A Lighting Study of the Ball State University Alumni Center

Vital Signs III

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ABSTRACT:

This report details a four-month instrumented field study of the luminous environments of the recently constructed Alumni Center at Ball State University in Muncie, Indiana. The Alumni Center was designed by the notable firm of Pei, Cobb, Freed and Partners. The triangular building centers on a two-story day lighted conservatory surrounded by office, conference, and other meeting spaces.

During early visits to the building, initial observations of the building and its lighting conditions were noted, and sample lighting measurements were taken. As the study progressed, more consistently patterned illumination readings were taken throughout the building to obtain a general measure of the lighting conditions. Based on these data, a decision was made to concentrate the study on the conservatory. Initial illumination readings taken in the conservatory on a sunny afternoon revealed the potential for excessive levels of illumination and brightness. Therefore, illumination data loggers were placed at four locations within the conservatory to observe in detail the varying levels of illumination over a several day period. Instantaneous illumination readings were also taken at 36 points throughout the conservatory in order to understand the illumination distribution within the space. Lastly, lumi-

nance readings were taken on various surfaces within the conservatory in order to get an indication of some factors that influence the visual comfort in the conservatory.

The study findings revealed that the overall fluctuation of illumination within the conservatory is minimal over the course of day. The distribution of light on the horizontal plane is gradual with maximum horizontal plane contrast ratios of 6:1. Visual field mapping of luminance values within the "normal visual field" revealed vertical plane contrast ratios of 15:1. These findings supported our hypothesis that in spite of the potential for excessive levels of illumination and brightness, the conservatory remains a visually comfortable space.

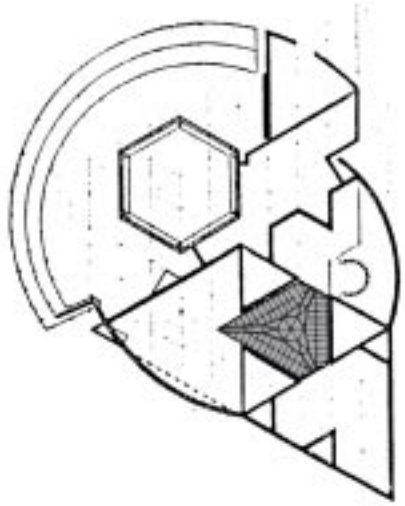
5. Detail of lights in stairwell.

6. View of board room.

7. View of conservatory.

8. View from balcony into conservatory.

INTRODUCTION:



9. Plan of Alumni Center.

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10. View of typical meeting room.

11. View of auditorium.

This lighting study of the Alumni Center was conducted as a part of an architectural elective course entitled Vital Signs III offered through the Department of Architecture and administered by CERES at Ball State University in Muncie, Indiana.

The Alumni Center is located on the campus of Ball State University in Muncie, Indiana. The heart and focal point of the building is the hexagonally shaped conservatory which is largely day lighted by a faceted skylight that uses both transparent and translucent glass. The spaces surrounding the conservatory on the first floor and beyond the balcony on the second floor do not rely on the conservatory for natural light, but instead rely on artificial light and secondary natural light received from the exterior windows in adjacent office areas. On the first floor, the spaces surrounding the conservatory include circulation, meeting, and gathering areas. A row of conference rooms runs along the east side of the building. Larger meeting rooms run along the west side of the building. A large two story hexagonally shaped auditorium space is located in the northwest corner of the building. Finally, along the north wall of the building are the kitchen and other maintenance and office spaces. The second floor is devoted solely to offices and conference rooms.

The artificial lighting throughout the building is achieved largely via compact fluorescent and low voltage halogen luminaires. The conference rooms have compact fluorescent fixtures with simple on/off control. The meeting rooms also have compact fluorescent fixtures in addition to halogen spotlights, and there is some control over which fixtures are on or off at any given time. The board room and the auditorium have the widest range of fixtures and electric lighting control. The lighting can be modified from a very low, soft level of illuminance to a more intense, bright level.

Throughout the building there is a similar use of window treatment. The window blinds, which for the most part are kept in full cover position in the conference rooms on the first floor and varying cover in the offices on the second floor, are made of a mesh material that screens light, yet are still transparent enough to see through to the outside.

The skylight in the conservatory consists of two types of glass. The majority of the skylight facets are covered in translucent glass primarily for the purpose of screening views to the three mechanical towers. The remainder of the glass in the skylight facets is transparent.

12. Detail of spotlights in conservatory.

13. View of typical window treatment.

14. View of skylights in conservatory.

15. View of balconies on second floor.

A variety of different materials are used for walls and floor treatment within the conservatory. For the most part, the walls are covered in drywall with brick edging around the major openings. The base is limestone, and the floor treatment is hexagonal ceramic tile.

HYPOTHESIS:

The conservatory space with its large top light area allows for substantial amounts of natural light to enter the building. In spite of the potential for excessive levels of illumination and brightness, the conservatory remains a visually comfortable space, as a result of the effective filtering and softening of the natural light passing through the skylight facets and reflecting off of the conservatory walls.

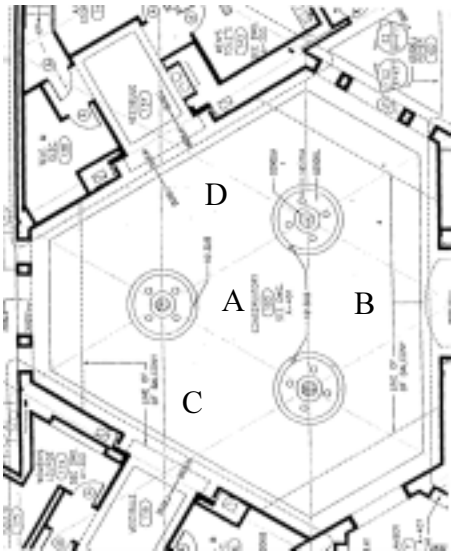
METHODOLOGY:

STEP 1:

Initial illumination readings were taken throughout the Alumni Center in order to obtain a general measure of the lighting conditions in the building and to examine how these levels relate to accepted illumination and visual comfort standards. Using a hand-held Sylvania digital light meter, we took illumination readings in every day lighted space in the building. The readings were taken at a horizontal plane approximately 32 inches above the floor. The readings were taken on an overcast morning with the interior lights on between the hours of 9:00 and 11:00 a.m. on a March day. On average, three to five readings were taken per space with the exception of the assembly room and conservatory where fifteen readings were taken. Exterior illumination readings were taken at intervals of approximately fifteen minutes so that an accurate daylight factor for each space could be calculated.

