SAE Aerospace
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AEROSPACE RECOMMENDED PRACTICE

SAE ARP498 REV. B

Issued 1957-08
Revised 1968-02
Reaffirmed 2001-10
Noncurrent 2007-09

Superseding ARP498A

Design, Layout, Criteria - Plastic Integrally Lighted Panels

RATIONALE

The rationale for Noncurrency is that a survey with some of the light plate suppliers has shown they do not use and were not aware of it. This document has only been a design guide and not a recommended practice. The consensus is the ARP has not been used and is obsolete and is not required because in lieu of this document, AS7788 is used as a requirements document.

NONCURRENT NOTICE

This specification has been declared "NONCURRENT" as of September 2007. It is recommended, therefore, that this document not be specified for new designs.

Each of these "NONCURRENT" documents is available from SAE.

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Design, Layout, Criteria — Plastic Integrally Lighted Panels

1. SCOPE:

1.1 This document is intended to cover the design of plastic lighted panels, mounting plates, and their installation.

1.2 Reference Documents:

MIL-P-7788A	Plate, Plastic, Lighting Type I, II, III.
MIL-C-18012	Control Configurations and Markings for Plastic Lighting Plates, Control Panels and Placards.
MIL-C-6781	Control Panel Aircraft Equipment, Part or Console Mounted.
MIL-P-5425	Plastic, Sheet, Acrylic
MS25010	Light, Panel, Plastic Plate Lighting
MS25237	Lamps Incandescent
MS24367	Lamps Incandescent
MS24515	Lamps Incandescent

2. GENERAL:

2.1 The basic and only reason for the use of plastic lighted panels is to make it possible to illuminate various indicia on the panels, cockpit controls, etc. This must be accomplished in a manner that will allow the pilot or operator to clearly observe his controls at night without impairing his adaptation to the dark.

2.2 Integrally Illuminated Panels:

Edge lighted panels, completely furnished with light fixtures electrically connected by means of circuitry (imbedded, printed, or separate) to connectors or terminals at other locations on the panel, are called "integrally illuminated panels."

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3. DESIGN CONSIDERATIONS:

3.1 The primary factor that must be understood by the designer, when designing lighted panels, is that the lighting characteristics of the panel must be considered simultaneously with the layout of the equipment on the panel. This consideration is necessary so that the panel will be illuminated satisfactorily.

3.2 Consideration should be given to the fact that any one light will illuminate satisfactorily only an area that can be covered by a 2-in. radius swung from the center of the light source. This rule is true only if there is no obstruction (such as a hole, cutout, etc.) between the light source and the indicia to be illuminated. If there is an obstruction between the light source and the indicia to be illuminated, special methods must be used. It is suggested that a lighting engineer familiar with these practices be consulted.

3.3 Large areas of light-emitting surfaces on a panel should be avoided; otherwise these areas will appear as bright spots.

4. GENERAL LIGHT PRINCIPLES:

4.1 Panel:

The basic material of the panel is acrylic which is coated with a suitable white and black material to meet MIL-P-7788A. By some method such as removing the black and exposing the white, a character is created which is readily visible in the daylight. For use after dark, light is piped through the panel and allowed to escape at these points thus producing a visible character on an unlighted background.

4.2 When the lamp is centered in the lamp hole and the filament mass is approximately centered within the thickness of the acrylic sheet, the optimum condition for light entry will exist. Light rays will radiate spoke-like through the wall of the hole with virtually no refractive effect, and will disseminate themselves through the acrylic between the two surfaces on the panel, one or both of which may be coated with white or black laminates or paint.

4.3 Unlike clear uncoated panels which, mirrorlike, optically reflect the light rays for long distances across a panel (e.g., auto speedometer), any light ray which strikes a coated surface, from the inside, is scattered, diffused, and sometimes partially absorbed. Only the rays which are somewhat collimated parallel to the plane of the panel will travel any distance. All the others are broken up and ricochet into obscurity in about two to four inches of travel across this type of control panel.

4.4 Lighting Aids:

4.4.1 Just as there are factors which will act to obstruct light, there are others which can promote good lighting. One simple example is the placement of the lettering near the edge of the panel. This allows the lettering to use the light reflected from the edge when the edge is painted white.

4.4.2 Another aid is that of "reflecting cut." In this case, a 45 deg cut is placed in the bottom of the panel off of which the light is bounced up to the lettering. A "light pipe" can be used to supply light around an obstruction; a light pipe is a round piece of uncoated plastic inserted into the panel. (See Fig. 7.)

4.5 Illumination:

4.5.1 The light assemblies shall be located to provide illumination of sufficient brightness with as even a distribution as possible throughout each panel. The brightness of the brightest marking shall not be more than 5 times that of the dimmest marking on any one panel. The brightest marking shall never be greater than 5.0 ft-1, the dimmest marking shall not be less than 1.0 ft-1, when measured in unfiltered white light.

