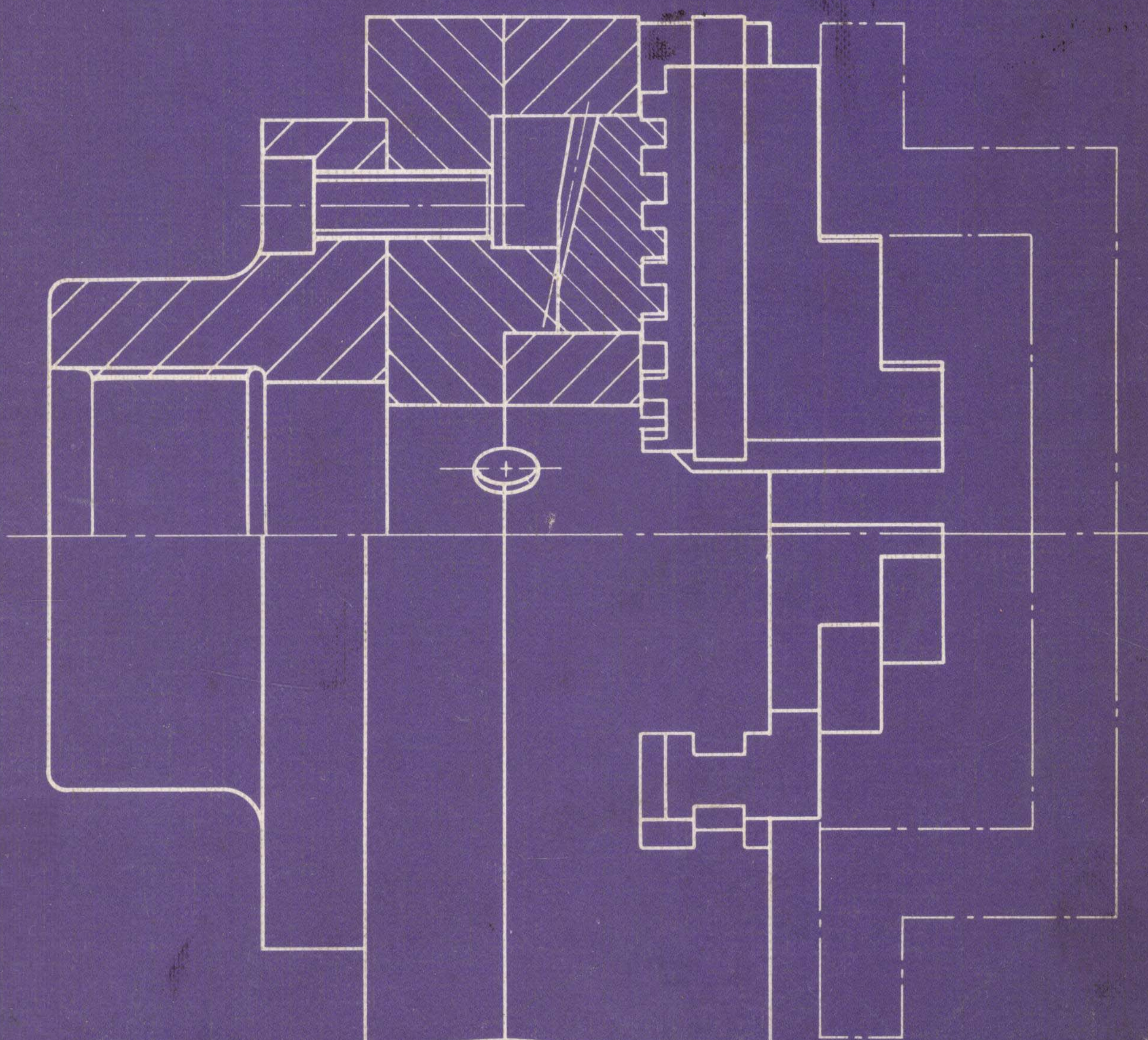
ENGINEERING DRAWING

WITH PROBLEMS AND SOLUTIONS

K.R.HART



ENGINEERING DRAWING

With Problems and Solutions

Second Edition

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AUTHOR'S PREFACE

This book is primarily intended for use by students who are engaged in courses leading to the awards of Ordinary and Advanced Level Certificates, Engineering Degrees, Higher Technician Certificates and Diplomas, Technician Certificates and Diplomas, and Membership of the Professional Engineering Institutions. The questions have therefore been selected principally from past papers issued by these Examining Authorities, although the time-allocations and solutions are the author's own.

It will be appreciated that a variation in standard exists between different examinations and by careful selection of questions and the inclusion of private work provision has been made to ensure that the questions have been graded progressively from a standard slightly below Ordinary Level G.C.E. to that of Engineering Degree Examinations. A serious attempt has been made to cover the complete range of questions that occur in engineering drawing examinations between these two standards.

A principal feature of the book is the provision of model solutions whereby the student can correct his own work with the minimum of supervision. Therefore notes and, in certain examples, pictorial projections have been added as an aid for comprehension of the given solutions. In the author's opinion worked examples are a valuable method of instruction not normally provided in books on engineering drawing.

