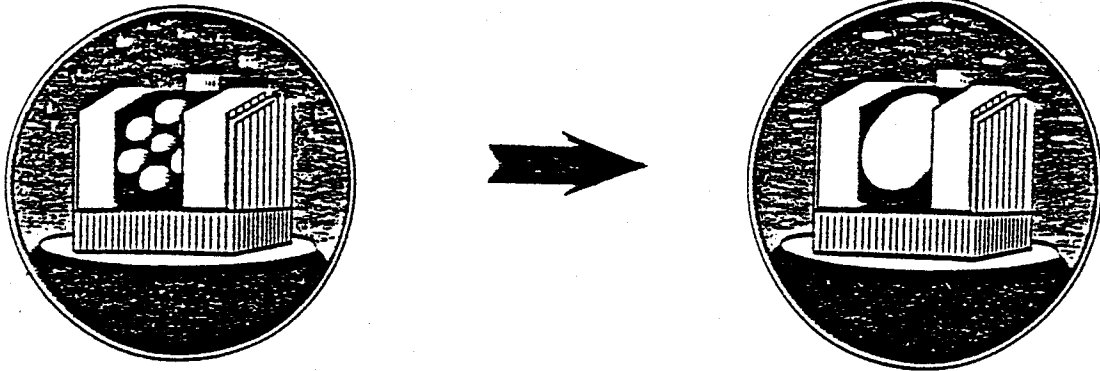


6.5 METER TELESCOPE



MMT Conversion Technical Memorandum #94-1

Contact Stress on the 6.5 m Mirror Due to Thermal Expansion

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January 1994

Contact stress on the 6.5 m mirror due to thermal expansion

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January 28, 1994

1.0 Abstract

Three finite element models were created to determine the contact stress on the 6.5 m mirror due to thermal expansion of the support system attachment pucks and their flexures. The models show that the coefficient of thermal expansion (CTE) of the puck should be closely matched to the CTE of the flexural attachment to the load spreading frame.

2.0 Introduction

The 6.5 m mirror support system is attached to the mirror by metal disks (pucks) adhered to the backplate of the mirror with RTV. These pucks are bolted to high-strength steel flexures (Figure 1). Previous finite element models showed that the flexure needs to be made out of high-strength steel (reference 5). All of the models in this report use G43400CD alloy steel for the flexures.

The materials used in the pucks in these models are Invar 36, G43400CD, and a material with a CTE 10% greater than that of G43400CD. In each model the temperature is varied over a range of 40 C, and a 333.3 N axial force is applied to the center of each flexure (Figure 2). The resulting contact stress profile and the pressure concentration factor (PCF) is described in section 4.0.

All models assume a rigid mirror and uniform temperatures.

3.0 Model parameters

Axisymmetric plane elements with the material properties given in Table 1 were used to model the puck and flexure.

TABLE 1. Material Properties

Material	CTE (micron/m/C)	Young's Modulus -E (MPa)	Poisson Ratio	Yield Strength (MPa)
G43400CD alloy steel	11.0	200,000	0.29	682
RTV	324	5.6	0.49932	
Invar 36	-1.2	148,000	0.30	
E6 glass	2.9	65,000	0.24	

4.0 Model results

Figure 3 shows the stress applied normal to the mirror backplate (contact stress) across the radius of the puck for all three materials. Figure 4 shows an expanded scale plot of the contact stress profile for a steel puck.

Table 2 shows how the CTE of the puck affects the pressure concentration factor (PCF). To keep the stress in the glass below 0.7MPa, the PCF should be less than 3.0 (see reference 1). The lowest PCF occurs when the flexure and the puck have the same CTE.

TABLE 2. PCF versus Puck CTE

Material Puck	CTE (micron/m/C)	PCF axial load, delta T = 40 C
Invar 36	1.2	21.5
4340 Steel	11.0	3.1
Steel (CTE + 10%)	12.1	5.3

Figure 5 shows a magnified view of the displacement of the puck and flexure with a 40 C increase in temperature and a 333 N axial load applied to the top of the flexure.

