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CONVAIR

A DIVISION OF GENERAL DYNAMICS CORPORATION

SAN DIEGO

REPORT 8-07303

DATE 9 Sept. 1953

MODEL 8

REVISIONS
"A" 9-22-54
"B" 12-19-55
"C" 2-27-56

CONTRACT NO.

TITLE

CONVAIR
A DIVISION OF GENERAL DYNAMICS CORPORATION
SAN DIEGO

SPECIFICATION FOR

OPTICAL QUALITY OF

PILOT'S ENCLOSURE

TRANSPARENT MATERIAL

REPORT NO. 8-07303

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NO.	DATE	BY	REVISIONS	PAGES AFFECTED
A	9-22-54	Avgerenos Phillippi	Specification MIL-P-8184 added	1
B	12-19-55	Heitzman Phillippi	Specification re-written	All
C	2-27-56	Heitzman Phillippi	Revised Specification to include "Inspection Method II". Changes marked with letter "C" in margin.	All

FORM 1812 A-6

No.	Date	By		Pages Affected
D	6-3-57	Lumgair	Added par. 3.2.4.3	13
			Added par. 3.2.4.4	13
			Figure 5A revised	22
			Figure 5B revised	23
E	5-8-58	McLeod	Para. 2.7.2 revised text & table	5&6

R. McLEOD 5/8/58
Whiten 9/1/58
5/9/58
FOR W.R. LEE A/E RS/15
C&L - OK RC Hear 2/23/61

1. SCOPE:

1.1 These specification defines optical inspection methods which directly measure distortion in transparencies.

1.1.1 Outlined herein are data and requirements are outlined as follows:

(a) Contributing factors affecting distortion and the manner by which they may be used or compensated.

(b) Determination of allowable limits of distortion and where to use those limits.

(c) The mechanism and tools for the inspection methods.

2. FUNDAMENTAL CONSIDERATIONS:

2.1 APPEARANCE OF DISTORTION:

2.1.1 When viewing a straight line through a transparency, which distorts, the straight line can be distorted in one or more of three ways. It can be stretched, compressed, or bent. If the distortion of this line produces stretching or compressing it may be undetected, but if it produces bending it is easily detectable. Similarly, it is the apparent bending of straight lines which causes the greatest annoyance to pilots and is the clue that enables the pilot to be aware of the associated distortions of stretching and compressing. Also the magnitude of bending indicates the relative magnitude of stretching and compressing. With these facts understood it can be determined by general agreement of pilots, the amount of distortion permissible in enclosure transparencies. The measurement of this degree of bending of straight lines by distortion will establish definite limits for the inspection method.

2.1.2 It can be seen from the foregoing that it is necessary to couple distortion the pilot observes with that which is measured during inspection.

2. FUNDAMENTAL CONSIDERATIONS (Cont)

2.2 EFFECT OF OBJECT ATTITUDE:

2.2.1 Another point for consideration, is the attitude of the observed straight line relative to the transparency. As previously stated, distortion which stretches or compresses, can be present and still be undetected. For example, assume the horizon is being viewed through an airplane windshield which produces distortion and the horizon attitude relative to the windshield is horizontal. In this attitude, also assume that the properties of this windshield are such that the distortion has stretched or compressed, but not bent, the straight line of the horizon. The distortion will then remain undetected. If the airplane is banked 45° the attitude of the horizon, relative to the windshield, changes by the same amount, but the distortion now bends the straight line of the horizon making the distortion detectable.

2.2.2 From the example above it can be seen that a transparency in an airplane in service can produce distortion which varies with the relative attitude of the elements. The distortion can become undetectable or detectable with increments of only 45° rotation between the transparency and the viewed object. The inspection method must duplicate this changing attitude in order to find the distortion which is seen and detected by the pilot. See Illustration Figure I-A.

2.2.3 Numerous tests have substantiated this changing distortion with changing attitude between transparency and viewed object and Figure I-B shows three such tests in which a straight line was rotated through 180°. The line was bent during this rotation and the degree of bending was measured and plotted on a graph to construct the curves. The maximum and minimum distortion consistently occur with 45° of rotation. These curves also show distortion peaking at two places which consistently occur with approximately 90° of rotation. One distortion peak is usually greater.

2. FUNDAMENTAL CONSIDERATIONS (Cont)

2.3 EFFECT OF TRANSPARENCY POSITION:

2.3.1 The amount of distortion seen, when the line of sight is 90° to the transparency, is no measure of the amount which will be experienced as the line of sight becomes some other angle. Transparencies in aircraft are almost always installed at some angle other than normal to the pilot's line of sight. Usually, as this angle of incidence becomes greater, the distortion increases. However there is no factor by which this increase can be predicted. In some instances the distortion observed was greater with the line of sight at 90° to the transparency than at an angle less than 90°. The irregular behavior of distortion, relative to the angle of incidence between the pilot's line of sight and the transparency surface, makes necessary the evaluation of distortion in the transparency as it will ultimately be installed in the aircraft. The inspection methods must examine the transparency in the same relative position as the one in which it will be installed.

2.3.2 In all aircraft enclosures the position of the pilot's eye(s) relative to the transparencies is defined and it is this point from which all distortion is evaluated. Lines of sight taken from any position other than the pilot's eye position automatically change most of the incidence angles of the lines of sight. Any change in these angles results in different distortion. The location of the pilot's eye(s) when viewing through the transparency is also the point which must be used in the inspection mechanisms.

2.4 EFFECT OF OBJECT DISTANCE AND OBSERVER DISTANCE:

2.4.1 The magnitude of distortion can be increased when viewing an object through a transparency by increasing the distance between the object and the transparency. With an object at infinity the distortion observed will be at its greatest possible amount and as this distance (between object and transparency) is reduced the amount of distortion will also be reduced until both distance and distortion approach zero. In order to verify these facts, tests were made to determine the variation of distortion with increasing object distance from the transparency. As shown in Figure 2 a fixed distance between transparency and viewing point was selected and the distance between transparency and object was varied. At definite distances the amounts of distortion were measured to plot a curve. The six curves shown in

2. FUNDAMENTAL CONSIDERATIONS (Cont)

Figure 2 were all derived by viewing through the same area of the same transparency. Each curve shown used a fixed distance between the transparency and viewing point. The distance is indicated on each curve.

2.4.2 With the ability to predict the variation of distortion relative to the distance between transparency and viewing point and the distance between transparency and viewed object it is possible to calculate the percentage of maximum distortion that will be present with any fixed combination of distances. When a pilot views a straight horizontal line through the windshield such as used for the curves in Figure 2, with his eye 3 feet from the windshield and the line 7 feet from the windshield, the straight line appears bent 3.44°. See Figure 2. When the same line is moved along the line of sight to an infinite distance, represented by the horizon, it will appear bent 5.38° (See Figure 2, 3 feet curve at 10,000 feet). The 5.38° is the maximum amount of distortion because the horizon, for all practical purposes, is an infinite distance from the windshield. C

2.5 REPLACEMENT OF VIEWED OBJECT WITH OPTICAL IMAGE: C

2.5.1 The object as seen through a transparency by the pilot can be recreated as an optical image. The pilot's point of view is replaced with a projector and from an actual object within the projector light can be projected through the transparency to produce an optical image of the object. The object image focused at infinity will show the same maximum distortion characteristics that are experienced by a pilot viewing actual objects at infinity. Also the magnitude of distortion shown by the object image will decrease as the distance between the transparency and the object image becomes less. Curves in Figure 3 show the percentage of maximum distortion obtained for a given distance of object image from projector. C

2.6 INSPECTION METHODS: C

2.6.1 INSPECTION METHOD I: Inspection Method I is the inspection of an optical image of an object as seen through a transparency and observed from the pilot's point of view. C

2.6.2 INSPECTION METHOD II: Inspection Method II is the inspection of the object image projected through a transparency from the pilot's point of view and observed on the actual object side of the transparency. C

2. FUNDAMENTAL CONSIDERATIONS (Cont)

2.7 LIMITATIONS SET BY ACTUAL EXPERIENCE:

2.7.1 The entire extent of transparent area within aircraft pilot's enclosures is useful and due to the maneuverability of aircraft certain areas become optically critical. The maneuvers of final approach and landing an airplane generally require the same area of visibility through the transparency and this is the most important area. This is the critical vision area and shall produce minimum distortion. This will be zone "A". A slightly less critical vision area, but also important, is the viewing area required for taxing and gliding turns. This area will be zone "B". Non-critical vision areas are those involved in straight climb, cruising, level turns, take-off runs, and straight glide. This is important area outside "A" and "B" and this will be zone "C". The remaining useful area for general viewing is the least critical vision area and will be zone "D".*

* Taken from C.A.A. Technical Development Report No. 123 "Airline Pilot" Questionnaire Study on Cockpit Visibility Problems".

* See C.A.A. Technical Development Report No. 179 "A Study of Pilot's Eye Movements During Visual Flight Conditions" for a guide in zoning.

