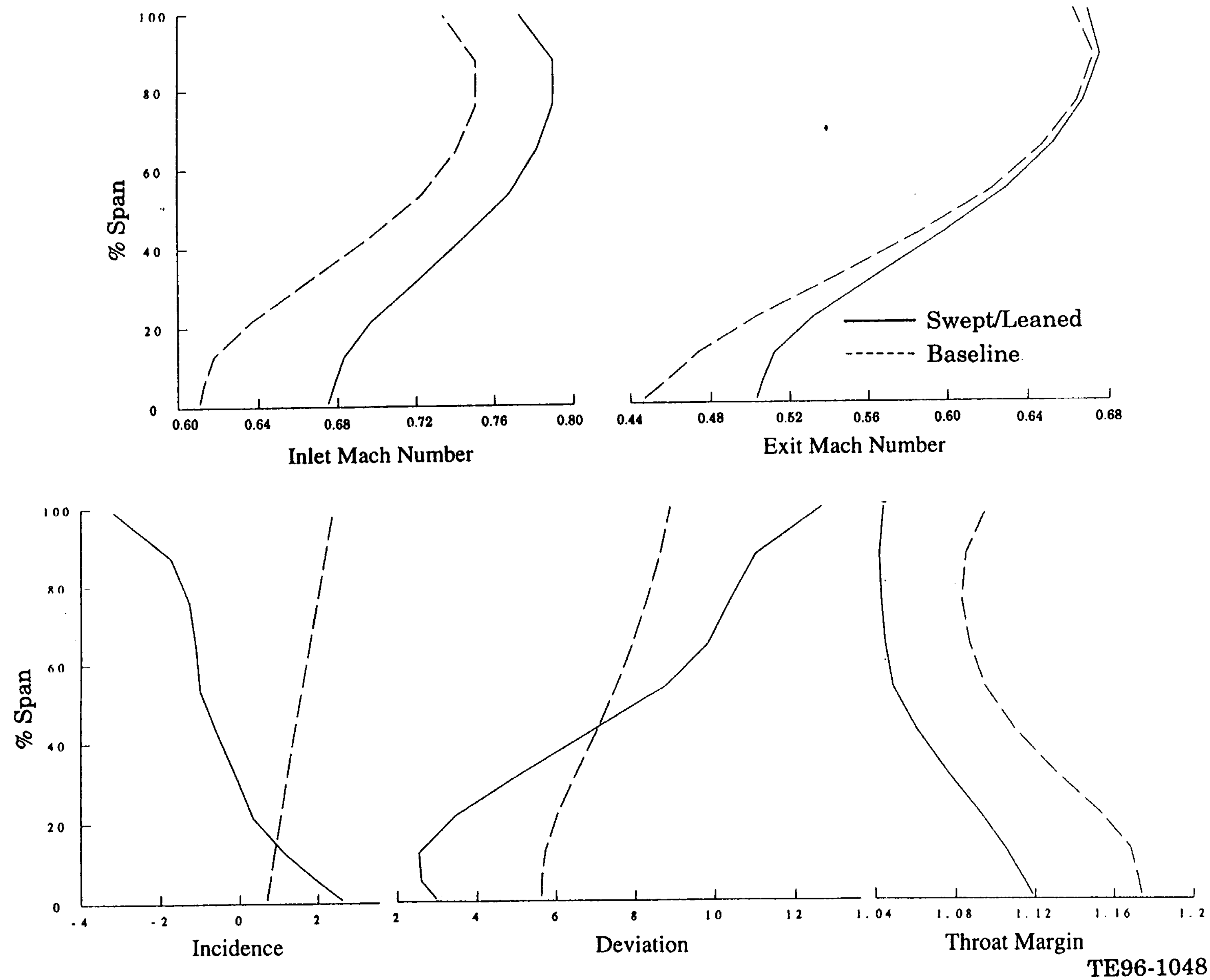


Figure 35. Swept/leaned vane design pint incidence, deviation, throat margin, and Mach number profiles.

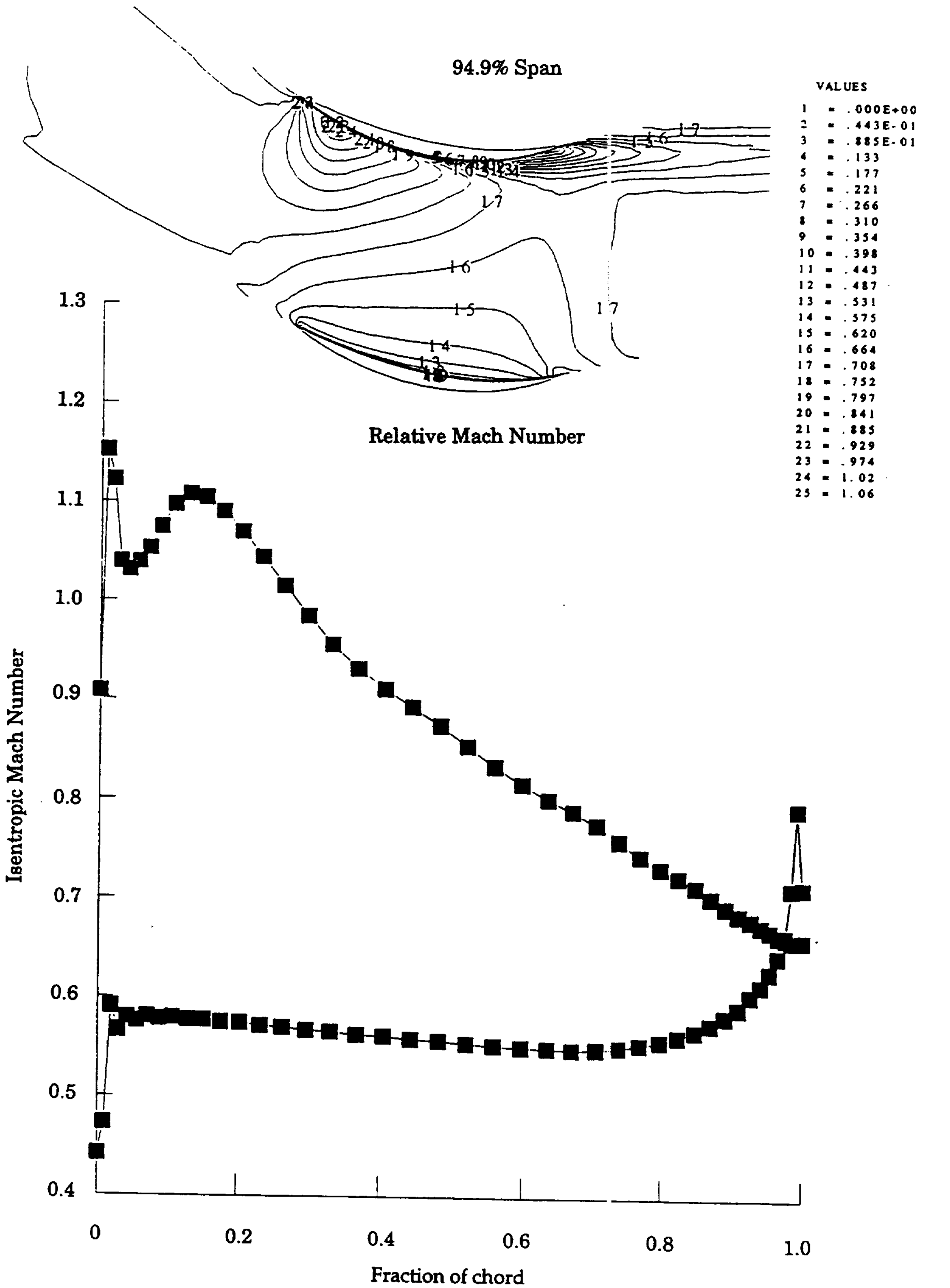


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Figure 36. Swept/leaned vane design point flowfield — near-tip section.

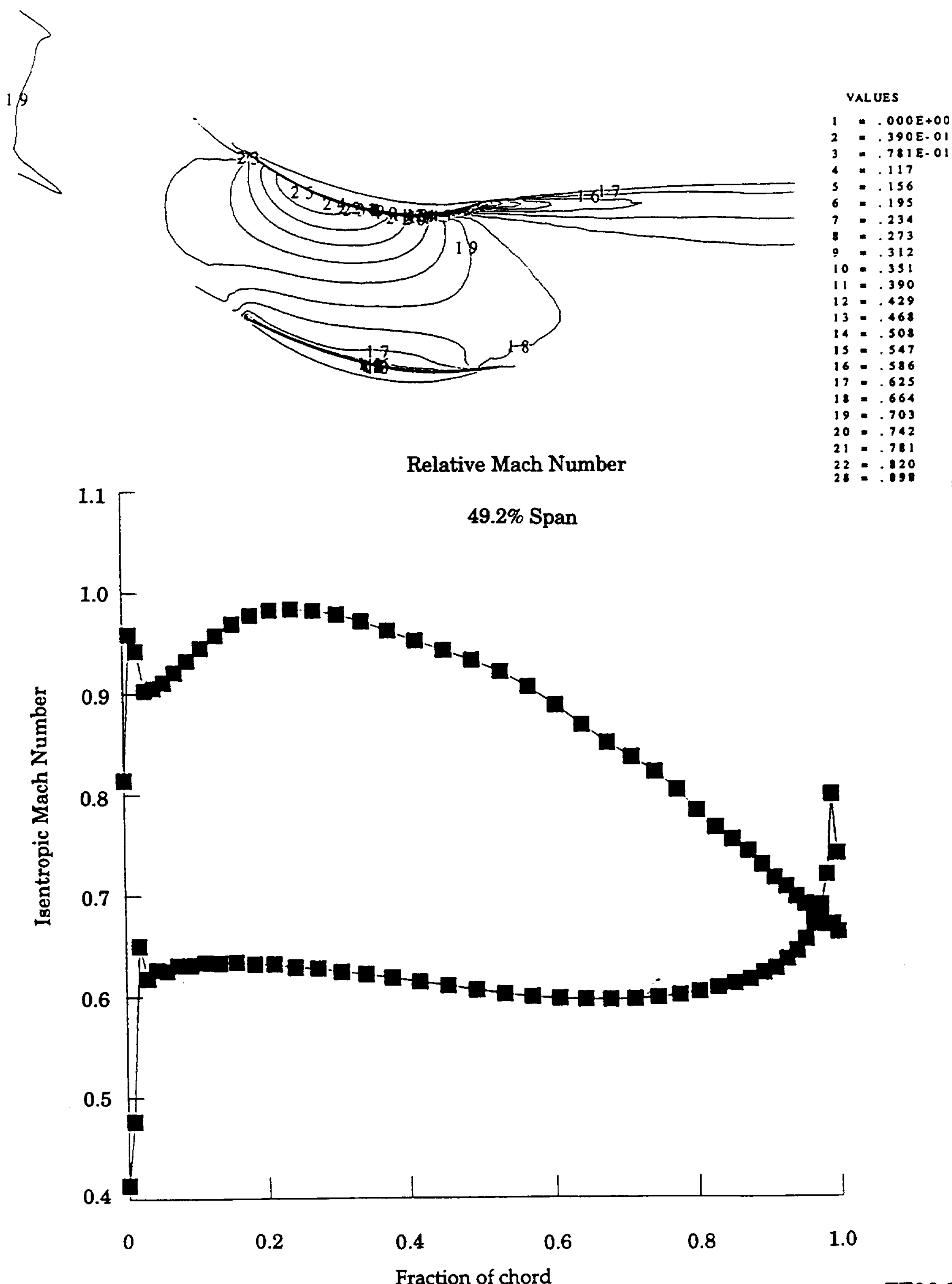

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Figure 37. Swept/leaned vane design point flowfield — midspan section.

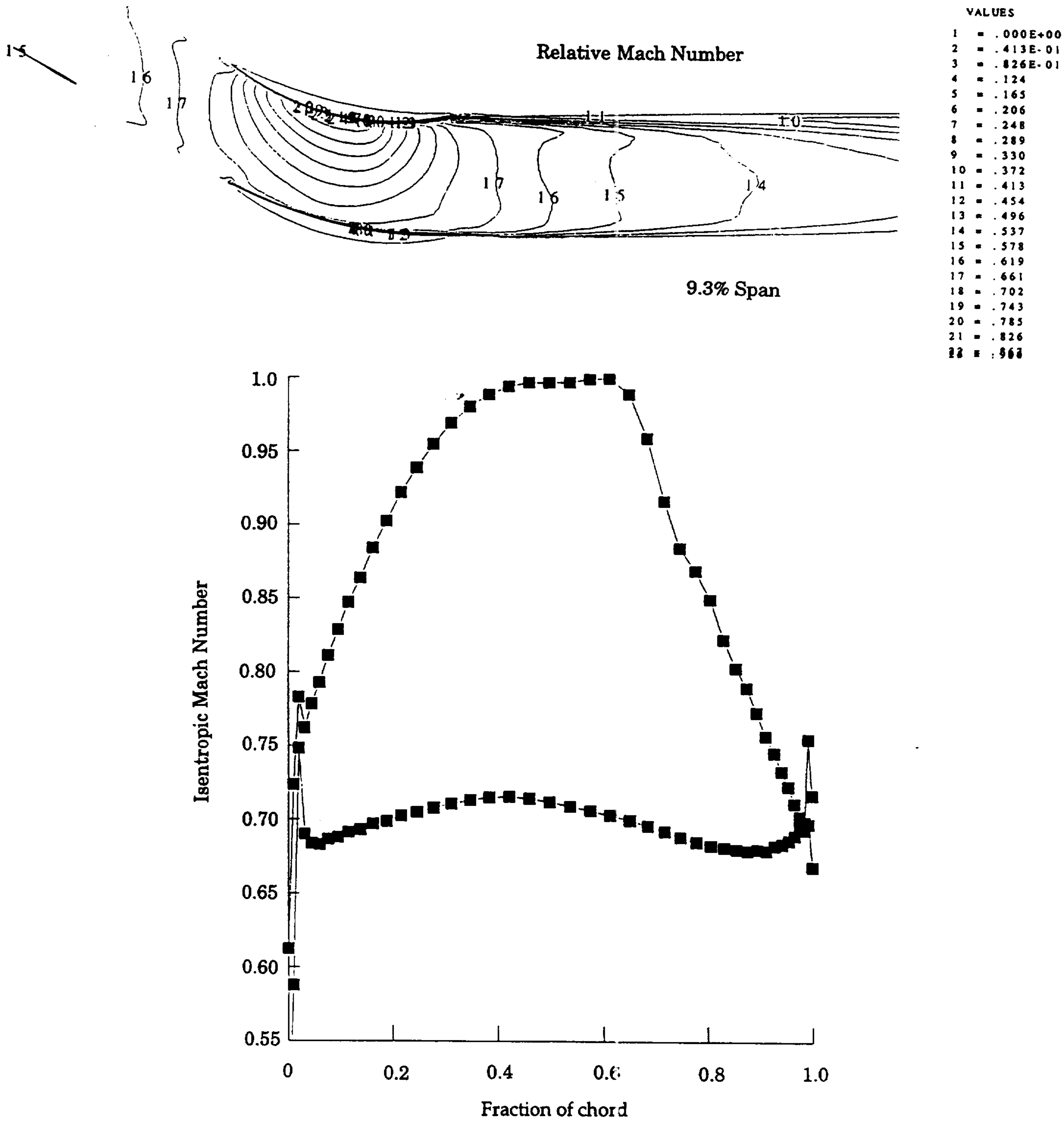


Figure 38. Swept/leaned vane design point flowfield — near-hub section.

Low Speed Requirements

This inlet is required to operate at maximum takeoff flow without internal flow separation for up to 20 degrees angle of attack (AOA) and at free stream Mach numbers ranging from 0 to 0.25, which are typical of levels encountered during aircraft terminal operations. No external inlet separation requirements have been considered; however, it is presumed in case of engine out or shut down, the nacelle forebody cowl will not separate at climbing speeds with AOA below 15 degrees. No crosswind and ground operational requirements have been considered either. For simplicity, an axisymmetric nacelle design with zero inlet droop angle is assumed adequate for this application.

High Speed Requirements

The design cruise Mach number will equal 0.80. At the design cruise Mach number the fore and aft nacelle cowl contours are designed for minimal spillage and wave drag. Normally the engine nacelle is designed to have minimal total drag for a range of cruise Mach numbers, since the corresponding aircraft may be required to operate at different altitudes and flight Mach numbers. Generally, it is desirable to have a nacelle design so its overall drag remains constant or close to the design goal for flight Mach numbers at least 5-10% above the design cruise Mach value. This upper limit of Mach number is called the drag divergence Mach number (M_{dd}). For this design, M_{dd} is fixed at 0.86.

Other Constraints (Geometrical)

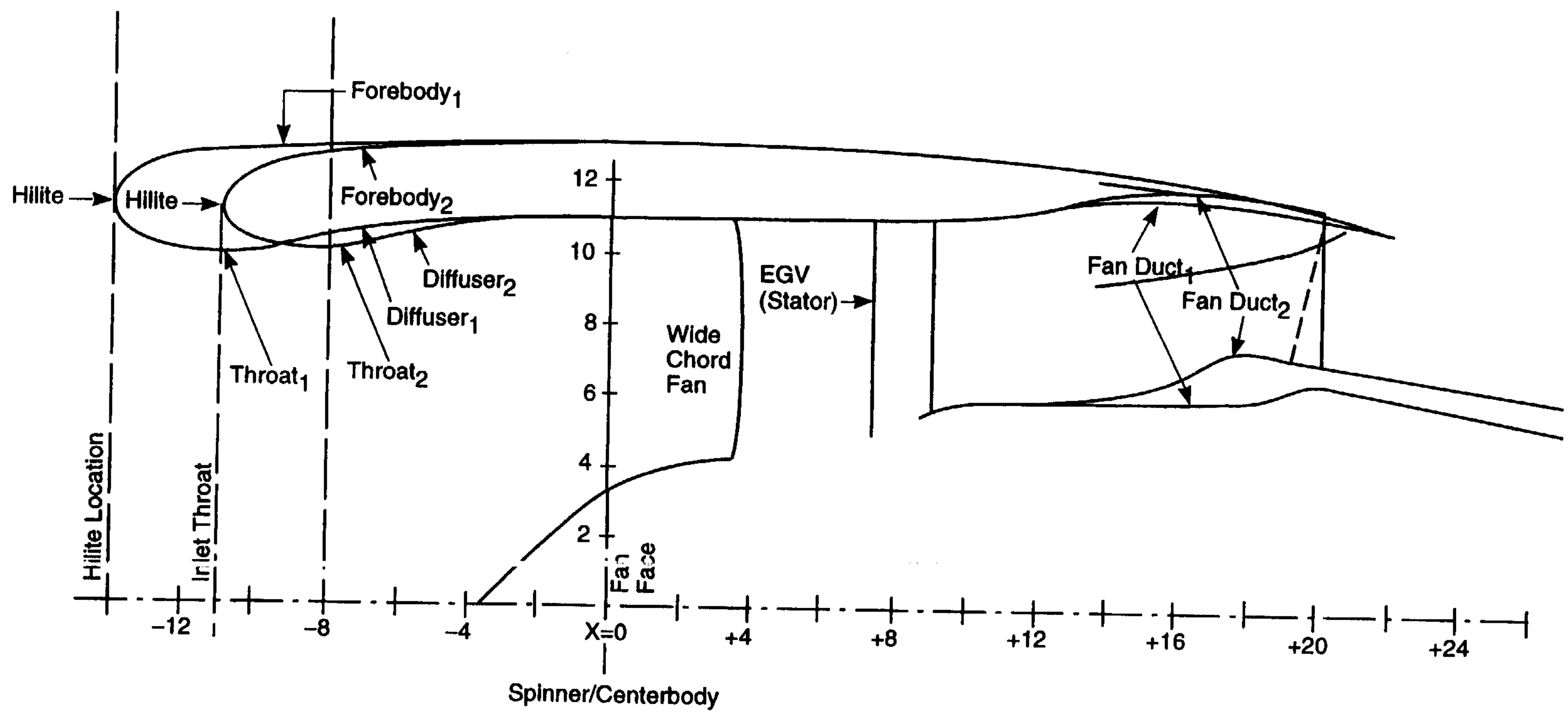
The nacelle aft cowl is designed to match the NASA propulsion simulator ducted prop drive rig. This requirement essentially sizes the overall test model dimensions, establishes the fan cowl and the core cowl boattail angles, and also locates the truncation point of the core cowl near the simulator metric station. The nacelle internal flow lines are constrained by the Allison wide chord fan design with a tip diameter of 22.0 in.

Since the model inlet flow and the fan duct flow are the same, the fan nozzle exit area is also sized to pass the maximum inlet corrected flow. Compared to the corresponding flight worthy nacelle, the fan nozzle is slightly larger than a scaled-up realistic fan nozzle design. The fan nozzle discharge coefficient (Cd) is assumed to be 0.984 (same value was used in the corresponding engine cycle) for choked flow nozzle conditions. No additional fan duct pressure loss has been included.

Initially, two different inlet/nacelle designs were developed to evaluate and compare the overall nacelle size required to incorporate various noise suppression linings. Figure 39 compares the nacelle aerolines for these configurations; however, due to program time and funding limitations, a single design with a compact inlet and diffuser length having (L) inlet/Dff of 0.50 was selected as a baseline nacelle configuration. The selected design provides adequate surface area, or space, for advanced acoustic treatments both in the inlet/diffuser region and in the fan duct. The duct and cowl lengths are sufficient, when scaled to the reference engine size, to accommodate an advanced thrust reverser design. The geometrical characteristics of the baseline nacelle are presented in Figure 40. The extra-long fan duct provides enough space to conduct tests with alternate OGV strut designs involving a set of sweep angles and varied axial lengths between fan trailing edge (TE) and leading edge of the OGVs. The fan and the core cowl contours have been designed to meet the above requirements with the external boattail angles of 10.8 and 8.8 degrees, respectively, consistent with wing mounted nacelles configured for low boattail pressure drag and with reduced nacelle/wing interference drag.

3.2.2 Aeroline Development

The inlet/nacelle contours have been generated using an Allison proprietary geometry code. This enabled an efficient, smooth flow path to be generated for enveloping engine hard points as well as maintaining the desired geometrical characteristics. NASA provided the attachment hard points on the



Configuration 1 Linlet/DFF = 0.64, LFC/Dmax = 1.38

Configuration 2 Linlet DFF = 0.50, LFC/Dmax = 1.19 → Baseline

TE96-1052A-2

Figure 39. High bypass ducted propeller drive rig — nacelle layout.

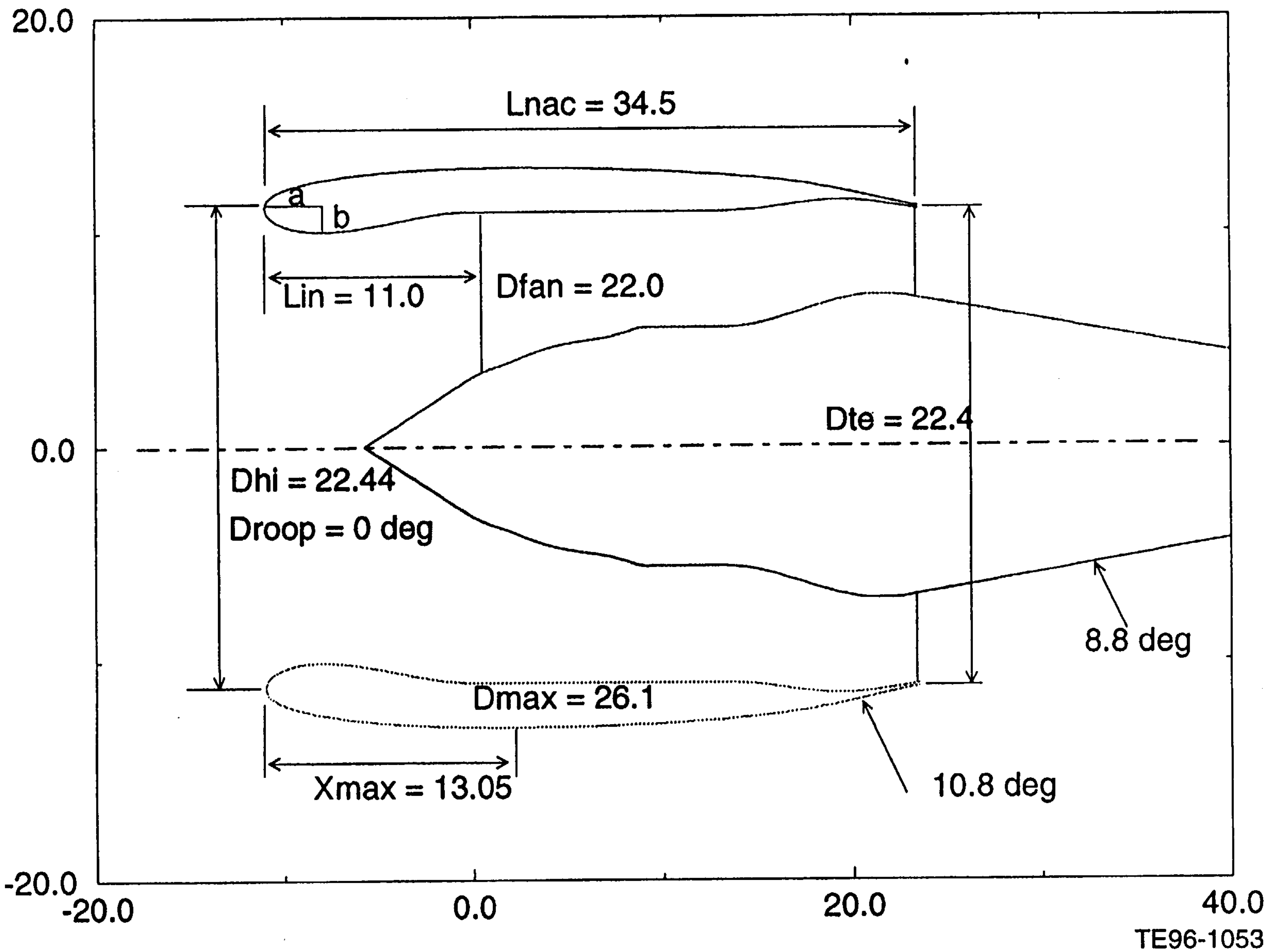


Figure 40. Nacelle aerolines.

simulator flow path to maintain surface continuity between nacelle aft fairings and the drive shaft. Analytical or empirical 1-D techniques were used to provide preliminary performance projections prior to conducting a detailed CFD flow analysis. Figure 40 illustrates the nacelle aerolines along with important dimensions.

3.2.3 CFD Analysis

Inlet flow-field predictions using PMARC, a panel method code, were obtained to confirm the aerodynamic characteristics of the nacelle design. Figure 41 presents the baseline nacelle configuration analyzed, showing surface panels. Three flight conditions were analyzed using PMARC. These conditions are critical to the inlet design for engine operability and maximum cruise operation, and are as follows:

(1) M_{inf} = 0.2, AOA - 20 deg, Wcorr = 102.78 lb
(2) M_{inf} = 0.8, AOA = 0.0 deg, Wcorr = 102.78 lb
(3) M_{inf} = 0.0. AOA = deg, Wcorr = 104.5 lb

The analysis was conducted at several other conditions to calibrate the flow solution and the aerodynamic load calculation methods. Since this nacelle design will only be tested at low-speed conditions, condition (1) was used for the detail inlet/nacelle analyses. Typical surface flow distributions for the above conditions are enclosed in Figures 41, 42, and 43. Boundary layer analysis (Figure 44) was conducted using PMARC pressure distributions to provide surface skin friction Cf distribution on the inlet and nacelle to verify a separation-free flow.

3.2.4 Aerodynamic Loads

The pressure distribution obtained from the PMARC analysis at angle of attack was integrated over the nacelle length to obtain the resultant load and moment on the static structure due to operation at this condition. The results show both magnitude and point of application (fan face = 0.0) (Table II). These results were combined with the standard aerodynamic loads generated on the vane airfoils from deswirling of the fan rotor exit flow to determine the structural integrity of the static structure.

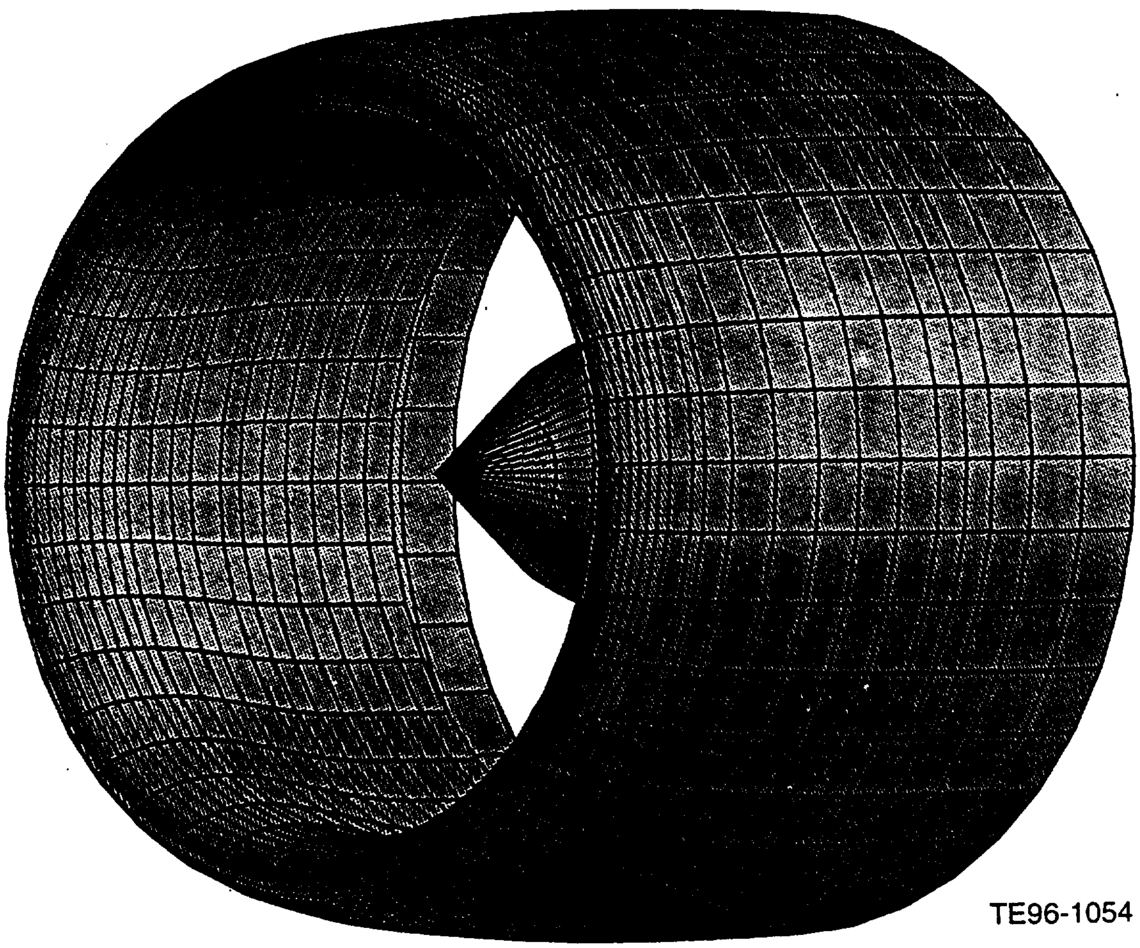


Figure 41. PMARC panels.

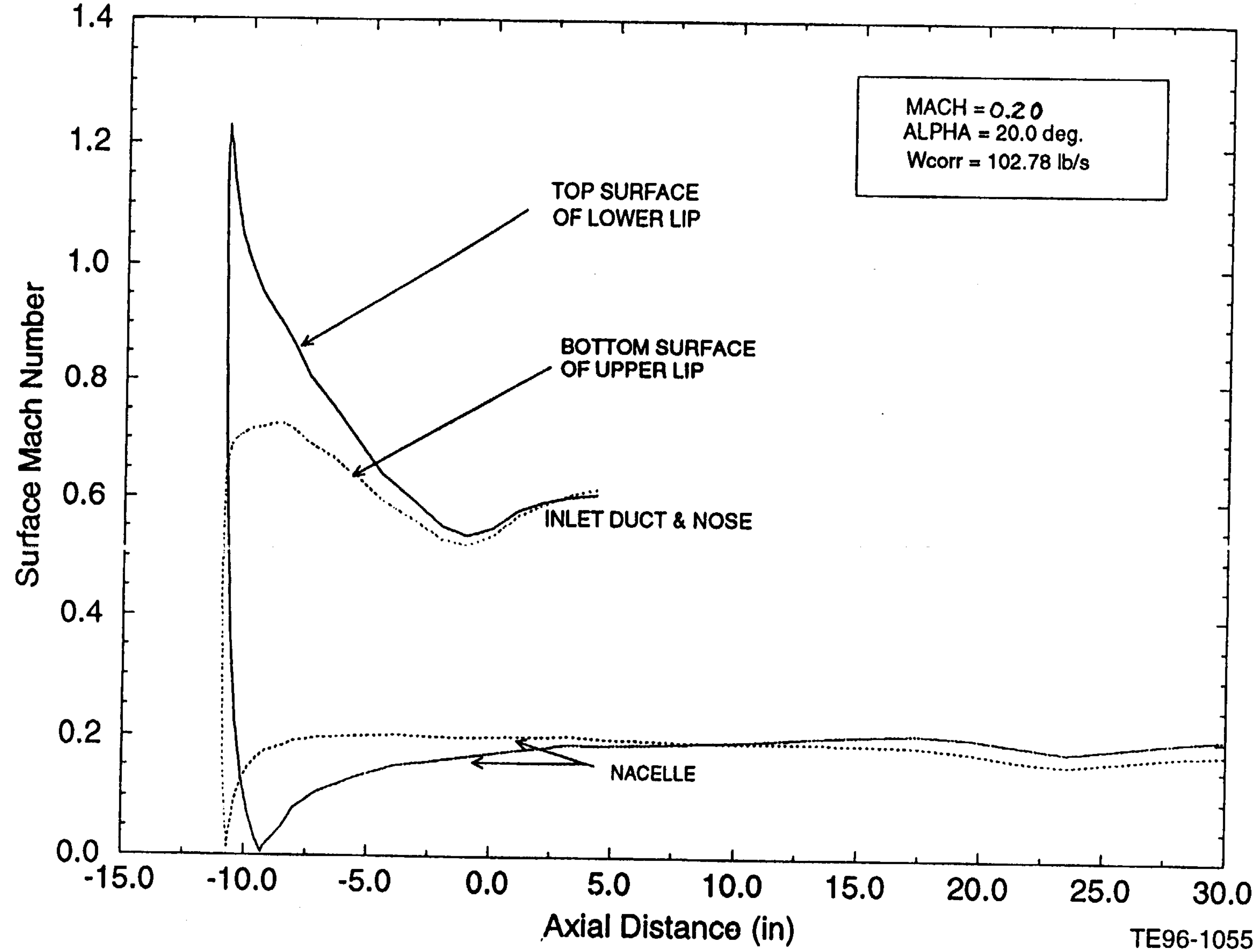


Figure 42. Acoustical HBPR nacelle — baseline Mach number distribution.

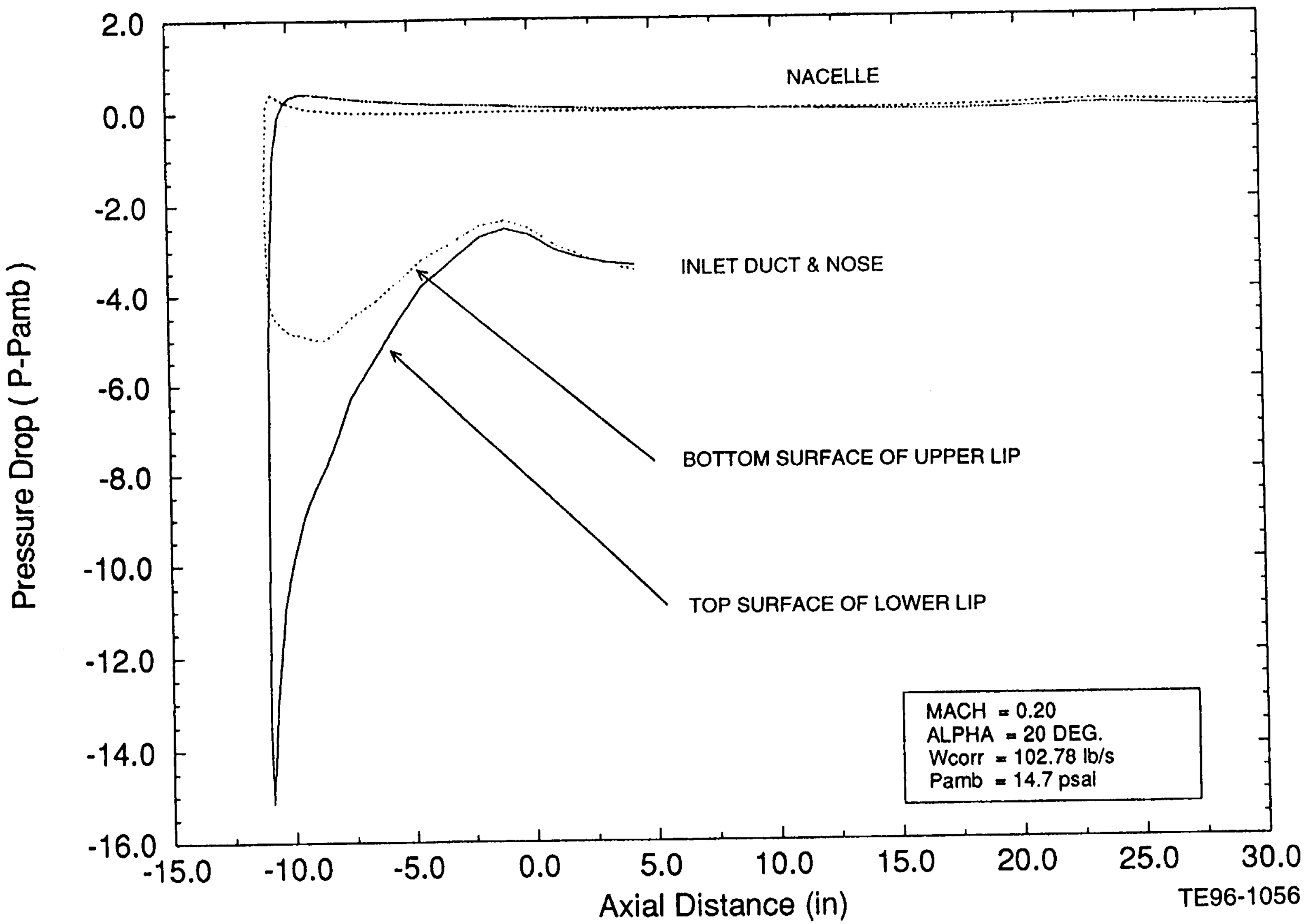


Figure 43. Acoustical HBPR nacelle — baseline pressure distribution.

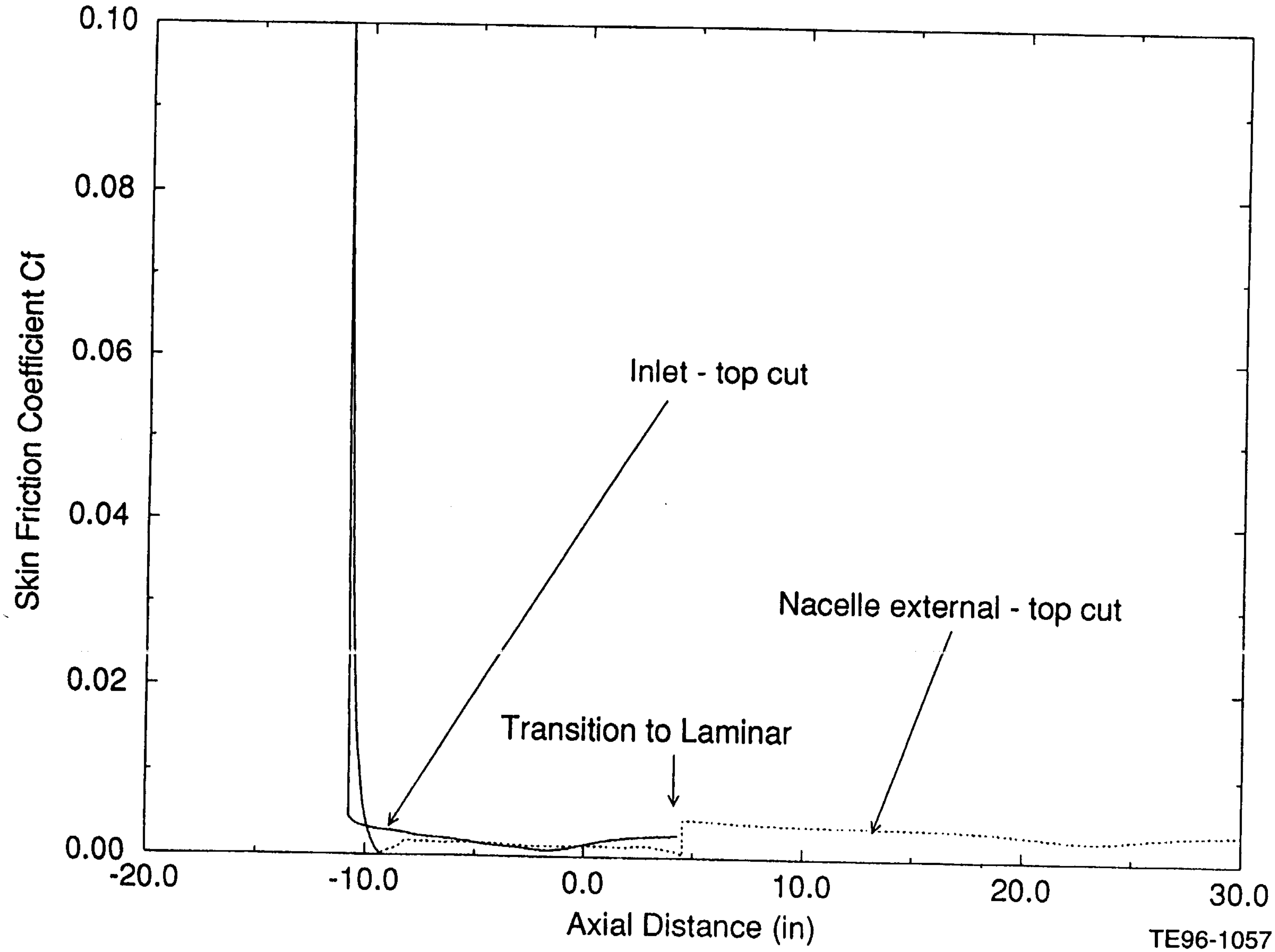


Figure 44. Acoustical HBPR nacelle — baseline skin friction coeffecient.

Table II.
Nacelle aerodynamic loads at 15 degree angle of attack.

Patch coefficients

Patch	Name	CN	CA	CY	C_m	C_n	C_l	Patch area/SREF
1	Spinner	0.0000	-0.0262	-0.0002	0.0000	0.0000	0.0000	0.0122
2	Patch %%2 - fanface	0.0000	-0.1673	0.0000	0.0000	0.0000	0.0000	0.0223
3	Patch %%3 - inlet duct	0.0000	0.0315	-0.0112	0.0000	0.0003	0.0000	0.0577
4	Patch %%4 - nose	0.0000	-0.0721	-0.0218	0.0000	0.0020	0.0000	0.0152
5	Patch %%5 - nacelle	0.0000	-0.0084	-0.0021	0.0000	0.0005	0.0000	0.1920
6	Patch %%6 - plume	0.0000	0.0000	0.0146	0.0000	0.0034	0.0000	0.1171
7	Patch %%7 - exit end	0.0000	-0.0138	0.0000	0.0000	-0.0003	0.0000	0.0272

Patch loads and moments (lb)

Patch	Name	FN	FA	FY	MY	MZ	MX	Patch area - in.^{2}
1	Spinner	-0.0001	-154.9907	-1.0351	0.0000	0.5839	0.0000	176.3459
2	Patch %%2 - fanface	0.0000	-991.4127	0.0000	0.0001	-0.1111	0.0000	320.4652
3	Patch %%3 - inlet duct	-0.0001	186.6494	-66.5297	0.0000	24.1452	0.0000	831.0043
4	Patch %%4 - nose	0.0001	-427.0309	-129.3578	0.0002	178.6471	0.0000	219.3218
5	Patch %%5 - nacelle	0.0001	-49.9820	-12.3626	-0.0005	47.4809	0.0000	2764.5623
6	Patch %%6 - plume	0.0000	0.0000	86.3899	-0.0001	304.9659	0.0000	1686.5090
7	Patch %%7 - exit end	0.0000	-81.6807	0.0000	0.0000	-30.1228	0.0000	392.1487

Calculation of centroid of each patch segment (in.)

Patch	Name	X bar	Y bar	Z bar	Patch area - in.^{2}
1	Spinner	-8.3826	-0.0108	0.0012	176.3459
2	Patch %%2 - fanface	1.0000	-0.0013	0.0012	320.4652
3	Patch %%3 - inlet duct	-5.4339	0.3845	0.0000	831.0043
4	Patch %%4 - nose	-9.8761	2.0285	0.0000	219.3218
5	Patch %%5 - nacelle	-16.0723	7.4242	-0.0001	2764.5623
6	Patch %%6 - plume	42.3613	1.0000	0.0000	1686.5090
7	Patch %%7 - exit end	1.0000	-4.4254	0.0000	392.1487

4.0 STRUCTURAL DESIGN

4.1 ROTATING COMPONENTS

The fan rotor assembly is composed of three primary components, an integral bladed disk (blisk) consisting of 18 airfoils and a hub; a spinner; and a torque sleeve. The blisk and torque sleeve are assembled to form a bolted assembly. The blisk is positioned radially on the torque sleeve at a pilot surface and retained through a bolted flange arrangement. Torque is transferred between the two components through a single shear pin. The spinner is threaded onto the forward portion of the torque sleeve to remove the need for attachment bolts and the associated access holes, which have produced additional tones in previous NASA test programs. The torque sleeve attaches to the drive rig through a force balance. Assembly is by way of four cross keys that are integral to the torque sleeve and mate with matching slots in the force balance. A titanium alloy, AMS 4928 in the solution treated and annealed state, was selected for the blisk and spinner due to its high strength to density ratio. Stainless steel, AMS 5659, was selected for the torque sleeve to meet the strength and life requirements of the cross keys.

4.1.1 Stress and Deflection Analysis

Structural assessment criteria employed to evaluate the structural integrity of the rotating components followed standard Allison practice for nonflight applications. Specific areas evaluated included rupture (tensile failure) speeds for both the blade and disk, section average and local tensile yielding, creep, low cycle fatigue life, and deflection under combined aerodynamic and centrifugal loading. No analysis of bird ingestion damage was attempted, but fan blade geometric parameters (such as leading edge radius) were constrained to lie within current engine experience.

All analysis was performed using the finite element method. A model of the blisk, torque sleeve, and spinner was generated for execution in the Allison proprietary finite element model (FEM) procedure, STRATA. Following Allison standard procedure, the analysis was conducted in two parts. A 2-D axisymmetric analysis was performed on the disk, with the blade centrifugal loading applied as distributed tractions along the rim surface. The blade stresses were determined separately, with the airfoils represented by a mesh of 8-node meanline shell elements. The airfoil is attached rigidly to a plate oriented at the flow-path convergence angle. Based on Allison experience, stress concentration effects in the fillet regions are not modeled directly. Instead, a stress concentration factor (k_t) is applied to the analytical results in the row of nodes immediately outboard of the hub boundary nodes. Standard values for k_t have been determined that yield an acceptable safety factor.

The structural audit sheets presented in Tables II and III summarize the results of this analysis as compared to material limits. Material properties contained in these tables were obtained from an Allison proprietary data base and include a sufficient sample size to establish statistical variations. For design assessment, the material properties used are those corresponding to three standard deviations (-3σ) below the mean of the material data base. Figure 45 presents the material properties of the titanium alloy used in the blisk and spinner, while Figure 46 presents similar data for the stainless steel used for the torque sleeve.

Airfoil, disk, spinner, and torque sleeve stresses were calculated at the design speed (N_d) of 10,400 rpm, including the appropriate aerodynamic loads. Complete results of the stress analysis, in the form of isostress contour plots, is presented in Appendix E. The results presented for the airfoil include the effects of offsetting the stacking axis axially and circumferentially to balance the loading across the hub cross section. To ensure structural integrity, stress levels averaged over an appropriate section were required to be less than 0.8 of the tensile yield strength. For the disk, averages were obtained for both radial and tangential stress in the web and radial stress only around the flange attachment holes. For the airfoil, an average radial stress across the hub cross section was obtained. Results of the analysis indicate the maximum average stress occurs in the airfoil hub. The predicted levels are very low compared to the

Table III.
NASA 22-in. fan rig structural audit checklist — fan blade.

Objective/ concern	Critical parameter	Calculation method	Design criteria	Material	Maximum temp - °F	Parameter	Allowable mean	N	-Ns	Calculated result	Location	Satisfy criteria	Comments
Tensile limit	Average section stress	FEM 3-D mean line shell	0.8 Fty	Ti 6-4 STAN	150	Stress	124	3	112 ksi	32.75 ksi	Pressure surface	Yes	
Burst	Average section stress	FEM 3-D mean line shell	$1.0\ \text{Ftu} \left(\frac{\text{Nmss}}{\text{Nb}}\right)^2 \left(\frac{\text{Nd}}{\text{Nmss}}\right)^2$	Ti 6-4 STAN	150	Stress	77.32	3	70.36 ksi	32.75 ksi	Pressure surface	Yes	Max stress
Creep	Average section stress	FEM 3-D mean line shell	1.0 Fcreep for 0.1% creep in 1000 test cycle life	Ti 6-4 STAN	150	Stress	>100.0	3	>100.0 ksi	32.75 ksi	Pressure surface	Yes	Max stress
LCF	Steady state Kt = 1.4	FEM 3-D Mean line shell	1000 cycle test cycle life (0-maximum-0 cycles)	Ti 6-4 STAN	150	Life			1000 cyc	$>3 \times 10^6$ cycle	Hub	Yes	
	Steady state Kt = 2.0	FEM 3-D Mean line shell	1000 cycle test cycle life (0-maximum-0 cycles)	Ti 6-4 STAN	150	Life			1000 cyc	$>3 \times 10^6$ cycle	Leading edge	Yes	
HCF	Steady state Kt = 1.0	FEM 3-D Mean line shell	>±15 ksi vibratory capability, 3×10^7 cyc at Nmss, maximum temperature	Ti 6-4 STAN	150	Stress	79.21	3	67.75 ksi	32.75 ksi	Pressure surface	Yes	
	Steady state Kt = 1.4	FEM 3-D Mean line shell	>±15 ksi vibratory capability, 3×10^7 cyc at Nmss, maximum temperature	Ti 6-4 STAN	150	Stress	68.50	3	54.12 ksi	27.22 ksi	Hub	Yes	
	Steady state Kt = 2.0	FEM 3-D Mean line shell	>±15 ksi vibratory capability, 3×10^7 cyc at Nmss, maximum temperature	Ti 6-4 STAN	150	Stress	52.44	3	33.67 ksi	19.48 ksi	Leading edge	Yes	

Table IV.
NASA 22-in. fan rig structural audit checklist — fan disk.

Objective/ concern	Critical parameter	Calculation method	Design criteria	Material	Maximum temp - °F	Parameter	Allowable mean	N	-Ns	Calculated result	Location	Satisfy criteria	Comments
Tensile limit	Average web rad stress	FEM axisymmetric	0.8 Fty	Ti 6-4 STAN	150	Stress at Nd	136.3	3	122.8 ksi	2.93 ksi	Web	Yes	
	Average web tang stress		0.8 Fty	Ti 6-4 STAN	150	Stress at Nd	123.9	3	111.6 ksi	12.41 ksi	Web	Yes	
	Average hole rad stress		0.8 Fty	Ti 6-4 STAN	150	Stress at Nd	123.9	3	111.6 ksi	<1.0 ksi	Hole	Yes	
Tensile ultimate	Average web rad stress	FEM axisymmetric	0.95 Ftu $\left(\frac{Nmss}{Nb}\right)^2\left(\frac{Nd}{Nmss}\right)^2$	Ti 6-4 STAN	150	Stress at Nd	73.5	3	66.8 ksi	2.93 ksi	Web	Yes	
	Average web tang stress		0.95 Ftu $\left(\frac{Nmss}{Nb}\right)^2\left(\frac{Nd}{Nmss}\right)^2$	Ti 6-4 STAN	150	Stress at Nd	73.5	3	66.8 ksi	12.41 ksi	Web	Yes	
	Average hole rad stress		0.95 Ftu $\left(\frac{Nmss}{Nb}\right)^2\left(\frac{Nd}{Nmss}\right)^2$	Ti 6-4 STAN	150	Stress at Nd	73.5	3	66.8 ksi	<1.0 ksi	Hole	Yes	
Burst	Average section tang stress	FEM axisymmetric	0.95 Ftu $\left(\frac{Nmss}{Nb}\right)^2\left(\frac{Nd}{Nmss}\right)^2$	Ti 6-4 STAN	150	Stress at Nd	73.5	3	66.8 ksi	11.85 ksi	Average	Yes	
Creep	Average section tang stress	FEM axisymmetric	1.0 Fcreep for 0.2% creep in 1000 test cycle life	Ti 6-4 STAN	150	Stress at Nd	>100.0	3	>100.0 ksi	11.85 ksi	Average	Yes	
LCF	Peak stress	FEM axisymmetric	1000 test cycle life (0-max-0 cycles)	Ti 6-4 STAN	150	Life		3	1000 cyc	>10^7 cyc	Fillet	Yes	
	Hole			Ti 6-4 STAN	150	Life		3	1000 cyc	> 10^7 cyc	Hole	Yes	

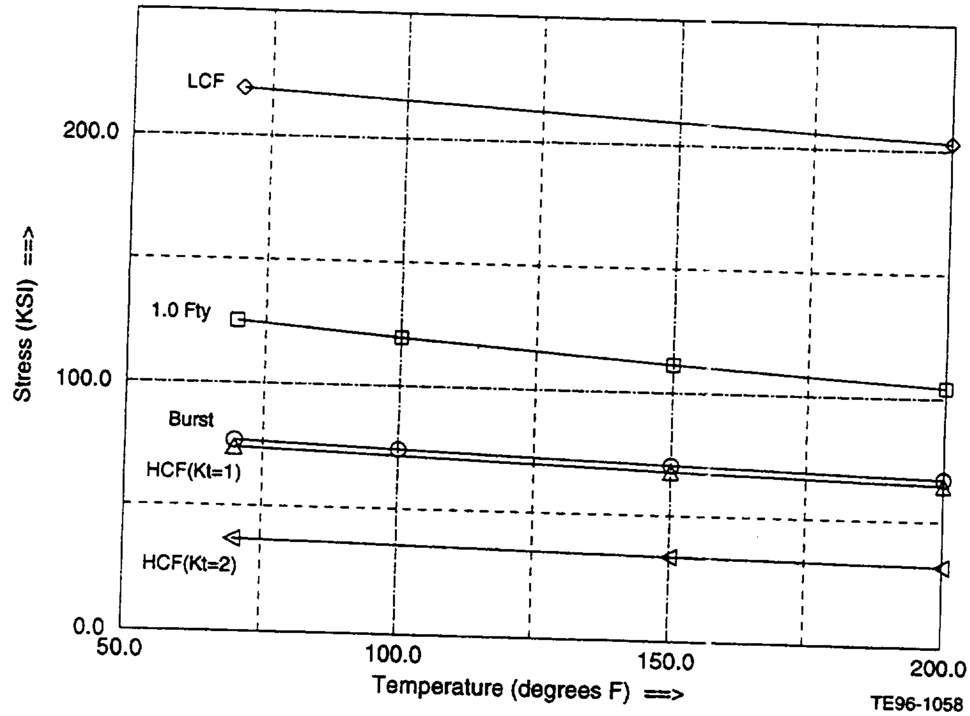


Figure 45. Material properties of Ti6-4 (AMS 4928).

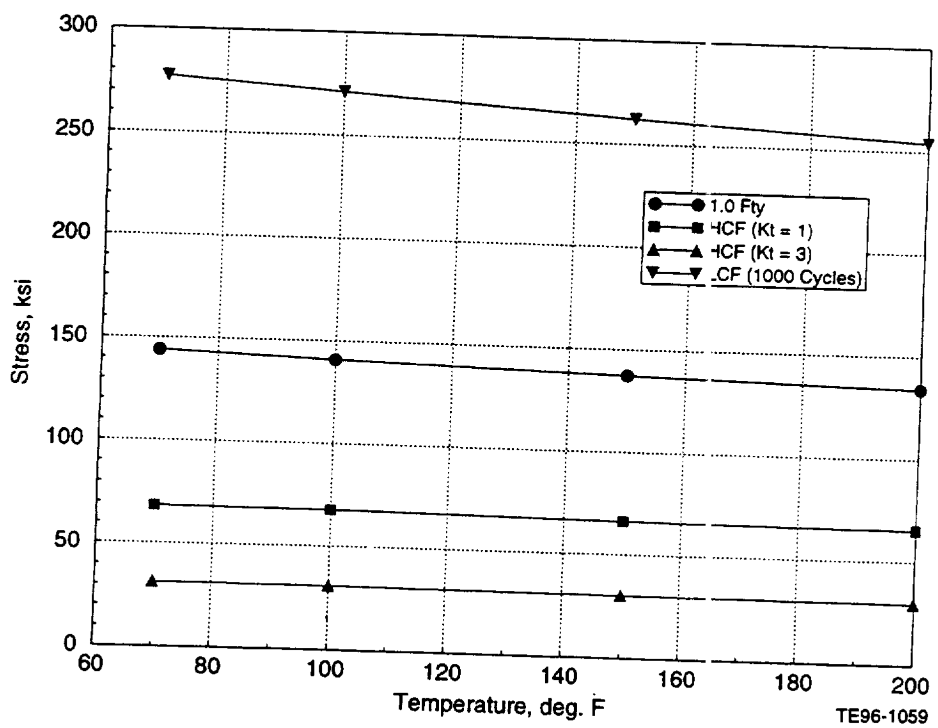


Figure 46. Material properties of 17-4PH (AMS 5643): H 1100 annealed.

allowable values for the materials selected, easily satisfying the criteria. Since the blisk and torque sleeve form a bolted assembly, the integrity of the assembly must also be ensured. An axial stress field exists across the blisk to torque sleeve flange that tends to open this joint. Flange fastener sizes and assembly torque levels were determined based on the predicted axial stress levels across the flange to ensure separation will not occur. Torque transfer between the blisk and torque sleeve is accomplished through a dowel pin. The cross section of this pin was sized to carry the full rotor torque load at the maximum steady-state operating conditions in shear without help from the flange bolts.

The burst speed corresponds to the rotational speed at which either the airfoil or disk cross section is no longer able to support the centrifugal loading. Standard Allison design practice requires the burst speed be at least 25% above the maximum steady-state operating speed of the part. For this rig, the maximum operating speed has been defined as 105% of the design mechanical speed, or 10,920 rpm. Allison design criteria are intended to ensure tensile failure will occur first in the airfoil. For gas turbine disks with cross sections whose thickness varies radially, failure can occur as a result of either radial or tangential overload. For an ideally ductile material, redistribution of the cross-sectional loading would occur, delaying failure until the full cross section reached the material ultimate strength. As a result, the primary variable used in assessing disk tensile failure margin is the average stress across the full disk cross section. In certain cases the material may not be sufficiently ductile to fully redistribute the loading, resulting in failure due to overstress of a local cross section. To ensure a local failure condition would not affect the burst margin, average tangential and radial stresses over the disk web and average radial stresses around the flange holes were also determined Referring to Table III, the limiting tensile loading in the disk for this design is the result of tangential stress. Little difference is observed between averaging over the full cross section or the web cross section. The predicted levels for the disk are substantially less than the 0.95 of tensile ultimate allowed by the criteria at 125% of maximum steady-state operating speed. The maximum average stress levels again occur in the airfoil hub. Referring to Table III, the design criteria require these average levels to be less than the tensile ultimate for the blade material at 125% of the maximum speed. The predicted levels satisfy these criteria. Ratioing the airfoil average stresses by the square of rotational speed, burst is calculated to occur at a speed corresponding to 183% of the maximum steady-state operating speed.

Due to the limited running requirements for the rig, a minimum acceptable low cycle fatigue life of 1000 type 1 cycles (idle-maximum-idle) was established. The low cycle fatigue strength for AMS 4928 and AMS 5659 is shown in Figures 47 and 48 as a plot of cycles to crack initiation as a function of von Mises equivalent stress. For the airfoil, the life critical locations are in the hub fillet and along the leading edge. Stresses in the hub fillet were again determined through the application of a stress concentration factor of 1.4 to the finite element results, rather than through direct calculation. Along the leading edge the effects of small body foreign object damage have been included through the application of a stress concentration factor of 2. Based on these equivalent stress levels, minimum fatigue life in excess of 1 million cycles can be expected.

In addition to the stress results presented above, deflections were obtained from the finite element analysis. The predicted deflections in critical areas are shown in Figure 49. At the tip, the leading edge radial deflection of 0.020 in. was used to set the static clearance between the outer flow-path wall and the airfoil to preclude rubbing over the test speed range. At the pilot surface between the blisk and torque sleeve, the blisk was predicted to grow an additional 0.001 in. compared to the torque sleeve, due to the difference in elastic modulus of the two materials employed. In order to ensure accurate centering of the blisk on the torque sleeve at speed, this differential growth must not be allowed to open the pilot. To accomplish this, the mating pilot surfaces have been dimensioned to provide an interference fit at assembly. The predicted deflections were also used in an iterative procedure to determine the correct manufacturing coordinates to provide the intended aerodynamic shape at the design speed. The coordinates for the airfoil at static, 85% N_d, and N_d are tabulated in Appendix B.

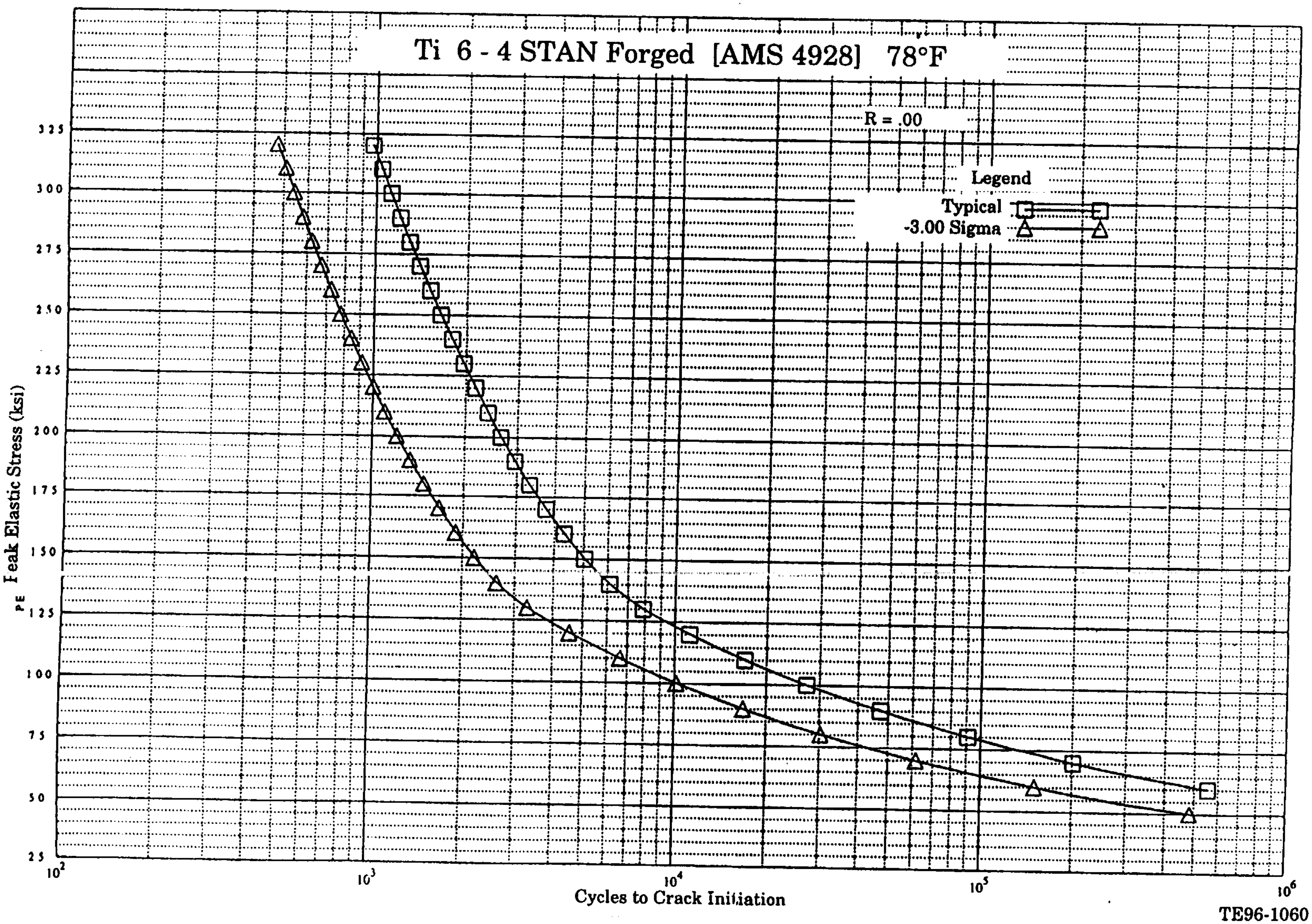


Figure 47. Low cycle fatigue strength for AMS 4928 (Ti 4-6 STAN forged) at 78°F.

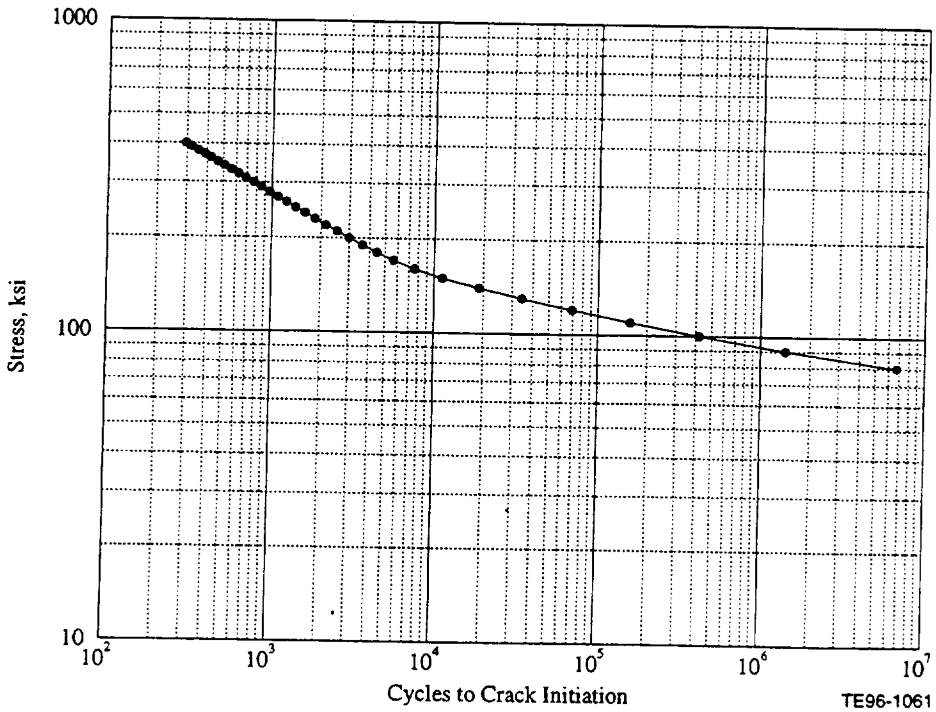


Figure 48. Low cycle fatigue strength of AMS 5659 (17-4PH) at 70°F.

4.1.2 Vibration Analysis

Vibration analysis of the integral bladed disk was carried out to define potential areas of vibratory response and to ensure adequate high cycle fatigue strength was available to allow operation over the entire design speed range. Specific consideration was given to avoidance of flutter over the rig operational envelope, placement of potential resonant conditions in speed ranges away from where substantial test time was to be accumulated, and satisfaction of minimum fatigue strength requirements over the entire bladed disk

Natural frequencies of the bladed disk system were obtained from finite element analysis at a series of rotational speeds. The finite element model consisted of a single airfoil supported on a pie-shaped sector of the disk. The periodic structure of the system was retained through application of cyclic symmetry boundary conditions along the edges of the disk sector. The airfoil was represented by a mesh of 8-node meanline shell elements, while the disk was modeled with 20-node solid elements. For completeness, comparisons of natural frequency and mode shape were made between the full bladed disk model and a cantilevered airfoil model. This comparison indicated insignificant levels of disk participation in the vibratory modes.

The results of the natural frequency analysis, in the form of a Campbell diagram, are presented in Figure 50. Plots of the deflected mode shape and resulting vibratory stress distribution are found in Appendix F. The diagonal engine order lines represent the locus of excitation frequencies produced by flow asymmetry with wavelength corresponding to the order number. Low order excitation (i.e., 2, 3, or 4EO) is typically the result of inflow total pressure or temperature distortion. Allison development experience indicates the coincidence of the fundamental bending (1B) and torsion (1T) natural frequencies with second and third-engine order should be avoided in speed ranges where significant operational time will be

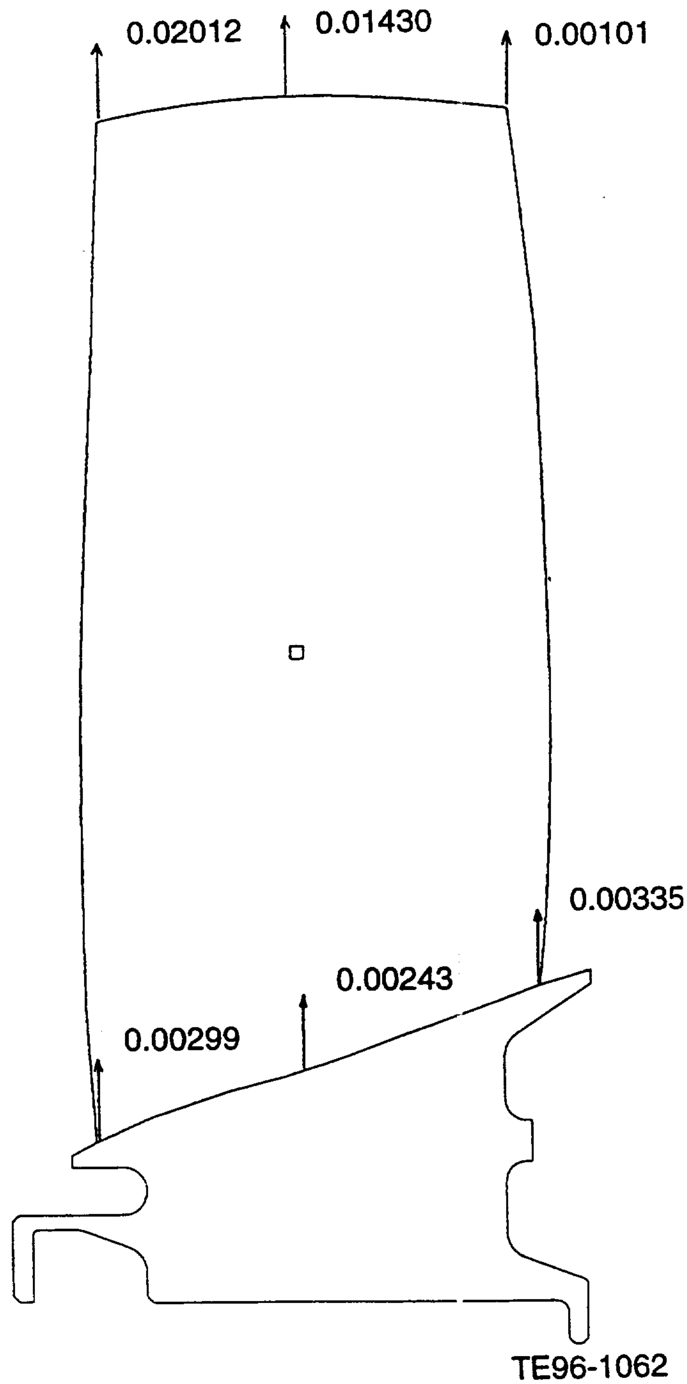


Figure 49. Predicted rotor radial deflections.

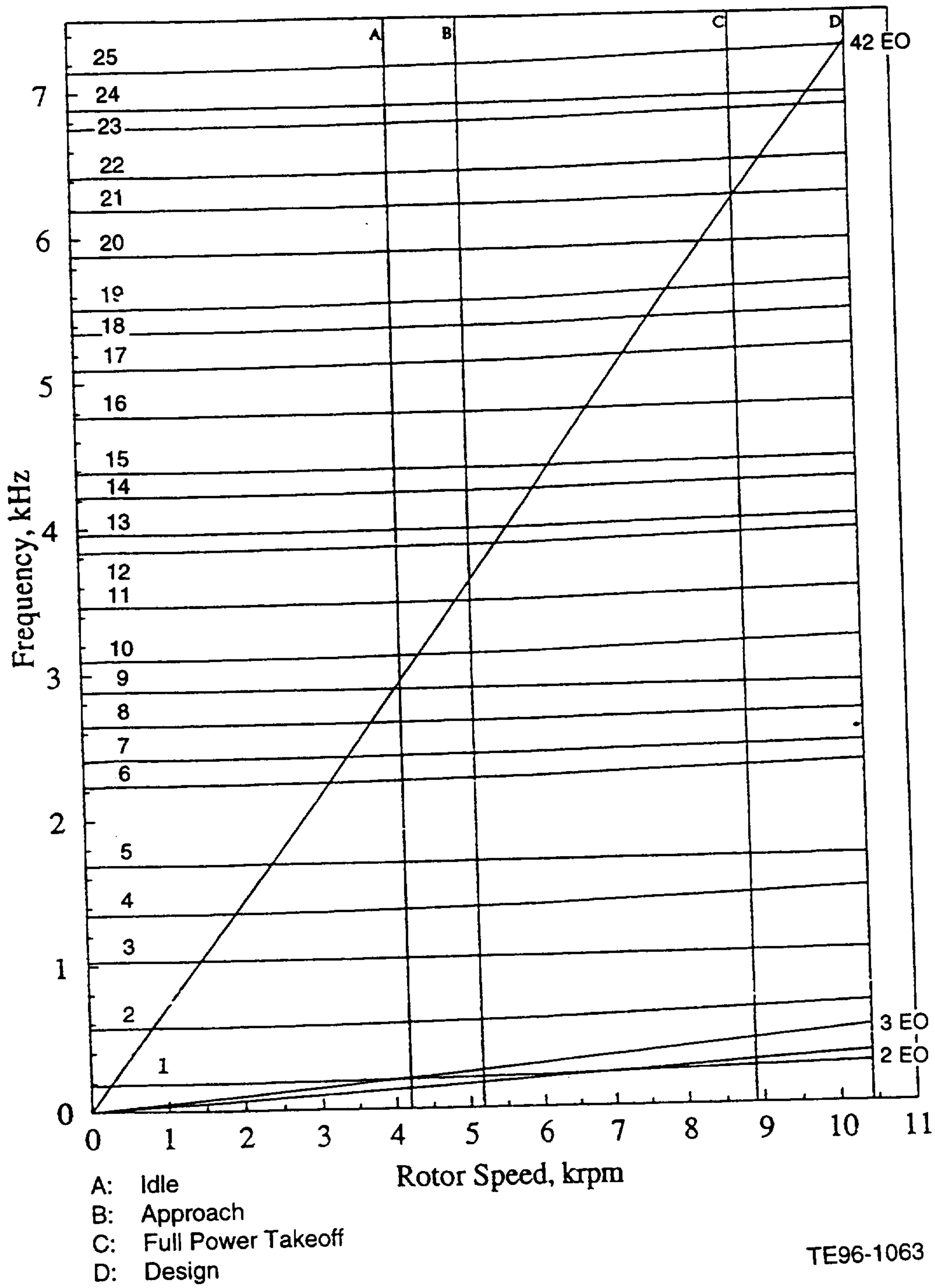


Figure 50. Campbell diagram of blade.

accumulated. Of particular concern for the current design are the speeds corresponding to full power takeoff(8,840 rpm), approach (5,200 rpm), and design point (10,400 rpm) where the majority of the data is to be obtained. In recognition of this, the natural frequencies of the 1B and 1T modes were adjusted to provide a minimum 15% speed margin relative to 2 and 3EO at these critical speeds. Of secondary concern was excitation of higher order modes by the vane leading edge pressure field. There are 42 vanes in this stage, resulting in potential excitation at 42EO and its harmonics. It was not possible to provide a 15% speed margin between all natural modes and 42EO at the speeds of primary interest. Accurate prediction of the resonant response of a mode to excitation has not been achieved yet, thus precluding identification of specific modes whose resonant amplitudes will be unacceptably large. The design strategy was thus to minimize the number of modes experiencing resonant coincidence near the three speeds of interest. As finally accepted, it was possible to provide a 10% speed margin between 42EO and all modes except the 21st mode. Due to the relatively generous spacing between the rotor trailing edge and the stator leading edge, a weak excitation should be present, resulting in a low level response. Based on rig testing of similar components with similar rotor-to-stator spacing, responses of less than 10 ksi are anticipated.

A second area of major concern is the avoidance of flutter throughout the operational range of the rig. A combination of analytical and empirical methods have been developed at Allison for prediction of flutter onset. An analytical method, which predicts the aerodynamic damping associated with a specific modal deflection pattern, is available and has proven highly reliable. However, due to the method's mathematical formulation, it is only applicable in supersonic flows. The present design tip speed results in inlet relative Mach numbers too low for application of the analysis. To augment the analytical method, an empirical correlation has been developed based on a nondimensional or reduced frequency defined as the product of chord*frequency/(2* inlet relative velocity). Empirical limits (minimum values) have been established at 0.2 for the fundamental bending mode and 0.6 for the first mode with significant torsional motion. For the current design, the calculated reduced frequencies of the relevant modes are 0.29 and 0.72. These satisfy the criteria.

Since total avoidance of vibration is seldom feasible, it is necessary to ensure typical levels of vibratory response will not result in fatigue failures. The endurance strength is the vibratory stress level in fully reversed bending that can be imposed on a material without producing high cycle fatigue failures. The endurance strength is reduced when a mean stress field is present, with the endurance strength approaching zero as the mean stress approaches the tensile ultimate. This material behavior is typically presented graphically in the Goodman diagram. In order to ensure a reasonable vibratory response will not result in fatigue, Allison requires the minimum vibratory allowable stress be at least 15 ksi for all locations on the airfoil, after accounting for the reduction in allowable due to mean stresses. In assessing this criterion, fatigue data for notched specimens with theoretical stress concentrations, k_t, of 1.4 and 2.0 are used in the hub and edge regions respectively to account for fillet effects and foreign object damage. In other regions, fatigue data are based on unnotched specimens, $k_t = 1.0$. The fan design possesses a minimum fatigue allowable stress of 16 ksi in the leading edge region, which satisfies the criteria, Figure 51.

4.2 STATIC COMPONENTS

The rig static structure is composed of a primary structural backbone connecting to the drive rig static force balance, a vane assembly composed of seven segments with six airfoils in each segment, and a series of spool segments forming the internal flow-path and nacelle outer profile. In order to isolate the acoustic effects of vane geometry, no separate structural frame is provided, forcing the vanes to become a load carrying member. The vane segments are tied to the static structure support by three bolts and a 0.250-in. shear pin. The shear pin provides the primary load path to ground, while the radial fasteners seat the vane segment against the static support. As discussed in Section 2.0, four vane configurations are to be tested. In order to accomplish configurational changes with a minimum effort, all spool pieces downstream of the vane trailing edge are split axially to form bolted assemblies. The static structure support and vane assemblies are constructed of stainless steel, AMS 5643 (17-4 PH) heat treated to the H1100

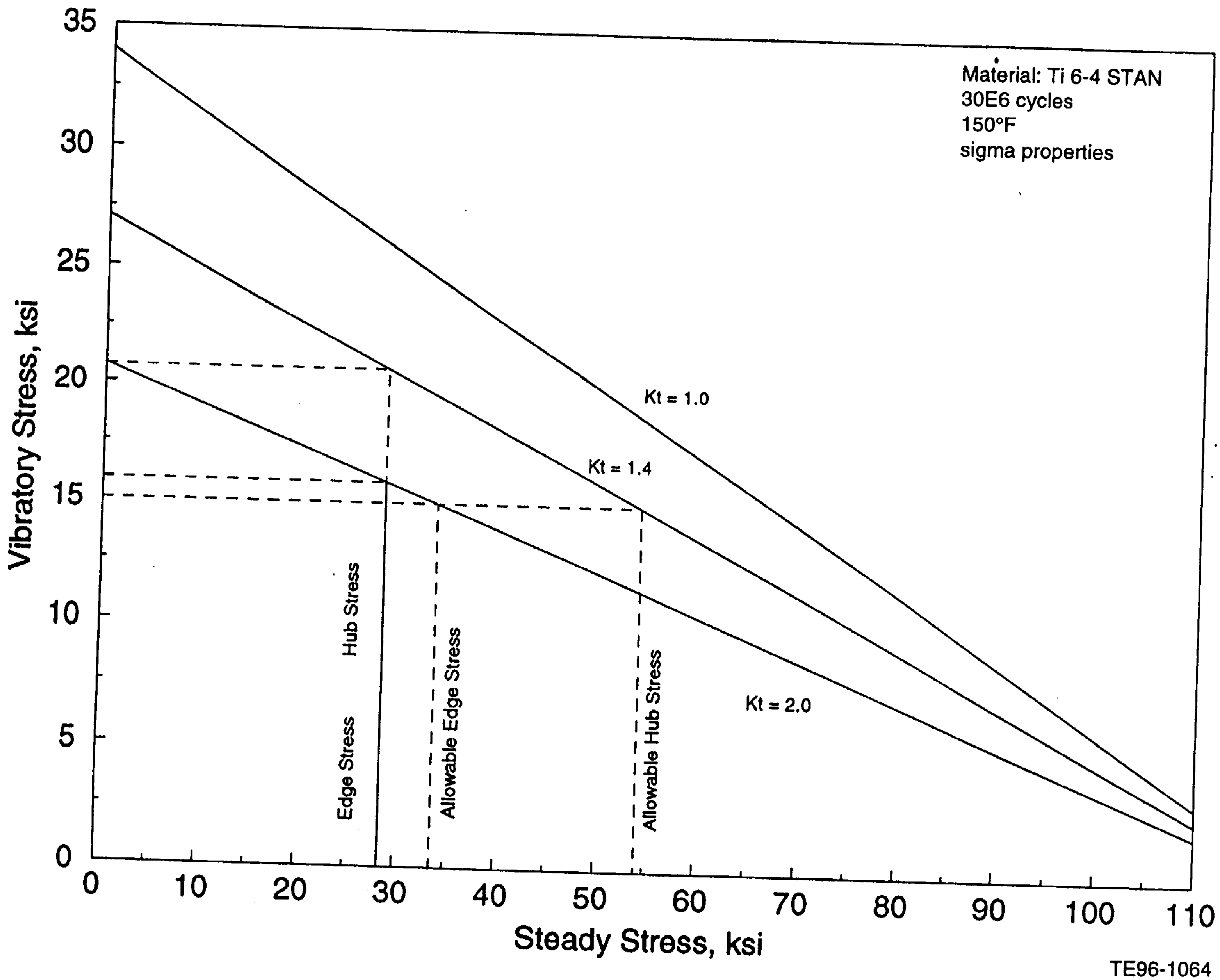


Figure 51. Goodman diagram of blade.

specification, to provide the required strength and rigidity. The flow-path spool pieces are constructed of aluminum alloy, AMS 4127 (6061) in the T6 condition, to minimize overhung weight. Weight reduction was a priority to minimize the 1g deflection at the blade track and to facilitate handling during assembly. Additional outer flow-path pieces have been designed to adapt the rig to an existing bellmouth and variable area nozzle, allowing stage performance measurements to be acquired. To deal with the additional deflection resulting from the insertion of these pieces, provisions for external support have been provided.

4.2.1 Stress and Deflection Analysis

Structural analysis was carried out for each of the vane configurations at two loading conditions. The first loading condition represents standard rig operation and consists of the nacelle weight and aerodynamic loading generated on the vanes as they deswirl the rotor discharge flow. In the second condition, additional aerodynamic loads are applied as a result of operating the nacelle at an angle of attack to the wind tunnel flow. Structural assessment criteria employed to evaluate the integrity of the static components followed standard Allison practice for nonflight applications. Specific consideration was given to tensile rupture, tensile yielding, creep, low cycle fatigue, and deflection resulting from nonaxisymmetric loading. Due to the limited life, research nature of the rig, no provisions for containment in the event of an airfoil failure were included in the design of the nacelle. For this reason, human proximity to the rig during operation should be avoided.

All structural analysis was performed using the finite element method. A model composed of a 1/42 sector of the entire static structure, corresponding to a single vane passage, was generated for each of the four vane configurations for analysis in the Allison proprietary FEM procedure, STRATA. The vane inner band was descretized using 20-node solid elements. Beam elements were employed to represent the inner band attachment bolts, inner band shear pin, and the attachment bolts in the outer flanges. The rest of the structure was modeled with 8-node meanline shell elements. The static structure attachment to ground was through two spring elements at the pilot surfaces representing the rig static balance stiffness.

As previously mentioned, structural analysis of the rig was based on two loading conditions. Operation of the rig at an angle to the tunnel flow produces a nonaxisymmetric loading on the nacelle. Harmonic loading of the sector model was used to account for this asymmetry. As a result of the asymmetric load application, the stress and deflection patterns are also asymmetric. For nonsymmetric loading conditions, structural criteria are assessed at the worst location in the assembly. At the edges of the modeled sector, cyclic symmetric boundary conditions consistent with a split hoop are applied along the faces of the inner and outer bands. A secondary result of applying cyclic symmetry over a single vane passage width is that the model represents a structure with one bolt and one shear pin for each airfoil. This modeling inaccuracy will not affect the stress and deflection field away from the attachment points and was used to reduce computer resource requirements. To assess the stresses in the shear pin and attachment bolts, it was assumed removal of the additional constraints results in an equal increase in load in the remaining members. This produces a factor of six increase in the section stresses in the shear pin and a factor of two increase in the bolt stresses. This approach is not entirely accurate, but the resulting stresses are so low that a more accurate approach was deemed unnecessary. The bolted flanges on the outer duct pieces away from the vanes were not represented in detail in the finite element model. Bending stresses in the flanges were determined by hand calculation. A conservative approach was taken, requiring a single flange segment between two bolts to carry the entire nacelle bending moment due to angle of attack operation.

The structural audit sheet (Table V) summarizes the results of the analysis relative to the design criteria. The primary structural concern for the static components is the occurrence of section yielding. Yielding is assessed using equivalent stress as defined by the Von Mises criteria. Referring to Table V, the peak equivalent stress occurs in the baseline vane hub trailing edge fillet when this vane is installed in the aft position, Figure 1b. This stress is 41% of the material yield, which satisfies the Allison criteria. As axial sweep is introduced, the peak stress levels decrease. This is a result of changes in the load transfer mechanism between the configurations. For the baseline vane, which has a radial stack axis, the nacelle loading is reacted out by the vane in pure bending about an axis normal to the airfoil plan view. This results in the majority of the load being transferred along the leading and trailing edge. As sweep is introduced, a portion of the nacelle load is transferred as tension parallel to the stack axis, similar to diagonal members in a truss. Since the section structural efficiency in tensile loading is greater than for bending, the resulting peak stress is reduced.

Table VI shows the circumferential variation in peak stress due to the load asymmetry for each of the vane configurations. Also shown in the table is the maximum stress due to the normal aerodynamic deswirl loads. Complete results of the stress analysis, in the form of isostress contour plots, is presented in Appendix G. Referring again to the audit sheet, the maximum stress in any of the flanges is found to be 7.5 ksi. These flanges are retained with 34 fasteners with 0.190-in. diameter. Standard torque levels for these fasteners will be sufficient to prevent opening of the flanges. The stress levels shown for the fasteners on the vane inner band reflect the Allison design practice of preloading fasteners at bolted joints to 80% of the material yield. In this application, the fastener stress is composed of 57 ksi due to preload and a 23 ksi bending stress from the vane loading. As in the rotating components, the design goal for low cycle fatigue life was 1000 type 1 cycles (minimum). Crack initiation is governed by local stress peaks; thus, the vane hub trailing edge fillet stress of 56 ksi will set the life potential for the static structure. The vanes are constructed from wrought 17-4PH stainless steel. Since the limiting stress occurs along an edge, a theoretical stress concentration of 3 is applied for life assessment to account for possible small object foreign object damage in this area. Based on these assumptions, the predicted low cycle fatigue life is 66,000 cycles.

In addition to the stress field induced in the vane and nacelle structure, operation at angle of attack will produce a deflection of the casing relative to the blade tip. The design is intended to have a uniform running clearance of 0.020 in. at the design rotational speed. The casing deflection at the blade track due to the nacelle loads is tabulated for the various vane configurations in Table VII. A maximum radial deflection of 0.006 in. is predicted and will occur in the swept and leaned configuration. Complete plotted results of the deflection analysis for both load conditions are presented in Appendix H.

4.2.2 Vibration Analysis

Vibration analysis of the static structure was carried out to define potential areas of vibratory response and ensure adequate high cycle fatigue strength was available to allow operation over the entire design speed range. Specific consideration was given to avoidance of flutter over the rig operational envelope, placement of potential resonant conditions in speed ranges away from critical test speeds, and satisfaction of minimum fatigue strength requirements over the entire structure.

Natural frequencies of the static structure assembly were obtained from finite element analysis. A finite element model of a 1/42 sector of the structure was generated for each of the four vane configurations and for both the flight and performance measurement ducting arrangements. Above the third natural mode, deflections tend to isolate in the vane assembly. To reduce the computational requirements, a reduced order finite element model representing the airfoil and vane outer and inner band was constructed to obtain these higher modes. Comparisons of the full system and reduced order models for a limited number of modes substantiated the accuracy of this approach. In the performance configuration, weight isolation for the inlet bellmouth and variable area nozzle will be provided. Based on the methods under consideration for providing this weight isolation, it was assumed they would not contribute to the system stiffness. The connection between Allison's static structure and the rig static force balance was simulated by springs at the pilot locations, with spring rates obtained from Boeing design documentation provided by NASA. Natural frequencies and mode shapes were calculated using the Allison finite element code, STRATA. Calculations of system response to unbalance were carried out using the Allison forced response code MODLRESP, running as a post-processor to STRATA.

Table V.
Structural audit of static components.

Objective/ concern	Critical parameter	Calculation method	Design criteria	Material	Maximum temp - °F	Parameter	3σ allowable	Calculated result	Location	Configuration	Loading condition	Satisfy criteria	Comments
Yield	Tensile + bending stress	3-D FEM	0.8 Fty	17-4 PH	120	Stress	111.2 ksi	56.7 ksi	Vane hub TE fillet	Aft vane	Vane & AOA loads + weight	Yes	
	Tensile + bending stress	3-D FEM	0.8 Fty	A-286	120	Stress	80.2 ksi	80.2 ksi	Vane inner band bolt	Swept & leaned vane	Vane & AOA loads + weight	Yes	Assumes 57 ksi tensile stress due to bolt preload
	Bending stress	3-D FEM	0.8 Fty	A-286	120	Stress	80.2 ksi	19.2 ksi	Vane inner band shear pin	Aft vane	Vane & AOA loads + weight	Yes	
	Bending stress	Hand calc.	0.8 Fty	17-4 PH	120	Stress	111.2 ksi	3.2 ksi	Vane outer band fwd flange	Aft vane	AOA loads	Yes	
	Bending stress	Hand calc.	0.8 Fty	Al 6061-T6	120	Stress	23.8 ksi	<1 ksi	Case/ vane outer band fwd flange	Aft vane	AOA loads	Yes	
	Bending stress	Hand calc.	0.8 Fty	17-4 PH	120	Stress	111.2 ksi	7.5 ksi	Support flange	Baseline vane	AOA loads	Yes	
	Shear stress	Hand calc.	0.55 Fty	A-286	120	Stress	55.1 ksi	<1 ksi	Static balance bolt	Aft vane	AOA loads	Yes	
LCF	Peak equiv stress + Kt	3-D FEM	1000 cycles w/Kt = 3.0	17-4 PH	120	Cycles	1000	5300 cyc	Vane hub TE fillet	Aft vane	Vane & AOA loads + weight	Yes	
	Peak equiv stress + Kt	3-D FEM	1000 cycles w/Kt = 3.0	A-286	120	Cycles	1000	>10^5 cycles	Vane inner band bolt	Swept & leaned vane	Vane & AOA loads + weight	Yes	
HCF	Peak equiv stress + Kt	3-D FEM + Goodman diagram	>±15 ksi vibrtory capability w/Kt = 3.0 1 x 10^7 cyc	17-4PH	120	Vibratory stress	>±15 ksi capability	18.6 ksi	Vane hub TE fillet	Aft vane	Vane & AOA loads + weight	Yes	

Table VI.

NASA scaled fan rig nacelle vane static stress summaries (All values Von Mises equivalent stresses [ksi]).

Description	Vane Tip LE	Vane Tip TE	Vane Hub LE	Vane Hub TE	Bolt	Shear pin
Maximum stress due to vane loads	9.1	44.0	36.3	48.3	16.0	15.0
Maximum stress due to vane + AOA loads + nacelle weight						
Vane 1, 90 deg	12.5	27.2	53.5	29.9	13.8	18.6
Vane 6, ~135 deg	10.6	28.8	50.4	33.5	13.6	16.2
Vane 11, ~180 deg	8.4	35.1	40.7	41.9	14.4	15.0
Vane 17, ~225 deg	7.9	44.6	28.1	51.1	16.0	16.8
Vane 22, 270 deg	8.0	48.8	23.2	54.2	16.6	17.4
Vane 27, ~315 deg	7.9	46.6	25.9	51.8	16.4	15.6
Vane 32, ~0 deg	9.1	39.7	35.2	44.4	15.4	15.0
Vane 38, ~45 deg	11.9	30.9	48.3	33.8	14.4	18.0

Description	Vane Tip LE	Vane Tip TE	Vane Hub LE	Vane Hub TE	Bolt	Shear pin
Maximum stress due to vane loads	8.8	43.2	32.7	48.6	17.8	14.4
Max stress due to vane + AOA loads + nacelle weight						
Vane 1, 90 deg	12.4	25.8	48.6	29.2	16.6	19.2
Vane 6, ~135 deg	11.1	26.6	46.7	31.8	16.4	16.8
Vane 11, ~180 deg	9.2	33.1	37.9	40.3	16.8	13.8
Vane 17, ~225 deg	7.7	44.0	24.7	52.0	18.0	15.6
Vane 22, 270 deg	7.1	49.2	18.9	56.7	18.4	17.4
Vane 27, ~315 deg	7.1	47.3	21.3	53.9	18.0	16.2
Vane 32, ~0 deg	8.5	40.0	30.5	45.2	17.4	16.2
Vane 38, ~45 deg	11.4	30.3	43.1	33.8	16.8	19.2

Description	Vane Tip LE	Vane Tip TE	Vane Hub LE	Vane Hub TE	Bolt	Shear pin
Maximum stress due to vane loads	35.8	6.2	24.1	14.2	11.8	15.6
Maximum stress due to vane + AOA loads + nacelle weight						
Vane 1, 90 deg	43.0	14.1	34.3	8.2	7.6	18.6
Vane 6, ~135 deg	38.5	12.6	31.2	9.2	8.0	17.4
Vane 11, ~180 deg	32.7	8.3	25.0	15.3	9.6	16.8
Vane 17, ~225 deg	29.2	3.6	18.2	24.2	13.2	18.0
Vane 22, 270 deg	29.5	3.6	16.4	26.2	15.4	18.6
Vane 27, ~315 deg	32.0	3.7	19.2	22.8	14.2	16.2
Vane 32, ~0 deg	36.7	7.1	25.3	14.6	11.0	14.4
Vane 38, ~45 deg	42.5	12.3	32.5	9.2	8.8	17.4

Description	Vane Tip LE	Vane Tip TE	Vane Hub LE	Vane Hub TE	Bolt	Shear pin
Maximum stress due to vane loads	32.8	11.7	7.4	46.5	14.4	16.2
Maximum stress due to vane + AOA loads + nacelle weight						
Vane 1, 90 deg	24.0	2.8	7.2	33.1	3.4	18.0
Vane 6, ~135 deg	30.1	1.3	3.0	37.0	4.6	16.8
Vane 11, ~180 deg	36.1	8.4	5.4	43.8	11.2	17.4
Vane 17, ~225 deg	37.5	16.3	14.4	49.3	20.4	6.6
Vane 22, 270 deg	34.5	17.8	16.3	49.8	22.8	18.0
Vane 27, ~315 deg	30.4	13.3	12.0	47.4	18.8	15.6

Table VI (cont)

Description	Tip LE	Tip TE	Hub LE	Hub TE	Bolt	Shear pin
Vane 32, ~0 deg	26.0	5.6	3.6	42.3	10.4	16.2
Vane 38, ~45 deg	22.3	2.1	5.5	35.1	3.0	18.6

Notes:

All values are Von Mises equivalent stresses (ksi)

0 degrees is top dead center, with angle increasing counterclockwise (aft looking forward)

Table VII.

NASA scaled fan rig nacelle blade track deflection summary (deflections in inches).

Description	Baseline vane Radial	Baseline vane Tangential	Baseline vane Axial	Aft Vane Radial	Aft Vane Tangential	Aft Vane Axial
Maximum deflection due to vane + AOA loads + weight						
Vane 1, 90 deg	4.260e-03	-7.030e-02	-5.620e-03	4.940e-03	-6.940e-02	-5.660e-03
Vane 6, ~135 deg	3.350e-03	-7.310e-02	-6.820e-03	4.260e-03	-7.290e-02	-6.570e-03
Vane 11, ~180 deg	6.120e-04	-7.470e-02	-1.010e-02	1.220e-03	-7.500e-02	-9.510e-03
Vane 17, ~225 deg	-2.910e-03	-7.360e-02	-1.430e-02	-3.410e-03	-7.400e-02	-1.350e-02
Vane 22, 270 deg	-4.190e-03	-7.080e-02	-1.580e-02	-5.290e-03	-7.050e-02	-1.500e-02
Vane 27, ~315 deg	-3.270e-03	-6.880e-02	-1.460e-02	-4.100e-03	-6.770e-02	-1.410e-02
Vane 32, ~0 deg	-6.280e-04	-6.780e-02	-1.140e-02	-8.100e-04	-6.630e-02	-1.110e-02
Vane 38,~45 deg	2.880e-03	-6.850e-02	-7.190e-03	3.230e-03	-6.720e-02	-7.240e-03

Description	Swept vane Radial	Swept vane Tangential	Swept vane Axial	Swept and leaned vane Radial	Swept and leaned vane Tangential	Swept and leaned vane Axial
Maximum deflection due to vane + AOA loads + weight						
Vane 1, 90 deg	3.420e-03	-5.820e-02	5.000e-03	5.740e-03	-1.710e-02	1.340e-03
Vane 6, ~135 deg	3.170e-03	-6.100e-02	3.340e-03	4.850e-03	-2.120e-02	-1.100e-03
Vane 11, ~180 deg	6.240e-04	-6.250e-02	-7.120e-04	1.295e-03	-2.371e-02	-6.668e-03
Vane 17, ~225 deg	-2.960e-03	-6.140e-02	-5.620e-03	-3.890e-03	-2.240e-02	-1.320e-02
Vane 22, 270 deg	-4.220e-03	-5.850e-02	-7.200e-03	-5.990e-03	-1.860e-02	-1.510e-02
Vane 27, ~315 deg	-3.010e-03	-5.690e-02	-5.540e-03	-4.720e-03	-1.610e-02	-1.270e-02
Vane 32, ~0 deg	-2.790e-04	-5.620e-02	-1.530e-03	-1.010e-03	-1.460e-02	-7.160e-03
Vane 38, ~45 deg	2.820e-03	-5.690e-02	3.390e-03	3.730e-03	-1.500e-02	-6.390e-04

The results of the natural frequency analysis of the full system, in the form of a Campbell diagram, are presented for the four vane configurations in Figures 52 through 55. Coincidence of the natural frequencies of these modes with first engine order (1EO) was of primary concern, since residual rotor unbalance would be capable of exciting a resonant response at such a coincidence. When configured with the flight inlet and nozzle, two modes were found that exhibited a 1EO coincidence in the steady-state speed range. It was not possible to adjust the frequencies of these modes sufficiently to move the resonant conditions outside the test speeds of the rig. Since both modes produced a resultant radial deflection at the blade track, excessive resonant amplitude could result in contact between the rotor tips and the casing. To determine the likelihood of such an event, a forced response analysis was conducted using a unit unbalance load applied in phase at the static structure support pilot surfaces. A damping of 6.3% (log decrement) was assumed, a conservative assumption based on Allison experience. The resulting blade track deflections for the pitch mode, which is the most sensitive to excitation, is presented in Figure 56.

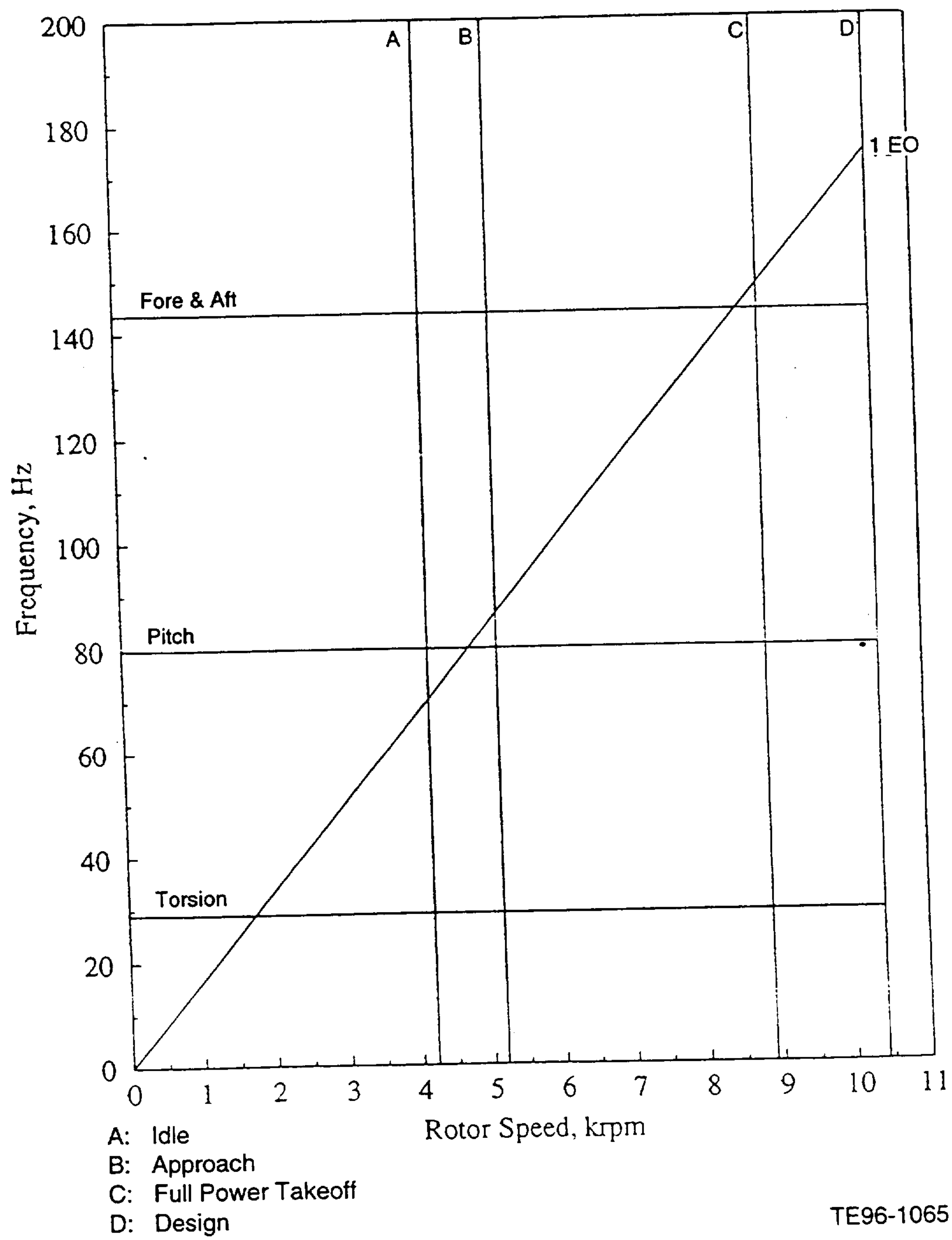


Figure 52. Campbell diagram for baseline vane in acoustic testing setup — assembly modes.

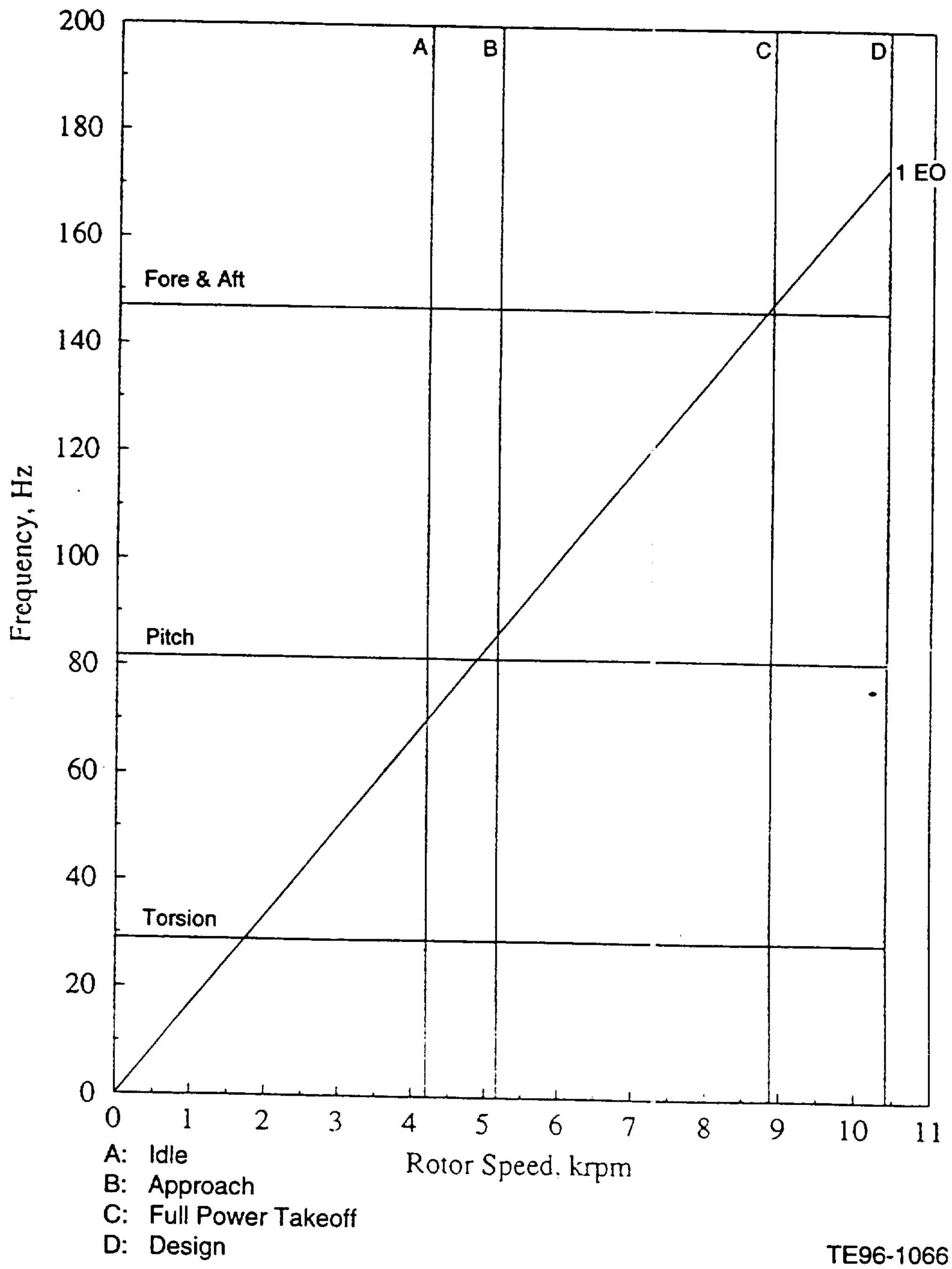


Figure 53. Campbell diagram for aft vane in acoustic testing setup — assembly modes.

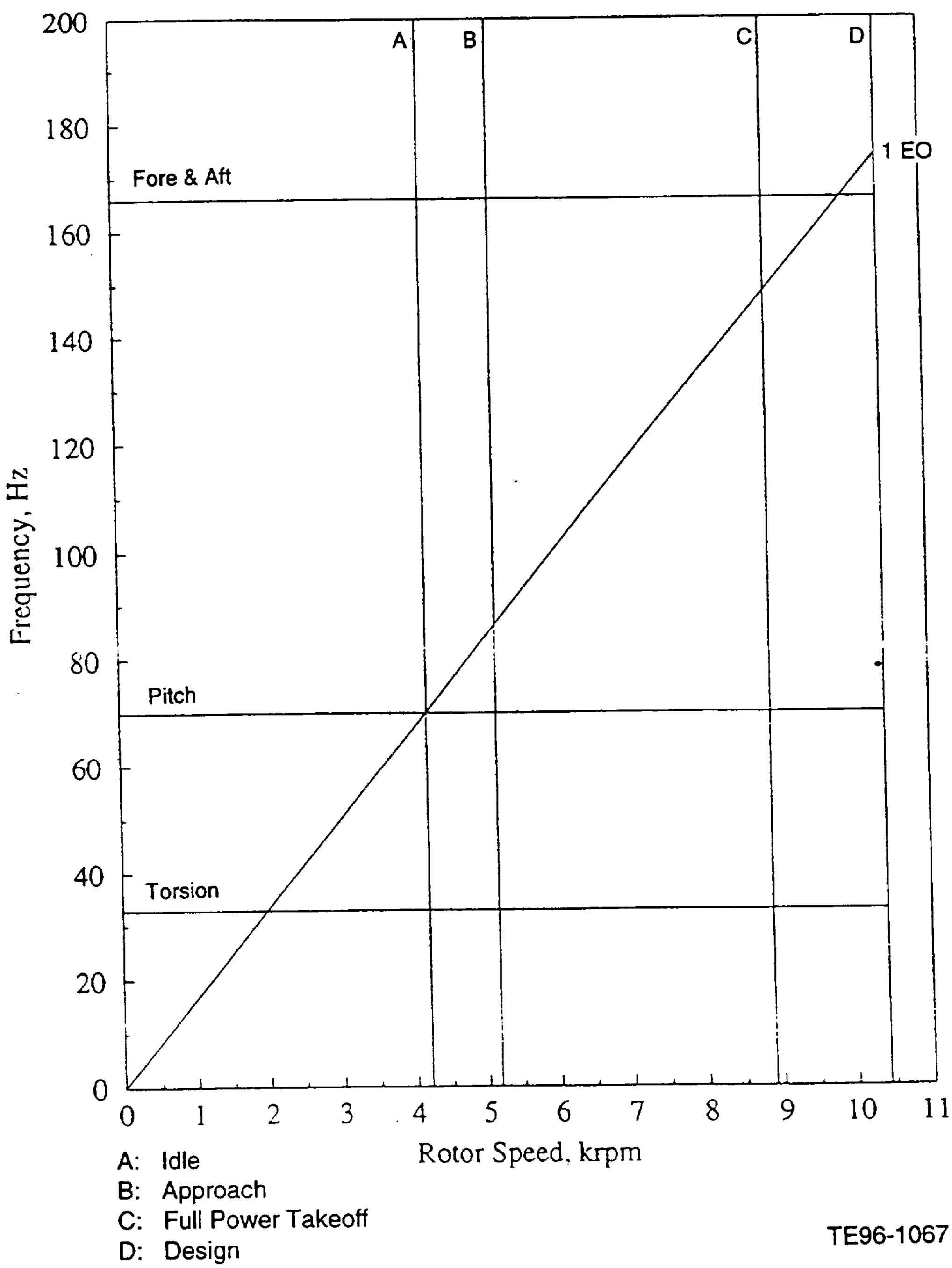


Figure 54. Campbell diagram for swept vane in acoustic testing setup — assembly modes.

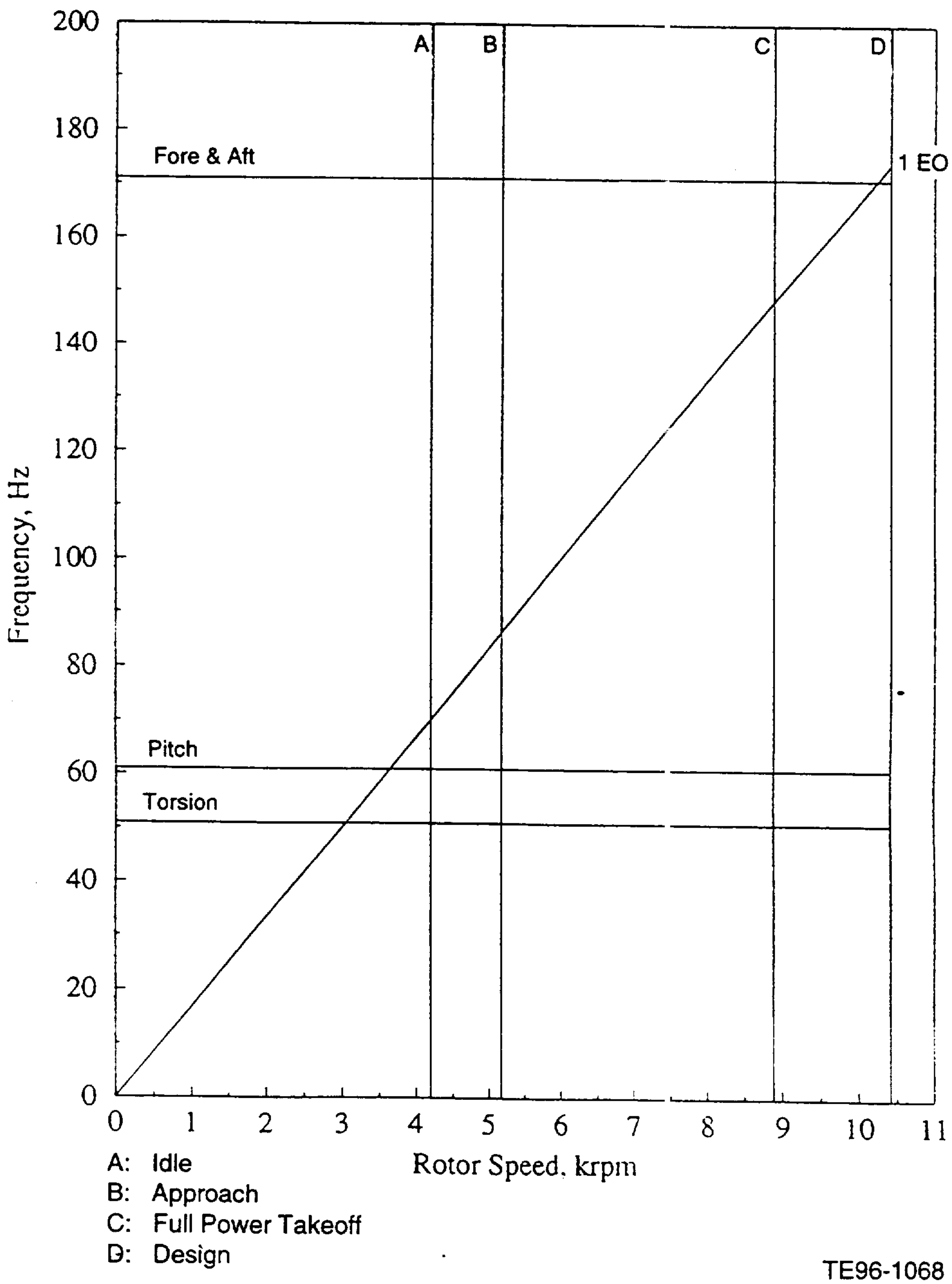


Figure 55. Campbell diagram for swept and leaned vane in acoust.c testing setup — assembly mode.

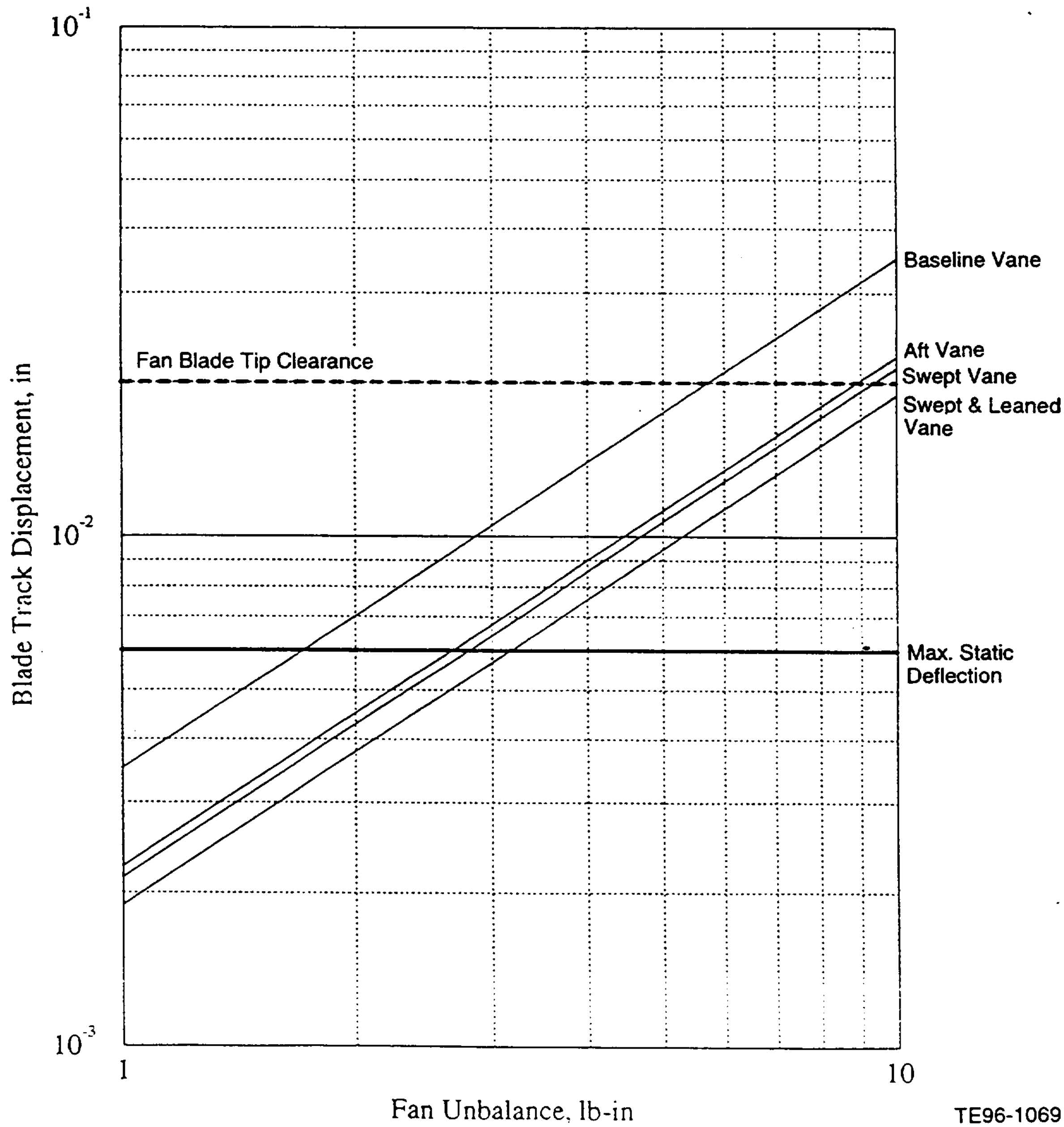


Figure 56. Blade track radial deflection versus fan unbalance — pitch mode of acoustic testing setup.

Accounting for the 0.005 in. (worst case) of static deflection occuring during angle of attack operation, a minimum unbalance of 4 in.-lb would be required to produce a rubbing condition for this mode. This level is two orders of magnitude larger than Allison balance requirements for hardware of this size. When configured in the performance mode, only one mode, labeled fore and aft in the Campbell diagram, coincides with 1EO within the steady speed range, Figures 57 through 60. A response calculation showed a residual unbalance greater than 10 in.-lb would be required to produce rubbing in this instance (Figure 61). The Campbell diagrams for the higher frequency modes, involving motion of only the vanes, are presented in Figures 62, 63, and 64 and correspond to the four test configurations. Since these modes involve vibration of only the vane segments, the results are independent of the nacelle configuration and do not change when the radially stacked airfoil is moved into the aft position. Since the rotor contains 18 blades, the primary concern for resonant vibration is the placement of the 18EO coincidences with the natural modes. Allison experience with fixed geometry vanes indicates resonant excitation of the fundamental bending, or 1B, mode should be avoided in the steady-state speed range. For all configurations, 1B-18EO resonance occurs well below the test speed range. This resonance should impose no restrictions on the test program. Three other modes are predicted to encounter resonant excitation within the steady-state speed range. The fundamental torsion (1T) and second bending (2B) modes exhibit a coincidence with 18EO at part speed conditions. For both of these modes at least a 15% speed margin exists between the resonant speed and the speeds at which the primary acoustic data will be acquired. Should an unexpectedly high response be observed in either of these modes, a modification to the test matrix to avoid the resonance can be implemented without compromising the test objectives. The second torsion (2T) mode of the vanes is also susceptible to an 18EO resonance. This resonance is predicted to occur approximately 5% below the design speed for the two swept configurations and at the design speed for the baseline configuration. Accurate prediction of aerodynamically induced resonant vibration levels remains beyond the state of the art. Review of recent Allison vane design experience reveals a number of successful core compressor stages have similar occurrences. In these stages, the measured response of the second torsion mode has been uniformly low. Since the present rig employs a much larger spacing between the rotor and stator than possible in a core stage, no unacceptable vibratory response of the 2T mode is expected and no attempt was made to change its natural frequency so as to avoid the 18EO resonance. Plots of the deflected mode shapes and resulting vibratory stress distributions are provided in Appendix I for the system modes and Appendix J for the vane modes.

While a relatively rare occurrence for a vane, avoidance of flutter throughout the operational range must be ensured. Allison has developed an empirical criterion for flutter avoidance based on reduced frequency as described in the rotating components section. Empirical limits for minimum acceptable values have been established at 0.2 for the fundamental bending mode and 0.6 for the fundamental torsion mode. The calculated reduced frequencies for the relevant modes for each of the vane configurations is presented in Table VIII. All configurations satisfy the requirements

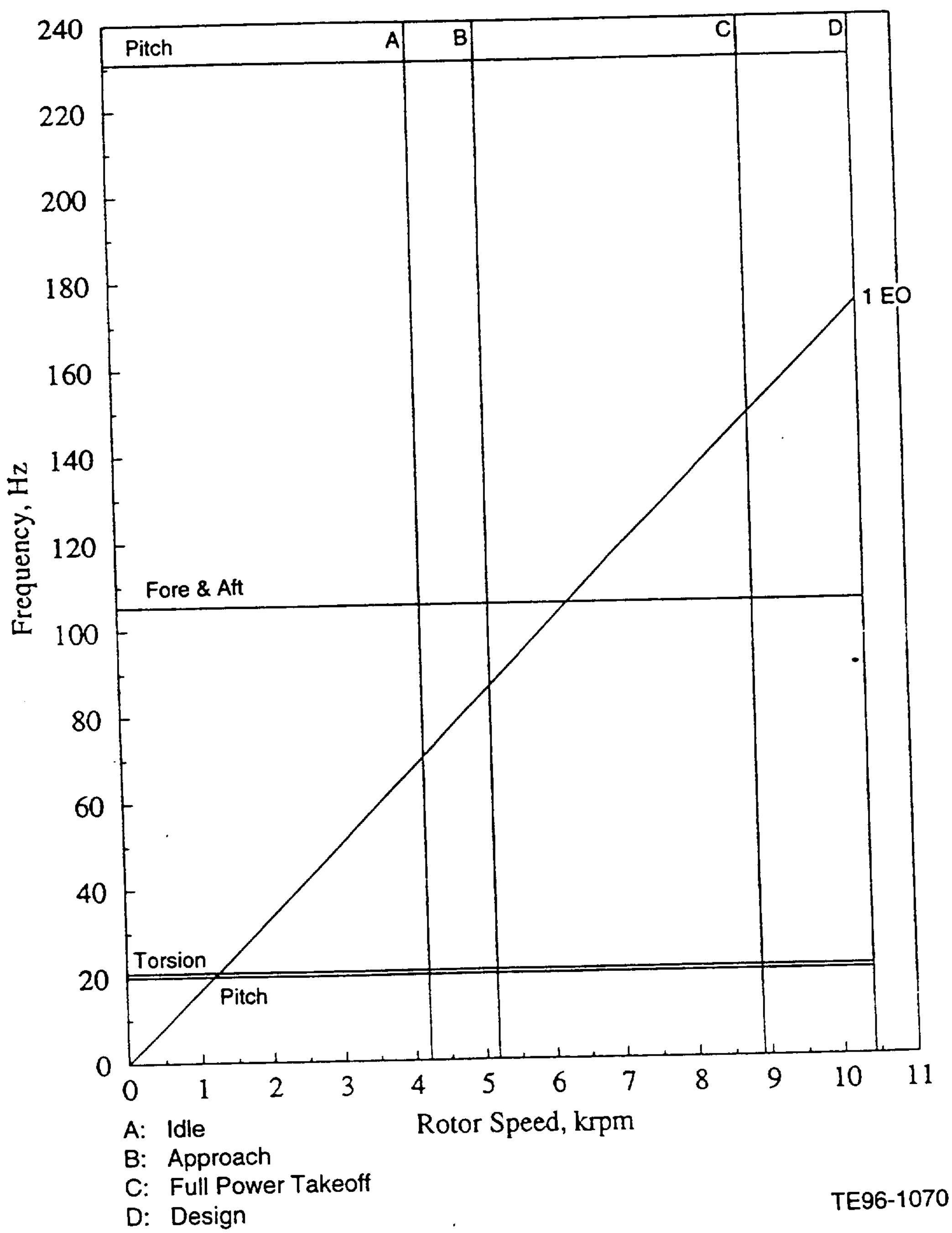


Figure 57. Campbell diagram for baseline vane in performance calibration setup — assembly mode.

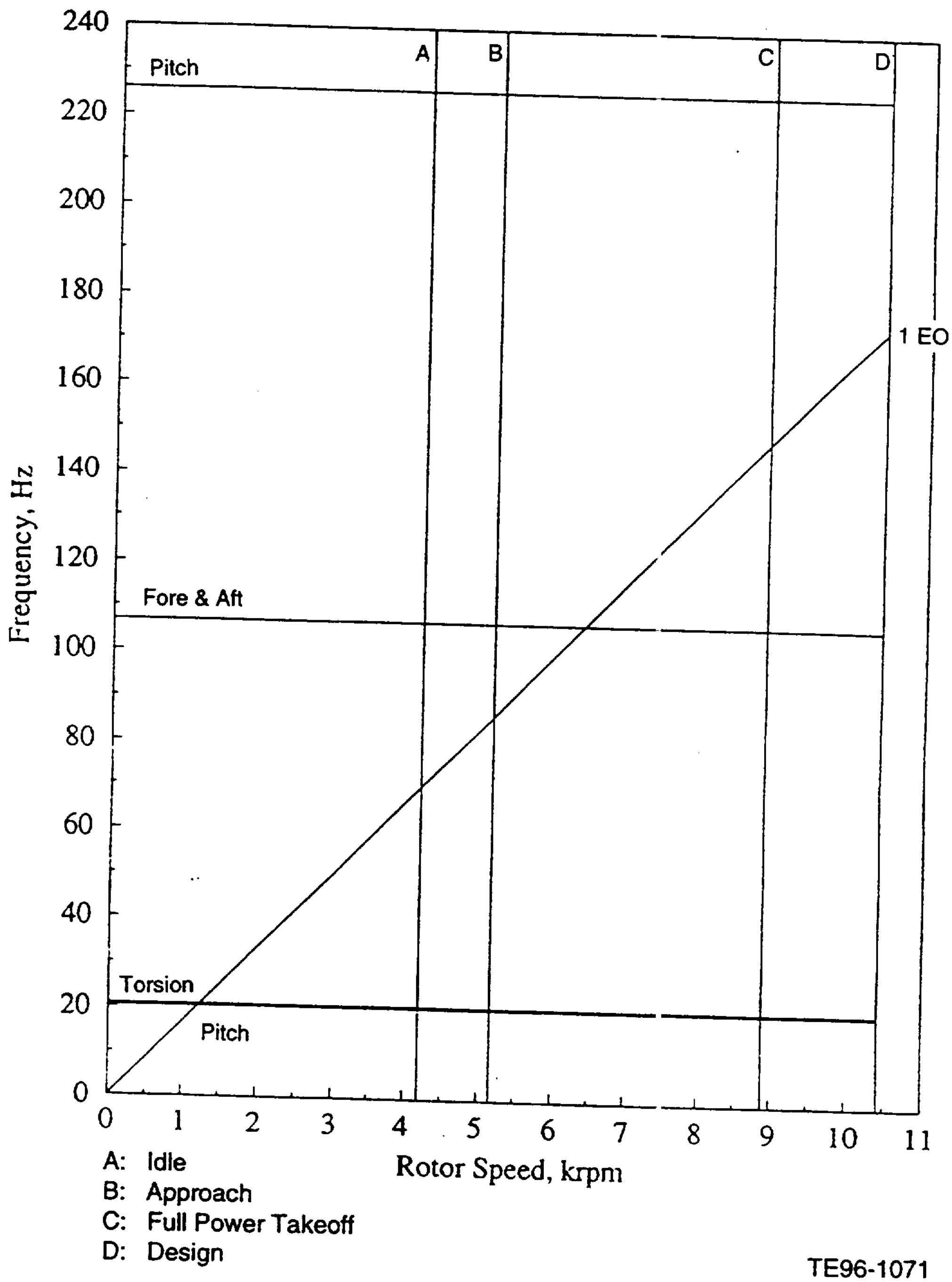


Figure 58. Campbell diagram for aft vane in performance calibration setup — assembly mode.

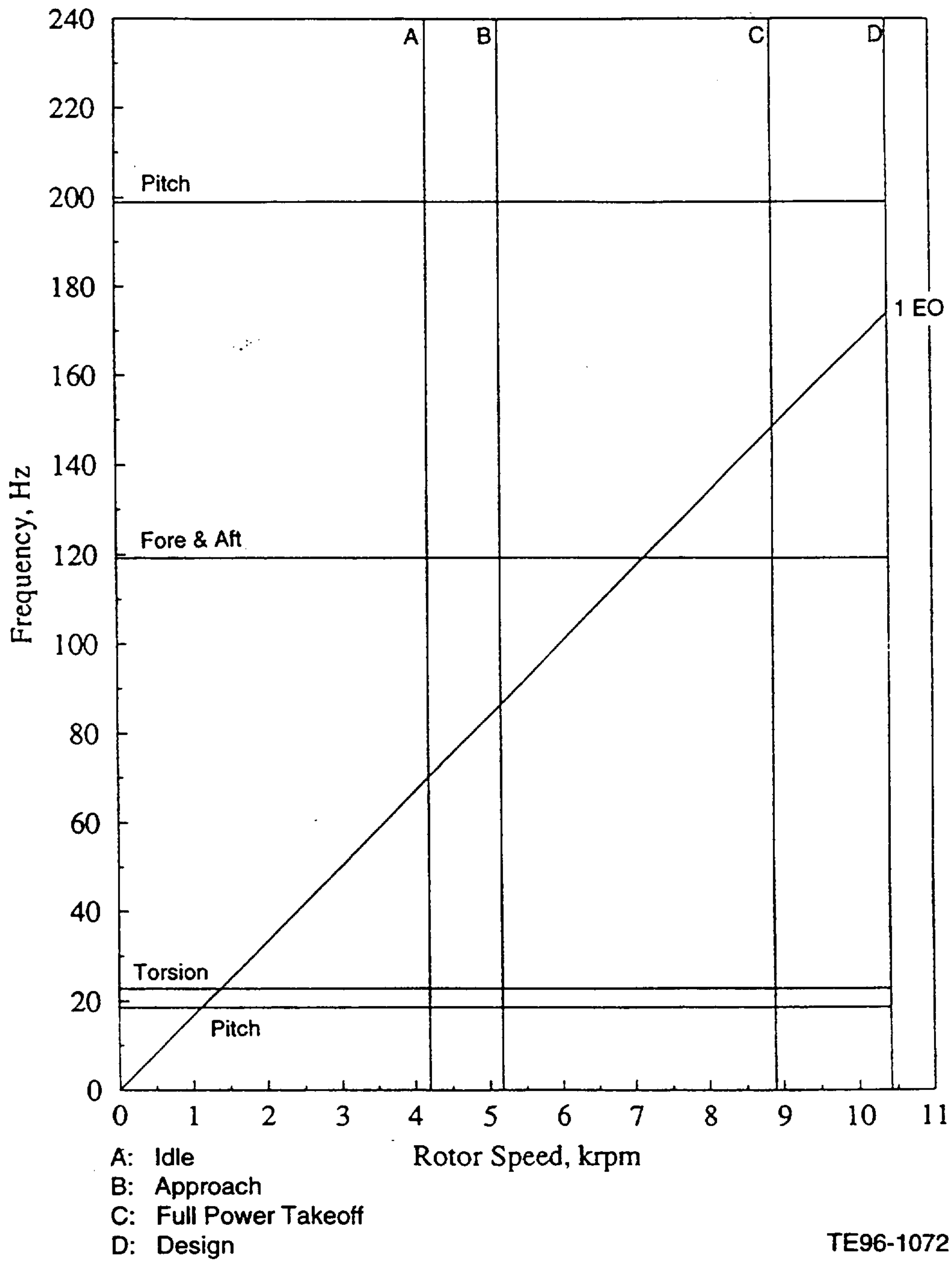


Figure 59. Campbell diagram for swept vane in performance calibration setup — assembly mode.

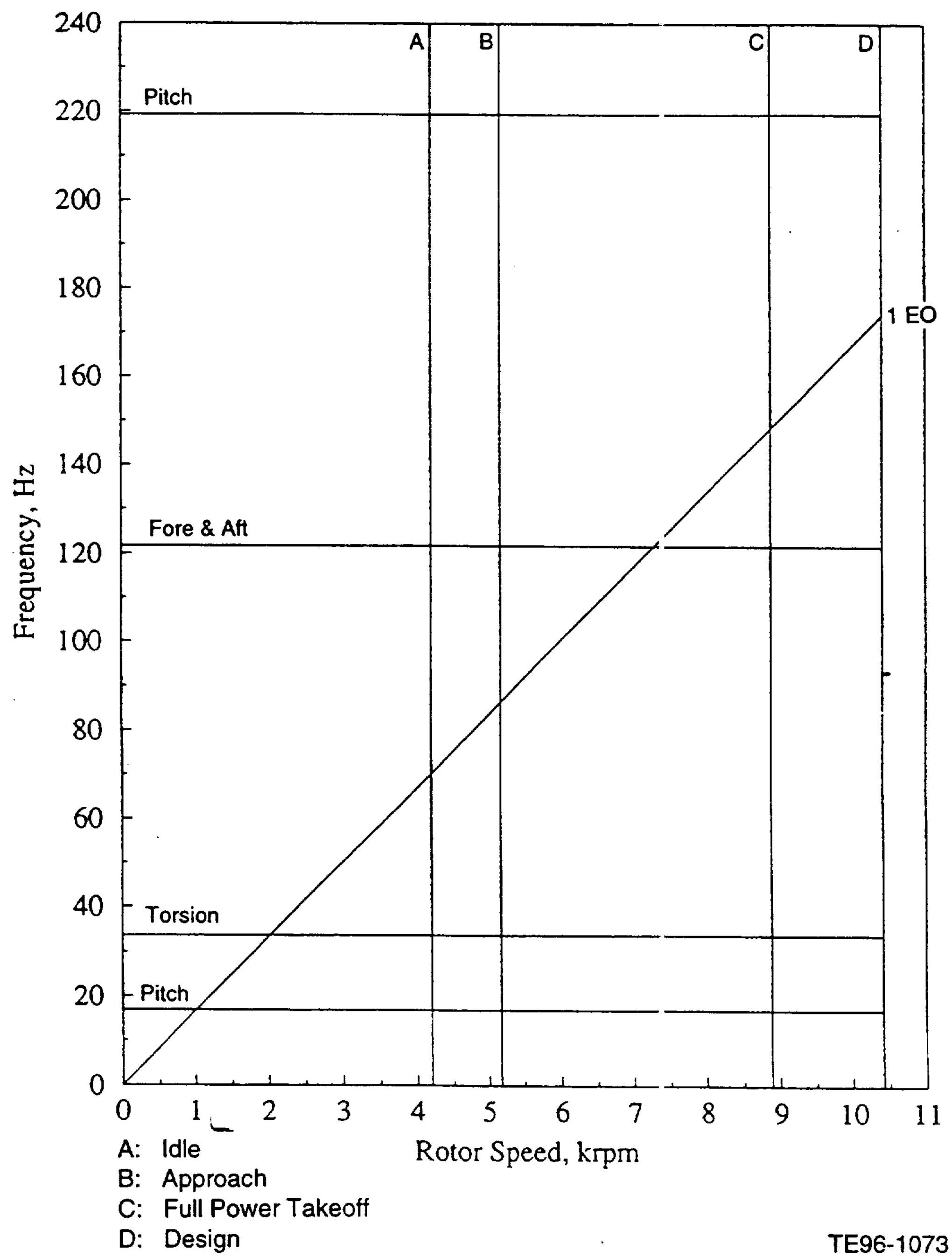


Figure 60. Campbell diagram for swept and leaned vane in performance calibration setup — assembly mode.

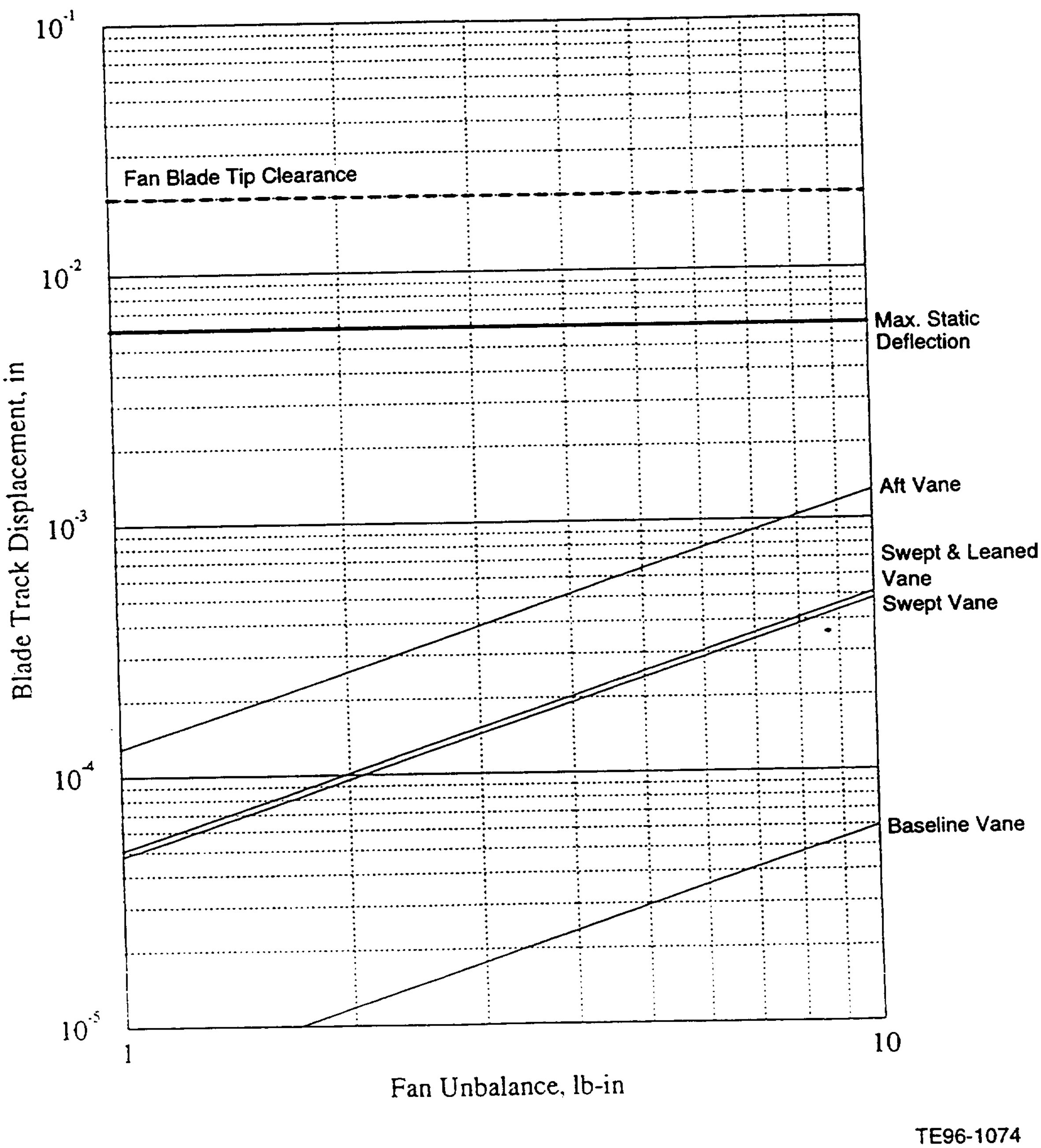


Figure 61. Blade track radial deflection versus fan unbalance — fore and aft mode of performance calibration setup.

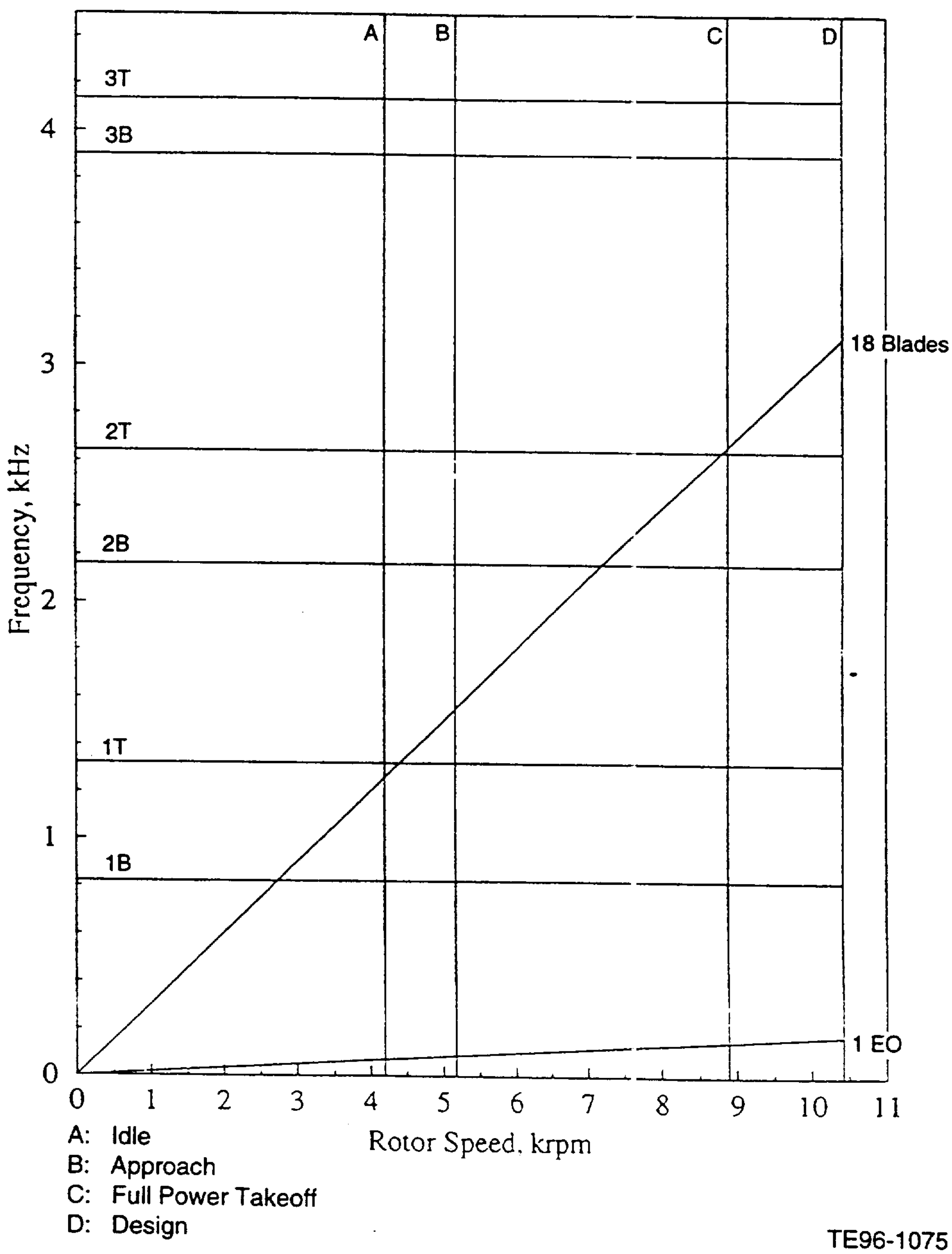


Figure 62. Campbell diagram for baseline and aft vanes — airfoil modes.

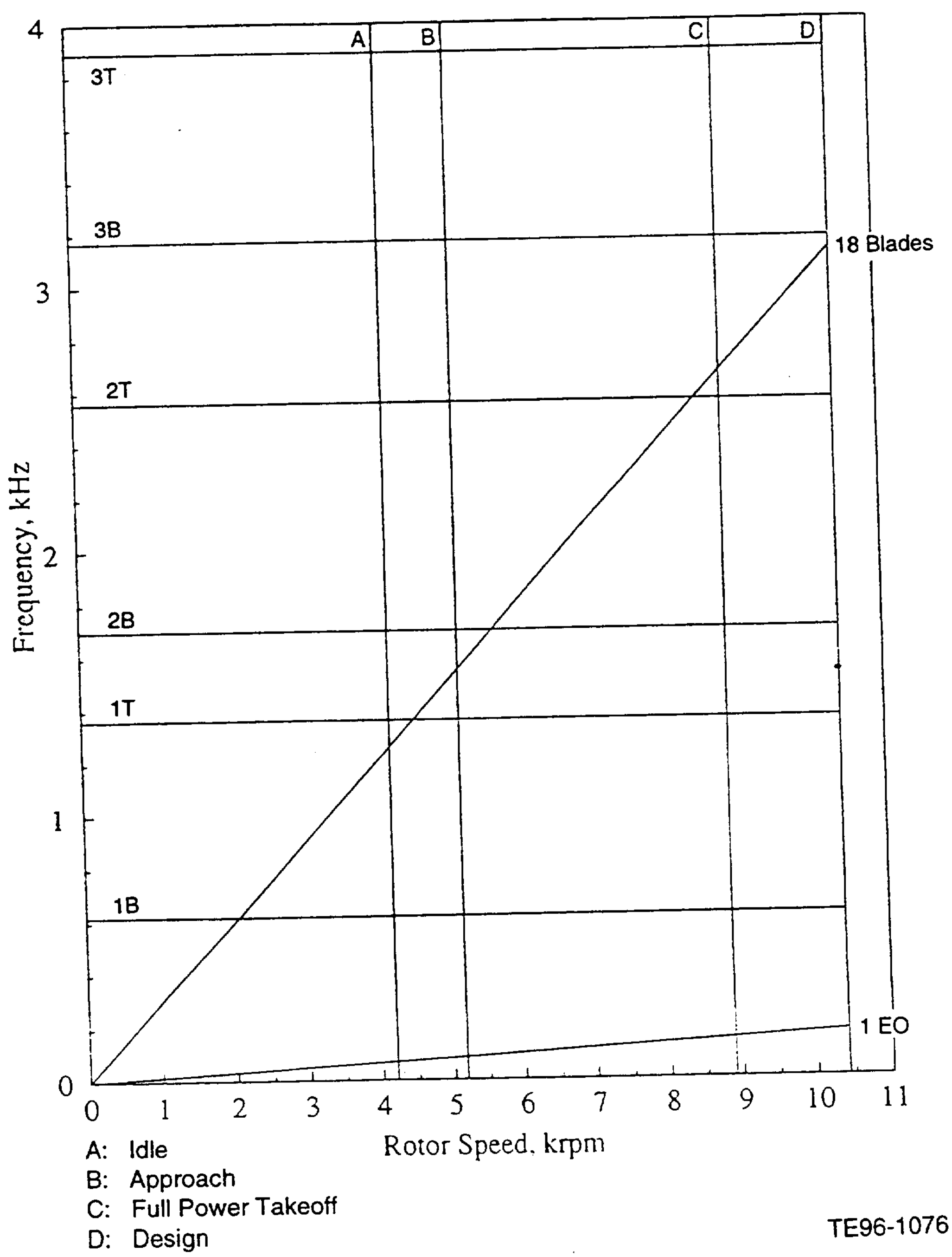


Figure 63. Campbell diagram for swept vane — airfoil modes.

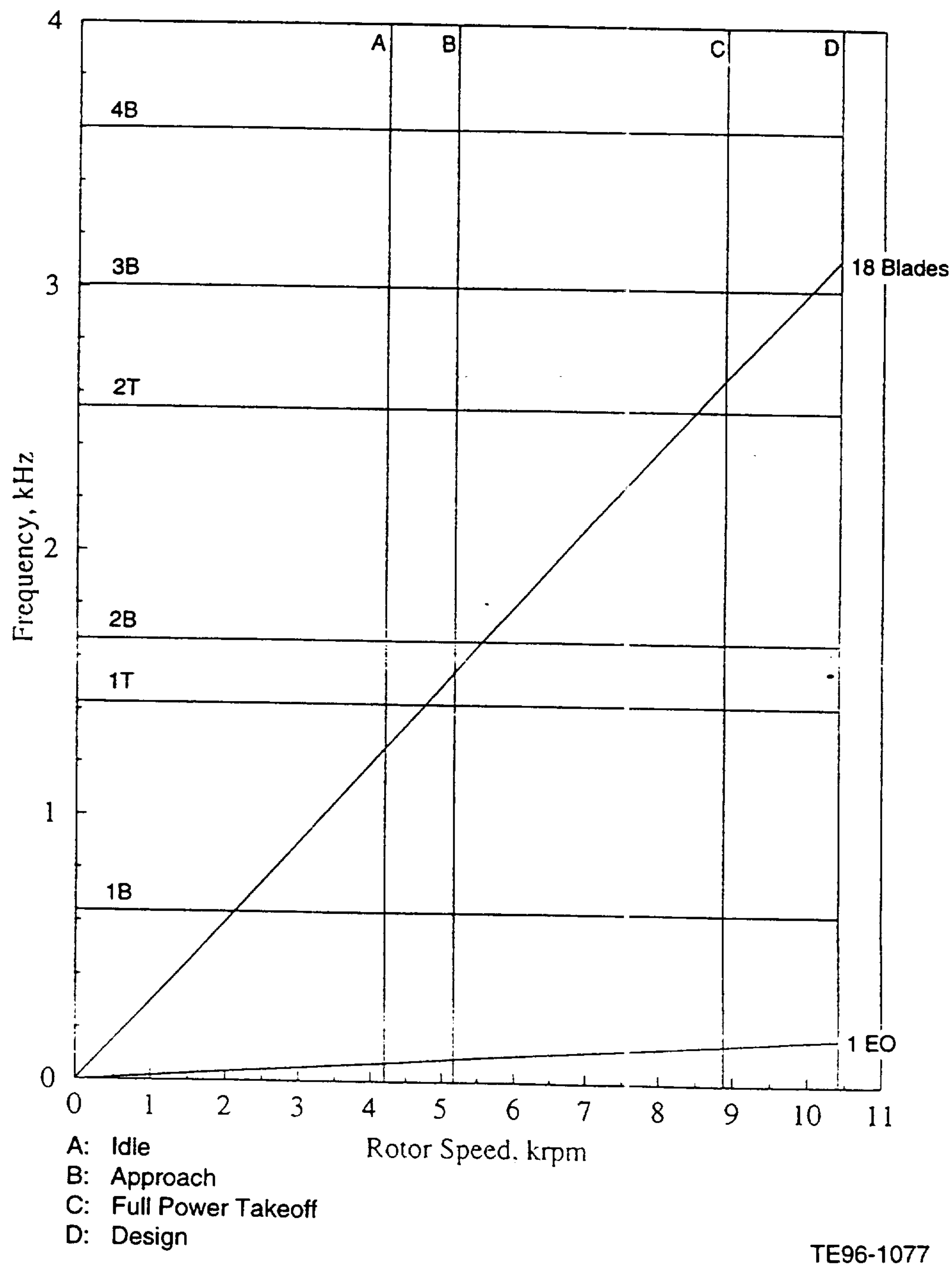


Figure 64. Campbell diagram for swept and leaned vanes — airfoil modes.

A Goodman diagram for each of the four vane configurations is presented in Figures 65 through 68. As discussed in the rotating components section, Allison design criteria require the part be able to withstand a 15 ksi vibratory stress without experiencing a high cycle fatigue failure. This requirement must be satisfied at the location where the combination of mean stress and stress concentration effects (k_t) is most restrictive. For all the vane configurations, the maximum mean stress occurs along an airfoil edge. At this location material data for a k_t of 3.0 is used to allow for the possibility of foreign object damage. All vane configurations satisfy the criteria.

Table VIII.
Flutter parameter vane configurations.

Configuration	1B - Hz	1T - Hz	75% chord	Velocity - ft/sec	1B (reduced)	1T (reduced)
Baseline	820	1320	1.810	761	0.51	0.82
Aft vane	820	1320	1.810	761	0.51	0.82
Swept vane	619	1362	1.500	774	0.31	0.69
Swept and leaned	636	1428	1.500	774	0.32	0.72
					>0.2 required	>0.6 required

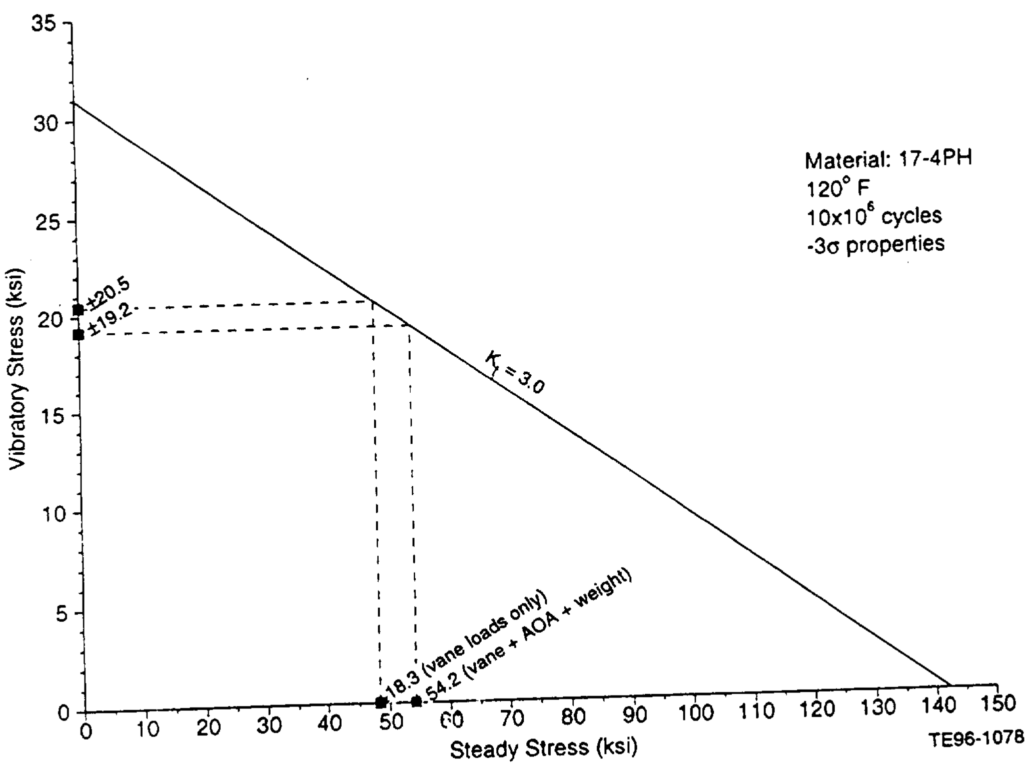


Figure 65. Goodman diagram for baseline vane.

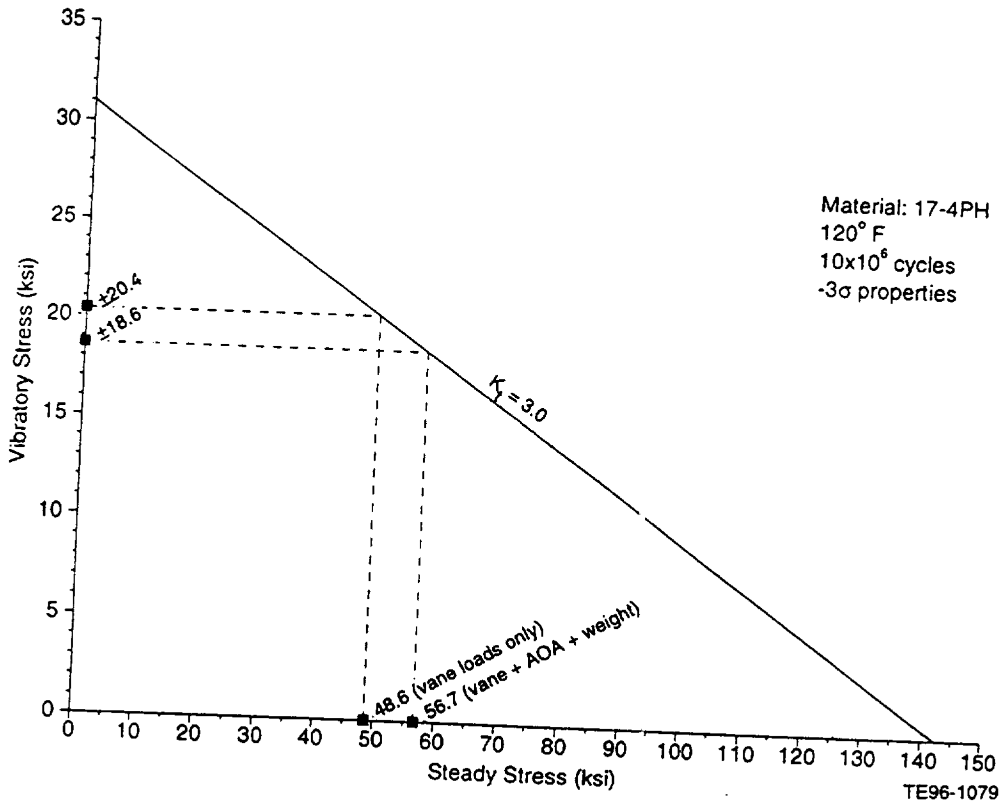


Figure 66. Goodman diagram for aft vane.

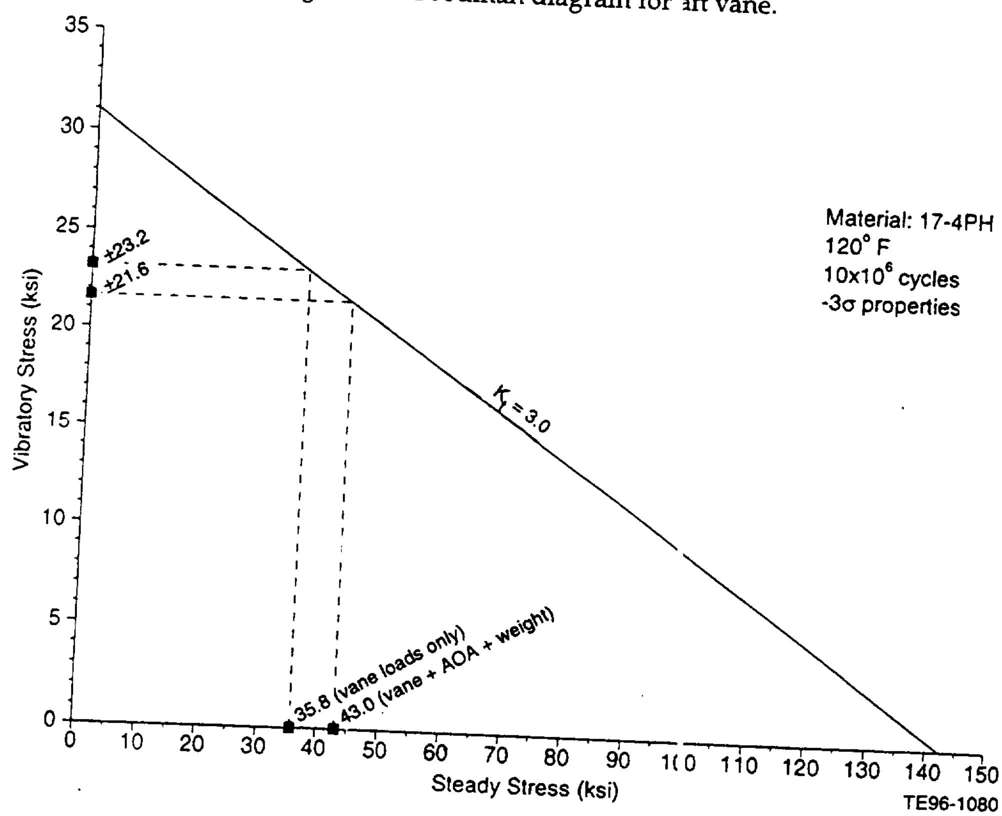


Figure 67. Goodman diagram for swept vane.

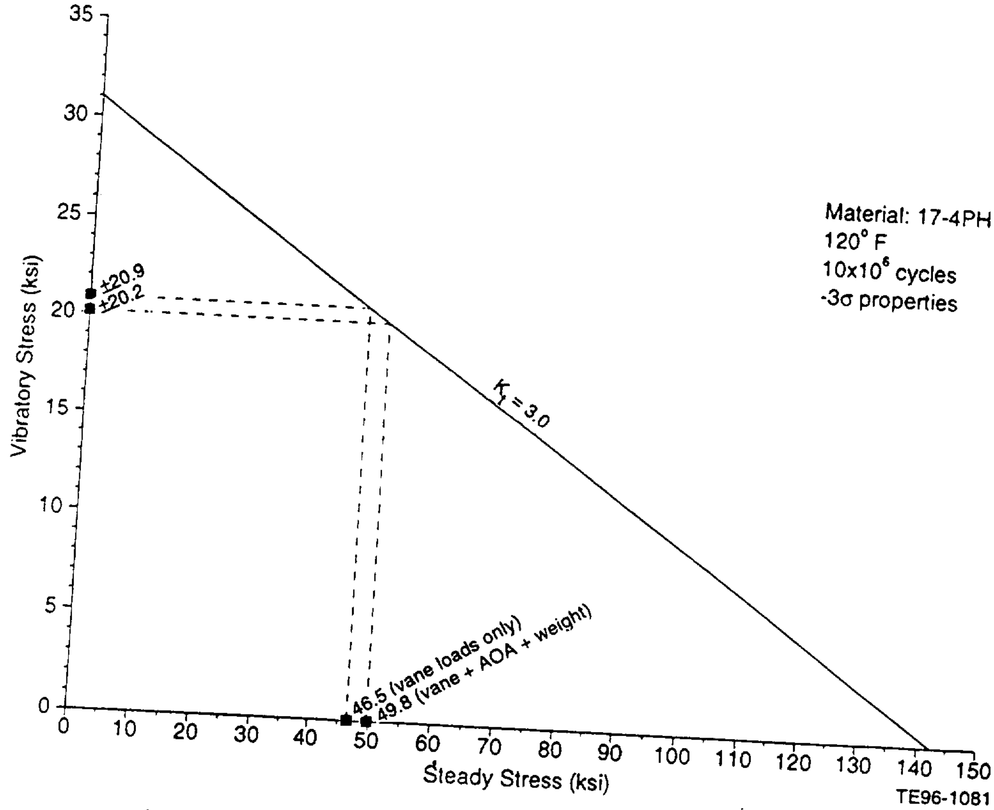


Figure 68. Goodman diagram for swept and leaned vane.

APPENDIX A

THE BASELINE LOW NOISE FAN:
AERODYNAMIC DESIGN POINT
BLADE AND VANE ELEMENT PERFORMANCE AND GEOMETRY OUTPUT

27 APR 94 * * * * Baseline Low Noise Fan * * * * 16:10:32 94/117
INTERSTAGE DATA
PAGE 1
COPY 1 OF 1

STATION NO. 1 Aerodynamic Design Point
ANNULUS EXIT 1

MASS FLOW RATE 102.78
CORRECTED FLOW RATE 102.78
FLOW RATE/SQ. FT. 39.18 (CORRECTED)
ANNULUS AREA 2.62 SQ. FT = 377.8 SQ.IN
MASS AVE. TOTAL PRESSURE 14.70
MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
.869	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	.0	1
1.882	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	10.0	3
2.895	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	20.0	5
3.908	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	30.0	7
4.921	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	40.0	9
5.934	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	50.0	11
6.947	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	60.0	13
7.961	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	70.0	15
8.974	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	80.0	17
9.987	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	90.0	19
11.000	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	100.0	21

ANNULUS 2

MASS FLOW RATE 102.78
CORRECTED FLOW RATE 102.78
FLOW RATE/SQ. FT. 39.18 (CORRECTED)
ANNULUS AREA 2.62 SQ. FT = 377.8 SQ.IN
MASS AVE. TOTAL PRESSURE 14.70
MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
.877	581.5	.0	2.02	14.70	12.09	518.7	490.5	581.5	.535	581.5	.1	1
1.894	582.8	.0	4.35	14.70	12.08	518.7	490.4	582.8	.537	582.8	10.1	3
2.911	584.9	.0	5.58	14.70	12.06	518.7	490.2	584.9	.539	584.9	20.2	5
3.925	587.3	.0	6.05	14.70	12.04	518.7	489.9	587.4	.541	587.4	30.2	7
4.938	589.8	.0	5.89	14.70	12.02	518.7	489.7	589.8	.544	589.8	40.2	9
5.950	592.0	.0	5.23	14.70	12.00	518.7	489.5	592.0	.546	592.0	50.2	11
6.959	593.8	.0	4.19	14.70	11.99	518.7	489.3	593.9	.548	593.9	60.1	13
7.968	595.3	.0	2.86	14.70	11.97	518.7	489.1	595.3	.549	595.3	70.1	15
8.976	596.3	.0	1.36	14.70	11.96	518.7	489.0	596.3	.550	596.3	80.0	17
9.984	596.7	.0	-.23	14.70	11.96	518.7	489.0	596.7	.550	596.7	90.0	19
10.992	596.7	.0	-1.81	14.70	11.96	518.7	489.0	596.7	.550	596.7	99.9	21

27 APR 94 * * * * * Baseline Low Noise Fan * * * * *
STATION NO. 3 Aerodynamic Design Point
ANNULUS EXIT 3

16:10:32 94/117

MASS FLOW RATE 102.78
CORRECTED FLOW RATE 102.78

FLOW RATE/SQ. FT. 39.18 (CORRECTED)
ANNULUS AREA 2.62 SQ. FT = 377.7 SQ.IN

MASS AVE. TOTAL PRESSURE 14.70
MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
.884	560.4	.0	2.66	14.70	12.26	518.7	492.5	560.4	.515	560.4	.1	1
1.913	568.9	.0	9.90	14.70	12.19	518.7	491.7	569.0	.523	569.0	10.3	3
2.934	575.9	.0	12.55	14.70	12.13	518.7	491.0	576.1	.530	576.1	20.4	5
3.951	582.1	.0	13.11	14.70	12.08	518.7	490.4	582.2	.536	582.2	30.4	7
4.963	587.4	.0	12.40	14.70	12.04	518.7	489.9	587.6	.541	587.6	40.4	9
5.971	592.0	.0	10.86	14.70	12.00	518.7	489.4	592.1	.546	592.1	50.4	11
6.977	595.7	.0	8.78	14.70	11.97	518.7	489.1	595.7	.549	595.7	60.3	13
7.980	598.5	.0	6.37	14.70	11.95	518.7	488.8	598.6	.552	598.6	70.2	15
8.983	600.6	.0	3.78	14.70	11.93	518.7	488.6	600.6	.554	600.6	80.1	17
9.985	601.8	.0	1.14	14.70	11.92	518.7	488.5	601.8	.555	601.8	90.0	19
10.987	602.3	.0	-1.44	14.70	11.91	518.7	488.4	602.3	.556	602.3	99.9	21

ANNULUS 4

MASS FLOW RATE 102.78
CORRECTED FLOW RATE 102.78

FLOW RATE/SQ. FT. 39.19 (CORRECTED)
ANNULUS AREA 2.62 SQ. FT = 377.6 SQ.IN

MASS AVE. TOTAL PRESSURE 14.70
MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
.896	504.8	.0	43.55	14.70	12.68	518.7	497.3	506.6	.463	506.6	.3	1
1.964	534.5	.0	36.95	14.70	12.46	518.7	494.7	535.8	.491	535.8	10.8	3
2.998	555.3	.0	34.35	14.70	12.30	518.7	492.9	556.3	.511	556.3	21.0	5
4.016	571.0	.0	31.19	14.70	12.17	518.7	491.4	571.8	.526	571.8	31.1	7
5.023	583.2	.0	27.23	14.70	12.07	518.7	490.3	583.8	.538	583.8	41.0	9
6.023	592.8	.0	22.71	14.70	11.99	518.7	489.3	593.2	.547	593.2	50.9	11
7.018	600.1	.0	17.88	14.70	11.93	518.7	488.6	600.4	.554	600.4	60.7	13
8.011	605.5	.0	12.94	14.70	11.88	518.7	488.1	605.6	.559	605.6	70.5	15
9.001	609.2	.0	8.04	14.70	11.85	518.7	487.7	609.3	.563	609.3	80.3	17
9.992	611.4	.0	3.31	14.70	11.83	518.7	487.5	611.4	.565	611.4	90.0	19
10.982	612.2	.0	-1.15	14.70	11.83	518.7	487.4	612.2	.565	612.2	99.8	21

27 APR 94   * * * * *   Baseline Low Noise Fan   Aerodynamic Design Point   * * * * *   16:10:32 94/117

STATION NO. 5
ANNULUS EXIT 5

MASS FLOW RATE 102.78
CORRECTED FLOW RATE 102.78

FLOW RATE/SQ. FT. 39.46 (CORRECTED)
ANNULUS AREA 2.60 SQ. FT = 375.0 SQ.IN

MASS AVE. TOTAL PRESSURE 14.70
MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
1.229	451.1	.0	141.89	14.70	12.93	518.7	500.0	472.9	.431	472.9	.3	1
2.189	501.0	.0	105.94	14.70	12.64	518.7	496.8	512.0	.468	512.0	10.1	3
3.182	537.9	.0	84.80	14.70	12.39	518.7	494.0	544.5	.500	544.5	20.2	5
4.169	565.2	.0	69.28	14.70	12.19	518.7	491.6	569.4	.524	569.4	30.3	7
5.150	585.4	.0	56.36	14.70	12.03	518.7	489.8	588.1	.542	588.1	40.3	9
6.124	600.4	.0	44.90	14.70	11.91	518.7	488.5	602.1	.556	602.1	50.2	11
7.096	611.4	.0	34.43	14.70	11.83	518.7	487.4	612.4	.566	612.4	60.2	13
8.066	619.3	.0	24.70	14.70	11.76	518.7	486.7	619.8	.573	619.8	70.1	15
9.036	624.5	.0	15.61	14.70	11.72	518.7	486.1	624.7	.578	624.7	80.0	17
10.006	627.6	.0	7.13	14.70	11.69	518.7	485.8	627.6	.581	627.6	89.9	19
10.979	628.7	.0	-.72	14.70	11.68	518.7	485.7	628.7	.582	628.7	99.8	21

ANNULUS 6

MASS FLOW RATE 102.78
CORRECTED FLOW RATE 102.78

FLOW RATE/SQ. FT. 40.62 (CORRECTED)
ANNULUS AREA 2.53 SQ. FT = 364.3 SQ.IN

MASS AVE. TOTAL PRESSURE 14.70
MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
2.154	469.5	.0	244.00	14.70	12.51	518.7	495.3	529.1	.485	529.1	.2	1
2.809	514.1	.0	194.68	14.70	12.35	518.7	493.5	549.7	.505	549.7	7.6	3
3.628	553.2	.0	153.20	14.70	12.15	518.7	491.[illegible]	574.0	.528	574.0	16.8	5
4.506	583.7	.0	119.99	14.70	11.97	518.7	48[illegible]	595.9	.549	595.9	26.7	7
5.408	607.0	.0	93.39	14.70	11.81	518.7	48[illegible]	614.2	.567	614.2	36.9	9
6.322	624.9	.0	71.70	14.70	11.68	518.7	48[illegible]	629.0	.582	629.0	47.2	11
7.244	638.6	.0	53.50	14.70	11.58	518.7	484.4	640.9	.594	640.9	57.6	13
8.170	648.8	.0	37.78	14.70	11.50	518.7	483.5	649.9	.603	649.9	68.1	15
9.101	655.7	.0	23.84	14.70	11.44	518.7	482.8	656.1	.609	656.1	78.6	17
10.037	659.6	.0	11.23	14.70	11.41	518.7	482.4	659.7	.613	659.7	89.1	19
10.978	660.7	.0	-.29	14.70	11.40	518.7	482.3	660.7	.614	660.7	99.7	21

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STATION NO. 7 Aerodynamic Design Point INTERSTAGE DATA
ANNULUS EXIT 7 PAGE 4
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MASS FLOW RATE 102.78
CORRECTED FLOW RATE 102.78

FLOW RATE/SQ. FT. 43.13 (CORRECTED)
ANNULUS AREA 2.38 SQ. FT = 343.1 SQ.IN

MASS AVE. TOTAL PRESSURE 14.70
MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
3.308	609.8	.0	298.98	14.70	11.23	518.7	480.2	679.1	.632	679.1	.1	1
3.707	631.1	.0	250.97	14.70	11.23	518.7	480.2	679.1	.632	679.1	5.3	3
4.296	650.6	.0	202.64	14.70	11.21	518.7	480.0	681.4	.634	681.4	12.9	5
4.999	665.5	.0	162.61	14.70	11.17	518.7	479.5	685.1	.638	685.1	22.1	7
5.773	677.0	.0	130.49	14.70	11.13	518.7	479.0	689.5	.642	689.5	32.1	9
6.591	686.3	.0	103.79	14.70	11.09	518.7	478.5	694.1	.647	694.1	42.7	11
7.438	694.0	.0	80.20	14.70	11.05	518.7	478.0	698.7	.652	698.7	53.7	13
8.304	700.3	.0	58.26	14.70	11.01	518.7	477.5	702.7	.656	702.7	65.0	15
9.185	704.9	.0	37.26	14.70	10.98	518.7	477.1	705.9	.659	705.9	76.4	17
10.077	707.8	.0	16.85	14.70	10.96	518.7	476.9	708.0	.661	708.0	88.0	19
10.977	709.0	.0	-2.36	14.70	10.95	518.7	476.8	709.0	.662	709.0	99.7	21

27 APR 94 * * * * * Baseline Low Noise Fan * * * * * INTERSTAGE DATA
STATION NO. 8 Aerodynamic Design Point PAGE 5
ROTOR EXIT 1 16:10:32 94/117 COPY 1 OF 1

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 35.55 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.25
CORRECTED FLOW RATE 78.30 ANNULUS AREA 2.20 SQ. FT = 317.1 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.6
CORRECTED TIP SPEED 1000. FT/SEC ROTOR ADIABATIC EFFICIENCY 94.1
PRESSURE RATIO 1.378 CUMULATIVE ADIABATIC EFFICIENCY 94.1

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
4.454	578.7	442.0	149.24	17.63	12.98	548.5	502.4	743.4	.676	597.7	.3	1
4.747	575.4	425.8	136.36	17.73	13.22	549.3	505.0	728.7	.661	591.3	4.8	3
5.212	571.8	407.6	119.56	17.90	13.54	550.8	508.6	712.3	.644	584.2	11.9	5
5.803	572.9	404.9	102.75	18.29	13.90	554.3	512.4	709.0	.639	582.0	20.9	7
6.472	581.0	416.0	87.20	18.89	14.26	559.4	516.3	719.8	.646	587.5	31.1	9
7.186	593.5	427.1	72.53	19.56	14.64	565.1	520.2	734.8	.657	598.0	41.9	11
7.920	608.4	434.6	58.42	20.24	15.00	570.8	524.0	750.0	.668	611.2	53.1	13
8.665	620.9	433.5	44.46	20.78	15.33	575.5	527.6	758.6	.674	622.5	64.4	15
9.418	630.7	428.4	30.88	21.21	15.63	579.7	531.3	763.1	.675	631.4	75.9	17
10.177	635.5	416.5	17.86	21.47	15.89	582.8	534.8	760.0	.670	635.7	87.5	19
10.952	626.4	393.4	5.80	21.40	16.10	583.9	538.3	739.8	.650	626.5	99.3	21

RELATIVE MACH NOS. INLET	RELATIVE MACH NOS. EXIT	TOTAL TEMP RISE	TOTAL TEMP RATIO	WHEEL SPEED IN	WHEEL SPEED OUT	ROTOR PRESSURE RATIO	ROTOR ADIABATIC EFFICIENCY	ROTOR POLYTROPIC EFFICIENCY	S.L. NO.
.691	.545	29.81	1.057	300.7	404.9	1.200	92.9	93.1	1
.706	.537	30.61	1.059	337.0	431.5	1.206	93.3	93.5	3
.731	.532	32.18	1.062	390.5	473.9	1.218	93.6	93.8	5
.766	.536	35.58	1.069	454.5	527.5	1.245	94.1	94.3	7
.807	.550	40.77	1.079	524.8	588.4	1.285	94.7	94.8	9
.855	.572	46.47	1.090	599.2	653.2	1.331	95.1	95.3	11
.907	.601	52.12	1.100	676.1	720.0	1.377	95.3	95.5	13
.962	.636	56.87	1.110	754.9	787.8	1.414	94.9	95.2	15
1.021	.675	61.08	1.118	835.0	856.1	1.443	93.9	94.2	17
1.081	.718	64.16	1.124	916.1	925.2	1.461	92.5	92.9	19
1.143	.764	65.22	1.126	997.9	995.6	1.456	90.1	90.6	21

S.L. NO.	DIFFUSION FACTOR	OMEGA BAR	DELTA PS/Q	SOLIDITY	TOTAL TURNING	ABSOLUTE FLOW ANGLE INLET	ABSOLUTE FLOW ANGLE EXIT	K.&S. EQU. DIFFUSION FACTOR	RELATIVE FLOW ANGLE INLET	RELATIVE FLOW ANGLE EXIT	RELATIVE VELOCITY INLET	RELATIVE VELOCITY EXIT	RELATIVE TEMPERATURE INLET	RELATIVE TEMPERATURE EXIT
1	.326	.051	.413	2.579	27.44	.00	36.49	1.278	23.88	-3.56	742.7	598.8	526.	532.
3	.351	.048	.449	2.406	25.84	.00	35.76	1.315	26.39	.55	758.2	591.3	528.	534.
5	.381	.045	.488	2.191	23.34	.00	34.90	1.365	29.82	6.47	785.4	587.9	531.	537.
7	.410	.043	.514	1.984	21.66	.00	34.83	1.416	33.56	11.90	822.1	594.8	536.	542.
9	.434	.040	.525	1.804	20.92	.00	35.30	1.462	37.28	16.36	866.5	612.3	542.	548.
11	.450	.038	.523	1.655	20.08	.00	35.53	1.496	40.80	20.72	917.0	639.3	549.	554.
13	.457	.037	.508	1.532	19.03	.00	35.41	1.518	44.06	25.03	972.3	674.6	557.	562.
15	.456	.040	.483	1.431	17.41	.00	34.86	1.527	47.05	29.64	1031.3	716.2	566.	570.
17	.450	.047	.450	1.346	15.68	.00	34.16	1.526	49.79	34.11	1093.4	762.7	577.	580.
19	.439	.055	.414	1.274	13.64	.00	33.23	1.515	52.30	38.66	1157.8	814.1	589.	590.
21	.423	.068	.375	1.212	10.74	.00	32.13	1.495	54.61	43.87	1224.2	869.0	602.	601.

