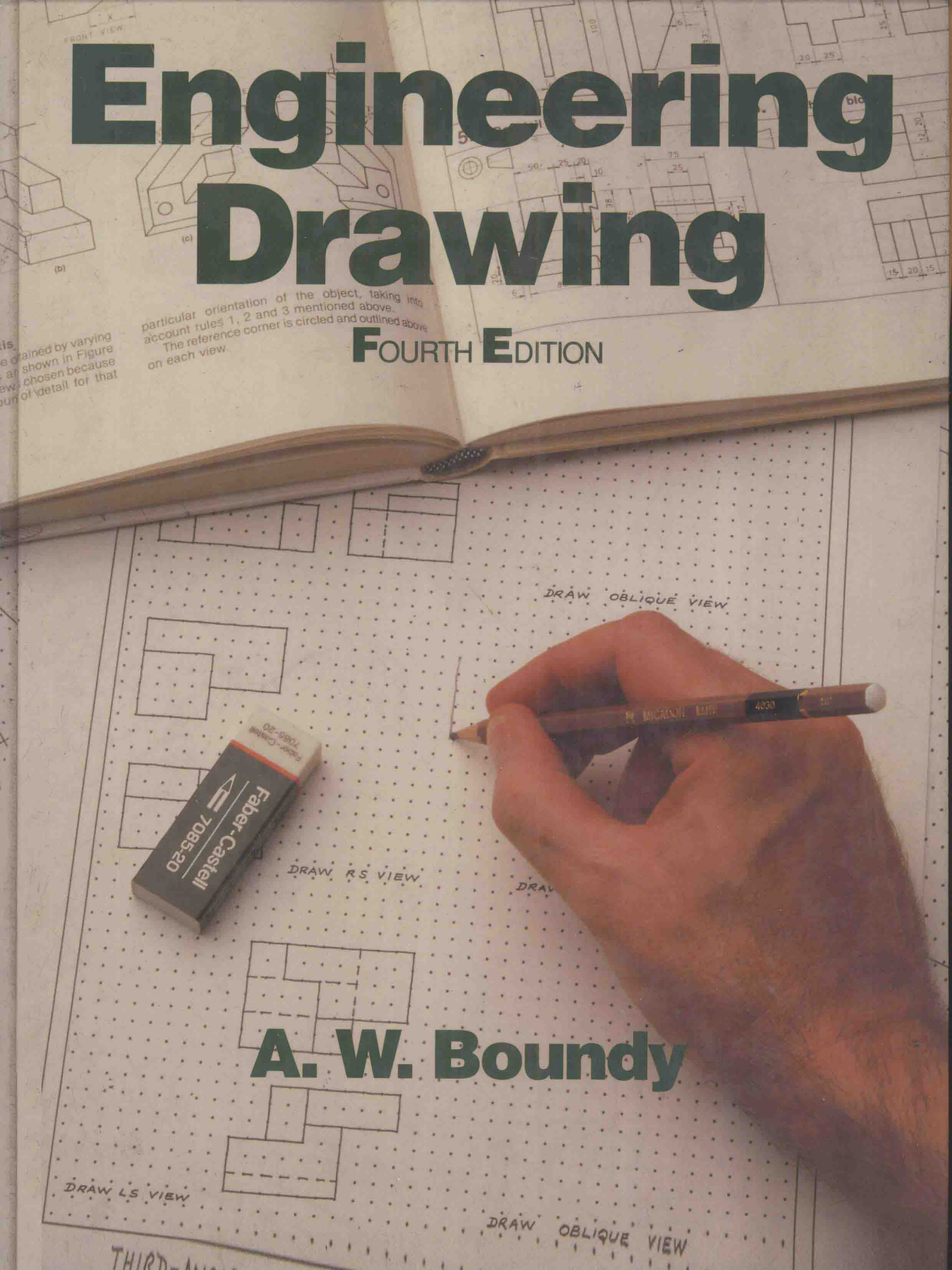
Engineering Drawing

FOURTH EDITION



A. W. Boundy

Engineering Drawing

FOURTH EDITION

A. W. Boundy

AssDipMechEng, MPhil

Lecturer
School of Engineering
University of Southern Queensland

McGRAW-HILL BOOK COMPANY Sydney
New York San Francisco Auckland Bogotá
Caracas Lisbon London Madrid Mexico City
Milan Montreal New Delhi San Juan
Singapore Tokyo Toronto

Second edition 1980
Reprinted 1981 (twice), 1982, 1983, 1984, 1985, 1986
Third edition 1987
Reprinted 1988, 1989, 1990, 1991
Fourth edition 1992

National Library of Australia Cataloguing-in-Publication data:

Boundy, A. W. (Albert William)
Engineering drawing.

