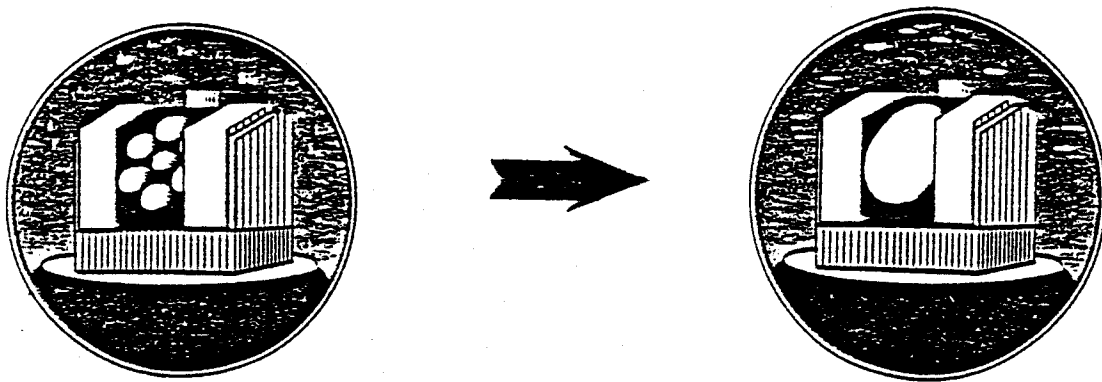


6.5 METER TELESCOPE



MMT Conversion Technical Memorandum #94-4

Static Support Deflection Analysis

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April 1994

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April 1, 1994

1.0 Abstract

This report describes a one -dimensional analysis of the motion of the 6.5m mirror before and after engagement with the static supports.

2.0 Introduction

The static supports in the mirror cell support the mirror whenever the pneumatic mirror support system is not in operation. They must support the mirror both during normal operation and in the event of a pneumatic system failure.

3.0 Experimental data

The current design of the static support is shown in Figure 1. The weight of the mirror is supported by an elastomer shock mount. This mount has a measured axial stiffness of 280 N/mm (1600 lb/in) and has been designed to have similar lateral stiffness.

During normal operation, the weight of the mirror is supported by 198 pneumatic cylinders. Each cylinder is controlled by a pneumatic servo valve. The current control valve takes 0.5 seconds to change force from full pressure to zero. The following one-dimensional analysis of the static support assumes that the pressure falls off as a cosine function with a frequency ω equal to π rads/sec.

4.0 Analysis

This analysis examines the motion of the mirror in three stages (Figure 2). Stage 1 describes the mirror motion after the pneumatic supports are turned off. Stage 2 describes the mirror motion from the instant that the static supports are engaged until the air pressure in the pneumatic cylinders reaches zero. Stage 3 describes the mirror motion after the air in the pneumatic cylinders is depleted.

This analysis does not include frictional damping. Damping has the effect of decreasing the amplitude of the oscillations.

4.1 Stage 1

The pneumatic supports hold the mirror a maximum of 7 mm above the static supports. Thus should the pneumatic system fail, the mirror will fall less than or equal to 7 mm before engaging the static supports. This will take 0.205 seconds. The equation of motion for the first 0.205 seconds is:

$$y''(t) = g(\cos(\omega t) - 1)$$

4.2 Stage 2

After $t=0.205$ the mirror will have dropped 7 mm and begins to engage the static support. The velocity at the beginning of stage 2 is -0.111 m/s.

The one-dimensional natural frequency η of 198 supports, each with a stiffness of 1600 lb/in, supporting a 20,000 lb mirror is:

$$\eta = \sqrt{\frac{k}{m}} = \sqrt{\frac{198 \times 1600 \times 384}{20,000}} = 78 \text{ (rad/second)} = 12.4 \text{ Hz}$$

The equation of motion from $t=0.205$ until the air pressure in the pneumatic cylinders drops to zero at $t=0.5$ is:

$$y''(t) = g(\cos(\omega t) - 1) - (\eta^2 \times y(t))$$

4.3 Stage 3

After $t=0.5$, the air in the pneumatic cylinder is depleted and the entire weight of the mirror is supported by the static support. The equation of motion simplifies to:

$$y''(t) = -(\eta^2 \times y(t)) - g$$

Using the maximum deflection of 3.2 mm shown in figure 2, the maximum deceleration equals 9.7m/s^2 or $0.99g$.

4.4 Static Deflection

The static deflection of the elastomer mount under the weight of the mirror can be calculated from the natural frequency.

$$y(\text{static}) = \frac{g}{\eta^2} = \frac{9810}{(78)^2} = 1.61\text{mm}$$

5.0 Summary

The current choice of elastomer static supports exerts a $0.99g$ load on the mirror. This is a very gentle and acceptable mirror "crash". The 3.2 mm maximum deflection of the support is small enough to assure that there is no interference between the mirror and any part of the mirror cell.

When the mirror comes to rest the weight of the mirror will cause the static supports to compress 1.61 mm.

Any frictional damping within the elastomer mount will have the effect of decreasing the maximum deflections and accelerations.

6.0 List of Figures

Figure 1. Static support layout

Figure 2. Plot of dynamic response