



3.1 SCOPE.

3.1.1 Purpose. This section defines various drafting practices such as drawing scale, lettering, line work, sectioning, and projection, and descriptive geometry applicable to making new engineering drawings and their subsequent revisions. Note: Some material from this section has been relocated to Appendix A1 “Past Practices – Manual Drafting Techniques.” The material may still be pertinent for those companies still producing drawings manually and/or having to revise manually-prepared existing drawings, but most of industry has adopted CAD as the preferred medium for generating drawings. Thus, some of this content may be considered as outdated by some readers. To allay this concern we moved the material to the aforementioned Appendix. Some content that is mostly pertinent to manual drawing preparation has been retained in this SECTION as it also applies to CAD-generated drawings.

3.2 APPLICABLE DOCUMENTS. Note: DoD Policy Memo 05-3 “Elimination of Waivers to Cite Military Specifications and Standards in Solicitation and Contracts” has eliminated the need for waivers to use MIL-SPECS and MIL-STDS on DoD contracts. (See PREFACE 1, Section 2)

L-F-340	Film, Sensitized, Wash-off: Diazotype
L-P-519	Plastic Sheet Tracing, Glazing and Matte Finish
MIL-PRF-5480	Data, Engineering and Technical: Reproduction
MIL-M-9868	Microfilm of Engineering Documents, 35mm, Requirements for (Inactive for new application after 1/6/95: Use JEDMICS)
MIL-PRF-28000	Digital Representation for Communication of Product
MIL-DTL-31000	Technical Data Packages, General Specifications
MIL-STD-17/1	Mechanical Symbols (Non-Aerospace) (INACTIVE)
MIL-STD-17/2	Mechanical Symbols for Aeronautical, Aerospacecraft and Spacecraft (INACTIVE)
MIL-STD-25	Ship Structural Symbols for Use on Ship Drawings
MIL-STD-1840	Automated Interchange of Technical Information
ANSI/ASME Y10.3M	Letter Symbols for Quantities Used in Mechanics (CNCLD)
ASME Y14.2M	Line Conventions and Lettering
ASME Y14.3	Multiview and Sectional View Drawings
ASME Y14.7.1	Gear Drawing Standards - Part 1 for Spur, Helical, Double Helical and Rack (INACTIVE)
ASME Y14.7.2	Gear and Spline drawing Standards - Part 2 for Bevel and Hypoid Gears (INACTIVE)
ASME Y14.13	Mechanical Spring Representation (CNCLD)
ANSI Y14.17	Fluid Power Diagrams (CNCLD)



3.2 APPLICABLE DOCUMENTS. (Continued)

ASME Y14.38	Abbreviations for Use on Drawings
ASME Y14.100	Engineering Drawing Practices
ASME Y32.2.6	Graphical Symbols for Heat Power Apparatus (INACTIVE)
ANSI Y32.4	Graphic Symbols for Plumbing Fixtures for Diagrams Used in Architecture and Building Construction (INACTIVE)
ANSI/IEEE Y32.9	Graphic Symbols for Electrical Wiring and Layout Diagrams Used in Architecture and Building Construction
ASME Y32.10	Graphic Symbols for Fluid Power Diagrams (INACTIVE)
AWS A2.4	Symbols for Welding, Brazing and Nondestructive Testing
AWS A3.0	Welding Terms and Definitions
IEEE STD 91/91A	Graphic Symbols For Logic Functions
IEEE STD 200	Reference Designations for Electrical and Electronic Parts and Equipment (INACTIVE)
IEEE STD 260.1	American National Standard Letter Symbols for Units of Measurement (SI) Units, Customary Inch-Pound units and certain Other Units
IEEE STD 260.3	American National Standard Mathematical Signs and Symbols for Use in Physical Sciences and Technology
IEEE STD 280	Letter Symbols for Quantities Used in Electrical Science & Electrical Engineering
IEEE STD 315/315A	Graphic Symbols for Electrical and Electronics Diagrams
IEEE STD 991	Preparation of Logic Circuit Diagrams
IPC-2221A	Generic Standard on Printed Board Design (Supersedes IPC-D-275)
IPC-2222	Sectional Design Standard for Rigid Organic Printed Boards (Supersedes IPC-D-275)
IPC-T-50	Terms and Definitions for Interconnecting and Packaging Electronic Circuits
IPC-D-350	Printed Board Description in Digital Form
SAE AS1290	Graphic Symbols For Aircraft Hydraulic and Pneumatic Systems
ISO-128	Technical Drawings-General Principles of Presentation
ISO-3098-2	Technical Drawings-Lettering-Part 1: Currently Used Characters
ISO-5455	Technical Drawings-Scales



3.2 APPLICABLE DOCUMENTS. (Continued)

ISO HDBK Vol. 1	Technical Drawings in General-Mechanical Engineering Drawings
ISO HDBK Vol. 2	Technical Drawings: Mechanical Engineering Drawings, Construction Drawings, Drawing Equipment

3.3 DEFINITIONS. (*Alphabetically Listed*)

3.3.1 Engineering Drawing. An engineering drawing is an engineering document or digital data file(s) that discloses by means of pictorial or textual presentations, or combinations of both, directly or by reference, the physical and functional end product engineering requirements of an item.

3.3.1.1 Dimensioned Drawing. A drawing depicting a design with the size given, as applicable, by means of dimensions.

3.3.1.2 Undimensioned Drawing. A drawing depicted to a precise scale on environmental stable material and used for printed circuits and loft line information and fabrication of templates, patterns, or printed circuits.

3.3.1.3 Digital Data (Digital Drawing). Engineering drawings prepared by other than manual means (such as computer generated drawings) shall provide all of the information required by the particular drawing type or level of design disclosure. Minor variations from the requirements as specified herein to accommodate document preparation are acceptable as long as these variations meet the requirements relative to the information contents.

3.3.2 Enlargement Scale. A scale where the ratio is larger than 1 to 1 and the object presentation increases in size as the ratio increases.

3.3.3 Full Size. A scale with a ratio of 1 to 1 or actual size.

3.3.4 Layout Drawing. A drawing clearly showing the shapes, sizes, location, clearances, and materials of a design and its adjacent parts. Layouts are used to convey information to customers, vendors, and as a master drawing from which "production" drawings are prepared. Layout drawings are not released for the manufacture of parts.

3.3.5 Production Drawing. An engineering drawing that discloses the physical and functional engineering end product requirements for parts, assemblies and installations required for the manufacture or assembly of an experimental or production model end item. They are released, controlled and normally required for customer submittal.

3.3.6 Reduction Scale. A scale where the ratio is smaller than 1 to 1 and the object presentation decreases in size as the ratio decreases.

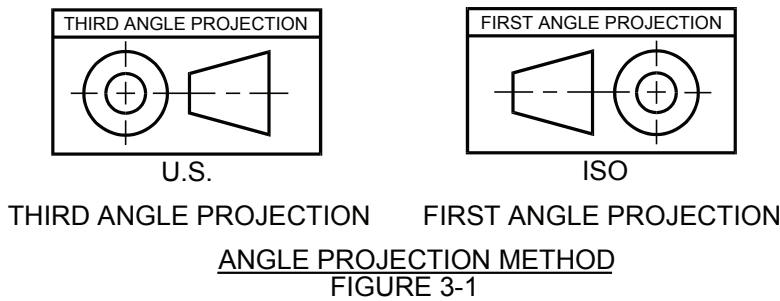
3.3.7 Scale. The ratio of the size of an object represented on a drawing compared to the actual size of the object.



3.4 GENERAL PRINCIPLES OF PRESENTATION.

3.4.1 Orthographic Projection. Orthographic projection methods shall be applied to technical engineering drawings for the purpose of uniformity. All example drawings and figures portrayed in this manual will be presented using the "third angle projection method". This policy is generally adopted in the U.S. while the "first angle projection method" is used internationally (ISO).

3.4.2 Method Of Identifying The Relative Position Of Drawing Views. To clarify any confusion regarding the arrangement of views (this manual shows both inch [U.S.] and metric [international] treatments), the following symbols will be added to drawings as necessary to verify the angle projection method that is portrayed. See FIGURE 3-1.

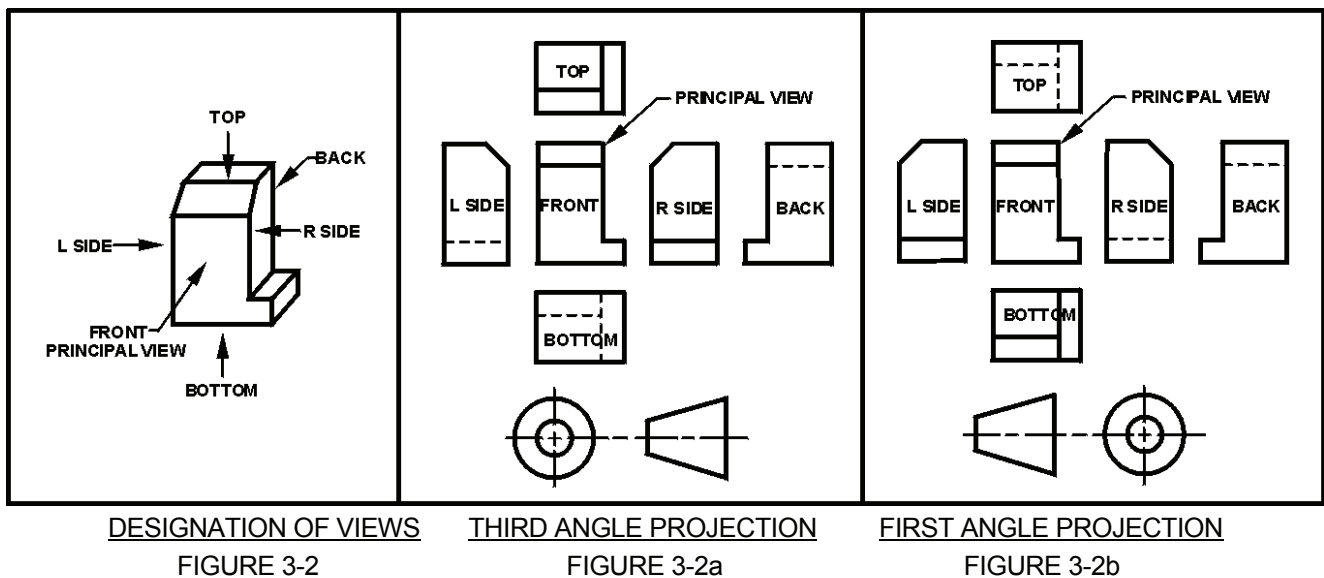


3.4.3 Third Angle Projection Method. This method is preferred and used in the U.S. See FIGURE 3-2a. For interpretation of this method See FIGURE 3-2.

3.4.4 First Angle Projection Method. Countries using international (ISO) standards prefer this method. See FIGURE 3-2b. For interpretation of this method See FIGURE 3-2.

3.4.5 Use Of Projection Symbol. The appearance of the third angle projection symbol in the vicinity of the title block as described in Section M4 is as follows:

- a. U.S. drawings using inch dimensioning - Not required.
- b. U.S. drawings using metric dimensioning - Mandatory use.
- c. INTERNATIONAL (ISO users) using metric dimensioning - Not required.





3.4.6 Microfilming Requirements for Drawings in Accordance with MIL-M-9868, Excluding Layouts. Major drawing defects resulting in rejected microfilm are: numbers or characters too light, not clear, or illegible, discontinuous or light lines, and foreign material or markings in drawing area. Adherence to the following guidelines will assist in keeping microfilm rejections to a minimum. MIL-M-9868 is inactive for new application after 1/6/95: Use JEDMICS. See PARAGRAPH 3.4.7.

3.4.6.1 New Drawings. Drawing lines and lettering shall meet the legibility and reproducibility requirements of MIL-PRF-5480, and shall be in accordance with ASME Y14.2M and the following:

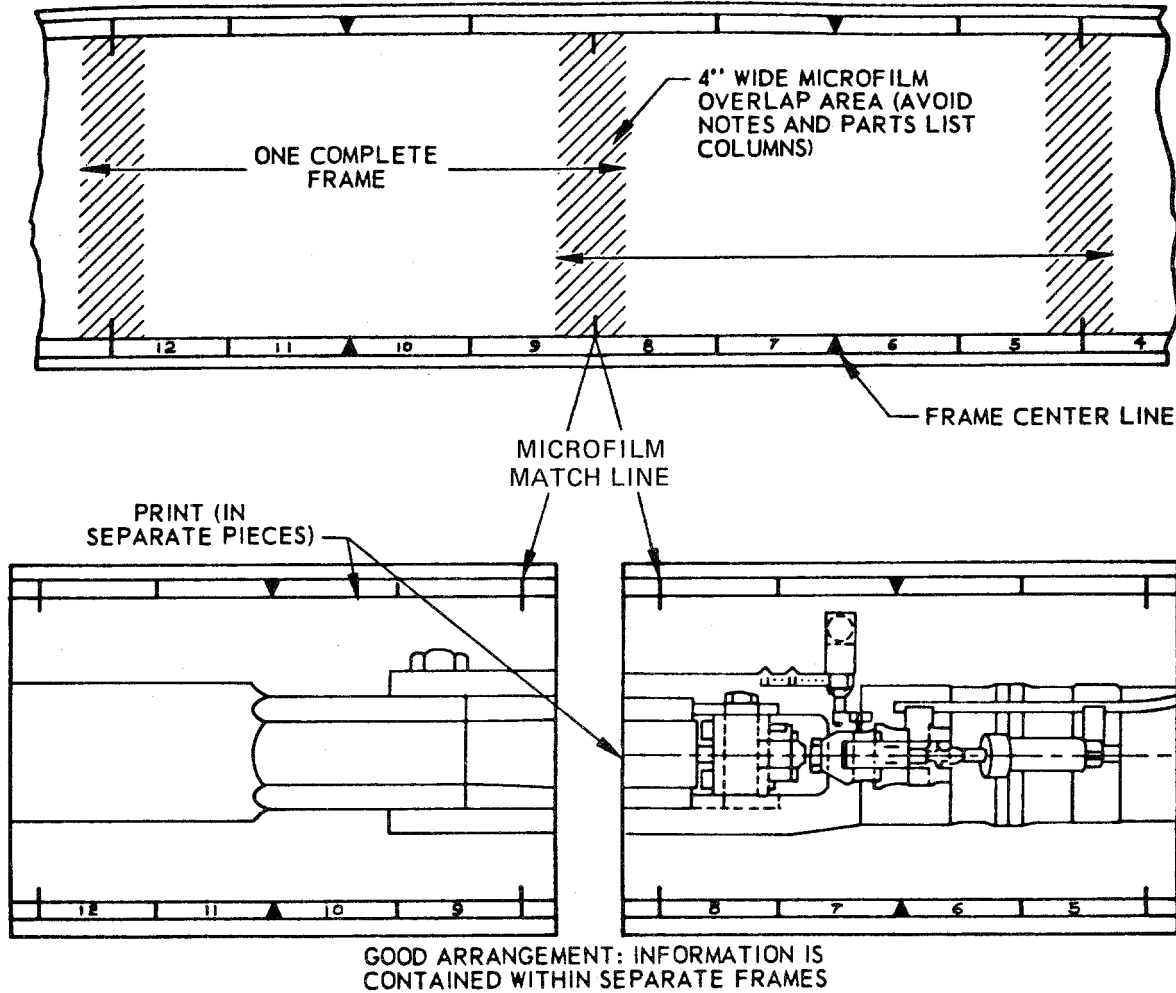
- a. Do not show unnecessary views.
- b. When possible, place views, sections and Parts List columns between the micro film match lines. See FIGURE 3-3.
- c. Use standard size drawing formats (See SECTION 6) with microfilm arrow marks.
- d. Lines and characters shall have even density in accordance with ASME Y14.2M.
- j. Avoid use of parentheses in notes, field call outs or parts lists.
- n. Drawings made with photographs will not meet microfilm requirements and must not be used unless specifically authorized by contract.
- o. Decimal points must be uniform, dense and large enough to be of microfilm quality.

Note: The bullet letters missing the sequence above have been moved to Non-Mandatory Appendix A at the end of the DRM. See PARAGRAPH 3.4.6.1 in Appendix A for drawing rules specific to manually prepared (non-CAD) drawings.

3.4.6.2 Revised Drawings. Same as for "new drawings" plus the following:

- b. Letters, numbers, and lineweights shall be consistent with the original drawing preparation.
- c. Conform to original style of lettering.

Note: The bullet letters missing the sequence above have been moved to Non-Mandatory Appendix A at the end of the DRM. See PARAGRAPH 3.4.6.2 in Appendix A for drawing rules specific to manually prepared (non-CAD) drawings.



PLACING OF VIEWS BETWEEN MICROFILM MATCH LINES

FIGURE 3-3

3.4.6.3 Computer-Aided Design (CAD) Drawings. The use of digital data files in preparing drawings is acceptable provided:

- a. Line conventions and letters may vary for digital data file prepared drawings provided that applicable legibility requirements are met.
- b. Drawing maintenance requirements and the requirements of this Drawing Requirements Manual (DRM) can be met.
- c. Microfilming requirements per MIL-M-9868 (Inactive for new application after 1/6/95) can be met. Use JEDMICS. See PARAGRAPH 3.4.7.



3.4.6.3 Computer-Aided Design (CAD) Drawings. (Continued)

- d. Digital data files are prepared in accordance with the Joint Engineering Data Management Information and Control System (JEDMICS) for storing, retrieving, controlling, managing and distributing engineering data in standard digital format throughout DoD and Industry. Engineering data stored, controlled and distributed by JEDMICS supports the following:
 - (1.) Manufacture, installation, operation and maintenance of equipment.
 - (2.) Receipt of engineering data from original equipment manufacturers.
 - (3.) Re-engineering parts to different specifications.
 - (4.) Preparing bid sets for spare and repair parts acquisition and replenishment.

3.4.7 Digital Data Delivery Per JEDMICS. Digital data is the preferred delivery method for data. If this option is selected either by option or invoked by contract, it is imperative that an electronic format is selected that can be received, stored, retrieved and used by Government and Industry customers. (Ref: MIL-DTL-31000)

3.4.8 Axonometric (Isometric And Pictorial) Views. Isometric, pictorial, and other views are permitted on drawings as required. Such views are easy to create using 3D CAD software. Refer to PARAGRAPHS 26.1.3 and 26.5.5 in SECTION 26 and the remainder of SECTION 26 for more information.

3.5 SCALE OF DRAWING.

3.5.1 Scale Selection. Wherever possible, drawings should show an object or assembly to full scale, or larger where items or features are too small to see clearly if depicted at full scale. When not practical, drawings may be prepared to a reduced scale. See TABLE 3-1.

** SCALE	FRACTIONAL (U.S.)	METRIC (ISO)
FULL SIZE	1/1	1:1
HALF SIZE	1/2	1:2
QUARTER SIZE	1/4	* 1:4
FIFTH SIZE	* 1/5	1:5
TENTH SIZE	1/10	1:10
DOUBLE SIZE	2/1	2:1
FOUR TIMES SIZE	4/1	* 4:1
FIVE TIMES SIZE	* 5/1	5:1
TEN TIMES SIZE	10/1	10:1

* Non Preferred

** If there is a need for larger or smaller scale than those shown in the Table, it is recommended that the scale be derived by multiplying the whole number by powers of 10. Intermediate scales may be chosen when necessary.

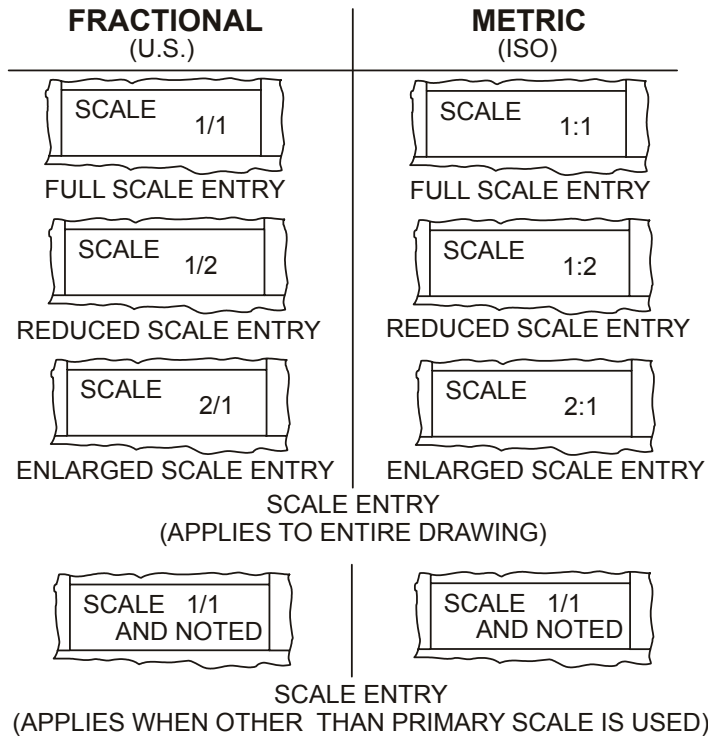
Note: 2D and 3D CAD models should always be modeled at full scale. This excludes CAD files of diagrammatic drawings such as schematics and logic diagrams.

PREFERRED DRAWING SCALES

TABLE 3.1

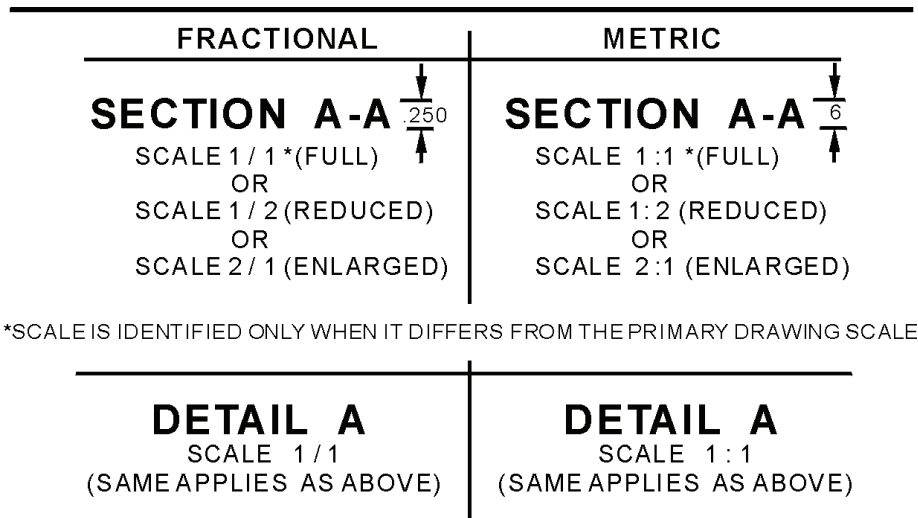


3.5.2 Scale Indication. The primary scale of the overall drawing presentation shall be as a ratio and placed in the Drawing Scale Block located within the Title Block. See FIGURE 3-4.



SCALE ENTRY
FIGURE 3-4

3.5.3 Scale Indication Other Than Primary. Scales that either enlarge or reduce the object from the primary scale used on the drawing shall be identified and entered directly below the DETAIL, VIEW or SECTION extracted from the object. See FIGURE 3-5.



SECTIONAL AND EXTRACTED SCALE IDENTIFICATION
FIGURE 3-5

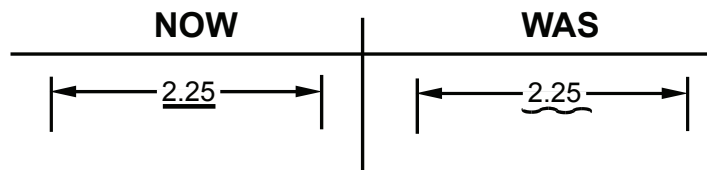
Note: The parenthetic comments shown in FIGURE 3-5 such as “(FULL)” or “(REDUCED)” is not required on the drawing.



3.5.4 Scale Of Reproduced Print. The scale of the reproduced original drawing may differ from the original drawing as a result of the techniques, hardware, and software used to reduce or enlarge the drawing.

3.5.5 Change In Dimension. Drawings are drawn to scale within .03 inches. When dimensional changes are made on released drawings, and it is not practical to change the detail to agree with the new dimension, the dimension is underscored with a straight thick line to indicate the out-of-scale condition. See FIGURE 3-6. Care must be taken that if this action is taken on an older drawing, other out-of-scale dimensions shall be changed from the previous wavy line practice to the current straight thick line practice. Where the product definition is on an interactive computer graphics system the scale of the feature and dimension shall be maintained.

Note: This practice primarily applies to manually prepared drawings. Drawings prepared using CAD software and printing equipment (e.g. laser printers) should be more accurate than is described above.



OUT-OF-SCALE CONDITION

FIGURE 3-6

3.5.6 Reduced Scale Drawings. Drawings may be made for large parts whose major view may be clearly shown at a smaller scale to reduce the size of the drawing format. These drawings may contain appropriately labeled larger size views or sections of complicated portions if necessary for clarity. See FIGURE 3-5.

3.5.7 Enlarged Scale Drawings. Drawings of exceptionally small parts or views may be drawn to an enlarged scale for clarity. See FIGURE 3-5.

3.5.8 No Scale Drawings. Certain drawings or figures, such as wiring and schematic diagram drawings cannot be drawn to a specific scale. On such drawings, the scale block shall read "**NONE**".

3.6 LETTERING.

Note: CAD software and the font styles and font sets therein should be formatted and set up so the following requirements are achieved. In general, the output from CAD systems and the quality of lettering far exceeds what was possible on manually prepared drawings.

3.6.1 Lettering. (except SECTION, DETAIL or VIEW "Letters") Lettering shall be single stroke upper case, commercial gothic; however, for special design requirements (i.e., name plates, connector pin, etc.), lower case lettering may be used. Inclined or vertical (Preferred) lettering may be used but only one type shall appear on a single drawing. See FIGURES 3-7a, 3-7b and 3-7c for lettering styles.

