THE DESIGN OF A PORTABLE FLOOR LAMP

Thesis by

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ABSTRACT

A portable floor lamp has been developed for residential lighting, employing modern light sources to provide illumination of optimum quantity and quality for reading and a variety of room lighting effects. Improvement over existing types was accomplished by use of adjustable auxiliary reading light, below eye level, in conjunction with general luminaire of standard height. Specular reflection from glossy paper was markedly reduced by decreasing light source brightness and increasing its area relative to the printed page. Illumination intensity level was raised to 100 footcandles by reducing distance between page and source, while adequate brightness of surroundings was maintained by over-all room lighting from general lighting unit. Indicator on reading lamp assists user in selection of proper illumination for each visual task. Operation cost was reduced 30 per cent by partial use of fluorescent light sources. Design embodies conclusions drawn from extensive research in marketing, manufacturing, consumer preferences, competitive products and the science of light and vision, to provide a versatile, sight-saving lamp for successful mass production and marketing.

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INTRODUCTION

In surveying the field of consumer products it was an obvious conclusion that portable lamps were more in need of re-design than any other widely used item on the market. Today's lamp is a pathetic compromise between the ancient and the modern. There is no great difference between the shape of the lamp today and its kerosene predecessor. Lamps to see by, rather than to look at, are a rarity and lamps which provide a combination of good lighting qualities for close work, versatility of lighting effects, and good appearance are non-existent.

It was with these facts in mind that the most widely used residential lighting unit, the floor lamp, was chosen as the basic design problem for this thesis.

Figure 1. Photograph of Lamp

DESCRIPTION OF DESIGN

A versatile, sight-saving floor lamp has been developed for mass production and marketing. It consists of a general lighting unit employing a 12 inch "circline" fluorescent tube and an R-40 "Bolite" to provide various levels of general room illumination, and an adjustable reading unit using an 8 inch "circline" in a shallow reflector to provide up to 100 footcandles of glareless illumination for close work. This reading light may be oriented in any position, providing infinite flexibility and versatility, for use as a bridge or piano lamp or for indirect and localized lighting effects. Luminous plastic control switches are located on the reading reflector for easy access from both seated and standing positions and an indicator is provided to help the user select the proper illumination for each visual task.

Operating cost has been cut 30 per cent by using fluorescent light sources and objectionable features such as hum, flicker, radio interference and high color temperature have been corrected. Construction is of aluminum or steel and a variety of finishes are provided by plating, synthetic enamel or anodizing. The general lighting unit uses either an impregnated fiber glass shade or a bottom-louvered parabolic spinning for acceptance in either conventional or modern homes.

The lamp's numerous sales features provide for successful marketing in the present distribution channels with a minimum of competition and its many functional advantages and its lasting beauty insure wide consumer acceptance and continued satisfaction.

FACTORS IN THE DEVELOPMENT OF THE MARKET

Although light is a basic need in the home, it has always been sold as a style item. Style has been the easiest approach to a buying public consisting largely of women interested in decoration rather than illumination.

Due to this style appeal, the industry developed as a group of craftware manufacturers with no large quantity production or well established marketing systems. Mass education and quantity production were first applied to the home lighting field in 1933 as a result of the Better Light Better Sight Campaign,[1] sponsored by the large utilities. Although this campaign increased the consumer's use and knowledge of light, it was only a beginning in the educational and promotional work needed in the field.

PROMOTION AND DISTRIBUTION

At present, there is little sales activity by the power companies and lamps are sold through conventional channels. Annual shows are held throughout the country, to which lamp manufacturers send samples. Buyers from retail stores attend these shows and order from the selections presented. Also most companies have salesmen or local representatives. This basic distribution system dictates a lamp design that will sell not only to the consumer but also to the dealer at a trade show. For these reasons, self-evident selling features should be embodied in the design and sound talking points must be provided for the salesmen.

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[1] See appendix K for references

The manufacturer's mark-up is from 50 to 100 per cent* over manufacturing cost and the dealer's mark-up is the same, resulting in a total mark-up of 100 to 300 per cent over manufacturing cost. Any added manufacturing cost, such as fluorescent tubes and ballasts will be greatly magnified by this mark-up before the lamp is retailed. Increase in price should be compensated for by sales features such as economy of operation, better lighting quality, etc.

The portable lamp market is effectively still in its introductory stage.[2] The real potentialities of the market will not be realized until the public is more fully educated as to its lighting needs. The industry is aware of this fact and is taking definite action by developing educational programs such as the Planned Lighting Program,[3] an all industry promotional effort, coordinated by the Edison Electric Institute. Another example of unified promotional effort in home lighting is the organization of Certified Lamp Manufacturers,[4] a group of over 100 lamp manufacturers who have established definite lighting standards and pooled a part of their promotional efforts. The mass education in lighting provided by these programs will result in an ever-increasing demand for functional portable lamps with good lighting characteristics.

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* Culp's Electric Co. Pasadena, Calif., Barker Brothers, Los Angeles, Calif.

THE PRESENT AND FUTURE MARKET

The present portable lamp market is good in all respects. Prior to the war there were about 30,000,000[5] portable lamps, including both floor and table models, sold annually at an estimated value of $90,000,000. At the close of the war, surveys[5] showed that around 50 per cent of homes would buy an average of two floor lamps as soon as production could meet this demand. The Edison Electric Institute[6] predicts the following sales results in the next five years:

> 10% of homes will buy complete planned lighting.
> 50% of homes will make substantial improvements in their out of date lighting.
> 30% will make minor lighting improvements.
> 10% will probably make no change at all.

In other words, the next five years will bring:

> 4,500 new better sight lamps per 1,000 homes.
> 3,700 new better light fixtures per 1,000 homes.

The average American Home of $8,000 spends only about $250 on wiring and Lighting fixtures.[7] Few investments give as much for so little. Manufacturers of home lighting equipment would be wise to base their growth on this fact. Consumer education and good design could easily double this expenditure. Considering a potential annual market of 1,000,000 new homes,[8] this represents a large business.

APPROACH

A survey was made to study the advantages and limitations of various lamps being sold in the present market. This serves the purpose of analysing the design competition which a new lamp would face. Also it helps to orient the design with respect to the present level of public acceptance or taste.

The survey is divided into two parts, a comparison of the main types of present day floor lamps and secondly, the conclusions drawn from the survey.

THE CERTIFIED LAMPS are conventional shade type lamps with a central three-way 300 watt light source and glass diffusing bowl. The larger models have an additional 32 watt circline fluorescent. Designers of the individual companies design the lamps, while design of the lighting unit and promotional activities are carried on by a special group appointed by the manufacturers. (see figure 2 for illustration)

ADVANTAGES

1. Good lighting qualities, based on IES standards.
2. Provides 50 footcandles.
3. Good mechanical and electrical construction.
4. Lighting units are mass produced with resultant economy.

DISADVANTAGES

1. Specular reflection from glossy paper.
2. Performance hindered by conventional exterior appearance.
3. No shielding of fluorescent tube to prevent radio interference.
4. Eclectic Design.
5. Switches unhandy.
6. Shades difficult to clean.

FIG. 2 CERTIFIED LAMPS

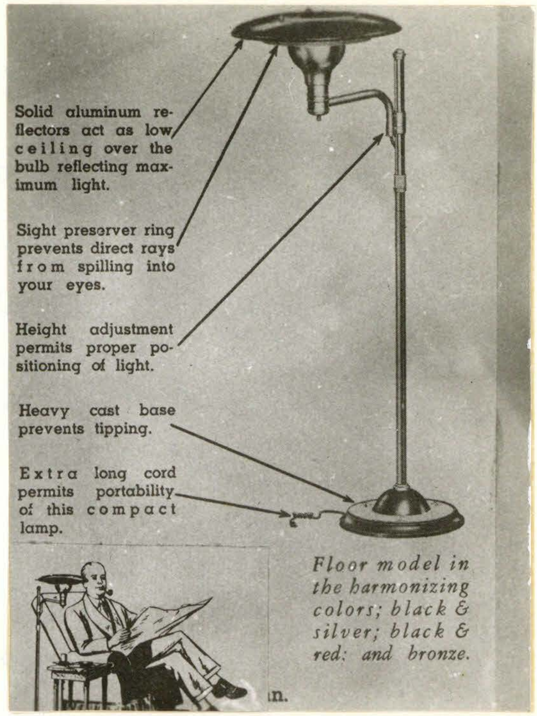


FIG. 3 THE SIGHT LIGHT

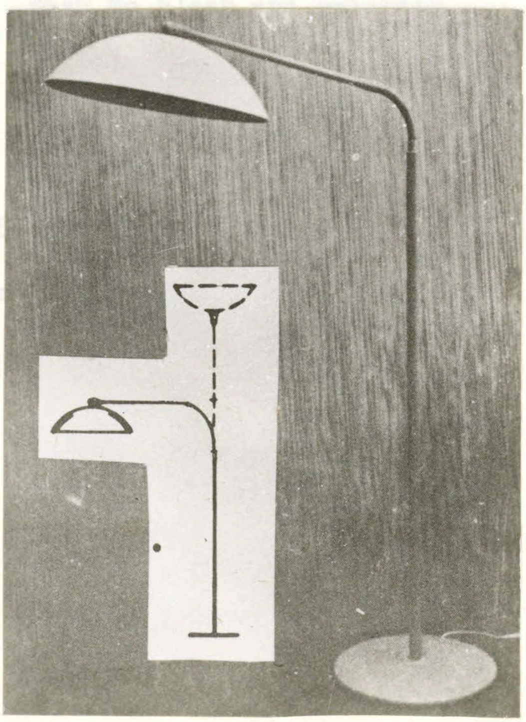


FIG. 4 KURT VERSEN LAMP

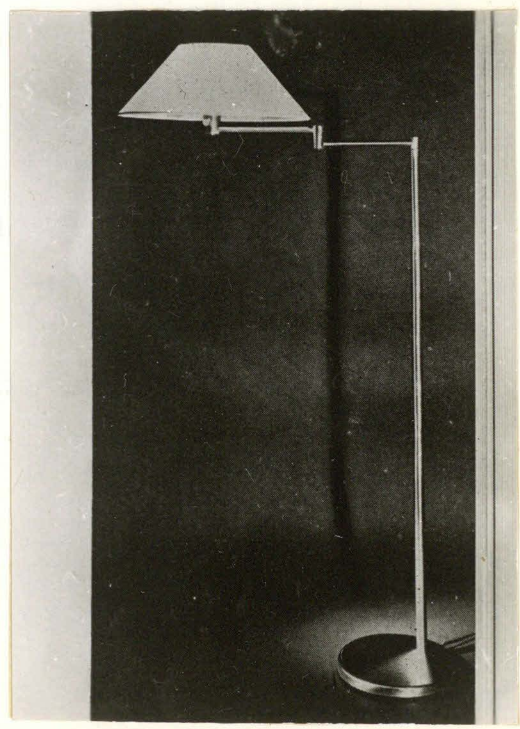


FIG. 5 WALTER VON NESSEN LAMP

THE SIGHT LIGHT provides indirect light from a large reflector below eye level for close work. (see figure 3)

ADVANTAGES

1. Excellent quality lighting with little specular reflection.
2. Provides 60 footcandles.
3. Easy to manufacture
4. Economical to operate (100 watts)
5. Inexpensive ($22.95)

DISADVANTAGES

1. Provides no general lighting.
2. No adjustment of illumination level.
3. Design is too severe.

KURT VERSEN LAMPS represent the latest development in functional modern lamps. (see figure 4.)

ADVANTAGES

1. Excellent design.
2. Easy to clean and maintain.
3. Versatile lighting effects.
4. Inexpensive ($28).

DISADVANTAGES

1. Glare and specular reflection from bare bulbs.
2. Low level of illumination.
3. Design too severe for most homes.

WALTER VON NESSEN LAMPS represent the modern version of conventional lamps. (see figure 5)

ADVANTAGES

1. Excellent design for the present market.
2. Simple functional, easy to maintain.

DISADVANTAGES

1. Do not provide more than 20 footcandles.
2. High price ($48)
3. Switch not easily accessible.

CONCLUSIONS

1. There is a definite lack of sales features in most lamps. They are sold mainly on the basis of decorative appeal. By adding features such as optional indirect light only, luminous readily accessible switches, etc. it would be possible to help lamp sales tremendously.

2. Lamps that provide good illumination for reading lack versatility and functionally pleasing appearance, while the versatile lamps provide poor lighting qualities.

3. The simplified shade lamp represents the present level of public acceptance. The taste during the next two or three years will tend steadily toward the functional modern. However, the best selling lamps will be those which retain the same general appearance as those which are widely accepted today.

APPROACH

To determine the needs and wants of the potential lamp buyer, a careful study of the subject was made, using several different approaches in order to give proper perspective to the results.

First, a study was made of what the consumer asks for and buys in portable lamps. Next, the results of a nationwide survey in home lighting were analysed. For a third approach, lighting needs in a variety of homes were observed and analysed to determine what the consumer actually needs and wants in home lighting.

WHAT THE CONSUMER ASKS FOR AND BUYS IN FLOOR LAMPS

The first phase of the survey consisted of a number of personal interviews with buyers and sales personnel in department stores, furniture stores and electrical shops in the Southern California area.

Results showed that:

1. What the consumer buys in floor lamps is based largely on appearance and whether the lamps will go well with present furnishings.

2. Ease of maintenance and lighting characteristics rank second.

3. The average customer will pay about $40 for a floor lamp.

4. Fluorescent light sources in floor lamps have been accepted fairly well. However, there is a minority which has had bad experiences with fluorescent lighting, with respect to flicker, radio interference or overly high color temperatures. Sales to this group could be made by emphasizing the elimination of such previous defects.

5. A completely functional, unadorned lamp would be accepted by those interested in modern furnishings and by a certain group with conventional furnishings. The sales on such a lamp would be very dependent on tactics of the sales force. The most important person to convince of the lamp's merit is the retail salesperson. Once convinced of the lamp's value and given sufficient sales features, he can sell to a large number who would otherwise purchase conventional lamps. A good illustration of the latent demand for such a lamp is the case of the Sight Light. The Sight Light (see figure 3) is the only lamp on the market manufactured and promoted purely on the basis of functional

lighting qualities. All of the sales outlets consulted, reported excellent sales. One store* alone estimated its sales at 500 to 1000 per year. The lamp was usually purchased for use with conventional furnishings.

6. Bronze finish is most popular because it matches dark wood found in most conventional furnishings. Natural brass and pastel shades are next in popularity with copper, wood and aluminum being used extensively for modern interiors.

WHAT THE CONSUMER ASKS FROM THE LIGHTING INDUSTRY

Material for the second phase of the survey was obtained from research done by the Small Homes Guide.[9] (see appendix A for questionaire)

Findings of this survey showed that:

1. Most suggestions about lighting are concerned with simple improvements which indicate that people have had insufficient experience with home lighting refinements to organize their expectations about new developments.

2. The initiative and ideas for new lighting developments must still come from the industry.

3. The small home owner will be conservative and will accept refinements only as he becomes convinced of their need.

4. Wherever close work, involving eye strain, is done sight saving lamps are considered a necessity by half of those voting.

AN ANALYSIS OF WHAT THE CONSUMER ACTUALLY NEEDS AND WANTS

To analyse the consumer's needs in portable lamps, it was necessary to observe the activities taking place in a number of homes to determine the use of lighting in typical present day living patterns. The study was made with the following questions in mind:

1. Who used the lamps?
2. Where were the lamps used?
3. How were the lamps used?
4. What made the lamps and lighting acceptable?
5. How could the lamps be used to better advantage?

*Parmelee Dohrman Co., Los Angeles, Calif.

The results are tabulated as follows:

1. Lamps used by each member of the family, but to the greatest extent by those from high school age on.

2. Lamps used most often at the side and slightly to the rear of an easy chair, often at the end or behind a davenport. Used almost exclusively for living rooms and dens.

3. Lamps used about 60 percent of time for close work of varying difficulty. Close work is about 60 to 70 per cent reading, typical task being eight point type on papers ranging from glossy magazines to dull news print. Time involved varies from few minutes to four or five hours. Average time is one hour, with typical periods running three hours from 7 to 10 P.M. Sewing, hobbies, card games, etc. make up remainder of close work. Sewing dark materials is most difficult task usually attempted with this type illumination.

4. Qualities influencing acceptability of lamps and lighting:

   a. Must express individuality. This need is fundamental in modern society where man's desire for creative expression is seldom satisfied.

   b. Must create associations with home and feelings of security.

   c. Must not suggest the effects found in public places.

   d. Brightness patterns are most powerful elements creating environment. When adaptive brightness level is low, high brightness ratios are acceptable. When adaptive level is high, brightness-ratios must be reduced to retain a comparable sense of acceptability.[10]

   e. Through the ages, man has become accustomed to low levels of low color temperature light and has come to associate these with home.

   f. Variety of brightness patterns using light and shadow for emphasis of form and texture, creates interest and acceptability.

5. How floor lamps can be used to better advantage in the home:

   a. Since these lamps are used over half the time for close work, it is important that they provide adequate light for this purpose.

   b. Lamps should have improved means of adjusting amount of light for a specific task. The form of the home is frequently inflexible and lighting is the only all-over standard home requirement with the capacity for variety.

   c. General atmosphere created by lamp and its lighting should be in definite contrast with harsh monotonous lighting encountered in public places.

   d. An important need which must be satisfied by all home furnishings is that of creating a feeling of individuality.

This has been attained in the past by variations in the lamp's ornamentation. In the future this need can be more effectively and economically satisfied by providing simple mass produced lamps which will produce a wide range of individual lighting effects, which will be able not only to make the home unique and provide a daily variety of lighting environment to suit the occasion, but also will help to satisfy the need for creative expression.

e. Rules for proper lighting should be designed into a lamp. This could be accomplished by having a calibrated indicator which would be labeled in such a fashion that the householder need not make a mistake in lighting.

f. Materials should be used more honestly in lamps. Their properties should be well adapted to their function and to the methods and processes used to fabricate them.

g. Lamp design should fit in with any type of furnishings or architecture.

h. Lamp should be easy to maintain, easy to dust and clean and light sources should be easy to replace.

