THE DESIGN OF A COMBINATION PROJECTOR AND VIEWER FOR USE WITH COLORED TRANSPARENCIES

T H E S I S B Y J A M E S M C I N T O S H

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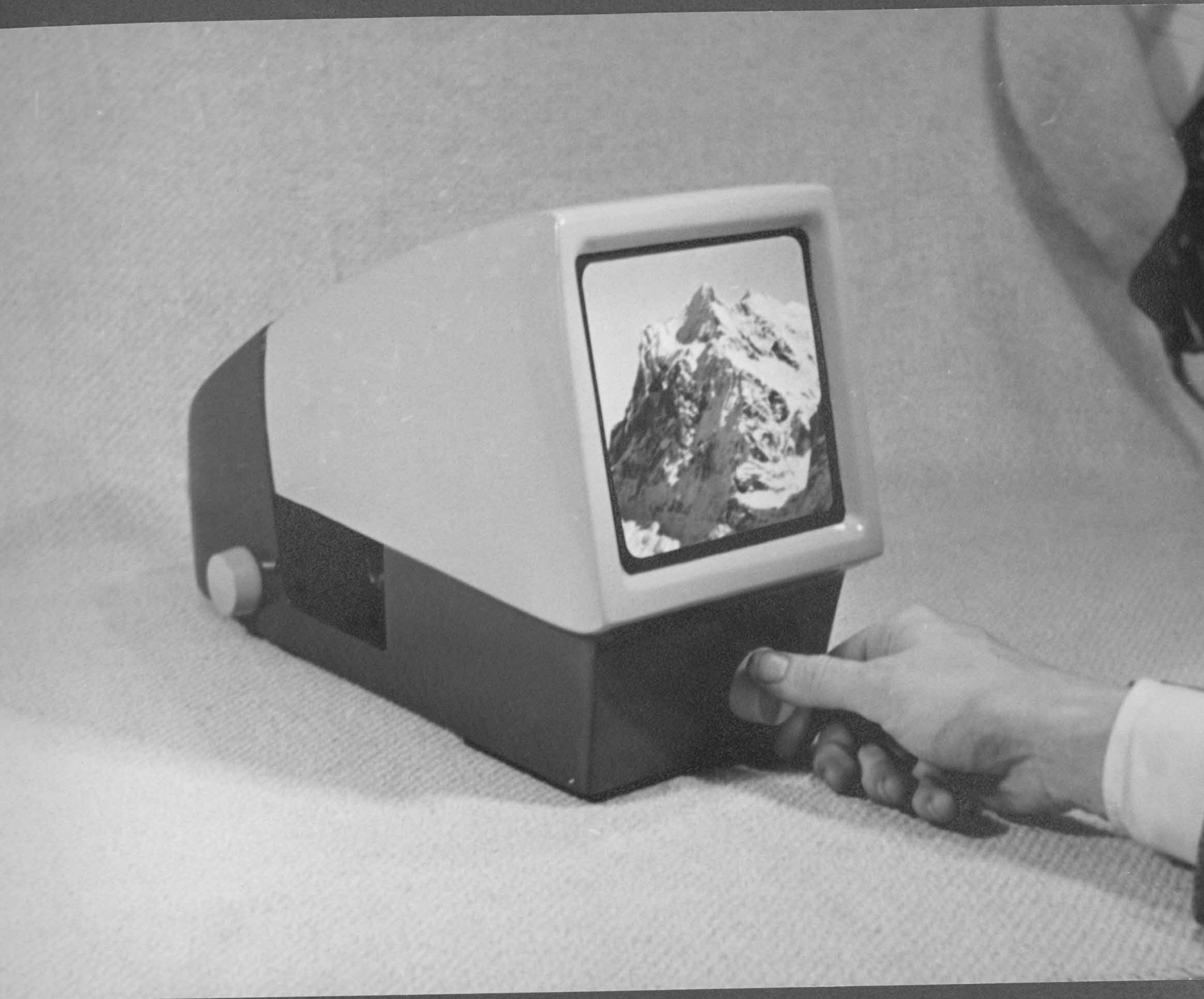

ABSTRACT

A study of the photographic field has revealed a need for a more versatile method of viewing still color transparencies of 35 millimeter and similar size.

The conditions of the market, the consumer preferences, and the sales procedures concerning photographic goods were investigated. The results of these investigations established the criteria upon which the final design was based.

The engineering and appearance design of a machine utilizing one optical system for both projecting and viewing the transparencies has been completed and is herein presented.

The device is fundamentally a complete projector with the addition of a viewing screen built into the upper case. The optical system projects the picture into a pair of mirrors that turn the light beam up and back onto the viewing screen. For distant projection, the lower mirror drops out of position and permits the picture to be projected through an opening located in the rear of the machine.

The optical, electrical, and slide changing systems are housed in a two piece anodized aluminum die cast case.

A C K N O W L E D G M E N T S

The author wishes to express his appreciation for the inspiration, guidance, and criticism received from the faculty of the Industrial Design Section and from the members of his examining committee: Mr. David Welch, Dean Franklin Thomas, and Mr. Salvatore Merendino.

Further thanks are due to the many manufacturers and dealers who have given so freely of their time and wide knowledge as well as to the other graduate students of the Industrial Design Section for their valuable criticism.

Then last, but by far not least, great appreciation is due to a very understanding and helpful wife.

T A B L E O F C O N T E N T S

T A B L E   O F   C O N T E N T S

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L I S T O F I L L U S T R A T I O N S

INTRODUCTION TO THE PROBLEM

With the war over, photography as a hobby has risen to heights never before expected. This phenomenal increase is in great part due to the widespread use of color film. The sales of colored film have reached such proportions today that many manufacturers and dealers have found that while their overall photographic sales have continued to rise, there has been a definite reduction in the sales of all equipment having solely to do with conventional black and white photography.*

Today the photographer has a choice of two types of colored film; the colored transparency and the colored positive print. The first type is the most popular at present. The biggest reason for this is the greater accuracy and beauty of its color as contrasted to the poorer, fuzzier color in the positive prints. There are certain definite disadvantages, however, that go with color transparencies. The biggest lies in the difficulty of properly observing the pictures. For almost all amateur work, the color transparencies are on 35 millimeter or similiar size film. This leaves one with a picture of little more than one square inch in size, which is far too small to be comfortably viewed. These color transparencies must therefore be enlarged and they must also be back lighted to give them the brilliancy necessary for viewing.

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* Reference: Interview with M. H. Sieman, Chief Buyer Photographic Goods, Broadway Department Stores Inc., Los Angeles, Calif.

This problem of illuminating and enlarging the pictures for suitable observation may be, and has been, overcome successfully in four different ways. The first is by the projection, with a lamp and optical system, of the picture upon an opaque surface. The picture is then viewed upon this screen in a darkened room. The second is by projection of the picture, with a similiar optical system, upon a nearby translucent screen. With a properly constructed screen, this viewing may be done in a well lighted room. The third procedure consists of viewing the transparency through a magnifying lens with the light projected through the transparency from a built in electric lamp. In the fourth method the transparency is viewed through a magnifying lens while the combination is aimed at a distant light source for illumination.

Of the above systems the first two are the most satisfactory and although they are the best available, they do not completely answer the problem by themselves. A combination of the two could be a much better solution. The design presented herein proposes just such a combination. That is, a combination of the two best methods of viewing the transparencies, adapted so that the inherent advantages of each system are enhanced by the advantages of the other system. Today there is no one device on the market that permits one to either project the transparencies in a darkened room or to project them upon an enclosed screen for viewing in a well lighted room. This combination further permits the use of one relatively expensive optical system for two separate uses, i.e., viewing and projecting.

The design has been developed after due consideration of the problems arising from the manufacture and the sales of the apparatus. Various optical systems have been studied to determine the best system for this application, considering the accuracy demanded, the use, and the cost. Various materials and methods of manufacture have been considered, until the materials and methods of manufacture deemed consistant with the cost and use of the device, have been arrived at. The methods of sales and distribution have been studied along with consumer desires. The results of these studies played an important part in the development of the design.

THE MARKET

THE CONSUMER

The ViewAll* has been designed primarily for the amateur photographer market. This market is potentially large and today is not covered by any device similar to the ViewAll.

It must be further remembered that the ViewAll is, and will remain, to the amateur photographer purely a luxury item. This factor will influence the sales of the device in two basic ways.

1. Its sales will be directly dependent upon the state of the business cycle or more specifically dependent upon that part of the national personal income considered available as disposable income.
2. As a luxury item, the ViewAll will be in direct competition with all other luxury items, not just in competition with other projectors and viewers.

Both these factors indicate the necessity for keeping the tooling and manufacturing costs as low as possible while still maintaining a luxurious product. Still more important, these factors indicate the necessity for a well planned aggressive advertising program.

The ViewAll would have many valuable uses other than that of

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* Suggested trade name of unit.

supplying the photographic enthusiast with a new means of enjoying his colored transparencies. Its other two greatest uses would lie in the fields of sales and of education.

Its use as a sales aid could be taken advantage of in the field as well as in the office. The compact size of the ViewAll plus the fact that it may be operated in a well lighted room as well as in a darkened one greatly increases its utility here. It will now be possible for the salesman to present full color pictures of his merchandise rather than bulky samples or ineffective black and white photographs. This will be of great advantage to a salesman of capital equipment and to the man selling a service such as a Travel Agency, an Architect, or an Industrial Designer.

The use of the ViewAll as a visual education aide would be unlimited. These educational uses could vary from the school room to the employee education program in industry.

Aside from presenting the instructor with a means of presenting extremely vivid and life-like illustrations, the ViewAll has the added advantage of catering, in the size of its formed image, to small as well as to large groups.

DISTRIBUTION CHANNELS

Photographic goods are distributed in two general patterns. They are:

1. From the manufacturer to large wholesale houses. The wholesale houses then distribute the merchandise to the individual dealers.
2. Directly from the manufacturer to a local warehouse and from there to the local dealers.

In all cases distribution is nation-wide and the equipment is shipped assembled from the manufacturer's factory to the various sales outlets. This indicates the desirability of the following:

1. The unit must be as small and light as manufacture will permit, to prevent the shipping charges from becoming too great a part of the selling price.
2. The unit must be extremely strong and durable to withstand the shipping and handling that it will be subject to.

In over 90 per cent of the dealer outlets visited in Los Angeles and vicinity, it was found that the dealers carried competing equipment of more than one manufacture on their shelves. The only exception proved to be the exclusive Kodak dealership in Los Angeles.

This leads one to the conclusion that in the sales of projectors and like equipment, the opinions of the dealers concerning the equipment is of prime importance. A survey of these dealer opinions have formed the basis of the market analysis for the ViewAll.

COMPETITION

Today while there is no single device on the market that combines the functions of the projector and the viewer, there are excellent examples of each of the other four types of projectors and viewers. These vary in price from less than a dollar for the simple magnifier type up to several hundred dollars for the best projectors.* The sales of projectors indicate that they present by far the most popular method of observing the color transparencies.

The projectors themselves vary in price from twenty dollars to two hundred dollars. The smaller ones are suitable only for short projection throws, while the more expensive models may be used for the long throws necessary in auditorium use. The excellence of the optical system as well as the strength of the projection lamp increases directly with the cost of the projector. By far the greatest number of sales are made in the price range from thirty-five dollars to fifty dollars. In general, projectors in this price range use Astigmatic lenses of about 4 inches effective focal length and use either 100 or 150 watt projection lamps.*

Since there is no comparable product on the market today, it will be necessary in studying the buying habits of the consum-

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* See Appendix B.

ers, to study either the sales of projectors or of the viewers. In as much as there is only one viewer on the market today that utilizes a projection-type optical system and since this unit has been in the stores only six or seven months, it will not be too helpful to base the market analysis upon the sales of this Kodak Table Top Viewer. It will be more advantageous to look into the sales of the several projectors that have been available for a longer period.

RESULTS OF THE MARKET SURVEY

Interviews with over twenty-five photographic dealers in the Los Angeles vicinity revealed the following important information regarding the sales of projectors:

1. The greatest number of projectors sold fell into the price range from thirty-five dollars to fifty dollars.
   a. Most dealers considered the price of the present projection-type viewer to be too high for the amateur photographer market.
   b. They did not consider the price of this viewer to be too high for the professional market.
2. All believed that the customers would be willing to pay from fifteen to twenty dollars more for a combination projector and viewer than they would be willing to pay for a projector of equal quality.
3. The brand name of the manufacturer was the most important factor in the customer's initial impression of a projector. This influenced, but did not make the final sale.
4. The most important sales point was the clarity and sharpness of the image.
   a. This image clarity was much more important than other sales points such as; appearance, ease of operation, and ease of maintenance.

These same interviews further revealed the following factors which influence the design of projectors and similiar equipment:

1. The device must have the appearence of being a piece of precision machinery.
2. Almost all dealers and users stated their preference or desire for an automatic or semi-automatic slide changing feature.
    a. Most expressed dissatisfaction with the automatic slide changers now on the market.
3. The market shows a very definite material preference for die cast metals.
    a. Sheet metal construction is associated with cheapness.
    b. Plastic cases are not considered strong or durable enough.
4. There was no definite color preference expressed as long as the color is dark and subdued.
    a. The use of black for the cases is declining today in favor of greys and greyed down tones of other dark colors.

CONCLUSIONS

The ViewAll has been designed for sale to the amateur photographer. The secondary market in the fields of sales and education have been considered and should be exploited.

The selling price should be kept in the range of 60 dollars to 80 dollars for the maximum number of sales.

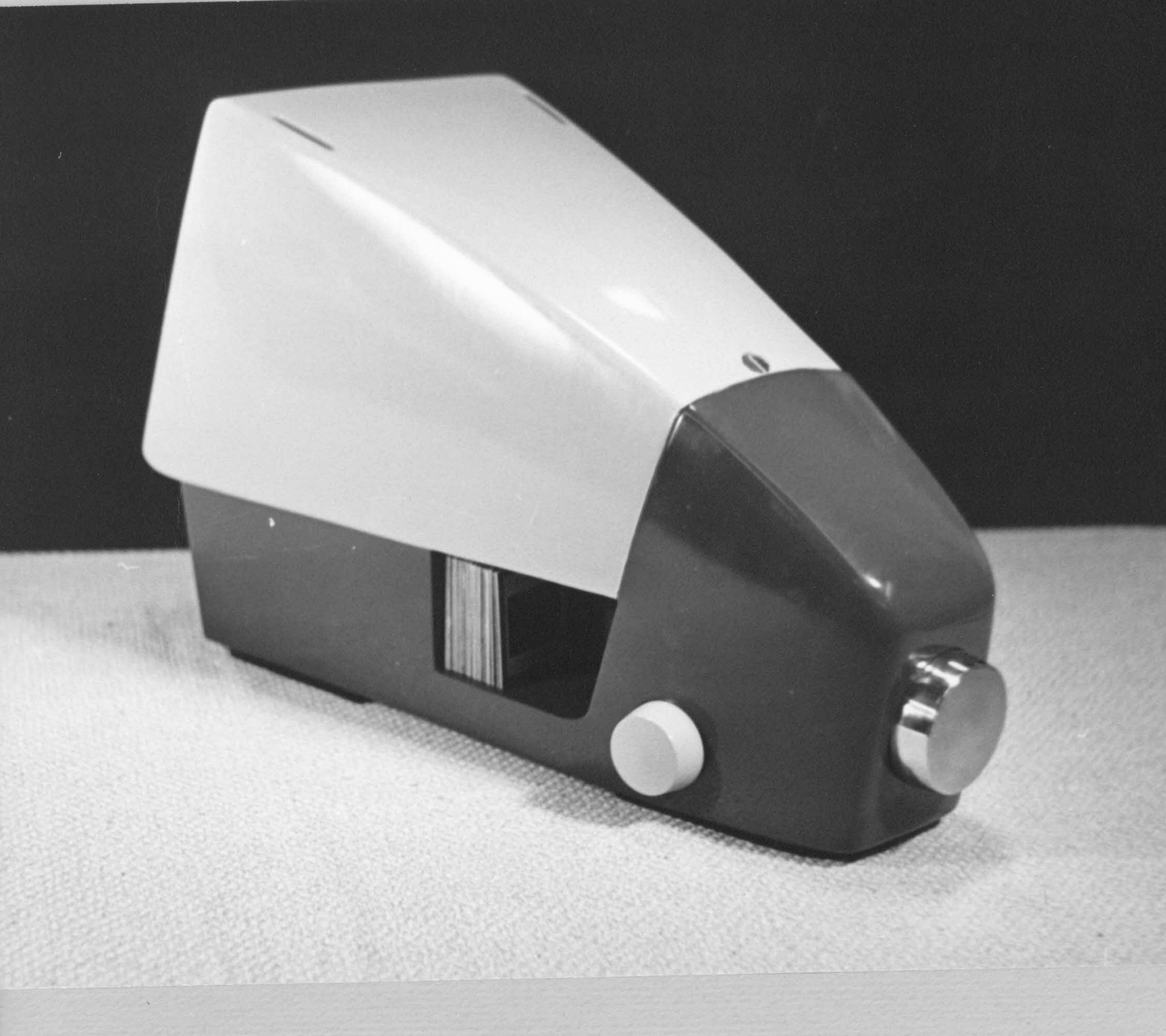

FIGURE 1

THE DESIGN

DESIGN SUMMARY

The ViewAll, as finally designed consists of a two piece housing made of die cast aluminum. The case has been anodized to give it a lasting deep color finish. The colors dark grey-blue and grey with red and chromium trim were chosen with care so as to be appealing to the consumer and yet remain unobtrusive. The screen is made of ground glass backed with a light concentrating acrylic screen. There are three control knobs located on the ViewAll. The right-hand knob is for focusing the optical system. The left-hand knob is used to raise and lower the mirror when changing from using the ViewAll as a projector to using it as a Viewer. The third knob, located under the viewing screen, is used in operating the slide changing mechanism. See figure 1 on opposite page.

OPTICAL SYSTEM OF VIEWALL

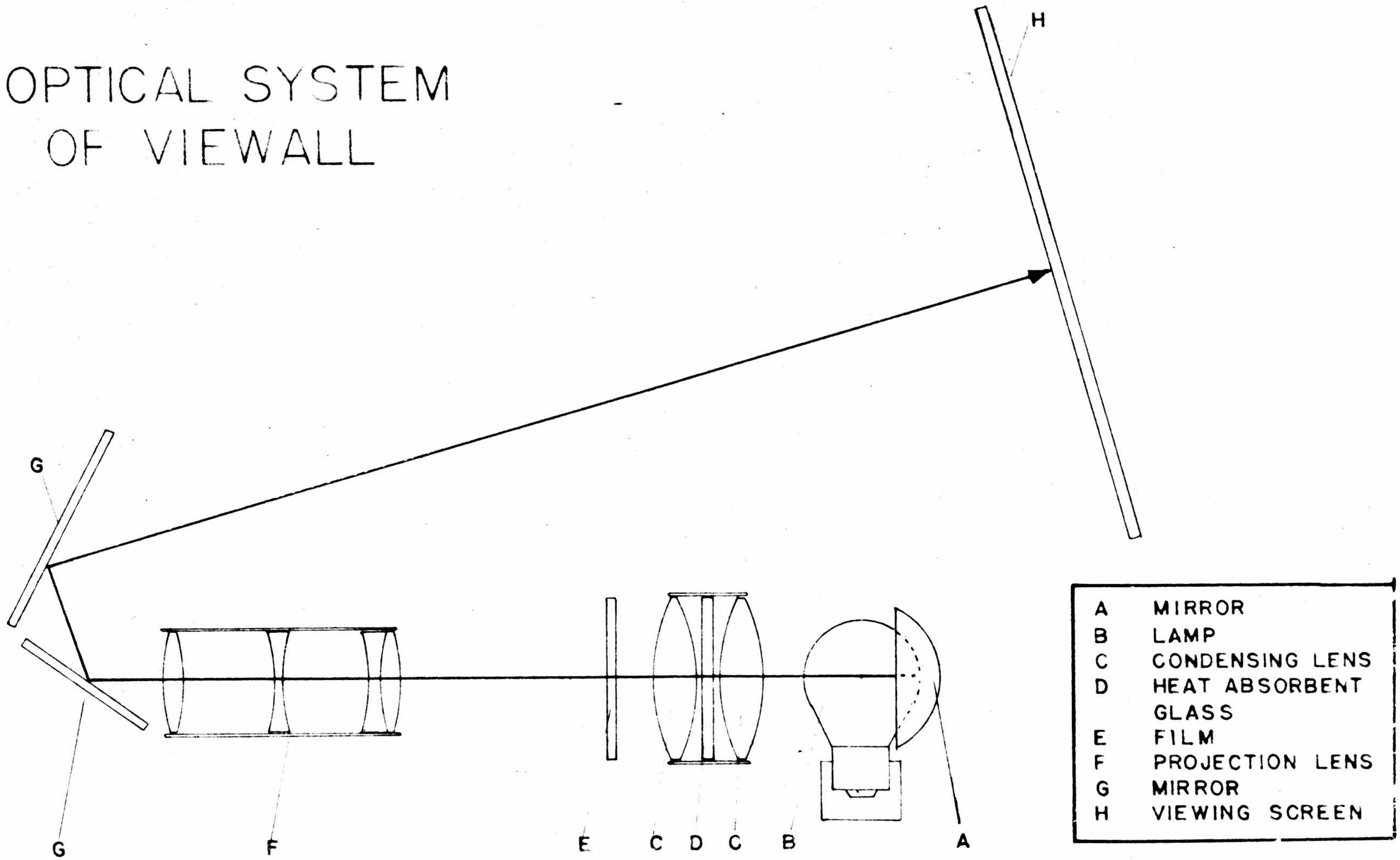

FIGURE 2

MCINTOSH

THE BASIC OPTICAL SYSTEM

The ViewAll is fundamentally a complete projector with the addition of a viewing screen located a small distance in front of the projection lenses. This viewing screen is translucent so that the projected image can be viewed from the side opposite the projector. Connecting the screen and the optical system is an enclosed lightway which serves to keep outside light from falling on the back of the screen and thus reducing the intensity of the projected image.

The design problem of keeping the final unit as small as possible is of the first importance. Its difficulty is easily seen when the size of the basic projector (9 inches by 5 inches by 4 inches) and the distance from the lenses to the screen (over 8 inches) are considered.

