THE AMES DEMONSTRATIONS IN PERCEPTION

by WILLIAM H. ITTELSON

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A GUIDE TO THEIR CONSTRUCTION AND USE

By WILLIAM H. ITTELSON

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TO MY WIFE

Preface

In this volume I have attempted to present some of the more important demonstrations in perception that have been developed by Adelbert Ames, Jr., initially with the Dartmouth Eye Institute and later with the Institute for Associated Research at Hanover, New Hampshire. Taken together, these demonstrations have over a period of time acquired for themselves a name, "the Ames demonstrations;" a name that is emphatically rejected by Ames himself, who insists on the cooperative nature of the endeavor that produced them and generously overemphasizes the contributions of his coworkers. Nevertheless, the Ames demonstrations would not exist except for the unique combination of creative imagination and technical ingenuity of the man from whom they derive their name.

Taken as a whole, the demonstrations make it possible to observe perceptual phenomena ranging from the simplest visual experiences to extremely complex situations involving action. It is increasingly being recognized that they offer a coherent and comprehensive series of observations of importance to psychology, psychiatry, philosophy, education, art and architecture, and related fields.

Increased use of the demonstrations in research and educational centers has been accompanied by increased demand for details of their construction and operation. Although there are several manuscripts and publications describing one or more of the demonstrations, as yet there is no available source in which all the demonstrations are described or even listed and in which detailed information is presented from which they can be constructed.

The purpose of the present work is to fill this gap. With this end in view, each demonstration is treated separately as a physical piece of laboratory equipment, with the following information provided:

1. A brief introductory note;
2. A photograph or drawing of the apparatus;
3. A brief description of the apparatus and its operation;
4. An outline of typical observations using the apparatus, illustrated where possible;
5. A construction drawing of the apparatus.

Each construction drawing, together with the accompanying photograph and description, provides sufficient information for any reasonably competent laboratory technician to duplicate the apparatus. Minor construction details have for the most part been omitted both in the interest of simplicity and in the recognition that each laboratory favors its own particular type of construction depending on the facilities and materials available.

For the sake of brevity, only a very brief account of how to operate the apparatus and a few typical observations are offered with each demonstration. Even the simplest of the demonstrations can be used in a variety of ways and can show a wide variety of possible phenomena, a complete listing of which would be inappropriate and unnecessary. A little thought and ingenuity on the part of the interested investigator can be relied upon to reveal other potentialities of the demonstrations. The particular methods of operation and the observations that have been selected for description represent a distillation of the experiences of the author and others in viewing the demonstrations for themselves and in studying many hundreds of observers in one or more of the situations described. However, they are offered only as suggestions and illustrations.

[Readers who are interested in other ways of operating the demonstrations and other phenomena that they show are referred especially to manuals written by A. Ames, Jr. (2), Merle Lawrence (23), Ross Mooney (35,36,37,38), and Hoyt Sherman (32). A comprehensive summary of experimental and theoretical work utilizing these demonstrations can be found in Kilpatrick (23). Some of the demonstrations can also be seen in a motion picture, "Demonstrations in Perception," produced by the Naval Photographic Center at the request of the Professional Division, Bureau of Medicine and Surgery.]

The theoretically minded reader will note that no attempt has been made to explain the phenomena that are experienced. This is in keeping with the announced aim of this work. However, various interpretations and hypotheses have been formulated by the author and others and can be found in the references provided in the bibliography appended at the end of the text. In this connection it is to be hoped that the inclusion of most of the demonstrations in one volume, which necessitates their being considered as a whole, will make evident the futility of piecemeal theorizing and point up the fact that an adequate theoretical understanding of any one of the demonstrations should be broad enough to encompass them all.

The conception and construction of the various demonstrations, which took place over a long period of years, followed an evolutionary pattern. Experience with the simpler demonstrations led to the conception of the more complicated ones. The demonstrations are presented in this volume more or less in the order of their evolutionary development.

Each demonstration constitutes a scientific inquiry into a particular controlled concrete visual situation in which (1) certain aspects are kept constant, (2) certain other aspects are varied, and (3) the effect of such variations on certain other aspects is qualitatively determined. In all cases special care needs to be taken that visual indications of which the investigator may not even be aware are not operative. Many of the details of construction have been empirically worked out to accomplish this purpose.

The not inconsiderable financial investment represented by the development and production of the pieces of apparatus described in this volume has been provided largely by support from the Rockefeller Foundation, whose officers have offered both funds and enthusiastic encouragement most generously. Important assistance has also been obtained through grants from the Quaker Hill Foundation. In addition, special financing was made available by Mr. and Mrs. E. K. Hall, Jr. for the construction of the full size monocular distorted room and the binocular distorted rooms. This volume itself is one of several publications in preparation deriving from a larger project initiated by the Professional Division, Bureau of Medicine and Surgery, and subsidized by the Office Of Naval Research, contract N6onr 27014 with Princeton University and contract Nonr-496(01) with the Institute for Associated Research, under Navy Medicine's policy of encouraging basic research in perceptual phenomena as they relate to personality theory and social psychiatry. The opinions expressed, however, are those of the author and do not represent the opinions or policy of the United States Navy.

With the exception of the binocular distorted rooms, every one of the demonstrations was constructed by Kimball Whipple, in charge of the shop of the Institute for Associated Research. The drawings were for the most part done by Dr. Amos Chang, while I am indebted for the remaining to John Harrison Rudolph and Rudolph Amann. Special thanks are due to David E. Scherman, through the courtesy of Scientific American, for the photographs illustrating the effects obtained with the balloon, overlay, and rotating trapezoid demonstrations.

Hadley Cantril, to whom I am permanently indebted for first introducing me to the Ames demonstrations, has in large measure made this volume possible by his continuing support of the work reported here. His personal encouragement, as well as his never-failing ability to provide helpful suggestions at crucial points, have been invaluable. The manuscript has been read in whole or in part by Hadley Cantril, F. P. Kilpatrick, and Merle Lawrence, all of whom have provided much-needed criticism. In addition, the entire manuscript has been read by Ames whose critical comments were most helpful. In all fairness to him, it should be added that not all his suggestions were incorporated in the final version.

The tedious mechanical tasks involved in preparing the manuscript have been most patiently borne by Mrs. Alice Weymouth and Mrs. Grace Langenhop. The thousand and one administrative hitches unavoidably entailed in the production not only of this volume but more especially of the demonstrations described in it have been systematically overcome as they arose by John Pearson, whose neverfailing good humor has frequently provided the otherwise missing essential ingredient. Finally, special thanks are due Martha Lane Ittelson for providing the design for the cover of this volume.

The Ames demonstrations themselves speak of their creator. It would be redundant to add further tribute, except to record my personal appreciation of the opportunity of knowing Ames and my thanks to him for the many hours we have spent together both at work in his laboratory and at conversation in his office. These are experiences which have become a permanent part of me.

Princeton, New Jersey
February 1952

W. H. I.

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LIST OF ILLUSTRATIONS

THE AMES DEMONSTRATIONS IN PERCEPTION

1. THE STAR POINT DEMONSTRATION

A star point is a minute point of light. When viewed in an otherwise completely dark room, it represents the simplest possible visual experience. And yet even in this elementary situation important depth and direction effects can be observed. A single star point cannot be accurately localized either in apparent distance or direction, even using both eyes. Its apparent distance, for example, is largely determined by such factors as knowledge of the size of the room in which it is being viewed. When using one eye, the apparent relative distance of two star points is affected by their relative brightness -- the brighter appears nearer -- and by their relative positions -- the lower of two star points appears nearer or farther when the points are respectively in the lower or upper part of the visual field.

Apparatus

The star point apparatus consists of a light-tight box containing three small holes, each illuminated by a separate light placed within the box. The brightness of the two outside lights can be continuously varied so that as one becomes brighter the other grows dimmer.

Viewing conditions

The star points are viewed in an otherwise completely dark room from a distance of ten or more feet. It is desirable to hold the head stationary, but no headrest is needed. Monocular observation is used except when otherwise noted.

Typical observations

A single star point appears to be localized at a fairly stable distance, which is dependent in both monocular and binocular observation primarily on knowledge of the viewing conditions. For example, if observers are familiar with the dimensions of the experimental room, they see the star point at distances limited by those dimensions. If the point is presented in such a way that it might in fact be a star in the sky, they will tend to see it off at great distances.

The apparent direction of a single star point is very unstable and continually shifts (autokinetic effect).

With two star points visible, both at eye level and the same distance from the observer, the brighter point appears nearer. If the relative brightness is continuously varied, the brighter point appears to approach and the dimmer to recede.

With the two points of equal, constant brightness, one vertically above the other, when the points are near the floor, the upper appears farther away to a standing observer. When they are near the ceiling, the lower appears farther away, provided the ceiling is high enough to give the effect.

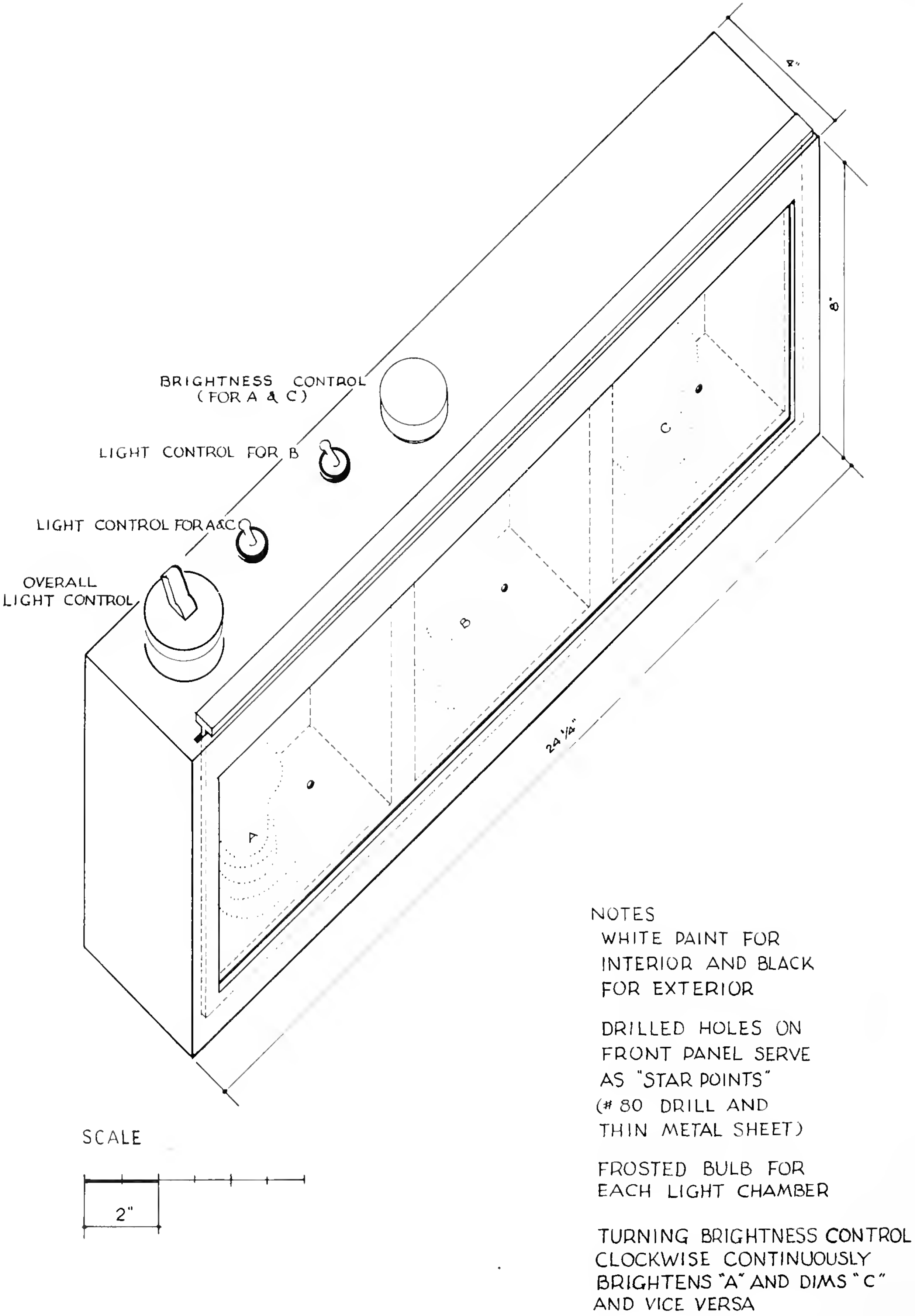


Fig. 1.1. Apparatus for the star point demonstration.

2. THE LINE DEMONSTRATION

The use of illuminated lines, viewed in an otherwise completely dark room, introduces the simplest visual conditions under which size can be continuously and systematically controlled. In monocular observation, the relative apparent distance of two lines is dependent on their relative lengths -- the longer appears nearer -- and on their relative positions -- the lower may appear nearer even though shorter.

Apparatus

The apparatus for the line demonstration consists of a light-tight box on the front of which are four narrow slits, each illuminated by a separate light that can be turned on or off independently of the others.

Viewing conditions

The apparatus is viewed monocularly at eye level in a completely dark room from a distance of ten feet or more. The head should not be moved, but no headrest is needed.

Typical observations

When two lines of different lengths are illuminated, the longer appears nearer.

When three lines of different lengths are illuminated,1the depth effect is greater, with the longest line appearing nearest and the shortest line farthest.

When two lines of different lengths are illuminated with the shorter line lower than the longer, the shorter line appears nearer for most observers.

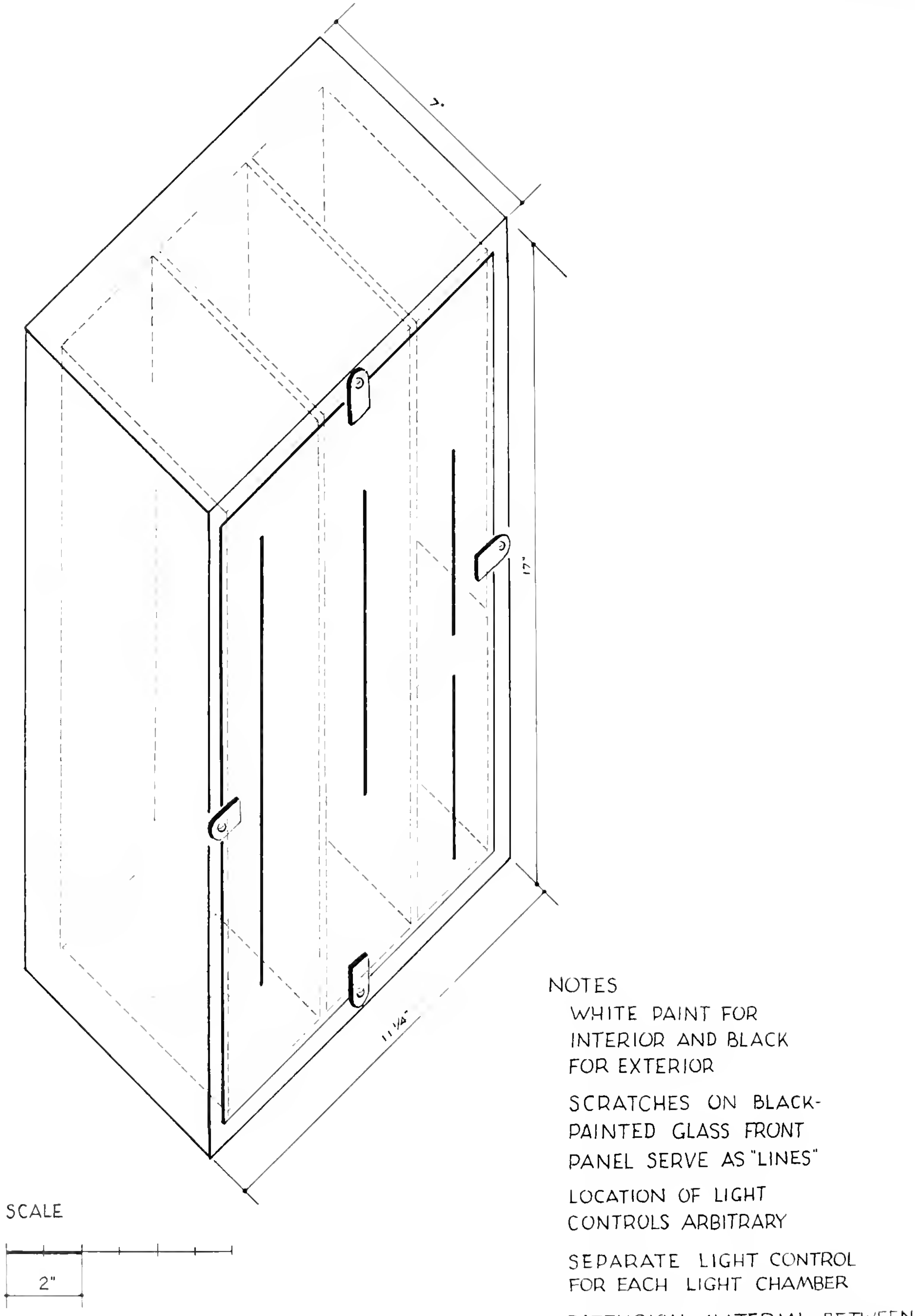


Fig. 2.1. Apparatus for the line demonstration.

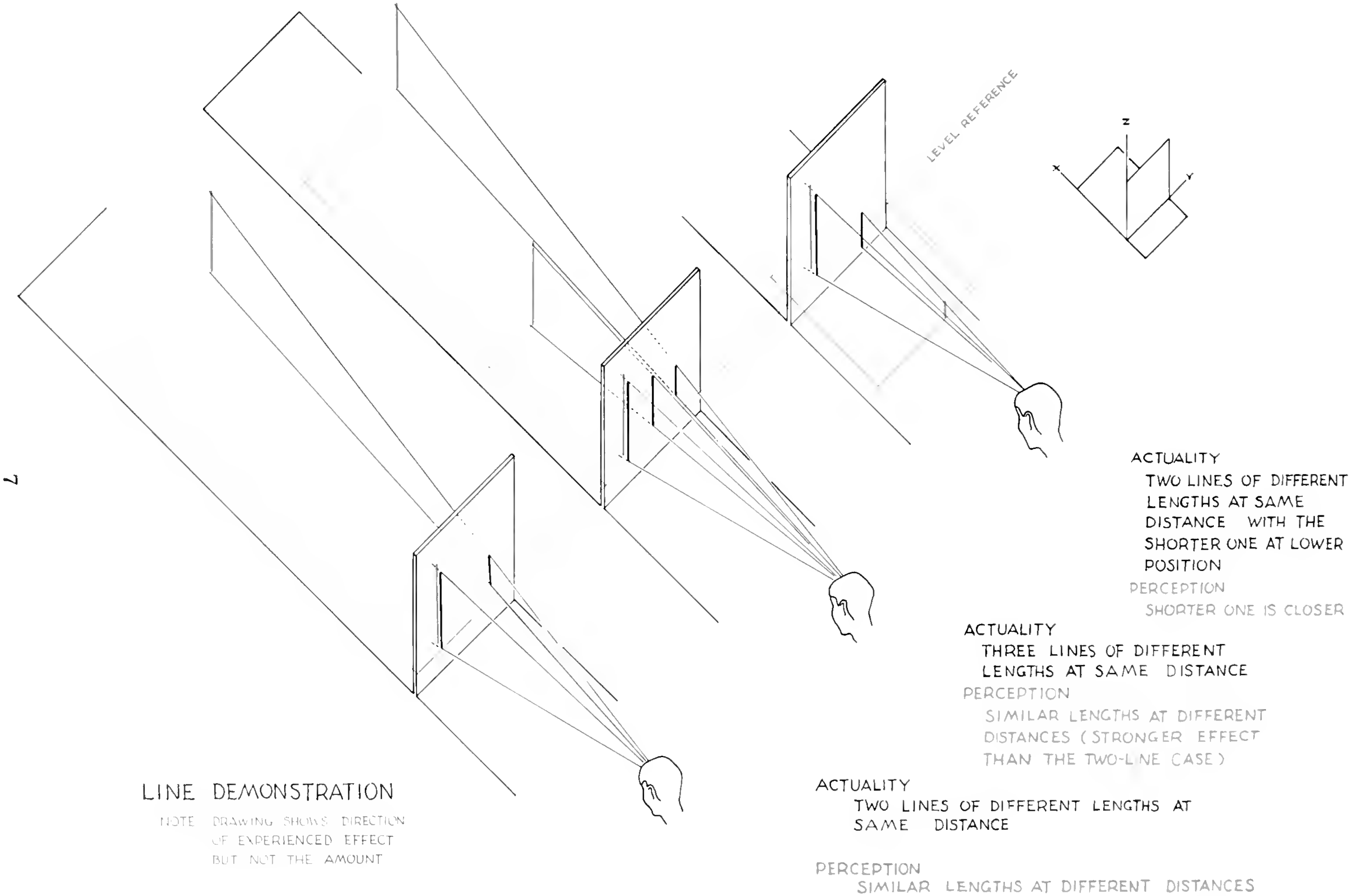


Fig. 2.2. Typical observations obtained with the line demonstration.

3. THE SIZE-BRIGHTNESS DEMONSTRATIONS

The relative sizes of objects and their relative brightnesses provide indications of their relative distances. In the size-brightness demonstrations the depth effects of size and brightness can be illustrated both singly and in combination. Brightness provides a depth indication -- the brighter object appears nearer. Similarly, the larger object appears nearer. When these two indications supplement, the depth effect is enhanced. When they conflict, it is diminished, with size being the more important indication for most observers. Continuous change of one or both of these indications is more compelling than static difference.

Apparatus

The two size-brightness demonstrations, the balloon demonstration and the square demonstration, are similar in that each provides two objects whose size and brightness can be independently varied. They differ only in the nature of the objects used.

A. The balloon demonstration makes use of two balloons, each illuminated from above by a separate light source. The size of the balloons can be varied continuously by a lever operating a bellows so that as either balloon grows larger, the other becomes smaller. Similarly, the illumination can be controlled by another level so that as one balloon becomes brighter, the other grows dimmer. These effects can be made to supplement each other, i.e., the balloon which is made larger can also be made brighter, or to conflict, i.e., the balloon which is made larger can also be made dimmer.

B. The square demonstration consists of a light-tight box on the front of which are two variable-size square diaphragm openings. Each opening is covered with a light-diffusing material and is illuminated from behind by a separate light source. The sizes of the square diaphragm openings can be continuously varied so that as either grows larger, the other becomes smaller. Similarly, the illumination can be controlled so that as one square grows brighter, the other becomes dimmer. These effects can be made to supplement or to conflict as described for the balloon demonstration.

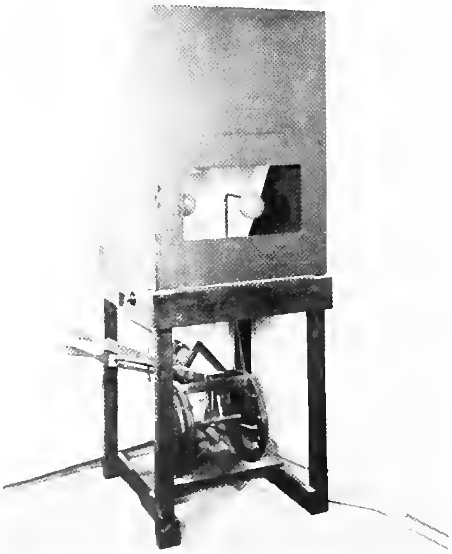


Fig. 3.1. The balloon demonstration.

Fig. 3.2. The square demonstration.

Size alone

Brightness alone

Fig. 3.3. The balloon demonstration from the viewing point

Size and brightness supplementing

Viewing conditions

Either apparatus is viewed monocularly, except where otherwise noted, from a distance of ten or more feet. The room should be completely dark so that only the two illuminated objects are visible. No headrest is required.

Typical observations

With illumination equated and held constant, and size continuously varying, the object which is growing larger appears to approach and the one becoming smaller to recede.

With size equated and held constant, and illumination continuously varying, the object which is growing brighter appears to approach and the one becoming dimmer to recede.

With both size and brightness continuously varying and supplementing, the apparent movement is greatly enhanced. This apparent movement continues to be observed even if both eyes are used and movement parallax is introduced. However, if the objects are held fixed at a constant size-brightness difference, binocular observation and parallax destroy the effect.

With both size and brightness continuously varying but conflicting, the apparent movement is diminished, but for most observers the larger object still appears to approach. An occasional observer reports the reverse effect, with the brighter object apparently approaching.

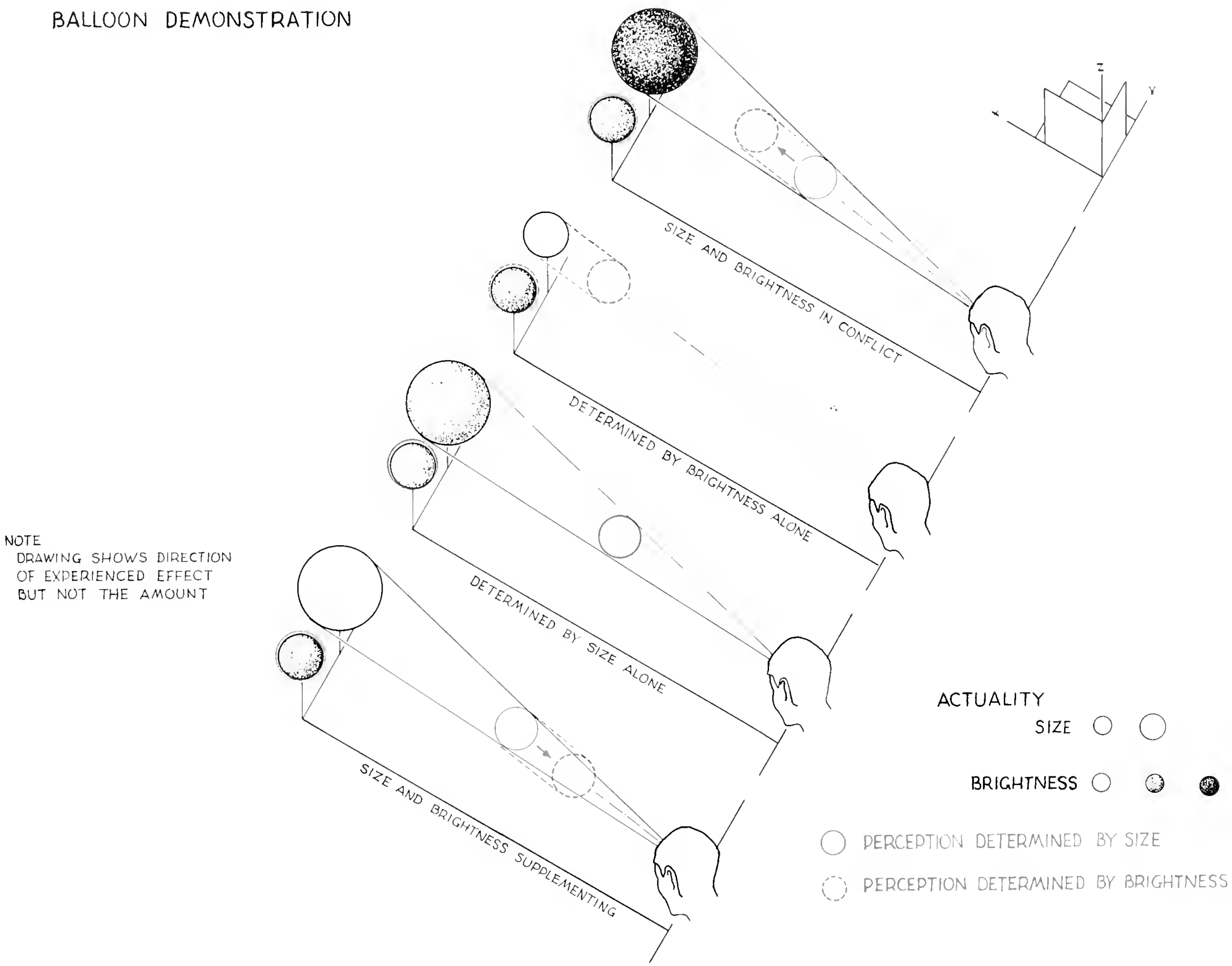


Fig. 3.4. Typical observations obtained with the balloon demonstration.

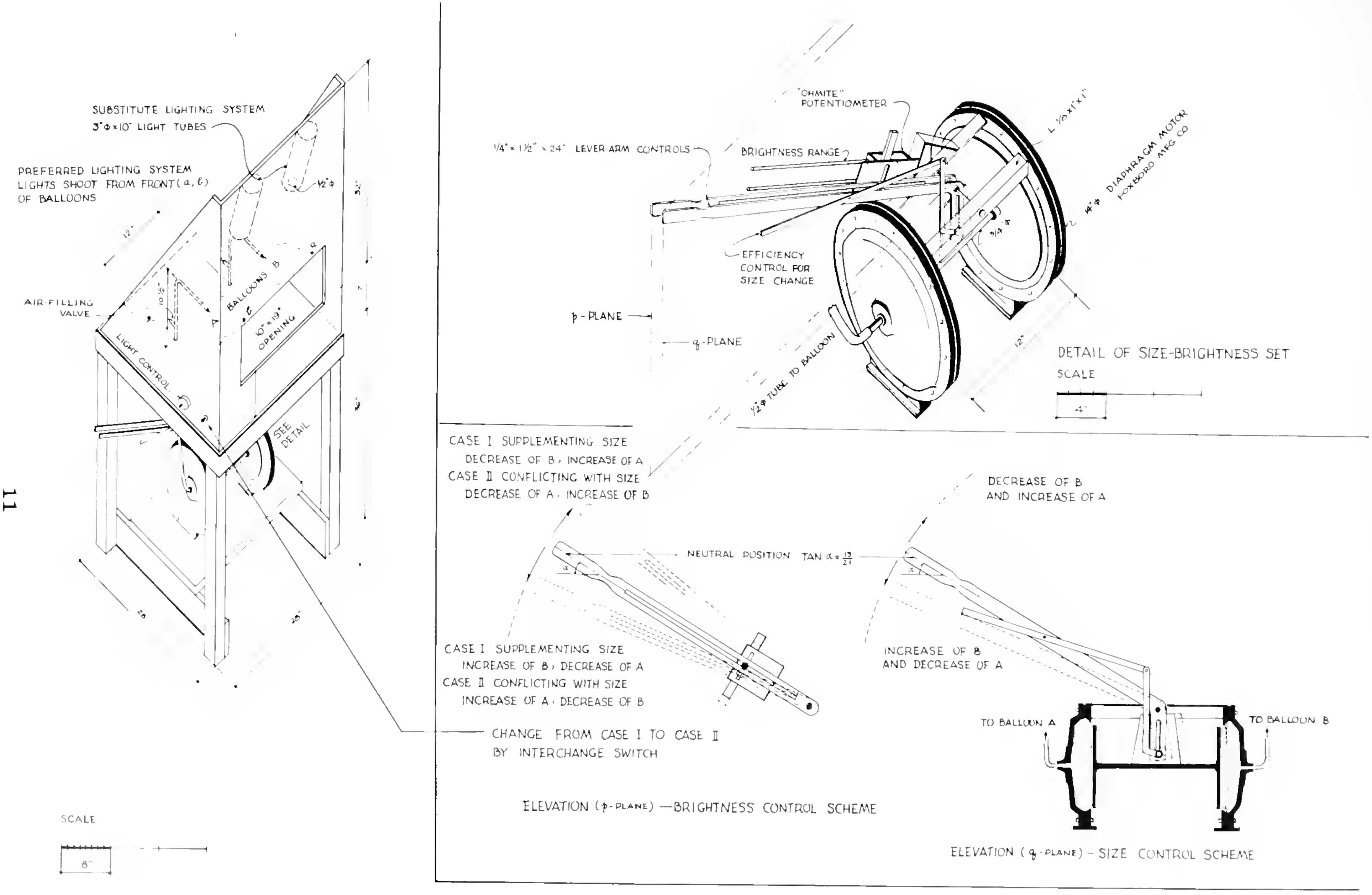


Fig. 3.5. Apparatus drawing for the balloon demonstration.

