NONRESIDENT
TRAINING
COURSE

April 1995

Engineering Aid 3

NAVEDTRA 14069

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Although the words "he," "him," and "his" are used sparingly in this course to enhance communication, they are not intended to be gender driven or to affront or discriminate against anyone.

COMMANDING OFFICER
NETPMSA
6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32509-5237

04 Jun 96

ERRATA # 2

Specific Instructions and Errata for Training Manual

ENGINEERING AID BASIC

1. This errata supersedes all previous errata.

2. No attempt has been made to issue corrections for errors in typing, punctuation, and so forth, that do not affect technical accuracy or readability.

3. Make the following changes:

Page	Column	Change
2-3	1	Replace "Naval Publications and Forms Center" with "Aviation Support Office"
3-11		Replace figure 3-14 with figure 3-14 A & B
3-19	2	Replace "DOD-STD-1OOC" with "MIL-STD-1OOE"
5-7		Replace figure 5-12 with figures 5-11 and 5-12
7-17	1	Replace figure 7-22 with figures 7-21 and 7-22
14-19		Replace caption in figure 14-20 with "Sample field notes from cross-section leveling at first three stations shown in figure 14-17."
14-28	2	Replace 1200/3.7 with 3.7/1200
14-28	2	Replace 800/-5.0 with -5.0/800

DRAWING FORMATS

Drawing format is the systematic space arrangement of required information within the drafting sheet. This information is used to identify, process, and file drawings methodically. Standard sizes and formats for military drawings are arranged according to DoD-STD-100C, *Engineering Drawing Practices,* and MIL-HDBK- 1006/1, *Policy and Procedures for Project Drawing and Specification Preparation.* With the exception of specific local command requirements, DoD-STD-1OOC and MIL-HDBK-1006/1 are your guidelines for preparing SEABEE drawings.

Most of the documents applicable to these standards have recently been revised and updated in order to gain like information and to share uniformity of form and language within the Naval Construction Force and between DoD organizations. Other influencing factors are the current widespread use of reduced-size copies of both conventional and computer-generated drawings and exchange of microfilm.

SHEET SIZES

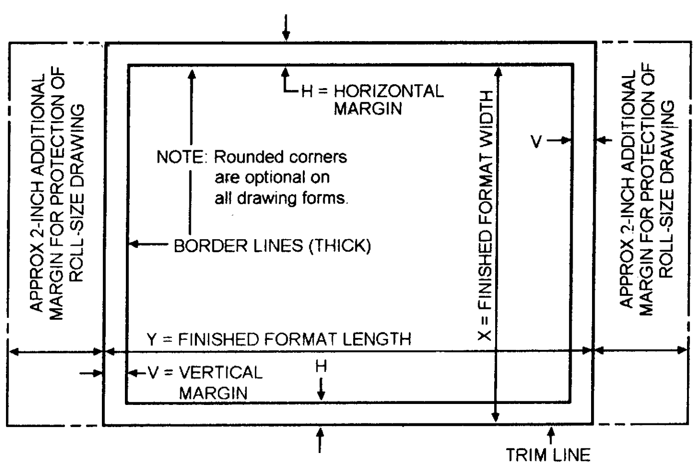
Standard drawing sheet sizes are used to facilitate readability, reproduction, handling, and uniform filing. Blueprints produced from standard size drawing sheets are easily assembled in sets for project stick files and can readily be folded for mailing and neatly filed in project letter size or legal size folders. (Filing drawings and folding blueprints will be covered later in this training manual.)

Finished format sizes for drawings shown in figure 3-14, view A, are according to ANSI Y14.1

FLAT SIZES					ROLL SIZES					
SIZE DESIGNATION LETTER	X (WIDTH)	Y (LENGTH)	MARGIN H (HORIZ)	MARGIN V (VERT)	SIZE DESIGNATION LETTER	X (WIDTH)	Y (LENGTH) MIN	Y (LENGTH) MAX	MARGIN H (HORIZ)	MARGIN V (VERT)
A(HORIZ)	8.5	11.0	0.38	0.25	G	11.0	22.5	90.0	0.38	0.50
A(VERT)	11.0	8.5	0.25	0.38	H	28.0	44.0	145.0	0.50	0.50
B	11.0	17.0	0.38	0.62	J	34.0	55.0	176.0	0.50	0.50
C	17.0	22.0	0.75	0.50	K	40.0	55.0	143.0	0.50	0.50
D	22.0	34.0	0.50	1.00						
E	34.0	44.0	1.00	0.50						
F	28.0	40.0	0.50	0.50						

NOTES: 1. ADDITIONAL PROTECTION MARGINS FOR ROLL SIZE DRAWINGS ARE NOT INCLUDED IN ABOVE DIMENSIONS.
2. ALL DIMENSIONS ARE IN INCHES.

A



B

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Figure 3-14.—Guide for preparing horizontal and vertical margins, sizes, and finished drawing format.

