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THE PHYSICAL PRINCIPLES AND
PROPERTIES OF LIGHTING DESIGN
FOR INTERIORS: A COMPILATION FROM
A SURVEY OF LITERATURE

Thesis for the Degree of M. A.
MICHIGAN STATE UNIVERSITY
KATHLEEN PARRISH PETERSON
1970

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THE PHYSICAL PRINCIPLES AND PROPERTIES OF
LIGHTING DESIGN FOR INTERIORS: A
COMPILATION FROM A SURVEY OF
LITERATURE

By

Kathleen Parrish Peterson

A SPECIAL PROBLEM

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TABLE OF CONTENTS

INTRODUCTION	1
An Historical Sketch of Lighting	1
The Need for the Study of Lighting Interiors	1
Chapter	
I. GENERAL PROBLEMS, PRINCIPLES, AND OBJECTIVES OF LIGHTING	3
Definitions of General Lighting Terms.	3
The General Problem.	5
The Principles of Good Lighting.	10
The Environmental Objectives of Residence Lighting.	13
II. LIGHT CONTROL	18
PART ONE: PRINCIPLES OF LIGHT CONTROL, LIGHTING METHODS, AND MODES OF DISTRIBUTION	
The Physical Principles of Light	18
Lighting Methods.	28
PART TWO: DESCRIPTIONS, FUNCTIONS, AND MATERIALS USED IN LIGHT CONTROL	
Materials Used in Light Control.	31
Finishes Used in Luminaires	32
III. TYPES OF LIGHT: QUANTITY AND QUALITY	33
Natural Light.	33
Artificial Light.	37
Quantity of Light	46
Quality of Light.	55

Chapter

IV. STRUCTURAL, PORTABLE, AND ACCESSORY LIGHTING	59
Structural Lighting.	59
Portable Lighting	66
Accessory Lighting	71
V. NEW DIRECTIONS IN LIGHTING AND THE FUTURE OF LIGHTING IN INTERIORS.	75
Contemporary Lighting Today	75
New Innovations in Lighting	76
The Future of Lighting for Interior Designers	76
BIBLIOGRAPHY	78

APPENDICES

Appendix

A. Basic Modes of Lighting	82
B. Incandescent Lamp Shapes.	84
C. Shapes of Fluorescent Tubes.	85
D. Structural Lighting Types	86
E. Portable Lighting Measurements and Placement .	90
F. Contemporary Portable and Accessory Lighting .	95

LIST OF TABLES

Table	Page
1. Reflectances and Approximate Munsell Values for Interior Surfaces of Residences . . .	57
2. Lumen Counter Method.	58

LIST OF FIGURES

Figure	Page
1. The Law of Reflection	19
2. Specular Reflections	19
3. Specular Reflections	19
4. Spread Reflection	21
5. Diffuse Reflection	21
6. Compound--Diffuse and Specular	22
7. Compound--Diffuse and Spread.	22
8. Compound--Specular and Spread	22
9. Parabolic Reflector.	23
10. Elliptical Reflector	23
11. Circular or Spherical Reflector.	23
12. Refraction.	25
13. Refraction.	25
14. Direct Transmission.	26
15. Spread Transmission.	26
16. Diffuse Transmission	26
17. Diagrams of Light Measurement	48

INTRODUCTION

An Historical Sketch of Lighting

The electric filament lamp, invented by Edison in 1879, revolutionized man's way of life. Prior to his discovery, man was forced to light his environment by natural sources of light or by kerosene and oil lamps. In 1910, Dr. William Coolidge improved upon Edison's carbon filament lamp and produced the tungsten filament lamp, still in use today with only minor modifications. In 1931, Langmuir discovered that by filling the tungsten lamp with inert gas, he could double the efficiency of the incandescent lamp. Other modifications, such as inside frosting and coiled filaments, further improved the incandescent lamp (General Electric, Incandescent Lamps, 1962, p. 3). In 1938, the fluorescent lamp came into being, and since that time has undergone significant advances (General Electric, Fluorescent Lamps, 1965, p. 3).

The Need for the Study of Lighting Interiors

Lighting for contract and residential design has been sadly neglected by interior designers in the past. It has been the experience of this investigator in practice,

as well as in discussion with other practicing interior designers and educators, that there is a definite and urgent need for the study of lighting design.

In order to fulfill this need, a compilation such as the one described herein, can serve as a guide for future course planning or as a basis for a course syllabus. It is the purpose of this paper to create for the student and/or instructor of Interior Design, a compilation of known requirements concerning the physical principles and properties of lighting design for interiors.

CHAPTER I

GENERAL PROBLEMS, PRINCIPLES, AND OBJECTIVES OF LIGHTING

Definitions of General Lighting Terms

In order to gain an understanding of specific lighting concepts, it is necessary at this point, to define certain lighting terms. These terms are divided into three groups: (1) the measurement of light, (2) visual terms, and (3) lighting equipment.

1. The measurement of light.--

Candela: "the unit of luminous intensity of a light source in a specified direction.

Lumen: "a unit for the light-producing power of a light source . . . the rate at which light falls on a one square foot area surface which is equally distant one-foot from a source whose intensity is one candela.

Footcandle: "Density of light striking each and every point on a segment of the inside surface of an imaginary one-foot radius sphere with a 1-candle-power source at the center" (General Electric, Light; Measurement and Control, p. 5).

Footlambert: the quantitative unit for measuring the brightness of a surface; "If a surface held one-foot from a candle appears perfectly white and diffuse, its brightness is one footlambert" (Interiors, 1950, p. 118).

Brightness: the degree of apparent lightness on a surface.

2. Visual terms.--Kaufman (1966, p. 3-7) defines visual terms in the following ways:

Visual field: "the locus of objects or points in space which can be perceived when the head and eyes are kept fixed.

Visual task: "those details and objects which must be seen for the performance of a given activity, including the immediate background of the details or objects.

Visual surround: "all the portions of the visual field except the visual task.

Glare: "the sensation produced by brightnesses within the visual field that are sufficiently greater than the luminance to which the eyes are adapted to cause annoyance, discomfort, or loss in visual performance and visibility."

3. Lighting equipment.--

Luminaire: a total lighting unit which includes the source of artificial light and the fixture housing the source.

Lamp: "a generic term for a man-made source of light . . . (a lighting unit consisting of a lamp with shade, reflector, enclosing globe, housing or other accessories is also called a 'lamp.' In such cases, in order to distinguish between the assembled unit and the light source within it, the latter is often called a 'bulb' or 'tube' if it is electrically powered.)" (Ibid.).

Bulb: a layman's term for lamp; also the varied glass, shaped enclosure of a lamp which keeps air out and filling gas in.

The General Problem

I. Considerations Pertinent to the Analysis and Solution of Most Interior Lighting Design Problems

Light, the subject of this paper, obviously is a necessity if we are to see the world around us. Without some kind of light we could not see form, line, color, or texture. The ways in which light are used by the interior designer, architect, or lighting designer, determine whether or not our visual, aesthetic, emotional, and spatial needs are met. In the past, light, especially daylight, was used "to give form to planes, curved surfaces, and structural design" (Ibid., p. 10-2). At the start of the twentieth century, attempts to use artificial light as a structural element were begun (Kohler and Luckhardt, 1959, p. 117). Today, on a much broader basis, artificial light is used for the same purposes. The availability of the many different types of light sources, luminaires, light control devices, and lighting equipment has made it possible to use an almost unlimited range of lighting treatments to create a desired effect. In all aspects, the art of lighting is influenced by the individual interpretation of the interior designer, the architect, and the lighting designer (Kaufman, p. 10-2).

A. Function of the structure.--The application of lighting is greatly influenced by the function of the structure. The application techniques designated for commercial or industrial lighting have developed around lighting solutions for the differing types of visual tasks generally encountered in each type of building. Each technique is a combination of engineering theory, applied experience, and acceptance on the part of the consumer of the type of application for a particular field. Kaufman (p. 10-2) states:

. . . Because these include more than an objective assessment of engineering considerations, it is necessary to relate the design of a lighting installation to the particular occupancy of the space it is to serve.

Commercial and residential applications differ in that:

The near-uniformity of light distribution employed in schools and offices is usually incompatible with the intent of most residential interiors. . . . The tastes and varying eyesight demands of the individual family necessitate various lighting effects (IES Committee on Residence Lighting, 1953, p. 133).

Commercial or industrial lighting further differs from residential lighting in that " . . . In the home . . . light is used chiefly to create a mood--not to the exclusion of other considerations, but predominately" (Kohler and Luckhardt, p. 133). The visual task, however, is considered of primary importance in a building, regardless of the function of the building.

B. Lighting systems.--Illuminating engineers have classified lighting systems as: (1) "the general type of lighting produced," and (2) "the general layout of luminaires" (Kaufman, p. 10-2). The Illuminating Engineering Society (IES) has grouped generically the general type of light produced as: (1) general, (2) local, (3) localized general, and (4) supplementary.¹

C. Luminaires.--Luminaires have been classified on the basis of light distribution. They are direct, semi-direct, general diffuse, semi-indirect, and indirect (Ibid.).

D. The selection of light sources.--The selection of light sources, their luminaire characteristics, and the layout system "are closely interrelated in an application technique" (Ibid.). Local conditions, such as temperature, dust and dirt, or color will greatly influence the selection of the light source, how it is applied, operated, and its output and maintenance.² Economics becomes the deciding factor where various light sources are equally applicable (Ibid.).

E. The initial and operating costs.--The initial and operating costs are of primary concern in any lighting system design. The costs must be balanced against the

¹See Chapter II.

²See Chapter IV.

results, and the designer must rely upon his personal experience and the experience of others in the solution of comparable problems if there is any such experience available (Ibid., p. 10-3). Kohler and Luckhardt (p. 133) feel that " . . . All good lighting must provide for the needs of vision, satisfy hygienic requirements, meet aesthetic standards, and achieve a good spatial impression and do all this economically."

II. General Statements Concerning Interior Lighting Design Problems

The eye, like the rest of the body, dislikes strain and welcomes ease. Comfortable lighting makes it easy to see what you are doing and where you are going. It brings out all the beauty in the rooms you live in-- shows up the subtlest colors, the textures, the forms, so that you can enjoy them at any hour (House and Garden, 1967, pp. 110-11).

To the interior designer, lighting may be considered an art. To the illuminating engineer, lighting is considered a science. In reality, it is both of these, and both concepts must be employed in the design of lighting systems if the system is to meet the needs of those for whom it is being designed. Kaufman (p. 10-1) supports this idea with his statement:

The art and science of modern interior lighting design is broader in scope than it is often thought to be. In general, it involves several factors: light and vision, the visual response of the eye under varying light and environmental conditions. Others relate to the production, control, and distribution of electric light. And still others relate to the enclosure itself, or building structure, including size, shape, color, and related decorative considerations.

Whiton, in Elements of Interior Design and Decoration (1965), states the general problem to be one of practical and aesthetic considerations, although he naturally emphasizes the aesthetic more than does Kaufman when Whiton (p. 679) states:

. . . The planning of artificial lighting presents a problem that requires both practical and esthetic considerations. The average room needs light for general illumination and special lights for particular areas or activities. The lighting equipment and fixtures must be consistent with the style of decorations, must contribute to the desired character and atmosphere, and must be adequate for the purpose of the room.

The psychological and physiological implications of lighting must not be neglected.¹ Kohler and Luckhardt (p. 117) state:

. . . Just as every artist must learn to handle the tools of his craft correctly, so he who would build in light, would use light superlatively as a building block, must know the virtues of light, the physiological and psychological effects connected with light in order to master them.

This writer firmly believes that the interior designer should and must strike a balance between being able to apply the science of lighting and the art of lighting. Because progress is being made so rapidly in the lighting field, it is the responsibility of the interior design student as well as the practicing interior designer to keep abreast of the new developments and apply this knowledge in the best ways possible. Kaufman (p. 10-2) supports this

¹See paper by Judith Orr, Michigan State University, 1969, for the psychological and emotional effects of lighting.

with his statement that designers must have " . . . a competent knowledge of the principles of light control and of the lighting tools and devices which are available for the problem involved."

The Principles of Good Lighting

I. The Aims of Good Lighting

The Illuminating Engineering Society (IES Code, 1961, p. 1) states three aims of good lighting. They are: (1) to "promote work and other activities carried on," (2) to "create, in conjunction with the structure, a pleasing environment conducive to interest and a sense of well-being," and (3) to "promote the safety of the people using the building."

To support the IES aim of safety, the Committee on Residence Lighting (p. 7) has elucidated on this point for residential use. They believe that all lighting and the switches that control the lighting, must be strategically placed in order to insure positive and rapid seeing from one room to another. This is particularly true at danger locations such as stairs, medicine cabinets, and equipment with moving parts--from kitchen appliances to electric razors. The Committee also suggests for convenience, as well as safety, the use of low-wattage night lights in bathrooms, bedrooms, halls, and at the top of stairs.

II. The Realization of the Aims of Good Lighting

Equally applicable to commercial or industrial lighting and to home lighting, these aims must be realized in a variety of ways spelled out below (IES Code, p. 1).

A. Planning brightness and color patterns.--Careful planning of the brightness and color patterns¹ in the work or task area and the surrounding area is essential because attention must be drawn naturally to the important areas, detail must be seen quickly and accurately, and the room should be free from gloom and monotony.

B. Directional lighting.--Directional lighting should be used where it is appropriate to assist in seeing detail and to give good modeling of objects, such as art objects, paintings, etc.

C. Glare.--Glare, reflected or direct, must be controlled in order to eliminate any visual discomfort. The degree of glare from a direct view of a light source depends on the brightness and area of the source, its position, and the average brightness of the room background. Reflected glare is caused by polished or glossy surfaces and can be reduced by rearranging the position of the light source out of the angle of vision, by reducing

¹See Chapter III.

surface brightness of the source, and by increasing the lightness of the immediate background to the task (Ibid., p. 6).

D. Flicker.--Flicker results when discharge lamps operate on alternating current and their light output varies in each cycle. One will find this annoying flicker often in tubular fluorescent lamps. It may be overcome by fitting opaque shields over the lampends, or by screening the ends from direct view (Ibid., p. 7).

E. Correlating lighting throughout an area.--Correlating lighting throughout an area is necessary in order to prevent excessive brightness differences between adjacent areas as well as for safety precautions.

F. Installing emergency lighting systems.--Installing emergency lighting systems is a preventative measure against injury in case of a power failure to the regular lighting system.

G. Maintaining lighting installations.--Maintaining lighting installations is all-important to a lighting system to increase the life of the lamp and increase the efficiency level of the lamp. The IES (Ibid., p. 10) feels that:

. . . Unless both the structure of a building and the lighting equipment are well maintained, the aims of good lighting will in time be defeated; the lighting, natural or artificial, will no longer fulfill its purpose adequately, the cost of providing useful light

will increase, and the appearance of the building will deteriorate. . . . Films of dust and dirt deposit on all room surfaces and the consequent depreciation in reflection factors affects the level of illumination in the room.

Unless the luminaire and the room surfaces are maintained, both factors will increase lamp inefficiency and decrease the life of an expensive and necessary item in the home. Luminaires of all types, also, are a natural attraction to bugs, dust, and dirt. If the luminaires are not cleaned regularly, the output efficiency of the luminaire is reduced greatly.

H. Lighting output efficiency.--Lighting output efficiency "of artificial lighting equipment decreases progressively with time from three causes:" (Ibid., p. 11)

1. A gradual fall in light output of the lamps.
2. A decrease in the efficiency of fittings caused by dust or other deposits on reflecting or transmitting surfaces.
3. The permanent discoloration of reflecting or transmitting surfaces caused by corrosion (apparent in some atmospheres), by age, or by radiation (Ibid., p. 28).

The Environmental Objectives of Residence Lighting

Unlike some commercial or industrial lighting systems, residence lighting has no set systems of lighting for most areas. Any visual task performed by an individual

may take place in any room. Therefore, lighting of the individual task areas is usually considered first by the designer. These areas are then tied together with some form of general or environmental lighting system. "This 'tying-together' process is important in achieving a comfortable visual environment" (Kaufman, p. 15-1). As stated earlier in the chapter, there are four things that must be considered in supplying a pleasing lighting environment, and those things for which all good lighting must provide. They are:

1. Supplying the needs of vision. In supplying the needs of vision, the designer must consider the "seeing zones" (Ibid.) and luminance ratios in these zones. The three "seeing zones" are:
 - a. Zone 1--the task itself, which demands local lighting.
 - b. Zone 2--the area immediately surrounding the task.
 - c. Zone 3--the general surroundings.

