SURFACE MEASURING TECHNIQUE

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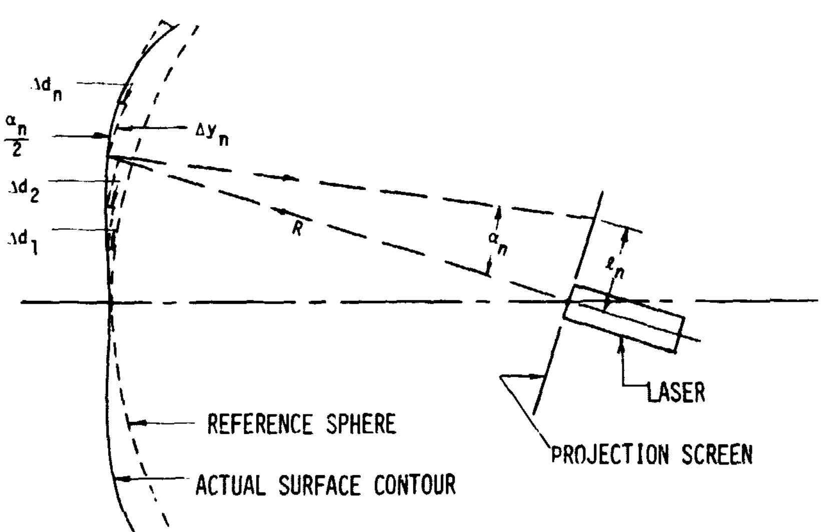
SURFACE MEASURING TECHNIQUE

A modified Foucault or knife edge test (ref. 1) is applied to measure the surface contour of a large circular electrostatically formed concave reflector. The technique is diagramed in the figure. The aperture of a 3 milliwatt HeNe laser is placed at the estimated center of curvature of the reflector with its beam directed toward the geometric center of the reflector. A projection screen to receive the reflected laser beam is attached to the laser and remains normal to the emerging laser beam as the laser scans the surface of the reflector. If the concave surface is a true spherical surface the reflected beam always returns to the laser aperture in the center of the screen. For a nonspherical surface the reflected beam falls on the screen at a distance, ℓ, from the laser aperture. From geometry the reflector surface deviations, Δd, from a truly spherical surface are related, to a good approximation, to the linear distance ℓ. The reflector's contour is calculated by summing the incremental Δd's for all incremental Δy's. An error analysis of the measurement technique indicates a 50 percent error in surface deviations is likely. Propagation errors due to the summing operation are known to contribute strongly to the error. More exact solutions are being sought.

REFLECTOR SURFACE MEASUREMENT TECHNIQUE
(MODIFIED FOUCAULT OR KNIFE EDGE TEST)