4th ed.
Includes index.
ISBN 0 07 452947 1.

1. Mechanical drawing. I. Title.

604.2

Produced in Australia by McGraw-Hill Book Company Australia Pty Limited
4 Barcoo Street, Roseville, NSW 2069
Typeset in Australia by Midland Typesetters Pty Ltd
Printed in Australia by Macarthur Press

Sponsoring Editor: Barry McCarthy
Production Editor: Valerie Marlborough
Designer: George Sirett

Preface

This book has been written for students of Engineering Drawing. Two features of the book will, I hope, make the subject easier to understand and use of the text beneficial.

First, lengthy explanatory detail has been reduced to a minimum, with the step-by-step method of instruction being used wherever possible.

Second, the problem format is that of examination questions, giving the student essential practice in this approach.

Emphasis has been placed on providing a large number and wide variety of problems for the various topics dealt with. Therefore, a complete instructional and practical syllabus can be prepared to a content depth consistent with prescribed course objectives.

Several reference tables commonly used by drafters have been included so that students may gain knowledge and practice in their use when solving the problems. The tables, along with other information, make the book a valuable reference for practising drafters and engineers.

The fourth edition has been revised throughout to conform to current Australian Standards.

A number of the diagrams and tables in this book are based on Australian Standard 1100.*201-84, and the publishers acknowledge with thanks the consent of Standards Australia to freely reproduce them.*

Contents

1 Introductory and standards information

Engineering drawing is the main method of communication between all persons concerned with the design and manufacture of components; the building and construction of works; and engineering projects required by management or professional engineering staff.

The practice of drawing is in many ways so repetitive that, in the interests of efficient communication, it is necessary to standardise methods to ensure the desired interpretation.

Standards Australia has recommended standards for drawing practice in all fields of engineering, and these are set out in their publications Australian Standard (AS) 1100 *(Technical drawing) Parts 101 (General principles) and 201 (Mechanical drawing).*

This section presents the standards which are relevant to mechanical drawing, and provides other introductory information that is often required by drafters and students.

Standard abbreviations

The abbreviations in Table 1.1 have been selected from the more comprehensive list found in *AS 1100* Part 101, and are those which are commonly used on mechanical engineering drawings.

Table 1.1 Standard abbreviations

Term	*Abbreviation*	*Term*	*Abbreviation*
A		diamond pyramid hardness number (vickers)	HV
abbreviation	ABBR	dimension	DIM
absolute	ABS	distance	DIST
across flats	AF	drawing	DRG
addendum	ADD	**E**	
approximate	APPROX	elevation	ELEV
arrangement	ARRGT	equivalent	EQUIV
assembly	ASSY	external	EXT
assumed datum	ASSD	**F**	
automatic	AUTO	figure	FIG
auxiliary	AUX	fillister head	FILL HD
average	AVG	flange	FLG
B		flat	FL
bearing	BRG	**G**	
bottom	BOT	galvanise	GALV
bracket	BRKT	galvanised iron	GI
brass	BRS	galvanised-iron pipe	GIP
building	BLDG	general arrangement	GA
C		general-purpose outlet	GPO
capacity	CAP	geometric reference frame	GRF
cast iron	CI	grade	GR
cast-iron pipe	CIP	grid	GD
cast steel	CS	**H**	
centre line	CL	head	HD
centre of gravity	CG	height	HT
centre-to-centre, centres	CRS	hexagon	HEX
chamfer	CHAM	hexagon head	HEX HD
channel	CHNL	hexagon-socket head	HEX SOC HD
cheese head	CH HD	high strength	HS
chrome plated	CP	high-tensile steel	HTS
circle	CIRC	horizontal	HORIZ
circular hollow section	CHS	**I**	
circumference	CIRC	inside diameter	ID
coefficient	COEF	internal	INT
cold-rolled steel	CRS	**J**	
computer-aided design and drafting	CAD	joint	JT
computer-aided manufacture	CAM	junction	JUNC
concentric	CONC	**L**	
contour	CTR	least material condition	LMC
corner	CNR	left hand	LH
counterbore	CBORE	length	LG
countersink	CSK	longitudinal	LONG
countersunk head	CSK HD	**M**	
cross-recess head	C REC HD	machine	M/C
cup head	CUP HD	malleable iron	MI
cylinder	CYL	material	MATL
D		maximum	MAX
dedendum	DED	maximum material condition	MMC
detail	DET	mechanical	MECH
diagonal	DIAG	mild steel	MS
diagram	DIAG		
diameter	DIA		
diametral pitch	DP		

