ENGINEERING DRAWING

[PLANE AND SOLID GEOMETRY]

[IN FIRST-ANGLE PROJECTION METHOD]

by

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FOREWORD

It gives me pleasure to introduce this text-book on Engineering Drawing by Prof. N. D. Bhatt of the Birla Vishvakarma Mahavidyalaya to students of Engineering. Prof. Bhatt has been teaching this subject for over twenty years and has deservedly earned the reputation of being one of the best teachers in the subject.

This book covers the syllabus usually prescribed for the Pre-engineering and First Year of the Degree and Diploma courses in Engineering and deals with the fundamental principles of this basic subject which have been treated by Prof. Bhatt with his characteristic lucidity.

I am sure the book will prove a boon to students and help them to acquire a sound knowledge of the subject without which a really satisfactory progress cannot be achieved in any branch of Engineering.

June 6, 1958

S. B. JUNNARKAR
M.B.E., B.A., B.Sc. Hons. (Eng.), London
POONA

ELEMENTARY ENGINEERING DRAWING

PREFACE

From the very early days, man realized that if he had to construct any structure or machine correctly and methodically, he must first record his ideas before starting construction work. These recorded ideas become more vivid and forceful if they are shown on paper in form of a drawing of the structure or machine. Such a drawing will be of very great help to the man who looks after the construction of this structure or machine.

Indeed, "technical drawing is the language of engineering". Without the good knowledge of drawing, an engineer is nowhere and he could not have constructed the various magnificent structures or intricate machines. Evidently, any one connected in any way, with engineering construction must understand this language of engineers. Technical drawing is, therefore, indispensable today and shall continue to be so as long as engineering and technology continue to be of use in the activities of man.

By means of drawing, the shape, size, finish, colour and construction of any object (no matter how complex) can be described accurately and clearly. The engineer should develop his skill, in two phases of technical drawing; first, he must be able to draw clearly and rapidly, the freehand technical sketches; secondly, he must be proficient in drawing to scale the instrumental drawing. The purpose of the present volume is to give the basic principles of the instrumental drawing only.

The book covers the syllabi in Engineering Drawing of many University Colleges and Polytechnics in India and has been written keeping in view the difficulties of a beginner in the subject of Engineering Drawing. I am quite hopeful that this book will serve its purpose very well for young and budding engineers.

I am highly indebted to Principal S. B. Junnarkar for his valuable guidance and for his kindness to write a suitable foreword for the book. I am also thankful to Prof. V. B. Priyani of Birla Vishvakarma Mahavidyalaya for going through the initial manuscript and for offering constructive suggestions. Finally, I feel grateful to the following:

(i) The authorities of the Universities of Bombay, Poona and Gujarat, and the Department of Technical Education, Bombay, for their kind permission to include a few questions set at their examinations. (ii) Mr. N. M. Panchal and Mr. M. D. Bhatt for their help in preparing pencil sketches. (iii) Mr. L. D. Bhatt for preparing the excellent typed manuscript. (iv) Mr. Ramanbhai C. Patel of Charotar Book Stall for careful proof-reading and for his efforts to see the book out in proper time. (v) The Anand Press authorities for the care and interest shown in the printing and get-up of this book. (vi) The Prabhat Process Studio for the promptness and good work of block-making.

Any suggestion to improve the value of this book will be gratefully received and will be incorporated in subsequent editions after due scrutiny.

June 30, 1958 **N. D. BHATT**

EIGHTH EDITION

Upto six editions, the book hardly underwent any fundamental change. Under the inspiration of the Indian Standards Institution, the industries in a large measure have switched on to the third-angle projection system. So have a vast majority of Technical Institutions. "Elementary Engineering Drawing", too, must keep step with the changes. There was a phased change-over beginning with the seventh edition. This edition has completed the change. Nevertheless, the first-angle projection system has not been altogether discarded. The fundamentals of both the systems are juxtaposed and elucidated.

The chapters on (i) Development of surfaces, (ii) Isometric projection and (iii) Conversion of pictorial views into orthographic views have been treated in some greater depth. This and the increase of the illustrative problems and practice exercises have evidently enlarged the size of the book and inevitably led to a little rise in price.

I should not miss this opportunity to record my gratitude to the numerous teachers for their very useful suggestions and the students for their excellent response to the book, without which this edition should not have come into being.

January 26, 1970 **N. D. BHATT**

FORTY-SECOND EDITION

The first edition was originally published in 1958 and now has entered in its 42nd Edition during 42 years, proves its popularity and utility among the teachers as well as the students of Engineering Institutions of our country.

This edition has been entirely revised and enlarged by adding the following *four* chapters: (1) Screw Threads (2) Screwed Fastenings (3) Riveted Joints and Welded Joints (4) Computer Aided Drafting.

It was thought desirable to include this fourth chapter on 'Computer Aided Drafting' which has now acquired an important place in this subject. We are thankful to Dr. S. S. Khandare of Y. C. College of Engineering, Nagpur for contributing this chapter. We are also highly obliged to Shri R. C. Patel of Charotar Publishing House, Anand for correcting the Proofs.

This book provides a wealth of information and describes an exciting new paradigm and is also a valuable tool for all the Engineering students, who wish to deepen and acquire a sound knowledge of this important subject (Language of Engineers) without which a really satisfactory progress cannot be achieved in any branch of Engineering.

We shall feel obliged to receive comments, suggestions and opinions from the readers to enhance the utility of the book.

August 15, 2000

N. D. BHATT
V. M. PANCHAL

FIFTIETH EDITION

We are inundated with joy to present before you the FIFTIETH EDITION of this most standard text-book. At the outset, we would like to mention that splendid response to earlier editions is prodigious. Despite such favourable responses, it was felt that the utility of the book could be further enhanced. This is one of the most comprehensive revisions since the book was first published. As a result, all the drawings have been redrawn with utmost intelligibility. Many new examples, drawings are incorporated along with some new text matter. This text-book is thoroughly revised, extensively enlarged, completely updated. Chapter on Computer Aided Drafting (CADr) is entirely rewritten with inclusion of *50 self-interactive and self-learning practice modules*. This book accompanied by a computer CD as a novel pedagogical concept, containing *51 selected audiovisual animation modules* presented for better visualization and understanding of the subject of Engineering Drawing.

We take this opportunity to thank Prof. V. M. Panchal, Former Professor in Mechanical Engineering, Faculty of Technology and Engineering, M. S. University of Baroda for revising the entire book and adding many new typical examples. We express our hearty gratitude to Prof. Pramod R. Ingle, Lecturer in Mechanical Engineering, B and B Institute of Technology, Vallabh Vidyanagar for redraw all the drawings with precision, rewriting the chapter on Computer Aided Drafting (CADr) and revising the entire book.

