MECHANIC DIESEL

NSQF LEVEL - 4

1st Semester

TRADE THEORY

SECTOR: Automobile

Directorate General of Training

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

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE, CHENNAI

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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 Mentor Councils comprising various stakeholder's viz. Industries, Entrepreneurs, Academicians and representatives from ITIs.

The National Instructional Media Institute (NIMI), Chennai, an autonomous body under Ministry of Skill Development & Entrepreneurship is entrusted with developing producing and disseminating Instructional Media Packages (IMPs) required for ITIs and other related institutions.

The institute has now come up with instructional material to suit the revised curriculum for **Mechanic Diesel 1st semester Trade Theory NSQF Level - 4 in Automobile Sector under Semester Pattern.** The NSQF Level - 4 Trade Theory 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 Level - 4 trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 4 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

RAJESH AGGARWAL
Director General/ Addl.Secretary
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New Delhi - 110 001

PREFACE

The National Instructional Media Institute (NIMI) was established in 1986 at Chennai by then Directorate General of Employment and Training (D.G.E & T), Ministry of Labour and Employment, (now under Ministry of Skill Development and Entrepreneurship) Government of India, with technical assistance from the Govt. of the Federal Republic of Germany. The prime objective of this institute is to develop and provide instructional materials for various trades as per the prescribed syllabi under the Craftsman and Apprenticeship Training Schemes.

The instructional materials are created keeping in mind, the main objective of Vocational Training under NCVT/NAC in India, which is to help an individual to master skills to do a job. The instructional materials are generated in the form of Instructional Media Packages (IMPs). An IMP consists of Theory book, Practical book, Test and Assignment book, Instructor Guide, Audio Visual Aid (Wall charts and Transparencies) and other support materials.

The trade practical book consists of series of exercises to be completed by the trainees in the workshop. These exercises are designed to ensure that all the skills in the prescribed syllabus are covered. The trade theory book provides related theoretical knowledge required to enable the trainee to do a job. The test and assignments will enable the instructor to give assignments for the evaluation of the performance of a trainee. The wall charts and transparencies are unique, as they not only help the instructor to effectively present a topic but also help him to assess the trainee's understanding. The instructor guide enables the instructor to plan his schedule of instruction, plan the raw material requirements, day to day lessons and demonstrations.

IMPs also deals with the complex skills required to be developed for effective team work. Necessary care has also been taken to include important skill areas of allied trades as prescribed in the syllabus.

The availability of a complete Instructional Media Package in an institute helps both the trainer and management to impart effective training.

The IMPs are the outcome of collective efforts of the staff members of NIMI and the members of the Media Development Committees specially drawn from Public and Private sector industries, various training institutes under the Directorate General of Training (DGT), Government and Private ITIs.

NIMI would like to take this opportunity to convey sincere thanks to the Directors of Employment & Training of various State Governments, Training Departments of Industries both in the Public and Private sectors, Officers of DGT and DGT field institutes, proof readers, individual media developers and coordinators, but for whose active support NIMI would not have been able to bring out this materials.

R. P. DHINGRA
EXECUTIVE DIRECTOR

Chennai - 600 032

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following Media Developers and their sponsoring organisations to bring out this Instructional Material **(Trade Theory)** for the trade of **Mechanic Diesel** under **Automobile** Sector for ITIs.

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NIMI records its appreciation for the Data Entry, CAD, DTP operators for their excellent and devoted services in the process of development of this Instructional Material.

NIMI also acknowledges with thanks the invaluable efforts rendered by all other NIMI staff who have contributed towards the development of this Instructional Material.

NIMI is also grateful to everyone who has directly or indirectly helped in developing this Instructional Material.

INTRODUCTION

TRADE THEORY

This manual of trade theory consists of theoretical information for theFirst Semester Course of the Mechanic Diesel. The contents are sequenced according to the practical exercise contained in NSQF LEVEL - 4 syllabus on Trade Practical. Attempt has been made to relate the theoretical aspects with the skill covered in each exercise to the extent possible. This correlation is maintained to help the trainees to develop the perceptional capabilities for performing the skills.

The trade theory has to be taught and learnt along with the corresponding exercise contained in the manual on trade practical. The indications about the corresponding practical exercises are given in every sheet of this manual.

It will be preferable to teach/learn trade theory connected to each exercise at least one class before performing the related skills in the shop floor. The trade theory is to be treated as an integrated part of each exercise.

The material is not for the purpose of self-learning and should be considered as supplementary to class room instruction.

TRADE PRACTICAL

The trade practical manual is intended to be used in practical workshop. It consists of a series of practical exercises to be completed by the trainees during the First Semester Course of Mechanical Diesel supplemented and supported by instructions / informations to assist in performing the exercises. These exercises are designed to ensure that all the skills in compliance with NSQF LEVEL - 4 syllabus are covered.

The manual is divided into six modules. The distribution of time for the practical in the six modules are given below:

Module 1	Safety workshop practice	25 Hrs
Module 2	Measuring, marking & workshop tools	100 Hrs
Module 3	Fastening and fitting	125 Hrs
Module 4	Electrical and electronics	100 Hrs
Module 5	Arc & Gas welding	75 Hrs
Module 6	Hydraulics and pneumatics	50 Hrs
Module 7	Specification and service equipments	25 Hrs
	Total	525 Hrs

The skill training in the shop floor is planned through a series of practical exercises centered around some practical project. However, there are few instances where the individual exercise does not form a part of project.

While developing the practical manual, a sincere effort was made to prepare each exercise which will be easy to understand and carry out even by below average trainee. However the development team accept that there is a scope for further improvement. NIMI looks forward to the suggestions from the experienced training faculty for improving the manual.

CONTENTS

LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

- **Check & perform measuring & marking by using various measuring & marking tools. (Vernier callipers, micrometre, telescope gauges, dial bore gauges, dial indicators, straightedge, feeler gauge, thread pitch gauge, vaccum gauge, tire pressure gauge.)**
- **Plan & perform basic fastening & fitting operation by using correct hand tools, machine tools & equipment.**
- **Trace and test all electrical & electronic components & circuits and assemble circuit to ensure functionality of system.**
- **Join components by using Arc & Gas welding.**
- **Trace & test hydraulic and pneumatic components**
- **Check & interpret vehicle specification data and VIN, select & opearte various service station equipment.**

Organization of ITI's and scope of the mechanic diesel trade

Objectives: At the end of this lesson you shall be able to
- **state brief introduction about Industrial Training Institutes (ITI)**
- **state about the organized structure of the Institute.**

Brief Introduction of Industrial Training Institute (ITIs)

Industrial Training Institute plays a vital role in economy of the country, especially interms of providing skilled manpower.

The Directorate General of Training (DGT) comes under **Ministry of Skill Development and Entrepreneurship (MSDE)** offers a range of vocational training trades in different sectors based on economy /labour market. The vocational training programmes are delivered under the aegis of **National Council of Vocational Training (NCVT).** Craftsmen Training scheme (CTS) and Apprenticeship Training Scheme (ATS) and two pioneer programmes of NCVT for Propagatory Vocational Training.

Total number of ITIs in India as on April 2016 is about 13105 (Govt. it is 2293 + 10812 Private affiliated ITIs). They are giving training about 132 trades including Engineering and Non-engineering trades with the duration of 1 or 2 years. The minimum eligibility for admission in ITIs 8th, 10th and 12th pass with respect to the trades and admission process will be held in every year in July.

From 2013, semester pattern was introduced with 6 months/Semester and revised the syllabus for each semester. Then in 2014, they introduced and implemented "Sector Mentor council (SMC)" re-revised syllabus under 11 sectors of about 87 trades.

At the end of each semester, All India Trade Test (AITT) will be conducted in every July and January, with OMR answer sheet pattern and multiple choice type questions.

After passing, National trade certificates (NTC), will be issued by DGT which is authorized and recognized internationally. In 2017, for some trades they have introduced and implemented National Skill Qualification Frame work (NSQF) with Level 4.

After finishing instructional training with 'NTC' certificate, they have to undergo Apprenticeship training (ATS) for one or two year with respect to trades under the Apprentice ACT 1961, in various government and private establishments with stipend. At the end of the Apprenticeship training, All India Apprentice Test will be conducted and apprentice certificate will be issued. They can get job opportunities in private or government establishment in India/Abroad or they can start small scale industries in manufacturing or in service sector with subsidiary government loan.

Organizational Structure of ITIs

The head of the institute is the Principal /DDT/HDT under him one vice-principal (VP). then Training Officers (TO), Group Instructors (GI) who are the management and supervisory staff. Then deputy training officer (DTO) Assistant Training Officers (ATO)/junior training officer (JTO) technical assistants are under Training officers for each trade and for Workshop calculations, Engineering Drawing, Employability skills etc. Administrative office staff superintendent , UDC, LDC, office assistant, employees. Hostel Superintendent (H.S.) physical Education Trainer (PET), Library incharge, Pharmacist,store keeper etc. will be under the one umbrellas of the institute.

Scope of the mechanic diesel trade

Objectives: At the end of this lesson you shall be able to
- **importance and scope of the diesel mechanic trade training**
- **general discipline in the institute.**

Scope of the diesel mechanic trade training : Mechanic diesel trade under craftsmen training scheme (CTS) is one of the most popular trade delivered nation wide through the network of ITI. This trade one year (2 semester) duration.

- Identify the various types of tools equipment, raw materials, spares used in mechanic diesel trade,
- Practice to measuring, fitting, welding, sheet metal works, mechanical and electrical and hydraulic system fault diagnosis and rectification
- Practice to indent and repairing various type of diesel engines,

Carrier Progress Pathways: Can join the apprenticeship training in different types of industries and often National Apprenticeship Certificate (NAC)

Can join Craftsman Instructor Training Scheme (CITS) to become an instructor in ITIs

Job Opportunities

- Mechanic diesel can join in central and state government establishments, like railway, airport, marine, military, joins as a service technician in dealer of agricultural machinery minining, trucks, bus, car, stationary engines, compressors, diesel generators, construction equipments, etc.
- employment. opportunities in overseas.

Self-employment opportunities

- Service centre in rural and urban areas.
- Maintenance contractor
- Manufacturer of sub-assembly
- Dealership/agency for automobile spare parts
- Own repair shop or garrage.

General discipline in the institute : Always be polite, courteous while in institue

Do not arguments with others, on matters of related to your training or with the office while seeking clarifications

Do not bring bad name to your institute by your improper habitude.

Do not waste your precious time in gossips with your friends and on activities other than training.

Do not be late to the theory practical and other classes.

Do not unnecessarily interfere in other's activities.

Do very attentive and listen to the lecture carefully during the theory classes and practical demonstration given by the training staff.

Give respect to your trainer and all other training staff, office staff and co-trainees.

Be interested in all the training activities.

Do not make noise or be playful while undergoing training.

Keep the institute premises neat and clean avoid poluting the environment.

Do not take away any material from the institute which does not belong to you.

Always attend the institute well dressed and good physical appearance.

Be regular to attend the training without fail and avoid absent from the theory or practical classes for simple reasons.

Prepare well before writing a test/examination.

Avoid any malpractice during the test/examination.

Write your theory and practical records regularly and submit them on time for correction

Take care of your safety as well as other's safety while doing the practicals.

Knowledge of personal safety and safety precautions in handling diesel machines.

Objectives: At the end of this lesson you shall be able to
- **state the is personal protective equipment and its purpose**
- **name the two categories of personal protective equipment**
- **list the most common type of personal protective equipment**
- **list the conditions for selection of personal protective equipment**
- **state the safety precaution in handling diesel machines.**

Personal Protective Equipment (PPE)

Devices, equipment, clothing are used by the employees, as a last resort, to protect against hazards in the workplace. The primary approach in any safety effort is that the hazard to the workmen should be eliminated or controlled by engineering methods rather than protecting the workmen through the use of personal protective equipment (PPE). Engineering methods could include design change, substitution, ventilation, mechanical handling, automation, etc. In situations where it is not possible to introduce any effective engineering methods for controlling hazards, the workmen shall use appropriate types of PPE.

As changing times have modernized the workplace, government and advocacy groups have brought more safety standards to all sorts of work environments. The Factories Act, 1948 and several other labour legislations 1996 have provisions for effective use of appropriate types of PPE.

Ways to ensure workplace safety and use personal protective equipment (PPE) effectively.

- Workers to get up-to-date safety information from the regulatory agencies that workplace safety in their specific area.
- To use all available text resources that may be in work area and for applicable safety information on how to use PPE best.
- When it comes to the most common types of personal protective equipment, like goggles, gloves or bodysuits, these items are much less effective if they are not worn at all times, or whenever a specific danger exists in a work process. Using PPE consistent will help to avoid some common kinds of industrial accidents.
- Personal protective gear is not always enough to protect workers against workplace dangers. Knowing more about the overall context of your work activity can help to fully protect from anything that might threaten health and safety on the job.
- Inspection of gear thoroughly to make sure that it has the standard of quality and adequately protect the user should be continuously carried out.

Categories of PPEs

Depending upon the nature of hazard, the PPE is broadly divided into the following two categories:

1 **Non-respiratory:** Those used for protection against injury from outside the body, i.e. for protecting the head, eye, face, hand, arm, foot, leg and other body parts

2 **Respiratory:** Those used for protection from harm due to inhalation of contaminated air.

They are to meet the applicable BIS (Bureau of Indian Standards) standards for different types of PPE.

The guidelines on 'Personal Protective Equipment' is issued to facilitate the plant management in maintaining an effective programme with respect to protection of persons against hazards, which cannot be eliminated or controlled by engineering methods listed in table1.

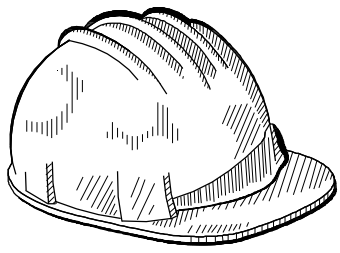
Table1

No.	Title
PPE1	Helmet
PPE2	Safety footwear
PPE3	Respiratory protective equipment
PPE4	Arms and hands protection
PPE5	Eyes and face protection
PPE6	Protective clothing and coverall
PPE7	Ears protection
PPE8	Safety belt and harnesses

Common type of personal protective equipments and their uses and hazards are as follows:

Types of protection	Hazards	PPE to be used
Head protection (Fig 1)	1. Falling objects 2. Striking against objects 3. Spatter	Helmets
Foot protection (Fig 2)	1. Hot spatter 2. Falling objects 3. Working wet area	Leather leg guards Safety shoes Gum boots
Nose (Fig 3)	1. Dust particles 2. Fumes/ gases/ vapours	Nose mask
Hand protecion (Fig 4)	1. Heat burn due to direct contact 2. Blows sparks moderate heat 3. Electric shock	Hand gloves
Eye protection (Fig 5, Fig 6)	1. Flying dust particles 2. UV rays, IR rays heat and High amount of visible radiation	Goggles Face shield Hand shield Head shield
Face Protection (Fig 6, Fig 7)	1. Spark generated during Welding, grinding 2. Welding spatter striking 3. Face protection from UV rays	Face shield Head shield with or without ear muff Helmets with welders screen for welders
Ear protection (Fig 7)	1. High noise level	Ear plug Ear muff
Body protection (Fig 8, Fig 9)	1. Hot particles	Leather aprons

Fig 1



HELMET

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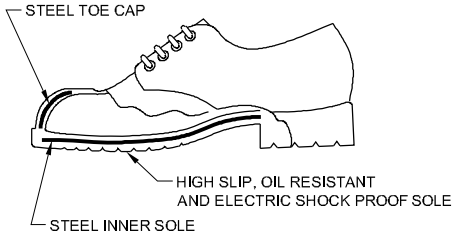
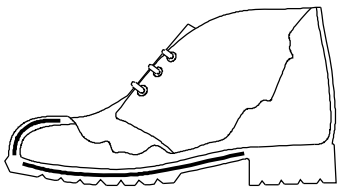
Fig 2



INDUSTRIAL SAFETY SHOE

STOUT LEATHER PREVENTS
INJURY TO THE ANCHILIES TENDON



INDUSTRIAL SAFETY BOOT

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Fig 3

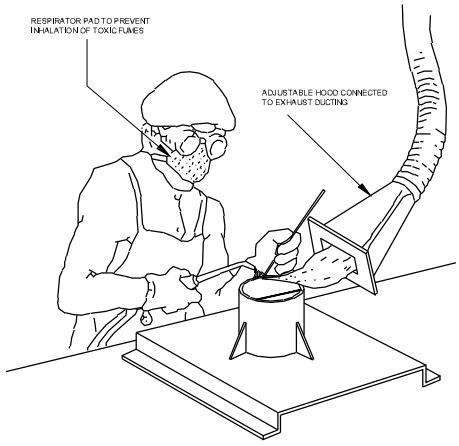

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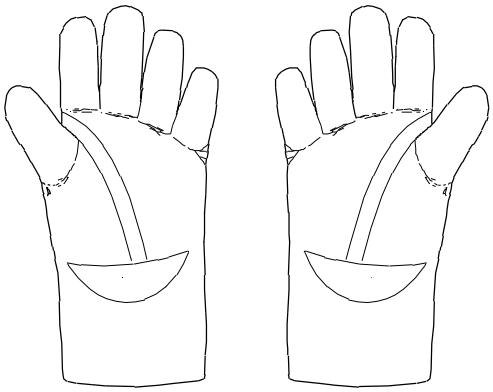
Fig 4



GLOVES

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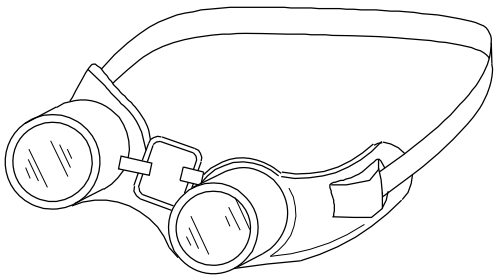
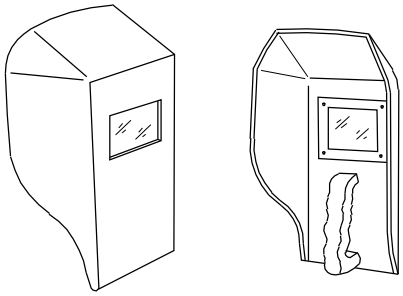
Fig 5



GOGGLES

MDN110215

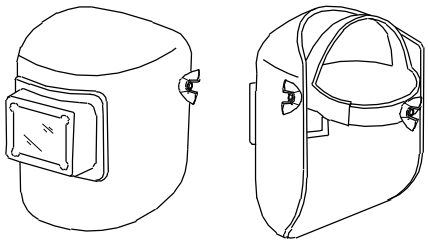
Fig 6



HAND SCREEN

MDN110216

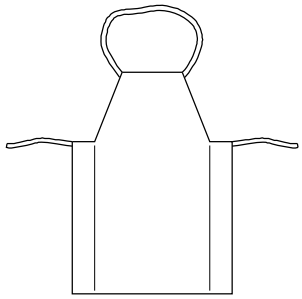
Fig 7



WELDING HELMET

MDN110217

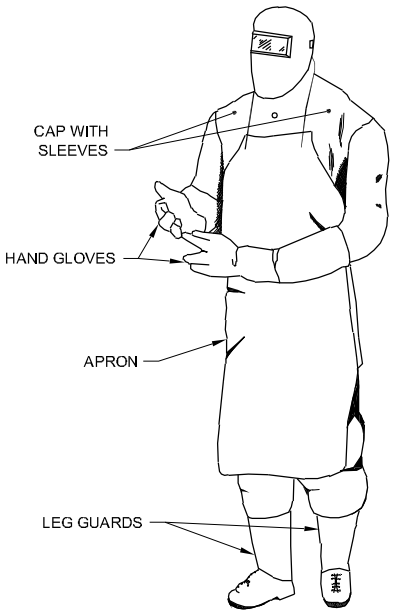
Fig 8



APRON

MDN110218

Fig 9



LEG GUARDS

MDN110219

Quality of PPE's

PPE must meet the following criteria with regard to its quality-provide absolute and full protection against possible hazard and PPE's be so designed and manufactured out of materials that it can withstand the hazards against which it is intended to be used.

Selection of PPE's requires certain conditions

- Nature and severity of the hazard
- Type of contaminant, its concentration and location of contaminated area with respect to the source of respirable air
- Expected activity of workmen and duration of work, comfort of workmen when using PPE
- Operating characteristics and limitations of PPE
- Easy of maintenance and cleaning and
- Conformity to Indian/ International standards and availability of test certificate.

Proper use of PPEs

Having selected the proper type of PPE, it is essential that the workmen wears it. Often the workmen avoids using PPE. The following factors influence the solution to this problem.

- The extent to which the workmen understands the necessity of using PPE
- The ease and comfort with which PPE can be worn with least interference in normal work procedures
- The available economic, social and disciplinary sanctions which can be used to influence the attitude of the workmen
- The best solution to this problem is to make 'wearing of PPE' mandatory for every employee.
- In other places, education and supervision need to be intensified. When a group of workmen are issued PPE for the first time.

Safety precaution in handling diesel machine:

- Diesel mechanic must know the safety rules first and then practice to handling diesel machine as well as we known, when accident starts means safety rules are not followed during the handling of diesel machine. So safety precautions are always based on good sense.
- The following precautions are to be observed to keep a diesel mechanic/personal accident free.

General safety:

- Do not spill the fuel and lubricant on work place, the spills may cause for the risk of slipping.
- Keep all flammable material away from the diesel machine.
- Always keep clean hand and tools while work on machine
- Keep the diesel machines operating area free from any form of fire.
- Safety operation of diesel machine:
- Don't operate the machine with loose engine mounting
- Don't operate the machine without lubricant
- Don't spill diesel during fill in to the fuel tank
- Keep the empty diesel /lubricant can away from the machine.
- Ensure stationary engine exhaust gas outlet should be far away from work place otherwise it will be harm full to human health
- Use preheat before start the diesel engine
- Use safe guard around rotating part of the engine
- Maintains the coolant and lubricant level in the engine.
- Always keep engine in an upright places for easy handling and safety.
- use specified grade lubricant and coolant in an engine

safety of rubber hose and pipes:

- Inspect the rubber hose periodically and replace the damaged parts
- Inspect the fuel leaks in fuel system and rectify the leakages
- Inspect the exhaust gas leaks and rectify the leakages
- Check the engine performance if any air lock in fuel system, bleed the fuel system.
- **Safety of engine operation:**
- Check the coolant circulation and pressure cap function
- Check the oil pressure
- Check the tappet noise and rectify the noise/adjust the defective tappet
- Check the abnormal noise in the engine
- Check leakages of lubricant and coolant in the engine and rectify the leakages.
- Ensure free air circulation in engine operating place

Concept of house keeping & 5S method

Objectives: At the end of this lesson you shall be able to
- **elements of house keeping and cleanliness at work place**
- **state the concept of 5'S' techniques.**

Concept of house keeping

House keeping is the systematic process of making home/ work place neat and clean. House keeper is responsible for administering housekeeping maintenance and for assuring that every thing is in order and he is responsible for systematic administration of activities that provide segregation, storage, transfer, processing treatment and disposal of solid waste (which is collected during cleaning)

Scope of house keeping maintenance

The scope of work hieghly depend on where the house keeping activity is performed in general, maintains clean liness and orderliness, Furnishes the room, office, workplace, house keeping supervisor assisted by an assistant house keeper.

- eye appeal
- safety
- maintenance

Elements of housekeeping and cleanliness at workplace

The major elements which are normally included in the housekeeping and cleanliness practices at the workplace are described below.

- **Dust and dirt removal:** Working in dusty and dirty area is unhygienic as well as unhealthy for the employees since there can be respiratory type irritations. Also, If dust and dirt are allowed to accumulate on surfaces, there is a potential for a slip hazard. Hence, regular sweeping the workplace for the removal of dust and dirt is an essential housekeeping and cleanliness practice. Further, compressed air is not to be used for removing dust or dirt off employees or equipment. Compressed air can caused dirt and dust paticles to be embedded under the skin or in the eye.
- **Employees facilities:** Adequate employees facilities such as drinking water, wash rooms, toilet blocks, and rest rooms etc. are to be provided for the employees at the workplace so that employees can use them when there is a need. Cleanliness at the place of these facilities is an important aspect of the facilities.
- **Flooring:** Floors are to be cleaned regularly and immediately if liquids or other materials are spilled. Poor floor conditions are a leading cause of accidents in the workplace. Area such as entranceways which cannot be cleaned continously are to have mats or some type of anti-slip flooring. It is also important to replace worn, ripped or damaged flooring that poses a trip hazard.
- **Lighting:** Adequate lighting reduces the potential for accidents. It is to be ensured that inoperative light fixtures are repaired and dirty light fixtures are cleaned regularly so that the light intensity levels are maintained at the workplace.
- **Aisles and stairways:** Aisles and stairways are to be kept clear and not to be used for storage. Warning signs and mirrors can improve sight lines in blind corners and help prevent accidents. It is also important to maintain adequate lighting in stairways. Further stairways need to have railings preferably round railings for adequate grip.
- **Spill control:** The best method to control spills is to prevent them from happening. Regular cleaning and maintenance on machines and equipment is an essential practice. Also, the use of drip pans where spills might occur is a good preventative measure. When spills do occur, it is important to clean them up immediately. When cleaning a spill, it is required to use the proper cleaning agents or absorbent materials. It is also to be ensured that the waste products are disposed of properly.
- **Waste disposal:** The regular collection of the waste materials contribute to good housekeeping and cleanliness practices. It also makes it possible to separate materials that can be recycled from those going to waste disposal facilities. Allowing material to build up on the floor wastes time and energy since additional time is required for cleaning it up. Placing containers for wastes near the place where the waste is produced encourages orderly waste disposal and makes collection easier. All recyclable wastes after their collection are to be transferred to their designated places so that the waste materials can be dispatched to the point of use or sold.
- **Tools and equipment:** Tools and equipment are required to be inspected prior to their use. Damaged or worn tools are to be taken out of service immediately. Tools are to be cleaned and returned to their storage place after use.

- **Maintenance:** One of the most important elements of good housekeeping and cleanliness practices is the maintenance of the equipment and the buildings housing them. This means keeping buildings, equipment and machinery in safe and efficient working condition. When a workplace looks neglected means there are broken windows, defective plumbing, broken floor surfaces and dirty walls etc. These conditions can cause accidents and affect work practices. It is important to have a replacement program for replacing or fixing broken and damaged items as quickly as possible.
- **Storage:** Proper storage of materials is essential in a good housekeeping and cleanliness practice. All storage areas need to be clearly marked. Flammable, combustible, toxic and other hazardous materials are to be stored in approved containers in designated areas which are appropriate for the different hazards that they pose. The stored materials are not to be obstruct aisles, stairs, exits, fire equipment, emergency eyewash fountains, emergency showers, or first aid stations. Also it is important that all containers be labeled properly. If materials are being stored correctly, then the incidents of strain injuries, chemical exposures and fires get reduced drastically.
- **Clutter control:** Cluttered workplaces typically happen because of poor housekeeping practices. This type of workplace can lead to a number of issues which include ergonomic as well as injuries. It is important to develop practices where items like tools, chemicals, cords, and containers are returned to their appropriate storage location when not in use. Clutter is not only unattractive but, in a work area, it is also a serious threat to safety. Danger to the employees increases if the established exit routes and doors are blocked. For this reason, as well as to prevent slips and trips, assorted waste materials need to be disposed of promptly in the appropriate waste containers. Aisles are to be kept clear of obstructions for obvious reasons.
- **Individual workspace:** Individual workspace need to be kept neat, cleared of everything not needed for work. Many workplace injuries occur right in the employee's workspace. This space is often overlooked when conducting general housekeeping and cleanliness inspections. It is necessary to make a checklistwhich is to be used by the employees to evalute their workspace.

It can be said that a clean work area demonstrate the pride employees have with the job and the culture of safety at the workplace.

5 Steps (5s) - Concept (Fig 1)

5s is a people-oriented and practice-oriented approach. 5s expects every one to participate in it. It becomes a basic for continuous improvement in the organisation.

The terms (5s) 5 steps are

Step 1: SEIRI (Sorting out)

Step 2: SEITON (Systematic arrangement)

Step 3: SEISO (Shine cleanliness)

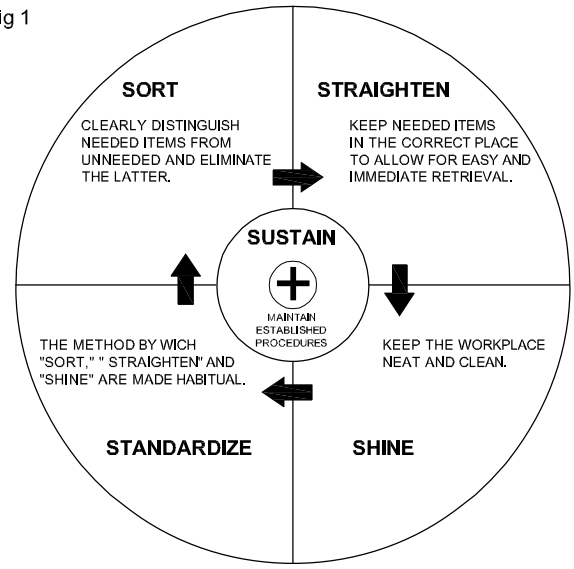
Step 4: SEIKTSU (Stanardization)

Step 5: SHITSURE (Self discipline)

Fig 1 shows the 5s concept wheel.

The list describes how to organize a work space for efficiency and effectiveness by identifying and storing the items used, maintaining the area and items and sustaining the new order.