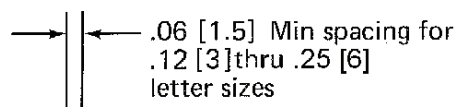
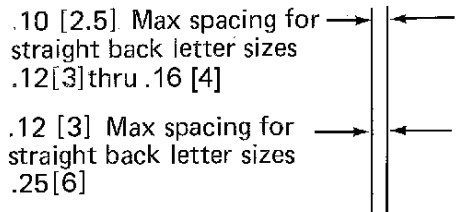
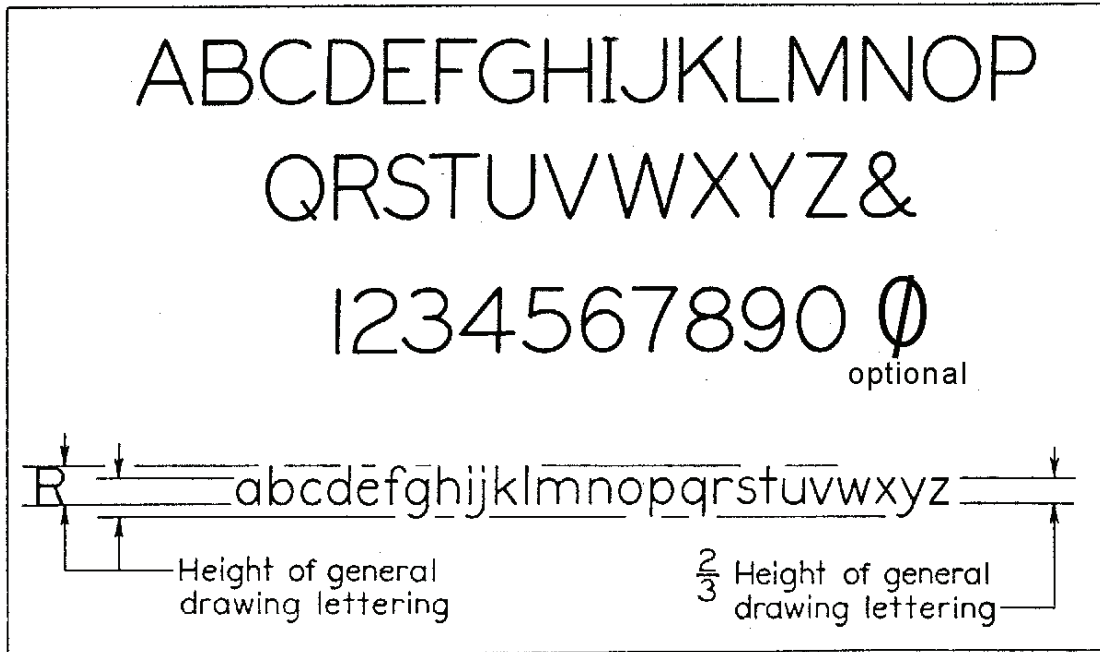
3.6.2 Letter Application. Freehand lettering, typewriter, or the use of mechanical lettering devices such as templates and lettering machines may be used. Whatever method used all characters, in general, are to conform to gothic style and must be legible in full or reduced size copy using any accepted method of reproduction.

3.6.3 Letters And Numerals With Similarities. Alpha and numeric characters that are similar shall be readily distinguishable to the reader as follows:

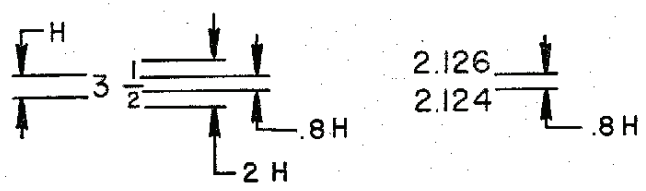
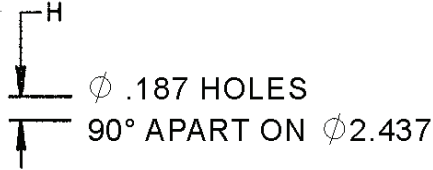
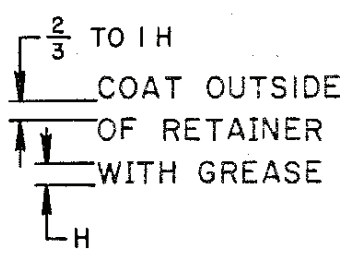
- Letter I (Eye) shall be shown as " I ", not " l ".
- Letter O shall be shown as " O ", not " Ø ", " ∅ " or " ∅ ".
- Numeral zero with a slash is optional. However, when the slash is used, the numeral zero shall be an oval and not round. i.e. " 0 " not " ○ " so as not to be construed as the symbol for "diameter".



PREFERRED



ABCDEFGHIJKLMNOPQRSTUVWXYZ
 abcdefghijklmnopqrstuvwxyz
 1234567890



VERTICAL CHARACTER STYLE & SPACING
 (Bracketed [] numbers are in millimeters)

FIGURE 3-7a

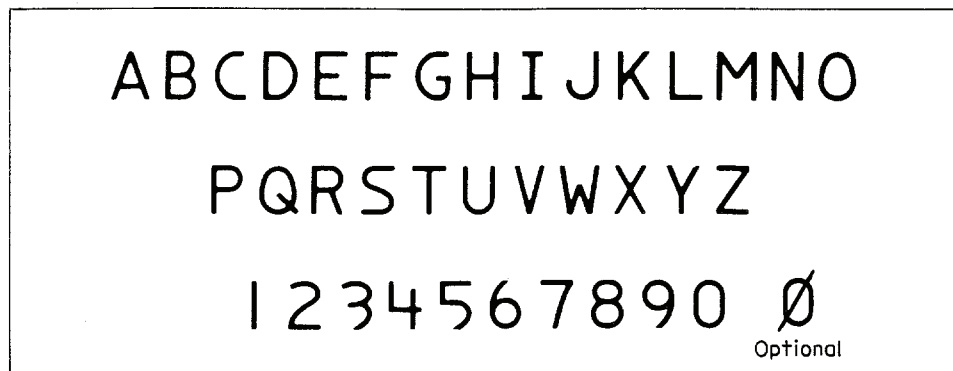


ABCDEFGHIJKLMNPOQRSTUVWXYZ
abcdefghijklmnpqrstuvwxy
1234567890

INCLINED CHARACTER STYLE & SPACING

SEE VERTICAL CHARACTER STYLE FOR SPACING BETWEEN LETTERS AND LINES

FIGURE 3-7 b



INCLINED CHARACTER STYLE & SPACING

Bracketed [] numbers are in millimeters)

FIGURE 3-7c



3.6.4 Letter Spacing. Letter spacing should be spaced as evenly and consistently as possible. Normally, the space between words and between lines should be greater than the height of one letter minimum. Lettering shall be such that microfilm blow back and reproductions of the drawing shall not show evidence of filled-in loops or leaching of character to character.

3.6.5 Lettering Size. All lettering must meet microfilm reproduction requirements. The letter sizes listed in TABLE 3-2 provide those minimum heights.

USE	INCH		METRIC mm	DRAWING SIZE [mm]
	FREEHAND	MECHANICAL	FREEHAND OR MECHANICAL	
<ul style="list-style-type: none"> • DRAWING NUMBER IN TITLE BLOCK • CAGE CODE • REVISION LETTER² 	.16	.12	3	17 x 22 AND SMALLER [420 x 594]
	.25	.24	6	LARGER THAN 17 x 22 [420 x 594]
<ul style="list-style-type: none"> • DRAWING TITLE • CAGE CODE NUMBER 	.25	.24	6	ALL SIZES
<ul style="list-style-type: none"> • "SECTION" LETTERS (A-A) • "DETAIL OR VIEW" LETTERS (A) • TABULATION LETTERS (A,B, etc.) 	.25	.24	6	
<ul style="list-style-type: none"> • WORD "SECTION" "DETAIL" OR "VIEW" • ZONE LETTERS IN MARGINS/BORDERS • ZONE NUMERALS IN MARGINS/BORDERS 	.25	.24	6	
<ul style="list-style-type: none"> • DRAWING BLOCK HEADINGS 	.10	.10	2.5	
<ul style="list-style-type: none"> • DIMENSIONS • TOLERANCES • NOTES • ZONE LETTERS ON FIELD OF DRAWING • SUBTITLES FOR SPECIAL VIEWS 	.13	.12	3	
<ul style="list-style-type: none"> • TABLES • REVISIONS • PARTS LIST 	.16	.12	3	LARGER THAN 17 x 22 [420 x 594]

NOTE: 1. When drawing information contains upper and lower case lettering, it may be necessary to have the upper case lettering height at a minimum of .18 inch [5mm] to assure legible lower case on prints made from microfilm.

2. When used within the title block.

RECOMMENDED MINIMUM LETTER HEIGHTS

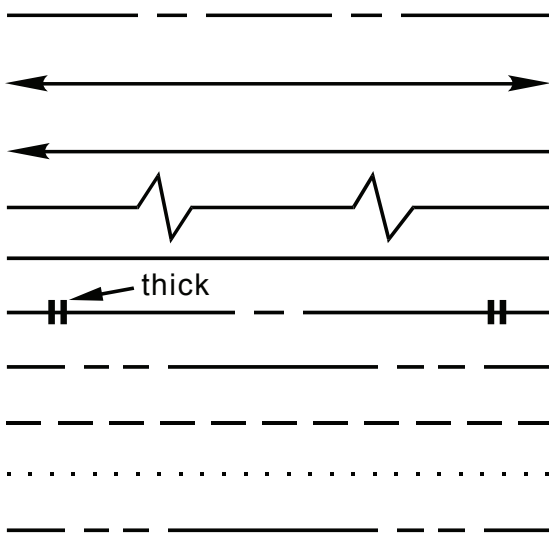
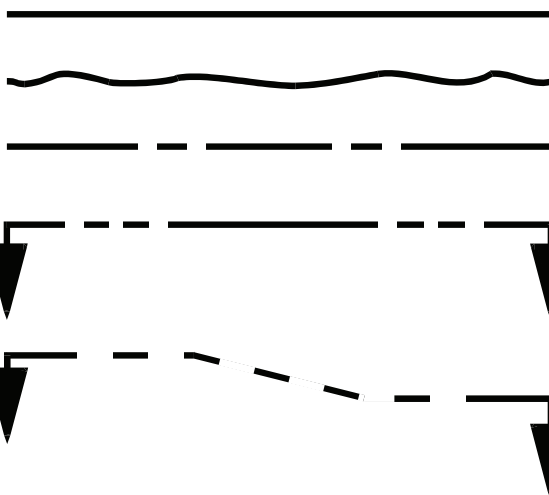
TABLE 3-2

3.6.6 Letters And Numerals Position. Letters and numerals shall be printed parallel to the bottom of the drawing, regardless of the position of dimension lines. The only exception is given in ASME Y14.5M-1994, which allows certain dimension and tolerance values to be oriented such that they may be read from the right side of the drawing when using the baseline style of rectangular coordinate dimensioning.



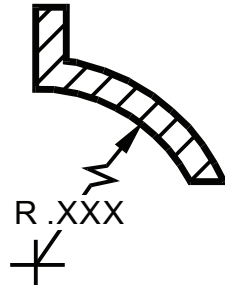
3.7 TYPES OF LINES.

3.7.1 Line Quality. All lines shall be opaque and each type of line shall have uniform width, using the line characteristics recommended in TABLE 3-3, except on diagrammatic drawings. All lines shall satisfy the requirements for microfilming.

WEIGHT OF LINE	LINE	APPLICATION
THIN		<p>CENTER LINE</p> <p>DIMENSION AND EXTENSION LINE</p> <p>LEADER</p> <p>BREAK (LONG)</p> <p>SECTIONING LINE</p> <p>SYMMETRY LINE</p> <p>PHANTOM</p> <p>HIDDEN</p> <p>STITCH</p> <p>DATUM TARGET LINE</p>
THICK		<p>OUTLINE OF OBJECT (VISIBLE LINE)</p> <p>BREAK SHORT)</p> <p>CHAIN LINE (special dim. & tol. zone treatment)</p> <p>CUTTING PLANE OR VIEWING PLANE</p> <p>CUTTING PLANE FOR COMPLEX OR OFFSET VIEWS</p>

TYPES OF LINES
TABLE 3-3

3.7.2 Dimension Lines. Dimension lines shall terminate in arrowheads and should be unbroken, except for the insertion of the dimension value and related information. When dimensioning radii, it is permissible to break the dimension line if true center of the radius falls off the drawing into another view, or interferes with the logical dimensioning procedure. See TABLE 3-3 and FIGURE 3-8.

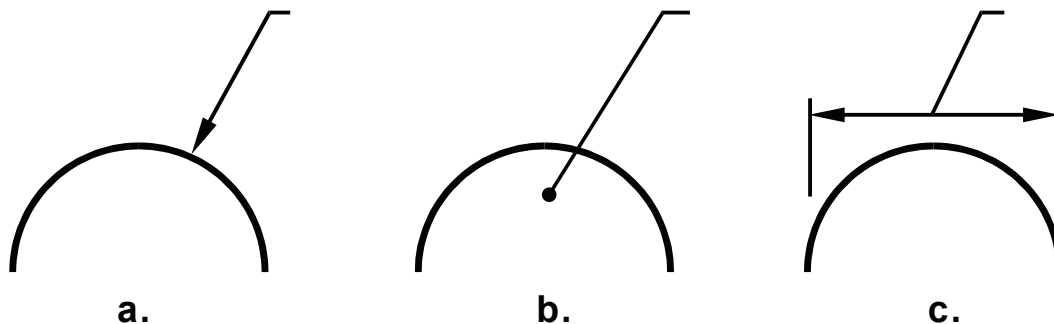


BROKEN DIMENSION LINE

FIGURE 3-8

3.7.3 Leader Lines. Leader lines are used to indicate a feature, a part, a portion of a feature, or other annotation to which a dimension, note, or other reference applies. Leader lines are extended at a constant angle. Leader lines are not curved. See FIGURE 3-11. The end of the leader pointing toward the indicated feature shall terminate as follows (See TABLE 3-3 and FIGURE 3-9.)

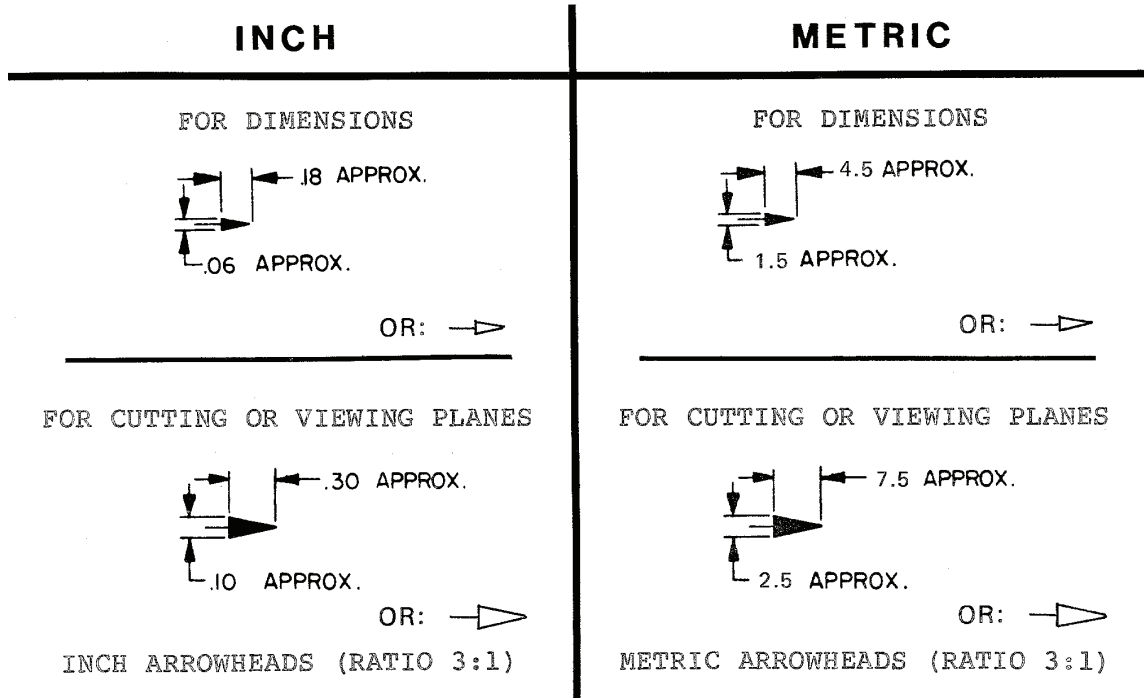
- a. A leader that terminates at a line shall terminate in an arrowhead, except as shown in c. below.
- b. A leader that terminates within the outline of an object shall terminate in a dot.
- c. A leader that terminates at a dimension line as shown in c. below shall terminate without a dot or arrowhead.



LEADER LINES

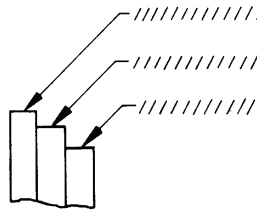
FIGURE 3-9

3.7.3.1 Arrowheads. Arrowheads are drawn as shown in FIGURE 3-10.



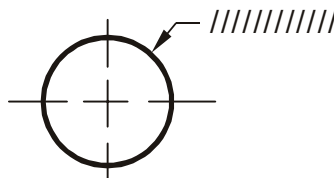
ARROWHEADS
 FIGURE 3-10

3.7.3.2 Leader Lines Used With Notes. Leaders terminate at the lettering end with a line approximately .125 inch [3.18 millimeter] long, parallel to the lettering of the note and are extended at a constant angle to the part or portion affected by the note.



TERMINATION OF LEADER LINES
 FIGURE 3-11

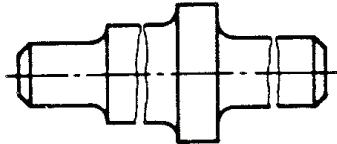
3.7.3.3 Leader Lines Used With A Circular Area, Shaft, or Hole. The leader line from a dimension and/or local note to a circular area, shaft, or hole shall be directed toward the center of the circle representing the shaft, hole or area, with the arrowhead terminating at the edge of the circle. See FIGURE 3-12.



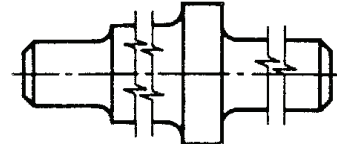
LEADER LINE DIRECTION
 FIGURE 3-12

3.7.3.4 Leader Lines That Cross Dimension Lines. Leader lines should not cross dimension or other leader extension lines. When it is unavoidable that a leader cross a dimension line, the leader line or dimension line is not broken at the point of intersection.

3.7.4 Break Lines. Short breaks shall be indicated by solid freeform lines; long breaks shall be indicated by full ruled lines with zig zags. See TABLE 3-3 and FIGURE 3-13.



SHORT BREAKS

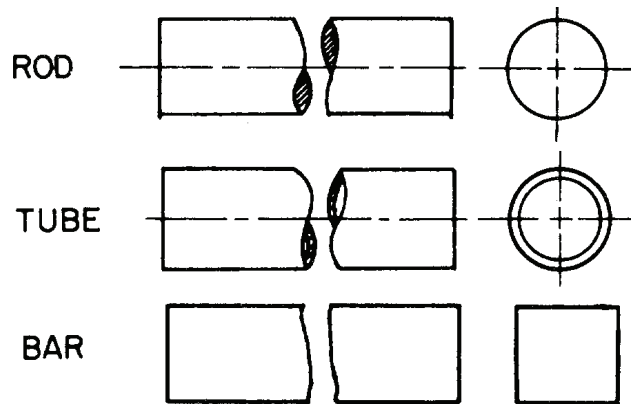


LONG BREAKS, (ALSO SHORT IF

PRACTICAL)

FIGURE 3-13

3.7.4.1 Break-Out Methods. Shafts, rods, tubes, etc., which have a portion of their length broken out, shall indicate the ends of the break as in FIGURE 3-14.



BREAKLINES

FIGURE 3-14

3.7.5 Center Lines. Center lines are shown in pertinent views of holes, round shapes on detail drawings, on assembly drawings to indicate the center of features, or to indicate the travel of a center. See TABLE 3-3 and FIGURE 3-15. Center lines may cross without voids. See FIGURE 3-14. Very short center lines may be unbroken if there is no confusion with other lines. (Note: Center lines are not required on annotated models.)

3.7.6 Phantom Lines. Phantom lines are used to indicate an alternate position, repeated detail, or the interfacing position of an absent part. They shall be composed by a series of one long and two short dashes evenly spaced with a long dash at each end. See TABLE 3.3 and FIGURES 3.15, 3.16 and 3.17.

3.7.7 Section Lining. Section lining shall be used to indicate the exposed surface of an object in a cross-sectional view. See TABLE 3-3 and FIGURE 3-15.

3.7.8 Extension Lines. Extension lines shall be used to indicate the extent of a dimension or an extension from a surface. They shall not touch the object outline. See TABLE 3-3 and FIGURE 3-15.



3.7.9 Datum Target Lines. Datum target lines are used to establish datum target lines or the boundary of datum target areas, and consist of one long dash and two short dashes evenly spaced, per TABLE 3-3. See SECTION 5 for the use of datum targets. Datum target lines are the same as Phantom lines.

3.7.10 Hidden Lines. Hidden lines are used to represent features that are not directly visible in a particular view. Hidden lines should be used when required for clarity and shall consist of short evenly spaced dashes. They should begin with a dash in contact with the line from which they start, except when such a dash would form a continuation of a collinear object line. Dashes should touch at corners, and arcs should start with dashes on the tangent points. See TABLE 3-3 and FIGURE 3-15.

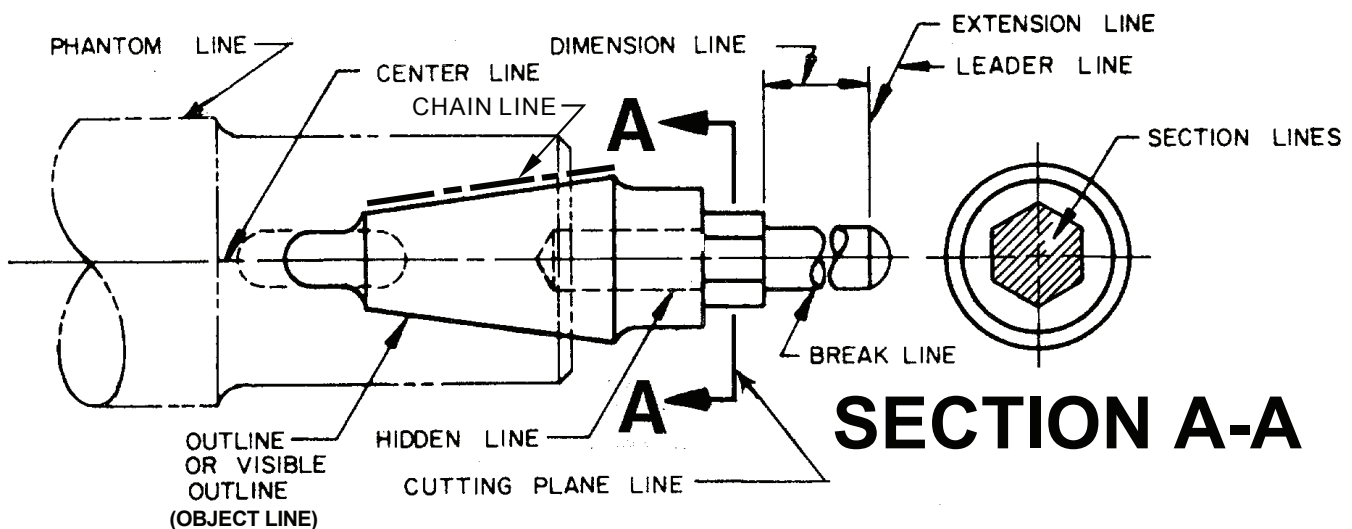
3.7.10.1 Hidden Surfaces Intersect. If possible, when two or more hidden surfaces intersect, a dash in one line should cross a dash in the other line.

3.7.11 Cutting Plane And Viewing Lines. When it is necessary to indicate where a section is taken, a cutting plane line is used. Section letters are placed in front of the directional arrowheads, except for alternate viewing plane in which case they are placed in back of directional arrowheads. See TABLE 3-3 and FIGURE 3-15.

3.7.12 Object Lines (Outline Or Visible Outline). Object lines shall be used for all lines on the drawing representing the visible outlines of the object. See TABLE 3-3 and FIGURE 3-15.

3.7.13 Chain Lines. Chain lines are used to indicate a limited length or area receiving additional treatment within limits specified on the drawing. See FIGURE 3-15. Chain lines are also used to indicate a projected tolerance zone. Chain lines consist of appropriate length lines and short dashes. See TABLE 3-3.

3.7.14 Stitch Lines. Stitch lines are used to indicate a sewing or stitching process and are shown as dots approximately .01 inch [0.3mm] in diameter and .01 inch [0.3mm] apart. Short dashes may be used over extended lengths. See TABLE 3-3.



LINE CONVENTIONS

FIGURE 3-15

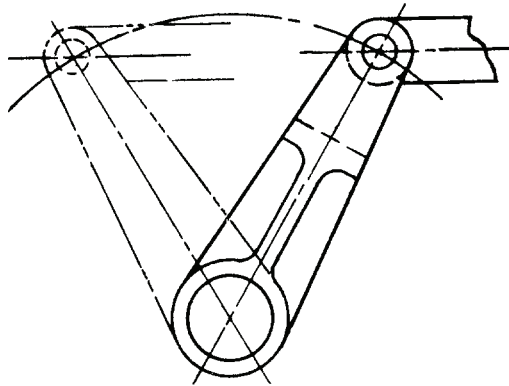
ALTERNATE POSITION

FIGURE 3-16

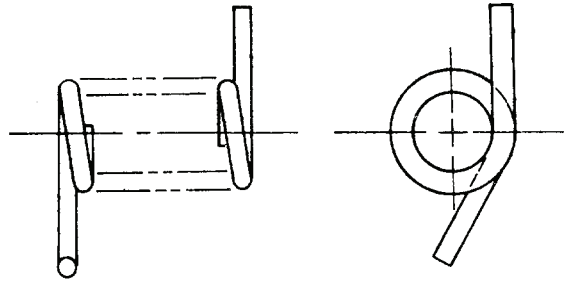
REPEATED DETAIL

FIGURE 3-17

3.8 DRAFTING SYMBOLS.

3.8.1 Drafting Symbol Definitions. Each drafting symbol shall be defined in a note or legend on the drawing or by reference to an approved source. Symbols depicted in this Manual are listed as follows:

See SECTION 6 for ZONE CROSS REFERENCE symbols.

See SECTION 9 for USE & SIZE OF FLAGNOTE (Delta) symbols.

See SECTION 5 for DIMENSIONING AND TOLERANCING AND GEOMETRIC DIMENSIONING AND TOLERANCING symbols.

See SECTION 13 for SURFACE TEXTURE symbols.

See SECTION 14 for WELDING symbols.

See SECTION 18 for ARCHITECTURAL symbols.

See SECTION 22 for ELECTRICAL and ELECTRONIC symbols.