4.6 Location of Equipment:

The equipment on any panel should be arranged in accordance with its functional requirements and rules governing such arrangements. However, lettering and markings on these panels are illuminated by edge lighting through plastic panels; this fact should not be forgotten, and sufficient space in the proper places must be provided for light assemblies.

4.7 Location of Light Assemblies:

Whenever possible, light assemblies should be located in such a way as to afford direct illumination to all lettering. It is possible to illuminate markings which are not in direct line with the source.

4.8 Number of Light Assemblies:

4.8.1 The number of assemblies per panel will depend on several factors:

(a) size of the panel,
(b) size, shape, and number of holes and cutouts in the plastic plate,
(c) provision for sufficient illumination in case of failure of lamps,
(d) number of lamp assemblies will depend on the type of lamp used.

4.8.2 This means that the minimum number of lamps per panel is two. A small panel which could adequately be illuminated by one light assembly would still require two lamps to insure against blackout of the panel in case of lamp failure.

4.9 Fastening of Plastic Plates to Base Plate:

It is necessary that fasteners be used to secure plastic plates to the mounting plate. For this requirement, a minimum of 2 black oxidized 6-32 screws and a thin walled bushing or crushproof grommet should be used.

4.10 Rounding of Hole and Outside Edges of Plastic Plates:

To provide painted edges of the plates and of holes and cutouts in the plastic plates, which are as durable as the top surface, both the top and the bottom edges should have a radius or chamfer of .02. All corners, inside and outside, should have a radius of 1.6 to 1.8.

4.11 Edge Lighting of Counter Wheels:

4.11.1 The dials or counter wheel design should be considered here. The presentation (character, lines, and pointers as employed) should be white against a dull black background with a contrast ratio, defined; i.e., $C = \frac{B_2 - B_1}{B_1}$, where B is the brightness of the background and B_2 is the brightness of the marking. The value of contrast C, when measured under day-light illumination should not be less than 12.

4.11.2 The number of scale graduations on dials should be held to a minimum, using only enough graduations to assure the accuracy of reading that may be required. Scale values should be applied for optimum clarity of reading, and the display on the dial should be restricted to pertinent data only. The surface of the characters and lines to be displayed must be flush with, or raised slightly above, the face of the background. This applies to dials and counters which are flood lighted only. If the surface of a character is depressed below the surface of the background, the shoulder of the background thus created will cast a shadow over a portion, or perhaps all, of the stroke width of the line because of the obliqueness of the approaching light ray. In some cases, this condition has completely obliterated the line of character.

4.11.3 In the case of counter wheels, the drive mechanism and wheel and plates are usually metallic and consequently bright. A mask with openings over the characters to be displayed is usually employed because this conceals light-reflecting parts and all characters other than those to be displayed. The front surface of this mask should be finished dull black, the same as the background referred to earlier.

4.11.4 The size of the mask openings should include the dimensions of the character to be displayed, all manufacturing tolerances affecting the location of the opening relative to the position of the character, and an allowance for the angularity of the approaching light rays. (Fig. 4, angle "B".)

4.11.5 Since displays are usually covered with a transparent window, care should be exercised in determining the size of window. The window should be large enough not to surpress any approaching light rays.

4.11.6 In designing the opening for counter wheels in the lighting panel itself, the starting point should be the face of the wheel. The calculations to obtain the height of the opening are as outlined in the following paragraph.

4.11.7 Because of the manufacturing tolerance in the drive mechanism, one-half of the character height is added to the maximum permissible mislocation of the character from the centerline of the wheel. To this sum are added all other tolerances influencing the location of the lighting panel opening from the centerline of the wheel. This total sum is considered as one-half of the character height for purposes of this calculation and is the starting point for computing the height dimension. The distance from the front face of the panel to the face of the counterwheel should be determined. From this dimension should be deducted the thickness of the glass in front of the counter, if any is used. Because the line-of-sight angle requirement is normally 30 deg (Fig. 4), half of the opening height can be computed by triangulation, utilizing the 30 deg/sight angle and the distance from counter to front face of the panel. However, since the thickness of the glass is disregarded, the angle of refraction through the glass should be computed (Sin I = Sin R, where I = angle of incidence; R = refraction). Once this angle is determined, the height increase due to the refraction of the light beam through the glass can be computed. The sum of this dimension and the height, computed without regard to the glass, is equal to one-half the height of the opening.