CONCLUSIONS

What the consumer asks for and buys in home lighting is often far from what he really wants and needs. Lighting is a commodity that everyone needs. As a result, the consumer buys from the limited selection of equipment on the market. This does not in any way prove that he is getting what he wants, but only that he is taking what he can get. The consumer's wants are both conscious and unconscious. He seldom knows what they are until they are translated into a form which he can see and use. This inarticulateness on the part of the consumer has long been used as an excuse for arbitrary design and production by the majority of lamp manufacturers. A bitter objection to change has been that "Consumers will not accept it". Yet it has been proven that when means to specific ends take on entirely new forms to fulfill their purpose more effectively, they are accepted after a fair trial.[11]

PART IV

TECHNICAL RESEARCH

APPROACH

The purpose of the technical research was to determine what constitutes ideal illumination for optimum seeing comfort and to determine means of obtaining such illumination from a floor lamp. The research thoroughly covered the fundamental work in illumination and vision done by Luckiesh and Moss of the General Electric Company. In addition, a careful survey was made of all the important articles published during the last ten years by the Illuminating Engineering Society. Specific information and advice was obtained from a number of prominent lighting engineers and experts on illumination and vision.

EVOLUTION OF VISION

Man's eyes have evolved over a period of millions of years under the lighting conditions of nature, with the result that they are best adapted to nature's illumination of 100 to 9,000[12] footcandles* and to the resulting brightnesses of 5 to 450 footlamberts reflected from typical surfaces found in nature. (5% reflectance factor) Man is also adapted to the continuous spectrum of sunlight and the natural distribution of 80 per cent direct sunlight and 20 per cent indirect light from the sky. This basic reference point established by natural lighting should be followed very closely in lamp design.

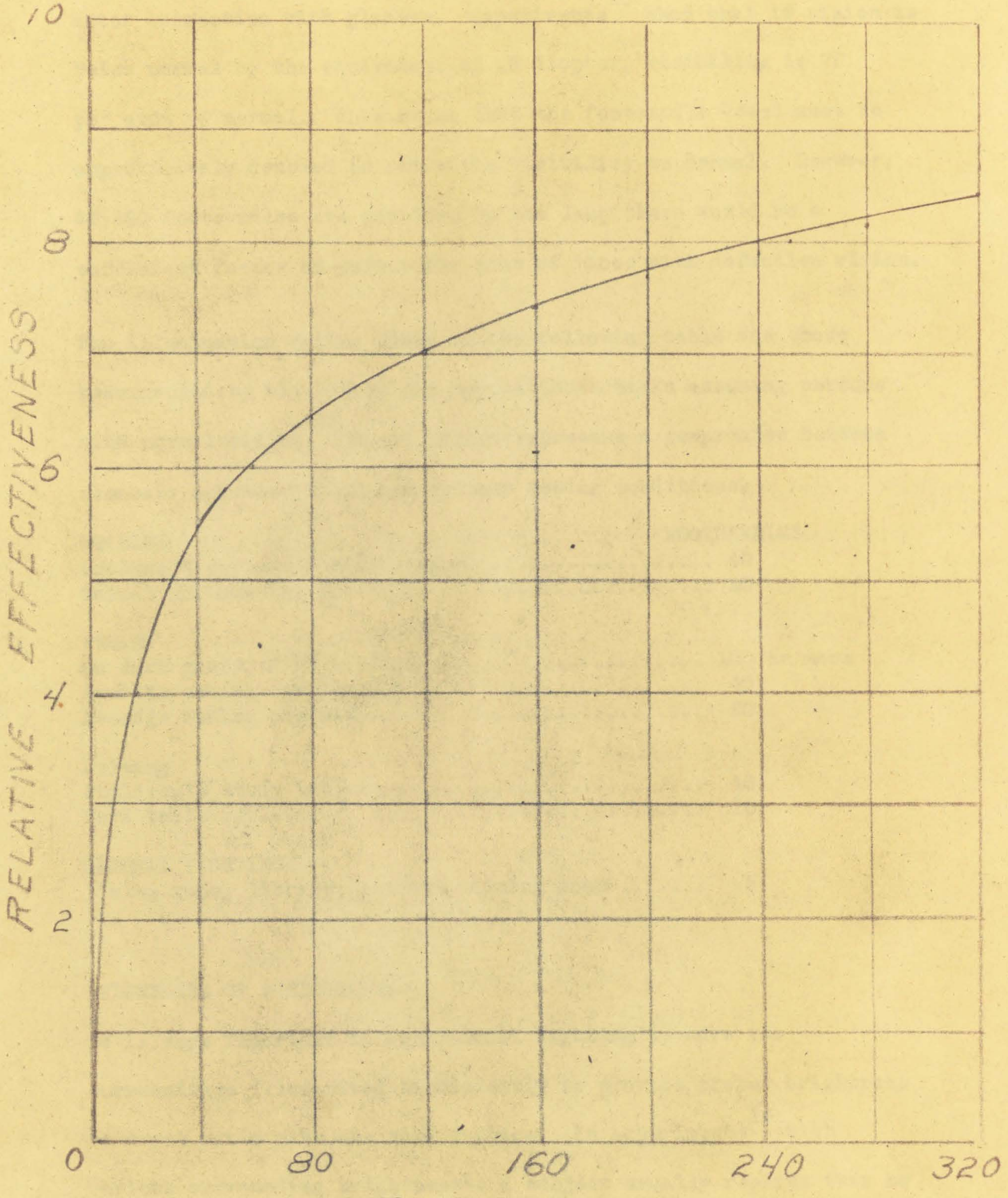
The ability to see depends upon four variables: size, contrast, brightness, and time of exposure. The lack of any one of these variables must be compensated for by the others. In reading and similar home tasks, brightness is the only controllable factor.

*See appendix I for definition of terms

Effectively, there are only two levels of illumination---one for barely seeing and one for easiest seeing. The level used in practice is a compromise based on economic considerations. For most common visual tasks, less than a footcandle is necessary for barely seeing. All researches which have dealt with ease of seeing indicate that the level for easiest seeing is above 100 footcandles, even for the relatively easy task of reading type of large size and high contrast.[12] For easiest seeing in the case of small objects of low contrasts and brightnesses, easiest seeing is obtained from hundreds and even thousands of footcandles.

Psycho-physiological effects such as fatigue, nervous muscular tension, blinking, and heart-rate are noticeably reduced when illumination levels above 100 footcandles are used for prolonged critical visual tasks.[13]

Since a floor lamp is used over half the time for reading and close work, it is essential that it be able to provide levels of illumination close to 100 footcandles, in order to approximate conditions of optimum seeing comfort. The effectiveness of illumination is not directly proportional to increase in light but follows a geometric law as shown in figure 6. It is in the lower values of illumination where the most rapid gain is made at the lowest cost. As a rule of thumb, the footcandle level must be doubled to produce a significant improvement in seeing. With this fact in mind, it may be seen that it would not be economically logical to increase the illumination provided by a floor lamp above 100 footcandles since the next step in visual effectiveness would be 200 footcandles.



EFFECTIVENESS OF SEEING AND ILLUMINATION

FIGURE 6

The vision of a large percentage of persons is below normal even after correction with glasses. Experiments[15] show that if vision is below normal by the equivalent of .5 diopter, visibility is 75 per cent of normal. This means that the footcandle level must be approximately doubled to raise the visibility to normal. However, if 100 footcandles are provided by the lamp there would be a sufficient factor of safety for most of those with defective vision.

The illumination values given in the following table are those recommended by the I.E.S. for typical home tasks assuming persons with normal vision.[16] These values represent a compromise between economic considerations and optimum seeing conditions.

READING	FOOTCANDLES
Prolonged periods (smaller type)	40
Casual periods (larger type)	20
SEWING	
On dark goods, fine needlework	100 or more
Average sewing (prolonged)	40
Average sewing periods	20
Writing	
Children's study table	40
Card table	10
GENERAL LIGHTING	
Living room, library, sunroom, dining room	5

BRIGHTNESS OF SURROUNDINGS

It is very important in residential lighting to have the surroundings illuminated sufficiently to provide proper brightness contrast ratio with the work surface. In experiments[16] with various surrounding brightnesses a subject usually reports that he can "see better" when the surrounding field is dark, than when it is illuminated to the same brightness as the central field.

Actually, he cannot. The data show that the psychological factor of attention or concentration is apparently more influential in a superficial appraisal than the physiological effect of brightness contrast, as revealed by accurate measurements of visual efficiency.[17] It is necessary then to make a compromise. The surroundings should be definitely darker than the central field, but not so dark that visual fatigue is caused by the adaption process as the subject looks alternately at the work and the surroundings. In reading, the brightness of the printed page sets the state of adaption. Visual comfort is best when the immediate surroundings have the same brightness as the book. Immediate surroundings should never be less than one tenth the page brightness. The general surroundings should never have large areas with brightnesses less than one tenth the task brightness or large areas near the line of vision more than ten times the task brightness.[18]

The consumer survey showed that in more than half of the homes, portable lamps provide the only source of general room illumination. Under these circumstances, it is extremely important to design a floor lamp to provide the major part of the required general room lighting. For a 100 footcandle lamp, this would mean general lighting of 10 footcandles or more.

GLARE

Glare is any brightness within the field of vision causing discomfort, interference with vision, or eye fatigue. It may be caused by:

1. High brightness of the source.
2. High contrast between source and background.
3. Specular reflection from surfaces of high gloss.

To avoid the annoyance of glare, it has been recommended[19] that brightness in the central part of the visual field should not exceed 500 to 1300 footlamberts when viewed continuously. These limits are for small areas. Where the field of vision includes nothing but the luminous element, 75 footlamberts is the maximum recommended.

Specular reflection reduces visibility and often causes discomfort glare. Orientation of the visual task or the light source is helpful. However, many books, magazines, and newspapers cannot be held in a single plane, with the result that the annoyance of specular reflection is often unavoidable. A magazine that has been folded in the mails or even a straight magazine picks up specular reflections, regardless of its orientation with respect to the lamp.

The glare effects from specular reflection increase:

1. As the angle of incidence increases.
2. As the brightness of the source increases.
3. As the distance of the glare source from the work increases.[20]

To design a floor lamp which is free from specular reflection, light source brightness must be lowered and illumination increased. This leaves the alternatives of using a larger light source at the standard height or bringing the light source nearer the reading plane. To reduce specular reflection to a minimum, the light source brightness should be decreased, its size increased, and the whole unit brought nearer the reading plane.[21]

AN ANALYSIS OF LIGHT SOURCES

The following table gives a general comparison of fluorescent and incandescent light sources:

PROPERTY	INCANDESCENT	FLUORESCENT
Spectral quality	Greater quantity of red and infra red than daylight	Wide range of color temperatures available. Fluorescent light blue compared to incandescent. New phosphors now developed which provide more red light.[22] Light contains sharp peaks of the mercury spectrum, giving slight monochromatic effect.
Efficiency	18.3 lumens per watt for 200 watt bulb.	40 lumens per watt for 32 watt tube plus auxilliary.
Initial cost	17¢ for 100 watt bulb	$1.75 for 32 watt circline
Life	1000 or 750 hours	2500 hours at 3 hours burning time per start. Life is governed by number of starts.
Cost of light	.5¢ per hour for 1600 lumens (100 watt bulb at 17¢ and lasting 1000 hours. power 5¢ per kwh)	.3¢ per hour assuming 32 watt circline and 8 watt ballast. (initial cost $1.75, life 2000 hours, output 1600 lumens)
Flicker	Little or no flicker on 60 cycle. Relative flicker: 40 watt-----13% deviation from mean output 100 watt---- 5% deviation from mean output	Light drops almost to zero between each half cycle. This can be corrected by use of two lamps on special circuit which causes them to operate out of phase with each other. Relative flicker: W. Fluor.-------35% deviation from mean output W. Fluor. tulamp balast----16% deviation from mean output

Analysis cont.

PROPERTY	INCANDESCENT	FLUORESCENT
Noise	Noiseless	Ballasts tend to have 60 cycle hum. Can be reduced to inaudibility by proper installation and the use of good quality ballasts.
Radio interference	None	Electrical instability at electrodes sets up continuous radiation which tends to cause radio interference.
Effect on the eye	Incandescent lamps have proven themselves over a long period of time to be satisfactory light sources with no harmful effects if they are used properly. Careful shielding is necessary due to high brightness.	Fluorescent lights when used properly have no known harmful effects. Flicker is objectionable to a certain few. Also the use of high color temperature lamps may cause slight chromatic abberration. With the rapid improvement of phosphors, the fluorescent may soon be able to excell the incandescent in color quality. However the discontinuities due to the mercury lines can be argued against on the basis of the difference from natural sunlight.
Thermal effects	About 60 to 70 percent of energy given off as radiant heat.	About 20 to 30 per cent as radiant heat
Size	Require much smaller space	Always in the form of a straight or curved tube which takes up more space.
Brightness	High brightness	Low brightness

The results of this comparison indicate that the fluorescent source with its low brightness, high efficiency and long life, would be ideally suited to floor lamp design provided that, hum, flicker and radio interference were eliminated and the new low color-temperature sources were used. The extra initial cost of the fluorescent installation would be paid for by the saving in electricity during the life of the first set of tubes.* During its life time the saving in electricity would easily pay for the lamp. Incandescent light should be used in conjunction with the fluorescents both to increase the light output for a given sized unit and to satisfy consumers who have had bad experiences with fluorescents.

Of the lamps now available, the circline fluorescents are the best fluorescent sources for use in portable lamps. The incandescent bulb best suited to floor lamp design is the Bolite, a 200 watt R-40 bulb, which has a diffusing glass coating on the neck section to provide low brightness for down lighting in conjunction with a large component of indirect light. (see appendix B for additional data on these lamps)

RADIO INTERFERENCE AND FLICKER

The application of circline fluorescents to portable lamps in homes raises problems of radio interference. Research[23] has shown that it is possible to reduce interference entirely below the tolerance noise level by use of a wire screen under the lamp shade grounded to the frame and ballast in conjunction with a radio interference

*Assuming 2500 lumens at a saving of .3¢ per hour for a period of 2500 hours represents a saving of $7.50.

capacitor across the supply line. (see figure 13) This method of screening should be designed into the lamp so that it does not appear as an after thought.

Flicker effect may be reduced in a single fluorescent lamp by using it simultaneously with an incandescent bulb. The best method, however, is to operate two lamps together, one with its current limiting choke alone which produces a lagging power factor and the other with a condenser added to the circuit which produces a leading power factor. The lamps then operate out of phase, producing a much more nearly uniform light output. A combination of these methods would provide excellent flicker correction for the floor lamp design.

I.E.S. AND C.L.M. SPECIFICATIONS FOR PORTABLE LAMPS

The Illuminating Engineering Society has set up recommended performance standards[24] for portable lamps. These standards are based upon a study made by the Committee on Residence Lighting. Although this study is far from complete, it represents the best work yet done on the subject and should be used as a reference point in the design of all home lighting equipment. A review of these recommendations and how they were derived[25] is included in appendix C.

Since the Certified Lamp program is one of the largest promotional efforts in the present portable lamp market, it would be wise for any design to meet their specifications. Since the specifications are rather lengthy, they may be found in appendix D.

APPROACH

In approaching this design problem, the ideal solution was first outlined as embodying all the features found desirable by the research work. Next, a variety of design themes based on this ideal solution were tried and the most promising were worked on and refined further. From these was selected the one which seemed to be the most practical interpretation of the ideal solution. This design was then engineered and subjected to further refinement, the end product being the final design.

THE IDEAL SOLUTION

The ideal solution to the problem would embody all of the following features and improvements, which represent the basic conclusions drawn from all phases of the research.

1. Since portable lamps are used over 50 per cent of the time for close work, they should provide adequate light for this purpose plus a factor of safety for persons with defective vision. This would mean increasing the work surface illumination to 100 footcandles or more.

2. At this suggested level of illumination background brightness becomes critical, both visually and aesthetically. General illumination should be raised to at least one tenth the work surface brightness. 100 footcandles on the reading plane would dictate a component of indirect light greater than 10 footcandles.

3. The quality of the light should be improved by:

   a. Reduction of direct glare by better shielding of light source.

   b. Reduction of reflected glare caused by uneven distribution of light.

   c. Reduction of specular reflection by decreasing light source brightness and increasing the size of the source in relation to the work surface.

   d. Correcting spectral quality of the source.

4. It should have suitable means of adjusting the amount of light

required for a specified task.

5. Rules for proper lighting should be designed into the lamp. This could be accomplished by having a calibrated indicator which would be labeled in such a fashion that the user could not unintentionally make a mistake in lighting.

6. The lamp should be versatile enough to provide a number of lighting effects, such as:

a. Indirect light only, medium level for dramatic effects and conversation.

b. High level of over all illumination, for dull days and casual close work by a number of people in the immediate area of the lamp.

c. Low level over all illumination for conversation and to provide safe passage through the room.

d. Should possibly have provision for different color temperature sources to create interesting color effects. This could be accomplished by using flesh tint or gold fluorescent, etc.

7. The lamp should have a light distribution such that the position of the work surface in relation to the light source would not be highly restricted.

8. Materials should be used more honestly relative to their function and their process of manufacture.

9. The design and finishes should be universal enough to fit in with any type of furniture, drapes and decorations, and architecture. There should also be variety enough to satisfy the consumers basic desire for individuality and selection.

10. The unit should be easy to operate. The switch should be easy to find and adjust. A phosphorescent switch which would glow in the dark would be very helpful and would also provide a good sales point. The lamp should be easy to pick up and move about.

11. It should have no objectionable features such as flicker, or radio interference.

12. It should be easy to maintain, easy to dust and clean, and its light sources and ballasts easy to replace. Any mechanism should be fool-proof and simple in operation. The lamp should be structurally strong and stable. Finish should be durable and shade washable.