Term	*Abbreviation*
minimum	MIN
modification	MOD
modulus of elasticity	E
modulus of section	Z
moment of inertia	I
mounting	MTG
mushroom head	MUSH HD
N	
negative	NEG
nominal	NOM
nominal size	NS
not to scale	NTS
number	NO
O	
octagon	OCT
outside diameter	OD
P	
parallel	PAR
part	PT
pattern	PATT
pipe	P
pipeline	PL
pitch-circle diameter	PCD
phosphor bronze	PH BRZ
position	POSN
positive	POS
prefabricated	PREFAB
pressure	PRESS
pressure angle	PA
Q	
quantity	QTY
R	
radius	RAD
raised countersunk head	RSD CSK HD
rectangular	RECT
rectangular hollow section	RHS
reference	REF
regardless of feature size	RFS
required	REQD
right hand	RH
Rockwell hardness A	HRA
Rockwell hardness B	HRB
Rockwell hardness C	HRC
rolled-holled section	RHS
rolled-steel angle	RSA
rolled-steel channel	RSC
rolled-steel joist	RSJ
roughness value	R_a
round	RD
round head	RD HD
S	
schedule	SCHED
section	SECT
sheet	SH
sketch	SK
spherical	SPHER
spigot	SPT
spotface	SF
spring steel	SPR STL
square	SQ
square hollow section	SHS
stainless steel (corrosion-resistant steel)	CRES
standard	STD
Standards Association of Australia	SAA
steel	ST
switch	SW
T	
tangent point	TP
temperature	TEMP
thread	THD
tolerance	TOL
true position	TP
true profile	TP
U	
undercut	UCUT
universal beam	UB
universal column	UC
V	
vertical	VERT
volume	VOL
W	
wrought iron	WI
Y	
yield point	YP

Types of line

The types of line which are commonly used in engineering drawings are illustrated in Table 1.2.

Figure 1.1 includes examples of the use of nine types of lines, lettered to correspond with the types above (with the exception of type *F*).

1. The *visible outline* of the bracket, type *A*, is heavy and dark enough to make it stand out clearly on the drawing sheet. This line should be of even thickness and darkness.
2. The *dimension, projection, cross-hatching* and *leader line*, type *B*, is illustrated. Leader lines are of two types, one which terminates with an arrowhead at an outline and the other which terminates in a dot (4) within the outline of the part to which it refers. Leaders should be nearly at right angles to any line or surface. Further uses of type *B* lines are to partly outline the adjacent part to which the bracket is bolted and to represent fictitious outlines such as

Table 1.2 Types of lines

Type	*Description*	*Drawing example*	*Usage*
A	continuous thick line		to indicate visible outlines
B	continuous thin line		for fictitious outlines, dimensions, projection, hatching and leader lines; also for the imaginary intersection of surfaces, revolved sections, adjacent parts, fold and tangent bend lines, short centre lines, and for indicating repeated detail
C	continuous thin freehand line		on part sectional boundary lines or to terminate a part view, and for short break lines
D	continuous thin ruled line with intermittent zigzag		to show a break on an adjacent member to which a component is attached; also to indicate a break in a long continuous series of lines on architectural or structural drawings
E	thin dashed line	s q s = 1 mm minimum q = 2s to 4s	to show outlines of hidden features: • for complete hidden features, the line should begin and end with a dash • dashes should meet at corners • where a hidden line is a continuation of a visible outline, it should commence with a space
F	medium dashed line	(proportions as for E)	in electrotechnology drawing only; for assemblies, boxes and other containers
G	thin chain line	s q p s = 1 mm minimum q = 2s to 4s p = 3q to 10q	to indicate centre lines, pitch lines, path movement, developed views, material for removal and features in front of a cutting plane
H	chain line, thick at the ends and at change of direction but thin elsewhere	(proportions as for G)	to indicate a cutting plane for sectional views
J	thick chain line	(proportions as for G)	to indicate surfaces that must comply with certain requirements such as heat treatment or surface finish
K	thin double-dashed chain line	(proportions as for G)	to indicate adjacent parts, alternative and extreme positions of moving parts, centroidal lines and tooling profiles

