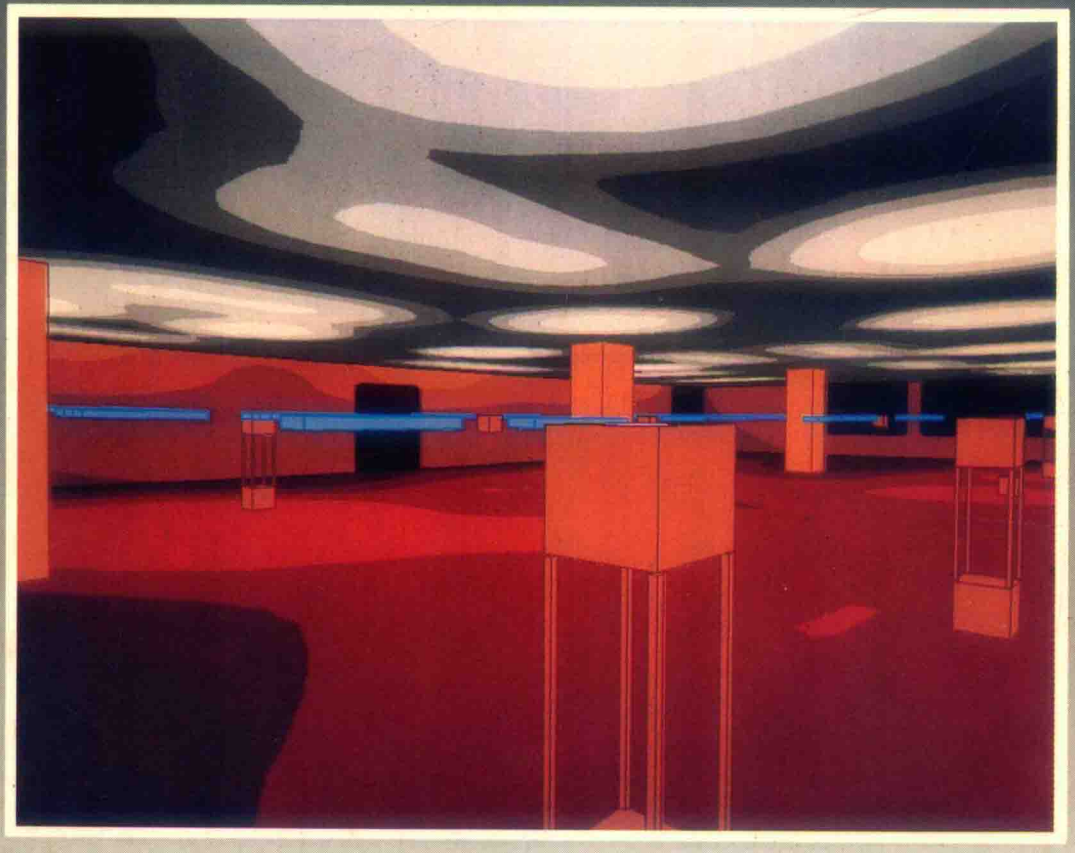
ARCHITECTURAL LIGHTING DESIGN



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Introduction

The intention of this book is not to provide the last word or even the most definitive word on architectural lighting. The goal is rather to be a portfolio of design and technical information that can serve as a springboard to more technical references and texts while providing substantial information for the architect and designer who are engaged in lighting their own designs or are working with a professional lighting designer.

Lighting is a complex and ethereal aspect of the architectural design process. Very few architects and engineers ever give more than lip service to truly designing the lighting environment. Too often, the job is shunted off to the electrical engineer or the lighting sales representative. Furthermore many have the false impression that a good-looking reflected ceiling plan is a lighting design. Most electrical engineers calculate lighting levels and provide layouts that assure the client of a maintained lighting level. Typical layouts and calculations traditionally have consisted only of these concerns, with the recent addition of energy consumption problems. While many manufacturer's representatives are quite knowledgeable, they primarily know products, not design. The architect often fails to realize that the problems of visual comfort and reflected glare can have a greater impact on the effectiveness of the lighting installation than does the pattern of fixture placement or initial luminance.