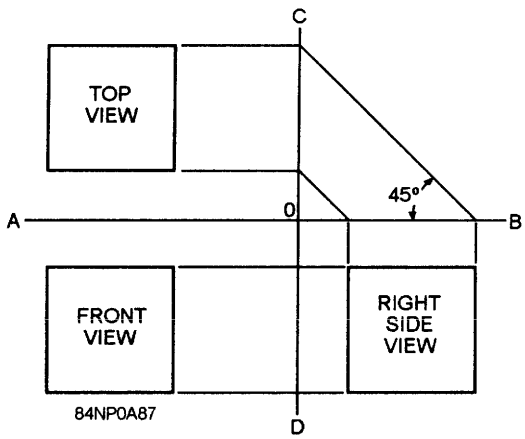

Figure 5-11.—Alternative method of extending to top view projection lines.

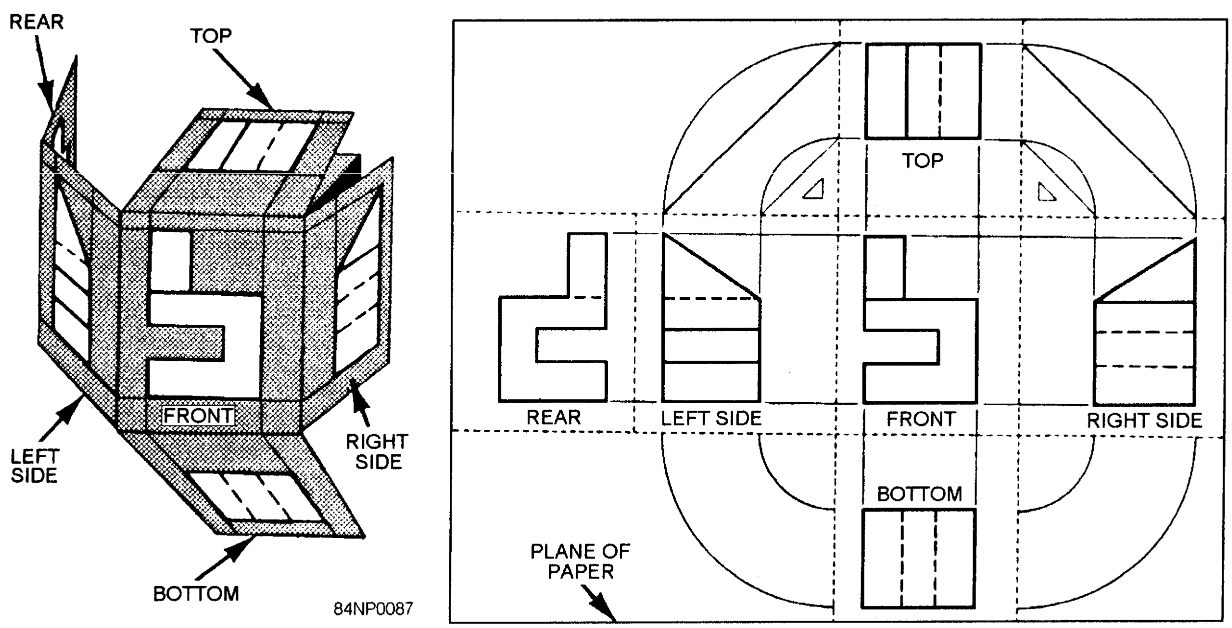

Figure 5-12.—American standard arrangement of views in a six-view third-angle multi-view projection.

view always lies in the plane of the drafting surface and does not require any rotation. Notice that the front, right side, left side, and rear views line up in direct horizontal projection.

Use the minimum number of views necessary to show an item. The three principal views are the top, front, and right-side. The TOP VIEW (also called a PLAN in architectural drawings) is projected to and drawn on an image plane above the front view of the object. The FRONT VIEW (ELEVATION) should show the most characteristic shape of the object or its most natural appearance when observed in its permanent or fixed position. The RIGHT-SIDE VIEW (ELEVATION) is located at a right angle to the front and top views, making all the views mutually perpendicular.

SPACING OF VIEWS.— Views should be spaced on the paper in such a manner as

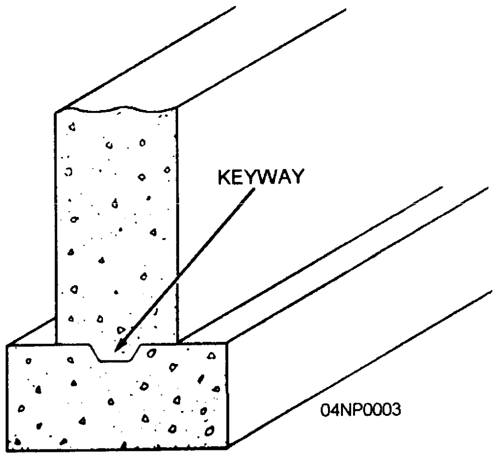

Figure7-21.—Construction joint between wall and footing with a keyway.