Kaufman (p. 15-1) states:

In the immediate surround . . . , luminances that are noticeably greater than the task luminance or which are less than 1/10 the task luminance contribute to visual discomfort and are apt to be distracting. The luminance of substantial areas in the general surround should not exceed ten times the task luminance or be much less than 1/10 as bright. . . . These luminance relationships become more important as illumination levels increase and as duration of tasks is lengthened.

The IES takes this approach to luminance ratios (Ibid., p. 10-1):

The general approach to low luminance ratios over an entire visual field is to limit the luminance of the luminaires and fenestration, and to build up the luminance of all other interior surfaces (ceiling, walls, trim, floor, work surfaces, and equipment) by suitable reflectances, textures, and distribution of light.

The balance of illumination in the visual field can be accomplished by reducing high luminances at window areas and luminaires by shielding and by low-transmission shading materials; by balancing large areas of room surfaces using favorable finishes;¹ and by providing additional lighting in the visual surround (Ibid., p. 15-1).

2. Supply a hygienic lighting system. Research has indicated that adverse effects may result from less than optimum lighting. The National Technical Conference of the IES reported in 1966 (p. 6) that:

. . . Long exposure to less than optimum lighting conditions can affect the health and accelerate the aging process of people, and day by day can unfavorably affect their attitude to their work and their physiological efficiency.

In relation to daylight factors and hygiene, Kohler and Luckhardt (p. 129) stress the importance that German school doctors,

¹See Table 1, "Reflectances and Approximate Munsell Values for Interior Surfaces of Residences."

hygienists, and governmental agencies placed on lighting in school rooms. They state:

. . . school doctors early questioned whether the lighting in school rooms by day was adequate for reading and writing. Soon thereafter, hygienists began studying what supply of light should be provided in living quarters, and certain government agencies also turned their attention to these problems and sought to solve them by regulation.

Kohler and Luckhardt (p. 130) also go on to discuss the legislative provisions that were made over 160 years ago by Prussian provincial common law demanding that the tenant, "if he steps to a closed window in the lowest story, may see the sky." This was inspired by the sense that "it is one of the rights of man to have the space in which he dwells arranged so that he can feel well and keep well; it is a rule of hygiene" (Ibid.).

Unfortunately this code was dropped in modern times when air conditioning and artificial light began to influence people so that their need to see and move to daylight was no longer necessary. Kohler and Luckhardt, however, point out that we have conveniently forgotten about the un-air-conditioned tenements of most cities with their sad and unhygienic surroundings, and feel that such a requirement as the Prussians made so many years

ago is still very appropriate and needed in our own day.

3. Meeting aesthetic standards. Meeting aesthetic standards should not be neglected by the designer of the lighting system. By virtue of their education, experience in dealing with aesthetics, and natural love of beauty, interior designers should be the most aware of these standards of lighting and seek to attain them at all times.¹
4. Achieving good spatial relationships. Well-planned, designed lighting systems can achieve good spatial relationships within a specified area.²

¹See Chapter IV, also, for discussion of aesthetic design factors in structural, portable, and accessory lighting.

²See Chapter III, quality and quantity of light.

CHAPTER II

LIGHT CONTROL

PART ONE: PRINCIPLES OF LIGHT CONTROL, LIGHTING METHODS, AND MODES OF DISTRIBUTION

The Physical Principles of Light

Light, which is that portion of radiant energy which reacts upon the eye to produce the sense of sight, may be controlled in the following ways: (1) reflection, (2) refraction, (3) transmission, (4) polarization, (5) diffusion, and (6) absorption. These physical principles of light control will be discussed in detail.

I. Reflection

Kaufman (p. 6-1) defines reflection as "the process by which a part of the light falling on a medium leaves that medium from the incident side." Reflection is divided into four types: (1) specular, (2) spread, (3) diffuse, and (4) compound. We shall look at each type of reflection separately (see Figure 1, page 19).

A. Specular reflection.--The surface is of a polished medium, as in polished or electroplated metals

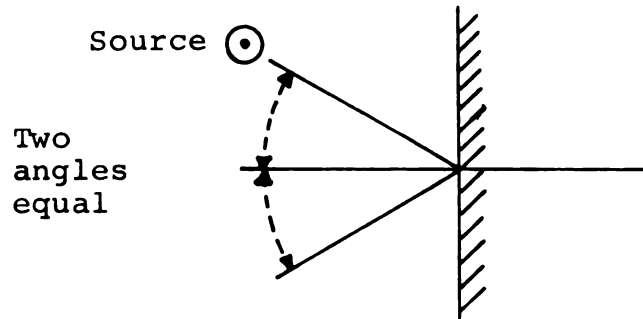
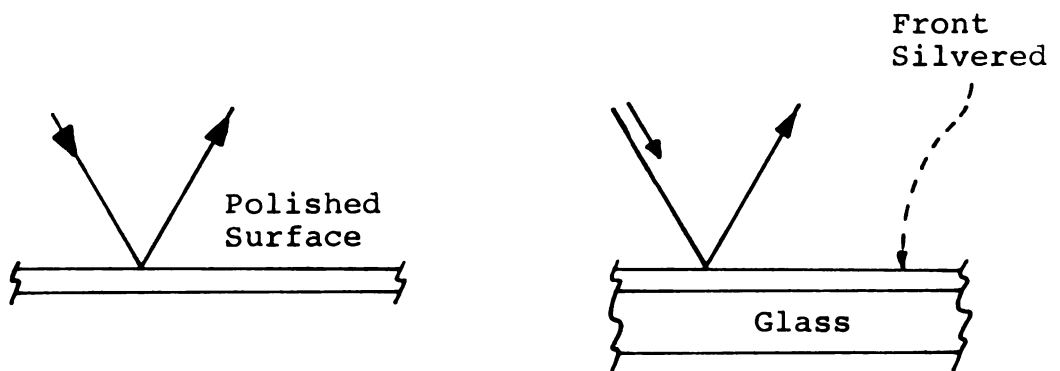


Figure 1.--The Law of Reflection



Figures 2 and 3.--Specular Reflections

(copper or gold), silvered glass, or plastic mirrors (see Figures 2 and 3, page 19).

B. Spread reflection.--The surface is figured in some way such as corrugated, deeply etched, or hammered. Any rays that are reflected from such surfaces are spread. Depolished metals, brushed or pebbled surfaces "consist of small specular surfaces in irregular planes" (Ibid., p. 6-2) (see Figure 4, page 21).

C. Diffuse reflection.--The surfaces are rough or "composed of minute crystals of pigment particles" (Ibid., p. 6-2). Flat paints and other matte surfaces or finishes exhibit very little light direction control. These surfaces are used when a wide distribution of light is desired (see Figure 5, page 21).

D. Compound reflection.--Many compound materials, such as embossed aluminum or semi-gloss paint, exhibit a combination of specular, spread, and diffuse reflections (see Figures 6, 7, and 8, page 22).

E. Basic reflector contours.--There are three common reflector contours which control the light being emitted at the source. They are: (1) parabolic, (2) elliptical, and (3) circular or spherical (see Figures 9, 10, and 11, page 23).

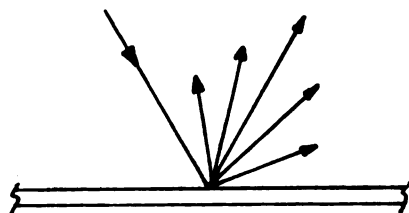


Figure 4.--Spread Reflection

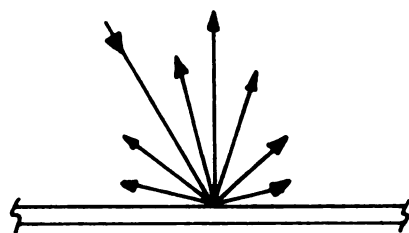


Figure 5.--Diffuse Reflection

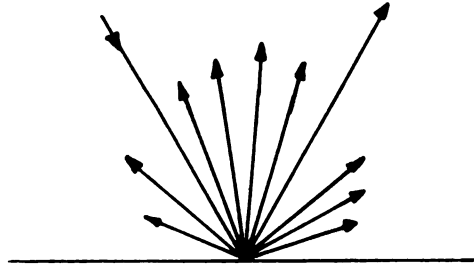


Figure 6.--Compound--Diffuse and Specular

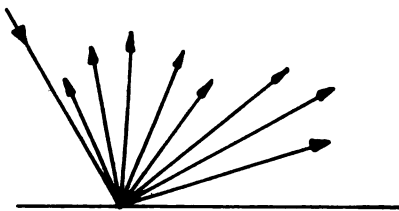


Figure 7.--Compound--
Diffuse and Spread

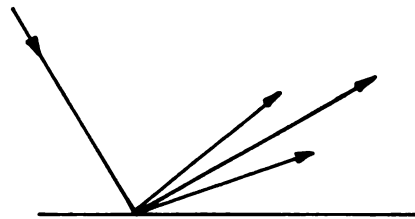


Figure 8.--Compound--
Specular and Spread

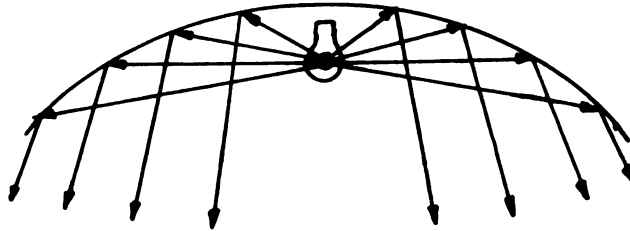


Figure 9.--Parabolic Reflector

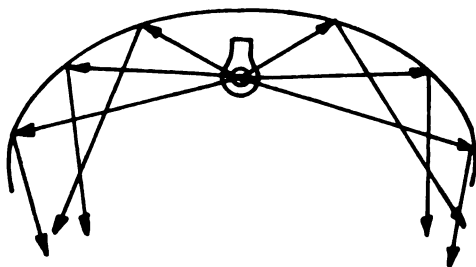


Figure 10.--Elliptical Reflector

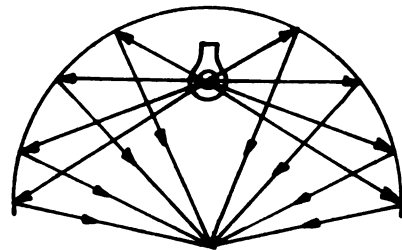


Figure 11.--Circular or Spherical Reflector

II. Refraction

Kaufman explains refraction in this manner:

A change in the velocity of light occurs when a ray leaves one material and enters another of greater or less optical density. . . . Except when light enters at an angle normal [perpendicular] to the surface of a medium of different density, the change in speed always is accompanied by a bending of the light from its original path at the point of entrance (Ibid., p. 6-2). (See Figures 12 and 13.)

This kind of phenomenon is apparent when we view at an angle a straw or pencil in a glass of water, and the object appears to bend at the surface of the water. Prisms and lenses, either convex or concave lenses, are used as refractors as well.

III. Transmission

Materials used in the transmission of light may be glass, plastics, textiles, crystals, etc. Transmission is achieved in four ways: (1) direct, (2) spread, (3) diffuse, and (4) mixed.

A. Direct transmission.--The direction and characteristics of the light beam sent through clear glass or plastics are not changed appreciably (see Figure 14, page 26).

B. Spread transmission.--Spread transmission occurs when a beam of light is sent through a lightly diffusing medium, such as frosted glass. Spread transmission is used for brightness control, where sparkle and brilliance

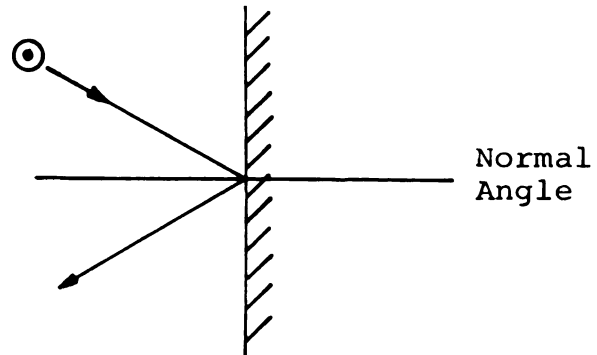


Figure 12.--Refraction

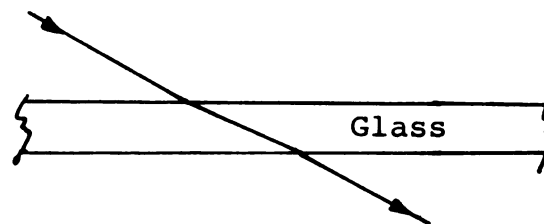


Figure 13.--Refraction

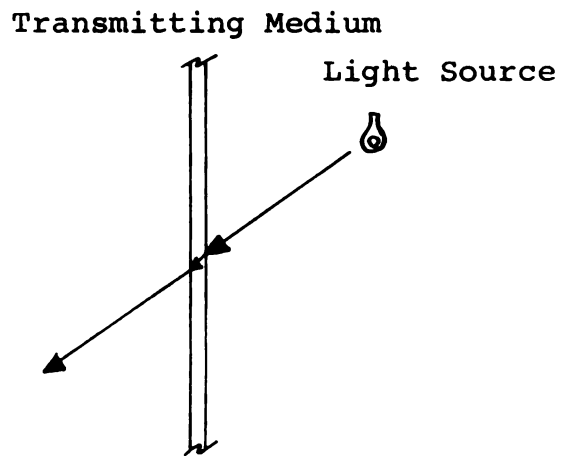


Figure 14.--Direct Transmission

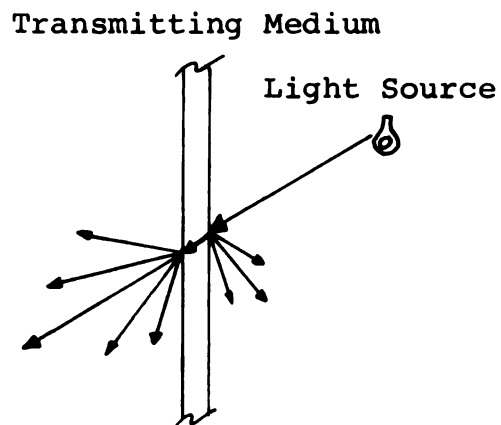


Figure 15.--Spread Transmission

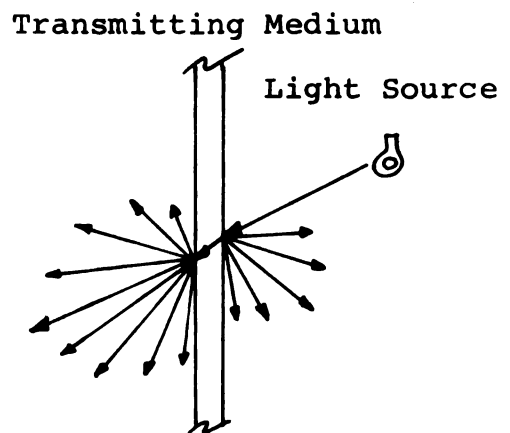


Figure 16.--Diffuse Transmission

is desired, and in enclosed globes of moderate uniform brightness (see Figure 15, page 26).

C. Diffuse transmission.--Diffuse transmission occurs when light is sent through a dense medium. Light is then scattered in all directions. Examples of these mediums would be white, opal, and prismatic glassware (General Electric, Light Measurement and Control, pp. 21-22) (see Figure 16, page 26).

D. Mixed transmission.--Mixed transmission permits regular transmission of certain colors while it diffuses others. Opal glass is an example (Kaufman, pp. 6-8, 6-9).

