Describing and Measuring the Driver's Field of View—SAE J1050a

SAE Recommended Practice
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DESCRIBING AND MEASURING THE DRIVER'S FIELD OF VIEW—SAE J1050a

SAE Recommended Practice

Report of Human Factors Engineering Committee and Automotive Safety Committee approved September 1973 and revised by Human Factors Engineering Committee January 1977.

1. Purpose and Scope—This SAE Recommended Practice establishes a uniform method for describing and measuring the driver's direct and indirect fields of view. This method is based on the use of the 95th percentile Eyellipse described in the Recommended Practice Motor Vehicle Driver's Eye Range—SAE J941d and on the Three-Dimensional Reference System described in the Recommended Practice Motor Vehicle Fiducial Marks—SAE J182a. This method relates to both the driver's interior and exterior visibility environment and is applicable to the passenger car, multi-purpose passenger vehicle, truck and bus.

2. Definitions

2.1 Eyellipse—The contraction of the words "eye" and "ellipse" and is so named because of the elliptical shape of the driver's eye range. The term "eyellipse" should only be applied to the driver's eye range described in this recommended practice. Eyellipse is synonymous with driver's eye range. The Eyellipse template is a two-dimensional drafting tool consisting of a plan view and side view of the driver's left and right eye ranges.

2.2 Sight Line—A line which is constructed by the designer to extend from the Eyellipse centroid, the left or right eye ellipse centroid, or a tangent point on the Eyellipse contour either to a target point or at a given angle from a line drawn parallel to the zero Y plane or ground.

2.3 Sight Plane—A plane which is constructed by the designer to extend from a tangent point on the Eyellipse contour, either to a target point or at a given angle from a plane parallel to the zero Y plane or ground, and which establishes field-of-view boundaries based on the known percentage of driver eye locations which fall on either side of the plane.

Note: In the side view, a sight plane constructed to the upper or lower edge of the Eyellipse contour is seen as a line. In the plan view, a sight plane constructed to the left or right edge of the left or right Eyellipse contour is seen as a line. A pair of sight lines may be used to define a unique sight plane which is not normal to either the side or plan view.

2.4 Vision—The ability of the driver to see; ocular perception.

2.5 Field of View—The solid angle subtended by sight planes emanating from tangents on the Eyellipse contours.

2.6 Direct Field of View—The view capable of being seen without the aid of mirrors.

2.7 Indirect Field of View—The view capable of being seen by mirror reflection.

2.8 Monocular View—The field of view that can be seen by one eye (Figs. 1 and 2).

2.9 Binocular View—The total field of view that can be seen by both eyes simultaneously (Figs. 1 and 2).

2.10 Ambinocular View—The total field of view that can be seen by both eyes separately.

Note: It is not limited to the binocular field but includes, in addition, monocular field visible to the right eye but not to the left eye, and vice versa (Figs. 1 and 2).

2.11 Peripheral View—The field of view which extends laterally from a sight plane or line from either eye, in the temporal direction to form an included angle of no more than 90 deg with the sight plane or line. The vertex of the angle is at the eyepoint. The area within the peripheral field of view is on the temporal side of the driver's line of sight.

Note: The peripheral view in the nasal direction is not included in this definition because the view overlaps the temporal peripheral view of the opposite eye and is considered redundant. (Fig. 2).

2.12 Binocular Obstruction—Any obstruction within the ambinocular view which produces an area behind the obstruction which cannot be seen by either eye simultaneously.

Note: An object having an apparent width which is equal to or less than the effective interpupillary distance is not considered a binocular obstruction when viewing objects in the exterior environment (Fig. 2).

2.13 A-Pillar—Any roof support forward of the SgRP.

Note: It includes non-transparent items such as windshield mouldings and door frames, attached to or continuous with such a support.

2.14 Seating Reference Point (SgRP)—The manufacturer's design reference point is a unique design H-point which:

a) Establishes the rearmost normal design driving or riding position of each designated seating position which includes consideration of all modes of adjustment, horizontal, vertical and tilt, in a vehicle;

b) Has X, Y, Z coordinates established relative to the designed vehicle structure;

c) Simulates the position of the pivot center of the human torso and thigh, and

d) Is the reference point employed to position the two-dimensional drafting template with the 95th percentile leg described in SAE Recommended Practice "Devices for Use in Defining and Measuring Vehicle Seating Accommodation—SAE J826b.

2.15 Effective Interpupillary Width—The effective width between parallel sight lines, one from each eye ellipse.

Note: The width, when using the SAE J941d Eyellipse without eye turns is 2.54 in (65 mm). [1] This effective width decreases with increased eye turn (Fig. 2).

2.16 Vision Origin Points—They are vision points (V points) and eye points (E points), which rotate around neck pivot points (P points).

2.16.1 Vision Point (V point)—A specific point on a sight plane. It is used in lieu of the complete Eyellipse contour in specifying specific direct field of view requirements.

2.16.2 Eye Points (E points)—Specific points on the left and right eye ellipse contours positioned in the same relative position on each ellipse.

Note: When using the SAE J941d Eyellipse, they are located 2.54 in (65 mm) apart and rotate around a P point. They, when combined with a neck pivot point (P point), are used in lieu of the complete Eyellipse contour.

2.17 Neck Pivot Point (P point)—A specific point about which the driver's head turns on a horizontal plane. The point is 3.88 in (98 mm) rear of the mid-point between the eye points (E points). [2] It, when combined with the eye points (E points), is used in lieu of the complete Eyellipse contour.

2.18 Panel Work Plane—A plane constructed by the designer on which the display surface of instrument panel controls, indicators, and tell-tales are projected for a visibility evaluation.

2.19 Display Surface—A surface or plane which passes through the legend on a control, indicator or tell-tale.

[1] Paul L. Connolly and Konrad H. Marcus, "Human and Visual Factor Considerations for the Design of Automotive Periscopic Rear Vision Systems." Paper 680404 presented at SAE Mid-year Meeting, May 1968.

[2] W. A. Devlin and Ronald W. Roe, "The Eyellipse and Considerations in the Driver's Forward Field of View." Paper 680105 presented at SAE Automotive Engineering Congress, January 1968.