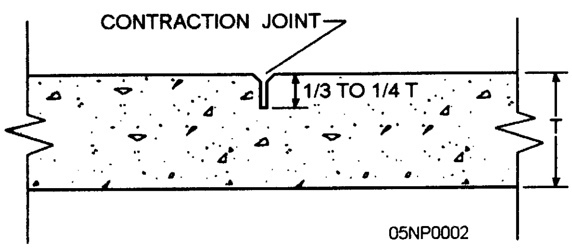

Figure 7-22.—Use of a contraction joint.

incident to shrinkage of the concrete. Atypical dummy contraction joint (fig. 7-22) is usually formed by cutting a depth of one third to one fourth the thickness of the section. Some contracting joints are made with no filler or with a thin coat of paraffin or asphalt and/or other materials to break the bond. Depending on the extent of local temperature, joints in reinforced concrete slabs may be placed at 15- to 25-ft intervals in each direction.

Expansion Joints

Wherever expansion might cause a concrete slab to buckle because of temperature change, expansion joints (also called isolation joints) are required. An expansion joint is used with a pre-molded cork or mastic filler to separate sections from each other, thus allowing room for expansion if elongation or closing of the joint is anticipated. Figures 7-23, 7-24, and 7-25 show expansion joints for a variety of locations. Expansion joints may be installed every 20 ft.

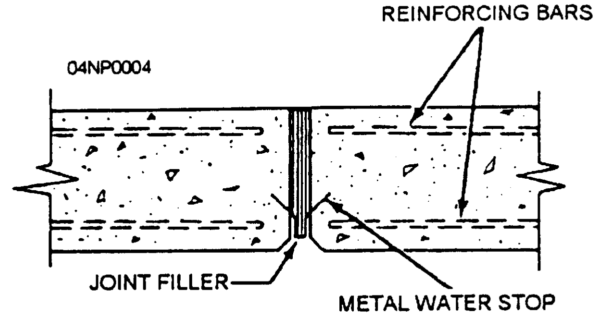

Figure 7-23.—Expansion joint for a wall.

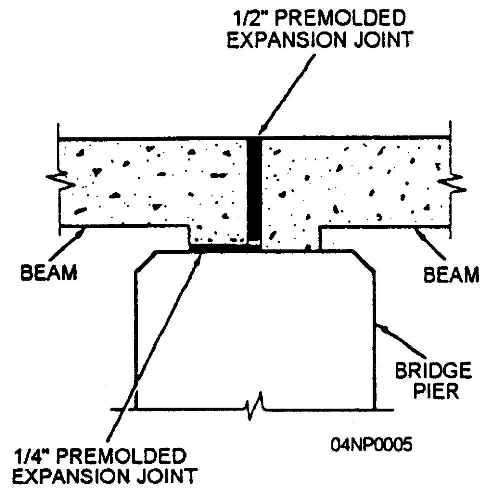

Figure 7-24.—Expansion joint for a bridge.

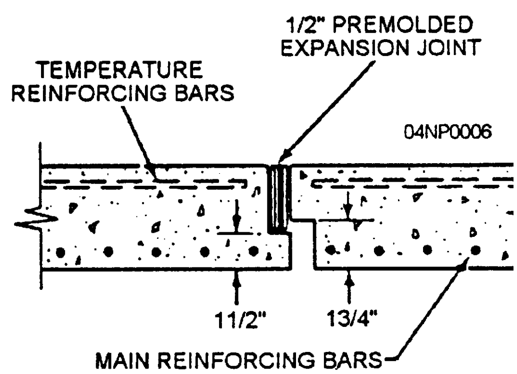

Figure 7-25.—Expansion joint for a floor slab.

CONCRETE FORMS

Most structural concrete is made by placing (also called CASTING) plastic concrete into

PREFACE

By enrolling in this self-study course, you have demonstrated a desire to improve yourself and the Navy. Remember, however, this self-study course is only one part of the total Navy training program. Practical experience, schools, selected reading, and your desire to succeed are also necessary to successfully round out a fully meaningful training program.

THE COURSE: This self-study course is organized into subject matter areas, each containing learning objectives to help you determine what you should learn along with text and illustrations to help you understand the information. The subject matter reflects day-to-day requirements and experiences of personnel in the rating or skill area. It also reflects guidance provided by Enlisted Community Managers (ECMs) and other senior personnel, technical references, instructions, etc., and either the occupational or naval standards, which are listed in the *Manual of Navy Enlisted Manpower Personnel Classifications and Occupational Standards*, NAVPERS 18068.

THE QUESTIONS: The questions that appear in this course are designed to help you understand the material in the text.