2.7.2 The following table has been established from the opinions of experienced pilots. The pilots were requested to look through numerous pieces of windshield glass used in the Convair 340 commercial airplane. (Pilot and glass located correctly with respect to eye point and angle of incidence). Each piece was classified by the pilots as either objectional, marginal, or acceptable. The transparency was then inspected by the method outlined in this Specification, and values for the [illegible] distortion angles were established.

This table is representative of the values that are accurate for any transparency from the pilot's point of view.

Considerations of the design and the manufacturing art for each different transparency configuration must be taken into account before maximum distortion angles can be realistically established.

* This criteria shall be established for each transparency configuration and called out on the applicable drawing.

2. FUNDAMENTAL CONSIDERATIONS (Cont)

Zone	Distortion Angle (At Infinity)	Zone Definition	Maneuvers
A	2°	Area of Critical Vision for Dangerous Maneuvers	Approach Landing
B	4°	Area of Critical Vision for Maneuvers (Outside Zone A)	~~[illegible]~~ Taxying Gliding Turns
C	6°	Area of Non-Critical Vision for Maneuvers (Outside Zone A & B)	Straight Glide Straight Climb Cruising Level Turns Take-Off Run
D	8°	Area of Non-Critical Vision	General Viewing

The distortion angle for each zone above must be adjusted for the inspection apparatus by the percentage of maximum distortion obtained in Figure 3, for Inspection Method I and Method II.

2.7.3 The direction of sight required by the pilot, for the various maneuvers of the airplane, can be measured in degrees to the left, right, up and down. For all the common maneuvers definite zones and distortion limits within these zones for the transparencies have been established. By drawing the geometry of lines of sight a supplementary drawing of any particular transparency can be made showing the area of each zone. See Figure 4. This drawing can also locate the pilot's eyes point dimensionally. The supplementary drawing serves to transfer the zones to the transparency to be inspected and also correctly positions the transparency relative to the point which will be used in the inspection mechanisms.

2.8 CORRELATION OF ACTUAL EXPERIENCE AND INSPECTION METHOD I:

2.8.1 The limit set forth by pilots for distortion in a transparency is essentially the distortion they have experienced in service. These limits can be considered as the maximum.

2. FUNDAMENTAL CONSIDERATIONS (Cont)

amount the transparency will distort because most of the objects viewed by pilots will be long distances from the transparency. The limits can be converted into measured angles and these angles in turn can be reduced by the required amount for the confines of an inspection apparatus. The curves shown in Figure 3 are made to correlate maximum distortion (distortion seen by pilots) with the smaller amount of distortion that will be seen at time of inspection. In these six curves the distance between viewing point and transparency and the distance between transparency and viewed object have been added together. To explain the use of these curves for correlation, use the same set of conditions as in the previous example. Assume a viewing point 3 feet from a windshield which is identical to the pilot's relationship to this windshield in actual use. The object to be viewed here will be 7 feet distant from the windshield.

Viewing point to windshield = 3 feet

Object to windshield = 7 feet

Total inspection distance = 10 feet

Now using the 10 foot curve on Figure 3 take the 3 foot line on "DISTANCE BETWEEN VIEWING POINT (PROJECTION POINT) AND TRANSPARENCY" scale and at the point of intersection with the 10 foot curve go across to the "PERCENT OF MAXIMUM DISTORTION" scale and read 64 percent.

In this example: (Pilot's limit taken from table on page 6) C

Pilot limit for distortion = 8° C

Percent of maximum distortion = 64 percent

8° x .64 = 5.12° C

The inspector shall accept a windshield showing no greater distortion than 5.12°. C

2.9 CORRELATION OF ACTUAL EXPERIENCE AND INSPECTION METHOD II: C

2.9.1 For prime considerations see first part of Paragraph 2.8.1. C
Convert pilot's distortion limits by the reduced amount

2. FUNDAMENTAL CONSIDERATIONS (Cont)

shown by the curves in Figure 3. To explain the use of these curves for correlation, use the same set of conditions as in example of Paragraph 2.8.1. Assume a projection point 3 feet from a windshield which is identical to the pilot's relationship to this windshield in actual use. The recreated object (the image from the projector) will be focused 7 feet distant from the windshield.

Projection point to windshield	=	3 feet
Object image to windshield	=	7 feet
Total inspection distance	=	10 feet

Now using the 10 foot curve on Figure 3, take the 3 foot line on "DISTANCE BETWEEN VIEWING POINT (PROJECTION POINT) AND TRANSPARENCY" scale and at the point of intersection within the 10 foot curve go across to the "PERCENT OF MAXIMUM DISTORTION" scale and read 64 percent.

In this example: (Pilot's limit taken from table on page 6) C

Pilot limit for distortion	=	8°
Percent of maximum distortion	=	64 percent

$8° \times .64 = 5.12°$

The inspector shall accept a windshield showing no greater distortion than 5.12°.

3. INSPECTION MECHANISMS: C

3.1 INSPECTION METHOD I: C

3.1.1 See Figure 5A for an illustration of the inspection mechanism used for Inspection Method I. C

This mechanism uses a lens in a position relative to the transparency which is the same as the relationship between the position of the pilot's eye(s) and the transparency.

3. INSPECTION MECHANISMS (Cont)

An illuminated grid is viewed through the transparency and the viewing is accomplished using the lens. The lens produces an image of the grid on a frosted view-plate for inspection.

3.1.2 GRID:

3.1.2.1 This is a true grid using straight parallel lines. Only parallel lines instead of cross grids are used to avoid confusion. The grid must be made to rotate in order to reproduce the changing attitude between the transparency and the viewed object in service. C

3. INSPECTION MECHANISMS (Cont)

3.1.2.2 The grid is a translucent material with black lines and is illuminated from the back side. The black lines should have a uniform spacing and the grid should be located at the greatest practical distance from the lens. C

3.1.2.3 Grid size 80.0 inches diameter C

Line size .03 inches wide

Line spacing .50 inches

Grid to lens distance 90.00 inches (7.5 feet)

3.1.3 TRANSPARENCY MOUNT:

3.1.3.1 The transparency is supported in a fixture that holds it in a position duplicating the transparency's actual position in an airplane.

3.1.3.2 If, when inspecting a transparency, it is not possible to cover all the transparency with one viewing, the transparency can be moved for additional viewings. The movement must be made by rotating the transparency about a pivot point on the inspection machine that will correspond to the pilot's head rotation relative to his eyes.

C

3.1.4 LENS:

3.1.4.1 A lens becomes the inspection viewing point and the optical center of the lens is at the single point which represents the point midway between the pilot's eyes. C

C

3.1.4.2 The lens is 28.00 focal length, 1:6.3 focal ratio, iris diaphram to 1:64 focal ratio, field of view 53° cone approximate and distortion and spherical aberration free.

3.1.5 CORRELATION PROCEDURE FOR INSPECTION METHOD I: C

3.1.5.1 In order to correlate the maximum distortion in a transparency with the distortion inspected, refer to Figure 3. C Consideration must be given to the various distances between all parts of the transparency and the inspection machine point which represents the pilot's viewing point.

3.1.5.2 EXAMPLE:

Object distance to point representing pilot's viewing point in the inspection mechanism is 7.5 feet and for the maximum coverage the transparency has been centered on the optical axis. The distance along the optical axis from the pilot's viewing point to the transparency is 2 feet.

3. INSPECTION MECHANISMS (Cont)

The distance at the nearest point is 1 foot and at the most distant point is 3 feet. Referring to Figure 3, three "percent of maximum distortion" values using the 7.5 feet curve are obtained. C

1 Ft. viewing pt. to transparency = 48 percent

2 Ft. viewing pt. to transparency = 57.5 percent

3 Ft. viewing pt. to transparency = 54 percent

$$\frac{.48+.575+54}{3} = .5316$$

Average percent of maximum distortion = 53.16 percent.

For this particular transparency any distortion inspected can be considered 53.16 percent of the maximum amount of distortion visible through the transparency viewing infinitely distant objects.

3.1.5.3 The following shows the small angle differences resulting from using the average percentage of maximum distortion with this transparency.

Zone "A" is from 1 foot to 2 feet from the pilot's viewing point.

Zone "A" = 2° maximum permissible distortion angle

1 ft. viewing point to transparency = 48 percent

2 ft. viewing point to transparency = 57.5 percent

Percent of maximum distortion average = 53.16 percent

$2° x .48 = .96°$ inspection distortion limit for 1 ft. distance

$2° x .575 = 1.15°$ inspection distortion limit for 2 ft. distance

$2° x .5316 = 1.06°$ average inspection distortion limit for this transparency

$\frac{.96°+1.15°}{2} = 1.05°$ average inspection distortion limit for zone "A"

3. INSPECTION MECHANISMS (Cont)

Zone "B" is from 2 feet to 3 feet from the pilot's viewing point.