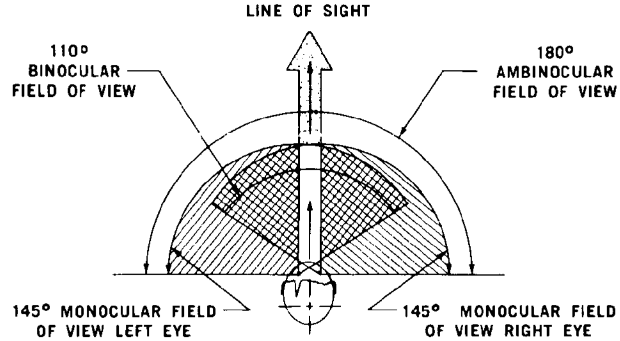


FIG. 1—TRADITIONAL DEFINITION OF TERMS

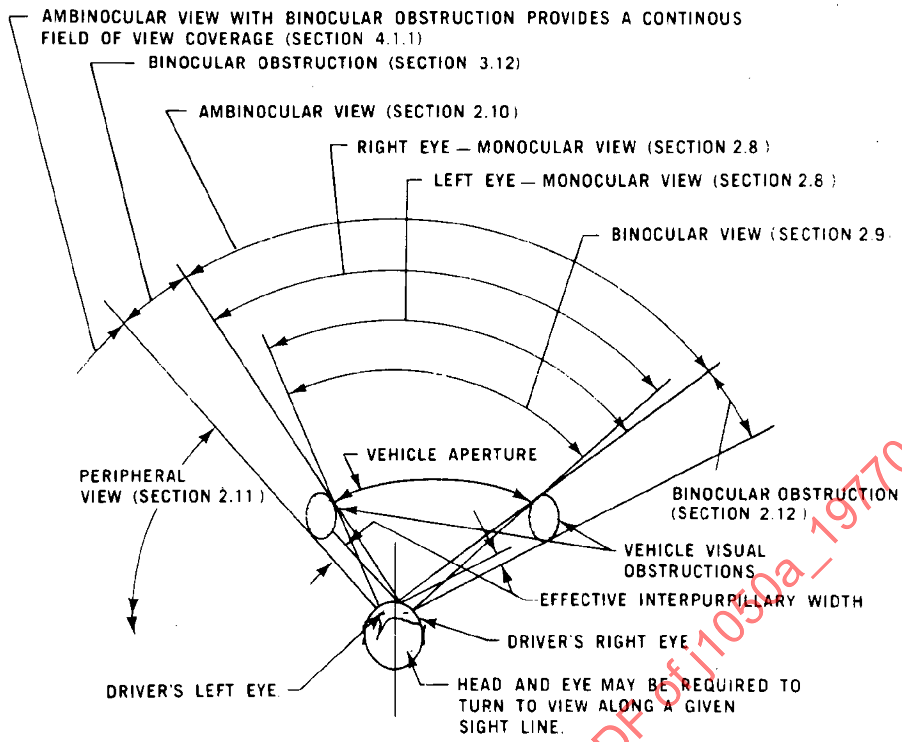


FIG. 2—DEFINITION OF TERMS THROUGH AN APERTURE OR AROUND AN OBSTRUCTION

Note: It is not necessarily the instrument panel surface or the glazing cover over an indicator or tell-tale.

2.20 Steering Wheel Rim Obstruction—The binocular obstruction caused by the steering wheel rim shown on the panel work plane as seen from any single pair of eyes within the Eyellipse.

2.21 Steering Wheel Hub and Spoke Obstruction—The binocular obstruction caused by the steering wheel hub and spokes shown on the panel work plane as seen from a tangent on the bottom edge of the Eyellipse.

3. General

3.1 Field of View Terms—Monocular, binocular and ambinocular field of view terms are defined in this SAE Recommended Practice relative to motor vehicle apertures and visual obstructions instead of traditional human physical limitations.

The traditional definition of the terms monocular, binocular, and ambinocular as illustrated in Fig. 1 are defined around a straight forward gaze and restricts the three fields of view to the physical limitations of the human eye and head. The 145 deg[3] monocular field of view from either eye as illustrated in Fig. 1 is a peripheral field of view, either side of the direct forward gaze, from the nasal to the temporal head obstruction. The 110 deg[3] binocular field of view is the overlap of the two monocular fields of view. The 180 deg ambinocular field of view is the inclusion of both monocular fields of view.

This SAE Recommended Practice, however, defines the terms monocular, binocular and ambinocular as illustrated in Fig. 2 to the driver's field of view through a vehicle aperture or as obstructed by a vehicle visual obstruction rather than to the limits of the human eye or head. The fields of view in Fig. 2 are illustrated by direct sight lines along which the driver views the limits of the vehicle aperture opening or a vehicle visual obstruction by turning his eyes or eyes and head. The monocular field of view (definition 2.8) as illustrated in Fig. 2 is the direct field of view through the vehicle aperture as seen by either eye separately. The binocular field of view (definition 2.9) is the direct field of view through the vehicle aperture as seen by both eyes simultaneously. The ambinocular field of view (definition 2.10) is the direct field of view through the vehicle aperture as seen by both eyes separately.

The procedure in this SAE Recommended Practice constructs sight lines from the driver's eyes that are parallel when viewed in the exterior visibility environment but converge on an object viewed in the interior visibility environment.

3.2 The Eyellipse and Fields of View—This Recommended Practice uses the following different applications of the Eyellipse to properly describe and measure the driver's field of view as follows:

a) Eyellipse tangent cutoff contours.
b) Eyellipse centroid.
c) Vision origin points (V points and E points) developed from the Eyellipse.

The field of view is measured in terms of the following:

a) What is available to the driver.
b) What is available from a vehicle.
c) That specified by a requirement.

The Eyellipse tangent cutoff contour is the best application of the Eyellipse to describe and measure all three of the above fields of view. Generally, the drafting procedures in this practice will use the Eyellipse contours. There are some circumstances, however, where the Eyellipse centroid or vision origin points may be used as alternatives. These are as follows:

a) The Eyellipse centroid can be used as the most acceptable single point to measure the limits of the window sizes of a group of motor vehicles. The results of these measurements can then be comparatively evaluated in terms of the relative sizes of these day light openings.
b) The vision origin points (V points and E points) can be used to measure specific field of view requirements for which the points were developed. The results of these measurements will only indicate whether the vehicle being measured complies to a specific requirement.

3.3 Developing V Points and P Points—A vision point (V point) is simply a specific point on a sight plane. For example, tangent points A, B, C, and D in Fig. 7 could be called V points. These points have a fixed

[3] Paul L. Connolly, W. A. Devlin and Konrad H. Marcus, "Design Aspects for Rear Vision in Motor Vehicles." SAE SP-253, March 1964.

spatial relationship to the Eyellipse locator lines XX, YY, and ZZ and can be called out by coordinates in the Three Dimensional Reference System without the presence of the Eyellipse.

By extending the sight planes A, B, and C rearward to where they all intersect at point F in Fig. 7, a single V point could be established which would enable the measuring of the three angular requirements from one point rather than three. This will simplify the complexity of the number of points, but it does narrow the range of angles that can be measured from the single point. For example, a 5 deg increase in angle M between a sight plane directly forward and sight plane A, when measured from point A, would pass the new sight plane slightly inside the contour of the Eyellipse rear of point A (Fig. 3). However, if the increased angle were measured from point F, the new sight plane would deviate considerably more from the tangent on the Eyellipse contour (Fig. 4). Therefore, care should be taken when developing V points to confine their use to acceptable limits.

A neck pivot point (P point) is simply a point about which the neck pivots horizontally and is positioned such that the eye points (E points) will fall tangent to the Eyellipse when viewing directly forward. The neck pivot point J in Fig. 8 or D in Fig. 9, for example, could be called P points. These points, as with V points, have specific spatial relationships with the Eyellipse locator lines XX, YY, and ZZ and can be called out by coordinates in the Three Dimensional Reference System without the presence of the Eyellipse.

Sections 5 and 6 are a drafting procedure which provides a method of describing and measuring the driver's field of view.

3.4 Exterior Environment—The following procedures describe the driver's direct and indirect fields of view of his exterior environment (Fig. 5):

A) The driver's direct ambinocular view with eye movement only extends laterally in both directions from directly forward to 30 deg to the left to 30 deg to the right (Drafting procedure, Section 5.1, Fig. 7.)

B) The driver's direct ambinocular view with eye and head movement extends laterally in both directions from the view defined in (A) above to 90 deg to the left to 90 deg to the right of straight forward (Drafting procedure, Section 5.2, Fig. 8.)