VALUE: In completing this course, you will improve your military and professional knowledge. Importantly, it can also help you study for the Navy-wide advancement in rate examination. If you are studying and discover a reference in the text to another publication for further information, look it up.

1991 Edition Prepared by
EAC Andres M. Embuido,
EACS Reynaldo N. Azucena, and
EACS Gary L. Davis
1995 Revision
EAC(SCW) Michael R. Mann

Published by
NAVAL EDUCATION AND TRAINING
PROFESSIONAL DEVELOPMENT
AND TECHNOLOGY CENTER

NAVSUP Logistics Tracking Number
0504-LP-026-7350

Sailor's Creed

"I am a United States Sailor.

I will support and defend the Constitution of the United States of America and I will obey the orders of those appointed over me.

I represent the fighting spirit of the Navy and those who have gone before me to defend freedom and democracy around the world.

I proudly serve my country's Navy combat team with honor, courage and commitment.

I am committed to excellence and the fair treatment of all."

CONTENTS

CREDITS

The illustration indicated below is included in this edition of *Engineering Aid Basic* through the courtesy of the designated company. Permission to use this illustration is gratefully acknowledged.

SOURCE	**FIGURE**
ELE International, Inc.	15-28

horizontal would be parallel or perpendicular (or nearly so) to a prominent visible outline, the angle should be changed to 30°, to 60°, or some other angle. If two adjacent sectioned surfaces are shown, the hatching should be in opposite directions, as shown in figure 5-34, view B. If still a third surface is included, it should be hatched at another suitable angle to make the surface clearly stand out separately from the other surfaces (figure 5-34, view C). Note that the hatching lines on one surface are not permitted to meet those on an adjacent surface.

In drawing section lining, use a sharp, medium-grade pencil (H or 2H). Space the lines as uniformly as possible by eye. As a rule, spacing of the lines should be as generous as possible, yet close enough to distinguish the sectioned surface clearly. For average drawings, space the lines about 3/32 in. or more apart.

Diagonal hatching on an auxiliary section should be drawn at 45 degrees to the horizontal, with respect to the section. Figure 5-35 shows this rule.

In a revolution or other view of an object in other than the normal position, the diagonal hatching on a section should be drawn at 45 degrees to the horizontal or vertical axis of the object as it appears in the revolution. Figure 5-36 shows this rule.

Axonometric Projection

Axonometric single-plane projection is another way of showing an object in all three dimensions in a single view. Theoretically, axonometric projection is orthographic projection in that only one plane is used and the projection lines are perpendicular to the plane of projections. It is the object itself, rather than the projection lines, that is inclined to the plane of projection.

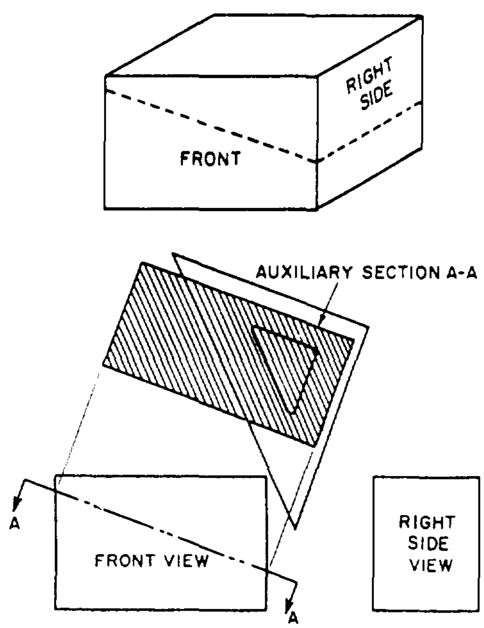

Figure 5-35.-Diagonal hatching on an auxiliary section.

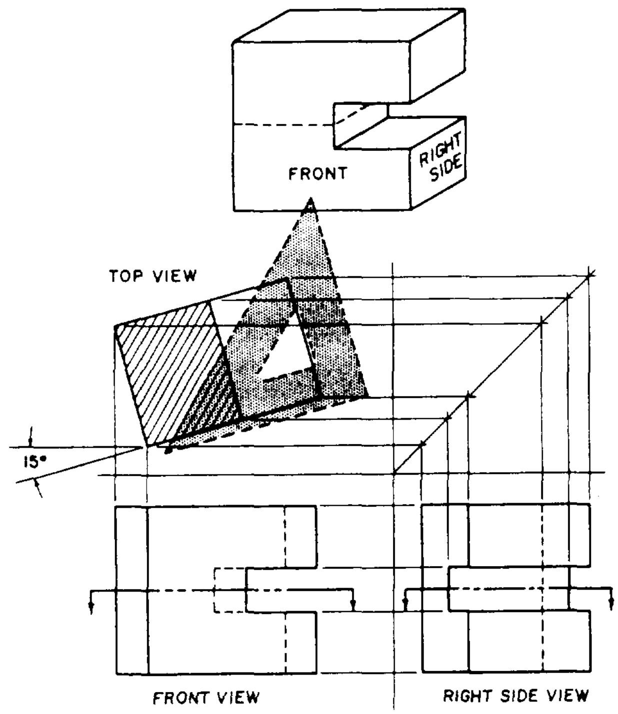

Figure 5-36.-Diagonal hatching on a revolution.