Zone "B" = 4° maximum permissible distortion angle

2 ft. viewing pt. to transparency = 57.5 percent

3 ft. viewing pt. to transparency = 54 percent

Percent of maximum distortion average = 53.16 percent

4°x.575 = 2.3° inspection distortion limit for 2 ft. distance

4°x.54 = 2.16° inspection distortion limit for 3 ft. distance

4°x.5316 = 2.13° average inspection distortion limit for this transparency

$$\frac{2.3^\circ + 2.16^\circ}{2} = 2.23^\circ$$ average distortion limit for Zone "B"

In the above case it is practical to average out the percentage of maximum distortion.

3.2 INSPECTION METHOD II: C

3.2.1 See Figure 5-B for an illustration of the inspection mechanism used for Inspection Method II. C

This mechanism uses a projector in a position relative to the transparency which is the same as the relationship between the position of the pilot's eye(s) and the transparency. An image of a grid is projected through the transparency on to a translucent view screen for inspection.

3.2.2 GRID: C

3.2.2.1 Use parallel line rotatable grid. See Paragraph 4.1.2.1. C

3.2.2.2 The grid is on a photographic transparency with clear spaces and black lines. The lines are to be .032 wide and equally spaced at .30 to .40 on their projected image focused at 100 inches distance. C

3.2.3 TRANSPARENCY MOUNT: C

3.2.3.1 Use actual position. See Paragraph 4.1.3.1 C

3. INSPECTION MECHANISMS (Cont)

3.2.3.2 When additional viewings are necessary follow directions in Paragraph 4.1.3.2. C

3.2.4 GRID PROJECTOR: C

3.2.4.1 The projector position in the inspection machine is such that the optical center of the projection lens is at the single point which represents the point midway between the pilot's eyes. C

3.2.4.2 The projector lens is 3.00 focal length, 1:4.5 focal ratio, projection cone 53° approximate, and distortion and spherical aberration free. C

3.2.4.3 Optical inspection projector envelope Drawing 0-07004. D

3.2.4.4 Optical inspection projector Drawing 0-07007. D

3.2.5 CORRELATION PROCEDURE FOR INSPECTION METHOD II: C

3.2.5.1 Use Figure 3 and directions in Paragraph 3.1.5.1. C

3.2.5.2 See example of procedure in Paragraphs 3.1.5.2 and 3.1.5.3. For Method II use Figure 3 to obtain percentage of maximum distortion values. C

3.3 TRANSPARENCY INSPECTION PROCEDURES:

3.3.1 POSITIONING TRANSPARENCY:

3.3.1.1 By following the previous directions the transparency is properly situated within the inspection mechanism. The following describes the inspection of the transparency.

3.3.2 INSPECTING:

3.3.2.1 From the inspector's position the image of the grid can be seen. The image produced is the result of light which has passed through the transparency and any departure from the normal appearance of the grid lines can be seen. This departure is distortion.

3.3.3 GRID ROTATION:

3.3.3.1 At first sighting distortion may or may not be apparent and in either case it is necessary to rotate the grid. While the grid rotates the image must continuously be observed. The distortion, if created by the transparency, causes the image of the grid lines to bend, straighten, bend, and straighten again as the grid is rotated through 180°. The distortion cycle, pointed out here, repeats with continued rotation and the point of rotation where distortion produces the maximum bend in the grid lines can be found.

3. INSPECTION MECHANISMS (Cont)

3.3.4 DISTORTION MEASUREMENT:

3.3.4.1 Grid rotation is stopped where maximum line bending is found and it is here that the bent line is measured.

3.3.4.2 Example of measuring bent lines is shown in Figure 8.

3.3.5 ZONE MASKING:

3.3.5.1 The zone mask placed on the transparency can be seen on the view screen or view plate. With the maximum limit angle for each zone on the angle gages the inspector can compare the maximum bent line in a zone with the correct gage for that zone. If the bent lines (or line) exceed the angle on the gage the distortion present is greater than the amount allowed. Such a transparency shall be rejected. C

4. REQUIREMENTS AND TOOLS FOR INSPECTION:

4.1 DRAWINGS:

4.1.1 A supplementary drawing of the transparency to be inspected shall be provided. This drawing locates the zones on the transparency, locates the pilot's viewing point, and positions the transparency relative to the pilot's viewing point. (Explained in the discussion pages 5 and 6)

4.2 LIMITS:

4.2.1 The limits of distortion for each zone shall be known. (See page 6)

4.2.2 The limits of distortion shall be adjusted to the distortion that will be experienced in the inspection machine.

Use Figure 3 for Inspection Method I and C

for Inspection Method II.

4.3 ZONE MASKS:

4.3.1 A set of zone masks for locating the zone areas on the transparency shall be supplied to the inspector. The set of masks is designed to be placed on the transparency so that the area of each zone will be defined on the inspector's view screen or view plate. One type of mask is suggested here in illustration shown in Figure 6. This wire frame type mask has the advantage of allowing the inspector to observe more than one zone at a time and also permits inspection of distortion that may occur across zones. C

4. REQUIREMENTS AND TOOLS FOR INSPECTION (Cont)

4.5 MEASURING GAGE:

4.4.1 A set of angle measuring gages for use with the zone masks shall be supplied to the inspector. See Figure 7 for an illustration of angle gages. The angles on these gages shall be the adjusted limit angles allowed for each zone. See example on pages 6, 7, and 8, Paragraphs 2.8 and 2.9. C

5. NOTES:

5.1 GRID ROTATION CONTROL:

5.1.1 It is important for the inspector to have control of the grid rotation. The rotation action should be comparatively rapid and it should be possible to reverse the rotation. Clockwise and counter-clockwise action and quick stopping results in positive centering on the exact position of maximum line bending.

5.2 The inspector shall have control of an iris diaphram in the viewing lens of Inspection Method I and in the projection lens of Inspection Method II. It sometimes becomes necessary to increase the focal depth of the viewing or projection lens. When distortion is great and the grid lines are severaly bent they have a tendency to become wide. This increased width can be restored to a sharp line by regulating the diaphram. C

5.3 PHOTOGRAPHS:

5.3.1 When it is necessary to photograph the distortion in a transparency it can be accomplished directly in the inspection machine. First visual inspection shall be made in the usual manner, (see Paragraph 3.3, Transparency Inspection), to correctly position the grid. The photograph can then be taken to record the inspected distortion. C

5. NOTES (Cont)

5.3.1.1 For Inspection Method I large photographs may be made by using the inspection machine as a camera. The inspection view plate can be replaced with a photographic plate to produce a photograph. Small photographs may be made by replacing the inspection viewing lens with a standard camera.

5.3.1.2 For Inspection Method II a standard camera may be used to photograph the grid image on the inspection view screen.