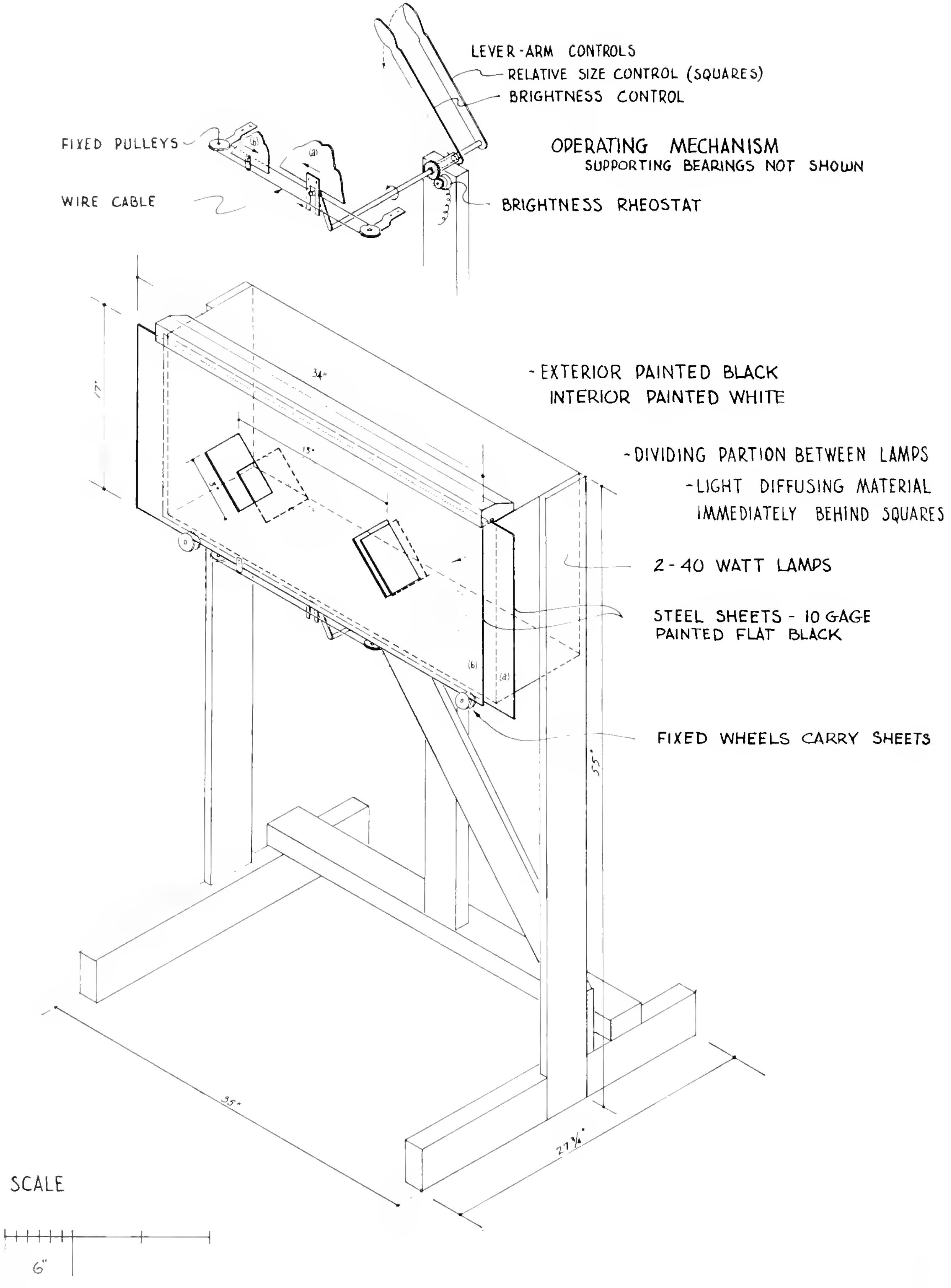


Fig. 3.6. Apparatus drawing for the square demonstration.

4. THE OVERLAY DEMONSTRATION

Overlay, the fact that a near object partially obscures objects behind it, provides one of the most important indications of relative distance. The overlay demonstration illustrates overlay as an isolated indication of relative distance and also compares its effectiveness to that of the indication of relative size.

Apparatus

The overlay demonstration consists of a table on which are mounted three rows of cards. The cards in the left hand row are of three different colors and of three different sizes proportioned so that all three cards subtend the same visual angle at the viewing point. The cards in the middle row are also of the same three different colors and also subtend the same visual angle at the viewing point. In the right hand row two of the cards are normal-size playing cards. In the middle and right hand rows the two near cards in each row are cut out in such a way as to produce a false indication of overlay. The posts to which the cards are attached have special mounts permitting lateral and vertical adjustments for alignment purposes.

Viewing conditions

The overlay demonstration is viewed from a headrest located at the end of the table in an evenly illuminated room. A shield on the headrest blocks off the left eye, insuring monocular observation of the cards. Appropriate adjustments are provided on the headrest so the cards can be viewed from the exact point for which the false overlay indications are aligned. The headrest adjustments are correct when a small ball on the table top is seen exactly in the center of a hole in the shield on the table in front of the headrest. Also provided on this shield are two flaps. When both flaps are raised, only the left hand row can be seen. When the left flap is lowered, the middle row is visible. Lowering the right flap reveals the right hand row. The entire shield can also be lowered, permitting the binocular observation of the table top and the bottom part of the rods holding the cards.

Typical observations

The left hand row and the middle row appear identical, the actually far card in the middle row appearing nearer than the middle card in that row and the actually near card farther than the middle card.

In the right hand row the actually near playing card appears farther away than the middle card in that row and extremely large. The actually far playing card appears in front of the middle card and very small.

If the entire shield is lowered while viewing the middle row of cards, the post holding the near card appears to bend backward, with its bottom at the apparent distance of its attachment to the table and its top at the farther apparent distance of the card mounted on it. Many observers do not experience this effect but instead see the posts in one apparent order and the cards in the opposite order.

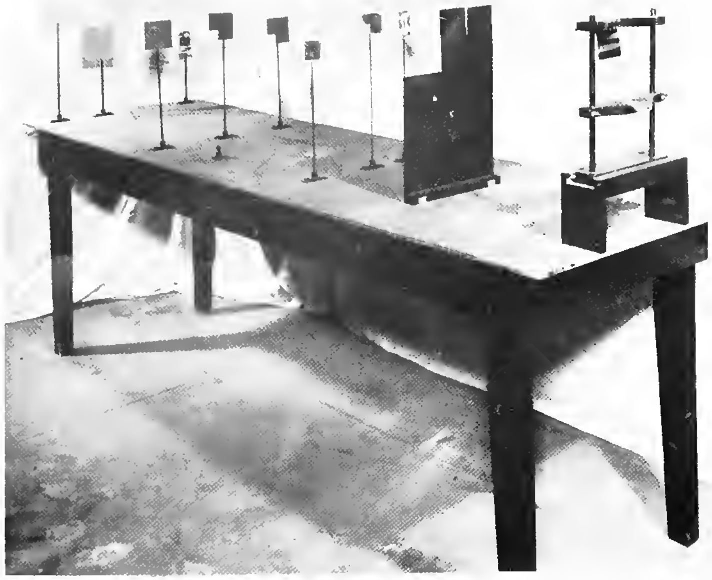


Fig. 4.1. The overlay demonstration.

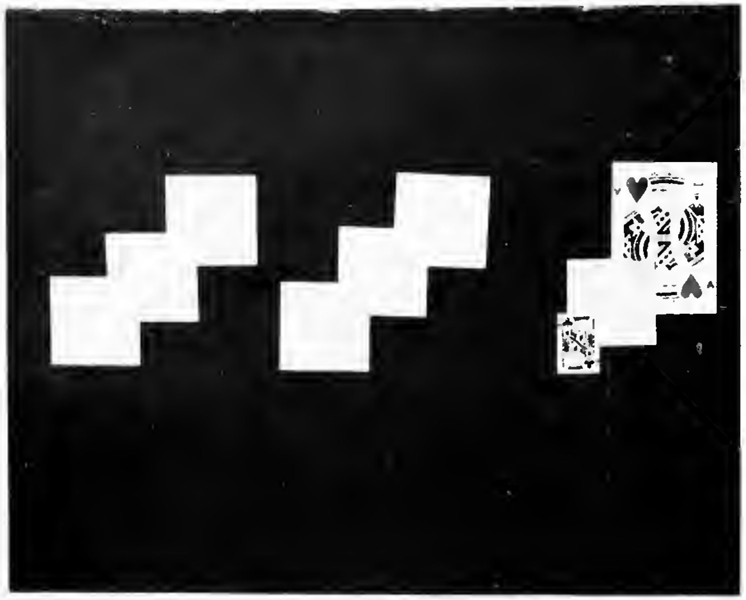


Fig. 4.2. The overlay demonstration from the viewing point.

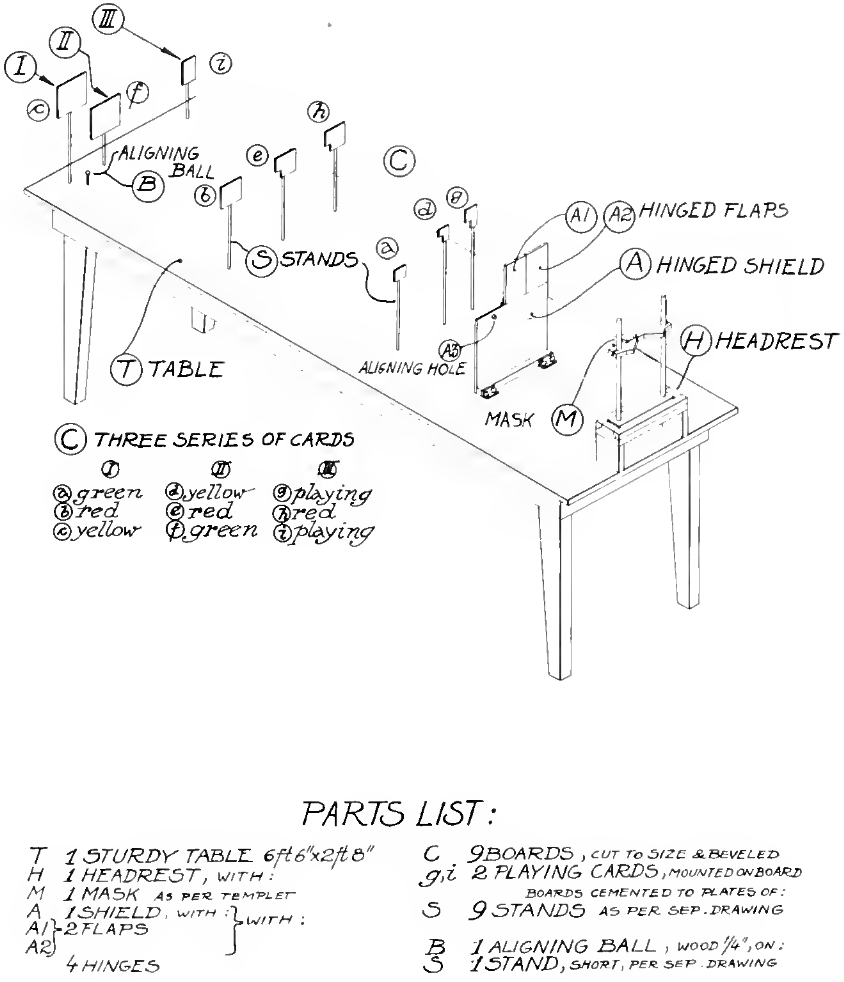


Fig. 4.3. Apparatus drawing for the overlay demonstration.

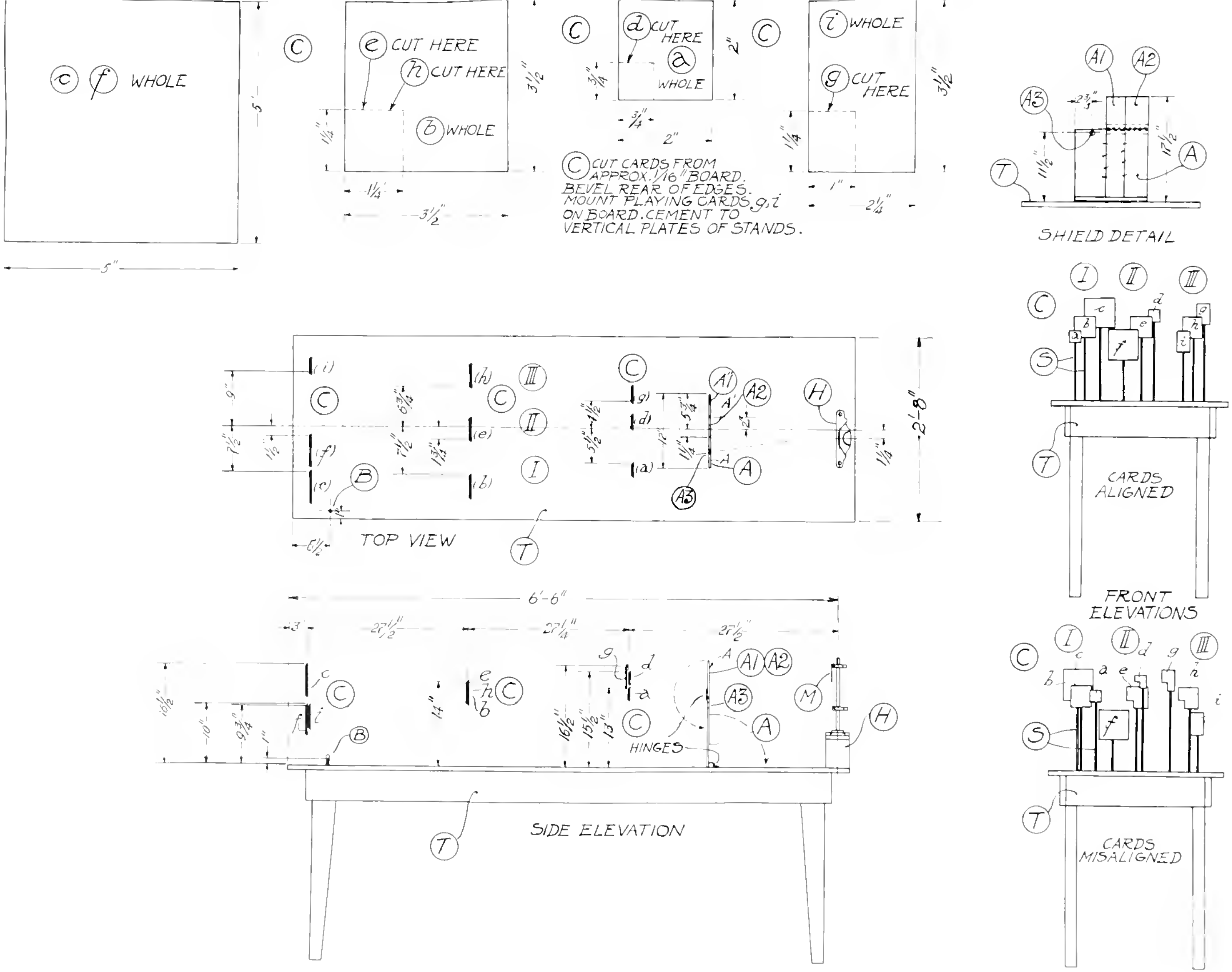


Fig. 4.4. Construction details for the overlay demonstration.

5. THE PARALLAX DEMONSTRATION

In everyday observation we are constantly in motion -- standing up, turning around, walking, sitting down. Very rarely, if ever, outside of the laboratory does an absolutely motionless person look at completely stationary objects for any length of time. As one moves about, the relative positions of objects change in a manner determined by the actual distances of the objects, thereby providing an indication of the apparent relative distances of these objects. In the parallax demonstration this indication of movement parallax is controlled by means of a mechanical arrangement so that it can be demonstrated both as an isolated distance indication and in conflict with the indication of size.

Apparatus

The parallax demonstration consists of a table at one end of which is a headrest that can swing right and left for a distance of about six inches. Attached to the headrest is a mechanical linkage on which are mounted two posts that swing back and forth as the headrest moves. This linkage is designed so that the far post, when viewed from the headrest, does not move relative to a stationary reference post. Similarly, the near post can be adjusted so that it does not move relative to a stationary point beyond the end of the table. Any desired objects, for example the triangles shown, can be placed on top of the moving posts.

Viewing conditions

The apparatus is viewed from the headrest, in a normally illuminated room. A shield cuts off the view of the table top from both eyes and of the two movable posts from the left eye but allows both eyes to see the reference post and objects attached to it. In operation, the observer slowly and continually moves his head from side to side, thereby moving the headrest and, through the linkage, the posts and the objects they support.

Typical observations

If two objects subtending the same visual angle, such as the triangles shown in the photograph, are placed on the posts, the far object apparently approaches to approximately the distance of the stationary post and becomes smaller, while the near object appears to recede and become larger.

This effect can also be observed if familiar objects e.g., match boxes, are placed on the posts. In this case, when the actually far object appears to approach, it is no longer seen in its familiar size but appears undersize, while the actually near object appears farther away and oversize.

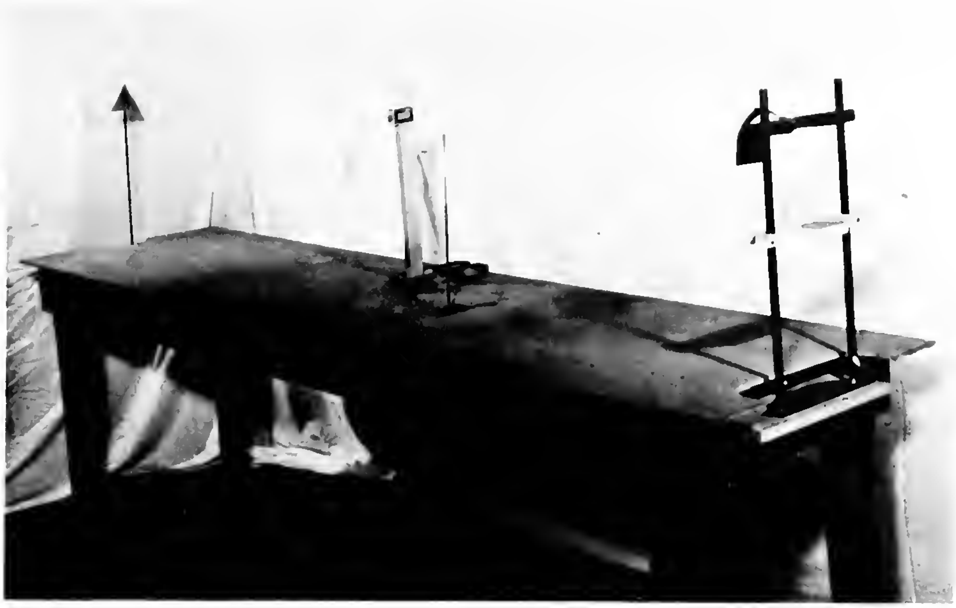


Fig. 5.1. The parallax demonstration.

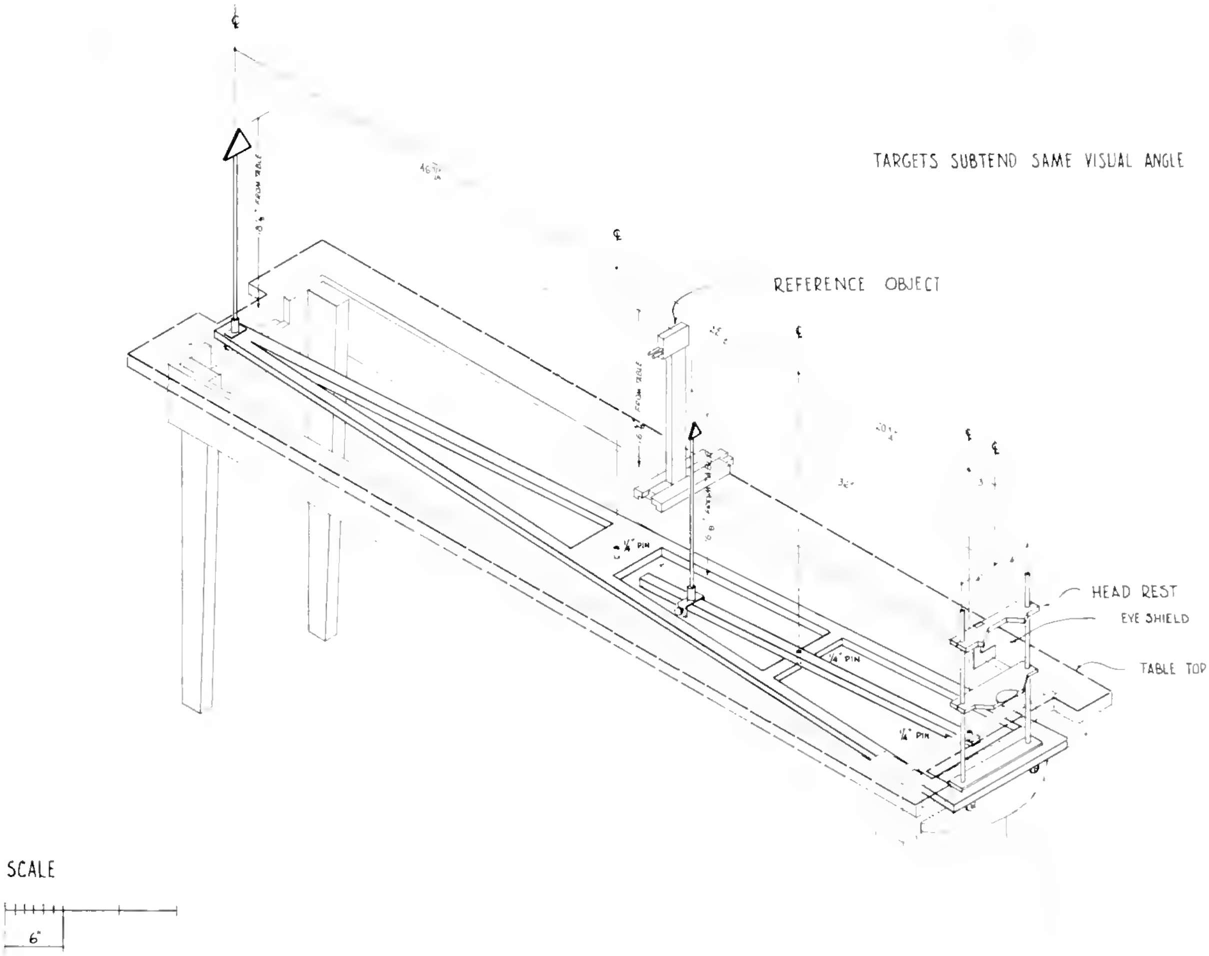


Fig. 5.2. Apparatus drawing for the parallax demonstration.

6. THE TOGETHERNESS AND APARTNESS DEMONSTRATION

Any visual perception can be analyzed into component parts, the elements of which seem to belong together, apart from the other components of the perception. The impingements from the table across the room for example seem to belong together quite apart from the wall behind it or the chair beside it. Among the many familiar indications that things are together or apart in space are brightness, color, light and shadow, sharpness of outline, and relative movement and binocular parallax. The togetherness and apartness demonstration illustrates all these as well as another, less frequently mentioned indication, continuity of contour or coincidence of edge. If the edges of two objects coincide, there is a strong indication that the two objects are together in space. By this indication alone, an object may appear at a distance quite different from its actual distance and of a size quite different from its true size.

Apparatus

The togetherness and apartness demonstration is mounted on a table along one edge of which are three posts holding ordinary playing cards. At the same height and distance as the middle or comparison card is suspended a fourth playing card, the test card. Two boards are hinged to the table top so that they can be raised or lowered at will. In the illustration both boards are shown raised, although in operation only one or the other is raised at any one time. A separate light source is provided for each of the cards.

Fig. 6.1. The togetherness and apartness demonstration.

Fig. 6.2. The togetherness and apartness demonstration from the viewing point.

Viewing conditions

The apparatus is viewed in a dark room against a uniform black background with the illumination on the cards equated. When the head is placed in the headrest, a small shield blocks off the view of the test card from the left eye. With this exception, both eyes view the entire apparatus. The headrest is adjustable laterally so that when the far board is raised the left edge of the test card can be made to coincide exactly with the right edge of the board. Similarly, when the near board is raised, the right edge of the test card can be made to coincide exactly with the left edge of the board.

Typical observations

With both boards down, the test card appears at the same distance as the comparison card and of the same size.

When the far board is raised, the test card appears to be attached to and at the same distance as the board, and very much larger than the comparison card.

When the near board is raised, the test card for many observers appears to be attached to and at the same distance as the board, and very much smaller than the comparison card. (For some observers it is probably the differences in accommodation at these near distances which cause sufficient difference in the sharpness of the outlines of the cards and the boards to destroy the effect.)

If in place of the uniform black background a mottled background is substituted and both boards are lowered, the test card appears to become part of this background and to appear very much larger than the comparison card.

The above effects are not experienced if both eyes are allowed to view the test card, if the head is moved to introduce movement parallax, or if the brightness of the test card is made radically different from that of the other cards and the boards.

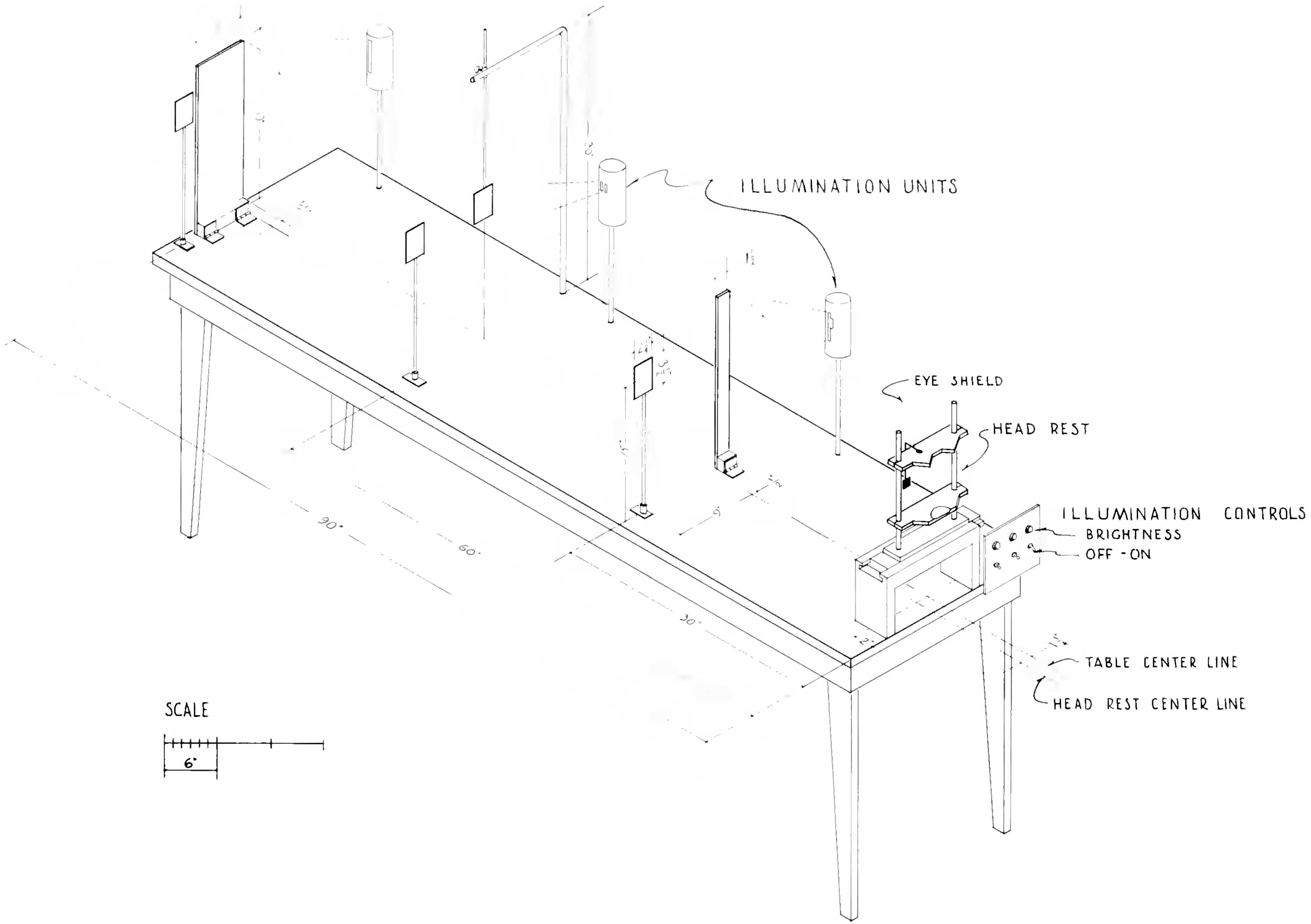


Fig. 6.3. Apparatus drawing for the togetherness and apartness demonstration.

7. THE THERENESS-THATNESS DEMONSTRATIONS

The known size of an object provides an indication of its apparent distance from an observer. In the thereness-thatness demonstration, familiar objects can be unequivocally and correctly localized in distance on the basis of this indication alone. Discrete changes in the size of such objects are seen as discrete changes in distance, and continuous change of size is seen as continuous movement in space. Unfamiliar objects, or even abstract shapes, are also quite definitely localized in distance. In these cases, however, the apparent distance usually does not coincide with the actual distance and varies widely from observer to observer. Furthermore, if the same observer attributes first one size and then another size to the same object, he sees this object first at one distance and then at another distance, even though it actually remains fixed at the same distance.

Apparatus

Both types of apparatus of the thereness-thatness demonstration consist of essentially two basic parts, a binocular comparison field and a test field. The test field provides some means for viewing a test object whose apparent distance is to be determined. The binocular comparison field provides distance indications relative to which this apparent distance is judged. The two models differ primarily in the nature of the test field. In the projector model the test object is an image projected on a screen in front of the observer. The mirror model uses real test objects which are reflected in front of the observer by means of a mirror arrangement.

A. The projector model is mounted on a long table at one end of which is a headrest. Extending along the left edge of the table is the comparison field consisting of five illuminated lucite rods. In addition any desired objects may be added to increase the definiteness of localization in this field. To the right, in the test field, is a movable screen on which any desired image can be projected. Extending at right angles to the table is the housing for the projector and controls. The primary control provides two concurrent adjustments. Turning the knob clockwise causes the image to grow larger and move across the screen to the right. Turning the knob in the opposite direction makes the image smaller and moves it across the screen to the left. A simplified version of this apparatus can be built in which the lateral movement of the image is eliminated and only size change provided. Other adjustments provide for separate control of the illumination of the projected image and of the objects in the comparison field and for changing the distance of the screen.