STEP 2:

After analyzing the test results obtained in step 1, we determined that the conservatory, with its large skylights and influx of natural light needed to be monitored more closely over time in order to measure the variability of lighting levels in the space. This variability could result in lighting measurements taken in the conservatory that are



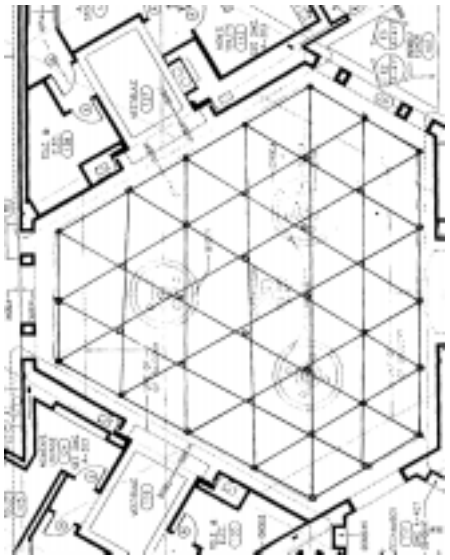
16. Location of Hobos within the Conservatory.

North

not predominantly representative and could lead to misinformed analysis and judgement of visual comfort. Illumination data loggers (Hobos) were placed at key locations in the conservatory (fig. 16) in order to measure the varying levels of illumination in the space over several days' time. Coincidentally, the readings were taken between March 20 to March 22 yielding illumination readings in the conservatory during the equinox.

STEP 3:

Step 2 revealed only moderate variation in illumination levels over the course of a given sunny or cloudy day. Therefore, it was determined that a more detailed study of illumination distribution throughout the conservatory would be beneficial in determining the patterns of illumination under these two primary conditions. The floor plan of the conservatory was divided into a grid of 36 points based on the triangular layout of the conservatory (fig. 17) so that an isolux map of the area could be created. Using a hand-held Sylvania light meter we took illumination readings at each of the 36 points under the two different sky conditions; sunny and cloudy. The measurements were taken in April under two conditions: (1) totally overcast sky conditions, and (2) mostly sunny sky conditions. In both cases, the artificial lights were on.



17. Grid of points for isolux map.

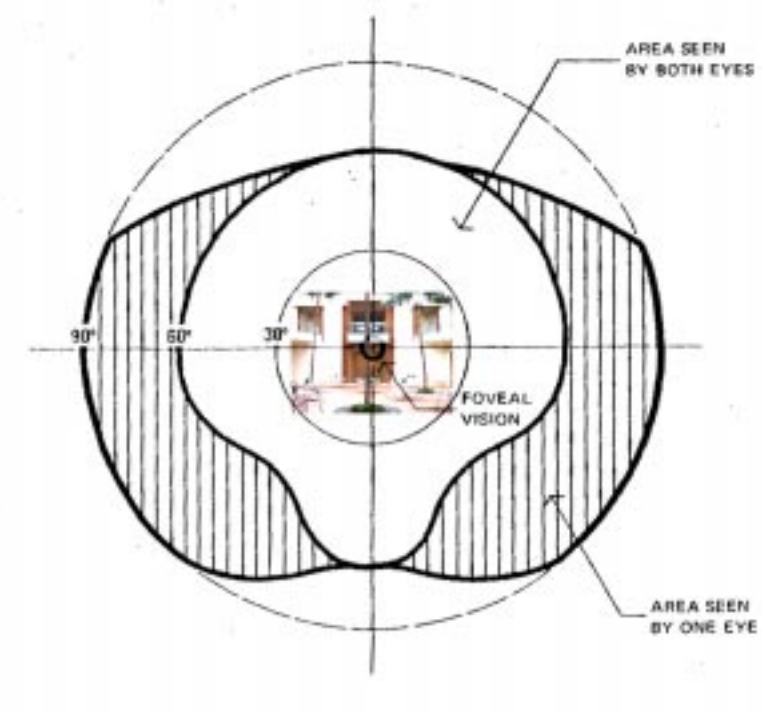
North

STEP 4:

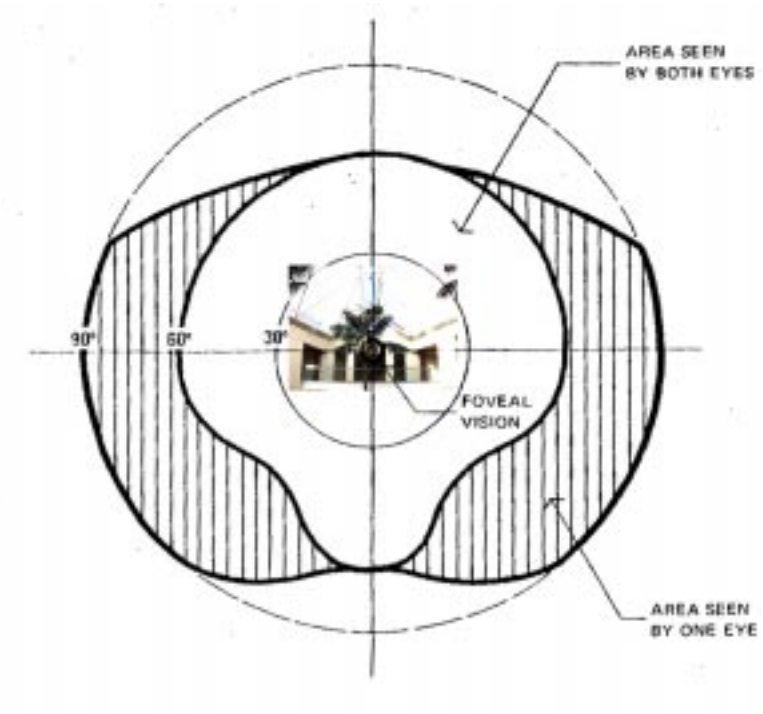
Illumination levels measured in steps 1 through 3 are not necessarily directly related to visual comfort but are rather measurements of the "potential for visual comfort." Therefore, in order to get an indication of some factors that more directly influence the visual comfort within the conservatory (such as: brightness contrast, size of brightness source, and brightness distribution within the visual field) luminance readings were taken on various surfaces within the conservatory. The readings were taken on both overcast and a clear days with a spot luminance meter.