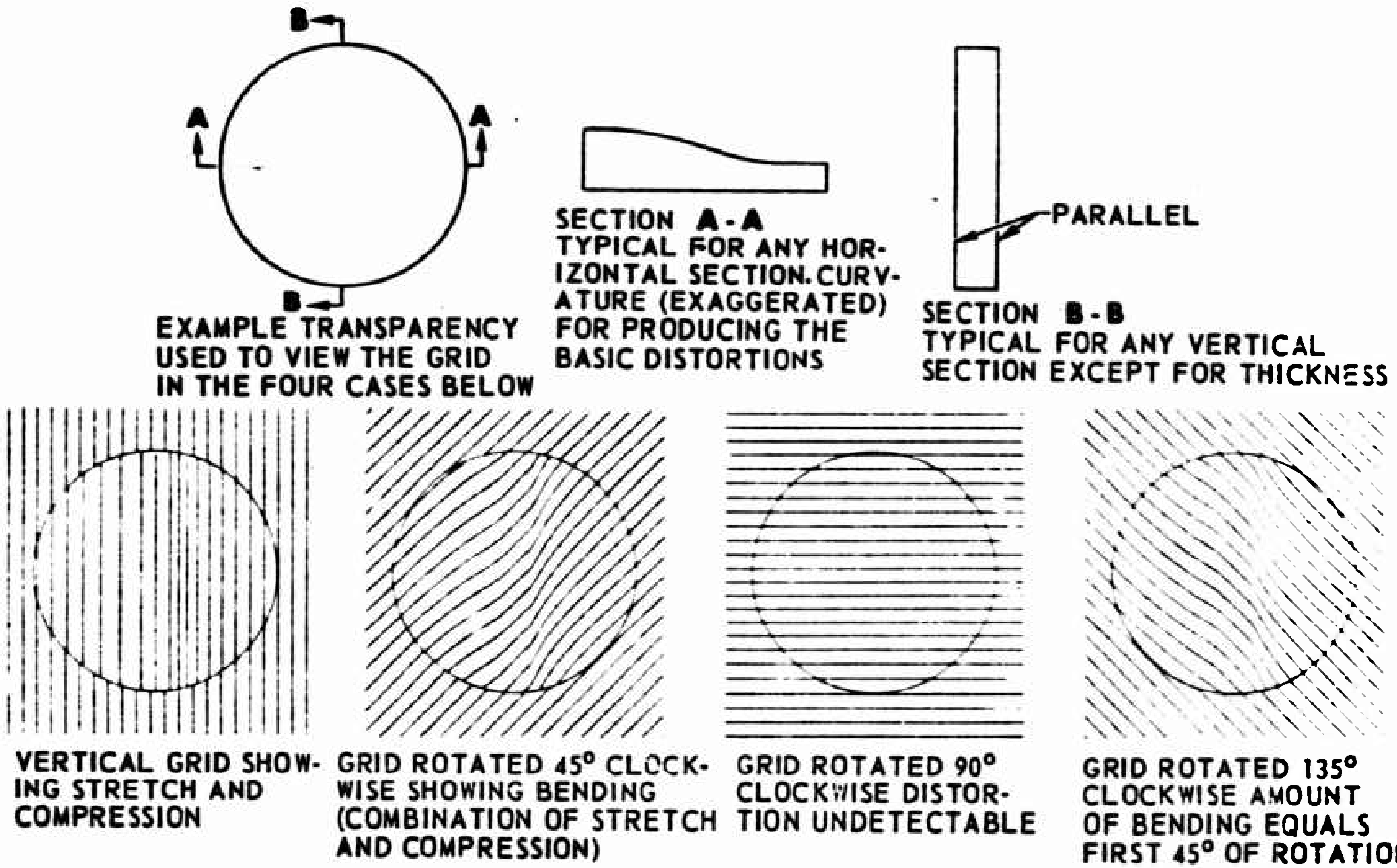

A
B
EXAMPLE TRANSPARENCY USED TO VIEW THE GRID IN THE FOUR CASES BELOW
SECTION A-A TYPICAL FOR ANY HORIZONTAL SECTION. CURVATURE (EXAGGERATED) FOR PRODUCING THE BASIC DISTORTIONS
PARALLEL
SECTION B-B TYPICAL FOR ANY VERTICAL SECTION EXCEPT FOR THICKNESS
VERTICAL GRID SHOWING STRETCH AND COMPRESSION
GRID ROTATED 45° CLOCKWISE SHOWING BENDING (COMBINATION OF STRETCH AND COMPRESSION)
GRID ROTATED 90° CLOCKWISE DISTORTION UNDETECTABLE
GRID ROTATED 135° CLOCKWISE AMOUNT OF BENDING EQUALS FIRST 45° OF ROTATION

FIGURE 1A

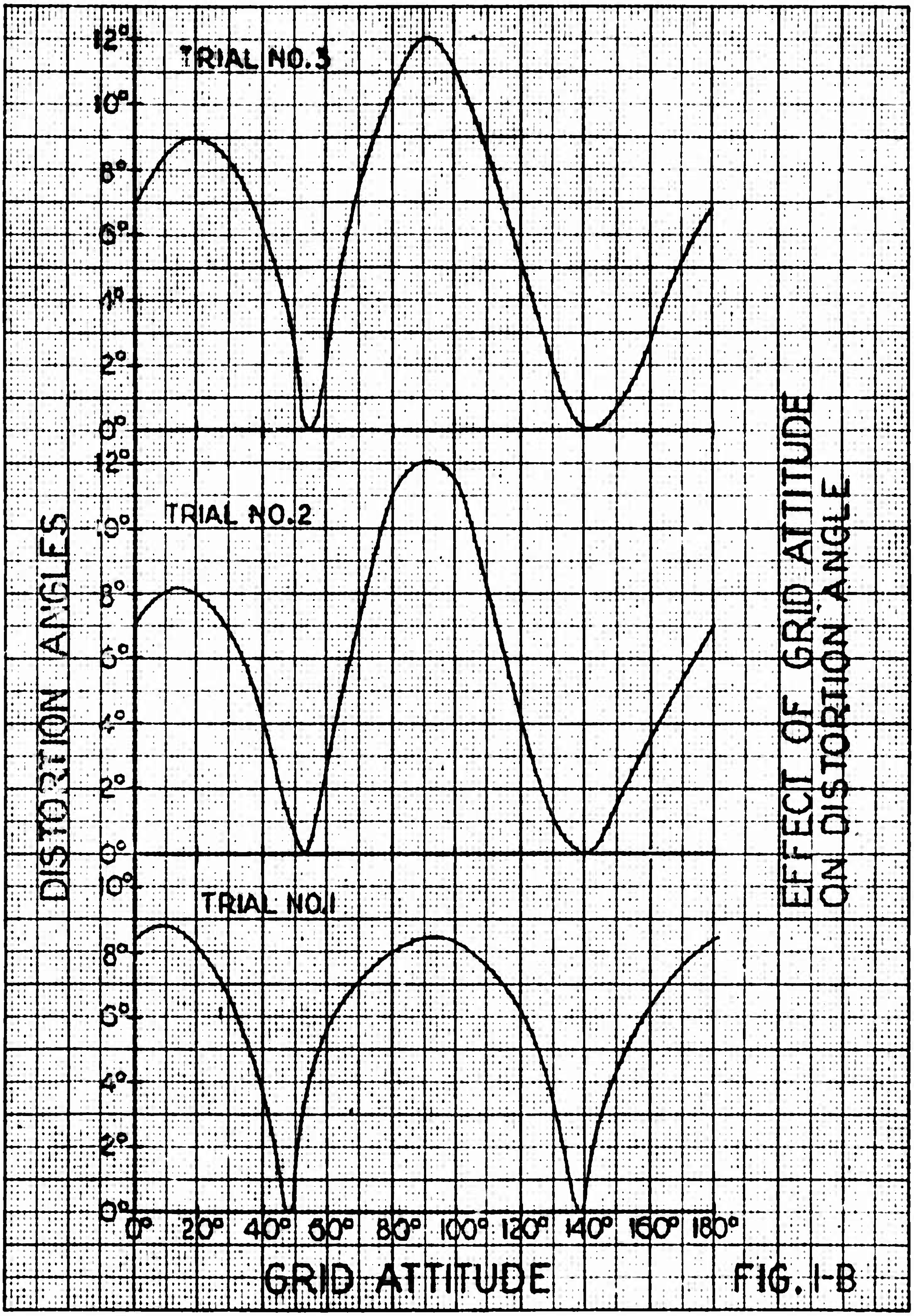

TRIAL NO.3
TRIAL NO.2
TRIAL NO.1
12°
10°
8°
6°
4°
2°
0°
0° 20° 40° 60° 80° 100° 120° 140° 160° 180°
DISTORTION ANGLES
GRID ATTITUDE
EFFECT OF GRID ATTITUDE ON DISTORTION ANGLE