5.0 Conclusion

The models show that Invar pucks bolted to steel flexures cause excessively high contact stress profiles with a high PCF under normal loads and temperatures. The model with steel pucks shows the lowest contact stress profile with a PCF = 3.1. Difference of CTE as low as 10% between the puck and the flexure causes unacceptable stress concentrations.

These results show that the flexure and the puck should have the same CTE. This could be assured if both parts were made from the same bar of material.

The next generation of models of the mirror by BCV will include models of the latest puck design. These models will check the local and global stress in the mirror and will determine if a PCF = 3.1 is acceptable.

6.0 List of Figures

Figure 1. Steel flexure and Invar puck.

Figure 2. Axisymmetric model of puck.

Figure 3. Contact stress at glue-glass interface: three puck materials.

Figure 4. Contact stress at glue-glass interface: steel puck.

Figure 5. Displacement of the puck and flexure: $\Delta T = 40\text{ C}$, axial load 333 N.

7.0 References

- 1) BCV report No. 144 Rev. 0, 11/92. This report explains the finite element model results that set the maximum PCF, forces, and moments that can be applied to the back of the 6.5 m mirror.
- 2) *Experimental Investigation of Silicone Adhesives for Mirror Support: Report #1*, Peter Gray, Steward Observatory, 10/14/93. This report explains experimental tests of the material properties of an RTV made by Dow Corning.
- 3) Columbus Tech memo UA-92-03: *Performance test results of the 6.5 meter support actuator design*, Shawn Callahan, MMTO, 9/16/92. This report shows the forces and moments that the mirror support actuator applies to the loadspreader in this report.

4) Large Binocular Telescope Project Tech Memo UA-93-xx: *Mirror Support System for Large Honeycomb Mirrors II*, John Hill, 11/2/93. This report explains the general concepts for supporting large honeycomb mirrors.

5) MMT Conversion Technical Memorandum #93-1: *Analysis and Design of the Glue Joint, Pucks, and Loadspreader used in the 6.5 m Mirror Support System*, Shawn Callahan, MMTO, 11/93. This report explains the stress analysis and design of the glue joint, puck, and loadspreader used in the 6.5 m mirror support system.