3.8.2 Graphic Symbols, Designations, Letter Symbols and Abbreviations. (Listed Alphabetically) Graphic symbols, designations, letter symbols and abbreviations used on engineering drawings shall be in accordance with the standards indicated. Whenever any of the above is not covered by approved standards, they may be used provided they are explained on each drawing or referenced to another document. The referenced document for non-standard symbols shall be furnished with the engineering drawings.

3.8.2.1 Flow Chart Symbols and Their Used in Micrographics. AIIM MS04.



- 3.8.2.2 **Graphic Symbols for Aircraft Hydraulic and Pneumatic Systems.** SAE AS1290.
- 3.8.2.3 **Graphic Symbols for Electrical and Electronics Diagrams.** IEEE STD 315 & Suppl IEEE STD 315a.
- 3.8.2.4 **Graphic Symbols for Fluid Power Diagrams.** ASME Y32.10 (INACTIVE).
- 3.8.2.5 **Graphic Symbols for Logic Functions.** IEEE STD 91 & Supplement IEEE STD 91a.
- 3.8.2.6 **Graphic Symbols for Plumbing Fixtures Used in Architecture & Building Construction.** ANSI Y32.4 (INACTIVE).
- 3.8.2.7 **Letter Symbols.** ASME Y10.3M (INACTIVE), IEEE STD 260.1 and IEEE STD 280.
- 3.8.2.8 **Logic Circuit Diagrams.** IEEE STD 991.
- 3.8.2.9 **Mathematical Signs and Symbols.** IEEE STD 260.3.
- 3.8.2.10 **Mechanical Symbols.** MIL-STD-17/1 (INACTIVE), ASTM F 856, ASTM F 1000, or ASME Y32.2.6 (INACTIVE) as applicable.
- 3.8.2.11 **Mechanical Symbols for Aerospace craft and Spacecraft Diagrams.** MIL-STD-17/2 (INACTIVE).
- 3.8.2.12 **Nondestructive Testing Symbols.** AWS A2.4.
- 3.8.2.13 **Printed Board Description in Digital Form.** IPC-D-350 or MIL-STD-28000.
- 3.8.2.14 **Printed Wiring Drawings.** IPC-2221A, IPC-2222, MIL-STD-2118 and IPC-T-50, as applicable.
- 3.8.2.15 **Reference Designations for Electrical and Electronics Parts and Equipment.** IEEE STD 200, IEEE STD 315 and Supplement IEEE STD 315a.
- 3.8.2.16 **Ship Structural Symbols.** MIL-STD-25.
- 3.8.2.17 **Welding Symbols.** ANSI/AWS A2.4 Together with Terms and Definitions AWS A3.0.

3.9 SECTION OR SECTIONAL VIEWS.

3.9.1 Sectional Views Shall Be In Accordance With ASME Y14.3M.

- 3.9.1.1 **Sectional View Cutting Plane.** A section or a sectional view is obtained by cutting away part of an object to shape and construction at the cutting plane. Sectional views shall not be taken from another sectional view.

3.9.2 Placement Of Sections. Sectional views are placed as closely as practicable behind the arrows showing the direction from which the view was taken. See FIGURE 3-18. When it is absolutely necessary to rotate a sectional view, the degree of rotation and direction are specified beneath the view. See FIGURE 3-19. Cutting planes for a single full section of a symmetrical part are not necessary, but when two or more sections are taken, all sections shall be identified. Sectional views shall be in line of projection, see FIGURE 3-20 and FIGURE 3-21, or otherwise identified if for some valid reason, (e.g. rotated, or separate sheet, etc.)

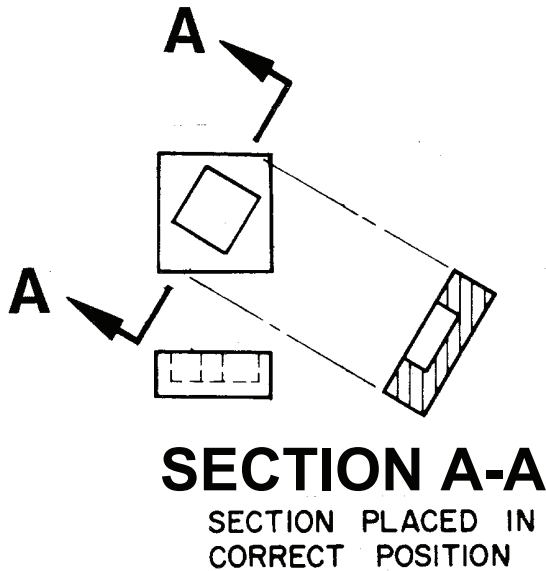


FIGURE 3-18

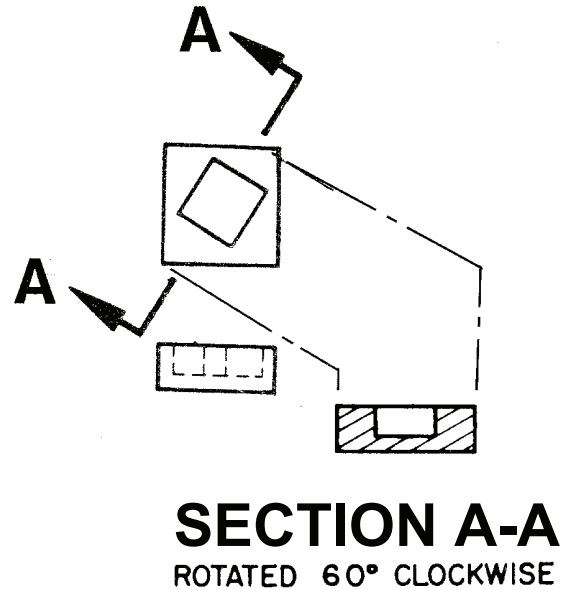


FIGURE 3-19

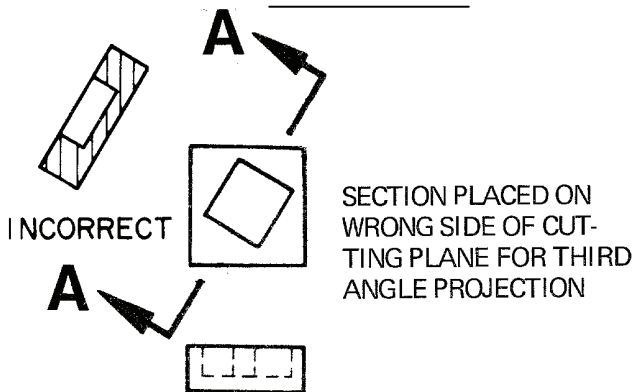


FIGURE 3-20

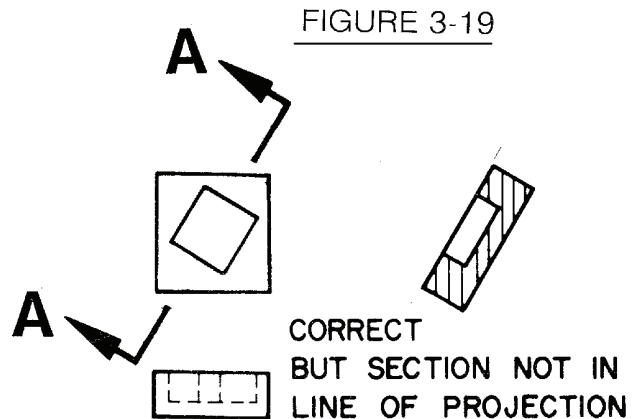


FIGURE 3-21

3.9.2.1 Sectional Views On Separate Sheet. Sectional views should appear on the same sheet as the subassembly, assembly, or detail drawings from which they are taken. When it is necessary to show sectional views on a separate sheet, view and cutting plane indications should be suitably cross-referenced by sheet and zone designations. When a sectional view appears on a different sheet than the sheet containing the cutting plane indication, the view will be oriented as it would appear if directly projected from the cutting plane and properly cross-referenced.



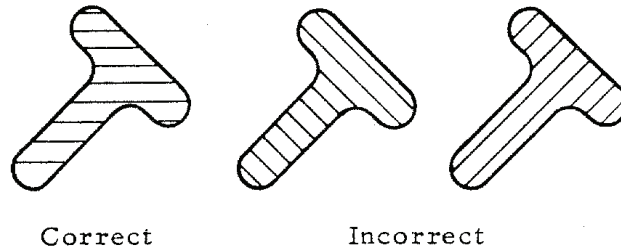
3.9.3 Section and View Identification Letters. Section letters are always used in pairs, A-A, B-B, C-C, etc. Should a drawing require so many sections that the single letters of the alphabet are exhausted; further sections may be identified by the use of combinations of different letters such as AA-AA, AB-AB, AC-AC, etc. The letters I, O, Q, S, X and Z are not used as section letters. Once a letter or combination of letters is established on a released drawing, it is not reused for another SECTION, VIEW, or DETAIL on the same drawing.

Example: **SECTION A-A, VIEW B, DETAIL C**

3.9.4 Section Titles. The letters which identify a cutting plane are used as part of the section title, which is placed directly under the section view. The word "SECTION" is not abbreviated. See FIGURE 3-22.

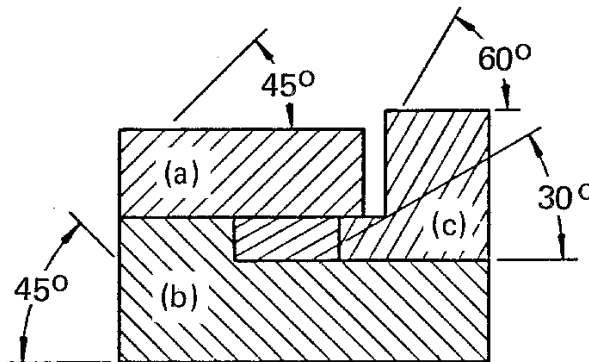
SECTION A-A
SECTION TITLE
FIGURE 3-22

3.9.5 Angle Of Section Lining. Section lining is generally constructed at an angle to the principal object lines of the sectional view, as shown in Figure 3-23, regardless of the position of the section on the drawing.



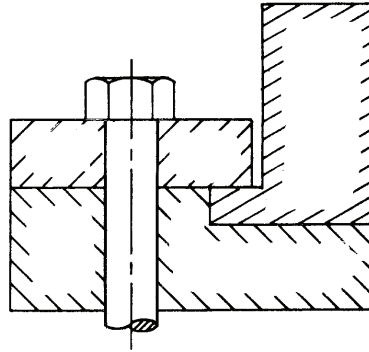
ANGLE OF SECTION LINES
FIGURE 3-23

3.9.6 Section Lining Or Cross-Sectioning. Sections lines are composed of uniformly spaced lines at an angle of 45 degrees to the base line of the section. On adjacent parts (a) and (b) in the figure below, the 45 degree lines are drawn in the opposite direction. On a third part, (c) adjacent to two other parts, the section lining shall be drawn at an angle of 30 or 60 degrees. See FIGURE 3-24. Where the 45 degree section lining is parallel or nearly parallel with the outline of the object, another angle is chosen.



SECTION LINES OF ADJACENT PARTS
FIGURE 3-24

3.9.6.1 Section Lining for Clarity. In addition to showing the shape and construction, sectional views may also be used to distinguish the individual components of an assembly or subassembly. This is accomplished by drawing sectional conventions on the exposed surfaces of the sectional view. Sectioning conventions do not cross dimensions or obscure other conventions on drawings. Sectioning conventions may be shown along the borders of the part only when clarity is not sacrificed. See FIGURE 3-25.



SECTIONING ADJACENT PARTS

FIGURE 3-25

3.9.6.2 Section Through Welds. If a cutting plane passes through two or more parts that are being permanently assembled by welding, brazing, etc., each detail part is individually cross-sectioned. When a group of permanently assembled parts is sectioned on its next assembly(s), it is cross-sectioned as one part.

3.9.7 Scale Of Sections. Sections should be drawn to the same scale as the views from which they are taken; if it is necessary to employ a different scale, it is specified directly below the section title as in PARAGRAPH 3.5.2 and FIGURE 3-5.

3.9.8 Types Of Sections And Sectional Views.

3.9.8.1 Thin Sections. Sections of sheet metal, packing, gaskets, etc., which are too thin for section lining, may be shown solid. See FIGURE 3-26. Where two or more thicknesses are shown, space conducive to microfilming should be left between them. See FIGURE 3-27.

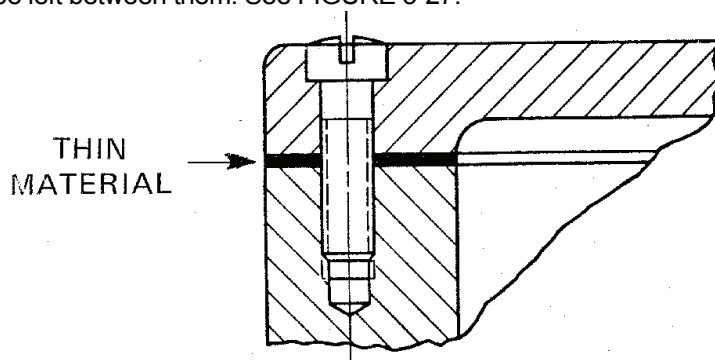


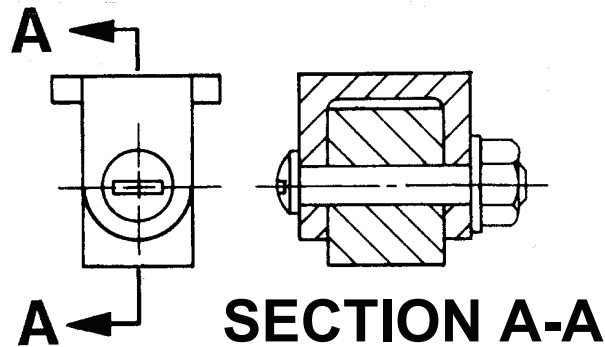
FIGURE 3-26

SECTION THRU THIN MATERIAL



FIGURE 3-27

3.9.8.2 Unlined Sections. Shafts, nuts, bolts, rods, rivets, keys, pins, and similar parts, whose axes lie in the cutting plane, are typically not cross-sectioned. See FIGURE 3-28.

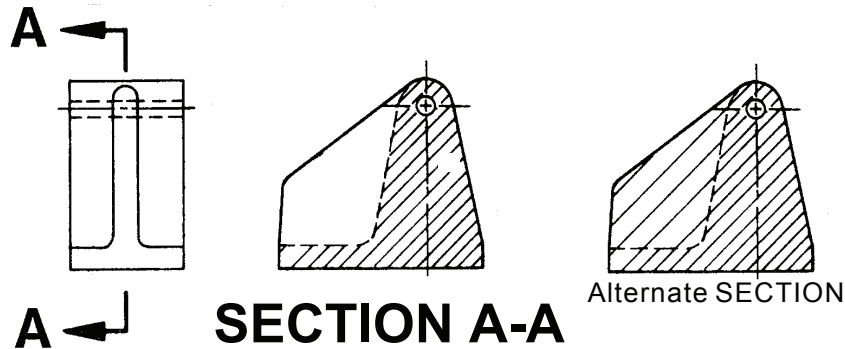


SECTION A-A

UNLINED SECTIONS

FIGURE 3-28

3.9.8.3 Sections Through Ribs, Webs, Etc. When the cutting plane passes through a rib, web, or similar element, section lines may be omitted from these parts. An acceptable alternate method of representation is to portray the line of intersection of the element (rib, web, etc.) with a hidden line. In cross-sectioning the element, every other section line is omitted to accent the division of the element and the body of the part. See FIGURE 3-29.



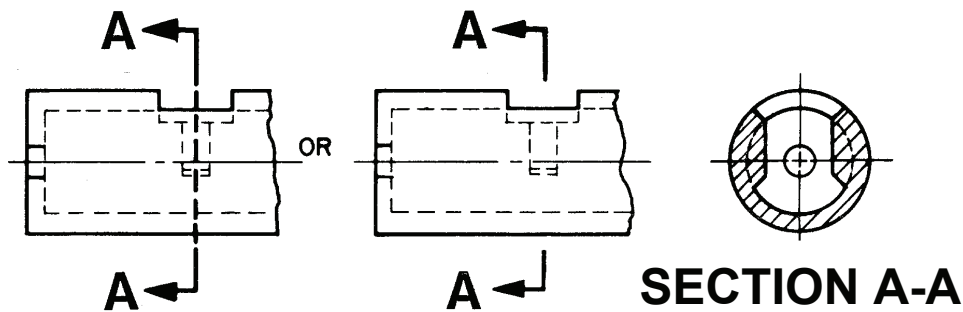
SECTION A-A

Alternate SECTION

SECTION THRU RIBS

FIGURE 3-29

3.9.8.4 Full Sections. A full section is a view which is obtained when the cutting plane extends entirely across the object. See FIGURE 3-30. Cutting plane lines may be omitted if the location of the cutting plane is obvious.

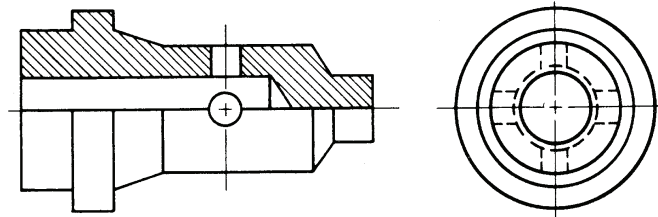


SECTION A-A

FULL SECTIONAL VIEW

FIGURE 3-30

3.9.8.5 Half Sections. A half section is a view of a symmetrical object which shows both the internal and external features. This is accomplished by passing two cutting planes at right angles to each other along the center lines of symmetrical axes. Thus, one quarter of the object is considered removed and the interior exposed to view. The cutting plane indications and section titles are omitted. See FIGURE 3-31.

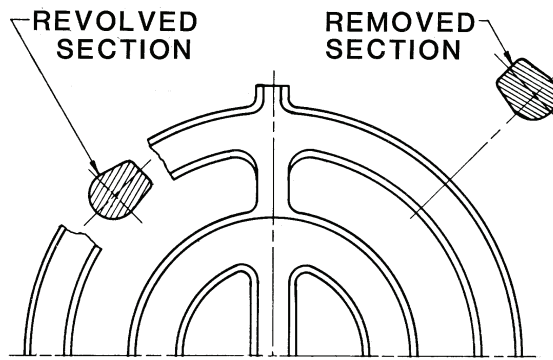


HALF SECTION OF SYMMETRICAL OBJECT

FIGURE 3-31

3.9.8.6 Revolved Sections. A revolved section is drawn directly on an exterior view to show the cross-sectional shape of a part, such as the spoke of a wheel. The cutting plane is passed perpendicular to the center line or axis of the part to be sectioned and the resulting section is rotated in place. The cutting plane indications are omitted for symmetrical sections. See FIGURE 3-32.

3.9.8.7 Removed Sections. A removed section may be used to illustrate particular parts of an object remotely. They are drawn like revolved sections, except that they are placed to one side and are often drawn to a larger scale than the view from which they were taken. This is done to show pertinent data. See FIGURE 3-32. Cutting plane indications are omitted.



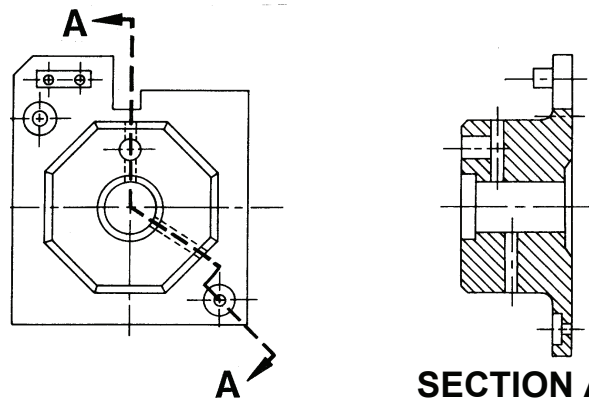
REMOVED AND REVOLVED SECTIONS

FIGURE 3-32

3.9.8.8 Offset and Aligned Sections. When the cutting plane is not a continuous plane, the resulting section is called an Offset or an Aligned section. See FIGURE 3-33. Cutting plane indications and section title are required.

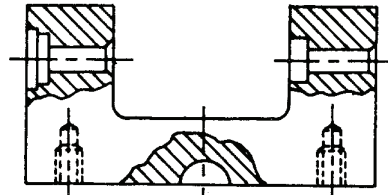
OFFSET AND ALIGNED SECTIONS

FIGURE 3-33



SECTION A-A

3.9.8.9 Broken-Out Section. When a sectional view of only part of the object is needed, broken-out sections may be used. The break-line convention is used to separate the sectional view portion from the exterior view. See FIGURE 3-34.

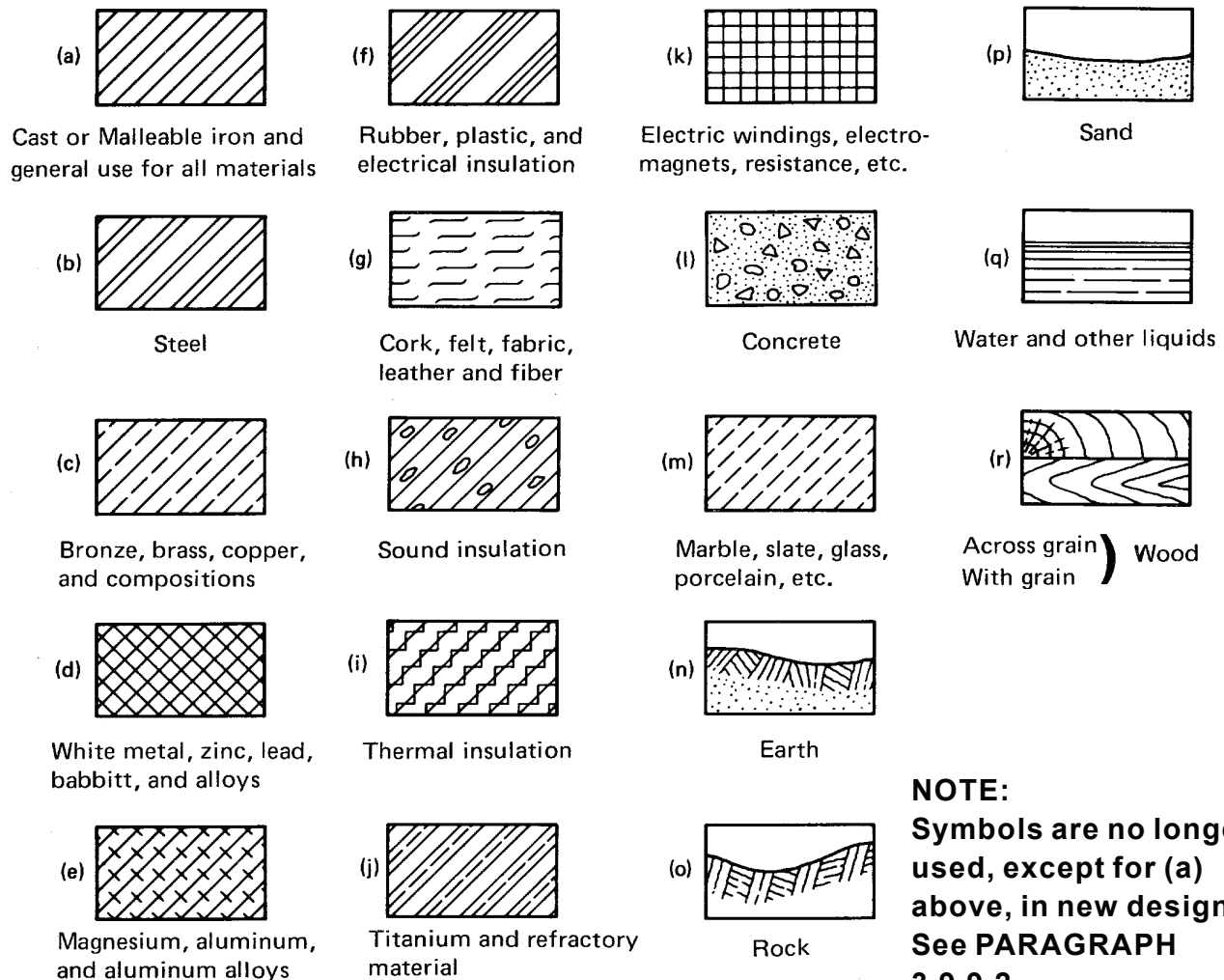


BROKEN-OUT SECTIONS
 FIGURE 3-34

3.9.9 Sectioning Conventions.

3.9.9.1 General Sectioning Symbol. The cross-sectioning symbol for cast iron is generally used on detail drawings, regardless of material, and on all other sectional views where practicable.

3.9.9.2 Individual Sectioning Symbols. Individual sectioning symbols for materials from which the parts are made are no longer desirable since 1972, but are portrayed in FIGURE 3-35 for identification purposes for drawings made previous to the date specified.



NOTE:
 Symbols are no longer used, except for (a) above, in new designs. See PARAGRAPH 3.9.9.2

CROSS SECTION SYMBOLS

FIGURE 3-35

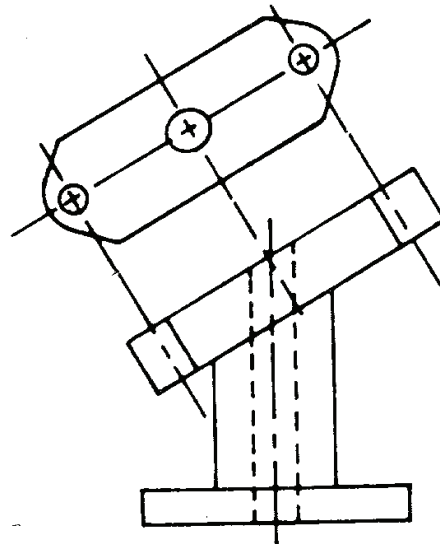


3.10 VIEW PROCEDURES.

3.10.1 Selection Of Views. Draw only those views necessary to clearly define the object. Avoid views that are meaningless or for picture purpose only.

3.10.2 Spacing And Identification Of Views. Provide ample space between views to permit placing dimensions and other annotation without crowding and to preclude the possibility of notes pertaining to one view overlapping or crowding the other views.