Generally examination questions tend to be rather academic in their presentation and not usually in accordance with normal Drawing Office Practice. The inclusion of some examples of industrial type drawings should help the student to appreciate this difference. All the drawings are to BS 308 (1972) and relevant BS Data Sheets have been included.

I gratefully acknowledge permission given by the following bodies to reproduce questions from their examination papers in Engineering Drawing: The Senate of the University of London: The Institution of Mechanical Engineers; The Part I Committee of the Joint Engineering Institutions; The City and Guilds of London Institute; The West African Examinations Council; U.S.T. Kumasi; Enfield College; The British Standards Institution. I would also like to record my sincere thanks for the help that I received from my colleagues Mr. D. J. Clarke, B.Sc. (Hons.) Eng., C.Eng., M.I.Mech.E., M.R.I.N.A., A.M.I.E.D., and Mr. T. Keating, C.Eng., M.I.Mech.E.

K.R.H.

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1 METRICATION

The Confederation of British Industries decided early in 1965 to recommend to the government that British Industry adopt the metric system. The government was impressed with the case put to it by the representatives of industry and gave its full support, indicating its hope that by 1975 the greater part of the country's industry would have effected the change.

The metric system chosen was the International System of Units (officially designated SI Units), and the British Standards Institution is engaged on a priority task of preparing some 1400 standards.

It was envisaged that design and drawing offices of British Industry would introduce metric sizes during 1968 and 1969 and would have completed this transition from imperial sizes by 1970 (see *Change to the metric system* published by EEUA). The Royal Society and CEI have also recommended that SI units be increasingly used in university and college teaching and in particular that numerical data appearing in examinations set to those students now entering courses of higher education be quoted in SI units.

Use of SI Units in Engineering Drawing

As far as engineering drawing is concerned, the use of SI units means that all dimensions will be stated in millimetres, or in metres on drawings of very large equipment.

When new designs are being developed it is important that the designer thinks in terms of metric sizes rather than inch sizes and their subsequent conversion. New designs will have to be prepared on a metric basis, using customary metric sizes and metric components, and taking account of internationally agreed metric standards and the practice of the principal metric countries. For existing designs which are to be converted to metric sizes BSI have made available a standard which provides a procedure for conversion which gives the essential accuracy required for precise dimensional interchangeability.

The drawings in this book have been selected from past papers set by various examining authorities and were dimensioned using inch units. These have been converted to the nearest millimetre with a certain amount of 'rounding off', and all screw threads have been changed from the many imperial types, i.e. BSW, BS Fine, BA, etc., to the metric thread sizes outlined in BS 3643, Parts 1, 2 and 3. This is the British Standard for ISO (International Standards Organization) metric screw threads and recommends that the coarse pitch series be used for the vast majority of general purpose applications. Although the ISO unified thread will still be acceptable and widely used, a complete change to ISO metric is recommended. An ISO metric thread is denoted in the manner shown:

M12 × 1·5 – 6H

where M .... indicates that the thread is of ISO metric form.
12 .... is the thread diameter in millimetres.
1·5 .... is the thread pitch in millimetres.
6H .... indicates the thread tolerance symbols and shows that it is an internal thread. (See table below.)

Alternatively M8 × 1·0 – 6g is an external thread.

Class of fit	Tolerance class	
	Internal	External
Close	5H	4h
Medium	6H	6g
Free	7H	8g

As previously mentioned, it has been recommended that the coarse pitch series of screw threads be used for the majority of general engineering applications. These coarse series threads are designated by the symbol M and the nominal thread diameter in millimetres, e.g. M30, together with the tolerance class in the normal way but it is not necessary to include the thread pitch.

Thus M30 – 6g indicates a Coarse Series thread
and M30 × 2 – 6g indicates a Fine Series thread.

BIBLIOGRAPHY

BS 308 Engineering Drawing Practice.
Part 1, 1972: General Principles.
Part 2, 1972: Dimensioning and Tolerancing of Size.
Part 3, 1972: Geometrical Tolerancing.
BS 350, Part 1, 1959; Part 2, 1962: Conversion Factors and Tables.
BS 1957, 1953: Presentation of Numerical Values.
BS 1991, 1961–7: Letter Symbols, Signs and Abbreviations, Parts 1 to 6.
BS 2045, 1965: Preferred Numbers.
BS 2856, 1957: Precise Conversion of Inch and Metric Sizes on Engineering Drawings.
BS 3580, 1964: Guide to Design Considerations on the Strength of Screw Threads.
BS 3643, 1967: ISO Metric Screw Threads, Parts 1, 2 and 3.
BS 3692, 1967: ISO Metric Hexagon Bolts, Screws and Nuts.
BS 3763, 1964: The International System (SI) Units.
BS 4168, 1967: Hexagon Socket Screws and Wrench Keys – Metric.
BS 4183, 1967: Metric Machine Screws and Machine Screw Nuts – Metric.
BS 4186, 1967: Recommendations for Clearance Holes for Metric Bolts and Screws – Metric.