13. The lamp should disassemble and be easily packed for shipping

14. It should be easy to manufacture and be well adapted to either small production (1000 to 2000 annual sales) or to large production (20,000 to 40,000 annual sales).

15. It should require a relatively small amount of tooling and no special processes to be manufactured in the average lamp shop. Certain more complicated pieces could be sub-contracted or standard stock.

16. It should meet C.L.M. Standards if possible.

17. Selling price should be kept below $60. which would dictate a manufacturing cost of $20 or less.

18. It should have numerous good talking points for the salesman and should have features which would attract large promotional groups such as the power companies.

In addition to these conclusions, the following suggestions, received in a letter from the country's leading expert in residential lighting * were very influential in directing the approach to the design:

"The basic problem pretty much comes down to producing higher illumination values on work planes that are practical and reduction of specular effects from glossy paper. You will note that the highest performance now provided is with the large CLM floor lamp using incandescent and fluorescent. I would like to see what can be done in working on the problem of a 100 footcandle lamp that would have good lighting qualities. In addition to this statement, I would like to see 50 footcandle lamps that were high in that phase of lighting quality which makes for high visibility of the printed page and in which there is freedom of a number of normal positions. In other words, not under high restricted positions of light source and page to be read."

ANALYSIS AND SELECTION OF DESIGN APPROACH

Many different approaches to the design problem were tried and analyzed in terms of the ideal solution. The different design themes were as follows:

1. The conventional type.

---

*Mr. E. W. Commery, in charge of Residential Lighting for the General Electric Co., member of the I.E.S. Committee on Residence Lighting and Technical consultant for the C.L.M.

2. The modified conventional type.

3. The square lamp using straight fluorescents.

4. A lamp with movable flood or spot light.

5. A lamp below eye level.

6. Combination general and below eye level lamp.

See appendix E for analysis and illustrations of these design approaches.

The approach using the combination general and below-eye-level lighting offered by far the most promising possibilities from the lighting standpoint and presented the most challenging aesthetic design problems. (see figure 7, 8 and 9 for illustrations) Its qualities are as follows:

ADVANTAGES

1. Low brightness and large size of light source relative to the reading surface with resultant reduction of specular reflection and increase of brightness contrast.

2. High levels of illumination. (100 footcandles or more)

3. General illumination is automatically provided by special switching arrangement.

4. General room illumination prevents eye strain, and accomodation fatigue by reducing the contrast between work surfaces and surroundings.

5. Illumination supplied to distant objects for the eyes to focus on and relax after doing close work.

6. It provides illumination similar to that in nature. 80 per cent of the light coming in direct parallel lines with the remaining light being highly diffused indirect lighting.

7. It provides more versatility of lighting effects:

FIG. 7. POSSIBLE DESIGN FOR GENERAL AND BELOW EYE LEVEL LAMP

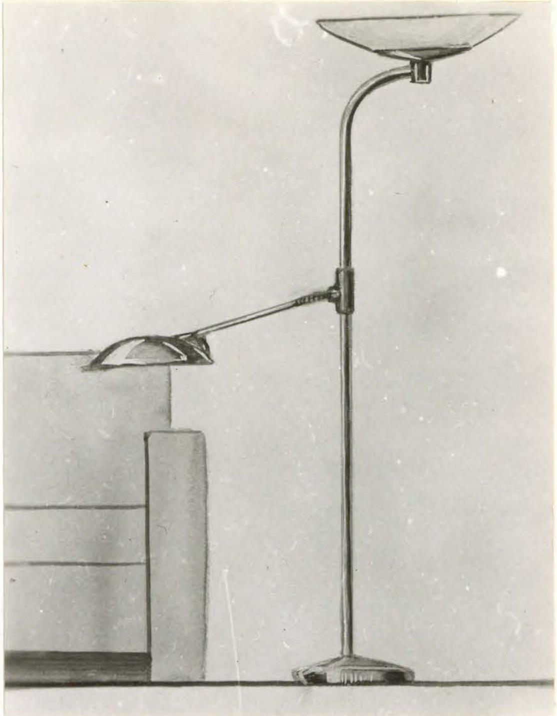


FIG. 8. POSSIBLE DESIGN FOR GENERAL AND BELOW EYE LEVEL LAMP

FIG. 9. POSSIBLE DESIGN FOR GENERAL AND BELOW EYE LEVEL LAMP

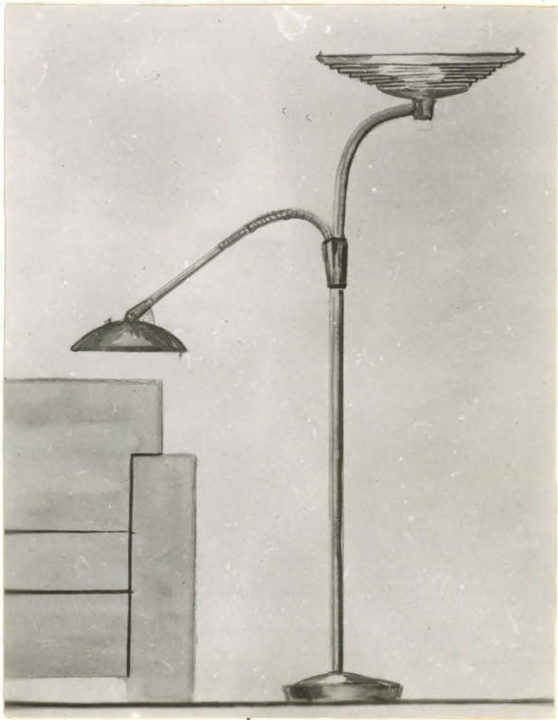


FIG. 10. DESIGN SELECTED FOR FINAL ENGINEERING AND REFINEMENT

DISADVANTAGES

1. More complicated and expensive to build.

2. Necessitates special switching arrangement.

3. Presents a more complicated form, aesthetically.

Having selected this approach, a thorough study was made of the basic problems in the design. They are as follows:

1. To provide proper aesthetic balance between the light source providing general illumination and the one providing below eye level light, in order to create a pleasing composition that would be acceptable in the home.

2. To make it possible for the higher light source to be easily adjusted both as to height and position relative to the reading material or work being done.

3. The development of a switching arrangement which would prevent the use of the reading light until the general illumination had been turned on.

4. Proper shielding of the light sources to prevent direct glare.

5. The design of a base which would provide proper stability characteristics for all positions of the reading light.

DESIGN

Using this design approach, many designs were roughed out, with a variety of forms, mechanisms, and light sources in order to find the design which most nearly approximated the ideal solution. After careful consideration of all factors, the design shown in figure 10 was selected for final refinement and engineering. This design has a very simple and beautiful composition of forms, each expressive of its individual function. The general illumination is provided by means of a 32 watt circline fluorescent plus a 200 watt incandescent Bolite. This unit, at eye level, is a shallow metal reflector with concentric louvers across the face to prevent glare. This reflector is mounted with a universal joint to an arm which in turn is attached to the lamp by a section of flexible tubing. Thus, the reading light may be oriented in any position either above or below eye level, providing wide flexibility and versatility. In addition, an indicator is provided on the reading lamp which is calibrated in terms of lighting for specific visual tasks. This shows the user how he should position the reflector in order to have the proper level of illumination. This indicator will be described later in more detail.

The two switches are located on the reading reflector where they are handy to reach from either a standing or sitting position.

MATERIALS AND PROCESSES

Careful consideration was given to the problem of determining the best materials and means of constructing the lamp. Since the lamps will probably go through an introductory period of low volume production, the materials and processes had to be chosen accordingly. The low production model will necessarily be a higher priced lamp and will be sold to the upper income group on the basis of quality and excellence of lighting. The high production model will compete on a price basis with present day lamps. To carry out this policy, cheaper materials and more economical processes will have to be used in the high production model. With these considerations in mind, the following production methods and materials were selected:

The structural members had three main functions: (1) to be light and strong; (2) to contain the wiring; (3) to present a pleasing exterior appearance. Metal tubing was the logical choice. Due to its lightness and strength, and relatively low price, 61 ST aluminum was chosen for all structural parts for the introductory model. For the high production model cold drawn seamless steel tubing was selected as the best material due to its low cost and ease of finishing.

A single parabolic spinning is made from 2S, 14 gauge aluminum sheet for the low production model or from 22 gauge hot rolled steel sheet for the high production model. The central section is removed and used for the reading lamp reflector and the remaining space is then filled in with concentric, circular louvers to create the general lighting unit. These louvers for the upper lamp are spun from the same type of material as the reflector. They are held rigidly in position by six slotted support members which in turn are screwed to the central casting and welded or soldered to the outer spinning.

The louvers for the reading lamp are fabricated by winding a continuous strip of one half inch .020" 24 ST aluminum on a spiral form. They are drilled and held rigidly in position by rods inserted in these holes. For high production, they are molded from urea formaldehyde.

The base and the various fittings are permanent mold aluminum castings for low production or zinc die castings for high production. Transitions between castings and tubing are made by pinned joints.

Consumer research indicated that bronze, brushed brass, copper, natural aluminum and pastel shades were desirable. The copper, brass, and bronze finishes are obtained by plating, while the pastel shades which would include a light grey and beige tan would be obtained by spray painting with synthetic enamel. The natural aluminum would be given a brushed finish with emery cloth and then a protective alumilite coating or a coat of clear lacquer. This selection of finishes would be sufficient for the introductory Model. A larger variety of finishes would be made available as production is increased.

No. 18 vinyl coated fixture wire is used for all internal wiring except for the 200 watt Bolite circuit which requires No. 16 asbestos covered wire. The external cord is No. 14 stranded wire covered with grey rubber. The switch control knobs are injection molded from phosphorescent polystyrene.

G.E. individual lamp holders (cat. No. 95x 841) are used to support the 32 watt circline and a channel type lamp holder (cat. No. 95x798) is used to support the 22 watt circline. The remainder of the electrical materials are indicated in the circuit diagram figure 13.

LOUVER AND SHADE DESIGN

The louvers for the reading lamp are one half inch deep and are spaced three fourths of an inch apart. This not only protects the lowest person at a distance of two feet, but also provides effective cutoff of the main cone of light within an included angle of 100 degrees, which will provide good work surface coverage at the various adjustment heights. (see diagram figure 11)

Louvers for the upper light have been spaced every inch and are one inch deep. This provides cut-off at a distance of three and one half feet from the central unit.

In order to extend sales to a greater number of consumers who have period furnishings, it was necessary to provide optional use of a conventional shade for the general lighting unit. Fiber glass impregnated with polyester resins was chosen because of its interesting texture and uniform light transmission. The size was determined from the Bolite shielding data appendix B.

REFLECTOR DESIGN

Due to the large size of the circline source in the reading reflector, no accurate optical calculations of the reflector's distribution curve could be made. The outer part of the reflector is parabolic in shape with the locus of its foci at the center of the circling tube. Appearance considerations dictated a smooth over all surface for the reflector, which precluded the use of a cardiod shaped reflector directly behind the tube which would have utilized more light from its rear surface. The final shape is shown in the working drawings, figure 14.

VISUAL TASK INDICATOR

The visual task indicator consists of a lucite dial attached to the support arm of the reading light. It passes through a slot in the reading reflector so that a varying amount of the dial is exposed as the reflector is pivoted on its axis. (see figure 12 for diagram) Assuming that the reading plane is a constant

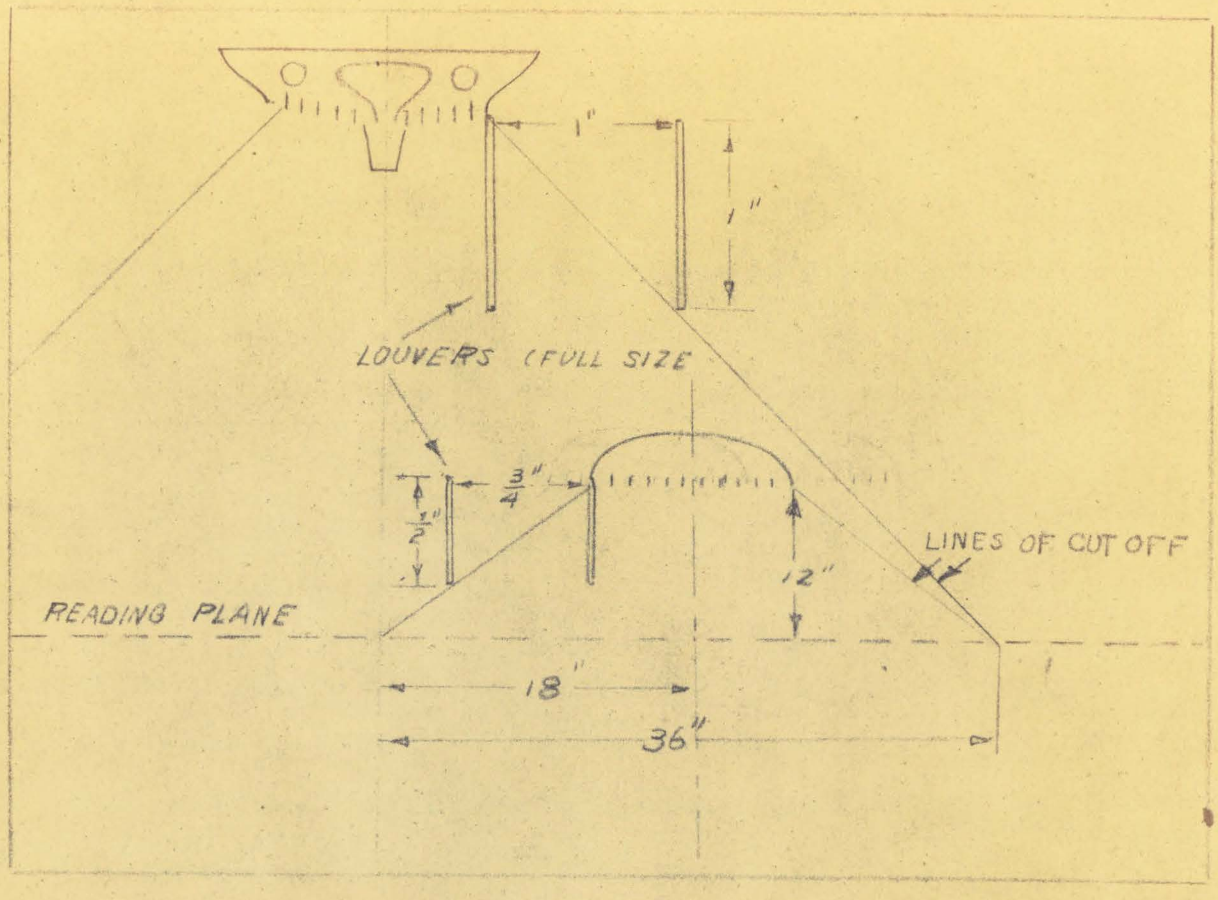


FIGURE 11. LOUVER CUT OFF AND LIGHT DISTRIBUTION

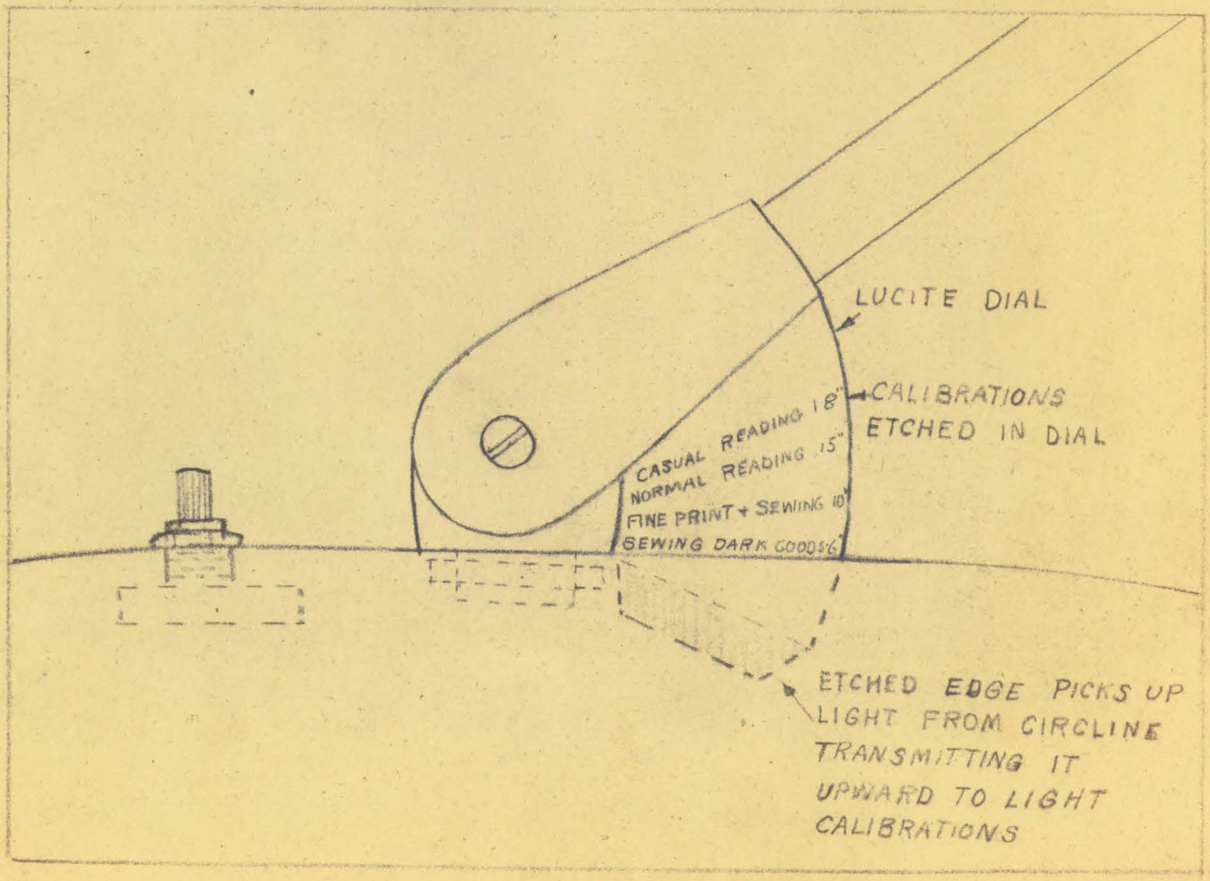


FIGURE 12. VISUAL TASK INDICATOR

height,* the distance of the reading light from this plane is proportional to the angle between the support arm and the reflector. Due to the inverse square law the illumination then bears a proportional relationship to this angle. This angle is divided by calibrations on the lucite dial which are labeled in terms of the visual tasks which may be performed with optimum seeing comfort with the reading lamp at the indicated position. This gives a fairly accurate indication that the proper amount of light is being obtained.