ASSUMPTION: $\ell \ll R$

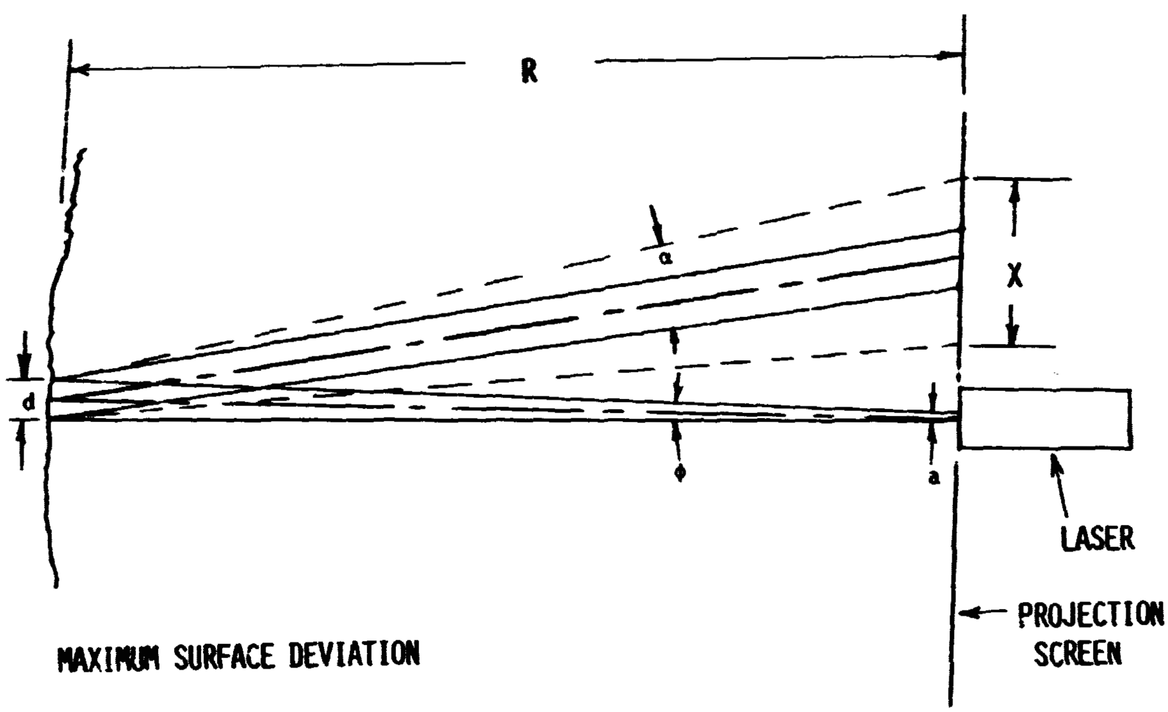
THEN $\pm\alpha \approx \frac{\pm\ell_n}{R}$ (RADIANS) AND $\pm\Delta d_n \approx \pm\frac{\alpha_n}{2}\cdot\Delta y_n$ (METERS)

APPROXIMATE SURFACE DEVIATION FROM REFERENCE SPHERE $d \approx \Delta d_1 + \Delta d_2 + \ldots \Delta d_n$

CHARACTERIZING SMALL SCALE SURFACE ROUGHNESS

Additional characterization of surface roughness on a scale small compared to the laser spot size at the reflector can be obtained from the increased laser spot size at the project screen. The maximum surface deviation, $h_{max.}$, from an average surface over the spot size, d, is given in terms of the laser parameters, the projection geometry and the increased laser spot size, x. The particular energy distribution in the increased laser spot size on the screen indicates a particular characteristic reflector surface roughness. Such indicators are helpful to characterize the surfaces of aluminized membranes applied to large space structures.

CHARACTERIZING SMALL SCALE SURFACE ROUGHNESS



MAXIMUM SURFACE DEVIATION

$$h_{max.} = d \cdot \alpha \text{ (METERS)}$$

WHERE

$$\alpha = \frac{\frac{1}{2}x + \frac{1}{2}(a + 2\phi R)}{R} \text{ (RADIANS)}$$

CONCAVE REFLECTOR PARAMETERS

The reflector was formed by loosely stretching an aluminized Kapton film over a plastic tube circular form. Two electrostatic electrodes are attached to the back of the reflector surface, one at the center of the circular surface and one concentric ring electrode located between the center and the edge of the reflector. Opposite potential electrodes are spaced a small distance behind those attached to the reflector. When potentials of 40,000 to 50,000 volts are applied the Kapton film tensions to form a concave surface. The surface material retains some creases which comes from handling and a few wavy wrinkles which are caused by material fabrication nonuniformities and assembly tensioning nonuniformities. Typical surface roughnesses due to creases are of the order of 0.1 mm while wrinkles are typically 1.0 mm.

