Segment Alignment Control System

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The segmented primary mirror for the LDR will require a special segment alignment control system to precisely control the orientation of each of the segments so that the resulting composite reflector behaves like a monolith. The W.M. Keck Ten-Meter Telescope, currently being constructed on the island of Hawaii, will utilize a primary mirror made up of 36 actively-controlled segments. Thus the Keck primary mirror and its segment alignment control system are directly analogous to the LDR. The problems of controlling the segments in the face of disturbances and control/structures interaction, as analyzed for the TMT, are virtually identical to those for the LDR.

In the TMT, the precise positioning of the segments so that their combined surfaces act as a uniform parabola is accomplished through the use of special actuators and sensors that form the segment alignment control system. FIGURE 1 is a plan view of the TMT primary mirror showing the segments and the locations of the actuators and position sensors. FIGURE 2 is a schematic diagram of the segment alignment control system. It illustrates the signal flow path and the way in which the sensors measure the relative displacement of two adjacent segments. An algorithm implemented in the control system computer calculates the angular position and the axial displacement for each segment relative to the desired orientation for the segment. Position commands, based on the computed errors, are sent to each of the 108 segment positioning actuators several times a second so that the surface of the mirror remains in the desired paraboloidal shape independent of deformations of the cell structure.

An analysis of the interaction between the segment alignment control system, the structural dynamics of the mirror cell, and the telescope optical system has been performed to determine to what extent disturbances, in particular aerodynamic forces from the wind acting on the primary mirror, would induce structural vibrations in the telescope and degrade optical performance. A second and equally important aspect of the study was to examine the structural dynamic/control system interaction. The primary effect of this interaction was to limit the bandwidth of the segment alignment system and, therefore, its ability to improve the optical performance in the presence of disturbances.

The three-dimensional plots of FIGURES 3 and 4 represent the total energy distribution at the prime focus. These plots are a good indication of how well the telescope's optical system and control system are performing because they show how photons arriving at the prime focus would be distributed. The improvement in the concentration of energy when the control system is engaged, as seen in FIGURE 4, is impressive. The dramatic improvement seen by comparing FIGURES 3 and 4 indicates that the

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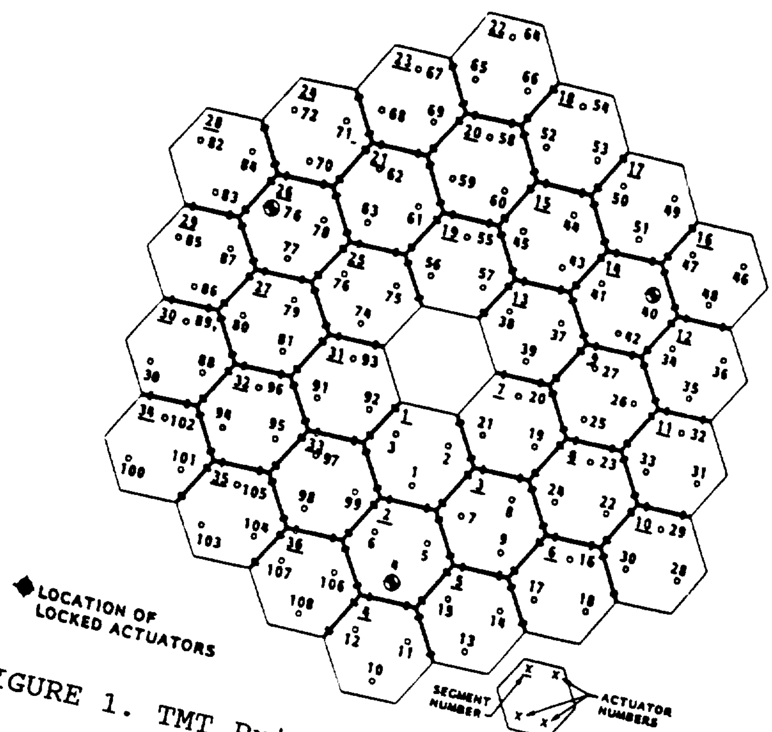
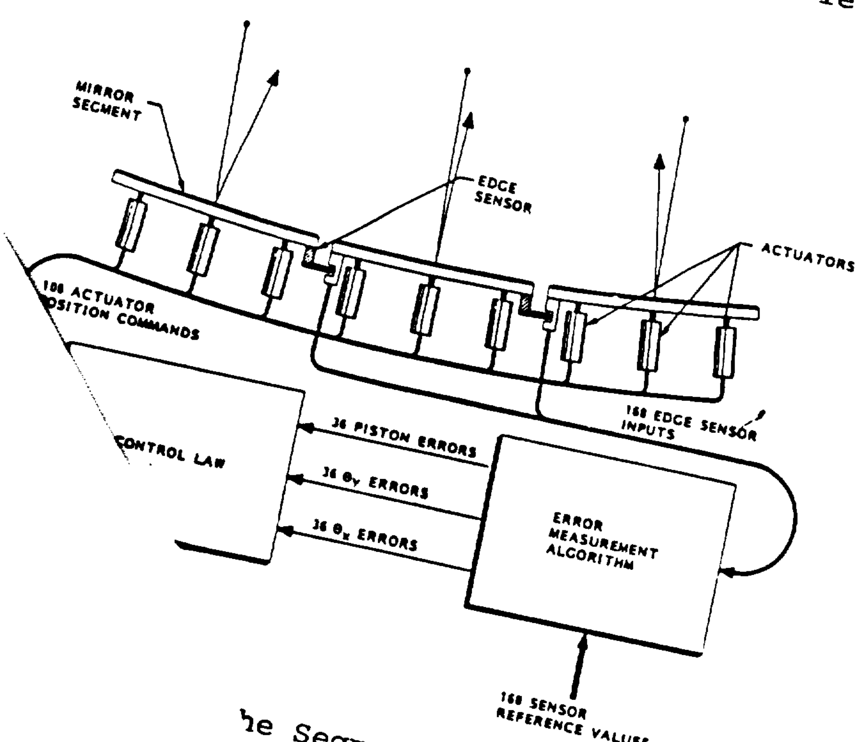