In addition, the dial has the proper reading plane to light source distance marked opposite the corresponding visual task. This allows the user to provide himself with the proper illumination within close limits of accuracy. Also it provides a method of attaining proper illumination on reading planes which vary widely from the usual height.

The bottom edge of the lucite dial is beveled and is provided with a diffusing surface so that light is picked up from the circline and transmitted upward through the dial. This light is intercepted by the etched calibrations making them luminous against the transparent dial. Thus attention is immediately drawn to the dial when the reading light is turned on. This not only will help improve seeing conditions for the user, but will be a constant reminder about the need for good lighting. Effectively it will be an excellent means of educating the public about better lighting.

*Reading plane height varies plus or minus 3 inches.

SWITCHING AND CIRCUITS

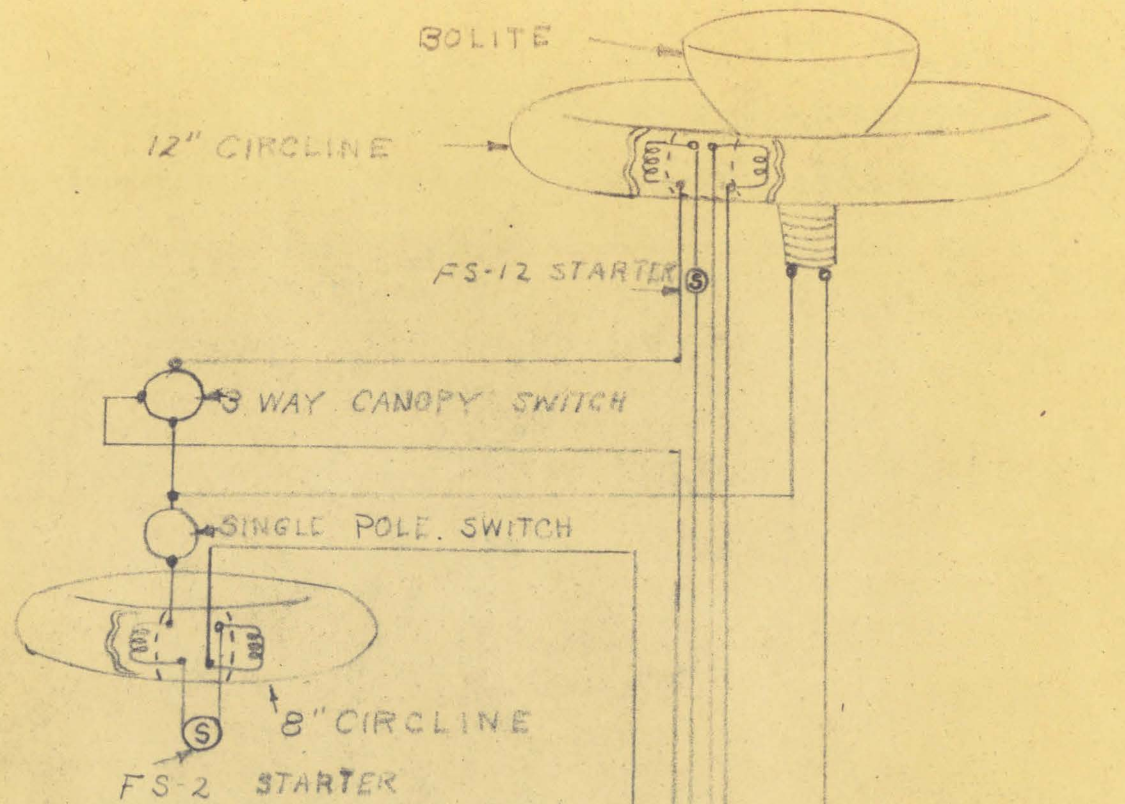
One of the main problems to solve in this type of lamp was that of switching and circuits. The top of the reading lamp reflector was selected as the ideal location for all controls, since this would make them accessible to a person in either a sitting or standing position. The problem was to provide versatility of lighting in combination with good reading light. The following conditions were found desirable:

1. High level of over-all illumination...32 watt fluorescent and 200 watt Bolite.
2. Medium level of over-all illumination...200 watt Bolite.
3. Low level of over-all illumination... 32 watt circline.
4. High level of overall illumination plus extra light for close work... 20 and 32 watt circlines plus 200 watt Bolite.

These switching arrangements are provided by means of the circuit shown in figure 13.

LEVEL OF ILLUMINATION

The levels of illumination attainable with this lamp have been calculated. (see appendix F) The results show that with all lights on and the reading lamp below eye level, up to 100 footcandles can be obtained on the reading plane. Distribution will be about 95 per cent direct and 5 per cent indirect. With the reading light off the general lighting unit provides about 30 foot candles in the immediate vicinity of the lamp and general room illumination of 8 footcandles. Distribution will be 80 percent direct and 20 per cent indirect. These values were determined on the basis of modern light colored room finishes and a standard 12 X 12 room.



switching conditions		light sources in operation
single switch	3-way switch	
off		none
on		Bolite + 8" circline
on		Bolite + 8" + 12" circline
on or off		12" circline
off		Bolite
off		Bolite + 12" circline

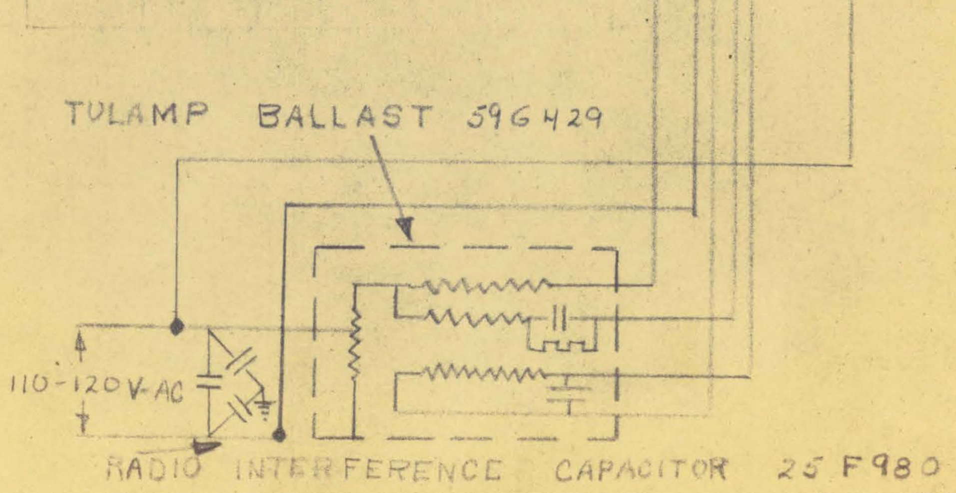


FIGURE 13

SHIELDING AND BRIGHTNESS

Calculations were made to determine the brightness of the louvers. (See appendix G) These brightness values were then compared with I.E.S. recommendations. The average brightness determined from points A, B, and C as specified in the I. E. S. testing procedure (see appendix B) were determined to be:

A ..... 1500 footlamberts
B ..... 208 footlamberts
C ..... 332 footlamberts

Corresponding values of C were as follows:

point	Calculated	Permissible
A	3200	3600
B	800	900
C	1300	2100

Hence, the brightnesses are within the limits established by the I.E.S.

ELIMINATION OF HUM

Hum from the fluorescent ballast has been reduced to inaudibility both by the use of high quality ballasts and by mounting them on soft rubber. (see working drawings, figure 14)

REDUCTION OF RADIO INTERFERENCE

Radio interference has been reduced below threshold noise level by shielding both fluorescent tubes with the metal louvers and reflectors and by use of the special General Electric radio interference capacitor, which consists of a .02 mfd condenser in delta with two .002 mfd condensers the common lead of which is grounded to the lamp frame. (see circuit diagram figure 13)