IV. Polarization

Polarization, a relatively new discovery, is explained by the General Electric Company in the following statement:

Ordinarily, light rays are considered to vibrate in all directions perpendicular to the direction of travel of the light. Light rays can be modified by polarization so that the vibrations are predominately in one plane. This polarization of the direction of vibration can be caused by a variety of transmitting or reflecting media. The sky, water surfaces and certain crystals such as tourmaline are examples of polarizing media in nature. Special polarizing plastic materials, transparent materials which have been internally stressed, and multi-layers of glass or plastic are examples of man-made polarizing materials (General Electric, Light Measurement and Control, p. 26).

V. Diffusion

Diffusion may be defined as "the breaking up of a beam of light and the spreading of its rays in many directions" (Kaufman, p. 3-9).

VI. Absorption

Absorption "occurs when a light beam passes through a transparent or translucent medium or meets a dense body. . . . Practically all colored objects owe their color to selective absorption in some part of the visible spectrum" (Ibid., p. 3-9). General Electric states that the most important use of absorption in the controlling of light is in producing colored light from white light sources:

. . . A selective-color filter is placed between the white light source and the surface which is to receive colored light. This filter absorbs parts of the spectrum, and allows other parts to be transmitted (General Electric, Light Measurement and Control, p. 25).

Lighting Methods

I. General Classification

Kaufman and others divide the general or generic lighting systems into three classifications:

A. General.--General lighting is that lighting which is at "an approximate uniform level of illumination . . . over an entire area" (Kaufman, p. 10-3), as in diffused ceiling fixtures over a large office area.

B. Localized general lighting.--Localized general lighting is that lighting which is "a functional arrangement of luminaires with respect to the visual task" (Ibid., p. 10-3), as in hanging fixtures over a work bench area.

C. Local or specific lighting.--Local or specific lighting may be described as a system which "provides lighting only over a relatively small area by the task and its immediate surround" (Kaufman, p. 10-3), such as a desk or piano lamp.

D. Supplementary light.¹

II. Directing Light

There are three ways in which light may be directed onto a surface or object. This is not to be confused with the above general classifications of lighting systems, or the methods of distribution which are to follow this section. Light can be directed from the luminaire or lamp in three ways:

A. Uplighting.--Uplighting is that light directed perpendicular onto a surface above the fixture, such as a ceiling.

B. Downlighting.--Downlighting is light that is directed downward from the fixture onto the surface directly

¹See Chapter IV, Structural, Portable, and Accessory Lighting.

below it, usually the floor. A wall or theatrical curtain may be down-lighted as well because an overall wash is given to the surface.

C. Projecting illumination.--Projecting illumination is directing light horizontally or diagonally to a certain surface or object one wishes to illuminate.

Methods or Modes of Light Distribution

The methods or modes of light distribution are specifically divided into five groups which are described and drawn in the chart in "Basic Modes of Lighting," Appendix A. These modes of light distribution are defined by Kohler and Luckhardt (p. 136) as "the several fundamental ways of using light in a room for illuminating purposes" (Kohler and Luckhardt, p. 136). They go on to describe lamps as being the artifacts which embody the sources of light, while "fixtures control the light of lamps for light purposes" (Ibid.). They feel it is the nature of this control that determines the mode of lighting.

PART TWO: DESCRIPTIONS, FUNCTIONS, AND MATERIALS USED IN LIGHT CONTROL

In order that the reader may gain some awareness of the materials used in light control, their descriptions, and their functions, the writer has prepared this information in outline form. A detailed description of this information may be found in IES Lighting Handbook, 1966 (Kaufman, ed.), pages 6-13 through 6-20.

A. Materials Used in Light Control

1. Glass

a) Types

- (1) pressed
- (2) blown
- (3) rolled
- (4) drawn

b) Use in Lighting

- (1) control of light and other radiant energy
- (2) protection of light sources
- (3) safety
- (4) decoration
- (5) diffuse light

2. Plastics

a) Types

- (1) thermosetting
- (2) thermoplastic

b) Uses--Chart "Uses in Lighting of Important Resins"

3. Steel

a) Types

- (1) hot-rolled
- (2) cold-rolled
- (3) porcelain enamel sheet

b) Uses in lighting

- (1) structural capacity
- (2) bars and rods in lighting equipment

c) Finishes

- (1) galvanized sheet
- (2) pre-painted sheet
- (3) aluminum sheet
- (4) plastic-coated sheet
- (5) pre-plated sheets
 - (a) chrome
 - (b) brass
 - (c) copper

4. Aluminum

a) Types

- (1) shapes
- (2) sheets

b) Uses in Lighting

- (1) structural parts
- (2) light controlling surfaces
 - (a) reflectors
 - (b) louvers
 - (c) baffles
 - (d) decorative surfaces

c) Finishes

5. Stainless Steel

a) Types

- (1) straight chrome group
- (2) chrome-nickel group
- (3) chrome-nickel-manganese group

- b) Uses in Lighting
 - (1) outdoor installations
 - (2) reflectors
 - (3) lighting equipment hardware
- 6. Copper
 - a) Uses
 - (1) conductors
 - (2) control of electrical energy used for lighting
- 7. Non-ferrous Alloys
 - a) Types and Uses
 - (1) brass used for decorative purposes
 - (2) bronze used for marine equipment
- B. Finishes Used in Luminaires
 - 1. Finishes Defined
 - 2. Types
 - a) Organic coatings
 - (1) laquer for decoration and protection
 - (2) enamel for decoration and protection and reflectance
 - (3) baking laquer (baked clear) for decoration and protection
 - (4) plastic dispersion for corrosion and abrasion resistance and concealing defects
 - b) Ceramic coatings--porcelain enamels fired on glass and metals
 - (1) for corrosion resistance
 - (2) good reflectance
 - (3) easy maintenance
 - (4) reducing brightness and increasing diffusion
 - c) Metallic coatings
 - (1) electroplating
 - (2) brass
 - (3) silver
 - (4) dip and spray coatings
 - d) Laminates
 - e) Chemical conversion coatings

CHAPTER III

TYPES OF LIGHT: QUANTITY AND QUALITY

Natural Light

I. Definition of Natural Light

Natural light may be defined as that light which is produced and/or emitted by a natural light source.

II. Sources of Natural Light

The most obvious sources of natural light are the sun and moon. The less obvious perhaps, but as much a part of natural light are the sky and the ground. Whereas the sun and the moon are considered direct sources of natural light, the sky and the ground are usually referred to as transmitting and reflecting sources, respectively. The sun directs its light rays through particles in the atmosphere which function as transmitters of the sun's rays. In contrast, light rays are reflected from the ground and may account for as much as 10 to 15 per cent of the total daylight reaching a window area (Kaufman, p. 7-1).

III. Availability and Variability of Natural Light

The availability and variability of natural light is in a constant state of flux. One notices these changes especially during the daylight hours. Daily and seasonal motions of the sun cause variations in the amount, direction, and intensity of light. Kohler and Luckhardt (p. 130) state:

. . . Daylight lighting is subjected by nature to continual quantitative and qualitative change, altering its intensity and mood with the time of day and with the seasons. . . .

In the early morning hours, just before dawn, "the sky distributes light like fluorescent tubes, shadowless and even" (Interiors, 1952, p. 92). Upon the rising of the sun, "it is satisfying incandescent, a point source of light that creates form-giving shadow and movement to the earth" (Ibid.). In the evening as the sun sets, an even brightness is once again spread against the earth. It is this ability of daylight to change that gives it "its first appeal" (Interiors, 1950, p. 118). The IES (IES Code, 1961, p. 35) supports this viewpoint when they state:

" . . . One of the characteristics of daylight which gives it this appeal is the constant change both in quality and quantity creating interest and avoiding monotony."

The local terrain, landscaping, and nearby buildings will greatly affect available light by creating shadows, and partially or completely blocking the direct rays of light. In addition, the degree of cloudiness in the sky

and rapid changes in cloud movement will affect the amount, color, and distribution of light rays falling on a surface.

IV. Control of Natural Light

In order for natural light to be controlled and used as a design medium, Kohler and Luckhardt (p. 130) feel it is appropriate to recognize the reality of daylight illuminating engineering. They state:

. . . daylight, which might well be called the primary sustenance of life, has had only passing attention from engineering science as its value in human living and working space . . . intensive and extensive research on daylighting is going forward on every hand, so that we can properly speak of "daylight illuminating engineering," that is owing to [due to] the lighting technicians, who have recognized that the system originally set up for measuring and evaluating artificial light can be applied to daylight as well.

The need for natural daylight has been recognized in most modern provisions of law which "require that rooms intended for continual human occupancy must receive natural daylight" (Ibid.). This provision applies to continual human occupancy in a residence only, not a business establishment which is not occupied continuously.

To use natural light to its fullest and best advantage, and to cause the least amount of discomfort to inhabitants of a building, natural light must be controlled. Listed below are five suggested ways of controlling natural light that the interior designer might find especially helpful. They are:

1. By the use of fabric at window areas--opaque, semi-opaque, or translucent fabrics in lined

draperies, casements, and sheer draperies or curtains.

2. By the use of glass--translucent, diffused, or colored.
3. By taking advantage of natural architectural features of the building itself, such as roof overhangs or decorative grill work.
4. By the use of opaque materials--roller shades, Venetian blinds, wooden or plastic blinds, shutters.
5. By the use of shields or exterior awnings.
6. By the use of landscaping and other natural terrain.

The IES (IES Code, 1961, p. 35) has found that most people prefer working in buildings that have good daylighting, and "the importance placed on this is shown by the way in which sites are usually planned to make the best use of available natural light."

The IES (Ibid.) goes on to suggest that there are two types of interiors that must be considered in daylight design and control: (1) one interior in which inhabitants are able to move freely to the daylight, such as in the home, and (2) one interior in which the same or similar kinds of work are carried on over the entire area, such as in offices or factories. In the former, the main problem is to locate windows in relation to the function or purpose of the room. In the latter, the problem is to provide

"well-located pools of light with no unduly dark zones" (Ibid., p. 35). The lighting designer must make it possible for occupants to receive the correct amount of light from the right direction causing the least eye discomfort from sky glare.

Artificial Light

I. Definition of Artificial Light

Artificial light may be defined as that light which is produced and/or emitted by a man-made or artificial source.

II. Sources of Artificial Light

The most common examples of artificial light sources are the incandescent and fluorescent lights. Less common sources are high intensity discharge lamps--mercury vapor, Multi-Vapor,¹ and Lucalox.² Because the high-intensity discharge lamps are more commonly used as exterior lighting and in industrial settings, they will not be discussed in any detail here.³

¹General Electric's trade name for a high efficiency vapor lamp.

²General Electric's trade name for the highest efficiency vapor lamp.

³More information may be obtained on the high-intensity discharge lamps from General Electric's pamphlet, High Intensity Discharge Lamps, #TP-109, Large Lamp Department Publication, General Electric Company, Nela Park, Cleveland, Ohio 44112.

III. Efficiency of Artificial Light¹

The greatest efficiency in terms of a long lamp life or quantity of output must sometimes be sacrificed for a shorter lamp life and better quality of output or color rendition. Depending upon the needs of the individual or group of individuals for whom the lighting is being designed, these conflicting factors in efficiency play a significant role in determining the lamp specifications.

IV. Artificial Light as a Structural Element

Artificial light as a structural element in the lighting of interiors may be considered in two ways: (1) as an element of design, such as line or shape, which affects form, color, and texture; and (2) as a physical light source built into the room as a part of its finished structure.² At this point, we are concerned with light as an element of design, and how this ultimately affects people and objects in a particular space. The Residential Lighting Conference (General Electric, 1967, p. 1) states:

. . . The emphasis now is on the environmental aspects of lighting--its effect on texture and color--its emotional impact on people--the way lighting defines planes and spaces.

¹See also Chapter I.

²See Chapter IV, Structural Lighting.

V. Kinds of Artificial Light

The kinds of artificial light most commonly used in residential and contract interiors are incandescent and fluorescent.

A. Incandescent light.--Since the invention of the first electric filament lamp by Edison in 1879, the incandescent lamp, even though not the most efficient, has been a popular source of artificial light--it accounts for 60 per cent of the United States dollars spent for large lamps. Why is this so? Incandescent light is flexible, and is the least expensive in terms of initial equipment investment (General Electric, Incandescent Lamps, p. 3). (See Appendix B, "Incandescent Lamp Shapes.")

The glass bulb of an incandescent lamp keeps the air out while keeping the filling gas in. The bulb may be clear, frosted inside, coated with a diffusing material, or silvered or aluminized inside.

Incandescent lamps are designated by a two-part abbreviation. The first part, a letter, indicates the shape of the bulb, such as "F" for flame shape, "P" for pear shape, etc. The second part of the abbreviation, a number, indicates the maximum diameter of the bulb in eighths of an inch. An "R-40" designation is an example of a reflector bulb with a maximum diameter of five inches (Ibid., p. 10).

The incandescent lamp is normally classified into three major groups:

1. The large lamp group which operates on thirty volts or more. The interior designer and homemaker are most familiar with these shapes (see Appendix B).
2. The miniature group which operates on less than thirty volts. These lamps may be used in automobiles, aircraft, flashlights, or as Christmas tree lights.
3. The photographic group, used for taking photos and supplying projection service.

The IES states that the primary consideration of lamp design for the incandescent lamp is that it "will produce the spectral radiation desired most economically for the application intended or . . . obtain the best balance of overall lighting cost in terms of the lighting results" (Kaufman, p. 8-1). In a similar vein, Whiton (p. 681) feels that the incandescent lamp is best designed for historical settings, spot lighting effects, and portable lamps, even though it is not as adaptable or versatile as fluorescent light.

Because incandescent light is considered a more concentrated and small, high brightness source, it is suggested that adequate shielding, directional control, and/or the use of diffusing materials be used. It is the experience of this writer that where these provisions are

not taken into consideration, uncomfortable conditions, such as heat and glare emitted by the source, are present.¹

B. Fluorescent Light.--Fluorescence is defined as "the property of a material to become self-luminous when acted upon by radiant energy, such as ultra-violet or X-rays" (General Electric, Fluorescent Lamps, p. 6).

The fluorescent lamp, which was developed for practical use in 1938 by General Electric, has undergone numerous changes and improvements since that time. One of the remarkable improvements in light and lamp life that has been made since 1950 is a 41 per cent increase in initial light output while increasing lamp life as well. There are available on the market today several standard sizes ranging from six to ninety-six inches in length, various shapes, and consuming from 4 to 215 watts (Ibid., p. 3).

There are several million fluorescent lamps which are used annually in industrial, institutional, commercial, and residential settings. In the past decade more than 50 per cent of the electric light used in the United States was fluorescent. It has gained its popularity in this nation for four reasons:

1. It is a highly efficient light producer resulting in lower lighting costs.

¹See Incandescent Lamps, by General Electric's Large Lamp Department for specifications.

2. It is very easy to maintain and possesses a long lamp life.
3. It has a much lower heat content for visual and thermal comfort than does incandescent and has a relatively low surface brightness.
4. It comes in a variety of sizes, shapes, and colors.

The most obvious distinguishing feature of fluorescent light is that it is a "line of light." This feature allows it to emit its light in a diffuse manner rather than in the directional or concentrated manner of incandescent light. For this reason, fluorescent light is suggested for areas that demand an even distribution of shadowless light, and where low contrast and little or no glare is desired. Examples of areas that demand this type of light are offices, school rooms, and industrial task centers.

This "line of light" is most commonly a straight line, but fluorescent light is not limited to this one shape. It is limited only by the fact that it must have two points between which an arc of energy must pass in order to ignite its gases thus producing fluorescence. The fluorescent lamp is currently available in circles, U-shapes, panels, and a special energy distribution shape, Power-Groove (General Electric, Fluorescent Lamps, p. 11) (see Appendix C for "Shapes of Fluorescent Tubes).

Another important feature of fluorescent light is that it is available in seven different achromatic levels

of white light and eight chromatic levels. It is also available in special energy distributions such as the Power-Groove. (The Power-Groove is used mostly in industrial settings where a higher output of light is needed. General Electric does not foresee its usage, for the present, in residential settings.)

In selecting fluorescent luminaires, Westinghouse (Fluorescent Lighting, p. 20) suggests that to use it to its best advantage, the luminaire should be chosen on the basis of its particular characteristics. They list eleven specific characteristics: (1) distribution, (2) efficiency, (3) brightness in the field of vision, (4) lighted appearance, (5) unlighted appearance, (6) resultant appearance of the lighted room, (7) ruggedness and durability, (8) ease of installation, (9) accessibility and flexibility, (10) maintenance and ease of cleaning, and (11) cost.