B. In the mirror model of the thereness-thatness demonstration the comparison field is viewed through a pair of half-silvered mirrors set at approximately 45° to the line of sight. These mirrors enable the observer to see superimposed on the comparison field any desired test object which can be physically quite removed from this field, such as the playing card mounted on the tangential motion apparatus as shown in the illustration. The comparison field contains two rows of illuminated lucite rods and a movable cart carrying a similar rod. Other objects may be used in addition to or in place of these rods. A control box provides six separate controls for illumination of the objects in the comparison field and of the test objects.

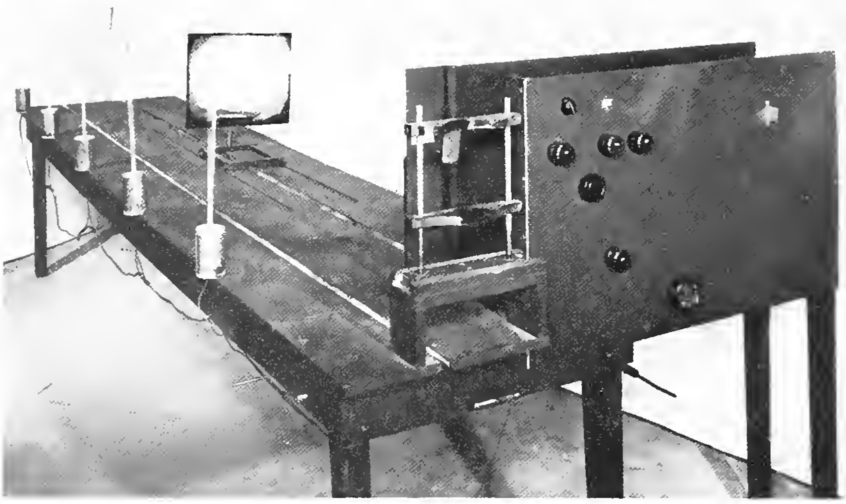


Fig. 7.1. The thereness-thatness demonstration, projector model.

Viewing conditions

A. The projector model is viewed in a dark room from the headrest provided. The comparison field on the left is visible to both eyes, but the image projected onto the screen is seen by the right eye only, through an opening in the shield. The distance of the projected image may simply be estimated relative to the posts, or the size of the image may be changed until it appears at the same distance as one of the posts.

B. The mirror model is also viewed in a dark room, the illuminated comparison posts being visible to both eyes through the half-silvered mirrors. Two adjustments are provided on the mirror mount, a lateral adjustment which allows the test object to be seen with one eye or with both, and an angular adjustment which controls the apparent angular direction of the test object with respect to the comparison field. Appropriate drapes and shields must be added to mask out all undesired parts of the apparatus. In making distance judgments the cart in the comparison field is moved until it appears to be at the same distance as the test object.

Typical observations

Any object in the test field is localized definitely and unequivocally at some apparent distance.

A familiar object, such as a playing card, is seen at its true distance. If an oversized playing card is used, it is seen closer than its true distance. For example, a double-size playing card is seen at one-half its actual distance. Similarly, undersized cards are seen farther than their true distances. For example, a half-size card is seen at twice its actual distance.

If an ambiguous object is used, its apparent distance depends on the particular interpretation the observer makes. For example, a white rectangle is seen at one distance following the suggestion that it is a calling card and at another distance if it is suggested to be an envelope.

The mirror model can also be used in conjunction with many of the other demonstrations in order to obtain a quantitative measure of the effect observed with those demonstrations. It is illustrated in use with the tangential motion demonstration.

Fig. 7.2. Typical observations using the projector model of the thereness-thatness demonstration.

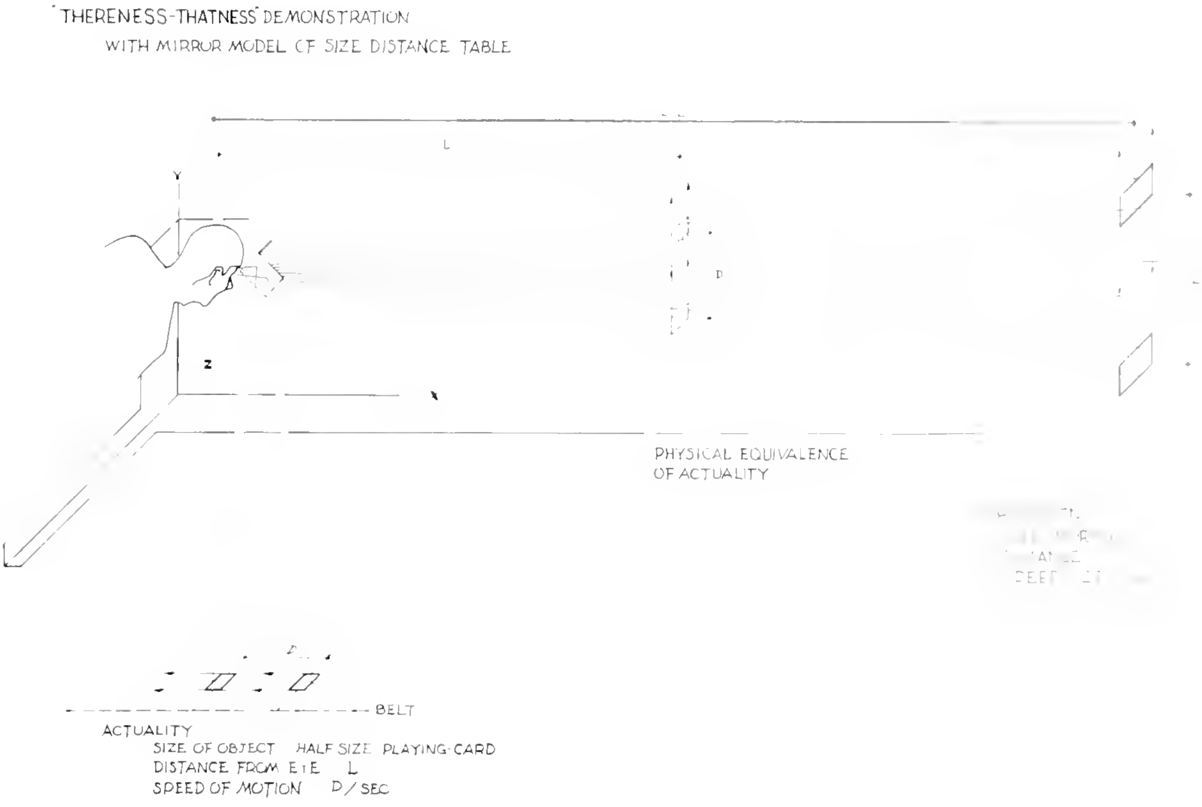


Fig. 7.3. Typical observations using the mirror model of the thereness-thatness demonstration in conjunction with the tangential motion demonstration.

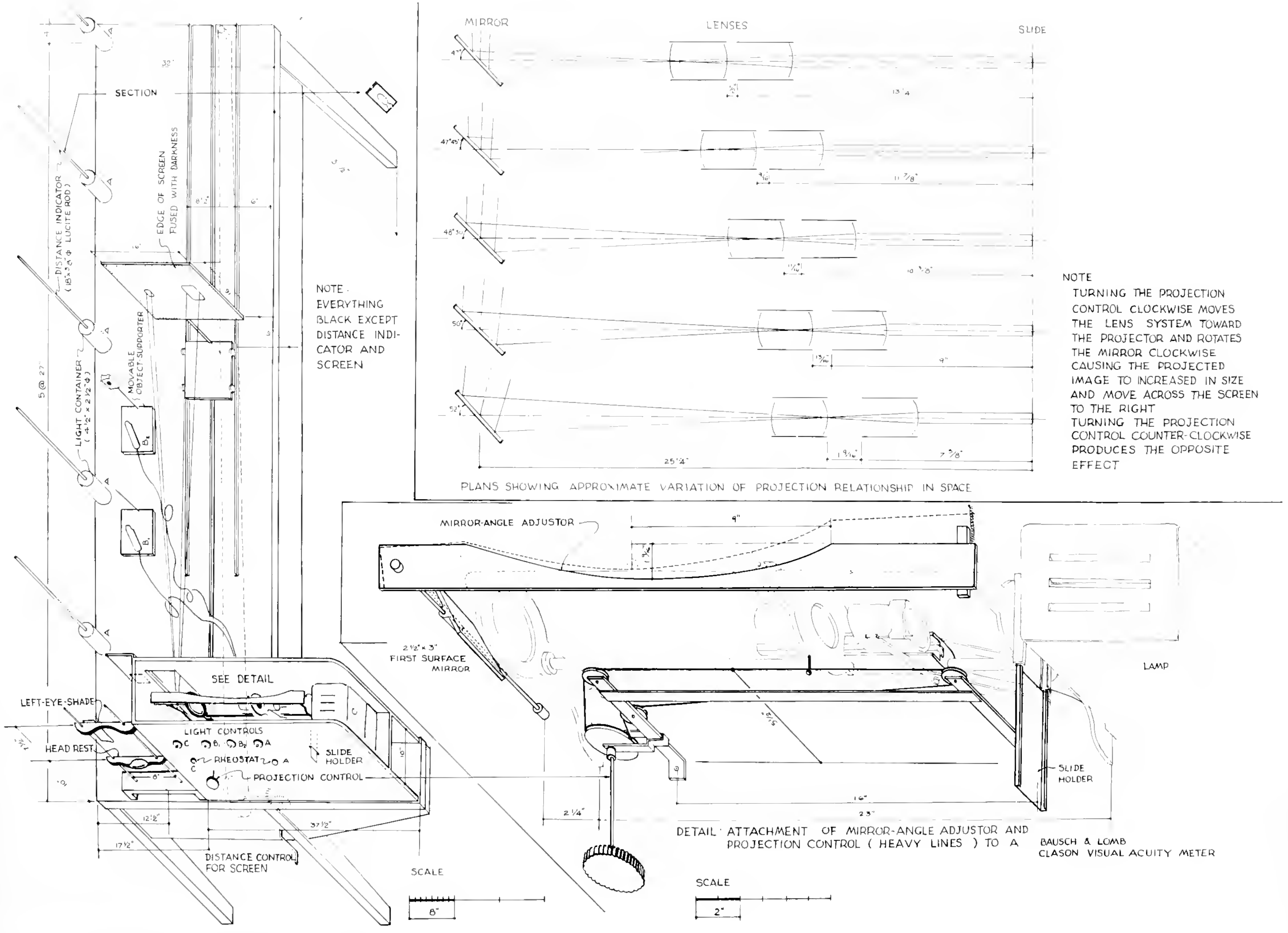


Fig. 7.4. Apparatus drawing for the thereness-thatness demonstration projector model.

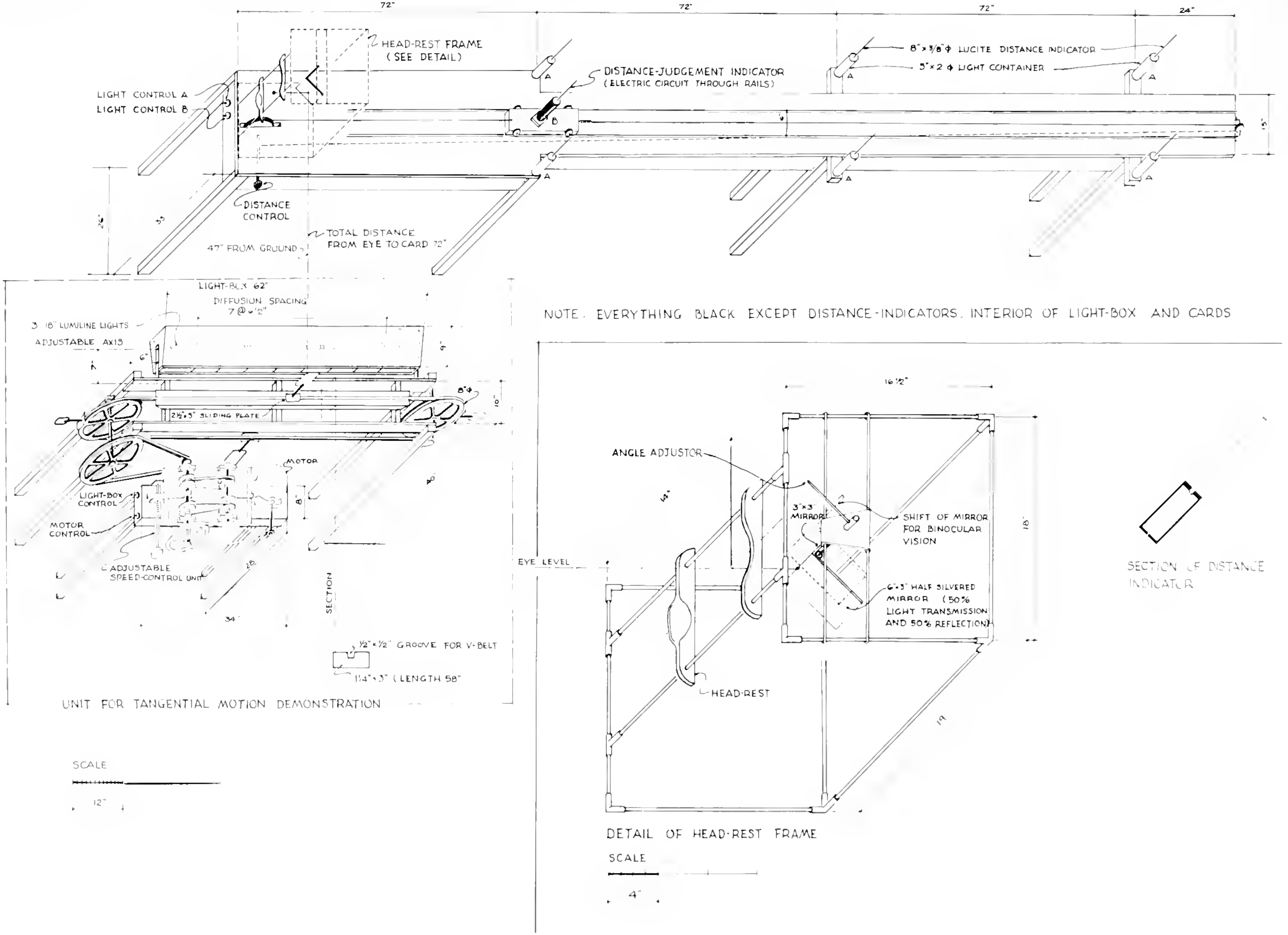


Fig. 7.5. Apparatus drawing for the thereness-thatness demonstration mirror model and the tangential motion demonstration.

8. THE CHAIR DEMONSTRATION

What a person sees when he looks at an object cannot be determined simply from a knowledge of the physical nature of that object, since an unlimited number of different physical objects can give rise to the same perception. In the chair demonstration three groups of strings in different arrangements and at different distances are seen as three similar chairs of the same size and at the same distance when viewed from the proper position.

Apparatus

The chair demonstration consists essentially of a large wooden box containing three peepholes. Behind each peephole and visible through it is one of the three different arrangements of white strings shown in the upper photographs. These three groups of strings in different arrangements and at different distances have only one property in common; they all produce the same image on the retina when viewed from the peepholes. The lower photographs taken through the peepholes indicate approximately the nature of the retinal patterns.

Viewing conditions

The apparatus is viewed through each of the peepholes in turn. The small size of the holes insures monocular observation.

Typical observations

A similar object is perceived through each of the three peepholes.

This object is generally described as a chair, seemingly constructed out of wire, three-dimensional, rectangular, of a definite size, and at a definite distance.

The order of looking through the peepholes has no influence on these observations.

When viewed from any other point except through the peepholes the three groups of strings appear quite different, and only one resembles a chair.

Even after viewing the strings from other points of view, they will appear to be chairs when seen through the peepholes.

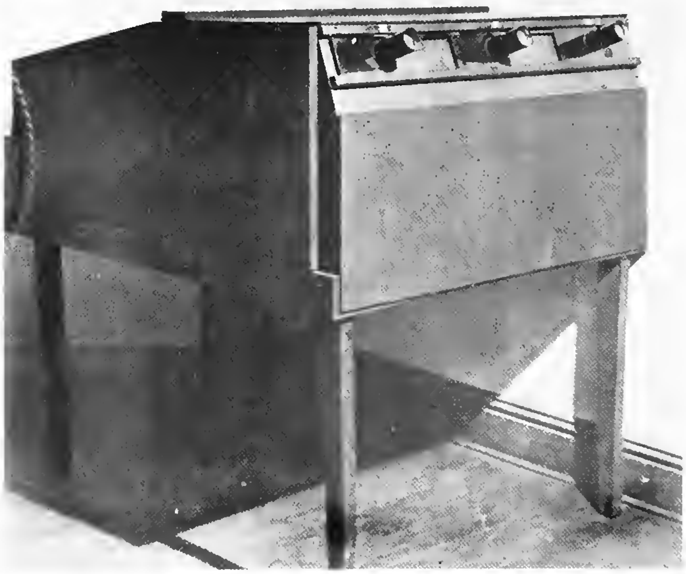


Fig. 8.1. The chair demonstration.

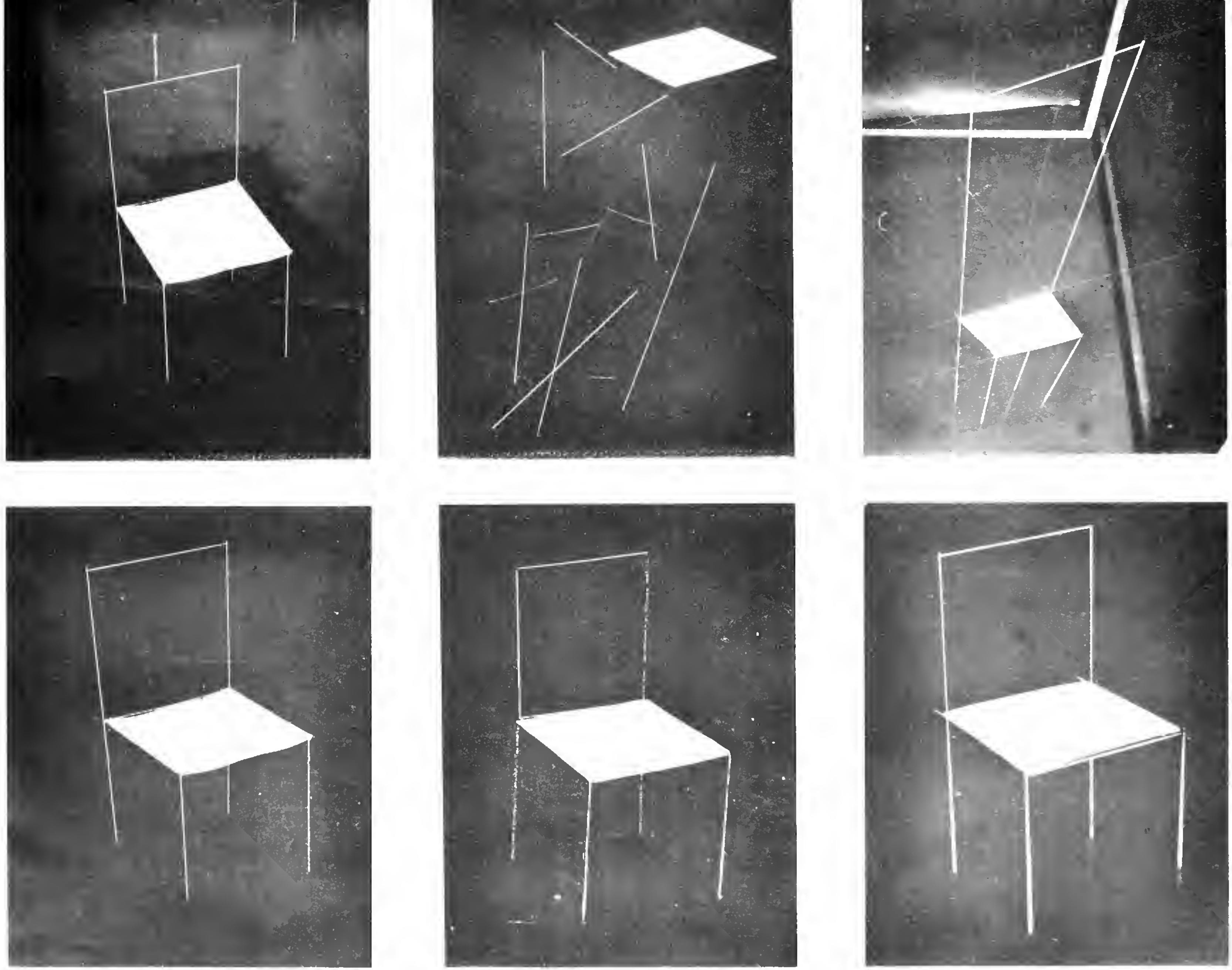
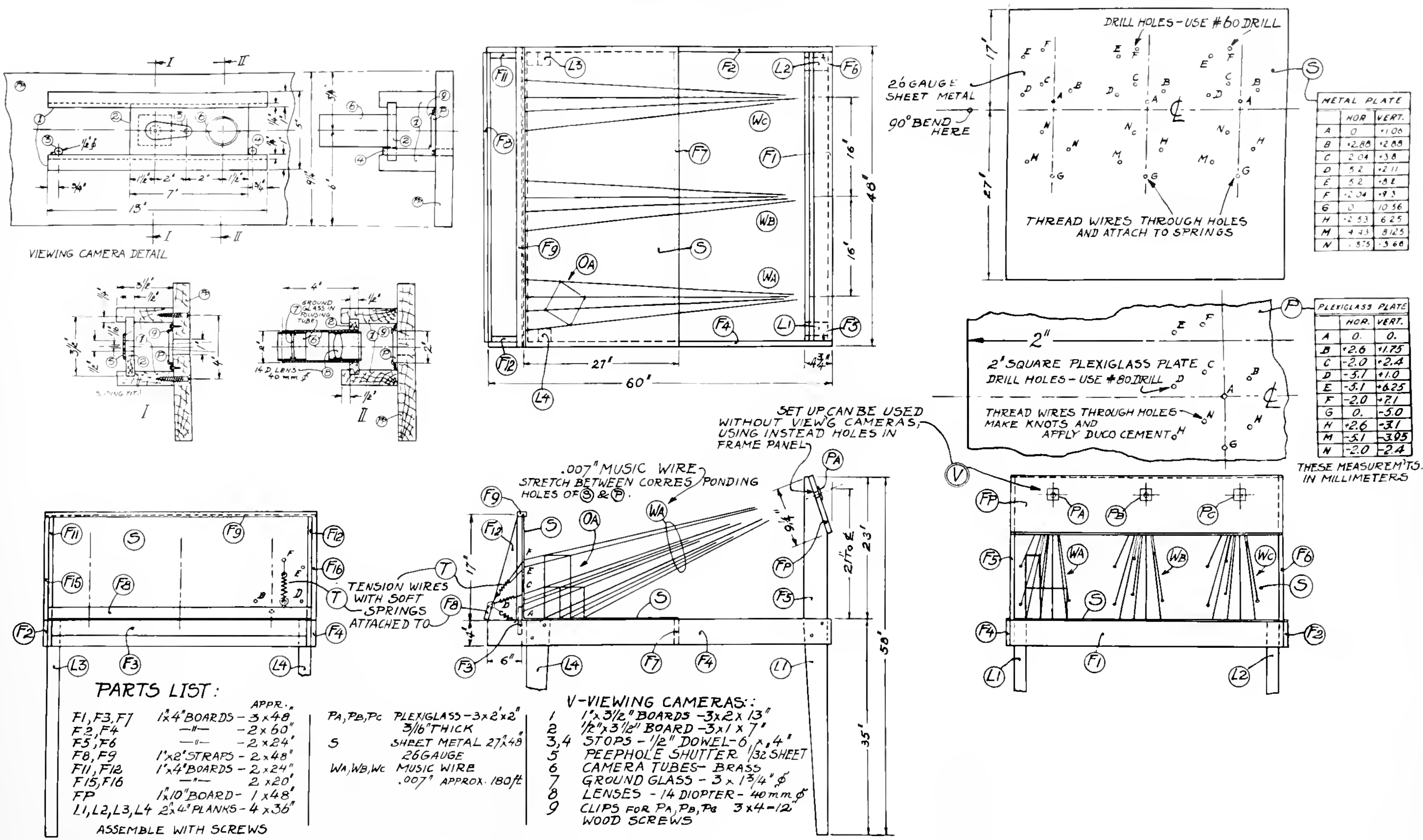


Fig. 8.2. The chair demonstration Above: from behind the apparatus.
Below: from the viewing point.

CHAIRS



METAL PLATE	HOR	VERT.
A	0	+1.06
B	+2.88	+2.88
C	2.04	+3.8
D	5.2	+2.11
E	5.2	+8.2
F	+2.04	+9.3
G	0	10.56
H	+2.53	6.25
M	4.43	8.125
N	1.575	-3.68

PLEXIGLASS PLATE	HOR.	VERT.
A	0.	0.
B	+2.6	+1.75
C	-2.0	+2.4
D	-5.1	+1.0
E	-5.1	+6.25
F	-2.0	+7.1
G	0.	-5.0
H	+2.6	-3.1
M	-5.1	-3.95
N	-2.0	-2.4

THESE MEASUREM'TS. IN MILLIMETERS

PARTS LIST:

		APPR.
F1, F3, F7	1"x4" BOARDS	3 x 48"
F2, F4	— " —	2 x 60"
F5, F6	— " —	2 x 24"
F8, F9	1"x2" STRAPS	2 x 48"
F11, F12	1"x4" BOARDS	2 x 24"
F15, F16	— " —	2 x 20"
FP	1"x10" BOARD	1 x 48"
L1, L2, L3, L4	2"x4" PLANKS	4 x 36"

ASSEMBLE WITH SCREWS

PA, PB, PC	PLEXIGLASS - 3 x 2" x 2", 3/16" THICK
S	SHEET METAL 27" x 48", 26 GAUGE
WA, WB, WC	MUSIC WIRE .007" APPROX. 180 ft

V-VIEWING CAMERAS:

1. 1" x 3 1/2" BOARDS - 3 x 2 x 13"
2. 1/2" x 3 1/2" BOARD - 3 x 1 x 7"
3, 4. STOPS - 1/2" DOWEL - 6 x 4"
5. PEEPHOLE SHUTTER 1/32 SHEET
6. CAMERA TUBES - BRASS
7. GROUND GLASS - 3 x 1 3/4" ϕ
8. LENSES - 14 DIOPTER - 40 mm ϕ
9. CLIPS FOR PA, PB, PC 3 x 4 - 1/2" WOOD SCREWS

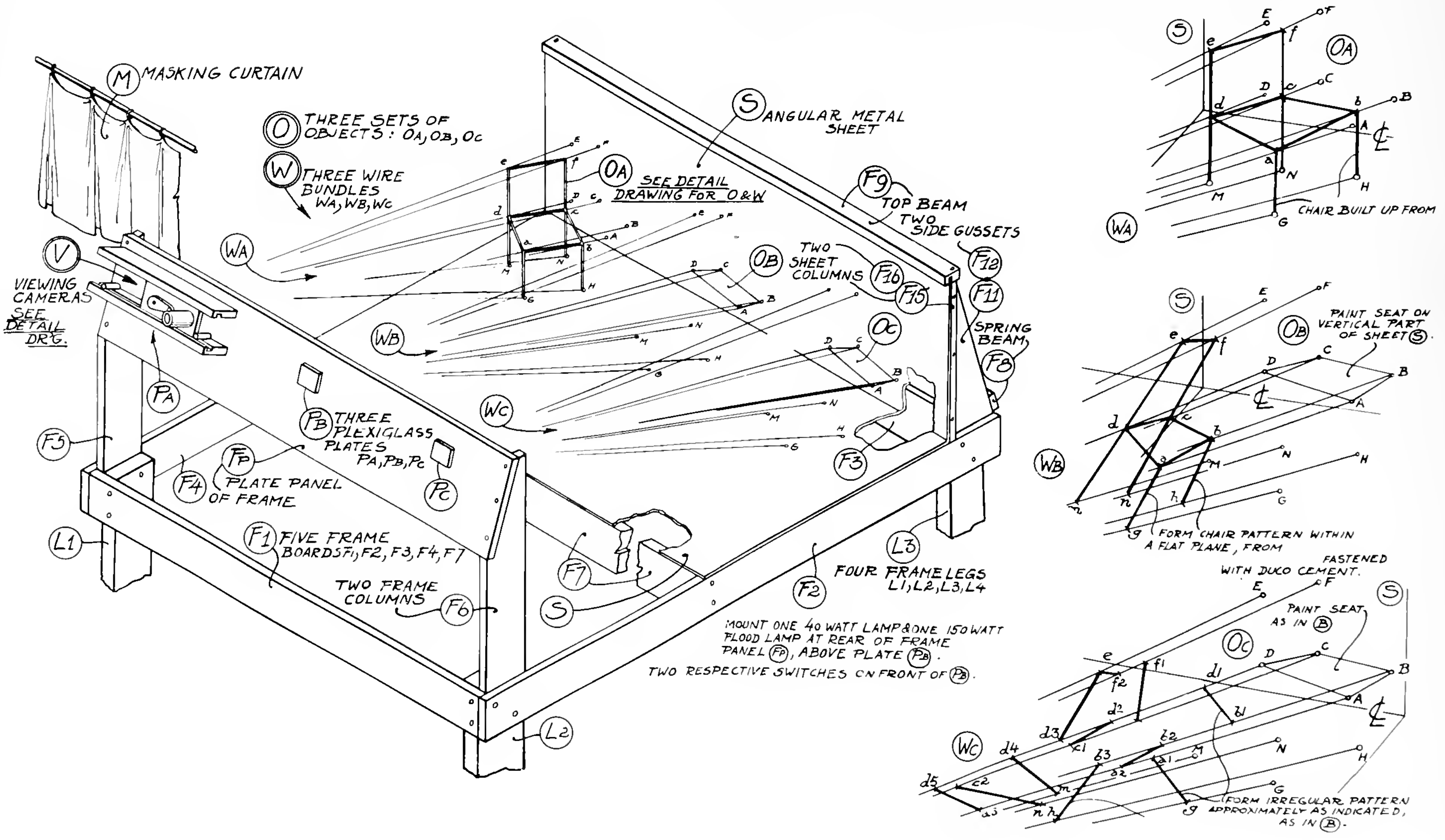


Fig. 8.3. Apparatus drawing for the chair demonstration.

9. THE WATCH-CARD-MAGAZINE DEMONSTRATION

The apparent distances of objects cannot be determined from the geometrical arrangements of the objects or from the geometry of the retinal image. In the watch-card-magazine demonstration two separate configurations of identical geometry give rise to two quite different perceptions.

Apparatus

The watch-card-magazine demonstration contains two identical groups of three objects each. On the right are a one-half size playing card, a normal-size playing card, and a double-size playing card. On the left are a watch in a rectangular case the same size as the half-size playing card, a normal playing card, and a magazine cover the same size as the double-size playing card. The half-size card and the watch are both 40 inches from the observer. The two normal-size cards are both 60 inches from the observer, and the large card and the magazine are both at 80 inches.

Each of these six objects is illuminated by a separate light with an individual brightness control, so that the illumination can be equated for all objects. Two switches control the lights on the left and those on the right separately.

Viewing conditions

The apparatus is viewed from the headrest in a dark room. A shield on the headrest comes between the eyes and allows only the right eye to see the right hand row and only the left eye to see the left hand row. The shield can be raised to allow binocular observation of both.