We are also indebted to Prof. R. S. Bhatt, Associate Professor in Mechanical Engineering, Birla Vishvakarma Mahavidyalaya (Engineering College), Vallabh Vidyanagar, Anand; Prof. Mukesh A. Bulsara, Assistant Professor in Mechanical Engineering, G. H. Patel College of Engineering and Technology (GCET), Vallabh Vidyanagar, Prof. N. V. Patel, Ex-Professor, L. D. Engineering College, Ahmedabad who were kind enough to send their suggestions to us for the improvement of the book. We are also grateful to Prof. S. H. Makwana, Lecturer in Mechanical Engineering, B & B Institute of Technology, Vallabh Vidyanagar, who spared no efforts in the tedious task of diligently correcting the final proofs. We are sincerely thankful to Cognifront, Nasik for preparing a unique CD and Repro India Ltd., Mumbai for their hearty co-operation and excellent printing of the book.

In spite of all the pains taken, it is possible that some errors may have escaped our attention. We shall be grateful if they are brought to our notice by sending e-mail at charotar@cphbooks.com, so that they can be corrected in subsequent edition. We strongly urge the readers to send their comments, suggestions and opinions to enhance the utility of the book.

August 24, 2010

PUBLISHERS

ELEMENTARY ENGINEERING DRAWING

TABLE OF CONTENTS

CONTENTS OF CD-ROM

NOTE ABOUT THE CD ACCOMPANYING THE BOOK

This book is accompanied by a CD, which contains audiovisual modules for better visualization and understanding of the subject.

It has been found in our research done over hundreds of students and dozens of colleges and universities that visualization IQ is lacking in different quantities among male and female students. It is therefore necessary to aid learning process by use of high quality computer animations as a novel pedagogical concept.

This CD contains 51 modules and CD is provided FREE with 50th Edition of the book.

Chapter No.	Chapter Name	Module No.	Particulars
1	Drawing Instruments and their uses	Module 01	Introduction of the subject and Various Drawing Instruments.
2	Sheet layout and freehand sketching	Module 02	Introduction of sheets and sheet layout
3	Lines, Lettering and Dimensioning	Module 03	Type of lines, Lettering and Dimensioning
5	Geometrical Construction	Module 04	To draw parallel line : To draw perpendicular to a given line: Problem 5-5
		Module 05	To divide a line in equal parts: Problem 5-8
		Module 06	To divide a circle in equal parts: Problem 5-10
		Module 07	To trisect a right angle: Problem 5-13
		Module 08	To construct an ogee or reverse curve: Problem 5-22
		Module 09	To construct regular polygons problem 5-26
		Module 10	Special methods of drawing regular polygons: Problem 5-27
		Module 11	Special methods of drawing regular polygons: Problem 5-29
6	Curves Used in Engineering Practice	Module 12	General method of constructin of an ellipse: Problem 6-1
		Module 13	Concentric circles method to draw an ellipse : Method ii of problem 6-2
		Module 14	General method of construction of a parabloa: Problem 6-8
7	Loci of Points	Module 15	The simple slider crank mechanism: Problem 7-6
		Module 16	The offset slider crank mechanism: Problem 7-7
		Module 17	Four bar mechanism: Problem 7-12
8	Orthographic Projection	Module 18	Problem 8-1
		Module 19	Problem 8-2
		Module 20	Problem 8-3
9	Projections of Points	Module 21	General
10	Projections of Straight Lines	Module 22	Line perpendicular to one of the planes
		Module 23	line inclined to one plane and parallel to the other
		Module 24	Projections of lines inclined to both the planes

Chapter 1

DRAWING INSTRUMENTS AND THEIR USES

1-1. INTRODUCTION

Drawing instruments are used to prepare drawings easily and accurately. The accuracy of the drawings depends largely on the quality of instruments. With instruments of good quality, desirable accuracy can be attained with ease. It is, therefore, essential to procure instruments of as superior quality as possible.

Below is the list of minimum drawing instruments and other drawing materials which every student must possess:

1. Drawing board
2. T-square
3. Set-squares — 45° and 30°- 60°
4. Drawing instrument box, containing:
   (i) Large-size compass with inter-changeable pencil and pen legs
   (ii) Lengthening bar
   (iii) Small bow compass
   (iv) Large-size divider
   (v) Small bow divider
   (vi) Small bow ink-pen
   (vii) Inking pen
5. Scales
6. Protractor
7. French curves
8. Drawing papers
9. Drawing pencils
10. Sand-paper block
11. Eraser (Rubber)
12. Drawing pins, clips or adhesive tapes
13. Duster
14. Drafting machine
15. Roll-n-draw.

We shall now describe each of the above in details with their uses:

This book is accompanied by a computer CD, which contains an audiovisual animation presented for better visualization and understanding of the subject. Readers are requested to refer Presentation module 1 for Introduction of the subject and various drawing instruments.

1-2. DRAWING BOARD (FIG. 1-1)

Drawing board is rectangular in shape and is made of strips of well-seasoned soft wood about 25 mm thick. It is cleated at the back by two battens to prevent warping. One of the edges of the board is used as the *working edge*, on which the T-square is made to slide. It should, therefore, be perfectly straight. In some boards, this edge is grooved throughout its length and a perfectly straight ebony edge is fitted inside this groove. This provides a true and more durable guide for the T-square to slide on.

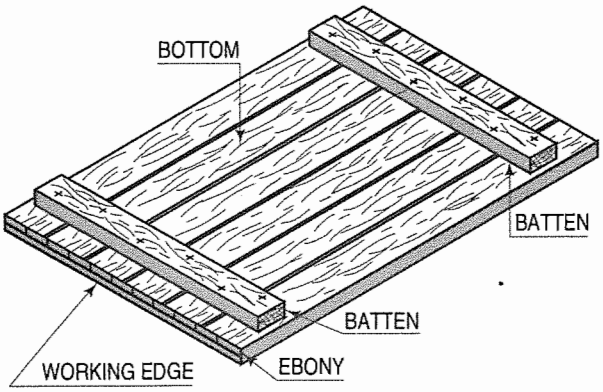

FIG. 1-1

TABLE 1-1
SIZES OF DRAWING BOARDS

Designation	Size (mm)
B0	1000 × 1500
B1	700 × 1000
B2	500 × 700
B3	350 × 500

Drawing board is made in various sizes. Its selection depends upon the size of the drawing paper to be used. The sizes of drawing boards recommended by the Bureau of Indian Standards (IS:1444-1989) are tabulated in table 1-1.

For use in schools and colleges, the last two sizes of the drawing boards are more convenient. Large-size boards are used in drawing offices of engineers and engineering firms. The drawing board is placed on the table in front of the student, with its working edge on his left side. It is more convenient if the table-top is sloping downwards towards the student. If such a table is not available, the necessary slope can be obtained by placing a suitable block of wood under the distant longer edge of the board.

1-3. T-SQUARE (FIG. 1-2)

A T-square is made up of hard-quality wood. It consists of two parts — the stock and the blade — joined together at right angles to each other by means of screws and pins. The stock is placed adjoining the working edge of the board and is made to slide on it as and when required. The blade lies on the surface of the board. Its distant edge which is generally bevelled, is used as the working edge and hence, it should be perfectly straight. The nearer edge of the blade is never used. The length of the blade is selected so as to suit the size of the drawing board. Now-a-days T-square is also available of celluloid or plastic with engraved scale.