Fig 1



5S CONCEPT WHEEL

Benefits of 5s

- Work place becomes clear and better organised.
- Working in working place becomes easier.
- Reduction in cost.
- People tend to be more disciplined.
- Delay is avoided.
- Less absenteeism.
- Better use of floor space.
- Less accidents.
- High productivity with quality etc.

Safe handling and periodic testing of lifting equipments

Objectives: At the end of this lesson you shall be able to
- **state the periodic testing of lifting equipments**
- **state the handling of lifting equipments**

Safe and successful lifting operations depends on periodical testing of lifting equipment, maintenance and handling of operation, failure of this equipment may result in significant loss and fatal accident.

Lifts and cranes

Safety precautions for handling of lifts and cranes.

- Never exceed the safe working load (SWL) of the equipment you are using.
- Always support vehicles with axle stands before working underneath them.
- There is always a danger when loads are lifted or suspended. Never work under an unsupported, Suspended or raised load such as a suspended engine.
- Always ensure that lifting equipment such as jacks, hoists, axle stands, slings, etc, are adequate and suitable for the job, In good condition and regularly maintained.
- Never improvise lifting tackle.

Periodic testing of lifting equipment

- Visually inspect the component of the lifting equipment such as lifting chain, slings chain hoist before operating the equipment.
- In Hydraulic function of lift (or) cranes cheek the oil level and top up the oil level periodically.
- The Hydraulic oil used in the lifts or cranes should be replaced periodically.
- The lifting equipment should be over hauled once (or) twice a year.
- Cheek the electrical connections of the lifting equipment periodically.
- The calibration of the lifting equipment should be done once in a year and calibration certificate must to obtained from the authorized testing center.

Safety disposal of used engine oil

Objectives: At the end of this lesson you shall be able to
- **state the purpose of disposal used oil**
- **state the method of safety disposal of used oil**

Waste oil

The waste oils, derived from fuels or lubricants, originally come from petroleum oil, sometimes known as mineral oils. Many lubricants may also contain synthetic components.

Waste oil is harmful to the environment and some, for example used engine oils, may cause cancer. so it needs to be managed carefully. You may need to account for Health and Safety guidance as well as the environment.

Purpose

Oils are defined as greasy, viscous substances from plant, animal, mineral sources (petroleum), and synthetics that are not soluble in water, and are usually flammable. These oils which have been used could be contaminated by physical or chemical impurities such as dirt, metal scrapings, and water. Oils that enter storm drains or waterways are a serious environmental hazard. used oil can pollute fresh water. The purpose of this procedure is to describe the proper means for handling and disposing of used oil from equipment maintenance operations, process procedures, and any other activities where used oils are generated.

This procedure applies to the disposal of any used oil that is collected during normal work functions at work place. Used oil may include:

1 Gasoline. Volatile, flammable, it can be ignited by sparks and flames even at cold temperatures. Vapors can migrate to distant ignition sources and in poorly ventilated spaces, can accumulate to explosive levels. Typical gasoline contains about 150 different chemicals including benzence, toluene and xylene.

Used Oil Disposal

2 Fuel oils. Fuel oils such as diesel fuel are petroleum based fluids which are some what volatile and flammable and can be ignited only when heated above 100°F. Vapors can travel and flash from ignition sources and can accumlate to explosive levels in poorly ventilated areas. All fuel oils consist of complex mixtures of aliphatic and aromatic hydrocarbons such as kerosene, benzene, and styrene.

3 Lubricating oils. Lubricating oils such as motor oil and hydraulic fluids are not volatile but are combustible. For lubricating oil to catch fire some other intense heat source (i.e., other materials on fire, hot engine manifold, etc.) must be present. Mineral-based lube oils are refined from

petroleum or crude oil and contain additives such as lead or metal sulphide and other polymers.

4 Transformer oil. Tranformer oil conducts heat away from and insulates equipment used to convert electricity from high amperage to low amperage lines. Transformer oil is a liquid by product of the distillation of petrolem to produce gasoline.

Cooking oils and grease: Cooking oils and grease are not volatile but they are combustible. With a 400°F flash point, another heat source must be present for cooking oils or grease to catch fire. Vegetable oils contain chemical solvents that are strong enough to dissolve engine seals and gaskets.

Note: for all other waste chemicals, please refer SOP regarding Used Chemical Disposal.

Procedures

Products saturated with petroleum products require special handling and disposal by licensed transporters. During the collection of used oils for disposal, some basic principles should be followed:

1 Wear gloves because oil contains chemicals and contaminants that are not good for skin contact.

2 Put used oil in a clean plastic or metal container in good condition and with a tight lid.

3 If the oil is hot, avoid sudden contact with other substances because mixing may cause ignition or the receiving container to fracture due to thermal shock.

4 Do not allow used fuel and used oils to mix with any other substances because unknown and dangerous chemical reactions may occur.

5 Keep used oils away from gas cylinders and gasoline.

6 Do not fill container to the top but allow a couple inches below the rim.

7 Label the container with contents,and department.

Safe handling of fuel spillage

Objectives: At the end of this lesson you shall be able to
- **state the safe handling of fuel spillage**
- **state the effect of fuel spillage in workplace.**

Diesel fuel is a flammable liquid and fuel spillage or leaks in work place maybe cause for slippage or fire hazard.

Safe handling of fuel:

1 Improper handling of fuel may cause for fuel spillage and explosion, so fuel handling should be use appropriate method.

2 Fuel should not be stored near the working hot engine

3 Don't refueling, when it is hot, fuel tank vapor may cause for fire.

4 No smoking is allowed when refueling to the engine.

5 Don't spill the fuel during refilling the fuel in fuel tank or fuel container.

6 Use funnel during filling the fuel in fuel tank to avoid fuel spillage

7 Use tray during air bleeding from the fuel system to avoid fuel spillage

8 Fuel leaks and spills near the engine may cause for accident so it should be clean and mopped up quickly as soon as the spillage.

9 Stationary engine fuel tank should be position away from any source of direct heat to the fuel tank

Safe disposal of toxic dust

Objectives: At the end of this lesson you shall be able to
- **list the waste material in a work shop**
- **explain the methods of disposal of waste material.**

Introduction

The Automobiles produces fumes containing unburnt gases such as carbon-monoxide, nitrogen oxide and other gases which are harmful to human health. Hence a systematic and scientifically designed methods are adopted for safe disposal of such toxic waste.

Dust from vehicle components to be blown into the air, since such dust floating in air for many hours, may cause harm to people who breath unknowingly.

Brake and clutch components produces dust, when used compressed air jet to clean them. While cleaning conforming the PPE to safety regulation & policies. This includes overall coat, Face mask, safety goggles for eyes earmuffs & earplug for ear protection, rubber gloves &barrier cream for hand and valved respirator for breathing.

Some auto parts having asbestos, is a toxic material, which cause lung cancer. Airborne dust in workshop leads to asthma and throat infections. Do not use compressed air to clean dust from various components & parts of the Vehicle. Solvent used for cleaning can also form a toxic waste. Wash work cloths separately from other cloths so that toxic dust does not get transfer to other clothes. After cleaning a vehicle, there are certain chemicals present in this vehicle diet which turns toxic. To eliminate the toxic waste, create small diet piles and dispose them spontaneous rather than waiting for big diet pile till the end of the day. Workshop diet is best cleaned using a water hose, which does not allow diet to fully. But the waste water must be caught in a sledge pit and not into the storm water drain. Vacuum cleaner is a best device control toxic waste. Providing high speed exhaust ventillation can solve toxic diet.

Use grease which can not re-used is stored in a separate container and stored with unique identification. In a similar manner waste oil is stored in separate container, labeled 'Waste oil' and stored in different location, meant for disposal used diesel oil and kerosene are also stored in separate containers and kept at disposal area.

Elementary first-aid

Objectives: At the end of this lesson you shall be able to
- **define first aid**
- **list out the first aid key points**
- **describe the responsiveness**

First aid is defined as the immediate care and support given to an acutely injured or ill person, primarily to save life, prevent further deterioration or injury, plan to shift the victims to safer places, provide best possible comfort and finally help them to reach the medical centre/ hospital through all available means. It is an immediate life-saving procedure using all resources available within reach.

Imparting knowledge and skill through institutional teaching at younger age group in schools, colleges, entry point at industry level is now given much importance. Inculcating such habits at early age, helps to build good healthcare habits among people.

First aid procedure often consists of simple and basic life saving techniques that an individual performs with proper training and knowledge.

The key aims of first aid can be summarized in three key points:

- **Preserve life:** If the patient was breathing, a first aider would normally place them in the recovery position, with the patient leant over on their side, which also has the effect of clearing the tongue from the pharynx. It also avoids a common cause of death in unconscious patients, which is choking on regurgitated stomach contents. The airway can also become blocked through a foreign object becoming lodged in the pharynx or larynx, commonly called choking. The first aider will be taught to deal with this through a combination of 'back slaps' and 'abdominal thrusts'. Once the airway has been opened, the first aider would assess to see if the patient is breathing.
- **Prevent further harm:** Also sometimes called prevent the condition from worsening, or danger of further injury, this covers both external factors, such as moving a patient away from any cause of harm, and applying first aid techniques to prevent worsening of the condition, such as applying pressure to stop a bleed becoming dangerous.
- **Promote recovery:** First aid also involves trying to start the recovery process from the illness or injury, and in some cases might involve completing a treatment, such as in the case of applying a plaster to a small wound.

ABC of first aid

ABC stands for airway, breathing and circulation.

- **Airway:** Attention must first be brought to the airway to ensure it is clear. Obstruction (choking) is a life-threatening emergency.
- **Breathing:** Breathing if stops, the victim may die soon. Hence means of providing support for breathing is an important next steps. There are several methods practiced in first aid.
- **Circulation:** Blood circulation is vital to keep person alive. The first aiders now trained to go straight to chest compressions through CPR methods.

When providing first aid one needs to follow some rule. There are certain basic norms in teaching and training students in the approach and administration of first aid to sick and injured.

Important guideline for first aiders

Evaluate the situation

Are there things that might put the first aider at risk. When faced with accidents like fire, toxic smoke, gasses, an unstable building, live electrical wires or other dangerous scenario, the first aider should be very careful not to rush into a situation, which may prove to be fatal.

Avoid moving the victim

Avoid moving the victim unless they are immediate danger. Moving a victim will often make injuries worse, especially in the case of spinal cord injuries.

Call emergency services

Call for help or tell someone else to call for help as soon as possible. If alone at the accident scene, try to establish breathing before calling for help, and do not leave the victim alone unattended.

Determine responsiveness

If a person is unconscious, try to rouse them by gently shaking and speaking to them.

If the person remains unresponsive, carefully roll them on the side (recovery position) and open his airway.

- Keep head and neck aligned.
- Carefully roll them onto their back while holding hishead.

First aid

- Call EMERGENCY number.
- Check the person's airway, breathing, and pulse frequently. If necessary, begin rescue breathing and CPR.
- If the person is breathing and lying on the back and after ruling out spinal injury, carefully roll the person onto the side, preferably left side. Bend the top leg so both hip and knee are at right angles. Gently tilt the head back to keep the airway open. If breathing or pulse stops at any time, roll the person on to his back and begin CPR.
- If there is a spinal injury, the victims position may have to be carefully assessed. If the person vomits, roll the entire body at one time to the side. Support the neck and back to keep the head and body in the same position while you roll.
- Keep the person warm until medical help arrives.
- If you see a person fainting, try to prevent a fall. Lay the person flat on the floor and raise the level of feet above and support.
- If fainting is likely due to low blood sugar, give the person something sweet to eat or drink when they become conscious.

DO NOT

- Do not give an unconscious person any food or drink.
- Do not leave the person alone.
- Do not place a pillow under the head of an unconscious person.
- Do not slap an unconscious person's face or splash water on the face to try to revive him.

Occupational health and safety

Objectives: At the end of this lesson you shall be able to
- **define safety**
- **state the goal of occupational health and safety**
- **explain need of occupational health and safety**
- **state what is occupational hygiene?**
- **list types of occupational hazards.**

Safety

Safety means freedom or protection from harm, danger, hazard, risk, accident, injury or damage.

Occupational health and safety

- Occupational health and safety is concerned with protecting the safety, health and welfare of people engaged in work or employment.
- The goal is to provide a safe work environment and to prevent hazards.
- It may also protect co-workers, family members, employers, customers, suppliers, nearby communities, and other members of the public who are impacted by the workplace environment.
- It involves interactions among many related areas, including occupational medicine, occupational (or industrial) hygiene, public health, and safety engineering, chemistry, and health physics.

Need of occupational health and safety

- Health and safety of the employees is an important aspect of a company's smooth and successful functioning.
- It is a decisive factor in organizational effectiveness. It ensures an accident-free industrial environment.
- Proper attention to the safety and welfare of the employees can yield valuable returns.
- Improving employees morale
- Reducing absenteeism
- Enhancing productivity
- Minimizing potential of work-related injuries and illnesses
- Increasing the quality of manufactured products and/or rendered services.

Occupational (Industrial) Hygiene

- Occupational hygiene is anticipation, recognition, evaluation and control of work place hazards (or) environmental factors (or) stresses
- This is arising in (or) from the workplace.
- Which may cause sickness, impaired health and well being (or) significant discomfort and inefficiency among workers.

Anticipation (Identification): Methods of identification of possible hazards and their effects on health

Recognition (Acceptance): Acceptance of ill-effects of the identified hazards

Evaluation (Measurement & Assessment): Measuring or calculating the hazard by Instruments, Air sampling and Analysis, comparison with standards and taking judgment whether measured or calculated hazard is more or less than the permissible standard

Control of Workplace Hazards: Measures like Engineering and Administrative controls, medical examination, use of Personal Protective Equipment (PPE), education, training and supervision

Occupational Hazards

"Source or situation with a potential for harm in terms of injury or ill health, damage to property, damage to the workplace environment, or a combination of these"

Types of occupational health hazards

- Physical Hazards
- Chemical Hazards
- Biological Hazards
- Physiological Hazards
- Psychological Hazards
- Mechanical Hazards
- Electrical Hazards
- Ergonomic Hazards.

1 Physical Hazards

- Noise
- Heat and cold stress
- Vibration
- Radiation (ionising & Nonionising)
- Illumination etc.,

2 Chemical Hazards

- Inflammable
- Explosive
- Toxic
- Corrosive
- Radioactive

3 Biological Hazards

- Bacteria
- Virus
- Fungi
- Plant pest
- Infection.

4 Physiological

- Old age
- Sex
- Ill health
- Sickness
- Fatigue.

5 Psychological

- Wrong attitude
- Smoking
- Alcoholism
- Unskilled
- Poor discipline
  - absentism
  - disobedience
  - aggressive behaviours
- Accident proneness etc,
- Emotional disturbances
  - voilence
  - bullying
  - sexual harassment

6 Mechanical

- Unguarded machinery
- No fencing
- No safety device
- No control device etc.,

7 Electrical

- No earthing
- Short circuit
- Current leakage
- Open wire
- No fuse or cut off device etc,

8 Ergonomic

- Poor manual handling technique
- Wrong layout of machinery
- Wrong design
- Poor housekeeping
- Awkward position
- Wrong tools etc,

Safety Slogan

A Safety rule breaker , is an accident maker

Safety practice - fire extinguishers

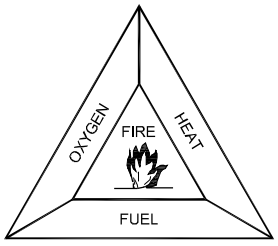
Objectives: At the end of this lesson you shall be able to
- **state the effects of a fire break out.**
- **state the causes for fire in a workshop**
- **state the general precautionary measures to be taken for prevention of fire.**
- **state the types of fire and different extinguishing agent**

Fire is the burning of combustible material. A fire in an unwanted place and on an unwanted occasion and in uncontrollable quantity can cause damage or destroy property and materials. It might injure people, and sometimes cause loss of life as well. Hence, every effort must be made to prevent fire. When a fire outbreak is discovered, it must be controlled and extinguished by immediate corrective action.

Is it possible to prevent fire? Yes, fire can be prevented by eliminating anyone of the three factors that causes fire.

The following are the three factors that must be present in combination for a fire to continue to burn. (Fig 1)

Fig 1



Fuel: Any substance, liquid, solid or gas will burn, if there is oxygen and high enough temperatures.

Heat: Every fuel will begin to burn at a certain temperature. It varies and depends on the fuel. Solids and liquids give off vapour when heated, and it is this vapour which ignites. Some liquids do not have to be heated as they give off vapour at normal room temperature say 15^0C, *eg.* petrol.

Oxygen: Usually exists in sufficient quantity in air to keep a fire burning.

Extinguishing of fire: Isolating or removing any of these factors from the combination will extinguish the fire. There are three basic ways of achieving this.

– **Starving** the fire of fuel removes this element.

– **Smothering** - ie. isolate the fire from the supply of oxygen by blanketing it with foam, sand etc.

– **Cooling** - use water to lower the temperature.

Removing any one of these factors will extinguish the fire.

Preventing fires: The majority of fires begin with small outbreaks which burn unnoticed until they have a secure hold. Most fires could be prevented with more care and by following some simple common sense rules.

Accumulation of combustible refuse (cotton waste soaked with oil, scrap wood, paper, etc.) in odd corners are a fire risk. Refuse should be removed to collection points.

The cause of fire in electrical equipment is misuse or neglect. Loose connections, wrongly rated fuses, overloaded circuits cause overheating which may in turn lead to a fire. Damage to insulation between conductors in cables causes fire.

Clothing and anything else which might catch fire should be kept well away from heaters. Make sure that the heater is shut off at the end of the working day.

Highly flammable liquids and petroleum mixtures (thinner, adhesive solutions, solvents, kerosene, spirit, LPG gas etc.) should be stored in the flammable material storage area.

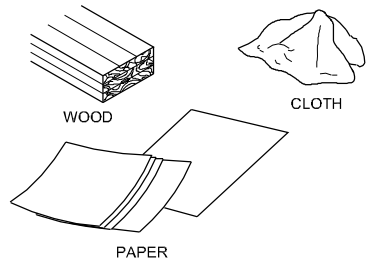
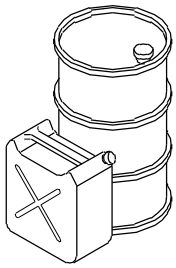
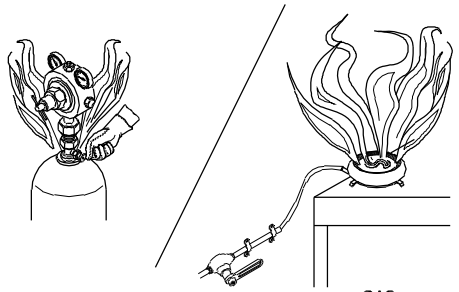
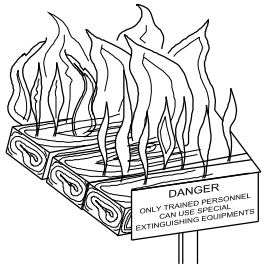
Blowlamps and torches must not be left burning when they are not in use.

Extinguishing fires: Fires are classified into four types in terms of the nature of fuel.(Fig 2,3,4 & 5)

Different types of fire have to be dealt with in different ways and with different extinguishing agents.

An extinguishing agent is the material or substance used to put out the fire, and is usually (but not always) contained in a fire extinguisher with a release mechanism for spraying into the fire.

It is important to know the right type of agent for extinguishing a particular type of fire; using a wrong agent can make things worse.There is no classification for 'electrical fires' as such, since these are only fires in materials where electricity is present.

Fuel	Extinguishing
Fig 2 CLASS 'A' FIRE  MDN110612	Most effective ie. cooling with water. Jets of water should be sprayed on the base of the fire and then gradually upwards.
Fig 3 CLASS 'B' FIRE  FLAMMABLE LIQUIDS AND LIQUIFIABLE SOLIDS MDN110613	Should be smothered. The aim is to cover the entire surface of the burning liquid. This has the effect of cutting off the supply of oxygen to the fire. Water should never be used on burning liquids. Foam, dry powder or CO2 may be used on this type of fire.
Fig 4 CLASS 'C' FIRE  MDN110614	Extreme caution is necessary in dealing with liquefied gases. There is a risk of explosion and sudden outbreak of fire in the entire vicinity. If an appliance fed from a cylinder catches fire - shut off the supply of gas. The safest course is to raise an alarm and leave the fire to be dealt with by trained personnel. Dry powder extinguishers are used on this type of fire. Special powders have now been developed which are capable of controlling and/or extinguishing this type of fire.
Fig 5 CLASS 'D' FIRE  METALS MDN110615	The standard range of fire extinguishing agents is inadequate or dangerous when dealing with metal fires. Fire on electrical equipment. Halon, Carbon dioxide, dry powder and vapourising liquid (CTC) extinguishers can be used to deal with fires in electrical equipment. Foam or liquid (eg. water) extinguishers must not be used on electrical equipment under any circumstances.

Electrical safety tips

Objectives: At the end of this lesson you shall be able to
- **rescue a person who is in contact with a live wire**
- **treat a person for electric shock/injury.**

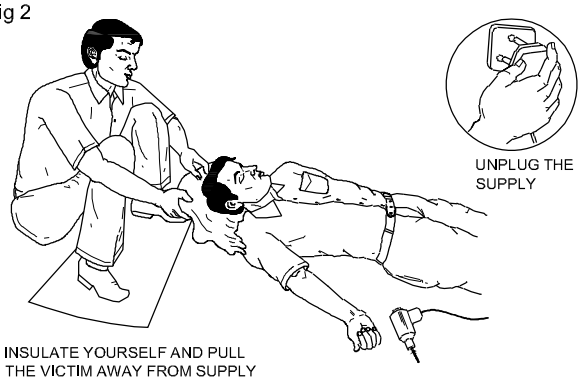
The severity of an electric shock will depend on the level of current which passes through the body and the length of time of contact. Do not delay, act at once. Make sure that the electric current has been disconnected.

If the casualty is still in contact with the supply - break the contact either by switching off the power, removing the plug or wrenching the cable free. If not, stand on some insulating material such as dry wood, rubber or plastic, or using whatever is at hand to insulate yourself and break the contact by pushing or pulling the person free. (Figs 1 & 2)

Fig 1

MDN110621

Fig 2



MDN110622

In bare foot, do not touch the victim with your bare hands until the circuit is made dead or he is moved away from the equipment.

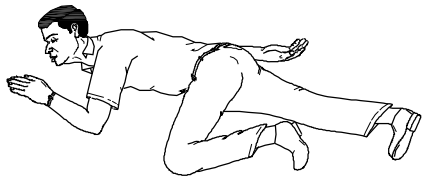
If the victim is aloft, measures must be taken to prevent him from falling or atleast make him fall safe.

Electric burns on the victim may not cover a big area but may be deep seated. All you can do is to cover the area with a clean, sterile dressing and treat for shock. Get expert help as quickly as possible.

If the victim is unconscious but is breathing, loosen the clothing about the neck, chest and waist and place the casualty in the recovery position.(Fig 3)

Keep a constant check on the breathing and pulse rate.

Fig 3



MDN110623

Keep the casualty warm and comfortable. (Fig 4)

Fig 4

MDN110624

Send for help.

Do not give an unconscious person anything by mouth.

Do not leave an unconscious person unattended

If the casualty is not breathing - Act at once - don't wate time!

Safety practice frist - aid

Electric shock: The severity of an electric shock will depend on the level of the current which passes through the body and the length of time of the contact.

Other factors that contribute to the severity of shock are:

- age of the person
- not wearing insulating footware or wearing wet foot wear
- weather condition
- floor is wet or dry
- mains voltage etc.

Effects of electric shock: The effect of current at very low levels may only be an unpleasant tingling sensation, but this in itself may be sufficient to cause one to lose his balance and fall.

At higher levels of current, the person receiving the shock may be throen off his feet and will experience sever pain, and possibly minor burns at the point of contact.

At an excessive level of current flow, the muscles may contract and the person unable to release his grip on the conductor. He becomes conscious and the muscles of the heart may contract spasmodically (fibrillation). This may be fatal.

Electric shock can also cause burning of the skin at the point of contact.

Treatment of electric shock

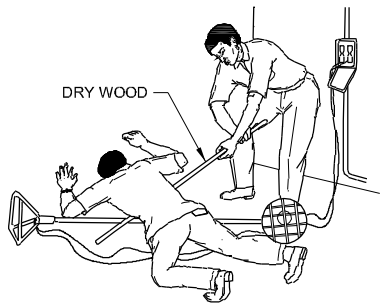
Prompt treatment is essential.

If assistance is close at hand, send for medical aid, then carry on with emergency treatment.

If you are alone, proceed with treatment at once.

Switch off the current, if this can be done without undue delay. Otherwise, remove the victim from contact with the live conductor, using dry non-conducting materials such as a wooden bar, rope, a scarf, the victim's coat-tails, any dry article of clothing, a belt, rolled-up newspaper, non-metallic hose, PVC tubing, bakelised paper, tube etc. (Fig 5)

Fig 5



Avoid direct contact with the victim. Wrap your hands in dry material if rubber gloves are not available.

Electrical buns: A person receiving an electric shock may also sustain burns when the current passes through his body. Do not waste time by applying first aid to the burns until breathing has been restored and the patient can breathe normally - unaided.

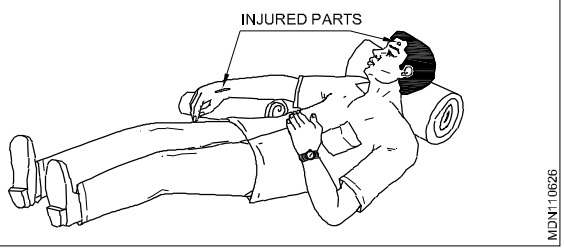
Burns and scalds: Burns are very painful. If a large area of the body is burnt, give no treatment, except to exclude the air, eg.by covering with water, clean paper, or a clean shirt. This relieves the pain.

Severe bleeding: Any wound which is bleeding profusely, especially in the wrist, hand or fingers must be considered serious and must receive professional attention. As an immediate first aid measure, pressure on the wound itself is the best means of stopping the bleeding and avoiding infection.

Immediate action: Always in cases of severe bleeding

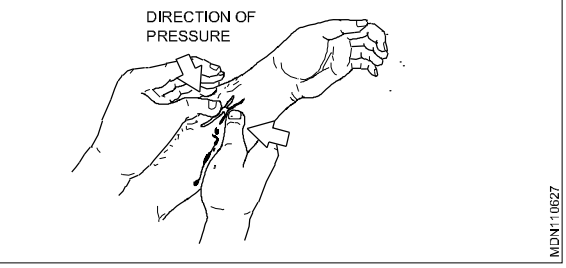
- make the patient lie down and rest
- if possible, raise the injured part above the level of the body (Fig 6)
- apply pressure to the wound
- summon assistance.

Fig 6



To control severe bleeding: Squeeze together the sides of the wound. Apply pressure as long as it is necessary to stop the bleeding. When the bleeding has stopped, put a dressing over the wound, and cover it with a pad of soft material. (Fig 7)

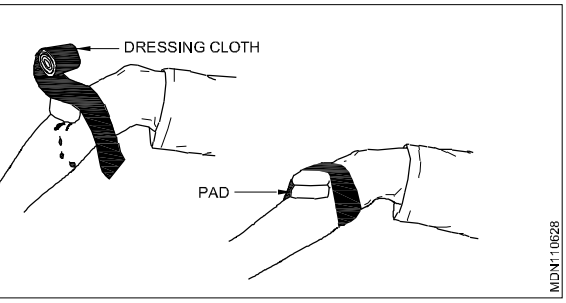
Fig 7



For an abdominal stab wound, such as may be caused by falling on a sharp tool, keep the patient bending over the wound to stop internal bleeding.

Large wound: Apply a clean pad (preferably an individual dressing) and bandage firmly in place. If bleeding is very severe apply more than one dressing. (Fig 8)

Fig 8



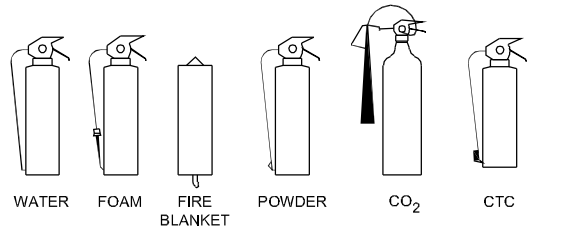
Follow the right methods of artificial respiration.

Used for different types of fire extinguishers

Objectives: At the end of this lesson you shall be able to
- **determine the correct type of fire extinguisher to be used based on the class of fire**

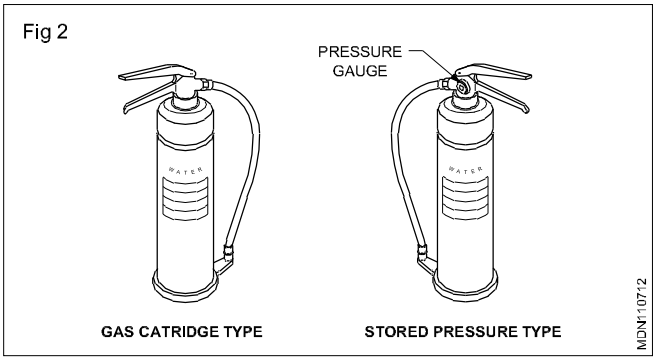
Many types of fire extinguishers are available with different extinguishing 'agents' to deal with different classes of fires. (Fig 1)

Fig 1



Water-filled extinguishers: There are two methods of operation. (Fig 2)

Fig 2

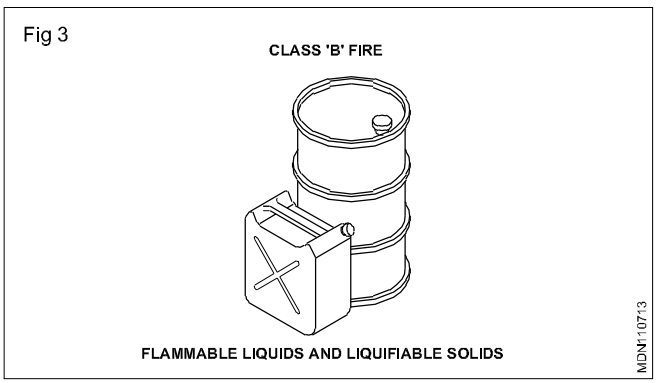


- Gas cartridge type
- Stored pressure type

With both methods of operation the discharge can be interrupted as required, conserving the contents and preventing unnecessary water damage.