To match the readings more closely with what a building user might actually experience, the study was then focused to include visual field brightness mapping. To determine the contrast between the luminance from various materials within the conservatory, visual field mapping of four typical views in the space was done. In order to help facilitate the visual field mapping process, photos of the conservatory were taken with a digital camera and downloaded to the computer for manipulation. The images to be used for the visual field mapping were modified using Photoshop, an image processing software program. The images were indexed to contain only ten colors and were then grayscaled. The reduction of tones and the elimination

18. View #1 of the conservatory with an overlay of the visual field diagram.



19. View #2 of the conservatory with an overlay of the visual field diagram.



of color reduced the complexity of the image and exaggerated the contrast boundaries. The modified images were helpful in identifying the relative intensity, size and location of the various predominant areas of brightness in the visual field. The identified areas in the visual field were then measured in the actual scene with the spot meter to collect luminance values. This process was repeated for the four typical views on both overcast and mostly sunny days. The location and size of the various predominant areas of brightness were then studied, and the contrast ratios were analyzed.

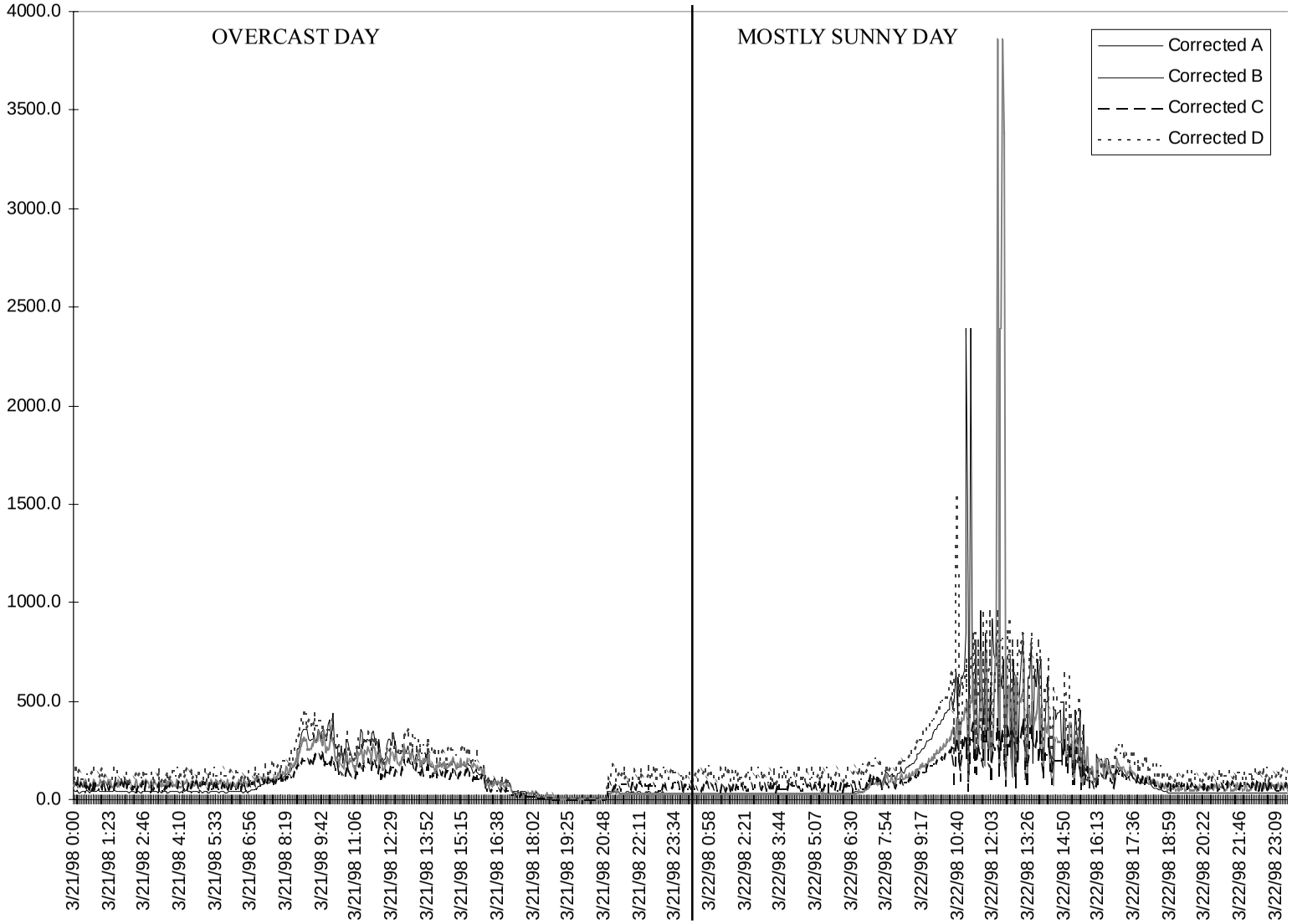
SPECIFIC FINDINGS:

After step 1 of our research methodology, we recorded illumination measurements throughout the building. On an overcast morning the readings ranged from a low of 29 fc in the “pre-function” space up to a high of 669 fc in the conservatory (fig. 20). The illumination readings in general for the building are above the minimum IES standard of 20 fc for visual task performance. The daylight factor in the conservatory reveals a ratio of approximately one to five (indoor to outdoor illumination) which suggests the potential for excessive levels of illumination on clear days.