To solve this size problem, the ViewAll was designed with the screen located directly above the optical system. See figure 2. When using the ViewAll as a viewer, the image is projected upon a pair of mirrors which turn the beam of light back upon itself and up to the viewing screen. The chimney serves to keep the light from the bulb from falling directly upon the screen. When using the ViewAll as a projector, the bottom mirror is dropped out of place and the light is projected straight out the back of the machine. Through careful location of all the component parts of the ViewAll, it has been possible to reduce its size to $15\frac{1}{2}$ by $7\frac{1}{2}$ by $10\frac{1}{2}$ inches and still maintain

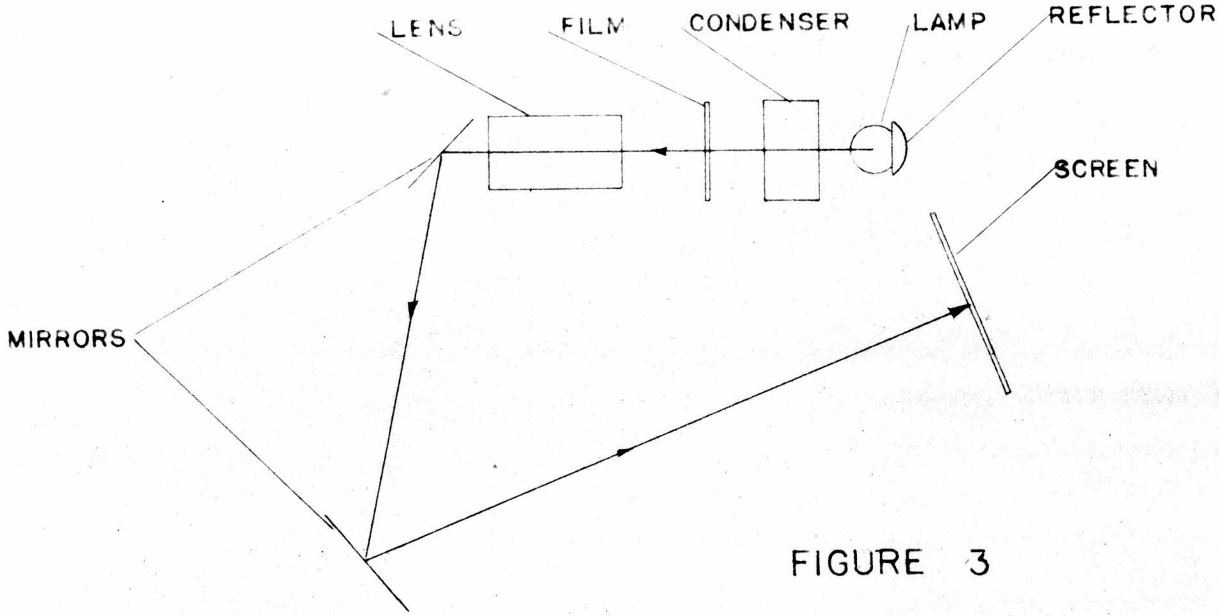

FIGURE 3

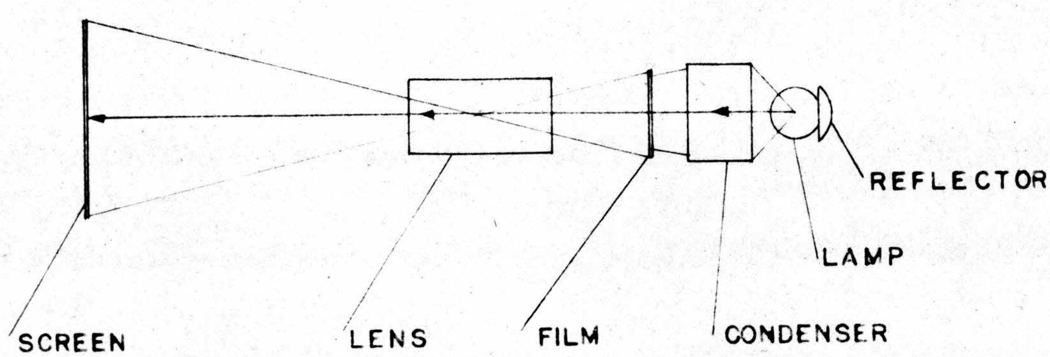

FIGURE 4

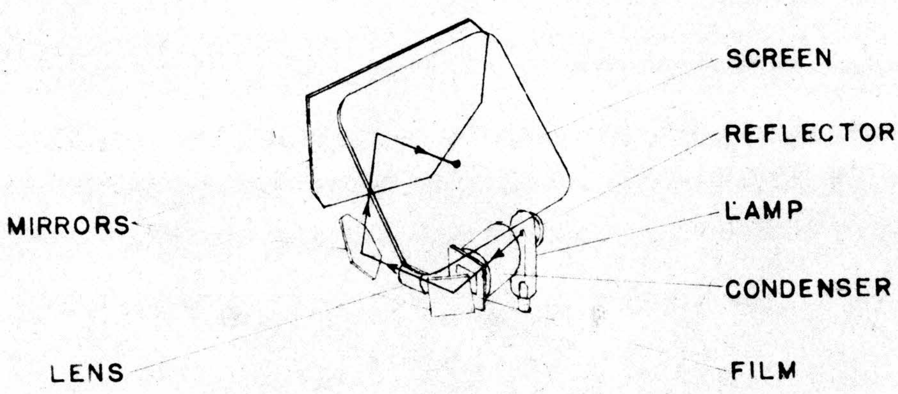

FIGURE 5

a projected image on the viewing screen of $6\frac{1}{2}$ by $6\frac{1}{2}$ inches.

The following variations of the basic optical system were considered and abandoned in favor of the system used:

1. The optical system located directly above the viewing screen. See figure 3.
2. The viewing screen located directly in front of the optical system. See figure 4.
3. The mirrors arranged so that the light was turned in a three dimensional path from the lenses up to the screen. See figure 5.

All of the above systems were abandoned for one or more of the following reasons:

1. Overall size of the unit proved to be larger than the minimum size obtained using the chosen optical system.
2. Final appearance of the case proved to be less appealing than that possible with the chosen optical system.
3. The beam of light, when leaving the machine, for distant projection, did not leave the machine in a horizontal path, as is required for proper projection.

THE OPTICAL SYSTEM - THE PROJECTION LENS

A "Tessar" type*, $3\frac{1}{2}$ inch effective focal length f/3.5 projection lens has been chosen for the projection system of the ViewAll.[1,2]

Lenses of different effective focal lengths were considered and the following conditions were found to exist:

To project from a 35 millimeter transparency to a projected image of $6\frac{1}{2}$ inches by $6\frac{1}{2}$ inches, the following distances between screen and lens are required with various lenses as listed.

$2\frac{1}{2}$"efl-----------$12\frac{1}{2}$"
3" efl-----------15"
$3\frac{1}{2}$"efl-----------$17\frac{1}{2}$"
4" efl-----------20"
$4\frac{1}{2}$"efl-----------$22\frac{1}{2}$"
5" efl-----------25"
6" efl-----------30"

Using lenses with an effective focal length much less than $3\frac{1}{2}$ inches necessitated locating the screen so close to the lens as to cause trouble in removing the heat from the lamp.

Using lenses with an effective focal length much more than $3\frac{1}{2}$ inches required enlarging the case to accomodate the enlarged lightway.

The brilliancy of the projected image is dependent upon the speed of the lens. This speed is in turn a function of the diameter of the elements of the system. The larger the di-

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*Eastman Kodak Co. "Ektanon" Lens.

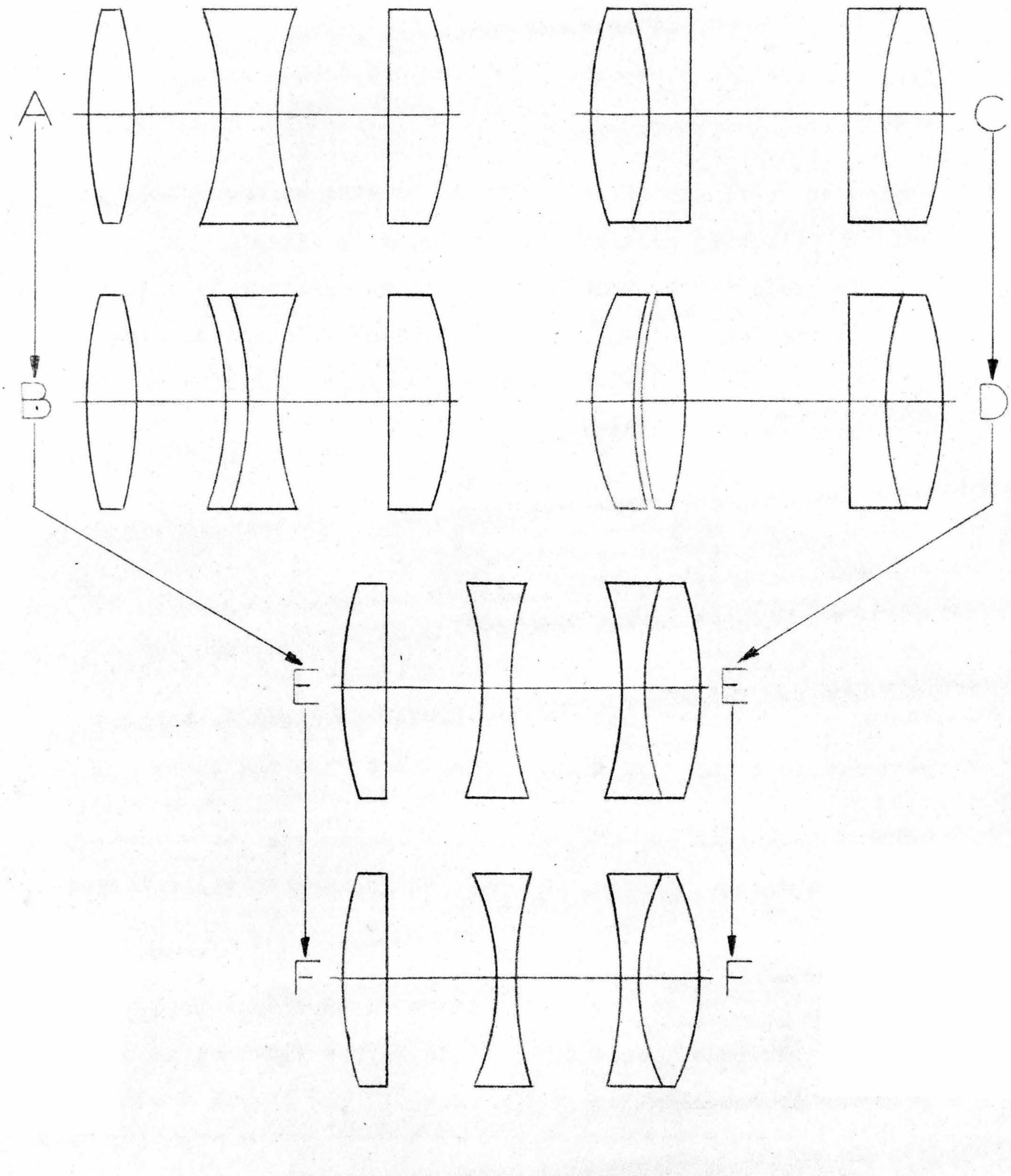

FIGURE 6

ameter, the more light will be transmitted. However, the cost of the projection lenses is also directly dependent upon the diameter of the lens. In general the cost of the lens will triple when the lens diameter is increased enough to double the speed of the system.* It is likewise true that the amount of distortion found in a lens also increases as the diameter of the lens is enlarged.[3,4]

After carefully balancing the advantages of various speed lenses against their several disadvantages, a lens speed of f/3.5 was chosen as being the optimum for use in the ViewAll. This choice is rather well supported by the experience of the market.** Seven of the ten projectors studied in the market survey use lenses either with speeds of f/3.5 or with speeds within 10 percent of f/3.5.

The Tessar-type Ektanon projection lens was chosen after a study of the following lenses: See figure 6.

a..Cook Triplet

b..Cook Anastigmatic Triplet

c.. Achromatic Symmetrical

d..Petzval projection lens

e..Tessar

f..Ektanon

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* Reference: Bausch & Lomb Projection Lens Price list E-11, Nov. 1, 1948.

** See Appendix B.

PROJECTION LENS MOUNTING

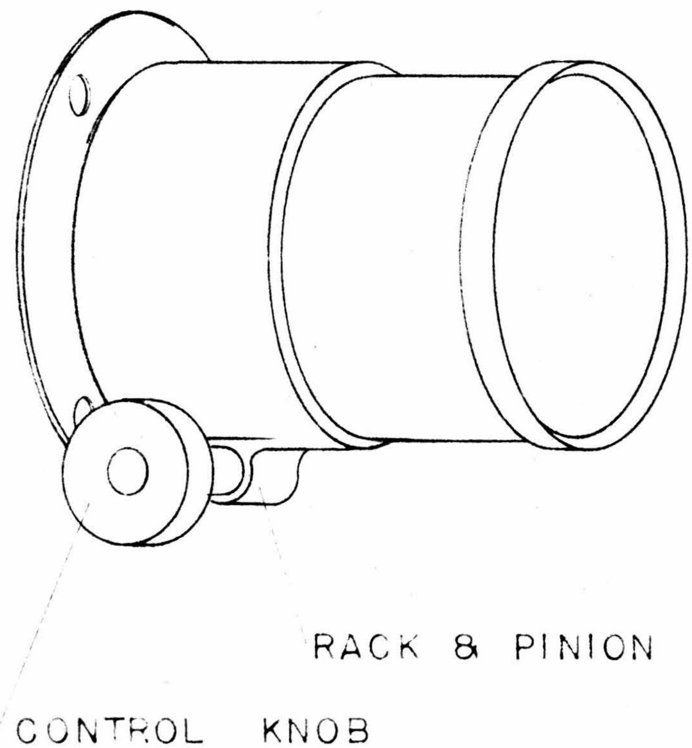

FIGURE 7

The figure shows the relationship between these various lenses.

The Achromat, its first variation the Symmetrical Achromatic, and the Petzval all give clear bright images, but ones with slight distortion. This distortion is not generally considered to be great enough to be of any harm in home projectors. The majority of the home projectors now on the market utilize one of these variations of the Achromatic.

The cook Triplet, the Triplet Anastigmatic, and the Tessar types give images as clear and bright as the Achromatics do and at the same time eliminate the slight distortion found in the Achromatic lenses.

The Ektanon, Tessar-type, projection lens gives the finest image of the above three and it has been chosen for use in the ViewAll. The color-correction in this lens is superior to that found in the other lenses considered. The importance of this factor is very great in dealing with the projection of colored pictures.[1,2,5]

It is suggested that the projection lens system be mounted in a standard rack and pinion arrangement. Figure 7 shows an application of this type of mounting as used by the Bausch & Lomb Co. This mounting gives a simple strong structure that can be installed in the base of the ViewAll with no additional parts being necessary.

The rack and pinion must be designed to permit a travel of 7/8 inches. This will permit focusing the system for use as a viewer as well as permit focusing for projection throws up to 50 feet.*

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* See Appendix E.

THE OPTICAL SYSTEM - THE CONDENSING LENSES

The condensing lens system of the ViewAll consists of two 2 inch symmetrical convex lenses each with a focal length of 2 inches. These two lenses are mounted close together as a pair and the effective focal length of this system is 1 inch.*

Condensing lenses are used in projection systems to concentrate as much light as is possible from the light source upon the image being projected. The larger the condensing lens, the greater the amount of light that will be concentrated upon the transparency and consequently the greater will be the efficiency of the optical system.

The two inch size of the condensing lenses used in the ViewAll was determined by balancing the greater efficiency of the larger lens against the increased cost and difficulty in fitting larger lenses into the case.

The symmetrical double convex condensing lens was chosen for the ViewAll because this type of lens has a shorter focal length than is found in either of the other two available types of condensing lenses, i.e., in the plano-convex or the concavo-convex.

It would have been possible to shorten this focal length even more through the use of a Fresnel lens. However the disad-

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* See Appendix C.

vantages of the increased cost and increased distortion that accompany the Fresnel lens outweigh the advantage of its slightly shorter focal length.

The condensing lenses shall be mounted as a pair in order to reduce further their effective focal length. In general, when two similar convex lenses are mounted in close proximity, i.e., under 3/4 of an inch, the effective focal length of the resulting system is one half of the focal length of the convex lens alone.*

The condensing lenses will be mounted in the ViewAll in a two piece stamped metal holder. The two halves of the holder are identical for manufacturing convenience.

The bottom half of the holder will be screwed, with sheet metal screws, to the base of the ViewAll. The upper half of the holder will be held to the bottom half with two coil springs.

It is suggested that the piece of heat absorbent glass, mentioned in the section concerning the heat dissipation, be mounted between the two condensing lenses. This will utilize this otherwise wasted space and also eliminate the need for a separate holder for this glass.

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* See Appendix C.

THE OPTICAL SYSTEM- COATING THE LENSES

All the lenses in the ViewAll shall be coated to reduce the losses in the system due to reflection at the lens surfaces. This coating will reduce these losses from 36 per cent to 13 percent.[4] The functioning of this coating is as follows:

When light passes from a medium of one density into a medium of different density, a certain amount of light, rather than passing through, is reflected back by this surface. This phenomenon is known as "Fresnel Reflection".

In order to determine the amount of light that is reflected by this phenomenon, it is necessary to apply Snell's Law for the special case of an air-glass interface with the light at normal incidence.

Snell's law states:

$$R = \frac{(n-1)^2}{(n\ 1)^2}$$

R- per cent of light reflected
n- index of refraction

Using an average index of refraction, n, as 1.5 for optical glass, it is seen that the reflectance is 0.04. This means that 4 per cent of the light is reflected back and is lost at each surface. There will be some slight loss within the glass itself by absorbtion, but for all practical purposes, this loss may be neglected.

In order to reduce this surface loss as much as possible, lenses are cemented together whenever the design permits.

The cement used is Canada Balsam. The index of refraction of Canada Balsam is very similiar to that of the glass. This eliminates the reflection losses at the cemented surfaces.

The other way to reduce these losses is by coating each air-glass surface with a transparent material that has a reflective index less than that of glass. When the light strikes this surface, some of it will reflect back at this surface while still more will reflect at the original glass surface.

If this coating is applied to a thickness of $\frac{1}{4}$ of a wave length of light* and if just half of the reflected light is reflected at the coated surface, then the two reflected light beams will be equal and out of phase by 90 degrees. This means that they will then cancel themselves and no light will be reflected at this surface.

In practice the reflection losses are not entirely eliminated, as the theory indicates, because of the variation in the wave length of light in the visible spectrum. However, these losses, now due to the red and blue reflected light, are reduced to a magnitude of only 0.6 per cent at each surface.

In order to have just half of the light reflected at the coated surface and half at the glass, it has been found that the index or refraction of this coating should be equal to the

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* The yellow-green wave length is used for this dimension because it lies in the center of the visible spectrum.

geometric mean of the refractive indexes of the glass and the air. This indicates the need for a different coating for each different type of glass. However, it has been found that any one of the below listed salts may be employed on all types of optical glass and still give two surface transmissions of over 98 per cent:

Sodium Fluoride

Calcium Fluoride

Magnesium Fluoride

Sodium Ammonium Fluoride

These salts all have different mechanical properties and the decision as to which one to use lies in this field.

In the ViewAll, it is recommended that Magnesium Fluoride be used and that the coating be applied to a thickness of 0.000014 centimeters. This coating is rather insoluable in water and has good enough abrasion resistant qualities to permit cleaning of the lenses without danger of harming the coating.

THE OPTICAL SYSTEM - THE LAMP

The lamp used in the ViewAll is a 100 watt 110 volt projection lamp manufactured by the General Electric Co. The manufacturer's designation is:

G.E. Projection Lamp 100 S11 100 watt.

The use of a lamp of lower voltage was considered because of the smaller amount of heat that it would generate. This advantage did not prove to be sufficient to permit the use of this bulb in place of the more common 110 volt type.

A hundred watt lamp proved to be sufficient to give the following results when used in the ViewAll.*

1. For viewing with an average transparency a screen briliancy of 200 foot candles is produced. (NOTE: To reduce the screen brilliancy to this useable level, a filter with a density of 50 per cent was added to the viewing screen.)
2. For projecting upon a white screen at a distance of 18 feet, a screen brilliance of 9.4 foot candles is obtained.

This permits the use of the ViewAll as a viewer in a room lighted to an intensity of 20 foot candles and permits its use as a projector in a room lighted to an intensity of 1 foot candle. [6]

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* See Appendix F.

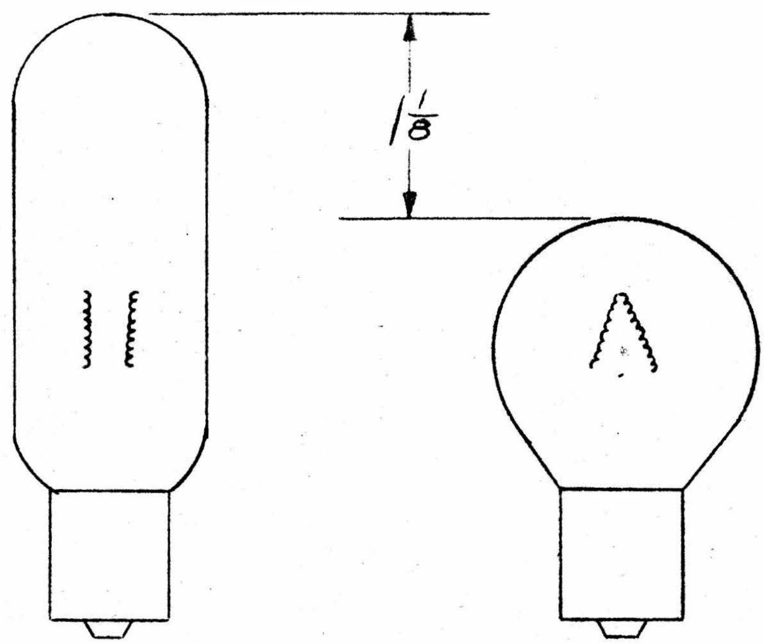


FIGURE 8

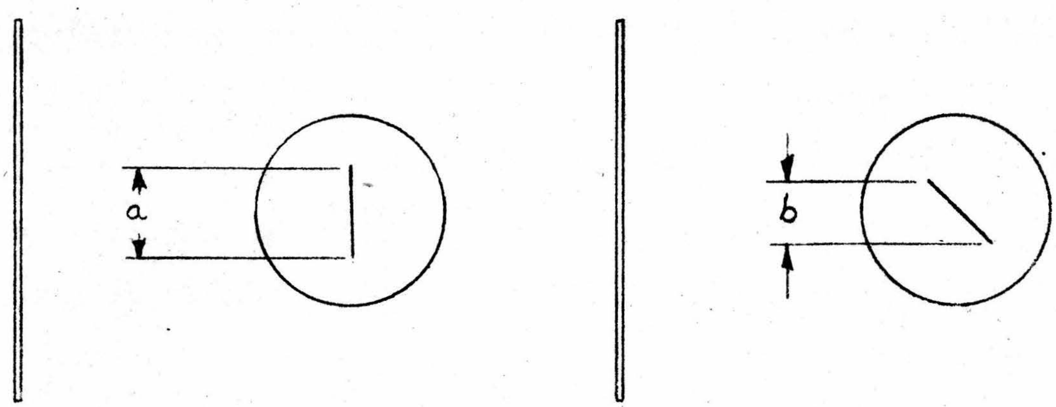


FIGURE 9

Several other 100 watt 110 volt projection lamps were considered, but the G.E. 100 S11 100W was chosen because of its small size.

Other standard 100 watt projection lamps were approximately 3¼ inches high while the S11 100 watt is only 2 3/8 inches high. This savings of 7/8 of an inch permits the lowering of the total case height by 1 1/8 inches. See figure 8. Since one of the main problems encountered in the design of the View-All was that of reducing the size, this lowering of the case silhouette was very desirable.

Because of the smaller bulb size, the filament operates at a higher temperature than does the filament in the larger bulbs. This tends to reduce the life of the bulb. The life of the S11 100 watt bulb is only 25 hours while the life of the bigger bulb is rated at 40 hours. However, since the smaller bulb only cost $.45 as compared to $1.35 for the larger bulb, it is apparent that the operating cost of the G.E. S11 100 watt bulb is lower than with the larger bulb.

As is noted in figure 9, it is necessary to locate the bulb accurately so as to utilize the maximum projected area of the filament. Figures 20 and 21 in the appendix, showing the polar distribution of the light from the bulb, emphasize this point.

Once the lamp socket has been accurately located in the base of the ViewAll during assembly, the problem of filament location is eliminated.