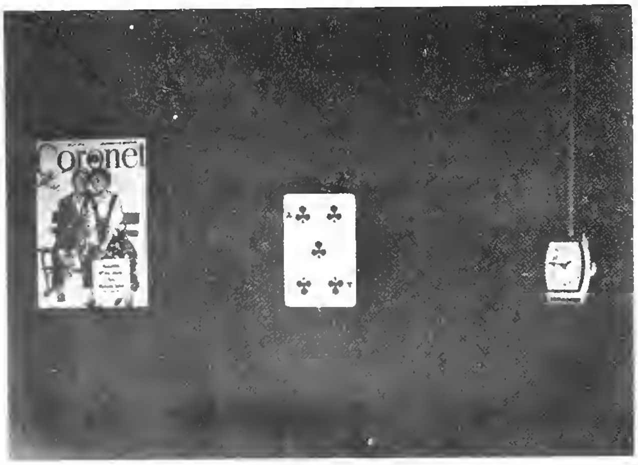
Typical observations

When the right hand row is viewed, it appears to be three normal-size playing cards in the apparent order from the observer, large-normal-small.

When the left hand row is seen, it appears to be a watch, a playing card, and a magazine of different sizes and in that apparent order.

When both rows are observed at once, the small card appears farther away and larger than the watch and the large card appears nearer and smaller than the magazine.

When the shield is raised, permitting binocular observation, the left hand row does not change, but the cards on the right appear to jump to their true positions. Occasionally an observer will report no apparent change in either row with binocular vision, even though he has good stereoscopic vision by other criteria.



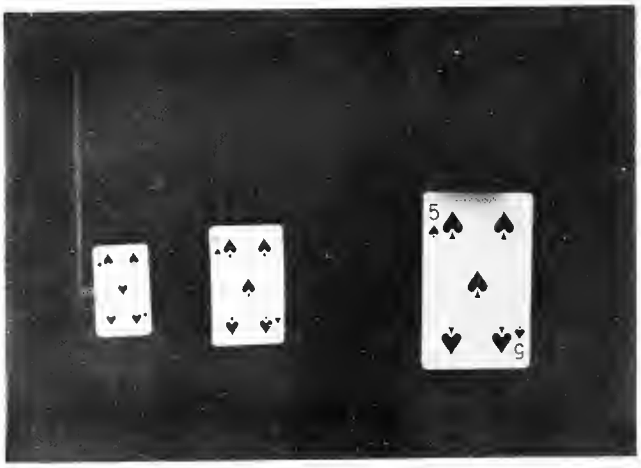


Fig. 9.1. The watch-card-magazine demonstration from the viewing point.

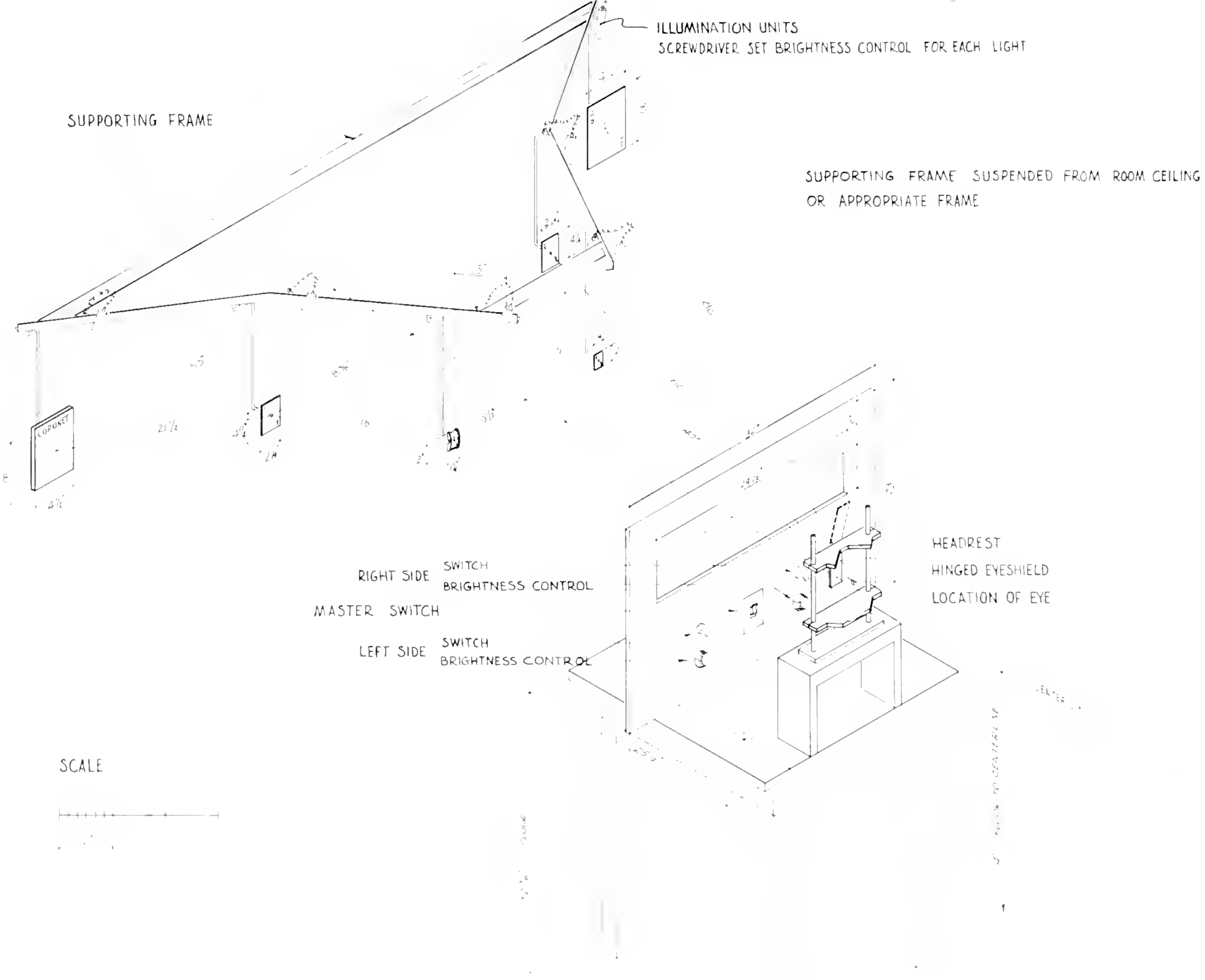


Fig. 9.2. Apparatus drawing for the watch-card-magazine demonstration.

10. THE AFTERIMAGE DEMONSTRATION

An afterimage is a visual image that can still be seen after the external physical source of stimulation has been removed. The perceived properties of afterimages are in many ways analogous to those related to actual objects. In the afterimage demonstration the relationship between the apparent size and the apparent distance of afterimages can be illustrated.

Apparatus

The afterimage demonstration consists of two basic parts, a means for producing afterimages and a means for viewing them.

The afterimages are produced by a small box on the front of which is a slot in which transparent negative photographs of any desired object can be placed. Inside the box is a photoflash bulb that can be fired by the experimenter at a moment when the observer is fixating the center of the photograph negative.

The afterimage is viewed from a headrest situated at one end of a long table on which there are three posts, fixed in distance but adjustable vertically and laterally. Mounted on these posts are cards cut out to give false indications of overlay. Mounted to the headrest is a small shield that cuts off the view of the middle card from one eye.

A separate, variable intensity light source is provided for each of these cards.

Viewing conditions

The afterimage demonstration is viewed in a room that is completely dark except for the lights on the cards.

An afterimage is formed by firing the flash bulb while fixating the center of the photograph on the front of the afterimage box. The head is then placed in the headrest and the afterimage projected onto the middle card. Appropriate adjustment of the overlay indications can make the middle card appear to be either in front of the near card or behind the far card.

Typical observations

When the middle card on which the afterimage is projected appears to be near, the afterimage appears to be small.

When the middle card on which the afterimage is projected appears to be far, the afterimage appears large.

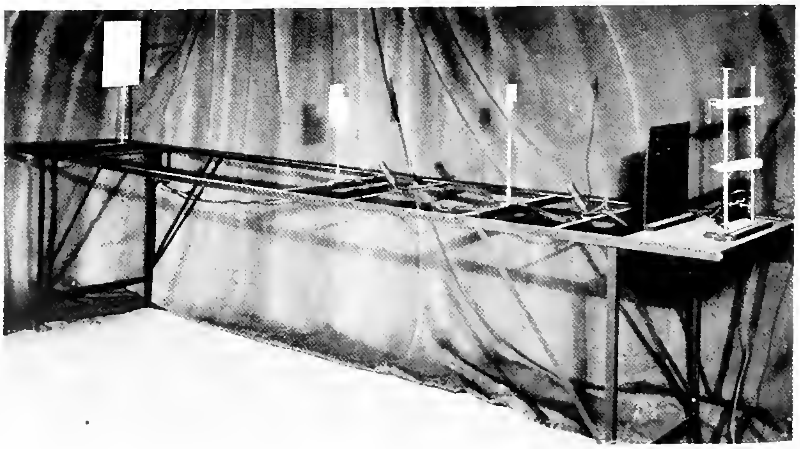


Fig. 10.1. The afterimage demonstration.

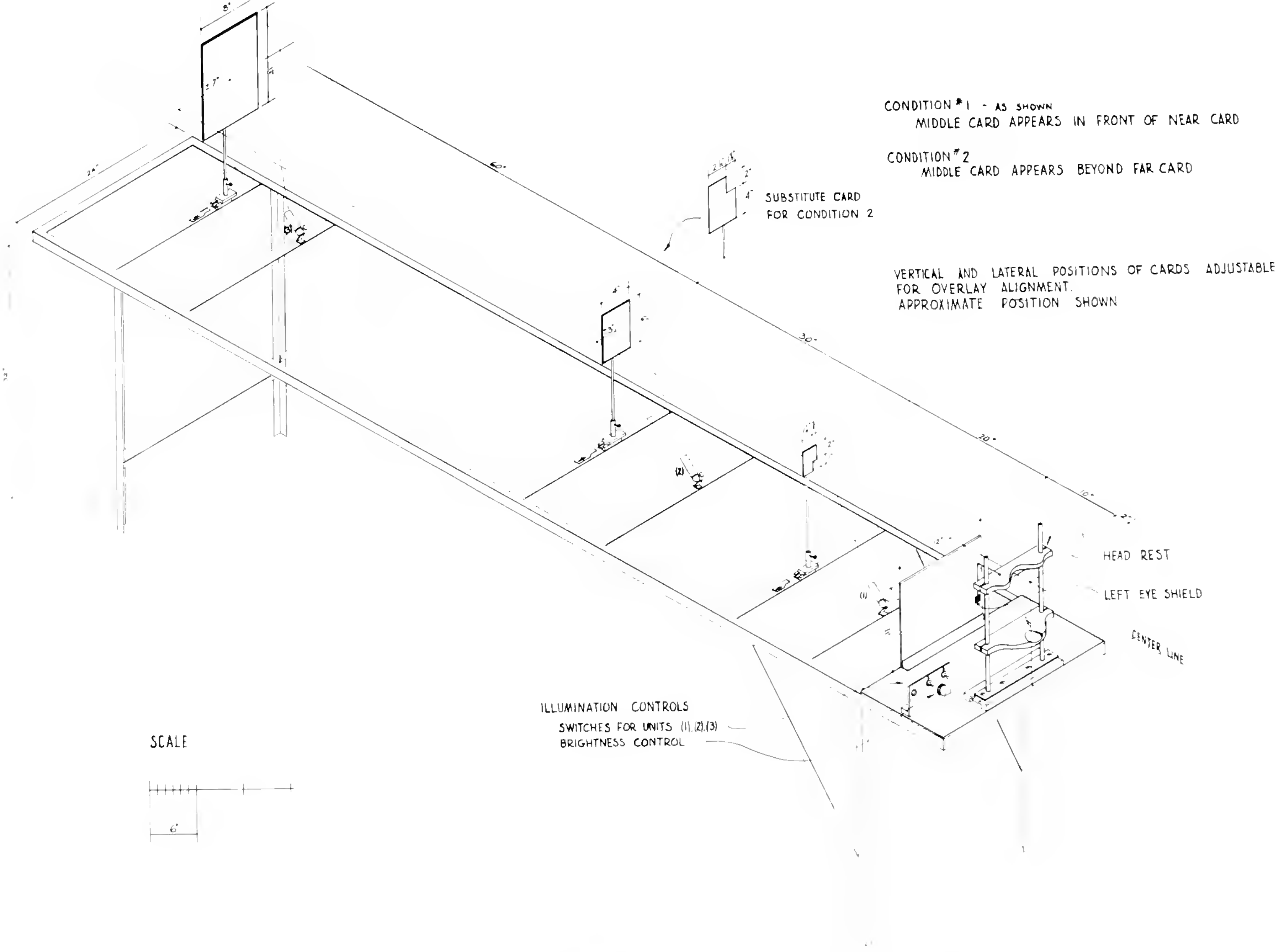


Fig. 10.2. Apparatus drawing for the afterimage demonstration.

11. THE ARTIFICIAL RETINA DEMONSTRATION

The apparent properties of a perceived object are not determined by the image of that object on the retina. In the artificial retina demonstration this fact is illustrated by means of a direct comparison between the perception and the retinal image. Arectangular window, when viewed from any distance and from any angle (except edgewise), is perceived as a rectangular window of constant size, but the image on the retina is different in shape and size for every viewing position and is never rectangular.

Apparatus

The apparatus consists of two parts, the first of which is a rectangular window constructed of wood and suspended from a double gimbal allowing rotation about its horizontal and vertical axes. The second part of the apparatus is the artificial retina, containing a lens mounted in the front of a wooden box and a ground glass curved to approximate the curvature of the retina, and mounted in the back of the box. The front is adjustable in order to focus the image on the ground glass. in the illustration the cover of the box has been removed to show details of construction.

Viewing conditions

The window is suspended in front of a black background in a dark room and illuminated brightly from in front. The artificial retina is placed several feet away from the window and focused until the image of the window is sharply projected on the ground glass. The observer stands behind the artificial retina so that he can see both the actual window and the projected image. The window is slowly turned about both of its axes so that it is viewed from all possible directions, and the artificial retina is moved so that the window is viewed from several different distances.

Typical observations

As the window turns through its various positions, it appears to be of a constant size and shape while continually changing its orientation in space. The image on the ground glass retina meanwhile is a constantly changing trapezoid that is not the same size or shape for any two positions of the window.

If the window is placed in a fixed position, and both observer and artificial retina move directly to or from it, the window appears to be a constant size and shape but at different distances while the image on the retina continually changes both size and shape.

Fig. 11.1. The artificial retina demonstration.

12. THE TILTING SCREEN DEMONSTRATION

The properties of a visual perception are not dependent on visual indications alone. One important nonvisual factor involves the egocentric localization of the observer and the direction of observation. In the tilting screen demonstration the visual indications and all optical conditions including the retinal image remain constant but what the observer sees is effected by the direction in which he is looking.

Apparatus

The image from a 35mm slide projector is reflected by a half-silvered mirror onto a screen. The screen and projector are mounted together on a frame that turns about the horizontal axis through the projector. A counterbalance system holds this frame in any desired position while allowing it to be moved easily. The screen itself can be turned about its own horizontal axis, and can be moved to or from the projector.

Viewing conditions

The demonstration is viewed in a dark room with the observer standing in front of the apparatus and looking with one eye through the half-silvered mirror, which places his eye at approximately the equivalent nodal point of the projector lens system. Under these conditions the image on the retina remains constant independent of any movement of the screen. (In place of the half-silvered mirror, a totally reflecting mirror with a peephole directly adjacent will produce the same effect.) As the screen is slowly raised or lowered, the observer moves his head and adjusts his body so that he continues to look through the half-silvered mirror at the projected image.

Typical observations

If a photograph of a tower taken by a camera pointed approximately 45^{o} upwards is projected on the screen, the tower appears to be vertical and normal in all respects when the screen is viewed approximately 45^{o} upward. As the screen is slowly moved down, the tower appears to change its position in space until it appears to be almost horizontal when the observer is looking approximately 45^{o} down.

Similar effects can be illustrated with a photograph of a stairwell taken by a camera pointed downward 45^{o}. When the screen is above the observer, the stairs appear to go up. When the screen is below, the stairs appear to go down.

In addition, effects similar to those already described for the chair demonstration can be illustrated by changing the tilt of the screen about its own horizontal axis or by moving the screen to or from the projector. The actual size and shape of the projected image changes radically under these conditions but the perception when looking through the peephole remains constant.

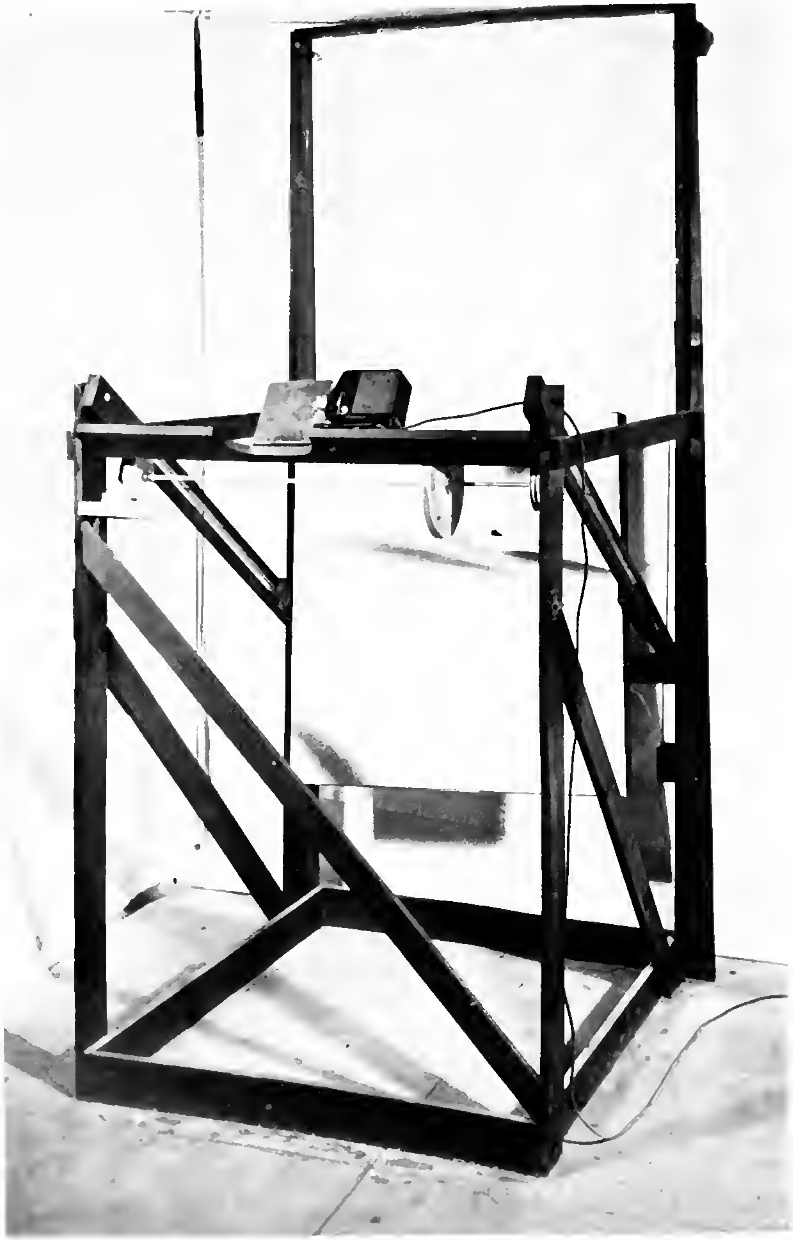


Fig. 12.1. The tilting screen demonstration.

Fig. 12.2. A typical slide for use with the tilting screen demonstration.

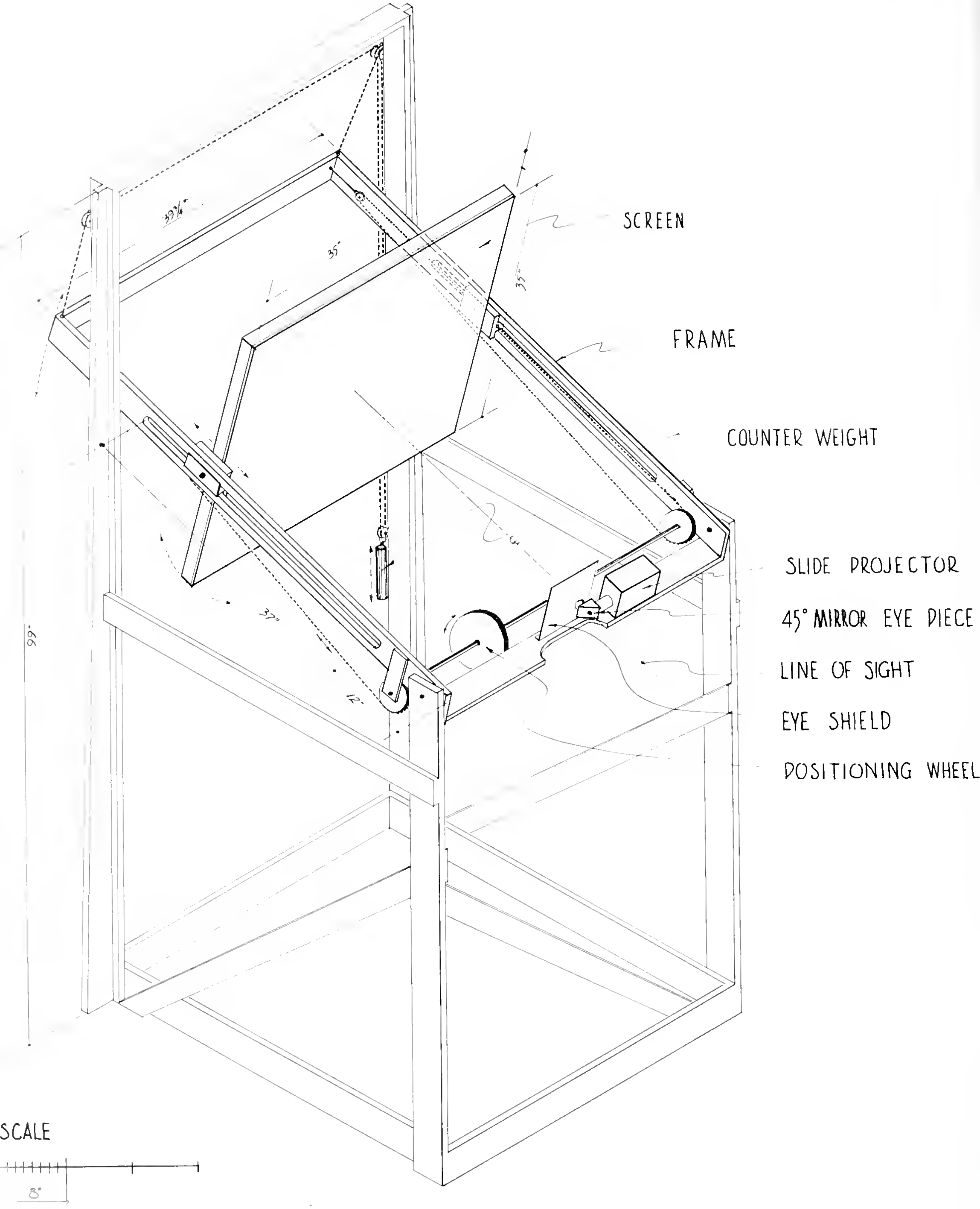


Fig. 12.3. Apparatus drawing for the tilting screen demonstration.

13. THE DISTORTED ROOM DEMONSTRATIONS

The distorted rooms are structures of various sizes and shapes that, when viewed from the proper point, appear to be normal rectangular rooms. Their design is based on the principle that any particular pattern of retinal stimulation, whether monocular or binocular, can be provided by an infinite number of external configurations. It is possible, therefore, to design an unlimited number of equivalent configurations all of which will appear identical. Several such rooms of different sizes and shapes and designed for both monocular and binocular observation have been constructed and are described in this section under four headings starting with rooms designed for monocular observation and concluding with binocular distorted rooms.

All of these rooms have several features in common. They all appear to be normal rectangular rooms. Objects placed within these rooms appear to be distorted while the rooms retain their normal appearance. Persons attempting to carry out simple actions in these rooms behave as if the rooms were actually rectangular, even though they previously have had complete knowledge of the true shape of the rooms. Even the simplest actions in these rooms are, therefore, initially unsuccessful.

13A. MONOCULAR ROOMS: LABORATORY-SIZE

Apparatus

Two different designs for laboratory-size distorted rooms are illustrated. The dimensions of these rooms are of the order of a four-foot cube. They are constructed of wood with all parts exactly proportioned to represent the parts of a normal room. Baseboards, window frames, etc., are all carefully cut out with this end in view. Illumination is provided by a single light in the ceiling. Painting simulates an ordinary room with brown floors, cream-colored walls and white ceilings and woodwork.

The general principles for the design of these rooms are illustrated in the accompanying drawings. Both rooms present to the retina the same pattern that would be produced by a normal rectangular room.

> [The two distortions shown were selected out of the unlimited number of possibilities so that they might also be used in conjunction with the aniseikonic lenses described in the next demonstration. Room No. 1 is designed to compensate for the binocular distortions introduced by axis-90 glasses, while room No. 2 compensates for the distortions of in-cyclo glasses. In these cases the binocular indications are artificially made to supplement the monocular, resulting in much more definite and unequivocal effects.]

Viewing conditions

Each room is viewed monocularly from the proper point as shown in the illustrations.

Typical observations

The two rooms, when viewed under these conditions, appear to be rectangular and identical.

If an observer is led to either room blindfolded, he perceives, immediately upon opening one eye, a perfectly rectangular room. If he places his head in the proper position while using both eyes the room does not appear rectangular. If he then closes one eye, the room initially appears distorted and gradually appears rectangular. The length of time consumed in this process varies widely from individual to individual, sometimes lasting thirty seconds or more.

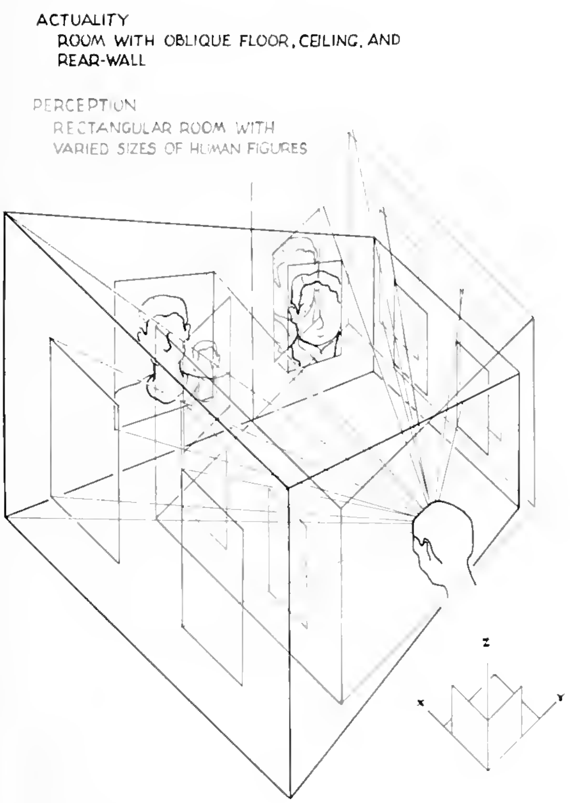
Objects placed in these rooms appear distorted in shape and size. Occasionally a local distortion is induced in a restricted area of the room (for example, an apparent depression in the floor) by an object placed within it, but in general the rooms resist efforts to make them appear distorted. Recurring patterns placed on the floor and walls are not effective; the patterns appear to distort while the rooms remain rectangular.

If an observer is given a pointer and asked to touch various parts of the room, he cannot do so accurately and quickly but behaves quite awkwardly, unexpectedly hitting the walls, floor, or ceiling. Performance is very little, if any, better if the observer has previously examined the room and become familiar with its shape and construction. Even under these conditions he acts as if the room were truly rectangular, as it appears to be.

Fig. 13A.1. Monocular distorted room no. 1 from the viewing point.

Fig. 13A.2. Monocular distorted room no. 1.

Fig. 13A.3. Monocular distorted room no. 2.



ig. 13A.4. Typical observation using monocular distorted room no. 1.

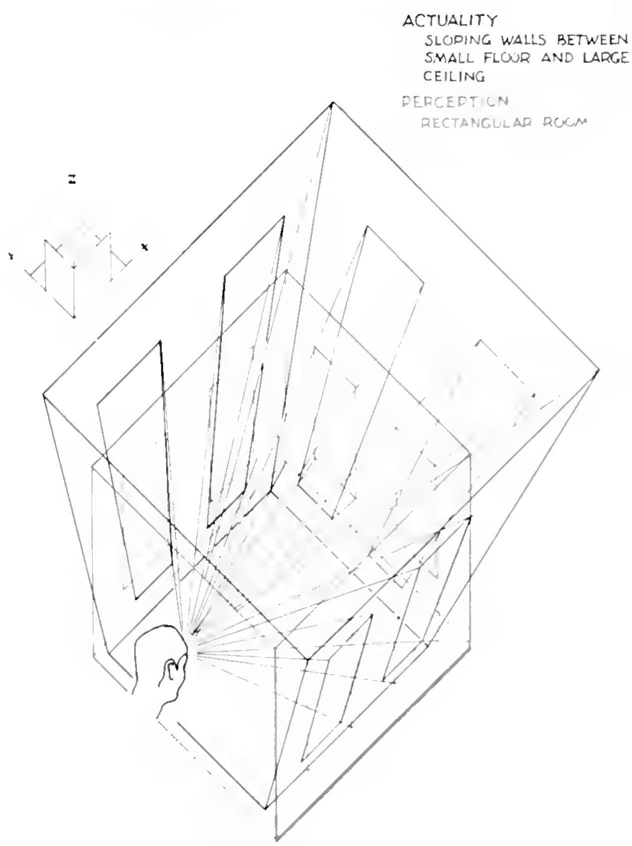
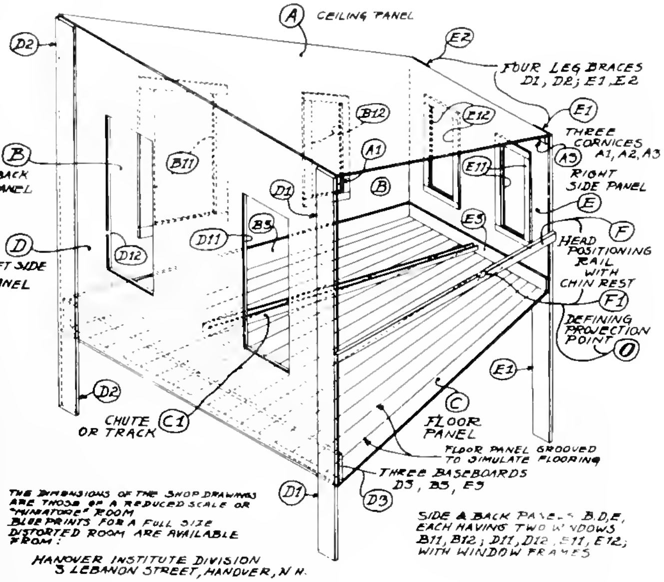
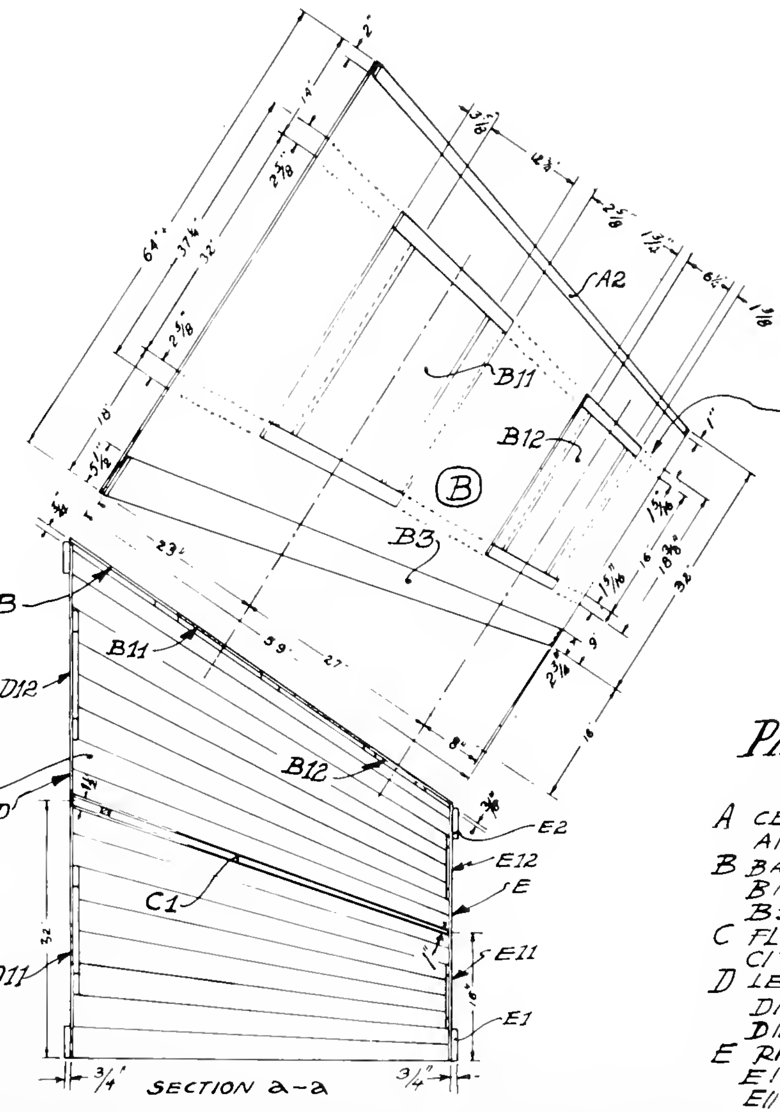


Fig. 13A.5. Typical observation using monocular distorted room no. 2.