27 APR 94 * * * * Baseline Low Noise Fan * * * *
STATION NO. 9 * * * * * Aerodynamic Design Point * * * * * INTERSTAGE DATA
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MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 36.06 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.25
CORRECTED FLOW RATE 78.30 ANNULUS AREA 2.17 SQ. FT = 312.7 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.6

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
4.622	581.6	425.9	133.01	17.63	13.09	548.5	503.7	733.0	.666	596.6	.3	1
4.902	579.5	412.3	122.92	17.73	13.29	549.3	505.9	721.7	.654	592.4	4.7	3
5.349	577.6	397.2	109.05	17.90	13.57	550.8	508.9	709.4	.641	587.8	11.7	5
5.919	580.6	397.0	94.51	18.29	13.89	554.3	512.3	709.7	.639	588.3	20.6	7
6.568	590.6	409.9	80.45	18.89	14.22	559.4	515.9	723.4	.650	596.0	30.8	9
7.262	604.5	422.5	66.78	19.56	14.57	565.1	519.5	740.5	.663	608.1	41.6	11
7.980	620.2	431.4	53.56	20.24	14.91	570.8	523.0	757.3	.675	622.5	52.8	13
8.710	632.9	431.3	40.65	20.78	15.22	575.5	526.6	767.0	.682	634.2	64.2	15
9.448	642.6	427.0	28.30	21.21	15.51	579.7	530.1	772.1	.684	643.2	75.8	17
10.196	646.8	415.7	16.68	21.47	15.77	582.8	533.6	769.0	.679	647.0	87.4	19
10.961	636.6	393.1	5.69	21.40	15.99	583.9	537.3	748.2	.658	636.7	99.4	21

ANNULUS 10

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 36.77 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.25
CORRECTED FLOW RATE 78.30 ANNULUS AREA 2.13 SQ. FT = 306.7 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.6

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
4.837	581.5	407.0	115.59	17.63	13.24	548.5	505.4	719.1	.652	592.9	.4	1
5.103	580.2	396.1	107.37	17.73	13.41	549.3	507.2	710.7	.644	590.0	4.7	3
5.531	580.0	384.1	95.99	17.90	13.65	550.8	509.8	702.3	.634	587.9	11.6	5
6.079	586.3	386.6	84.05	18.29	13.92	554.3	512.6	707.3	.637	592.3	20.5	7
6.705	600.5	401.6	72.32	18.89	14.19	559.4	515.5	726.0	.652	604.9	30.6	9
7.375	618.7	416.1	60.55	19.56	14.48	565.1	518.5	748.1	.670	621.7	41.4	11
8.069	638.3	426.6	48.71	20.24	14.76	570.8	521.5	769.3	.687	640.1	52.6	13
8.776	654.1	428.1	36.70	20.78	15.02	575.5	524.6	782.6	.697	655.1	64.1	15
9.493	666.0	425.0	24.75	21.21	15.26	579.7	527.7	790.5	.702	666.5	75.6	17
10.219	671.5	414.8	12.96	21.47	15.50	582.8	531.0	789.4	.699	671.6	87.4	19
10.964	662.1	393.0	1.13	21.40	15.71	583.9	534.5	769.9	.679	662.1	99.4	21

27 APR 94 * * * * * Baseline Low Noise Fan * * * * * INTERSTAGE DATA
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MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 37.44 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.25
CORRECTED FLOW RATE 78.30 ANNULUS AREA 2.09 SQ. FT = 301.1 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.6

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.020	591.0	392.2	95.12	17.63	13.28	548.5	505.8	715.6	.649	598.6	.4	1
5.272	590.3	383.4	92.26	17.73	13.42	549.3	507.3	709.9	.643	597.5	4.6	3
5.680	591.3	374.0	87.13	17.90	13.62	550.8	509.4	705.0	.637	597.6	11.4	5
6.206	599.3	378.6	80.15	18.29	13.85	554.3	511.9	713.4	.643	604.6	20.2	7
6.809	615.3	395.4	71.46	18.89	14.09	559.4	514.5	734.9	.661	619.4	30.2	9
7.458	635.0	411.5	61.09	19.56	14.34	565.1	517.1	759.1	.681	637.9	41.0	11
8.132	655.6	423.3	49.62	20.24	14.59	570.8	519.9	782.0	.699	657.5	52.2	13
8.822	672.3	425.9	37.45	20.78	14.84	575.5	522.7	796.7	.711	673.3	63.7	15
9.523	684.9	423.7	25.18	21.21	15.06	579.7	525.7	805.7	.717	685.3	75.4	17
10.235	691.2	414.2	13.09	21.47	15.27	582.8	528.8	805.9	.715	691.3	87.3	19
10.964	683.2	393.0	1.02	21.40	15.47	583.9	532.2	788.2	.697	683.2	99.4	21

ANNULUS 12

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 37.93 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.25
CORRECTED FLOW RATE 78.30 ANNULUS AREA 2.06 SQ. FT = 297.2 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.6

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.159	548.9	381.6	87.02	17.63	13.73	548.5	510.6	674.1	.608	555.7	.7	1
5.416	557.0	373.2	85.01	17.73	13.79	549.3	511.2	675.9	.610	563.5	5.0	3
5.826	570.1	364.7	81.07	17.90	13.88	550.8	512.1	681.6	.614	575.9	12.0	5
6.346	591.3	370.3	75.47	18.29	13.98	554.3	513.2	701.7	.632	596.1	20.9	7
6.937	619.4	388.1	68.09	18.89	14.10	559.4	514.5	734.1	.660	623.2	30.9	9
7.567	649.0	405.5	58.73	19.56	14.24	565.1	516.1	767.5	.689	651.7	41.6	11
8.220	677.0	418.8	47.92	20.24	14.39	570.8	517.8	797.5	.715	678.7	52.7	13
8.887	698.7	422.7	36.11	20.78	14.56	575.5	519.9	817.4	.731	699.6	64.1	15
9.566	714.2	421.8	24.04	21.21	14.73	579.7	522.4	829.8	.740	714.6	75.6	17
10.257	721.7	413.2	12.14	21.47	14.92	582.8	525.2	831.7	.740	721.8	87.4	19
10.967	714.2	392.9	.39	21.40	15.10	583.9	528.6	815.1	.723	714.2	99.4	21

27 APR 94   * * * *   Baseline Low Noise Fan   * * * *
STATION NO. 13   * * * * *   Aerodynamic Design Point   * * * * *   INTERSTAGE DATA
ANNULUS EXIT 13   * * * *   * * * *   PAGE 8
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MASS FLOW RATE 102.78   FLOW RATE/SQ. FT. 38.26 (CORRECTED)   MASS AVE. TOTAL PRESSURE 20.25
CORRECTED FLOW RATE 78.30   ANNULUS AREA 2.05 SQ. FT = 294.7 SQ.IN   MASS AVE. TOTAL TEMPERATURE 571.6

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.232	551.6	376.3	102.85	17.63	13.71	548.5	510.5	675.6	.610	561.1	.5	1
5.483	560.3	368.6	99.18	17.73	13.77	549.3	511.0	678.0	.612	569.0	4.9	3
5.886	574.2	361.0	93.27	17.90	13.84	550.8	511.8	684.7	.617	581.8	11.8	5
6.398	596.5	367.3	85.97	18.29	13.93	554.3	512.8	705.7	.636	602.7	20.7	7
6.980	625.9	385.7	77.05	18.89	14.04	559.4	513.9	739.2	.665	630.6	30.7	9
7.602	656.6	403.7	66.04	19.56	14.16	565.1	515.3	773.6	.695	659.9	41.4	11
8.246	685.6	417.4	53.42	20.24	14.30	570.8	516.9	804.4	.722	687.6	52.5	13
8.906	707.8	421.8	39.76	20.78	14.46	575.5	518.9	825.0	.739	708.9	63.9	15
9.578	723.6	421.3	25.98	21.21	14.63	579.7	521.3	837.7	.748	724.1	75.5	17
10.263	731.2	413.0	12.62	21.47	14.81	582.8	524.1	839.9	.748	731.3	87.3	19
10.967	723.7	392.9	-.04	21.40	14.99	583.9	527.4	823.5	.731	723.7	99.4	21

INTERSTAGE DATA
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27 APR 94   * * * * *   Baseline Low Noise Fan   * * * * *   16:10:32 94/117
STATION NO. 14   Aerodynamic Design Point
STATOR EXIT 1

MASS FLOW RATE	102.78	FLOW RATE/SQ. FT. 40.59 (CORRECTED)		MASS AVE. TOTAL PRESSURE	20.01
CORRECTED FLOW RATE	79.22	ANNULUS AREA 1.95 SQ. FT = 281.1 SQ.IN		MASS AVE. TOTAL TEMPERATURE	571.6
PRESSURE RATIO	1.362	CUMULATIVE ADIABATIC EFFICIENCY	90.5	STAGE ADIABATIC EFFICIENCY	90.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.655	498.2	.0	66.66	17.12	14.93	548.5	527.4	502.6	.446	502.6	1.0	1
5.900	510.3	.0	67.33	17.30	14.99	549.3	527.2	514.7	.457	514.7	5.6	3
6.290	528.8	.0	67.47	17.58	15.07	550.8	527.2	533.1	.474	533.1	12.8	5
6.778	563.0	.0	67.17	18.05	15.18	554.3	527.5	567.0	.504	567.0	21.8	7
7.322	610.1	.0	64.64	18.70	15.28	559.4	528.1	613.5	.545	613.5	31.9	9
7.892	657.1	.0	58.12	19.40	15.39	565.1	528.9	659.6	.585	659.6	42.5	11
8.477	699.3	.0	48.16	20.09	15.48	570.8	529.9	701.0	.621	701.0	53.3	13
9.074	729.5	.0	35.84	20.61	15.56	575.5	531.1	730.3	.646	730.3	64.3	15
9.686	750.5	.0	22.90	20.99	15.62	579.7	532.8	750.9	.663	750.9	75.7	17
10.314	761.0	.0	10.34	21.18	15.66	582.8	534.6	761.1	.671	761.1	87.3	19
10.968	752.1	.0	-.70	21.03	15.67	583.9	536.8	752.1	.662	752.1	99.4	21

ABSOLUTE INLET	MACH NOS. EXIT	TOTAL TEMP RISE	TOTAL TEMP RATIO	WHEEL SPEED IN	WHEEL SPEED OUT	STAGE PRESSURE RATIO	STAGE ADIABATIC EFFICIENCY	STAGE POLYTROPIC EFFICIENCY	S.L. NO.
.610	.446	29.81	1.057	.0	.0	1.165	77.7	78.2	1
.612	.457	30.61	1.059	.0	.0	1.177	80.9	81.4	3
.617	.474	32.18	1.062	.0	.0	1.196	84.6	85.0	5
.636	.504	35.58	1.069	.0	.0	1.228	88.1	88.5	7
.665	.545	40.77	1.079	.0	.0	1.273	90.7	91.1	9
.695	.585	46.47	1.090	.0	.0	1.320	92.3	92.6	11
.722	.621	52.12	1.100	.0	.0	1.367	93.0	93.3	13
.739	.646	56.87	1.110	.0	.0	1.402	92.5	92.9	15
.748	.663	61.08	1.118	.0	.0	1.428	91.1	91.5	17
.748	.671	64.16	1.124	.0	.0	1.441	89.0	89.6	19
.731	.662	65.22	1.126	.0	.0	1.431	85.8	86.5	21

S.L. NO.	DIFFUSION FACTOR	OMEGA BAR	DELTA PS/Q	SOLIDITY	TOTAL TURNING	ABSOLUTE FLOW ANGLE INLET	ABSOLUTE FLOW ANGLE EXIT	K.&S. EQU. DIFFUSION FACTOR
1	.376	.129	.312	2.223	33.85	33.85	.00	1.496
3	.364	.107	.309	2.126	32.93	32.93	.00	1.479
5	.350	.080	.303	1.987	31.82	31.82	.00	1.460
7	.334	.056	.285	1.836	31.36	31.36	.00	1.439
9	.321	.039	.257	1.692	31.45	31.45	.00	1.420
11	.311	.029	.227	1.562	31.46	31.46	.00	1.406
13	.305	.026	.199	1.447	31.26	31.26	.00	1.396
15	.303	.027	.174	1.346	30.75	30.75	.00	1.391
17	.303	.033	.151	1.256	30.19	30.19	.00	1.389
19	.302	.043	.128	1.176	29.46	29.46	.00	1.386
21	.303	.057	.106	1.103	28.49	28.49	.00	1.386

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Baseline Low Noise Fan
Aerodynamic Design Point

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MASS FLOW RATE 102.78
CORRECTED FLOW RATE 79.22

FLOW RATE/SQ. FT. 40.51 (CORRECTED)
ANNULUS AREA 1.96 SQ. FT = 281.6 SQ.IN

MASS AVE. TOTAL PRESSURE 20.01
MASS AVE. TOTAL TEMPERATURE 571.6

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.656	485.3	.0	4.33	17.12	15.08	548.5	528.9	485.3	.430	485.3	1.0	1
5.905	500.7	.0	6.73	17.30	15.11	549.3	528.4	500.8	.444	500.8	5.6	3
6.297	523.3	.0	9.35	17.58	15.16	550.8	528.0	523.4	.465	523.4	12.9	5
6.786	561.3	.0	11.18	18.05	15.23	554.3	528.0	561.4	.498	561.4	22.0	7
7.328	610.8	.0	11.76	18.70	15.31	559.4	528.4	611.0	.542	611.0	32.0	9
7.896	659.0	.0	11.07	19.40	15.40	565.1	529.0	659.1	.584	659.1	42.5	11
8.478	701.5	.0	9.48	20.09	15.48	570.8	529.8	701.6	.622	701.6	53.3	13
9.073	731.7	.0	7.26	20.61	15.54	575.5	531.0	731.8	.648	731.8	64.3	15
9.683	752.9	.0	4.74	20.99	15.60	579.7	532.6	752.9	.665	752.9	75.6	17
10.311	763.5	.0	2.09	21.18	15.63	582.8	534.3	763.5	.674	763.5	87.2	19
10.964	754.7	.0	-.64	21.03	15.64	583.9	536.5	754.7	.665	754.7	99.3	21

ANNULUS 16

MASS FLOW RATE 102.78
CORRECTED FLOW RATE 79.22

FLOW RATE/SQ. FT. 40.51 (CORRECTED)
ANNULUS AREA 1.96 SQ. FT = 281.6 SQ.IN

MASS AVE. TOTAL PRESSURE 20.01
MASS AVE. TOTAL TEMPERATURE 571.6

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.674	463.6	.0	1.32	17.12	15.25	548.5	530.6	463.6	.411	463.6	1.4	1
5.930	482.9	.0	3.10	17.30	15.25	549.3	529.9	482.9	.428	482.9	6.1	3
6.330	510.8	.0	5.21	17.58	15.27	550.8	529.1	510.9	.453	510.9	13.5	5
6.823	554.9	.0	6.90	18.05	15.29	554.3	528.6	554.9	.492	554.9	22.6	7
7.364	610.2	.0	7.75	18.70	15.32	559.4	528.4	610.3	.541	610.3	32.7	9
7.928	663.3	.0	7.60	19.40	15.35	565.1	528.5	663.3	.589	663.3	43.1	11
8.505	709.8	.0	6.66	20.09	15.38	570.8	528.8	709.8	.630	709.8	53.8	13
9.094	743.0	.0	5.13	20.61	15.40	575.5	529.6	743.0	.659	743.0	64.7	15
9.697	766.0	.0	3.24	20.99	15.43	579.7	530.9	766.0	.678	766.0	75.9	17
10.318	777.6	.0	1.17	21.18	15.44	582.8	532.5	777.6	.687	777.6	87.4	19
10.964	769.3	.0	-1.04	21.03	15.45	583.9	534.6	769.3	.679	769.3	99.3	21

27 APR 94 * * * * * Baseline Low Noise Fan * * * * * 16:10:32 94/117
STATION NO. 17 Aerodynamic Design Point
ANNULUS EXIT 17

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 40.51 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.01
CORRECTED FLOW RATE 79.22 ANNULUS AREA 1.96 SQ. FT = 281.6 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.6

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.667	461.0	.0	-1.27	17.12	15.27	548.5	530.8	461.0	.408	461.0	1.2	1
5.924	480.6	.0	-.69	17.30	15.27	549.3	530.0	480.6	.426	480.6	6.0	3
6.326	509.1	.0	.07	17.58	15.28	550.8	529.3	509.1	.451	509.1	13.4	5
6.820	553.7	.0	.73	18.05	15.30	554.3	528.7	553.7	.491	553.7	22.6	7
7.362	609.7	.0	1.10	18.70	15.32	559.4	528.5	609.7	.5[illegible]1	609.7	32.6	9
7.927	663.2	.0	1.14	19.40	15.35	565.1	528.5	663.2	.588	663.2	43.1	11
8.503	710.1	.0	.89	20.09	15.37	570.8	528.8	710.1	.630	710.1	53.8	13
9.092	743.6	.0	.43	20.61	15.40	575.5	529.5	743.6	.659	743.6	64.7	15
9.695	766.9	.0	-.18	20.99	15.41	579.7	530.8	766.9	.679	766.9	75.8	17
10.316	778.9	.0	-.89	21.18	15.43	582.8	532.3	778.9	.689	778.9	87.3	19
10.962	770.8	.0	-1.67	21.03	15.43	583.9	534.4	770.8	.680	770.8	99.3	21

ANNULUS 18

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 40.51 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.01
CORRECTED FLOW RATE 79.22 ANNULUS AREA 1.96 SQ. FT = 281.6 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.6

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.672	455.6	.0	.00	17.12	15.31	548.5	531.2	455.6	.403	455.6	1.3	1
5.931	475.7	.0	.00	17.30	15.31	549.3	530.4	475.7	.421	475.7	6.1	3
6.335	505.1	.0	.00	17.58	15.32	550.8	529.6	505.1	.448	505.1	13.6	5
6.831	551.3	.0	.00	18.05	15.32	554.3	528.9	551.3	.489	551.3	22.8	7
7.373	609.1	.0	.00	18.70	15.33	559.4	528.5	609.1	.540	609.1	32.8	9
7.937	664.6	.0	.00	19.40	15.33	565.1	528.4	664.6	.590	664.6	43.3	11
8.512	713.2	.0	.00	20.09	15.34	570.8	528.4	713.2	.633	713.2	53.9	13
9.098	748.2	.0	.00	20.61	15.34	575.5	528.9	748.2	.664	748.2	64.8	15
9.699	772.6	.0	.00	20.99	15.34	579.7	530.1	772.6	.685	772.6	75.9	17
10.316	785.3	.0	.00	21.18	15.34	582.8	531.5	785.3	.695	785.3	87.3	19
10.960	777.6	.0	.00	21.03	15.34	583.9	533.6	777.6	.687	777.6	99.3	21

27 APR 94 * * * * * Baseline Low Noise Fan * * * * *

Aerodynamic Design Point

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PERF. SUMMARY
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		D-FACTOR HUB	D-FACTOR MEAN	D-FACTOR TIP	EQUIVALENT DIFFUSION FACTOR HUB	EQUIVALENT DIFFUSION FACTOR MEAN	EQUIVALENT DIFFUSION FACTOR TIP	LOAD COEFFICIENT (MEAN WHEEL SPEED) HUB	LOAD COEFFICIENT (MEAN WHEEL SPEED) MEAN	LOAD COEFFICIENT (MEAN WHEEL SPEED) TIP	MACH NO.	SPECIFIC FLOW IN	SPECIFIC FLOW OUT	FLOW COEFF.
ROTOR	1	.326	.450	.423	1.453	1.565	1.510	.499	.777	1.091	1.143	43.13	35.55	1.145
STATOR	1	.376	.311	.303	1.510	1.519	1.538				.610	38.26	40.59	

		PRESSURE RATIO	CUMULATIVE PRESSURE RATIO	ADIABATIC EFFICIENCY	CUMULATIVE ADIABATIC EFFICIENCY	EXIT FLOW ANGLE HUB	EXIT FLOW ANGLE TIP	TOTAL TURNING HUB	TOTAL TURNING TIP	INLET AXIAL VELOCITY MEAN	HORSE POWER
ROTOR	1	1.378	1.378	94.1	94.1	-3.6	43.9	27.4	10.7	686.3	1845.7
STATOR	1	1.362	1.362	90.5	90.5	.0	.0	33.8	28.5	656.6	

27 APR 94 * * * * * Baseline Low Noise Fan / Aerodynamic Design Point * * * * * 16:10:32 94/117 FLOW PATH INFO COPY 1 OF 1

ALL DIMENSIONS ARE IN INCHES

STA NO.		AXIAL COORDINATE HUB	AXIAL COORDINATE TIP	AXIAL LENGTH HUB	AXIAL LENGTH TIP	RADIUS HUB	RADIUS TIP	AREA	DISPLACEMENT THICKNESS HUB	DISPLACEMENT THICKNESS TIP	SHAPE FACTOR HUB	SHAPE FACTOR TIP	BLOCKAGE FACTOR HUB	BLOCKAGE FACTOR TIP	AXIAL VELOCITY HUB	AXIAL VELOCITY TIP
1		-12.300	-12.300			.869	11.000	377.76	.000	.000	1.40	1.40	1.000	1.000	592.	592.
2		-10.000	-10.000	2.300	2.300	.869	11.000	377.76	.008	.008	1.55	1.55	1.000	.999	582.	597.
3		-8.000	-8.000	2.000	2.000	.869	11.000	377.76	.015	.013	1.53	1.53	1.000	.998	560.	602.
4		-6.000	-6.000	2.000	2.000	.869	11.000	377.76	.027	.018	1.58	1.52	1.000	.997	505.	612.
5		-4.000	-4.000	2.000	2.000	1.200	11.000	375.61	.029	.021	1.53	1.51	.999	.996	451.	629.
6		-2.000	-2.000	2.000	2.000	2.140	11.000	365.75	.014	.022	1.44	1.50	.999	.996	469.	661.
7		.000	.118	2.000	2.118	3.300	11.000	345.96	.008	.023	1.54	1.52	1.000	.995	610.	709.
8	ROTOR	3.294	3.298	3.294	3.180	4.433	11.000	318.40	.021	.048	1.58	1.79	.998	.990	579.	626.
9		4.000	4.000	.706	.702	4.600	11.000	313.66	.022	.039	1.59	1.47	.998	.991	582.	637.
10		5.000	5.000	1.000	1.000	4.812	11.000	307.37	.024	.036	1.58	1.45	.998	.992	581.	662.
11		6.000	6.000	1.000	1.000	4.995	11.000	301.75	.025	.036	1.55	1.48	.997	.992	591.	683.
12		7.000	7.000	1.000	1.000	5.120	11.000	297.78	.039	.033	1.79	1.48	.996	.992	549.	714.
13		7.436	7.381	.436	.381	5.200	11.000	295.20	.032	.033	1.47	1.51	.997	.992	552.	724.
14	VANE	9.069	9.122	1.633	1.741	5.600	11.000	281.63	.055	.032	1.77	1.49	.993	.992	498.	752.
15		10.804	10.804	1.735	1.682	5.600	11.000	281.61	.056	.036	1.51	1.54	.993	.991	485.	755.
16		12.000	12.000	1.196	1.196	5.600	11.000	281.61	.074	.036	1.65	1.51	.991	.991	464.	769.
17		13.000	13.000	1.000	1.000	5.600	11.000	281.61	.067	.038	1.43	1.55	.992	.991	461.	771.
18		14.500	14.500	1.500	1.500	5.600	11.000	281.61	.072	.040	1.44	1.53	.991	.990	456.	778.

27 APR 94 * * * * * Baseline Low Noise Fan * * * * *

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SURGE MARGIN
PAGE 1
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AIRFOIL	ALLISON FLOW COEF	SURGE MARGIN LOADING PARM	ASPECT RATIO	REYNOLDS NUMBER	LOSS MODIFIERS REYN# MODIF	LOSS MODIFIERS CL-LOSS COEFF.	CL/ SPAN	SARP	CH	EFFECTIVITY PARAMETERS AVE. REY.#	REYMOD	TCMOD	AXMOD	CHBAR	EFFECT IVITY
ROTOR 1	1.064	.4856	1.754	1788413.	.000	.0000	.0000								
VANE 1		.7460	3.094	748854.	.000										
	-----	------	-------												
AVERAGE	1.064	.6158	2.424					.846	.458	1268633.	1.054	1.056	.926	.519	.88380

LOAD COEFFICIENT	.3842
BASE SURGE MARGIN	-11.2
CORRECTION	-12.8

SURGE MARGIN	-24.0

SINGLE STAGE SURGE MARGIN CORRELATION

SOLIDITY	ASPECT RATIO	D-FACTOR	TIP MN	SURGE MARGIN
1.6553	1.7536	.4358	1.1433	17.28

ROTOR 1 AT STATION 8
THERE ARE 18 AIRFOILS.
THE AIRFOIL SHAPE IS ARB
THE INCIDENCE AND DEVIATION RULES WERE
INLET METAL ANGLES INPUT
EXIT METAL ANGLES INPUT

STRM LINE NO.	CAMBER	SETTING	INLET METAL ANGLE	EXIT METAL ANGLE	TRUE CHORD	THICK-NESS/CHORD	LEADING EDGE RADIUS	INCI-DENCE	DEVI-ATION	SOLID-ITY	STACK RADIUS	INFLECTION ANGLE	RAMP ANGLE
1	38.44	-.94	26.92	-11.53	3.494	.0942	.0400	-3.03	7.97	2.579	3.850	-3.46	19.18
3	35.64	4.40	28.54	-7.10	3.550	.0873	.0300	-2.15	7.65	2.406	4.198	2.14	17.55
5	31.33	10.48	30.88	-.45	3.635	.0771	.0170	-1.06	6.92	2.191	4.727	8.87	15.62
7	27.13	16.36	33.21	6.08	3.740	.0664	.0135	.35	5.82	1.984	5.376	14.50	13.81
9	25.07	21.60	36.17	11.10	3.856	.0554	.0109	1.10	5.25	1.804	6.099	20.45	12.12
11	23.45	26.69	39.27	15.82	3.980	.0453	.0088	1.53	4.90	1.655	6.867	28.03	10.39
13	21.85	31.33	42.22	20.37	4.108	.0376	.0074	1.84	4.66	1.532	7.661	34.68	8.49
15	20.05	35.65	45.05	25.00	4.238	.0318	.0067	2.00	4.64	1.431	8.470	38.83	6.40
17	18.20	39.51	47.79	29.60	4.370	.0286	.0062	2.00	4.52	1.346	9.291	42.75	4.15
19	16.26	43.40	50.30	34.04	4.503	.0275	.0062	2.00	4.62	1.274	10.122	46.04	1.79
21	13.76	47.15	52.61	38.85	4.639	.0275	.0064	2.00	5.02	1.212	10.966	49.16	-.46

STATOR 1 AT STATION 14
THERE ARE 42 AIRFOILS.
THE AIRFOIL SHAPE IS DCA
THE INCIDENCE AND DEVIATION RULES WERE
INPUT TABLES
AND NASA 2-D RULE.

STRM LINE NO.	CAMBER	SETTING	INLET METAL ANGLE	EXIT METAL ANGLE	TRUE CHORD	THICK-NESS/CHORD	LEADING EDGE RADIUS	INCI-DENCE	DEVI-ATION	SOLID-ITY	STACK RADIUS	INFLECTION ANGLE	RAMP ANGLE
1	38.78	13.76	33.15	-5.63	1.810	.0500	.0050	.70	5.63	2.223	5.443	13.76	14.53
3	37.81	13.26	32.16	-5.65	1.810	.0500	.0050	.77	5.65	2.126	5.691	13.26	14.26
5	36.66	12.60	30.92	-5.73	1.810	.0500	.0050	.89	5.73	1.987	6.088	12.60	13.77
7	36.35	12.14	30.31	-6.04	1.810	.0500	.0050	1.05	6.04	1.836	6.588	12.14	12.93
9	36.77	11.85	30.24	-6.53	1.810	.0500	.0050	1.22	6.53	1.692	7.151	11.85	11.60
11	37.09	11.51	30.05	-7.03	1.810	.0500	.0050	1.40	7.03	1.562	7.747	11.51	9.83
13	37.17	11.08	29.67	-7.51	1.810	.0500	.0050	1.59	7.51	1.447	8.361	11.08	7.77
15	36.85	10.54	28.97	-7.88	1.810	.0500	.0050	1.79	7.88	1.346	8.990	10.54	5.64
17	36.44	9.98	28.20	-8.24	1.810	.0500	.0050	1.99	8.24	1.256	9.632	9.98	3.59
19	35.80	9.37	27.26	-8.53	1.810	.0500	.0050	2.19	8.53	1.176	10.288	9.37	1.69
21	34.84	8.68	26.10	-8.74	1.810	.0500	.0050	2.40	8.74	1.103	10.968	8.68	.04

		AIRFOILS	SINGLE AIRFOIL VOLUME	TOTAL AIRFOIL VOLUME	POLAR MOMENT OF INERTIA	AXIAL STACK REF.	CENTER RADIUS OF	-- OF -- AXIAL POS.	GRAVITY TANG. POS.	STRESS/ DENSITY	STRESS STEEL	STRESS TITANIUM
ROTOR	1	18	3.4843	62.7167	183.8515	-.0296	6.9373	1.5287	-.0143	99.96	30.0	16.0
STATOR	1	42	.6428	26.9980	45.0443	-.0408	8.2124	8.2107	.0803			

THE TOTAL NUMBER OF ROTOR AIRFOILS 18
THE TOTAL NUMBER OF STATOR AIRFOILS 42

THE AIRFOIL VOLUME IS FOR A SOLID AIRFOIL AND NO ATTACHMENTS ARE INCLUDED
STRESS VALUES ARE IN THOUSANDS OF LBS./ SQ. IN.

THE STRESS VALUES LISTED FOR STEEL AND TITANIUM ARE BASED ON DENSITY VALUES OF 0.30 AND 0.16 LBS./CU. IN. RESPECTIVELY

THE VALUES OF POLAR MOMENT OF INERTIA ARE POLAR MOMENT OF INERTIA DIVIDED BY DENSITY - LB.-IN. SQ./LB./CU. IN.

POSITIVE AXIAL LOADS ON THE BLADES AND VANES CORRESPONDS TO POSITIVE THRUST WHICH IS OPPOSITE TO THE DIRECTION OF FLOW. POSITIVE TANGENTIAL LOAD IS OPPOSITE TO THE DIRECTION OF ROTOR ROTATION. THE BLADE LOADS INCLUDE A PRESSURE TERM AND A CHANGE IN MOMENTUM TERM AS DESCRIBED IN A TDR BY W.R.RATLIFF,3/30/61
ALL FORCES ARE IN POUNDS.
NOTE THAT THE ACCOMPANYING PUNCHED CARDS ARE COMPATIBLE WITH PROGRAM BB45(AQ83).

THE HUB AND TIP RAMP FORCES APPLY TO THE RAMP BETWEEN THE STATION THEY ARE PRINTED AT AND THE PRECEDING STATION EXCEPT WHERE SPECIFICALLY NOTED. THE EXCEPTIONS WILL BE ASSOCIATED WITH THE SPLITTER LOCATION ON FAN COMPRESSORS. THE FIRST CALCULATING STATION AFTER A BLADE ROW WILL BE MARKED ROTOR, STATOR OR IGV WHICHEVER IS APPROPRIATE. THE EXIT OF THE BLADE ROW IS APPROXIMATELY ONE-HALF OF THE PRINTED CLEARANCE IN FRONT OF THE INDICATED STATION.

THE TOTAL AXIAL AND TANGENTIAL LOADS REFLECT THE TOTAL LOAD ON ALL BLADES OR VANES IN EACH ROW. THE TOTAL COMPRESSOR LOAD IS THE SUM OF ALL OF THE AXIAL LOADS ON ALL OF THE BLADE AND VANES IN THE COMPRESSOR. THE TOTAL HUB AND TIP RAMP FORCE IS THE RAMP FORCE FROM THE FIRST BLADE/VANE ROW INLET(PRECEDING STATION) TO THE LAST BLADE/VANE ROW EXIT(AS PER INDICATED STATION). THE TOTAL THRUST IS THE TOTAL COMPRESSOR LOAD PLUS THE RAMP FORCE TOTALS. NOTE THAT THE RAMP FORCES ARE USUALLY DRAG FORCES. THE TOTAL ROTOR THRUST IS THE SUM OF ALL ROTOR BLADE AXIAL FORCES AND THE TOTAL HUB RAMP FORCE.

STATION NO. 8 ROTOR EXIT 1

STREAMTUBE AVE. RADIUS	AXIAL BLADE FORCE	AXIAL FORCE PER INCH	TANG BLADE FORCE	TANG FORCE PER INCH
3.954	.209	1.43	.736	5.03
4.127	.320	1.60	1.048	5.24
4.349	.448	1.83	1.343	5.48
4.613	.599	2.12	1.626	5.77
4.910	.776	2.49	1.916	6.15
5.233	.984	2.94	2.217	6.61
5.578	1.228	3.47	2.537	7.17
5.939	1.510	4.10	2.885	7.84
6.312	1.830	4.83	3.241	8.56
6.695	2.189	5.66	3.606	9.32
7.085	2.583	6.57	3.973	10.11
7.480	3.010	7.57	4.336	10.90
7.880	3.460	8.62	4.680	11.66
8.283	3.927	9.71	5.003	12.37
8.688	4.409	10.83	5.313	13.05
9.097	4.897	11.96	5.607	13.70
9.507	5.395	13.11	5.885	14.30
9.920	5.888	14.23	6.122	14.79
10.335	6.359	15.25	6.306	15.12
10.754	6.793	16.14	6.432	15.28
TOT. FORCE PER BLADE=	56.81		74.81	
TOT. FORCE PER ROW=	1022.65		1346.60	

HUB RAMP FORCE= -333.10
TIP RAMP FORCE= .00

RPM= 10417.40 NUMBER OF BLADES= 18

STATION NO. 14 STATOR EXIT 1

STREAMTUBE AVE. RADIUS	AXIAL BLADE FORCE	AXIAL FORCE PER INCH	TANG BLADE FORCE	TANG FORCE PER INCH
5.495	.058	.56	-.269	-2.61
5.619	.085	.58	-.387	-2.67
5.783	.112	.61	-.501	-2.75
5.981	.140	.66	-.614	-2.87
6.208	.172	.72	-.731	-3.05
6.458	.208	.80	-.857	-3.29
6.726	.249	.90	-.992	-3.60
7.007	.294	1.03	-1.140	-3.98
7.298	.341	1.16	-1.295	-4.39
7.596	.389	1.29	-1.454	-4.83
7.900	.436	1.43	-1.616	-5.29
8.207	.480	1.55	-1.778	-5.75
8.518	.519	1.66	-1.933	-6.19
8.832	.552	1.75	-2.080	-6.59
9.149	.580	1.82	-2.222	-6.96
9.470	.602	1.87	-2.357	-7.30
9.795	.618	1.89	-2.486	-7.62
10.123	.624	1.89	-2.596	-7.86
10.456	.619	1.84	-2.685	-7.99
10.796	.601	1.75	-2.748	-8.01
TOT. FORCE PER BLADE=	7.68		-30.74	
TOT. FORCE PER ROW=	322.54		-1291.11	

HUB RAMP FORCE= -194.40
TIP RAMP FORCE= .00

RPM= .00 NUMBER OF BLADES= 42

27 APR 94 * * * * Baseline Low Noise Fan * * * * THRUST BALANCE
SUMMARY OF * * * * * Aerodynamic Design Point * * * * * 16:10:32 94/117 PAGE 3
BLADE FORCES * * * * * * * * COPY 0 OF 1

STA NO.			TOTAL AXIAL LOAD	TOTAL TANG. LOAD	NUMBER OF BLADES	HUB AXIAL COOR.	HUB RADIUS	HUB RAMP FORCE	HUB STATIC PRESSURE	CASE AXIAL COOR.	CASE RADIUS	CASE RAMP FORCE	CASE STATIC PRESSURE	CLEAR-ANCE
1						-12.300	.869		12.00	-12.300	11.000		12.00	
2						-10.000	.869	.0	12.09	-10.000	11.000	.0	11.96	
3						-8.000	.869	.0	12.26	-8.000	11.000	.0	11.91	
4						-6.000	.869	.0	12.68	-6.000	11.000	.0	11.83	
5						-4.000	1.200	-27.6	12.93	-4.000	11.000	.0	11.68	
6						-2.000	2.140	-125.5	12.51	-2.000	11.000	.0	11.40	
7						.000	3.300	-235.3	11.23	.118	11.000	.0	10.95	
8	ROTOR	1	1022.6	1346.6	18	3.294	4.433	-333.1	12.98	3.298	11.000	.0	16.10	.4941
9						4.000	4.600	-61.8	13.09	4.000	11.000	.0	15.99	
10						5.000	4.812	-82.7	13.24	5.000	11.000	.0	15.71	
11						6.000	4.995	-74.6	13.28	6.000	11.000	.0	15.47	
12						7.000	5.120	-53.6	13.73	7.000	11.000	.0	15.10	
13						7.436	5.200	-35.6	13.71	7.381	11.000	.0	14.99	
14	STATOR	1	322.5	-1291.1	42	9.069	5.600	-194.4	14.93	9.122	11.000	.0	15.67	.2450
15						10.804	5.600	.0	15.08	10.804	11.000	.0	15.64	
16						12.000	5.600	.0	15.25	12.000	11.000	.0	15.45	
17						13.000	5.600	.0	15.27	13.000	11.000	.0	15.43	
18						14.500	5.600	.0	15.31	14.500	11.000	.0	15.34	

TOTAL COMPRESSOR AIRFOIL AXIAL LOAD	1345.2
TOTAL HUB RAMP FORCE	-835.8
TOTAL CASE RAMP FORCE	.0
TOTAL ROTOR THRUST	186.8
TOTAL COMPRESSOR THRUST	509.4
TOTAL ROTOR AIRFOIL AXIAL LOAD	1022.6
TOTAL ROTOR AIRFOIL PLATFORM LOAD	-333.1

27 APR 94 · STATION NO 8 · ROTOR NO. 1

Baseline Low Noise Fan
Aerodynamic Design Point

DATA REDUCTION · PAGE 1 · COPY 1 OF 1 · 16:10:32 94/117

MASS FLOW RATE 102.78 · HUB BLOCKAGE 99.8 PERCENT · HUB STATIC PRESSURE 12.98 · MASS AVE TOTAL PRESSURE 20.25
CORRECTED FLOW RATE 78.30 · TIP BLOCKAGE 99.0 PERCENT · TIP STATIC PRESSURE 16.10 · RPM 10417.4

SL NO	PER-CENT SPAN	INCI-DENCE	DEVI-ATION	INLET MACH NO.	EXIT MACH NO.	D-FACTOR	SHOCK LOSS COEF.	PROFILE LOSS COEF.	PROFILE PARA-METER	INLET FREE STRM A/ A*	MIN. PASS-AGE A/ A*	1ST CAP. MACH WAVE INCID.	LOAD COEF.	FLOW COEF.	EXIT RADIUS	DELTA DEVI-ATION	
1	.3	-3.03	7.97	.691	.545	.326		.0509	.00985	1.101	.938		1.438	2.028	4.454	3.10	1
3	4.8	-2.15	7.65	.706	.537	.351		.0479	.00995	1.090	.980		1.244	1.873	4.747	2.79	3
5	11.9	-1.06	6.92	.731	.532	.381		.0454	.01029	1.074	1.017		1.034	1.666	5.212	2.18	5
7	20.9	.35	5.82	.766	.536	.410		.0426	.01051	1.054	1.031		.886	1.464	5.803	1.25	7
9	31.1	1.10	5.25	.807	.550	.434		.0403	.01071	1.035	1.037		.790	1.290	6.472	.62	9
11	41.9	1.53	4.90	.855	.572	.450		.0383	.01083	1.019	1.039		.711	1.145	7.186	.19	11
13	53.1	1.84	4.66	.907	.601	.457	.0002	.0371	.01096	1.008	1.042		.642	1.026	7.920	-.09	13
15	64.4	2.00	4.64	.962	.636	.456	.0016	.0382	.01159	1.001	1.043		.574	.928	8.665	-.04	15
17	75.9	2.00	4.52	1.021	.675	.450	.0050	.0420	.01293	1.000	1.041	1.72	.513	.844	9.418	-.04	17
19	87.5	2.00	4.62	1.081	.718	.439	.0067	.0486	.01488	1.005	1.036	1.78	.455	.773	10.177	.26	19
21	99.3	2.00	5.02	1.143	.764	.423	.0100	.0583	.01735	1.016	1.036	1.92	.394	.710	10.952	1.06	21

STATOR NO. 1 AT STATION NO. 14

MASS FLOW RATE 102.78 · HUB BLOCKAGE 99.3 PERCENT · HUB STATIC PRESSURE 14.93 · MASS AVE TOTAL PRESSURE 20.01
CORRECTED FLOW RATE 79.22 · TIP BLOCKAGE 99.2 PERCENT · TIP STATIC PRESSURE 15.67

SL NO	PER-CENT SPAN	INCI-DENCE	DEVI-ATION	INLET MACH NO.	EXIT MACH NO.	D-FACTOR	SHOCK LOSS COEF.	PROFILE LOSS COEF.	PROFILE PARA-METER	INLET FREE STRM A/ A*	MIN. PASS-AGE A/ A*	1ST CAP. MACH WAVE INCID.	EXIT RADIUS	DELTA DEVI-ATION	
1	1.0	.70	5.63	.610	.446	.376		.1291	.02904	1.177	1.175		5.655	.00	1
3	5.6	.77	5.65	.612	.457	.364		.1073	.02524	1.175	1.173		5.900	.00	3
5	12.8	.89	5.73	.617	.474	.350		.0803	.02020	1.169	1.169		6.290	.00	5
7	21.8	1.05	6.04	.636	.504	.334		.0561	.01528	1.149	1.153		6.778	.00	7
9	31.9	1.22	6.53	.665	.545	.321		.0389	.01149	1.122	1.130		7.322	.00	9
11	42.5	1.40	7.03	.695	.585	.311		.0290	.00930	1.098	1.110		7.892	.00	11
13	53.3	1.59	7.51	.722	.621	.305		.0255	.00882	1.079	1.094		8.477	.00	13
15	64.3	1.79	7.88	.739	.646	.303		.0272	.01012	1.069	1.087		9.074	.00	15
17	75.7	1.99	8.24	.748	.663	.303		.0334	.01330	1.063	1.083		9.686	.00	17
19	87.3	2.19	8.53	.748	.671	.302		[illegible]	.01843	1.063	1.084		10.314	.00	19
21	99.4	2.40	8.74	.731	.662	.303		.0570	.02583	1.073	1.095		10.968	.00	21

AIRFOIL	MASS AVERAGED D-FACTOR	STAGE REACTION	MEANLINE SOLIDITY	MASS AVERAGED A/A* FREE STREAM	MASS AVERAGED A/A* MIN PASSAGE
ROTOR 1	.4352	.8958	1.655	1.019	1.035
STATOR 1	.3125		1.562	1.091	1.105
	--------		------		
AVERAGE	.3739		1.609		

Baseline Low Noise Fan
Aerodynamic Design Point

STAGE	LOAD COEFFICIENT	FLOW COEFFICIENT	STAGE ADIABATIC EFFICIENCY VANE TO VANE	STAGE PRESSURE RATIO VANE TO VANE	STAGE TEMPERATURE RISE VANE TO VANE
1	.707	1.063	94.11	1.378	52.89

STAGE 1

S.L. NO.	PRESSURE RATIO V - V	TEMPERATURE RISE V - V	ADIABATIC EFFICIENCY V - V
1	1.200	29.81	92.93
3	1.206	30.61	93.29
5	1.218	32.18	93.57
7	1.245	35.58	94.09
9	1.285	40.77	94.66
11	1.331	46.47	95.09
13	1.377	52.12	95.30
15	1.414	56.87	94.94
17	1.443	61.08	93.88
19	1.461	64.16	92.51
21	1.456	65.22	90.11

APPENDIX B

LOW NOISE FAN CONFIGURATION NO. 2:
AERODYNAMIC DESIGN POINT
BLADE AND VANE ELEMENT PERFORMANCE AND GEOMETRY OUTPUT

10 APR 95 ***** Baseline Low Noise Fan ***** INTERSTAGE DATA
STATION NO. 1 Aerodynamic Design Point PAGE 1
ANNULUS EXIT 1 15:45:31 95/100 COPY 1 OF 1

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 39.18 (CORRECTED) MASS AVE. TOTAL PRESSURE 14.70
CORRECTED FLOW RATE 102.78 ANNULUS AREA 2.62 SQ. FT = 377.8 SQ.IN MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
.869	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	.0	1
1.882	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	10.0	3
2.895	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	20.0	5
3.908	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	30.0	7
4.921	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	40.0	9
5.934	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	50.0	11
6.947	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	60.0	13
7.961	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	70.0	15
8.974	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	80.0	17
9.987	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	90.0	19
11.000	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	100.0	21

ANNULUS 2

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 39.18 (CORRECTED) MASS AVE. TOTAL PRESSURE 14.70
CORRECTED FLOW RATE 102.78 ANNULUS AREA 2.62 SQ. FT = 377.8 SQ.IN MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
.877	581.7	.0	2.02	14.70	12.09	518.7	490.5	581.7	.536	581.7	.1	1
1.894	582.9	.0	4.36	14.70	12.08	518.7	490.3	583.0	.537	583.0	10.1	3
2.911	585.0	.0	5.59	14.70	12.06	518.7	490.1	585.1	.539	585.1	20.2	5
3.926	587.4	.0	6.05	14.70	12.04	518.7	489.9	587.5	.541	587.5	30.2	7
4.939	589.8	.0	5.90	14.70	12.02	518.7	489.7	589.8	.544	589.8	40.2	9
5.950	592.0	.0	5.24	14.70	12.00	518.7	489.5	592.0	.546	592.0	50.2	11
6.959	593.8	.0	4.19	14.70	11.99	518.7	489.3	593.8	.548	593.8	60.1	13
7.968	595.3	.0	2.86	14.70	11.97	518.7	489.1	595.3	.549	595.3	70.1	15
8.976	596.2	.0	1.36	14.70	11.97	518.7	489.0	596.2	.550	596.2	80.0	17
9.984	596.7	.0	-.23	14.70	11.96	518.7	489.0	596.7	.550	596.7	90.0	19
10.992	596.7	.0	-1.81	14.70	11.96	518.7	489.0	596.7	.550	596.7	99.9	21

10 APR 95 * * * * Baseline Low Noise Fan * * * * INTERSTAGE DATA
STATION NO. 3 * * * * * * Aerodynamic Design Point * * * * * * PAGE 2
ANNULUS EXIT 3 * * * * * * * * 15:45:31 95/100 COPY 1 OF 1

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 39.18 (CORRECTED) MASS AVE. TOTAL PRESSURE 14.70
CORRECTED FLOW RATE 102.78 ANNULUS AREA 2.62 SQ. FT = 377.7 SQ.IN MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
.884	560.6	.0	2.66	14.70	12.26	518.7	492.5	560.6	.515	560.6	.1	1
1.913	569.1	.0	9.90	14.70	12.19	518.7	491.7	569.2	.523	569.2	10.3	3
2.934	576.0	.0	12.54	14.70	12.13	518.7	491.0	576.2	.530	576.2	20.4	5
3.951	582.1	.0	13.10	14.70	12.08	518.7	490.4	582.3	.536	582.3	30.4	7
4.963	587.5	.0	12.39	14.70	12.04	518.7	489.9	587.6	.541	587.6	40.4	9
5.971	592.0	.0	10.85	14.70	12.00	518.7	489.4	592.1	.546	592.1	50.4	11
6.977	595.7	.0	8.77	14.70	11.97	518.7	489.1	595.7	.549	595.7	60.3	13
7.980	598.5	.0	6.36	14.70	11.95	518.7	488.8	598.5	.552	598.5	70.2	15
8.983	600.5	.0	3.77	14.70	11.93	518.7	488.6	600.5	.554	600.5	80.1	17
9.985	601.8	.0	1.14	14.70	11.92	518.7	488.5	601.8	.555	601.8	90.0	19
10.987	602.3	.0	-1.44	14.70	11.91	518.7	488.4	602.3	.556	602.3	99.9	21

ANNULUS 4

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 39.19 (CORRECTED) MASS AVE. TOTAL PRESSURE 14.70
CORRECTED FLOW RATE 102.78 ANNULUS AREA 2.62 SQ. FT = 377.6 SQ.IN MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
.896	505.0	.0	43.58	14.70	12.68	518.7	497.3	506.9	.464	506.9	.3	1
1.964	534.7	.0	36.96	14.70	12.46	518.7	494.7	536.0	.491	536.0	10.8	3
2.998	555.4	.0	34.35	14.70	12.30	518.7	492.9	556.4	.511	556.4	21.0	5
4.016	571.0	.0	31.19	14.70	12.17	518.7	491.4	571.9	.526	571.9	31.1	7
5.023	583.2	.0	27.22	14.70	12.07	518.7	490.3	583.9	.538	583.9	41.0	9
6.023	592.8	.0	22.69	14.70	11.99	518.7	489.3	593.2	.547	593.2	50.9	11
7.018	600.1	.0	17.86	14.70	11.93	518.7	488.6	600.3	.554	600.3	60.7	13
8.011	605.5	.0	12.92	14.70	11.88	518.7	488.1	605.6	.559	605.6	70.5	15
9.001	609.2	.0	8.03	14.70	11.85	518.7	487.7	609.2	.563	609.2	80.3	17
9.992	611.3	.0	3.30	14.70	11.84	518.7	487.5	611.3	.565	611.3	90.0	19
10.982	612.1	.0	-1.15	14.70	11.83	518.7	487.4	612.1	.565	612.1	99.8	21

10 APR 95 * * * * Baseline Low Noise Fan * * * * INTERSTAGE DATA
STATION NO. 5 * * * * * Aerodynamic Design Point * * * * * PAGE 3
ANNULUS EXIT 5 * * * * * * * * 15:45:31 95/100 COPY 1 OF 1

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 39.46 (CORRECTED) MASS AVE. TOTAL PRESSURE 14.70
CORRECTED FLOW RATE 102.78 ANNULUS AREA 2.60 SQ. FT = 375.0 SQ.IN MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
1.229	451.3	.0	141.95	14.70	12.93	518.7	500.0	473.1	.431	473.1	.3	1
2.189	501.0	.0	105.93	14.70	12.64	518.7	496.8	512.1	.469	512.1	10.1	3
3.182	537.9	.0	84.75	14.70	12.39	518.7	494.0	544.6	.500	544.6	20.2	5
4.169	565.2	.0	69.19	14.70	12.19	518.7	491.6	569.4	.524	569.4	30.3	7
5.150	585.4	.0	56.24	14.70	12.03	518.7	489.8	588.1	.542	588.1	40.3	9
6.124	600.4	.0	44.78	14.70	11.91	518.7	488.5	602.1	.556	602.1	50.2	11
7.096	611.4	.0	34.31	14.70	11.83	518.7	487.4	612.4	.566	612.4	60.2	13
8.066	619.3	.0	24.60	14.70	11.76	518.7	486.7	619.8	.573	619.8	70.1	15
9.036	624.5	.0	15.53	14.70	11.72	518.7	486.1	624.7	.578	624.7	80.0	17
10.006	627.6	.0	7.08	14.70	11.69	518.7	485.8	627.6	.581	627.6	89.9	19
10.979	628.7	.0	-.73	14.70	11.68	518.7	485.7	628.7	.582	628.7	99.8	21

ANNULUS 6

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 40.62 (CORRECTED) MASS AVE. TOTAL PRESSURE 14.70
CORRECTED FLOW RATE 102.78 ANNULUS AREA 2.53 SQ. FT = 364.3 SQ.IN MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
2.154	470.0	.0	244.25	14.70	12.51	518.7	495.3	529.7	.485	529.7	.2	1
2.809	514.5	.0	194.82	14.70	12.35	518.7	493.4	550.2	.505	550.2	7.6	3
3.628	553.6	.0	153.26	14.70	12.15	518.7	491.2	574.4	.529	574.4	16.8	5
4.505	584.0	.0	119.97	14.70	11.97	518.7	489.0	596.2	.550	596.2	26.7	7
5.407	607.2	.0	93.30	14.70	11.81	518.7	487.2	614.4	.568	614.4	36.9	9
6.321	625.1	.0	71.55	14.70	11.68	518.7	485.7	629.1	.582	629.1	47.2	11
7.243	638.6	.0	53.33	14.70	11.58	518.7	484.4	640.9	.594	640.9	57.6	13
8.170	648.7	.0	37.61	14.70	11.50	518.7	483.5	649.7	.603	649.7	68.1	15
9.101	655.5	.0	23.71	14.70	11.44	518.7	482.8	655.9	.609	655.9	78.6	17
10.037	659.4	.0	11.16	14.70	11.41	518.7	482.4	659.4	.612	659.4	89.1	19
10.978	660.4	.0	-.30	14.70	11.40	518.7	482.3	660.4	.613	660.4	99.7	21

10 APR 95 * * * * Baseline Low Noise Fan * * * * INTERSTAGE DATA
STATION NO. 7 * * * * * Aerodynamic Design Point * * * * * PAGE 4
ANNULUS EXIT 7 * * * * * * * * 15:45:31 95/100 COPY 1 OF 1

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 43.13 (CORRECTED) MASS AVE. TOTAL PRESSURE 14.70
CORRECTED FLOW RATE 102.78 ANNULUS AREA 2.38 SQ. FT = 343.2 SQ.IN MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
3.308	610.2	.0	299.13	14.70	11.22	518.7	480.2	679.5	.632	679.5	.1	1
3.707	631.5	.0	250.93	14.70	11.22	518.7	480.2	679.5	.632	679.5	5.3	3
4.295	651.1	.0	202.29	14.70	11.20	518.7	479.9	681.8	.635	681.8	12.9	5
4.998	666.0	.0	161.87	14.70	11.17	518.7	479.5	685.4	.638	685.4	22.1	7
5.772	677.4	.0	129.42	14.70	11.13	518.7	479.0	689.7	.643	689.7	32.1	9
6.590	686.6	.0	102.53	14.70	11.09	518.7	478.5	694.2	.647	694.2	42.7	11
7.436	694.1	.0	78.91	14.70	11.05	518.7	478.0	698.5	.652	698.5	53.7	13
8.303	700.0	.0	57.11	14.70	11.01	518.7	477.5	702.4	.655	702.4	65.0	15
9.184	704.5	.0	36.37	14.70	10.98	518.7	477.2	705.4	.659	705.4	76.4	17
10.076	707.2	.0	16.32	14.70	10.96	518.7	476.9	707.4	.661	707.4	88.0	19
10.977	708.4	.0	-2.48	14.70	10.95	518.7	476.8	708.4	.662	708.4	99.7	21

10 APR 95 ★★★★ Baseline Low Noise Fan ★★★★ INTERSTAGE DATA
STATION NO. 8 Aerodynamic Design Point 15:45:31 95/100 PAGE 5
ROTOR EXIT 1 COPY 1 OF 1

MASS FLOW RATE 102.78
CORRECTED FLOW RATE 78.32
CORRECTED TIP SPEED 1000. FT/SEC
PRESSURE RATIO 1.377

FLOW RATE/SQ. FT. 35.56 (CORRECTED)
ANNULUS AREA 2.20 SQ. FT = 317.2 SQ.IN
CUMULATIVE ADIABATIC EFFICIENCY 94.1

MASS AVE. TOTAL PRESSURE 20.24
MASS AVE. TOTAL TEMPERATURE 571.5
ROTOR ADIABATIC EFFICIENCY 94.1

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
4.453	587.0	441.7	151.40	17.63	12.90	548.5	501.6	750.0	.683	606.2	.3	1
4.743	583.7	425.6	138.26	17.72	13.14	549.2	504.2	735.5	.668	599.9	4.7	3
5.205	579.9	407.1	120.92	17.90	13.47	550.8	507.7	718.8	.651	592.4	11.8	5
5.791	579.9	404.6	103.36	18.28	13.83	554.1	511.6	714.6	.644	589.0	20.7	7
6.457	586.1	415.5	87.04	18.88	14.21	559.3	515.7	723.7	.650	592.5	30.8	9
7.169	596.2	426.8	71.81	19.55	14.60	565.0	519.8	736.7	.659	600.5	41.7	11
7.905	608.7	434.7	57.45	20.22	14.99	570.7	523.8	750.2	.669	611.4	52.9	13
8.652	619.0	433.8	43.53	20.77	15.34	575.5	527.8	757.2	.672	620.6	64.2	15
9.408	627.2	428.6	30.22	21.21	15.66	579.7	531.6	760.2	.673	627.9	75.8	17
10.171	630.9	416.7	17.62	21.47	15.93	582.8	535.2	756.3	.667	631.1	87.4	19
10.950	621.1	394.1	6.05	21.40	16.16	584.0	538.9	735.6	.646	621.2	99.2	21

RELATIVE MACH NOS. INLET	RELATIVE MACH NOS. EXIT	TOTAL TEMP RISE	TOTAL TEMP RATIO	WHEEL SPEED IN	WHEEL SPEED OUT	ROTOR PRESSURE RATIO	ROTOR ADIABATIC EFFICIENCY	ROTOR POLYTROPIC EFFICIENCY	
.692	.553	29.79	1.057	300.7	404.8	1.200	93.0	93.2	1
.706	.545	30.57	1.059	337.0	431.2	1.206	93.4	93.6	3
.731	.539	32.09	1.062	390.5	473.2	1.218	93.7	93.9	5
.766	.542	35.48	1.068	454.4	526.4	1.244	94.2	94.4	7
.807	.554	40.63	1.078	524.7	587.0	1.284	94.7	94.9	9
.855	.574	46.33	1.089	599.1	651.7	1.330	95.1	95.3	11
.907	.601	52.02	1.100	676.0	718.6	1.376	95.3	95.5	13
.962	.634	56.82	1.110	754.8	786.5	1.414	94.9	95.2	15
1.020	.672	61.03	1.118	834.9	855.2	1.443	93.9	94.2	17
1.081	.714	64.16	1.124	916.0	924.6	1.461	92.5	92.9	19
1.143	.760	65.31	1.126	997.9	995.5	1.456	90.0	90.5	21

S.L. NO.	DIFFUSION FACTOR	OMEGA BAR	DELTA PS/Q	SOLIDITY	TOTAL TURNING	ABSOLUTE FLOW ANGLE INLET	ABSOLUTE FLOW ANGLE EXIT	K.&S. EQU. DIFFUSION FACTOR	RELATIVE FLOW ANGLE INLET	RELATIVE FLOW ANGLE EXIT	RELATIVE VELOCITY INLET	RELATIVE VELOCITY EXIT	RELATIVE TEMPERATURE INLET	RELATIVE TEMPERATURE EXIT
1	.315	.050	.396	2.580	27.35	.00	36.08	1.267	23.87	-3.48	743.1	607.3	526.	532.
3	.340	.047	.432	2.407	25.84	.00	35.35	1.303	26.38	.54	758.5	599.9	528.	534.
5	.371	.044	.472	2.192	23.44	.00	34.50	1.353	29.80	6.36	785.7	596.0	531.	537.
7	.402	.042	.501	1.985	21.85	.00	34.48	1.405	33.54	11.69	822.3	601.5	536.	542.
9	.428	.040	.516	1.806	21.12	.00	35.04	1.454	37.26	16.14	866.6	616.8	542.	547.
11	.447	.038	.517	1.657	20.26	.00	35.40	1.493	40.79	20.54	916.9	641.3	549.	554.
13	.457	.037	.506	1.534	19.15	.00	35.41	1.519	44.06	24.91	972.1	674.1	557.	562.
15	.458	.040	.484	1.432	17.45	.00	34.96	1.531	47.06	29.61	1031.1	713.8	566.	570.
17	.453	.047	.453	1.346	15.61	.00	34.32	1.531	49.81	34.19	1093.0	759.1	577.	580.
19	.442	.055	.418	1.274	13.50	.00	33.44	1.521	52.32	38.82	1157.4	810.1	589.	590.
21	.426	.069	.379	1.212	10.56	.00	32.39	1.501	54.63	44.08	1223.8	864.6	602.	601.

STATION NO. 9
ANNULUS EXIT 9

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 36.06 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.24
CORRECTED FLOW RATE 78.32 ANNULUS AREA 2.17 SQ. FT = 312.8 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
4.622	590.2	425.6	134.61	17.63	13.01	548.5	502.8	740.0	.673	605.3	.3	1
4.899	588.3	412.1	123.67	17.72	13.21	549.2	505.0	728.9	.661	601.2	4.7	3
5.342	586.3	396.7	108.38	17.90	13.49	550.8	508.0	716.1	.648	596.2	11.6	5
5.907	588.2	396.6	92.20	18.28	13.82	554.1	511.5	715.4	.645	595.4	20.4	7
6.552	596.0	409.5	76.80	18.88	14.17	559.3	515.3	727.2	.653	600.9	30.5	9
7.245	607.2	422.3	62.43	19.55	14.53	565.0	519.1	742.2	.664	610.4	41.3	11
7.963	620.2	431.5	49.23	20.22	14.90	570.7	523.0	757.1	.675	622.2	52.6	13
8.695	630.6	431.6	36.93	20.77	15.24	575.5	526.8	765.1	.680	631.7	64.0	15
9.438	638.5	427.2	25.60	21.21	15.55	579.7	530.5	768.7	.681	639.0	75.6	17
10.190	641.5	416.0	15.22	21.47	15.82	582.8	534.2	764.7	.675	641.6	87.3	19
10.960	630.6	393.7	5.58	21.40	16.06	584.0	538.0	743.4	.654	630.6	99.4	21

ANNULUS 10

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 36.76 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.24
CORRECTED FLOW RATE 78.32 ANNULUS AREA 2.13 SQ. FT = 306.8 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
4.835	600.9	406.8	118.52	17.63	13.06	548.5	503.4	735.3	.668	612.5	.4	1
5.095	599.8	396.2	108.04	17.72	13.23	549.2	505.2	726.9	.660	609.5	4.6	3
5.514	598.5	384.3	93.58	17.90	13.48	550.8	507.9	717.4	.649	605.8	11.3	5
6.053	601.5	387.1	78.72	18.28	13.77	554.1	511.0	719.6	.649	606.6	20.0	7
6.672	610.5	402.1	65.05	18.88	14.09	559.3	514.4	733.9	.660	614.0	30.1	9
7.341	622.9	416.8	52.63	19.55	14.42	565.0	518.0	751.3	.673	625.1	40.9	11
8.037	637.1	427.5	41.29	20.22	14.76	570.7	521.5	768.4	.686	638.5	52.1	13
8.749	648.7	429.0	30.58	20.77	15.07	575.5	525.1	778.3	.693	649.4	63.6	15
9.473	657.4	425.6	20.39	21.21	15.35	579.7	528.6	783.4	.695	657.7	75.3	17
10.208	660.9	415.2	10.56	21.47	15.61	582.8	532.1	780.6	.690	661.0	87.2	19
10.962	650.3	393.6	.75	21.40	15.84	584.0	535.9	760.2	.670	650.3	99.4	21

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 37.42 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.24
CORRECTED FLOW RATE 78.32 ANNULUS AREA 2.09 SQ. FT = 301.4 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.016	628.0	392.1	96.62	17.63	12.94	548.5	502.0	746.7	.680	635.4	.4	1
5.259	623.7	383.9	87.17	17.72	13.12	549.2	503.9	737.6	.670	629.8	4.4	3
5.654	618.5	374.8	74.53	17.90	13.37	550.8	506.7	727.0	.659	623.0	11.0	5
6.169	618.5	379.8	62.04	18.28	13.67	554.1	509.9	728.4	.658	621.6	19.5	7
6.765	625.8	396.6	50.93	18.88	13.99	559.3	513.4	742.6	.668	627.8	29.5	9
7.414	637.5	412.7	41.05	19.55	14.31	565.0	516.8	760.5	.682	638.8	40.3	11
8.093	651.6	424.5	32.12	20.22	14.63	570.7	520.2	778.4	.696	652.4	51.6	13
8.790	663.5	427.0	23.71	20.77	14.93	575.5	523.6	789.4	.704	663.9	63.2	15
9.500	672.9	424.4	15.69	21.21	15.19	579.7	527.0	795.7	.707	673.1	75.0	17
10.222	677.4	414.7	7.91	21.47	15.43	582.8	530.3	794.3	.703	677.4	87.0	19
10.962	668.5	393.6	.02	21.40	15.63	584.0	533.9	775.8	.685	668.5	99.4	21

ANNULUS 12

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 37.90 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.24
CORRECTED FLOW RATE 78.32 ANNULUS AREA 2.07 SQ. FT = 297.6 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.142	645.2	382.5	48.39	17.63	12.88	548.5	501.4	751.6	.685	647.0	.4	1
5.374	638.6	375.6	46.34	17.72	13.06	549.2	503.3	742.3	.675	640.3	4.3	3
5.755	631.0	368.2	43.34	17.90	13.32	550.8	506.1	731.8	.663	632.5	10.8	5
6.253	629.6	374.7	39.87	18.28	13.61	554.1	509.3	733.7	.663	630.8	19.3	7
6.835	636.6	392.5	35.85	18.88	13.91	559.3	512.6	748.7	.674	637.6	29.2	9
7.470	648.7	409.6	31.04	19.55	14.22	565.0	515.9	767.8	.689	649.4	40.0	11
8.136	663.6	422.3	25.54	20.22	14.52	570.7	519.1	787.0	.704	664.1	51.3	13
8.821	676.2	425.5	19.43	20.77	14.80	575.5	522.3	799.2	.713	676.5	62.9	15
9.520	686.2	423.5	13.02	21.21	15.05	579.7	525.6	806.5	.718	686.4	74.8	17
10.232	691.2	414.3	6.49	21.47	15.27	582.8	528.8	805.8	.715	691.2	86.9	19
10.962	682.8	393.6	-.15	21.40	15.47	584.0	532.3	788.1	.697	682.8	99.4	21

10 APR 95 * * * * Baseline Low Noise Fan * * * * INTERSTAGE DATA
STATION NO. 13 * * * * * Aerodynamic Design Point * * * * * PAGE 8
ANNULUS EXIT 13 * * * * * * * * 15:45:31 95/100 COPY 1 OF 1

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 37.94 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.24
CORRECTED FLOW RATE 78.32 ANNULUS AREA 2.06 SQ. FT = 297.3 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.166	613.4	380.7	9.80	17.63	13.21	548.5	505.0	722.0	.655	613.4	.5	1
5.404	611.5	373.5	13.65	17.72	13.35	549.2	506.5	716.7	.649	611.6	4.6	3
5.792	610.6	365.9	18.10	17.90	13.54	550.8	508.5	712.0	.644	610.9	11.2	5
6.295	616.8	372.2	21.37	18.28	13.76	554.1	510.9	720.7	.650	617.2	19.8	7
6.878	631.2	390.1	22.55	18.88	13.99	559.3	513.4	742.3	.668	631.6	29.7	9
7.510	649.5	407.4	21.52	19.55	14.23	565.0	516.0	767.0	.689	649.8	40.5	11
8.170	669.2	420.6	18.74	20.22	14.47	570.7	518.6	790.6	.708	669.4	51.8	13
8.847	685.4	424.2	14.71	20.77	14.70	575.5	521.4	806.2	.720	685.5	63.3	15
9.538	697.8	422.7	9.94	21.21	14.92	579.7	524.3	815.9	.727	697.9	75.1	17
10.241	704.3	413.9	4.83	21.47	15.12	582.8	527.3	817.0	.726	704.4	87.1	19
10.962	696.9	393.6	-.49	21.40	15.30	584.0	530.7	800.4	.709	696.9	99.4	21

ANNULUS 14

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 37.94 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.24
CORRECTED FLOW RATE 78.32 ANNULUS AREA 2.06 SQ. FT = 297.2 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.174	584.4	380.1	9.57	17.63	13.48	548.5	508.0	697.2	.631	584.5	.7	1
5.419	588.1	372.5	15.32	17.72	13.57	549.2	508.9	696.3	.630	588.3	4.9	3
5.814	594.5	364.4	21.88	17.90	13.70	550.8	510.2	697.6	.630	594.9	11.6	5
6.323	607.9	370.5	26.65	18.28	13.85	554.1	511.9	712.4	.642	608.5	20.3	7
6.907	628.3	388.5	28.42	18.88	14.03	559.3	513.8	739.2	.665	628.9	30.2	9
7.536	651.1	406.0	27.17	19.55	14.22	565.0	515.9	767.8	.689	651.7	40.9	11
8.192	674.1	419.4	23.62	20.22	14.43	570.7	518.2	794.3	.712	674.5	52.1	13
8.864	692.4	423.5	18.51	20.77	14.63	575.5	520.6	811.8	.726	692.7	63.6	15
9.548	706.3	422.2	12.60	21.21	14.82	579.7	523.3	823.0	.734	706.4	75.3	17
10.245	713.5	413.7	6.40	21.47	15.01	582.8	526.2	824.8	.733	713.6	87.1	19
10.961	706.4	393.7	.13	21.40	15.19	584.0	529.5	808.7	.717	706.4	99.3	21

10 APR 95 ***** Baseline Low Noise Fan ***** 15:45:31 95/100
STATION NO. 15 Aerodynamic Design Point
ANNULUS EXIT 15

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 37.95 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.24
CORRECTED FLOW RATE 78.32 ANNULUS AREA 2.06 SQ. FT = 297.2 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.199	537.7	378.3	23.10	17.63	13.90	548.5	512.4	657.9	.593	538.2	1.1	1
5.456	548.7	370.0	26.05	17.72	13.93	549.2	512.7	662.3	.597	549.3	5.5	3
5.865	565.5	361.3	29.43	17.90	13.98	550.8	513.2	671.7	.605	566.3	12.5	5
6.383	590.5	367.0	31.78	18.28	14.03	554.1	513.8	696.0	.626	591.4	21.3	7
6.969	621.8	385.0	32.06	18.88	14.11	559.3	514.7	732.1	.658	622.7	31.3	9
7.593	653.9	402.9	29.87	19.55	14.21	565.0	515.8	768.6	.690	654.6	41.9	11
8.240	683.8	417.0	25.65	20.22	14.33	570.7	517.2	801.4	.719	684.3	52.9	13
8.901	707.0	421.7	19.95	20.77	14.47	575.5	519.0	823.5	.737	707.3	64.2	15
9.574	723.8	421.1	13.49	21.21	14.62	579.7	521.3	837.5	.748	723.9	75.7	17
10.259	732.5	413.2	6.79	21.47	14.79	582.8	524.0	841.0	.749	732.5	87.4	19
10.962	725.8	393.6	.03	21.40	14.96	584.0	527.2	825.6	.733	725.8	99.4	21

ANNULUS 16

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 38.20 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.24
CORRECTED FLOW RATE 78.32 ANNULUS AREA 2.05 SQ. FT = 295.2 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.242	535.0	375.2	63.41	17.63	13.91	548.5	512.5	656.5	.591	538.8	.9	1
5.498	546.3	367.2	62.74	17.72	13.94	549.2	512.8	661.3	.596	549.9	5.3	3
5.905	564.1	358.9	61.44	17.90	13.98	550.8	513.2	671.4	.604	567.4	12.3	5
6.419	590.6	365.0	59.36	18.28	14.03	554.1	513.7	696.8	.627	593.6	21.1	7
7.001	624.1	383.3	55.44	18.88	14.08	559.3	514.4	734.5	.661	626.6	31.1	9
7.620	658.4	401.5	48.92	19.55	14.16	565.0	515.3	772.7	.694	660.2	41.8	11
8.261	690.3	415.9	40.22	20.22	14.26	570.7	516.5	806.9	.724	691.4	52.8	13
8.916	714.9	421.0	30.12	20.77	14.38	575.5	518.1	830.2	.744	715.6	64.1	15
9.584	732.6	420.7	19.58	21.21	14.52	579.7	520.2	845.1	.756	732.9	75.6	17
10.263	741.8	413.0	9.24	21.47	14.68	582.8	522.8	849.0	.757	741.8	87.3	19
10.961	735.3	393.7	-.33	21.40	14.85	584.0	526.1	834.1	.742	735.3	99.3	21

10 APR 95
STATION NO. 17 * * * * *
STATOR EXIT 1

Baseline Low Noise Fan
Aerodynamic Design Point

INTERSTAGE DATA
PAGE 10
COPY 1 OF 1

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MASS FLOW RATE 102.78
CORRECTED FLOW RATE 79.24
PRESSURE RATIO 1.362

FLOW RATE/SQ. FT. 40.62 (CORRECTED)
ANNULUS AREA 1.95 SQ. FT = 280.9 SQ.IN
CUMULATIVE ADIABATIC EFFICIENCY 90.5

MASS AVE. TOTAL PRESSURE 20.01
MASS AVE. TOTAL TEMPERATURE 571.5
STAGE ADIABATIC EFFICIENCY 90.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.681	493.6	.0	61.80	17.16	15.01	548.5	527.8	497.5	.442	497.5	1.3	1
5.925	507.5	.0	61.64	17.33	15.05	549.2	527.5	511.2	.454	511.2	5.9	3
6.313	528.2	.0	60.86	17.59	15.10	550.8	527.2	531.7	.472	531.7	13.1	5
6.799	564.8	.0	59.91	18.05	15.17	554.1	527.3	568.0	.504	568.0	22.1	7
7.339	613.7	.0	57.17	18.69	15.25	559.3	527.7	616.3	.547	616.3	32.1	9
7.906	662.0	.0	51.02	19.39	15.33	565.0	528.3	664.0	.589	664.0	42.6	11
8.487	705.4	.0	41.99	20.07	15.41	570.7	529.1	706.7	.627	706.7	53.4	13
9.080	736.4	.0	31.06	20.60	15.47	575.5	530.3	737.1	.653	737.1	64.4	15
9.688	758.1	.0	19.71	20.98	15.52	579.7	531.8	758.4	.671	758.4	75.7	17
10.313	769.1	.0	8.78	21.18	15.55	582.8	533.6	769.1	.679	769.1	87.3	19
10.964	760.4	.0	-.76	21.02	15.56	584.0	535.9	760.4	.670	760.4	99.3	21

ABSOLUTE MACH NOS. INLET	ABSOLUTE MACH NOS. EXIT	TOTAL TEMP RISE	TOTAL TEMP RATIO	WHEEL SPEED IN	WHEEL SPEED OUT	STAGE PRESSURE RATIO	STAGE ADIABATIC EFFICIENCY	STAGE POLYTROPIC EFFICIENCY	S.L. NO.
.591	.442	29.79	1.057	.0	.0	1.168	79.0	79.5	1
.596	.454	30.57	1.059	.0	.0	1.179	81.9	82.4	3
.604	.472	32.09	1.062	.0	.0	1.197	85.3	85.7	5
.627	.504	35.48	1.068	.0	.0	1.228	88.5	88.9	7
.661	.547	40.63	1.078	.0	.0	1.272	90.9	91.2	9
.694	.589	46.33	1.089	.0	.0	1.320	92.4	92.7	11
.724	.627	52.02	1.100	.0	.0	1.366	93.0	93.3	13
.744	.653	56.82	1.110	.0	.0	1.402	92.5	92.9	15
.756	.671	61.03	1.118	.0	.0	1.428	91.1	91.5	17
.757	.679	64.16	1.124	.0	.0	1.441	89.0	89.5	19
.742	.670	65.31	1.126	.0	.0	1.431	85.6	86.3	21

S.L. NO.	DIFFUSION FACTOR	OMEGA BAR	DELTA PS/Q	SOLIDITY	TOTAL TURNING	ABSOLUTE FLOW ANGLE INLET	ABSOLUTE FLOW ANGLE EXIT	K.&S. EQU. DIFFUSION FACTOR
1	.366	.125	.296	2.215	34.86	34.86	.00	1.481
3	.353	.104	.292	2.118	33.73	33.73	.00	1.464
5	.338	.078	.286	1.981	32.31	32.31	.00	1.445
7	.324	.054	.269	1.831	31.58	31.58	.00	1.425
9	.312	.038	.244	1.687	31.45	31.45	.00	1.409
11	.304	.028	.217	1.559	31.31	31.31	.00	1.398
13	.300	.025	.192	1.445	31.03	31.03	.00	1.391
15	.299	.027	.170	1.345	30.47	30.47	.00	1.387
17	.300	.033	.149	1.256	29.86	29.86	.00	1.386
19	.300	.043	.128	1.176	29.10	29.10	.00	1.385
21	.302	.057	.109	1.104	28.16	28.16	.00	1.385

10 APR 95 ***** Baseline Low Noise Fan ***** 15:45:31 95/100
STATION NO. 18 Aerodynamic Design Point
ANNULUS EXIT 18

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 40.52 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.01
CORRECTED FLOW RATE 79.24 ANNULUS AREA 1.96 SQ. FT = 281.6 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.668	489.8	.0	3.76	17.16	15.07	548.5	528.5	489.9	.435	489.9	1.3	1
5.913	504.5	.0	5.48	17.33	15.10	549.2	528.0	504.6	.448	504.6	5.8	3
6.303	526.2	.0	7.36	17.59	15.15	550.8	527.7	526.2	.467	526.2	13.0	5
6.789	563.6	.0	8.70	18.05	15.21	554.1	527.7	563.6	.500	563.6	22.0	7
7.330	612.8	.0	9.10	18.69	15.29	559.3	528.0	612.8	.544	612.8	32.0	9
7.896	661.0	.0	8.53	19.39	15.36	565.0	528.6	661.1	.586	661.1	42.5	11
8.477	704.1	.0	7.26	20.07	15.44	570.7	529.4	704.1	.624	704.1	53.3	13
9.071	734.8	.0	5.52	20.60	15.50	575.5	530.5	734.8	.651	734.8	64.3	15
9.681	756.3	.0	3.56	20.98	15.55	579.7	532.1	756.3	.669	756.3	75.6	17
10.307	767.2	.0	1.51	21.18	15.57	582.8	533.8	767.2	.677	767.2	87.2	19
10.959	758.4	.0	-.58	21.02	15.58	584.0	536.1	758.4	.668	758.4	99.2	21

ANNULUS 19

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 40.52 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.01
CORRECTED FLOW RATE 79.24 ANNULUS AREA 1.96 SQ. FT = 281.6 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.690	471.1	.0	1.46	17.16	15.22	548.5	530.0	471.1	.417	471.1	1.7	1
5.941	489.2	.0	2.98	17.33	15.23	549.2	529.3	489.2	.434	489.2	6.3	3
6.337	515.7	.0	4.77	17.59	15.24	550.8	528.6	515.8	.458	515.8	13.6	5
6.826	558.6	.0	6.18	18.05	15.26	554.1	528.2	558.6	.496	558.6	22.7	7
7.365	613.0	.0	6.84	18.69	15.28	559.3	528.0	613.1	.544	613.1	32.7	9
7.927	665.7	.0	6.66	19.39	15.31	565.0	528.1	665.7	.591	665.7	43.1	11
8.503	712.3	.0	5.80	20.07	15.34	570.7	528.4	712.3	.632	712.3	53.8	13
9.091	745.5	.0	4.43	20.60	15.36	575.5	529.2	745.5	.661	745.5	64.7	15
9.694	768.6	.0	2.77	20.98	15.39	579.7	530.5	768.6	.681	768.6	75.8	17
10.314	780.4	.0	.96	21.18	15.40	582.8	532.1	780.4	.690	780.4	87.3	19
10.960	771.9	.0	-.97	21.02	15.41	584.0	534.4	771.9	.681	771.9	99.3	21

10 APR 95 * * * * Baseline Low Noise Fan * * * *
STATION NO. 20 * * * * * Aerodynamic Design Point * * * * *
ANNULUS EXIT 20 * * * * * * * * INTERSTAGE DATA

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MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 40.52 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.01
CORRECTED FLOW RATE 79.24 ANNULUS AREA 1.96 SQ. FT = 281.6 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.680	468.8	.0	-1.96	17.16	15.24	548.5	530.2	468.8	.415	468.8	1.5	1
5.933	487.2	.0	-1.41	17.33	15.25	549.2	529.5	487.2	.432	487.2	6.2	3
6.330	514.1	.0	-.69	17.59	15.25	550.8	528.8	514.1	.456	514.1	13.5	5
6.821	557.4	.0	-.06	18.05	15.27	554.1	528.3	557.4	.495	557.4	22.6	7
7.361	612.2	.0	.32	18.69	15.29	559.3	528.1	612.2	.543	612.2	32.6	9
7.924	665.3	.0	.42	19.39	15.32	565.0	528.1	665.3	.590	665.3	43.0	11
8.500	712.1	.0	.27	20.07	15.34	570.7	528.5	712.1	.632	712.1	53.7	13
9.088	745.6	.0	-.07	20.60	15.36	575.5	529.2	745.6	.661	745.6	64.6	15
9.691	768.9	.0	-.54	20.98	15.38	579.7	530.5	768.9	.681	768.9	75.8	17
10.311	781.0	.0	-1.10	21.18	15.39	582.8	532.1	781.0	.691	781.0	87.2	19
10.957	772.8	.0	-1.73	21.02	15.40	584.0	534.3	772.8	.682	772.8	99.2	21

ANNULUS 21

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 40.52 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.01
CORRECTED FLOW RATE 79.24 ANNULUS AREA 1.96 SQ. FT = 281.6 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.686	463.5	.0	.00	17.16	15.28	548.5	530.6	463.5	.410	463.5	1.6	1
5.941	482.4	.0	.00	17.33	15.29	549.2	529.9	482.4	.427	482.4	6.3	3
6.340	510.3	.0	.00	17.59	15.29	550.8	529.1	510.3	.452	510.3	13.7	5
6.832	555.1	.0	.00	18.05	15.29	554.1	528.5	555.1	.493	555.1	22.8	7
7.372	611.8	.0	.00	18.69	15.30	559.3	528.1	611.8	.543	611.8	32.8	9
7.934	666.6	.0	.00	19.39	15.30	565.0	528.0	666.6	.592	666.6	43.2	11
8.509	715.2	.0	.00	20.07	15.30	570.7	528.1	715.2	.635	715.2	53.9	13
9.095	750.1	.0	.00	20.60	15.31	575.5	528.7	750.1	.665	750.1	64.7	15
9.695	774.5	.0	.00	20.98	15.31	579.7	529.8	774.5	.686	774.5	75.8	17
10.312	787.2	.0	.00	21.18	15.31	582.8	531.2	787.2	.697	787.2	87.3	19
10.955	779.4	.0	.00	21.02	15.31	584.0	533.4	779.4	.688	779.4	99.2	21

		D-FACTOR HUB	D-FACTOR MEAN	D-FACTOR TIP	EQUIVALENT DIFFUSION FACTOR HUB	EQUIVALENT DIFFUSION FACTOR MEAN	EQUIVALENT DIFFUSION FACTOR TIP	LOAD COEFFICIENT (MEAN WHEEL SPEED) HUB	LOAD COEFFICIENT (MEAN WHEEL SPEED) MEAN	LOAD COEFFICIENT (MEAN WHEEL SPEED) TIP	MACH NO.	SPECIFIC FLOW IN	SPECIFIC FLOW OUT	FLOW COEFF.
ROTOR	1	.315	.447	.426	1.452	1.566	1.506	.498	.775	1.093	1.143	43.13	35.56	1.146
STATOR	1	.366	.304	.302	1.526	1.516	1.531				.591	38.20	40.62	

		PRESSURE RATIO	CUMULATIVE PRESSURE RATIO	ADIABATIC EFFICIENCY	CUMULATIVE ADIABATIC EFFICIENCY	EXIT FLOW ANGLE HUB	EXIT FLOW ANGLE TIP	TOTAL TURNING HUB	TOTAL TURNING TIP	INLET AXIAL VELOCITY MEAN	HORSE POWER
ROTOR	1	1.377	1.377	94.1	94.1	-3.5	44.1	27.3	10.6	686.6	1843.6
STATOR	1	1.362	1.362	90.5	90.5	.0	.0	34.9	28.2	658.4	

10 APR 95 * * * * * * * * * * * * * * Baseline Low Noise Fan Aerodynamic Design Point * * * * * * * * * * * * * * 15:45:31 95/100 FLOW PATH INFO COPY 1 OF 1

ALL DIMENSIONS ARE IN INCHES

STA NO.		AXIAL COORDINATE		AXIAL LENGTH		RADIUS		AREA	DISPLACEMENT THICKNESS		SHAPE FACTOR		BLOCKAGE FACTOR		AXIAL VELOCITY	
		HUB	TIP	HUB	TIP	HUB	TIP		HUB	TIP	HUB	TIP	HUB	TIP	HUB	TIP
1		-12.300	-12.300			.869	11.000	377.76	.000	.000	1.40	1.40	1.000	1.000	592.	592.
2		-10.000	-10.000	2.300	2.300	.869	11.000	377.76	.008	.008	1.55	1.55	1.000	.999	582.	597.
3		-8.000	-8.000	2.000	2.000	.869	11.000	377.76	.015	.013	1.53	1.53	1.000	.998	561.	602.
4		-6.000	-6.000	2.000	2.000	.869	11.000	377.76	.027	.018	1.58	1.52	1.000	.997	505.	612.
5		-4.000	-4.000	2.000	2.000	1.200	11.000	375.61	.029	.021	1.53	1.51	.999	.996	451.	629.
6		-2.000	-2.000	2.000	2.000	2.140	11.000	365.75	.014	.022	1.44	1.50	.999	.996	470.	660.
7		.000	.118	2.000	2.118	3.300	11.000	345.96	.008	.023	1.54	1.52	1.000	.995	610.	708.
8	ROTOR	3.294	3.298	3.294	3.180	4.433	11.000	318.40	.020	.050	1.58	1.81	.998	.989	587.	621.
9		4.000	4.000	.706	.702	4.600	11.000	313.66	.022	.040	1.59	1.47	.998	.991	590.	631.
10		5.000	5.000	1.000	1.000	4.812	11.000	307.37	.022	.038	1.56	1.46	.998	.991	601.	650.
11		6.000	6.000	1.000	1.000	4.995	11.000	301.75	.021	.038	1.53	1.48	.998	.991	628.	668.
12		7.000	7.000	1.000	1.000	5.120	11.000	297.78	.022	.038	1.56	1.50	.998	.991	645.	683.
13		8.000	8.000	1.000	1.000	5.134	11.000	297.33	.032	.038	1.71	1.51	.997	.991	613.	697.
14		9.000	9.000	1.000	1.000	5.134	11.000	297.33	.040	.039	1.71	1.54	.996	.991	584.	706.
15		10.000	10.000	1.000	1.000	5.134	11.000	297.33	.065	.038	1.99	1.51	.993	.991	538.	726.
16		10.753	10.707	.753	.707	5.192	11.000	295.46	.050	.039	1.49	1.54	.994	.991	535.	735.
17	VANE	12.452	12.496	1.700	1.789	5.608	11.000	281.33	.072	.036	1.72	1.49	.991	.991	494.	760.
18		14.154	14.154	1.701	1.658	5.600	11.000	281.61	.068	.041	1.46	1.55	.991	.990	490.	758.
19		15.350	15.350	1.196	1.196	5.600	11.000	281.61	.090	.040	1.66	1.50	.989	.990	471.	772.
20		16.350	16.350	1.000	1.000	5.600	11.000	281.61	.080	.043	1.42	1.54	.990	.989	469.	773.
21		17.850	17.850	1.500	1.500	5.600	11.000	281.61	.086	.045	1.44	1.53	.989	.989	463.	779.

AIRFOIL	ALLISON FLOW COEF	SURGE MARGIN LOADING PARM	ASPECT RATIO	REYNOLDS NUMBER	LOSS MODIFIERS REYN# MODIF	CL-LOSS COEFF.	CL/ SPAN	SARP	CH	EFFECTIVITY PARAMETERS AVE. REY.#	REYMOD	TCMOD	AXMOD	CHBAR	EFFECTIVITY
ROTOR 1	1.064	.4870	1.754	1788377.	.000	.0000	.0000	.845	.450	1268483.	1.054	1.056	.849	.475	.94786
VANE 1		.7552	3.094	748589.	.000										
AVERAGE	1.064	.6211	2.424												

LOAD COEFFICIENT	.3789
BASE SURGE MARGIN	-9.8
CORRECTION	-12.8
SURGE MARGIN	-22.6

SINGLE STAGE SURGE MARGIN CORRELATION

SOLIDITY	ASPECT RATIO	D-FACTOR	TIP MN	SURGE MARGIN
1.6568	1.7536	.4352	1.1428	17.34

10 APR 95 * * * * * Baseline Low Noise Fan Aerodynamic Design Point * * * * *

BLADE GEOMETRY 15:45:31 95/100 COPY 1 OF 1 PAGE 1

ROTOR 1 AT STATION 8
THERE ARE 18 AIRFOILS.
THE AIRFOIL SHAPE IS ARB
THE INCIDENCE AND DEVIATION RULES WERE
INLET METAL ANGLES INPUT
EXIT METAL ANGLES INPUT

STRM LINE NO.	CAMBER	SETTING	INLET METAL ANGLE	EXIT METAL ANGLE	TRUE CHORD	THICK-NESS/CHORD	LEADING EDGE RADIUS	INCI-DENCE	DEVI-ATION	SOLID-ITY	STACK RADIUS	INFLECTION ANGLE	RAMP ANGLE
1	38.45	-.95	26.92	-11.54	3.494	.0942	.0400	-3.05	8.06	2.580	3.850	-3.47	19.17
3	35.69	4.38	28.54	-7.15	3.550	.0874	.0301	-2.16	7.68	2.407	4.196	2.12	17.49
5	31.42	10.44	30.88	-.54	3.634	.0771	.0171	-1.08	6.91	2.192	4.723	8.83	15.51
7	27.24	16.31	33.21	5.97	3.739	.0665	.0136	.33	5.72	1.985	5.370	14.45	13.63
9	25.17	21.55	36.17	11.00	3.855	.0555	.0109	1.09	5.15	1.806	6.092	20.38	11.88
11	23.55	26.63	39.27	15.72	3.979	.0454	.0088	1.52	4.82	1.657	6.859	27.95	10.13
13	21.95	31.28	42.22	20.27	4.106	.0377	.0074	1.84	4.63	1.534	7.653	34.62	8.24
15	20.13	35.60	45.05	24.92	4.237	.0319	.0067	2.01	4.69	1.432	8.464	38.80	6.18
17	18.25	39.48	47.79	29.54	4.369	.0286	.0062	2.02	4.66	1.346	9.286	42.72	3.98
19	16.29	43.38	50.30	34.01	4.503	.0275	.0062	2.02	4.82	1.274	10.119	46.03	1.70
21	13.77	47.15	52.61	38.84	4.638	.0275	.0064	2.02	5.24	1.212	10.965	49.16	-.49

STATOR 1 AT STATION 17
THERE ARE 42 AIRFOILS.
THE AIRFOIL SHAPE IS DCA
THE INCIDENCE AND DEVIATION RULES WERE
INLET METAL ANGLES INPUT
EXIT METAL ANGLES INPUT

STRM LINE NO.	CAMBER	SETTING	INLET METAL ANGLE	EXIT METAL ANGLE	TRUE CHORD	THICK-NESS/CHORD	LEADING EDGE RADIUS	INCI-DENCE	DEVI-ATION	SOLID-ITY	STACK RADIUS	INFLECTION ANGLE	RAMP ANGLE
1	38.59	13.75	33.04	-5.55	1.810	.0500	.0050	1.81	5.55	2.215	5.461	13.75	14.47
3	37.64	13.23	32.05	-5.59	1.810	.0500	.0050	1.68	5.59	2.118	5.711	13.23	14.06
5	36.51	12.58	30.83	-5.68	1.810	.0500	.0050	1.48	5.68	1.981	6.109	12.58	13.40
7	36.19	12.14	30.24	-5.95	1.810	.0500	.0050	1.34	5.95	1.831	6.610	12.14	12.43
9	36.62	11.85	30.16	-6.46	1.810	.0500	.0050	1.29	6.46	1.687	7.171	11.85	11.04
11	36.96	11.49	29.97	-6.99	1.810	.0500	.0050	1.33	6.99	1.559	7.764	11.49	9.28
13	37.13	11.08	29.64	-7.49	1.810	.0500	.0050	1.38	7.49	1.445	8.375	11.08	7.30
15	36.90	10.58	29.04	-7.87	1.810	.0500	.0050	1.43	7.87	1.345	8.999	10.58	5.28
17	36.58	10.04	28.33	-8.25	1.810	.0500	.0050	1.52	8.25	1.256	9.636	10.04	3.36
19	36.09	9.45	27.49	-8.60	1.810	.0500	.0050	1.61	8.60	1.176	10.288	9.45	1.59
21	35.25	8.81	26.44	-8.82	1.810	.0500	.0050	1.73	8.82	1.104	10.963	8.81	.07

10 APR 95
STATION NO 8 * * * * *
ROTOR NO. 1 * * * * *

Baseline Low Noise Fan
Aerodynamic Design Point * * * * *

DATA REDUCTION
PAGE 1
COPY 1 OF 1

MASS FLOW RATE 102.78
CORRECTED FLOW RATE 78.32
HUB BLOCKAGE 99.8 PERCENT
TIP BLOCKAGE 98.9 PERCENT
HUB STATIC PRESSURE 12.90
TIP STATIC PRESSURE 16.16
15:45:31 95/100
MASS AVE TOTAL PRESSURE 20.24
RPM 10417.4

SL NO	PER-CENT SPAN	INCI-DENCE	DEVI-ATION	INLET MACH NO.	EXIT MACH NO.	D-FACTOR	SHOCK LOSS COEF.	PROFILE LOSS COEF.	PROFILE PARA-METER	INLET FREE STRM A/ A*	MIN. PASS-AGE A/ A*	1ST CAP. MACH WAVE INCID.	LOAD COEF.	FLOW COEF.	EXIT RADIUS	DELTA DEVI-ATION	
1	.3	-3.05	8.06	.692	.553	.315		.0502	.00972	1.101	.935		1.437	2.029	4.453	3.19	1
3	4.7	-2.16	7.68	.706	.545	.340		.0472	.00980	1.090	.976		1.244	1.874	4.743	2.82	3
5	11.8	-1.08	6.91	.731	.539	.371		.0445	.01008	1.073	1.014		1.033	1.667	5.205	2.16	5
7	20.7	.33	5.72	.766	.542	.402		.0419	.01033	1.054	1.029		.886	1.466	5.791	1.13	7
9	30.8	1.09	5.15	.807	.554	.428		.0399	.01060	1.035	1.035		.789	1.291	6.457	.49	9
11	41.7	1.52	4.82	.855	.574	.447		.0382	.01079	1.019	1.039		.711	1.146	7.169	.09	11
13	52.9	1.84	4.63	.907	.601	.457	.0002	.0371	.01097	1.008	1.042		.642	1.027	7.905	-.13	13
15	64.2	2.01	4.69	.962	.634	.458	.0016	.0383	.01163	1.001	1.043		.574	.927	8.652	.00	15
17	75.8	2.02	4.66	1.020	.672	.453	.0046	.0423	.01300	1.000	1.043	1.76	.513	.844	9.408	.09	17
19	87.4	2.02	4.82	1.081	.714	.442	.0063	.0490	.01498	1.005	1.038	1.82	.455	.772	10.171	.45	19
21	99.2	2.02	5.24	1.143	.760	.426	.0102	.0590	.01750	1.016	1.039	1.98	.395	.710	10.950	1.27	21

STATOR NO. 1 AT STATION NO. 17

MASS FLOW RATE 102.78
CORRECTED FLOW RATE 79.24
HUB BLOCKAGE 99.1 PERCENT
TIP BLOCKAGE 99.1 PERCENT
HUB STATIC PRESSURE 15.01
TIP STATIC PRESSURE 15.56
MASS AVE TOTAL PRESSURE 20.01

SL NO	PER-CENT SPAN	INCI-DENCE	DEVI-ATION	INLET MACH NO.	EXIT MACH NO.	D-FACTOR	SHOCK LOSS COEF.	PROFILE LOSS COEF.	PROFILE PARA-METER	INLET FREE STRM A/ A*	MIN. PASS-AGE A/ A*	1ST CAP. MACH WAVE INCID.	EXIT RADIUS	DELTA DEVI-ATION	
1	1.3	1.81	5.55	.591	.442	.366		.1254	.02829	1.198	1.211		5.681	-.13	1
3	5.9	1.68	5.59	.596	.454	.353		.1039	.02452	1.193	1.203		5.925	-.09	3
5	13.1	1.48	5.68	.604	.472	.338		.0776	.01960	1.183	1.190		6.313	-.07	5
7	22.1	1.34	5.95	.627	.504	.324		.0543	.01483	1.158	1.164		6.799	-.09	7
9	32.1	1.29	6.46	.661	.547	.312		.0377	.01118	1.126	1.135		7.339	-.06	9
11	42.6	1.33	6.99	.694	.589	.304		.0283	.00910	1.099	1.109		7.906	-.03	11
13	53.4	1.38	7.49	.724	.627	.300		.0251	.00868	1.078	1.091		8.487	-.01	13
15	64.4	1.43	7.87	.744	.653	.299		.0270	.01003	1.066	1.080		9.080	-.02	15
17	75.7	1.52	8.25	.756	.671	.300		.0332	.01321	1.059	1.075		9.688	-.01	17
19	87.3	1.61	8.60	.757	.679	.300		.0431	.01833	1.058	1.075		10.313	.01	19
21	99.3	1.73	8.82	.742	.670	.302		.0568	.02573	1.067	1.085		10.964	-.01	21

AIRFOIL	MASS AVERAGED D-FACTOR	STAGE REACTION	MEANLINE SOLIDITY	MASS AVERAGED A/A* FREE STREAM	MASS AVERAGED A/A* MIN PASSAGE
ROTOR 1	.4346	.8956	1.657	1.019	1.035
STATOR 1	.3074		1.559	1.091	1.104
AVERAGE	.3710		1.608		

APPENDIX C

LOW NOISE FAN CONFIGURATION NO. 3:
AERODYNAMIC DESIGN POINT
BLADE AND VANE ELEMENT PERFORMANCE AND GEOMETRY OUTPUT

11 JUL 95 Used to configure Axially Swept (Only) Vane * * * * * ATV3
STATION NO. 1 * * * * * Aerodynamic Design Point * * * * *
ANNULUS EXIT 1

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 39.18 (CORRECTED) MASS AVE. TOTAL PRESSURE 14.70
CORRECTED FLOW RATE 102.78 ANNULUS AREA 2.62 SQ. FT = 377.8 SQ.IN MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
.869	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	.0	1
1.882	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	10.0	3
2.895	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	20.0	5
3.908	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	30.0	7
4.921	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	40.0	9
5.934	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	50.0	11
6.947	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	60.0	13
7.961	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	70.0	15
8.974	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	80.0	17
9.987	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	90.0	19
11.000	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	100.0	21

ANNULUS 2

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 39.18 (CORRECTED) MASS AVE. TOTAL PRESSURE 14.70
CORRECTED FLOW RATE 102.78 ANNULUS AREA 2.62 SQ. FT = 377.8 SQ.IN MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
.877	581.2	.0	2.02	14.70	12.09	518.7	490.5	581.2	.535	581.2	.1	1
1.894	582.5	.0	4.41	14.70	12.08	518.7	490.4	582.5	.536	582.5	10.1	3
2.911	584.7	.0	5.66	14.70	12.06	518.7	490.2	584.7	.539	584.7	20.2	5
3.926	587.2	.0	6.13	14.70	12.04	518.7	489.9	587.2	.541	587.2	30.2	7
4.939	589.7	.0	5.97	14.70	12.02	518.7	489.7	589.7	.543	589.7	40.2	9
5.950	591.9	.0	5.31	14.70	12.00	518.7	489.5	592.0	.546	592.0	50.2	11
6.960	593.9	.0	4.25	14.70	11.98	518.7	489.3	593.9	.548	593.9	60.1	13
7.969	595.4	.0	2.91	14.70	11.97	518.7	489.1	595.4	.549	595.4	70.1	15
8.976	596.4	.0	1.39	14.70	11.96	518.7	489.0	596.4	.550	596.4	80.0	17
9.984	596.9	.0	-.22	14.70	11.96	518.7	489.0	596.9	.550	596.9	90.0	19
10.992	596.8	.0	-1.81	14.70	11.96	518.7	489.0	596.8	.550	596.8	99.9	21

11 JUL 95 Used to configure Axially Swept (Only) Vane . . . ATV3 — INTERSTAGE DATA
STATION NO. 3 * * * * * Aerodynamic Design Point * * * * * — PAGE 2
ANNULUS EXIT 3 — 9:16:10 95/192 — COPY 1 OF 1

MASS FLOW RATE 102.78 — FLOW RATE/SQ. FT. 39.18 (CORRECTED) — MASS AVE. TOTAL PRESSURE 14.70
CORRECTED FLOW RATE 102.78 — ANNULUS AREA 2.62 SQ. FT = 377.7 SQ.IN — MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
.884	560.0	.0	2.66	14.70	12.27	518.7	492.5	560.0	.515	560.0	.1	1
1.913	568.6	.0	9.90	14.70	12.20	518.7	491.7	568.7	.523	568.7	10.3	3
2.935	575.7	.0	12.54	14.70	12.14	518.7	491.0	575.8	.530	575.8	20.4	5
3.952	581.9	.0	13.09	14.70	12.08	518.7	490.4	582.1	.536	582.1	30.4	7
4.963	587.4	.0	12.37	14.70	12.04	518.7	489.9	587.5	.541	587.5	40.4	9
5.972	592.0	.0	10.83	14.70	12.00	518.7	489.5	592.1	.546	592.1	50.4	11
6.977	595.7	.0	8.75	14.70	11.97	518.7	489.1	595.8	.549	595.8	60.3	13
7.981	598.6	.0	6.34	14.70	11.94	518.7	488.8	598.6	.552	598.6	70.2	15
8.983	600.6	.0	3.76	14.70	11.93	518.7	488.6	600.6	.554	600.6	80.1	17
9.985	601.9	.0	1.13	14.70	11.92	518.7	488.5	601.9	.555	601.9	90.0	19
10.987	602.4	.0	-1.44	14.70	11.91	518.7	488.4	602.4	.556	602.4	99.9	21

ANNULUS 4

MASS FLOW RATE 102.78 — FLOW RATE/SQ. FT. 39.19 (CORRECTED) — MASS AVE. TOTAL PRESSURE 14.70
CORRECTED FLOW RATE 102.78 — ANNULUS AREA 2.62 SQ. FT = 377.6 SQ.IN — MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
.896	504.4	.0	43.51	14.70	12.69	518.7	497.3	506.2	.463	506.2	.3	1
1.964	534.3	.0	36.96	14.70	12.46	518.7	494.8	535.6	.491	535.6	10.8	3
2.998	555.1	.0	34.36	14.70	12.30	518.7	492.9	556.2	.511	556.2	21.0	5
4.016	570.9	.0	31.20	14.70	12.17	518.7	491.4	571.7	.526	571.7	31.1	7
5.023	583.2	.0	27.23	14.70	12.07	518.7	490.3	583.8	.538	583.8	41.0	9
6.024	592.8	.0	22.71	14.70	11.99	518.7	489.3	593.2	.547	593.2	50.9	11
7.019	600.1	.0	17.88	14.70	11.93	518.7	488.6	600.4	.554	600.4	60.7	13
8.011	605.5	.0	12.94	14.70	11.88	518.7	488.1	605.7	.559	605.7	70.5	15
9.002	609.3	.0	8.04	14.70	11.85	518.7	487.7	609.3	.563	609.3	80.3	17
9.992	611.4	.0	3.31	14.70	11.83	518.7	487.5	611.5	.565	611.5	90.0	19
10.982	612.3	.0	[illegible]	14.70	[illegible]	518.7	487.4	612.3	.566	612.3	99.8	21

11 JUL 95 Used to configure Axially Swept (Only) Vane * * * * * ATV3
* * * * * Aerodynamic Design Point 9:16:10 95/192

STATION NO. 5
ANNULUS EXIT 5

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 39.46 (CORRECTED) MASS AVE. TOTAL PRESSURE 14.70
CORRECTED FLOW RATE 102.78 ANNULUS AREA 2.60 SQ. FT = 375.0 SQ.IN MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
1.229	450.5	.0	141.67	14.70	12.94	518.7	500.1	472.2	.431	472.2	.3	1
2.190	500.6	.0	105.79	14.70	12.65	518.7	496.9	511.6	.468	511.6	10.1	3
3.183	537.7	.0	84.67	14.70	12.39	518.7	494.0	544.3	.499	544.3	20.2	5
4.170	565.0	.0	69.15	14.70	12.19	518.7	491.7	569.3	.524	569.3	30.3	7
5.150	585.3	.0	56.24	14.70	12.03	518.7	489.8	588.0	.542	588.0	40.3	9
6.125	600.4	.0	44.80	14.70	11.92	518.7	488.5	602.1	.556	602.1	50.3	11
7.096	611.5	.0	34.35	14.70	11.83	518.7	487.4	612.4	.566	612.4	60.2	13
8.066	619.4	.0	24.64	14.70	11.76	518.7	486.6	619.8	.573	619.8	70.1	15
9.036	624.6	.0	15.56	14.70	11.72	518.7	486.1	624.8	.578	624.8	80.0	17
10.007	627.7	.0	7.10	14.70	11.69	518.7	485.8	627.7	.581	627.7	89.9	19
10.979	628.8	.0	-.73	14.70	11.68	518.7	485.7	628.8	.582	628.8	99.8	21

ANNULUS 6

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 40.62 (CORRECTED) MASS AVE. TOTAL PRESSURE 14.70
CORRECTED FLOW RATE 102.78 ANNULUS AREA 2.53 SQ. FT = 364.3 SQ.IN MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
2.154	469.6	.0	244.05	14.70	12.51	518.7	495.3	529.2	.485	529.2	.2	1
2.809	514.2	.0	194.80	14.70	12.35	518.7	493.5	549.9	.505	549.9	7.6	3
3.628	553.3	.0	153.44	14.70	12.15	518.7	491.2	574.2	.528	574.2	16.8	5
4.506	583.8	.0	120.32	14.70	11.97	518.7	489.1	596.0	.550	596.0	26.7	7
5.408	607.1	.0	93.76	14.70	11.81	518.7	487.2	614.3	.568	614.3	36.9	9
6.322	625.0	.0	72.05	14.70	11.68	518.7	485.7	629.1	.582	629.1	47.2	11
7.244	638.6	.0	53.81	14.70	11.58	518.7	484.4	640.9	.594	640.9	57.6	13
8.170	648.8	.0	38.02	14.70	11.50	518.7	483.5	649.9	.603	649.9	68.1	15
9.101	655.7	.0	24.00	14.70	11.44	518.7	482.8	656.1	.609	656.1	78.6	17
10.037	659.6	.0	11.32	14.70	11.41	518.7	482.4	659.7	.613	659.7	89.1	19
10.978	660.6	.0	-.28	14.70	11.40	518.7	482.3	660.6	.613	660.6	99.7	21

11 JUL 95 Used to configure Axially Swept (Only) Vane * * * * * ATV3
STATION NO. 7 * * * * * Aerodynamic Design Point
ANNULUS EXIT 7

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MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 43.13 (CORRECTED) MASS AVE. TOTAL PRESSURE 14.70
CORRECTED FLOW RATE 102.78 ANNULUS AREA 2.38 SQ. FT = 343.1 SQ.IN MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
3.308	606.4	.0	297.27	14.70	11.26	518.7	480.7	675.3	.628	675.3	.1	1
3.708	628.2	.0	249.86	14.70	11.26	518.7	480.6	676.1	.629	676.1	5.3	3
4.298	648.5	.0	202.01	14.70	11.23	518.7	480.2	679.3	.632	679.3	13.0	5
5.002	664.2	.0	162.22	14.70	11.19	518.7	479.7	683.8	.637	683.8	22.1	7
5.776	676.4	.0	130.20	14.70	11.14	518.7	479.1	688.8	.642	688.8	32.2	9
6.594	686.2	.0	103.53	14.70	11.09	518.7	478.5	694.0	.647	694.0	42.8	11
7.440	694.3	.0	79.96	14.70	11.04	518.7	478.0	698.9	.652	698.9	53.8	13
8.306	700.8	.0	58.05	14.70	11.00	518.7	477.4	703.2	.656	703.2	65.0	15
9.186	705.6	.0	37.09	14.70	10.97	518.7	477.1	706.6	.660	706.6	76.4	17
10.077	708.6	.0	16.73	14.70	10.95	518.7	476.8	708.8	.662	708.8	88.0	19
10.978	709.8	.0	-2.42	14.70	10.94	518.7	476.7	709.9	.663	709.9	99.7	21

11 JUL 95 Used to configure Axially Swept (Only) Vane * * * * * ATV3
STATION NO. 8 * * * * * Aerodynamic Design Point 9:16:10 95/192
ROTOR EXIT 1

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 35.58 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.25
CORRECTED FLOW RATE 78.31 ANNULUS AREA 2.20 SQ. FT = 316.9 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5
CORRECTED TIP SPEED 1000. FT/SEC ROTOR ADIABATIC EFFICIENCY 94.1
PRESSURE RATIO 1.378 CUMULATIVE ADIABATIC EFFICIENCY 94.1

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
4.453	583.8	441.2	169.77	17.63	12.89	548.4	501.4	751.2	.684	608.0	.3	1
4.745	580.7	425.2	153.51	17.73	13.13	549.2	504.1	735.9	.668	600.6	4.7	3
5.208	576.8	406.9	132.69	17.90	13.47	550.8	507.8	718.3	.650	591.9	11.8	5
5.796	576.9	404.5	112.41	18.29	13.84	554.2	511.8	713.5	.643	587.7	20.8	7
6.465	583.6	415.6	94.28	18.88	14.23	559.4	515.9	722.6	.649	591.1	30.9	9
7.178	594.7	426.9	77.72	19.55	14.61	565.1	519.9	736.2	.659	599.8	41.8	11
7.913	608.5	434.6	62.16	20.23	14.99	570.7	523.9	750.4	.669	611.7	53.0	13
8.659	620.0	433.7	47.01	20.78	15.34	575.5	527.7	758.1	.673	621.8	64.4	15
9.413	629.1	428.4	32.46	21.21	15.64	579.7	531.4	761.8	.674	629.9	75.8	17
10.174	633.4	416.5	18.72	21.47	15.91	582.8	535.0	758.3	.669	633.7	87.4	19
10.951	624.0	393.8	6.21	21.40	16.13	583.9	538.6	737.9	.649	624.1	99.3	21

RELATIVE MACH NOS. INLET	RELATIVE MACH NOS. EXIT	TOTAL TEMP RISE	TOTAL TEMP RATIO	WHEEL SPEED IN	WHEEL SPEED OUT	ROTOR PRESSURE RATIO	ROTOR ADIABATIC EFFICIENCY	ROTOR POLYTROPIC EFFICIENCY	S.L. NO.
.688	.555	29.75	1.057	300.7	404.8	1.200	93.1	93.3	1
.703	.546	30.55	1.059	337.1	431.3	1.206	93.5	93.6	3
.729	.539	32.09	1.062	390.7	473.5	1.218	93.7	93.9	5
.765	.541	35.51	1.068	454.7	527.0	1.244	94.2	94.4	7
.807	.553	40.69	1.078	525.1	587.7	1.285	94.7	94.9	9
.855	.573	46.39	1.089	599.4	652.5	1.331	95.1	95.3	11
.907	.601	52.07	1.100	676.4	719.4	1.377	95.3	95.5	13
.963	.635	56.86	1.110	755.1	787.2	1.414	94.9	95.2	15
1.021	.674	61.04	1.118	835.1	855.7	1.443	93.9	94.2	17
1.082	.716	64.14	1.124	916.1	924.9	1.461	92.5	92.9	19
1.144	.762	65.27	1.126	998.0	995.5	1.456	90.0	90.6	21

S.L. NO.	DIFFUSION FACTOR	OMEGA BAR	DELTA PS/Q	SOLIDITY	TOTAL TURNING	ABSOLUTE FLOW ANGLE INLET	ABSOLUTE FLOW ANGLE EXIT	K.&S. EQU. DIFFUSION FACTOR	RELATIVE FLOW ANGLE INLET	RELATIVE FLOW ANGLE EXIT	RELATIVE VELOCITY INLET	RELATIVE VELOCITY EXIT	RELATIVE TEMPERATURE INLET	RELATIVE TEMPERATURE EXIT
1	.309	.050	.387	2.580	27.43	.00	35.96	1.261	24.00	-3.42	739.2	609.1	526.	532.
3	.336	.047	.427	2.406	25.92	.00	35.29	1.300	26.50	.59	755.5	600.6	528.	534.
5	.370	.044	.471	2.191	23.49	.00	34.51	1.352	29.91	6.42	783.6	595.6	531.	537.
7	.402	.042	.502	1.984	21.86	.00	34.54	1.406	33.63	11.77	821.2	600.3	536.	542.
9	.430	.040	.518	1.805	21.09	.00	35.11	1.456	37.32	16.23	866.1	615.6	542.	547.
11	.448	.038	.519	1.656	20.20	.00	35.44	1.494	40.82	20.62	917.0	640.8	549.	554.
13	.457	.037	.507	1.533	19.10	.00	35.40	1.518	44.06	24.96	972.6	674.7	557.	562.
15	.457	.040	.483	1.431	17.42	.00	34.90	1.529	47.04	29.62	1031.8	715.3	566.	570.
17	.451	.047	.452	1.346	15.61	.00	34.22	1.529	49.77	34.15	1093.9	761.2	577.	580.
19	.440	.055	.416	1.274	13.53	.00	33.32	1.518	52.27	38.74	1158.3	812.4	589.	590.
21	.425	.069	.377	1.212	10.62	.00	32.25	1.499	54.58	43.96	1224.7	866.9	602.	601.

11 JUL 95 Used to configure Axially Swept (Only) Vane . . . ATV3 INTERSTAGE DATA
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MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 36.28 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.25
CORRECTED FLOW RATE 78.31 ANNULUS AREA 2.16 SQ. FT = 310.8 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
4.720	602.5	416.2	141.77	17.63	12.95	548.4	502.1	745.9	.679	619.0	.3	1
4.985	597.9	404.7	129.64	17.73	13.16	549.2	504.4	733.5	.666	611.8	4.5	3
5.413	592.5	391.5	113.41	17.90	13.46	550.8	507.7	719.2	.651	603.3	11.3	5
5.963	592.0	393.2	97.01	18.29	13.80	554.2	511.3	717.3	.647	599.9	20.1	7
6.597	598.9	407.3	81.81	18.88	14.15	559.4	515.1	728.9	.655	604.4	30.1	9
7.279	610.2	420.9	67.54	19.55	14.51	565.1	518.9	744.3	.666	613.9	40.9	11
7.989	623.8	430.5	54.04	20.23	14.87	570.7	522.7	759.9	.678	626.2	52.2	13
8.713	634.9	431.0	40.99	20.78	15.20	575.5	526.4	768.5	.683	636.3	63.7	15
9.449	643.2	426.8	28.55	21.21	15.50	579.7	530.1	772.4	.684	643.8	75.4	17
10.196	646.2	415.6	16.87	21.47	15.77	582.8	533.7	768.5	.679	646.4	87.2	19
10.961	635.1	393.4	5.89	21.40	16.01	583.9	537.5	747.1	.657	635.1	99.4	21

ANNULUS 10

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 36.95 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.25
CORRECTED FLOW RATE 78.31 ANNULUS AREA 2.12 SQ. FT = 305.2 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
4.912	606.7	399.9	100.18	17.63	13.08	548.4	503.6	733.5	.667	614.9	.4	1
5.165	602.0	390.5	95.19	17.73	13.27	549.2	505.6	723.9	.657	609.5	4.5	3
5.575	597.2	380.1	87.57	17.90	13.53	550.8	508.4	713.3	.645	603.6	11.2	5
6.106	598.8	384.0	78.67	18.29	13.82	554.2	511.5	715.6	.645	603.9	19.9	7
6.719	608.7	399.9	69.00	18.88	14.12	559.4	514.8	731.6	.658	612.6	29.9	9
7.381	623.4	415.1	58.54	19.55	14.43	565.1	518.1	751.3	.673	626.2	40.8	11
8.070	640.4	426.2	47.55	20.23	14.73	570.7	521.3	770.7	.689	642.2	52.0	13
8.774	654.4	428.0	36.09	20.78	15.02	575.5	524.5	782.8	.697	655.4	63.6	15
9.490	664.9	424.9	24.48	21.21	15.28	579.7	527.8	789.5	.701	665.4	75.3	17
10.217	669.4	414.7	12.88	21.47	15.52	582.8	531.2	787.6	.697	669.5	87.2	19
10.963	659.2	393.3	1.14	21.40	15.74	583.9	534.9	767.6	.677	659.2	99.4	21

11 JUL 95 Used to configure Axially Swept (Only) Vane * * * * * ATV3 INTERSTAGE DATA
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ANNULUS EXIT 11

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 37.42 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.25
CORRECTED FLOW RATE 78.31 ANNULUS AREA 2.09 SQ. FT = 301.3 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.045	581.7	389.4	77.01	17.63	13.41	548.4	507.1	704.2	.638	586.8	.5	1
5.296	584.5	380.9	75.75	17.73	13.51	549.2	508.2	701.7	.635	589.4	4.7	3
5.702	589.2	371.7	73.03	17.90	13.67	550.8	509.9	700.4	.633	593.7	11.5	5
6.223	599.7	376.8	68.85	18.29	13.86	554.2	512.0	711.6	.641	603.6	20.2	7
6.821	616.8	393.9	62.99	18.88	14.09	559.4	514.4	734.5	.661	620.0	30.2	9
7.465	636.5	410.4	55.26	19.55	14.33	565.1	517.0	759.3	.681	638.9	40.9	11
8.136	656.7	422.7	46.09	20.23	14.58	570.7	519.8	782.3	.700	658.3	52.2	13
8.823	672.7	425.7	35.78	20.78	14.83	575.5	522.7	796.9	.711	673.6	63.6	15
9.523	684.6	423.5	24.81	21.21	15.06	579.7	525.7	805.4	.716	685.1	75.3	17
10.234	690.3	414.1	13.37	21.47	15.28	582.8	528.9	805.1	.714	690.5	87.2	19
10.964	681.7	393.3	1.17	21.40	15.48	583.9	532.4	787.0	.696	681.7	99.4	21

ANNULUS 12

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 37.87 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.25
CORRECTED FLOW RATE 78.31 ANNULUS AREA 2.07 SQ. FT = 297.8 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.110	576.8	384.4	85.21	17.63	13.47	548.4	507.8	698.4	.632	583.1	.5	1
5.363	580.2	376.1	82.10	17.73	13.57	549.2	508.8	696.3	.630	586.0	4.8	3
5.769	586.1	367.3	77.28	17.90	13.72	550.8	510.4	696.0	.628	591.1	11.6	5
6.291	598.8	372.7	71.53	18.29	13.89	554.2	512.3	708.9	.639	603.0	20.4	7
6.887	619.0	390.1	64.67	18.88	14.09	559.4	514.4	734.5	.661	622.3	30.5	9
7.527	642.5	407.1	56.28	19.55	14.29	565.1	516.6	762.7	.684	644.9	41.3	11
8.191	666.9	419.9	46.56	20.23	14.49	570.7	518.9	789.4	.707	668.5	52.6	13
8.869	687.3	423.4	35.76	20.78	14.68	575.5	521.2	808.1	.722	688.2	64.0	15
9.557	703.9	421.9	24.40	21.21	14.85	579.7	523.6	821.1	.732	704.4	75.6	17
10.254	714.9	413.2	12.76	21.47	15.00	582.8	526.0	825.9	.734	715.1	87.4	19
10.967	712.9	393.2	.67	21.40	15.12	583.9	528.8	814.1	.722	712.9	99.4	21

11 JUL 95 Used to configure Axially Swept (Only) Vane . . . ATV3
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ANNULUS EXIT 13

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MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 38.25 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.25
CORRECTED FLOW RATE 78.31 ANNULUS AREA 2.05 SQ. FT = 294.8 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.229	583.1	375.7	75.93	17.63	13.48	548.4	507.9	697.8	.631	588.0	.5	1
5.472	585.6	368.7	76.44	17.73	13.57	549.2	508.8	696.2	.629	590.6	4.7	3
5.865	591.3	361.3	75.34	17.90	13.71	550.8	510.3	697.0	.629	596.1	11.5	5
6.371	605.2	368.0	72.43	18.29	13.86	554.2	511.9	712.0	.642	609.5	20.2	7
6.951	627.2	386.5	67.38	18.88	14.03	559.4	513.8	739.8	.666	630.9	30.2	9
7.577	652.3	404.4	59.86	19.55	14.20	565.1	515.7	769.8	.691	655.0	41.0	11
8.227	677.6	418.0	50.39	20.23	14.39	570.7	517.7	797.8	.715	679.5	52.2	13
8.894	698.3	422.3	39.53	20.78	14.56	575.5	519.9	817.0	.731	699.5	63.7	15
9.572	714.8	421.3	28.06	21.21	14.73	579.7	522.3	830.2	.741	715.4	75.4	17
10.261	725.5	413.0	16.40	21.47	14.87	582.8	524.8	835.0	.743	725.7	87.3	19
10.967	723.1	393.2	4.43	21.40	15.00	583.9	527.5	823.1	.731	723.1	99.4	21

ANNULUS 14

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 37.35 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.25
CORRECTED FLOW RATE 78.31 ANNULUS AREA 2.10 SQ. FT = 301.9 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.256	587.5	373.7	76.42	17.63	13.45	548.4	507.5	700.5	.634	592.4	.5	1
5.516	591.3	365.7	79.36	17.73	13.53	549.2	508.4	699.8	.633	596.6	4.8	3
5.935	597.1	357.1	82.95	17.90	13.67	550.8	509.9	700.6	.633	602.8	11.7	5
6.475	608.5	362.1	85.34	18.29	13.85	554.2	511.8	713.2	.643	614.5	20.7	7
7.093	625.5	378.8	83.33	18.88	14.07	559.4	514.2	736.0	.662	631.0	31.0	9
7.756	643.5	395.1	74.24	19.55	14.34	565.1	517.1	758.7	.680	647.8	42.0	11
8.438	660.7	407.6	57.92	20.23	14.63	570.7	520.3	778.5	.696	663.3	53.3	13
9.126	673.2	411.5	35.81	20.78	14.92	575.5	523.6	789.8	.704	674.1	64.7	15
9.816	682.5	410.8	10.41	21.21	15.18	579.7	526.9	796.7	.708	682.6	76.2	17
10.505	689.1	403.4	-16.21	21.47	15.37	582.8	529.7	798.6	.708	689.3	87.6	19
11.199	687.3	385.1	-41.61	21.40	15.46	583.9	532.1	788.9	.698	688.5	99.2	21

⊥ to edge	// to edge
471.9	366.1
473.8	365.4
477.0	371.4
485.8	377.3
501.5	376.1
521.6	381.4
544.5	381.9
565.9	368.8
586.5	351.2
605.1	331.1
616.7	307.7

STATION NO. 15
STATOR EXIT 1

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 40.27 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.03
CORRECTED FLOW RATE 79.14 ANNULUS AREA 1.97 SQ. FT = 283.0 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5
PRESSURE RATIO 1.363 CUMULATIVE ADIABATIC EFFICIENCY 90.9 STAGE ADIABATIC EFFICIENCY 90.9

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.653	520.8	.0	63.20	17.10	14.73	548.4	525.5	524.6	.467	524.6	1.0	1
5.910	529.4	.0	61.91	17.28	14.82	549.2	525.6	533.0	.474	533.0	5.7	3
6.319	541.9	.0	58.26	17.57	14.96	550.8	526.0	545.0	.485	545.0	13.3	5
6.831	568.4	.0	51.82	18.04	15.14	554.2	527.0	570.7	.507	570.7	22.7	7
7.397	607.5	.0	41.03	18.70	15.33	559.4	528.5	608.8	.540	608.8	33.2	9
7.984	648.0	.0	25.40	19.41	15.51	565.1	530.0	648.5	.575	648.5	44.0	11
8.576	687.0	.0	6.80	20.09	15.65	570.7	531.4	687.0	.608	687.0	54.9	13
9.170	718.5	.0	-12.13	20.62	15.72	575.5	532.5	718.6	.635	718.6	65.9	15
9.767	747.8	.0	-28.76	21.02	15.67	579.7	533.1	748.4	.661	748.4	76.9	17
10.370	775.8	.0	-40.46	21.23	15.49	582.8	532.6	776.9	.687	776.9	88.1	19
10.986	795.5	.0	-43.14	21.11	15.15	583.9	531.1	796.7	.705	796.7	99.4	21

ABSOLUTE MACH NOS. INLET	MACH NOS. EXIT	TOTAL TEMP RISE	TOTAL TEMP RATIO	WHEEL SPEED IN	WHEEL SPEED OUT	STAGE PRESSURE RATIO	STAGE ADIABATIC EFFICIENCY	STAGE POLYTROPIC EFFICIENCY	S.L. NO.
.634	.467	29.75	1.057	.0	.0	1.163	77.1	77.6	1
.633	.474	30.55	1.059	.0	.0	1.176	80.6	81.0	3
.633	.485	32.09	1.062	.0	.0	1.195	84.6	85.0	5
.643	.507	35.51	1.068	.0	.0	1.228	88.3	88.6	7
.662	.540	40.69	1.078	.0	.0	1.273	90.9	91.2	9
.680	.575	46.39	1.089	.0	.0	1.321	92.5	92.8	11
.696	.608	52.07	1.100	.0	.0	1.367	93.1	93.4	13
.704	.635	56.86	1.110	.0	.0	1.403	92.7	93.1	15
.708	.661	61.04	1.118	.0	.0	1.430	91.4	91.9	17
.708	.687	64.14	1.124	.0	.0	1.445	89.7	90.2	19
.698	.705	65.27	1.126	.0	.0	1.436	86.6	87.3	21

S.L. NO.	DIFFUSION FACTOR	OMEGA BAR	DELTA PS/Q	SOLIDITY	TOTAL TURNING	ABSOLUTE FLOW ANGLE INLET	ABSOLUTE FLOW ANGLE EXIT	K.&S. EQU. DIFFUSION FACTOR
1	.367	.127	.306	2.218	32.25	32.25	.00	1.484
3	.357	.105	.306	2.118	31.51	31.51	.00	1.472
5	.347	.078	.305	1.975	30.64	30.64	.00	1.458
7	.336	.054	.291	1.819	30.51	30.51	.00	1.442
9	.324	.038	.262	1.670	30.98	30.98	.00	1.424
11	.312	.028	.225	1.537	31.38	31.38	.00	1.406
13	.300	.025	.182	1.422	31.57	31.57	.00	1.388
15	.287	.027	.135	1.323	31.40	31.40	.00	1.370
17	.270	.032	.082	1.236	31.04	31.04	.00	1.349
19	.246	.039	.019	1.159	30.34	30.34	.00	1.323
21	.216	.048	-.052	1.091	29.22	29.22	.00	1.293

11 JUL 95 Used to configure Axially Swept (Only) Vane ATV3
STATION NO. 16 * * * * * Aerodynamic Design Point * * * * *
ANNULUS EXIT 16

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 40.17 (CORRECTED)
CORRECTED FLOW RATE 79.14 ANNULUS AREA 1.97 SQ. FT = 283.7 SQ.IN

MASS AVE. TOTAL PRESSURE 20.03
MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.683	471.6	.0	5.29	17.10	15.16	548.4	529.9	471.6	.418	471.6	1.5	1
5.938	486.2	.0	6.54	17.28	15.21	549.2	529.5	486.3	.431	486.3	6.3	3
6.340	507.4	.0	7.08	17.57	15.29	550.8	529.3	507.4	.450	507.4	13.7	5
6.840	544.3	.0	5.66	18.04	15.39	554.2	529.5	544.4	.483	544.4	23.0	7
7.391	593.8	.0	1.69	18.70	15.49	559.4	530.0	593.8	.526	593.8	33.2	9
7.964	643.6	.0	-4.36	19.41	15.57	565.1	530.6	643.6	.570	643.6	43.8	11
8.545	690.5	.0	-11.26	20.09	15.61	570.7	531.0	690.6	.611	690.6	54.5	13
9.134	728.4	.0	-17.62	20.62	15.59	575.5	531.3	728.6	.645	728.6	65.5	15
9.732	761.8	.0	-22.15	21.02	15.49	579.7	531.4	762.1	.674	762.1	76.5	17
10.340	790.1	.0	-23.11	21.23	15.31	582.8	530.8	790.4	.700	790.4	87.8	19
10.967	804.6	.0	-17.74	21.11	15.04	583.9	530.0	804.8	.713	804.8	99.4	21

ANNULUS 17

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 40.39 (CORRECTED)
CORRECTED FLOW RATE 79.14 ANNULUS AREA 1.96 SQ. FT = 282.2 SQ.IN

MASS AVE. TOTAL PRESSURE 20.03
MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.691	445.9	.0	-1.14	17.10	15.36	548.4	531.9	445.9	.394	445.9	1.7	1
5.954	467.2	.0	-.06	17.28	15.36	549.2	531.0	467.2	.413	467.2	6.6	3
6.362	497.7	.0	.78	17.57	15.37	550.8	530.1	497.7	.441	497.7	14.1	5
6.862	544.7	.0	.61	18.04	15.38	554.2	529.5	544.7	.483	544.7	23.4	7
7.406	603.1	.0	-.82	18.70	15.39	559.4	529.1	603.1	.535	603.1	33.4	9
7.970	659.8	.0	-3.18	19.41	15.39	565.1	528.8	659.8	.585	659.8	43.9	11
8.543	710.8	.0	-5.85	20.09	15.37	570.7	528.7	710.8	.631	710.8	54.5	13
9.126	749.5	.0	-8.10	20.62	15.33	575.5	528.8	749.5	.665	749.5	65.3	15
9.721	779.4	.0	-9.19	21.02	15.27	579.7	529.1	779.4	.691	779.4	76.3	17
10.331	798.8	.0	-8.24	21.23	15.20	582.8	529.7	798.8	.708	798.8	87.6	19
10.963	798.0	.0	-4.08	21.11	15.13	583.9	530.9	798.0	.706	798.0	99.3	21

11 JUL 95 Used to configure Axially Swept (Only) Vane * * * * * ATV3 INTERSTAGE DATA

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ANNULUS EXIT 18 COPY 1 OF 1

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 40.42 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.03

CORRECTED FLOW RATE 79.14 ANNULUS AREA 1.96 SQ. FT = 282.0 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.678	445.5	.0	-2.40	17.10	15.36	548.4	531.9	445.5	.394	445.5	1.4	1
5.941	467.4	.0	-2.87	17.28	15.36	549.2	531.0	467.4	.414	467.4	6.3	3
6.349	498.8	.0	-3.68	17.57	15.36	550.8	530.0	498.8	.442	498.8	13.9	5
6.848	546.6	.0	-4.87	18.04	15.37	554.2	529.3	546.6	.485	546.6	23.1	7
7.391	605.5	.0	-6.26	18.70	15.37	559.4	528.8	605.5	.537	605.5	33.2	9
7.954	662.0	.0	-7.51	19.41	15.36	565.1	528.6	662.1	.587	662.1	43.6	11
8.527	712.2	.0	-8.35	20.09	15.35	570.7	528.5	712.3	.632	712.3	54.2	13
9.112	749.2	.0	-8.47	20.62	15.33	575.5	528.8	749.3	.665	749.3	65.0	15
9.709	776.5	.0	-7.70	21.02	15.31	579.7	529.5	776.5	.688	776.5	76.1	17
10.322	792.4	.0	-5.83	21.23	15.28	582.8	530.5	792.5	.702	792.5	87.4	19
10.959	787.7	.0	-2.70	21.11	15.27	583.9	532.3	787.7	.696	787.7	99.2	21

ANNULUS 19

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 40.47 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.03

CORRECTED FLOW RATE 79.14 ANNULUS AREA 1.96 SQ. FT = 281.6 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.675	451.3	.0	.00	17.10	15.32	548.4	531.5	451.3	.399	451.3	1.4	1
5.936	472.8	.0	.00	17.28	15.32	549.2	530.6	472.8	.419	472.8	6.2	3
6.341	503.7	.0	.00	17.57	15.32	550.8	529.6	503.7	.446	503.7	13.7	5
6.838	550.9	.0	.00	18.04	15.33	554.2	528.9	550.9	.489	550.9	22.9	7
7.380	609.1	.0	.00	18.70	15.33	559.4	528.5	609.1	.540	609.1	33.0	9
7.943	664.7	.0	.00	19.41	15.33	565.1	528.3	664.7	.590	664.7	43.4	11
8.517	713.6	.0	.00	20.09	15.34	570.7	528.3	713.6	.633	713.6	54.0	13
9.103	748.9	.0	.00	20.62	15.34	575.5	528.8	748.9	.664	748.9	64.9	15
9.702	774.0	.0	.00	21.02	15.34	579.7	529.8	774.0	.686	774.0	76.0	17
10.317	787.9	.0	.00	21.23	15.34	582.8	531.1	787.9	.697	787.9	87.4	19
10.957	781.8	.0	.00	21.11	15.34	583.9	533.1	781.8	.691	781.8	99.2	21

		D-FACTOR HUB	D-FACTOR MEAN	D-FACTOR TIP	EQUIVALENT DIFFUSION FACTOR HUB	EQUIVALENT DIFFUSION FACTOR MEAN	EQUIVALENT DIFFUSION FACTOR TIP	LOAD COEFFICIENT (MEAN WHEEL SPEED) HUB	LOAD COEFFICIENT (MEAN WHEEL SPEED) MEAN	LOAD COEFFICIENT (MEAN WHEEL SPEED) TIP	MACH NO.	SPECIFIC FLOW IN	SPECIFIC FLOW OUT	FLOW COEFF.
ROTOR	1	.309	.448	.425	1.455	1.566	1.507	.497	.775	1.091	1.144	43.13	35.58	1.145
STATOR	1	.367	.312	.216	1.475	1.522	1.557				.634	37.35	40.27	

		PRESSURE RATIO	CUMULATIVE PRESSURE RATIO	ADIABATIC EFFICIENCY	CUMULATIVE ADIABATIC EFFICIENCY	EXIT FLOW ANGLE HUB	EXIT FLOW ANGLE TIP	TOTAL TURNING HUB	TOTAL TURNING TIP	INLET AXIAL VELOCITY MEAN	HORSE POWER
ROTOR	1	1.378	1.378	94.1	94.1	-3.4	44.0	27.4	10.6	686.2	1844.3
STATOR	1	1.363	1.363	90.9	90.9	.0	.0	32.2	29.2	643.5	

11 JUL 95 Used to configure Axially Swept (Only) Vane * * * * * ATV3 FLOW PATH INFO
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ALL DIMENSIONS ARE IN INCHES

STA NO.		AXIAL COORDINATE		AXIAL LENGTH		RADIUS		AREA	DISPLACEMENT THICKNESS		SHAPE FACTOR		BLOCKAGE FACTOR		AXIAL VELOCITY	
		HUB	TIP	HUB	TIP	HUB	TIP		HUB	TIP	HUB	TIP	HUB	TIP	HUB	TIP
1		155.968	155.968			.869	11.000	377.76	.000	.000	1.40	1.40	1.000	1.000	592.	592.
2		158.268	158.268	2.300	2.300	.869	11.000	377.76	.008	.008	1.55	1.55	1.000	.999	581.	597.
3		160.268	160.268	2.000	2.000	.869	11.000	377.76	.015	.013	1.53	1.53	1.000	.998	560.	602.
4		162.268	162.268	2.000	2.000	.869	11.000	377.76	.027	.018	1.58	1.52	1.000	.997	504.	612.
5		164.268	164.268	2.000	2.000	1.200	11.000	375.61	.029	.021	1.53	1.51	.999	.996	450.	629.
6		166.268	166.268	2.000	2.000	2.140	11.000	365.75	.014	.022	1.44	1.50	.999	.996	470.	661.
7		168.268	168.386	2.000	2.118	3.300	11.000	345.96	.008	.022	1.54	1.52	1.000	.996	606.	710.
8	ROTOR	171.562	171.566	3.294	3.180	4.433	11.000	318.40	.020	.049	1.57	1.80	.998	.989	584.	624.
9		172.538	172.268	.976	.702	4.700	11.000	311.03	.020	.039	1.57	1.46	.998	.991	602.	635.
10		173.519	173.268	.981	1.000	4.890	11.000	305.28	.023	.037	1.59	1.45	.998	.992	607.	659.
11		174.509	174.268	.990	1.000	5.015	11.000	301.38	.030	.036	1.68	1.48	.997	.992	582.	682.
12		175.004	175.268	.495	1.000	5.080	11.000	299.34	.030	.033	1.58	1.48	.997	.992	577.	713.
13		175.704	175.649	.700	.381	5.200	11.000	295.20	.029	.033	1.52	1.50	.997	.992	583.	723.
14		175.918	179.391	.214	3.742	5.228	11.249	359.80	.028	.050	1.47	1.62	.997	.989	587.	687.
15	VANE	177.639	181.162	1.721	1.771	5.600	11.016	337.27	.053	.030	1.78	1.41	.993	.993	521.	796.
16		179.322	181.718	1.683	.556	5.600	11.000	308.09	.083	.033	1.88	1.53	.990	.992	472.	805.
17		181.018	182.518	1.696	.800	5.600	11.000	292.27	.091	.037	1.66	1.61	.989	.991	446.	798.
18		182.518	183.318	1.500	.800	5.600	11.000	284.69	.078	.041	1.38	1.62	.990	.990	446.	788.
19		184.118	184.118	1.600	.800	5.600	11.000	281.61	.075	.043	1.33	1.59	.991	.990	451.	782.

11 JUL 95 Used to configure Axially Swept (Only) Vane ATV3

* * * * * Aerodynamic Design Point * * * * *

SURGE MARGIN
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AIRFOIL	ALLISON SURGE MARGIN FLOW COEF	LOADING PARM	ASPECT RATIO	REYNOLDS NUMBER	LOSS MODIFIERS REYN# MODIF	CL-LOSS COEFF.	CL/ SPAN	SARP	CH	EFFECTIVITY PARAMETERS AVE. REY.#	REYMOD	TCMOD	AXMOD	CHBAR	EFFECTIVITY
ROTOR 1	1.064	.4867	1.754	1788482.	.000	.0000	.0000								
VANE 1		.7510	3.159	732511.	.000										
	-----	------	------					.845	.488	1260497.	1.053	1.057	.881	.494	.98789
AVERAGE	1.064	.6188	2.456												

LOAD COEFFICIENT	.3812
BASE SURGE MARGIN	-10.4
CORRECTION	-13.3

SURGE MARGIN	-23.8

SINGLE STAGE SURGE MARGIN CORRELATION

SOLIDITY	ASPECT RATIO	D-FACTOR	TIP MN	SURGE MARGIN
1.6557	1.7536	.4344	1.1439	17.39

ROTOR 1 AT STATION 8
THERE ARE 18 AIRFOILS.
THE AIRFOIL SHAPE IS ARB
THE INCIDENCE AND DEVIATION RULES WERE
INLET METAL ANGLES INPUT
EXIT METAL ANGLES INPUT

STRM LINE NO.	CAMBER	SETTING	INLET METAL ANGLE	EXIT METAL ANGLE	TRUE CHORD	THICK-NESS/CHORD	LEADING EDGE RADIUS	INCI-DENCE	DEVI-ATION	SOLID-ITY	STACK RADIUS	INFLECTION ANGLE	RAMP ANGLE
1	38.46	-.96	26.92	-11.54	3.494	.0942	.0400	-2.91	8.12	2.580	3.849	-3.47	19.17
3	35.67	4.40	28.54	-7.13	3.550	.0873	.0300	-2.04	7.72	2.406	4.198	2.13	17.49
5	31.39	10.47	30.89	-.50	3.635	.0771	.0171	-.98	6.92	2.191	4.726	8.86	15.52
7	27.20	16.35	33.22	6.02	3.739	.0664	.0135	.40	5.75	1.984	5.374	14.49	13.66
9	25.14	21.59	36.18	11.05	3.856	.0554	.0109	1.13	5.18	1.805	6.097	20.43	11.94
11	23.51	26.67	39.28	15.77	3.980	.0453	.0088	1.53	4.84	1.656	6.865	28.01	10.20
13	21.91	31.32	42.23	20.33	4.107	.0376	.0074	1.83	4.63	1.533	7.659	34.66	8.32
15	20.10	35.63	45.06	24.96	4.238	.0318	.0067	1.98	4.66	1.431	8.469	38.82	6.26
17	18.23	39.50	47.80	29.57	4.370	.0286	.0062	1.97	4.58	1.346	9.290	42.74	4.04
19	16.28	43.39	50.30	34.03	4.503	.0275	.0062	1.97	4.71	1.274	10.121	46.04	1.73
21	13.77	47.15	52.61	38.84	4.639	.0275	.0064	1.96	5.12	1.212	10.966	49.16	-.48

STATOR 1 AT STATION 15
THERE ARE 42 AIRFOILS.
THE AIRFOIL SHAPE IS DCA
THE INCIDENCE AND DEVIATION RULES WERE
INPUT TABLES
AND NASA 2-D RULE.

STRM LINE NO.	CAMBER	SETTING	INLET METAL ANGLE	EXIT METAL ANGLE	TRUE CHORD	THICK-NESS/CHORD	LEADING EDGE RADIUS	INCI-DENCE	DEVI-ATION	SOLID-ITY	STACK RADIUS	INFLECTION ANGLE	RAMP ANGLE
1	39.30	10.87	30.52	-8.78	1.810	.0500	.0050	1.73	8.78	2.218	5.787	10.87	12.86
3	37.60	10.94	29.74	-7.86	1.810	.0500	.0050	1.77	7.86	2.118	6.004	10.94	12.66
5	36.49	10.56	28.81	-7.68	1.810	.0500	.0050	1.83	7.68	1.975	6.352	10.56	12.17
7	36.70	10.24	28.59	-8.10	1.810	.0500	.0050	1.92	8.10	1.819	6.796	10.24	11.18
9	37.77	10.14	29.02	-8.75	1.810	.0500	.0050	1.95	8.75	1.670	7.305	10.14	9.51
11	39.28	10.11	29.76	-9.53	1.810	.0500	.0050	1.62	9.53	1.537	7.867	10.11	7.18
13	40.73	10.03	30.40	-10.33	1.810	.0500	.0050	1.17	10.33	1.422	8.475	10.04	4.39
15	41.78	9.82	30.72	-11.07	1.810	.0500	.0050	.69	11.07	1.323	9.128	9.82	1.41
17	42.42	9.49	30.70	-11.72	1.810	.0500	.0050	.34	11.72	1.236	9.824	9.49	-1.55
19	42.46	8.99	30.21	-12.24	1.810	.0500	.0050	.12	12.24	1.159	10.558	8.99	-4.34
21	43.23	7.65	29.27	-13.97	1.810	.0500	.0050	-.05	13.97	1.091	11.330	7.65	-6.81

11 JUL 95 Used to configure Axially Swept (Only) Vane
STATION NO 8 * * * * * Aerodynamic Design Point * * * * * ATV3
ROTOR NO. 1

DATA REDUCTION
PAGE 1
COPY 1 OF 1

9:16:10 95/192

MASS FLOW RATE 102.78 HUB BLOCKAGE 99.8 PERCENT HUB STATIC PRESSURE 12.89 MASS AVE TOTAL PRESSURE 20.25
CORRECTED FLOW RATE 78.31 TIP BLOCKAGE 98.9 PERCENT TIP STATIC PRESSURE 16.13 RPM 10417.4

SL NO	PER-CENT SPAN	INCI-DENCE	DEVI-ATION	INLET MACH NO.	EXIT MACH NO.	D-FACTOR	SHOCK LOSS COEF.	P R O LOSS COEF.	F I L E PARA-METER	INLET FREE STRM A/ A*	MIN. PASS-AGE A/ A*	1ST CAP. MACH WAVE INCID.	LOAD COEF.	FLOW COEF.	EXIT RADIUS	DELTA DEVI-ATION	
1	.3	-2.91	8.12	.688	.555	.309		.0499	.00965	1.104	.937		1.435	2.016	4.453	3.24	1
3	4.7	-2.04	7.72	.703	.546	.336		.0469	.00975	1.092	.978		1.242	1.863	4.745	2.84	3
5	11.8	-.98	6.92	.729	.539	.370		.0443	.01005	1.075	1.016		1.032	1.660	5.208	2.17	5
7	20.8	.40	5.75	.765	.541	.402		.0419	.01034	1.055	1.031		.885	1.461	5.796	1.16	7
9	30.9	1.13	5.18	.807	.553	.430		.0399	.01062	1.035	1.036		.789	1.288	6.465	.53	9
11	41.8	1.53	4.84	.855	.573	.448		.0382	.01080	1.019	1.039		.711	1.145	7.178	.12	11
13	53.0	1.83	4.63	.907	.601	.457	.0002	.0371	.01097	1.008	1.042		.642	1.027	7.913	-.12	13
15	64.4	1.98	4.66	.963	.635	.457	.0016	.0382	.01162	1.001	1.043		.574	.928	8.659	-.03	15
17	75.8	1.97	4.58	1.021	.674	.451	.0045	.0422	.01297	1.000	1.042	1.71	.513	.845	9.413	.03	17
19	87.4	1.97	4.71	1.082	.716	.440	.0062	.0488	.01493	1.005	1.036	1.76	.455	.774	10.174	.35	19
21	99.3	1.96	5.12	1.144	.762	.425	.0101	.0587	.01743	1.016	1.037	1.91	.395	.711	10.951	1.15	21

STATOR NO. 1 AT STATION NO. 15

MASS FLOW RATE 102.78 HUB BLOCKAGE 99.3 PERCENT HUB STATIC PRESSURE 14.73 MASS AVE TOTAL PRESSURE 20.03
CORRECTED FLOW RATE 79.14 TIP BLOCKAGE 99.3 PERCENT TIP STATIC PRESSURE 15.15

SL NO	PER-CENT SPAN	INCI-DENCE	DEVI-ATION	INLET MACH NO.	EXIT MACH NO.	D-FACTOR	SHOCK LOSS COEF.	P R O LOSS COEF.	F I L E PARA-METER	INLET FREE STRM A/ A*	MIN. PASS-AGE A/ A*	1ST CAP. MACH WAVE INCID.	EXIT RADIUS	DELTA DEVI-ATION	
1	1.0	1.73	8.78	.634	.467	.367		.1269	.02860	1.151	1.159		5.653	3.16	1
3	5.7	1.77	7.86	.633	.474	.357		.1052	.02483	1.152	1.160		5.910	2.30	3
5	13.3	1.83	7.68	.633	.485	.347		.0783	.01983	1.152	1.162		6.319	2.00	5
7	22.7	1.92	8.10	.643	.507	.336		.0544	.01497	1.142	1.155		6.831	2.00	7
9	33.2	1.95	8.75	.662	.540	.324		.0376	.01125	1.125	1.142		7.397	2.00	9
11	44.0	1.62	9.53	.680	.575	.312		.0282	.00917	1.109	1.127		7.984	2.00	11
13	54.9	1.17	10.33	.696	.608	.300		.0250	.00877	1.097	1.115		8.576	2.00	13
15	65.9	.69	11.07	.704	.635	.287		.0268	.01012	1.091	1.108		9.170	2.00	15
17	76.9	.34	[illegible]	.708	[illegible]	.270		.0319	.01293	1.089	1.103		9.767	2.00	17
19	88.1	.12	12.24	.708	.687	.246		.0393	.01694	1.089	1.085		10.370	2.00	19
21	99.4	-.05	13.97	.698	.705	.216		.0482	.02211	1.096	1.071		10.986	3.03	21

Axially swept Vane.

AIRFOIL	MASS AVERAGED D-FACTOR	STAGE REACTION	MEANLINE SOLIDITY	MASS AVERAGED A/A* FREE STREAM	MASS AVERAGED A/A* MIN PASSAGE
ROTOR 1	.4338	.8945	1.656	1.020	1.035
STATOR 1	.2877		1.537	1.105	1.114
	--------		------		
AVERAGE	.3607		1.597		

11 JUL 95 Used to configure Axially Swept (Only) Vane ATV3

* * * * * Aerodynamic Design Point * * * * *

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STAGE	LOAD COEFFICIENT	FLOW COEFFICIENT	STAGE ADIABATIC EFFICIENCY VANE TO VANE	STAGE PRESSURE RATIO VANE TO VANE	STAGE TEMPERATURE RISE VANE TO VANE
1	.707	1.064	94.12	1.378	52.86

STAGE 1

S.L. NO.	PRESSURE RATIO V - V	TEMPERATURE RISE V - V	ADIABATIC EFFICIENCY V - V
1	1.200	29.75	93.12
3	1.206	30.55	93.46
5	1.218	32.09	93.74
7	1.244	35.51	94.19
9	1.285	40.69	94.70
11	1.331	46.39	95.09
13	1.377	52.07	95.29
15	1.414	56.86	94.92
17	1.443	61.04	93.91
19	1.461	64.14	92.54
21	1.456	65.27	90.04

APPENDIX D

LOW NOISE FAN CONFIGURATION NO. 4:
AERODYNAMIC DESIGN POINT
BLADE AND VANE ELEMENT PERFORMANCE AND GEOMETRY OUTPUT

31 JAN 95   Used to configure Swept and Leaned Vane   * * * * *   slv12   16:19:15   95/031
STATION NO. 1   * * * * * Aerodynamic Design Point
ANNULUS EXIT 1

MASS FLOW RATE 102.78   FLOW RATE/SQ. FT. 39.18 (CORRECTED)   MASS AVE. TOTAL PRESSURE 14.70
CORRECTED FLOW RATE 102.78   ANNULUS AREA 2.62 SQ. FT = 377.8 SQ.IN   MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
.869	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	.0	1
1.882	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	10.0	3
2.895	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	20.0	5
3.908	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	30.0	7
4.921	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	40.0	9
5.934	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	50.0	11
6.947	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	60.0	13
7.961	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	70.0	15
8.974	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	80.0	17
9.987	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	90.0	19
11.000	591.9	.0	.00	14.70	12.00	518.7	489.5	591.9	.546	591.9	100.0	21

ANNULUS 2

MASS FLOW RATE 102.78   FLOW RATE/SQ. FT. 39.18 (CORRECTED)   MASS AVE. TOTAL PRESSURE 14.70
CORRECTED FLOW RATE 102.78   ANNULUS AREA 2.62 SQ. FT = 377.8 SQ.IN   MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
.877	581.6	.0	2.02	14.70	12.09	518.7	490.5	581.6	.536	581.6	.1	1
1.894	582.8	.0	4.36	14.70	12.08	518.7	490.4	582.8	.537	582.8	10.1	3
2.911	584.9	.0	5.59	14.70	12.06	518.7	490.1	585.0	.539	585.0	20.2	5
3.925	587.4	.0	6.05	14.70	12.04	518.7	489.9	587.4	.541	587.4	30.2	7
4.938	589.8	.0	5.90	14.70	12.02	518.7	489.7	589.8	.544	589.8	40.2	9
5.950	592.0	.0	5.24	14.70	12.00	518.7	489.5	592.0	.546	592.0	50.2	11
6.959	593.8	.0	4.19	14.70	11.99	518.7	489.3	593.9	.548	593.9	60.1	13
7.968	595.3	.0	2.87	14.70	11.97	518.7	489.1	595.3	.549	595.3	70.1	15
8.976	596.3	.0	1.36	14.70	11.96	518.7	489.0	596.3	.550	596.3	80.0	17
9.984	596.7	.0	-.23	14.70	11.96	518.7	489.0	596.7	.550	596.7	90.0	19
10.992	596.7	.0	-1.81	14.70	11.96	518.7	489.0	596.7	.550	596.7	99.9	21

31 JAN 95
STATION NO. 3
ANNULUS EXIT 3

Used to configure Swept and Leaned Vane
* * * * * Aerodynamic Design Point * * * * *

slv12 16:19:15 95/031

MASS FLOW RATE 102.78
CORRECTED FLOW RATE 102.78
FLOW RATE/SQ. FT. 39.18 (CORRECTED)
ANNULUS AREA 2.62 SQ. FT = 377.7 SQ.IN
MASS AVE. TOTAL PRESSURE 14.70
MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
.884	560.4	.0	2.66	14.70	12.26	518.7	492.5	560.4	.515	560.4	.1	1
1.913	568.9	.0	9.89	14.70	12.19	518.7	491.7	569.0	.523	569.0	10.3	3
2.934	575.9	.0	12.53	14.70	12.13	518.7	491.0	576.0	.530	576.0	20.4	5
3.951	582.1	.0	13.09	14.70	12.08	518.7	490.4	582.2	.536	582.2	30.4	7
4.963	587.4	.0	12.39	14.70	12.04	518.7	489.9	587.6	.541	587.6	40.4	9
5.971	592.0	.0	10.85	14.70	12.00	518.7	489.4	592.1	.546	592.1	50.4	11
6.977	595.7	.0	8.78	14.70	11.97	518.7	489.1	595.7	.549	595.7	60.3	13
7.980	598.5	.0	6.37	14.70	11.95	518.7	488.8	598.6	.552	598.6	70.2	15
8.983	600.6	.0	3.78	14.70	11.93	518.7	488.6	600.6	.554	600.6	80.1	17
9.985	601.8	.0	1.14	14.70	11.92	518.7	488.5	601.8	.555	601.8	90.0	19
10.987	602.3	.0	-1.44	14.70	11.91	518.7	488.4	602.3	.556	602.3	99.9	21

ANNULUS 4

MASS FLOW RATE 102.78
CORRECTED FLOW RATE 102.78
FLOW RATE/SQ. FT. 39.19 (CORRECTED)
ANNULUS AREA 2.62 SQ. FT = 377.6 SQ.IN
MASS AVE. TOTAL PRESSURE 14.70
MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
.896	504.9	.0	43.56	14.70	12.68	518.7	497.3	506.7	.463	506.7	.3	1
1.963	534.6	.0	36.99	14.70	12.46	518.7	494.7	535.9	.491	535.9	10.8	3
2.998	555.3	.0	34.40	14.70	12.30	518.7	492.9	556.4	.511	556.4	21.0	5
4.015	571.0	.0	31.25	14.70	12.17	518.7	491.4	571.9	.526	571.9	31.1	7
5.023	583.2	.0	27.30	14.70	12.07	518.7	490.3	583.9	.538	583.9	41.0	9
6.023	592.8	.0	22.77	14.70	11.99	518.7	489.3	593.2	.547	593.2	50.9	11
7.018	600.1	.0	17.93	14.70	11.93	518.7	488.6	600.4	.554	600.4	60.7	13
8.011	605.5	.0	12.98	14.70	11.88	518.7	488.1	605.6	.559	605.6	70.5	15
9.001	609.2	.0	8.07	14.70	11.85	518.7	487.7	609.2	.563	609.2	80.3	17
9.992	611.4	.0	3.32	14.70	11.84	518.7	487.5	611.4	.565	611.4	90.0	19
10.982	612.2	.0	-1.15	14.70	11.83	518.7	487.4	612.2	.565	612.2	99.8	21

31 JAN 95 Used to configure Swept and Leaned Vane * * * * * slv12
STATION NO. 5 * * * * * Aerodynamic Design Point 16:19:15 95/031
ANNULUS EXIT 5

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 39.46 (CORRECTED) MASS AVE. TOTAL PRESSURE 14.70
CORRECTED FLOW RATE 102.78 ANNULUS AREA 2.60 SQ. FT = 375.0 SQ.IN MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
1.229	450.9	.0	141.82	14.70	12.93	518.7	500.0	472.7	.431	472.7	.3	1
2.189	500.8	.0	105.87	14.70	12.64	518.7	496.8	511.8	.468	511.8	10.1	3
3.182	537.8	.0	84.73	14.70	12.39	518.7	494.0	544.4	.500	544.4	20.2	5
4.170	565.1	.0	69.22	14.70	12.19	518.7	491.7	569.3	.524	569.3	30.3	7
5.150	585.3	.0	56.30	14.70	12.03	518.7	489.8	588.0	.542	588.0	40.3	9
6.125	600.4	.0	44.86	14.70	11.92	518.7	488.5	602.1	.556	602.1	50.3	11
7.096	611.4	.0	34.40	14.70	11.83	518.7	487.4	612.4	.566	612.4	60.2	13
8.066	619.3	.0	24.68	14.70	11.76	518.7	486.6	619.8	.573	619.8	70.1	15
9.036	624.6	.0	15.59	14.70	11.72	518.7	486.1	624.8	.578	624.8	80.0	17
10.006	627.7	.0	7.11	14.70	11.69	518.7	485.8	627.7	.581	627.7	89.9	19
10.979	628.8	.0	-.73	14.70	11.68	518.7	485.7	628.8	.582	628.8	99.8	21

ANNULUS 6

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 40.62 (CORRECTED) MASS AVE. TOTAL PRESSURE 14.70
CORRECTED FLOW RATE 102.78 ANNULUS AREA 2.53 SQ. FT = 364.3 SQ.IN MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
2.154	470.0	.0	244.24	14.70	12.51	518.7	495.3	529.6	.485	529.6	.2	1
2.809	514.4	.0	194.89	14.70	12.35	518.7	493.4	550.1	.505	550.1	7.6	3
3.628	553.4	.0	153.45	14.70	12.15	518.7	491.2	574.2	.528	574.2	16.8	5
4.505	583.8	.0	120.28	14.70	11.97	518.7	489.1	596.0	.550	596.0	26.7	7
5.408	607.1	.0	93.69	14.70	11.81	518.7	487.2	614.2	.567	614.2	36.9	9
6.322	624.9	.0	71.97	14.70	11.68	518.7	485.7	629.1	.582	629.1	47.2	11
7.243	638.6	.0	53.72	14.70	11.58	518.7	484.4	640.9	.594	640.9	57.6	13
8.170	648.7	.0	37.93	14.70	11.50	518.7	483.5	649.8	.603	649.8	68.1	15
9.101	655.6	.0	23.92	14.70	11.44	518.7	482.8	656.1	.609	656.1	78.6	17
10.037	659.6	.0	11.27	14.70	11.41	518.7	482.4	659.7	.612	659.7	89.1	19
10.978	660.6	.0	-.29	14.70	11.40	518.7	482.3	660.6	.613	660.6	99.7	21

31 JAN 95 Used to configure Swept and Leaned Vane
STATION NO. 7 * * * * * Aerodynamic Design Point * * * * * slv12 INTERSTAGE DATA
ANNULUS EXIT 7 16:19:15 95/031 PAGE 4
COPY 1 OF 1

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 43.13 (CORRECTED) MASS AVE. TOTAL PRESSURE 14.70
CORRECTED FLOW RATE 102.78 ANNULUS AREA 2.38 SQ. FT = 343.1 SQ.IN MASS AVE. TOTAL TEMPERATURE 518.7

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
3.308	606.9	.0	297.54	14.70	11.26	518.7	480.6	675.9	.629	675.9	.1	1
3.708	628.7	.0	250.07	14.70	11.25	518.7	480.5	676.6	.629	676.6	5.3	3
4.297	648.9	.0	202.15	14.70	11.22	518.7	480.2	679.7	.633	679.7	13.0	5
5.001	664.5	.0	162.30	14.70	11.18	518.7	479.7	684.1	.637	684.1	22.1	7
5.775	676.6	.0	130.23	14.70	11.14	518.7	479.1	689.0	.642	689.0	32.1	9
6.593	686.3	.0	103.55	14.70	11.09	518.7	478.5	694.1	.647	694.1	42.8	11
7.440	694.4	.0	79.98	14.70	11.04	518.7	477.9	699.0	.652	699.0	53.8	13
8.306	700.8	.0	58.07	14.70	11.00	518.7	477.4	703.2	.656	703.2	65.0	15
9.186	705.5	.0	37.11	14.70	10.97	518.7	477.1	706.5	.660	706.5	76.4	17
10.077	708.4	.0	16.75	14.70	10.95	518.7	476.8	708.6	.662	708.6	88.0	19
10.977	709.3	.0	-2.40	14.70	10.95	518.7	476.7	709.3	.662	709.3	99.7	21

31 JAN 95 Used to configure Swept and Leaned Vane * * * * * slv12 16:19:15 95/031
STATION NO. 8 * * * * * Aerodynamic Design Point
ROTOR EXIT 1

MASS FLOW RATE	102.78	FLOW RATE/SQ. FT. 35.58 (CORRECTED)	MASS AVE. TOTAL PRESSURE	20.25
CORRECTED FLOW RATE	78.31	ANNULUS AREA 2.20 SQ. FT = 317.0 SQ.IN	MASS AVE. TOTAL TEMPERATURE	571.5
CORRECTED TIP SPEED	1000. FT/SEC		ROTOR ADIABATIC EFFICIENCY	94.1
PRESSURE RATIO	1.378	CUMULATIVE ADIABATIC EFFICIENCY 94.1		

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
4.453	583.4	441.3	169.47	17.63	12.89	548.4	501.5	750.8	.684	607.5	.3	1
4.745	580.2	425.2	153.10	17.73	13.14	549.2	504.2	735.5	.668	600.1	4.7	3
5.208	576.4	407.0	132.25	17.90	13.48	550.8	507.8	717.9	.650	591.4	11.8	5
5.797	576.5	404.5	112.13	18.29	13.85	554.2	511.8	713.1	.643	587.3	20.8	7
6.465	583.2	415.7	94.28	18.88	14.23	559.4	515.9	722.3	.649	590.8	30.9	9
7.178	594.4	426.9	78.02	19.55	14.62	565.1	520.0	736.0	.658	599.5	41.8	11
7.914	608.2	434.6	62.61	20.23	14.99	570.8	523.9	750.2	.668	611.4	53.0	13
8.660	619.8	433.7	47.31	20.78	15.34	575.5	527.7	758.0	.673	621.6	64.4	15
9.414	629.1	428.4	32.15	21.21	15.64	579.7	531.4	761.8	.674	630.0	75.8	17
10.175	633.8	416.4	17.14	21.47	15.90	582.8	534.9	758.5	.669	634.0	87.4	19
10.951	625.0	393.6	2.66	21.40	16.12	583.9	538.5	738.6	.649	625.0	99.3	21

RELATIVE MACH NOS. INLET	MACH NOS. EXIT	TOTAL TEMP RISE	TOTAL TEMP RATIO	WHEEL SPEED IN	WHEEL SPEED OUT	ROTOR PRESSURE RATIO	ROTOR ADIABATIC EFFICIENCY	ROTOR POLYTROPIC EFFICIENCY	
.688	.554	29.76	1.057	300.7	404.8	1.200	93.1	93.3	1
.703	.545	30.56	1.059	337.1	431.3	1.206	93.4	93.6	3
.730	.539	32.10	1.062	390.7	473.5	1.218	93.7	93.9	5
.765	.541	35.51	1.068	454.7	527.0	1.244	94.2	94.4	7
.807	.552	40.70	1.078	525.0	587.7	1.285	94.7	94.9	9
.855	.573	46.40	1.089	599.4	652.6	1.331	95.1	95.3	11
.907	.601	52.08	1.100	676.3	719.4	1.377	95.3	95.5	13
.963	.635	56.86	1.110	755.1	787.3	1.414	94.9	95.2	15
1.021	.674	61.05	1.118	835.1	855.8	1.443	93.9	94.2	17
1.082	.717	64.14	1.124	916.1	925.0	1.461	92.5	92.9	19
1.144	.763	65.25	1.126	997.9	995.6	1.456	90.1	90.6	21

S.L. NO.	DIFFUSION FACTOR	OMEGA BAR	DELTA PS/Q	SOLIDITY	TOTAL TURNING	ABSOLUTE FLOW ANGLE INLET	ABSOLUTE FLOW ANGLE EXIT	K.&S. EQU. DIFFUSION FACTOR	RELATIVE FLOW ANGLE INLET	RELATIVE FLOW ANGLE EXIT	RELATIVE VELOCITY INLET	RELATIVE VELOCITY EXIT	RELATIVE TEMPERATURE INLET	RELATIVE TEMPERATURE EXIT
1	.310	.050	.389	2.580	27.42	.00	35.99	1.262	23.98	-3.43	739.8	608.6	526.	532.
3	.337	.047	.429	2.406	25.90	.00	35.32	1.301	26.48	.58	755.9	600.1	528.	534.
5	.371	.044	.472	2.191	23.47	.00	34.53	1.353	29.89	6.42	783.9	595.1	531.	537.
7	.403	.042	.504	1.984	21.83	.00	34.56	1.407	33.61	11.78	821.4	599.9	536.	542.
9	.430	.040	.519	1.805	21.07	.00	35.13	1.456	37.31	16.24	866.3	615.3	542.	547.
11	.448	.038	.519	1.656	20.18	.00	35.46	1.494	40.81	20.63	917.1	640.5	549.	554.
13	.457	.037	.507	1.533	19.08	.00	35.41	1.519	44.06	24.98	972.6	674.5	557.	562.
15	.457	.040	.484	1.431	17.41	.00	34.90	1.529	47.04	29.63	1031.8	715.2	566.	570.
17	.451	.047	.452	1.346	15.61	.00	34.21	1.528	49.77	34.16	1093.8	761.3	577.	580.
19	.440	.055	.416	1.274	13.55	.00	33.30	1.518	52.28	38.73	1158.1	812.8	589.	590.
21	.424	.069	.376	1.212	10.67	.00	32.21	1.497	54.60	43.92	1224.3	867.7	602.	601.