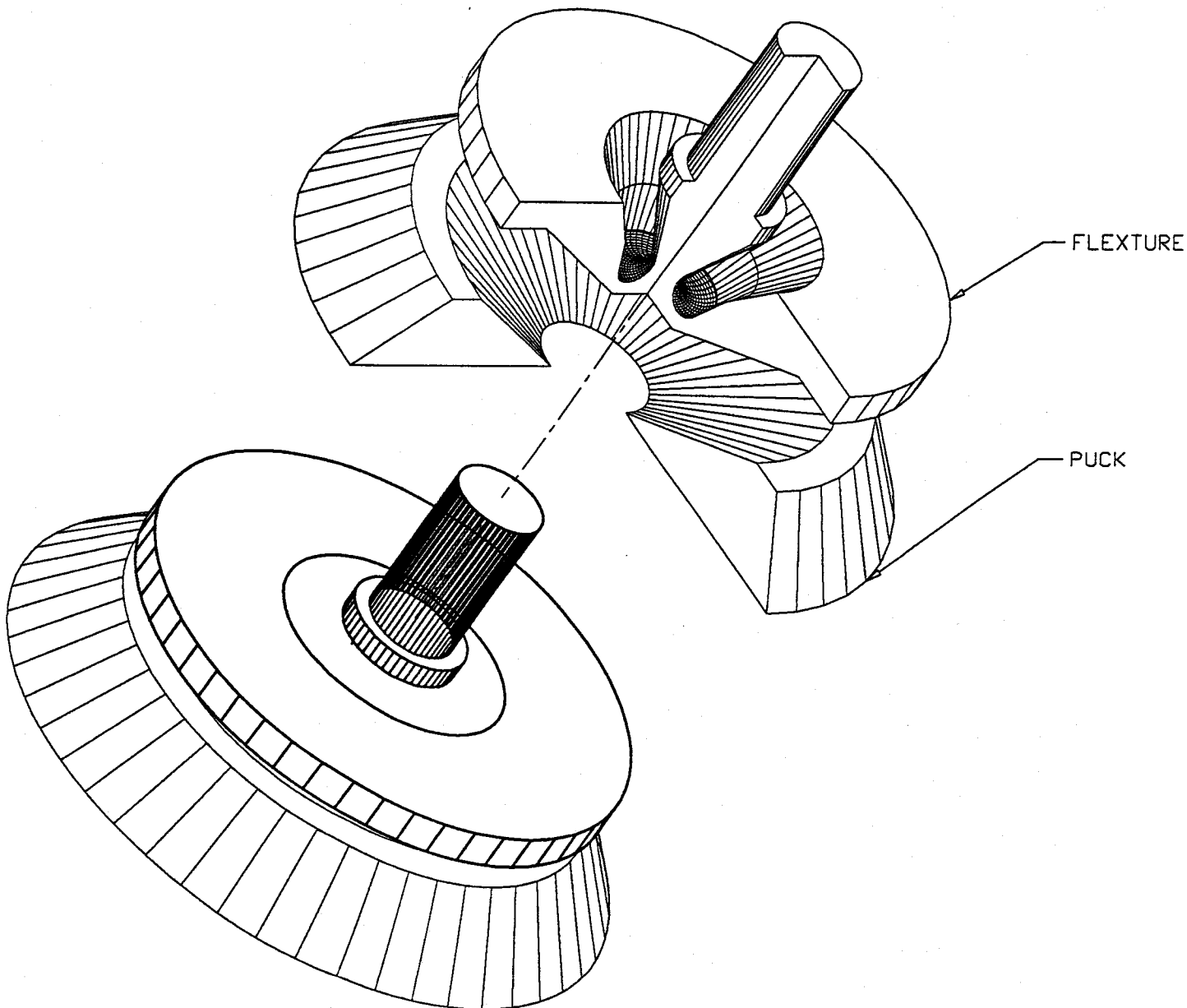
