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JPL TESTS OF A LAJET CONCENTRATOR FACET

By
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November 15, 1983

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ABS: A LaJet Energy Company (LEC) concentrator facet, 60 in. in diameter, was tested for imaging quality. The following two methods were used: (1) autofocus tests with a point source of light at the facet's radius of curvature; and (2) tests with the Sun close to the horizon as a distant source. The tests of the LaJet facet indicate that all of the solar image reflected by an LEC 460 solar concentrator made of like facets should fall within a 9-in. aperture if the outer facets are carefully adjusted. Such a concentrator would have acceptable performance, but complete evaluation must be made with an assembled concentrator.

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JPL Tests of a LaJet Concentrator Facet

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ABSTRACT

A LaJet Energy Company (LEC) concentrator facet, 60 in. in diameter, was tested for imaging quality at the Jet Propulsion Laboratory using two methods: (1) autofocus tests with a point source of light at the facet's radius of curvature, and (2) tests with the sun close to the horizon as a distant source. These tests of the LaJet facet indicate that all of the solar image reflected by an LEC 460 solar concentrator made of like facets should fall within a 9-in. aperture if the outer facets are carefully adjusted. Such a concentrator would have acceptable performance, but complete evaluation must be made with an assembled concentrator.

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SECTION I

INTRODUCTION

This report covers the imaging quality tests of a LaJet Energy Company (LEC) concentrator facet by Jet Propulsion Laboratory (JPL) personnel on May 24 and June 23, 1983. The facet is aluminized polyester film stretched over a partially evacuated round drum. The tests of this facet were performed at the JPL Foothill facilities in Pasadena, California, and at the JPL Parabolic Dish Test Site (PDTS), Edwards Test Station in the Mojave Desert, California. The light sources for these tests were a point source of light and the sun. For all of the tests, the facet focal length was 235 in. (470-in. radius of curvature). The installed facets will have focal lengths in the range of 210 to 250 in. The radius of curvature of each facet will be different, but the image quality of the assembled concentrator will be very similar to the test configuration. The purpose of these tests is to evaluate the imaging characteristics of a sample facet and to demonstrate the type of tests that can be conducted for quality control during facet manufacture and for characterization of a complete concentrator.