After step 2 of our research methodology we observed a relatively consistent pattern of illumination in the conservatory over a typical day’s time. The illumination readings resulted in a consistent pattern of rise and fall in illumination levels which is seen in similar form at all four data loggers which were placed throughout the conservatory. Not only is the overall pattern consistent at the different locations within the conservatory, but the pattern is fairly consistent from one day to the next regardless of sky conditions (fig. 21). These readings, with the exception of a few peaks resulting from small shafts of direct sunlight passing through the transparent glass, suggest that the

LOCATION	TIME	READING(fc)	METER	NOTES	DAYLIGHT FACTOR%
Outside	11:15 A.M.	3800	GE4	partly cloudy	
1		90	SYL.1	lights on, blinds down	2.47
2		669	SYL.1	lights on, blinds down	18.33
3		77	SYL.1	lights on, blinds down	2.11
4		95	SYL.1	lights on, blinds down	2.60
5		65	SYL.1	lights on, blinds down	1.78
6		74	SYL.1	lights on, blinds down	2.03
7		36	SYL.1	lights on, blinds down	0.99
7.5		82	SYL.1	lights on, blinds down	2.25
8		56	SYL.1	lights on, blinds down	1.53
9		29	SYL.1	lights on, blinds down	0.79
10		29	SYL.1	lights on, blinds down	0.79
11		93	SYL.1	lights on, blinds down	2.55
13		93	SYL.1	lights on, blinds down	2.55
13.5		83	SYL.1	lights on, blinds down	2.27
Outside	11:30 A.M.	3900	GE4		
15		59	SYL.1	lights on, blinds down	1.62
16		93	SYL.1	lights on, blinds up	2.55
17		111	SYL.1	lights on, blinds down	3.04
18		45	SYL.1	lights on, blinds down	1.23
19		60	SYL.1	lights on, blinds down	1.64
20		75	SYL.1	lights on, blinds up	2.05
21		35	SYL.1	lights on, blinds down	0.96
22		49	SYL.1	lights on, blinds up	1.34
Outside	11:55 A.M.	3250	GE4	partly cloudy	
Outside average		3650			

20. Chart of initial illumination readings taken throughout the building. (Light meters were tested under the same illumination condition so that variations between the two could be accounted for and corrected).

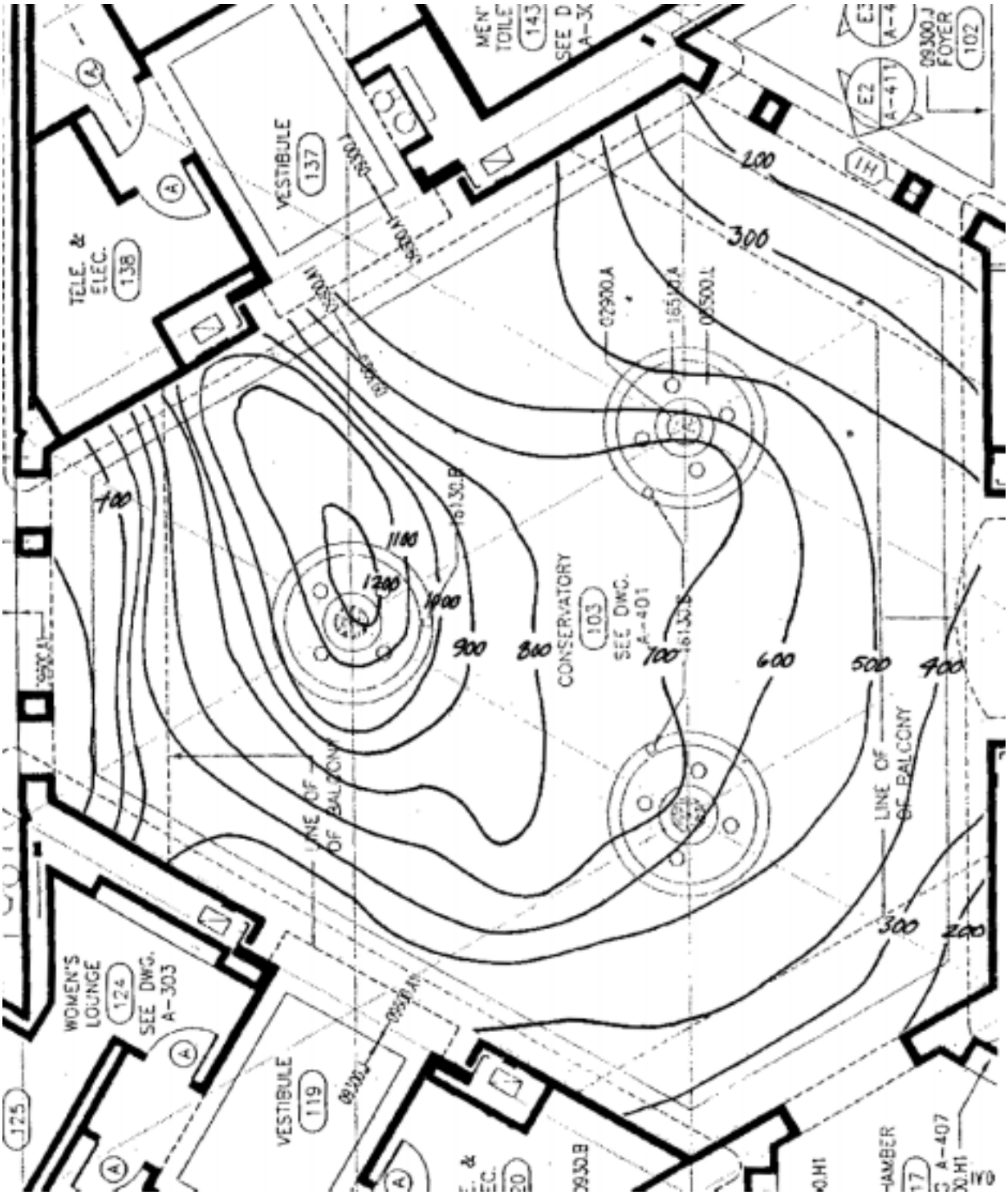


21. Graph of illumination measurements taken over a period of two days. (Hobo illumination readings were compared and color corrected against instantaneous illumination readings taken with SLY. 1).