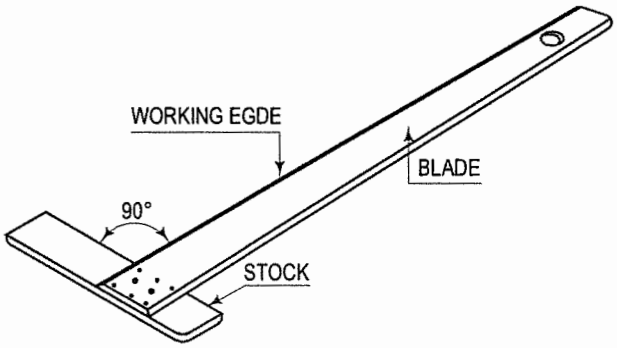

FIG. 1-2

Uses:

(i) The T-square is used for drawing horizontal lines. The stock of the T-square is held firmly with the left hand against the working edge of the board, and the line is drawn from left to right as shown in fig. 1-3. The pencil should be held slightly inclined in the direction of the line (i.e. to the right) while the pencil point should be as close as possible to the working edge of the blade. Horizontal parallel lines are drawn by sliding the stock to the desired positions.

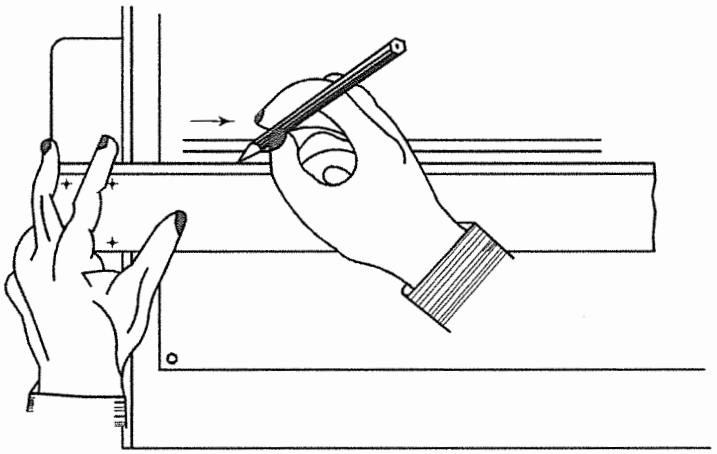

FIG. 1-3

(ii) The working edge of the T-square is also used as a base for set-squares to draw vertical, inclined or mutually parallel lines. A pencil must be rotated while drawing lines for uniform wear of lead. The T-square should never be used on edge other than the working edge of the board. It should always be kept on the board even when not in use.

(iii) Testing the straightness of the working edge of the T-square: Mark any two points *A* and *B* (fig. 1-4) spaced wide apart and through them, carefully draw a line with the working edge. Turn the T-square upside down as shown by dashed lines and with the same edge, draw another line passing through the same two points. If the edge is defective the lines will not coincide. The error should be rectified by planing or sand-papering the defective edge.

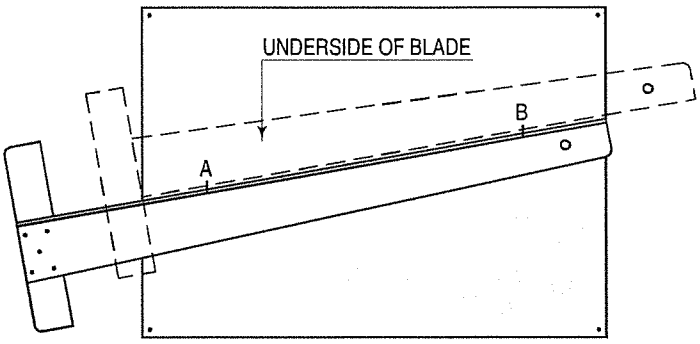

FIG. 1-4

1-4. SET-SQUARES (FIG. 1-5)

The set-squares are made of wood, tin, celluloid or plastic. Those made of transparent celluloid or plastic are commonly used as they retain their shape and accuracy for a longer time. Two forms of set-squares are in general use. A set-square is triangular in shape with one of the angle as right angle. The 30°-60° set-square of 250 mm length and 45° set-square of 200 mm length are convenient sizes for use in schools and colleges.

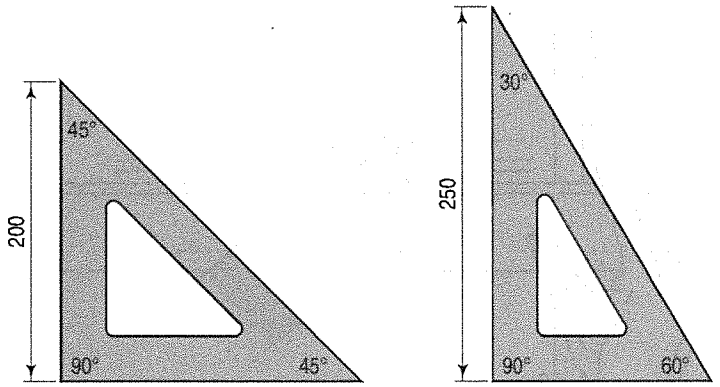

FIG. 1-5

Uses:

(i) Set-squares are used for drawing all straight lines except the horizontal lines which are usually drawn with the T-square. Vertical lines can be drawn with the T-square and the set-square.

(ii) In combination with the T-square, lines at 30° or 60° angle with vertical or horizontal lines can be drawn with 30°- 60° set-square and 45° angle with 45° set-square. The two set-squares used simultaneously along with the T-square will produce lines making angles of 15°, 75°, 105° etc.

(iii) Parallel straight lines in any position, not very far apart, as well as lines perpendicular to any line from any given point within or outside it, can also be drawn with the two set-squares.

(iv) A circle can be divided in six, eight, twelve and twenty four equal parts by using set-squares and T-square.

Problem 1-1. *To draw a line perpendicular to a given horizontal line from a given point within it.*

(i) Place the T-square a little below the given line (fig. 1-6).

(ii) Arrange any one set-square with one of the edges containing the right angle touching the working edge of the T-square, and the other edge passing through the given point.

(iii) Hold the T-square and the set-square in this position firmly with the left hand.

(iv) With the right hand, draw the required line through the given point in the upward direction as shown by the arrow. The pencil point should always be in contact with the edge of the set-square. A perpendicular from any given point outside the line can also be drawn in the same manner. Vertical parallel lines may be drawn by sliding the set-square along the edge of the T-square to the required positions.