Foam extinguishers (Fig 3):These may be of stored pressure or gas cartridge types. Always check the operating instructions on the extinguisher before use.

Fig 3



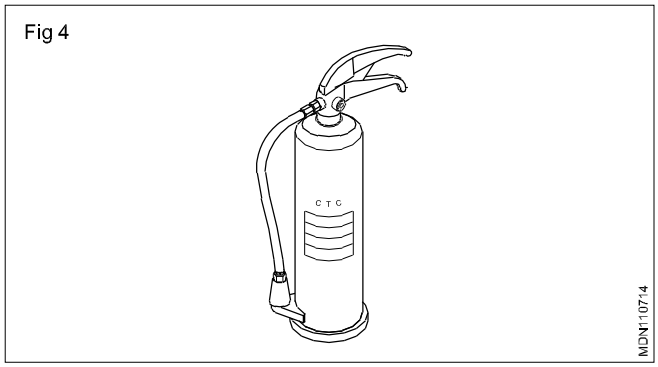
Most suitable for

- flammable liquid fires
- running liquid fires.

Must not be used on fires where electrical equipment is involved.

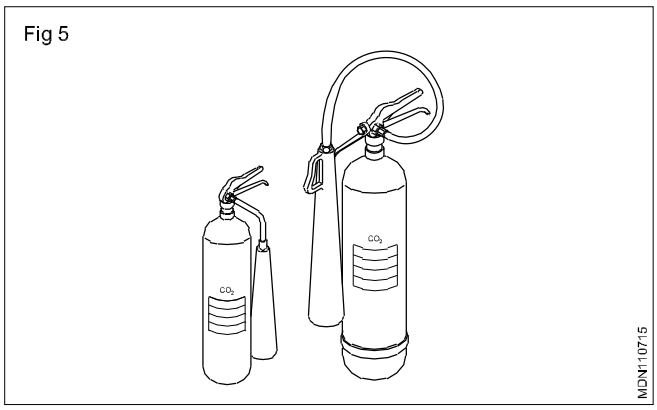
Dry powder extinguishers (Fig 4): Extinguishers fitted with dry powder may be of the gas cartridge or stored pressure type. Appearance and method of operation is the same as that of the water-filled one. The main distinguishing feature is the fork shaped nozzle. Powders have been developed to deal with class D fires.

Fig 4



Carbon dioxide (CO_2): This type is easily distinguished by the distinctively shaped discharge horn. (Fig 5).

Fig 5



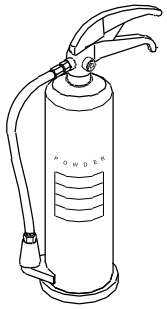
Suitable for Class B fires. Best suited where contamination by deposits must be avoided. Not generally effective in open air.

Always check the operating instructions on the container before use. Available with different gadgets of operation such as - plunger, lever, trigger etc.

Halon extinguishers (Fig 6)**:** These extinguishers may be filled with carbon-tetrachloride and Bromochlorodifluoro methene (BCF). They may be either gas cartridge or stored pressure type.

They are more effective in extinguishing small fires involving pouring liquids. These extinguishers are particularly suitable and safe to use on electrical equipment as the chemicals are electrically non-conductive.

Fig 6



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The fumes given off by these extinguishers are dangerous, especially in confined space.

The general procedure in the event of a fire:

- Raise an alarm.
- Turn off all machinery and power (gas and electricity).
- Close the doors and windows, but do not lock or bolt them. This will limit the oxygen feed to the fire and prevent its spreading.
- Try to deal with the fire if you can do so safely. Do not risk getting trapped.
- Anybody not involved in fighting the fire should leave calmly using the emergency exits and go to the designated assembly point. Failure to do this may mean that some person being unaccounted for and others may have to put themselves to the trouble of searching for him or her at risk to themselves.

Energy conservation process

Objectives: At the end of this lesson you shall be able to
- **define energy conservation**
- **classify energy conservation opportunities**

Energy Conservation

To achieve and maintain optimum energy procurement and utilization, throughout the organization

To minimize energy costs / waste without affecting production, comfort and quality.

To reduce environmental pollution per unit of industrial output - as carbon dioxide, smoke, sulphur dioxide.

Definetion of Energy Conservation

Energy conservation is achieved when growth of energy consumption is reduced, measured in physical terms.

Energy conservation can, therefore, be the result of several processes or developments, such as productivity increase or technological progress.

For example, replacing traditional light bulbs with Compact Fluorescent Lamps (CFL) (which use only 1/4th of the energy to same light output). Light Emitting Diode (LED) lamps are also used for the same purpose.

Energy Conservation Opportunities (ECOs)

Opportunities to conserve energy are broadly classified into three categories:

i) Minor ECOs

These are simple, easy to implement, and require less investment implementation time. These may correspond to stopping of leakage points, avoiding careless waste, lapses in housekeeping and maintenance etc.

ii) Medium ECOs

These are more complex, and required additional investment and moderate implementation time. For example, replacement of existing household appliances by new energy efficient ones.

iii) Major ECOs

These provide significant energy saving. They are complex and demand major investment and long implementation periods. For example, replacement or major renovation of old buildings, machineries etc.

Marking material

Objectives: At the end of this lesson you shall be able to
- **name the common types of marking material**
- **select the correct marking material for different applications.**

Common types of Marking Materials

The common marking materials are Whitewash, Cellulose Lacquer, Prussian Blue and Copper Sulphate.

Whitewash

Whitewash is prepared in many ways.

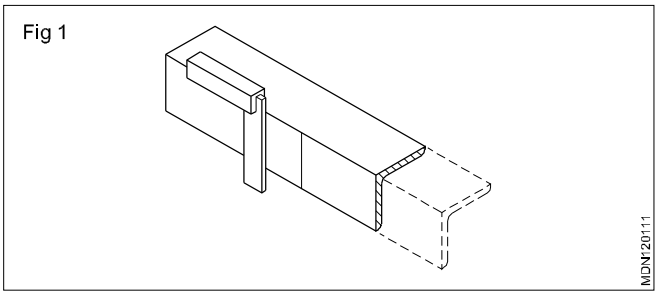
Chalk powder mixed with water

Chalk mixed with methylated spirit

White lead powder mixed with turpentine

Whitewash is applied to rough forgings and castings with oxidised surfaces. (Fig 1)

Fig 1



Whitewash is not recommended for workpieces of high accuracy.

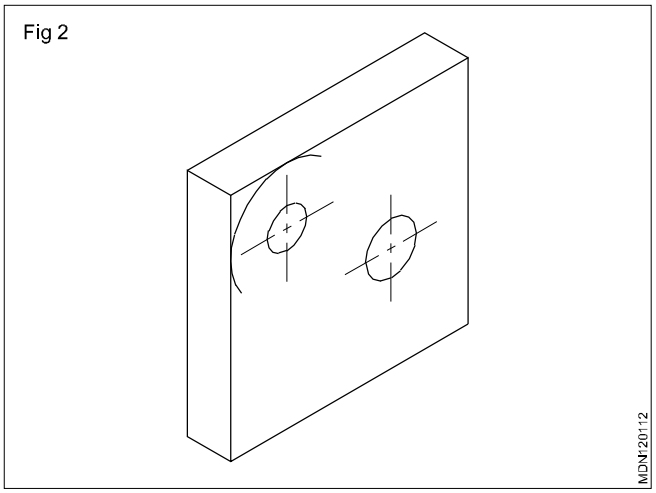
Cellulose Lacquer

This is a commercially available marking medium. It is made in different colours, and dries very quickly.

Prussian Blue

This is used on filed or machine-finished surfaces. This will give very clear lines but takes more time for drying than the other marking media. (Fig 2)

Fig 2



Copper Sulphate

The solution is prepared by mixing copper sulphate in water and a few drops of nitric acid. The copper sulphate is used on filed or machine-finished surfaces. Copper sulphate sticks to the finished surfaces well.

Copper sulphate needs to be handled carefully as it is poisonous. Copper sulphate coating should be dried well before commencing marking as, otherwise, the solution may stick on the instruments used for marking.

The selection of marking medium for a particular job depends on the surface finish and the accuracy of the workpiece.

Cleaning tools

Objectives : At the end of this lesson you shall be able to
- **state the different types of Cleaning Tools and their use**
- **state the precautions to be observed in the use of Cleaning Tools.**

Mechanical Cleaning Involves, brushing and abrasive Cleaning. It should be used very carefully on soft metals. Heavy deposits that exists even after chemical Cleaning can be removed by mechanical cleaning.

The General Cleaning Tools are

1) Wire brushes

2) Emery sheets.

Wire Brushes

Wire brushes are generally used for cleaning the work surfaces.

It is made of steel wires (or) Nylon bristles fitted on a wooden piece.

The steel wires are hardened and tempered for long life to ensure good cleaning action. Different types of wire brushes is shown in Fig 1.

Applications

1 Wire brushes can be used for cleaning uneven Surfaces

2 A hand wire brush can be used on exterior of the block and on the head.

3 A round wire brush fixed with a hand drill motor spindle can be used for cleaning of combustion chamber and parts of the head.

4 A wire wheel can be used to clean the valves.

5 Nylon bristles with impregnated abrasive brush can be used for Engine boring

6 A washing brush can be used to clean the cylinders by using Soap and Water.

7 Oil passages of cylinder block can be cleaned by running a long bottle type brush through all holes in the cylinder block.

8 It is used to clean work surface before and after welding

Safety precautions

Steel wire brushes should be used carefully on soft metals.

It should not make any scratches on the finished surface.

EMERY Sheet (Fig 2**)**

This is a type of paper used for sanding down hard and rough surfaces and also used for resistant technology purposes to give a smooth, shiny finish to manufactured products.

Emery paper is defined as a paper coated with abrasive particles in one side and used to produce smooth, shiny finish to manufactured products.

Description

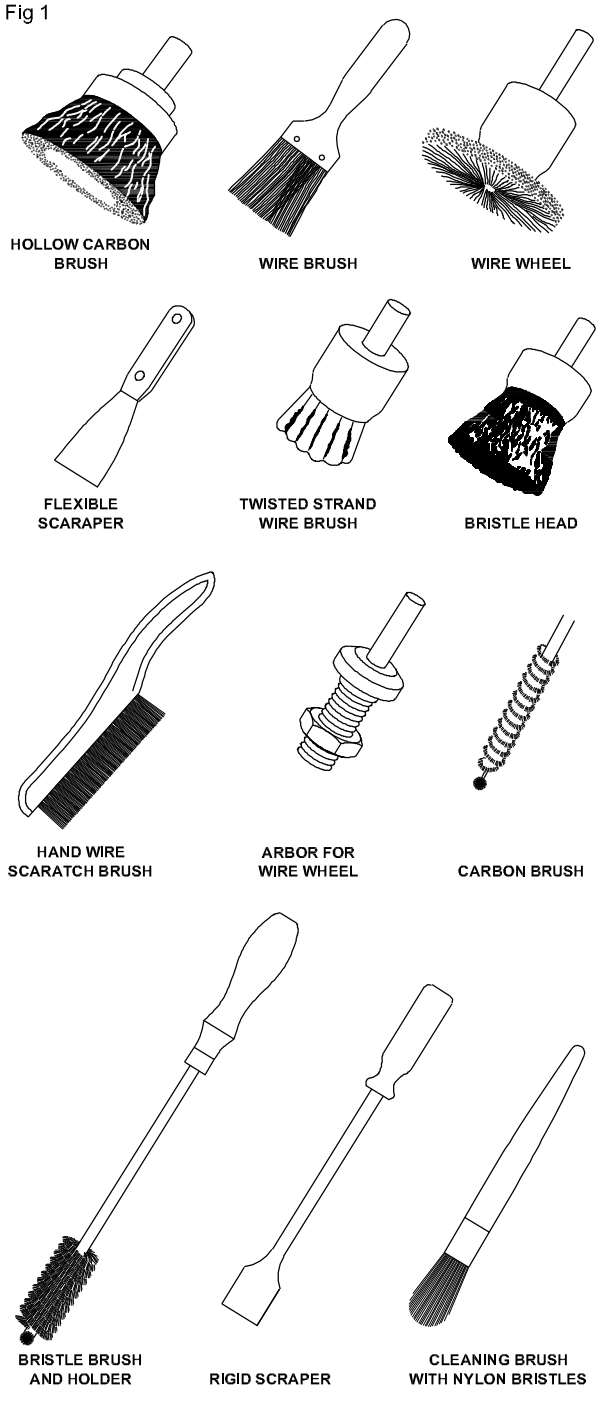
The each and every abrasive particle act as a cutting edge. The emery is considered for a suitable abrasive for workshop practices and the final adjustment of steel parts for a perfect fit. The emery paper is also used for cleaning, to remove rust from polished metal components.

The emery is graded by numbers and the Common sizes are from coarse to fine: 40, 46, 54, 60, 70, 80, 90. 100. 120, F and FF.

Safety Precautions

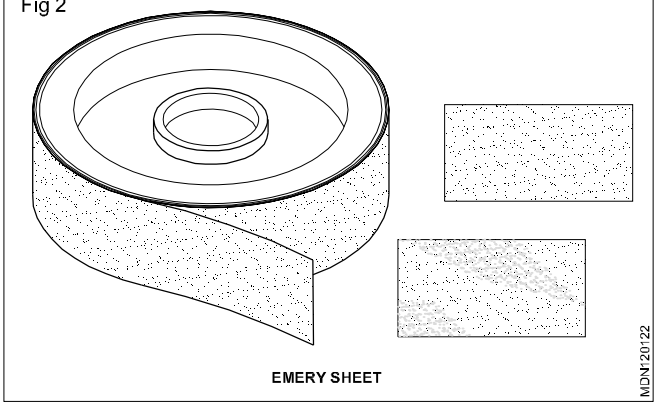
After cleaning with emery paper, component should be rinsed properly.

Fig 1



CLEANING TOOLS

Fig 2



EMERY SHEET

Scrapper

Objectives : At the end of this lesson you shall be able to
- **name the different type of scrappers**
- **state the features of each type of scrapper**
- **state the precaution to be observed while uses scrapper.**

Scraper is a hand tool which is used to scrap the workpiece surface by removing the smallest metal particles.

Application

It is used to obtain a smooth non scored and uniformly bearing surface which is required for sealing, sliding and guiding surface.

In automobiles it is used to remove carbon particles from cylinder head, piston head and manifold pipes

It is also used to scrap the bearings of cranks halt and sometimes the cylinder liner.

Type of scrapers

1. Flat scraper
2. Special scraper

Flat scraper

The cross section of this scraper is Flat. The cutting edge has Flat surface.

Use

It is used to scrap the high spots of a flat Surface

Special Scrapper

Special scraper is available for scraping and finishing curved surfaces.

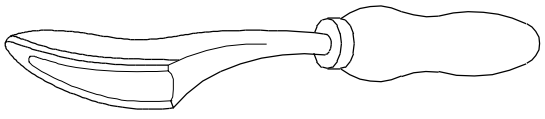
They are :

- half round scraper
- three-square scraper
- bull nose scraper

Half round scraper

The cross- section of this scraper is a segment and it tapers to a rounded point (Fig 1)

Fig 1

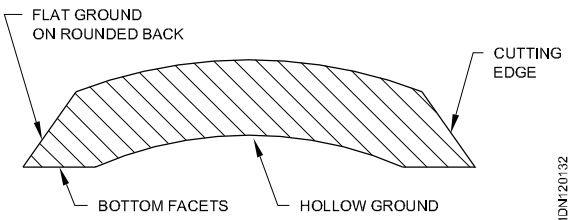


The round bottom face is curved and is hollow in the middle.

The bottom facet and the flat surfaces are ground along the edge to form the cutting edge. (Fig 2)

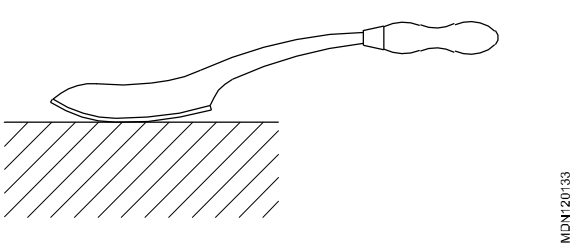
The cutting angle is between 45^0 and 65^0.

Fig 2



The curvature at the cutting edge helps to make point contact while scraping, and also helps to remove small spots. (Fig 3)

Fig 3

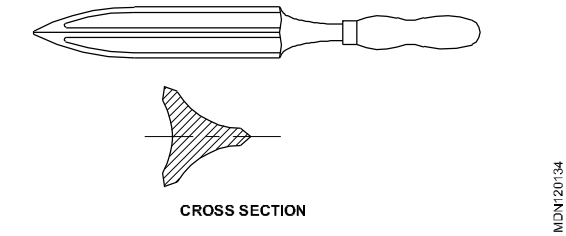


Three- square scraper (Fig 4)

This scraper is used for scraping small diameter holes and deburring the edges of holes.

The cross-section of this is triangular. This has more number of cutting edges and the hollow portion between the cutting edges helps in re-sharpening easily.

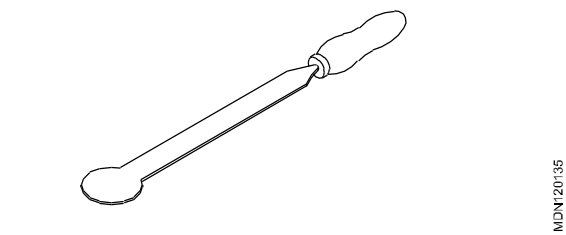
Fig 4



Bull nose scraper (Fig 5)

This scraper has the cutting edge shaped into a flat circular disc. The cutting edge forms about two thirds of the circle.

Fig 5



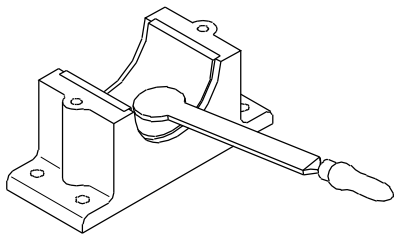
It is useful for scraping large bearings. (Fig 6) This scraper can be used in a longitudinal direction lika a flat scraper or with a circumferential movement like a half round scraper. This dual action helps to prevent ridges on the scraped surfaces.

Always use scrapers with firmly fitted handles.

Protect the cutting edges with a rubber cover when not in use.

Apply oil or grease on the cutting edges when not is use.

Fig 6



MDN120136

Surface plates

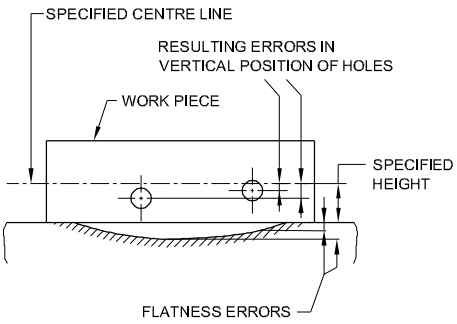
Objectives : At the end of this lesson you shall be able to

- **state the constructional features of surface plates**
- **state the application of different grades of surface plates**
- **specify surface plates and state the uses of marking tables.**

Surface plates - their necessity

When accurate dimensional features are to be marked or to be checked it is essential to have a datum plane with a perfectly flat surface. Marking using datum surfaces which are not perfectly flat will result in dimensional inaccuracies. (Fig 1) The most widely used datum surfaces in machine shop work are the surface plates and marking tables.

Fig 1



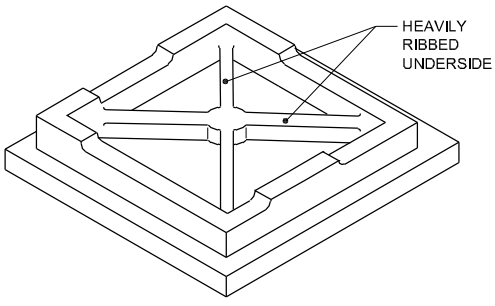
EFFECT OF MARKING-OUT FROM NON-FLAT SURFACE. NOTE THAT THE ERRORS IN THE HOLE POSITIONS ARE EQUAL TO THE FLATNESS ERRORS

MDN120141

Materials and construction

Surface plates are generally made of good quality cast iron which are stress-relieved to prevent distortion. The work-surface is machined and scraped. The underside is heavily ribbed to provide rigidity. (Fig 2)

Fig 2



CAST IRON SURFACE PLATE

MDN120142

For the purpose of steadiness and convenience in leveling. a three point suspension is given.

Smaller surface plates are placed on benches while the larger surface plates are placed on stands.

Other materials used

Granite is also used for manufacturing surface plates. Granite is a dense and stable material. Surface plates made of granite retain their accuracy, even if the surface is scratched. Burrs are not formed on these surfaces.

Classification and uses

Surface plates used for machine shop work are available in three grades - Grades 1, 2 and 3. The grade 1 surface plate is more acceptable than the other two grades.

Specifications

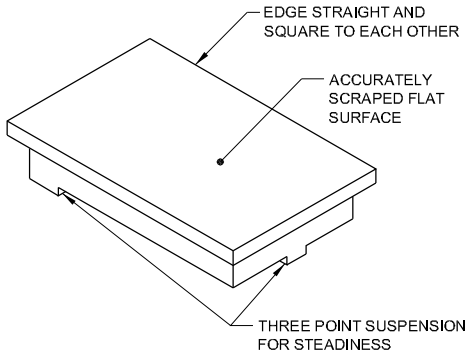
Cast iron surface plates are designated by their length, breadth, grade and the Indian Standard number.

Example

Cast iron surface plate 2000 x 1000 Gr1. I.S.2285.

Marking-off tables (Fig 3)

Fig 3



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These are heavily ribbed cast iron tables fitted with strong rigid legs. The top surface is accurately machined flat, and the sides square.

These are used for carrying out marking on heavy components. On certain types-parallel lines are engraved in both directions at a set distance.

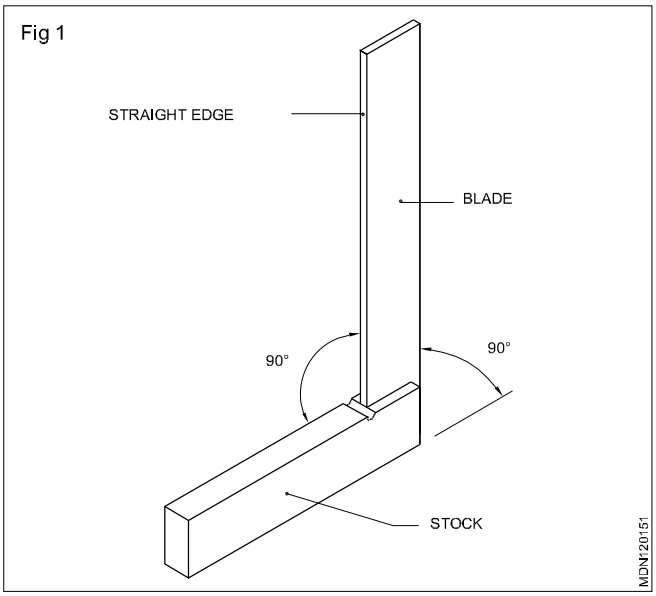
These lines serve as guides for positioning components while setting and marking.

Try square

Objectives : At the end of this lesson you shall be able to
- **name the parts of a try square**
- **state the uses of a try square.**

The try square (Fig. 1) is a precision instrument which is used to check squareness (angles of 90^0) of a surface.

Fig 1

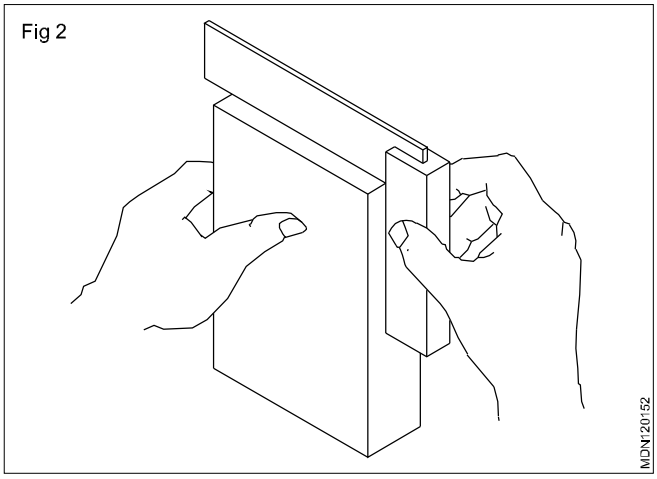


The accuracy of measurement by a try square is about 0.002 mm per 10 mm length, which is accurate enough for most workshop purposes. The try square has a blade with parallel surfaces. The blade is fixed to the stock at 90^0.

Uses

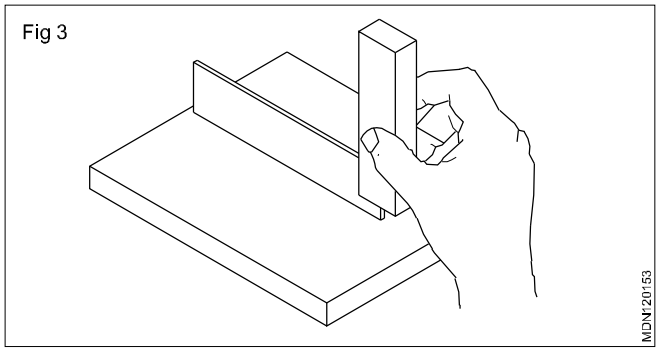
The try squareness is used (Figs 2 & 3)

Fig 2



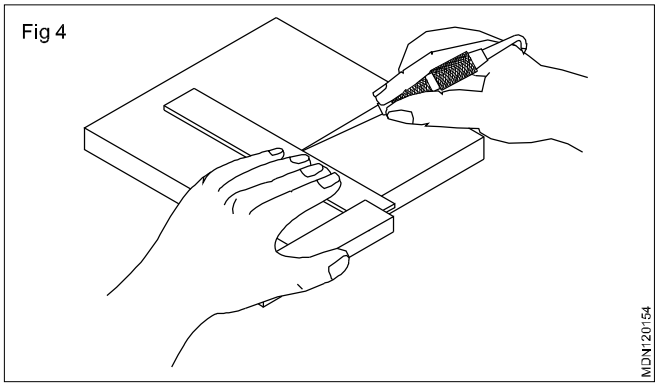
- check flatness of surfaces (Fig. 3)

Fig 3



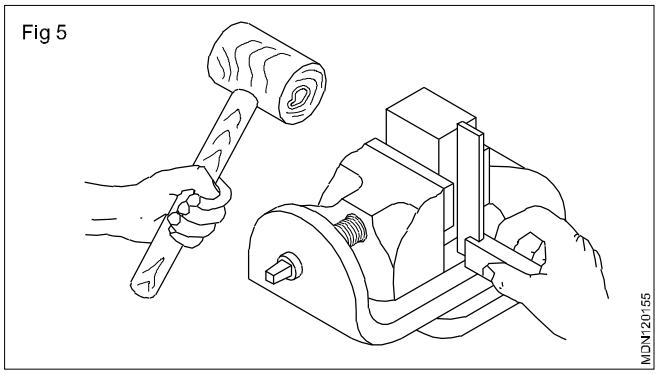
- mark lines at 90^0 to the edges of workpieces (Fig. 4)

Fig 4



- set workpieces at right angles on work. holding devices. (Fig. 5)

Fig 5



Try squares are made of hardened steel.

Try squares are specified according to the lengths of the blade, i.e 100 mm, 150 mm, 200 mm.

Use of a try square and steel rule.

Fig 6 shows the method of using a try square and a steel rule for accurate measurements.

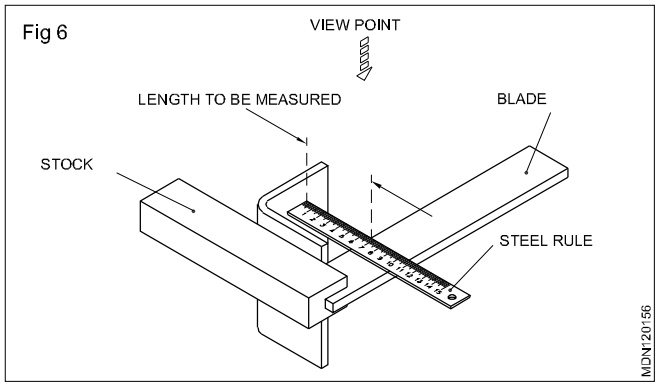
For maintaining accuracy it is important to see it, that the edges and surfaces of instruments are protected from damage and rust.

An experienced person can transfer measurements from a steel rule very accurately.

The steel rule graduations are accurately engraved, with the line thickness ranging from 0.12 to 0.18 mm.

Do not place a steel rule with any cutting tools. Apply a thin layer of oil when not in use.

For Accurate reading it is necessary to read vertically to avoid errors due to parallax



Types of calipers

Objectives : At the end of this lesson you shall be able to
- **name the commonly used calipers**
- **compare the features of firm joint and spring joint calipers**
- **state the advantage of spring joint calipers.**
- **state the uses of inside and outside calipers**

Calipers are simple measuring instruments used to transfer measurements from a steel rule to objects, and vice versa.

Calipers are of different types depending on the type of joint and the shape of leg.