BS Handbook No. 18, 1966: Metric Standards for Engineering.
PD 5686, 1972: The Use of SI Units.
Change to the Metric System in the United Kingdom. Report by the Standing Joint Committee on Metrication, HMSO.
Changing to the Metric System. Conversion Factors, Symbols and Definitions, HMSO.
Going Metric. Poster and leaflet, Ministry of Technology.
The Adoption of the Metric System in Engineering. Basic programme and guide, BSI.
Report of the Metric Standards Working Party, Forming a Basis for the Change over from Imperial Units to Metric Units. Published by the Plessey Company Limited (inquiries to the Department of Trade and Industry).

2 INTRODUCTION TO ENGINEERING DRAWING

Drawing is the principal means of communication in engineering. It is the method used to impart ideas, convey information and specify shape and is often said to be the language of the engineer. It is an international language and bound, like any other language, by rules and conventions. These may vary slightly in detail from country to country but the underlying basic principles are common and standard.

In the United Kingdom and many other countries, British Standard 308 is the accepted authority for the rules and conventions governing engineering drawing practice. It is therefore important that the engineering student should be familiar with this publication as he will be required to exhibit this knowledge in any examination in engineering drawing.

Draughtsmanship

In general, good draughtsmanship is an art obtained by experience and improved by constant practice. Correct choice and use of instruments, layout and clarity of views, neatness and legibility of printing, etc., contribute to give a drawing character and the professional appearance associated with good draughtsmanship.

However the basic fundamental of good draughtsmanship is linework, and in student drawings poor linework is a very common feature.

BS 308: Part 1: 1972 recommends the use of different types of line as illustrated in Figure 1A. It can be seen that each type has a clearly defined application and it is strongly recommended that the student should learn and apply these recommendations.

Type A

This line represents the visible outlines and thus defines the general overall shape. It should be bold, definite and uniform in thickness and density. Homogeneity of the line is important, but arcs and circles, being more difficult to draw, tend to be thinner and less dense than straight lines. Compasses should therefore contain a softer grade of lead than that used in the pencil.

Line control is easier using a pencil and straight edge than with compasses and it is helpful to draw all arcs and circles before blending tangent lines, starting from the point of tangency.

Type B

This line is used for dimension, projection, section and leader lines, and its use is discussed under the appropriate section at a later stage.

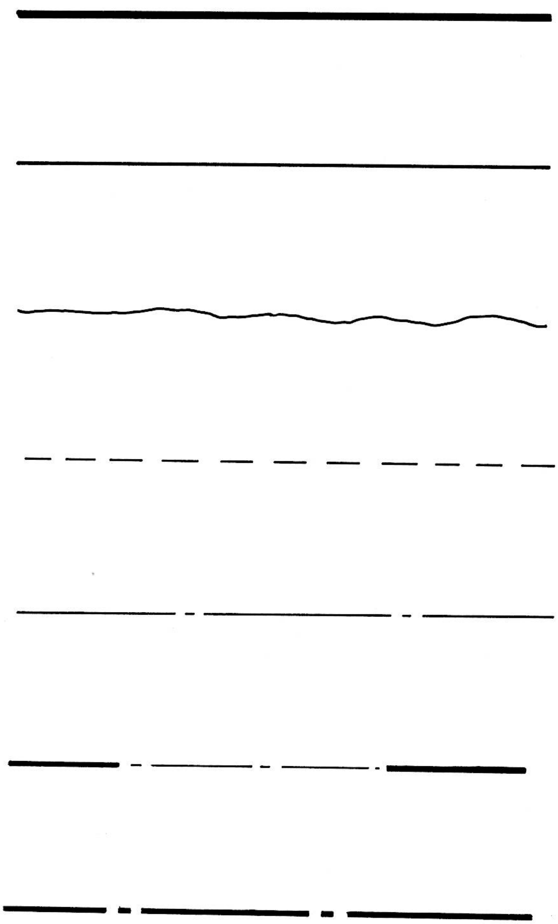
Type C

This continuous wavy thin line is used principally to limit partial views.

Type D

This broken line represents the outline of hidden detail and is one third to one half the thickness of Type A lines.

TYPE OF LINE	EXAMPLE	APPLICATION
continuous (thick)	A	visible outlines and edges
continuous (thin)	B	fictitious outlines and edges dimension and leader lines hatching outlines of adjacent parts outlines of revolved sections
continuous irregular (thin)	C	limits of partial views or sections when the line is not an axis
short dashes (thin)	D	hidden outlines and edges
chain (thin)	E	centre lines extreme positions of moveable parts
chain(thick at ends and at changes of direction, thin elsewhere)	F	cutting planes
chain (thick)	G	indication of surfaces which have to meet special requirements



LINES SHOULD BE SHARP AND DENSE TO OBTAIN GOOD REPRODUCTION.

LINES SPECIFIED AS THICK SHOULD BE FROM TWO TO THREE TIMES THE THICKNESS OF LINES SPECIFIED AS THIN.

CENTRE LINES SHOULD PROJECT FOR A SHORT DISTANCE BEYOND THE OUTLINE TO WHICH THEY REFER, BUT WHERE NECESSARY TO AID DIMENSIONING OR TO CORRELATE VIEWS, THEY MAY BE EXTENDED.

Figure 1A

Superimposition of hidden detail on a drawing often leads to vagueness concerning shape description. The use of this type of line involves techniques shown in Figure 1B which will clarify drawings involving complicated hidden detail.