FIG. I-B

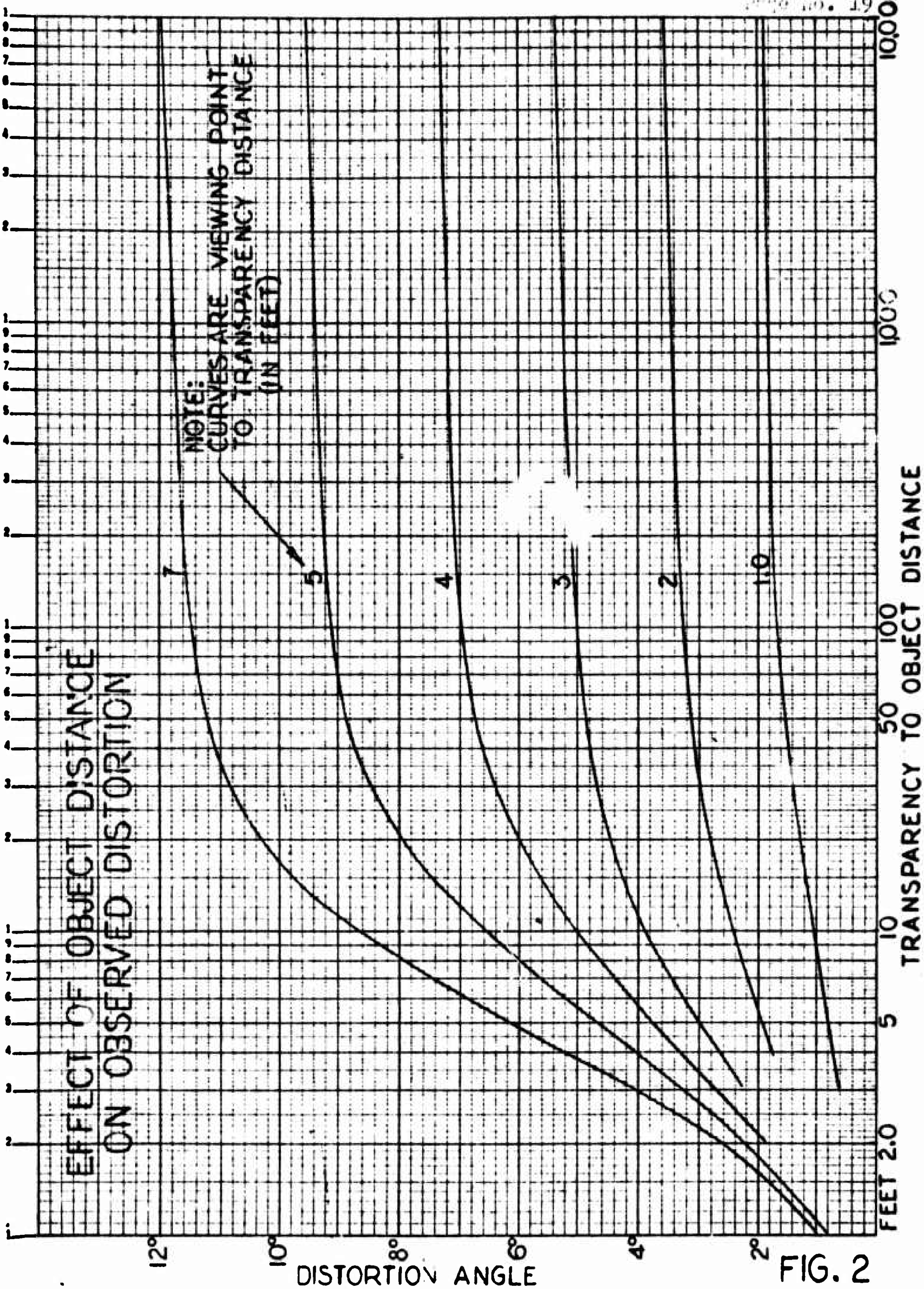

EFFECT OF OBJECT DISTANCE
ON OBSERVED DISTORTION
NOTE:
CURVES ARE VIEWING POINT
TO TRANSPARENCY DISTANCE
(IN FEET)
7
5
4
3
2
1.0
12°
10°
8°
6°
4°
2°
DISTORTION ANGLE
FEET 2.0
5
10
50
100
1000
10,000
TRANSPARENCY TO OBJECT DISTANCE

FIG. 2

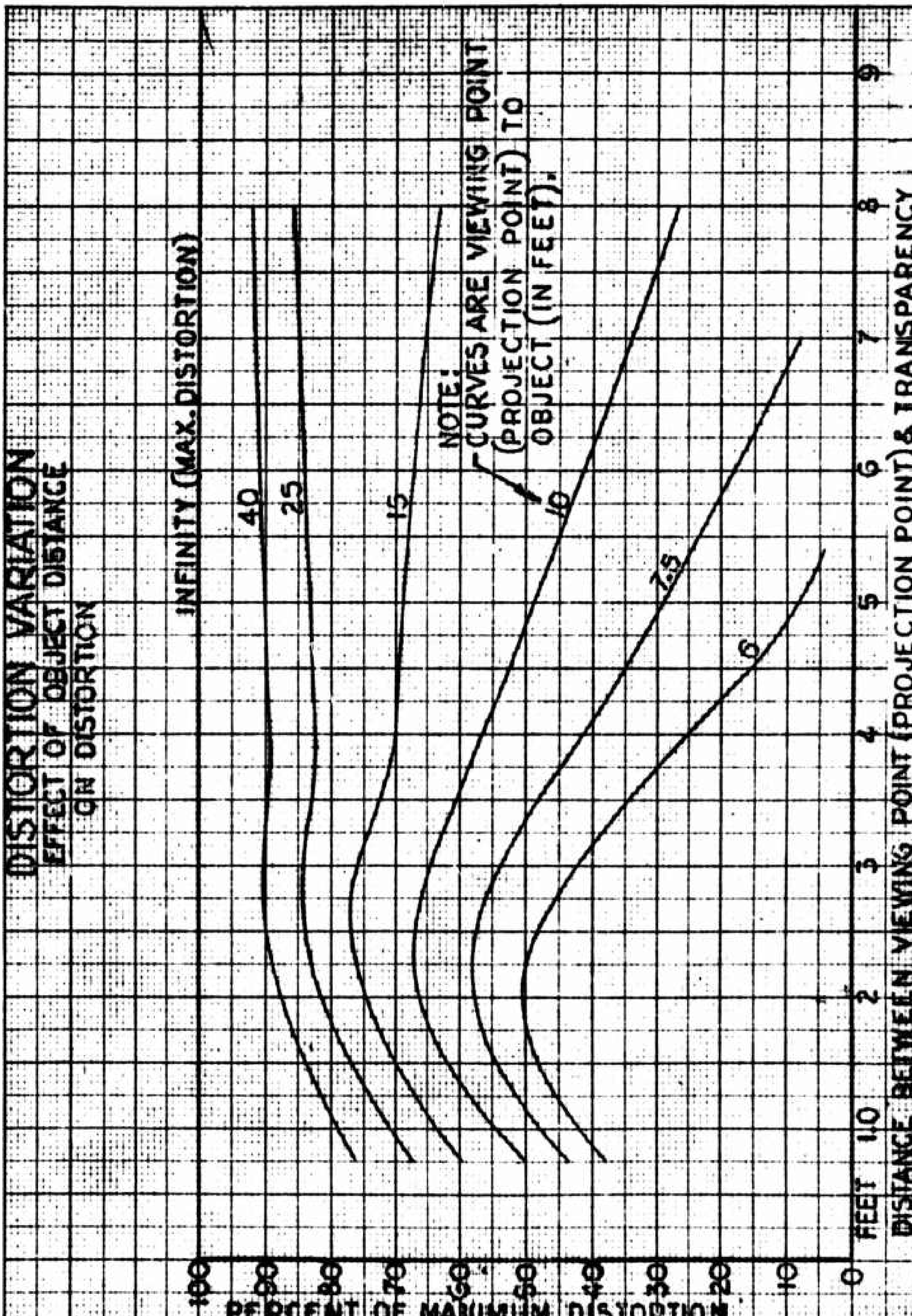
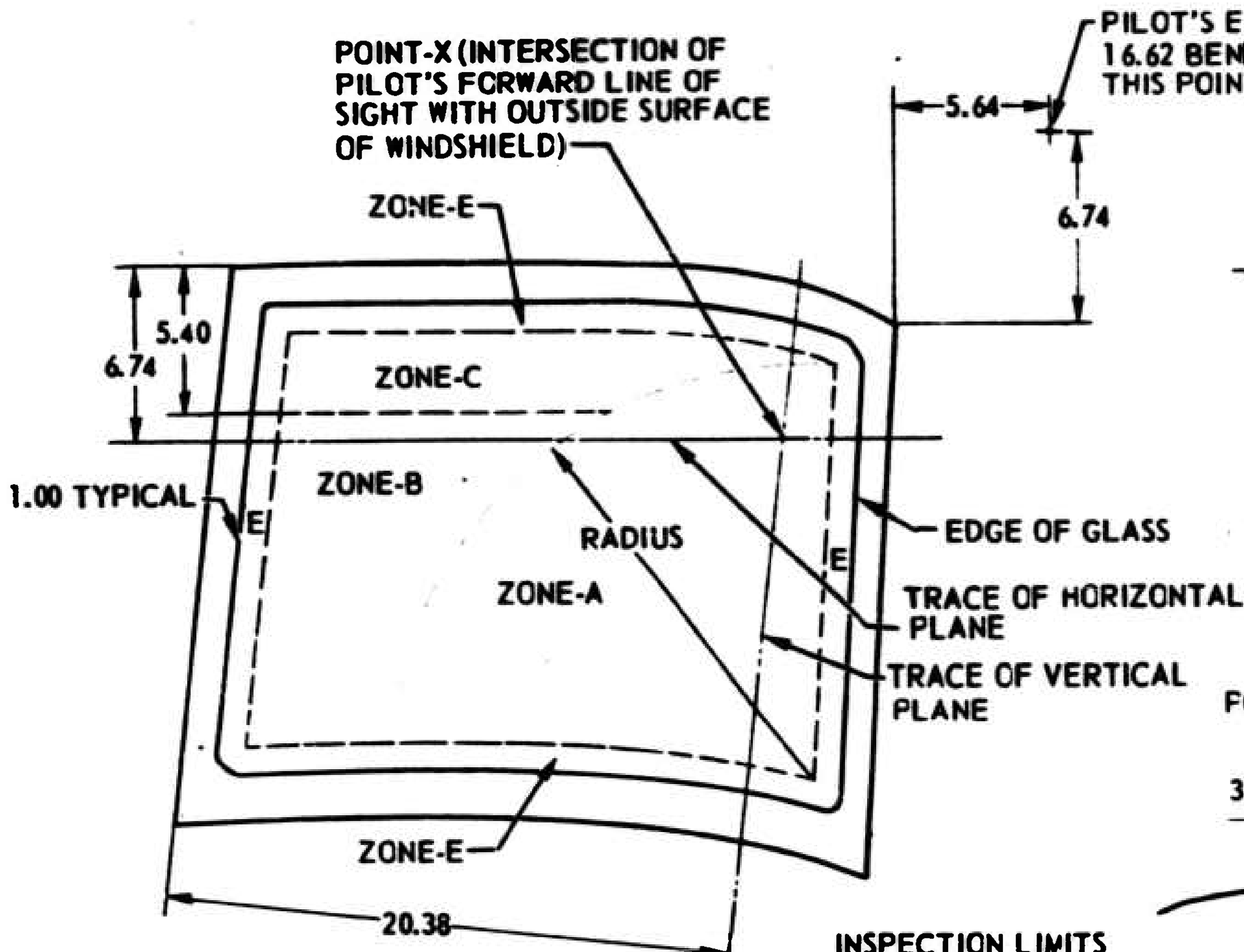
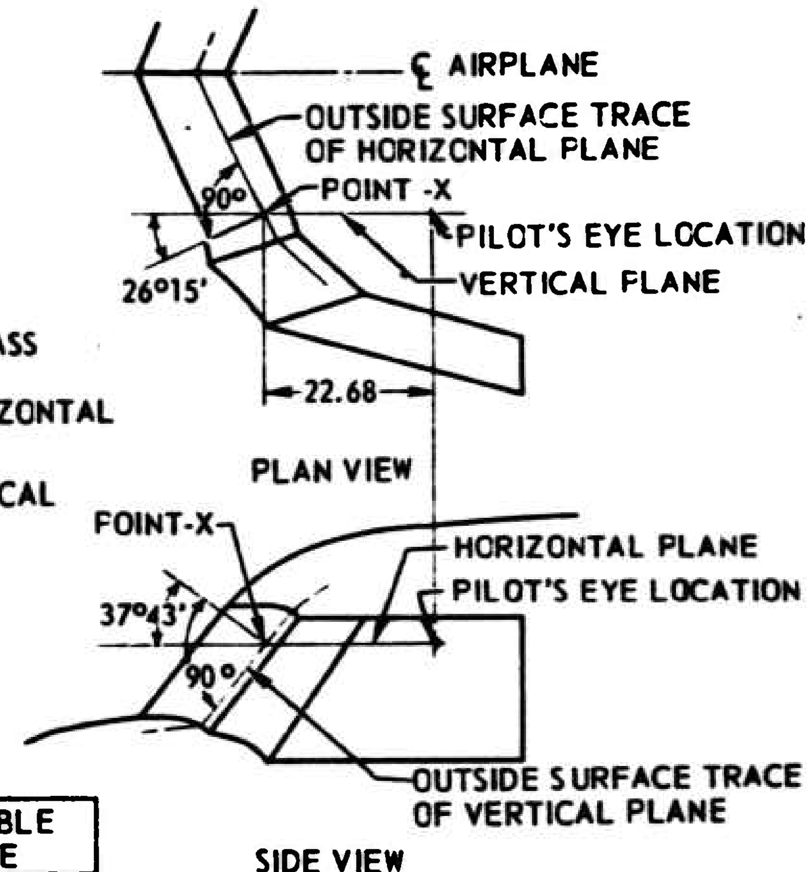