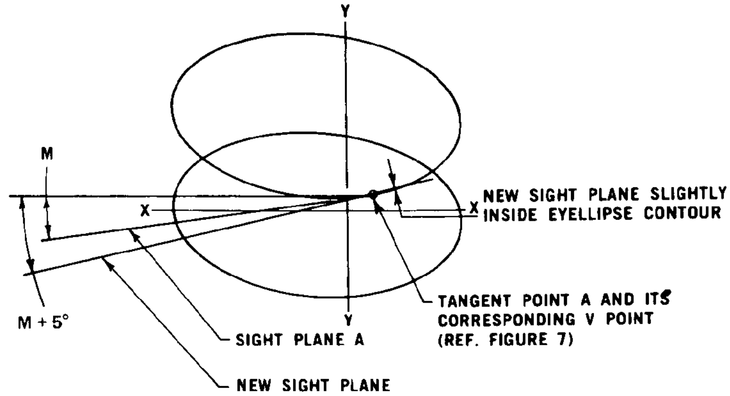


FIG. 3

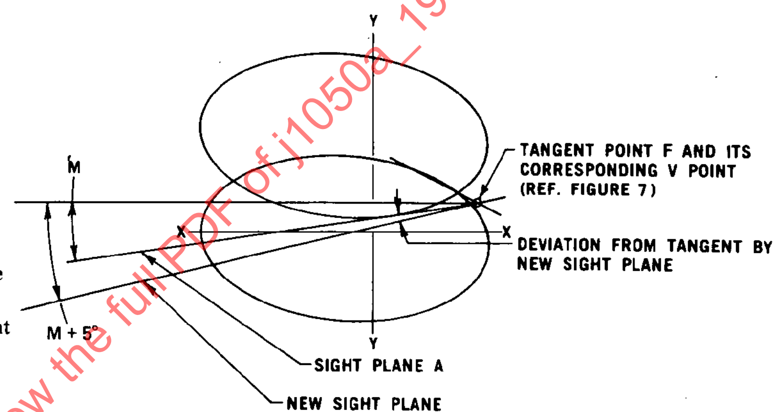


FIG. 4

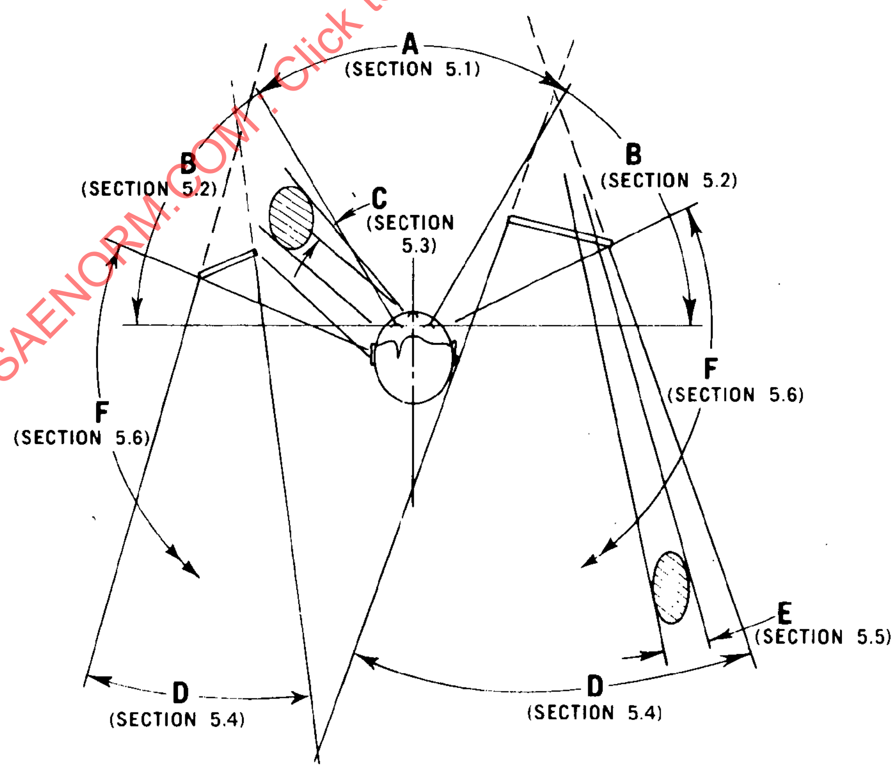


FIG. 5—FIELDS OF VIEW IN THE EXTERIOR ENVIRONMENT

C) The driver's direct binocular obstruction caused by A-pillars within the views defined in (A)or (B) above and forward of the driver's SgRP (Drafting procedure, Section 5.3, Fig. 9.)

D) The driver's indirect ambinocular view through a mirror located within the views defined in (A)or (B) and forward of the driver's SgRP (Drafting procedure 5.4, Fig. 10).

E) The driver's indirect monocular or binocular obstruction caused by the vehicle within the indirect views defined in(D). (Drafting procedure, Section 5.5, Fig. 11.)

F) Direct peripheral view adjacent to the indirect view defined in (D) above. (Drafting procedure, Section 5.6, Fig. 12.)

3.5 Interior Environment—The following procedures describe the driver's direct field of view of his interior environment.

a) The driver's direct binocular obstruction caused by the steering wheel rim within his view of the controls, indicators and tell-tales on the instrument panel. (Drafting procedure, Section 6.1, Figs. 13, 14, and 15.)

4. Methodology

4.1 The Exterior Environment

4.1.1 The Driver's direct field of view through vehicle apertures to the exterior environment shall be described and measured as an ambinocular field of view in conjunction with the binocular obstruction of vehicle obstructions. The combination of an ambinocular view with a binocular obstruction takes into consideration a continuous horizontal field of view as illustrated in Fig. 2.

Sight planes tangent to the left, right, top and bottom of the 95th percentile Eyellipse (Sight planes A, B, C, and D in Fig. 7), are used to describe the driver's direct field of view (Sections 5.1 and 5.2) and will insure that 95% of the drivers, as defined by the Eyellipse will see the field of view to the inside of each of the constructed sight planes. The tangent on the front of the 95th percentile Eyellipse (tangent point C in Fig. 9) was selected because it will describe any binocular obstruction (Section 5.3) in the driver's ambinocular field of view with the largest angle for a given obstruction. Any other tangent point on the Eyellipse will measure the given binocular obstruction to a smaller angle.

4.1.2 The driver's indirect field of view of the exterior environment shall also be described and measured as an ambinocular view (Section 5.4) through a rear view mirror. However, obstruction of the exterior environment caused by the vehicle, within the indirect ambinocular view through a rear view mirror shall be described and measured as a binocular obstruction (Section 5.5) if the entire obstruction is in view of both projected eye points through the mirror. If either projected eye point can only view one side of the obstruction through the mirror, the obstruction shall be described and measured as a monocular obstruction. The tangent on the rear of the 95th percentile Eyellipse (tangent point B) in Fig. 10 was selected because it will describe the indirect ambinocular field of view (Section 5.4) through a given mirror with the smallest angle for the mirror. Any other tangent point on the Eyellipse will measure the ambinocular field of view through a given mirror to a larger angle.

4.1.3 The driver's peripheral field of view to the exterior environment shall be described and measured in conjunction with the mirror being used to measure the indirect field of view. The peripheral angle shall be described as a monocular angle rear of the driver's view of the mirror.

The head turned eye point (eye point C', Fig. 12) was selected to describe the driver's peripheral field of view (Section 5.6) to insure a related peripheral view to the indirect view through the mirror. The location of the forward edge of the peripheral field of view will always fall adjacent to the driver's view of the mirror.

4.2 The Interior Environment—The driver's field of view in the interior environment shall be described and measured as an ambinocular view. Any obstruction in the interior environment caused by vehicle interior components shall be described and measured as a binocular obstruction.

A typical instrument panel obstruction caused by a steering wheel for an individual driver is shown in Fig. 6. The obstruction can be described as shadows of the steering wheel rim, hub and spokes projected on the instrument panel display surface from light sources at the driver's left and right eye. The darker portion of the circular shadow is the binocular obstruction caused by the steering wheel rim. The darker portion of the shadow below the rim is the binocular obstruction caused by the hub and spokes.