4.11.8 The approximate position of the observer (Fig. 5, point "A") from the face of the lighting panel should be determined on a projection of the line-of-sight. A line produced from the observer's position through point "B" near the face of the panel to the back of the panel will determine the height of the opening at the back of the panel (point "C"). Because the critical angle of glass with refractive index of 1.52 is approximately 42 deg, it is desirable to direct the rays from a location as close to the 30 deg sight angle as possible. To accomplish this, a reflecting surface of approximately .040 thickness is provided at the front of the lighting panel and a cut made into the center portion of the panel in such a manner that the light rays from the source are reflected to the surface at the front of the panel (Fig. 4). Since light intensity decreases with distance, it is readily seen that the longest and weakest rays from the top of the opening are complemented by the shortest and brightest rays from the bottom. Thus, an even intensity is maintained over the face of the counter.

4.11.9 Since light emitted from the end of the cut tends to increase the intensity on the counter wheels nearest the ends, light is emitted only from the top and bottom of the opening. Hence, the ends may be cut at a 30 deg angle from the back of the panel and painted out (Fig. 6).

4.11.10 The size of the opening for the illumination of a dial or a portion of a dial is computed in the same manner as that for a counter wheel. The cut in this case, however, may be continuous so that light is emitted from all around the opening.

4.11.11 The final consideration is the placement of the lamp sources. They should be centered on the counter opening width and placed equidistantly above and below the counter. If the lights cannot be centered because of interference or if the counter is over two inches in length, four lights, two above and two below, may be used in place of two. There should be no obstructions between the light source and the counter or dial opening.

4.11.12 The results that may be anticipated from this method of illumination are:

a. Minimum panel space is required.
b. Intensity on counters and dials is approximately twice that displayed on the face of the lighting panel.
c. Spilled light due to reflections from the face of the glass window and other causes is held to a minimum.
d. All intensities from the display are controllable.

4.12 Illumination of Lighted Knobs:

To illuminate a knob which has a clear bottom, the light is released from the lighting plate through a clear ring on the top of the plate. The outer diameter of the ring should be 0.10 in. smaller than the widest dimension of the knob dial. In other words, the knob should overlap the light releasing area by 0.10 in. on all sides to prevent light leakage from under the knob.

4.13 Switch Handle Illumination:

The position of a toggle switch, etc. should be illuminated by placing a ring of .105 in. width .063 in. from edge of hole.

4.14 Location of Lettering and Numbers:

4.14.1 The lettering and numbers should be located on the plastic plate as required for operation of equipment with which they are associated. Following are some general rules that should be observed in locating lettering, numerals, and markings:

a. Keep at least .063 in. away from the edges of the plate.
b. Keep at least .125 in. away from the edges of holes and cutouts; locating the lettering, numerals, and markings over a lamp creates bright ("hot") spots which are difficult to dim and should therefore be avoided if possible.

4.14.2 If at all possible, the lettering, numerals and markings should not be placed where direct illumination from any light assembly is cut off by a hole or cutout in the plastic plate. By "juggling" components (equipment, light units, lettering) it is possible to have at least one of the light units located within a permissible radius. The extra precaution taken during the design stage will simplify the problem of obtaining a more uniform illumination. Fig. 7 depicts some more common illumination balancing methods which can be used.

4.15 Width of Lines:

The width of lines shall not be greater than .025 inch. Excessively wide lines appear unnecessarily bright, diverting attention from the lettering and other markings on the panels.

5. PREPARATION OF DRAWINGS FOR EDGE LIGHTED PANELS:

5.1 The drawings of all illuminated panels and mounting plates should show one view on each drawing, and show the part normal size as the finished part will appear.

5.2 A Leroy lettering guide (or equivalent) can be used to show all lettering on view of the finished panel. This is to clarify the drawing such that callouts, notes, symbols, etc. cannot be interpreted as being part of the finished panel.

5.3 If more than one size of lettering is used, it should not be dimensioned (other than location) but should be coded. A note should be added to explain the height.

5.4 There may be a bill of material on the drawing.

5.5 All abbreviations used shall be per MIL-C-18012A.

5.6 Each lamp socket should be coded for electrical polarity.

5.7 Dimensions and Tolerances:

5.7.1 When designing a lighted control panel, it must be understood that methyl methacrylate, either cast or molded, is subject to dimensional variations, caused by humidity, machining, molding draft, solvents, etc. For this reason, dimensioning should be handled differently, but nevertheless be approached in a uniform manner.

5.7.2 The lighted control panel is basically a light conducting plate with many holes for the clearance of shafts, protruding nuts, and light sources. The relationship of the holes to each other is very important. The holes should provide adequate clearance to the unit going through the hole; even after the paint build-up decreases the inside diameter, it should still clear the control that protrudes through it. However, the hole should not be so oversized that it will excessively reduce or impede light transmission.