ISOMETRIC PROJECTION AND ISOMETRIC DRAWING.— Figure 5-37 shows a cube projected by ISOMETRIC PROJECTION, the most frequently used type of axonometric projection. The cube is inclined so that all of its surfaces make the same angle (35°16′) with the plane of projection. As a result of this inclination, the length of each of the edges shown in the projection is somewhat shorter than the actual length of the edge on the object itself. This reduction is called FORESHORTENING. The degree of reduction amounts to the ratio of 1 to the cosine of 35°16′, or 1/0.8165. This means that if an edge on the cube is 1 in, long, the projected edge will be 0.8165 in. long. As all of the surfaces make the same angle with the plane of projection, the edges all foreshorten in the same ratio. Therefore, one scale can be used for the entire layout; hence the term *isometric,* which literally means "one-scale."

Figure 5-38 shows an isometric projection as it would look to an observer whose line of sight was perpendicular to the plane of projection. Note

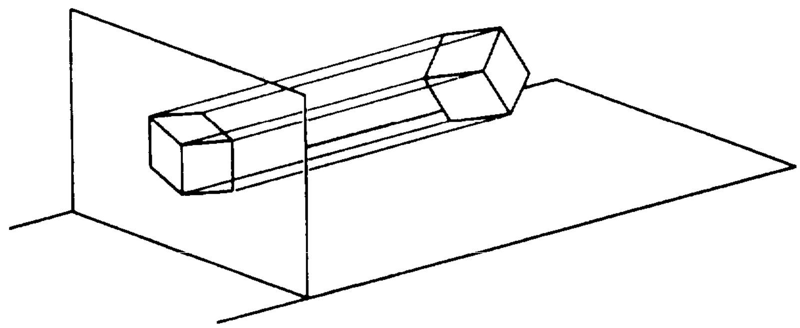

Figure 5-37.-Isometric projection of a cube.

that the figure has a central axis, formed by the lines OA, OB, and OC. The existence of this axis is the origin of the term *axonometric projection.* In an isometric projection, each line in the axis forms a 120-degree angle with the adjacent line, as shown. A quick way to draw the axis is to draw the perpendicular OC, then use a T square and 30°/60° triangle to draw OA and OB at 30 degrees to the horizontal. Since the projections of parallel lines are parallel, the projections of the other edges of the cube will be, respectively, parallel to these axes.

A rectangular object can be easily drawn in isometric by the procedure known as box construction. In the upperpart of figure 5-39, there is a two-view normal multi-view projection of a rectangular block. An isometric drawing of the block is shown below. You can see how you build the figure on the isometric axis and how you lay out the dimensions of the object on the isometric drawing. Because you lay out the identical dimensions, it is an isometric drawing rather than an isometric projection.

Non-isometric Lines.— If you examine the isometric drawing shown in figure 5-39, you will note that each line in the drawing is parallel to one or another of the legs of the isometric axis. You will also notice that each line is a normal line in the multi-view projection. Recall that a normal line is a line that, in a normal multi-view projection, is parallel to two of the planes of projection and perpendicular to the third. Thus,

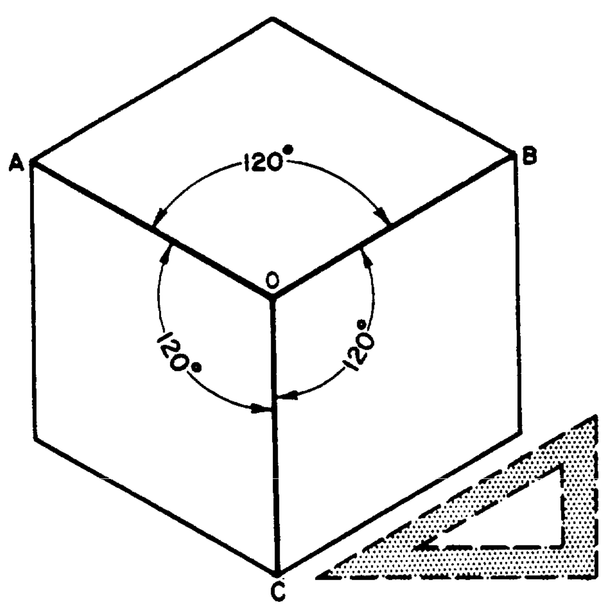

Figure 5-38.-Use of an isometric axis.