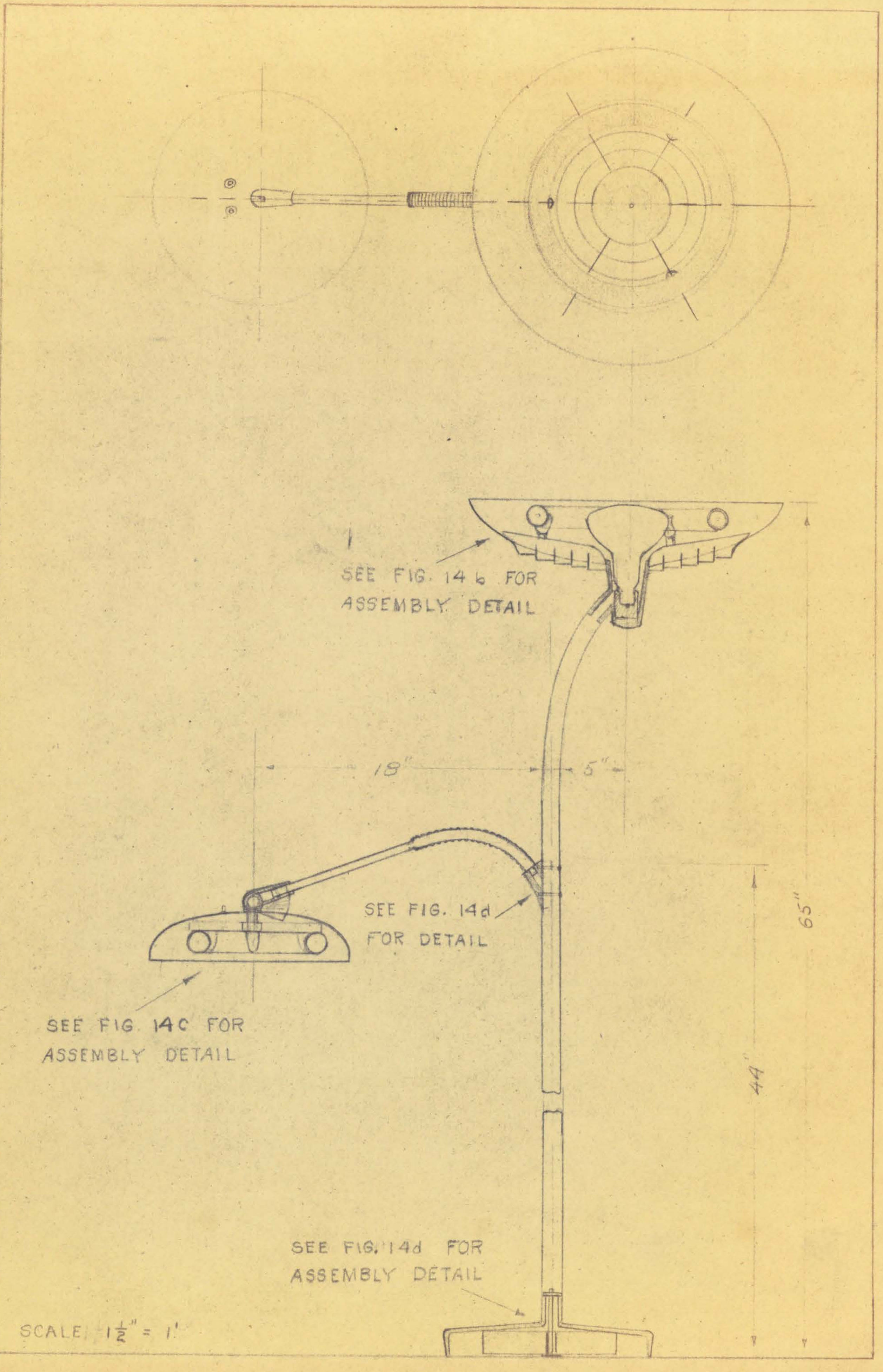


FIGURE 14a WORKING DRAWINGS

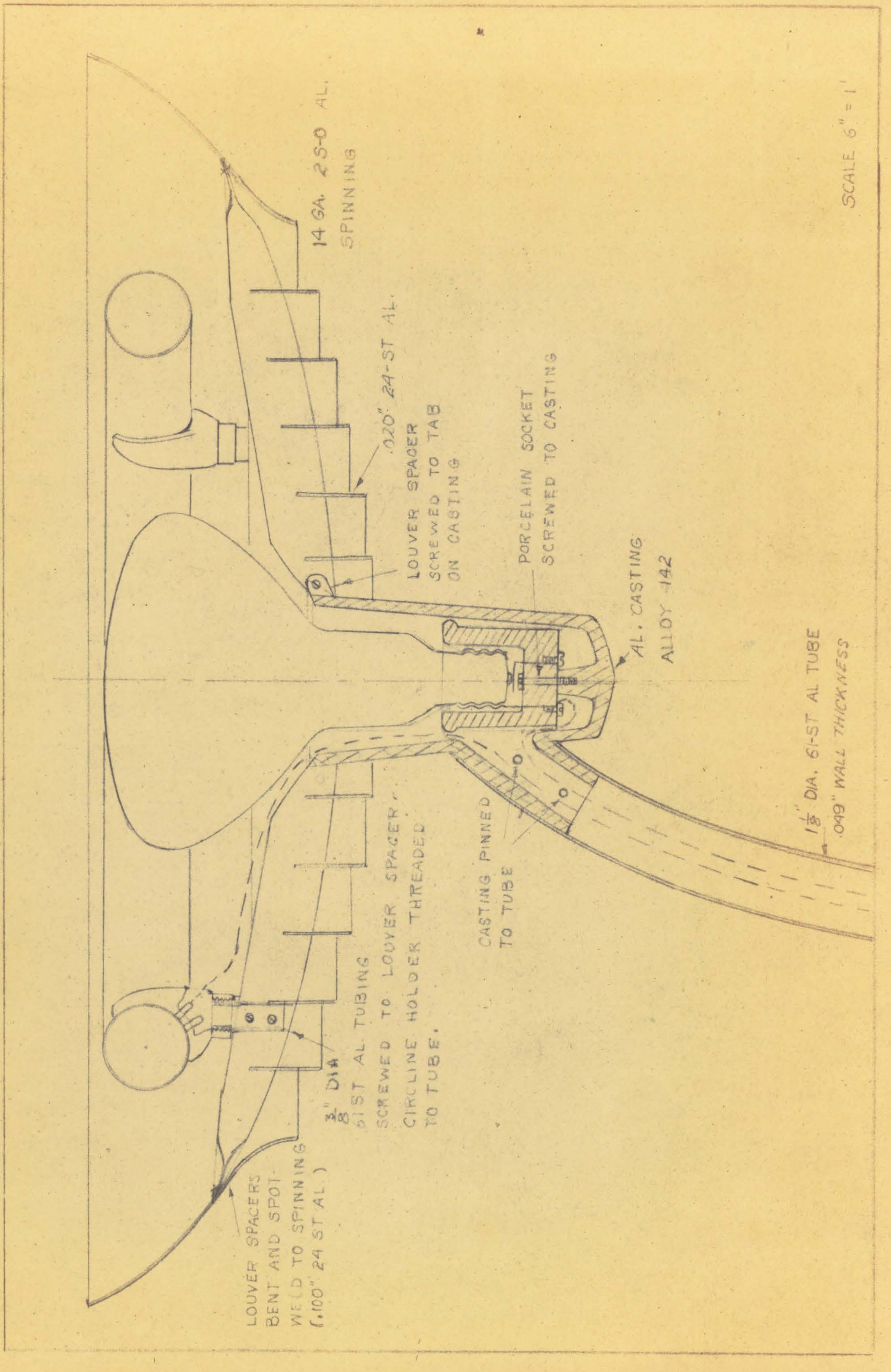


FIGURE 14b UPPER LIGHT ASSEMBLY DETAIL

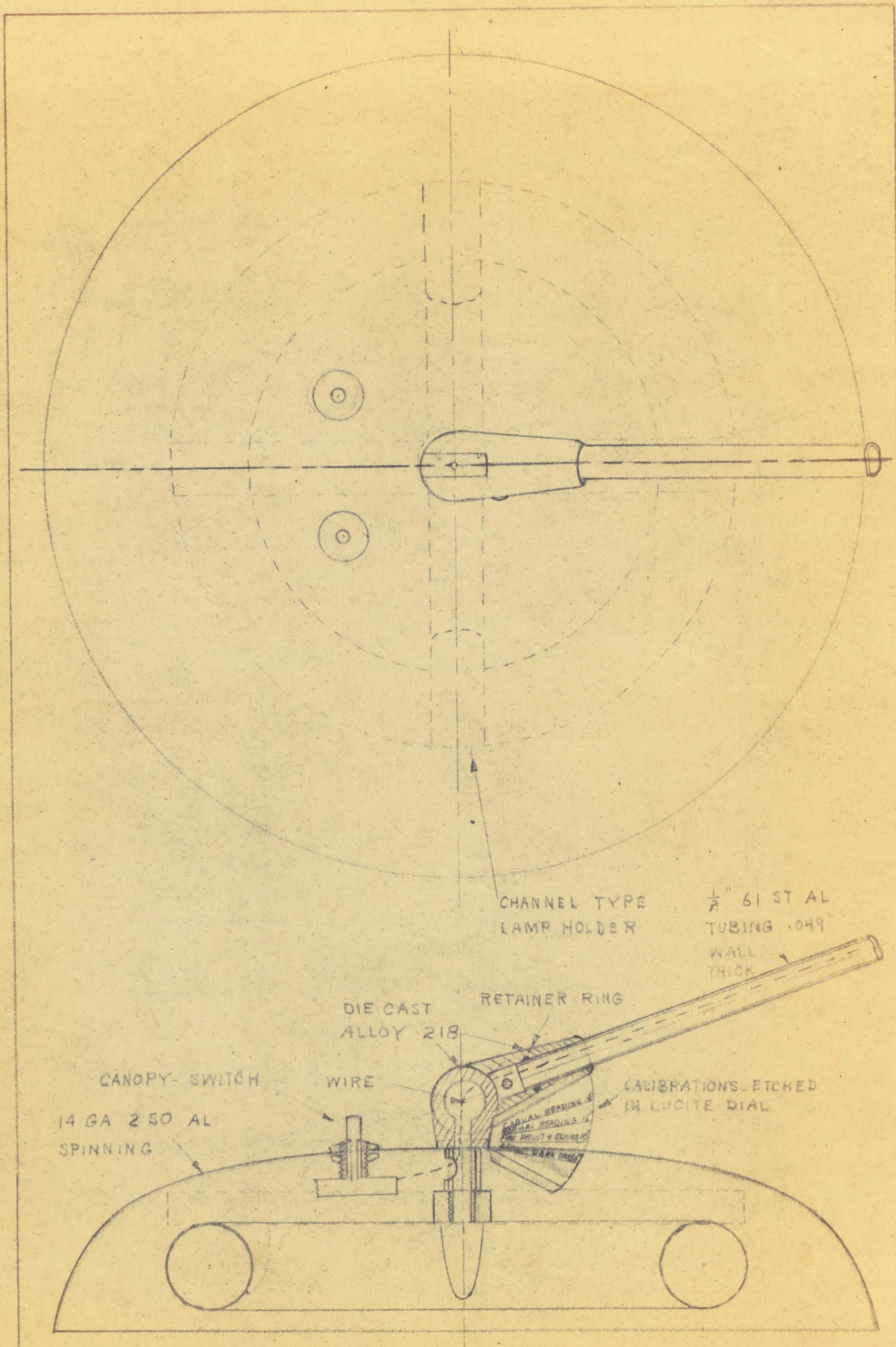


FIGURE 14C READING LIGHT DETAIL

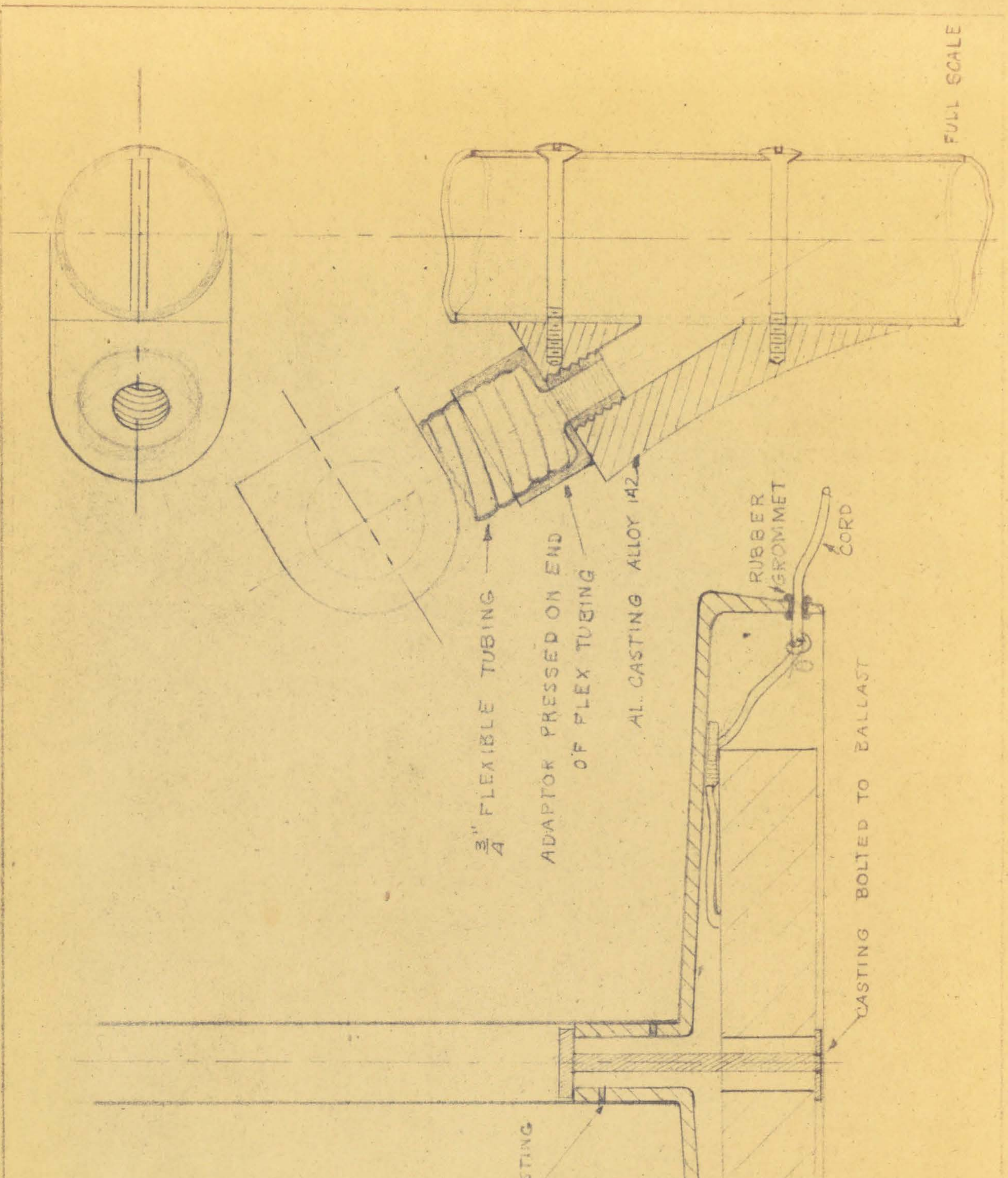


FIGURE 14 d DETAIL OF BASE AND TRANSITION CASTING

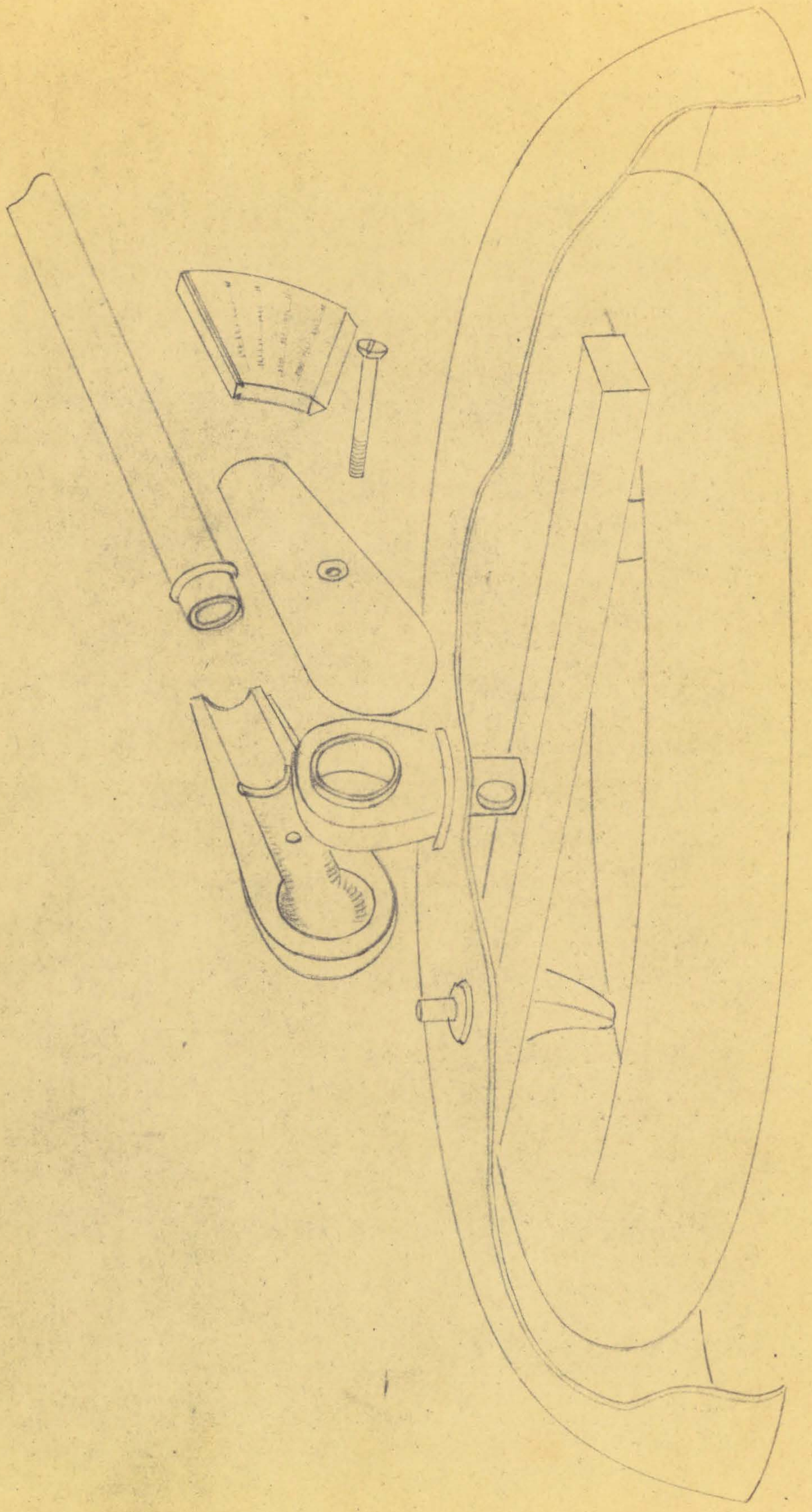


FIGURE 15 READING LAMP ASSEMBLY

STABILITY

Weights and conditions for stability were calculated. (see appendix H) These calculations showed that the weight of the lamp is approximately 17 pounds. With the reading lamp extended completely, the lamp may be tipped 12° from the vertical before an unstable condition is reached.

COST CONSIDERATIONS

A cost analysis was made to determine the manufacturing cost and probable retail selling price. (see appendix I for detailed analysis)

For the low production, introductory model, (2000 annual sales) the manufacturing cost is $21.53 and assuming a mark-up of 66%, by both the manufacturer and retailer, the retail price would be $60.

For high production (20,000 annual sales) the manufacturing cost is $18.79, and assuming a mark-up of 50% by both manufacturer and retailer the retail price would be $42.50.

FINAL DESIGN

After full consideration of engineering details, final refinements were made and the design was completed. The final design is illustrated in figures 16 through 21. It represents a marked improvement over all present day floor lamps. It can provide 100 footcandles of glareless illumination for reading in conjunction with adequate illumination of the surrounding room.

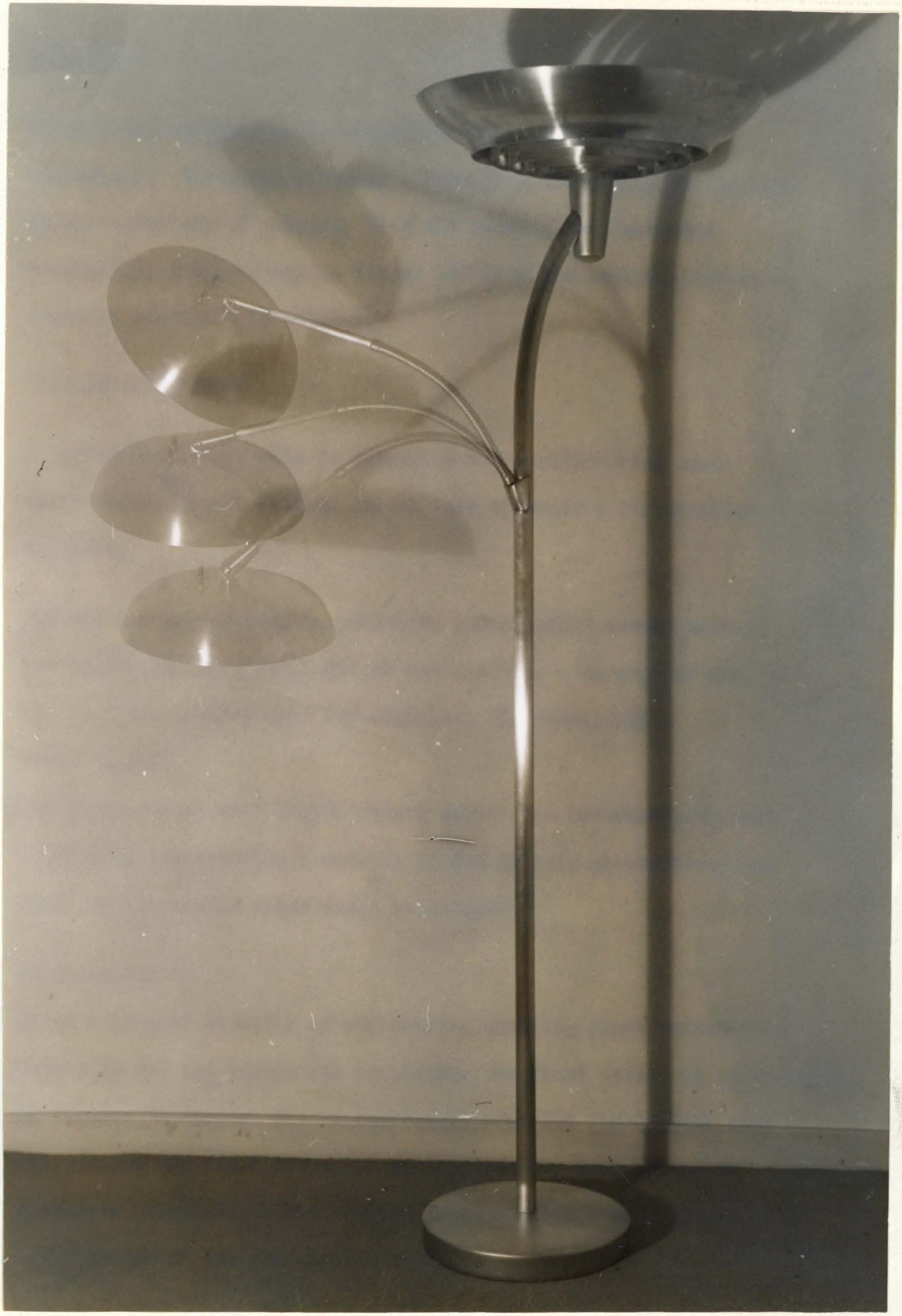


Figure 16, Photograph of Lamp

Figure 17, Photograph of Lamp with Conventional Shade

Figure 18
Photograph of Visual
Task Indicator

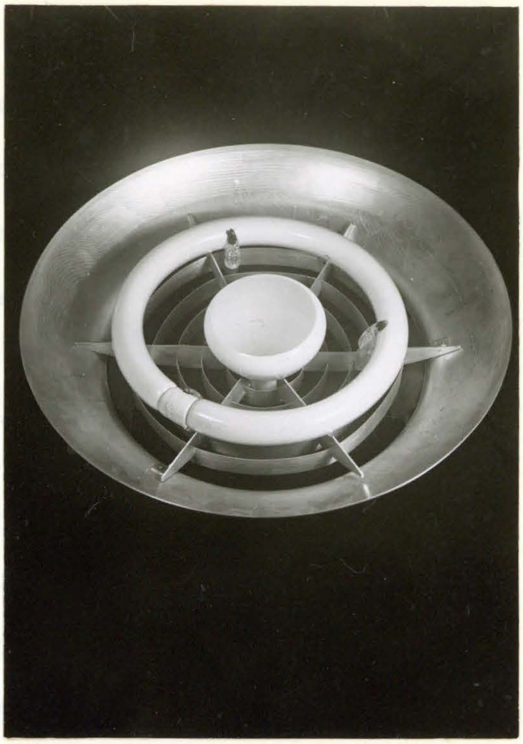


Figure 19
Photograph Showing Arrangement of Light Sources

Figure 20
Photograph of Reading Light
Being Used as a Piano Light

Figure 21
Photograph of Reading Light
Providing Indirect Light

Specular reflection from glossy paper, the major problem in reading lamp design, has been effectively eliminated by the large area low brightness reading lamp. In addition, the reading lamp is provided with a scale which tells the user at a glance, whether he has the proper illumination for a given task. (see figure 18) These sales features alone will create consumer interest and will be conducive to voluntary word of mouth advertising.

Since almost half the light is produced by flourescent light sources operation cost is about 30 percent less than most conventional lamps. This is an additional sales feature which would help in offsetting the higher cost of the unit.

Numerous lighting effects are available, including high and low levels of general illumination and localized direct lighting. Also the reading lamp may be oriented in any position so that it can be used for a piano light, bridge lamp, or for giving emphasis to certain areas, such as pictures or highlighting textures or draperies and creating interesting patterns of light and shade. (see figure 20 and 21) The various uses and available lighting effects are limitless. This versatility will create additional consumer interest, and acceptance, and will make it possible to carry out the ideal of modern decorative lighting---that light should emphasize texture or objects rather than be ornamented itself.

By embodying the latest technical information on modern light sources, it has been possible to eliminate all previous bad effects of fluorescent light. Flicker has been eliminated by use of a "Tulamp" ballast and ballast noise has been reduced to a minimum by the use of well designed ballasts with soft rubber mountings.

Radio interference has been reduced to inaudibility by use of proper shielding and special circuit arrangements. The announcement of coming production on new low color temperature fluorescents erases the last objection to fluorescents in the living room.