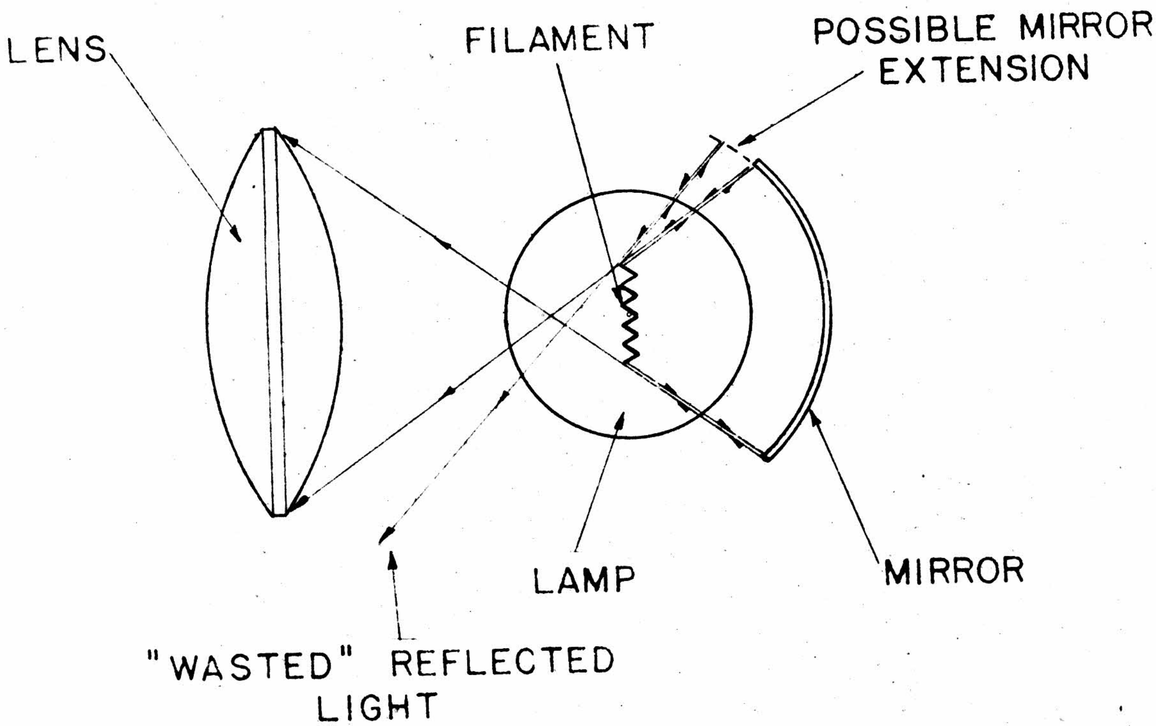

LENS
FILAMENT
POSSIBLE MIRROR EXTENSION
LAMP
MIRROR
"WASTED" REFLECTED LIGHT

FIGURE 10

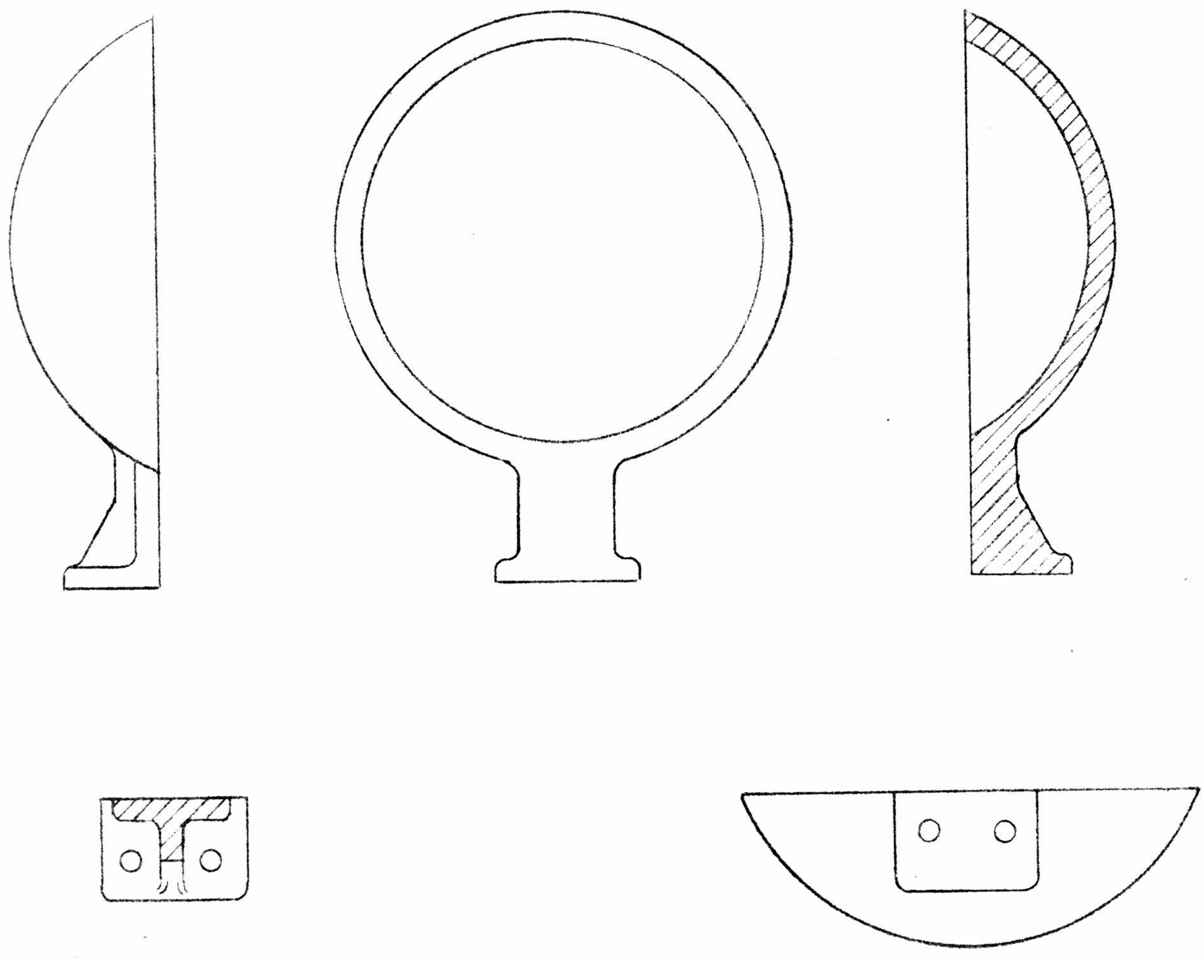
THE OPTICAL SYSTEM - THE CONDENSING MIRROR

The condensing mirror used in the ViewAll is a chromium plated zinc-alloy die casting. It has an effective diameter of 2 inches and is located $\frac{1}{2}$ inch behind the lamp.

This mirror is used to augment the condensing lens system. In doing so the mirror returns the light falling upon it back to the filament in the lamp and will in this way effectively increase the brilliance of the light source. For maximum efficiency, this mirror should be just large enough so that the light from the reflected image of the filament will be directly in line with the condensing lens. See figure 10. A larger mirror would tend to increase the brilliance of the filament a little more, but not in a way that could be utilized by the condensing lens system. Too great a concentration of light back on the filament would also tend to overheat the filament and thus shorten its life.

Consideration was paid to the possibility of silvering the back of the light bulb itself so that it might operate as the reflector. This, although theoretically a sound solution, is impractical because the soft glass of the bulb would be heated to its melting point.

It is proposed that the mirror be made of a zinc alloy die casting in order to obtain as accurate and as accurately mounted a reflecting surface as is possible. It is proposed that only



MIRROR

FIGURE 11

FULL SIZE

the reflecting surface itself be prepared and polished, even though the whole mirror be chromium plated. This is for reasons of economy since it is cheaper to plate than to mask. See figure 11.

A zinc alloy has been chosen as the material for the mirror because this metal may be both readily die cast and readily chromium plated.

The shape of the reflecting surface of the mirror has been studied and a spherical surface with the center of curvature at the center of the filament has been decided upon. This design is in keeping with good optical design.*

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* Reference (3), page 46.

MIRRORS

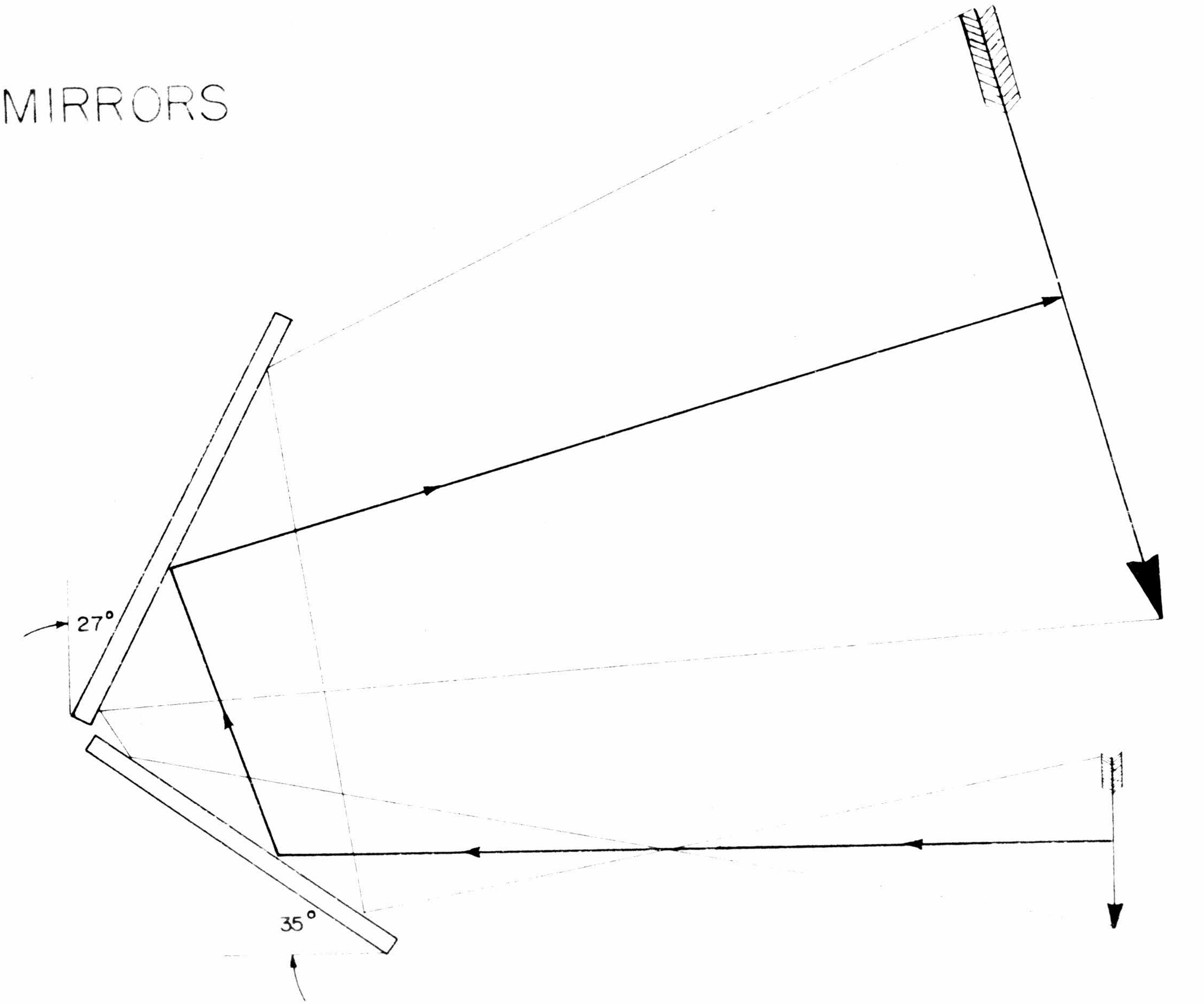

FIGURE 12

THE OPTICAL SYSTEM - THE MIRRORS

Two mirrors are necessary in the ViewAll to turn the light beam up from its normal path and back into the viewing screen. Figure 12 shows this arrangement.

These mirrors are made of plate glass front surfaced with aluminium and coated with a transparent silica salt. The salt coating will reduce the tarnishing effect of the atmosphere upon the aluminium. However, moisture from the fingers will tend to break this coating down and will thus cause considerable damage to the aluminium film. To prevent this as much as possible it is suggested that there be a decalcomania placed inside the upper case so that it will be plainly visible when the top is raised and the mirrors exposed. This decalcomania will warn against touching the mirror with the fingers.

Each mirror will be mounted in a stamped steel yoke or holder. This holder will in turn be screwed to the case. The glass mirror will be held in the holder by means of a felt pad and clamping screws. See figure 35 for the mounting details.

The holder for the lower mirror is made so that the mirror may be dropped out of position by turning the knob located on the left side of the ViewAll. This mirror is dropped out of position when the ViewAll is used as a projector. The spring arrangement shown in figure 32 is used to hold the mirror firmly in place both in the raised and in the lowered position.

THE OPTICAL SYSTEM - THE SCREEN

The screen of the ViewAll is composed of a piece of ground glass sandwiched to a dark acrylic plastic light concentrating screen. The screen is seven inches high by seven inches wide.

The ground glass screen was chosen after the following screens were considered and eliminated for the noted reasons:

1. Frosted acrylic plastic - dimensionally unstable, surface not sufficiently abrasion resistant.

2. Opal acrylic (density 40 percent) - projected image indistinct, dimensionally unstable, surface not sufficiently abrasion resistant.

3. Opal glass (density 40 per cent) - projected image indistinct, i.e. areas appeared "fuzzy" at edges.

4. Grey transparent ground glass (density 40 per cent) - cost proved to be greater than that of combination chosen.

The ground glass that was chosen, although superior to the other screens tested, had two disadvantages. They were:

1. The projected image appeared brighter in the center of the screen than at the edges; i.e., a "hot spot" was formed.

2. The image proved to be too brilliant for comfortable viewing. (400 foot candles.)

The acrylic light concentrating screen sandwiched behind the ground glass eliminated the first problem. This acrylic screen or lens is formed as follows:

A sheet of warm acrylic plastic is pressed into a brass mold into which a spiral line has been cut. This spiral, with the

LENSES

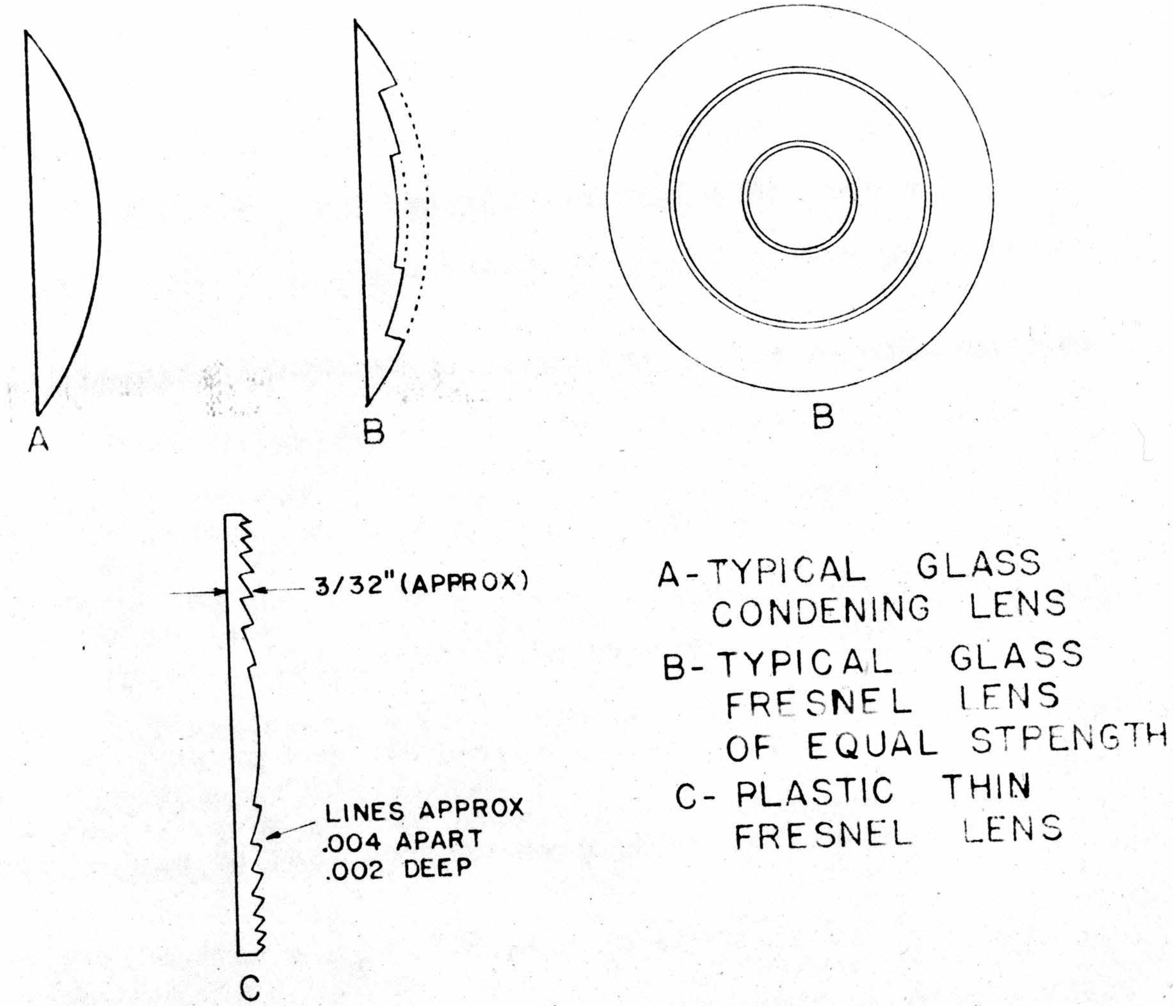

FIGURE 13

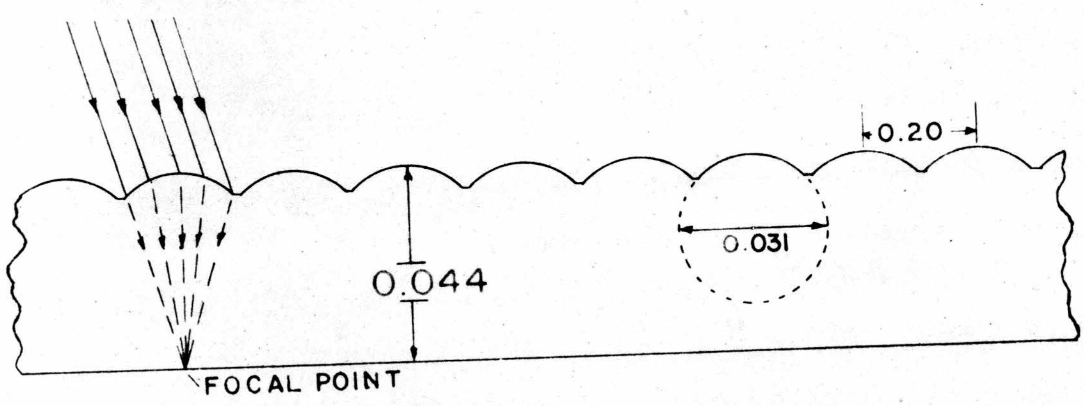

FIGURE 14

lines only several thousands of an inch apart, closely approximates a series of concentric circles. The angle at which these lines are scribed increases gradually from the center of the spiral to the outer edge. The final profile of this mold is that of the mirror image of a many faceted Fresnel lens. The plastic pressed into this mold then assumes this profile and is formed into a true Fresnel lens. See figure 13.

This acrylic Fresnel lens, when placed behind the ground glass eliminates the "hot spot" at the center of the projected image and distributes the light evenly across the entire screen.*

A light concentrating screen composed of many** minute plano-convex lenses, as seen in figure 14, was tested. This screen eliminated the big "hot spot" in the image, but the screen itself formed a disturbing pattern of thousands of minute "hot spots".

It is suggested that the acrylic used for the light concentrating screen be pigmented with enough pure black dye to increase its density to a value of 50 per cent. This will reduce the objectional screen brilliancy from 400 foot candles to a more practical level of 200 foot candles. Black dye is used so that the color of the projected pictures will not be affected.

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* "Increases over all image brightness 250% and increases corner brightness over 1000%." Flat Plastic Lenses - Modern Plastics Magazine, April 1949.

** 2900 lenses per square inch.

The size of the screen, seven inches by seven inches, was chosen as a compromise between the desire to have as large a screen as possible and at the same time have a case that was as small as possible.

A screen of this size has the following two additional advantages:

1. The size is such that the colors remain bright and concentrated.
2. With a screen of this size the whole image may be observed by the eye without scanning.* (6)

The acrylic screen and the ground glass are positioned as shown in figure 37 for the following reasons:

1. To obtain the optimum image as proven by experimentation.
2. To keep only the hard, smooth, easier to clean, glass surface on the outside of the ViewAll.

---

* Assumed that the screen will be located approximately 2½ feet from the eye during viewing.

THE CASE - A MATERIAL STUDY

The case of the ViewAll is made of die cast anodized aluminium.* The upper case, which serves to hold the viewing screen, is anodized a light grey color. The lower case, into which the optical system, slide changing mechanism, etc. are attached, is anodized a dark blue-grey color.

The following materials and methods of manufacture were considered and eliminated in favor of the die cast aluminium:

1. Sheet metal fabrication
2. Drawn metal
3. Aluminium sand casting
4. Zinc die casting
5. Thermosetting Plastic molding

The first three possibilities were eliminated because of the inferior appearance and high labor costs that would accompany their use.

Aluminium was chosen for die casting rather than zinc because of the more attractive and more durable surface coating available with the anodizing of the aluminium.

Plastic moldings were studied and eliminated for one reason only. That was because of the customer refusal to accept a plastic housing in a piece of expensive photographic equipment.

---

* Use Aluminium alloy with 3.8% magnesium (SAE std. no. 320, Type 1- Alcoa A214).

Melamine thermosetting plastic, however, would be the most suitable material for the top case of the ViewAll, as far as engineering considerations are concerned.

In future designs it will probably be possible to suggest the use of this plastic, but not today.

All the required bosses, screw holes, and locating lugs necessary to the assembly of the ViewAll will be die cast directly into the base. This construction will simplify assembly and will eliminate the necessity of aligning each optical system separately during assembly.

The ViewAll will be given a pleasing matt surface coating by first wire-wheel brushing the casting and then color anodizing it. This anodized coating is extremely durable and color-fast.

THE CASE - MATERIAL STUDY, THE KNOBS AND TRIM

It is suggested that the knobs used on the ViewAll be molded of Urea Formeldehyde thermosetting plastic. They will be molded red in color. This Urea plastic will give the knobs a fast color that will contrast well with the metalic case.

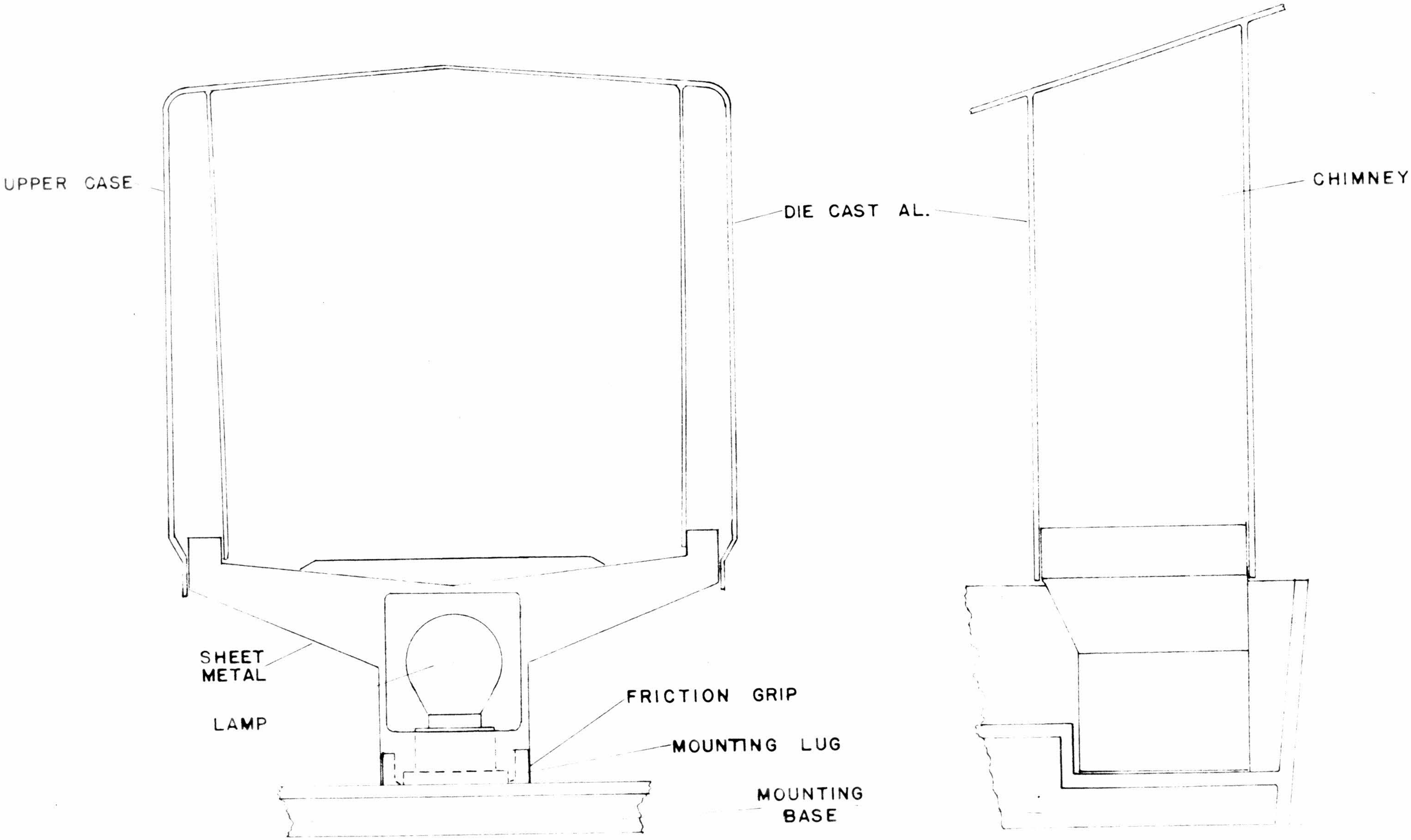
Urea Formaldehyde was chosen over other plastics because it is:

1. Relatively inexpensive
2. Easy to mold
3. Available in a variety of colors

The knobs will have the trademark of the manufacturer molded into the top of them. This trademark will be colored light grey by wiping paint into the molded depression. This trademark will help to identify the manufacturers and also help to raise the apparent height of the knobs.