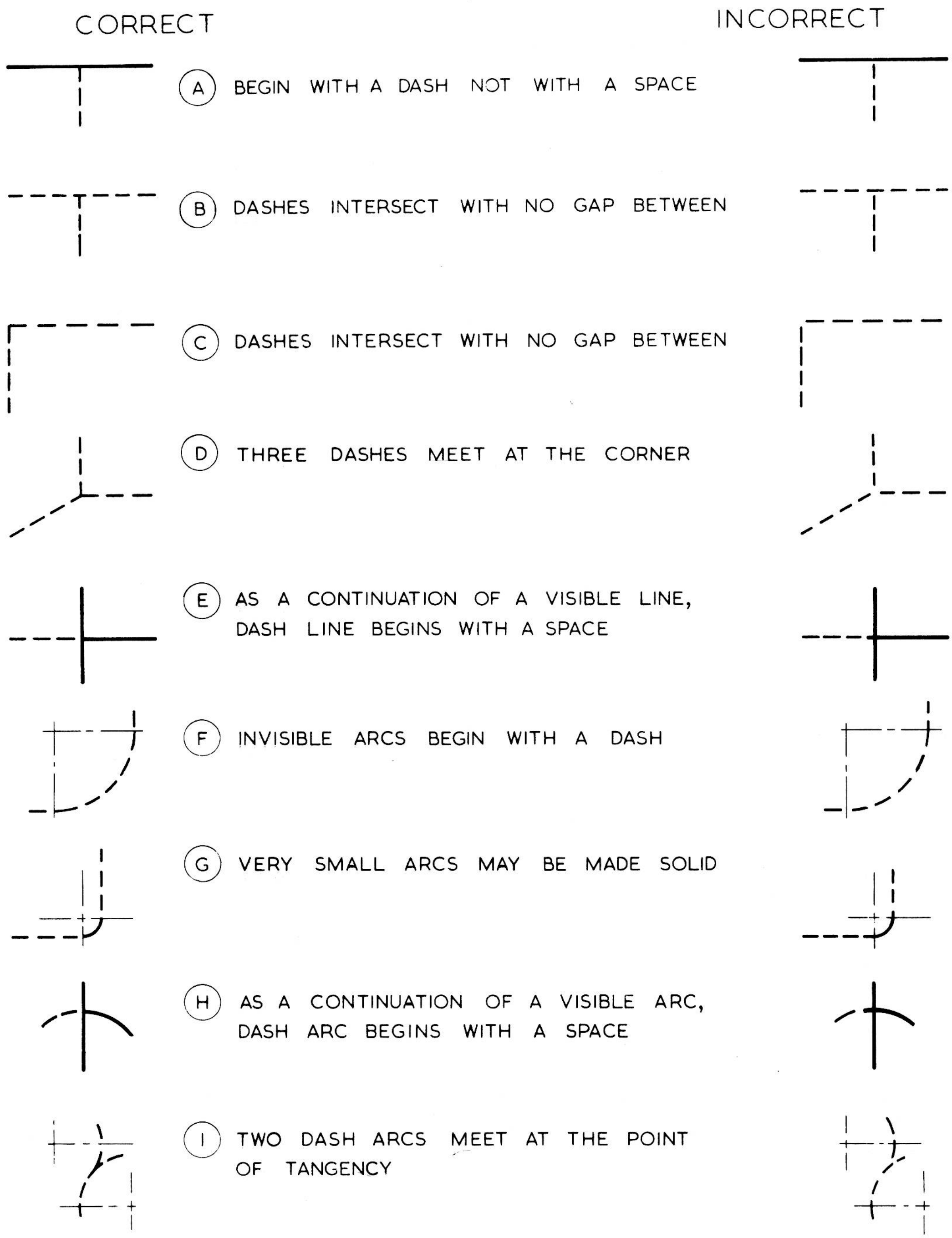


Figure 1B

Type E

This line principally represents the centre line of holes and other common features. It forms datum lines for dimensioning and axes of symmetry. Students are advised therefore to cultivate the habit of drawing these lines as in students' work they are generally most conspicuous by their absence.

Type A, B, D and E lines are in most common use and feature in all engineering drawing examinations. Figure 1C shows the typical use of all the recommended types of line; differentiation between them can only improve a student's standard of draughtsmanship, and of course, his allocation of marks for this aspect of engineering drawing examinations.

