# PHOTOMETRIC STUDIES OF THE AUSTIN "MOONLIGHT" TOWER LIGHTING SYSTEMS

By

Neilon J. Rowan

and

Ned E. Walton

Research Report 75-4

Supplementary Studies in Highway Illumination

Research Study Number 2-8-64-75

Sponsored by

The Texas Highway Department

In Cooperation with the

U. S. Department of Commerce, Bureau of Public Roads

October, 1966

TEXAS TRANSPORTATION INSTITUTE

Texas A&M University
College Station, Texas

TABLE OF CONTENTS



The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Bureau of Public Roads.

# PHOTOMETRIC STUDIES OF THE AUSTIN "MOONLIGHT" TOWER LIGHTING SYSTEMS

Through the cooperation of the city of Austin, Texas and the Texas Highway Department, the Texas Transportation Institute conducted a study of photometrics at the location of one of the 150-foot "moonlight" towers in Austin. This tower was equipped with six vertical burning mercury vapor lamps mounted in radial reflectors at uniform angular spacings of 60°. Photometric data were obtained for clear and phosphor coated mercury vapor lamps of 400- and 1000-watt type to determine the applicability of this simplified system to interchange "area" lighting. This study constituted one step in the high-level lighting phase of Research Project 2-8-64-75, "Supplementary Studies in Highway Illumination".

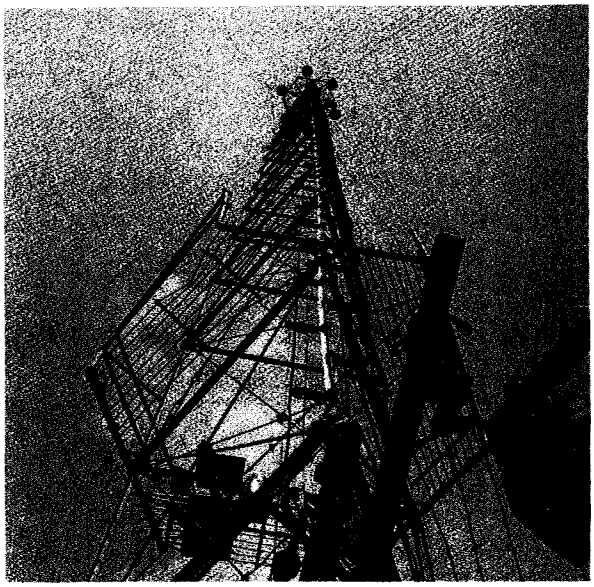
## Photometric Studies

Photometric studies were conducted at the Austin "moonlight" tower (Figure 1) to take advantage of the 150-foot mounting height which was not available at the highway illumination test facilities at the Texas A&M Research Annex. As previously indicated, four different types of lamps were used in these studies. Descriptions of the lamps and their rated output are as follows:

1. 400-watt mercury vapor, clear, 21,500 lumens.
2. 400-watt mercury vapor, phosphor coated, 21,000 lumens.
3. 1,000-watt mercury vapor, clear, 57,000 lumens.
4. 1,000-watt mercury vapor, phosphor coated, 54,000 lumens.