SECTION II

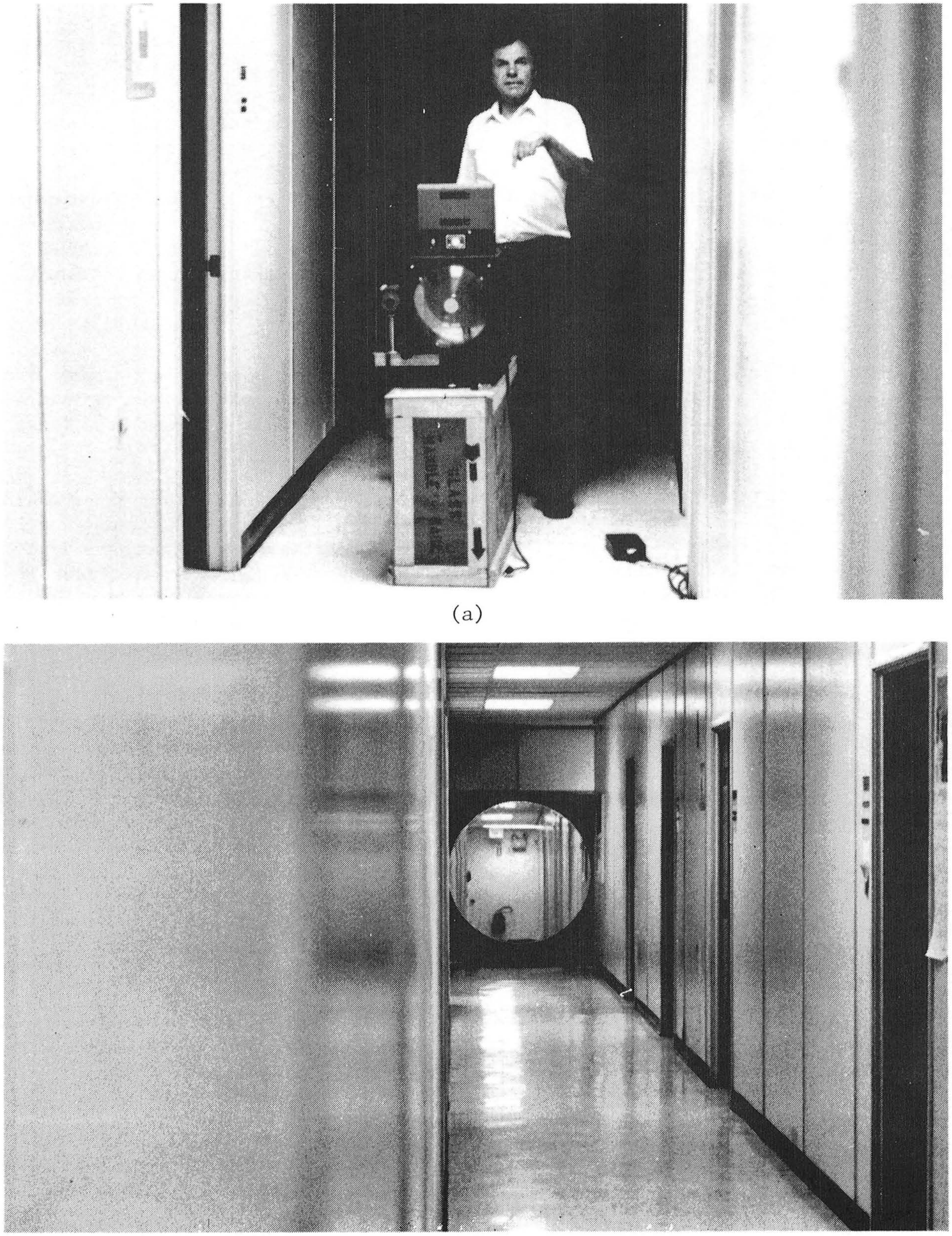
AUTOFOCUS TESTS

For the autofocus tests, the point source of light and the image plane were positioned close to the optical axis at a distance equal to the radius of curvature. For a perfect spherical facet, the image will be a point. This configuration has been used very successfully for testing of the PDTS test-bed concentrator facets. Figures 1a and 1b are photographs of the test configuration. Figures 2a through 2h are images made with the point source at the radius of curvature and a sequence of image planes near the source. These images show the optical aberrations that are present. A perfect spherical facet would have uniform circles for out-of-focus images. This highly sensitive optical test shows details of the image errors that otherwise would not be visible with the sun as a source. This effect can be seen by comparing the point source and solar source images included in this report. (See Figures 4 and 6.) The autofocus images are two times larger than the images that would be formed from a point source at infinity.

The quantitative measurements were made with a Fresnel lens in the image plane (at the radius of curvature), which formed an image of the facet on a translucent screen. This screen was viewed by a photometer to measure the amount of light in the image. A series of apertures and disks were mounted on the Fresnel lens to block the light outside or inside circular zones. The light not obscured by these masks was measured by the photometer.

Figure 3 is a graphical representation of the measured data. Each point indicates the fraction of the total image that falls inside of the indicated aperture radius. This type of graph is called an "intercept factor curve." The solid line is the mathematical representation of the measured data. This mathematical representation was used to estimate the intercept factor curve, which will be found with the sun as a source. If the facet imaging quality is good, then the optical aberrations and the size of the sun will determine the concentrator performance. Conversely, if the facet imaging quality is poor, the size of the sun and the aberrations will have little effect on concentrator performance. The difference between the point source curve and the estimated solar curve indicates that the facet imaging quality is acceptable. If this facet had somewhat larger errors, the concentrator performance would be degraded; that is, the safety margin is small.

Figures 4a through 4e are photographs of the image of the facet formed by the Fresnel lens through some of the focal plane apertures. These diagnostic photographs show the areas of the facet that form the image inside the aperture. The images indicate that the most serious image defects arise from the ellipsoidal shape of the facet surface, which could be the result of the biaxial character of the film or a slight imperfection in the shape of the support ring. If the film had been rotated with respect to the ring or the ring had been forcibly distorted, then this type of diagnostic photograph could be used to locate the source of these imperfections. The diagnostic photographs also show that there are some small imperfections in the facet surface near the support ring. None of the imperfections in the tested facet caused significant errors in the image, but a small increase in these imperfections would lead to serious image degradation.



(a)

(b)