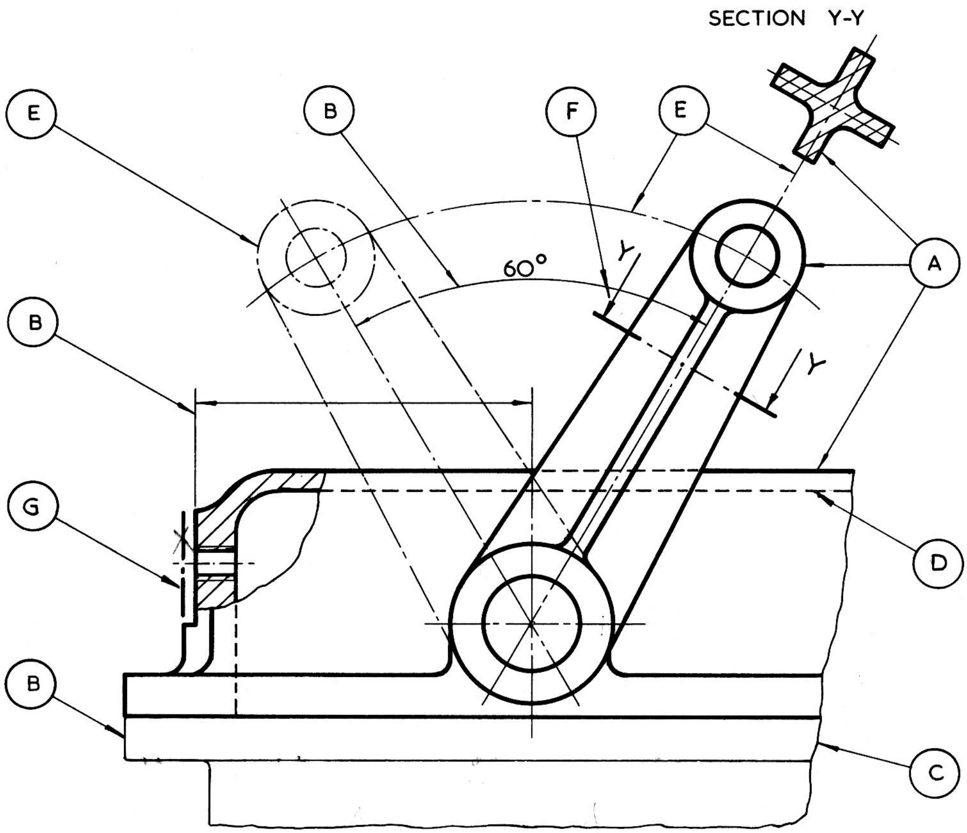


Figure 1C

3 ORTHOGRAPHIC PROJECTION

This is the method used to specify the shape description of a three dimensional object on drawing paper which is of course a two dimensional plane surface.

Projection is the representation on a plane surface of the image of an object as it is observed by a viewer. The plane on which the image is represented is known as the Plane of Projection. When the object is viewed orthogonally, i.e., at right angles to the plane of projection, then the representation of the image is said to be in orthographic projection.

In order to specify fully the shape of an object in orthographic projection at least two planes of projection are required. These principal planes of projection or reference are known as the Horizontal Plane (HP) and the Vertical Plane (VP) and are mutually perpendicular (Figure 2A). The intersection of these planes form quadrants or angles

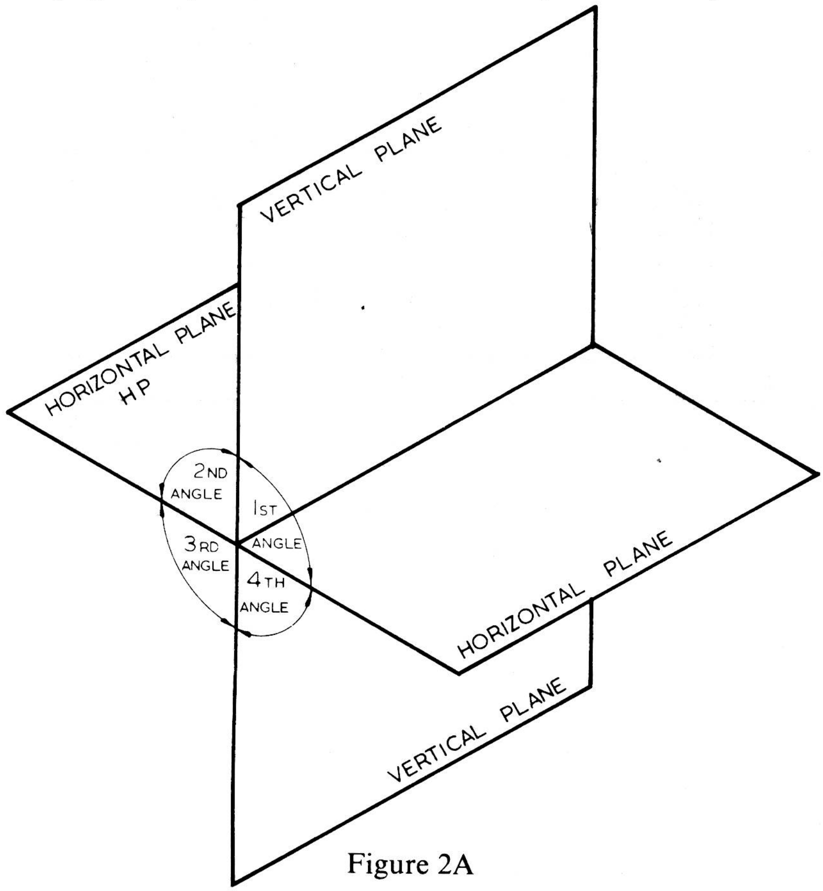


Figure 2A

of 90 degrees known as the 1st, 2nd, 3rd and 4th angles. Consider an object situated in space relative to the principal planes of reference as illustrated pictorially in Figure 2**B**.