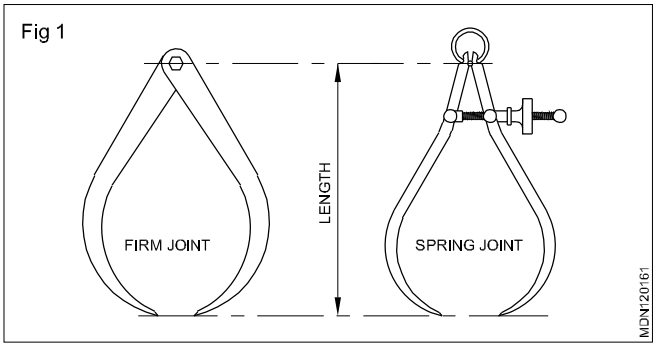
Types of joint

The commonly used calipers are:

- firm joint calipers
- spring joint calipers.

Firm Joint calipers (Fig. 1)

In the case of firm joint calipers, both legs are pivoted at one end. To take measurements of a workpiece. It is opened roughly to the required size. Fine setting is done by tapping the caliper lightly on a wooden surface.



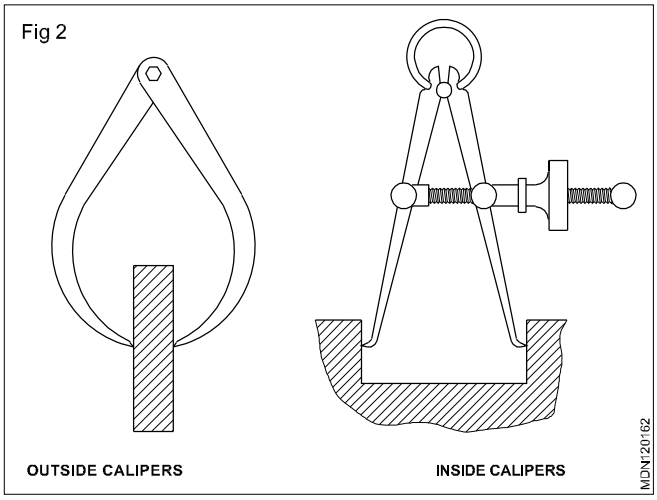
Spring joint calipers (Fig. 2)

For this type of calipers, the legs are assembled by means of a pivot loaded with a spring. For opening and closing the caliper legs, a screw and nut are provided.

Spring joint calipers have the advantage of quick setting. The setting made will not change unless the nut is turned.

The size of a caliper is specified by its length - which is the distance between the pivot centre and the tip of the leg.

The accuracy of the measurement taken depends very much on the sense of feel an touch. While measuring the job, you should get the feel when the legs are just touching the surface.



Types of legs

Outside and inside calipers are differentiated by the shape of the legs.

Calipers used for outside measurements are known as outside calipers. The calipers used be internal measurements are known as inside calipers.

Calipers are use along with steel rules, and the accuracy is limited to 0.5 mm; parallelism of jobs etc. can be checked with higher accuracy by using a caliper.

Jenny calipers

Objectives : At the end of this lesson you shall be able to
- **state the constructional features of jenny calipers**
- **name the types of jenny calipers**
- **state the uses of jenny calipers.**

Jenny calipers are used for marking and layout work.

These calipers are also known as hermaphrodite calipers, odd leg calipers, and leg and point calipers.

Jenny calipers have one leg with an adjustable divider point, while the other is a bent leg. The legs are joined together to make a firm joint.

USES

Jenny calipers are used for marking lines, parallel to inside and outside edges and for locating the centre of round bars.

These calipers are available with the usual bent leg or with a heel. The calipers, with ordinary bent legs, are used for drawing lines parallel along an inside edge, and the heel type is used to drawing parallel lines along outer edges (Figs 1 & 2).

The jenny calipers should be slightly inclined while scribing lines.

Fig 1

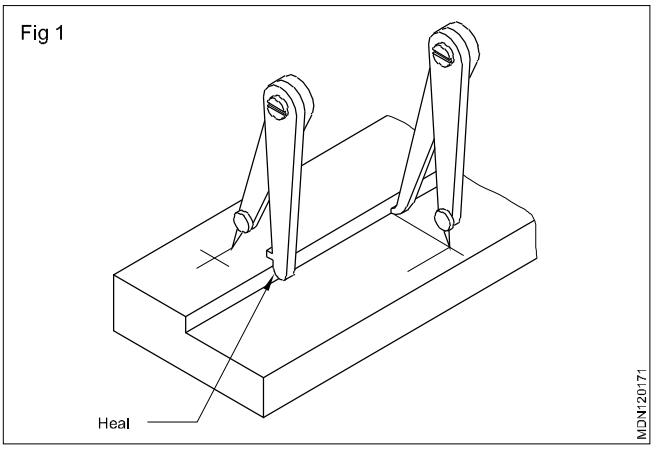
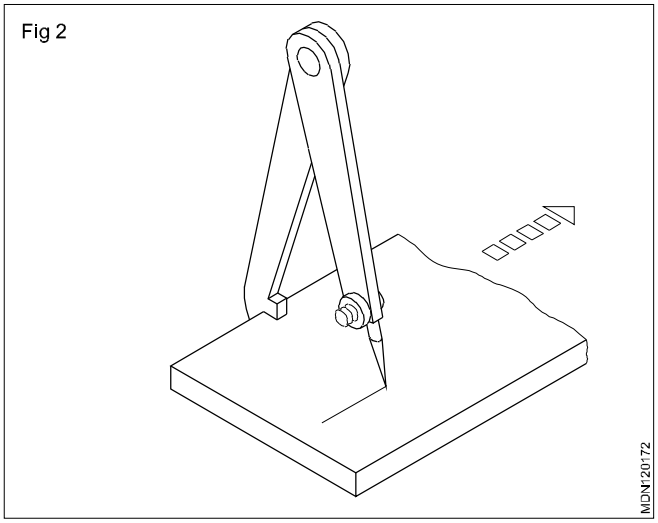


Fig 2



Jenny calipers can also be used for scribing lines along curved edges (Figs 3 & 4). While setting dimensions and scribing lines, both legs should be of equal length.

Fig 3

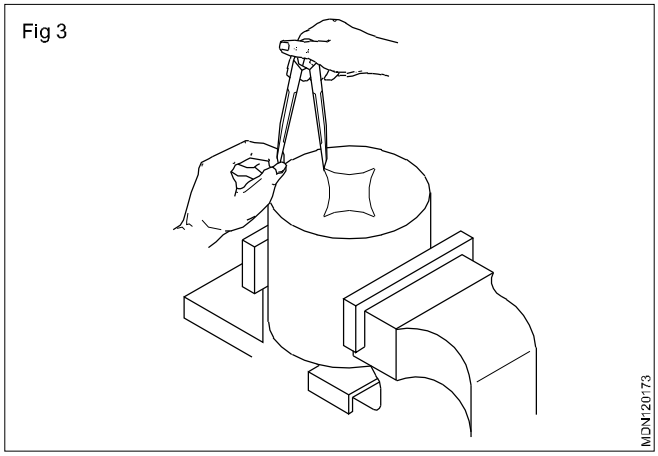
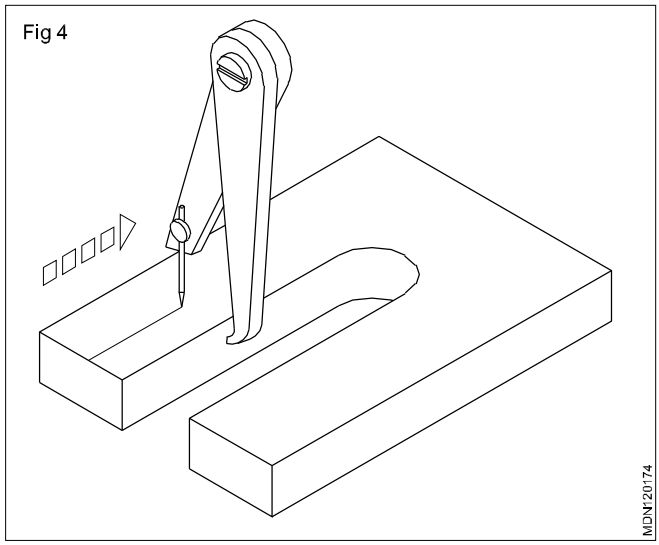
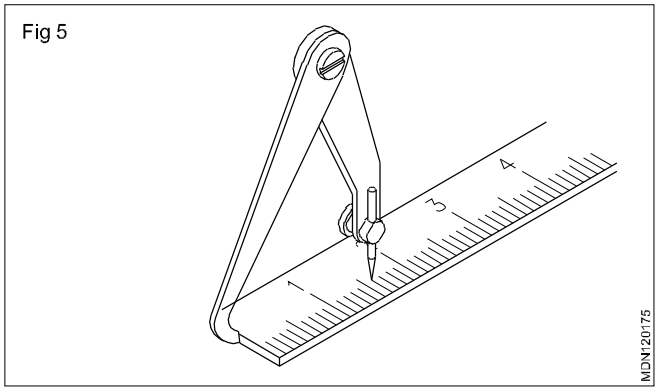


Fig 4



While setting dimensions for accurate setting the jenny caliper point should `click' into the graduation (Fig. 5).

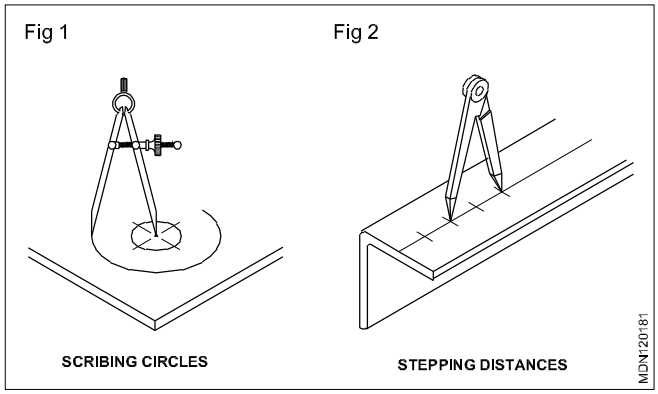
Fig 5



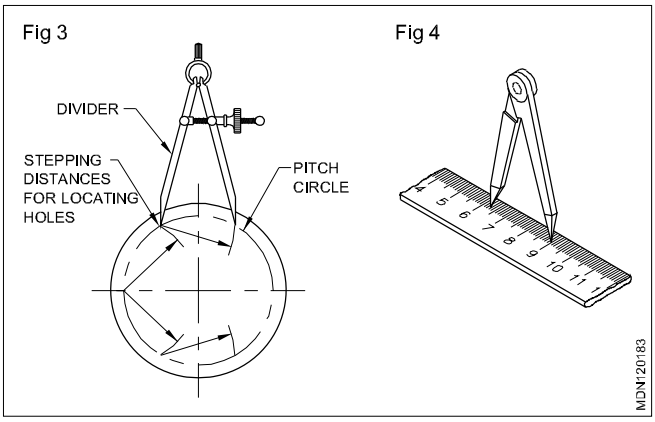
Dividers

Objectives : At the end of this lesson you shall be able to
- **name the parts of a divider**
- **state the uses of dividers**
- **state the specifications of dividers**
- **state the important aspects of be considered in respect of divider points.**

Dividers are used for scribing circles, arcs and transferring and stepping of distances. (Figs 1, 2 and 3)

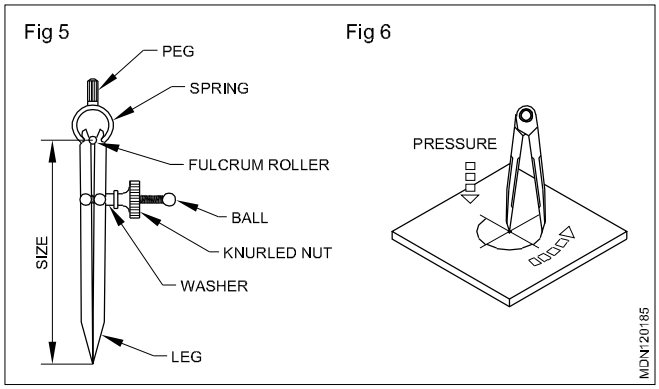


Dividers are available with firm joints and spring joints. The measurements are set on the dividers with a steel rule. (Fig 4)



The sizes of dividers range between 50 mm to 200 mm. The distance from the point to the centre of the fulcrum roller (pivot) is the size of the divider. (Fig 5)

For the correct location and seating of the divider legs, prick punch marks of 30° are used. (Fig 6)



Both the legs of the divider should always be of equal length.

Dividers are specified by the type of their joints and length.

The divider point should be kept sharp in order to produce timelines. Frequent sharpening with an oil stone is better than sharpening by grinding. Sharpening by grinding will make the points soft.

Do not sharpen the divider points on grinding wheels.

Surface Gauges

Objectives : At the end of this lesson you shall be able to
- **state the constructional features of surface gauges**
- **name the types of surface gauges**
- **state the uses of surface gauges**
- **state the advantages of universal surface gauges.**

The surface gauge is one of the most common marking tools used for.

scribing lines parallel to a datum surface

Types of surface gauges

- Surface gauges/scribing blocks are of two types.
- Fixed
- Universal (Fig. 1)

Surface gauge-fixed type (Fig. 2)

- setting jobs on machines parallel to a datum surface
- checking the height and parallelism of jobs
- setting jobs concentric to the machine spindle.

The fixed type of surface gauge consists of a heavy flat base and a spindle, fixed upright , to which a scriber is attached with a snug and a clamp-nut.

Fig 1

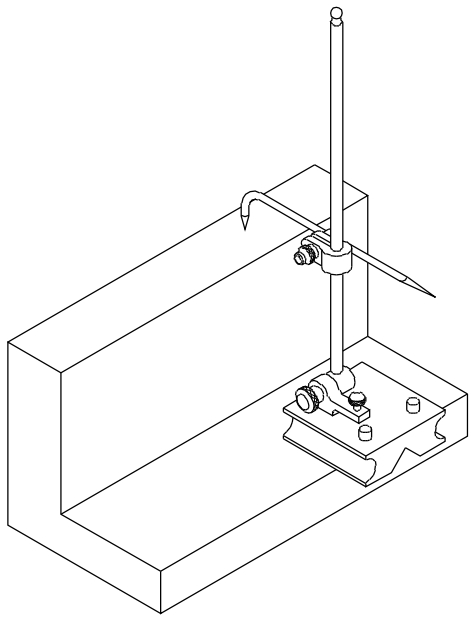


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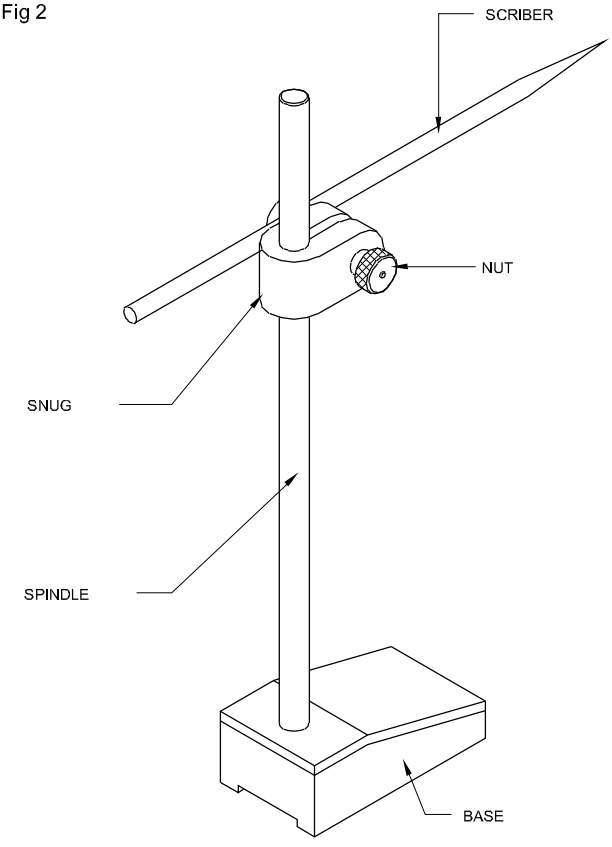
Fig 2



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Universal surface gauge (Figs 3 & 4)

This has the following additional features.

- The spindle can be set to any position.
- Fine adjustments can be made quickly.
- can also be used on cylindrical surfaces.

Fig 3

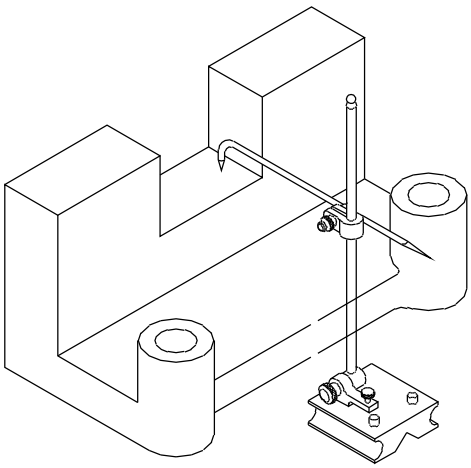

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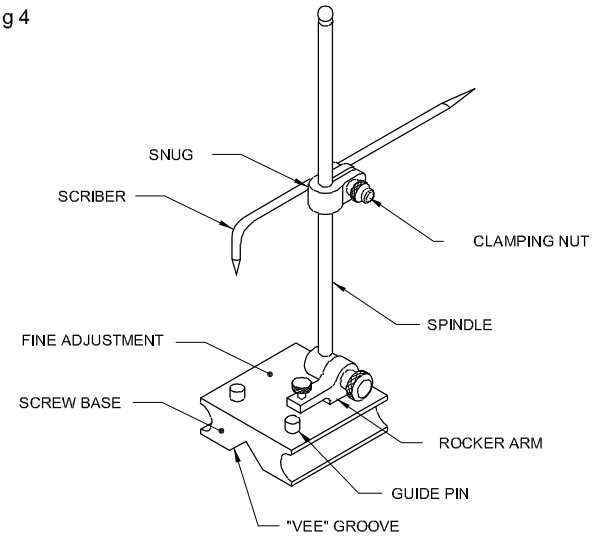
Fig 4



UNIVERSAL SURFACE GAUGE

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Scriber

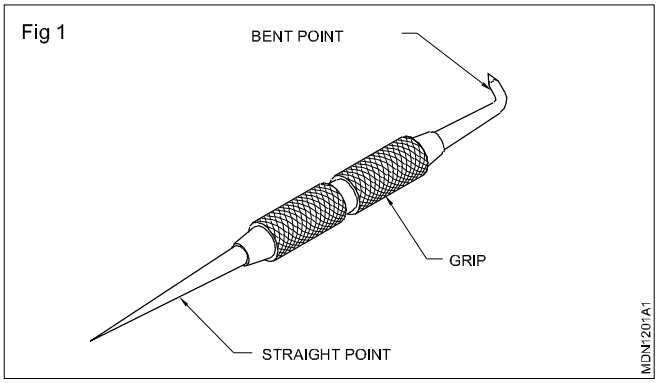
Objectives : At the end of this lesson you shall be able to
- **state the features of scribers**
- **state the uses of scribers.**

In layout work, it is necessary to scribe lines to indicate the dimensions of workpieces to be filed or machined .

The scriber is a tool used for this purpose. It is made of high carbon steel which is hardened. For drawing clear and sharp lines, a fine point is ground at one end.

Scribes are available in different shapes and sizes. The one most commonly used is the plain scriber (Fig. 1).

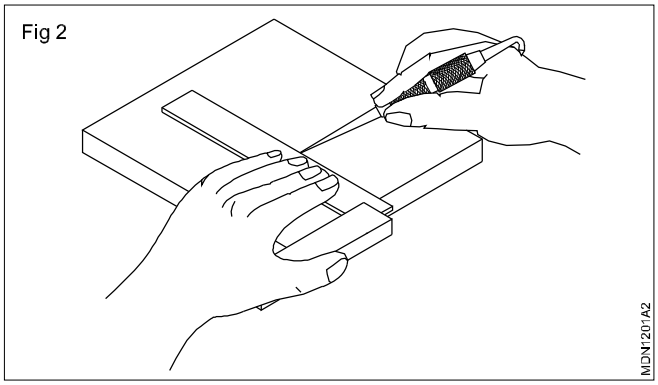
Fig 1



While scribing lines, the scriber is used like a pencil so that the lines drawn are close to the straight edge (Fig.2).

The point of the scriber should be ground and honed frequently for maintaining its sharpness.

Fig 2



Scriber points are very sharp, and they are to be handled very carefully. Do not put the scriber in your pocket. Place a cork on the point when not in use to prevent accidents.(when it is not in use)

Wheelbase, wheeltrack and measuring tape

Objectives: At the end of this lesson you shall be able to
- **define wheelbase**
- **define wheeltrack**
- **state measuring tape, its types and uses.**

The wheelbase of a vehicle equals the center distance between its front and rear wheels. (Fig 1)

Wheel/Track : The wheeltrack of a vehicle equals the center distance between its front wheels. As shown in the diagram. (Fig 4)

Measuring tape is a flexible ruler. It is made of ribbon cloth plastic fiber glass metal strip with lines for measurements. It is very common measuring tool used by many people. The available range are 3m, 5m and 10m.

Types

1. Plastic Tape (Fig 3)
2. Metal Tape (Fig 2)
3. Fibre glass
4. Ribbon cloth

Fig 1

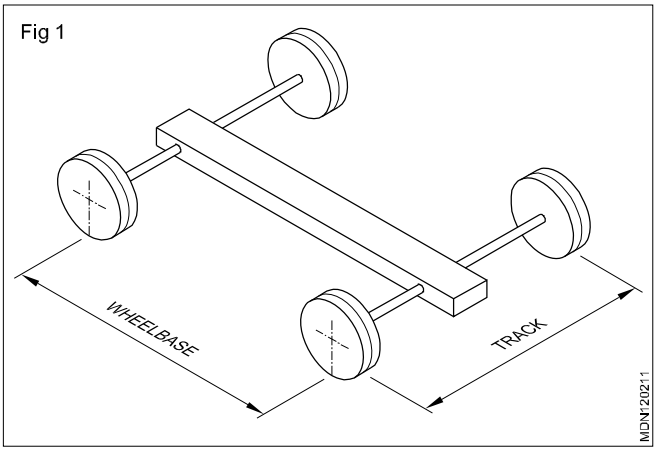


Fig 2

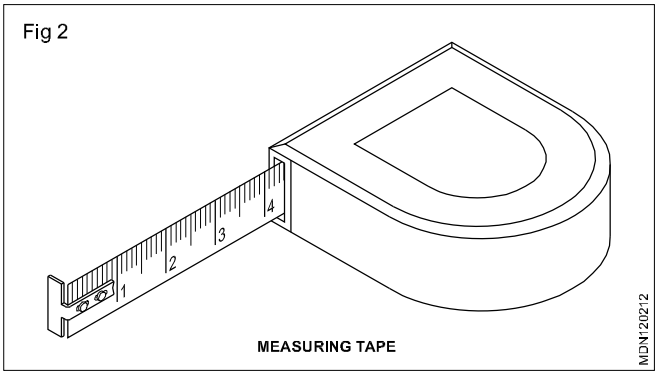


Fig 3

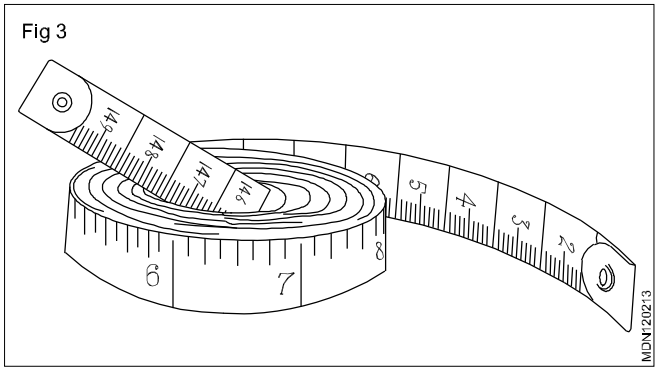
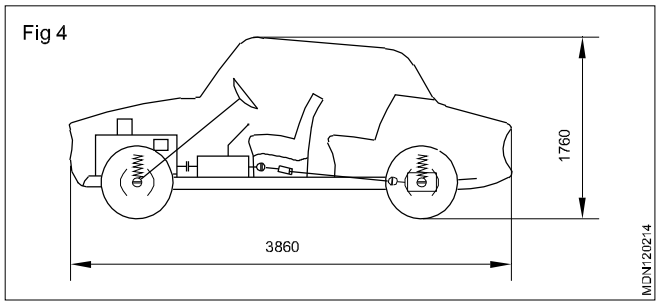


Fig 4



Application

Dress makers

Civil Engineers

Mechanical Engineers

Surveyors

Carpenters

Medical field

Accuracy

Measuring tapes are marks in metric and British system. The accuracy in metric system is 1mm and in British system is 1/8".

Limitation: Accouracy is not possible, because the tape is flexible and likely to elongate while measuring long ranges and distances.

Length measurement

Objectives: At the end of this lesson you shall be able to
- **name the base unit length measurement as per the International system of units of measurement (SI)**
- **state the multiples of a metre and their values.**

When we measure an object, we are actually comparing it with a known standard of measurement.

The base unit of length as per SI is the METRE Length SI UNIT and MULTIPLES

Base Unit

The base unit of length as per the System International is the metre. The table given below lists some multiples of a metre.

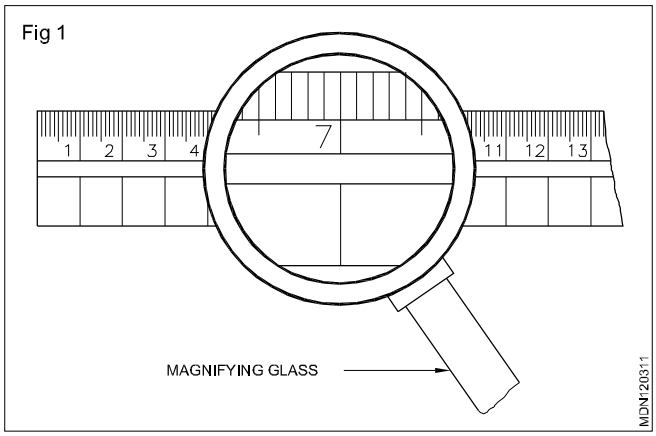
METRE (m)	=	1000 mm
CENTIMETRE(cm)	=	10 mm
MILLIMETRE (mm)	=	1000 mm
MICROMETRE (m)	=	0.001 mm

Measurement in engineering practice

Usually, in engineering practice, the preferred unit of length measurement is the millimetre (Fig. 1).

Both large and small dimensions are stated in millimetres

Fig 1



The British system of length measurement

An alternative system of length measurement is the British system. In this system, the base unit is the Imperial Standard Yard. Most countries, including Great Britain itself, have, however, in the last few years, switched over to SI units.

However in a regular Steel rule & in vernier caliper the main scale readings of metric in the bottom and imperial in inches in the top wih corrosponding vernier scales.

Engineer's steel rule

Objectives : At the end of this lesson you shall be able to
- **state the constructional features of an engineer's steel rule**
- **explain the uses of a steel rule**
- **state the maintenance aspects to be considered in respect of steel rules.**

When dimensions are given in a drawing without any indication about the tolerance, it has to be assumed that measurements are to be made with a steel rule.

Steel rule are made of spring steel or stainless steel. The edges are accurately ground to form straight edges.

The surface of the steel rule is satin-chrome finished to reduce glare, and to prevent rusting.

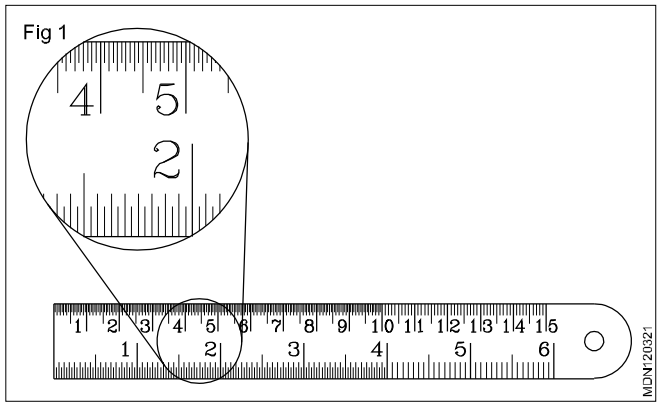
Sizes of steel rules (Fig. 1)

Steel rules are available in different lengts, the common sized being 150mm, 300 mm and 600 mm.

The engineer's steel rule is graduated in 10 mm, 5 mm, 1mm and 0.5 mm.

The reading accuracy of the steel rule is 0.5 mm.

Fig 1



Air impact wrench, air ratchet

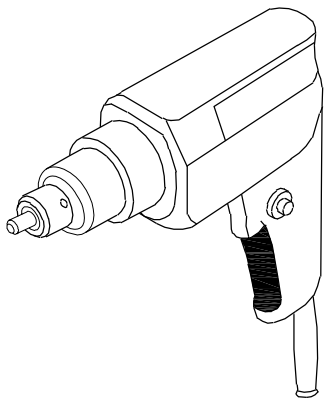
Objectives: At the end of this lesson you shall be able to
- **explain the use of air impact wrench**
- **explain the working principle of air impact wrench.**

Air impact wrench (Fig. 1)

Air Impact Wrench (also known as an impact or, Air Rattle Gun windy gun), Air wrench is a socket wrench power tool, which is used to deliver high torque. It works by storing energy in rotating mass and suddenly delivering it to output shaft.

Compressed Air is commonly used as the power source. Electric power can also be used as the source of power. cordless Electric devices are also used, and are very popular due to ease of working.