The great functional advancements made in this lamp design have necessitated the use of new forms and a definite departure from conventional design. An introductory period of lower production is therefore anticipated. The introductory production will be directed toward the group interested in functional modern furniture. A model will be produced with a conventional shade on the upper light for introductory sale to those with more conservative tastes. (see figure 17) The introduction to the public will of necessity be evolutionary. However, once acquainted with the lamp's advantages, and more aware of the functions associated with its form, public acceptance will be wide spread and large scale production with lowered price can be anticipated.

The lamp is well adapted to either low or high production with only a few changes in production techniques. This is very desirable considering the probable low volume production in the introductory period.

The design represents an honest use of modern materials. Finishes have been selected which go well with all types of furnishings and also which provide variety enough to satisfy the consumer's desire for individuality and selection. The lamp is convenient to operate. The switches are located on the reading unit, accessible both from a sitting and standing position. (see figure 18)

Phosphorescent plastic switch controls are an added sales feature, which eliminate fumbling and searching in the dark.

The lamp is easy to clean, and maintain and is stable in all positions. The numerous good sales features will make it very popular with salesmen, aid promotion, and encourage distribution.

The lamp's distinctive appearance and interesting composition of functional forms will immediately identify it both at the trade show and in the dealer's show room.

In short, this lamp represents a development which opens up vast new horizons both for the home lighting consumer and the lighting industry.

CONDITIONS

The following tests were made with the lamp operating in a 12 X 12 room with an eight foot ceiling (reflectance factor of 65 per cent for the ceiling and walls). The lamp was positioned with respect to chair and reading plane as prescribed by the I.E.S. and C.L.M. (see figure 22) To obtain values for the direct light components and for the shielding and brightness determinations, the measurements were made at night, out of doors to eliminate all effects due to the indirect light from ceilings and walls of the test room. All measurements were made with a Weston Illumination Metter, Model 603.

ILLUMINATION AND DISTRIBUTION

SWITCHING CONDITION	DISTANCE OF READING LAMP FROM READING PLANE (inches)	FOOTCANDLES ON READING PLANE	BRIGHTNESS CONTRAST, BOOK TO SURROUNDINGS	DIRECT LIGHT ON BOOK (%)	INDIRECT LIGHT ON BOOK (%)
ALL LIGHTS ON	6	240	18/1	93	7
"	9	210	15/1	92	8
"	12	165	11.5/1	90	10
"	15	100	9.5/1	84	16
"	18	70	9/1	77	23
BOLITE & READING LIGHT	12	140	17.5/1	92	8
BOLITE & 32 WATT CIRCLINE	--	33	4.5/1	52	48
BOLITE	--	18	3/1	39	61
32 WATT CIRCLINE	--	15	10/1	73	27

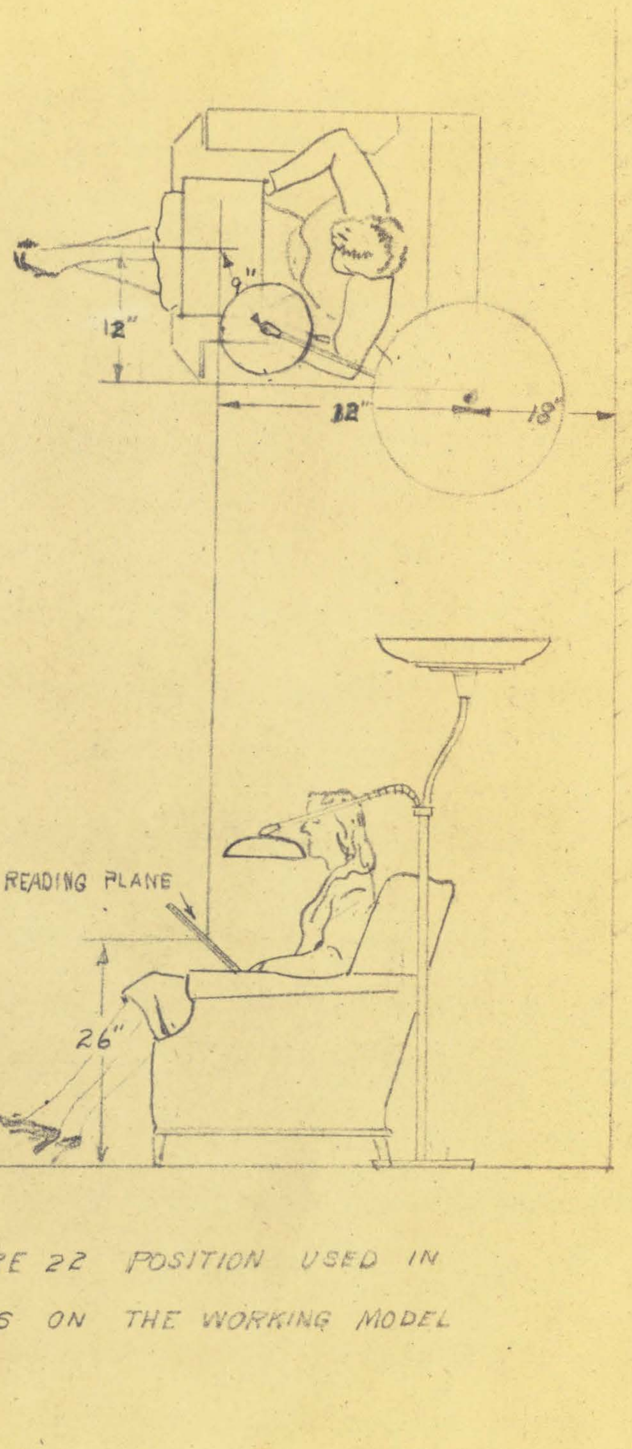


FIGURE 22 POSITION USED IN TESTS ON THE WORKING MODEL

SHIELDING AND BRIGHTNESS

Brightness values were determined for the test points A, B, and C as shown in appendix B and the corresponding values of "C" were calculated from the nomograph (appendix B). These values are compared with recommended values as follows: (note, reading lamp was placed at 38 inches above the floor or 12 inches above the reading plane, with louvers removed. Entire lamp was finished in brushed aluminum, representing the highest reflectance factor of all the proposed finishes)

POINT	FT-C AT TEST PT.		DISTANCE SQUARED		CANDLEPOWER AT TEST PT.	PROJECTED AREA SQ.IN.	C CALCULATED	C*MAXIMUM ALLOWABLE
A	9.8	x	$(2.8)^2$	=	77	22	3300	3600
B	2.2	x	$(3.5)^2$	=	27	41	740	900
C	2.8	x	$(5)^2$	=	70	51	1700	2100

CONCLUSIONS AND DESIGN MODIFICATIONS SUGGESTED BY TEST RESULTS

Preliminary tests on shielding and brightness showed that it was unnecessary to use louvers in the reading lamp as had been anticipated in earlier phases of the design. The final shielding and brightness tests were run with the reading lamp louvers removed. The test results showed that the brightness values were well within the limits established by the I.E.S.

With the reading lamp in the normal position (12 to 18 inches from the reading plane) the level of illumination ranged from 165 to 70 footcandles as predicted by the design calculations. Tests also showed that by bringing the reflector within six to nine inches from the work plane, levels of illumination over 200 footcandles could be obtained for such difficult tasks as sewing on dark cloth.

Brightness contrast between book and surroundings was close to the acceptable ratio of ten to one for normal positions of the reading lamp. In certain cases the contrast was greater than ten to one which indicated that additional sources of general illumination should be used in conjunction with the lamp whenever darker surroundings are encountered or when a room larger than the 12 x 12 test room is to be illuminated.

The light distribution varies from a maximum of 92% direct and 8% indirect to 61% and 39%, a typical value being 80% direct and 20% indirect.

Qualitative tests showed that specular reflection from glossy surfaces has been greatly reduced by this lamp as compared with the best C.L.M. floor lamp now on the market (32 watt circline and 300 watt incandescent)

In short, the results not only verified all design calculations but brought about the simplification of eliminating the louvers in the reading light, which resulted in lower production cost and greater light output than had been anticipated.

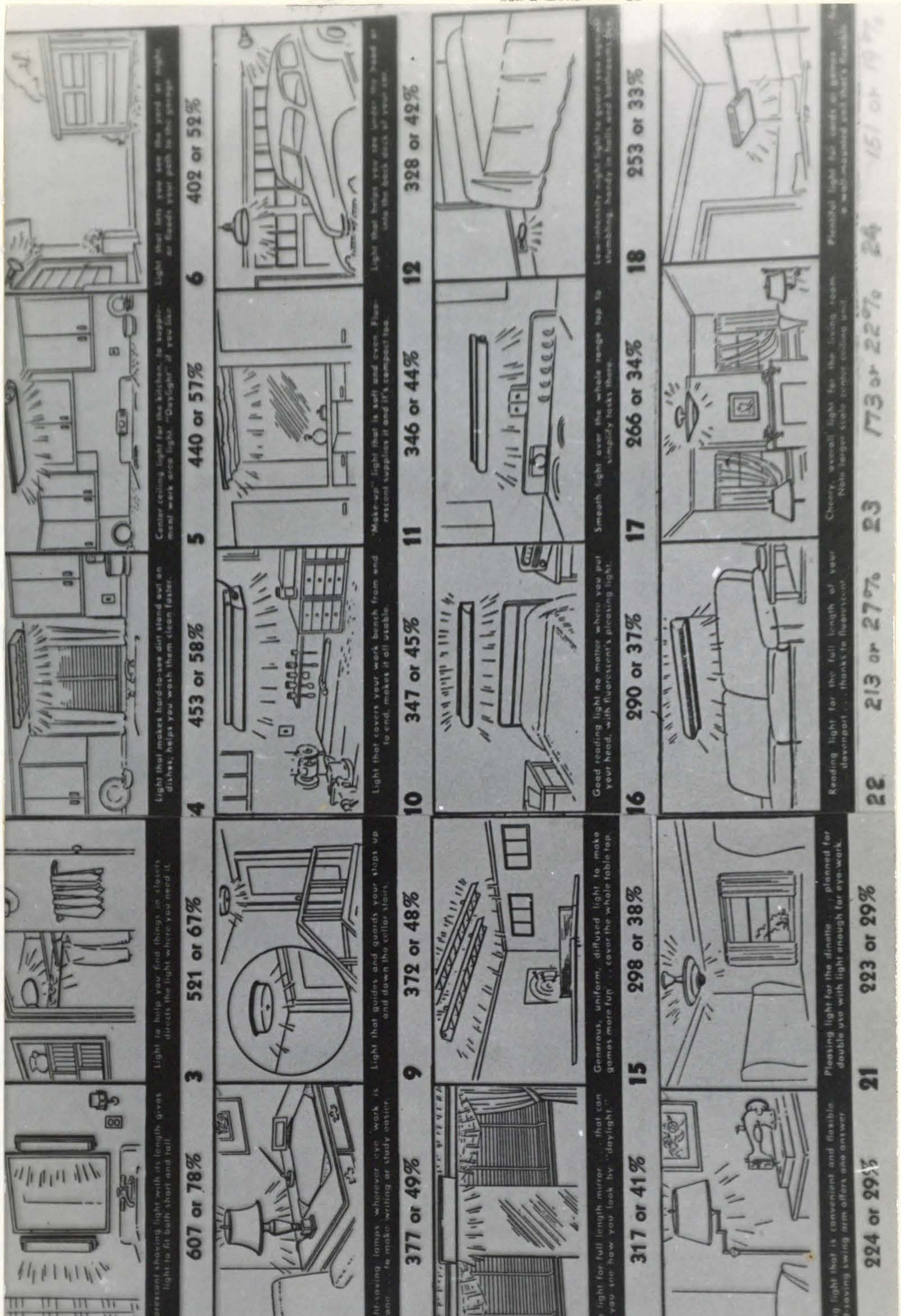
The study made of home lighting for this thesis indicated a tremendous need for study and improvement in this field. In particular there is a great need to bridge the gap between the science of seeing and the psychological and emotional reaction to interior lighting. In other words, it is a problem of creating lighting conditions for optimum seeing comfort and yet preserving the decorative variety of light and shade which is so aesthetically desirable.

At the present time, there is a great need for well designed lighting fixtures for the home. On the basis of the work done in this thesis, it would be easily possible to design several versatile lighting fixture components which could be used separately or in combination to provide wall fixtures, ceiling fixtures, desk lamps, etc. To design such a set of mass produced low priced components would be a definite contribution to modern lighting and architecture. At the present time, fixtures are being omitted in most residences because there are no well designed, low priced fixtures available.

Another valuable contribution to lighting would be the design of additional portable lamps along the lines suggested by this floor lamp design. Detachable wall lamps with flexible arms, desk lamps, bed lamps, bridge lamps, etc., could be developed directly from the components of this floor lamp. Due to lighting economies in the building of low priced homes, portable lamps will always be a basic need.

Further developments should be made with devices like the calibrated indicator for attaining proper illumination on the work surface. Such devices keep the need for good lighting before the public, and hence serve as excellent means of consumer education.

One other possibility worth considering for future research is that of producing illumination by means of phosphorescent room finishes which would be excited by ultra-violet light from indirect sources.



Small Homes Guide Consumer Questionaire
Figure 23

DATA ON INCANDESCENT BOLITE

Bulb	R-40 --- neck white
Watts	200
Volts	115-125
Base	Medium screw
M.O.L.	$6\frac{1}{2}$ inches
Burning Position	Base Down
Life	1000 hours
Average Lumen Output	3000
Special Features	The lamp is coated white on the inside from the base to a point 3/4 of an inch above the maximum diameter.

Brightness:

1. Looking at the filament through the frosted bulb top, 220 candles per square inch.

2. Looking at the inside of the white coating through the bulb top and at an angle of 30 degrees above the horizontal, 30 candles per square inch.

3. Looking at the outside of the lamp and at a right angle to the surface, 5.5 candles per square inch.

4. Looking at the neck of the lamp at a right angle from the surface 3 candles per square inch.

Shade Design:

Any shade which fits within the lines formed by a 40 degree cone with apex at the filament and the 70 degree cone with apex $1\frac{1}{2}$ inches below the filament will give satisfactory results.

For further data on Bolite, see Sylvania Engineering Bulletin E-29.

DATA ON CIRCLINE LAMPS

Lamp watts	20	32
Outside Diameter	8"	12"
Output in lumens	900	1600
Brightness (Ft-L)	2000	2040

DATA ON TULAMP 59G429

Operates one 8" tube and one 12" tube.

Net weight	6.3 lbs.
Watts loss	14
Line current	0.6 amps
Power factor	95
Diameter	8"
Thickness	1 3/8"

For further data on circlines see G.E. Lamp Dept. Bulletin LD 17.

I.E.S. RECOMMENDATIONS FOR PORTABLE LUMINAIRES.

The following section is devoted to a review of the I.E.S. recommendations for portables and how they were derived.

SHIELDING AND BRIGHTNESS

To protect the eye from undue brightness while in any normal location in a room it was necessary first to determine the dimensions of the human figure while in a standing or seated position. A choice of 1.3 times the standard deviation provided that only 10 percent of the individuals would be higher or lower than the limiting positions used.

Zone A (between 68 and 51 inches from the floor) would be occupied by the eye while the subject was standing and free to move about. The eye of a standing person would approach the top of the lamp to within two feet of the shade. Zone B (between 38 and 51 inches from the floor) would be occupied by the eye while the subject was sitting and hence not free to move about. The location of the eye could also be within two feet horizontal distance of the shade, but if this point be chosen at 38 inches, it restricts the amount of light possible from under the shade. Practical considerations set this horizontal distance at four feet for the 38 inch vertical height. An additional plane was taken at 34 inches to allow for a transition from the low shade brightness seen under the shade, to protect children, or to provide a factor of safety for a short woman seated in a slumped position in a low chair.

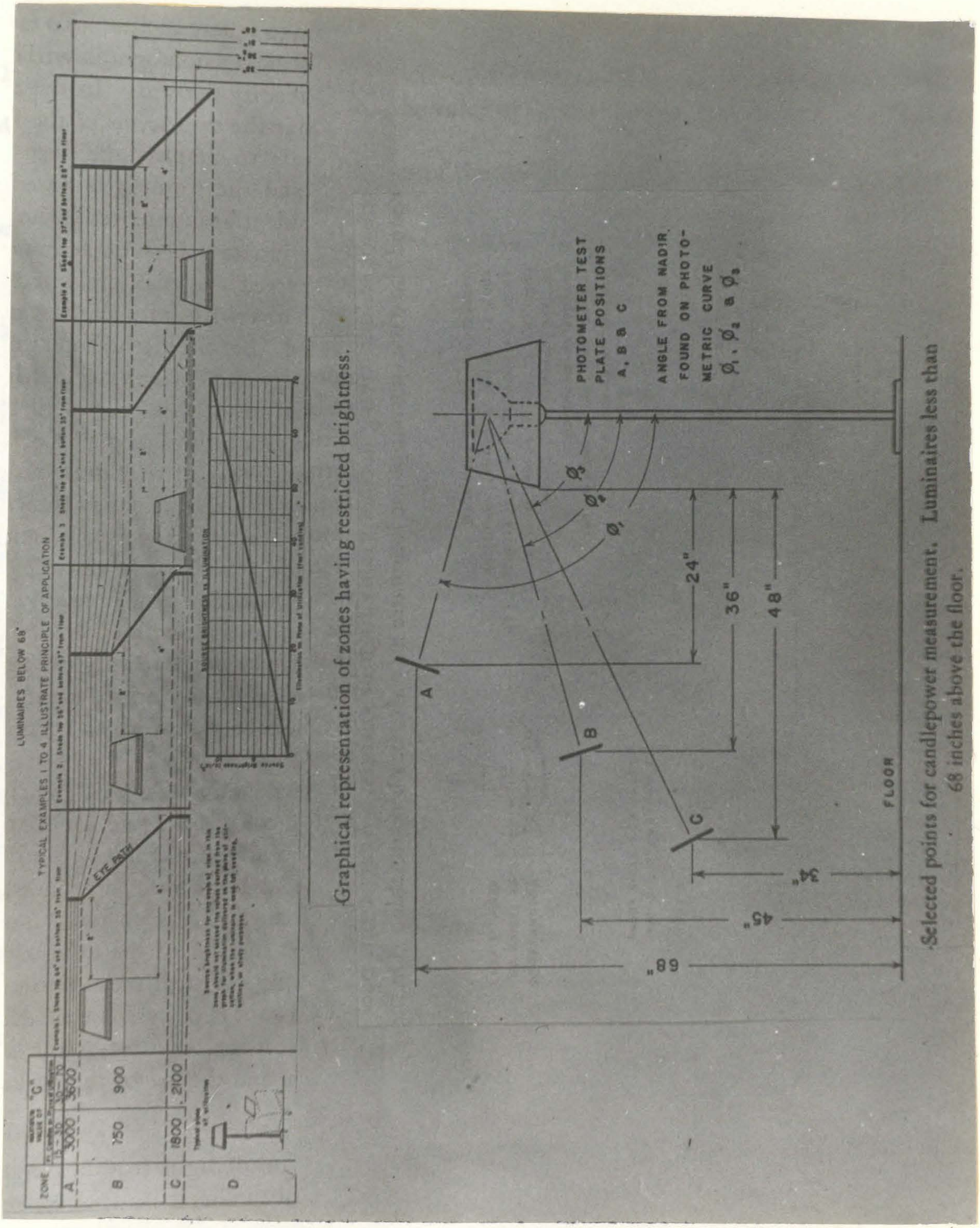
The selected points for test measurements are illustrated in figure 24.