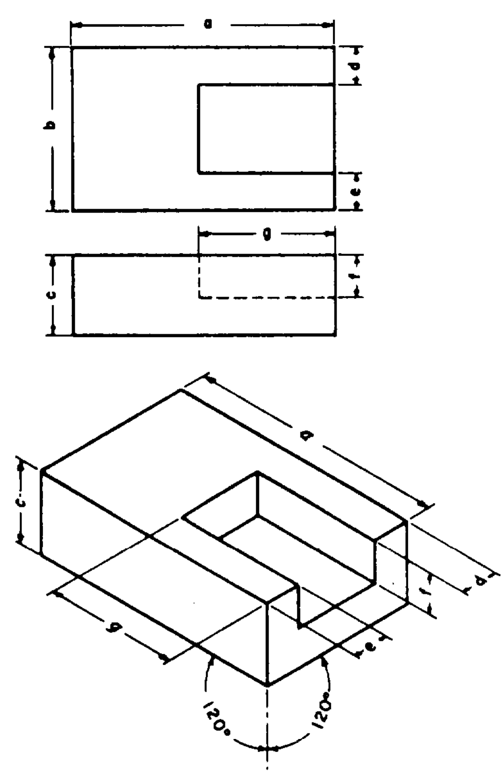

Figure 5-39.-Use of "box construction" in isometric drawing.

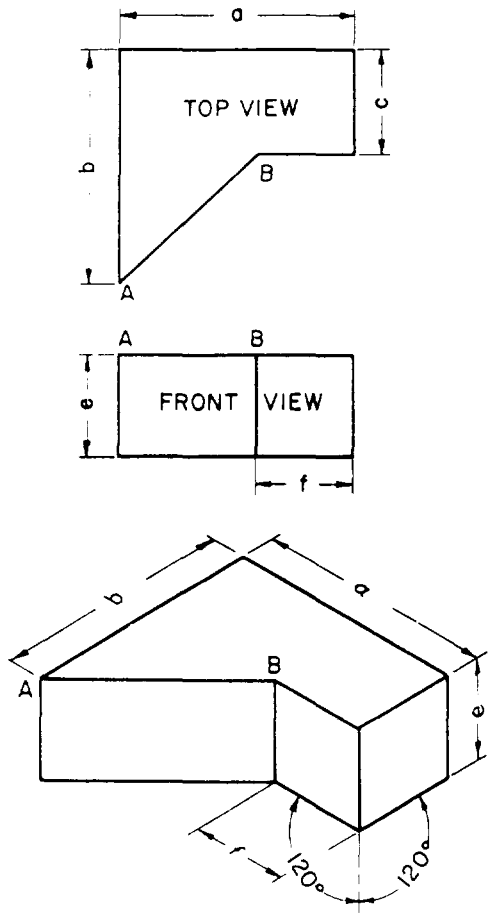

Figure 5-40.-A non-isometric line (AB) in an isometric projection.

a NON-ISOMETRIC LINE is a line that is not parallel to any one of the three legs of the isometric axis. It is not a normal line in a normal multi-view projection of the object.

The upperpart of figure 5-40 shows a two-view normal multi-view projection of a block. Though the line AB is parallel to the horizontal plane of projection, it is oblique to both the vertical and the profile planes. It is therefore not a normal, but an oblique, line in the multi-view projection, and it will be a non-isometric line in an isometric projection or drawing of the same object.

The line AB appears in its true length in the top multi-view view because it is parallel to the plane of the view (the horizontal plane); but it will appear as a non-isometric line, and therefore not in its true length, in an isometric drawing, as shown in the bottom part of figure 5-40. It follows that you cannot transfer AB directly from the multi-view projection to the isometric drawing. You can, however, transfer directly all the normal lines in the multi-view projection, which will be isometric lines appearing in their true lengths in the isometric drawing. When you have done this, you will have constructed the entire isometric drawing, exclusive of line AB and of its counterpart on the bottom face of the block. The end points of AB and of its counterpart will be located, however, and it will only be necessary to connect them by straight lines.

Angles in Isometric.—In a normal multi-view view of an object, an angle will appear in its true size. In an isometric projection or drawing, an angle never appears in its true size, Even an angle formed by normal lines, such as each of the 90-degree corner angles of the block shown in the bottom part of figure 5-41, appears distorted in isometric.