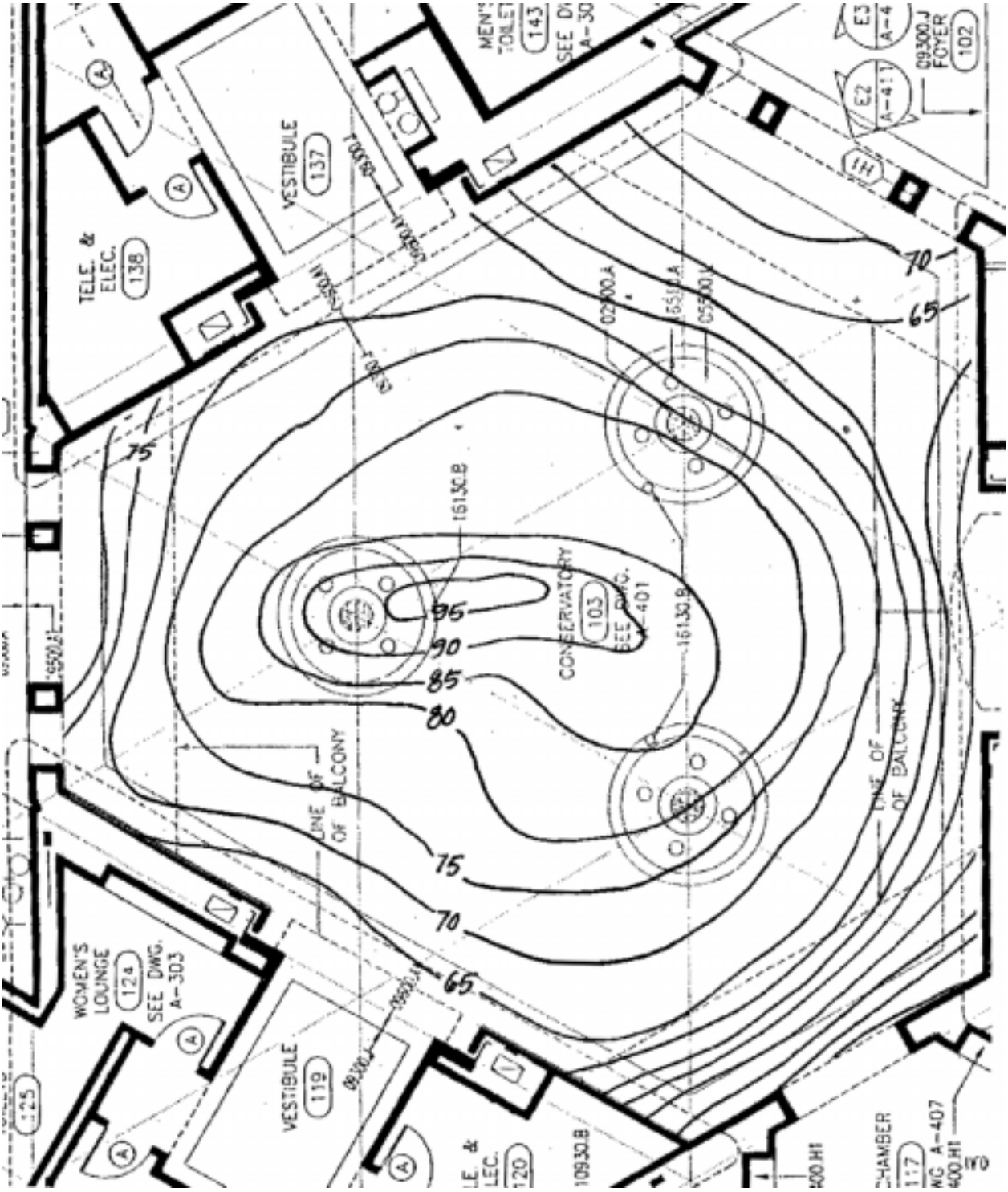
translucent glass and conservatory walls do a relatively effective job of controlling light distribution and reducing light level fluctuation.

Step 3 of our methodology revealed lighting patterns across the horizontal plane within the conservatory. Under sunny sky conditions illumination levels ranged from 200 fc in the southeast corner of the conservatory to 1200 fc just west of the conservatory center (fig. 22). The cloudy day readings resulted in a range from 65 fc around the perimeter of the conservatory to 95 fc in the center (fig. 23). The contrast in illumination levels reveal the potential for brightness contrast ratios of 6:1 which remain within the range of visual comfort.

Step 4 of the research methodology resulted in measurements directly related to the visual comfort in the conservatory. View #1 (fig. 24) is of an interior facade in the conservatory that is within the "normal visual field." Foot Lambert readings taken within view #1 on a mostly sunny day at 4:00 p.m. revealed levels ranging from 21 fL to 319 fL (fig. 27). This results in an overall ratio of 15:1. Readings of the same view #1 taken on a cloudy day at 4:00 p.m. revealed a range of 6 fL to 66 fL which results in a ratio of 11:1 (fig. 31). Both ratios are well within standard for



22. Isolux map of conservatory on a sunny day at 12:00 p.m.



23. Isolux map of conservatory on a cloudy day at 3:00 p.m.

North

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acceptable visual contrast. View #2 (fig. 32) is looking up to the balcony that surround the conservatory and reveal a large portion of the skylight. The middle strip of glass is transparent and the remainder is translucent. Foot Lambert readings within view #2 taken on a sunny day at 4:00 p.m. range from 32 fL to 2795 fL (fig. 35). The resulting ratio is 87:1. Readings taken within view #2 on a cloudy day at 4:00 p.m. range from 5 fL to 931 fL which result in an overall ratio of 186:1 (fig. 39). As the field of view is focused upwards towards the skylights, the contrast ration moves towards 100:1, and on an overcast day the ratio is well above 100:1. However, ratios within the "normal field of view" are low.