5.7.3 The panel should be dimensioned in accordance with the drafting room manual except as modified herein.

5.7.4 Linear dimensions should be vertical and horizontal from the center of one hole which has been located with respect to the edges. All other dimensions for the hole or cutout pattern should be from this hole. The metal mounting plate should be dimensioned in the same manner and from the same referenced hole. (See Fig. 1 and Fig. 2)

5.7.5 Tolerances (Minimum):

Linear:	0 to 10 in.	± .010
	10 to 15 in.	± .015
	15 to 20 in.	± .020
Diameter of hole after painting:		± 1/32
Depth of countersink and counterbore:		± 1/64

6. CIRCUITRY, LAMP ASSEMBLIES:

All circuitry and lamp assemblies should conform to the environmental requirements of MIL-P-7788A, unless otherwise specified.

6.1 Lamps should not be energized during environmental tests.

6.2 Dielectric Strength:

Unless otherwise specified, the lamp assemblies and the circuitry should be able to withstand a minimum of 500 v rms 60 cps for 1 minute between terminal and ground, with lamps removed. Panels should be tested as complete assemblies without lamps in holders.

6.3 Terminal Markings:

All terminal connectors should be marked for positive and negative position whenever possible.

7. LAMPS:

7.1 All lamp fixtures should be equipped with lamps aged and selected for a light output of 0:34:15% msc when operated at their rated voltage.

7.2 Filter (Color):

When the color is other than red, a suitable method should be used to convert all of the light emitted by the lamps to whatever the color requirements prescribed by the procuring agency. In the case of "aviation red," the filter should convert all of the light emitted by the lamps to aviation red per MIL-C-25050, except that the color should not be paler than NBS #3215 Pale Limit Filter.

8. SEPARATE CIRCUIT BOARDS:

8.1 When separate circuit boards are used, they should have a thickness of 1/32 in. ± 1/64.

8.1.1 All separate circuit boards should be coated with a suitable material to prevent short circuiting.

8.1.2 The separate circuit board should be separated from the back of the edge lighted panel with a suitable gasket cemented around the inner periphery of the circuit board, to prevent foreign material from entering.

8.2 Lamp Assembly:

8.2.1 Lamp assemblies should be securely attached to the panel and imbedded to prevent turning when subjected to the torque of lamp caps removal and replacement.

8.2.2 Imbedded Wire Circuitry: Imbedded wire circuitry should have no less than a .020 copper wire, or equivalent, and should be imbedded below the surface at least .010 min.

8.2.3 Imbedded wire circuitry should be placed into grooves into the panel and potted or cemented in place with a suitable clear material. The potting or plastic material should be one with a high dielectric strength and should have as low a moisture absorption point as practicable.

8.2.4 It is recommended than when imbedded circuitry is used, care should be taken to remove all flux from the solder joints and backs of lamp assemblies before potting or cementing.

8.2.5 Due to the coefficient of expansion and contraction of the plastic panel, it is essential that all solder joints be carefully checked to prevent cold soldering joints.

8.2.6 All imbedded wire assemblies should have a 360 deg mechanical wrap at lamp assembly terminals before soldering.

9. CONNECTORS:

Unless otherwise required, connectors should be of the concentric type.

10. DUO PANELS:

10.1 The duo panel should consist of a thin plastic indicia panel covering, but not in substantial optical contact with a light conducting panel; this light conducting panel being selectively painted on one surface and edges so as to reflect light conducted through the translucent markings of the indicia panel. (See Fig. 8 and Fig. 9)

10.2 Except for the lettering and markings, the front face edges and a minimum border of 1/8 in. on the rear side of the indicia panel should be coated with opaque material to give a black low gloss surface. The edges of the light conducting panel should be similarly coated with a 1/8 in. overlap on both front and rear surfaces, with this being applied over a highly reflective white coating. The nominal thickness of the assembled panel should be 5/16 inch.

10.3 Light Distribution:

Although the duo panel has different design considerations, the performance characteristics are quite different from the standard Type I or Type II of MIL-P-7788A. The limitation of the 2-in. radius for illumination does not apply in the case of the duo panel. The light transmission, because the light conducting panel is not painted on both sides, reacts as on the true edge lighting principle of acrylic. Therefore, the amount of lamp assemblies required for illumination is less than those of the Type I or Type II panels. Fig. 9 is an illustration of illumination of circular dial and pointer indicating instrument.