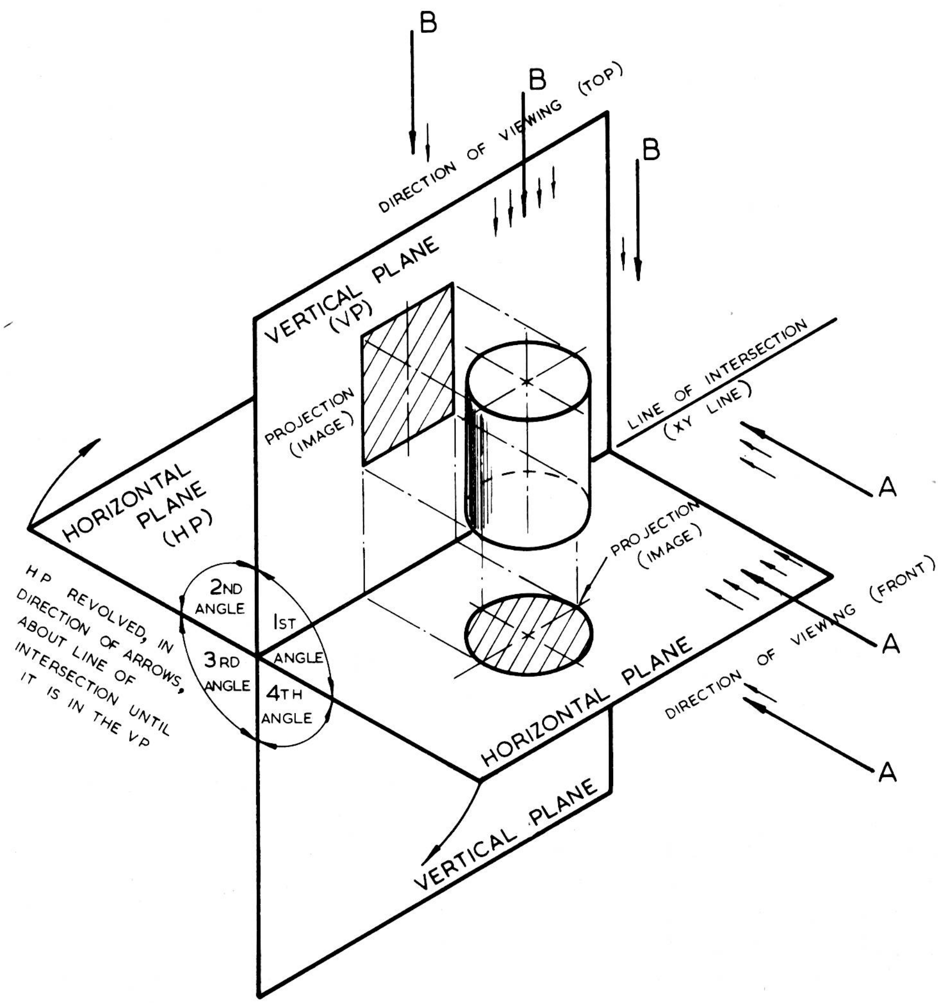


Figure 2**B**

Convention governing orthographic projection rules that:

1 The angles be designated as shown and therefore the object is said to be situated in the first angle.
2 The lines of sight are parallel, at right angles to the planes of projection and in general, the object is viewed from the top and front positions indicated regardless of the quadrant or angle in which it is situated.
3 The horizontal plane be revolved or rabatted about the line of intersection XY in the direction shown until it is coincident with the vertical plane.
4 The projection on the VP be known as the Elevation and the projection on the HP be known as the Plan.

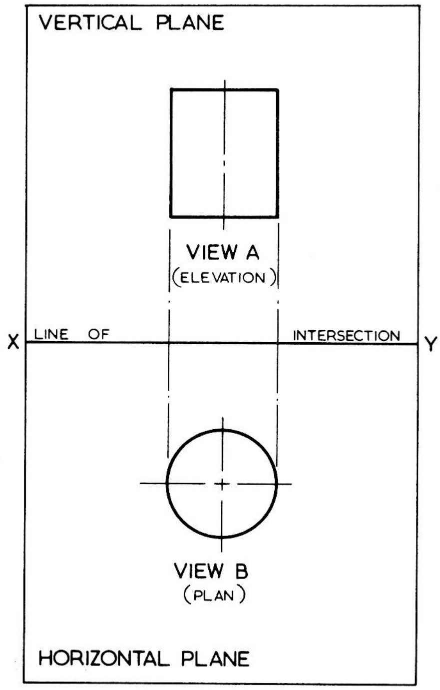


Figure 2C

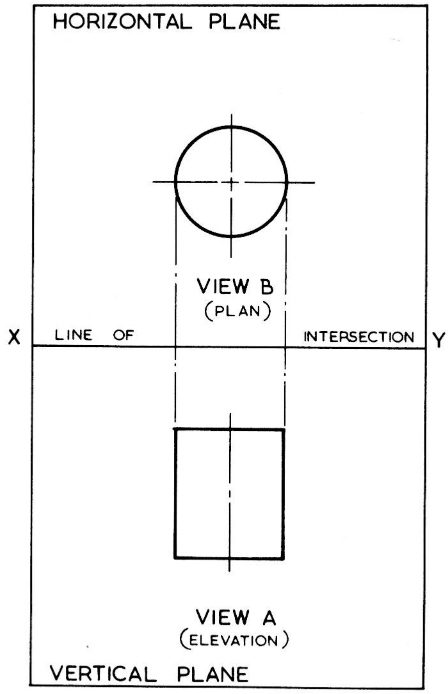


Figure 3A

Therefore in accordance with this accepted convention Figure 2C shows the Plan and Elevation of the object in First Angle Orthographic Projection.