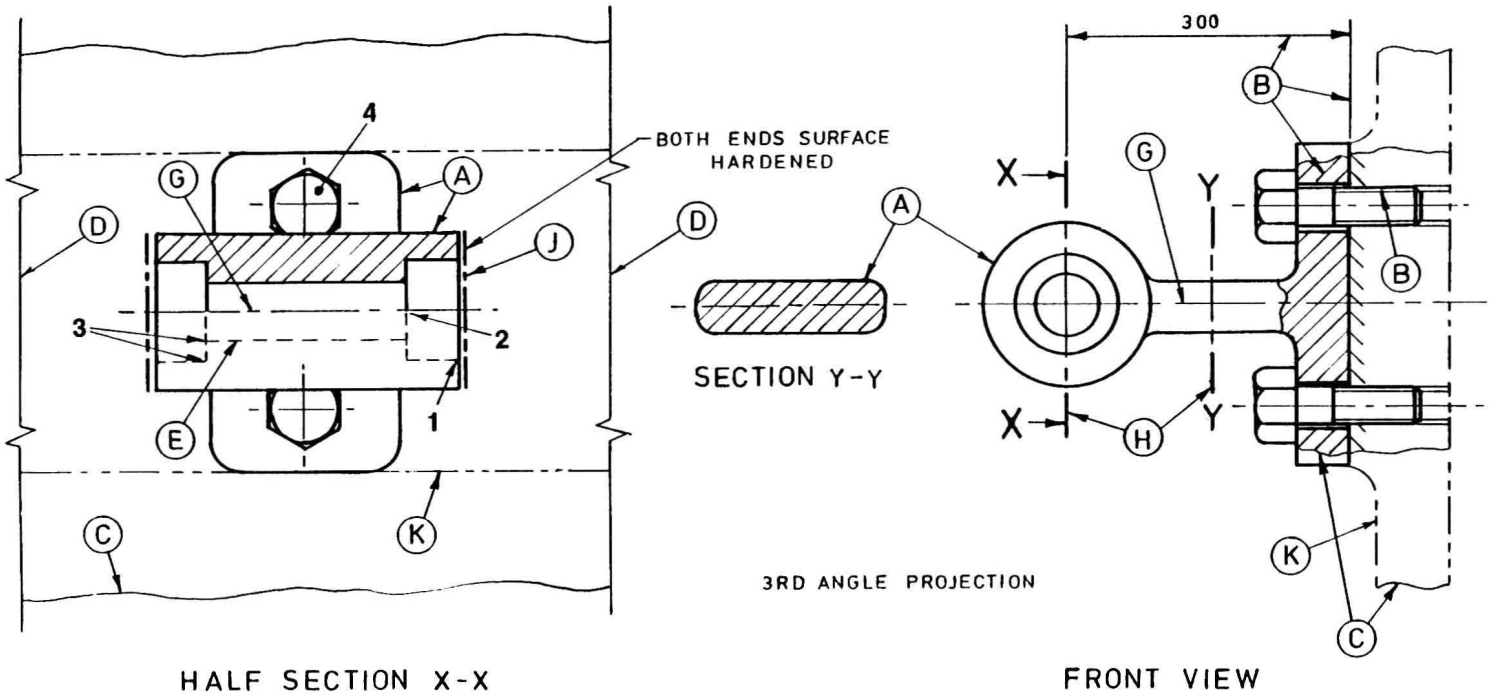


Fig. 1.1 *Use of different types of line*

minor diameters of male threads and major diameters of female threads (the latter are not illustrated).

3. The *short break line*, type *C*, is drawn freehand to terminate part views and sections as shown. It is also used to sketch the curved break section used on cylindrical members.
4. A *ruled zigzag line*, type *D*, is used for long break lines which extend a short distance beyond the outlines on which they terminate.
5. The *hidden outline line*, type *E*, represents internal features which cannot normally be seen.