The ring and cap covering the projection opening at the back of the ViewAll will be made of chromium plated die cast zinc. The front of the cap will be chromium plated and brushed to a soft sheen. There will be a red trademark enameled on this surface. The sides of the cap and the ring will be chromium plated and buffed to a high luster.

LAMP HOUSING AND CHIMNEY



1/2 SCALE

FIGURE 15

THE CASE - THE LAMP HOUSING AND CHIMNEY

The chimney of the ViewAll consists of a lamp housing and a double chimney. The lamp housing is made of stamped, spot welded sheet metal while the upper chimney is die cast integrally into the upper case. This upper chimney is divided into two channels that will carry the heat up and around the picture beam. The lower pair, i.e., the lamp housing and the yoke, will be fastened directly to the base. When the top is closed, the yoke will fit into the upper chimneys. See figure 15.

The function of the lamp housing and chimney will be to:

1. Prevent stray light from falling on the viewing screen from behind.
2. Aid in keeping the film and film area cool.
3. Help to keep the lamp itself cool.
4. Remove the heat from the bulb in such a way that heat waves are not formed that would distort the projected image.
5. Remove the heat so that the case will not become objectionably hot.

If the heat is not removed from the film and film area, the film will tend to warp and will, under even more severe conditions, tend to ignite.

To help keep the film cool, two other steps have been taken.

They are:

1. A piece of heat absorbent glass has been placed in the light beam between the lamp and the film. This glass will remove up to 80 per cent of the heat from the light beam.
2. Several cooling slots have been cut into the base of the ViewAll in the film area. These slots will admit cool air which will, upon heating, tend to rise up and out through the top of the machine thus causing a cool draft of air past the film.

The greatest cooling effect will be caused by the chimney and lamp housing. At the critical point in the chimney, that is at the center of the yoke, a second wall thickness of sheet metal has been added. This second layer of metal, with an air space between, will reduce the heat transmission at this point about 50 per cent.

Holes will be left in the base of the ViewAll around the lamp socket. These openings will permit the entrance of cool air at this point. This cool air going up the 10 inch chimney will form the cooling media used to carry the heat away from the lamp.

THE CASE - OTHER DESIGN DETAILS

The following features of the design of the ViewAll, although not of paramount importance, are important enough to the function of the ViewAll to warrant their mention:

1. The automatic light switch incorporated with the slide changing mechanism.
2. The winding posts for the electric cord.
3. The extra lamp holder.
4. The operating instructions.

There is a micro-switch incorporated with the slide changing mechanism that serves to turn off the lamp when the slides are being changed. This feature serves these two functions:

1. It minimizes the amount of heat generated by the lamp.
2. It eliminates the unpleasant vision of the changing slides.

There are three winding posts cast into the underside of the base of the ViewAll as shown in figure 32. It is proposed that the electric cord be wrapped around these posts when the ViewAll is not in use.

There is a holder for an extra projection lamp located safely within the base of the ViewAll. See figure 30. The advantage of this feature is obvious.

It is suggested that a set of operating instructions be glued to the underside of the ViewAll. These instructions would include:

1. How to operate the ViewAll as a projector.
2. How to operate the ViewAll as a viewer.
3. How to open the case.

Within the upper case, there would be a set of maintenance instructions glued in position so as to be plainly visible when the top is opened. These instructions would include:

1. How to release jammed slides.
2. How to change bulbs.
3. The trade designation of the bulb.
4. How to clean the mirrors and the lenses.

SLIDE CHANGING MECHANISM

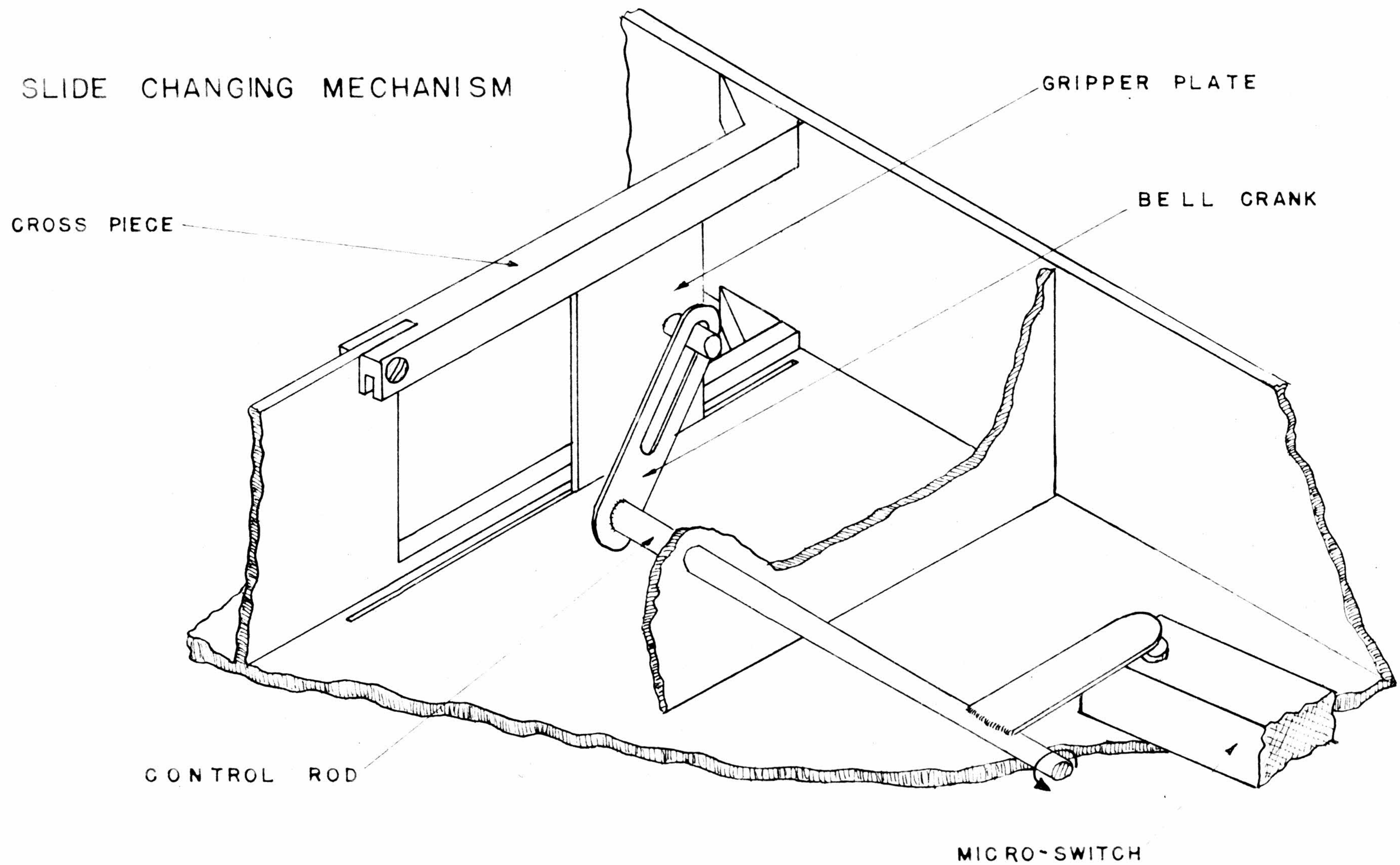


FIGURE 16

THE SLIDE CHANGING MECHANISM

The ViewAll is equipped with a semi-automatic slide changing mechanism. This mechanism is so designed that when the ViewAll is used as either a projector or a viewer, some 50 paper covered or 20 glass covered slides may be shown automatically.

To operate the slide changer, the transparencies are placed in the holder in the right-hand side of the ViewAll. The slides are changed during showing by turning the knob located under the viewing screen one-quarter of a turn to the left. After the slides have been shown, they may be removed, still in their original order, from the holder on the left-hand side of the machine.

The changer itself operates as follows:
When the knob is turned, it actuates the lever as shown in figure 16. This lever pushes the sliding plate with the two grippers along the built in track running across the machine. The grippers hold the edge of the transparency and push it firmly into position for projection. When the knob is released, a spring returns the changer to its original position where it grips the next transparency. When the knob is turned again, the gripper pushes this new transparency into position for projecting. While sliding into position, this transparency pushes the previous one across to the left and into the holder. This series of operations is continued until all the slides have been projected and are all, except the last one, in the left-

hand holder. To remove this last transparency from the machine, it is necessary to run another slide half way through the cycle. Then release the knob and pick the first slide out by hand from the left-hand holder and then pick the remaining slide out from the right side.

Two leaf springs are built into the slide changer to position the transparencies, both paper and glass mounted, carefully and gently into position while they are being projected. At no time does any part of the slide changer or the frame touch the film itself. All pushing, pulling, and sliding take place on the paper or glass mounting.

When the slide changing mechanism is operated, there is no tendency to push the machine out of position as it is so easy to do when using conventional slide changers. This is true with the ViewAll because all the actuating motion for the changer is rotorary rather than linear.

At no time during the operation of the ViewAll are there any parts of the slide changing mechanism protruding from the case in such a way that they are in danger of being bent and thus jammed. All moving parts, with the sole exception of the plastic knob, are housed within the case.

It would be possible with no basic changes in the design to make the slide changer either plunger or electrically operated There is sufficient room within the case to permit the installation of the necessary equipment. It is not suggested that this be included on the present model. The slight gain in convenience is not worth the rather large increase in cost that this would entail. A deluxe model, marketed at a later date, might include this feature.

ASSEMBLY

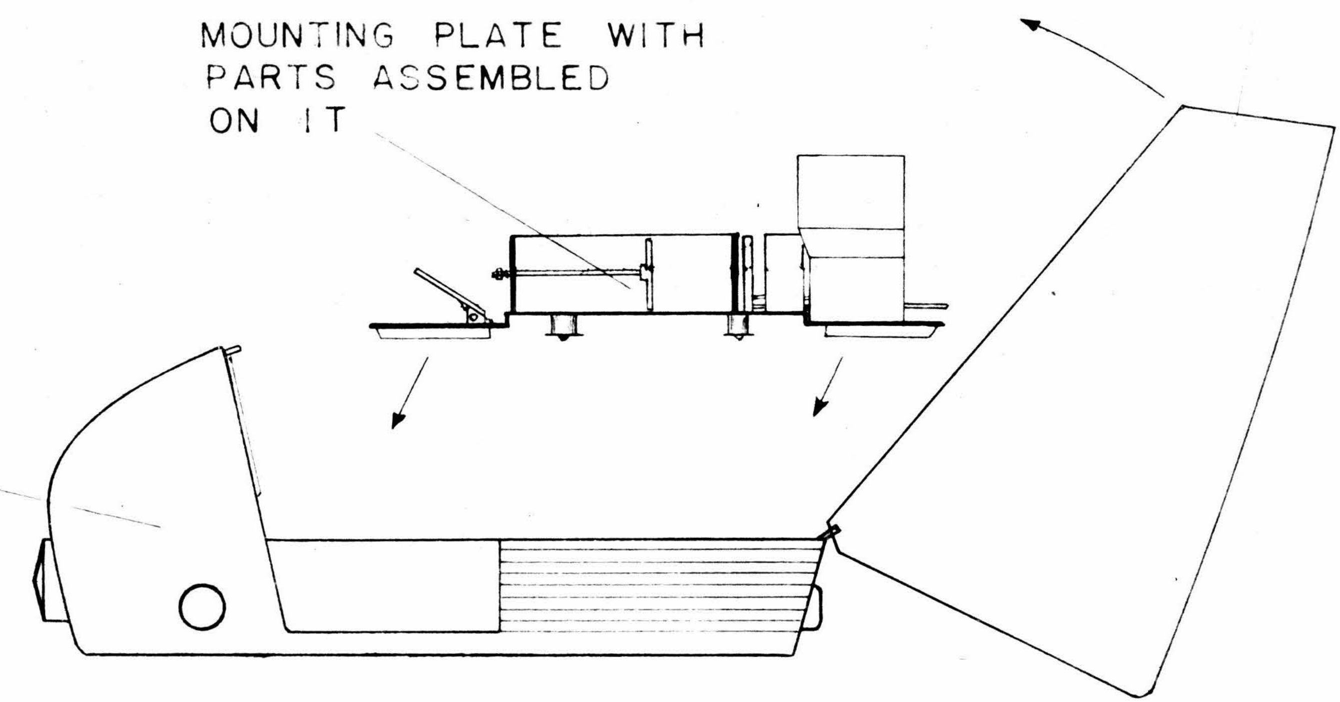


FIGURE 17

THE ASSEMBLY

All of the elements of the ViewAll's optical, electrical, and slide changing systems, with the exception of the upper mirror and the viewing screen, are mounted on the die cast mounting base. This base with the various parts assembled is shown in figure 29. Figures 30 - 32 show the base prior to assembly.

In general, the assembly will take place as follows: See Figure 17.

1. Screen placed in upper case and three holding clamps screwed into place.
2. Projection hole cover placed in lower case and peened to fasten in position.
3. Upper mirror placed in lower case, bracket screwed to cast-in lugs.
4. Following parts mounted to the base plate:
    a. heads for the cord winding posts
    b. projection lens mounting
    c. slide changer assembly
    d. top guide for slide changer
    e. micro switch
    f. slide changing mechanism spring
    g. lamp socket
    h. reflector
    i. lower mirror
    j. spring for lower mirror
    k. condensing lens system lower bracket

l. condensing lens system

m. condensing lens system upper bracket and spring

n. electrical wiring

o. lamp housing

5. The mounting base, with parts assembled to it is now screwed in place to the lugs in the lower case.

6. Mirror and projection lens control rods assembled.

7. Upper case attached to lower case with the hinge pins.

8. Coin slot screw is placed in the upper case to attach the upper case to the lower case.

9. Knobs placed on control rods.

It will be noted that this assembly entails a minimum of difficult interior assembly labor.

All lugs, walls, and holes necessary for assembling the parts to the mounting base are cast accurately in place. This will tend to eliminate the difficult problem of aligning the optical system.

A P P E N D I X

APPENDIX A

MARKET ANALYSIS

To determine the status of the market for the ViewAll, personal correspondence was carried on with the following manufacturers and editors:

American Optical Co., Buffalo, N.Y.

American Photographic Publishing Co., Boston, Mass.

Argus Inc., Ann Arbor, Mich.

Bausch & Lomb Optical Co., Rochester, N.Y.

Da-Lite Screen Co., Chicago, Ill.

Eastman Kodak Co., Rochester, N.Y.

Jam Handy Organization Inc., Detroit, Mich.

Minocam Photography Inc., Cincinnati, Ohio.

Popular Photography Inc., Chicago, Ill.

Reflexite Corp., New Canaan, Conn.

Society for Visual Education Inc., Chicago, Ill.

Waterbury Industries Inc., Waterbury, Conn.

Williams, Brown, & Earle Inc., Philadephia, Pa.

Proprietors of photographic stores in the following localities were interviewed. In these interviews, questionaires were not used, instead a more general and lengthy discussion of sales, consumer preferences, and merchandising practices was undertaken.

Locality	Number of Stores Visited
Los Angeles	14
Pasadena	8
Santa Barbara	2
Long Beach	1
Palm Springs	1

APPENDIX B

Market Analysis - Competitive Projectors

The following projectors and viewers were studied as to quality, price, and function.

Projectors

Kodaslide Projector Master Model
Mfg: Eastman Kodak Co.
Price: From $181 to $295 depending upon lens chosen.
Lamp: 300, 400, 500, 750 watt depending upon lens chosen.
Lens: From 5" f/3.5 to 11" f/3.7 all lenses coated. Ektanon and Ektar.
Body: Die cast Al anodized colors brown & buff.
Size: 12"x14"15" weight 11#.
Blower: Included.
Slide changer: Automatic changer not available.
Remarks: Excellent unit, but too expensive for the home market.

Kodaslide Projector Model 2A
Mfg: Eastman Kodak Co.
Price: $47.50.
Lens: 5" f/3.5 lumalized Ektanon lens.
Lamp: 150 watt.
Body: Black molded phenolic.
Size: 4"x5"x5¼".
Slide changer: Automatic changer $17.50 extra.
Remarks: Projects a very good image. Not too attractive.

Kodaslide Projector Model 1A
Mfg: Eastman Kodak Co.
Price: $27.50.
Lens: 4" f/3.5 lumalized Ektanon lens.
Lamp: 150 watt.
Body: Black molded phenolic.
Size: 3 1/4" x 5 1/4" x 9 3/8" long including lens.
Slide changer: Automatic changer $17.50 extra.
Remarks: Very attractive compact unit. Projected image bright but not too clear.

Bausch & Lomb 2"x2" Slide Projector
Mfg: Bausch & Lomb Co.
Price: $58.00.
Lens: 5" f/3.8 coated. Three lens condensing system with glass back coated mirror.

Lamp: 150 watt.
Body: Die cast. Green crackle finish with chrome & black trim.
Slide changer: Automatic changer not available.
Remarks: Unit operates well, but is not too attractive.

Vlulex Model AP-1
Mfg: Vulex Co.
Price: $64.50.
Lens: 2" f/3.5 coated.
Lamp: 150 watt.
Body: Die cast 2 parts - top grey crackle, bottom black crackle.
Remarks: Daylight viewing screen $6.75, only moderately successful.

Filmo Slide-Master
Mfg: Bell & Howell Co.
Price: Over $100.
Lens: 3.5" f/4.5, 5" f/3.5, or 7 1/2" f/4.5 coated.
Lamp: 500, 750, 1000 watt.
Body: Die cast brown crackle finish.
Slide changer: Automatic not available.
Remarks: Good machine, but not in the class considered.

Argus Pa100, Pa200 Projectors
Mfg: Argus Co.
Lens: 4" f/3.5 coated lens on both models.
Lamp: 100 watt on Pa100. 150 watt on Pa200.
Body: Die cast with black crackle finish.
Slide changer: Unique in that it operates with a rotary motion rather than linear. Works well, but is not automatic.
Remarks: Slightly odd looking with circular slide changer. Works well optically and mechanically.

LaBelle Model 301
Mfg: LaBelle Industries.
Price: $125.
Lens: 5" coated lens.
Lamp: 300 watt.
Body: Die cast pearl grey hammertone paint.
Slide changer: Fully automatic. Electrically operated. Works well, but is rather complicated. May be operated at distance from the projector.
Remarks: Quite expensive with only average optics. Unit very large - weighs 23#.

MK Spencer Delinescope
Mfg: American Optical Co.
Price: $47.50.
Lens: 5" f/3.75 coated lens.

Lamp: 150 Watt. Available with 200 watt bulb and electric blower for $93.50.
Slide changer: Automatic changer not available.
Body: Sheet metal with black crackle paint.
Remarks: Good performance only fairly attractive.

<u>SVE Entertainer 300</u>
Mfg: Society for Visual Education Co.
Lens: 5" coated lens.
Lamp: 300 watts.
Body: Die cast grey crackle finish.
Slide changer: Automatic. Slides fed in vertically by pushing a plunger. Simple in design and easy to operate.
Remarks: A good machine, rather attractive.

MARKET ANALYSIS - COMPETITIVE VIEWERS

The Leitz, Argus, and Adel viewers represent three common types of viewers on the market today.

All operate with a light source behind the transparency and with a plano-convex magnifying lens in front of the transparency.

<u>The Argus</u> (price approximately 4 dollars) is pocket size and operates from two "pencil" size dry cell batteries. The lens is approximately 1½ inches in diameter.

<u>The Leitz</u> (price approximately 67 dollars) is table size with a large viewing lens (approximately 4 inches in diameter). This viewer is equipped with a rheostat for varying the intensity of the light source.

<u>The Adel</u> (price approximately 9 dollars) is table size. Its viewing lens is approximately 3 inches in diameter. The case

is of black phenolic plastic.

In all three models, the observed image is bright, clear, and has a definite appearance of being three dimensional. The disadvantages of all models are:

1. Only one or two people may view the picture at one time. The distortion from the lens is too great when the film is viewed from the side.
2. The viewer represents a seperate piece of equipment from the projector.

APPENDIX C

THE CONDENSING LENS SYSTEM

Two two inch diameter symmetrical double convex lenses are mounted 3/4 inch apart (measuring from the optical center of the lenses). Each lens has a focal length of 1".

Calculations for the effective focal length of condensing lenses when mounted in pairs.

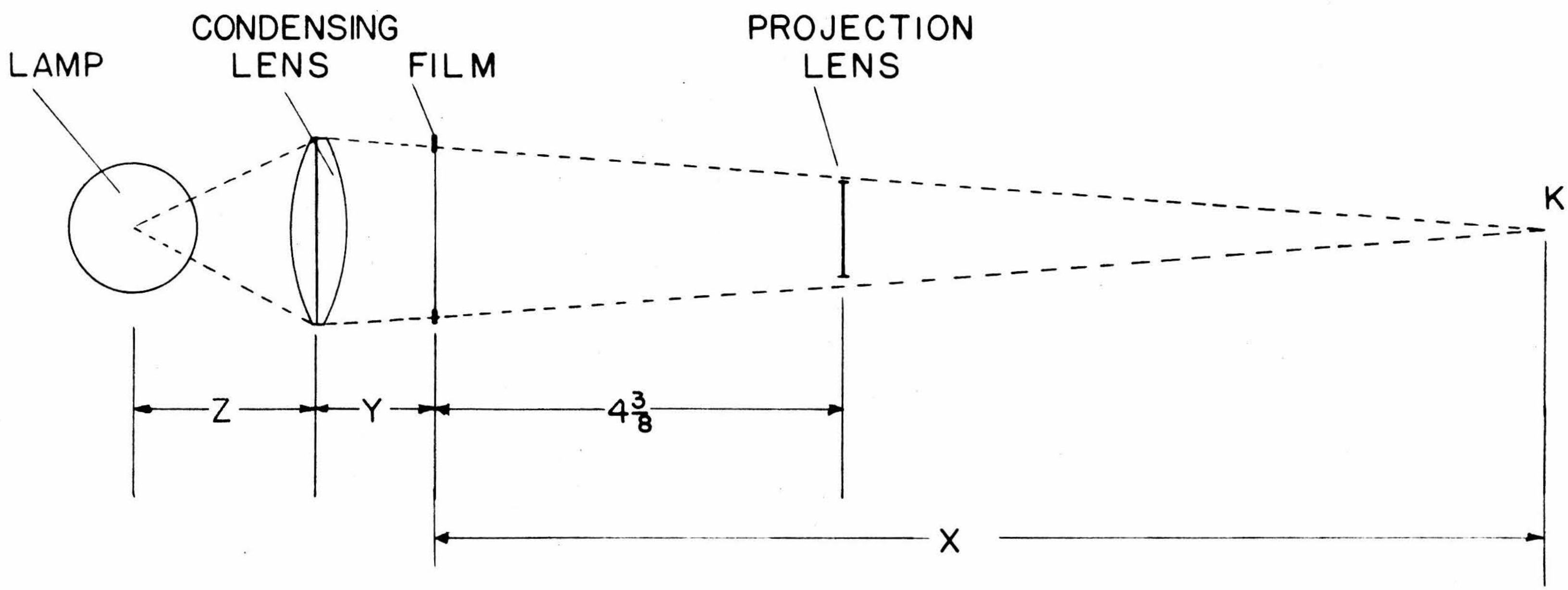
$$\text{e.f.l. (of each lens)} \div 2 = \text{e.f.l. of system}$$

$$2 \div 2 = 1 \text{ inch e.f.l.}$$

The effective focal length of the system is one inch.

The results arrived at were checked by test on optical bench.

OPTICAL SYSTEM - SPACING



APPENDIX D

CONDENSING LENS SYSTEM

1. "Y" may be chosen as any convenient distance that fulfils these three requirements:[4,5]

   a. The film area must be completely covered by the light from the condensing lens.

   b. The entrance to the projection lens must be completely covered by the light from the condensing lens.

   c. There must be sufficient space to permit the proper functioning of the slide changing mechanism.

   "Y" was chosen equal to $1\frac{1}{4}$ inches.

2. "X" may be chosen as any convenient distance that fulfils these two requirements:[4,5]

   a. The film area must be completely covered by the light from the condensing lens.

   b. The image of the filament, formed at point "k" must not fall on the viewing screen.

   "X" was chosen equal to 12 inches.