Consider the object situated in the Third Angle or quadrant (Figure 3B) and apply the same rules. It can be seen from Figure 3A that the views now in Third Angle Orthographic Projection are *exactly the same* as in First Angle Orthographic Projection but that the relative positions of the Plan and Elevation are different.

When the aforementioned rules are applied to objects situated in the 2nd and 4th angles their projections will be superimposed and therefore First or Third Angle Projection is obviously the most useful means of specifying the shape description of any object and both methods are used extensively.

Third Angle Projection is universal practice in the United States whilst First Angle Projection is most popular in Eastern Europe and the USSR. In the United Kingdom both modes of projection are in common use but it would appear that Third Angle Projection is gaining in popularity especially in the larger manufacturing industries.

However the current practice in most engineering drawing examinations is to supply details of the problem in First Angle Projection and permit the candidate to draw the solution in either First or Third Angle Projection. The solution to problems in this book are drawn in First or Third Angle Projection with no apparent preference for either mode, and the student should note that all views will be exactly the same regardless of the projection used and only the relative positions of the views will be different.

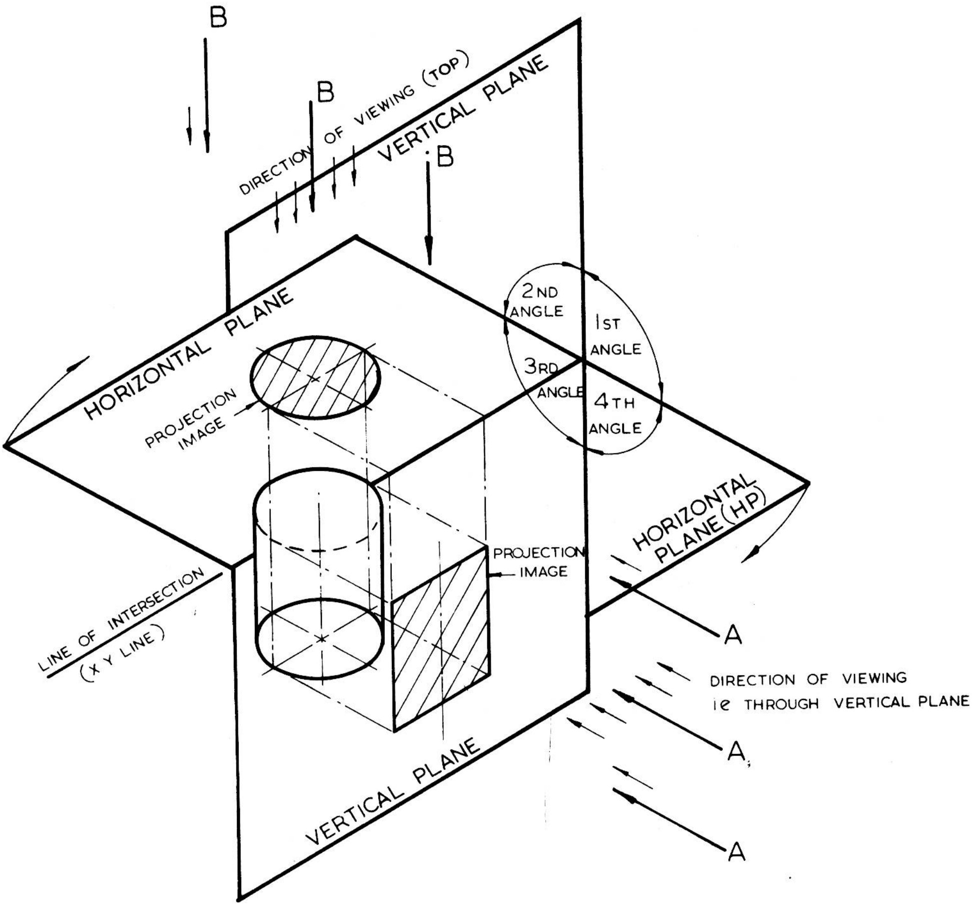


Figure 3B

Auxiliary Planes of Projection

The Elevation and Plan views may not always fully specify the shape description of an object. Consider the cylinder now positioned relative to the principal planes as shown in Figures 4 and 5. It can be seen that the Elevation and Plan views of a prism could be similar to that of the cylinder. Another view of the object is therefore necessary before the complete shape can be understood, and for this purpose another plane of projection termed an Auxiliary Vertical Plane (AVP) is introduced. This AVP is positioned perpendicular to both the VP and HP.

In First Angle Projection it was noted that the object is situated between the viewer and the plane of projection whilst in Third Angle Projection the plane of projection is placed between the object and the viewer.