4.2.1 Steering Wheel Rim—This method, as opposed to the exterior environment drafting procedures, establishes the binocular obstruction caused by the steering wheel rim for a single pair of eye points at the centroid of the Eyellipse and then shifts this obstruction about on the instrument panel according to the limits of the Eyellipse. This method measures whether any single driver, within the limits of the Eyellipse, can or cannot see any single control, indicator or tell-tale either above or below the steering wheel rim.

The characteristic size and shape of the rim obstruction is based on driver's viewing the instrument panel from the Eyellipse centroid. The centroid was selected for the following reasons:

a) Fore and aft (X) variation in driver eye location within the limits of the Eyellipse on the *thickness* of the rim obstruction in areas where displays are located. As the driver's eyes move closer to

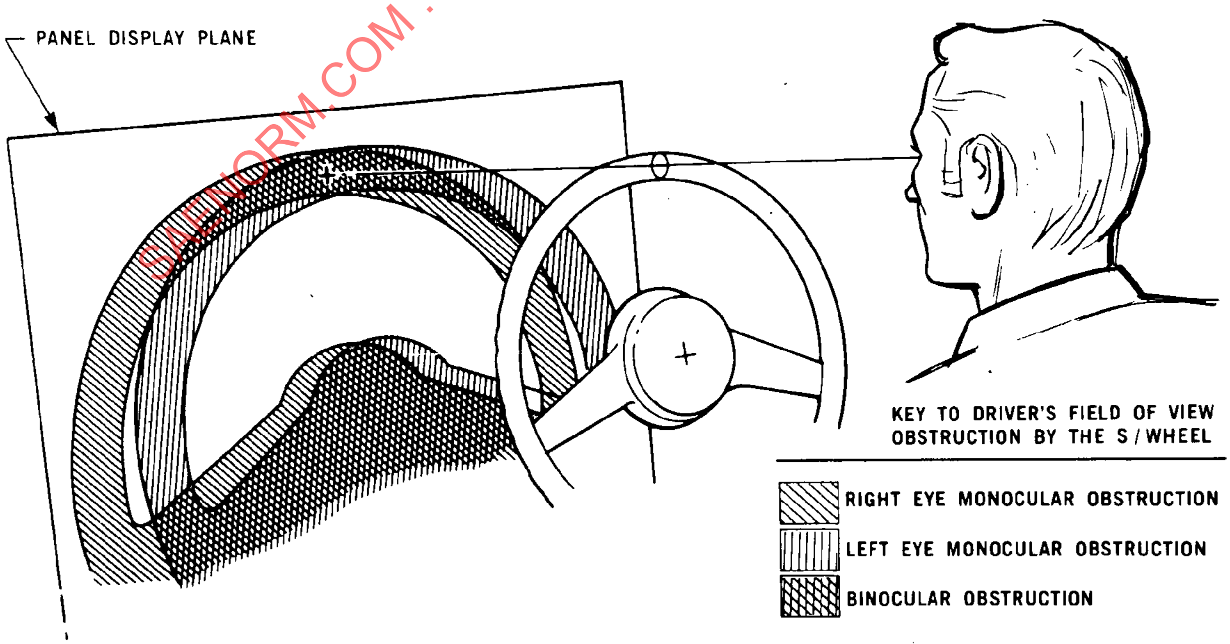


FIG. 6—OBSTRUCTION CAUSED BY STEERING WHEEL ON THE INSTRUMENT PANEL SURFACE

the steering wheel, obstructions caused by the more *horizontal* portions of the rim become larger while obstructions caused by the more *vertical* portions of the rim become smaller. Since displays generally appear where the rim is *angled*, the centroid provides a vantage point for definition of a characteristic rim obstruction.

b) Vertical (Z) and lateral (Y) variations in driver eye location within limits of the Eyellipse have little effect on size and shape of the rim obstruction.

c) Tangent sight lines drawn from the Eyellipse that define obstruction movement limits occur near an X plane at the Eyellipse centroid. Characteristic *spread* of the crescent-shaped rim obstruction based on the centroid, therefore, best describes the steering wheel rim obstruction at 95th percentile accommodation limits.

4.2.2 Steering Wheel Hub and Spokes—The hub and spoke obstruction is described on the panel display surface according to sight lines tangent at the bottom edge of the 95th percentile Eyellipse. This typically describes a worst case condition for drivers looking over the hub and spokes.

4.2.3 Application Considerations—These procedures insure that areas visible to 95% of the drivers can be described on the panel surface as well as provide a description of an individual driver's obstruction. The drafting procedure described in Section 6.1 approximates the steering wheel rim obstruction using circular arcs. The drafting approximation is identical to the actual steering wheel rim obstruction when the steering wheel face is parallel to the panel work plane, the rim section is circular and the Eyellipse centroid is in the same Y plane as the steering wheel center. However, for practical application, the drafting procedure will provide a reasonable and conservative approximation of the steering wheel rim obstruction on the instrument panel within dimensional arrangements listed in Section 6.1.1.

When these limits are exceeded, the actual steering wheel rim obstruction patterns become elliptical and cannot be accurately described with the drafting procedure. There are no application limits for constructing the area obstructed by the hub and horizontal spokes.

5. Drafting Procedure—Exterior Environment

5.1 Direct Ambinocular View with Eye Turning Only (Fig. 7)

5.1.1 Construct a sight plane A in the plan view tangent to the left edge of the right ellipse at point A and extend it from directly forward to a maximum of 30 deg [2] to the left of directly forward to a given target or at a given angle. Project point A to the side view to the major axis of the Eyellipse.

5.1.2 Construct a sight plane B in the plan view tangent to the right edge of the left ellipse at point B and extend it from directly forward to a maximum of 30 deg [2] to the right of directly forward to a view given target or at a given angle. Project point B to the side view to the major axis of the Eyellipse.

Note: The angle between the two sight planes constructed in Sections 5.1.1 and 5.1.2 is the direct, ambinocular field of view of the driver facing directly forward with no head turn to the left or right.

5.1.3 Construct a sight plane C in the side view, tangent to the top of the Eyellipse at point C and extend it from horizontal to a maximum inclined angle of 45 deg [3] above the horizon, to view a given target or at a given angle. Project point C to the plan view to both major axes of the Eyellipse.

5.1.4 Construct a sight plane D in the side view, tangent to the bottom of the Eyellipse at point D and extend it from horizontal to a maximum declined angle of 65 deg [3] below the horizon, to view a given target or at a given angle. Project point D to the plan view to both major axes of the Eyellipse.

Note: The angle between the sight planes constructed in Sections 5.1.3 and 5.1.4 in the side view is the vertical range of the driver's direct ambinocular field of view as constructed in Sections 5.1.1 and 5.1.2 above.

Note: The points that are projected to the side view in Sections 5.1.1 and 5.1.2 and to the plan view in Sections 5.1.3 and 5.1.4 are shown for reference only and are not essential to the drafting procedure.