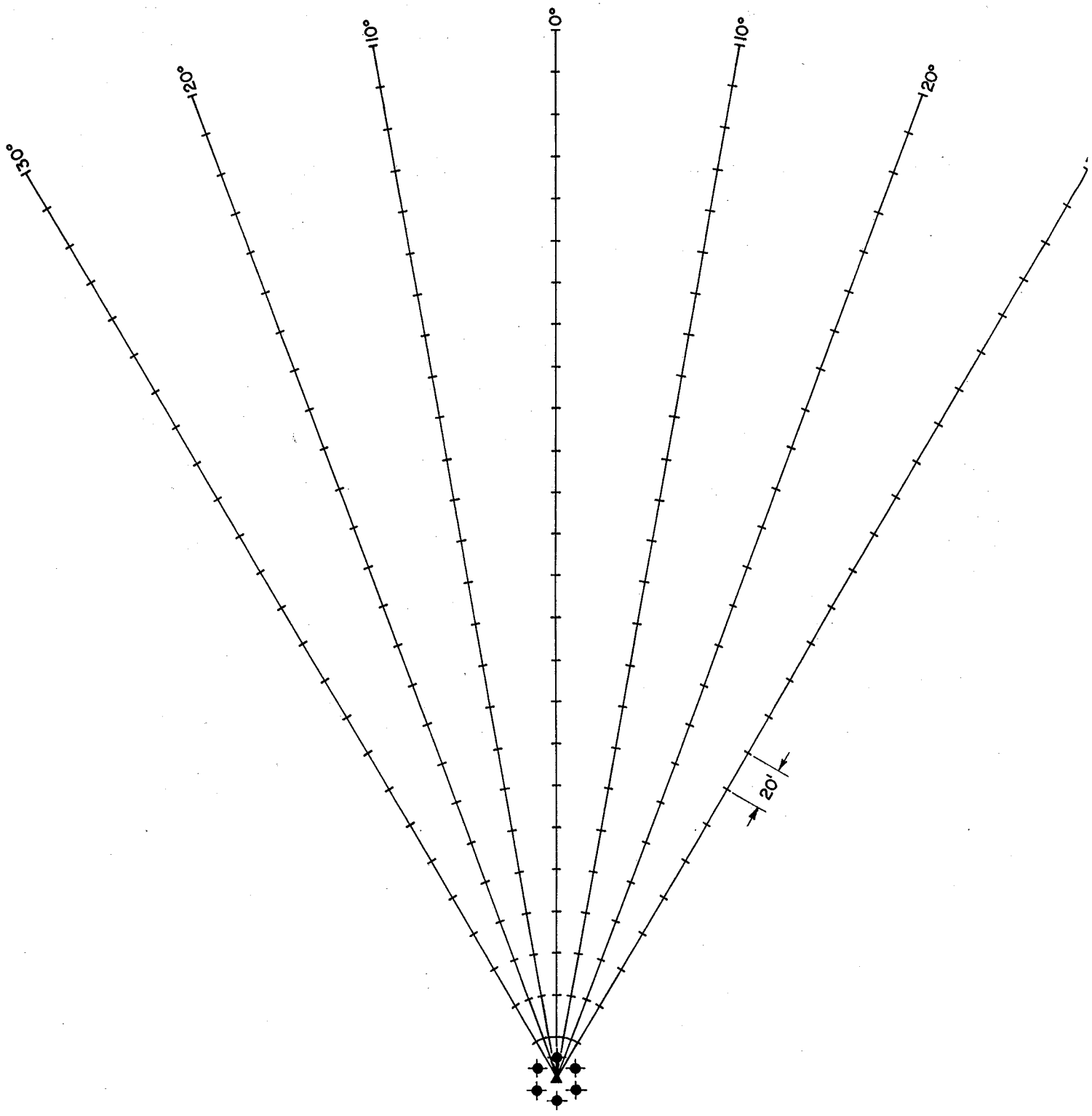
Each of the four different systems involved six lamps mounted in a 10-foot circle with 60° spacings. Each lamp was mounted vertically in an 18-inch radial type porcelain reflector.

A GE SL480-A street lighting meter, designed and calibrated to measure horizontal footcandles, was used for the photometric studies. To facilitate these studies, a 60° sector of the total lighted area was selected and radials bordering and within this sector were selected at 10° intervals, as shown in Figure 2. Then, points along each of these radials were established for measuring points so that consistent photometric data could be obtained. The center radial of the 60° sector was so positioned that it was aligned with one



"MOONLIGHT" TOWER LIGHTING SYSTEM

FIGURE 1




PLAN VIEW OF 60°-SECTOR STUDIED

FIGURE 2

of the six lamps. Since the lamps were uniformly spaced, this sector was assumed to be representative of all other sectors that may have been selected, and therefore, the data could be expanded to represent the entire lighted area.

## Results

A comparison of the various systems was made on the basis of the horizontal footcandle measurements. The photometric data obtained in these studies were tabulated and are included in the appendix. Iso-footcandle curves were prepared for each of the systems and are presented in Figures 3, 4, 5, and 6.

In the discussion of each of the systems, the principal concern is minimum light intensity within a given lighted area, and the uniformity of light within that area. By current THD standards for conventional roadway lighting, 0.10 horizontal footcandle is the minimum acceptable value, and all systems are evaluated on that basis. However, the experience with these systems and others indicates that the current standards for conventional lighting are not applicable to high-level lighting. The principal concern in any lighting installation is to provide adequate visibility, and high-level lighting systems provide good visibility well beyond the minimum of 0.10 footcandle. For this reason and for the lack of a better yardstick for comparison, a minimum value of 0.05 horizontal footcandle was arbitrarily selected as a second or alternate basis for comparison of the various systems.