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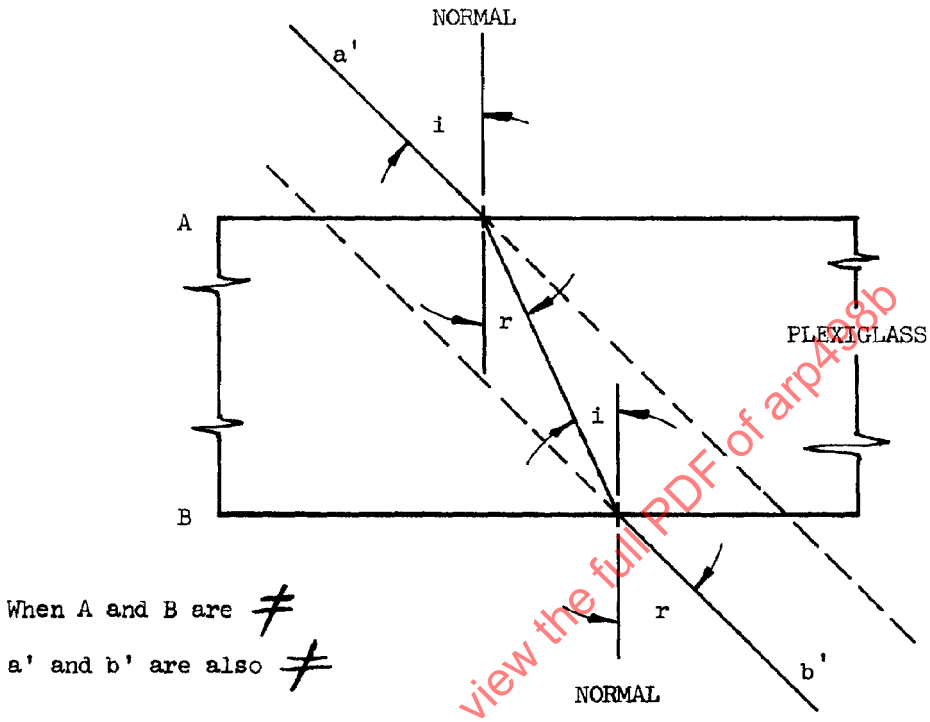

FIGURE 1 (A)

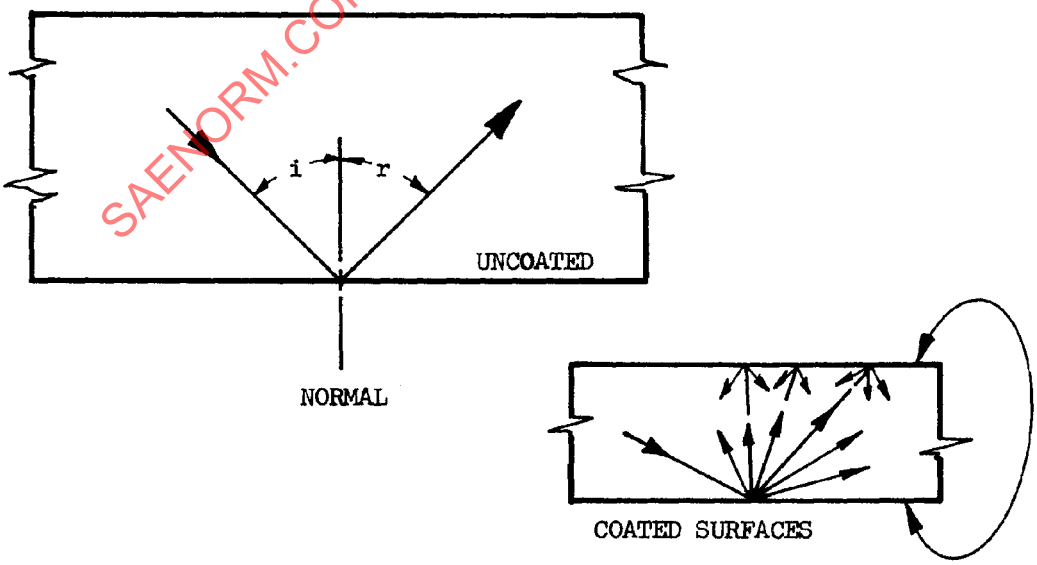

FIGURE 1 (B)