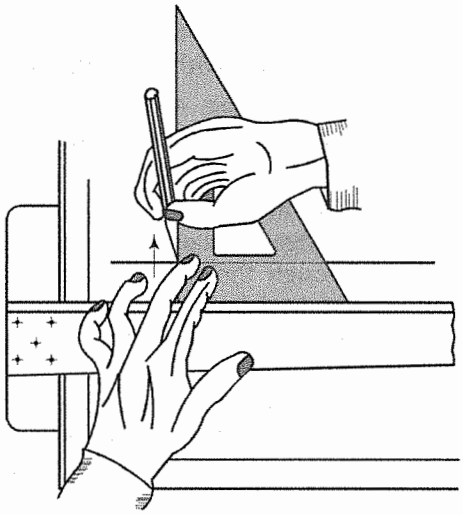

FIG. 1-6

Problem 1-2. *To draw a line inclined at 45°, 30° or 60° to a given horizontal line from a given point.*

(i) Place the edge containing the right angle of the 45° set-square on the edge of the T-square (fig. 1-7).

(ii) Slide it so that its longest edge (hypotenuse) passes through the given point and then draw the required line. The same line will make 45° angle with the vertical line passing through that point.

(iii) By turning the set-square upside down, the line making 45° angle in the other direction will be drawn. The lines can also be drawn by placing the set-square so that its longest edge coincides with the edge of the T-square and the other edge passes through the given point. A circle can similarly be divided into eight equal parts by lines passing through its centre (fig. 1-8).

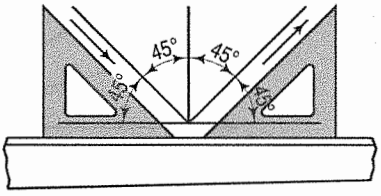

FIG. 1-7

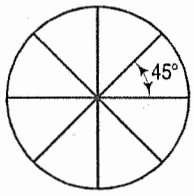

FIG. 1-8

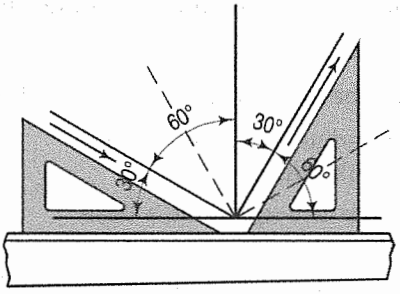

FIG. 1-9

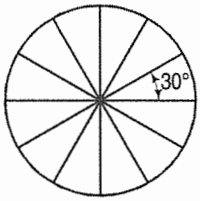

FIG. 1-10

Lines inclined at 30° or 60° to a given horizontal line can similarly be drawn with the aid of a 30°- 60° set-square (fig. 1-9). A circle may be divided into twelve equal divisions in the same manner (fig. 1-10).

Problem 1-3. *To draw a line inclined at 15° to a given horizontal line from a given point.*

(i) Place the 30°-60° set-square with its longer edge containing the right angle, coinciding with the edge of the T-square (fig. 1-11).

(ii) Arrange the 45° set-square with its longest edge on the longest edge of the 30°-60° set-square.

(iii) Slide the 45° set-square so that one of its edges containing the right angle passes through the given point, and draw the required line. The line drawn with the other edge will make 15° angle with the vertical line and 105° or 75° angles with the horizontal line. *A circle may thus be divided into 24 equal parts with the aid of the set-squares* (fig. 1-12).

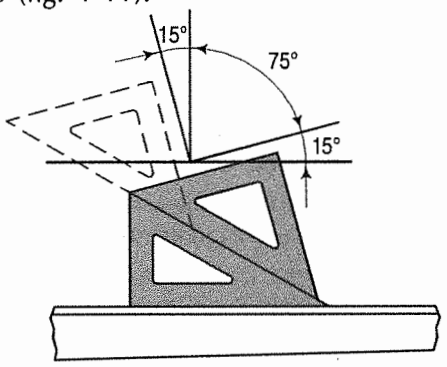

FIG. 1-11

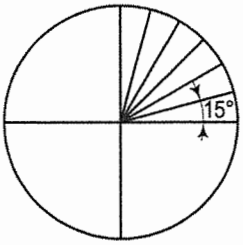

FIG. 1-12

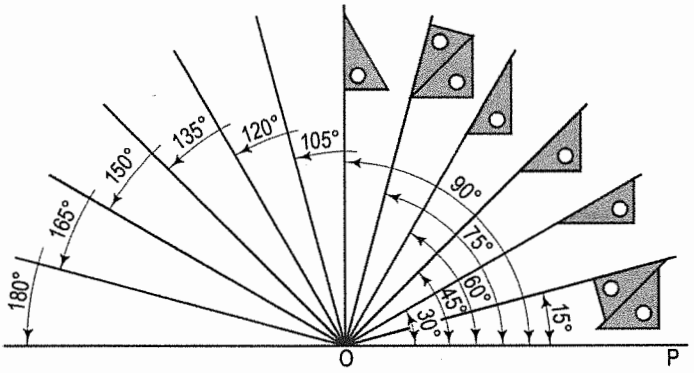

FIG. 1-13

Fig. 1-13 shows methods of drawing lines (with the aid of the T-square and set-squares) making angles with the horizontal line in multiples of 15° upto 180°.

Problem 1-4. *To draw a line parallel to a given straight line through a given point.*

The line *AB* and the point *P* are given (fig. 1-14).

(i) Arrange an edge of a set-square coinciding with *AB*.

(ii) Place the other set-square as a base for the first.

(iii) Hold the second set-square firmly and slide the first, till its arranged edge is along the point *P*.

(iv) Draw the line *CD* through *P*. *CD* is the required parallel line.

By keeping the edge of the T-square as base for the set-square, parallel lines, long distances apart, can be drawn.

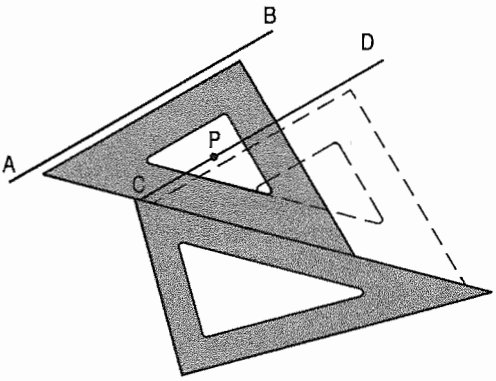

FIG. 1-14

Problem 1-5. *To draw a line perpendicular to a given line through a point within or outside it.*

The line *PQ* and the point *O* are given (fig. 1-15).

Method I:

(i) Arrange the longest edge of one set-square along *PQ*.

(ii) Place the second set-square or T-square as base along one of the edges containing the right angle.

(iii) Holding the base set-square firmly, rotate the first set-square so that its other edge containing the right angle coincides with the edge of the base set-square.

(iv) Slide the first set-square till its longest edge is on the point *O* and draw the required line *AB*.

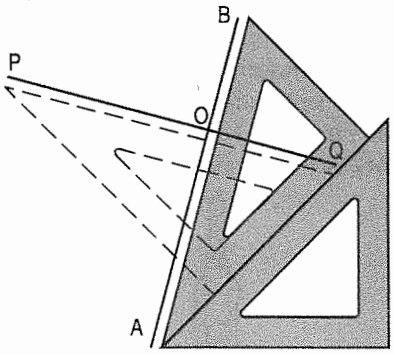

FIG. 1-15

Method II:

(i) Arrange one set-square with an edge containing the right angle along the line *PQ* (fig. 1-16).