The same principle used in transferring a non-isometric line is used to transfer an angle in isometric. The upperpart of figure 5-41 shows a two-view multi-view projection of a block. On the top face of the block, the line AB makes a 40-degree angle with the front edge. The line AB is an oblique (that is, not normal) line, which will appear as a non-isometric line in the isometric drawing. You locate the end points of AB on the isometric drawing by

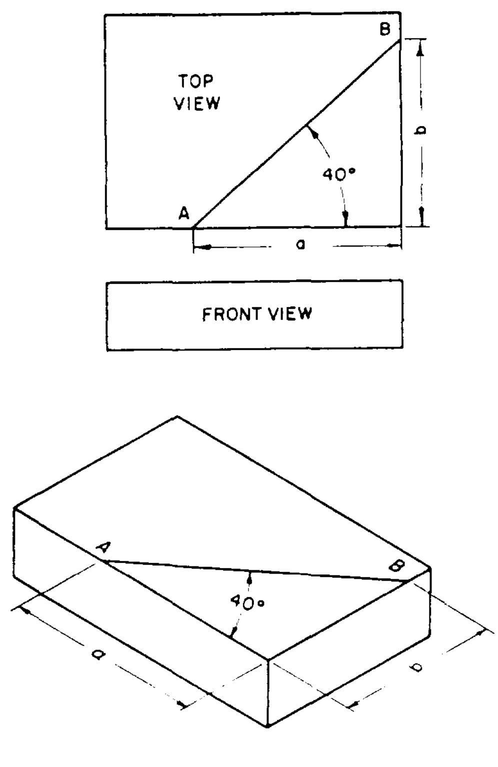

Figure 5-41.-Drawing an angle in isometric.

measuring distances along normal lines on the multi-view projection and laying them off along the corresponding isometric lines on the isometric drawing. The angle that measures 40 degrees on the top multi-view view measures only about 32 degrees on the isometric drawing. Note, however, that it is labeled 40 degrees on the isometric drawing. This is because it actually is a 40-degree angle as it would look on a surface plane at the isometric angle of inclination.

Circles in Isometric.— A circle in a normal multi-view view will appear as an ellipse in an isometric drawing. This is shown in figure 5-42, view A.

A procedure that maybe used to construct an isometric circle is shown in figure 5-42, view B. The steps of that procedure are as follows:

1. Draw the isometric center lines of the circle. Then, using those center lines, lay off an isometric square with sides equal to the diameter of the circle.
2. From the near corners of the box, draw bisectors to the opposite intersections of the center lines and the box. The bisectors will intersect at four points (A, A´, B, B´), which will be the centers of four circular arcs.
3. Draw two large arcs with radius R, using Points A and A´ as centers, Draw the two smaller arcs with radius r, using Points B and B´ as centers.

If the above discussion seems familiar, it should. It is simply an approximation of the four-point method you studied in the previous chapter. However, it can be used only when drawing isometric circles on an isometric drawing.

Noncircular Curves in Isometric.— A line that appears as a noncircular curve in a normal multi-view view of an object appears as a non-isometric line in an isometric drawing. To transfer such a line to an isometric drawing, you must plot a series of points by measuring along normal lines in the multi-view view and transferring these measurements to corresponding isometric lines in the isometric drawing.

The upperpart of figure 5-43 shows a two-view multi-view projection of a block with

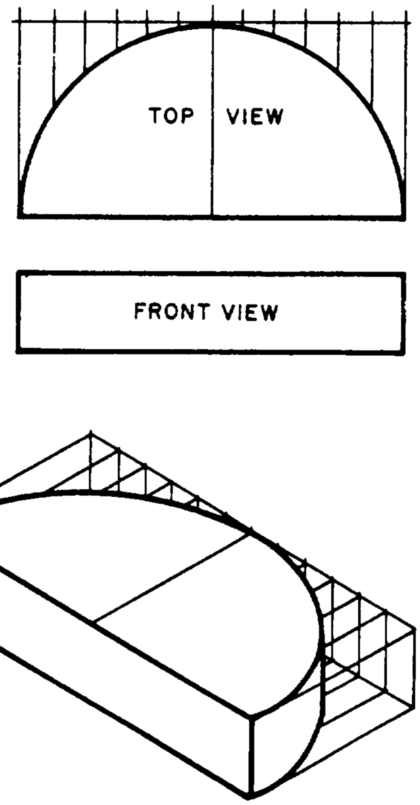

Figure 5-43.-Method of drawing a noncircular curve in isometric.

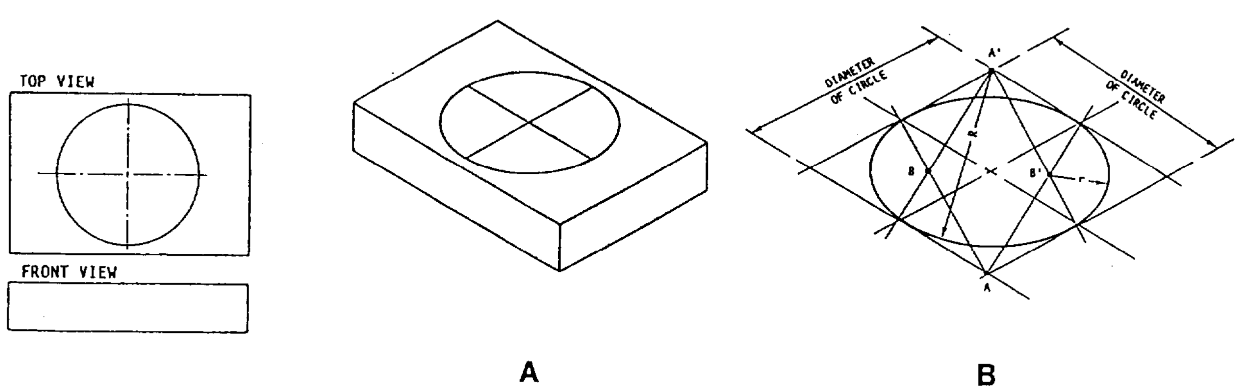

Figure 5-42.-A circle on a normal multi-view view appears as an ellipse in an isometric drawing.