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 36.50 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.25
CORRECTED FLOW RATE 78.31 ANNULUS AREA 2.15 SQ. FT = 308.9 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
4.720	602.1	416.3	141.64	17.63	12.95	548.4	502.1	745.6	.679	618.6	.3	1
4.990	597.7	404.3	129.19	17.73	13.17	549.2	504.4	733.1	.666	611.5	4.6	3
5.424	592.8	390.8	112.77	17.90	13.46	550.8	507.7	719.0	.651	603.5	11.5	5
5.980	593.2	392.2	96.25	18.29	13.80	554.2	511.3	717.6	.647	601.0	20.3	7
6.617	601.3	406.1	80.79	18.88	14.14	559.4	515.0	730.1	.656	606.7	30.4	9
7.301	613.9	419.7	66.16	19.55	14.49	565.1	518.7	746.6	.669	617.5	41.3	11
8.010	628.9	429.4	52.31	20.23	14.83	570.8	522.2	763.3	.681	631.1	52.5	13
8.733	641.4	430.1	39.04	20.78	15.14	575.5	525.8	773.2	.688	642.6	64.0	15
9.464	651.2	426.1	26.54	21.21	15.42	579.7	529.2	778.6	.690	651.7	75.6	17
10.205	655.9	415.2	14.84	21.47	15.67	582.8	532.6	776.4	.686	656.1	87.4	19
10.962	647.3	393.2	3.65	21.40	15.87	583.9	536.2	757.4	.667	647.3	99.4	21

ANNULUS 10

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 37.31 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.25
CORRECTED FLOW RATE 78.31 ANNULUS AREA 2.10 SQ. FT = 302.2 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
4.913	601.5	399.9	99.04	17.63	13.13	548.4	504.1	729.1	.662	609.6	.4	1
5.174	597.1	390.0	93.63	17.73	13.32	549.2	506.1	719.3	.652	604.4	4.7	3
5.595	594.0	378.9	85.77	17.90	13.57	550.8	508.8	709.8	.642	600.2	11.5	5
6.137	598.8	382.2	76.71	18.29	13.83	554.2	511.7	714.5	.644	603.7	20.4	7
6.756	612.5	397.8	66.76	18.88	14.10	559.4	514.6	733.4	.659	616.2	30.5	9
7.420	630.9	413.0	55.95	19.55	14.37	565.1	517.5	756.1	.678	633.4	41.4	11
8.107	651.0	424.3	44.74	20.23	14.64	570.8	520.3	778.3	.696	652.5	52.7	13
8.807	667.7	426.5	33.35	20.78	14.88	575.5	523.2	793.0	.707	668.5	64.1	15
9.515	680.8	423.8	22.16	21.21	15.11	579.7	526.1	802.2	.713	681.1	75.7	17
10.232	688.0	414.1	11.33	21.47	15.31	582.8	529.1	803.1	.712	688.1	87.4	19
10.964	681.3	393.2	.70	21.40	15.49	583.9	532.4	786.6	.695	681.3	99.4	21

31 JAN 95 Used to configure Swept and Leaned Vane * * * * * slv12 16:19:15 95/031
STATION NO. 11 * * * * * Aerodynamic Design Point
ANNULUS EXIT 11

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 38.04 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.25
CORRECTED FLOW RATE 78.31 ANNULUS AREA 2.06 SQ. FT = 296.4 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.045	579.3	389.5	80.10	17.63	13.42	548.4	507.3	702.6	.636	584.8	.5	1
5.307	583.5	380.2	83.79	17.73	13.51	549.2	508.2	701.5	.635	589.5	4.9	3
5.728	591.3	370.1	83.78	17.90	13.65	550.8	509.7	702.6	.635	597.2	11.9	5
6.264	606.3	374.4	78.38	18.29	13.80	554.2	511.4	716.9	.647	611.3	20.9	7
6.872	627.9	391.1	68.87	18.88	13.99	559.4	513.4	743.0	.669	631.7	31.0	9
7.520	651.8	407.6	57.10	19.55	14.19	565.1	515.6	770.8	.692	654.3	41.9	11
8.188	675.5	420.1	44.73	20.23	14.40	570.8	517.9	796.8	.714	677.0	53.0	13
8.869	694.9	423.5	32.54	20.78	14.60	575.5	520.3	814.5	.728	695.7	64.4	15
9.557	710.4	421.9	21.09	21.21	14.78	579.7	522.8	826.5	.737	710.7	75.9	17
10.254	720.0	413.2	10.51	21.47	14.94	582.8	525.4	830.2	.739	720.1	87.5	19
10.965	716.4	393.1	.55	21.40	15.08	583.9	528.3	817.2	.725	716.4	99.4	21

ANNULUS 12

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 38.61 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.25
CORRECTED FLOW RATE 78.31 ANNULUS AREA 2.03 SQ. FT = 292.0 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.116	559.9	384.1	100.60	17.63	13.60	548.4	509.2	686.4	.620	568.9	.6	1
5.390	571.5	374.3	100.40	17.73	13.63	549.2	509.5	690.5	.624	580.2	5.2	3
5.822	588.3	364.1	94.50	17.90	13.69	550.8	510.2	698.2	.630	595.8	12.5	5
6.362	611.6	368.6	83.00	18.29	13.78	554.2	511.1	718.9	.649	617.2	21.7	7
6.967	640.2	385.8	68.78	18.88	13.90	559.4	512.4	750.7	.676	643.9	31.9	9
7.604	669.7	403.0	54.22	19.55	14.03	565.1	514.0	783.5	.705	671.9	42.6	11
8.259	698.1	416.5	40.76	20.23	14.18	570.8	515.6	813.9	.731	699.3	53.7	13
8.923	721.3	420.9	28.66	20.78	14.31	575.5	517.4	835.6	.749	721.9	64.9	15
9.595	739.8	420.3	18.07	21.21	14.44	579.7	519.4	851.1	.762	740.1	76.3	17
10.274	751.9	412.4	8.87	21.47	14.56	582.8	521.6	857.6	.766	752.0	87.7	19
10.967	750.5	393.1	.80	21.40	14.66	583.9	524.2	847.2	.755	750.5	99.4	21

31 JAN 95 Used to configure Swept and Leaned Vane
STATION NO. 13 * * * * * Aerodynamic Design Point * * * * * slv12
ANNULUS EXIT 13

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 40.11 (CORRECTED) MASS AVE. TOTAL PRESSURE 20.25
CORRECTED FLOW RATE 78.31 ANNULUS AREA 1.95 SQ. FT = 281.1 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.343	630.1	367.7	134.85	17.63	12.99	548.4	502.6	741.9	.675	644.3	.4	1
5.598	641.2	360.4	122.08	17.73	13.03	549.2	502.9	745.6	.678	652.7	4.8	3
5.999	654.9	353.3	103.86	17.90	13.10	550.8	503.7	751.3	.683	663.1	11.9	5
6.503	672.8	360.6	85.73	18.29	13.22	554.2	505.0	768.1	.697	678.2	20.8	7
7.073	695.1	380.0	70.20	18.88	13.36	559.4	506.7	795.3	.721	698.7	30.8	9
7.683	718.7	398.9	56.85	19.55	13.52	565.1	508.5	823.9	.745	720.9	41.5	11
8.316	741.7	413.7	44.72	20.23	13.70	570.8	510.5	850.4	.768	743.0	52.7	13
8.962	759.7	419.1	33.02	20.78	13.87	575.5	512.8	868.3	.782	760.4	64.0	15
9.619	772.7	419.2	21.78	21.21	14.05	579.7	515.3	879.4	.790	773.0	75.6	17
10.286	779.0	411.9	11.16	21.47	14.23	582.8	518.2	881.2	.790	779.0	87.4	19
10.969	771.4	393.0	1.85	21.40	14.41	583.9	521.5	865.8	.773	771.4	99.4	21

31 JAN 95 Used to configure Swept and Leaned Vane * * * * * slv12 16:19:15 95/031 INTERSTAGE DATA
STATION NO. 14 * * * * * Aerodynamic Design Point PAGE 9
STATOR EXIT 1 COPY 1 OF 1

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 41.08 (CORRECTED) MASS AVE. TOTAL PRESSURE 19.97
CORRECTED FLOW RATE 79.39 ANNULUS AREA 1.93 SQ. FT = 278.3 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5
PRESSURE RATIO 1.359 CUMULATIVE ADIABATIC EFFICIENCY 89.9 STAGE ADIABATIC EFFICIENCY 89.9

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.599	560.6	.0	52.07	17.06	14.35	548.4	522.0	563.1	.503	563.1	.8	1
5.840	564.6	.0	50.92	17.23	14.47	549.2	522.5	566.9	.506	566.9	5.2	3
6.230	572.0	.0	49.84	17.51	14.64	550.8	523.3	574.2	.512	574.2	12.4	5
6.726	594.9	.0	49.11	17.99	14.84	554.2	524.5	596.9	.532	596.9	21.4	7
7.284	632.2	.0	46.76	18.66	15.03	559.4	525.9	633.9	.564	633.9	31.7	9
7.870	671.9	.0	41.03	19.37	15.21	565.1	527.3	673.1	.598	673.1	42.4	11
8.470	708.9	.0	32.27	20.05	15.35	570.8	528.8	709.7	.629	709.7	53.4	13
9.077	735.4	.0	21.57	20.58	15.47	575.5	530.5	735.7	.652	735.7	64.5	15
9.695	754.3	.0	10.48	20.95	15.55	579.7	532.3	754.4	.667	754.4	75.8	17
10.325	764.8	.0	-.16	21.14	15.58	582.8	534.1	764.8	.675	764.8	87.3	19
10.975	758.9	.0	-9.75	20.98	15.54	583.9	536.0	759.0	.669	759.0	99.2	21

ABSOLUTE MACH NOS. INLET	ABSOLUTE MACH NOS. EXIT	TOTAL TEMP RISE	TOTAL TEMP RATIO	WHEEL SPEED IN	WHEEL SPEED OUT	STAGE PRESSURE RATIO	STAGE ADIABATIC EFFICIENCY	STAGE POLYTROPIC EFFICIENCY	S.L. NO.
.675	.503	29.76	1.057	.0	.0	1.161	75.8	76.3	1
.678	.506	30.56	1.059	.0	.0	1.172	79.0	79.5	3
.683	.512	32.10	1.062	.0	.0	1.191	83.0	83.4	5
.697	.532	35.51	1.068	.0	.0	1.224	87.0	87.3	7
.721	.564	40.70	1.078	.0	.0	1.269	90.0	90.3	9
.745	.598	46.40	1.089	.0	.0	1.318	91.8	92.1	11
.768	.629	52.08	1.100	.0	.0	1.364	92.5	92.8	13
.782	.652	56.86	1.110	.0	.0	1.400	92.1	92.5	15
.790	.667	61.05	1.118	.0	.0	1.426	90.6	91.1	17
.790	.675	64.14	1.124	.0	.0	1.438	88.5	89.1	19
.773	.669	65.25	1.126	.0	.0	1.428	85.1	85.9	21

S.L. NO.	DIFFUSION FACTOR	OMEGA BAR	DELTA PS/Q	SOLIDITY	TOTAL TURNING	ABSOLUTE FLOW ANGLE INLET	ABSOLUTE FLOW ANGLE EXIT	K.&S. EQU. DIFFUSION FACTOR
1	.350	.124	.294	2.211	29.71	29.71	.00	1.463
3	.352	.105	.307	2.115	28.91	28.91	.00	1.464
5	.352	.081	.321	1.979	28.05	28.05	.00	1.466
7	.349	.058	.320	1.829	28.00	28.00	.00	1.461
9	.343	.041	.303	1.685	28.54	28.54	.00	1.451
11	.337	.031	.279	1.556	28.96	28.96	.00	1.442
13	.333	.027	.254	1.442	29.11	29.11	.00	1.434
15	.331	.029	.231	1.341	28.86	28.86	.00	1.429
17	.332	.036	.209	1.253	28.47	28.47	.00	1.426
19	.331	.046	.186	1.174	27.87	27.87	.00	1.421
21	.329	.059	.163	1.103	27.00	27.00	.00	1.416

31 JAN 95 Used to configure Swept and Leaned Vane
STATION NO. 15 * * * * * Aerodynamic Design Point * * * * * slv12 INTERSTAGE DATA
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MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 40.78 (CORRECTED)
CORRECTED FLOW RATE 79.39 ANNULUS AREA 1.95 SQ. FT = 280.4 SQ.IN
MASS AVE. TOTAL PRESSURE 19.97
MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.669	503.9	.0	12.63	17.06	14.86	548.4	527.3	504.1	.448	504.1	1.3	1
5.914	516.5	.0	15.20	17.23	14.91	549.2	527.0	516.7	.459	516.7	5.8	3
6.305	536.1	.0	17.97	17.51	14.99	550.8	526.8	536.4	.477	536.4	13.1	5
6.795	572.0	.0	19.57	17.99	15.08	554.2	526.9	572.3	.509	572.3	22.1	7
7.339	619.9	.0	19.05	18.66	15.18	559.4	527.3	620.2	.551	620.2	32.2	9
7.909	666.9	.0	16.24	19.37	15.28	565.1	528.0	667.1	.592	667.1	42.8	11
8.492	709.1	.0	11.85	20.05	15.36	570.8	528.9	709.2	.629	709.2	53.6	13
9.087	739.6	.0	6.62	20.58	15.42	575.5	530.0	739.6	.655	739.6	64.6	15
9.695	762.1	.0	1.17	20.95	15.45	579.7	531.4	762.1	.674	762.1	75.8	17
10.317	775.9	.0	-4.07	21.14	15.43	582.8	532.7	775.9	.686	775.9	87.4	19
10.963	772.9	.0	-8.79	20.98	15.36	583.9	534.2	773.0	.682	773.0	99.3	21

ANNULUS 16

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 40.64 (CORRECTED)
CORRECTED FLOW RATE 79.39 ANNULUS AREA 1.95 SQ. FT = 281.3 SQ.IN
MASS AVE. TOTAL PRESSURE 19.97
MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.683	471.4	.0	1.34	17.06	15.13	548.4	529.9	471.4	.418	471.4	1.5	1
5.936	489.4	.0	3.27	17.23	15.14	549.2	529.3	489.4	.434	489.4	6.2	3
6.335	516.3	.0	5.48	17.51	15.16	550.8	528.6	516.4	.458	516.4	13.6	5
6.827	560.0	.0	7.06	17.99	15.20	554.2	528.1	560.1	.497	560.1	22.7	7
7.368	615.0	.0	7.52	18.66	15.23	559.4	527.9	615.0	.546	615.0	32.7	9
7.932	667.9	.0	6.79	19.37	15.27	565.1	527.9	667.9	.593	667.9	43.2	11
8.508	714.6	.0	5.18	20.05	15.29	570.8	528.2	714.6	.634	714.6	53.9	13
9.096	748.2	.0	3.04	20.58	15.31	575.5	528.9	748.2	.664	748.2	64.7	15
9.699	772.3	.0	.78	20.95	15.32	579.7	530.1	772.3	.684	772.3	75.9	17
10.317	785.9	.0	-1.15	21.14	15.30	582.8	531.4	785.9	.695	785.9	87.4	19
10.961	780.4	.0	-2.13	20.98	15.27	583.9	533.2	780.4	.689	780.4	99.3	21

31 JAN 95 Used to configure Swept and Leaned Vane * * * * * slv12 16:19:15 95/031

STATION NO. 17 * * * * * Aerodynamic Design Point
ANNULUS EXIT 17

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 40.60 (CORRECTED) MASS AVE. TOTAL PRESSURE 19.97
CORRECTED FLOW RATE 79.39 ANNULUS AREA 1.96 SQ. FT = 281.6 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.680	461.5	.0	-.45	17.06	15.20	548.4	530.7	461.5	.409	461.5	1.5	1
5.938	481.0	.0	.30	17.23	15.21	549.2	530.0	481.0	.426	481.0	6.3	3
6.339	510.2	.0	1.17	17.51	15.21	550.8	529.1	510.2	.452	510.2	13.7	5
6.833	556.5	.0	1.78	17.99	15.23	554.2	528.4	556.5	.494	556.5	22.8	7
7.374	613.8	.0	1.93	18.66	15.25	559.4	528.0	613.8	.545	613.8	32.9	9
7.936	668.6	.0	1.57	19.37	15.26	565.1	527.9	668.6	.594	668.6	43.3	11
8.510	716.5	.0	.85	20.05	15.27	570.8	528.0	716.5	.636	716.5	53.9	13
9.096	750.8	.0	-.07	20.58	15.28	575.5	528.6	750.8	.666	750.8	64.7	15
9.697	774.9	.0	-.99	20.95	15.28	579.7	529.7	774.9	.687	774.9	75.9	17
10.315	787.7	.0	-1.70	21.14	15.28	582.8	531.2	787.7	.697	787.7	87.3	19
10.958	780.3	.0	-1.96	20.98	15.27	583.9	533.2	780.3	.689	780.3	99.2	21

ANNULUS 18

MASS FLOW RATE 102.78 FLOW RATE/SQ. FT. 40.60 (CORRECTED) MASS AVE. TOTAL PRESSURE 19.97
CORRECTED FLOW RATE 79.39 ANNULUS AREA 1.96 SQ. FT = 281.6 SQ.IN MASS AVE. TOTAL TEMPERATURE 571.5

RADIUS INCHES	AXIAL VELOCITY	WHIRL VELOCITY	RADIAL VELOCITY	TOTAL PRESSURE	STATIC PRESSURE	TEMPERATURES TOTAL	TEMPERATURES STATIC	ABSOLUTE VELOCITY	ABSOLUTE MACH NO.	MER. VELOCITY	PERCENT SPAN	S.L. NO.
5.680	458.8	.0	.00	17.06	15.22	548.4	530.9	458.8	.406	458.8	1.5	1
5.938	478.6	.0	.00	17.23	15.23	549.2	530.1	478.6	.424	478.6	6.3	3
6.341	508.3	.0	.00	17.51	15.23	550.8	529.3	508.3	.451	508.3	13.7	5
6.836	555.3	.0	.00	17.99	15.24	554.2	528.5	555.3	.493	555.3	22.9	7
7.376	613.6	.0	.00	18.66	15.25	559.4	528.0	613.6	.545	613.6	32.9	9
7.938	669.3	.0	.00	19.37	15.25	565.1	527.8	669.3	.594	669.3	43.3	11
8.511	718.0	.0	.00	20.05	15.25	570.8	527.8	718.0	.637	718.0	53.9	13
9.096	752.8	.0	.00	20.58	15.25	575.5	528.4	752.8	.668	752.8	64.7	15
9.696	777.0	.0	.00	20.95	15.26	579.7	529.5	777.0	.689	777.0	75.9	17
10.314	789.3	.0	.00	21.14	15.26	582.8	531.0	789.3	.699	789.3	87.3	19
10.957	781.2	.0	.00	20.98	15.26	583.9	533.1	781.2	.690	781.2	99.2	21

31 JAN 95 Used to configure Swept and Leaned Vane
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PERF. SUMMARY
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		D-FACTOR HUB	D-FACTOR MEAN	D-FACTOR TIP	EQUIVALENT DIFFUSION FACTOR HUB	EQUIVALENT DIFFUSION FACTOR MEAN	EQUIVALENT DIFFUSION FACTOR TIP	LOAD COEFFICIENT (MEAN WHEEL SPEED) HUB	LOAD COEFFICIENT (MEAN WHEEL SPEED) MEAN	LOAD COEFFICIENT (MEAN WHEEL SPEED) TIP	MACH NO.	SPECIFIC FLOW IN	SPECIFIC FLOW OUT	FLOW COEFF.
ROTOR	1	.310	.448	.424	1.454	1.566	1.509	.497	.776	1.091	1.144	43.13	35.58	1.145
STATOR	1	.350	.337	.329	1.436	1.471	1.508				.675	40.11	41.08	

		PRESSURE RATIO	CUMULATIVE PRESSURE RATIO	ADIABATIC EFFICIENCY	CUMULATIVE ADIABATIC EFFICIENCY	EXIT FLOW ANGLE HUB	EXIT FLOW ANGLE TIP	TOTAL TURNING HUB	TOTAL TURNING TIP	INLET AXIAL VELOCITY MEAN	HORSE POWER
ROTOR	1	1.378	1.378	94.1	94.1	-3.4	43.9	27.4	10.7	686.3	1844.4
STATOR	1	1.359	1.359	89.9	89.9	.0	.0	29.7	27.0	718.7	

31 JAN 95 Used to configure Swept and Leaned Vane FLOW PATH INFO
* * * * * Aerodynamic Design Point * * * * * slv12 COPY 1 OF 1
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ALL DIMENSIONS ARE IN INCHES

STA NO.		AXIAL COORDINATE		AXIAL LENGTH		RADIUS		AREA	DISPLACEMENT THICKNESS		SHAPE FACTOR		BLOCKAGE FACTOR		AXIAL VELOCITY	
		HUB	TIP	HUB	TIP	HUB	TIP		HUB	TIP	HUB	TIP	HUB	TIP	HUB	TIP
1		155.968	155.968			.869	11.000	377.76	.000	.000	1.40	1.40	1.000	1.000	592.	592.
2		158.268	158.268	2.300	2.300	.869	11.000	377.76	.008	.008	1.55	1.55	1.000	.999	582.	597.
3		160.268	160.268	2.000	2.000	.869	11.000	377.76	.015	.013	1.53	1.53	1.000	.998	560.	602.
4		162.268	162.268	2.000	2.000	.869	11.000	377.76	.027	.018	1.58	1.52	1.000	.997	505.	612.
5		164.268	164.268	2.000	2.000	1.200	11.000	375.61	.029	.021	1.53	1.51	.999	.996	451.	629.
6		166.268	166.268	2.000	2.000	2.140	11.000	365.75	.014	.022	1.44	1.50	.999	.996	470.	661.
7		168.268	168.386	2.000	2.118	3.300	11.000	345.96	.008	.023	1.54	1.52	1.000	.996	607.	709.
8	ROTOR	171.562	171.566	3.294	3.180	4.433	11.000	318.40	.020	.049	1.57	1.80	.998	.989	583.	625.
9		172.538	172.768	.976	1.202	4.700	11.000	310.95	.020	.038	1.57	1.46	.998	.992	602.	647.
10		173.519	174.268	.981	1.500	4.890	11.000	307.31	.024	.036	1.61	1.48	.998	.992	602.	681.
11		174.509	175.968	.990	1.700	5.015	11.000	309.95	.030	.035	1.66	1.51	.997	.992	579.	716.
12		175.004	177.368	.495	1.400	5.080	11.000	322.01	.035	.033	1.71	1.53	.996	.992	560.	751.
13		175.919	179.271	.915	1.903	5.323	11.005	338.41	.020	.036	1.41	1.58	.998	.991	630.	771.
14	VANE	177.654	181.066	1.735	1.795	5.555	11.016	335.24	.044	.041	1.78	1.57	.995	.990	561.	759.
15		179.322	181.718	1.668	.652	5.600	11.000	308.09	.069	.037	1.84	1.47	.991	.991	504.	773.
16		181.018	182.518	1.696	.800	5.600	11.000	292.27	.083	.039	1.69	1.52	.990	.990	471.	780.
17		182.518	183.318	1.500	.800	5.600	11.000	284.69	.080	.042	1.49	1.56	.990	.990	462.	780.
18		184.118	184.118	1.600	.800	5.600	11.000	281.61	.080	.043	1.41	1.55	.990	.989	459.	781.

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AIRFOIL	ALLISON FLOW COEF	SURGE MARGIN LOADING PARM	SURGE MARGIN ASPECT RATIO	REYNOLDS NUMBER	LOSS MODIFIERS REYN# MODIF	LOSS MODIFIERS CL-LOSS COEFF.	CL/ SPAN	SARP	CH	EFFECTIVITY PARAMETERS AVE. REY.#	REYMOD	TCMOD	AXMOD	CHBAR	EFFECT IVITY
ROTOR 1	1.064	.4863	1.754	1788535.	.000	.0000	.0000								
VANE 1		.6851	3.078	775551.	.000			.837	.419	1282043.	1.054	1.055	.881	.491	.85288
	-----	------	------												
AVERAGE	1.064	.5857	2.416												

LOAD COEFFICIENT	.4143
BASE SURGE MARGIN	-19.5
CORRECTION	-12.7

SURGE MARGIN	-32.2

SINGLE STAGE SURGE MARGIN CORRELATION

SOLIDITY	ASPECT RATIO	D-FACTOR	TIP MN	SURGE MARGIN
1.6557	1.7536	.4345	1.1435	17.39

ROTOR 1 AT STATION 8
THERE ARE 18 AIRFOILS.
THE AIRFOIL SHAPE IS ARB
THE INCIDENCE AND DEVIATION RULES WERE
INLET METAL ANGLES INPUT
EXIT METAL ANGLES INPUT

STRM LINE NO.	CAMBER	SETTING	INLET METAL ANGLE	EXIT METAL ANGLE	TRUE CHORD	THICK-NESS/CHORD	LEADING EDGE RADIUS	INCI-DENCE	DEVI-ATION	SOLID-ITY	STACK RADIUS	INFLECTION ANGLE	RAMP ANGLE
1	38.46	-.96	26.92	-11.54	3.494	.0942	.0400	-2.93	8.11	2.580	3.849	-3.47	19.17
3	35.67	4.40	28.54	-7.13	3.550	.0873	.0300	-2.06	7.71	2.406	4.197	2.13	17.50
5	31.39	10.47	30.89	-.50	3.635	.0771	.0171	-1.00	6.92	2.191	4.726	8.85	15.53
7	27.20	16.35	33.22	6.03	3.739	.0664	.0135	.39	5.75	1.984	5.374	14.49	13.68
9	25.13	21.59	36.18	11.05	3.856	.0554	.0109	1.12	5.19	1.805	6.097	20.43	11.96
11	23.51	26.67	39.28	15.78	3.980	.0453	.0088	1.53	4.85	1.656	6.865	28.01	10.22
13	21.90	31.32	42.23	20.33	4.107	.0376	.0074	1.83	4.64	1.533	7.659	34.66	8.35
15	20.09	35.63	45.06	24.97	4.238	.0318	.0067	1.98	4.66	1.431	8.469	38.82	6.28
17	18.22	39.50	47.80	29.57	4.370	.0286	.0062	1.97	4.58	1.346	9.290	42.74	4.07
19	16.27	43.39	50.30	34.03	4.503	.0275	.0062	1.98	4.70	1.274	10.121	46.04	1.75
21	13.77	47.15	52.61	38.84	4.639	.0275	.0064	1.99	5.08	1.212	10.966	49.16	-.47

STATOR 1 AT STATION 14
THERE ARE 42 AIRFOILS.
THE AIRFOIL SHAPE IS DCA
THE INCIDENCE AND DEVIATION RULES WERE
INPUT TABLES
AND NASA 2-D RULE.

STRM LINE NO.	CAMBER	SETTING	INLET METAL ANGLE	EXIT METAL ANGLE	TRUE CHORD	THICK-NESS/CHORD	LEADING EDGE RADIUS	INCI-DENCE	DEVI-ATION	SOLID-ITY	STACK RADIUS	INFLECTION ANGLE	RAMP ANGLE
1	30.05	12.06	27.08	-2.97	1.810	.0500	.0060	2.63	2.97	2.211	5.695	8.27	8.31
3	29.45	12.12	26.84	-2.60	1.810	.0500	.0060	2.06	2.60	2.115	5.911	8.59	7.87
5	29.42	12.17	26.88	-2.54	1.810	.0500	.0060	1.17	2.54	1.979	6.265	9.50	7.47
7	31.10	12.11	27.66	-3.44	1.810	.0500	.0060	.34	3.44	1.829	6.721	10.32	7.17
9	33.73	11.77	28.63	-5.10	1.810	.0500	.0060	-.09	5.10	1.685	7.238	10.87	6.73
11	36.41	11.31	29.52	-6.89	1.810	.0500	.0060	-.56	6.89	1.556	7.791	11.31	5.97
13	38.85	10.69	30.12	-8.73	1.810	.0500	.0060	-1.01	8.73	1.442	8.372	10.69	4.92
15	39.80	10.07	29.98	-9.83	1.810	.0500	.0060	-1.11	9.83	1.341	8.980	10.07	3.70
17	40.13	9.68	29.74	-10.39	1.810	.0500	.0060	-1.27	10.39	1.253	9.614	9.68	2.44
19	40.58	9.30	29.59	-10.99	1.810	.0500	.0060	-1.73	10.99	1.174	10.276	9.30	1.24
21	42.82	8.77	30.18	-12.64	1.810	.0500	.0060	-3.18	12.64	1.103	10.966	8.77	.20

31 JAN 95 Used to configure Swept and Leaned Vane
STATION NO 8 * * * * * Aerodynamic Design Point * * * * * slv12
ROTOR NO. 1

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DATA REDUCTION
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MASS FLOW RATE 102.78 HUB BLOCKAGE 99.8 PERCENT HUB STATIC PRESSURE 12.89 MASS AVE TOTAL PRESSURE 20.25
CORRECTED FLOW RATE 78.31 TIP BLOCKAGE 98.9 PERCENT TIP STATIC PRESSURE 16.12 RPM 10417.4

SL NO	PER-CENT SPAN	INCI-DENCE	DEVI-ATION	INLET MACH NO.	EXIT MACH NO.	D-FACTOR	SHOCK LOSS COEF.	P R O F I L E LOSS COEF.	P R O F I L E PARA-METER	INLET FREE STRM A/ A*	MIN. PASS-AGE A/ A*	1ST CAP. MACH WAVE INCID.	LOAD COEF.	FLOW COEF.	EXIT RADIUS	DELTA DEVI-ATION	
1	.3	-2.93	8.11	.688	.554	.310		.0499	.00966	1.103	.937		1.435	2.018	4.453	3.23	1
3	4.7	-2.06	7.71	.703	.545	.337		.0470	.00976	1.092	.978		1.242	1.865	4.745	2.84	3
5	11.8	-1.00	6.92	.730	.539	.371		.0444	.01007	1.074	1.016		1.032	1.661	5.208	2.17	5
7	20.8	.39	5.75	.765	.541	.403		.0419	.01034	1.054	1.030		.885	1.462	5.797	1.17	7
9	30.9	1.12	5.19	.807	.552	.430		.0399	.01062	1.035	1.036		.789	1.289	6.465	.54	9
11	41.8	1.53	4.85	.855	.573	.448		.0382	.01079	1.019	1.039		.711	1.145	7.178	.13	11
13	53.0	1.83	4.64	.907	.601	.457	.0002	.0371	.01096	1.008	1.042		.642	1.027	7.914	-.11	13
15	64.4	1.98	4.66	.963	.635	.457	.0016	.0382	.01161	1.001	1.043		.574	.928	8.660	-.02	15
17	75.8	1.97	4.58	1.021	.674	.451	.0045	.0422	.01296	1.000	1.042	1.71	.513	.845	9.414	.03	17
19	87.4	1.98	4.70	1.082	.717	.440	.0062	.0487	.01492	1.005	1.036	1.77	.455	.773	10.175	.34	19
21	99.3	1.99	5.08	1.144	.763	.424	.0101	.0586	.01740	1.016	1.037	1.92	.394	.711	10.951	1.12	21

STATOR NO. 1 AT STATION NO. 14

MASS FLOW RATE 102.78 HUB BLOCKAGE 99.5 PERCENT HUB STATIC PRESSURE 14.35 MASS AVE TOTAL PRESSURE 19.97
CORRECTED FLOW RATE 79.39 TIP BLOCKAGE 99.0 PERCENT TIP STATIC PRESSURE 15.54

SL NO	PER-CENT SPAN	INCI-DENCE	DEVI-ATION	INLET MACH NO.	EXIT MACH NO.	D-FACTOR	SHOCK LOSS COEF.	P R O F I L E LOSS COEF.	P R O F I L E PARA-METER	INLET FREE STRM A/ A*	MIN. PASS-AGE A/ A*	1ST CAP. MACH WAVE INCID.	EXIT RADIUS	DELTA DEVI-ATION	
1	.8	2.63	2.97	.675	.503	.350		.1235	.02792	1.114	1.119		5.599	-1.33	1
3	5.2	2.06	2.60	.678	.506	.352		.1053	.02488	1.111	1.114		5.840	-1.73	3
5	12.4	1.17	2.54	.683	.512	.352		.0813	.02054	1.107	1.105		6.230	-2.00	5
7	21.4	.34	3.44	.697	.532	.349		.0583	.01593	1.096	1.092		6.726	-1.66	7
9	31.7	-.09	5.10	.721	.564	.343		.0411	.01219	1.080	1.075		7.284	-.82	9
11	42.4	-.56	6.89	.745	.598	.337		.0310	.00998	1.065	1.060		7.870	.07	11
13	53.4	-1.01	8.73	.768	.629	.333		.0275	.00953	1.053	1.048		8.470	.98	13
15	64.5	-1.11	9.83	.782	.652	.331		.0294	.01095	1.046	1.044		9.077	1.40	15
17	75.8	-1.27	10.39	.790	.667	.332		.0358	.01428	1.042	1.042		9.695	1.40	17
19	87.3	-1.73	10.99	.790	.675	.331		.0459	.01954	1.043	1.041		10.325	1.40	19
21	99.2	-3.18	12.64	.773	.669	.329		.0594	.02695	1.050	1.043		10.975	2.01	21

AIRFOIL	MASS AVERAGED D-FACTOR	STAGE REACTION	MEANLINE SOLIDITY	MASS AVERAGED A/A* FREE STREAM	MASS AVERAGED A/A* MIN PASSAGE
ROTOR 1	.4339	.8946	1.656	1.020	1.035
STATOR 1	.3358		1.556	1.060	1.057
	-------		------		
AVERAGE	.3849		1.606		

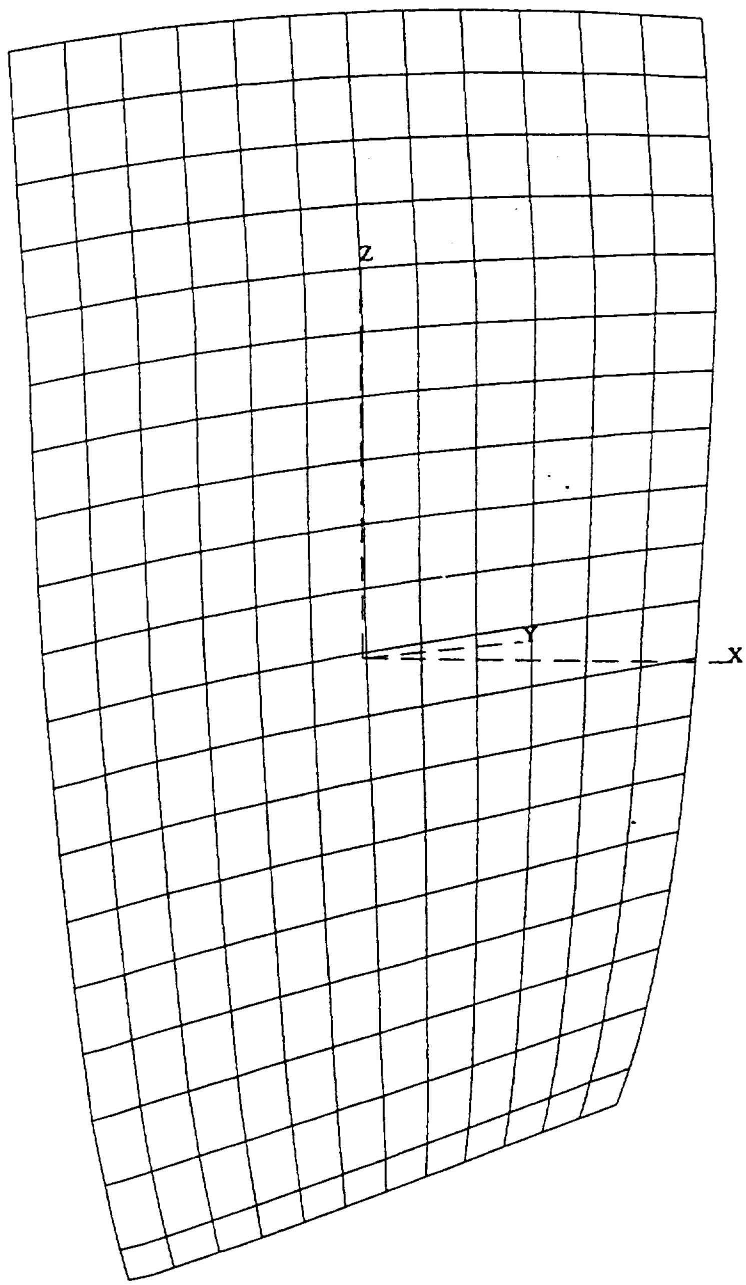
STAGE	LOAD COEFFICIENT	FLOW COEFFICIENT	STAGE ADIABATIC EFFICIENCY VANE TO VANE	STAGE PRESSURE RATIO VANE TO VANE	STAGE TEMPERATURE RISE VANE TO VANE
1	.707	1.063	94.13	1.378	52.86

STAGE 1

S.L. NO.	PRESSURE RATIO V - V	TEMPERATURE RISE V - V	ADIABATIC EFFICIENCY V - V
1	1.200	29.76	93.10
3	1.206	30.56	93.44
5	1.218	32.10	93.72
7	1.244	35.51	94.18
9	1.285	40.70	94.69
11	1.331	46.40	95.09
13	1.377	52.08	95.29
15	1.414	56.86	94.92
17	1.443	61.05	93.91
19	1.461	64.14	92.55
21	1.456	65.25	90.07

APPENDIX E

STRUCTURAL ANALYSIS RESULTS ROTATING COMPONENTS



TITLE NASA 22in FAN DEFAULT BC'S HOT-TO-COLD [MaC] LNF.FNL - Pressure Surface
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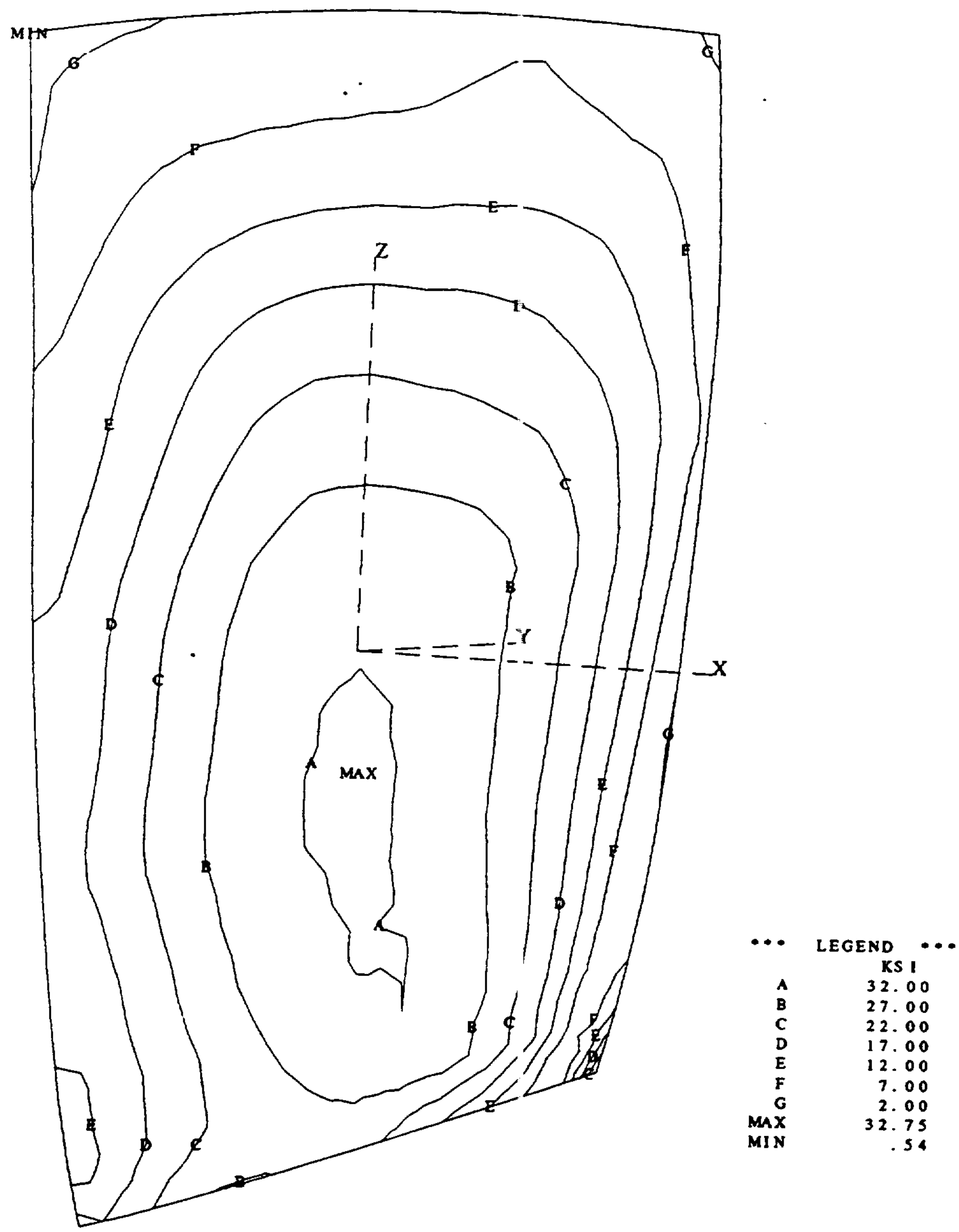

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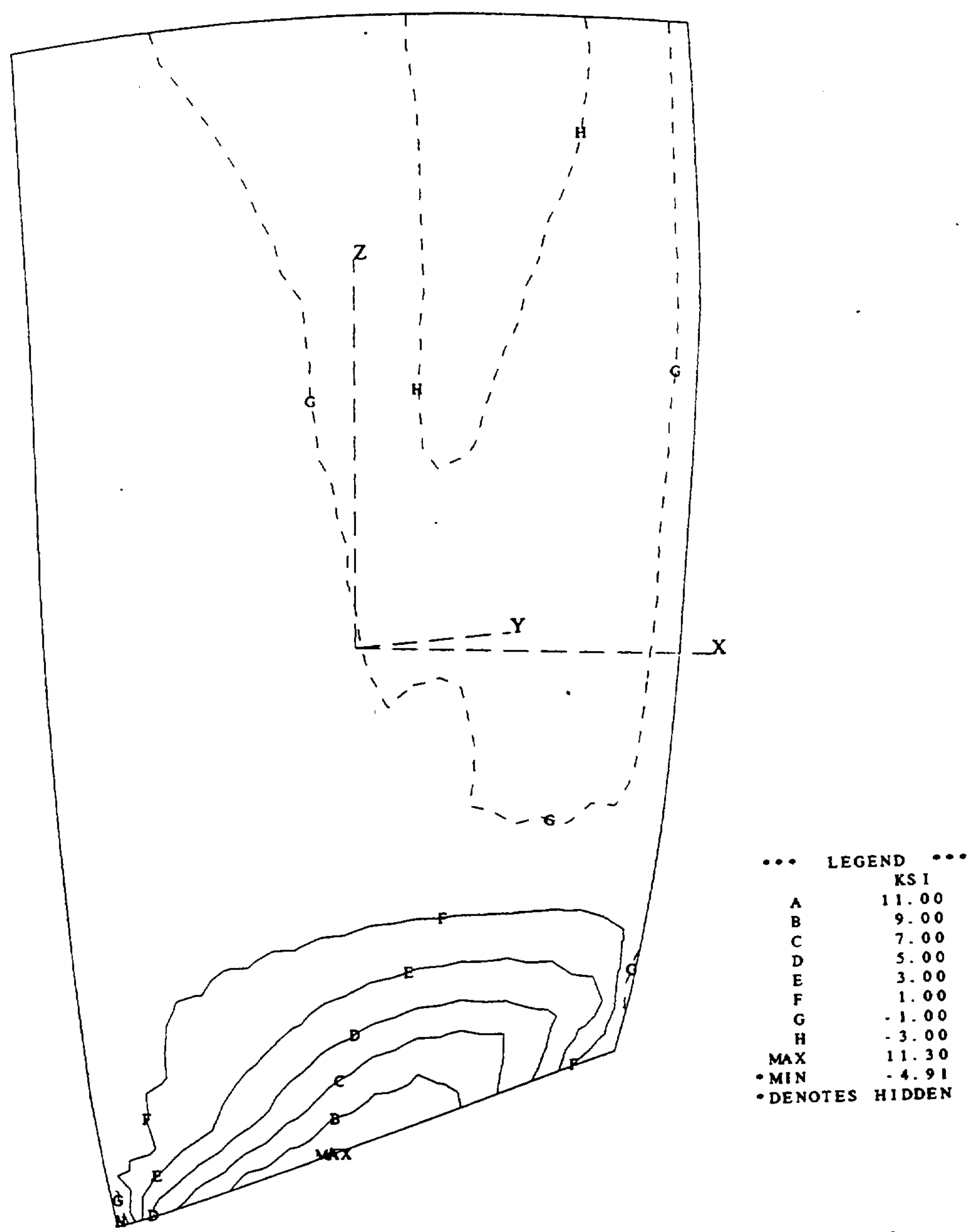

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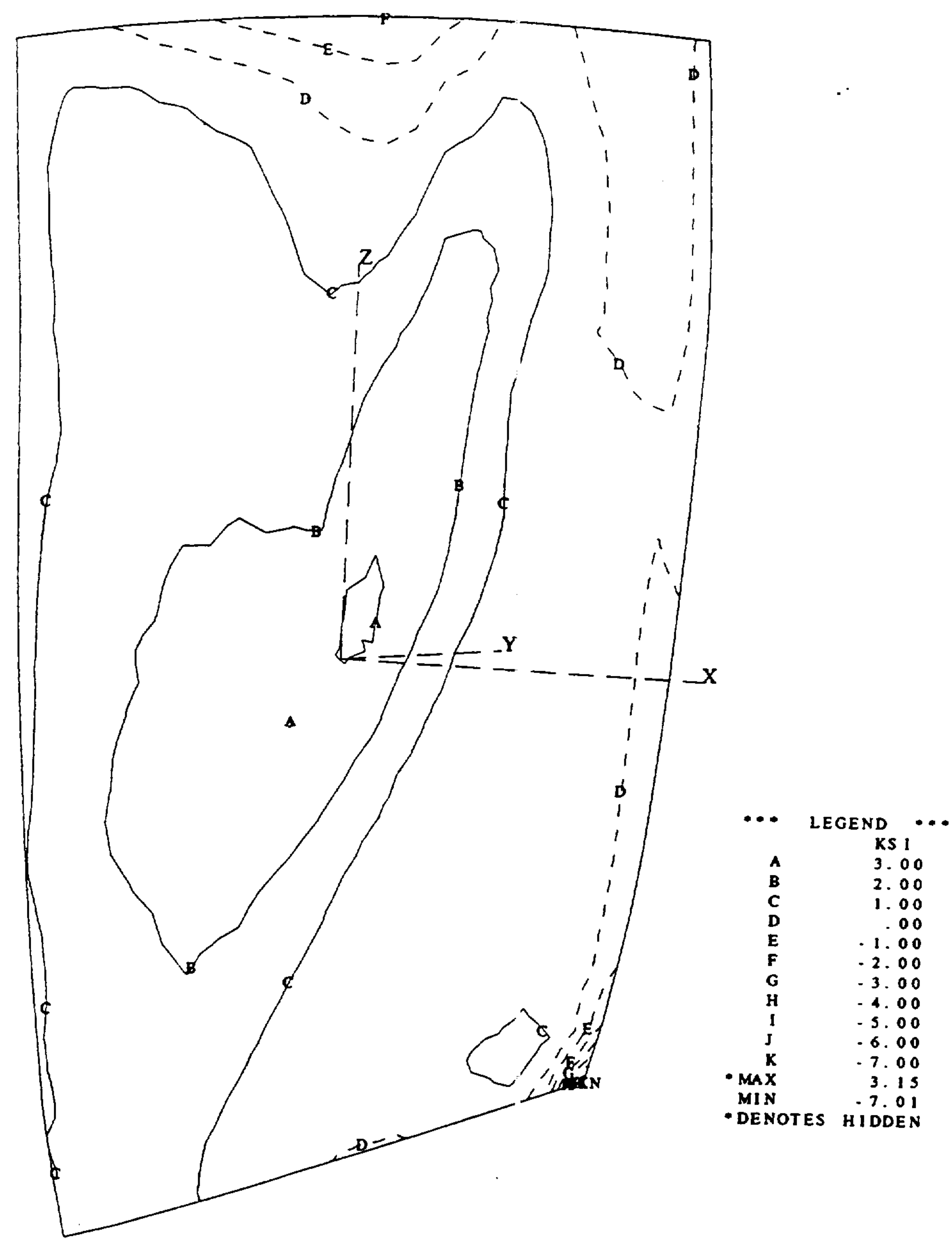

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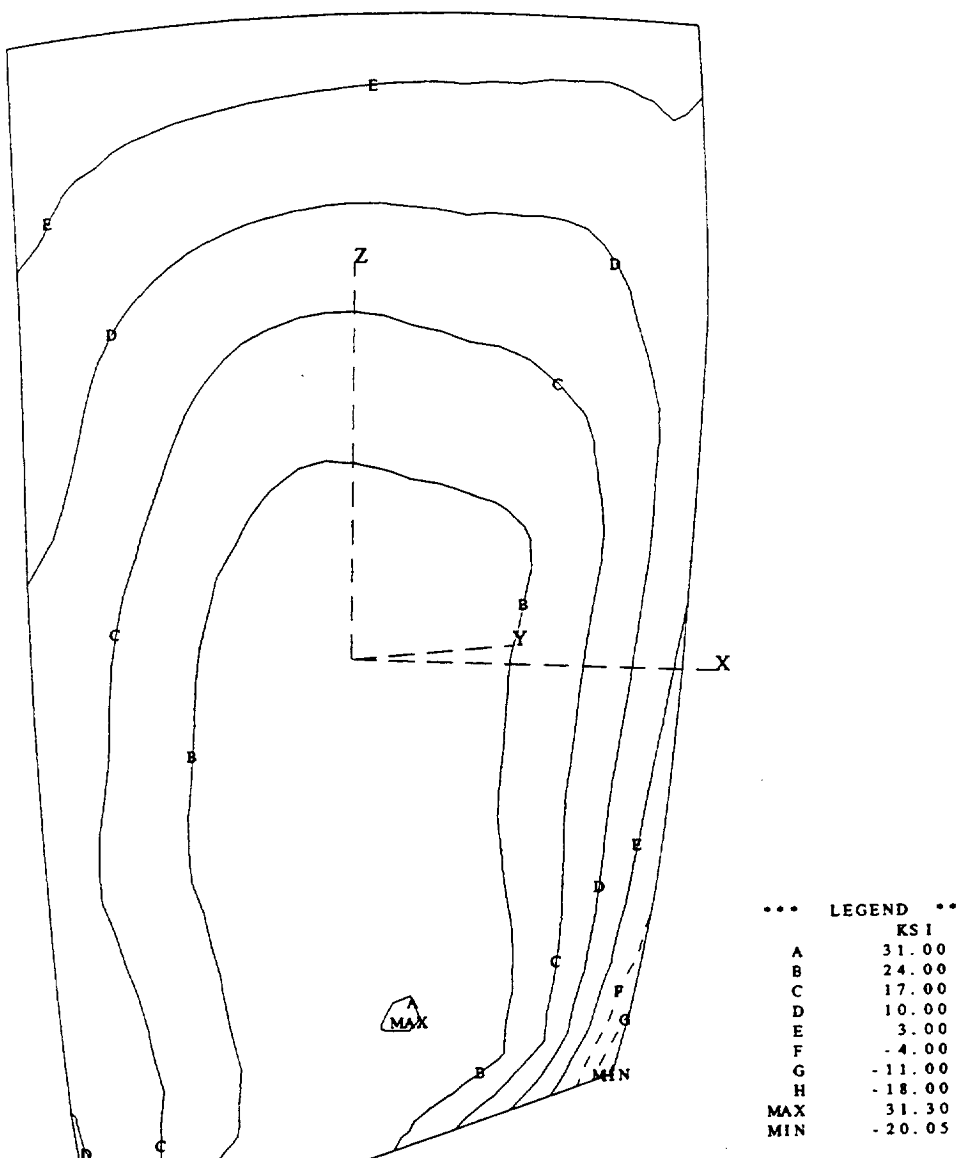

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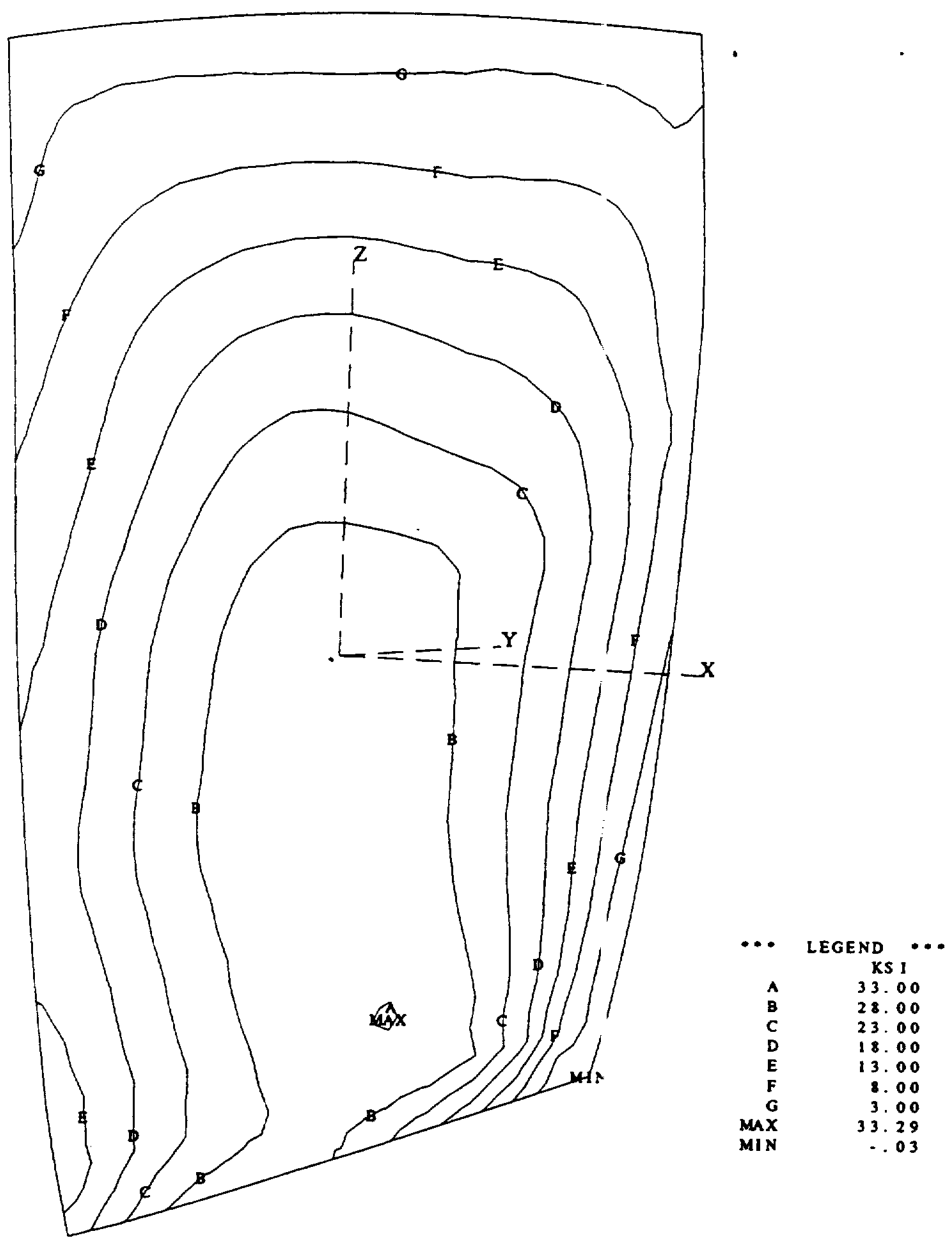

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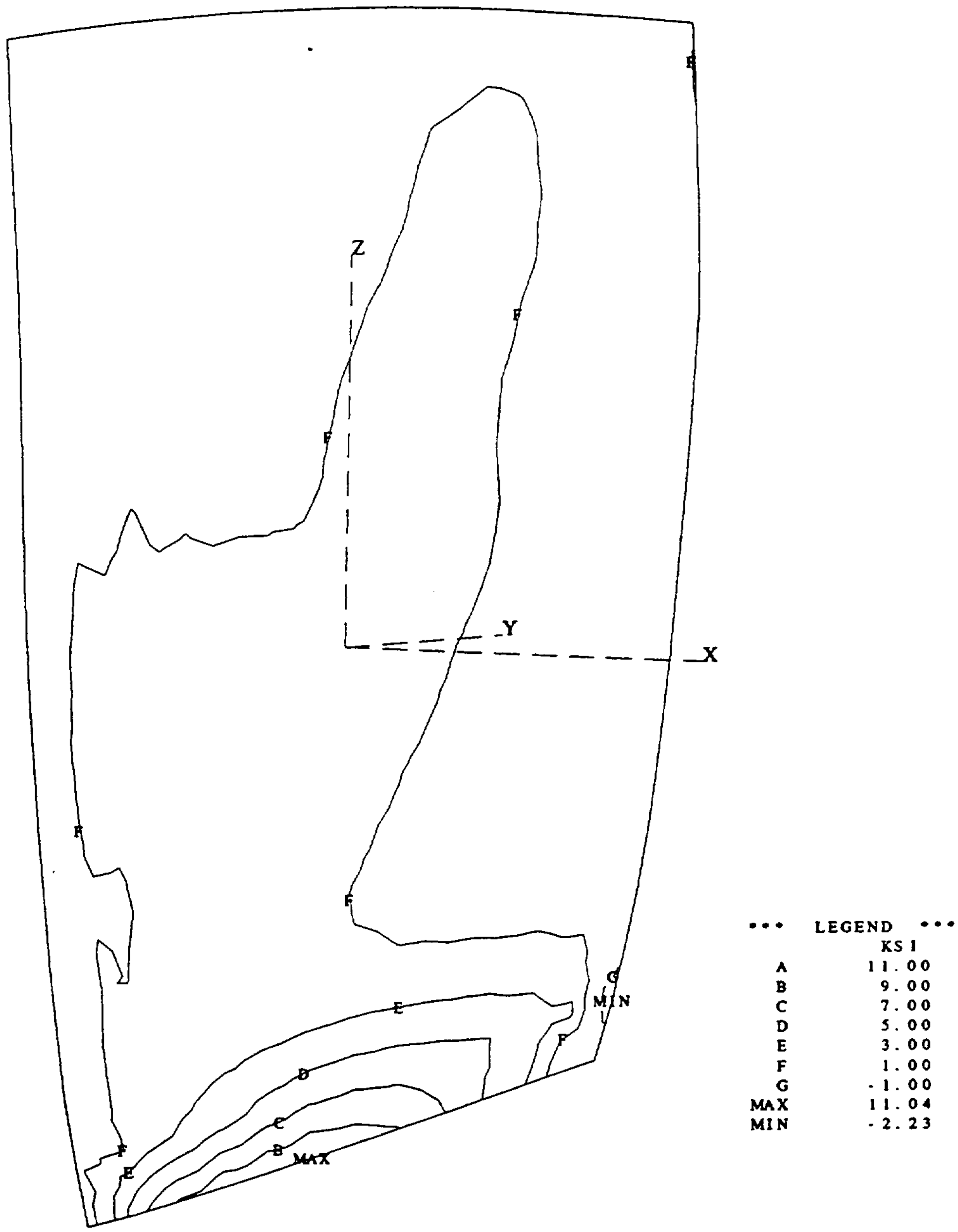

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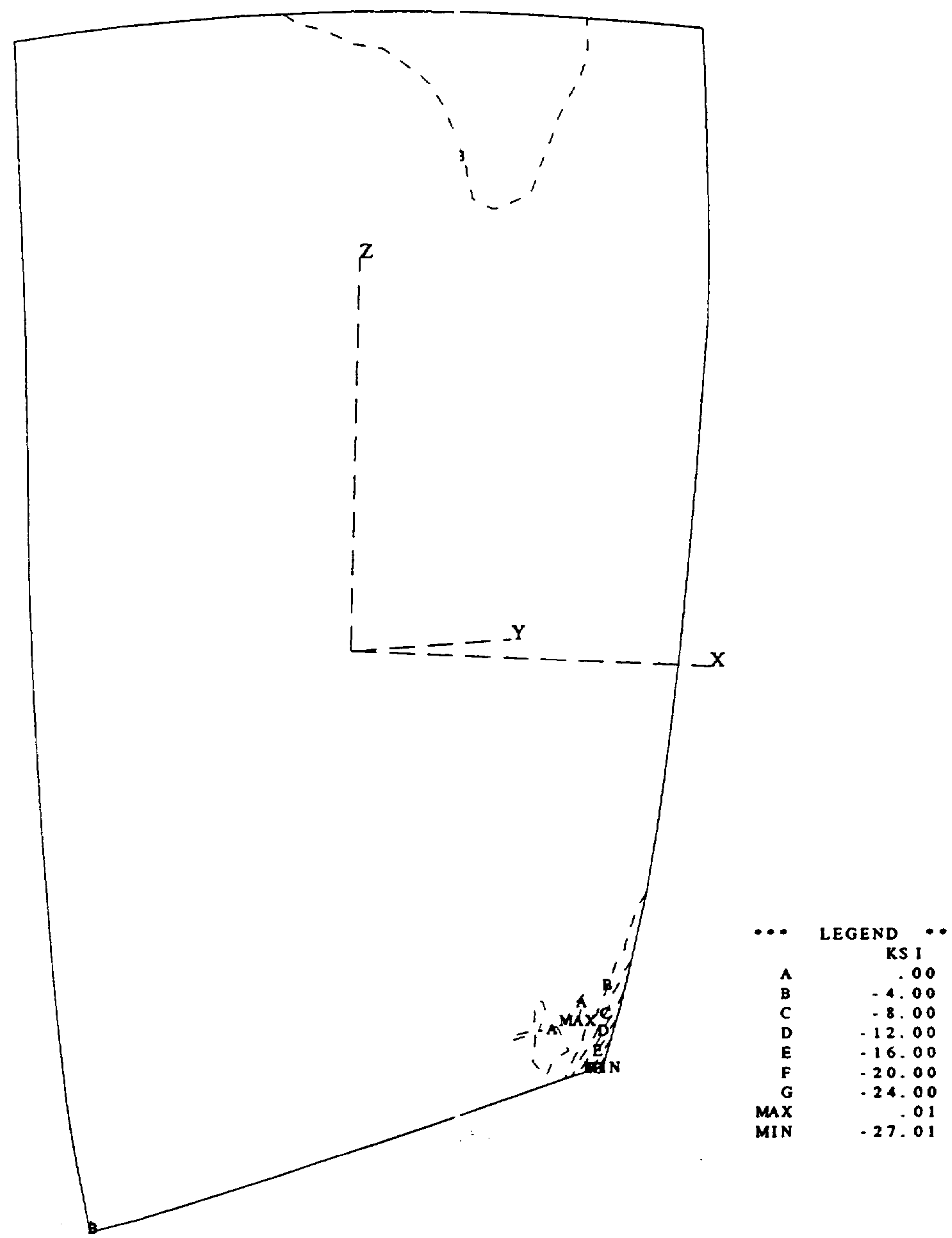

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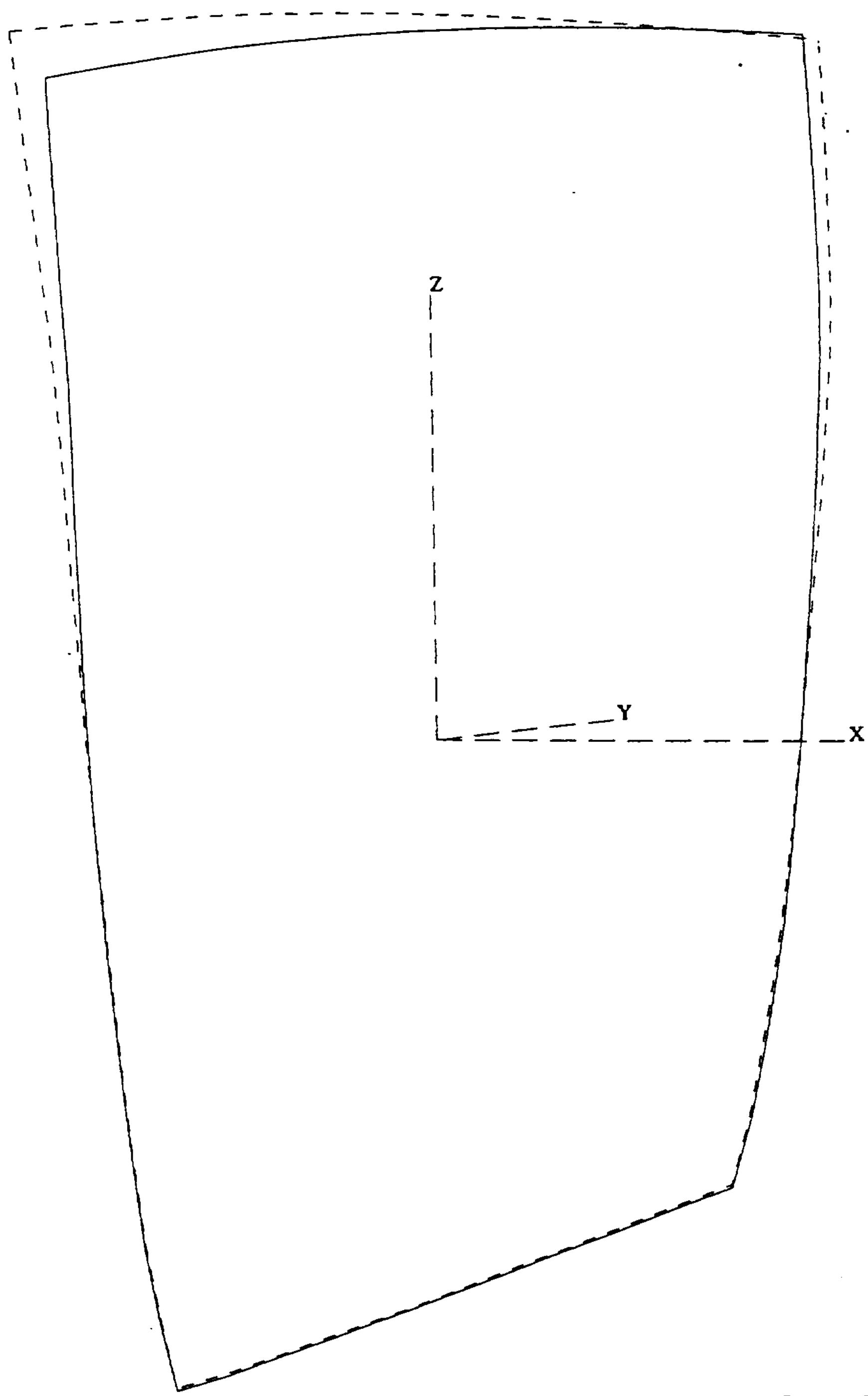

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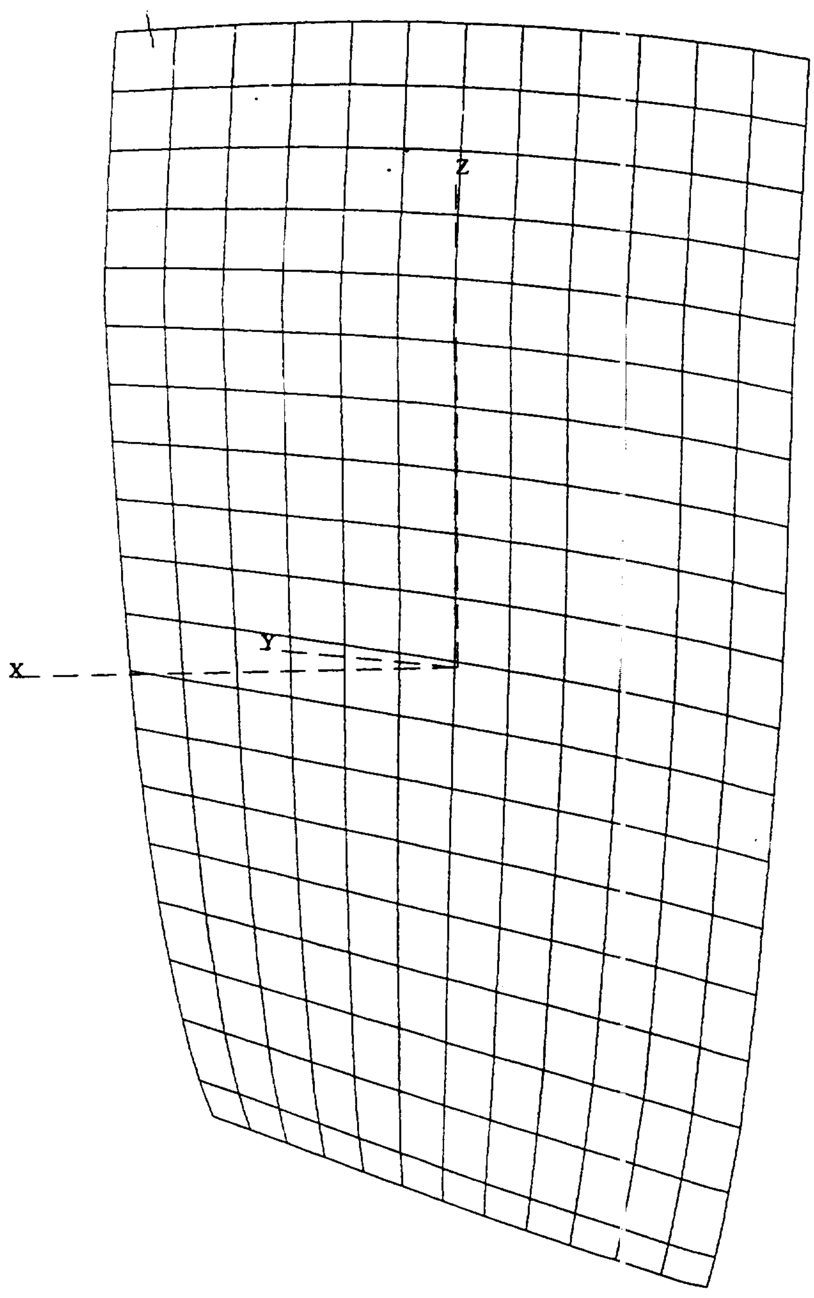

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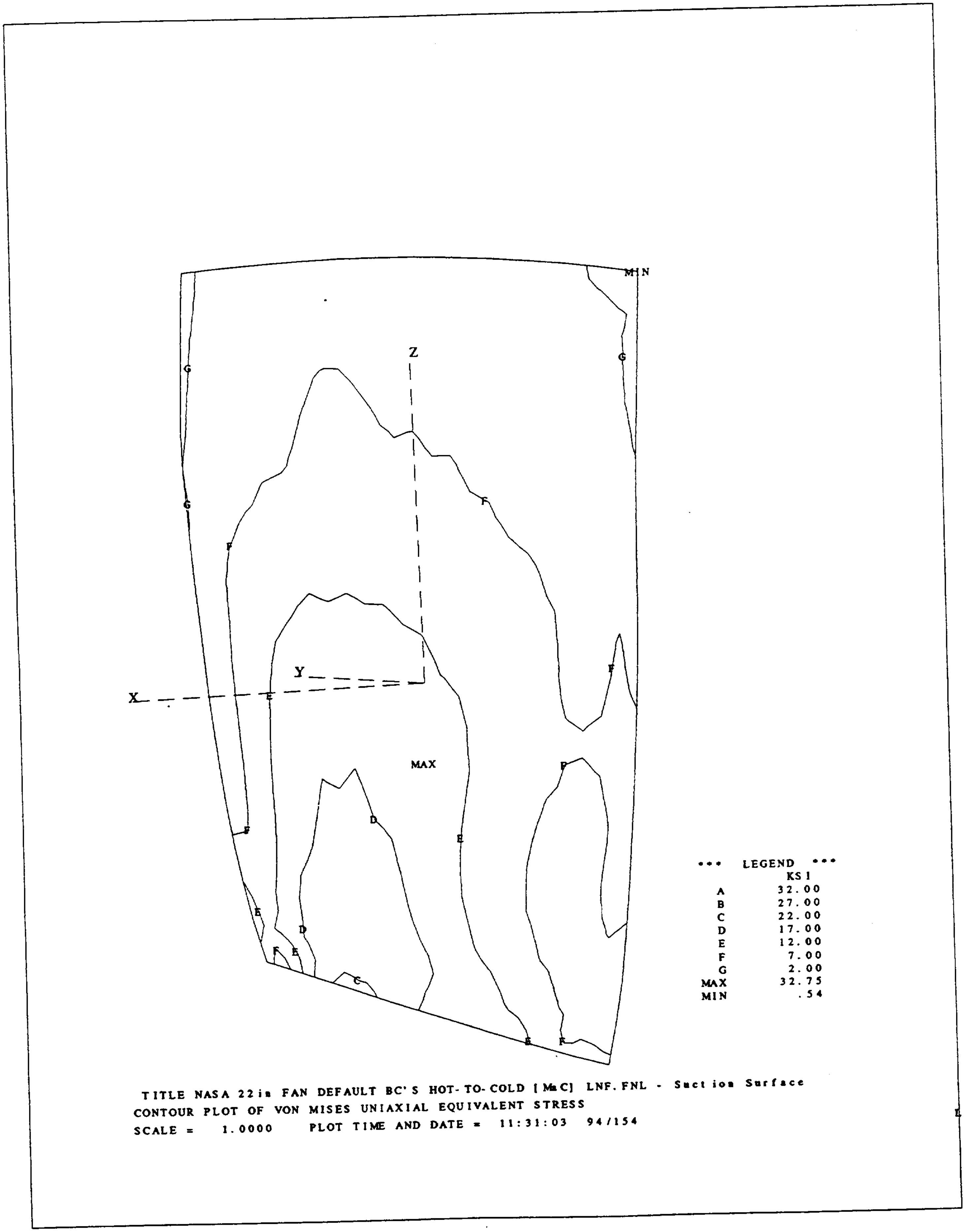
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Z
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X
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G 2.00
MAX 32.75
MIN .54
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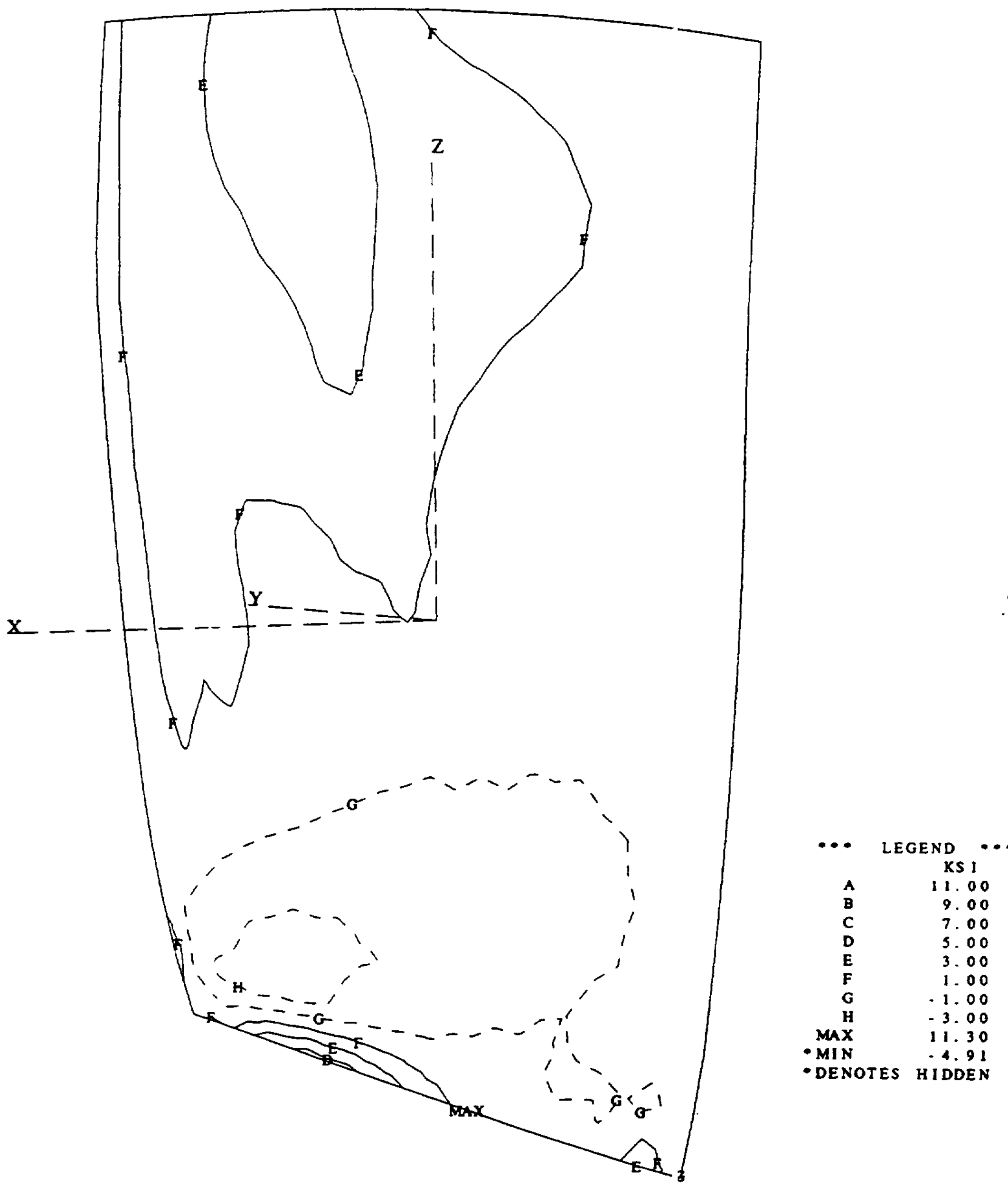

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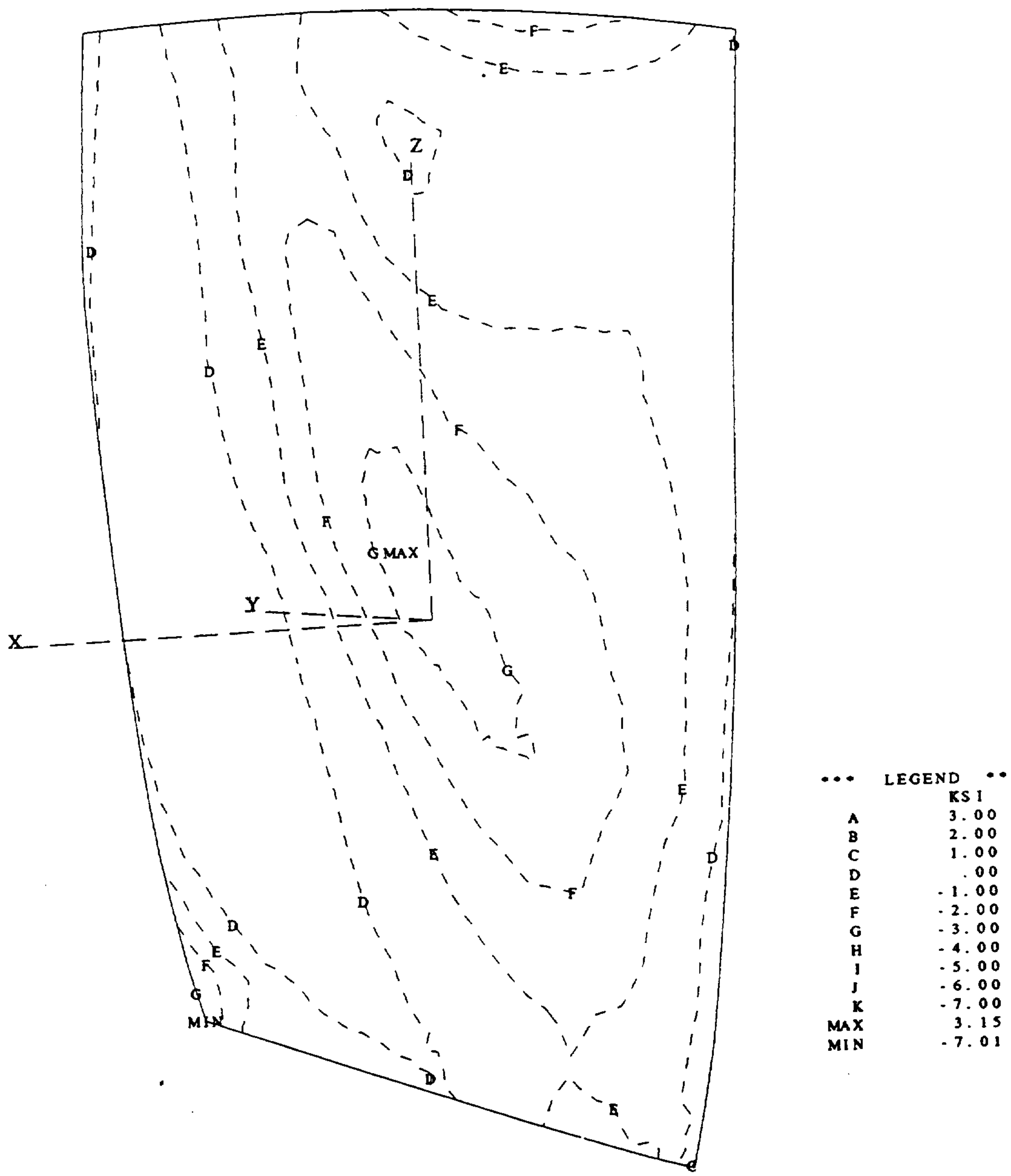

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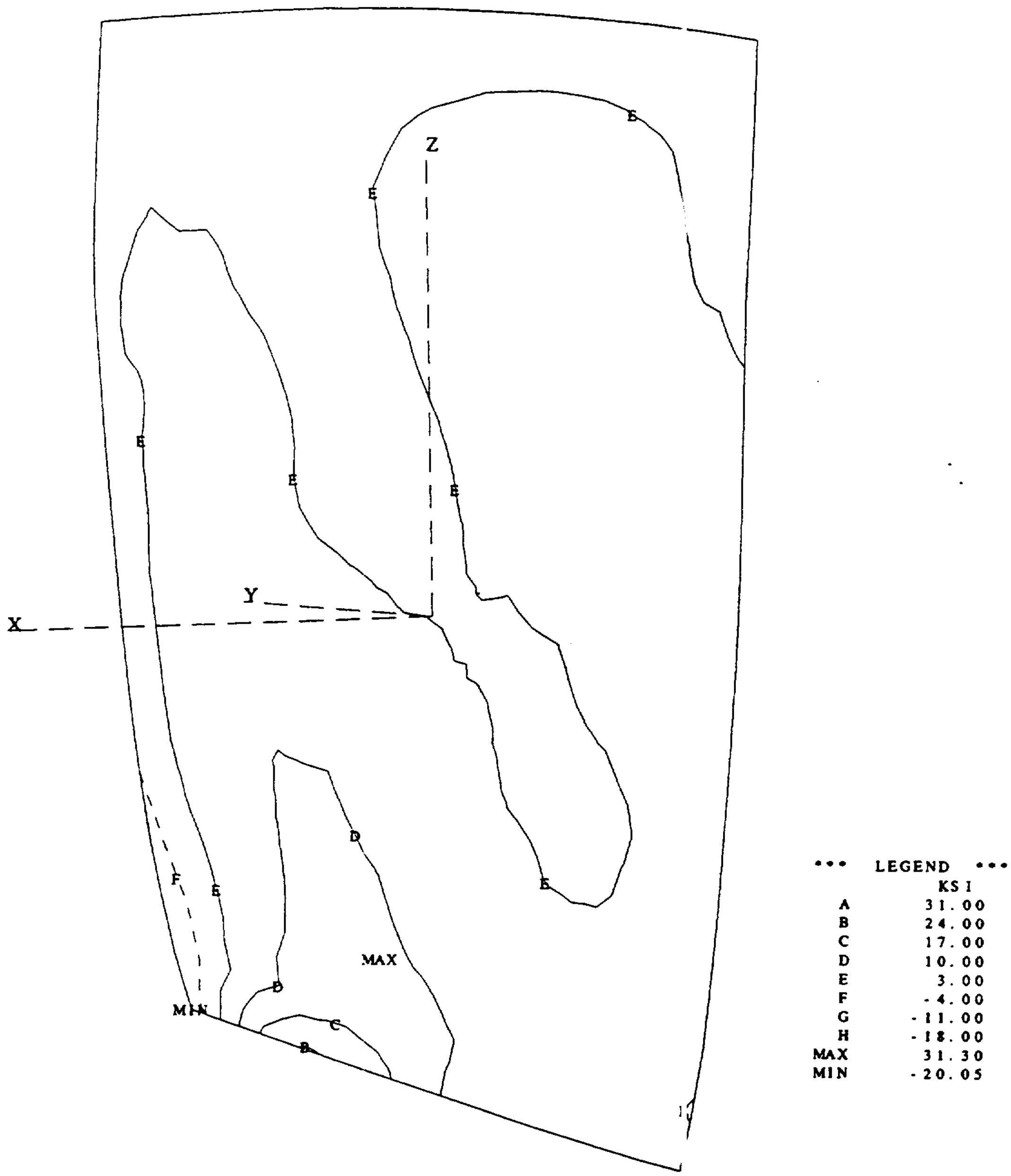

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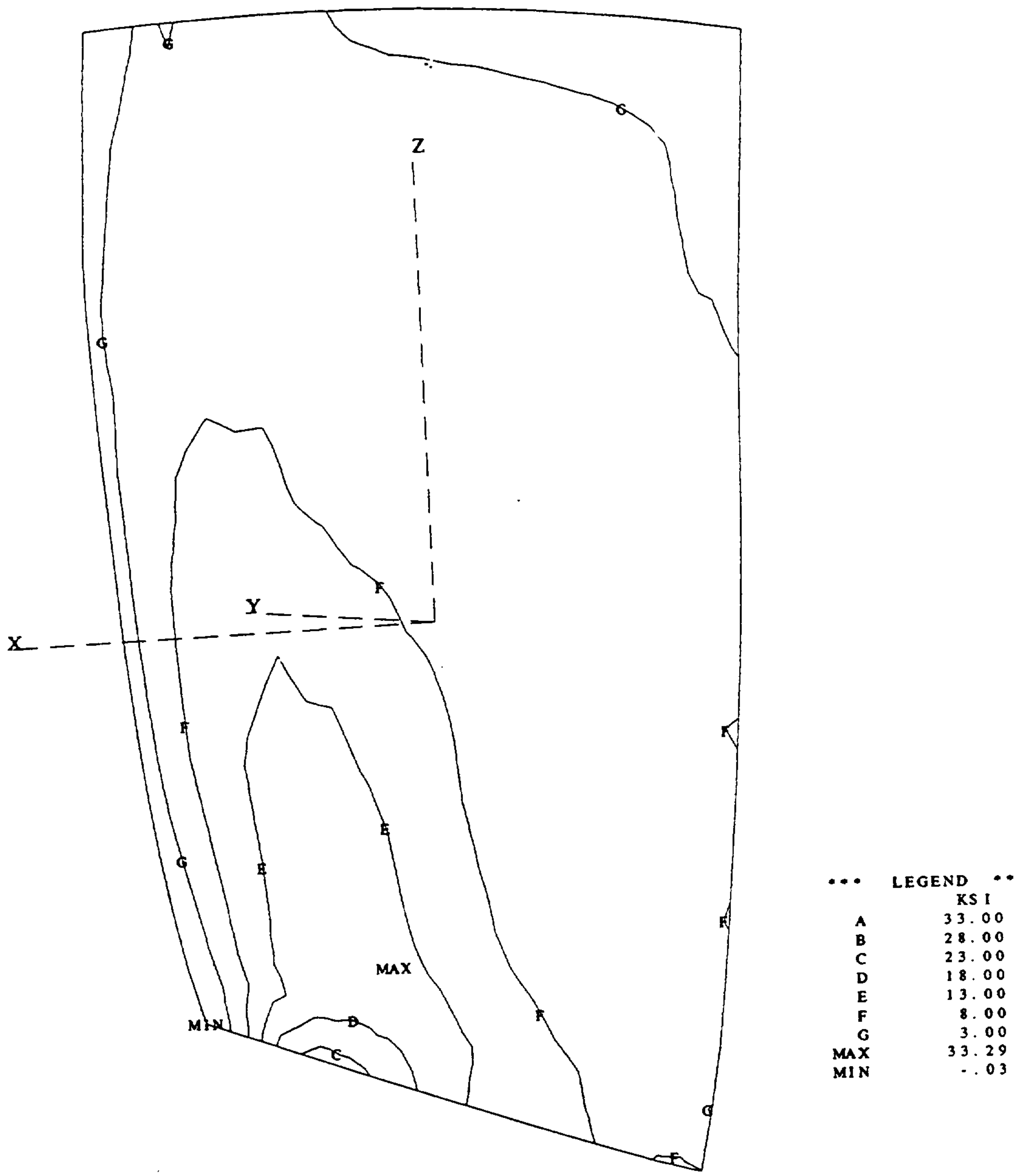

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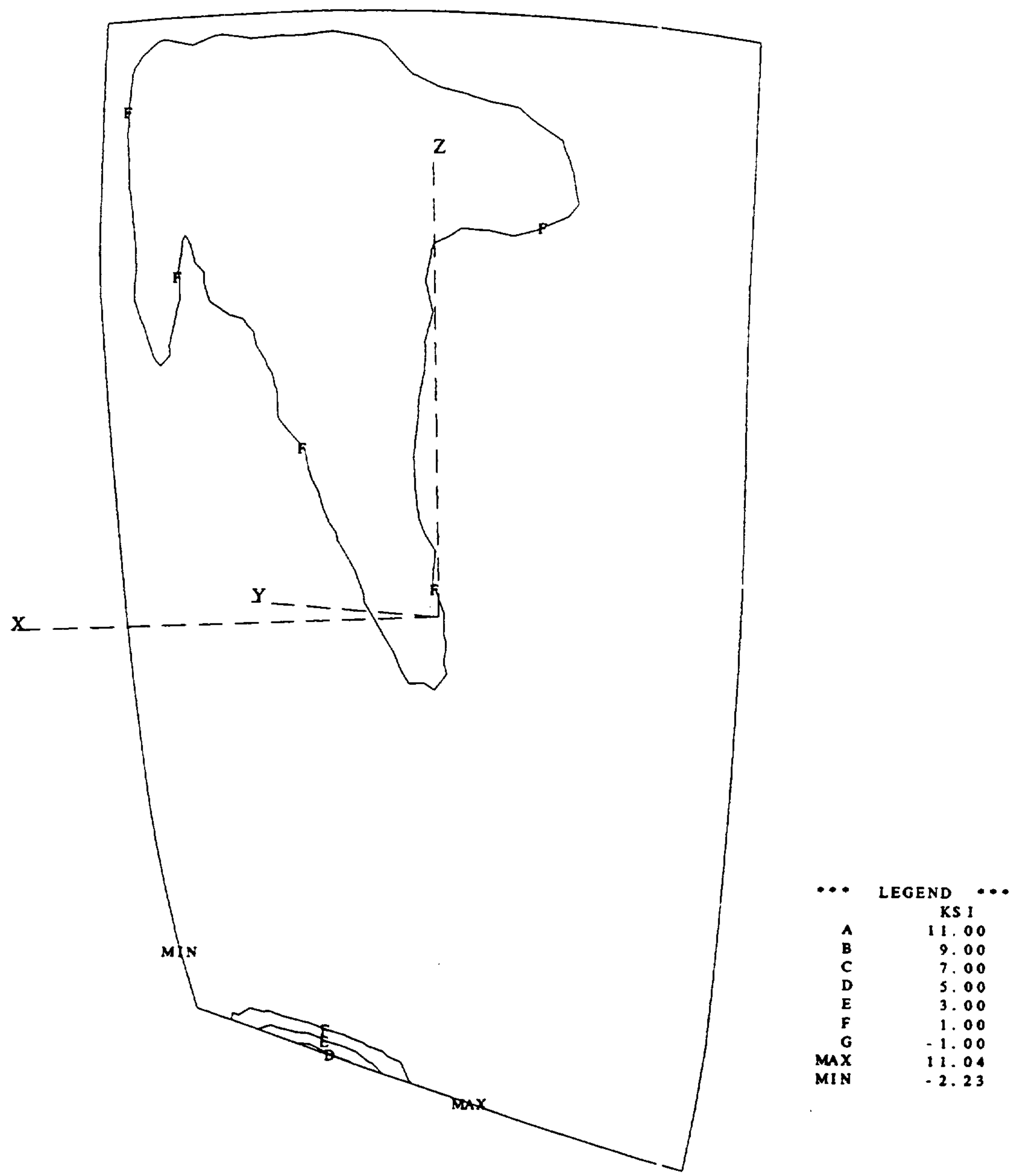

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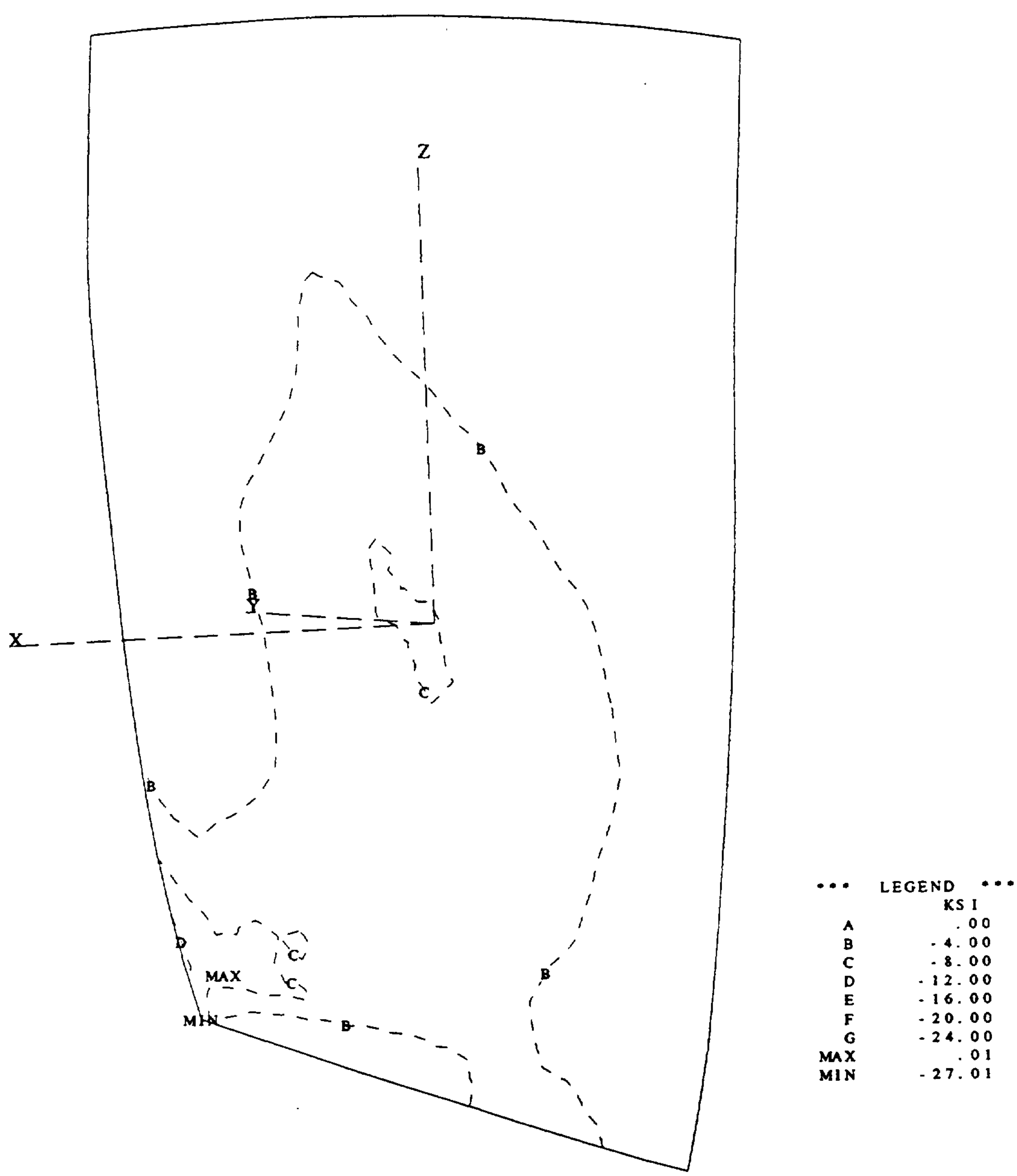

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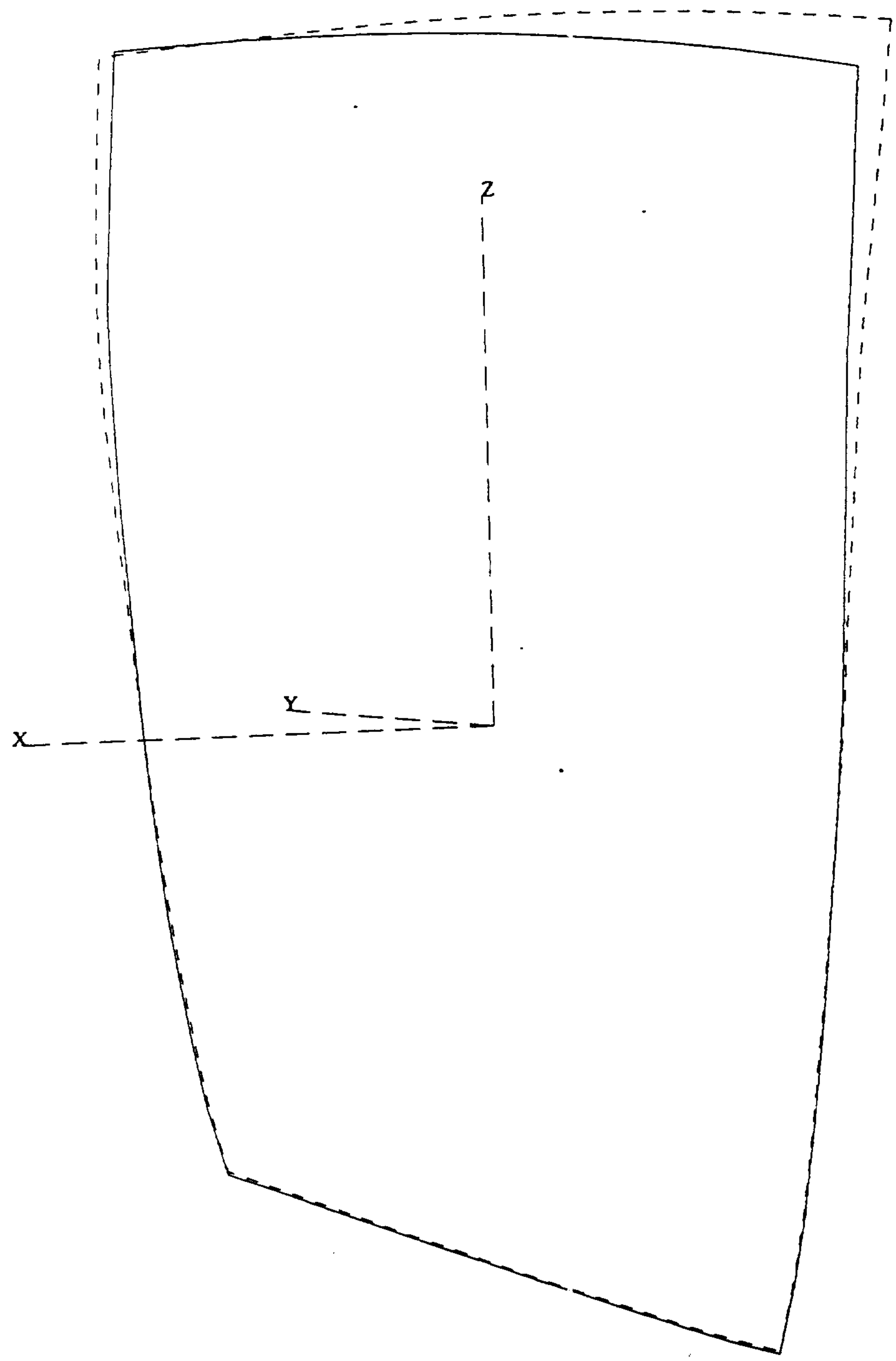

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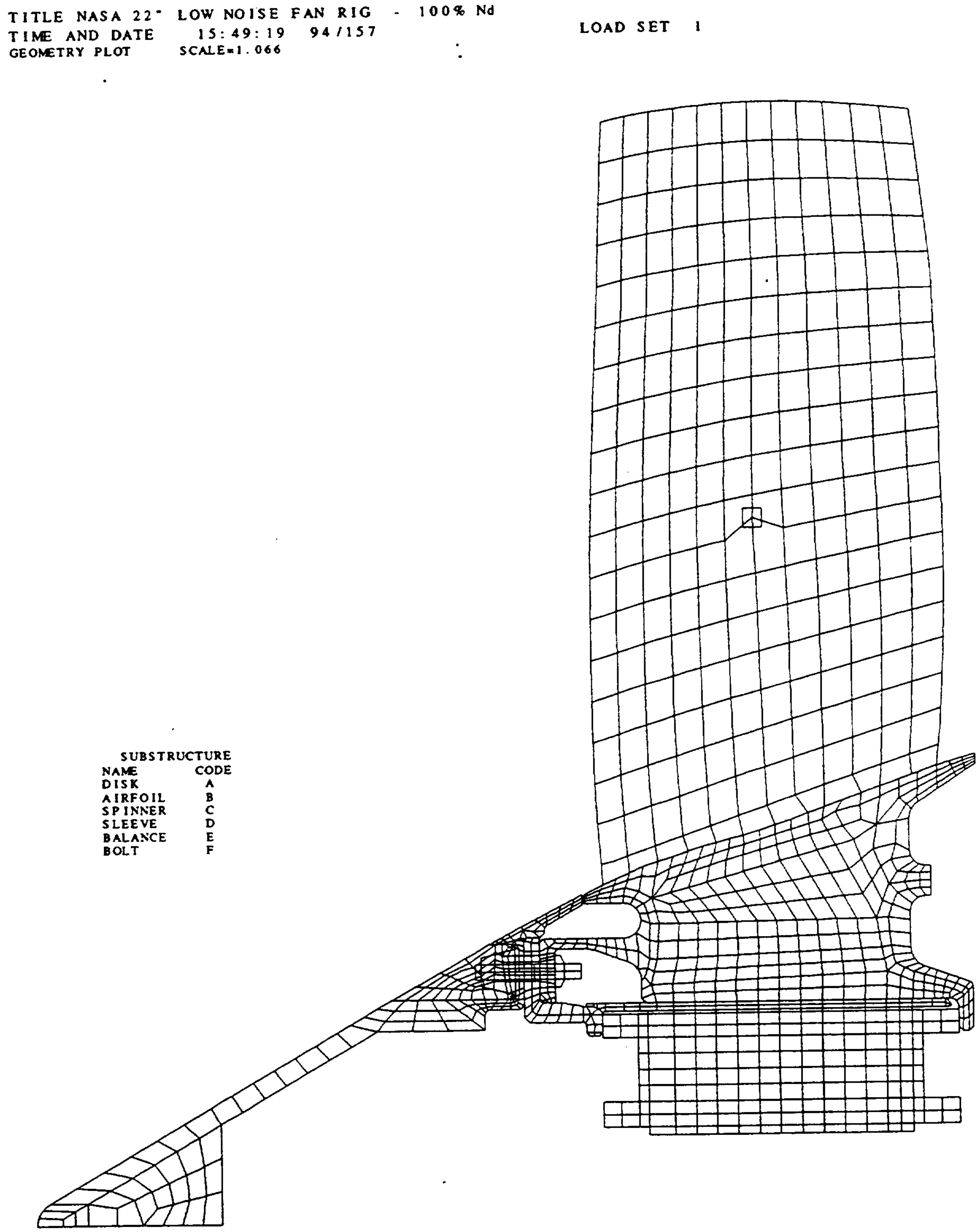

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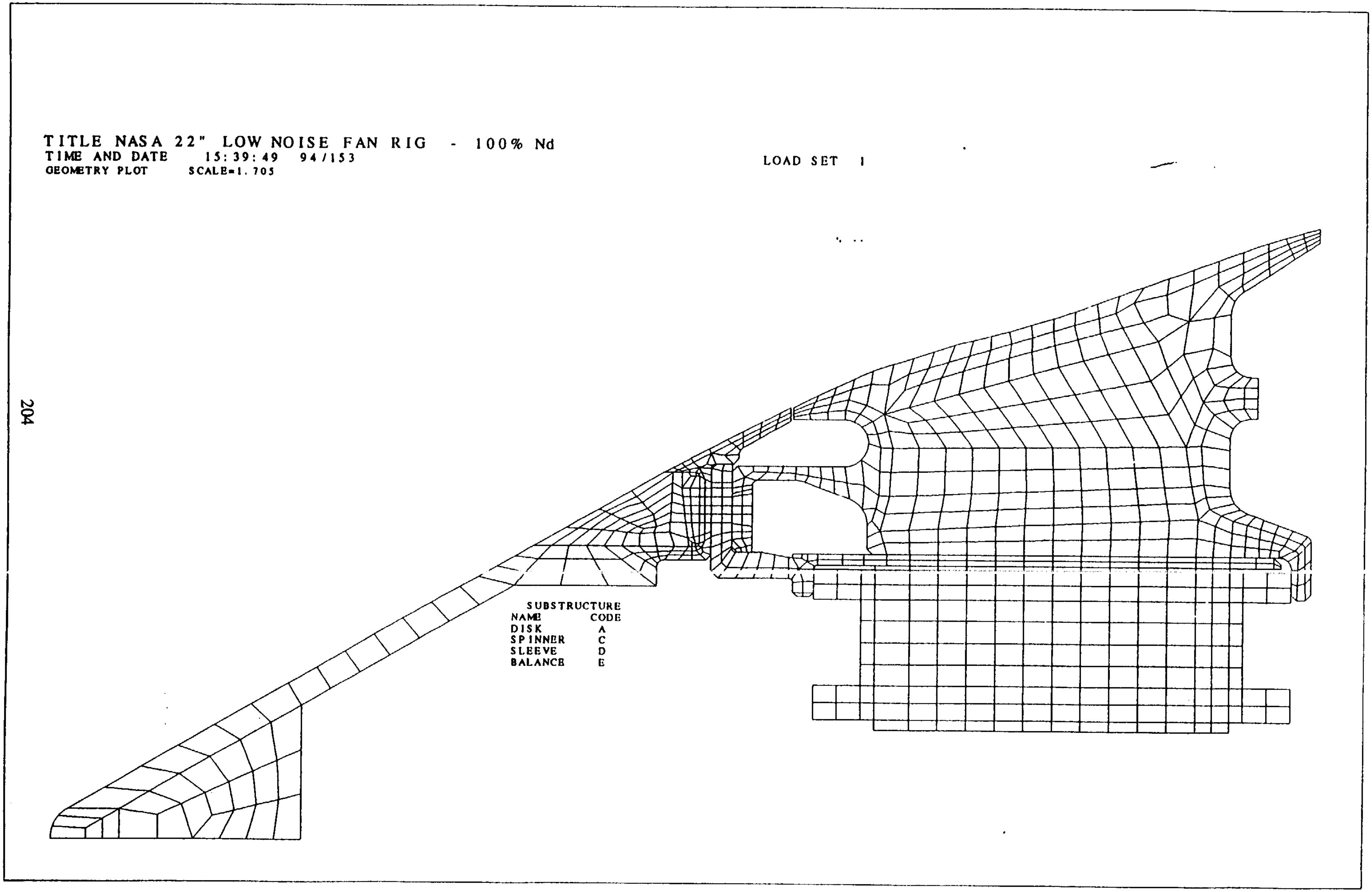
AIRFOIL B
SPINNER C
SLEEVE D
BALANCE E
BOLT F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TIME AND DATE 15:39:49 94/153
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SPINNER C
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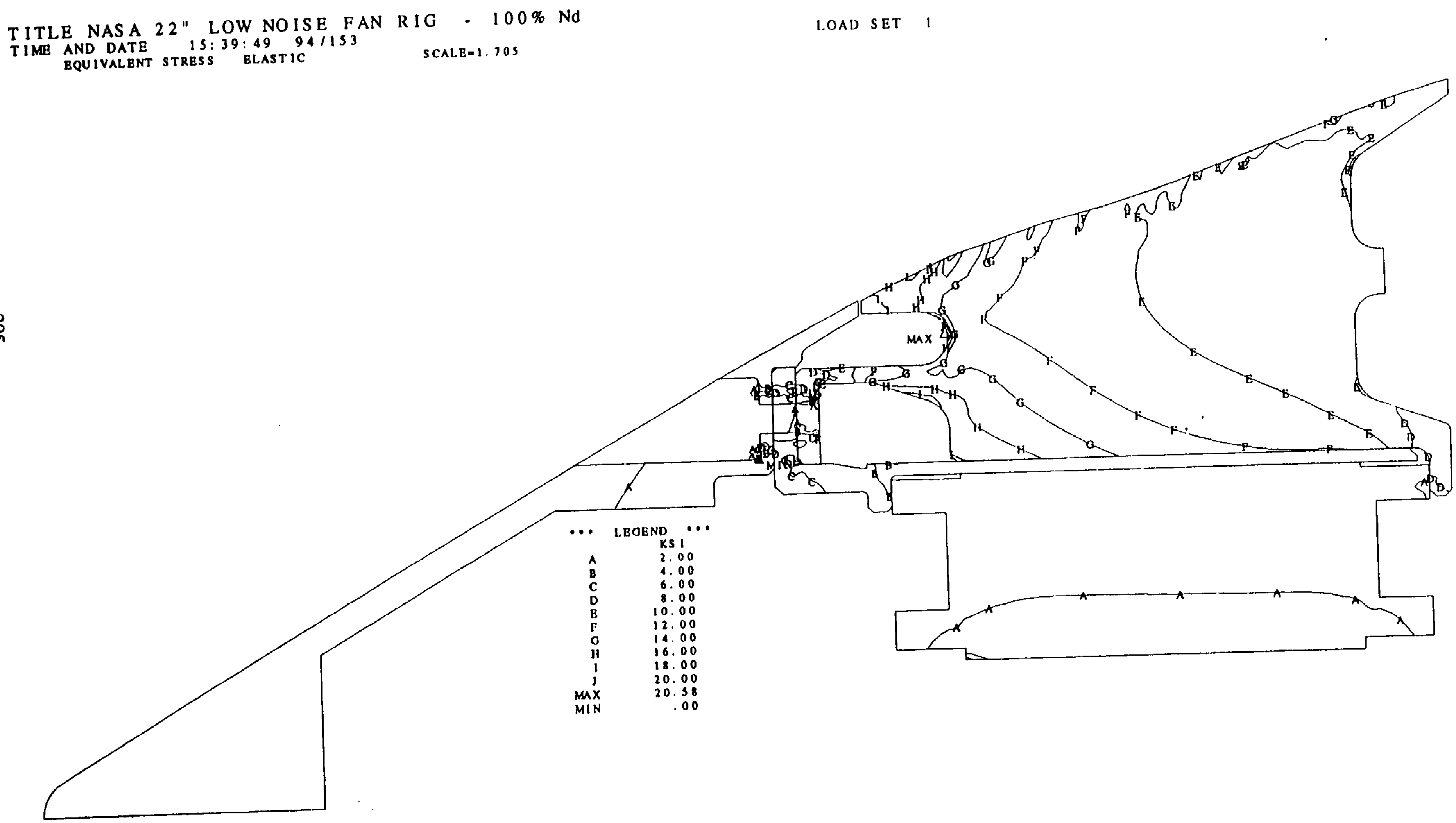
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C 6.00
D 8.00
E 10.00
F 12.00
G 14.00
H 16.00
I 18.00
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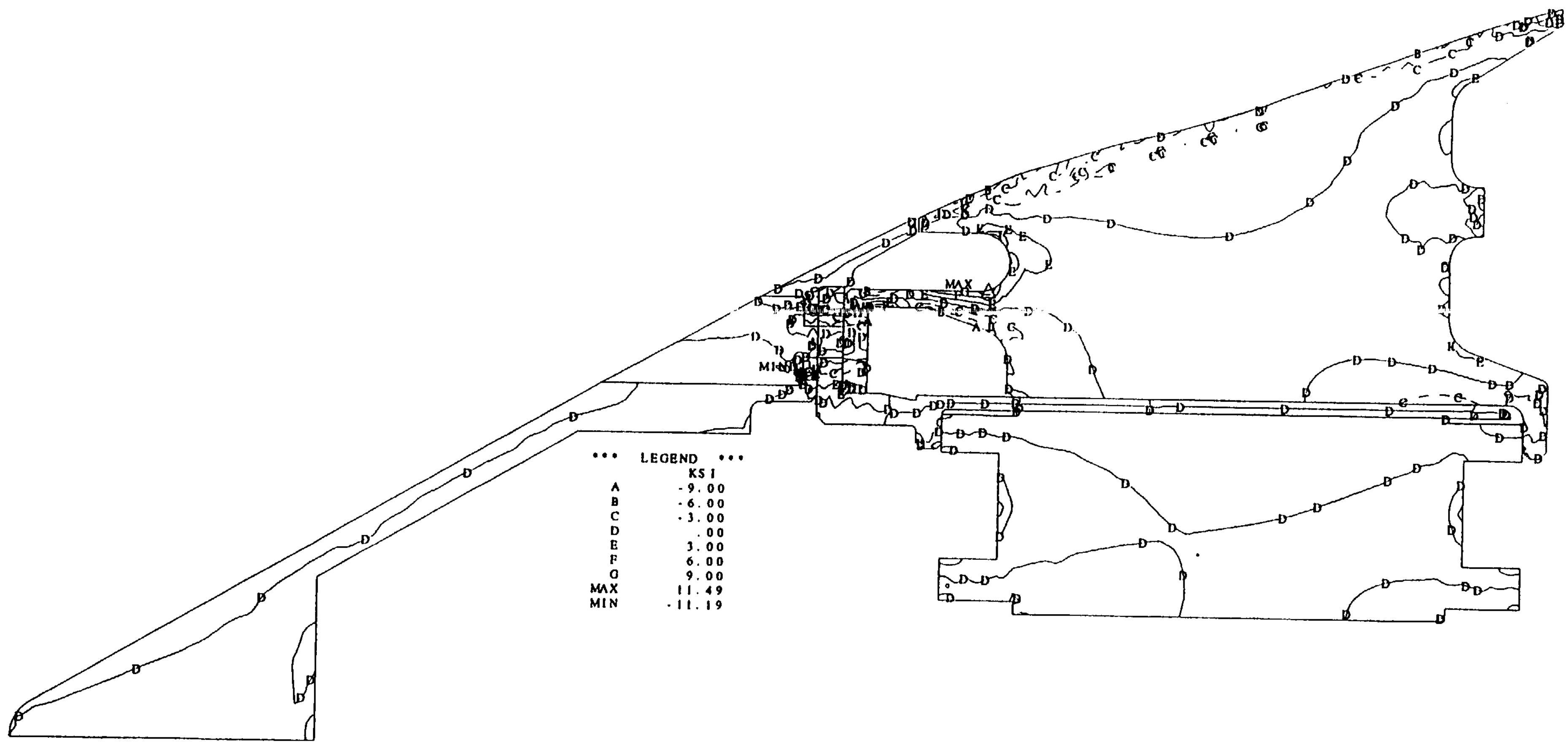

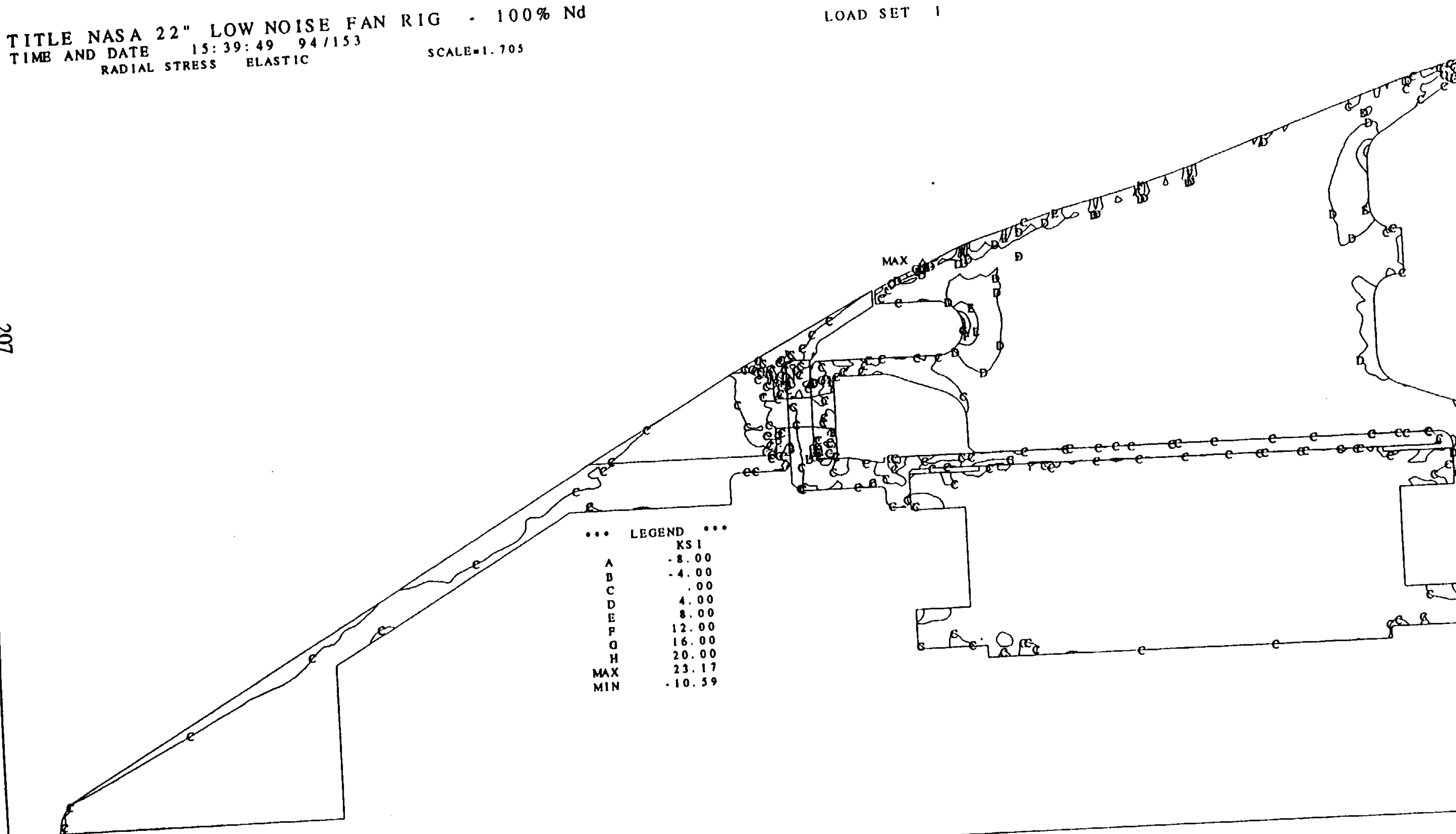
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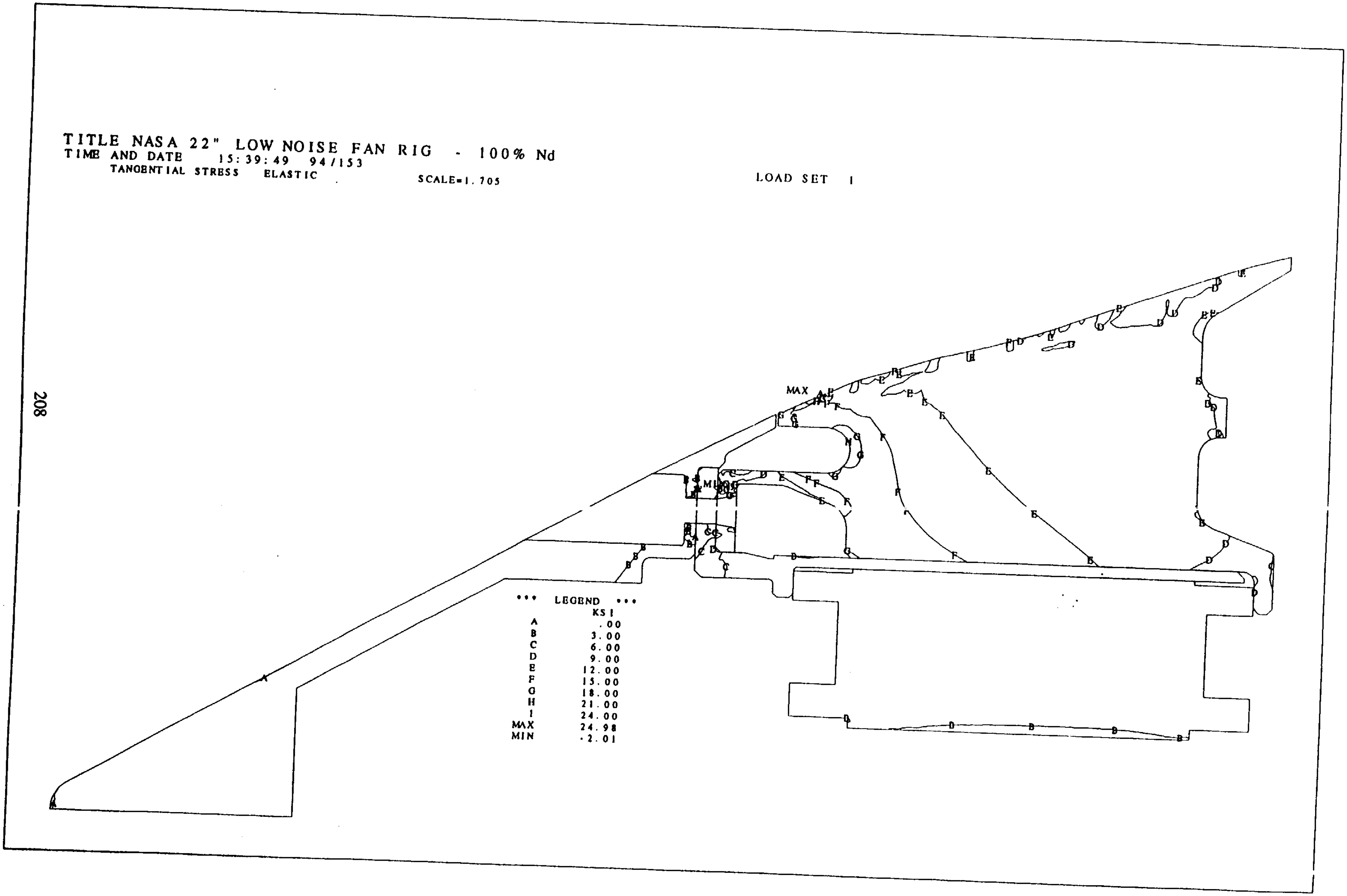
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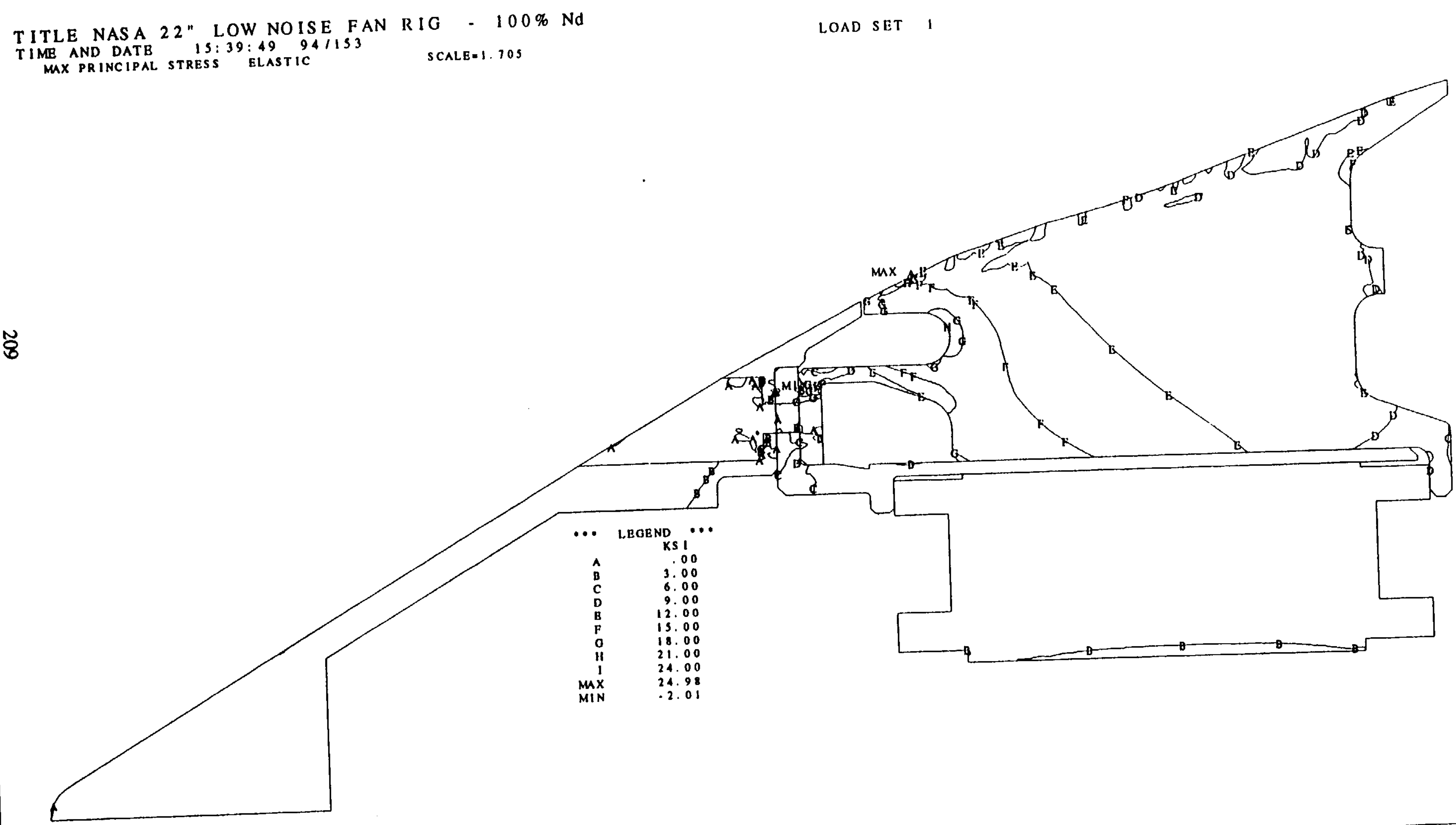

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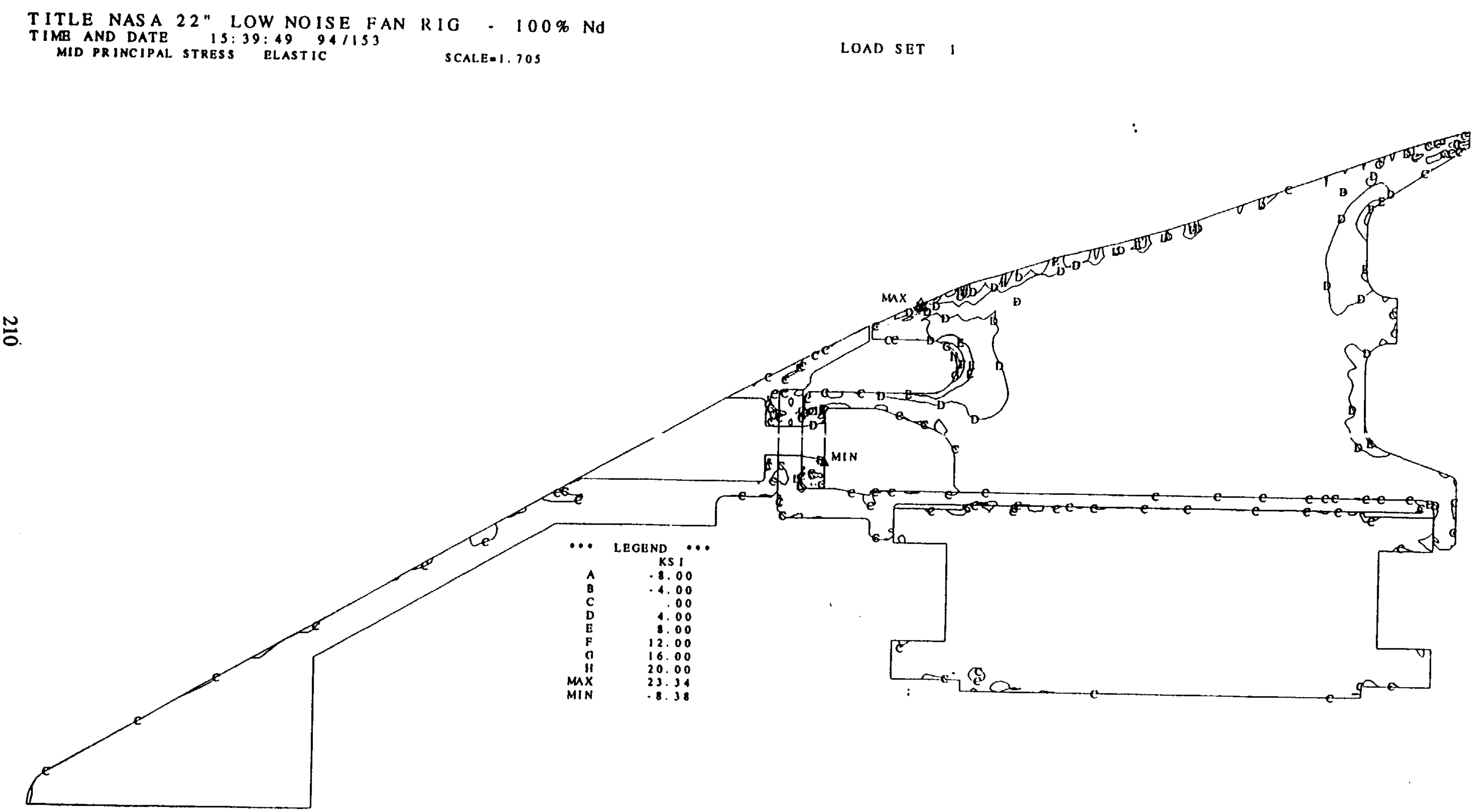
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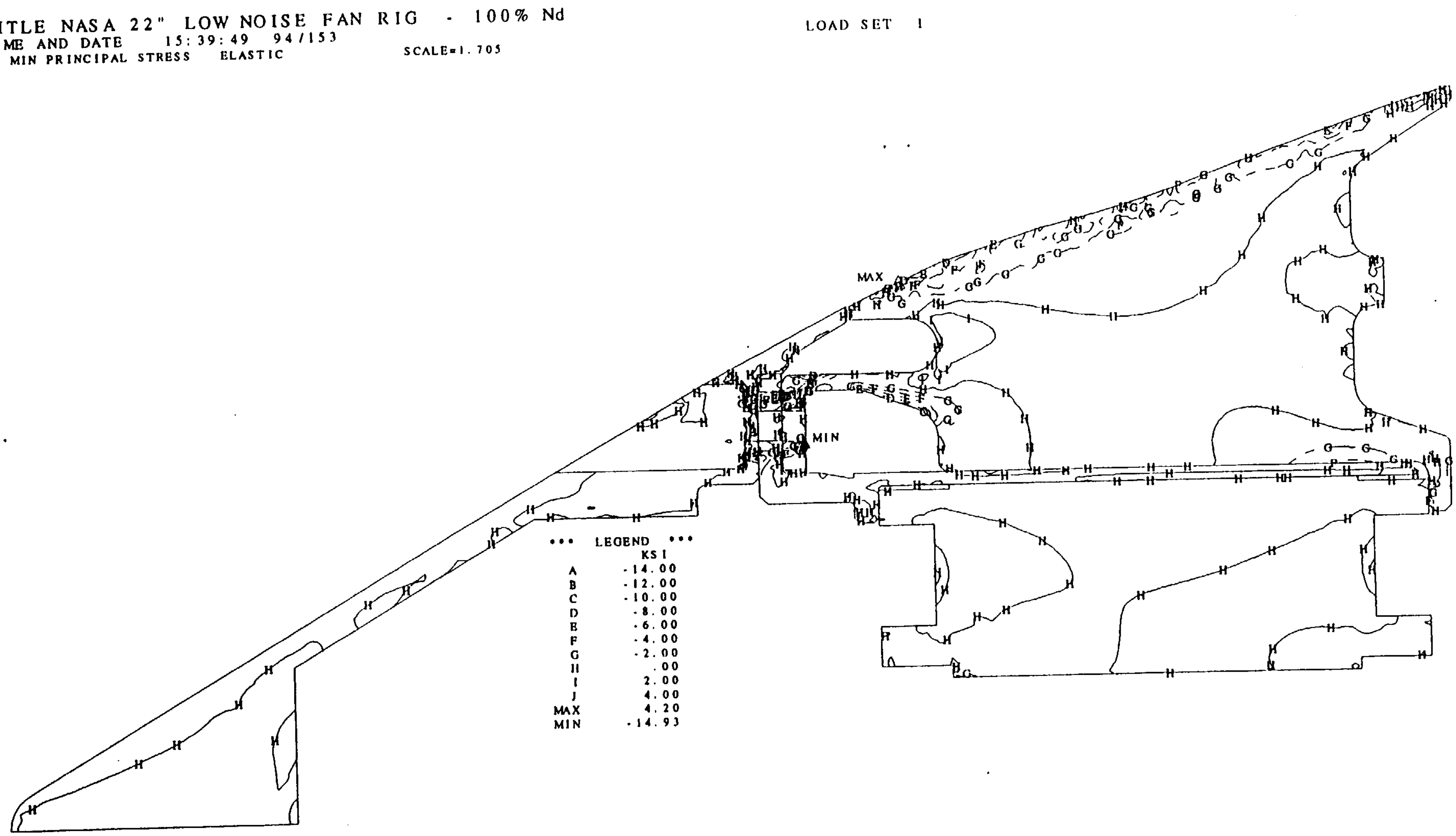
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MIN
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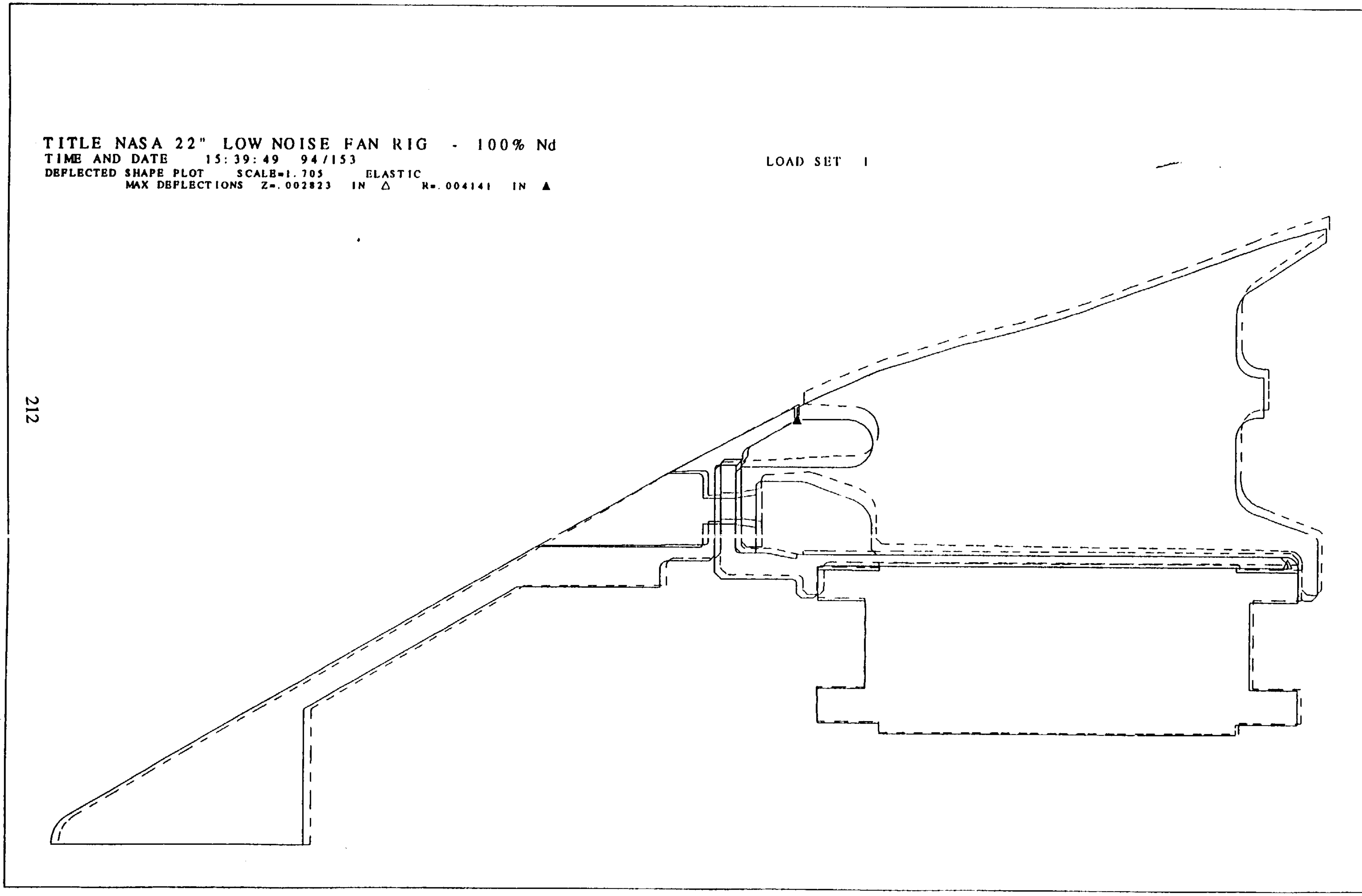
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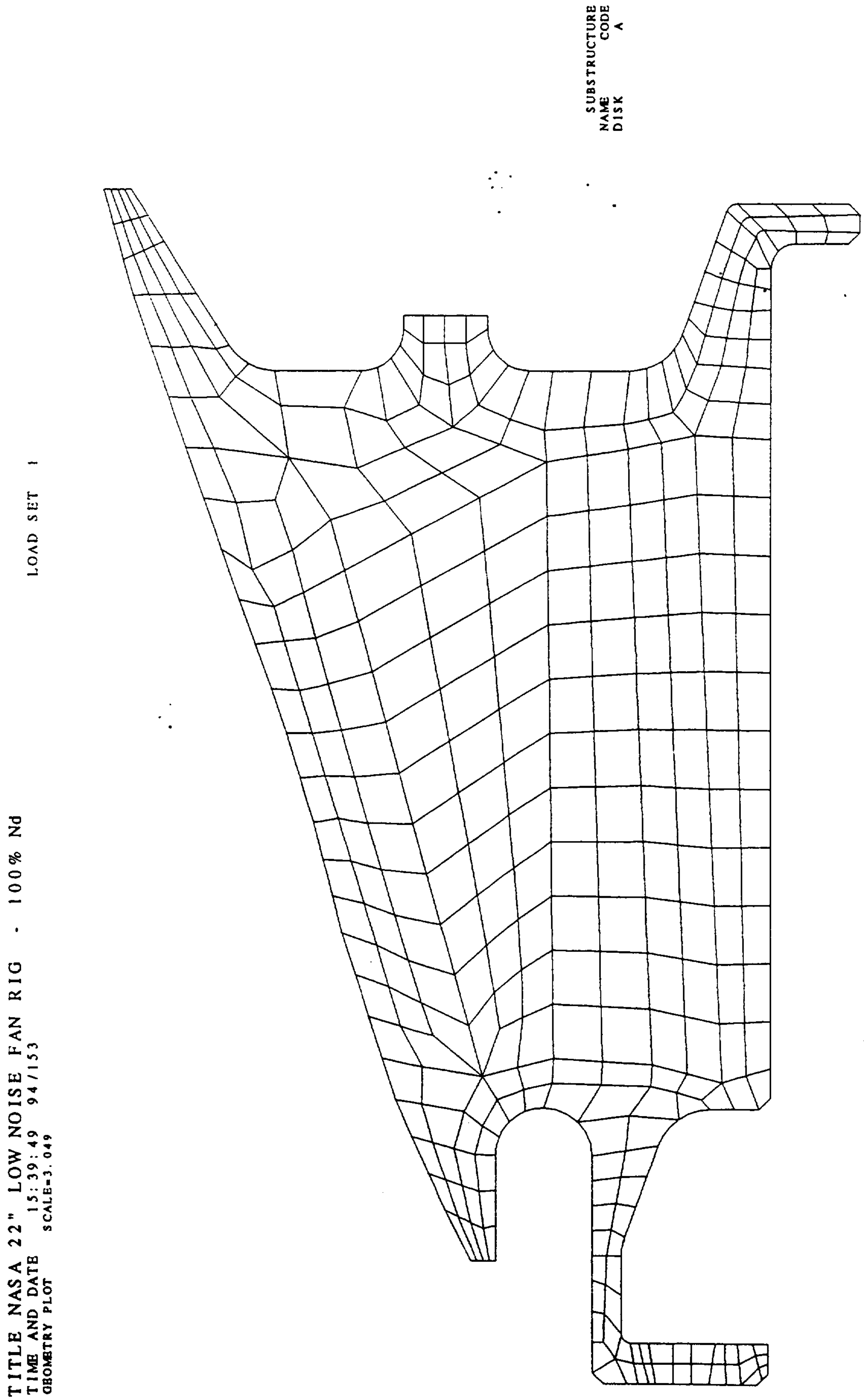
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NAME CODE
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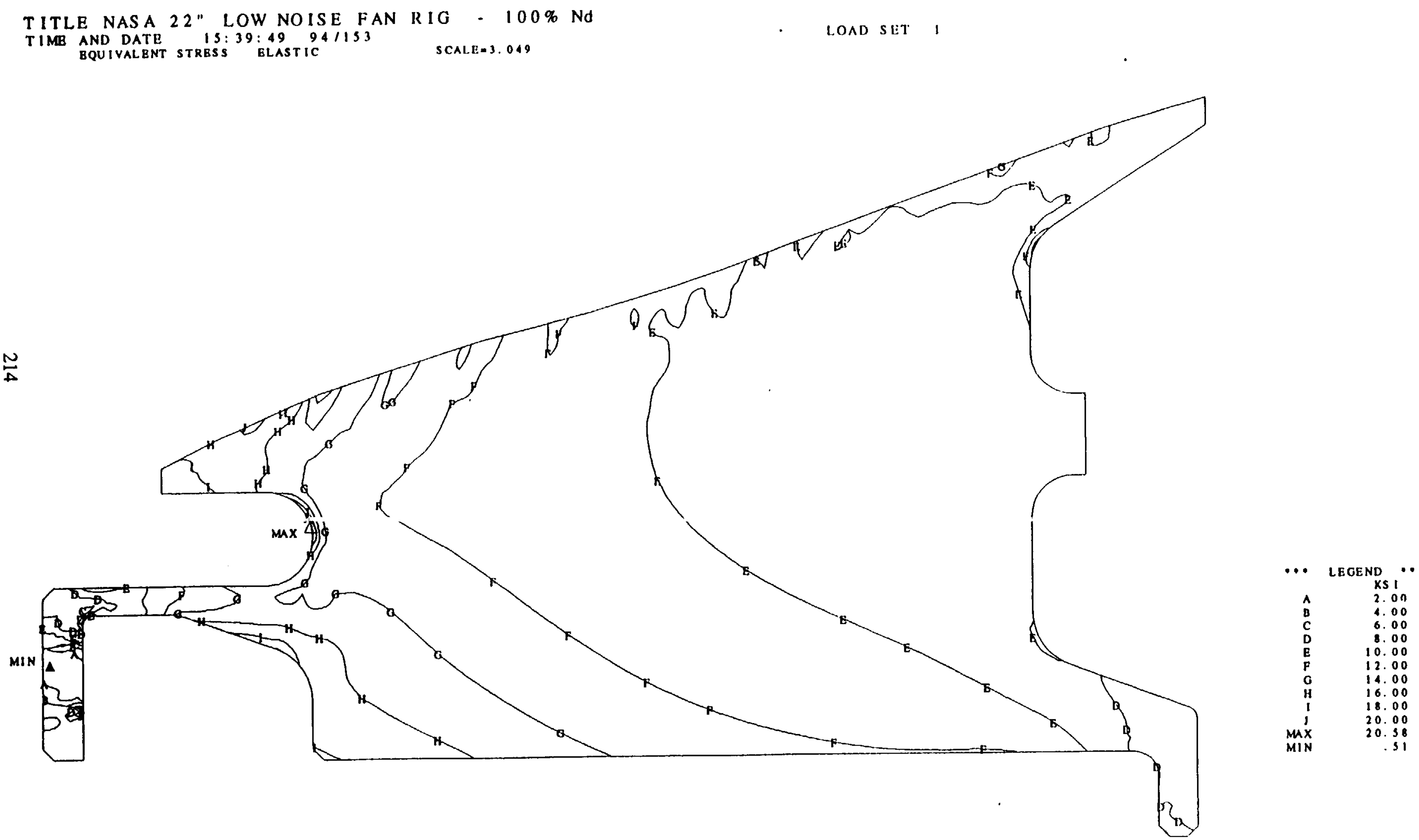

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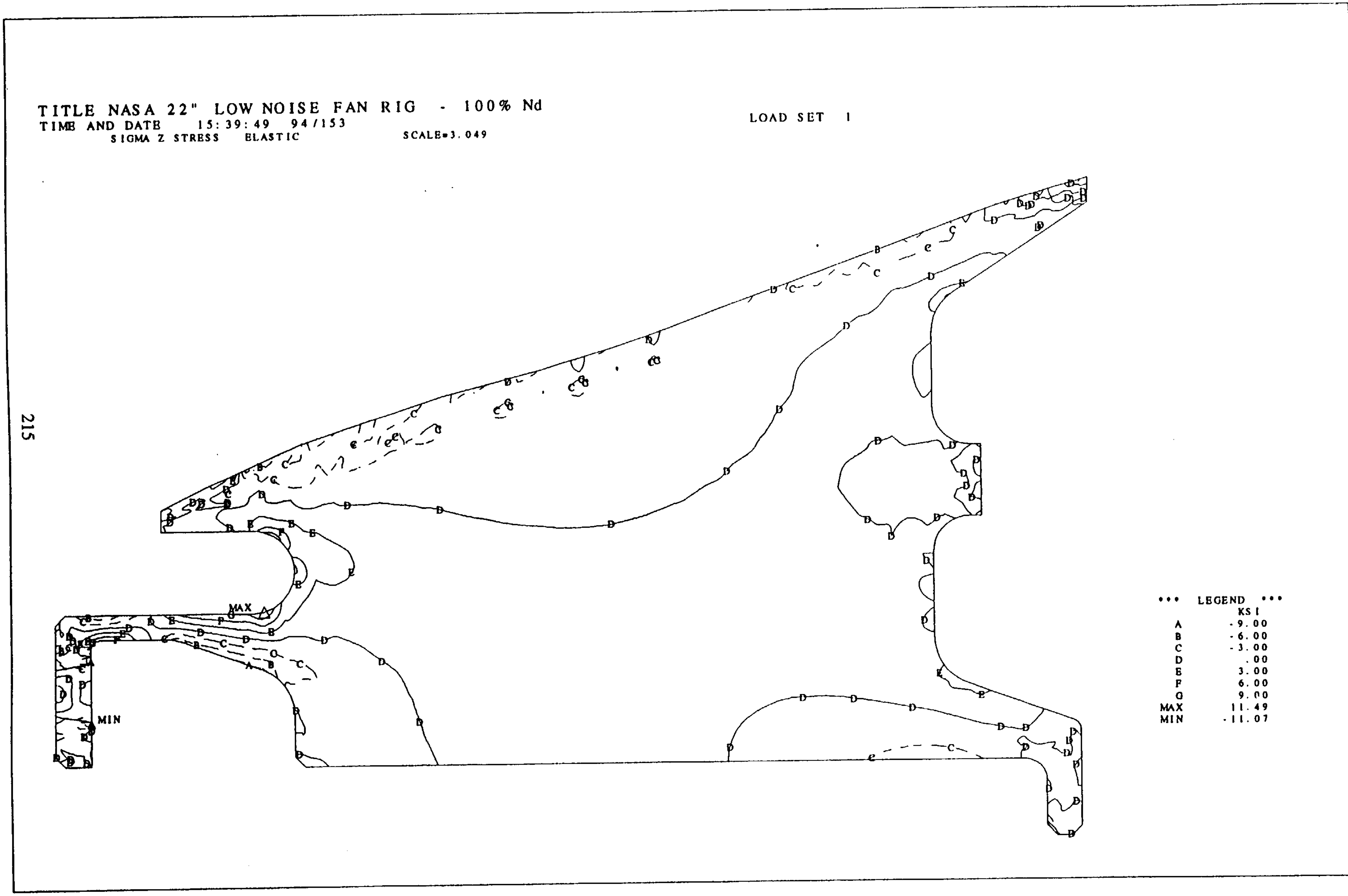
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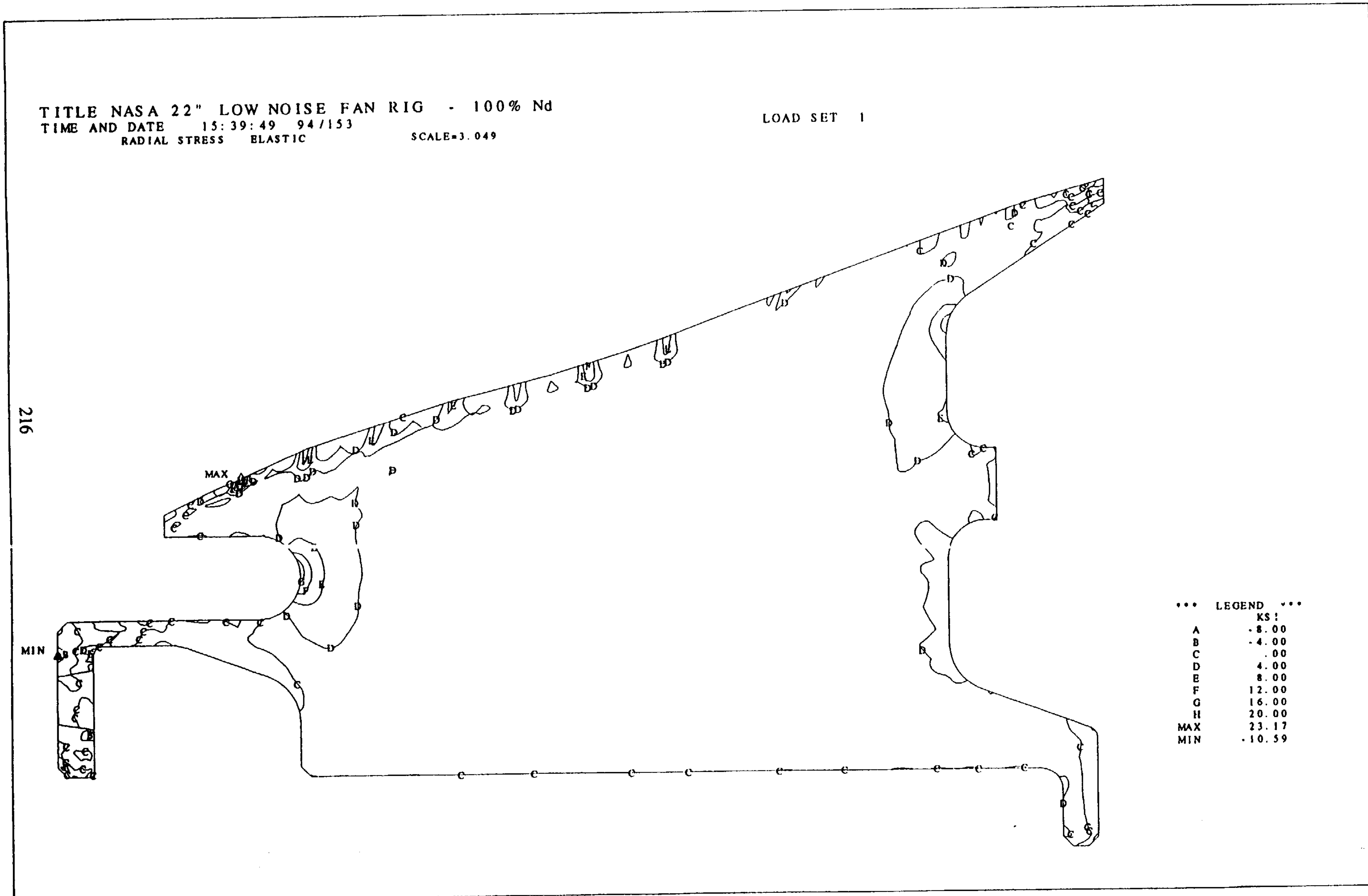
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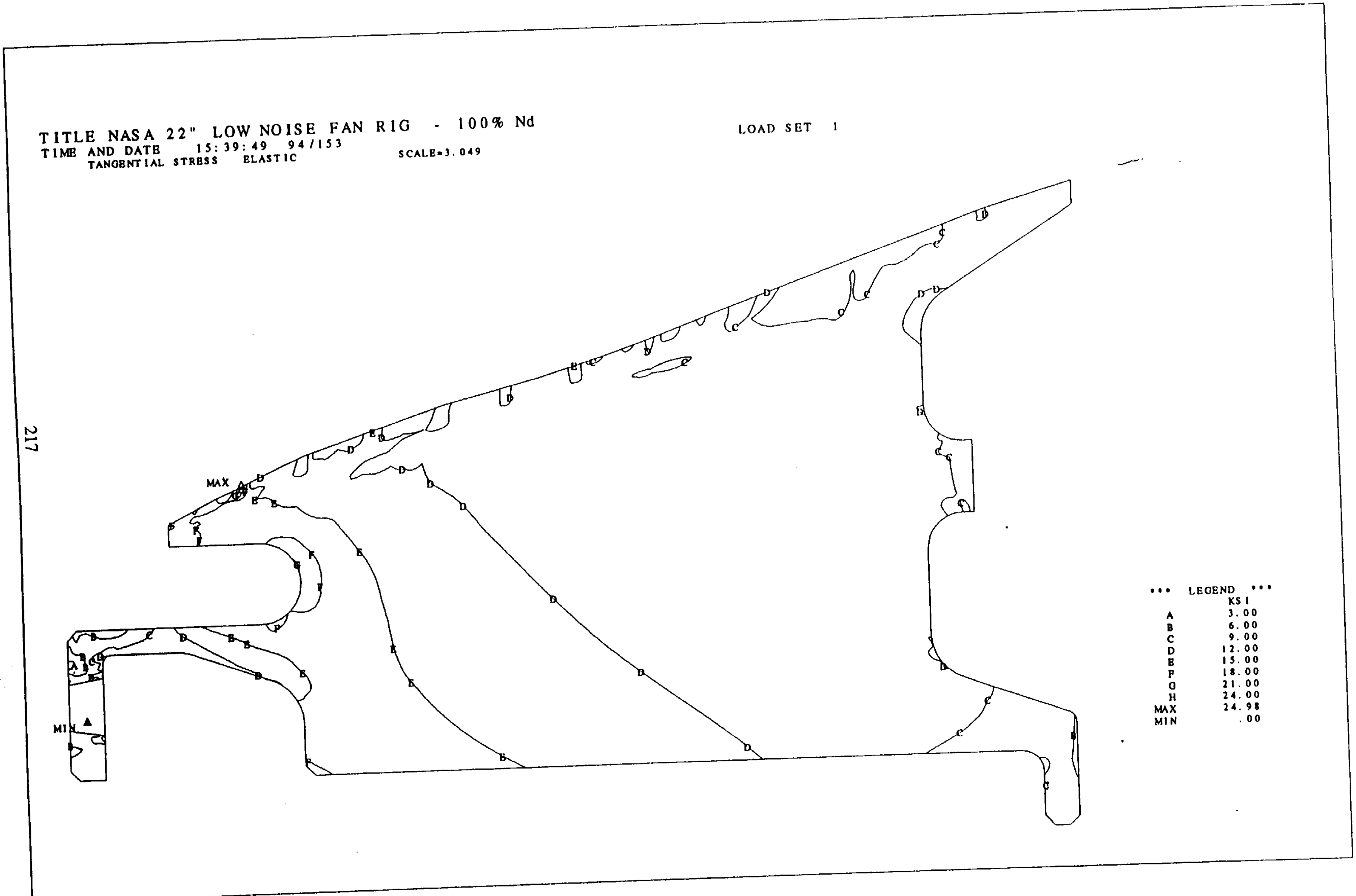
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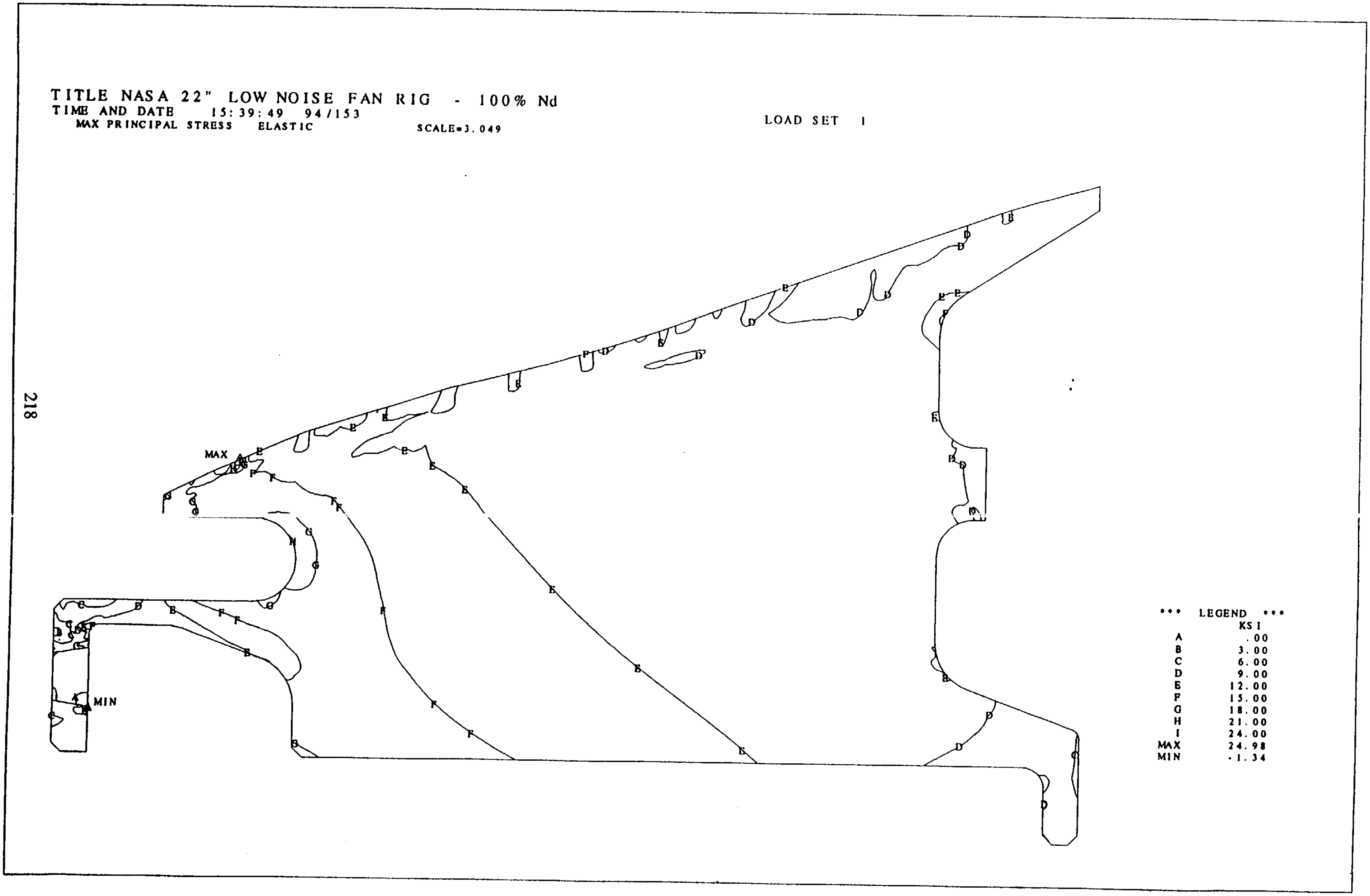
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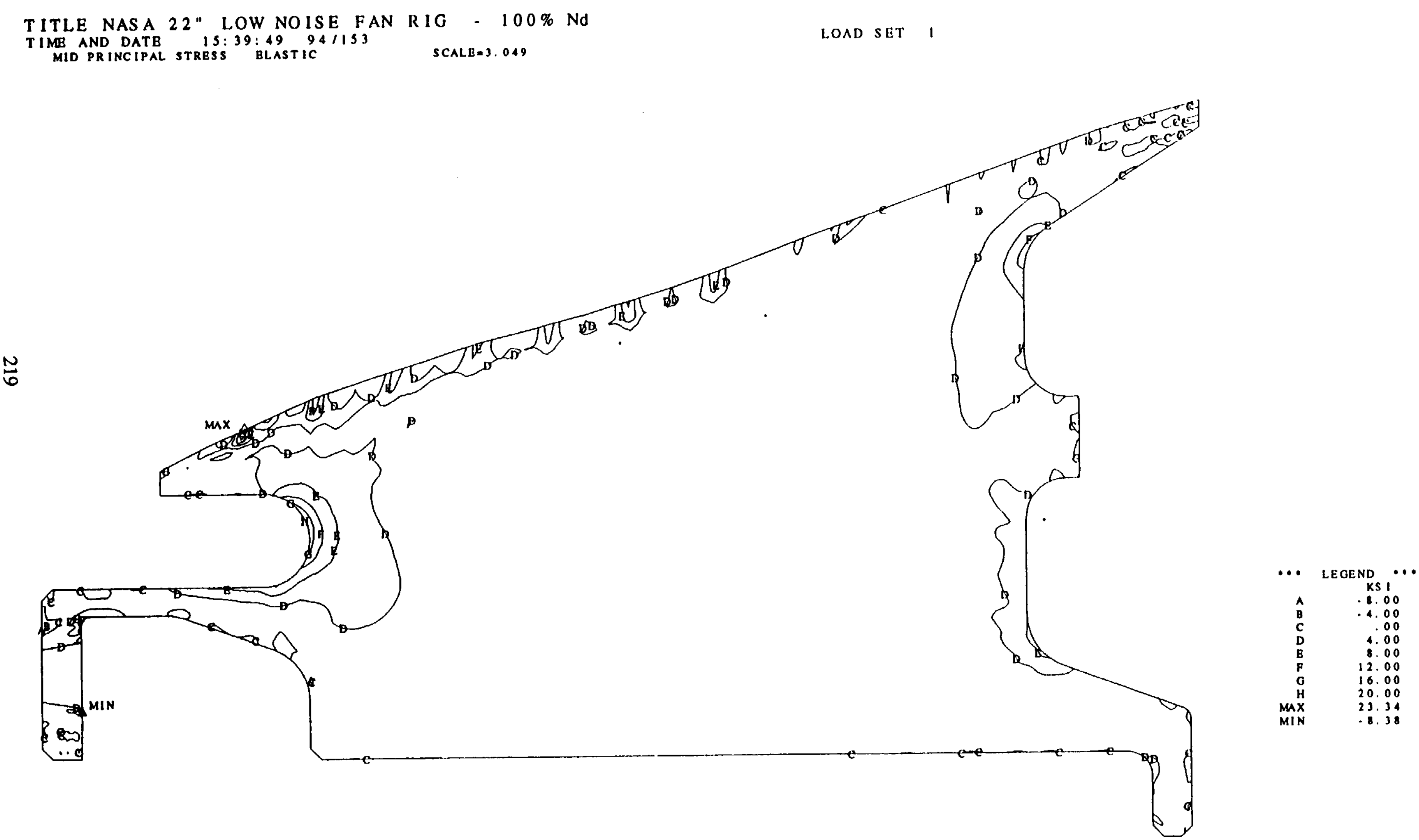

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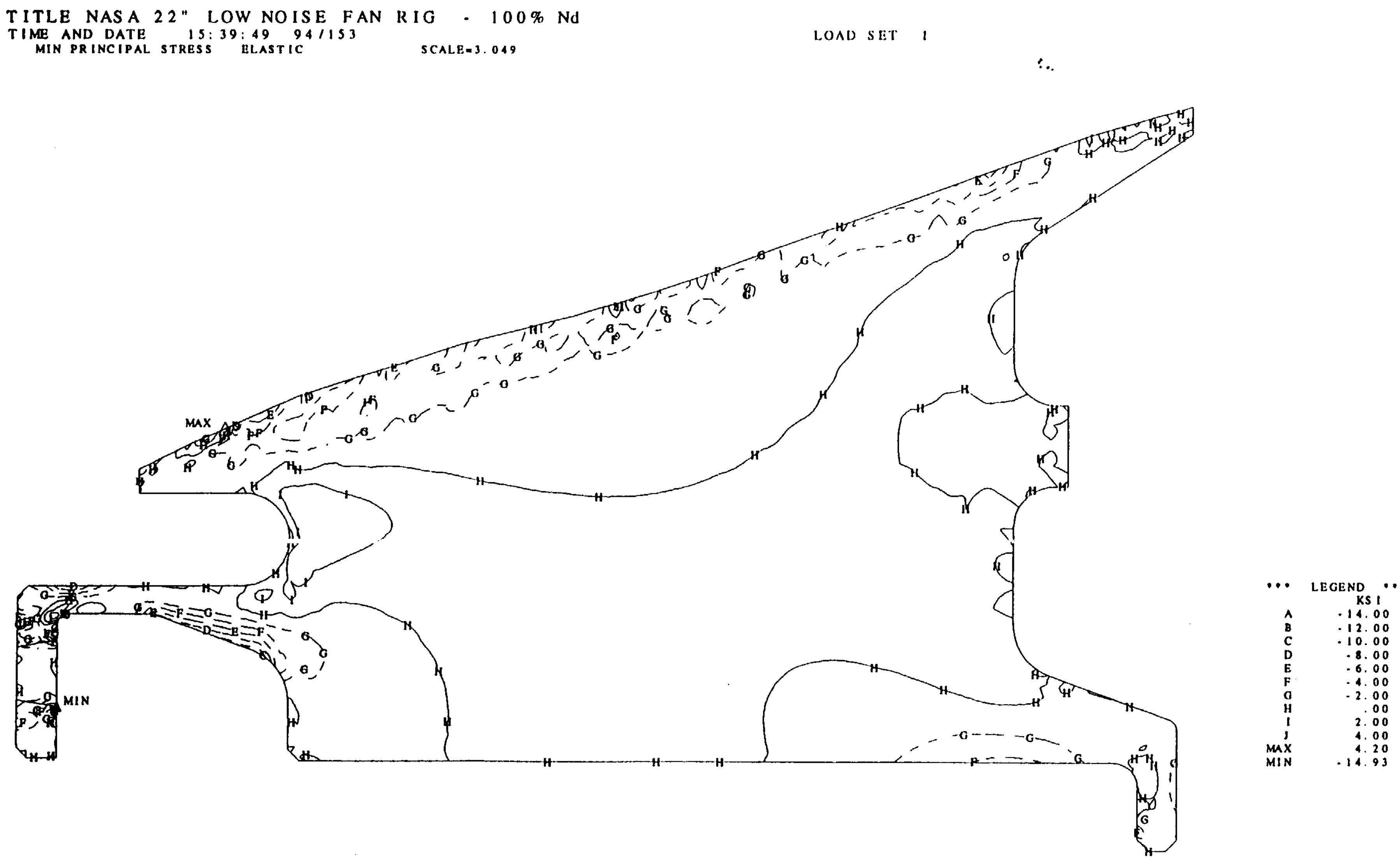
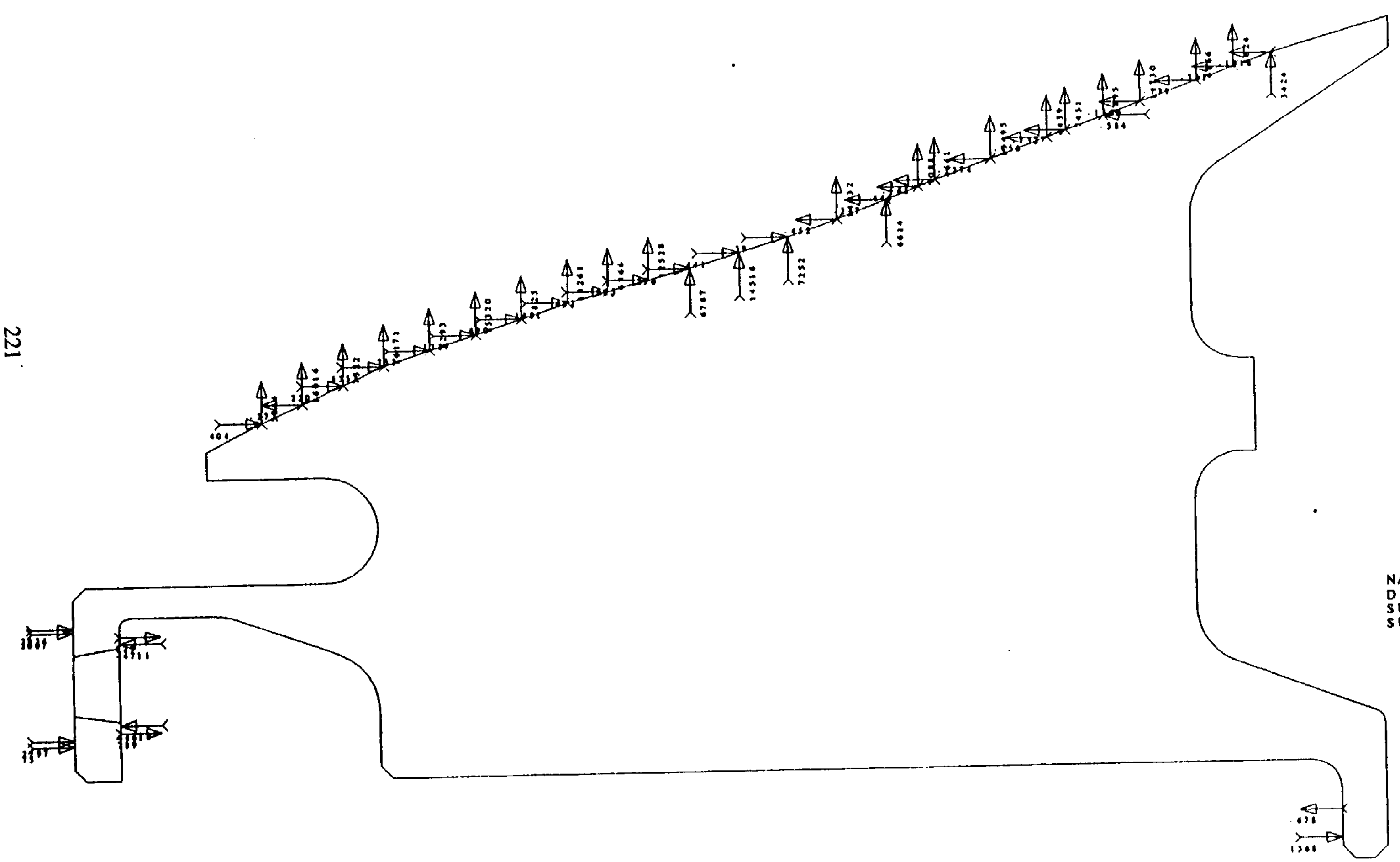
C .00
D 4.00
E 8.00
F 12.00
G 16.00
H 20.00
MAX 23.34
MIN -8.38


TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
TIME AND DATE 15:39:49 94/153
MIN PRINCIPAL STRESS ELASTIC
SCALE=3.049
LOAD SET 1
MAX
MIN
*** LEGEND ***
KSI
A -14.00
B -12.00
C -10.00
D -8.00
E -6.00
F -4.00
G -2.00
H .00
I 2.00
J 4.00
MAX 4.20
MIN -14.93

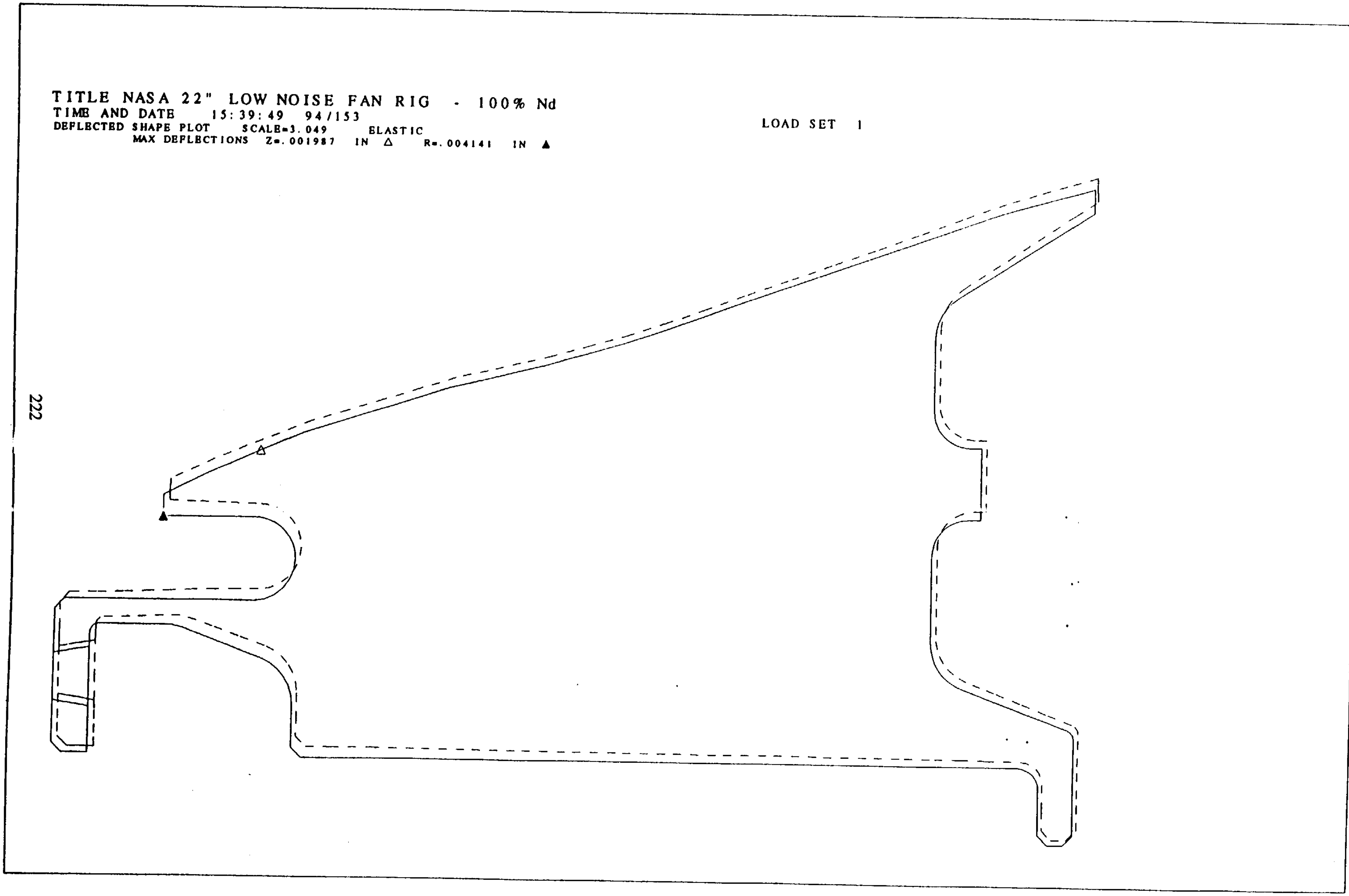
TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
TIME AND DATE 15:39:49 94/153
GEOMETRY PLOT WITH BOUNDARY REACTIONS IN TOTAL LOAD ELASTIC