(ii) Place the second set-square or T-square as a base under the longest edge.

(iii) Slide the first set-square on the second till the other edge containing the right angle is on the point *O* and draw the required line *AB*.

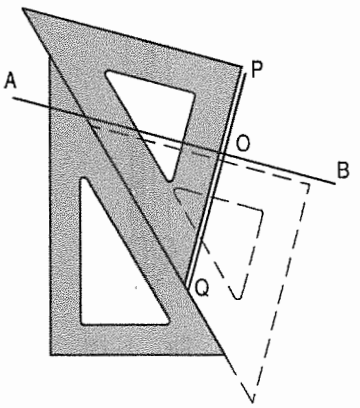

FIG. 1-16

Problem 1-6. *To draw a line parallel to a given straight line at a given distance, say 20 mm from it* (fig. 1-17).

Let *AB* be the given line.

(i) From any point *P* in *AB*, draw a line *PQ* perpendicular to *AB* (Problem 1-5).

(ii) Mark a point *R* such that *PR* = 20 mm.

(iii) Through *R*, draw the required line *CD* parallel to *AB* (Problem 1-4).

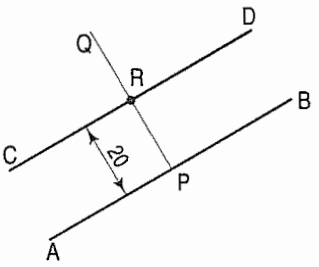

FIG. 1-17

1-5. DRAWING INSTRUMENT BOX

The drawing instrument box contains the following as mentioned earlier:

(1) Large-size compass with interchangeable pencil and pen legs
(2) Lengthening bar
(3) Small bow compass
(4) Large-size divider
(5) Small bow divider
(6) Small bow ink-pen
(7) Inking pen.

(1) Large-size compass with interchangeable pencil and pen legs (fig. 1-18)**:** The compass is used for drawing circles and arcs of circles. It consists of two legs hinged together at its upper end. A pointed needle is fitted at the lower end of one leg, while a pencil lead is inserted at the end of the other leg. The lower part of the pencil leg is detachable and it can be interchanged with a similar piece containing an inking pen. Both the legs are provided with knee joints. Circles upto about 120 mm diameter can be drawn with the legs of the compass kept straight. For drawing larger circles, both the legs should be bent at the knee joints so that they are perpendicular to the surface of the paper (fig. 1-19).

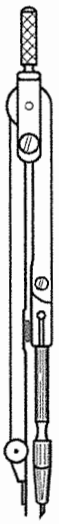

FIG. 1-18

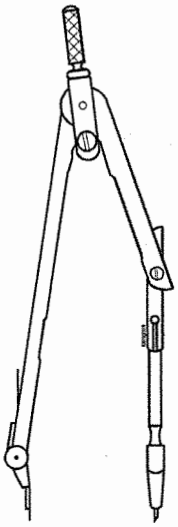

FIG. 1-19

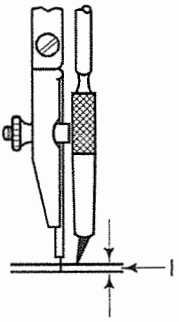

FIG. 1-20

As the needle is required to be inserted slightly inside the paper, it is kept longer than the lead point. *The setting of the pencil-lead relative to the needle, and the shape to which the lead should be ground are shown in fig. 1-20.*

To draw a circle, adjust the opening of the legs of the compass to the required radius. Hold the compass with the thumb and the first two fingers of the right hand and place the needle point lightly on the centre, with the help of the left hand. Bring the pencil point down on the paper and swing the compass about the needle-leg with a twist of the thumb and the two fingers, in clockwise ↻ direction, until the circle is completed. The compass should be kept slightly inclined in the direction of its rotation. *While drawing concentric circles, beginning should be made with the smallest circle.*

(2) Lengthening bar: Circles of more than 150 mm radius are drawn with the aid of the lengthening bar. The lower part of the pencil leg is detached and the lengthening bar is inserted in its place. The detached part is then fitted at the end of the lengthening bar, thus increasing the length of the pencil leg (fig. 1-21).

It is often necessary to guide the pencil leg with the other hand, while drawing large circles.

(3) Small bow compass: For drawing small circles and arcs of less than 25 mm radius and particularly, when a large number of small circles of the same diameter are to be drawn, small bow compass is used (fig. 1-22).

Curves drawn with the compass should be of the same darkness as that of the straight lines. It is difficult to exert the same amount of pressure on the lead in the compass as on a pencil.

It is, therefore, desirable to use slightly softer variety of lead (about one grade lower, HB or H) in the compass than the pencil used for drawing straight lines, to maintain uniform darkness in all the lines.

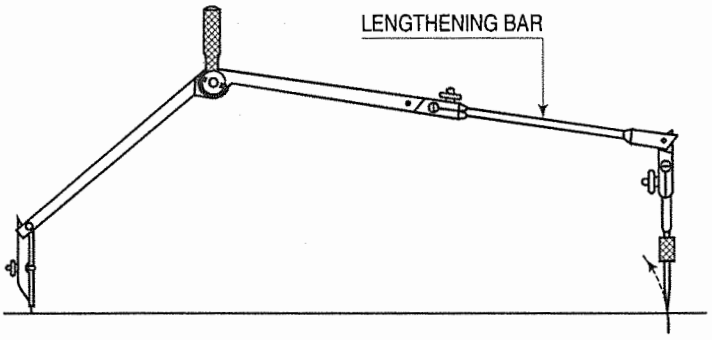

FIG. 1-21

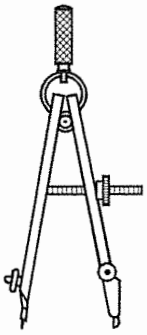

FIG. 1-22

FIG. 1-23

(4) Large-size divider: The divider has two legs hinged at the upper end and is provided with steel pins at both the lower ends, but it does not have the knee joints (fig. 1-23).

In most of the instrument boxes, a needle attachment is also provided which can be interchanged with the pencil part of the compass, thus converting it into a divider.

The dividers are used:

(i) to divide curved or straight lines into desired number of equal parts,

(ii) to transfer dimensions from one part of the drawing to another part, and

(iii) to set-off given distances from the scale to the drawing.

They are very convenient for setting-off points at equal distances around a given point or along a given line.

(5) Small bow divider: The small bow divider is adjusted by a nut and is very convenient for marking minute divisions and large number of short equal distances.

Problem 1-7. *To divide a straight line into a number of equal parts — say 3.*

The straight line *AB* is given (fig. 1-24).

(i) Set the legs of the divider so that the steel pins are approximately $\frac{1}{3}$ of the length of the line apart.