an elliptical edge. To make an isometric drawing of this block, draw the circumscribing rectangle on the top multi-view view, lay off equal intervals as shown, and draw perpendiculars at these intervals from the upper horizontal edge of the rectangle to the ellipse. Then draw the rectangle in isometric, as shown below, and plot a series of points along the elliptical edge by laying off the same perpendiculars shown in the top multi-view view. Draw the line of the ellipse through these points with a french curve.

Alternate Positions of Isometric Axis.— Up to this point, the isometric axis has been used with the lower leg vertical. The axis may, however, be used in any position, provided the angle between adjacent legs is always 120 degrees. Figure 5-44 shows how varying the position of the axis varies the view of the object.

Diagonal Hatching in Isometric.— Diagonal hatching on a sectional surface shown in isometric should have the appearance of making a 45-degree angle with the horizontal or vertical axis of the surface. If the surface is an isometric surface (one that makes an angle of 35°16' with the plane of projection), lines drawn at an angle of 60 degrees to the horizontal margin of the paper, as shown in figure 5-45, present the required appearance. To show diagonal hatching on a non-isometric surface, you must experiment to determine the angle that presents the required appearance.

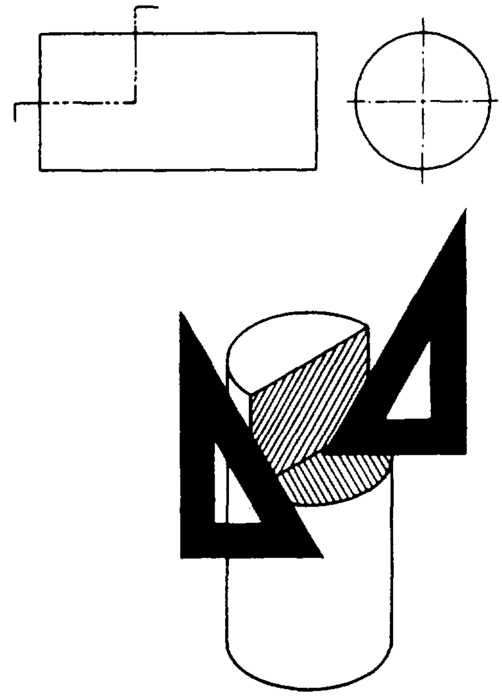

Figure 5-45.-An example of diagonal hatching in isometric.

DIMETRIC AND TRIMETRIC PROJECTION.— TWO other subclassifications of the axonometric projection category are dimetric and trimetric projections; however, these types are used less frequently than isometric projections and will not be discussed further in this training manual.

OBLIQUE SINGLE-PLANE PROJECTION

We have seen that an object may be drawn showing length and width on a single plane. Depth

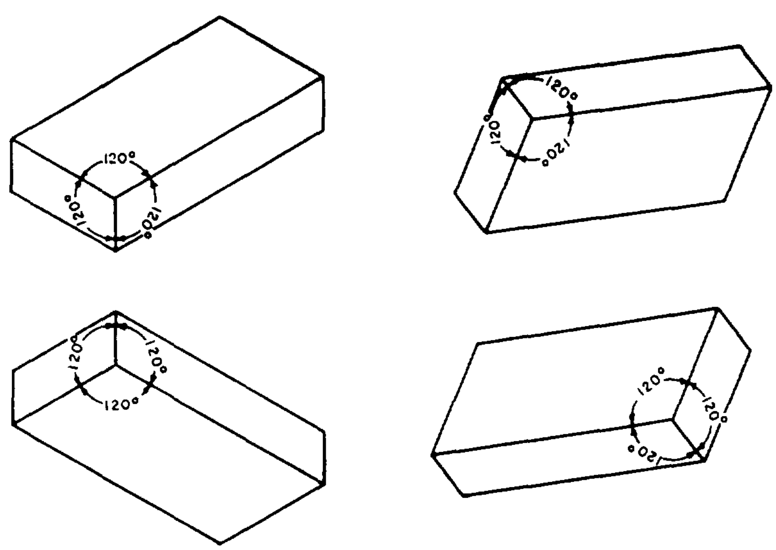

Figure 5-44.-Various positions of isometric axes.