DISTORTED ROOM

CEILING, BACK & SIDE PANELS: 1/4" PLYWOOD
WINDOW FRAMES, CORNICES & BASE BOARDS: 3/8" MOULDING
SCRATCH FLOOR PANEL TO SIMULATE FLOORING: 16 BOARDS
TAPER BACK PANEL BASE BOARD, CORNICE & WINDOW FRAMES AS INDICATED WITH LEFT & RIGHT SIDE PANEL DIMENSIONS LARGEST & SMALLEST, RESPECTIVELY.

PARTS LIST:

- A CEILING PANEL: 1/4" PLYWOOD
  - A1, A2, A3 CORNICES
- B BACK PANEL: 1/4" PLYWOOD
  - B11, B12 TWO WINDOWS
  - B3 BASE BOARD
- C FLOOR PANEL: 1/4" PLYWOOD
  - C1 TRACK
- D LEFT SIDE PANEL: 1/4" PLYW.
  - D1, D2 LEGS & BRACES
  - D11, D12 TWO WINDOWS
- E RIGHT SIDE PANEL: 1/4" PLY.
  - E1, E2 LEGS & BRACES
  - E11, E12 TWO WINDOWS
- F HEAD POSITIONING RAIL WITH CHINREST F1

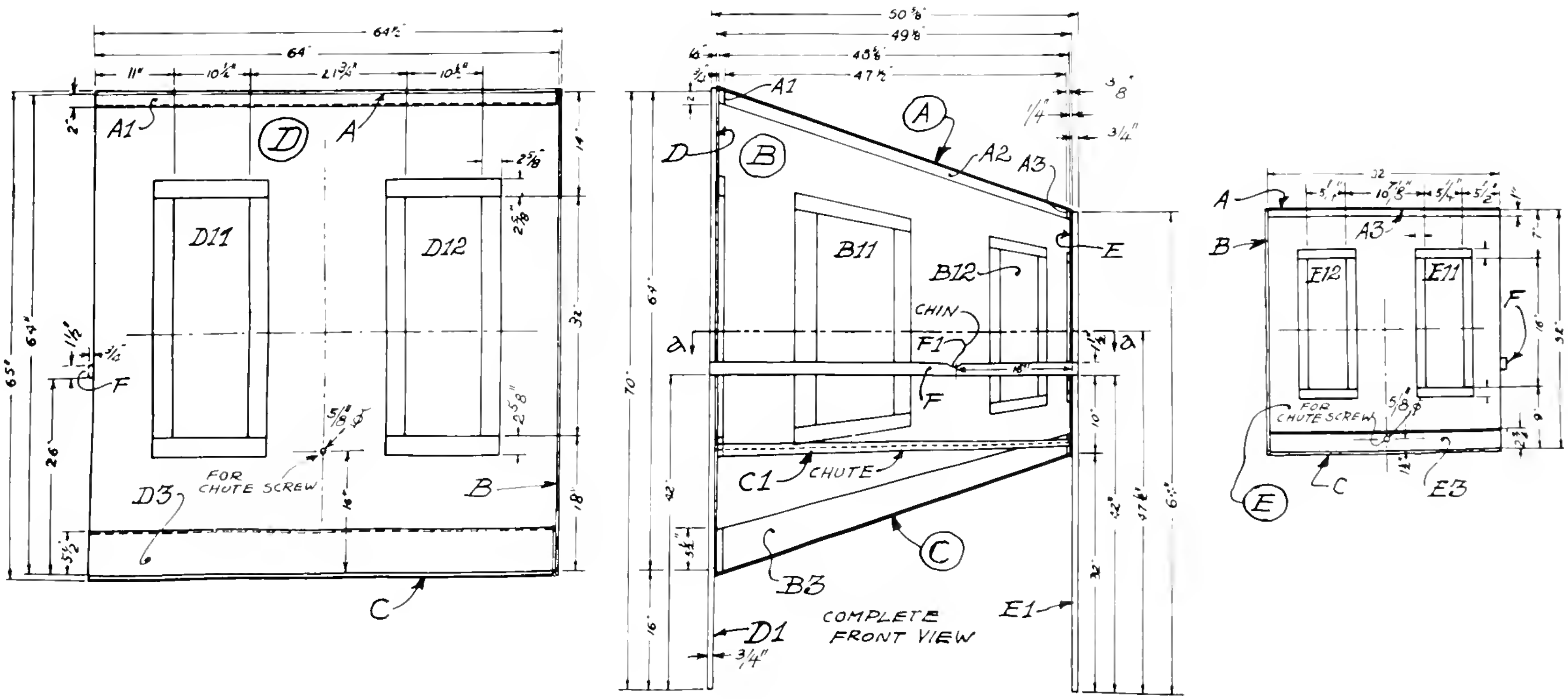


Fig. 13A.6. Apparatus drawing for monocular distorted room no. 1.

The full size monocular distorted room is an enlarged version of monocular laboratory room No. 1. In size it corresponds roughly to a twelve-foot cube. Its construction is similar to that of the laboratory model except for structural details necessitated by the greater size and weight. The room illustrated has been built to withstand the weather, but this is not necessary if adequate interior space can be provided.

The effects which can be experienced in the full size room are similar to those previously described for the laboratory model with the important addition that the room is large enough to accommodate several persons and large-sized objects. The appearance of the room and the effects experienced are more compelling than in the smaller models.

Fig. 13B.1. The full size monocular distorted room, exterior view.

Fig. 13B.2. The full size monocular distorted room from the viewing point.

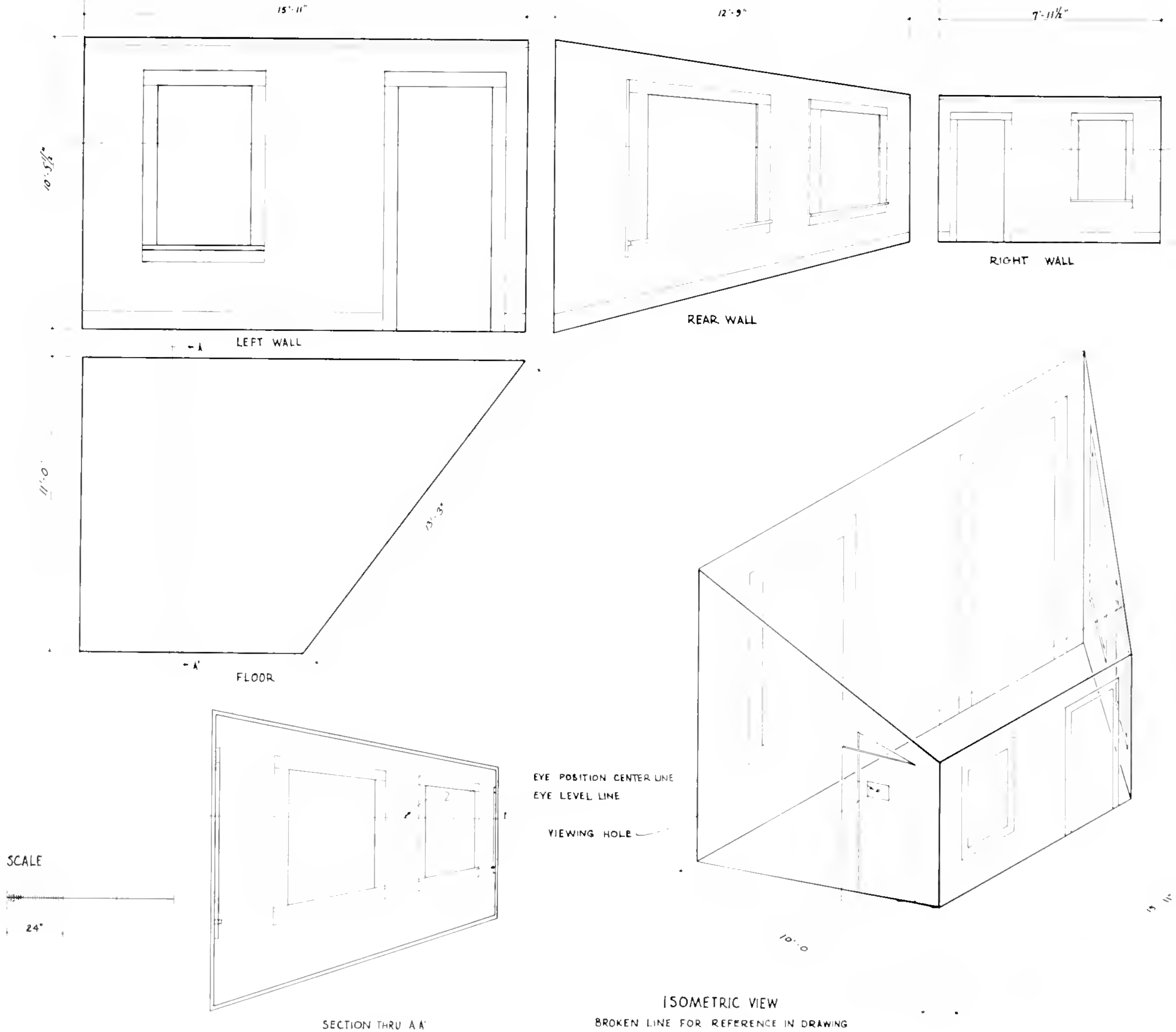


Fig. 13B.3. Apparatus drawing for the full size monocular distorted room.

The "architect's room" illustrates one way in which the principles underlying the construction of the distorted rooms might be utilized in architectural design. The demonstration consists of a scale model of a long narrow room. However, when viewed from a point corresponding to a door at one end, it appears to be an almost square room.

Apparatus

The "architect's room" consists of a model room made of plywood. On the inside surfaces are painted patterns of windows, floor, and ceiling as shown in the illustration. A special lighting arrangement provides even illumination throughout the interior.

Viewing conditions

The interior of the room is viewed monocularly through a peephole provided at one end. The peephole can be raised, permitting binocular observation.

Typical observations

Although in actual construction the room is long and narrow with only two windows at the far end, it appears to be an almost square room with four windows at the far end.

This effect is sufficiently compelling to be experienced to a greater or lesser extent for most observers when using binocular observation.

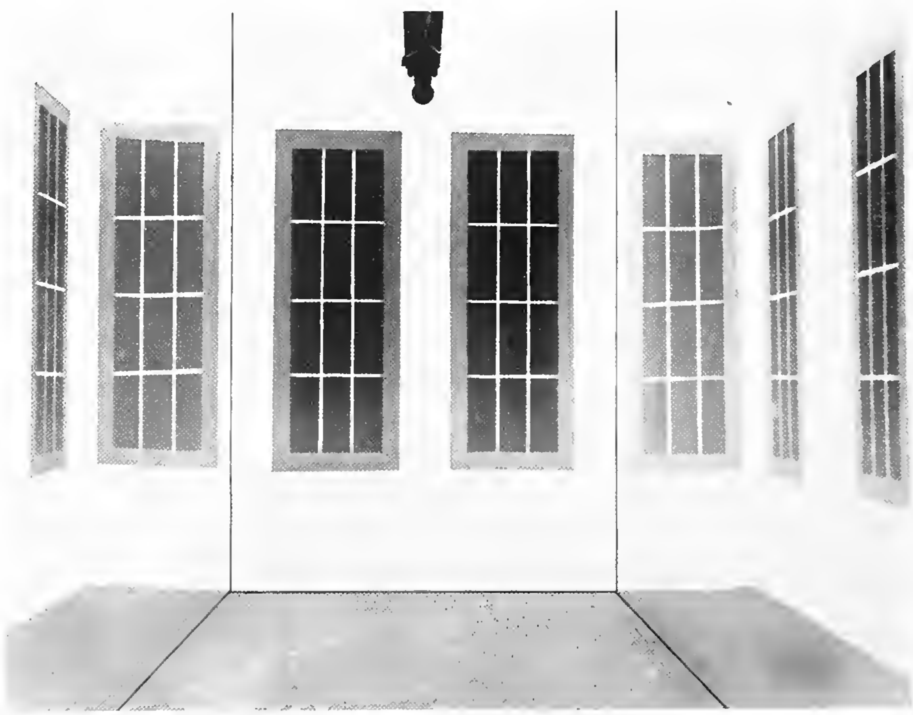


Fig. 13C.1. The "architect's room" from the viewing point with the outlines of the actual room drawn in.

Fig. 13C.2. The "architect's room," exterior view.

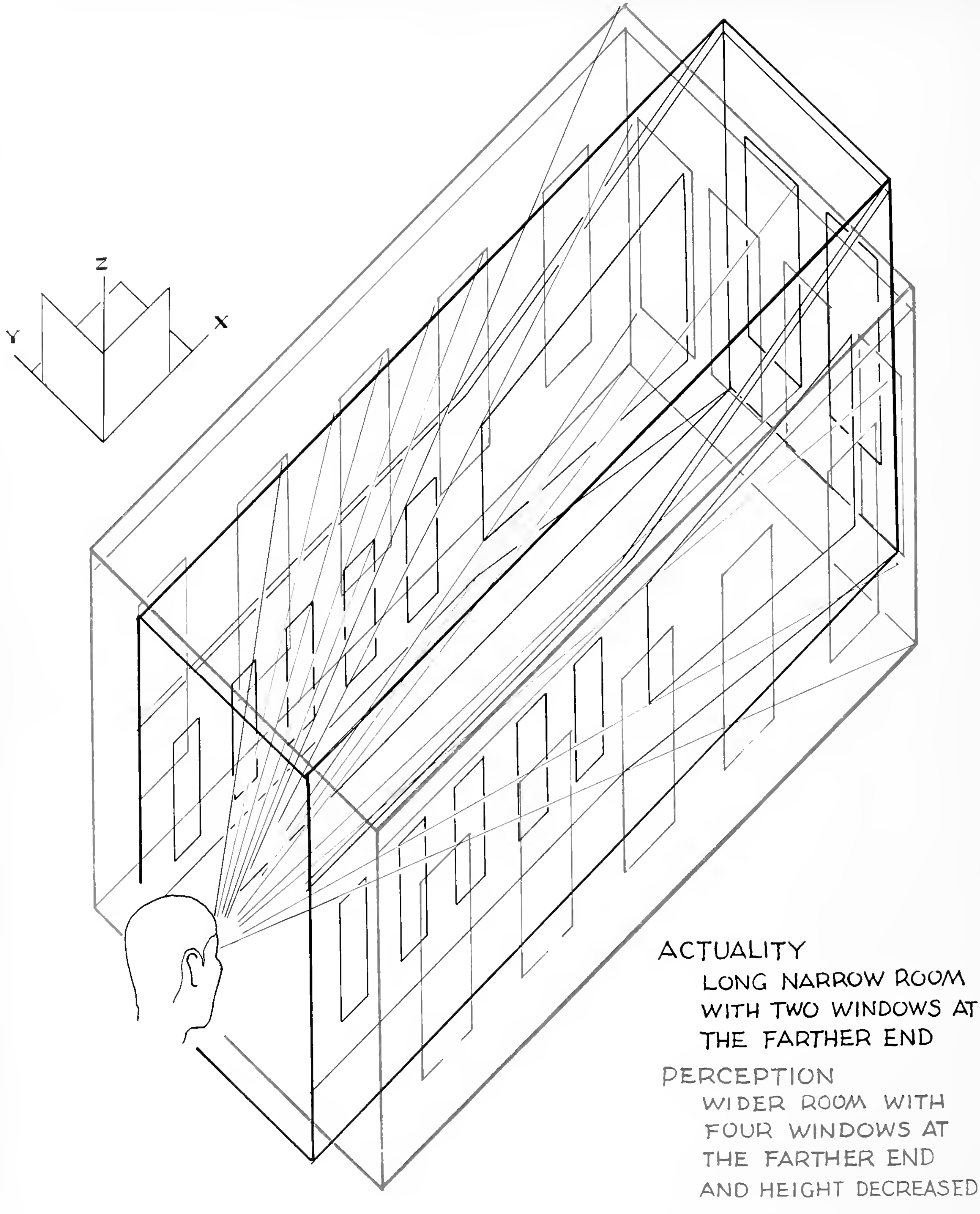


Fig. 13C.3. Typical observation using the "architect's room."

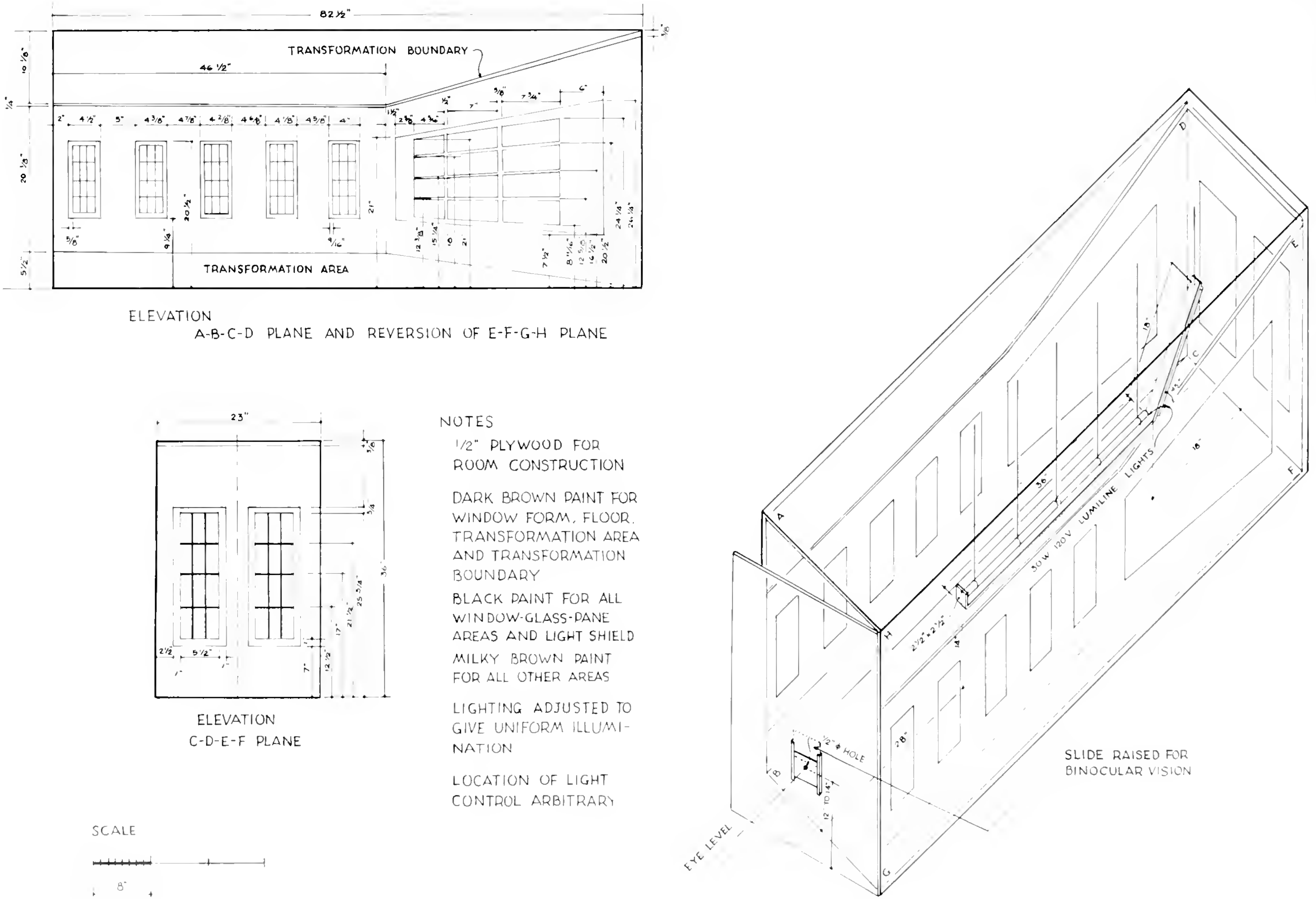


Fig. 13C.4. Apparatus drawing for the "architect's room" demonstration.

13D. THE BINOCULAR DISTORTED ROOMS

Two surfaces are defined as binocularly equivalent if every point on one surface provides the same binocular disparity as a corresponding point on the other surface. Two such surfaces will appear identical in binocular observation provided they are also monocularly equivalent. An infinite number of surfaces can be designed that are binocularly equivalent to any given surface. The binocular distorted rooms described in this section represent two out of the unlimited number of possible configurations that are binocularly equivalent to a rectangular room. One of the rooms described is an "interior room," i.e., it is smaller than the rectangular room to which it is equivalent. The other is an "exterior room," i.e., larger than the equivalent rectangular room.

Fig. 13D.1. The "interior" binocular distorted room.

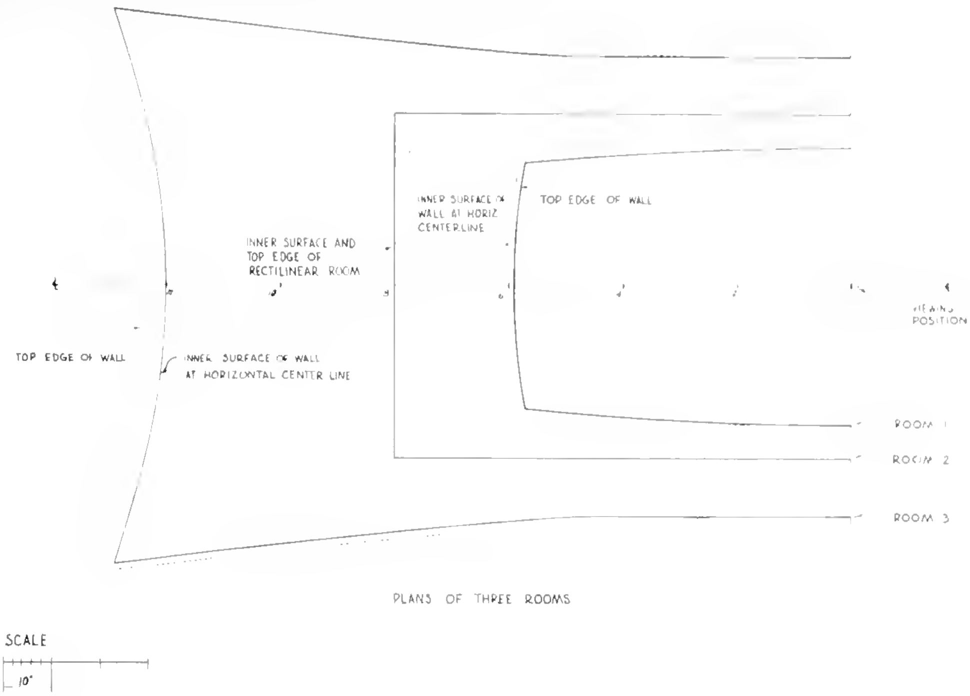


Fig. 13D.2. Horizontal cross-sections of the binocular distorted rooms
Room 1: The "interior" room.
Room 2: The equivalent rectangular room.
Room 3: The "exterior" room.

Apparatus

The two rooms are designed to be equivalent to a rectangular room 8' x 6'. One room, the "exterior" room, is larger and the other, the "interior" room, is smaller than these dimensions. The walls of these rooms are complex curved surfaces shown in cross-section in the diagram. The actual construction, undertaken by a shipbuilding concern, consists of plywood molded to a frame cut to the calculated curves. Similar patterns of floor boards, windows, etc., are painted in the proper scale and shape on the two rooms, thereby insuring that they will be monocularly as well as binocularly equivalent. Illumination is provided by four bulbs placed at the four corners of the front wall.

Viewing conditions

The rooms are viewed binocularly from the point indicated in the diagram.

Typical observations

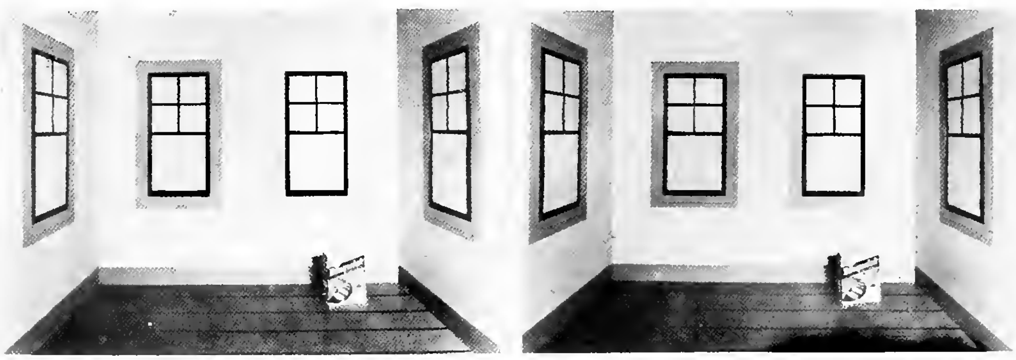
Observers who are blindfolded until they are in the proper viewing position, and are in this way shown first one room and then the other, report that both rooms appear rectangular and of substantially the same size and shape.

Apparent distortions in the size and shape of objects placed in these rooms can be observed.

If observers are allowed to examine the rooms, or even to catch a glimpse of the exterior dimensions, before seeing them from the proper point, the rooms are reported to appear rectangular but of different sizes that closely approximate the actual sizes.

The "interior" room

The "exterior" room



The "interior" room with an object inside

The "exterior" room with the same object

Fig. 13D.3. Stereoscopic photographs of the binocular distorted rooms taken from the viewing position

14. THE ANISEIKONIC GLASSES DEMONSTRATION

Aniseikonic glasses produce distortions in binocular disparity without significantly affecting any other aspect of the retinal images. Although these lenses were designed for clinical use, they are also important tools for the experimental study of binocular space perception since they allow one to alter binocular disparities while viewing everyday environments without affecting any of the other distance indications. Most observers when wearing the glasses experience the greatest apparent distortion when viewing environments which have relatively few monocular depth indications and experience the least apparent distortion in environments in which there are relatively many monocular indications.

Apparatus

A. The lenses. Eikonic or size lenses enlarge the image on the retina along one axis only without in any other way altering its optical properties. The design and construction of these lenses are highly technical optical problems, a detailed discussion of which would be out of place here. Two size lenses that produce different magnifications along the same or different axes combine to form a pair of aniseikonic or unequal-size glasses. The two types of these glasses most useful for demonstration purposes are schematically described in the diagram and are illustrated in the photograph. Each of these glasses may be turned over, making a total of four different glasses that are available.

B. The leaf room. The leaf room provides an environment that offers a minimum of monocular depth indications. It consists simply of a cube of wire mesh (with one side open) mounted on a wooden frame. Attached to the wire mesh and completely covering the interior of the cube, with the exception of the open side, are oak leaves that have been chemically treated to preserve their freshness.

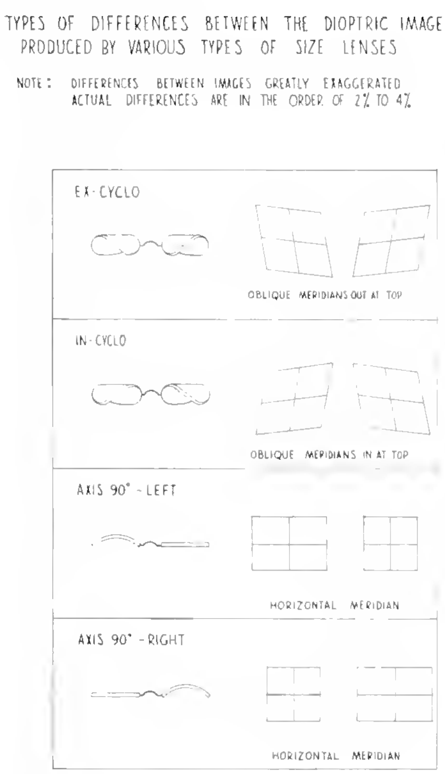


Fig. 14.1. Schematic representation of the aniseikonic glasses.

Fig. 14.2. Aniseikonic glasses.

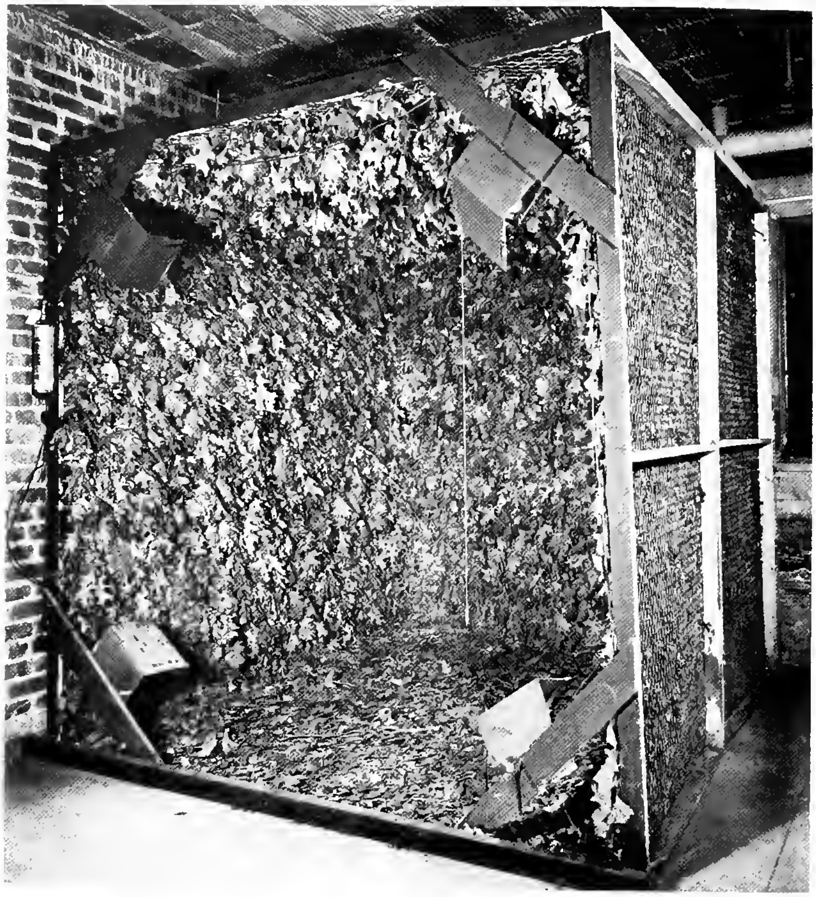


Fig. 14.3. The leaf room.