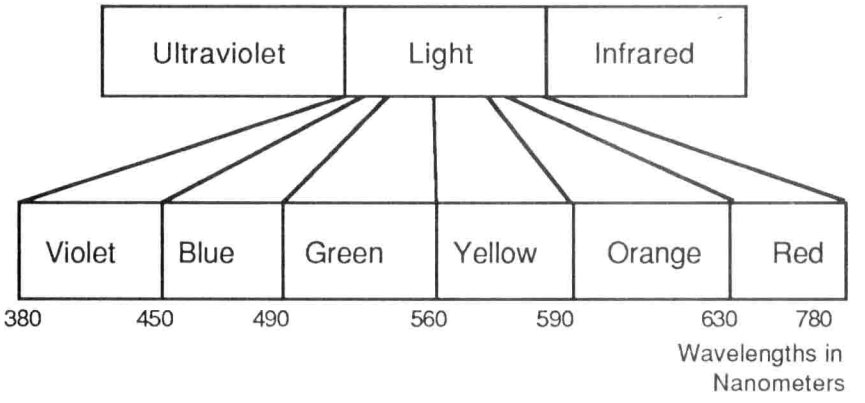
Chapter 1

THE DESIGN MEDIUM

There is a great deal more to the art and science of lighting than physics and technology. The process of lighting design must also take into account the relationship between the luminous environment and the eye and mind of the human observer. The psychology of the environment is, of course, always at play in the perception and relationship of people and architecture, but in the case of lighting the relationship is heightened. The actual way the eye/mind combination perceives light is a dynamic thing and bears at least equal value in the lighting design process. In this chapter we will consider both the process of vision and the effect of lighting and perception on the experience of the lighted architecture itself. You should come away with a better understanding of the importance of these considerations in both the design and implementation of the luminous architectural environment.

THE PROCESS OF VISION

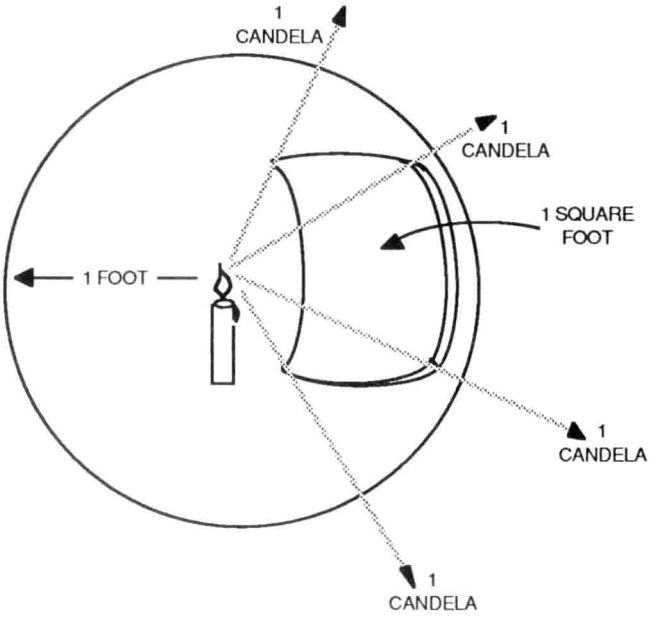
In order to see there must be light, an object, a receptor (the eye) and a decoder (the brain). LIGHT is electromagnetic energy emitted in the visible portion of the spectrum. White light results from combining different wavelengths of visible energy.



Spectrum. Fig 1-1

All the light below 380 nanometers is ultraviolet and above 780 is infrared. The eye is unable to perceive these wave lengths but the skin responds. Skin is tanned as a result of the effect of ultraviolet and is warmed by infrared. The visible spectrum contains all the colors of the rainbow and when it is seen in combination is perceived as white light.

The light output of a source is measured in LUMENS. The INTENSITY of light (luminous intensity) in a given direction is measured in CANDELAS. When light strikes a surface it is measured in FOOTCANDLES-- one footcandle (fc) being the illumination on the surface one foot away from a standard candle (or one lumen per square foot).



Footcandle Chart. Fig 1-2

The figure above represents a sphere equidistant from the point of the light source. The inside surface of the sphere is one foot away from the candle flame and one square foot of light falling on the surface represents one foot candle.

We do not see footcandles. Rather, we see the brightness resulting from light transmitted or reflected by a surface. This BRIGHTNESS is measured in FOOTLAMBERTS. There is always a subtractive interaction between a surface and the light falling on it. Light energy is absorbed or interfered with by surfaces. Some light is always lost.