More specifically, General Electric (Fluorescent Lamps, p. 8) suggests the consideration of three important elements in choosing lamp color: (1) efficiency, (2) color rendition, and (3) whiteness. If a designer wishes to obtain the best color rendition, a necessary reduction in efficiency must be taken into account.

The lamps designed for the highest efficiency and with only acceptable color rendition in the achromatic levels are the cool white, warm white, white and daylight fluorescent lamps. These lamps are relatively weak in red rendition. The lamps designed for the most natural

and complimentary color rendition of colored materials and complexions, but with a resultant decrease in efficiency, are the deluxe cool white and deluxe warm white. These lamps tend to give a better balance in output by the addition of red light. The soft white fluorescent lamp is used where there is a demand for light which is very rich in red and emits an overall pinkish cast (General Electric, Fluorescent Lamps, p. 8).

Most authorities agree that there are three classifications of fluorescent lamps:

1. Pre-heat lamps require a few seconds for the preheating process.
2. Instant start lamps start as soon as the current to the lamp is turned on, thus eliminating the need for starters and simplifying lighting systems and maintenance. These lamps may be as long as eight feet because the pre-heating process is eliminated.
3. Rapid start lamps start in one to two seconds which make it possible to dim or flash this type of lamp. These are the most popular today and are used most frequently in new fluorescent lighting system installations.

Even though significant improvements have been made on fluorescent lamps since they were first developed, one will still find very adverse reactions to this type of

light. Kohler and Luckhardt aptly describe such adverse reactions when they state:

Unfortunately, there is still a very strong prejudice against the use of fluorescent lighting in the home owing to [due to] early misuses . . . when home lighting with fluorescent fixtures is correctly executed, it is quite impossible for the layman to tell from the lighting what kind of source is being used . . . the vast majority of people are very much guided by their pocketbooks, and it is therefore wise to save on lighting expense by using fluorescent tubes (p. 195).

One area of fluorescent lighting which has not been discussed, but which is bound to play an increasingly important role in our lives in the future, is that of electroluminescence or a similar type of source. Electroluminescence is described by Kaufman (p. 8-43) as "A thin area source in which light is produced by a phosphor excited by a pulsating electrical field." More simply, one can find it used in a variety of situations--night lights, switch plates, instrument panels, clock faces, telephone dials, thermometers, or signs. Although it is available in green, blue, yellow, or white and can be fabricated easily into shapes because of its flexibility, it is limited in its size to a 12" x 12" square. It is the hope of current lighting researchers and manufacturers that it will eventually become a mode for changing entire wall areas to a desired color by the "flick of a switch." For the present, its application is limited to locations where general illumination is low. Two outstanding advantages of electroluminescence are its long life and low power consumption.

Quantity of Light

Quick, accurate, and easy seeing requires not only an adequate amount of light, but also careful control of light distribution. Great strides have been made in lighting research over the past few years in measuring the effects of light on sight. These researches have clearly indicated that good lighting produces many benefits, such as increased safety and improved performance and greater ease of seeing (General Electric, Light Measurement and Control, p. 3).

The above statement reflects the importance of quantity and quality of light and light distribution, and the interrelated roles they play in planning an interior lighting system. It should be noted that because of this interrelation of roles, the following sections will not be as clearly defined as previous segments have been.

Kaufman (p. 10-10) describes the quantity of illumination as enough light to permit the quick, accurate performance of a task. The IES handbook does recommend, however, more specific levels of illumination for various tasks.¹

Other authors on this point offer somewhat more concrete explanations of the quantity of light and how it is measured. Kohler and Luckhardt (p. 119) state that, "Just as electrical work is measured in watt-hours or kilowatt hours, quantity of light is measured in lumen hours."

¹See Kaufman, 1966, IES Lighting Handbook for illumination level specifications.

I. Measurement of Light

The candela, lumen, footcandle, and footlambert (defined in Chapter I) are all means by which light may be measured. Each plays a significant role in the measurement of a quantity of light. Victoria Ball gives an explanation of roles played by each unit of light measurement. She states:

. . . As this light [from one candle] travels outward into space equally in all directions, the amount of it which flows in a relatively limited direction is measured on a square foot on the inside surface of the standard sphere which has a uniformly diffusing surface. This unit of measurement is called a lumen.
 . . . A lumen is the measure of luminous flux or flow. One candlepower can produce 12.57 lumens, because the surface of a sphere of one foot radius is 12.57 square feet.

The amount of light which shines upon any particular area becomes less the farther that area is removed from the light source. The amount of light at a particular place is expressed in candles per square foot or footcandles.

. . . a footlambert . . . appraises the brightness or apparent amount of light concentrated on a location (Ball, 1965, p. 150).

The instrument used for measuring light is called the light meter. It measures lighting levels in terms of footcandles and has a range from 0 to 5000 footcandles (see Figure 17, page 48).

II. Determining Levels of Illumination

Determining levels of illumination in an area is a second important consideration in the measurement of light quantity. These levels are calculated by a process called the lumen counter method. General Electric suggests

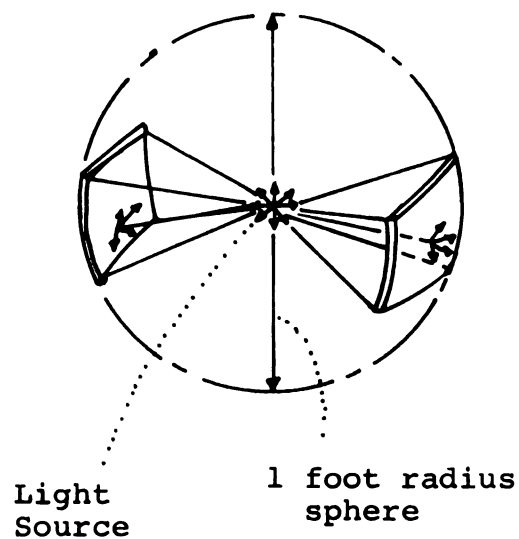
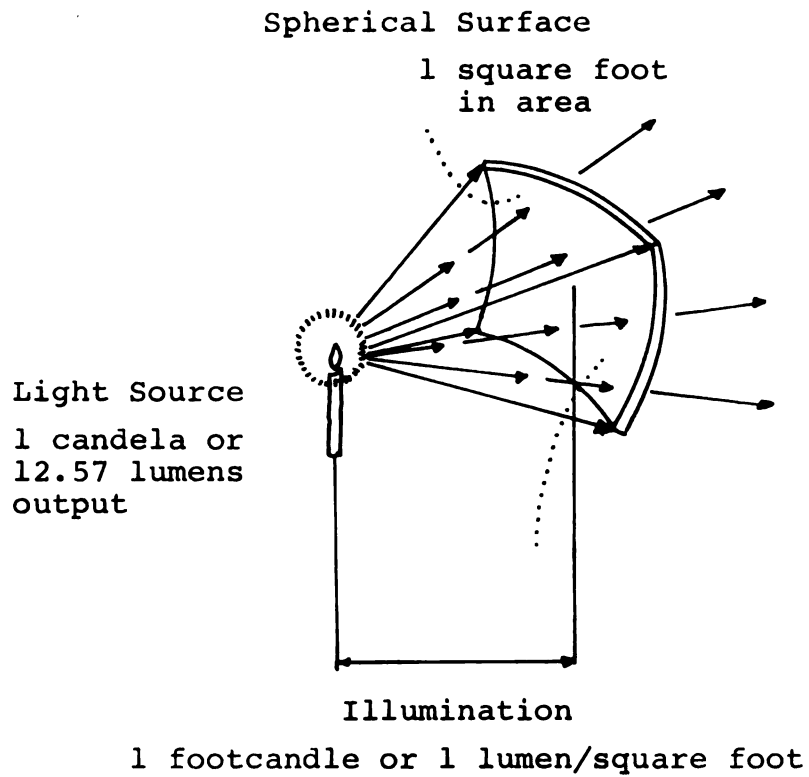


Figure 17.--Diagrams of Light Measurement

four sequential steps that should be followed to obtain the optimum illumination levels:

1. Determine where the lights are to be placed and the number of lights which are to be used.
2. Calculate the square footage of the room.
3. Multiply the room's square footage by the suggested number of lumens per square foot.
4. Consult the lamp lumen index for the lumen output of the lamp or tube desired to determine if the number and kinds of lamps you have chosen will attain desired levels of illumination (see Table 2).

These levels could be attained easily if no attention was given to the quality of light (discussed below). Pfister (1961, p. 27) states that a great percentage of the lamps and fixtures on today's market will not supply the recommended number of footcandles for the more critical visual tasks. New equipment and light sources are badly needed to produce these levels realistically and comfortably. Pfister does suggest, however, that this situation may be remedied by using equipment of the best lighting performance which is available, and supplementing it with built-in elements (Pfister, p. 28).

A study by Gore (1963) revealed that accuracy and speed of a task were better under high levels of illumination than under low levels. Although the difference was

not significant for statistical requirements, Gore does maintain that further research to uncover objective methods of measurement are appropriate to indicate human reactions to quantity and quality of light. Gore's hypothesis was that "humans perform less efficiently with lower levels of illumination when the task requires fine lines of discrimination" (Gore, p. 28). She measured the physical conditions of blood pressure, pulse rate, and galvanic skin response. These physical indicators of bodily responses, she contended, could be measured and correlated to the responses of differing lighting levels. The task employed was to copy names, addresses, and phone numbers from a telephone book using illumination levels varying from five to seventy footcandles per square foot.

III. Luminance Ratios

A third consideration in planning the quantity of light for a specific lighting system is luminance ratios and their relationship to the zones (zones 1, 2, and 3) of light.¹

IV. The Planning of Brightness Patterns

The planning of brightness patterns is the fourth consideration in planning light quantity for lighting systems. The IES describes brightness as being determined

¹See Chapter I.

by the speed and accuracy with which a task is executed, the duration of critical vision, and the general level of brightness in the room. The visual performance of the task is naturally related to the speed and accuracy with which the task is executed (IES Code, 1961, p. 1).

V. Reflectances

Reflectances are generally considered to play a vital role in the planning of brightness patterns. General Electric states:

Reflectances of interior finishes not only affect lighting system efficiency, but also influence visual comfort. Studies of visual comfort point out clearly that extreme brightness contrasts--between the specific task and its immediate surroundings, and between the task and more remote parts of the environment--can cause discomfort and fatigue.

For prolonged work, the brightness pattern should be well balanced. Control of the brightness pattern depends on the directional distribution of light, and on the reflectances of room surfaces (General Electric, Light and Interior Finishes, p. 3). (See Table 1.)

In relation to lighting efficiency, researchers have found that the higher the reflectance of a surface, the higher the utilization of light. To illustrate this statement, a room in which all surfaces were a flat white, would produce the highest light utilization possible. This kind of sterile environment, however, would not be judged desirable from a practical and psychological standpoint (Ibid., p. 3).

VI. Specific Task Brightness

When planning specific task brightness, the IES (IES Code, 1961, p. 2) suggests that the following items should not be overlooked:

1. The visual demands of the task.
2. The welfare, safety, and amenity judged appropriate to the occupation.
3. Illumination of all working areas should not be less than fifteen lumens per square foot.
4. There should be some uniformity of illumination over the utilizable area of the task.

VII. Brightness of General Surroundings

After the task brightness has been determined, other segments of the lighting system should be planned to give proper emphasis, visual comfort, and interest.

Brightness of general surroundings should:

1. Be sufficiently high to allow the eyes to adapt from the task to the rest of the environment.
2. Create a cheerful environment without causing visual discomfort or distraction.
3. Provide for "visual rest centres" for exacting detail (Ibid., p. 3).

VIII. Revealing Color, Texture, and Form

Careful thought must also be given to revealing color, texture, and form. The IES states that moderate differences in color and texture between the task and its background cause detail to become more recognizable and enhance contrast in the setting. Strong contrasts, however, should be avoided because of the distraction they can cause to the eye (Ibid., p. 2).

Kohler and Luckhardt (p. 135), agreeing with the IES, state:

Some uniformity of illumination is necessary. . . . A room should not show disturbing differentials of brightness distribution in the field of vision.

The same authors in discussing the effect of light on the revealing of color in the home state:

In general . . . the relationship between level of illumination, color of light and color rendition and sense of ease . . . are of paramount importance in the design of residential interiors (p. 195).

The IES (IES Code, 1961, p. 8) in discussing the rendering of color, also refers to reflection characteristics of the illuminating source as a determinant of the appearance of colored surfaces. The Society feels that daylight is the most pleasing source of light by which the natural color of objects is viewed, and that artificial light sources tend to change this appearance to a certain degree.

Color matching is, in some occupations (such as that of the interior designer), a critical judgment of

color or color comparisons. It is therefore essential that the artificial lighting systems that are designed (and preferred for this type of work) are designed as special lighting systems. The advantage of an artificial, special-color-rendering system is that it provides constant quantity and quality of light (Ibid., p. 8).

An illustrative example of a special color rendering lighting system is the one employed by the Burlington House Division of Burlington Industries. The system was designed using the General Electric "Chroma-Line" fluorescent lamps which give spectral characteristics closest to the color of noon daylight and northern skylight.

La Guisa states in Light magazine (1969, p. 3):

Mixing various types of lamps in various ratios is expensive, cumbersome, and difficult to adjust and maintain; whereas, the single-source approach with fluorescent lamps locks in on one specific chosen color objective. Critical work-a-day color appraisals, selection and matching under a single-source system has distinct advantages: it's quick and convenient, uses standard luminaires and circuitry, light-color remains uniform and there are no control adjustments or settings which are subject to error (Light, 1969, p. 3).

In revealing form and texture, the IES suggests that by changing the direction of light, both form and surface texture can be emphasized or de-emphasized. One might refer to this directional component as modelling. The appearance or solidarity of a three-dimensional object is affected by the direction from which light falls on the object. Modelling may improve the visibility of some tasks,

or may give a more pleasing or grotesque appearance to an object.

The control of glare and flicker are also necessary considerations in planning brightness patterns in lighting systems.¹

The Quality of Light

The quality of light is as important as the quantity of light. In determining priorities for a lighting system, the quantity of light needed is established first, and the quality of light must be of equal consideration to provide a well-planned lighting system. Measurement of light, determination of levels of illumination, luminance ratios, brightness patterns, reflectances, brightness of general surroundings, and the rendering of color, form, and texture are all considerations in determining the quality of light as well as the quantity.

In addition to these considerations, work and family living patterns affect the quality of lighting. Because of a substantial increase in informality and naturalness of the family in past years, one room may be used for several different functions; therefore, it must be lighted to accommodate these varied activities.

Trends in housing design will also have an ultimate effect on the quality of lighting because of the recent tendency to reduce the total amount of wall and ceiling

¹See Chapter I.

space. Many homes are being planned more openly, and there is a desire for bringing a natural outdoor environment inside. For these reasons, lighting designers must provide illumination subjectively for persons, rather than objectively lighting a specific room (IES Code, 1953, p. 3).

In schools and offices, however, the near-uniformity of light "is usually incompatible with the intent of most residential interiors . . . the tastes and varying eyesight demands of the individual family necessitate various lighting effects" (Ibid., p. 3).

Kaufman (p. 10-10) concisely sums up the concept of quality of illumination when he states that quality includes three necessary items:

1. Having the ability to see comfortably--eliminating direct glare, and minimizing brightness differences in the visual field.
2. Having freedom from annoying shadows.
3. Having satisfactory illumination uniformity.

TABLE 1.--Reflectances and approximate Munsell Values for interior surfaces of residences.^a

Surface	Reflectance %	Approximate Munsell Values
Ceiling	60-90	8-9.5
Fabric treatment on large wall areas	45-85	7-9.3
Walls	35-60	6.5-8
Floors	15-35	4.5-6.5

^aJohn Kaufman, ed., IES Handbook (4th ed.; New York: Illuminating Engineering Society, 1966), p. 15-2, Figure 15-3.