FIGURE 1. TMT Primary Mirror Plan View



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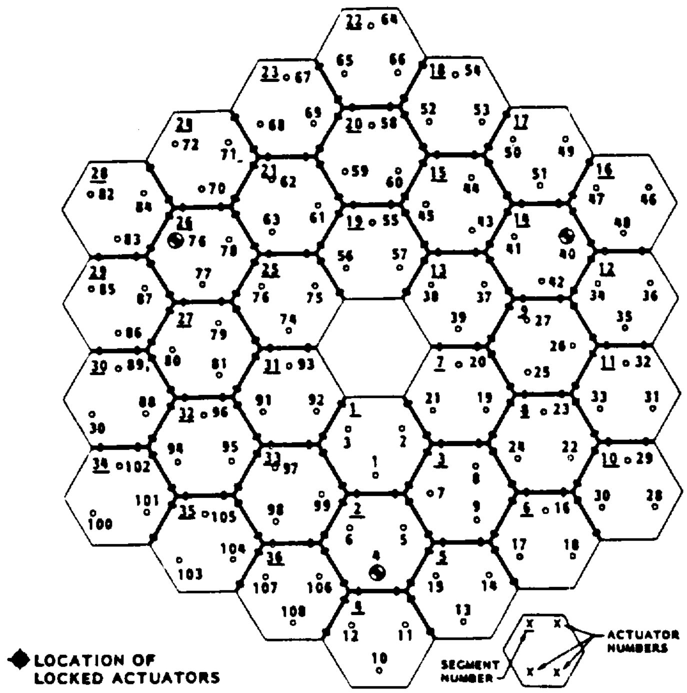

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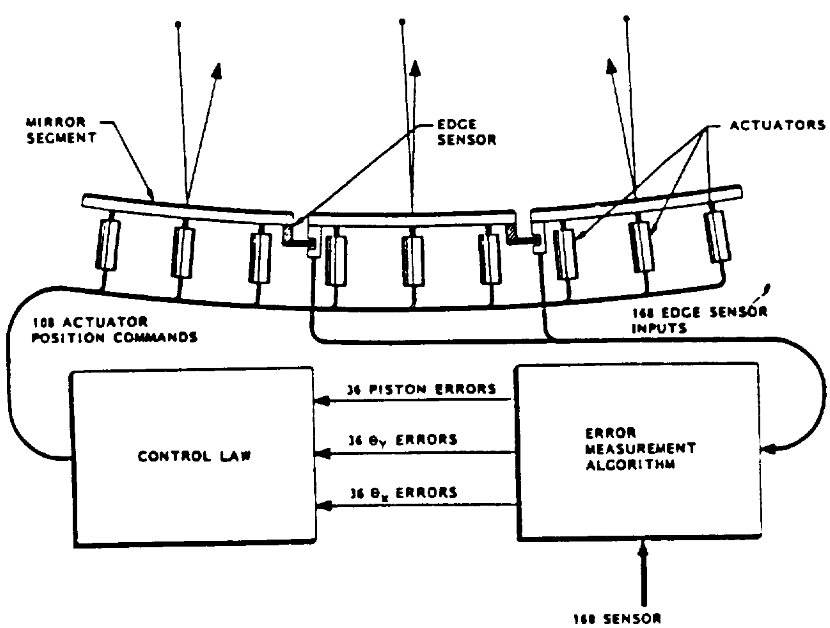

FIGURE 2. Schematic of the Segment Alignment Control System

B. Panels and Materials Papers