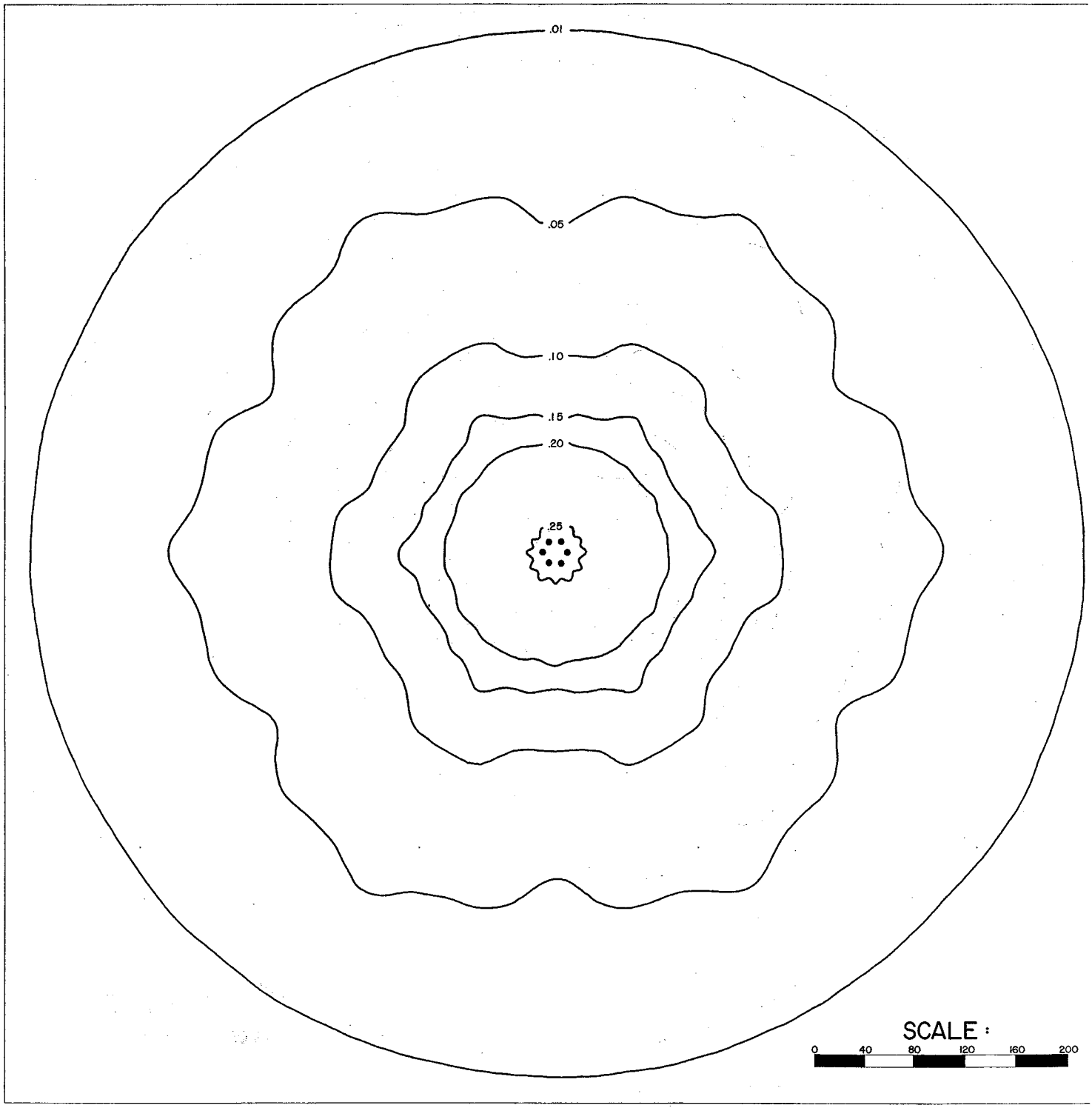
## 400-Watt Clear Lamps

The 400-watt clear lamp system provided an effective radius of lighted area of 200 feet with a minimum intensity of 0.10 horizontal footcandle. Considering the minimum acceptable intensity to be 0.05 horizontal footcandle, the effective radius of this system was 300 feet.

Maximum to minimum and average to minimum intensity ratios were computed for the 0° radial (Figure 2). All rays within a given sector produce quite similar intensity values and would, therefore, yield essentially the same uniformity ratios as the 0° radial. For the 0.10 minimum acceptable value, the maximum to minimum ratio was 2.6 and the average to minimum ratio was 1.8. Considering the minimum acceptable intensity to be 0.05, the maximum to minimum ratio was 5.2 and the average to minimum ratio was 2.8.