   A hidden outline should commence with a dash (1) except where it is a continuation of a visible outline (2), where there is a space first. Corners and junctions (3) should be formed by dashes.
6. The *centre line*, type *G*, denotes the axis of symmetrical views as well as the axis and centre lines of holes. Centre lines project a short distance past the outline. When produced further for use as dimension lines, they may revert to thin continuous (type *B*) lines. Type *G* lines may also be used to show the outline of material which has to be removed (not shown).
7. The *cutting plane of the section*, X-X, is represented by the type *H* line. Arrows are located at right angles to the thick ends of the line, and point to the direction in which the sectional view is being taken.

   In the case of the removed section, Y-Y, which merely shows the cross-sectional shape of the member, it is immaterial which direction the view is taken from, and the arrows may be left off the cutting plane.
8. *Surfaces requiring special treatment* such as heat treatment or surface finish may be indicated with a type *J* line drawn parallel to the profile of the surface in question.
9. When drawing a component where it is necessary to show its relationship to an adjacent part, the latter is outlined using a type *K* line. Other uses of this type of line are to indicate extreme positions of movable parts, and to outline tooling profiles in relation to work set up in machine tools.

Scales

The scales recommended for use with the metric system are:

Full size	1:1
Enlargement	2:1, 5:1, 10:1
Reduction	1:2, 1:2.5, 1:5, 1:10

Use of scales

Engineering drawings may be prepared full size, enlarged or reduced in size. Whatever size of scale is used, it is important that it be noted in or near the title block.

Indication of scales

When more than one scale is used, they should be shown close to the view(s) to which they refer and a note in the title block should read "scales as shown".

If a drawing has predominantly one scale, the main scale should be shown in the title block together with the notation "or as shown" to indicate the use of other scales elsewhere on the drawing.

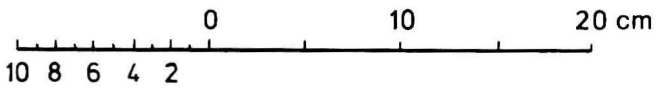
Sometimes it is necessary to use different scales on the one view, for example on a structural steel truss where the cross-sections of members are drawn to a larger scale than the overall dimensions of the truss. Such variations are indicated on the drawing, for example:

Scales

Member cross-sections	1:10
Truss dimensions	1:100

If a particular scale requirement needs to be used on a drawing, it may be shown by one of the following methods:

1. a scale shown on the drawing, for example:



2. the word "scale" followed by the appropriate ratio, for example *SCALE 1:10*
3. the words "scale:none" in or near the title block, for example on pictorial drawings

Line thicknesses

Thicknesses for the various types of line are divided into specific groups according to the size of drawing sheet being used. Table 1.3 shows the metric sheet size, the line type and thickness applicable in each case.

Sizes of drawing paper

Preferred sheet series

Standards Australia has recommended that paper sizes be based on the "A" series of the International Organization for Standardization (ISO), and these sizes are specified in *AS 1100* Part 101. This series is particularly sutable for reduction onto 35 mm microfilm because the ratio of 1: $\sqrt{2}$ is constant for the sides of the paper (Fig. 1.2(a)) and this ratio is also used for the microfilm frame.

Paper sizes are based on the A0 size, which has an area of 1 square metre. This allows paper weights to be expressed in grams per square metre.

The relationship between the various paper sizes is illustrated in Figure 1.2(a) and (b), where the application of the 1:$\sqrt{2}$ side ratio can be seen. An A0 size sheet can be divided up evenly into the various other sizes simply by halving the sheet on the long side in each case. This is shown in Figure 1.2(c). The dimensions of metric sheets from size A0 to A4 are given in the table of Figure 1.2(d), together with appropriate border widths for each sheet size.