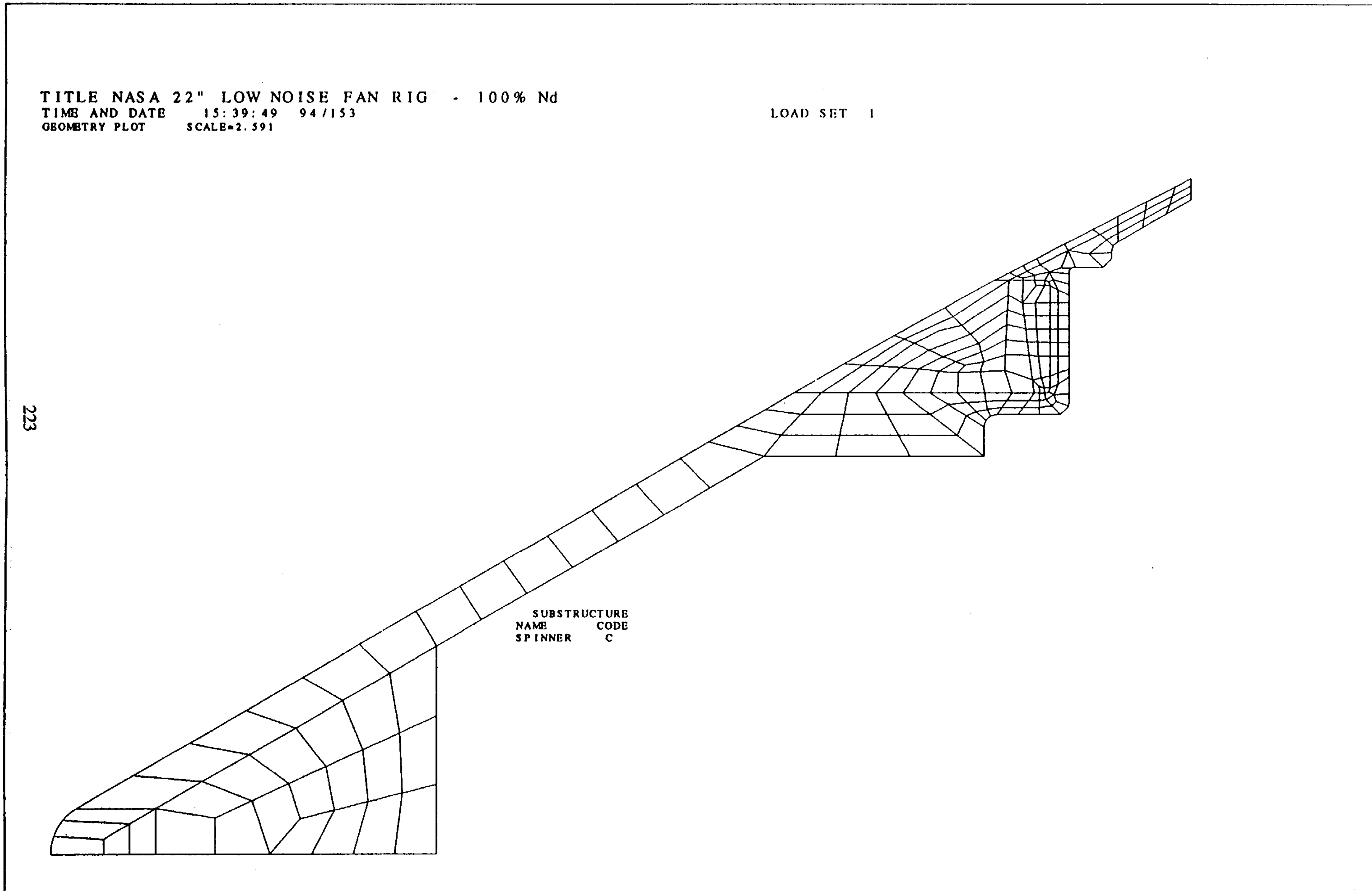
LOAD SET 1

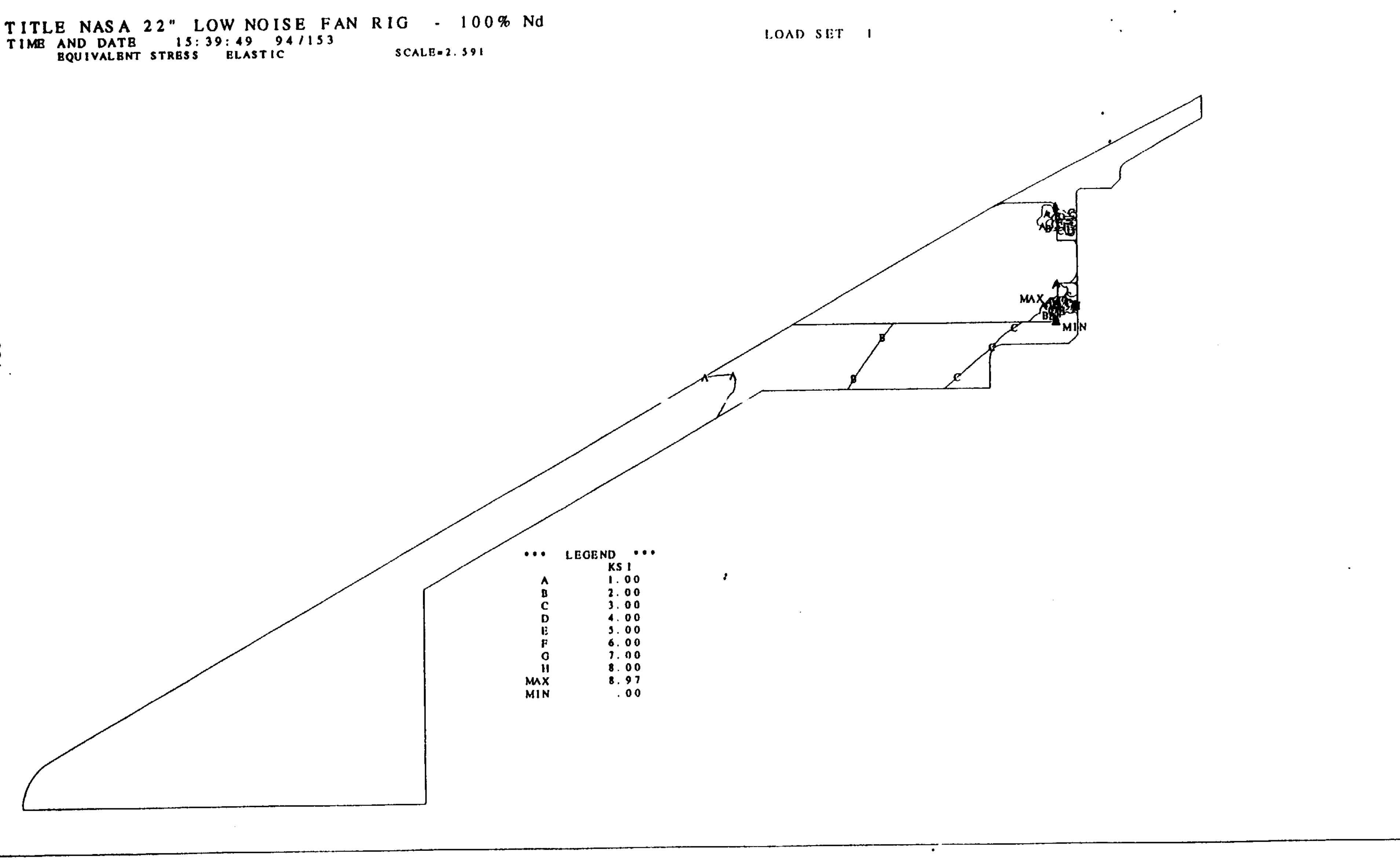


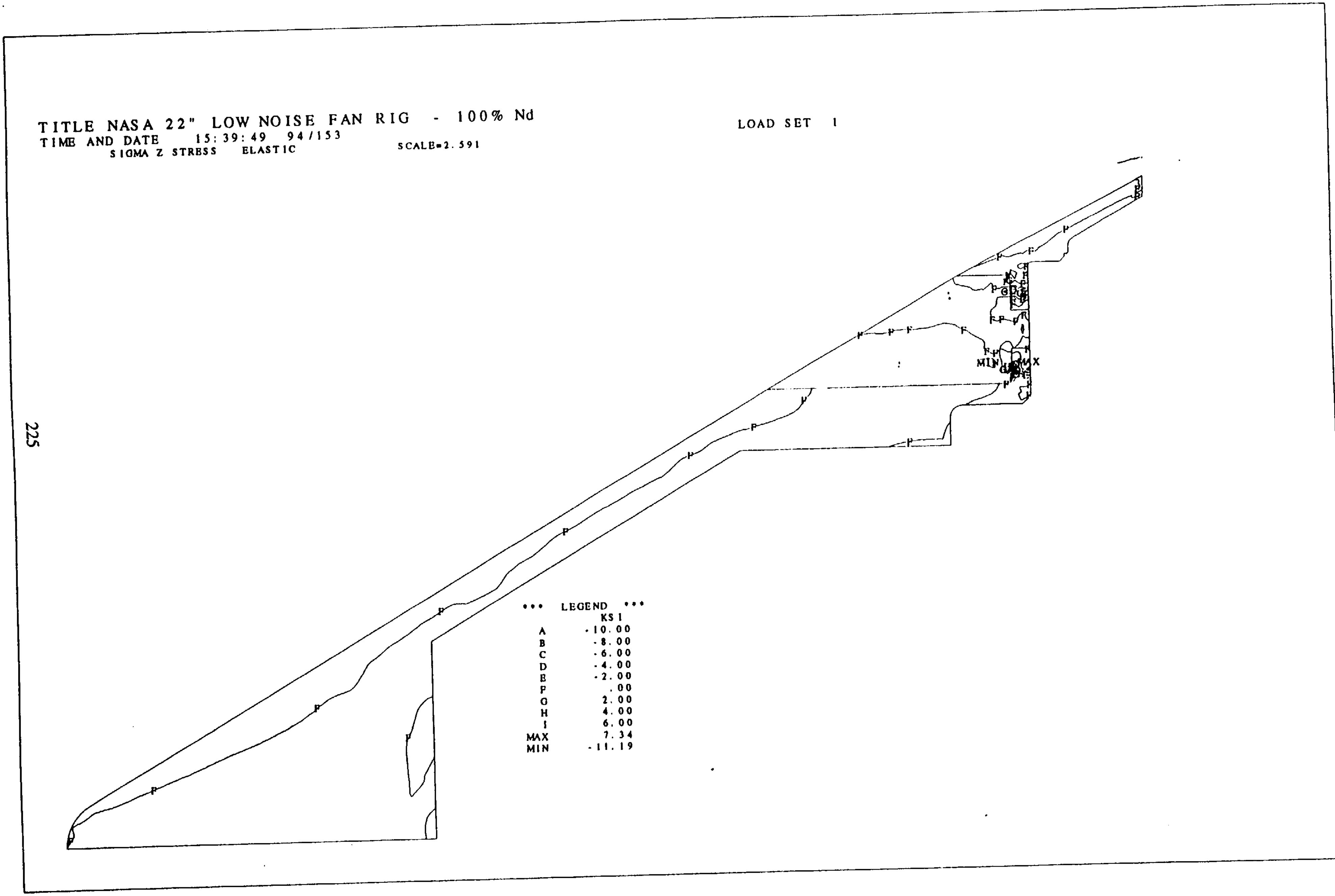
SUBSTRUCTURE

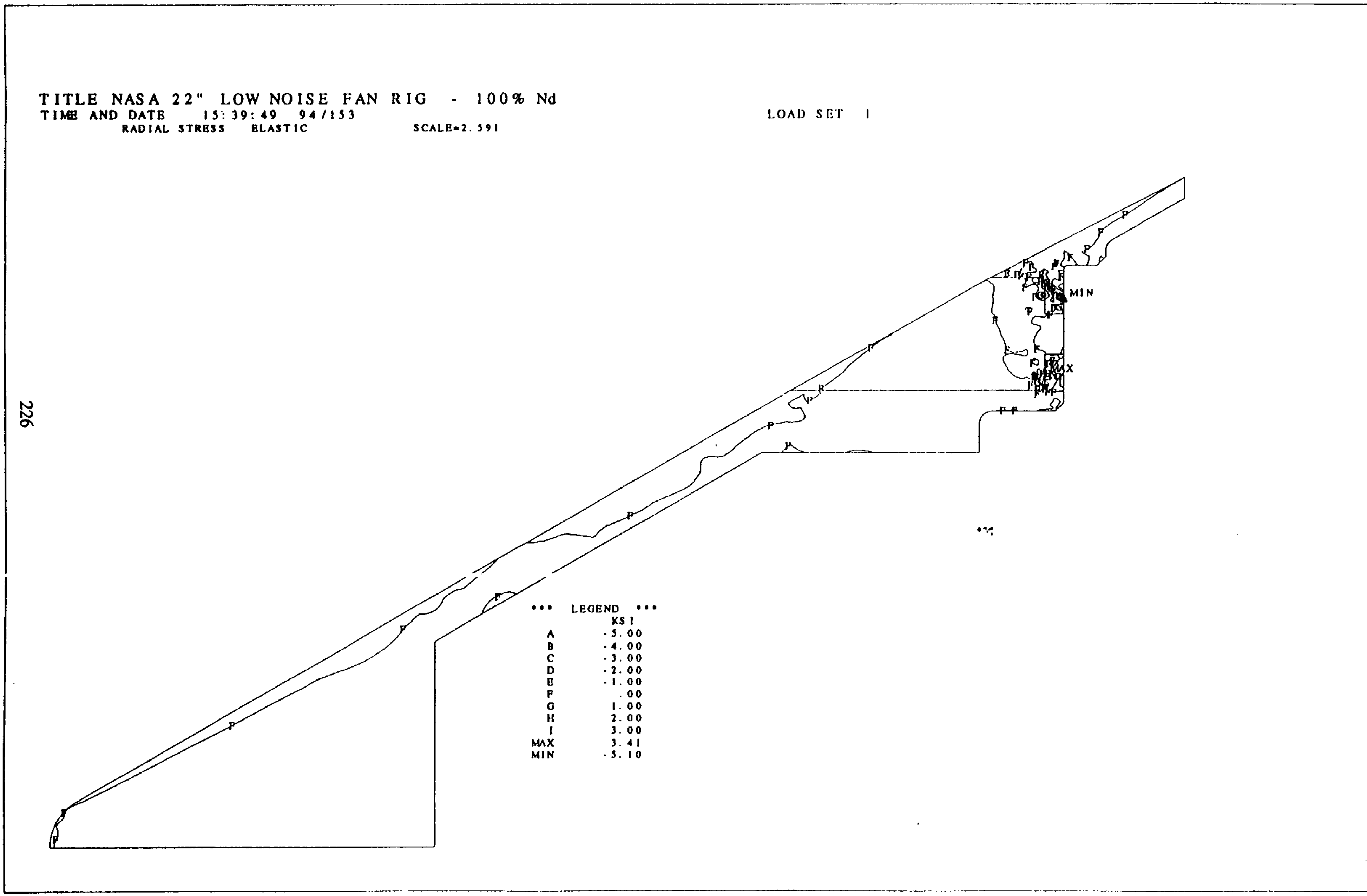
NAME	CODE
DISK	A
SUM Z	690
SUM R	232519

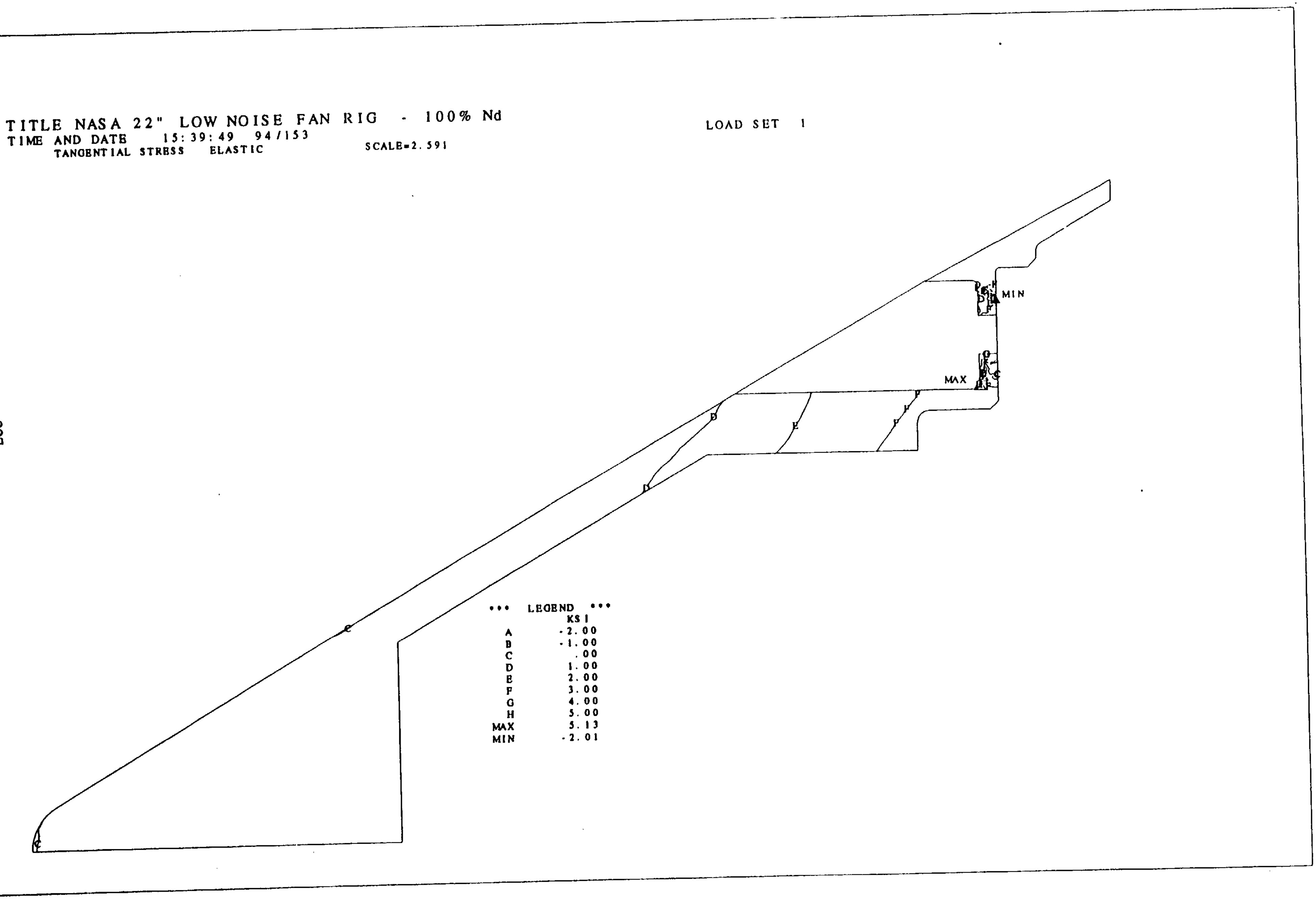

TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
TIME AND DATE 15:39:49 94/153
DEFLECTED SHAPE PLOT SCALE=3.049 ELASTIC
MAX DEFLECTIONS Z=.001987 IN △ R=.004141 IN ▲
LOAD SET 1

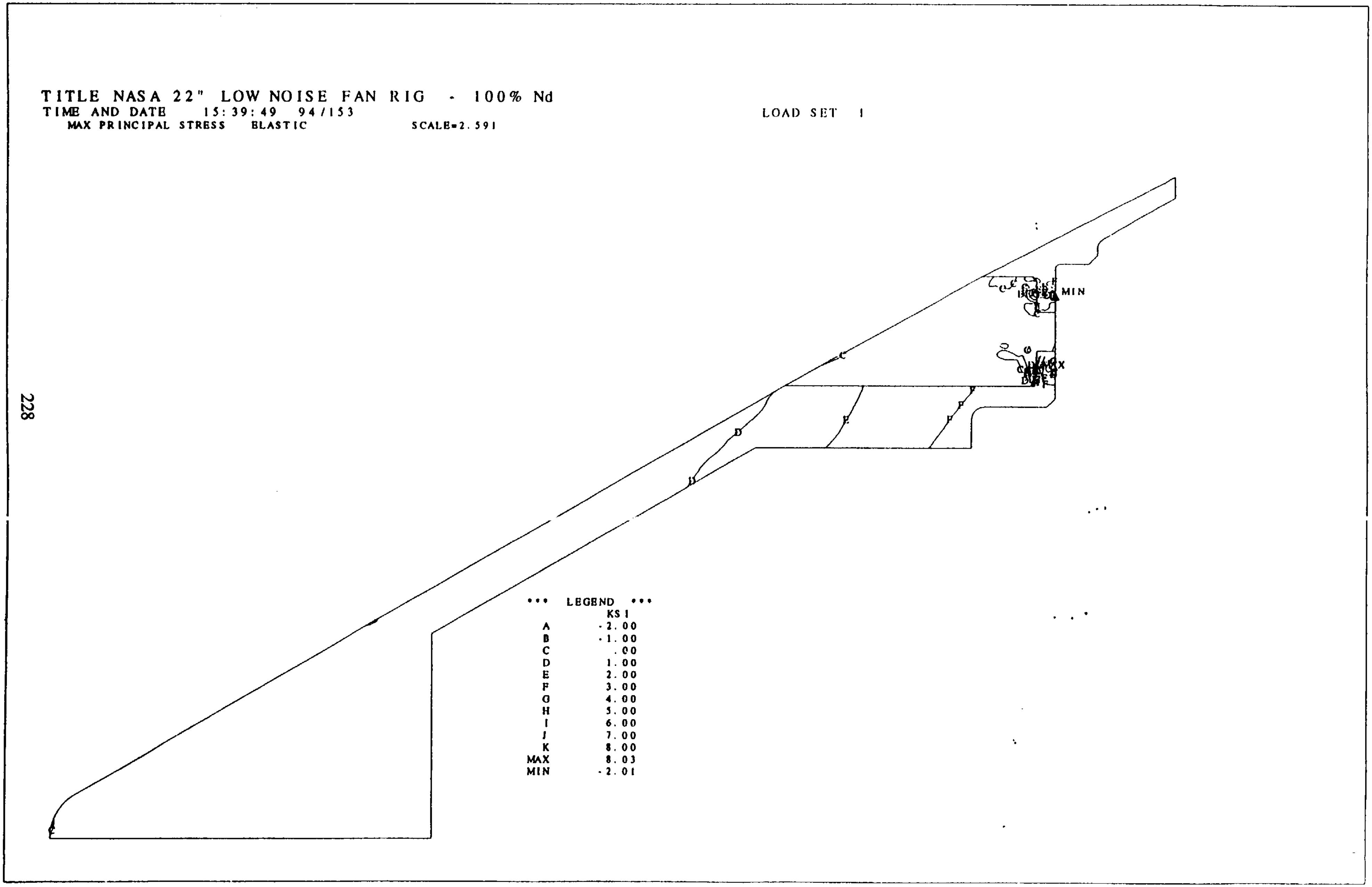

TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
TIME AND DATE 15:39:49 94/153
GEOMETRY PLOT SCALE=2.591
LOAD SET 1
SUBSTRUCTURE
NAME CODE
SPINNER C

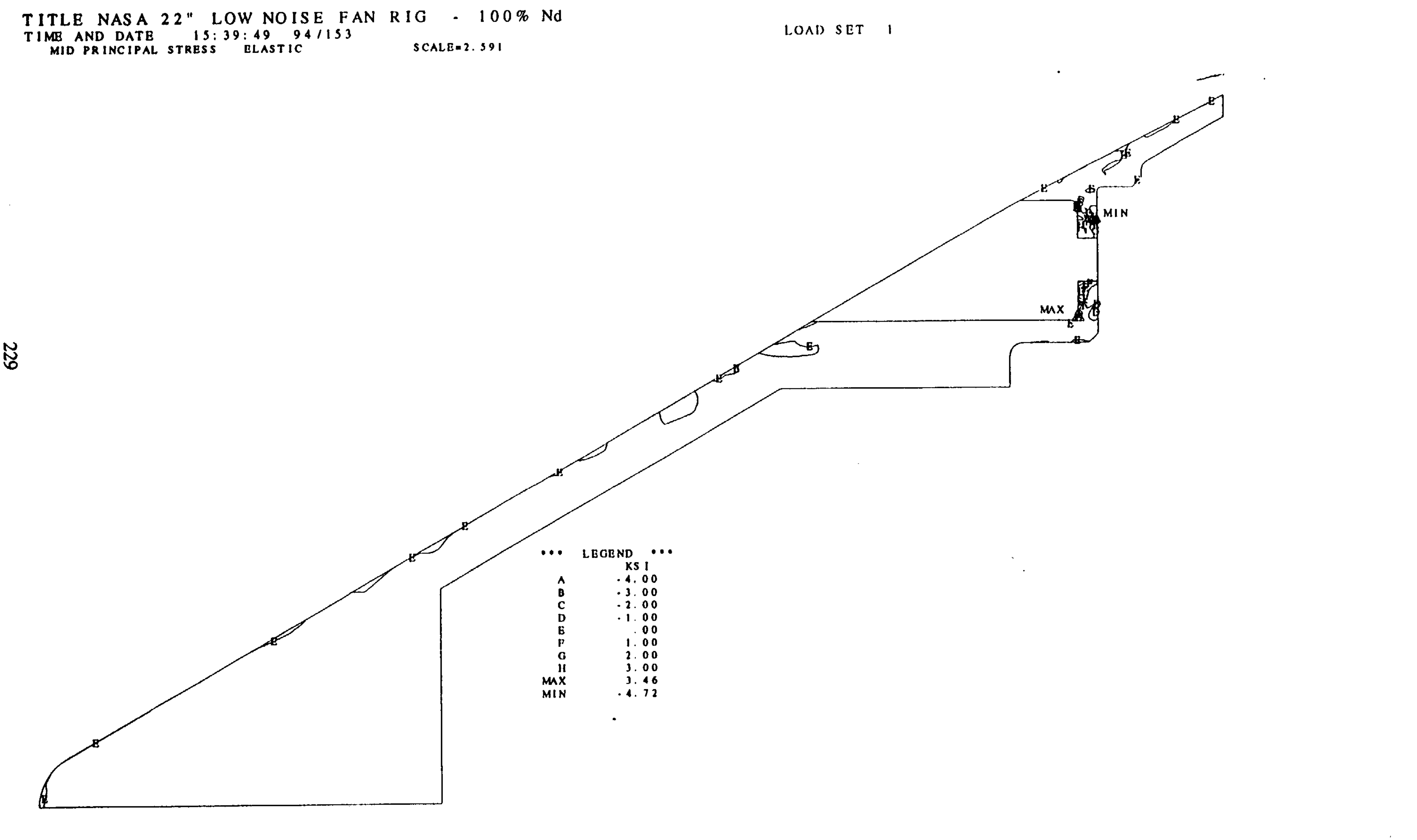

TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
TIME AND DATE 15:39:49 94/153
EQUIVALENT STRESS ELASTIC
SCALE=2.591
LOAD SET 1
MAX
MIN
*** LEGEND ***
KSI
A 1.00
B 2.00
C 3.00
D 4.00
E 5.00
F 6.00
G 7.00
H 8.00
MAX 8.97
MIN .00

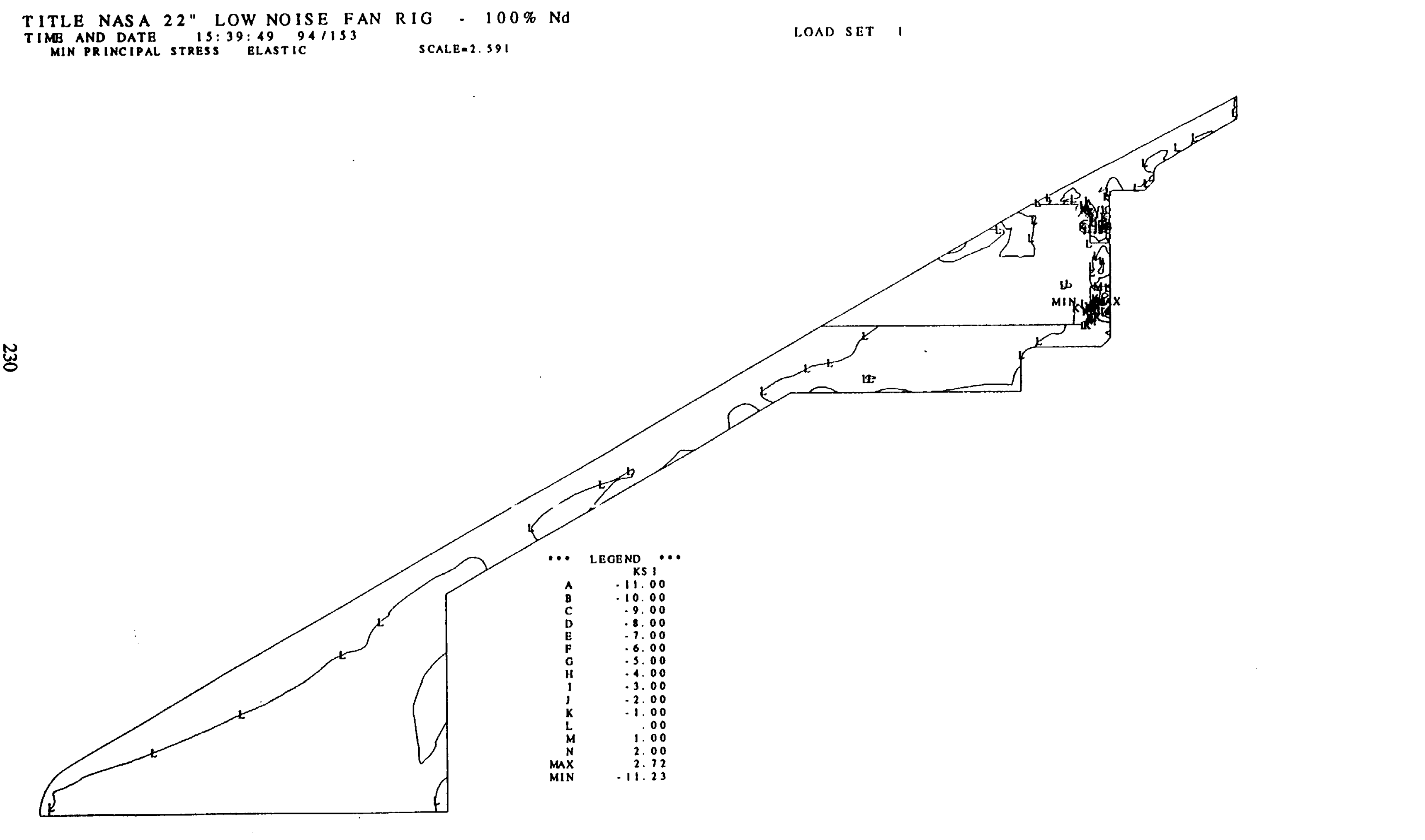

TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
TIME AND DATE 15:39:49 94/153
SIGMA Z STRESS ELASTIC
SCALE=2.591
LOAD SET 1
MIN
MAX
*** LEGEND ***
KSI
A -10.00
B -8.00
C -6.00
D -4.00
E -2.00
F .00
G 2.00
H 4.00
I 6.00
MAX 7.34
MIN -11.19


TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
TIME AND DATE 15:39:49 94/153
RADIAL STRESS ELASTIC
SCALE=2.591
LOAD SET 1
MIN
MAX
*** LEGEND ***
KSI
A -5.00
B -4.00
C -3.00
D -2.00
E -1.00
F .00
G 1.00
H 2.00
I 3.00
MAX 3.41
MIN -5.10


TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
TIME AND DATE 15:39:49 94/153
TANGENTIAL STRESS ELASTIC
SCALE=2.591
LOAD SET 1
MIN
MAX
*** LEGEND ***
KSI
A -2.00
B -1.00
C .00
D 1.00
E 2.00
F 3.00
G 4.00
H 5.00
MAX 5.13
MIN -2.01

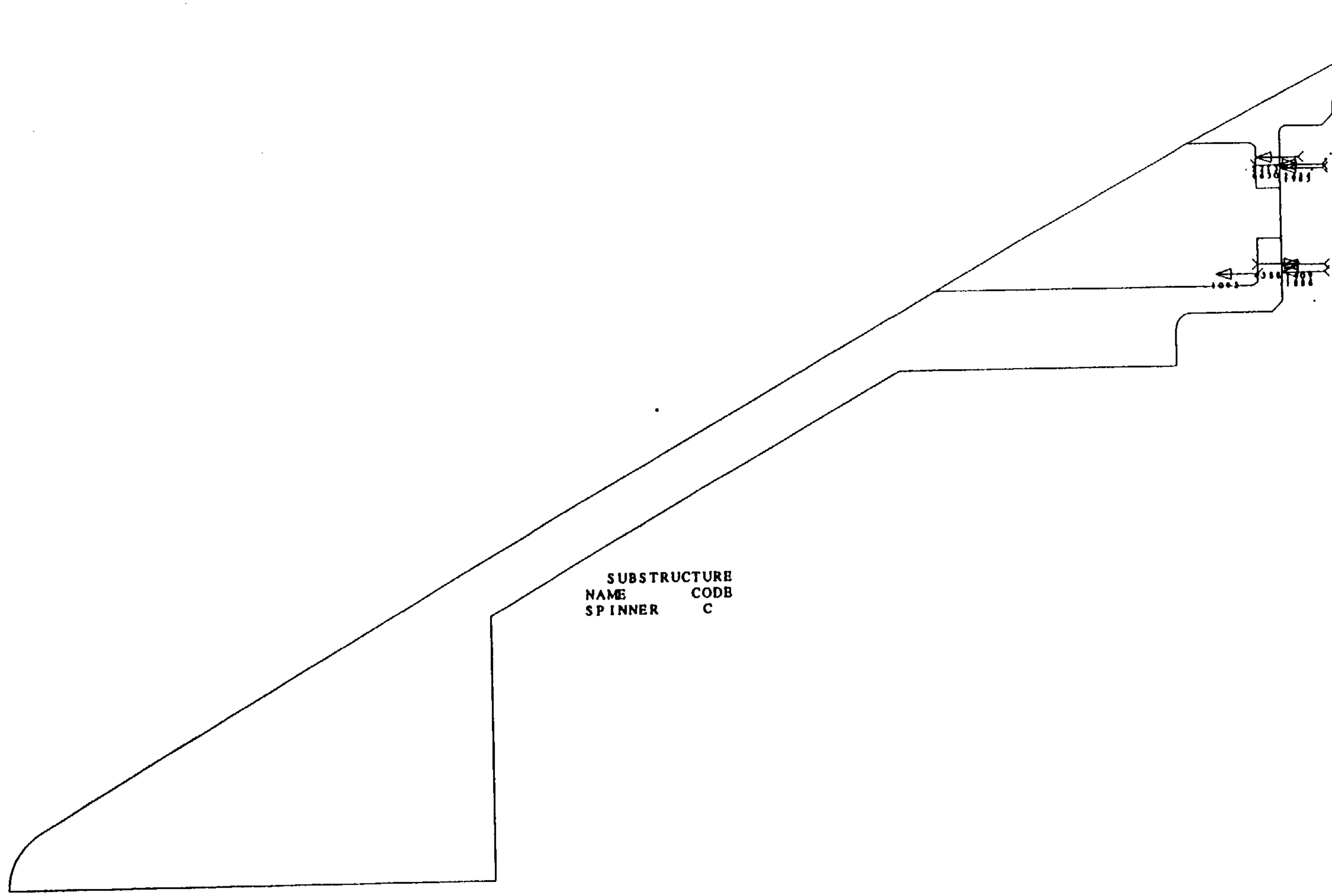

TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
TIME AND DATE 15:39:49 94/153
MAX PRINCIPAL STRESS ELASTIC
SCALE=2.591
LOAD SET 1
*** LEGEND ***
KSI
A -2.00
B -1.00
C .00
D 1.00
E 2.00
F 3.00
G 4.00
H 5.00
I 6.00
J 7.00
K 8.00
MAX 8.03
MIN -2.01

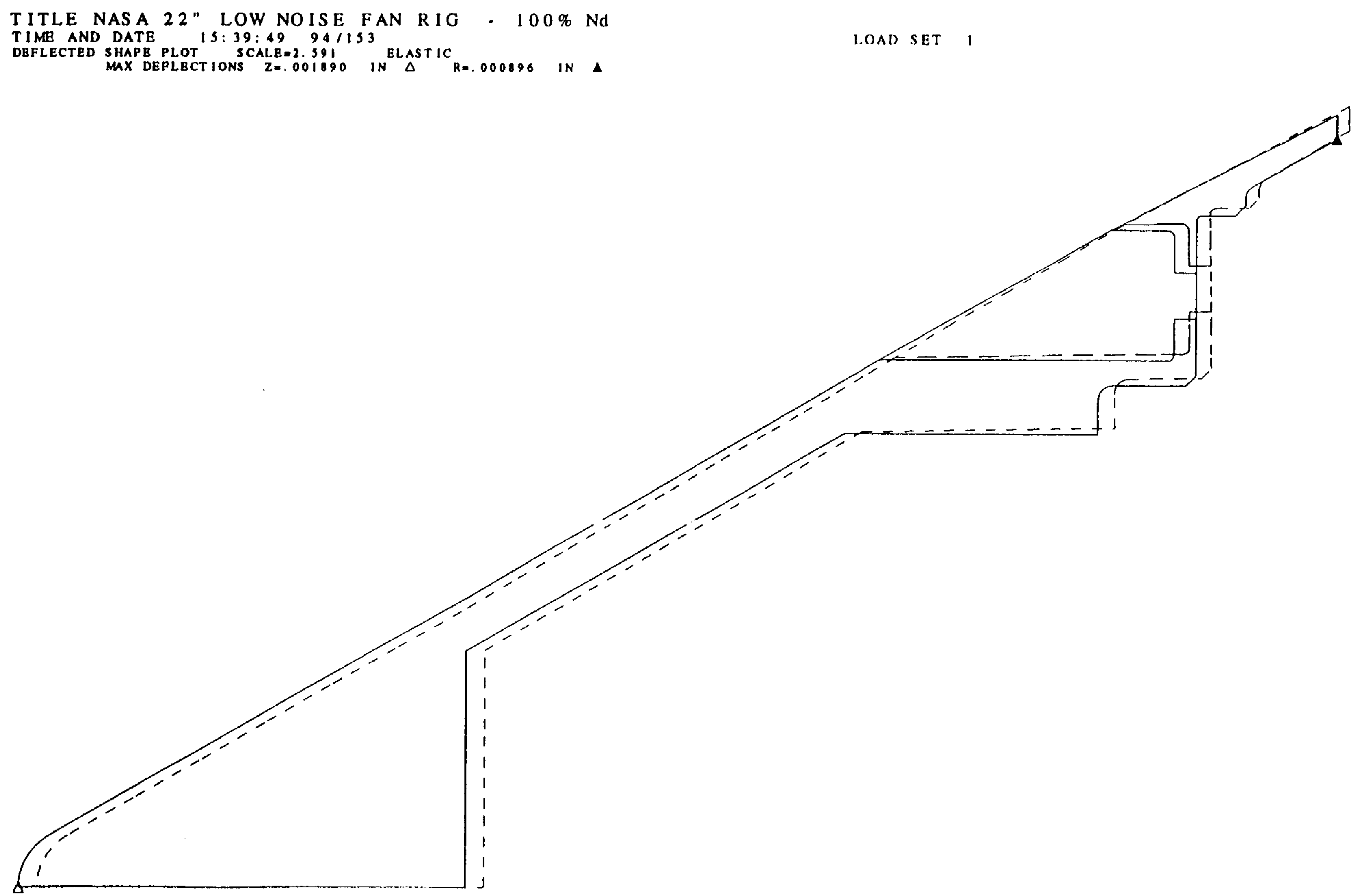

TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
TIME AND DATE 15:39:49 94/153
MID PRINCIPAL STRESS ELASTIC
SCALE=2.591
LOAD SET 1
MIN
MAX
*** LEGEND ***
KSI
A -4.00
B -3.00
C -2.00
D -1.00
E .00
F 1.00
G 2.00
H 3.00
MAX 3.46
MIN -4.72


TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
TIME AND DATE 15:39:49 94/153
MIN PRINCIPAL STRESS ELASTIC
SCALE=2.591
LOAD SET 1
MIN
MAX
*** LEGEND ***
KSI
A -11.00
B -10.00
C -9.00
D -8.00
E -7.00
F -6.00
G -5.00
H -4.00
I -3.00
J -2.00
K -1.00
L .00
M 1.00
N 2.00
MAX 2.72
MIN -11.23

TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
TIME AND DATE 15:39:49 94/153
GEOMETRY PLOT WITH BOUNDARY REACTIONS IN TOTAL LOAD ELASTIC

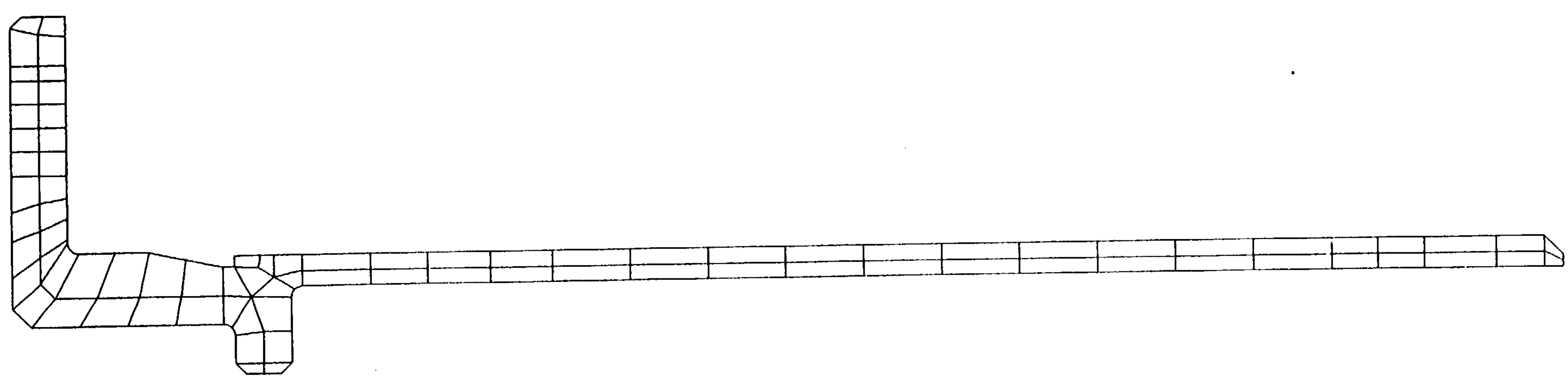
LOAD SET 1

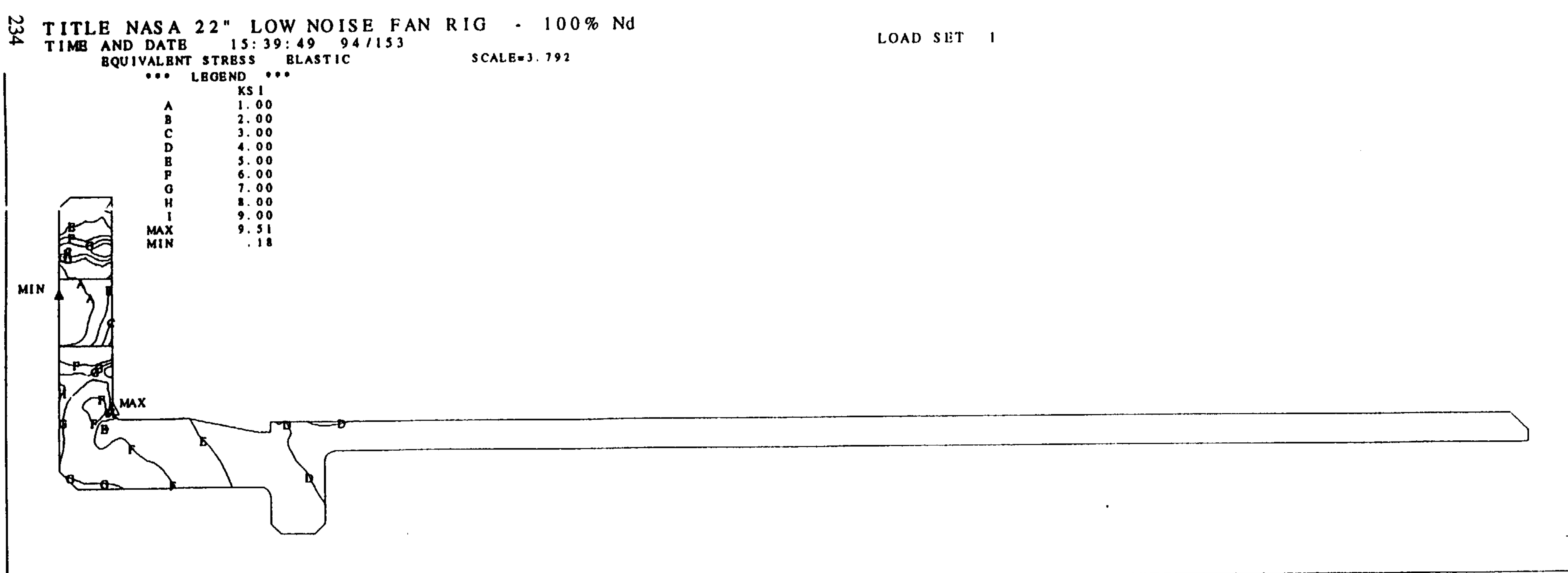


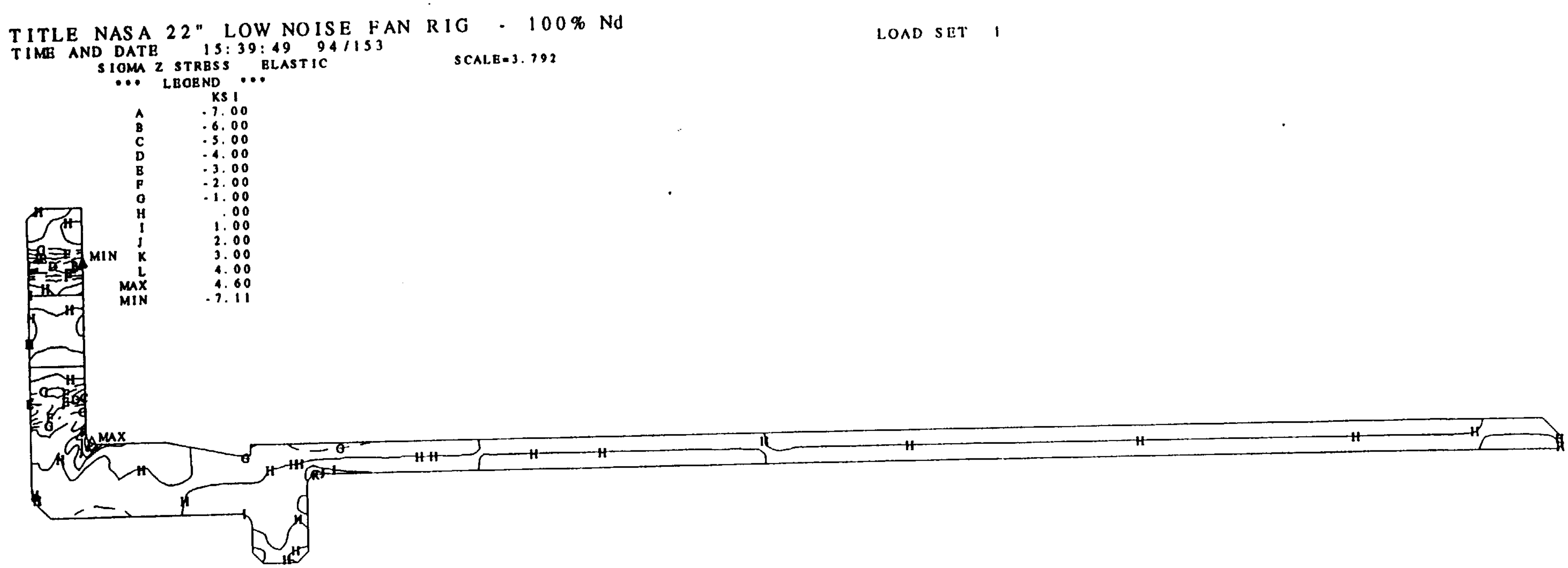

TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
TIME AND DATE 15:39:49 94/153
DEFLECTED SHAPE PLOT SCALE=2.591 ELASTIC
MAX DEFLECTIONS Z=.001890 IN △ R=.000896 IN ▲
LOAD SET 1

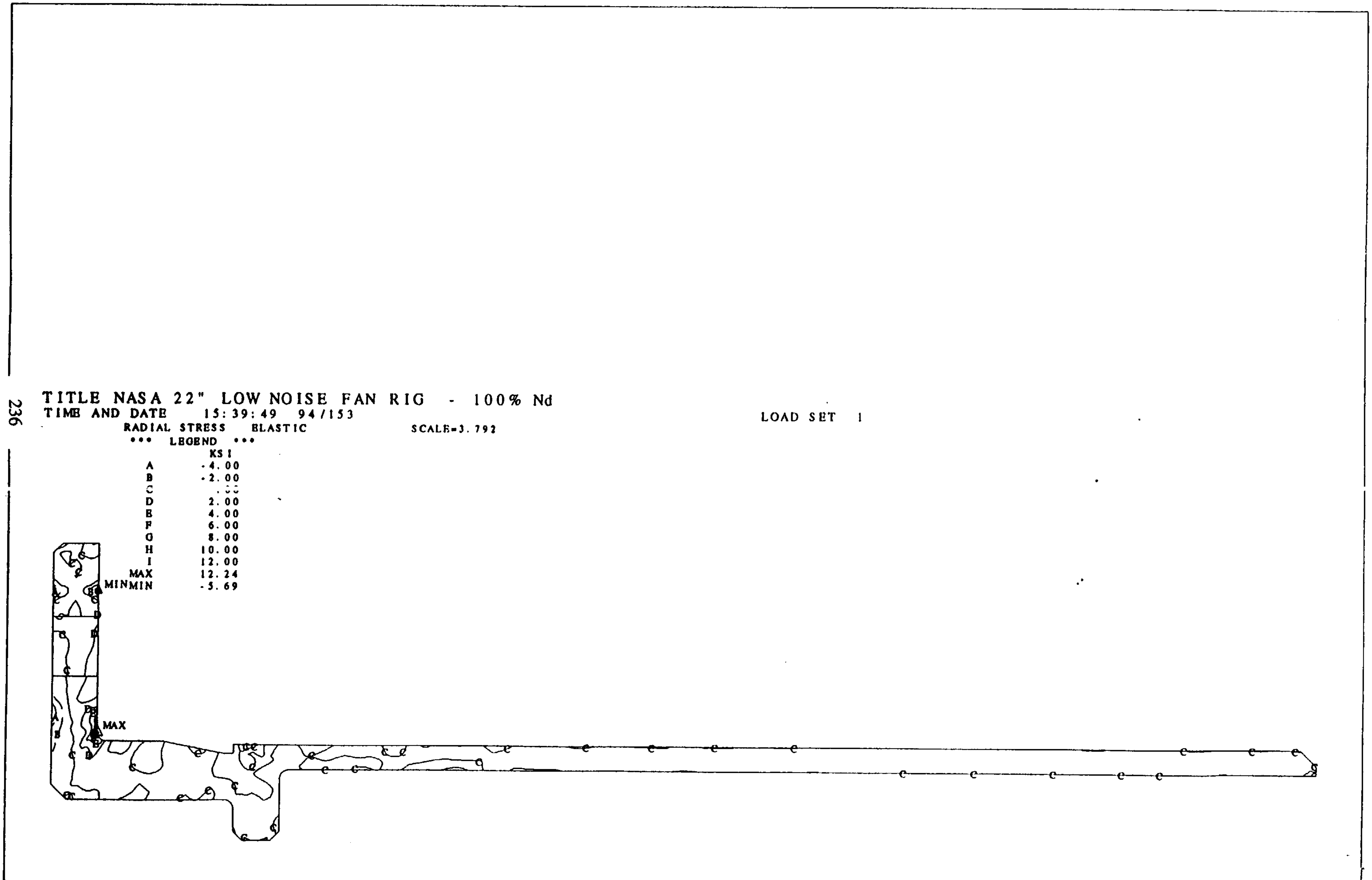
TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
TIME AND DATE 15:39:49 94/153
GEOMETRY PLOT SCALE=3.792
SUBSTRUCTURE
NAME CODE
SLEEVE D

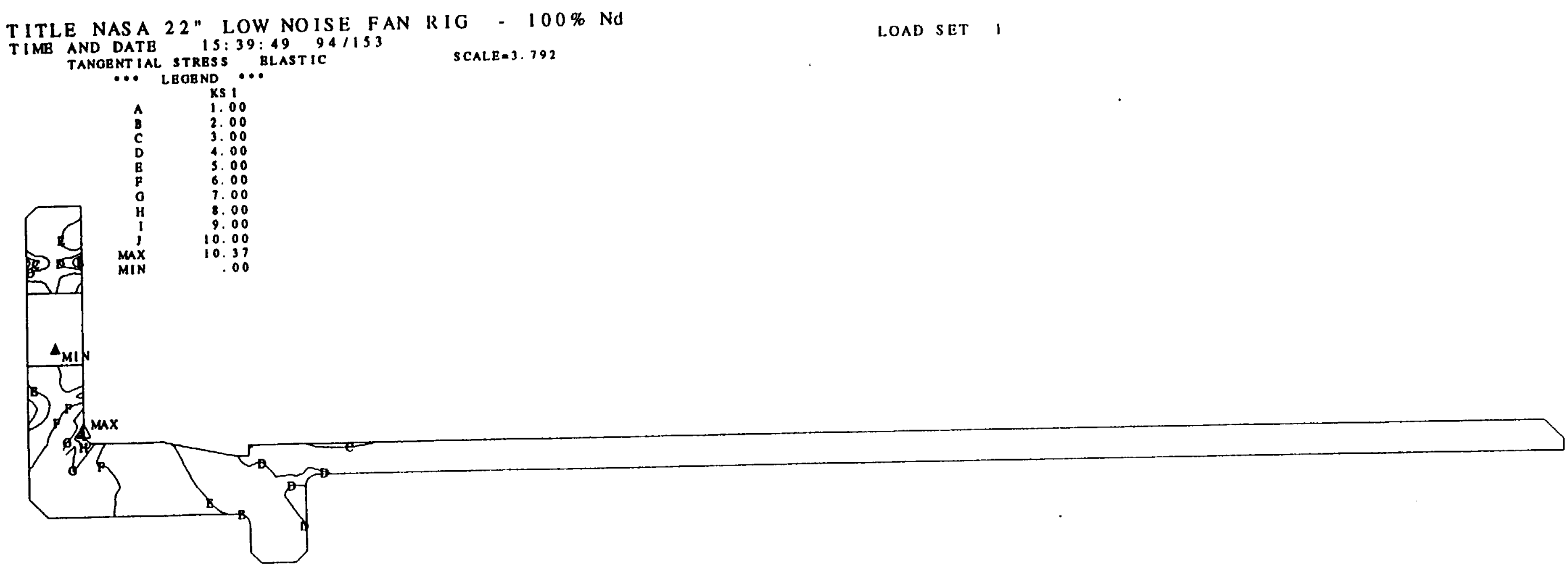
LOAD SET 1

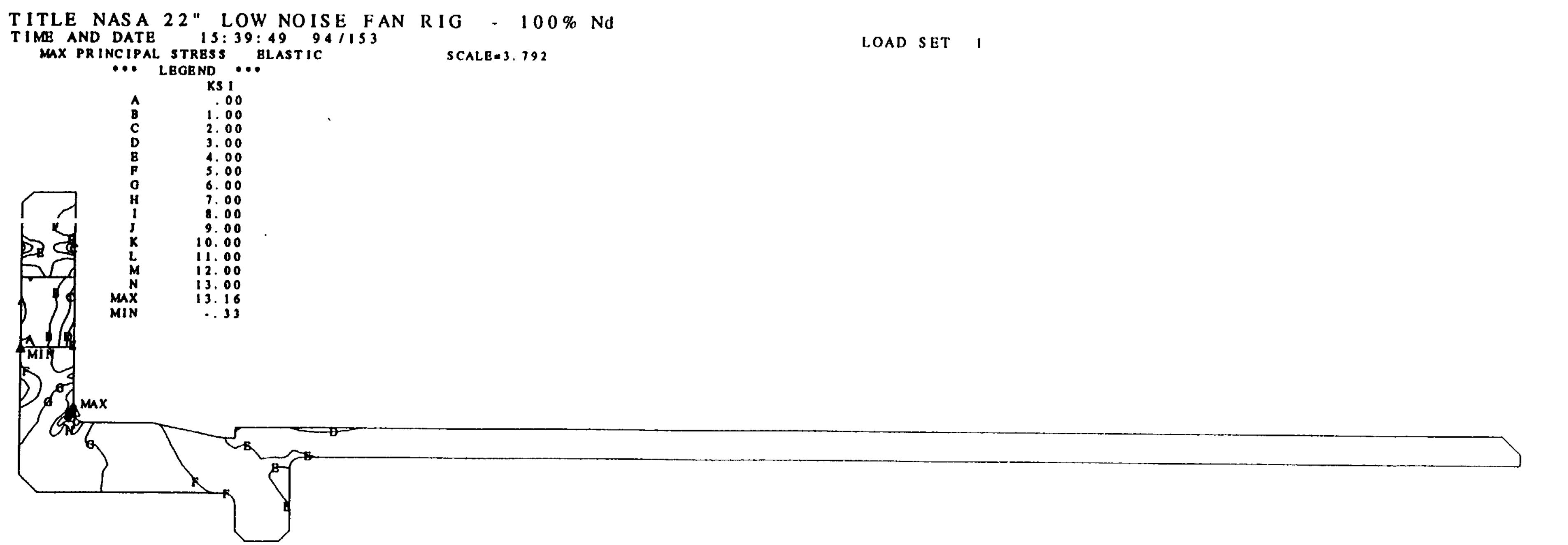


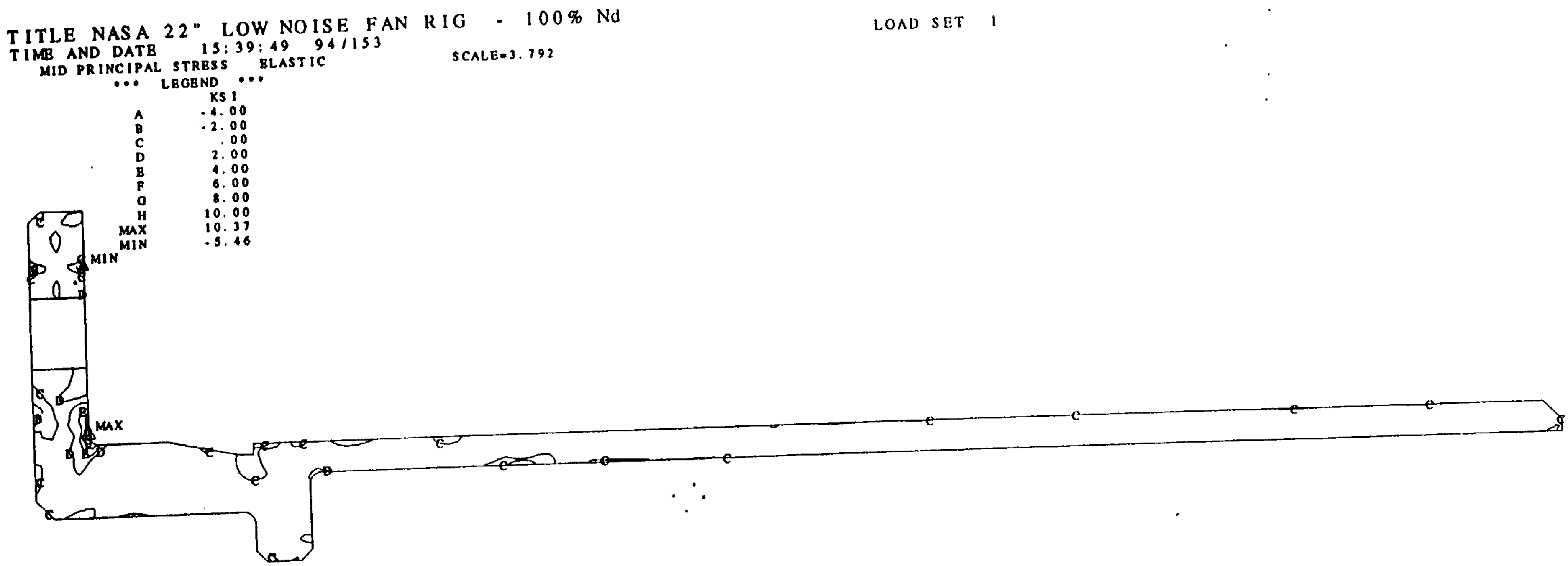

TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
TIME AND DATE 15:39:49 94/153
EQUIVALENT STRESS ELASTIC
SCALE=3.792
LOAD SET 1
*** LEGEND ***
KSI
A 1.00
B 2.00
C 3.00
D 4.00
E 5.00
F 6.00
G 7.00
H 8.00
I 9.00
MAX 9.51
MIN .18
MIN
MAX


TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
LOAD SET 1
TIME AND DATE 15:39:49 94/153
SIGMA Z STRESS ELASTIC
SCALE=3.792
*** LEGEND ***
KSI
A -7.00
B -6.00
C -5.00
D -4.00
E -3.00
F -2.00
G -1.00
H .00
I 1.00
J 2.00
K 3.00
L 4.00
MAX 4.60
MIN -7.11
MIN
MAX


TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
TIME AND DATE 15:39:49 94/153
RADIAL STRESS ELASTIC
SCALE=3.792
LOAD SET 1
*** LEGEND ***
KSI
A -4.00
B -2.00
C .00
D 2.00
E 4.00
F 6.00
G 8.00
H 10.00
I 12.00
MAX 12.24
MIN -5.69
MIN
MAX


TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
LOAD SET 1
TIME AND DATE 15:39:49 94/153
TANGENTIAL STRESS ELASTIC
SCALE=3.792
*** LEGEND ***
KSI
A 1.00
B 2.00
C 3.00
D 4.00
E 5.00
F 6.00
G 7.00
H 8.00
I 9.00
J 10.00
MAX 10.37
MIN .00
MIN
MAX


TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
TIME AND DATE 15:39:49 94/153
LOAD SET 1
MAX PRINCIPAL STRESS ELASTIC
SCALE=3.792
*** LEGEND ***
KSI
A .00
B 1.00
C 2.00
D 3.00
E 4.00
F 5.00
G 6.00
H 7.00
I 8.00
J 9.00
K 10.00
L 11.00
M 12.00
N 13.00
MAX 13.16
MIN -.33
MAX
MIN

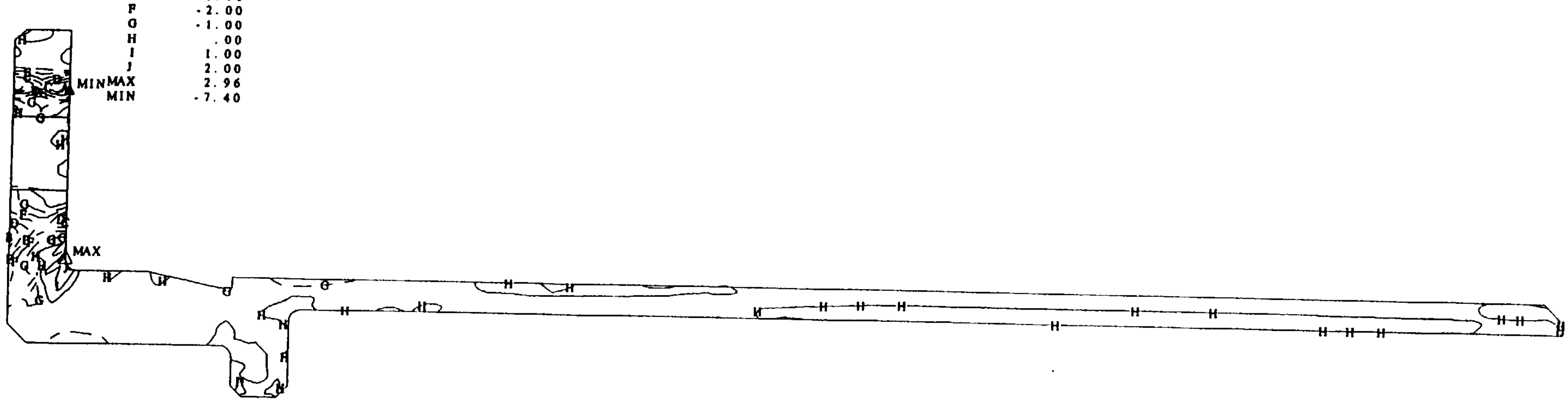


TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
TIME AND DATE 15:39:49 94/153
MID PRINCIPAL STRESS ELASTIC
*** LEGEND ***
KSI
A -4.00
B -2.00
C .00
D 2.00
E 4.00
F 6.00
G 8.00
H 10.00
MAX 10.37
MIN -5.46
SCALE=3.792
LOAD SET 1
MIN
MAX

TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
TIME AND DATE 15:39:49 94/153
MIN PRINCIPAL STRESS ELASTIC SCALE=3.792 LOAD SET 1

*** LEGEND ***

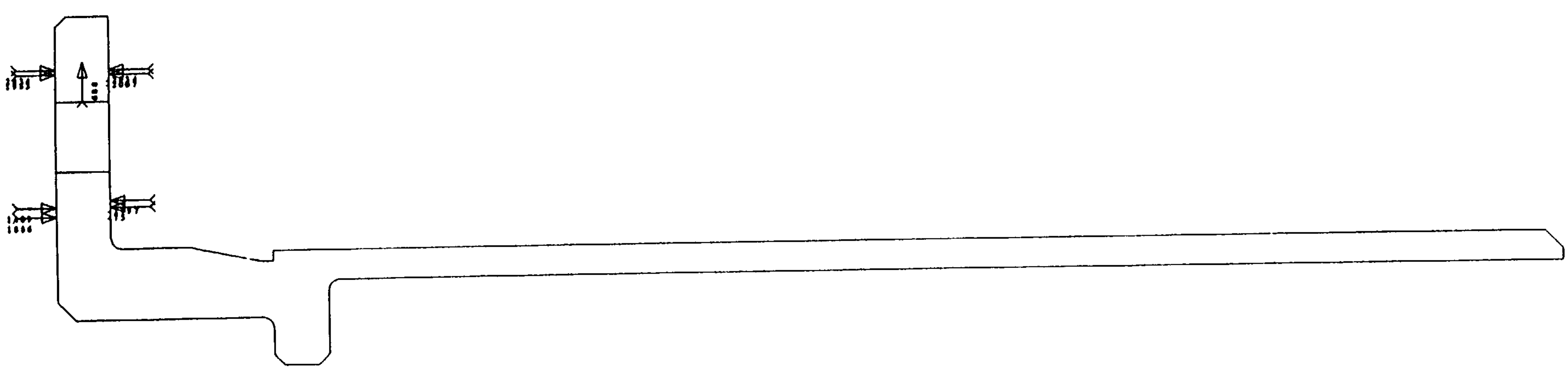
	KSI
A	-7.00
B	-6.00
C	-5.00
D	[illegible]
E	-3.00
F	-2.00
G	-1.00
H	.00
I	1.00
J	2.00
MAX	2.96
MIN	-7.40



TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
TIME AND DATE 15:39:49 94/153
GEOMETRY PLOT WITH BOUNDARY REACTIONS IN TOTAL LOAD ELASTIC

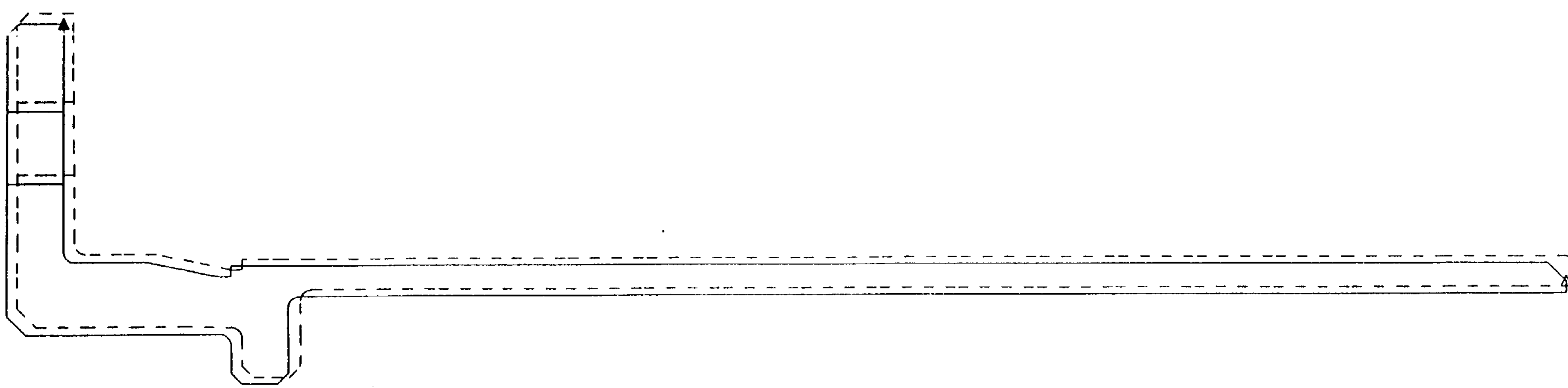
LOAD SET 1

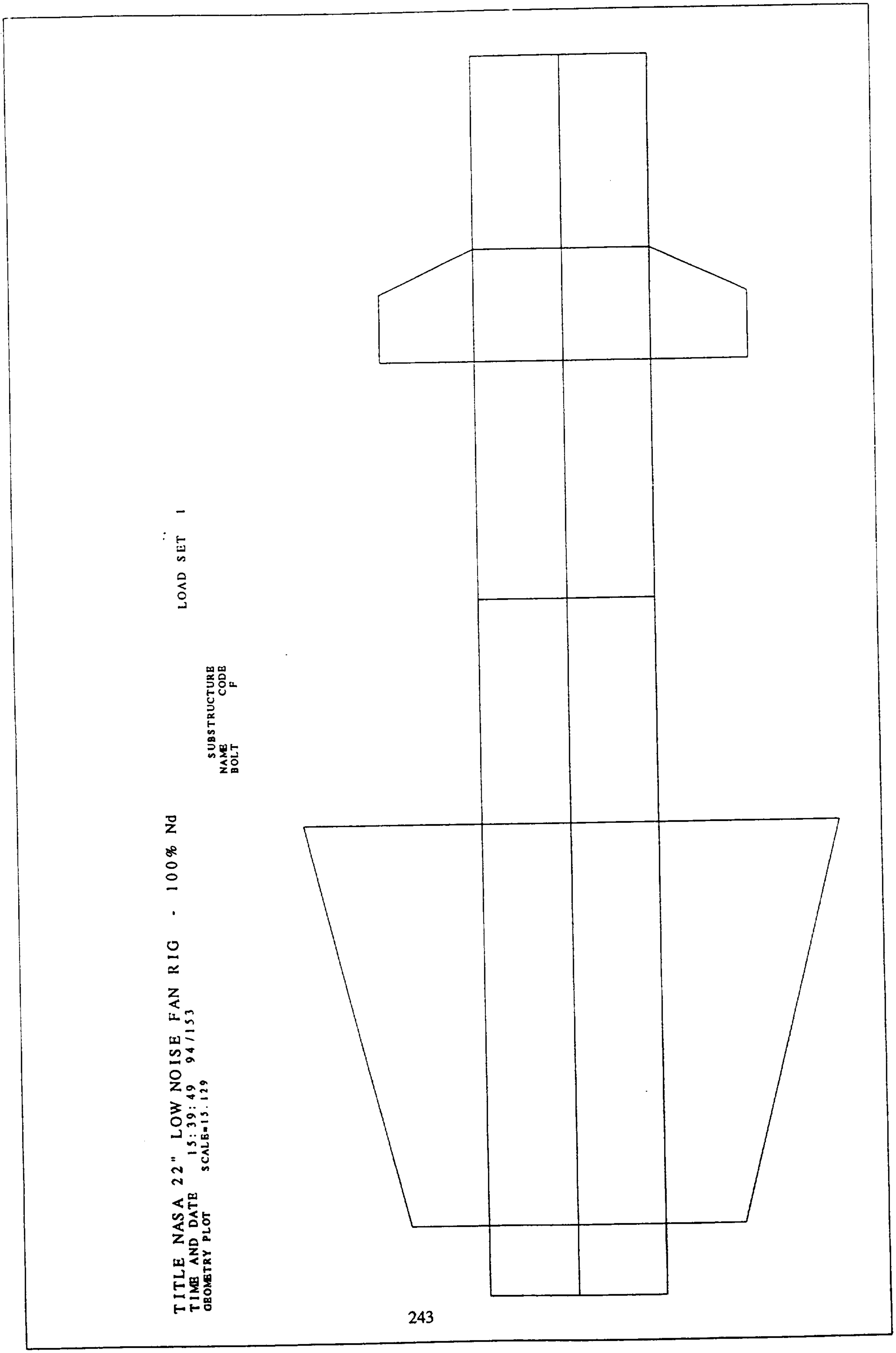
SUBSTRUCTURE	
NAME	CODE
SLEEVE	D
SUM R	688

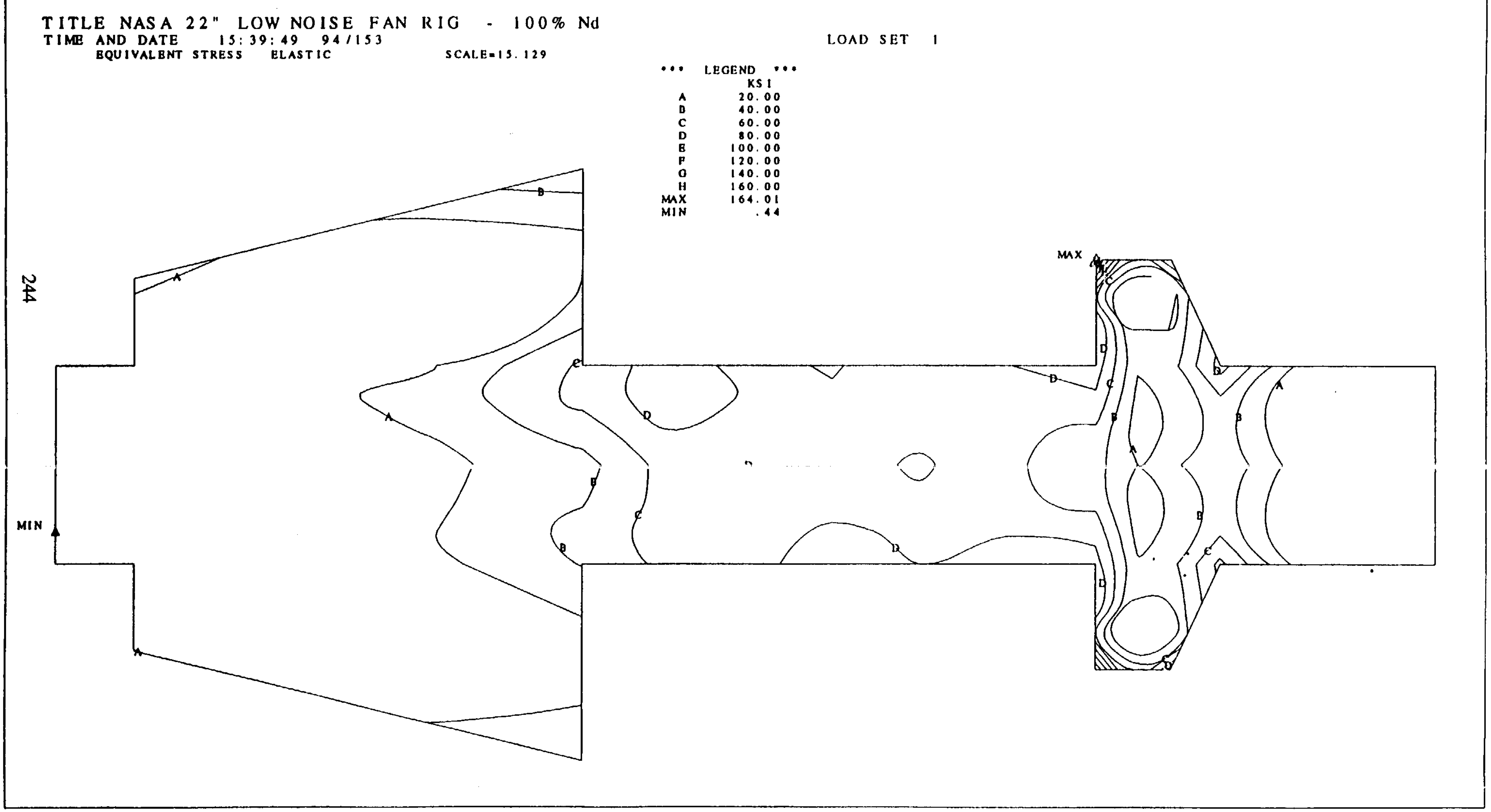


TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
TIME AND DATE 15:39:49 94/153
DEFLECTED SHAPE PLOT SCALE=3.792 ELASTIC
MAX DEFLECTIONS Z=.002823 IN △ R=.001473 IN ▲

LOAD SET 1




TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
TIME AND DATE 15:39:49 94/153
GEOMETRY PLOT SCALE=15.129
SUBSTRUCTURE
NAME CODE
BOLT F
LOAD SET 1

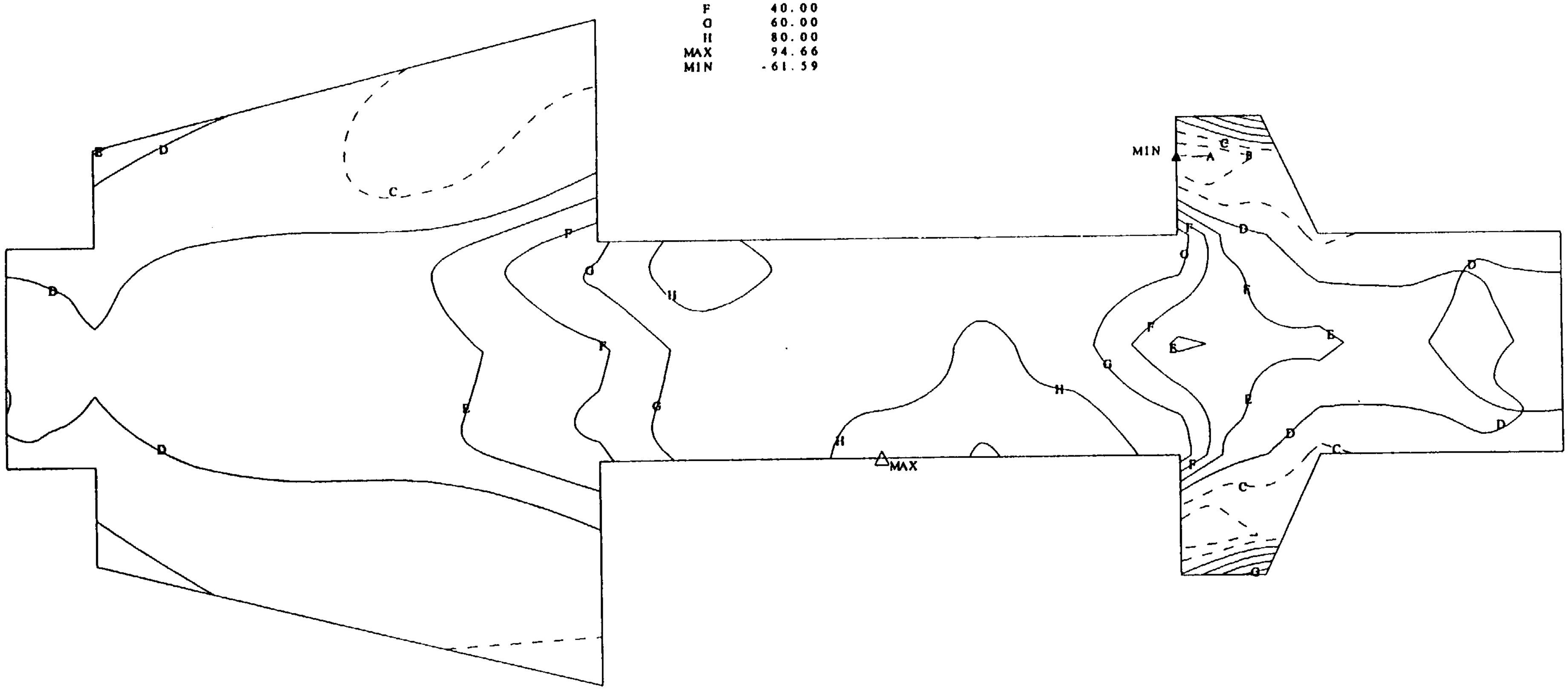

TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
TIME AND DATE 15:39:49 94/153
EQUIVALENT STRESS ELASTIC
SCALE=15.129
LOAD SET 1
*** LEGEND ***
KSI
A 20.00
B 40.00
C 60.00
D 80.00
E 100.00
F 120.00
G 140.00
H 160.00
MAX 164.01
MIN .44
MAX
MIN

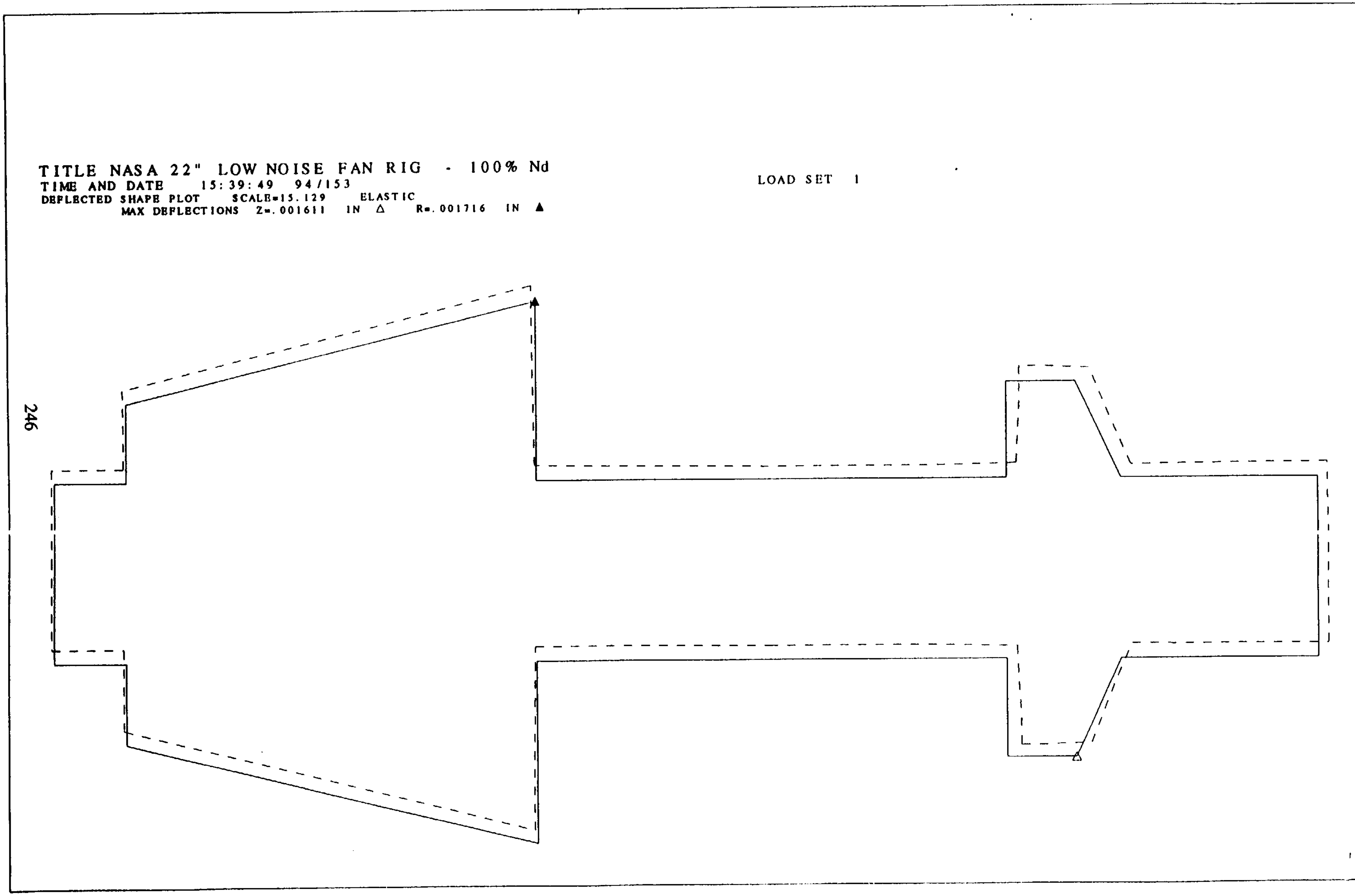
TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
TIME AND DATE 15:39:49 94/153
SIGMA Z STRESS ELASTIC SCALE=15.129

LOAD SET 1

*** LEGEND ***

	KSI
A	-60.00
B	-40.00
C	-20.00
D	.00
E	20.00
F	40.00
G	60.00
H	80.00
MAX	94.66
MIN	-61.59




TITLE NASA 22" LOW NOISE FAN RIG - 100% Nd
TIME AND DATE 15:39:49 94/153
DEFLECTED SHAPE PLOT SCALE=15.129 ELASTIC
MAX DEFLECTIONS Z=.001611 IN △ R=.001716 IN ▲
LOAD SET 1

APPENDIX F

RESULTS OF DYNAMIC ANALYSIS BLISK

Figure A1: Mode Shape of Blade Mode 1

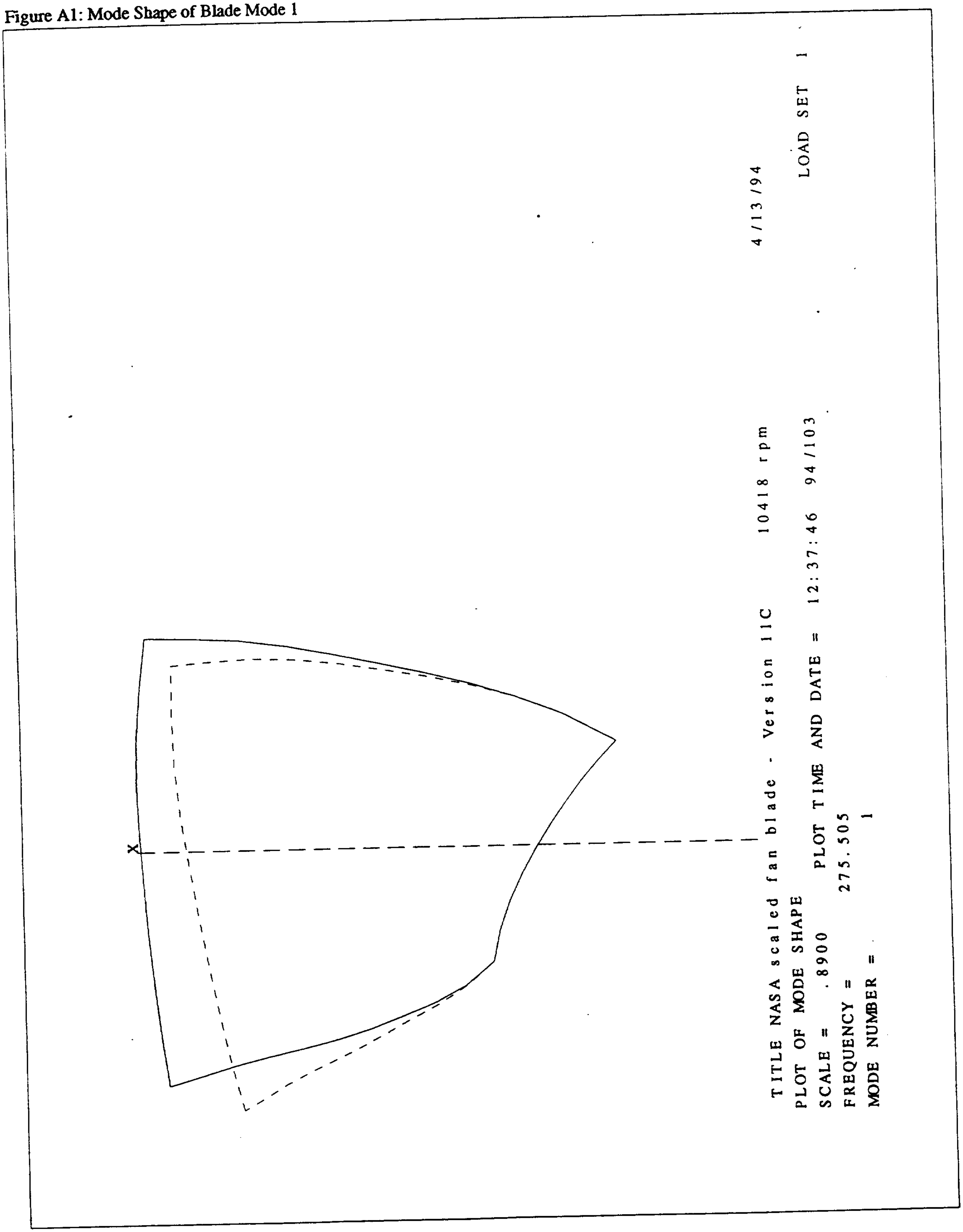


Figure A2: Mode Shape of Blade Mode 2

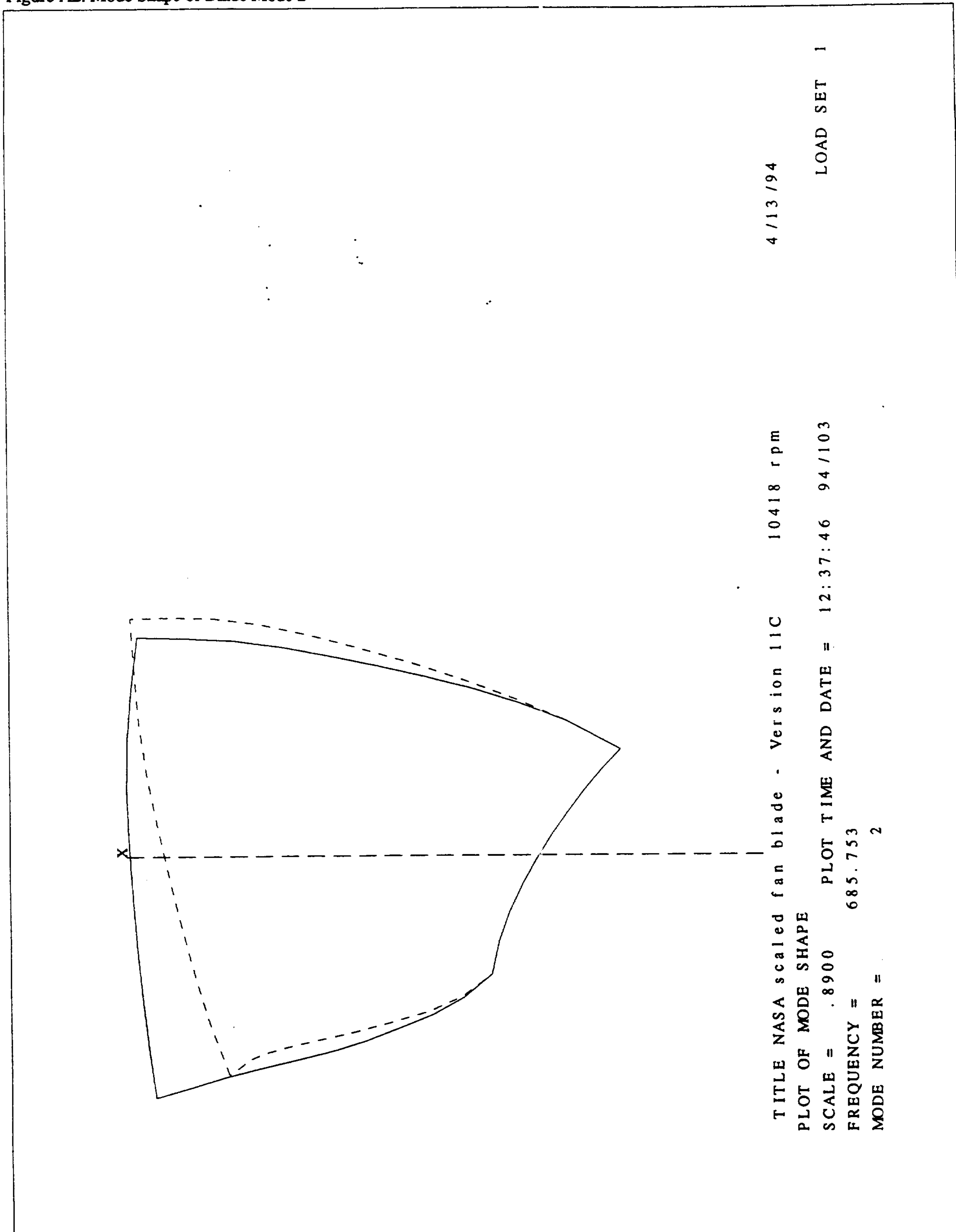


Figure A3: Mode Shape of Blade Mode 3

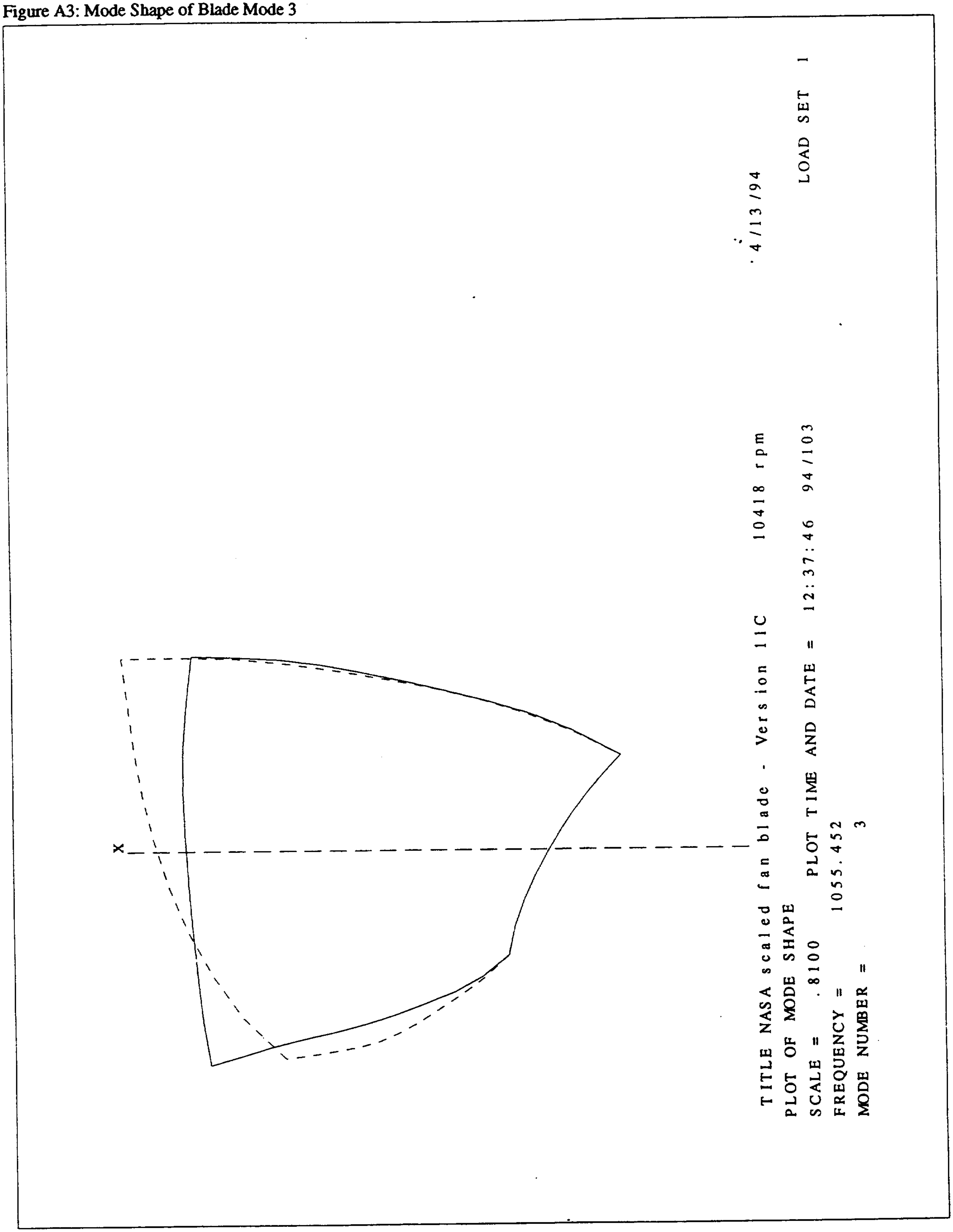


Figure A4: Mode Shape of Blade Mode 4

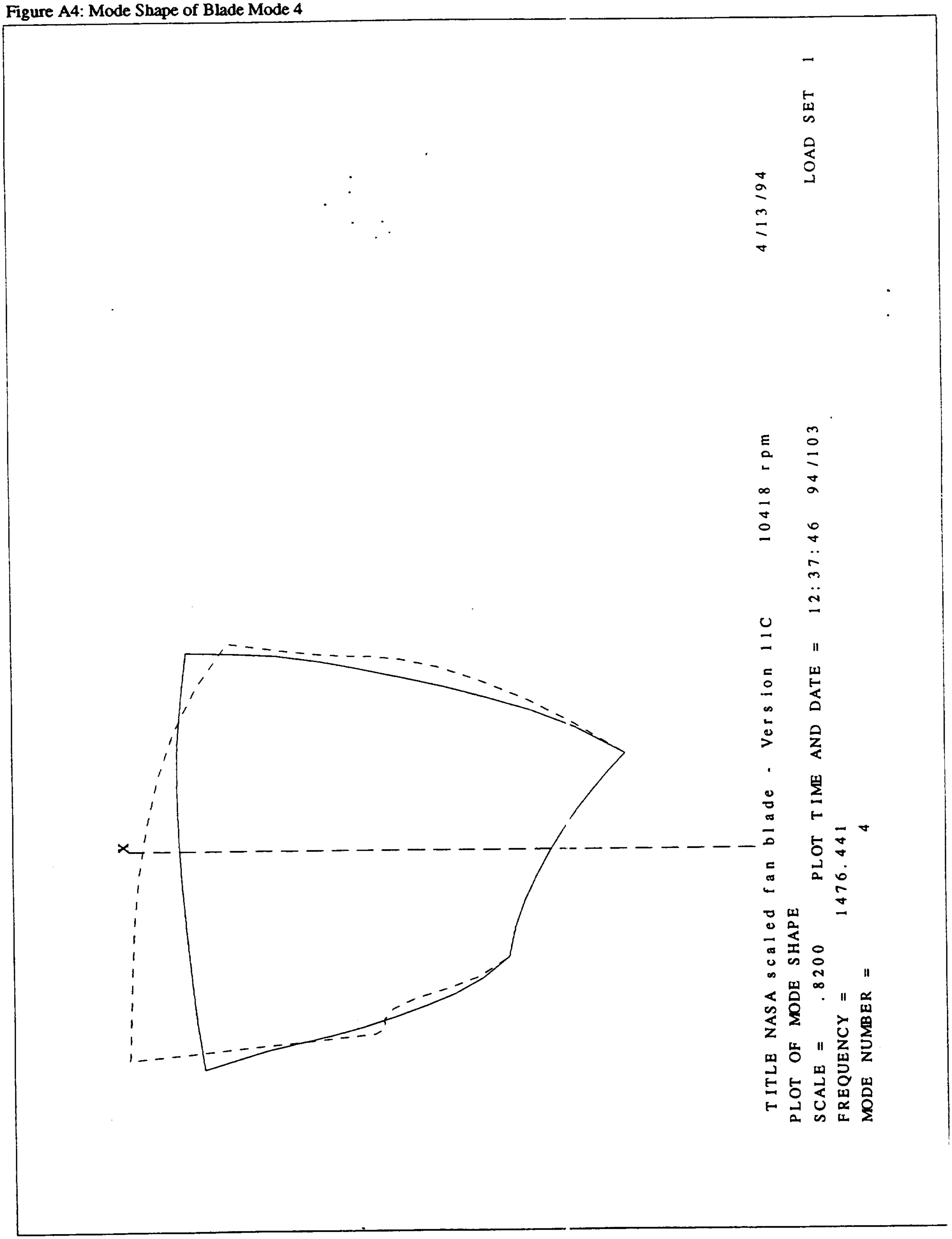


Figure A5: Mode Shape of Blade Mode 5

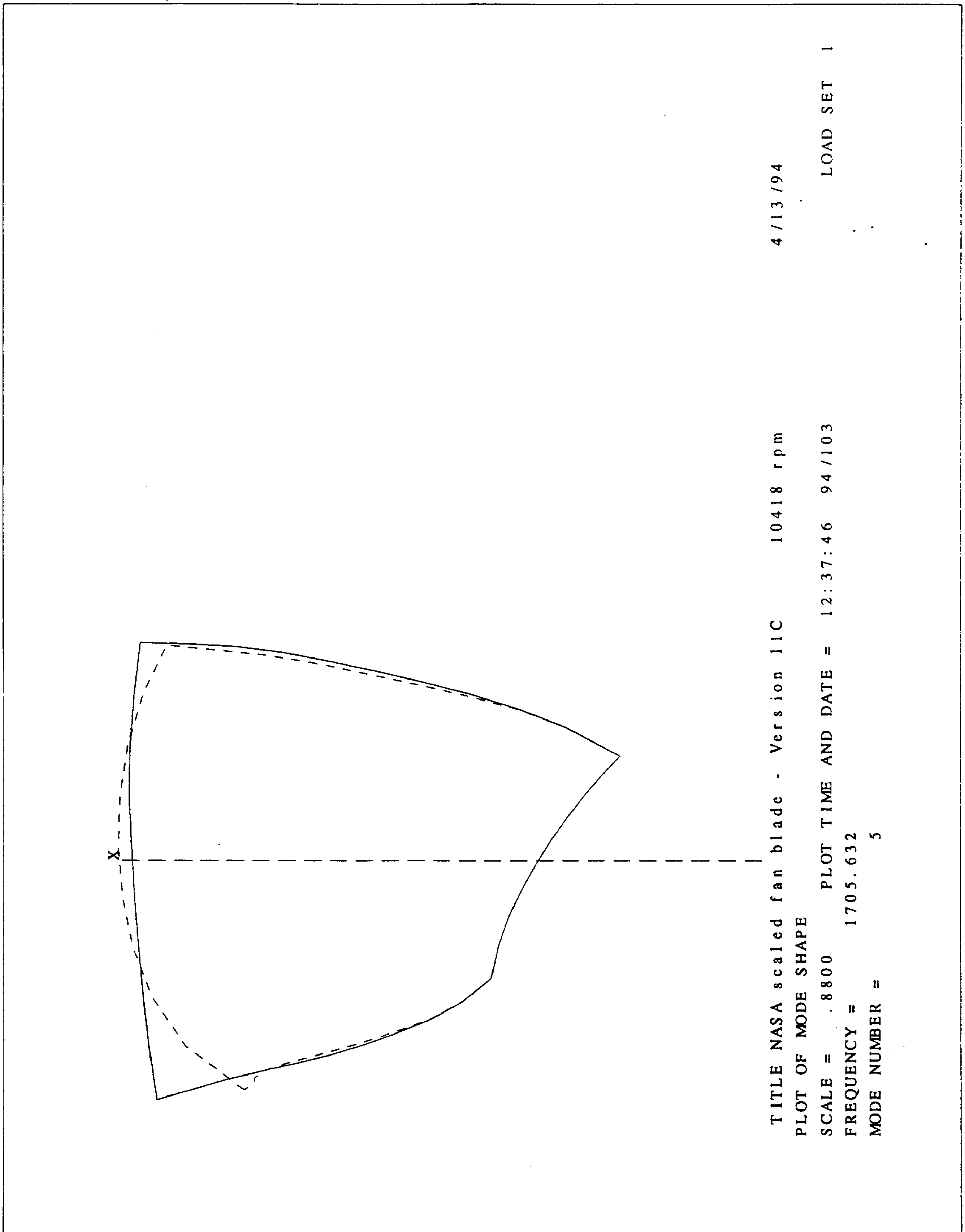


Figure A6: Mode Shape of Blade Mode 6

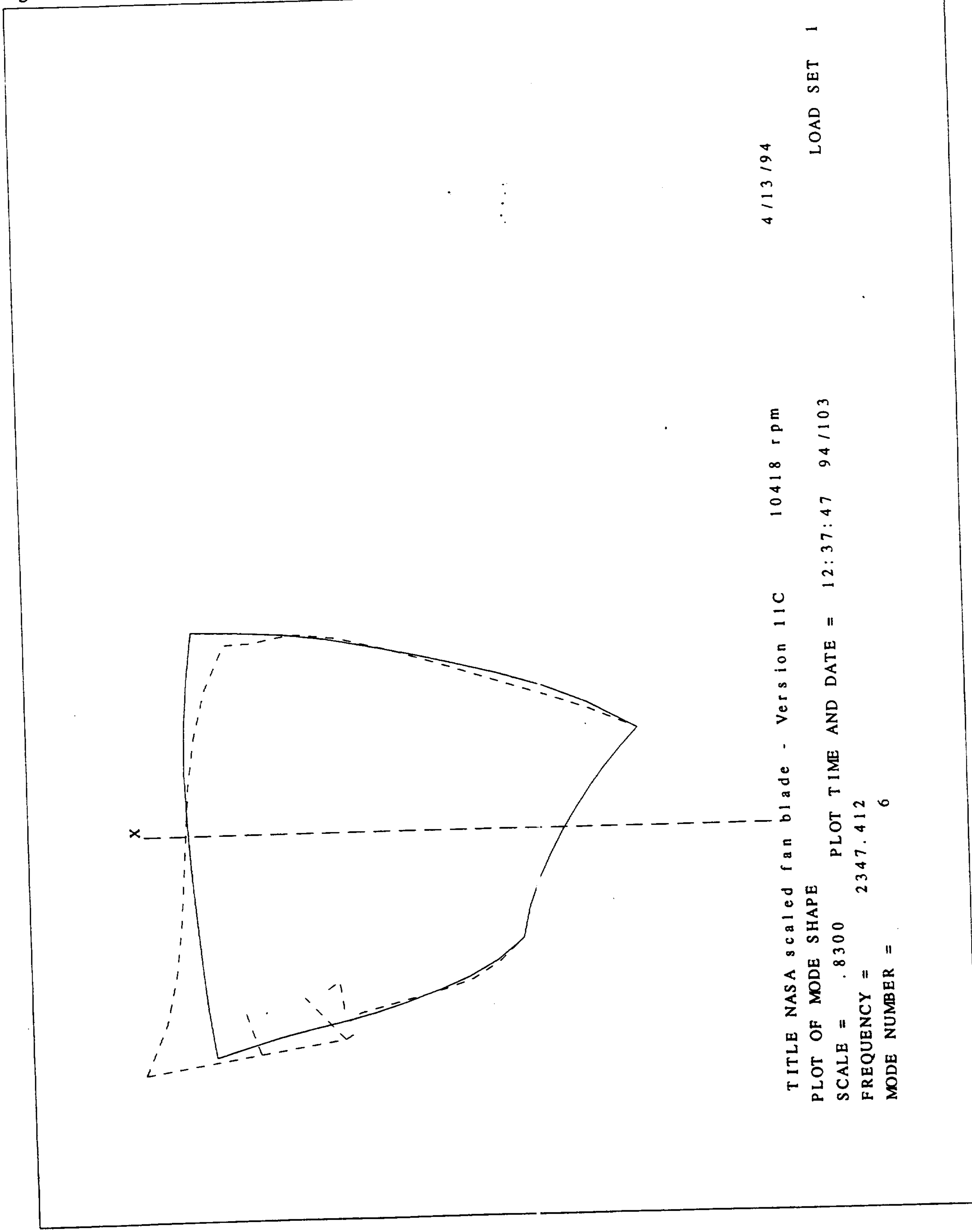


Figure A7: Mode Shape of Blade Mode 7

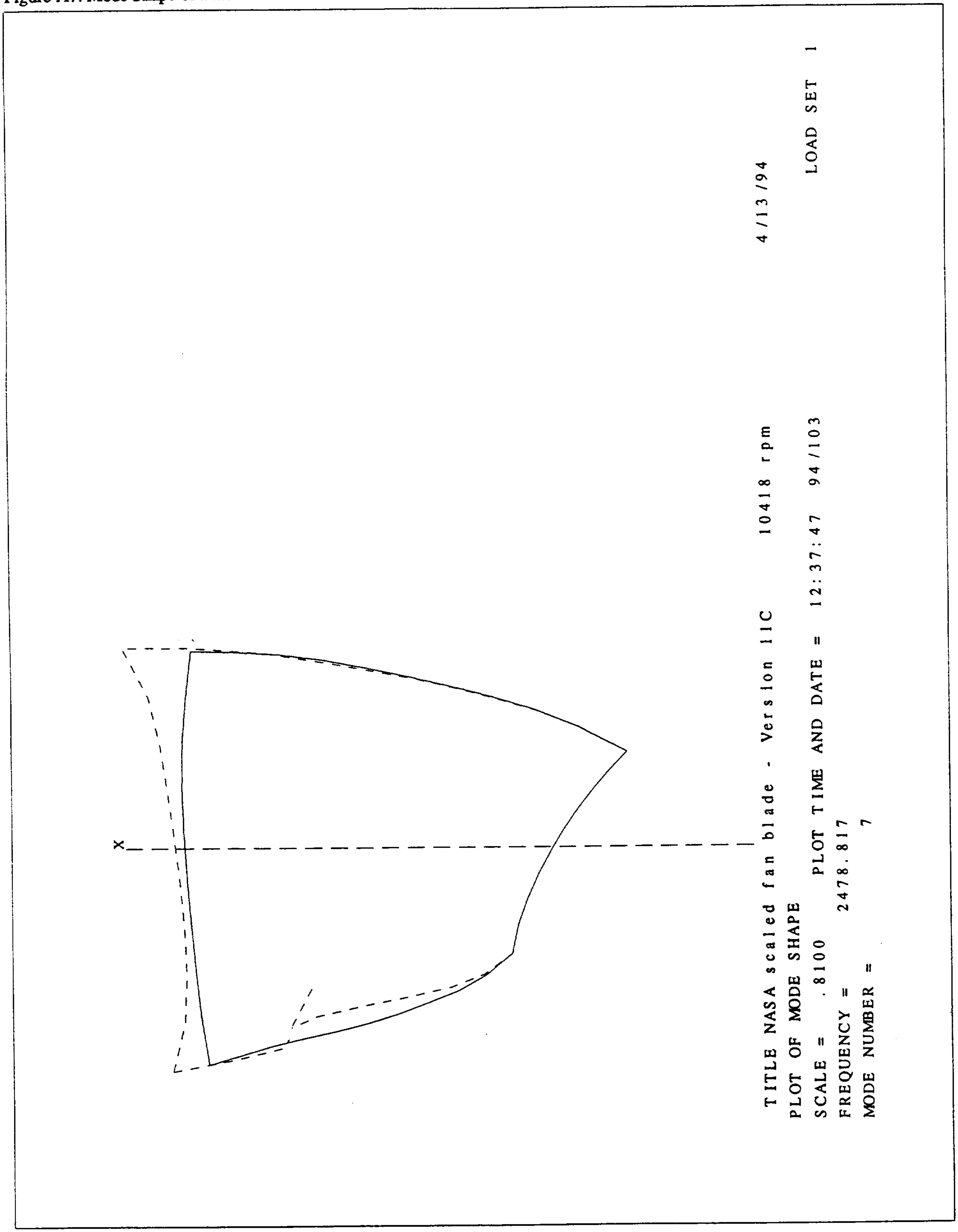


Figure A8: Mode Shape of Blade Mode 8

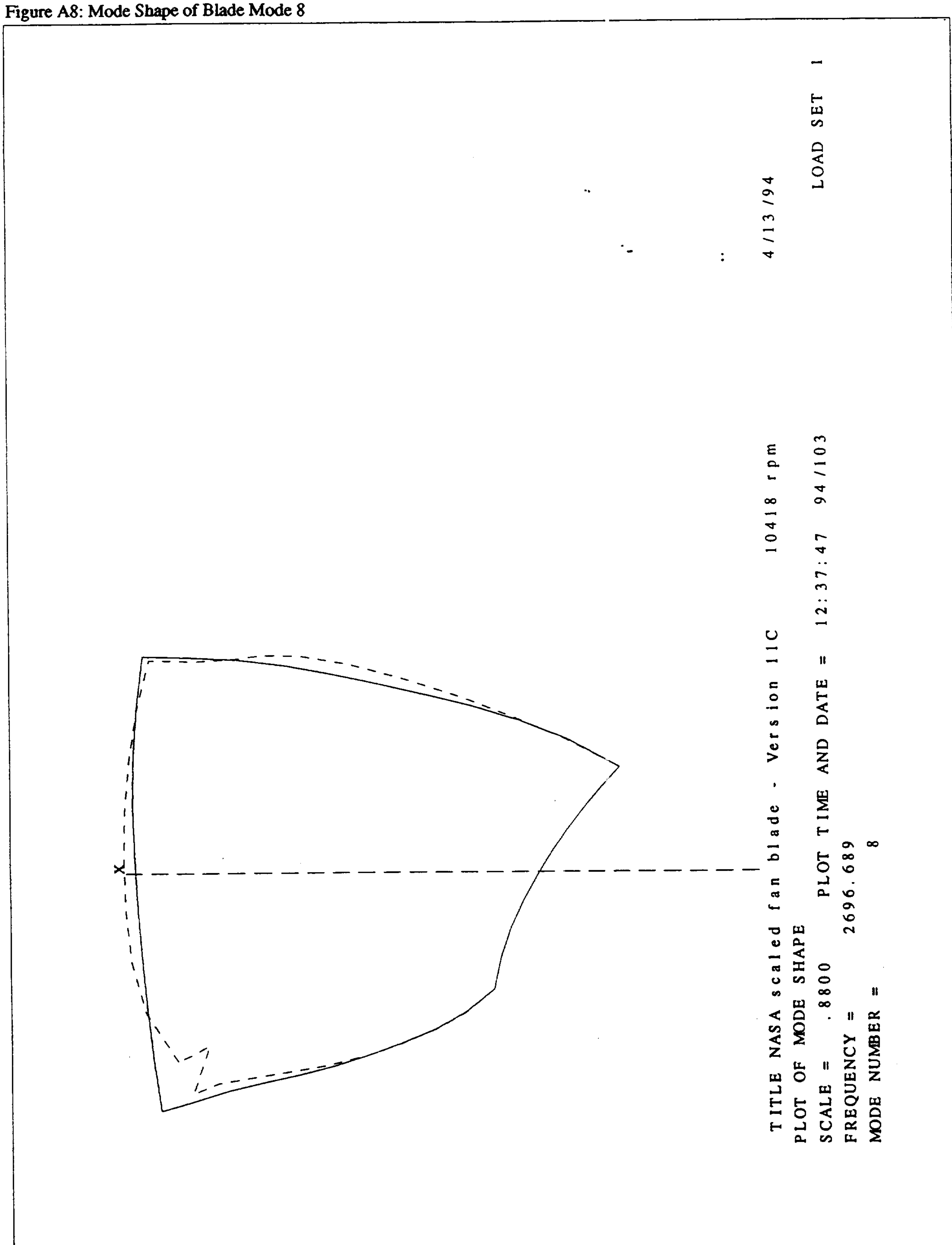


Figure A9: Mode Shape of Blade Mode 9

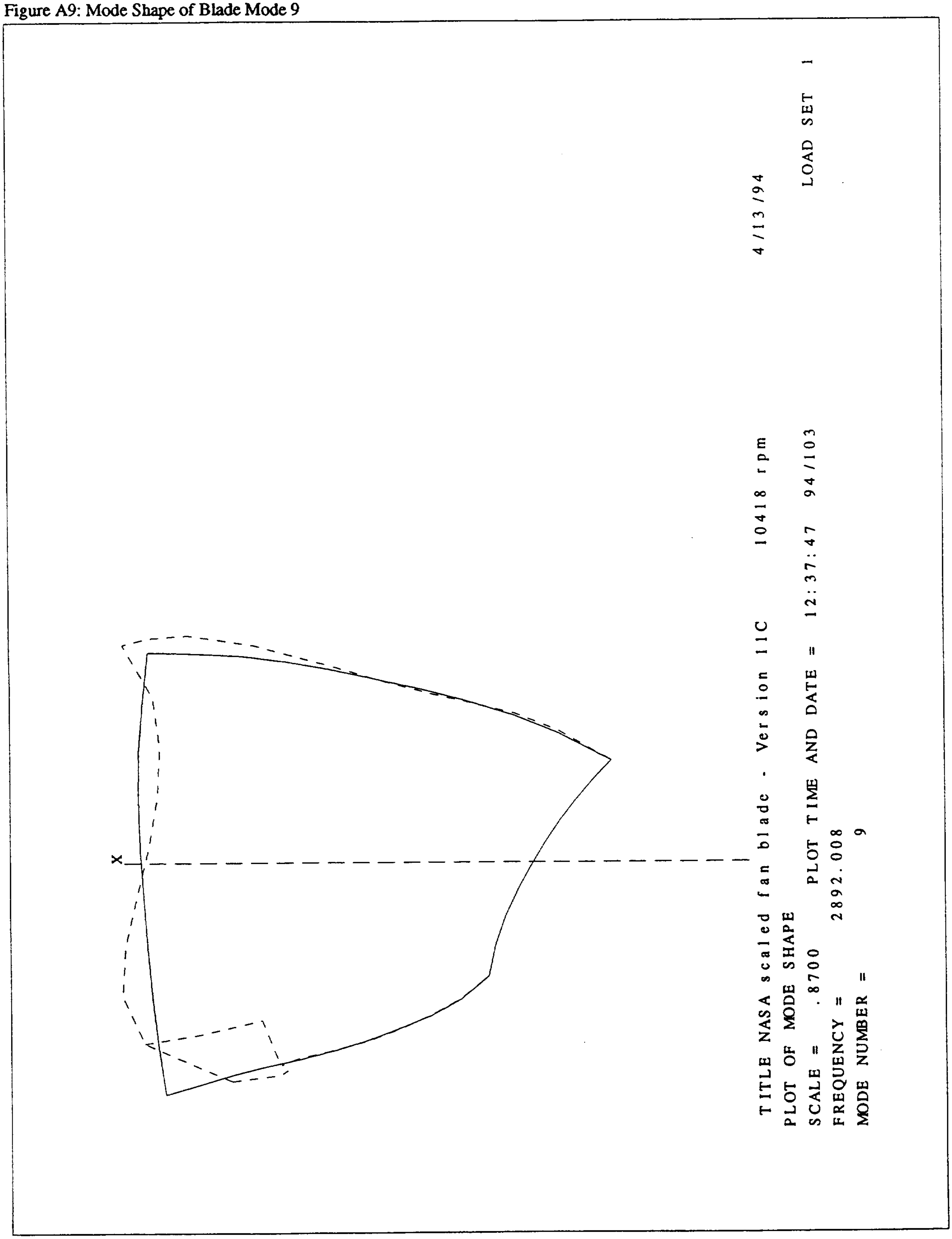


Figure A10: Mode Shape of Blade Mode 10

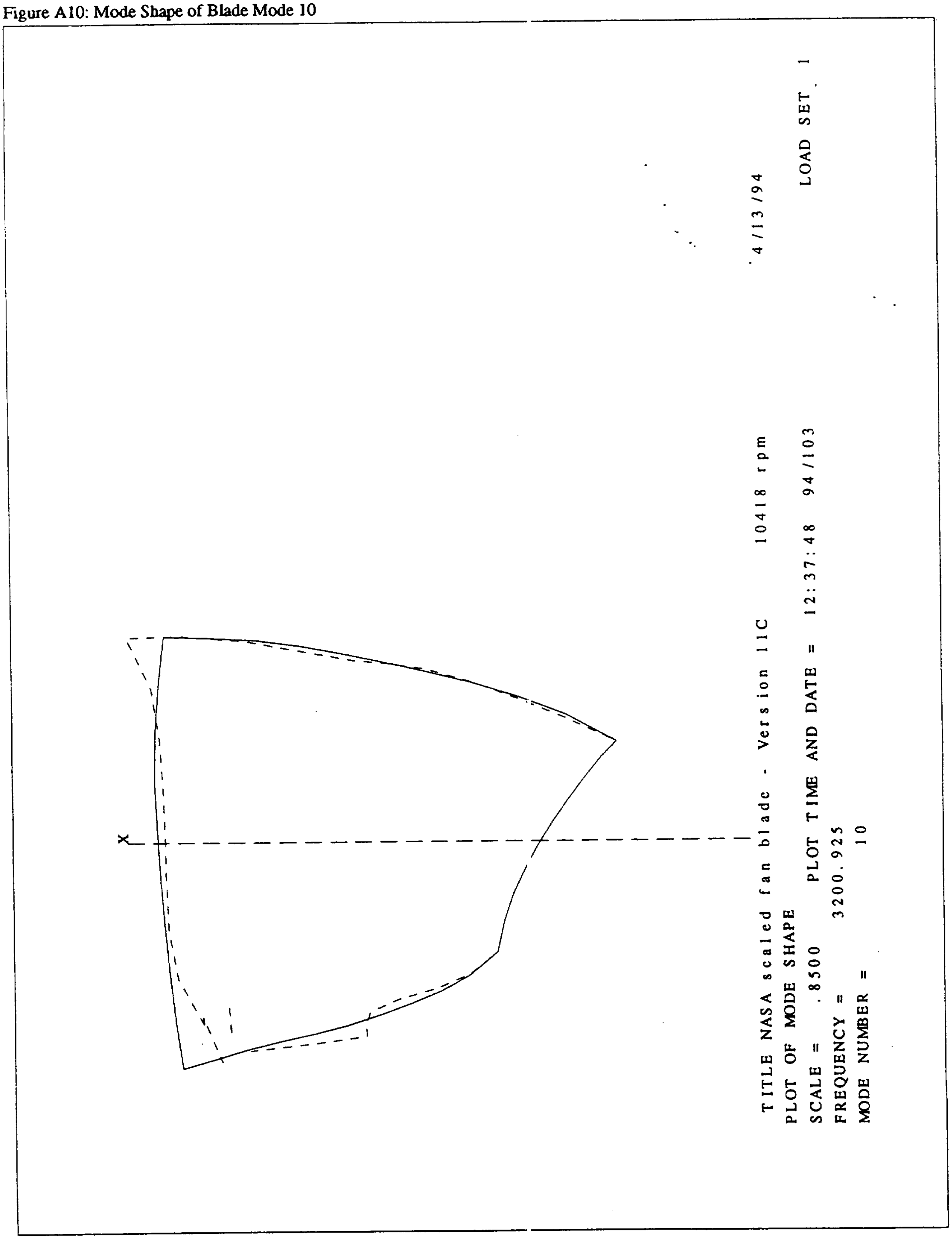


Figure A11: Node Line Plot of Blade Mode 1 - Pressure Side

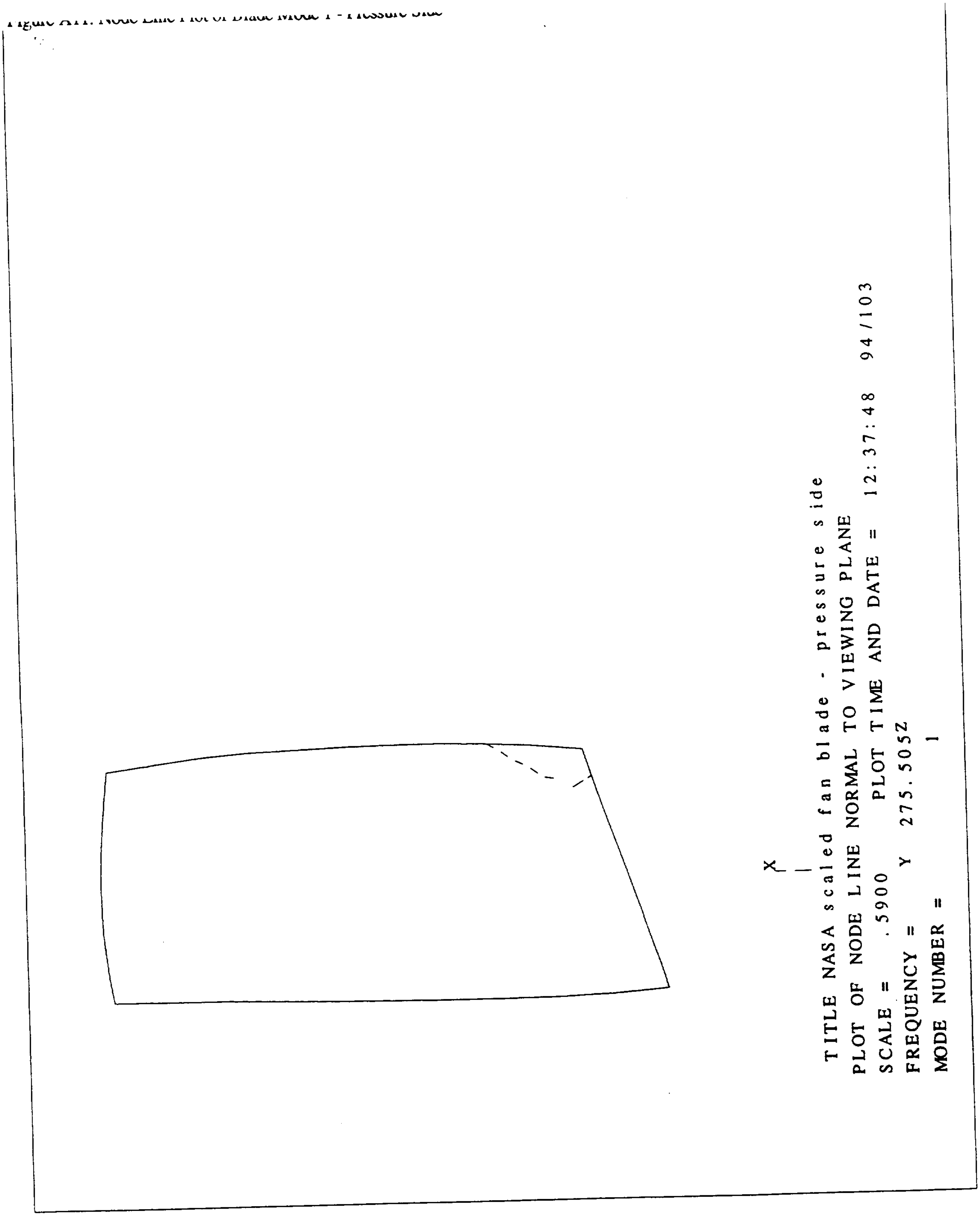
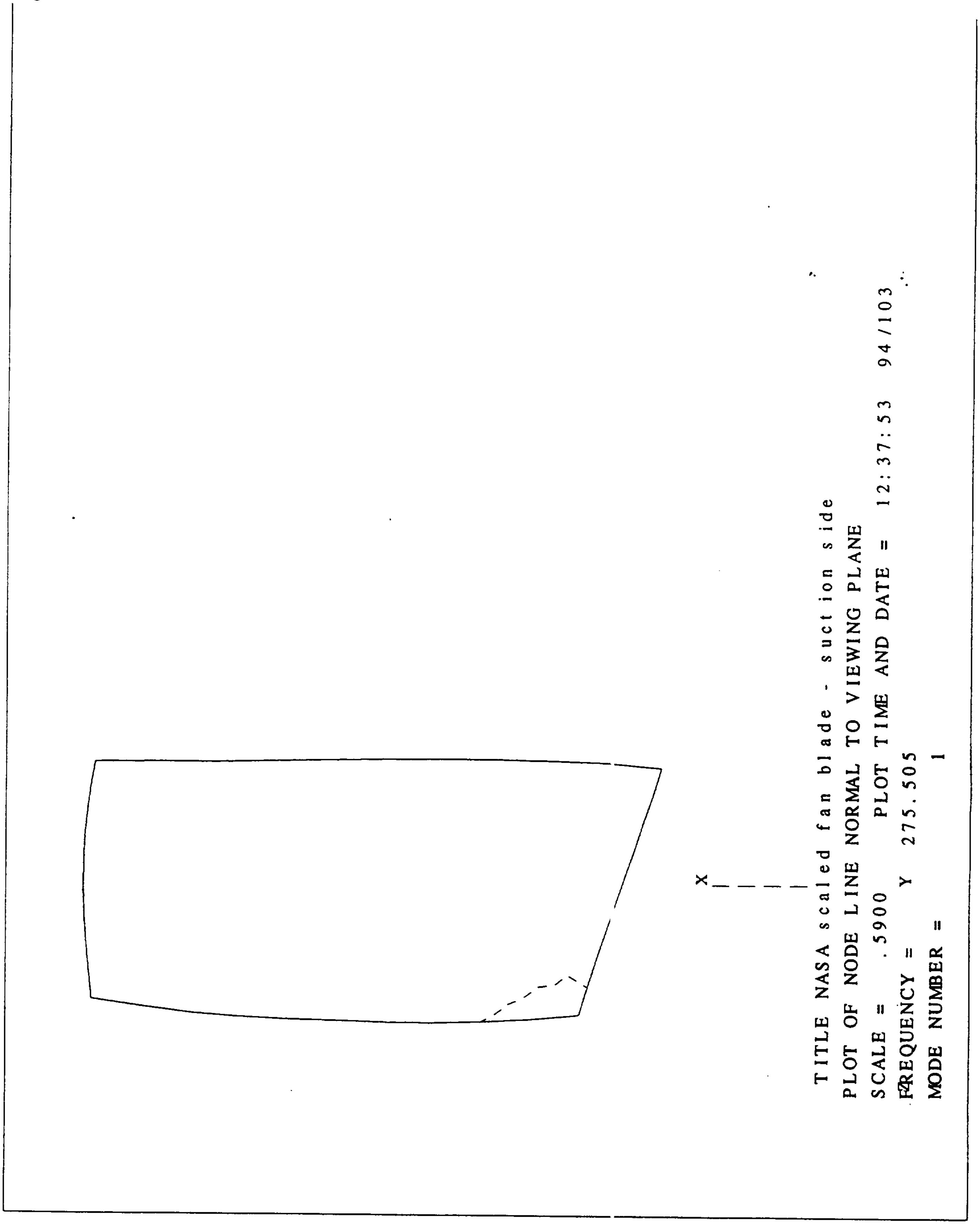
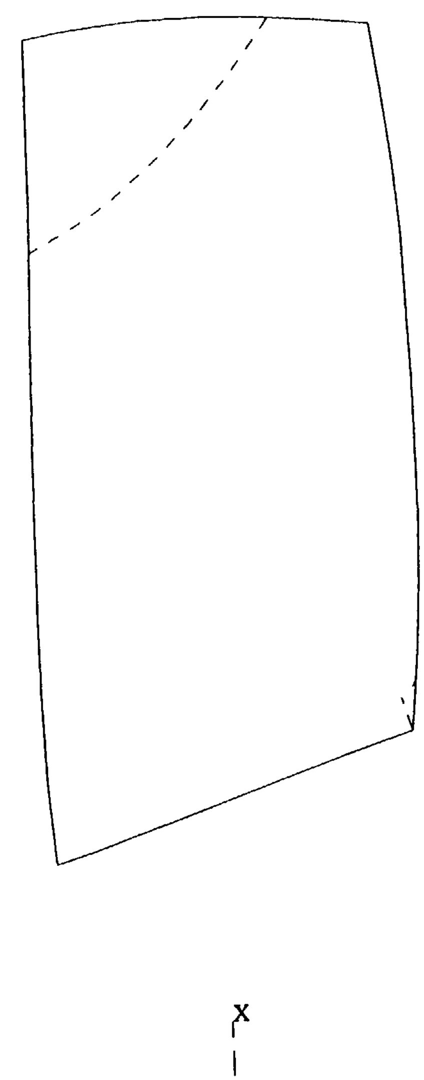


Figure A12: Node Line Plot of Blade Mode 1 - Suction Side





TITLE NASA scaled fan blade - pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .5900 PLOT TIME AND DATE = 12:37:48 94/103
FREQUENCY = 685.753
MODE NUMBER = 2

Figure A14: Node Line Plot of Blade Mode 2 - Suction Side

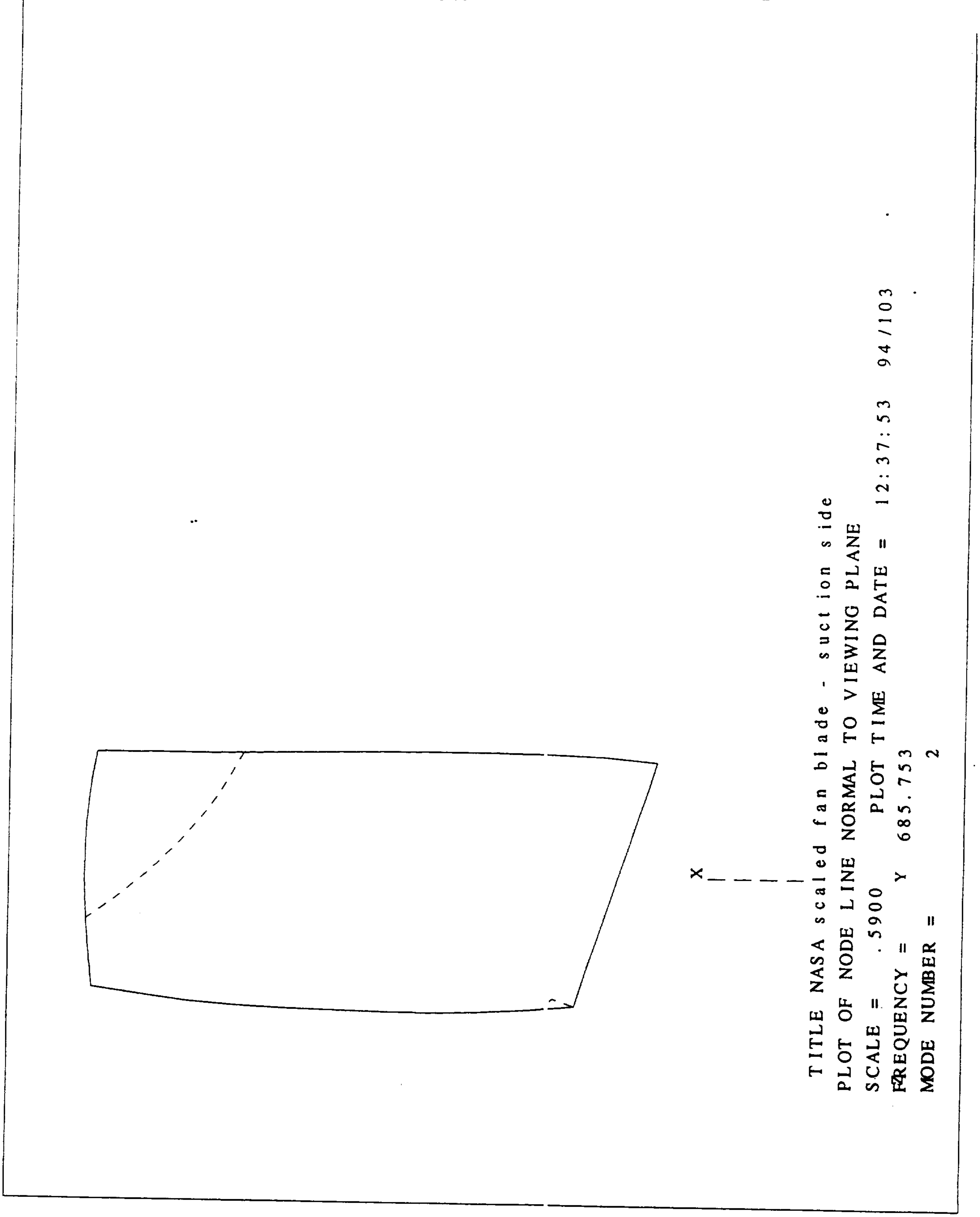


Figure A15: Node Line Plot of Blade Mode 3 - Pressure Side

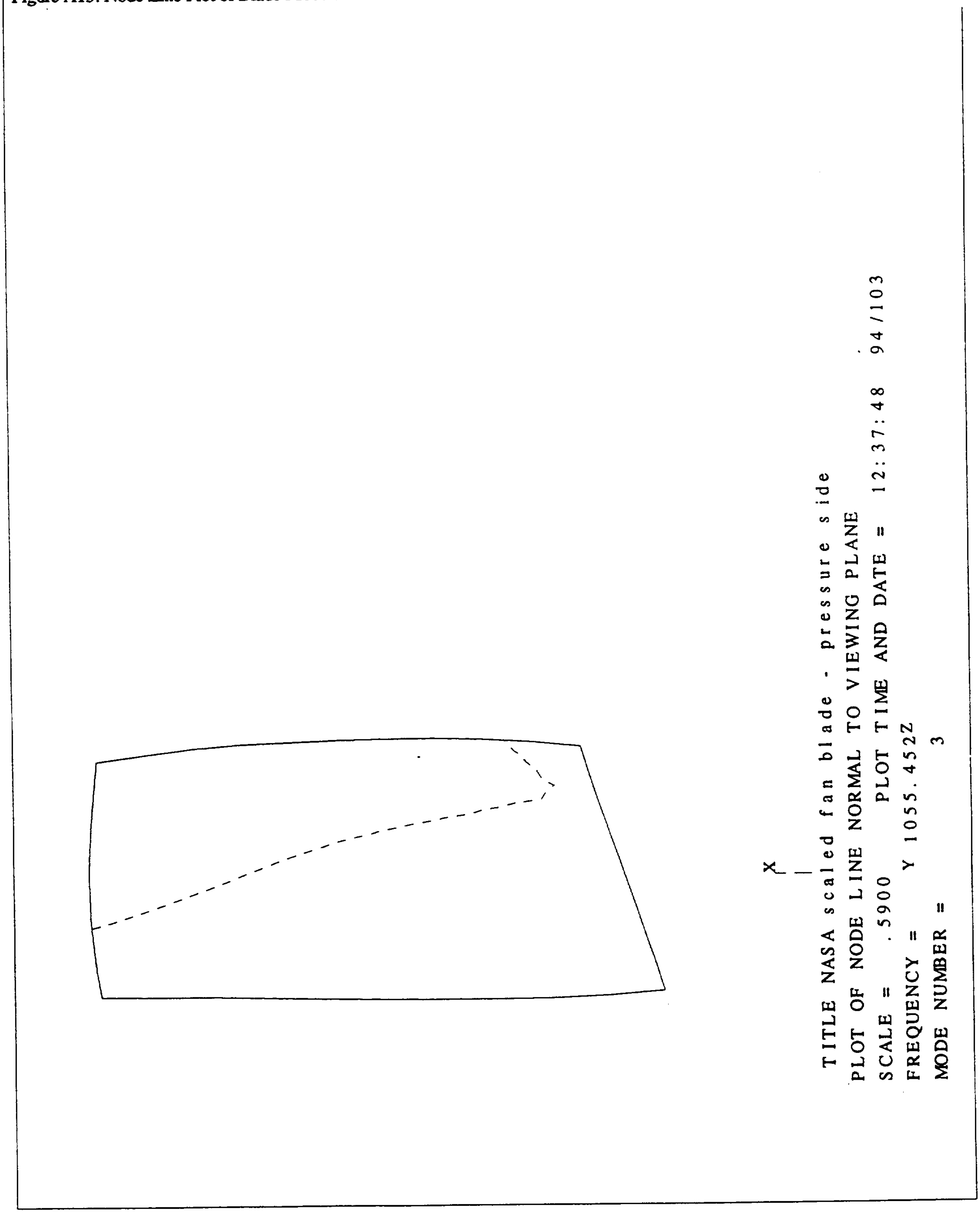


Figure A16: Node Line Plot of Blade Mode 3 - Suction Side

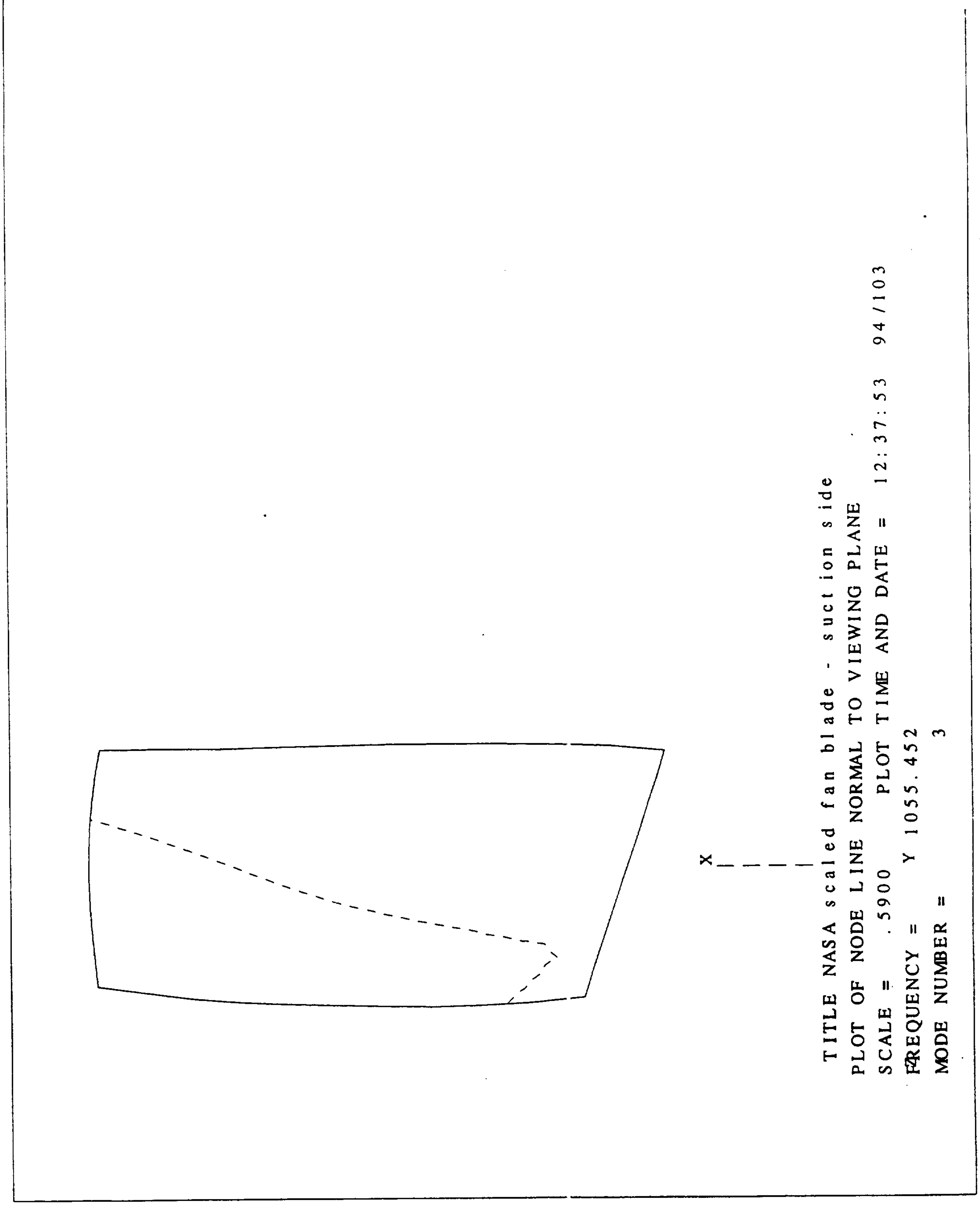


Figure A17. Node Line Plot of Blade Mode 4 - Pressure Side

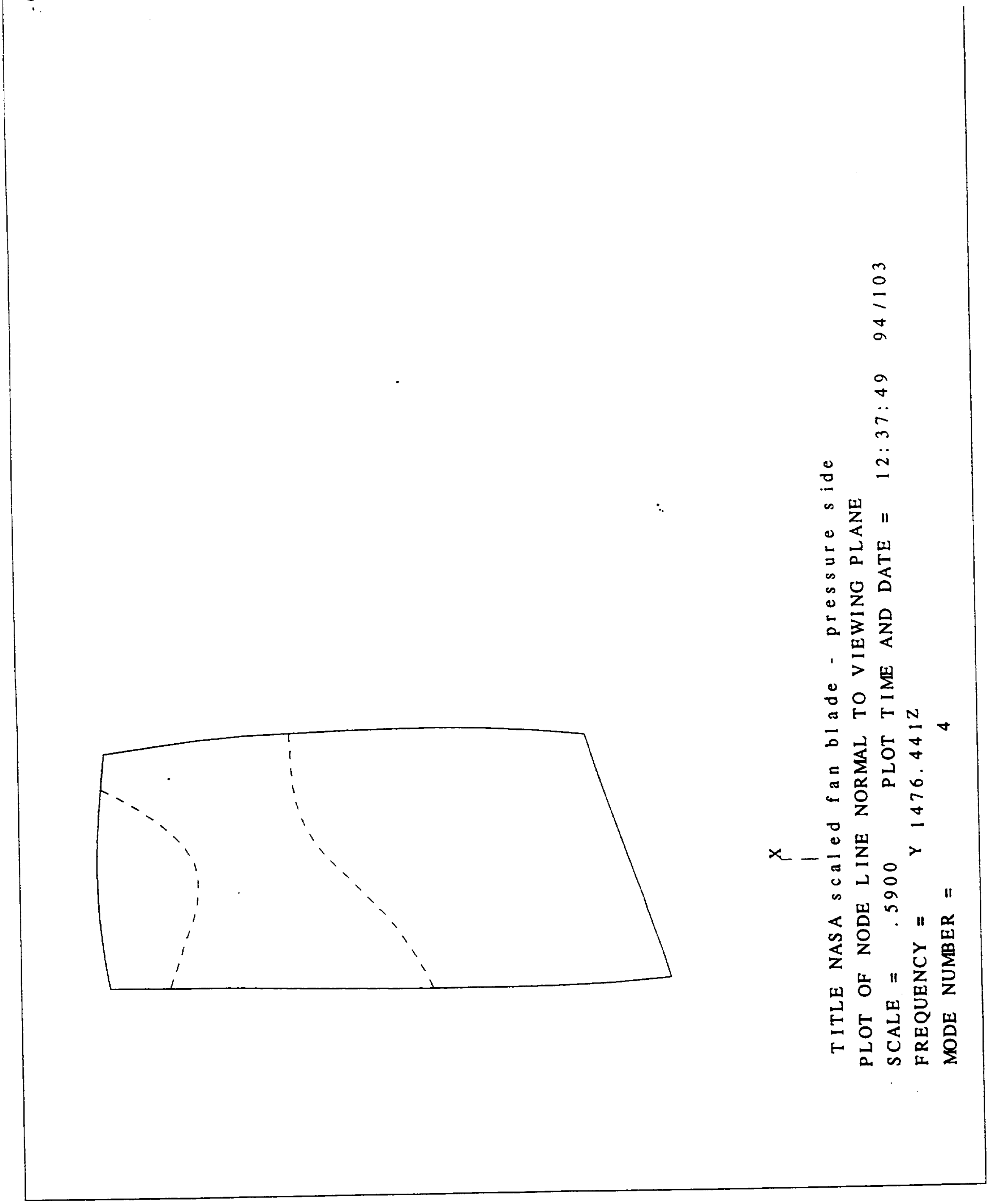
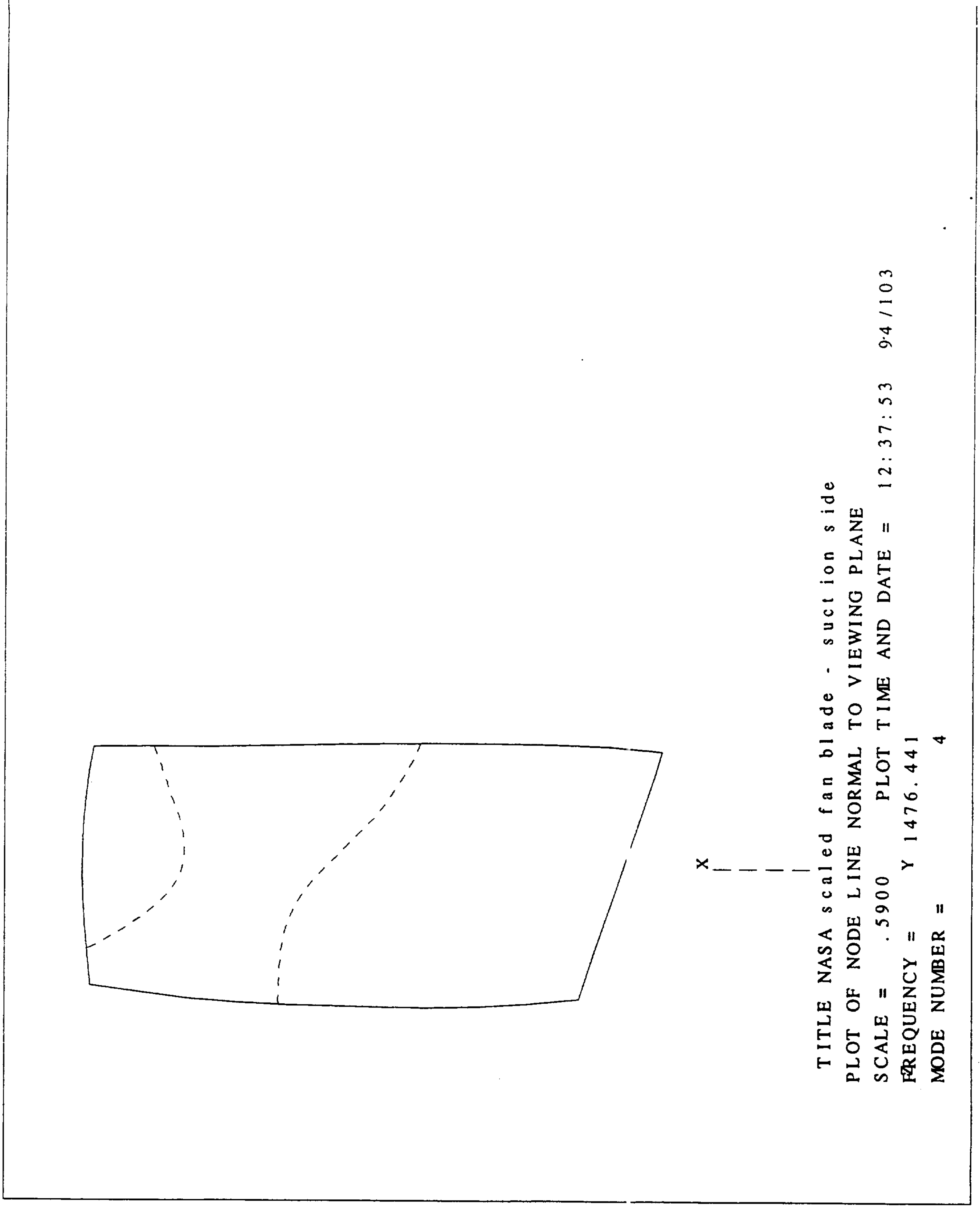
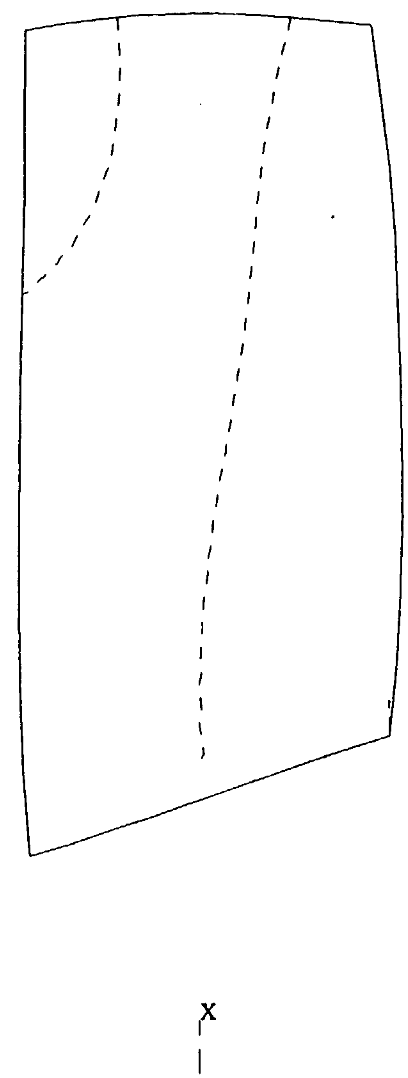


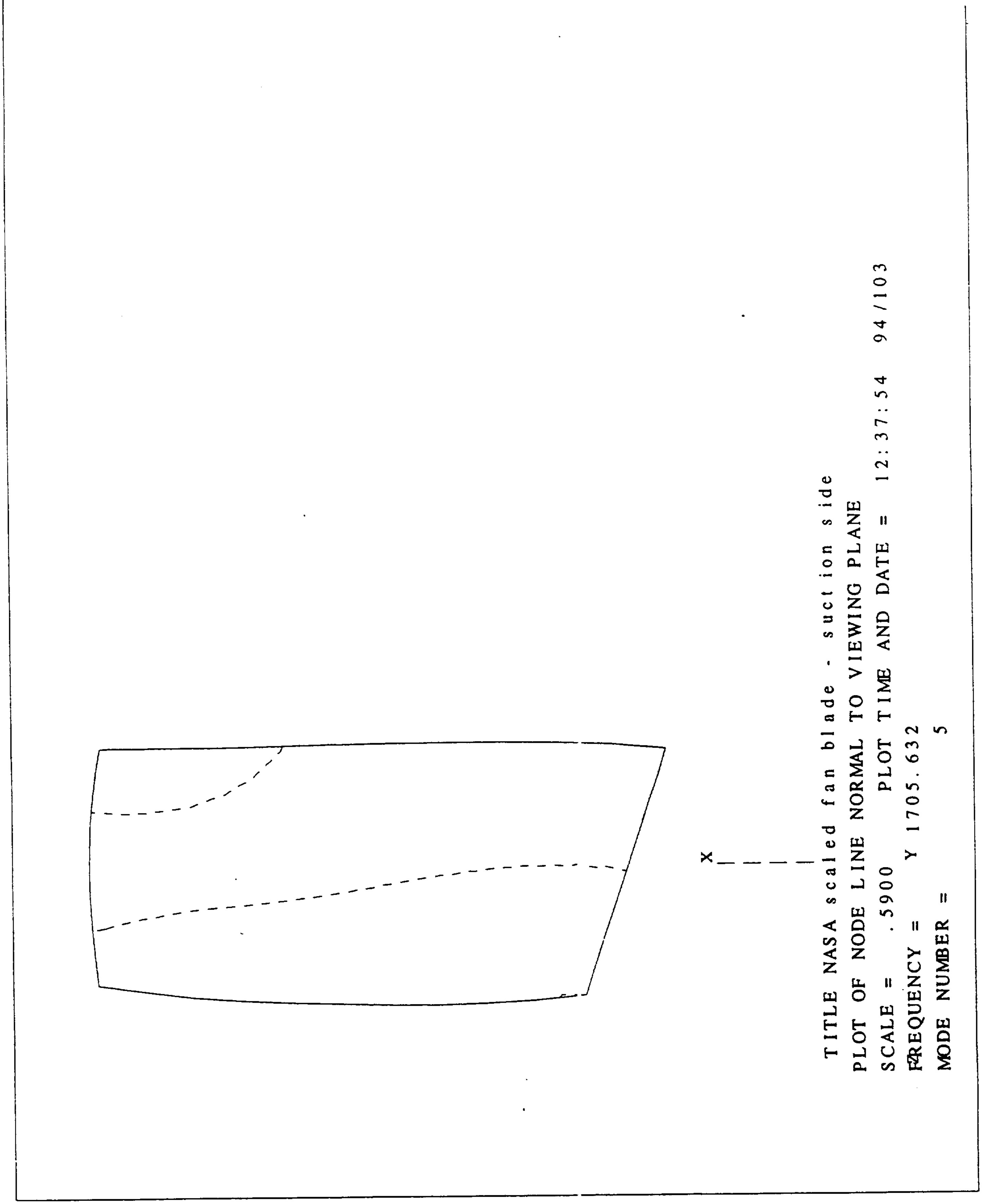
Figure A18: Node Line Plot of Blade Mode 4 - Suction Side

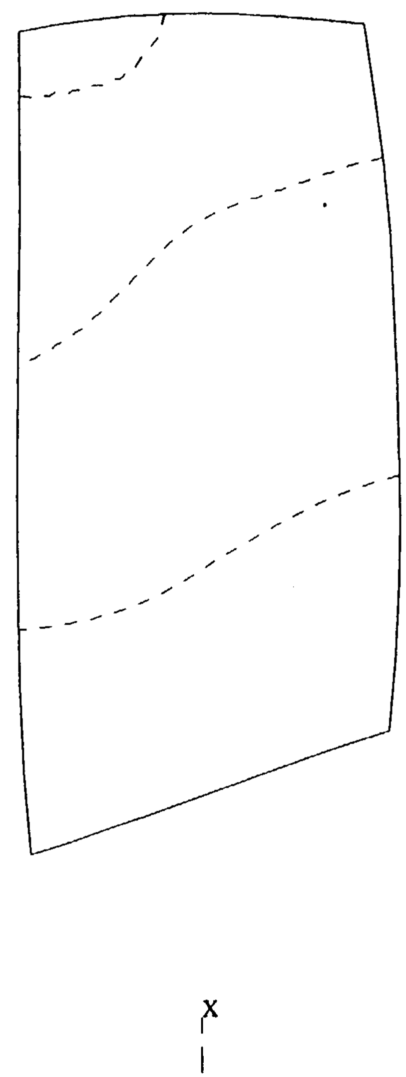




TITLE NASA scaled fan blade - pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .5900 PLOT TIME AND DATE = 12:37:49 94/103
FREQUENCY = 1705.632
MODE NUMBER = 5

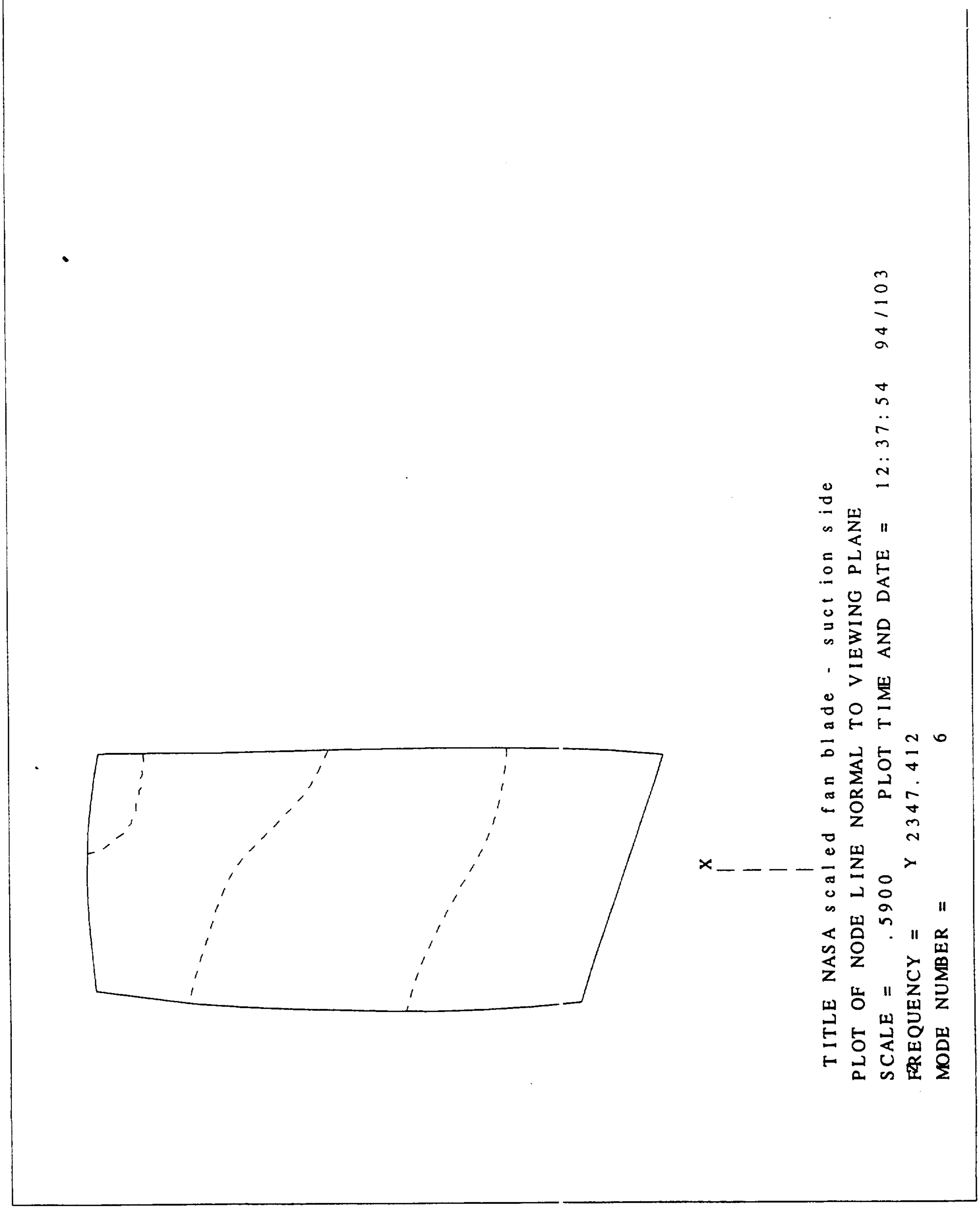
Figure A20: Node Line Plot of Blade Mode 5 - Suction Side





TITLE NASA scaled fan blade - pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .5900 PLOT TIME AND DATE = 12:37:50 94/103
FREQUENCY = Y 2347.412Z
MODE NUMBER = 6

Figure A22: Node Line Plot of Blade Mode 6 - Suction Side



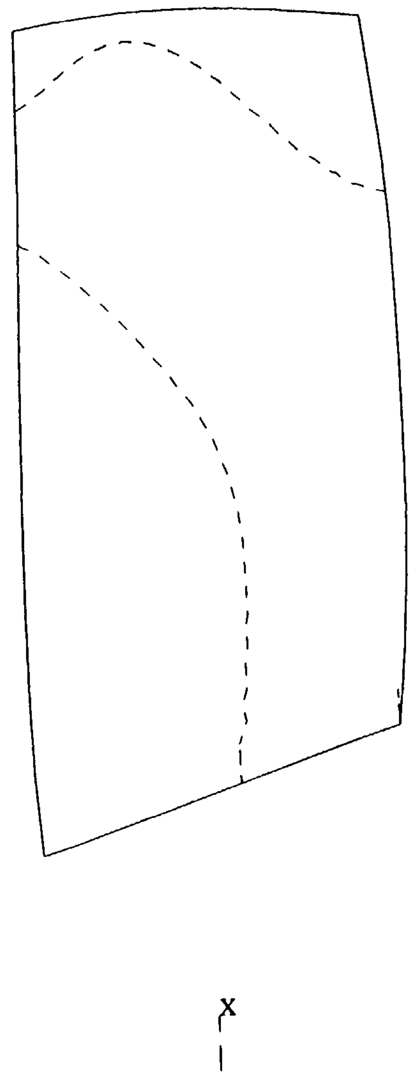
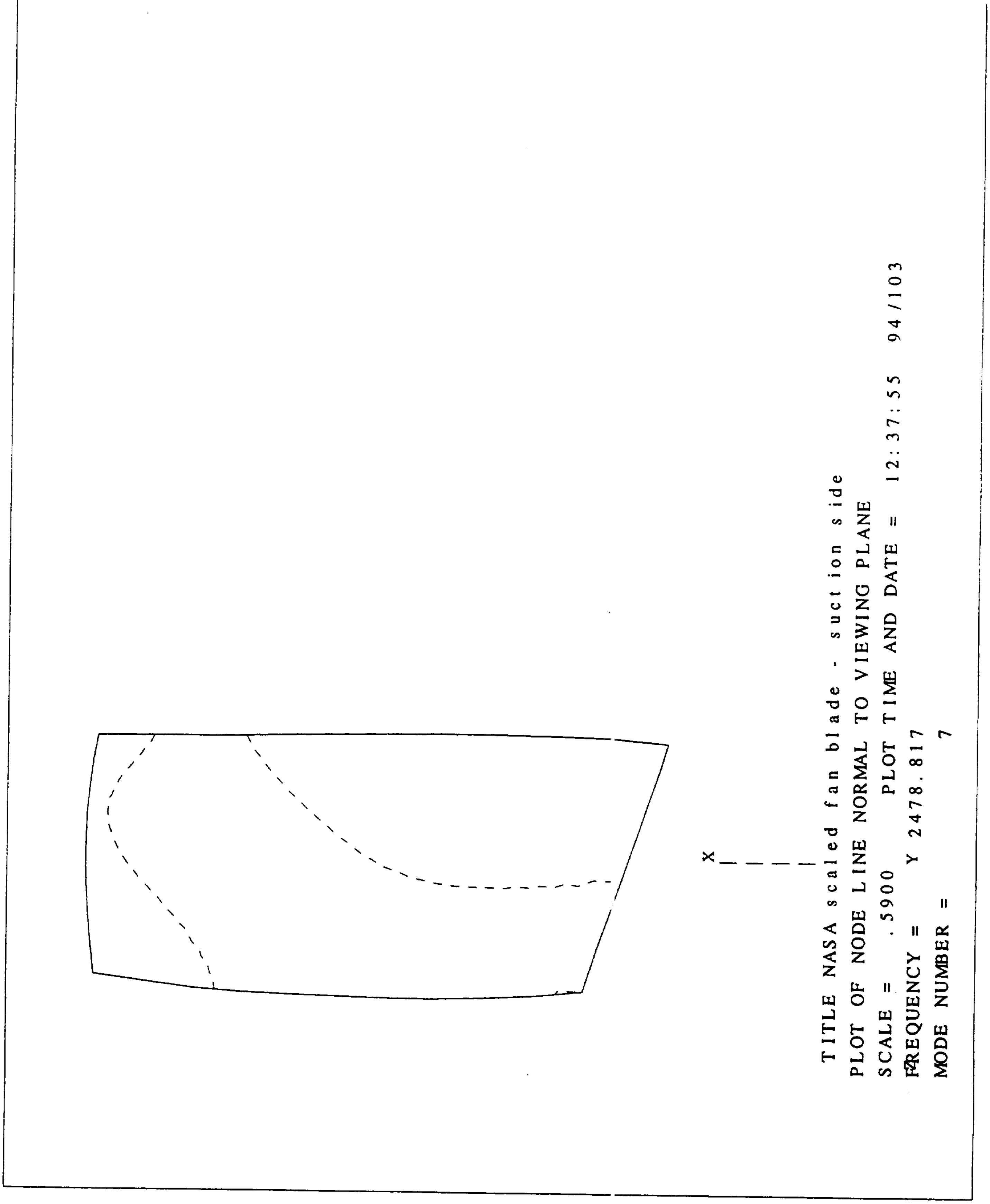
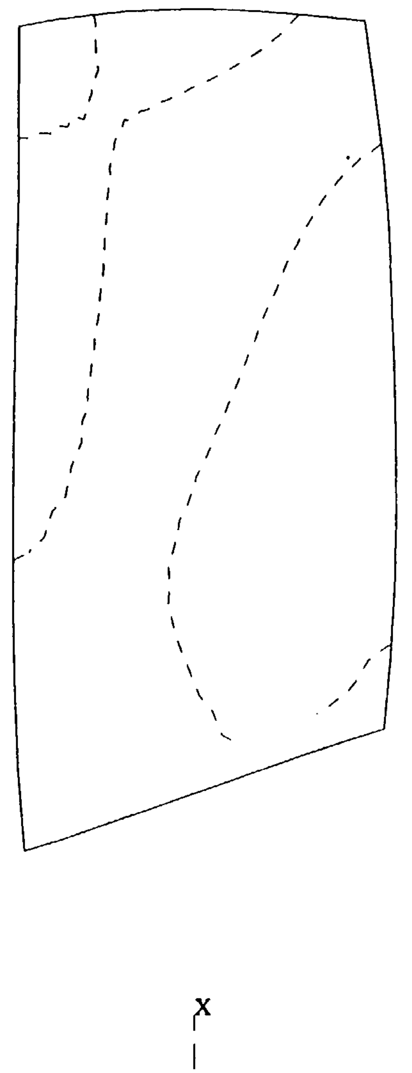

X
TITLE NASA scaled fan blade - pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .5900 PLOT TIME AND DATE = 12:37:50 94/103
FREQUENCY = Y 2478.817Z
MODE NUMBER = 7

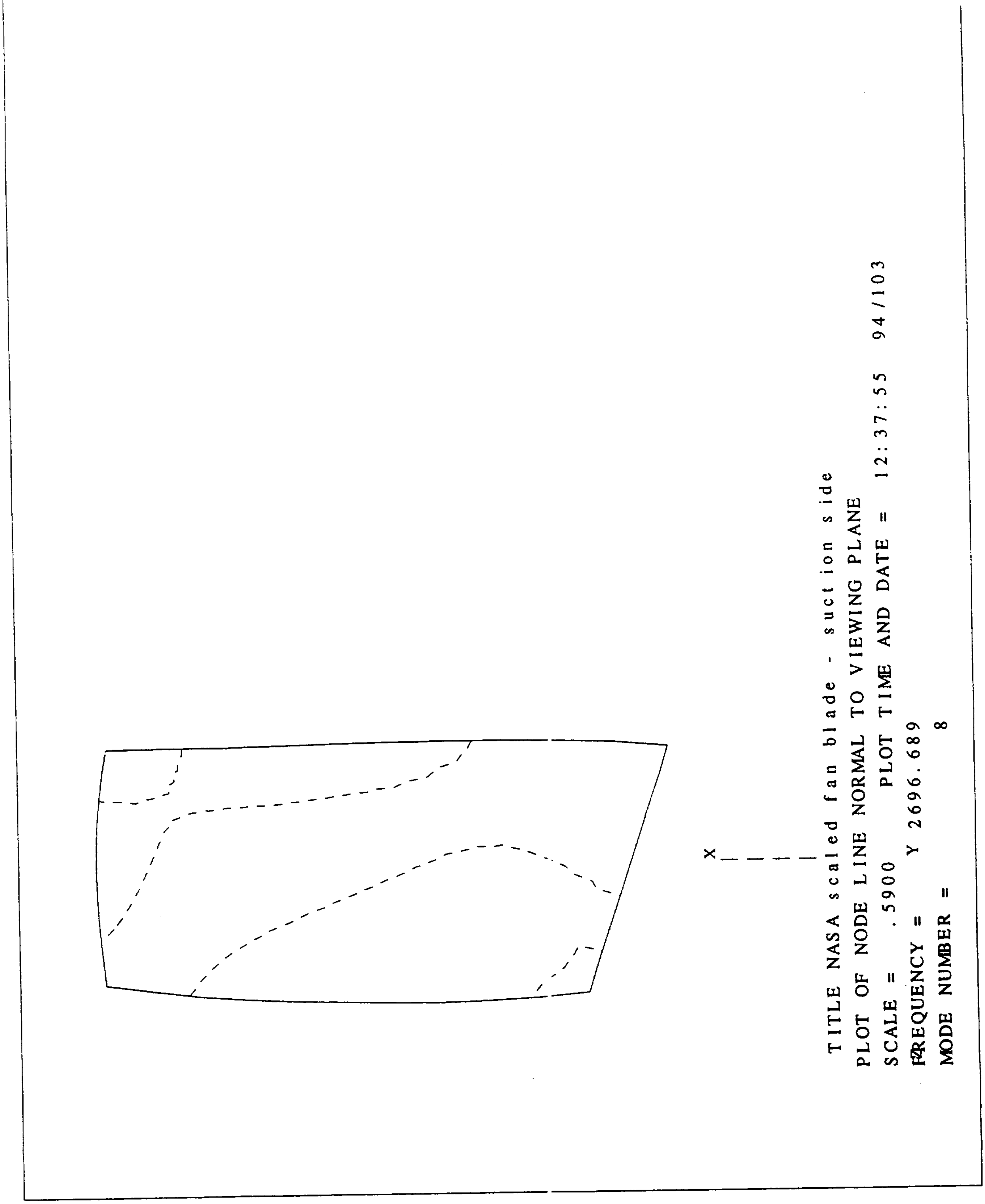
Figure A24: Node Line Plot of Blade Mode 7 - Suction Side

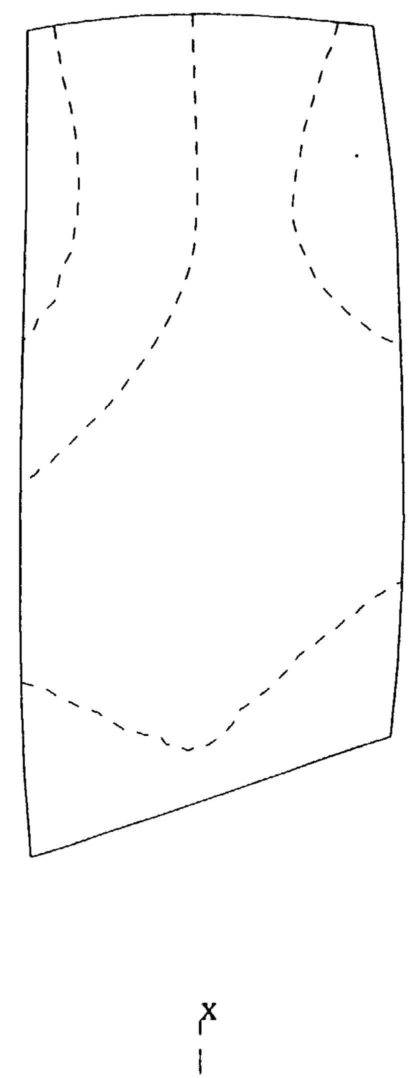




TITLE NASA scaled fan blade - pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .5900 PLOT TIME AND DATE = 12:37:51 94/103
FREQUENCY = 2696.689
MODE NUMBER = 8

Figure A26: Node Line Plot of Blade Mode 8 - Suction Side





TITLE NASA scaled fan blade - pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .5900 PLOT TIME AND DATE = 12:37:52 94/103
FREQUENCY = 2892.008
MODE NUMBER = 9