TABLE 2.--Lumen counter method.

Lumens Required Per Square Foot ^a			
Living Room	80 per sq. ft.	Bathroom	65 per sq. ft.
Dining Room	45 per sq. ft.	Hallway	45 per sq. ft.
Kitchen	80 per sq. ft.	Laundry	70 per sq. ft.
Bedroom	70 per sq. ft.	Work Bench	
		area	70 per sq. ft.

^aRecommended Minimum

LUMENS: The amount of light generated by the lamp or the tube at the light source.

FOOTCANDLES: A measurement of light that reaches any given surface. Footcandles are usually measured at table tops, open books held in normal reading position, etc., but not at the lamp or tube.

METHOD FOR DETERMINING LUMENS FOR A ROOM

1. Decide where lights are to be placed and the number of lights to be used.
2. Measure area to be lighted; express in square feet, (i.e., 15' x 20' = 300 sq. ft.).
3. Multiply square feet (300) by lumen requirement (i.e., 80 per sq. ft. for living room) 300 x 80 = 24,000 lumens.
4. Consult lamp lumen index for individual lamp or tube lumen output to find out if the number and kind of lamp or tubes selected will attain the desired number of lumens as listed above.

Examples:

One 20 ft. drapery cornice will take five 40-watt Home-line tubes at 1,840 lumens per tube.	9,200
Two 75-watt recessed R-30 spotlights (over piano) at 770 lumens per lamp	1,540
Two 3-light (100/200/300) lamp (pair of table lamps) at 4,660 lumens per lamp.	9,320
One 3-light (50/100/150) lamp (chair side table lamp) at 2,130 lumens per lamp	2,130
Four 60-watt lamp (in desk lamp) at 840 lumens per lamp	3,360

TOTAL	Desired	24,000	Actual lumens	25,500
LUMENS	Desired	80 per sq. ft.	Actual lumens	85

Note: Material adapted from General Electric Company, Nela Park, Cleveland, Ohio

CHAPTER IV

STRUCTURAL, PORTABLE, AND ACCESSORY LIGHTING

Structural, portable, and accessory lighting may be classified as three general types of lighting which employ different luminaires, construction techniques, and methods of distribution. It is a necessity that lighting designers be familiar with each of these lighting types, how they function, and where they should be placed in order to assist the lighting designer in creating the best possible lighting system.

Structural Lighting

It is of utmost importance that structural light¹ be an integral part of the initial planning of a building (whether it be an office building, home, or industrial setting) so that the lighting and the building may function together as a total unit. There has been a growing "dependence on lighting to enhance and unify the esthetic and functional properties of the contract [and residential] interior" (Contract, 1963, p. 40).

¹See Appendix D for structural lighting types.

I. Definition of Structural Lighting

Structural lighting may be defined as "the term used by lighting designers to describe light sources built into the home as a part of its finished structure" (General Electric, Residential Structural Lighting, p. 2). It may be referred to sometimes as architectural or built-in lighting. Structural lighting also denotes a custom design and installation to fit a particular situation (Ibid.). It is not limited to use, however, in a residential setting.

II. Considerations Pertinent to Analysis and Placement of Structural Lighting

A. Function.--Function is the first consideration in the analysis and placement of structural lighting.

1. One of the major functions of structural lighting is to enhance and light the walls and ceiling of the room in which it is placed. Lighting designers feel that this is important because walls and ceilings account for approximately 75 per cent of the room surfaces. Two examples of this type of structural lighting which enhance and light walls and ceilings are cove and valance lighting, discussed below.
2. Another function of structural lighting is to provide for general lighting such as that found

in offices or areas that demand a more even distribution of light (Ibid.).

Nielsen states that there are many functions of "designed light" which could apply to structural lighting as well:

. . . It must obviously illuminate the activities requiring illumination. It must enlarge or minimize space when required. It must enliven and emphasize the best architectural and decorative details of any given space while underplaying, or even eliminating, the undesirable features. It must also serve to establish the desired mood, be it gaiety, solemnity, grandeur, or pleasure (Contract, 1963, p. 40).

B. Area.--The area in which the structural lighting is to be placed is a second consideration in the analysis and placement of structural lighting. Three elements of area should be considered:

1. The architectural features and their placement in the area, such as windows, fireplaces, stairwells, ceiling beams, soffits, etc. These features will determine construction techniques, luminaire selection, and light distribution methods.
2. The area arrangement, such as natural traffic paths and how they determine furnishing arrangement, focal points, etc.
3. The appropriateness of the lighting element to the area which determines luminaire selection and method of light distribution. General Electric states:

Because structural lighting is built right into walls and ceilings, it can be designed to blend with any period decorative motif or color scheme. It can blend or contrast with its background. Since it has very little styling, structural lighting does not become dated in appearance (General Electric, Residential Structural Lighting, p. 2).

III. Kinds of Structural Lighting

Most lighting authorities agree that there are seven basic types of structural lighting which may be applied to residential or commercial interiors. These basic types of structural lighting are generally classified as: (a) valance lighting, (b) cornice lighting, (c) wall bracket lighting, (d) cove lighting, (e) soffit lighting, (f) luminous ceiling panels, and (g) luminous wall panels.¹ Other authorities also include recessed, semi-recessed, adjustable, or any other custom designed and/or installed luminaires.

A. Valance lighting.--Valance lighting is always connected with a window. Light is directed both downward over the wall and draperies and upward over the ceiling. Valance faceboards can be as decorative as desired, and should always be painted a flat white on the inside in order to reflect and utilize all possible light. Fluorescent light is recommended for valance lighting.

¹See Appendix D.

B. Cornice lighting.--Cornice lighting is placed where the ceiling and wall meet. All light is directed downward and will give a dramatic effect to walls, textures, wall coverings, draperies, pictures, or other wall hangings below it. Because cornices give the illusion of greater ceiling heights, they are ideal for rooms with low ceilings, such as basements or recreation rooms. Both incandescent and fluorescent light may be utilized in cornices.

C. Wall bracket lighting.--Wall brackets are of two basic types--high and low. They are considered by General Electric to be "probably the single, most useful structural lighting device" (General Electric, Residential Structural Lighting, p. 5). Their construction differs depending on whether they are to be used to provide general light (high brackets) or specific light for tasks (low brackets) which are performed close to the wall. Fluorescent light is most commonly used.

D. Cove lighting.--Cove lighting directs all of its light upward to the ceiling where it is in then reflected back into the room. Cove lighting sometimes is referred to as "indirect lighting." Because cove lighting provides very uniform and relatively flat, lifeless light, it should be supplemented with other luminaires (Ibid., p. 12). Fluorescent light is suggested for most cove installations.

E. Soffit lighting.--Soffit lighting is lighting that may be designed into the space provided by the architectural soffit--"The underside of any architectural member . . . " (Ibid., p. 9). The two basic uses of soffit lighting are: (1) to direct light downward onto a horizontal surface such as a counter top, and (2) to direct light outward to a vertical plane such as the face.

F. Luminous ceiling panels.--Luminous ceiling panels provide an even distribution of light near the ceiling level by using translucent diffusers beneath fluorescent lamps. They create a sense of spaciousness thus making them especially suited to kitchens, bathrooms, recreation rooms, entryways, and even dining areas. In designing the luminous ceiling panel, the lighting designer should consider the room size, room proportion, and intended use of the room. "An entire ceiling, however, need not be luminous to be effective and attractive" (Ibid., p. 10).

G. Luminous wall elements.--Luminous wall elements are similar to luminous ceiling elements in their construction, but differ in their location, the wall. Luminous wall elements tend to possess high brightness levels which may be distracting to the eye after prolonged periods of time. These high brightness levels can be reduced to a comfortable level by: (1) using dimmers on the lamps, (2) masking part of the lamp with black electrical

tape, (3) using a dense patterned diffuser, and (4) using an overlay of grillwork on the diffuser (Ibid., p. 13).

IV. Application of Structural Lighting to Interiors

It is the responsibility of the lighting designer (whether that person be an interior designer, architect, or illuminating engineer) to determine how structural lighting for a specified area is to be applied to that area. That person must be familiar with the above, similar, or more detailed information if the structural lighting used will function to meet the needs of the individuals in the space, and will function as a design element in that space. There is no simple or short formula for success in designing and applying structural lighting to an area--it necessitates the use of available resources, materials, and skills.

V. Aesthetic Design Factors

Aesthetic design factors are directly related to the functions of structural lighting (see II, above). Therefore the lighting designer must first know how different structural lighting functions before he can make any decision involving the design of the lighting element.

VI. Special Effects with Structural Lighting

Special effects with structural lighting are limited only by the creativity of the lighting designer. If the

designer of the lighting system is somewhat unsure what the ultimate outcome of the design will be, he should not hesitate to consult with a lighting consulting firm or illuminating engineer.

Portable Lighting

A well-designed portable lamp slights neither its functional nor decorative role. It will provide the amount of light needed for a seeing task, and at the same time be decoratively correct in its setting (General Electric, See Your Home in a New Light, p. 6).

The above statement reflects the intent of the portable lamp. It is unfortunate, however, that the same statement does not reflect how a major portion of the lamps on the market today are designed. Portable lighting is perhaps the most neglected area of lamp design. While structural lighting has, for the most part, kept pace with ever-increasing demands for better lighting, portable lamp manufacturers have failed to meet the needs of the consumer. It is also unfortunate that the unknowing consumer is the victim of a manufacturer's desire to sell a product rather than design a well-functioning, decorative lamp. The IES states that portable luminaires are practical and effective only if they coordinate overall artistic design and technologically good lighting design (IES Code, 1953, p. 9).

I. Definition of Portable Lighting

Portable lighting is that lighting which may be moved from one place to another according to the demands of the task and the needs of the individual. Portable lamps should be used where there is a task to be performed, and should be used only to supplement structural lighting. Too often portable luminaires are the only sources of light in a room. They are not designed to provide all the general illumination, but only contribute to it for mood or to enhance an area. Most portable lamps spread their light in an area as small as "forty to fifty square feet" (General Electric, See Your Home in a New Light, p. 7) (see Appendix E).

II. Considerations Pertinent to the Analysis and Placement of Portable Lighting

A. Function.--The first consideration is function. In order for a portable lamp to function properly, it must:

1. Be placed correctly (see C. below).
2. Utilize the correct shade--"The shade should be deep enough so that you never look into the light source from either above or below" (House Beautiful, 1953, p. 61). The shade should be almost as wide at the top as at the bottom so that some of the light contributes to the general illumination of the room. Translucent

shades are preferred as long as the shade does not reveal the "bulb" as a large, bright spot. If an opaque shade is desired, the outside of it should be approximately the same value level as the nearest wall (Ibid.).

3. Utilize the right kind of lighting equipment. A high quantity of light being emitted by a portable lamp does not necessarily mean that this light is the best quality. If glare or high brightness at the source is evident, a diffusing bowl or reflector lamp is recommended.

B. Color.--A second consideration in analyzing and placing a portable luminaire is color. The color of the light should blend well with daylight to avoid noticeable color differences. Also it should be acceptable at the illumination level which will prevail at night (IES Code, 1961, p. 39).

C. Placement.--A third consideration in analysis and placement of portable luminaires involves the area in which the luminaire is to be placed. The activities which are carried on in the room and the architectural layout will determine the furniture arrangement in the space. The furniture arrangement, in turn, will determine where the task areas will be located. The kind of task and its location must be known before the portable luminaire can be placed properly.

III. Kinds of Portable Luminaires

Recently, portable luminaire classification has been defined less rigidly than of fifteen or twenty years ago. Contract magazine states:

There is greater freedom of design, a more experimental attitude toward component materials, and less rigid adherence to prescribed categories in the new portable lamps and lighting fixtures . . . (Contract, 1963, p. 22).

There are two broad categories which most authorities will still agree upon--the floor lamp and table lamp. There are, however, almost as many variations of these two types of portable luminaires as there are lamp designers. Generally, the table lamp differs from the floor lamp in height, although there are exceptions to this in contemporary portable luminaires. Lamp heights are based on average eye heights for both men and women:

Women: 40" seated in lounge chair; 61" standing
Men: 42" seated in lounge chair; 64" standing
(General Electric, See Your Home in a New Light, p. 6).

IV. Application to Interiors

The design of the fixture should suit that of the interior as a whole, and so we require new fixtures that are totally integrated with the construction of the room. This is a beautiful and fascinating problem which the designer can solve satisfactorily . . . (Kohler and Luckhardt, pp. 194-95).

The above quotation aptly describes the challenge which faces the lighting designer, particularly the interior designer, in applying portable luminaires to interiors. There are three general ways in which the interior designer

can help to harmonize portable luminaires with their surroundings:

1. Harmonize styles, colors, scale, and materials.
2. Match bases with matching shades (lamp sizes and type will vary).
3. Match shades with individual bases (General Electric, See Your Home in a New Light, p. 7).

Whiton (p. 680) states in Elements of Interior Design and Decoration:

A room that is to be decorated in any of the historic styles should be equipped with such of the newer forms as may be adaptable, providing they do not conflict with the harmony of style of the room.

The interior designer has the responsibility of selecting portable luminaires which will function for a specific task as well as adding to and becoming an integral part of the aesthetics of the room. Some interior designers find it difficult to locate appropriately styled lamps for some interiors, thus requiring a custom design. Many will wire artifacts which they have found for portable luminaires and will design custom lamp shades for them.

Luckiesh, a noted illuminating engineer and author, states that some portable luminaires are "at best . . . only an object in the entire setting" (1925, p. 74). He does not feel that the function of the lamp is taken into consideration when the lamps are designed. He states further that "The lighting fixture remains a more or less vitalized ornament" (Ibid.).

V. Effects of Portable Lighting in the Interior

Most authorities agree that the appeal of portable lighting is in its ability to contribute a certain mood and atmosphere to the room. General Electric states: "The warmth and graciousness it radiates is not to be had from any other light source" (See Your Home in a New Light, p. 6).

Portable lighting should give a soft glow of light rather than harsh or glaring illumination which could be distracting or harmful to the eye.

Accessory Lighting

Up to this point, structural and portable lighting have been discussed. There are, however, luminaires which do not fall into either of these categories, but which are not classified in the literature as fitting into any other category. For convenience in referring to these unclassified types of lighting (such as decorative wall sconces and chandeliers) the writer will call them accessory lighting.

I. Definition of Accessory Lighting

Accessory lighting is that lighting which may be placed more permanently than portable lighting, but is not considered built-in or structural lighting. It is generally decorative in nature and may or may not be physically

functional. Accessory lighting could be described as "Lighting to look at."¹

II. Considerations Pertinent to the Analysis and Placement of Accessory Lighting

A. Function.--Function is the first consideration in the placement and analysis of accessory lighting. Although some accessory lighting, by definition, may not serve any specific purpose, that accessory lighting which does physically function should provide the necessary quantity and quality of light in a specified area. It is especially important that this type of light be free of glare and high brightnesses if it is only used as "lighting to look at."

B. Area.--Area is the second consideration. In mounting accessory lighting on a wall, average eye heights in sitting and standing positions must be considered as they are in portable lighting. Ceiling pendant lamps or chandeliers should be hung above eye level at a standing or sitting position in order to reduce direct eye glare or brightness.

C. Color.--Color of the luminaire and the light it emits are the third considerations in analysis and placement

¹Taken from a film by Lightolier.

of accessory lighting. The color should blend well with daylight and nightlight, and should enhance the decor of which it is a part.

III. Kinds of Accessory Lighting

Because of the decorative and/or functional nature of accessory lighting, there are many variations of accessory luminaires. Some of these variations are; wall mounted sconces; pendant luminaires hung from the ceiling or decorative chandeliers; combination wall and ceiling suspended lamps (used with chains, etc.); or fiber-optic lights (see Appendix F for examples of contemporary accessory lighting).

IV. Application to Interiors

The accessory luminaires which serve no seeing function should be in addition to structural lighting, and should not attempt to take the place of it. The design of accessory lighting should also be congruous with the historic styles of other furnishings and lighting elements in the room. In a contemporary setting, the interior designer has more freedom within which to work because of the continuous flood of contemporary luminaires available on the market today.