3. "Z" was determined from the distance X = 12 inches and the following relationship:[4]

$$\frac{X - f}{f} = \frac{f}{Z - f}$$

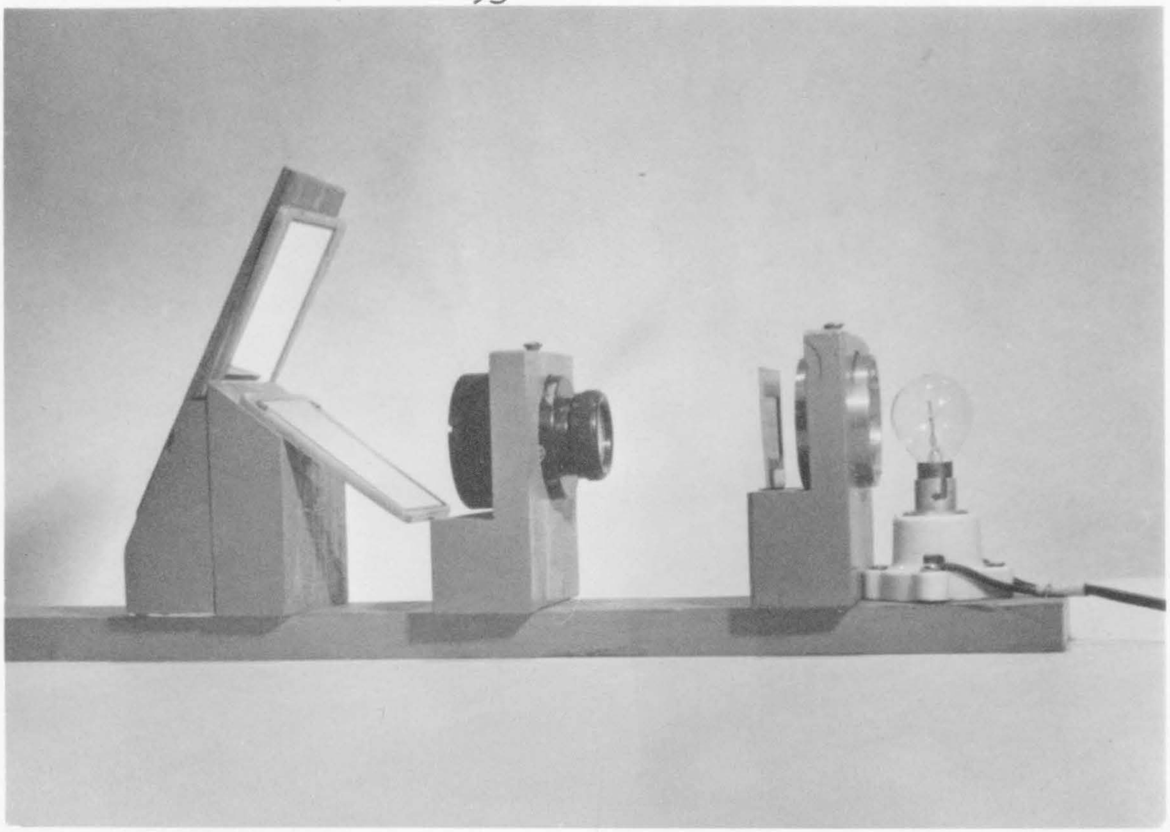
f = efl of lens = 1
Z = distance to prime image
X = distance to formed image = 12 inches

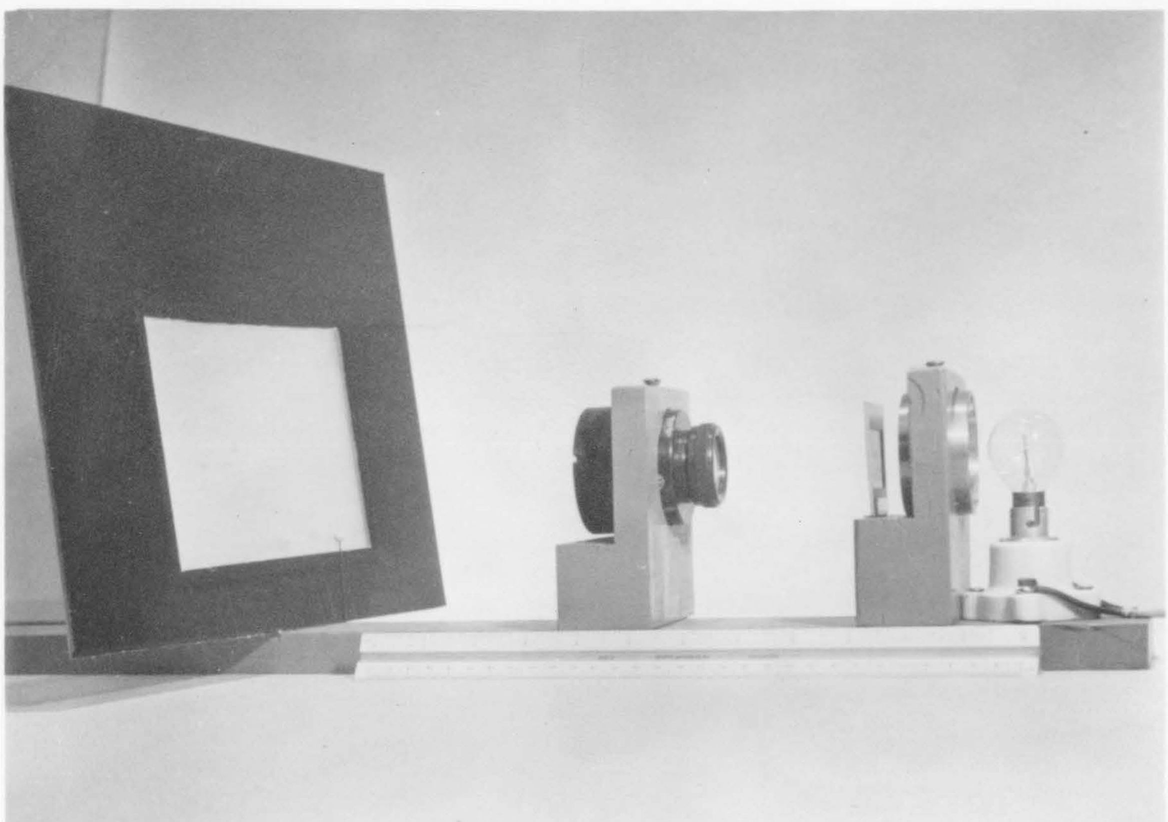
$$\frac{12 - 1}{1} = \frac{1}{Z - 1}$$

$$11 = \frac{1}{Z - 1}$$

$$Z = 1\ 1/11 \text{ inches}$$

Distances X and Y were chosen after optical bench tests.





OPTICAL TEST SET UP

TABLE I

R MAGNIFICATION	U LENS TO FILM	V LENS TO SCREEN
1	7"	7"
2	5 1/4"	10 1/2"
3	4 11/16"	14"
4	4 3/8"	17 1/2"
5	4 3/16"	21"
6	4 1/16"	24 1/2"
7	4"	28"
8	3 15/16"	31 1/2"
10	3 7/8"	38 1/2"
15	3 3/4"	56"
20	3 11/16"	6' 1 1/2"
25	3 5/8"	7' 7"
30	3 19/32"	9' 1/2"
50	3 9/16"	14' 10"
70	3 17/32"	22' 2"
100	3 1/2"	29' 5"
INFINITE	3 1/2"	INFINITY

APPENDIX E

PROJECTION LENS SYSTEM

Determination of the distance from the lens to the film and the distance from the lens to the screen for various magnifications.

The following relationships are employed:[4]

$$R = \frac{v-f}{f} \qquad R = \frac{f}{u-f}$$

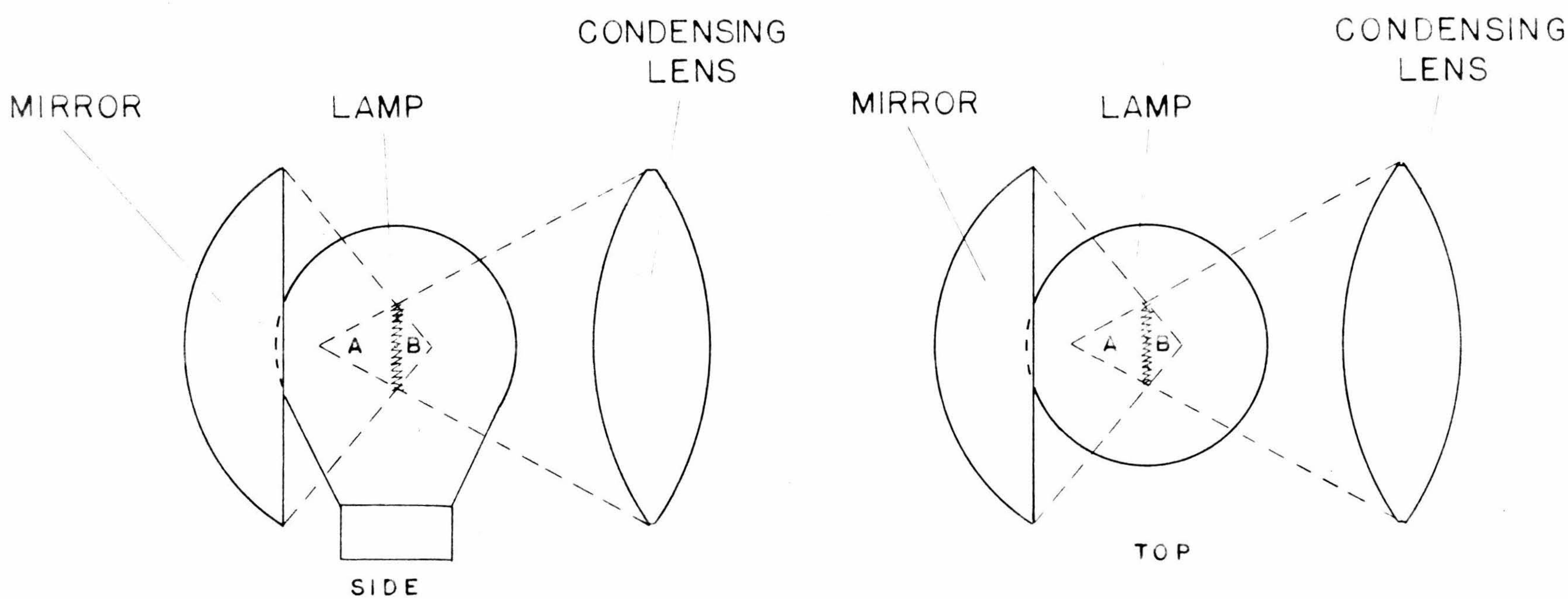
R - magnification power
f - efl of lens
u - distance to prime image
v - distance to formed image

for values of R from 1 to 100, the corresponding values of u and v are as shown in Table I.

The screen in the ViewAll is located $17\frac{1}{2}$ inches in front of the projection lens (when in the position for viewing). This requires a maximum distance from the film to the lens of 4 3/8 inches. When projecting any distance over 30 feet, the lens must be $3\frac{1}{2}$ inches from the film. (Although the lamp is not strong enough to permit such great projection throws, the use of the great distance here gives the design a range sufficient to meet all possible conditions).

The total travel of the lens will therefore be from 4 3/8 inches to $3\frac{1}{2}$ inches or 7/8 inches. The projection lens will be mounted with a rack and pinion designed to permit this travel.

EFFECTIVE UTILIZATION OF LIGHT



A = 63° B = 110°

FIGURE 19

FULL SCALE

APPENDIX F

LIGHTING CALCULATIONS

It is important to determine the intensity that may be expected in the image projected by the ViewAll. For these calculations, certain tests and experiments were made. The assumptions, tests and results are as follows:

Assumptions:

The bulb: It is assumed that the 100 watt projection lamp will produce a total of 2000 lumens or 20 lumens per watt. (Incandescent lamps generally produce from 18 to 21 lumens per watt depending upon the % of rated voltage at which they are operated). (In a small, short-life bulb like the S11 100 where the efficiency is high, it is a reasonable assumption that the figure 20 lumens per watt be used.)

The lenses: Reflection losses are assumed to be 1% at each air-glass surface. This loss factor is greater than may be theoretically obtained with coated lenses, but this over estimate will take care of other losses, such as absorption of light in the glass, that can not be readily calculated.

The mirrors: Front surfaced mirrors of polished aluminum have very low losses and these losses may be neglected.

Tests:

From the plan and elevation drawings of the lamp, condensing lenses, and mirror (seen in figure 19) it is seen that the

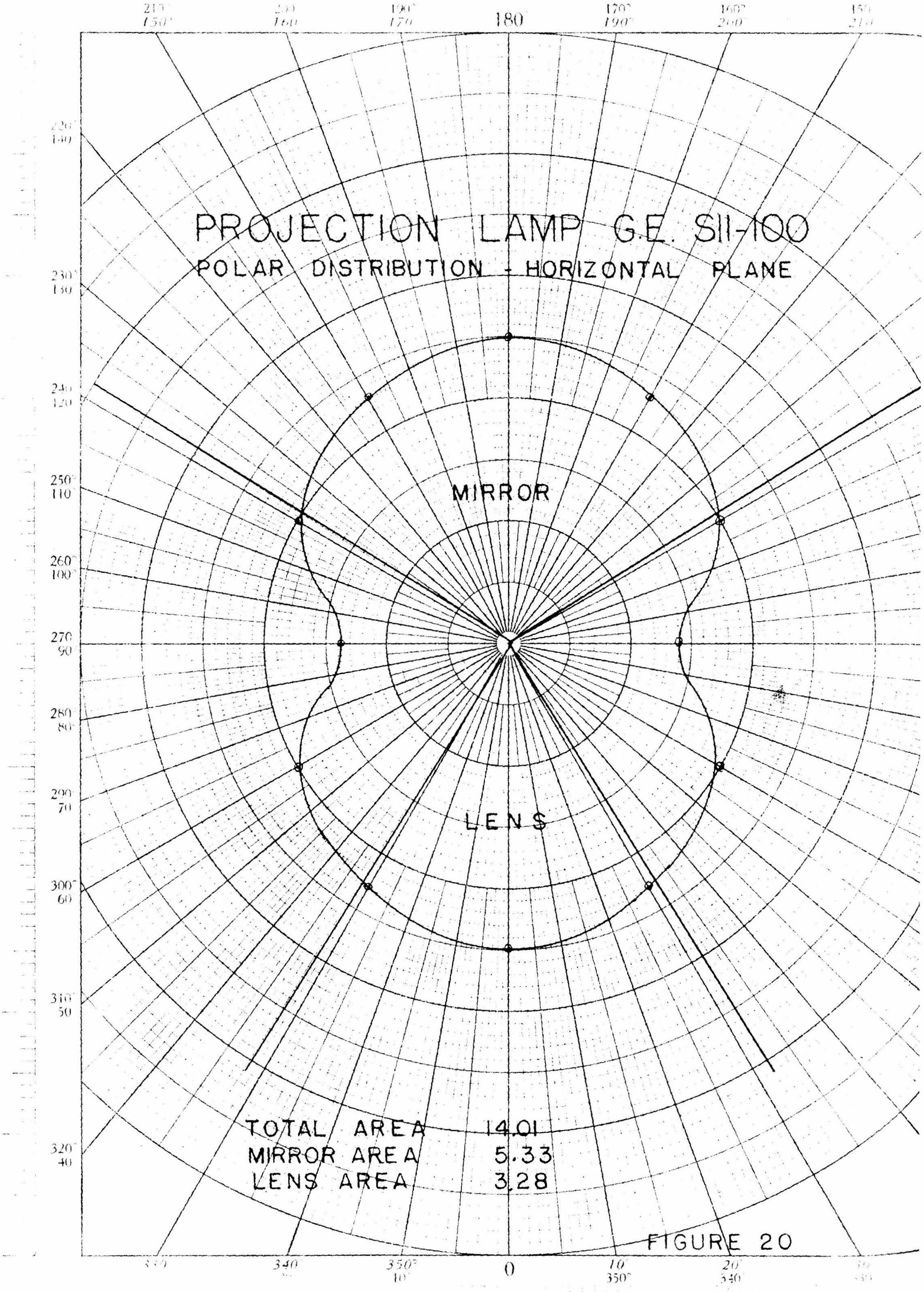

PROJECTION LAMP G.E. S11-100
POLAR DISTRIBUTION - HORIZONTAL PLANE
MIRROR
LENS
TOTAL AREA 14.01
MIRROR AREA 5.33
LENS AREA 3.28
180
0
270
90

FIGURE 20

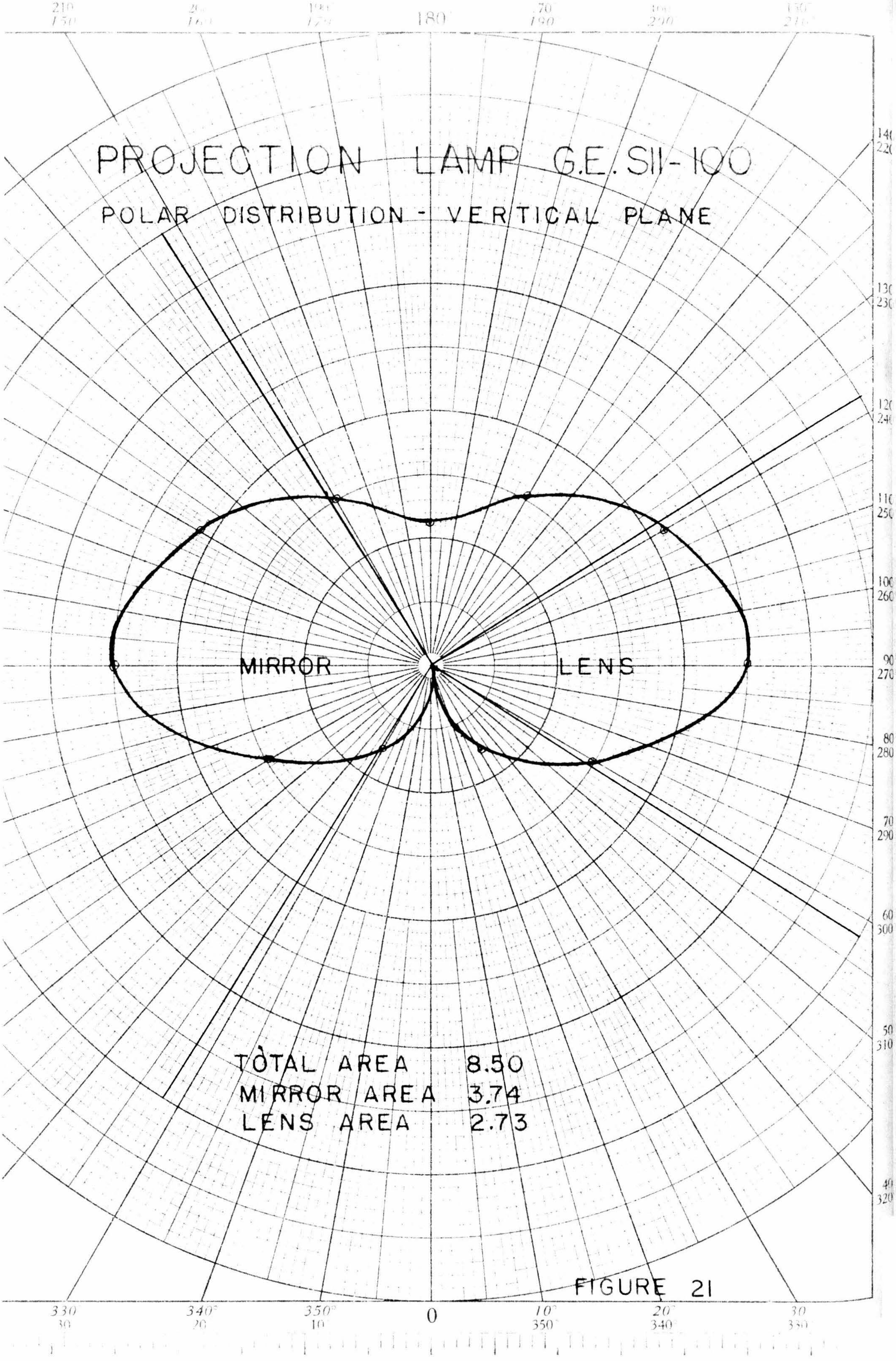

PROJECTION LAMP G.E. SII-100
POLAR DISTRIBUTION - VERTICAL PLANE
MIRROR
LENS
TOTAL AREA 8.50
MIRROR AREA 3.74
LENS AREA 2.73

FIGURE 21

light from a solid angle of 110° falls upon the mirror and that light from a solid angle of 63° falls upon the condensing lenses.

To determine the amount of the 2000 lumens produced by the lamp that fall within our useable 110 plus 63 degrees, it is necessary to determine the distribution of the light from the bulb. To do this an intensity curve for the bulb was determined by experimentation and the results are plotted on polar coordinates in fig. 20 and fig. 21. Fig. 20 shows the distribution pattern in the horizontal plane of the filament while fig. 21 shows the distribution pattern in a vertical plane taken normal to the filament.

By superimposing upon these polar distribution charts the angles 110° and 63° showing the amount of light that is used, it is possible to determine the percentage of the light produced that is actually used. This percentage is represented by the ratio of the total area under the curve compared to the area of the used portion.

In the horizontal plane we have:

Total area.................14.01 sq. in.

Mirror area.......5.33 sq.in.

Lens area.........3.28 sq.in.

Total used area 8.61 sq.in.

Therefore: 8.61/14.01 equals 61.5% light used.

REFLECTION LOSSES IN OPTICAL SYSTEM

FIGURES REPRESENT % OF ORIGINAL LIGHT

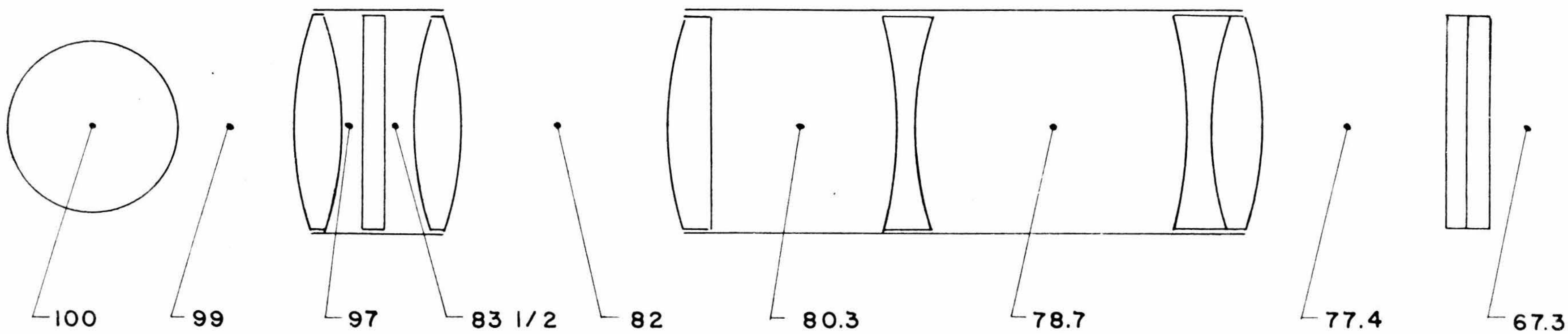
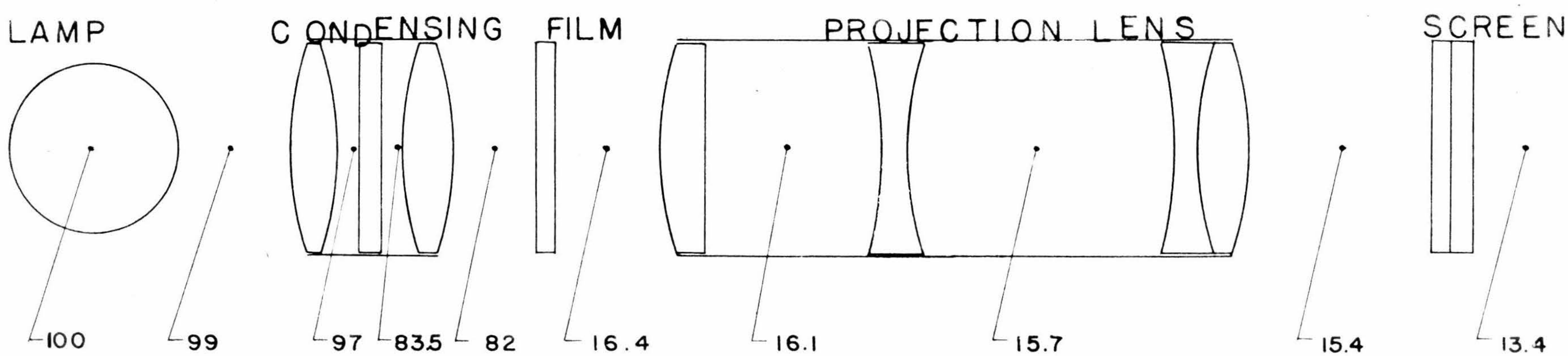


FIGURE 22



In the Vertical plane we have:

Total area................8.50 sq. in.

Mirror area.......3.74 sq. in.

Lens area.........2.73 sq. in.