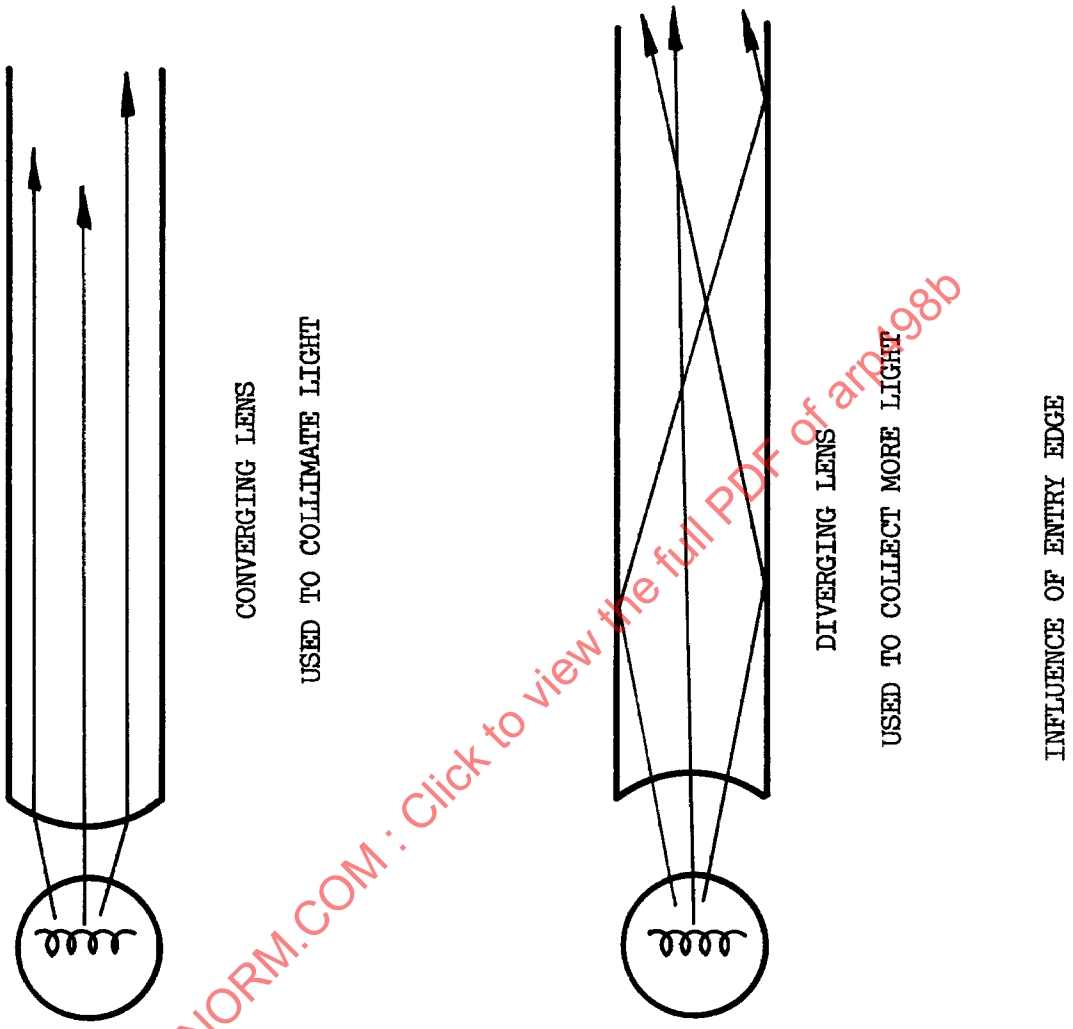

FIGURE 2