The zonal system for establishing the desirable brightness provides for limiting the flux which will reach the eye of the observer when it is located in certain selected angular positions in relation to the luminaire. This system makes use of a factor which for the purposes of these recommendations is called the direct viewing discomfort brightness limit index, and is expressed as a constant "C". This method is based on an adaptation of the Holladay Formula,[26] in which the committee arbitrarily selected certain values of background or adaptive brightness which were considered representative of the typical condition which might be encountered in home lighting.* Against these selected adaptive conditions the size and brightness of luminous portions of the luminaire are permitted to vary in accordance with the formula:

$$\frac{144\,\pi \times CP_1}{A_1{}^{3/4}} + \frac{144\,\pi \times CP_2}{A_2{}^{3/4}} = C$$

In this formula, A_1 is the sum of the projected areas of those luminous portions of the luminaire which appear approximately uniform in brightness when compared with the luminaire as a whole. A_2 is the sum to all other projected areas of those luminous portions which appear higher in brightness than the base brightness as established for areas included in A_1. CP_1 is the candle power as measured from the established viewing

*The values of background or adaptive brightness selected by the committee are as follows: Portable Luminaires producing 15-30 footcandles--5 ft-L , Producing 30-70 footcandles--10 ft-L.



(Reproduced from pages 531 and 533, Illuminating Engineering, Vol. XLI, No. 7, July, 1946)

FIGURE 24

points for all the areas included in A_1. CP_2 is the candle power as measured from the same viewing points as for CP_1, but including only the candle power from the areas included in A_2. This formula and the values of C recommended in figure 24 apply only to luminaires in which the projected area of the entire luminous portion does not exceed 350 square inches. To facilitate the calculations involved in the use of this formula a nomograph is provided from which values may be readily derived. (see figure 25)

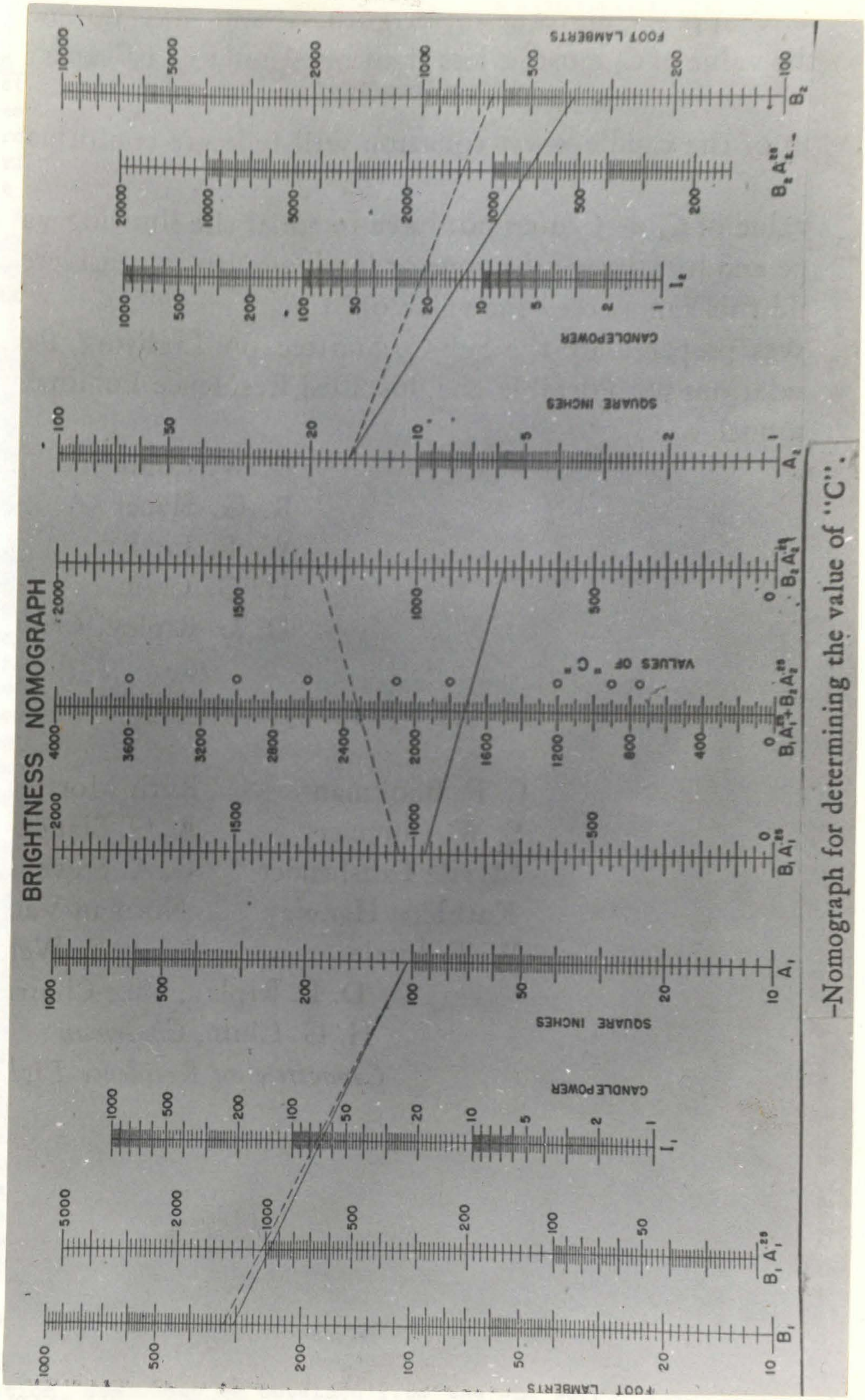
DISTRIBUTION

Recommended Minimum Components of Light Above the Horizontal For General Purpose Portable Luminaires:

Height of Top of Lamp from Floor	Upward Component in percent of Luminaire Output
55" and above	20%
50" to 55"	10%
47" to 50"	5%

EFFICIENCY

General purpose portable lamps with light centers 38 inches or more above the floor, should have efficiencies of 50 per cent or greater.



(Reproduced from page 547, Illuminating Engineering, Vol. XLI, No. 7, July, 1946)

FIGURE 25

C.L.M. SPECIFICATIONS FOR FLOOR LAMPS

"Lighting Service- To provide illumination at large living room chairs, at davenports, at pairs of grouped chairs, etc., for casual reading, including moderate periods of reading small type; ordinary sewing on light goods, writing, and for other similar visual work. General illumination shall also be supplied to assist in providing improved seeing conditions; (a) through reducing the contrast between the book, table, paper or sewing being closely viewed and the areas immediately surrounding the closely-viewed material; (b) to aid in reducing the effect of shine from the glossier papers.

Lighting Performance- (A) An average of 35 footcandles is to be supplied to a reading test-plane 14 inches wide and 12 inches high. (B) less than an average of 15 percent of the footcandles set forth in (A) shall be supplied from the outside of the shade, the ceiling and upper side walls of the room.
A total light output of approximately 3200 lumens or more shall be provided by the complete lamp.

Visual Comfort- To attain satisfactory shielding of the eyes from unpleasant brightnesses, the light source shall be shielded in accordance with the requirements set forth. Control of the brightness of the source is also desirable in minimizing the reduction of the visibility of the print due to reflections of the source into the eye at certain angles of view. Both of these factors relating brightness to discomfort glare and the reduction of visibility call for the control of brightness. The appraisals of brightness control shall be made in the following manner:

By (A) measuring the value of illumination received from the top opening of the shade only at a point 68 inches above the floor and two feet out from the bottom edge of the shade. This value shall not exceed 8 footcandles.

By (B) measuring the value of illumination received from the shade and the lower opening of the shade at a point 45 inches above the floor and three feet out from the edge of the shade. This value shall not exceed 3.5 footcandles.

By (D) measuring the value of illumination obtained from the source of light as seen below the bottom of the shade at an angle (45 degrees) below the horizontal. This value is not to exceed 10 footcandles at 5 feet from the source. The shade is to be removed from the lamp for this part of the test. The projected area of the light source when viewed along this 45 degree line shall not be substantially less than 45 square inches. Reasonable uniformity of brightness of the light source must also obtain when it is viewed along this 45 degree line.

Additional specifications on safety, mechanical and electrical construction, etc. may be obtained from the CLM secretary, 2116 Keith Building, Cleveland 15, Ohio.

VARIOUS DESIGN APPROACHES

THE CONVENTIONAL TYPE

The conventional type as illustrated in figure 26, consists of a light source enclosed by a fabric shade. The brightness being controlled in some designs by means of translucent bowls surrounding the light source.

ADVANTAGES

1. Relatively simple electrically and mechanically.
2. Cheap to manufacture due to use of standard switches, fittings, etc.
3. Provides wide variations of design for sales appeal.

DISADVANTAGES

1. Low level of illumination. Most produce only about 20 footcandles, the maximum being 50 footcandles.
2. Quality of lighting is poor in most cases due to specular reflection or glare from light source.
3. The switches are hard to find and operate.
4. The shades are hard to keep clean.

MODIFIED CONVENTIONAL

The modified conventional lamp is shown in figure 27. This would consist of a trumpet shaped or parabolic shaped spinning, containing a 3-way 300 watt bulb, surrounded by a fiber glass or plastic shade. Beneath the shade would be a 32 and 40 watt circline. The shade would be louvered underneath to prevent glare from the light source and to permit the use of a shallower shade.

ADVANTAGES

1. It would have simple neat appearance and would not be a radical change from present models. Hence, it would be just about right for the present market.
2. It would provide 40 to 60 footcandles depending upon whether a glass bowl or metal spinning were used.
3. The quality of illumination would be better than present lamps because the size of the light source has been increased and its brightness decreased slightly.
4. The flicker characteristic would be eliminated by use of lead and lag ballasts for the two fluorescents.

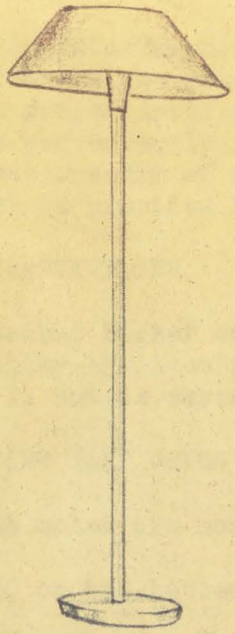


FIG. 26 CONVENTIONAL LAMP

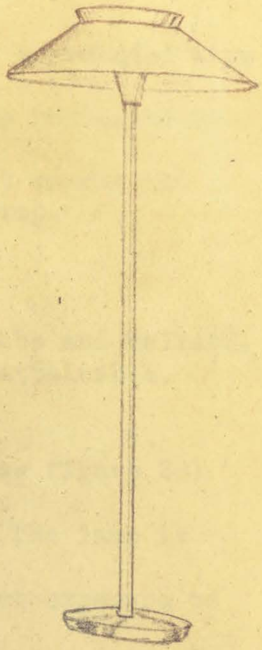


FIG. 27 MODIFIED CONVENTIONAL

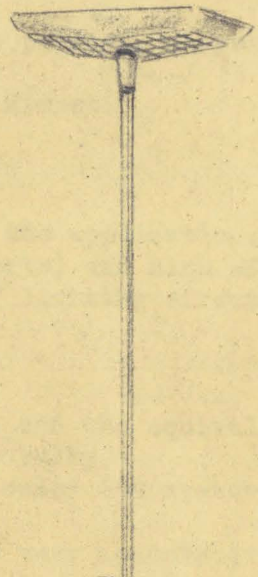


FIG. 28 SQUARE LAMP USING STRAIGHT FLUORESCENTS

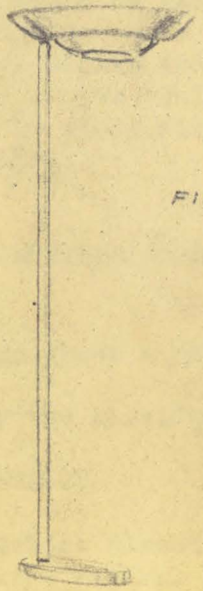


FIG. 29 LAMP WITH MOVABLE SPOT LIGHT

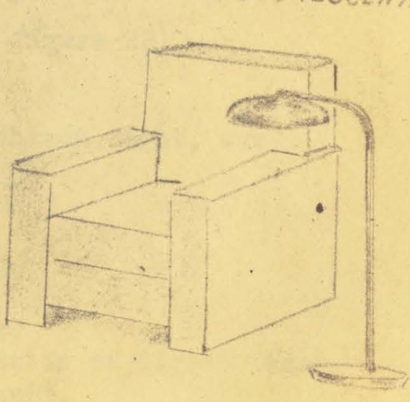


FIG 30 LAMP BELOW EYE LEVEL

5. Radio interference would be minimized by use of a grounded wire screen in the shade.
6. The proper level of illumination to use would be indicated by the conveniently located dial.
7. Great freedom of the relative positions of light source and book is provided by the wide coverage of this lamp.

DISADVANTAGES

1. Somewhat higher cost due to extra fluorescent tube and ballast.
2. Quality of light is very good but not the best attainable.
3. It is not as versatile as might be desired.

THE SQUARE LAMP USING STRAIGHT FLUORESCENT TUBES (see figure 28)

Here the tubes are mounted parallel to each other. The lamp is louvered on the bottom to shield the eyes from direct exposure to the tube brightness. One side provides direct and indirect light, while the other side provides direct.

ADVANTAGES

1. Light source is ideal for the application. It has extremely low brightness (1000 footlamberts) and high efficiency.
2. It provides versatility of lighting effects.

DISADVANTAGES

1. It would require 10 tubes, and the equivalent in ballasts, which would be excessively bulky.
2. It would not have any low color temperature sources, to provide warmth and charm.
3. Square shapes would not be very acceptable in a living room, since it would always have to be orientated with respect to something.

LAMP WITH MOVABLE FLOOD OR SPOT LIGHT (see figure 29)

This design shows a movable spot light for direct light, surrounded by two circlines.

ADVANTAGES

1. It provides directional control of light.
2. Simulates natural sunlight, with combination of direct light and higher color temperature indirect light.

DISADVANTAGES

1. Spot or flood light would be much too bright and much too small in relation to the size of a book. It would cause intolerable specular reflection.

LAMP BELOW EYE LEVEL (see figure 30)

This would consist of a metal reflector containing a circline or a double reflector containing a low wattage incandescent. These would be adjustable by the user so that they would always be below eye level.

ADVANTAGES

1. Low brightness and large size relative to the work surface, with resultant reduction of specular reflection and increase of brightness contrast.
2. High levels of illumination. (100 footcandles or more)
3. Small in size.

DISADVANTAGES

1. Would provide no general illumination.
2. A person would be likely to use it without any other illumination and cause eye strain due to high contrast between work and surroundings.
3. It provides no adjustment for amount of illumination required.
4. The lamp has to be very near the user.
5. It provides no versatility of lighting effects.

LEVEL OF ILLUMINATION

The probable levels of illumination which will be attainable with this lamp have been calculated as follows:

General Illumination:

$$\text{Footcandles} = \frac{\text{Utilization Factor X Maintenance Factor X Lumens}}{\text{Area of room}}$$

$$= \frac{.36 \text{ X } .7 \text{ X } (1600 + 3000)}{12 \text{ X } 12} = \underline{8 \text{ footcandles}}$$

Assume 2/3 is indirect: 2/3x8= 5.3 footcandles

Direct Light from General Lighting Unit

Direct component from Bolite is 70 cp.
Work plane is at a radius of approx. 3 ft.

$$\frac{70}{(3)^2} = 8 \text{ footcandles}$$

1/3 of lumens from 32 watt circline are utilized in an area of radius 3 ft.

1/3 X .7 X 1600 = 370 lumens

$$\frac{370}{\Pi(3)^2} = 13 \text{ footcandles}$$

Direct component = 8 + 13 = 21 footcandles

Total light on reading plane from general unit = 21 + 5 = 26 ft-c.

Distribution: 19% indirect, 81% direct

Light from Reading Unit

20 watt circline output = 900 lumens
Assume reflector efficiency of 50%

$$\text{Reflected light} = \frac{.50 \text{ X } .7 \text{ X } 900}{2} = 158 \text{ l.}$$

$$\text{Direct light} = \frac{.7 \text{ X } 900}{2} = \ldots\ldots\ldots \underline{315 \text{ l.}}$$

Total = 473 lumens

With lamp below eye level and center of reflector a distance of 18 inches from book, light covers approx. a circle of radius 18 inches.

$$\frac{437}{\Pi(1.5)^2} = 67 \text{ footcandles}$$

With both general and reading lamp on a total of 67 + 21 + 5 = 93 ≈ 100 footcandles are produced.
distribution 5% indirect 95% direct.