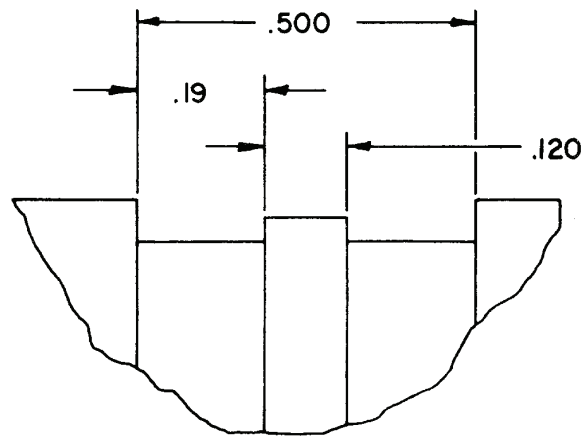
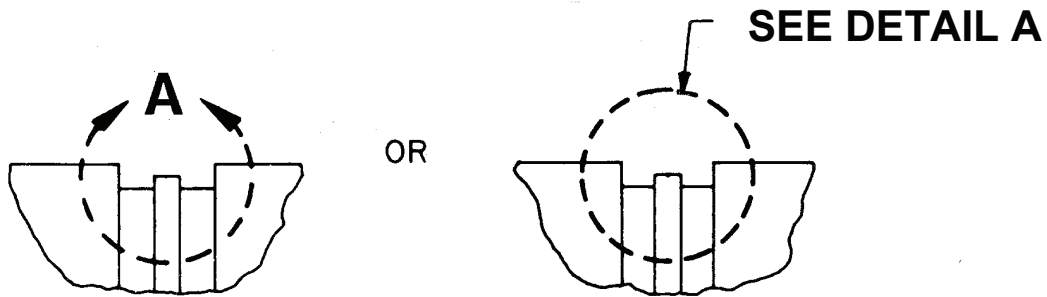
3.10.3 Auxiliary Views. Objects having inclined faces or other features which are not parallel to any of the three principal planes of projection may require one or more auxiliary views to show the true shape of such features. In many cases, partial auxiliary views, which show only the pertinent features, may be employed to illustrate features not clearly shown by principal views. The auxiliary view is arranged as though the auxiliary plane were revolved into the plane of the paper. See FIGURE 3-36.



AUXILIARY VIEW

FIGURE 3-36

3.10.4 Detail View Letters. A detail view shows a portion of a drawing in the same plane and in the same arrangement, but in greater detail than is shown in the principal view. A detail view is usually shown at a larger scale than the parent view. See FIGURE 3-37. The use of a single letter and rules for usage are the same as for section letters. See PARAGRAPHS 3.9.3 and 3.9.4 of this section.



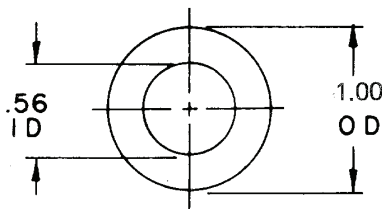
DETAIL A

SCALE $\frac{4}{1}$

DETAIL VIEWS

FIGURE 3-37

3.10.5 One View Drawings. One view drawings are permissible for simple linear-extruded shapes, such as cylindrical, square, hexagonal, etc. objects of uniform thickness, and spherical shapes, if the necessary dimensions can be properly indicated. See FIGURE 3-38.



.06 THK STOCK

ONE VIEW DRAWING

FIGURE 3-38



3.10.6 Drawings Without Views. In those instances where words will adequately describe the part, no views need be shown. See FIGURE 3-39.

REV.	APPLICATION		REVISIONS			
	NEXT ASSY	USED ON	REV.	DESCRIPTION	DATE	APPROVED
SH	<p>NOTES:</p> <p>1. MATERIAL: STEEL BAR MIL-S-5626 CONDITION B</p> <p>2. HEAT TREAT: ROCKWELL C21, MIL-H-6875</p> <p>.875 ± .002 DIA STOCK x 4.00 ± .03 LONG</p> <p>DISTRIBUTION STATEMENT A. APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED.</p>					
DWG. NO.						

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: DECIMALS - ANGLES .XX ± .03 ± 2° .XXX ± .010	CONTRACT NO.				
DO NOT SCALE DRAWING	APPROVALS	DATE	TITLE BAR		
TREATMENT SEE NOTE 2	DRAWN				
FINISH	CHECKED		SIZE	CAGE CODE	DWG NO.
	ENGR				REV.
	DESIGN ACTIVITY		SCALE		SHEET

DRAWING WITHOUT VIEWS

FIGURE 3-39

3.10.7 – Deleted



3.11 MECHANICAL SPRING DRAFTING PRACTICE.

3.11.1 Types of Springs The type of springs most commonly used are described herein as:

- a. Compression - Style: Helical, Cylindrical, Volute, Coned disk.
- b. Extension - Style: Helical.
- c. Torsion - Style: Helical, Torsion bar, Spiral.
- d. Flat - Style: Cantilever.
- e. Constant Load - Style: Flat.
- f. Garter - Style: Helical.

3.11.2 Special Data Notes Special data notes shall apply to drawing requirements for springs. The following notes are recommended:

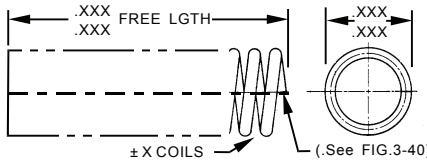
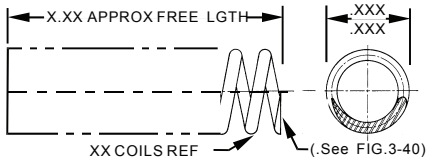


- a. **STRESS AT _____°F ± _____°F FOR _____MINUTES, AFTER COINING (or FORMING.)**
- b. **HARDNESS RANGE Rc _____ TO _____ HARDNESS NOT MEASURED IN DEGREES.**
- c. **SQUARENESS OF ENDS IN FREE POSITION WITHIN _____DEGREES.**
- d. **COLD SET TO SOLID.**
- e. **SHOT PEEN (give specification) TO _____INTENSITY.**
- f. **PROTECTIVE COATING (give specification).**
- g. **NON DESTRUCTIVE INSPECTION (give specification).**
- h. **THE BODY SHALL NOT CAMBER MORE THAN _____INCH IN ITS ENTIRE LENGTH.**
- i. **TEST OVER ARBOR DIA _____INCH.**
- j. **TO WITHSTAND TEMPERATURES OF _____°F FOR _____HOURS WITH LOSS NOT TO EXCEED _____%.**
- k. **TO WITHSTAND _____DEFLECTIONS FROM INITIAL TO FINAL POSITION WITH LOSS OF LOAD NOT TO EXCEED _____%.**

3.11.3 Simplified Drafting Practice. Springs may be depicted using simplified drafting methods to represent repetitive features. These include the following types of springs:

- a. Compression - Helical Spring. See TABLE 3-4. For typical mono-detail drawing, See FIGURE 3-41.



a. Compression - Helical Spring (Continued)

LOAD SPECIFIED	COMPRESSION HELICAL SPRINGS	DRAWING REQUIREMENTS
NONE	 <p>OTHER INFO REQD:</p> <ul style="list-style-type: none"> • MATL SPEC • WIRE DIA • DIRECTION OF HELIX (LH SHOWN) • SPECIAL DATA (See PARA 3.11.2) 	<ol style="list-style-type: none"> 1. Specify free length with tolerance. 2. When spring operates over guide, specify inside diameter of coil with tolerance. 3. Specify total number of coils with a tolerance.
ONE	 <p>OTHER INFO REQD:</p> <ul style="list-style-type: none"> • MATL SPEC • WIRE DIA • DIRECTION OF HELIX (LH SHOWN) • LOAD AT COMPRESSED LGTH OF X.XX INCH = XX LB ± XX LB. • SPECIAL DATA (See PARA 3.11.2) 	<ol style="list-style-type: none"> 1. Specify approx free length. 2. When spring operates over guide, specify inside diameter of coil with tolerance. 3. Specify total number of coils; designate REF. 4. Specify the one load, with tolerance, that is required at one definite length.
TWO	 <p>OTHER INFO REQD:</p> <ul style="list-style-type: none"> • MATL SPEC • WIRE DIA • DIRECTION OF HELIX (LH SHOWN) • LOAD AT COMPRESSED LGTH OF X.XX INCH = XX LB ± XX LB. • LOAD XX LB + XXLB AT X.XX INCH FOR THE LOAD REQD OF THE TWO DEFINED COMPRESSED LENGTHS. • SPECIAL DATA (See PARA 3.11.2) 	<ol style="list-style-type: none"> 1. Specify approx free length. 2. When spring operates over guide, specify inside diameter of coil with tolerance. 3. Specify total number of coils; designate REF. 4. Specify a load with tolerance for each of two definite compressed lengths. The load being the sum of the initial and the final operating positions in the assembly.
SPRING RATE SPECIFIED	 <p>OTHER INFO REQD:</p> <ul style="list-style-type: none"> • MATL SPEC • WIRE DIA • DIRECTION OF HELIX (LH SHOWN) • LOAD AT COMPRESSED LGTH OF X.XX INCH = XX LB ± XX LB. • SPRING RATE XX LB/IN. + XX LB/IN. BETWEEN COMPRESSED LGTH OF XX INCH AND XX INCH. • SOLID LGTH WITHOUT PERMANENT SET = X.XX INCH. • SPECIAL DATA (See PARA 3.11.2) 	<ol style="list-style-type: none"> 1. Specify approx free length. 2. When spring operates over guide, specify inside diameter of coil with tolerance. 3. Specify total number of coils; designate REF. 4. Specify spring rate. 5. Specify the two lengths between which the rate should be checked.

HELICAL SPRINGS USED IN COMPRESSION

TABLE 3-4 (continued on next page)



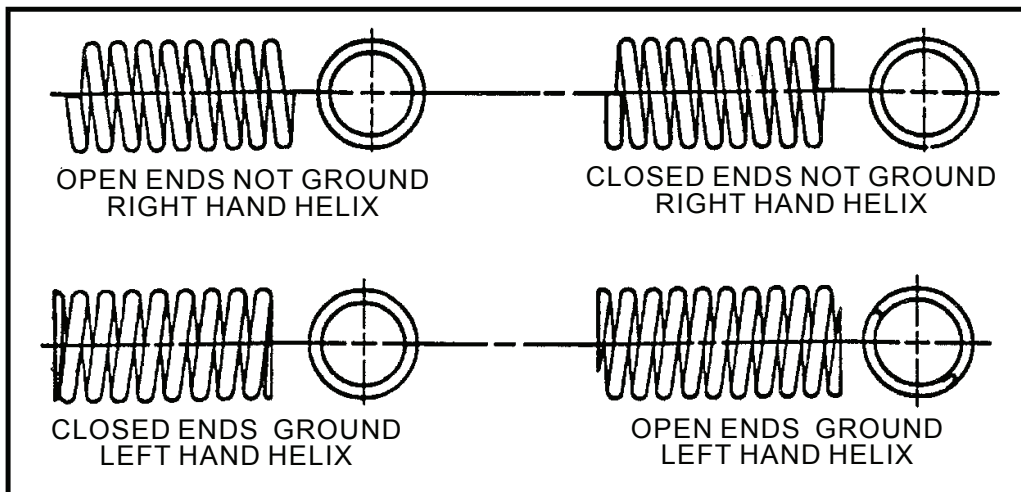
(TABLE 3-4 continued)

General Notes:

1. When the direction of the helix is a design requirement, the direction of the helix is specified as “LEFT-HAND” (LH) or “RIGHT-HAND (RH) or “OPTIONAL”, if applicable. Consideration to which hand, “LH” or “RH”, is selected should be made when a plug is screwed into the end of the spring or where one spring fits inside another. In this latter case, one spring should be designated left-hand and the other spring right-hand. Left-hand helix is preferred and most popular for compression springs.
2. Helical compression spring ends are shown in FIGURE 3-40. When necessary, the ends should be dimensioned.
3. Springs should not be designed to be compressed to solid in operation except when this requirement is essential to the spring’s function.

HELICAL SPRINGS USED IN COMPRESSION

TABLE 3-4 (Continued from previous page)

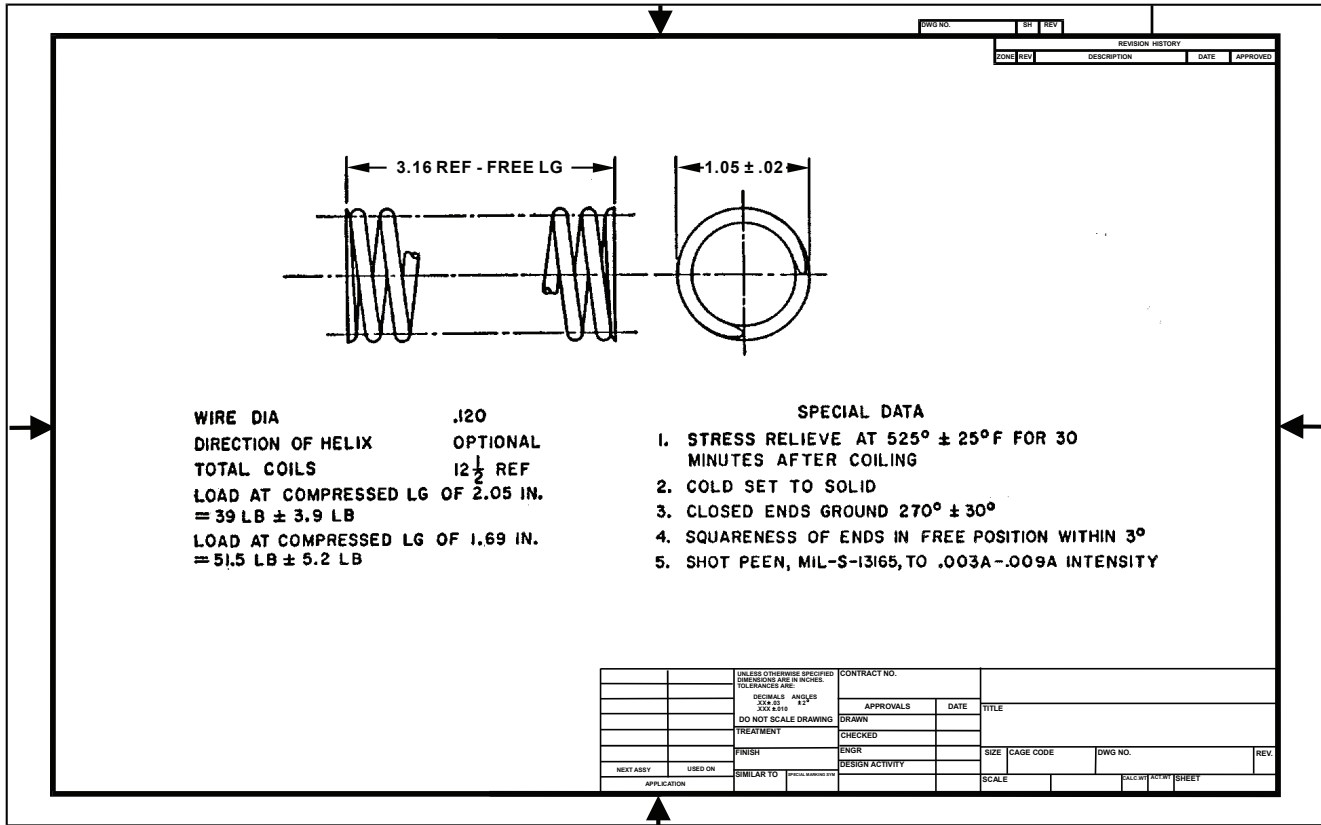


TYPES OF ENDS FOR HELICAL COMPRESSION SPRINGS

FIGURE 3-40



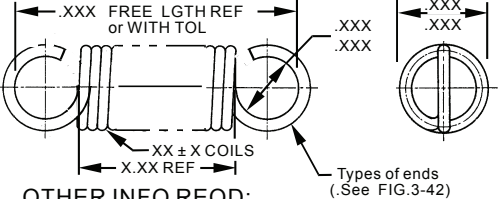
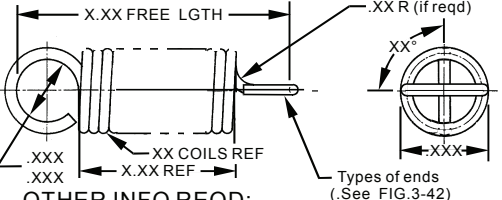
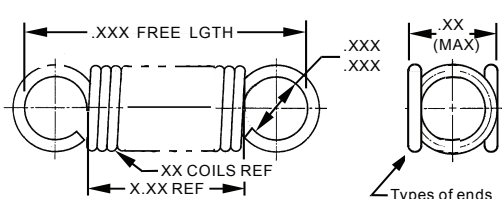
a. Compression - Helical Spring (Continued)



TYPICAL MONO-DETAIL DRAWING OF A HELICAL COMPRESSION SPRING
FIGURE 3-41



b. Tension-Helical Spring. See TABLE 3-5 . For typical mono-detail drawing, See FIGURE 3-43.

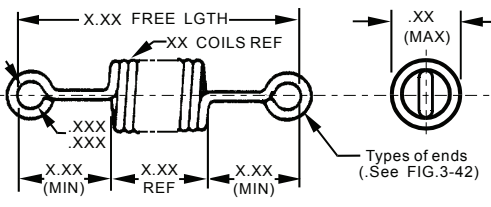
LOAD SPECIFIED	EXTENSION HELICAL SPRINGS	DRAWING REQUIREMENTS
NONE	 <p>OTHER INFO REQD:</p> <ul style="list-style-type: none"> • MATL SPEC • WIRE DIA • DIRECTION OF HELIX (LH SHOWN) • INITIAL LOAD XX LB ± XX LB OR SPECIFY "INITIAL LOAD OPTIONAL" • MAX EXTENDED LGTH BETWEEN INSIDE ENDS WITHOUT PERMANENT SET =X.XX INCH • SPECIAL DATA (See PARA 3.11.2) 	<ol style="list-style-type: none"> 1. Specify free length as "REF" or free lgth with tolerance. 2. Relative position of ends. 3. Specify total number of coils with a tolerance. 4. Specify inside diameter of hook or loop with a tolerance. 5. When essential to design requirements,specify initial tension, otherwise specify "INITIAL LOAD OPTIONAL".
ONE	 <p>OTHER INFO REQD:</p> <ul style="list-style-type: none"> • MATL SPEC • WIRE DIA • DIRECTION OF HELIX (LH SHOWN) • INITIAL LOAD XX LB ± XX LB OR SPECIFY "INITIAL LOAD OPTIONAL" • LOAD XX LB ± XX LB AT X.XX INCH EXTENDED LGTH. • SPECIAL DATA (See PARA 3.11.2) 	<ol style="list-style-type: none"> 1. Specify free length as "REF" or without tolerance whichever is applicable. 2. Relative position of ends. 3. Specify total number of coils, designate as "REF". 4. Specify inside diameter of hook or loop with a tolerance. 5. When essential to design requirements,specify initial tension, otherwise specify "INITIAL LOAD OPTIONAL". 6. Specify the load, with a tolerance that is required at the extended length, preference is the initial assembled length.
TWO	 <p>OTHER INFO REQD:</p> <ul style="list-style-type: none"> • MATL SPEC • WIRE DIA • DIRECTION OF HELIX (LH SHOWN) • INITIAL LOAD XX LB ± LB OR SPECIFY "INITIAL LOAD OPTIONAL" • LOAD XX LB ± XX LB AT EXTENDED LENGTH OF X.XX INCH. • LOAD XX LB ± XX LB AT OPERATING LENGTH OF X.XX INCH. • SPECIAL DATA (See PARA 3.11.2) 	<ol style="list-style-type: none"> 1. Specify free length as "REF" or without tolerance whichever is applicable. 2. Relative position of ends. 3. Specify total number of coils, designate as "REF". 4. Specify inside diameter of hook or loop with a tolerance. 5. When essential to design requirements,specify initial tension, otherwise specify "INITIAL LOAD OPTIONAL". 6. Specify the load, with a tolerance that is required at each of the two defined extended lengths.

HELICAL SPRINGS USED IN TENSION

TABLE 3-5 (Continued on next page)



Table 3-5 (Continued)

LOAD SPECIFIED	EXTENSION HELICAL SPRINGS	DRAWING REQUIREMENTS
SPRING RATE SPECIFIED	 <p>OTHER INFO REQD:</p> <ul style="list-style-type: none"> • MATL SPEC • WIRE DIA • DIRECTION OF HELIX (LH SHOWN) • INITIAL TENSION XX LB ± LB OR SPECIFY "INITIAL LOAD OPTIONAL" • SPRING RATE XX LB/IN. ± XX LB PER IN. BETWEEN EXTENDED LGTH OF X.XX IN. AND X.XX IN.. • LOAD AT OPERATING LGTH OF X.XX INCH = XX LB ± XX LB. • SPECIAL DATA (See PARA 3.11.2) 	<ol style="list-style-type: none"> 1. Specify free length as "REF" or without tolerance whichever is applicable. 2. Relative position of ends. 3. Specify total number of coils, designate as "REF".. 4. Specify inside diameter of hook or loop with a tolerance. 5. When essential to design requirements,specify initial tension, otherwise specify "INITIAL LOAD OPTIONAL". 6. Specify spring rate with tolerance.

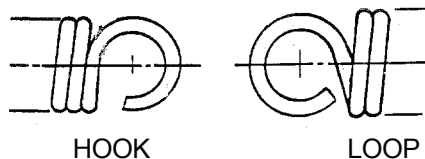
General Notes:

1. When direction of helix is a design requirement, the direction of the helix is specified as "LEFT-HAND"(LH) or "RIGHT-HAND"(RH) or "Optional" if applicable. Left-Hand helix is most commonly used.
2. Helical extension spring ends are shown in FIGURE 3-42. Extension spring ends shall be completely delineated and dimensioned.
3. Relative position of the ends shall be specified with tolerance. When relative position of the ends is not a requirement, add the note:

"ANGULAR RELATION OF ENDS NOT IMPORTANT"

4. Spring ends are classified as "hooks" or "loops". A hook has an open space between its end and the body of the spring. A loop is a closed hook.

For example:

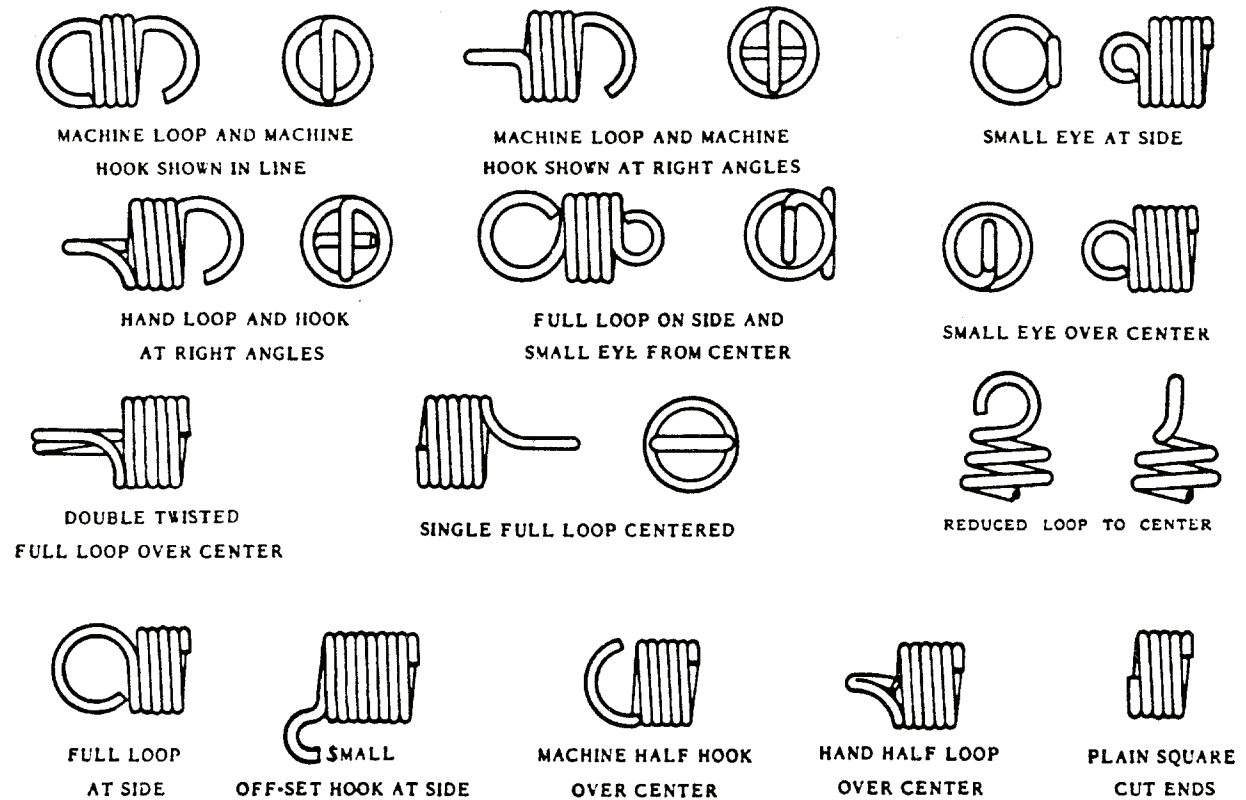


5. Helical extension springs should specify the maximum allowable extended length without causing permanent set as a precaution of over-extending the spring at assembly.