Figure 1. Test Configuration for Autofocus Tests

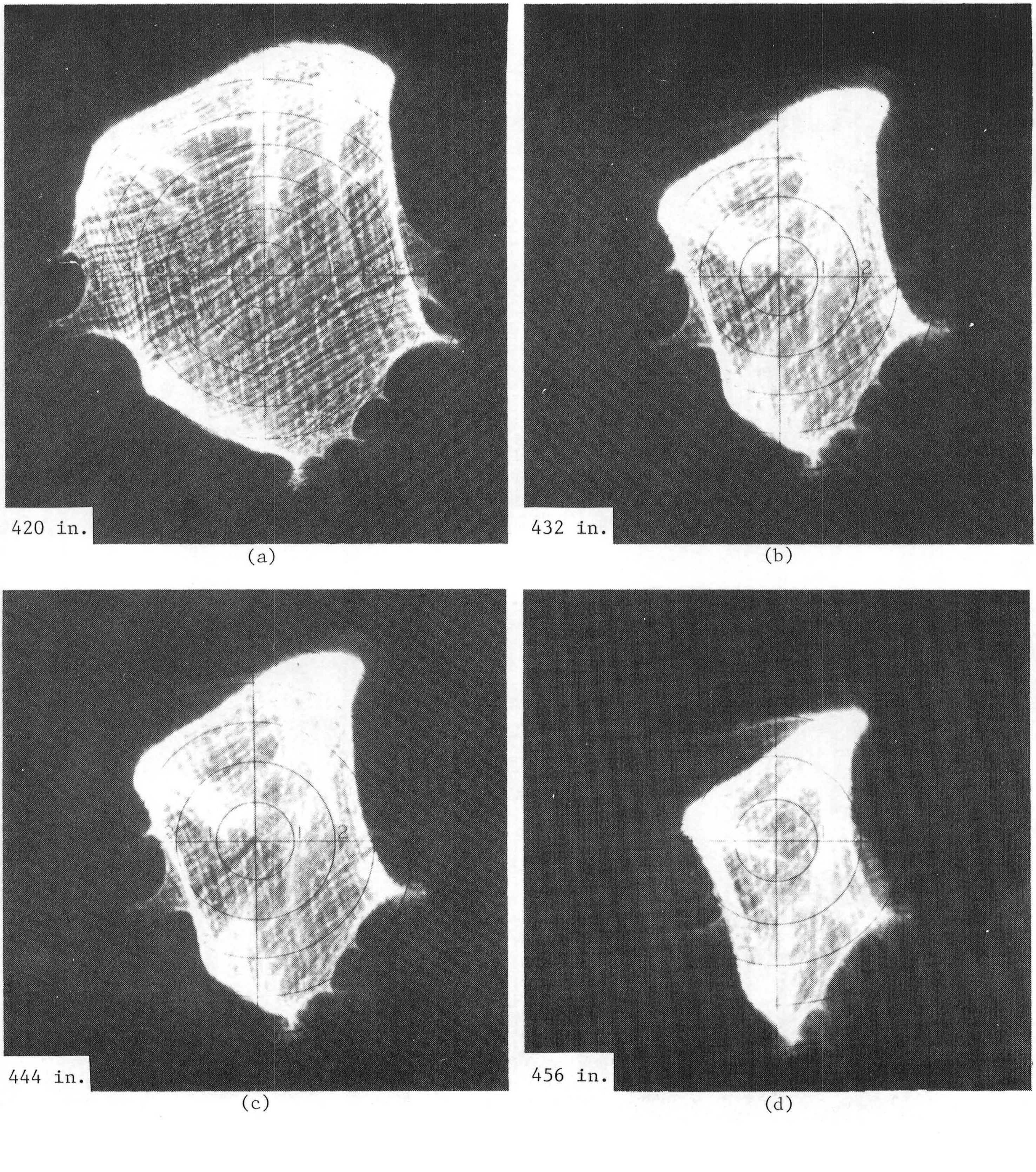
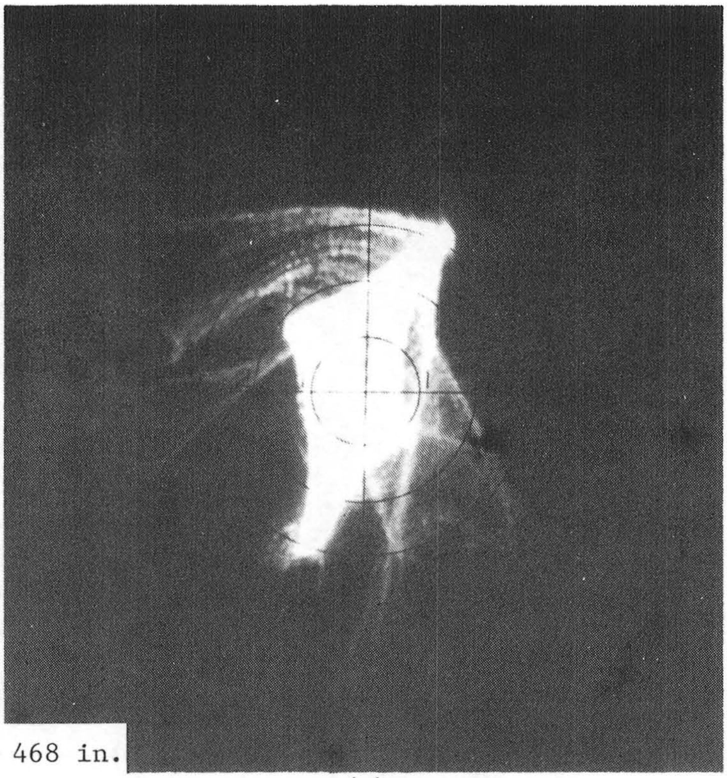
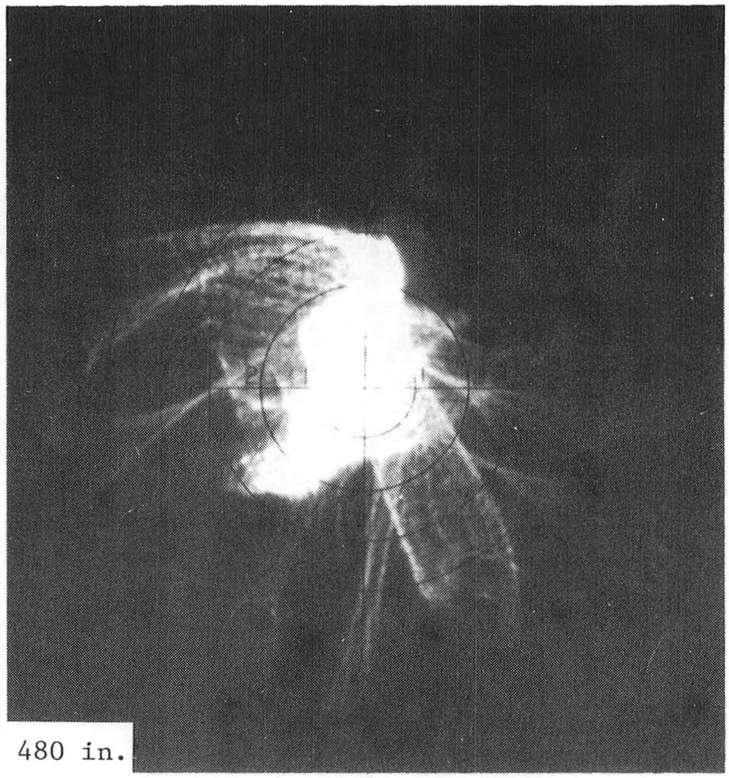