V. Aesthetic Design Factors and the Effect of Accessory Lighting in the Interior

The design of an accessory luminaire will determine what effect that light has in a particular space. If the

lamp chosen by the lighting designer does not reflect the mood or emotional feeling of the room, or does not enhance the space, it has not accomplished its goal as an accessory luminaire. Just as other accessories, such as paintings or sculpture are chosen judiciously, the accessory luminaire must be chosen with the same care and appropriately placed. Maguire, in Light magazine states:

Reaching the design objective requires the judicious application of standard mass-produced equipment to create exactly the effects my clients want. So, obviously, the achievement of creative objectives depends upon the understanding and use of both the scientific and artistic foundations of lighting (Light, 1968, p. 6).

CHAPTER V

NEW DIRECTIONS IN LIGHTING AND THE FUTURE OF LIGHTING IN INTERIORS

Contemporary Lighting Today

I. How Far Have We Come?

As long as man is a curious being, he will continue making new discoveries, and discoveries in lighting have not been and will not be an exception. In General Electric's Light magazine (1963, p. 23) the authors sum up what has been done in the past fifty years:

. . . lighting has advanced from a preoccupation with the efficiency and distribution of the light source and equipment to an increased concern with the attainment of optimum brightness patterns in the total visual environment. . . .

. . . shifted emphasis from the lighting system to design elements within the space. The appearance of color, texture, form . . . and of people . . . which modern design emphasizes, can be more fully appreciated with a lighting system which in itself is unobtrusive and comfortable (Light, XXXII, 1963, p. 23).

II. How Much Farther Can We Go?

No one can predict with any accuracy what may take place in the years to come. General Electric does feel, however, that within five to ten years the Lucalox high

intensity discharge lamp (which gives off more than 100 lumens per watt) will hold a dominant position in industrial lighting. It will be later that we find Lucalox applied in offices, schools, stores, restaurants, and other large installations. General Electric does not as yet predict use in residences, but because of its higher lighting levels which in turn reduces the number of fixtures and cost, and its acceptable color quality, Lucalox does have a future in contract installations.

Illuminating engineers, architects, and interior designers do know, however, that lighting is becoming an increasingly important commodity in our everyday lives and that this trend will continue at an ever-increasing rate.

New Innovations in Lighting

Appendix E show illustrations of the most recent innovations in lighting. It does not pretend to be an exhaustive list of all the different types of lighting fixtures. Its intent is only to introduce the reader to and make him aware of what is being done in lighting today.

The Future of Lighting for Interior Designers

I. How Can the Interior Designer Contribute?

1. By making himself become aware of new developments in lighting and knowing the principles of good lighting.

2. By educating his clients about good lighting as it relates to that client's needs and desires.
3. By refusing to accept and use lighting of poor design and quality.
4. By planning and specifying the best possible quality lighting available.

After discussing lighting with a number of practicing interior designers, the investigator found a very real desire on their part to become more interested in and aware of lighting, its good and bad design features, the importance of quality and quantity in lighting, and in educating the client in their actual lighting needs. They felt lighting has been very sadly neglected in past years and must now become as much a tool in good interior design as texture, form, line, and color have been in the past. Because of the fast pace that has been set by recent lighting discoveries, they felt that the practicing interior designer will have a difficult task in keeping abreast of these new lighting discoveries and designs. But they also felt that lighting is of such significance as to warrant this challenge.

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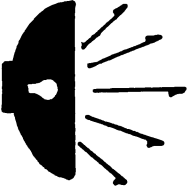
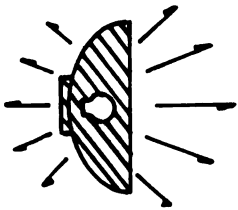
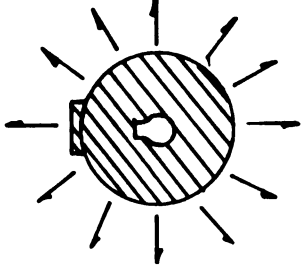
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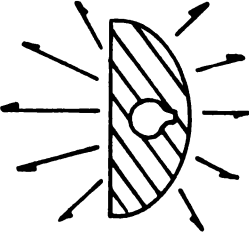
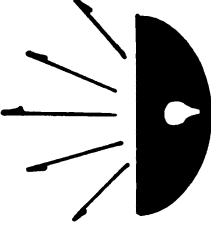
APPENDICES

APPENDIX A

BASIC MODES OF LIGHTING

[Adapted from Walter Kohler and Wassili Luckhardt,
Lighting in Architecture (New York: Reinhold
Publishing Co., 1959), Figure 19: "Basic modes
of lighting," p. 136.]

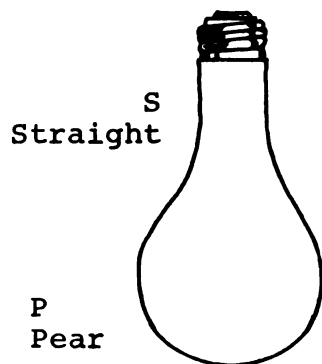
Mode of Distribution	Type of Housing	Percentage of Illumination Above Horizontal	Lighting Effect
Direct		0-10%	Strong horizontal illumination. Ceiling and upper walls dark. Limited freedom from glare. Uniformity only if placed fairly high.
Semi-direct		10-40%	Ceiling and upper walls lighter, low horizontal illumination. Free from glare. Medium to soft shadows. Illumination fairly uniform with normal placement.
Uniform		40-60%	

Mode of Distribution	Type of Housing	Percentage of Illumination Above Horizontal	Lighting Effect
Semi-indirect		60-90%	Ceiling and upper walls lighter, low horizontal illumination. Free from glare. Medium to soft shadows. Illumination fairly uniform with normal placement.
Indirect		90-100%	Virtually shadow-free. Free from glare. Maximum uniformity of illumination, horizontal further reduced.
Legend:  Opaque  Translucent			

APPENDIX B

INCANDESCENT LAMP SHAPES

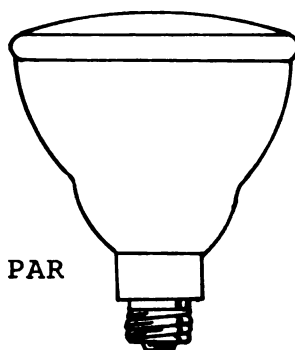
[General Electric, Incandescent Lamps, #TP-110,
Large Lamp Department, Nela Park, Cleveland,
Ohio, p. 10.]



S
Straight

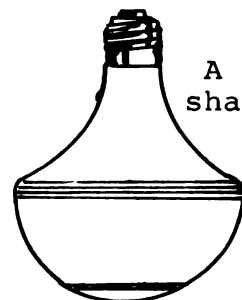
P
Pear

PS



PAR

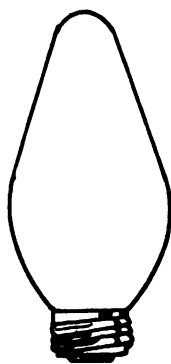
Parabolic Aluminized
Reflector



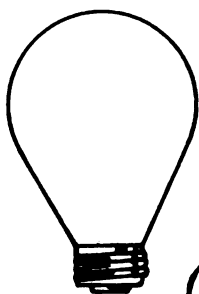
A
shape

G
shape

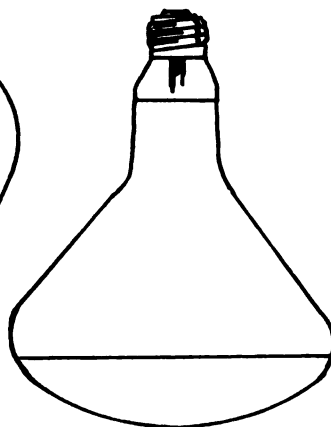
GA



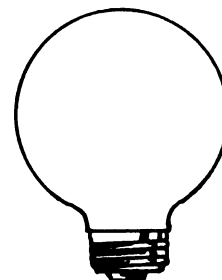
F
Flame
Shape



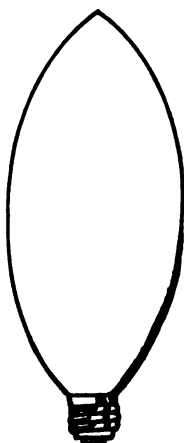
P
Pear
Shape



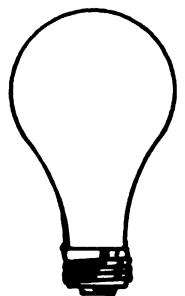
R
Reflector



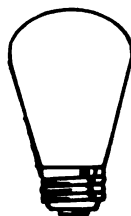
G
Globular



B
Flame
Shape



A
Arbitrary



S
Straight
Side



T
Tubular

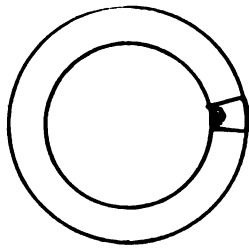


C
Cone
Shape

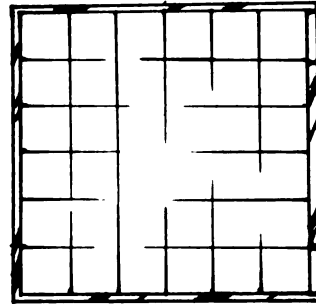
APPENDIX C

SHAPES OF FLUORESCENT TUBES

[General Electric, Fluorescent Lamps, #TP-111,
Large Lamp Department, Nela Park, Cleveland, Ohio,
1965, p. 11.]



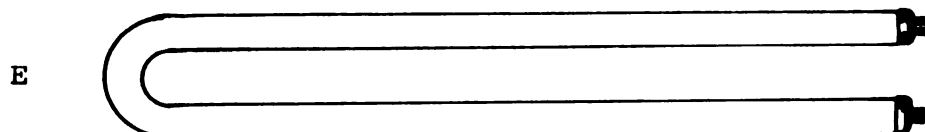
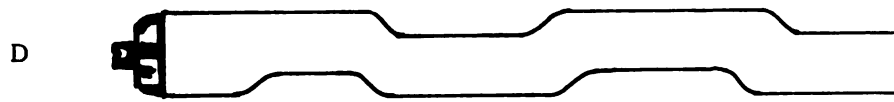
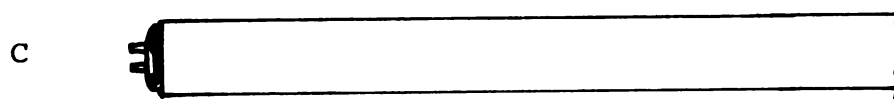
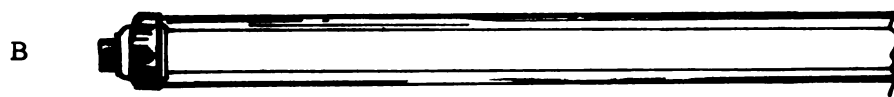
Circline



Panel

Tubular

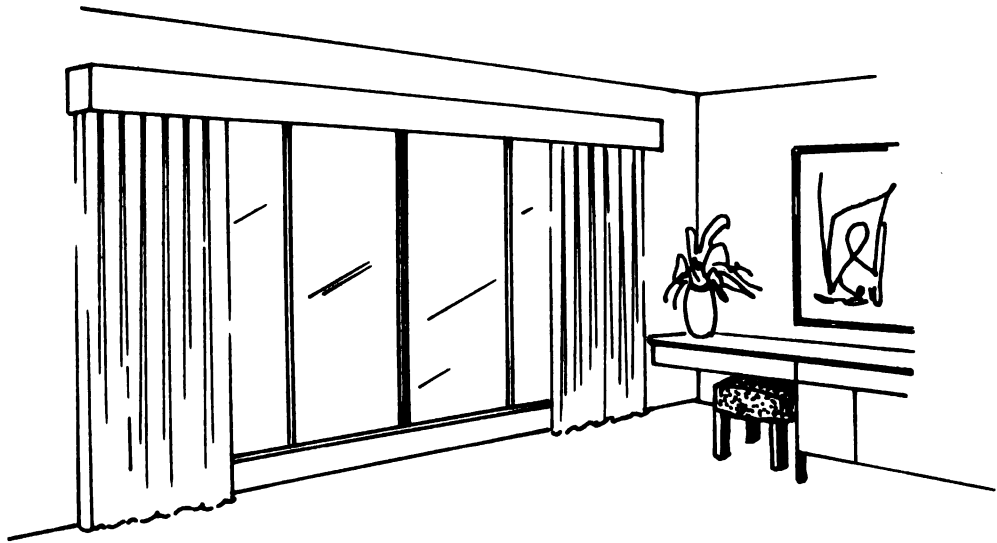
- A. High output slimline
- B. Encased slimline
- C. Pre-heat rapid start
- D. Power groove
- E. U-shape



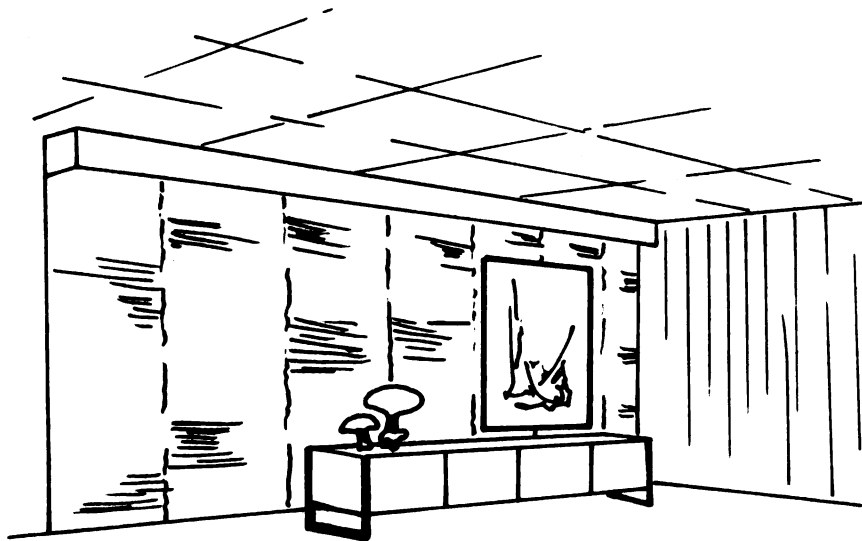
APPENDIX D

STRUCTURAL LIGHTING TYPES

[Adapted from John Kaufman, ed., IES Handbook,
4th edition, New York: Illuminating Engineering
Society, 1966, pp. 15-14 and 15-15.]