This system is maintained when using auxiliary planes and the plane is also rabatted about XY until it is in the Vertical Plane.

Figures 4 and 5 illustrate the principle and it should again be noted that only the relative position of the views alters depending on whether First or Third Angle Projection is used.

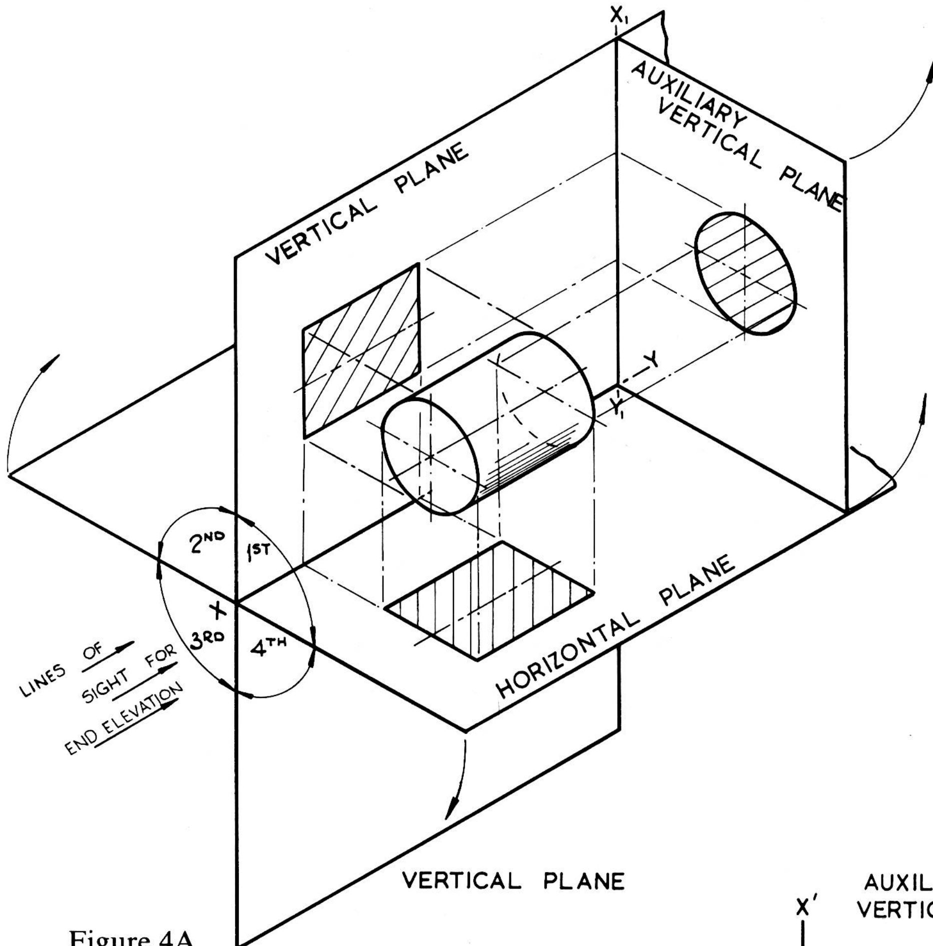


Figure 4A

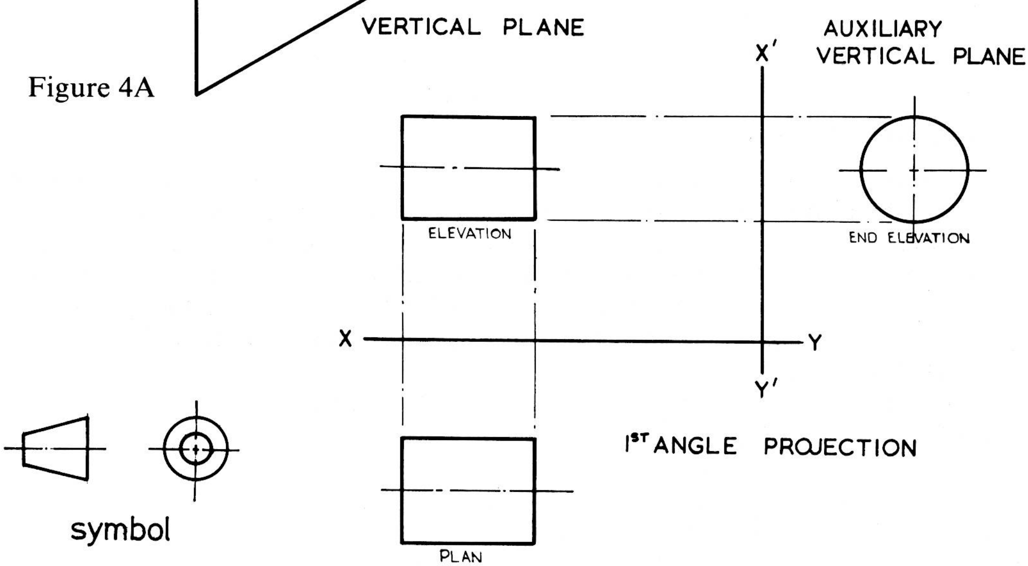


Figure 4B

HORIZONTAL PLANE