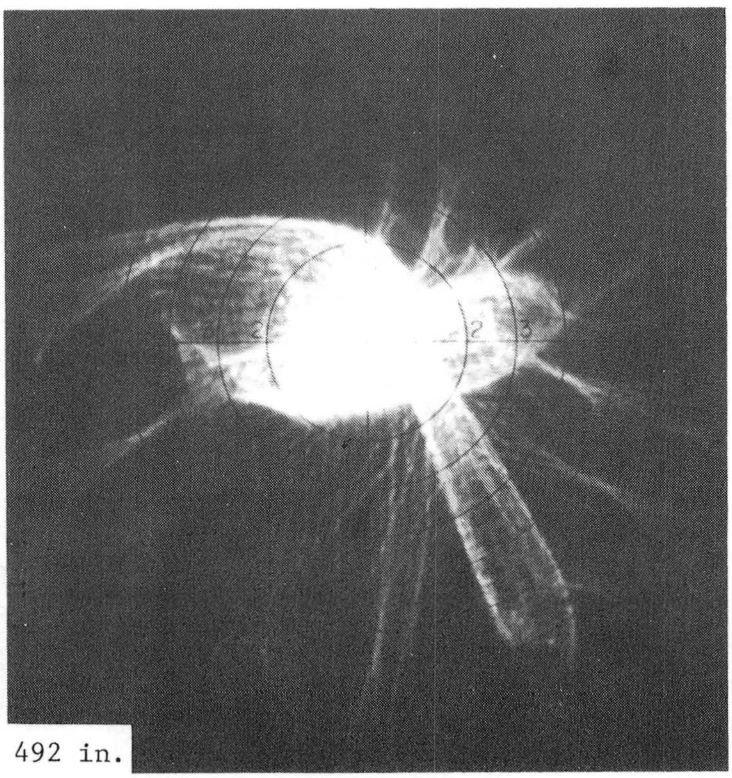
Figure 2. Images of Facet with Point Source at Radius of Curvature