DISTORTION VARIATION
EFFECT OF OBJECT DISTANCE
ON DISTORTION
INFINITY (MAX. DISTORTION)
40
25
15
10
7.5
6
NOTE:
CURVES ARE VIEWING POINT
(PROJECTION POINT) TO
OBJECT (IN FEET).
PERCENT OF MAXIMUM DISTORTION
100
90
80
70
60
50
40
30
20
10
0
FEET
1.0
2
3
4
5
6
7
8
9
DISTANCE BETWEEN VIEWING POINT (PROJECTION POINT) & TRANSPARENCY
(ALONG THE LINES OF SIGHT)

FIG. 3



TRUE VIEW - LEFT HAND WINDSHIELD LOOKING INBOARD



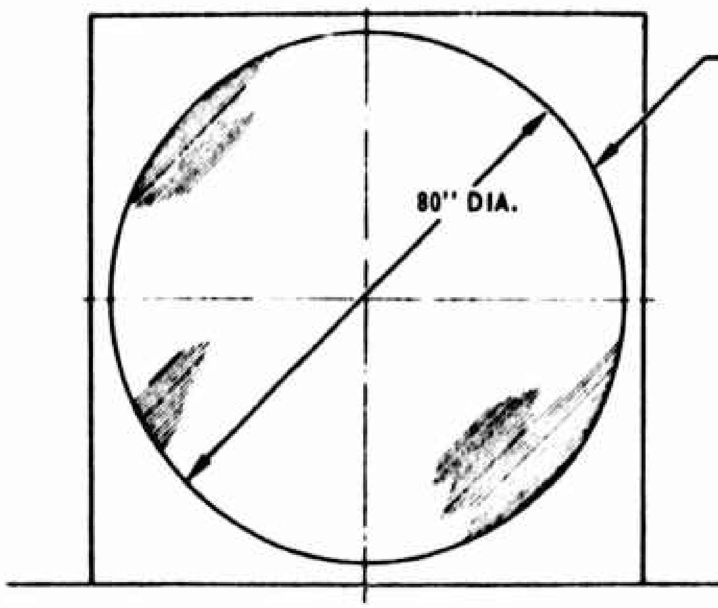