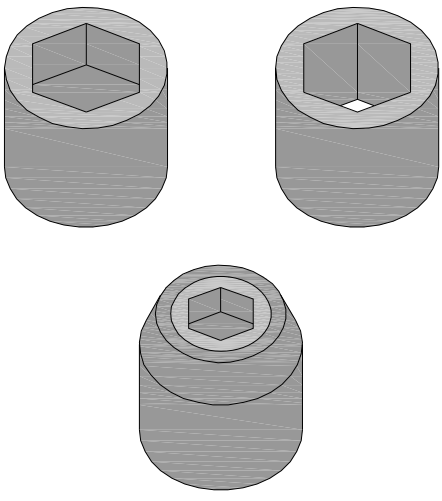
Fig 1



The Air impact wrench is to be used along with a specially hardened impact socket extension and joints to withstand sudden force.

Generally a special 6 inch pin socket is used with air impact wrench. (Fig. 2)

Fig 2



Air Ratchet (Fig.3)

An Air Ratchet is a quite identical to General ratchet wrench.

It is also having square drive at different sizes.

The socket drive is turned by a Air Motor. When we pull the trigger, Air motor gets activated it turns the socket drive.

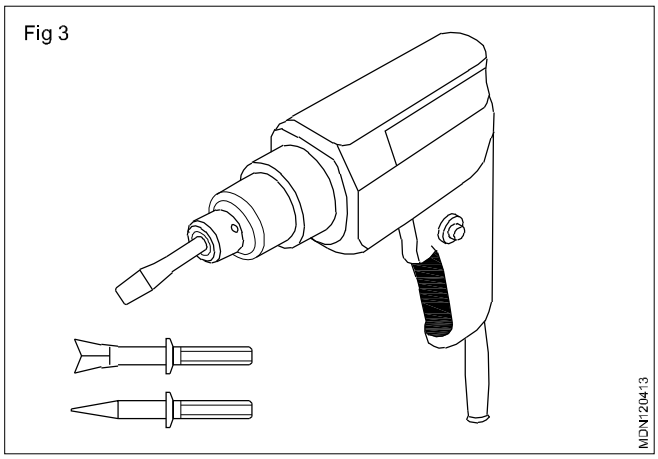
The direction of socket drive can be changed to clockwise (or) anti clockwise as per the user requirement.

Air Ratchet operates with more speed unless torque. In case where more torque is required we should use Air impact wrench.

Air Chisel

Air chisel is used for cutting the bolts to nuts of vehicle body sheet.

Fig 3



The compressed Air provides more force and much efficient than a hand chisel and Hammer.

Air chisel can be used with different types of chisel kit, depending upon the job.

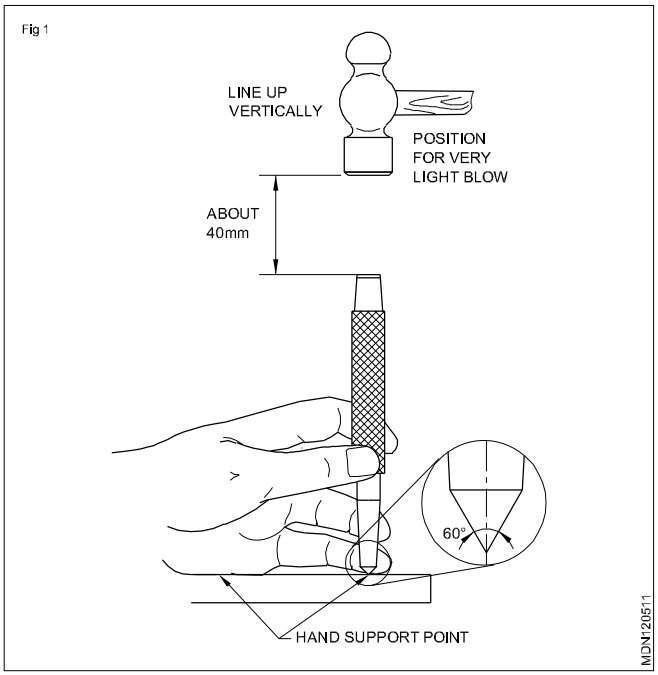
Hand tools

Objectives: At the end of this lesson you shall be able to
- **state the application of punches.**

Punches are used in sheet metals and other work to mark position on work. (Fig 1)

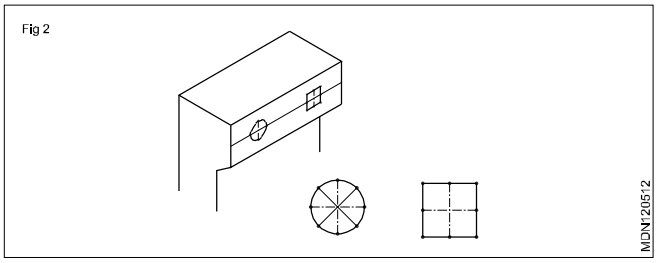
Prick punches

Fig 1



These punches are used to make witness marks on scribed lines. (Fig 2)

Fig 2



This makes it easier to see accurate marking out lines.

- to check the location of the centre positions before centre punching. (Fig 3)
- to locate the pivot points of compasses for scribing circles. (Fig 4)

A 100 mm prick punch with a 7 mm diameter body could have a 2.5 mm diameter point ground to an angle of 60° or 30°

Centre punches

These punches are similar to prick punch, and it is generally larger then prick punch.

A 100 mm centre punch could have a 10 mm diameter body and a 6 mm diameter point ground to an angle of 90°

Fig 3

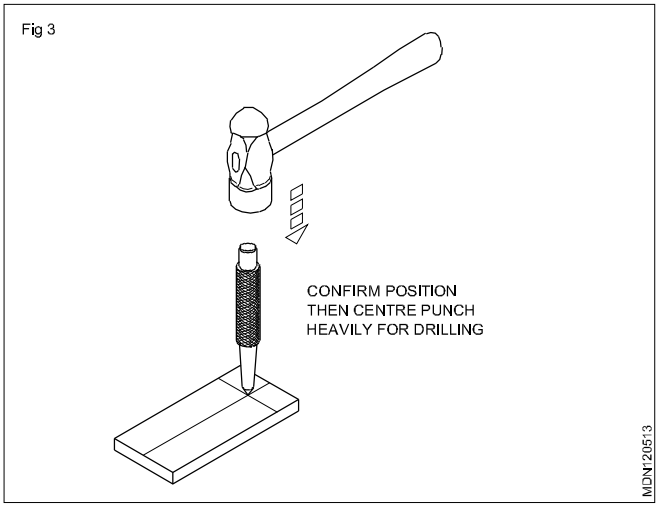
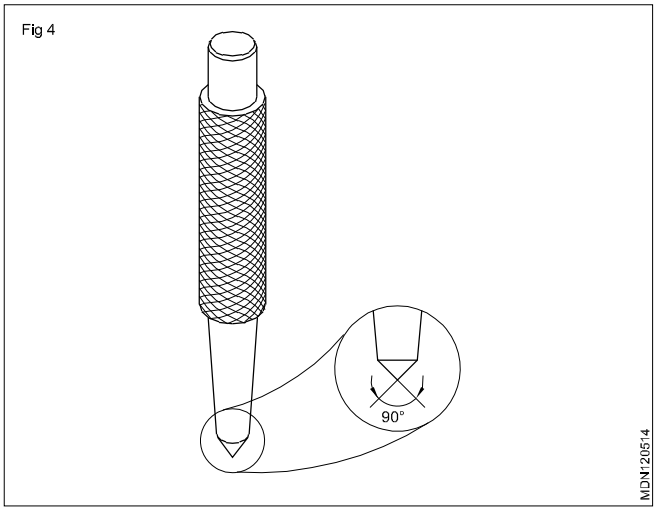


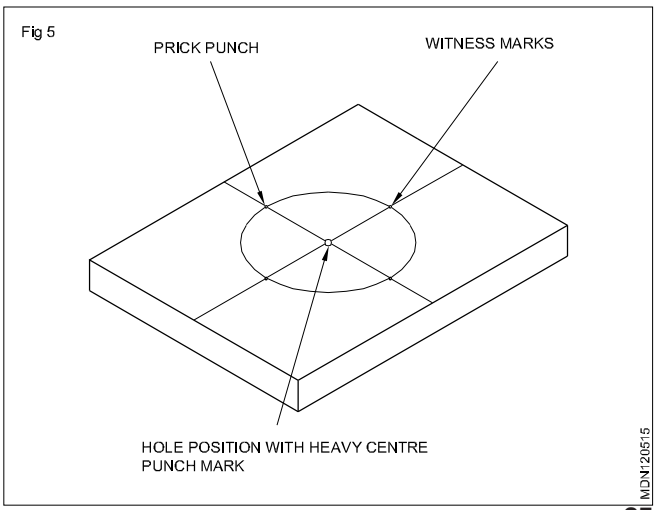
Fig 4



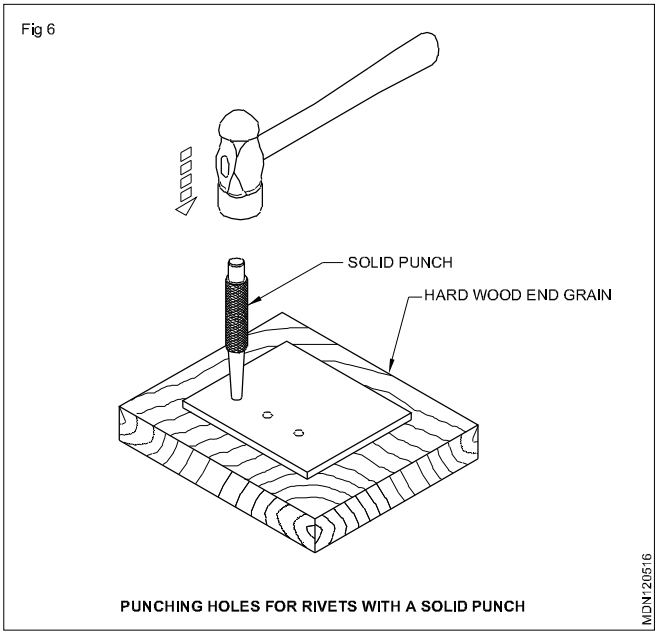
Centre punches are used:

- to make deeper witness marks on scribed lines and to locate a centre position and make it easier for the drill to start correctly. (Fig 5)

Fig 5



Solid punch (Fig 6)

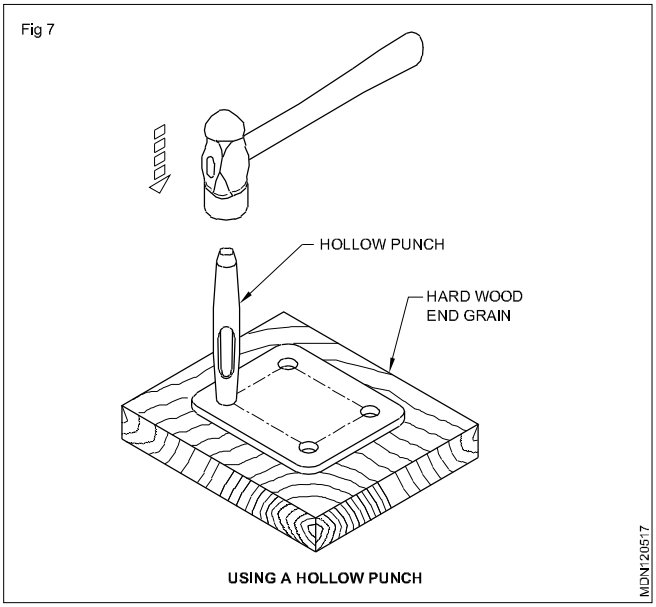


In riveting sheet metal, holes must be equally spaced and lined up. The holes in the metal are usually punched with solid punches.

Letter and number punches

Also known as letter stamps or number stamps, letter punches are used to emboss the impression of a letter of number into a workpiece. They are most common in the reverse image, this allows the end result to be immediately readable, however they may be made as a positive image. This is essential in the case of die or mold making and ensure that the finished product will be readable, as a die is a negative image.

Hollow punch (Fig 7)



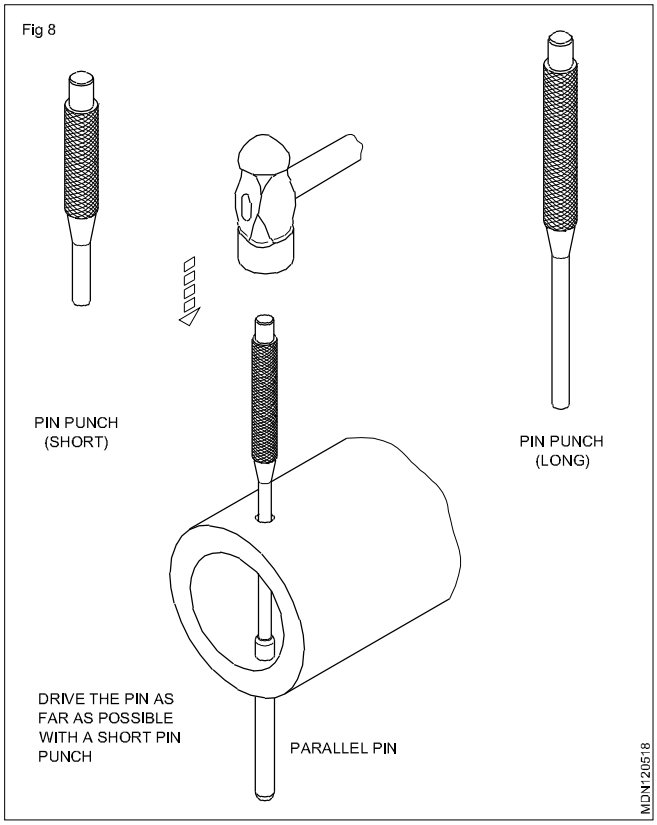
These punchase are also used to punch holes in thin sheet metal, leather, plastic cork etc. Gaskets, seals and spacers are made using hollow punches.

While using solid or hollow punches, the materials is rigidly supported with a block of wood (with the end of grain up) or lead. This will also avoid any damage to the tip of the punch while punching.

Pin punches (Fig 8)

Pin punches are used to drive locating or locking pins, dowels and rivets out of their holes.

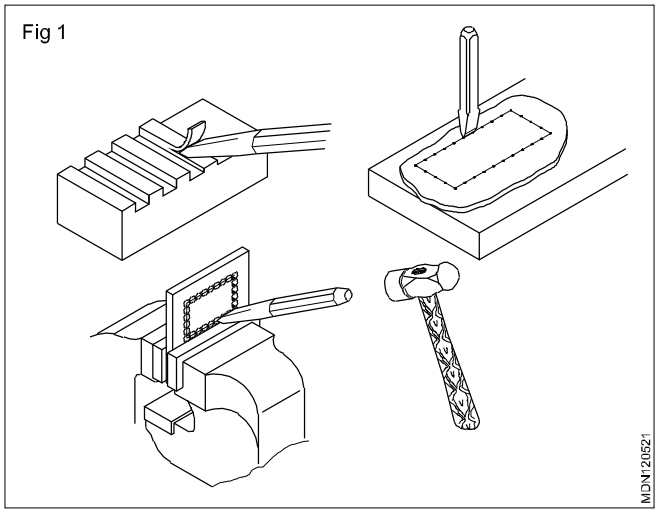
Pin punches are available in a set of 5 pins of dia.3,4,5,6 and 8 mm with a knurled body to a length of approximately 150 mm.



Chisel

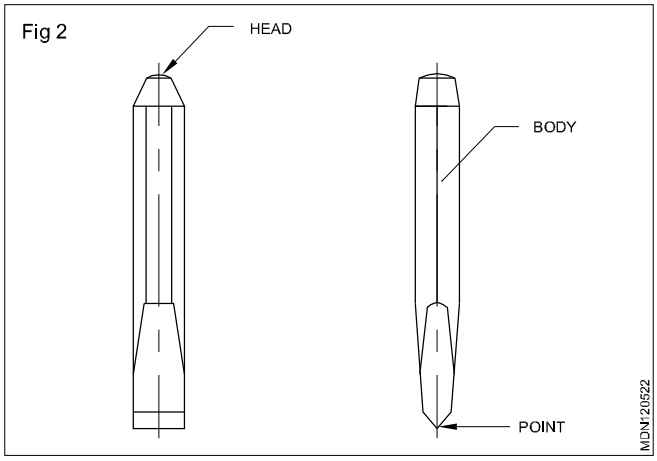
Objectives : At the end of this lesson you shall be able to
- **list the uses of a cold chisel**
- **name the parts of a cold chisel**
- **state the different types of chisels.**

The cold chisel is a hand cutting tool used by fitters for chipping and cutting off operations. (Fig. 1)



Chipping is an operation of removing excess metal with the help of a chisel and hammer. Chipped surfaces being rough, they should be finished by filing.

Parts of a chisel (Fig. 2)



A chisel has the following parts.

Head

Body

Point or cutting edge

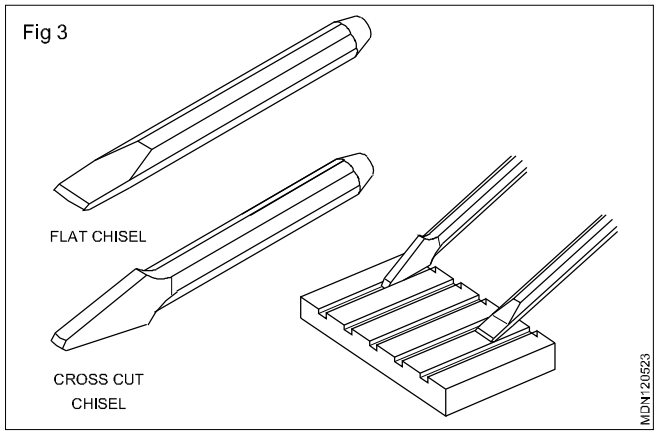
Chisels are made from high carbon steel or chrome vanadium steel. The cross-section of chisels is usually hexagonal or octagonal. The cutting edge is hardened and termpered.

Common types of chisels

There are four common types of chisels

- Flat chisel (1)
- Cross-cut chisel (2)
- Hall round nose chisel
- Diamond point chisel

Flat chisels (Fig. 3)



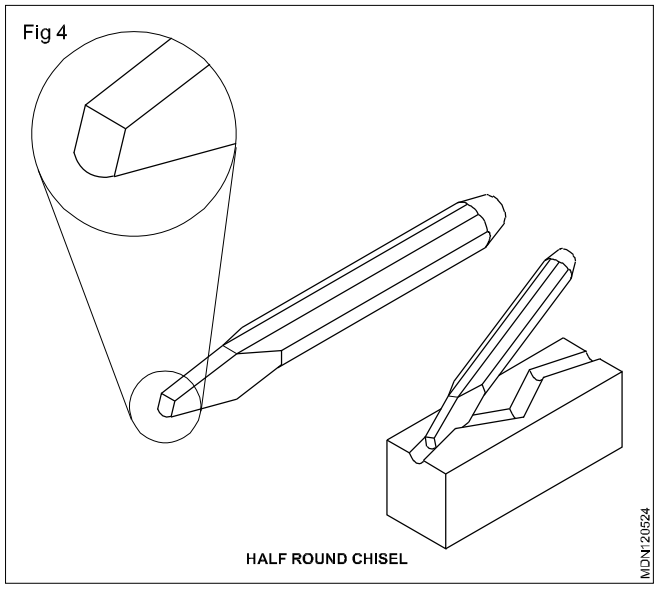
They are used to remove metal from large flat surfaces and chip excess metal of weld joints and castings.

Cross-cut or cape chisels (Fig. 3)

These are used for cutting keyways, grooves and slots.

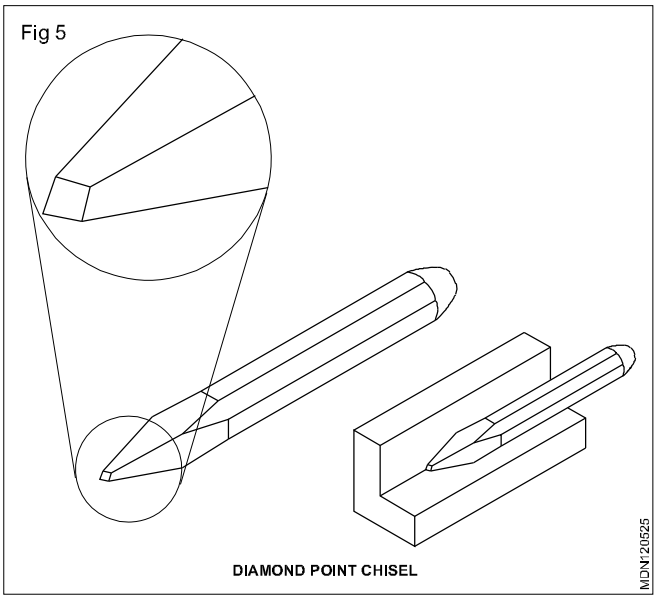
Half round nose chisels (Fig. 4)

They are used for cutting curved grooves (oil grooves)



Diamond point chisels (Fig. 5)

These are used for squaring materials at the corners.



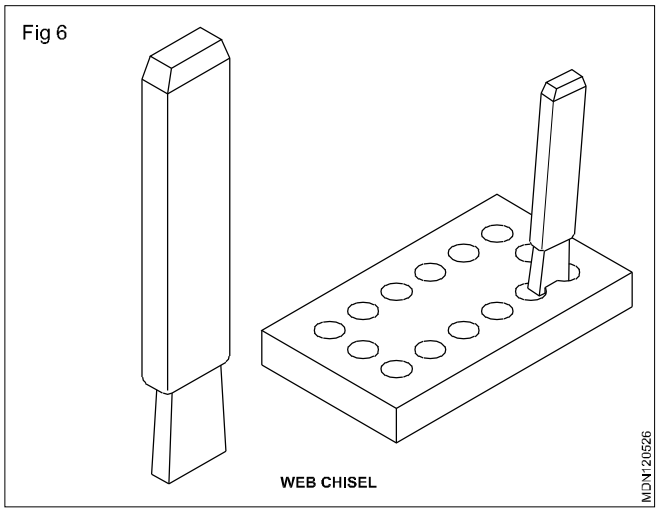
Web chisels/punching chisels (Fig. 6)

These chisels are used for separating metals after chain drilling.

Chilsels are specified according to their

- length
- width of cutting edge
- type
- cross-section of body

The length of the chisels ranges from 150mm to 400mm. The width of the cutting edge varies according to the type of chisels.



Angles of chisels

Objectives : At the end of this lesson you shall be able to

- **select the point angles of chisels for different materials.**
- **state the different cutting angles of a chisel**
- **state the effect of rake and clearance angles.**

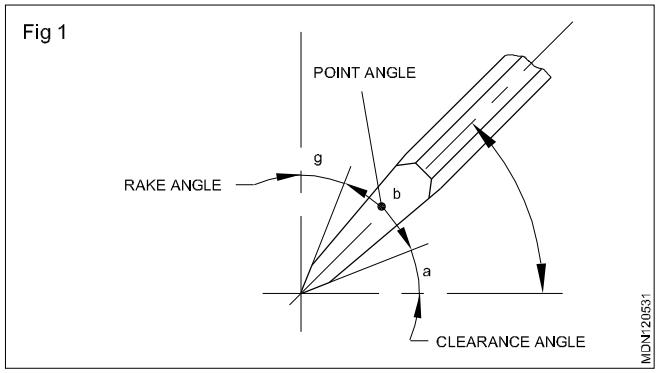
Point angles and materials (Fig 1)

Correct point/cutting angles of the chisel depends on the materials to be chipped. Sharp angles are given for soft materials, and wide angles for hard materials.

The correct point angle and angle of inclination generate the correct rake and clearance angles.

Rake angle (Fig. 1)

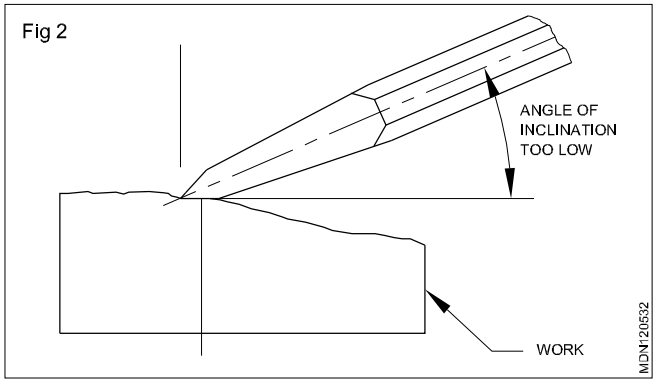
Rake angle `γ' is the angle between the top face of the cutting point, and normal to the work surface at the cutting edge.



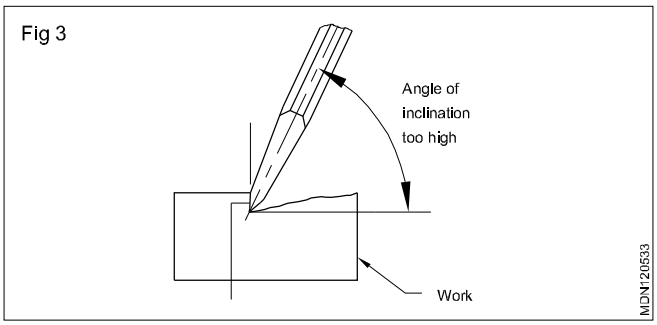
Clearance angle (Fig. 1)

Clearance angle `α' is the angle between the bottom face of the point and tangent to the work-surface originating at the cutting edge.

If the clearance angle is too low or zero (Fig. 2), the rake angle increases. The cutting edge cannot penetrate into the work. The chisel will slip.



If the clearance angle is too great (Fig. 3), the rake angle reduces. The cutting edge digs in, and the cut progressively increases.



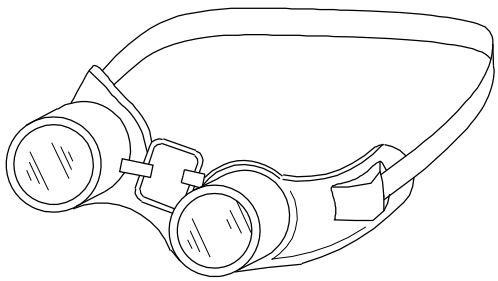
Material to be cut	Point angle	Angle Inclination
High carbon		
steel	65°	39.5°
cast iron	60°	37°
Mild steel	55°	34.5°
Brass	50°	32°
Copper	45°	29.5°
Aluminium	30°	22°

Chipping goggles (Fig. 4): It is used to protect the eyes while chipping the slag or grinding the job.

It is made of Bakelite frame fitted with clear glasses and an elastic band to hold it securely on the operator's head.

It is designed for comfortable fit, proper ventilation and full protection from all sides.

Fig 4



MDN120534

Hammers

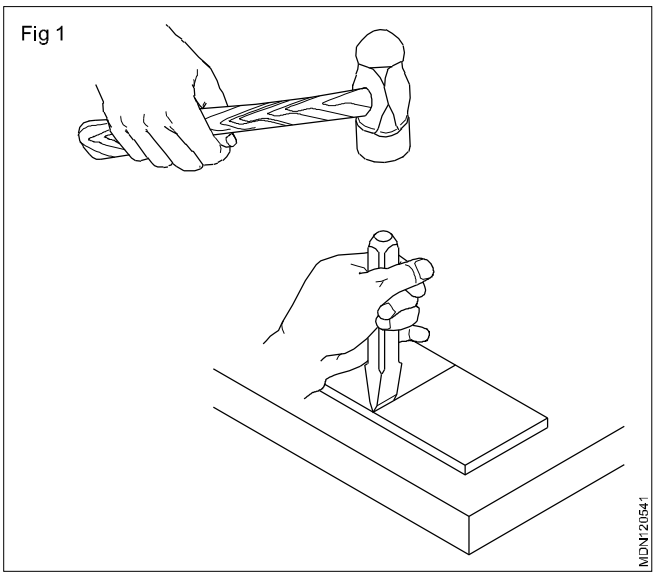
Objectives : At the end of this lesson you shall be able to

- **state the uses of an engineer's hammer**
- **list the parts of an engineer's hammer and state their functions**
- **name the types of engineer's hammers**
- **specify the engineer's hammer,**

An engineer's hammer (Fig. 1) is a hand tool used for striking purposes while

- punching
- bending
- straightening
- chipping
- forging
- riveting

Fig 1



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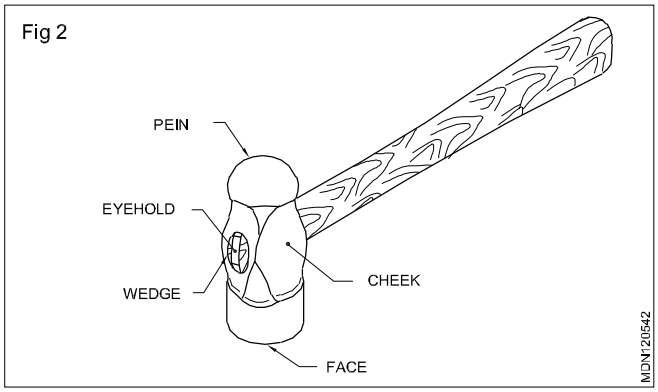
Major parts of a hammer (Fig. 2)

The major parts of a hammer are a head and a handle.

The head is made of drop-forged carbon steel, while the wooden handle must be capable of absorbing shock.