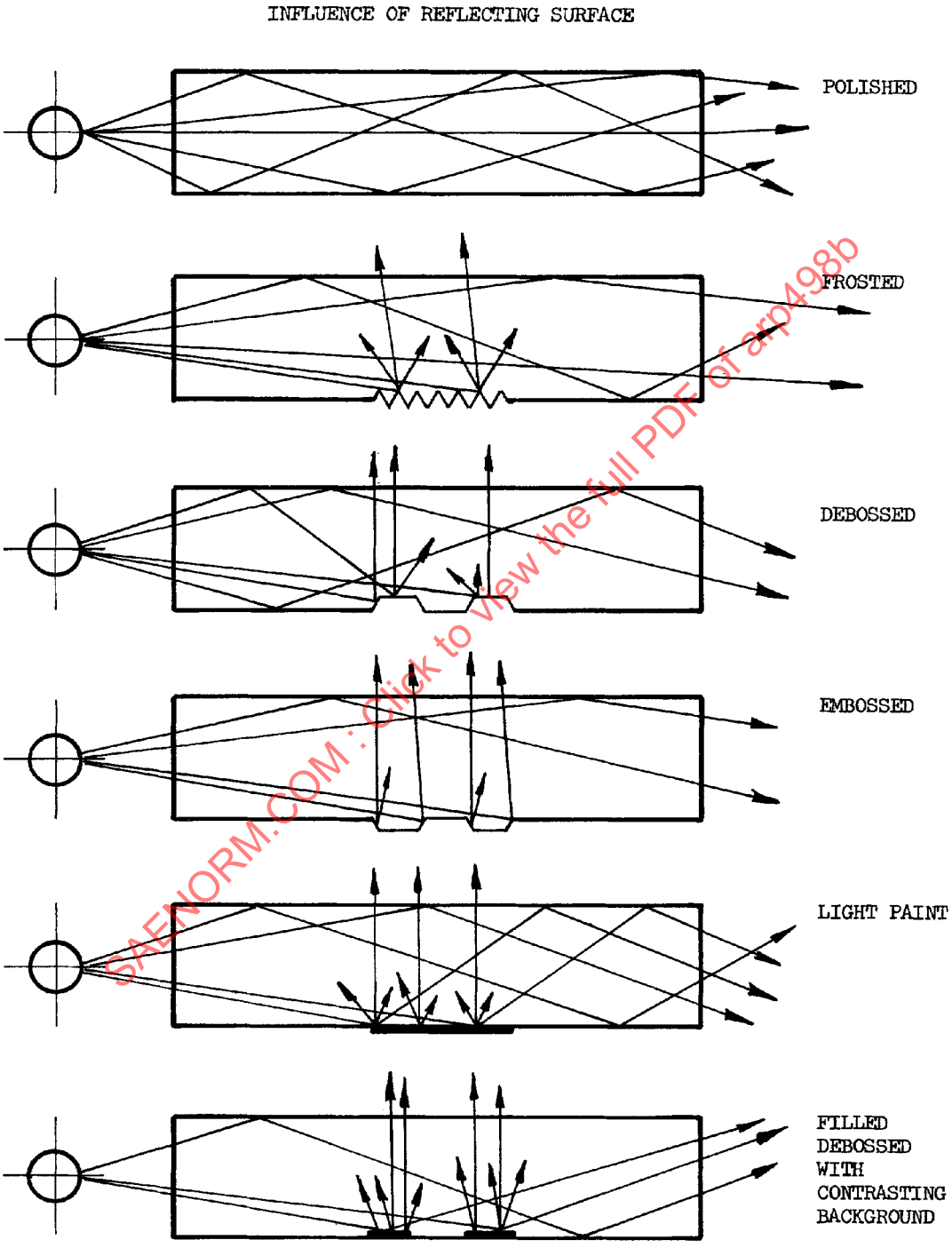

FIGURE 3

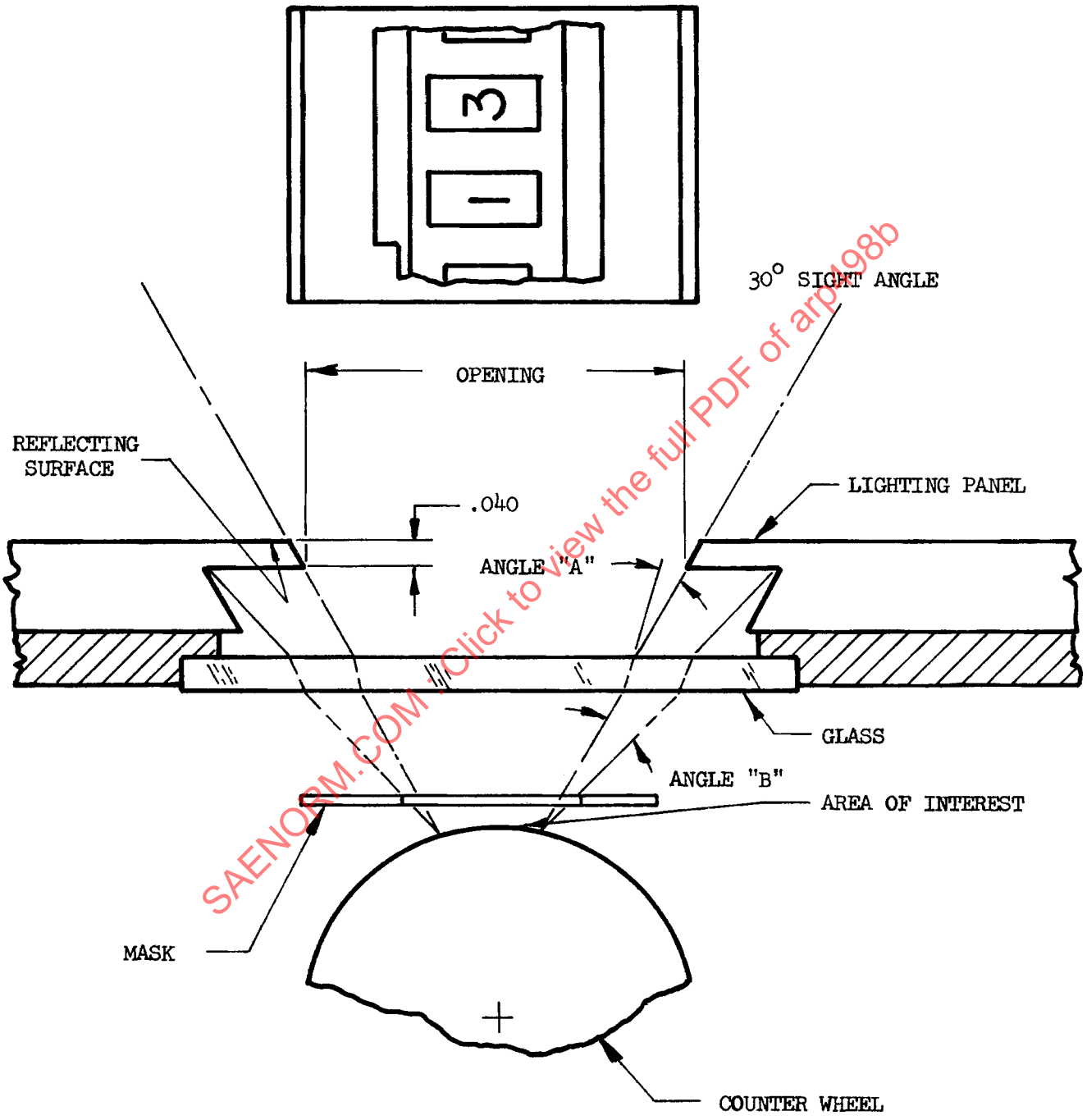