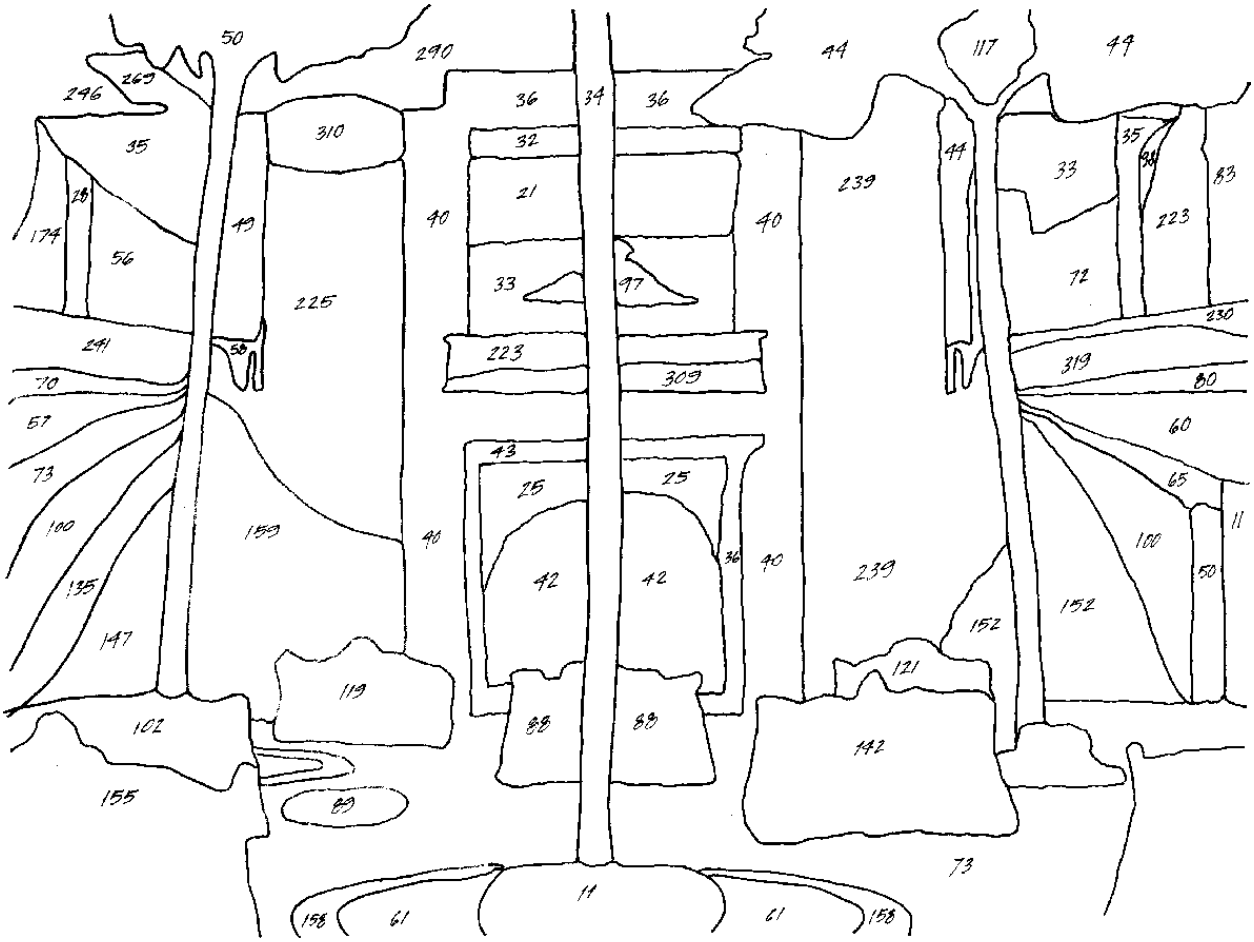
VIEW #1: sunny day

24. Original photograph of conservatory taken around 4:00 p.m. on a sunny March afternoon.

25. Image modified in Photoshop. The total colors were limited to ten, and the image was then grayscaled in order to exaggerate the contrast within the view.

26. Tracing of the major areas of brightness within the view overlaid on the grayscaled image. Spot readings of the outlined areas are indicated in foot Lamberts.

VIEW #1: sunny day



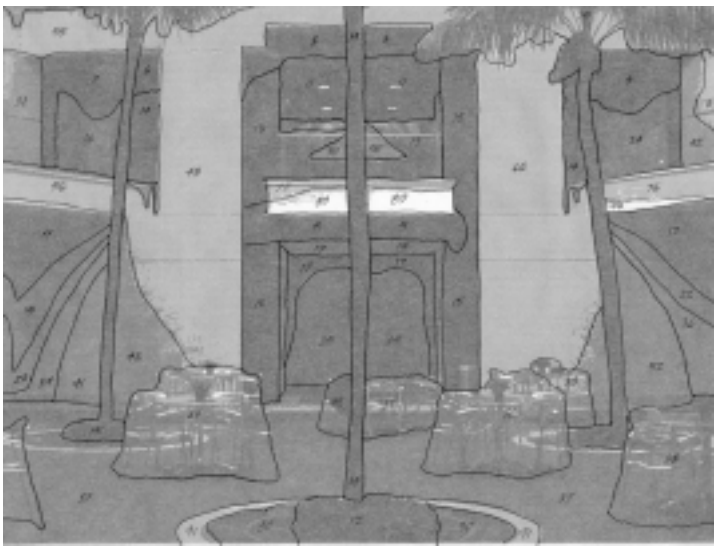
27. Visual field map of View #1 on a sunny afternoon.