Figure A28: Node Line Plot of Blade Mode 9 - Suction Side

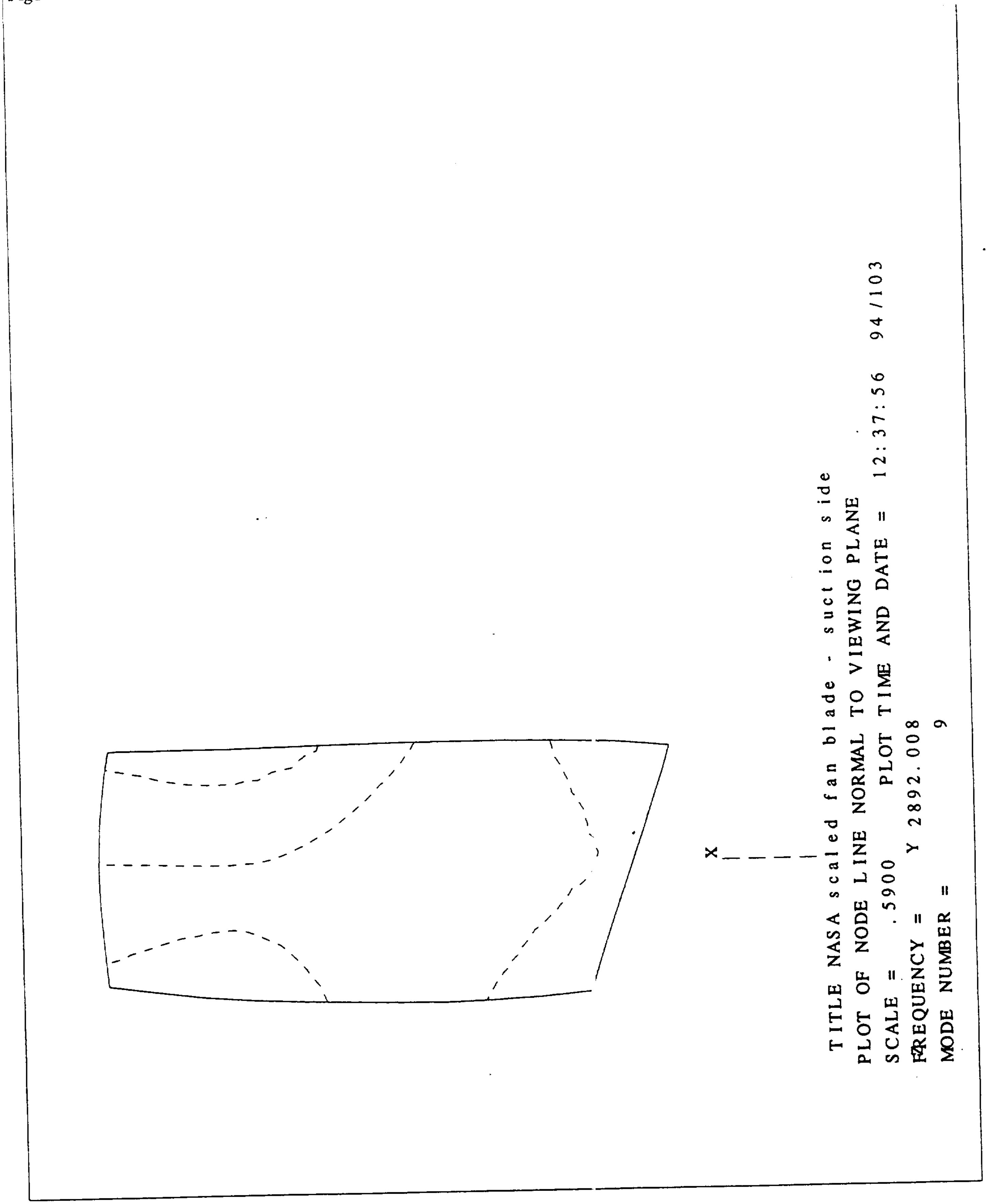


Figure A29: Node Line Plot of Blade Mode 10 - Pressure Side

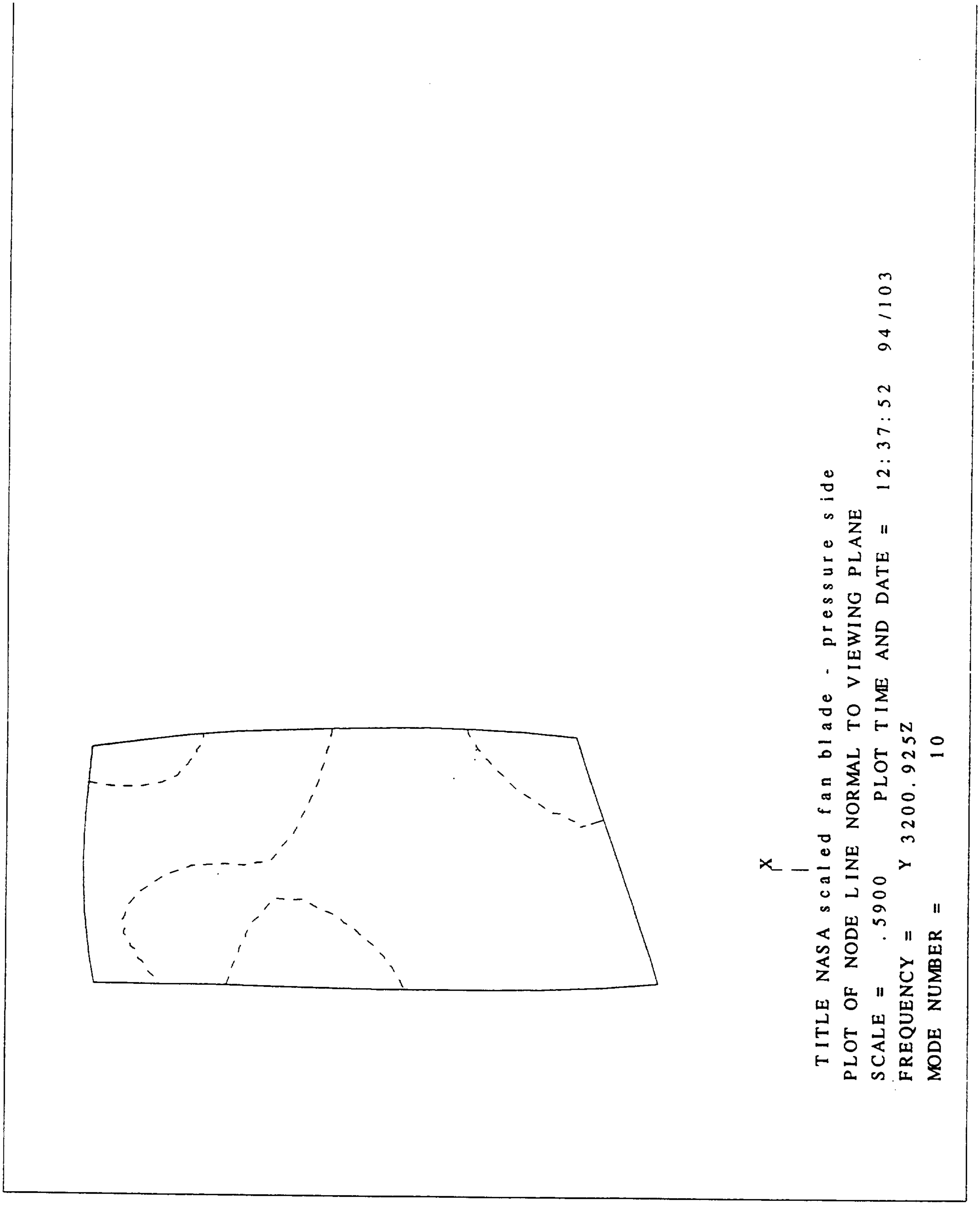


Figure A30: Node Line Plot of Blade Mode 10 - Suction Side

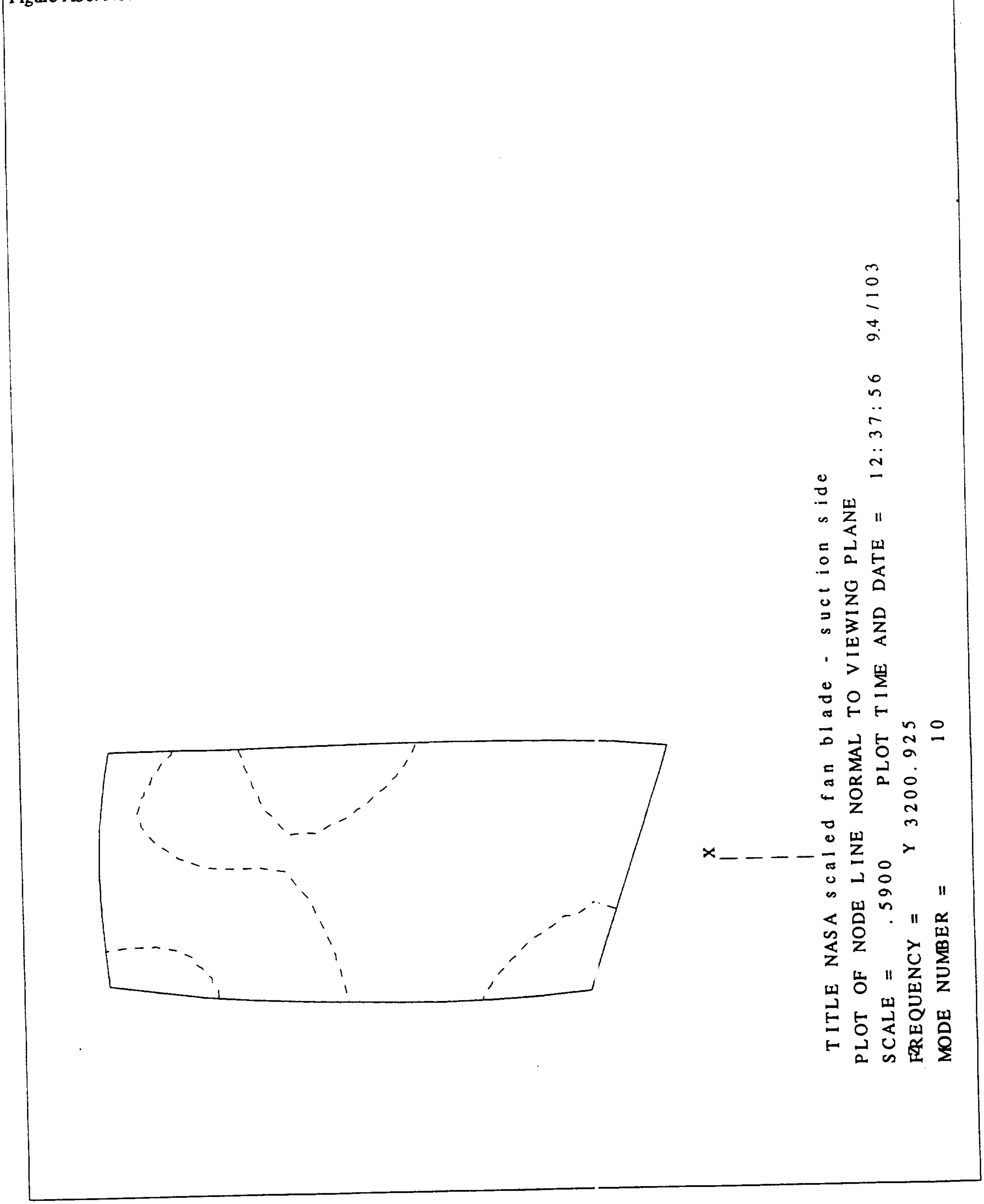


Figure A31: Dynamic Stress Plot of Blade Mode 1 - Pressure Side

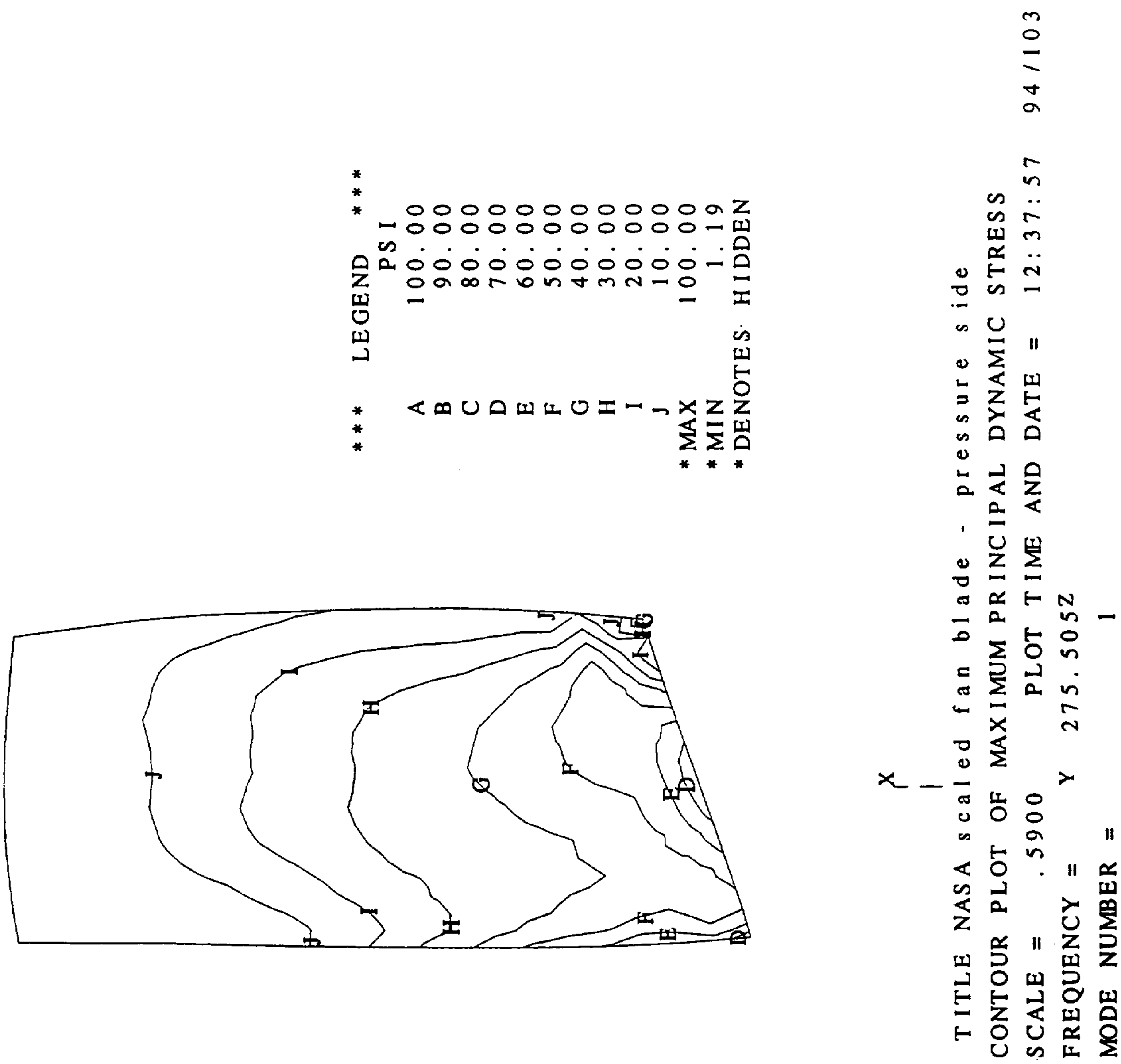
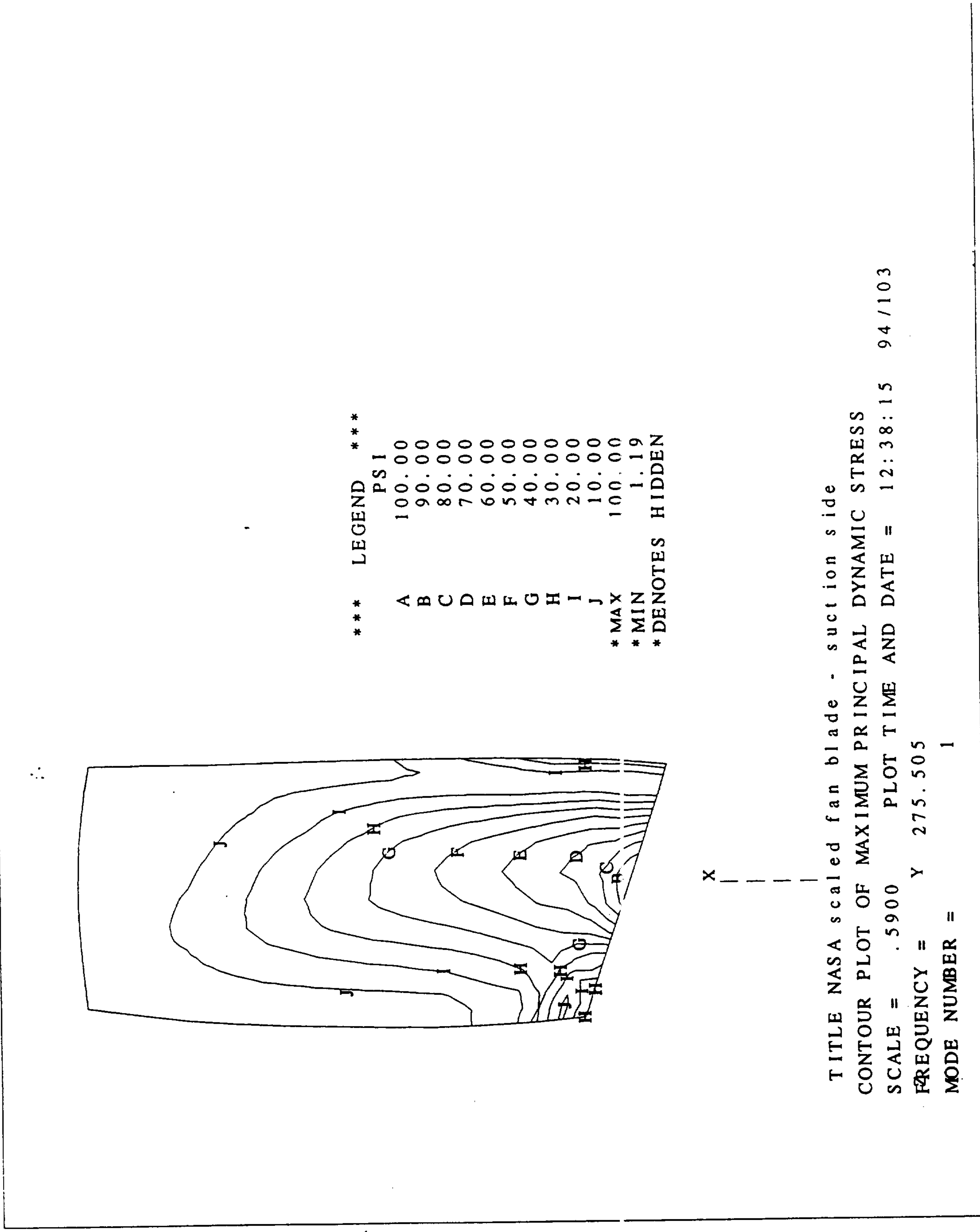
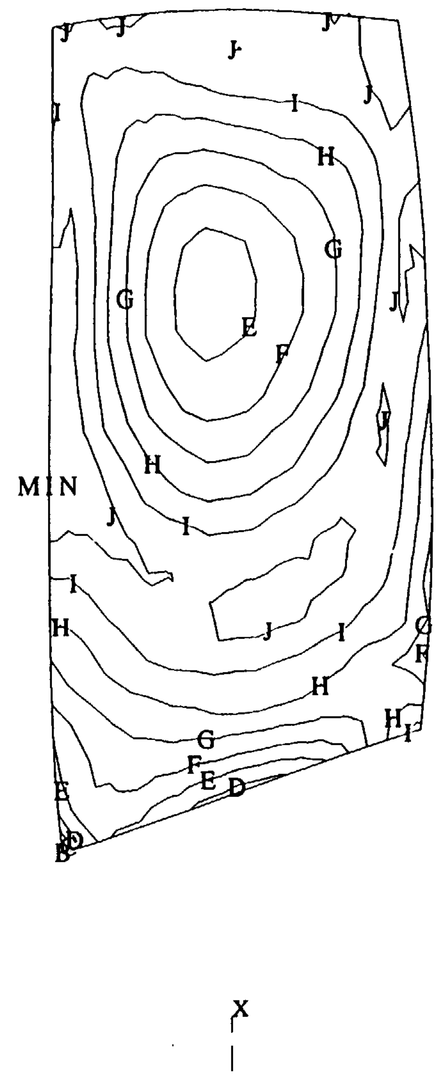


Figure A32: Dynamic Stress Plot of Blade Mode 1 - Suction Side





*** LEGEND ***	
	PSI
A	100.00
B	90.00
C	80.00
D	70.00
E	60.00
F	50.00
G	40.00
H	30.00
I	20.00
J	10.00
*MAX	100.00
MIN	1.85
*DENOTES HIDDEN	

TITLE NASA scaled fan blade - pressure side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .5900 PLOT TIME AND DATE = 12:37:58 94/103
FREQUENCY = 685.753
MODE NUMBER = 2

Figure A34: Dynamic Stress Plot of Blade Mode 2 - Suction Side

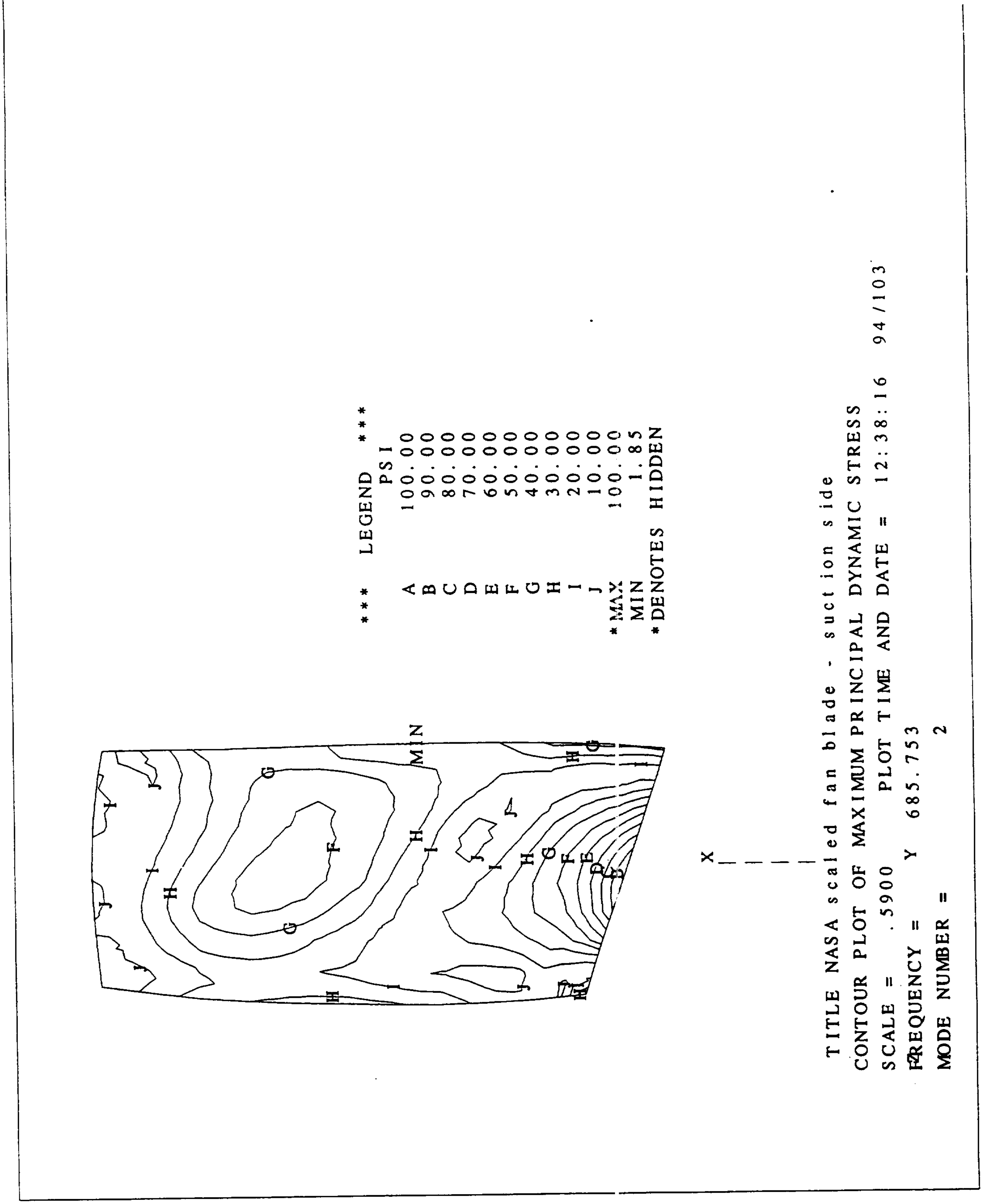


Figure A35: Dynamic Stress Plot of Blade Mode 3 - Pressure Side

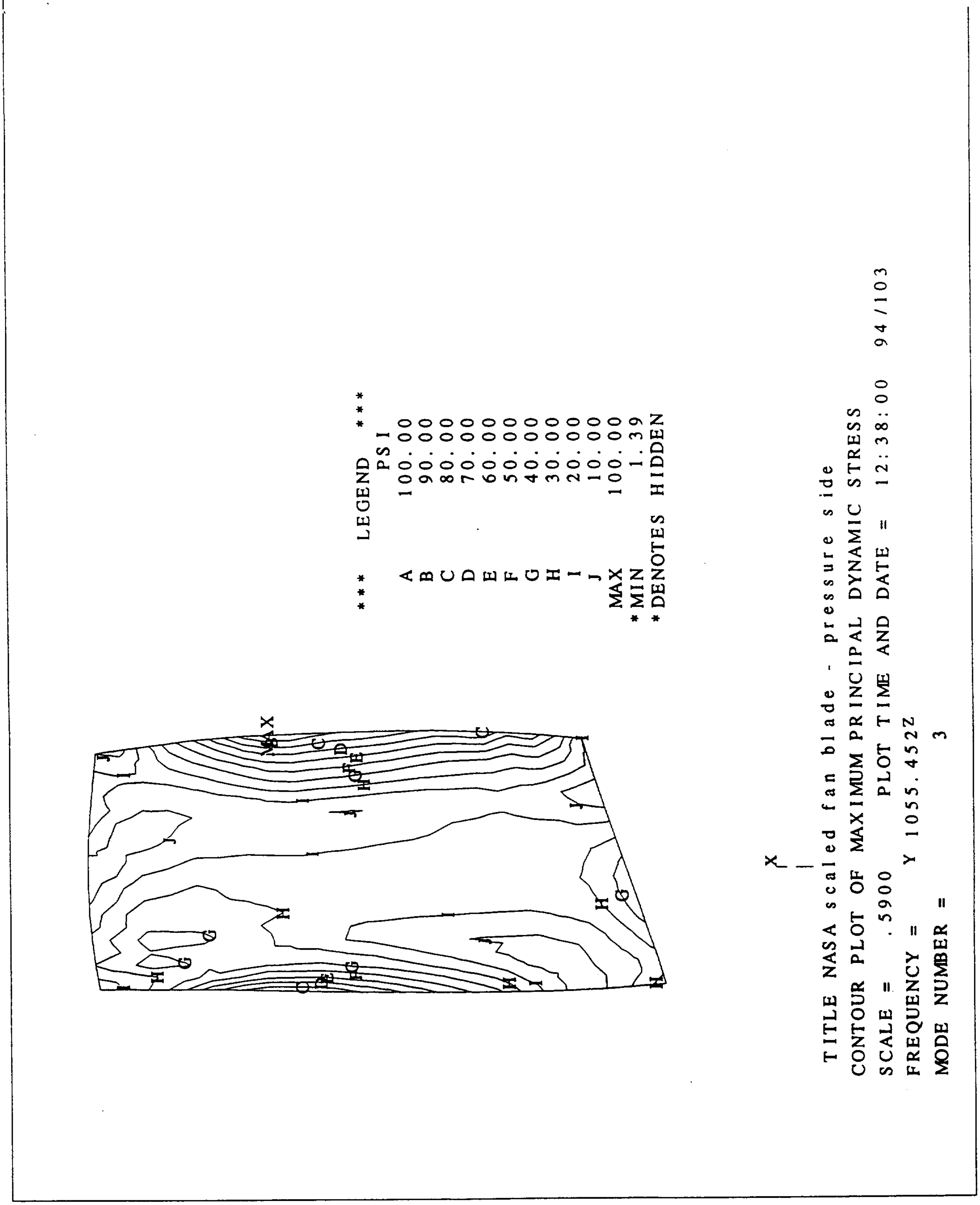
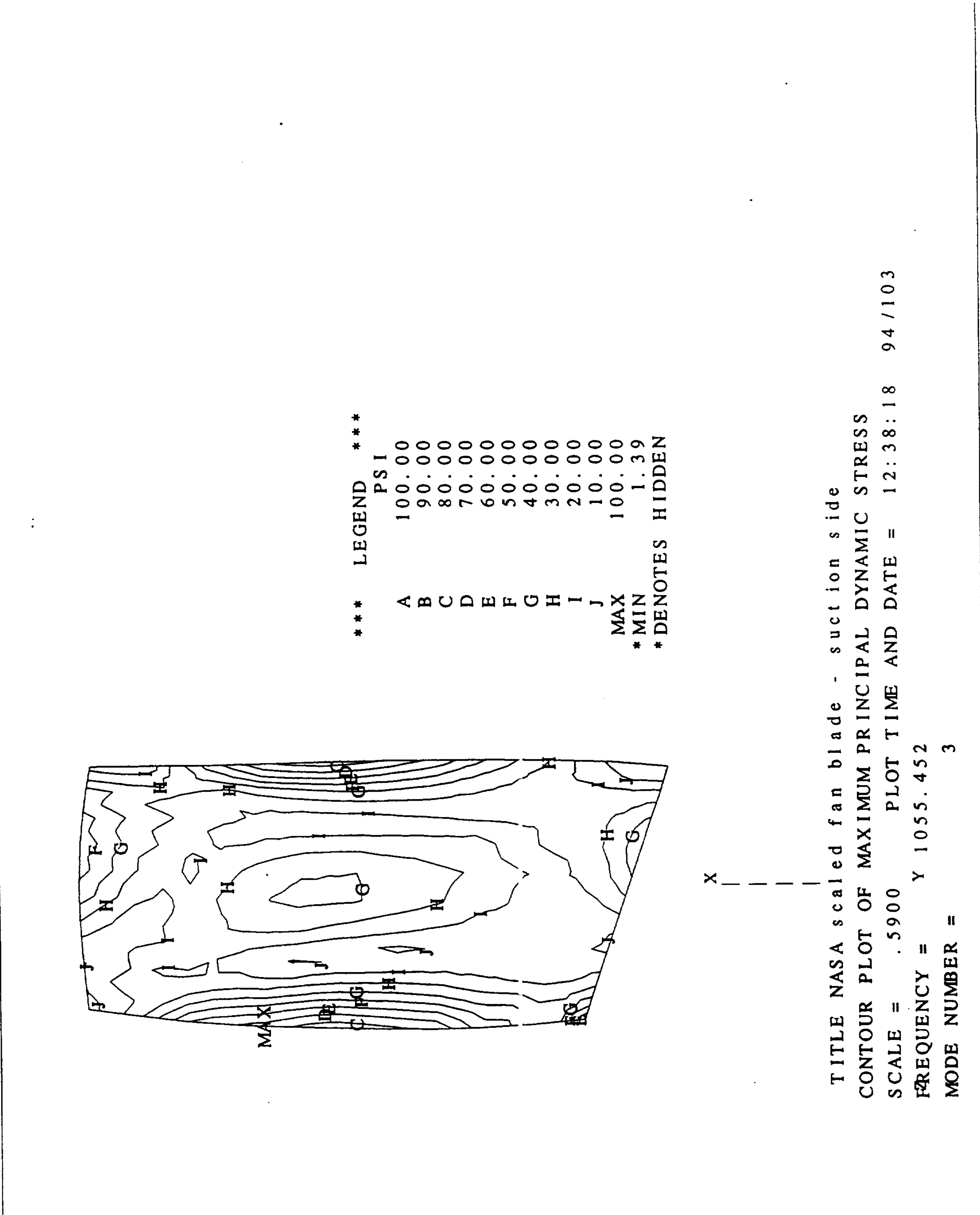
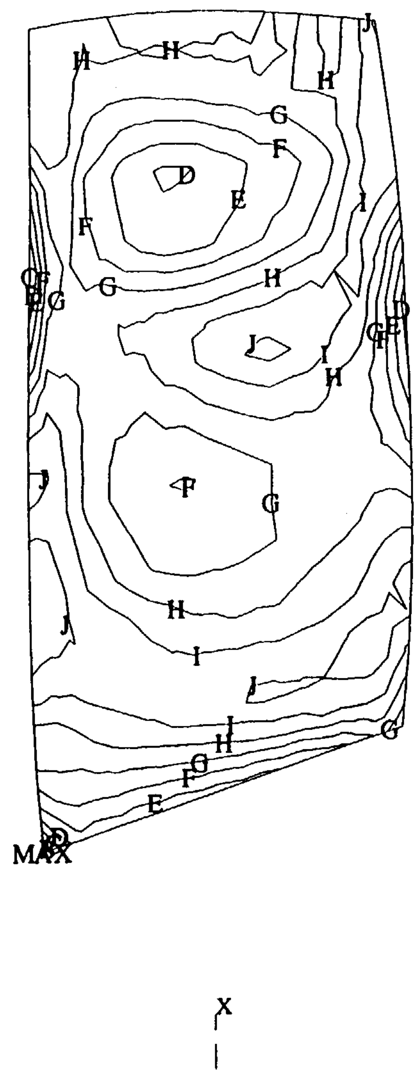


Figure A36: Dynamic Stress Plot of Blade Mode 3 - Suction Side





*** LEGEND ***

	PSI
A	100.00
B	90.00
C	80.00
D	70.00
E	60.00
F	50.00
G	40.00
H	30.00
I	20.00
J	10.00
MAX	100.00
*MIN	2.77

*DENOTES HIDDEN

TITLE NASA scaled fan blade - pressure side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .5900 PLOT TIME AND DATE = 12:38:02 94/103
FREQUENCY = Y 1476.441Z
MODE NUMBER = 4

Figure A38: Dynamic Stress Plot of Blade Mode 4 - Suction Side

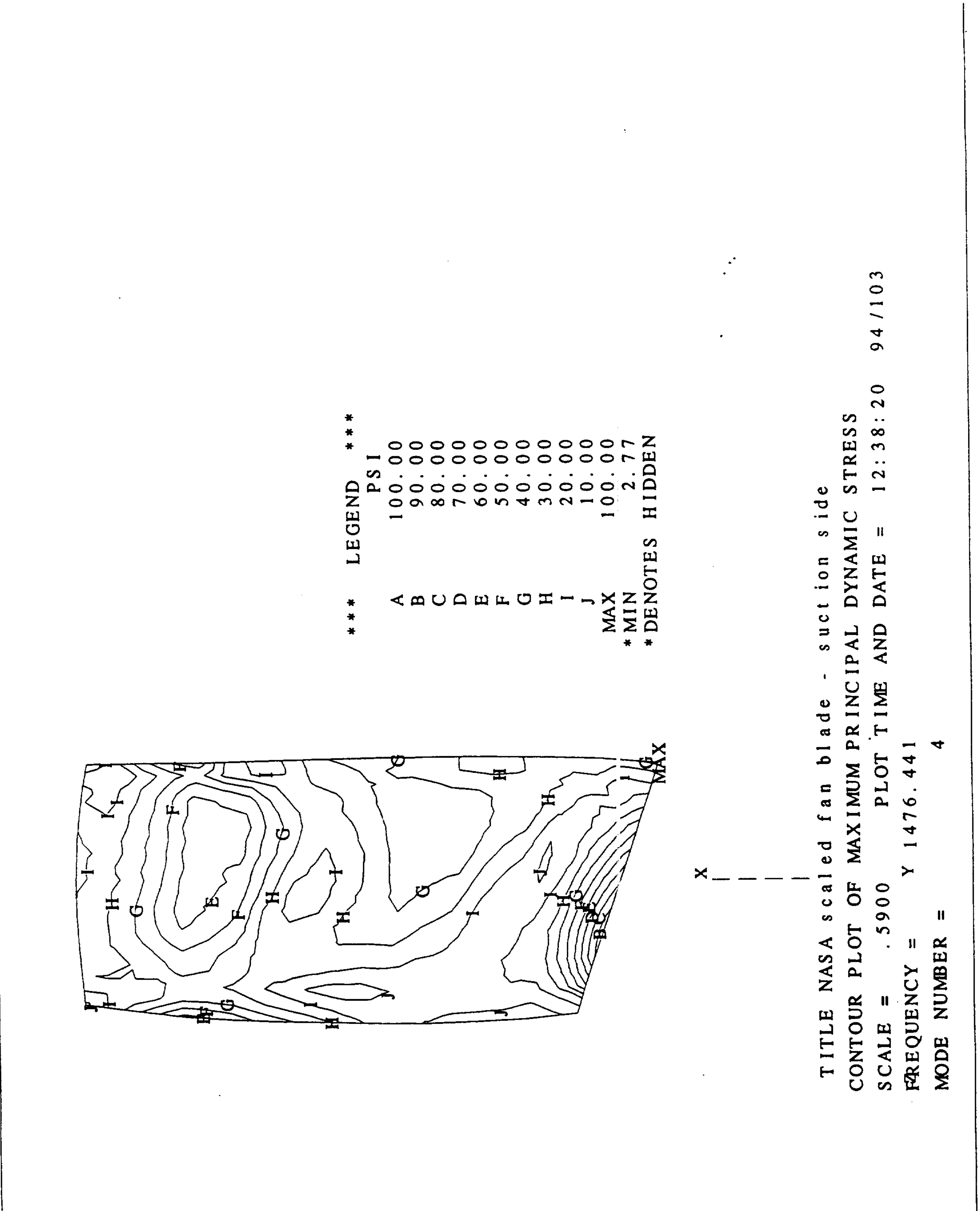


Figure A39: Dynamic Stress Plot of Blade Mode 5 - Pressure Side

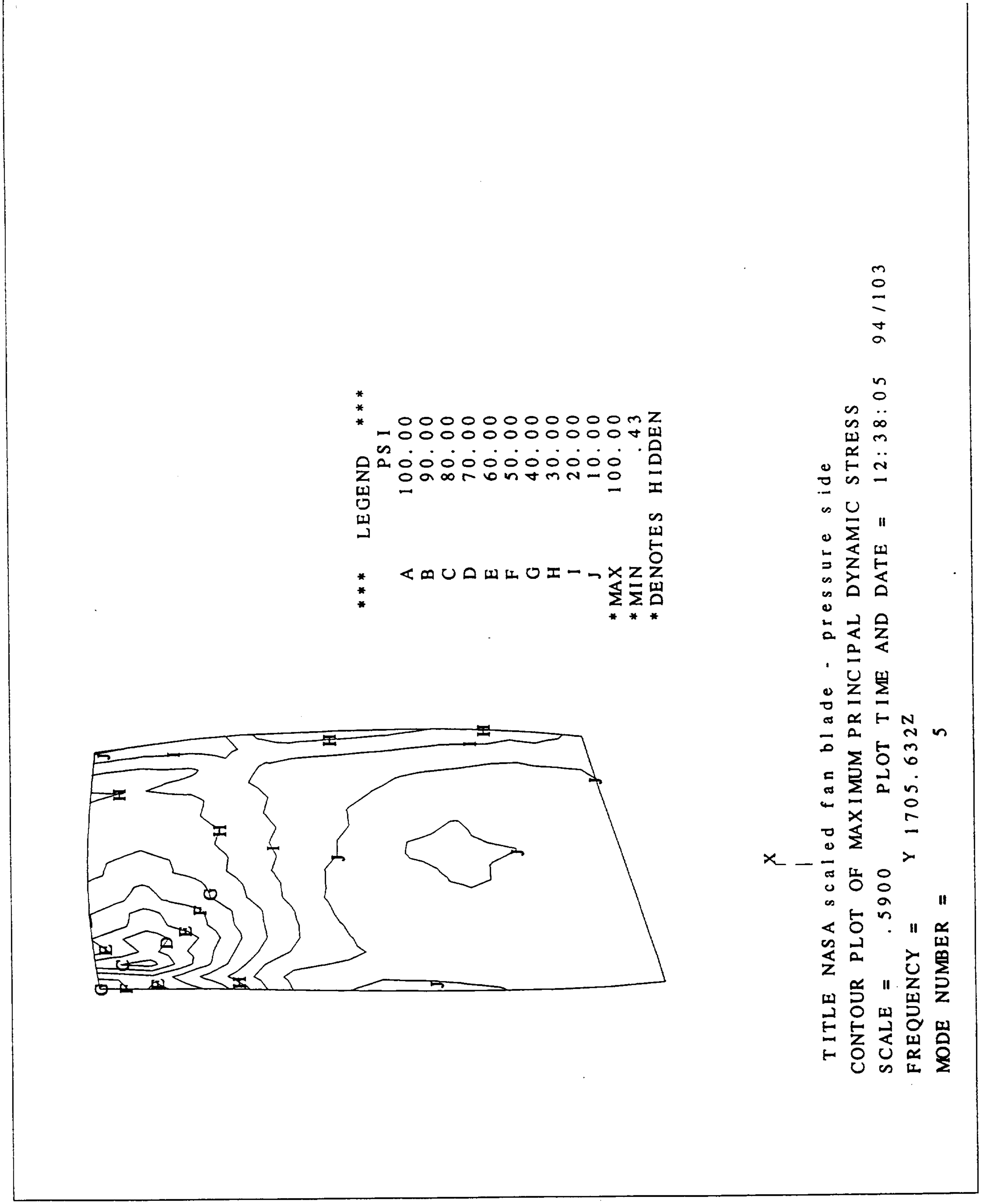


Figure A40: Dynamic Stress Plot of Blade Mode 5 - Suction Side

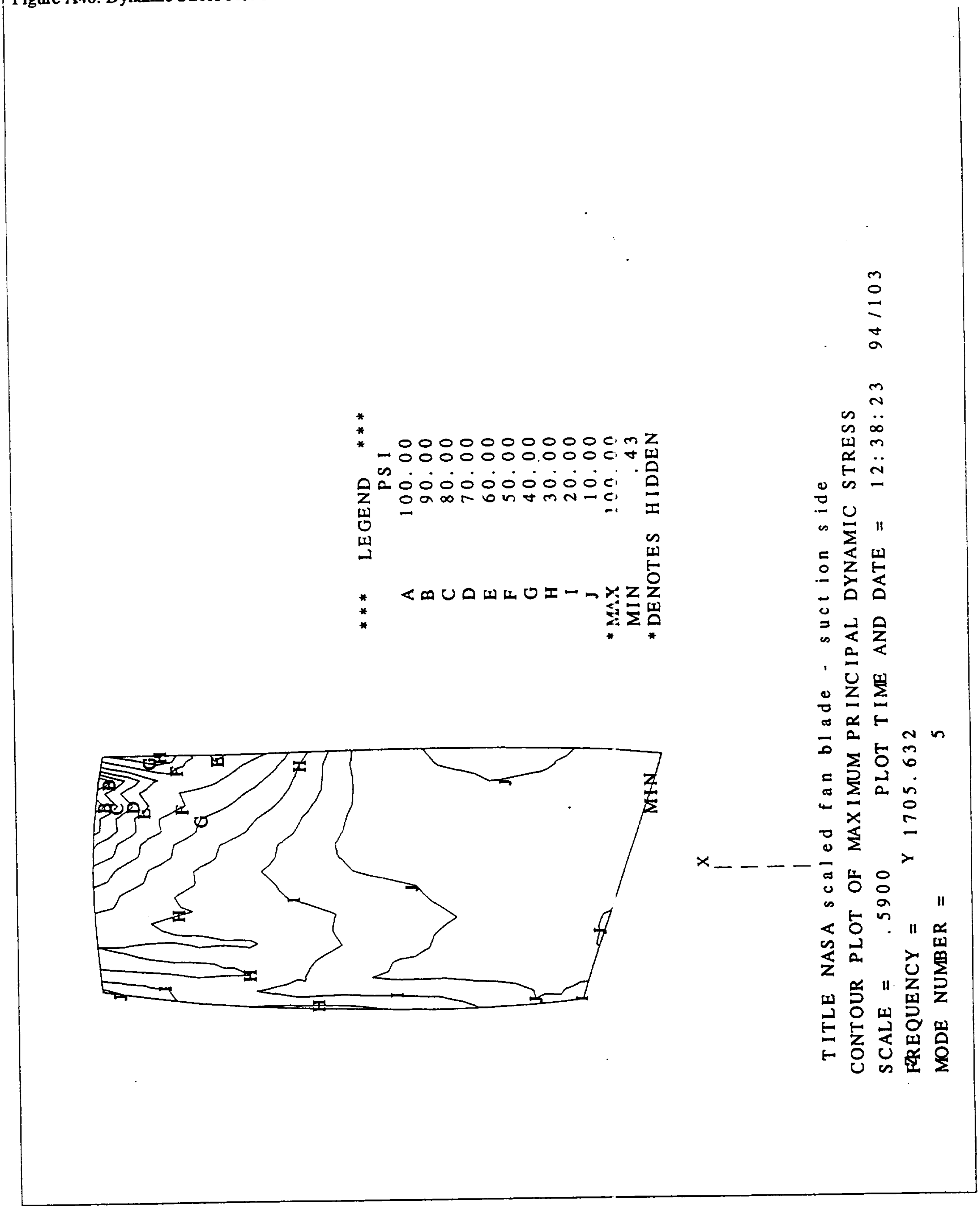


Figure A41: Dynamic Stress Plot of Blade Mode 6 - Pressure Side

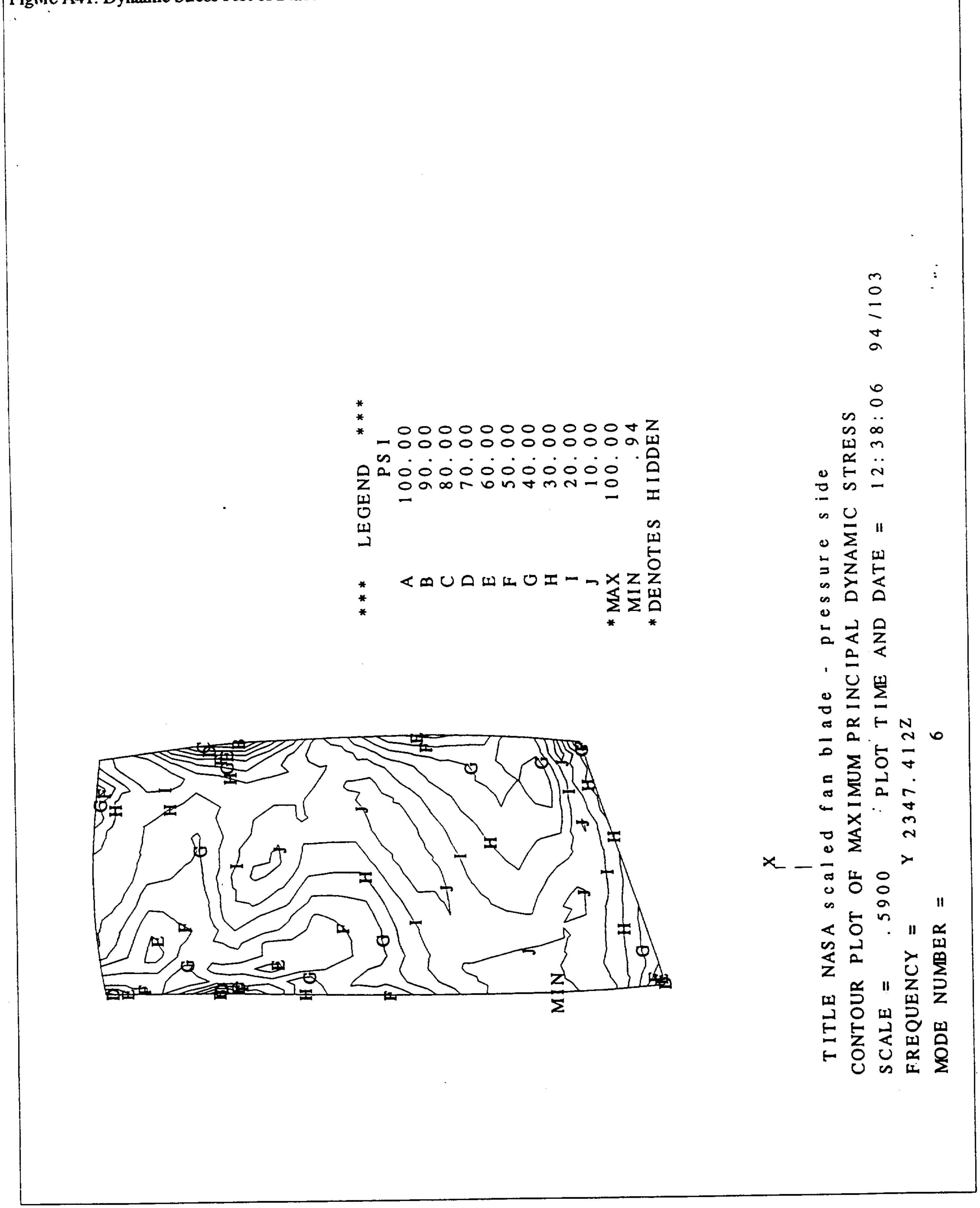


Figure A42: Dynamic Stress Plot of Blade Mode 6 - Suction Side

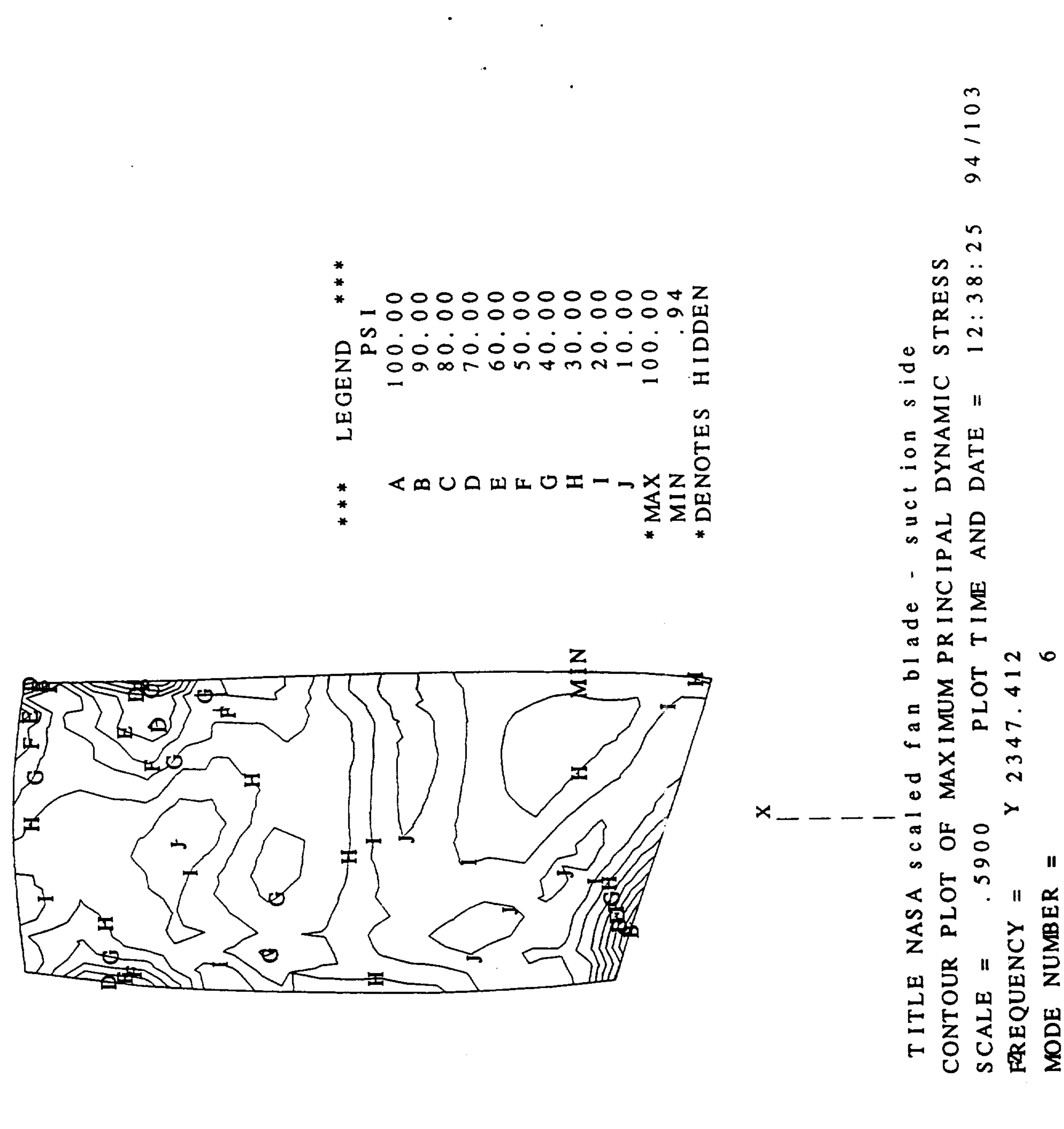


Figure A43: Dynamic Stress Plot of Blade Mode 7 - Pressure Side

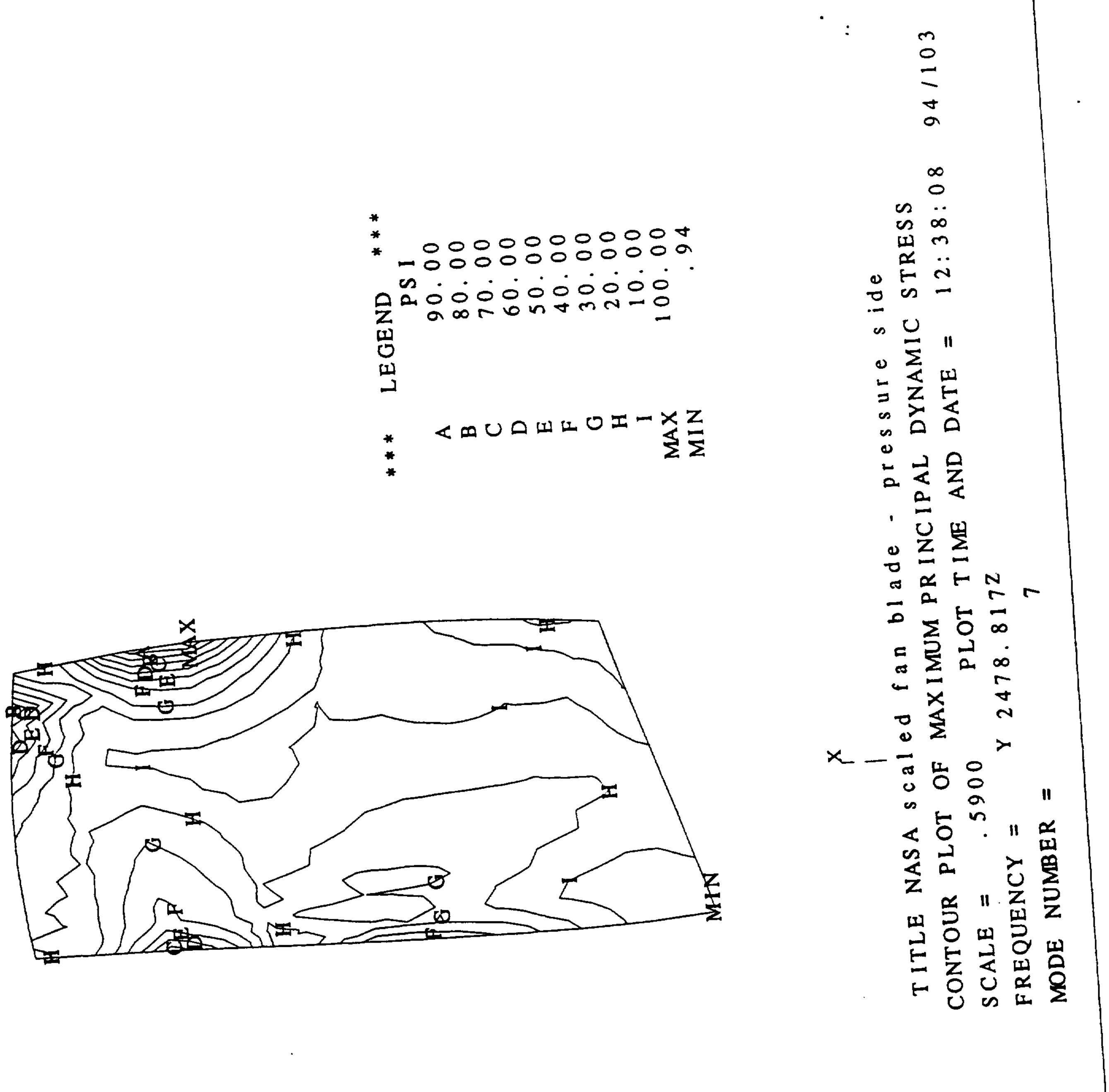


Figure A44: Dynamic Stress Plot of Blade Mode 7 - Suction Side

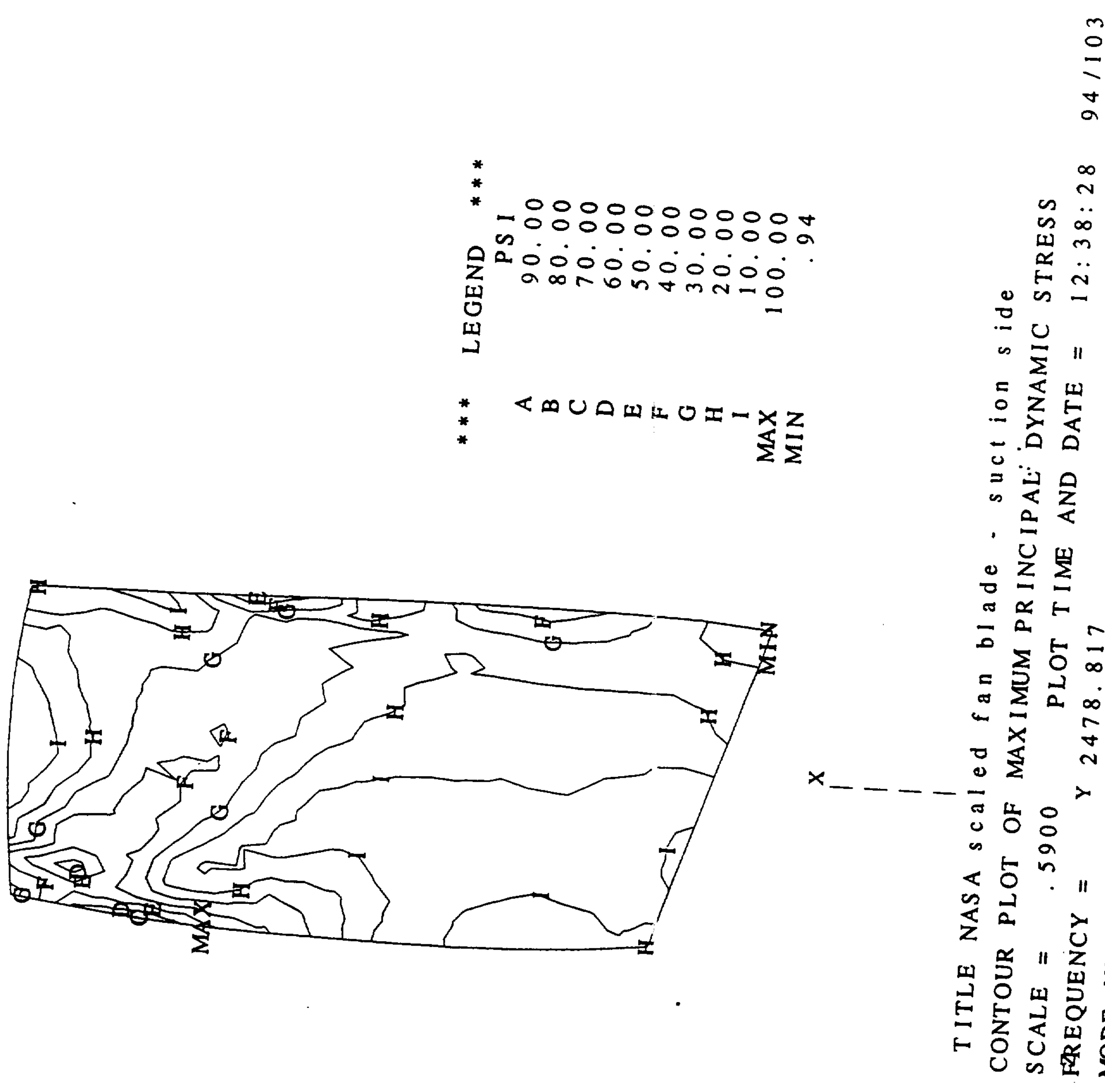


Figure A45: Dynamic Stress Plot of Blade Mode 8 - Pressure Side

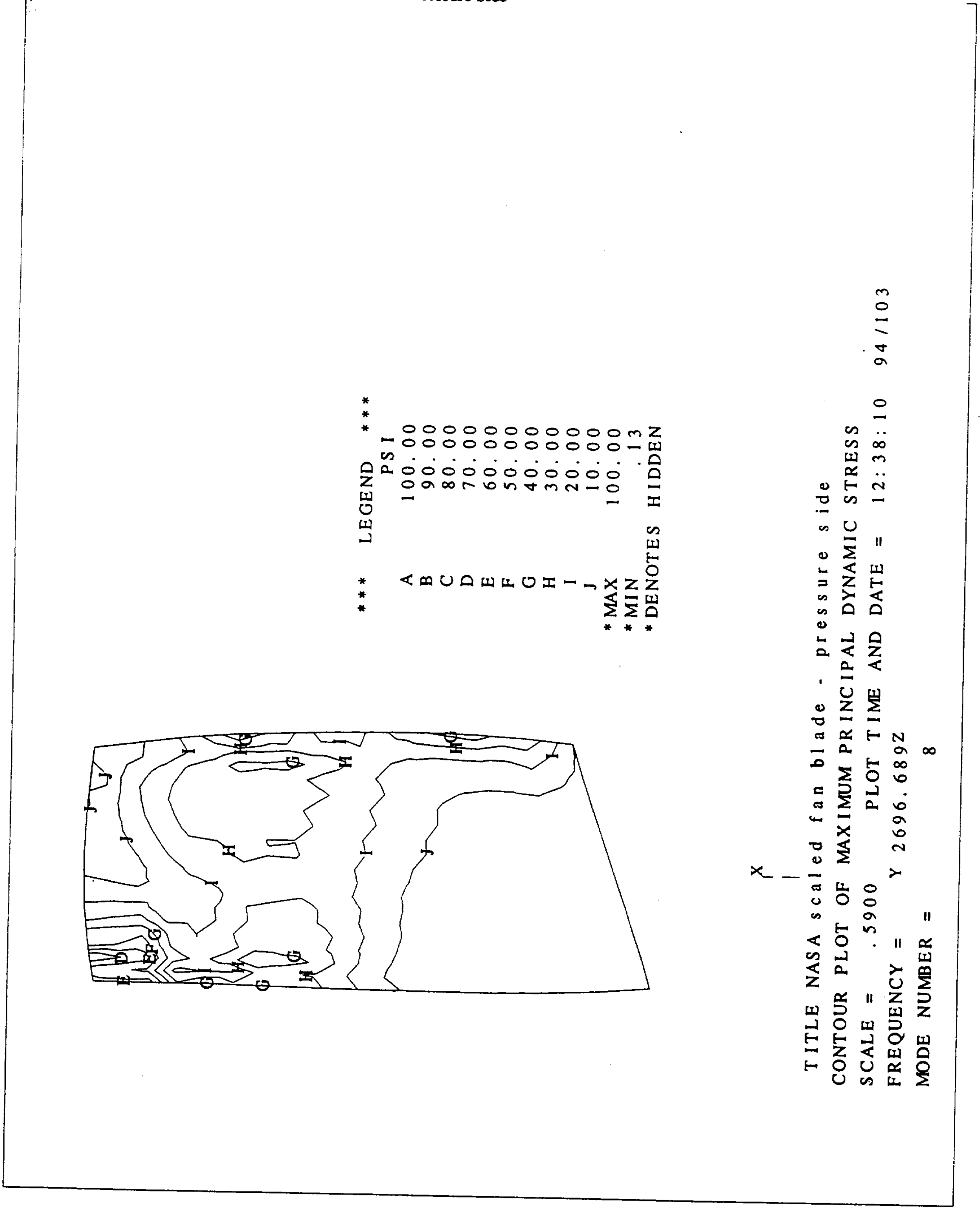


Figure A46: Dynamic Stress Plot of Blade Mode 8 - Suction Side

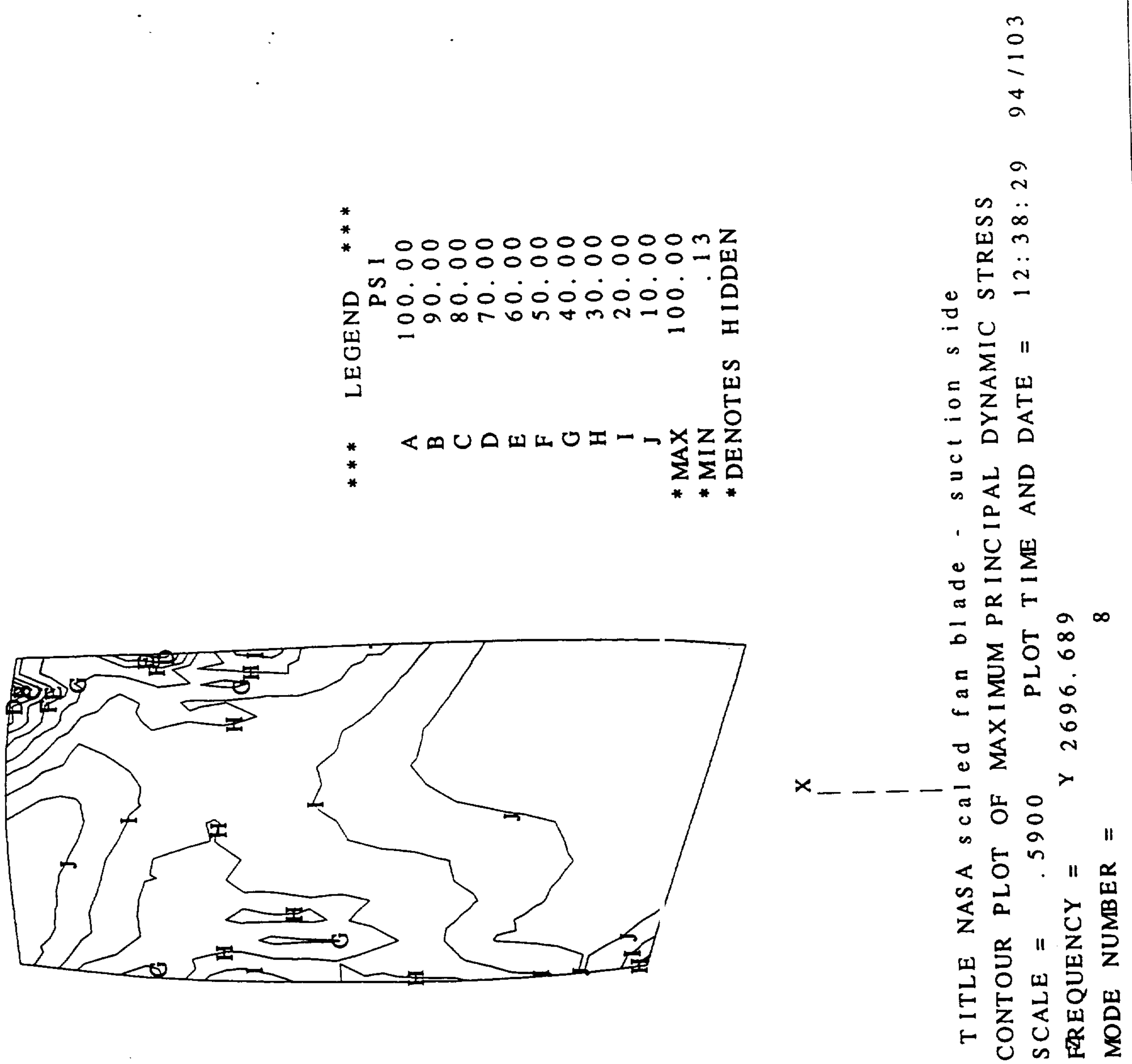


Figure A47: Dynamic Stress Plot of Blade Mode 9 - Pressure Side

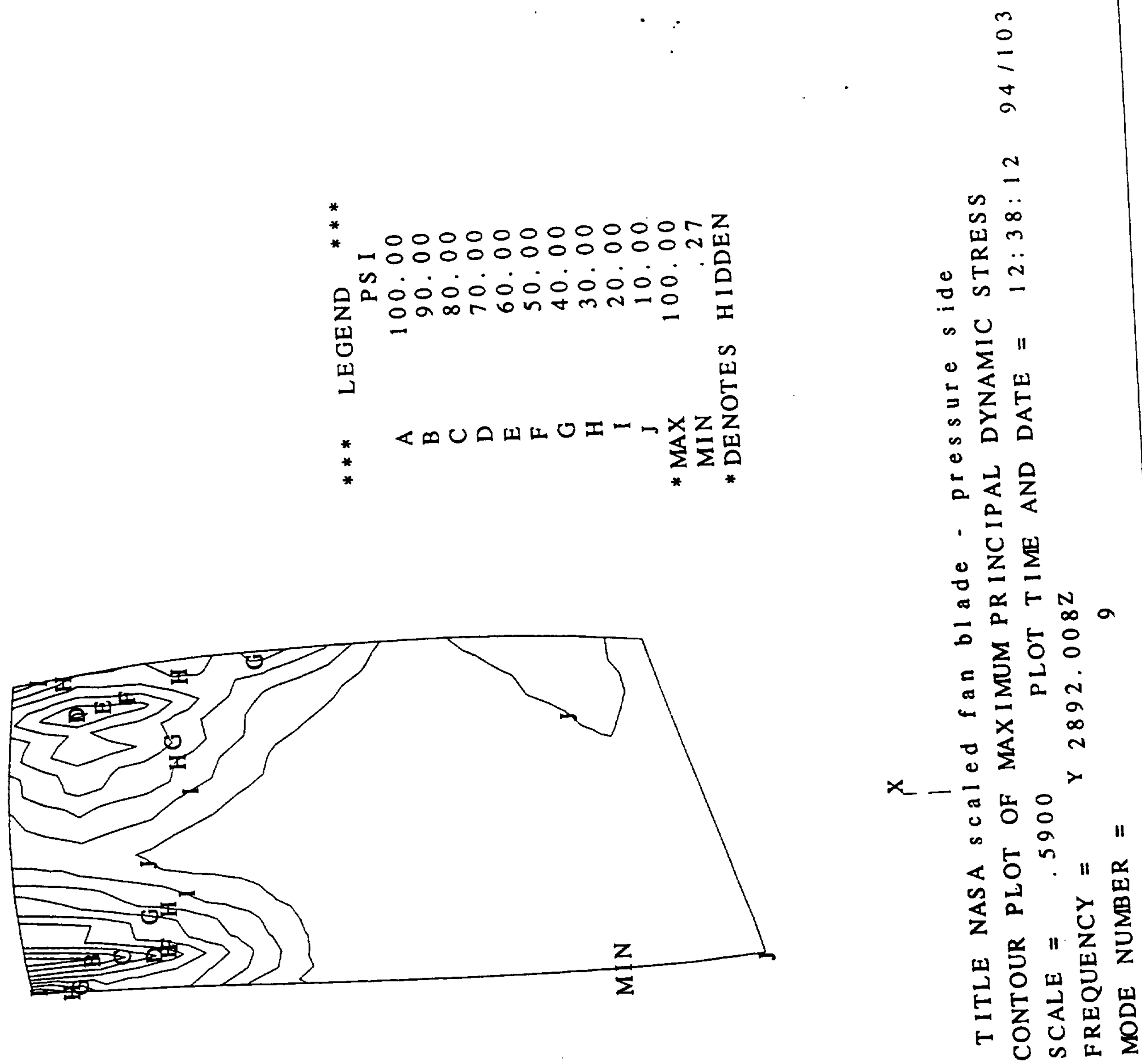


Figure A48: Dynamic Stress Plot of Blade Mode 9 - Suction Side

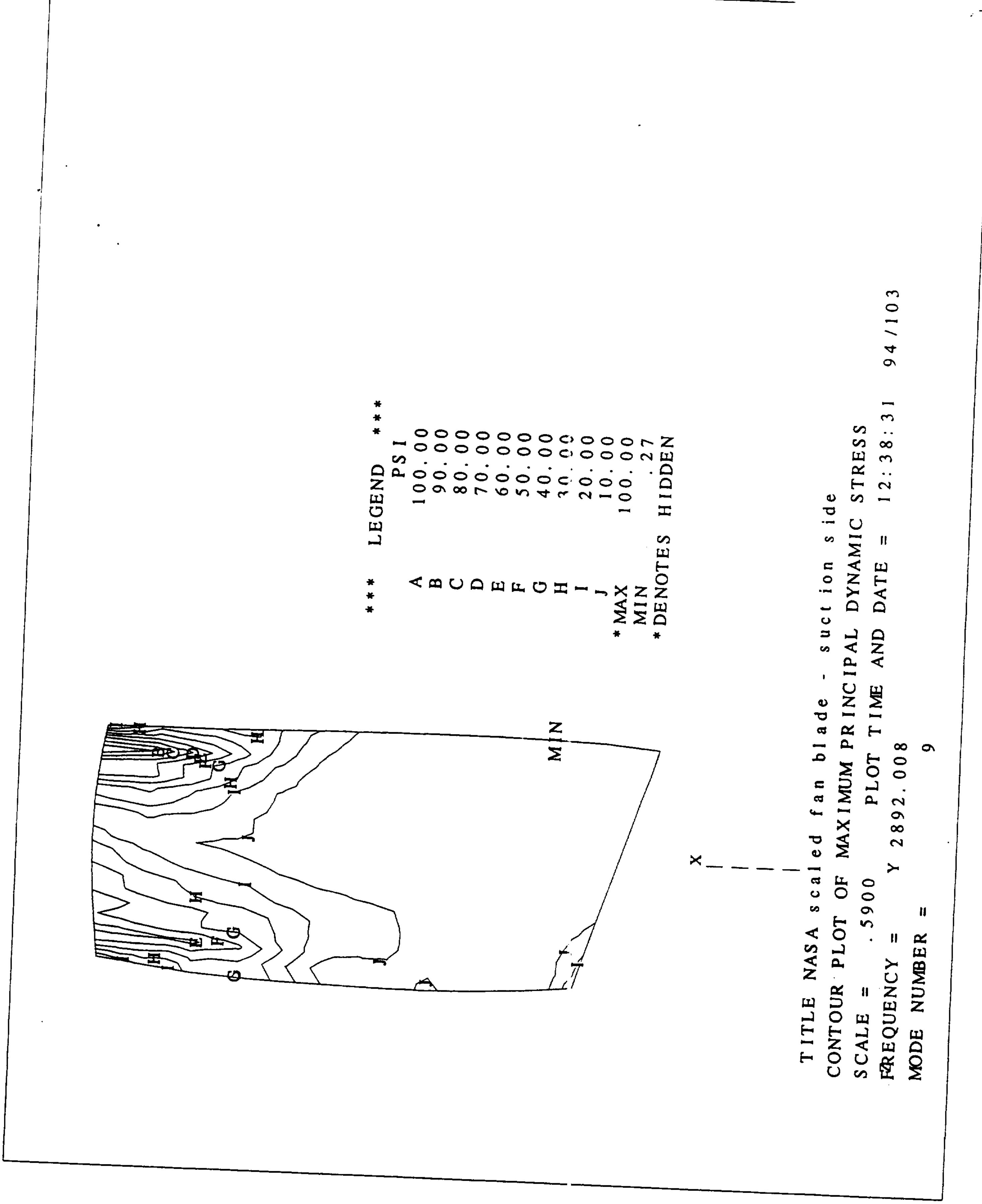
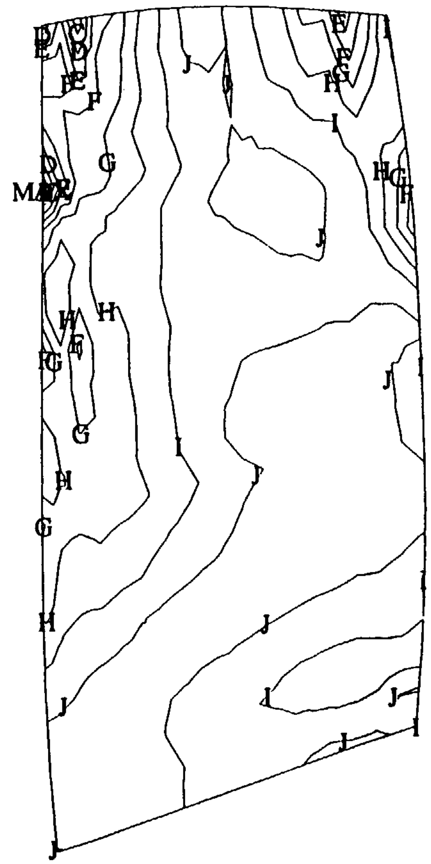


Figure A49. Dynamic Stress Plot of Blade Mode 10 - Pressure Side



*** LEGEND ***	
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A	100.00
B	90.00
C	80.00
D	70.00
E	60.00
F	50.00
G	40.00
H	30.00
I	20.00
J	10.00
MAX	100.00
*MIN	1.30

*DENOTES HIDDEN

TITLE NASA scaled fan blade - pressure side

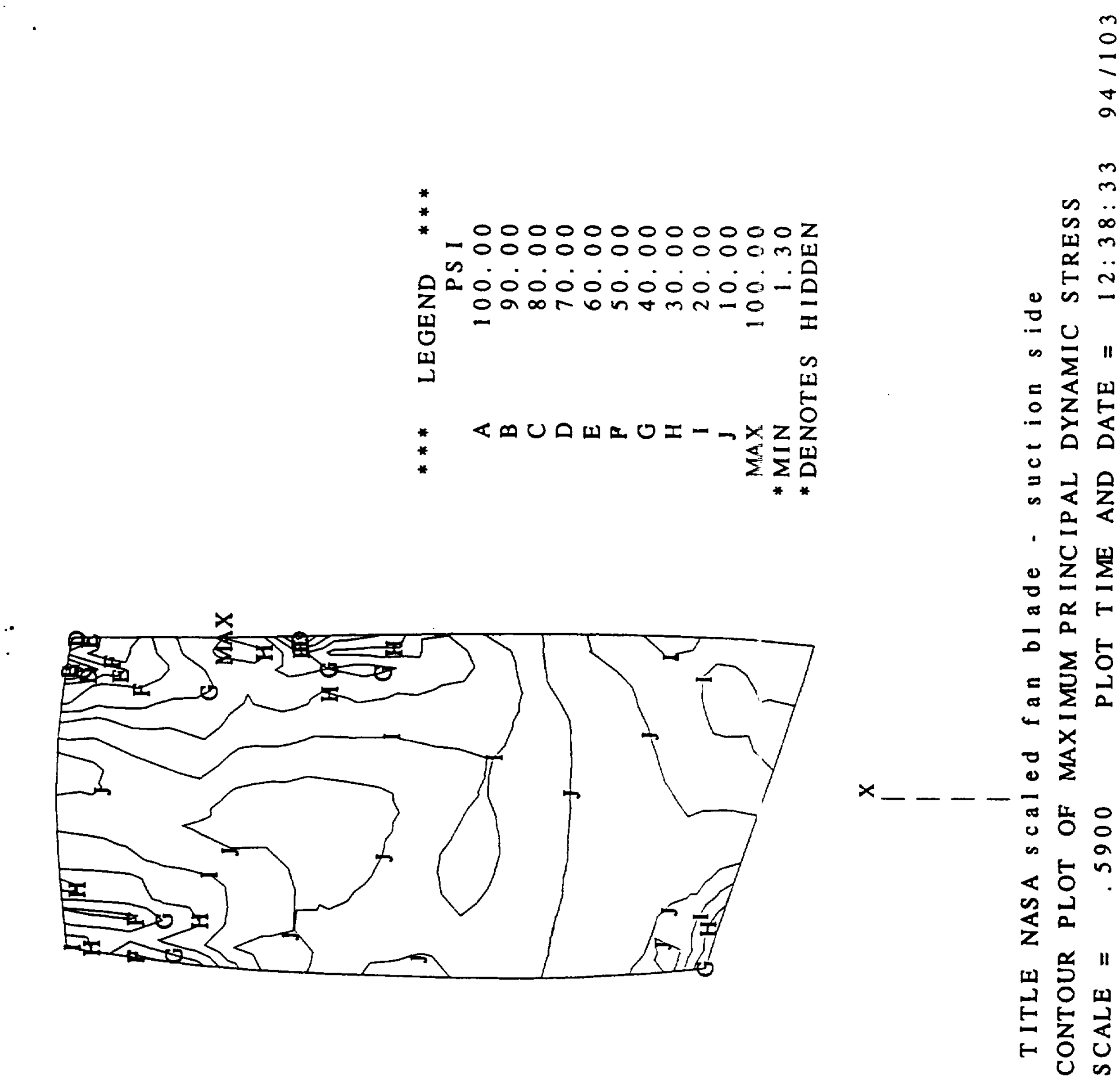
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS

SCALE = .5900 PLOT TIME AND DATE = 12:38:13 94/103

FREQUENCY = Y 3200.925Z

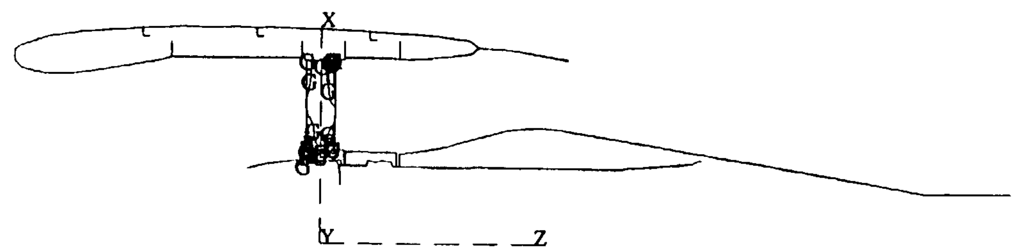
MODE NUMBER = 10

Figure A50: Dynamic Stress Plot of Blade Mode 10 - Suction Side



APPENDIX G

STRESS ANALYSIS RESULTS STATIC STRUCTURE



*** LEGEND ***

	KSI
A	60.00
B	51.00
C	42.00
D	33.00
E	24.00
F	15.00
G	6.00
*MAX	60.09
*MIN	.00

*DENOTES HIDDEN

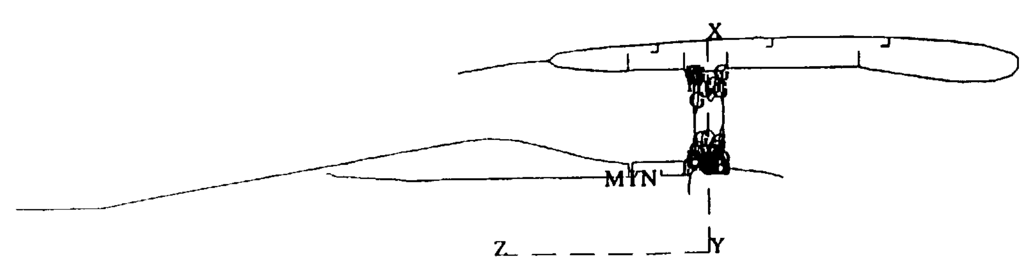
TITLE NASA rig w/ baseline vane: vane loads

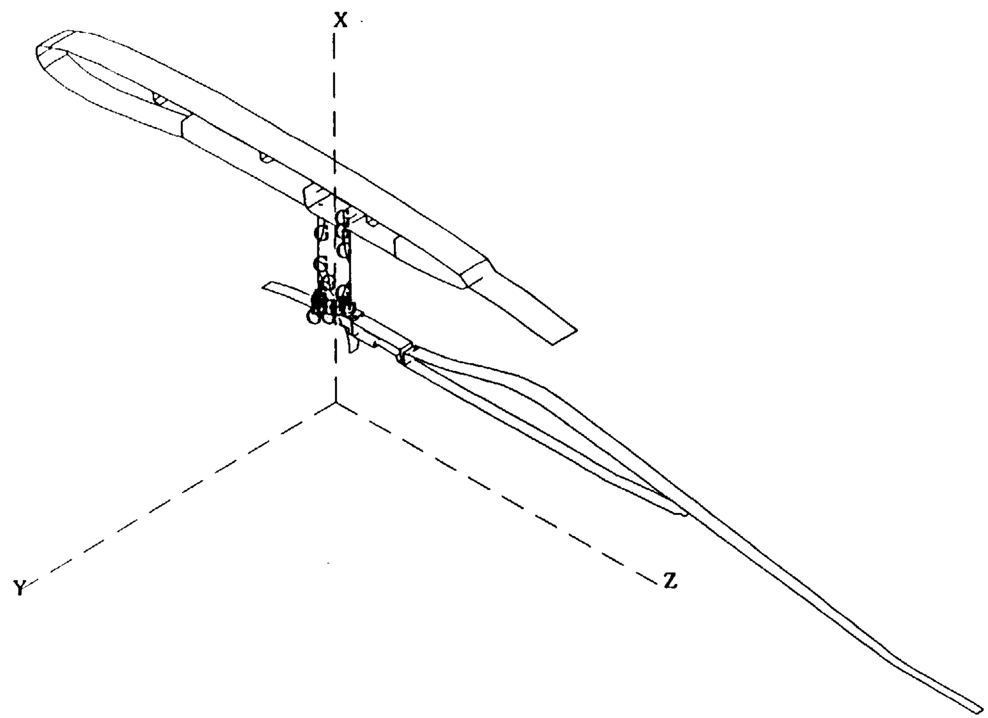
updated 2/8/95

CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS

SCALE = .0990 PLOT TIME AND DATE = 17:21:03 95/039

LOAD SET 1


X
MIN
Z
Y
*** LEGEND ***
KSI
A 60.00
B 51.00
C 42.00
D 33.00
E 24.00
F 15.00
G 6.00
*MAX 60.09
MIN .00
*DENOTES HIDDEN
updated 2/8/95
TITLE NASA rig w/ baseline vane: vane loads
CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS
SCALE = .1000 PLOT TIME AND DATE = 17:22:28 95/039
LOAD SET 1



*** LEGEND ***

	KSI
A	60.00
B	51.00
C	42.00
D	33.00
E	24.00
F	15.00
G	6.00
*MAX	60.09
*MIN	.00

*DENOTES HIDDEN

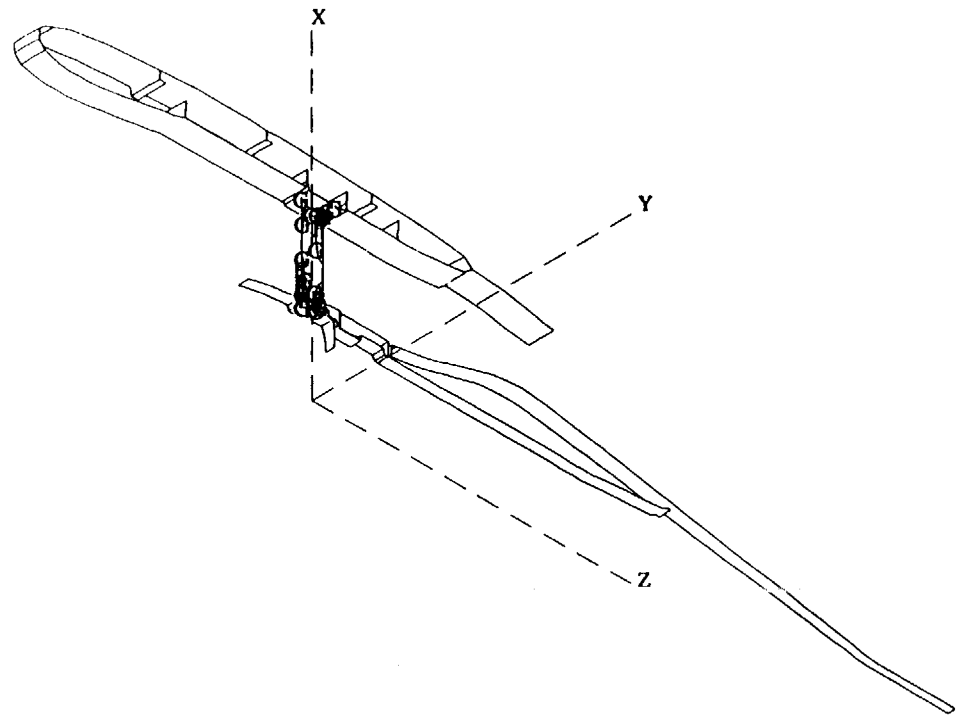
TITLE NASA rig w/ baseline vane: vane loads

updated 2/8/95

CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS

SCALE = .1300 PLOT TIME AND DATE = 17:23:59 95/039

LOAD SET 1



*** LEGEND ***	
	KSI
A	60.00
B	51.00
C	42.00
D	33.00
E	24.00
F	15.00
G	6.00
*MAX	60.09
*MIN	.00
*DENOTES HIDDEN	

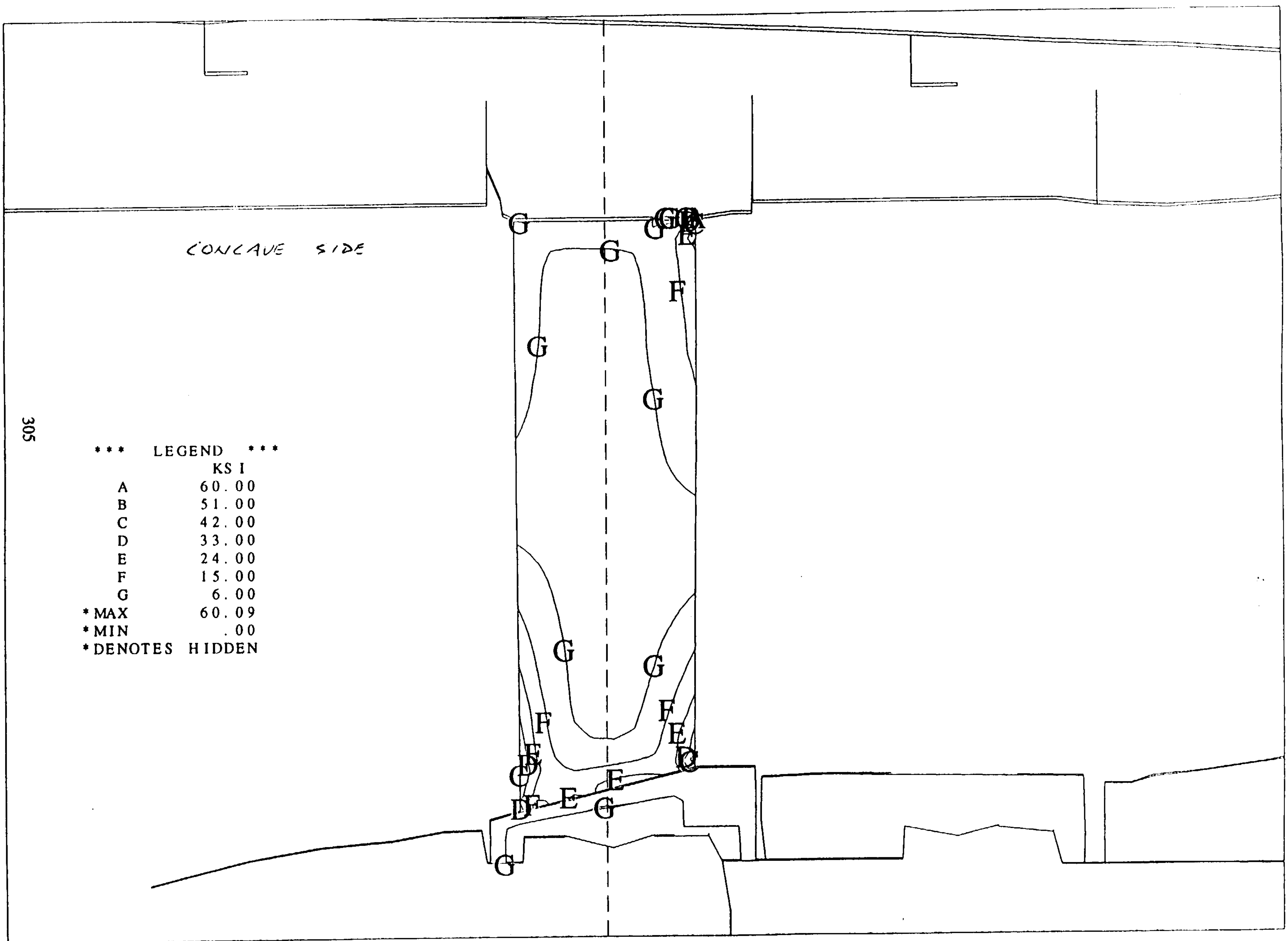
TITLE NASA rig w/ baseline vane: vane loads

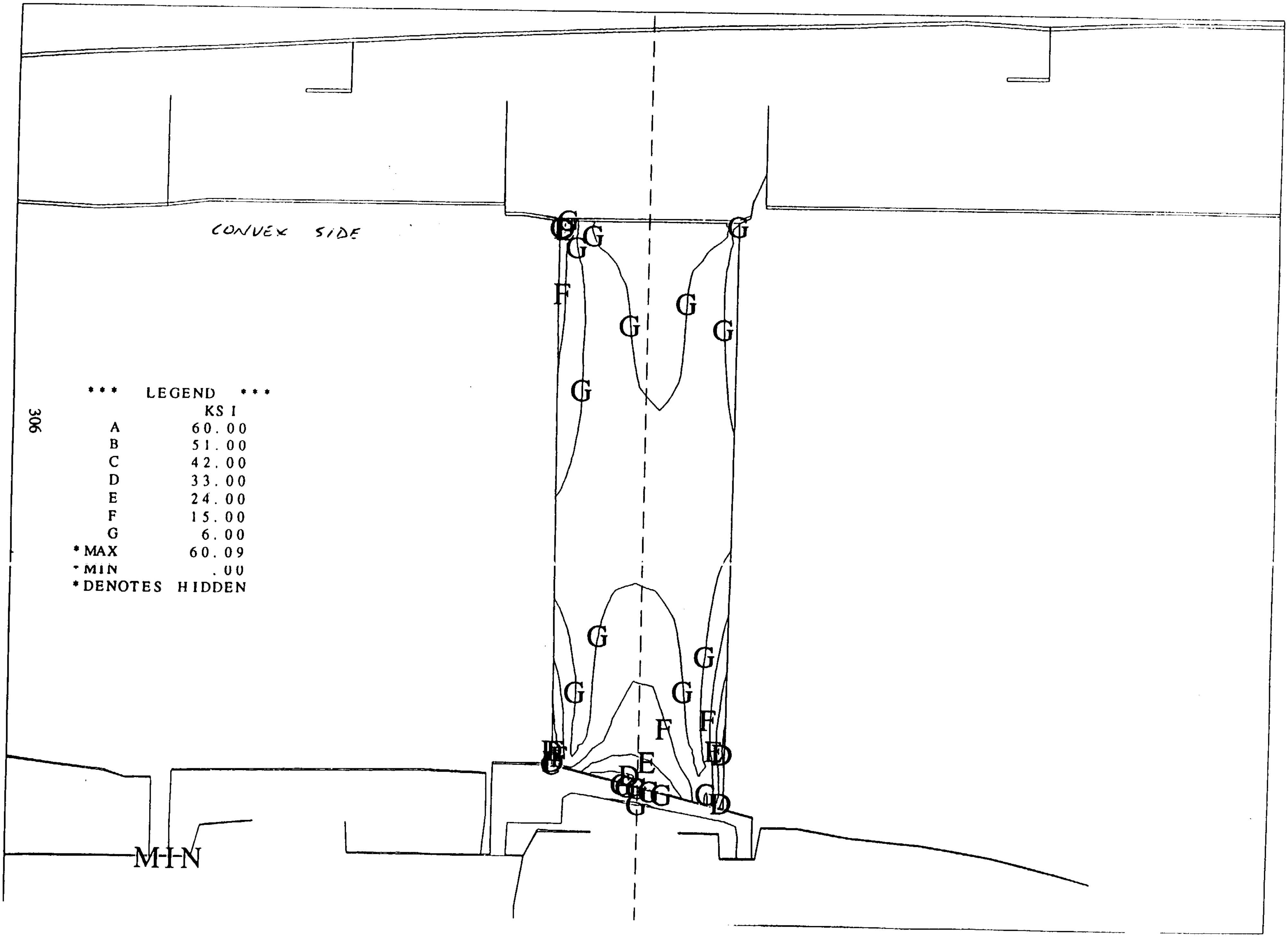
updated 2/8/95

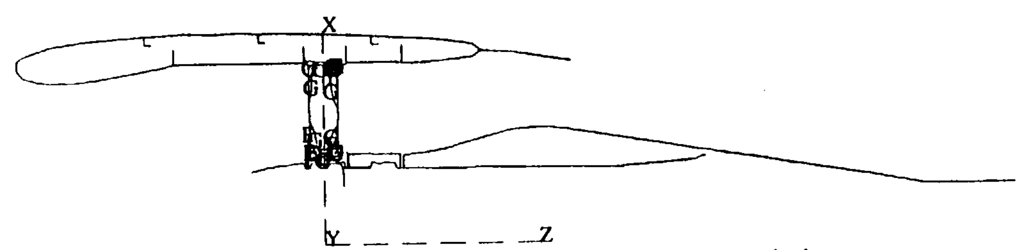
CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS

SCALE = .1300 PLOT TIME AND DATE = 17:25:22 95/039

LOAD SET 1


CONCAVE SIDE
*** LEGEND ***
KSI
A 60.00
B 51.00
C 42.00
D 33.00
E 24.00
F 15.00
G 6.00
*MAX 60.09
*MIN .00
*DENOTES HIDDEN


CONVEX SIDE
*** LEGEND ***
KSI
A 60.00
B 51.00
C 42.00
D 33.00
E 24.00
F 15.00
G 6.00
*MAX 60.09
*MIN .00
*DENOTES HIDDEN
MIN



*** LEGEND ***

	KSI
A	67.00
B	57.00
C	47.00
D	37.00
E	27.00
F	17.00
G	7.00
*MAX	67.89
*MIN	.00

*DENOTES HIDDEN

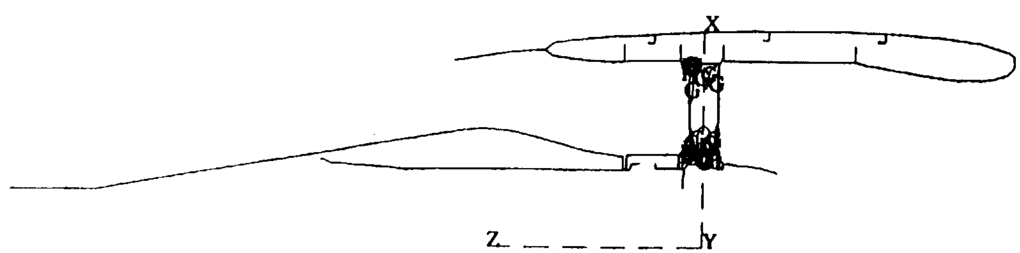
updated 2/8/95

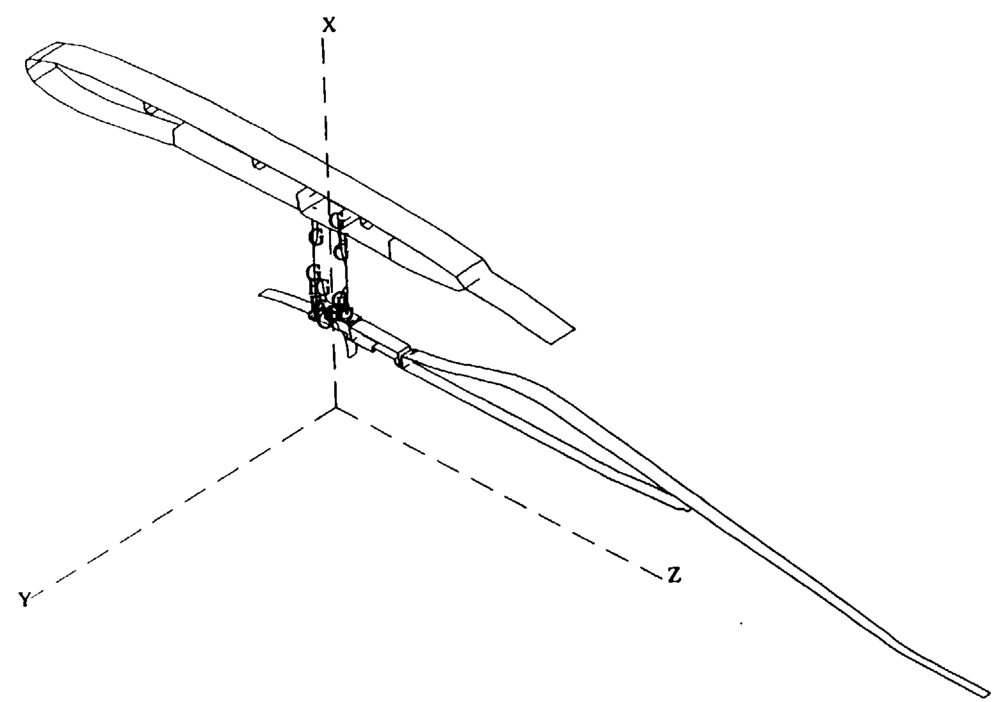
TITLE NASA rig w/ baseline vane: vane + AOA + weight;

CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS

SCALE = .0990 PLOT TIME AND DATE = 19:12:02 95/039

LOAD SET 3


X
Z
Y
*** LEGEND ***
KSI
A 67.00
B 57.00
C 47.00
D 37.00
E 27.00
F 17.00
G 7.00
*MAX 67.89
*MIN .00
*DENOTES HIDDEN
TITLE NASA rig w/ baseline vane: vane + AOA + weight;
CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS
SCALE = .1000 PLOT TIME AND DATE = 19:13:26 95/039
updated 2/8/95
LOAD SET 3



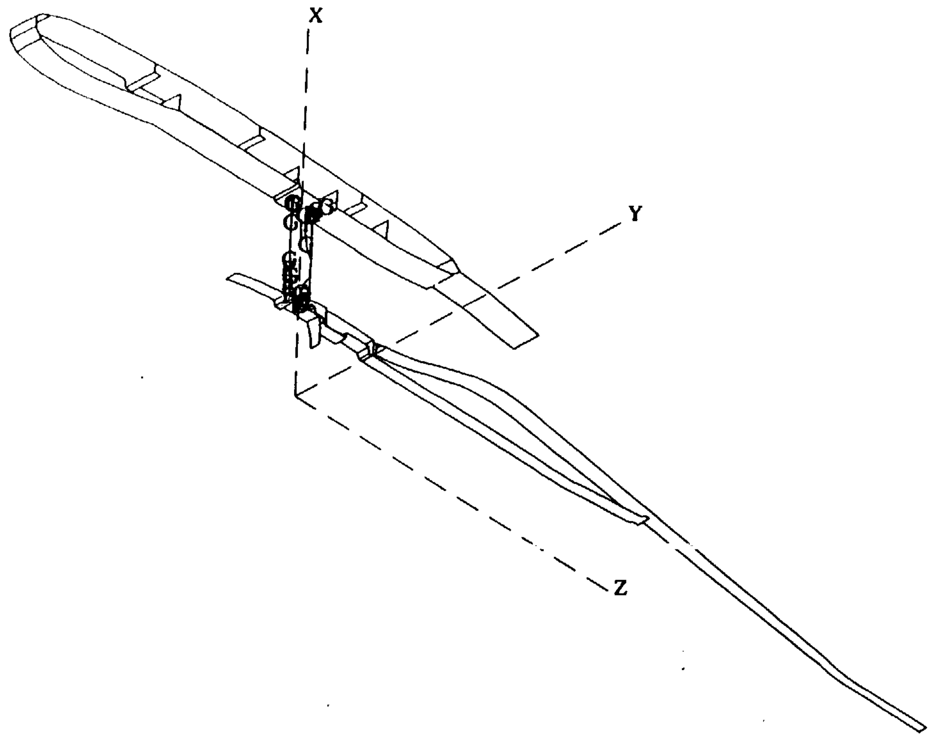
*** LEGEND ***	KSI
A	67.00
B	57.00
C	47.00
D	37.00
E	27.00
F	17.00
G	7.00
*MAX	67.89
*MIN	.00

*DENOTES HIDDEN

updated 2/8/95

TITLE NASA rig w/ baseline vane: vane + AOA + weight;
CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS
SCALE = .1300 PLOT TIME AND DATE = 19:14:45 95/039

LOAD SET 3



*** LEGEND ***

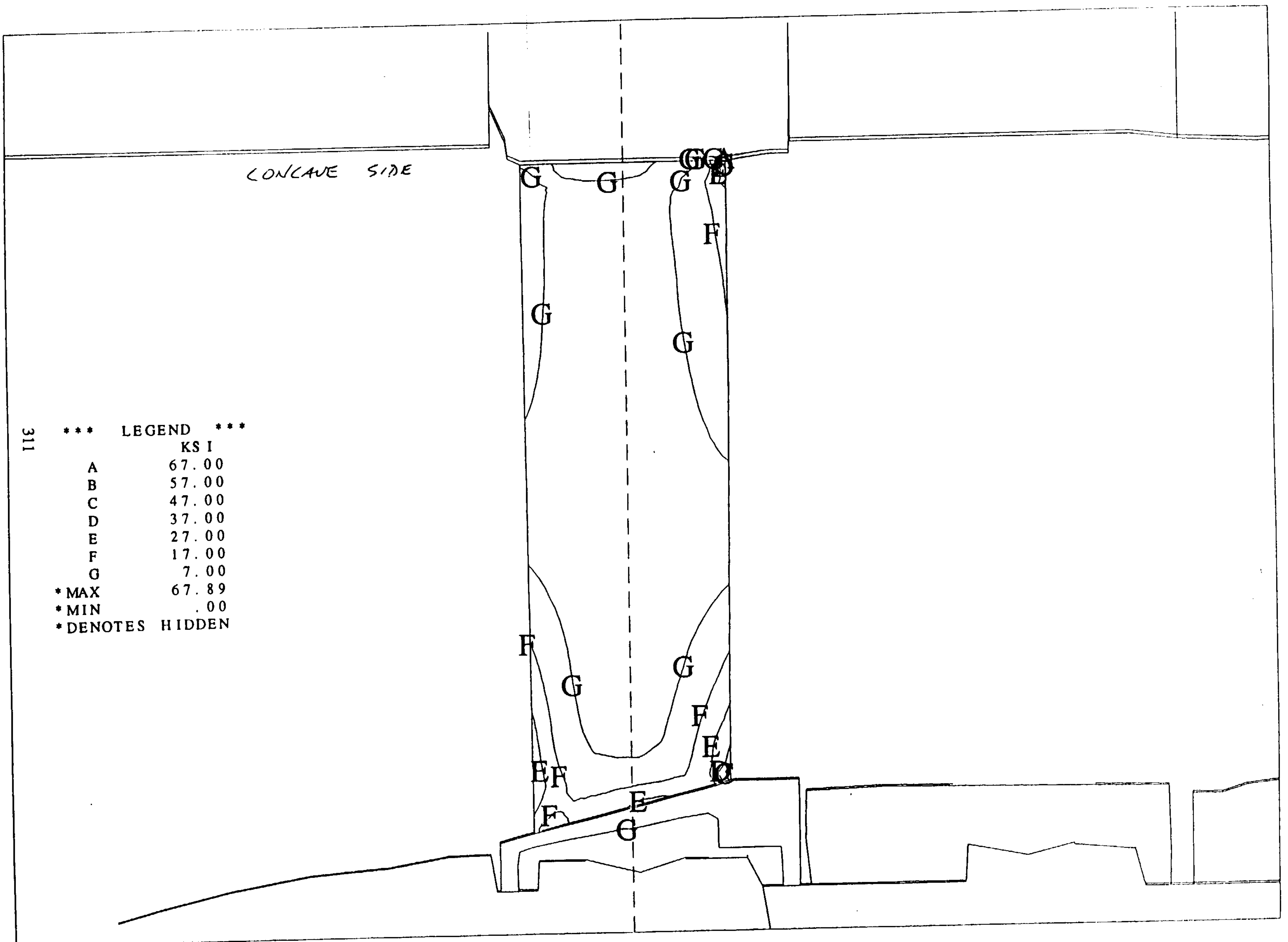
	KSI
A	67.00
B	57.00
C	47.00
D	37.00
E	27.00
F	17.00
G	7.00
*MAX	67.89
*MIN	.00

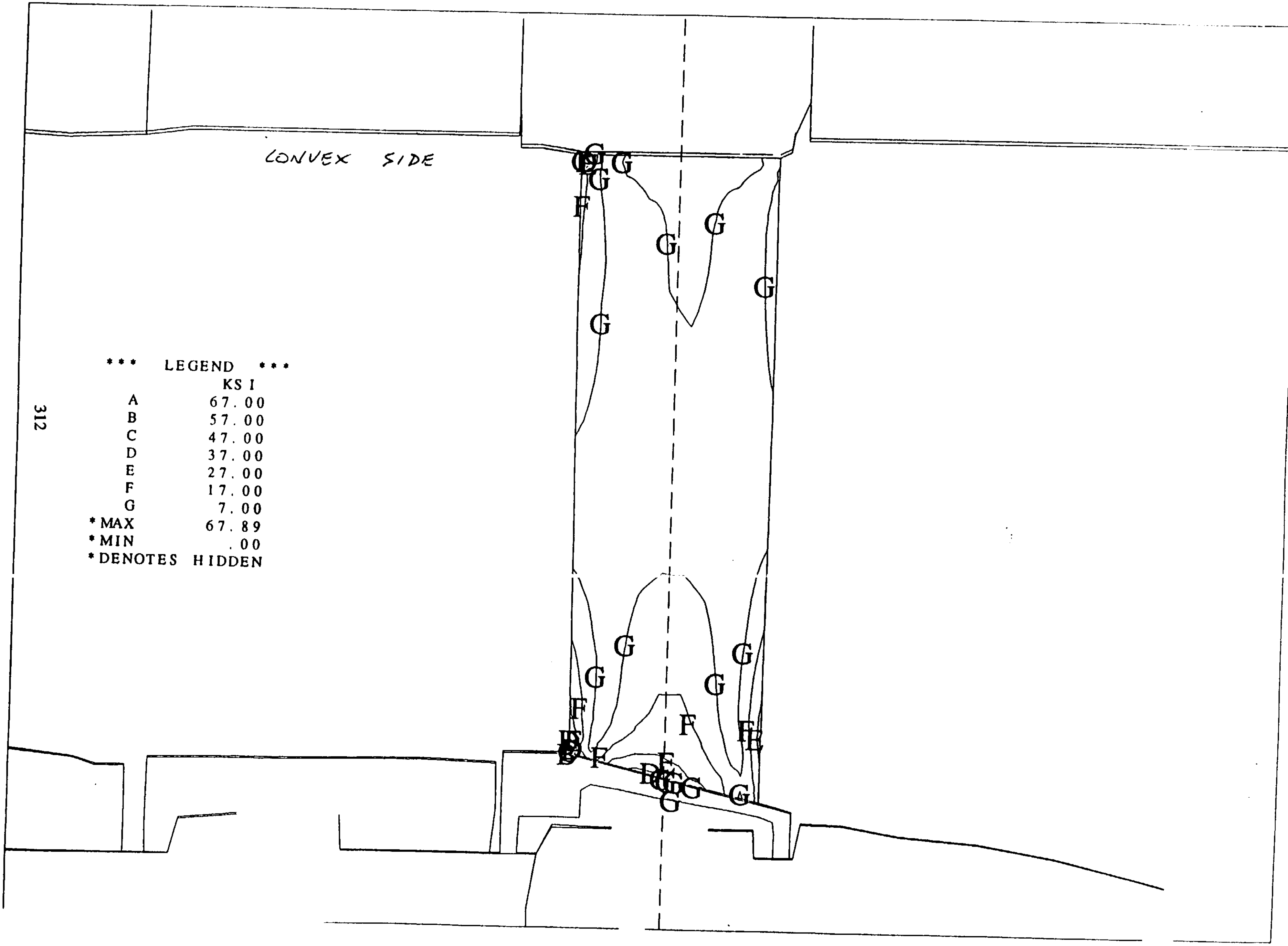
*DENOTES HIDDEN

TITLE NASA rig w/ baseline vane: vane + AOA + weight;
CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS
SCALE = .1300 PLOT TIME AND DATE = 19:15:49 95/039

updated 2/8/95

LOAD SET 3

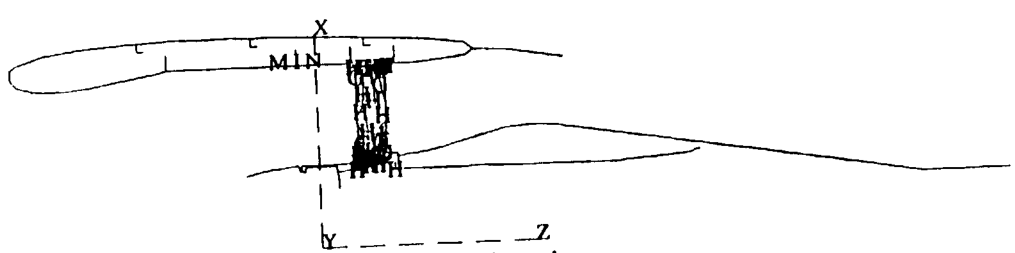

CONCAVE SIDE
*** LEGEND ***
KSI
A 67.00
B 57.00
C 47.00
D 37.00
E 27.00
F 17.00
G 7.00
* MAX 67.89
* MIN .00
* DENOTES HIDDEN


CONVEX SIDE
*** LEGEND ***
KSI
A 67.00
B 57.00
C 47.00
D 37.00
E 27.00
F 17.00
G 7.00
*MAX 67.89
*MIN .00
*DENOTES HIDDEN

*** LEGEND ***

	KSI
A	59.00
B	51.00
C	43.00
D	35.00
E	27.00
F	19.00
G	11.00
H	3.00
*MAX	59.38
MIN	.00

*DENOTES HIDDEN



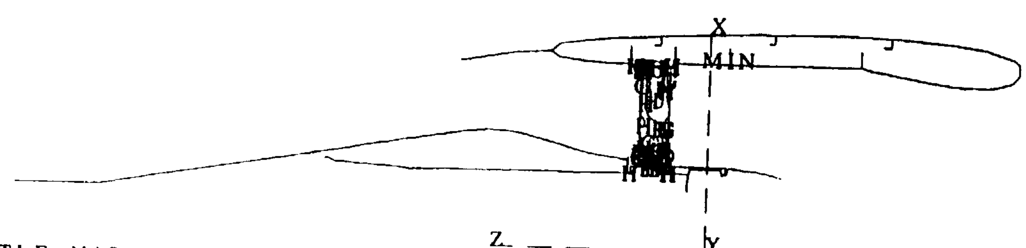
3/07/95

TITLE NASA rig w/ aft vane: vane loads

CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS

SCALE = .0990 PLOT TIME AND DATE = 16:08:01 95/066

LOAD SET 1



TITLE NASA rig w/ aft vane: vane loads
CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS
SCALE = .1000 PLOT TIME AND DATE = 16:08:51 95/066

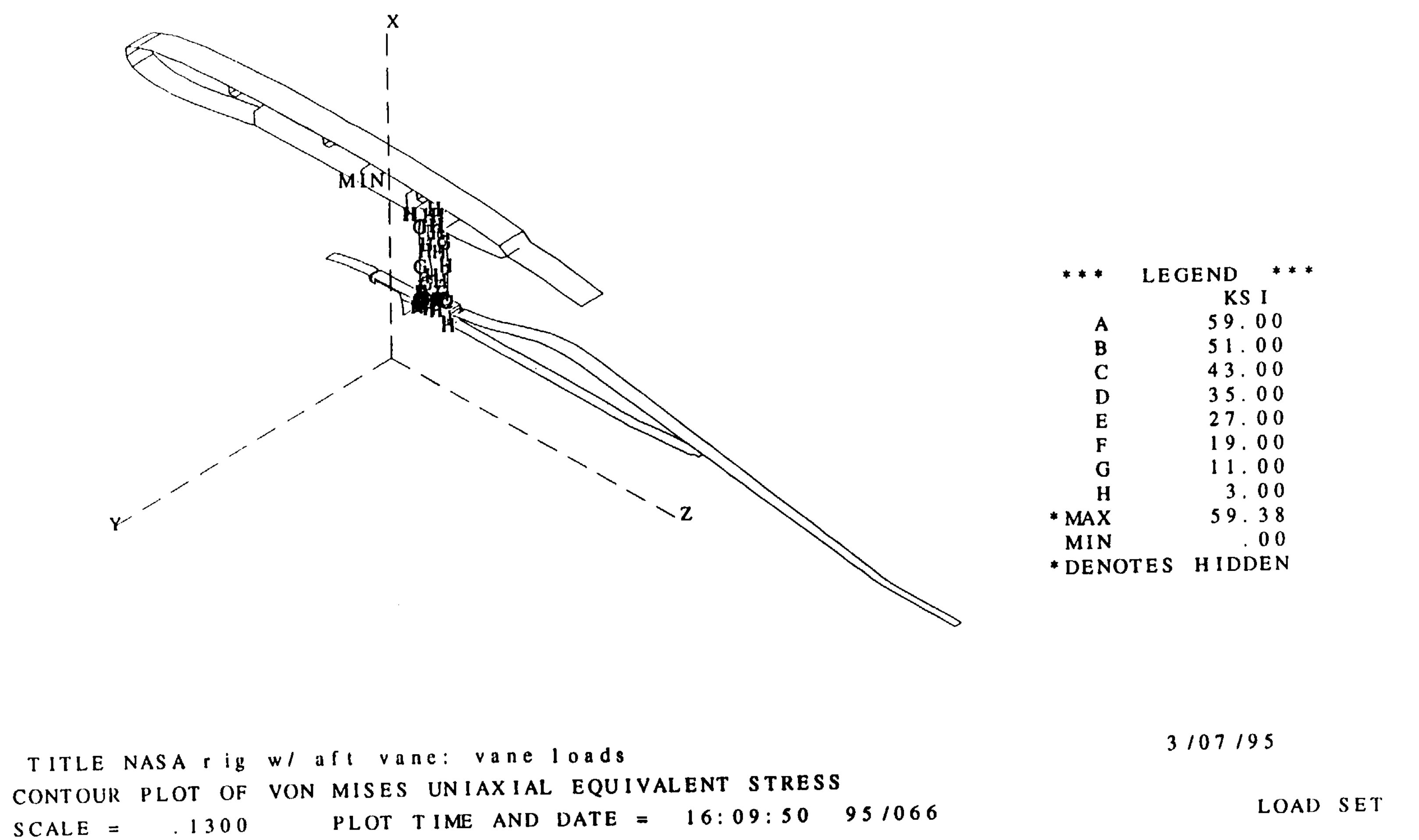
*** LEGEND ***

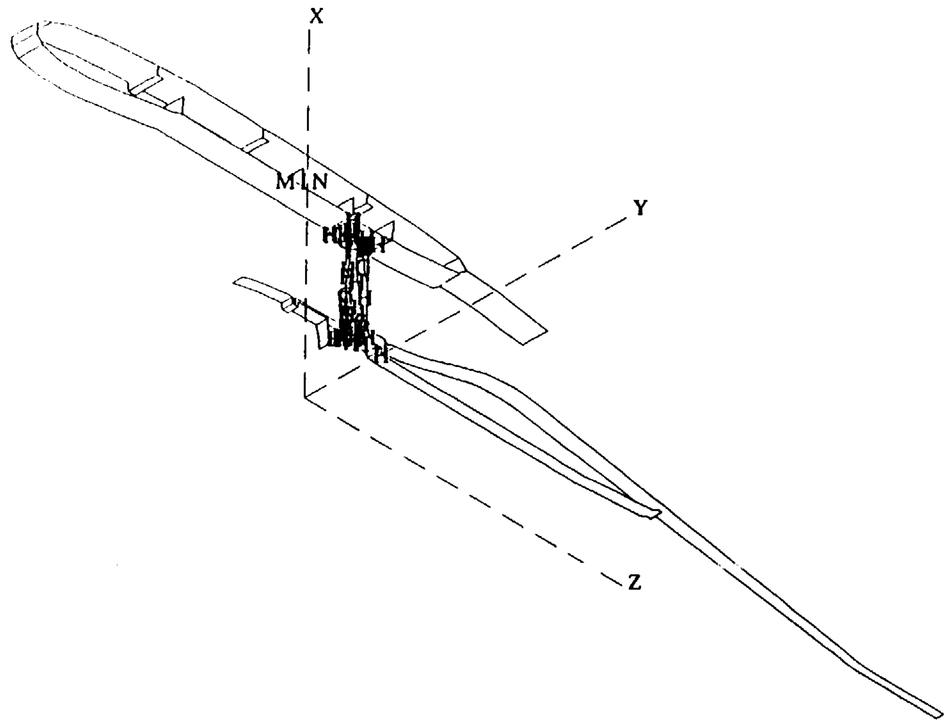
	KSI
A	59.00
B	51.00
C	43.00
D	35.00
E	27.00
F	19.00
G	11.00
H	3.00
*MAX	59.38
MIN	.00

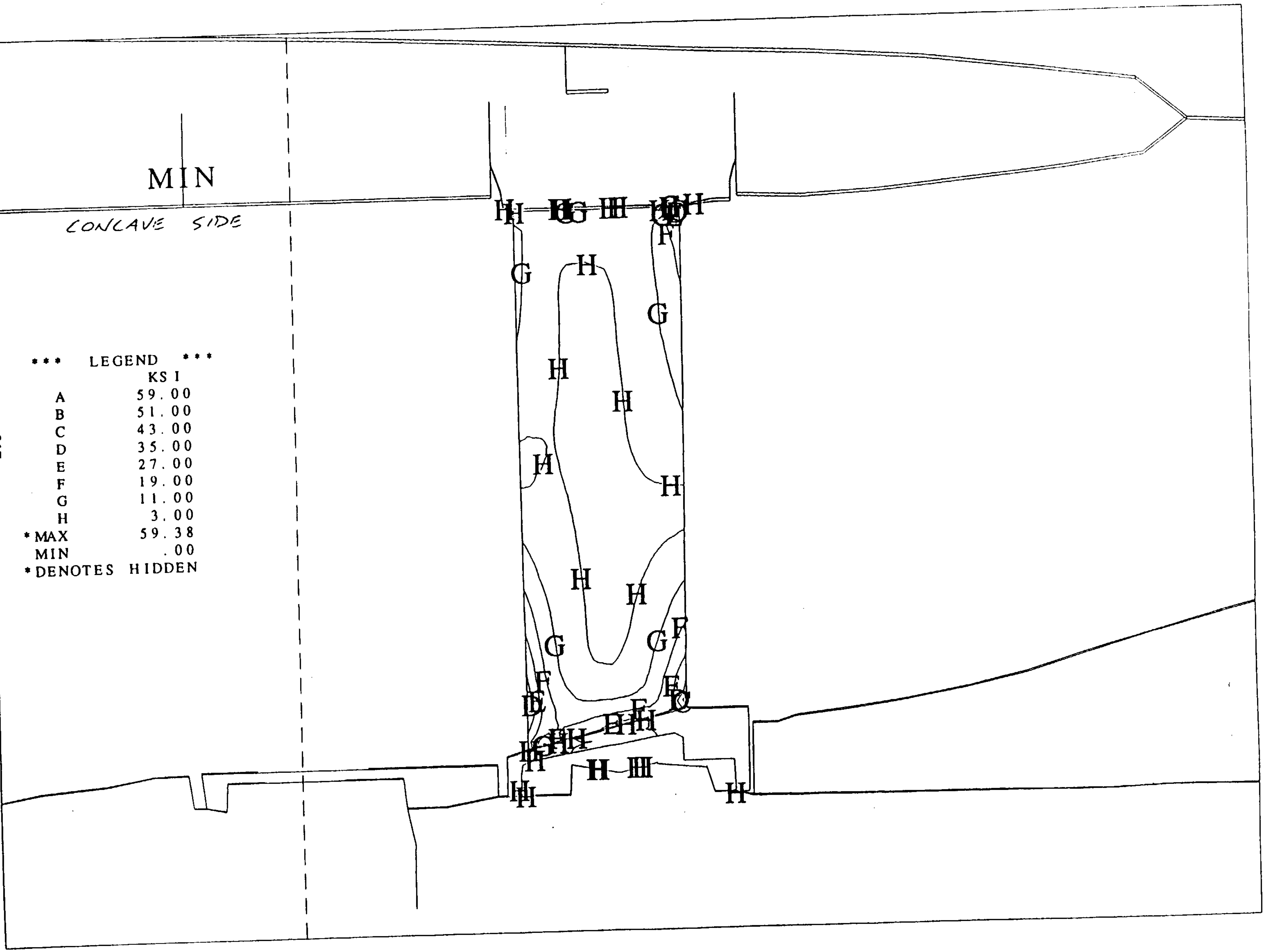
*DENOTES HIDDEN

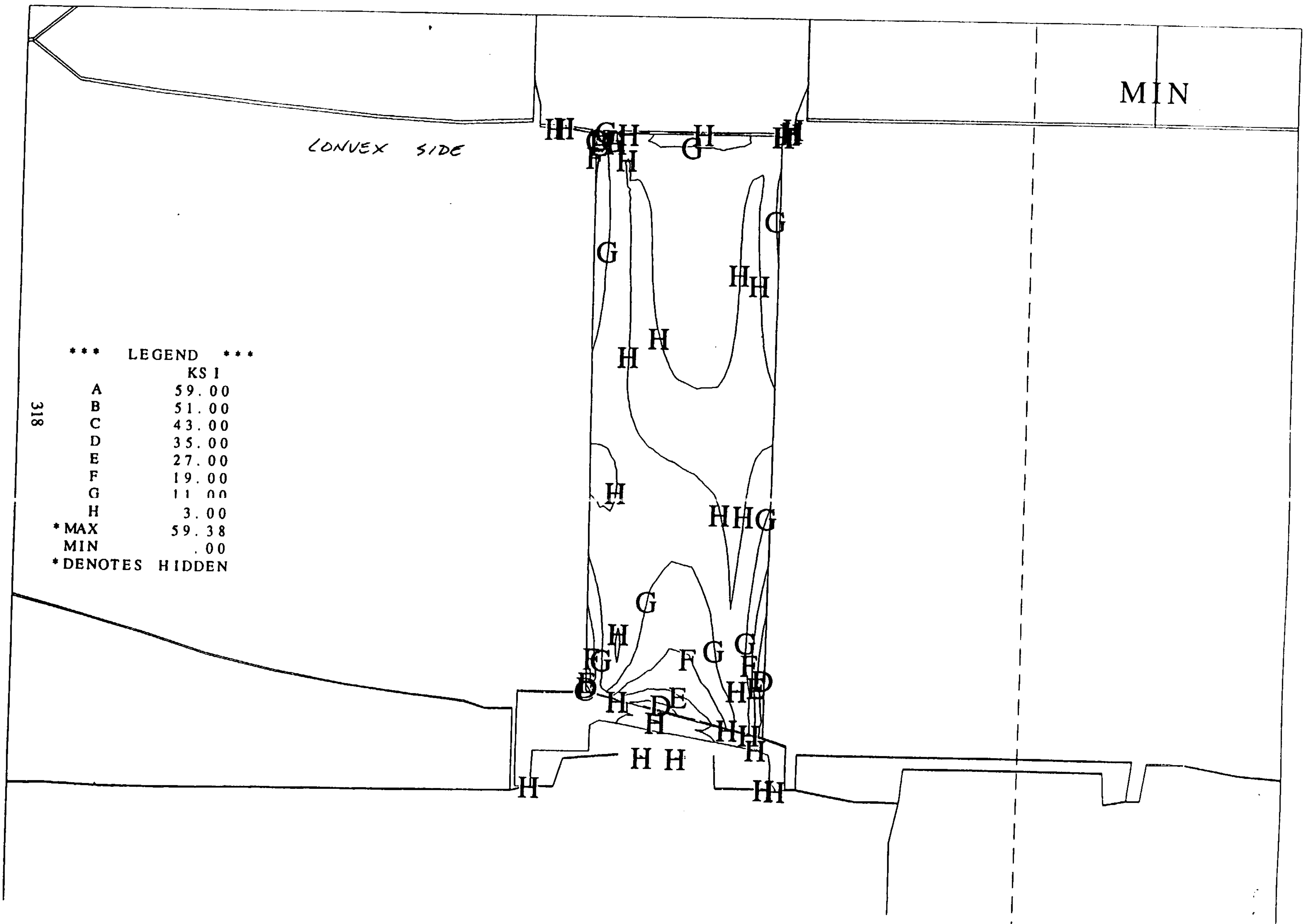
3/07/95

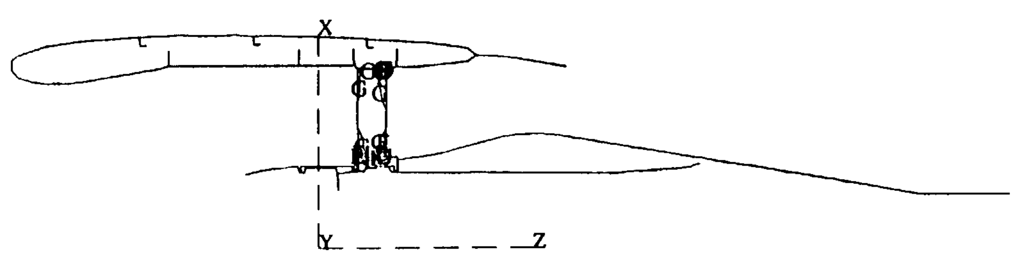
LOAD SET 1


X
Y
Z
MIN
*** LEGEND ***
KSI
A 59.00
B 51.00
C 43.00
D 35.00
E 27.00
F 19.00
G 11.00
H 3.00
*MAX 59.38
MIN .00
*DENOTES HIDDEN
3/07/95
TITLE NASA rig w/ aft vane: vane loads
CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS
SCALE = .1300 PLOT TIME AND DATE = 16:09:50 95/066
LOAD SET 1


X
Y
Z
MIN
*** LEGEND ***
KSI
A 59.00
B 51.00
C 43.00
D 35.00
E 27.00
F 19.00
G 11.00
H 3.00
*MAX 59.38
MIN .00
*DENOTES HIDDEN
TITLE NASA rig w/ aft vane: vane loads
3/07/95
CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS
SCALE = .1300 PLOT TIME AND DATE = 16:10:46 95/066
LOAD SET 1


MIN
CONCAVE SIDE
*** LEGEND ***
KSI
A 59.00
B 51.00
C 43.00
D 35.00
E 27.00
F 19.00
G 11.00
H 3.00
*MAX 59.38
MIN .00
*DENOTES HIDDEN


MIN
CONVEX SIDE
*** LEGEND ***
KSI
A 59.00
B 51.00
C 43.00
D 35.00
E 27.00
F 19.00
G 11.00
H 3.00
*MAX 59.38
MIN .00
*DENOTES HIDDEN

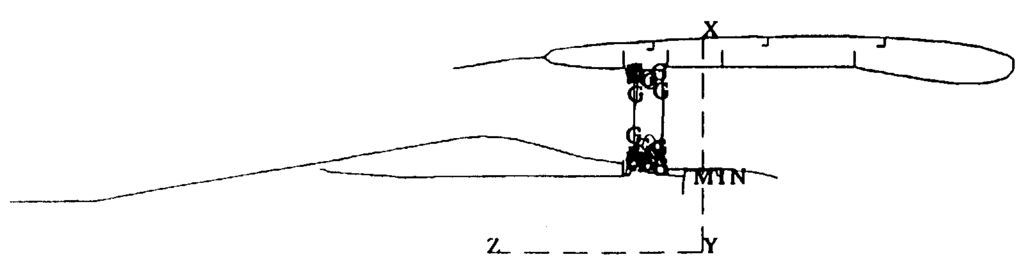


*** LEGEND ***	
	KSI
A	68.00
B	58.00
C	48.00
D	38.00
E	28.00
F	18.00
G	8.00
*MAX	68.84
*MIN	.00
*DENOTES HIDDEN	

TITLE NASA rig w/ aft vane: vane + AOA + weight; 3/07/95

CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS

SCALE = .0990 PLOT TIME AND DATE = 17:21:32 95/066 LOAD SET 3



*** LEGEND ***

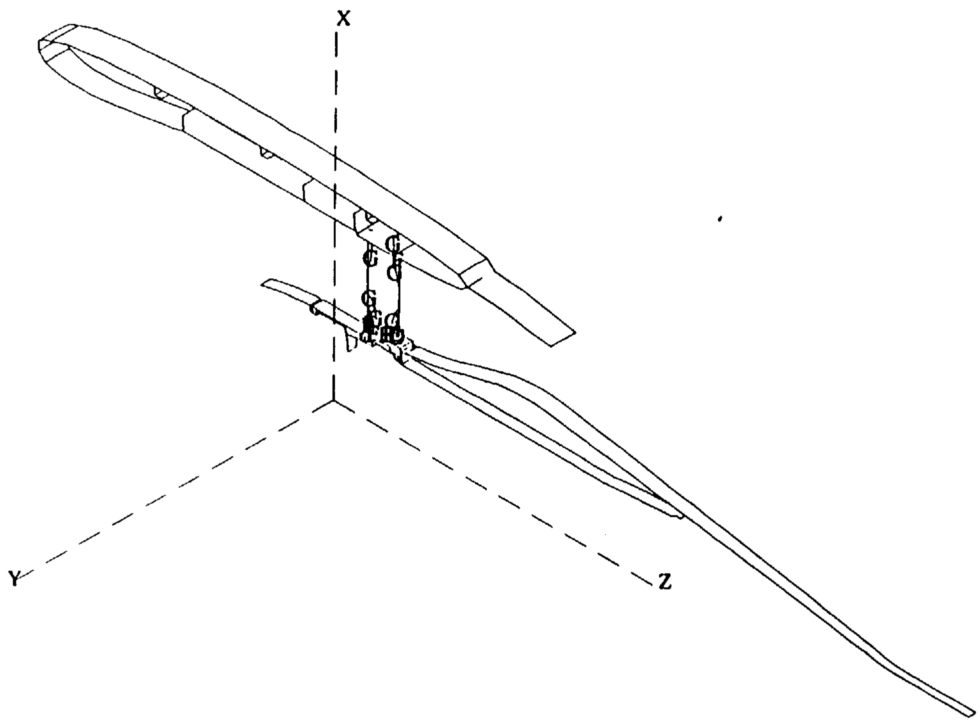
	KSI
A	68.00
B	58.00
C	48.00
D	38.00
E	28.00
F	18.00
G	8.00
*MAX	68.84
MIN	.00

*DENOTES HIDDEN

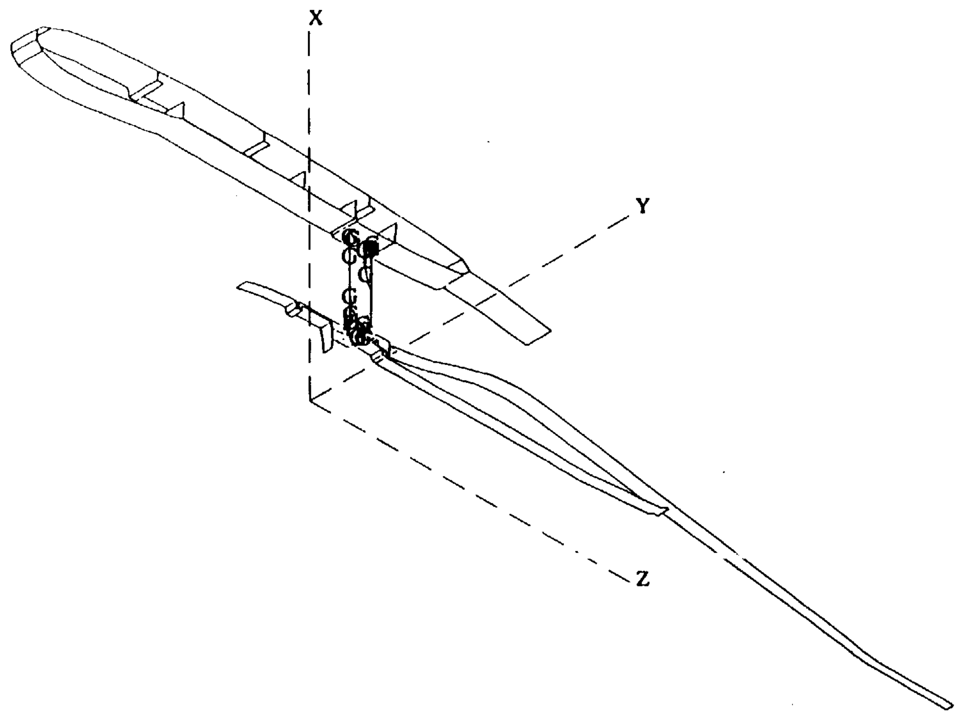
TITLE NASA rig w/ aft vane: vane + AOA + weight; 3/07/95

CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS

SCALE = .1000 PLOT TIME AND DATE = 17:22:22 95/066 LOAD SET 3



TITLE NASA rig w/ aft vane: vane + AOA + weight; 3/07/95
CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS
SCALE = .1300 PLOT TIME AND DATE = 17:23:11 95/066 LOAD SET 3

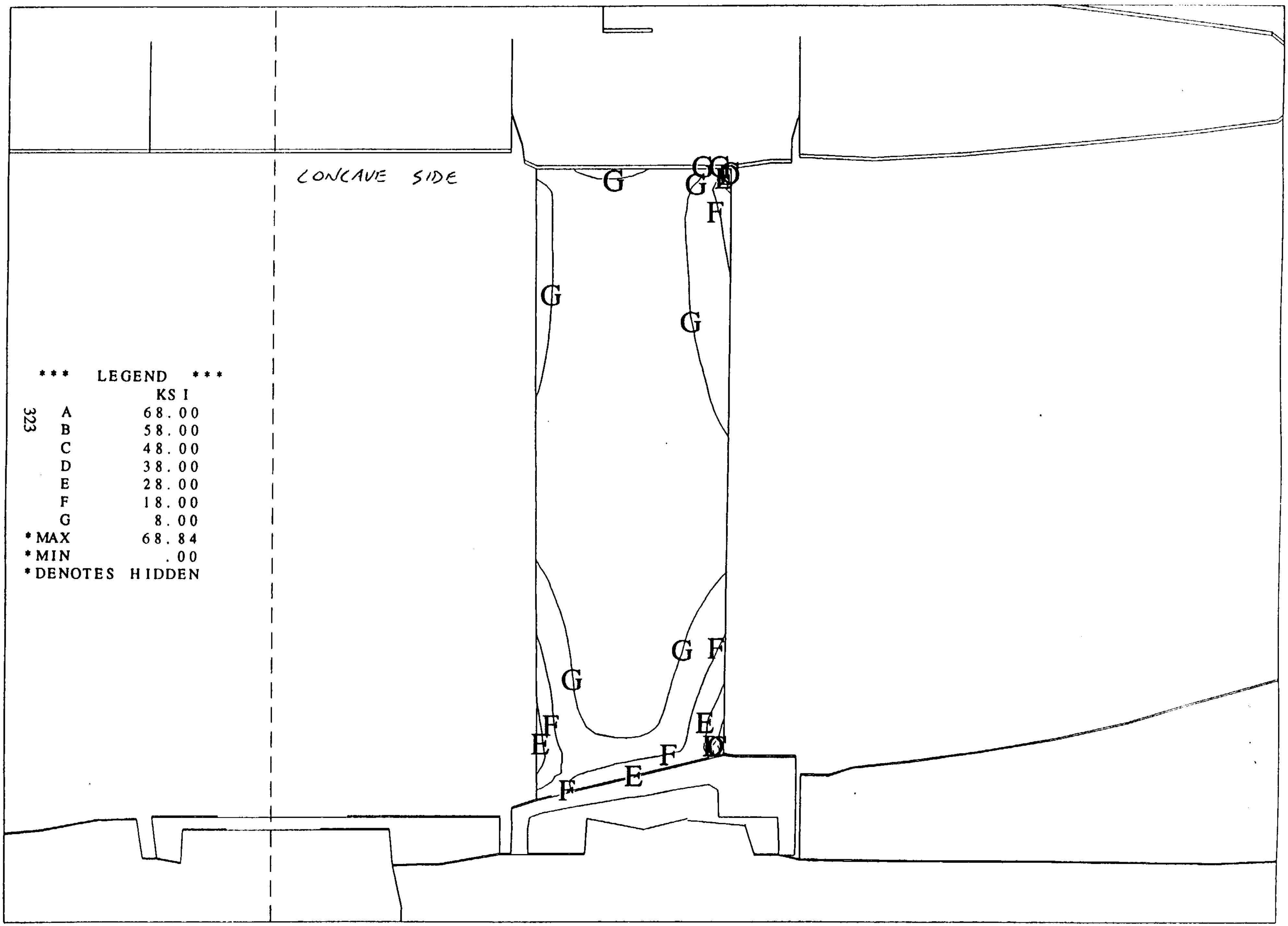


*** LEGEND ***

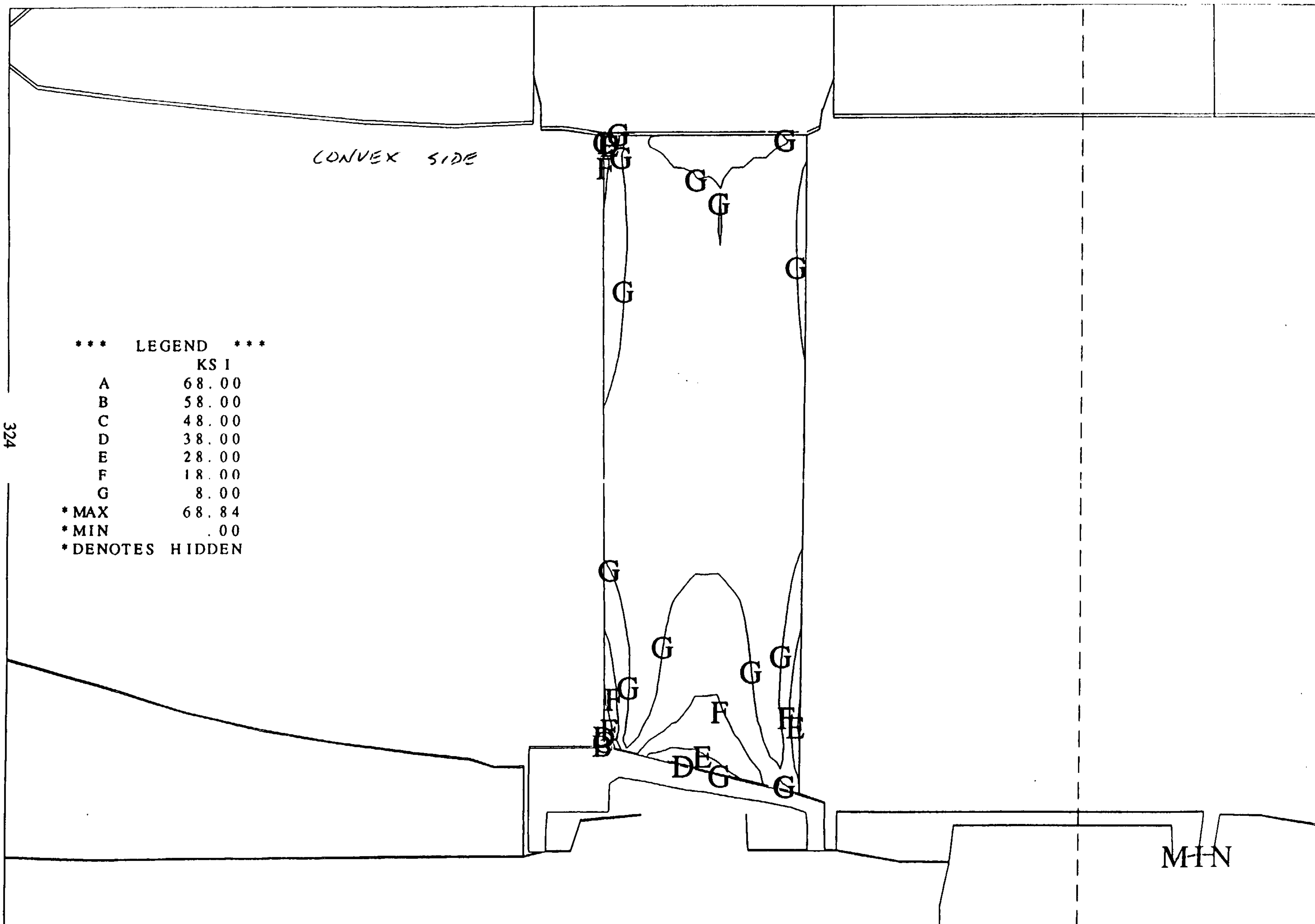
	KSI
A	68.00
B	58.00
C	48.00
D	38.00
E	28.00
F	18.00
G	8.00
*MAX	68.84
*MIN	.00

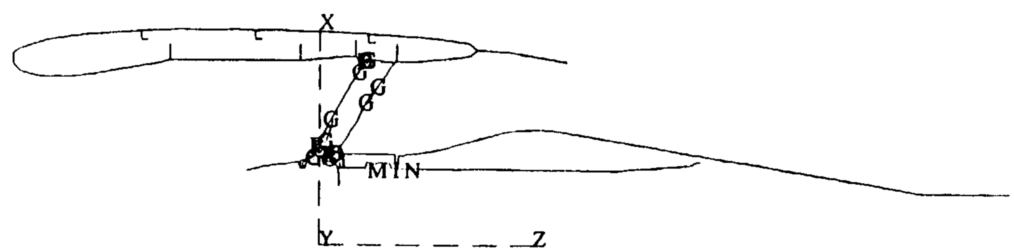
*DENOTES HIDDEN

TITLE NASA rig w/ aft vane: vane + AOA + weight; 3/07/95
CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS
SCALE = .1300 PLOT TIME AND DATE = 17:23:51 95/066 LOAD SET 3



CONCAVE SIDE
G
G G
G F
F
G
G
G F
G
F
E
E
F
E
F
*** LEGEND ***
KSI
A 68.00
B 58.00
C 48.00
D 38.00
E 28.00
F 18.00
G 8.00
*MAX 68.84
*MIN .00
*DENOTES HIDDEN
323


CONVEX SIDE
*** LEGEND ***
KSI
A 68.00
B 58.00
C 48.00
D 38.00
E 28.00
F 18.00
G 8.00
*MAX 68.84
*MIN .00
*DENOTES HIDDEN
MIN



*** LEGEND ***

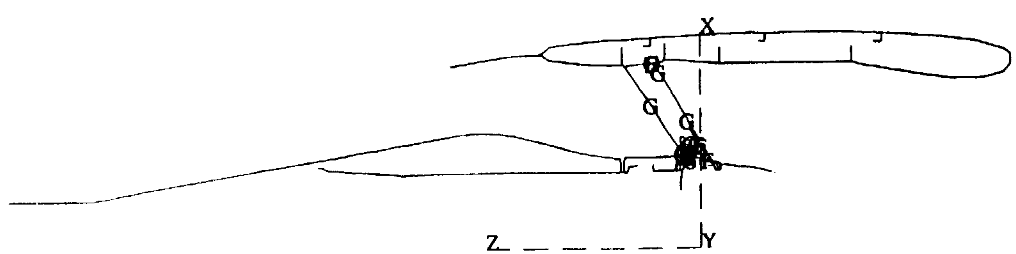
	KSI
A	70.00
B	60.00
C	50.00
D	40.00
E	30.00
F	20.00
G	10.00
*MAX	73.60
MIN	.00

*DENOTES HIDDEN

TITLE NASA rig w/ swept vane: vane loads updated 2/11/95

CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS

SCALE = .0990 PLOT TIME AND DATE = 08:03:39 95/042 LOAD SET 1



*** LEGEND ***

	KSI
A	70.00
B	60.00
C	50.00
D	40.00
E	30.00
F	20.00
G	10.00
*MAX	73.60
*MIN	.00

*DENOTES HIDDEN

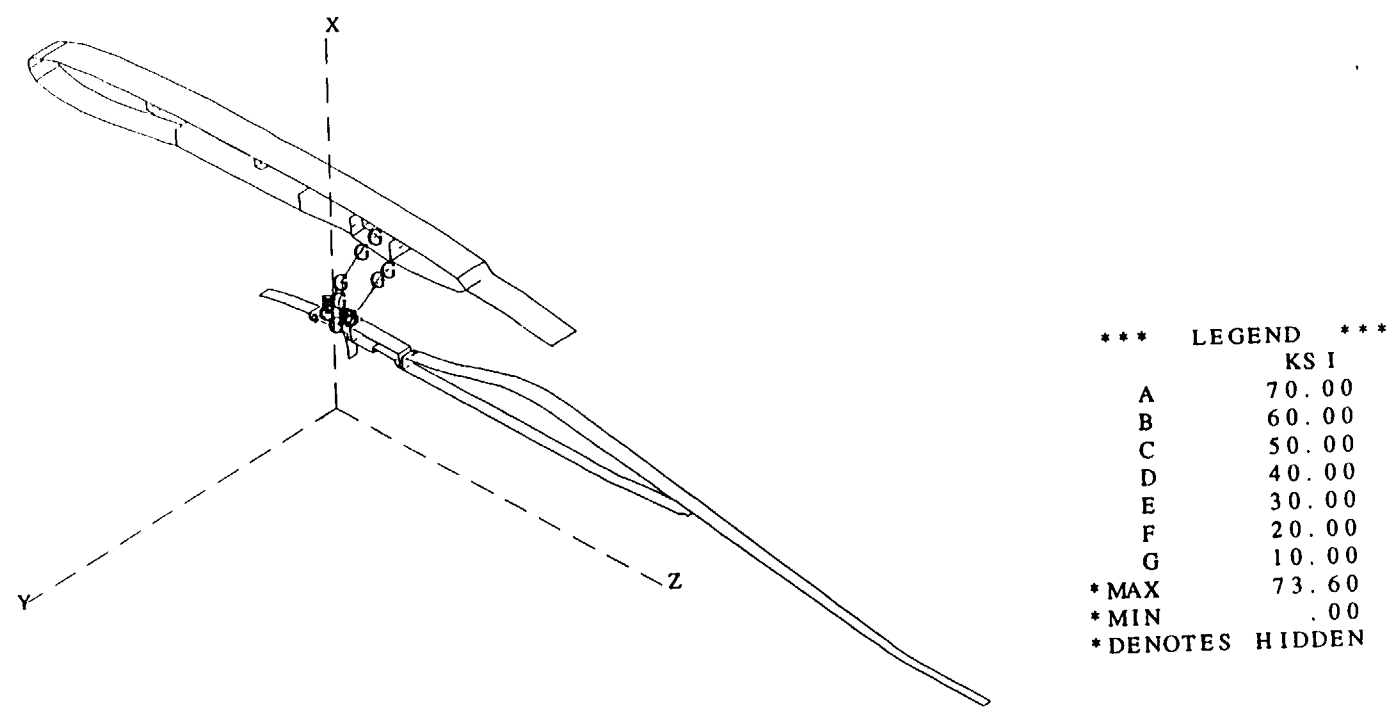
updated 2/11/95

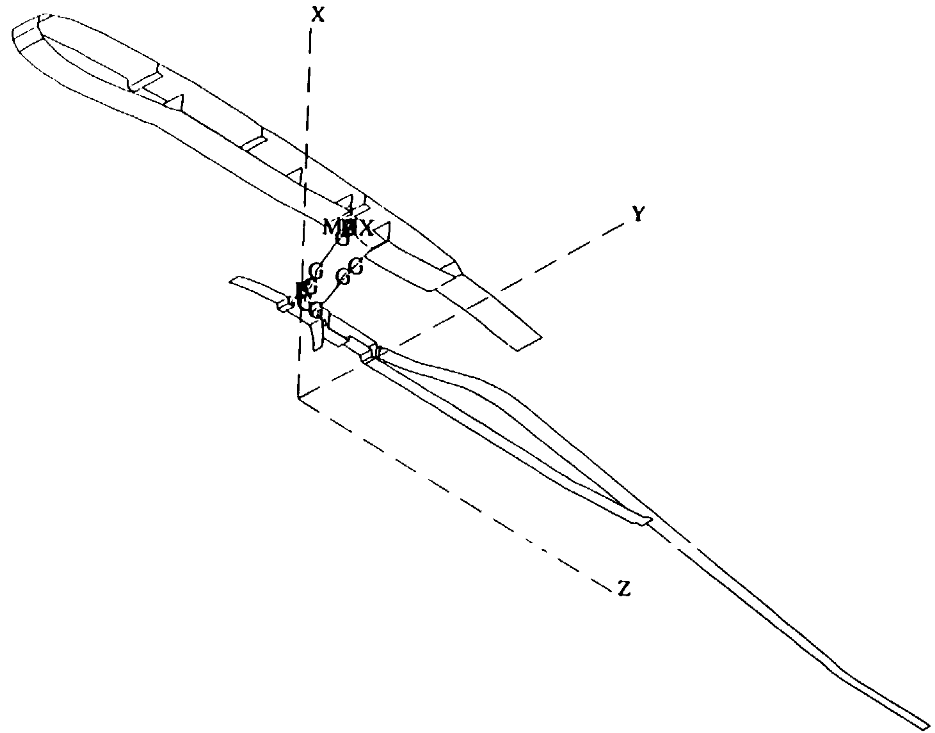
TITLE NASA rig w/ swept vane: vane loads

CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS

SCALE = .1000 PLOT TIME AND DATE = 08:04:10 95/042

LOAD SET 1


X
Y
Z
G
*** LEGEND ***
KSI
A 70.00
B 60.00
C 50.00
D 40.00
E 30.00
F 20.00
G 10.00
*MAX 73.60
*MIN .00
*DENOTES HIDDEN
updated 2/11/95
TITLE NASA rig w/ swept vane: vane loads
CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS
SCALE = .1300 PLOT TIME AND DATE = 08:04:38 95/042
LOAD SET 1



*** LEGEND ***

	KSI
A	70.00
B	60.00
C	50.00
D	40.00
E	30.00
F	20.00
G	10.00
MAX	73.60
*MIN	.00

*DENOTES HIDDEN

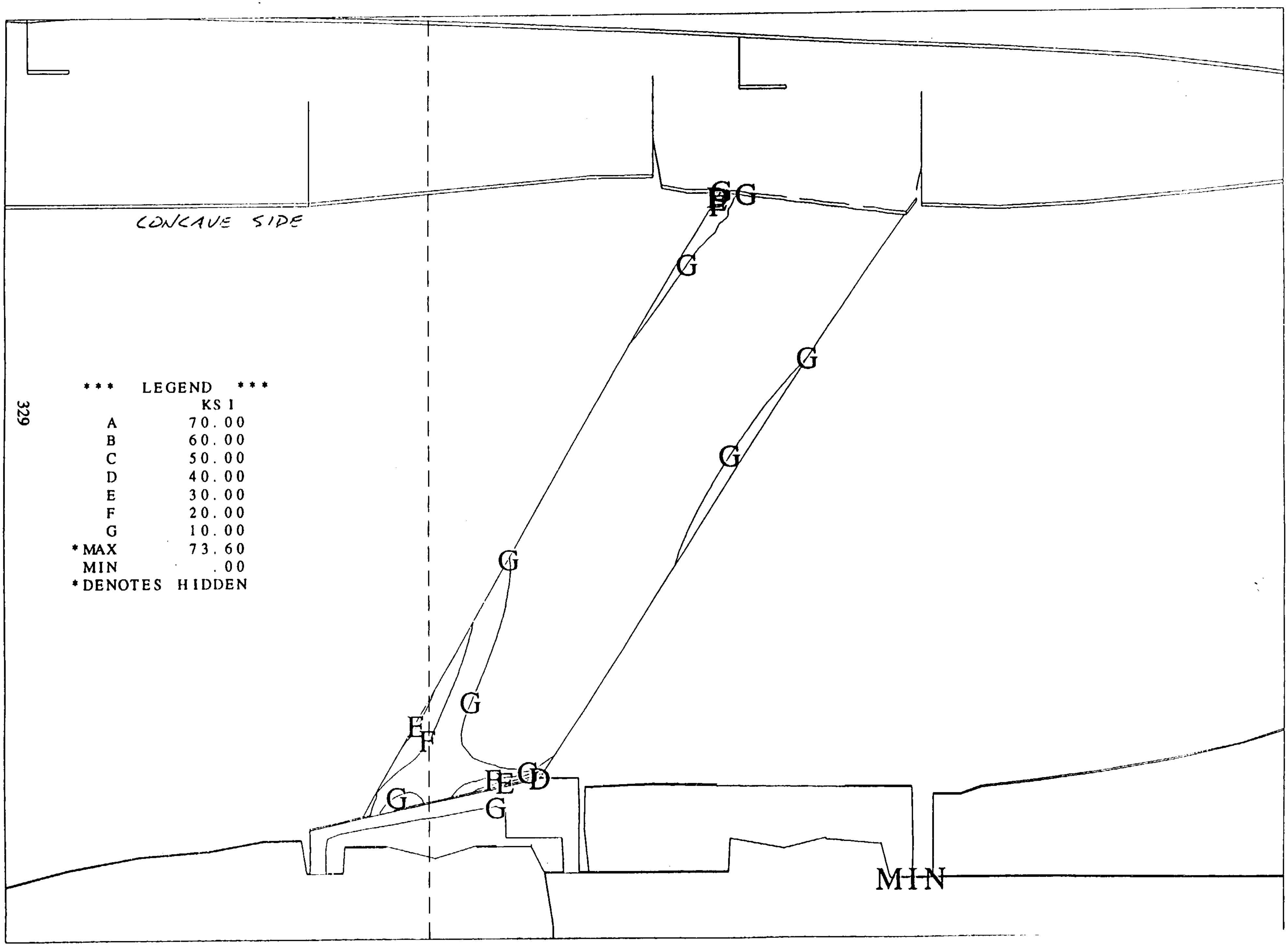
TITLE NASA rig w/ swept vane: vane loads

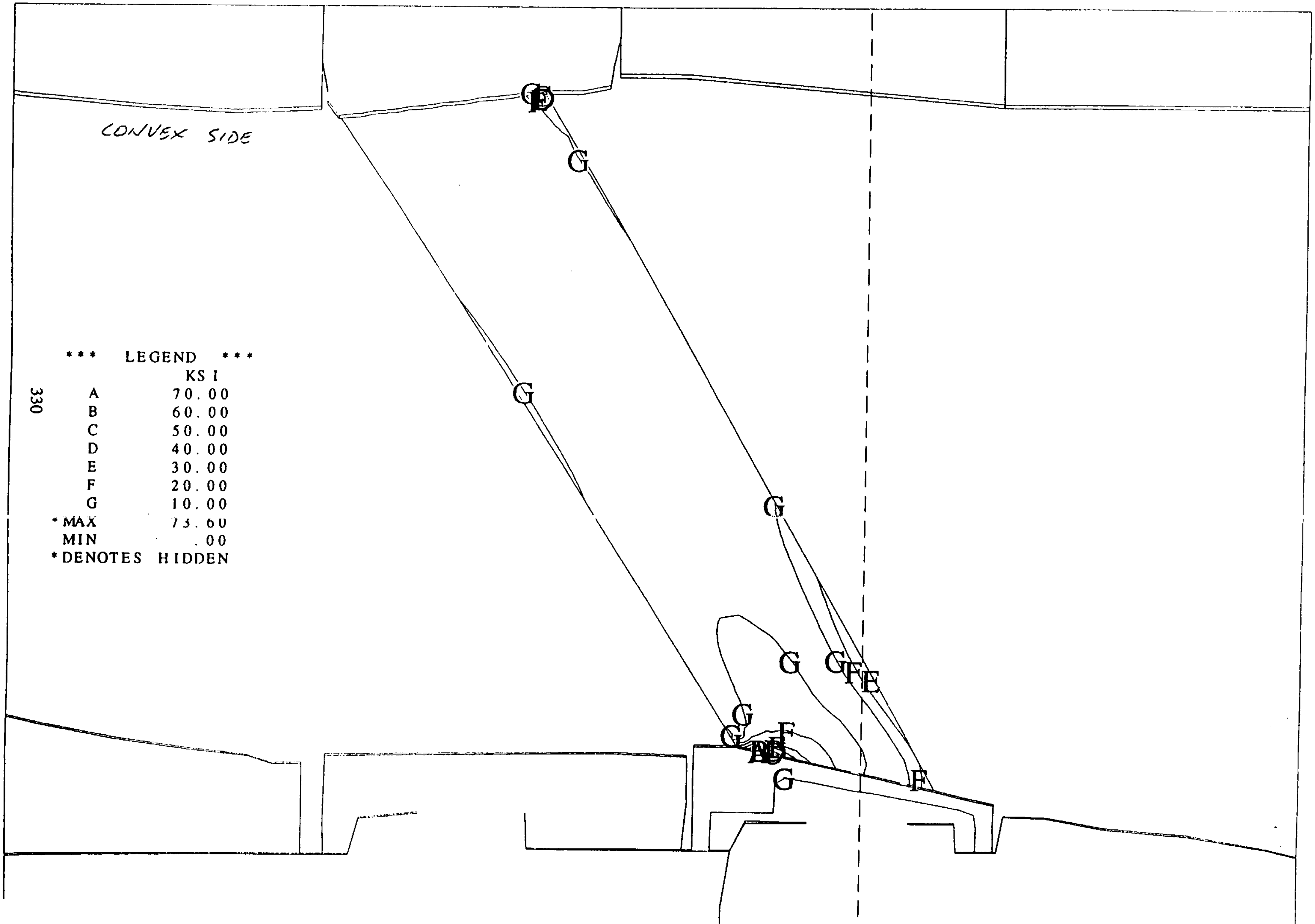
CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS

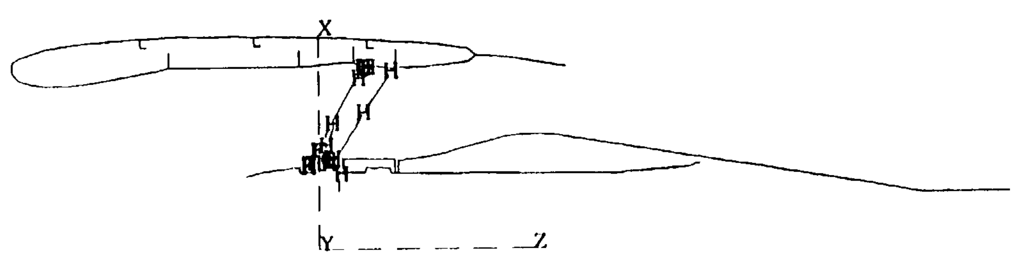
SCALE = .1300 PLOT TIME AND DATE = 08:05:04 95/042

updated 2/11/95

LOAD SET 1


CONCAVE SIDE
*** LEGEND ***
KSI
A 70.00
B 60.00
C 50.00
D 40.00
E 30.00
F 20.00
G 10.00
*MAX 73.60
MIN .00
*DENOTES HIDDEN
MIN


CONVEX SIDE
*** LEGEND ***
KSI
A 70.00
B 60.00
C 50.00
D 40.00
E 30.00
F 20.00
G 10.00
*MAX 73.60
MIN .00
*DENOTES HIDDEN
A
B
C
D
E
F
G



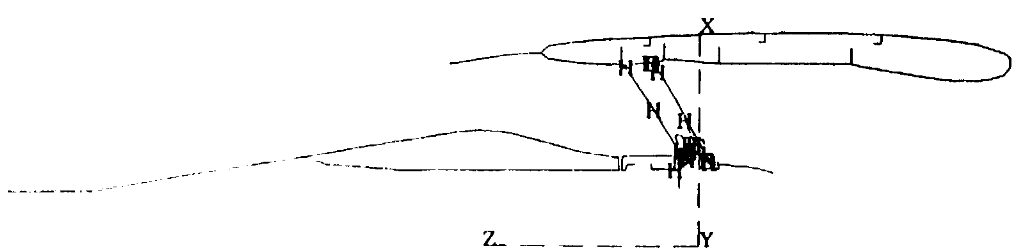
*** LEGEND ***	
	KSI
A	80.00
B	70.00
C	60.00
D	50.00
E	40.00
F	30.00
G	20.00
H	10.00
*MAX	88.81
*MIN	.00

*DENOTES HIDDEN

TITLE NASA rig w/ swept vane: vane + AOA loads + weight updated 2/11/95

CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS

SCALE = .0990 PLOT TIME AND DATE = 08:29:20 95/042 LOAD SET 3

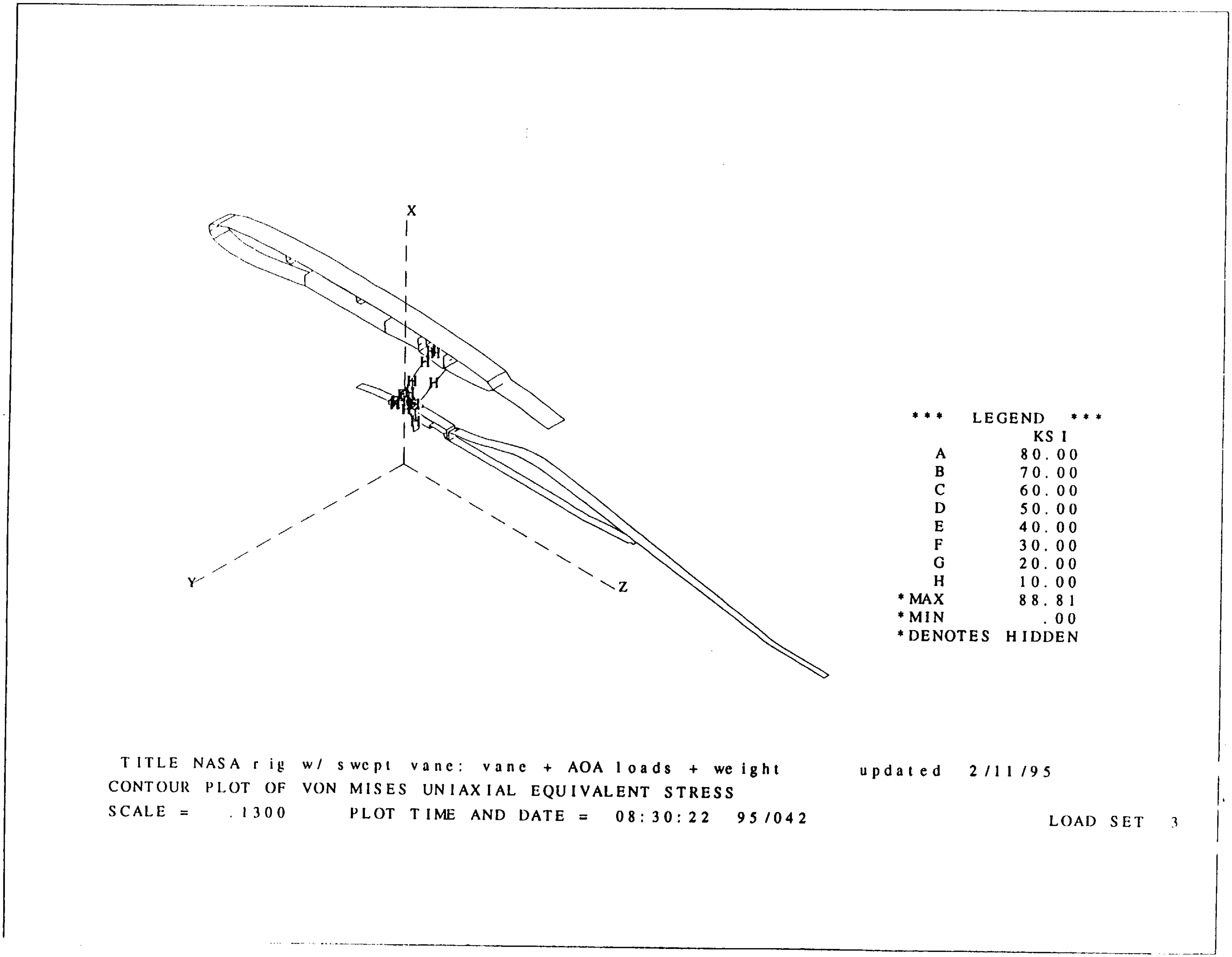


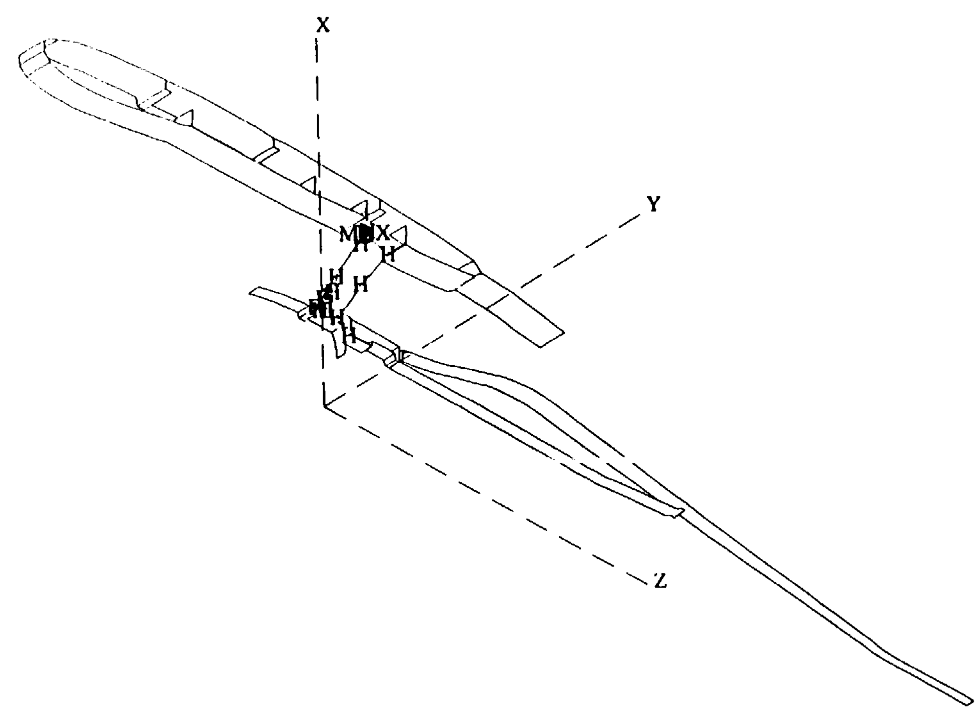
*** LEGEND ***

	KSI
A	80.00
B	70.00
C	60.00
D	50.00
E	40.00
F	30.00
G	20.00
H	10.00
*MAX	88.81
*MIN	.00

*DENOTES HIDDEN

TITLE NASA rig w/ swept vane: vane + AOA loads + weight updated 2/11/95
CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS
SCALE = .1000 PLOT TIME AND DATE = 08:29:52 95/042 LOAD SET 3


X
Y
Z
*** LEGEND ***
KSI
A 80.00
B 70.00
C 60.00
D 50.00
E 40.00
F 30.00
G 20.00
H 10.00
*MAX 88.81
*MIN .00
*DENOTES HIDDEN
TITLE NASA rig w/ swept vane: vane + AOA loads + weight updated 2/11/95
CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS
SCALE = .1300 PLOT TIME AND DATE = 08:30:22 95/042
LOAD SET 3

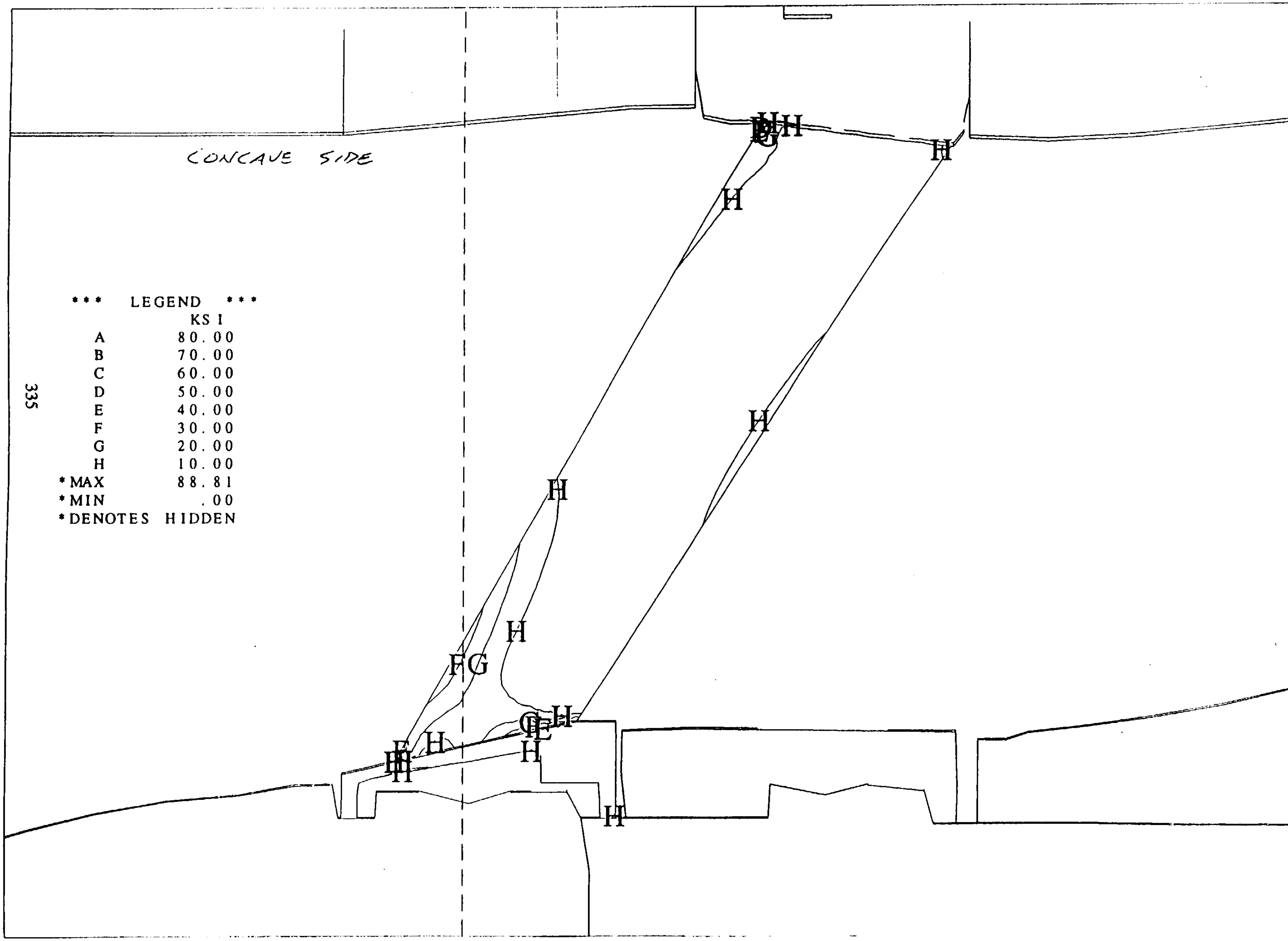


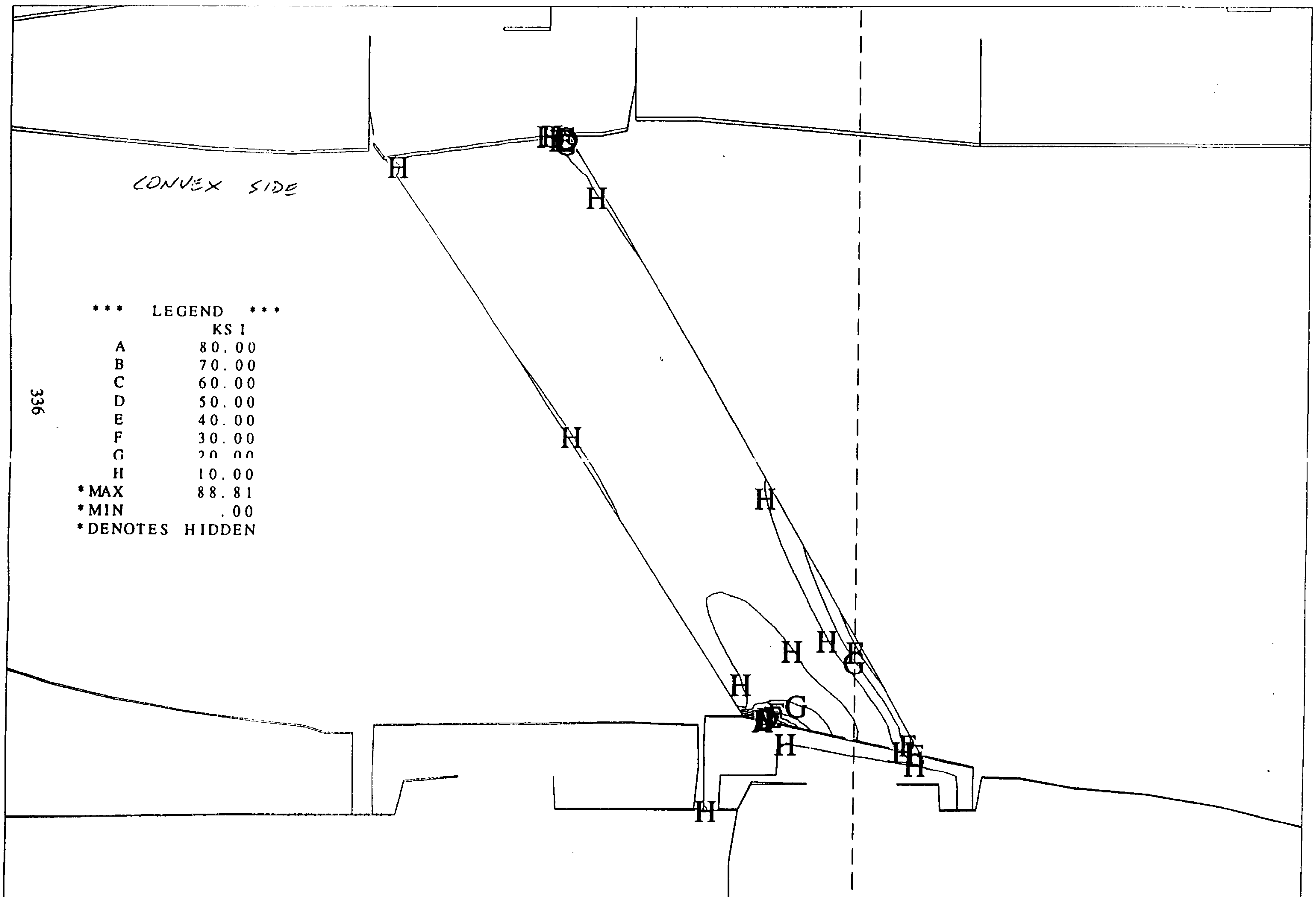
*** LEGEND ***

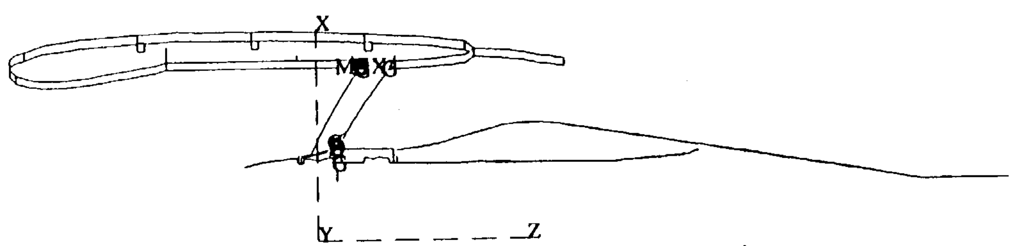
	KSI
A	80.00
B	70.00
C	60.00
D	50.00
E	40.00
F	30.00
G	20.00
H	10.00
MAX	88.81
*MIN	.00

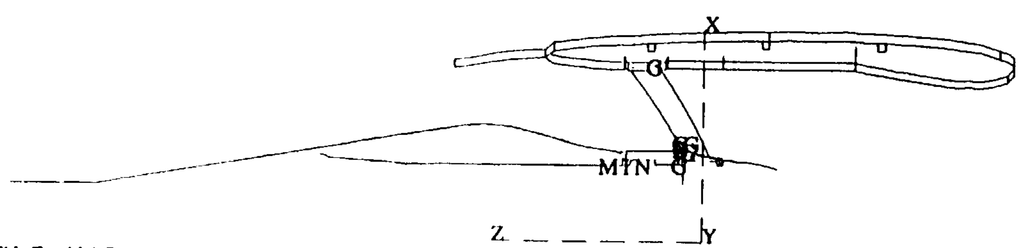
*DENOTES HIDDEN

TITLE NASA rig w/ swept vane: vane + AOA loads + weight updated 2/11/95
CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS
SCALE = .1300 PLOT TIME AND DATE = 08:30:49 95/042 LOAD SET 3


CONCAVE SIDE
*** LEGEND ***
KSI
A 80.00
B 70.00
C 60.00
D 50.00
E 40.00
F 30.00
G 20.00
H 10.00
*MAX 88.81
*MIN .00
*DENOTES HIDDEN


CONVEX SIDE
*** LEGEND ***
KSI
A 80.00
B 70.00
C 60.00
D 50.00
E 40.00
F 30.00
G 20.00
H 10.00
*MAX 88.81
*MIN .00
*DENOTES HIDDEN


X
MAX
Y
Z
*** LEGEND ***
KS I
A 70.00
B 60.00
C 50.00
D 40.00
E 30.00
F 20.00
G 10.00
MAX 77.05
*MIN .00
*DENOTES HIDDEN
updated 2/11/95
TITLE NASA rig w/ swept & leaned vane: vane loads
CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS
SCALE = .0990 PLOT TIME AND DATE = 07:40:13 95/042
LOAD SET 1



*** LEGEND ***	KSI
A	70.00
B	60.00
C	50.00
D	40.00
E	30.00
F	20.00
G	10.00
*MAX	77.05
MIN	.00

*DENOTES HIDDEN

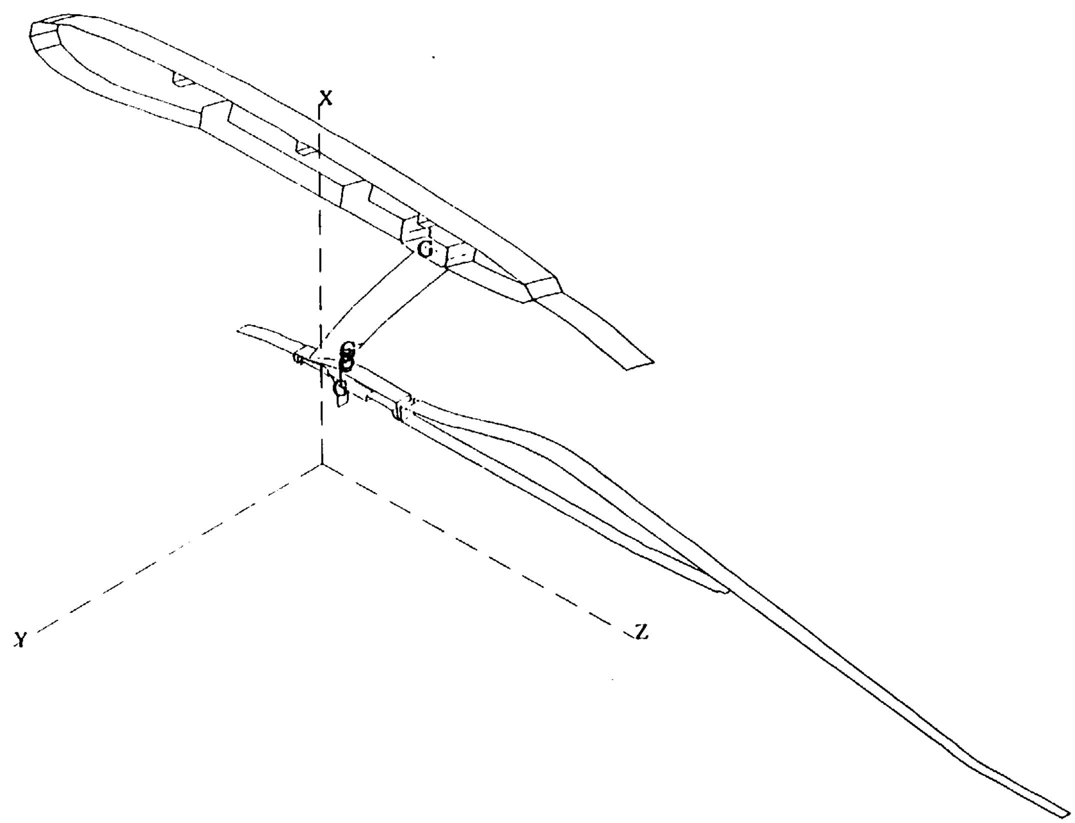
TITLE NASA rig w/ swept & leaned vane: vane loads

CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS

SCALE = .1000 PLOT TIME AND DATE = 07:41:19 95/042

updated 2/11/95

LOAD SET 1



*** LEGEND ***

	KSI
A	70.00
B	60.00
C	50.00
D	40.00
E	30.00
F	20.00
G	10.00
*MAX	77.05
*MIN	.00

*DENOTES HIDDEN

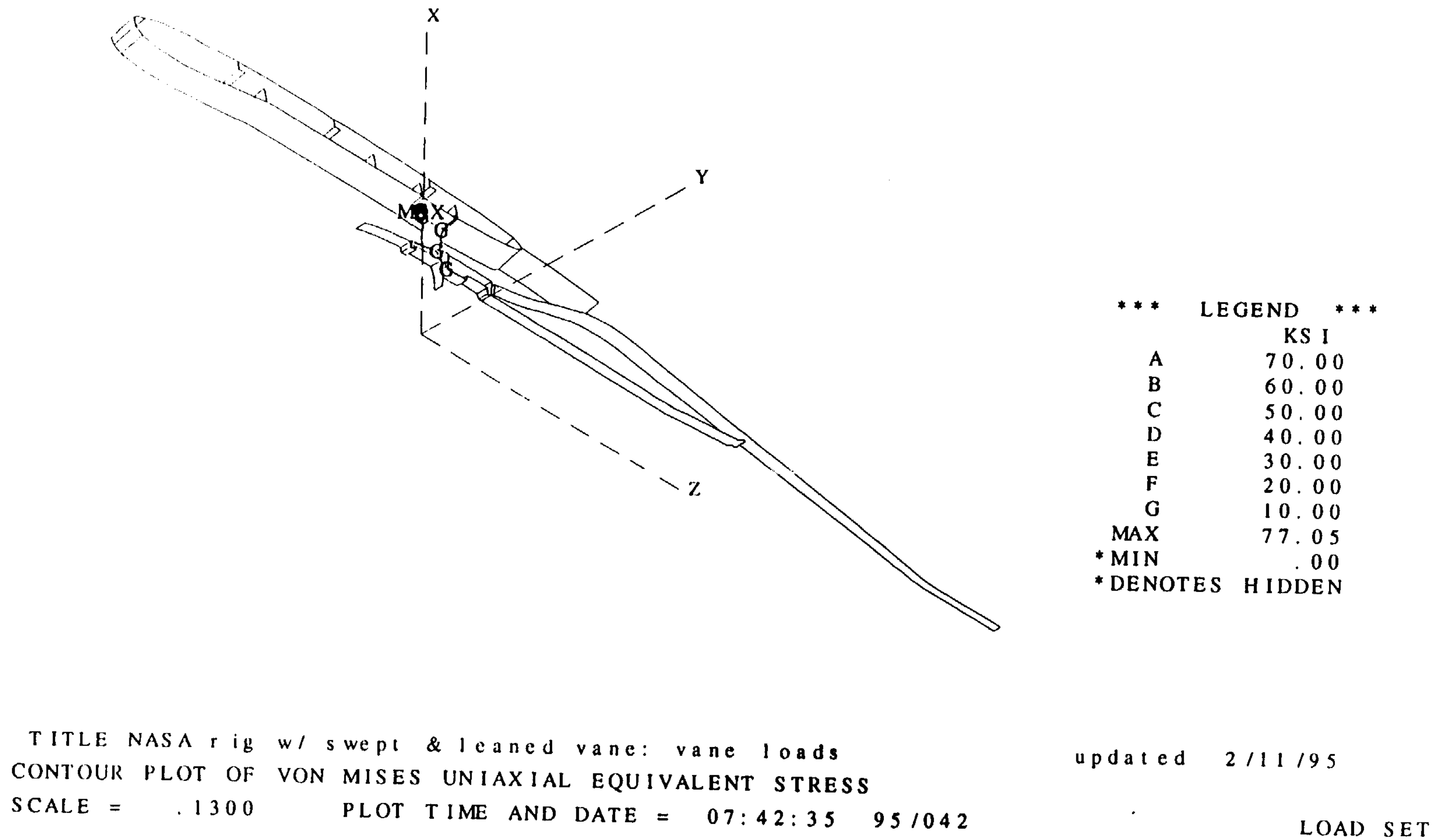
TITLE NASA rig w/ swept & leaned vane: vane loads

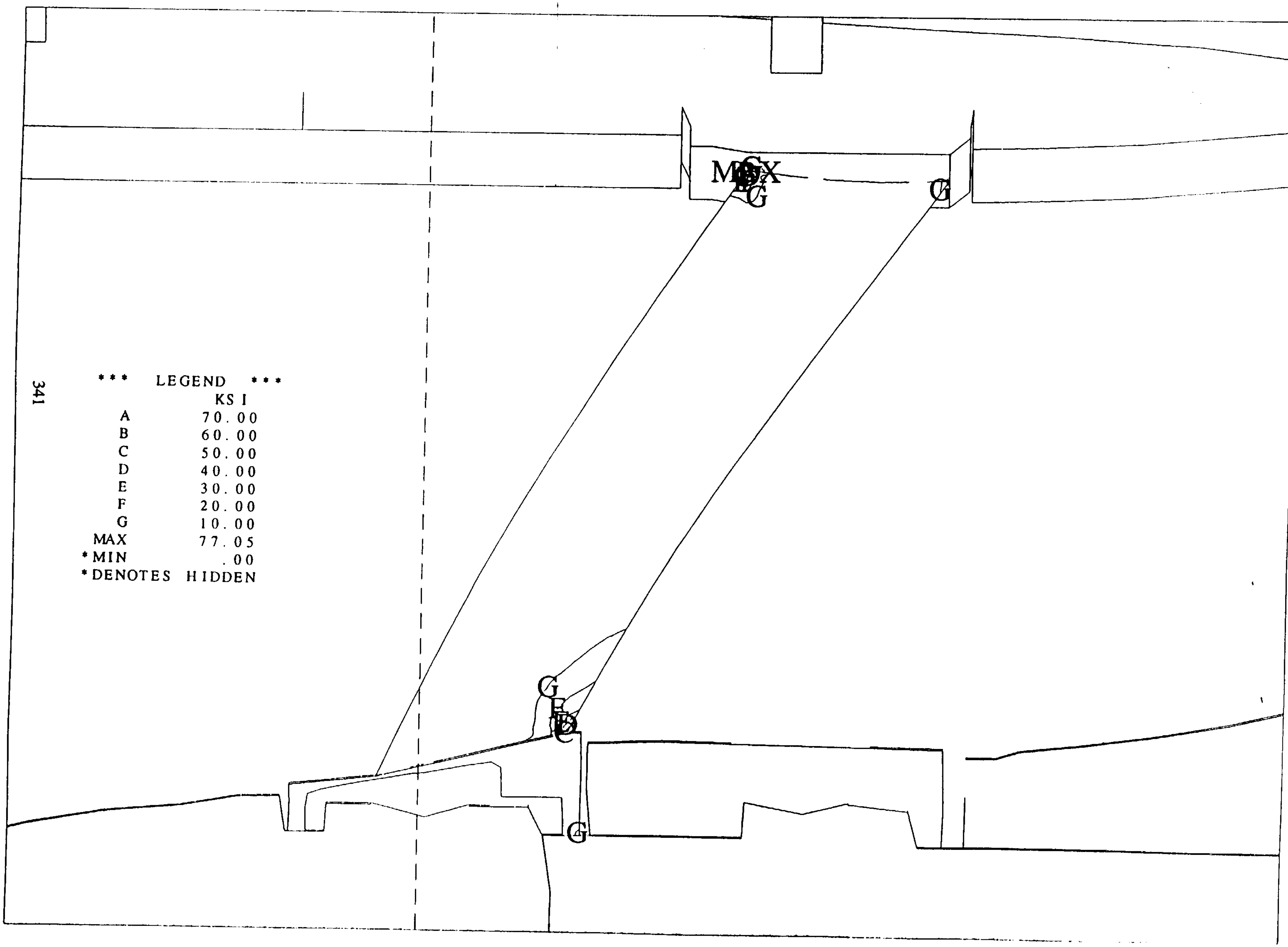
updated 2/11/95

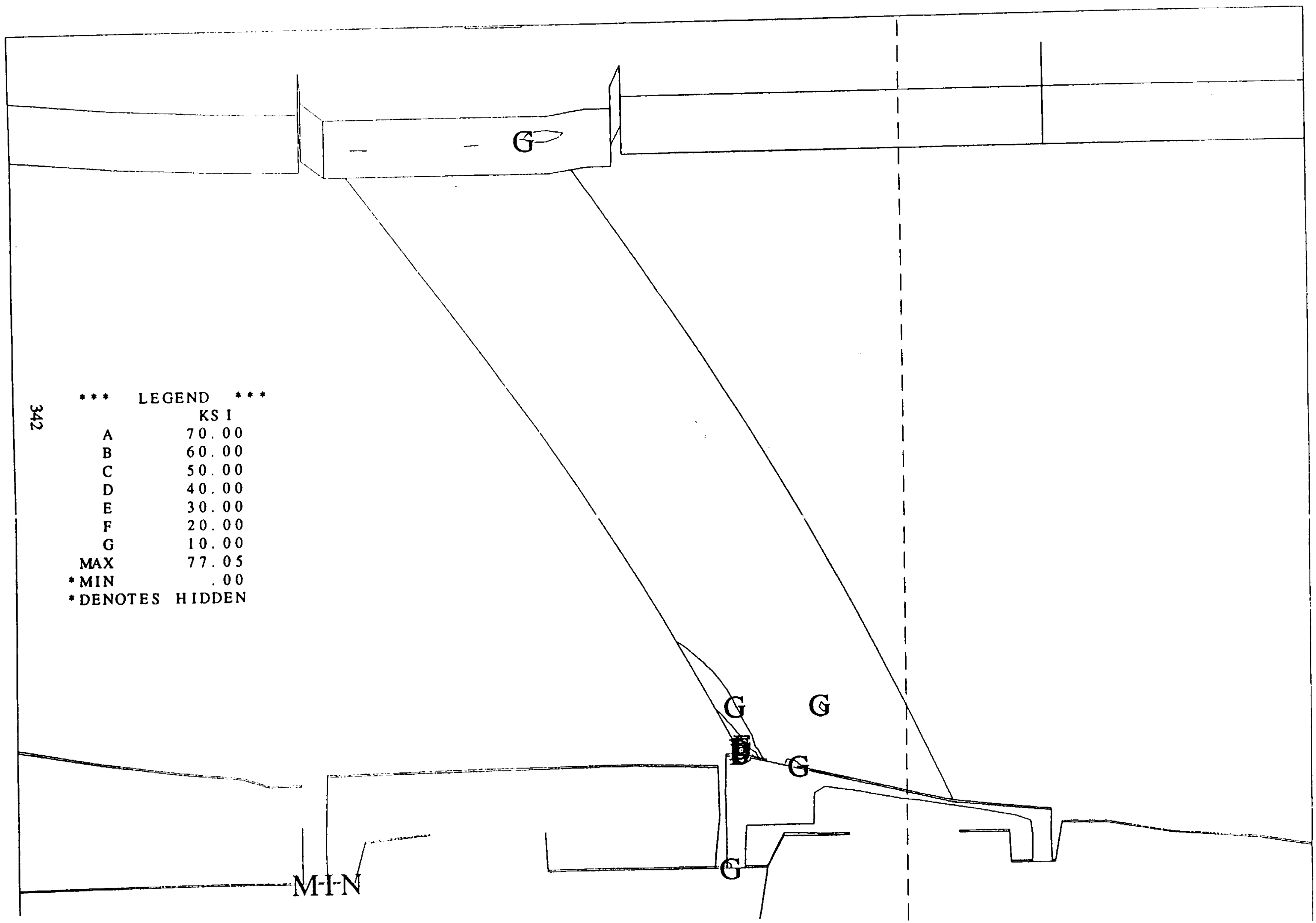
CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS

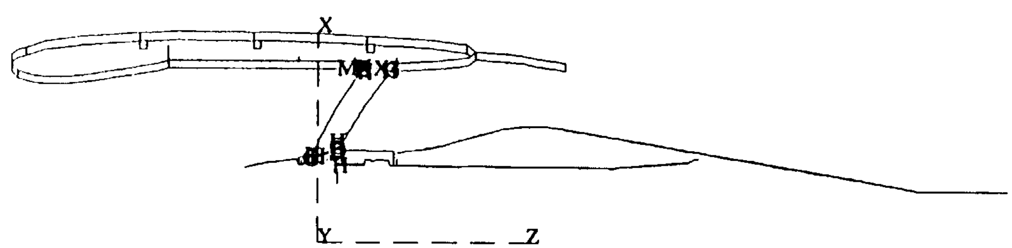
SCALE = .1500 PLOT TIME AND DATE = 07:41:58 95/042

LOAD SET 1


X
Y
Z
MAX
G
G
G
*** LEGEND ***
KSI
A 70.00
B 60.00
C 50.00
D 40.00
E 30.00
F 20.00
G 10.00
MAX 77.05
*MIN .00
*DENOTES HIDDEN
TITLE NASA rig w/ swept & leaned vane: vane loads
updated 2/11/95
CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS
SCALE = .1300 PLOT TIME AND DATE = 07:42:35 95/042
LOAD SET 1

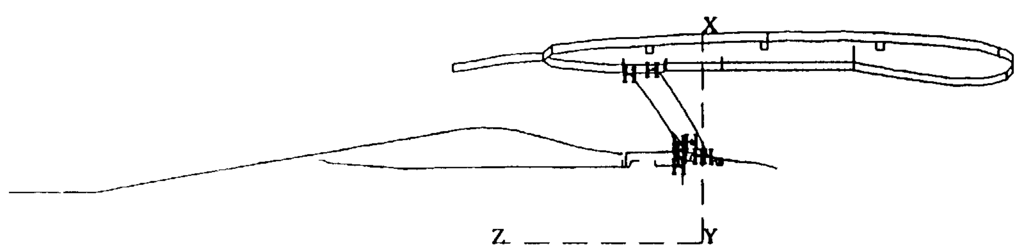

*** LEGEND ***
KSI
A 70.00
B 60.00
C 50.00
D 40.00
E 30.00
F 20.00
G 10.00
MAX 77.05
*MIN .00
*DENOTES HIDDEN
MAX
G
F
E
D
C

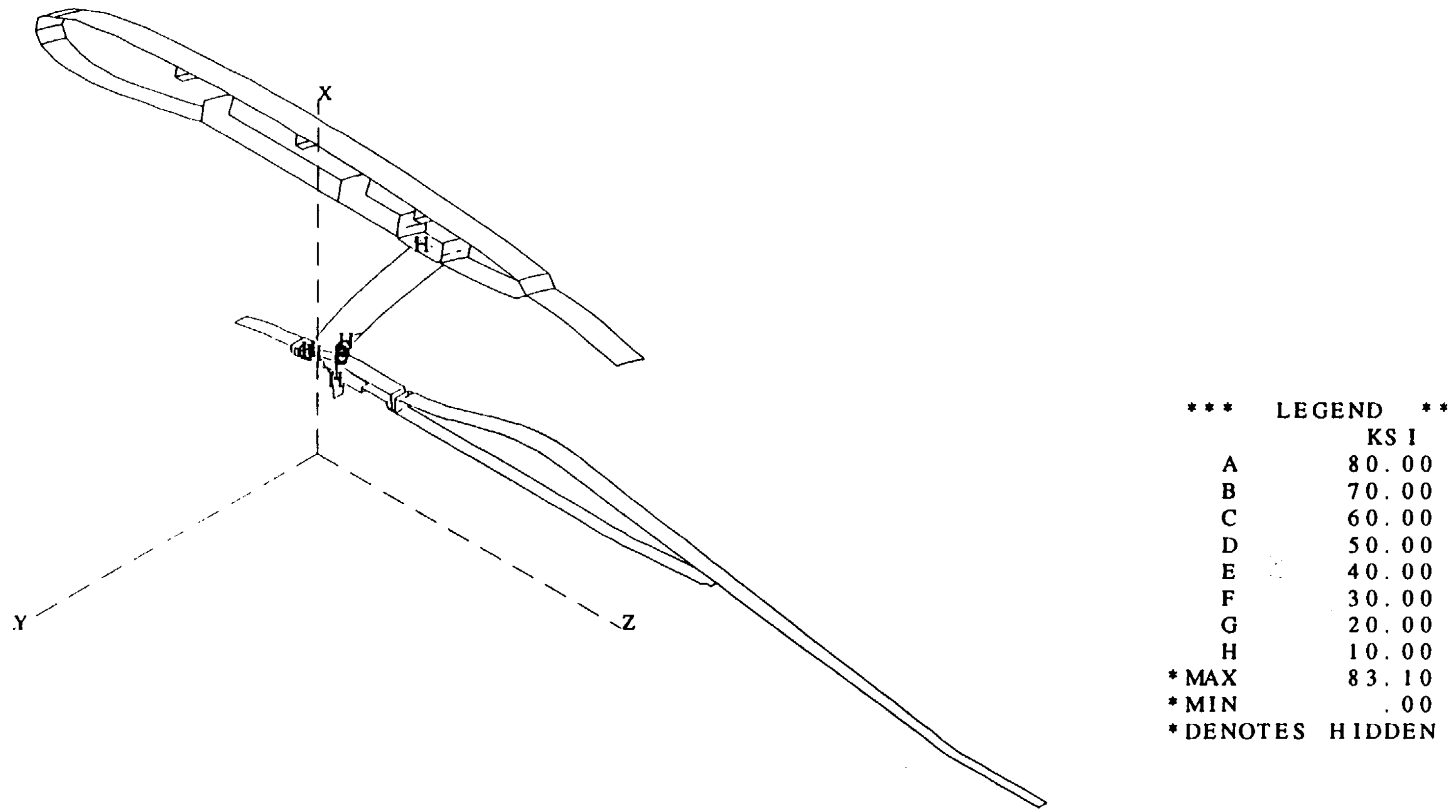

*** LEGEND ***
KSI
A 70.00
B 60.00
C 50.00
D 40.00
E 30.00
F 20.00
G 10.00
MAX 77.05
*MIN .00
*DENOTES HIDDEN
G
G
G
G
G
MIN

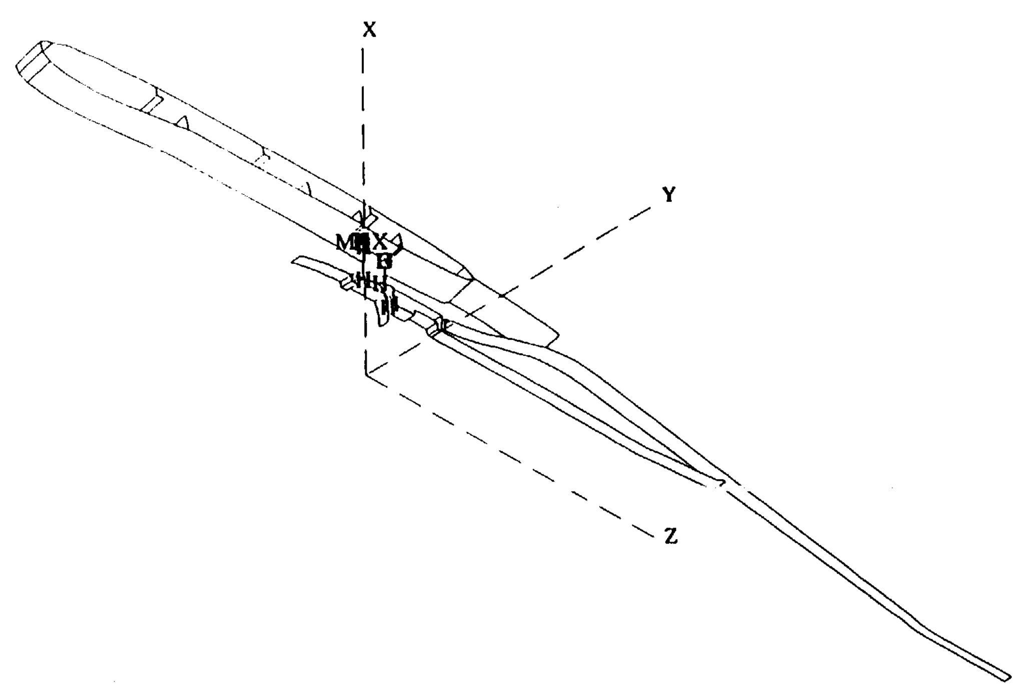


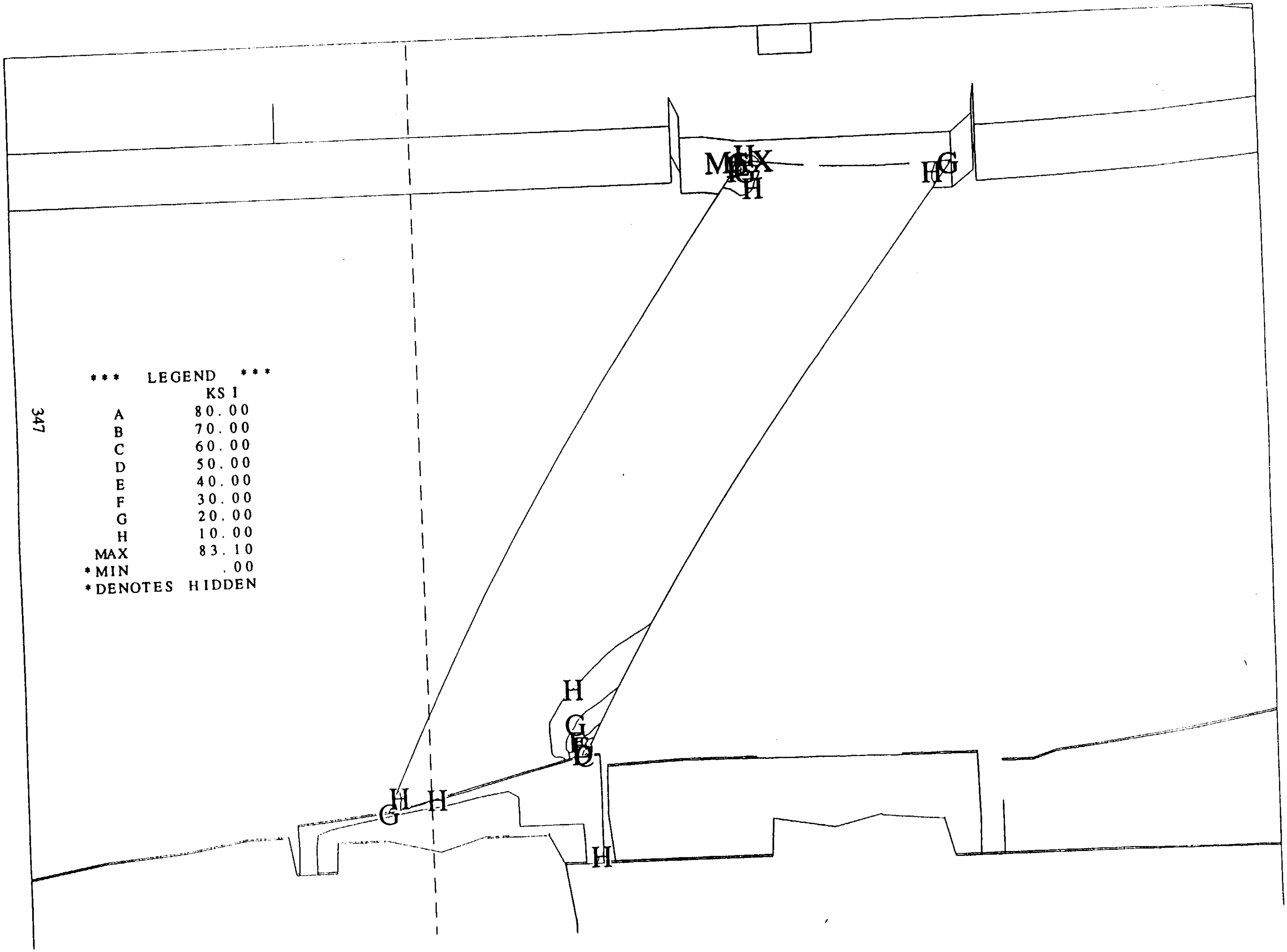
*** LEGEND ***	
	KSI
A	80.00
B	70.00
C	60.00
D	50.00
E	40.00
F	30.00
G	20.00
H	10.00
MAX	83.10
*MIN	.00
*DENOTES HIDDEN	

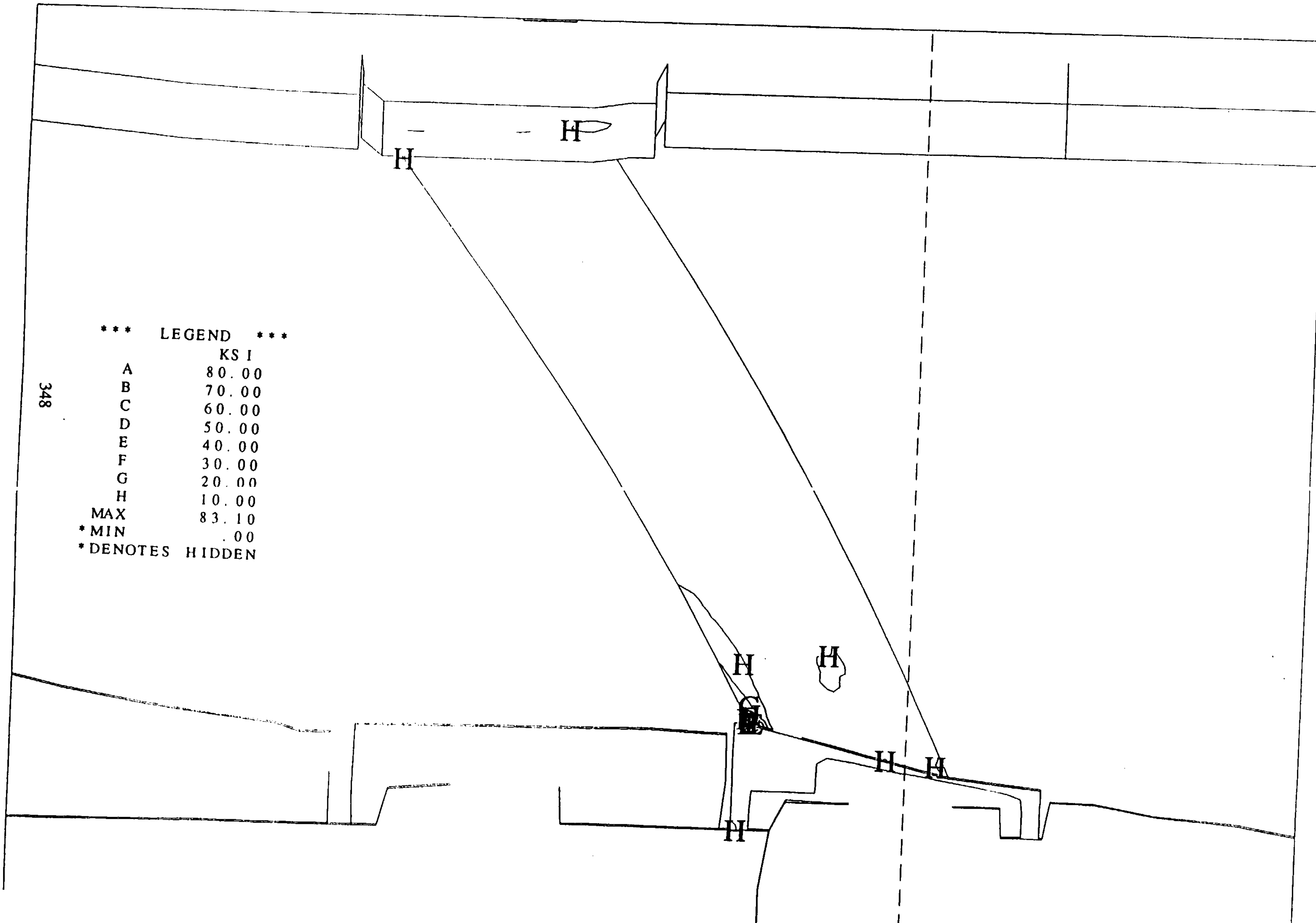
TITLE NASA rig w/ swept & leaned vane: vane + AOA + weight updated 2/11/95
CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS
SCALE = .0990 PLOT TIME AND DATE = 09:15:38 95/042 LOAD SET 3


X
Z
Y
*** LEGEND ***
KSI
A 80.00
B 70.00
C 60.00
D 50.00
E 40.00
F 30.00
G 20.00
H 10.00
*MAX 83.10
*MIN .00
*DENOTES HIDDEN
TITLE NASA rig w/ swept & leaned vane: vane + AOA + weight updated 2/11/95
CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS
SCALE = .1000 PLOT TIME AND DATE = 09:16:45 95/042 LOAD SET 3


X
Y
Z
H
*** LEGEND ***
KSI
A 80.00
B 70.00
C 60.00
D 50.00
E 40.00
F 30.00
G 20.00
H 10.00
*MAX 83.10
*MIN .00
*DENOTES HIDDEN
TITLE NASA rig w/ swept & leaned vane: vane + AOA + weight updated 2/11/95
CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS
SCALE = .1500 PLOT TIME AND DATE = 09:17:47 95/042 LOAD SET 3

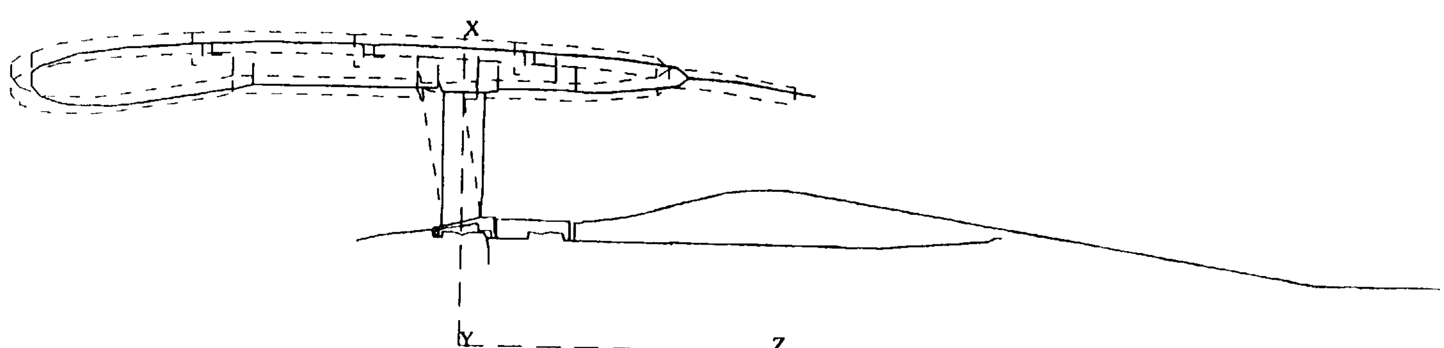

X
Y
Z
MAX
B
H
*** LEGEND ***
KSI
A 80.00
B 70.00
C 60.00
D 50.00
E 40.00
F 30.00
G 20.00
H 10.00
MAX 83.10
*MIN .00
*DENOTES HIDDEN
TITLE NASA rig w/ swept & leaned vane: vane + AOA + weight
updated 2/11/95
CONTOUR PLOT OF VON MISES UNIAXIAL EQUIVALENT STRESS
SCALE = .1300
PLOT TIME AND DATE = 09:18:51 95/042
LOAD SET 3


*** LEGEND ***
KSI
A 80.00
B 70.00
C 60.00
D 50.00
E 40.00
F 30.00
G 20.00
H 10.00
MAX 83.10
*MIN .00
*DENOTES HIDDEN


*** LEGEND ***
KSI
A 80.00
B 70.00
C 60.00
D 50.00
E 40.00
F 30.00
G 20.00
H 10.00
MAX 83.10
*MIN .00
*DENOTES HIDDEN

APPENDIX H

STATIC STRUCTURE DEFLECTION ANALYSIS RESULTS



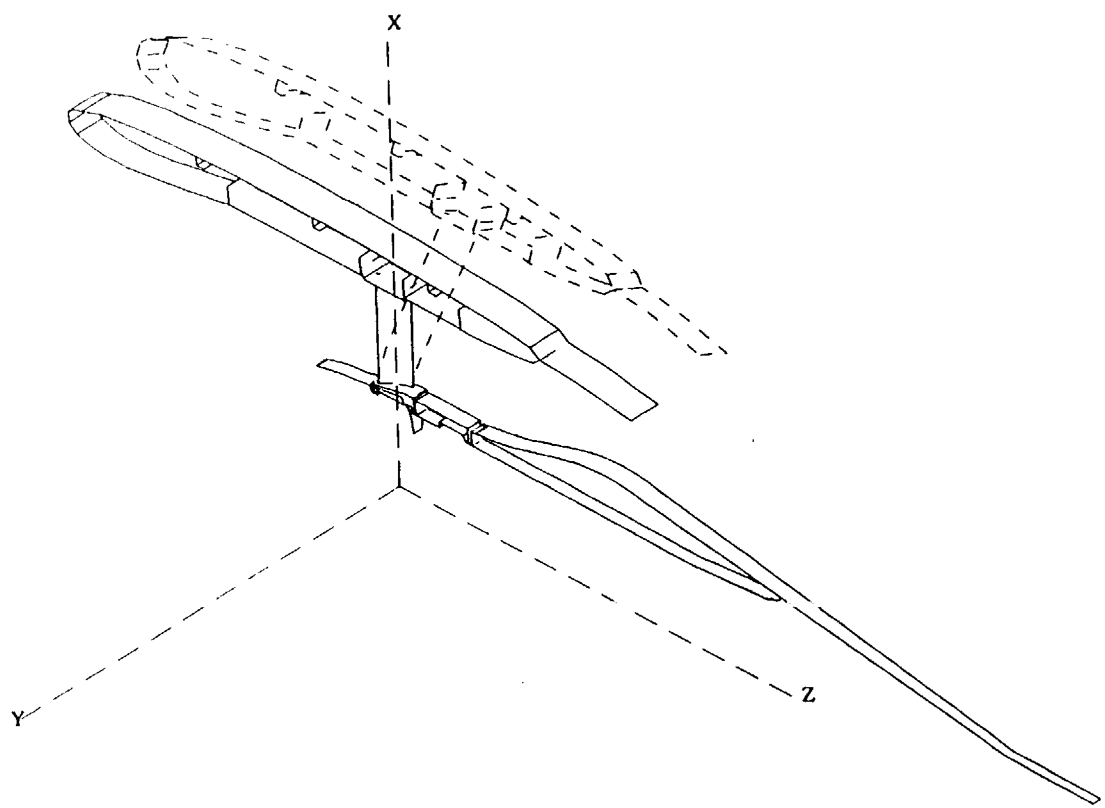
TITLE NASA rig w/ baseline vane: vane loads

updated 2/8/95

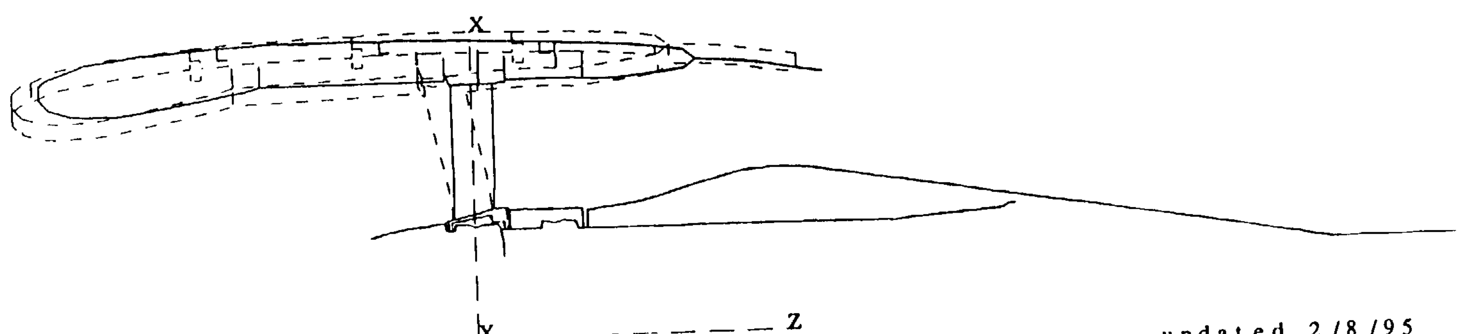
PLOT OF DEFLECTED SHAPE

SCALE = .1400 PLOT TIME AND DATE = 17:17:00 95/039

LOAD SET 1



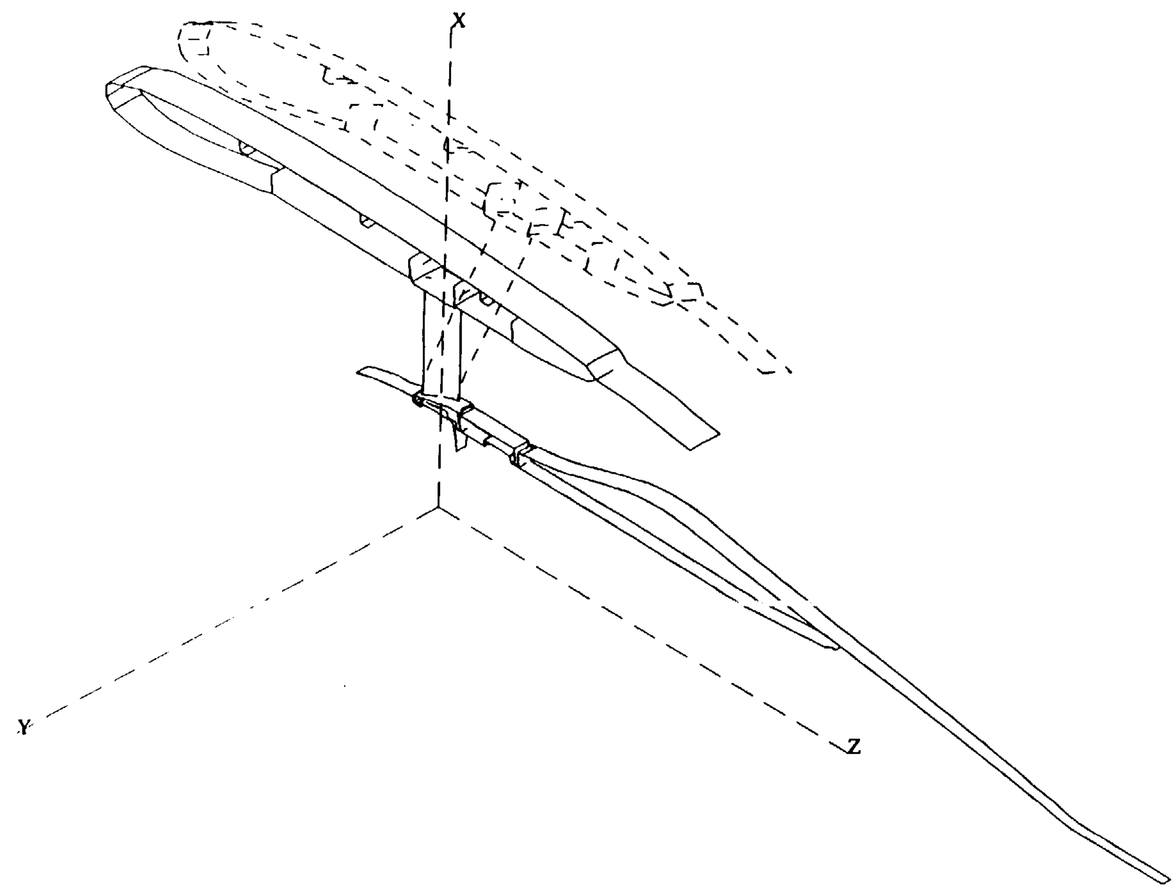
TITLE NASA rig w/ basel ine vane: vane loads
updated 2/8/95
PLOT OF DEFLECTED SHAPE
LOAD SET 1
SCALE = .1400 PLOT TIME AND DATE = 17:19:07 95/039



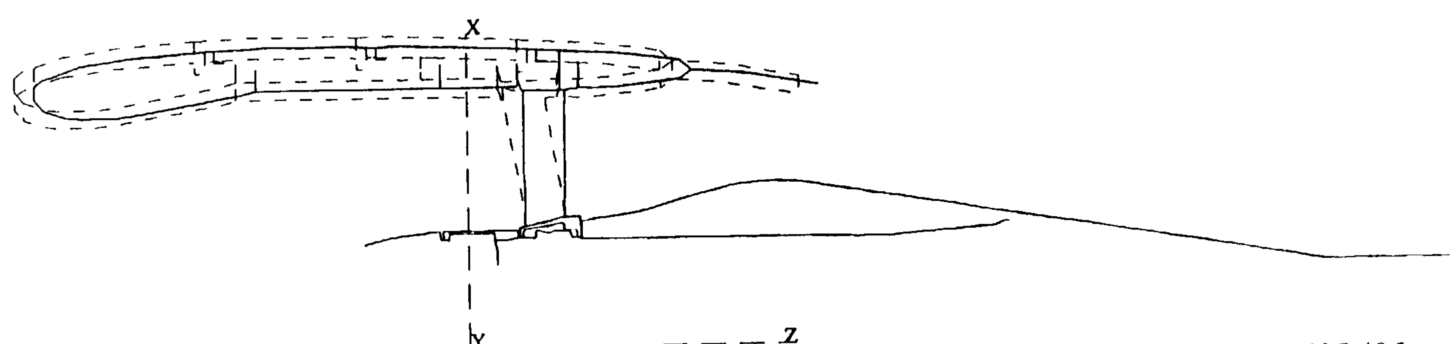
TITLE NASA rig w/ baseline vane: vane + AOA + weight;   updated 2/8/95

PLOT OF DEFLECTED SHAPE   LOAD SET 3

SCALE = .1400   PLOT TIME AND DATE = 19:08:55 95/039



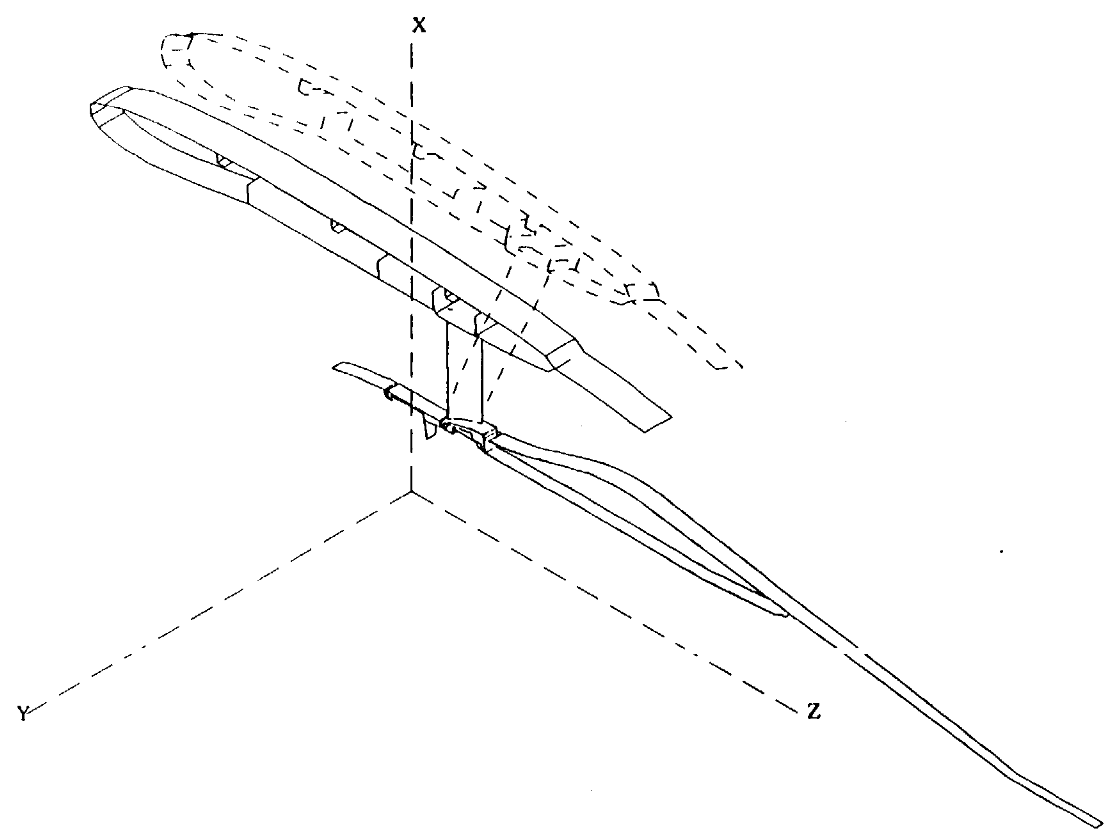
TITLE NASA rig w/ baseline vane: vane + AOA + weight; updated 2/8/95
PLOT OF DEFLECTED SHAPE
SCALE = .1500 PLOT TIME AND DATE = 19:10:31 95/039 LOAD SET 3



TITLE NASA r ig w/ aft vanc: vane loads
PLOT OF DEFLECTED SHAPE
SCALE = .1400 PLOT TIME AND DATE = 16:06:18 95/066

3/07/95

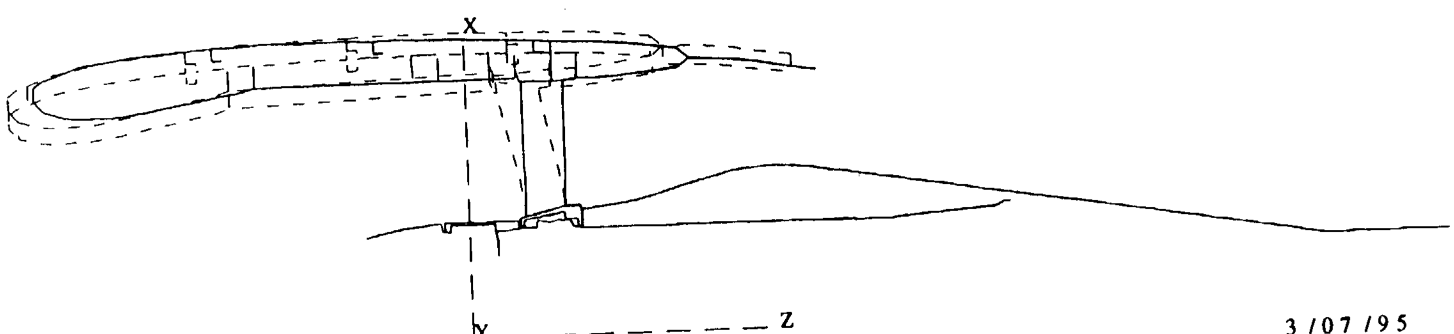
LOAD SET 1



TITLE NASA rig w/ aft vane: vane loads 3/07/95

PLOT OF DEFLECTED SHAPE

SCALE = .1400 PLOT TIME AND DATE = 16:07:18 95/066 LOAD SET 1



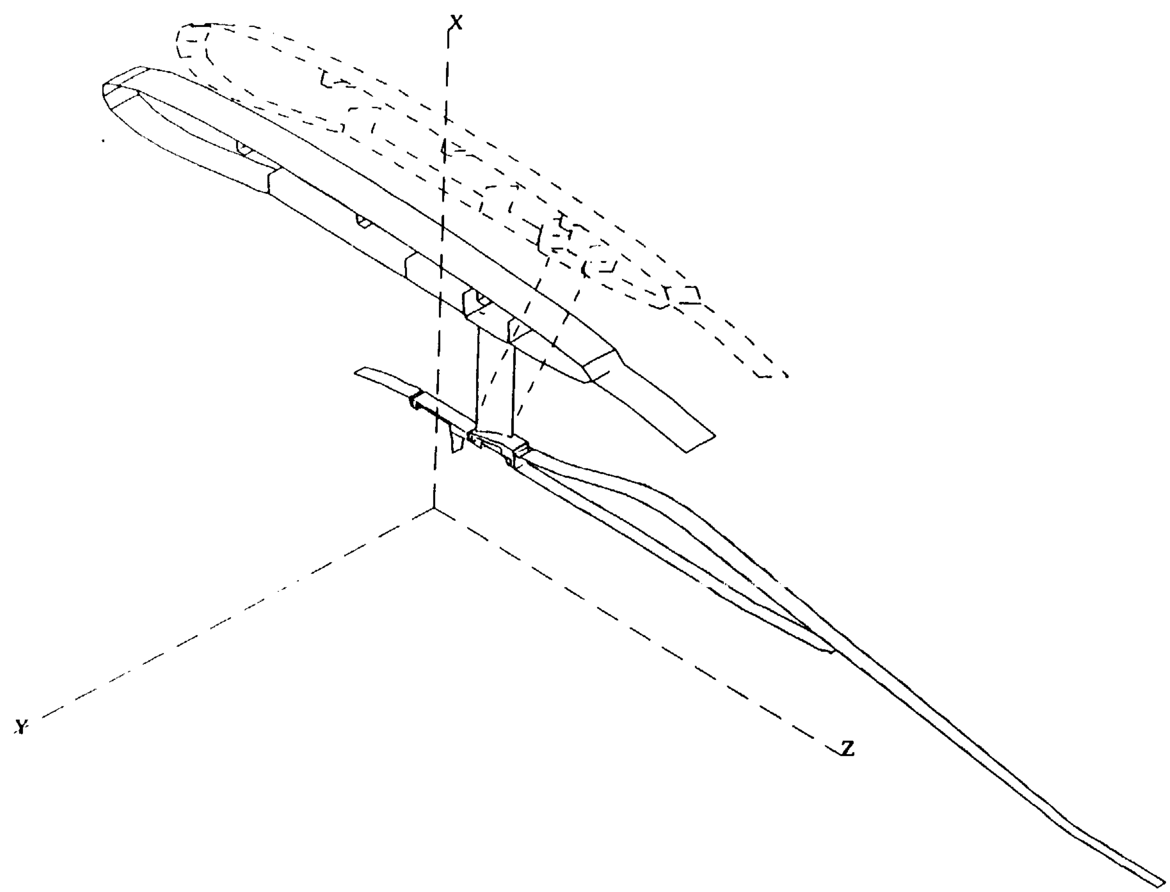
3 /07 /95

TITLE NASA r ig w/ aft vane: vane + AOA + we ight;

PLOT OF DEFLECTED SHAPE

LOAD SET 3

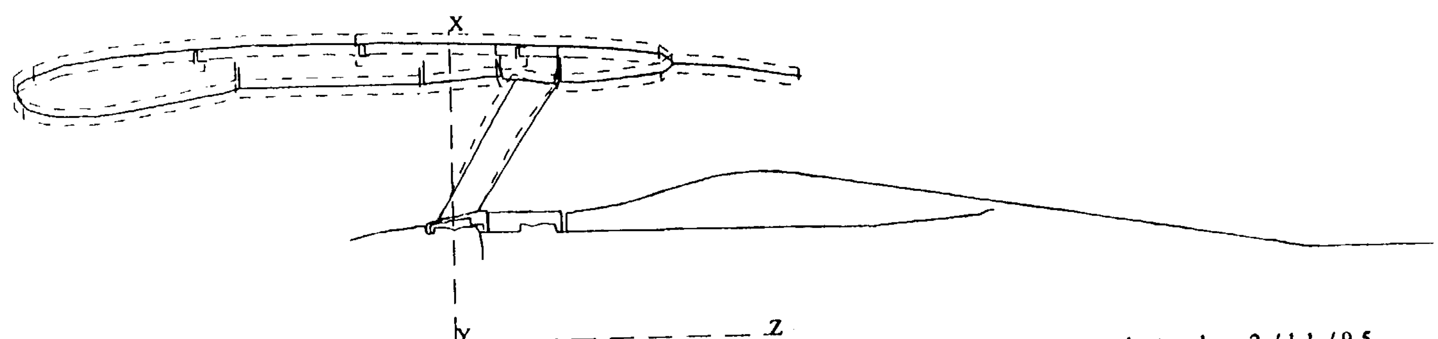
SCALE = .1400 PLOT TIME AND DATE = 17:19:26 95/066

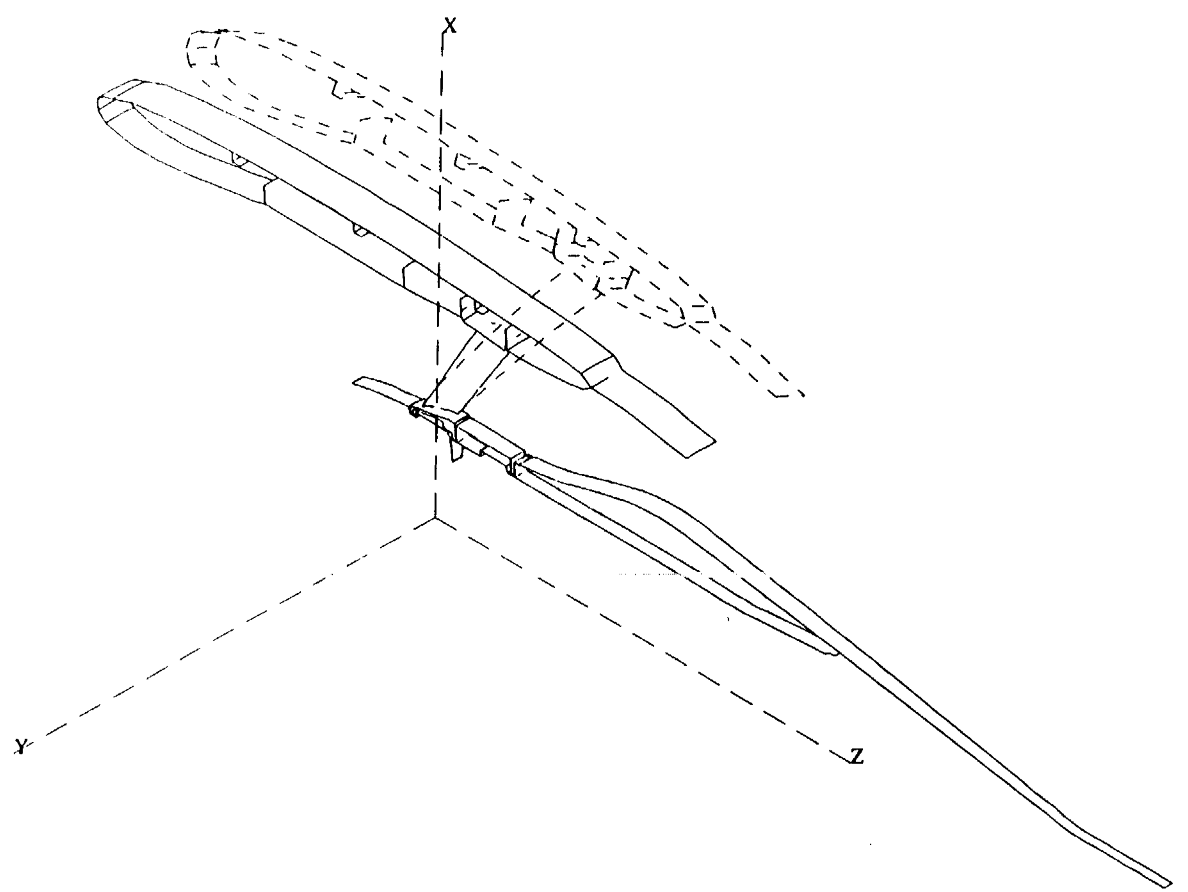


TITLE NASA r ig w/ aft vane: vane + AOA + we ight;
PLOT OF DEFLECTED SHAPE
SCALE = .1500 PLOT TIME AND DATE = 17:20:26 95/066

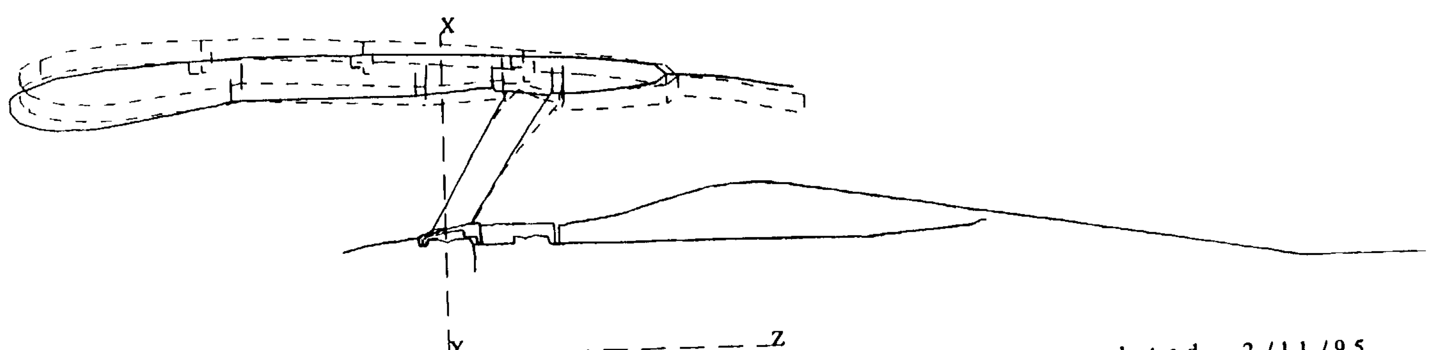
3/07/95

LOAD SET 3

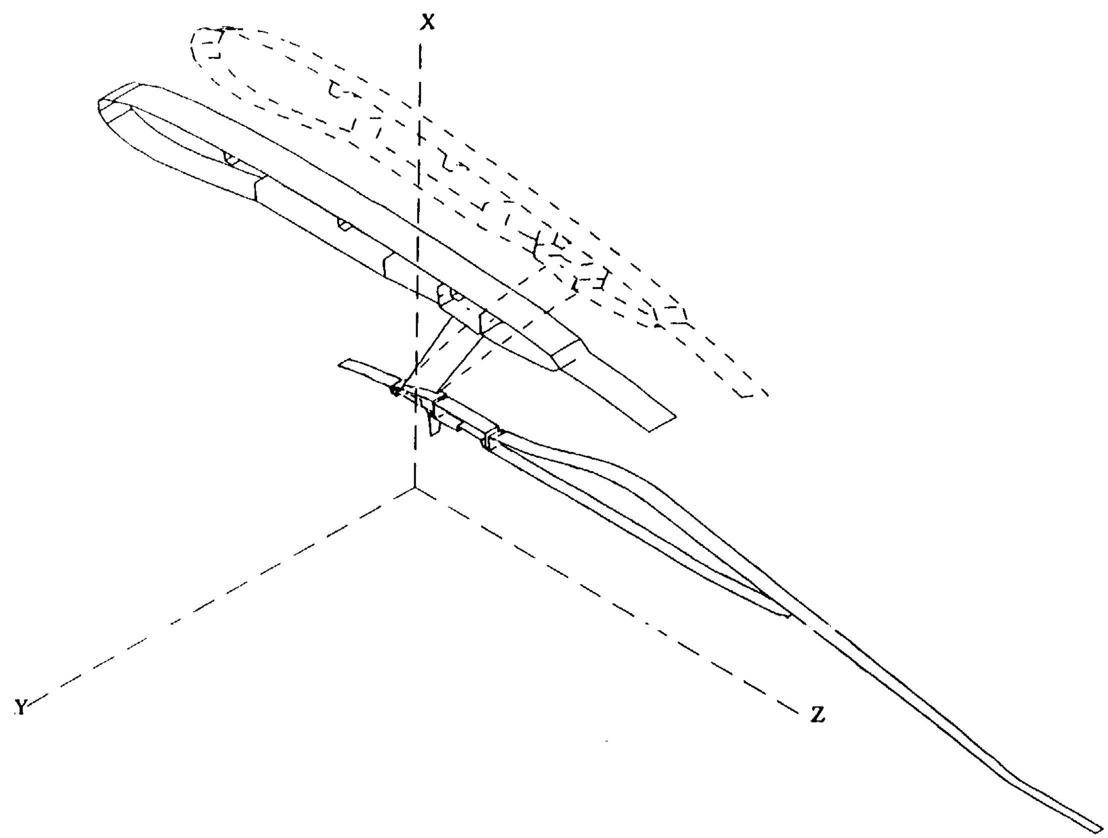

X
Y
Z
TITLE NASA r ig w/ swept vane: vane loads
updated 2/11/95
PLOT OF DEFLECTED SHAPE
LOAD SET 1
SCALE = .1400 PLOT TIME AND DATE = 08:02:09 95/042



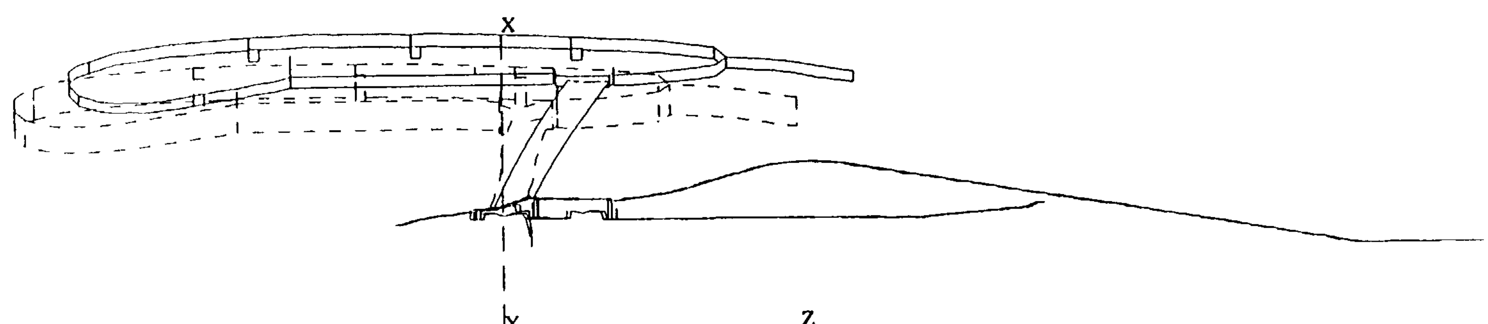
TITLE NASA rig w/ swept vane: vane loads updated 2/11/95
PLOT OF DEFLECTED SHAPE
SCALE = .1500 PLOT TIME AND DATE = 08:02:54 95/042 LOAD SET 1



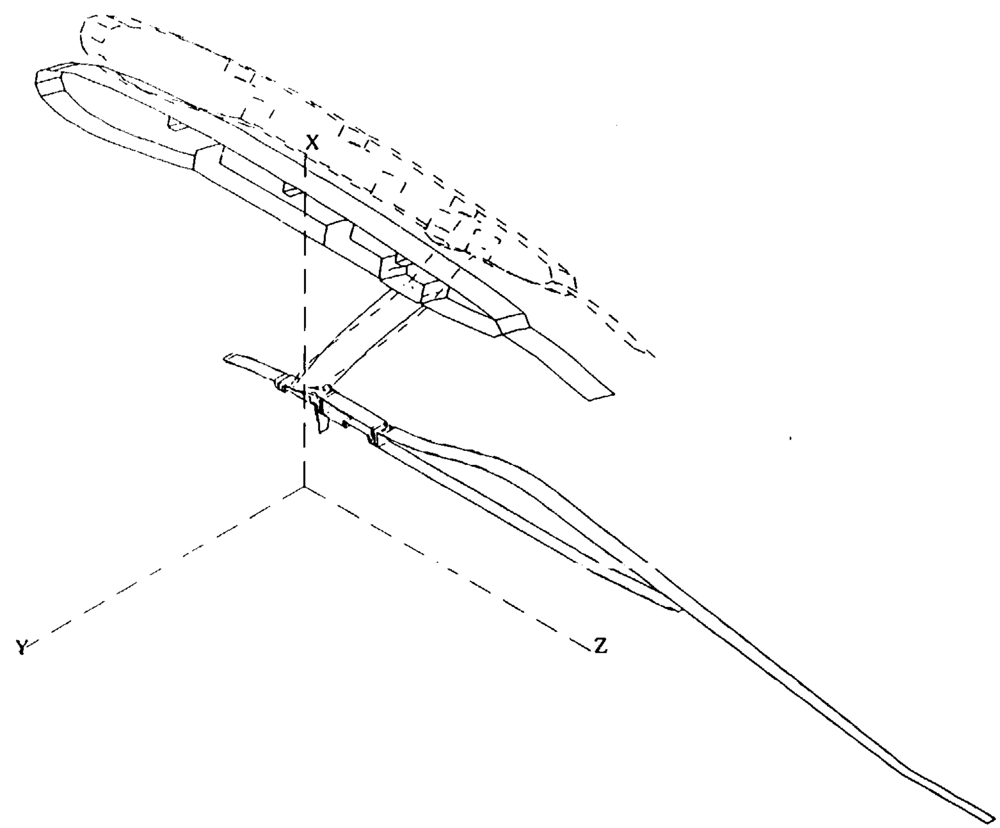
TITLE NASA rig w/ swept vane: vane + AOA loads + weight   updated 2/11/95
PLOT OF DEFLECTED SHAPE   LOAD SET 3
SCALE = .1400   PLOT TIME AND DATE = 08:27:53 95/042



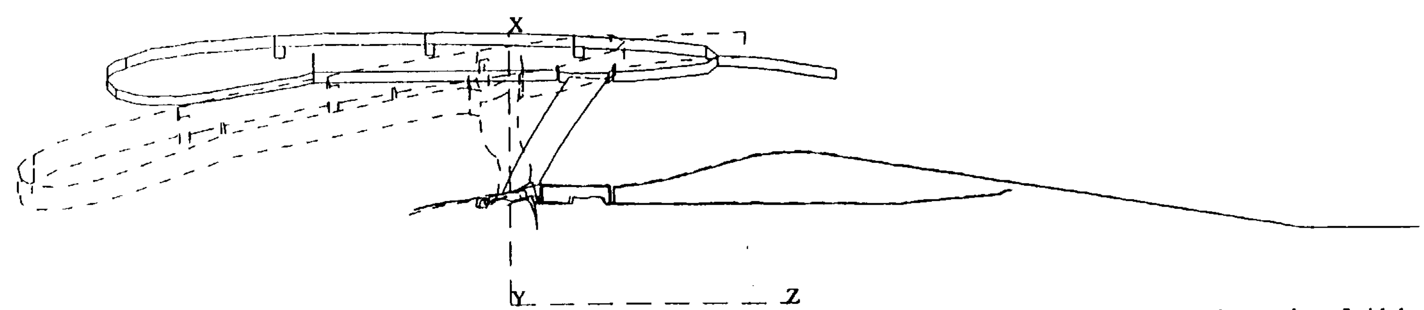
TITLE NASA rig w/ swept vane: vane + AOA loads + weight updated 2/11/95
PLOT OF DEFLECTED SHAPE
SCALE = .1400 PLOT TIME AND DATE = 08:28:37 95/042 LOAD SET 3



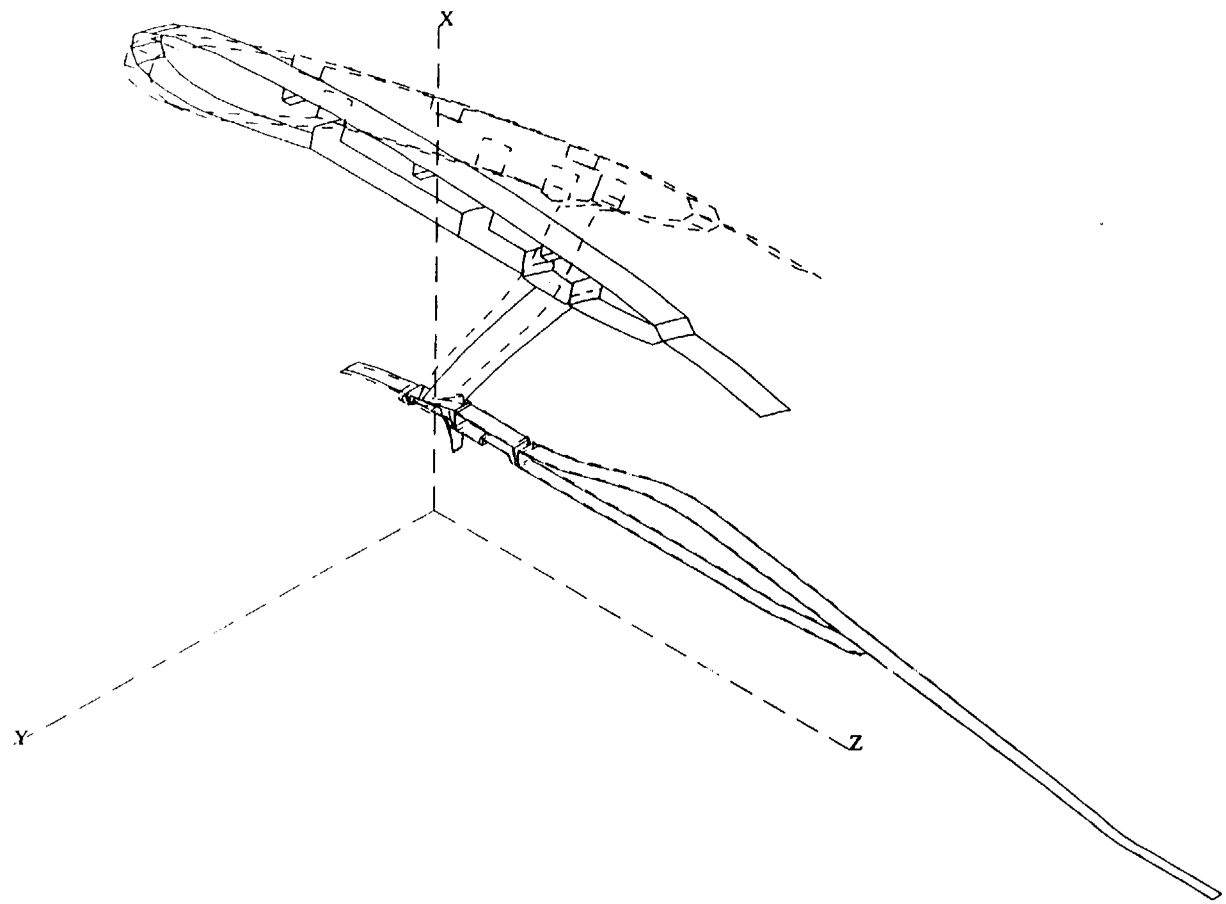
TITLE NASA r'ig w/ swept & leaned vane: vane loads updated 2/11/95
PLOT OF DEFLECTED SHAPE
SCALE = .1400 PLOT TIME AND DATE = 07:37:00 95/042 LOAD SET 1



TITLE NASA rig w/ swept & leaned vane: vane loads updated 2/11/95
PLOT OF DEFLECTED SHAPE
SCALE = .1400 PLOT TIME AND DATE = 07:38:44 95/042 LOAD SET 1



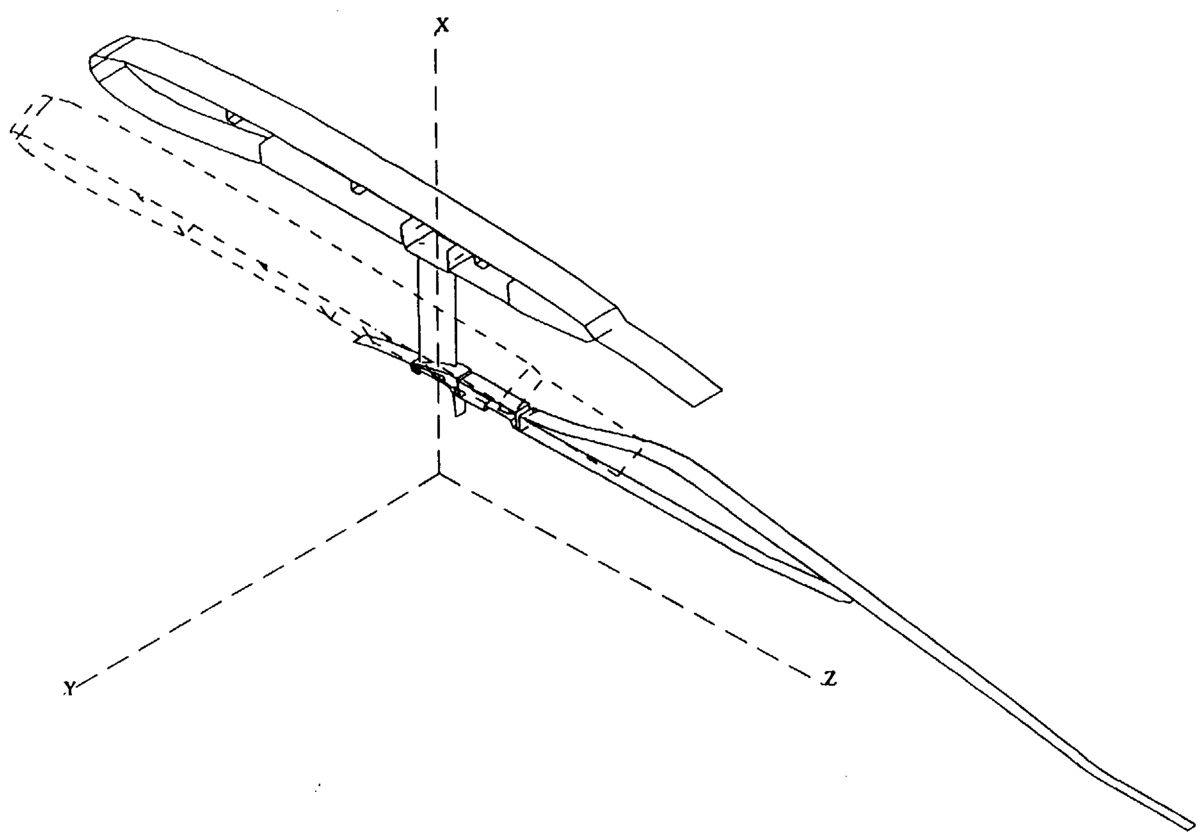
TITLE NASA rig w/ swept & leaned vane: vane + AOA + weight updated 2/11/95
PLOT OF DEFLECTED SHAPE
SCALE = .1300 PLOT TIME AND DATE = 09:12:10 95/042 LOAD SET 3

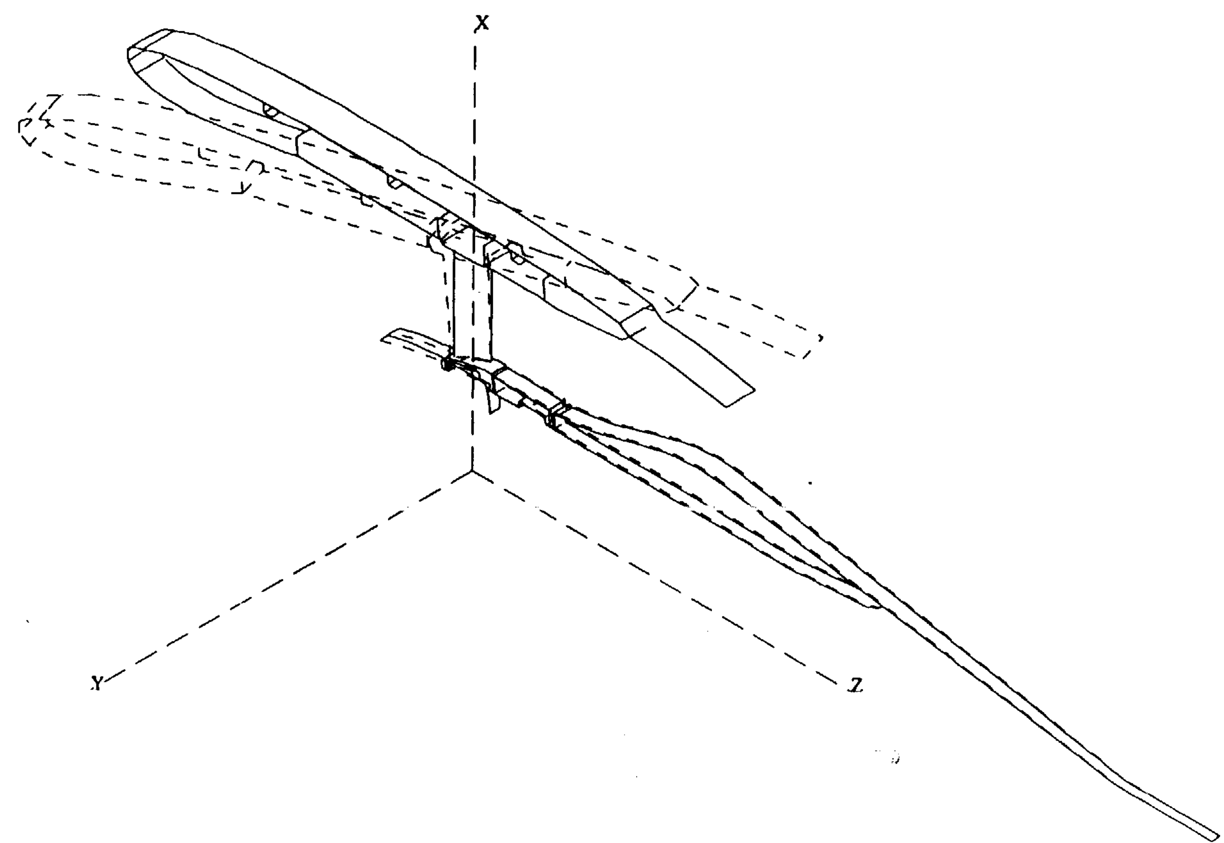


TITLE NASA rig w/ swept & leaned vane: vane + AOA + weight updated 2/11/95
PLOT OF DEFLECTED SHAPE
SCALE = .1600 PLOT TIME AND DATE = 09:13:59 95/042 LOAD SET 3

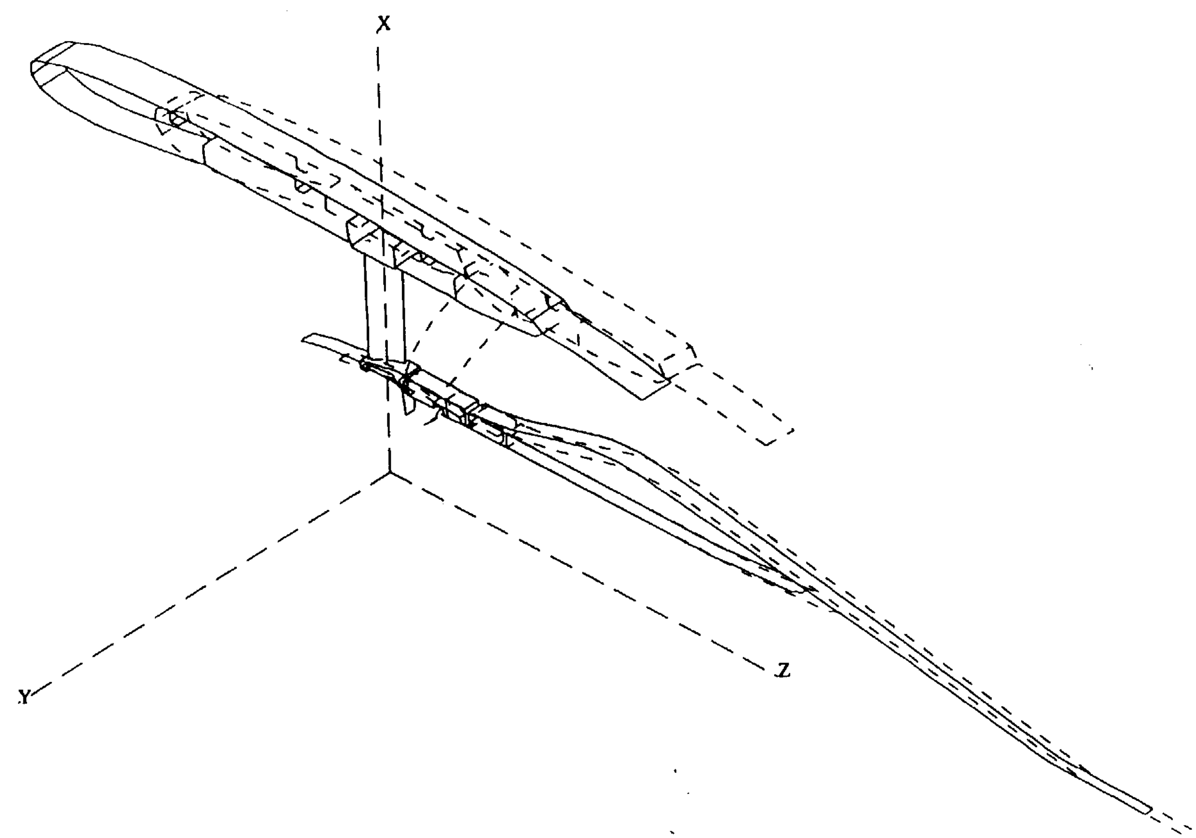
APPENDIX I

RESULTS OF DYNAMIC ANALYSIS OF FULL NACELLE SYSTEM


X
Y
Z
TITLE NASA fan rig nacelle ass'y; baseline vane
2/11/95
PLOT OF MODE SHAPE
SCALE = .1600
PLOT TIME AND DATE = 15:37:07 95/207
LOAD SET 1
FREQUENCY = 29.014
SECTOR PATTERN = 0
MODE NUMBER = 1
PHI = .00



TITLE NASA fan rig nacelle ass'y; baseline vane 2/11/95
PLOT OF MODE SHAPE
SCALE = .1600 PLOT TIME AND DATE = 17:59:46 95/207 LOAD SET 2
FREQUENCY = 79.782 SECTOR PATTERN = 1
MODE NUMBER = 1 PHI = .00



2/11/95

TITLE NASA fan rig nacelle ass'y; baseline vane

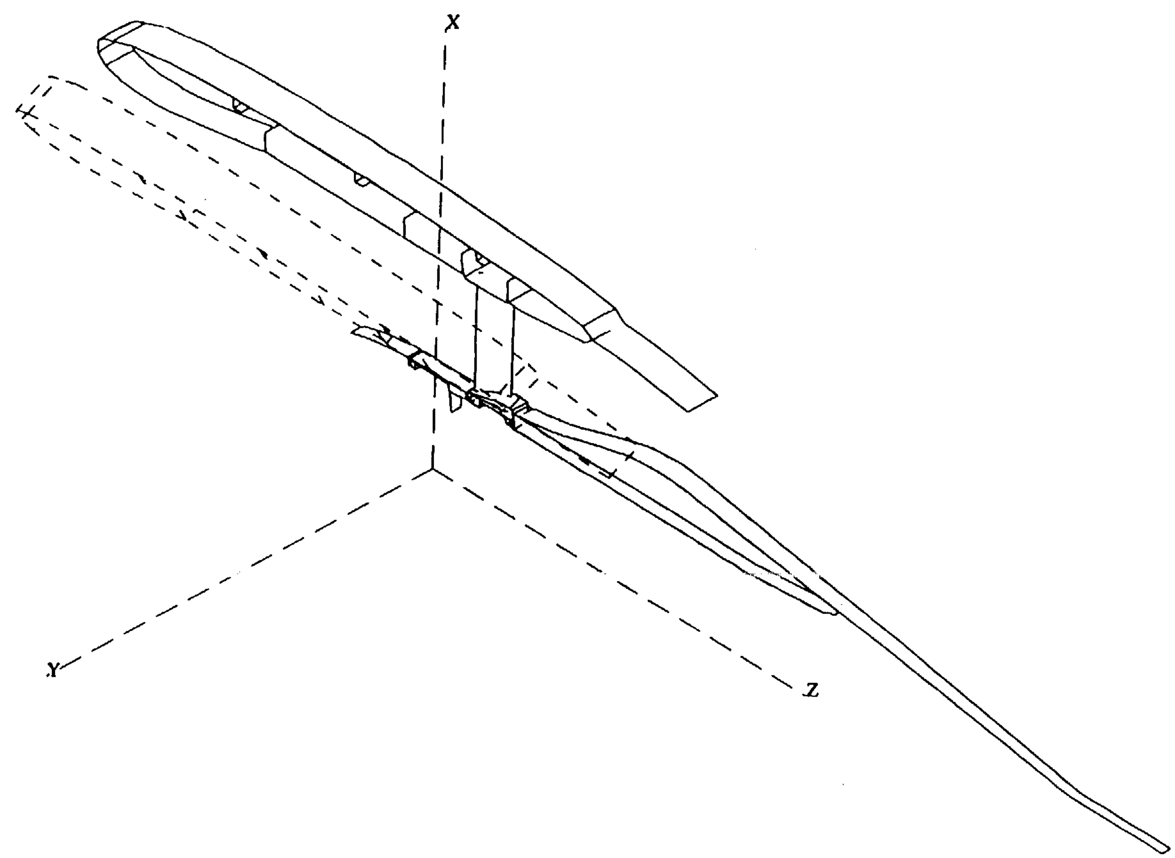
PLOT OF MODE SHAPE

LOAD SET 1

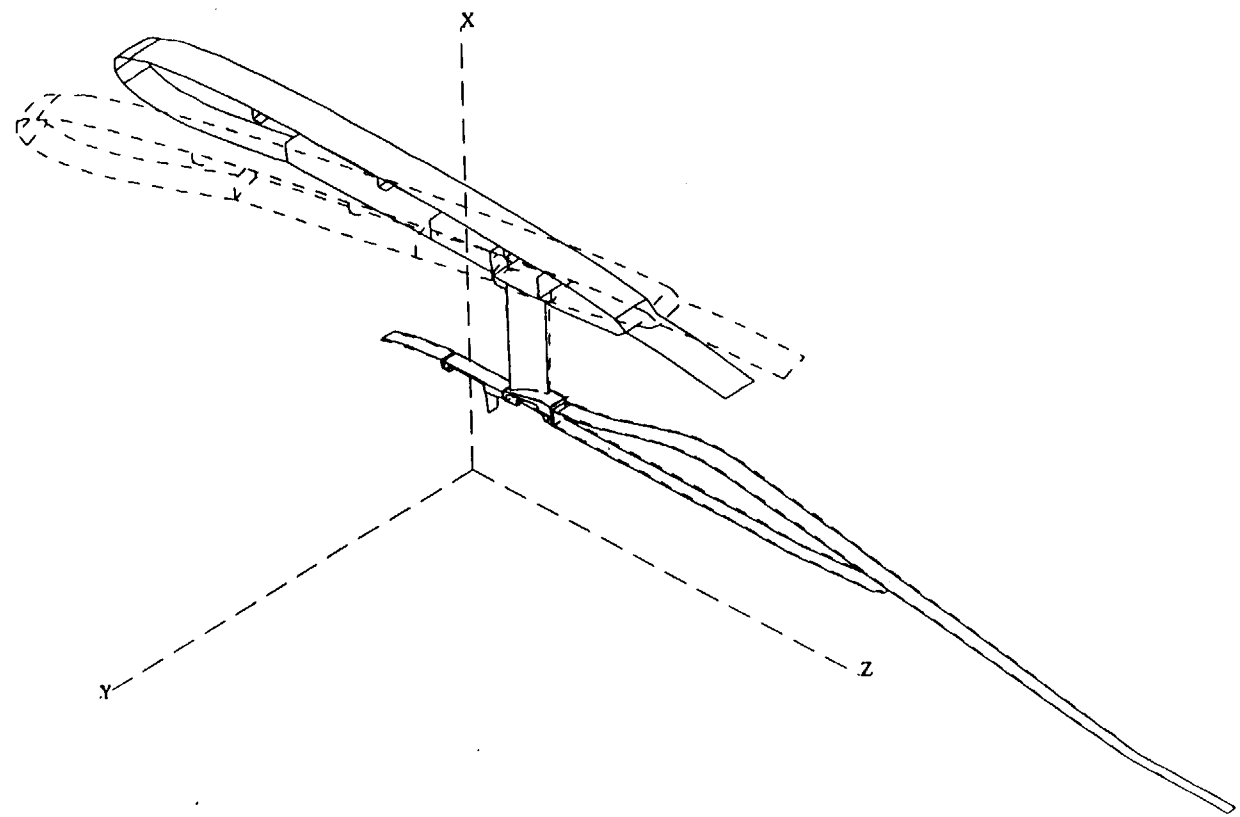
SCALE = .1600 PLOT TIME AND DATE = 15:39:30 95/207

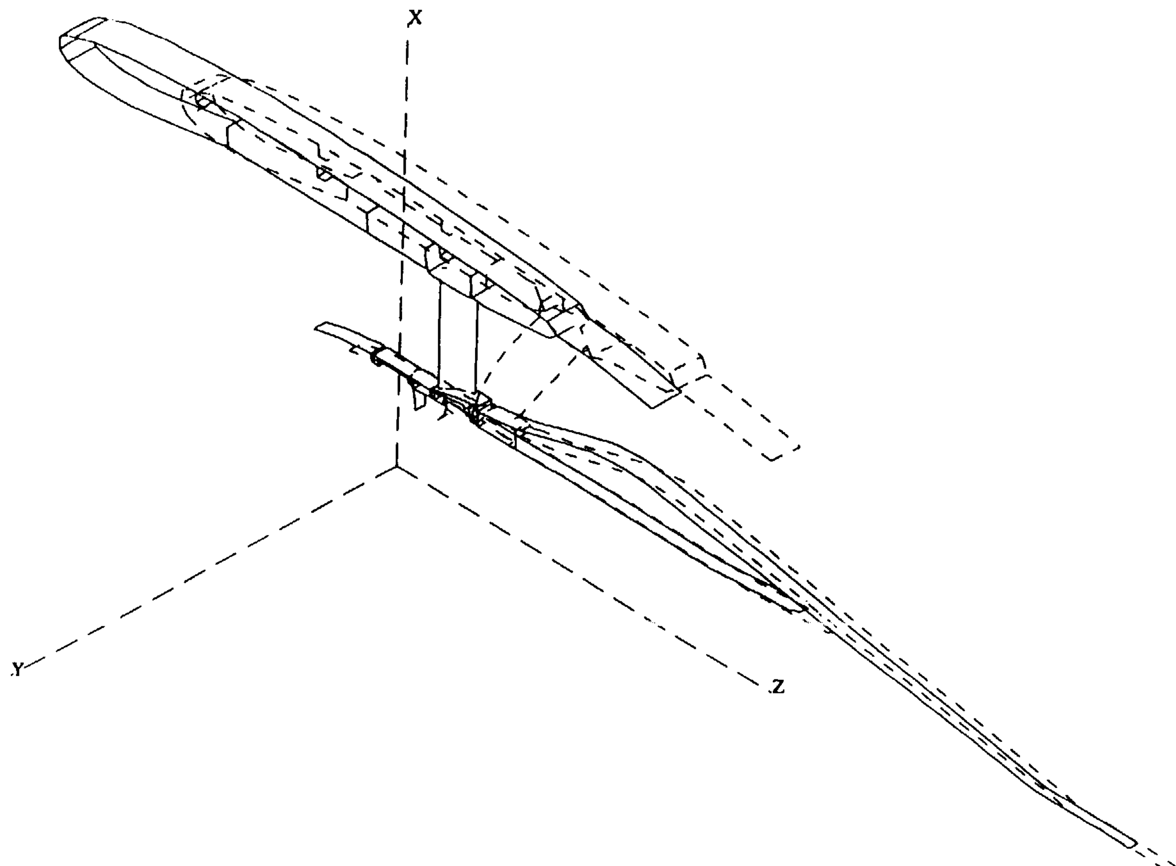
FREQUENCY = 143.709 SECTOR PATTERN = 0

MODE NUMBER = 2 PHI = .00

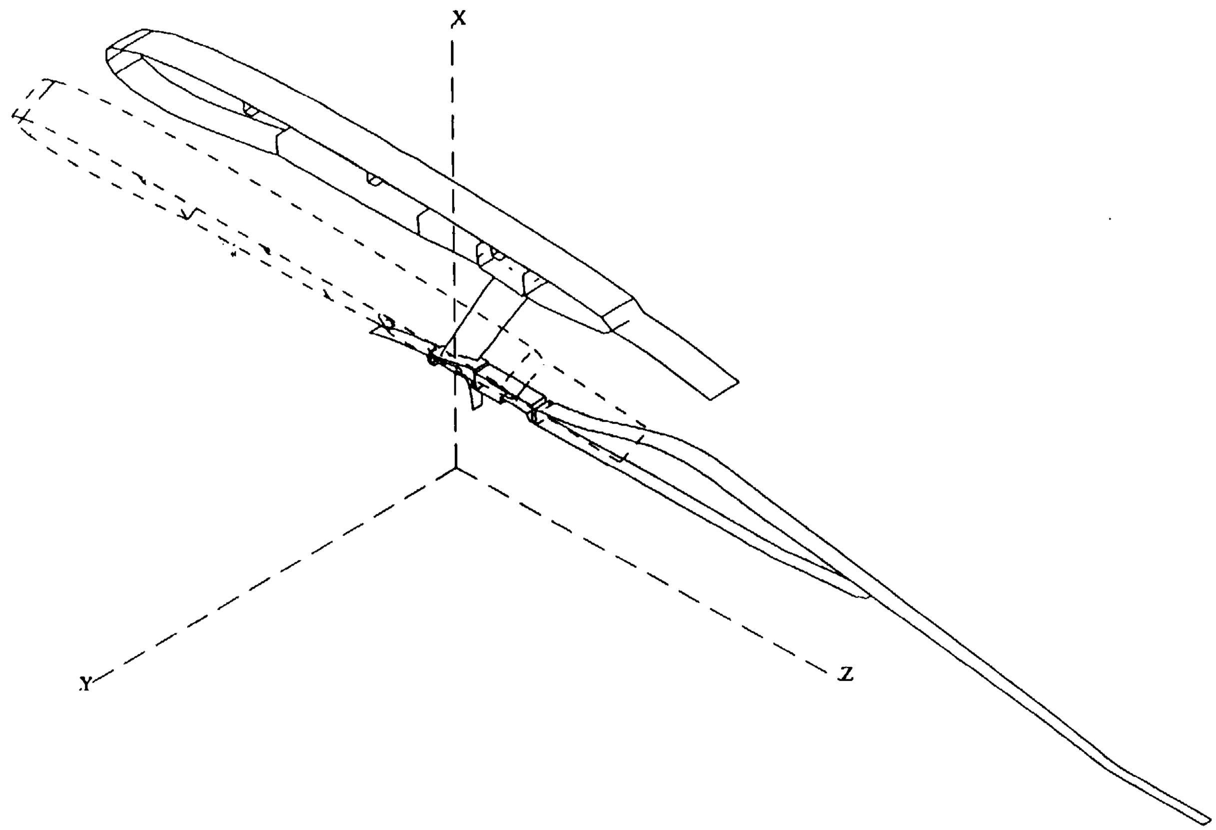


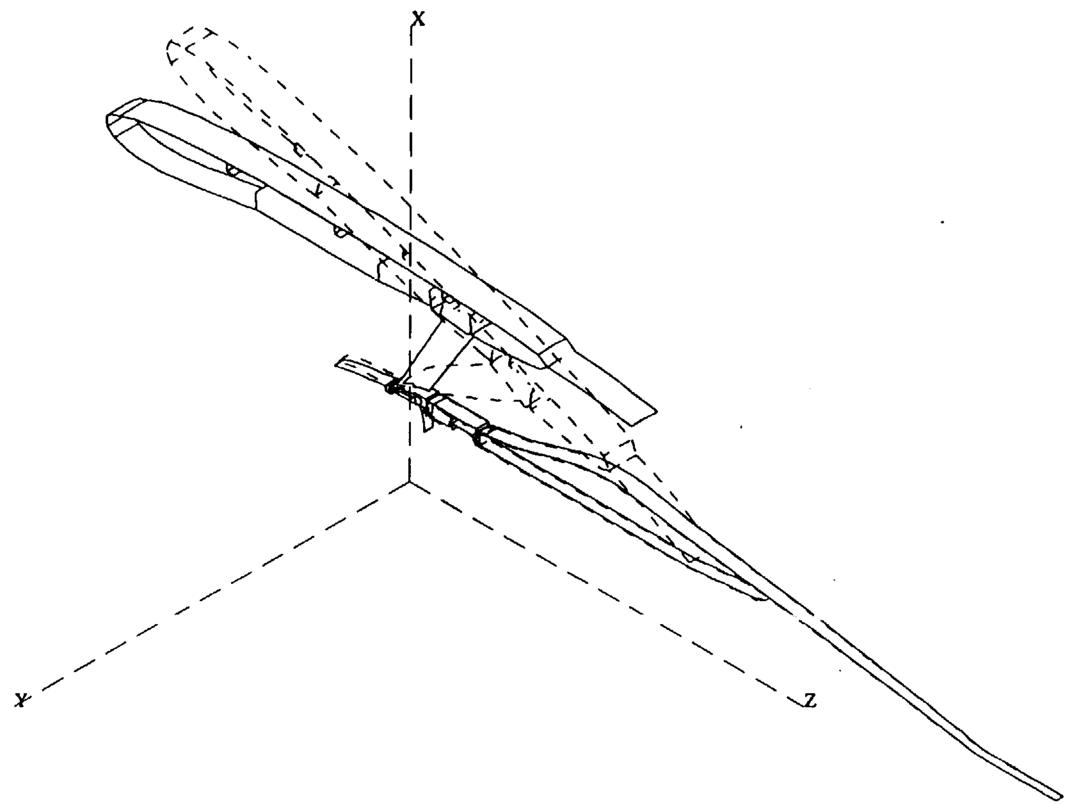
TITLE NASA fan rig nacelle ass'y; aft vane 2/14/95
PLOT OF MODE SHAPE
SCALE = .1600 PLOT TIME AND DATE = 15:47:58 95/207
FREQUENCY = 29.011 SECTOR PATTERN = 0 LOAD SET 1
MODE NUMBER = 1 PHI = .00


X
Y
Z
TITLE NASA fan rig nacelle ass'y; aft vane
2/14/95
PLOT OF MODE SHAPE
LOAD SET 2
SCALE = .1600
PLOT TIME AND DATE = 18:08:22 95/207
FREQUENCY = 81.631
SECTOR PATTERN = 1
MODE NUMBER = 1
PHI = .00

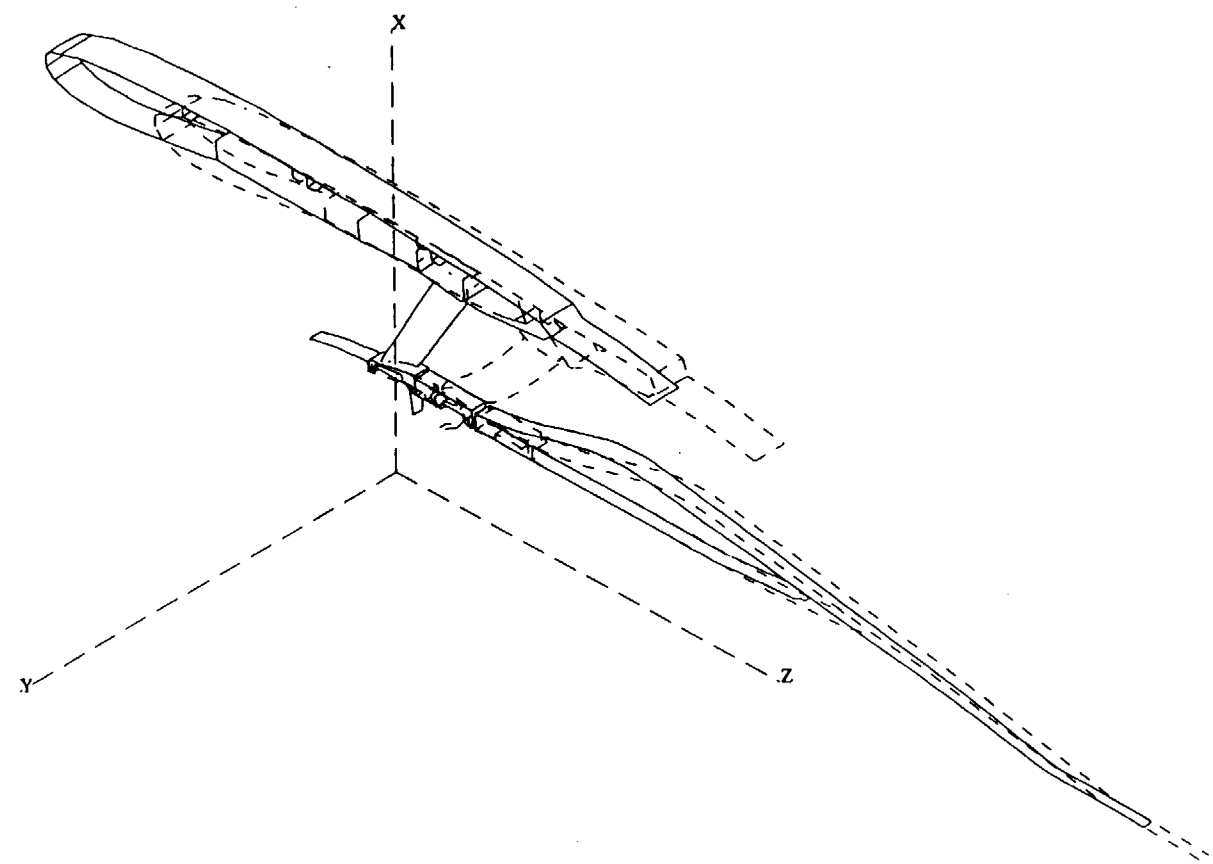


TITLE NASA fan rig nacelle ass'y; aft vane 2/14/95
PLOT OF MODE SHAPE
SCALE = .1600 PLOT TIME AND DATE = 15:48:59 95/207 LOAD SET 1
FREQUENCY = 146.982 SECTOR PATTERN = 0
MODE NUMBER = 2 PHI = .00


X
Y
Z
TITLE NASA fan rig nacelle ass'y; swept vane
updated 2/11/95
PLOT OF MODE SHAPE
LOAD SET 1
SCALE = .1600
PLOT TIME AND DATE = 17:48:08 95/207
FREQUENCY = 32.623
SECTOR PATTERN = 0
MODE NUMBER = 1
PHI = .00



TITLE NASA fan rig nacelle ass'y; swept vane updated 2/11/95
PLOT OF MODE SHAPE
SCALE = .1400 PLOT TIME AND DATE = 20:39:00 95/207 LOAD SET 2
FREQUENCY = 70.022 SECTOR PATTERN = 1
MODE NUMBER = 1 PHI = .00



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PLOT OF MODE SHAPE
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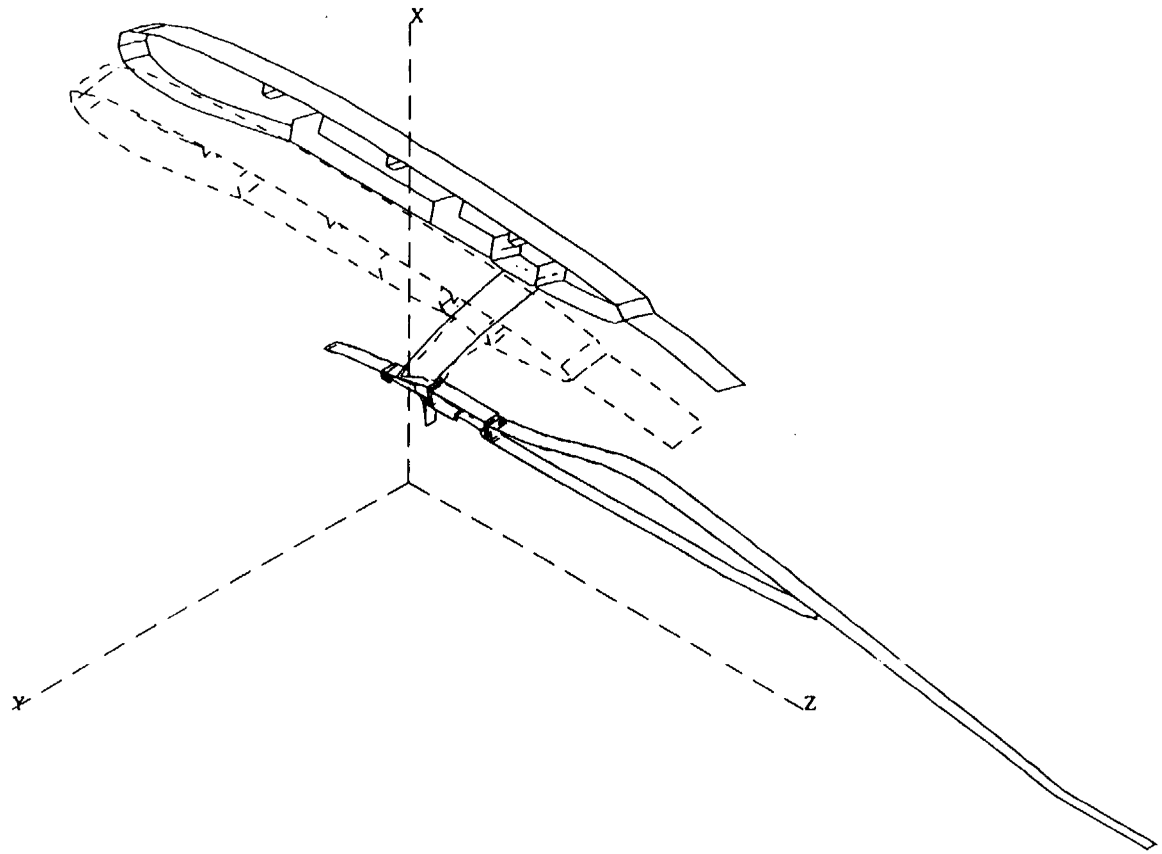
FREQUENCY = 166.042 SECTOR PATTERN = 0
MODE NUMBER = 2 PHI = .00



TITLE NASA fan rig nacelle ass'y; swept & leaned vane updated 2/11/95
PLOT OF MODE SHAPE
SCALE = .1600 PLOT TIME AND DATE = 17:47:27 95/207 LOAD SET 1
FREQUENCY = 50.604 SECTOR PATTERN = 0
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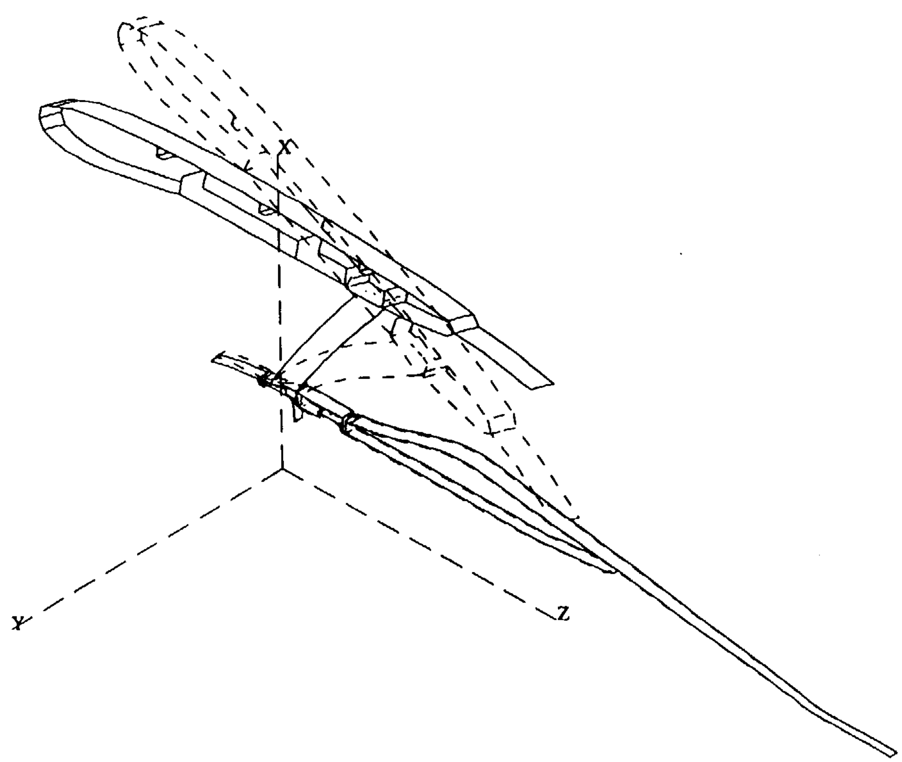


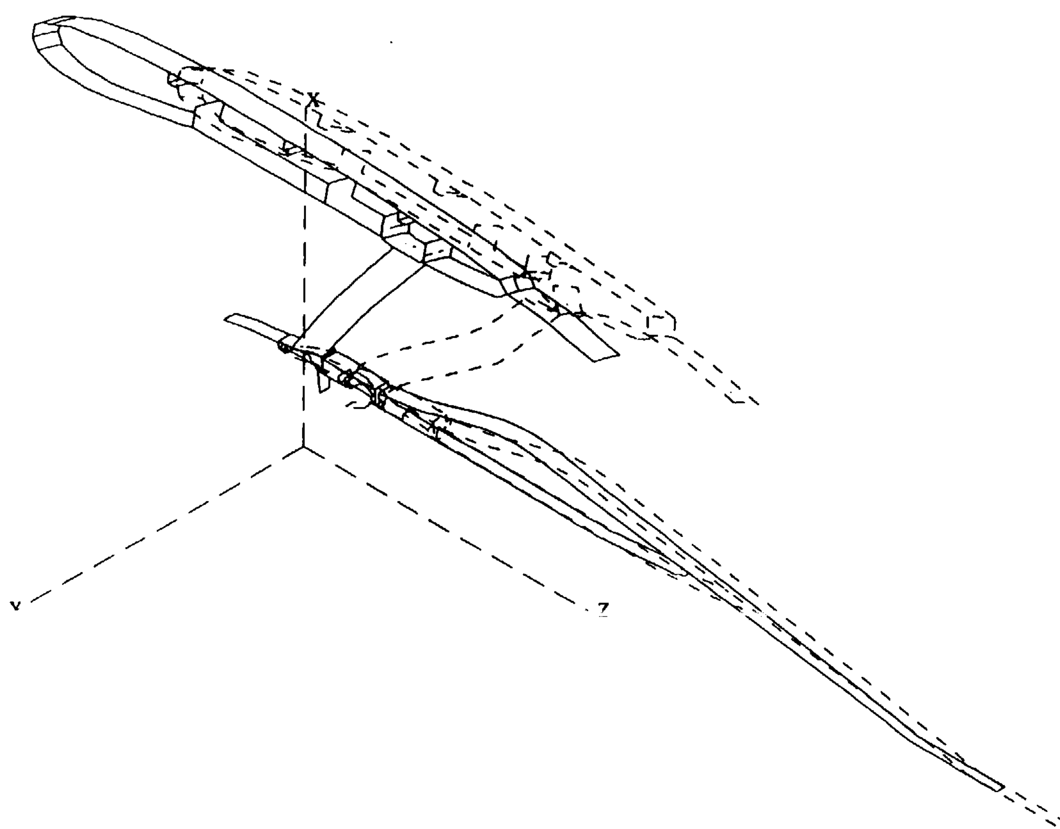
TITLE NASA fan rig nacelle ass'y; swept & leaned vane   updated 2/11/95

PLOT OF MODE SHAPE   LOAD SET 2

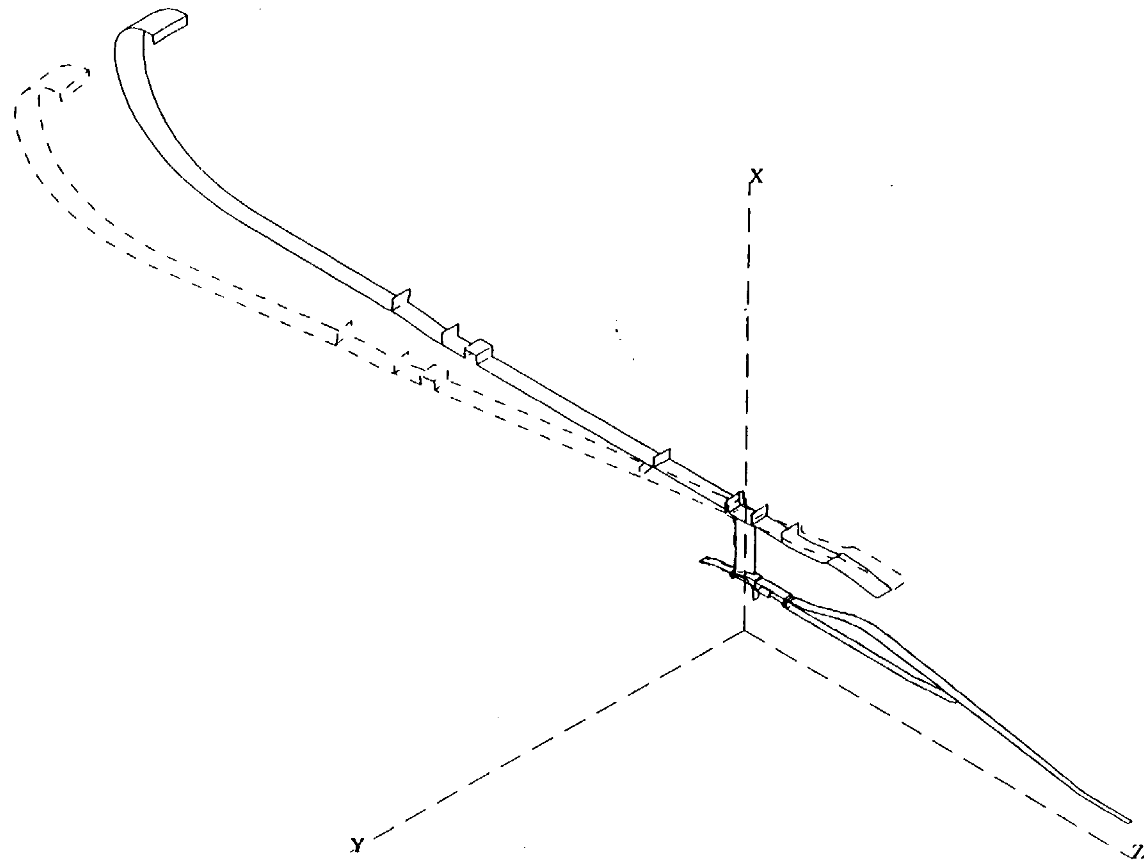
SCALE = .1300   PLOT TIME AND DATE = 20:33:48 95/207

FREQUENCY = 61.232   SECTOR PATTERN = 1

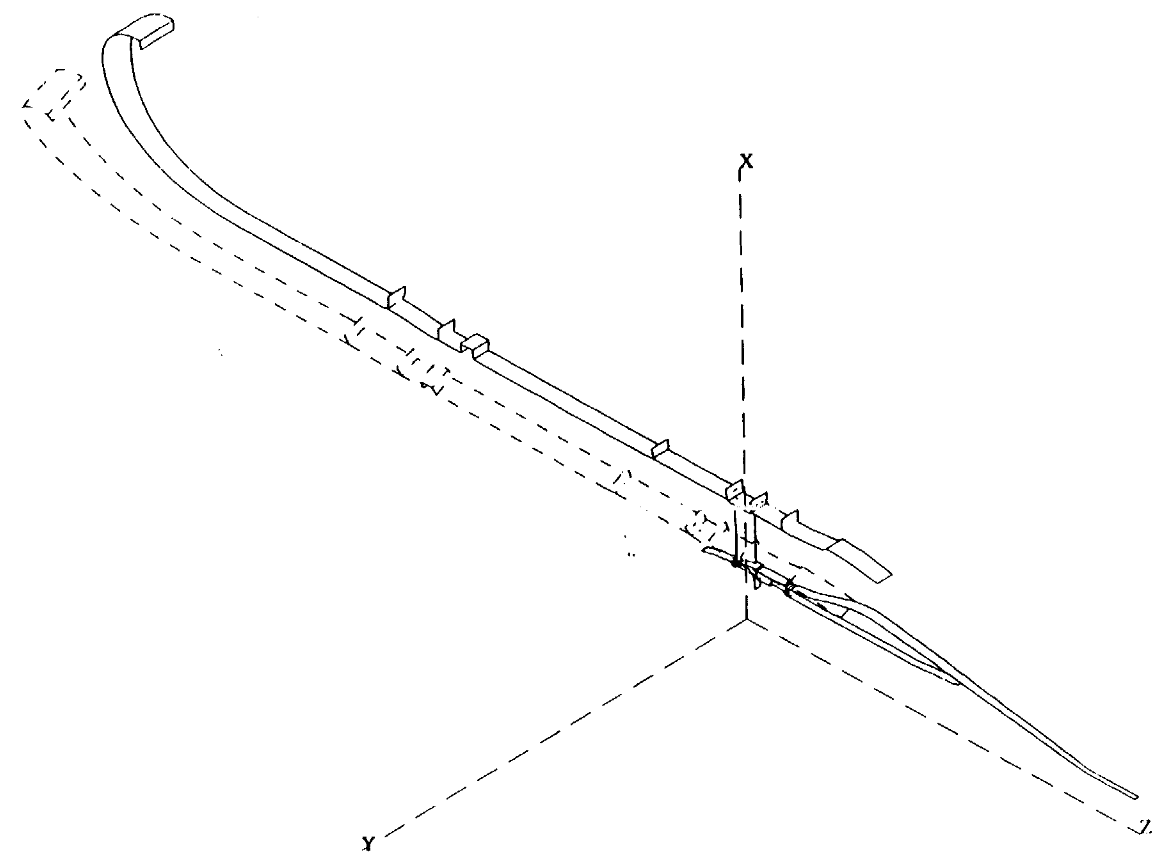
MODE NUMBER = 1   PHI = .00



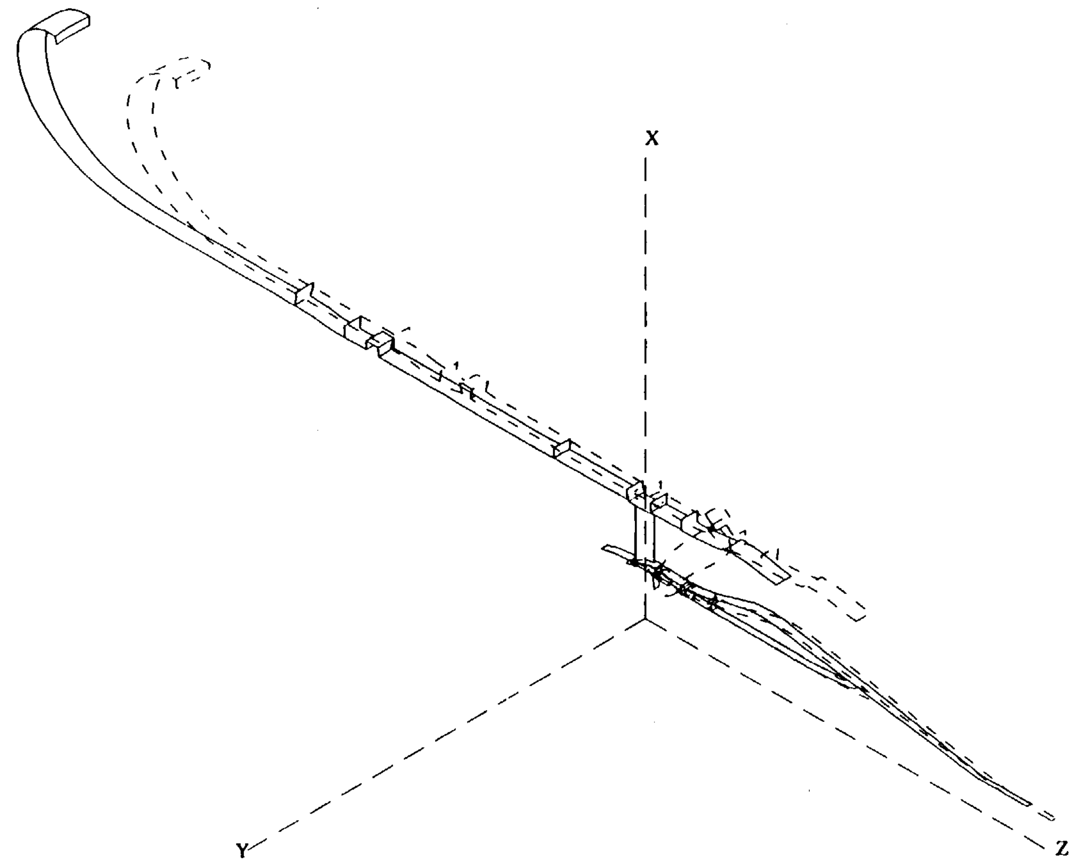
TITLE NASA fan rig nacelle ass'y; swept & leaned vane   updated 2/11/95
PLOT OF MODE SHAPE
SCALE = .1500   PLOT TIME AND DATE = 17:48:09 95/207   LOAD SET 1
FREQUENCY = 171.446   SECTOR PATTERN = 0
MODE NUMBER = 2   PHI = .00



TITLE NASA fan rig nacelle ass'y w/ inst. spool & baseline vane 3/15/95
PLOT OF MODE SHAPE
SCALE = .0830 PLOT TIME AND DATE = 13:28:31 95/074 LOAD SET 2
FREQUENCY = 19.949 SECTOR PATTERN = 1
MODE NUMBER = 1 PHI = .00



TITLE NASA fan rig nacelle ass'y w/ inst. spool & baseline vane 3/15/95
PLOT OF MODE SHAPE LOAD SET 1
SCALE = .0830 PLOT TIME AND DATE = 13:10:40 95/074
FREQUENCY = 20.870 SECTOR PATTERN = 0
MODE NUMBER = 1 PHI = .00



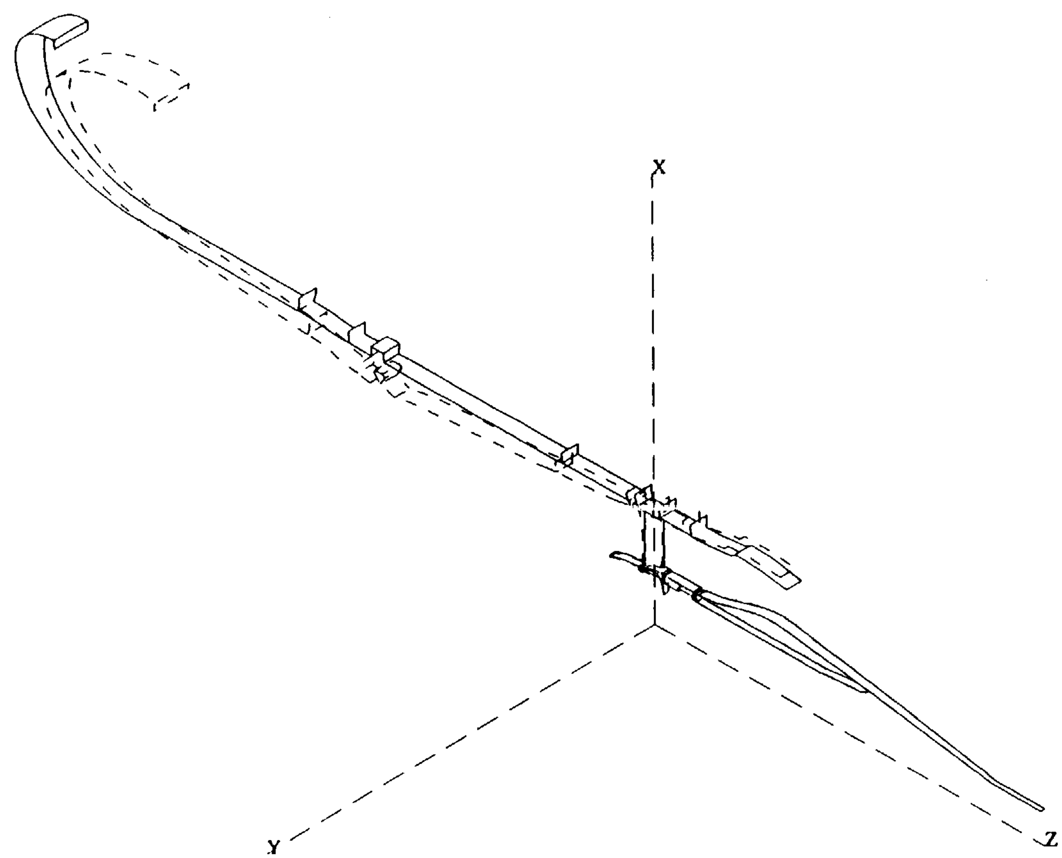
TITLE NASA fan rig nacelle ass'y w/ inst. spool & baseline vane 3/15/95

PLOT OF MODE SHAPE

SCALE = .0820 PLOT TIME AND DATE = 13:11:13 95/074 LOAD SET 1

FREQUENCY = 105.215 SECTOR PATTERN = 0

MODE NUMBER = 2 PHI = .00



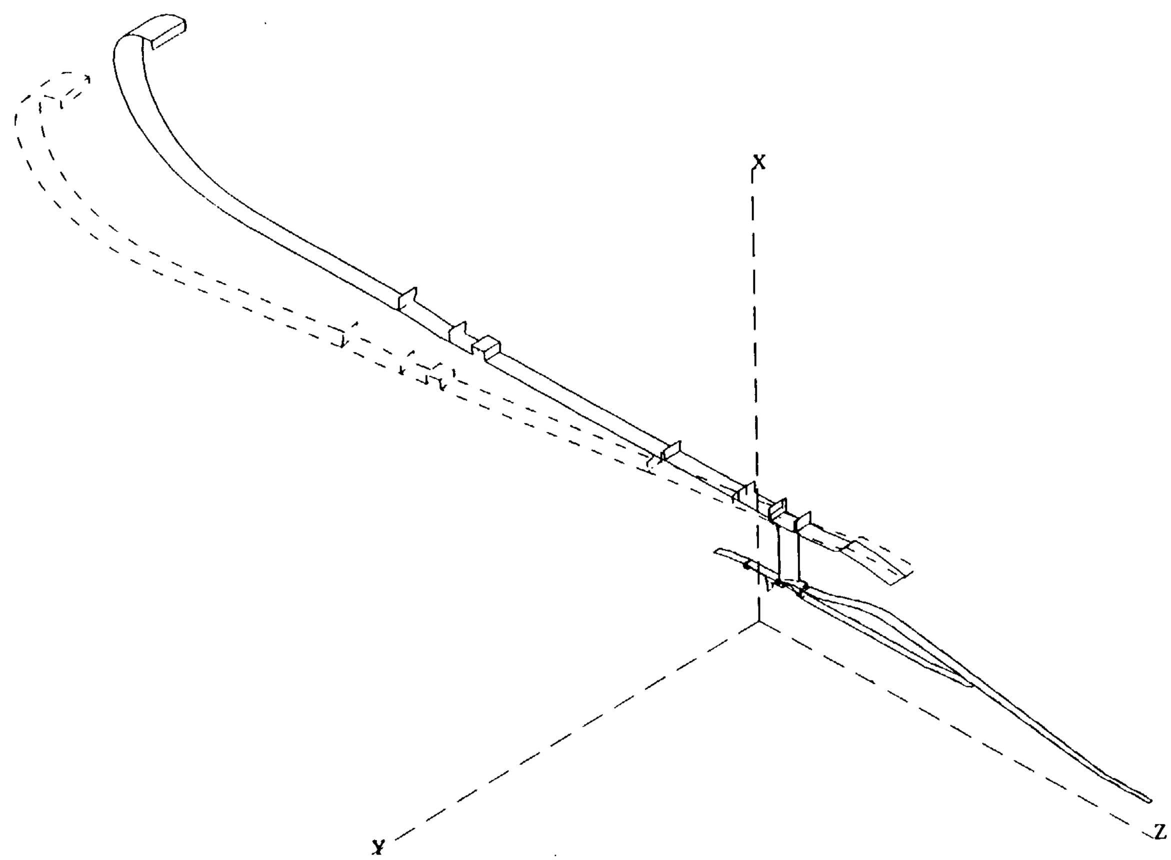
TITLE NASA fan rig nacelle ass'y w/ inst. spool & baseline vane 3/15/95

PLOT OF MODE SHAPE

SCALE = .0830 PLOT TIME AND DATE = 13:28:54 95/074 LOAD SET 2

FREQUENCY = 230.697 SECTOR PATTERN = 1

MODE NUMBER = 2 PHI = .00



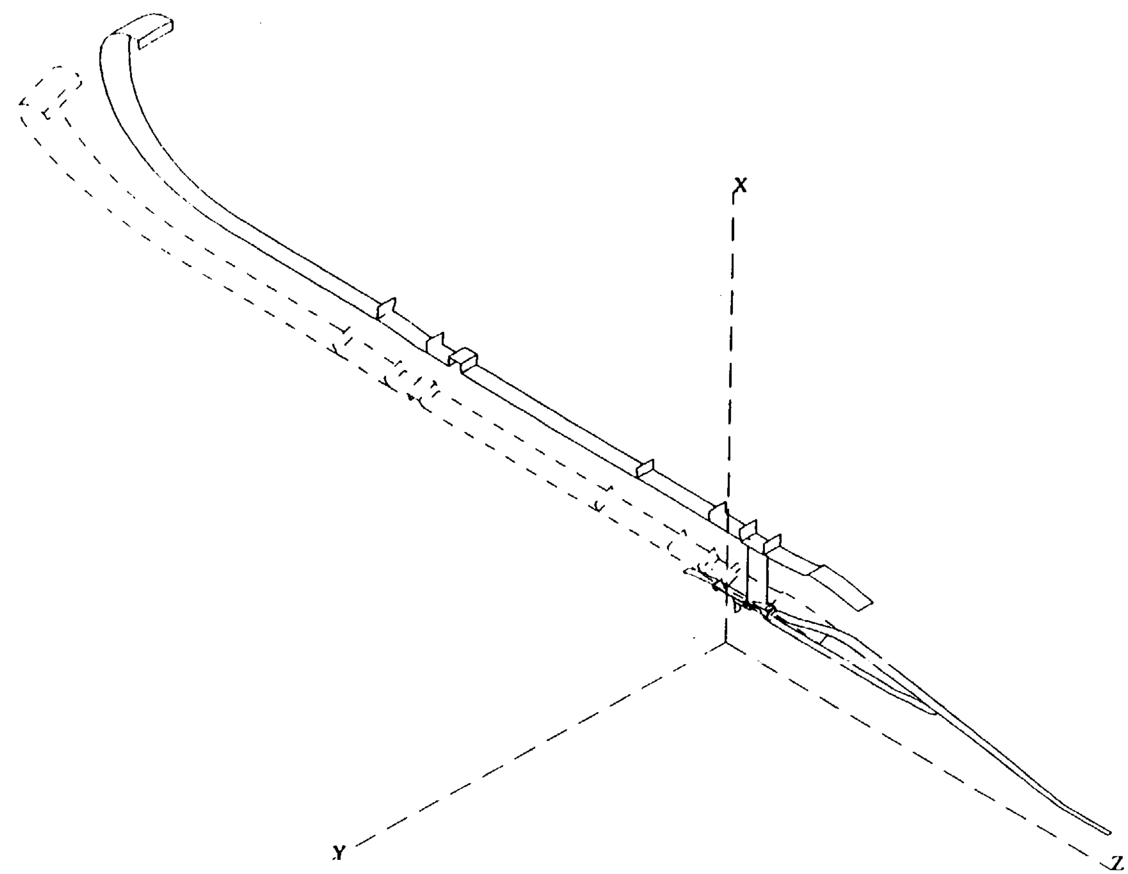
TITLE NASA fan rig nacelle ass'y w/ inst. spool & aft vane   3/01/95

PLOT OF MODE SHAPE   LOAD SET 2

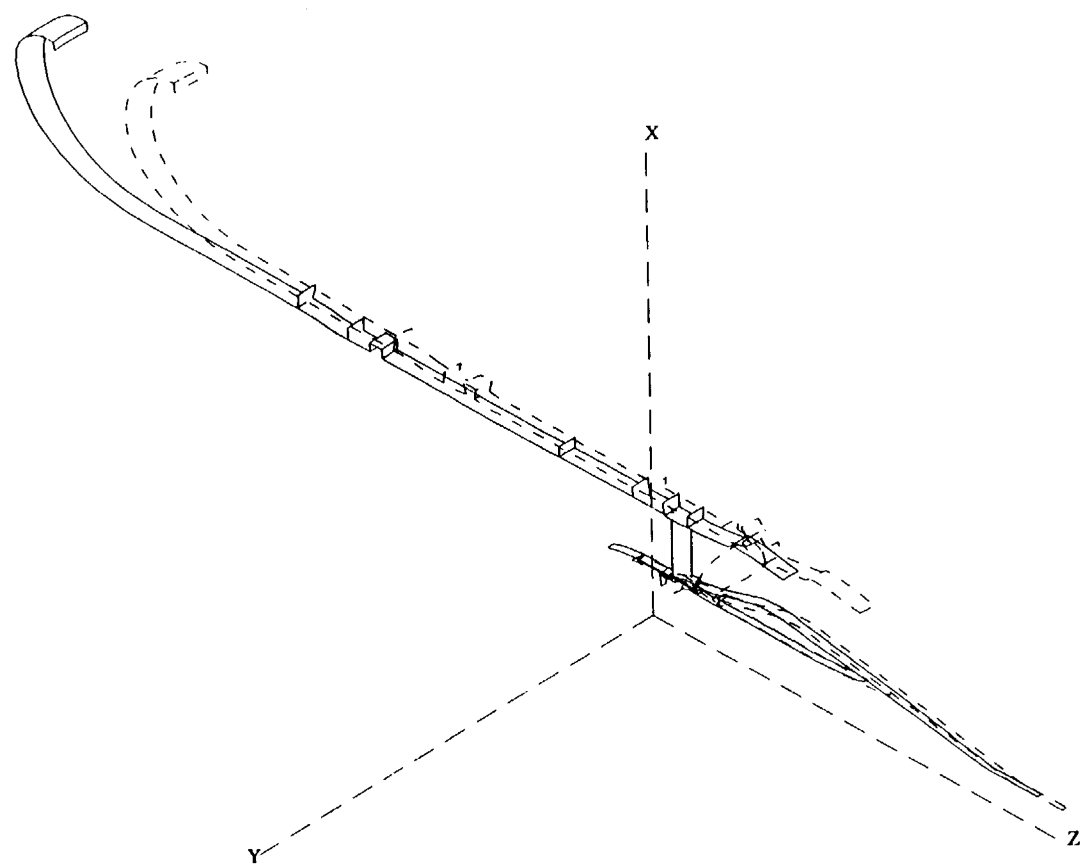
SCALE = .0830   PLOT TIME AND DATE = 11:49:48 95/060

FREQUENCY = 20.507   SECTOR PATTERN = 1

MODE NUMBER = 1   PHI = .00



TITLE NASA fan rig nacelle ass'y w/ inst. spool & aft vane 3/01/95
PLOT OF MODE SHAPE
SCALE = .0830 PLOT TIME AND DATE = 11:34:07 95/060 LOAD SET 1
FREQUENCY = 20.876 SECTOR PATTERN = 0
MODE NUMBER = 1 PHI = .00



TITLE NASA fan rig nacelle ass'y w/ inst. spool & aft vane — 3/01/95

PLOT OF MODE SHAPE — LOAD SET 1

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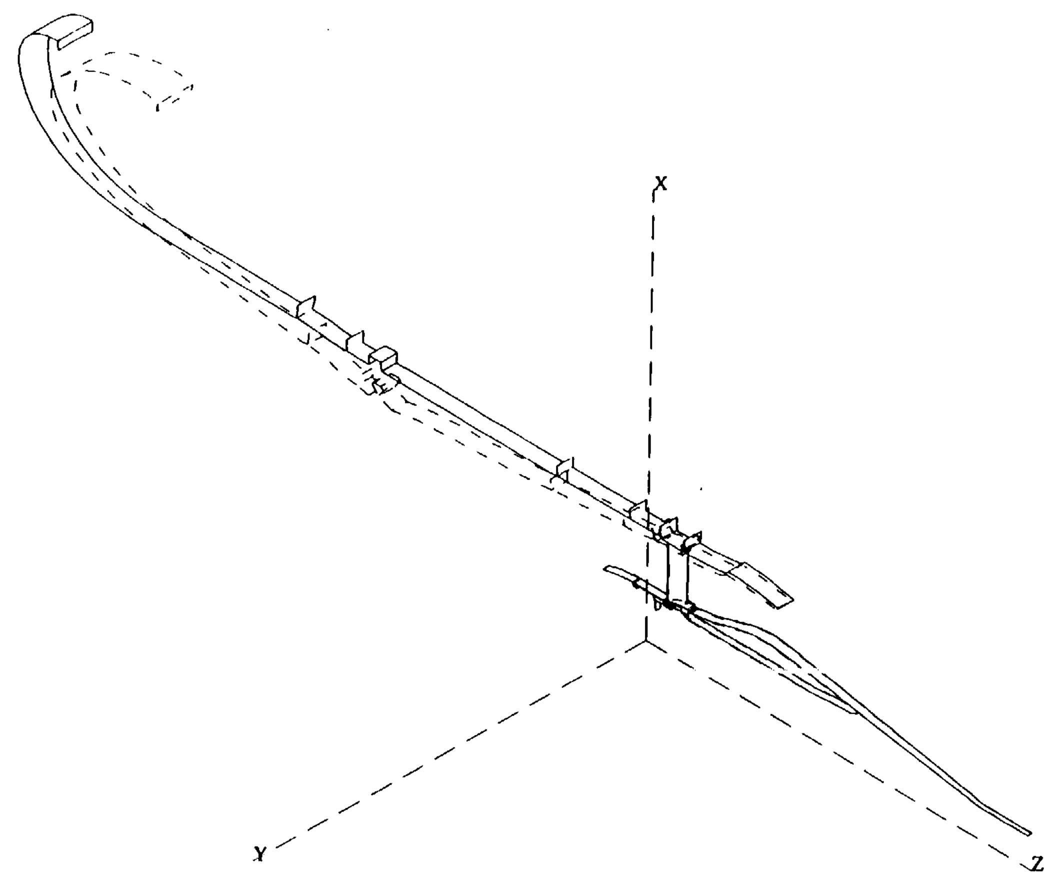
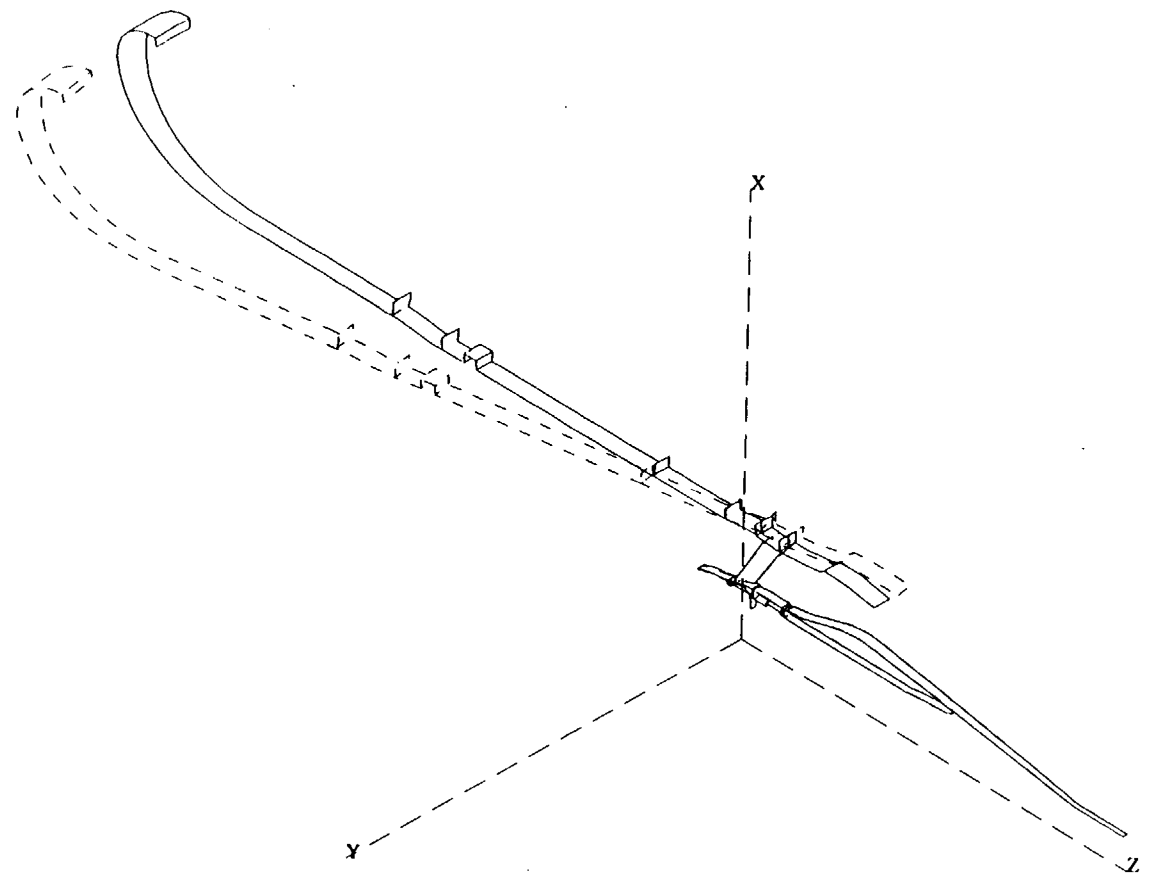
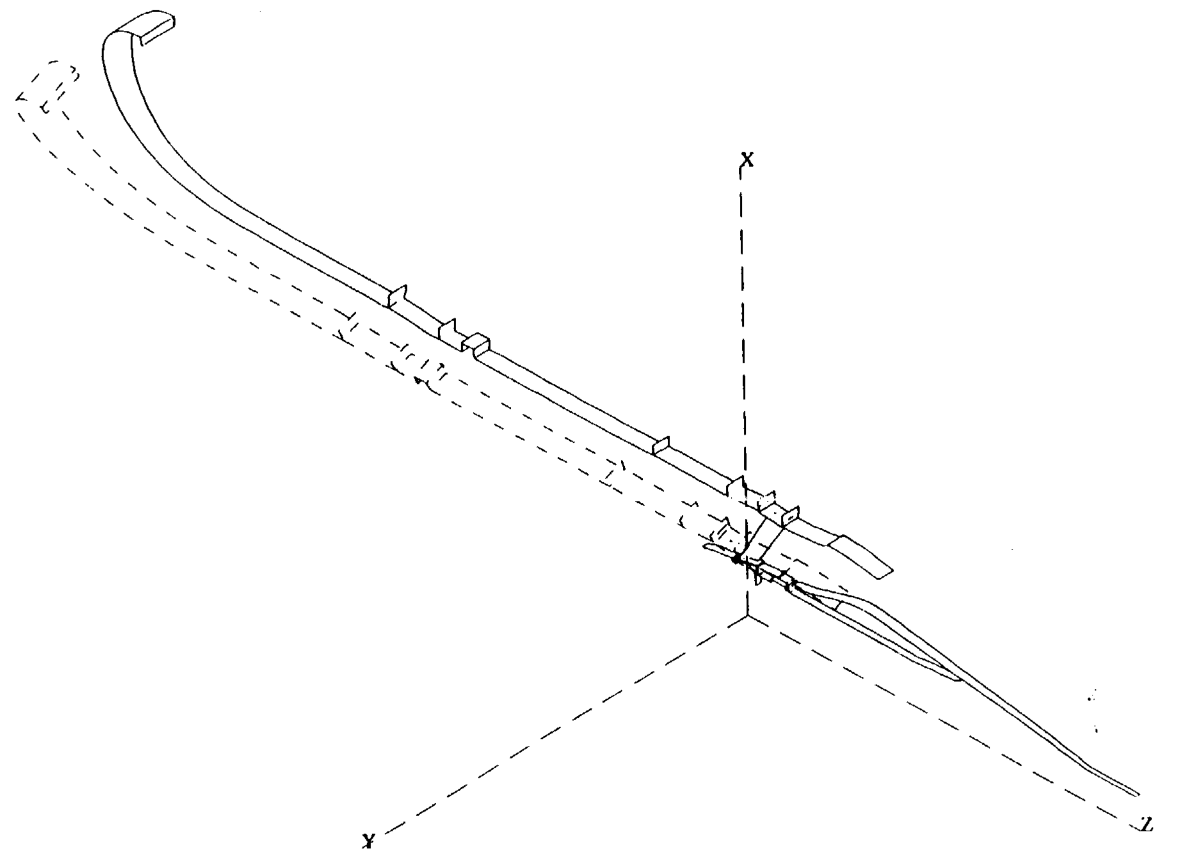
MODE NUMBER = 2 — PHI = .00

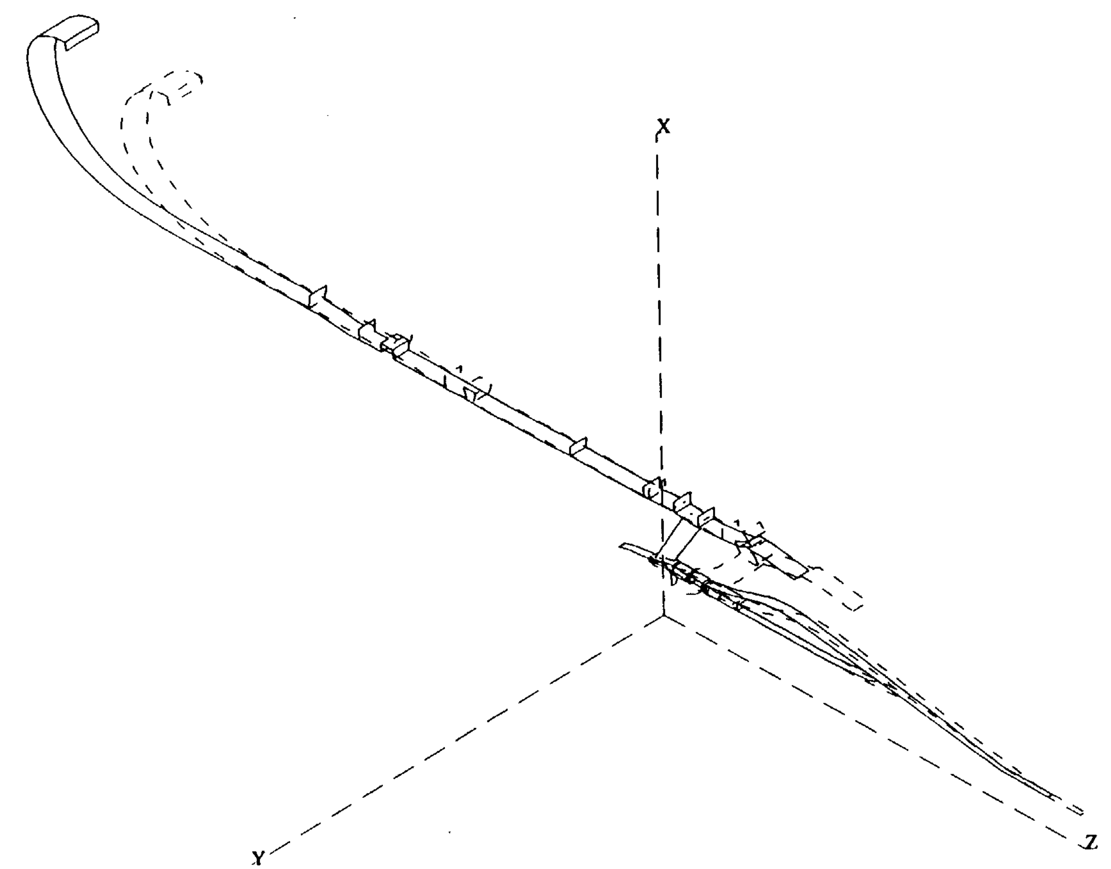


TITLE NASA fan rig nacelle ass'y w/ inst. spool & aft vane 3/01/95
PLOT OF MODE SHAPE
SCALE = .0830 PLOT TIME AND DATE = 11:50:08 95/060 LOAD SET 2
FREQUENCY = 225.854 SECTOR PATTERN = 1
MODE NUMBER = 2 PHI = .00

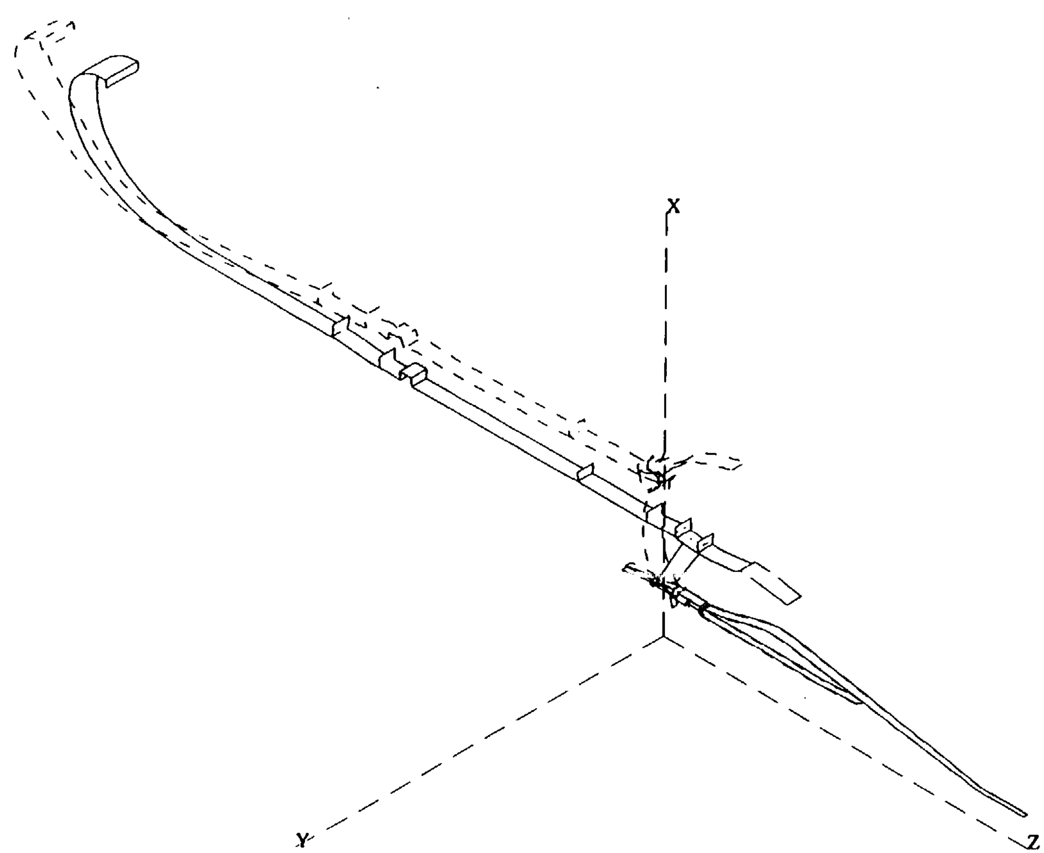


TITLE NASA fan rig nacelle ass'y w/ inst. spool & swept vane 3/15/95
PLOT OF MODE SHAPE
SCALE = .0830 PLOT TIME AND DATE = 15:05:45 95/074 LOAD SET 2
FREQUENCY = 18.577 SECTOR PATTERN = 1
MODE NUMBER = 1 PHI = .00

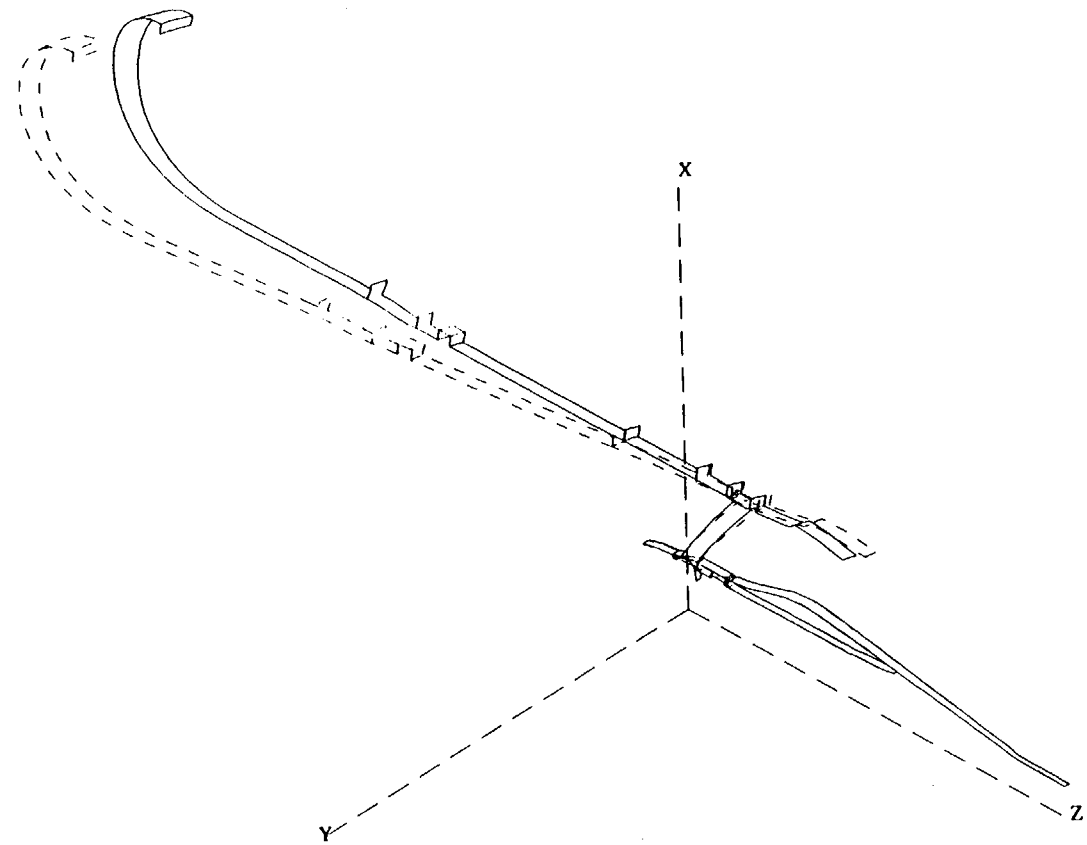

X
Y
Z
TITLE NASA fan rig nacelle ass'y w/ inst. spool & swept vane
3/15/95
PLOT OF MODE SHAPE
LOAD SET 1
SCALE = .0830
PLOT TIME AND DATE = 14:34:36 95/074
FREQUENCY = 22.867
SECTOR PATTERN = 0
MODE NUMBER = 1
PHI = .00



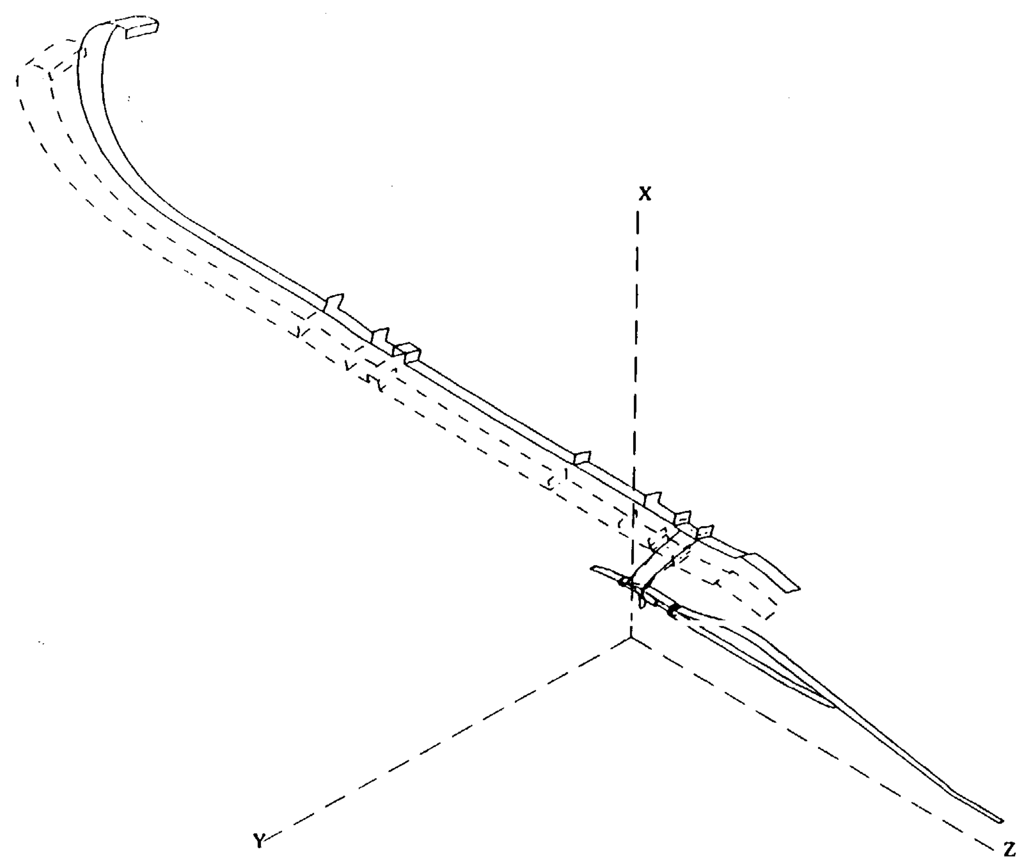
TITLE NASA fan rig nacelle ass'y w/ inst. spool & swept vane 3/15/95
PLOT OF MODE SHAPE
SCALE = .0820 PLOT TIME AND DATE = 14:35:09 95/074 LOAD SET 1
FREQUENCY = 119.080 SECTOR PATTERN = 0
MODE NUMBER = 2 PHI = .00



TITLE NASA fan rig nacelle ass'y w/ inst. spool & swept vane 3/15/95
PLOT OF MODE SHAPE
SCALE = .0780 PLOT TIME AND DATE = 15:06:32 95/074 LOAD SET 2
FREQUENCY = 198.899 SECTOR PATTERN = 1
MODE NUMBER = 2 PHI = .00



TITLE NASA fan rig nacelle ass'y w/ inst. spool + swept & leaned vane 3/15/95
PLOT OF MODE SHAPE LOAD SET 2
SCALE = .0800 PLOT TIME AND DATE = 15:27:10 95/074
FREQUENCY = 16.812 SECTOR PATTERN = 1
MODE NUMBER = 1 PHI = .00



TITLE NASA fan rig nacelle ass'y w/ inst. spool + swept & leaned vane 3/15/95
PLOT OF MODE SHAPE
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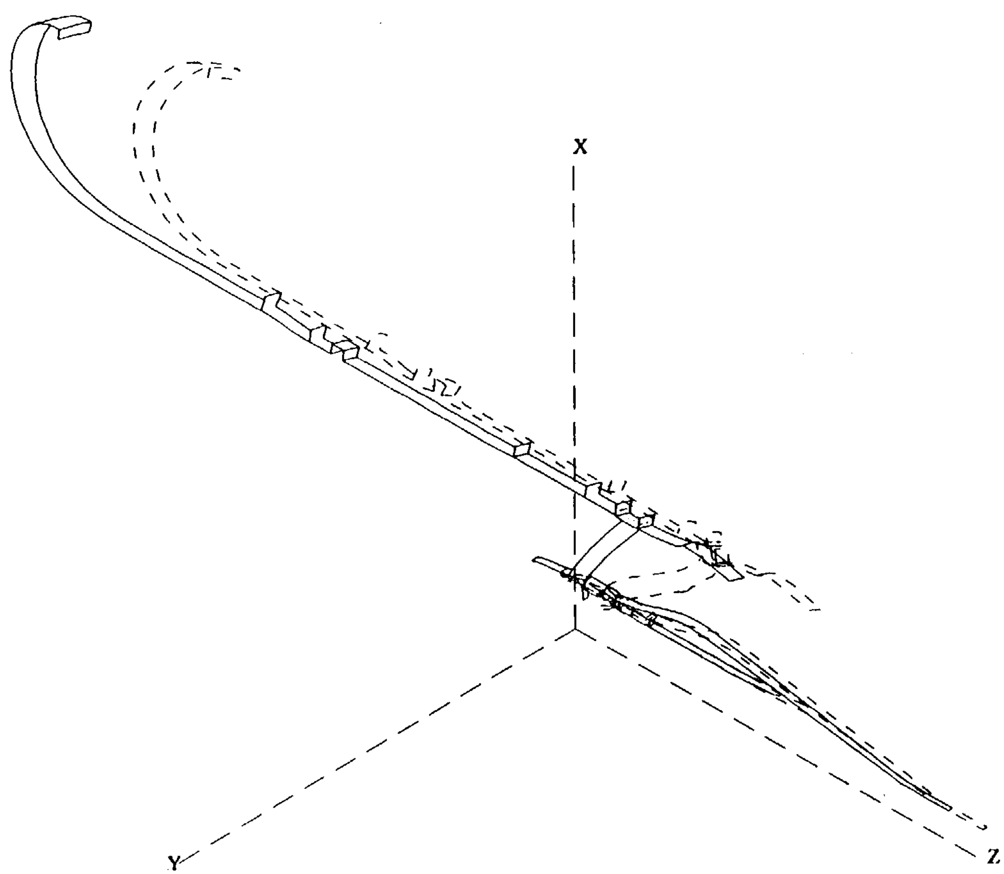
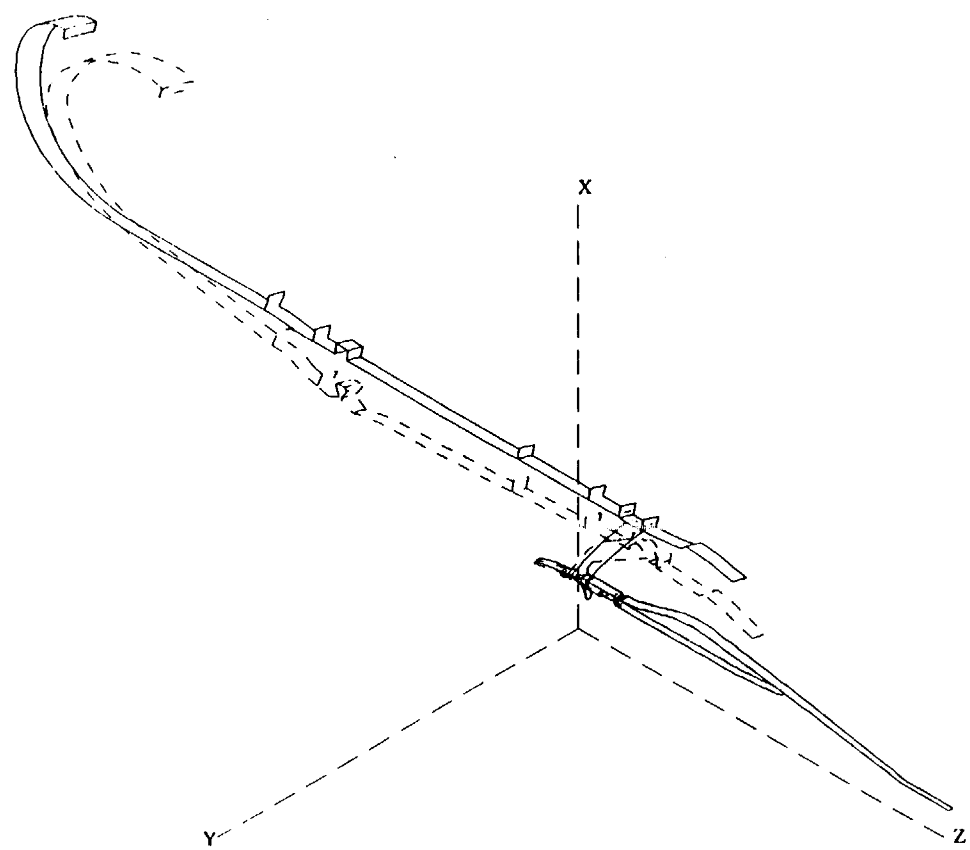
FREQUENCY = 33.795 SECTOR PATTERN = 0
MODE NUMBER = 1 PHI = .00



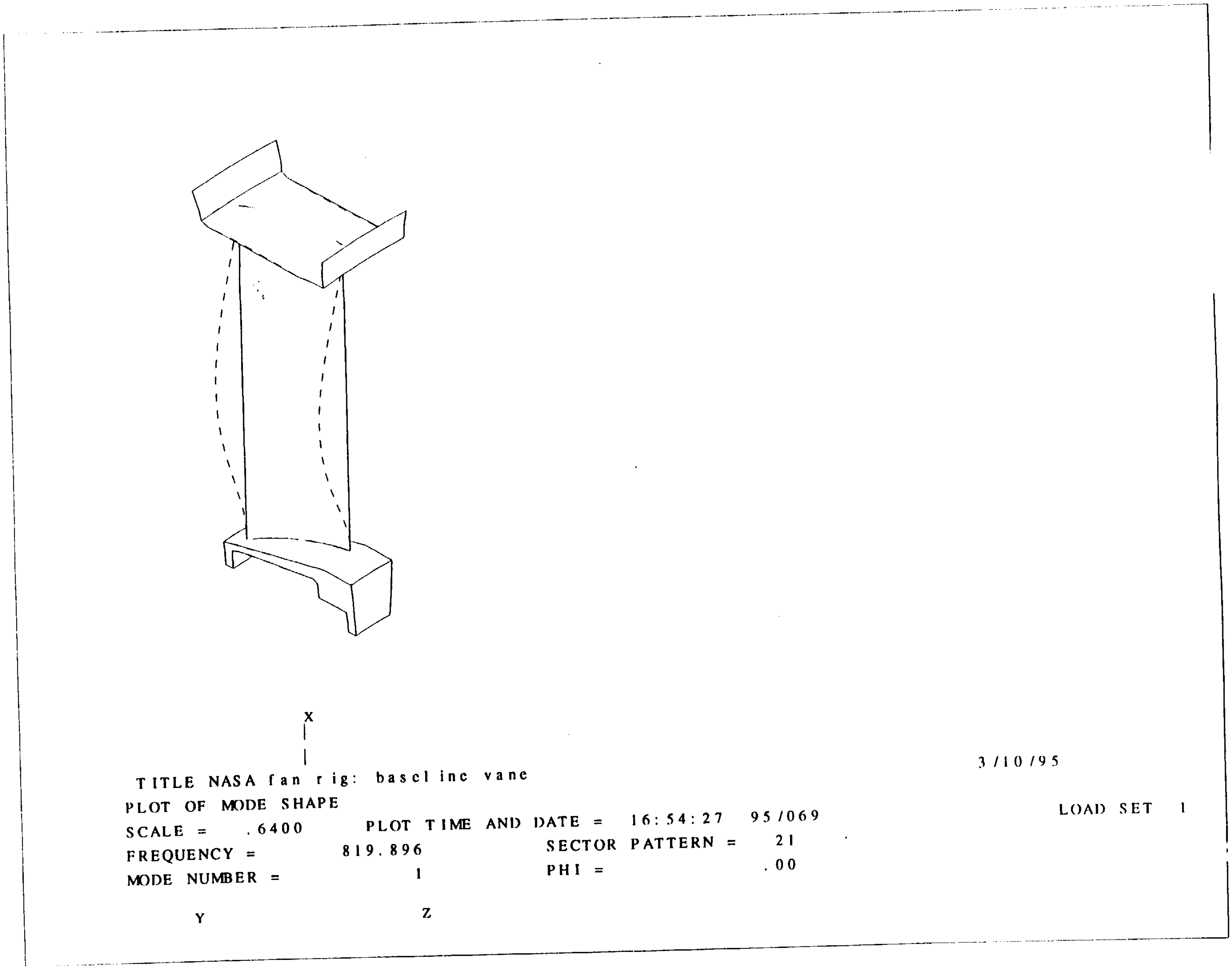
TITLE NASA fan rig nacelle ass'y w/ inst. spool + swept & leaned vane 3/15/95
PLOT OF MODE SHAPE
SCALE = .0800 PLOT TIME AND DATE = 14:58:02 95/074 LOAD SET 1
FREQUENCY = 121.725 SECTOR PATTERN = 0
MODE NUMBER = 2 PHI = .00

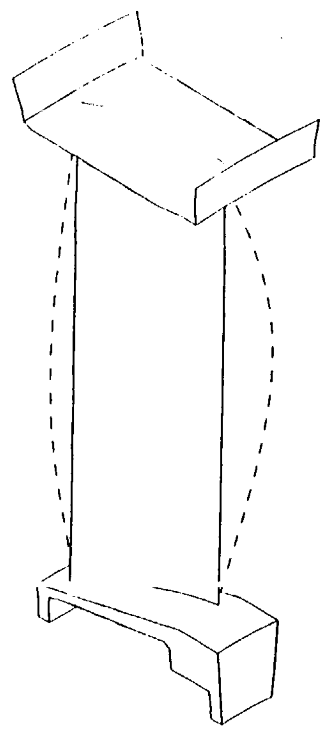


TITLE NASA fan rig nacelle ass'y w/ inst. spool + swept & leaned vane 3/15/95
PLOT OF MODE SHAPE
SCALE = .0800 PLOT TIME AND DATE = 15:28:12 95/074 LOAD SET 2
FREQUENCY = 219.253 SECTOR PATTERN = 1
MODE NUMBER = 2 PHI = .00

APPENDIX J

RESULTS OF DYNAMIC ANALYSIS VANE MODES


X
TITLE NASA fan rig: baseline vane
PLOT OF MODE SHAPE
SCALE = .6400
PLOT TIME AND DATE = 16:54:27 95/069
FREQUENCY = 819.896
SECTOR PATTERN = 21
MODE NUMBER = 1
PHI = .00
Y
Z
3/10/95
LOAD SET 1



X

TITLE NASA fan rig: baseline vane 3/10/95

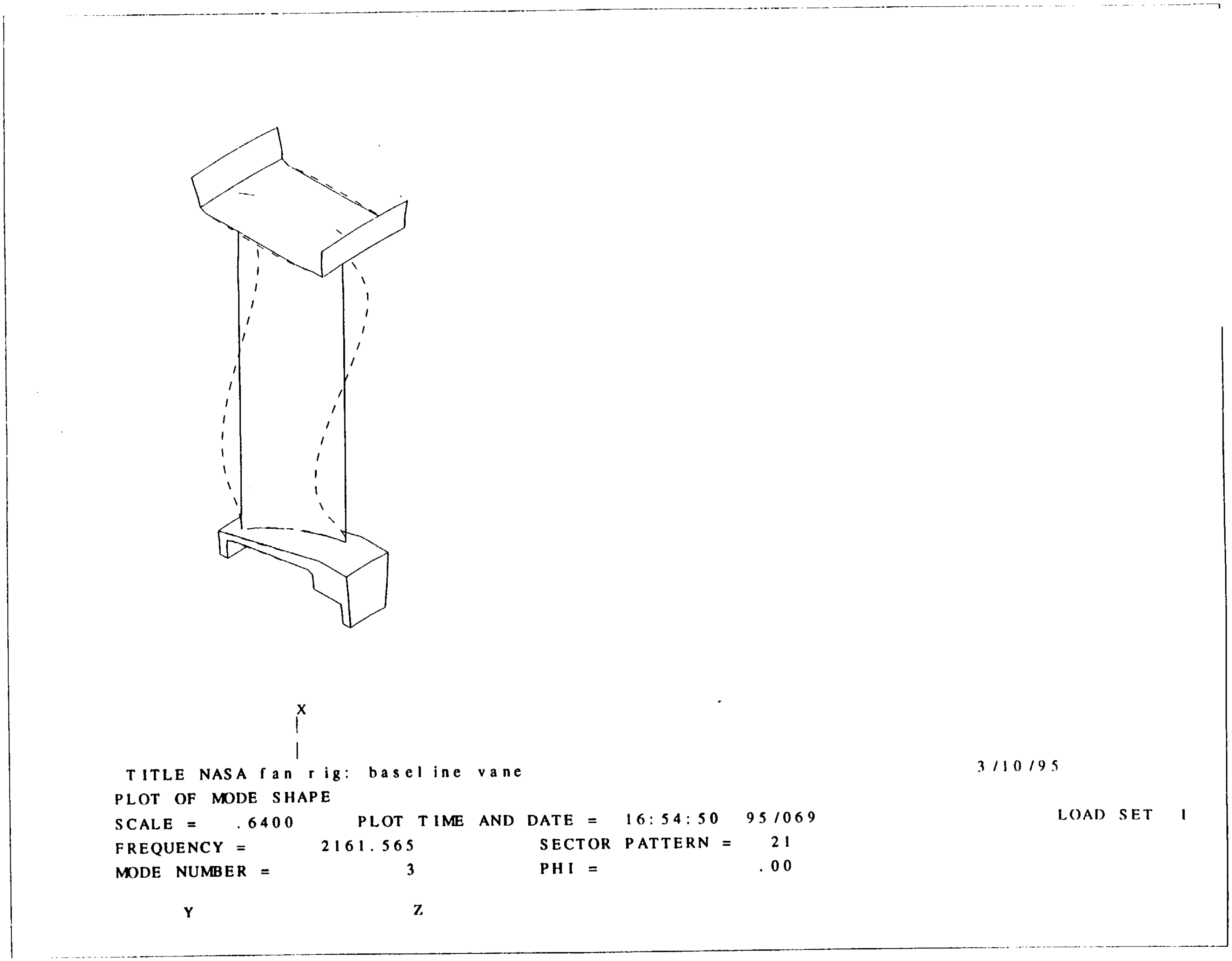
PLOT OF MODE SHAPE

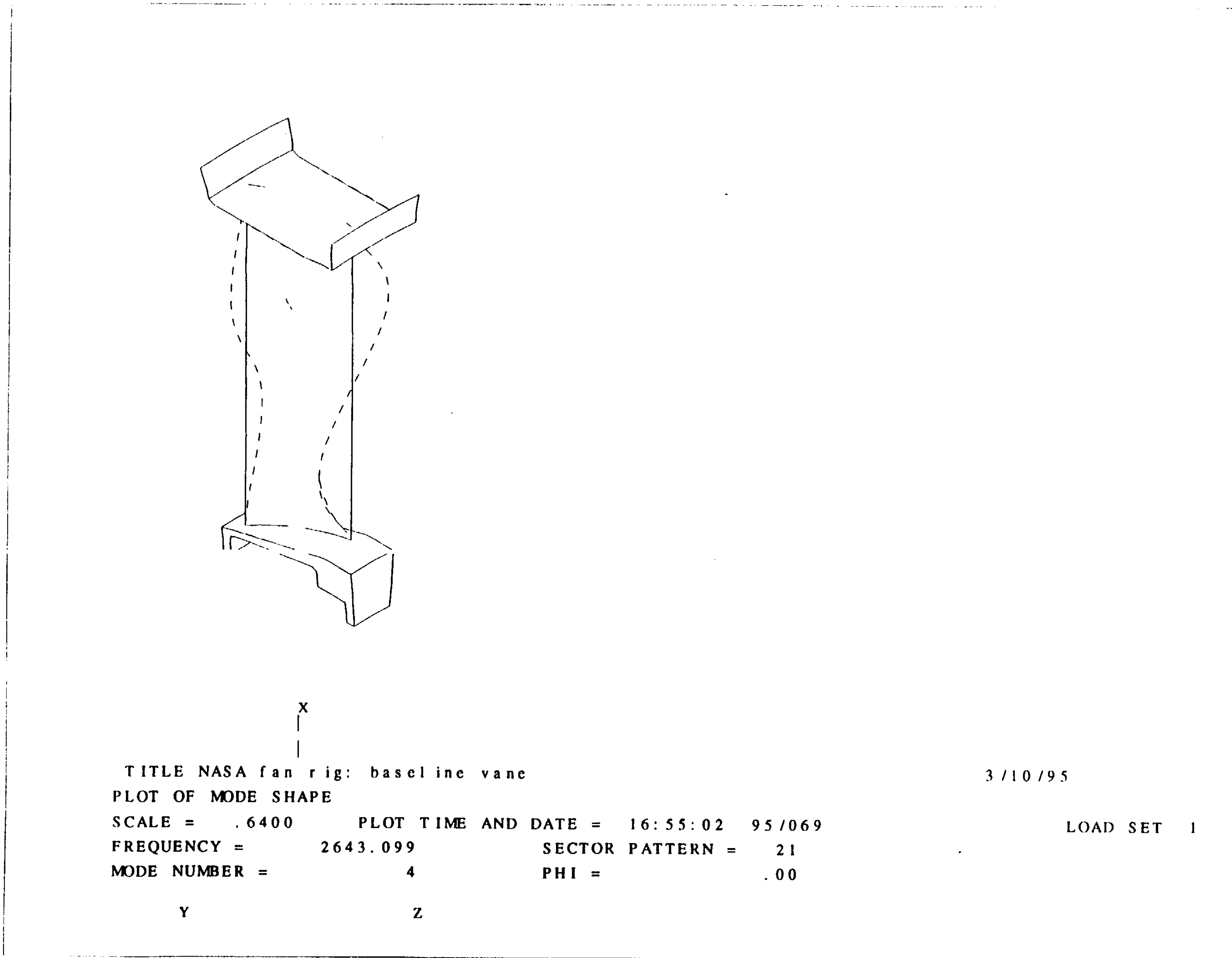
SCALE = .6400 PLOT TIME AND DATE = 16:54:38 95/069 LOAD SET 1