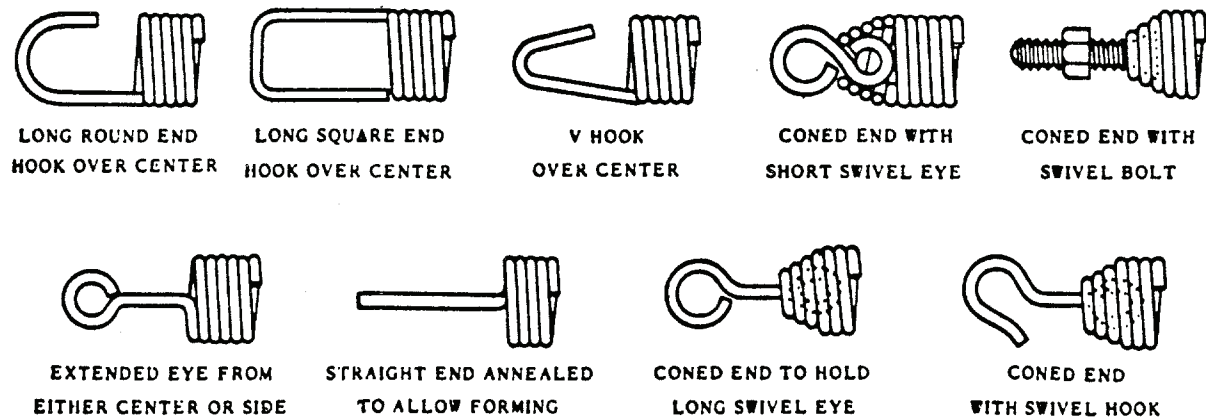
HELICAL SPRINGS USED IN TENSION

TABLE 3-5 (Continued from previous page)

b. Extension-Helical Spring. (Continued)



ALL THE ABOVE ENDS ARE STANDARD TYPES FOR WHICH
 NO SPECIAL TOOLS ARE REQUIRED



THIS GROUP OF SPECIAL ENDS REQUIRE SPECIAL TOOLS

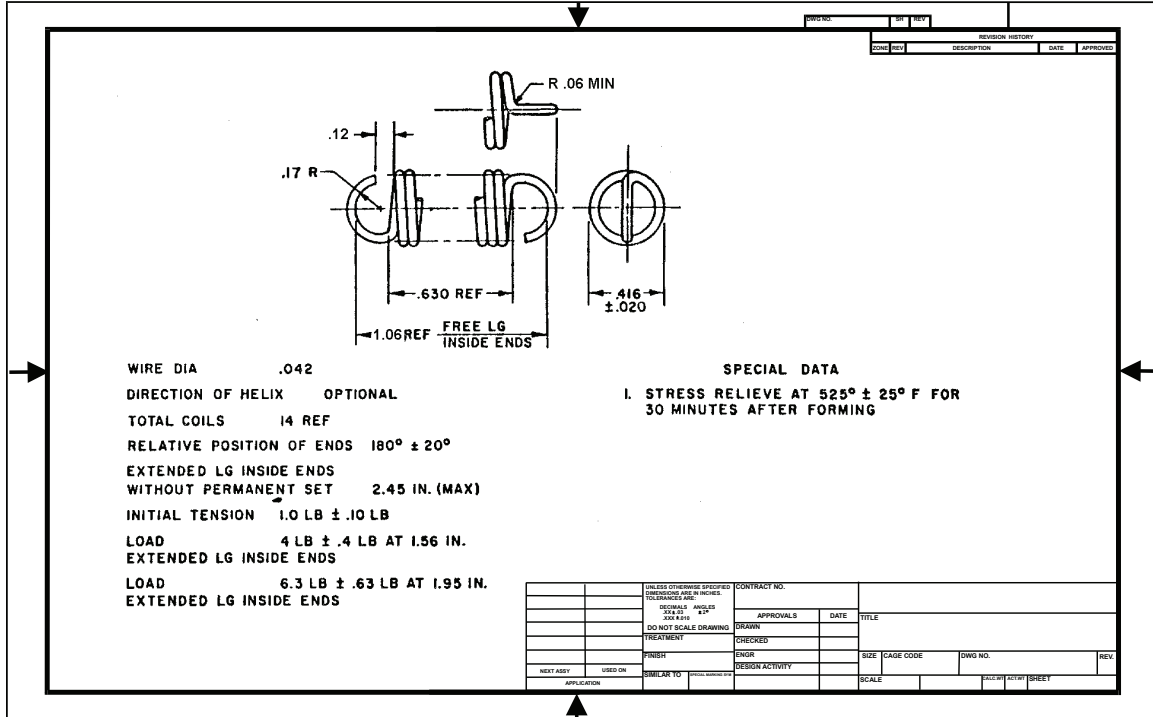
GENERAL NOTES:

1. The types of ends required and the relative position of the ends shall be completely dimensioned and clearly delineated on the drawing.

TYPES OF ENDS FOR HELICAL TENSION SPRINGS

FIGURE 3-42

b. Extension-Helical Spring. (Continued)



TYPICAL MONO-DETAIL DRAWING OF A HELICAL EXTENSION SPRING

FIGURE 3-43

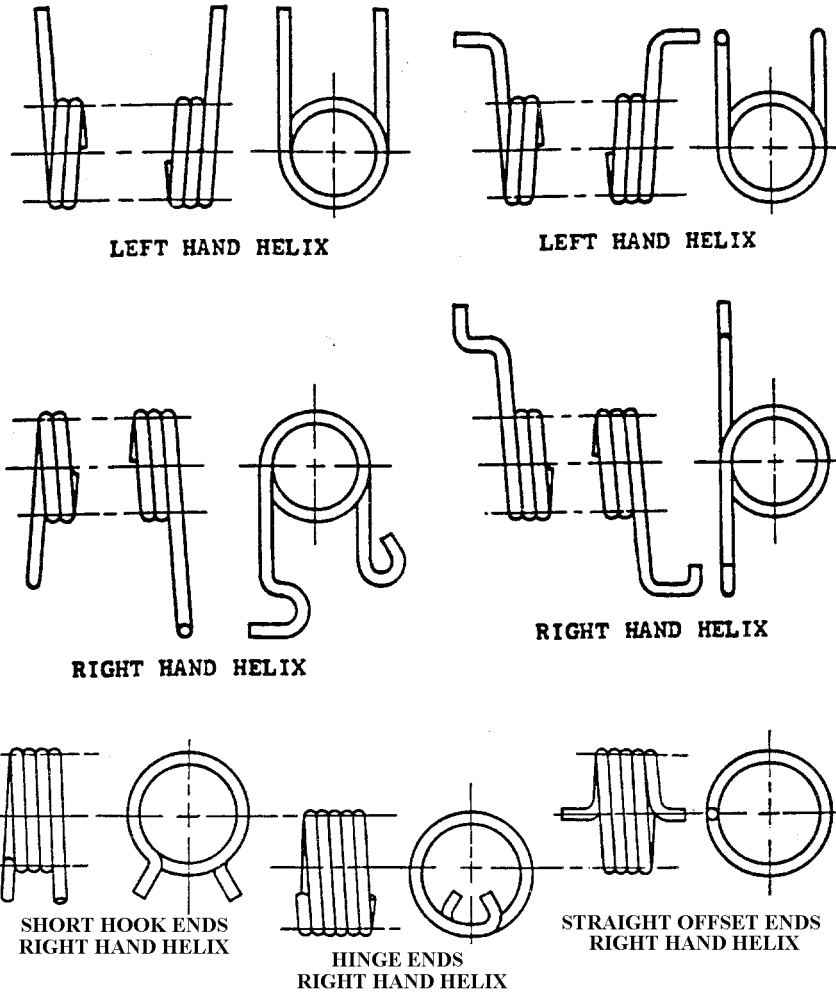
c. Torsion-Helical Spring. See TABLE 3-6. For typical mono-detail drawing, see FIGURE 3-46.

TORSION HELICAL SPRINGS	DRAWING REQUIREMENTS
<p>OTHER INFO REQD:</p> <ul style="list-style-type: none"> • MATL SPEC • WIRE DIA • DIRECTION OF HELIX (LH SHOWN). • PITCH = .XX INCH REF or APPLY INITIAL TORQUE = XX LB IN. ± XX LB IN. • TORQUE AT FINAL POSITION = XX LB IN. ± LB IN.. • MAXIMUM DEFLECTION WITHOUT SET BEYOND FINAL POSITION = XX DEGREES. • SPRING RATE = XX LB IN PER DEGREE REF. • SPECIAL DATA (See PARA 3.11.2) 	<ol style="list-style-type: none"> 1. Specify free length as "REF" or with tolerance if essential to the design.. 2. Specify direction of helix as it is important to design. Specify LH or RH so that the applied loads tend to wind up the spring in operation. 3. Specify ID of spring with tolerance for rod over which the spring is tested. 4. Specify total number of coils; designate "REF" or with tolerance if essential to the design. 5. Specify the degree (°) REF for the FREE POSITION and the degree (°) for the INITIAL and FINAL POSITIONS of the torsion spring. 6. Specify the pitch as "REF"; except when initial torque is required and seldom desirable. 7. Specify torque at the initial and final positions between the deflected end. However, when more than one revolutions is made, specify the number of revolutions and torque from the free position. Tolerances shall be applied to the torque loads. 8. Specify spring rate in pound inches per degree of deflection as a "REF" or with a tolerance for applications such as calibration scale in which case designate the loads at deflected positions as "REF".

HELICAL SPRINGS USED IN TORSION

TABLE 3-6

c. Torsion-Helical Spring (Continued)



GENERAL NOTES:

1. The types of ends required and the relative position of the ends shall be completely dimensioned and clearly delineated on the drawing.
2. Helical-torsion extension spring ends are shown in FIGURE 3-44. Extension spring ends shall be completely delineated on the drawing.
3. Relative position of the ends shall be specified with tolerance. When relative position of the ends is not a requirement, add the note;

ANGULAR RELATION OF ENDS NOT IMPORTANT.

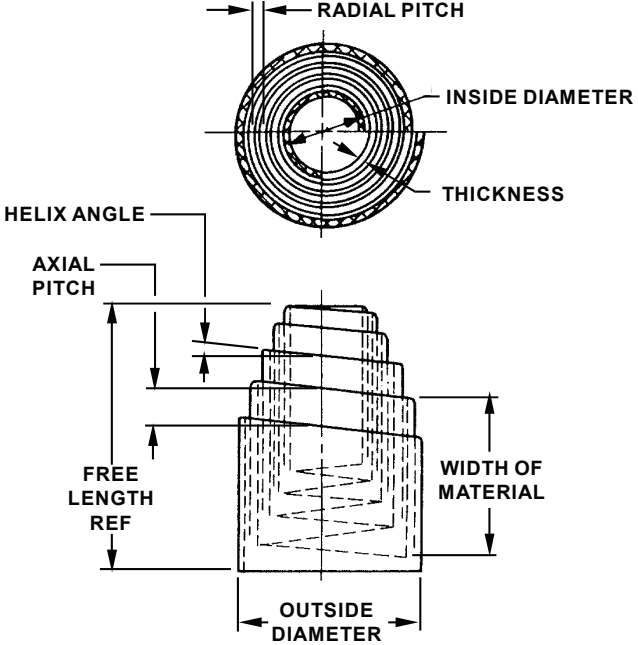
TYPES OF ENDS FOR HELICAL TORSION SPRINGS

FIGURE 3-44



3.11.4 Normal Drafting Practice. Springs shall be depicted on drawings by providing all necessary dimensioning to physically describe the features of the spring and data to describe the performance of the spring. Springs which fall into that style are Spiral, Torsion Bar, Volute, Coned Disk and Flat springs and of the following types:

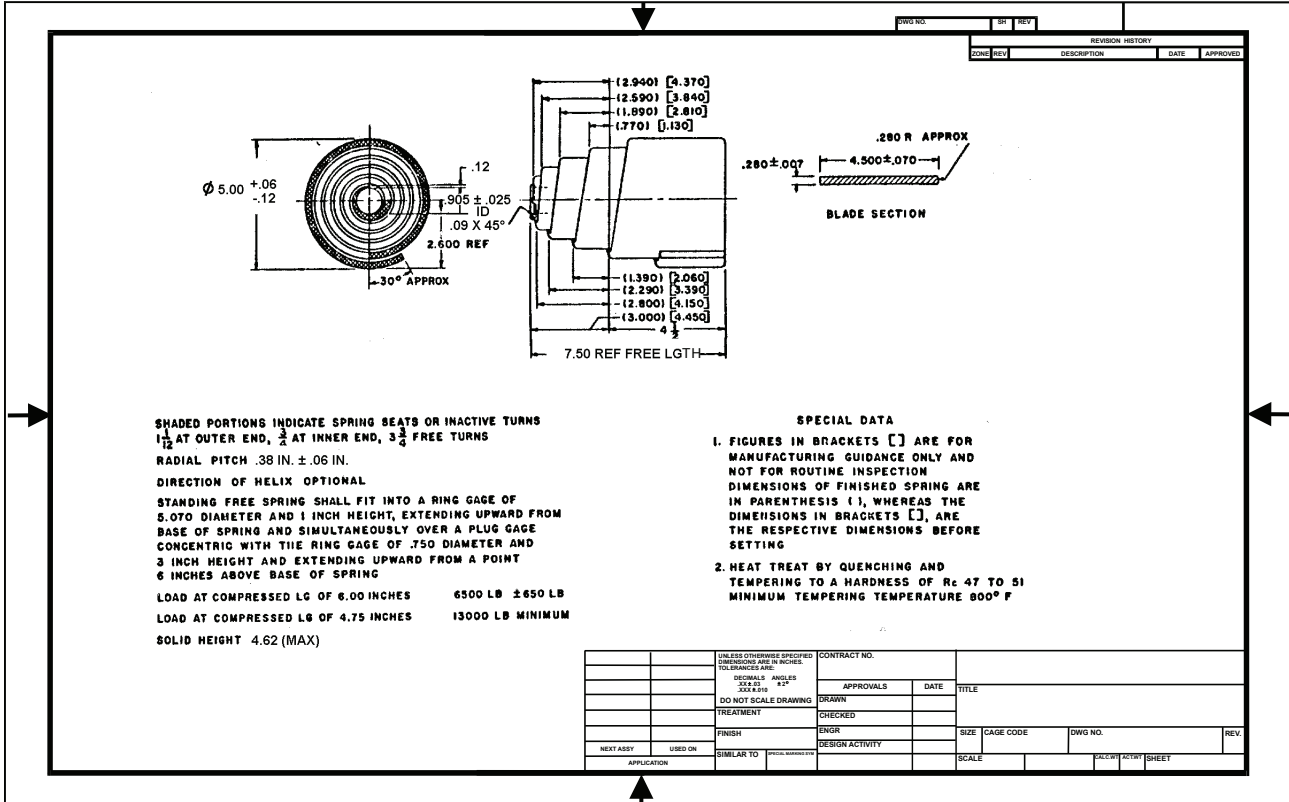
- a. Compression-Volute (See TABLE 3-8). For typical mono-detail drawing, See FIGURE 3-48.

COMPRESSION VOLUTE SPRINGS	DRAWING REQUIREMENTS
 <p>OTHER INFO REQD:</p> <ul style="list-style-type: none"> • MATL SPEC • MATL SIZE: .XXX IN. THICK .XXX IN. WIDE • DIRECTION OF HELIX. • RADIAL PITCH = .XXX IN. ± .XXX IN. • AXIAL PITCH = .XXX IN. ± .XXX IN. • HELIX ANGLE = XX° ± XX° • LOAD AT COMPRESSED LGTH OF X.XX INCH = XX LB ± XX LB AT INITIAL OPERATING POSITION. • LOAD AT COMPRESSED LGTH OF X.XX INCH = XX LB ± XX LB AT FINAL OPERATING POSITION. • SOLID LGTH = X.XX INCH MAX • SPECIAL DATA (See PARA 3.11.2) 	<ol style="list-style-type: none"> 1. Specify free length as a "REF". 2. Specify outside and inside diameter as toleranced diameters. 3. Specify total number of coils as "REF" or with tolerance if essential to design. 4. Specify radial pitch in inches with a tolerance. 5. Specify the preferable axial pitch or the helix angle with a tolerance. If the axial pitch is constant, the helix angle will vary; if the helix angle is constant, the pitch will vary. 6. Specify the solid length as a maximum dimension allowing for the tolerance on the width of the blade. The spring should be permitted to go to solid only as a bumper when a design requirement.

VOLUTE SPRINGS USED IN COMPRESSION

TABLE 3-8

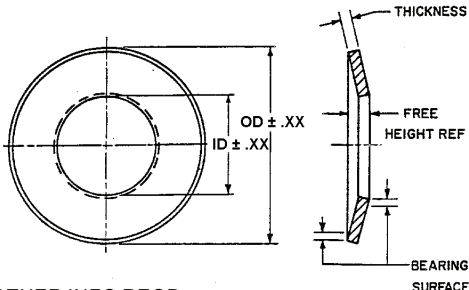
a. Compression-Volute Spring (Continued)



TYPICAL MONO-DETAIL DRAWING OF A COMPRESSION VOLUTE SPRING

FIGURE 3-48

b. Compression-Coned Disc. See TABLE 3-9. For typical mono-detail drawing, See FIGURE 3-50. For method of stacking Cone Disc Springs, See FIGURE 3-49.

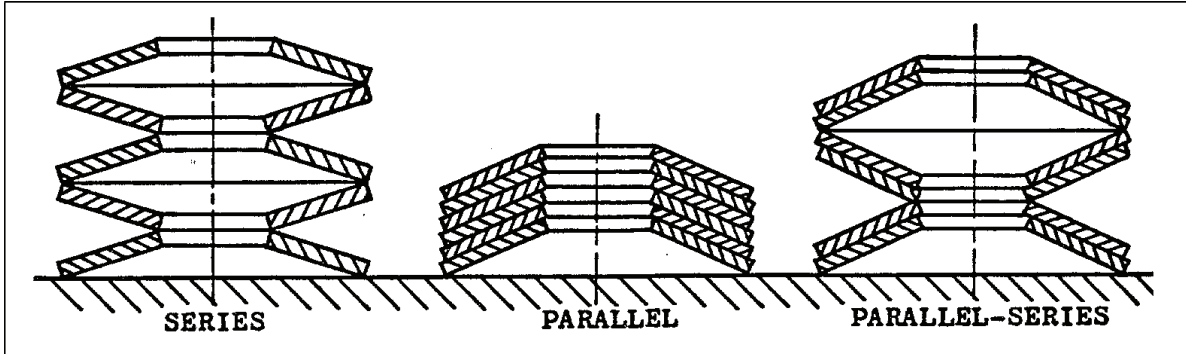
COMPRESSION CONED DISC SPRING	DRAWING REQUIREMENTS
 <p>OTHER INFO REQD:</p> <ul style="list-style-type: none"> MATL SPEC THICKNESS OF MATL = .XXX IN. LOAD AT COMPRESSED HEIGHT OF .XXX INCH = XX LB \pm XX LB FOR SINGLE DISC. LOAD AT COMPRESSED HEIGHT OF .XXX INCH = XX LB \pm XX LB AT INITIAL OPERATING POSITION FOR STACKED DISC SETS. (See FIGURE 3-50). LOAD AT COMPRESSED HEIGHT OF .XXX INCH = XX LB \pm XX LB AT FINAL OPERATING POSITION FOR STACKED DISC SETS. (See FIGURE 3-49). SPECIAL DATA (See PARA 3.11.2) 	<ol style="list-style-type: none"> Specify free height as a "REF" as either an individual disc or stacked. When essential to the design, individual or stacked disc heights may be tolerated. Specify inside and outside diameters with tolerance. Bearing surfaces should not exceed .030 inches wide. When important, concentricity between outside and inside diameters shall be within .003 inchs (.006FIM) for disc springs 2 inches and less for outside diameters and .005 (.010FIM) for disc springs over 2 inches outside diameter. Bearing surfaces must be parallel within .XXX inch at .XXX from center. Specify only one load with tolerance for a single disc. For stacked disc specify the loads with a tolerance at definite compressed lengths, preferably at the initial and final operating position. When discs are stacked, the following note shall be included on the detail drawing. "STACKS SHALL BE SECURED TOGETHER IN THE SEQUENCE OF TESTING AND SUCH SEQUENCE SHALL BE RETAINED UPON INSTALLATION."

CONED SPRINGS USED IN COMPRESSION

TABLE 3-9

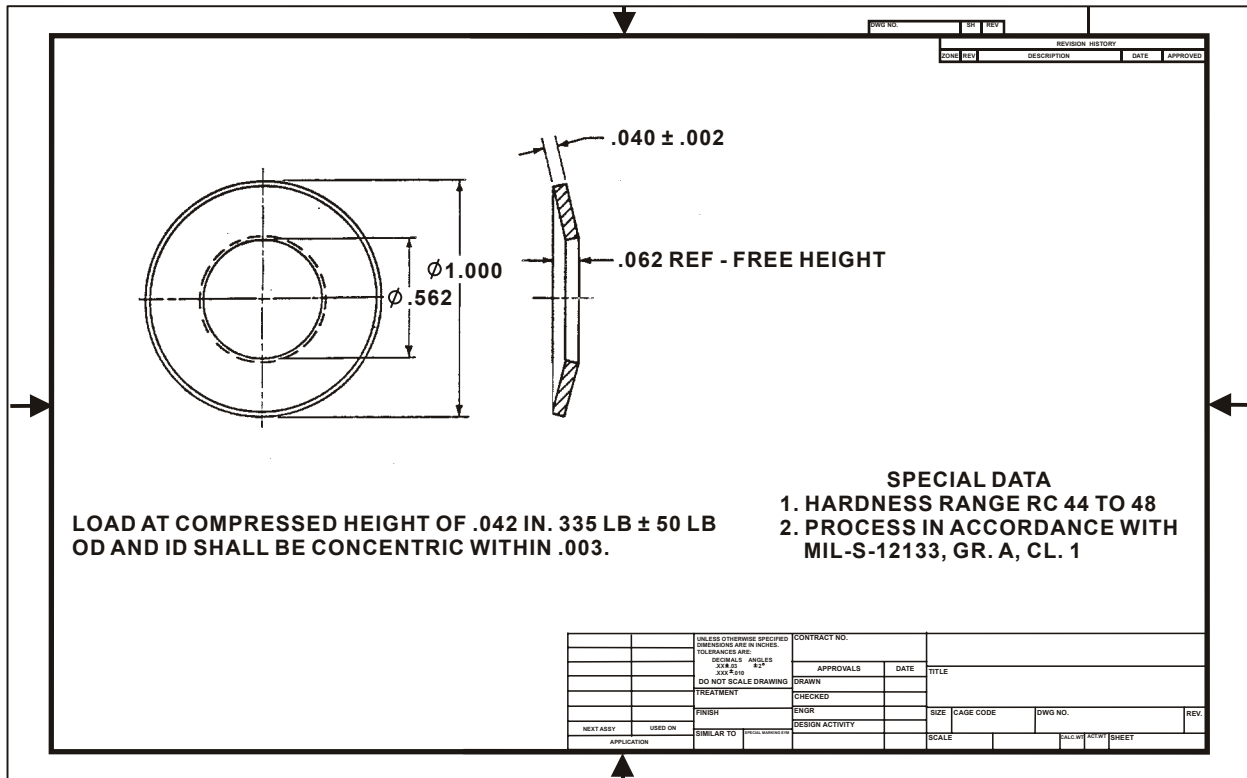


b. Compression-Coned Disc (Continued)



METHOD OF STACKING CONED DISC SPRINGS

FIGURE 3-49

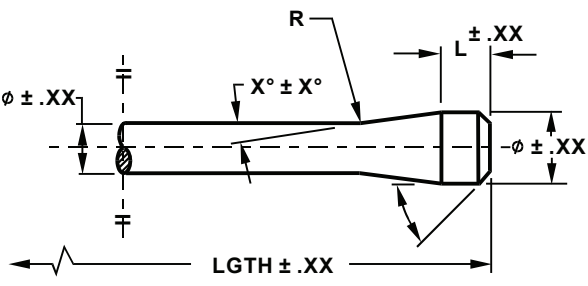


TYPICAL MONO-DETAIL DRAWING OF A COMPRESSION CONED DISC SPRING

FIGURE 3-50

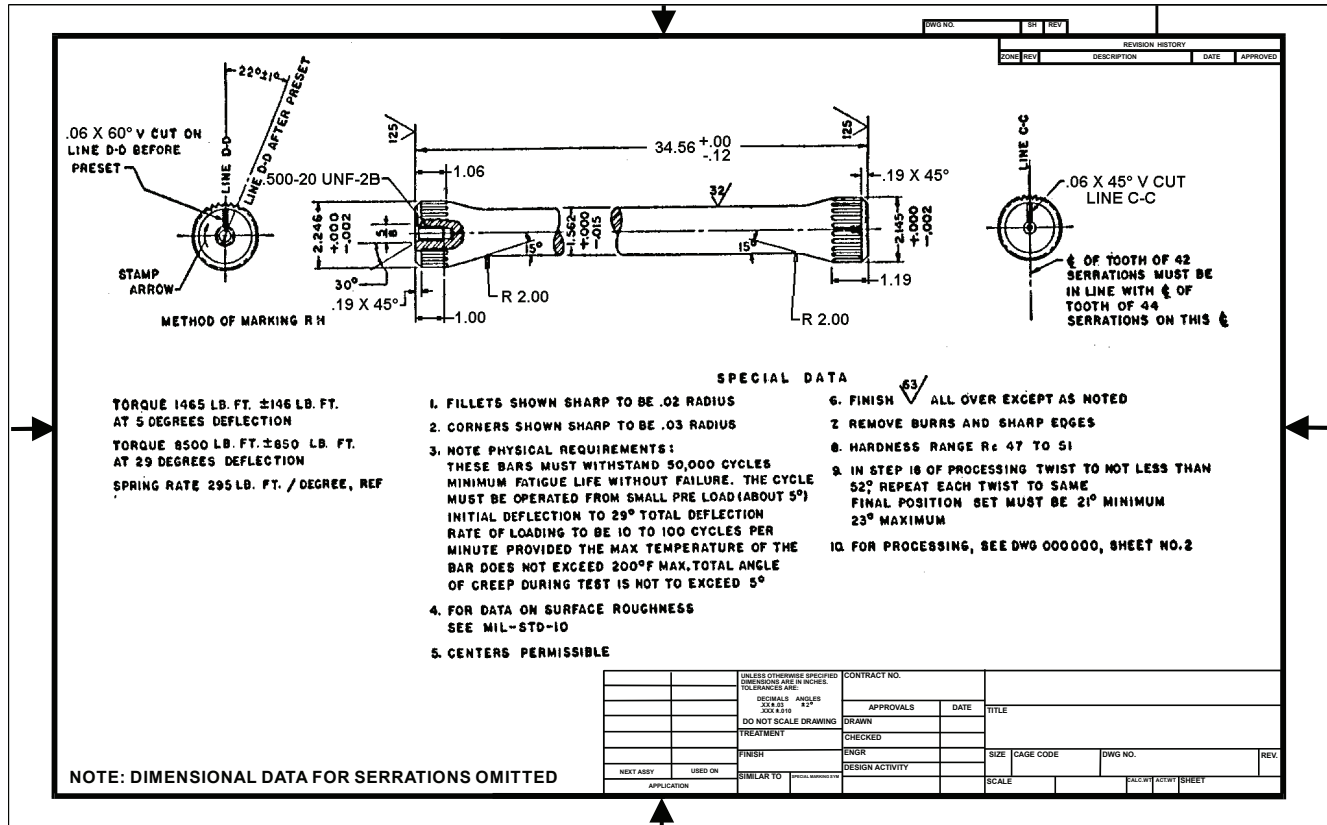


c. Torsion-Torsion Bar. See TABLE 3-10. For typical mono-detail drawing, See FIGURE 3-51

TORSION TORSION BAR SPRING	DRAWING REQUIREMENTS
 <p>NOTE: TORSION BAR SYMMETRICAL ABOUT SYMMETRICAL SYMBOL</p> <p>OTHER INFO REQD:</p> <ul style="list-style-type: none"> • MATL SPEC • TORQUE XX LB IN. ± LB IN. AT XX DEGREES DEFLECTION • SPRING RATE = XX LB IN. PER DEGREE REF. • DIRECTION OF WINDUP MARKING • ANGULAR RELATION BETWEEN ENDS • SPECIAL DATA (See PARA 3.11.2) 	<ol style="list-style-type: none"> 1. Specify overall length and the end lengths with tolerances. 2. Specify all dimensions delineated with tolerances except for chamfers and radii. 3. Specify torque load with tolerances in LB inchs or LB feet at definite amount of deflection in degrees of rotation from free position. Torque loads should be specified at the initial and the final operating positions in the assembly. 4. Specify spring rate in LB INCH PER DEG, as a "REF". 5. Specify in detail type of ends such as involute, spline, serrations, etc. 6. Specify for cold set torsion bar springs only the direction of windup of load in service. An arrow shall be placed on the end of the spring. 7. Torsion bar springs which are cold set shall have a scribed line (approx .06 X 60°v) on each end of the spring. The end view shall show the angular relation between the ends before and after coldsetting.