## 400-Watt Phosphor Coated Lamps

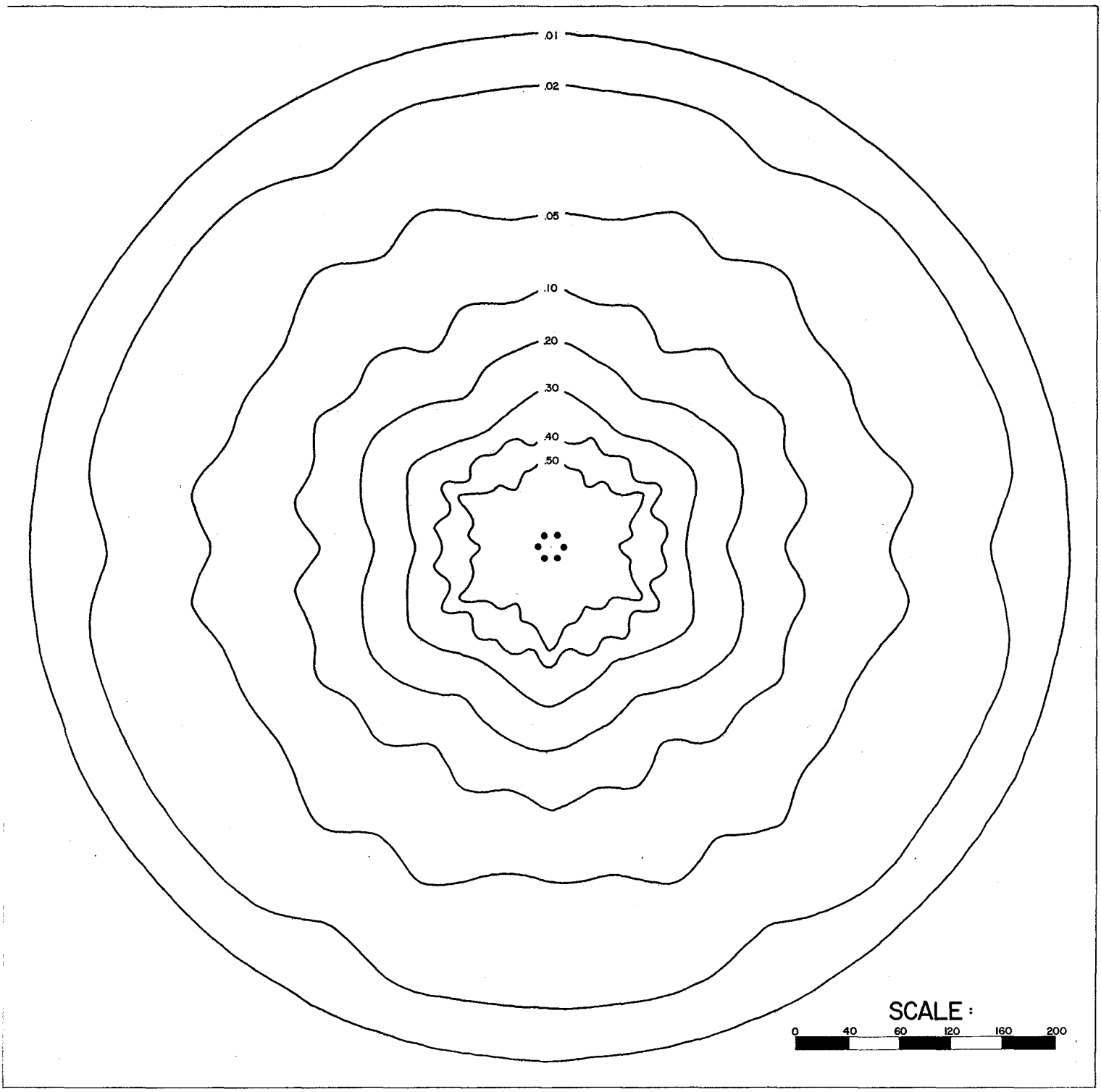
Considering the area within the minimum acceptable intensities, this system was very similar to the system using clear lamps. An effective




ISO-FOOTCANDLE CURVE 400 WATT CLEAI

MOUNTING HEIGHT : 150'