Fig 2



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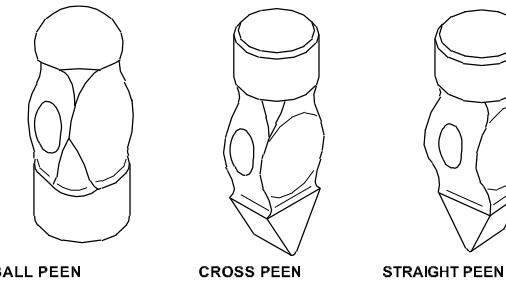
The parts of a hammer head are the

- face (1)
- pein (2)
- cheek (3)
- eyehole (4)
- wedge (5)

The face is the striking portion. Slight convexity is given to it avoid digging of the edge.

The pein is the other end of the head. It is used for shaping and forming work like riveting and bending. The pein is of different shapes like the (Fig. 3)

Fig 3



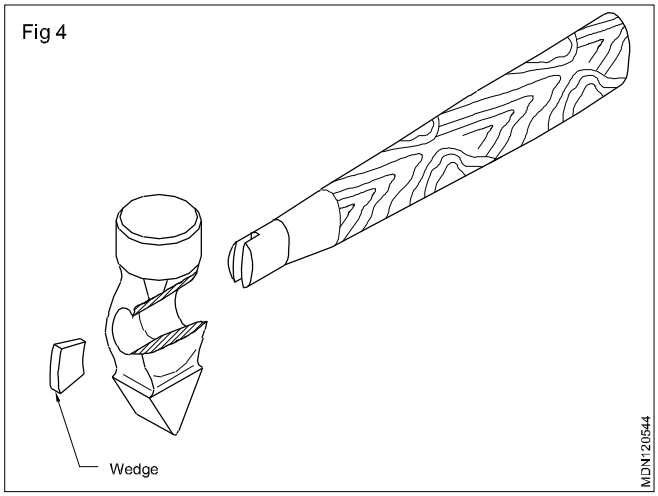
MDN120543

- ball pein
- crosspein
- straight pein

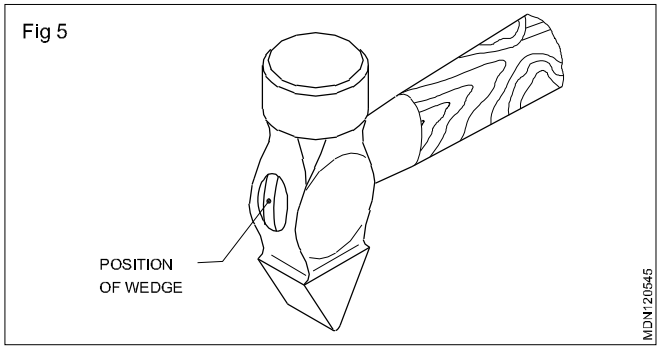
The face and the pein are hardened.

The cheek is the middle portion of the hammer-head. The weight of the hammer is stamped here.

This portion of the hammer-head is left soft.



An eyehole is meant for fixing the handle. It is shaped to fit the handle rigidly. The wedges fix the handle in the eye hole. (Fig 4,5)



Specification

An engineer's hammers are specified by their weight and the shape of the pein. Their weight varies from 125 gms to 1.5 kg.

The ball pein hammers are used for general work in a machine/fitting shop.

Before using a hammer

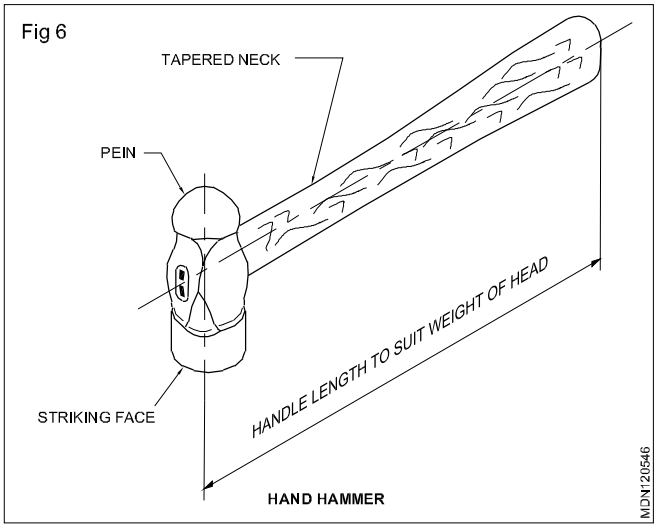
make sure the handle is properly fitted

select a hammer with the correct weight suitable for the job

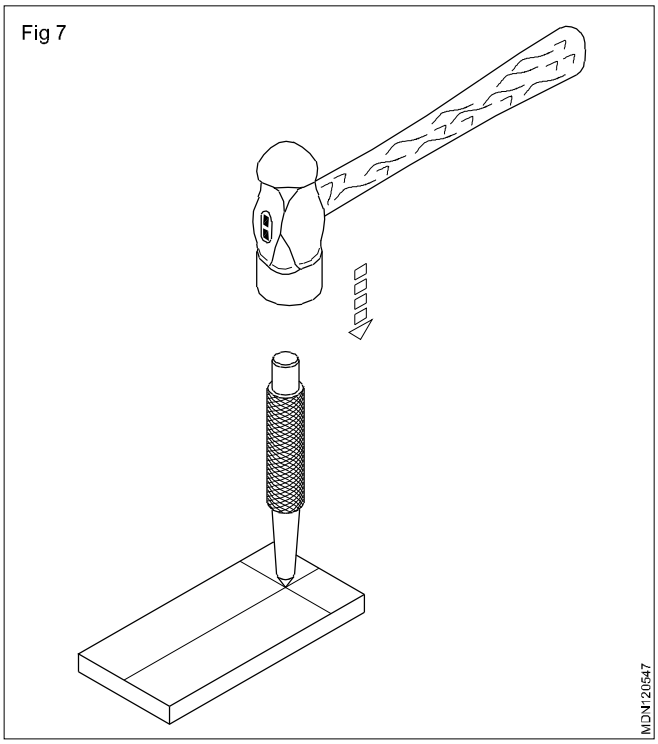
check the head and handle for any cracks

ensure the face of the hammer is free from oil or grease.

The figure shows the different parts of a hammer (Fig. 6). The handle is fitted in the eye-hole of the hammer.



The face of the hammer is used for general work, such as striking chisels and punches and levelling and working over joints. (Fig. 7)



Ball pein hammer (Fig. 8)

A ball pein head is used to spread metal in all directions.

This hammer has a semi-spherical pein suitable for riveting. (Fig. 9)

It is used for shaping the cylindrical end of a metal rivet to form a rivet head.

Cross pein hammer (Fig. 10)

A cross pein head is used to spread metal in one direction in the line of striking.

This has a blunt wedge-shaped pein at right angles to the axis of the handle.

Fig 8

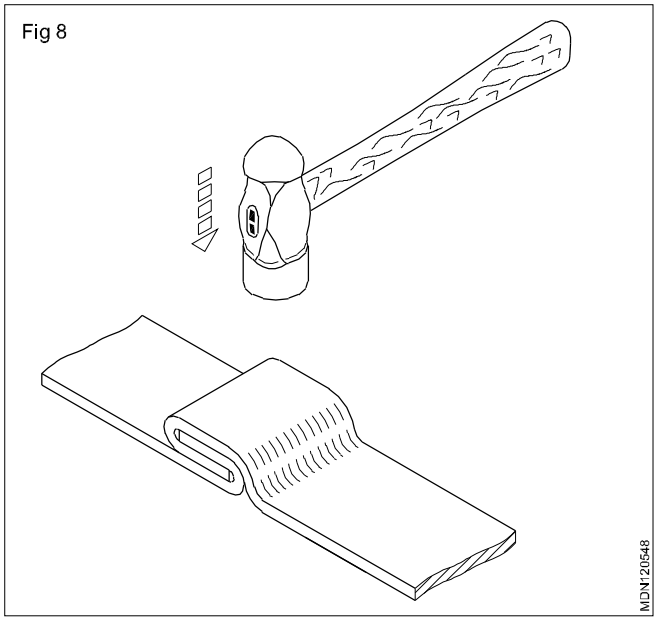


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Fig 9

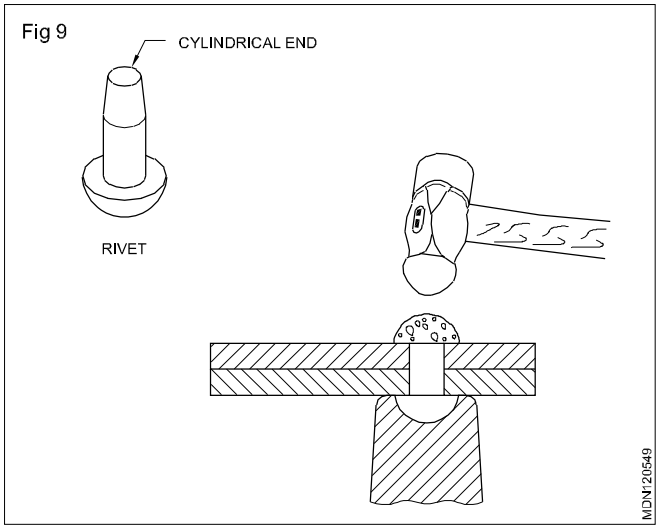

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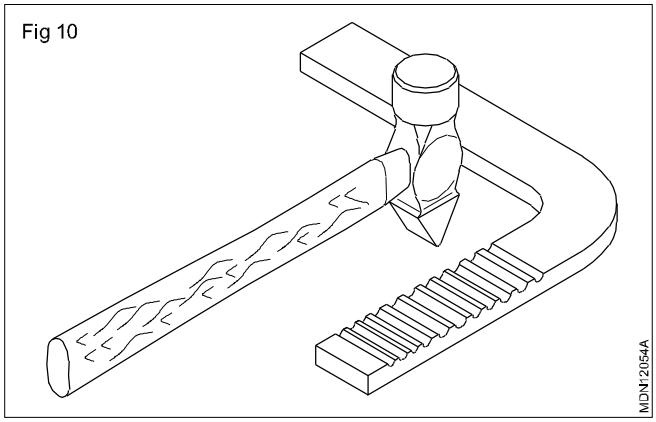
Fig 10



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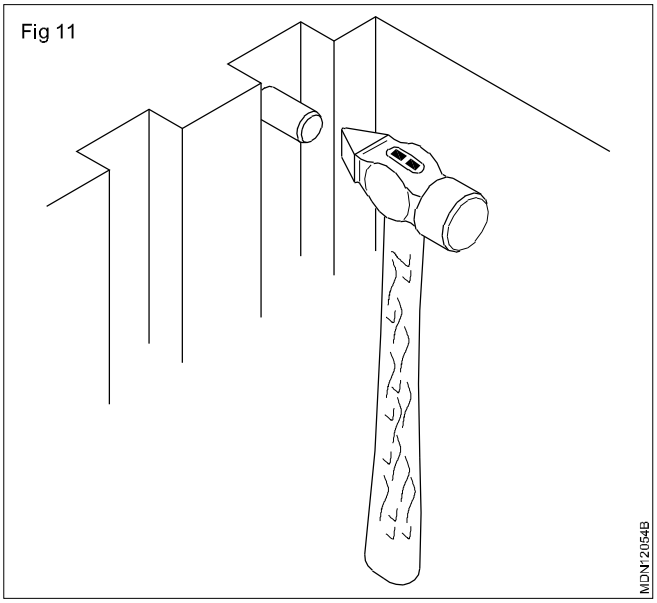
Straight pein hammer

A straight pein hammer is used to spread metal in one direction at right angles to the line of striking (Fig. 11)

Fig 11



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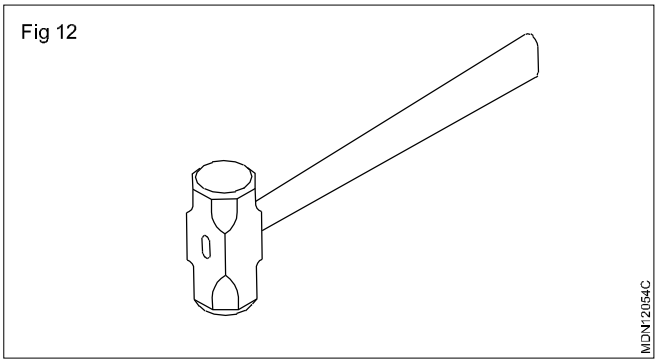
This hammer has a blunt wedge-shaped pein in line with the axis of the handle.

A lump hammer or club hammer is a small sledgehammer (Fig. 12) whose relatively light weight and short handle allow single-handed use. It is useful for light demolition work, driving masonry nails, and for use with a steel chisel when cutting stone or metal. In this last application, its weight drives the chisel more deeply into the material being cut than lighter hammers.

Fig 12



MDN120544C

Wooden Mallet

Objectives : At the end of this lesson you shall be able to
- **name the different types of mallets**
- **state the uses of each type of mallets.**

Mallets

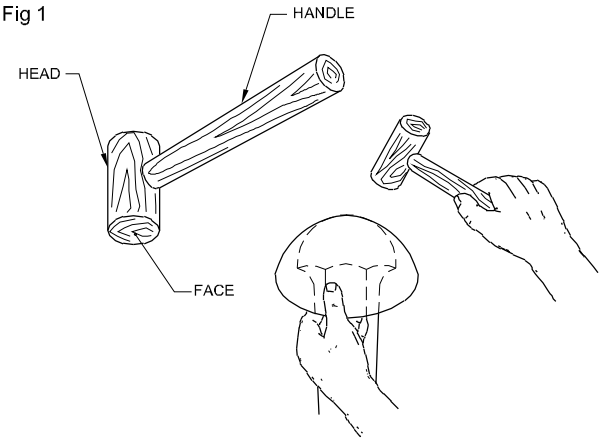
Mallets are soft hammers and are made of raw hide, hard rubber copper, brase, lead or wood, and are used to strike a soft and light blow on the metal.

Types and uses

Standard wooden mallets (Fig. 1) are used for general purpose work like flattening, bending etc.

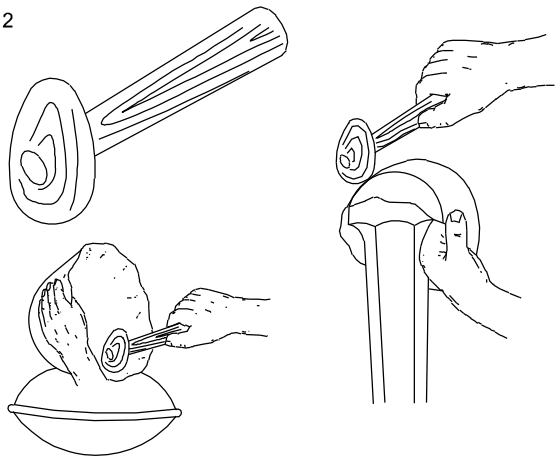
Bossing mallets (Fig. 2) are used for hollowing panel beatings etc.

Fig 1



STANDARD WOODEN MALLET

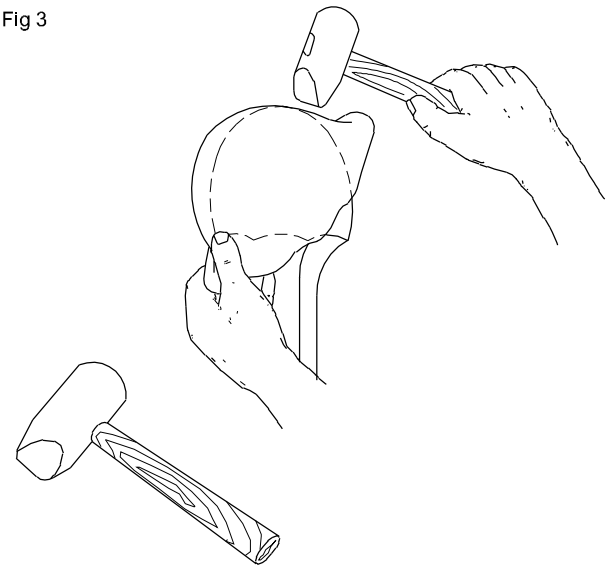
Fig 2



SHAPING THE HEMISPHERICAL BOWL BY RAISING BOSSING MALLET

An end-faked mallet (Fig. 3) is used for stretching, hammering etc.

Fig 3



Screwdrivers

Objectives : At the end of this lesson you shall be able to

- **classify the hand-held screwdrivers**
- **state the features of standard screwdrivers**
- **list out the different types of special screwdrivers and their specific uses**
- **specify standard screwdrivers.**

Screwdrivers are used to tighten or loosen screws which are fixed in the machine element.

Classification

- Standard type with tips to suit recessed head screw slots.
- Special type with tips to suit recessed head screws

Features of Standard screwdrivers (Fig. 1)

Screwdrivers must have:

- tips (1) of turn screws with slotted heads
- handles of metals, wood or moulded insulating material(2), shaped to give a good grip for turning (3).
- blades of hardened and tempered carbon steel or alloy steel
- round or square blade with length (4) ranging from 40mm to more than 350mm.
- flared tips which vary in length and thickness with the length of the blade.

Standard Screwdrives

Standard screwdrivers are classified as:

- heavy duty screwdrivers
- light duty screwdrivers
- stumpy screwdrivers

Heavy duty screwdrivers (Fig 2 & 3)

This screwdriver has a square blade for applying extra twisting force with the end of the spanner. Heavy duty screwdrivers of London pattern have a flat blade and are mostly used by carpenters.

Fig 1

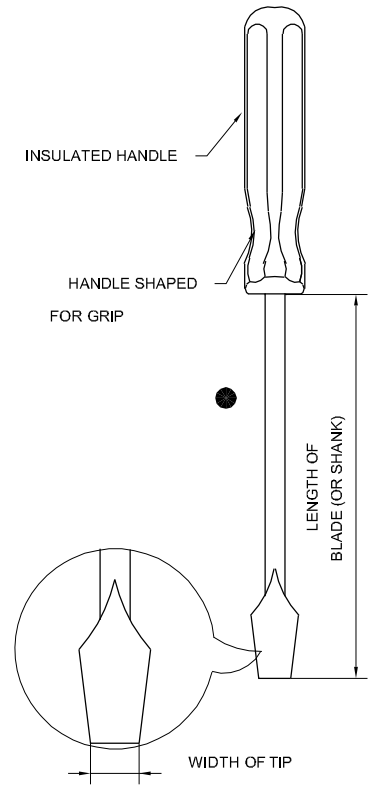


Fig 2

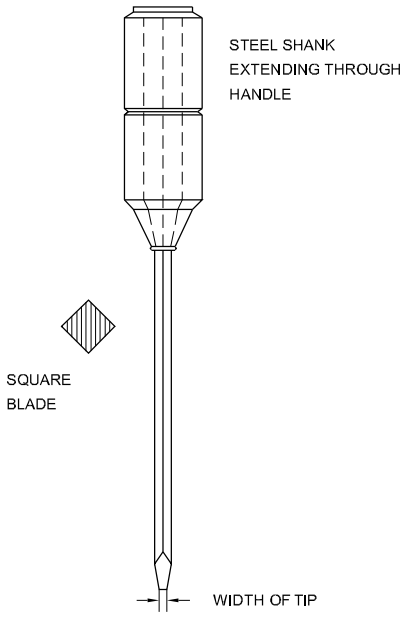
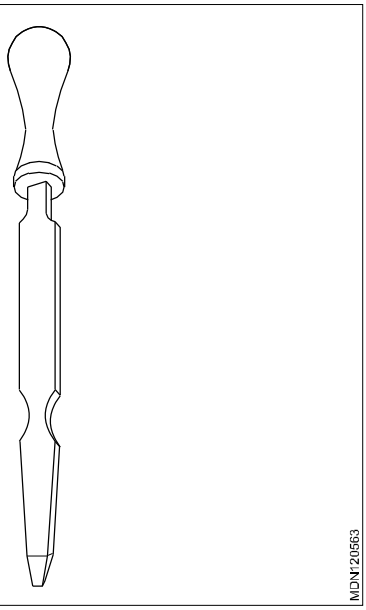


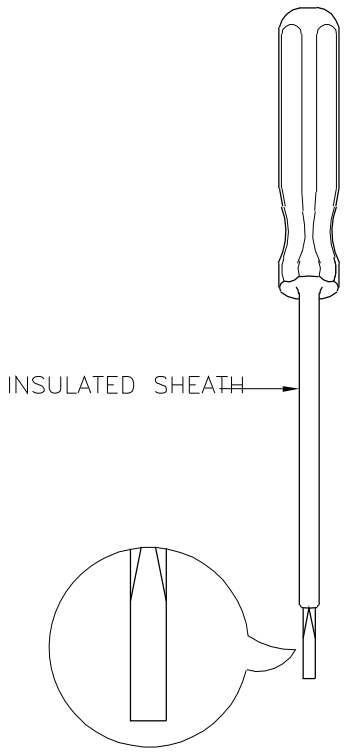
Fig 3



Light duty screwdrivers (Fig. 4)

This screwdriver has a round blade with parallel tips. This screwdriver is used by electricians. The blades are sheathed in insulation to avoid short circuting live parts.

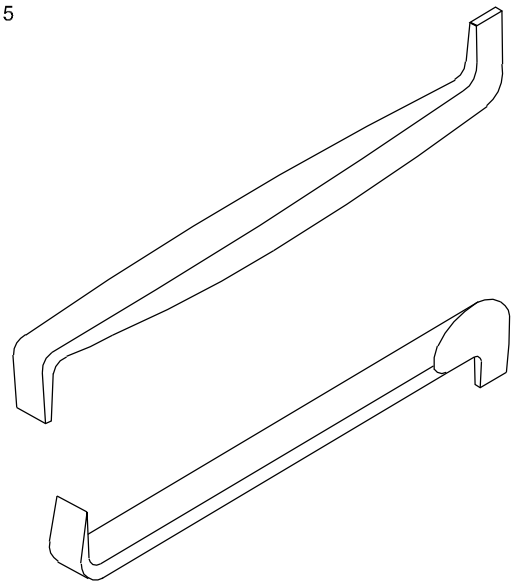
Fig 4



Stumpy screwdrivers (Fig. 5)

These are small sturdy screwdrivers. They are used when other types of screwdrivers cannot be used due to the space limitations.

Fig 5



MDN120565

Special screwdrivers and their uses

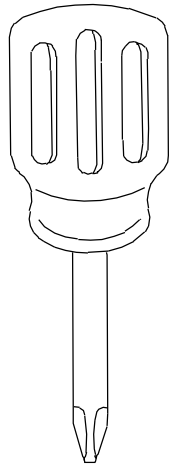
Offset screwdriver (Fig. 6)

Offset screwdrivers are used on screws which are placed in blind spaces.

They are made with short blades and with the tips at right angle.

Greater turning force can be applied on screws by these screwdrivers because of their leverage.

Fig 6



STUMPY SCREW DRIVER

MDN120566

Ratchet screwdriver (Fig. 7)

The following are the features of ratchet screwdrivers.

These screwdrivers are made with a three-position ratchet contol for screwing, unscrewing of a screw and also providing a neutral position.

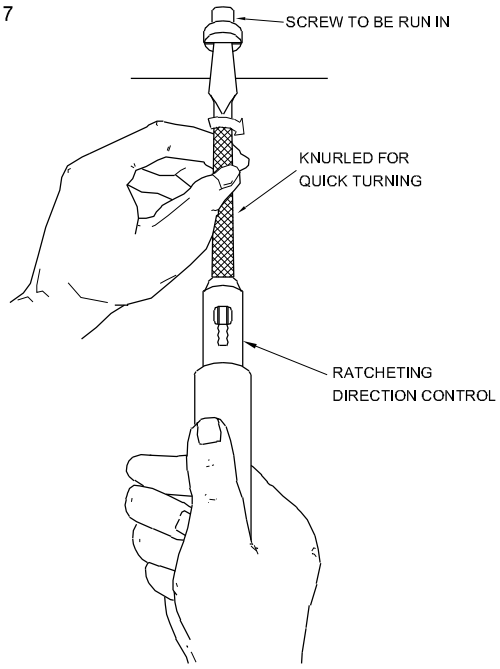
They are used for tuning screws in confined spaces.

They can be operated without changing the hand grip.

They are used for slackening or tightening with a medium force.

They are used in mass production.

Fig 7



RATCHET SCREWDRIVER

MDN120567

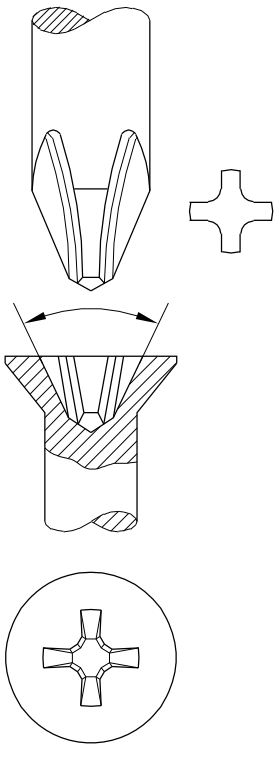
Phillips (cross-recess) screwdrivers (Fig. 8)

Phillips screwdrivers have cruciform or cross-shaped tips that are unlikely to slip from the cruciform slots in Philips recessed head screws.

The end of the four flats is tapered to an angle of 53°

The extreme end is ground to 110°.

Fig 8



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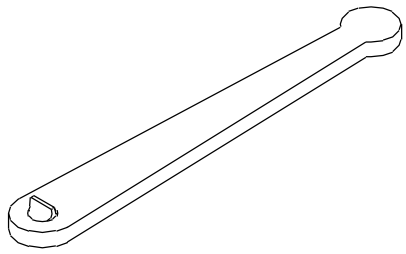
Four different sizes to cover the full range of screws are available. These are specified by point sizes 1,2,3 & 4 which correspond to the size of the Phillips screw heads.

For quicker application ratchet offset screwdrivers are also available with renewable tips. (Fig. 9)

Fig 9



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Specification

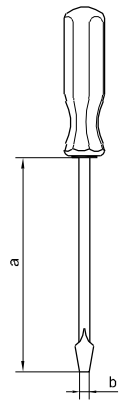
Screwdrivers are specified (Fig. 10) according to the

- length of the blade (a)
- width of the tip (b).

Normal blade length : 45 to 300mm. Width of blade : 3 to 10mm.

The blades of screwdrivers are made of carbon steel or alloy steel, hardened and tempered.

Fig 10

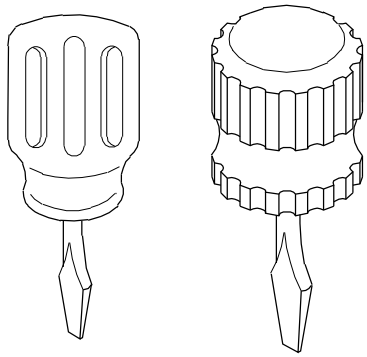


MDN12056A

Screwdrivers for special uses

Small sturdy screwdrivers (Fig. 11) are available for use where there is limited space.

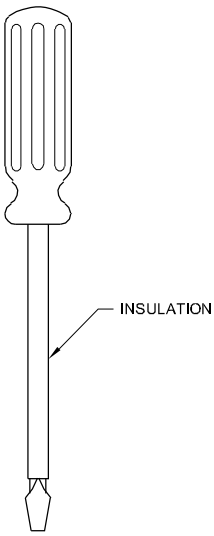
Fig 11



MDN12056B

Screwdrivers with blades sheathed in insulation are available for the use of electricians (Fig. 12)

Fig 12

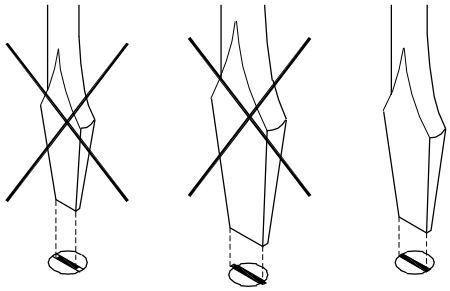


MDN12056C

Precautions

Use screwdrivers with tips correctly fitting into the screw slot. (Fig. 13)

Fig 13



MDN12056D

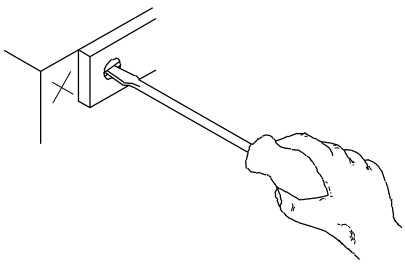
Make sure your hand and the handle are dry.

Hold the screwdrivers axis in line with the axis of the screw.

While using a Philips screwdriver apply more downward pressure.

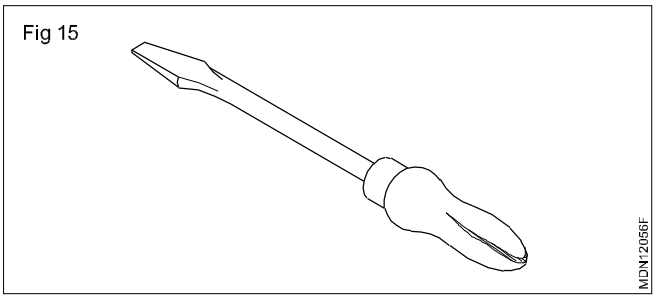
Keep your hand away to avoid injury due to slipping of the screwdriver. (Fig. 14)

Fig 14



MDN12056E

Do not use screwdrivers with split or defective handles. (Fig. 15)



In the case of damaged screwdrivers, the blades can be ground (the faces will be parallel with the sides of the screw slot) and used. While grinding ensure the end of the tips is as thick as the slot of the screw.

While using screwdrivers on small jobs, brace the job on the bench or hold them in a vice.

Specification of a screwdriver

Screwdrivers are specified according to the

- length of the blade
- width of the tip

The normal blade length varies from 45mm to 300mm and the width of the blade varies from 3mm to 10mm.