Viewing conditions

The aniseikonic glasses are worn in the same manner as any other pair of spectacles. They may be worn over the observer's regular glasses. Whatever particular environment is being studied is viewed in the normal manner by an observer wearing the glasses. The leaf room is viewed by an observer seated at the open end of the room and looking into it.

Typical observations

When standing on a lawn, an observer wearing axis-90 glasses sees the lawn tip to the right or left as the case may be. Excyclo glasses cause the lawn to slope up away from the observer, while incyclo glasses cause the lawn to slope down away from the observer.

When driving a car, an observer wearing axis-90 glasses sees objects in front of him apparently shifted to the right or the left. Excyclo glasses create the impression of being lifted high above the ground, whil incyclo glasses produce the opposite effect.

When wearing either type of glasses indoors, many observers experienc very little if any distortion in most ordinary rooms.

When wearing the glasses and looking into the leaf room, an observer experiences the optimum apparent distortion.

The use of the aniseikonic glasses with the monocular distorted rooms has already been described.

For almost every observer there is an appreciable time lag between putting on the glasses and the appearance of the distortions described. This interval varies from a few seconds to as long as several minutes.

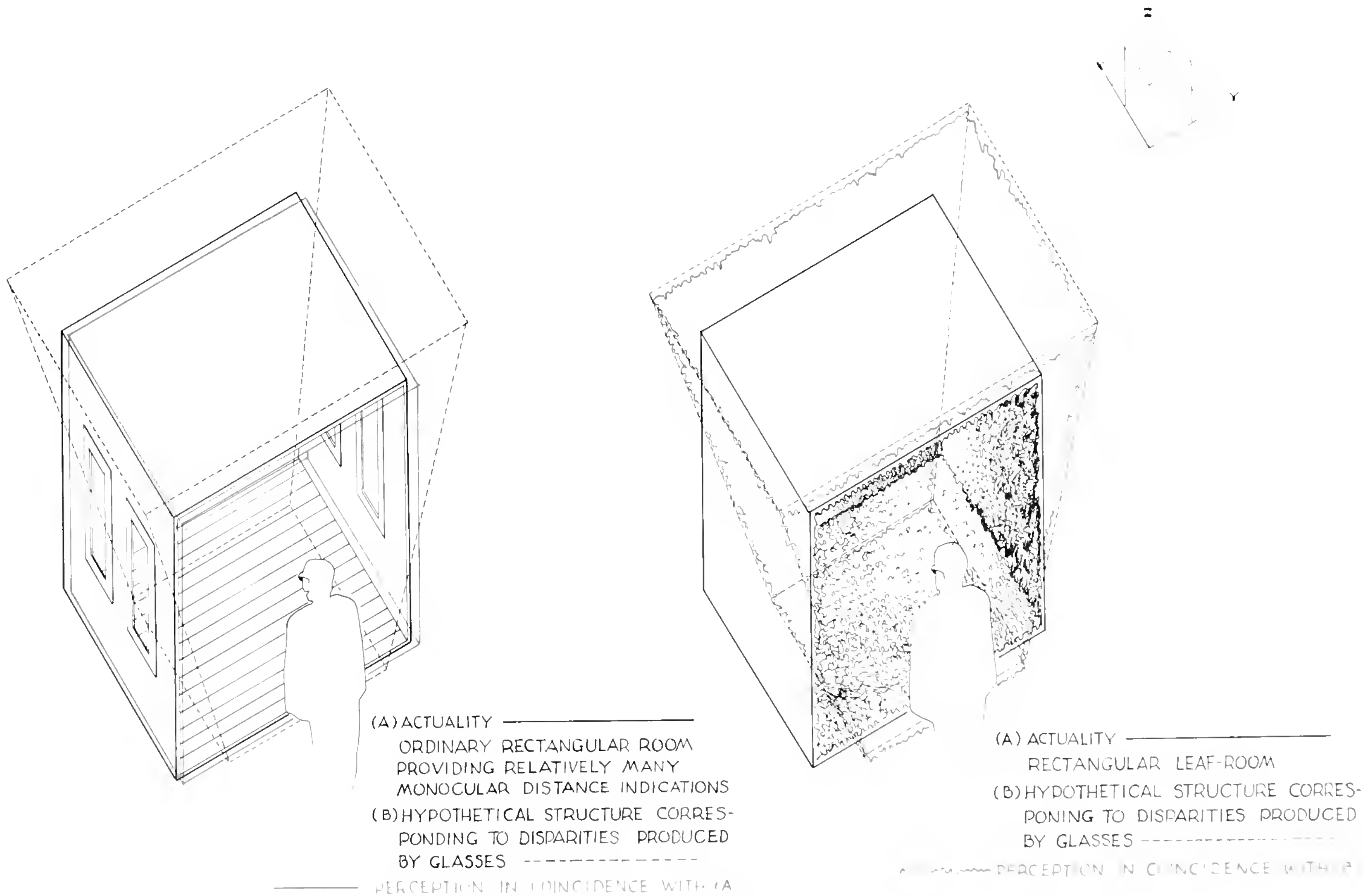


Fig. 14.4. Typical observations using the aniseikonic glasses.

15. THE RADIAL MOTION DEMONSTRATION

Continuous change of size is an indication of continuous movement in a radial direction. This fact has long been known and is illustrated in several of the other demonstrations. The radial motion demonstration contains within one piece of apparatus the means for demonstrating virtually all that is known concerning this particular phenomenon, including the conditions under which size-change is seen as radial movement, the apparent distance and speed of such movement, and the factors influencing the region of space within which the apparent movement takes place, including the effect of immediately prior experience.

Apparatus

A light-tight box, on the front of which is a square diaphragm opening, is driven back and forth on a track through a distance of six feet by an electric motor. The square diaphragm opening is formed by two metal plates, moving in slots on the front of the light box. Each of these metal plates engages one of a second pair of tracks, whose inclination and separation can be varied. As the box moves back and forth, variations in the size of the diaphragm opening are controlled by the inclination of this second pair of tracks. Three fixed spacings -- narrow, medium, and wide -- are provided at each end of the size control tracks. Five basic settings of these tracks are used:

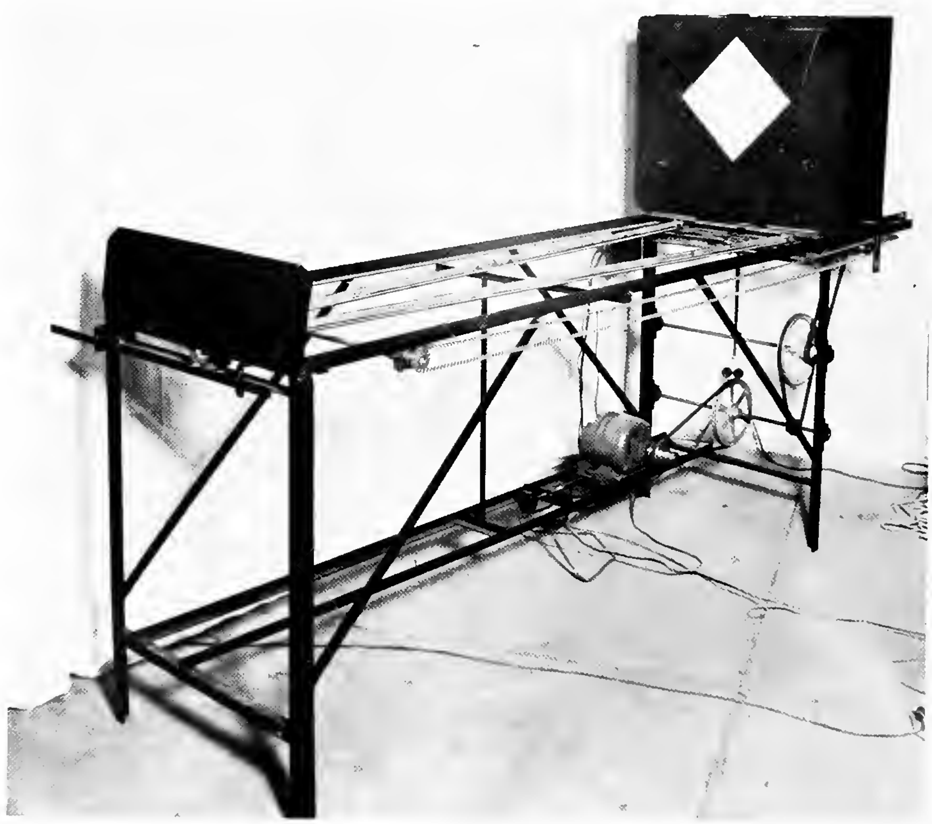


Fig. 15.1. The radial motion demonstration.

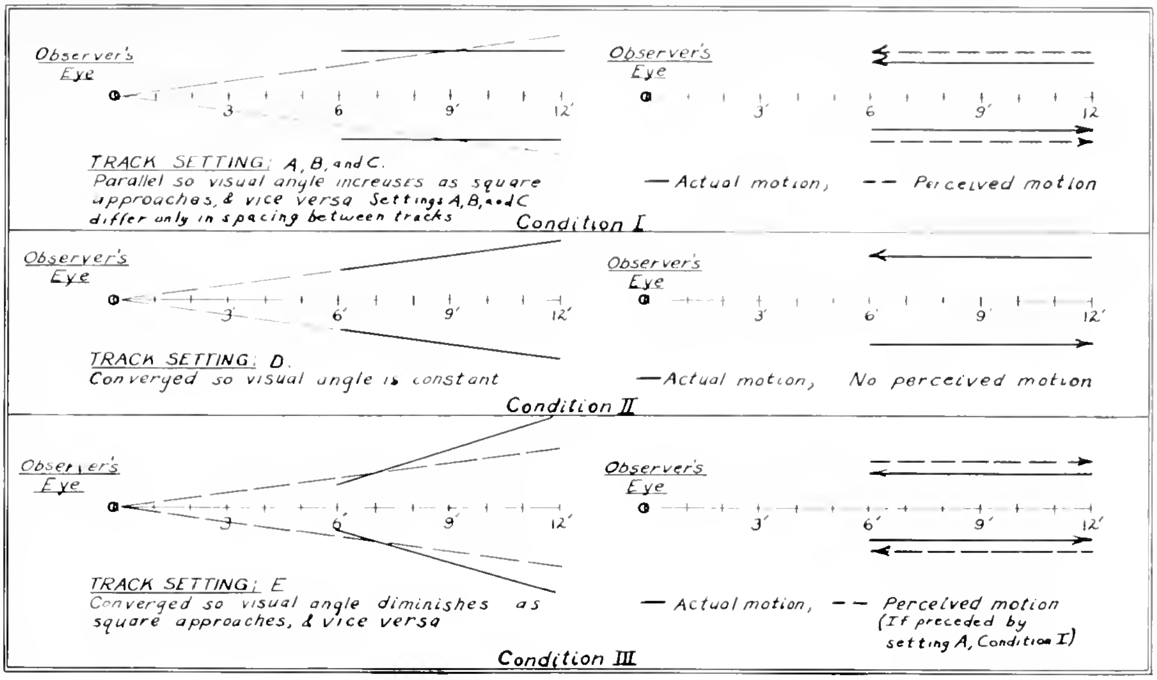


Fig. 15.2. The basic settings of the radial motion apparatus.

Setting A: both ends of the tracks at medium spacing. The square diaphragm remains of constant medium size as it moves back and forth.

Setting B: both ends of the tracks at wide spacing. The square diaphragm remains of constant large size as it moves back and forth.

Setting C: both ends of the tracks at narrow spacing. The square diaphragm remains of constant small size as it moves back and forth.

Setting D: near end of the track at medium spacing and far end at wide spacing. The square diaphragm decreases in size as it approaches the observer and increases as it recedes in such a way that at all times it subtends a constant angle at the observation point.

Setting E: near end of the tracks at narrow spacing and far end at wide spacing. The size of the square diaphragm decreases as it approaches the observer and increases as it recedes in such a way that at all times it subtends the same angle as would be subtended by a medium size square moving at the same constant speed through the same region in space but in the opposite physical direction.

Viewing conditions

The diaphragm opening is observed in an otherwise dark room from a headrest at a distance of six feet from the shield at the near end of the track. Observation is monocular except where otherwise noted.

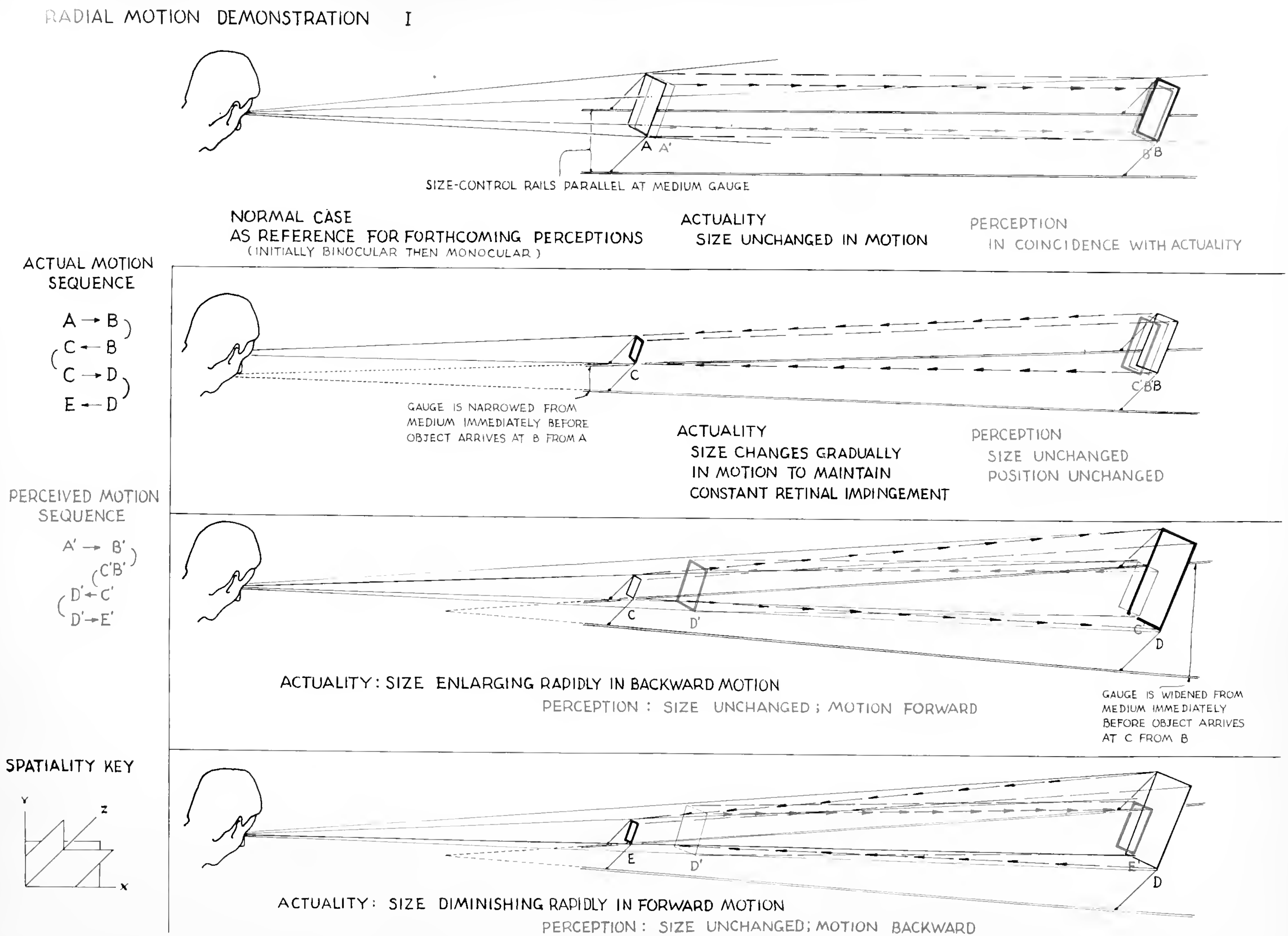


Fig. 15.3. Typical observations using the radial motion demonstration.

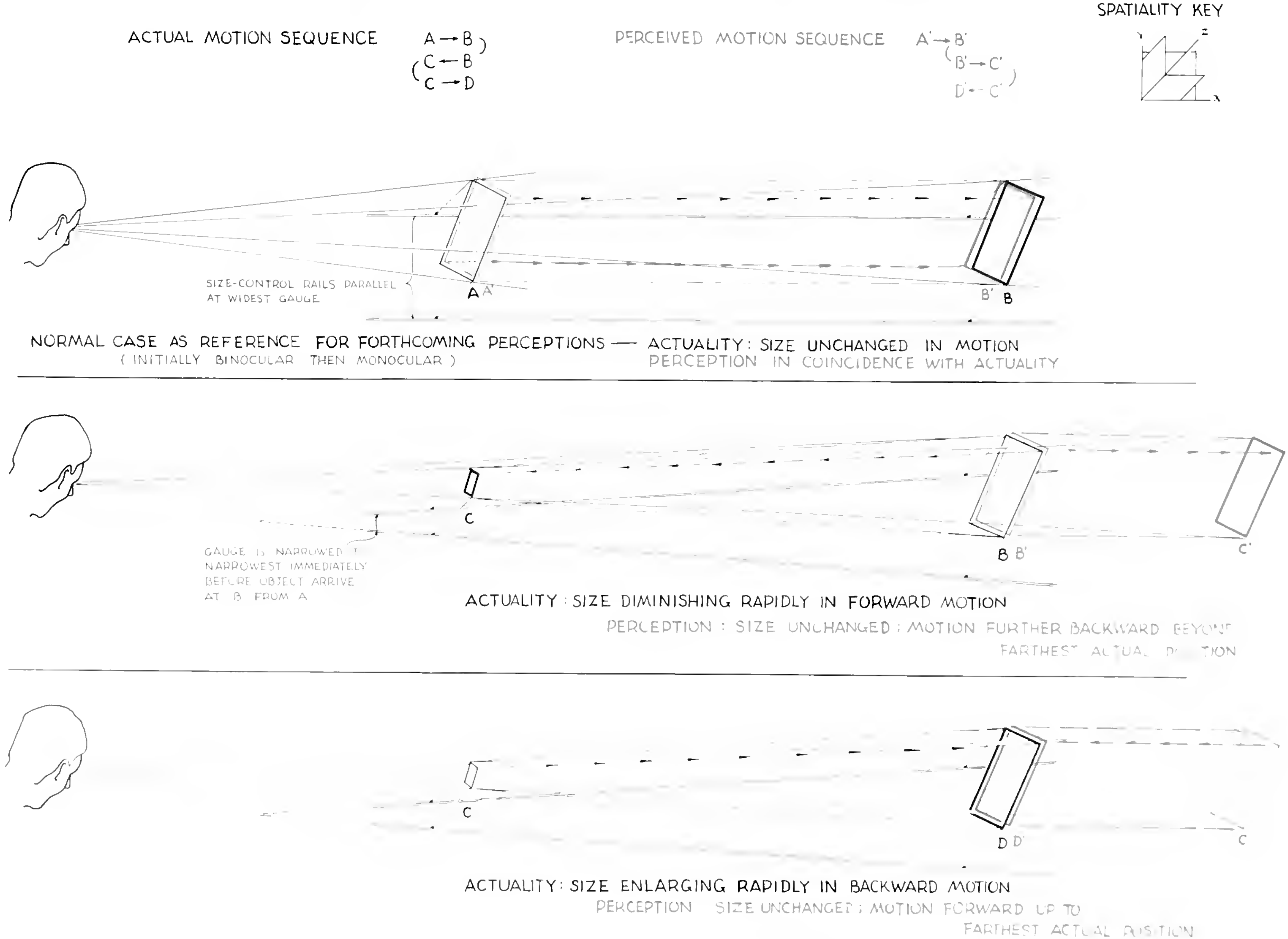


Fig. 15.4. Typical observations using the radial motion demonstration.

Typical observations

The following observations are made continuously, one following directly after the other in the order given:

Setting A (binocular observation): the observer sees a square of constant medium size moving back and forth at a constant speed, approaching to a distance of approximately six feet from him and receding to a distance of approximately twelve feet.

Setting A (monocular observation): the observer sees substantially the same thing as described above under binocular observation.

Setting D: the observer sees a medium size square standing motionless in front of him.

Setting E: the observer sees a square of constant medium size moving back and forth at a constant speed, approaching to a distance of approximately six feet from him and receding to a distance of approximately twelve feet.

Setting B (binocular observation): the observer sees a square of constant large size moving back and forth at a constant speed, approaching to a distance of approximately six feet from him and receding to a distance of approximately twelve feet.

Setting B (monocular observation): the observer sees substantially the same thing as under binocular observation.

Setting E: the observer sees a square of constant large size approaching to a distance of approximately twelve feet from him and receding to a distance of approximately twenty-four feet.

Setting C (binocular observation): the observer sees a square of constant small size moving back and forth at a constant speed, approaching to a distance of approximately six feet from him and receding to a distance of approximately twelve feet.

Setting C (monocular observation): the observer sees substantially the same thing as under binocular observation.

Setting E: the observer sees a square of constant small size approaching to a distance of approximately three feet from him and receding to a distance of approximately six feet.

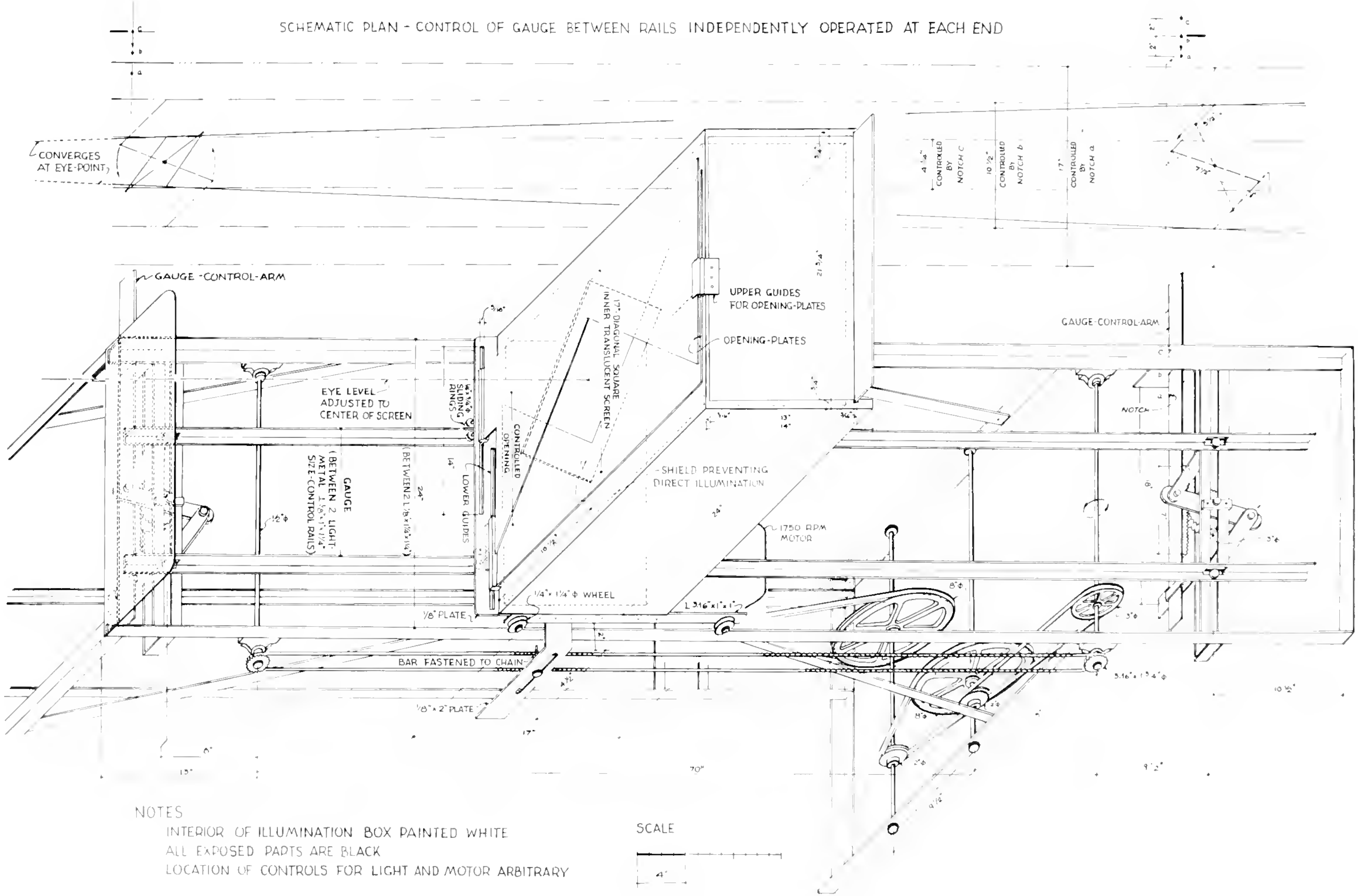


Fig. 15.5. Apparatus drawing for the radial motion demonstration.

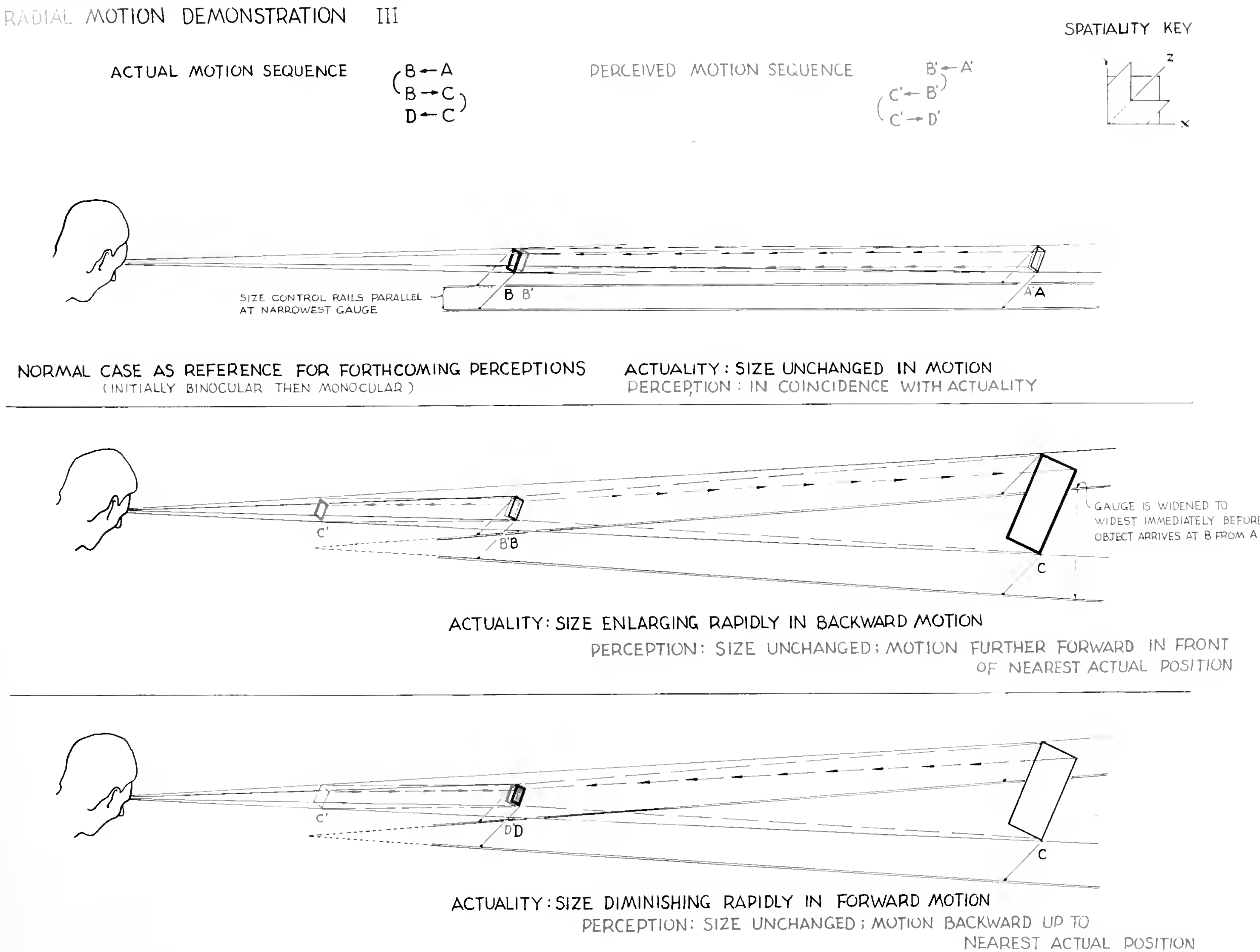


Fig. 15.6. Typical observations using the radial motion demonstration.

Movement perceived at a constant apparent distance from the observer is defined as tangential motion. The perception of this type of movement is related to stimulation moving laterally across the retina, but this relationship is complicated by many other factors. In the tangential motion demonstration some of the simpler aspects of this type of movement can be illustrated, such as the relation between the apparent size and distance of a moving object and its apparent speed and distance of travel.

Apparatus

The tangential motion apparatus consists of a long narrow table, approximately 7' x 1', carrying on its top a track in which moves an endless belt. This belt carries four mounts to which rods holding any desired test objects can be attached. In the photograph two such mounts are shown, one holding a double-size playing card and the other a three-quarter-size playing card. The cards are illuminated by a tubular light running the length of the track but hidden from view in the photograph. The cards are shown turned away from this light source so that their faces can be seen, printed in reverse for use with the mirror model of the thereness-thatness demonstration. The belt is driven at variable speed by an electric motor, through a speed-controlling mechanism. The apparatus shown permits continuous adjustment of the speed of the moving belt from 0.01 feet/sec. to 6 feet/sec.

Viewing conditions

The apparatus is viewed monocularly at a distance of six feet or more in an otherwise dark room. It is frequently used in conjunction with the mirror model of the thereness-thatness demonstration, but can equally well be operated alone.

Typical observations

If a familiar object, such as a playing card, is placed on one of the mounts, it appears to be moving laterally in front of the observer at approximately its true speed and distance.

If an undersized and an oversized card are placed on the apparatus at the same time, as illustrated in the photograph, the oversized card appears to be moving at less than its true speed and at a distance nearer than its true distance, while the undersized card appears to be moving at more than its true speed and at a distance farther than its true distance. This effect has already been illustrated in connection with the mirror model of the thereness-thatness demonstration.

Fig. 16.1. The tangential motion demonstration
Note: Fig. 7.5 contains an apparatus drawing of this demonstration.