Total used area 6.47 sq. in.

Therefore: 6.47/8.50 equals 76% light used.

The total percent of the light used then is:

76% of the vertical times 61.5% of the horizontal

.76 x .615 or .468

Therefore 46.8% of the light emmited by the bulb is actually used. This means that of the 2000 lumens produced, .468 x 2000 or 936 lumens are used.

Next the percentage density of the heat absorbent glass, the screen, and an average transparency were determined. They were determined by the following procedure: A footcandle meter was placed under a constant light source. Both the meter and the light source were held stationary. An intensity reading was taken with the light meter. The item to be tested was then placed directly over the lightmeter so that all the light entering the meter had to pass through the test specimen. Dividing the meter reading taken with the specimen in place by the original reading gave the per cent of light that the tested item let pass through. The results were as follows:

Heat absorbent glass---30/35 or 86%

Ground glass screen----30.5/35 or 87%

*Transparency..............6.8/35 or 20%

Now the losses for the entire system were calculated. Fig. 23 shows the results with an average transparency projected. Fig. 22 shows the results with no transparency in place. The figures in all cases represent the percent of the light that had reached that point.

Carrying through the final calculations we have:

46% of the light used.

13.4% of this light reaches the eye of the viewer in the form of an illuminated projected image.

This image will be illuminated with 2000 x .467 x .134 or 125 lumens.

<u>For viewing:</u>

Screen area (maximum) 6.75" x 6.75" or 45 sq. in. or 45/144 or .312 ft. sq. Then:

lumens = foot candles x ft. sq.

125 = f.c. x .312

or 400 foot candles illumination on the viewing screen.

This means that there is sufficient illumination to view the image under a direct light of 40 foot candles (and still maintain a brightness ratio of 10:1). Since rooms are not usually

---

* To obtain this average transparency figure, fifty transparencies were chosen at random and were tested. The results ranged from 2/35 or 6% to 15/35 or 43% with the average being 6.8/35 or 20%.

this brightly lit, it would be wise to reduce this brilliance some by the addition of a filter or screen with a density of about 50%. This would reduce the intensity of the screen to 200 foot candles, which is a more useable intensity, i.e., less danger of "hot spots" in the picture and less chance for eye strain.

For projecting:

It is assumed that in a house projector a projection throw of 18 or 20 feet will be as great as is desired. With a projection lens of $3\frac{1}{2}$" effective focal length, at 18 feet, the screen size will be 4.2' x 3.15' or 13.3 sq. ft. Again:

lumens = foot candles x sq. ft.

125 = foot candles x 13.3

or 9.4 foot candles illumination of the viewing screen. This means that in a darkened room of about 1 foot candle intensity, even with a throw of 18 feet, there will be sufficient screen brilliance for comfortable viewing.

APPENDIX G

COST ANALYSIS

TOP CASE: Material die cast aluminium. @ 22¢/#
Volume 23.5 in^3
Weight 2.083#
Material cost 45.8¢
material cost x 3 = Mfg. cost
45.8¢ x3= $1.37
Finishing - anodizing @ 10¢/ft^2 (done on contract)
3 ft^2 x 10 = 30¢
Total Manufacturer's cost **$1.67**

BOTTOM CASE: Material die cast aluminium @ 22¢/#
Volume 21.21 in^3
Weight 1.966#
Material cost 43.3¢
material cost x 3 is mfg. cost
43.3¢ x3= $1.30
Finishing - anodizing @ 10¢/ft^2
2 ft^2 x 10 = 20¢
Total manufacturer's cost **$1.50**

MOUNTING PLATE: Material die cast aluminium @ 22¢/#
Volume 17.77 in^3
Weight 1.64#
Material cost 36.1¢
material cost x 3 is mfg. cost
36.1 x 3 = $1.08
Total Manufacturing cost **$1.08**

LAMP REFLECTOR
SLIDE CHANGING CROSS BAR
PROJECTION HOLE COVER
SLIDE CHANGER GRIPPER PLATE
2-PRESSURE PADS FOR SLIDE CHANGER
Material zinc die cast @ 20¢/#
Volume .75, .75, .179, .67, 1.5 or total 4.46 in^3
Weight 1.16#
Material cost 23.2¢
Material cost x 3 = mfg. cost
23.3¢ x 3 = 69¢
Total manufacturing cost **$ .69**

LAMP HOUSING
CONDENSING LENS HOLDERS -2
SCREEN BRACKETS -2
SLIDE CHANGING LEVER
SCREEN HOLDING CLAMPS -3

Material sheet metal, stamped and formed @ 6.7¢/#
Area 87, 12, 1.5, 1.5, 27.5 or total 134.5 in^2
Weight 1.31#
Material cost 8.77¢
material cost x 3 = mfg. cost
8.77 x 4 = 35.2¢
Total manufacturing cost **$.35**

RODS FOR SLIDE FEEDER -2
CONTROL RODS -3

Material 1/8" drill rod @ 50¢/#
Length total 20" or 1 2/3'
Weight .0638#
Material cost 3.19¢
material cost x 3 = mfg. cost
3.19 x 3 = 9.2¢
Total manufacturing cost **$.09**

PLASTIC CONTROL KNOBS -3

Material Urea Phenolic plastic @ 20¢/#
Volume 6.26 in^3 x 3, total 1.878 in^3
Weight .0978#
Material cost 02¢
material cost x 8 = mfg. cost
Total manufacturing cost **$.16**

ACRYLIC PLASTIC SCREEN

Material plastic @ 49¢/#
Volume 6.15 in^3
Weight .262#
Material cost 12.85¢
material cost x 3 = mfg. cost
12.85 x 3 = 39¢
Total manufacturing cost **$.39**

GROUND GLASS SCREEN

Estimate from optical supply catalogue **$.20**

HEAT ABSORBENT GLASS

Estimate from optical supply catalogue **$.10**

FRONT SURFACED MIRRORS -2

Estimate from optical supply catalogue **$.75**

LAMPS -2	
Estimate from G.E. price list	$.75
MICRO SWITCH	
Estimate from radio parts catalogue	$.75
ELECTRIC CORD	
Estimate from radio parts catalogue	$.25
MISCELLANEOUS MACHINE PARTS	
Assorted screws -25 Hinge pin screws -2 Dime slot screw Washers (heads for cord posts) -4	$.25
COIL SPRINGS -6	
Each spring 1½" long 2/16"d	$.12
PROJECTION HOLE COVER CAP ATTACHMENT	
Brass tubing 2½"d 3/8" long threaded	$.15
LENSES	
Projection lens system plus condensing lens as per Eastman Kodak Price list.	$8.00

Note: Estimates taken from price lists in the following manner: List price divided by 2 to give an estimate of mfg. cost. Mfg. mark-up varies from 3 to 8 depending upon the nature of the manufacturing process involved.

ASSEMBLY LABOR	
Estimated as 1/2 hour at mfg. charge of $5.00 per hour. Total assembly labor cost	$2.50
TOOLING CHARGES	
Estimated - 3 die casting molds for the aluminium die cast parts @ $5000 each. One multiple cavity mold with six different cavities for the six die cast zinc parts @ $1000 per cavity. Other assorted assembly jigs at $1000. Total tooling charges $22,000. For an estimated run of 10,000 units, the total tooling charges per unit is $2.20	
Total tooling burden	$2.20
TOTAL MATERIAL MFG. COSTS	$17.25
TOTAL MANUFACTURING COST	$21.95

ESTIMATED SELLING PRICE

Manufacturing cost x 3 = Selling price

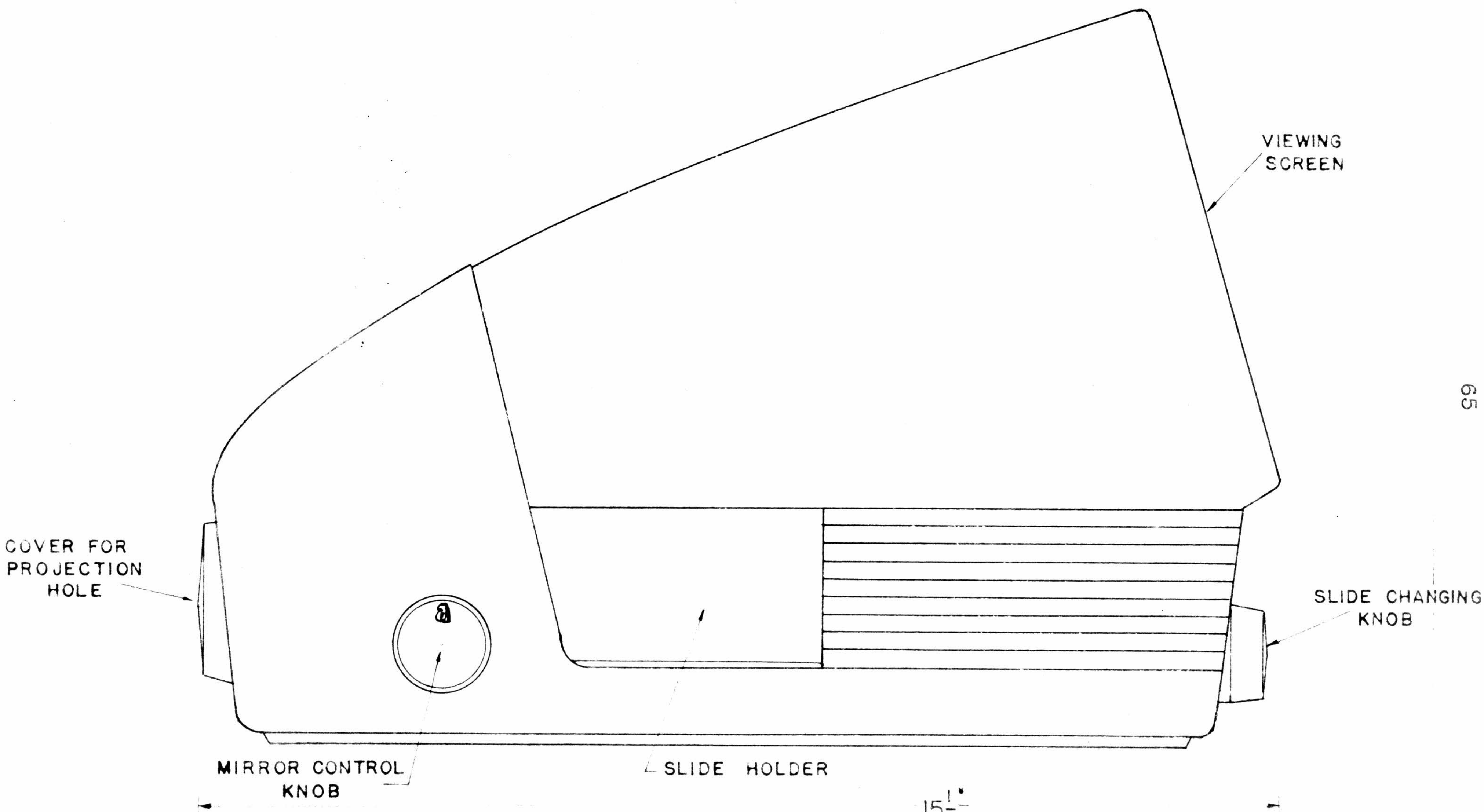
$22 x 3 = 66.00

Estimated selling price	$66.00

A P P E N D I X H

Supplementary drawings of the ViewAll and important parts

SIDE ELEVATION :NOTE: RIGHT SIDE SIMILAR



1/2 SCALE

FIGURE 24

FRONT & REAR ELEVATION

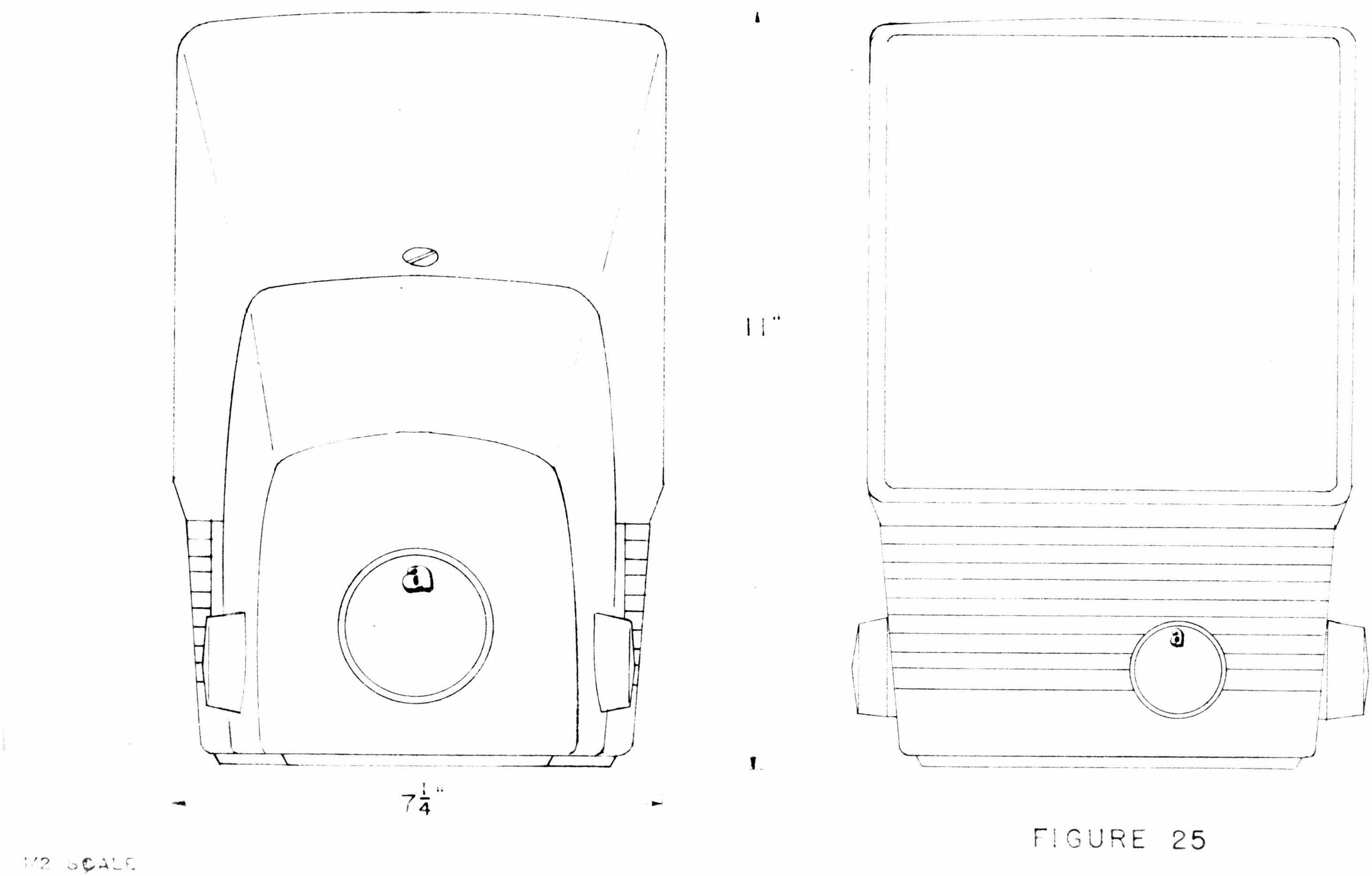
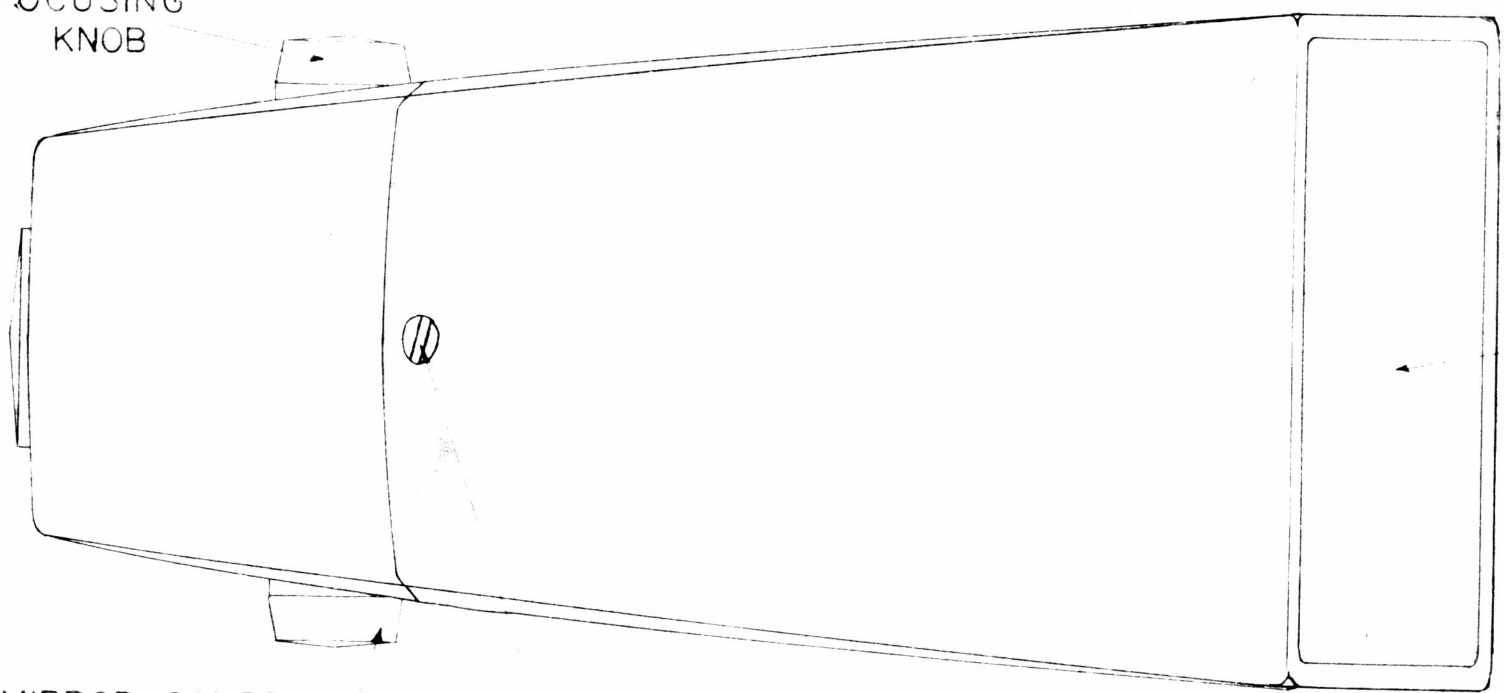