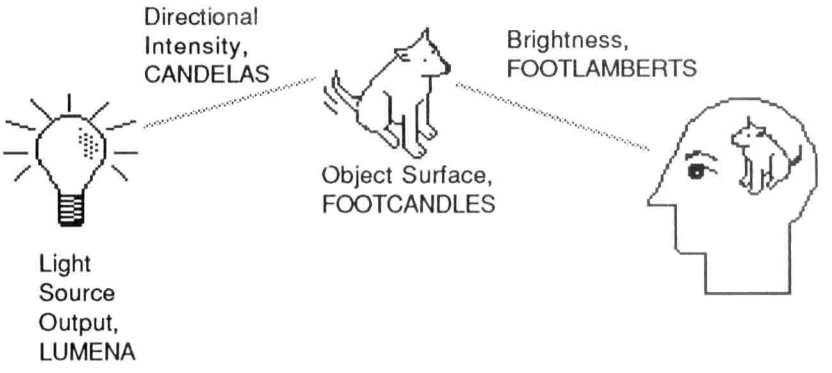


Chart of Vision. Fig 1-3

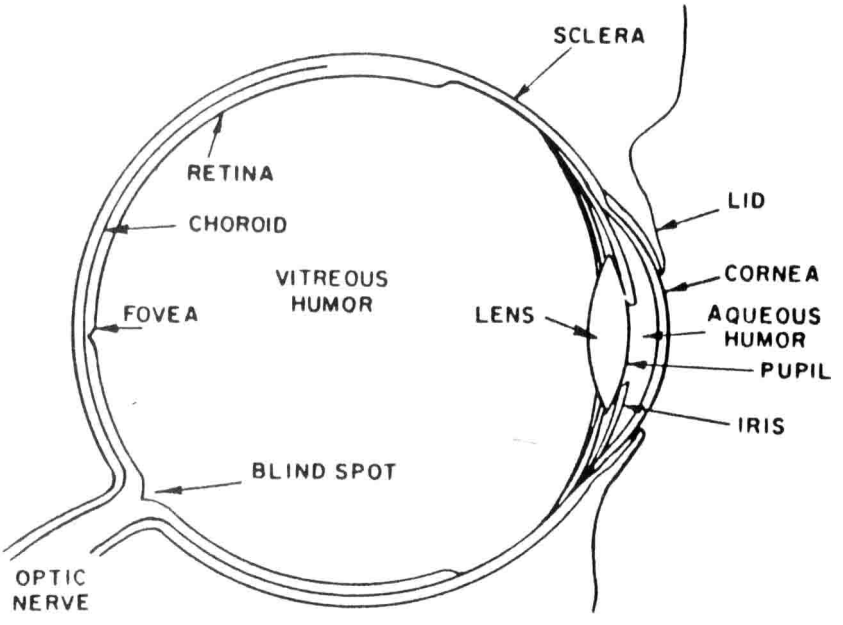
The light rays reflected or transmitted from the object whose brightness we see stimulate electrochemical receptors in the eye that transmit signals to the brain. The brain and the eye cooperate in transforming radiant energy into the sensation of vision.

This is a clear representation of the system nature of vision and indicative of the need to be aware of all the elements that combine to make vision possible. We will next consider the effects of human physiology on the vision process and the differences between age and youth in vision.

PHYSIOLOGICAL FACTORS

The eye responds to electromagnetic energy-wavelengths in the range between ultraviolet and infrared radiation. The eye is most responsive to the yellow-green portion of the spectrum.

The eye is a complex mechanism that can be understood by comparison to the camera. It consists of a lens system, an image receptor and a mechanism to focus and control the various relationships. The iris and pupil are analogous to the diaphragm and shutter of the camera and the lens, of course, relates to the camera lens. The retina is similar to the camera film. There are two kinds of nerve receptors that receive and transmit light stimulus to the brain. These occur in the retina and are called rods and cones. Rods are responsible for daylight and color vision while cones specialize in dawn and dusk vision. Malfunction of the rod system can result in color blindness while damaged cones can result in night blindness. The vitreous humor refracts light and assists the lens in controlling the vision process.



Eye Chart. Fig 1-4

DEFINITIONS

VISUAL FIELD

The VISUAL FIELD is the area the eye sees. This field normally extends 10 degrees in the vertical. The finest details are seen only in a small area at the back of the eye known as the fovea. Details become progressively less distinct as they approach the outer limit of the visual field although movement and changes in brightness levels remain readily discernible even at the periphery.

ACCOMMODATION

ACCOMMODATION is the process by which the eye locates and focuses on an object. The eye physically changes shape in order to accommodate the distance from the object. The nearer the object, the more convex the lens of the eye will be. The farther away the object, the flatter the lens. Prescription glasses compensate for the inability of the lens to change shape sufficiently to provide clear vision.

ADAPTATION

ADAPTATION involves the size of the pupil opening and the sensitivity of the retina. The pupil of the eye opens wide in low levels of light and gets smaller as the light level increases. The chart indicates the range of lighting level, from moonlight (about .01 footcandles) to tropical noon, in which humans see. A change also occurs in the photochemical substances of the retina. It takes longer to adapt from light to dark, for example going into a movie theater in the daytime, than it does to adapt from dark to light.