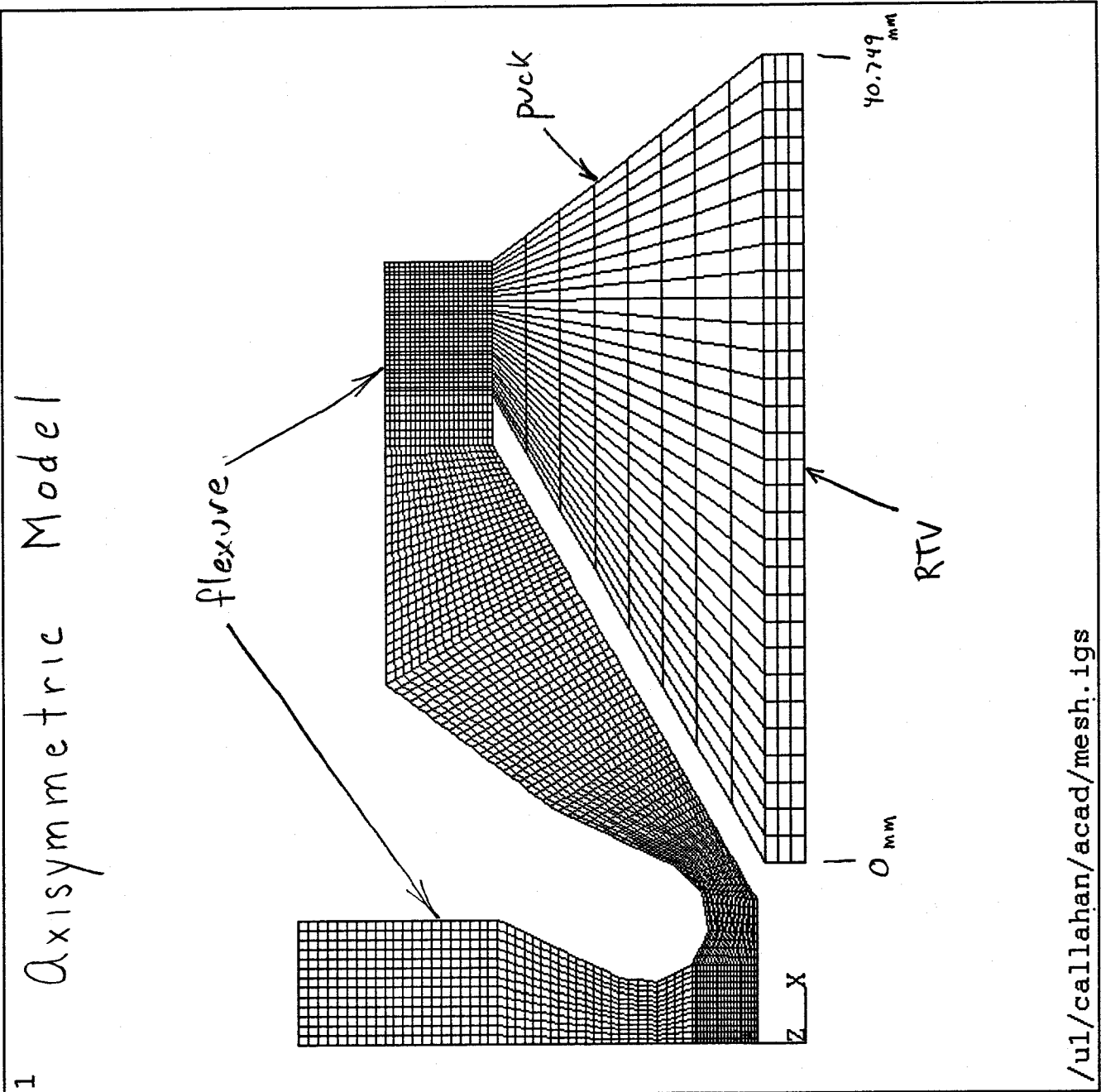