Non-preferred sheet series

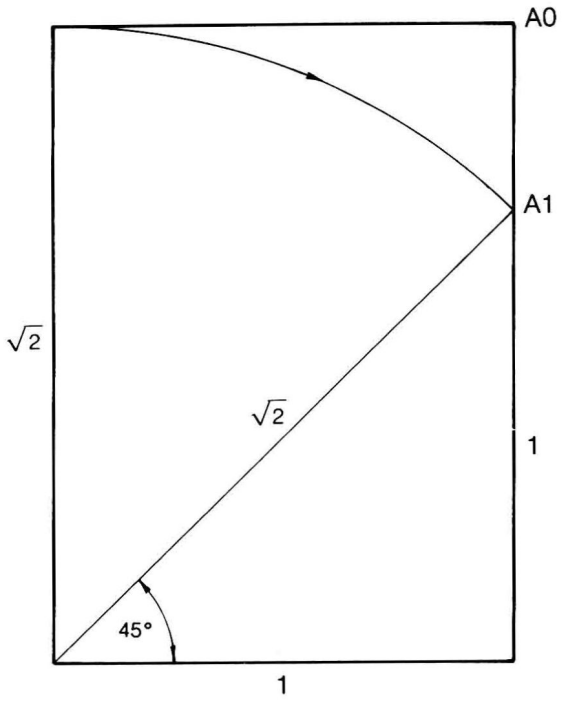
The "B" series of sheet sizes provides for a range of sheets designated by B1, B2, B3, B4, etc., which are intermediate between the A sizes. The relationship of the B and A sizes is shown in Figure 1.2(b); B sizes are in broken outline.

Rolls

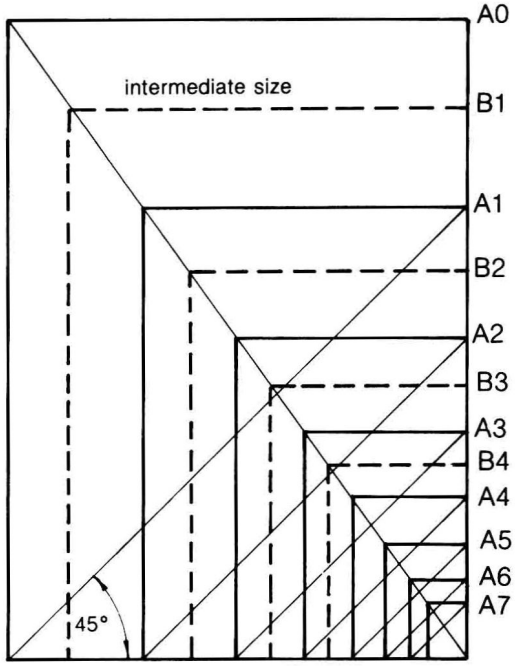
The standard widths of rolls are 860 mm and 610 mm. Drawing sheets can be cut off the roll to suit individual drawings.

Table 1.3 Line thicknesses for various sheet sizes

Sheet size	*Line type and thickness (mm)*									
	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*J*	*K*
A0	0.7	0.35	0.35	0.35	0.35	0.5	0.35	0.35 0.7	0.7	0.35
A1	0.5	0.25	0.25	0.25	0.25	0.35	0.25	0.25 0.5	0.5	0.25
A2, A3, A4	0.35	0.18	0.18	0.18	0.18	0.25	0.18	0.18 0.35	0.35	0.18



(a)

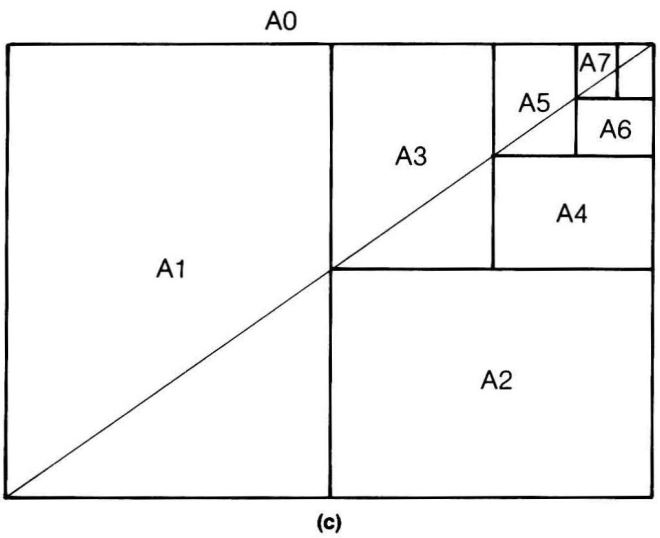


(b)