5.2 Direct Ambinocular View With Eye and Head Turning (Fig. 8)

5.2.1 Construct a sight plane G in the plan view tangent to the left edge of the right ellipse at point G and extend it from 30 deg to the left of straight forward to 90 deg to the left of straight forward to view a given

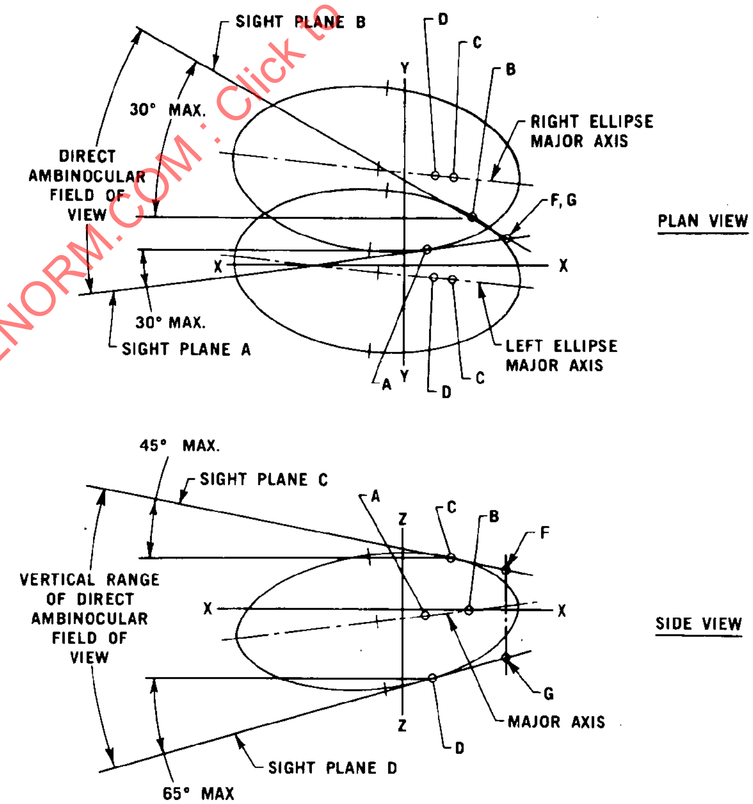


FIG. 7—DIRECT AMBINOCULAR FIELD OF VIEW (EYE MOVEMENT ONLY)

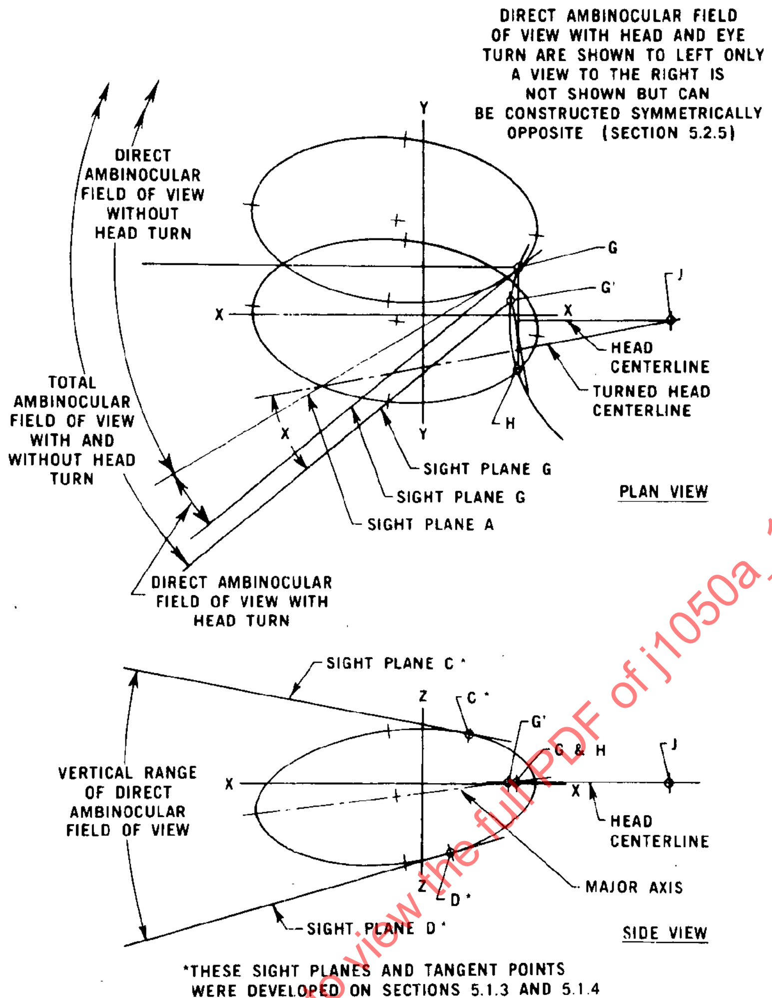


FIG. 8–DIRECT AMBINOCULAR FIELD OF VIEW (EYE AND HEAD MOVEMENT)

target or at a given angle. Project point G to the major axes of the Eyellipse in the side view.

5.2.2 Construct tangent point H in the plan view on the left ellipse laterally from the equivalent tangent point G on the right ellipse.

Note: Tangent points G and H represent a driver's right and left eye when his head is facing directly forward.

5.2.3 Construct point J in the plan view on a longitudinal line 3.88 in (98 mm) directly rear of the midpoint between points G and H. This longitudinal line is the driver's head centerline and point J is the neck pivot point. Project points H and J to the side view to a horizontal plane through point G.

5.2.4 Rotate points G and H to the left around point J in the plan view, until a sight plane G′ from the relocated point G (point G′) is directed to the given target or at the given angle used in Section 5.2.1. The head centerline shall rotate around point J until the angle W formed between the turned head centerline and the sight plane G′ is 30 deg.

Note: The sight plane A is shown in Fig. 8 for reference only (Section 5.1.1). The angle between sight plane A and sight plane G′ is added direct ambinocular field of view with head turn from directly forward to a maximum of 60 deg to the left and utilizing 30 deg of eye turn to the left.

5.2.5 Repeat the above, Sections 5.2.1 through 5.2.4, from the left ellipse looking to the right.

Note: The angle between sight line G′ and the equivalent plane constructed to the right is the total direct ambinocular view of the driver facing any lateral direction from 60 deg to the left of directly forward to 60 deg to the right of directly forward and utilizing a maximum of 30 deg of eye turn to the left or right. Sections 5.1 and 5.2 construct an available direct ambinocular view in the forward 180 deg. Combinations of Sections 5.1 and 5.2 may be used if the desired forward angles to the right were greater than 30 deg and to the left were less than 30 deg, or if reversed.

5.2.6 Sight planes C and D directed to a given target or at a given angle in the side view are constructed in the same manner as sight planes C and D in Section 5.1.

5.3 Direct Binocular Obstruction by A-Pillars (Fig. 9)

5.3.1 Construct a horizontal section A-A through the A-pillar at the height of the expected tangent point B to the Eyellipse in the side view.

Note: The height of the A-pillar section constructed in Section 5.3.1 could alternately be taken at the height of the intersection of the Eyellipse side view major axis and the forward edge of the Eyellipse side view contour.

5.3.2 Construct a sight line B in the plan view from the closest point on the left ellipse to a tangent to the left edge of the A-pillar section constructed above. Point A is the tangent on the pillar and point B is the tangent on the left ellipse. Project points A and B to the side view to a horizontal plane through the A-pillar section.

5.3.3 Construct tangent point C in the plan view on the right ellipse laterally from the equivalent tangent point B on the left ellipse.

Note: Tangent points B and C represent a driver's left and right eyes when his head is facing directly forward.

5.3.4 Construct point D in the plan view on a longitudinal line 3.88 in (98 mm) directly rear of the midpoint between points B and C. This longitudinal line is the driver's head centerline and point D is the neck pivot point. Project points C and D to the side view to the horizontal plane through the A-pillar section.