1. Valance Lighting



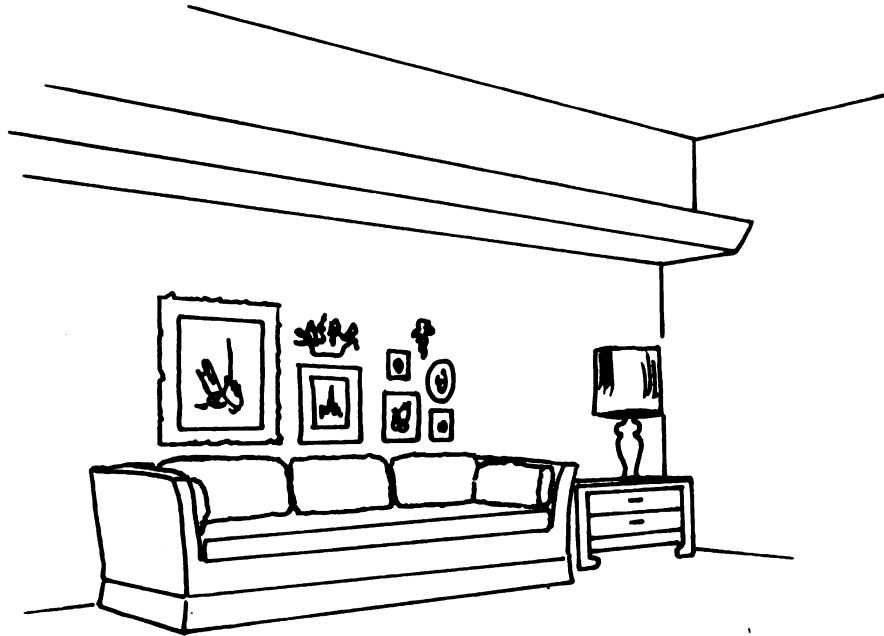
2. Cornice Lighting



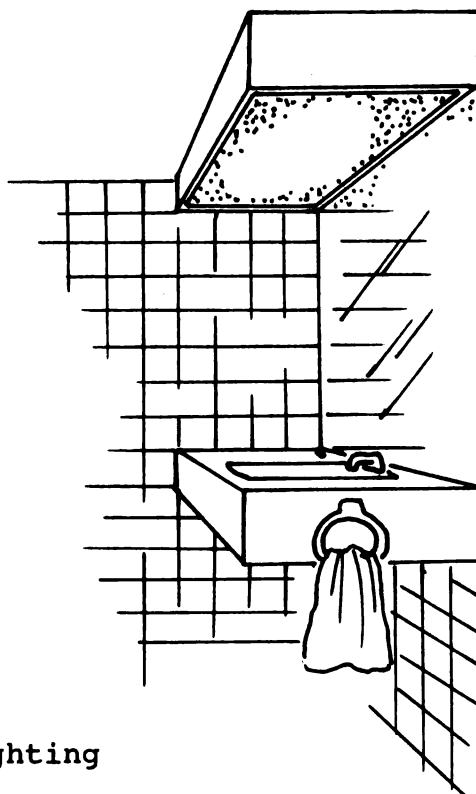
3. High Wall Bracket Lighting



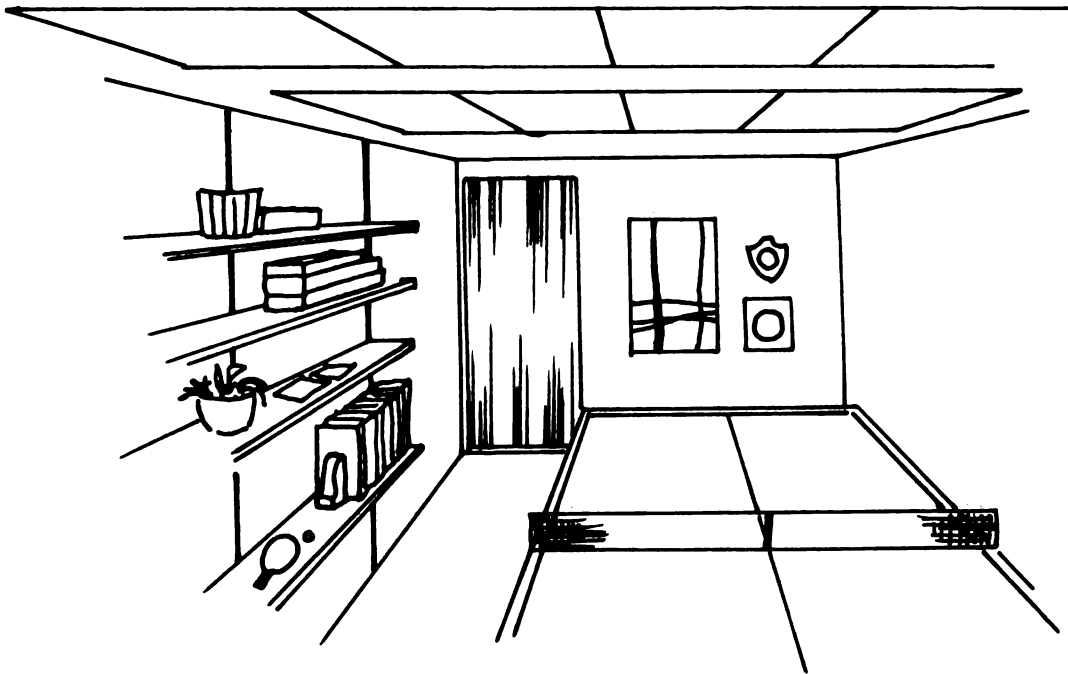
4. Low Wall Bracket Lighting



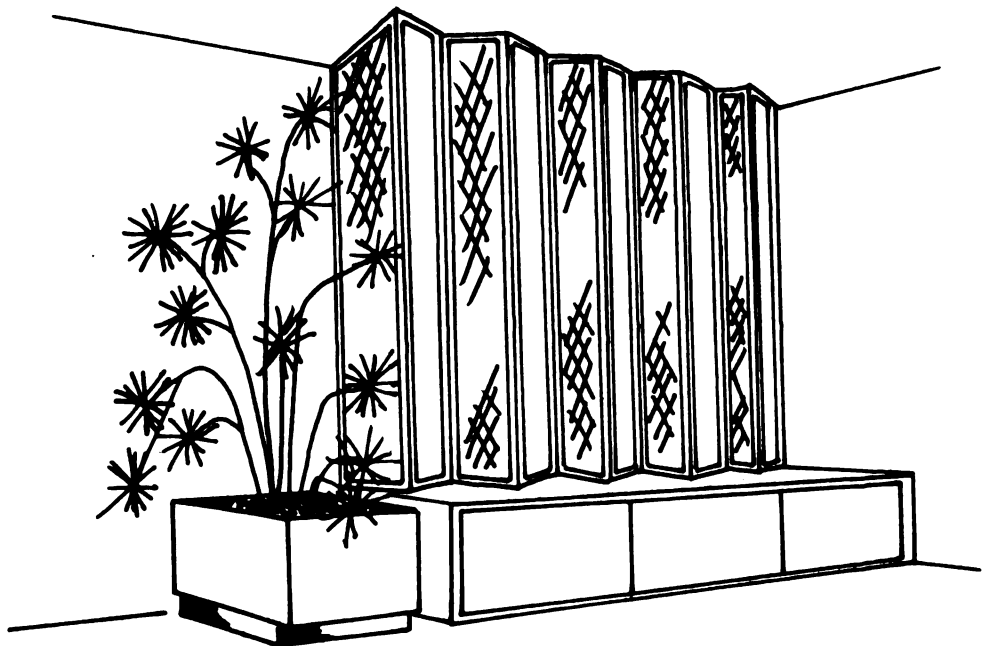
5. Cove Lighting



6. Soffit Lighting



7. Luminous Ceiling Panel Lighting



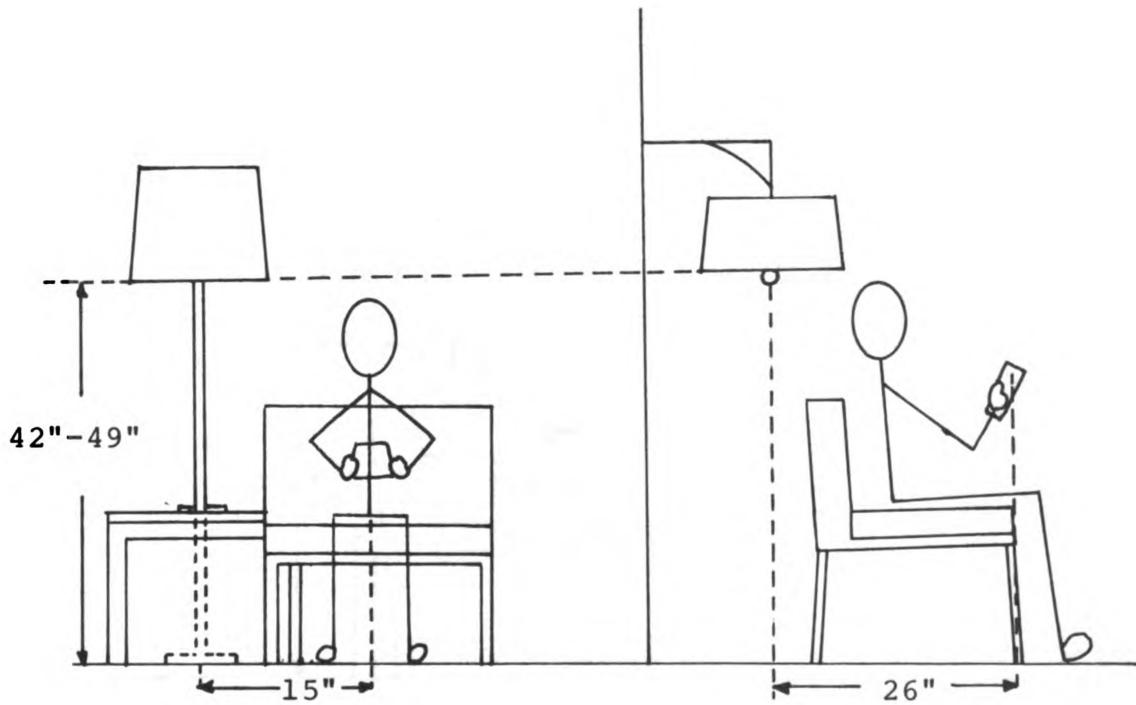
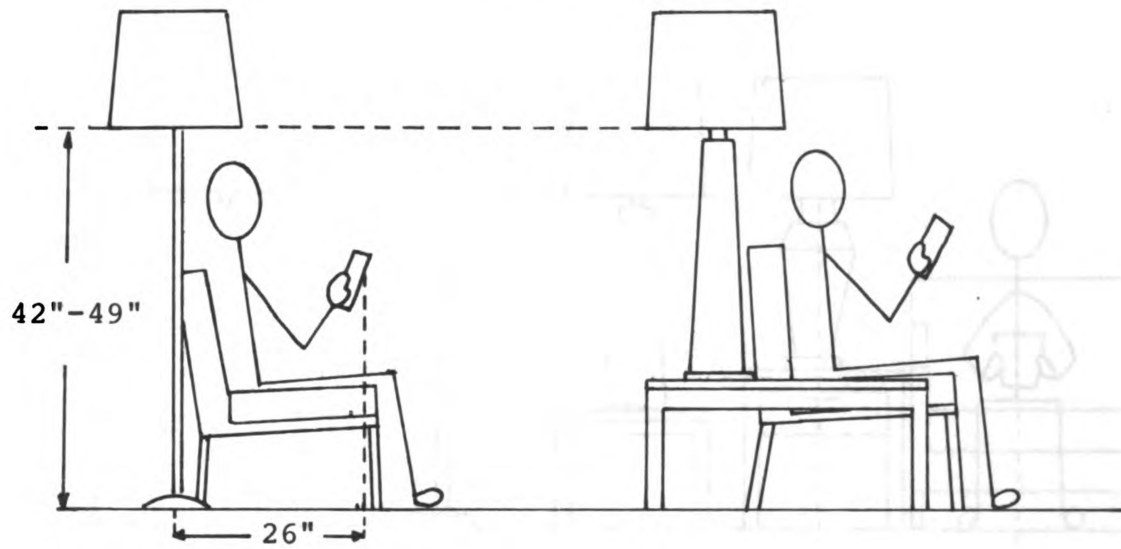
8. Luminous Wall Panel Lighting

APPENDIX E

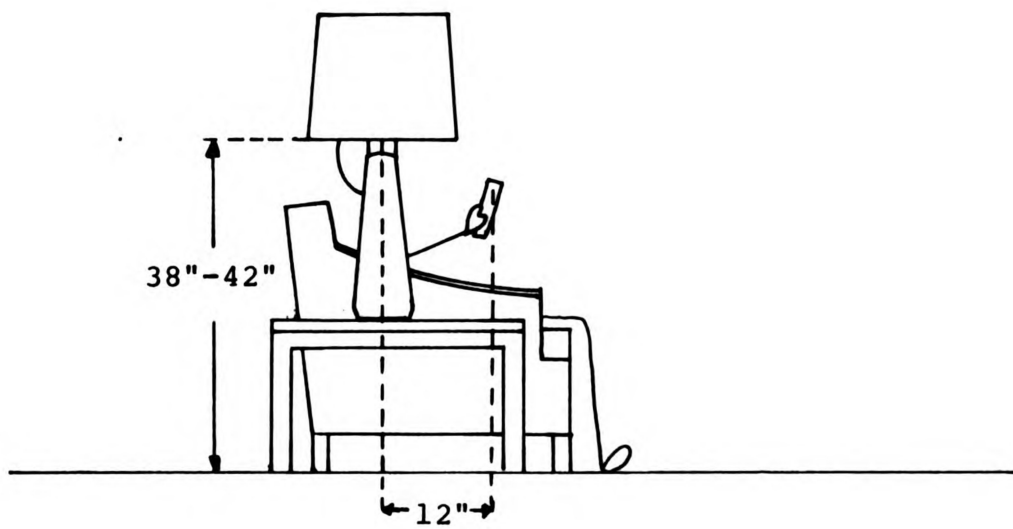
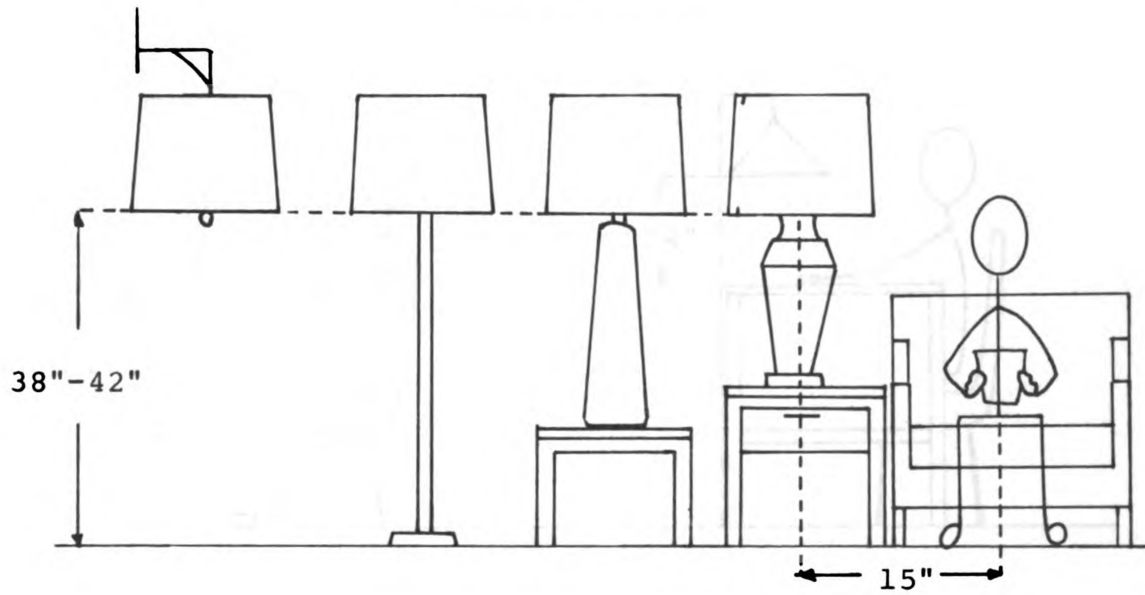
PORTABLE LIGHTING MEASUREMENTS