VIEW #1: cloudy day

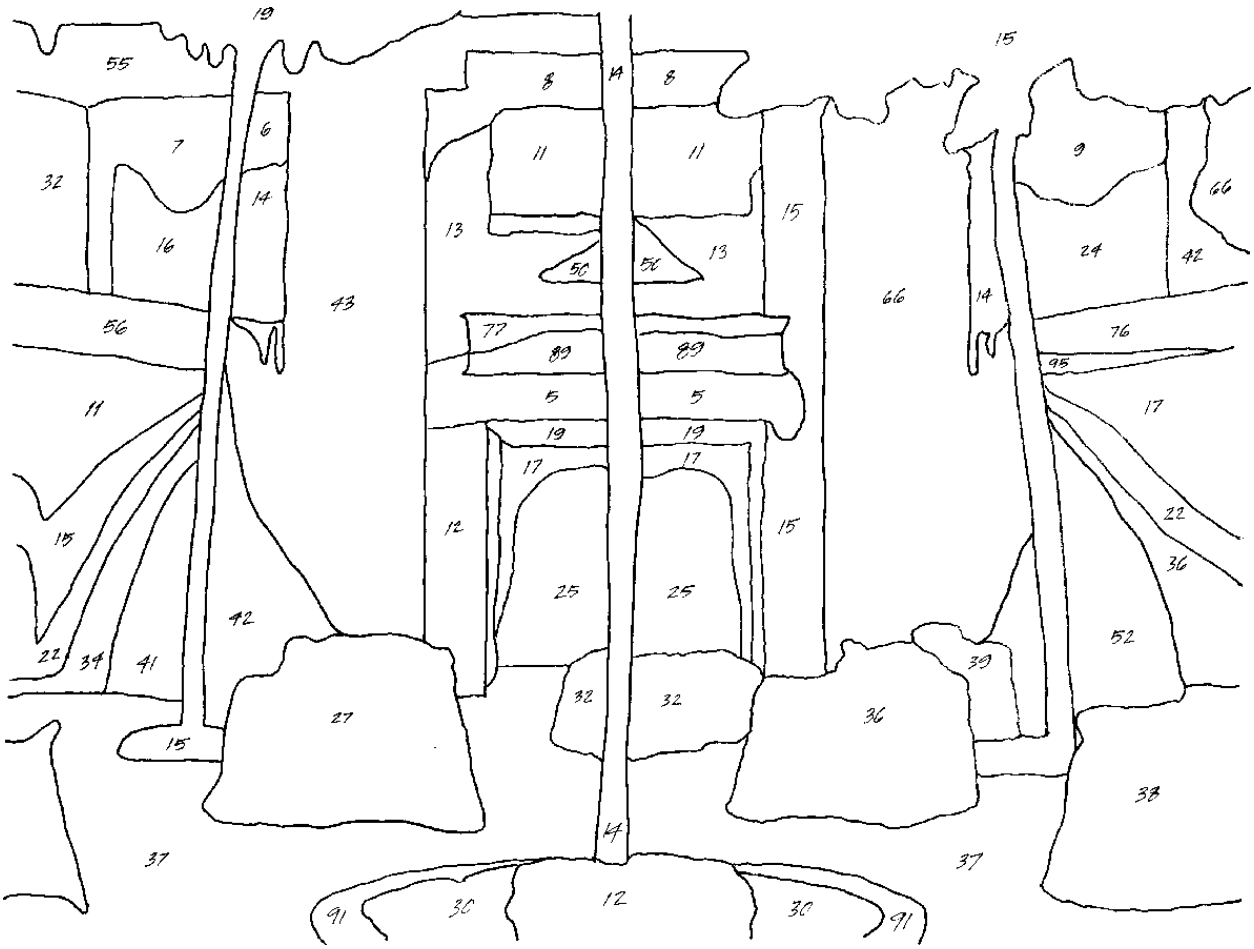
28. Original photograph of conservatory taken around 4:00 p.m. on an overcast March afternoon.

29. Image modified in Photoshop. The total colors were limited to ten, and the image was then grayscaled in order to exaggerate the contrast within the view.

30. Tracing of the major areas of brightness within the view overlaid on the grayscaled image. Spot readings of the outlined areas are indicated in foot Lamberts.



VIEW #1: cloudy day



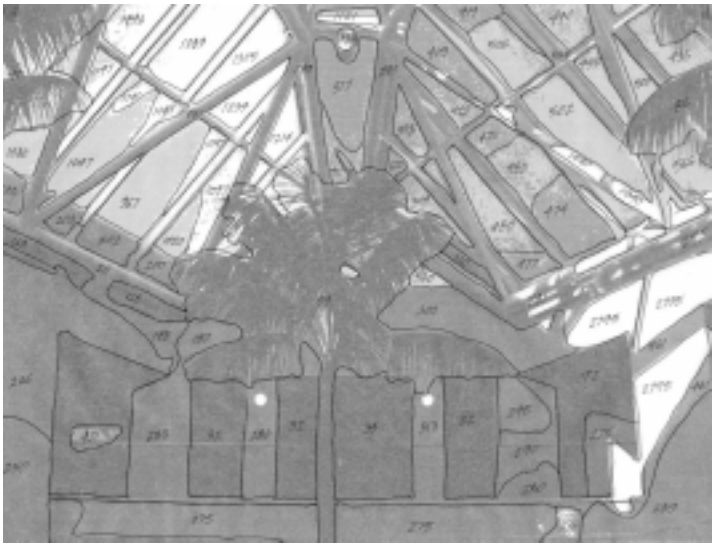
31. Visual field map of View #1 on a cloudy afternoon.