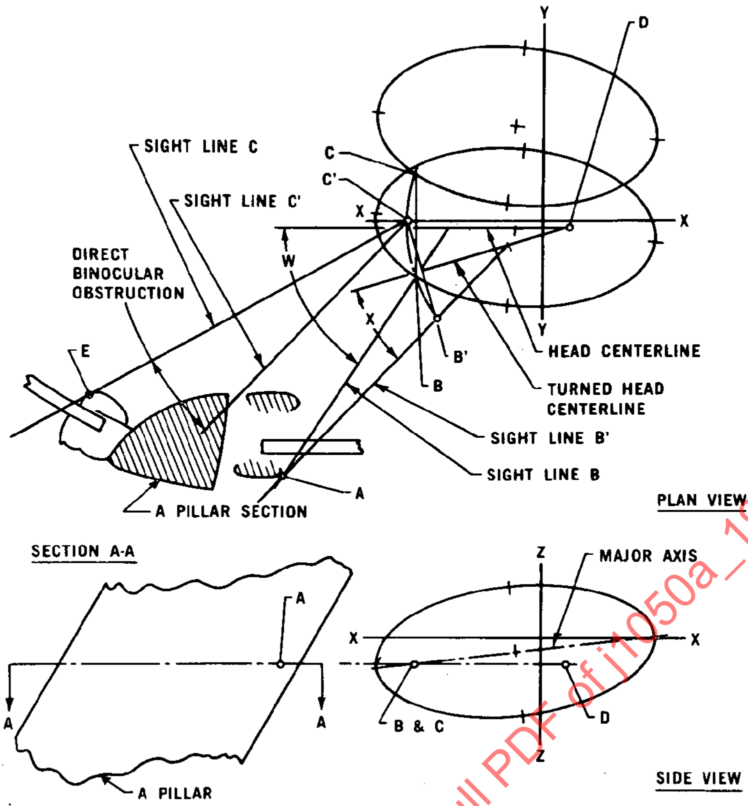


FIG. 9–DIRECT BINOCULAR OBSTRUCTION

Note: If the sight line B forms an angle W of 30 deg or less to the head centerline, continue with Section 5.3.6.

5.3.5 Rotate points B and C to the left around point D in the plan view until a sight line B′ from the relocated point B (point B′) is viewing point A and forms an angle X of 30 deg to the turned head centerline.

5.3.6 Construct a sight line C from point C when no head turn is required or from the relocated point C (point C′) when head turn is required, to a tangent to the right edge of the A-pillar at point E.

5.3.7 Construct a sight line C′ from point C when no head turn is required or from C′ when head turn is required, parallel to sight line B′ to the A-pillar section.

Note: If the two sight lines B′ and C diverge away from the driver, the angle formed between the sight lines is the direct binocular obstruction and can be measured between sight lines C and C′. If the two sight lines B′ and C converge or are parallel, there is no binocular obstruction.

5.4 Indirect Ambinocular Field of View (Fig. 10)

Note: This procedure is based on the design of a passenger car inside rear view mirror, however the procedure is applicable to any mirror located in the driver's direct ambinocular field of view.

5.4.1 Construct a sight line A in the plan view from the mirror mounting pivot closest to the reflective surface point A to the furthest tangent on the furthest ellipse. The further tangent on the ellipse is point B. Project point B to the side view to the major axis of the Eyellipse. Project point A and sight line A also to the side view.

Note: If the mirror mounting pivot point is unknown the mirror reflective surface mid-point could be used. Point B represents the furthest eye point from the mirror and will establish the smallest field of view of any other tangent point on the Eyellipse contour, assuming the mirror has adequate adjustment.

5.4.2 Construct tangent point C in the plan view on the right ellipse laterally from the equivalent tangent point B on the left ellipse.

Note: Tangent points B and C represent a driver's left and right eyes when his head is facing directly forward.

5.4.3 Construct the neck pivot point D in the plan view on the head centerline 3.88 in (98 mm) directly rear of the midpoint between points B and C. Project points C and D to the side view to a horizontal plane through point B.

5.4.4 Rotate points B and C around point D in the plan view until a sight line E can be constructed from the relocated point B (point B′) viewing point E on the upper right corner of the mirror reflectant surface, with the sight line E forming an angle X of 30 deg to the turned head centerline. Project point B′, line E and point E to the side view.

5.4.5 Construct sight plane E′ through point E to the projected eye point B″. Project sight line E′ and point B″ to the side view.

Note: The compound angle between the Sight Line E and the front of the mirror reflectant surface is equal to the compound angle between the sight line E′ and the rear of the mirror reflectant surface. The location of the projected eye point B″ on sight line E′ is equal to the true length of line E.

5.4.6 Construct sight line F and F′ from point B′ through point F on the lower right corner of the mirror reflectant surface in the same manner as sight lines E and E′ in Sections 5.4.4 and 5.4.5 above. The projected eye point for sight lines F and F′ is determined in the same manner as Section 5.4.5 above and will fall on point B″. Project sight line F and F′ to the side view.

5.4.7 Construct sight lines G and G′ and H and H′ from eye point C′ through points G and H on the left end of the mirror reflectant surface in the same manner as sight lines E and E′ in Sections 5.4.4 and 5.4.5 above. The projected eye points for sight lines G, G′, H, and H′ is determined in the same manner as Section 5.4.5 above and will fall on point C″. Project sight lines G, G′, H, and H′ and points C′ and C″ to the side view.

Note: Using an acceptable drafting procedure to moveable overlays, the sight lines E′, F′, G′ and H′ can be directed to view in a predetermined direction.

5.5 Indirect Monocular or Binocular Obstruction (Fig. 11)

Note: This layout procedure is based on the completed layout of the indirect ambinocular field of view defined in Section 5.4, Fig. 10. The points B″ and C″ are used to layout the monocular or binocular obstruction of pillars or other objects in the indirect ambinocular field of view in a

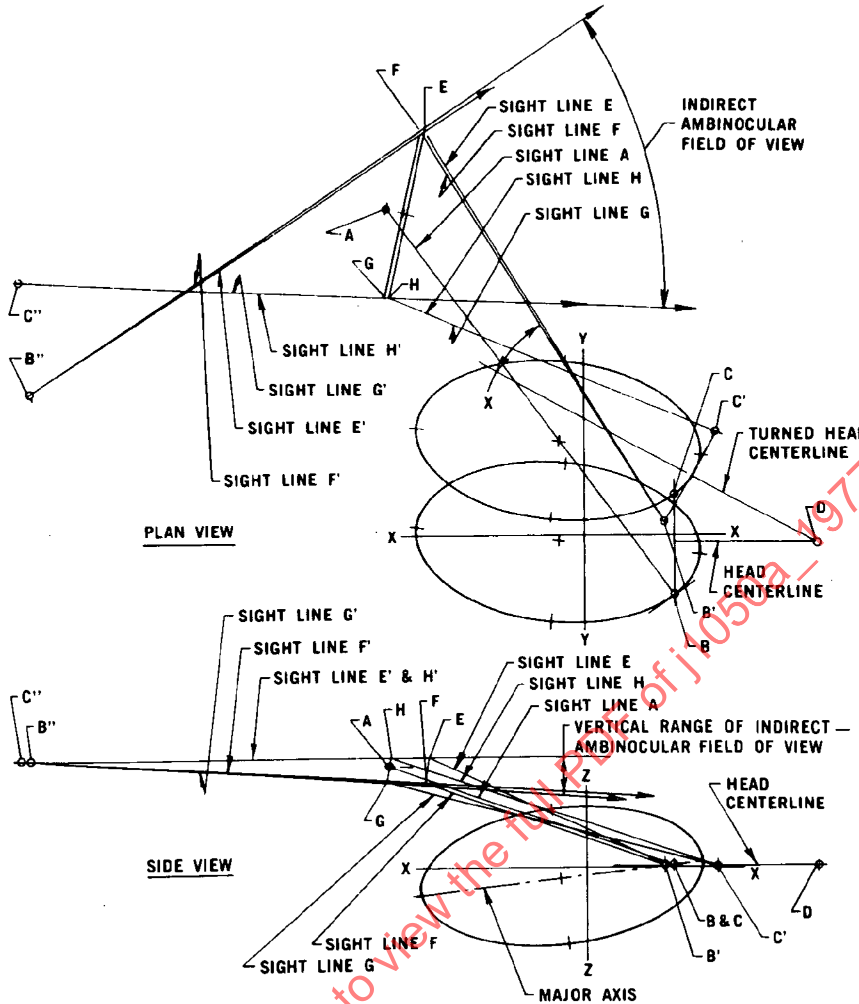


FIG. 10–INDIRECT–AMBINOCULAR FIELD OF VIEW

similar way points B' and C' are used to layout the binocular obstruction in the direct ambinocular field of view (Fig. 6). In this procedure, however, the location of the projected eye points are dependent primarily on the aim of the mirror while in the direct field of view they are dependent on the location of the pillar.