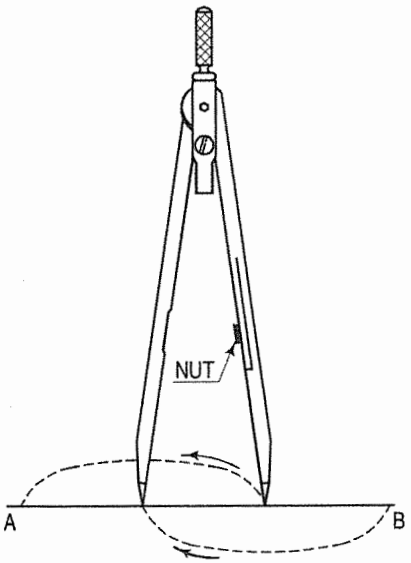

FIG. 1-24

(ii) Step this distance lightly from one end of the line, say *B*, turning the divider first in one direction and then in the other. If the last division falls short, increase the set distance by approximately $\frac{1}{3}$ of the difference by means of the nut, keeping the other point of the divider on the paper. If the last division goes beyond the end of the line, decrease the set distance by $\frac{1}{3}$ of the difference.

(iii) Re-space the line, beginning from the starting point, and adjusting the divider until the required setting is obtained.

With some practice, it will be possible to obtain the desired result with less trials and in short time. The trial divisions should be set-off as lightly as possible so that the paper is not pricked with large and unnecessary holes.

Any arc or a circle can similarly be divided into any number of equal divisions.

(6) Small bow ink-pen: It is used for drawing small circles and arcs in ink.

(7) Inking pen (fig. 1-25): This is used for drawing straight lines and non-circular arcs in ink. It consists of a pair of steel nibs fitted to a holder made of metal or ivory. Ink is filled between the two nibs to about 6 mm length by means of a quill which is usually fitted to the cork of the ink bottle. The gap between the nibs through which the ink flows and upon which the thickness of the line depends is adjusted by means of the screw *S*.

The pen should be kept sloping at about 60° with the paper in the direction of drawing the line and the ends of the nibs should be slightly away from the edge of the T-square or set-square. The screw should be on the side, farther from the T-square.

As the ink dries rapidly, the pen should be used immediately after it is filled. The inside faces of the nibs should be frequently cleaned for the ink to flow freely and to maintain uniformity in thickness of lines. Ink should never be allowed to dry within the pen. There should be no ink on the outside of the nibs and hence, the pen should never be dipped in ink.

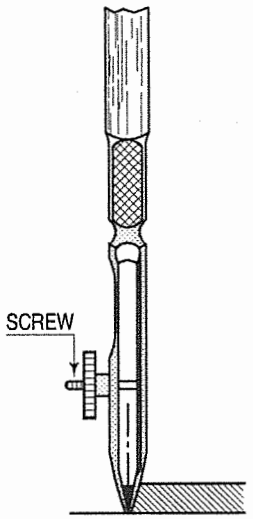

FIG. 1-25

For drawing large circles and circular arcs, inking attachment should be fitted in place of the pencil leg in the compass.

1-6. SCALES (FIG. 1-26)

Scales are made of wood, steel, celluloid or plastic or card board. Stainless-steel scales are more durable. Scales may be flat or of triangular cross-section. 15 cm long and 2 cm wide or 30 cm long and 3 cm wide flat scales are in common use. They are usually about 1 mm thick. Scales of greater thickness have their longer edges bevelled. This helps in marking measurements from the scale to the drawing paper accurately. Both the longer edges of the scales are marked with divisions of centimetres, which are sub-divided into millimetres.

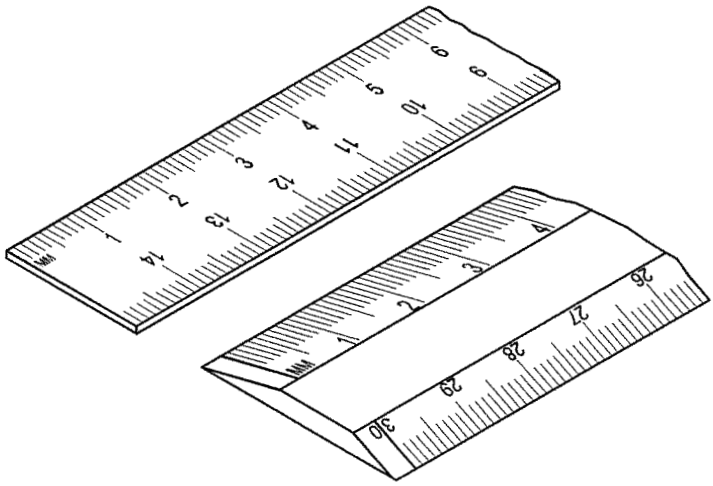

FIG. 1-26

Various other types of scales are described in chapter 4.

The scale is used to transfer the true or relative dimensions of an object to the drawing. It is placed with its edge on the line on which measurements are to be marked and, looking from exactly above the required division, the marking is done with a fine pencil point. *The scale should never be used as a straight-edge for drawing lines. The card-board scales are available in a set of eight scales. They are designated from M1 to M8 as shown in table 1-2.*

TABLE 1-2
STANDARD SCALES

Designation	Description	Scale
M1	Full size	1:1
	50 cm to a metre	1:2
M2	40 cm to a metre	1:2.5
	20 cm to a metre	1:5
M3	10 cm to a metre	1:10
	5 cm to a metre	1:20
M4	2 cm to a metre	1:50
	1 cm to a metre	1:100
M5	5 mm to a metre	1:200
	2 mm to a metre	1:500
M6	3.3 mm to a metre	1:300
	1.66 mm to a metre	1:600
M7	2.5 mm to a metre	1:400
	1.25 mm to a metre	1:800
M8	1 mm to a metre	1:1000
	0.5 mm to a metre	1:2000

1-7. PROTRACTOR (FIG. 1-27)

Protractor is made of wood, tin or celluloid. Protractors of transparent celluloid are in common use. They are flat and circular or semi-circular in shape. The commonest type of protractor is semi-circular and of about 100 mm diameter. Its circumferential edge is graduated to 1° divisions, is numbered at every 10° interval and is readable from both the ends. The diameter of the semi-circle (viz. straight line 0-180°) is called the base of the protractor and its centre O is marked by a line perpendicular to it.

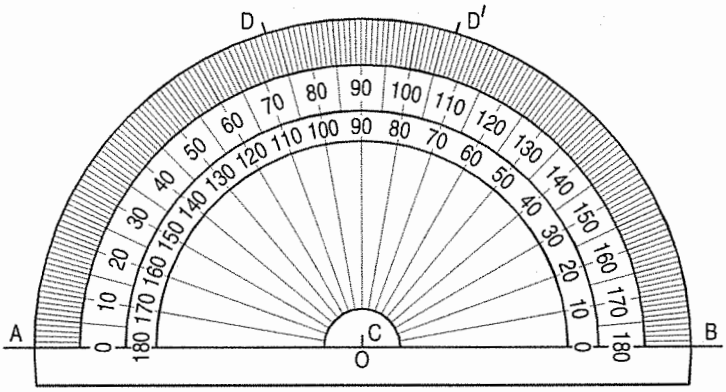

FIG. 1-27

The protractor is used to draw or measure such angles as cannot be drawn with the set-squares. A circle can be divided into any number of equal parts by means of the protractor.