FIGURE 4

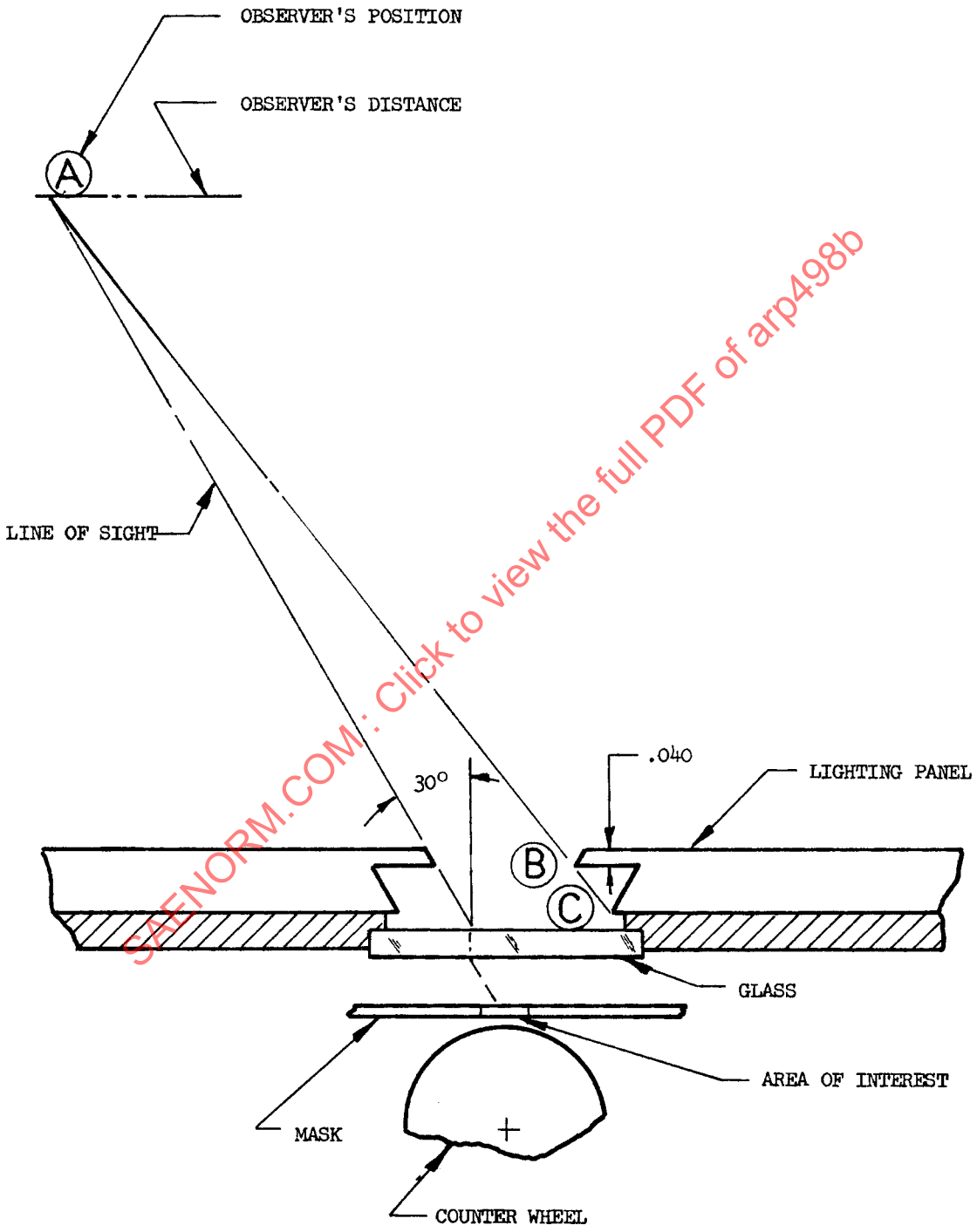

FIGURE 5