THE EYE AND AGE

Twenty/twenty vision is what normal twenty year olds can see at twenty feet. The eyes of a healthy twenty year old adjust quickly and easily to changes in brightness in the environment. As eyes age, they lose their elasticity, reducing their ability to accommodate easily. Adaptation from one light level to another takes longer and the range of sensitivity drastically diminishes the ability to see at low light levels. A sixty year old needs ten time as much light as a normal twenty year old to perform the same seeing task with equal speed and accuracy.

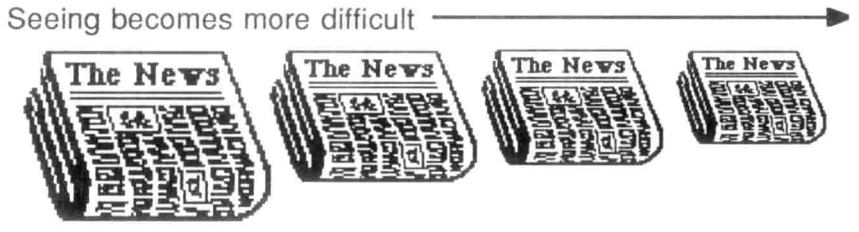
PHYSICAL FACTORS

DEFINITIONS

SIZE

The four factors that determine visibility are:

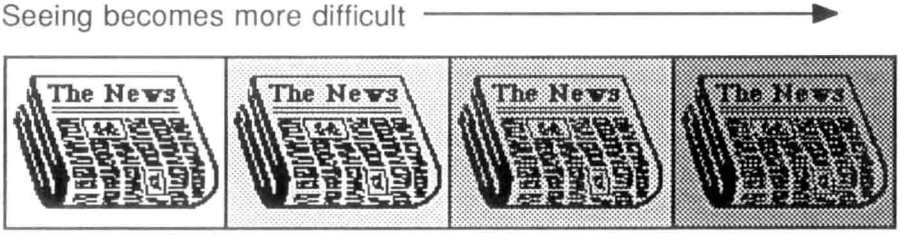
SIZE. The bigger or nearer an object, the easier it is to see.



The nearer an object, the easier to see. Fig 1-5

CONTRAST

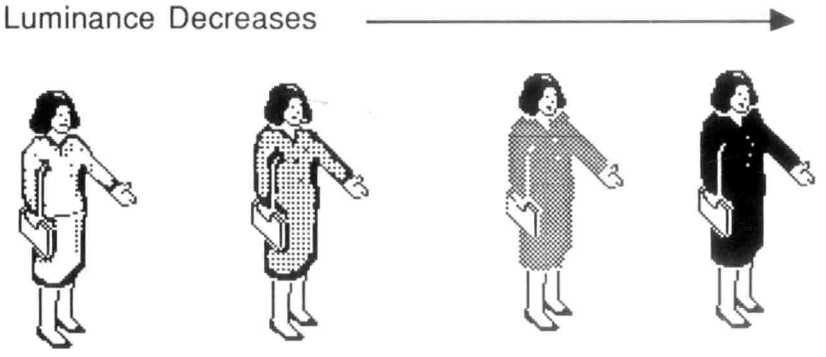
CONTRAST. The difference in brightness (luminance) of an object and its background. Black letters on white paper are easy to read because the contrast approaches 100% but grey lettering with only 40% reflectance on grey paper of 80% will only have a contrast of 50% and be hard to see. Visibility can be increased by adding illumination or the use of color.



More contrast means increased visibility. Fig 1-6

LUMINANCE

LUMINANCE is the proper term for what is often called brightness. Luminance is the amount of light reflected or transmitted by an object. A light colored surface reflects more light than a dark one, hence more illumination is needed on a dark surface to equal the luminance of a similar light surface.



Luminance - reflected light. Fig 1-7

TIME

TIME or how long it takes to see. The less light, the longer it takes to see details. The time factor is especially important where motion is involved, as in driving. Under low light levels, an object appears to move more slowly than under high levels of illumination.

QUANTITY OF LIGHT

Electric light sources, whether incandescent, fluorescent or high intensity discharge, are known in the industry as LAMPS. Except for decorative bulbs, bare lamps are a source of glare, therefore they are shielded and their output is controlled by LUMINAIRES (fixtures). Some lumens are always lost in a luminaire by being blocked or absorbed. LUMINAIRE EFFICIENCY is the ratio of the lumen output of the luminaire to the lumen output of the lamp, expressed as a percentage.