FIGURE 1

ANSYS 5.0
JAN 27 1994
18:31:05
ELEMENTS
TYPE NUM

ZV =1
DIST=27.5
XF =25
YF =12.754



1 Axisymmetric Model

figure 2

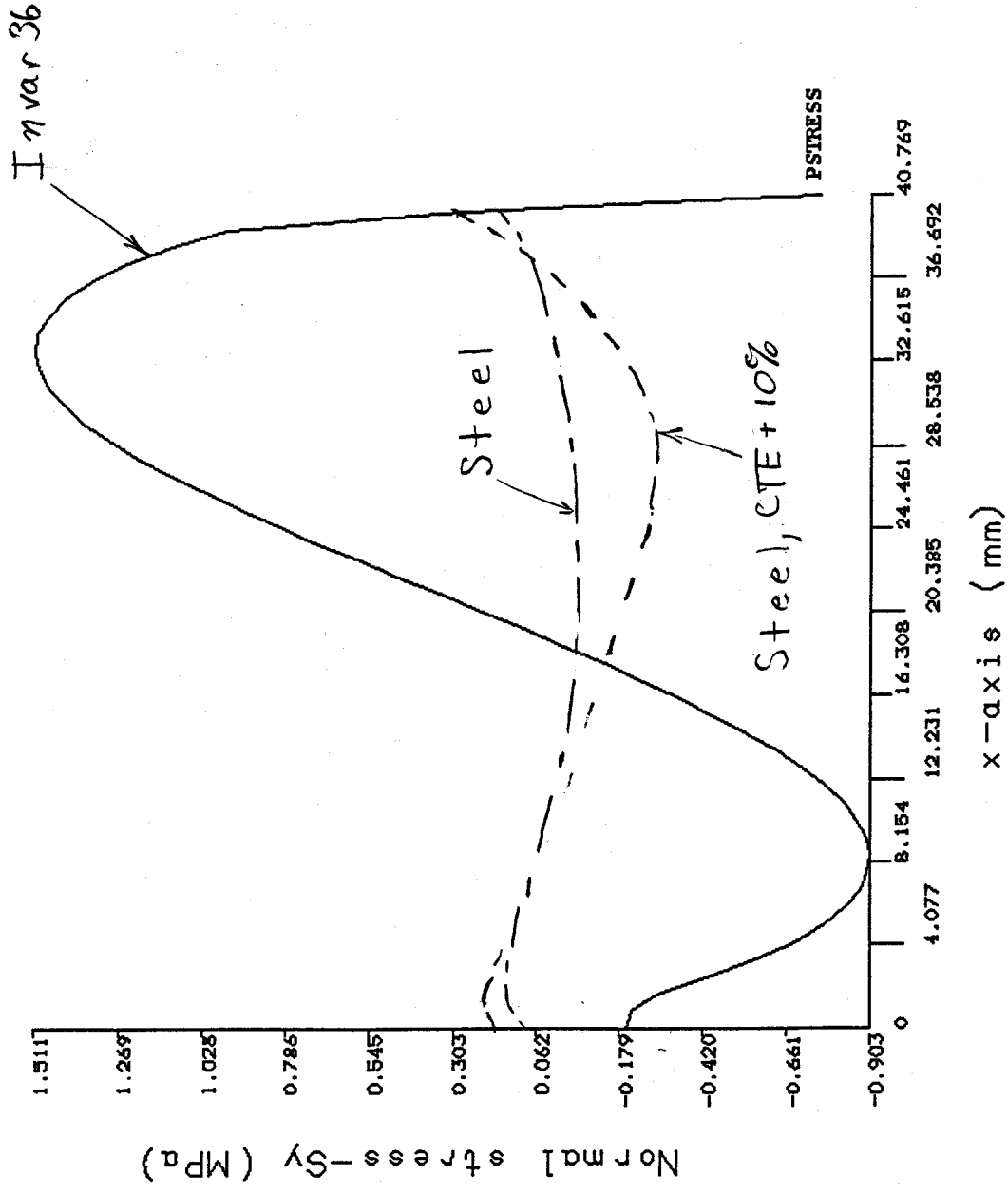
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 JAN 27 1994
 18:25:36