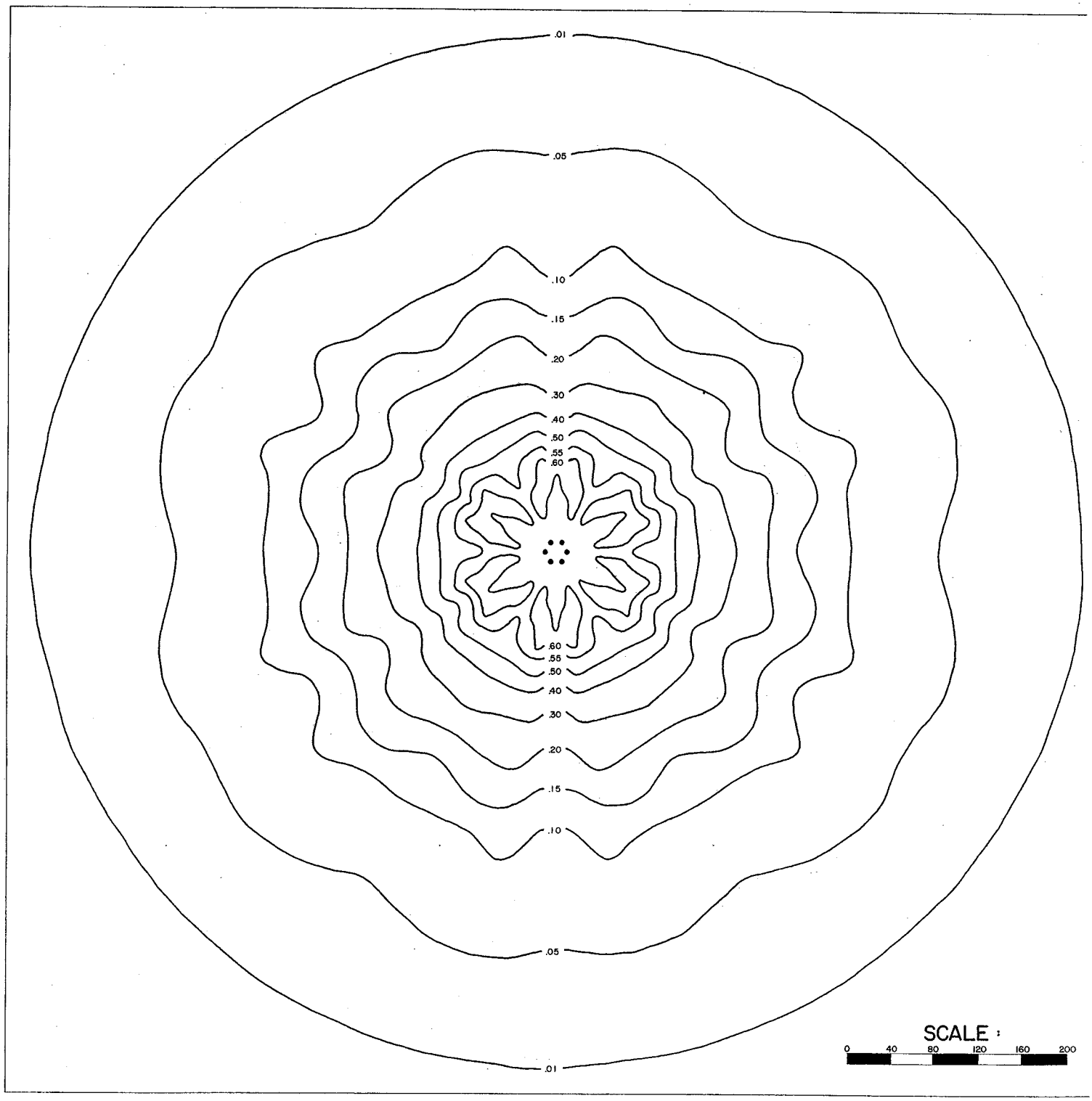
FIGURE 3




ISO-FOOTCANDLE CURVE 400 WATT PHOSPHOR COATED

MOUNTING HEIGHT : 150'