VIEW #2: sunny day

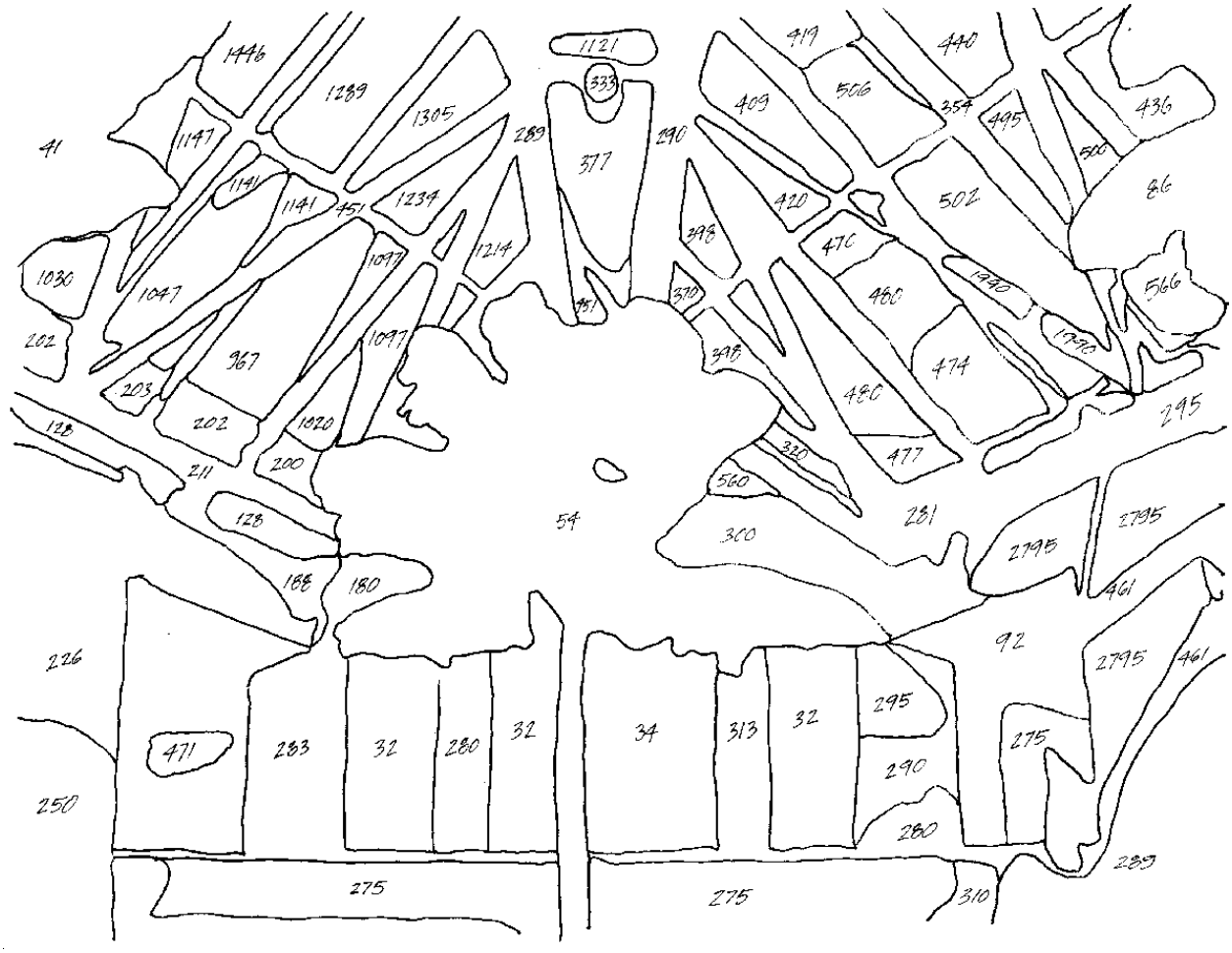
32. Original photograph of conservatory taken around 4:00 p.m. on a sunny March afternoon.

33. Image modified in Photoshop. The total colors were limited to ten, and the image was then grayscaled in order to exaggerate the contrast within the view.

34. Tracing of the major areas of brightness within the view overlaid on the grayscaled image. Spot readings of the outlined areas are indicated in foot Lamberts.



VIEW #2: sunny day



35. Visual field map of View #2 on a sunny afternoon.

VIEW #2: cloudy day

36. Original photograph of conservatory taken around 4:00 p.m. on an overcast March afternoon.

37. Image modified in Photoshop. The total colors were limited to ten, and the image was then grayscaled in order to exaggerate the contrast within the view.

38. Tracing of the major areas of brightness within the view overlaid on the grayscaled image. Spot readings of the outlined areas are indicated in foot Lamberts.

VIEW #2: cloudy day

39. Visual field map of View #2 on a cloudy afternoon.

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CONCLUSIONS:

In summary, the hypothesis that the conservatory in the Alumni Center is a visually comfortable space can be supported based upon the following factors:

- Although the conservatory space with its large top light area allows for substantial amounts of natural light to enter the building and thus allows for potentially excessive levels of illumination, the overall fluctuation of illumination in the space at the horizontal plane is minimal over the course of day.
- In addition, the distribution of light within the conservatory at the horizontal plane is gradual with contrasts of only 6:1. This is in spite of the fact that illumination levels are as high as 1200 fc.
- Finally, visual field mapping of views within the conservatory revealed contrast ratios of only 15:1 for views within the "normal visual field." Only as the view is shifted up towards the skylight does the contrast ratio reach or exceed levels of 100:1.

Therefore, the conclusion can be made that, due to the effective filtering and softening of the natural light which passes through the skylights and reflects off of the conservatory walls, the conservatory remains a visually comfortable space.

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APPENDIX:

General Observations:

The conservatory is the center and focal point of the building and is formed in a hexagonal shape. This space is largely day lighted by a large pyramidal skylight that uses both transparent and translucent glass.

40. View of conservatory.

41. View of skylight in conservatory.

The conference rooms located at the southeast corner of the building make use of a combination of both natural and artificial light. Punched windows along the east wall admit a good amount of natural light, up to 76 fc on an overcast morning. The boardroom has the most flexible lighting control and fixture variety of all the conference rooms. Halogen lights surround the conference table and are adjustable to create a variety of different settings.

42. View of exterior window details.

The second floor of the Alumni Center is used for office space. The open office space is without direct access to natural light, while the private offices are mostly located along the exterior of the building and have similar punched windows and shades. These windows on the northwest side of the building provide a comfortable amount of natural light in the space. In contrast, windows on the southwest side of the building permit levels of illumination in excess of IES standards on clear afternoons largely as a result of the directional angles of the sun.

43. View of typical conference room.