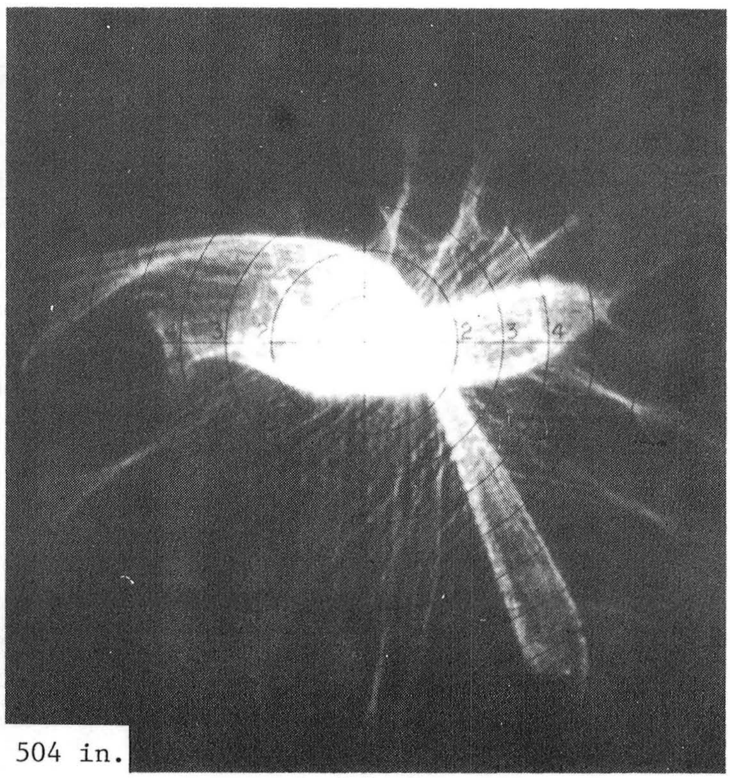
(e)



(f)



(g)



(h)

Figure 2. Images of Facet with Point Source at Radius of Curvature (Cont'd)