POST1
 STEP=3
 SUB =1
 TIME=3
 PATH PLOT
 NOD1=3726
 NOD2=3729

ZV =1
 DIST=0.75
 XF =0.5
 YF =0.5
 ZF =0.5
 CENTROID HIDDEN

Puck Material:
 --- Invar 36
 --- Steel
 --- Steel, CTE+10%

1 Contact stress at glue-glass interface

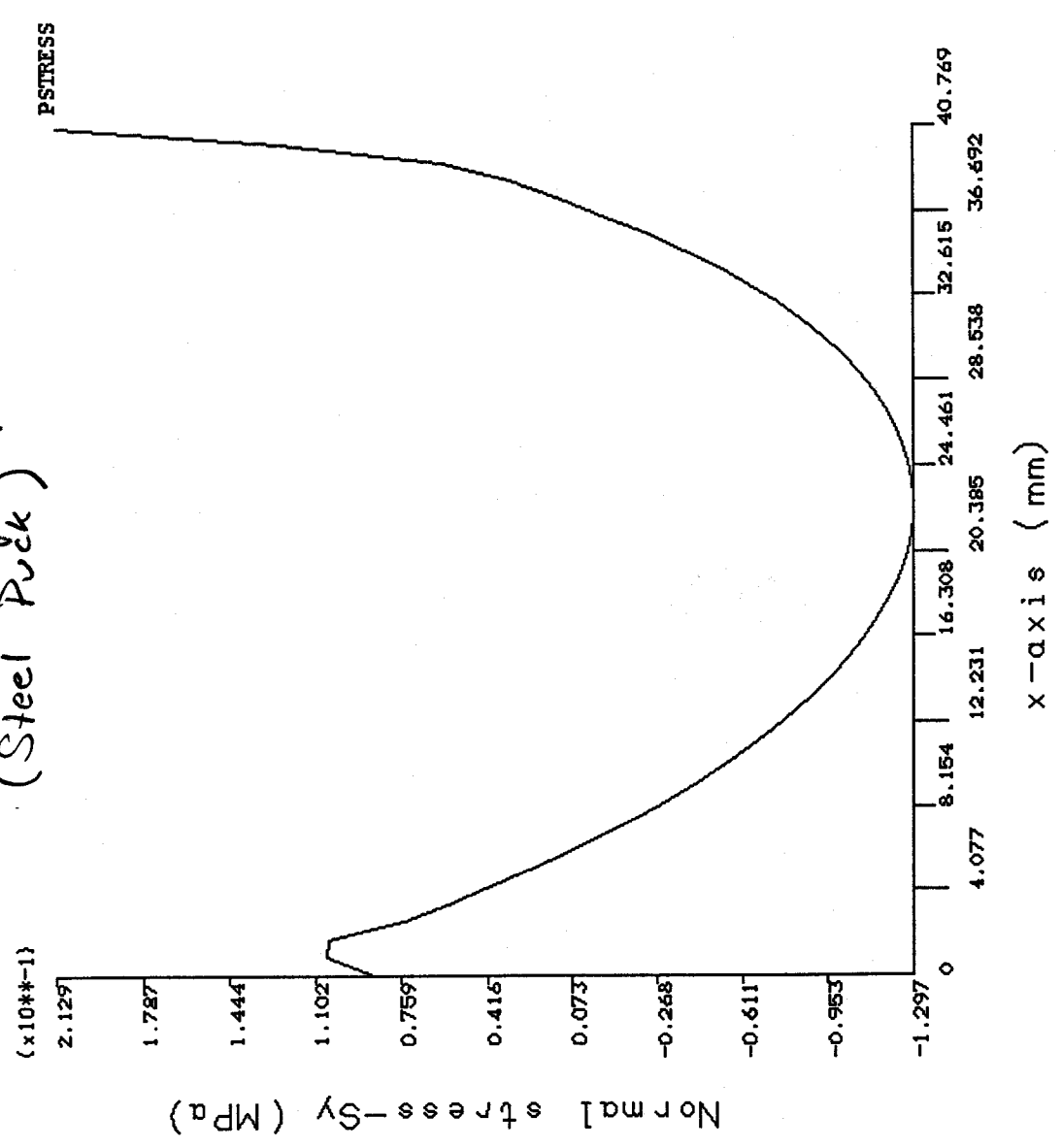


delta T=30C + 333N axial load

figure 3

ANSYS 5.0
 JAN 28 1994
 09:03:09
 POST1
 STEP=3
 SUB =1
 TIME=3
 PATH PLOT
 NOD1=3726
 NOD2=3729
 ZV =1
 DIST=0.75
 XF =0.5
 YF =0.5
 ZF =0.5
 CENTROID HIDDEN