PILOT'S ENCLOSURE GEOMETRY

INSPECTION LIMITS

ZONE	MAXIMUM ALLOWABLE DISTORTION ANGLE
A	1.14°
B	2.28°
C	3.42°
E	INSPECTION FREE

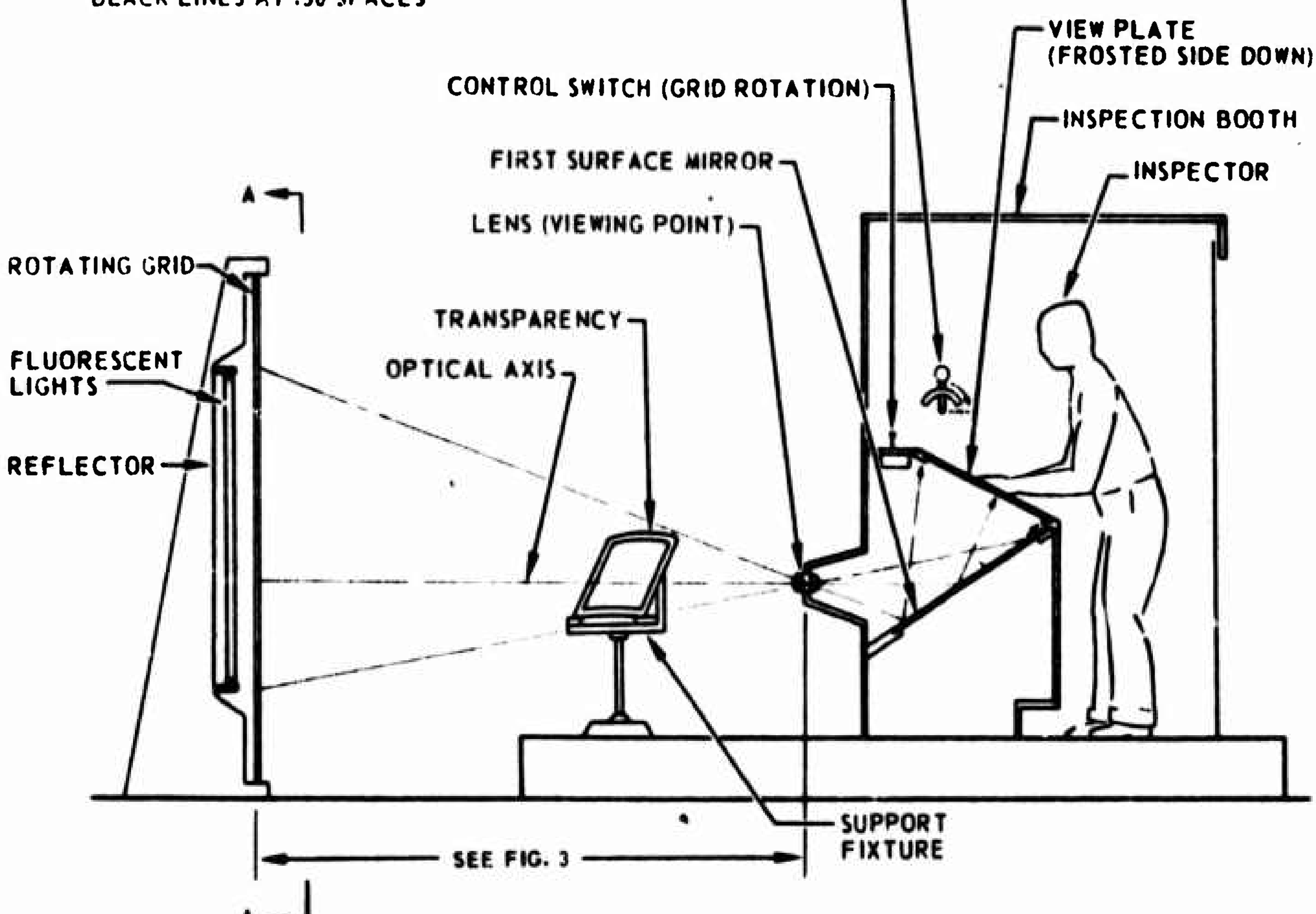
WINDSHIELD SUPPLEMENTARY DRAWING FOR INSPECTION PURPOSES

FIGURE 4



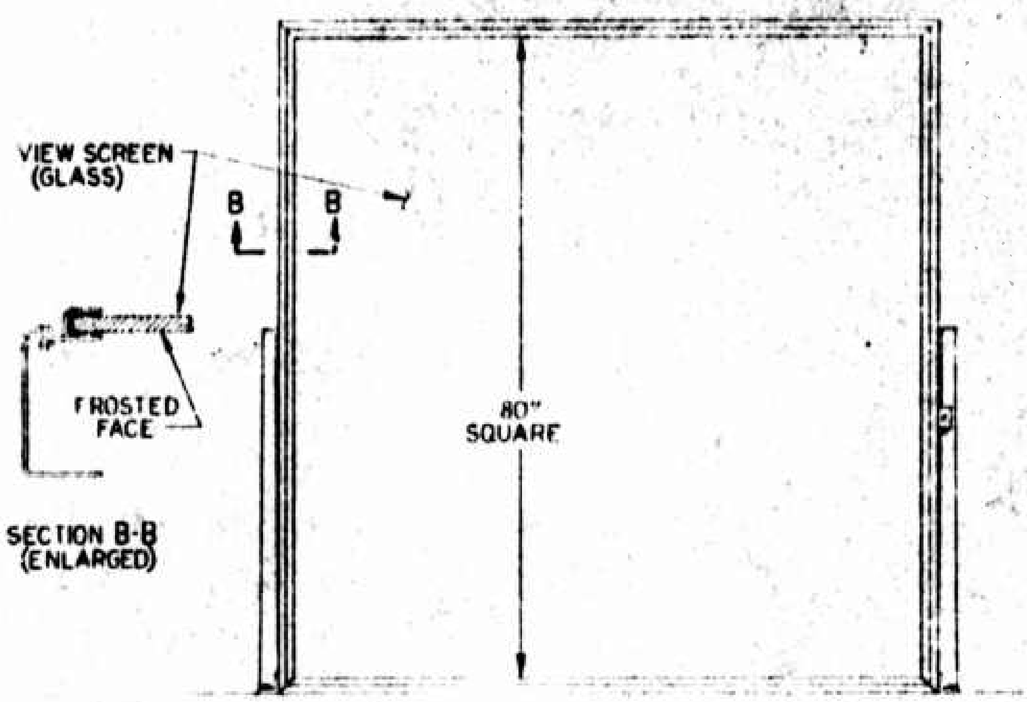
VIEW A-A

DATA:
LENS-FOCAL LENGTH 28.00 - f RATIO 1:6.3
GRID - FROSTED PLATE GLASS .032 PARALLEL
BLACK LINES AT .50 SPACES