Problem 1-8. *To draw a line making an angle of 73° with a given line through a given point in it.*

Let AB be the line and C the point in it.

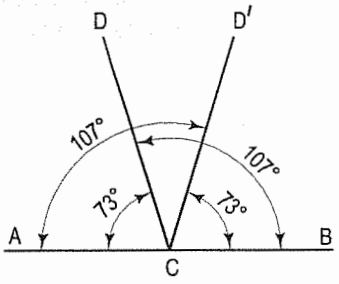

FIG. 1-28

(i) Set the protractor with its base coinciding with AB (fig. 1-28) and its centre exactly on the point C.

(ii) Mark a point D opposite to the 73° division and join C with D. Then $\angle ACD = 73°$ (fig. 1-28). Another point D' can be marked against the reading from the other side. In this case $\angle BCD' = 73°$ while $\angle ACD' = 107°$.

1-8. FRENCH CURVES

French curves are made of wood, plastic or celluloid. They are made in various shapes, one of which is shown in fig. 1-29. Some set-squares also have these curves cut in their middle.

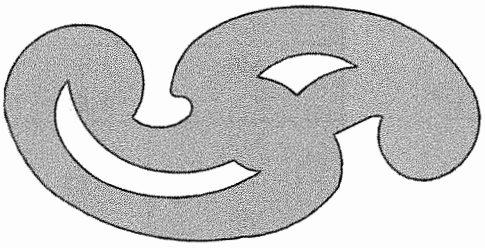

FIG. 1-29

French curves are used for drawing curves which cannot be drawn with a compass. Faint freehand curve is first drawn through the

known points. Longest possible curves exactly coinciding with the freehand curve are then found out from the french curve. Finally, neat continuous curve is drawn with the aid of the french curve. Care should be taken to see that no corner is formed anywhere within the drawn curve.

1-9. DRAWING PAPERS

Drawing papers are available in many varieties. For ordinary pencil-drawings, the paper selected should be tough and strong. It should be uniform in thickness and as white as possible. When the rubber eraser is used on it, its fibres should not disintegrate. Good quality of paper with smooth surface should be selected for drawings which are to be inked and preserved for a long time. It should be such that the ink does not spread. Thin and cheap quality paper may be used for drawings from which tracings are to be prepared. The standard sizes of drawing papers recommended by the Bureau of Indian Standards (B.I.S.). are given in table 2-1.

Surface area of A0 size is one square metre. Successive format sizes (from A0 to A5) are obtained by halving along the length or doubling along the width. The areas of the two supsequent sizes are in the ratio 1:2. See fig. 1-30.

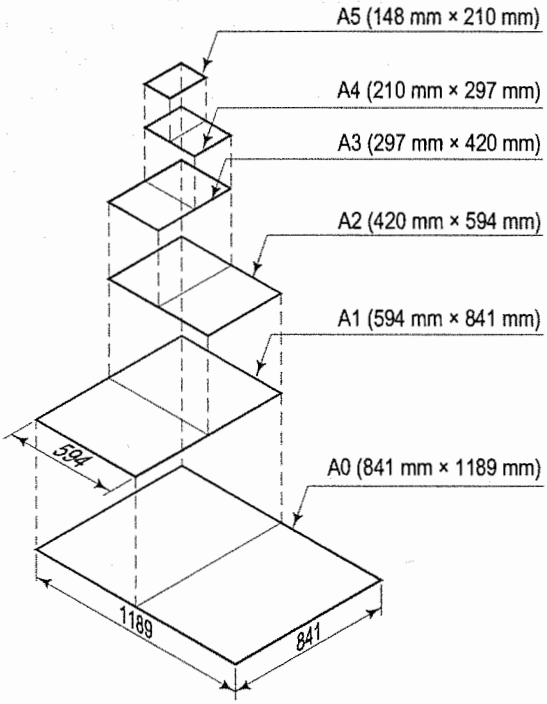

FIG. 1-30

1-10. DRAWING PENCILS

The accuracy and appearance of a drawing depend very largely on the quality of the pencils used. With cheap and low-quality pencils, it is very difficult to draw *lines of uniform shade and thickness*. The grade of a pencil lead is usually shown by figures and letters marked at one of its ends. Letters HB denote the medium grade. The increase in hardness is shown by the value of the figure put in front of the letter H, viz. 2H, 3H, 4H etc. Similarly, the grade becomes softer according to the figure placed in front of the letter B, viz. 2B, 3B, 4B etc.

Beginning of a drawing should be made with H or 2H pencil using it very lightly, so that the lines are faint, and unnecessary or extra lines can be easily erased. The final fair work may be done with *harder pencils, e.g. 3H and upwards.* Lines of uniform thickness and darkness can be more easily drawn with hard-grade pencils.

H and HB pencils are more suitable for lettering and dimensioning. For freehand sketching, where considerable erasing is required to be done, soft-grade pencils such as HB should be used.

Great care should be taken in mending the pencil and sharpening the lead, as the uniformity in thickness of lines depends largely on this. The lead may be sharpened to *two* different forms:

(i) Conical point and
(ii) Chisel edge.

The conical point is used in sketch work and for lettering etc. With the chisel edge, long thin lines of uniform thickness can be easily drawn and hence, it is suitable for drawing work.

To prepare the pencil lead for drawing work, the wood around the lead from the end, other than that on which the grade is marked, is removed with a pen-knife, leaving about 10 mm of lead projecting out, as shown in fig. 1-31(a).

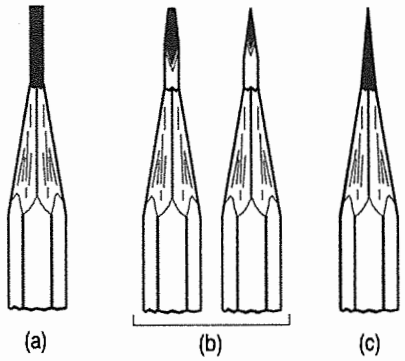

FIG. 1-31

The chisel edge [fig. 1-31(b)] is prepared by rubbing the lead on a sand-paper block, making it flat, first on one side and then on the other by turning the pencil through a half circle. For making the conical end [fig. 1-31(c)] the pencil should be rotated between the thumb and fingers, while rubbing the lead.

The pencil lead should occasionally be rubbed on the sand-paper block (while doing the drawing work) to maintain the sharpness of the chisel edge or the pointed end.

Instead of wooden pencils, Mechanical clutch pencils with a different lead size and grade like 5 mm, 4 mm and H, 2H, HB etc., are also available. Sharpening is not required in such pencils.

1-11. ERASER (RUBBER)

Soft India-rubber is the most suitable kind of eraser for pencil drawings. It should be such as not to spoil the surface of the paper. Frequent use of rubber should be avoided by careful planning.

1-12. DRAWING PINS, CLIPS OR ADHESIVE TAPES

These are used to fix the drawing paper on the drawing board. The needle part of the pin is generally made of steel, while the head may be of plated mild steel or brass. Pins of about 15 mm to 20 mm diameter and about 1 mm thick flat heads made of brass are quite convenient, as they do not rust. Pins should be so inserted that the heads sit on the surface of the paper. Clips or adhesive tapes are often used instead of the pins. (Refer fig. 1-32).

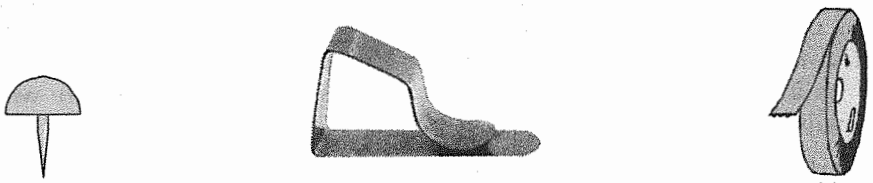

FIG. 1-32

1-13. SAND-PAPER BLOCK

It consists of a wooden block about 150 mm × 50 mm × 12 mm thick with a piece of sand-paper pasted or nailed on about half of its length, as shown in fig. 1-33.

The sand-paper, should be replaced by another, when it becomes dirty or worn out. This block should always be kept within easy reach for sharpening the pencil lead every few minutes.

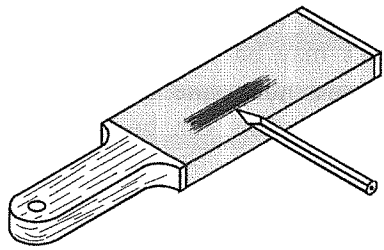

FIG. 1-33

1-14. DUSTER

Duster should preferably be of towel cloth of convenient size. Before starting work, all the instruments and materials should be thoroughly cleaned with the duster. The rubber crumbs formed after the use of the rubber should be swept away by the duster and not by hand. The underside of the T-square and the set-squares or the drafting machine which continuously rub against the paper should be frequently cleaned.

1-15. DRAFTING MACHINE (FIG. 1-34)

The uses and advantages of the T-square, set-squares, scales and the protractor are combined in the drafting machine. Its one end is clamped by means of a screw, to the distant longer edge of the drawing board. At its other end, an adjustable head having protractor markings is fitted. Two blades of transparent celluloid accurately set at right angles to each other are attached to the head.

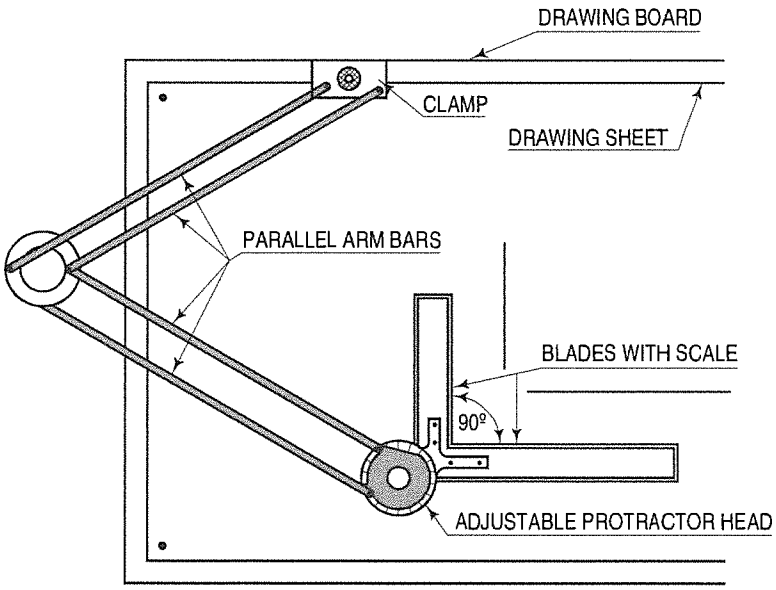

FIG. 1-34

The machine has a mechanism which keeps the two blades always parallel to their respective original position, wherever they may be moved on the board. The blades have scales marked on them and are used as straight edges. In some machines, the blades are removable and hence a variety of scales can be used. The blades may be set at any desired angle with the help of the protractor markings.

Thus, by means of this machine, horizontal, vertical or inclined parallel lines of desired lengths can be drawn anywhere on the sheet with considerable ease and saving of time. Drafting machines are common among the college students and draughtsmen.

1-16. ROLL-N-DRAW (FIG. 1-35)

It consists of graduated roller, scale of 16 centimeter and protactor. It is ideal for drawing vertical lines, horizontal lines, parallel lines, angles and circles.

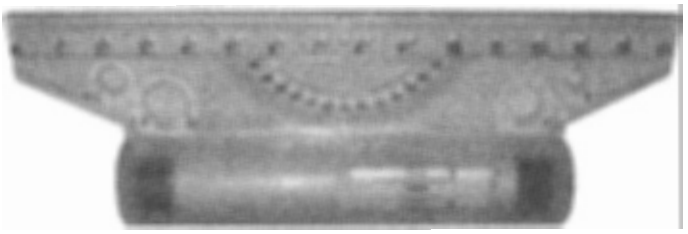

FIG. 1-35

1-17. GENERAL SUGGESTIONS FOR DRAWING A SHEET

(1) Cleaning the instruments: Clean the drawing board and the T-square and place them on the table, with the working edge of the board on your left-hand side and the stock of the T-square attached to that working edge. Clean all other instruments and materials and place them on a neat piece of paper by the side of the board. When a drafting machine is used, clean the drafting machine before fixing on drawing board.

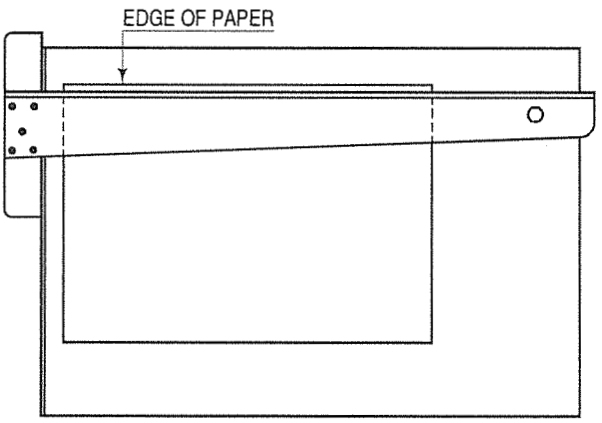

FIG. 1-36

(2) Pinning the paper to the drawing board: Place the paper at about equal distances from the top and bottom edges of the board and one of its shorter edges at about 25 mm from the working edge of the board. When the paper is