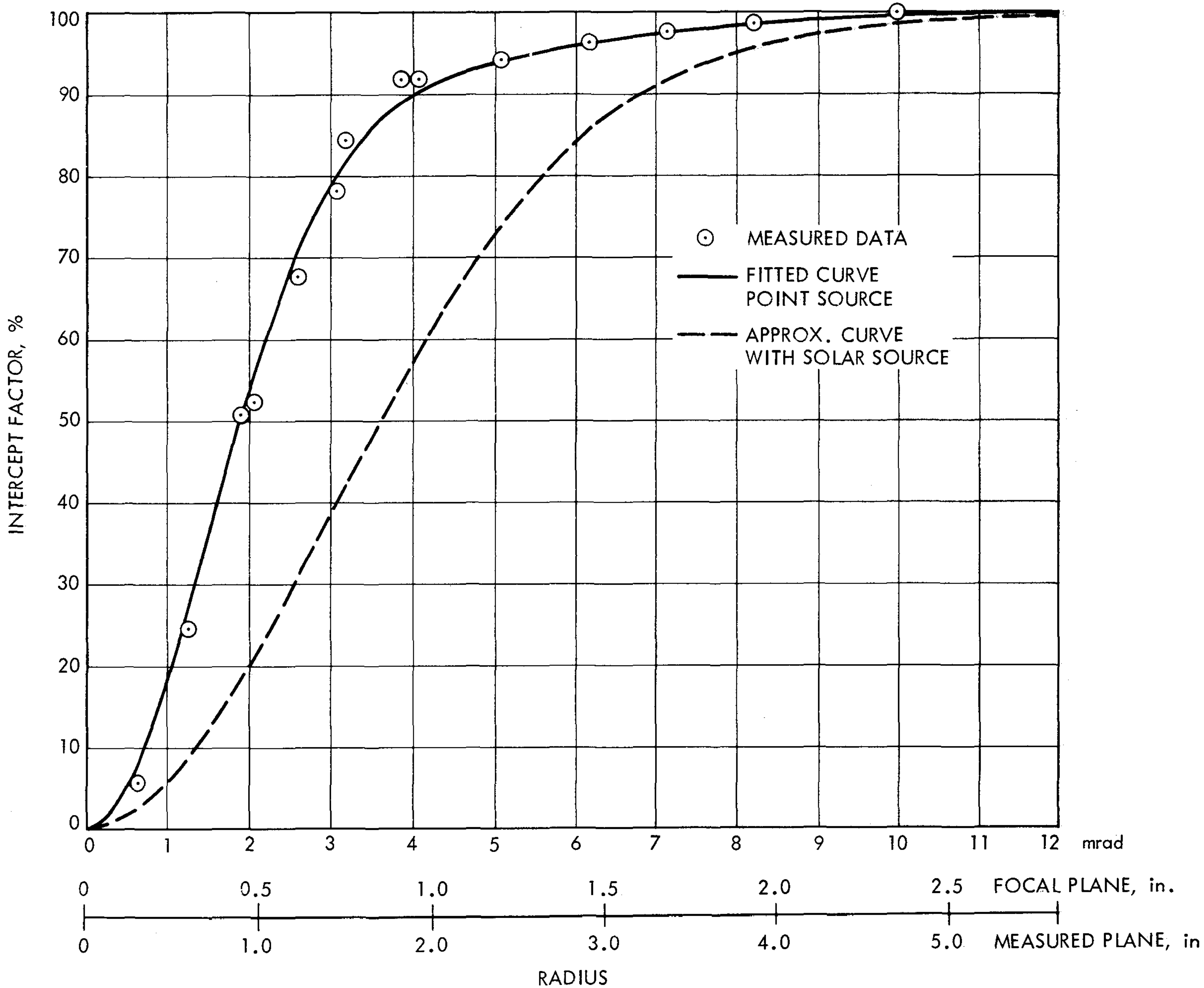


Figure 3. Intercept Factor Curve Using Measured Data

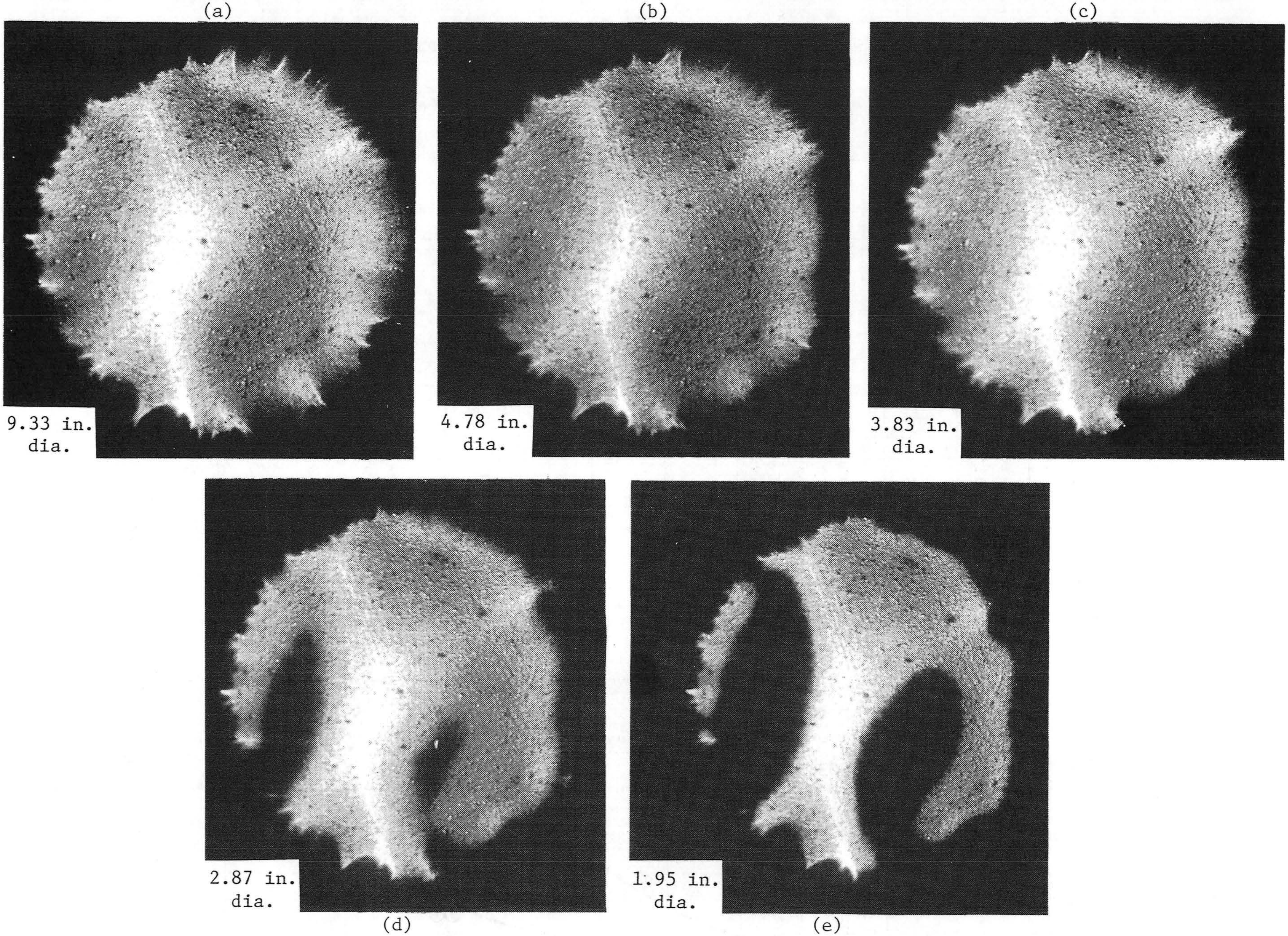


Figure 4. Images of Facet Formed Through Focal Plane Apertures with a Fresnel Lens

SECTION III

SOLAR SOURCE TESTS

The final series of tests were made at the Parabolic Dish Test Site, Edwards Test Station, using the sun near the horizon as a source. The facet was tested in both on-axis and off-axis configurations. The on-axis configuration represents a facet positioned near the optical axis of an assembled LEC 460 concentrator; the off-axis configuration is for a facet at the outer edge of the concentrator. The off-axis configuration is shown in Figure 5.