SHIELDING AND BRIGHTNESS CALCULATIONS

The worst brightness problem exists when reading lamp is in the up position (approx. 3.5 to 4 feet from the floor).

Assume:
- a. louvers have completely diffusing finish and reflectance of .6
- b. Due to angle of incidence and loss due to diffusion, the average brightness reflected by the louvers will be .3 times the brightness of the source for point B and .5 for point C.

General lighting unit

Average source brightness = 2000 Ft-L

Average brightness of louvers:
.7 X .6 X .3 X 2000 = 255 Ft-L for point B

.7 X .6 X .5 X 2000 = 430 Ft-L for point C

Approx. projected areas have been determined as:

36 sq. in. from point B
60 sq. in. from point C
30 sq. in. from point A

Reading Lamp

Brightness of circline = 2000 Ft-L.
Area of reflector = 110 sq. inches.
Approx. $\frac{1}{4}$ of louver area will be subjected to direct source brightness.

.6 X .3 X .7 X 2000 = 255 Ft-L for point B

.6 X .5 X .7 X 2000 = 430 Ft-L for point C

Average brightness will depend on reflector brightness. Assume reflectance of .7

$$.7 \times .7 \times 2000 \times \frac{144}{110} = 1280 \text{ Ft-L}$$

.6 X .3 X 1280 = 230 .6 X .5 X 1280 = 380

Average brightness of louvers:

$\frac{1}{4}$ X 255 + 3/4 X 230 = 63 + 173 = 236 point B

$\frac{1}{4}$ X 430 + 3/4 X 380 = 107 + 286 = 393 point C

Projected area of lower louvers:

10 sq. in. point B, 15 sq. in. point C.

For determining values of C from nomograph (appendix C), brightness of general unit and reading unit were averaged.

Av. brightness from pt. A $= 1500$ ft-L

Av. brightness from pt. B $= \frac{10}{46} \times 236 + \frac{36}{46} \times 255 = 251$ Ft-L

Av. brightness from pt. C $= \frac{15}{75} \times 393 + \frac{60}{75} \times 430 = 423$ Ft-L

Values of C were determined from nomograph (appendix C)

POINT	BRIGHTNESS	CALCULATED C	PERMISSIBLE C
A	1500 Ft-L	3200	3600
B	250 Ft-L	800	900
C	423 Ft-L	1300	2100

Hence brightnesses are within limits established by the I.E.S.

Due to initial assumptions made, brightness values represent only an order of magnitude.

WEIGHT AND STABILITY CALCULATIONS

PART	WEIGHT
READING LAMP REFLECTOR	11.5 OZ
$8\frac{1}{4}$" CIRCLINE	7.5
CHANNEL LAMP HOLDER	8.0
STARTER AND SOCKET	1.0
SWIVEL HEAD ASSEMBLY	5.0
TOTAL WT. OF READING LAMP ASSEMBLY	32.0 OZ
FLEX ARM AND TUBE	8.0 OZ = .5#
UPPER REFLECTOR AND LOUVER ASSEMBLY	1#9.0 OZ
BOLITE	4.5
12" CIRCLINE	11.5
CIRCLINE HOLDERS	.5
SOCKET	2.5
STARTER	1.0
CASTING	10.0
TOTAL WT. OF UPPER UNIT	1# 39 OZ= 3.4#
MAIN COLUMN	1.0#
TRANSITION CASTING	0.1
TOTAL WT. OF COLUMN	1.1#
BASE	3.5#
BALLAST	6.5#
TOTAL WT. OF BASE UNIT	10.0#
TOTAL WEIGHT OF LAMP	17.0#

DETERMINATION OF CENTROID (see figure 31 for diagram showing distribution of weight)

$$\bar{y} = \frac{+3.5x62 + .97x28 + .1x43 + .5x45 + 2x40 + 10x1}{17} = \frac{361}{17} = 21.3''$$

$$\bar{x} = \frac{-3.5x5 + .5x9 + 2x18}{17} = \frac{23}{17} = 1.41''$$

Therefore the lamp may be tipped through an angle $\theta = \tan^{-1}\frac{(6-1.4)}{(21.3)} = \tan^{-1} .216 = 12^{o}$ before an unstable condition is reached. (see figure 31)

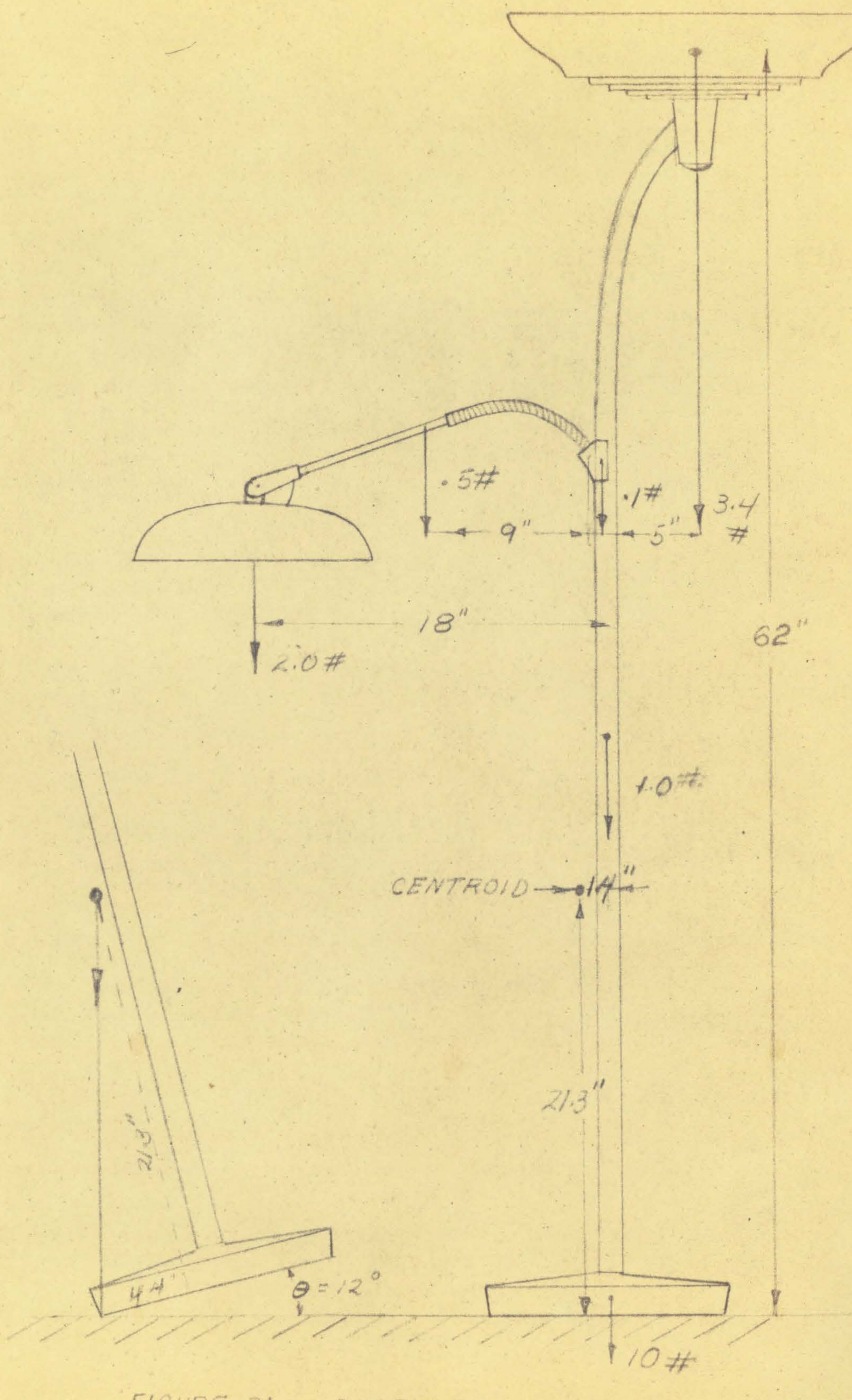


FIGURE 31. DISTRIBUTION OF WEIGHT

APPENDIX I

COST ANALYSIS

DIRECT MATERIAL (low production model)

	Wt.(#)	Cost/#	No.	Cost
A. Spinnings, 14 ga 2S-0 Al.	1.2	$.375	1	$.450
B. Strip for louvers, .020"x1" strip $l = \pi(12 + 10 + 8 + 6 + 4) = 126$ $wt = lwtd = 126 x 1 x .020 x .1 =$	0.25	.375	1	.095
C. Tubing 1 1/8" dia., .049" thick $wt = t\pi Dlr = .049\pi x 1.125 x 56 x .1 =$	0.97	.460	1	.445
$\frac{1}{2}$" dia., .049" thick, 61 ST Al. $wt = t\pi Dlr = .049\pi .5 x 10 x .1 =$	0.08	.500	1	.004
D. Casting for socket housing $wt = t\pi Dlr = (\frac{5}{32} x \pi x 2.12 x 5 x 1) + (\frac{5}{32} x \pi x .2)$ $= .52 + .98 =$	0.62	.400	1	.248
E. Transition Casting, 1cu "	0.10	.400	1	.040
F. Base Casting 3/16" wall thickness $wt = \pi r^2 td + \pi DtHd = \pi 8^2 \frac{x3}{16} x .1 + \pi 12 \frac{x3}{16}$ $x 2 x .1 = 2.1 + 1.4 =$	3.50	.400	1	1.40
G. Louver Spacers .100" 24 ST 7sq" ea. $wt = Atd = .7 x .1 x .1 =$	0.70	.350	1	.147
H. Lucite Dial				.500
				$3.329
I. Flex Tubing, 8", 3/4" dia., ·23x8/12=.1.53		$.230/ft	1	.153
J. Swivel Fitting			1	.620
K. AF Fixture Wire no. 16, 14'@$.017/ft				.244
L. Wall Plug			1	.070
M. Flamenol covered fixture wire, no. 18, 14'@$.012/ft				.168
Rubber covered cord no. 14 stranded, 10' @$.o19/ft				.190
N. Canopy Switch (single)			1.	.240
Canopy Switch (two circuit selector)			1	.290
O. Porcelain Socket			1	.220

COST ANALYSIS (Con't)

	No.	Cost
P. 95X840 lampholders	2	.360
Q. 95X840 lampholder	1	.440
R. 59G429 ballast	1	3.100
S. 12" circline	1	1.160
T. $8\frac{1}{4}$" circline	1	1.100
U. Bolite	1	.830
V. Starter sockets	2	.230
W. FS-12	1	.240
X. FS-2	1	.190
Y. 95X798 channel type lamp holder	1	.820
Z. 25F980 radio interference capasitor	1	.480
		$10.915
		3.329
TOTAL DIRECT MATERIAL ...		$14.244

DIRECT LABOR

	time	price/min.	cost
A. Spinning	10	$.040	.400
B. Cut and bend tubing	2	.025	.050
C. Cut and spot weld louvers	2	.025	.050
D. Polish castings	3	.025	.075
E. Stamp louver spacers	4	.025	.010
F. Drill and tap castings	3	.025	.075
G. Wiring and Assembly	90	.025	2.250
H. Msc	10	.025	.250
I. Spray painting	10	.025	.250
DIRECT LABOR			$ 3.390
DIRECT MATERIAL			14.244
PRIME COST			$17.63
BURDEN (50%DL)			$1.69
			19.32

COST ANALYSIS (con't)

	19.32
Die costs :	
Spinning Die $200	
Louver spacer Die $100	
Jigs for tapping etc. $200	
Total ......$500 amortized over 2000	
Production run	.25
MANUFACTURING COST	19.57
ADMINISTRATIVE EXPENSES	1.96 (10% MC)
SELLING COST..................................	$21.53
MARGIN OF PROFIT (assume 66%)	14.00
WHOLESALE PRICE	35.53
RETAIL MARK-UP (assume 66%)	23.60
RETAIL PRICE	$59.13 or $60.00

DIRECT MATERIAL (high production model)

	WT(#)	Price/#	Cost
A. Spinnings, 26 ga hot rolled steel 24" dia. .750#/sq ft. $\pi(1)^2$x .750 = ...	2.36	.130	.307
B. Strip for louvers, cold rolled steel, 26 ga 1" wide 126 sq in. 126/144x.750	.65	.060	.039
C. Tubing 1 1/8" dia. cold drawn seamless 22 ga.328 #/ft x $\frac{.56}{.2}$ = ...	1.53	.173	.264
D. Tubing ½" 24 ga .112#/ft		.140	.016
E. Castings, Zamac no. 5 alloy socket casting 2.4x.1x.62x,13		.130	.192
F. Transition casting, 2.4x.1x.13		.130	.031
G. Base, 2.4x3.5x.13 = 1.09		.130	1.092
H. Lucite dial			.500
			$ 2.441
Total of prefabricated parts.......			$10.915
Direct material....................			$13.356

COST ANALYSIS (cont)

DIRECT LABOR (high production model)

	time	price/min	Cost
A. Spinning	10	.040	.400
B. Cut and bend tubing	2	.025	.050
C. Cut and spot weld louvers	2	.025	.050
D. Stamp louver spacers	.4	.025	. 010
E. Wiring and assembly	50	.025	1.250
F. Msc	5	.025	.125
G. Spray painting	5	.025	.125

Direct Labor	$ 1.610
Direct Material	13.356
Prime Cost	14.966
Burden 100% of Direct Labor	1.610
Tooling Costs $10,000 amortized over 20,000 production	.50
	17.08
Administrative costs	1.71
Selling cost	$18.79
Margin of profit (assume 50%)	9.39
	$28.18
Retail Mark-up (assume 50%)	14.09
Retail price	$42.27 or $42.50

GLOSSARY

The <u>LUMEN</u> is the flux (time rate of flow of light energy) emitted through a unit solid angle from a point source of one candle.

The <u>FOOTCANDLE</u> is the illumination on a surface, one square foot in area, on which is uniformly distributed a flux of one lumen.

The <u>FOOTLAMBERT</u> is the unit of brightness equal to the average brightness of any surface emitting or reflecting one lumen per square foot.

The <u>REFLECTANCE</u> is the ratio of the light reflected by the body to the incident light.

The <u>COLOR TEMPERATURE</u> (in a popular sense) refers to the degree of whiteness of a light source. It is obtained by comparing the color with that of a standard laboratory radiator heated to the proper temperature to give the same color light.

<u>DIOPTERS</u> express the power of a lens as the reciprocal of the focal length in meters.

<u>COEFFICIENT OF UTILIZATION:</u> the total flux received by the reference plane divided by the total flux from the lamps illuminating it.

<u>LUMINOUS INTENSITY</u> is the solid angular luminous flux density in the direction in question. It equals the quotient of the flux on an element of surface by the angle subtended by the element when it is viewed from the source.

The <u>CANDLE</u> is the unit of luminous intensity.

<u>BRIGHTNESS</u> is the luminous intensity of any surface in a given direction per unit of projected area of the surface viewed from that direction.

REFERENCES

1. Wickstrum, B. K. The Dealer's Expanding Stake in Today's Lighting Market, Electrical Merchandising (Jan. 47) P. 48

2. Armstrong, R. W. The Dealer's Year in Lighting. Electrical Merchandising, (Jan. 48) P. 52

3. Armstrong, R. W. The Dealer's Year in Lighting. Electrical Merchandising, (Jan. 48) P. 53

4. Armstrong, R. W. The Dealer's Year in Lighting. Electrical Merchandising, (Jan. 48) P. 104

5. Wickstrum, B. K. The Dealer's Expanding Stake in Today's Lighting Market, Electrical Merchandising, (Jan. 47) P. 49

6. Armstrong, R. W. The Dealer's Year in Lighting, Electrical Merchandising, (Jan. 48) P. 54

7. Lippincott, G. J. Design For Business. P. 84

8. Lippincott, G. J. Design For Business. P. 85

9. Magazine of Light, No. 5 (43), P. 24

10. Commery, E. W., Studies of Illumination and Brightness In Residential Interiors, Illumination Engineering, (Jan. 47) P. 87

11. Nowland, Lighting Horizons, 111. Eng., (Feb. 45) P. 116

12. Luckiesh, M. and Moss, F., The Science of Seeing, (37) P. 342

13. Kraehenbuehl, J., Electrical Illumination. (42) P. 56

14. Kraehenbuehl, J., Electrical Illumination. (42) P. 47

15. Luckiesh, M. and Moss, F., The Science of Seeing. (37) P. 354

16. Recommended Practice of Home Lighting, 111 Eng. (June 45) P. 339

17. Commery, E. W., Studies of Illumination and Brightness in Residential Interiors, 111 Eng. (Jan. 47) P. 85

18. Commery, E. W., Studies of Illumination and Brightness in Residential Interiors, 111 Eng. (Jan. 47) P. 88

19. Kraehenbuehl, J., Electrical Illumination, (42) P. 50

20. Luckiesh, M. and Moss, F., The Science of Seeing, (37) P. 310

21. Commery, E. W., Studies of Illumination and Brightness in Residential Interiors, 111. Eng. (Jan. 47) P. 89

22. Buck, G. G. and Froelick, H. C., Color Characteristics of Human Complexions, 111. Eng. (Jan. 48) P. 27

REFERENCES CONT.

23. Shorey, L. F. and Gray, S. M., A Preliminary Study of Radio Interference as Caused by Fluorescent Lamps in the Home. Ill. Eng. (Mar. 47) P. 305

24. Lighting Performance Recommendation for Portable and Installed Residence Luminaires. Ill. Eng. (July 46), P. 521.

25. Ripley, D. L. Basis for the Selection of Values used in the Lighting Performance Recommendations for Portable and Installed Luminaires, Ill. Eng., (May 47), P. 563

26. Holladay, L. L., The Fundamentals of Glare and Visibility, Journal of the Optical Society of America. (1926) Bul. 12, P. 288

27. I.E.S. Lighting Handbook. (47) P. 3-6, 3-7.