AND PLACEMENT

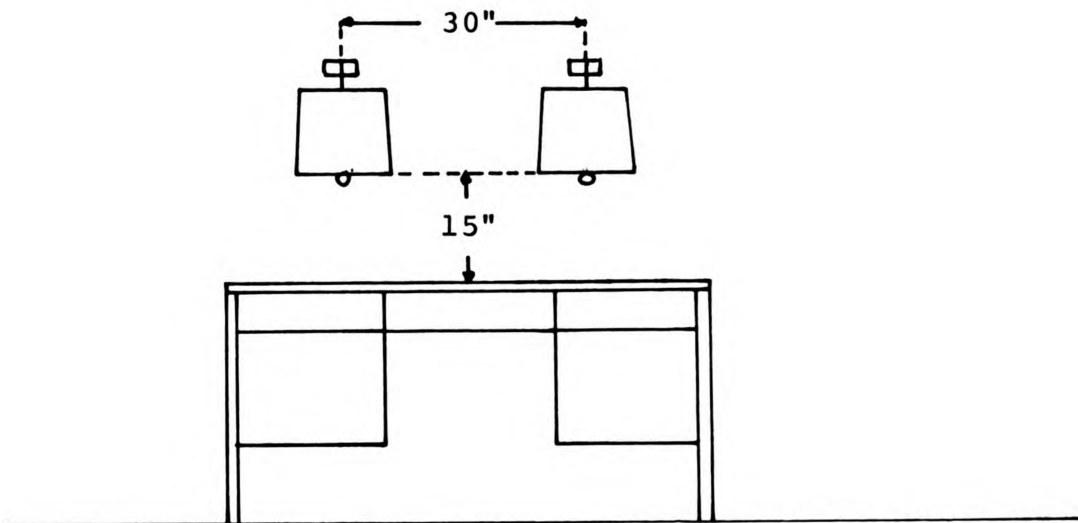
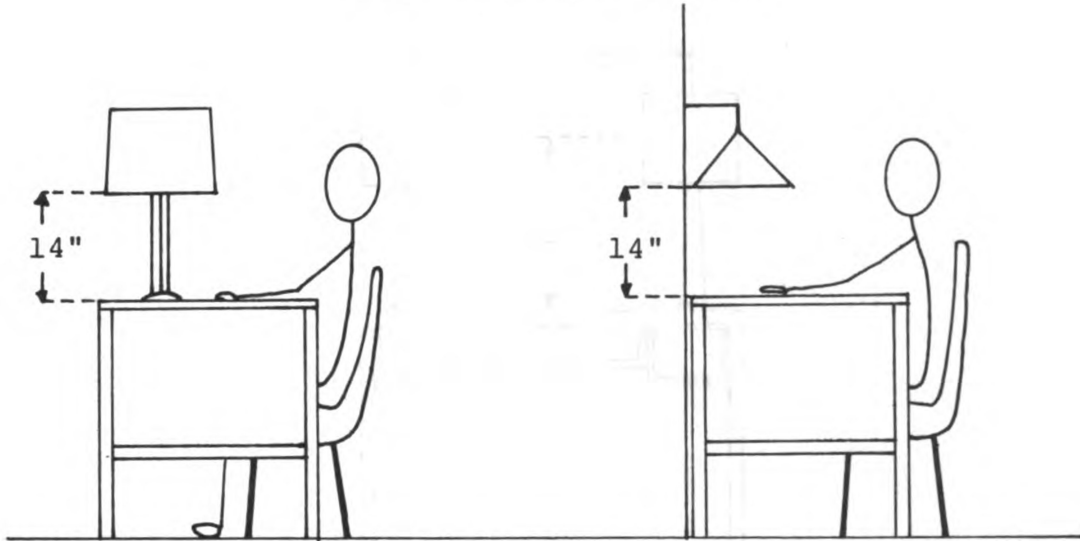
Portable Luminaire Placed Behind
Seated Person



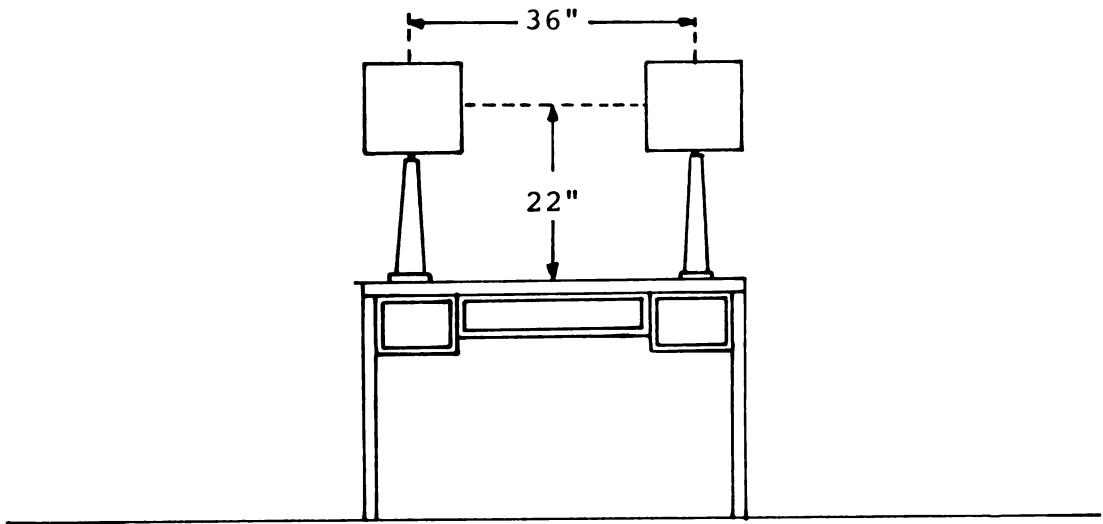
Portable Luminaire Placed Beside
Seated Person



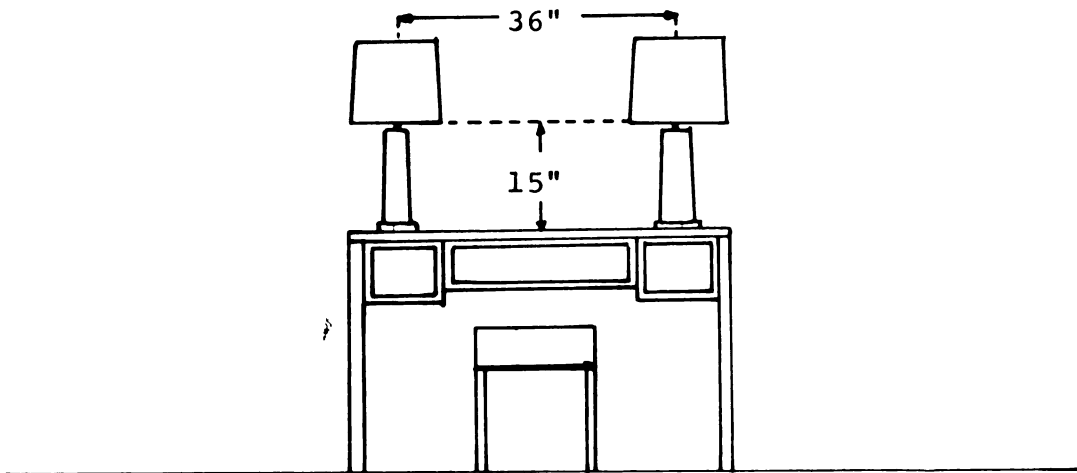
Portable Luminaire Placed at Desk in
Front of Seated Person



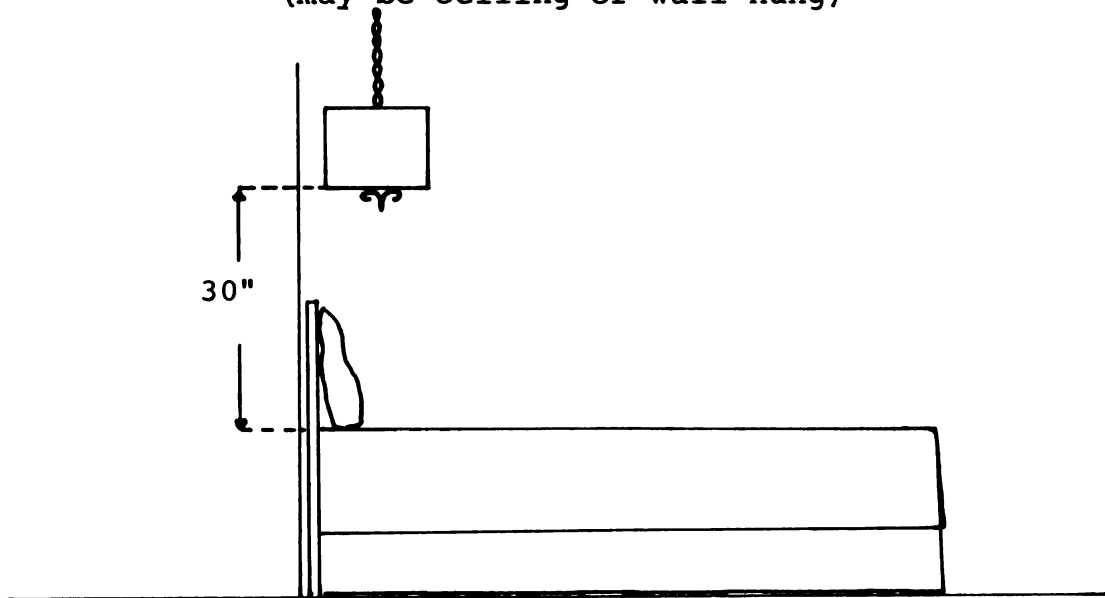
Portable Luminaires Placed at Either Side
of Vanity with Person Standing



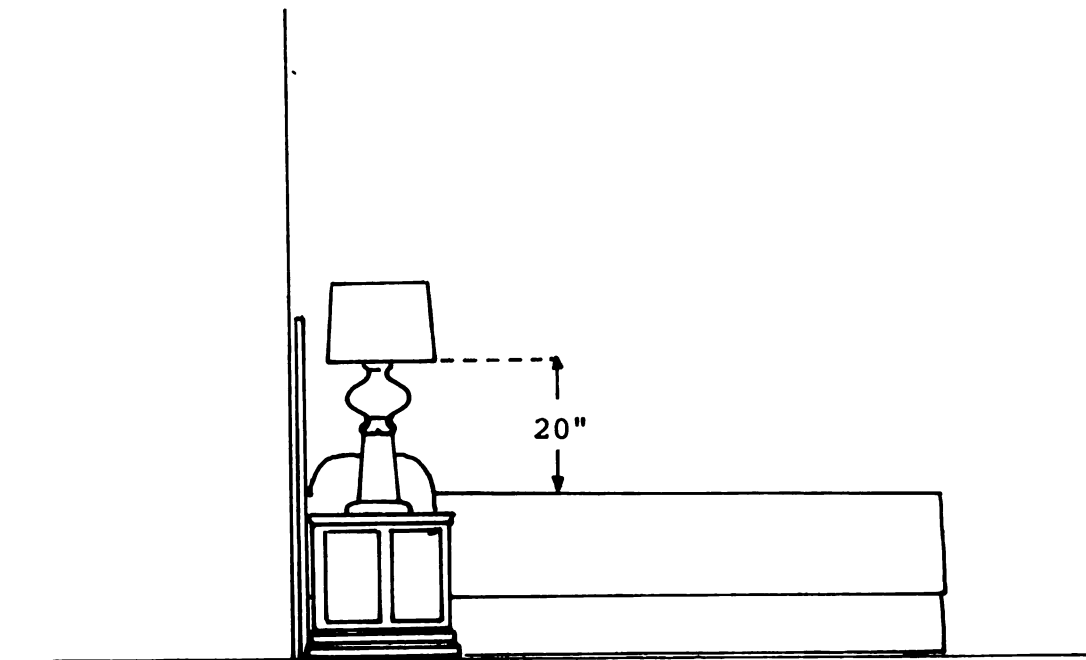
Portable Luminaires Placed at Either Side
of Vanity with Person Seated



Portable or Accessory Luminaire Placed Over Bed
(may be ceiling or wall hung)



Portable Luminaire Placed Beside Bed



APPENDIX F

CONTEMPORARY PORTABLE AND
ACCESSORY LIGHTING

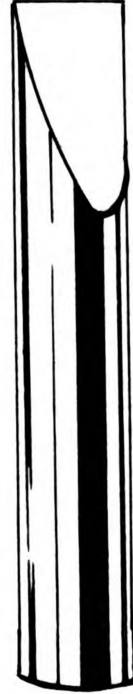
Contemporary Portable Lighting
[Habitat, Inc., New York, N.Y.]



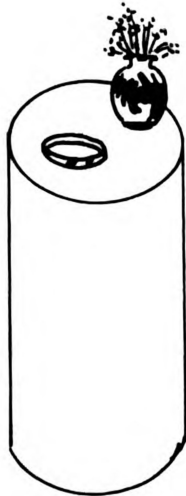
Floor Lamp
#9540



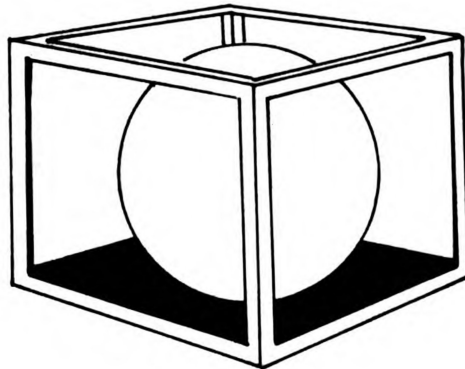
Floor Lamp
#9552



Floor Lamp
#9592

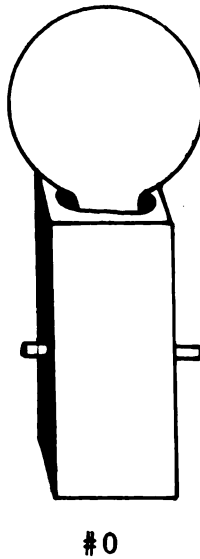
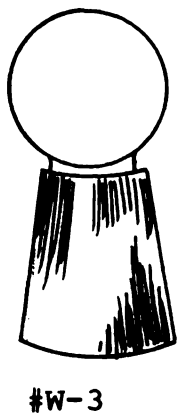
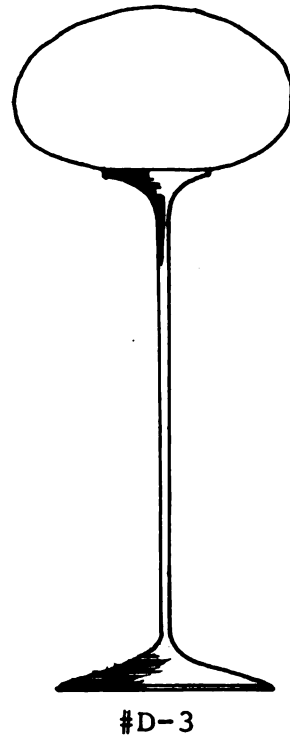
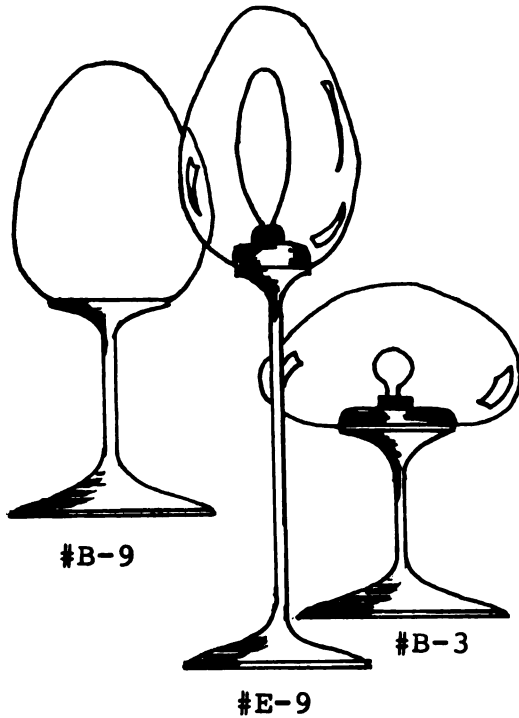


Floor Lamp
#9570

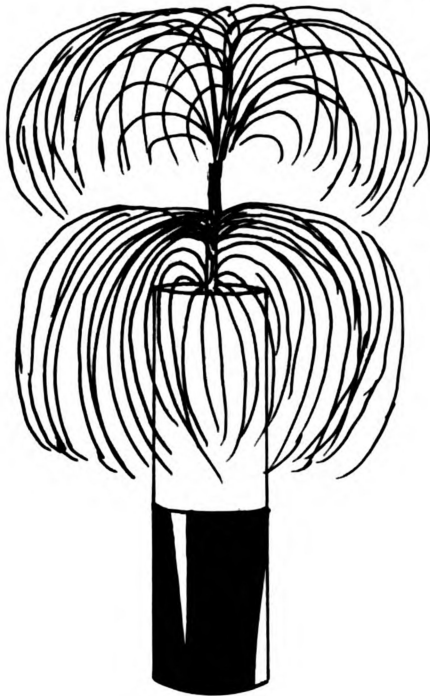


Floor Lamp
#9671

Contemporary Portable Lighting
["Stemplites," Design Line, Inc., El Segundo, California]



Contemporary Accessory Lighting
[CGI, Inc., New York, N.Y. and Poly-Optics, Inc.,
Santa Ana, California]



#119

"Starfire" line

Fiber-optic light
by CGI, Inc.

"Atlantis"

Fiber-optic light
by Poly-Optics, Inc.



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