In addition to photographing the image of the sun in the nominal focal plane, the images were photographed 1 ft either side of the nominal focal plane along the target/facet line. These images are shown in Figures 6a through 6f. The white metal target had concentric circular slots with radial increments of 1 in. As expected, the largest image was found at the off-axis position. The smallest off-axis image appears to be a short distance behind the nominal focal plane and has a diameter of between 8 and 9 in. As indicated by the autofocus tests, the on-axis image is very good.

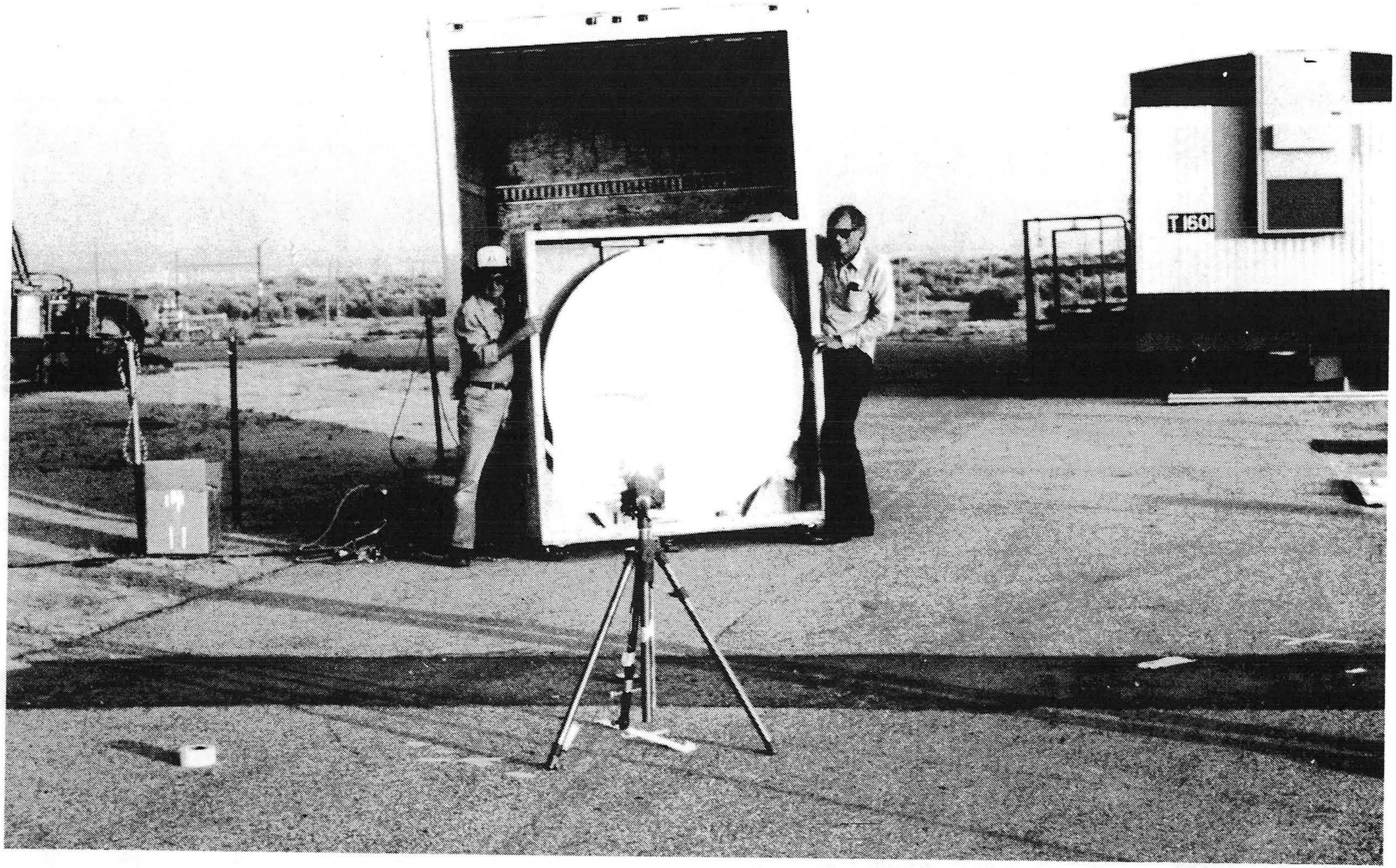
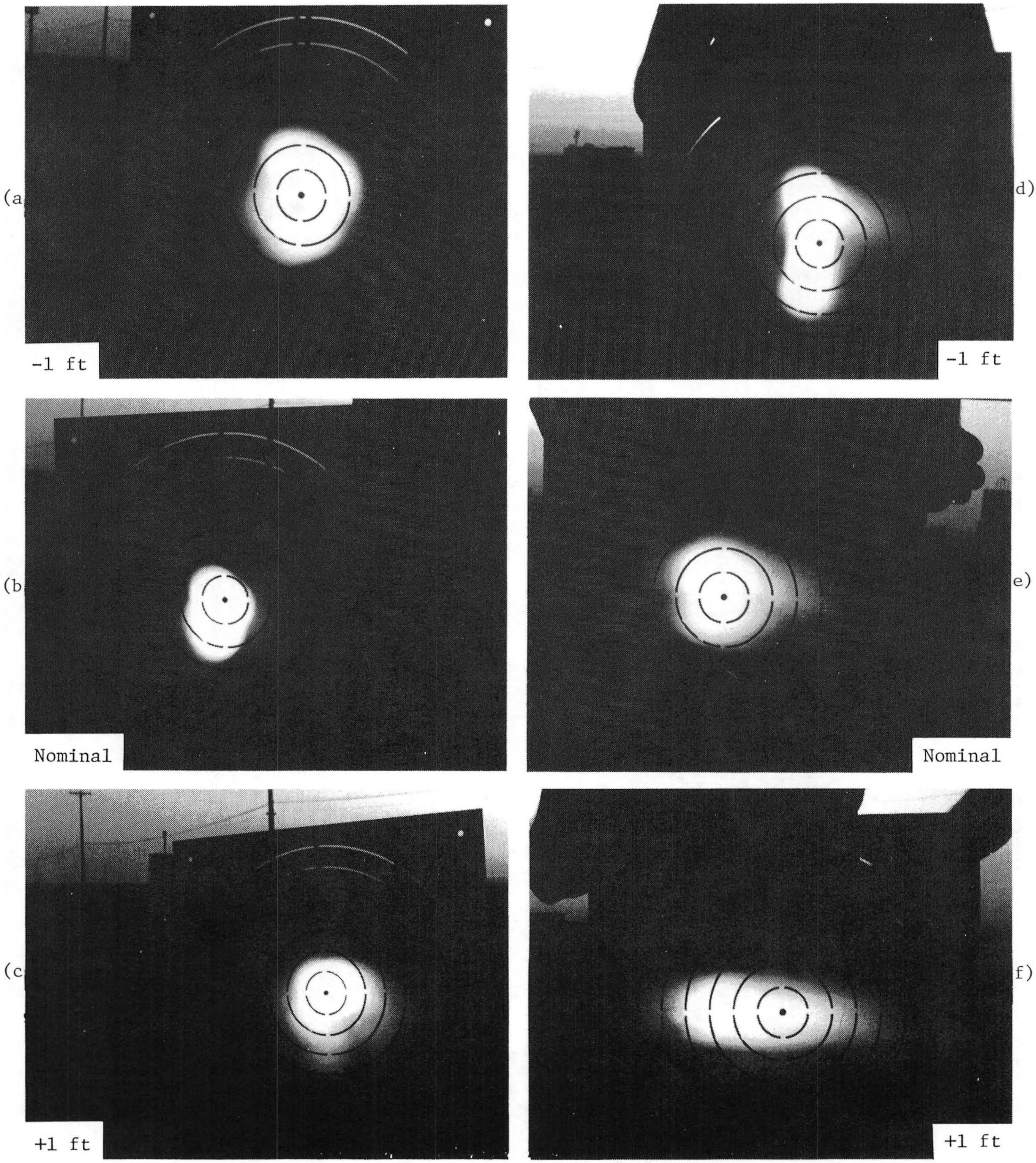


Figure 5. Test Configuration for Sun Tests



On Axis

Off Axis

Figure 6. Images of Facet with Sun as Source

SECTION IV

CONCLUSION

The JPL tests of the sample LaJet facet indicate that all of the solar image should fall within a 9-in. aperture if the outer facets are carefully adjusted. The facet surfaces are measurably different from a spherical surface. Although these surface imperfections are not large enough to cause serious image degradation, it is clear that manufacturing procedures must be carefully controlled to insure that the LaJet concentrator has an acceptable operating performance. The tests covered by this report give an indication of concentrator performance, but the final evaluation of performance must be made with an assembled concentrator.

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