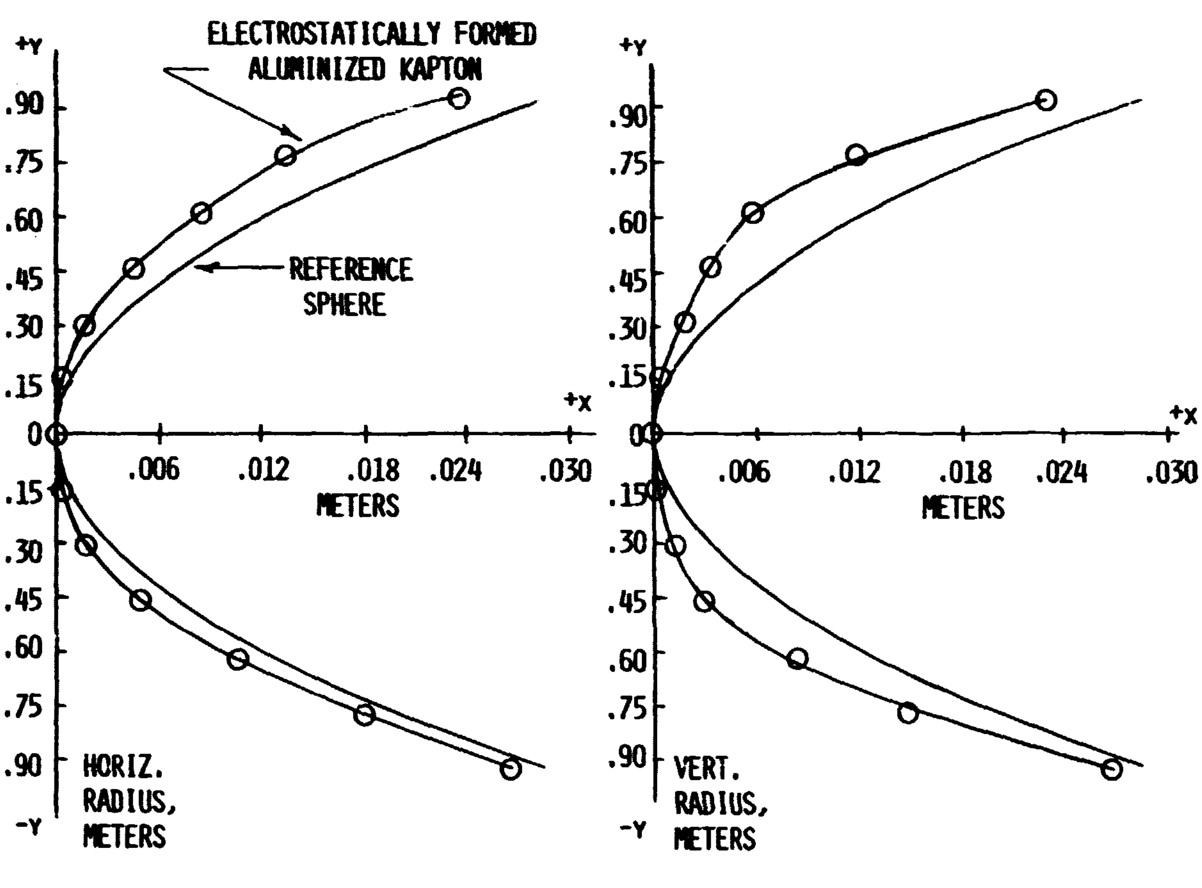
CONCAVE REFLECTOR PARAMETERS

- DIAMETER - 1.83 METERS (72 INCHES)
- FOCAL LENGTH - 7.32 METERS (288 INCHES)
- MATERIAL - ALUMINIZED KAPTON
- SURFACE FORMING - ELECTROSTATIC FIELD

MEASUREMENT RESULTS

A smooth curve of the actual electrostatically formed reflector surface is compared to a curve representing a reference sphere. Measurements of surface slope and deviation were calculated every 15 cm along the reflector's horizontal and vertical diameters using the modified knife edge measurement technique. The reference sphere and the actual surface were adjusted to coincide at the geometric center of the circular reflector. The maximum deviation from a sphere is approximately 6 mm. No effort was made to electrostatically control the figure of the surface during these measurements.

REFLECTOR SURFACE ACCURACY MEASUREMENT RESULTS



REFERENCE

1. Smith, Warren J.: Modern Optical Engineering, The Design of Optical Systems, pp. 439-443, McGraw-Hill Book Company, New York, New York.