5.5.1 Extend sight line E', shown on Fig. 10, through the rear of the vehicle. (Fig. 11A).

5.5.2 Construct a new sight line A from C" through point E on the mirror upper right corner and through the rear of the vehicle.

Note: If the object to be evaluated for obstruction falls within the two lines constructed in Sections 5.5.1 and 5.5.2 above, it will be measured monocularly, in that it can only be completely seen through the mirror by the one eye point B". (See Fig. 11A). If the object to be evaluated for obstruction falls completely inside of line A, it will be measured binocularly in that it can be seen through the mirror from both eye points B" and C" simultaneously (See Fig. 11C). If the object to be evaluated for obstruction is bisected by sight line A, it will totally be evaluated monocularly in that both sides of an object must be in view of both eyes to measure it binocularly. The B-pillar in Fig. 11B must be totally evaluated monocularly.

5.5.3 Construct a sight line B and C to either side of the B-pillar from eye point B". (Fig. 11B).

Note: The angle formed by sight lines B and C is the monocular obstruction angle of the B-pillar at a given height within the indirect ambinocular field of view.

5.5.4 Construct a sight line F from the projected eye point C" tangent to the right side of the C-pillar section (Fig. 11C).

5.5.5 Construct a sight line G from the projected eye point B" tangent to the left side of the C-pillar section.

5.5.6 Construct a sight line F' from the projected eye point B" parallel to sight line F.

Note: If the two sight lines F and G diverge away from the mirror, the angle formed between the sight lines is the binocular obstruction and can be measured between sight lines F and F'. If the two sight lines F and G converge or are parallel there is no binocular obstruction.

The above drafting procedure defining the monocular and binocular angles of obstruction were constructed through the top of the mirror reflectant surface. This procedure is applicable at any height through the mirror reflectant surface.

5.6 Direct Peripheral View (Fig. 12)

Note: This layout procedure is based on the completed layout of the indirect ambinocular view defined in Section 5.4 and Fig. 10. The direct peripheral view extends from the lateral limits of the driver's view through a rear view mirror.

5.6.1 Construct a vertical sight plane J in the plane view from point C' parallel to sight line E to the desired length through point C'.

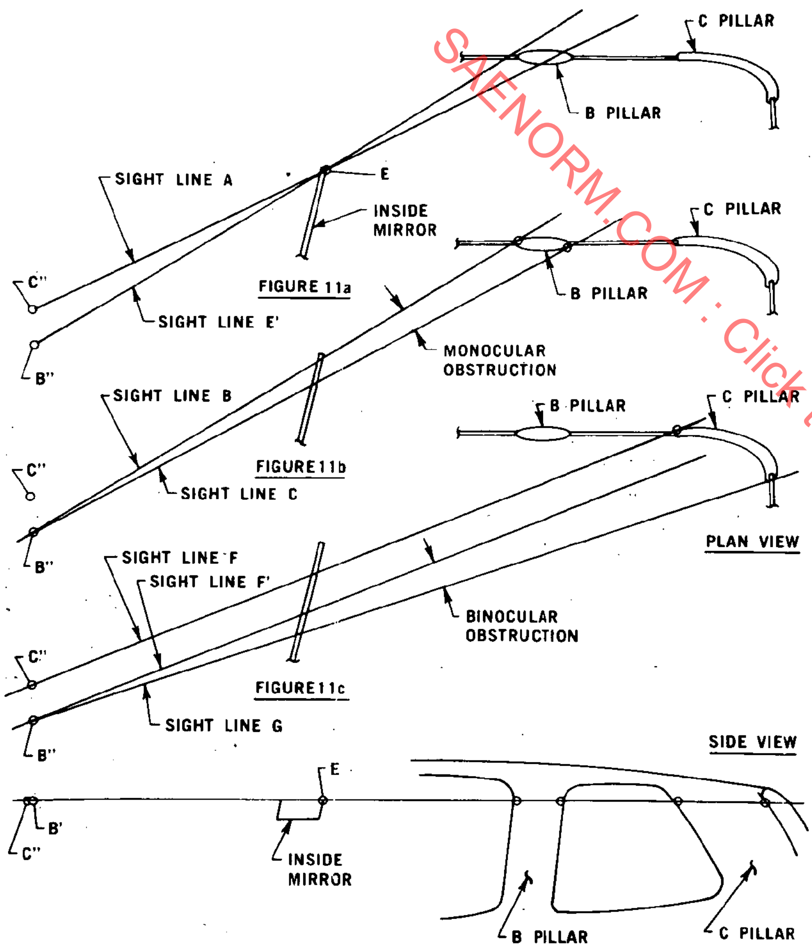
5.6.2 Construct a vertical sight plane K from point C' to the desired length, 90 deg rear of sight plane J.

Note: The angle between sight lines J and K is the direct peripheral field of view.

6.0 Drafting Procedure–Interior Environment

6.1 Direct Binocular Obstruction by the Steering Wheel

Note: This procedure is based on a layout of the Eyellipse, steering wheel rim and control, indicator, or tell-tale display surfaces in their design location in the side and plan views. The Eyellipse centroid cannot be offset laterally more than 2.5 in (63 mm) from the center of the steering



FIG' 11–INDIRECT–MONOCULAR AND BINOCULAR OBSTRUCTIONS

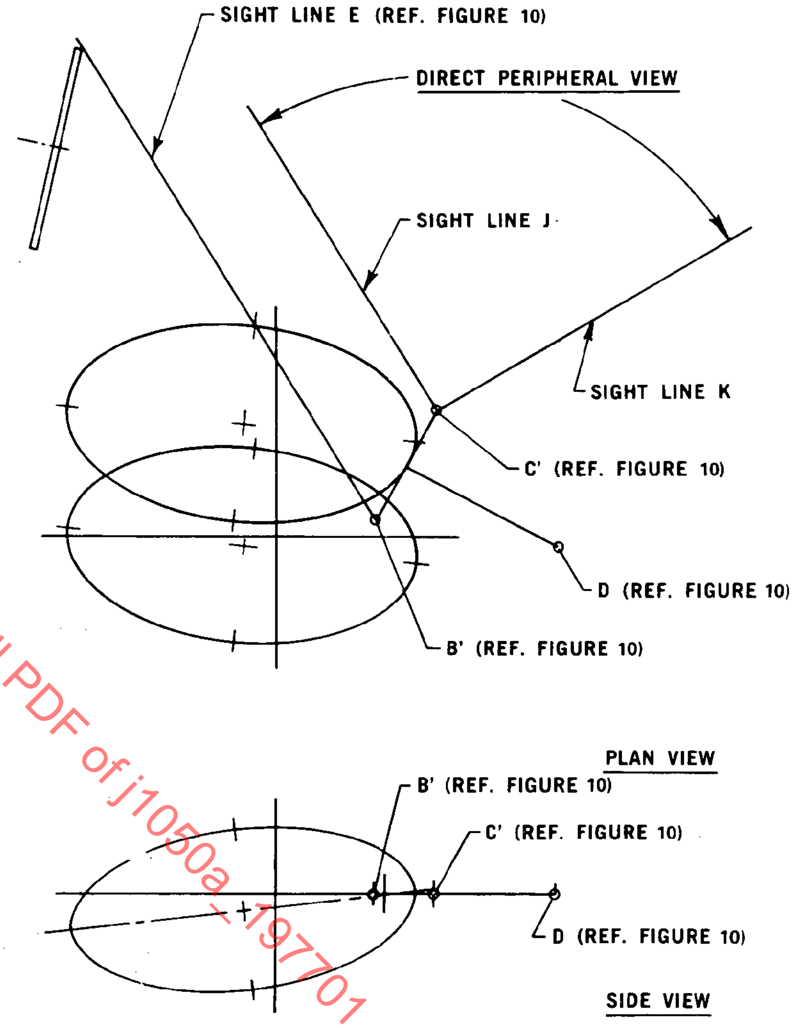


FIG. 12–DIRECT PERIPHERAL VIEW

wheel rim face. The steering wheel rim face must be between 0 deg to 60 deg from the vertical. Angles up to 75 deg can be considered if the steering wheel diameter is greater than 20 in (510 mm).