TORSION BAR SPRINGS USED IN TORSION

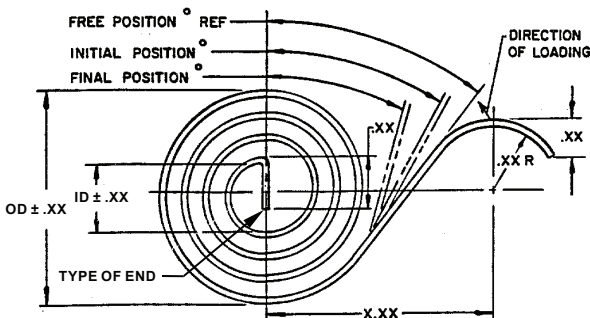
TABLE 3-10



TYPICAL MONO-DETAIL DRAWING OF A TORSION BAR SPRING

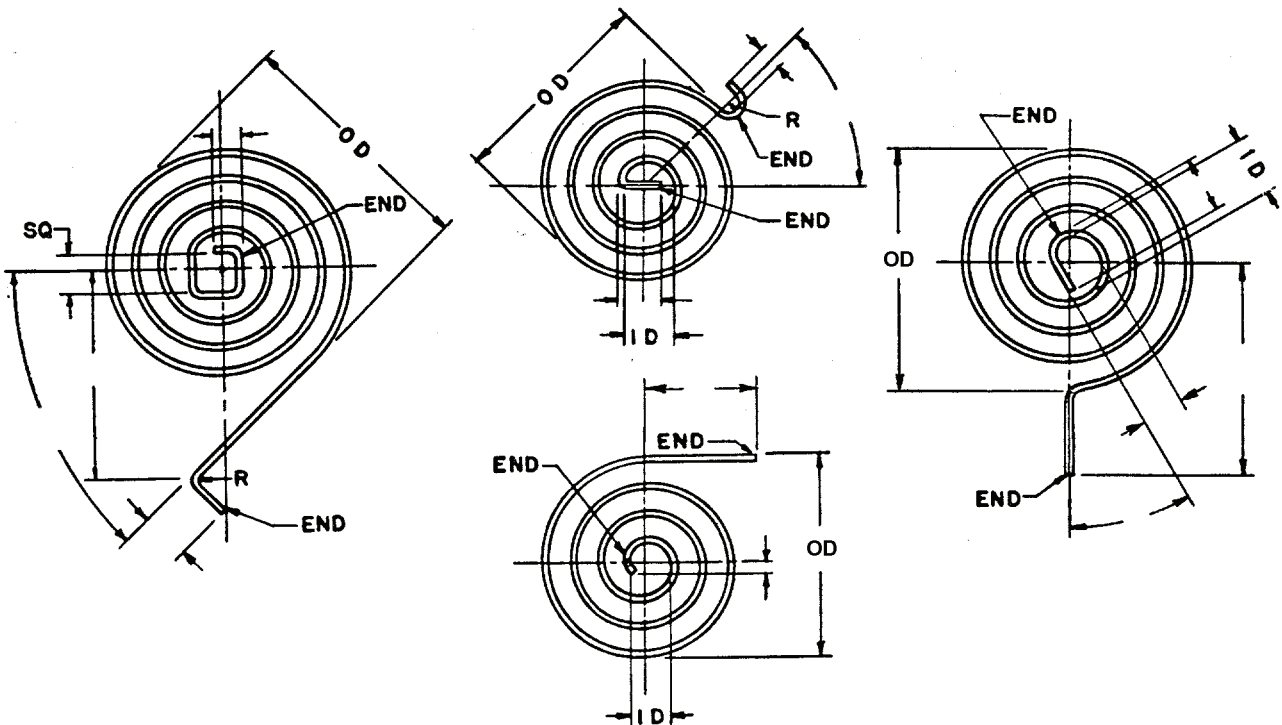
FIGURE 3-51

d. Torsion-Spiral Spring. See TABLE 3-11. For typical mono-detail drawing, See FIGURE 3-53

TORSION SPIRAL SPRING	DRAWING REQUIREMENTS
 <p>OTHER INFO REQD:</p> <ul style="list-style-type: none"> • MATL SPEC • MATL SIZE: .XXX IN. THICK .XX IN. WIDE • DEVELOPED LGTH OF MATL = X.XX REF. • ACTIVE LENGTH OF MATL = X.XX REF. • NUMBER OF COILS IN FREE POSITION = XX "REF". • TORQUE = LB IN. ± LB IN. AT XX DEG DEFLECTION. • SPRING RATE = XX LB IN./DEG • MAXIMUM DEFLECTION WITHOUT SET = XX DEG • SPECIAL DATA (See PARA 3.11.2) 	<ol style="list-style-type: none"> 1. Specify outside and inside diameter of coil in free position with tolerance. 2. Specify developed length of material and active length of material as "REF". The developed (total) length is the sum of the active length and the inactive length comprising the material forming the ends and the portion of a coil(s) that hugs the shaft. 3. Specify the degrees (°) REF for the FREE POSITION and the degrees (°) for the INITIAL and FINAL POSITIONS of the spiral spring. 4. Specify number of coils in free position as "REF". 5. Specify the torque at the final position of the outside end as it relates to the delineated inside end. 6. Specify maximum deflection beyond final position without set. 7. Specify type of end. The ends shall be completely delineated and dimensioned on detail drawings. See FIGURE 3-52.

SPIRAL SPRINGS USED IN TORSION

TABLE 3-11

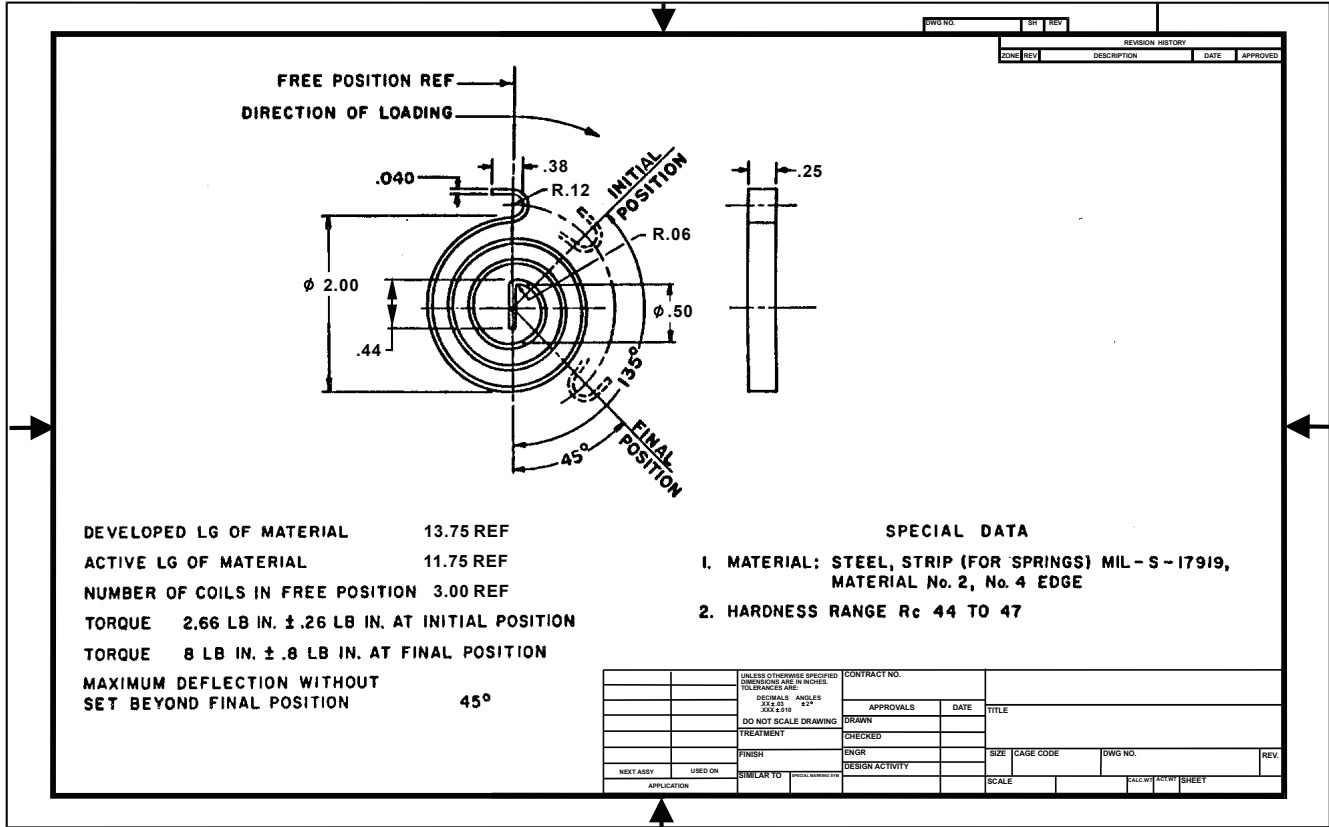


TYPES OF ENDS FOR SPIRAL TORSION SPRINGS

FIGURE 3-52



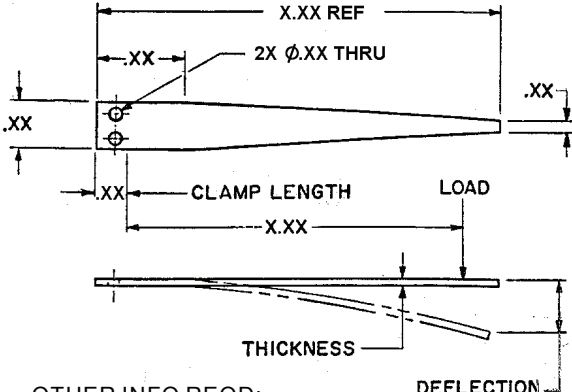
d. Torsion-Spiral Spring (Continued)



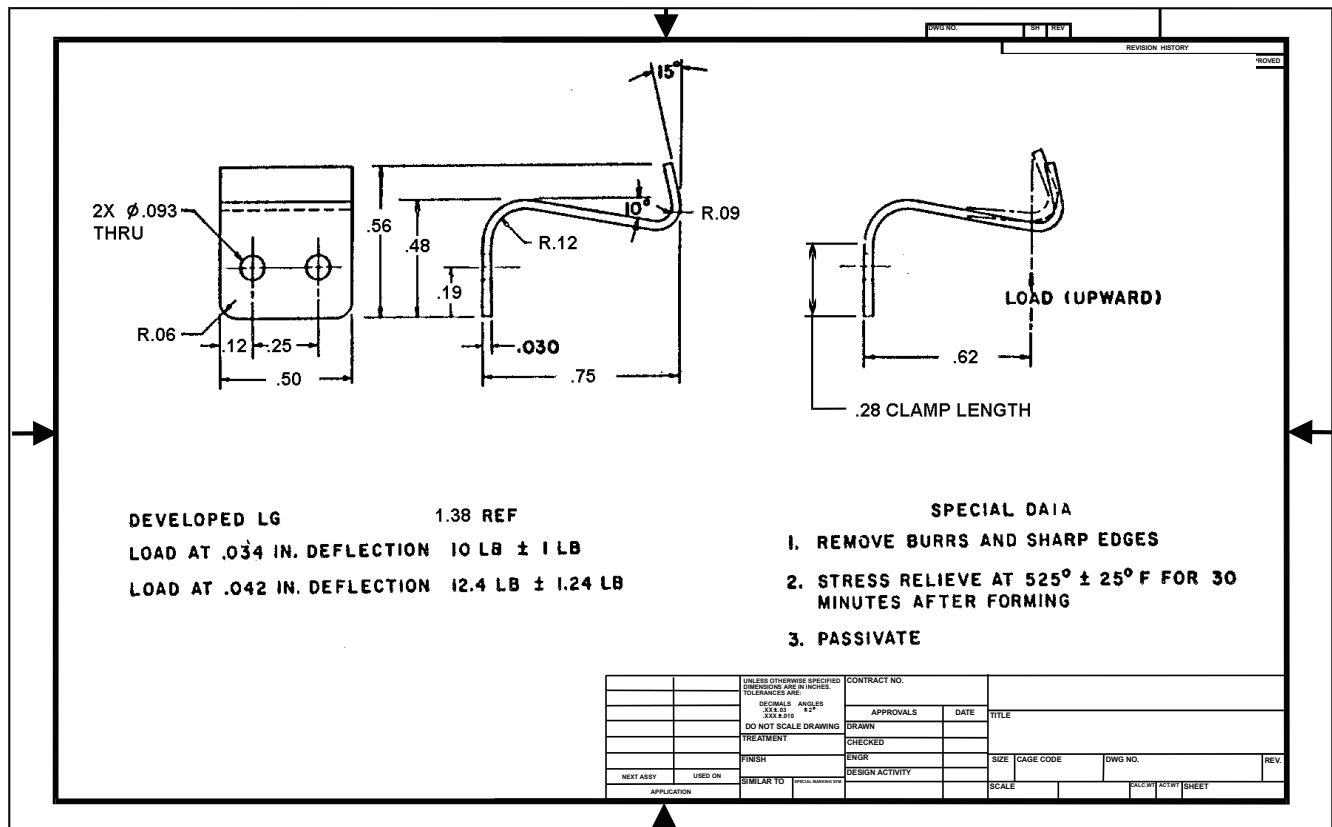
TYPICAL MONO-DETAIL DRAWING OF SPIRAL TORSION SPRING
FIGURE 3-53



e. Flat-Cantilever Spring. See TABLE 3-12. For typical mono-detail drawing, See FIGURE 3-54.

FLAT CANTILEVER SPRING	DRAWING REQUIREMENTS
 <p>OTHER INFO REQD:</p> <ul style="list-style-type: none"> • MATL SPEC • MATL SIZE: .XXX IN. THICK .XX IN. WIDE • DEFLECTION = .XX IN. AT INITIAL LOAD OF XX LB ± XX LB. • DEFLECTION = .XX IN. AT FINAL LOAD OF XX LB ± XX LB. • SPECIAL DATA (See PARA 3.11.2) 	<ol style="list-style-type: none"> 1. Specify the developed overall length as a "REF" or with a tolerance when space is limited. 2. Specify the clamp length. The clamp length is used for mounting and load testing and considered as inactive. 3. Specify load at distance from end of clamp length. This distance is the moment arm of the load. 4. Show the direction of the applied load to produce a prescribed deflection. 5. Specify, when applicable, loads and moments at the initial and final operating positions shall be given. 6. Tolerances shall be applied to loads not to deflections. 7. The showing of the deflected position can be helpful.

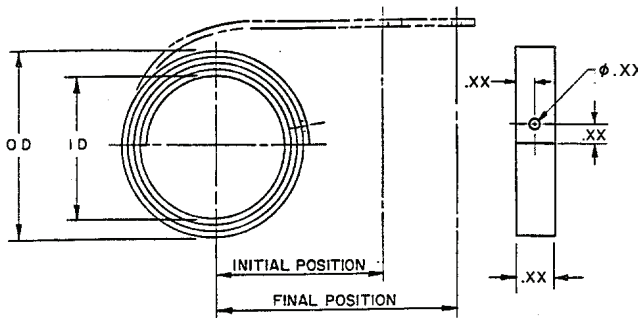
FLAT SPRING USED IN CANTILEVER
 TABLE 3-12



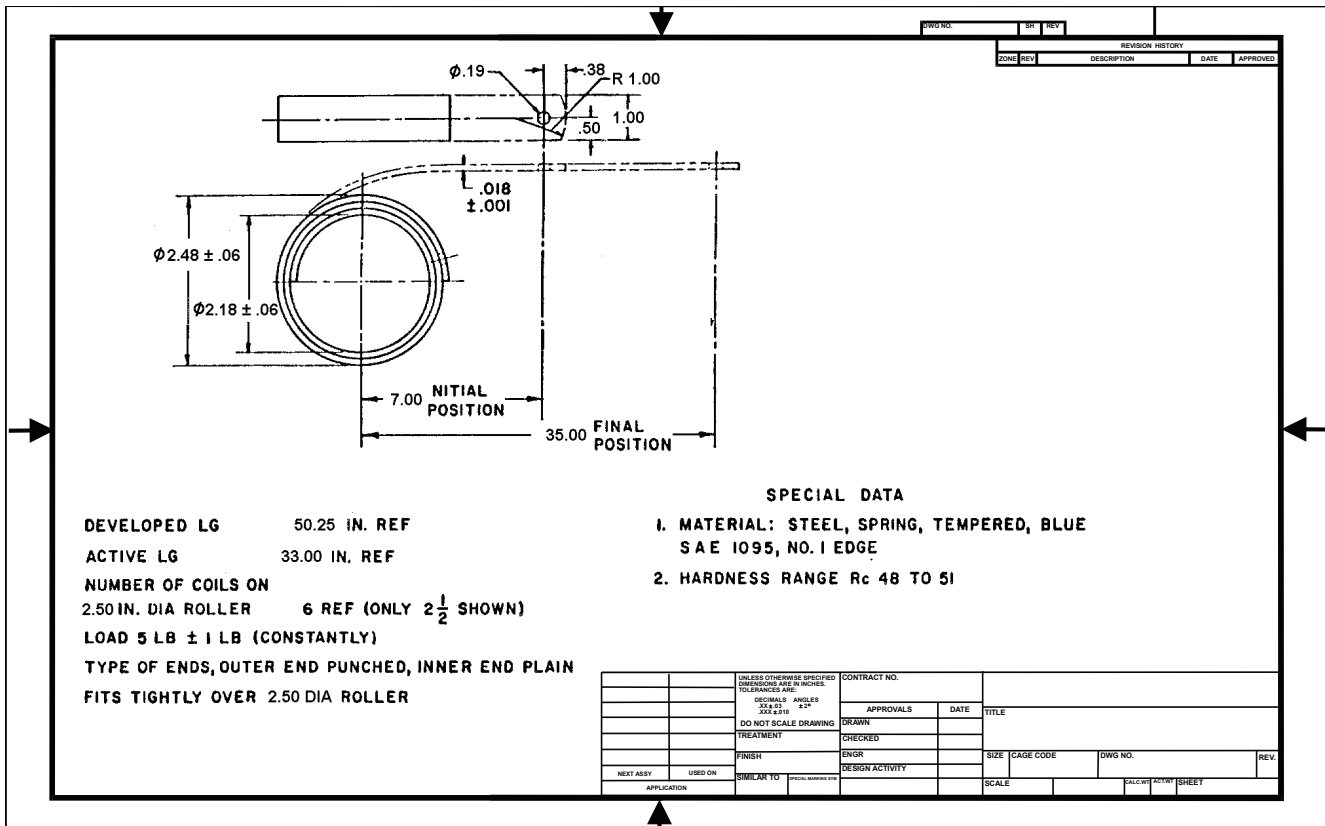
TYPICAL MONO-DETAIL DRAWING OF A FLAT SPRING
 FIGURE 3-54



f. Constant Load-Flat Spring. See TABLE 3-13. For typical mono-detail drawing, See FIGURE 3-55.

CONSTANT LOAD FLAT SPRING	DRAWING REQUIREMENTS
 <ul style="list-style-type: none"> • OTHER INFO REQD: MATL SPEC • MATL SIZE: .XXX IN. THICK .XX IN. WIDE • DEVELOPED LENGTH = XX REF. • ACTIVE LENGTH = XX IN. REF • NUMBER OF COILS = XX REF • CONSTANT LOAD = XX LB ± XX LB • SPECIAL DATA (See PARA 3.11.2) 	<ol style="list-style-type: none"> 1. Specify the load as uniformly constant in pounds with a tolerance. 2. Specify the initial and final position without a tolerance. 3. Outer ends should be completed delineated on the drawing as punched hole, slotted or formed for fastening purposes. 4. Inner end must be free to rotate over a pulley or roller. 5. Specify the pulley or roller diameter usually 15 to 20% larger than the inside diameter of the spring and should be so noted on the drawing.

FLAT SPRING USED IN CONSTANT LOAD
TABLE 3-13



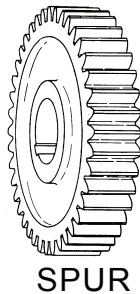
TYPICAL MONO-DETAIL DRAWING OF A CONSTANT LOAD SPRING
FIGURE 3-55

3.12 GEAR DRAFTING PRACTICE.

The drafting practice of gears described herein is limited only to the variety of gears depicted and are meant only to portray gears in use, assembly, their relationship to each other as their shafts may be parallel or in an angular relationship their axes may be intersecting or non-intersecting. Their design and detail drawings are best left to Gear Drawing Standards, ASME Y14.7.1 (INACTIVE) Part 1 and gear and Spline Drawing Standard, ASME Y14.7.2 (INACTIVE) Part 2 for this complex subject. Determination must be made whether the gear manufacturer is obligated to make the gear pass certain running or functional tests, a simple detail gear drawing is prepared with performance requirements stated. When a detail drawing of a gear is fully dimensioned, responsibility for the gear's performance is that of the design activity.

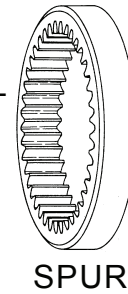
3.12.1 Types of gears. The types of gears most commonly used are described as:

- a. Spur
 - 1. External
 - 2. Internal



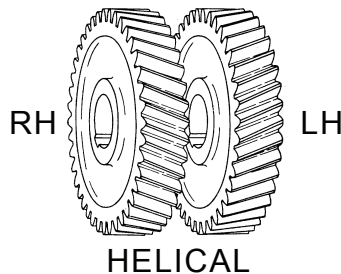
EXTERNAL

INTERNAL



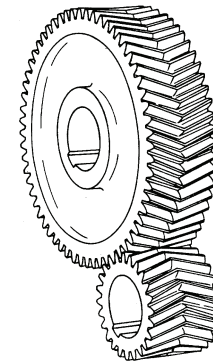
SPUR

- b. Helical or Herringbone
 - 1. External
 - 2. Internal



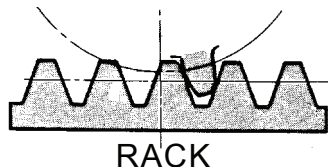
HELICAL

- c. Double Helical or Herringbone
 - 1. External
 - 2. Internal



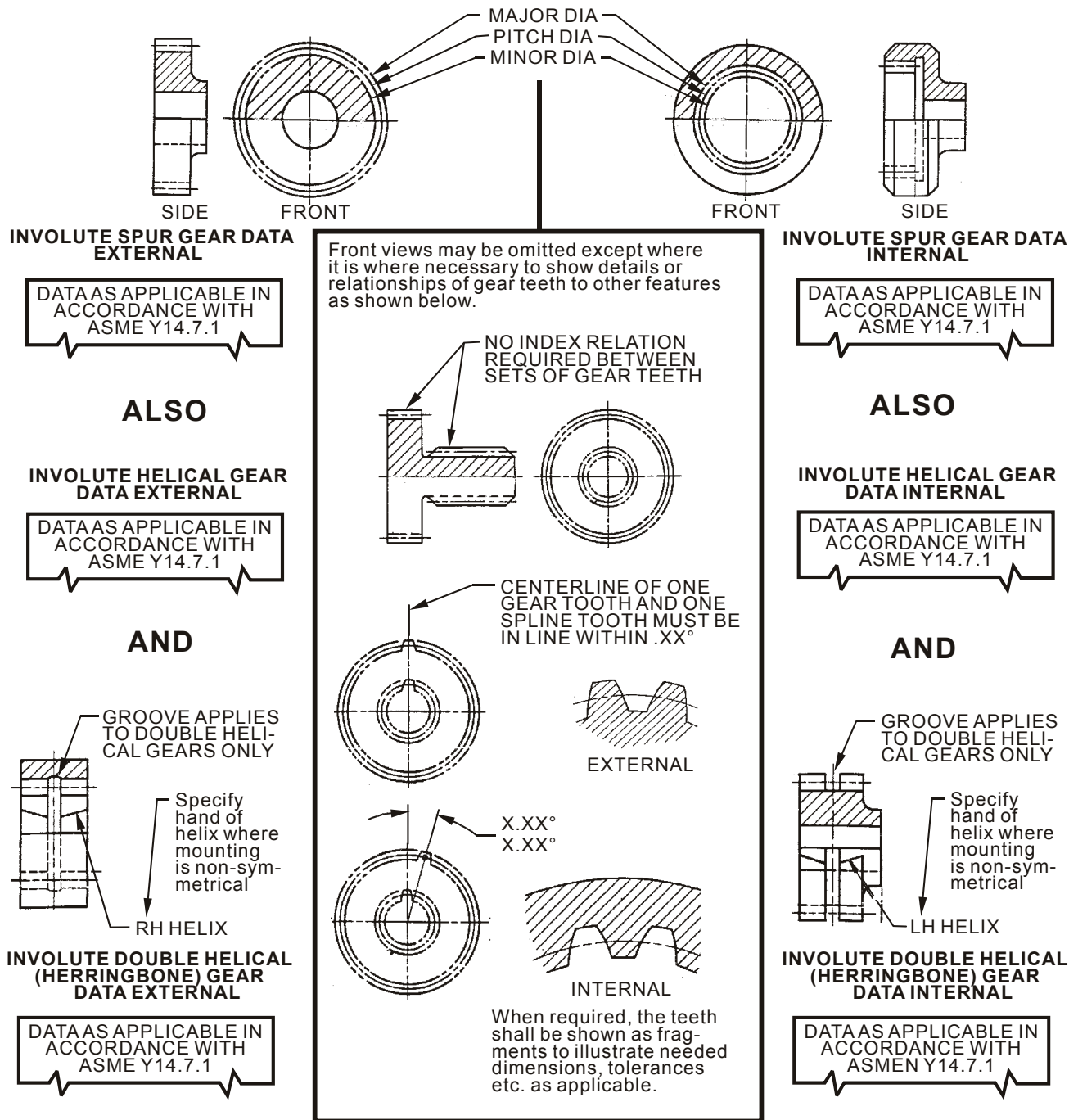
HERRINGBONE

- d. Racks
 - 1. Spur
 - 2. Helical



RACK

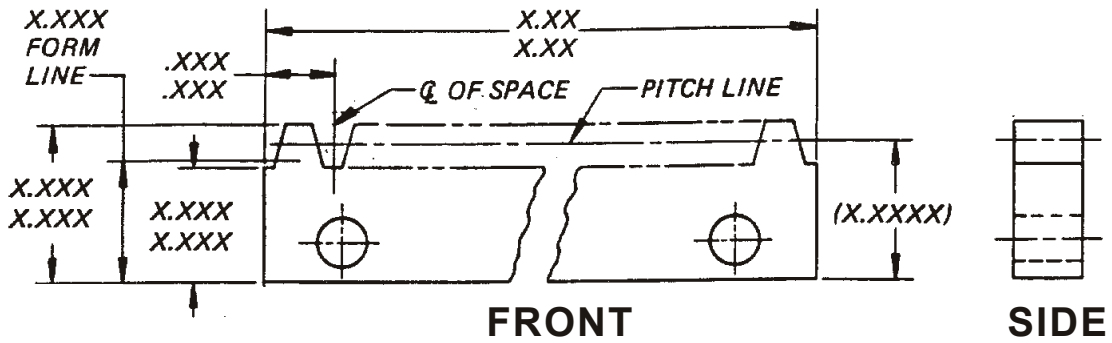
3.12.2 Simplified Drafting Practice The repetitive details of gear teeth are depicted using simplified drafting practices, whether they rotate to transmit power and/or angular motion between shafts or convert circular motion to rectilinear motion or vice versa. Simplified drafting practices may be used to show none, one or two teeth outlines as needed for orientation with other features of the gear and provide dimensions and tolerances as required. See FIGURES 3-56 and 3-57.