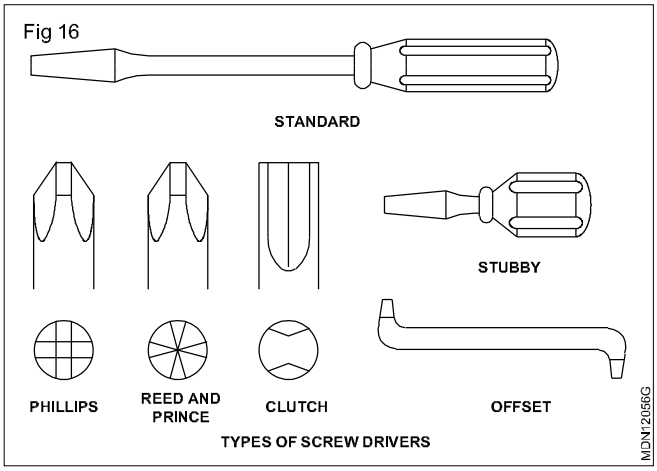
Screw driver (Fig 16): There are several different size of screw drivers of the standard, reed & prince & phillips types.

The offset screw driver is useful in tight quarters where even a “Stubby” cannot be used.

Safety:

1 Always use correct type and size screw drivers.

2 Don’t do repair work by holding the job on the hand with the help of screw driver, if may slips it pierce the hand.



Allen keys

Objectives : At the end of this lesson you shall be able to

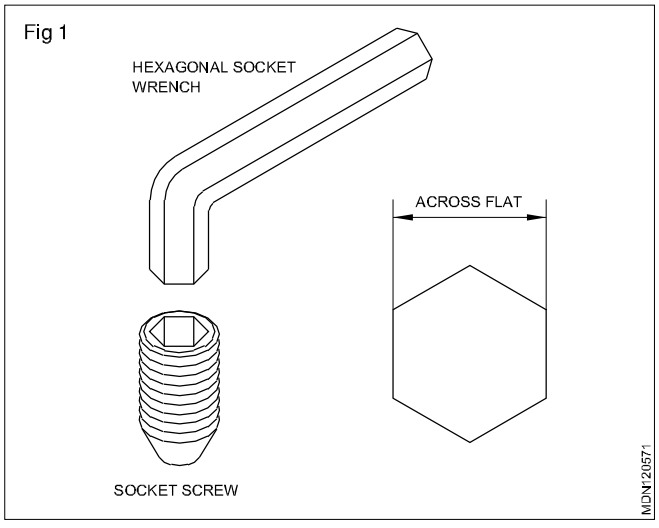
- **state the features and uses of hexagon socket screw keys**
- **specify hexagon socket screw keys**.

Hexagon socket screw keys/Allen keys are made from hexagonal section bars of chrom vanadium steel.

These are hardened and tempered. These are bent to `L’ shape. The size of an Allen key is identified by the size across the flat of the hexagon.

Uses

They are used to tighten or loosen screws having internal hexagon sockets, (Fig.1)



Allen keys, available in different sets in plastic wallets, surprise of a set of 8 (2 to 10mm)

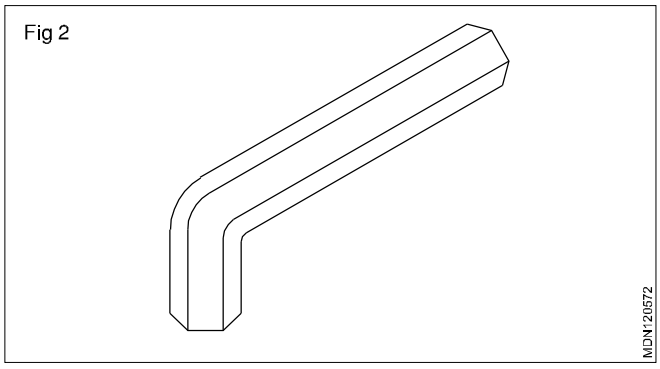
2,3,4,5,6,7,8 and 10mm

Sizes of Allen keys (Fig. 1)

Individual pieces are available as follows.1, 1.5, 2, 2.5, 3, 4, 5, 6, 8, 10, 12, 14, 17, 19, 22, 24, 27, 32 and 36.

Designation of Allen keys (Fig. 2)

A hexagonal socket screw key of width across flat 8 mm shall be designated as Key 8 IS:3082.



Bench vice

Objectives : At the end of this lesson you shall be able to
- **name the parts and uses of a bench vice**
- **specify the size of a bench vice**
- **state the uses of vice clamps.**

Vices are used for holding workpieces. They are available in different types. The vice used for bench work is called as bench vice or (Engineer's vice)

A bench vice is made of cast iron or cast steel and it is used to hold work for filling, sawing, threading and other hand operations.

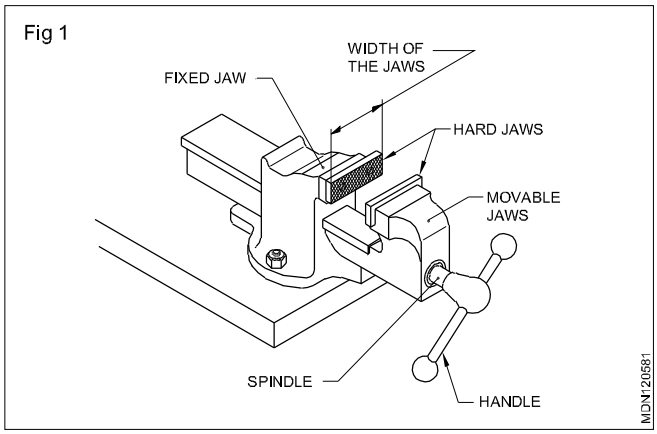
The size of the vice is stated by the width of the jaws.

Parts of a bench vice (Fig.1)

The following are the parts of the vice

The Vice is generally bolted and secured in a wooden work table, and is useful for operations like filing, chipping, hacksawing, bending sheetmetal etc.

Fig 1



Fixed jaw, movable jaw, hard jaws, spindle, handle, box-nut and spring are the parts of vice.

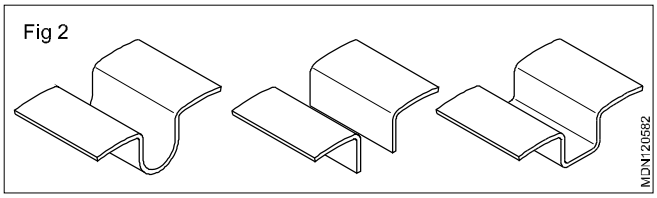
The box-nut and the spring are the internal parts.

Vice clamps or soft jaws (Fig. 2)

The hold a finished work use soft jaws (vice clamps) made of aluminium over the regular jaws. This will protect the work surface from damage.

Do not over-tighten the vice as, the spindle may get damaged.

Fig 2



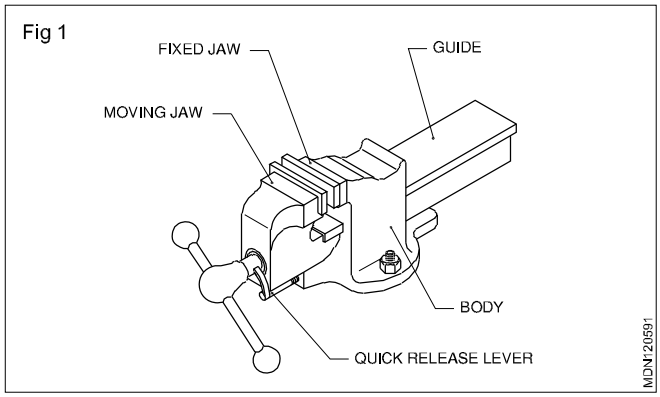
Types of vices

Objectives : At the end of this lesson you shall be able to
- **state the construction and advantages of a quick releasing vice**
- **state the uses of pipe vice, toolmakers vice, hand vice and pin vice.**

There are different types of vices used for holding workpieces. They are quick releasing vice, pipe vice, hand vice pin vice and toolmaker's vice.

Quick releasing vice (Fig 1)

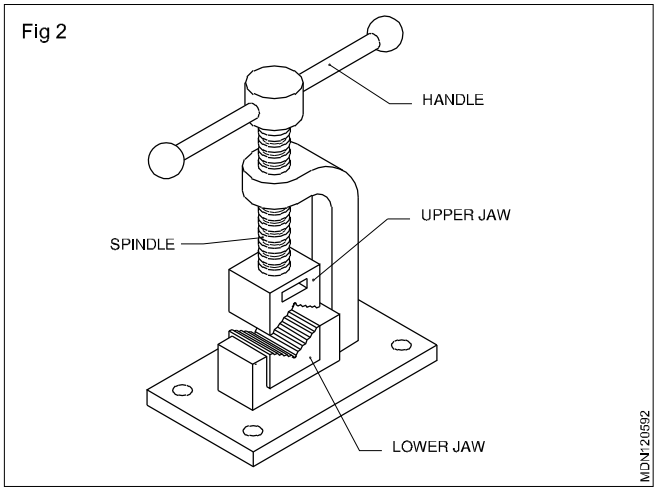
Fig 1



A quick releasing vice is similar to an ordinary bench vice but the opening of the movable jaw is done by using a trigger (lever). If the trigger at the front of the movable jaw is pressed, the nut disengages the screw and the movable jaw can be set in any desired place quickly.

Pipe vice (Fig 2)

Fig 2

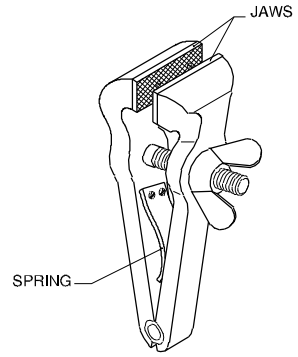


A Pipe vice is used for holding round sections of metal, and pipes. In this vice, the screw is vertical and movable. The jaw works vertically.

The pipe vice grips the work at four points on its surface. The parts of a pipe vice are shown in Fig. 2.

Hand vice (Fig 3)

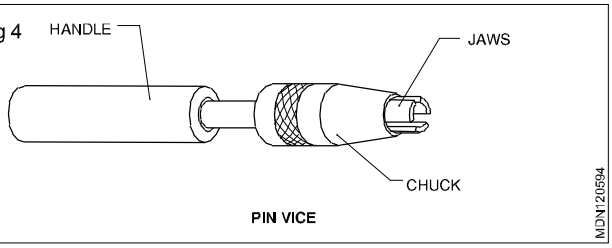
Fig 3



Hand vices are used for gripping screws, rivets, keys, small drills and other similar objects which are too small to be conveniently held in the bench vice. A hand vice is made in various shapes and sizes. The length varies from 125 to 150 mm and the jaw width from 40 to 44 mm. The jaws can be opened and closed using the wing nut on the screw that is fastened to one leg, and passes through the other.

Pin vice (Fig 4)

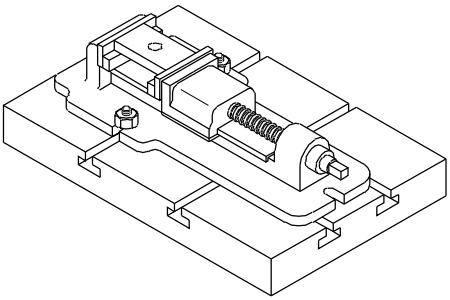
Fig 4



The pin vice is used for holding small diameter jobs. It consists of a handle and a small collet chuck at one end. The chuck carries a set of jaws which are operated by turning the handle.

Toolmaker's vice (Fig 5)

Fig 5



The toolmaker's vice is used for holding small work which required filing or drilling and for marking of small jobs on the surface plate. This vice is made of mild steel.

Toolmaker's vice is accurately machined.

C- Clamps and toolmaker's clamps

Objectives : At the end of this lesson you shall be able to
- **state the purpose of using clamps**
- **specify the requirements of the clamping devices**
- **state the features and uses of 'C' clamps**
- **state the features of Toolmaker's clamps.**

Purpose of using clamps

Clamps are used for preventing the movement of work, and for holding the job tight.

Requirements of clamping devices

Should be able to manipulate for easy loading.

Should provide the required clamping force.

Should be capable of locking with minimum movement.

Should accommodate a range of sizes of jobs.

(Fig 1) shows a typical clamping device, employing a screw and nut to provide the clamping force.

'C' Clamps

These clamps are in the shape of a 'C'. The 'C' clamp has its body forged or cast. One end of the clamp is machined flat. The other end is drilled and threaded to accommodate a screw-rod which is operated by a handle. The screw-rod carries a swivel pad which is free to revolve. The clamp is hardened and the face is serrated. (Fig 2)

Fig 1

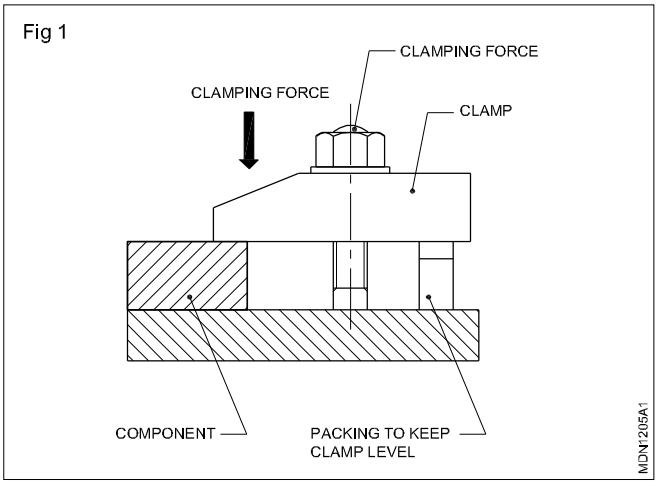
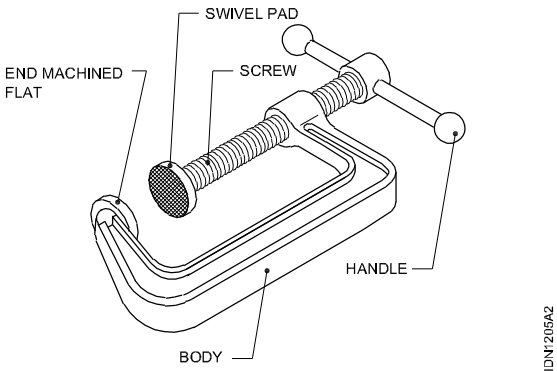


Fig 2



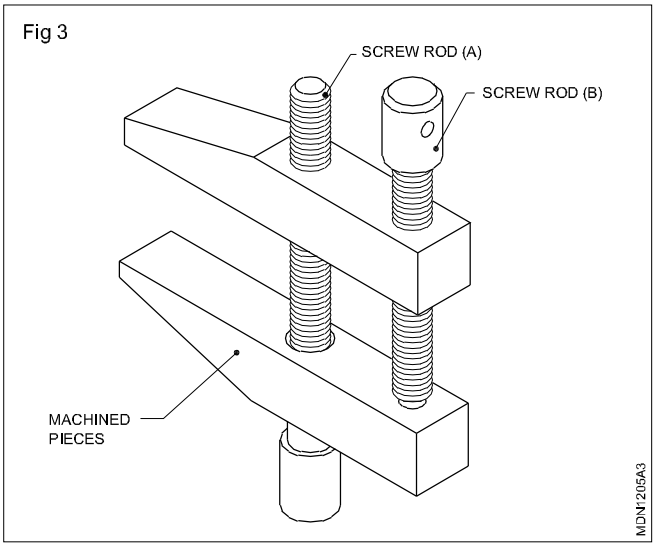
These clamps are used to hold work, on an angle plate or a drill press table, and also, for holding two or more workpieces together.

The swivel pad on the end of the clamping screw helps in clamping surfaces which are not parallel. 'C' clamps are available for light and heavy duty work.

Toolmaker's clamps

This is the type most commonly used by toolmakers for holding small, machined, flat pieces for further operations. They have two rectangular pieces of steel perfectly machined. The inner faces which come in contact with the workpiece are perfectly parallel. They are assembled by means of two threaded rods. The screw-rod (A) is rotated in one direction to adjust the gap between the two holding faces. The other screw (B) when tightened maintains the required pressure. (Fig 3)

Fig 3



The head of the screw-rod (B) is provided with a hole through which a cylindrical pin may be passed for tightening purposes. The toolmaker's clamps are for holding a previously machined work which is flat and parallel.

The toolmaker's clamp is not suitable for doing any heavy operations on the workpiece since the contacting and holding area of the clamp is limited. It is meant for holding light jobs. It is also called as parallel clamp.

'U' Clamps

These are clamps used along with 'V' Blocks as an accessory. These clamps serve the purpose of holding the round work securely in the 'V' groove for layout operations as well as for machining operations.

Spanners and their uses

Objectives : At the end of this lesson you shall be able to

- **state the necessity of spanners**
- **identify the different types of spanners**
- **specify the spanners**
- **list out the parts of adjustable spanners**
- **state the features of 'C' spanners and their uses.**

Spanners are used for operating threaded fasteners, bolts and nuts. They are made with jaws or opening that fit square on hexagonal nuts and bolts and screw heads. They are made of high tensile or alloy steel. They are drop-forged and heat-treated for strength. Finally they are given a smooth surface finish for ease of gripping.

Spanners are considerably in shape to provide ease of operation under different conditions.

The basic types of spanners are : (Fig. 1)

- Open end spanners (1)
- tube or tubular box spanners (2)
- Socket spanners (3)
- Ring spanners (4)

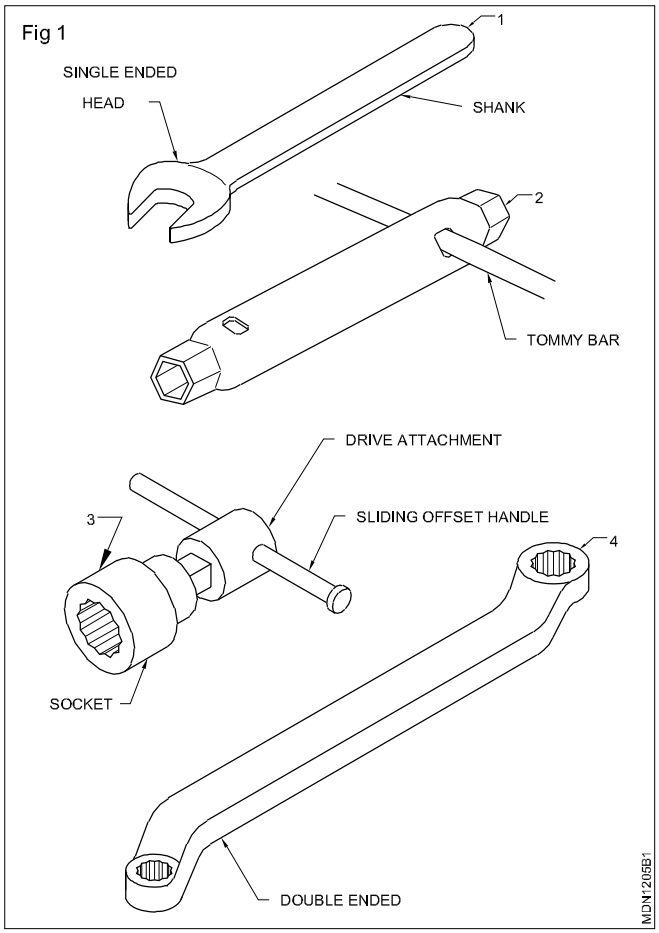
The correct spanner fits exactly and allows room for use. They should also permit the job to be done in a shorter time.

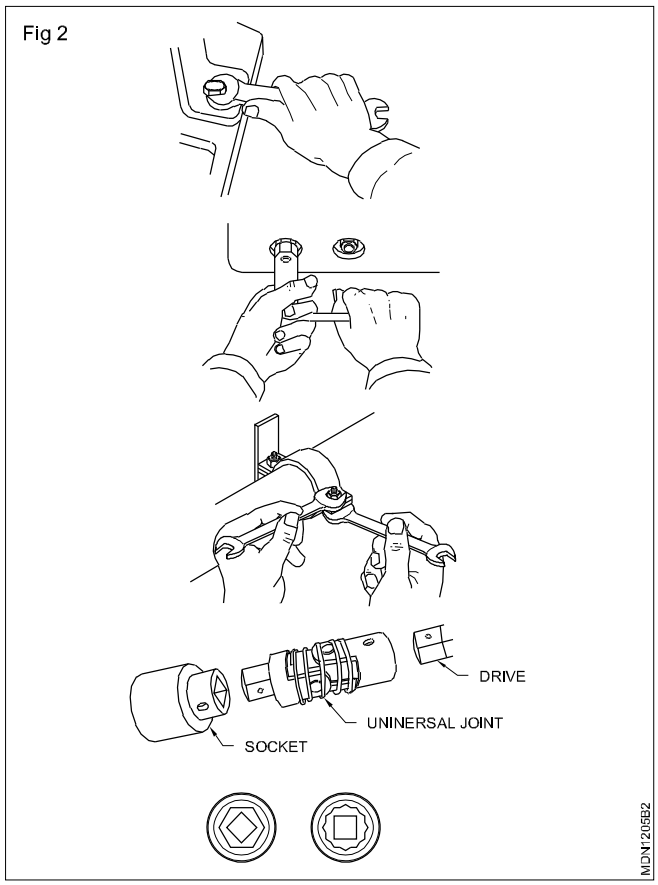
The following are the points to be noted for using spaners in a safe way. (Fig. 2)

Use open end and ring spanners by pulling on the shank. It is safest to pull as there is less chance of hitting your knuckles if the spanner or nut slips suddenly. If you are forced to push the spanner, use the base of your hand and keep your hand open.

Use both hands for large spanners.

Keep yourself balanced and firm to avoid slipping yourself, if the spanner slips suddenly, Hold on to some support, if there is any chance of falling.





Use both hands as shown in the figure, when using tubular box spanners. (Fig. 2)

Use two spanners as shown in the figure to stop the head of the bolt rotating as the nut is operated. (Fig. 2)

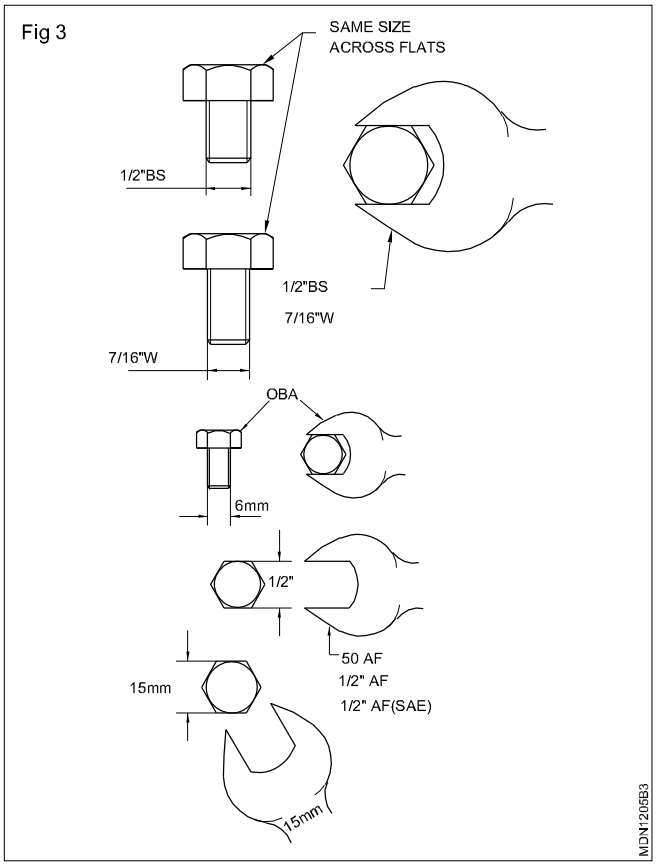
Socket spanners may be turned by accessories which have square driving ends. (Fig. 2)

Size and identification of spanners

The size of a spanner is determined by the nut or bolt it fits. The distance across the flats of a nut or bolt varies both with the size and the thread system. (Fig 4)

In the British system the nominal size of the bolt is used to identify the spanner. (Fig. 3)

In the unified standard system (Fig. 3), the spanners are marked with a number based on the gas requirement decimal equivalent of the nominal fractional size across the flats of the hexagon, following the sign A/F or with the fractional size across the flats following the sign A/F. In the metric system, spanners are marked with the size across the jaw opening followed by the abbreviation 'mm'.



To fit exactly, a spanner must be :

- of the correct size
- placed correctly on the nut
- in good condition.

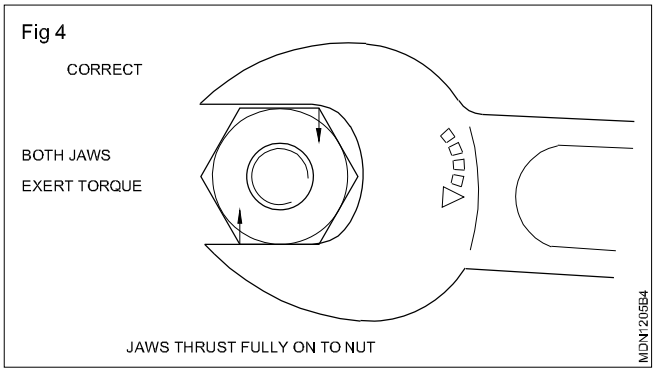
Spanners have their jaws slightly wider than the width of the nut so that they can be placed into position easily. Any excess more than a few hundredths of a millimeter clearance could cause the spanner to slip under pressure.

Place the spanner so that its jaws bearfully on the flats of the nut.

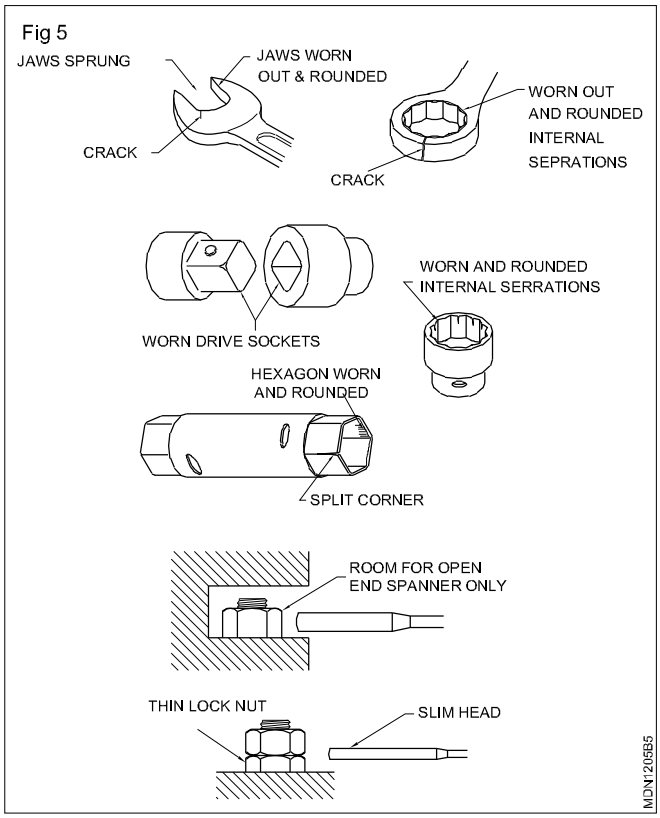
Incorrect use damages the spanners & the nuts too.

Discard any defective spanners. The spanners illustrated here are dangerous for use.

Choose spanners that allow room for use.



Nuts in inaccessible positions may be reached with socket spanners, with special drawing accessories. (Flg 5)



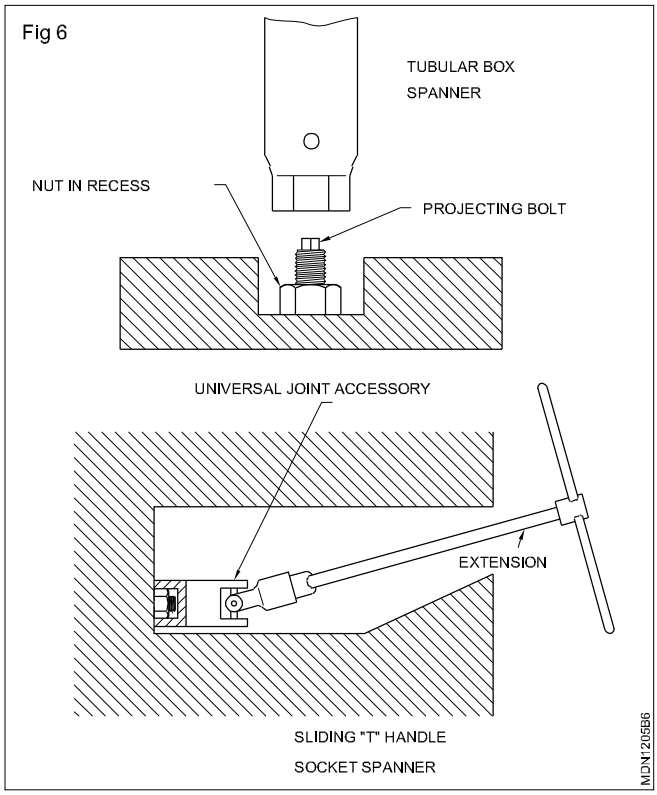
Length of spanners (Fig. 6)

Normally spanners have a length that is about ten times the width of the jaw opening.