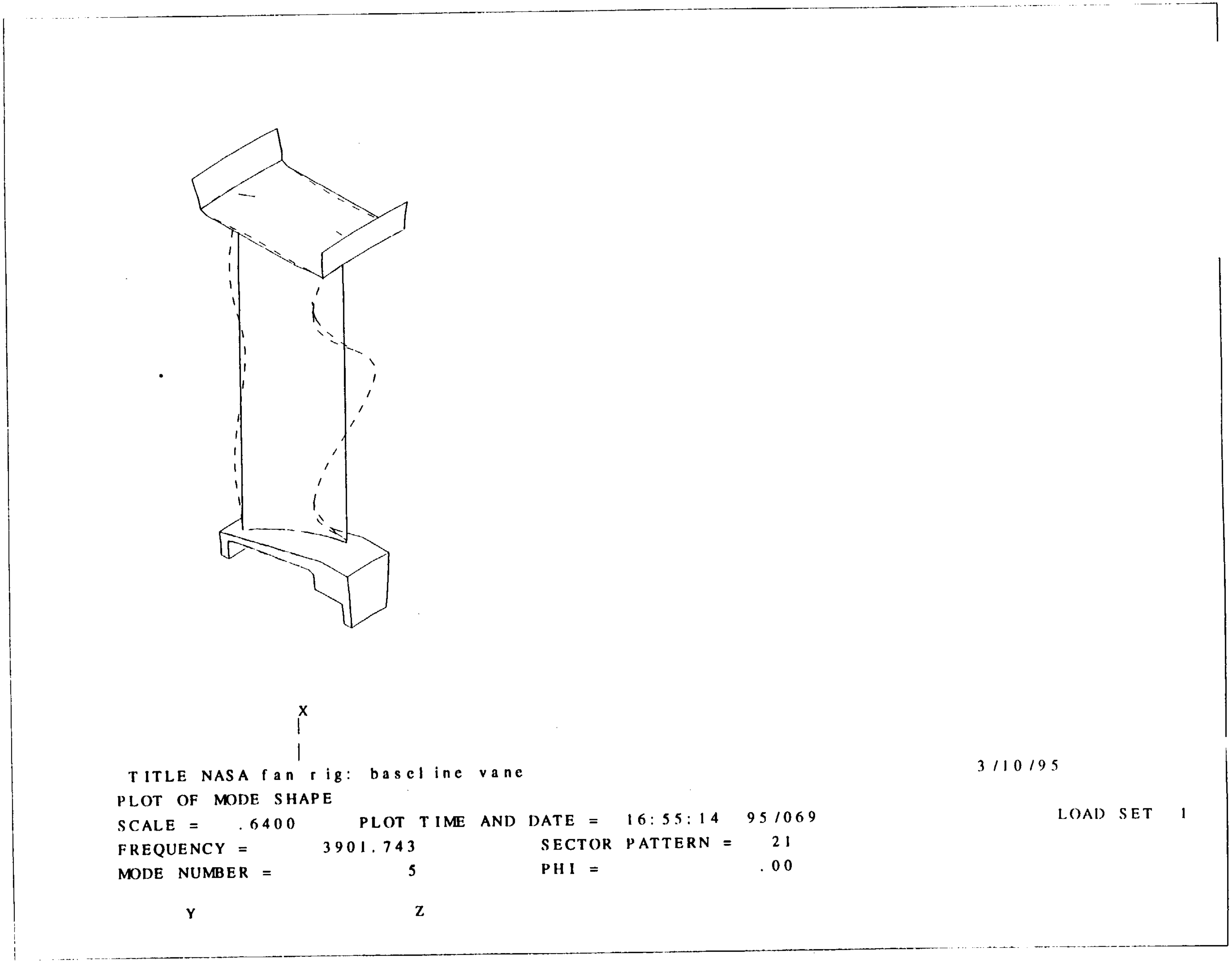
FREQUENCY = 1319.669 SECTOR PATTERN = 21

MODE NUMBER = 2 PHI = .00

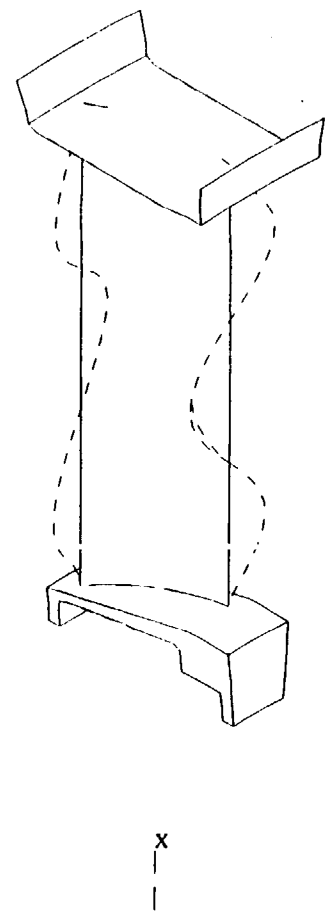
Y Z


X
TITLE NASA fan rig: baseline vane
3/10/95
PLOT OF MODE SHAPE
SCALE = .6400
PLOT TIME AND DATE = 16:54:50 95/069
LOAD SET 1
FREQUENCY = 2161.565
SECTOR PATTERN = 21
MODE NUMBER = 3
PHI = .00
Y
Z


X
TITLE NASA fan rig: baseline vane
3/10/95
PLOT OF MODE SHAPE
SCALE = .6400
PLOT TIME AND DATE = 16:55:02 95/069
LOAD SET 1
FREQUENCY = 2643.099
SECTOR PATTERN = 21
MODE NUMBER = 4
PHI = .00
Y
Z



X
TITLE NASA fan rig: baseline vane
3/10/95
PLOT OF MODE SHAPE
SCALE = .6400
PLOT TIME AND DATE = 16:55:14 95/069
LOAD SET 1
FREQUENCY = 3901.743
SECTOR PATTERN = 21
MODE NUMBER = 5
PHI = .00
Y
Z



TITLE NASA fan rig: baseline vane 3/10/95

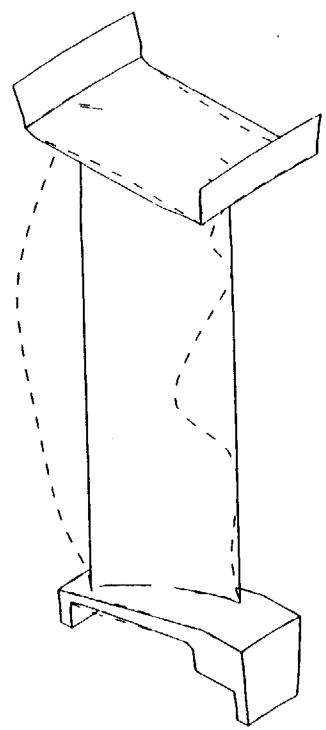
PLOT OF MODE SHAPE

SCALE = .6400 PLOT TIME AND DATE = 16:55:25 95/069 LOAD SET 1

FREQUENCY = 4134.750 SECTOR PATTERN = 21

MODE NUMBER = 6 PHI = .00

Y Z



X

TITLE NASA fan rig: baseline vane

3/10/95

PLOT OF MODE SHAPE

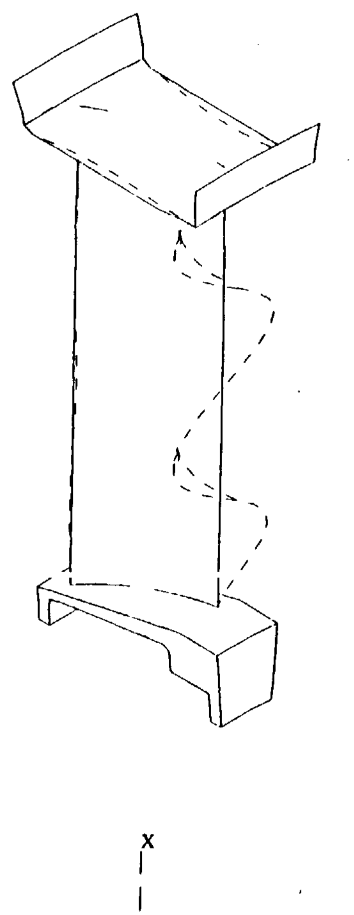
LOAD SET 1

SCALE = .6400 PLOT TIME AND DATE = 16:55:36 95/069

FREQUENCY = 5405.889 SECTOR PATTERN = 21

MODE NUMBER = 7 PHI = .00

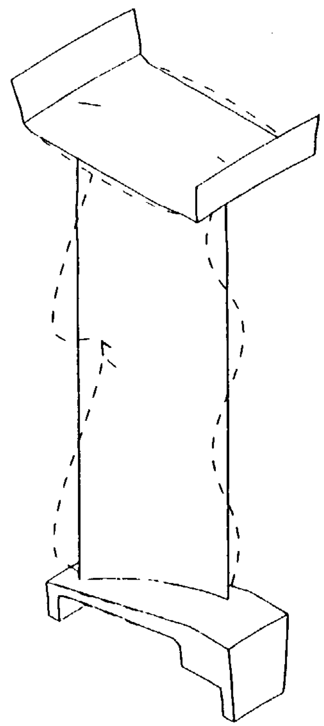
Y Z



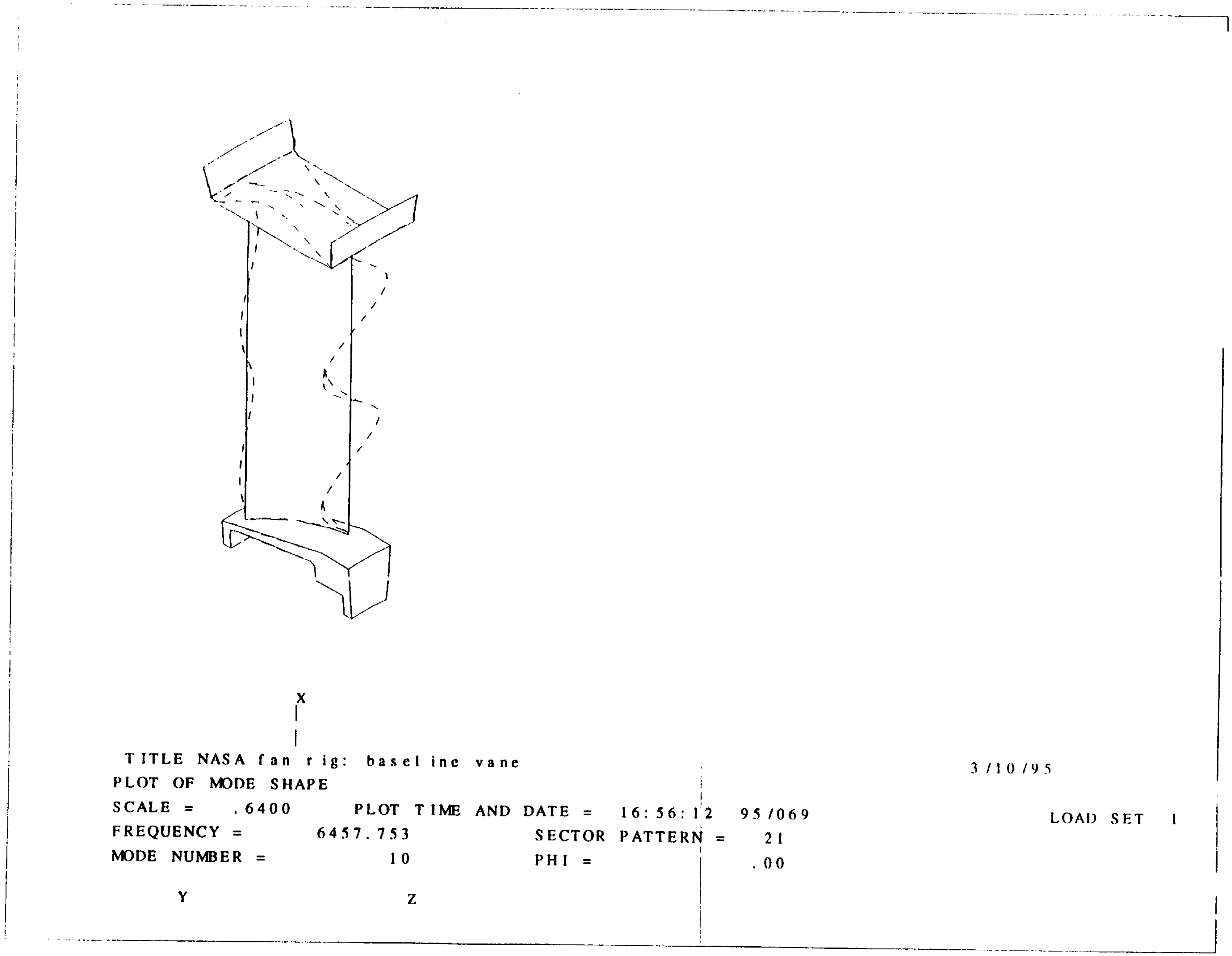
TITLE NASA fan rig: baseline vane
PLOT OF MODE SHAPE
SCALE = .6400 PLOT TIME AND DATE = 16:55:48 95/069
FREQUENCY = 5574.935 SECTOR PATTERN = 21
MODE NUMBER = 8 PHI = .00

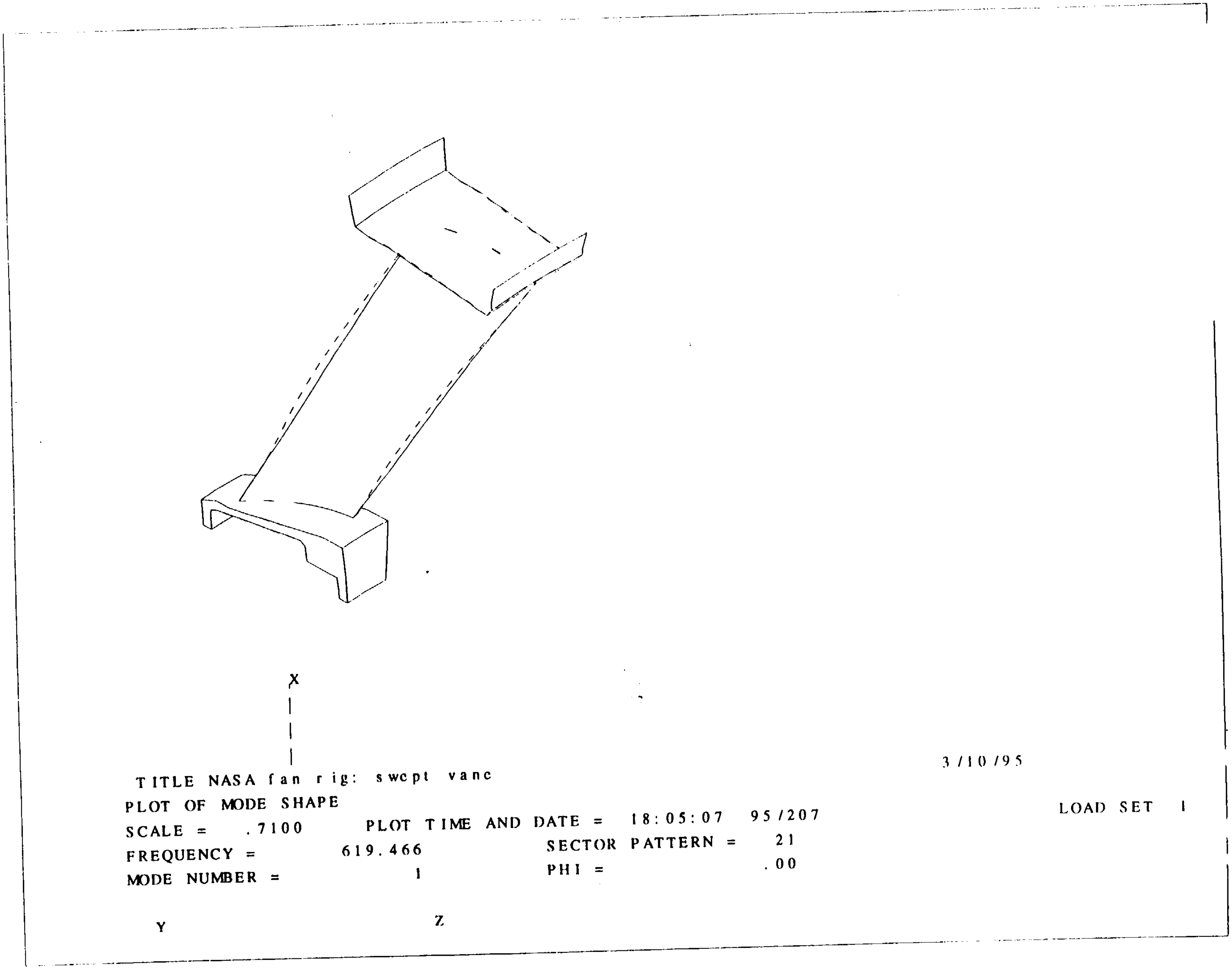
3/10/95

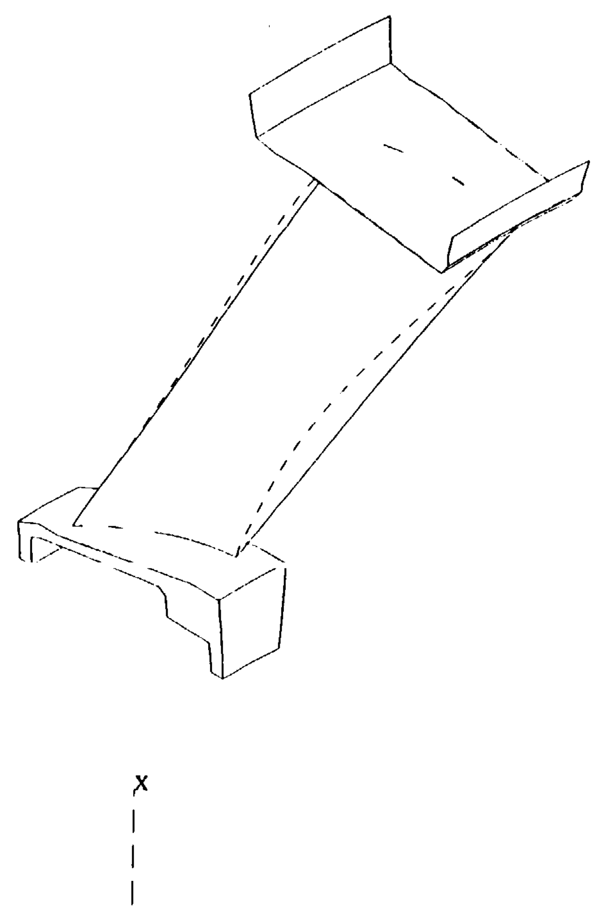
LOAD SET 1



TITLE NASA fan rig: baseline vane 3/10/95
PLOT OF MODE SHAPE
SCALE = .6400 PLOT TIME AND DATE = 16:55:59 95/069 LOAD SET 1
FREQUENCY = 5850.500 SECTOR PATTERN = 21
MODE NUMBER = 9 PHI = .00


X
TITLE NASA fan rig: baseline vane
3/10/95
PLOT OF MODE SHAPE
SCALE = .6400
PLOT TIME AND DATE = 16:56:12 95/069
LOAD SET 1
FREQUENCY = 6457.753
SECTOR PATTERN = 21
MODE NUMBER = 10
PHI = .00
Y
Z

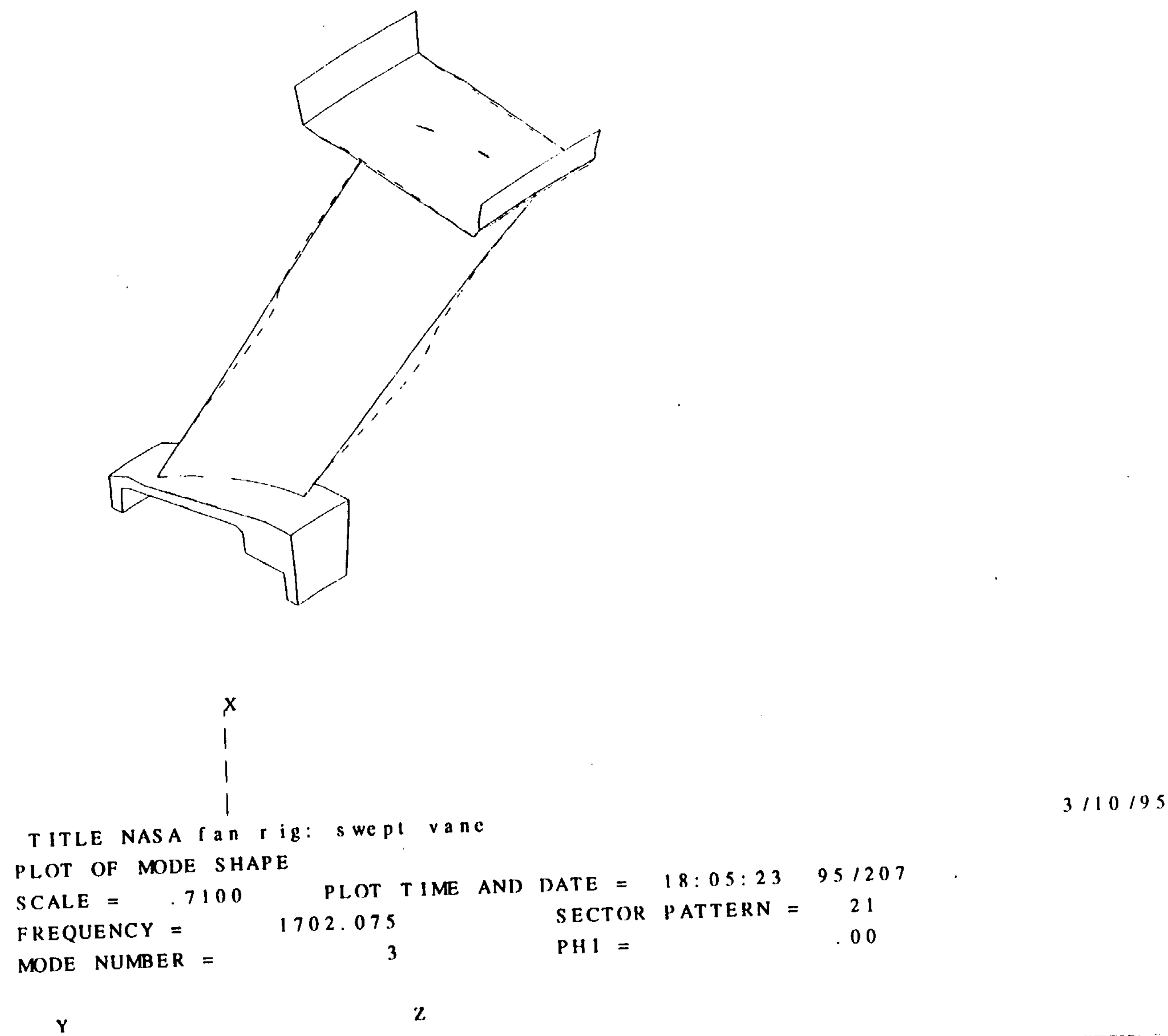

X
3 /10 /95
TITLE NASA fan rig: swept vane
PLOT OF MODE SHAPE
LOAD SET 1
SCALE = .7100
PLOT TIME AND DATE = 18:05:07 95/207
FREQUENCY = 619.466
SECTOR PATTERN = 21
MODE NUMBER = 1
PHI = .00
Y
Z

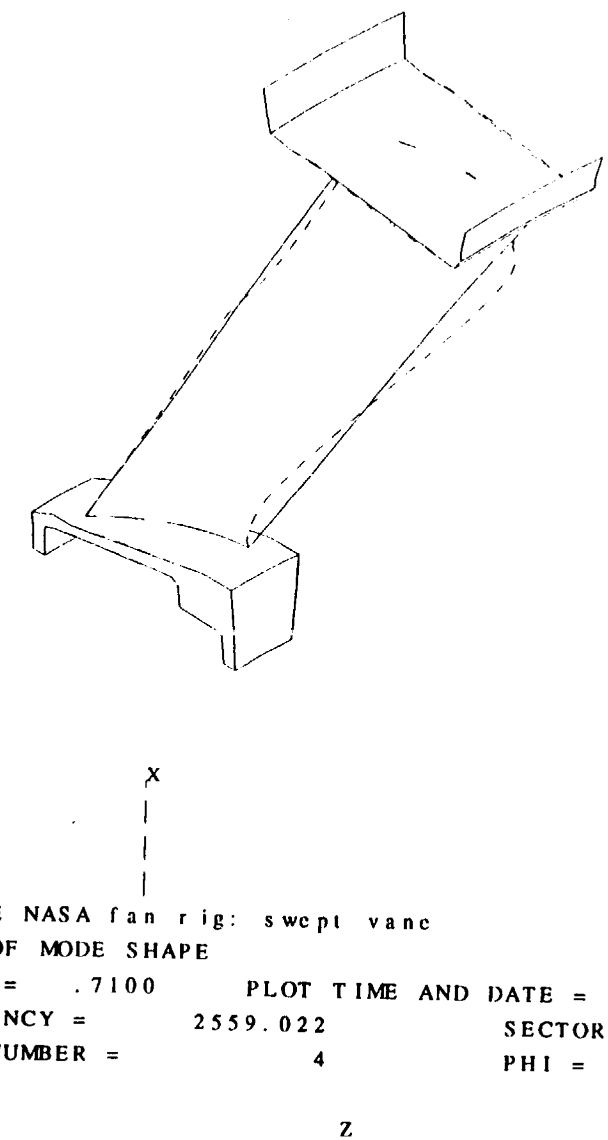


TITLE NASA fan rig: swept vane
PLOT OF MODE SHAPE
SCALE = .7100 PLOT TIME AND DATE = 18:05:15 95/207
FREQUENCY = 1361.907 SECTOR PATTERN = 21
MODE NUMBER = 2 PHI = .00

3/10/95

LOAD SET 1

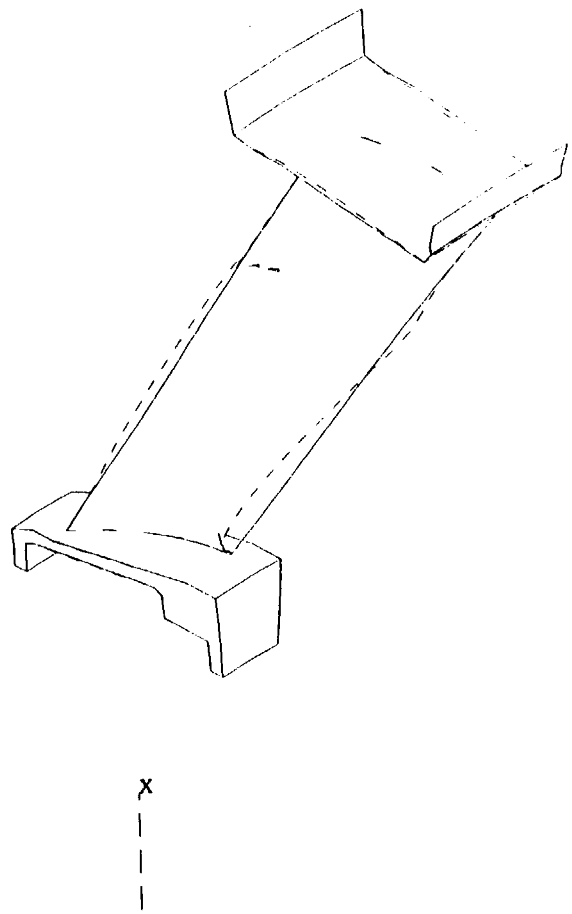

X
Y
Z
3/10/95
TITLE NASA fan rig: swept vane
PLOT OF MODE SHAPE
LOAD SET 1
SCALE = .7100
PLOT TIME AND DATE = 18:05:23 95/207
FREQUENCY = 1702.075
SECTOR PATTERN = 21
MODE NUMBER = 3
PHI = .00



TITLE NASA fan rig: swept vane
PLOT OF MODE SHAPE
SCALE = .7100 PLOT TIME AND DATE = 18:05:31 95/207
FREQUENCY = 2559.022 SECTOR PATTERN = 21
MODE NUMBER = 4 PHI = .00

3/10/95

LOAD SET 1



3 /10 /95

TITLE NASA fan rig: swept vane

PLOT OF MODE SHAPE

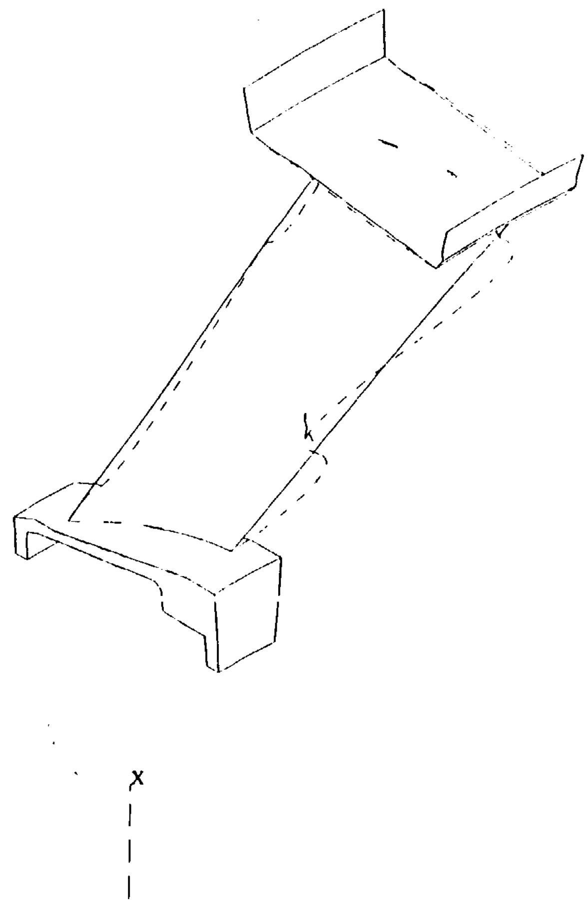
LOAD SET 1

SCALE = .7100 PLOT TIME AND DATE = 18:05:39 95/207

FREQUENCY = 3167.500 SECTOR PATTERN = 21

MODE NUMBER = 5 PHI = .00

Y Z



TITLE NASA fan rig: swept vane

PLOT OF MODE SHAPE

SCALE = .7100 PLOT TIME AND DATE = 18:05:48 95/207

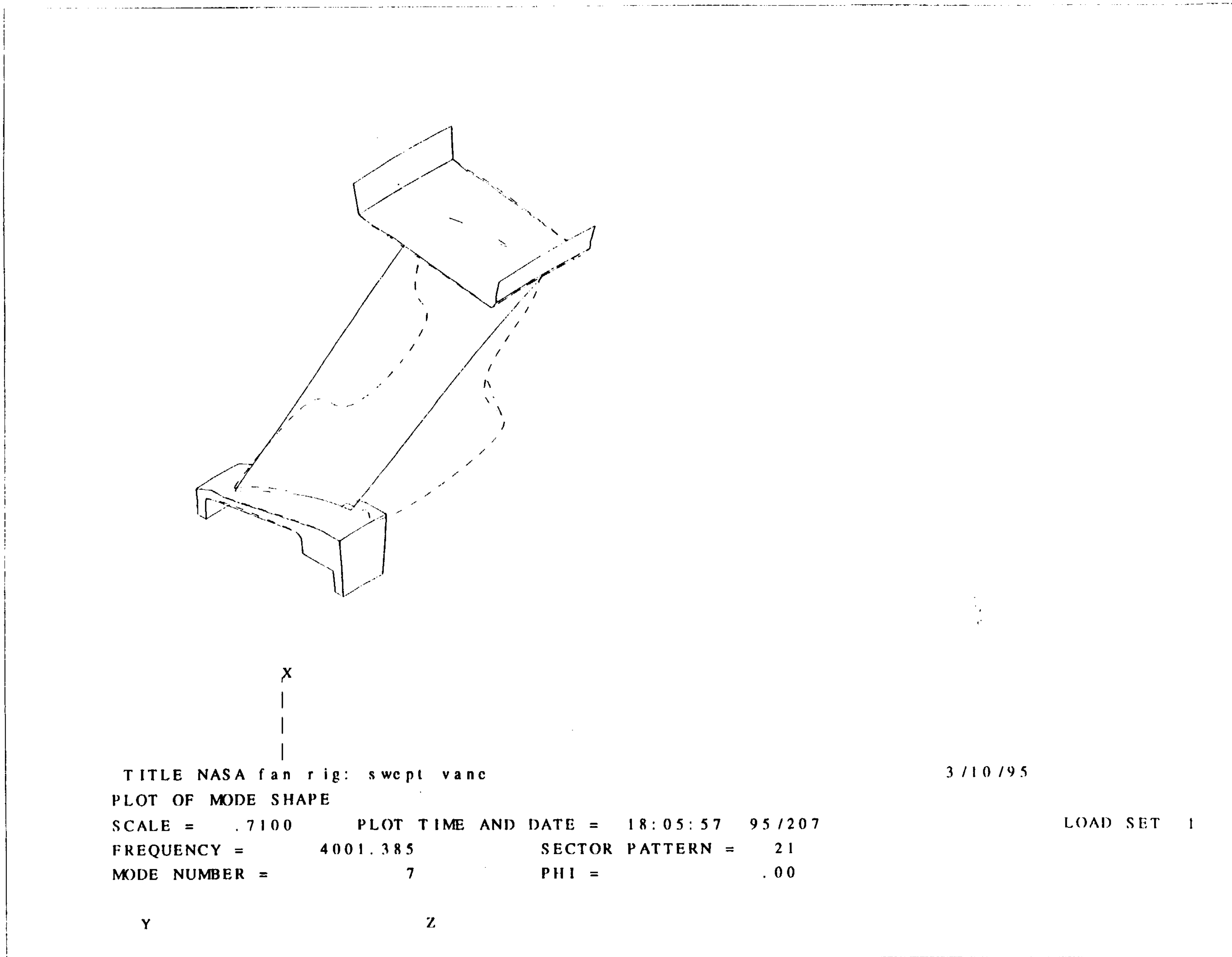
FREQUENCY = 3889.117 SECTOR PATTERN = 21

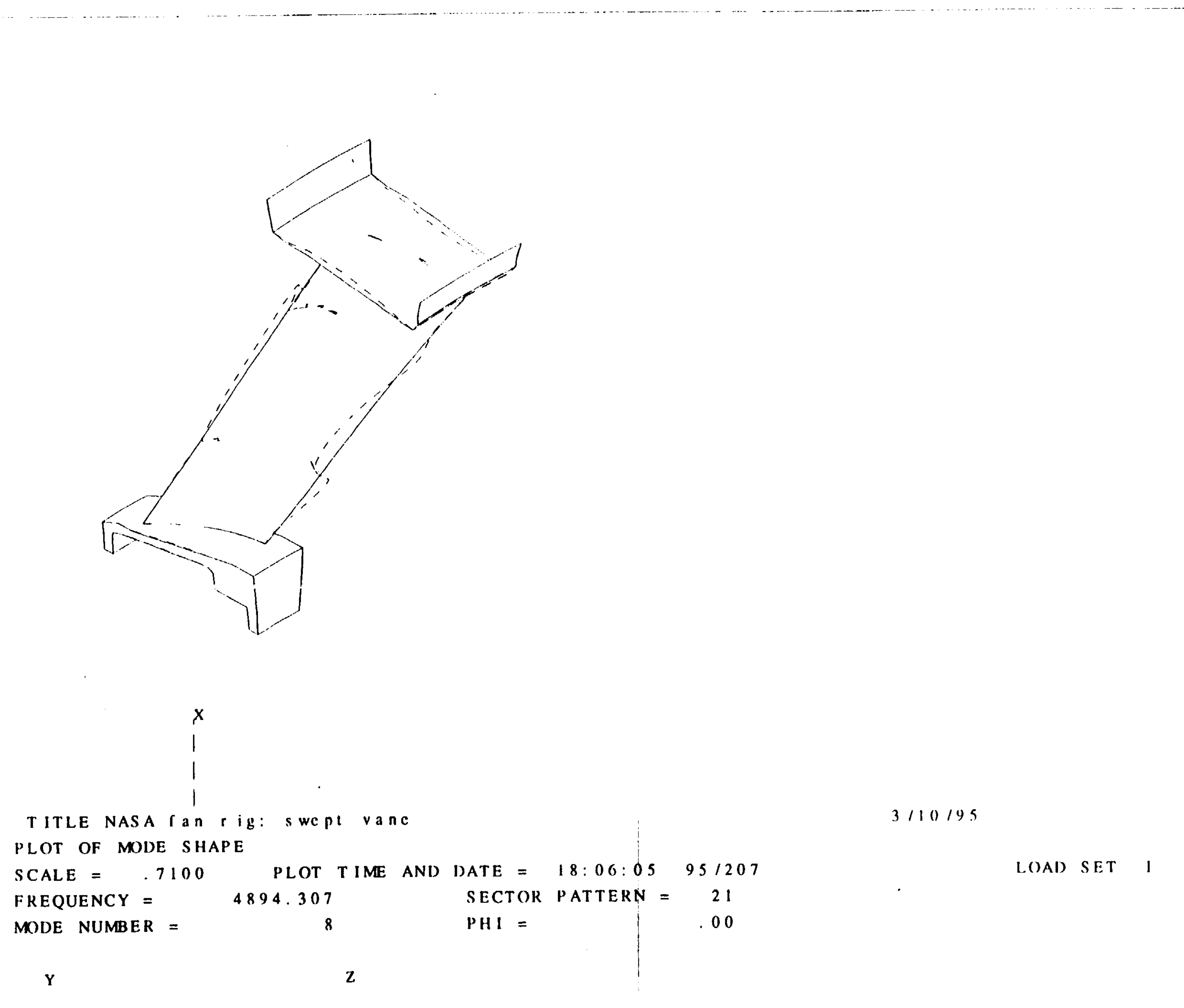
MODE NUMBER = 6 PHI = .00

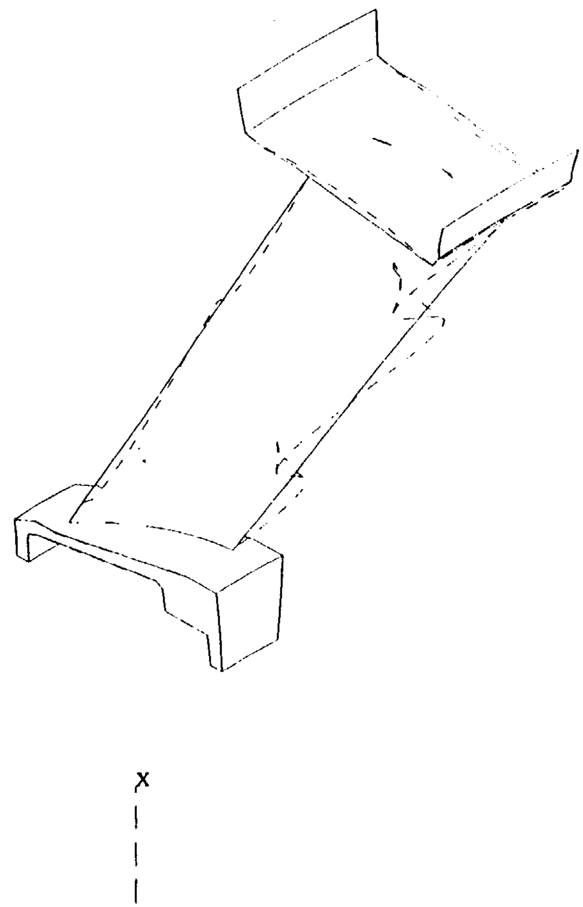
3/10/95

LOAD SET 1

Y Z


X
TITLE NASA fan rig: swept vane
3/10/95
PLOT OF MODE SHAPE
SCALE = .7100
PLOT TIME AND DATE = 18:05:57 95/207
LOAD SET 1
FREQUENCY = 4001.385
SECTOR PATTERN = 21
MODE NUMBER = 7
PHI = .00
Y
Z


X
TITLE NASA fan rig: swept vane
3/10/95
PLOT OF MODE SHAPE
SCALE = .7100
PLOT TIME AND DATE = 18:06:05 95/207
LOAD SET 1
FREQUENCY = 4894.307
SECTOR PATTERN = 21
MODE NUMBER = 8
PHI = .00
Y
Z



TITLE NASA fan rig: swept vane 3/10/95

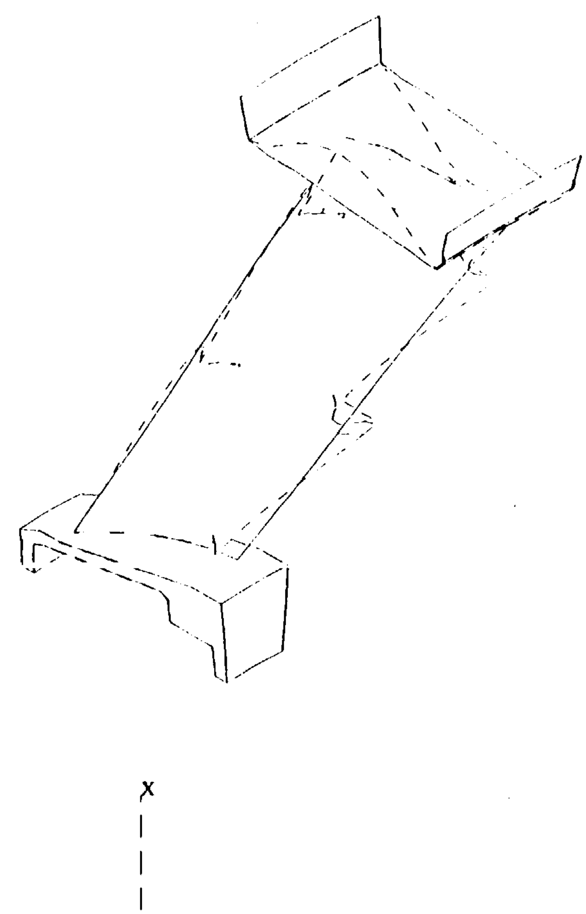
PLOT OF MODE SHAPE

SCALE = .7100 PLOT TIME AND DATE = 18:06:14 95/207 LOAD SET 1

FREQUENCY = 5349.077 SECTOR PATTERN = 21

MODE NUMBER = 9 PHI = .00

Y Z



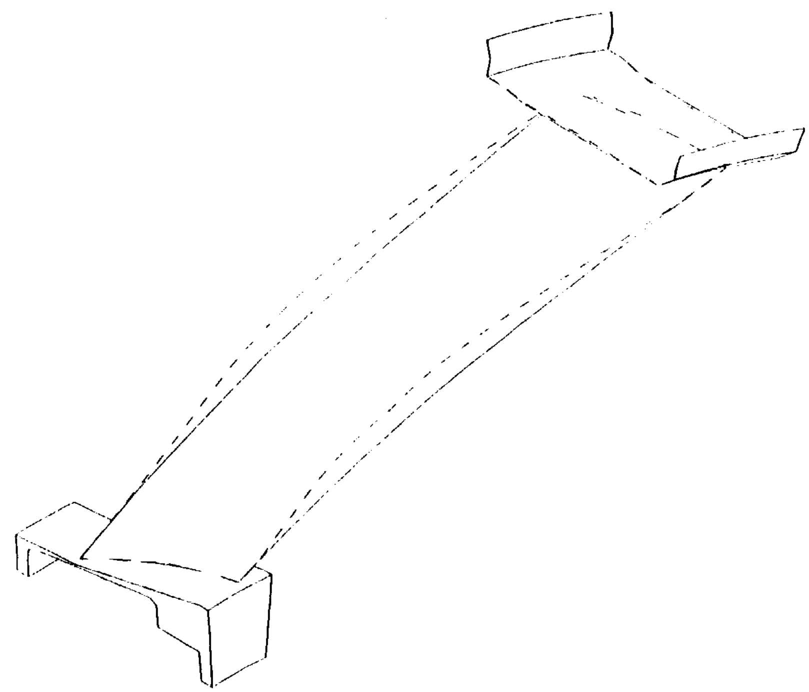
TITLE NASA fan rig: swept vane 3/10/95

PLOT OF MODE SHAPE

SCALE = .7100 PLOT TIME AND DATE = 18:06:24 95/207 LOAD SET 1

FREQUENCY = 6353.275 SECTOR PATTERN = 21

MODE NUMBER = 10 PHI = .00



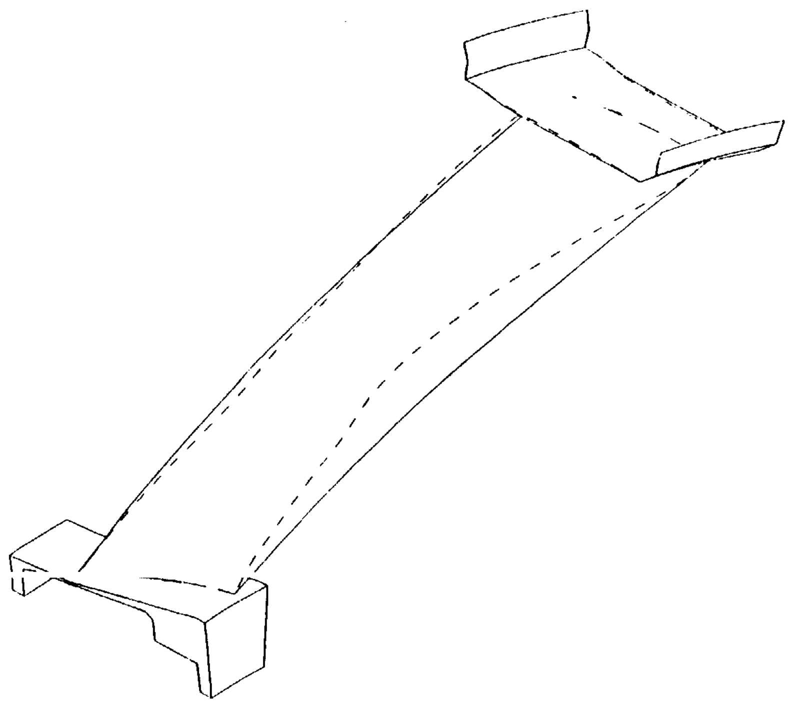
TITLE NASA fan rig: swept & leaned vane   3/10/95

PLOT OF MODE SHAPE

SCALE = .6800   PLOT TIME AND DATE = 18:04:18 95/207   LOAD SET 1

FREQUENCY = 636.257   SECTOR PATTERN = 21

MODE NUMBER = 1   PHI = .00



X

TITLE NASA fan rig: swept & leaned vane   3/10/95

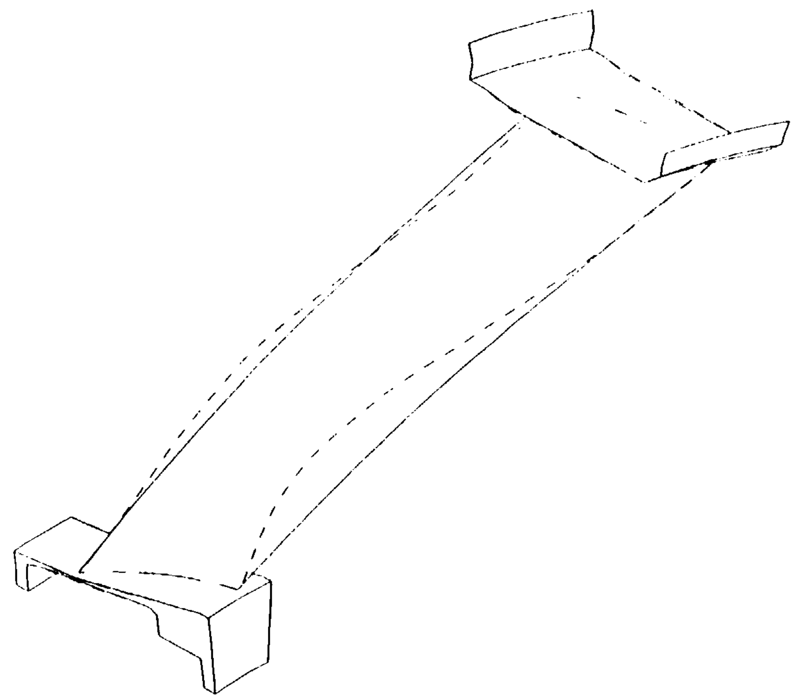
PLOT OF MODE SHAPE   LOAD SET 1

SCALE = .6800   PLOT TIME AND DATE = 18:04:26 95/207

FREQUENCY = 1428.280   SECTOR PATTERN = 21

MODE NUMBER = 2   PHI = .00

Y   Z



X

TITLE NASA fan rig: swept & leaned vane — 3/10/95

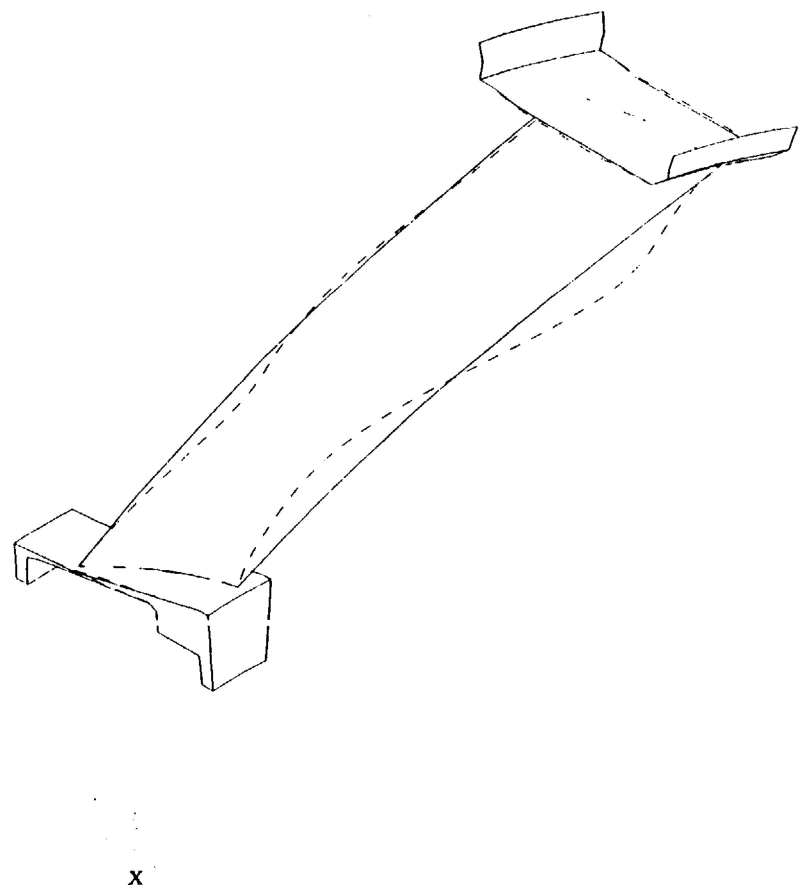
PLOT OF MODE SHAPE — LOAD SET 1

SCALE = .6800 — PLOT TIME AND DATE = 18:04:34 95/207

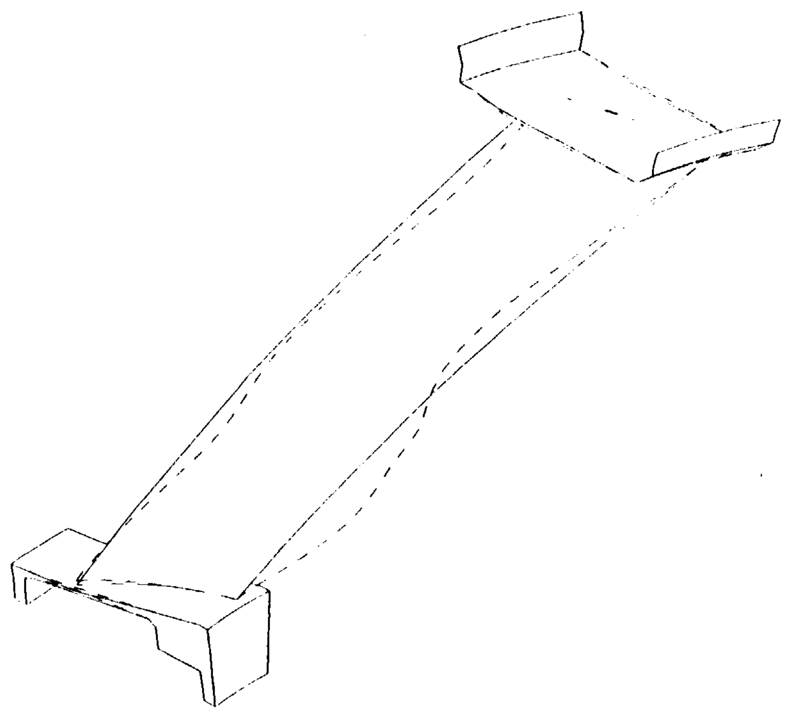
FREQUENCY = 1663.802 — SECTOR PATTERN = 21

MODE NUMBER = 3 — PHI = .00

Y Z



TITLE NASA fan rig: swept & leaned vane 3/10/95
PLOT OF MODE SHAPE
SCALE = .6800 PLOT TIME AND DATE = 18:04:43 95/207 LOAD SET 1
FREQUENCY = 2545.286 SECTOR PATTERN = 21
MODE NUMBER = 4 PHI = .00



3/10/95

TITLE NASA fan rig: swept & leaned vane

LOAD SET 1

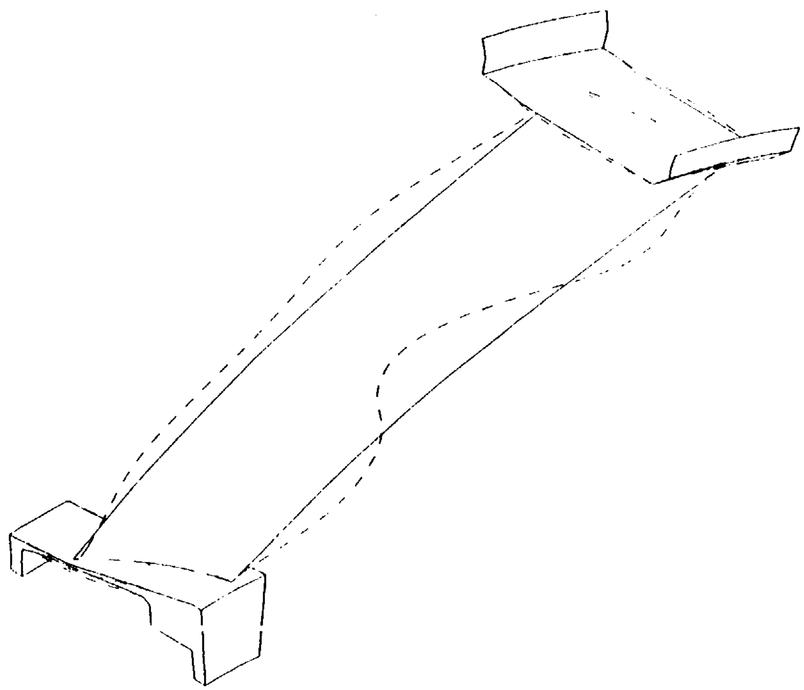
PLOT OF MODE SHAPE

SCALE = .6800 PLOT TIME AND DATE = 18:04:51 95/207

FREQUENCY = 3007.614 SECTOR PATTERN = 21

MODE NUMBER = 5 PHI = .00

FIGURE A54



X

TITLE NASA fan rig: swept & leaned vane

3/10/95

PLOT OF MODE SHAPE

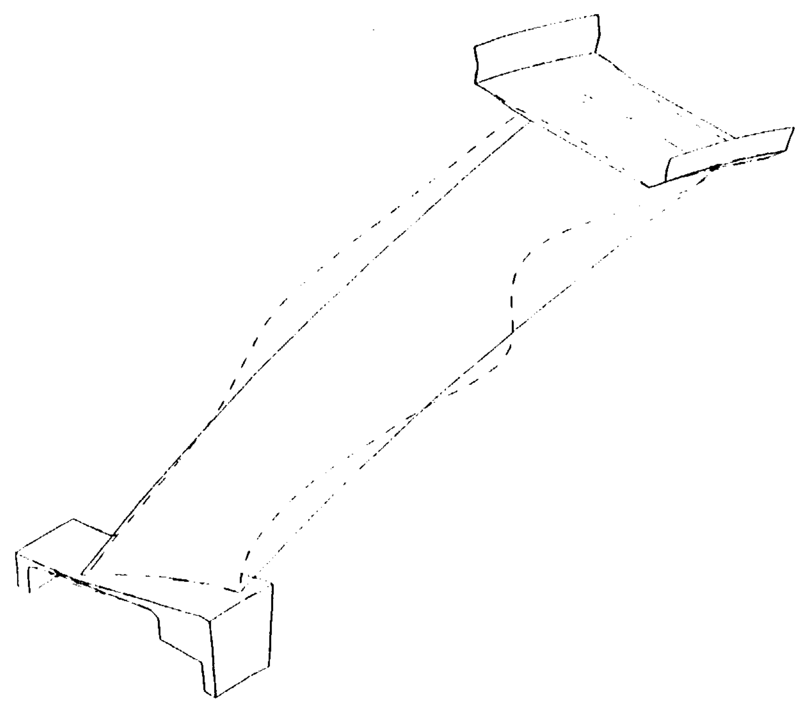
SCALE = .6800 PLOT TIME AND DATE = 18:05:01 95/207

LOAD SET 1

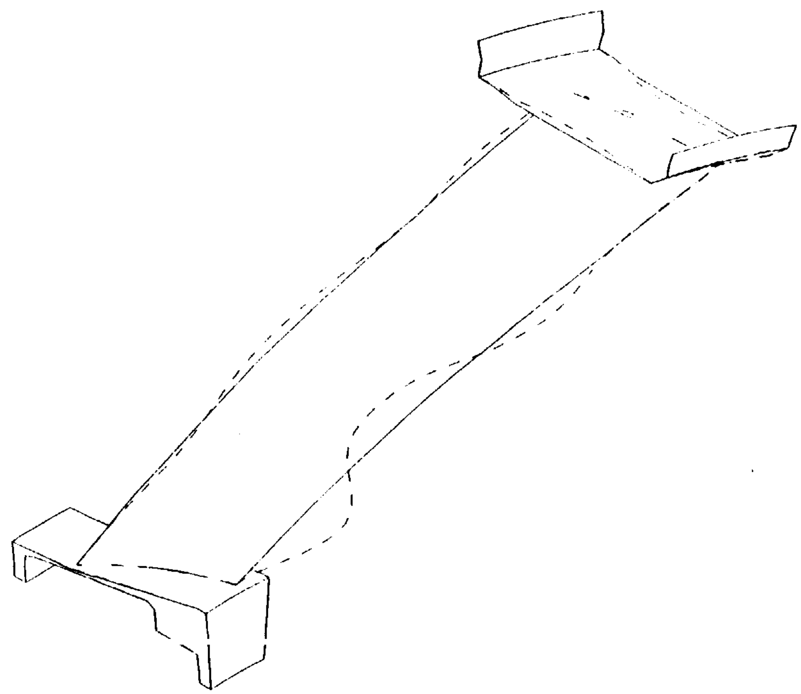
FREQUENCY = 3603.865 SECTOR PATTERN = 21

MODE NUMBER = 6 PHI = .00

Y Z



X
TITLE NASA fan rig: swept & leaned vane
3/10/95
PLOT OF MODE SHAPE
SCALE = .6800
PLOT TIME AND DATE = 18:05:09 95/207
LOAD SET 1
FREQUENCY = 4035.621
SECTOR PATTERN = 21
MODE NUMBER = 7
PHI = .00
Y
Z



X

TITLE NASA fan rig: swept & leaned vane 3/10/95

PLOT OF MODE SHAPE

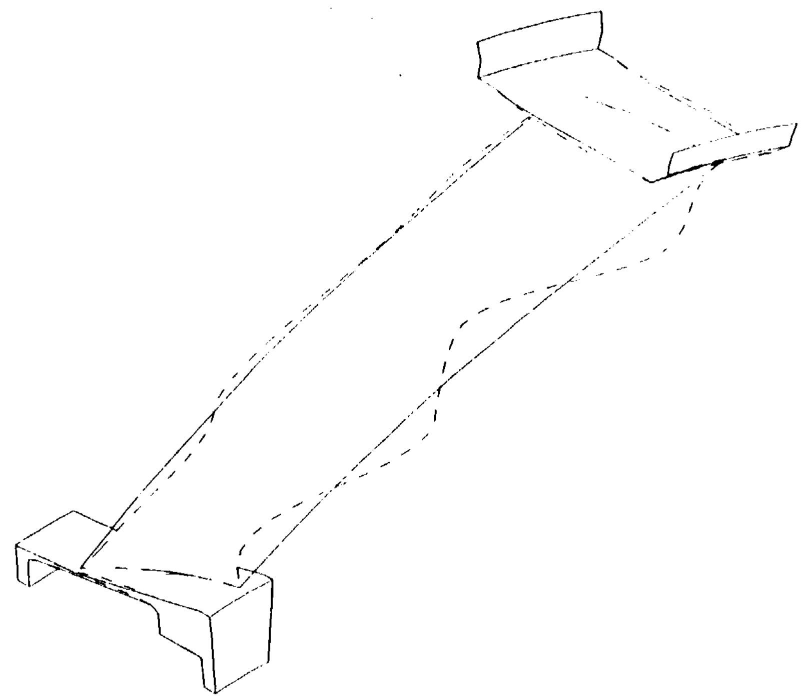
SCALE = .6800 PLOT TIME AND DATE = 18:05:18 95/207 LOAD SET

FREQUENCY = 4861.682 SECTOR PATTERN = 21

MODE NUMBER = 8 PHI = .00

Y Z

FIGURE A57



X

TITLE NASA fan rig: swept & leaned vane 3/10/95

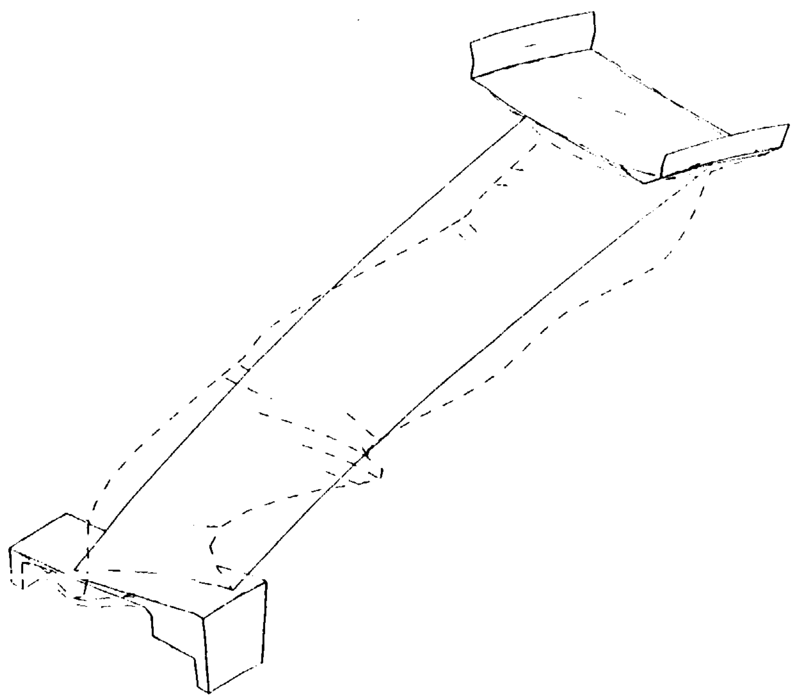
PLOT OF MODE SHAPE

SCALE = .6800 PLOT TIME AND DATE = 18:05:27 95/207 LOAD SET 1

FREQUENCY = 5460.979 SECTOR PATTERN = 21

MODE NUMBER = 9 PHI = .00

Y Z



X

TITLE NASA fan rig: swept & leaned vane 3/10/95

PLOT OF MODE SHAPE

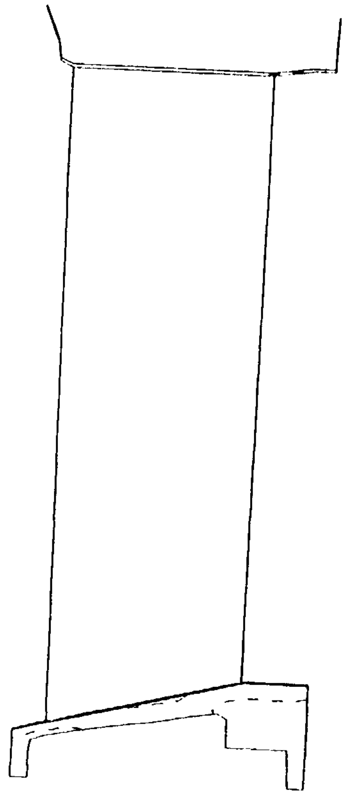
SCALE = .6800 PLOT TIME AND DATE = 18:05:36 95/207 LOAD SET 1

FREQUENCY = 6041.609 SECTOR PATTERN = 21

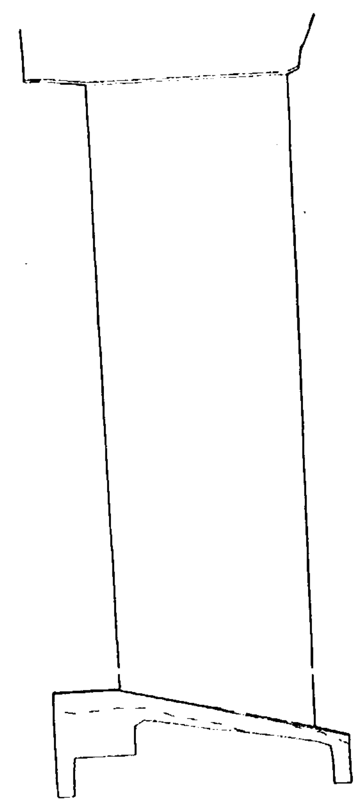
MODE NUMBER = 10 PHI = .00

Y Z

458



TITLE NASA scaled fan rig - baseline vane pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = X .6200 PLOT TIME AND DATE = 16:56:23 95/069
FREQUENCY = 819.896 SECTOR PATTERN = 21
MODE NUMBER = 1 PHI = .00
LOAD



X

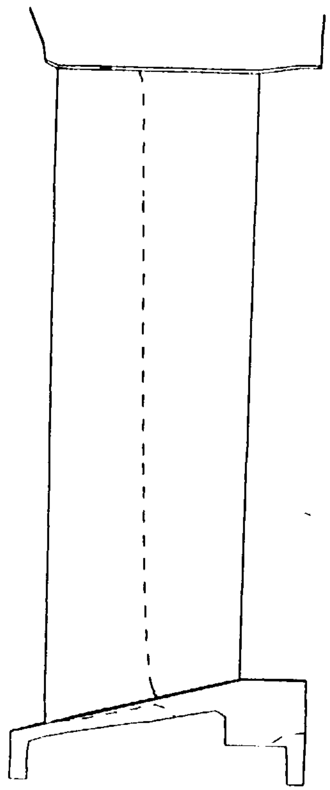
TITLE NASA scaled fan rig - baseline vane suction side

PLOT OF NODE LINE NORMAL TO VIEWING PLANE LOAD

SCALE = .6200 PLOT TIME AND DATE = 16:58:00 95/069

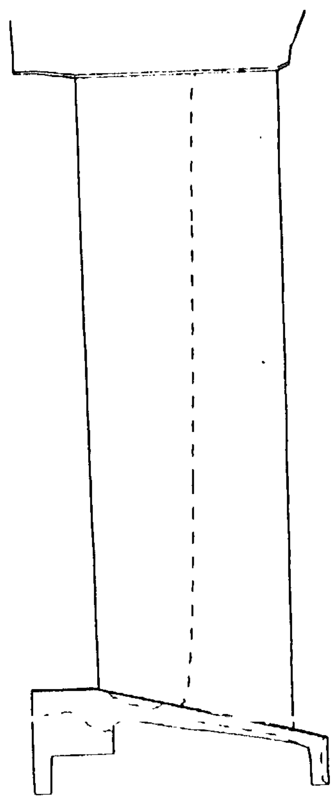
FREQUENCY = 819.896 SECTOR PATTERN = 21

MODE NUMBER = 1 PHI = .00



TITLE NASA scaled fan rig - baseline vane pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE =X .6200 PLOT TIME AND DATE = 16:56:30 95/069
FREQUENCY = 1319.669 SECTOR PATTERN = 21
MODE NUMBER = 2 PHI = .00

LOAD



X

TITLE NASA scaled fan rig - baseline vane suction side

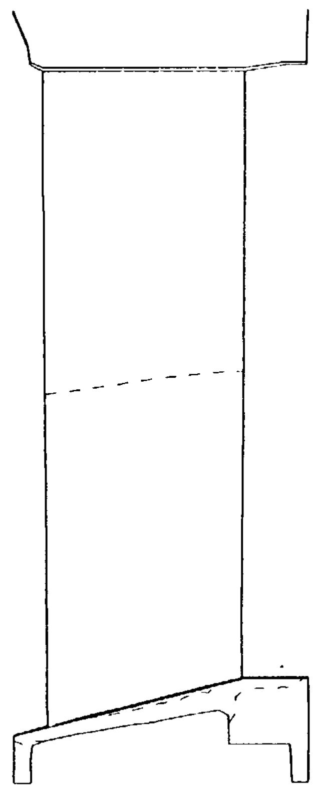
PLOT OF NODE LINE NORMAL TO VIEWING PLANE

SCALE = .6200 PLOT TIME AND DATE = 16:58:07 95/069

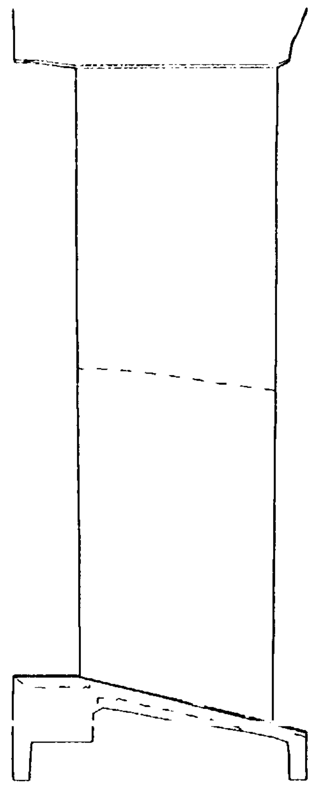
FREQUENCY = 1319.669 SECTOR PATTERN = 21

MODE NUMBER = 2 PHI = .00

LOAD



TITLE NASA scaled fan rig - baseline vane pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE =X .6200 PLOT TIME AND DATE = 16:56:39 95/069 LOAD
FREQUENCY = 2161.565 SECTOR PATTERN = 21
MODE NUMBER = 3 PHI = .00



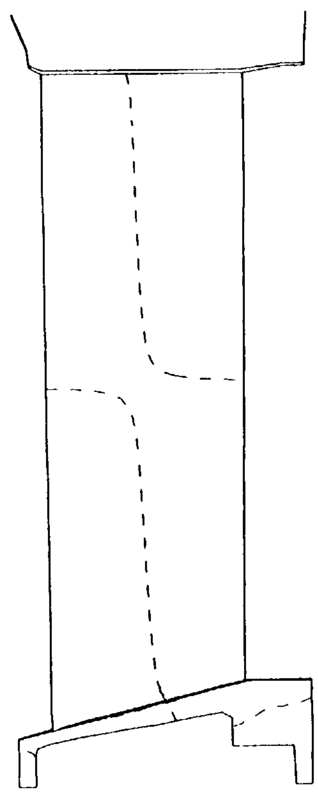
TITLE NASA scaled fan rig - baseline vane suction side

PLOT OF NODE LINE NORMAL TO VIEWING PLANE

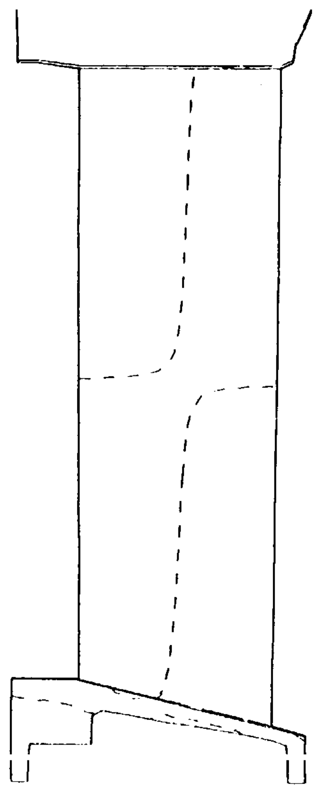
SCALE = .6200 PLOT TIME AND DATE = 16:58:16 95/069 LOAD

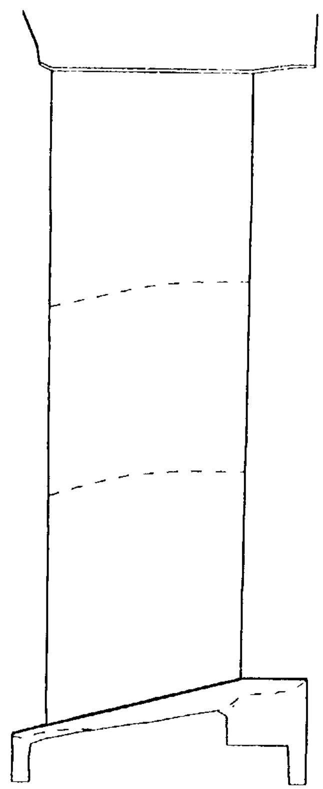
FREQUENCY = 2161.565 SECTOR PATTERN = 21

MODE NUMBER = 3 PHI = .00



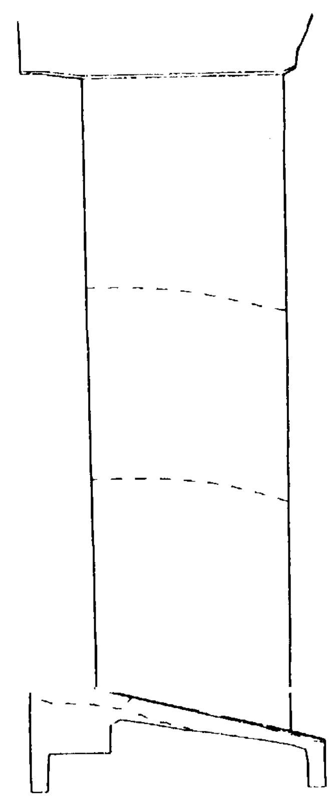
TITLE NASA scaled fan rig - baseline vane pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = X .6200 PLOT TIME AND DATE = 16:56:47 95/069 LOAD
FREQUENCY = 2643.099 SECTOR PATTERN = 21
MODE NUMBER = 4 PHI = .00


X
TITLE NASA scaled fan rig - baseline vane suction side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6200 PLOT TIME AND DATE = 16:58:23 95/069
FREQUENCY = 2643.099 SECTOR PATTERN = 21
MODE NUMBER = 4 PHI = .00
LOAD

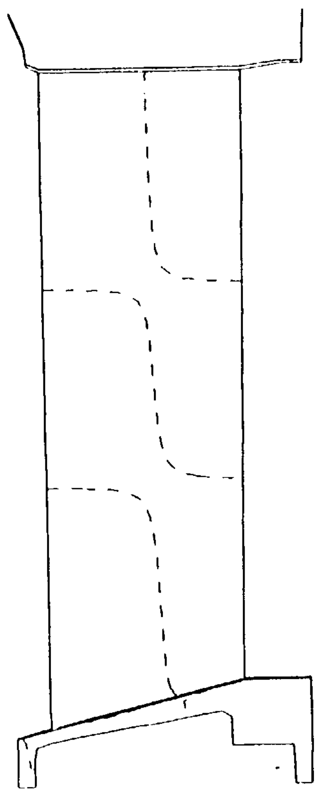


TITLE NASA scaled fan rig - baseline vane pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = X .6200 PLOT TIME AND DATE = 16:56:56 95/069
FREQUENCY = 3901.743 SECTOR PATTERN = 21
MODE NUMBER = 5 PHI = .00

LOAD



TITLE NASA scaled fan rig - baseline vane suction side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6200 PLOT TIME AND DATE = 16:58:33 95/069 LOAD
FREQUENCY = 3901.743 SECTOR PATTERN = 21
MODE NUMBER = 5 PHI = .00



TITLE NASA scaled fan rig - baseline vane pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = X .6200 PLOT TIME AND DATE = 16:57:04 95/069
FREQUENCY = 4134.750 SECTOR PATTERN = 21
MODE NUMBER = 6 PHI = .00

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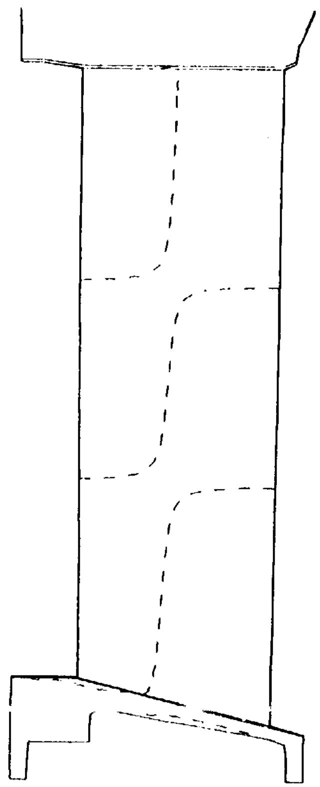

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TITLE NASA scaled fan rig - baseline vane suction side

PLOT OF NODE LINE NORMAL TO VIEWING PLANE

SCALE = .6200 PLOT TIME AND DATE = 16:58:41 95/069

FREQUENCY = 4134.750 SECTOR PATTERN = 21

MODE NUMBER = 6 PHI = .00

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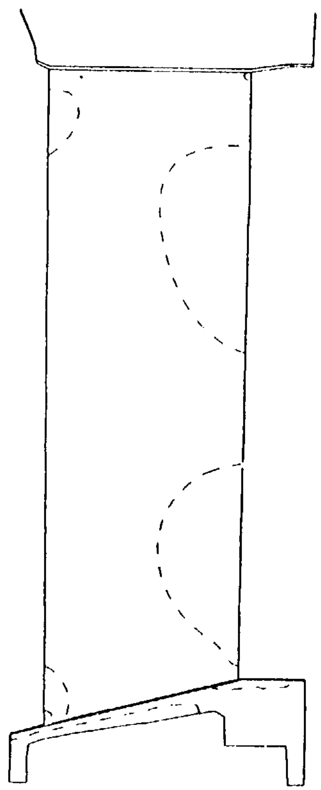

TITLE NASA scaled fan rig - baseline vane pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = X .6200 PLOT TIME AND DATE = 16:57:15 95/069
FREQUENCY = 5405.889 SECTOR PATTERN = 21
MODE NUMBER = 7 PHI = .00

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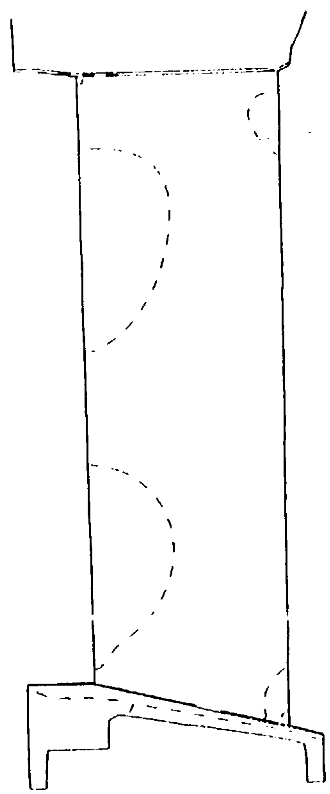
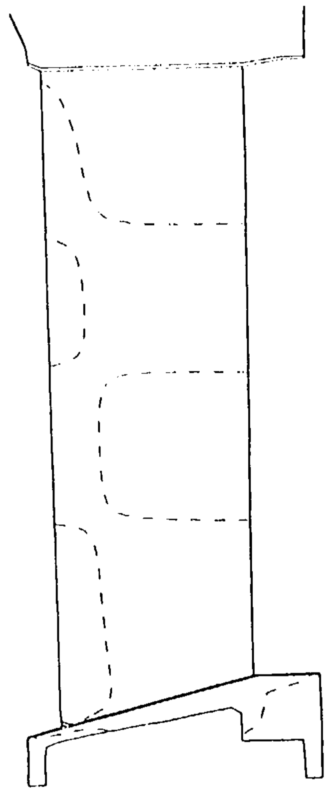


TITLE NASA scaled fan rig - baseline vane suction side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE LOAD
SCALE = .6200 PLOT TIME AND DATE = 16:58:51 95/069
FREQUENCY = 5405.889 SECTOR PATTERN = 21
MODE NUMBER = 7 PHI = .00



TITLE NASA scaled fan rig - baseline vane pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE =X .6200 PLOT TIME AND DATE = 16:57:25 95/069
FREQUENCY = 5574.935 SECTOR PATTERN = 21
MODE NUMBER = 8 PHI = .00
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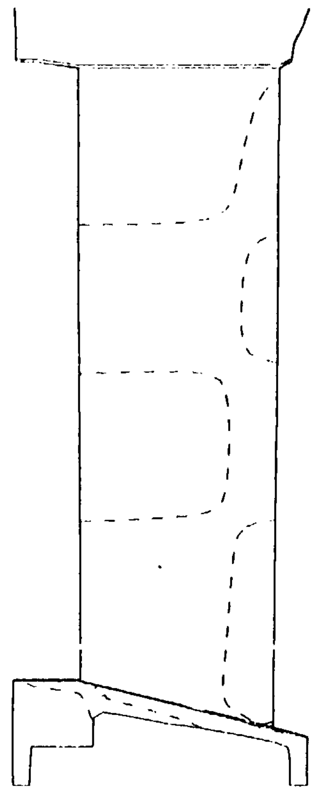

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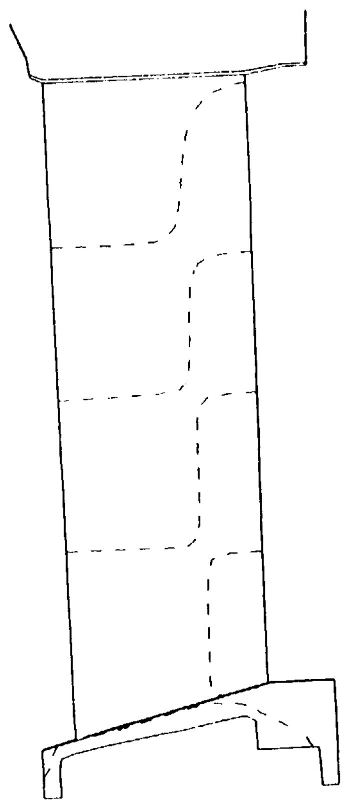
TITLE NASA scaled fan rig - baseline vane suction side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6200 PLOT TIME AND DATE = 16:59:01 95/069 LOAD
FREQUENCY = 5574.935 SECTOR PATTERN = 21
MODE NUMBER = 8 PHI = .00



TITLE NASA scaled fan rig - baseline vane pressure side

PLOT OF NODE LINE NORMAL TO VIEWING PLANE

SCALE = X .6200 PLOT TIME AND DATE = 16:57:35 95/069

FREQUENCY = 5850.500 SECTOR PATTERN = 21

MODE NUMBER = 9 PHI = .00

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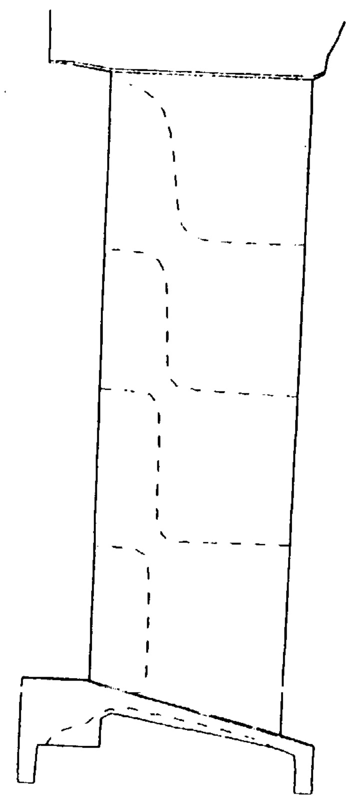

TITLE NASA scaled fan rig - baseline vane suction side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6200 PLOT TIME AND DATE = 16:59:12 95/069
FREQUENCY = 5850.500 SECTOR PATTERN = 21
MODE NUMBER = 9 PHI = .00

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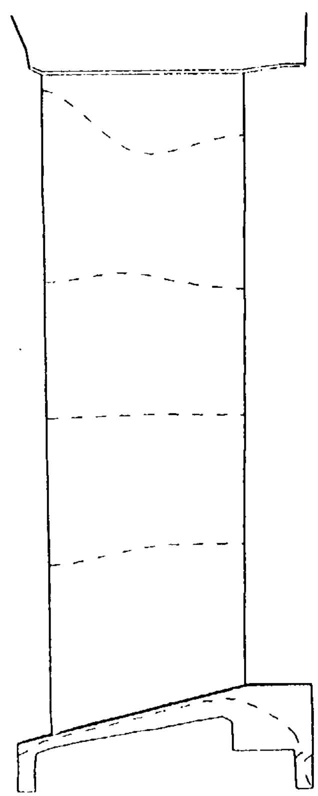
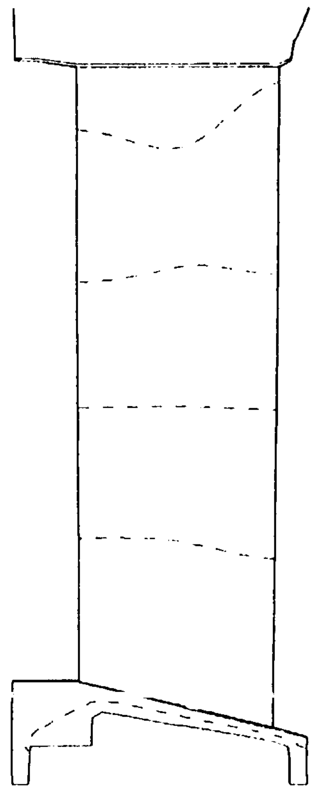


TITLE NASA scaled fan rig - baseline vane pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = X .6200 PLOT TIME AND DATE = 16:57:46 95/069 LOAD
FREQUENCY = 6457.753 SECTOR PATTERN = 21
MODE NUMBER = 10 PHI = .00



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TITLE NASA scaled fan rig - baseline vane suction side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
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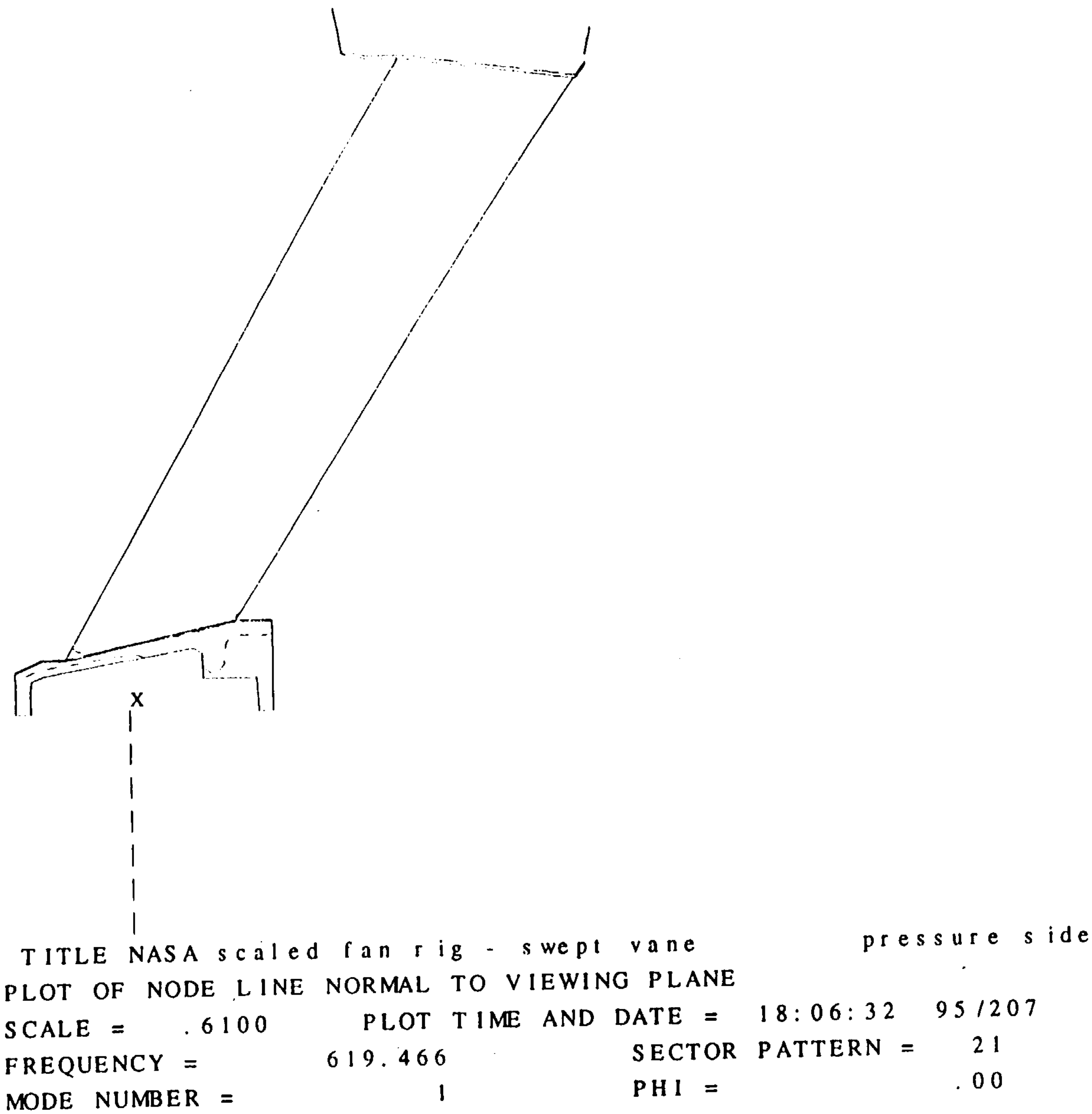
FREQUENCY = 6457.753 SECTOR PATTERN = 21
MODE NUMBER = 10 PHI = .00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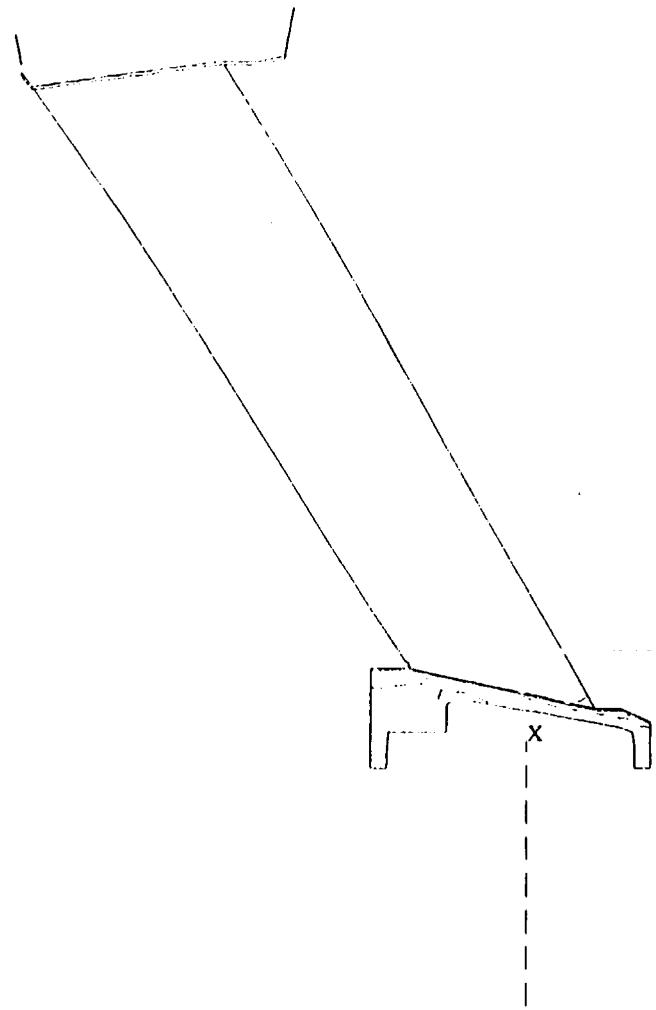
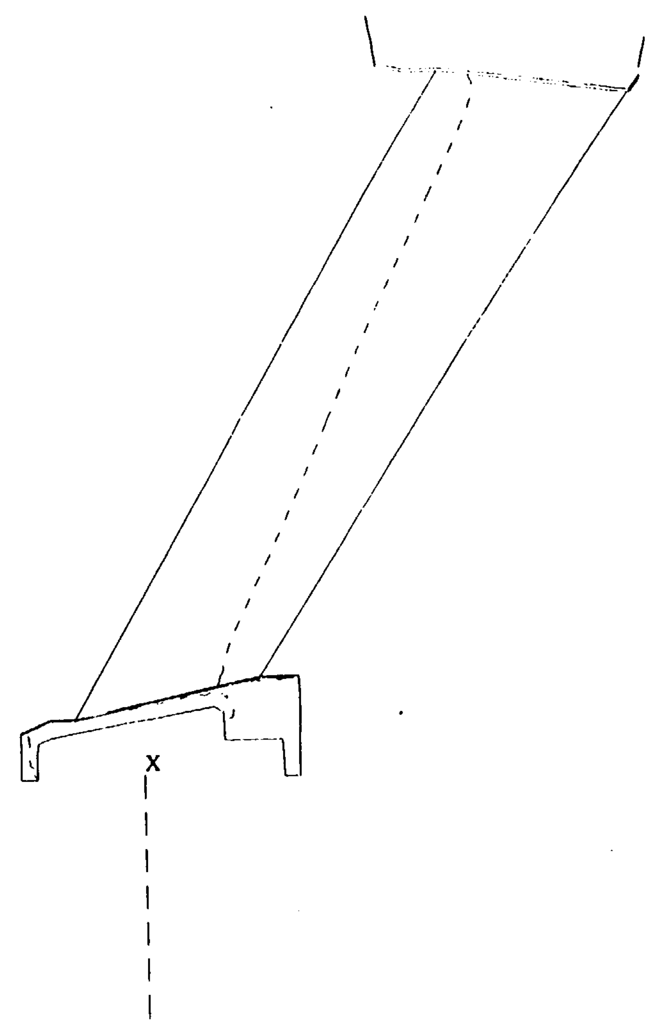
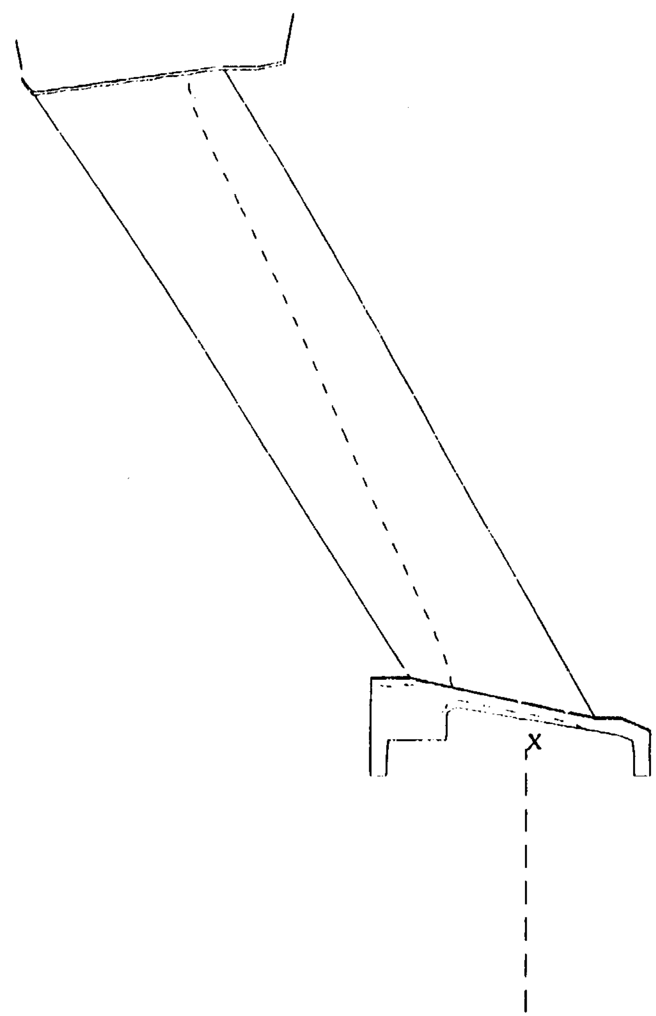
TITLE NASA scaled fan rig - swept vane pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6100 PLOT TIME AND DATE = 18:06:32 95/207
FREQUENCY = 619.466 SECTOR PATTERN = 21
MODE NUMBER = 1 PHI = .00



TITLE NASA scaled fan rig - swept vane . suction side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6100 PLOT TIME AND DATE = 18:07:40 95/207
FREQUENCY = 619.466 SECTOR PATTERN = 21
MODE NUMBER = 1 PHI = .00



TITLE NASA scaled fan rig - swept vane pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6100 PLOT TIME AND DATE = 18:06:37 95/207
FREQUENCY = 1361.907 SECTOR PATTERN = 21
MODE NUMBER = 2 PHI = .00



TITLE NASA scaled fan rig - swept vane suction side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
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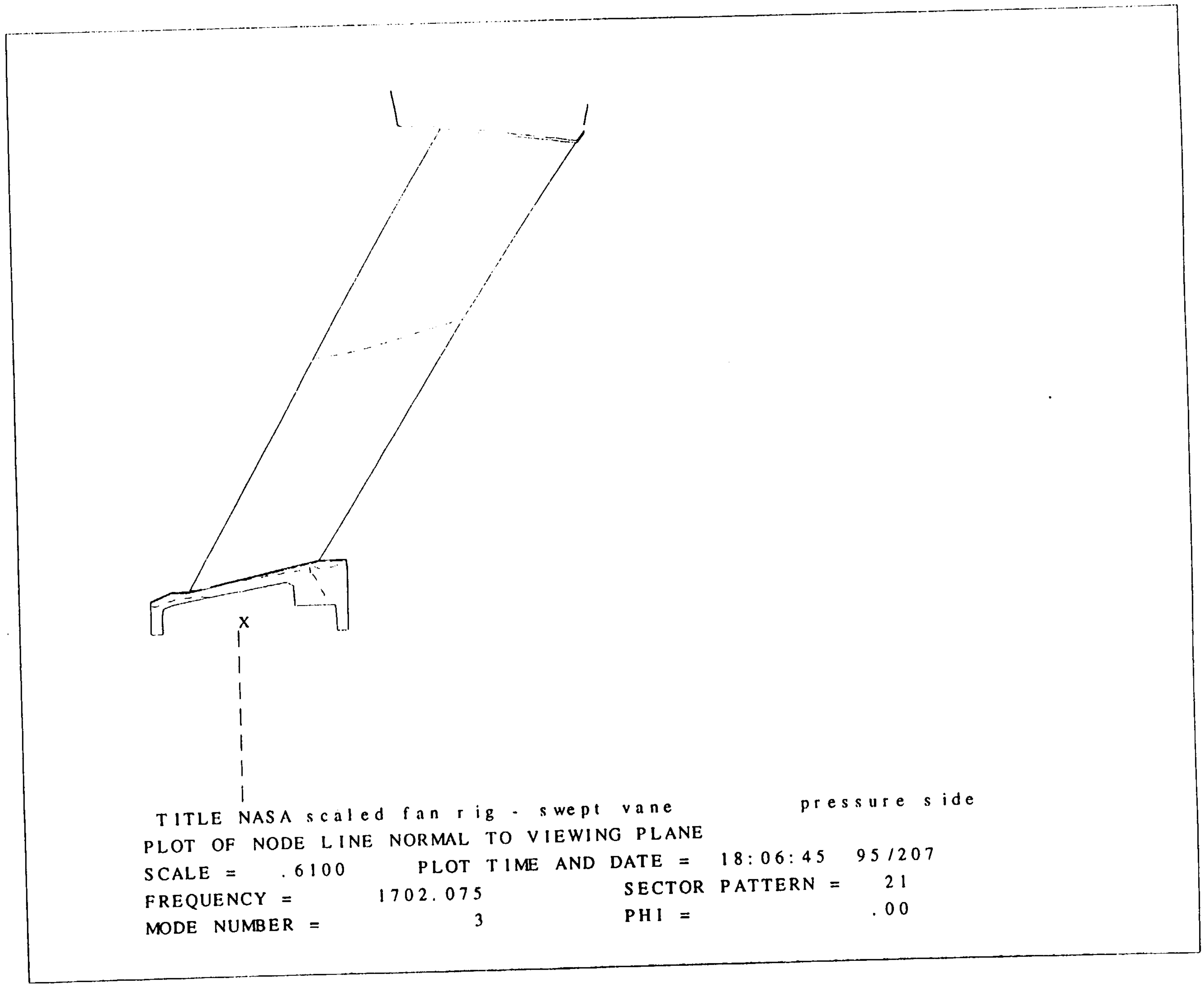
FREQUENCY = 1361.907 SECTOR PATTERN = 21
MODE NUMBER = 2 PHI = .00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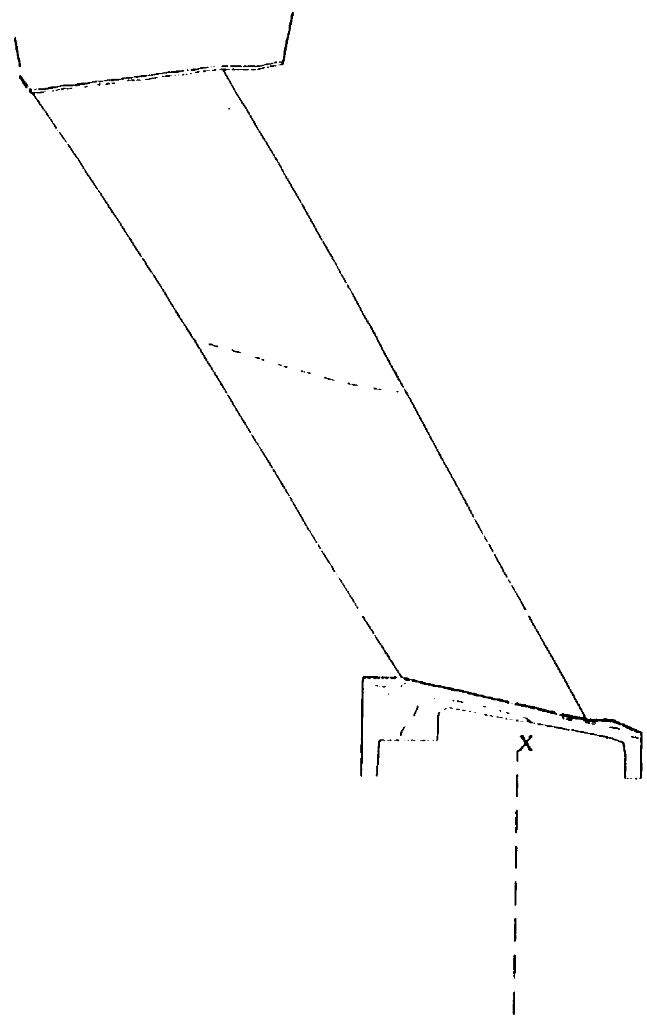
TITLE NASA scaled fan rig - swept vane pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6100 PLOT TIME AND DATE = 18:06:45 95/207
FREQUENCY = 1702.075 SECTOR PATTERN = 21
MODE NUMBER = 3 PHI = .00


TITLE NASA scaled fan rig - swept vane suction side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
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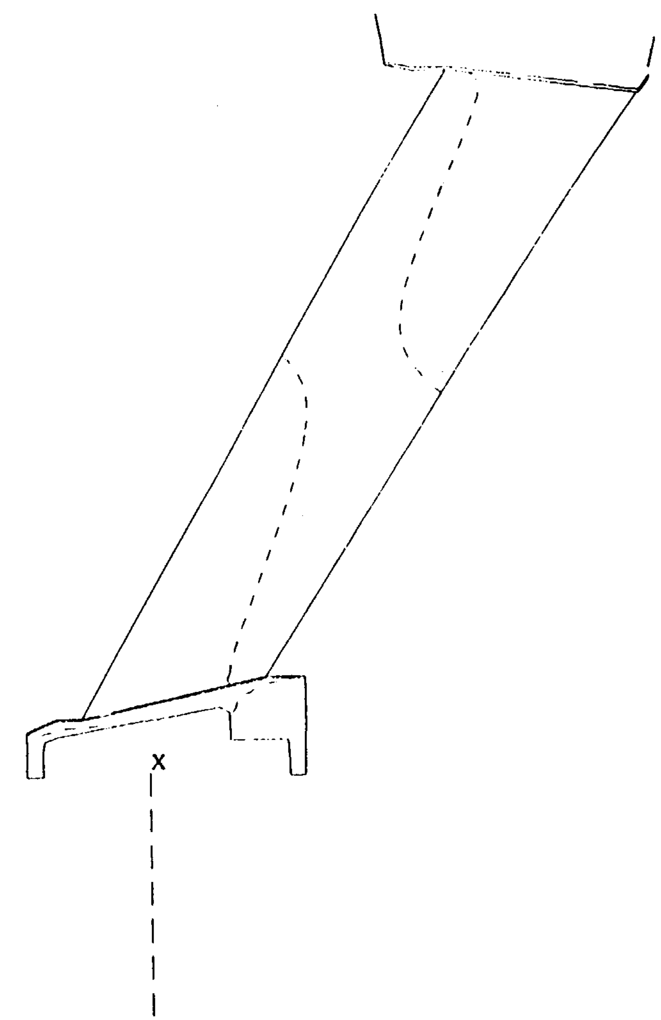
FREQUENCY = 1702.075 SECTOR PATTERN = 21
MODE NUMBER = 3 PHI = .00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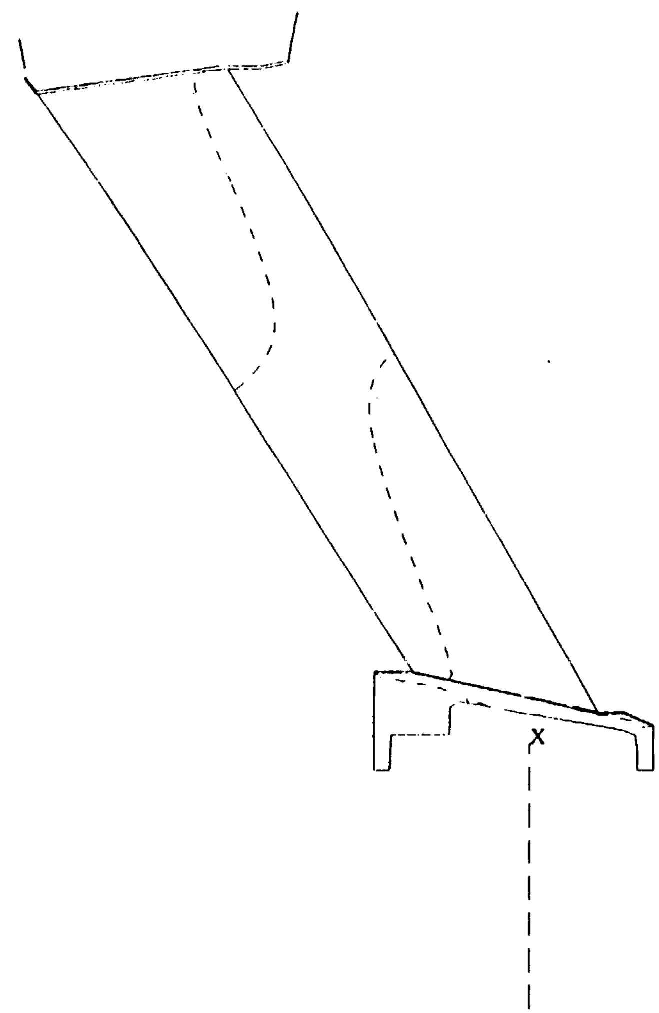
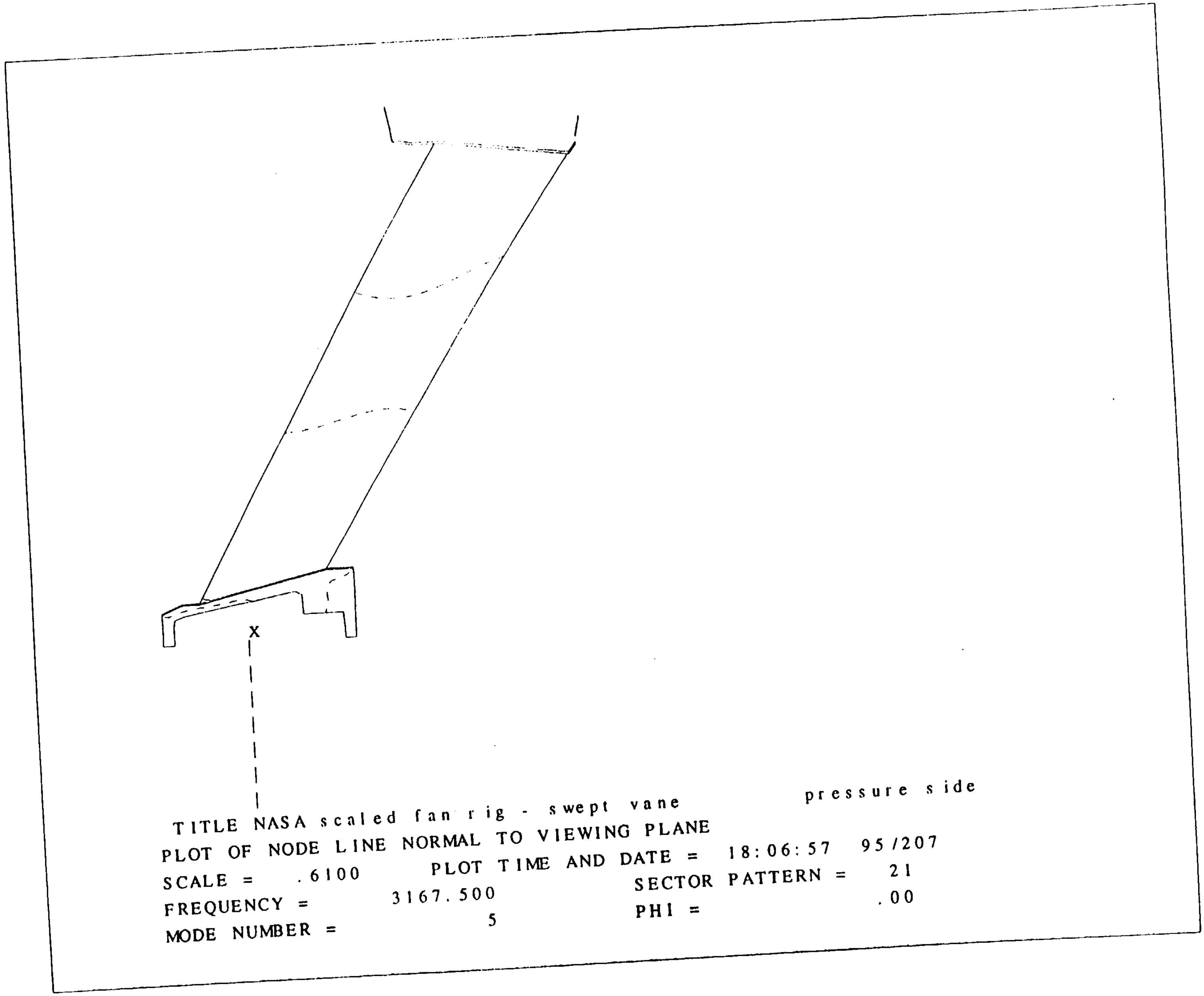
TITLE NASA scaled fan rig - swept vane pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6100 PLOT TIME AND DATE = 18:06:50 95/207
FREQUENCY = 2559.022 SECTOR PATTERN = 21
MODE NUMBER = 4 PHI = .00



TITLE NASA scaled fan rig - swept vane suction side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6100 PLOT TIME AND DATE = 18:07:57 95/207
FREQUENCY = 2559.022 SECTOR PATTERN = 21
MODE NUMBER = 4 PHI = .00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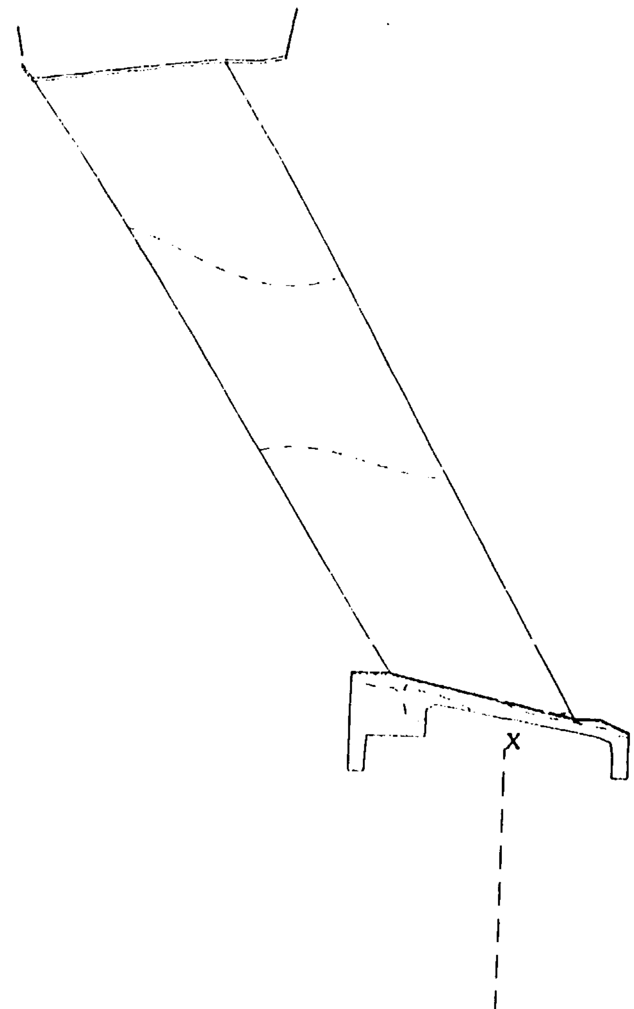
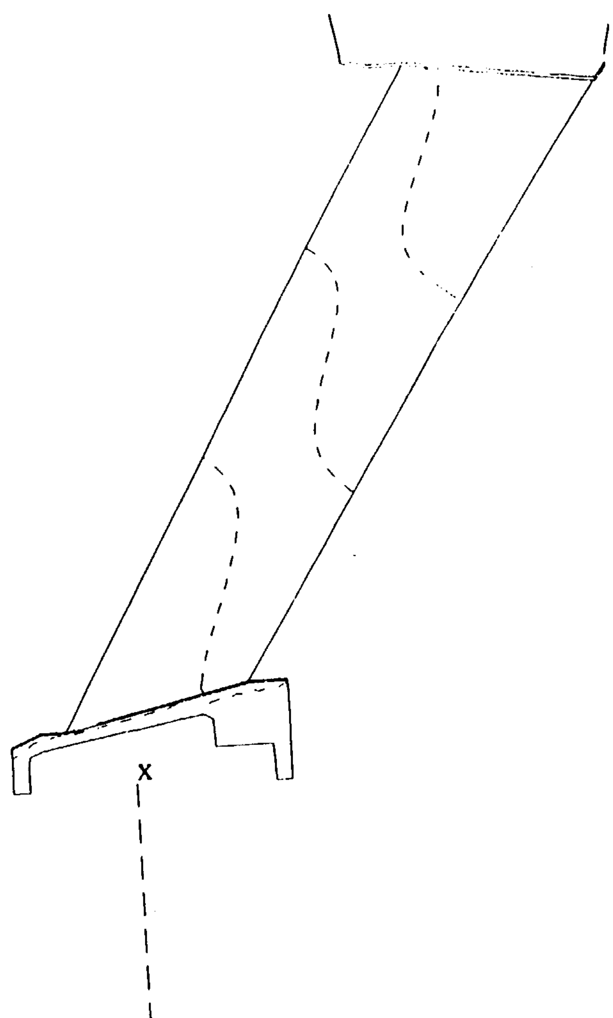
TITLE NASA scaled fan rig - swept vane pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6100 PLOT TIME AND DATE = 18:06:57 95/207
FREQUENCY = 3167.500 SECTOR PATTERN = 21
MODE NUMBER = 5 PHI = .00



TITLE NASA scaled fan rig - swept vane suction side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6100 PLOT TIME AND DATE = 18:08:03 95/207
FREQUENCY = 3167.500 SECTOR PATTERN = 21
MODE NUMBER = 5 PHI = .00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TITLE NASA scaled fan rig - swept vane
pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6100
PLOT TIME AND DATE = 18:07:03 95/207
SECTOR PATTERN = 21
FREQUENCY = 3889.117
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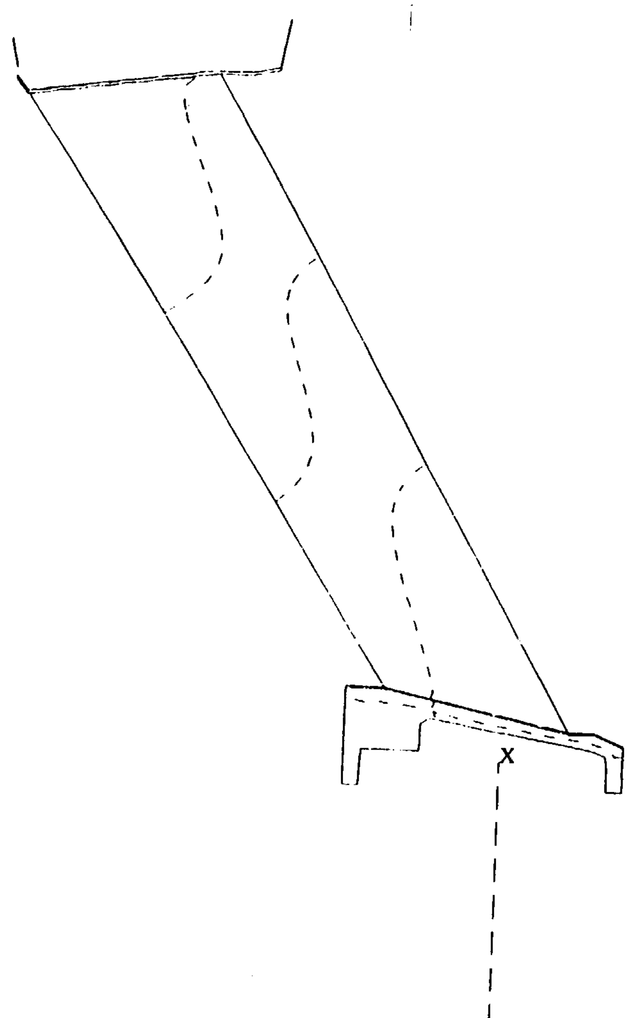
MODE NUMBER = 6



TITLE NASA scaled fan rig - swept vane suction side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
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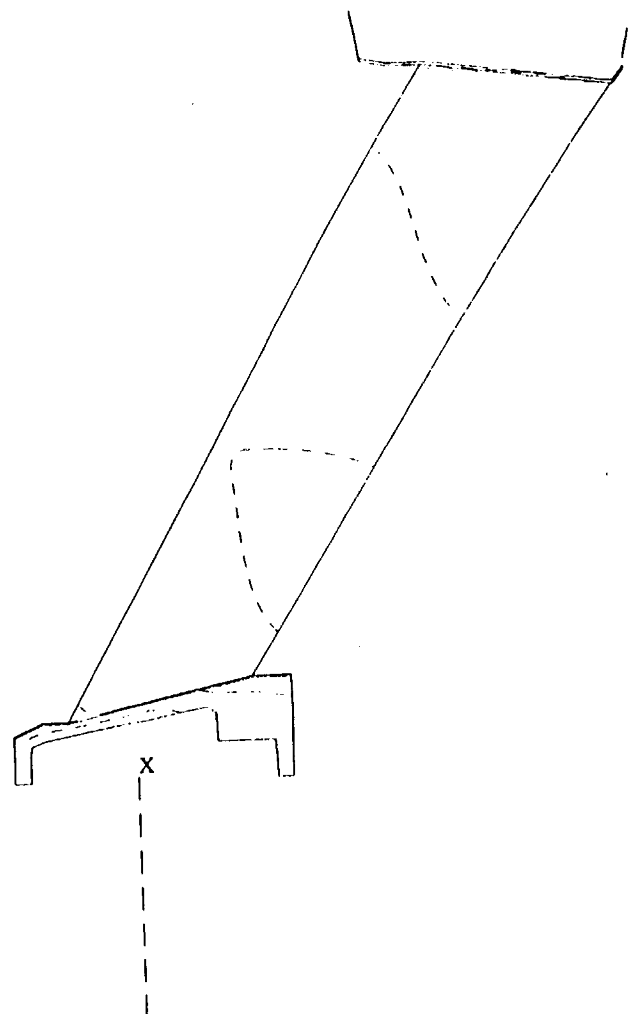
FREQUENCY = 3889.117 SECTOR PATTERN = 21
MODE NUMBER = 6 PHI = .00



TITLE NASA scaled fan rig - swept vane pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
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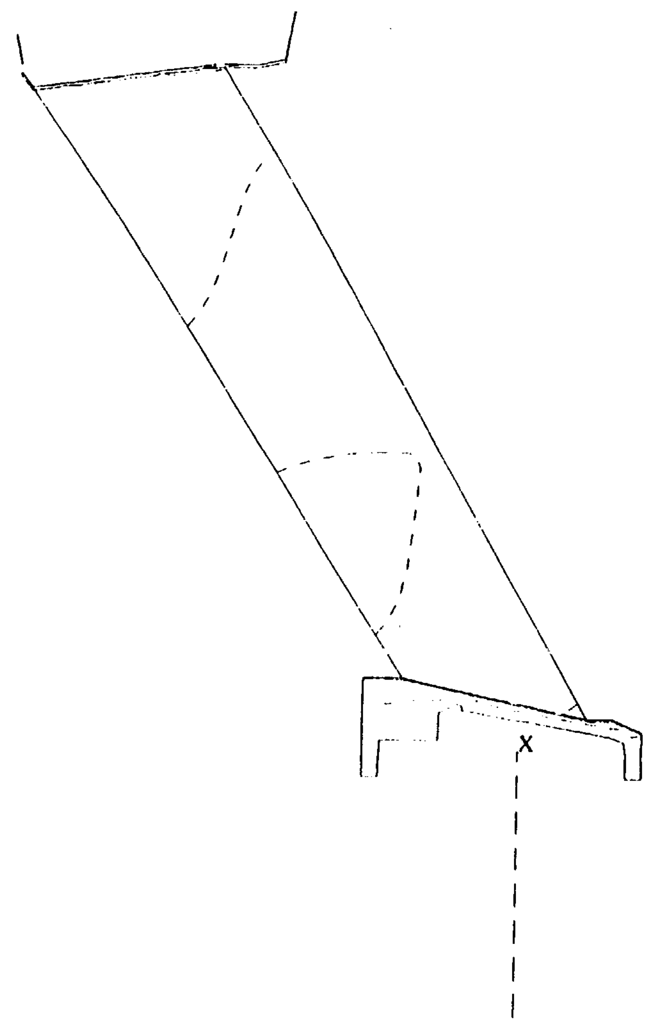
FREQUENCY = 4001.385 SECTOR PATTERN = 21
MODE NUMBER = 7 PHI = .00



TITLE NASA scaled fan rig - swept vane   suction side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
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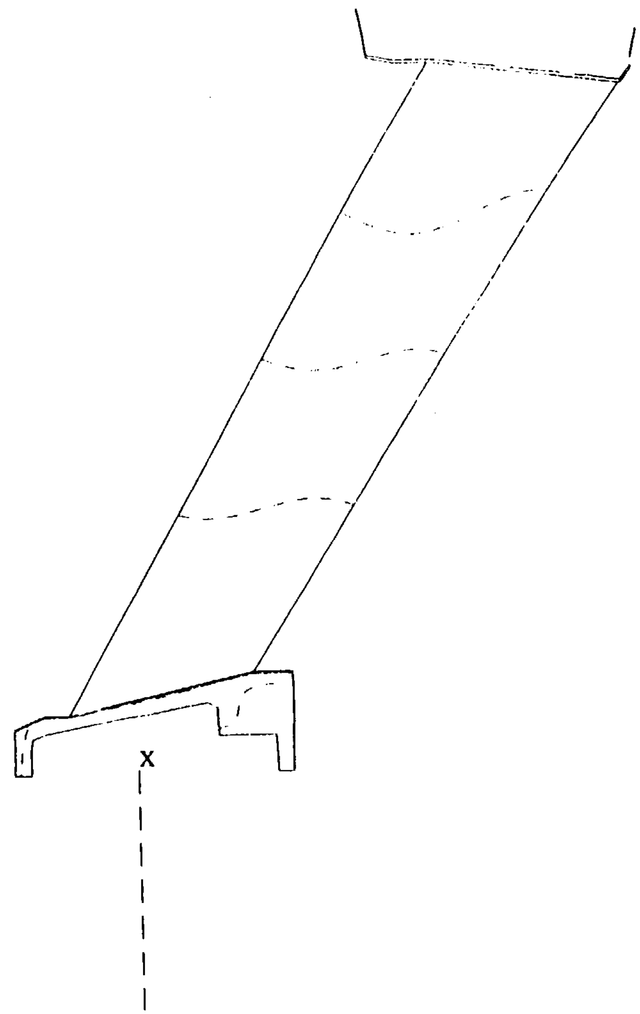
FREQUENCY = 4001.385   SECTOR PATTERN = 21
MODE NUMBER = 7   PHI = .00



TITLE NASA scaled fan rig - swept vane   pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
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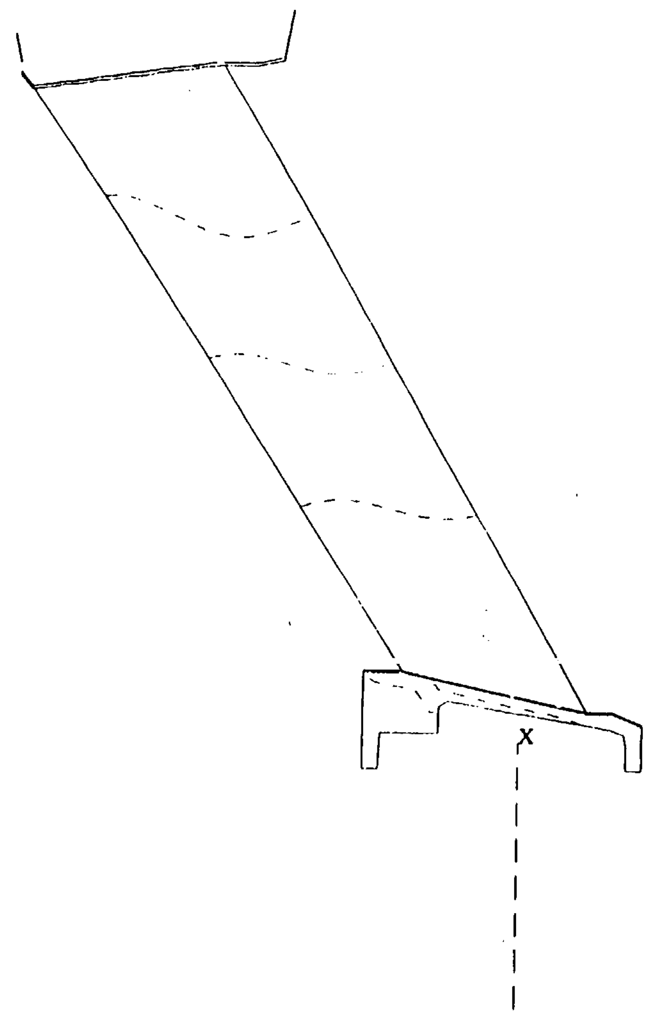
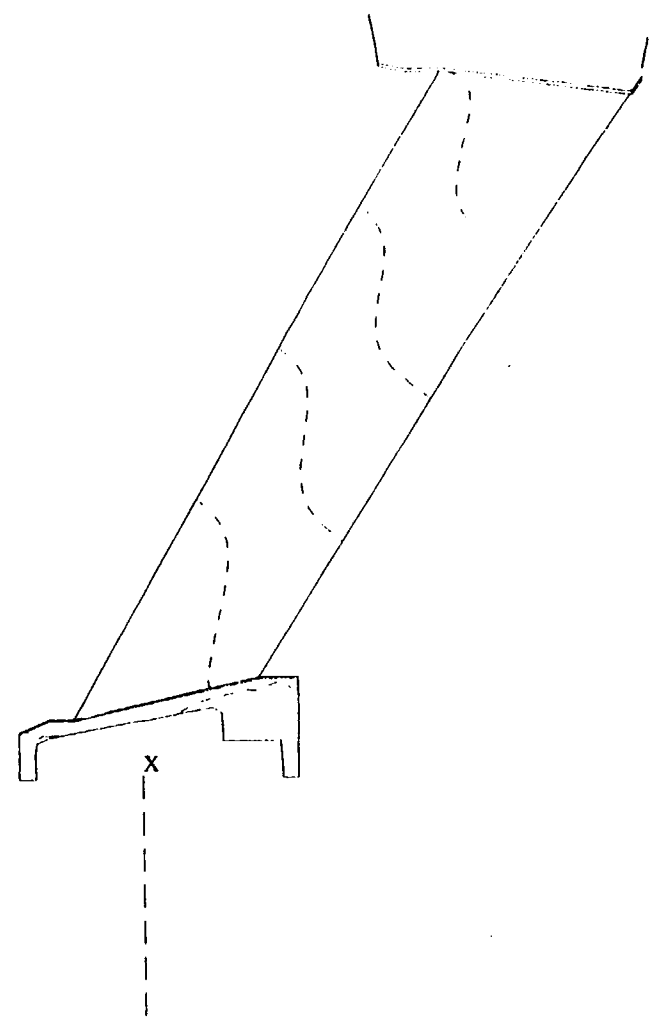
FREQUENCY = 4894.307   SECTOR PATTERN = 21
MODE NUMBER = 8   PHI = .00



TITLE NASA scaled fan rig - swept vane · suction side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6100 PLOT TIME AND DATE = 18:08:23 95/207
FREQUENCY = 4894.307 SECTOR PATTERN = 21
MODE NUMBER = 8 PHI = .00



TITLE NASA scaled fan rig - swept vane pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
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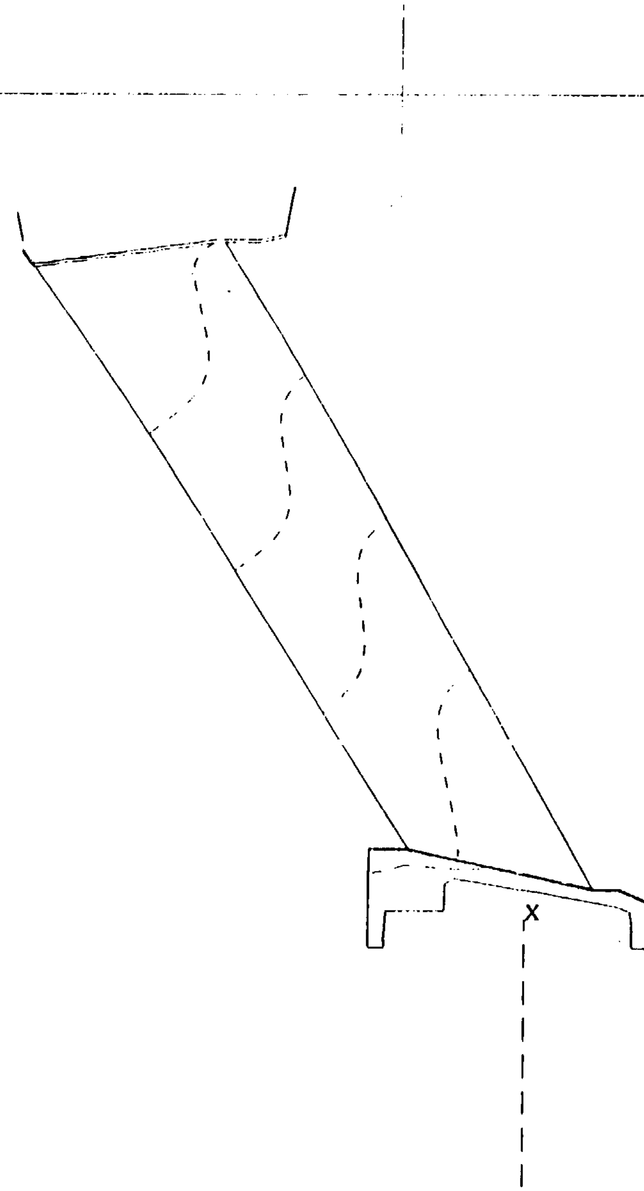
FREQUENCY = 5349.077 SECTOR PATTERN = 21
MODE NUMBER = 9 PHI = .00



TITLE NASA scaled fan rig - swept vane suction side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
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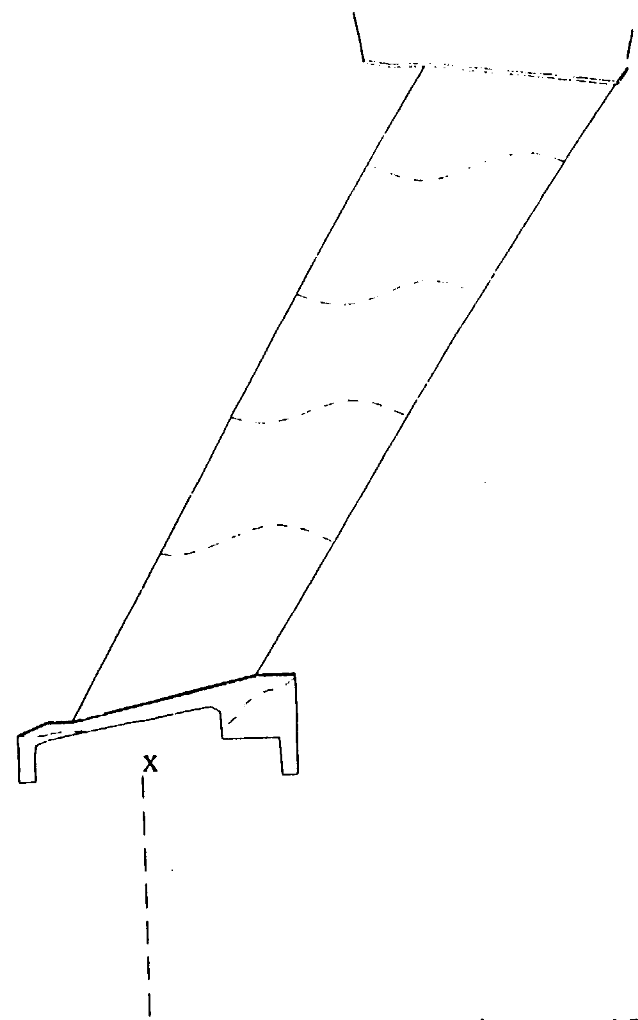
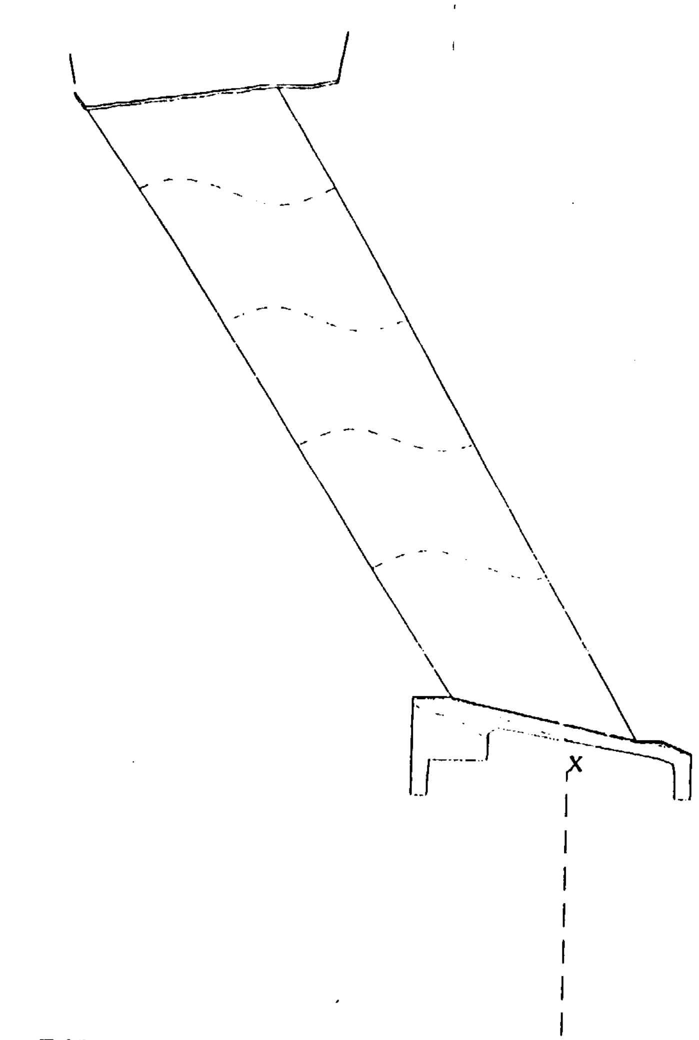
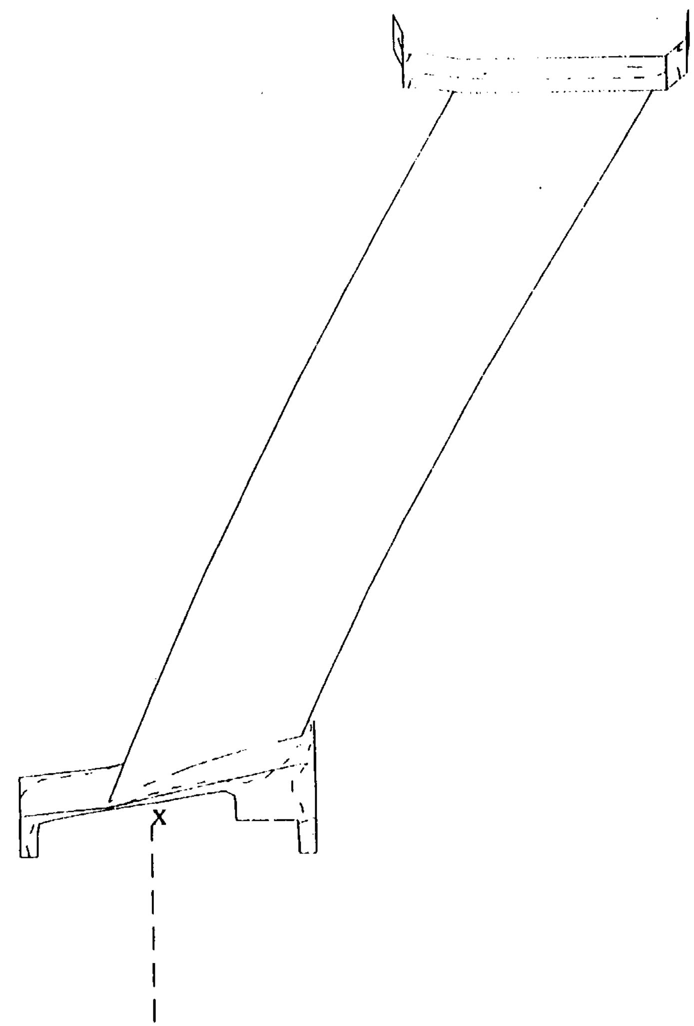
FREQUENCY = 5349.077 SECTOR PATTERN = 21
MODE NUMBER = 9 PHI = .00



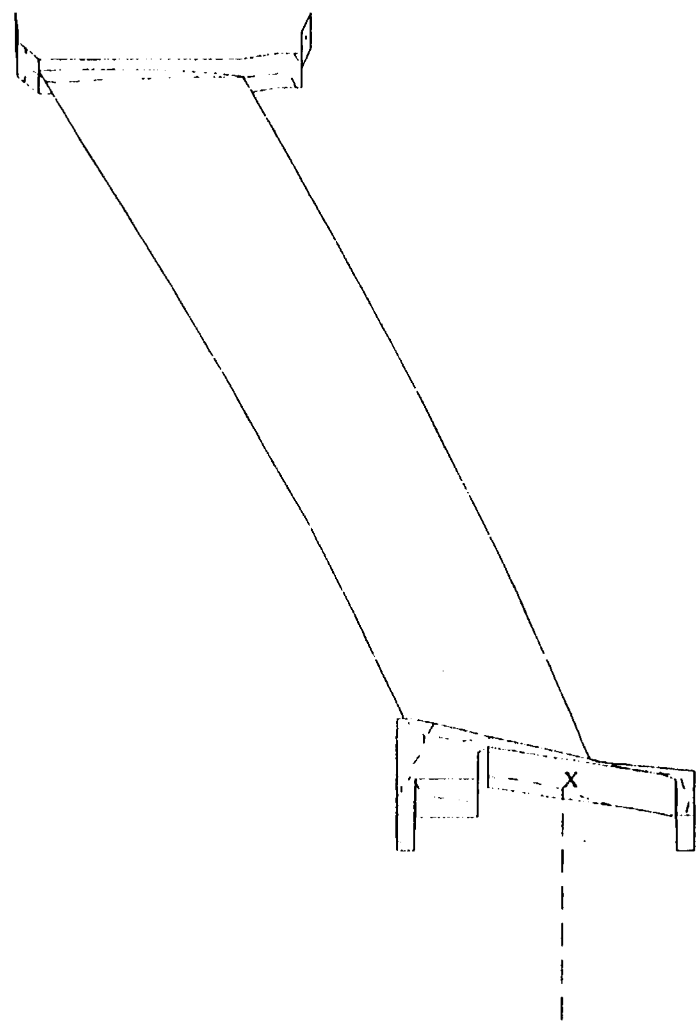
TITLE NASA scaled fan rig - swept vane pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6100 PLOT TIME AND DATE = 18:07:30 95/207
FREQUENCY = 6353.275 SECTOR PATTERN = 21
MODE NUMBER = 10 PHI = .00



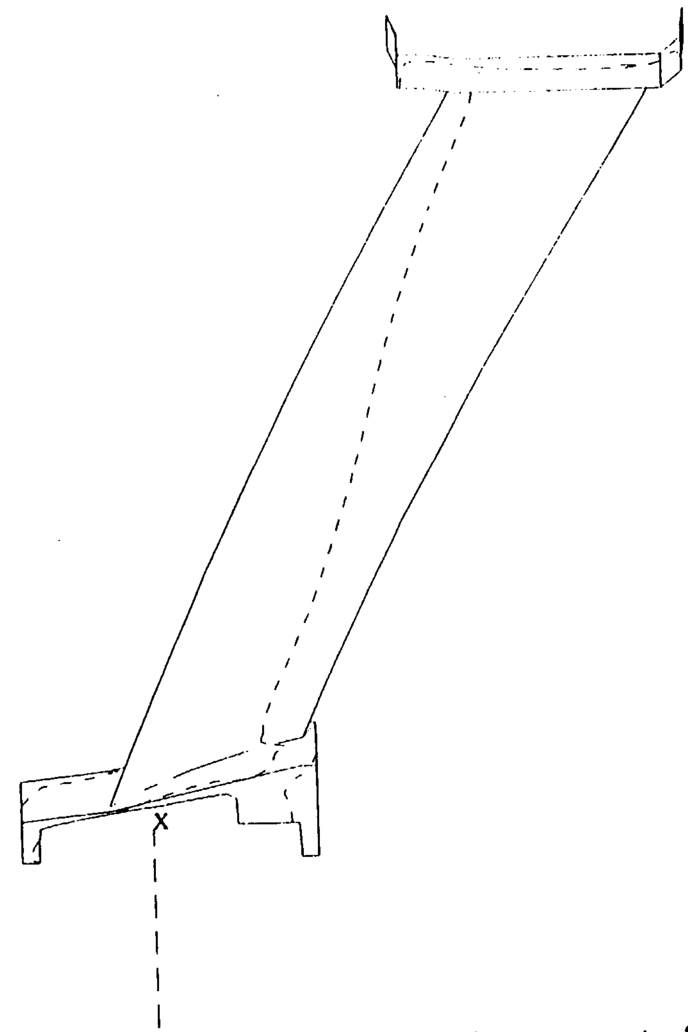
TITLE NASA scaled fan rig - swept vane   suction side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6100   PLOT TIME AND DATE = 18:08:38 95/207
FREQUENCY = 6353.275   SECTOR PATTERN = 21
MODE NUMBER = 10   PHI = .00



TITLE NASA scaled fan rig - swept & leaned vane pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6500 PLOT TIME AND DATE = 18:05:45 95/207 LO
FREQUENCY = 636.257 SECTOR PATTERN = 21
MODE NUMBER = 1 PHI = .00



TITLE NASA scaled fan rig - swept & leaned vane suction side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6500 PLOT TIME AND DATE = 18:07:11 95/207 LO
FREQUENCY = 636.257 SECTOR PATTERN = 21
MODE NUMBER = 1 PHI = .00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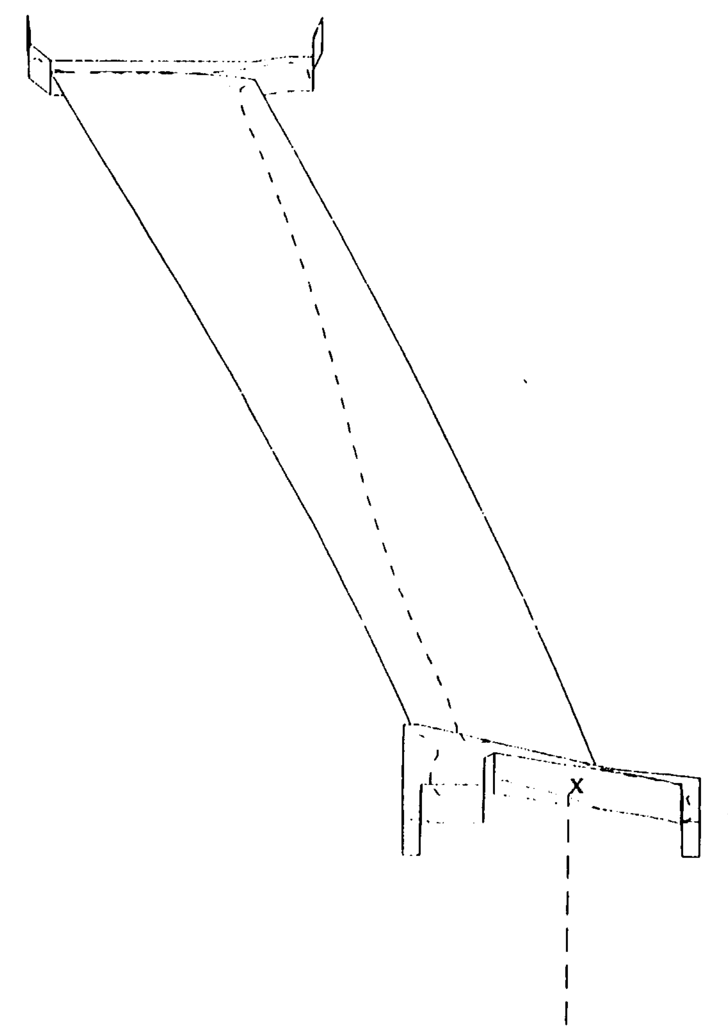
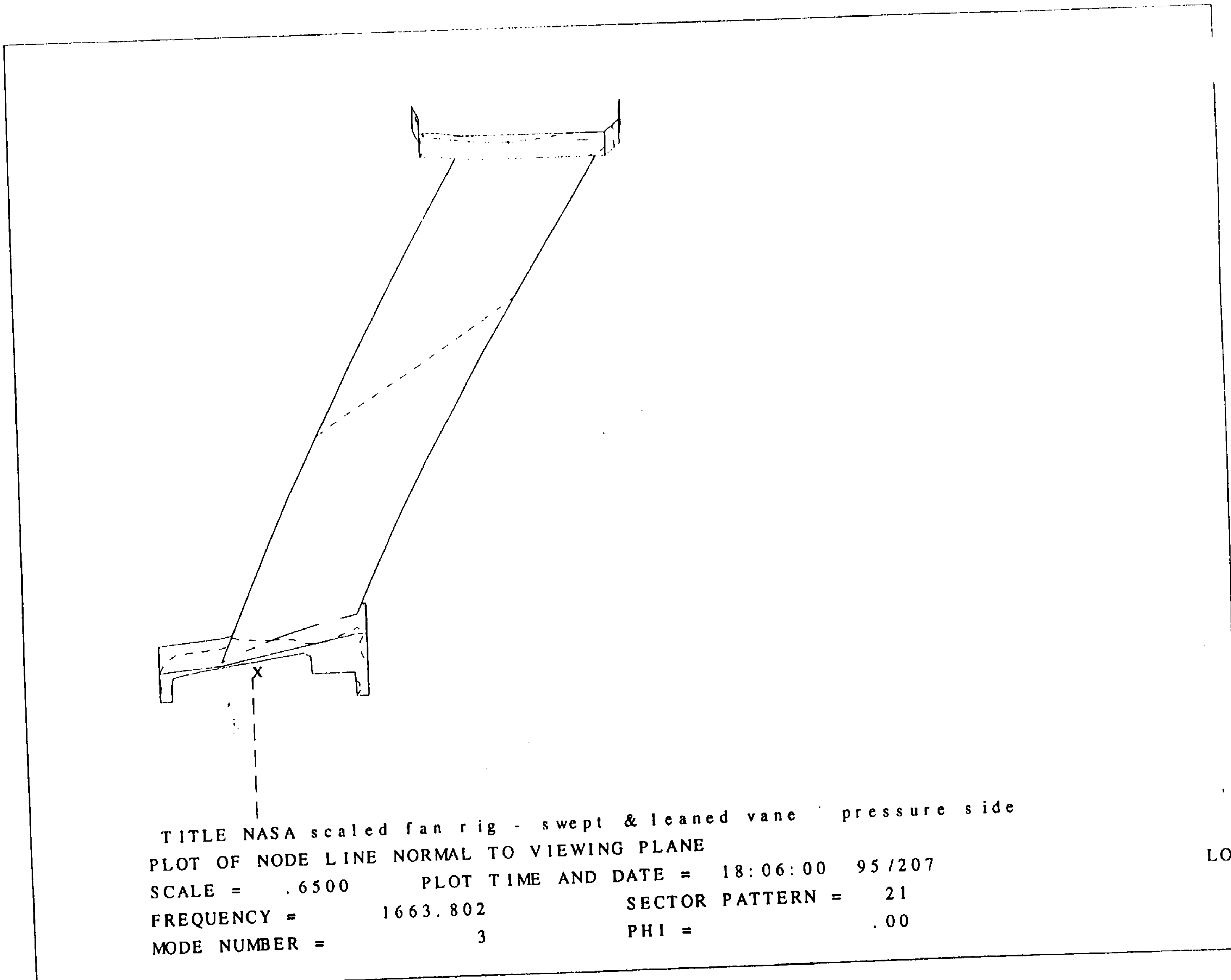
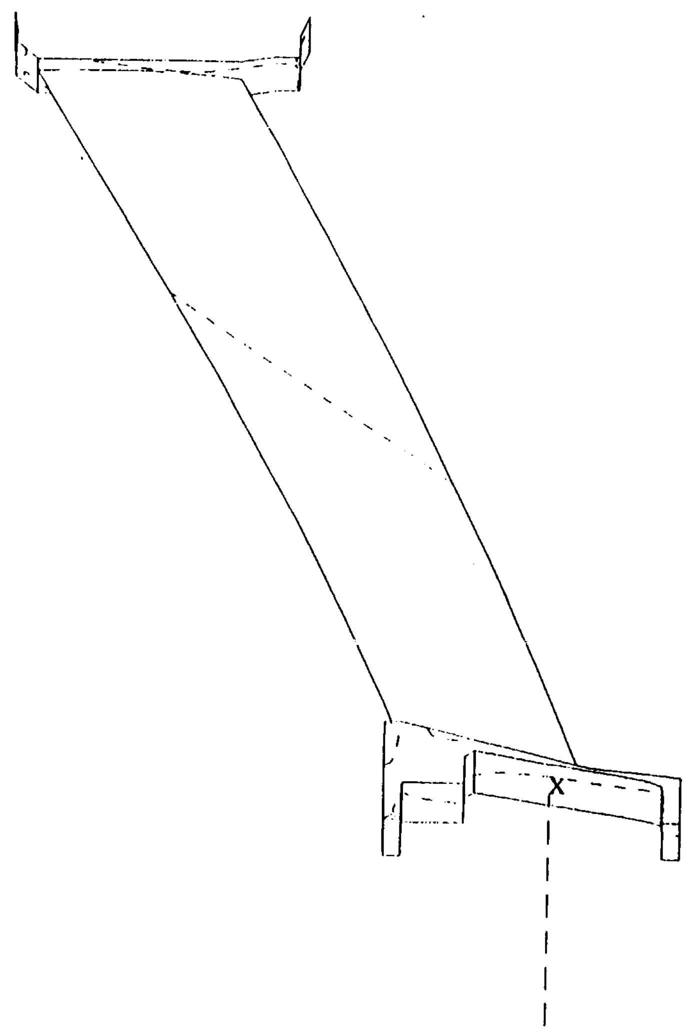
TITLE NASA scaled fan rig - swept & leaned vane pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6500 PLOT TIME AND DATE = 18:05:52 95/207
FREQUENCY = 1428.280 SECTOR PATTERN = 21
MODE NUMBER = 2 PHI = .00
LO



TITLE NASA scaled fan rig - swept & leaned vane suction side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6500 PLOT TIME AND DATE = 18:07:19 95/207 LO
FREQUENCY = 1428.280 SECTOR PATTERN = 21
MODE NUMBER = 2 PHI = .00


TITLE NASA scaled fan rig - swept & leaned vane pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6500 PLOT TIME AND DATE = 18:06:00 95/207
FREQUENCY = 1663.802 SECTOR PATTERN = 21
MODE NUMBER = 3 PHI = .00
LO
X



TITLE NASA scaled fan rig - swept & leaned vane suction side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
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FREQUENCY = 1663.802 SECTOR PATTERN = 21
MODE NUMBER = 3 PHI = .00

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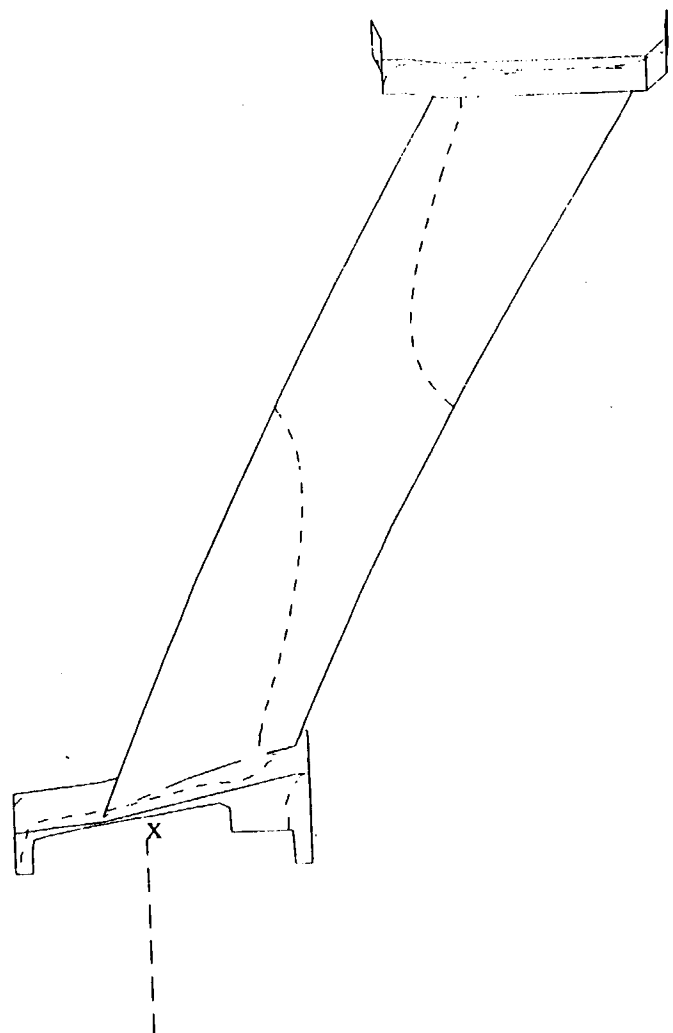
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TITLE NASA scaled fan rig - swept & leaned vane pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
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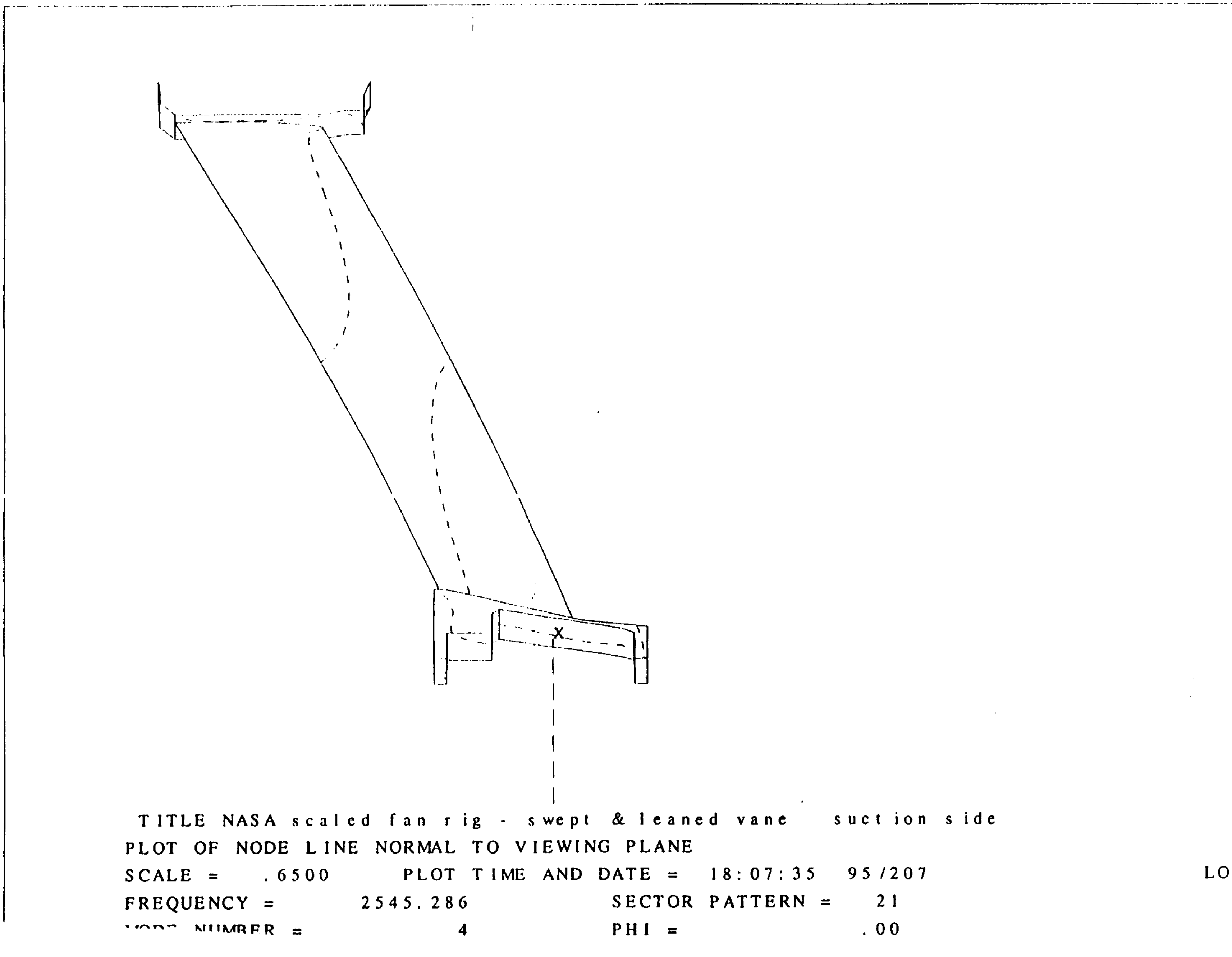
FREQUENCY = 2545.286 SECTOR PATTERN = 21
MODE NUMBER = 4 PHI = .00


TITLE NASA scaled fan rig - swept & leaned vane suction side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6500 PLOT TIME AND DATE = 18:07:35 95/207
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FREQUENCY = 2545.286 SECTOR PATTERN = 21
NUMBER = 4 PHI = .00
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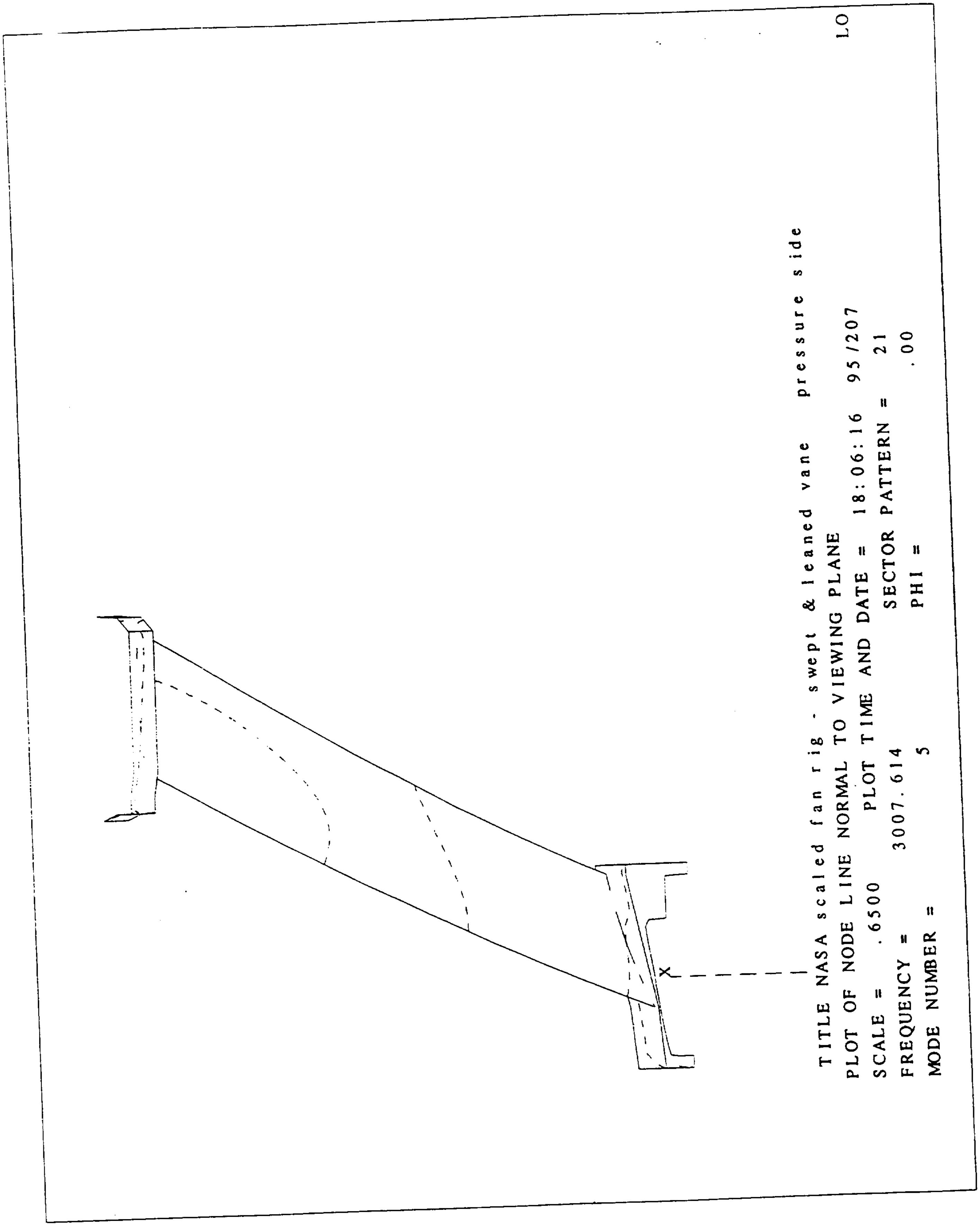
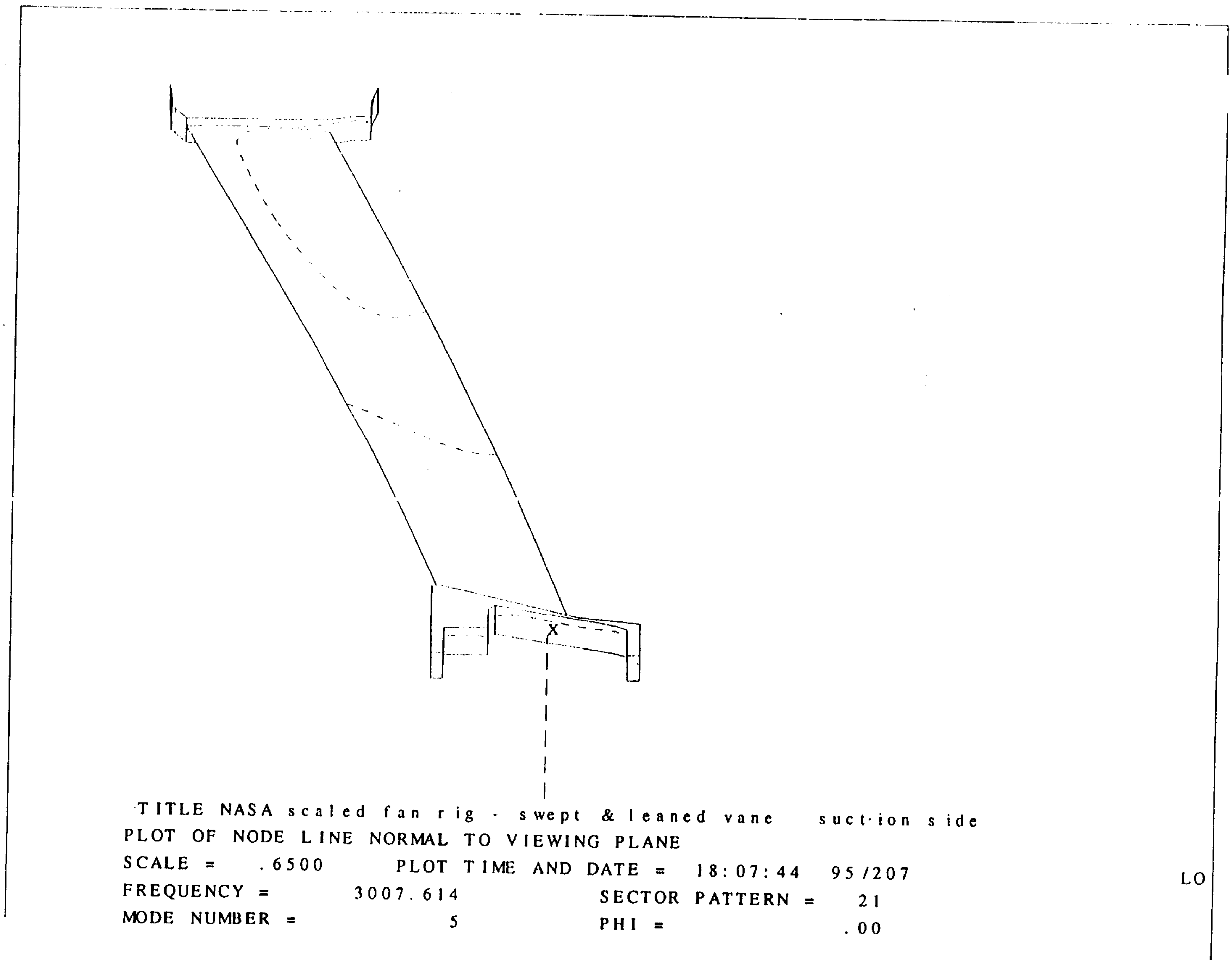
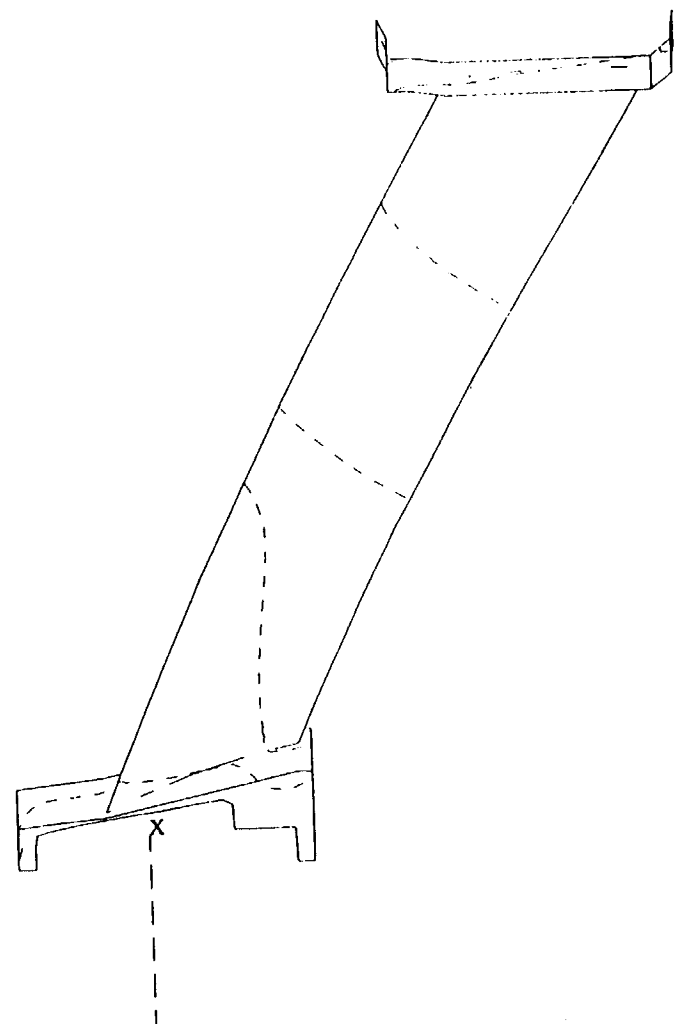

TITLE NASA scaled fan rig - swept & leaned vane pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6500 PLOT TIME AND DATE = 18:06:16 95/207
FREQUENCY = 3007.614 SECTOR PATTERN = 21
MODE NUMBER = 5 PHI = .00
LO
X


TITLE NASA scaled fan rig - swept & leaned vane suction side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6500 PLOT TIME AND DATE = 18:07:44 95/207
FREQUENCY = 3007.614 SECTOR PATTERN = 21
MODE NUMBER = 5 PHI = .00
LO



TITLE NASA scaled fan rig - swept & leaned vane pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
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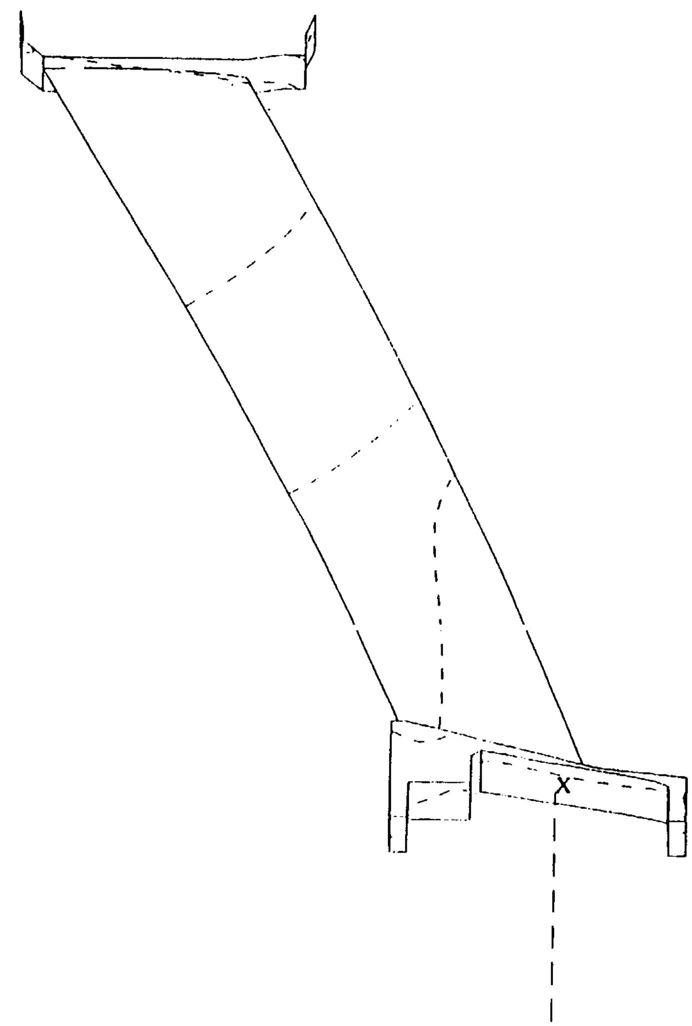
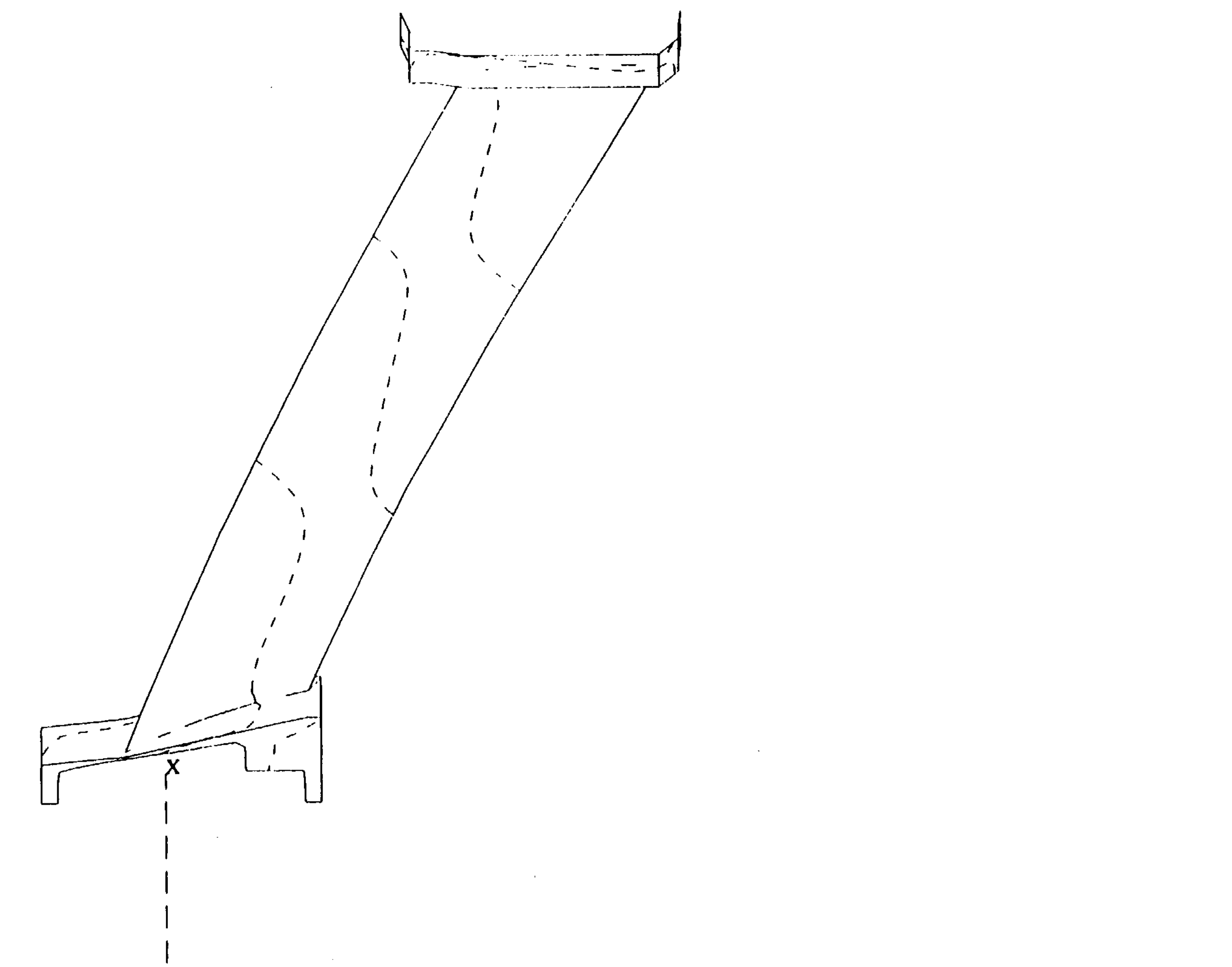
FREQUENCY = 3603.865 SECTOR PATTERN = 21
MODE NUMBER = 6 PHI = .00

LO



TITLE NASA scaled fan rig - swept & leaned vane suction side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6500 PLOT TIME AND DATE = 18:07:52 95/207
FREQUENCY = 3603.865 SECTOR PATTERN = 21
MODE NUMBER = 6 PHI = .00