Note: ASME Y14.7.1 is Inactive.

DRAWING PRESENTATION OF CIRCULAR MOTION SPUR AND HELICAL GEARS

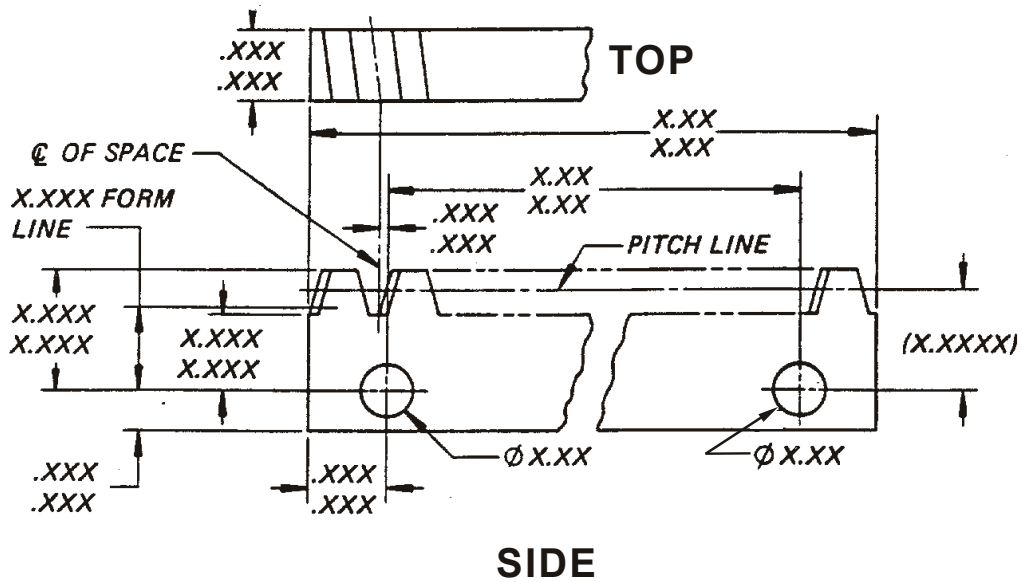
FIGURE 3-56



SPUR RACK DATA

DATA AS APPLICABLE IN ACCORDANCE WITH ASME Y14.7.1

AND



HELICAL RACK DATA

DATA AS APPLICABLE IN ACCORDANCE WITH ASME Y14.7.1

DRAWING PRESENTATION OF RECTILINEAR MOTION SPUR AND HELICAL GEARS

FIGURE 3-57

3.13 DESCRIPTIVE GEOMETRY.

3.13.1 This section is included to provide standard practices in the use of descriptive geometry on engineering drawings. The adoption of these methods of construction and the common use of the various terms will greatly facilitate the interpretation of drawings, particularly those involving several projections. Note: Even though the material shown in this section is depicted using manual techniques, it is still pertinent and important for CAD-based applications.

3.13.2 Fundamental Principles.

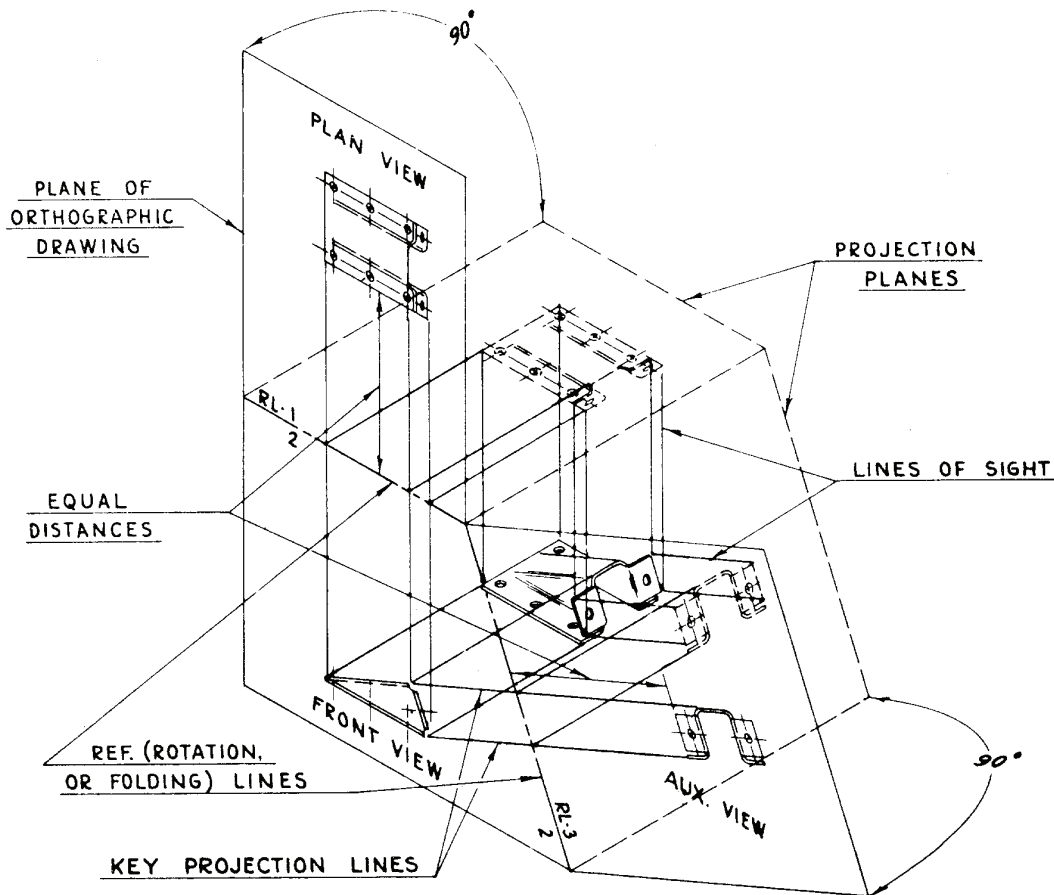
3.13.2.1 In third angle projection, the plane is always between the object and the observer.

3.13.2.2 Projection planes for views are always rotated into the plane of the drawing through a 90 degree angle. Rotation takes place about lines which may be visualized as hinges between adjacent projection planes. These lines are variously referred to as reference lines, rotation lines, or folding lines; hereafter, called reference lines.

3.13.2.3 Considering each view separately, the reference lines represent edge views of other projection planes.

3.13.2.4 The lines of sight from the object to each projection plane are parallel to each other and perpendicular to the projection plane.

3.13.2.5 Perpendicular distances from the projection plane to the object are equal in all views taken perpendicular to that plane. See FIGURE 3-58.



DESCRIPTIVE GEOMETRY FUNDAMENTALS
 FIGURE 3-58



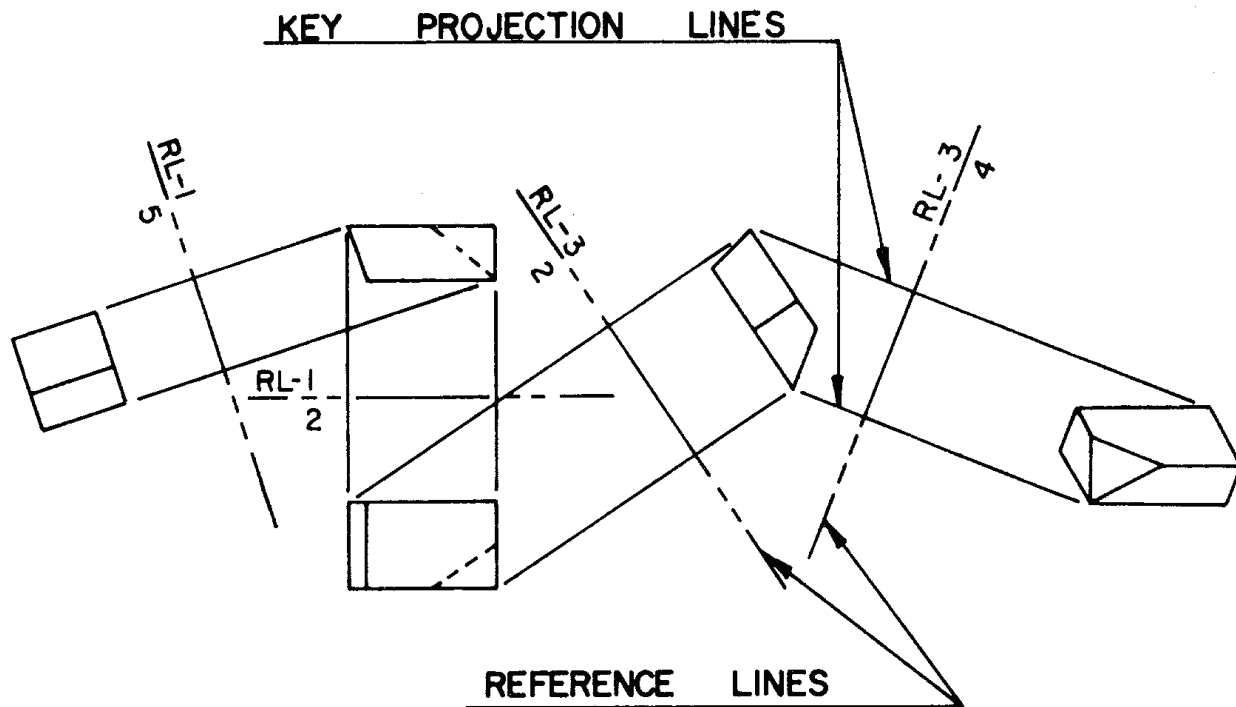
3.13.3 Use Of Reference Lines On Drawings. See FIGURE 3-59.

3.13.3.1 The drawing shown in FIGURE 3-59 and succeeding problems illustrate the principles of descriptive geometry, and show the reference (rotation or folding lines) between all views. The reference lines, if used on releasable drawings, should be temporary construction lines only and should not appear on the finished drawing. They need not remain on layouts for the conventional views (plan, front, side) or where a single auxiliary view is projected from a normal view. The key projection lines for all auxiliary views should, however, remain on both releasable drawings and layouts. On layouts where two or more oblique views are taken in succession, the reference lines should be shown as a phantom line and labeled as shown in FIGURE 3-59.

3.13.3.2 Notice that this manner of labeling the reference lines tells three things:

- a. Identifies the line as a reference line between views.
- b. Identifies the views on either side of the line.
- c. Identifies the order in which views are drawn.

3.13.3.3 Where reference lines remain on the layout labeled as above, the views need not be otherwise identified; however, if a view cannot be directly projected due to lack of space and must be located elsewhere on the drawing, then the conventional method of cutting a view plane and cross-referencing the view shall be used.



DESCRIPTIVE GEOMETRY REFERENCE LINES

FIGURE 3-59

3.13.4 PROBLEM 1: To Find the True Length of a Line. See FIGURE 3-60.

3.13.4.1 A line will show in its true length when projected onto a plane which is parallel to the line in space. When two views of a line are given, neither of which is a true view, a third view may be constructed which will show the true length. This is done by drawing a reference line (edge view of the new projection plane) parallel to one of the given views and projecting the line onto that plane.

3.13.4.2 In FIGURE 3-60 draw RL-2/3 parallel to A_2B_2 . Draw projection lines through end points A_2 and B_2 at 90° to the reference line. Set off distance from RL-2/3 to A_2 equal to distance from RL-1/2 to A_1 . Also, set off distance to B_3 equal to distance to B_1 . It should be noted that distances required to construct a view are obtained from the second proceeding view. This is a general rule to be followed in all descriptive geometry problems. Draw true length A_3B_3 .

PROBLEM 1A. TO FIND TRUE ANGLE

GIVEN: θ & B

$$\tan \alpha = \frac{x}{y}$$

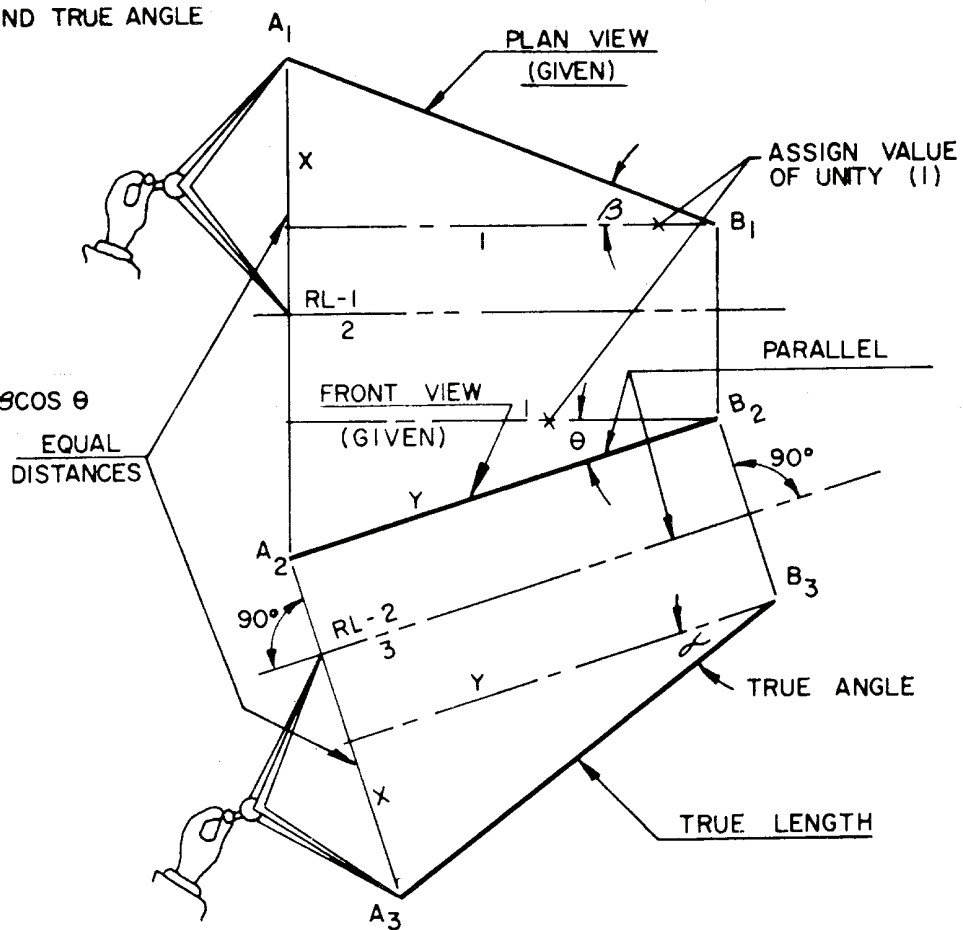
$$\tan \beta = \frac{x}{1}$$

$$x = \tan \beta$$

$$\cos \theta = \frac{1}{y}$$

$$y = \frac{1}{\cos \theta}$$

$$\tan \alpha = \frac{\tan \beta}{\frac{1}{\cos \theta}} = \tan \beta \cos \theta$$



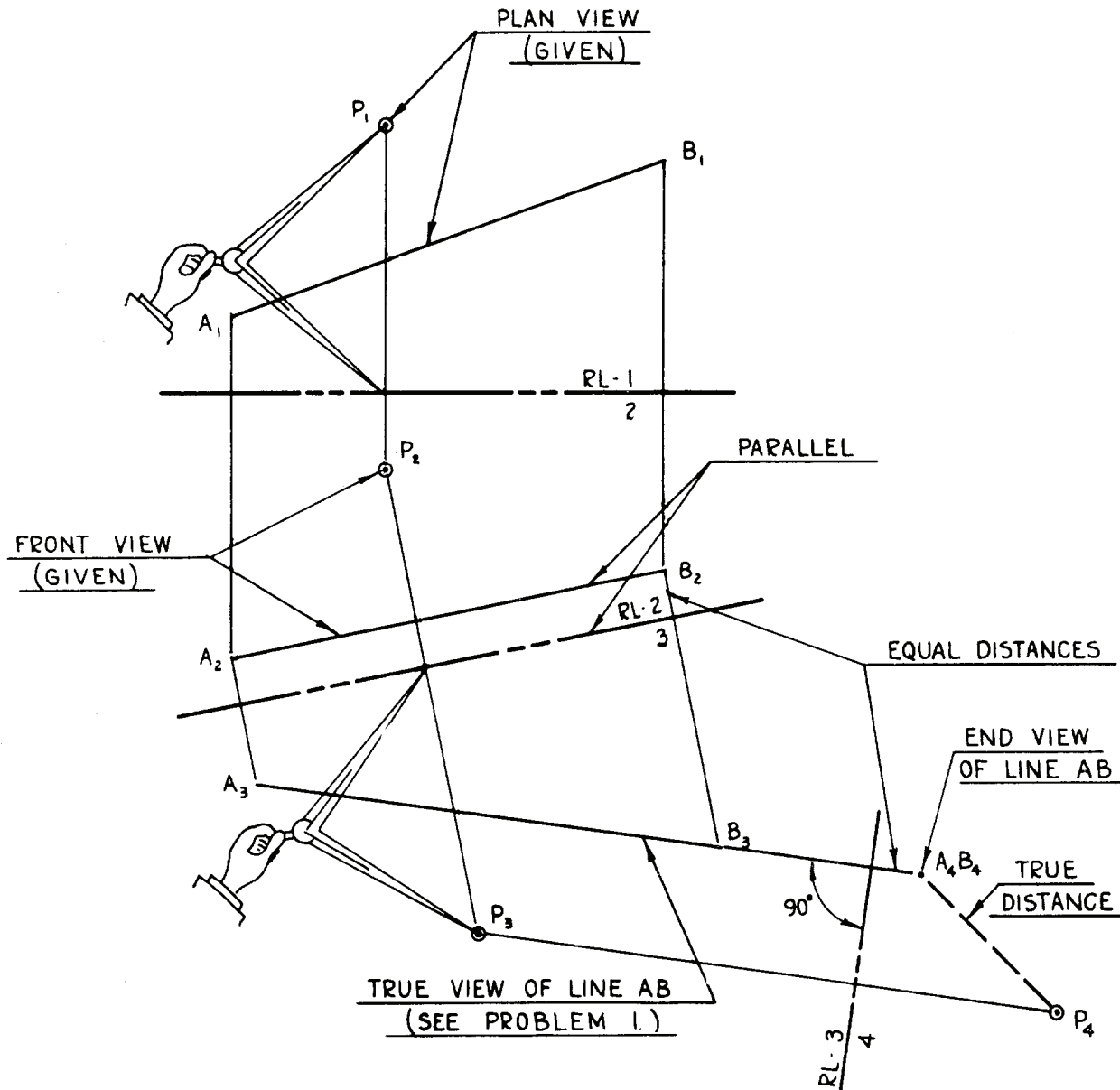
TRUE LENGTH OF LINE AND TRUE ANGLE
 FIGURE 3-60



3.13.5 PROBLEM 2: To Find the Perpendicular Distance from a Point to a Line. See FIGURE 3-61.

3.13.5.1 The true perpendicular distance from a point to a line will show in a projection which gives an end view of the line (where the line would also appear as a point.)

3.13.5.2 Construct the true view of line A_3B_3 , as explained in Problem 1. Draw a reference line RL-3/4 perpendicular to A_3B_3 . The line, when projected onto this plane, will show as a point A_4B_4 . Project the point P into the 3rd and 4th views, obtaining distances from reference lines each time from the second preceding view. True distance is shown by dashed line $P_4A_4B_4$.

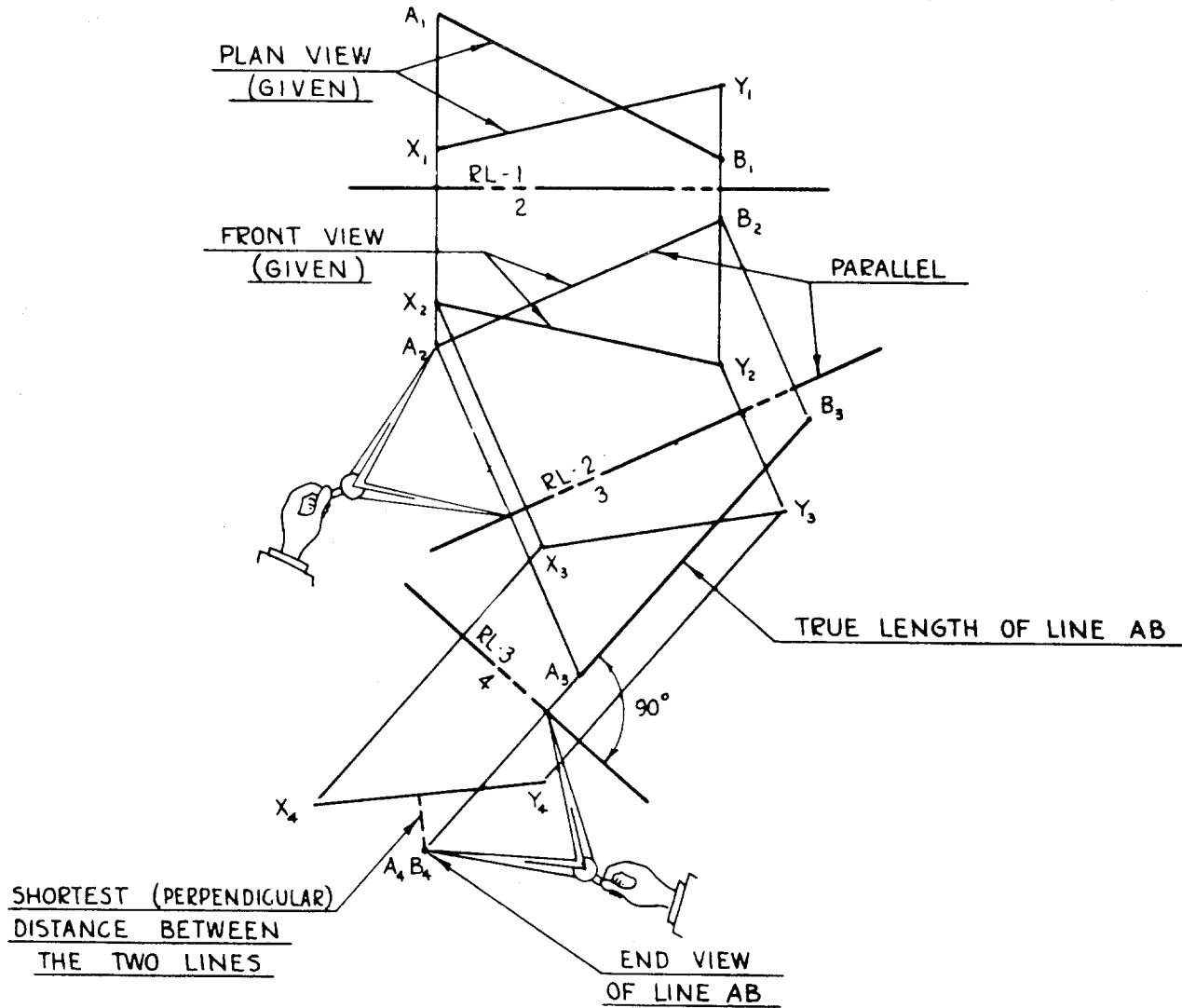


PERPENDICULAR DISTANCE POINT TO LINE
FIGURE 3-61

3.13.6 PROBLEM 3: To Find the Shortest Distance Between Two Non-Intersecting Straight Lines. See FIGURE 3-62.

3.13.6.1 The shortest distance between two non-intersecting straight lines will show in a projection giving the end view of either line.

3.13.6.2 Construct the end view A_4B_4 of line AB, as explained in Problem 2. Project the other line XY into the 3rd and 4th views. The shortest distance will now show as perpendicular from the point A_4B_4 to the line X_4Y_4 . (Note: X_4Y_4 is not a true length.)