FIGURE 4

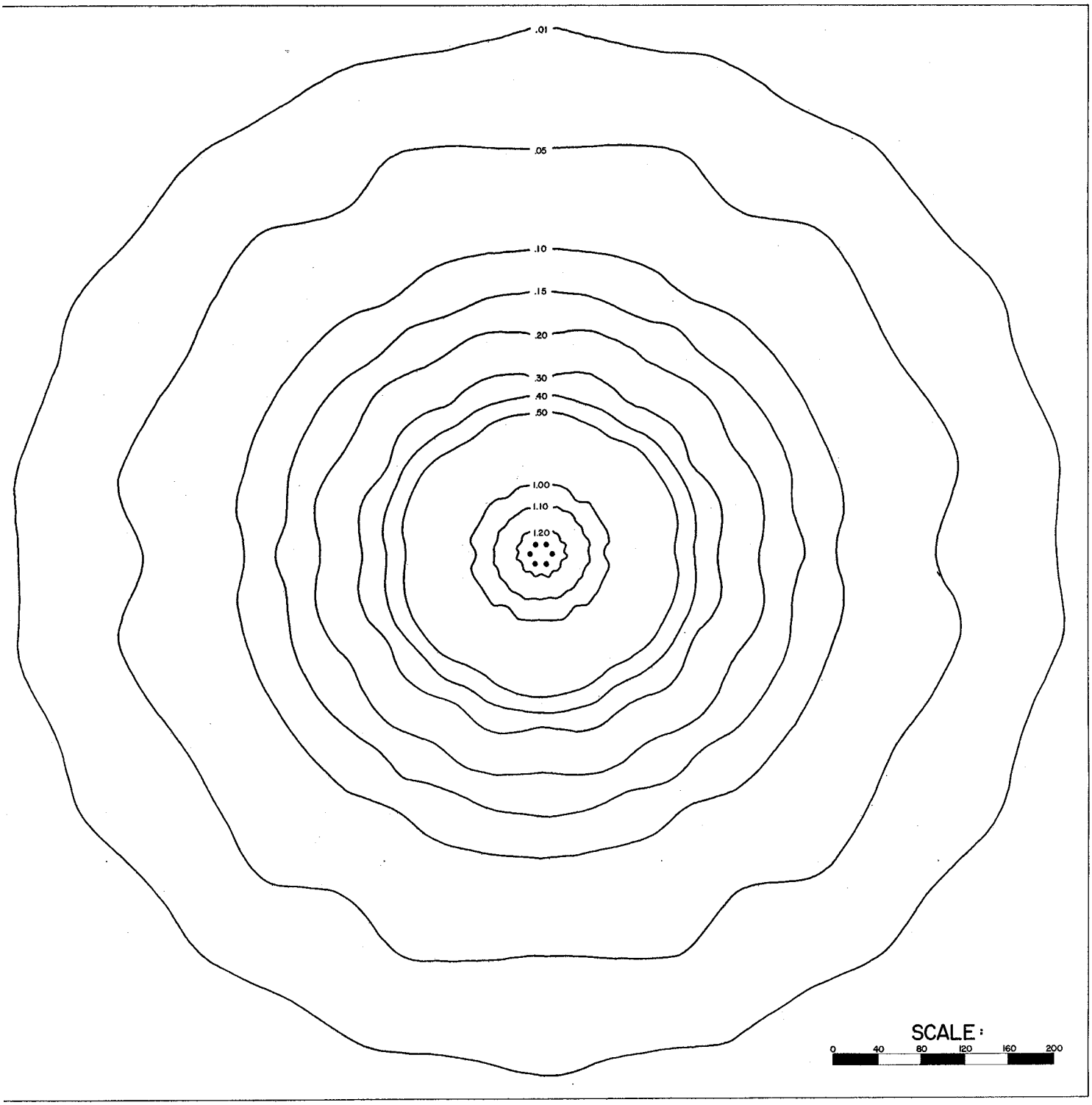



ISO-FOOTCANDLE CURVE

1000 WATT CLEAR

MOUNTING HEIGHT : 150'

FIGURE 5




SO-FOOTCANDLE CURVE 1000 WATT PHOSPHOR COATED

MOUNTING HEIGHT : 150'

FIGURE 6

radius of 200 feet was obtained on the basis of the 0.10 footcandle minimum. For the 0.05 footcandle minimum this radius was 280 feet. The maximum to minimum and average to minimum ratios were considerably higher, however; 7.8 and 4.0, respectively, for the 0.10 footcandle minimum, and 15.6 and 6.1 respectively, for the 0.05 minimum. These larger ratios indicate that the coated lamps direct considerably more light to an area immediately adjacent to the tower.

1000-Watt Clear Lamps

With the higher output of the 1000-watt clear lamps, an effective radius of 280 feet was obtained using 0.10 footcandle as a minimum. The maximum to minimum ratio was 6.1 and the average to minimum ratio was 4.7. Based on a minimum intensity of 0.05 footcandles the effective radius was extended to 380 feet with a maximum to minimum ratio of 12.2 and average to minimum ratio of 6.6.

1000-Watt Phosphor Coated Lamps

The 1000-watt phosphor coated lamps increased the maximum intensity values considerably while the effective radius remained at 280 feet for the 0.10 footcandle minimum and 380 feet for the 0.05 footcandle minimum. Since the maximum intensity values were increased appreciably, the maximum to minimum and average to minimum ratios were increased accordingly. These were 12.0 and 7.3 respectively for the 0.10 footcandle minimum and 24.0 and 10.2 respectively for the 0.05 footcandle minimum.

General Appraisal

It is immediately obvious that the current standards for conventional roadway lighting are not applicable to high level lighting. The 0.10 horizontal footcandle minimum intensity is not indicative of visibility conditions provided by the high-level lighting systems. Simply by observation it would appear that adequate visibility can be realized with intensity levels at 0.05 footcandles or less. It is apparent that other criteria must be established for judging or evaluating high-level lighting systems.

Some ideas regarding the development of new criteria can be gained in defining or discussing the anticipated function of high-level area lighting. The objective in high-level lighting is to provide sufficient light in an interchange area so that the driver will be able to establish the geometric configuration of the interchange in its proper relation. For this purpose a panoramic view, that is, an unobstructed or complete view of the area in every direction is required to obtain such general information. The driver recognizes vertical surfaces much more readily than horizontal surfaces. In other words, it is more important

that the driver see relief features rather than roadway surfaces. In order that vertical surfaces may be readily seen, the horizontal component of light rays (vertical footcandles), takes on a greater importance than do horizontal footcandles. Therefore, for regions of low intensity in terms of horizontal footcandles, the vertical footcandles (the horizontal component) are much greater and thus enhance the visibility of objects which present a vertical surface. On this basis, it is possible that vertical footcandles would be a more realistic measure of the performance of high-level lighting systems.