6.1.1 Panel Work Plane—Construct a panel work plane, seen as a line in the side view, between -5 deg to 45 deg forward of vertical, as close as possible but not farther than 0.50 in (17 mm) from the controls, indicators or tell-tales display surfaces being studied.

Note: Additional panel work planes may be required when additional display surfaces are outside the 0.50 in (17 mm) requirement.

Project, normal to the panel work plane, the control, indicator or tell-tale display surfaces to the panel work plane surface.

6.1.2 Steering Wheel Rim Obstruction (Fig. 13)

6.1.2.1 Locate point 1, the center of the rim section at the upper most portion of the steering wheel rim (12 o'clock) in the plan and side views.

6.1.2.2 Construct line A from the Eyellipse centroid through point 1 to the panel work plane and locate point 2 (the most obscured point) at the intersection of line A on the panel work plane in side view. Project line A and point 2 to the plan view.

6.1.2.3 Construct a panel work line in plan view that passes through point 2 and is parallel to the side view (Y plane).

6.1.2.4 Locate point 3, the center of the upper half of the steering wheel on a plane passing through point 1 parallel to the steering wheel face, in plan and side views.

6.1.2.5 Locate point 4, the center of the rim section at the most vertical portion of the rim (9 o'clock) in the plan and side views. Construct line B parallel to the side view (Y plane) through point 4 in plan and side views.

6.1.2.6 Construct an orthogonal work line in plan view from point 3 through line B and locate point 5 in plan and side views.

6.1.2.7 Construct line C from the Eyellipse centroid through point 5 and locate point 6 at the intersection of line C and the panel work plane in side view. Locate point 6 in plan view and extend an orthogonal work line through the plan view panel work line to establish point 8 in plan view.

Note: If the steering column is skewed more than 2 deg from the zero Y plane, the obstruction pattern to the left of the panel work line and to the right of the panel work line must be constructed separately. Construct line C from the Eyellipse centroid through point 4 to describe the obstruction pattern to that side of the panel work line. The obstruction pattern on the other side of the panel work line is obtained by repeating the instructions from Section 6.1.2.5 on using the appropriate steering wheel rim center location (point 4) for the *mirrored* construction of line C on the other side of the panel work line.

6.1.2.8 Construct a plane seen as line D in side view from point 2, 90 deg to line B downward through line C to establish point 9 in side and plan views.

6.1.2.9 Construct an arc in plan view through point 9 using point 2 as center. Locate point 10 in plan view at the intersection of this arc with an orthogonal work line that passes through point 8 and point 6.

Note: Point 10 in plan view may be either forward or rearward of point 9 depending on the geometry of the panel work plane and steering wheel.

Transfer the plan view distance between point 8 and point 10 to the side view from point 2 downward along the panel work plane and establish point 11 in side view. Locate point 11 in plan view on the panel work line.

6.1.2.10 Construct two lines E and F from the left and right ellipse centroids through point 1 to an orthogonal work line through point 2 and locate points 12 and 13 on the panel work plane in plan view. Project points 12 and 13 downward, parallel to the panel work line on the panel work plane to an orthogonal work line through point 11 and establish points 14 and 15.

6.1.2.11 Construct two lines G and H from the Eyellipse centroid, tangent to the top and bottom edges of the upper steering wheel rim section to points 16 and 17 on the panel work plane in side view.

6.1.2.12 Construct a true view of the panel work plane around the panel work line as illustrated in Fig. 13. Construct two pairs of circular arcs on the panel work plane that pass through points 16 and 17 and whose centers are at points 14 and 15. The area mutually enclosed by the two pairs of arcs shown in Fig. 13, describes the steering wheel rim obstruction. If the construction of the arcs are such that the panel work plane forward of more vertical portions of the steering wheel rim converges to 0.1 in (2.5 mm) or less, truncate the ends of the enclosed area at this location

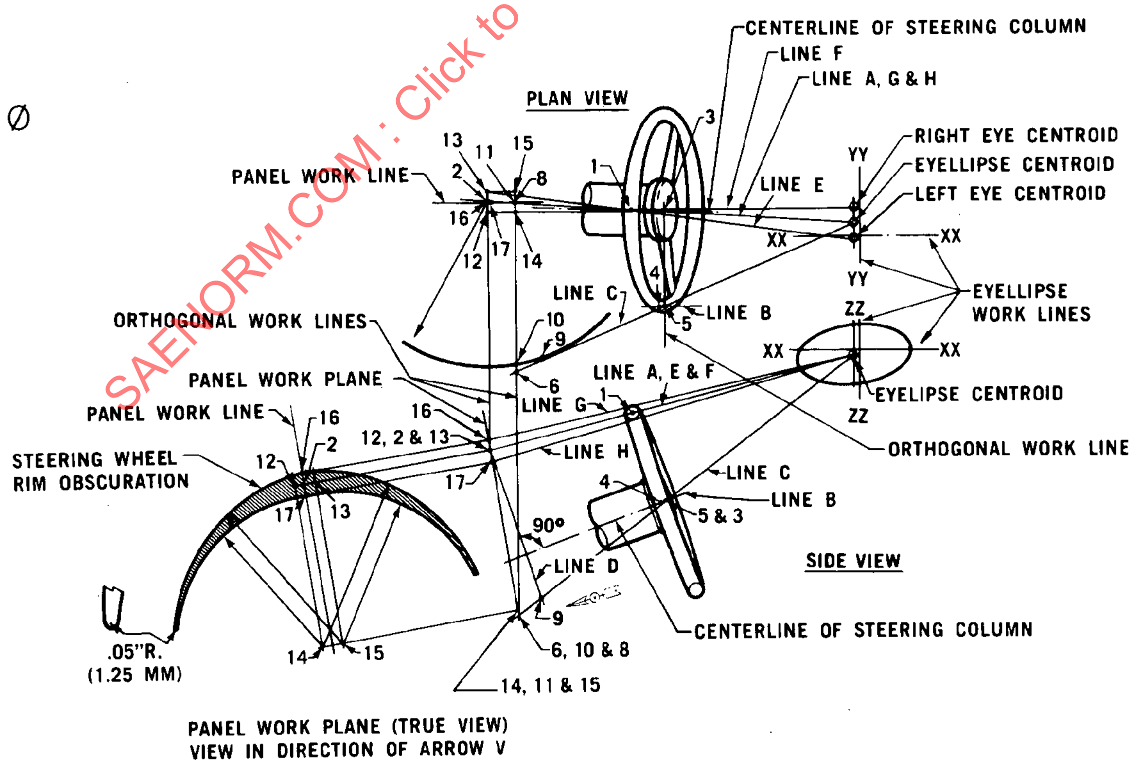


FIG. 13—DRAFTING PROCEDURE FOR CONSTRUCTION—THE STEERING WHEEL RIM OBSCURATION