FIGURE 25

TOP VIEW



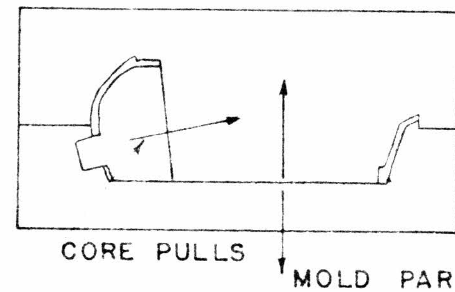
1/2 SCALE

FIGURE 26

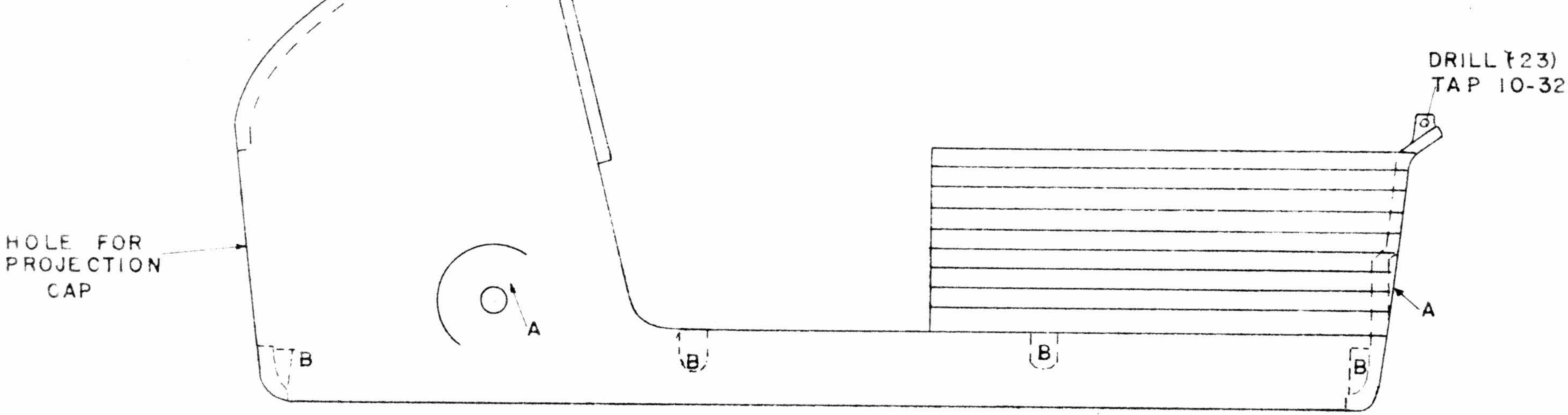
BOTTOM CASE

DIE CAST ALUMINIUM
ANODIZED DARK BLUE-GREY

A-CAST DEPRESSION FOR KNOB
B-BOSS FOR ASSEMBLING TO BOTTOM PLATE

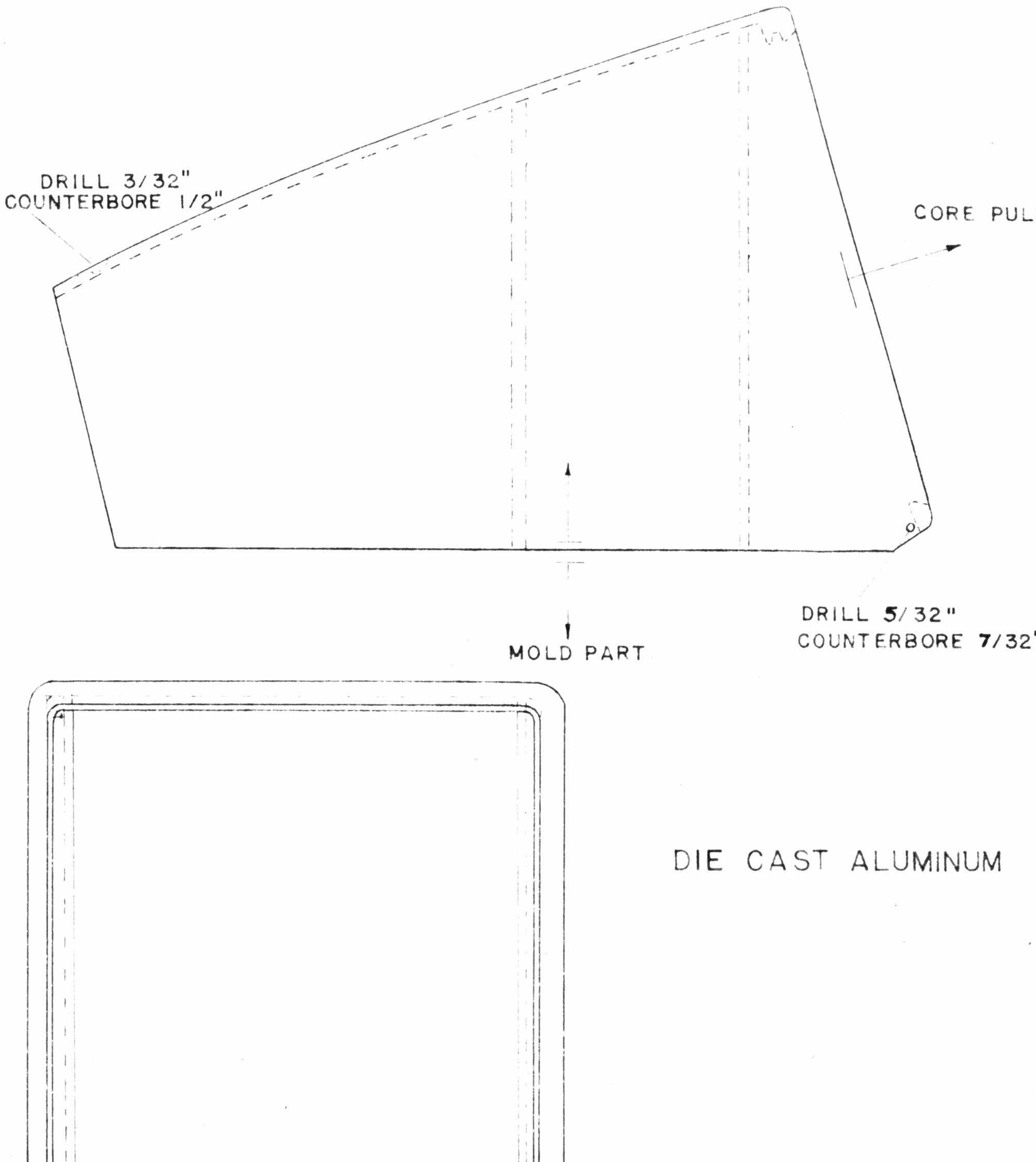


SCHEMATIC OF MOLD THROUGH ℄



1/2 SCALE

FIGURE 27

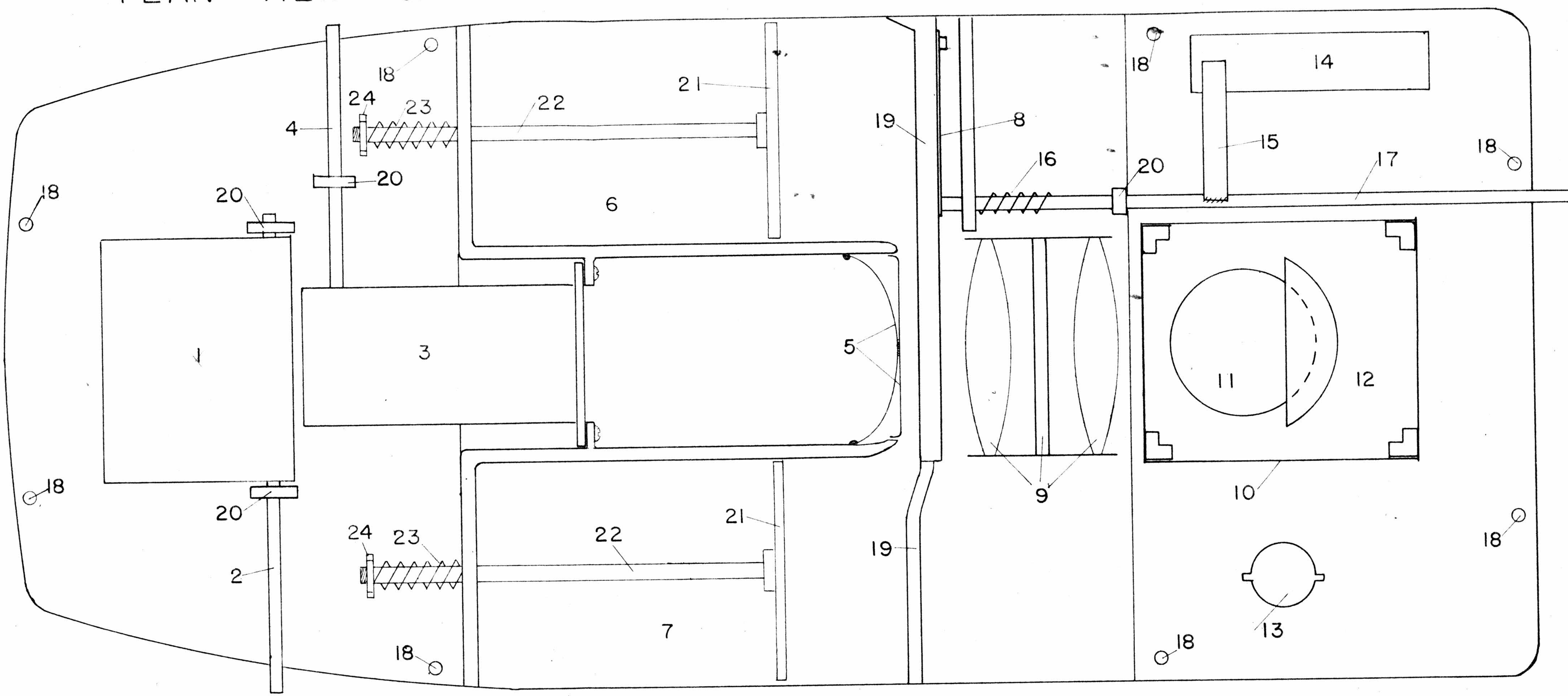


TOP CASE

SCALE

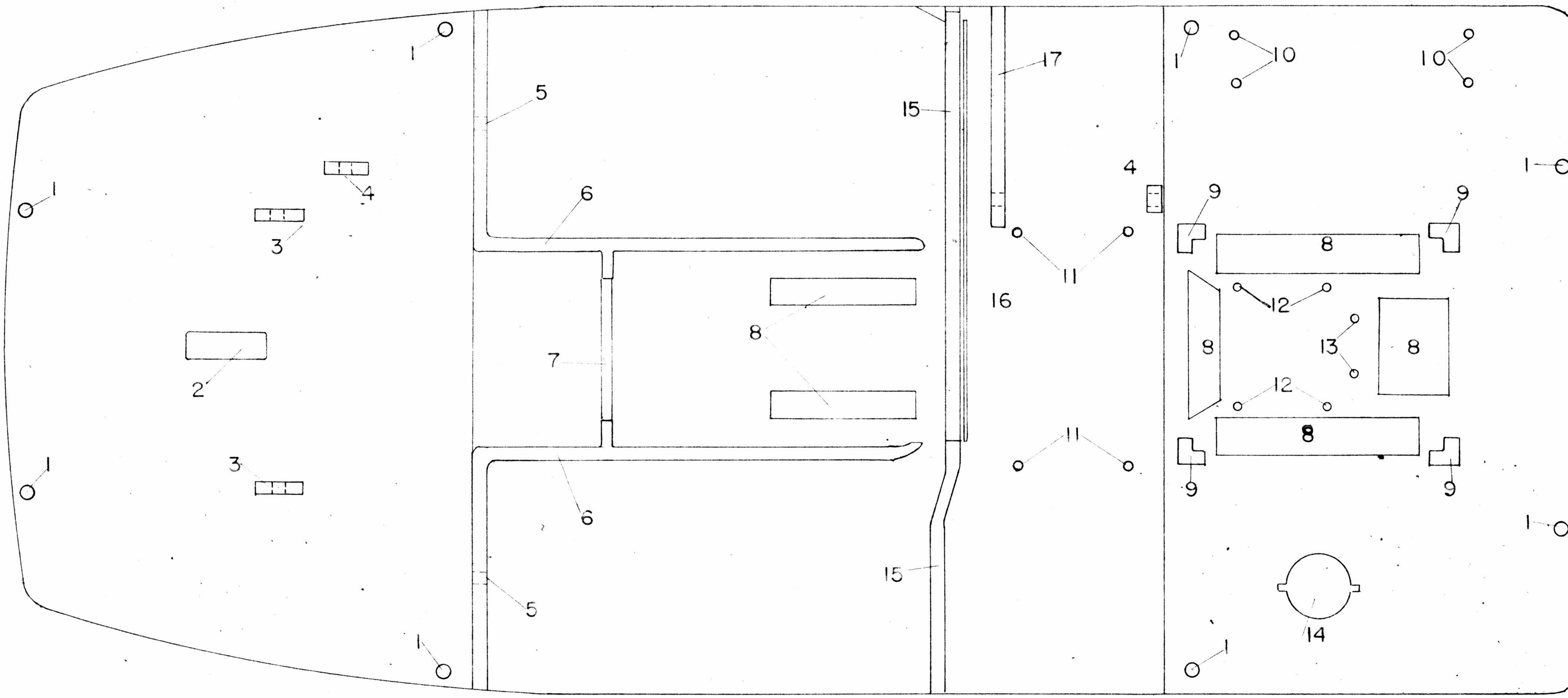
FIGURE 28

PLAN VIEW OF BASE SHOWING PARTS ASSEMBLY - FIGURE 29



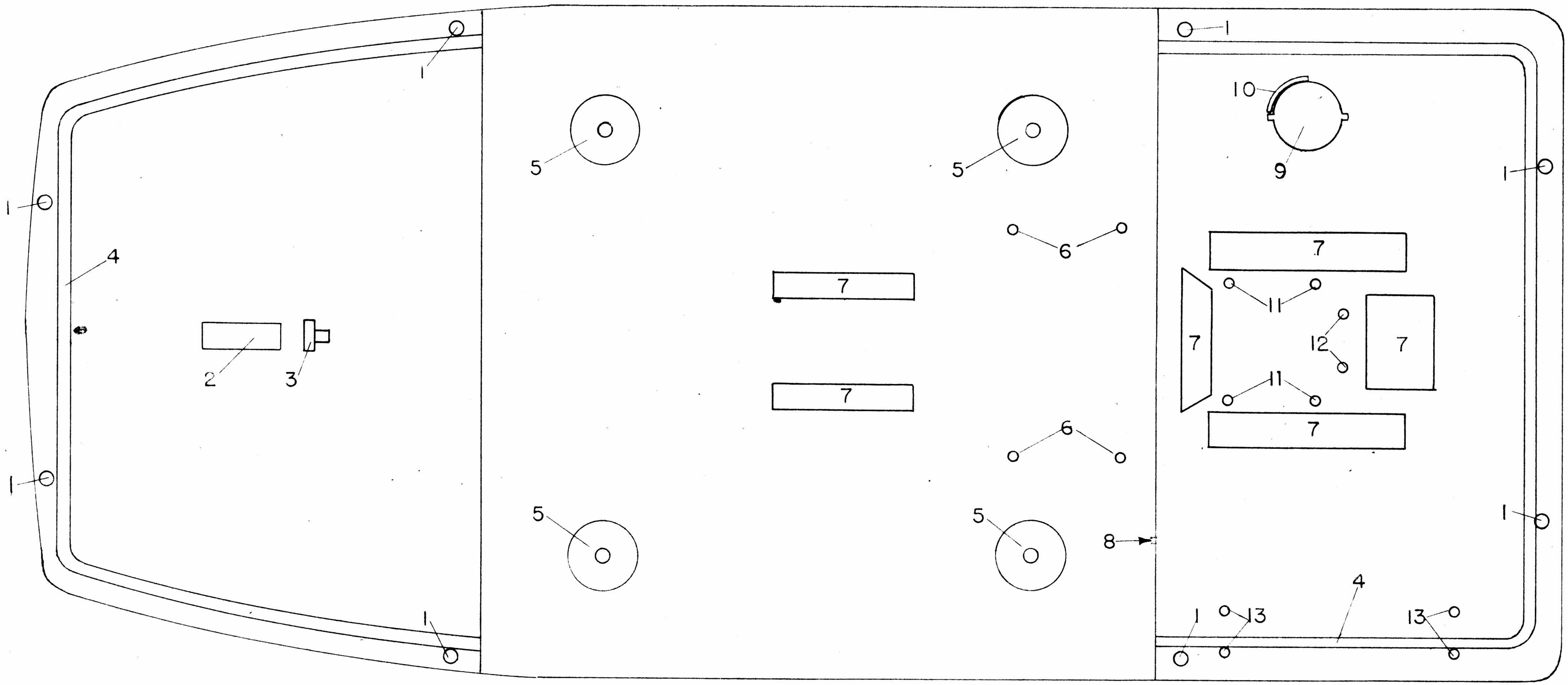
1 MIRROR
2 MIRROR CONTROL
3 PROJECTION LENS
4 LENS CONTROL
5 SPRING & GUIDE
6 FILM LOADING HOLDER
7 FILM HOLDER
8 SLIDE CHANGER LEVER
9 CONDENSER LENSES
10 LAMP HOUSING
11 LAMP
12 REFLECTOR
13 SPARE LAMP HOLDER
14 MICRO SWITCH
15 SWITCH CONTROL
16 RETURN SPRING
17 SLIDE CHANGING CONTROL
18 ASSEMBLY SCREW HOLES
19 GUIDE FOR SLIDES
20 BUSHINGS, CAST IN
21 SLIDE PUSHER
22 SLIDE PUSHER ROD
23 SPRING
24 NUT

PLAN VIEW OF BASE AS DIE CAST FIGURE 30



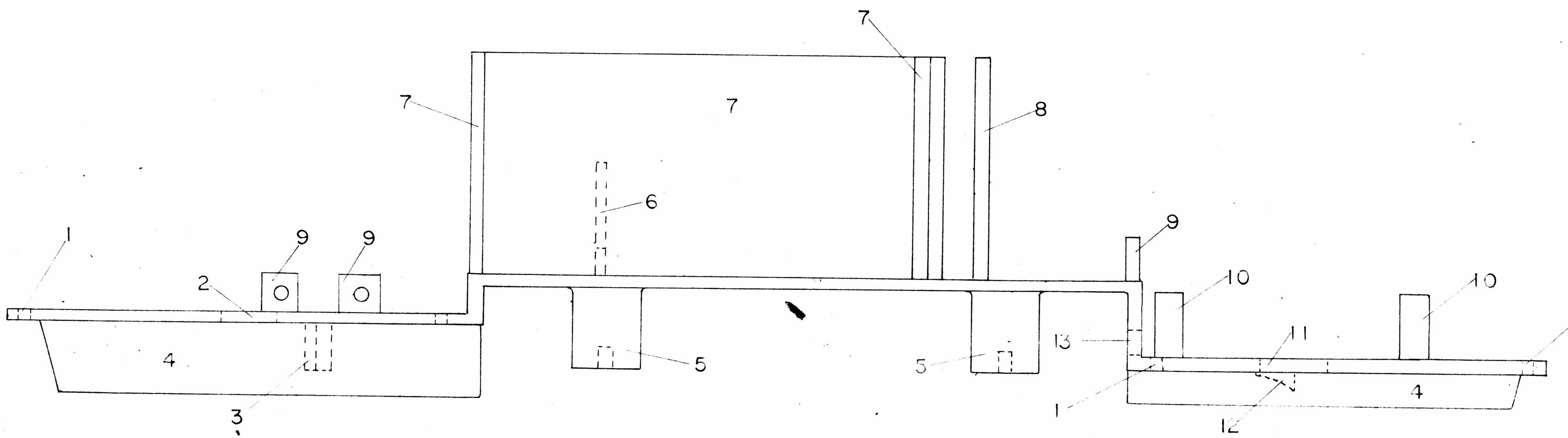
1 ASSEMBLY SCREW HOLES
2 HOLE FOR SPRING
3 LUGS FOR BUSHINGS
4 LUG FOR BUSHING
5 HOLE FOR SLIDE PUSH
6 WALL
7 YOKE FOR LENS
8 VENT HOLES
9 LUG FOR CHIMNEY
10 HOLES FOR MICRO SW.
11 HOLES FOR LENS M'TING
12 HOLES - LAMP BASE
13 HOLES - MIRROR MOUNT
14 SPARE LAMP HOLE
15 WALL - SLIDE GUIDE
16 SLOT - SLIDE CHANGER
17 WALL

BOTTOM VIEW OF BASE AS CAST FIGURE 31

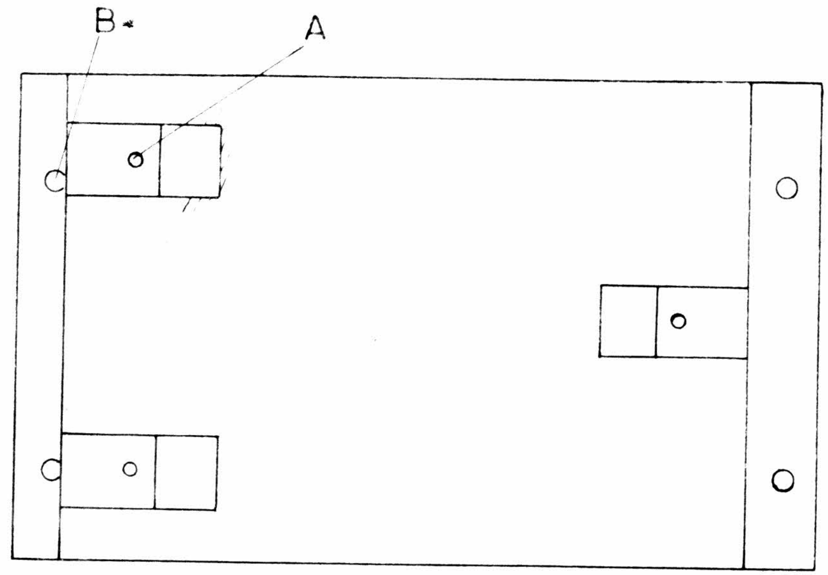


1 ASSEMBLY SCREW HOLES
2 HOLE FOR SPRING
3 LUG FOR SPRING
4 FOOT FOR MACHINE
5 CORD WINDING POST
6 HOLES - CONDENSER MOUNTING
7 VENT HOLES
8 HOLE FOR CORD (HORIZONTAL)
9 SPARE LAMP HOLE
10 LOCKING CAM - SPARE LAMP
11 LAMP BASE HOLES
12 HOLES FOR MIRROR MOUNT
13 HOLES FOR MICRO SWITCH

SIDE VIEW OF BASE - FIGURE 32



1 ASSEMBLY SCREW HOLES
2 HOLE FOR SPRING
3 LUG FOR SPRING
4 FOOT FOR MACHINE
5 CORD WINDING POST
6 YOKE FOR LENS SUPPORT
7 WALL FOR SLIDE HOLDER
8 WALL
9 LUG FOR BUSHING
10 LUG FOR CHIMNEY
11 HOLE FOR SPARE LAMP
12 LOCKING CAM FOR SPARE LAMP
13 HOLE FOR CORD

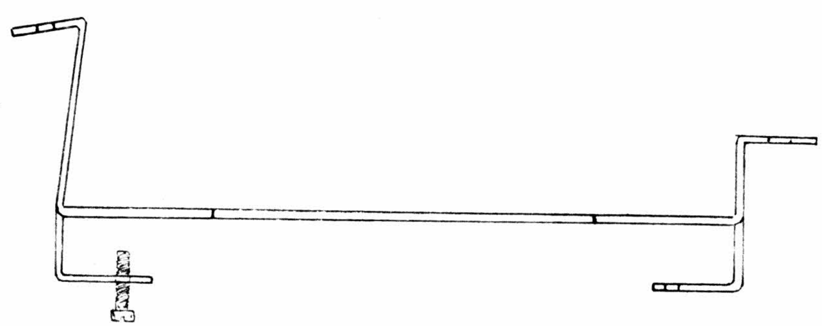


BRACKET FOR UPPER MIRROR

STAMPED AND BENT FROM 20 GAGE SHEET STEEL

A– DRILL (33) AND TAP (4-40)
B– DRILL 5/32"

NOTE FELT PAD PLACED BETWEEN MIRROR AND BRACKET



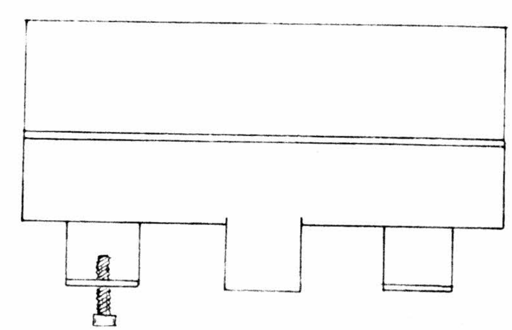
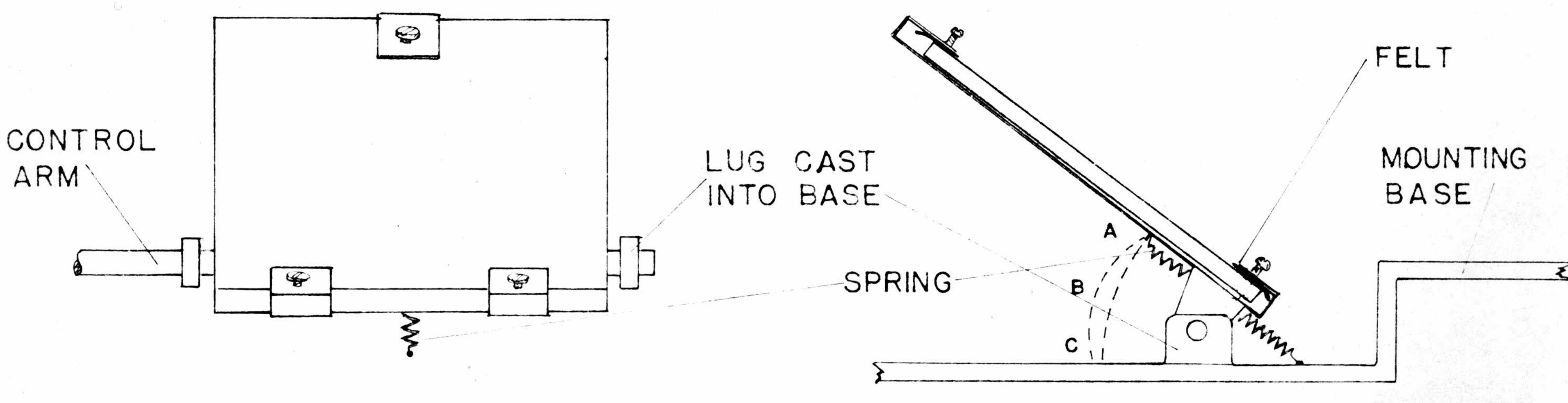


FIGURE 34

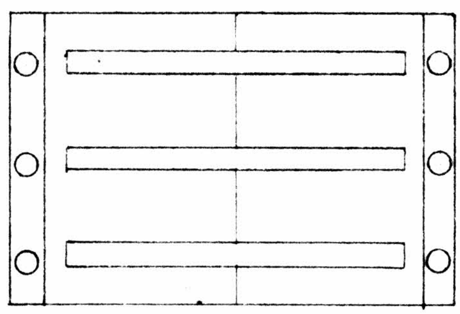
BOTTOM MIRROR BRACKET & SPRING



NOTE: SPRING TENSION GREATER IN POSITIONS A & C THAN IN B. SPRING THEREFORE HOLDS MIRROR IN EITHER UP OR DOWN POSITION.