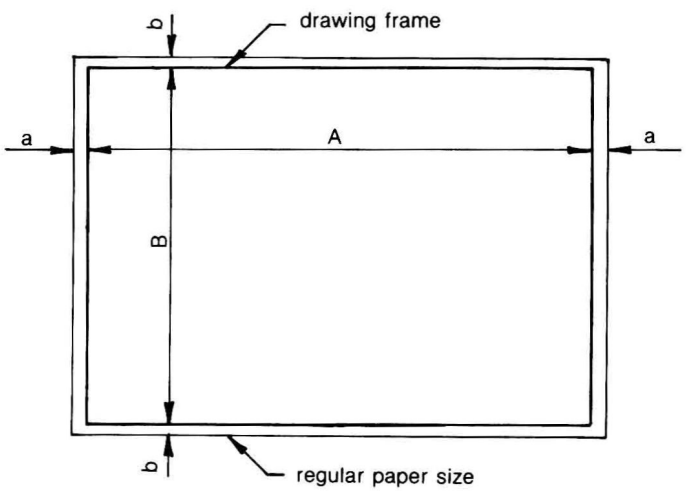
Note: The sides of metric drawing paper sheets are in the ratio of 1: $\sqrt{2}$
Area of the AO size = 1 m²

Drawing frames without a filing margin

Paper size	*Border width (mm)*		*Dimensions of drawing frame (mm)*
	both sizes	*top and bottom*	
	a	*b*	*A* × *B*
A0	28	20	1133 × 801
A1	20	14	801 × 566
A2	14	10	566 × 400
A3	10	7	400 × 283
A4	7	5	283 × 200



(c)



(d)

Fig. 1.2 *Paper sizes*

Layouts of drawing sheets

Standard layouts for drawing sheets of all sizes are given in *AS 1100* Part 101. Figures 1.3 and 1.4 show typical layouts of A1 and A2 sheets, illustrating the paper size, drawing frame with microfilm camera alignment marks and zoning or grid referencing details. Additionally Figure 1.4 includes a parts list and a revisions table. The layout of Figure 1.3 is suitable for detail drawings, while that of Figure 1.4 is suitable for multidetail and assembly drawings.

Sheet frames (borderlines)

It is usual for each sheet to be provided with a drawing frame a short distance in from the edge of the paper. Drawing frames are standardised for the various sizes of paper, and Figure 1.2(d) details this information for frames without a filing margin.

Title block

The title block represents the general information source for a drawing. It is normally placed in the bottom right-hand corner of the drawing frame. Figure 1.5 illustrates title block dimensions for various sheet sizes, together with the type of information which should be contained in the title block and its location.

Material or parts list

When a drawing includes a number of parts on the one sheet, or when an assembly drawing of a number of parts is required, a tabulated list of the parts is attached to the top of the title block and against the right-hand drawing frame as shown in Figure 1.4.

The list should give the following information:

1. the item or part number
2. the part name
3. the quantity required
4. the material and its specification
5. the drawing number of each individual part
6. other information considered appropriate

A separate standard drawing sheet may be used to set out a parts list alone when it is desirable or when the list is very large. Such a list should be provided with a standard title block and a revisions table. For further details see *AS 1100* Part 101.

Revisions table

A table of revisions is located normally in the upper right-hand corner of the drawing frame as shown in Figure 1.4.

The ability to effect revisions or modifications to existing drawings is an important requirement in all drawing and design offices. In many instances when only minor modifications are required, it is much easier to revise an existing drawing than to create a new one. However, such modifications must be tabulated to record existing details of the feature as well as the modification.

Each change should be identified by a symbol such as a letter or number placed close to the revision on the drawing. The letter or number may (but need not) be encircled on the drawing. Reference is made to the symbol in the tabulated details of the change (see Figs 6.1 and 6.2). Drawings so modified should be given a new issue number or letter situated in the title block adjacent to the drawing number.

If a particular modification affects the interchangeability of a part, the modified part should be allocated a new drawing number.

Zoning

Drawings may be divided into zones by a grid reference system based on numbers and letters as shown in Figures 1.3 and 1.4. Zoning is located inside the drawing frame.

The purpose of a grid reference system is to assist location of detail. It is particularly useful on large drawings.

Horizontal zones are designated by capital letters starting with A, reading from top to bottom. Vertical zones are designated by numbers reading from left to right.

The number of zones and widths of zone margins to be used on various sheet sizes are detailed in Table 1.4. Further use of zoning is shown in Figure 6.2, where a revision in the table designates a change of thread form (Whitworth to metric), and the reference C2 is a grid reference indicating the position on the sectional view of the thread in question, that is symbol Ⓐ.