The panoramic view provided by the systems was excellent, especially with the 1000-watt phosphor coated lamps. Continued efforts should be directed to the establishment of new area lighting criteria and to the science of developing more effective high-level lighting systems.

# A P P E N D I X  A

Photometric Data
400-Watt Clear Lamps
60-Degree Sector

| Distance From Light Source (Ft.) | Horizontal Footcandles* | | | | | | |
|---|---|---|---|---|---|---|---|
| | 30° | 20° | 10° | 0° | 10° | 20° | 30° |
| 20 | .26 | .25 | .24 | .26 | .24 | .25 | .26 |
| 40 | .22 | .21 | .22 | .21 | .22 | .21 | .22 |
| 60 | .27 | .25 | .24 | .25 | .24 | .25 | .27 |
| 80 | .26 | .27 | .26 | .25 | .26 | .27 | .26 |
| 100 | .22 | .21 | .22 | .24 | .22 | .21 | .22 |
| 120 | .18 | .19 | .17 | .17 | .17 | .19 | .18 |
| 140 | .16 | .15 | .13 | .13 | .13 | .15 | .16 |
| 160 | .13 | .12 | .12 | .13 | .12 | .12 | .13 |
| 180 | .11 | .12 | .10 | .10 | .10 | .12 | .11 |
| 200 | .10 | .10 | .09 | .09 | .09 | .10 | .10 |
| 220 | .09 | .09 | .08 | .08 | .08 | .09 | .09 |
| 240 | .08 | .08 | .08 | .08 | .08 | .08 | .08 |
| 260 | .07 | .07 | .07 | .06 | .07 | .07 | .07 |
| 280 | .06 | .06 | .06 | .05 | .06 | .06 | .06 |
| 300 | .06 | .05 | .06 | .04 | .06 | .05 | .06 |
| 320 | .05 | .05 | .04 | .04 | .04 | .05 | .05 |
| 340 | .05 | .04 | .04 | .03 | .04 | .04 | .05 |
| 360 | .04 | .04 | .03 | .03 | .03 | .04 | .04 |
| 380 | .03 | .03 | .03 | .02 | .03 | .03 | .03 |
| 400 | .02 | .03 | .02 | .02 | .02 | .03 | .02 |
| 420 | .02 | .02 | .02 | .02 | .02 | .02 | .02 |
| 440 | .01 | .01 | .01 | .01 | .01 | .01 | .01 |

*0-degree ray is aligned with one light source; 30-degree ray is midway between two light sources.

Photometric Data
400-Watt Phosphor Coated
60-Degree Sector

| Distance From Light Source (Ft.) | Horizontal Footcandles* | | | | | | |
|---|---|---|---|---|---|---|---|
| | 30° | 20° | 10° | 0° | 10° | 20° | 30° |
| 20 | .50 | .63 | .62 | .78 | .62 | .63 | .50 |
| 40 | .53 | .57 | .55 | .71 | .55 | .57 | .53 |
| 60 | .46 | .52 | .51 | .63 | .51 | .52 | .46 |
| 80 | .41 | .44 | .40 | .50 | .40 | .44 | .41 |
| 100 | .31 | .35 | .34 | .39 | .34 | .35 | .31 |
| 120 | .23 | .27 | .29 | .32 | .29 | .27 | .23 |
| 140 | .18 | .23 | .24 | .25 | .24 | .23 | .18 |
| 160 | .14 | .16 | .18 | .20 | .18 | .16 | .14 |
| 180 | .09 | .14 | .12 | .16 | .12 | .14 | .09 |
| 200 | .08 | .10 | .09 | .11 | .09 | .10 | .08 |
| 220 | .07 | .08 | .07 | .08 | .07 | .08 | .07 |
| 240 | .05 | .07 | .06 | .07 | .06 | .07 | .05 |
| 260 | .05 | .05 | .05 | .05 | .05 | .05 | .05 |
| 280 | .04 | .05 | .04 | .04 | .04 | .05 | .04 |
| 300 | .03 | .04 | .03 | .03 | .03 | .04 | .03 |
| 320 | .02 | .03 | .02 | .02 | .02 | .03 | .02 |
| 340 | .02 | .02 | .02 | .02 | .02 | .02 | .02 |
| 360 | .01 | .02 | .02 | .02 | .02 | .02 | .01 |
| 380 | .01 | .01 | .01 | .01 | .01 | .01 | .01 |
| 400 | .01 | .01 | .01 | .01 | .01 | .01 | .01 |

*0-degree ray is aligned with one light source; 30-degree ray is midway between two light sources.

Photometric Data
1000-Watt Clear Lamps
60-Degree Sector

| Distance From Light Source (Ft.) | Horizontal Footcandles* | | | | | | |
|---|---|---|---|---|---|---|---|
| | 30° | 20° | 10° | 0° | 10° | 20° | 30° |
| 20 | .54 | .56 | .56 | .58 | .56 | .56 | .54 |
| 40 | .58 | .55 | .62 | .54 | .62 | .55 | .58 |
| 60 | .58 | .62 | .61 | .57 | .61 | .62 | .58 |
| 80 | .61 | .65 | .58 | .53 | .58 | .65 | .61 |
| 100 | .53 | .55 | .54 | .52 | .54 | .55 | .53 |
| 120 | .42 | .49 | .45 | .47 | .45 | .49 | .42 |
| 140 | .32 | .34 | .34 | .36 | .34 | .34 | .32 |
| 160 | .25 | .30 | .30 | .32 | .30 | .30 | .25 |
| 180 | .20 | .25 | .23 | .25 | .23 | .25 | .20 |
| 200 | .18 | .21 | .20 | .18 | .20 | .21 | .18 |
| 220 | .15 | .18 | .17 | .15 | .17 | .18 | .15 |
| 240 | .13 | .15 | .15 | .14 | .15 | .15 | .13 |
| 260 | .09 | .14 | .11 | .11 | .11 | .14 | .09 |
| 280 | .07 | .11 | .09 | .09 | .09 | .11 | .07 |
| 300 | .07 | .09 | .07 | .07 | .07 | .09 | .07 |
| 320 | .06 | .07 | .06 | .06 | .06 | .07 | .06 |
| 340 | .06 | .06 | .06 | .05 | .06 | .06 | .06 |
| 360 | .05 | .05 | .05 | .05 | .05 | .05 | .05 |
| 380 | .05 | .05 | .05 | .04 | .05 | .05 | .05 |
| 400 | .04 | .05 | .03 | .03 | .03 | .05 | .04 |
| 420 | .03 | .04 | .02 | .03 | .02 | .04 | .03 |
| 440 | .02 | .03 | .02 | .02 | .02 | .03 | .02 |
| 460 | .02 | .02 | .02 | .02 | .02 | .02 | .02 |
| 480 | .01 | .01 | .01 | .01 | .01 | .01 | .01 |
| 500 | .01 | .01 | .01 | .01 | .01 | .01 | .01 |

*0-degree ray is aligned with one light source; 30-degree ray is midway between two light sources.

Photometric Data
1000-Watt Phosphor Coated
60-Degree Sector

| Distance From Light Source (Ft.) | Horizontal Footcandles* | | | | | | |
|---|---|---|---|---|---|---|---|
| | 30° | 20° | 10° | 0° | 10° | 20° | 30° |
| 20 | 1.20 | 1.20 | 1.23 | 1.20 | 1.23 | 1.20 | 1.20 |
| 40 | 1.14 | 1.09 | 1.12 | 1.10 | 1.12 | 1.09 | 1.14 |
| 60 | 1.02 | 1.02 | 1.03 | 1.00 | 1.03 | 1.02 | 1.02 |
| 80 | .88 | .89 | .85 | .82 | .85 | .89 | .88 |
| 100 | .72 | .70 | .70 | .68 | .70 | .70 | .72 |
| 120 | .55 | .57 | .55 | .52 | .55 | .57 | .55 |
| 140 | .44 | .42 | .42 | .40 | .42 | .42 | .44 |
| 160 | .32 | .32 | .32 | .33 | .32 | .32 | .32 |
| 180 | .25 | .27 | .27 | .27 | .27 | .27 | .25 |
| 200 | .20 | .21 | .21 | .20 | .21 | .21 | .20 |
| 220 | .18 | .18 | .17 | .16 | .17 | .18 | .18 |
| 240 | .15 | .15 | .14 | .15 | .14 | .15 | .15 |
| 260 | .14 | .12 | .11 | .10 | .11 | .12 | .14 |
| 280 | .10 | .10 | .10 | .10 | .10 | .10 | .10 |
| 300 | .09 | .09 | .09 | .08 | .09 | .09 | .09 |
| 320 | .07 | .07 | .07 | .07 | .07 | .07 | .07 |
| 340 | .06 | .06 | .07 | .05 | .07 | .06 | .06 |
| 360 | .05 | .06 | .06 | .05 | .06 | .06 | .05 |
| 380 | .05 | .05 | .05 | .05 | .05 | .05 | .05 |
| 400 | .04 | .05 | .04 | .04 | .04 | .05 | .04 |
| 420 | .03 | .03 | .04 | .03 | .04 | .03 | .03 |
| 440 | .03 | .02 | .03 | .03 | .03 | .02 | .03 |
| 460 | .02 | .01 | .02 | .01 | .02 | .01 | .02 |
| 480 | .01 | .01 | .01 | .01 | .01 | .01 | .01 |
| 500 | .01 | .01 | .01 | .01 | .01 | .01 | .01 |

*0-degree ray is aligned with one light source; 30-degree ray is midway between two light sources.