FIGURE 35

CONDENSER LENS HOLDER



HOLDER OF TWO SIMILAR PIECES OF STAMPED SHEET STEEL - 22 GAGE

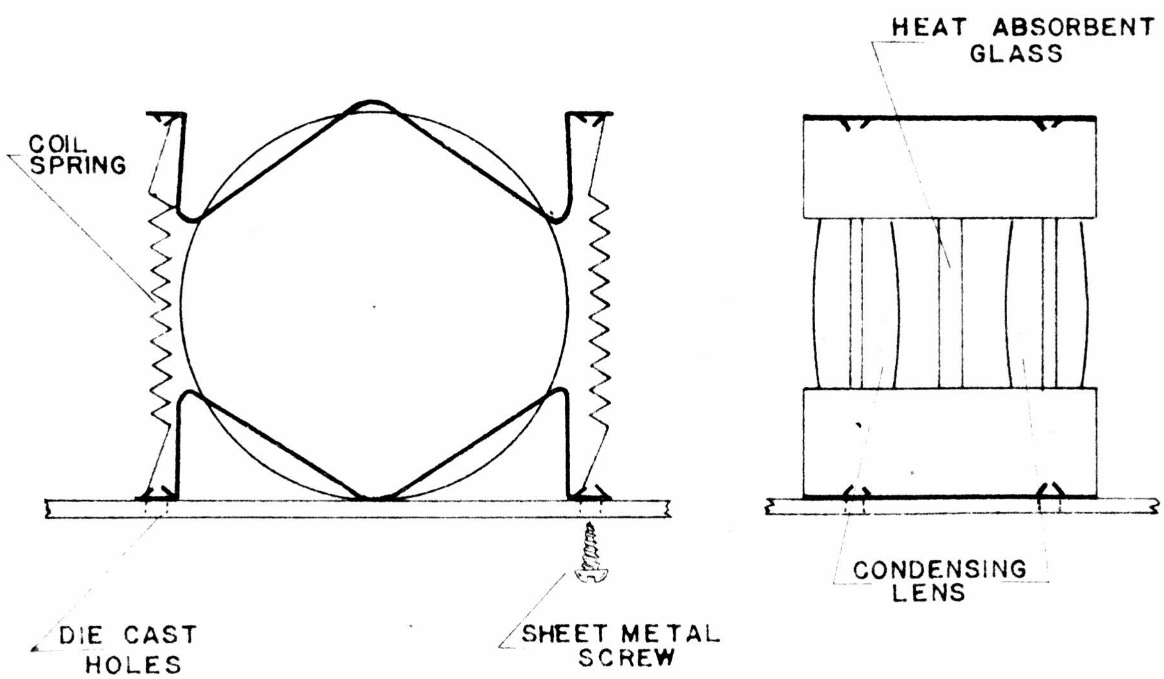


FIGURE 36

SCREEN INSTALLATION

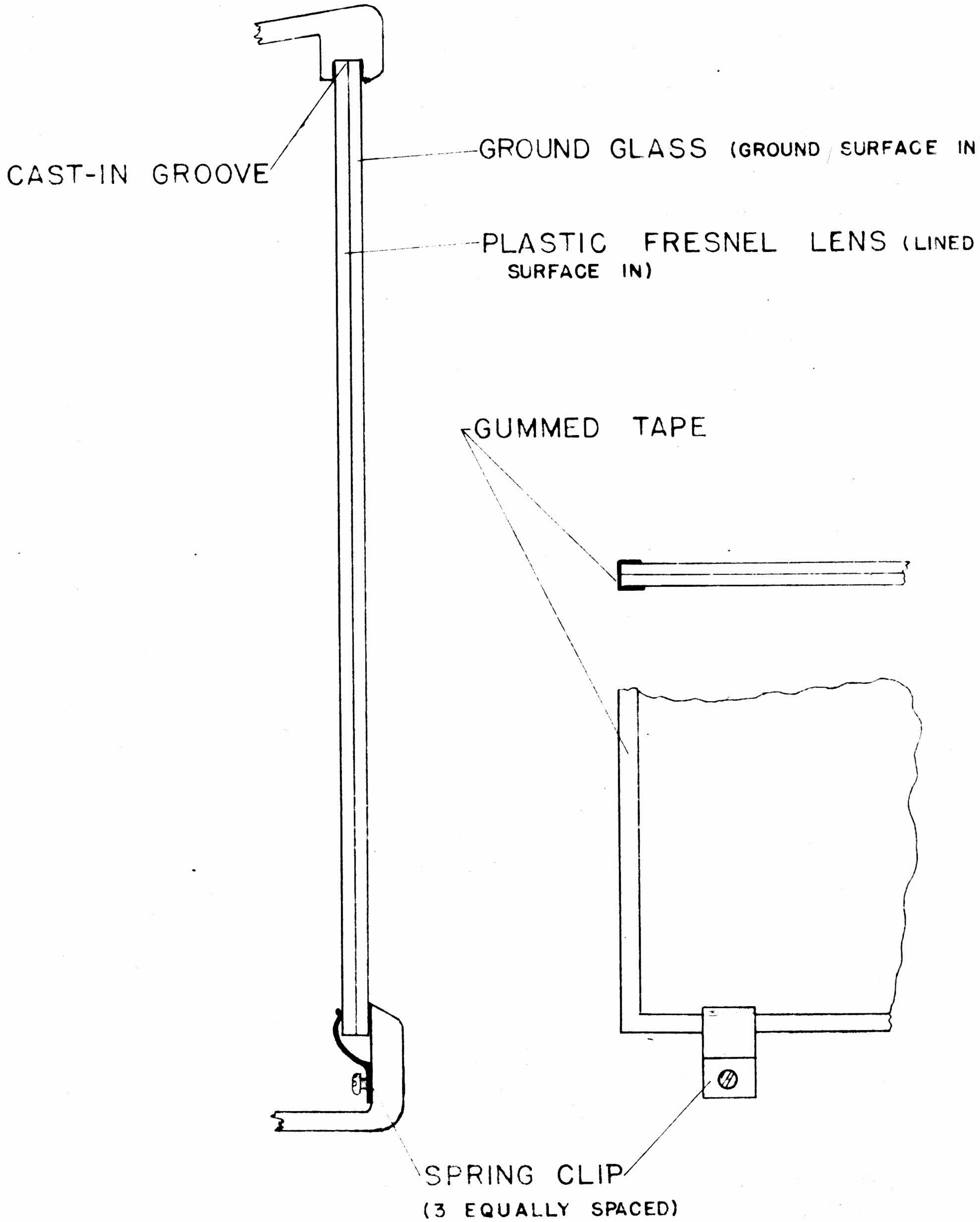
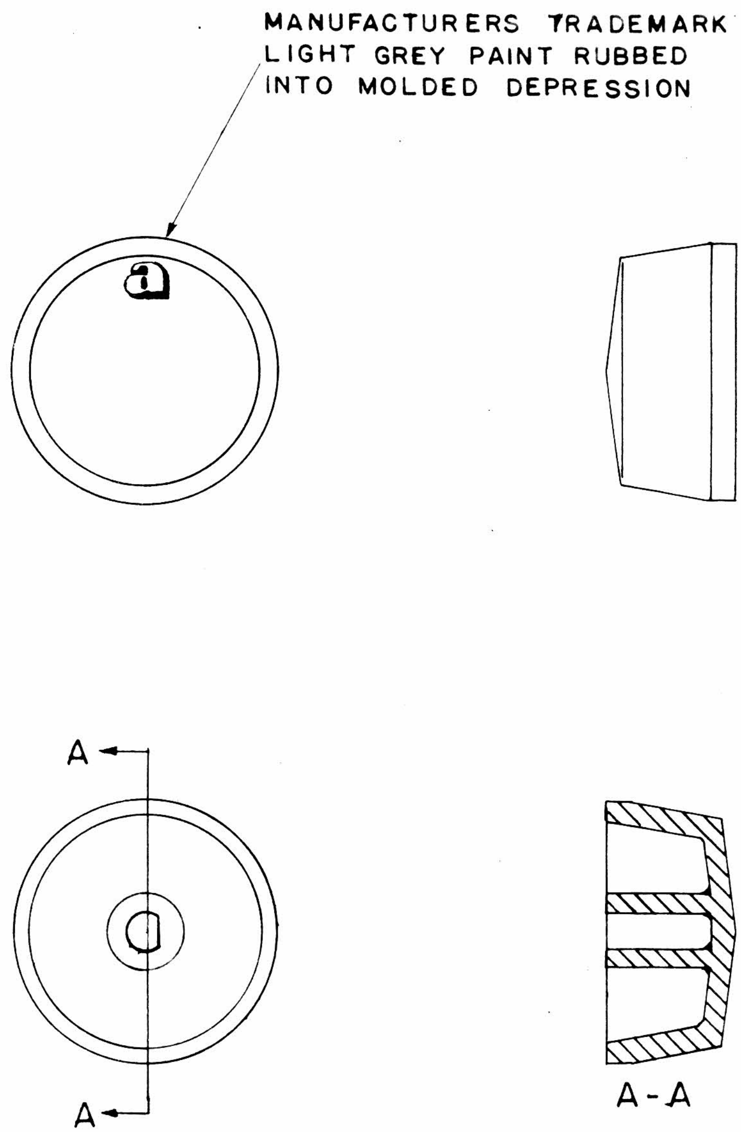


FIGURE 37

FULL SIZE



CONTROL KNOBS FOR VIEWALL

3 REQUIRED

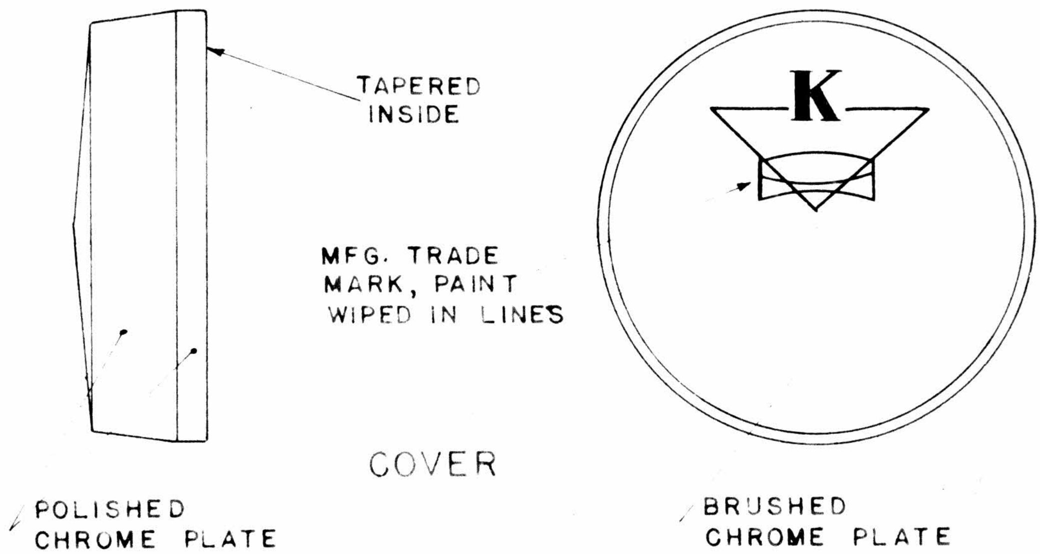
KNOBS COMRESSION MOLDED OF
RED UREA FORMALDEHYDE PLASTIC

MCINTOSH

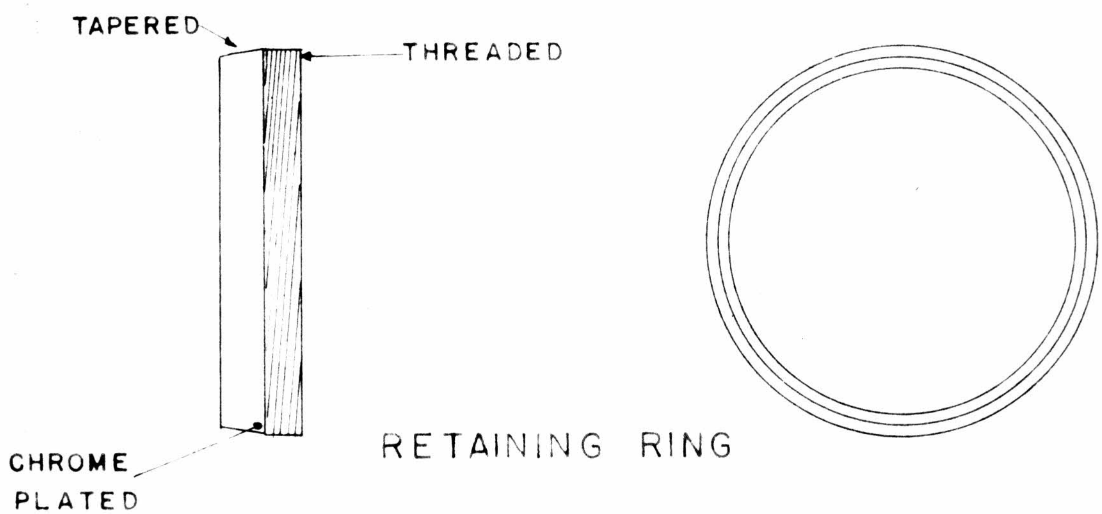
FULL SIZE

FIGURE 38

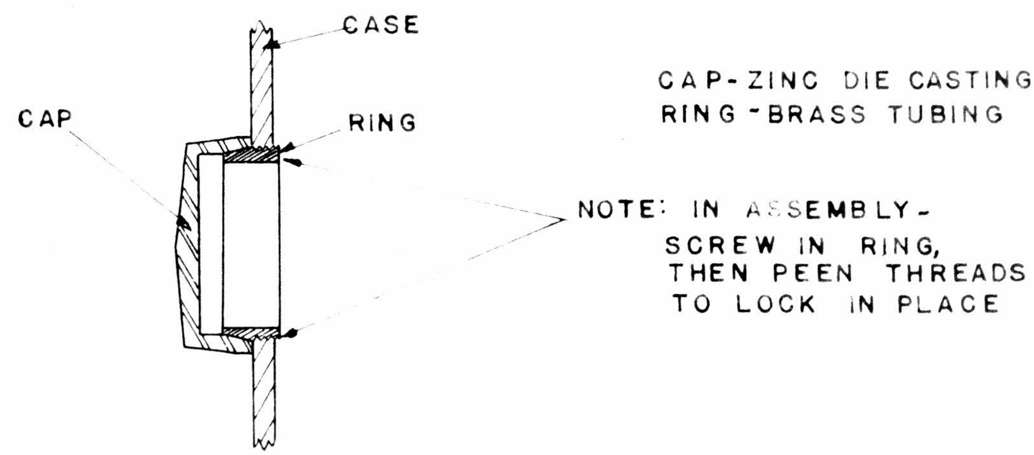
PROJECTION HOLE COVER



COVER



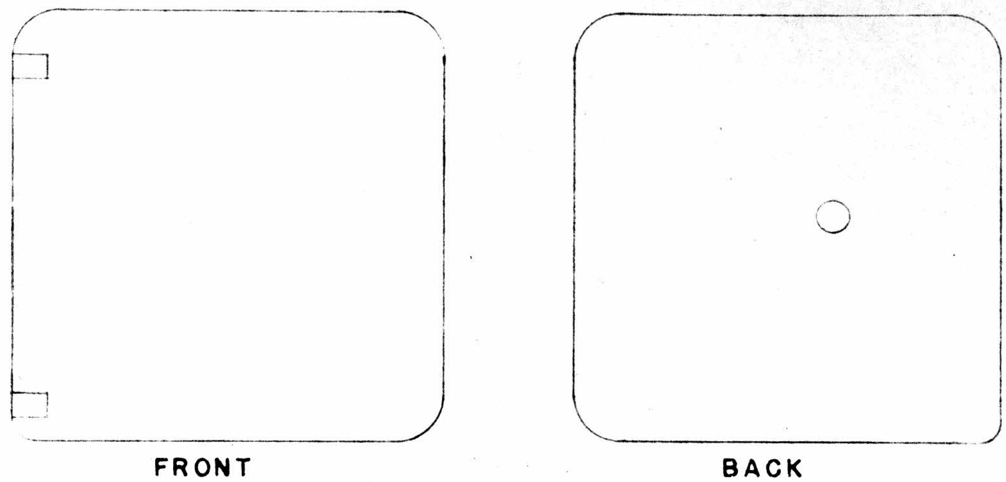
RETAINING RING

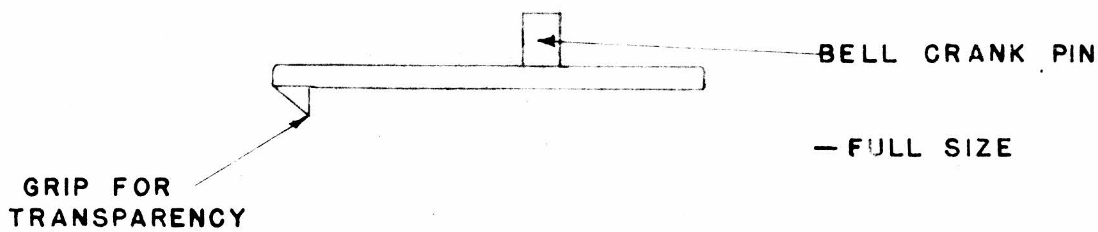


ASSEMBLY

FIGURE 39

SLIDE CHANGING MECHANISM — GRIPPER PLATE





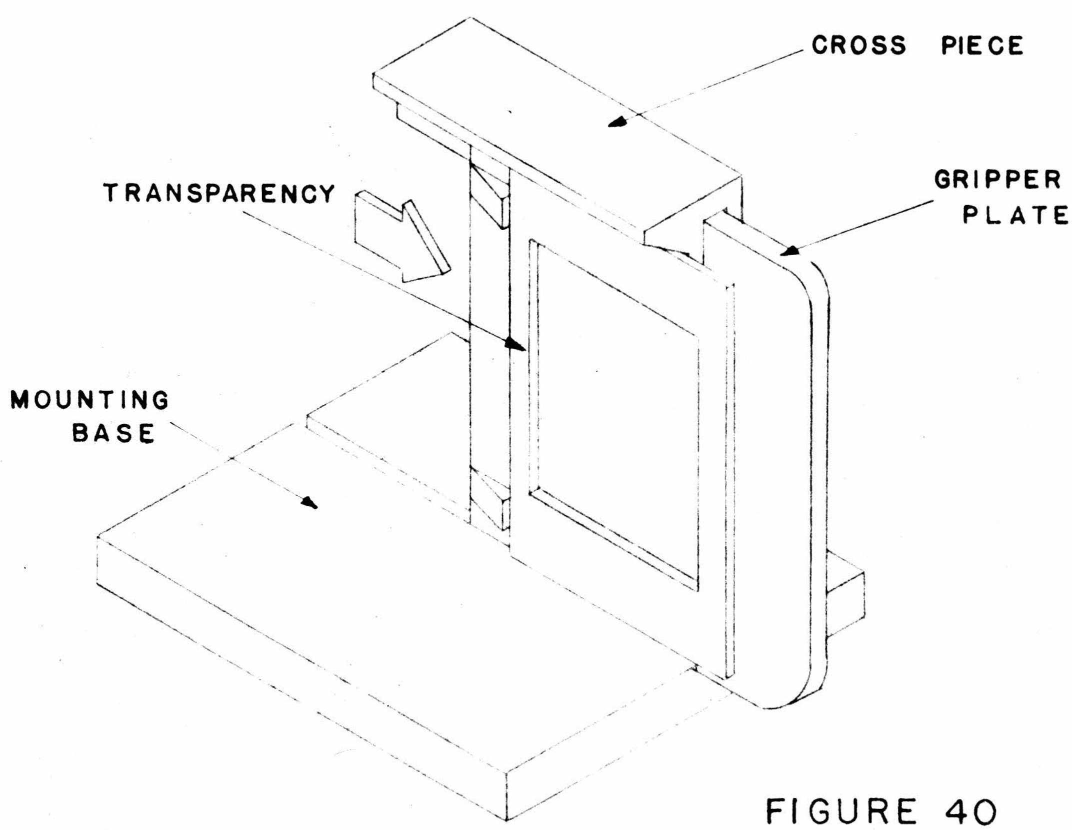
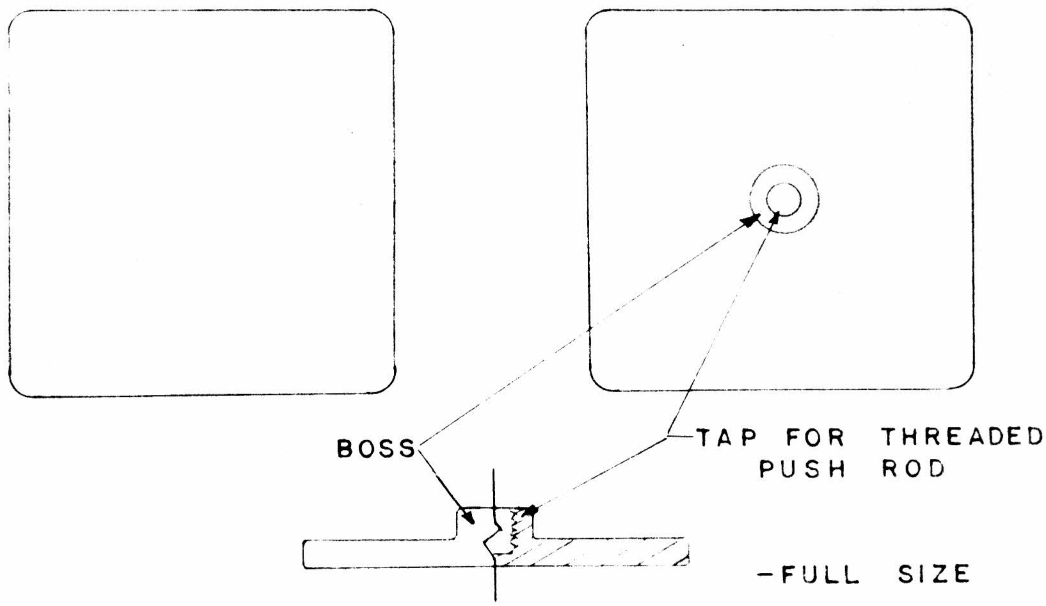


FIGURE 40

PRESSURE PAD — SLIDE HOLDER



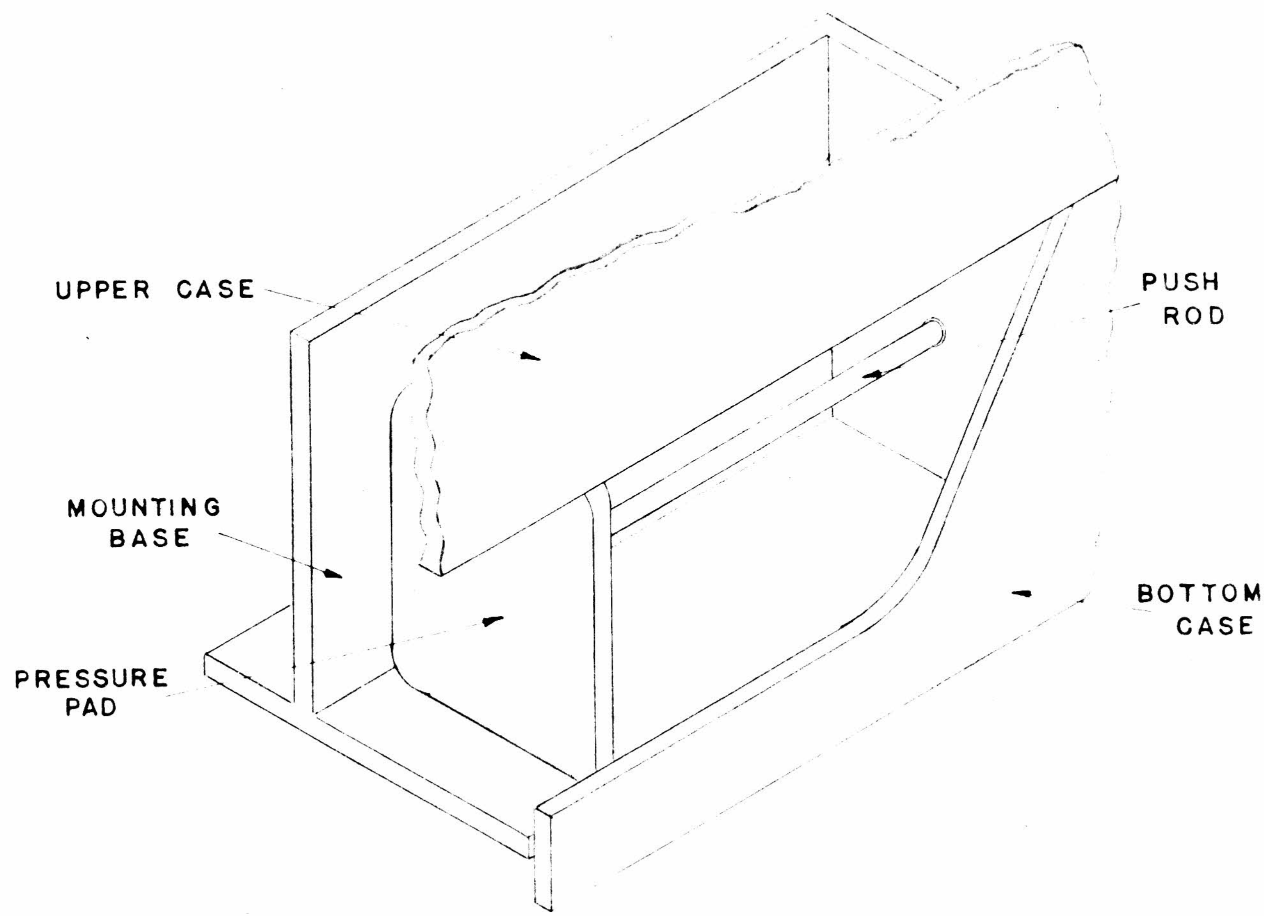


FIGURE 41

B I B L I O G R A P H Y

1. "Kodak Lenses" by Eastman Kodak Co., Eastman Kodak Co., Rochester, N.Y. 1946 Second Printing.

2. "Photographic Lenses and Shutters" by R.W. St.Clair, Ziff-Davis Publishing Co., Chicago, New York 1904, 10th Printing.

3. "Elements of Optics" by Joseph Valsek, McGraw-Hill Book Co., New York, 1932.

4. "Fundamentals of Optical Engineering" by Donald H. Jacobs, McGraw-Hill Book Co., 1943 1st edition.

5. "How to Build Projectors" by S. Brown, Edmund Salvage Co., Audibon, N.J., 1947.

6. "The Science of Seeing" by Luckiesh & Moss, D. Van Nostrand and Co., New York, 1948.

GENERAL REFERENCES

1. "The Theory of Optics" by Paul Drude, translated by Mann and Millikin. Longmans, Green, & Co., London 1939.

2. "Lecture Experiments in Optics" by B.K. Johnson, Edward Arnold & Co., London 1930.

3. "Introduction to Physical Optics" by J.K. Robertson, D. Van Nostrand Co., 3rd edition, 2nd printing New York, 1942.

4. "Business Statistics" by Riggleman & Frisbee.

5. "Modern Plastics Encyclopedia" 1948, Plastics Catalogue Corp., New York, 1948.

6. "Handbook on Designing for Quantity Production" by Herbert Chase, McGraw-Hill Book Co., New York, 1944.

7. "Developing Marketable Products" by Ben Nash, McGraw-Hill Book Co., New York, 1945.

8. "Die Casting for Engineers" by New Jersey Zinc Co., New Jersey Zinc Co., New York, 1942.