Table 1.4 Details of grid references

	Size of drawing				
Detail	**A0, B1**	**A1, B2**	**A2, B3**	**A3, B4**	**A4**
number of vertical zones designated (1, 2, etc.)	16	12	8	6	4
number of horizontal zones designated (A, B, etc.)	12	8	6	4	4
width of margins for grid reference (mm)	10	7	7	5	5

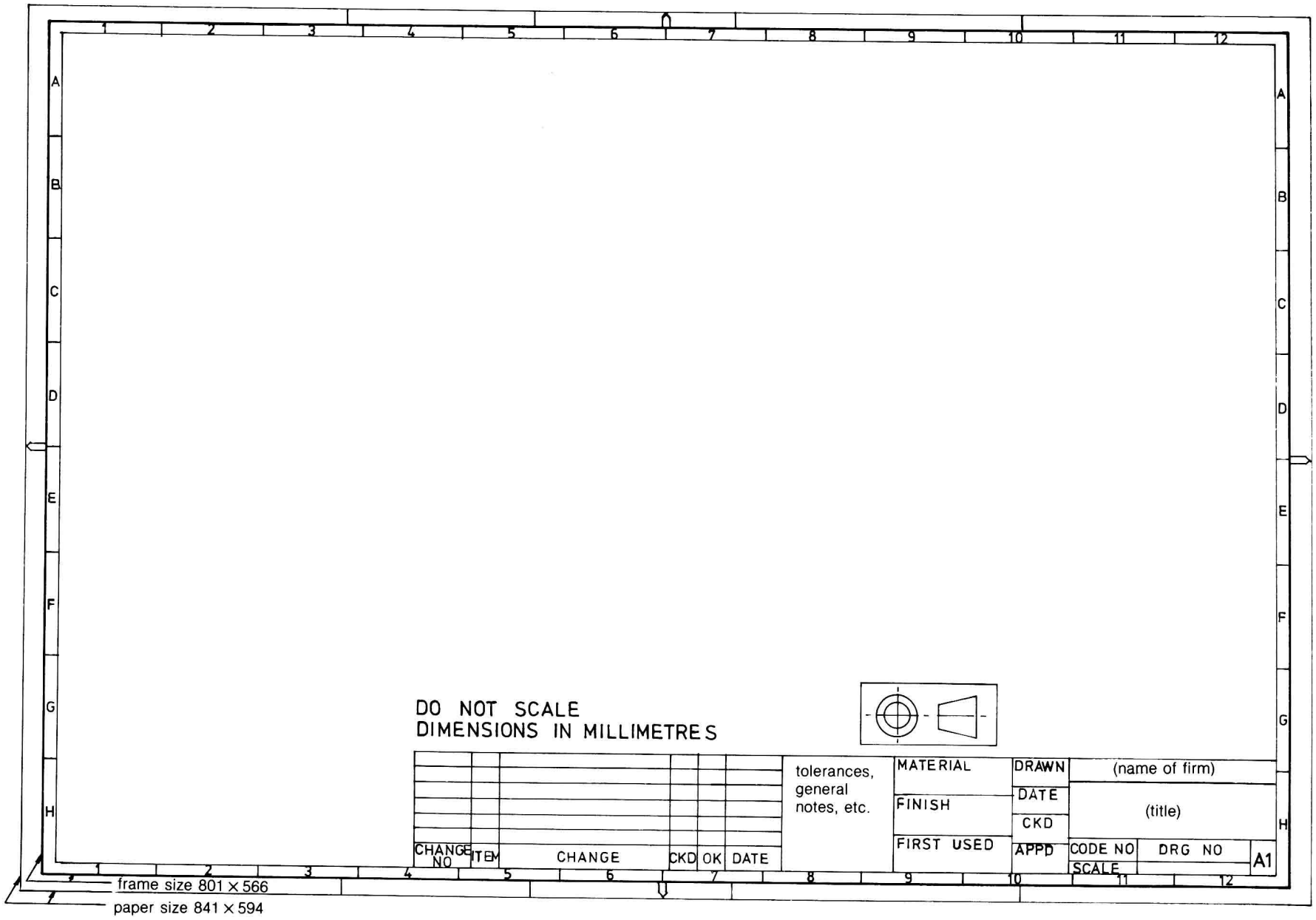


Fig. 1.3 *Typical layout of a drawing sheet (suitable for detail drawings)*