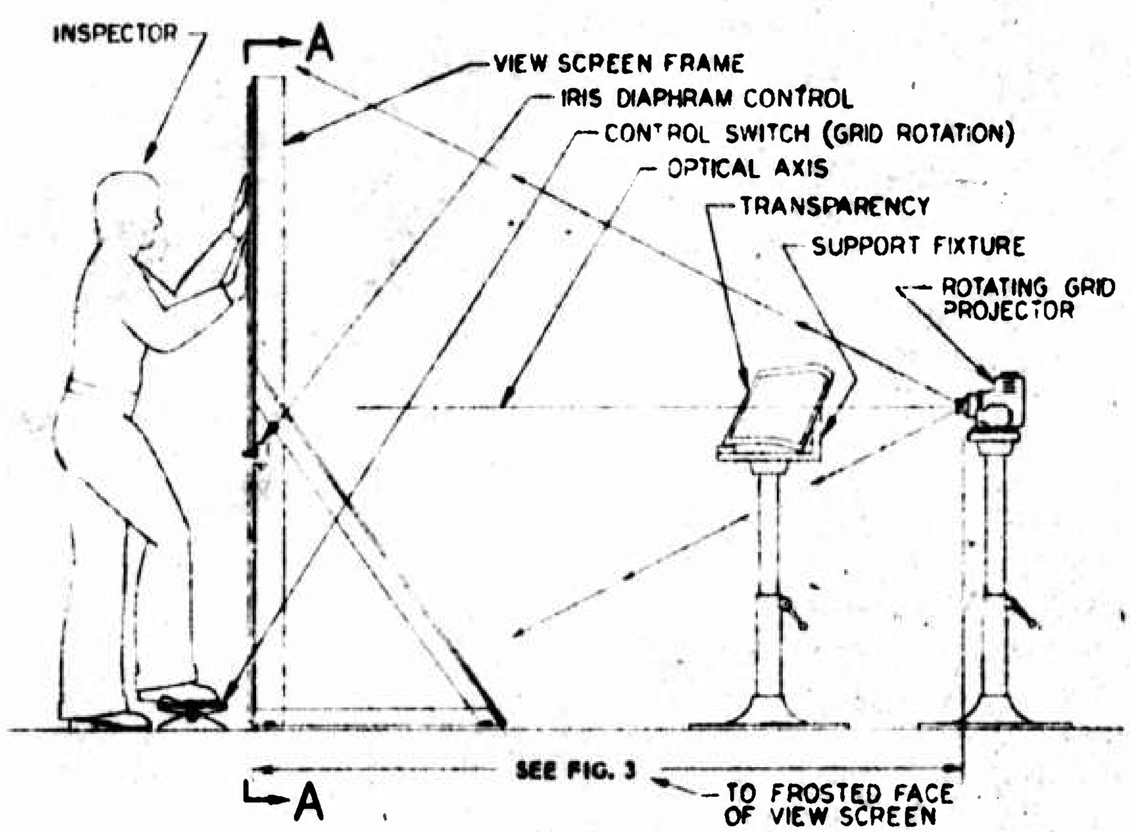


CUT AWAY VIEW OF INSPECTION MACHINE

FIGURE 5A



VIEW A-A



SIDE VIEW OF INSPECTION MACHINE

FIGURE 5-B

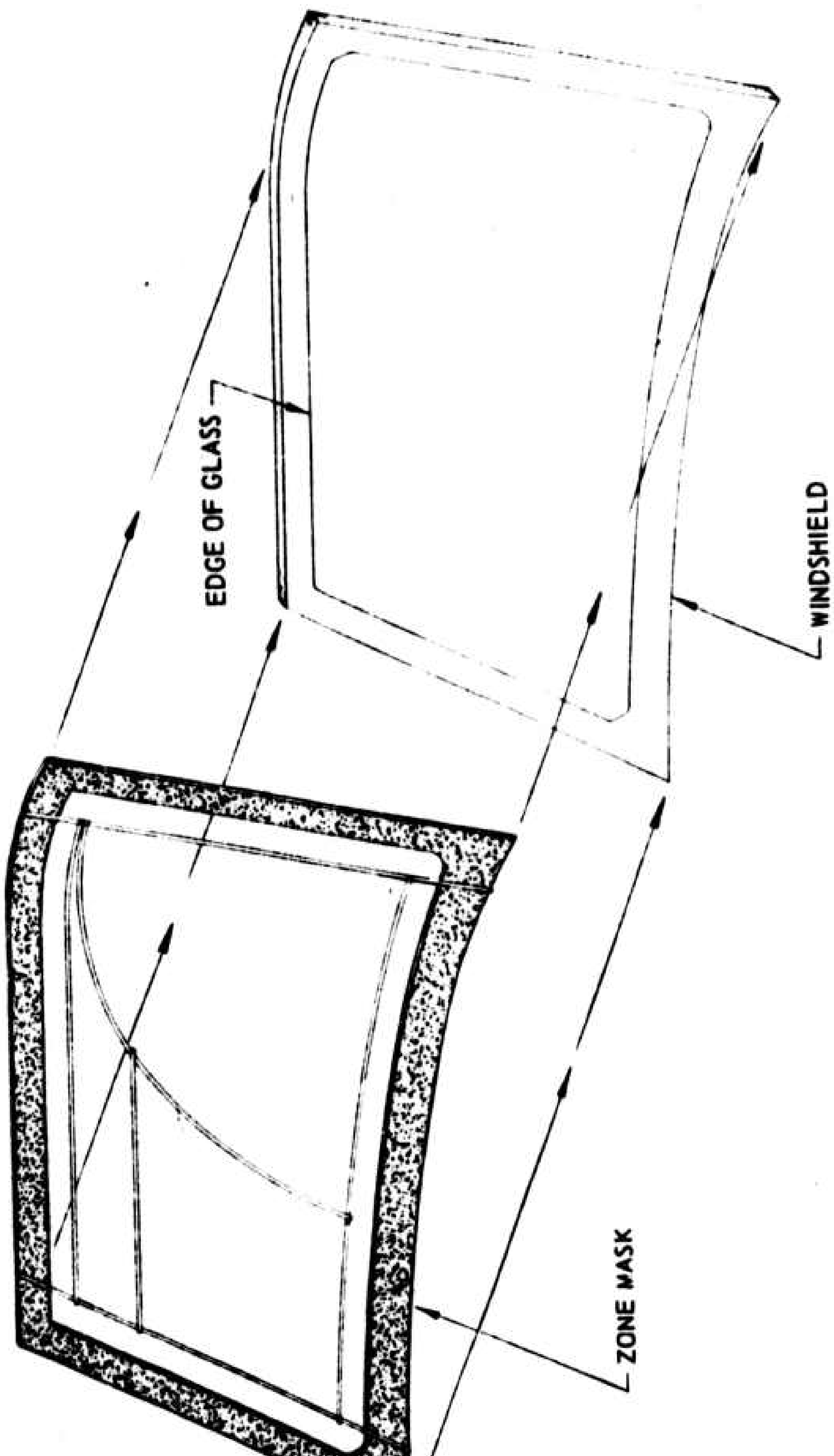
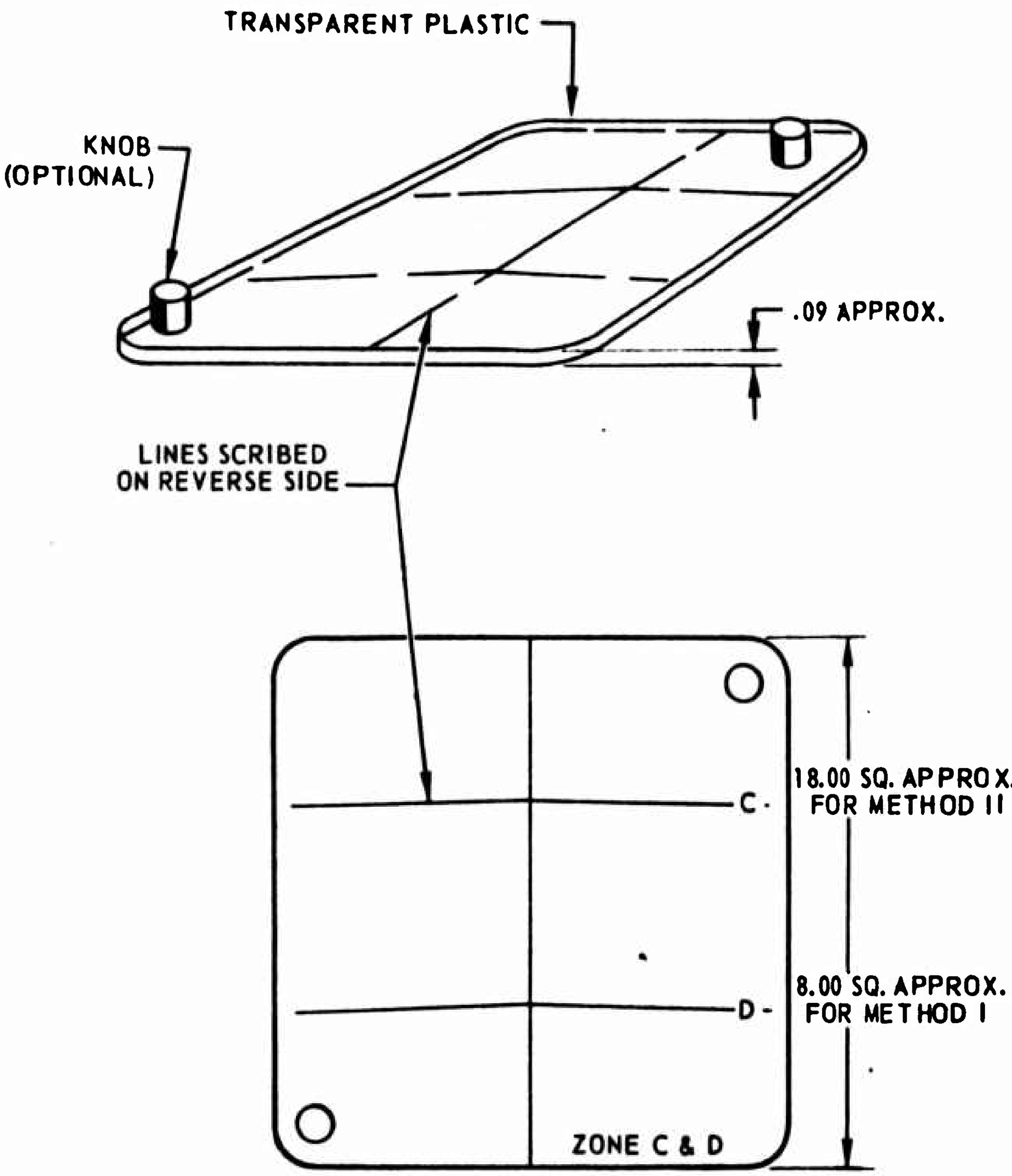


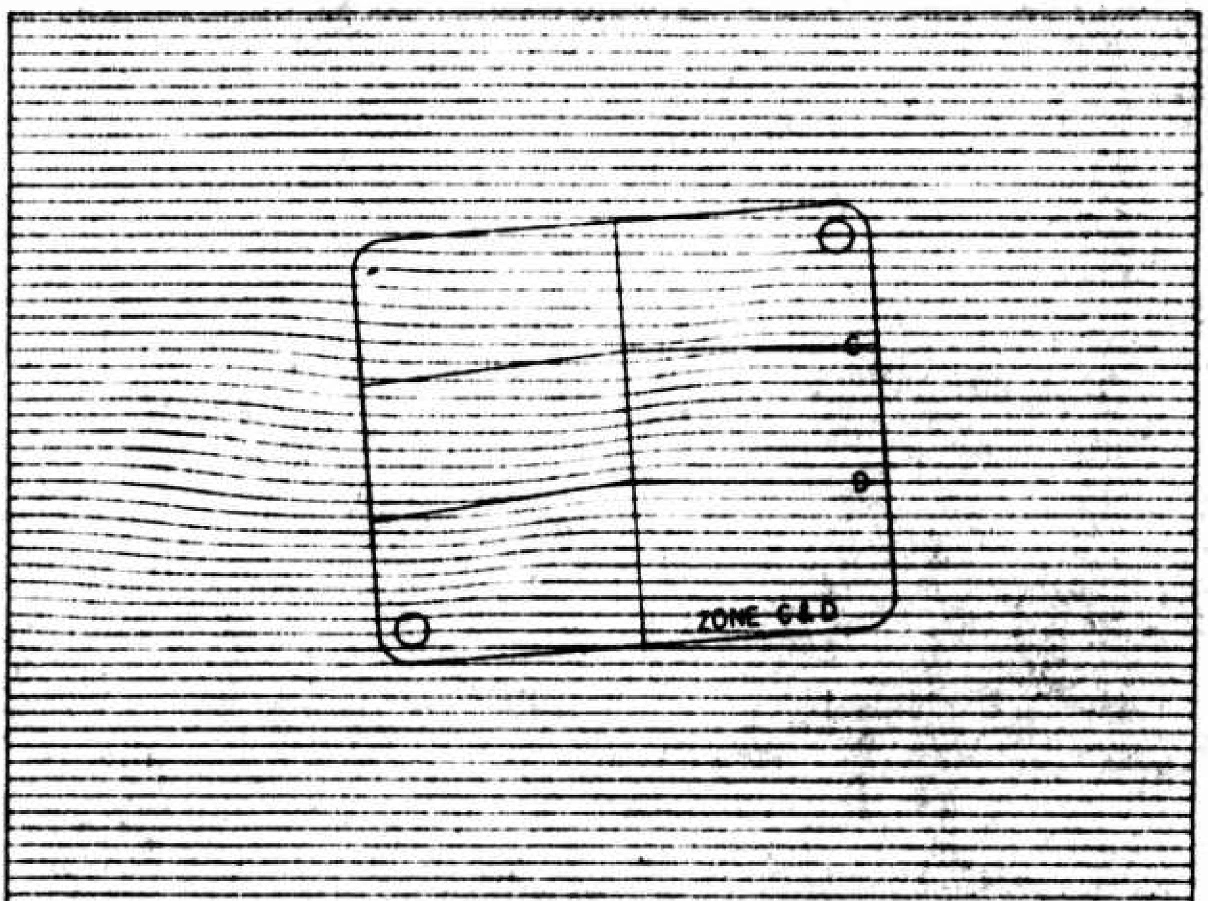
FIGURE 6

REPORT NO. 8-07303



ANGLE GAGE

FIGURE 7



MEASURING WITH AN ANGLE GAGE
SHOWING LINE WITH GREATEST BEND
MATCHING ANGLE ALLOWED FOR ZONE-D
(ANGLES EXAGGERATED)

FIGURE 8