Indications of tangential motion can be combined with indications of radial motion to produce apparent movement along complex three-dimensional paths. In the circular motion demonstration appropriate indications of tangential movement at variable speed together with appropriate indications of radial movement at variable speed are perceived as circular movement at constant speed.

Apparatus

The apparatus contains a mount, A, which is electrically driven so that it oscillates through an arc, BCD, of about forty degrees at a distance of 8' 9" from the observer's eye, E. The rate of angular movement about this point E is mechanically controlled to be the same as that which would result from an object describing a hypothetical circle, BFDG, with a three-foot radius at a constant angular velocity about a center, C, 8' 9" from E. This means that the angular velocity about the observation point, E, is variable, being zero at the two end-points, B and D, and reaching a maximum halfway between them. This maximum, furthermore, is greater for movement in one direction (left to right or BCD) than in the other direction (right to left or DCB).

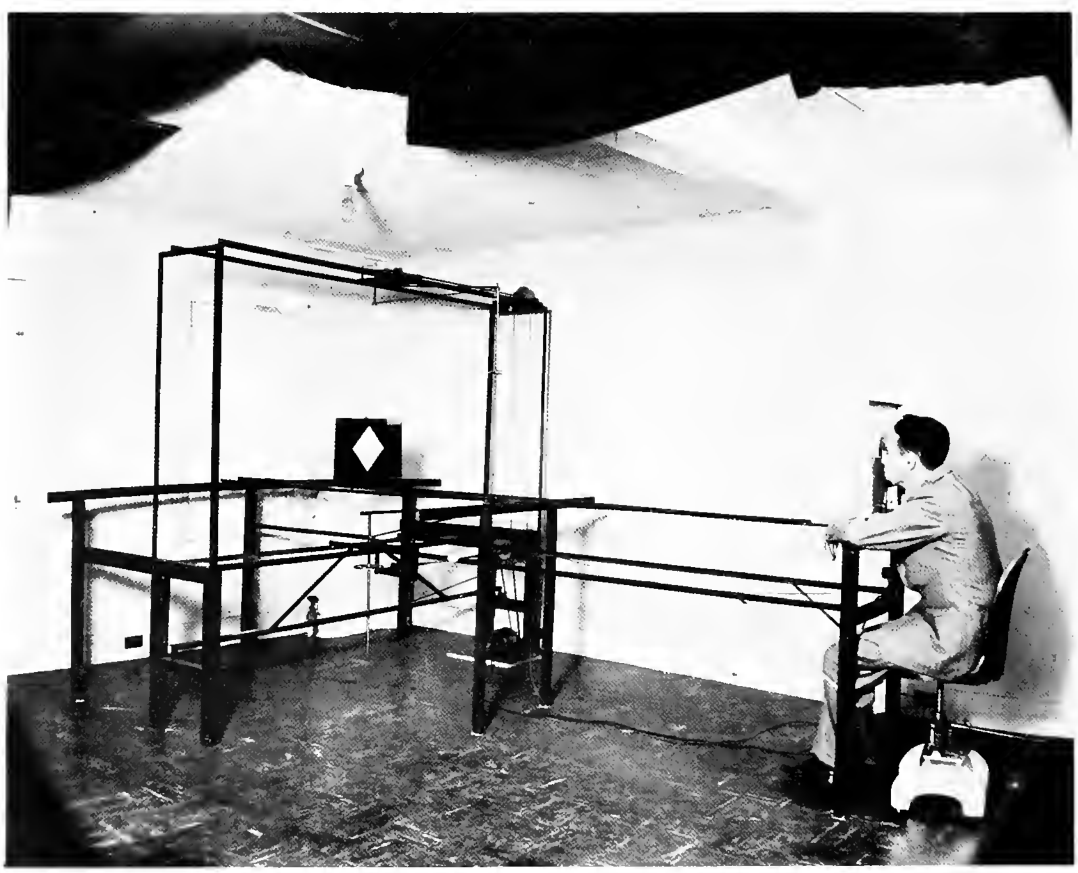


Fig. 17.1. The circular motion demonstration.

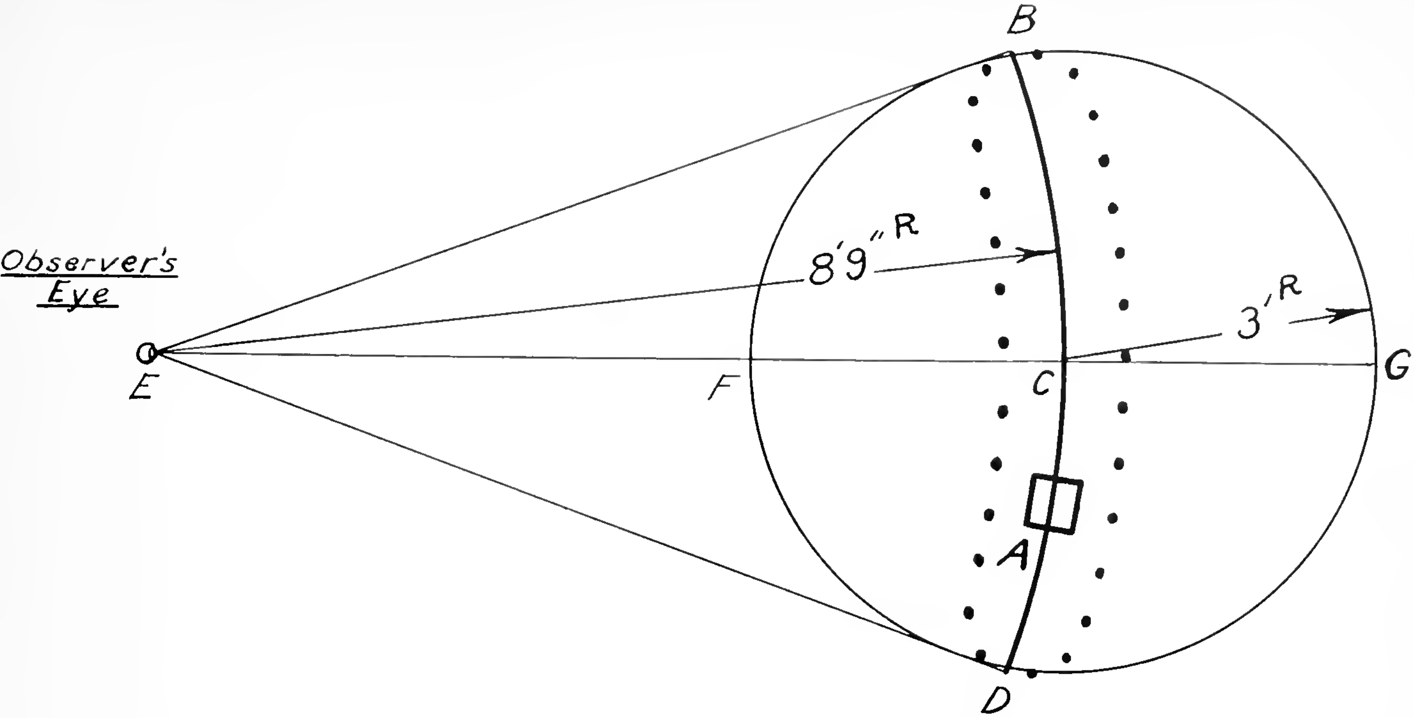


Fig. 17.2. Schematic representation of the circular motion demonstration.

To the movable mount, A, can be attached either a star point of light or a light-tight box with a variable-size square diaphragm opening. It is possible, by means of a mechanical linkage, to vary the size of this diaphragm opening in such a way that the angle it subtends at point E exactly corresponds at all times to the angle that would be subtended by a square surface normal to the line of sight from E and moving in a counterclockwise direction about the hypothetical circle BFDG.

Viewing conditions

The apparatus is viewed monocularly in an otherwise dark room from the headrest provided.

Typical observations

When the star point of light is placed on the moving mount, it is seen as moving in a shallow ovate arc approximately as indicated by the dotted line in the diagram. Its apparent speed of movement is variable, being considerably greater in one direction (left to right) than in the other direction.

When the light box with the square diaphragm opening is placed on the moving mount, but the size of the opening is held constant, an observer sees a constant-size square swinging from side to side at variable speeds at a constant distance from him.

When the light box with the square diaphragm opening is placed on the moving mount and its size varied in the manner described above, an observer sees a square of constant size moving in a circle at a constant rate of speed.

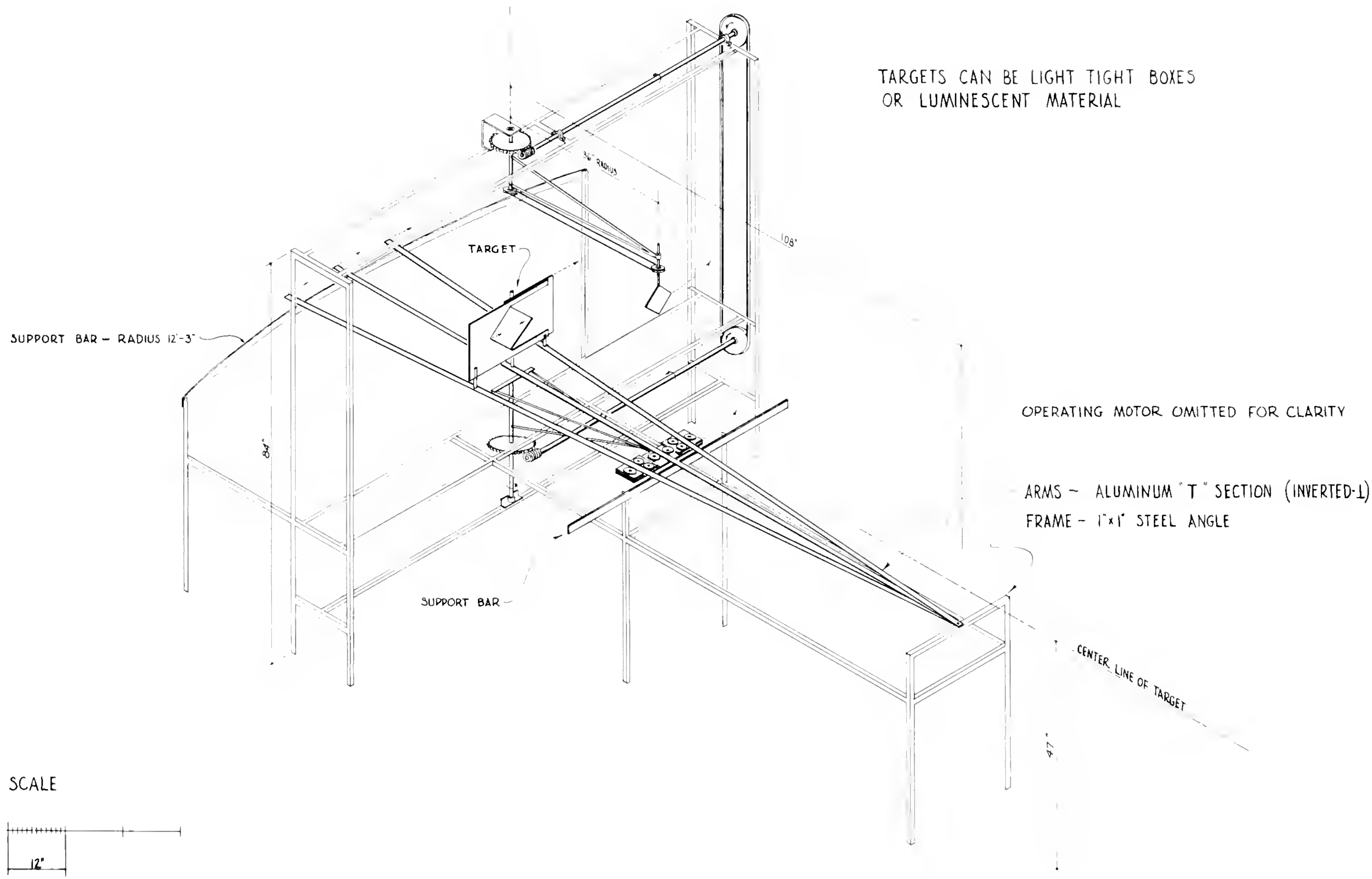


Fig. 17.3. Apparatus drawing for the circular motion demonstration.

18. THE "S" MOTION DEMONSTRATION

Indications of tangential movement can be combined with indications of static distance to produce apparent movement along complex paths. In the "S" motion demonstration objective tangential movement is perceived as movement along an S-shaped path when some of the other indications, primarily that of overlay, are systematically altered.

Apparatus

A thin metal trapezoidal shape, with openings corresponding to window panes and with appropriate shadows painted on the face, is placed relative to the observer's eye in the position A'B' as shown on the diagram. A small electric motor drives a fine thread in such a way that light objects suspended from it, e.g., a small card cut out of paper, can be driven across the field of view at a constant speed along the straight path CD, passing through one of the near openings of the trapezoid.

Viewing conditions

The apparatus is viewed against a black background, monocularly, from a headrest provided at the point indicated. Appropriately placed lights illuminate the face of the trapezoid and the moving card throughout the length of its path.

Typical observations

The trapezoid is perceived as an ordinary rectangular "window" in the position AB on the diagram.

A card moving along the straight line CD is seen as moving in the approximately S-shaped path indicated. As the card moves across the field of view, it initially appears to the right of the "window" and against a homogeneous black background. Under these conditions, it is seen as constant in size moving from right to left at a constant speed in a direction parallel to the observer's frontal plane. When it moves to a position such that part of it is behind the near edge of the trapezoid, it appears to be passing behind the far edge of the apparent rectangle. As the card moves completely through the near opening of the trapezoid, it comes between the observer and successively farther parts of the trapezoid. To the observer, however, it appears to be passing in front of successively nearer parts of the apparent rectangle. The card under these conditions appears to be moving toward the observer more or less parallel to the apparent plane of the rectangle and at the same time decreasing in apparent size. The card finally appears to pass completely in front of the rectangle and continues to travel in a straight line at a constant speed and size.

Many observers do not experience the decrease in apparent size as the card appears to approach.

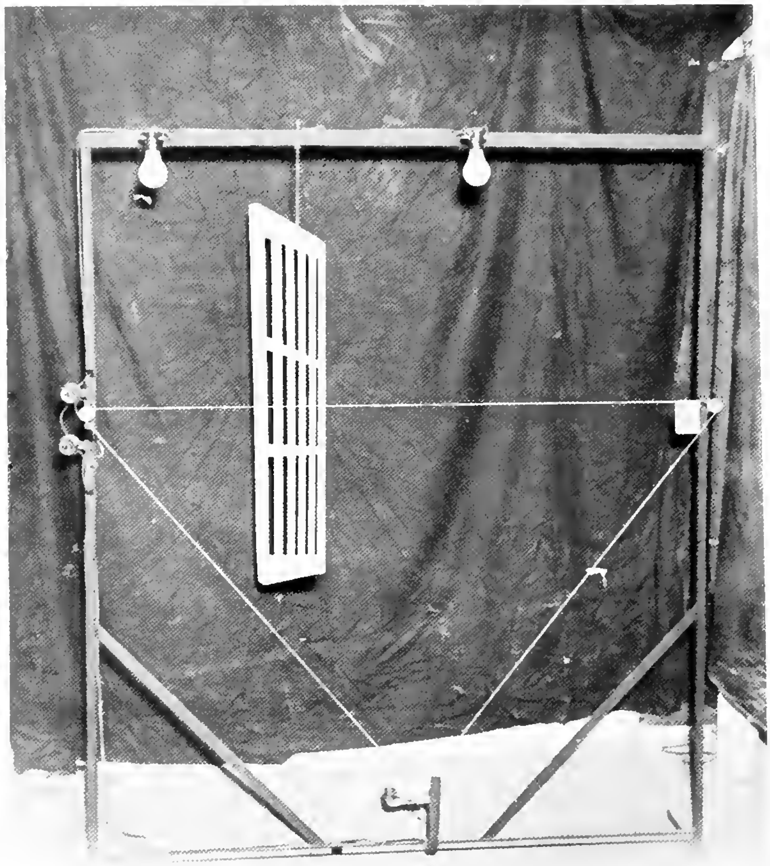


Fig. 18.1. The "S" motion demonstration.

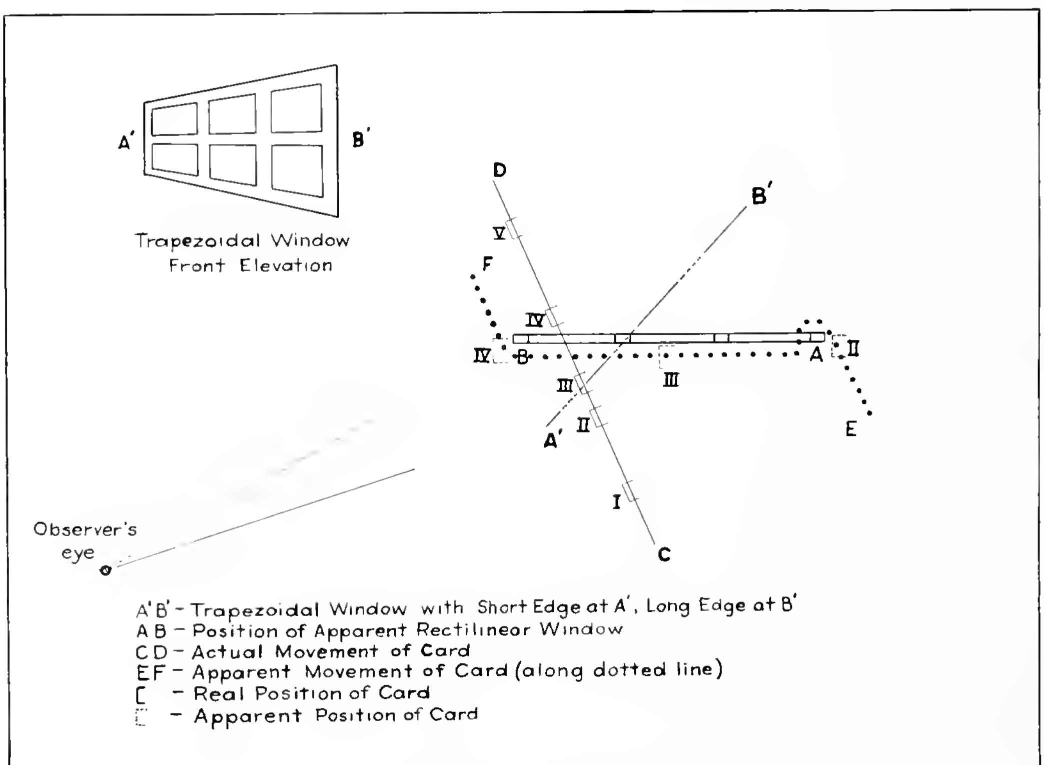


Fig. 18.2. Schematic representation of the "S" motion demonstration.

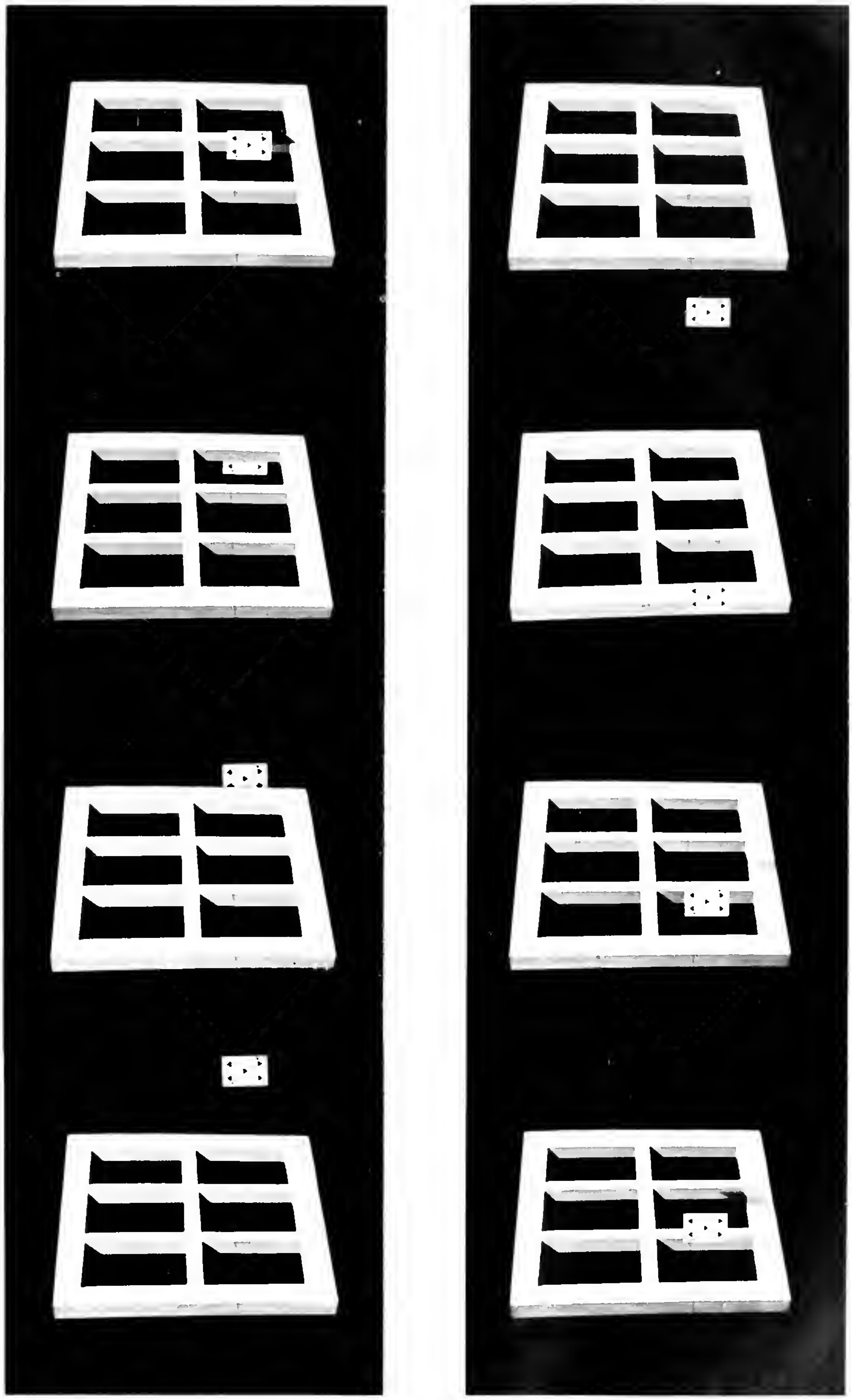


Fig. 18.3. The "S" motion demonstration from the viewing point.

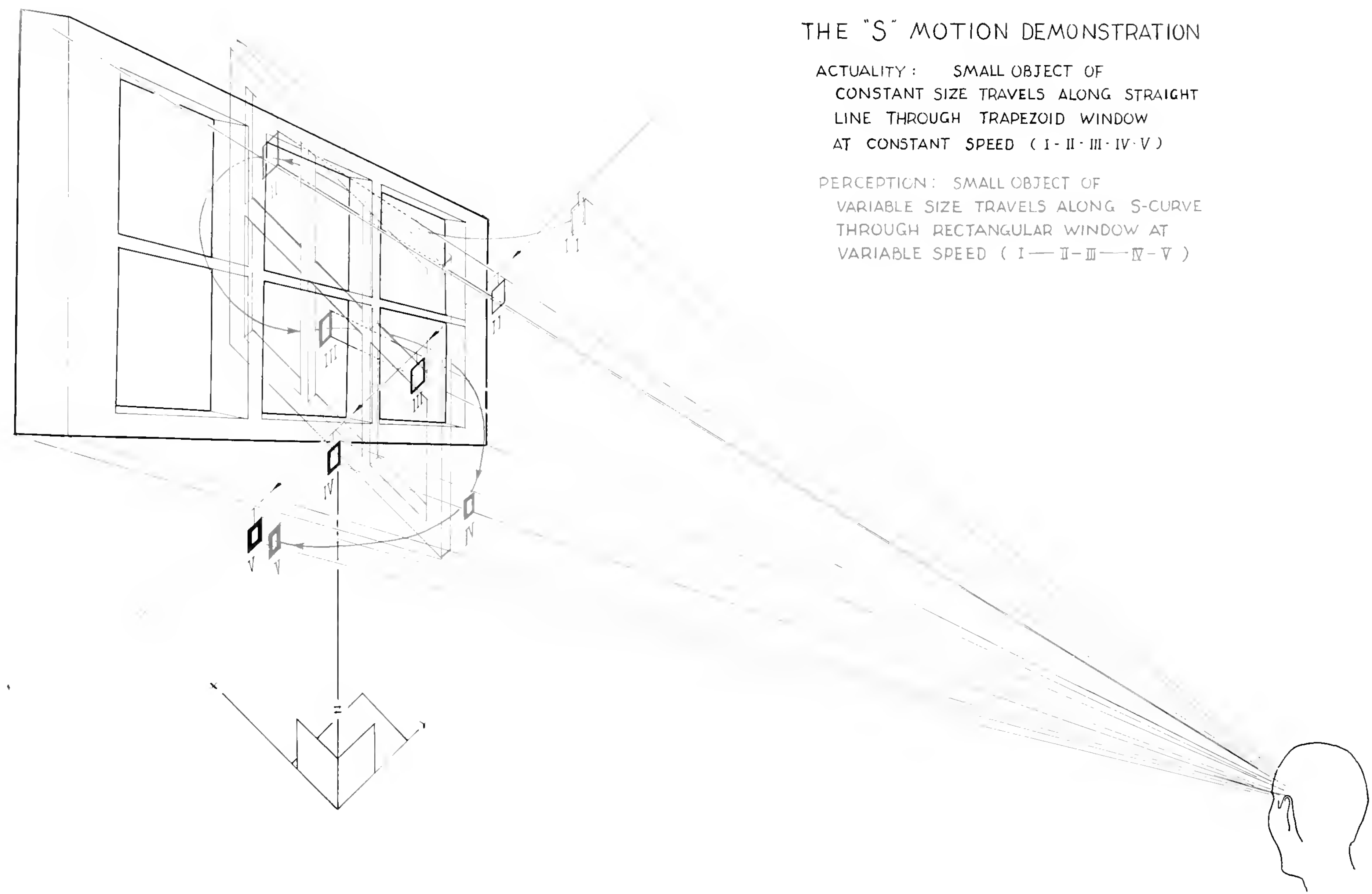


Fig. 18.4. Typical observations using the "S" motion demonstration.

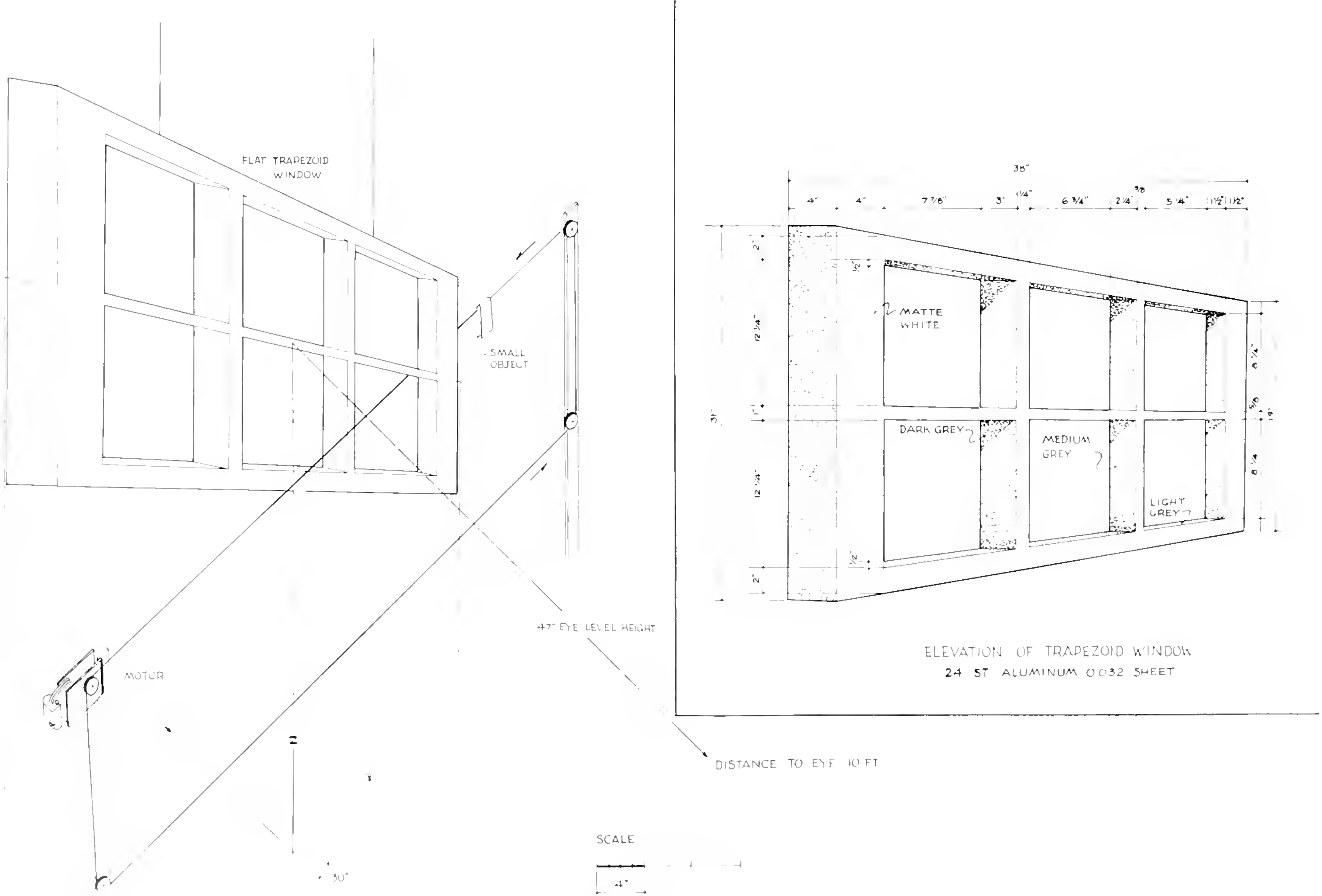


Fig. 18.5. Apparatus drawing for the "S" motion demonstration.

19. THE ROTATING TRAPEZOID DEMONSTRATION

The rotating trapezoid demonstration combines many of the visual indications illustrated by the other demonstrations in constantly changing patterns of agreement and conflict. What is experienced in viewing this demonstration eludes verbal description. As the trapezoid rotates it appears to oscillate and change size, while objects attached to it appear to become detached or else strangely contorted in ways that are never quite the same for any two observers, or for the same person from one moment to the next.

Apparatus

A trapezoid of sheet metal, with holes cut out to resemble window panes and shadows painted to give the appearance of thickness, is mounted on a vertical shaft that rotates at approximately two revolutions per minute, driven by a small electric motor. Various objects are provided to be mounted on the trapezoid and rotate with it. For example, a tube can be suspended through one of the openings, or a cube can be attached to one edge of the trapezoid.

Viewing conditions

The rotating trapezoid, with or without objects attached, is viewed from a distance of ten feet or more monocularly, or binocularly from twenty-five feet or more. The center of the trapezoid preferably should be at eye-level height. Equal illumination is provided from the right and the left of the line of sight of the observer. (The portable model that is illustrated is completely self-contained in a small carrying case and can be used for demonstrations before large groups in which considerable departure from these ideal viewing conditions can safely be tolerated.)