SHORTEST DISTANCE NON-INTERSECTING LINES
 FIGURE 3-62

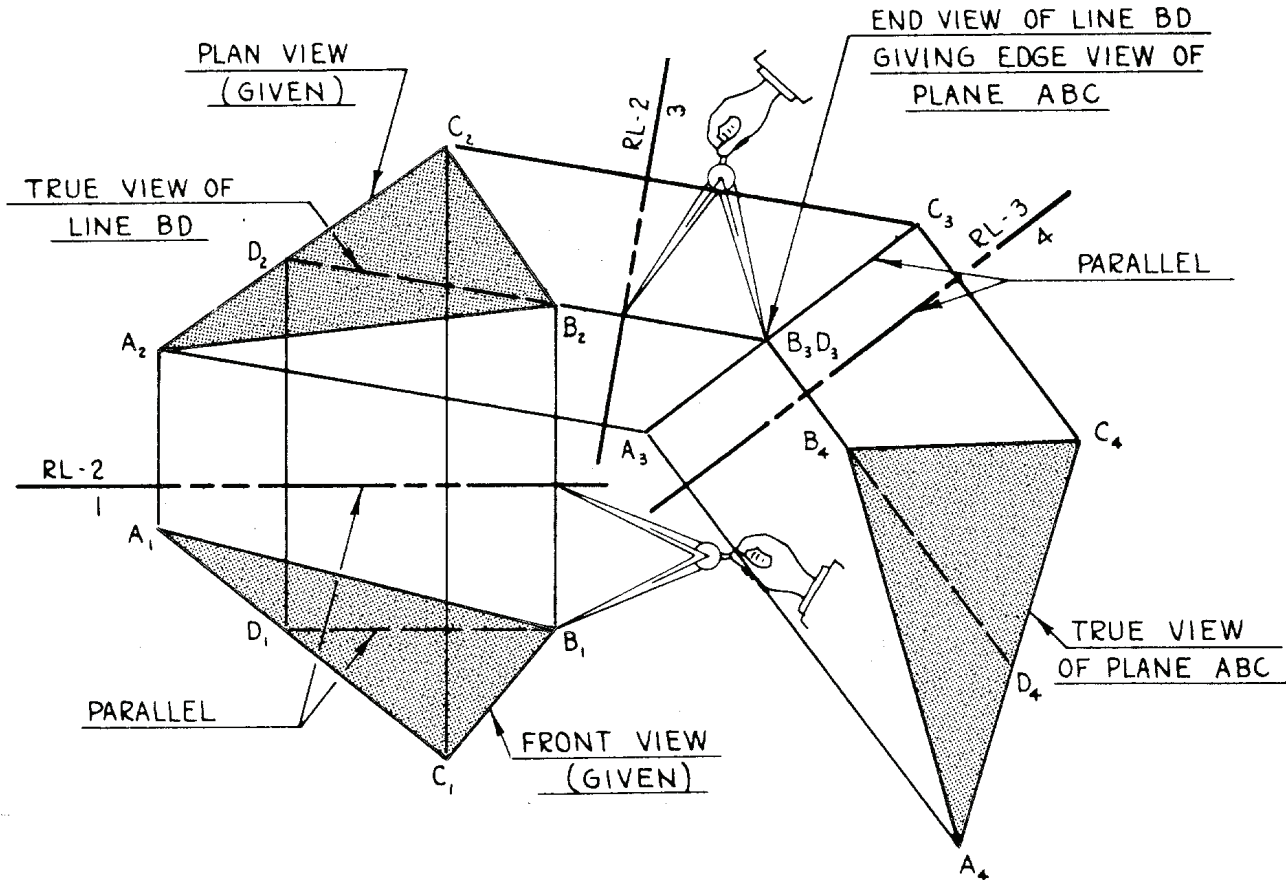
3.13.7 PROBLEM 4: To Find the True View of a Plane. See FIGURE 3-63.

3.13.7.1 A plane will show in its true size and form when projected onto a plane which is parallel to it. To do this, first obtain an edge view. The end view of any line in the plane will give an edge view of the plane.

3.13.7.2 This could be done by constructing an end view of any of the three boundary lines AB, AC, or CB. It can be done with one less view, however, by choosing an arbitrary line B_1D_1 which lies on the plane ABC and which is parallel to RL-2/1.

3.13.7.3 Since the front view B_1D_1 of the line BD is parallel to the projection plane of the plan view, the plan view B_2D_2 of line BD is a true length. The next projection is onto a plane perpendicular to this true length B_2D_2 and gives an end view of the line and, therefore, an edge view $A_3B_3C_3$ of the plane. The true view of the plane can now be projected onto a plane parallel to $A_3B_3C_3$.

3.13.7.4 The same results could be obtained by choosing the arbitrary line in the plane view parallel to RL-2/1. The true length would then appear in the front view from which an edge view of the plane could be projected and, therefore, a true view.

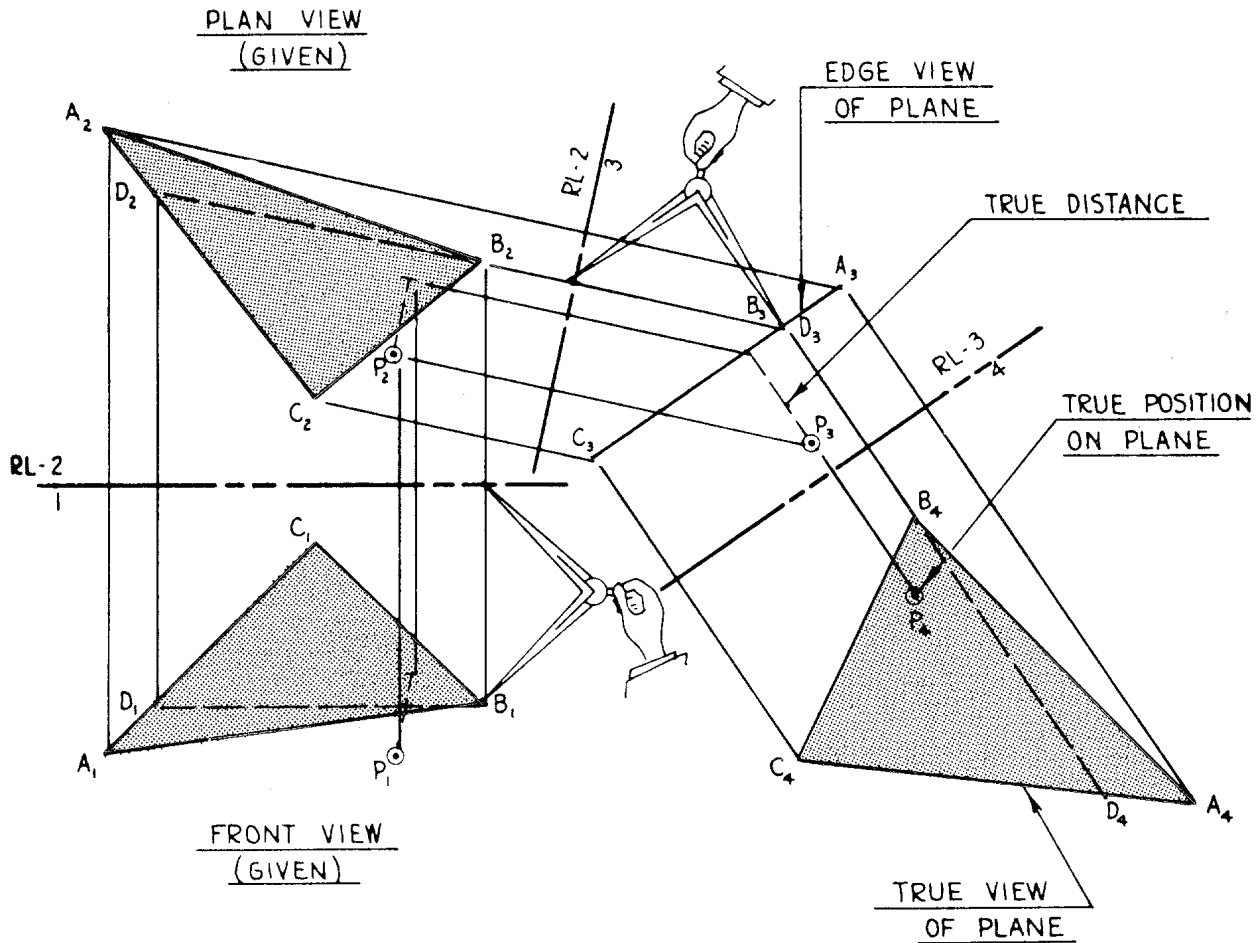


TRUE VIEW OF A PLANE
 FIGURE 3-63

3.13.8 PROBLEM 5: To Find True distance from a Point to a Plane and Locate Projection of the Point on the Plane. See FIGURE 3-64.

3.13.8.1 Construct edge view and true view of plane as explained in Problem 4. Project the point P into these views. The true distance shows as a perpendicular line from P_3 to the edge view of the plane $A_3B_3C_3$.

3.13.8.2 The intersection of this line with the plane can now be projected back into the plane and front views to locate the projection of the point on the plane in these views. The true position of the point projected on the plane shows in the true view of the plane at P_4 .

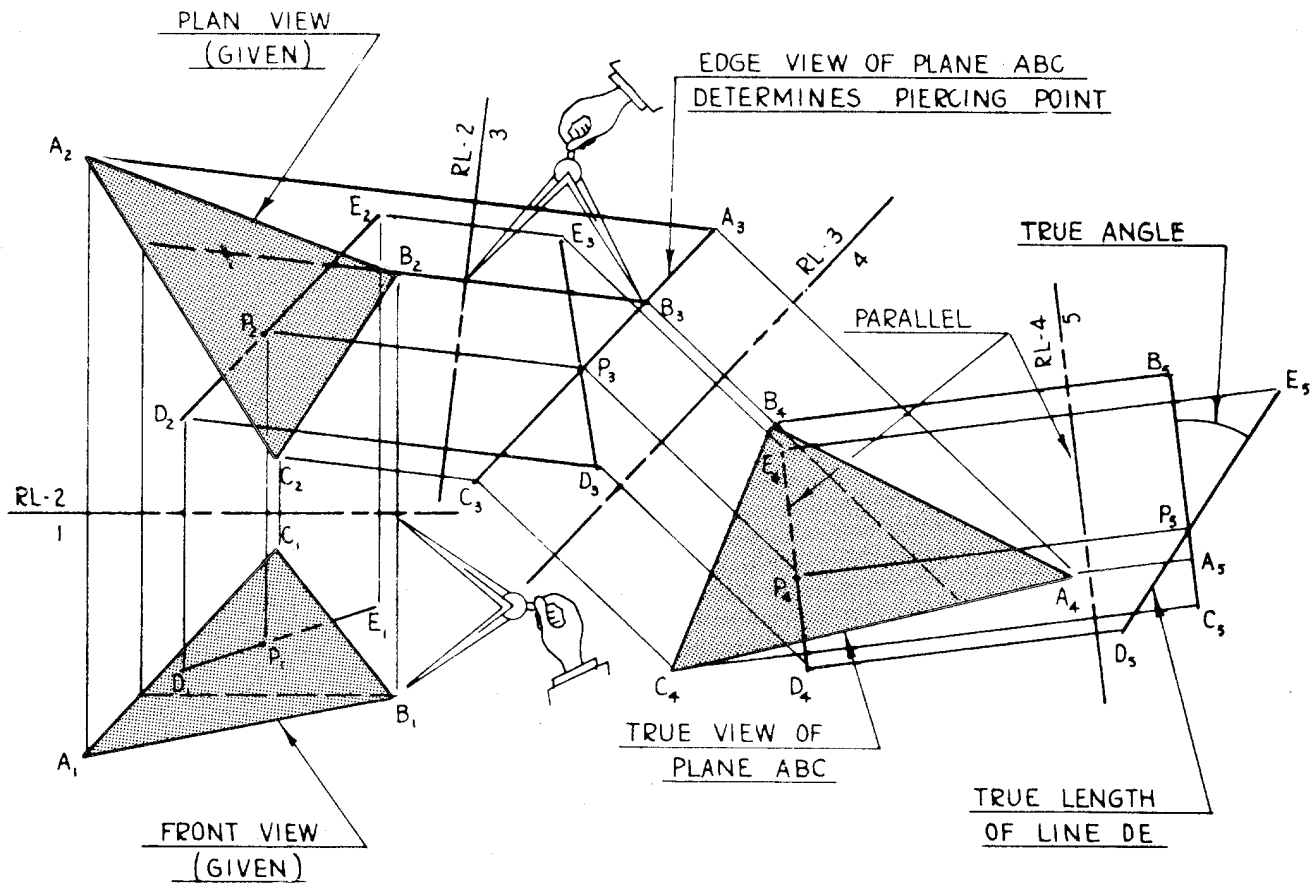


TRUE DISTANCE POINT TO PLANE AND PROJECTION OF POINT
FIGURE 3-64

3.13.9 PROBLEM 6: To Find the True Angle Between a Line and a Plane and Locate the Point Where the Line Pierces the Plane. See FIGURE 3-65.

3.13.9.1 The true angle between the line and the plane will show in an edge view of the plane taken in such a manner as to also show the true length of the line. The piercing point may be determined from any edge view.

3.13.9.2 First construct the edge view and true view of the plane as explained in Problem 4 and project the line DE into these views. The piercing point P_3 may now be projected back to the plan and front views. To get the true angle, construct a fifth view. Draw reference line RL-4/5 parallel to D_4E_4 . Project the line and plane into this view. This will give another edge view of the plane, which also shows the true length D_5E_5 of the line and, therefore, shows the true angle.

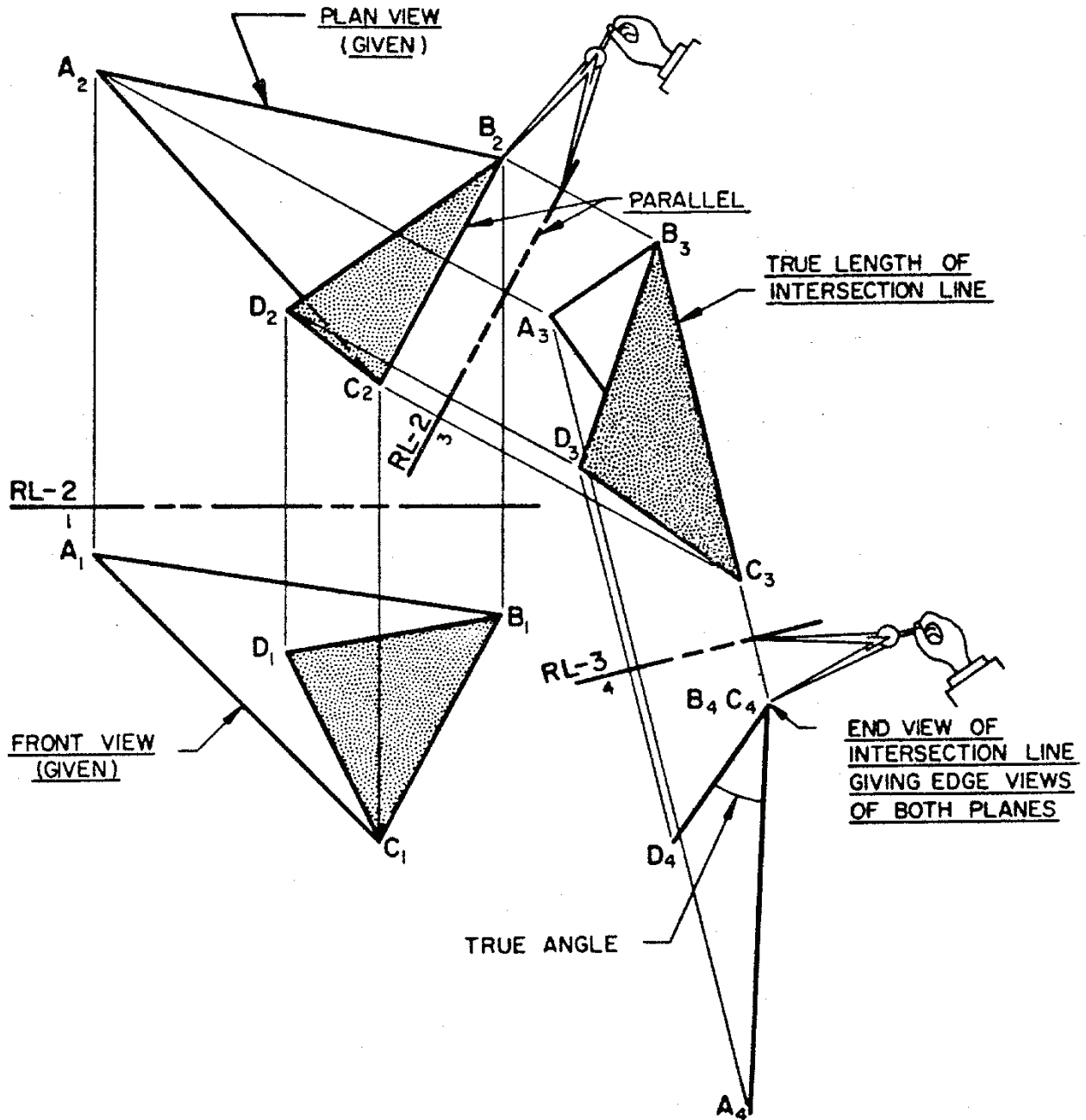


TRUE ANGLE LINE AND PLANE AND PIERCING POINT
FIGURE 3-65

3.13.10 PROBLEM 7: To Find the True Angle Between Two Planes, Intersection Line Known. See FIGURE 3-66.

3.13.10.1 The true angle between the two planes will show in a view which gives the edge view of both planes. Since the intersection line is common to both planes, the end view of the intersection line will show the edge view of both planes.

3.13.10.2 Construct the true view, B_3C_3 and end view, B_4C_4 of line BC as explained in Problems 1 and 2. Project the other points necessary to draw the planes into these views. The true angle may now be measured between the edge views $D_4B_4C_4$ and $A_4B_4C_4$.



TRUE ANGLE BETWEEN PLANES INTERSECTION KNOWN
 FIGURE 3-66

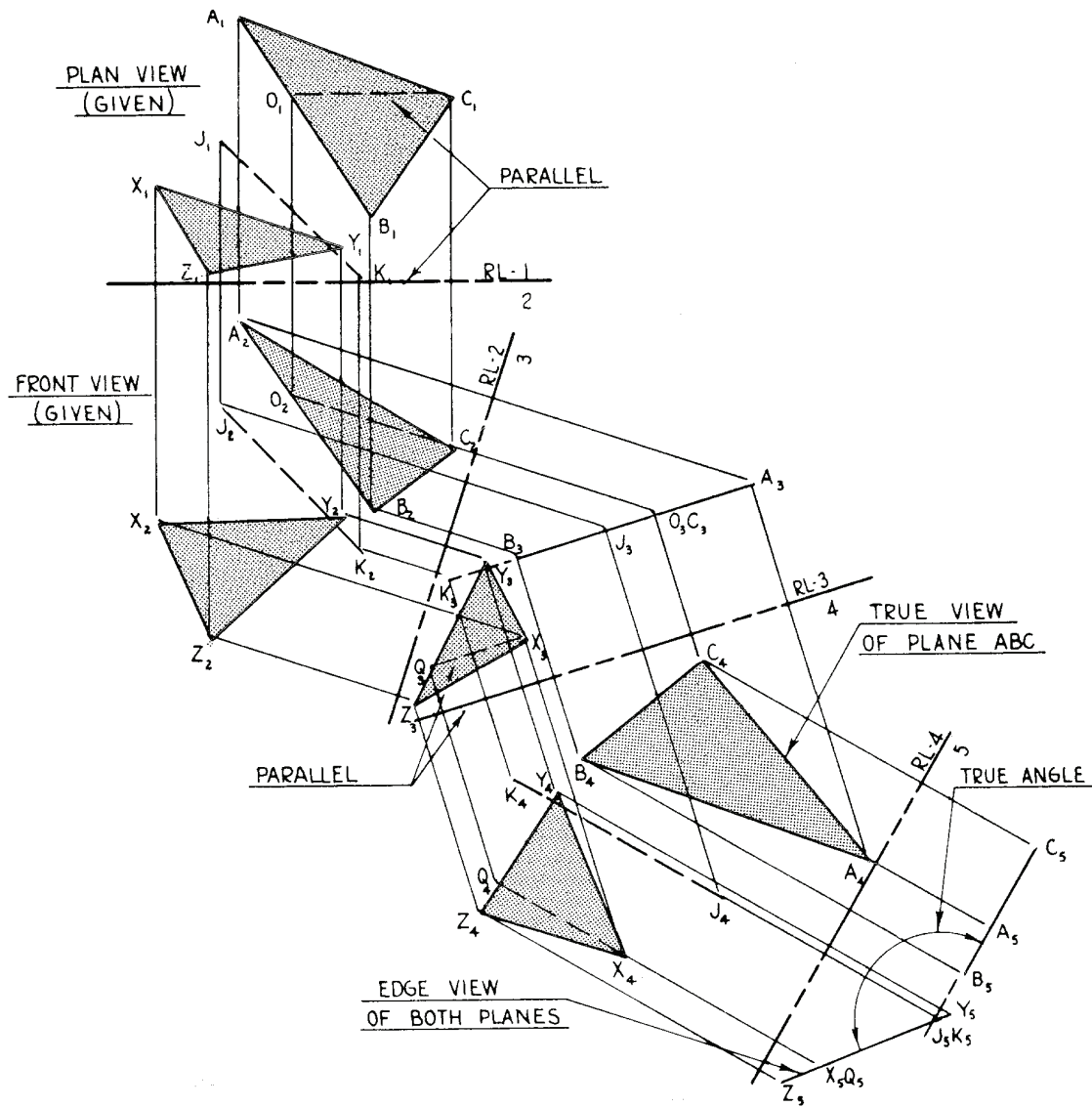


3.13.11 PROBLEM 8: To Find the True Angle Between Two Planes, Intersection Line Not Known. See FIGURE 3-67.

3.13.11.1 Since the intersection line is not given, the method described in Problem 7 cannot be used.

3.13.11.2 Construct the edge view and true view of plane ABC as explained in Problem 4. Now any view taken off the true view $A_4B_4C_4$ will give an edge view of this plane but the one which also gives an edge view of plane XYZ needs to be selected. Now apply the same principle to plane XYZ in views 3, 4, and 5 as plane ABC in views 1, 2, and 3, by drawing Q_3X_3 parallel to $RL-3/4$. This gives a true length Q_4X_4 and, therefore, the edge view $Z_5X_5Y_5$. Now construct the edge view $B_5A_5C_5$ of the other plane in this view and obtain the true angle.

3.13.11.3 If the intersection line of the two planes is required in the plan and front views, it may be obtained by projecting back from the end view J_5K_5 of the intersection in the last view. This gives a true view of the line in View 4. Any two points J_4K_4 on the line may now be projected into views 3, 2, and 1 to determine the line in the original views.

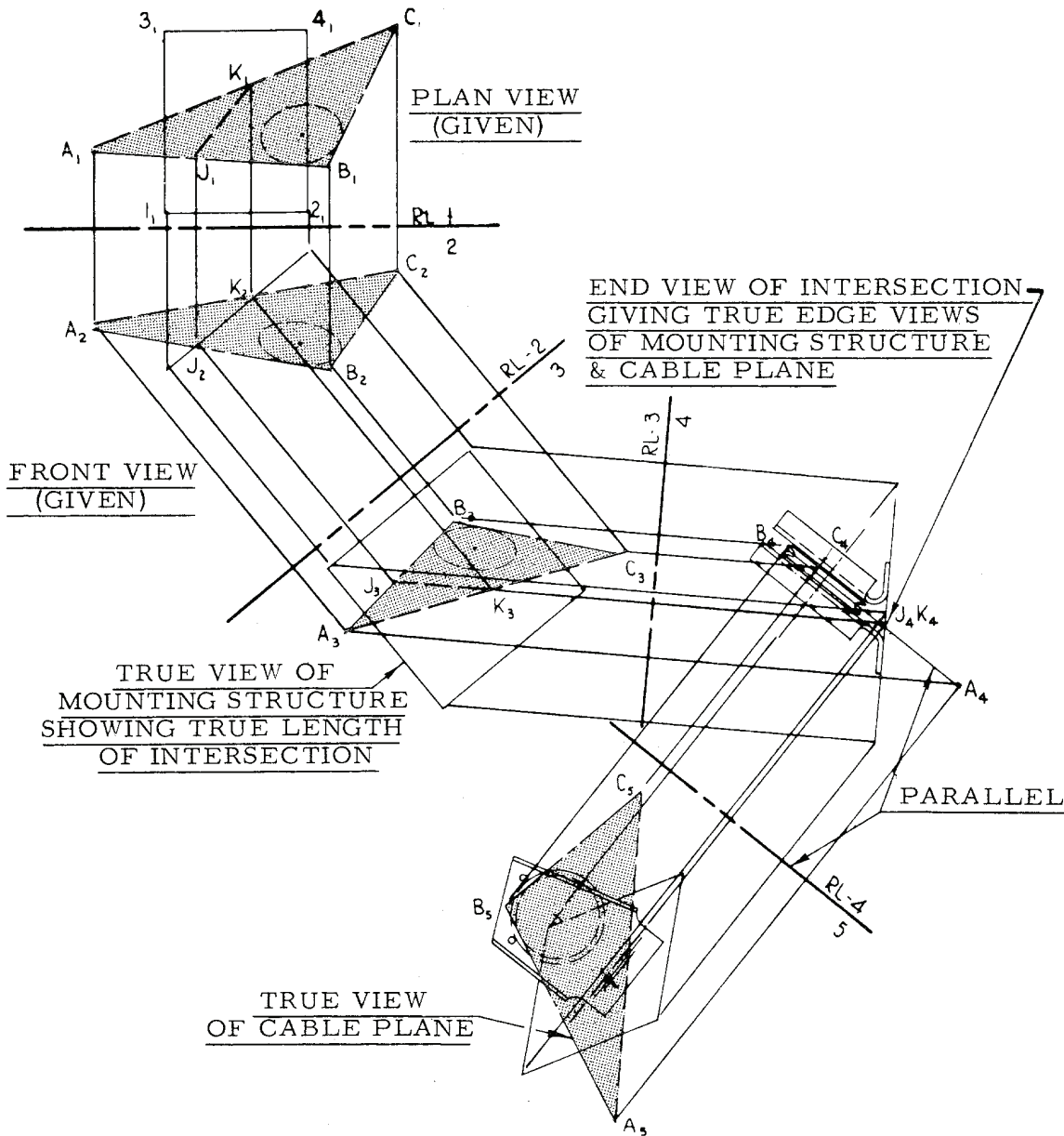


TRUE ANGLE BETWEEN PLANES INTERSECTION NOT KNOWN
FIGURE 3-67

3.13.12 PULLEY BRACKET LAYOUT. See FIGURE 3-68.

3.13.12.1 The pulley bracket problem in FIGURE 3-68 illustrates a common application of some of the foregoing principles of descriptive geometry. Given is the plane of the mounting structure 1, 2, 3, 4 and, the cable plane ABC. It is desired to obtain a view which shows the edge views of both planes and also a true view of the cable plane in order to design the bracket.

3.13.12.2 Notice that since the edge view of the mounting structure was given in the front view, a true view of this plane can be obtained which also shows the true length J_3K_3 of the intersection line in the first auxiliary view taken (view 3). The edge view (view 4) can now be obtained by projecting onto a plane perpendicular to J_3K_3 . The true view of the cable plane is then projected onto a plane parallel to A_4B_4 .



PULLEY BRACKET LAYOUT
FIGURE 3-68



NOTES: