

# ENGINEERING DRAWING

## (NSQF)

1<sup>st</sup> YEAR  
(For 2 Year Trades)

Revised Syllabus - 2022

### Group 2

#### Group 2 CTS Trades Covered

Fitter, Turner, Machinist, Machinist Grinder, Mechanic Machine Tool Maintenance, Operator Advance Machine Tool, TDM (D&M), TDM (J&F), Mechanic Mining Machinery, Textile Mechatronics, Basic Designer & Virtual Verifier, Advanced CNC machining, Aeronautical Structure & Equipment Fitter



Directorate General of Training

DIRECTORATE GENERAL OF TRAINING  
MINISTRY OF SKILL DEVELOPMENT & ENTREPRENEURSHIP  
GOVERNMENT OF INDIA



**NATIONAL INSTRUCTIONAL  
MEDIA INSTITUTE, CHENNAI**

Post Box No. 3142, CTI Campus, Guindy, Chennai - 600 032

**Engineering Drawing (NSQF) 1<sup>st</sup> Year (For 2 Year Trades)**  
**Group 2 Engineering Trades**  
**As per Revised syllabus 2022 under CTS**

**Developed & Printed by**



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## FOREWORD

The Government of India has set an ambitious target of imparting skills to 30 crores people, one out of every four Indians, by 2020 to help them secure jobs as part of the National Skills Development Policy. Industrial Training Institutes (ITIs) play a vital role in this process especially in terms of providing skilled manpower. Keeping this in mind, and for providing the current industry relevant skill training to Trainees, ITI syllabus has been recently updated with the help of comprising various stakeholder's viz. Industries, Entrepreneurs, Academicians and representatives from ITIs.

The National Instructional Media Institute (NIMI), Chennai, has now come up with instructional material to suit the revised curriculum for **Engineering Drawing 1<sup>st</sup> Year (For 2 Year Trades) NSQF Group 2 Engineering Trades** under CTS will help the trainees to get an international equivalency standard where their skill proficiency and competency will be duly recognized across the globe and this will also increase the scope of recognition of prior learning. NSQF trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

The Executive Director & Staff of NIMI and members of Media Development Committee deserve appreciation for their contribution in bringing out this publication.

Jai Hind

**SHRI. ATUL KUMAR TIWARI., I.A.S.,**

Director General/Addl. Secretary  
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New Delhi - 110 001

## PREFACE

The National Instructional Media Institute(NIMI) was set up at Chennai, by the Directorate General of Training, Ministry of skill Development and Entrepreneurship, Government of India, with the technical assistance from the Govt of the Federal Republic of Germany with the prime objective of developing and disseminating instructional Material for various trades as per prescribed syllabus and Craftsman Training Programme(CTS) under NSQF levels.

The Instructional materials are developed and produced in the form of Instructional Media Packages (IMPs), consisting of Trade Theory, Trade Practical, Test and Assignment Book, Instructor Guide, Wall charts, Transparencies and other supportive materials. The above material will enable to achieve overall improvement in the standard of training in ITIs.

A national multi-skill programme called SKILL INDIA, was launched by the Government of India, through a Gazette Notification from the Ministry of Finance (Dept of Economic Affairs), Govt of India, dated 27th December 2013, with a view to create opportunities, space and scope for the development of talents of Indian Youth, and to develop those sectors under Skill Development.

The emphasis is to skill the Youth in such a manner to enable them to get employment and also improve Entrepreneurship by providing training, support and guidance for all occupation that were of traditional types. The training programme would be in the lines of International level, so that youths of our Country can get employed within the Country or Overseas employment. The **National Skill Qualification Framework (NSQF)**, anchored at the National Skill Development Agency(NSDA), is a Nationally Integrated Education and competency-based framework, to organize all qualifications according to a series of **levels of Knowledge, Skill and Aptitude**. Under NSQF the learner can acquire the Certification for Competency needed at any level through formal, non-formal or informal learning.

The **Engineering Drawing** 1<sup>st</sup> Year (For 2 Year Trades) NSQF Group 2 - Engineering Trades under CTS is one of the book developed by the core group members as per the NSQF syllabus.

The **Engineering Drawing** 1<sup>st</sup> Year (For 2 Year Trades) NSQF Group 2 - Engineering Trades under CTS as per NSQF) is the outcome of the collective efforts of experts from Field Institutes of DGT, Champion ITI's for each of the Sectors, and also Media Development Committee (**MDC**) members and Staff of **NIMI**. NIMI wishes that the above material will fulfill to satisfy the long needs of the trainees and instructors and shall help the trainees for their Employability in Vocational Training.

NIMI would like to take this opportunity to convey sincere thanks to all the Members and Media Development Committee (MDC) members.

Chennai - 600 032

EXECUTIVE DIRECTOR

## ACKNOWLEDGEMENT

The National Instructional Media Institute (NIMI) sincerely acknowledge with thanks the co-operation and contribution of the following Media Developers to bring this IMP for the course **Engineering Drawing 1<sup>st</sup> Year (For 2 Year Trades) Group 2 - Engineering Trades** as per NSQF.

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NIMI records its appreciation of the **Data Entry, CAD, DTP Operators** for their excellent and devoted services in the process of development of this IMP.

NIMI also acknowledges with thanks, the efforts rendered by all other staff who have contributed for the development of this book.

# INTRODUCTION

Theory and procedure along with the related exercises for further practice

This book on theory and procedure along with related exercises contains theoretical information on **1<sup>st</sup> Year Engineering drawing** NSQF (For 2 Year Revised syllabus 2022 Group 2 - Engineering Trades) and procedure of drawing/ sketching different exercise for further practice are also available. Wherever required, BIS specification has been used.

Exercise for further practice

The practice exercise is given with Theory and procedure for 1<sup>st</sup> Year book made obsolete as it was felt that, it is very difficult to work in workbook using drawing instruments. It is well known fact that, any drawing is prepared on suitable standard size of drawing sheets only.

The instructor is herewith advised to go through the instructions given below and to follow them in view of imparting much drawing skill in the trainees.

Acquiring the above said ability and doing small drawings is not a simple task. These books will provide a good platform for achieving the said skills.

**Time allotment:**

**Duration of 1<sup>st</sup> Year : 40 Hrs**

Sl. No.	Topic	Exercise No.	Time Allotment
1	Introduction to Engineering Drawing and Drawing Instruments	1.1.01 - 1.1.05	2
2	Lines and Free hand drawing	1.2.06 - 1.2.09	6
3	Drawing of Geometrical Figures	1.3.10 - 1.3.13	4
4	Dimensioning	1.4.14 - 1.4.16	2
5	Concept and Reading of Drawing	1.5.17 - 1.5.19	14
6	Symbolic Representation	1.6.20	4
7	Reading of Job drawing of related trades	1.7.21	8
			<b>40 Hrs</b>

## Instructions to the Instructors

It is suggested to get the drawing prepared on A4/A3 sheets preferably on only one side. If separate table and chair facility is available for every trainee then it is preferred to use A3 sheets and if the drawing hall is provided with desks then A4 sheets may be used. However while preparing bigger drawings on A4 sheets suitable reduction scale to be used or multiple sheets may be used for detailed and assembly drawings.

First the border and the title block to be drawn only for the first sheet of the chapter. Eg. for conical sections only first sheet will have the title block whereas the rest of the sheets of that chapter will have only borders.

Serial number of sheet and total no. of sheets to be mentioned on each sheet.

The completed sheet to be punched and filled in a box file/ suitable files and preserved by the trainees carefully after the approval of instructor, VP and Principal of the Institute.

The file may be referred by the authority before granting the internal marks at the end of the Year.

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### LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

- **Read and apply engineering drawing for different application in the field of work.**

# SYLLABUS

**1<sup>st</sup> Year**

**Group 2 Revised syllabus 2022  
2 Year Engineering trades under CTS**

**Duration: 1 Year**

**CTS Trades Covered:** Fitter, Turner, Machinist, Machinist Grinder, Mechanic Machine Tool Maintenance, Operator Advance Machine Tool, TDM (D&M), TDM (J&F), Mechanic Mining Machinery, Textile Mechatronics, Basic Designer & Virtual Verifier, Advanced CNC machining, Aeronautical Structure & Equipment Fitter

S.no.	Syllabus	Time in Hrs
1	Introduction to Engineering Drawing and Drawing Instruments – <ul style="list-style-type: none"> <li>• Conventions</li> <li>• Sizes and layout of drawing sheets</li> <li>• Title Block, its position and content</li> <li>• Drawing Instruments</li> </ul>	2
2	Lines - Types and applications in drawing Free hand drawing of - <ul style="list-style-type: none"> <li>• Geometrical figures and blocks with dimension</li> <li>• Transferring measurement from the given object to the free hand sketches.</li> <li>• Free hand drawing of hand tools and measuring tools.</li> </ul>	6
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5	Concept and reading of Drawing in <ul style="list-style-type: none"> <li>• Concept of axes plane and quadrant</li> <li>• Concept of Orthographic and Isometric projections</li> <li>• Method of first angle and third angle projections (definition and difference)</li> </ul>	14
6	Symbolic representation - <ul style="list-style-type: none"> <li>• Different symbols used in the related trades.</li> </ul>	4
7	Reading of Job drawing of related trades.	8
	<b>Total</b>	<b>40</b>



**Introduction to engineering drawing and drawing instruments**

**Communication**

There are many different ways of communicating ideas, information, instructions, requests, etc. They can be transmitted by signs or gestures, by word of mouth, in writing, or graphically. In an industrial context the graphical method is commonly used with communication is achieved by means of engineering drawings.

If oral and written communication only were used when dealing with technical matters, misunderstandings could arise, particularly in relation to shape and size. The lack of a universal spoken language makes communication and understanding even more difficult because of the necessity to translate both words and meaning from one language to another.

However, the universally accepted methods used in graphical communication through engineering drawings eliminate many of these difficulties and make it possible for drawing prepared by a British designer to be correctly interpreted or “read” by, for example, his German, French or Dutch counterparts.

Equally important, the components shown on the drawings could be made by suitably skilled craftsmen of any nationality provided they can “read” an engineering drawing.

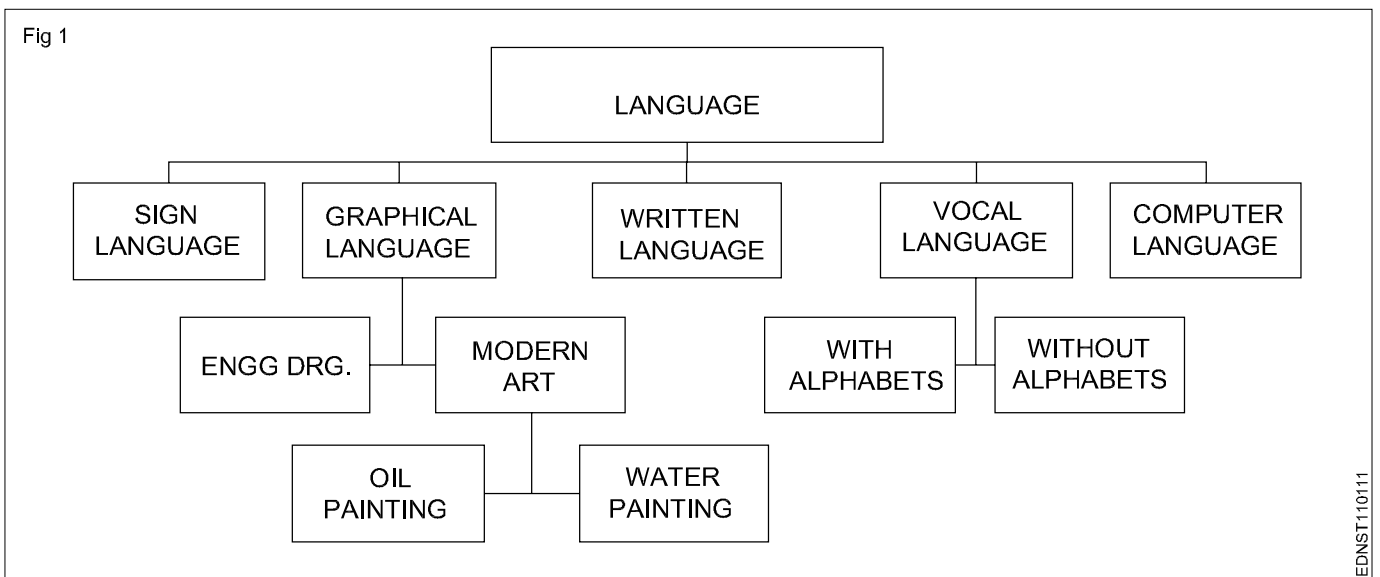
Conventionally prepared engineering drawings provide the main means of communication between the “ideas” men (the designers and draughtsman) and the craftsmen (machinists, fitters, assemblers, etc.). For the communication to be effective, everyone concerned must interpret the drawing in the same way. Only then will the finished product be exactly as the designer envisages it.

To ensure uniformity of interpretation, the British Standards Institution has prepared a booklet entitled BS 308:1972, Engineering Drawing Practice. Now in three parts, this publication recommends the methods which should be adopted for the preparation of drawing used in the engineering industry.

The standards and conventions in most common use and hence those required for a basic understanding of engineering drawing are illustrated and explained in this book.

**Language**

1 It is the media of communication (Fig 1)



## Conclusion

Effective communication is possible when graphical language is supported by written language/vocal language and vice versa.

Engineering drawing is a language that uses both graphical language and written language for effective communication.

**Engineering drawing is a graphical language that also uses written language for effective communication.**

## The importance of Engineering Drawing

The economic success of any country is mainly dependent on its industrial development. Due to globalization, any industry in our country is expected to be of a global market standard. For the above-mentioned reasons, our Indian products require very high quality for their size, dimension, fit, tolerance, and finish etc.

To produce the best standard product, all the technical personnel (Engineers to Craftsman) in an industry must have a sound knowledge of engineering drawing because engineering drawing is the language of engineers. Engineering drawing is a universal language. Different types of lines make up their alphabets. Technical personnel in any industry, including craftsman, are expected to communicate anything concerning a part or a component by means of drawings involving lines, symbols, conventions, abbreviations etc.

With our spoken languages, it is impossible to express the details of a job or a product. Engineering drawing knowledge and practise are a must for designing or producing a component or part. Even a small mistake in the drawing may reflect very badly on the product. Therefore, reading and doing engineering drawings are very essential for craftsmen and engineers.

A drawing is a graphical representation of an object, or part of it, and is the result of creative thought by an engineer or technician. When one person sketches a rough map in giving direction to another, this is graphic communication. Graphic communication involves using visual materials to relate ideas. Drawings, photographs, slides, transparencies, and sketches are all forms of graphic communication. Any medium that uses a graphic image to aid in conveying a message, instructions, or an idea is involved in graphic communication.

One of the most widely used forms of graphic communication is the drawing. Technically, it can be defined as **"a graphic representation of an idea, a concept or an entity which actually or potentially exists in life"**

Drawing is one of the oldest forms of communicating, dating back even farther than verbal communication. The drawing itself is a method of communicating necessary information about an abstract, such as an idea or concept or a graphic representation of some real entity, such as a machine part, house or tools. There are two basic types of drawings: Artistic and Technical drawings.

## Technical drawings

Technical drawings allows efficient communication among engineers and can be kept as a record of the planning process. Since a picture is worth a thousand words, a technical drawing is a much more effective tool for engineers than a written plan.

The technical drawing, on the other hand is not subtle, or abstract. It does not require an understanding of its creator, only on understanding of technical drawings. A technical drawing is a means of clearly and concisely communicating all of the information necessary to transform an idea or a concept in to reality. Therefore, a technical drawing often contains more than just a graphic representation of its subject. It also contains dimensions, notes and specifications.

## Fields of use

Technical drawing is the preferred method of drafting in all engineering fields, including, but not limited to, civil engineering, electrical engineering, mechanical engineering and architecture.

## Purpose of studying engineering drawing

- 1 To develop the ability to produce simple engineering drawing and sketches based on current practice
- 2 To develop the skills to read manufacturing and construction drawings used in industry.
- 3 To develop a working knowledge of the layout of plant and equipment.
- 4 To develop skills in abstracting information from calculation sheets and schematic diagrams to produce working drawings for manufacturers, installers and fabricators.

## Main types of Engineering drawing

Regardless of branch of engineering the engineering drawing is used. However based on the major engineering branches, engineering drawing can be classified as follows: (Fig 2)

### Mechanical Engineering drawings

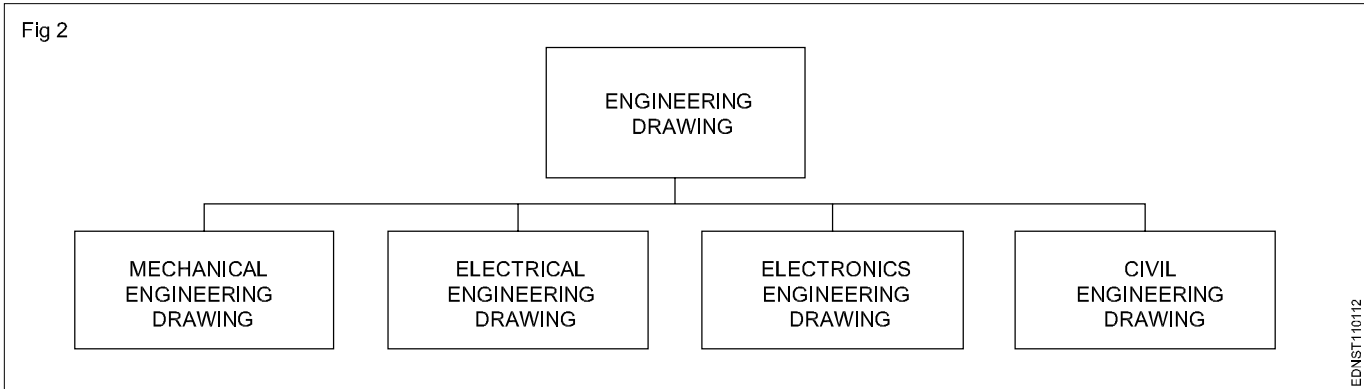
Some examples of mechanical engineering drawings are part and assembly drawings, riveted joints, welded joints, fabrication drawings, pneumatics and hydraulics drawings, pipeline diagrams, keys coupling drawings etc. (Fig 3&4)

### Electrical engineering drawing

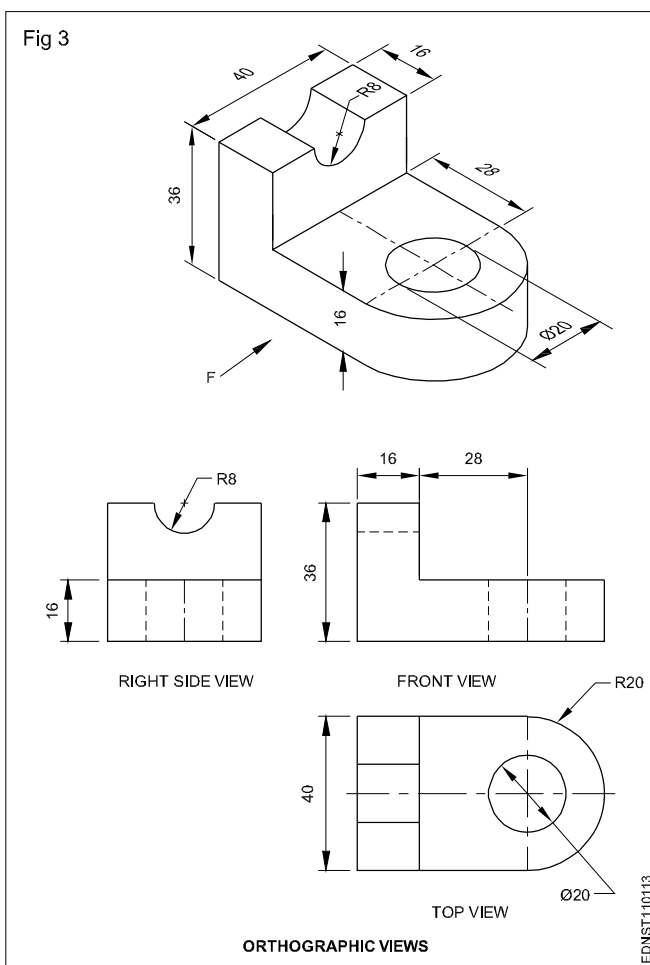
Wiring diagrams of home and industries, circuit diagrams, electrical installation drawings etc.

### Example

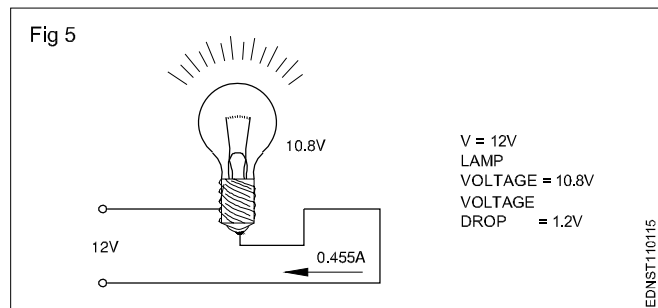
The voltage supply to a filament lamp is 10.8V. The voltage should be 12V. (Fig 5)



**Mechanical Engineering Drawings (Fig 3&4)**

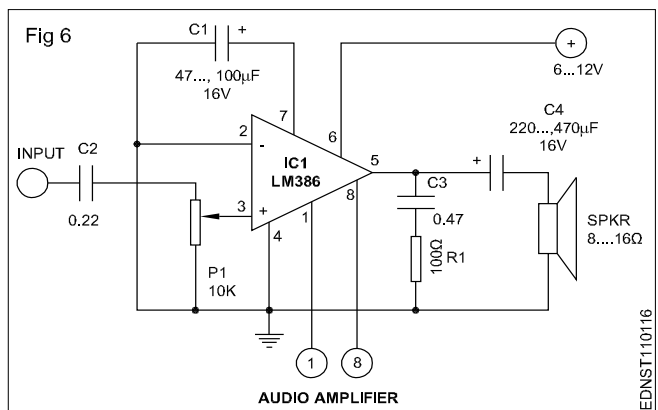


**Electrical Engineering Drawing (Fig 5)**

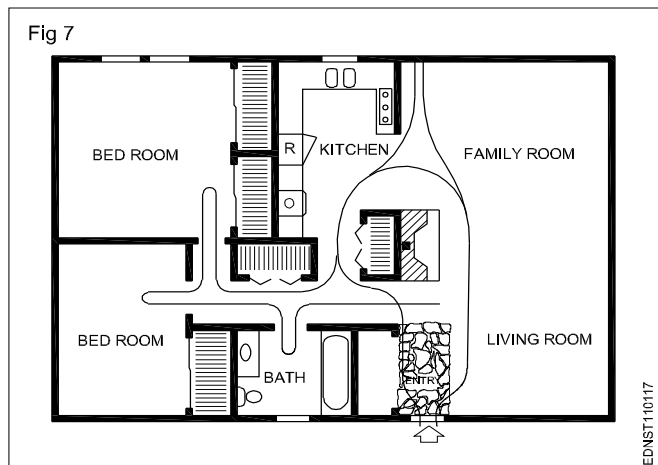


**Electronics Engineering Drawing**

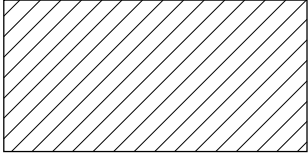
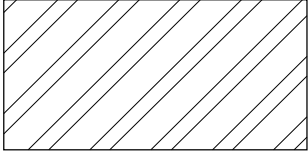
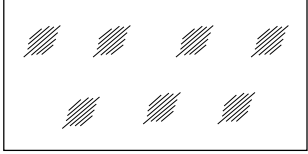
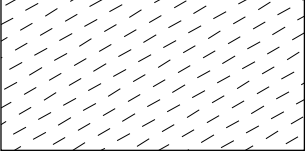
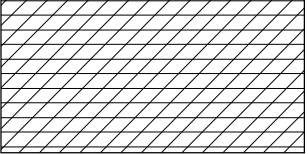
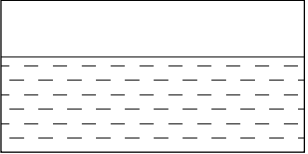
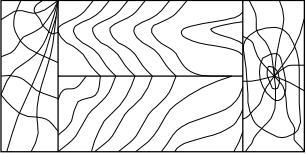
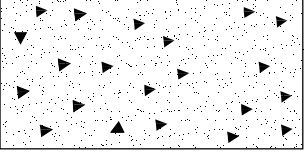
**Audio amplifier (Fig 6)**



**Civil Engineering Drawing (Fig 7)**



**Conventions**

TYPE	CONVENTION	MATERIALS
Metals		Steel, Cast Iron, Copper and its Alloys, Aluminium and its alloy, etc
		Lead, Zinc, Tin, White-metal, etc.
Glass		Glass
Packing and Insulating materials		Porcelain, Stoneware, Marble, Slate etc
		Asbestos, Fibre, Felt, Synthetic resin products, Paper, Cork, Linoleum, Rubber, Leather, Wax, insulating & Filling Materials etc
Liquid		Water, Oil, Petrol, Kerosene etc
Wood		Wood, Plywood etc
Concrete		Concrete

**Sizes and layout of drawing sheets**

**Size of drawing sheets (in mm):** While being worked on or handled, the drawing sheets are prone to tear along the edges. So slightly larger(untrimmed) sheets are preferred. They are trimmed afterwards. IS:10811:1983 lays down such as designation of preferred trimmed and untrimmed sizes.

**Designation of sheets:** The drawing sheets are designated by symbols such as A0, A1, A2, A3, A4 and A5. A0 being the largest and A5 is smallest. Table 1 below gives the length and breadth of the above sizes of sheets. (Trimmed and untrimmed)

The relationship between two sides is same as that between a side of a square and its diagonal.

TABLE 1

Designation	Trimmed size	Untrimmed size
A0	841 x 1189	880 x 1230
A1	594 x 841	625 x 880
A2	420 x 594	450 x 625
A3	297 x 420	330 x 450
A4	210 x 297	240 x 330
A5	148 x 210	165 x 240

Special elongated series increasing its widths, double, treble etc. are denoted as follows A3 x 3, A3 x 4, A4 x 3, A4 x 4, A4 x 5. Please refer Table 2.

TABLE 2

**Special elongated series**

Designation	Size
A3 x 3	420 x 891
A3 x 4	420 x 1189
A4 x 3	297 x 630
A4 x 4	297 x 841
A4 x 5	297 x 1051

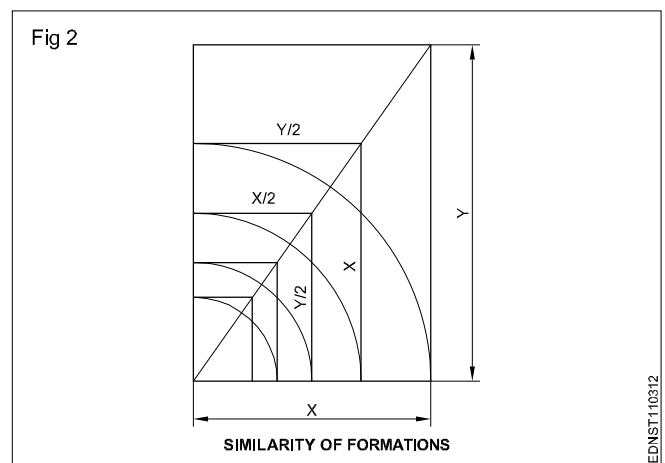
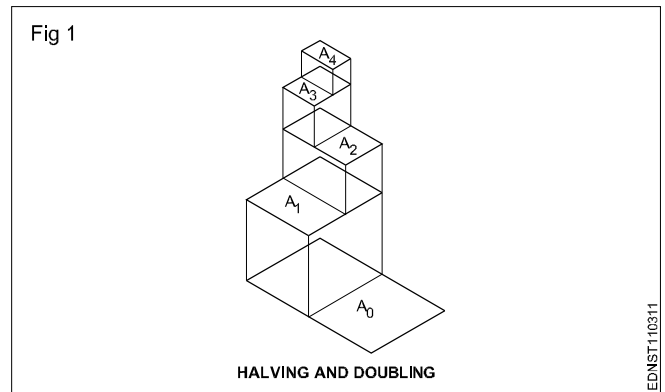
Fig 1 & 2 shows how the sheet sizes are formed by halving/doubling and similarity of format.

White drawing papers that do not turn yellow on exposure to air are used for finished drawings, maps, charts and drawings for photographic reproductions.

For pencil layouts and working drawings, cream-coloured papers are best suited.

**Quality drawing paper:** The drawing papers should have sufficient teeth or grain to take the pencil lines and withstand repeated erasing.

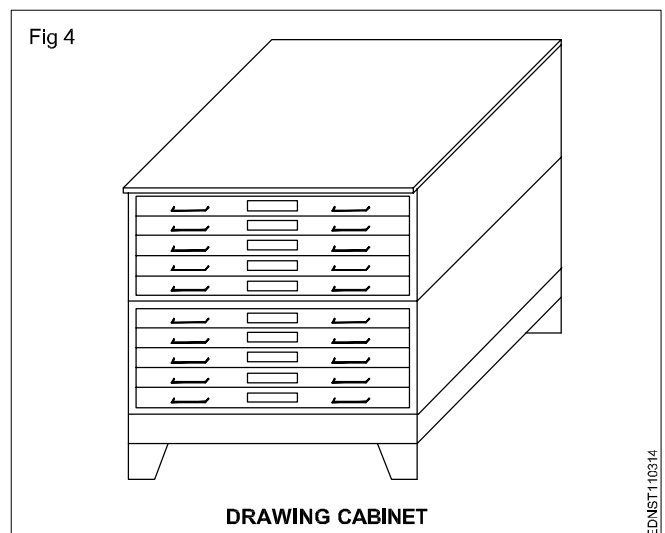
To get uniform lines, backing paper is to be placed on the drawing board before fixing drawing/tracing paper,. Before starting the drawing, the layout should be drawn. (Ref: IS:10711)



The following is the method of folding printed drawing sheets as recommended by BIS. (Fig 3)

**Method of folding of printed drawing sheets as per BIS SP: 46-2003**

When drawings sheets are in more numbers, they have to be folded and kept in order to save the trace required for preserving them (Fig 4).

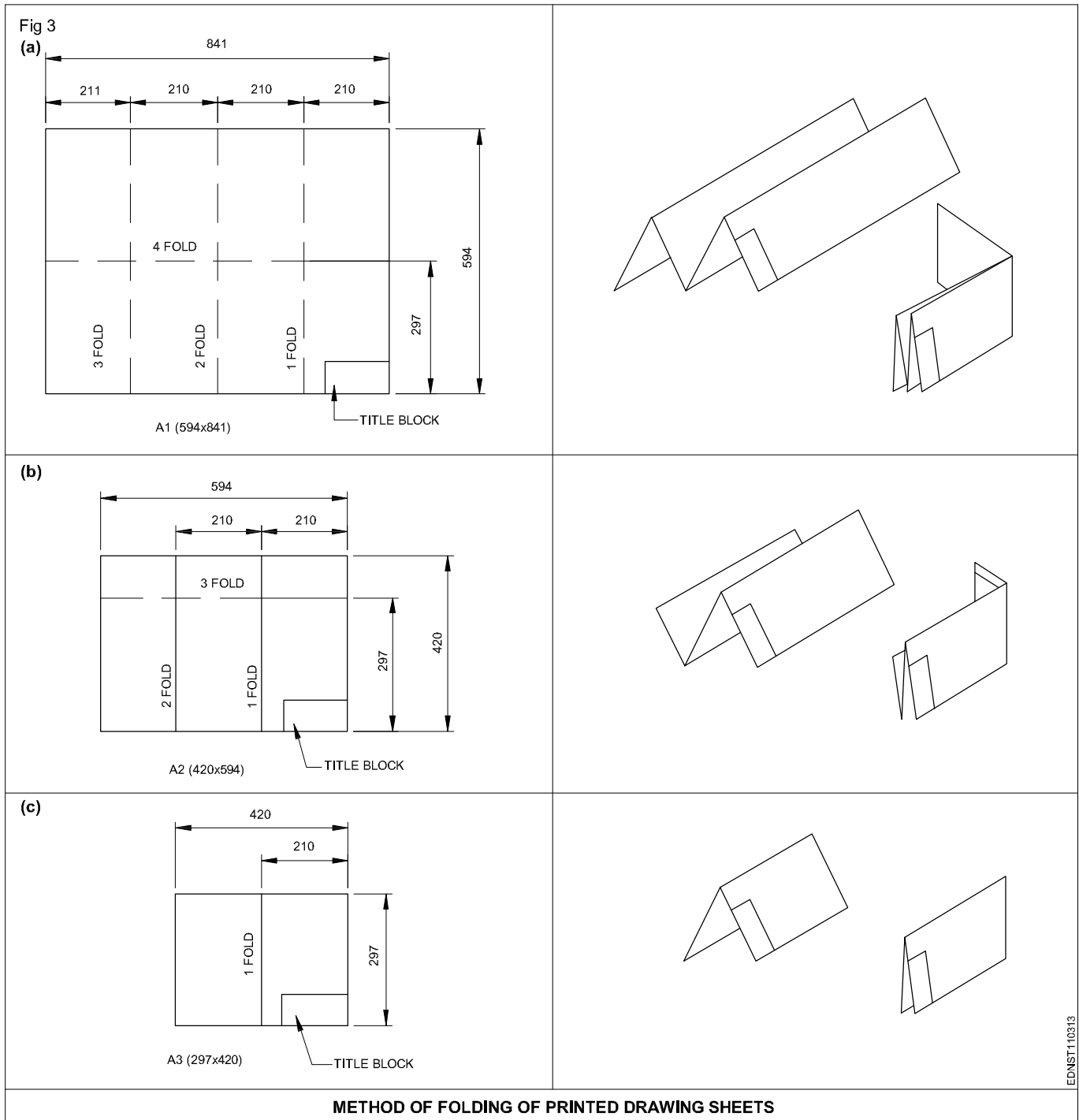


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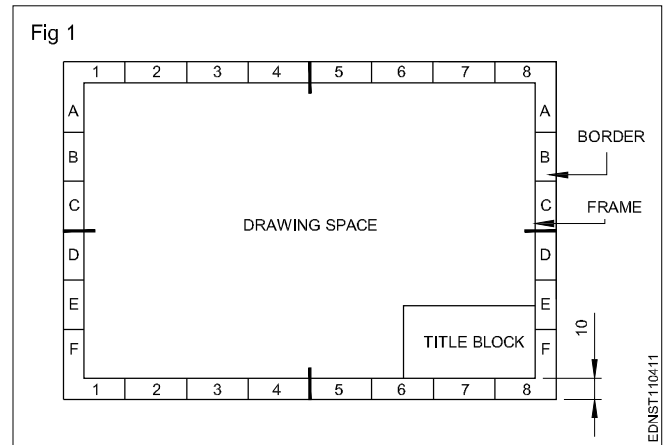
**Method of folding printed drawing sheets (Fig 3)**



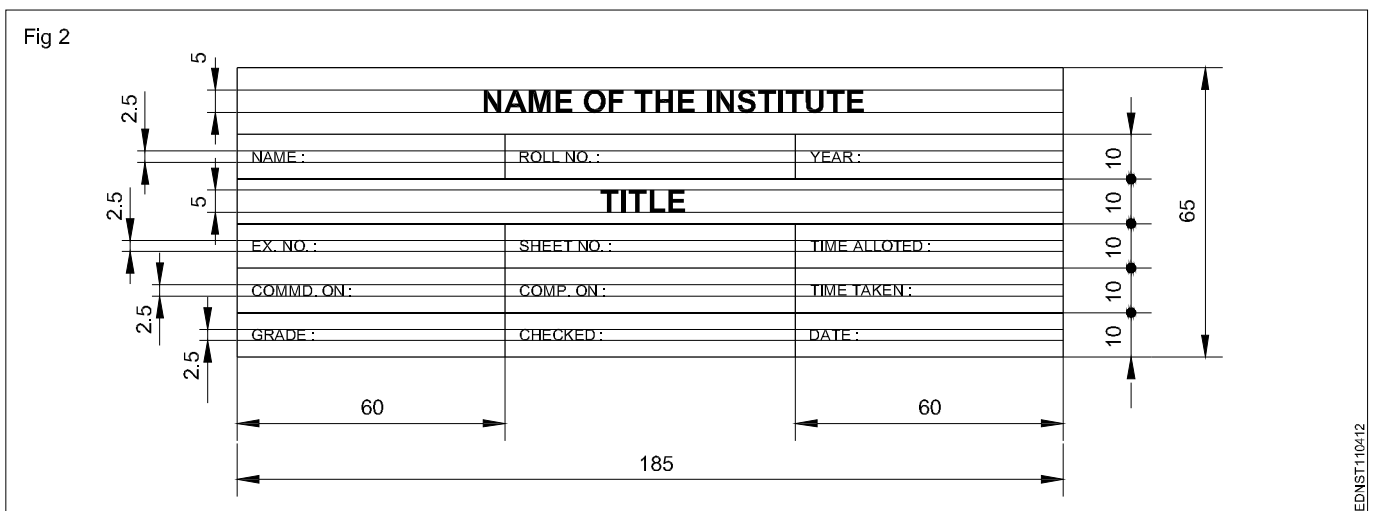
**Title block, its position and content**

**Layout of drawing sheet**

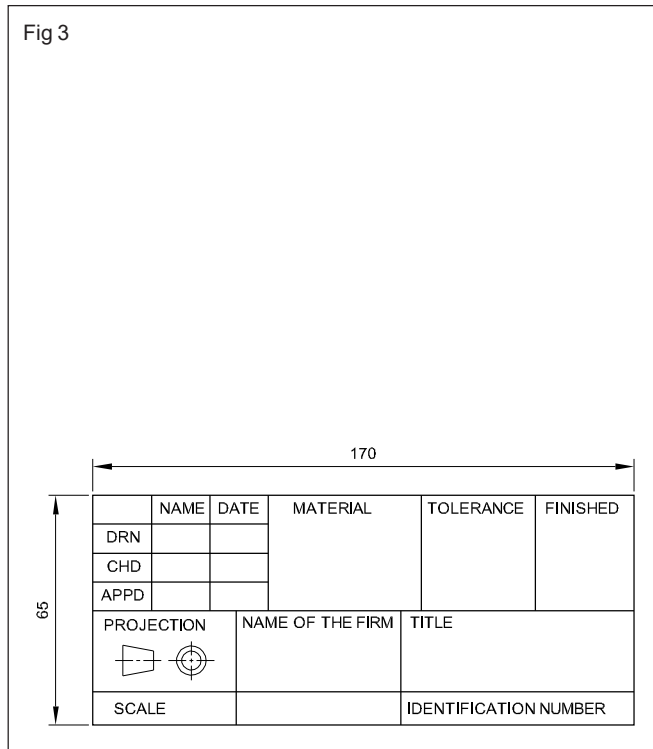
As a standard practice, sufficient margins are to be provided on all sides of the drawing sheet. The drawing sheet should have drawing space and title space. A typical layout of a drawing sheet is shown in the (Fig 1 & 2).



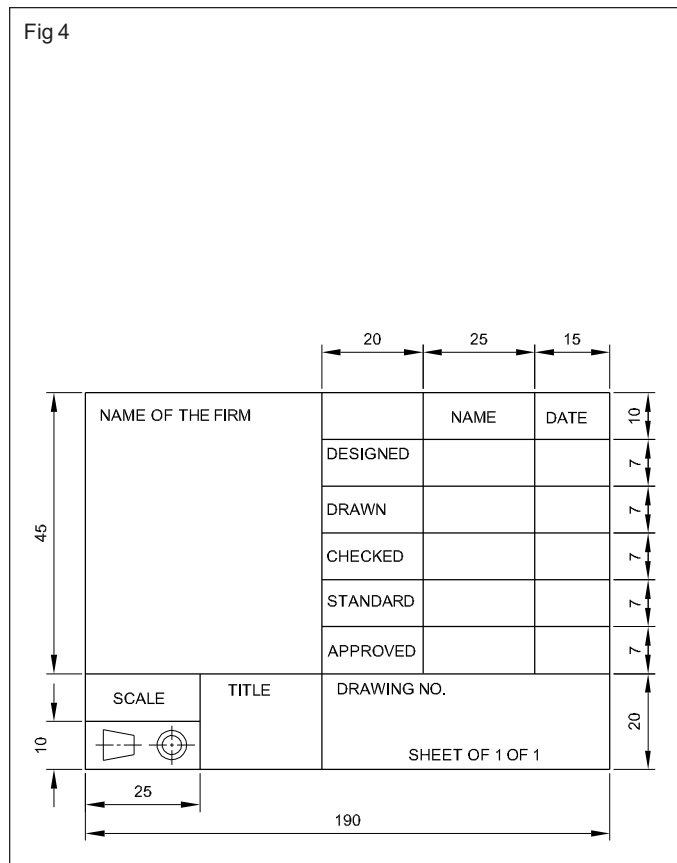
**Title Block - 1**



Title Block - 2

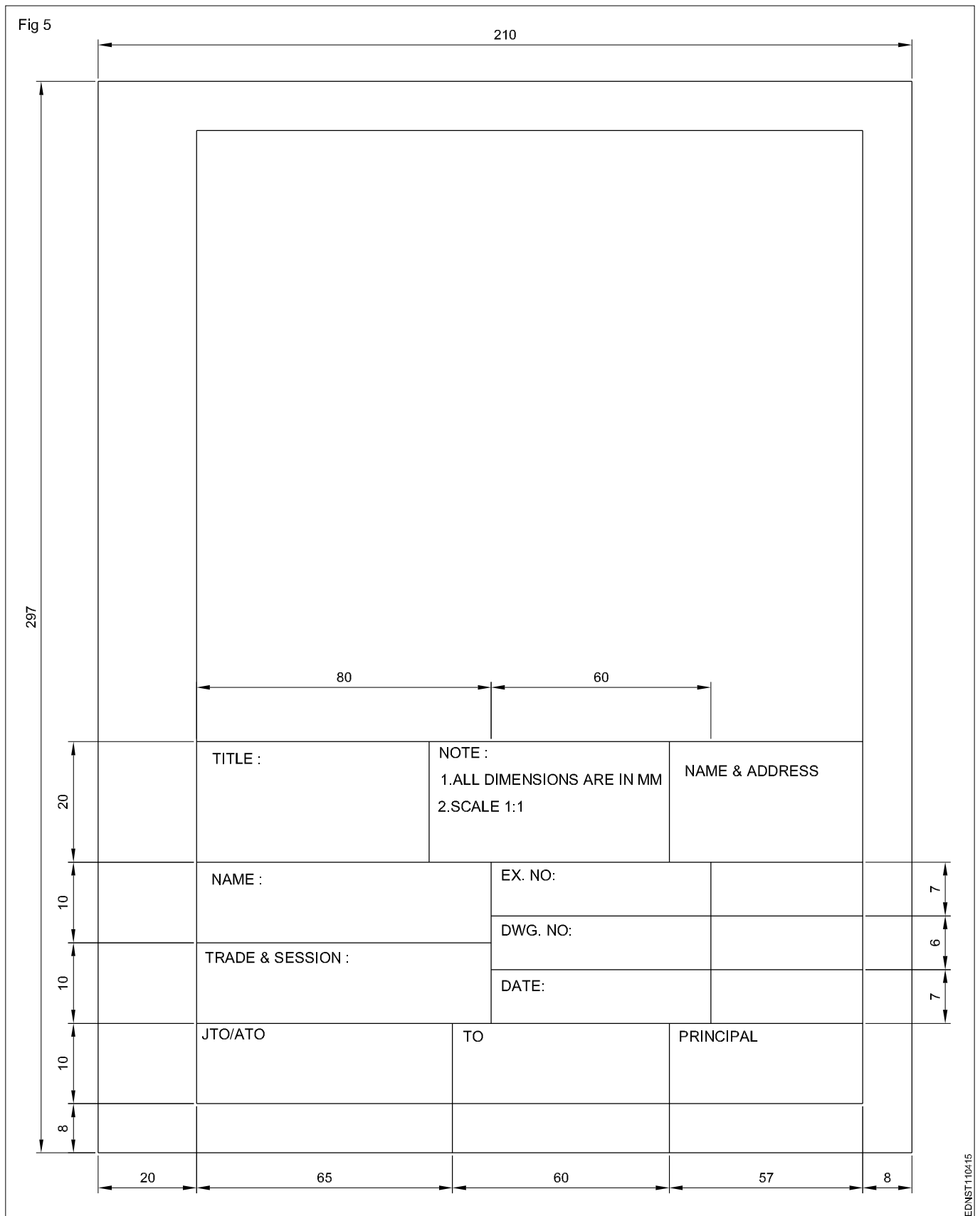


Title Block - 3





**Title Block - Position and content - 1**



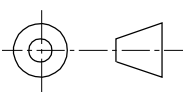
## Title Block - Position and content - 2

Fig 6

DO NOT SCALE

REVISION			
SL.N	DESCRIPTION	DATE	APPX
A	M12 WAS $\frac{1}{2}$ WHIT.	14.12.18	A.W.D

4			
3			
2			
1	A7325	VALVE BODY	1
TECH	DRG OR PART NO.	DESCRIPTION	QTY.

UNLES OTHERWISE STATED ALL DIMENSIONS IN MILLIMETRES. TOLERANCES LINEAR: ANGULAR:		DRN 1:1:78 JKL	(NAME OD THE FIRM)	
		CKD 2:1:78 MLN	(TITLE OF DRW.)	
		APPD 5:1:78 AWB	SIZE A3	DRG NO A24641
		ISSUED 4:2:78 PFP	SCALE 1:2	SHEET 1 OF 1
DRAFTING STANDARD AS 1100	FINISH AS MACHINED			

U

EDNST110416

### Item Reference on Drawing Sheet

05	TIGHTENING PIN	01	MILD STEEL	
04	WORK PIECE	01	ANY MATL.	
03	SCREW ROD	01	STD.	
02	"U" CLAMP	01	CAST IRON	
01	"V" BLOCK	01	CAST IRON	
PART NO	DESCRIPTION OF ITEM	QTY/ASSY	MATERIAL	REMARKS
<b>BILL OF MATERIALS</b>				

The drawing sheet on which the drawings to be prepared should be prepared first by following the procedure given below:

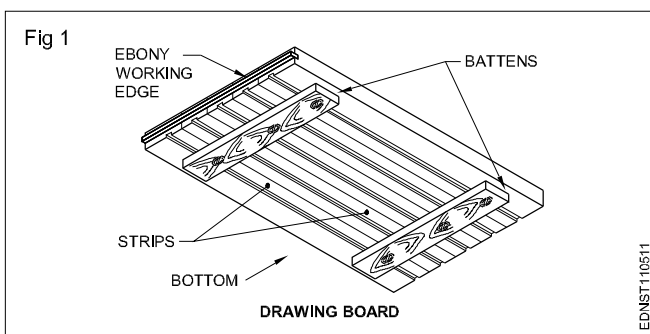
- 1 Take A4/A3 drawing sheet.
- 2 Mark the borders and draw the title block as mentioned.

- 3 Follow the same procedure for A3 drawing sheet where the title block is to be drawn right side bottom corner and the border dimensions remain same.
- 4 Title block to be drawn whenever the title of the drawing changes. Eg. for the geometrical construction chapter the title block may be drawn in the first sheet only where as on the remaining sheets borders to be drawn before they are used for preparing drawings.

**Drawing instruments**

The following are the commonly used equipment in a drawing office.

**Drawing board** (Fig 1): Drawing board is one of the main item of equipment for Draughtsman. It is used for supporting the drawing paper/tracing paper for making drawings. It is made of well-seasoned wood strips of about 25 mm thick or masonite, free from knots and warping. It should be softer enough to allow insertion and removal of drawing pins. Two battens are fastened to the board by screws, in slotted joints. They prevent warping and at the same time permit expansion and contraction of the strips due to the change of moisture in the atmosphere.



One of the shorter edges of the drawing board is provided with an "ebony edge" (hardwood) fitted perfectly straight.

Standard drawing boards are designated as follows as per IS:1444-1989.

Sl. No.	Designation	Size (mm)
1	D0	1500 x 1000 x 25
2	D1	1000 x 700 x 25
3	D2	700 x 500 x 15
4	D3	500 x 350 x 15

The working edge (ebony) must be straight.

Now-a-days drawing boards are available with laminated surfaces. The flatness can be checked by placing a straight edge on its surface. If no light passes between them, the surface is perfectly flat.

**'T' Square:** It is of 'T' shape, made of well-seasoned wood. It has two parts., head/stock and blade. One of the edges of the blade is the working edge. The blade is screwed to this head such that the working edge is at a right angle to the head. (Fig 2a)

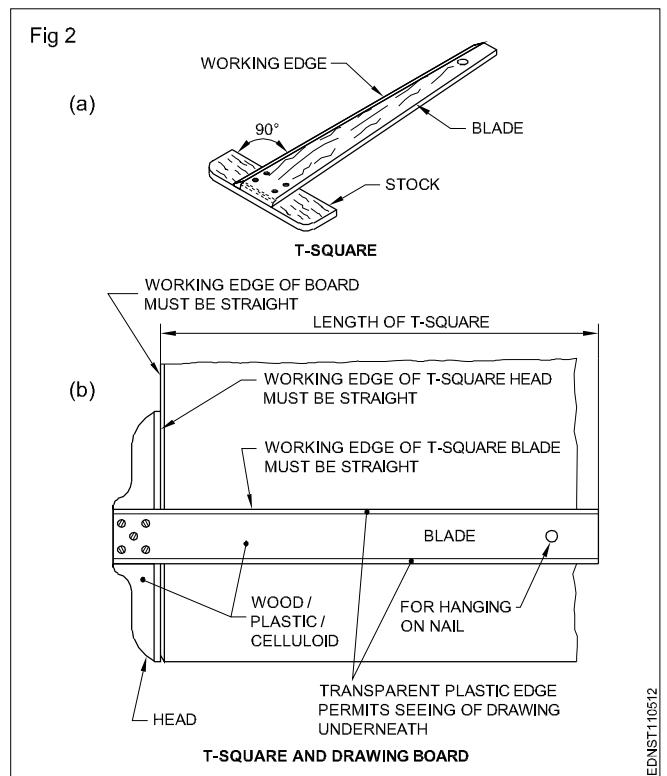
The standard 'T' square is designated as follows with dimensions shown in mm; as per IS:1360-1989.

Sl. No.	Designation	Blade length
1	T0	1500
2	T1	1000
3	T2	700
4	T3	500

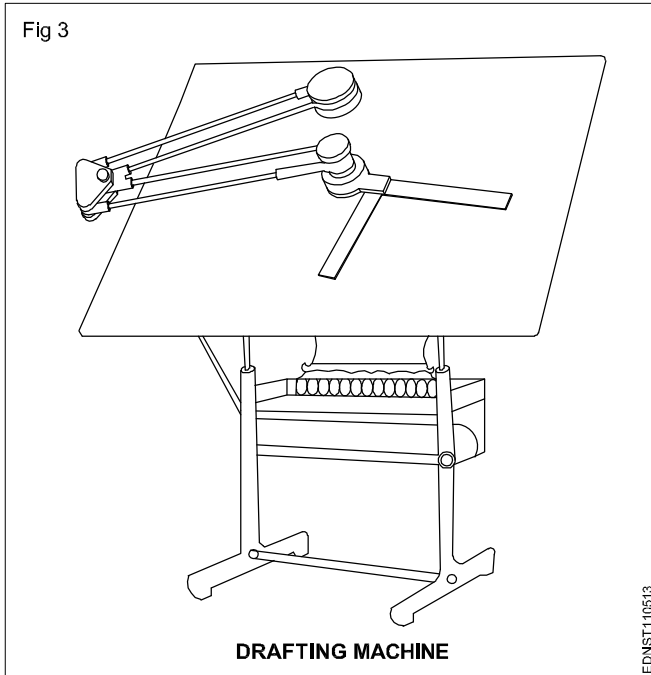
The 'T' square is used with its head against the ebony edge of the drawing board to draw horizontal lines, and parallel lines and to guide/hold the set squares, stencils etc.

Fig 2b shows how the 'T' square is used.

'T' square should never be used as a hammer or as a guide for trimming papers.



**Drafting in the machine** (Fig 3): It serves the functions of a Tee square, set square, protractor and scale. They come in different sizes and have a pattern called the 'Pantograph' type. It is fitted on the top left side, edge of the drafting board, mounted on an adjustable frame or table. It requires a large area of working place. The angle of the drafting board can be adjusted by the pedal operating system. There are two counterweights to balance the angular position of the board and the drafting head. It is more suitable for the production drawing office.



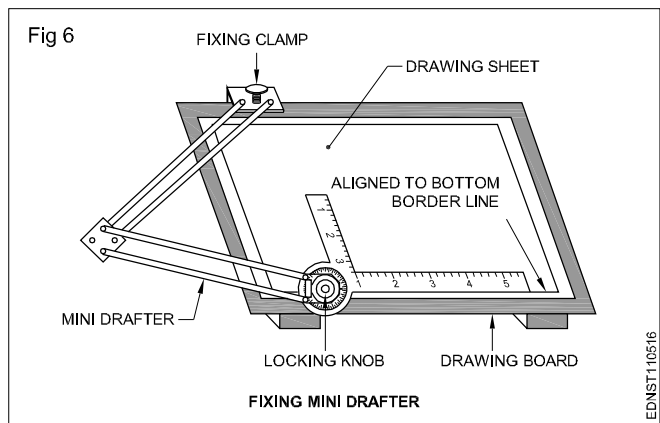
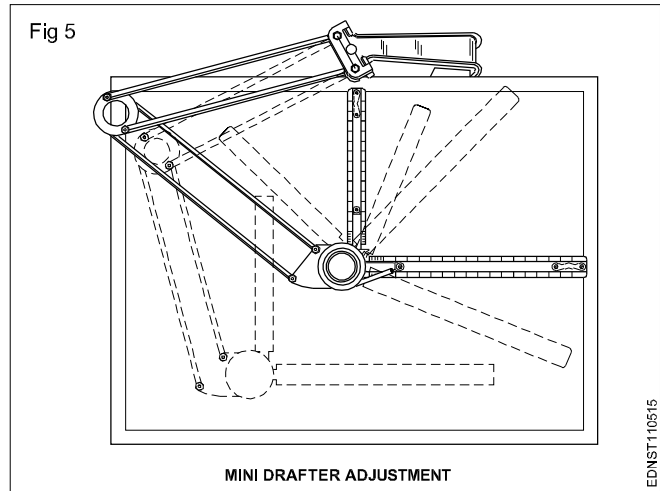
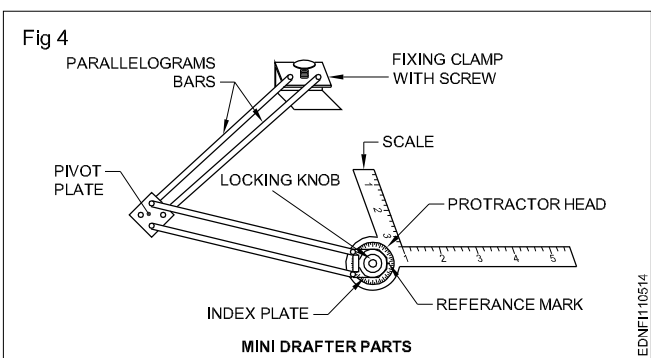
On the other end, a protractor head H with swivelling and locking arrangement is fitted with two scales at right angles.

The protractor head has a spring-loaded clutch relieving handle, which rotates and locks at 15° intervals automatically. For setting any angle other than multiples of 15°, the clutch spring is released and by rotating the centre knob, the zero line is set to the required angle and the friction clutch knob is tightened. It is capable of rotating 180°, thereby any angle can be set.

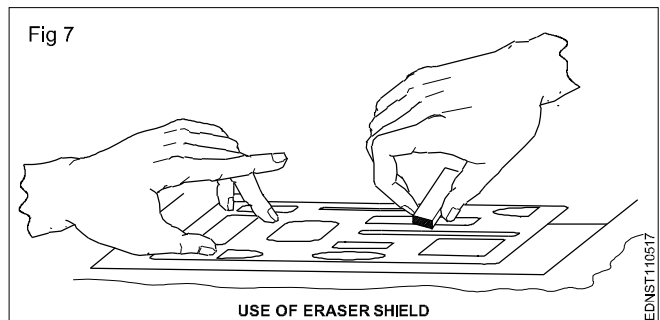
The scales are bevelled on both sides, graduates to 1:1 & 1:2. They can be reversed with the help of dovetail slide fitting.

There is a fine adjusting mechanism on the drafting head to set the scale parallel to the edge of the board. The scales also can be adjusted if there is an error in measuring 90° between them.

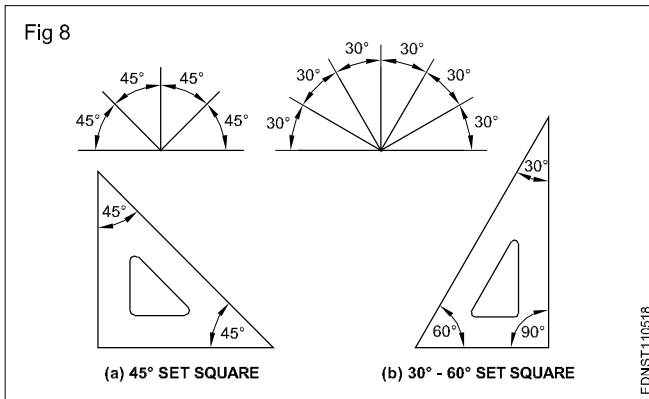
The mini drafter is an important device used for making drawing quickly & accurately. This instrument has the combination of T-square, set square, protractor and scales, it helps to draw the drawings at a faster rate. (Fig 4,5 & 6)



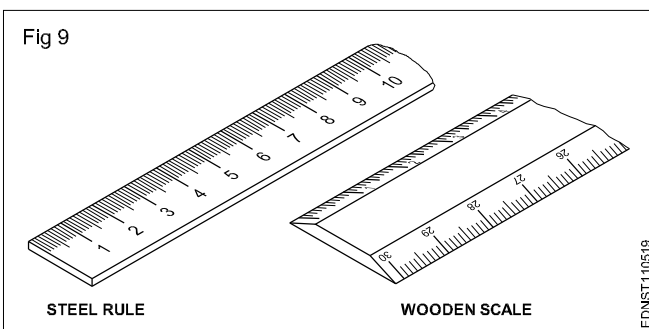
**Erasing shield:** When, on a drawing, if a part of a line or some lines among many other lines needs to be erased or modified, in a normal way erasing will damage the other nearby lines. In such a situation an erasing shield is effectively useful. It is a thin metallic sheet having small openings of different sizes and shapes. A suitable opening is aligned to the line to be erased and the line is removed by the eraser. (Fig 7)



**Set square (IS:1361-1988):** Transparent celluloid /Plastic set squares are preferred and are commonly used rather than ebonite ones. They are two in number, each having one corner with 90°. The set square with 60° & 30° of 250 mm long and 45° of 200mm long is convenient for use. (Fig 8)



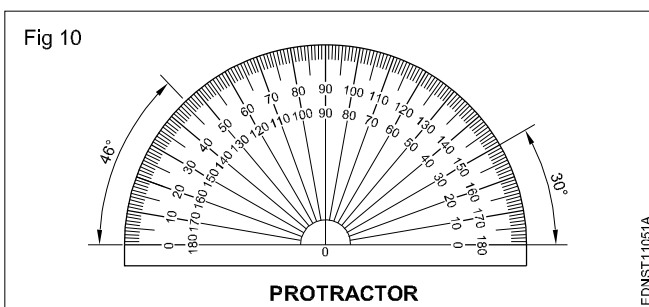
**Scales:** Scales are used to transfer and or measure the dimensions. They are made of wood, steel, ivory, celluloid or plastic, stainless steel scales are more durable. different types of scales used are shown in Fig 9. They are either flat, bevel-edged or triangular cross-sections. Scales of 15cm long, 2cm wide or 30cm long 3.5cm wide are in general use.



**Protractor:** A protractor is an instrument for measuring angles. It is semi-circular or circular and is made of a flat celluloid sheet.

The angles can be set or measured from both sides, aligning the reference line and point '0' with the corner point of the angle.

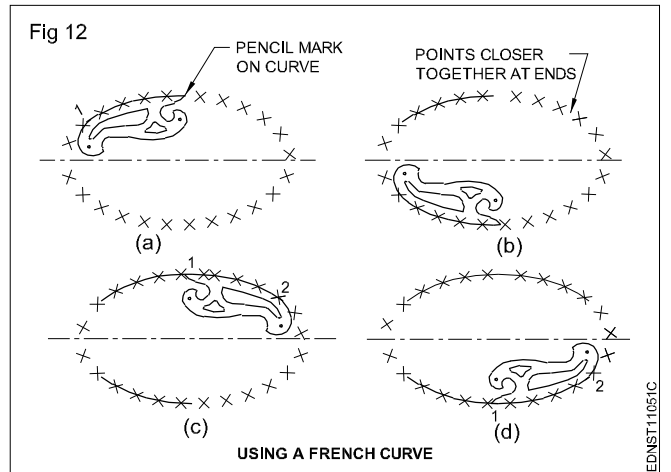
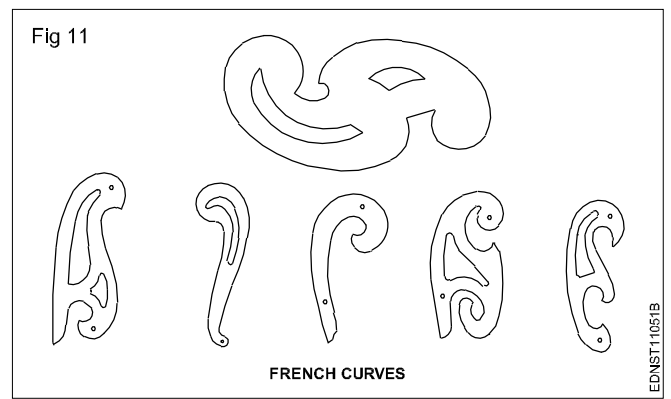
Figure 10 shows how to read or set the angle. A protractor can also be used to divide a circle or draw sectors.



### French curves (Fig 11)

These are made in many different shapes, normally come in sets of 6, 12, 16 etc. French curves are best suited to draw smooth curves/arcs (which cannot be drawn by a compass) with ease. To draw a smooth curve using a french curve first set it by trial against a part of the line to be drawn, then shift it to the next portions.

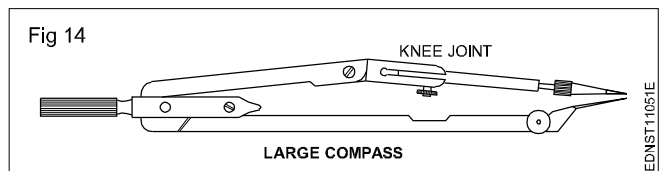
Fig 12 shows how to use the french curve and draw smooth curves. They are made of transparent celluloid (no bevel edge).



An instrument box contains the following: (Fig 13a to h)

- Large compass (with attachment facility) (a)
- Large divider (b)
- Bow compasses (pencil/ink), bow divider (c)
- Lengthening bar (d)
- Pen point for attachment (e)
- Screwdriver (f)
- Lead case (g)
- Liner (h)

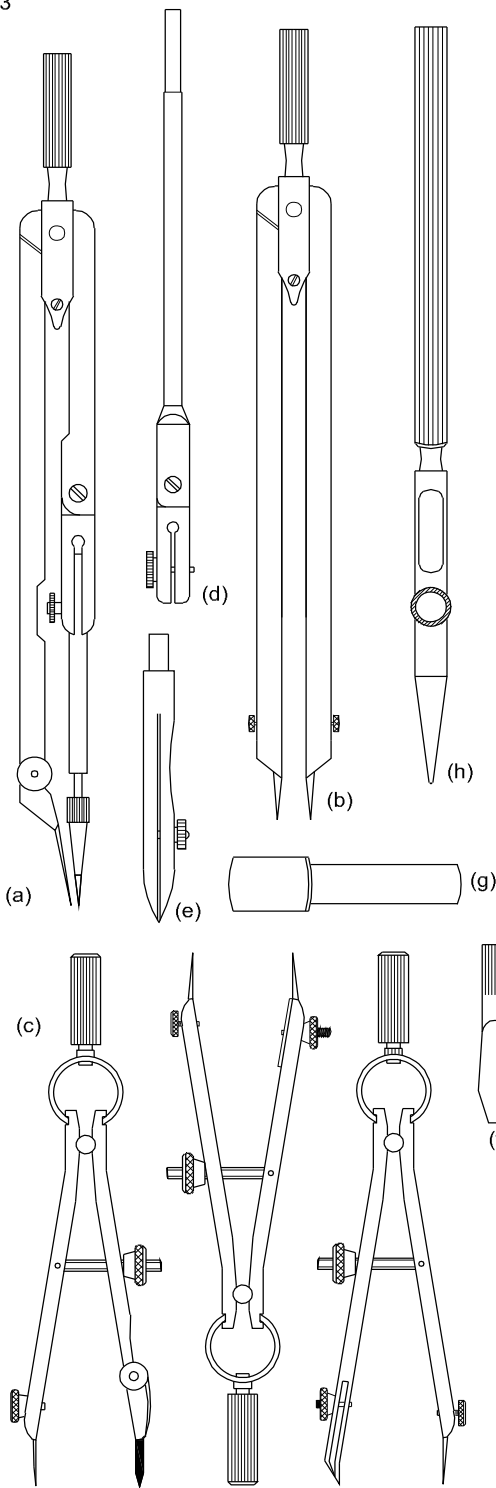
**Large compass** (Fig 14): It has a knee joint in one leg that permits the insertion of a pen or pencil point or attaching a lengthening bar with a pen or pencil point attached to it. It is used for drawing large circles/arcs and also for taking large measurements.



**As a rule, while drawing concentric circles, small circles should be drawn first before the centre hole gets worn.**

**Large divider:** It is used to transfer dimensions and divide lines into several equal parts. Divider with adjustable joints is preferable rather than plain legs. (Fig 15)

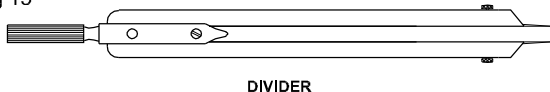
Fig 13



DRAWING INSTRUMENTS

EDNST11051D

Fig 15

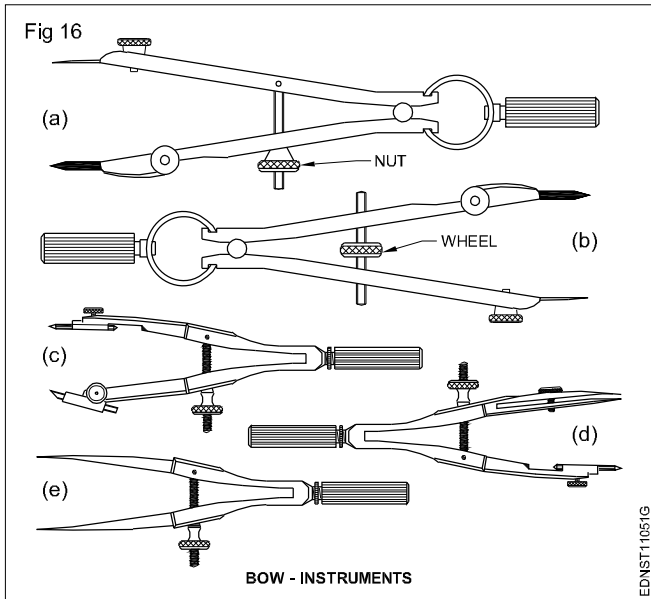


DIVIDER

EDNST11051F

**Bow instruments:** Bow pencil and bow pen compass are used for drawing circles of approximately 25 mm radius. A bow divider is used for marking or dividing smaller spaces. There are two types (i) Integral legs with spring action (ii) two legs are held with a curved spring on top with a handle on it.

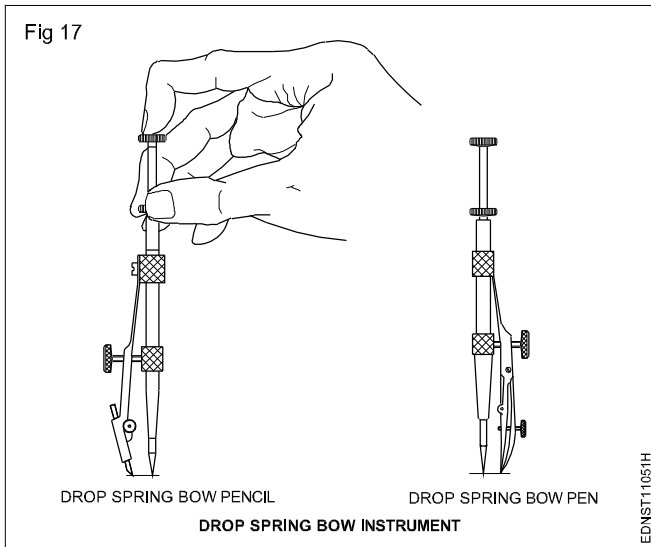
Fig 16 shows different types of bow instruments. Adjustments should be made with the thumb and middle finger.



BOW - INSTRUMENTS

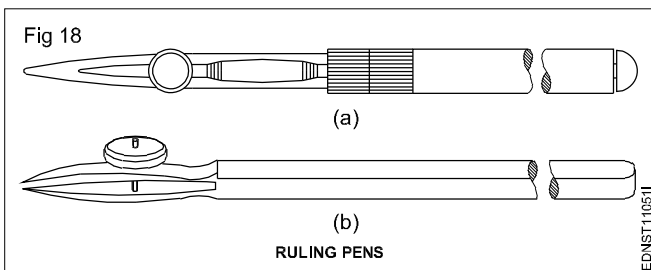
EDNST11051G

**Drop spring bow pencil and pen (Fig 17):** Drop spring bow pencil and pen are designed for drawing multiple identical small circles. Example: rivet holes, drilled/reamed holes. The central pin is made to move freely up and down through the tube attached to the pen or pencil unit.



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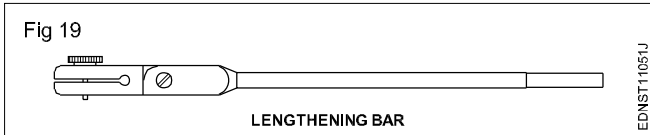
**Inking pen or liner or ruling pen (Fig 18):** It is used to ink the straight lines drawn with the instruments but never for freehand lines or lettering.



RULING PENS

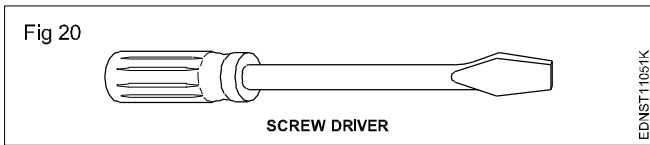
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**Lengthening bar** (Fig 19): To draw larger circles, it is fitted to the compass. The pencil point or pen point is inserted into its end.

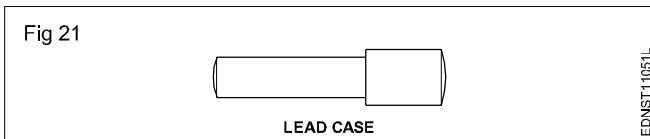


Replaceable spare pencils, pens and needle points for the compass are available in the instrument box.

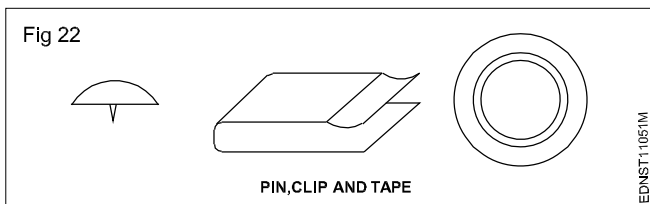
**Screwdriver** (Fig 20): Used for adjusting the screws of the instruments.



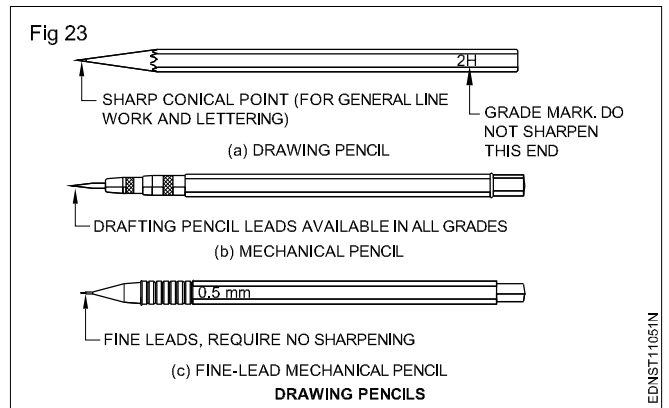
**Lead case** (Fig 21): Lead case is the box for holding the pencil leads.



**Pin, Clip, Cello tape:** Drawing sheet should be fastened onto the drawing board firmly temporarily so that it does not shake during preparing the drawing. For this purpose, the pins, clips and cello tapes are used (Fig 22)



## Pencils, Grade and Selection (Fig 23)



**Grades of pencils:** Pencils are graded according to the hardness or softness of the lead.

**The hardest pencil is 9H grade and the softest pencil is 7B grade.** The selection of the grade of pencils depends on the type of line work required and the paper on which it is used.

Softer lead pencils are used to produce thicker and darker line work, but they wear out quickly. Medium grades of H and 2H are used for general line work as well as for lettering.

**Selection of pencils:** Pencil grades vary from one brand to another brand. Select the grades of the pencil depending upon the type of line work. For construction lines, you can choose 2H or 3H, for lettering and object lines grade H pencils. In general H, HB and 2H are used.

H - medium-hard

HB - medium-soft

2H - hard

Now-a-days automatic (Mechanical) pencils or clutch pencils are available in different sizes (lead dia. 0.3, 0.5, 0.7 or 0.9). Leads can be replaced as per the required grade of hardness. They produce lines of uniform width without sharpening.

**Free hand drawing of - Geometrical figures and blocks with dimension**

**Lines - Types and applications in drawing**





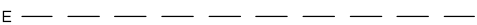





Drawings are made up of different types of lines. Just a language with alphabet and grammar.

Lines of different thicknesses and features are used for specific use. (Fig 1 and 2)

Technical drawings are drawn with different types of lines. By proper choice and application of lines, product features can be correctly defined in a drawing. Different types of lines recommended for specific applications are given in Table 1.

Table 1

**Types of lines and their application**

Lines	Description	General applications See figure and other relevant figure
A  0.5	Continuous thick	A1 Visible outlines A2 Visible edges
B  0.2	Continuous thin (straight)	B1 Imaginary lines of intersection B2 Dimension lines B3 projection lines or extension line B4 Leader lines B5 Hatching B6 Outlines of revolved sections in place B7 Short centre lines B8 Thread line B9 Diagonal line
C  0.2	Continuous thin free hand	C1 Limits of partial or interrupted views & sections, if the limit is not a chain thin
D  0.2	Continuous thin (Straight) with zig-zags	D1 Line (See figures)
E  0.3	Dashed thick	E1 Hidden outlines E2 Hidden edges
F  0.2	Dashed thin	F1 Hidden outlines F2 Hidden edges
G  0.2	Chain thin	G1 Centre lines G2 Lines of symmetry G3 Trajectories
H  0.3	Chain thin, thick at ends & changes of direction	H1 Cutting planes
J  0.5	Chain thick	J1 Indication of lines or surfaces to which a special requirement applies
K  0.2	Chain thin double-dashed	K1 Outlines of adjacent parts K2 Alternative and extreme positions of movable parts K3 Centroidal lines K4 Initial outlines prior to forming K5 Parts situated in front of the cutting plane

- 1 This type of line is suited for production of drawings by machines.
- 2 Although two alternatives are available, it is recommended that on any one drawing, only one type of line be used.

In the above range, for craftsmen, 0.5 is preferred. Table 2 shows the 0.5 line range and other lines under this range.

The numbers on the right side of the lines refer to the line thickness in mm.



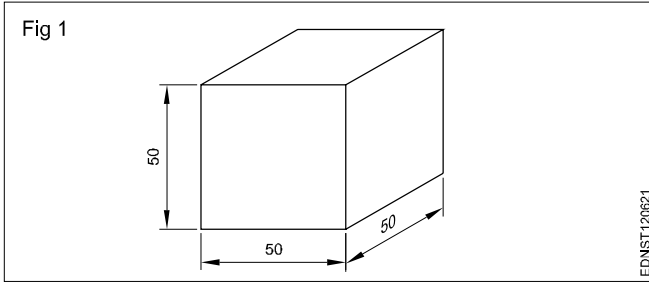
## Geometrical figures and block with dimension

**Freehand sketching:** Apart from making drawing using instruments, often craftsmen will be required to make drawings with their free hand.

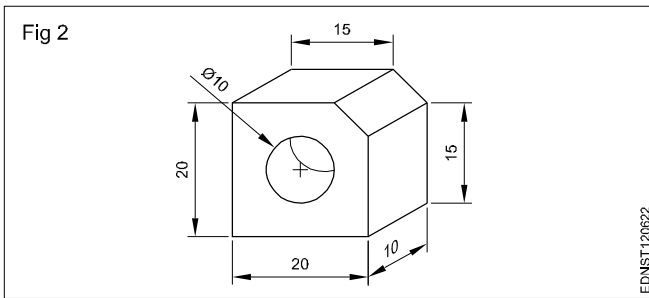
Freehand sketching is the easiest method to express the shape of a piece part or a component by an engineer or craftsman.

Freehand sketches are not usually made to scale. However, they should be as nearly to the proportions as possible.

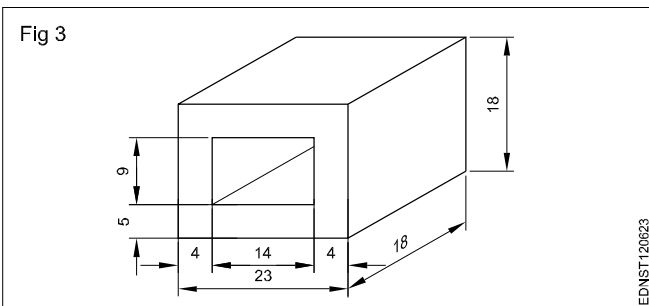
### Cube (Fig 1)



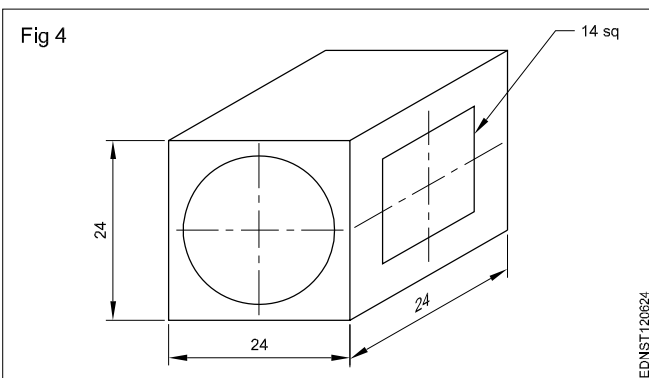
### Square block (Fig 2)



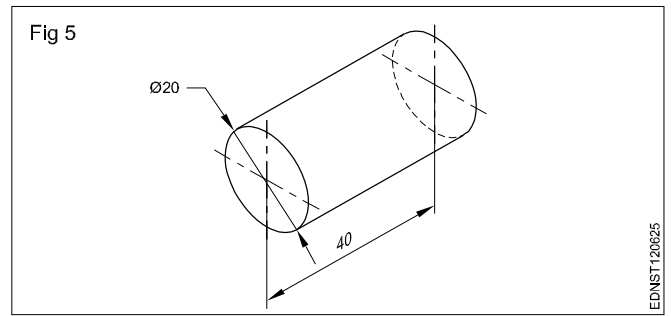
### Rectangular block (Fig 3)



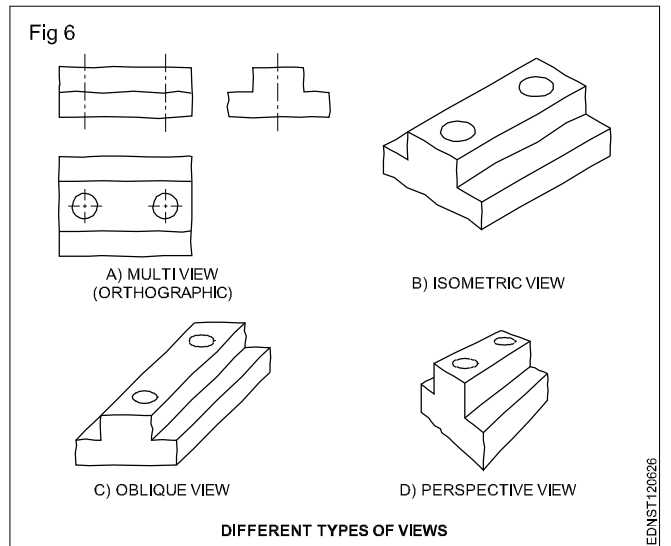
### Cube block (Fig 4)



### Cylinder (Fig 5)



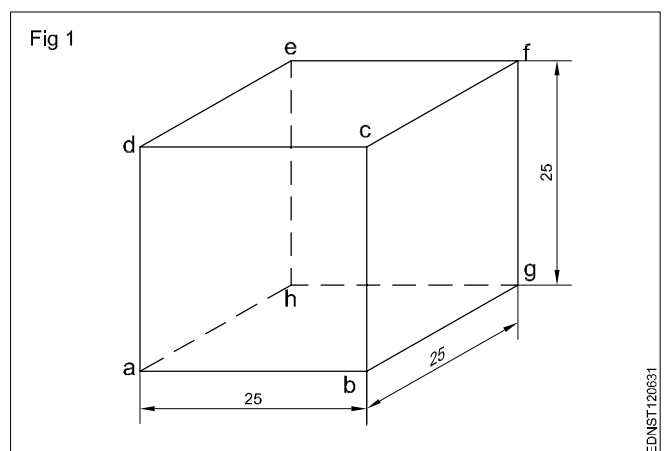
**Materials for free hand sketching:** A4 size sheet (preferably a pad instead of loose papers) pencils of soft grade. Example H, HB, and a good quality eraser are the only materials required. For drawing different darkness, the pencil points should be sharpened to a conical shape. Fig 6 shows some free hand sketches of different types of views.



### Procedure

Freehand drawing of solid figures, cubes, cuboids, cone, prism, pyramid, frustum of a cone with dimensions

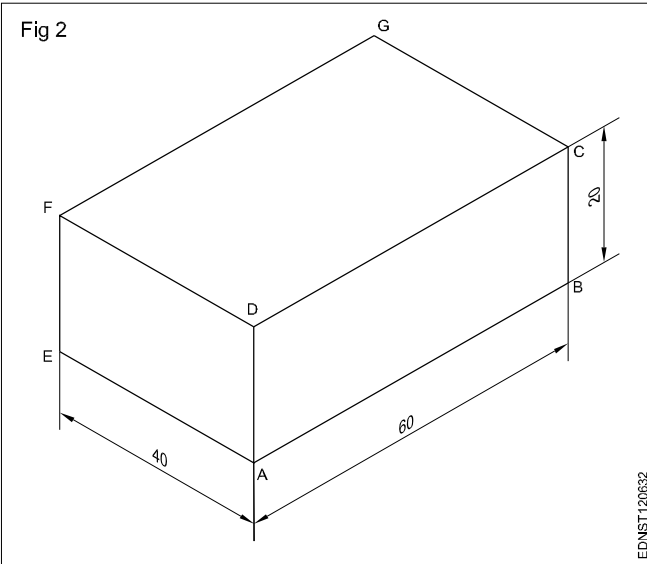
### Cube (Fig 1)



- Draw squares of a, b, c and d.
- Draw  $30^\circ$  from points b, c and d for the length of 25mm.
- Mark point g from b, f from c and e from d as shown in the figure.
- Joint all points.

### Cuboid (Fig 2)

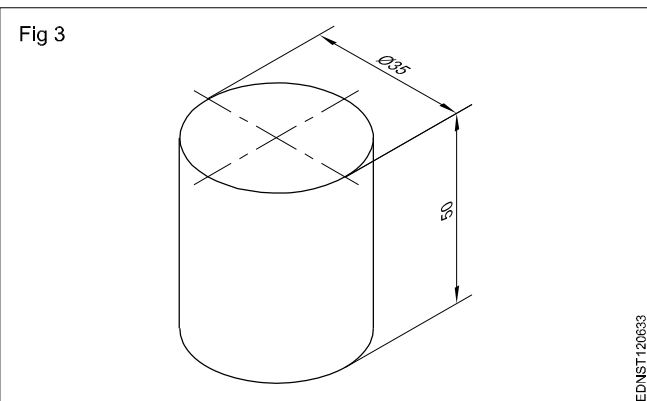
Draw the isometric drawing of a cuboid of base 60 mm x 40 mm and the height of 20 mm. (Fig 2)



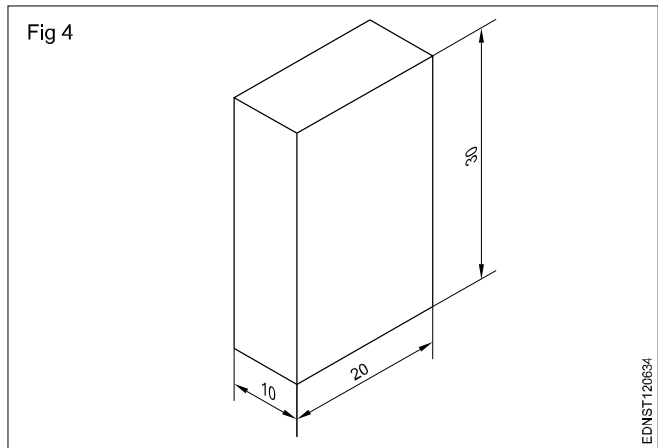
Draw the three isometric axes through the point 'A'.

- Mark  $AB = 60\text{mm}$ ,  $AE = 40\text{mm}$  and  $AD = 20\text{mm}$  representing the three sides of cuboid.
- Draw two vertical lines  $EF$  and  $BC$  parallel to  $AD$  from points  $E$  and  $B$  respectively.
- Similarly, draw two more lines parallel to  $AB$  and  $AE$  to mark  $G$ 's interesting point from  $F$  and  $C$ .
- Draw lines parallel to  $DC$  and  $FG$  Draw lines parallel to  $DF$  and  $GC$ .
- Join all the points.

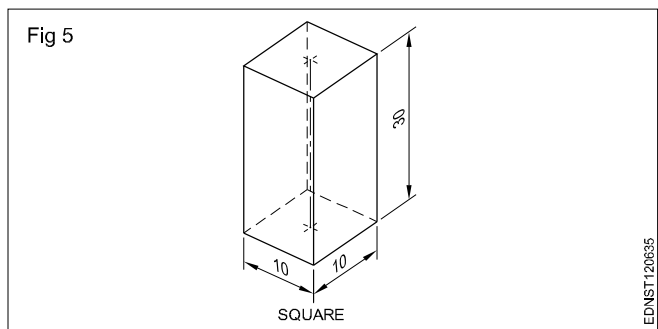
### Cylinder (Fig 3)



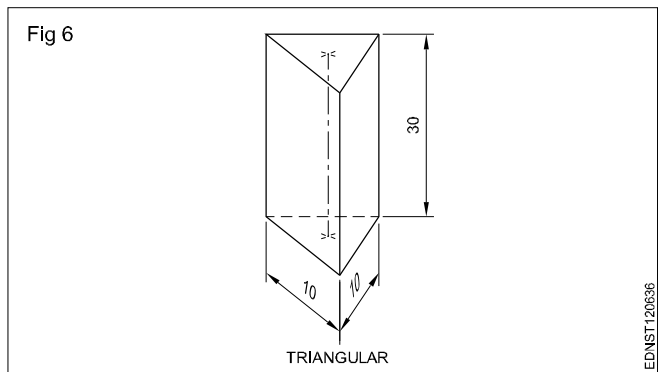
### Rectangular prism (Fig 4)



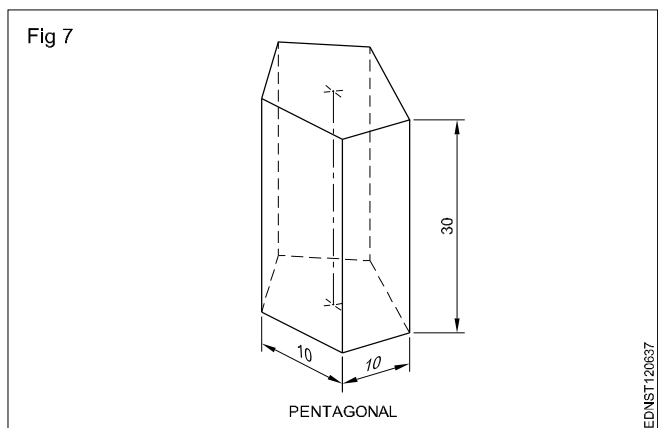
### Square Prism (Fig 5)



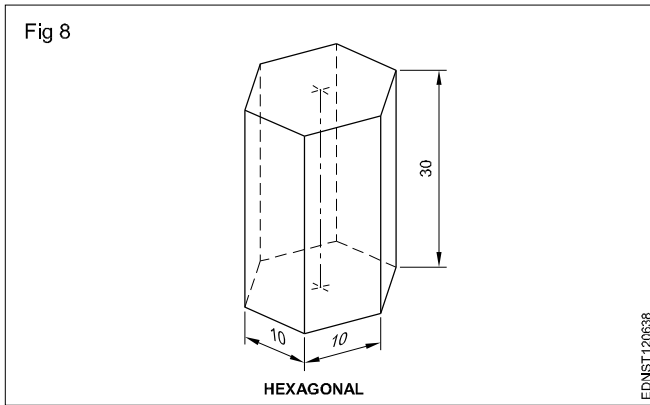
### Triangular Prism (Fig 6)



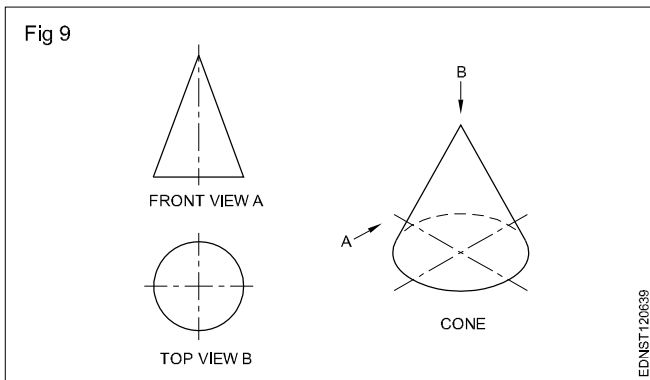
### Pentagonal prism (Fig 7)



### Hexagonal prism (Fig 8)



**Cone:** When a right-angled triangle revolves about one of its sides forming the right angle, a cone is generated. Cone forming has a circular face and a slant curved surface. (Fig 9)



**Pyramids:** Pyramids are polyhedron solids having a base surface whose shape may be triangular, square or polygon and as many slant triangular faces as there are sides in the base. All the slant triangular faces join at a common point called APEX.

Similar to prisms, pyramids also are known by the shape of their base viz triangular, square, rectangular, pentagonal, hexagonal etc. The imaginary line joining the centre of the base to the apex is called the AXIS.

Fig 10 shows some pyramids and their views.

When a semi-circle revolves about its diameter a sphere is generated. A sphere has no flat surface. (Fig 11D)

**Frustums:** Pyramid/cone is cut parallel to the base and the top portion is removed. The remaining bottom portion is called the frustum of a pyramid/cone.

If the cutting plane is at an angle to the axis/base, the pyramids or cones are called "Truncated pyramids or cones".

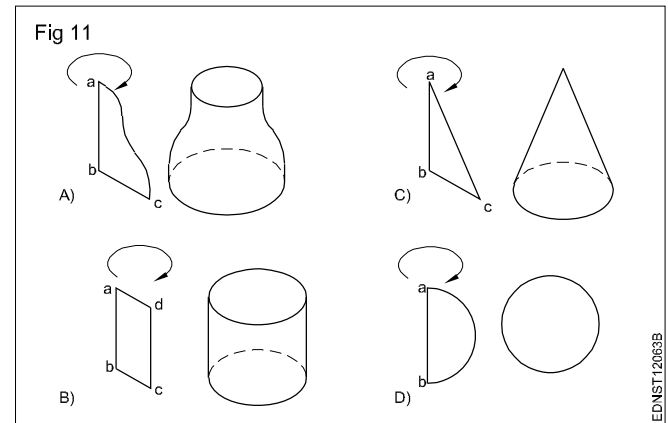
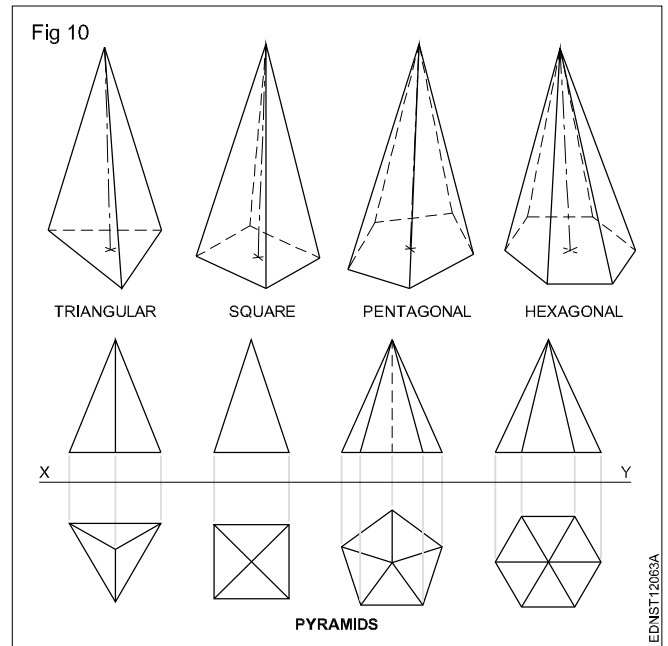
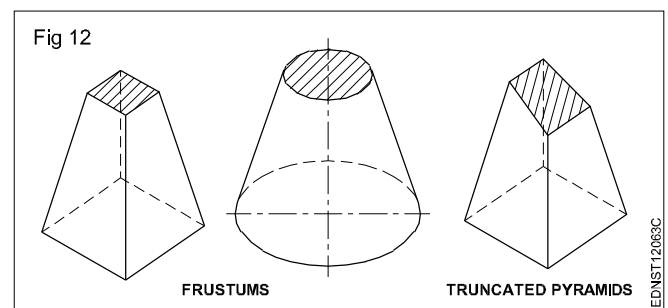
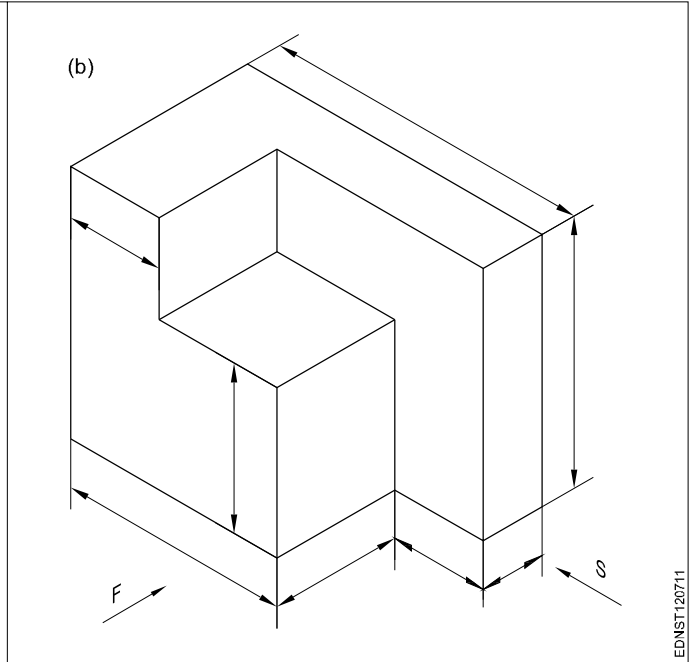
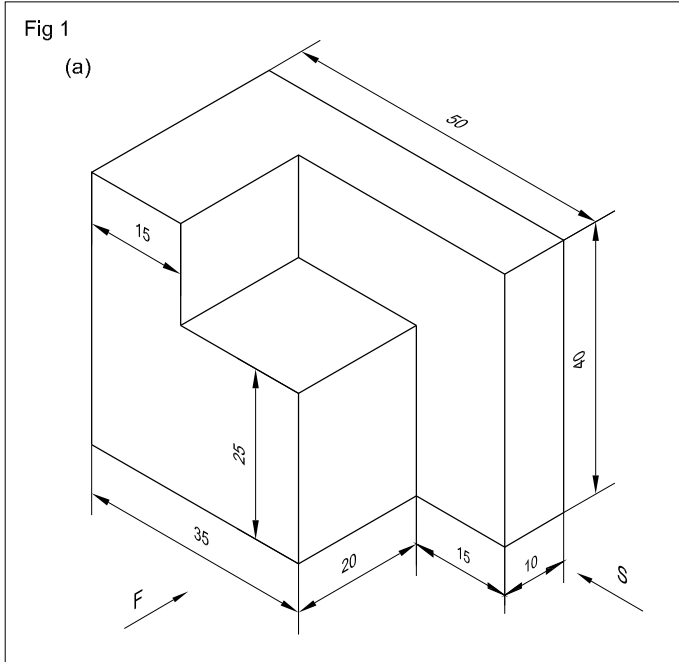


Fig 12 shows frustums and truncated pyramids.

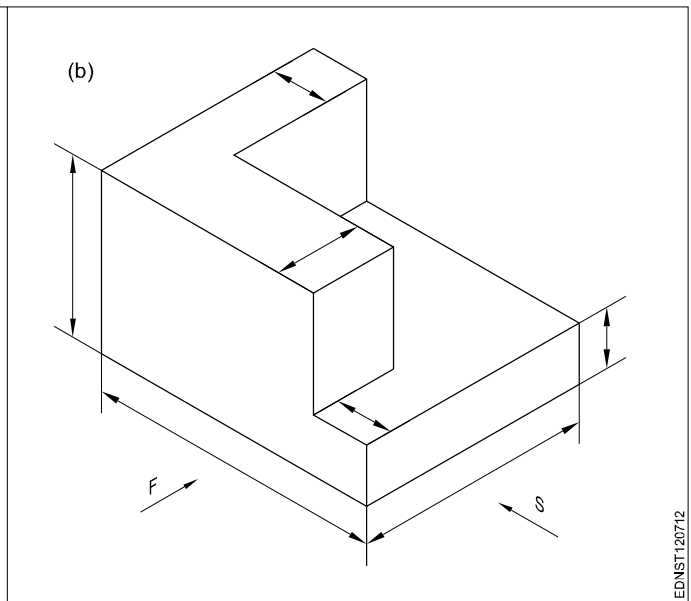
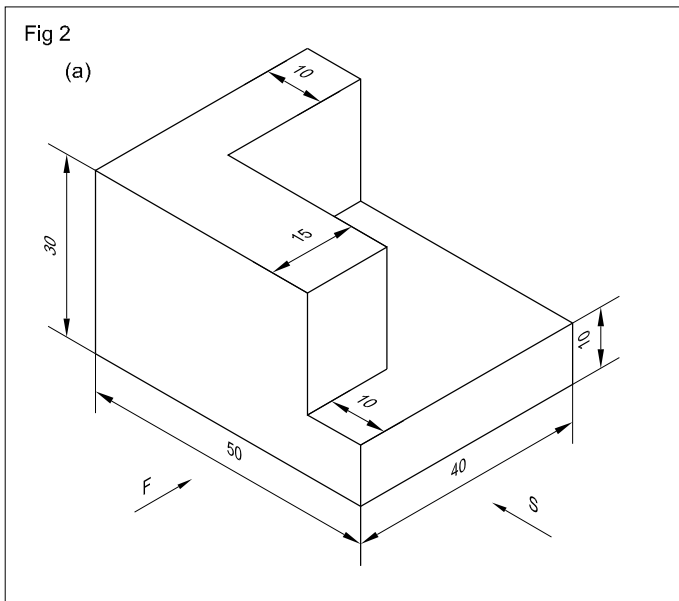
All items we use are solids. Their shapes may confirm individual geometrical solids like prisms, cones or other combinations.



Free hand drawing of - Transferring measurement from the given object to the free hand sketches



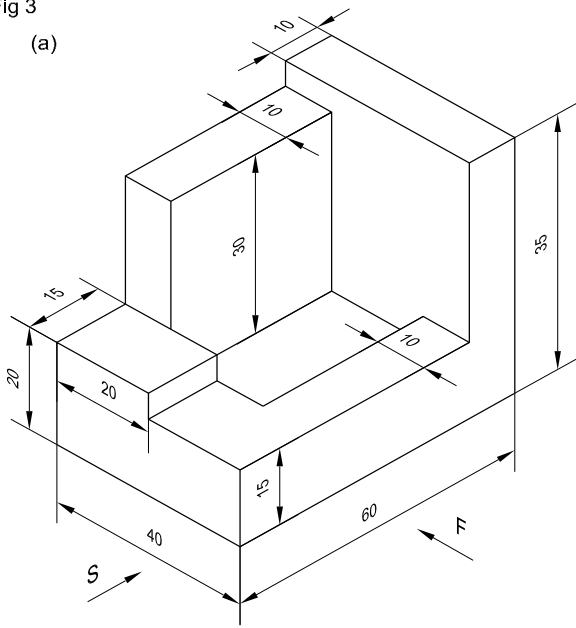
EDNST120711



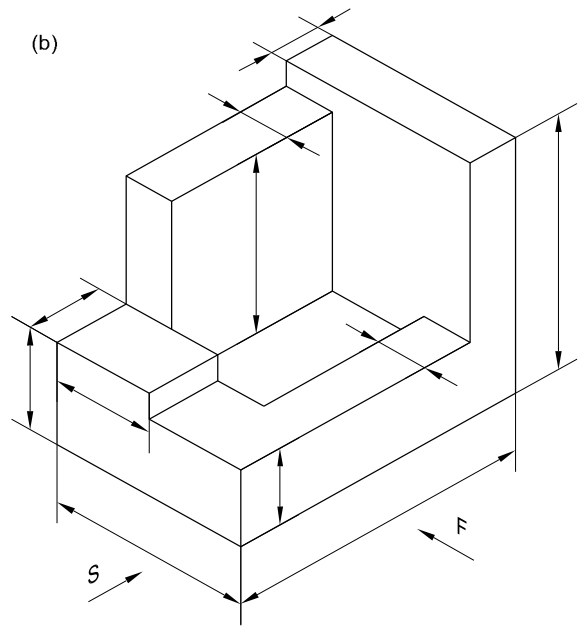
EDNST120712

Fig 3

(a)



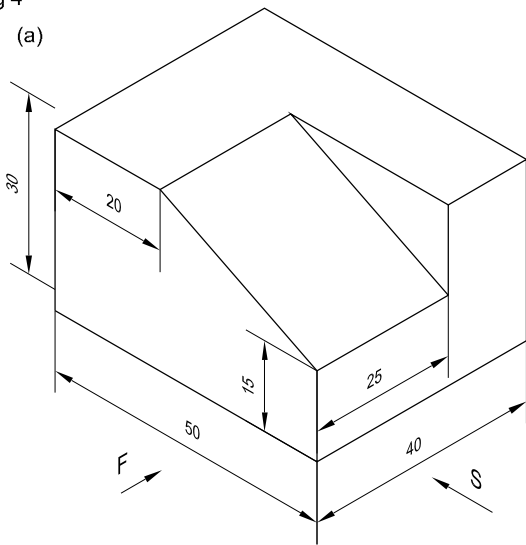
(b)



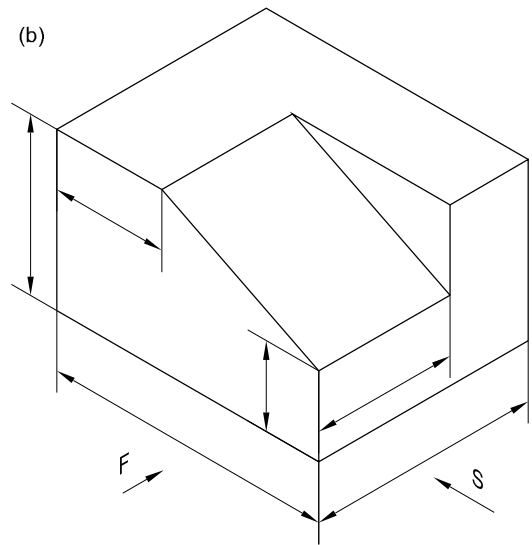
EDNST120713

Fig 4

(a)



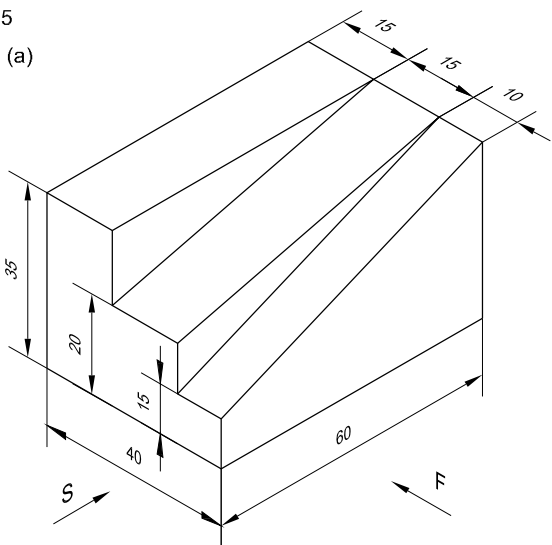
(b)



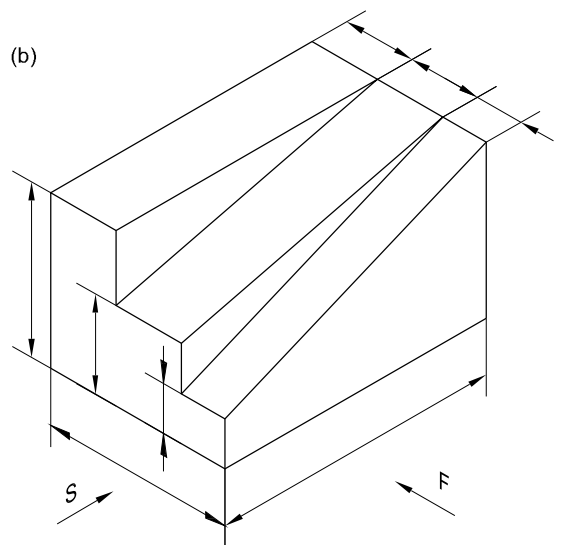
EDNST120714

Fig 5

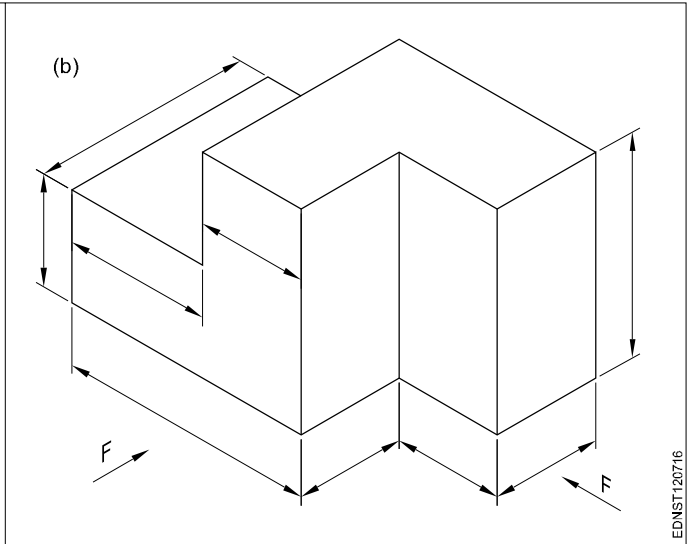
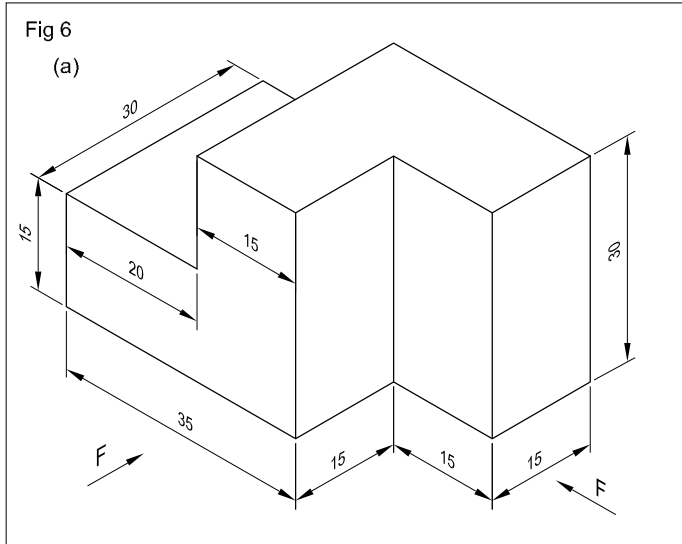
(a)



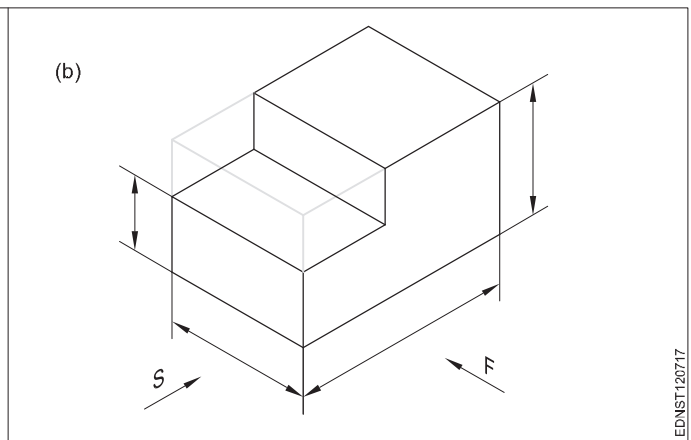
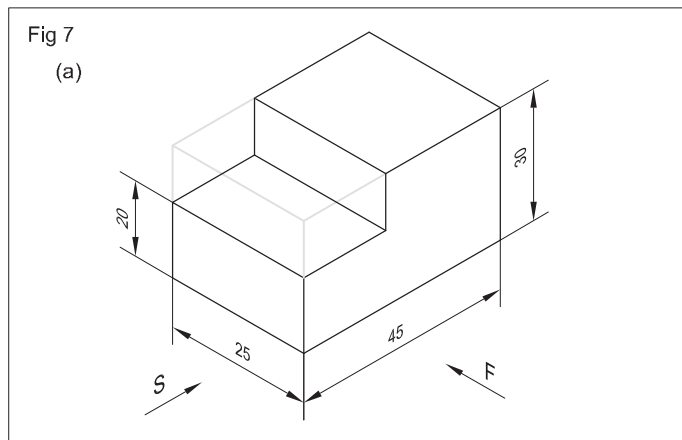
(b)



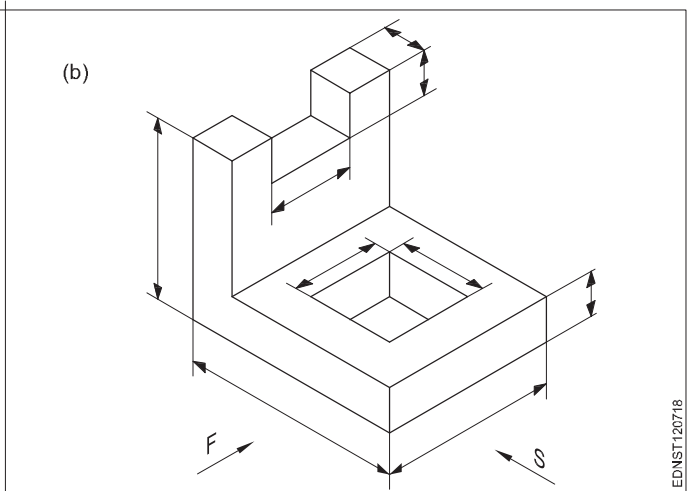
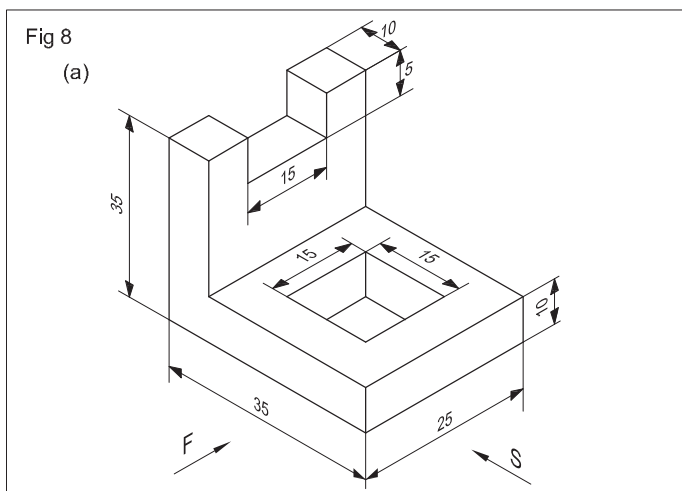
EDNST120715



EDNST120716



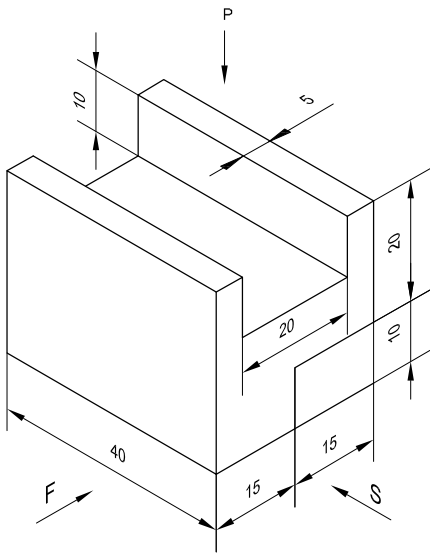
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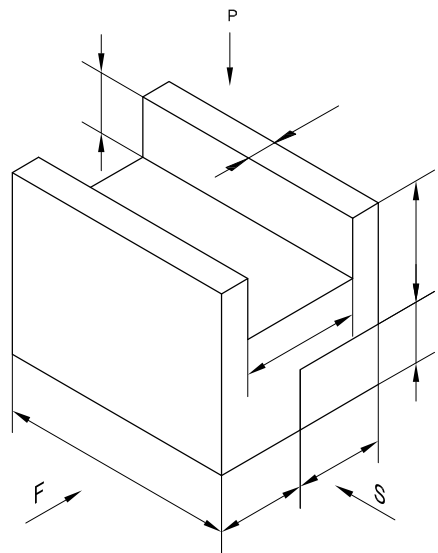
EDNST120718

Fig 9

(a)



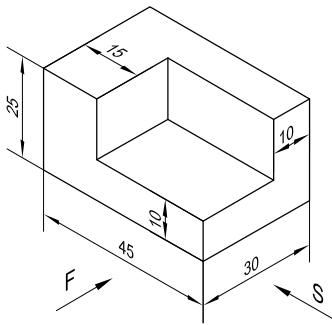
(b)



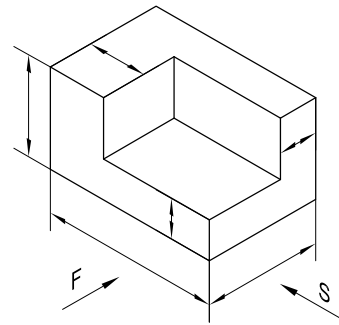
EDNST120719

Fig 10

(a)



(b)



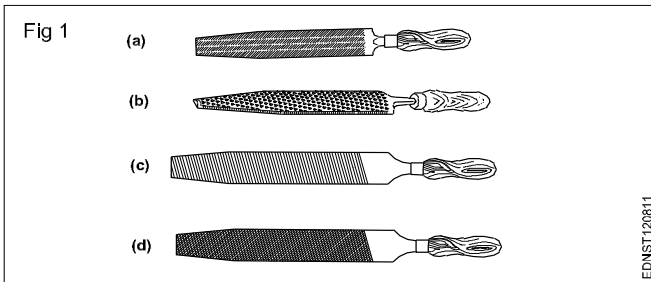
EDNST12071A

**Free hand drawing of hand tools**

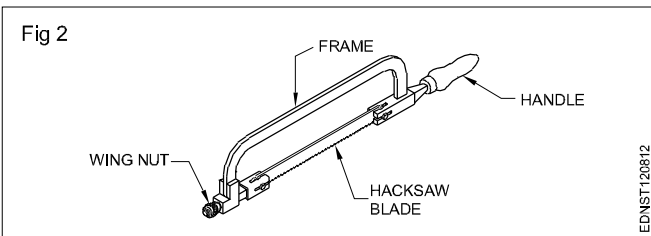
**Hand Tools**

**Files (Fig 1)**

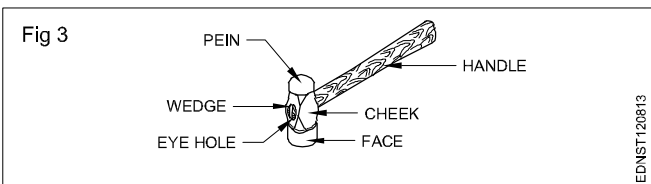
- a Curved cut file
- b Rasp cut file
- c Single cut file
- d Double cut file



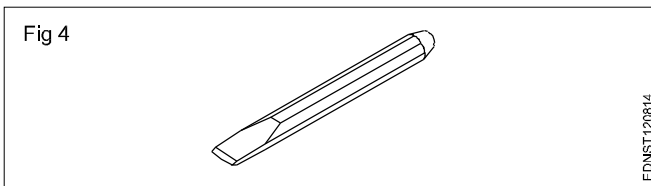
**Hacksaw (Fig 2)**



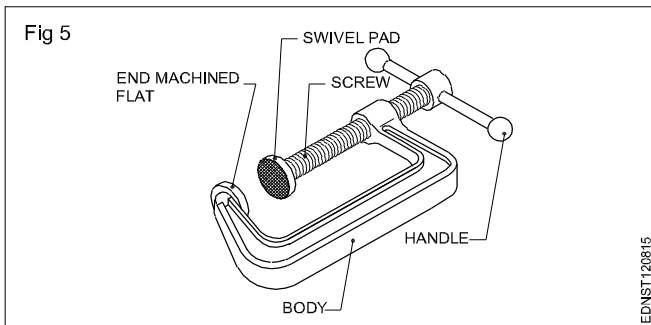
**Ball pein hammer (Fig 3)**



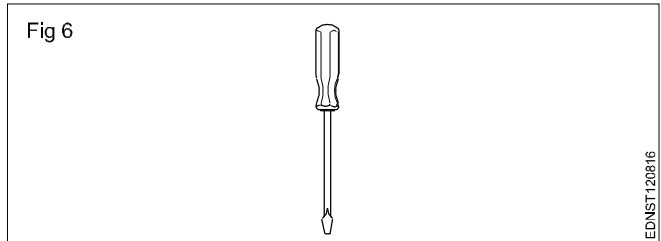
**Chisel (Fig 4)**



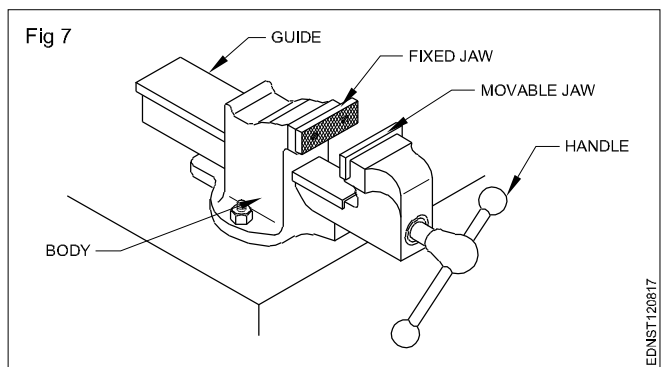
**'C' clamp (Fig 5)**



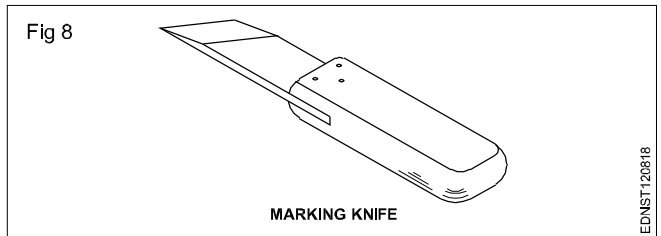
**Screw driver (Fig 6)**



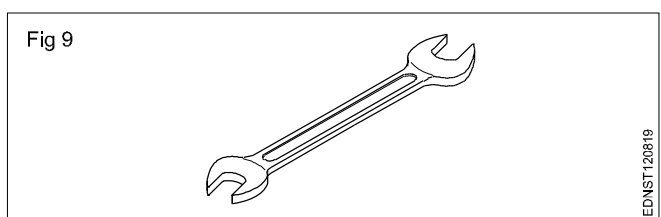
**Bench vice (Fig 7)**



**Marking knife (Fig 8)**

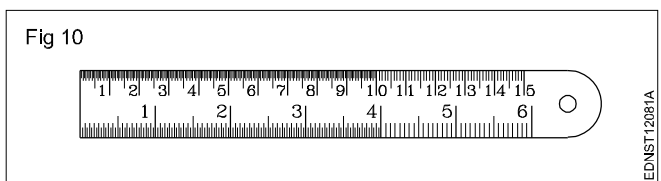


**Open end spanner (Fig 9)**



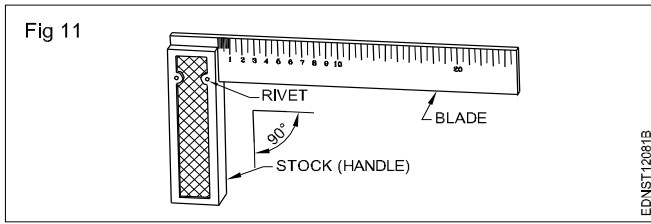
**Measuring Tools**

**Steel rule (Fig 10)**

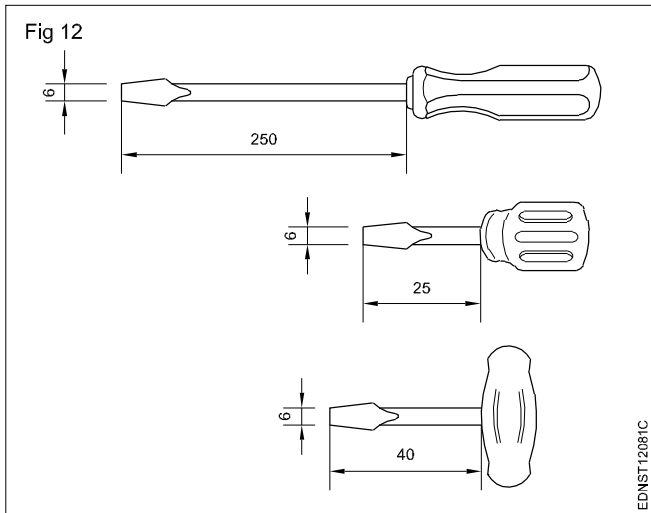




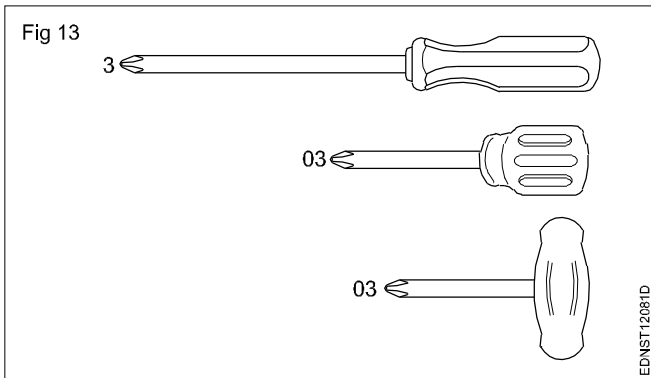
Try square (Fig 11)



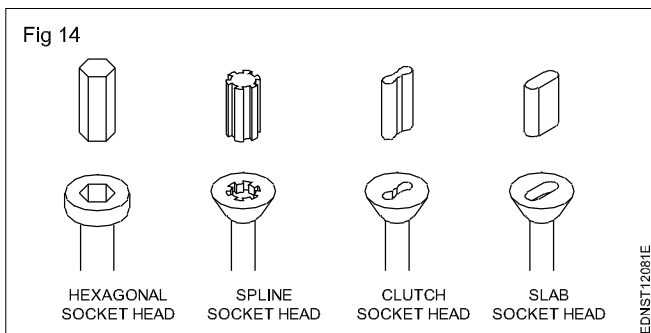
Screw driver (Fig 12)



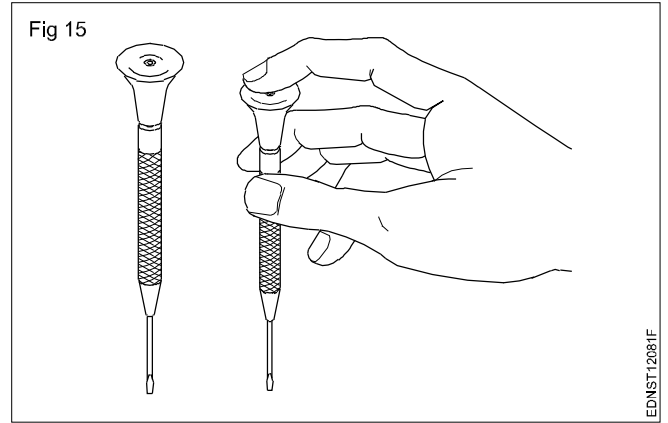
Screw driver with cross type tips (Fig 13)



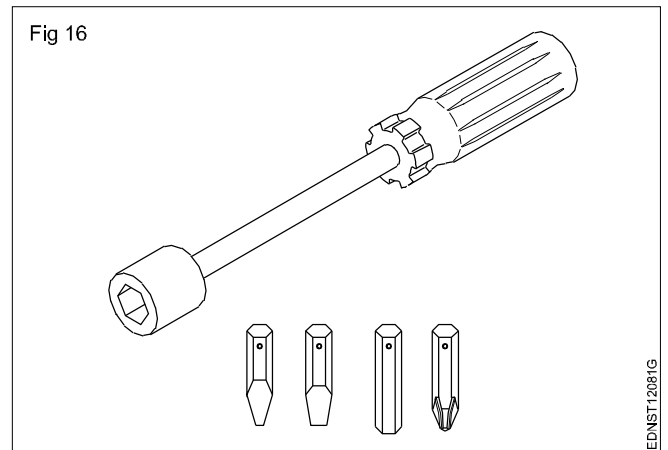
Screw tips aided screw heads (Fig 14)



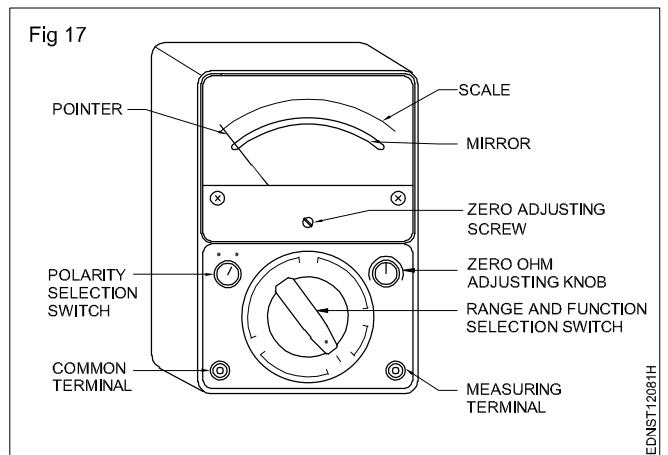
Instrument screw driver (Fig 15)



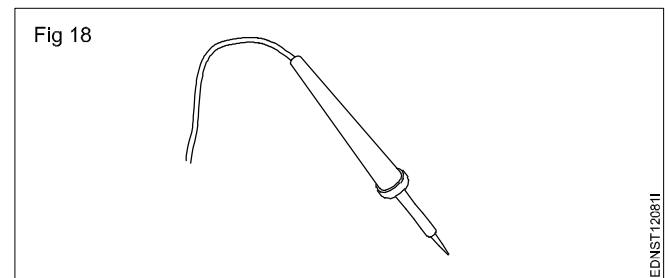
Screw driver interchangeable tips (Fig 16)



Analog multimeter (Fig 17)



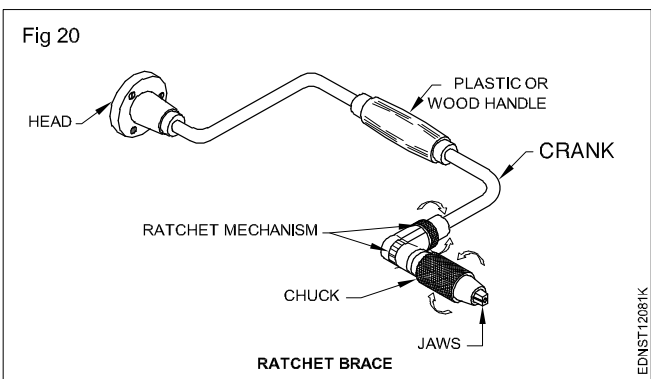
Soldering iron (Fig 18)



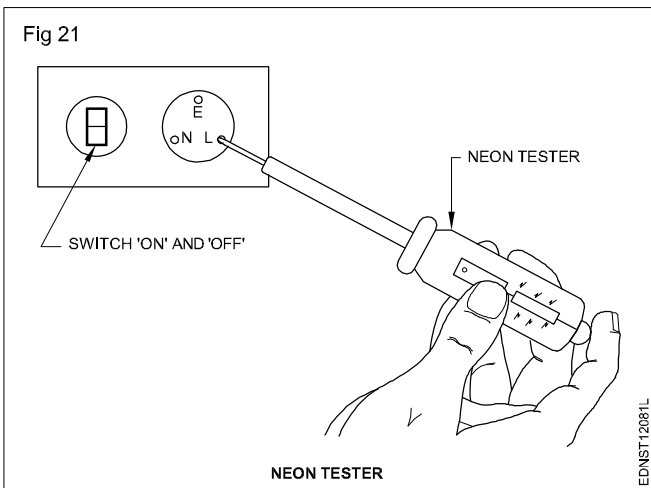
Soldering work station (Fig 19)



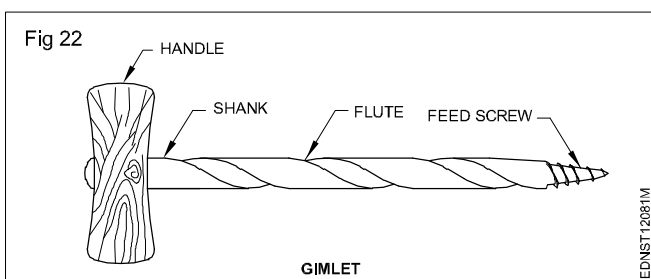
Ratchet brace (Fig 20)



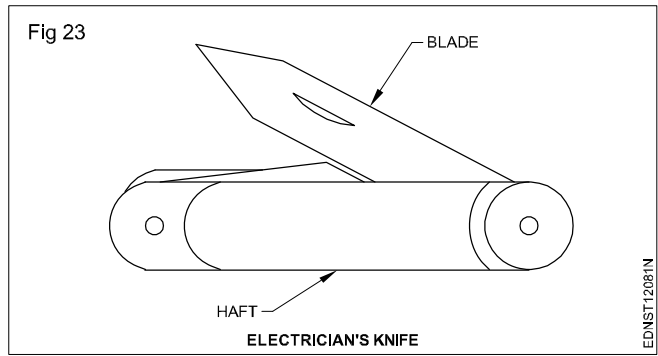
Neon Tester (Fig 21)



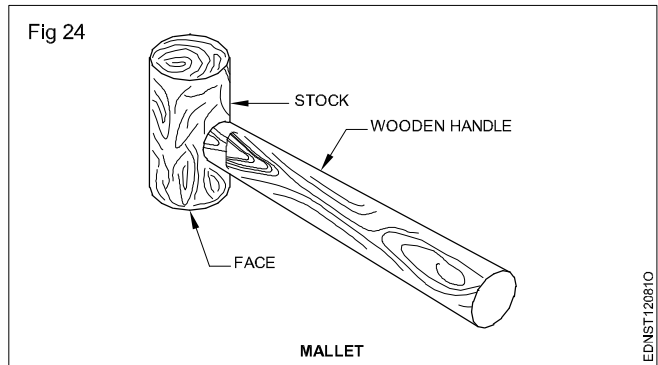
Gimlet (Fig 22)



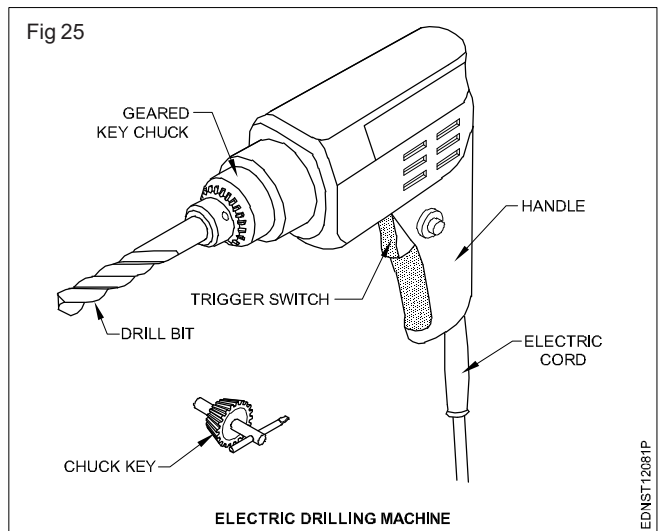
Electrician's knife (Fig 23)



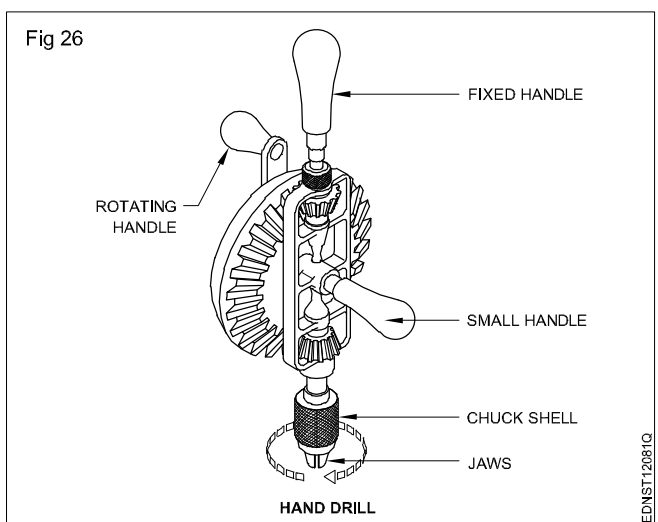
Mallet (Fig 24)



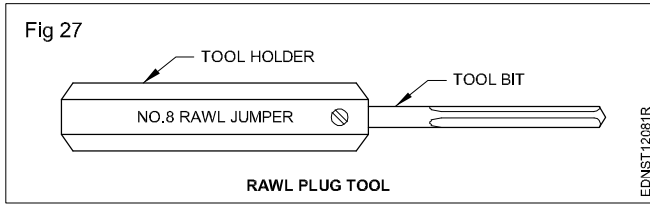
Electric drilling machine (Fig 25)



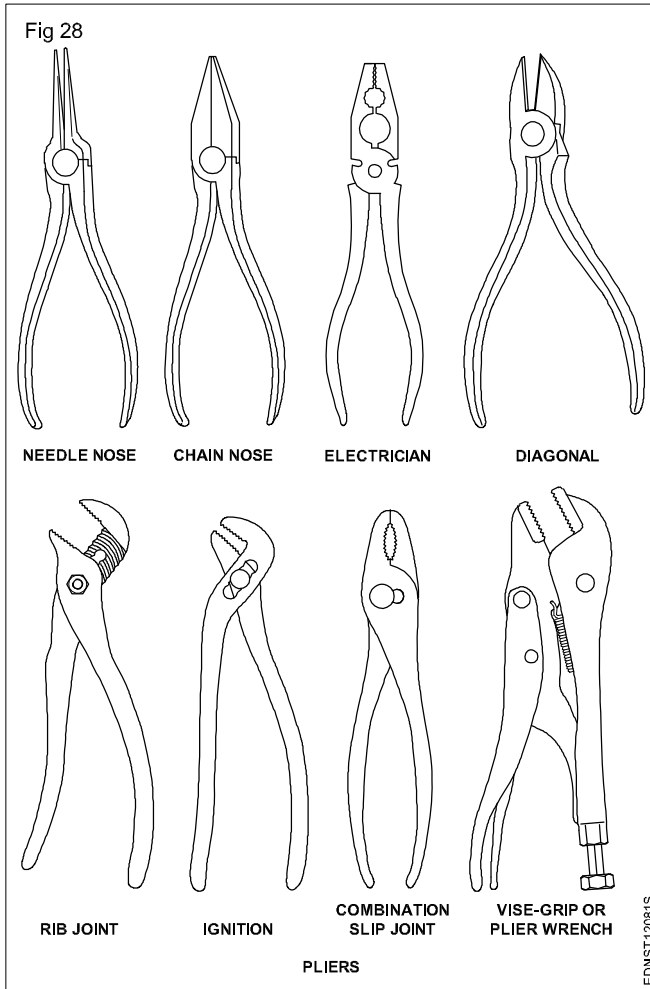
Hand drill (Fig 26)



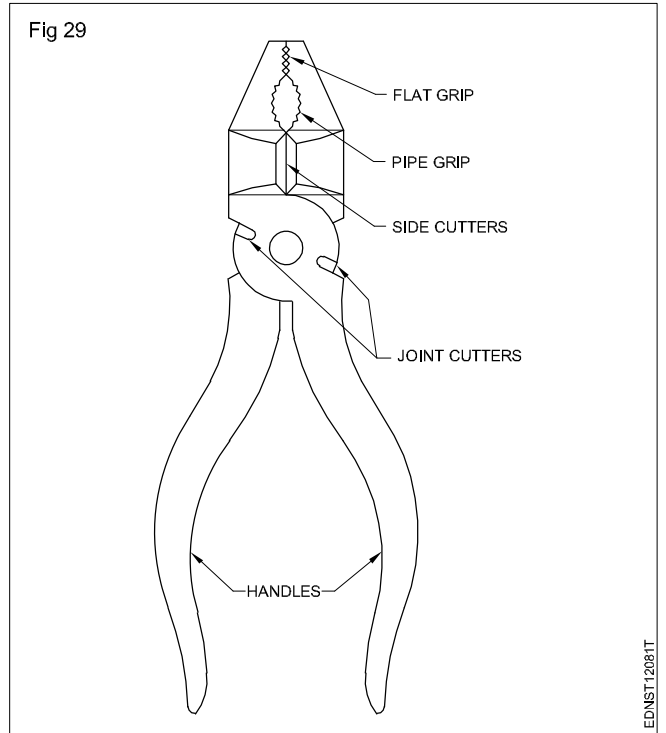
Rawl plug tool (Fig 27)



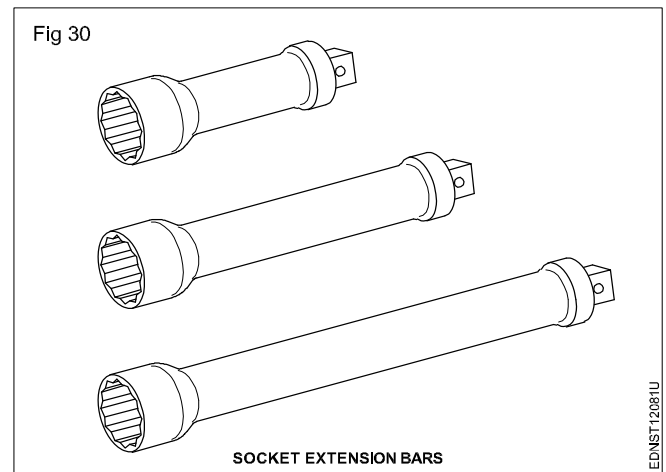
Pliers (Fig 28)



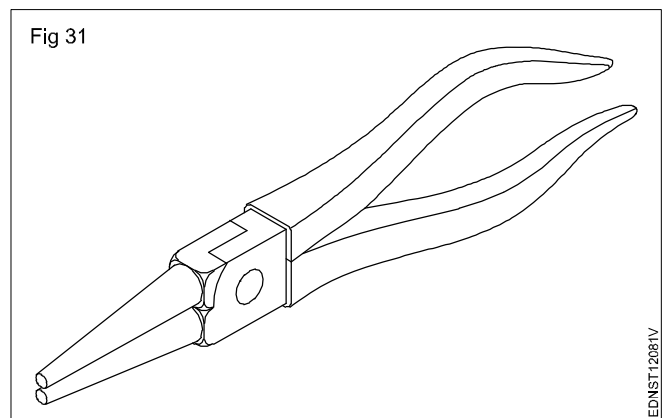
Cutting plier (Fig 29)



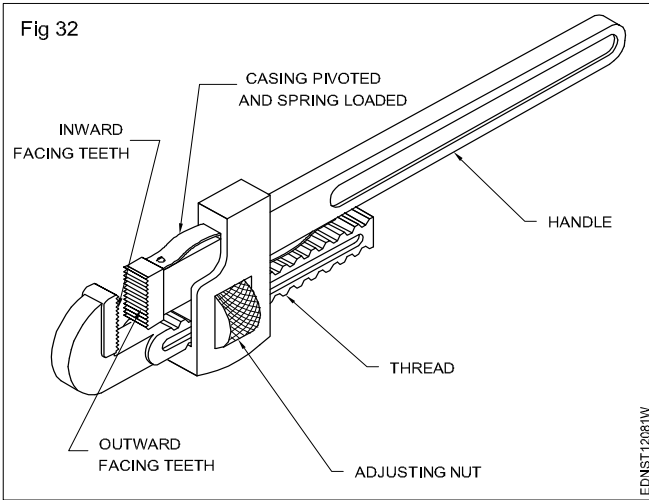
Socket extension bars (Fig 30)



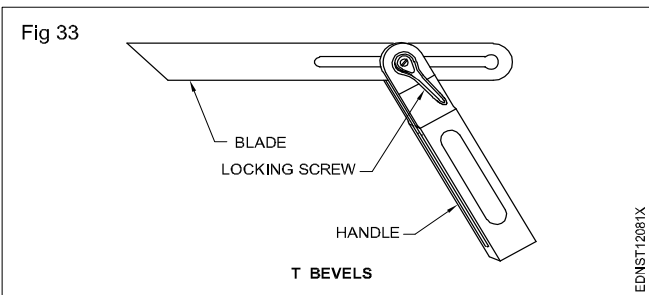
Round nose plier (Fig 31)



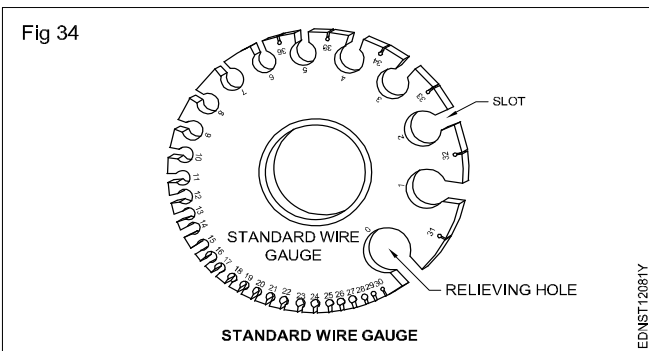
Stillson pipe wrench (Fig 32)



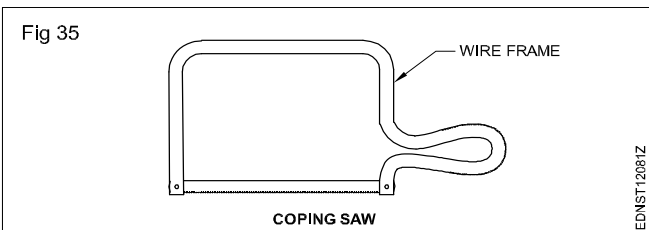
'T' - Bevels (or) bevel square (Fig 33)



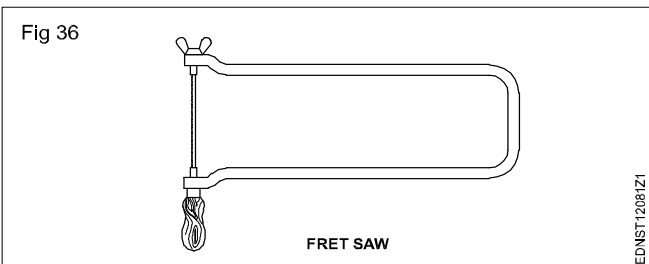
Standard wire gauge (Fig 34)



Coping saw (Fig 35)



Fret saw (Fig 36)



I-V Curve tracer (Fig 37)



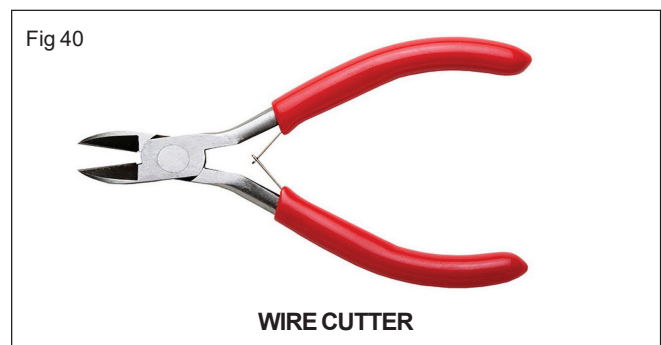
Clamp meter (Fig 38)



Battery filler (Fig 39)



Wire cutter (Fig 40)



Thermography camera (Fig 41)



Battery Tester (Hydrometer) (Fig 45)



Pyranometer (Fig 42)



Measuring tape (Fig 46)



Nut drivers (Fig 43)



Mini tool kit (Fig 47)



Wire stripper (Fig 44)



PPE kit (Fig 48)



Torch light (Fig 49)



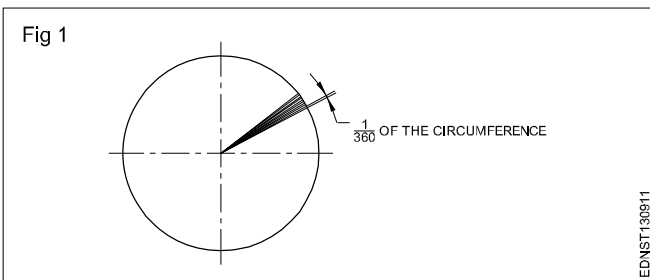
Insulation tester (Fig 50)



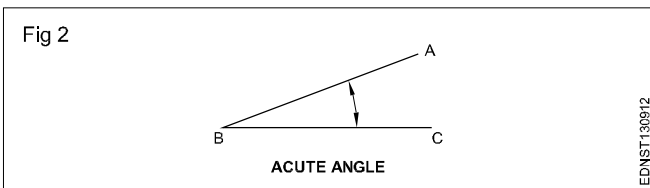
**Drawing of geometrical figures - Angle & triangle**

**Angles:** Angle is the inclination between two straight lines meeting at a point or meeting when extended. AB and BC are two straight lines meeting at B. The inclination between them is called an angle. The angle is expressed in degrees or radians.

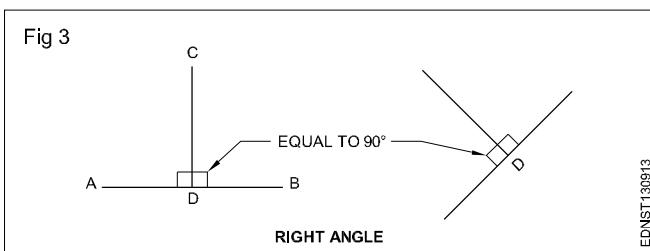
**Concept of a degree:** When the circumference of a circle is divided into 360 equal parts and radial lines are drawn through these points, the inclination between the two adjacent radial lines is defined as one degree. Thus a circle is said to contain 360°. (Fig 1)



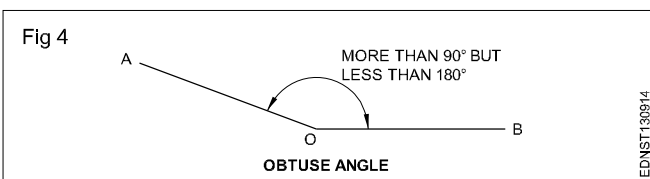
**Acute angle:** An angle that is less than 90° is called an acute angle. (Fig 2)



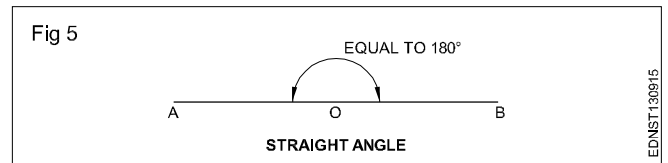
**Right angle:** The angle between a reference line and a perpendicular line is called a right angle. (Fig 3)



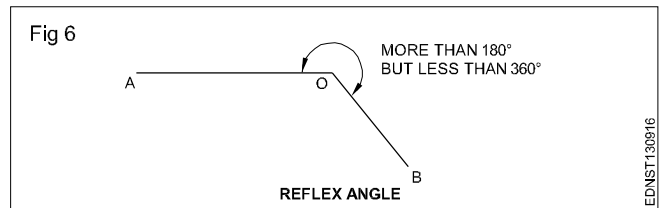
**Obtuse angle:** This refers to an angle between 90° and 180°. (Fig 4)



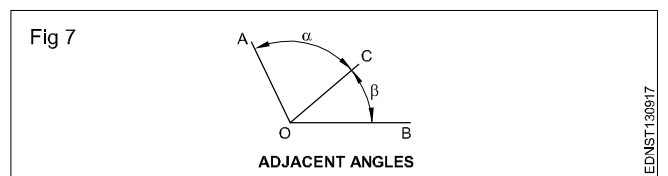
**Straight angle:** This refers to an angle of 180°. This is also called the angle of a straight line. (Fig 5)



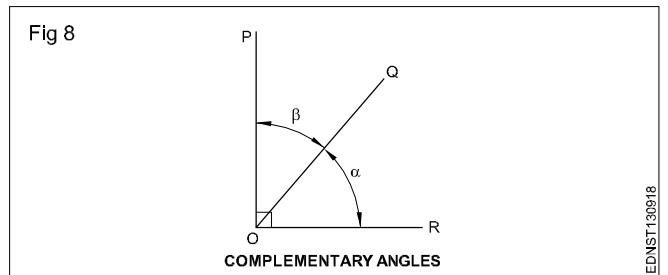
**Reflex angle:** It is the angle that is more than 180°, but less than 360°. (Fig 6)



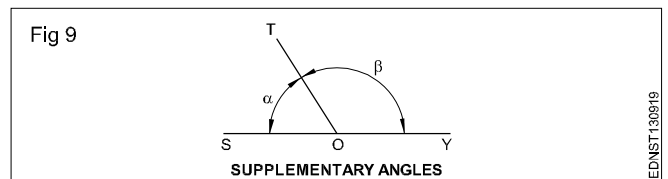
**Adjacent angles:** These are the angles lying on either side of a line. (Fig 7)



**Complementary angles:** When the sum of the two angles is equal to 90°, angle POQ + angle QOR = 90° angle POQ and angle QOR are complementary angles to each other. (Fig 8)



**Supplementary angle:** When the sum of the two adjacent angles is equal to 180°, for example, angle SOT + angle TOY = 180°, angle SOT and angle TOY are supplementary angles to each other. (Fig 9)



## Triangle - different types

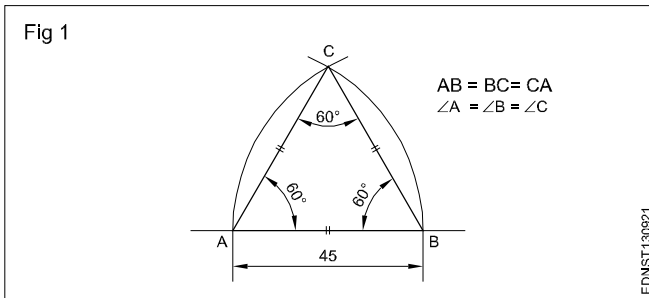
Triangle is a closed plane figure having three sides and three angles. The sum of the three angles always equals to  $180^\circ$ .

To define a triangle, we need to have a minimum of three measurements as follows:

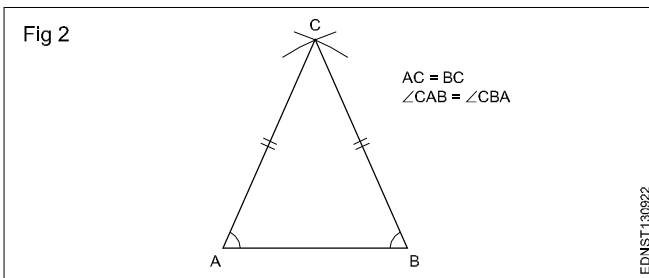
- 3 sides or
- 2 sides and one angle or
- 2 angles and one side

### Types of triangles

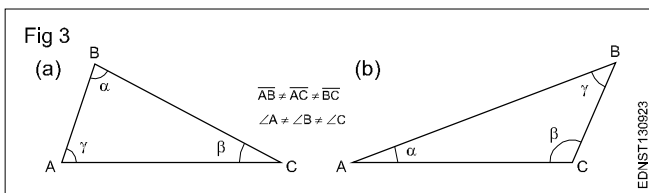
**1 Equilateral triangle** is a triangle having all the three sides equal. Also all the three angles are equal ( $60^\circ$ ). (Fig 1)



**2 Isosceles triangle** has two of its sides equal. The angles opposite the two equal sides are also equal. (Fig 2)



**3 Scalene triangle** has all three sides unequal in length. All three angles are also unequal. (Fig 3)



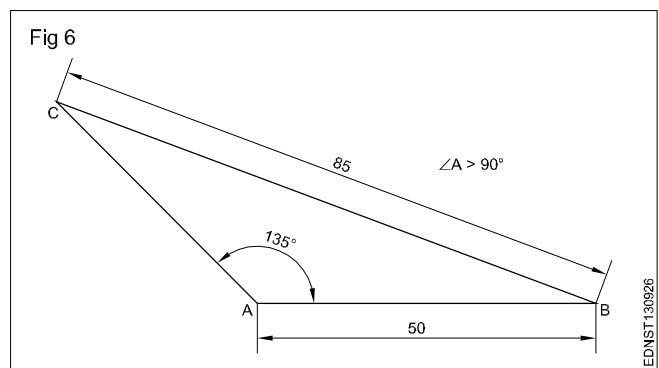
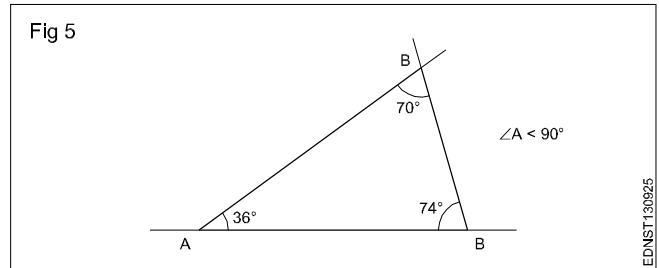
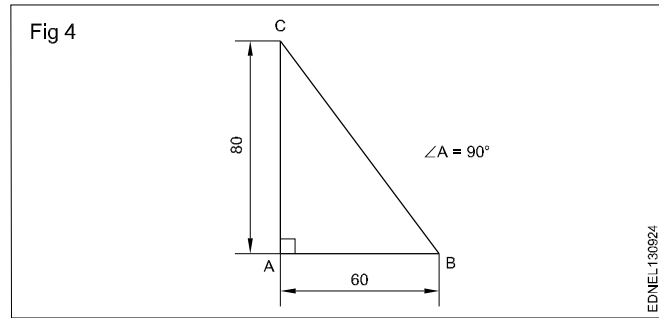
**4 A right-angled triangle** is one in which one of the angles is equal to  $90^\circ$  (Right angle). The side opposite the right angle is called the hypotenuse. (Fig 4)

**5 An Acute angled triangle** is one in which all the three angles are less than  $90^\circ$ . (Fig 5)

**6 Obtuse angled triangle** has one of the angles more than  $90^\circ$ . (Fig 6)

**The sum of the three angles in any triangle is equal to  $180^\circ$ .**

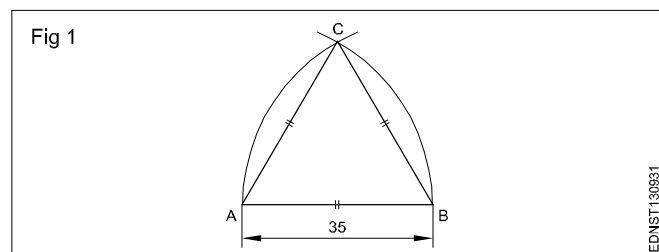
**The sum of any two sides is more than the third side.**



### Procedure to draw the triangle

**1 Equilateral triangle (Fig 1)  $AB = BC = CA = 35$  mm.**

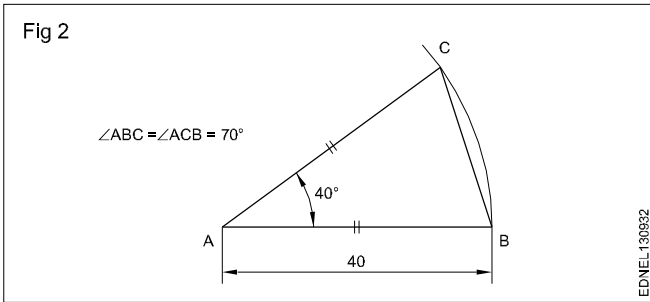
- Draw a line and mark AB 35 mm side of the triangle.
- Draw radius from centre A and B, arcs cutting mark at C (Fig 1).
- Join CA and CB.
- ABC is a required triangle.



**2 Isosceles triangle :  $AB = AC = 60$  mm &  $\angle BAC = 40^\circ$ .**

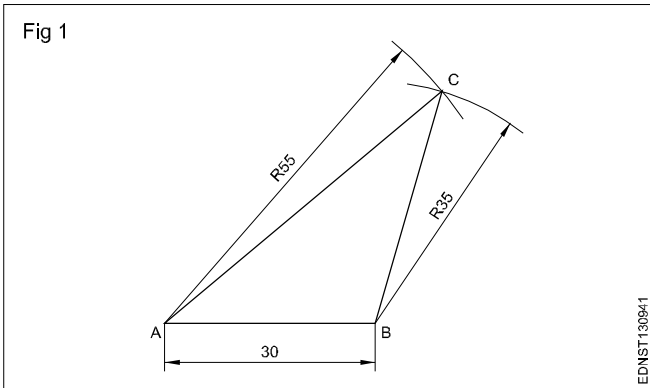
- Draw the side AB equal to 60 mm. 'A' as the centre, draw an arc of radius AB.
- Draw a line AC at  $40^\circ$  to AB.
- Join BC to form the triangle ABC. (Fig 2)





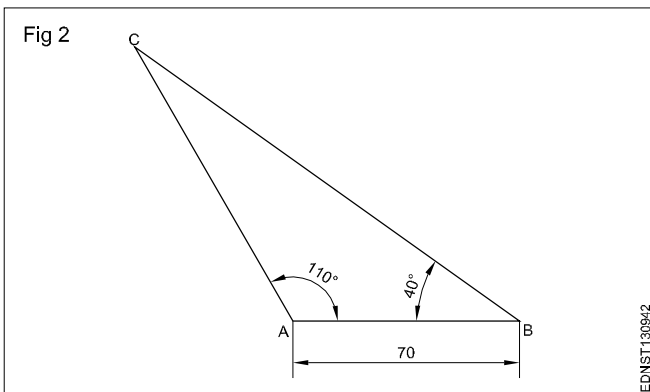
### Exercise

- 1 Scalene triangle:  $AB = 30$  mm,  $AC = 55$  mm &  $BC = 35$  mm. (Fig 1)

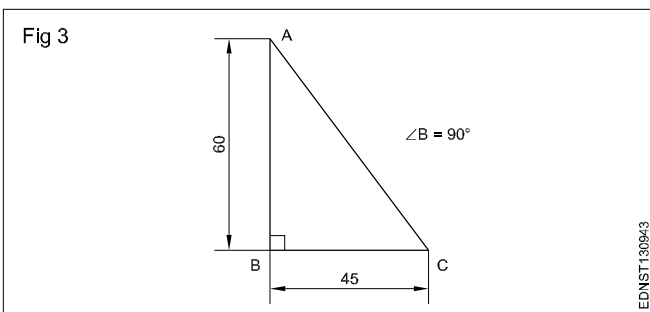


- 2 Scalene triangle:  $AB = 70$  mm. (Fig 2)

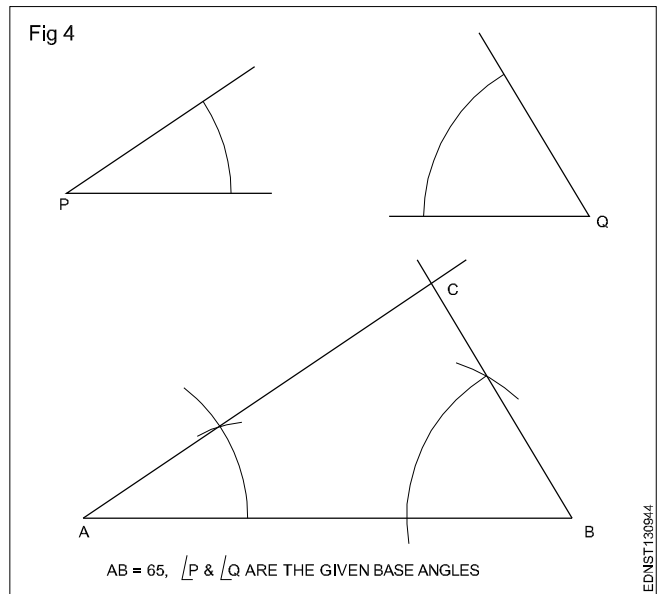
$\angle ABC = 40^\circ$  &  $\angle BAC = 110^\circ$



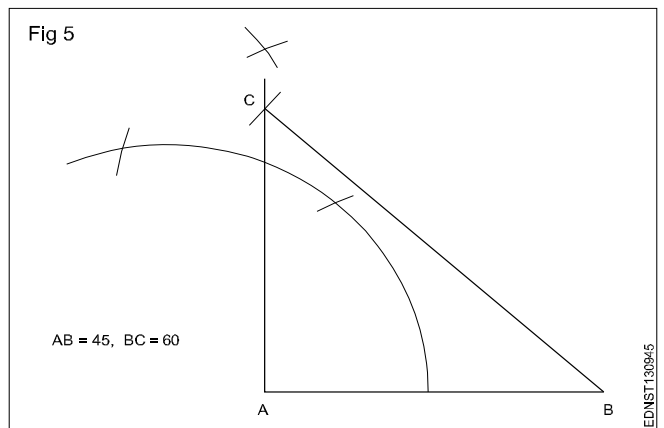
- 3 Right angled triangle:  $AB = 60$  mm,  $BC = 45$  mm. (Fig 3)



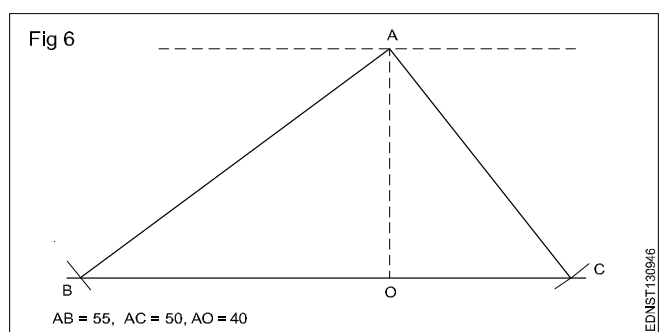
- 4 Draw a triangle when one side and 2 angles being given in Fig 4.



- 5 Draw a right angled triangle when the base and hypotenuse being given in Fig 5.



- 6 Draw a triangle with the altitude and two sides being given in Fig 6.



**Drawing of geometrical figures - Circle**

**Circle:** Circle is a plane figure bounded by a curve, formed by the locus of a point which moves so that it is always at a fixed distance from a stationary point the "Centre".

**Radius:** The distance from the centre to any point on the circle is called the "Radius".

**Diameter:** The length of a straight line between two points on the curve, passing through the centre is called the "Diameter". (D: Dia or d) It is twice the radius.

**Circumference:** It is the linear length of the entire curve, equal to  $\pi D$ .

**Arc:** A part of the circle between any two points on the circumference or periphery is called an 'Arc'.

**Chord:** A straight line joining the ends of an arc is called the chord. (Longest chord of the circle is the diameter)

**Segment:** A part of the circle or area bound by the arc and chord is the segment of the circle.

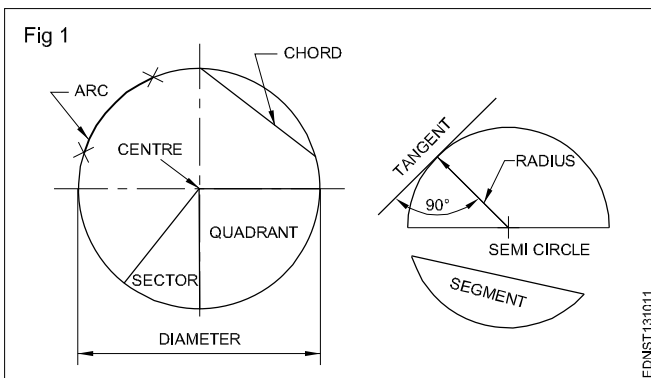
**Sector:** It is the part of a circle bounded by two radii (plural of radius) meeting at an angle and an arc.

**Quadrant:** Part of a circle with radii making  $90^\circ$  with each other is a quadrant (one-fourth of the circle).

Half of the circle is called a semi-circle.

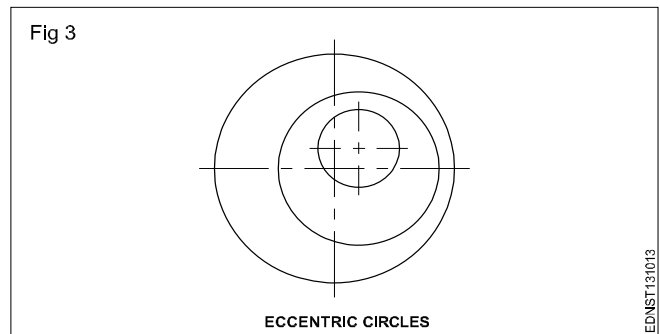
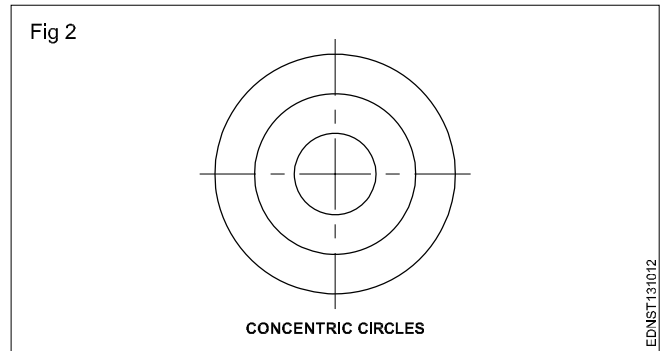
**Tangent:** The tangent of a circle is a straight line just touching the circle at a point. It does not cut or pass through the circle when extended.

Fig 1 shows all the above elements.



**Concentric circles:** When two or more circles (drawn) have a common centre, they are called concentric circles. Ball-bearing is the best example of concentric circles. (Fig 2)

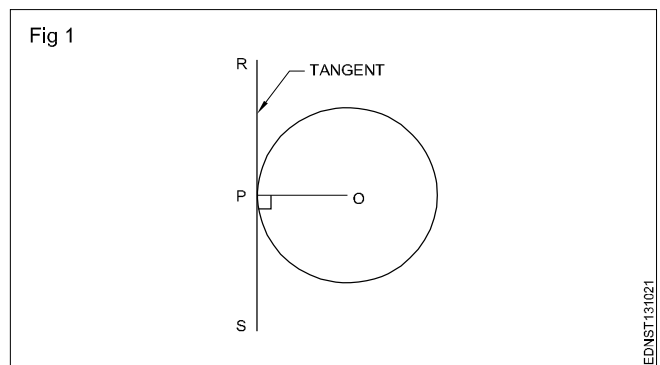
**Eccentric circles:** Circles within a circle but with different centres are called eccentric circles. (Fig 3)



**Circle and Arcs**

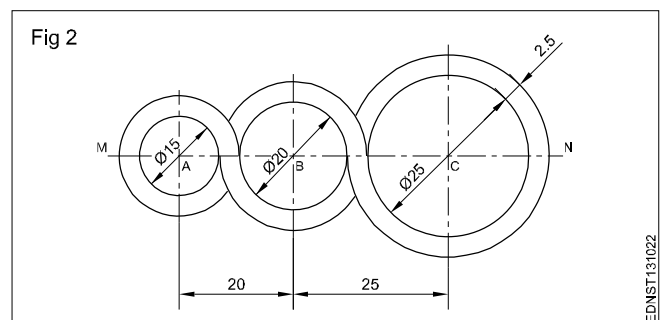
**Exercise**

- 1 Draw a tangent to a given circle of  $\phi$  50 mm at any point 'P' on it. (Fig 1)

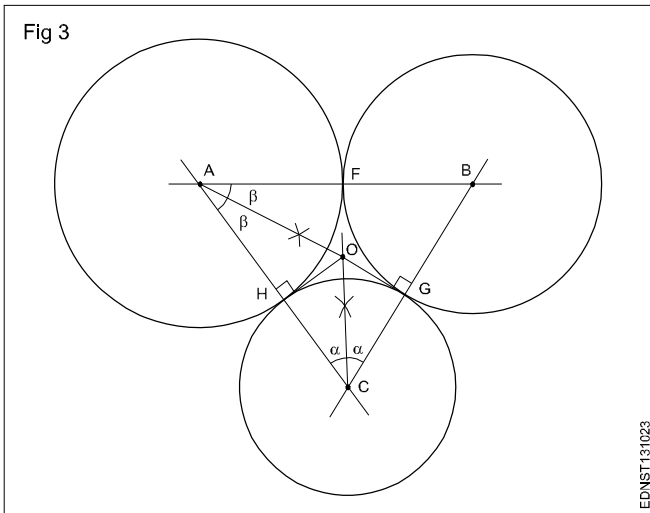


- 2 Draw a loop of 3 circles pattern. (Fig 2)

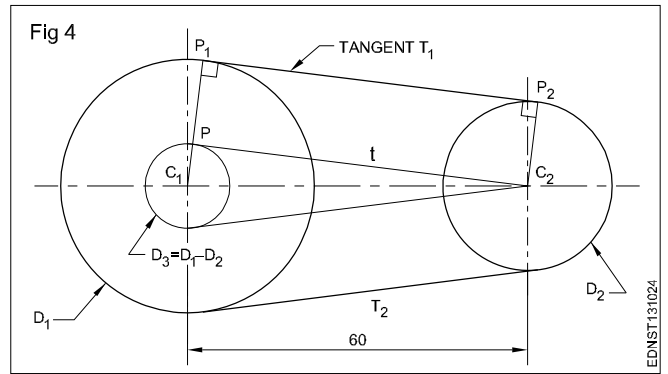
Draw any line MN and mark points A,B and C. So that AB = 20 mm and BC = 25 mm.



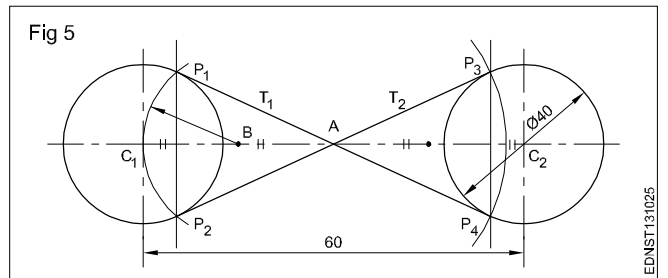
**3 3 Draw three circles tangential to each other if centres A, B & C are given. (Fig 3)**



**4 Draw external tangents to circles of dia 40 and 30 and centre distance 60 mm. (Fig 4)**

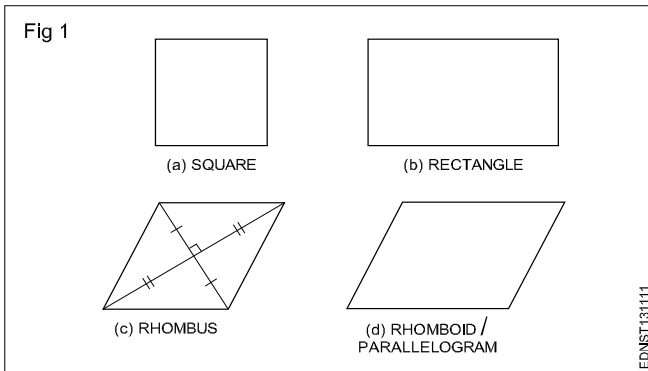


**5 Draw internal tangents to circles of the same diameter 40 each and a centre distance of 60 mm. (Fig 5)**



Drawing of geometrical figures - Square, rectangle and parallelogram

A quadrilateral is a plane figure bounded by four sides and four angles. The sum of the four angles in a quadrilateral is equal to  $360^\circ$ . The side joining opposite corners is called diagonal. To construct a quadrilateral out of four sides, four angles and two diagonals a minimum of five dimensions are required of which two must be sides. Quadrilaterals are also referred as Trapezium. (Fig 1)



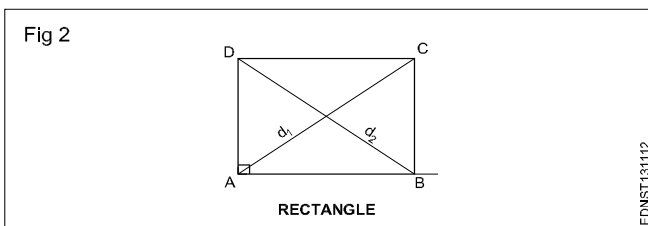
Types of quadrilaterals (Fig 1)

- Square
- Rectangle
- Rhomboid / Parallelogram

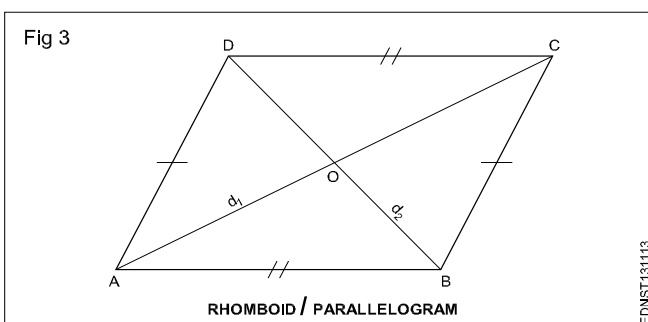
**Square:** In a square all the four sides are equal and its four angles are at right angles. The two diagonals are equal and perpendicular to each other.

**Rectangle (Fig 2):** In a rectangle, opposite sides are equal and parallel and all four angles are right angles.

Fig 2 shows a rectangle ABCD, Sides  $AB = DC$  and  $BC = AD$ . Diagonals AC and BD are equal. Diagonals are not bisected at right angles.



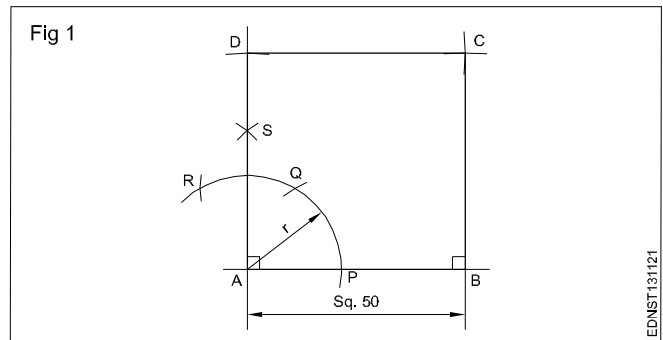
**Rhomboid/Parallelogram (Fig 3):** In a parallelogram, opposite sides are equal and parallel. Opposite angles are also equal. Diagonals are not equal but bisect each other.



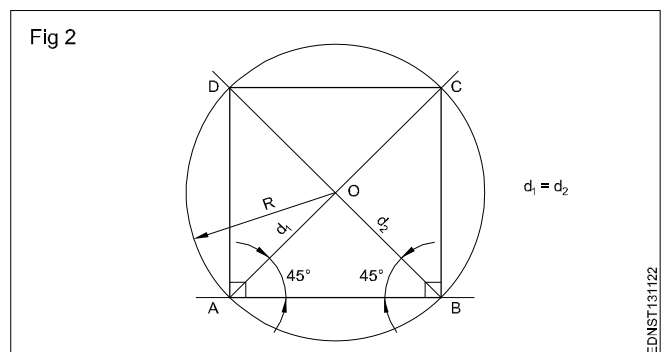
Procedure to draw the square, rectangle and parallelogram

Square

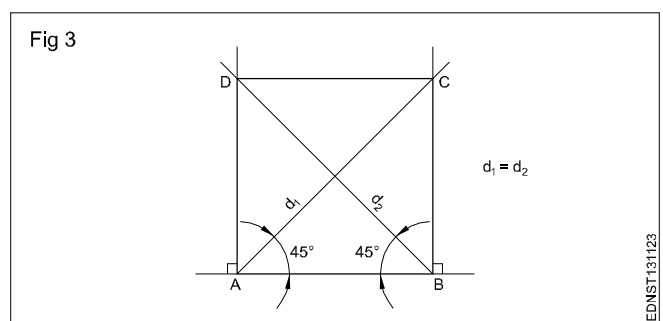
1 **1st method (Fig 1):** A square of side 50 mm by erecting perpendicular.



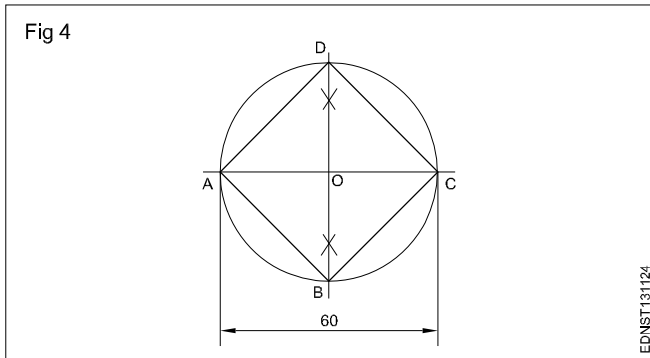
2 **2nd method (Fig 2):** A square of side 60 mm using  $45^\circ$  setsquare and compass.



3 **3rd method (Fig 3):** A square of side 60 mm long by erecting perpendicular and also using  $45^\circ$  setsquare.

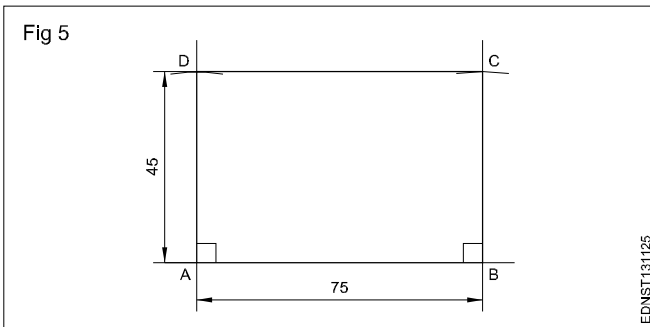


**4 Square having diagonal 60 mm (Fig 4)**



**5 Rectangle (Fig 5)**

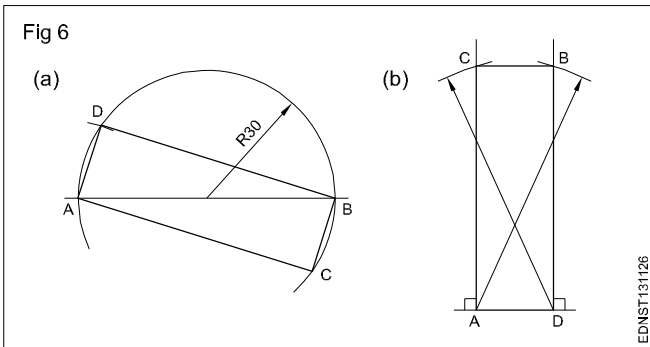
Side AB = 75 mm, side AD = 45 mm using setsquare and compass.



**6 Rectangle - Diagonal - 60 mm and one side 20 mm 1st method (Fig 6a)**

2nd method (Fig 6b)

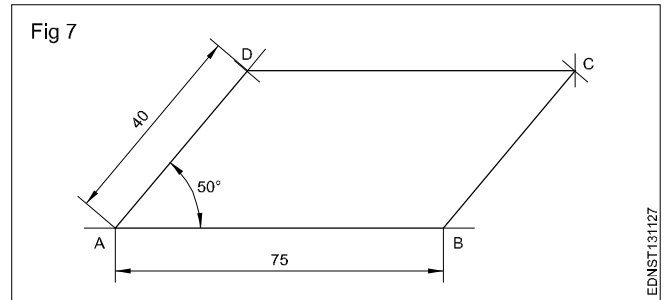
ADBC is the required rectangle of side 20 mm and diagonal 60 mm.



**7 Parallelogram (Fig 7)**

Sides = 75 mm and 40 mm

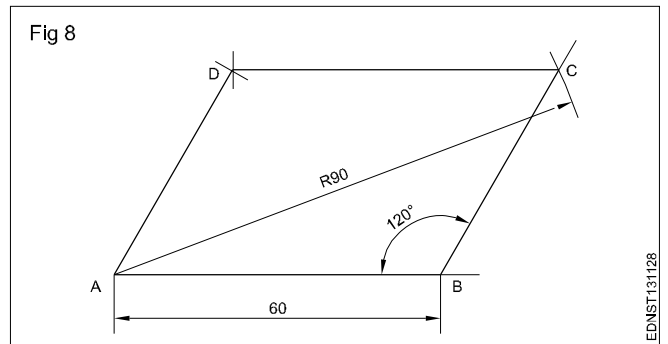
Angle between them: 50°



**8 Parallelogram (Fig 8)**

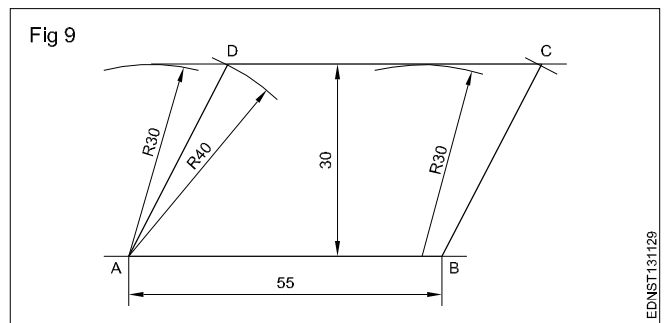
Parallelogram - Side AB = 60 mm

Diagonal AC = 90 mm ∠ABC = 120°



**9 Parallelogram (Fig 9)**

Sides AB = 55 mm, BC = 40 mm and vertical height = 30 mm.



**Lettering and numbering - Single stroke**

**Styles of lettering:** Many styles of lettering are in use today. However, a few styles which are commonly used are shown in Fig 1.

Fig 1

<b>ABCDEFGH</b> <b>abcdefgh</b>	GOTHIC ALL LETTERS HAVING THE ELEMENTARY STROKES OF EVEN WIDTH ARE CLASSIFIED AS GOTHIC
<b>ABCDEFGH</b> <b>abcdefgh</b>	ROMAN ALL LETTERS HAVING THE ELEMENTARY STROKES "ACCENTED" OR CONSISTING OF HEAVY AND LIGHT LINES ARE CLASSIFIED AS ROMAN
<i>ABCDEFGH</i> <i>abcdefgh</i>	ITALIC ALL SLANTING LETTERS ARE CLASSIFIED AS ITALIC. THESE MAY BE FURTHER DESIGNATED AS ROMAN-ITALICS, GOTHIC-ITALICS, TEXT-ITALICS
<b>ABCDEF</b> <b>abcd</b>	TEXT THIS TERM INCLUDES ALL STYLES OF OLD ENGLISH, GERMAN TEXT, BRADELY TEXT OF OTHERS OF VARIOUS TRADE NAMES. TEXT STYLES ARE TOO ILLEGIBLE FOR COMMERCIAL PURPOSES

EDNST131211

**Standard heights/Width:** The standard heights recommended by BIS SP: 46-2003 are in the progressive ratio of "square root 2". They are namely 2.5 - 3.5 - 5 - 7 - 10 - 14 and 20 mm. The height of lower case letter (without tail or stem) are 2.5, 3.5, 5, 7, 10 and 14 mm.

There are two standard ratios for the line thickness "d". They are A & B. In A = line thickness (d) is h/14 and in B=line thickness (d) is h/10.

**Lowercase** means small letters, as opposed to capital letters. The word yes, is for example, is in **lowercase**, while the word YES is in **upper case**. For many programmes, this distinction is very important. Programmes that distinguish between **uppercase** and **lowercase** are said to be case sensitive

The width of different letters in terms of "d" is as follows:

**Lettering A**

Width (W)	Capital letters	Width
1	I	1d
5	J,L	5d
6	C,E,F	6d
7	B,D,G,H,K,N,O,P,R,S,T,U & Z	7d
8	A,Q,V,X,Y	8d
9	M	9d
12	W	12d

**Lower case letters and numerals**

Width (W)	Letters/Numerals	Width
1	i	1d
3	j,l	3d
4	f,t,l	4d
5	c,r	5d
6	a,b,d,e,g,h,k,n,o,p,q,s,u,v;3;5	6d
7	a,0 (zero), 2,4,6,7,0,8,9	7d
9	m	9d
10	w	10d

The width of different letters in terms of stroke (line) is as follows:

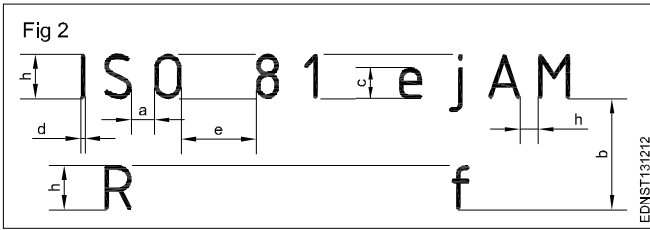
**Uppercase Lettering BIS SP: 46-2003**

Width (W)	Capital letters
1	I
4	J
5	C,E,F,L
6	B,D,G,H,K,N,O,P,R,S,T,U & Z
7	A,M,Q,V,X,Y
9	W

**Lower case letters and numerals**

Width (W)	Letters/Numerals
1	i
2	l
3	j,l
4	c,f,r,t
5	a,b,d,e,g,h,k,n,o,,q,s,u,v,x,y,x 0,2,3,5 to 9
6	a,4 0,2,3,5 to 9

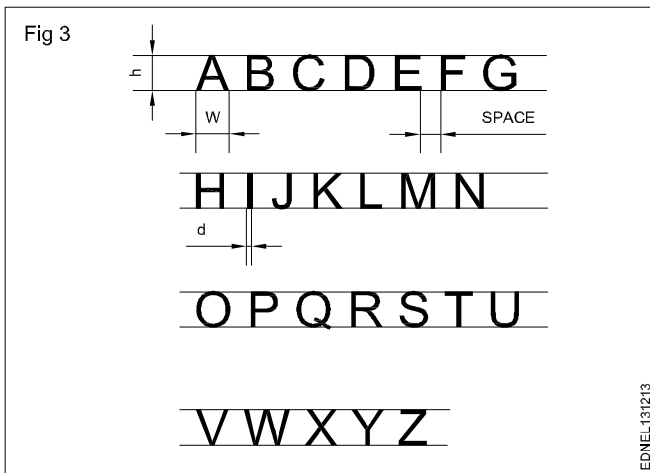
**Spacing of letters:** Recommended spacing between characters, a minimum spacing of baselines and minimum spacing between words as per BIS SP: 46-2003 are given below in Fig 2.



**Lettering**

**Procedure**

- 1 Print 10 mm single stroke capital letters and numerals in vertical style using either scale or set-square and by freehand. (Fig 1)



- Draw horizontal parallel lines (thin lines) of 10 mm distance.

**10 mm distances denote the height of the letter.**

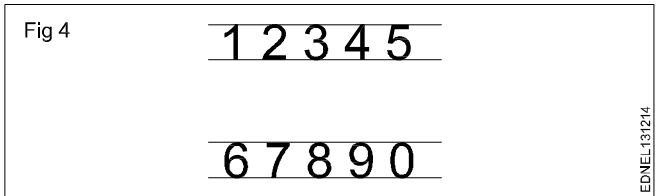
- Mark the width of the letters recommended by BIS (IS:9609-1983)

**The width of different letters in terms of 'd' is as follows: 'd' indicates stroke thickness i.e d: h/ 10.**

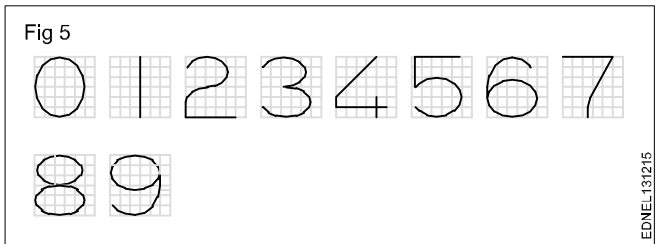
Width (W)	Capital letters
1	I
4	J
5	C, E, F, L
6	B, D, G, H, K, N, O, P, R, S, T, U & Z
7	A, M, Q, V, X, Y
9	W

**For curved letters use a smooth freehand curve.**  
**Print straight line letters using either scale or set-squares.**  
**To maintain the uniform thickness of the line, use a conical point soft grade pencil and avoid too much sharpness.**  
**Guidelines of both top and bottom should always be drawn with a sharp pencil.**

Numerals 2.1 (Fig 2)



- Follow the same procedure of letters.
- 'h' is height of numerals and 'd' is the stroke thickness.
- Width of numerals in terms of 'd' is as follows shown in square grid (Fig 3).



- 2 Print 10 mm single stroke capital letters and numerals in inclined style (Fig 4).



Practice the following lettering exercises in A3/A4 paper as per the given ratio

1 Single stroke inclined letters of ratio 7:6, 7:5, 7:4, 7:3, 7:1 (Fig 5)

Fig 7



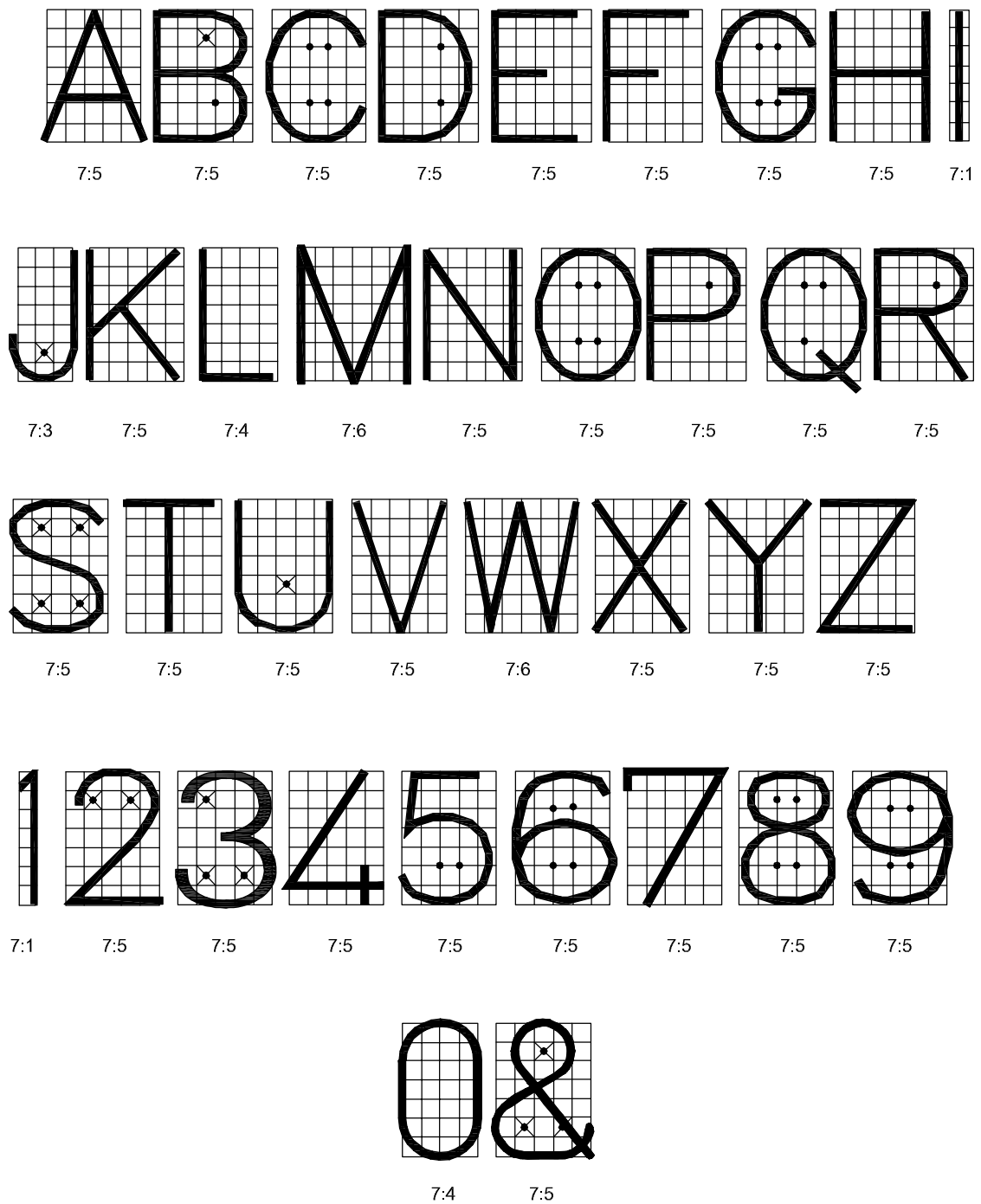
SINGLE STROKE INCLINED LETTERS

EDNEL131217



2 Single stroke vertical letters of ratio 7:6, 7:5, 7.4, 7:3, 7:1 (Fig 6)

Fig 8

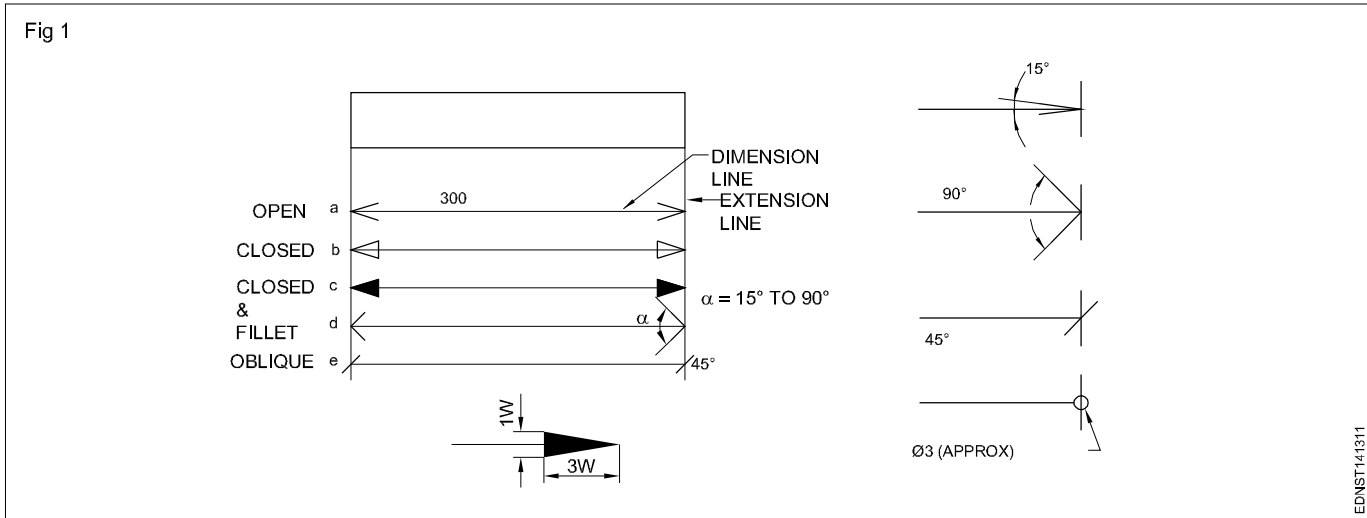


SINGLE STROKE VERTICAL LETTERS

EDNEL131218

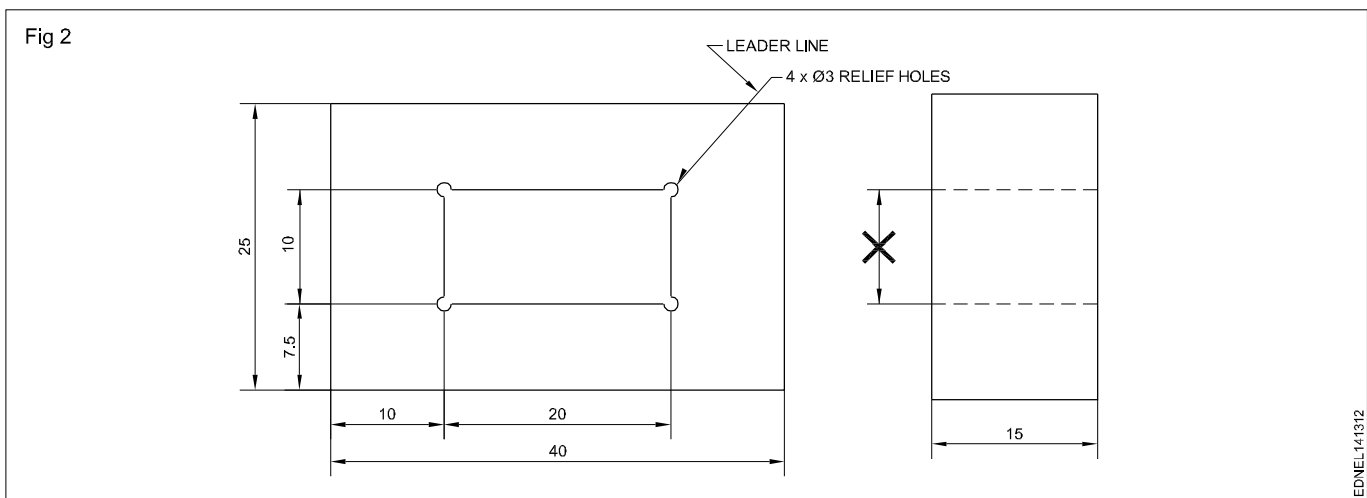
Dimensioning Practice - Types of arrowhead

**Dimension line:** These are thin continuous lines, terminated at ends by arrowheads, dots or oblique lines touching the extension line. (Fig 1)



A dimension line may cut or cross another dimension line where there is no other way.

Dimension to the hidden lines be avoided. (Fig 2)



Arrowheads may be placed outside where space is insufficient.

**Leader line:** It is a thin continuous line. It connects a note or dimension with the features to which it applies. (Fig 2)

**Termination and Origin indication:** The size of the terminations (arrowheads/oblique strokes) shall be proportional to the size of the drawing. Only one style of arrowhead shall be used on a single drawing. However, where the space is too small for the arrowheads, it may be substituted by a dot or by an oblique line. Arrowheads are drawn as short lines forming barbs at any convenient

included angle between 15° and 90°. They may be open, closed or closed and filled in. Oblique strokes are drawn as short lines inclined at 45°. (Fig 1)

**Indicating dimensional values on drawings:** All dimensional values shall be shown on drawings in characters of sufficient size to ensure complete legibility on the original drawings as well as on reproductions made from micro-filming.

They shall be placed in such a way that they are not crossed or separated by any other line on the drawing.

## Dimensioning - Position of dimensioning (aligned, unidirectional)

### Definitions related to dimensioning

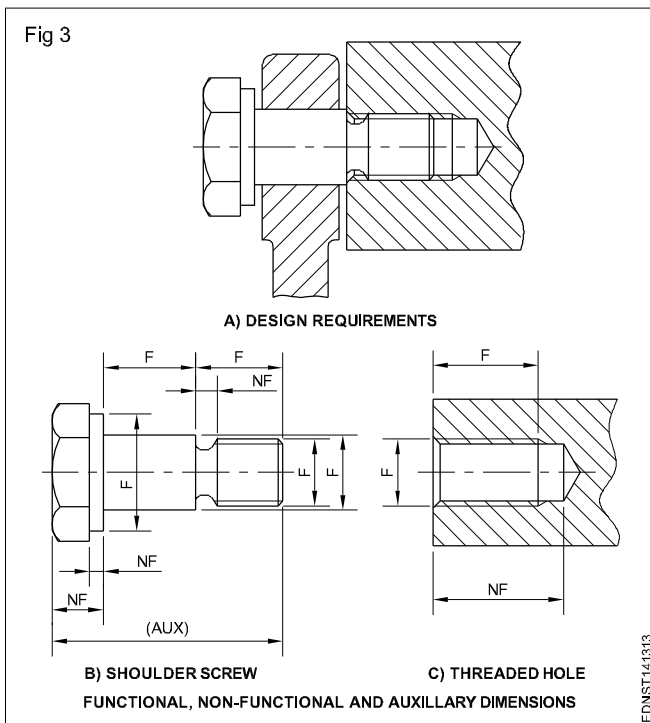
**Dimension:** It is a numerical value expressed as an appropriate unit of measurement and indicated graphically on technical drawings with lines, symbols and notes.

**Dimensions are classified according to the following types:**

**Functional dimension (F):** It is a dimension that is essential to the function of the component or space. They are generally shown with limits. (Fig 3)

**Non-functional dimension (NF):** It is a dimension that is not essential for the function of the component or space.

**Auxiliary or Reference dimension (AUX/REF):** It is the dimension given for information only. It is derived from the values given on the drawing or related documents and it does not give in the production or inspection. (Fig 3)

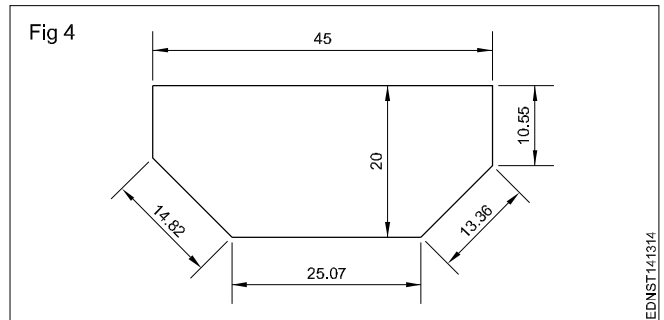


## Methods of indicating values

**Methods of indicating values:** There are two methods used for indicating the values. Only one method should be used on anyone drawing.

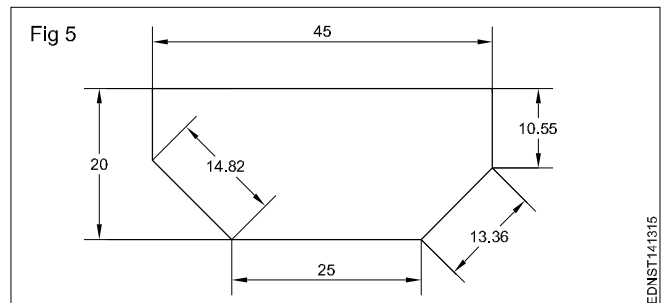
### Method 1 Aligned system

Dimensional values shall be placed parallel to their dimension lines and preferably near the middle, above and clear of the dimension line. However, values shall be indicated so that they can be read from the bottom of the the right-hand side of the drawing. Dimension lines are not broken. Dimensioning of angles is also given in the same way. (Fig 4) This method is known as an **aligned system** of dimensioning.



### Method 2 Unidirectional system

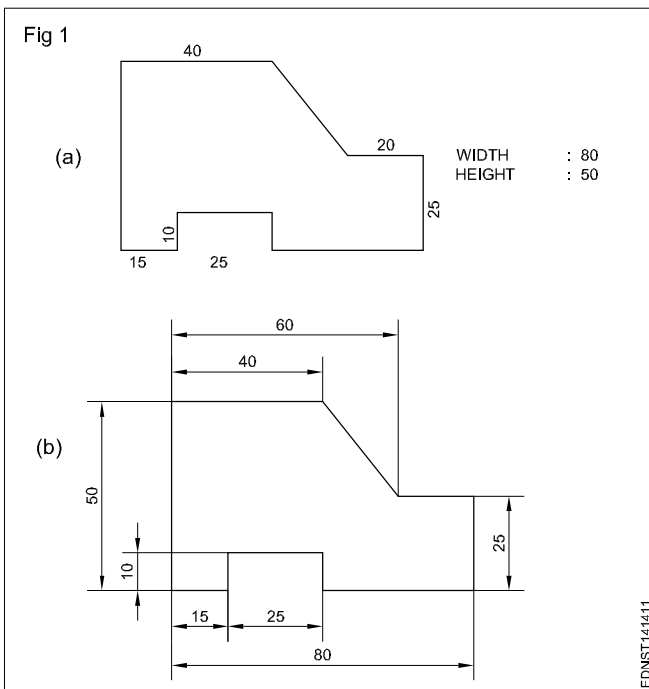
Dimensional values shall be indicated so that they can be read from the bottom of the drawing sheet. Non-horizontal dimension lines are interrupted, preferably near the middle so that the value can be inserted. (Fig 5). This method is termed a **unidirectional system** of dimensioning.



**Practice of dimensioning**

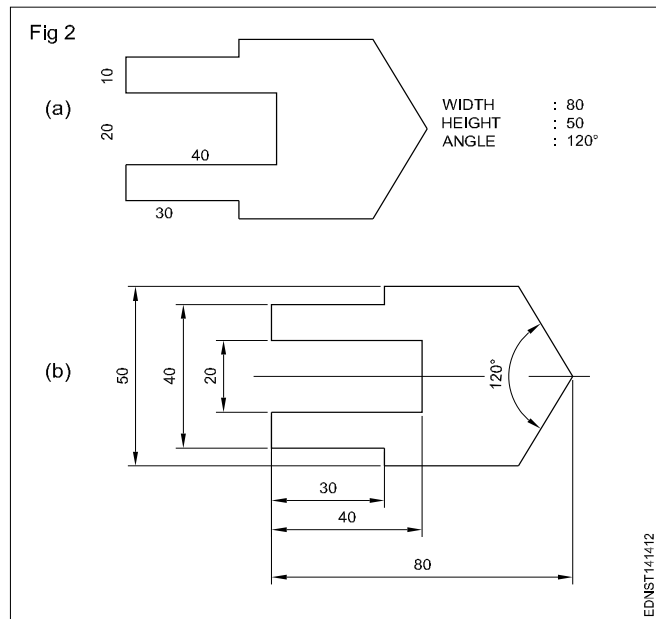
1 To the given drawing of the profile sheet metal as shown in Fig 1, place the dimensions in the aligned system. (Fig 1a)

- Draw the drawing of the sheet metal to 1:1 scale.
- Draw the extension lines in continuation of outlines.
- Draw the dimension lines. (Fig 1b)
- Place the dimension value near the middle and above the dimension line to be read from "bottom and right hand side" of the drawing.



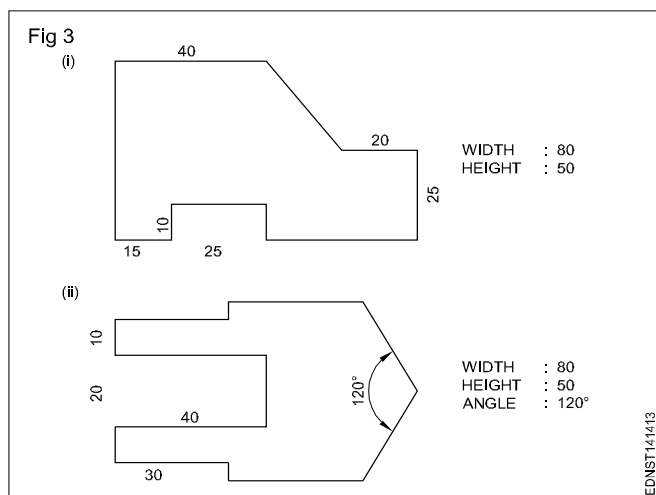
2 To the given drawing of the profile sheet metal as shown in Fig 2a, give the dimensions in the unidirectional system. (Fig 2b)

- Place the horizontal dimensions above and middle of the dimension line without break.
- Break the dimension in the middle of all non-horizontal dimension lines.



3 Draw the two sheet metal templates to full scale with appropriate lines use 0.5 range line thickness. (Fig 3)

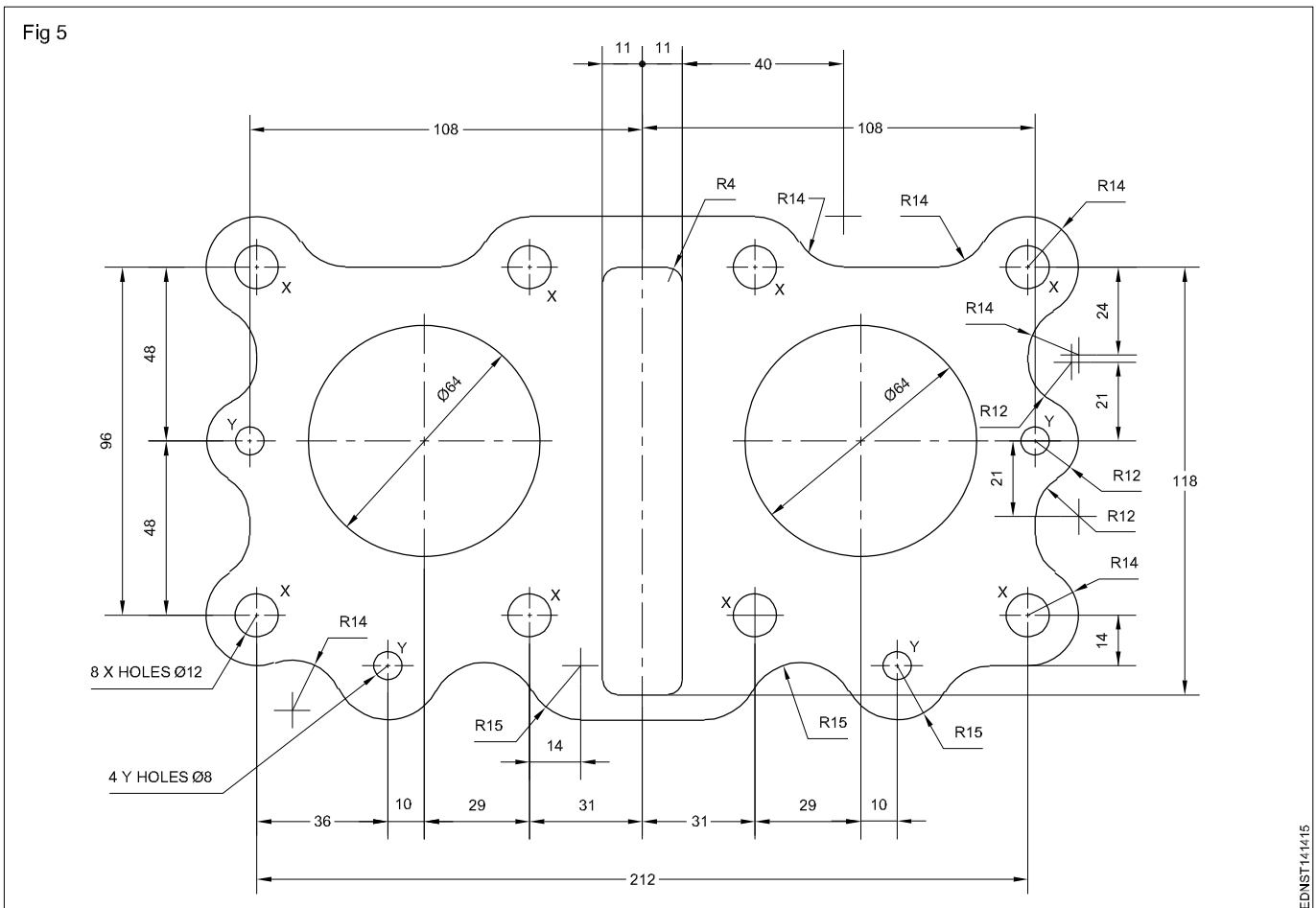
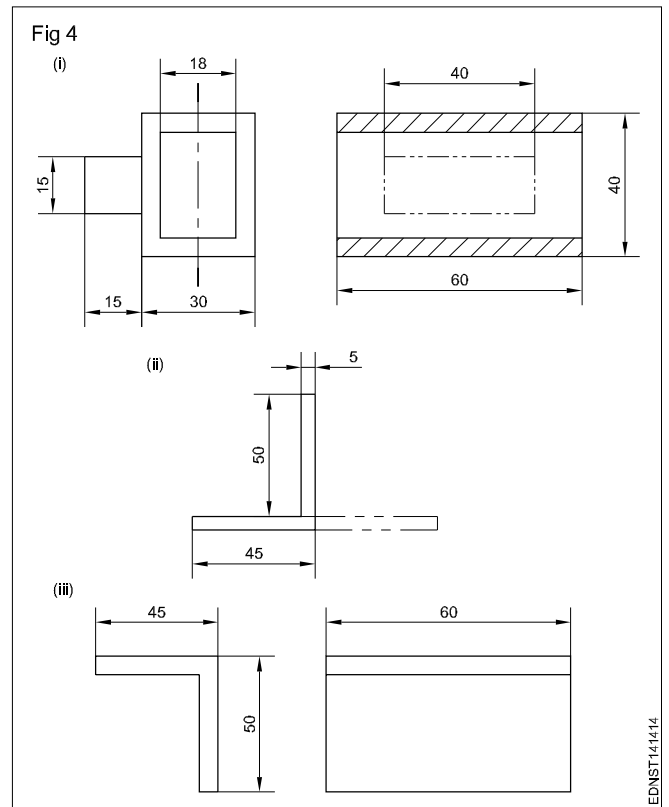
- Draw a rectangular block of length 80 mm and width 50 mm in thin lines.
- Incorporate the features of the template as per the given dimension.
- Draw by thick lines all visible outlines.
- Give dimensions and maintain the line thickness as per the line range (0.5).
- Complete the figure and remove the unwanted lines.



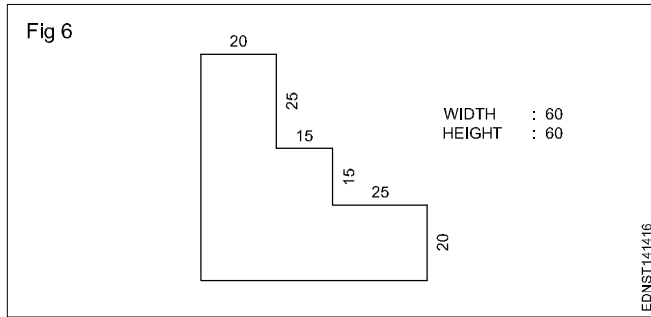
- 4 Draw the figures given. Maintain the types of lines as per the B.I.S and choose correct line thickness. (Fig 4)
- According to the given dimensions, draw the figures given in Fig 4.
  - Select the appropriate lines and maintain uniformity.
  - Remove (erase) unwanted lines, arcs and complete the drawing.

**Note: Draw the dimension line terminations as per IS:11669-1986.**

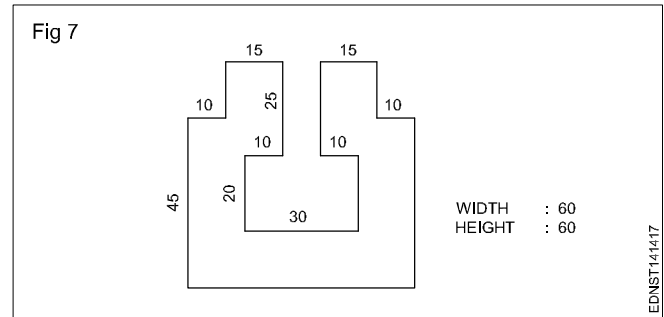
- 5 The motor cycle engine gasket is shown in figure 5. There are some mistakes in dimensioning. Reproduce the same in the A3/A4 sheet provided and correct the mistakes according to the aligned system of dimensioning. (Fig 5)



6 Draw the given cover plate and give the dimensions in the aligned system. (Fig 6)



7 Draw the cover plate given in the figure and place the dimensions in the unidirectional system. (Fig 7)



**Symbolic representation - Different electrical symbols used in the related trade**

**Sign and symbols for Electrical group trades**

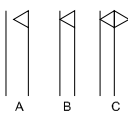
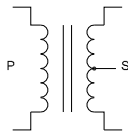
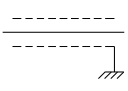
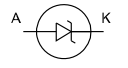
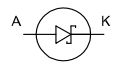
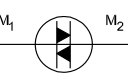
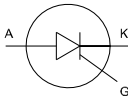
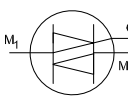
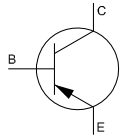
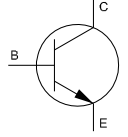
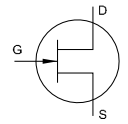
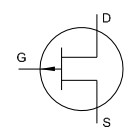
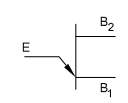
S.No.	Description	Symbol
1	D.C.	
2	A.C.	
3	Positive	
4	Negative	
5	Single Phase A.C. 50 Hz	
6	Three Phase A.C., 50 Hz	
7	A.C. / D.C.	
8	3-Phase line	
9	Neutral line	
10	Earth	
11	Cell	

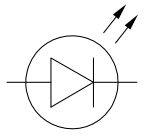
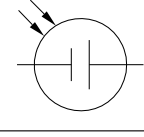
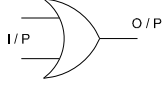
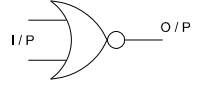
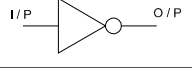
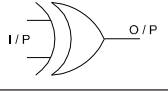

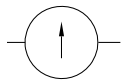

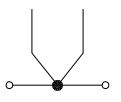
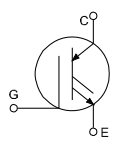
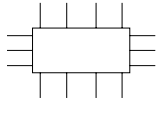
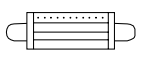

S.No.	Description	Symbol
12	Battery	
13	Single pole single throw switch	
14	Push-button switch	
15	Energy meter	
16	Alternator	
17	Generator	
18	D.C. Motor	
19	A.C. Motor Single phase	
20	3-phase squirrel cage motor	
21	3-phase slip ring motor	



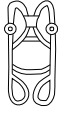






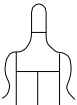


S.No.	Description	Symbol
22	Capacitor: Fixed, variable	
23	Electrolytic Capacitor	
24	Two-way switch	
25	Fuse: ordinary cartridge	
26	Socket 2 pin, 3 pin	
27	Aerial / Antenna	
28	Voltmeter	
29	Ammeter	
30	Ohm Meter	
31	Watt Meter	
32	Lamp	
33	Electric bell	
34	Buzzer	
35	Connections: star, Delta	
36	Choke	



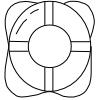








S.No.	Description	Symbol
37	Transformers	
38	Resistor : Fixed	
39	Resistor: variable	
40	Diode	
41	Auto transformer	
42	SCR	
43	UJT	
44	SPS T switch	
45	DPS T switch	
46	SPD T switch	
47	DPD T switch	
48	Single Pole 5 way rotary switch	
49	SPDT slide switch	





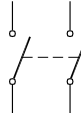

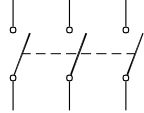



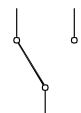

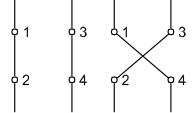
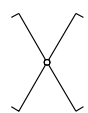


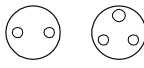
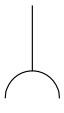

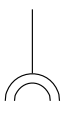


S.No.	Description	Symbol
50	Relay contacts	
51	Transformer tapped secondary	
52	Shielded wire	
53	Zener diode	
54	Schottky diode	
55	Diac	
56	SCR	
57	TRIAC	
58	PNP transistor	
59	NPN transistor	
60	FET N-channel	
61	FET P-channel	
62	Unijunction transistor	











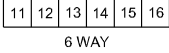



S.No.	Description	Symbol
63	LED diode	
64	Photo voltaic cell	
65	OR Gate	
66	NOR Gate	
67	NOT Gate	
68	EX-OR Gate	
69	Piezo-electric buzzer	
70	Galvanometer	
71	Analog multimeter	
72	Thermo couple meter	
73	IGBT	
74	IC	
75	Protectional mask	
76	Disposal respirator	

S.No.	Description	Symbol
77	Escape hood	
78	Bump cap	
79	Fall protection	
80	First-aid kit	
81	Respirator	
82	Traffic safety	
83	Reflective vest	
84	Nuisance mask	
85	Surubs	
86	Apron	
87	Electrical gloves	
88	Face shield	

S.No.	Description	Symbol
89	Fire extinguisher	
90	hand protection	
91	Survival ring buoy	
92	Safety vest	
93	Ear plugs	
94	Rubber boots	
95	Protective headphones	
96	Fire boots	
97	Gas mask	
98	Radiation detector	
99	Eye protection	

**SOME SYMBOLS FROM B.I.S. FOR WIRING SCHEMES**

Sl.No.	Description	Symbols used in the circuit diagram	Symbols used in layout
1	One-way switch, single pole		
2	One-way switch, two poles		
3	One-way switch, three poles		
4	Multi-position switch single pole		
5	Two-way switch		
6	Intermediate switch		
7	Push-button or bell-push		
8	Socket outlets, 6A		
9	Socket outlets, 16A		
10	Lamp or outlet for lamp		

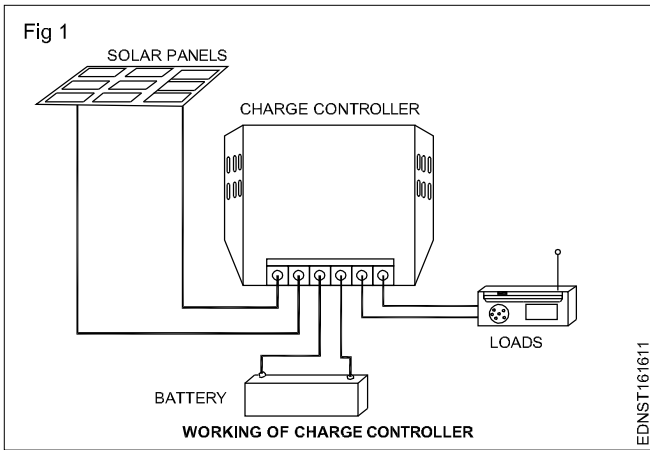
Sl.No.	Description	Symbols used in the circuit diagram	Symbols used in layout
11	Fuse		 MAIN & D.B FUSE BOARDS
12	Bell		
13	Buzzer		
14	Earth point		
15	Circuit breaker		
16	Terminal strip		N.A
17	Link (closed)		N.A
18	Plug and socket (male and female)		N.A
19	Ceiling rose		N.A

N.A: Not applicable

**Reading of electrical circuit diagram**

**Circuit Diagram**

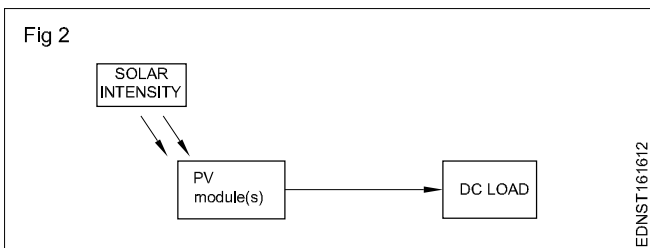
**Working of charge controller (Fig 1)**



**This unit performs 4 major functions**

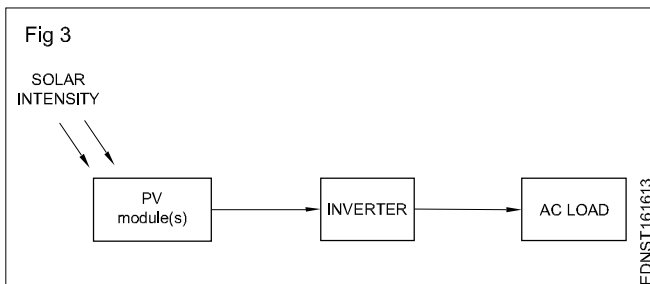
- 1 Charges the battery.
- 2 Gives an indication when battery is fully charged.
- 3 In case of overload, the load switch is in OFF condition ensuring the load is cut off from the battery supply.

**Off - Grid System (Fig 2)**



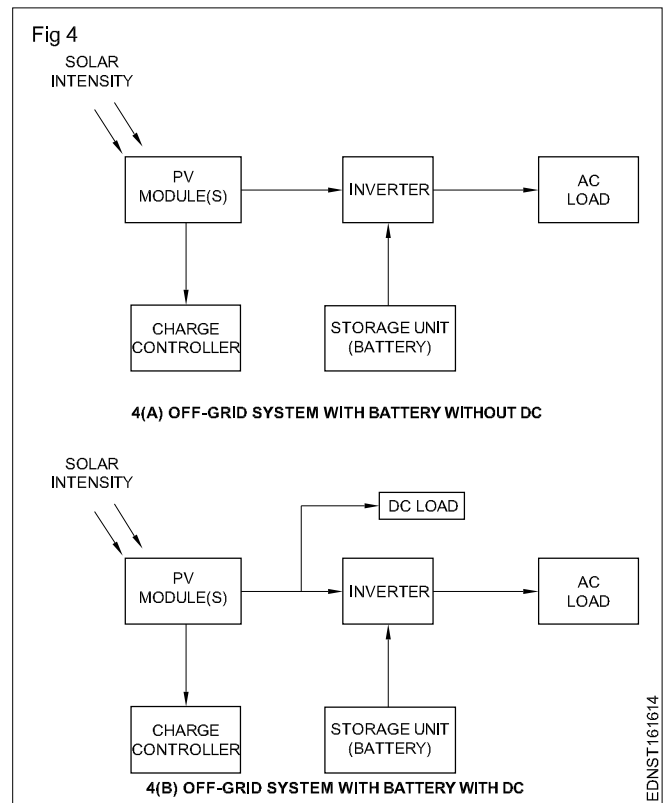
**Direct-coupled system (Fig 3)**

Another type of off-grid system is the type that incorporate inverter unit for conversion of DC voltage to AC at appropriate voltage level. (Fig 3)

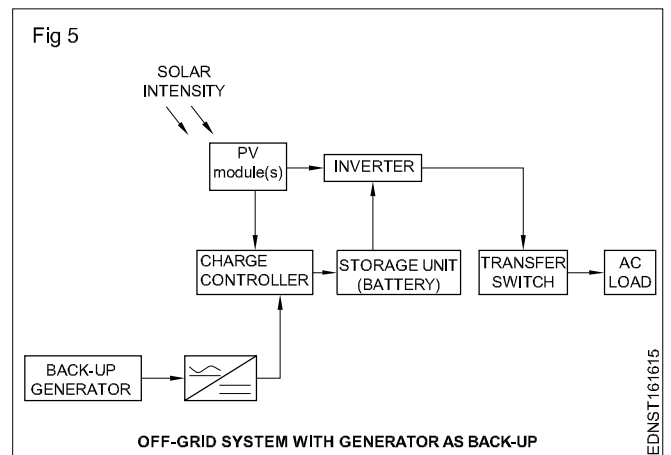


**System with inverter (Fig 4)**

The problem of no electricity generation in the night is eliminated with the inclusion of storage unit (batteries) as backup energy in the night. The block diagrams of this type is shown in Fig 4.

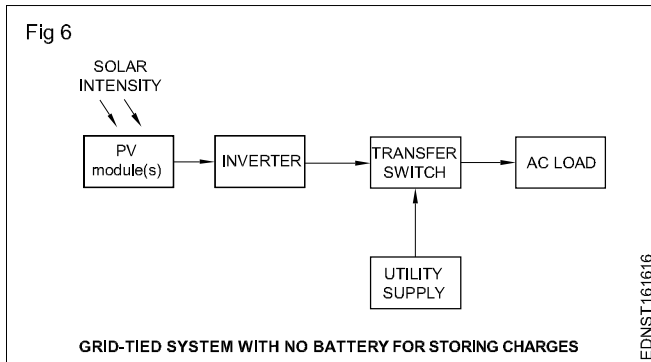


**Off-Grid system with generator as back - up (Fig 5)**

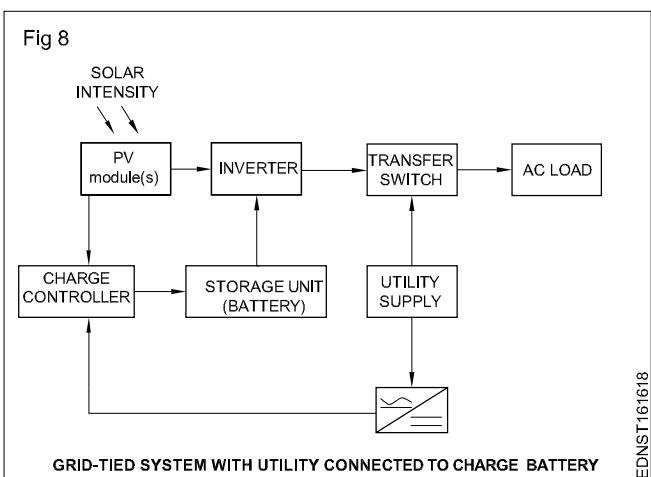
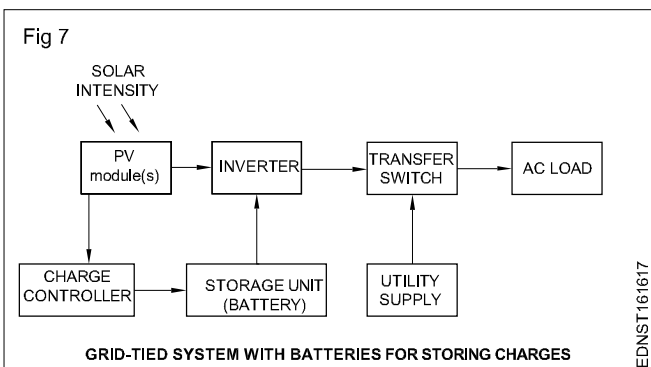


## Grid-tied systems

Grid-tied system also called on-grid or utility interactive. Grid-tied systems are designed to operate in parallel with and interconnected with the electric utility grid. Below are the block diagrams of grid-tied systems. (Fig 6)

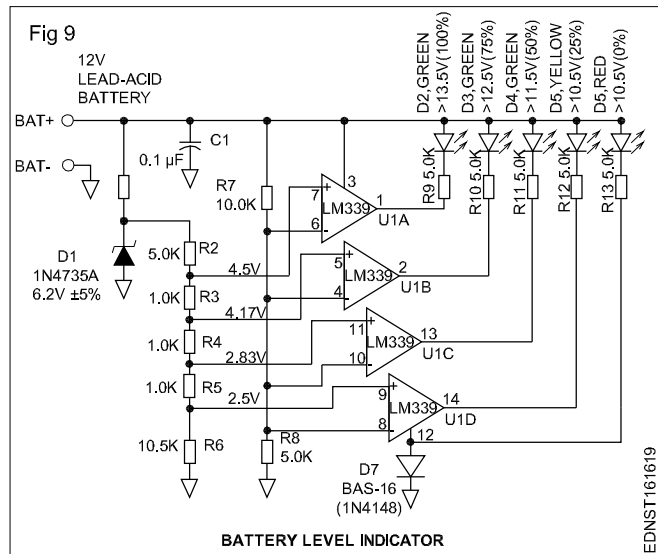


Grid-tied system can also be connected in a way that utility supply will be charging battery in the period of low light intensity. It has the same features as off-grid system with engine generator back-up. In the case of long cloudy days and utility outage, there is likely to be blackout. (Fig 7&8)



## Battery level indicator (Fig 9)

This battery level indicator offers five LEDs that light up progressively as the voltage increases: These five LEDs show the approximate charge of the battery in percentage; each LED represents approximately a 25% charge on the battery.



## Read and write the following. (Fig 1 to 9)

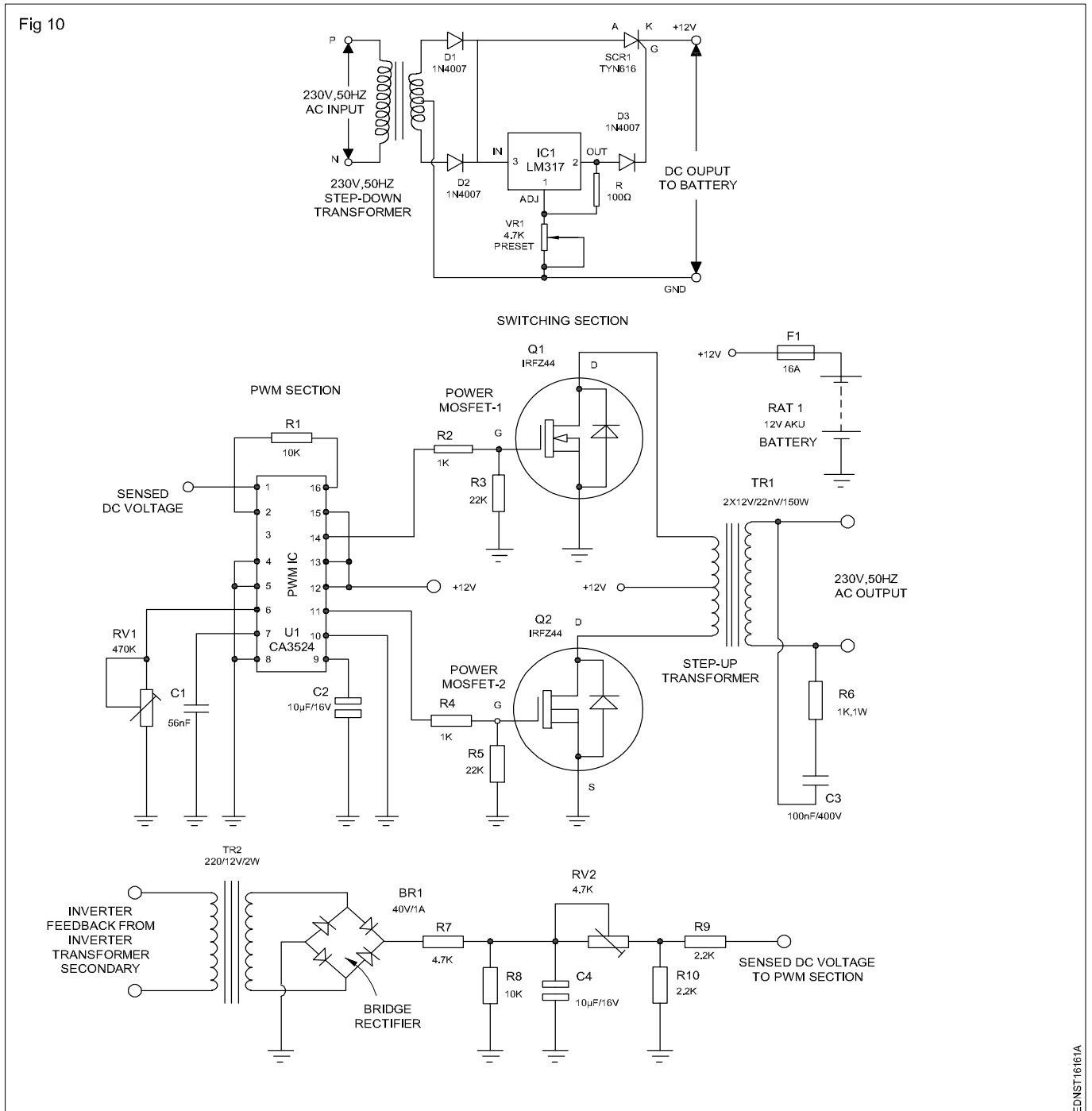
- 1 What is the use of Solar panel?
- 2 State charge controller?
- 3 Why batteries is essential for solar system?
- 4 What is the functions of transfer switch?
- 5 What is the utility supply?
- 6 What is the use of inverter?
- 7 What is Grid system?
- 8 What happen incase of long cloudy days in PV system?
- 9 What is embedded micro controller?
- 10 Why PWM technique is used?
- 11 Why battery level indicator is used in PV system?
- 12 What is stand alone system?
- 13 What is direct coupled system?
- 14 What are the four major functions of microcontroller?
- 15 What is the use of Diode IN 4735A?

### Microcontroller based inverter

The major sections of a modern inverter producing pure sine wave, designed using the simple electronic devices to the complex embeded microcontrollers is shown in

Fig 10. It uses pulse width modulation techique, different sensors, actuators, LCD display for status, audible alarm, feather touch switches, etc. for the reliable and user-friendly failsafe operation.

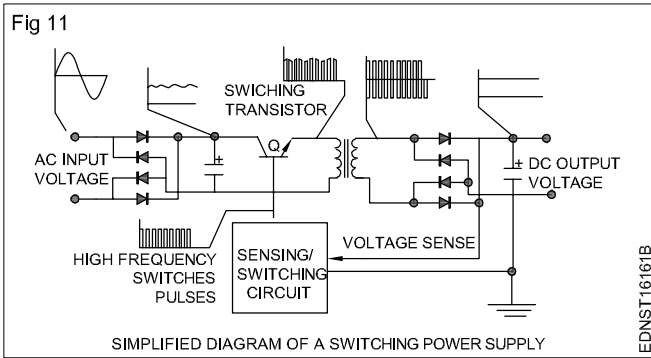
### Microcontroller based inverter (Fig 10)



### Read and write the following. (Fig 10)

- 1 What is the use of LM 317?
- 2 Explain the function of PWM section?
- 3 What is the function of power MOSFET?
- 4 Explain the switching section?
- 5 What is a function of SCR?
- 6 Why step up transformer is used?
- 7 What is sensed DC voltage?
- 8 What is the use of bridge rectifier?
- 9 Explain the inverter feedback system?
- 10 Why two MOSFETs are used in this diagram?

### Function of SMPS in PC (Fig 11)



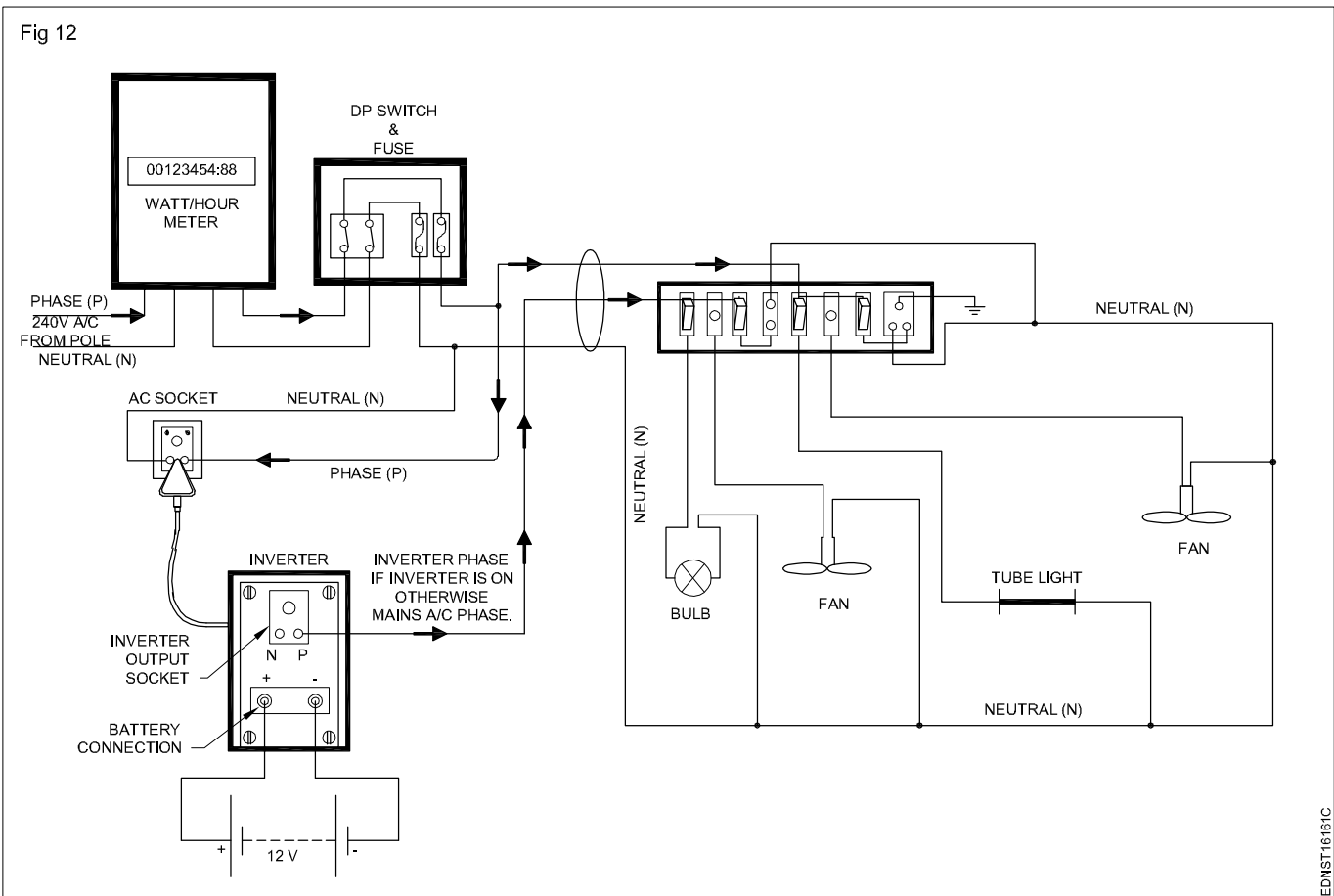
A simplified diagram of switching mode power supply is shown in Fig 11.

AC line input is rectified and converted to DC voltage. The DC voltage is switched at high frequency nearly 20 KHz. The switched voltage is fed to the high frequency step down transformer.

### Read and write the following. (Fig 11)

- 1 What is the use of sensing circuit?
- 2 How to produce high frequency switching pulses?
- 3 What is pulse width?
- 4 Why diodes are used?
- 5 Explain the switching transistor?
- 6 Compare input and output waveform?

### Inverter installation (Fig 12)

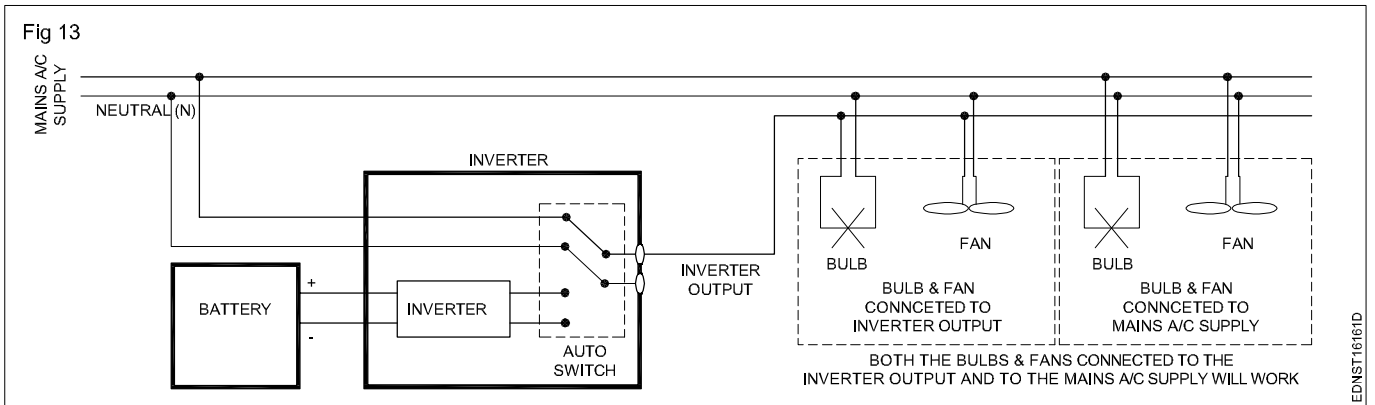


### Read and write the following. (Fig 12)

- 1 How to install inverter?
- 2 What is DP switch?
- 3 How to protect the inverter from overload?
- 4 How to make panel board?
- 5 What is the purpose of inverter?
- 6 What is the use of MCB?
- 7 What is the use of watt hour meter?



A.C supply returns, the inverter will once again connect the load, which are connected to its output to the main supply (Fig 13)



Read and write the following. (Fig 13)

- 1 Draw the installation diagram of inverter?
- 2 How to find inverter output is AC or DC?
- 3 How to make layout diagram of inverter circuit?
- 4 What are the safety required to connect battery?
- 5 How to connect battery in the inverter circuit?
- 6 What is inverter?

Racking and mounting components of solar (Fig 14 & 15)



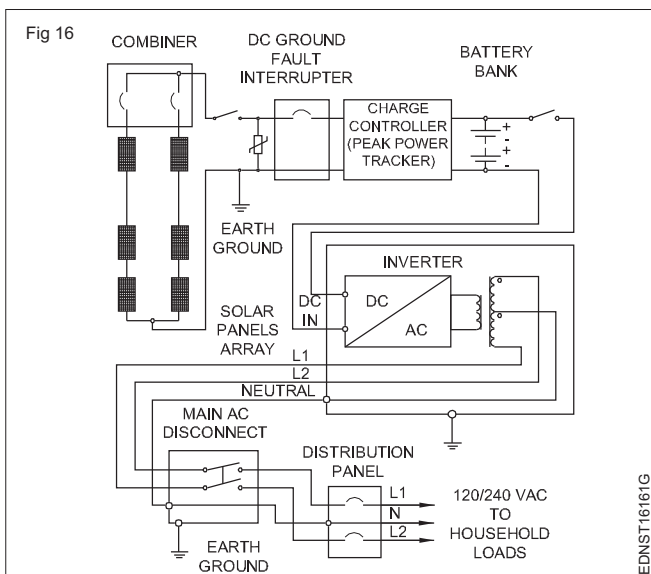
Fig 15



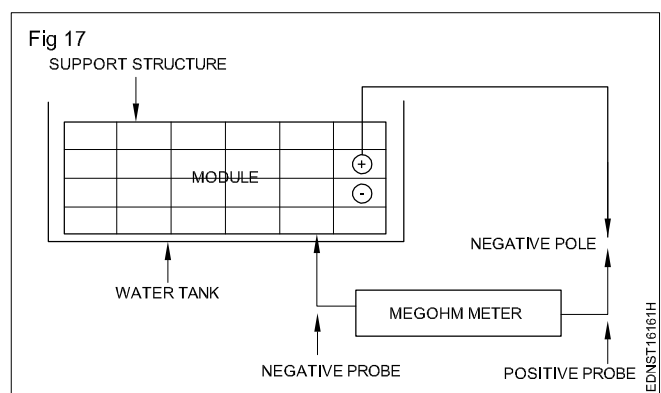
Read and write the following. (Fig 14&15)

- 1 What is the use of hooks?
- 2 Why washers are used?
- 3 What is Brace assembly?
- 4 What is the use of attachments?
- 5 Why rails are used?
- 6 What is the use of skirt?

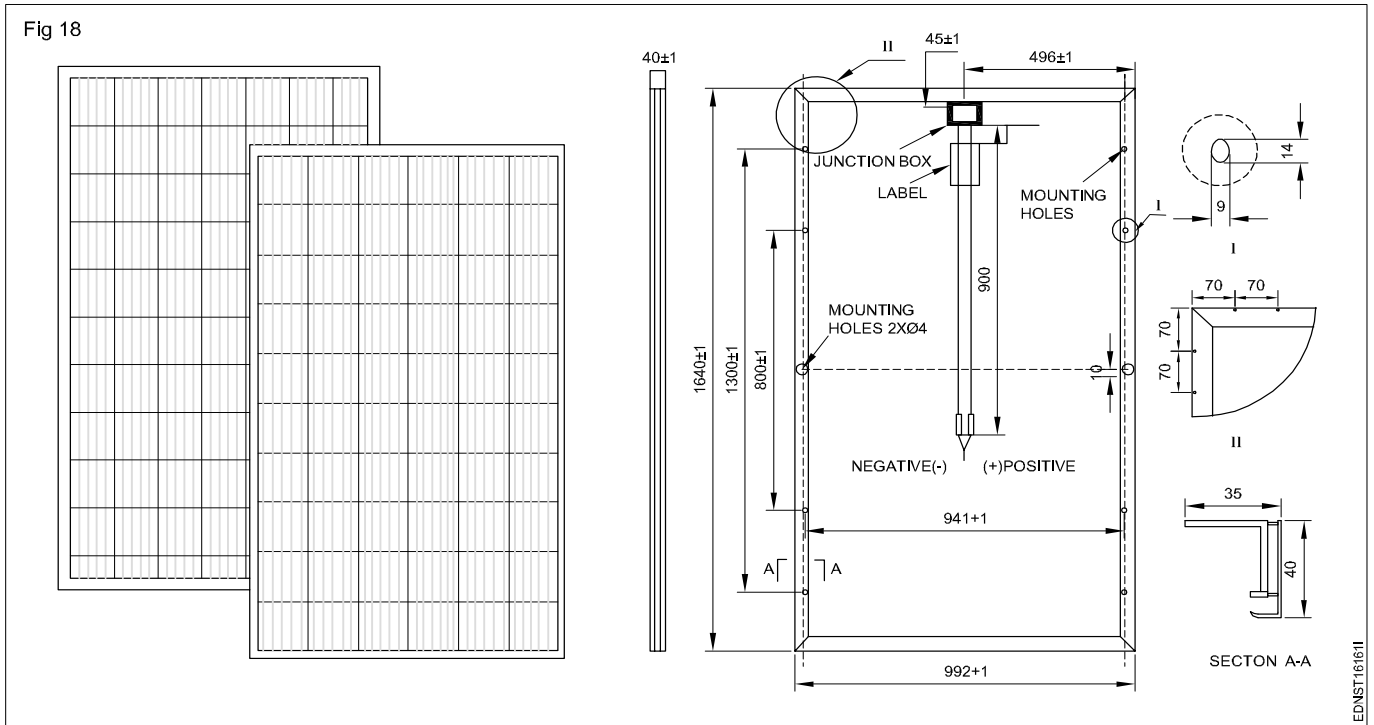
Wiring diagram of an Off grid solar PV electrical system (Fig 16)



Measuring of insulation resistance to analyze wet leakage current on PV module. (Fig 17)



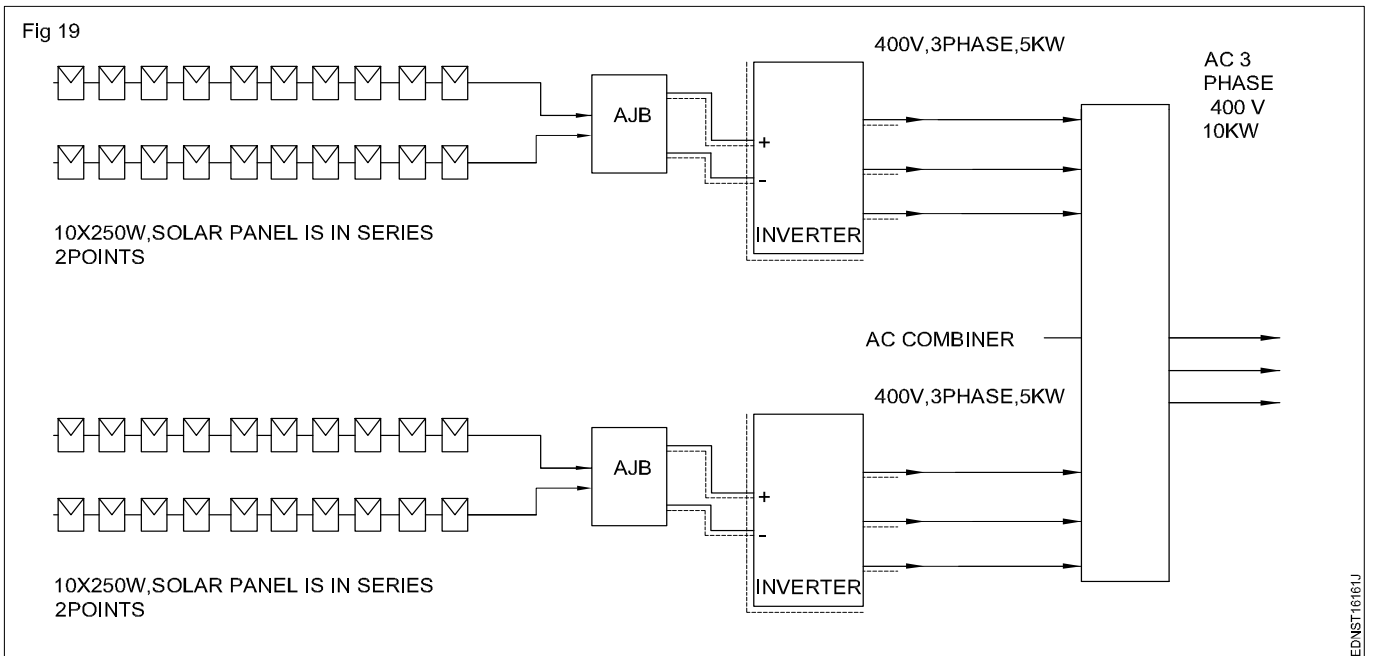
**Dimensions of a solar panel 250 W (Fig 18)**



**Read and write the following. (Fig 16,17&18)**

- 1 What is combiner?
- 2 What is the use of solar panels?
- 3 What is the function of distribution panel?
- 4 What is peak power tracker?
- 5 How to draw the dimension of solar power?
- 6 How to analyse wet leakage current?

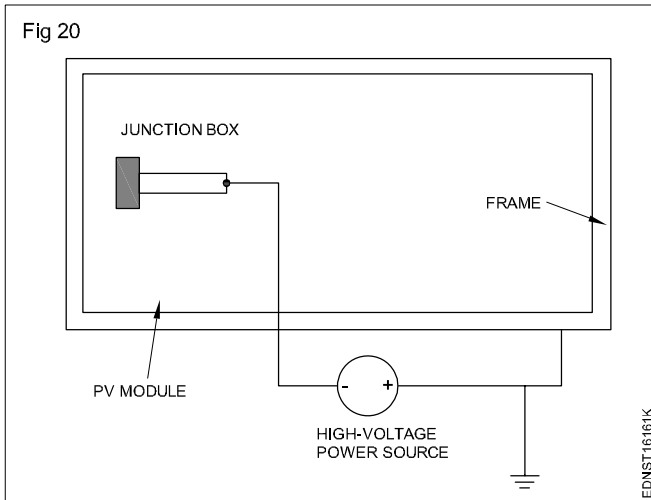
**Sample Single Line Diagram (SLD) for 10 kW SPV plant (Fig 19)**



Read and write the following. (Fig 19)

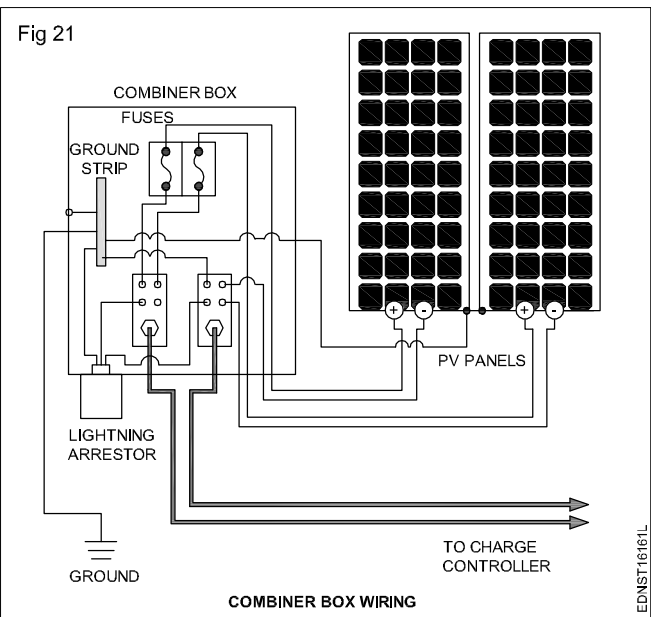
- 1 How to connect solar panel in series?
- 2 How to connect solar panel in parallel?
- 3 What is AC combiner?

**Schematic diagram for PD test (Fig 20)**

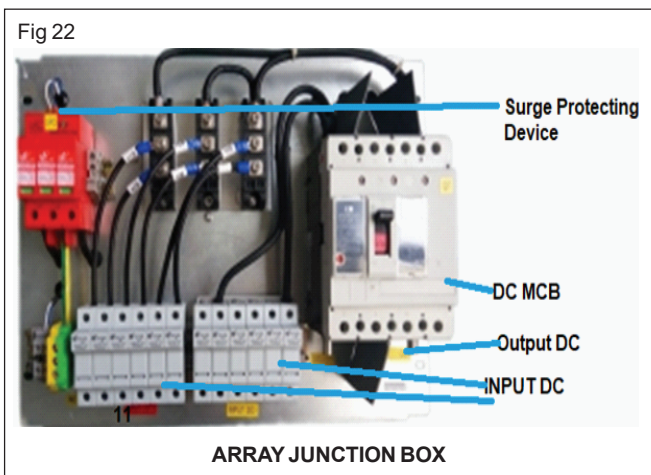


**Wire the Array Junction Box for series wiring**

**AJB wiring - Combiner box (Fig 21)**



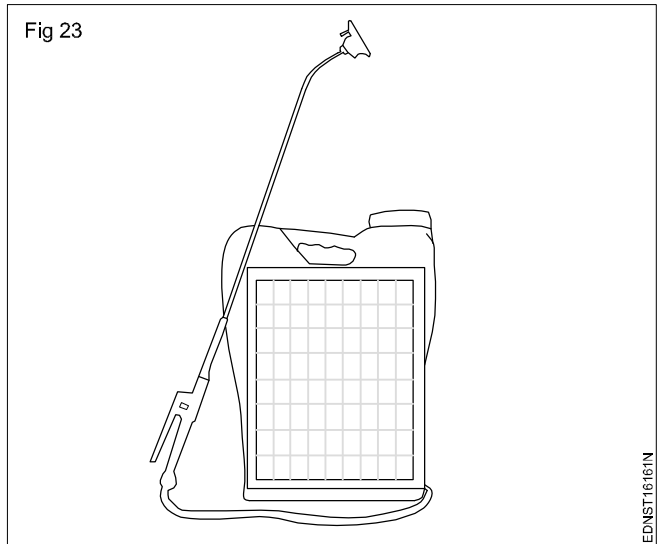
**Parts of AJB (Fig 22)**



**Read and write the following. (Fig 20,21&22)**

- 1 What is combiner box?
- 2 What is the use of junction box?
- 3 Why lightning arrester is used in combiner box assembling?
- 4 What is AJB?
- 5 What is the use of surge protecting device?

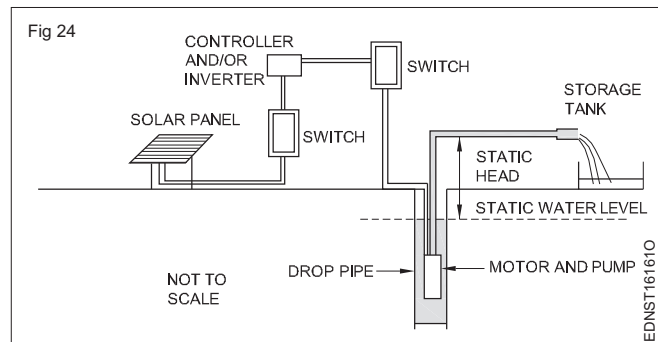
**Solar Fertilizer/Pesticide sprayer (Fig 23)**



**Read and write the following. (Fig 23)**

- 1 How to use solar fertilizer sprayer?
- 2 What are the safeties needed while using solar sprayer?
- 3 How to maintain the solar fertilizer sprayer?

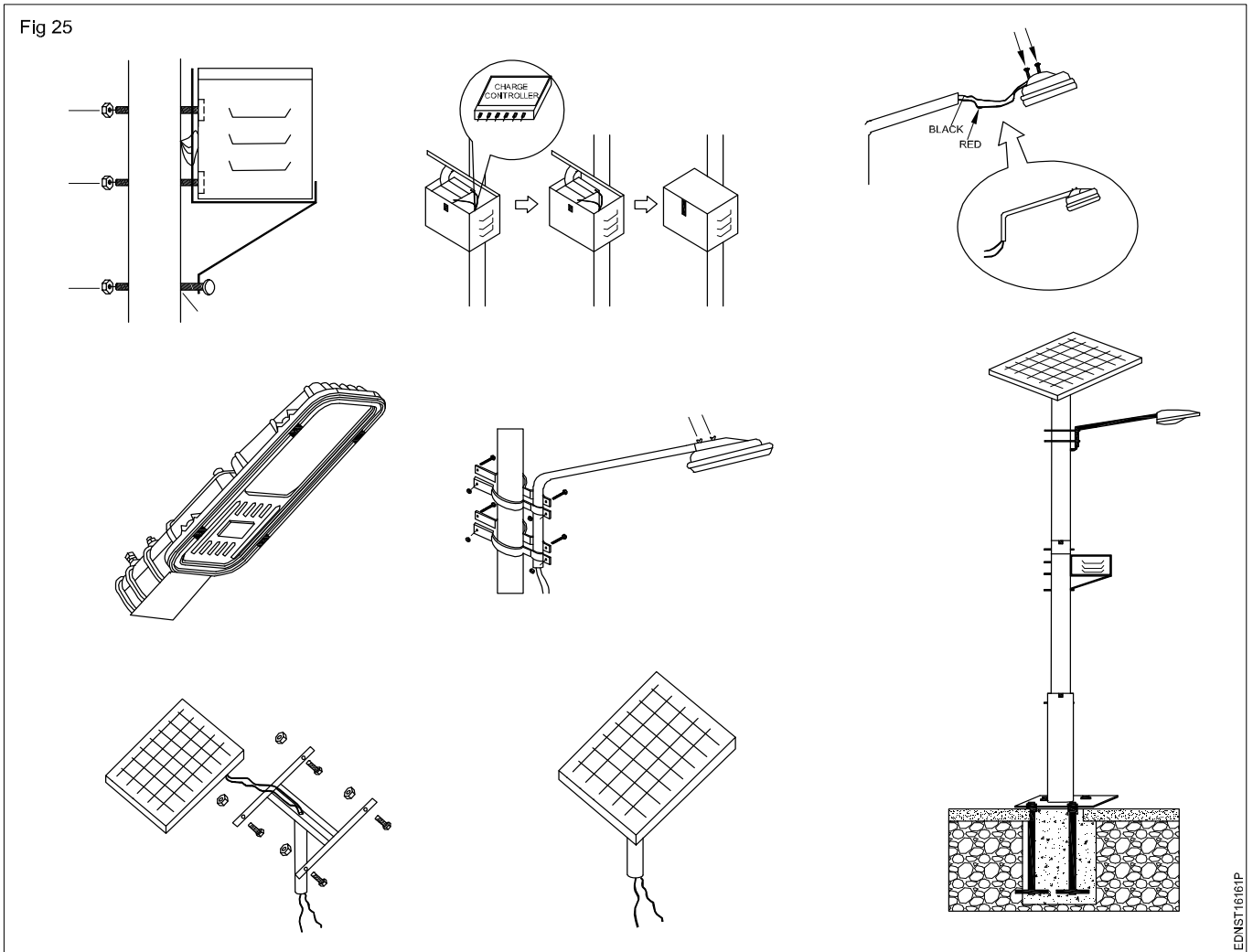
**Circuit diagram of solar pump system (Fig 24)**



**Read and write the following. (Fig 24)**

- 1 What is the static head?
- 2 What is the use of DROP pipe?
- 3 How solar panel works?
- 4 How to maintain static water level?
- 5 What is the use of solar pump system?
- 6 What are the safety precautions needed for the motor and pump?

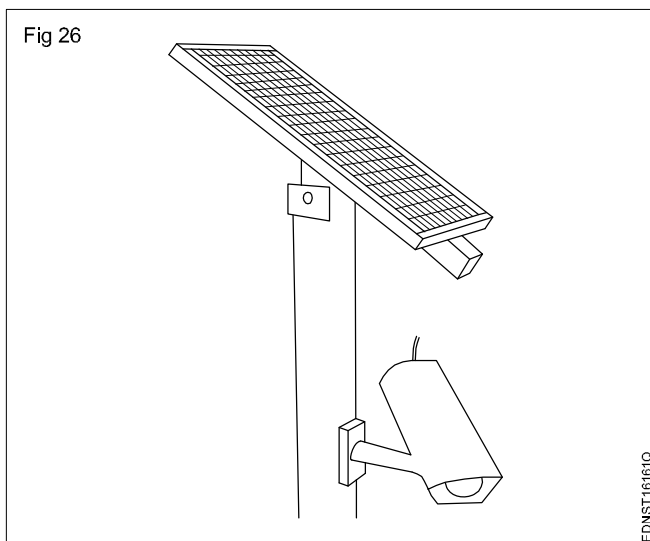
## Erecting integrated solar LED Street light. (Fig 25)



### Read and write the following. (Fig 25)

- 1 How to connect intergrated solar LED street light?
- 2 What are the safety precautions needed?
- 3 How to use manual charge controller?

### Solar Security System (Fig 26)



Solar Security system using a Manual charge controller rated (12V, 10 A), Solar battery (12V, 100 Ah), Solar panel (75 W) and Security camera & CCTV/Intruder alarm (12 V DC).

### Read and write the following. (Fig 26)

- 1 How to install security camera in streets?
- 2 What is the use of CCTV camera?
- 3 How to maintain the security camera system?
- 4 What are safety methods adopted while installing the CCTV camera?

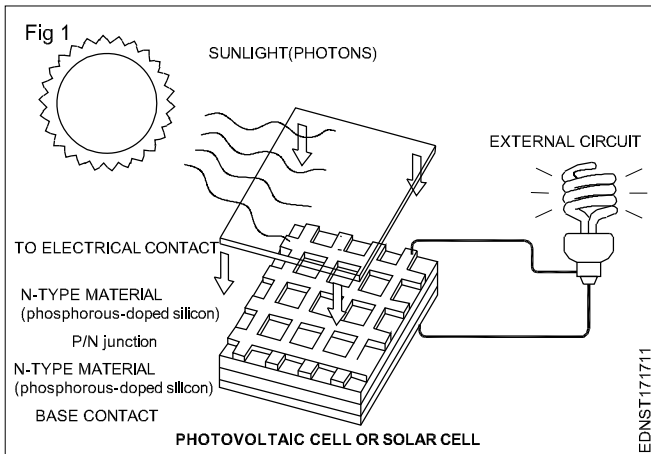
**Reading of electrical layout drawing**

**Layout diagram**

**Photovoltaic cells or solar cell (Fig 1)**

Photovoltaic (PV) cells, or solar cells, take advantage of the photoelectric effect to produce electricity. PV cells are the building blocks of all PV systems because they are the devices that convert sunlight to electricity.

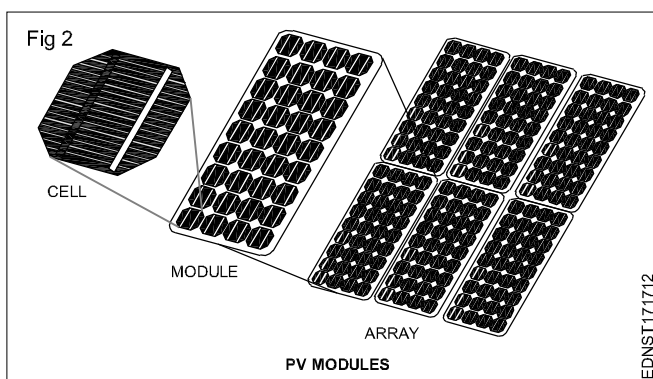
**Photovoltaic Module or solar panel**



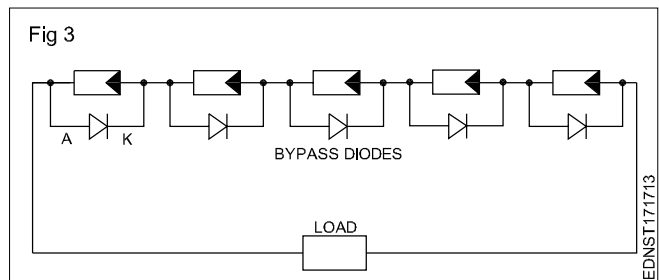
A solar module is an individual solar panel - consisting of multiple solar cells, wiring, a frame, and glass. PV or solar modules are manufactured in standard sizes such as 36-cell, 60-cell and 72-cell modules.

**Photovoltaic array**

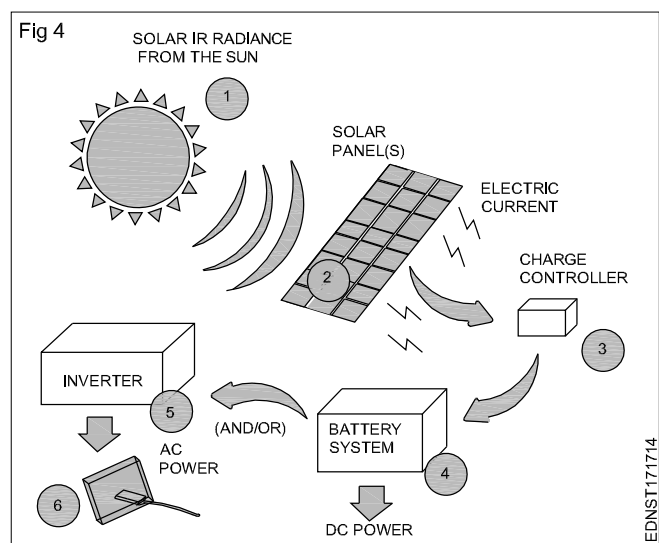
Photovoltaic array is the complete power-generating unit, consisting of any number of PV modules and panels, as shown in Fig 2.



**By pass Diode (Fig 3)**



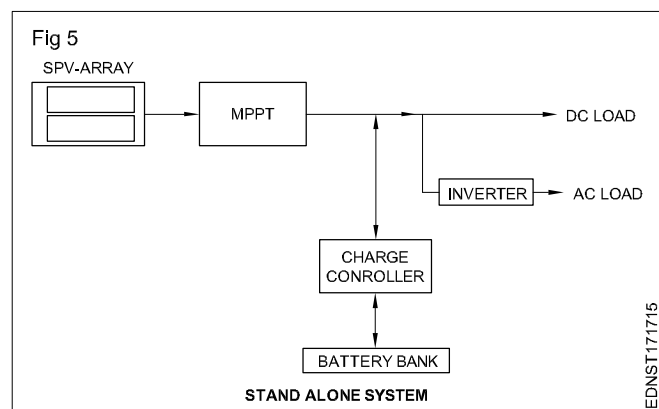
**Solar Electricity principles (Fig 4)**



**Block diagram of different SPV system**

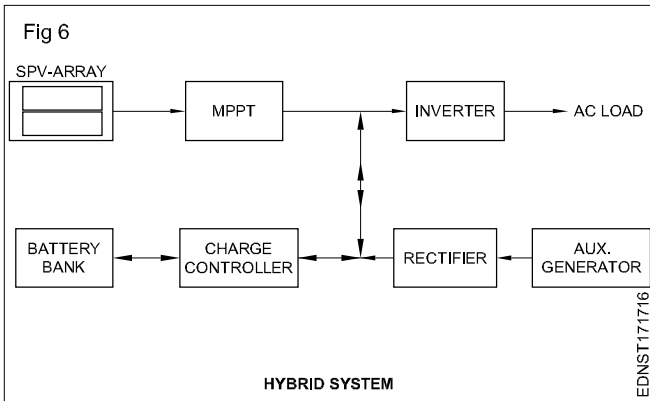
**Stand alone system (Fig 5)**

The entire power is generated by an SPV array and stored in a battery to be provided in response to demand. (Fig 5)



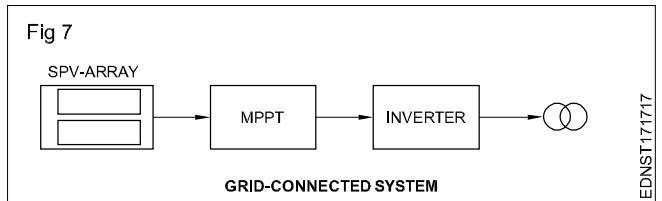
### Hybrid system (Fig 6)

In addition to an SPV array, other means such as AC mains, wind and diesel generators are also used to supply power. (Fig 6)

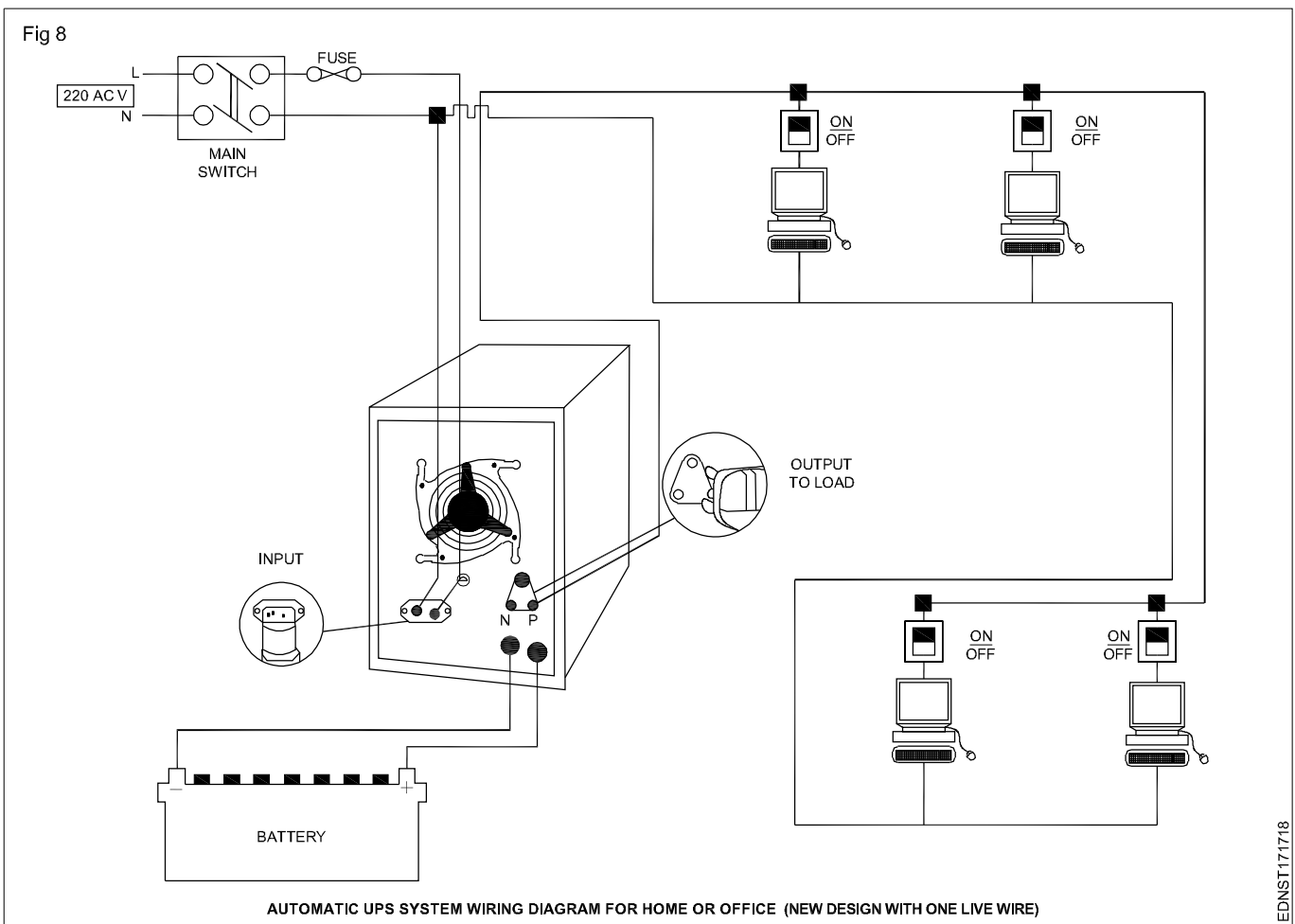


### Grid-Connected system (Fig 7)

In such system the output of SPV planes is connected to the grid and there is no storage battery; metering is used to keep account of imported and exported power by the user. (Fig 7)



### Single phase UPS system wiring diagram (Fig 8)

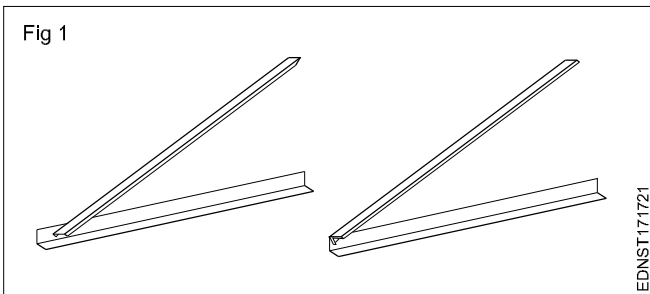


**Read and write the following. (Fig 1 to 8)**

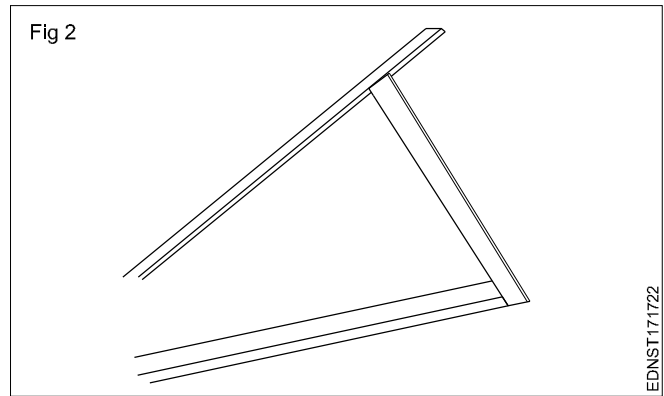
- 1 How solar panel collects solar energy?
- 2 What is the use of charge controller?
- 3 Why battery is used in solar power?
- 4 How overload is cut-off from battery?
- 5 What is the use of inverter?
- 6 Explain off-grid system?
- 7 What is the use of battery level indicator?
- 8 What is the approximate charge of the battery in percentage?
- 9 What are the colour LED used in battery level indicator?
- 10 Explain the function of microcontroller based inverter?
- 11 What is the use of charge over realy in microcontroller inverter?
- 12 What is the supply voltage needed for Lm 317 IC?
- 13 What is the function of SCR TYN 616 in switching circuit?
- 14 What is inverter transformer?
- 15 What is the use of surge protector?
- 16 What is hybrid system?

**Preparation of frame setup to mount the SPV panel**

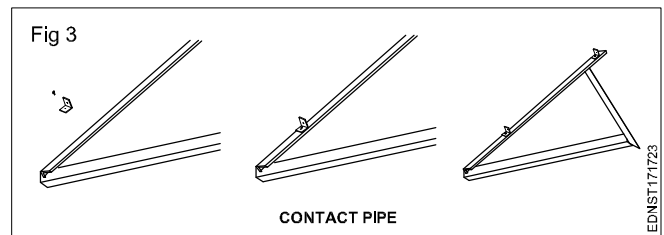
- 1 Contact pipe with M8 x 25 contact base pipe as shown in Fig 1.



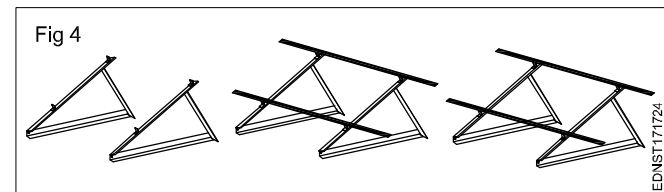
- 2 Use M8 x 25 contact support pipe as shown in Fig 2.



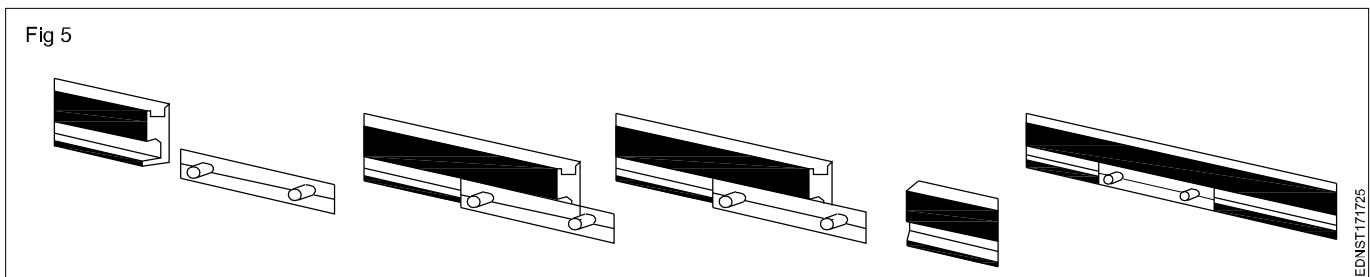
- 3 Rail AC with M8 x 25 fixed on contact pipe as shown in Fig 3.



- 4 Take 2 fixed tile rack and position them with rail as shown in Fig 4.



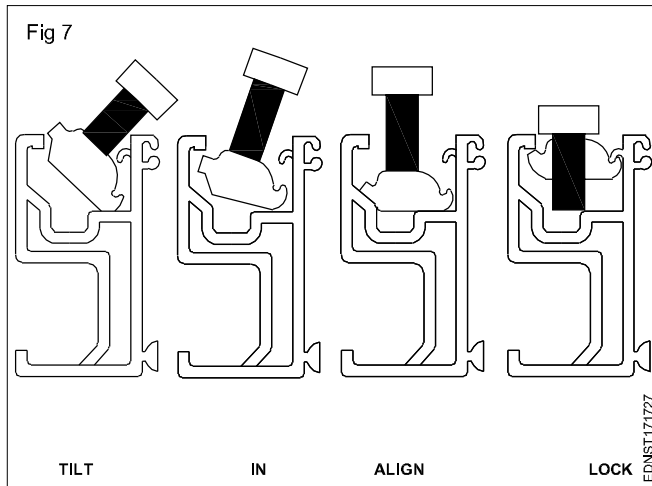
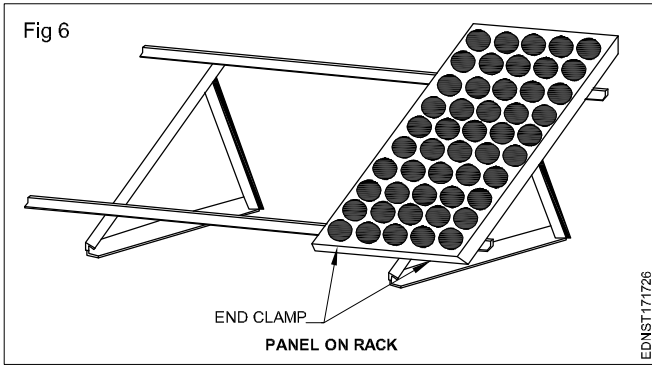
- 5 Slide the splice on the rear side of the pre-assembled rails. Fasten the first bolt. Then slide the next rail into the splice as shown in Fig 5.



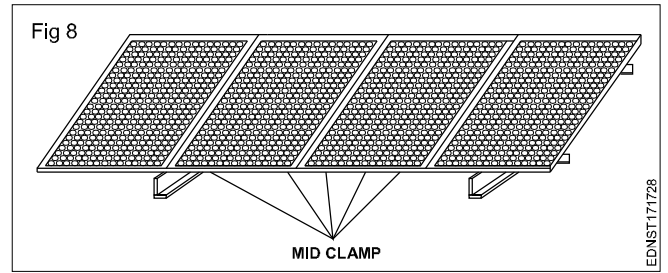
- 6 Put one panel on the rack, use 2 end clamps to hold and fix by following the picture as shown in Fig 6 (Attention: End of Rail distance must < 25 mm to 30 mm).

- 7 Install the method for mid clamp and end clamp as shown in Fig 7.



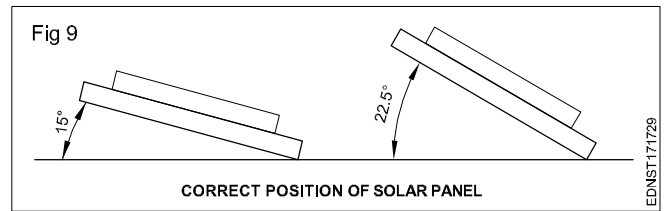


8 Follow and use mid clamp fixed between panels as shown in picture of Fig 8.



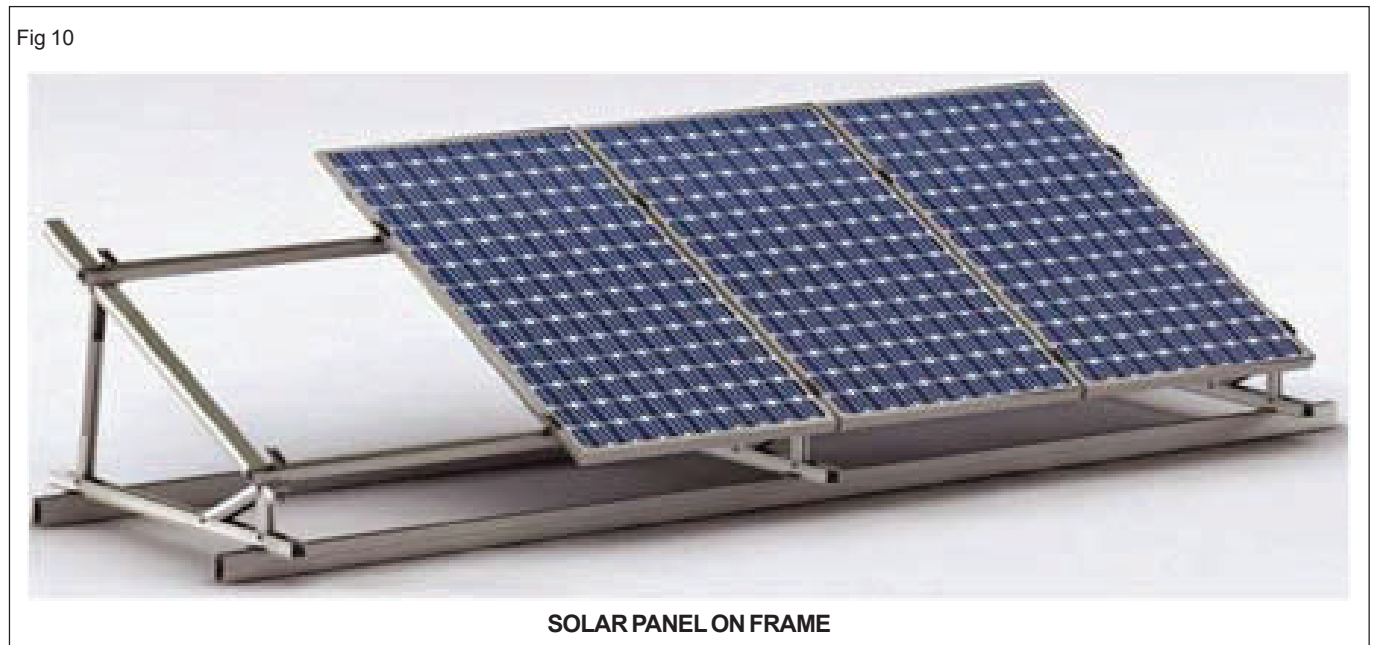
### Selection of correct position of solar panel and installation

- 1 Select the best/perfect angle for solar panels with the help of manual to produce the maximum power.
- 2 Refer to the perfect angle for standard roof pitch angle as shown in Fig 9.



- 3 Mark the holes after selecting the place and angle of inclination.
- 4 Drill the hole on the roof with the help of drilling machine.
- 5 Fix the frame with the help of screw.
- 6 Place the panel on frame as shown in Fig 10.

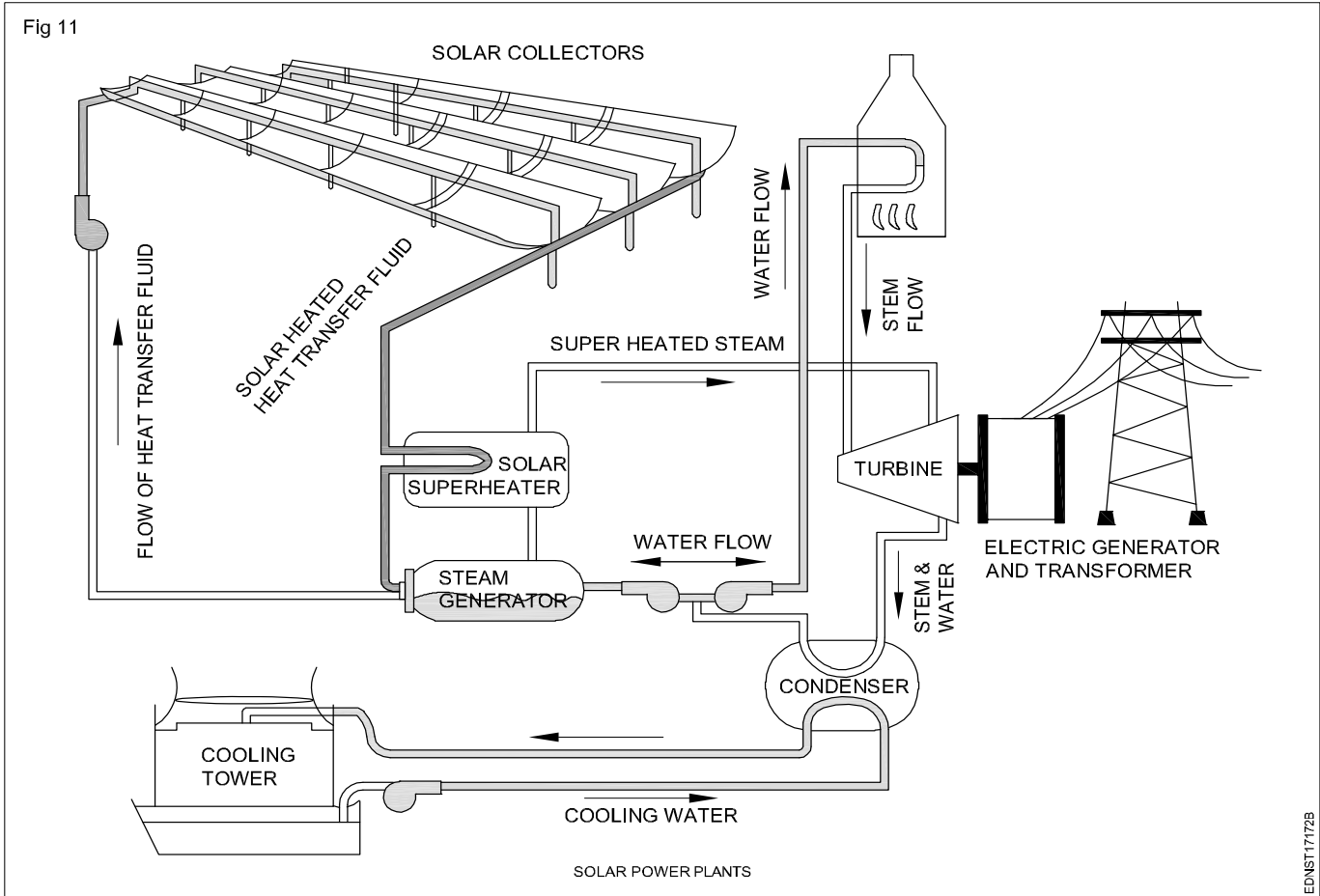
### Solar panel on frame (Fig 10)



### Read and write the following. (Fig 1 to 10)

- 1 How to prepare frame setup to mount SPV panel?
- 2 How to install mid clamp and end clamp?
- 3 How to fix the panels?
- 4 How to select the correct position of solar panels?

## Solar Thermal Power Plants (Fig 11)



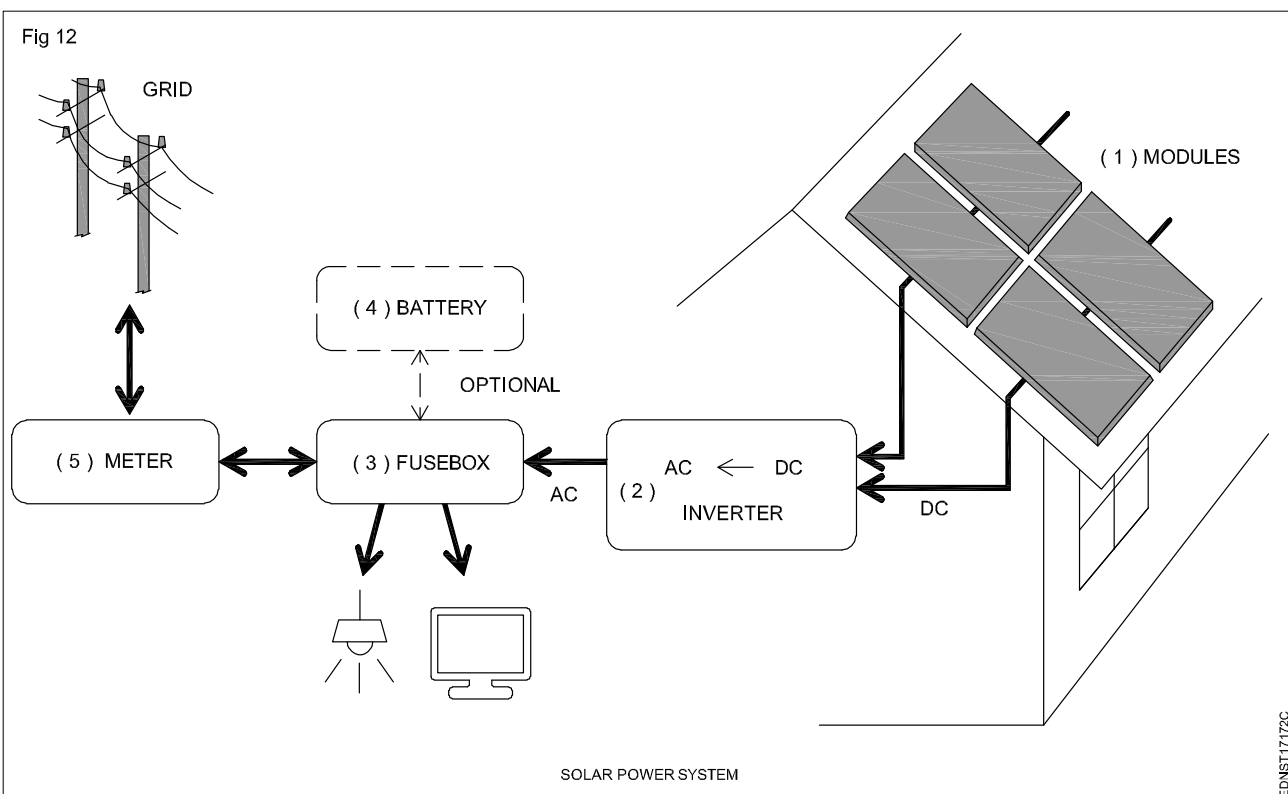
Read and write the following. (Fig 11)

- 1 What is the purpose of solar super heater?
- 2 How steam generator works?

3 How turbine works in solar thermal power plants?

4 Explain the cooling process in solar thermal power plants?

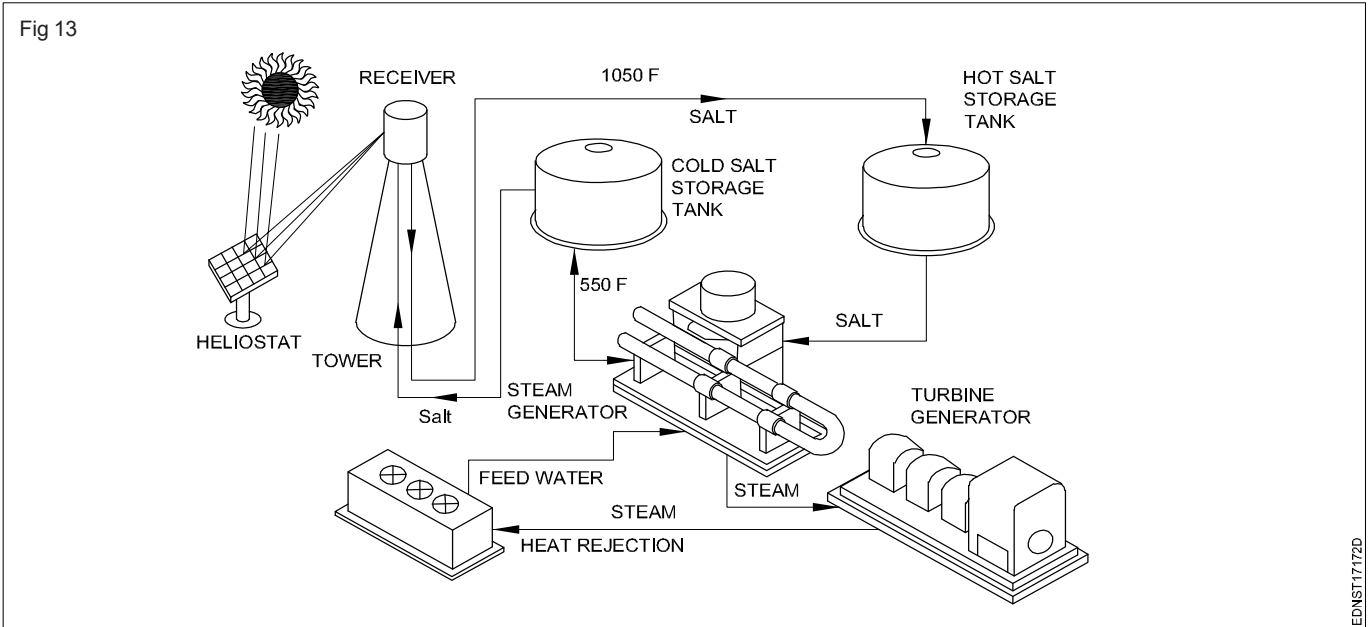
## Solar Power System (Fig 12)



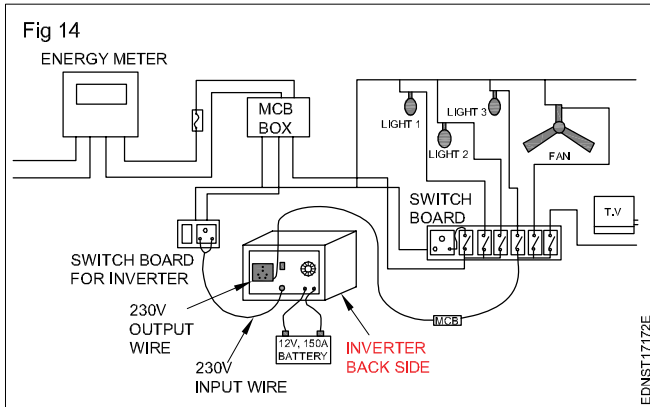
**Read and write the following. (Fig 12)**

- 1 What is the use of fuse box?
- 2 How DC is connected to AC?
- 3 Which material is used to collect solar energy?
- 4 What is grid?
- 5 How to connect solar power to grid connected system?
- 6 Explain the solar power system?
- 7 How to connect the solar power system to GRID?
- 8 What are the safety methods used in Grid connected system?
- 9 Why fuse box is used?
- 10 What is the purpose of meter?
- 11 How inverter works?
- 12 How to connect the modules?

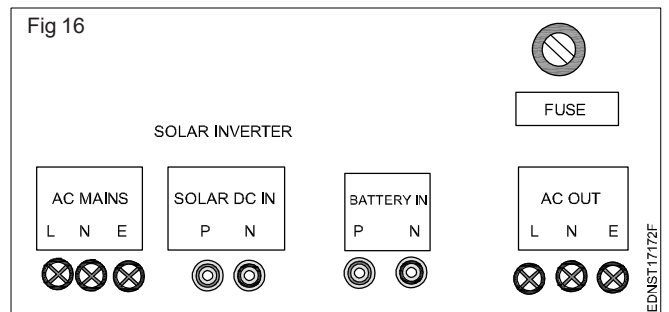
**CSP - Solar power tower – Functional block diagram (Fig 13)**



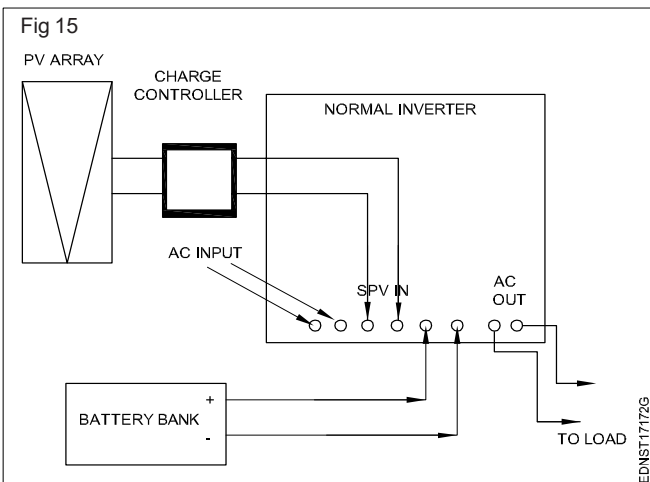
**Normal inverter for Home (Fig 14)**



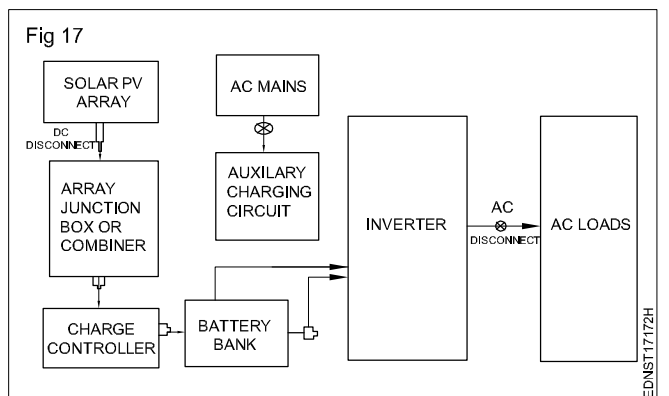
**Back panel of a Solar inverter (Fig 16)**



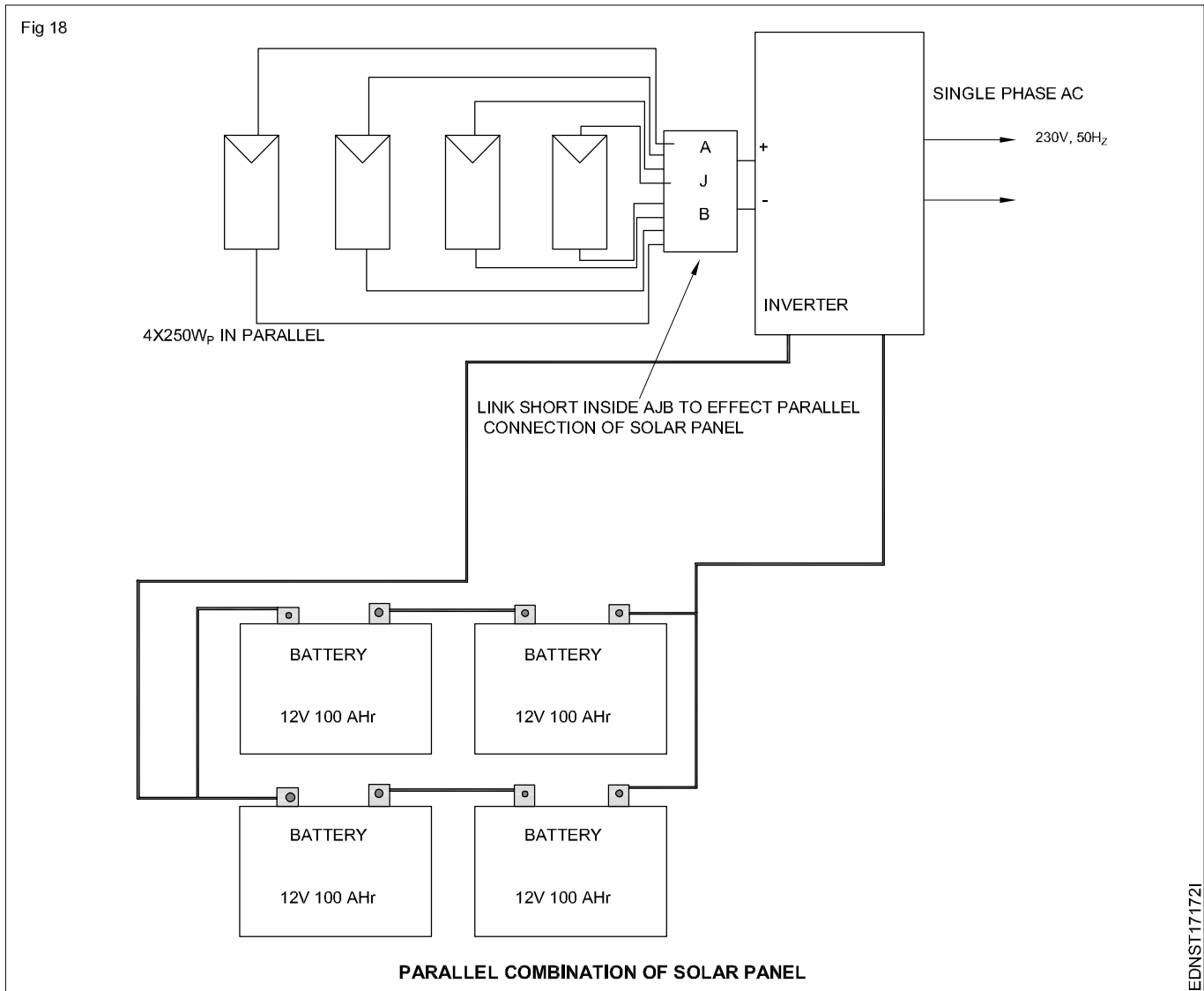
**Normal Inverter converted to Solar inverter (Fig 15)**



**Block diagram of an Off grid Solar PV electrical system (Fig 17)**



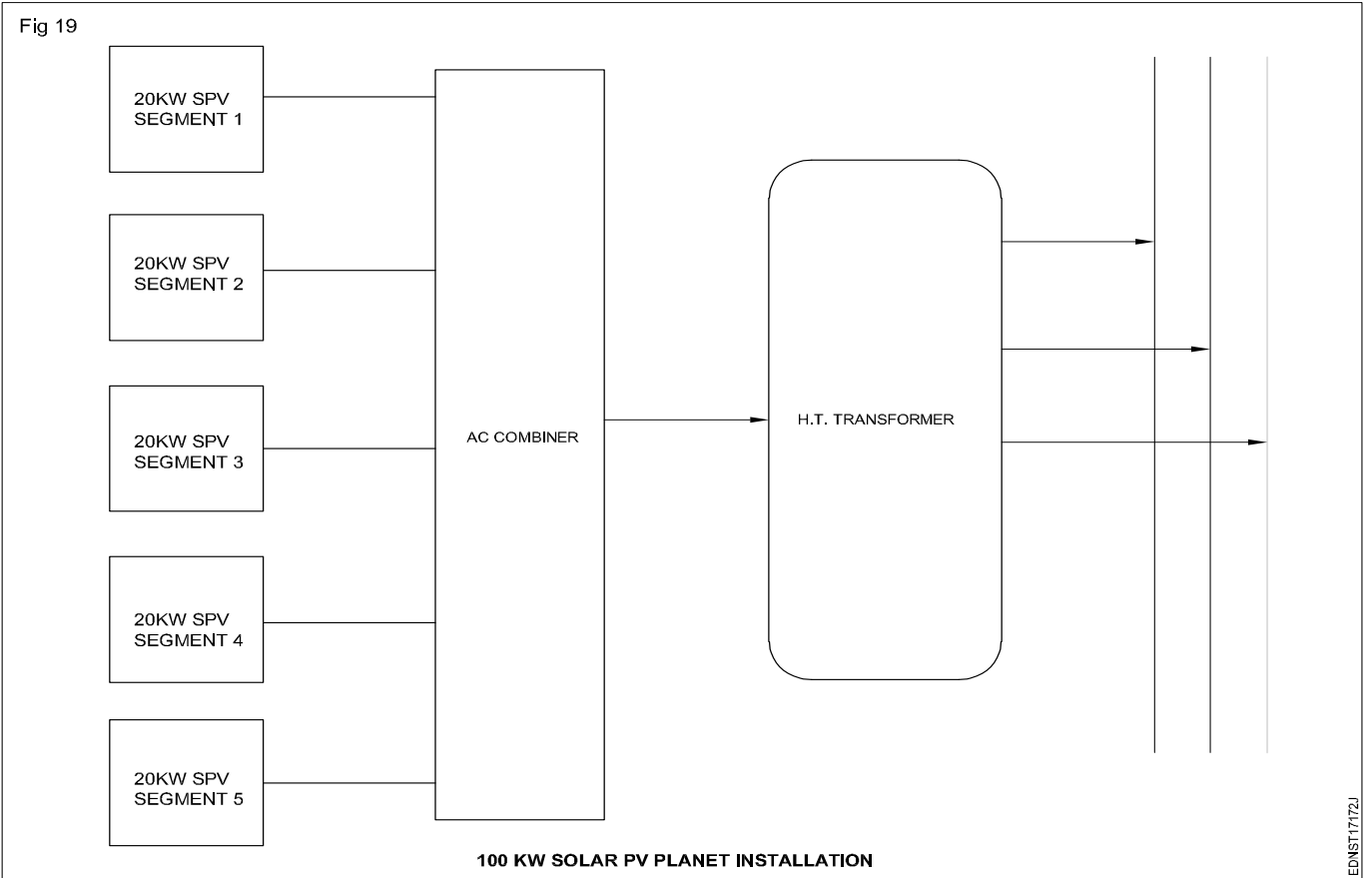
**SLD for 1 kW using parallel combination of solar panels (Fig 18)**



**Read and write the following. (Fig 13 to 18)**

- 1 Why hot salt storage tank is used in solar power tower?
- 2 How steam generator works?
- 3 How heat rejected?
- 4 What is the use of turbine generator?
- 5 What is the use of MCB Box?
- 6 How energy meter connected at home?
- 7 What is the use of charge controller?
- 8 What is the use of battery bank?
- 9 What is the use of parallel combination of solar panel?
- 10 What is the use of auxiliary charging circuit?
- 11 What is combiner?
- 12 Why batteries are connected in parallel?
- 13 What is the function of SOLAR PV array?

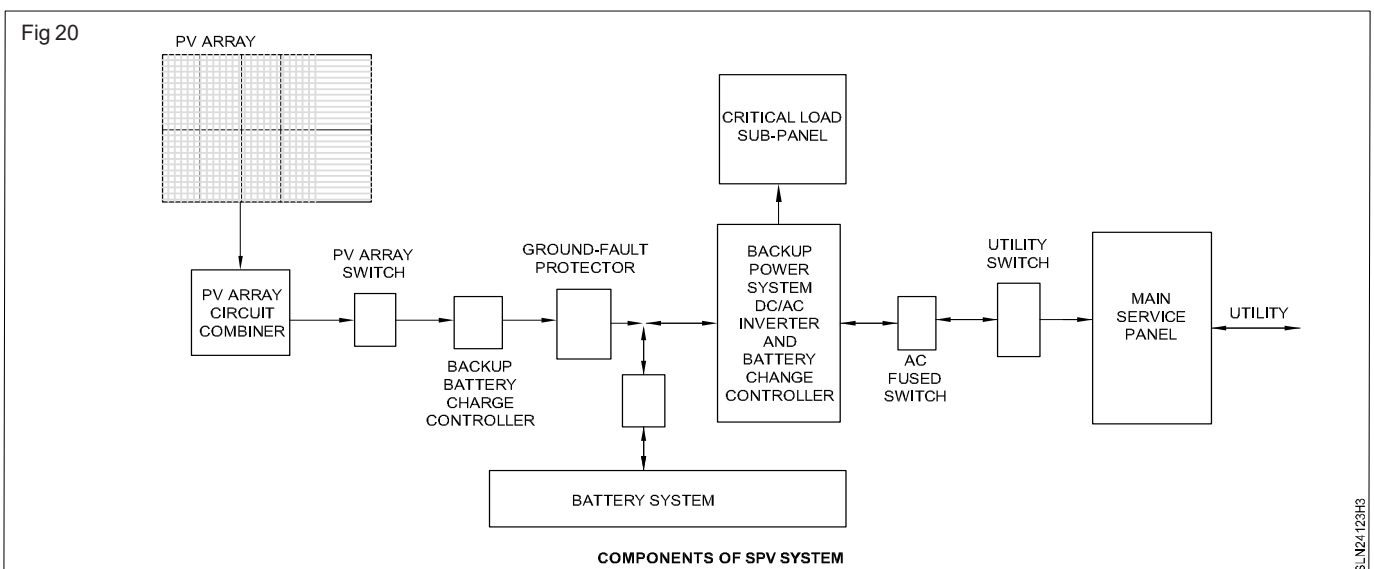
### 100 kW Solar PV plant installation (Fig 19)



#### Read and write the following. (Fig 19)

- 1 What is the use of AC combiner?
- 2 Why H.I transformer is used?
- 3 How to install 100kw SPV plant?
- 4 How to connect SPV segment?

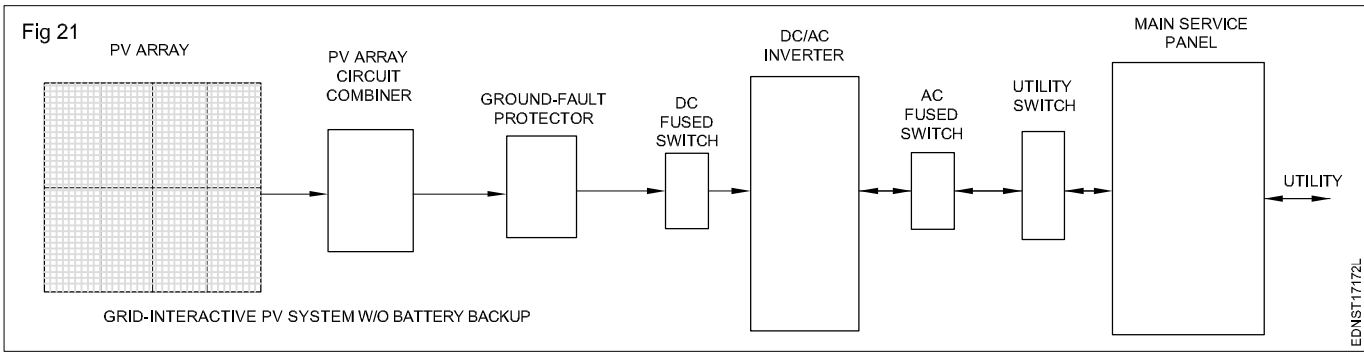
#### Components of SPV system proposed, layout and flow of energy directions (Fig 20)



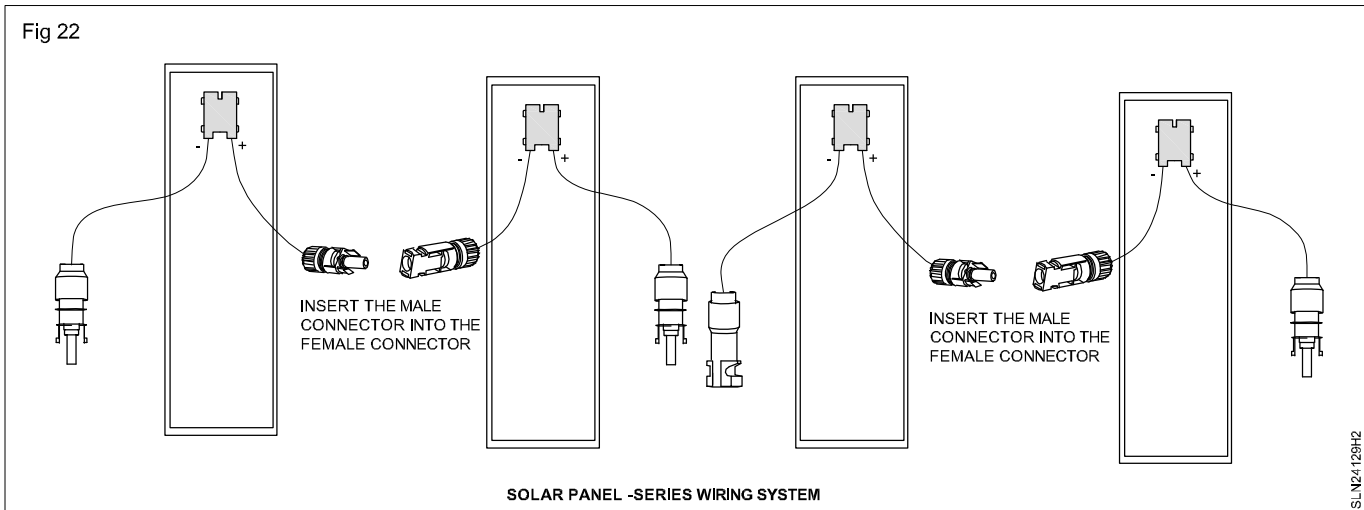
#### Read and write the following. (Fig 20)

- 1 What is the function of PV array?
- 2 What is critical load sub-panel?
- 3 What is the use of utility switch?
- 4 How charge controller works?

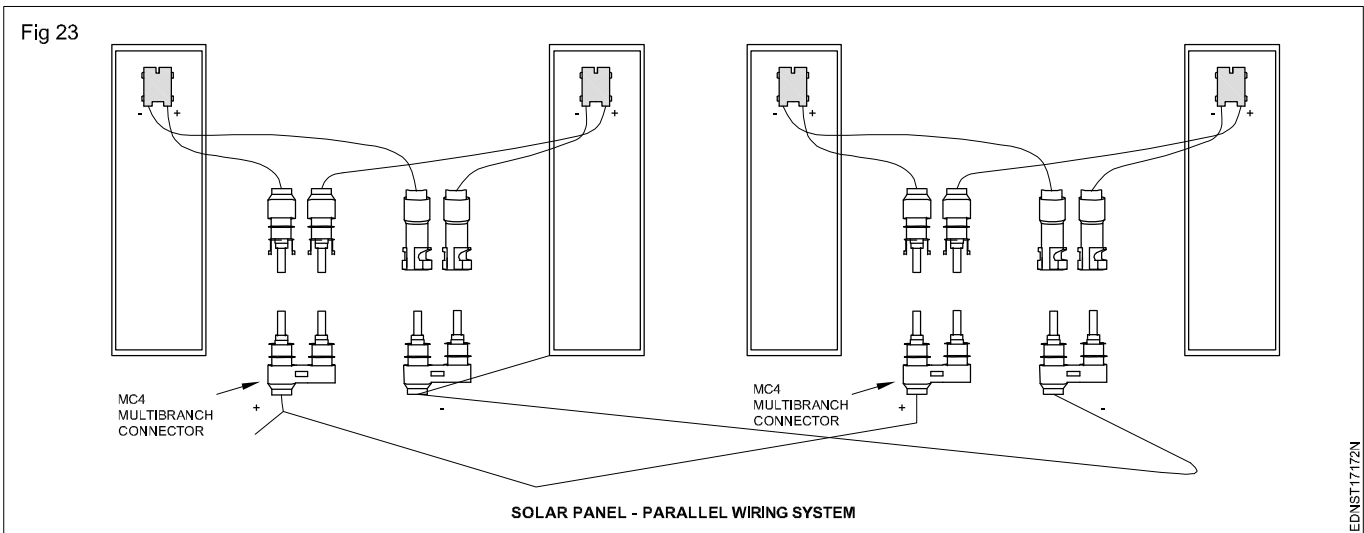
**Components of Grid interactive SPV system without battery backup. (Fig 21)**



**Carry out wiring on mounted solar panels for series wiring by using MC4 (Fig 22)**



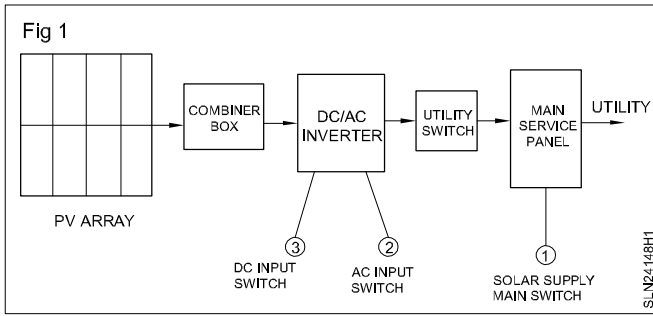
**Carry out wiring on mounted solar panels for parallel wiring by using MC4 (Fig 23)**



**Read and write the following. (Fig 21,22&23)**

- |   |  |
|---|--|
| <p>1 What is the use of Ground fault protector?</p> <p>2 What is the function of PV array circuit combiner?</p> | <p>3 What is the use of AC fused switch?</p> <p>4 How to connect series wiring by using MC4?</p> <p>5 How to connect parallel wiring by using MC4?</p> |
|---|--|

**Shut down procedure (Fig 24)**

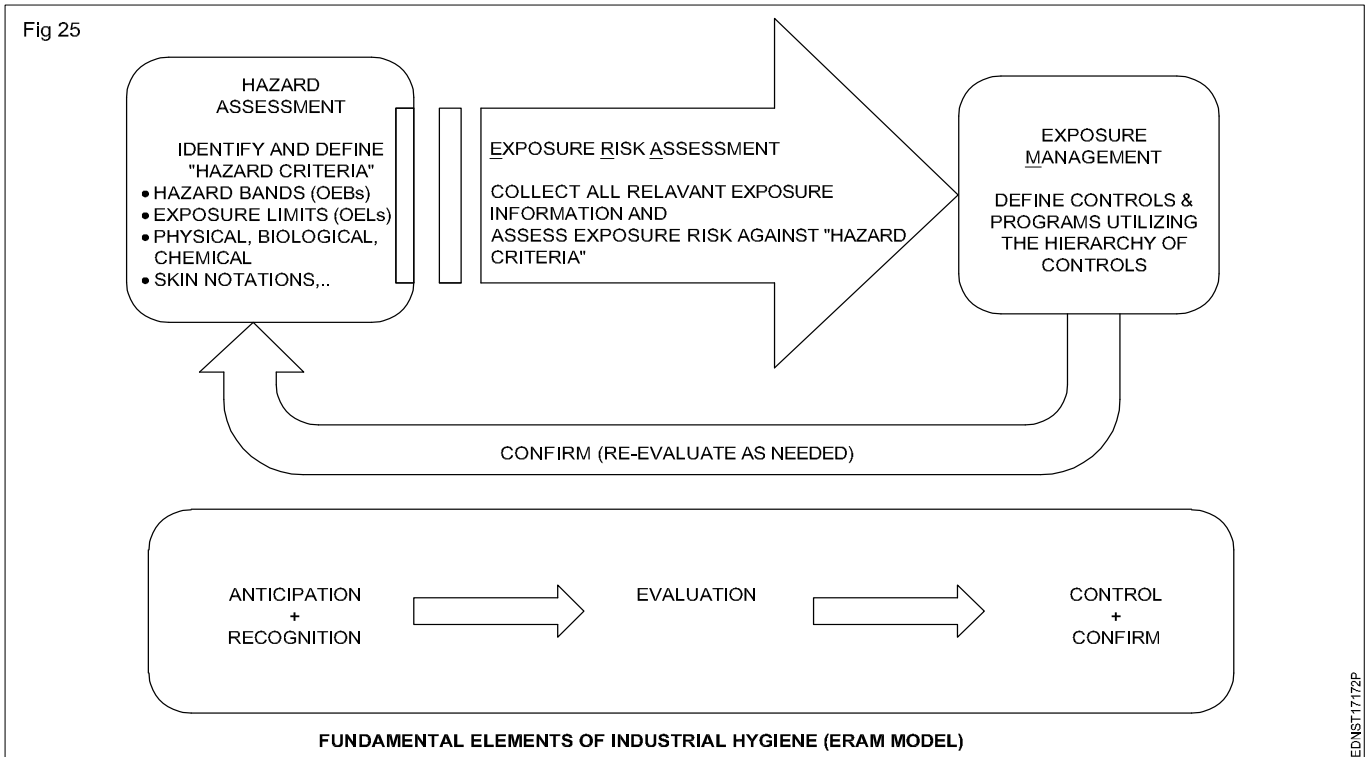


The diagram shows the shutdown sequence in a simple block diagram understandable to the customer.

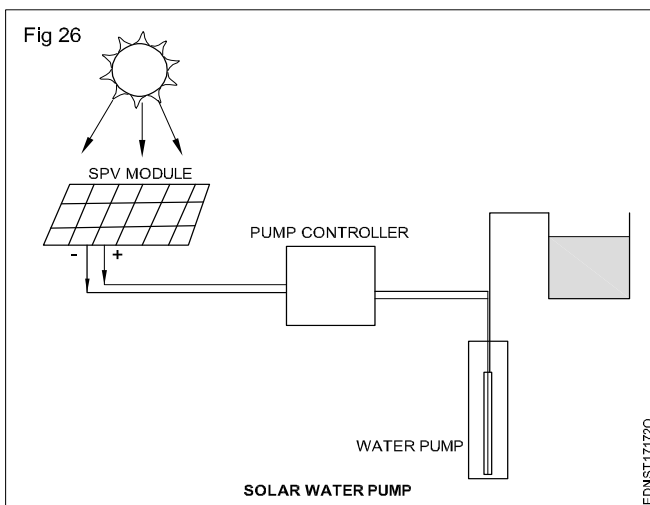
**Read and write the following. (Fig 24)**

- 1 What is the shutdown procedure?
- 2 What is the use of main service panel?
- 3 What is utility switch?

**Fundamental elements of industrial hygiene (Eram model) (Fig 25)**



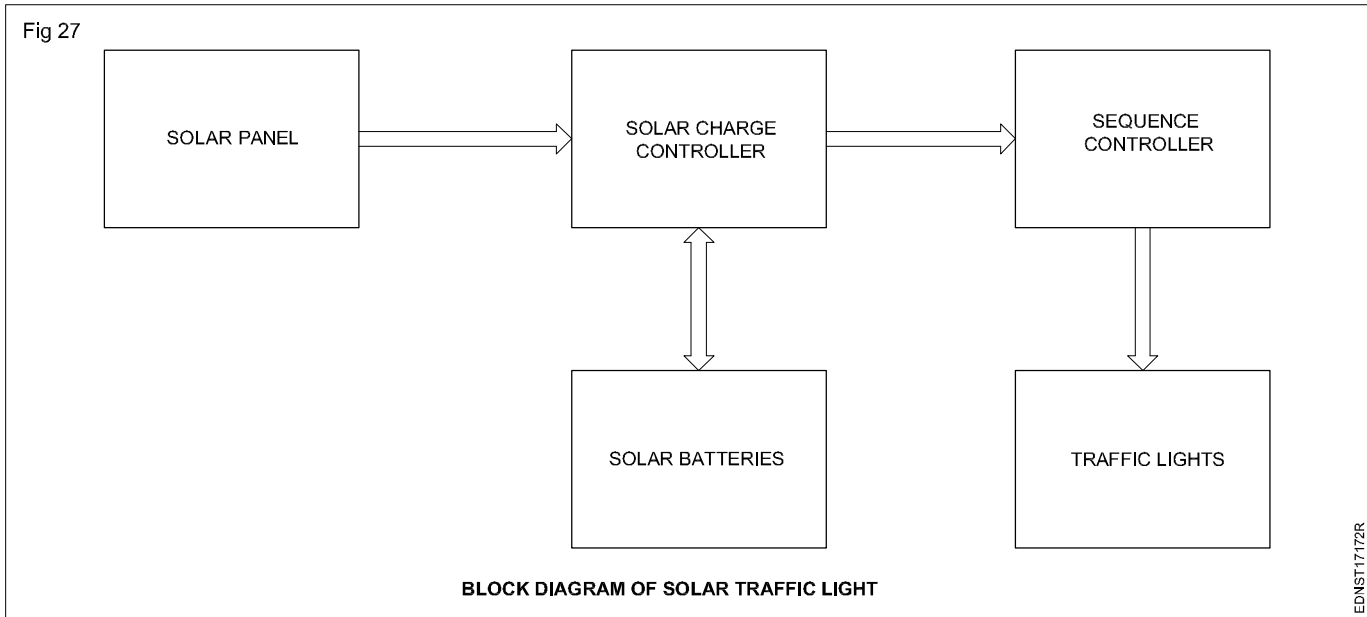
**Block diagram of Solar water pump (Fig 26)**



**Read and write the following. (Fig 25&26)**

- 1 What are the fundamental elements of industrial hygiene?
- 2 What is exposure risk management?
- 3 What is hazard assesment?
- 4 What is the use of pump controller?
- 5 How SPV module works?
- 6 How water pump works?
- 7 What is Hazard criteria?
- 8 Explain exposure management?
- 9 What is Re-evaluation?

### Block diagram of Solar traffic light (Fig 27)



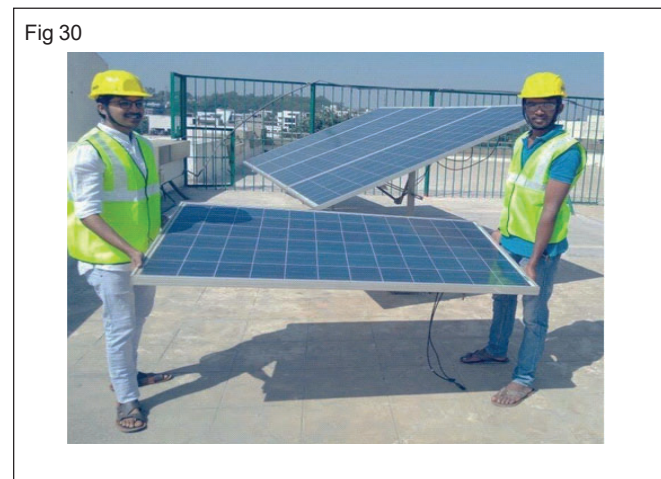
### Solar Technician Mounting Solar panel. (Fig 28)



Solar panels 4 x 250 W mounted on mounting structures. (Fig 29)



### Solar technicians handling panel for next set of mounting. (Fig 30)



### Read and write the following. (Fig 27,28,29&30)

- 1 What is solar panel?
- 2 What is the use of charge controller?
- 3 What is the function of sequence controller?
- 4 How solar traffic lights works?
- 5 How solar battery stored solar energy?
- 6 How to mount the solar panel?
- 7 What is mounting structures?
- 8 How to handle solar panels while mounting?
- 9 What are the necessary safety precautions needed for SPV panel mounting?
- 10 Differentiate solar arrays and solar panels?