Typical observations

When the trapezoid alone is viewed, it appears to be a rectangle of varying size and thickness oscillating at varying speed through an arc of approximately 100°.

When a cube is attached to the small end of the trapezoid, it is seen as traveling in a circular path about the apparently oscillating rectangle, so that during part of its movement the cube "breaks away" and seems to float freely through space.

When a tube is suspended through one of the openings, part of the time the tube and the apparent rectangular window are perceived as moving in opposite directions. When they "meet," several different effects can be seen. The most commonly reported are that the tube either "bends around" or else "cuts through" the apparent rectangle.

Observers tend to see the tube "bend around" if it has previously been suggested to them that the tube is actually made of flexible material. On the other hand, if it is suggested that the tube is actually rigid, observers tend to see it "cut through."

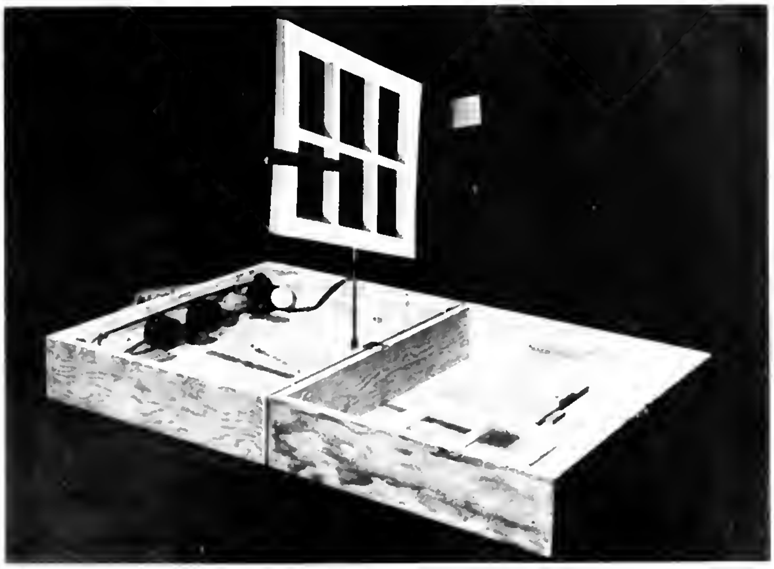


Fig. 19.1. The rotating trapezoid demonstration.

Fig. 19.2. The rotating trapezoid demonstration from the viewing position.

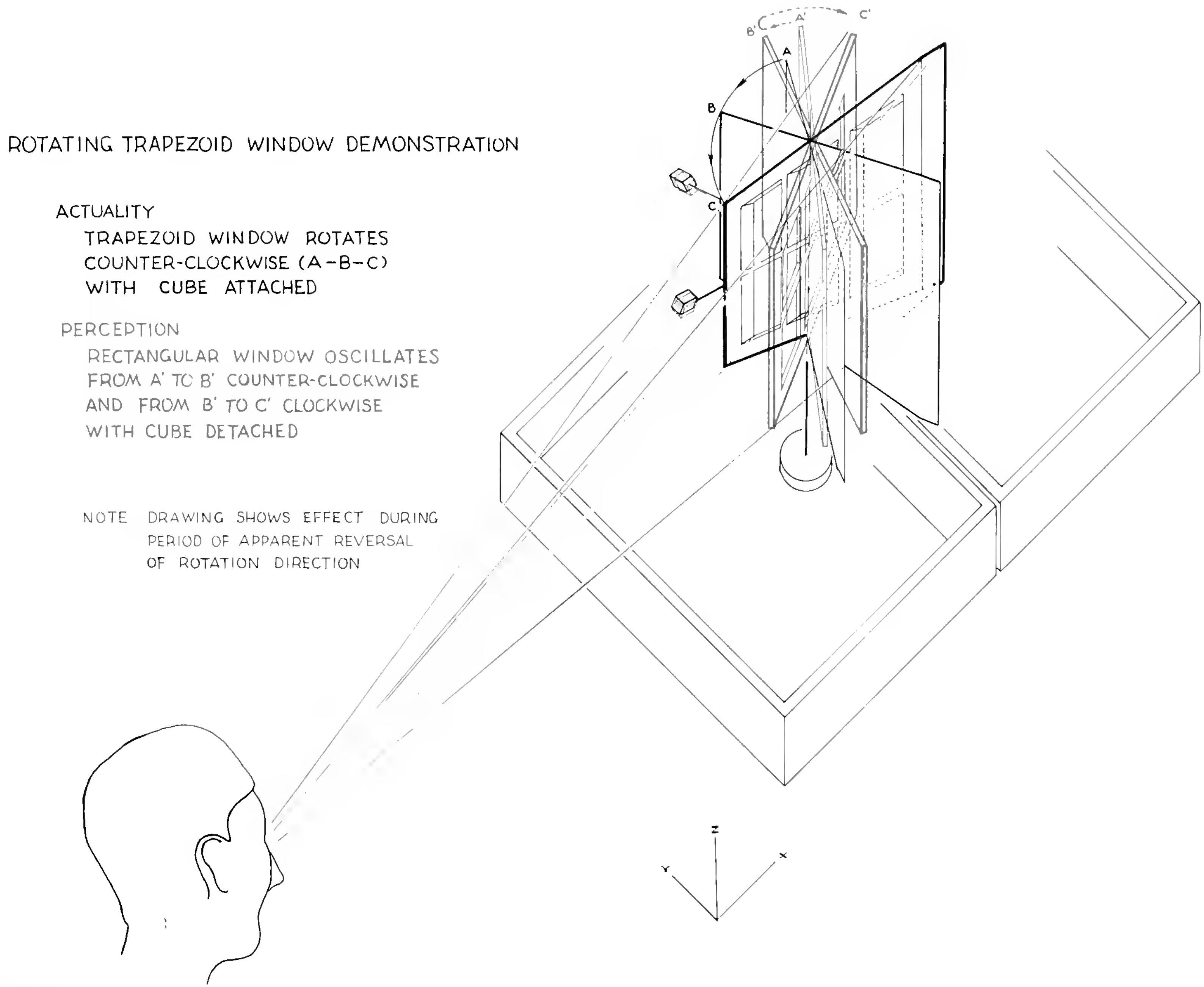


Fig. 19.3. Typical observations using the rotating trapezoid demonstration with cube attached.

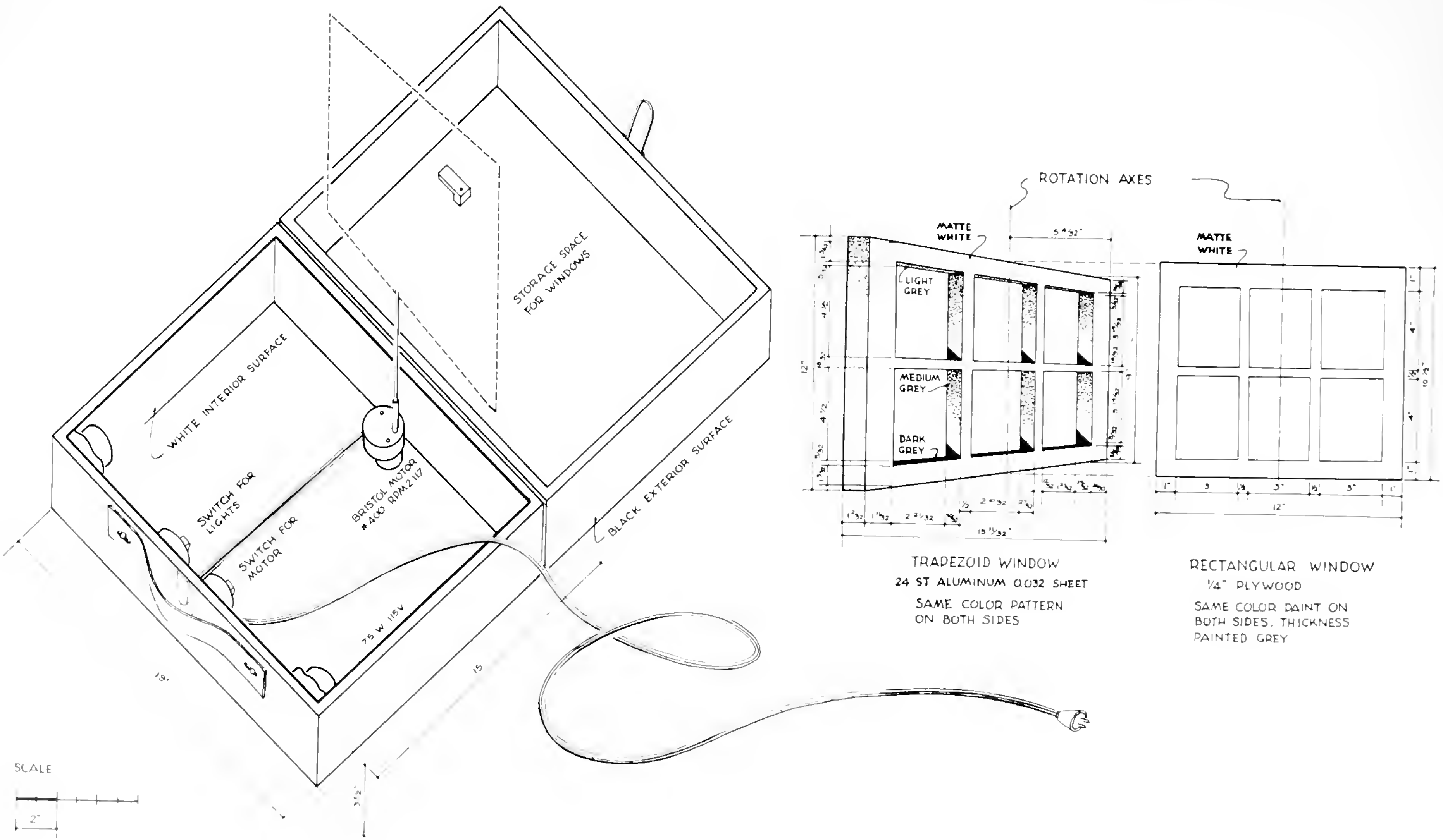


Fig. 19.4. Apparatus drawing for the rotating trapezoid demonstration.

20. THE SURETY DEMONSTRATION

In the demonstrations previously described, it has been necessary to isolate and carefully to control all the visual indications. More commonly, however, in everyday experience, a whole host of different indications are present to varying extents. These indications usually tend to supplement each other; each one of them, if taken alone, would give rise to approximately the same apparent localization as would any other one. This agreement between indications is rarely if ever perfect, and occasionally severe conflicts may be present, i.e., one of the indications, if taken alone, would give rise to apparent localization radically different from that related to the other indications. The surety demonstration illustrates the effect of both supplementing and conflicting indications on the resultant perception itself and on the subjective sense of surety that an observer experiences with respect to such perceptions.

Apparatus

The surety demonstration consists basically of two wood grids, one rectangular in shape and the other trapezoidal, mounted with their planes vertical and oriented with respect to the observer as shown in the illustration.

The inner faces of both grids are painted white and are illuminated by separate light sources that light only these surfaces and which can be adjusted so that only these surfaces are visible to the observer.

The front edges of the mullions of both grids are painted gray and are separately illuminated by a second pair of light sources, the thickness lights. These lights can be continuously varied in intensity from a minimum brightness under which the thickness of the mullions is not visible to a maximum at which the thickness is clearly illuminated.

A headrest is provided that can be kept fixed in one position or can swing from side to side to introduce movement parallax.

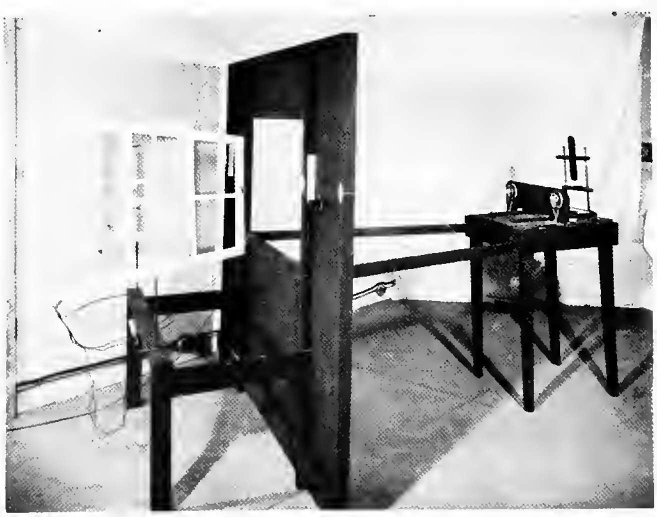


Fig. 20.1. The surety demonstration.

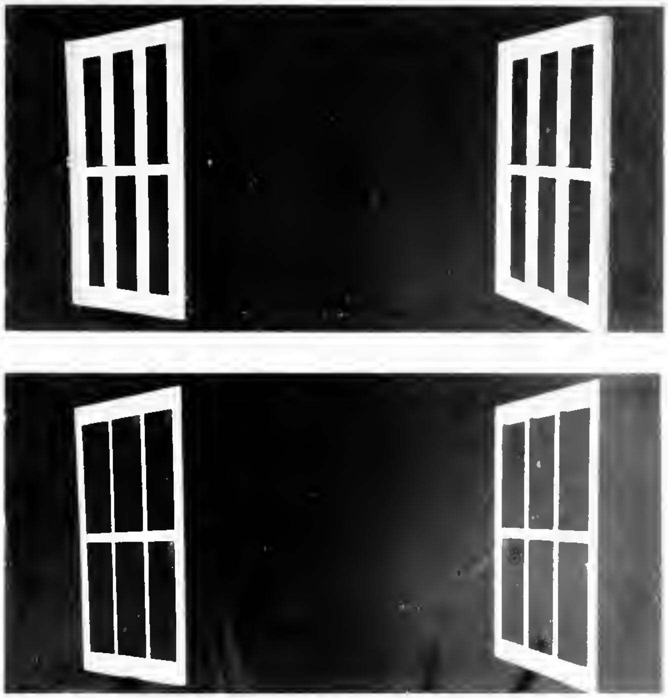


Fig. 20.2. The surety demonstration from the viewing point under conditions of high illumination (top) and low illumination (bottom).

Viewing conditions

The grids are viewed monocularly in an otherwise completely dark room from the headrest provided.

Typical observations

With the thickness lights set at minimum intensity and the head stationary both grids appear to be identical rectangular "windows" with their planes parallel.

Under the same conditions, if the head is slowly moved from side to side, the actually rectangular window does not appear to change while the trapezoidal window appears to "weave" back and forth in space. Accompanying this is a diminished sense of surety as to the true shape of the trapezoidal grid.

If, with the head stationary, the intensity of the thickness lights is slowly changed from lowest to highest, a sequence of observations can be made. Initially, as noted above, the trapezoidal grid appears to be a perfect rectangle. There is a high degree of subjective surety associated with this perception. At first, as the illumination is raised, the trapezoid remains rectangular in appearance, but with a diminished sense of subjective surety. At still higher levels of illumination a point is reached at which the appearance of the trapezoidal grid becomes anomalous and may lie anywhere between the apparent rectangular and the actual trapezoidal shape. For some observers the appearance changes continuously throughout this region. These experiences are accompanied by a high degree of subjective uncertainty. Finally, at the highest levels of illumination, the trapezoidal grid is perceived in its true shape with a relatively high degree of surety.

None of the effects described above is experienced with respect to the actually rectangular grid.

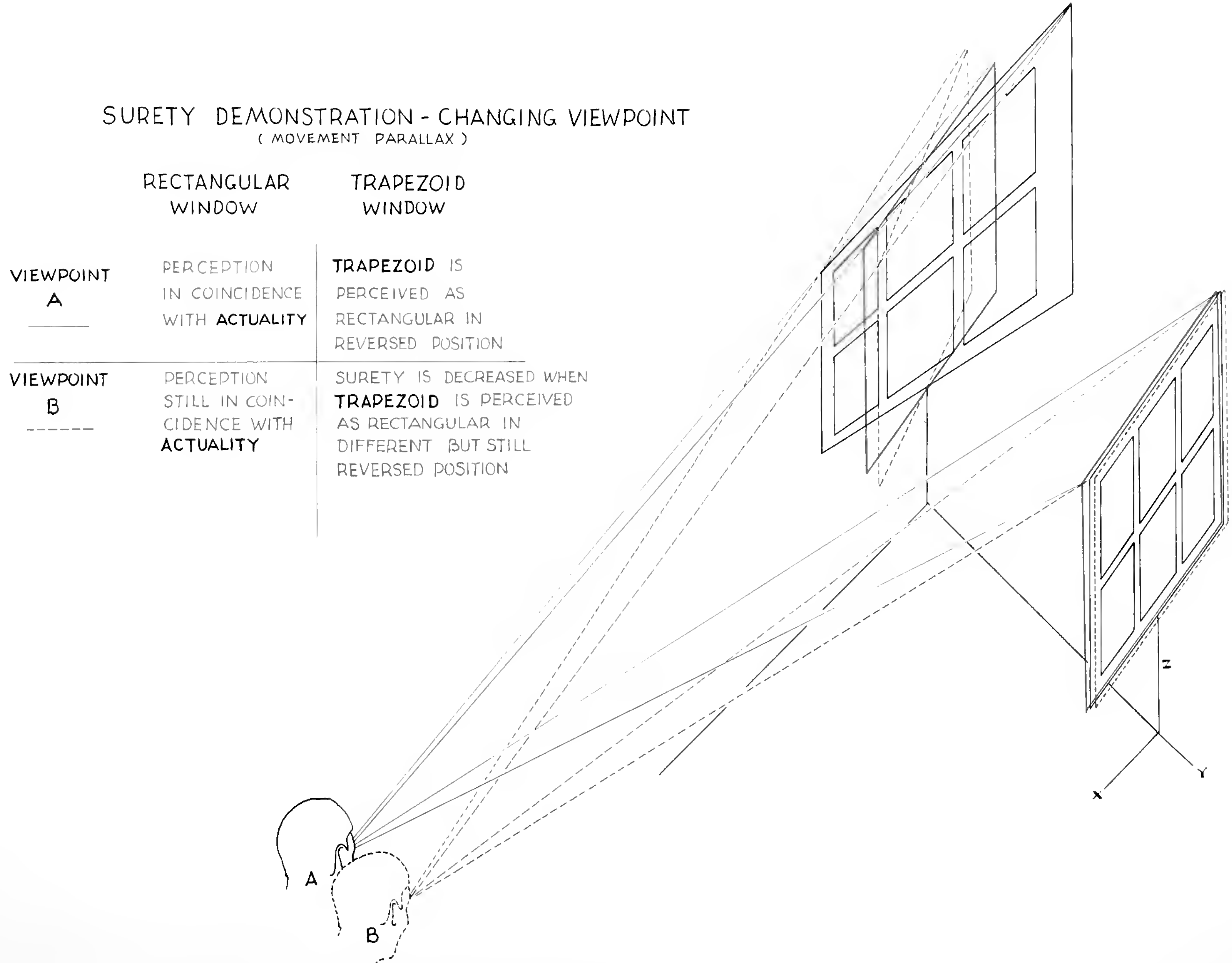


Fig. 20.3. Typical observation of the parallax effect using the surety demonstration.

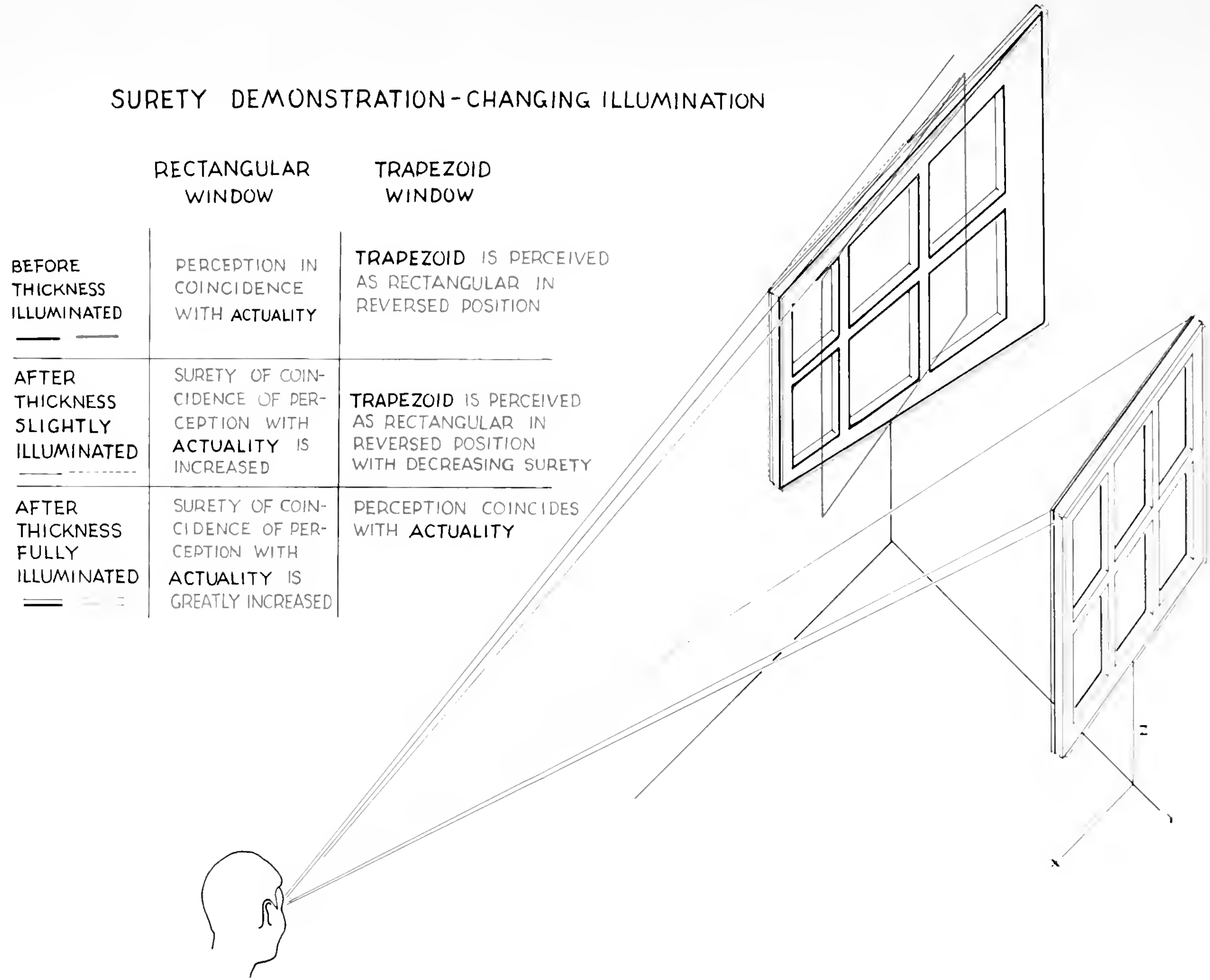


Fig. 20.4. Typical observation of the **illumination** effect using the surety demonstration.

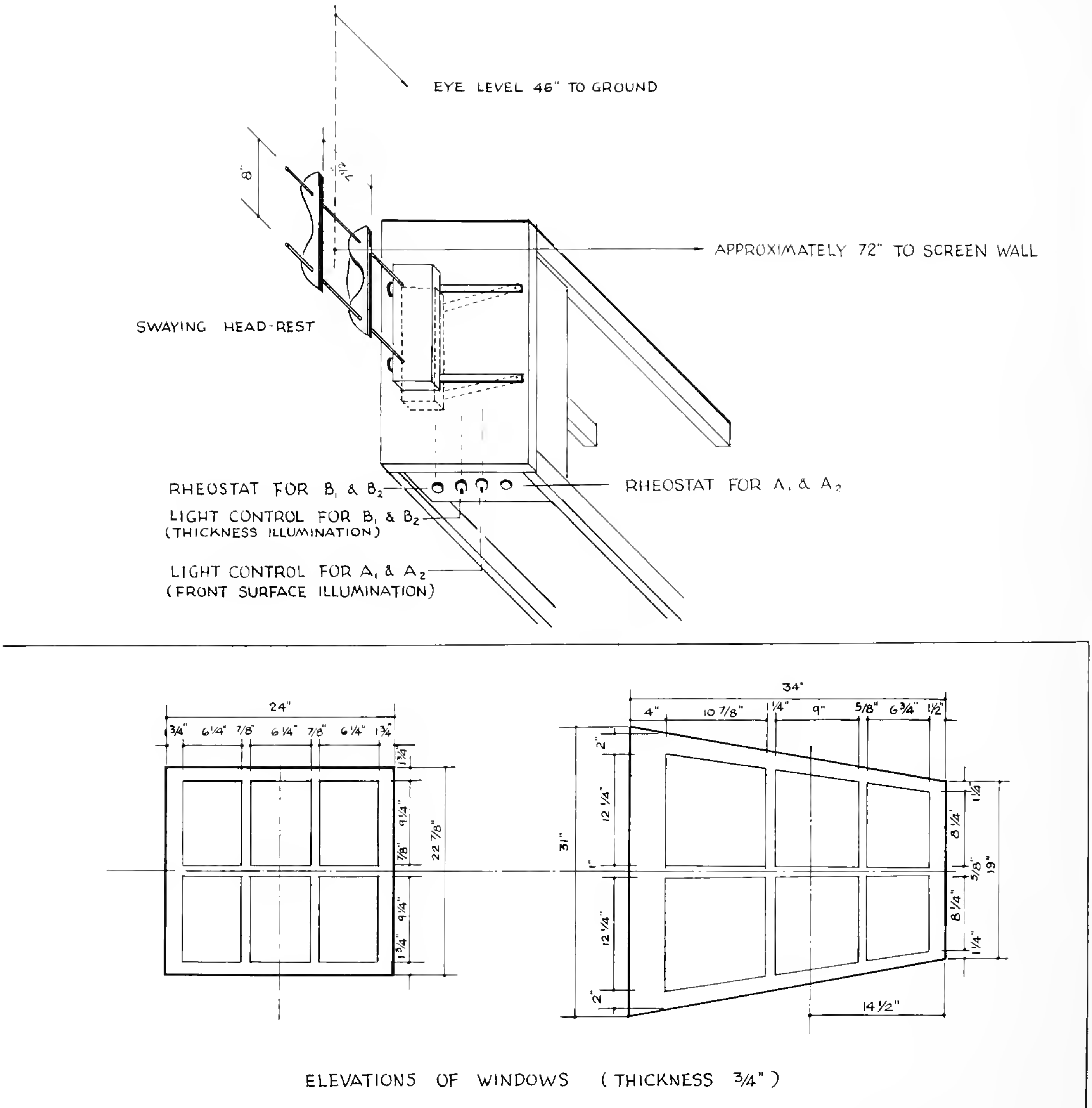
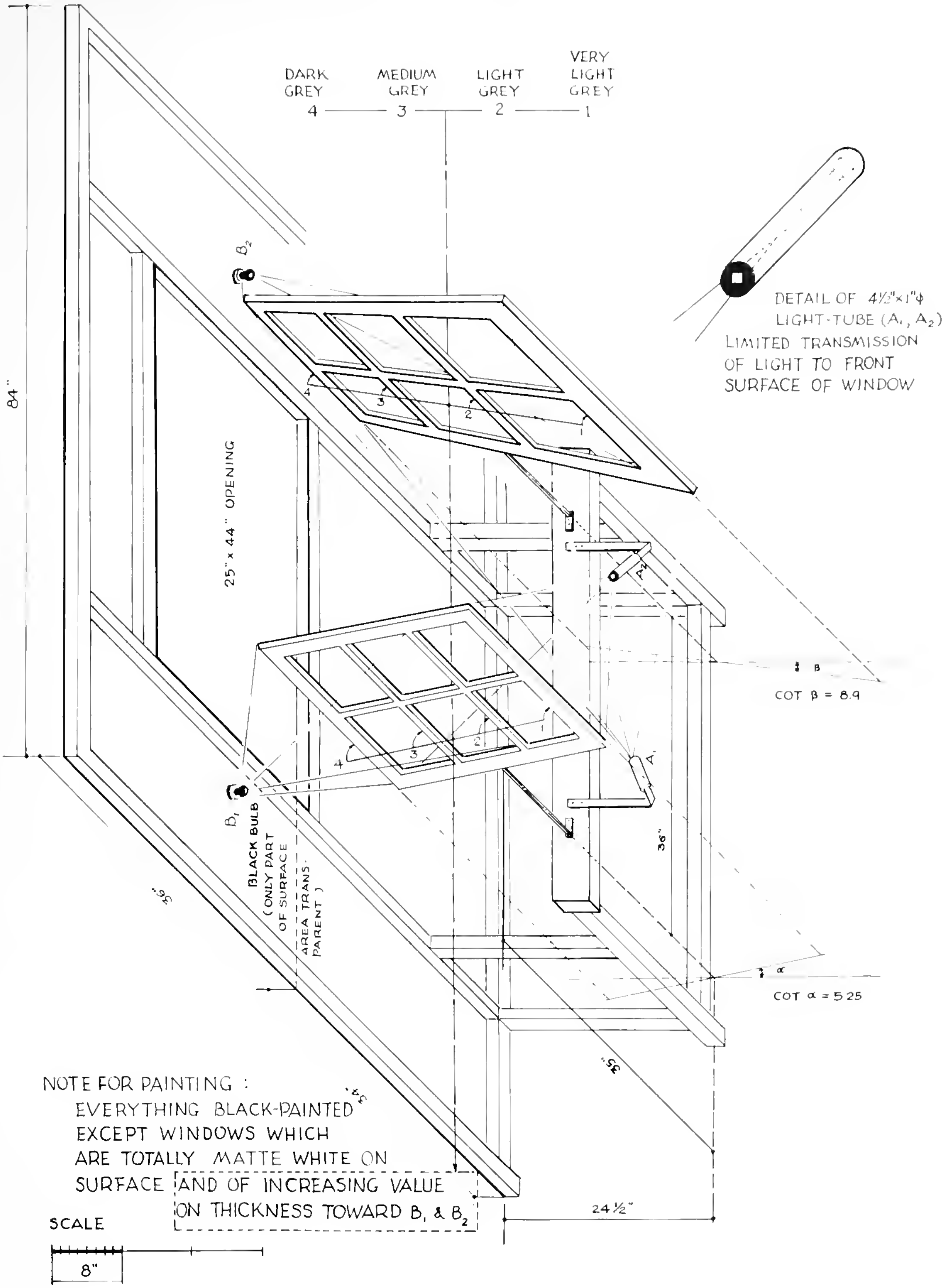


Fig. 20.5. Apparatus drawing for the surety demonstration.


DARK GREY 4
MEDIUM GREY 3
LIGHT GREY 2
VERY LIGHT GREY 1
DETAIL OF 4½"×1"φ LIGHT-TUBE (A₁, A₂)
LIMITED TRANSMISSION OF LIGHT TO FRONT SURFACE OF WINDOW
84"
25" × 44" OPENING
B₂
A₂
A₁
B₁
BLACK BULB
(ONLY PART OF SURFACE AREA TRANSPARENT)
COT β = 8.9
COT α = 5.25
36"
35"
34"
24½"
NOTE FOR PAINTING :
EVERYTHING BLACK-PAINTED EXCEPT WINDOWS WHICH ARE TOTALLY MATTE WHITE ON SURFACE AND OF INCREASING VALUE ON THICKNESS TOWARD B₁ & B₂
SCALE
8"

BIBLIOGRAPHY

of

Books and Articles Referring to the Ames Demonstrations in Perception

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Works dealing exclusively or primarily with the Ames demonstrations are listed as primary references. Those dealing only secondarily or tangentially with the demonstrations are arranged according to areas of interest.

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