LO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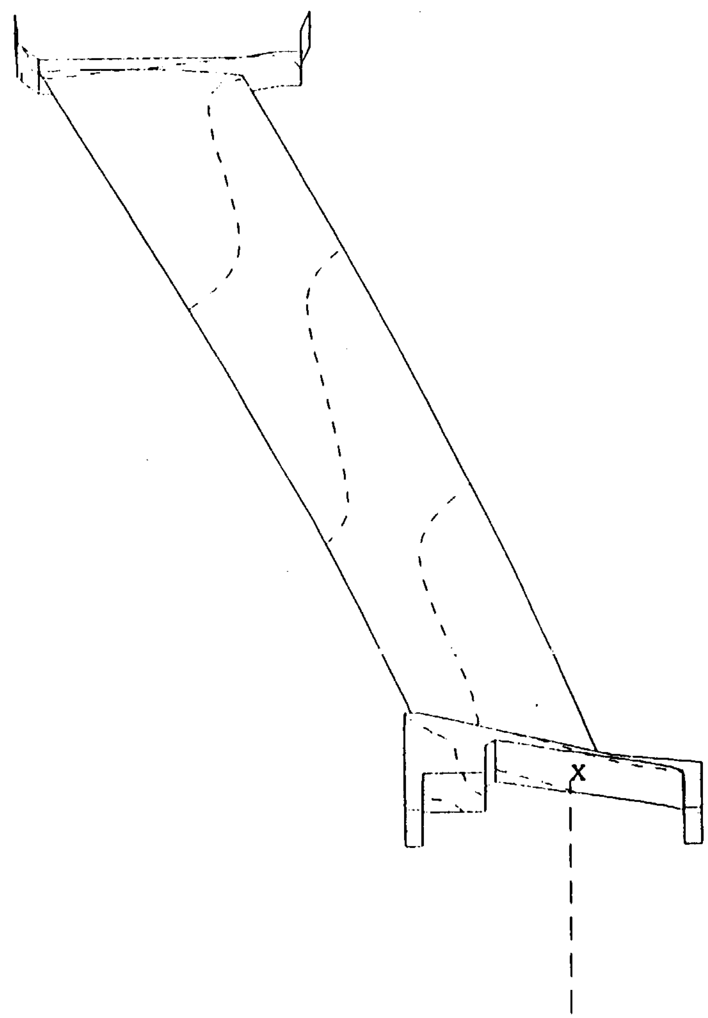
TITLE NASA scaled fan rig - swept & leaned vane pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6500 PLOT TIME AND DATE = 18:06:32 95/207
LO
FREQUENCY = 4035.621 SECTOR PATTERN = 21
MODE NUMBER = 7 PHI = .00



TITLE NASA scaled fan rig - swept & leaned vane suction side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
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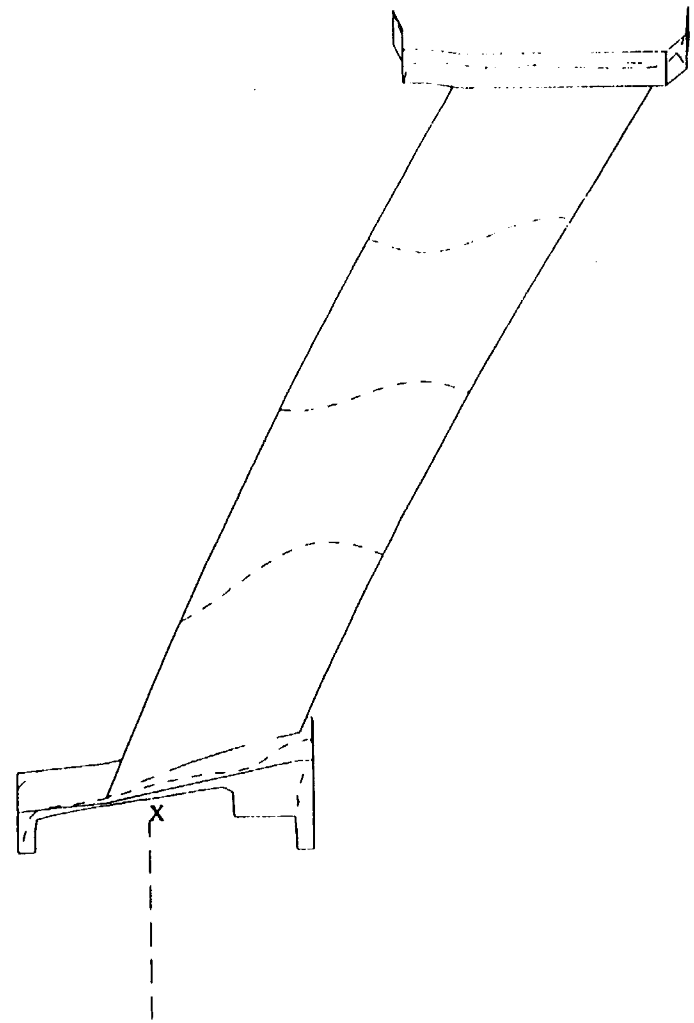
FREQUENCY = 4035.621 SECTOR PATTERN = 21
MODE NUMBER = 7 PHI = .00



TITLE NASA scaled fan rig - swept & leaned vane   pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
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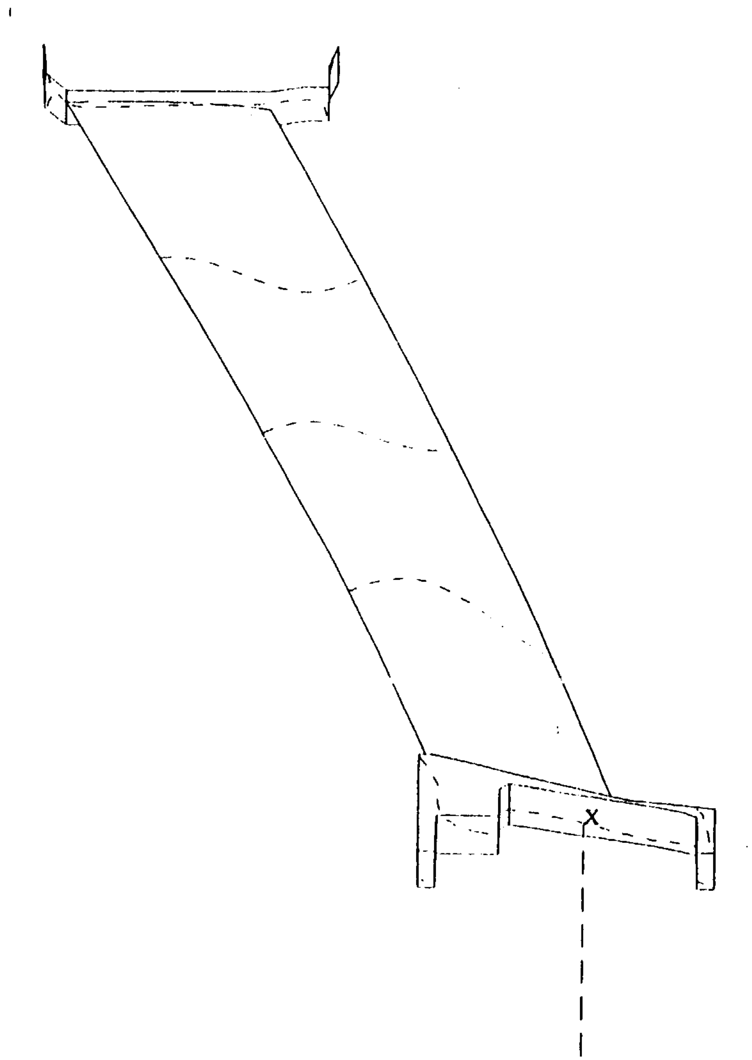

TITLE NASA scaled fan rig - swept & leaned vane suction side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
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MODE NUMBER = 8 PHI = .00

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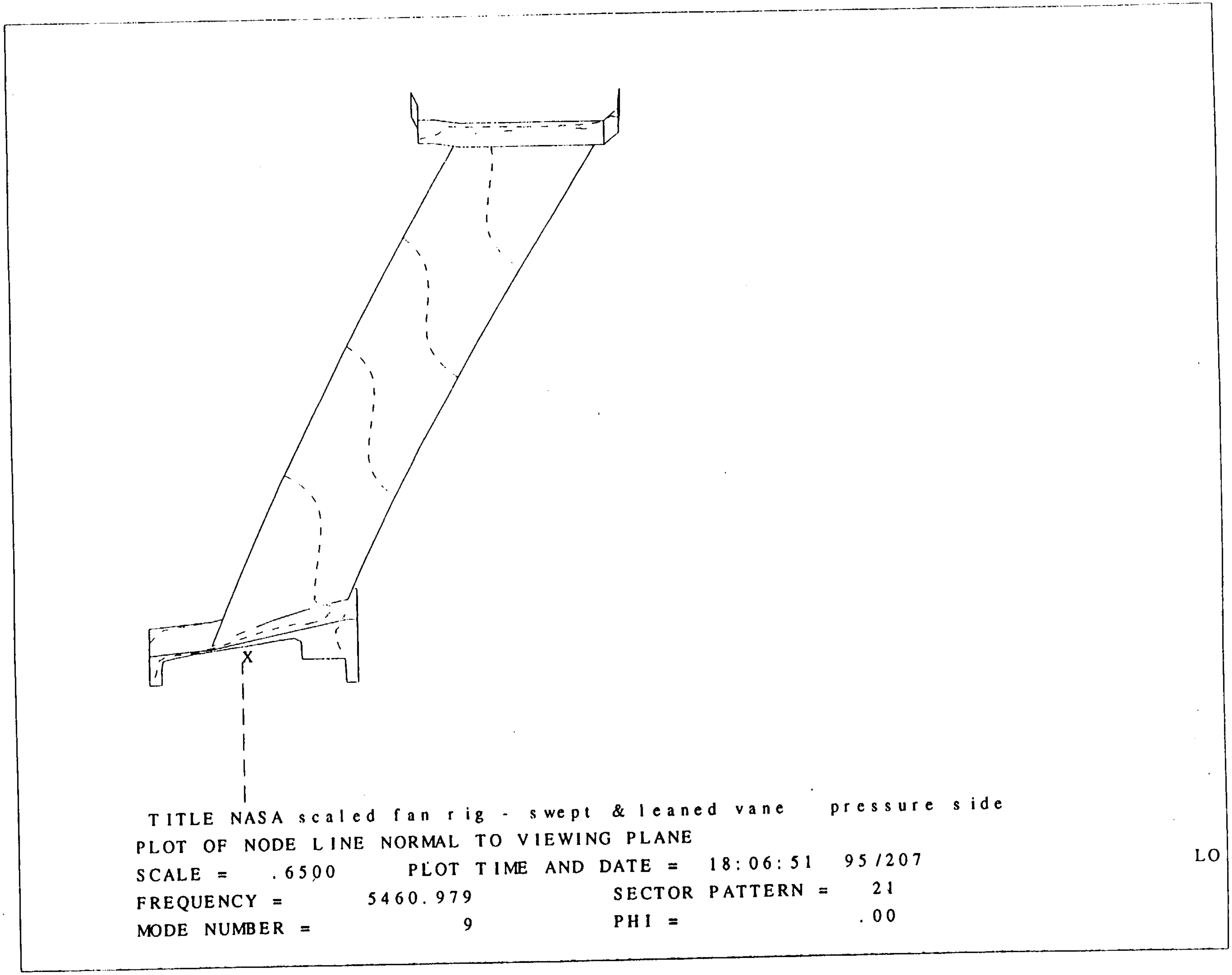
TITLE NASA scaled fan rig - swept & leaned vane pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
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FREQUENCY = 5460.979 SECTOR PATTERN = 21
MODE NUMBER = 9 PHI = .00
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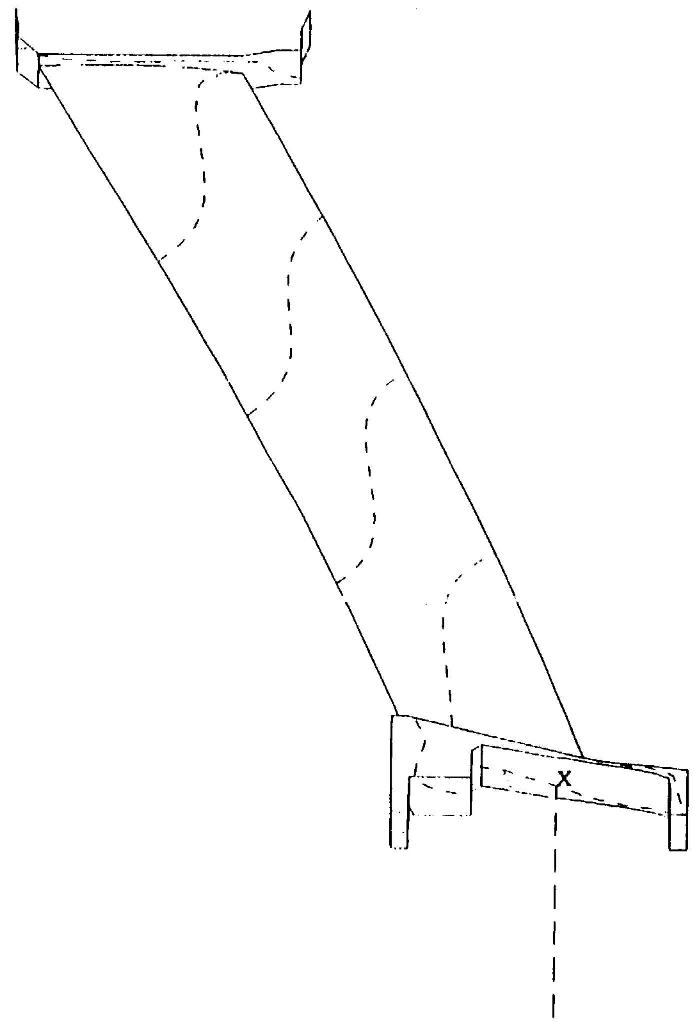

TITLE NASA scaled fan rig - swept & leaned vane suction side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
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FREQUENCY = 5460.979 SECTOR PATTERN = 21
NODE NUMBER = 9 PHI = .00

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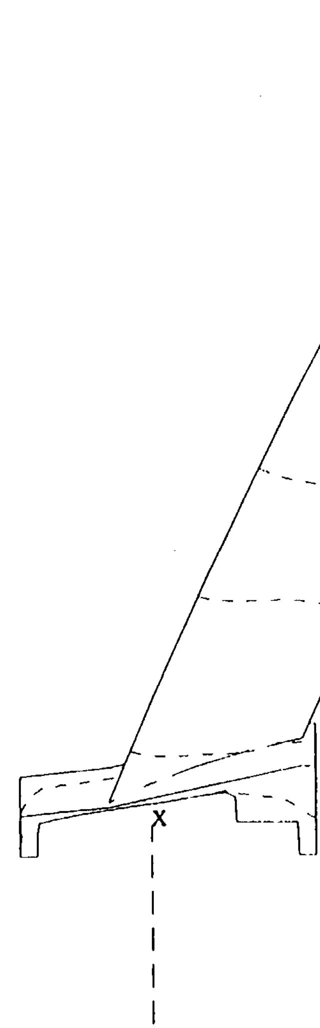

TITLE NASA scaled fan rig - swept & leaned vane pressure side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
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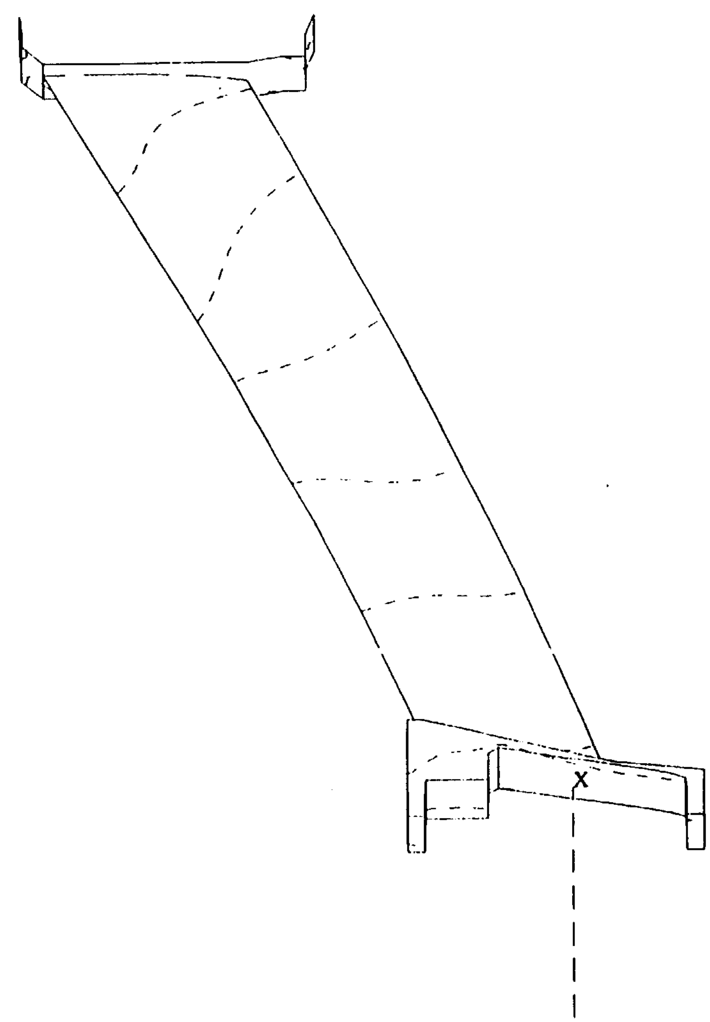
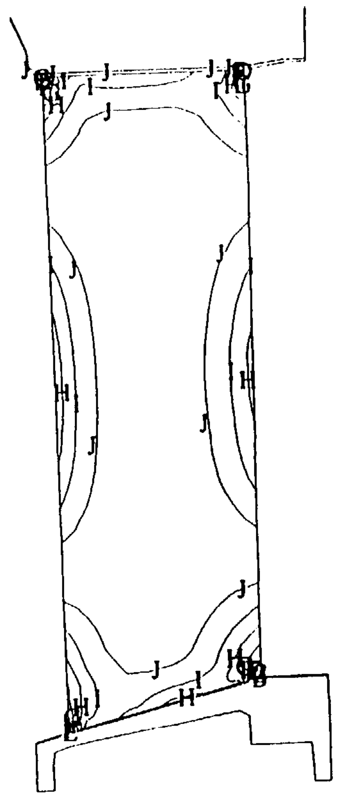
FREQUENCY = 6041.609 SECTOR PATTERN = 21
MODE NUMBER = 10 PHI = .00



TITLE NASA scaled fan rig - swept & leaned vane suction side
PLOT OF NODE LINE NORMAL TO VIEWING PLANE
SCALE = .6500 PLOT TIME AND DATE = 18:08:30 95/207
FREQUENCY = 6041.609 SECTOR PATTERN = 21
MODE NUMBER = 10 PHI = .00

Appendix C: Dynamic Stress Contour Plots

List of Figures



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F	50.00
G	40.00
H	30.00
I	20.00
J	10.00
*MAX	100.00
*MIN	.01

*DENOTES HIDDEN

TITLE NASA scaled fan rig - baseline vane pressure side

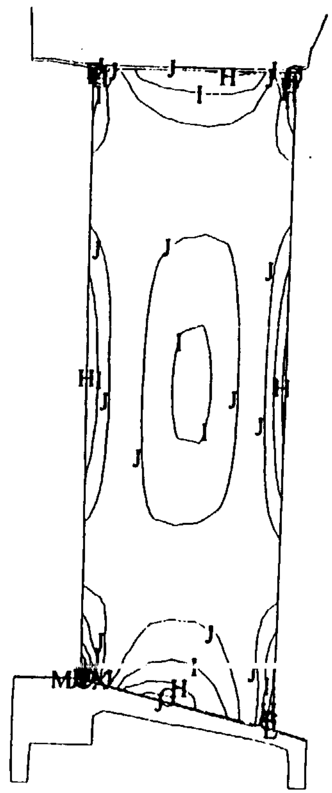
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS

LOAD

SCALE =X .6200 PLOT TIME AND DATE = 16:59:33 95/069

FREQUENCY = 819.896 SECTOR PATTERN = 21

MODE NUMBER = 1 PHI = .00



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I	20.00
J	10.00
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*DENOTES HIDDEN

TITLE NASA scaled fan rig - baseline vane suction side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
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MODE NUMBER = 1 PHI = .00

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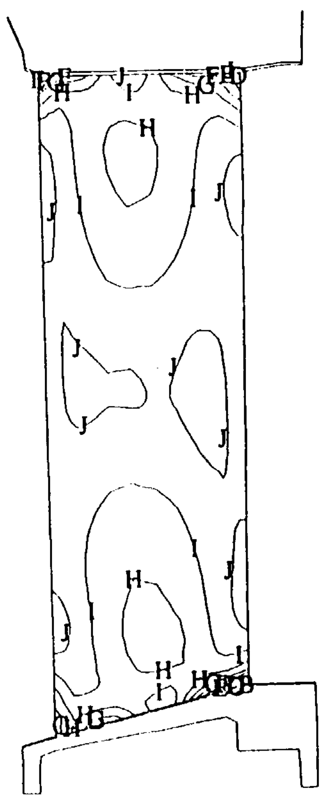

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J	10.00	
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*DENOTES HIDDEN		

TITLE NASA scaled fan rig - baseline vane pressure side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE =X .6200 PLOT TIME AND DATE = 16:59:49 95/069 LOAD
FREQUENCY = 1319.669 SECTOR PATTERN = 21
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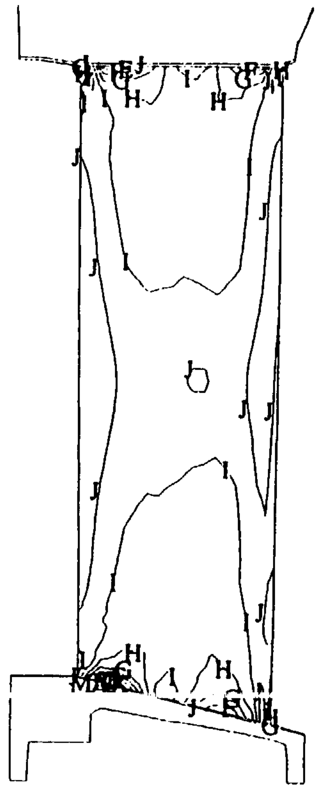

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I	20.00
J	10.00
MAX	100.00
*MIN	.01

*DENOTES HIDDEN

X

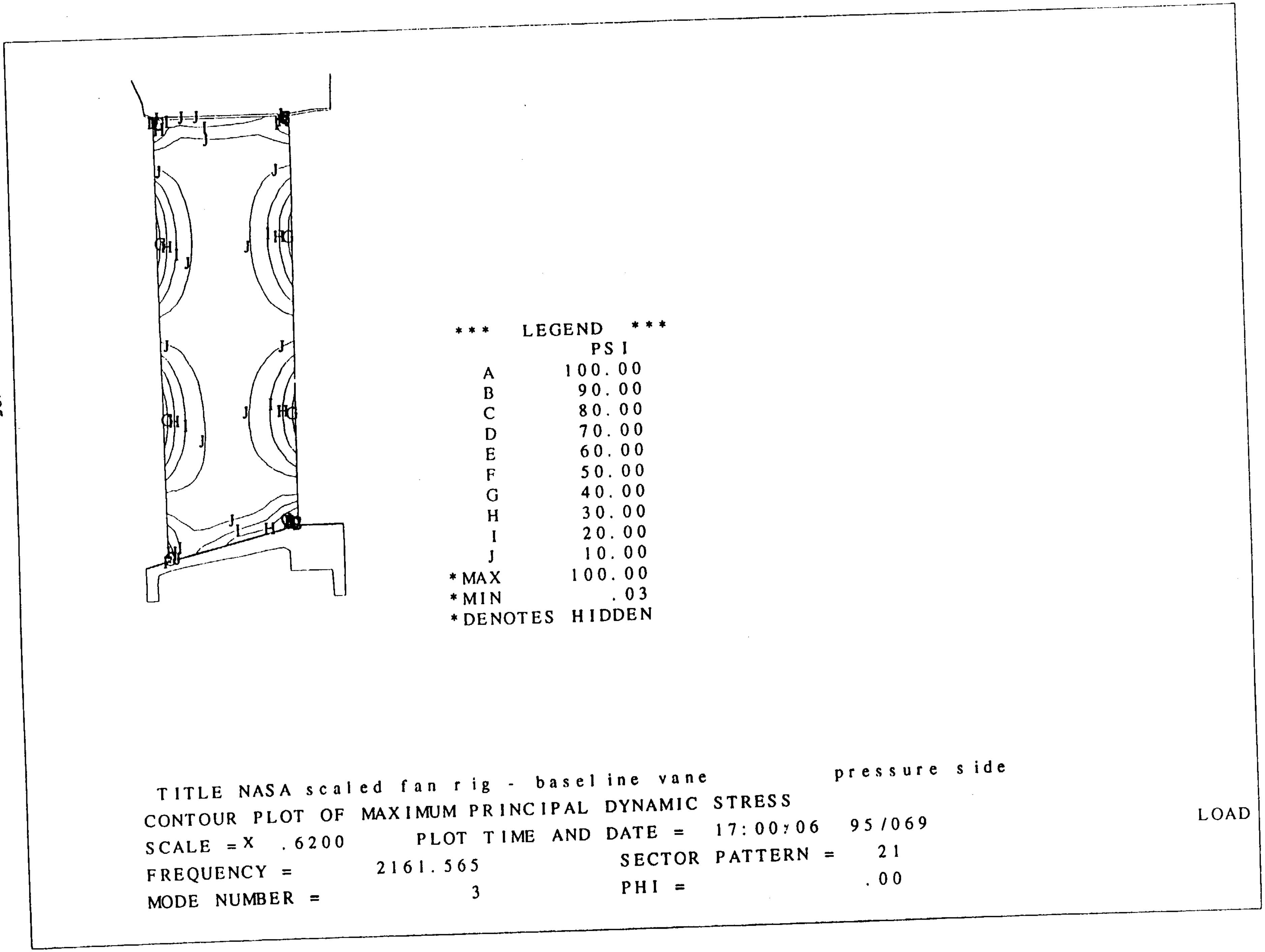
TITLE NASA scaled fan rig - baseline vane suction side

CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS

SCALE = .6200 PLOT TIME AND DATE = 17:09:12 95/069 LOAD

FREQUENCY = 1319.669 SECTOR PATTERN = 21

MODE NUMBER = 2 PHI = .00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I 20.00
J 10.00
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TITLE NASA scaled fan rig - baseline vane pressure side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE =X .6200 PLOT TIME AND DATE = 17:00:06 95/069
FREQUENCY = 2161.565 SECTOR PATTERN = 21
MODE NUMBER = 3 PHI = .00
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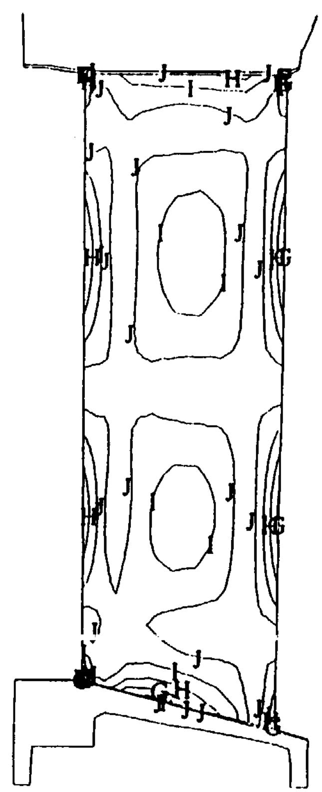

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*DENOTES HIDDEN

X

TITLE NASA scaled fan rig - baseline vane suction side

CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS

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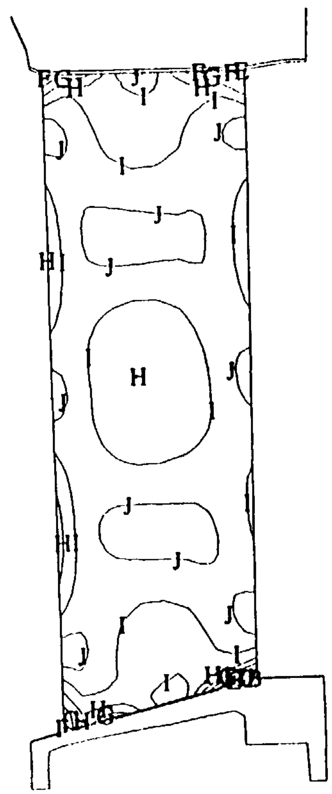
FREQUENCY = 2161.565 SECTOR PATTERN = 21

MODE NUMBER = 3 PHI = .00



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TITLE NASA scaled fan rig - baseline vane pressure side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
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FREQUENCY = 2643.099 SECTOR PATTERN = 21
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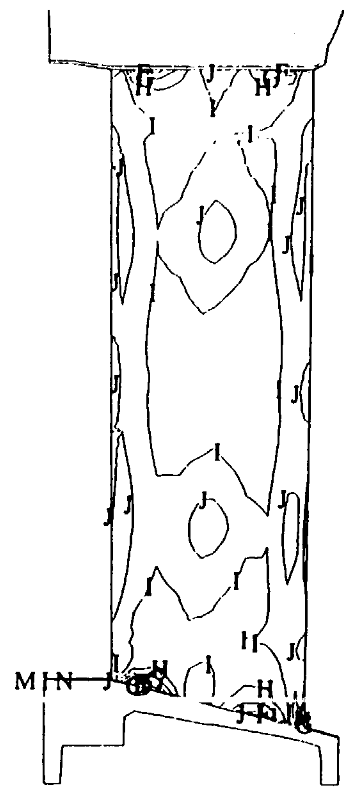

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J	10.00
*MAX	100.00
MIN	.00

*DENOTES HIDDEN

X

TITLE NASA scaled fan rig - baseline vane suction side

CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS

SCALE = .6200 PLOT TIME AND DATE = 17:09:55 95/069 LOAD

FREQUENCY = 2643.099 SECTOR PATTERN = 21

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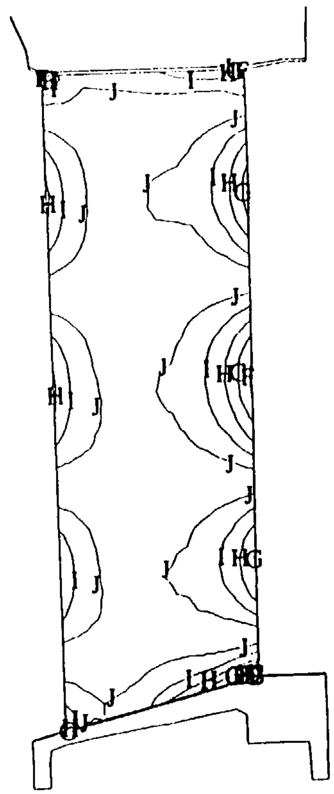

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J	10.00
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*DENOTES HIDDEN

TITLE NASA scaled fan rig - baseline vane pressure side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
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FREQUENCY = 3901.743 SECTOR PATTERN = 21
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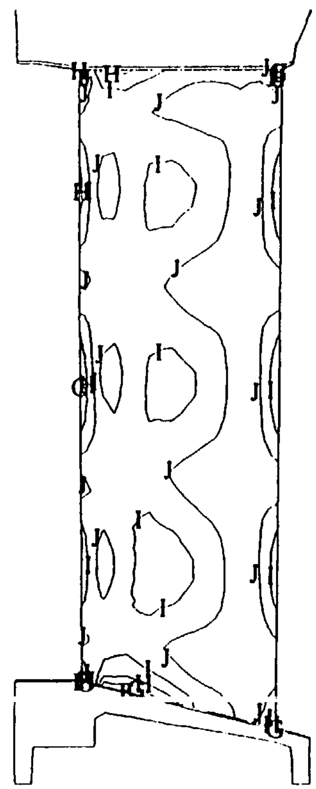

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J	10.00
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*DENOTES HIDDEN

X

TITLE NASA scaled fan rig - baseline vane suction side

CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS

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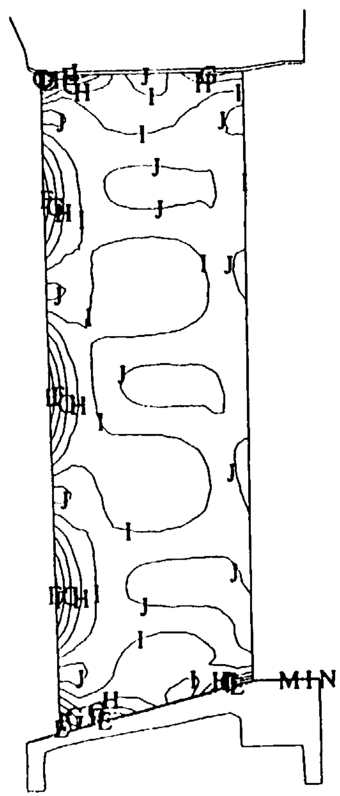

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J	10.00
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*DENOTES HIDDEN	

TITLE NASA scaled fan rig - baseline vane   pressure side

CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS

SCALE =X .6200   PLOT TIME AND DATE = 17:01:00 95/069

FREQUENCY = 4134.750   SECTOR PATTERN = 21

MODE NUMBER = 6   PHI = .00

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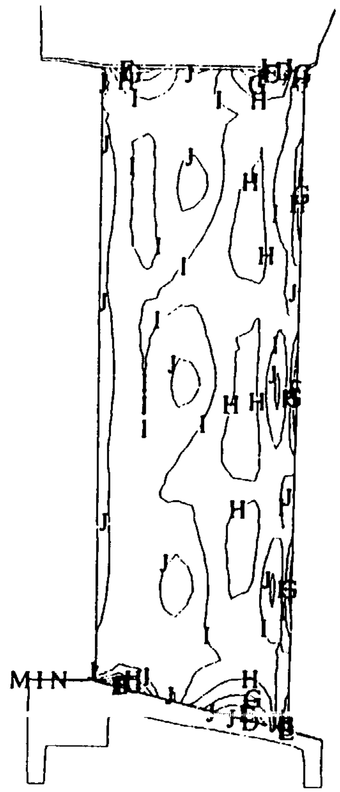
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J 10.00
*MAX 100.00
MIN .01
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TITLE NASA scaled fan rig - baseline vane suction side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
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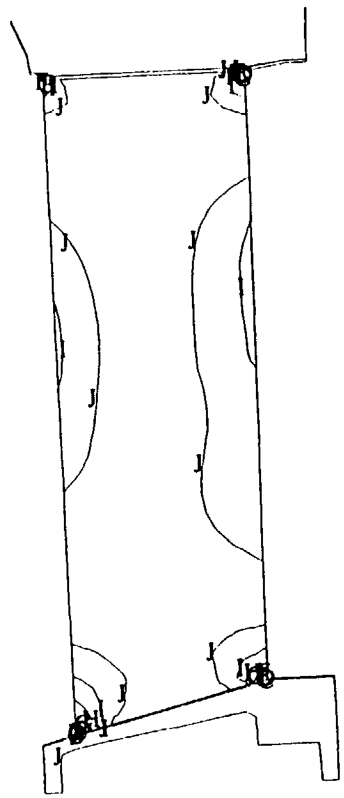

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TITLE NASA scaled fan rig - baseline vane pressure side
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FREQUENCY = 5405.889 SECTOR PATTERN = 21
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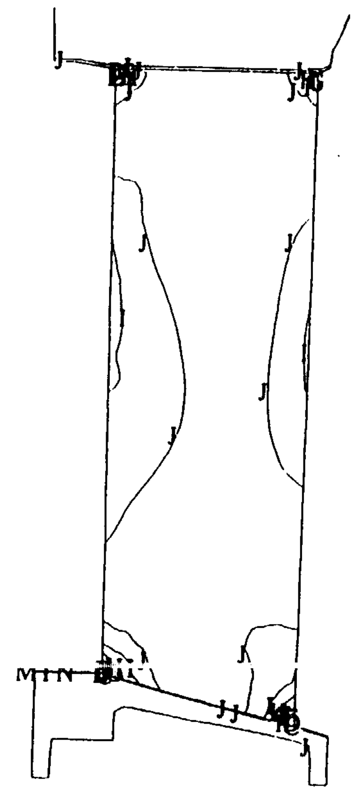

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J	10.00
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*DENOTES HIDDEN

TITLE NASA scaled fan rig - baseline vane suction side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
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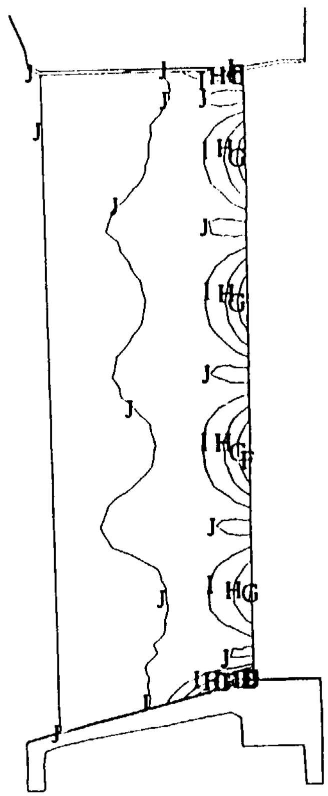

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I	20.00
J	10.00
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*DENOTES HIDDEN

TITLE NASA scaled fan rig - baseline vane pressure side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
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FREQUENCY = 5574.935 SECTOR PATTERN = 21
MODE NUMBER = 8 PHI = .00

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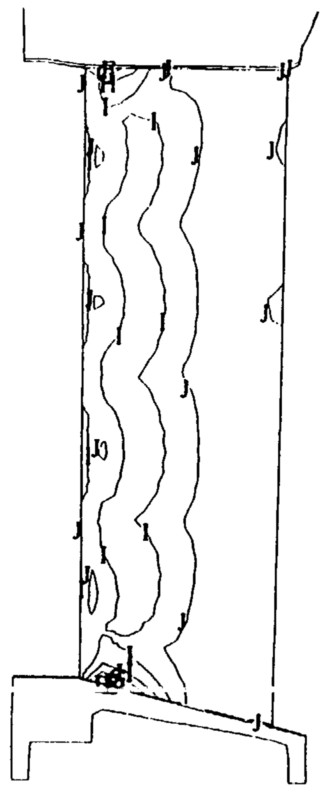

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I	20.00
J	10.00
*MAX	100.00
*MIN	.02

*DENOTES HIDDEN

X

TITLE NASA scaled fan rig - baseline vane suction side

CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS

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MODE NUMBER = 8 PHI = .00

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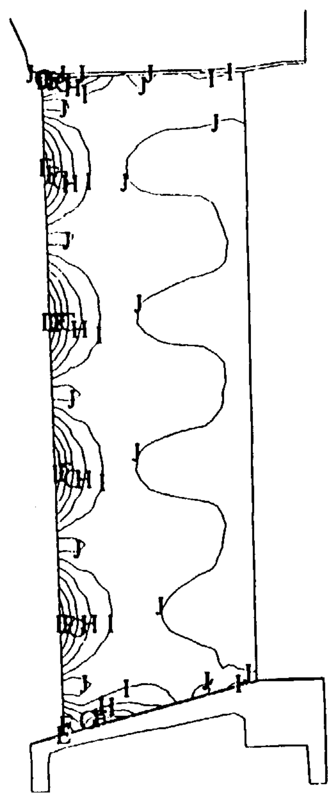

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I	20.00
J	10.00
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*DENOTES HIDDEN

TITLE NASA scaled fan rig - baseline vane pressure side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS LOAD
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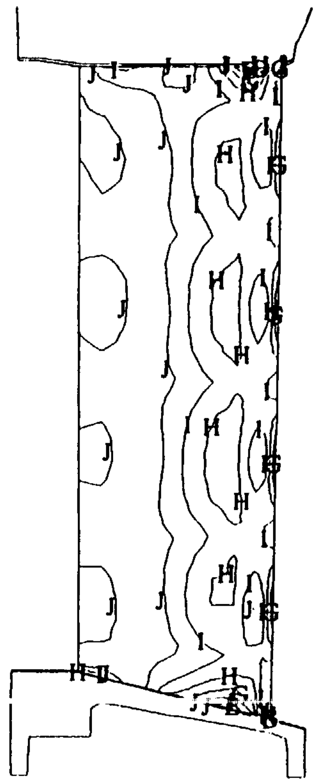

*** LEGEND ***

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J	10.00
*MAX	100.00
*MIN	.00

*DENOTES HIDDEN

X

TITLE NASA scaled fan rig - baseline vane   suction side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
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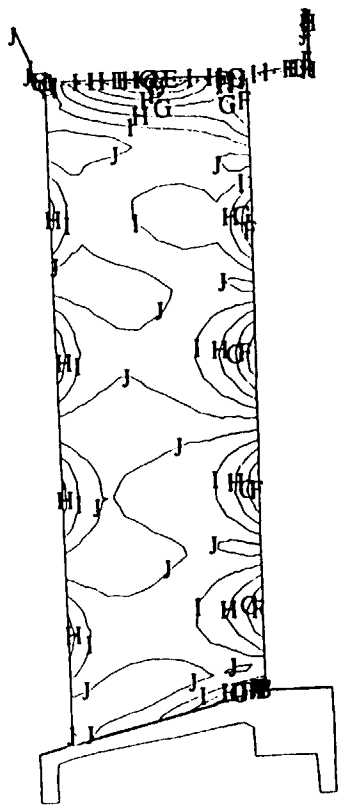

*** LEGEND ***

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H	30.00
I	20.00
J	10.00
*MAX	100.00
*MIN	.01

*DENOTES HIDDEN

TITLE NASA scaled fan rig - baseline vane pressure side

CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS

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FREQUENCY = 6457.753 SECTOR PATTERN = 21

MODE NUMBER = 10 PHI = .00

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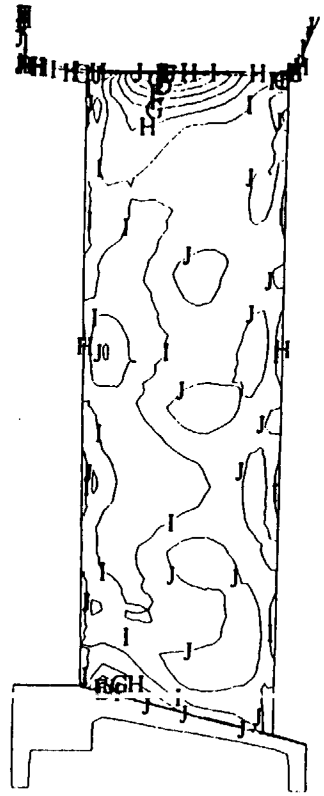

*** LEGEND ***

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I	20.00
J	10.00
*MAX	100.00
*MIN	.01

*DENOTES HIDDEN

X

TITLE NASA scaled fan rig - baseline vane suction side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
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FREQUENCY = 6457.753 SECTOR PATTERN = 21
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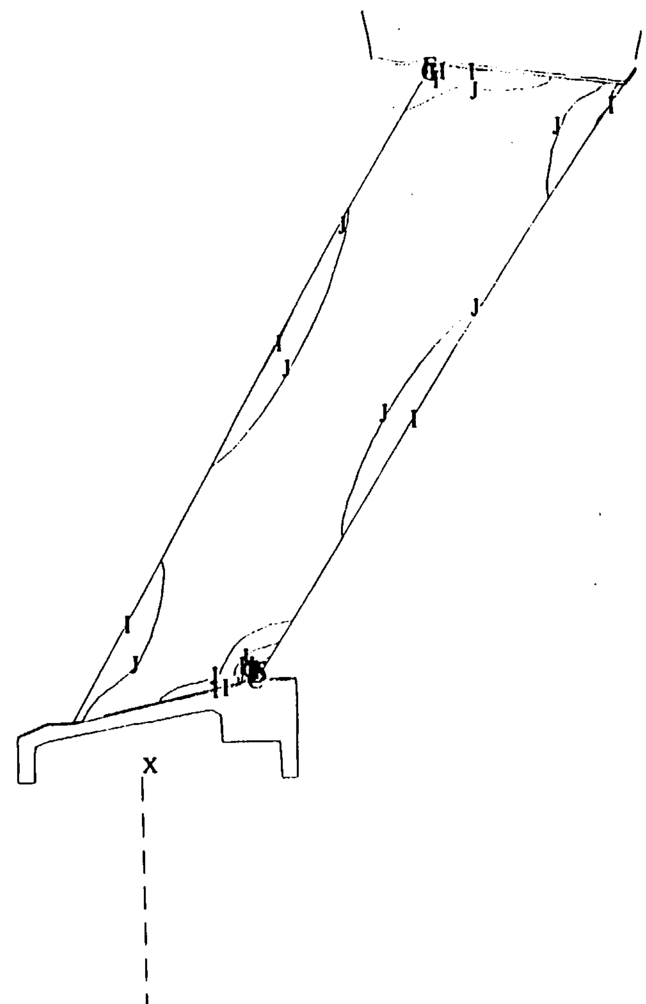

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D 70.00
E 60.00
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G 40.00
H 30.00
I 20.00
J 10.00
*MAX 100.00
*MIN .03
*DENOTES HIDDEN
TITLE NASA scaled fan rig - swept vane pressure side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
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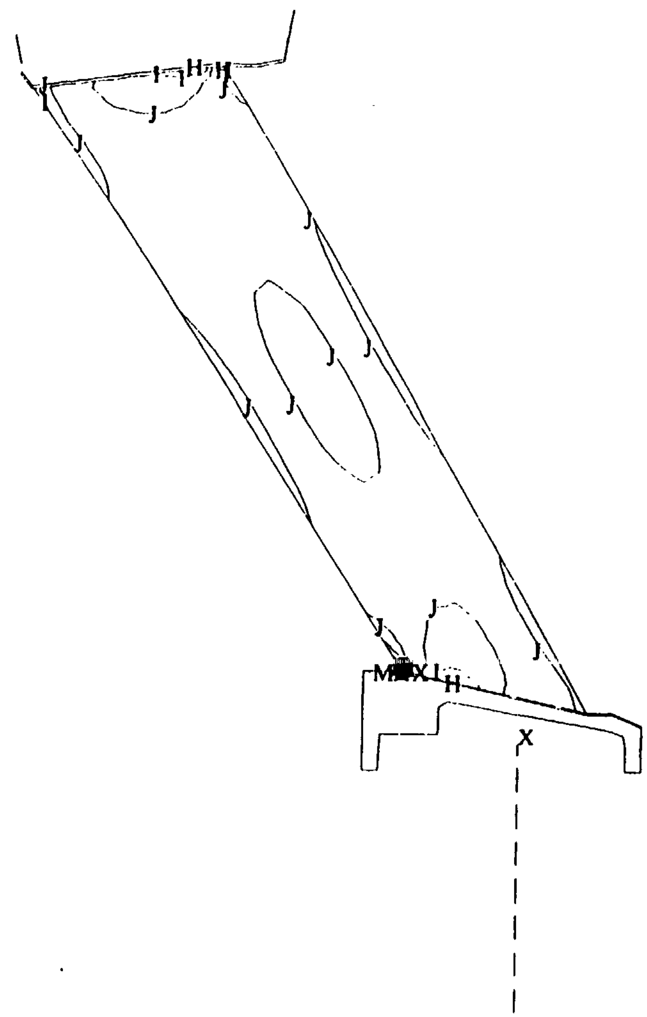

*** LEGEND ***

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F	50.00
G	40.00
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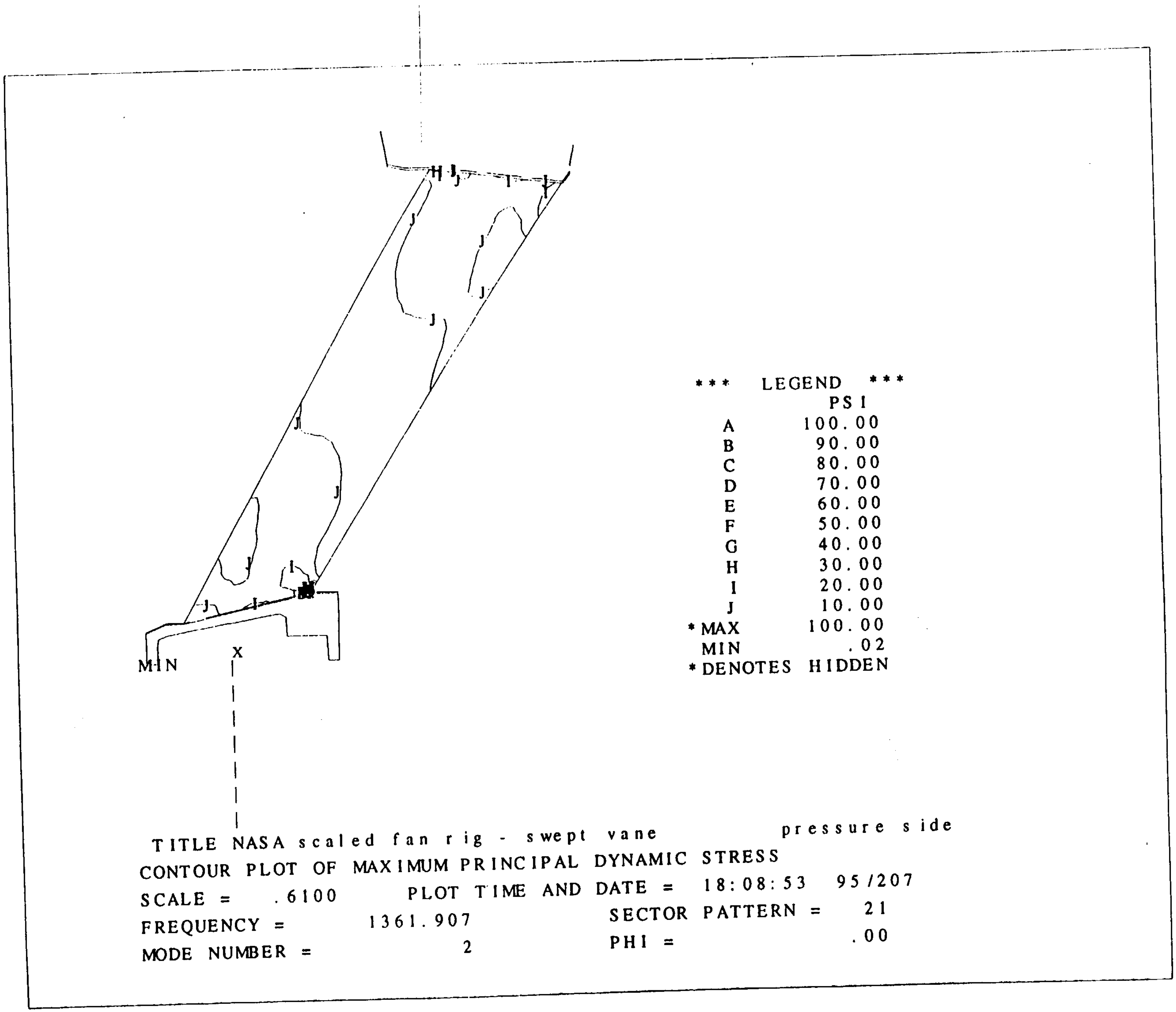
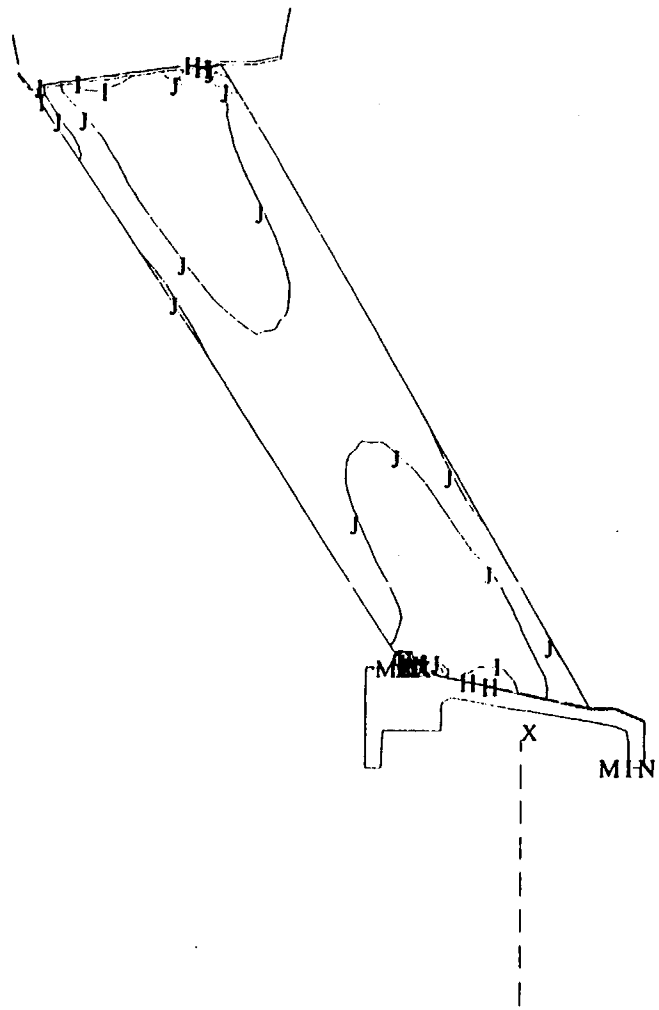
I	20.00
J	10.00
MAX	100.00
*MIN	.03

*DENOTES HIDDEN

TITLE NASA scaled fan rig - swept vane suction side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6100 PLOT TIME AND DATE = 18:10:00 95/207
FREQUENCY = 619.466 SECTOR PATTERN = 21
MODE NUMBER = 1 PHI = .00


H
I
J
X
MIN
*** LEGEND ***
PSI
A 100.00
B 90.00
C 80.00
D 70.00
E 60.00
F 50.00
G 40.00
H 30.00
I 20.00
J 10.00
*MAX 100.00
MIN .02
*DENOTES HIDDEN
TITLE NASA scaled fan rig - swept vane pressure side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6100 PLOT TIME AND DATE = 18:08:53 95/207
FREQUENCY = 1361.907 SECTOR PATTERN = 21
MODE NUMBER = 2 PHI = .00



*** LEGEND ***	PSI
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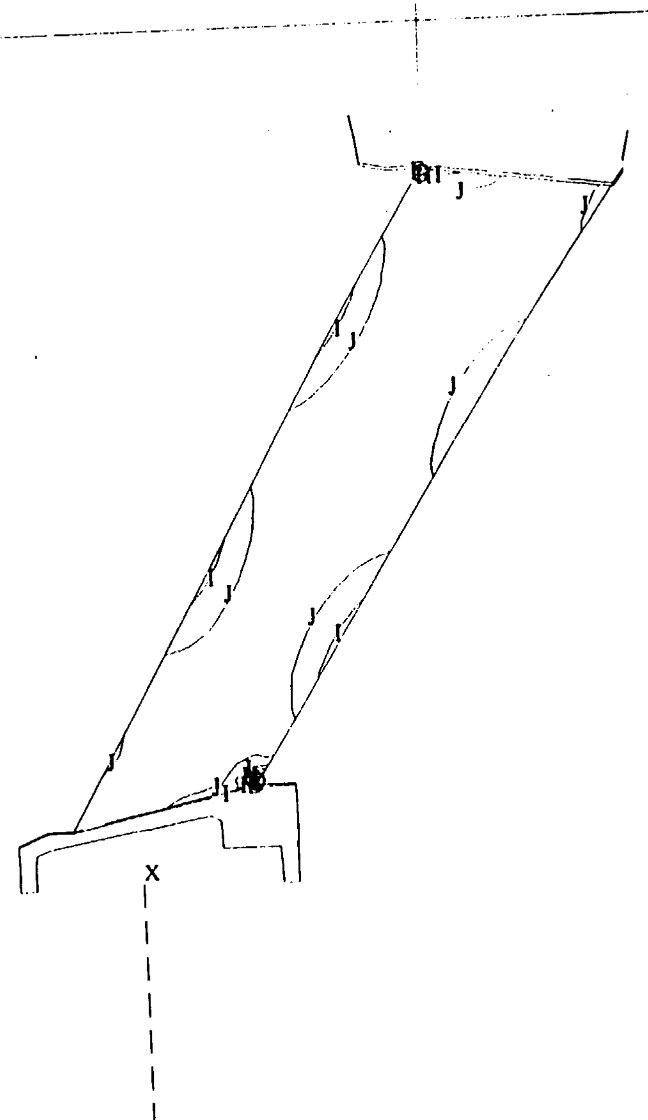
C	80.00
D	70.00
E	60.00
F	50.00
G	40.00
H	30.00
I	20.00
J	10.00
MAX	100.00
MIN	.02

TITLE NASA scaled fan rig - swept vane suction side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6100 PLOT TIME AND DATE = 18:10:07 95/207
FREQUENCY = 1361.907 SECTOR PATTERN = 21
MODE NUMBER = 2 PHI = .00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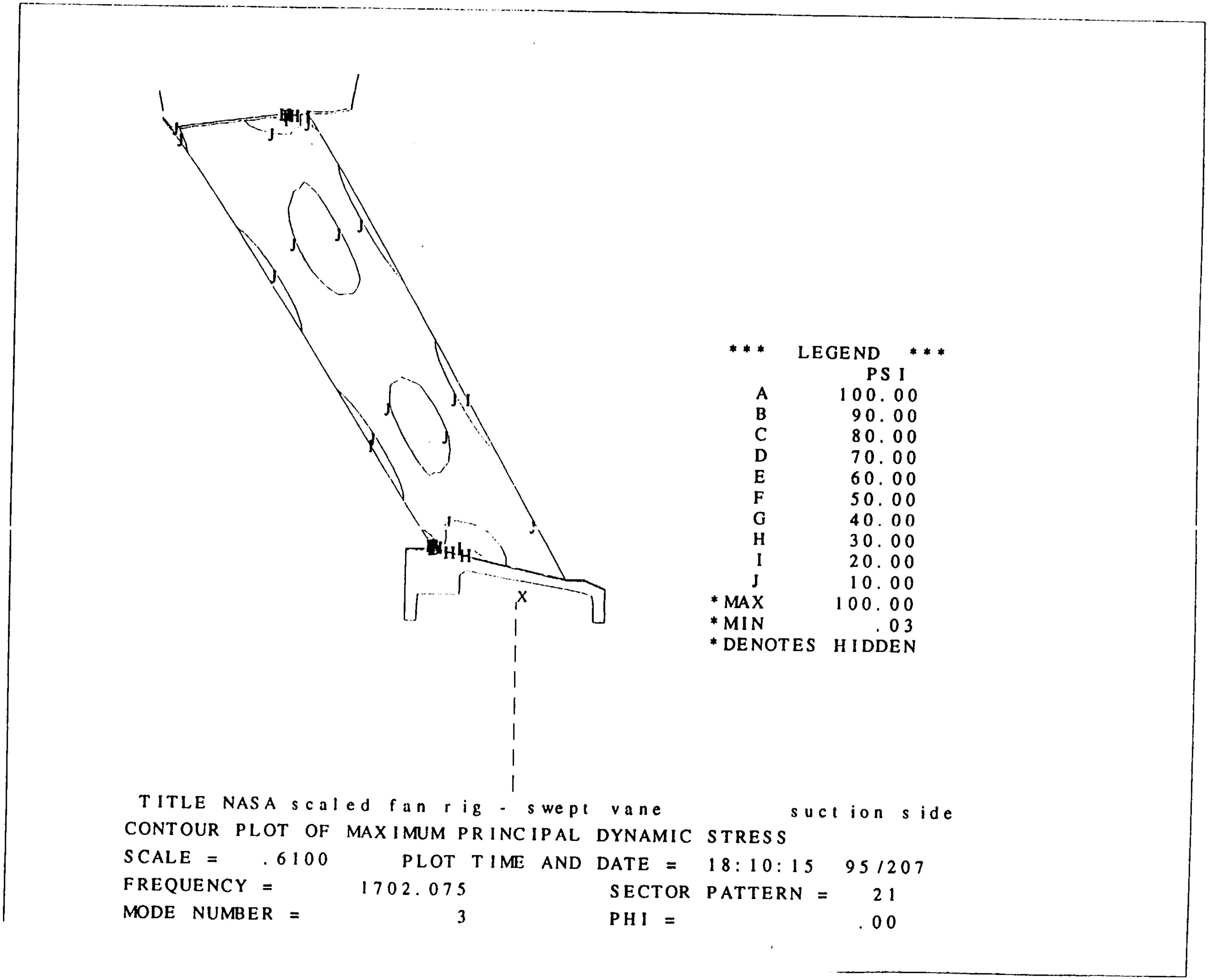
B 90.00
C 80.00
D 70.00
E 60.00
F 50.00
G 40.00
H 30.00
I 20.00
J 10.00
*MAX 100.00
*MIN .03
*DENOTES HIDDEN
TITLE NASA scaled fan rig - swept vane pressure side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6100 PLOT TIME AND DATE = 18:09:00 95/207
FREQUENCY = 1702.075 SECTOR PATTERN = 21
MODE NUMBER = 3 PHI = .00



*** LEGEND ***
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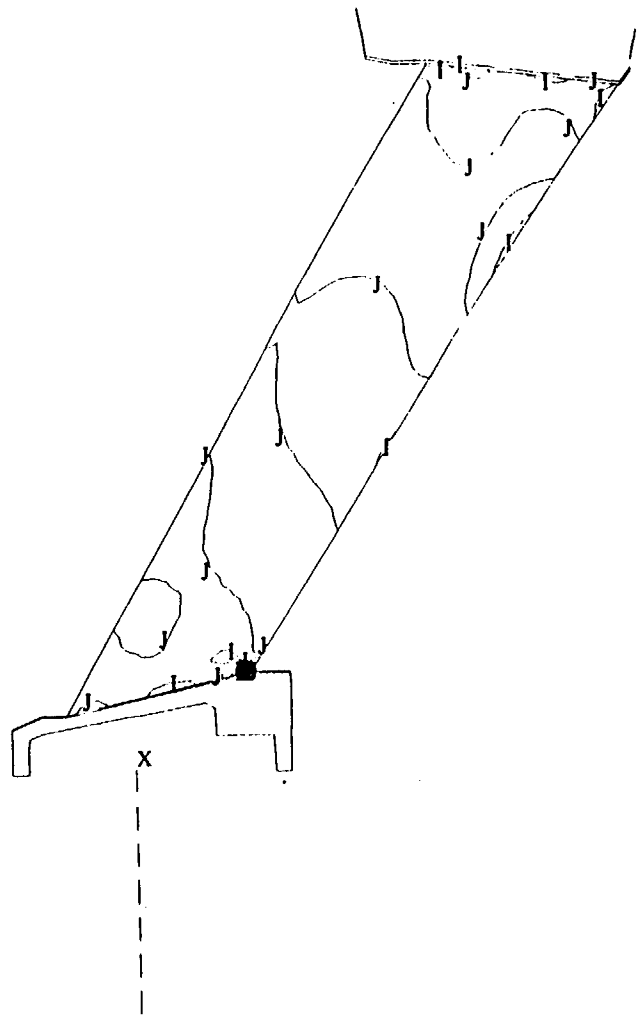
B 90.00
C 80.00
D 70.00
E 60.00
F 50.00
G 40.00
H 30.00
I 20.00
J 10.00
*MAX 100.00
*MIN .03
*DENOTES HIDDEN
TITLE NASA scaled fan rig - swept vane suction side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6100 PLOT TIME AND DATE = 18:10:15 95/207
FREQUENCY = 1702.075 SECTOR PATTERN = 21
MODE NUMBER = 3 PHI = .00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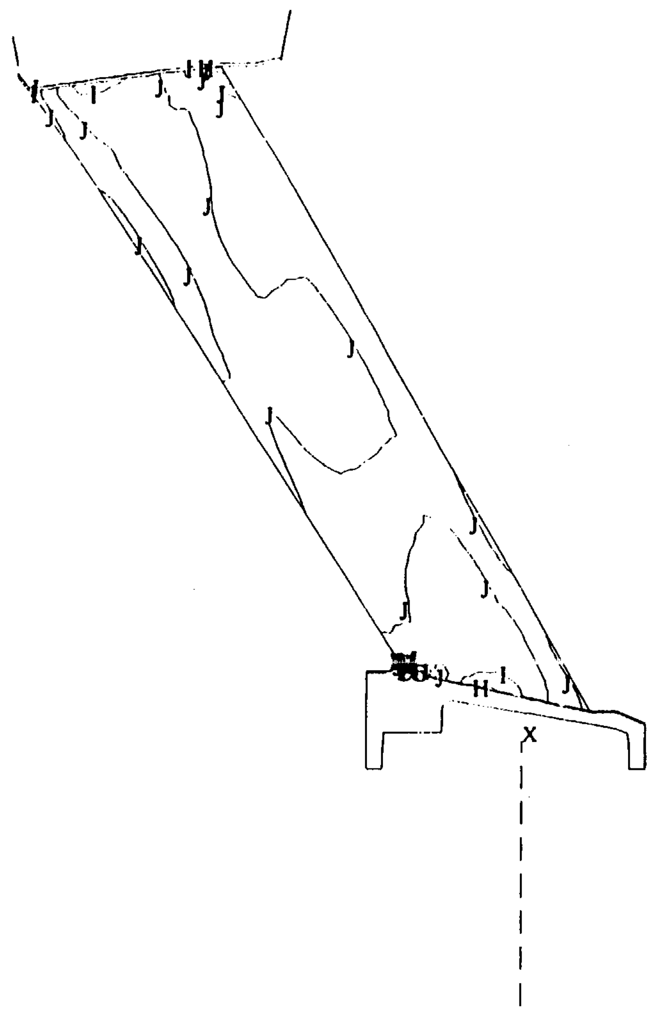
*** LEGEND ***
PSI
A 100.00
B 90.00
C 80.00
D 70.00
E 60.00
F 50.00
G 40.00
H 30.00
I 20.00
J 10.00
*MAX 100.00
*MIN .02
*DENOTES HIDDEN
TITLE NASA scaled fan rig - swept vane pressure side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6100 PLOT TIME AND DATE = 18:09:06 95/207
FREQUENCY = 2559.022 SECTOR PATTERN = 21
MODE NUMBER = 4 PHI = .00



*** LEGEND ***

		PSI
A		100.00
B		90.00
C		80.00
D		70.00
E		60.00
F		50.00
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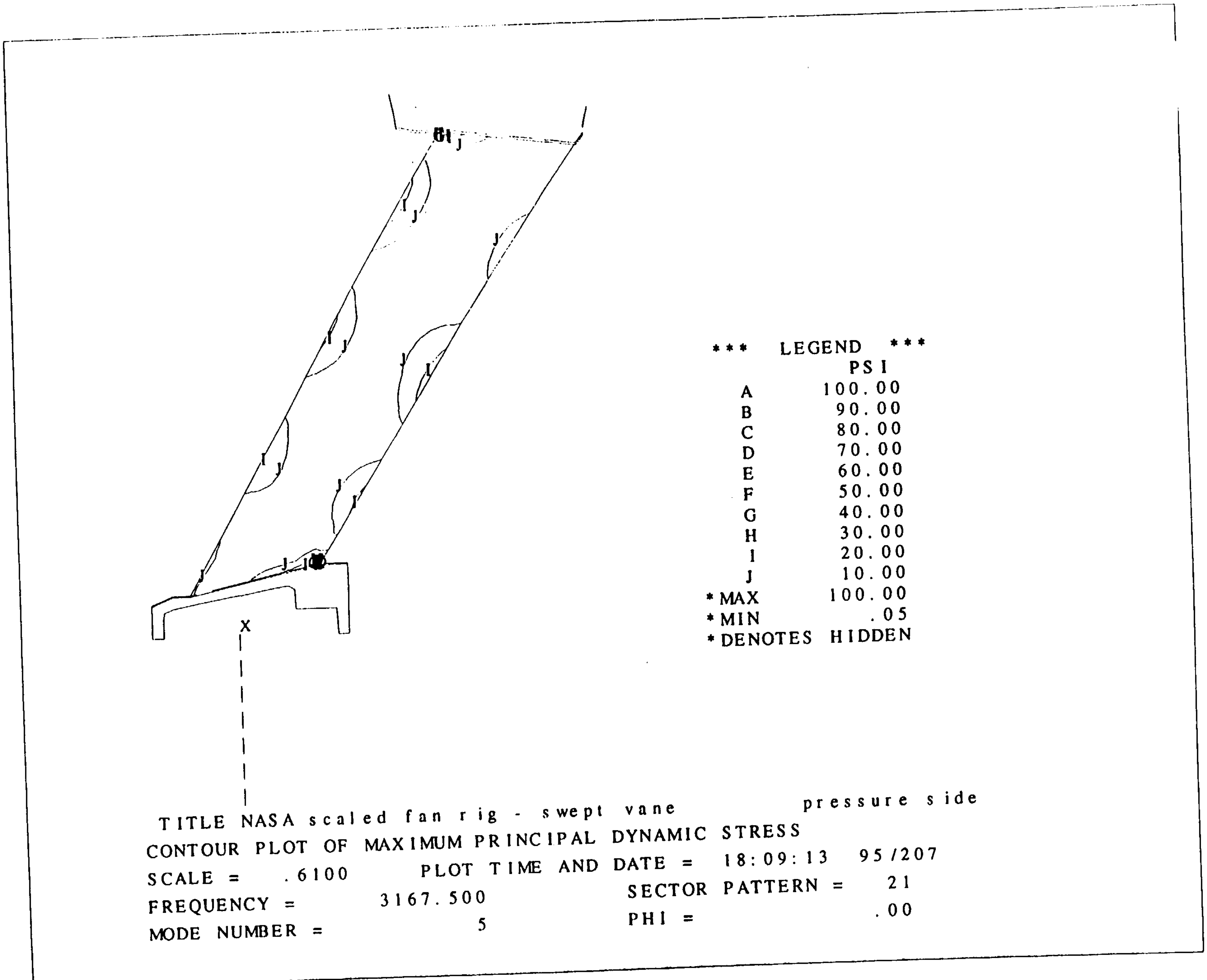
H		30.00
I		20.00
J		10.00
*MAX		100.00
*MIN		.02
*DENOTES HIDDEN		

TITLE NASA scaled fan rig - swept vane suction side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6100 PLOT TIME AND DATE = 18:10:23 95/207
FREQUENCY = 2559.022 SECTOR PATTERN = 21
MODE NUMBER = 4 PHI = .00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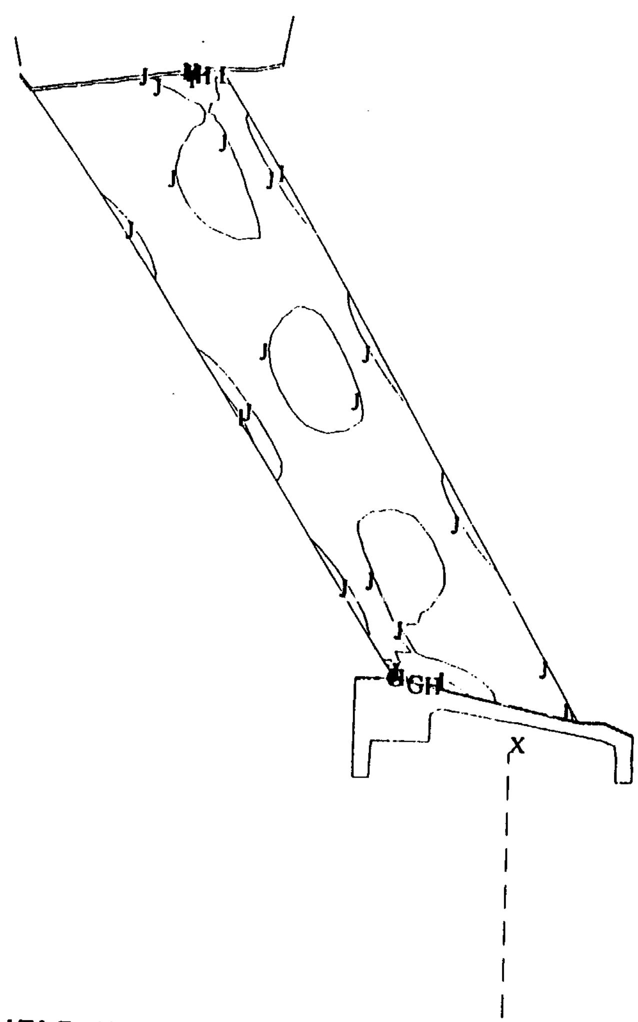
D 70.00
E 60.00
F 50.00
G 40.00
H 30.00
I 20.00
J 10.00
* MAX 100.00
* MIN .05
* DENOTES HIDDEN
X
TITLE NASA scaled fan rig - swept vane pressure side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6100 PLOT TIME AND DATE = 18:09:13 95/207
FREQUENCY = 3167.500 SECTOR PATTERN = 21
MODE NUMBER = 5 PHI = .00

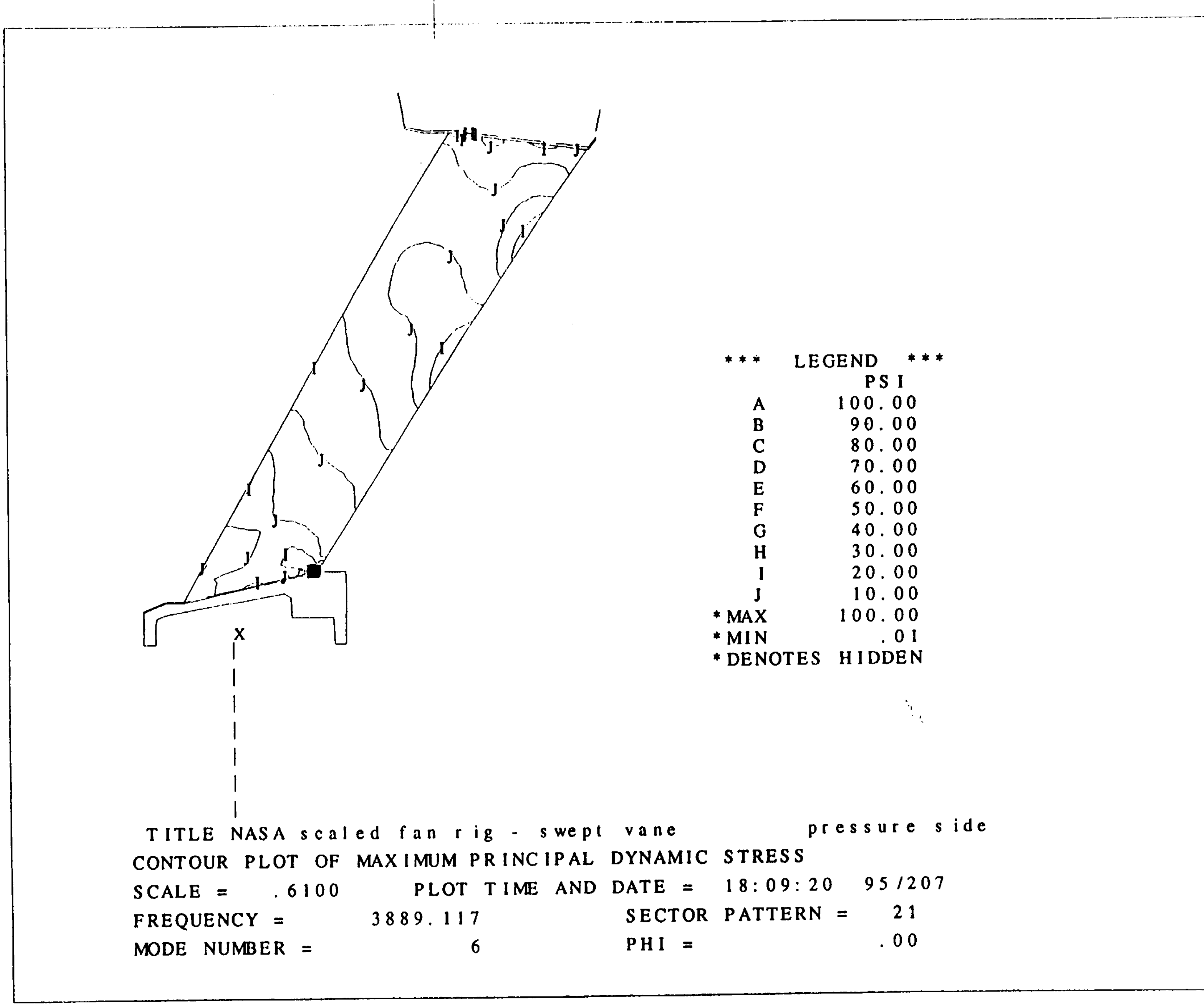


*** LEGEND ***

	PSI
A	100.00
B	90.00
C	80.00
D	70.00
E	60.00
F	50.00
G	40.00
H	30.00
I	20.00
J	10.00
*MAX	100.00
*MIN	.05

*DENOTES HIDDEN

TITLE NASA scaled fan rig - swept vane suction side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6100 PLOT TIME AND DATE = 18:10:31 95/207
FREQUENCY = 3167.500 SECTOR PATTERN = 21
MODE NUMBER = 5 PHI = .00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B 90.00
C 80.00
D 70.00
E 60.00
F 50.00
G 40.00
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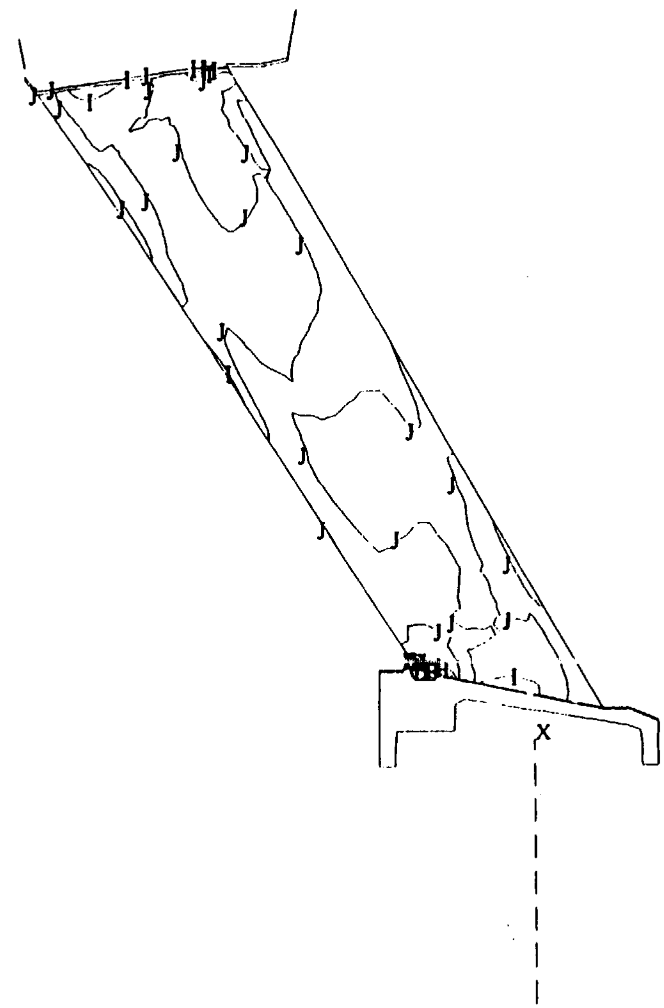
I 20.00
J 10.00
*MAX 100.00
*MIN .01
*DENOTES HIDDEN
TITLE NASA scaled fan rig - swept vane pressure side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6100 PLOT TIME AND DATE = 18:09:20 95/207
FREQUENCY = 3889.117 SECTOR PATTERN = 21
MODE NUMBER = 6 PHI = .00


*** LEGEND ***
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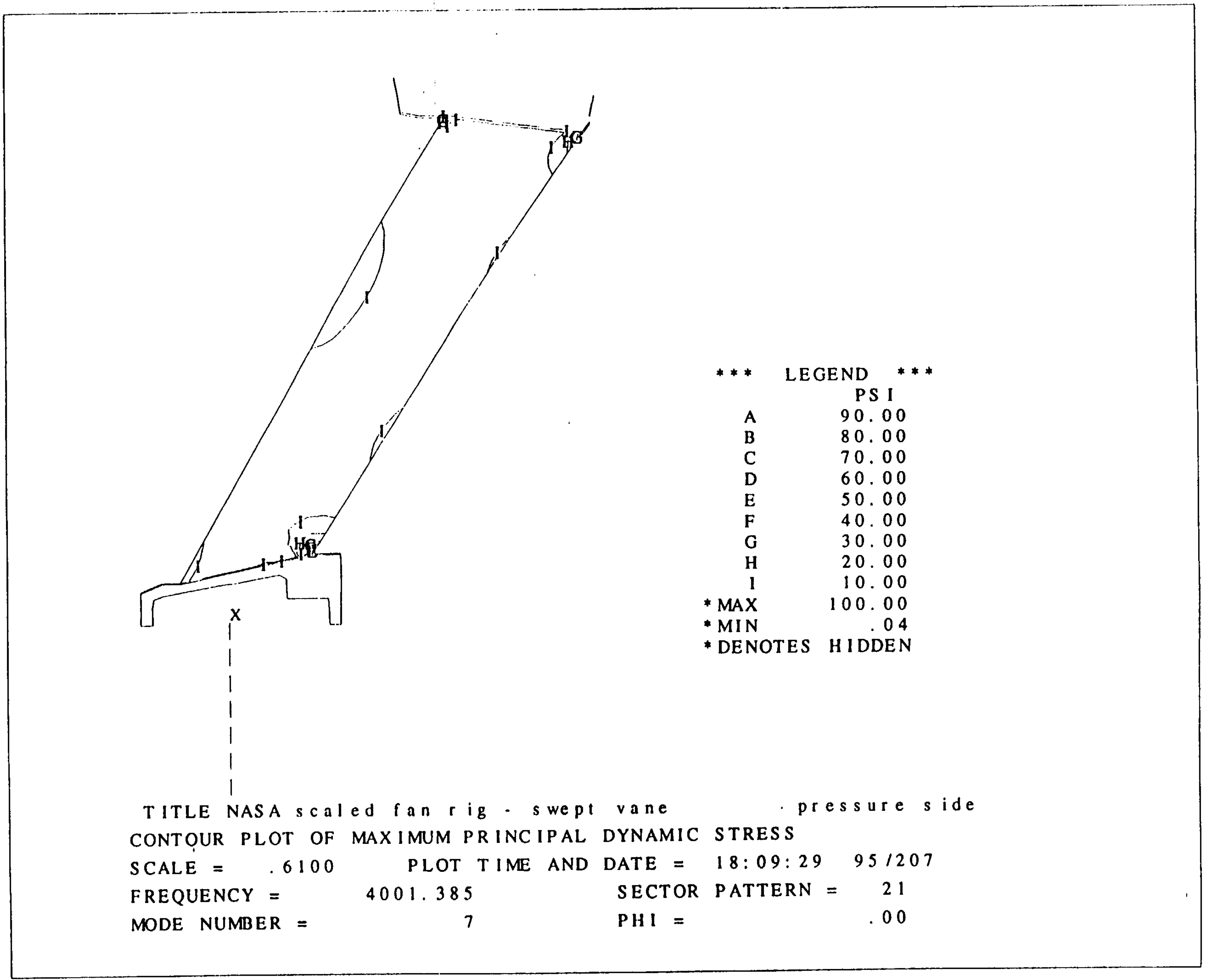
C 80.00
D 70.00
E 60.00
F 50.00
G 40.00
H 30.00
I 20.00
J 10.00
*MAX 100.00
*MIN .01
*DENOTES HIDDEN
TITLE NASA scaled fan rig - swept vane suction side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6100 PLOT TIME AND DATE = 18:10:39 95/207
FREQUENCY = 3889.117 SECTOR PATTERN = 21
MODE NUMBER = 6 PHI = .00


*** LEGEND ***
PSI
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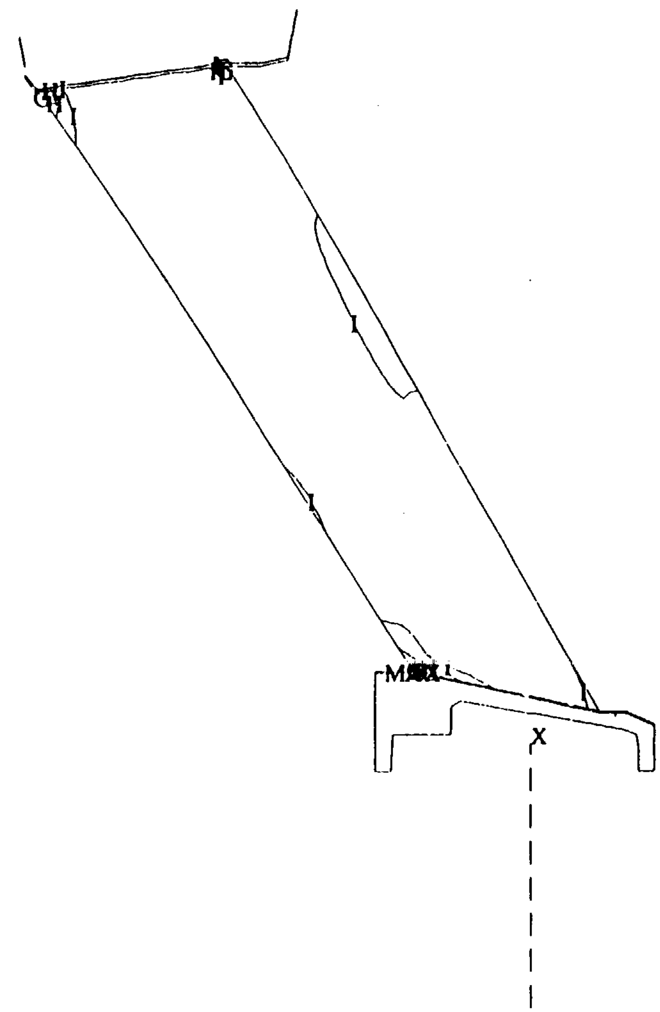
B 80.00
C 70.00
D 60.00
E 50.00
F 40.00
G 30.00
H 20.00
I 10.00
*MAX 100.00
*MIN .04
*DENOTES HIDDEN
X
TITLE NASA scaled fan rig - swept vane · pressure side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6100 PLOT TIME AND DATE = 18:09:29 95/207
FREQUENCY = 4001.385 SECTOR PATTERN = 21
MODE NUMBER = 7 PHI = .00



*** LEGEND ***	PSI
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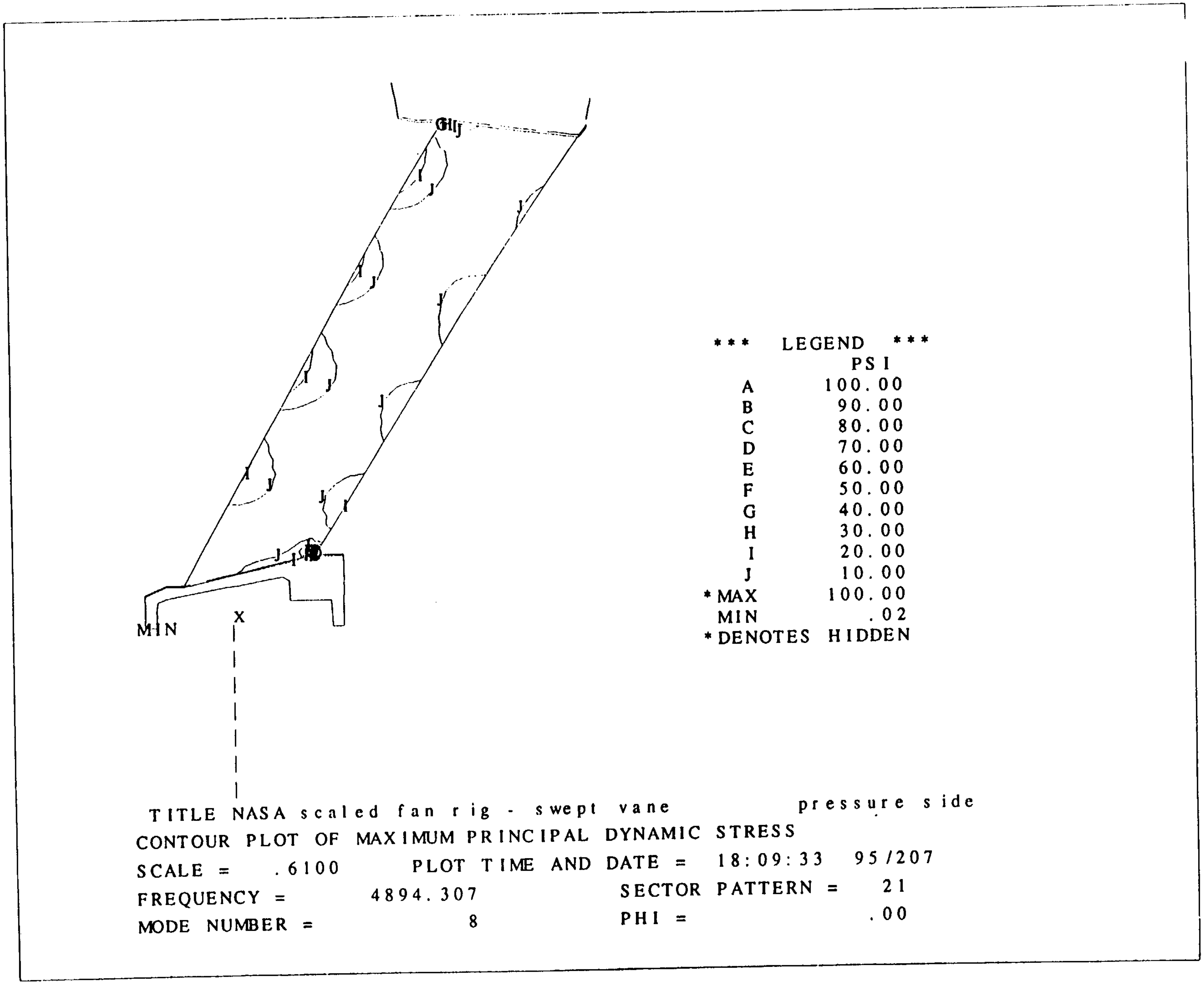
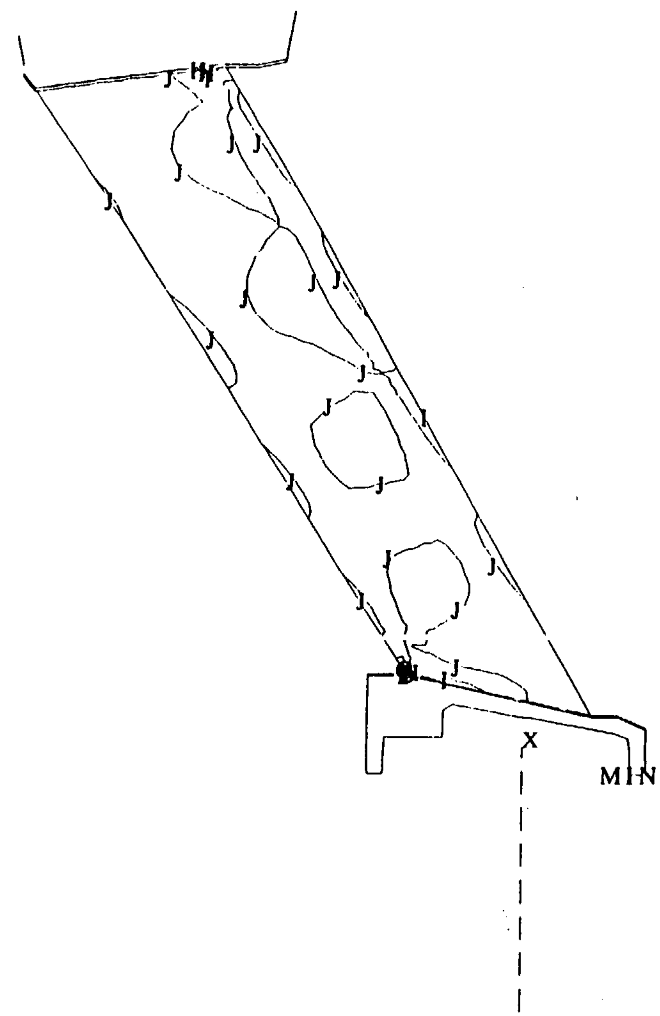
C	70.00
D	60.00
E	50.00
F	40.00
G	30.00
H	20.00
I	10.00
MAX	100.00
*MIN	.04

*DENOTES HIDDEN

TITLE NASA scaled fan rig - swept vane suction side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6100 PLOT TIME AND DATE = 18:10:49 95/207
FREQUENCY = 4001.385 SECTOR PATTERN = 21
MODE NUMBER = 7 PHI = .00



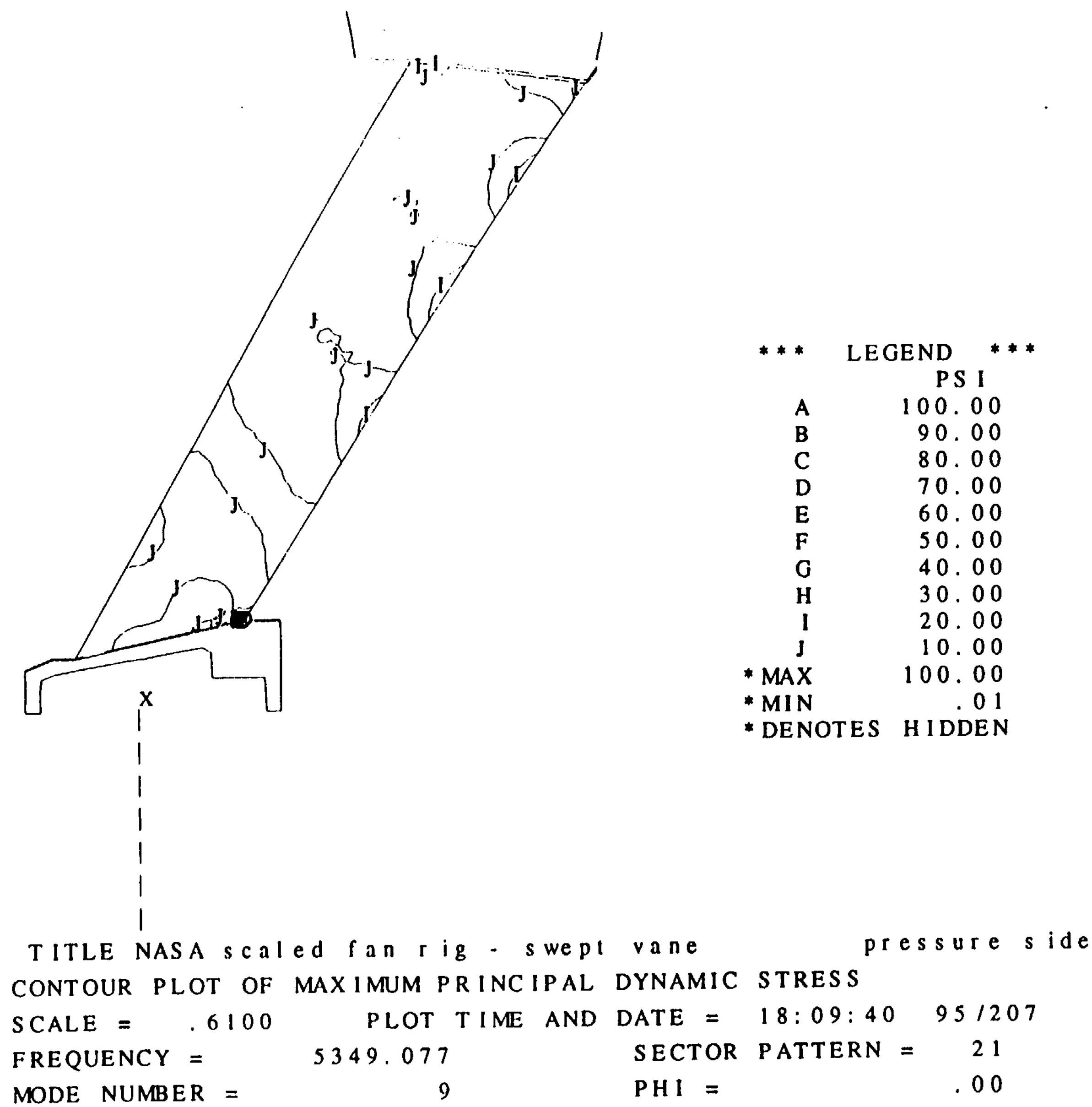
GHIJ
MIN
X
*** LEGEND ***
PSI
A 100.00
B 90.00
C 80.00
D 70.00
E 60.00
F 50.00
G 40.00
H 30.00
I 20.00
J 10.00
*MAX 100.00
MIN .02
*DENOTES HIDDEN
TITLE NASA scaled fan rig - swept vane pressure side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6100 PLOT TIME AND DATE = 18:09:33 95/207
FREQUENCY = 4894.307 SECTOR PATTERN = 21
MODE NUMBER = 8 PHI = .00



*** LEGEND ***	PSI
A	100.00
B	90.00
C	80.00
D	70.00
E	60.00
F	50.00
G	40.00
H	30.00
I	20.00
J	10.00
*MAX	100.00
MIN	.02

*DENOTES HIDDEN

TITLE NASA scaled fan rig - swept vane · suction side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6100 PLOT TIME AND DATE = 18:10:53 95/207
FREQUENCY = 4894.307 SECTOR PATTERN = 21
MODE NUMBER = 8 PHI = .00


*** LEGEND ***
PSI
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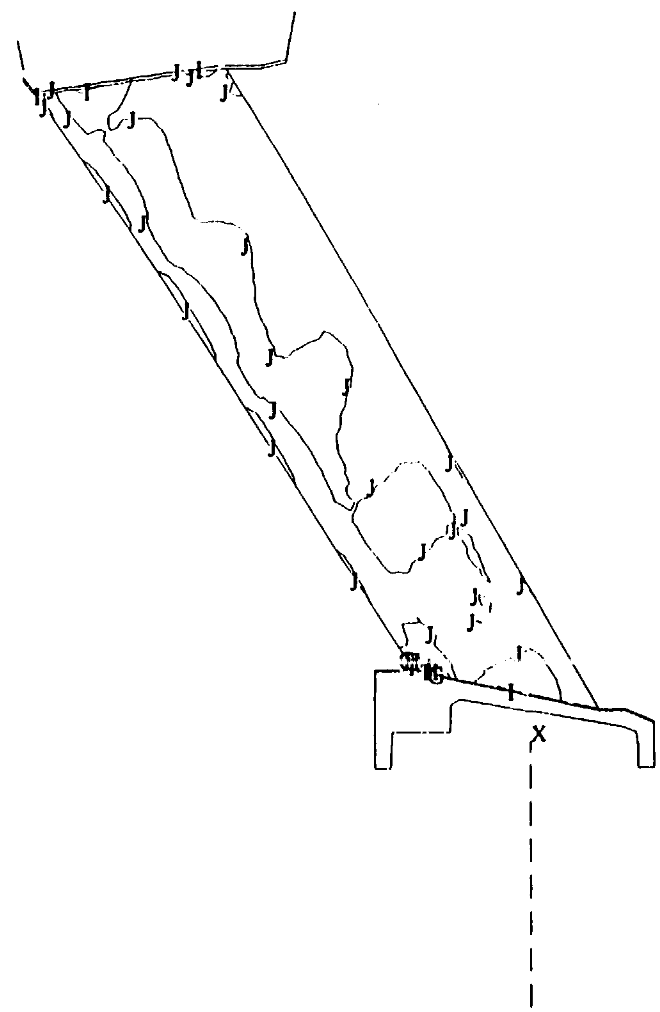
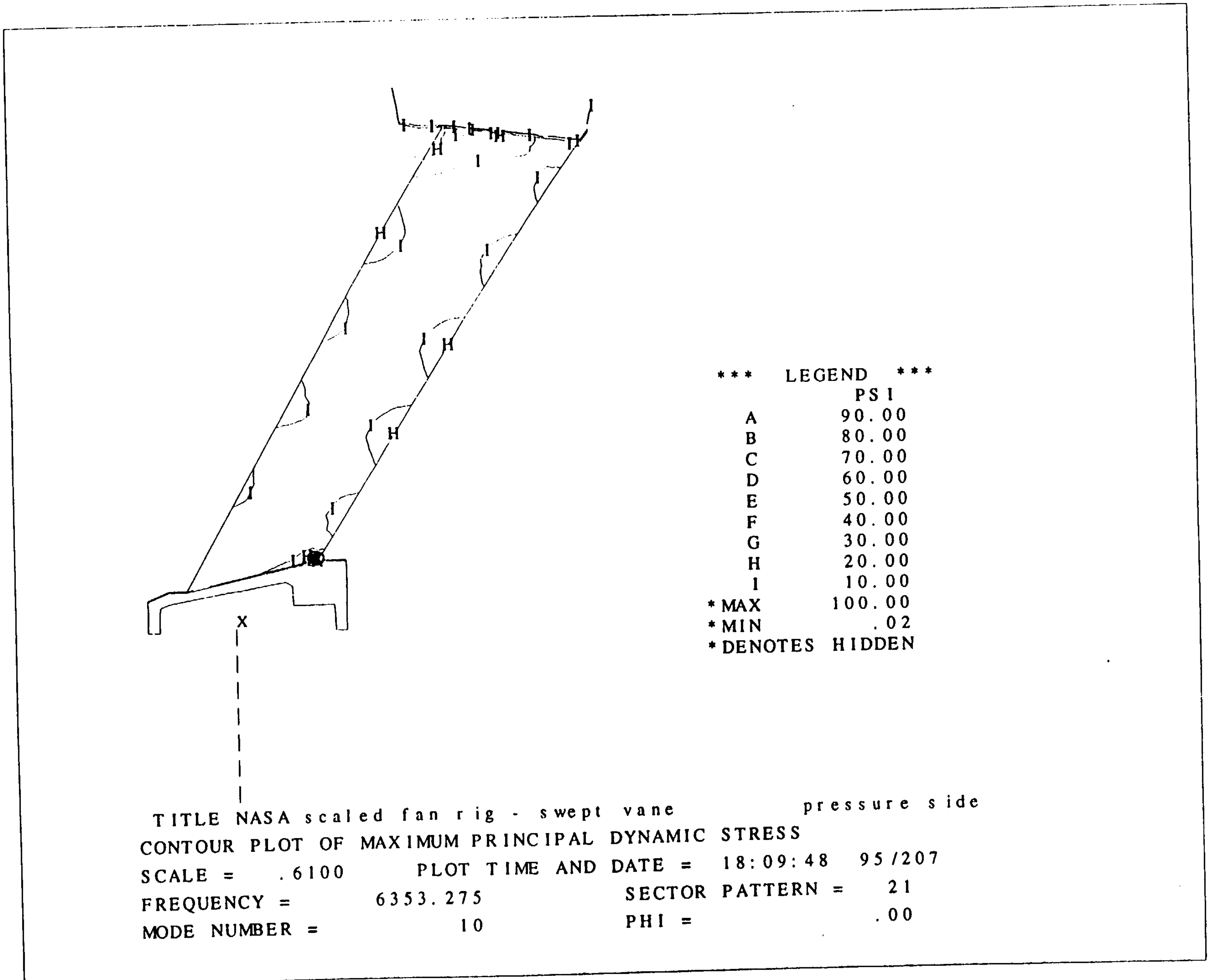
B 90.00
C 80.00
D 70.00
E 60.00
F 50.00
G 40.00
H 30.00
I 20.00
J 10.00
*MAX 100.00
*MIN .01
*DENOTES HIDDEN
X
TITLE NASA scaled fan rig - swept vane pressure side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6100 PLOT TIME AND DATE = 18:09:40 95/207
FREQUENCY = 5349.077 SECTOR PATTERN = 21
MODE NUMBER = 9 PHI = .00



*** LEGEND ***	
	PSI
A	100.00
B	90.00
C	80.00
D	70.00
E	60.00
F	50.00
G	40.00
H	30.00
I	20.00
J	10.00
*MAX	100.00
*MIN	.01
*DENOTES HIDDEN	

TITLE NASA scaled fan rig - swept vane suction side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6100 PLOT TIME AND DATE = 18:11:02 95/207
FREQUENCY = 5349.077 SECTOR PATTERN = 21
MODE NUMBER = 9 PHI = .00


*** LEGEND ***
PSI
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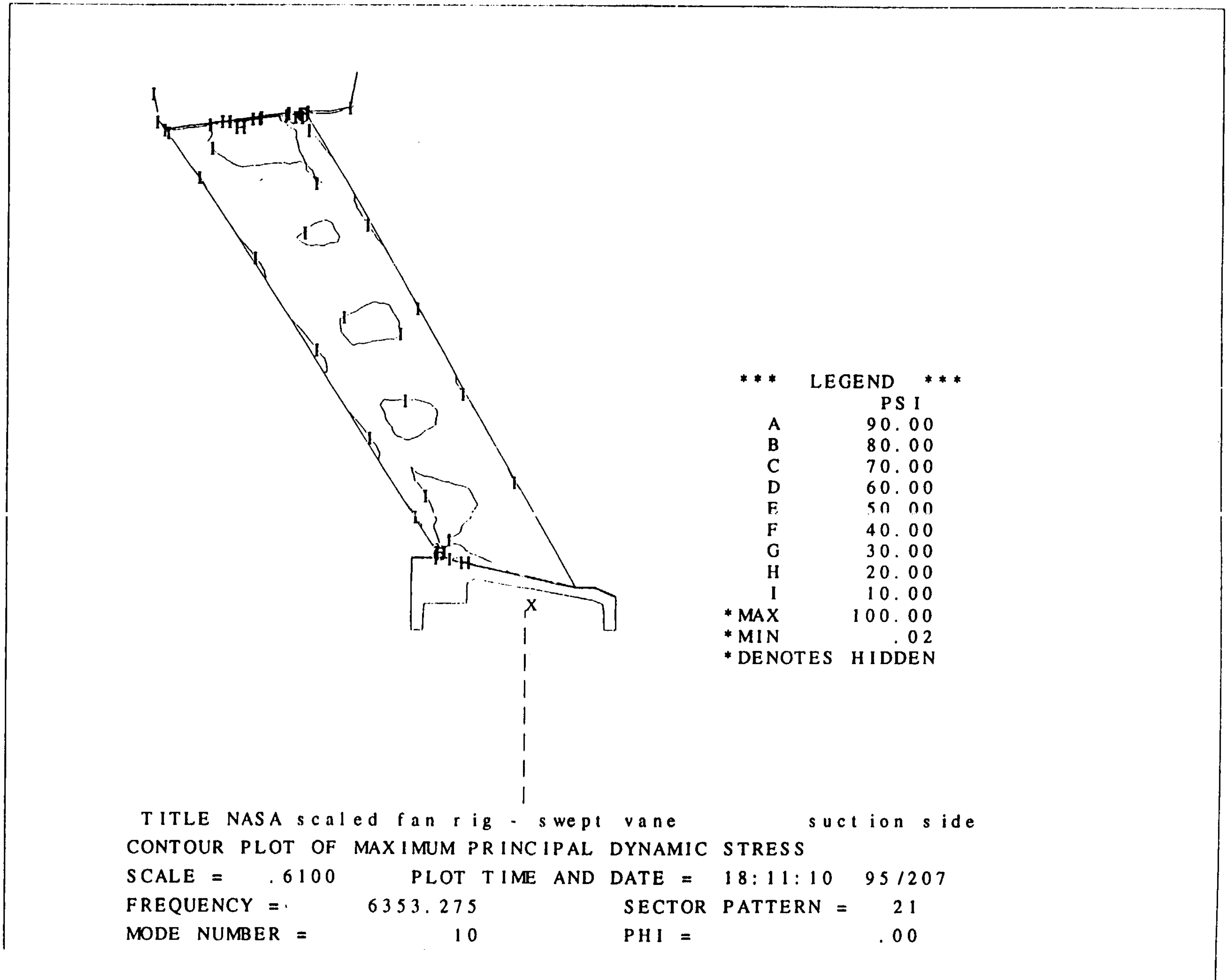
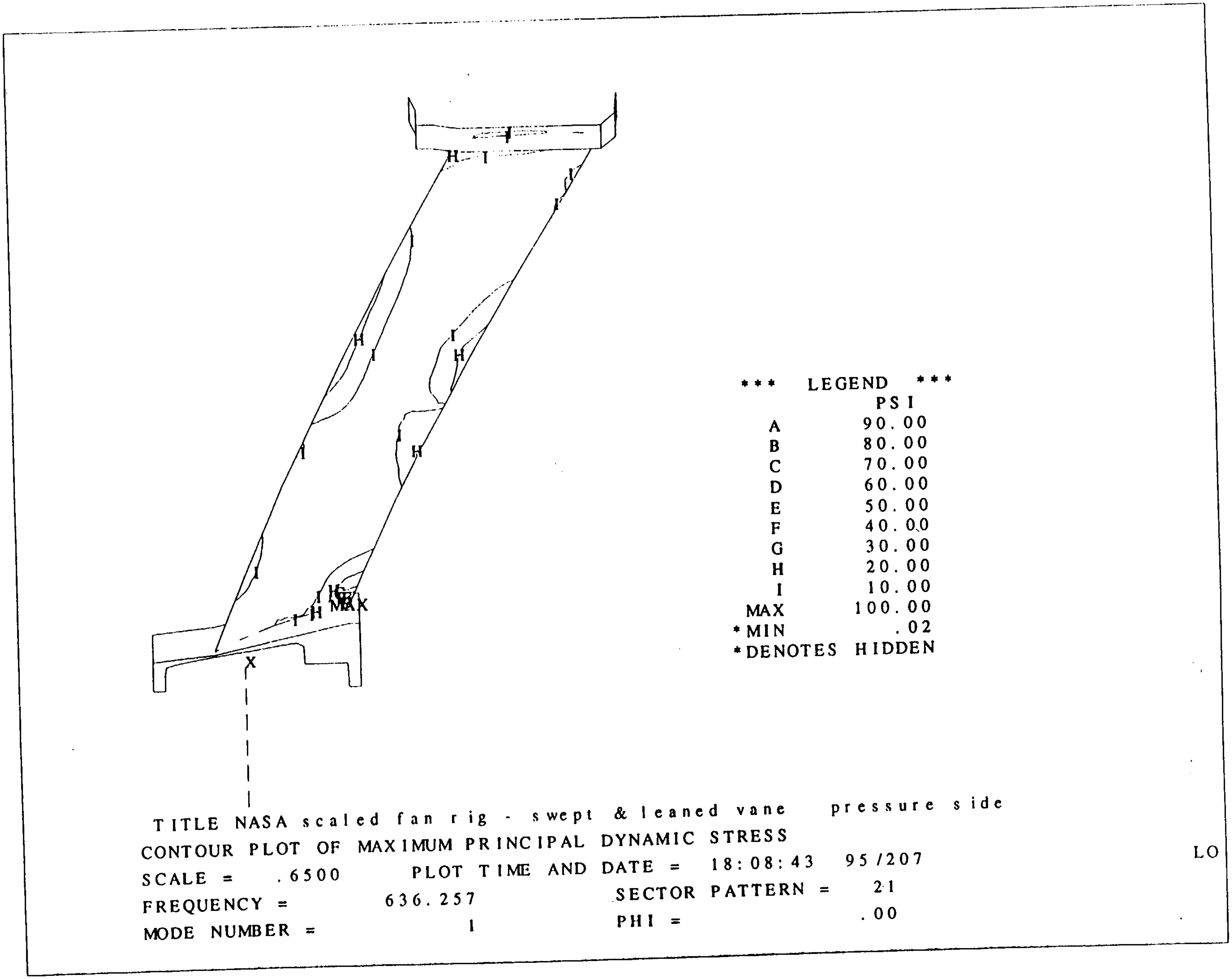
B 80.00
C 70.00
D 60.00
E 50.00
F 40.00
G 30.00
H 20.00
I 10.00
*MAX 100.00
*MIN .02
*DENOTES HIDDEN
X
TITLE NASA scaled fan rig - swept vane pressure side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6100 PLOT TIME AND DATE = 18:09:48 95/207
FREQUENCY = 6353.275 SECTOR PATTERN = 21
MODE NUMBER = 10 PHI = .00



X
*** LEGEND ***
PSI
A 90.00
B 80.00
C 70.00
D 60.00
E 50.00
F 40.00
G 30.00
H 20.00
I 10.00
*MAX 100.00
*MIN .02
*DENOTES HIDDEN
TITLE NASA scaled fan rig - swept vane suction side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6100 PLOT TIME AND DATE = 18:11:10 95/207
FREQUENCY = 6353.275 SECTOR PATTERN = 21
MODE NUMBER = 10 PHI = .00


*** LEGEND ***
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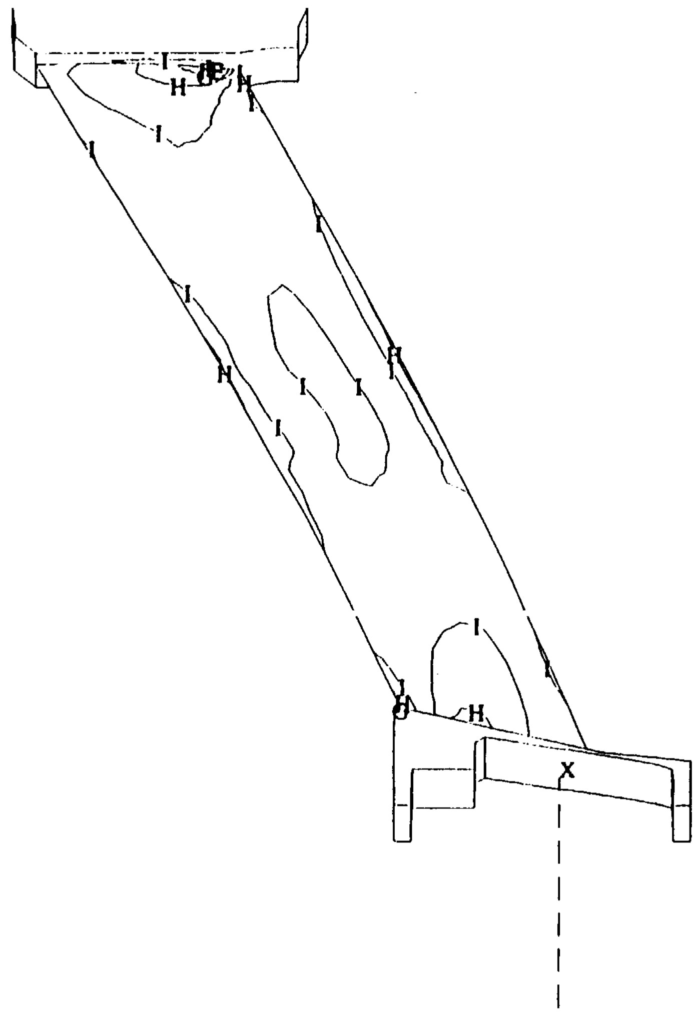
C 70.00
D 60.00
E 50.00
F 40.00
G 30.00
H 20.00
I 10.00
MAX 100.00
*MIN .02
*DENOTES HIDDEN
TITLE NASA scaled fan rig - swept & leaned vane pressure side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6500 PLOT TIME AND DATE = 18:08:43 95/207
FREQUENCY = 636.257 SECTOR PATTERN = 21
MODE NUMBER = 1 PHI = .00
LO

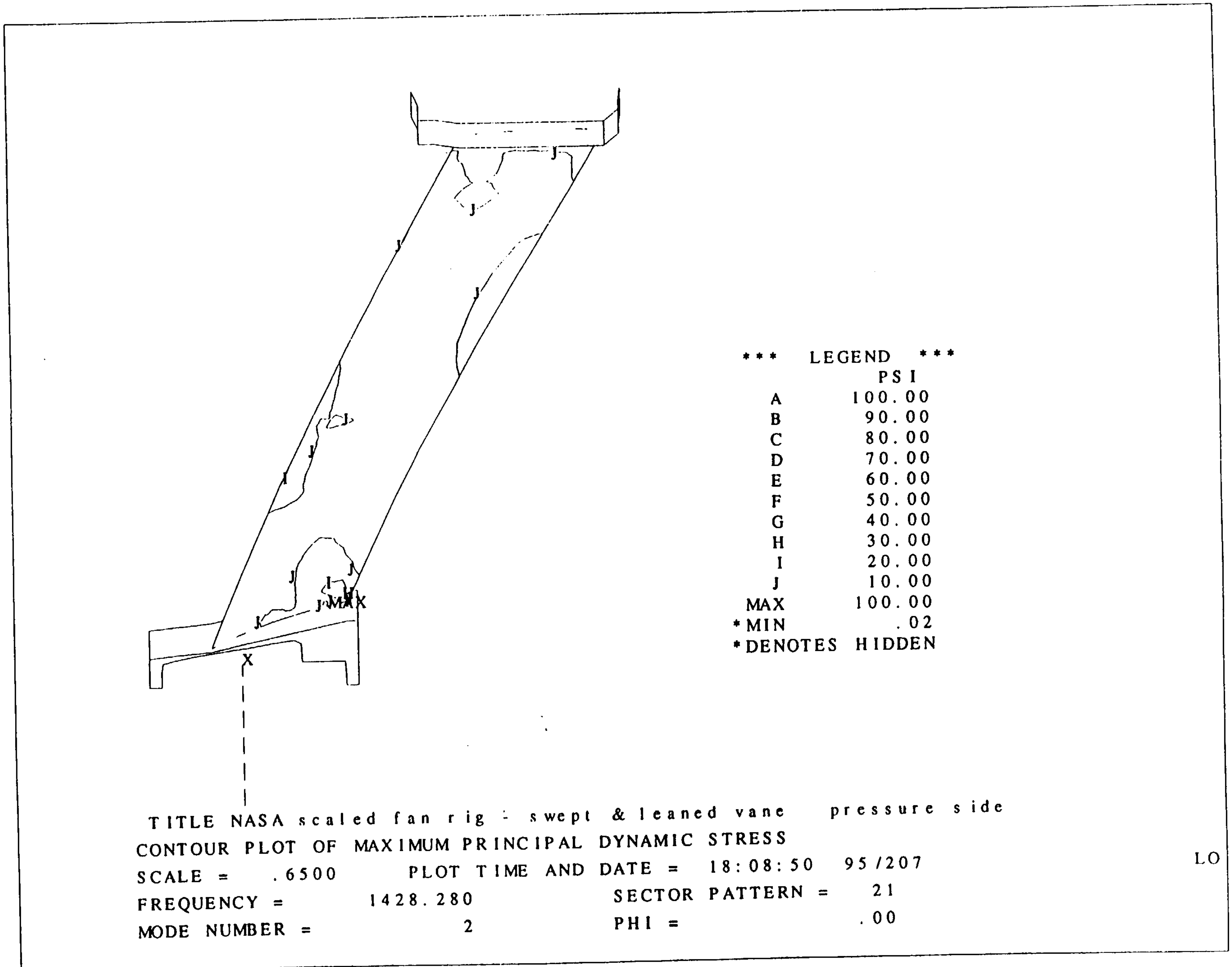


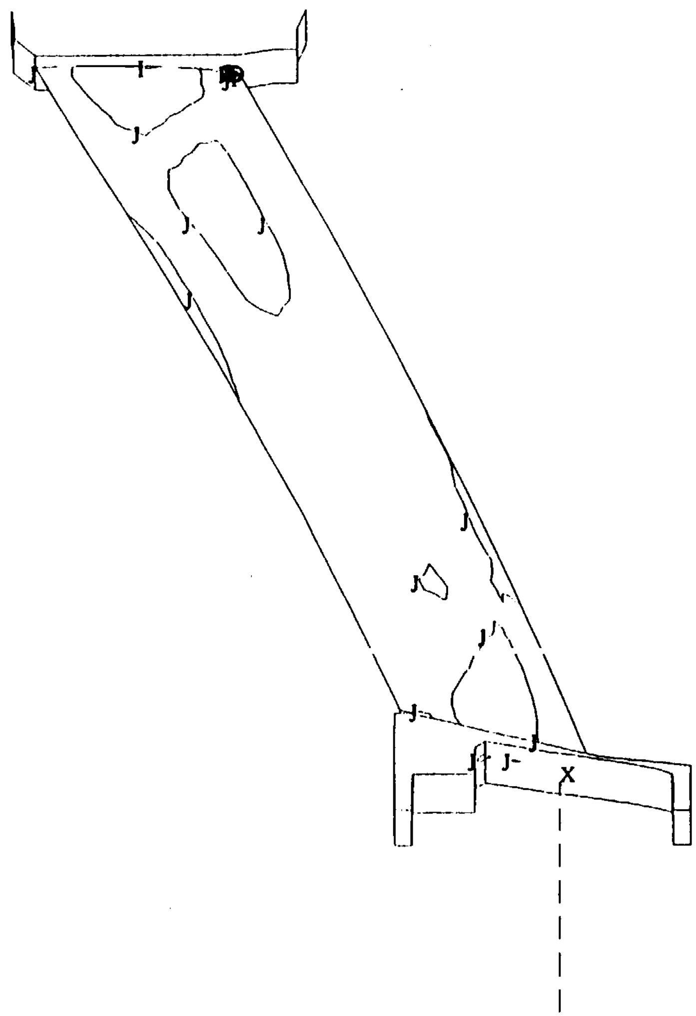
*** LEGEND ***

	PSI
A	90.00
B	80.00
C	70.00
D	60.00
E	50.00
F	40.00
G	30.00
H	20.00
I	10.00
*MAX	100.00
*MIN	.02

*DENOTES HIDDEN

TITLE NASA scaled fan rig - swept & leaned vane suction side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6500 PLOT TIME AND DATE = 18:09:51 95/207 LO
FREQUENCY = 636.257 SECTOR PATTERN = 21
MODE NUMBER = 1 PHI = .00


J
J
J
J
J
J
I
J
I
J
J
J
MAX
X
X
*** LEGEND ***
PSI
A 100.00
B 90.00
C 80.00
D 70.00
E 60.00
F 50.00
G 40.00
H 30.00
I 20.00
J 10.00
MAX 100.00
*MIN .02
*DENOTES HIDDEN
TITLE NASA scaled fan rig - swept & leaned vane pressure side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6500 PLOT TIME AND DATE = 18:08:50 95/207
FREQUENCY = 1428.280 SECTOR PATTERN = 21
MODE NUMBER = 2 PHI = .00
LO



*** LEGEND ***

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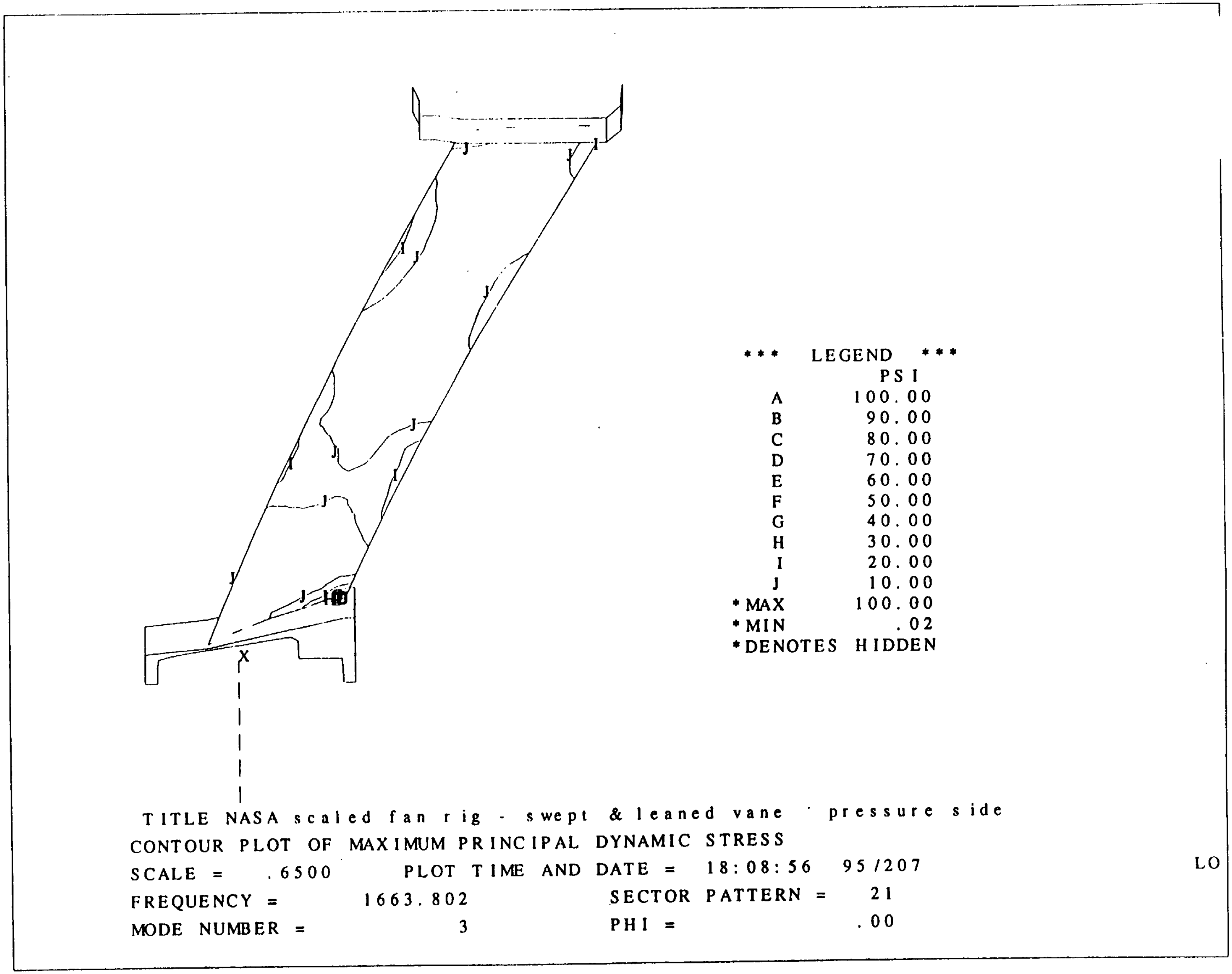
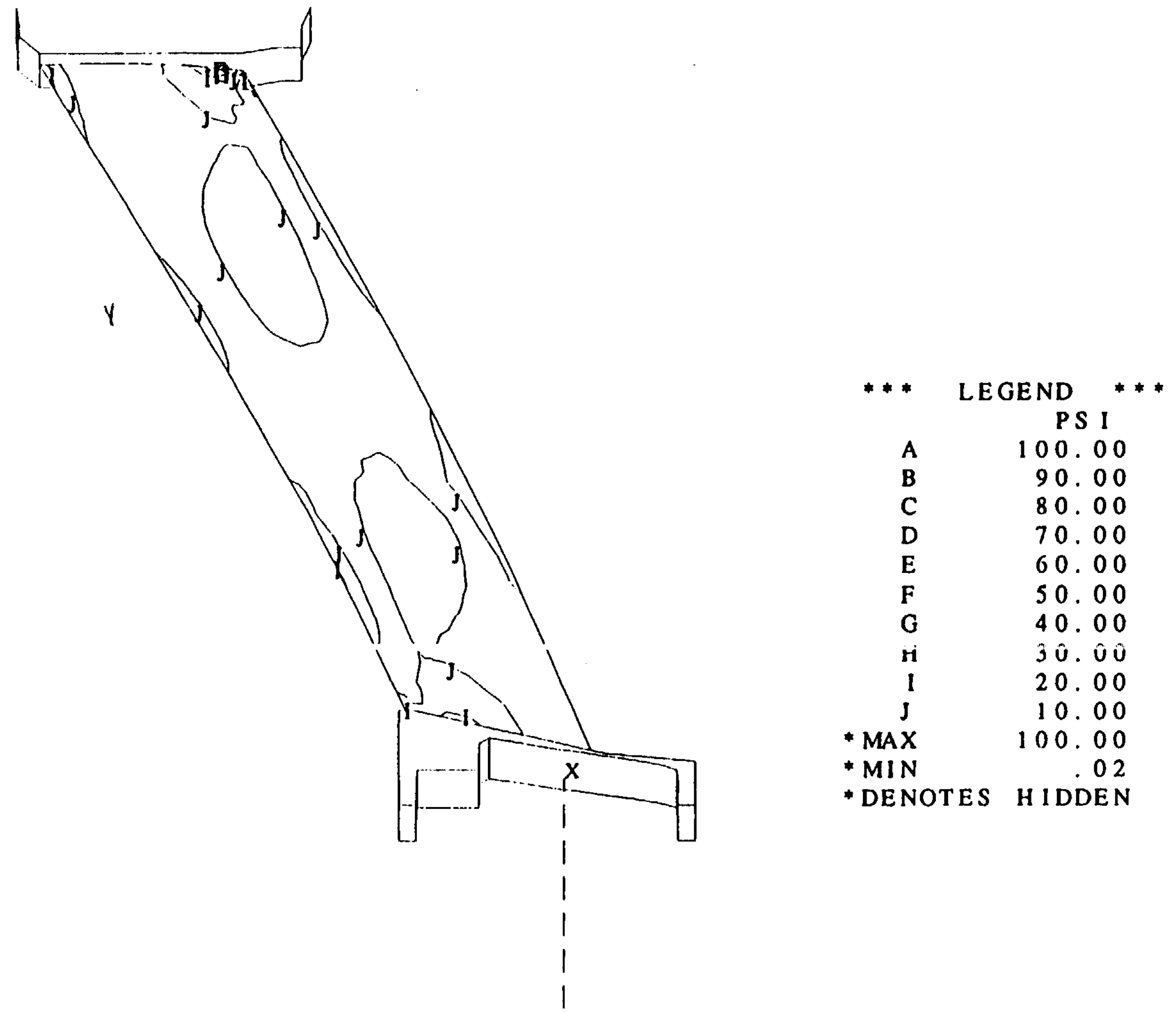
B	90.00
C	80.00
D	70.00
E	60.00
F	50.00
G	40.00
H	30.00
I	20.00
J	10.00
*MAX	100.00
*MIN	.02

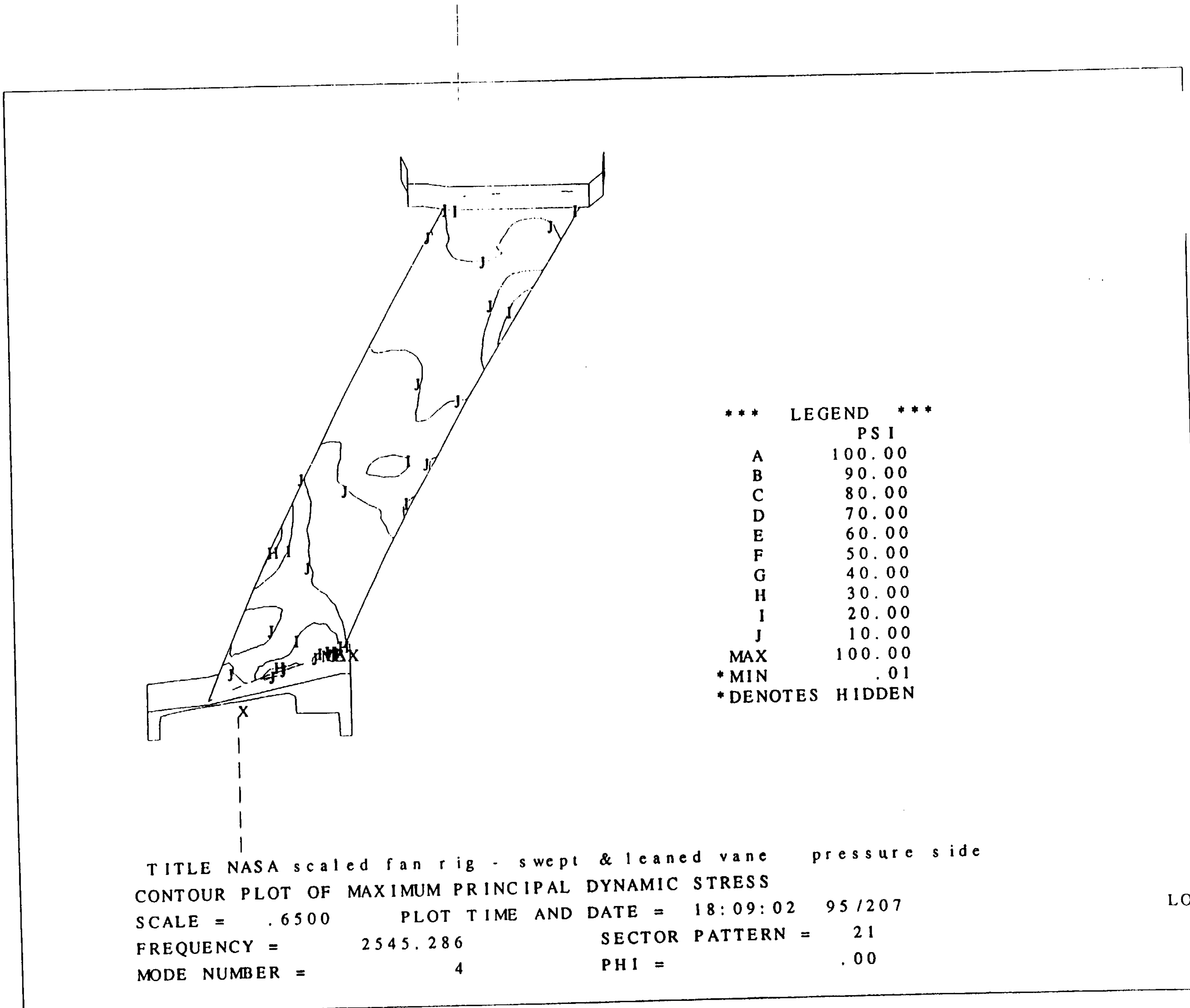
*DENOTES HIDDEN

TITLE NASA scaled fan rig - swept & leaned vane suction side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6500 PLOT TIME AND DATE = 18:10:00 95/207 LO
FREQUENCY = 1428.280 SECTOR PATTERN = 21
MODE NUMBER = 2 PHI = .00


J
I
*** LEGEND ***
PSI
A 100.00
B 90.00
C 80.00
D 70.00
E 60.00
F 50.00
G 40.00
H 30.00
I 20.00
J 10.00
*MAX 100.00
*MIN .02
*DENOTES HIDDEN
X
TITLE NASA scaled fan rig - swept & leaned vane pressure side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6500 PLOT TIME AND DATE = 18:08:56 95/207
FREQUENCY = 1663.802 SECTOR PATTERN = 21
MODE NUMBER = 3 PHI = .00
LO



TITLE NASA scaled fan rig - swept & leaned vane suction side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6500 PLOT TIME AND DATE = 18:10:06 95/207 LO
FREQUENCY = 1663.802 SECTOR PATTERN = 21
MODE NUMBER = 3 PHI = .00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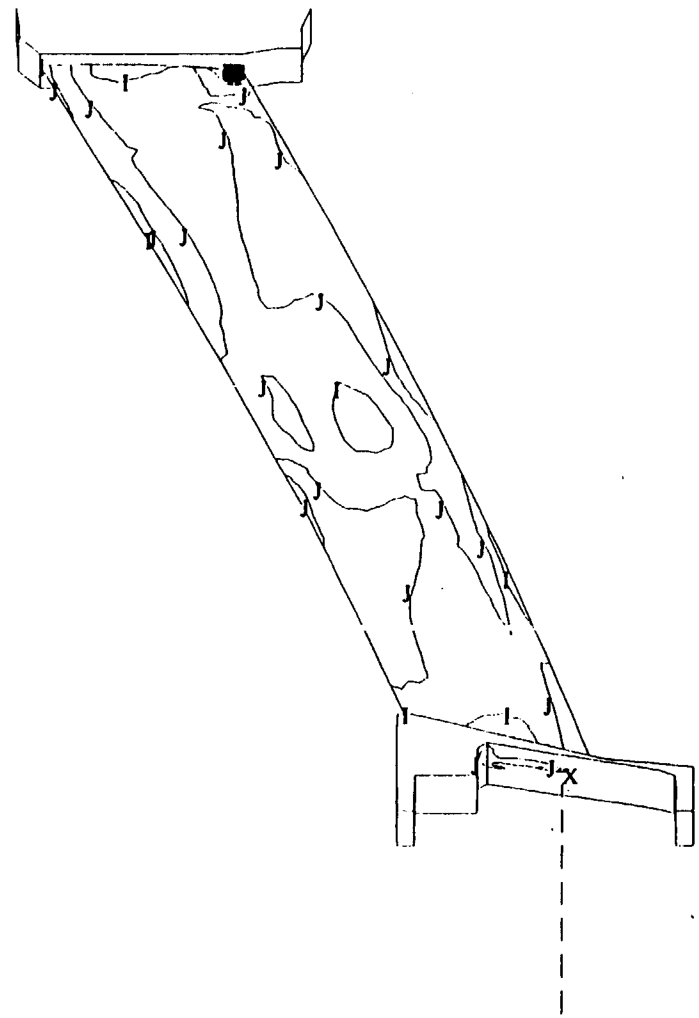
D 70.00
E 60.00
F 50.00
G 40.00
H 30.00
I 20.00
J 10.00
MAX 100.00
*MIN .01
*DENOTES HIDDEN
TITLE NASA scaled fan rig - swept & leaned vane pressure side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6500 PLOT TIME AND DATE = 18:09:02 95/207
FREQUENCY = 2545.286 SECTOR PATTERN = 21
MODE NUMBER = 4 PHI = .00
LO


*** LEGEND ***
PSI
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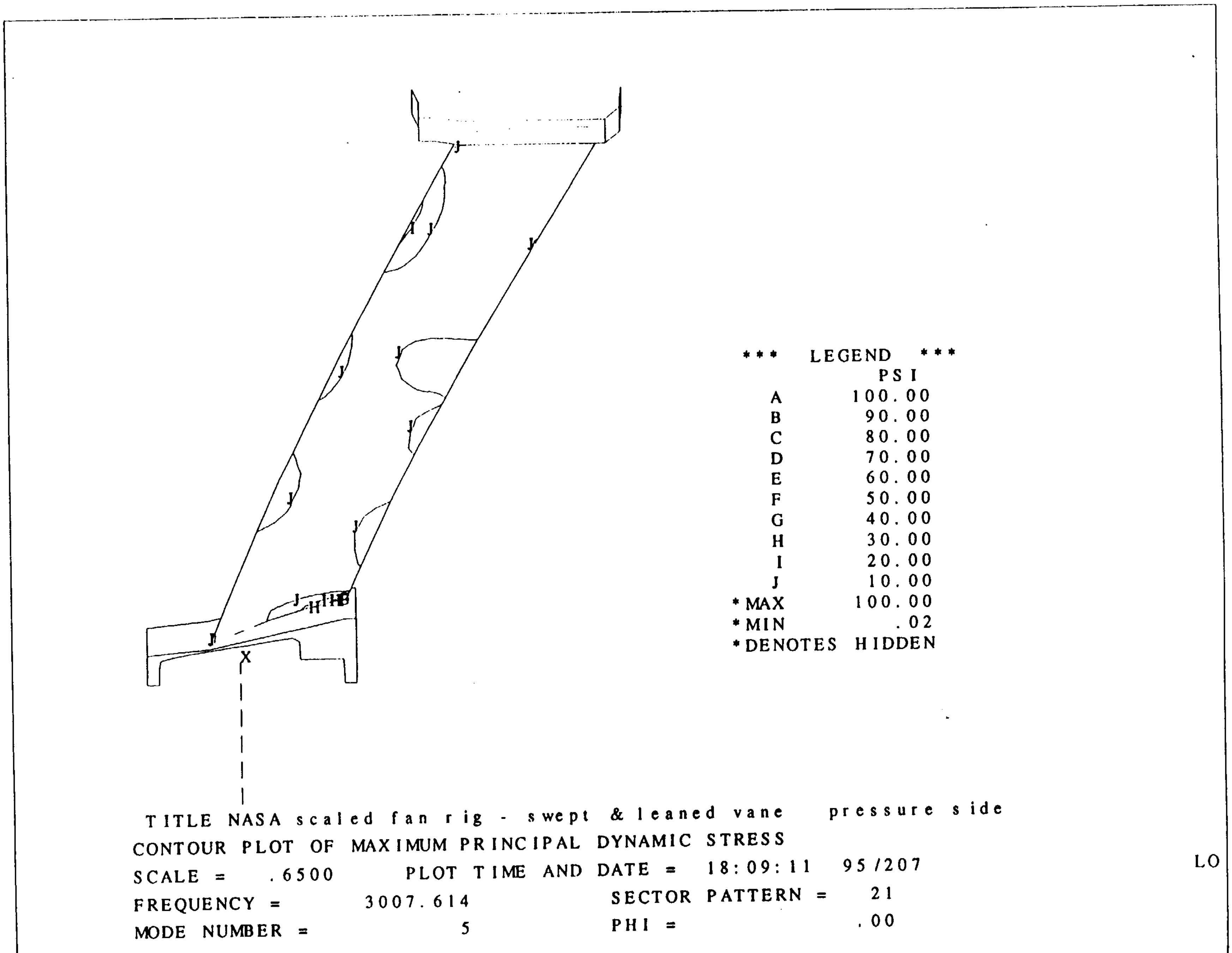
C 80.00
D 70.00
E 60.00
F 50.00
G 40.00
H 30.00
I 20.00
J 10.00
*MAX 100.00
*MIN .01
*DENOTES HIDDEN
TITLE NASA scaled fan rig - swept & leaned vane suction side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6500 PLOT TIME AND DATE = 18:10:16 95/207
LO
FREQUENCY = 2545.286 SECTOR PATTERN = 21
MODE NUMBER = 4 PHI = .00


*** LEGEND ***
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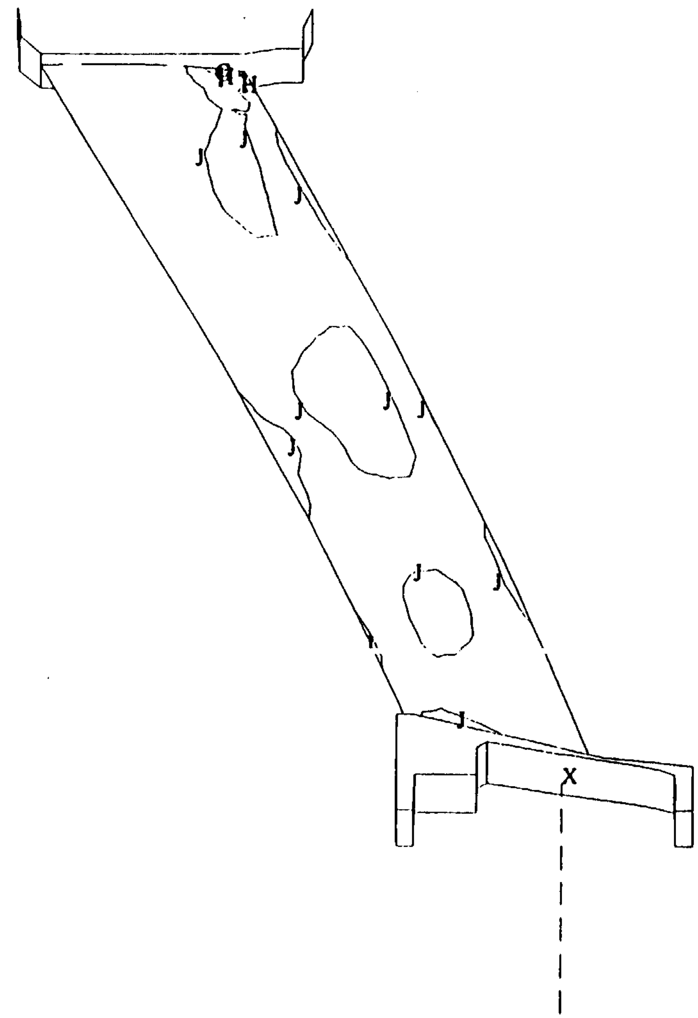
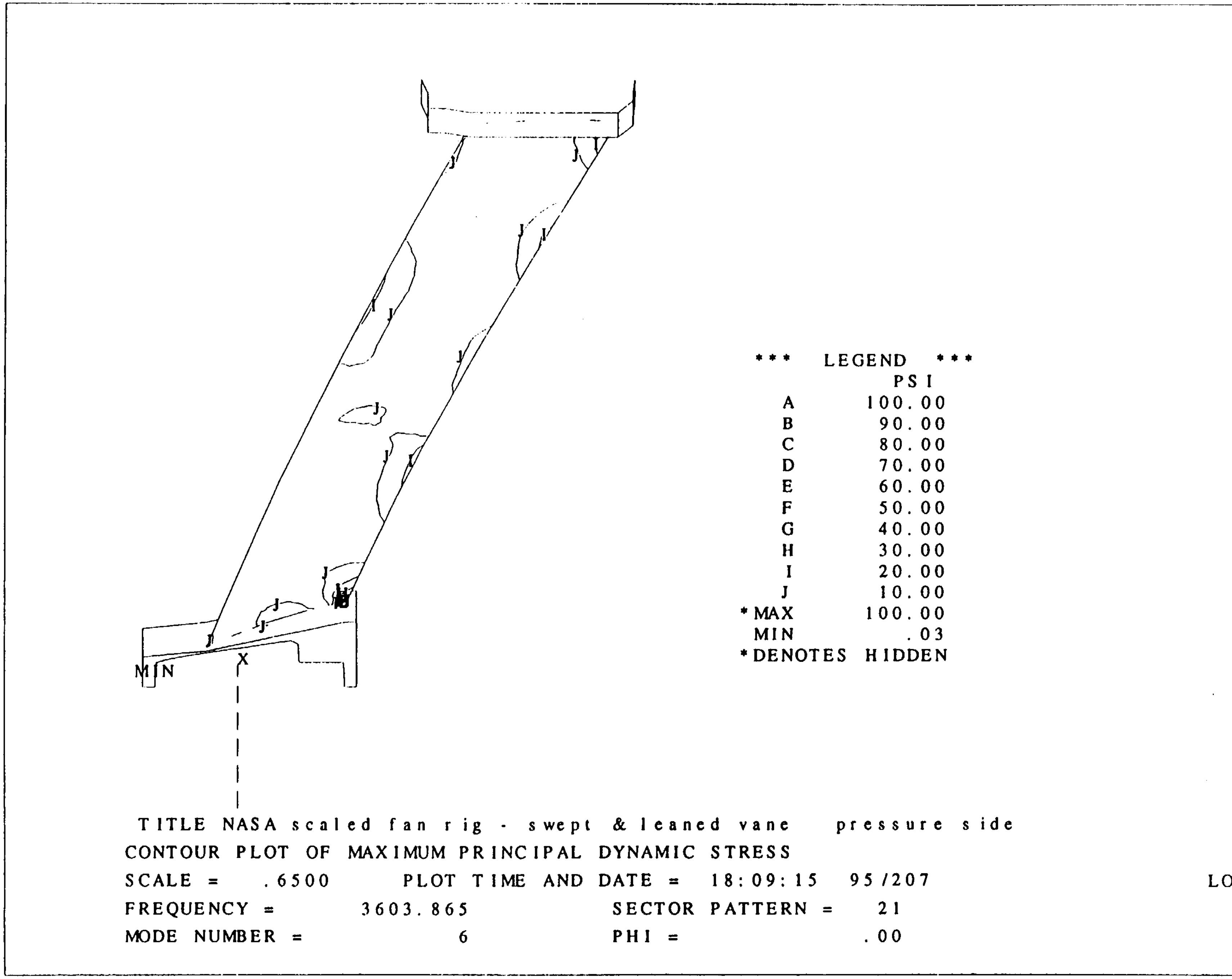
C 80.00
D 70.00
E 60.00
F 50.00
G 40.00
H 30.00
I 20.00
J 10.00
* MAX 100.00
* MIN .02
* DENOTES HIDDEN
TITLE NASA scaled fan rig - swept & leaned vane pressure side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6500 PLOT TIME AND DATE = 18:09:11 95/207
FREQUENCY = 3007.614 SECTOR PATTERN = 21
MODE NUMBER = 5 PHI = .00
LO


H
J
X
*** LEGEND ***
PSI
A 100.00
B 90.00
C 80.00
D 70.00
E 60.00
F 50.00
G 40.00
H 30.00
I 20.00
J 10.00
*MAX 100.00
*MIN .02
*DENOTES HIDDEN
TITLE NASA scaled fan rig - swept & leaned vane suction side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6500 PLOT TIME AND DATE = 18:10:27 95/207
FREQUENCY = 3007.614 SECTOR PATTERN = 21
MODE NUMBER = 5 PHI = .00
LO


MIN
X
J
I
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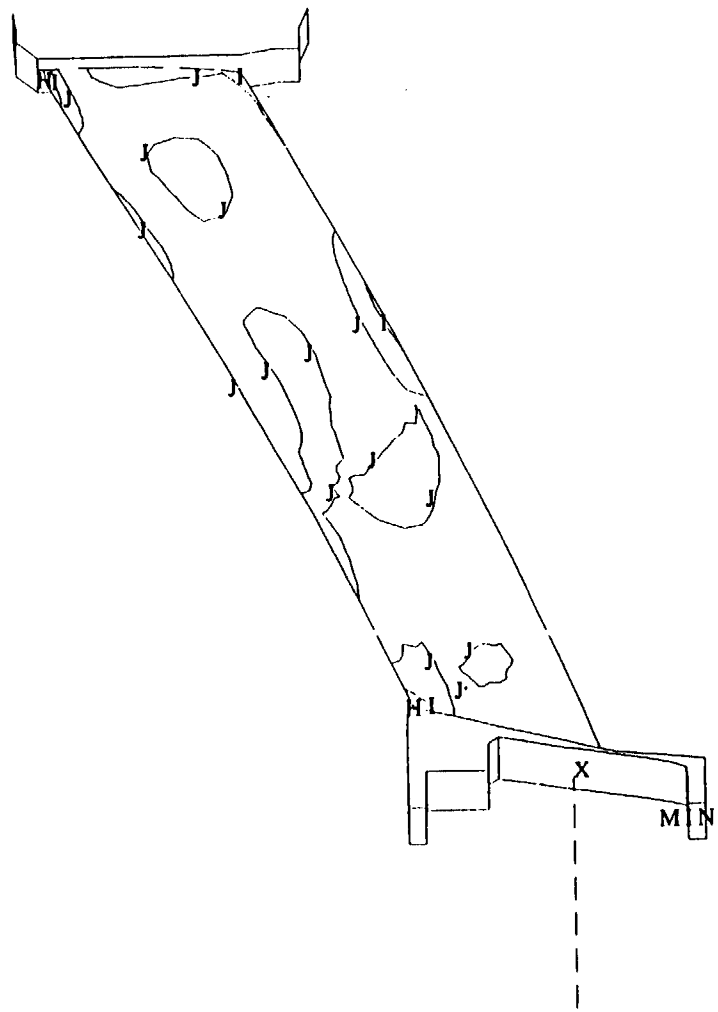

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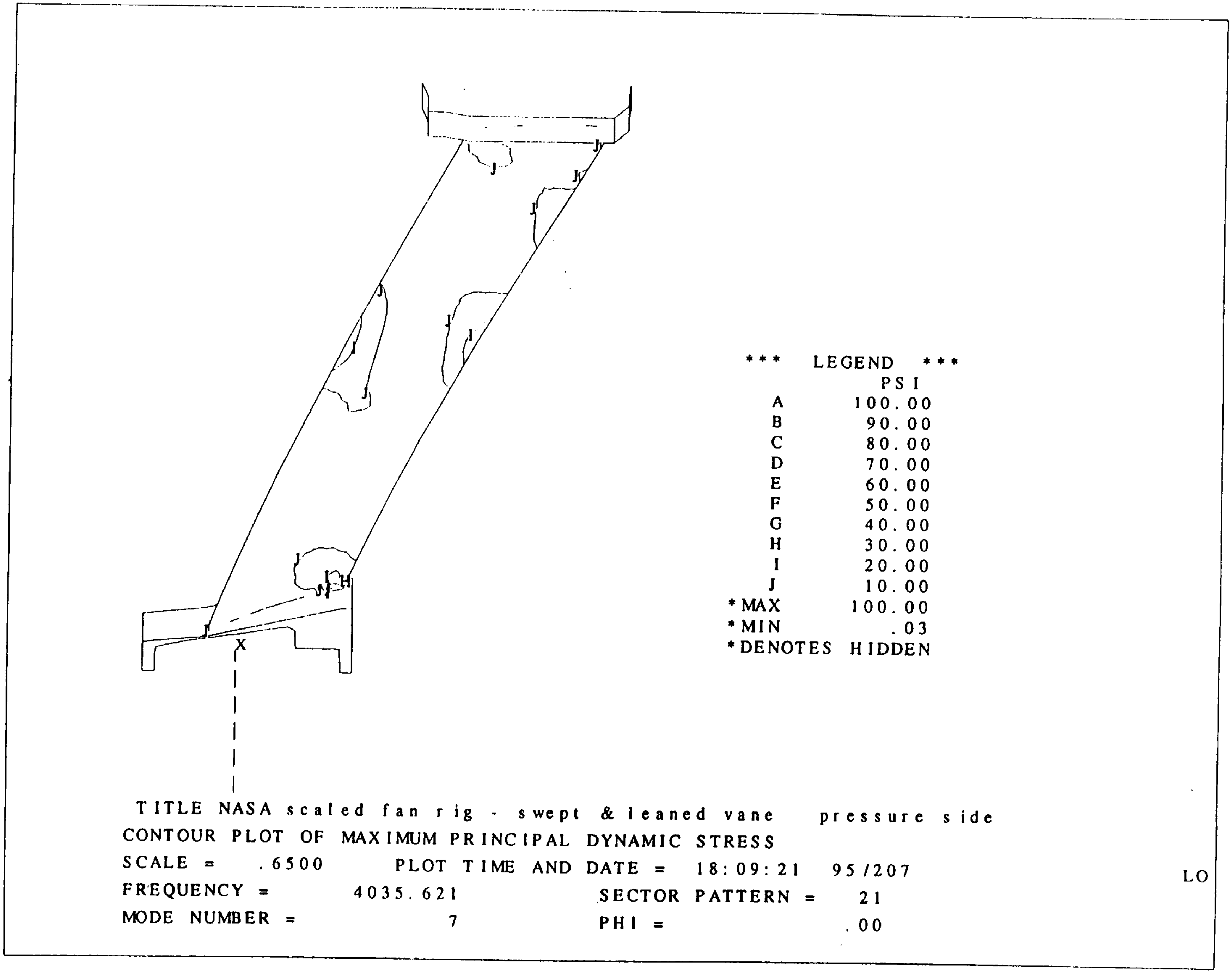
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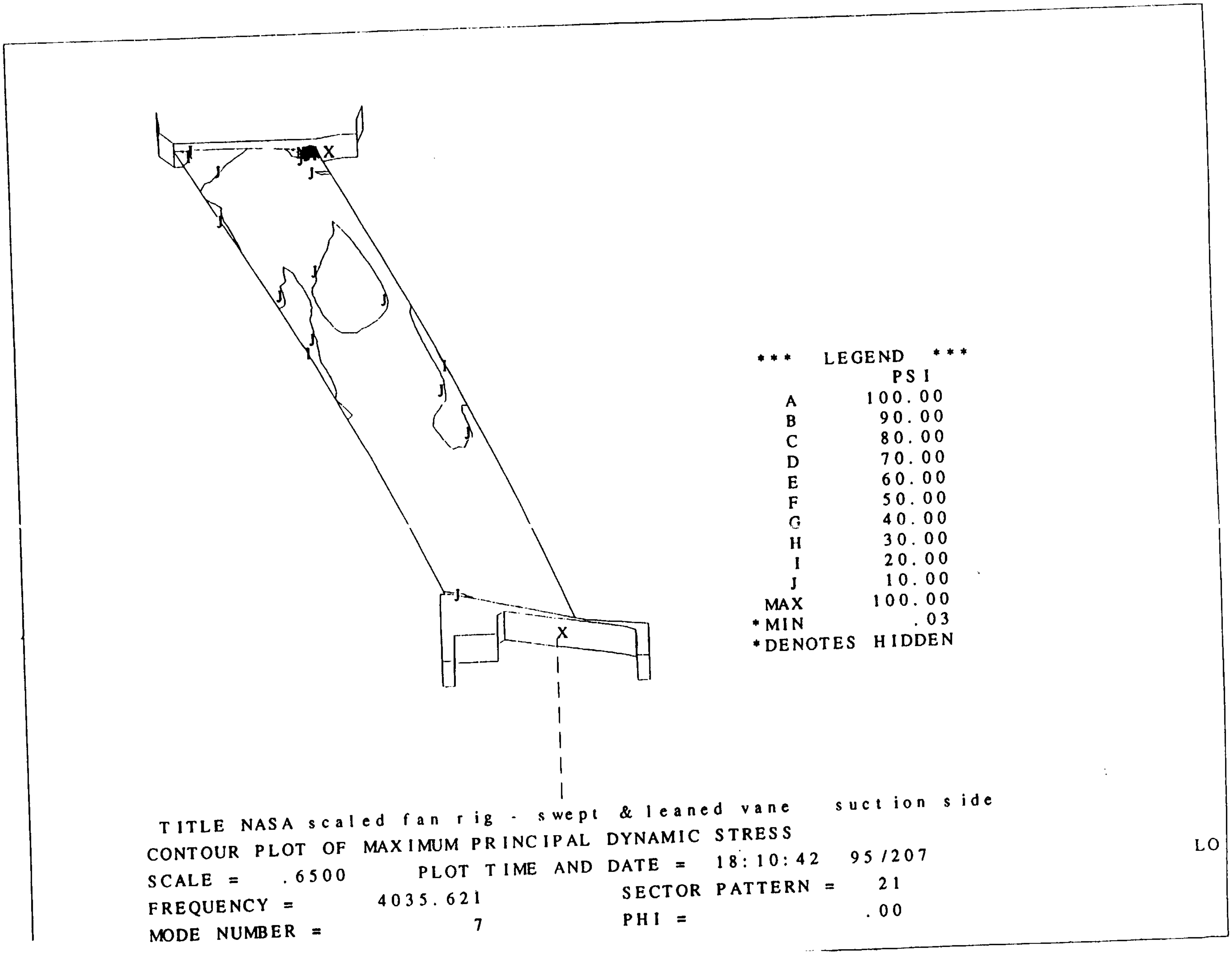
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TITLE NASA scaled fan rig - swept & leaned vane suction side
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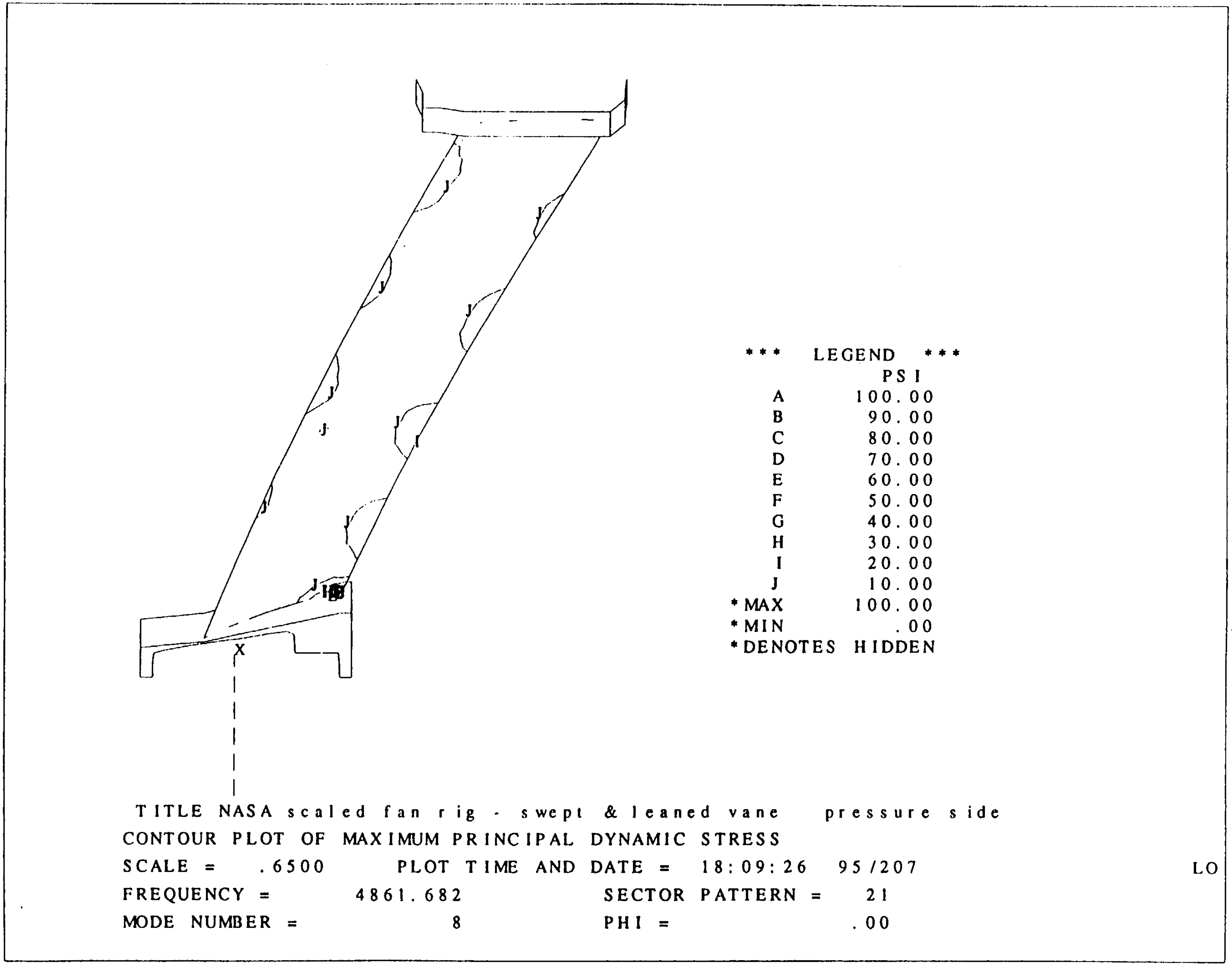
J
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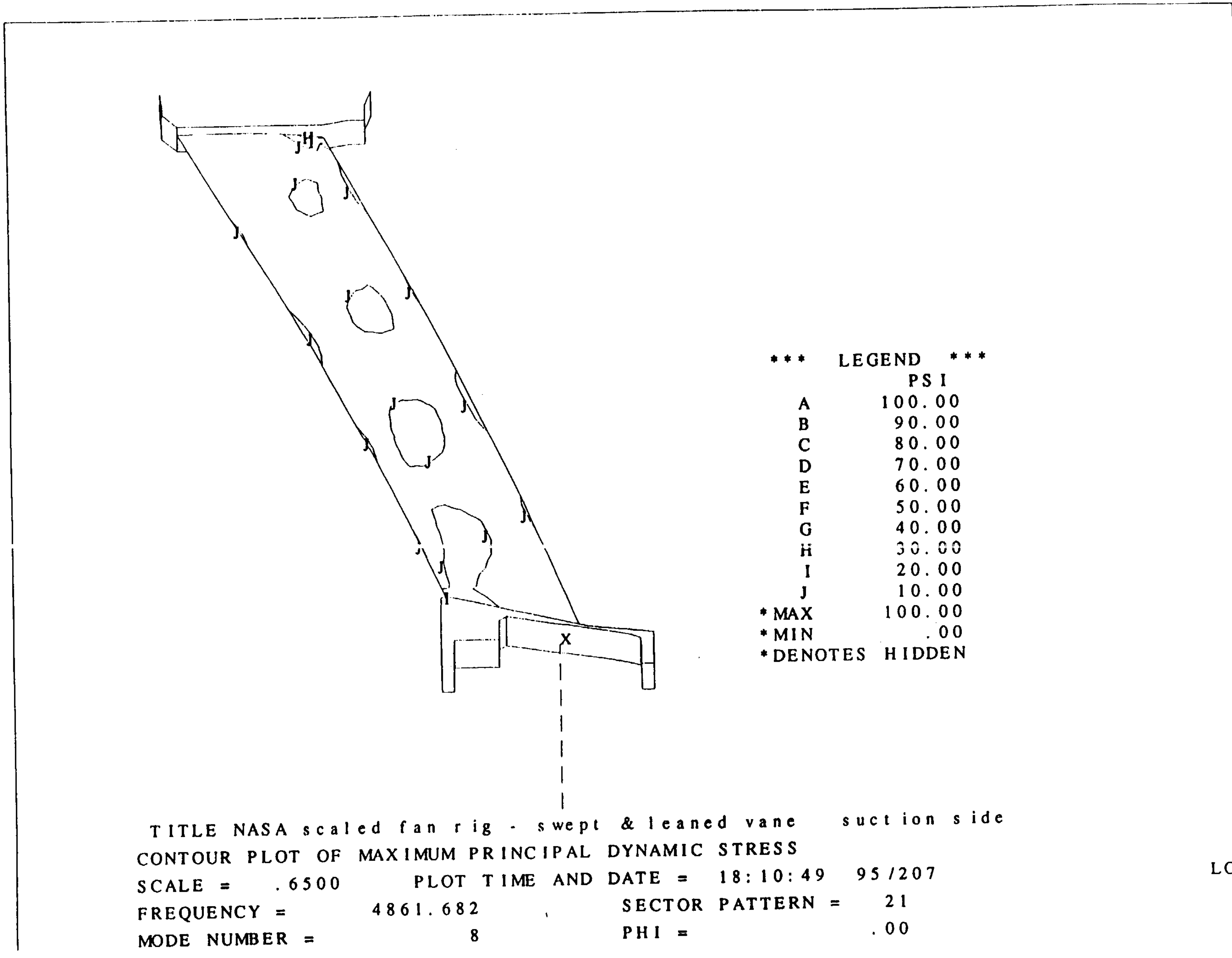
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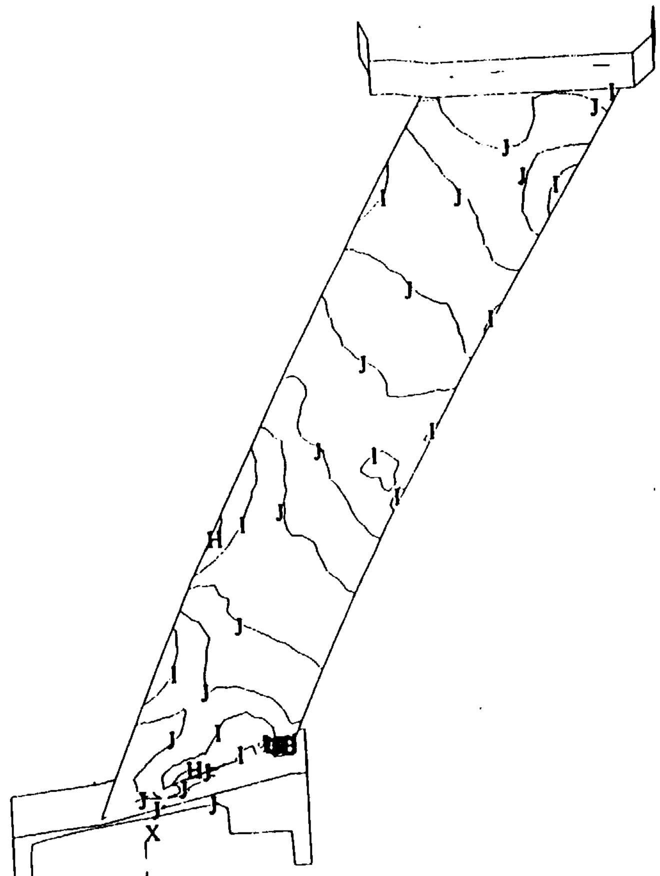

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*DENOTES HIDDEN

TITLE NASA scaled fan rig - swept & leaned vane · pressure side
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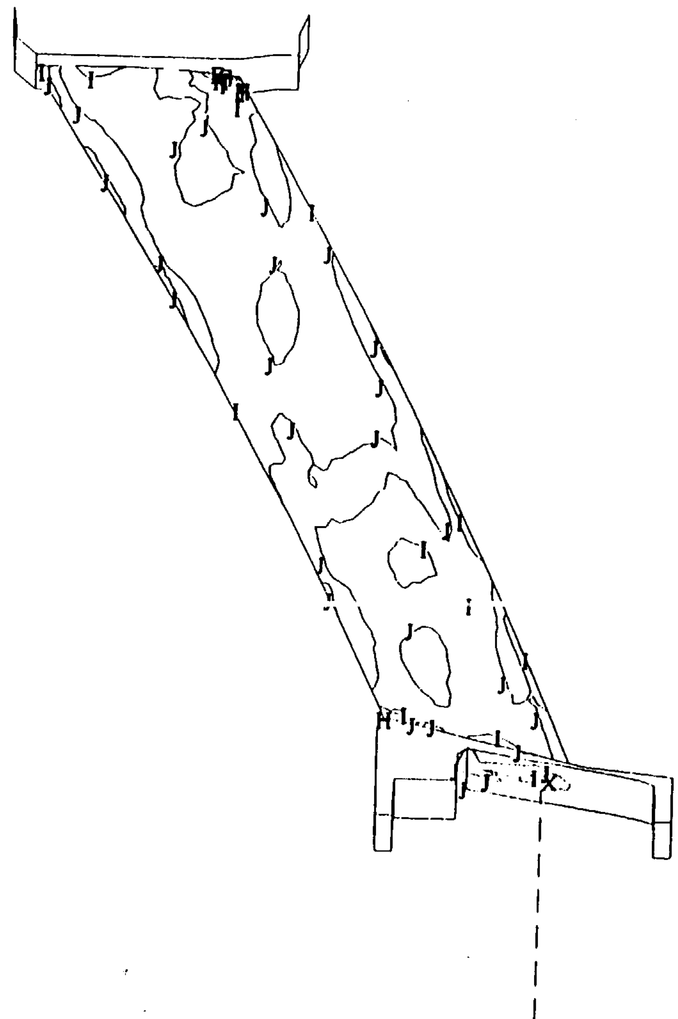

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TITLE NASA scaled fan rig - swept & leaned vane suction side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
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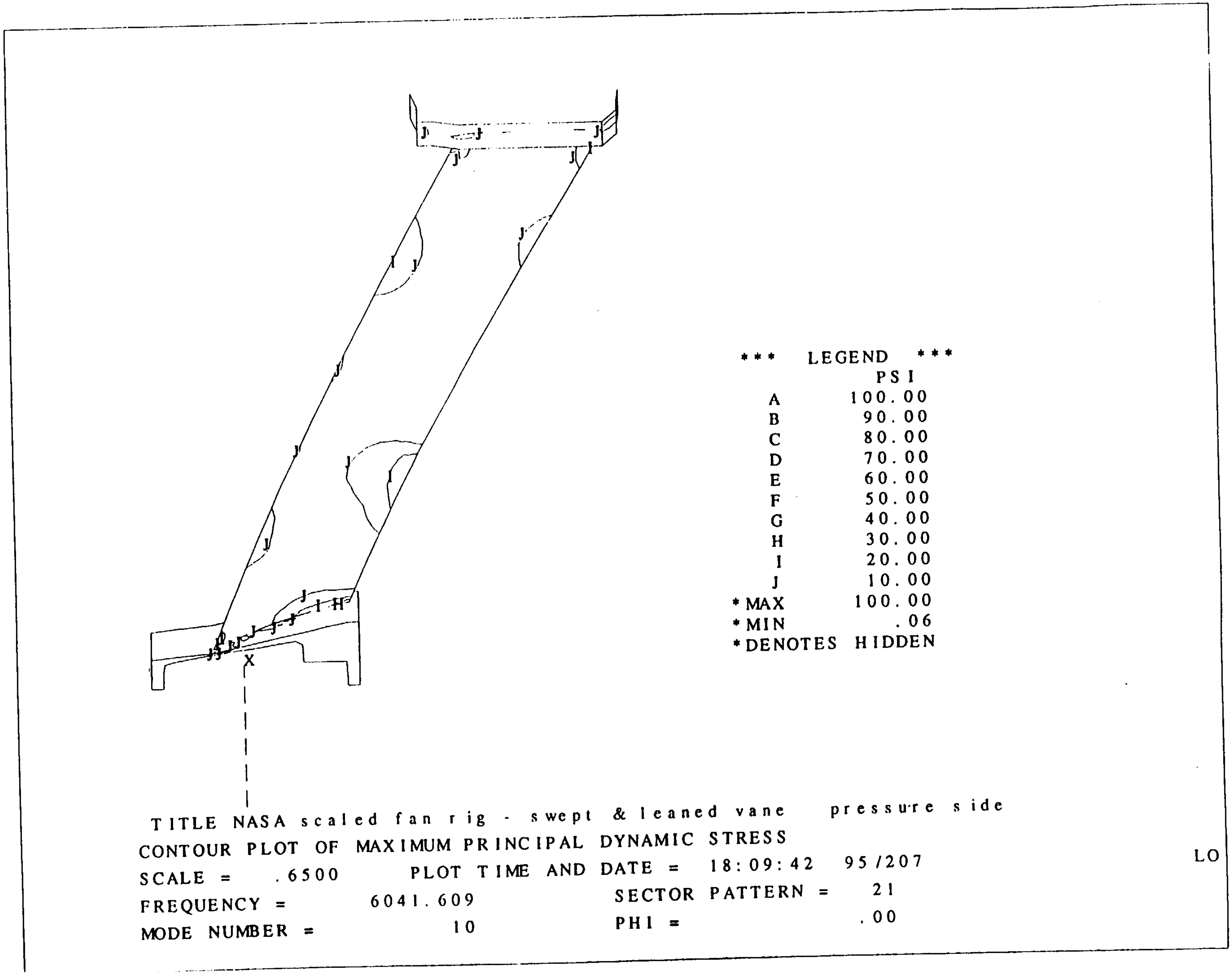
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TITLE NASA scaled fan rig - swept & leaned vane pressure side
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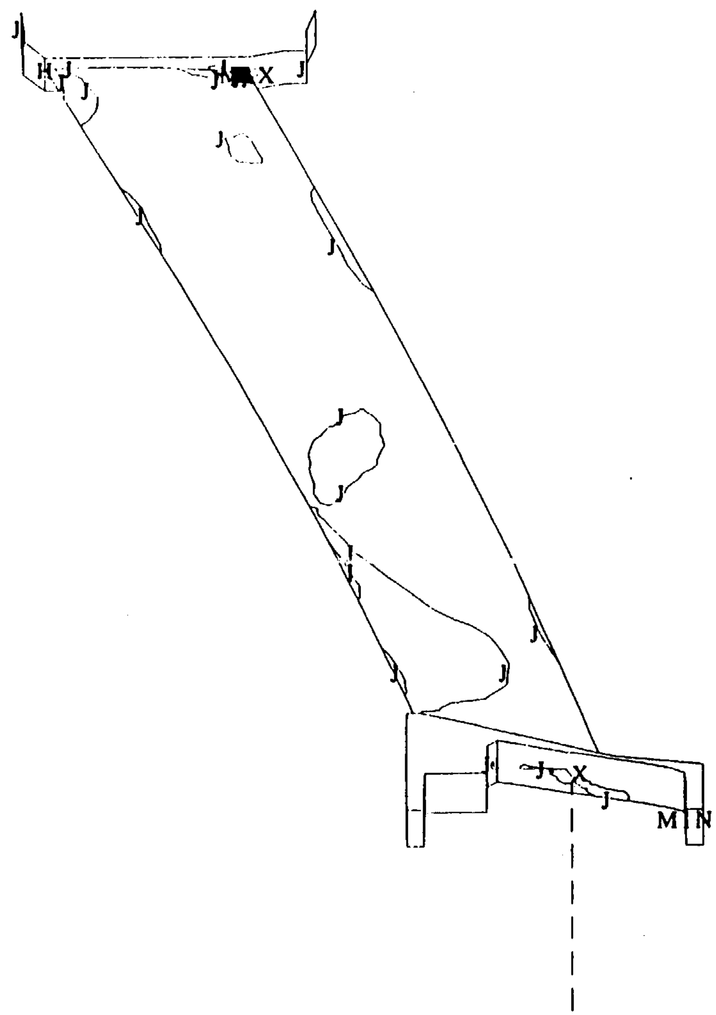

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TITLE NASA scaled fan rig - swept & leaned vane suction side
CONTOUR PLOT OF MAXIMUM PRINCIPAL DYNAMIC STRESS
SCALE = .6500 PLOT TIME AND DATE = 18:11:09 95/207 LO
FREQUENCY = 6041.609 SECTOR PATTERN = 21
MODE NUMBER = 10 PHI = .00

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13. ABSTRACT *(Maximum 200 words)*

This report describes the design of a low tip speed, moderate pressure rise fan stage for demonstration of noise reduction concepts. The fan rotor is a fixed-pitch configuration delivering a design pressure ratio of 1.378 at a specific flow of 43.1 lbm/sec/ft^2. Four exit stator configurations were provided to demonstrate the effectiveness of circumferential and axial sweep in reducing rotor-stator interaction tone noise. The fan stage design was combined with an axisymmetric inlet, conical convergent nozzle, and nacelle to form a powered fan-nacelle subscale model. This model has a 22-inch cylindrical flow path and employs a rotor with a 0.30 hub-to-tip radius ratio. The design is fully compatible with an existing NASA force balance and rig drive system. The stage aerodynamic and structural design is described in detail. Three-dimensional (3-D) computational fluid dynamics (CFD) tools were used to define optimum airfoil sections for both the rotor and stators. A fan noise predictive system developed by Pratt & Whitney under contract to NASA was used to determine the acoustic characteristics of the various stator configurations. Parameters varied included rotor-to-stator spacing and vane leading edge sweep. The structural analysis of the rotor and stator are described herein. An integral blade and disk configuration was selected for the rotor. Analysis confirmed adequate low cycle fatigue life, vibratory endurance strength, and aeroelastic suitability. A unique load carrying stator arrangement was selected to minimize generation of tonal noise due to sources other than rotor-stator interaction. Analysis of all static structural components demonstrated adequate strength, fatigue life, and vibratory characteristics.

SUBJECT TERMS
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