Contact Stress at glue-glass interface
 (Steel Puck)



delta T=30C + 333N axial load, steel flexure - steel puck

figure 4

ANSYS 5.0
JAN 27 1994
18:29:03
DISPLACEMENT
STEP=3
SUB =1
TIME=3
RSYS=0
DMX =0.112845
SEPC=98.813

DSCA=24.37
ZV =1
DIST=27.5
XF =25
YF =12.754
CENTROID HIDDEN
EDGE

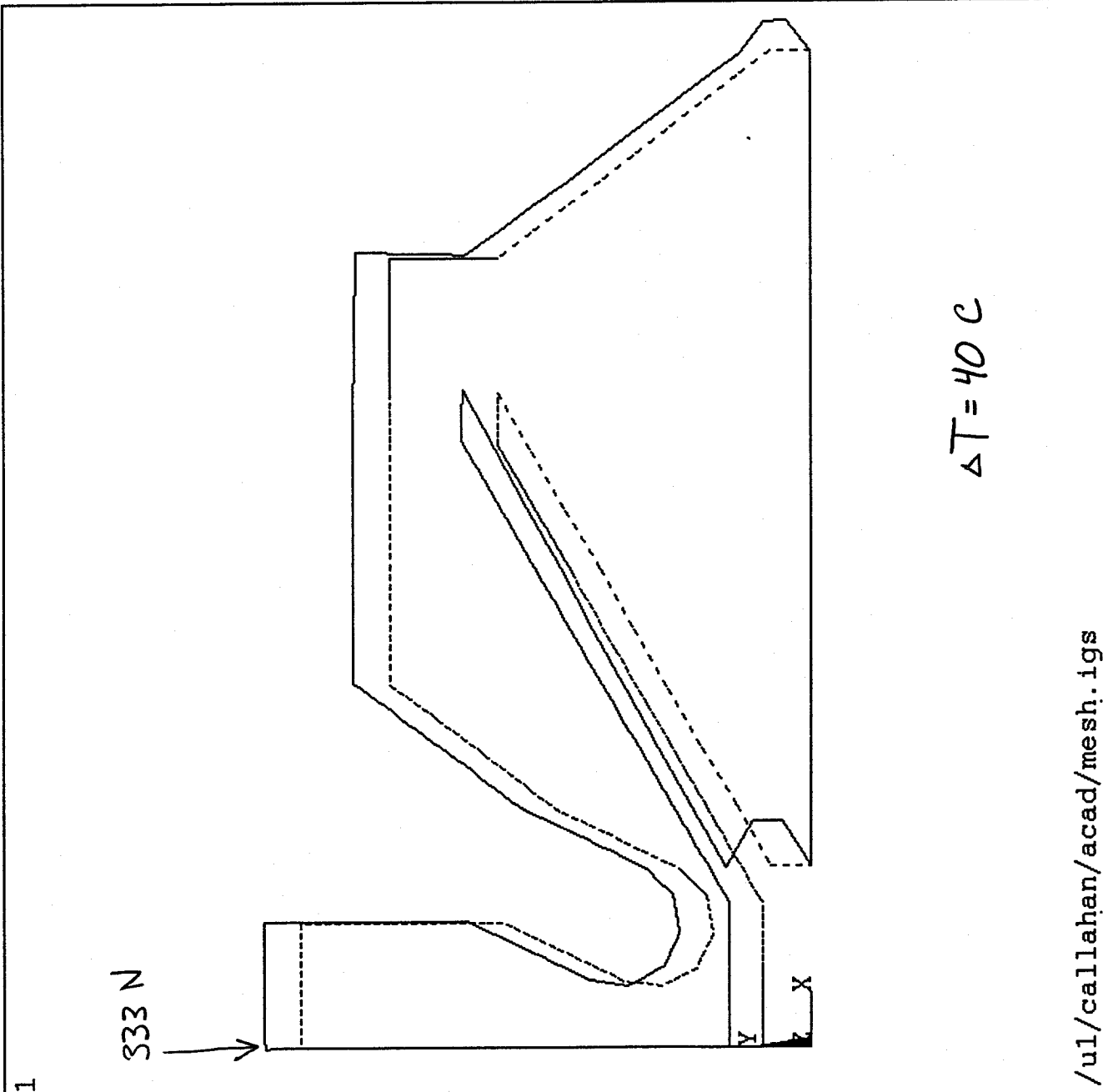


figure 5

$\Delta T = 40 C$