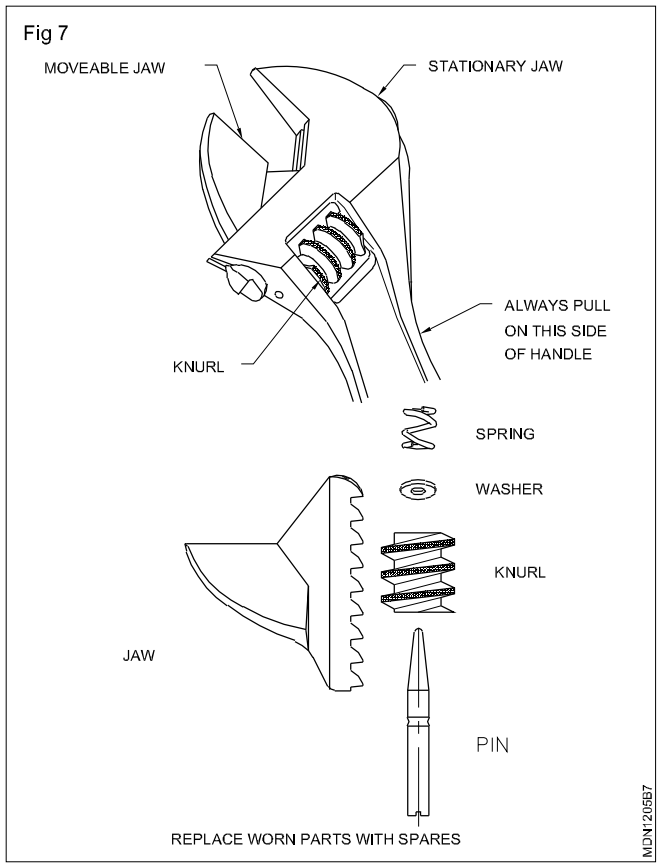
Never exert excessive pull on a spanner, particularly by using a pipe to extend the length of a spanner.

Excess turning effect of the spanner could result in :

- striping the thread
- shearing the bolt
- straining the jaws of the spanner
- making the spanner slip and cause an accident.

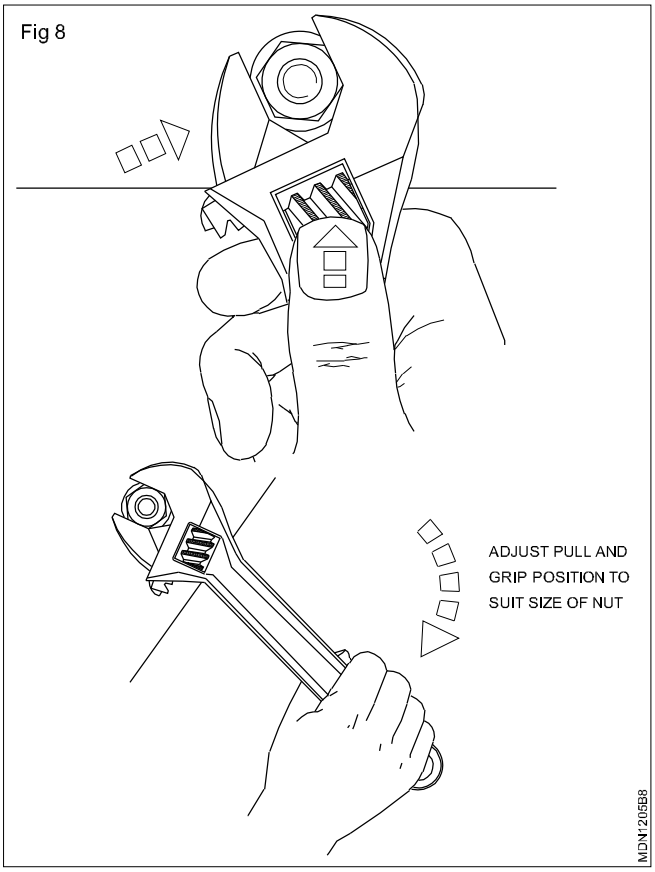


Adjustable spanners (Figs 7 & 8)



Most common types of adjustable spanners are similar to open and spanners, but they have one movable jaw. The opening between the jaws of a typical 250 mm spanner can be adjusted from zero to 28.5 mm. Adjustable spanners may range in length from 100 mm to 760 mm. the type illustrated has its jaws set an angle of 22 1/2^0 to the handle. Adjustable spanners are convenient for use where a full kit of spanners cannot be carried about. They are not intended to replace fixed spanners which are more suitable for heavy service. If the movable jaw or knurled screw is cracked or worn out, replace them with spare ones.

Fig 8



When using the adjustable spanner follow the steps given below.

Place it on the nut so that the jaw opening points in the same general direction the handle is to be pulled. In this position the spanners are less liable to slip and the required turning force can be exerted without damage to the moving jaw and knurl.

Push the jaws into full contact with the nut.

Use the thumb to tighten the adjusting knurl so that the jaws fit the nut strongly.

Pull continuously. The length of the handle is designed to suit the maximum opening of the jaws. With small nuts, a very small pull on the handle will produce the required torque.

'C' spanners (Hook spanners) (Fig. 9)

It has a lug that fits in a notch, cut in the outer edge of a round nut. The 'C' section is placed around around the nut in the direction in which it is to be turned. In adjustable hook wrenches, part of the 'C' section pivots to fit nuts with a range of diameters. A set of three spanners is needed to cover diameters from 19 mm to 120 mm.

The applications of 'C' spanners are shown in the figure.

C' Spanners are also used for zero - selfing of micrometer.

With socket spanners (Fig. 10), use the reversible ratchet handle for doing fast work, where turning space is restricted.

Fig 9

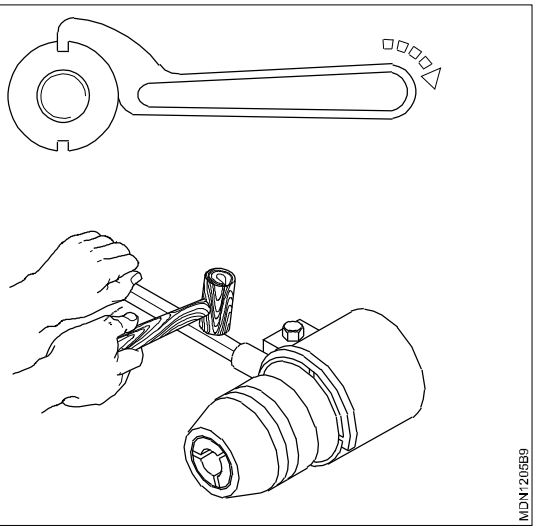
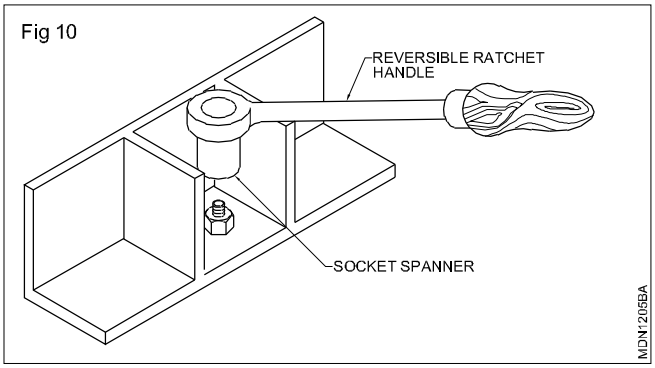
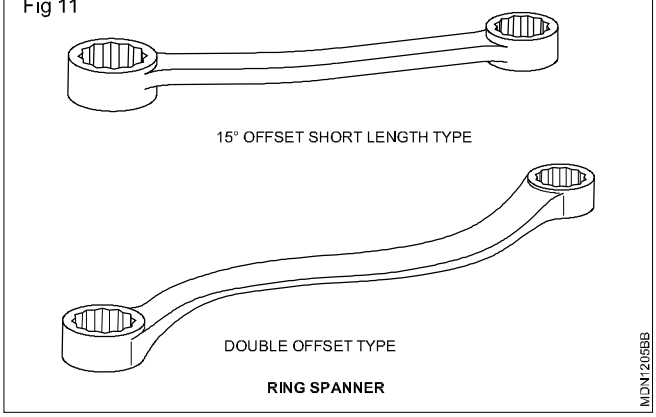


Fig 10



Ring or box spanner (Fig 11)**:** For critical tighting and loosening of nuts. For multi contact on bolts and nuts.

Fig 11



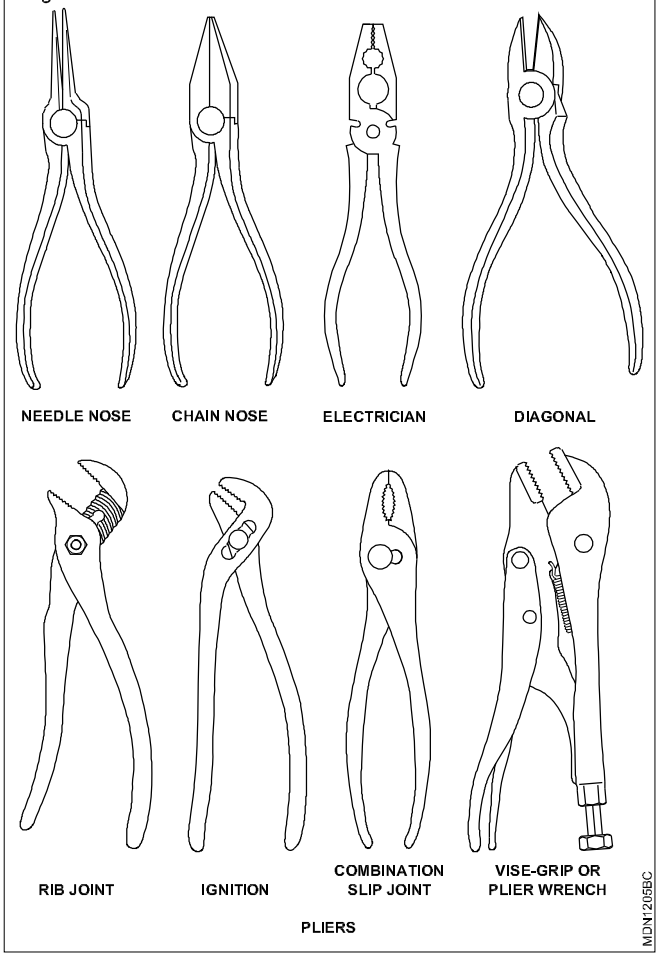
Pliers (Fig 12)**:** Pliers are commonly used for cutting wires, holding parts, crimping electrical connections and bending cotter pins.

Safety:

1 Avoid cutting hardened objects.

2 Never use pliers to turn nuts, bolts or tubing fitting.

Fig 12



PLIERS

Combination of ring and open end spanner (Fig 13)**:** This tool has a box end on one end and an open end on the other. Both ends are of the same size.

Fig 13

COMBINATION OF RING AND OPEN END SPANNER

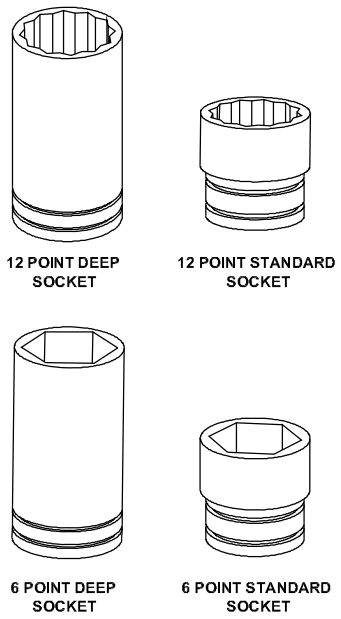
Socket spanners (Fig 14)**:** The socket is one of the fastest and most convenient of all the spanners. Sockets come in two sizes; standard and deep.

Standard sockets will handle the most of the works, while the extra reach of the deep socket is occasionally needed.

Swivel socket (Fig 15)**:** The swivel socket allows the user to turn fasterners at an angle.

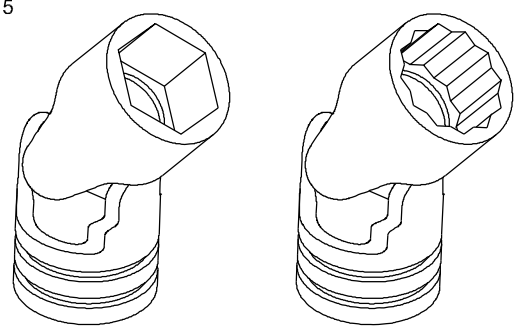
Socket handles: Several different drive handles are used. The speed handle (Fig 16 & 17) is used whenever possible as it can be turned rapidly.

Fig 14



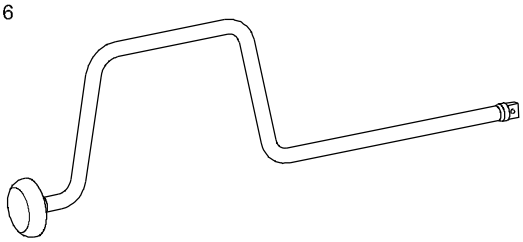
SOCKET SPANNER

Fig 15



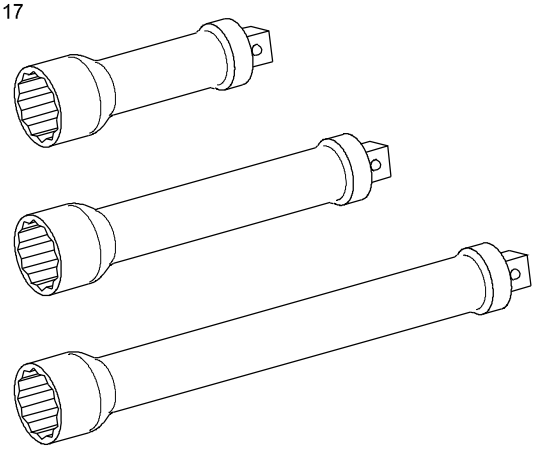
SWIVEL SOCKETS

Fig 16



SOCKET SPEED HANDLE

Fig 17



SOCKET EXTENSION BARS

Pliers

Objectives : At the end of this lesson you shall be able to
- **state the features of pliers**
- **state the uses of pliers.**

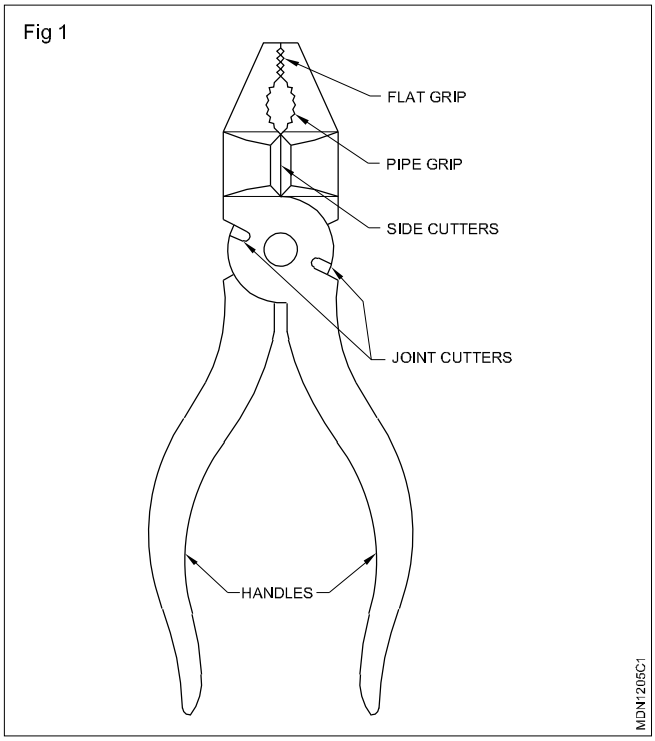
Features

Pliers have a pair of legs joined by a pivot, hinge or fulcrum pin. Each leg consists of a long handle and a short jaw.

Elements of pliers with two joint cutters (Fig. 1) **(Combination pliers)**

- Flat jaw
- Pipe grip
- Side Cutters

Fig 1



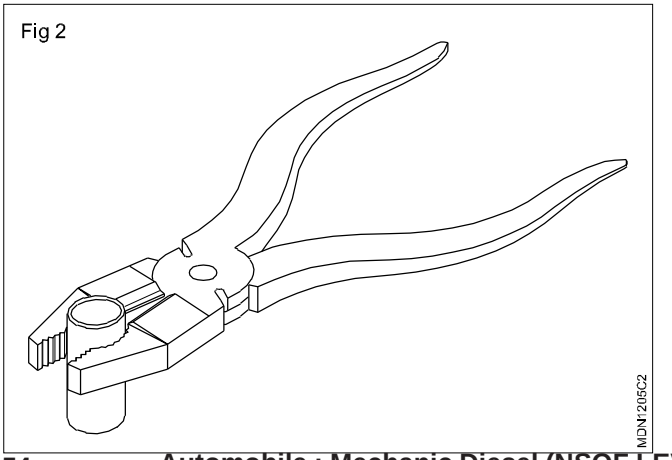
- Joint cutters
- Handles

Features

Flat jaw tips are serrated for general gripping.

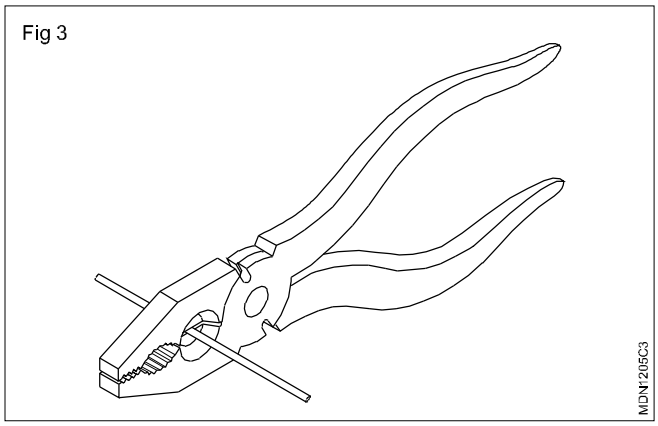
Pipe grip is serrated for gripping cylindrical objects. (Fig 2)

Fig 2



Cutters are provided for cutting off soft wires. (Fig 3)

Fig 3

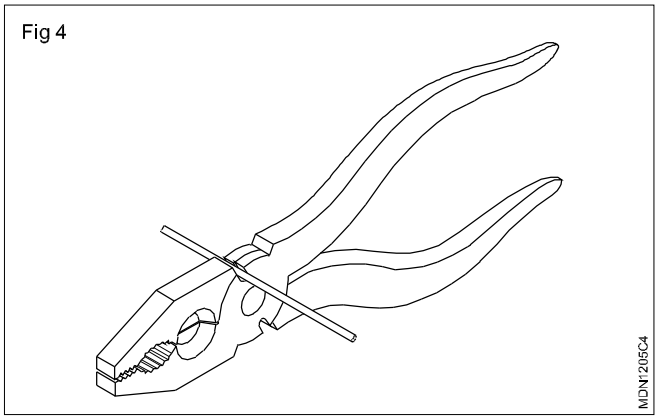


Two joint cutters are provided for cutting or shearing off steel wires (Fig 4)

Handles are used for applying pressure by hand.

Pliers are available in sizes from 150 mm to 230 mm. (Size = Overall length)

Fig 4

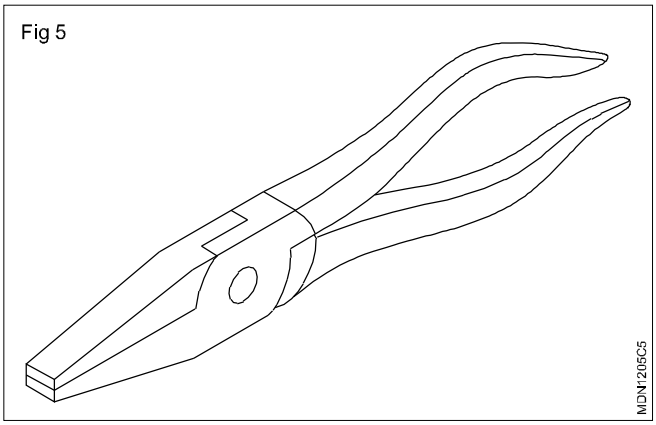


Other types of pliers

Flat nose pliers

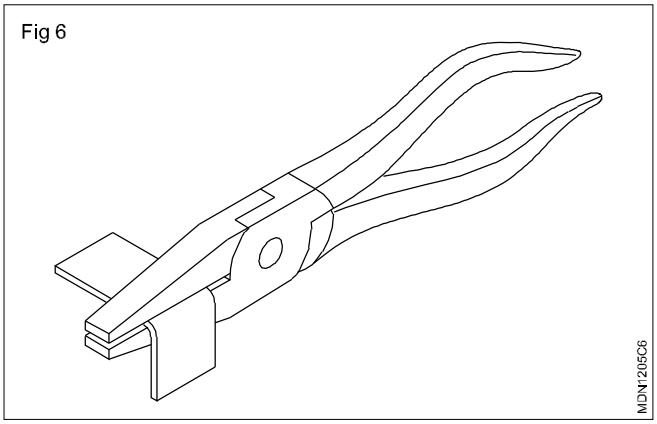
It has tapered wedge jaws with flat gripping surfaces which may be either smooth or serrated. (Fig 5)

Fig 5



It is used for bending and folding narrow strips of thin (Fig.6)

Fig 6



Roundnose Pliers

This type of pliers is made with tapered round shaped (Fig.7) They are used to shape loops in wires and the form curves in light metal strips (Fig.8)

Fig 7

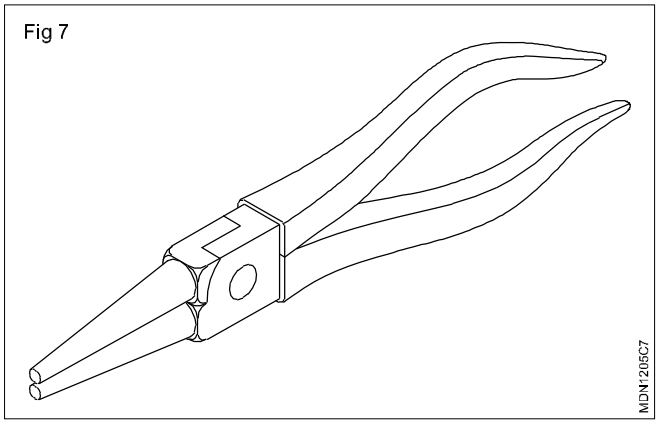
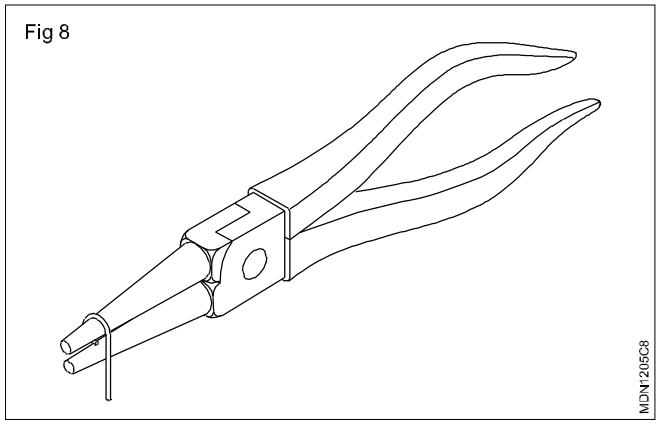


Fig 8

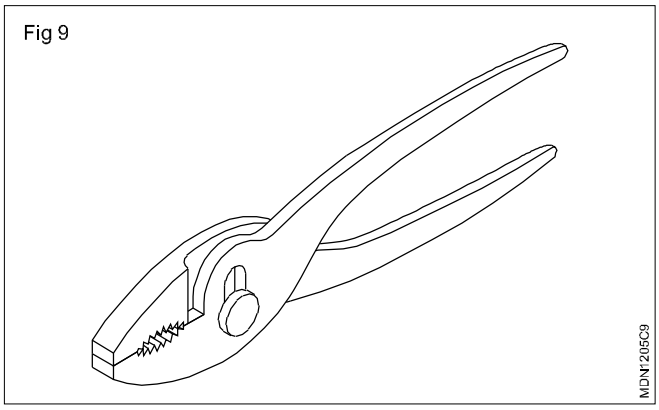


Slip-joint pliers

These pliers are available in various ranges of positions with different shapes of pivot pins so that they have various ranges of jaw opening.

Mainly used for gripping. (Fig 9)

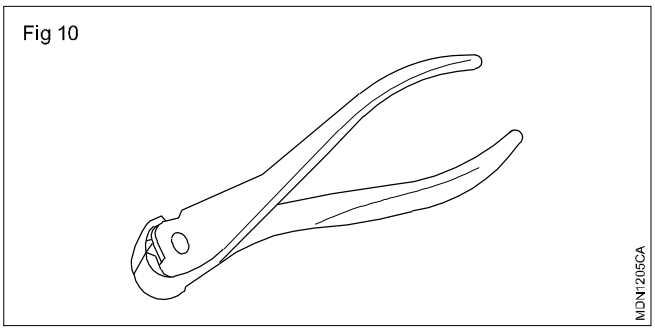
Fig 9



End cutting pliers

These pliers have the same uses as the side cutting pliers. (Fig 10)

Fig 10



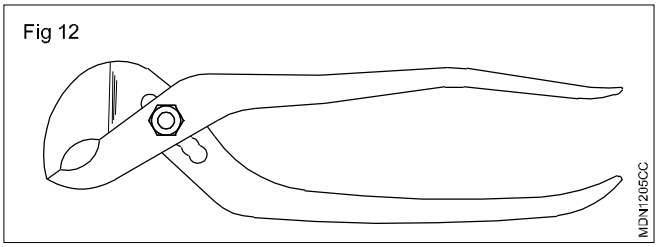
Circlip pliers

Circlip pliers are used for fitting and removing circlips in assembly works.

Internal circlip plier

It is used to fit and remove the internal circlip in the groove of the bore. (Fig 11)

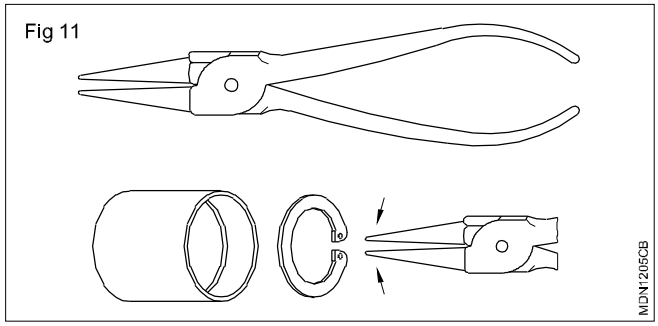
Fig 12



Slip-joint, multi-grip pliers

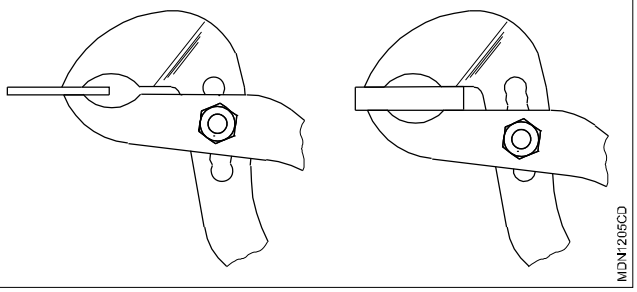
It is similar to the grip pliers but has more openings in the legs. It gives a range of jaw openings. It allows parallel gripping by the jaws in a number of positions. (Fig 12)

Fig 11



The shape and length of the leg are different from those of the slip-joint pliers. (Fig.13)

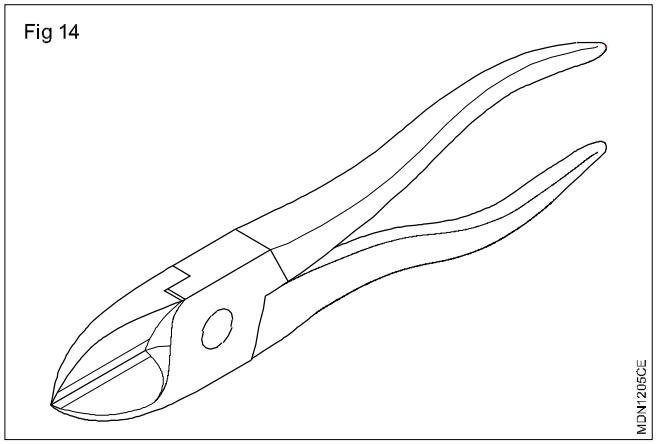
Fig 13



Side cutting pliers

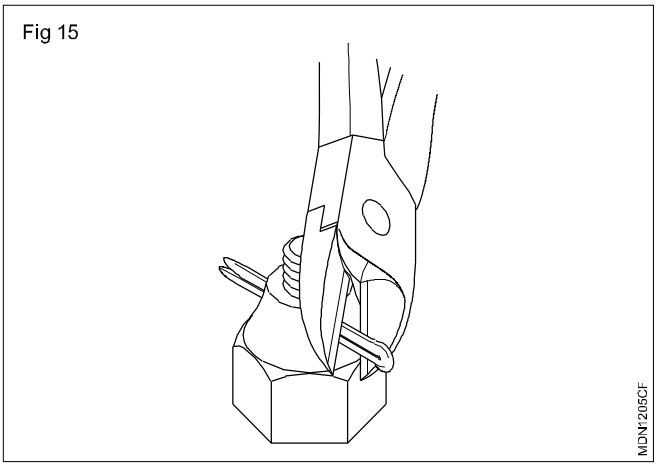
It is made with jaws set at an angle. (Fig.14)

Fig 14



They are used for shearing off wires in confined spaces and cutting off wires close to the surface level. (Fig.15)

Fig 15



They are also used for spreading the cotter pin.

External circlip pliers.

External circlip pliers are used to fit and remove the external circlip in the grooves of the shafts.

Locking pliers

The locking lever of the locking pliers is attached with a movable handle which clamps the jaws on to an object of any shape.

It has high gripping power.

The screw in the handle enables adjustment of the lever action to the work size.

SNIPS (Straight & Bent)

Objectives : At the end of this lesson you shall be able to
- **state the uses of straight and bent snips**
- **state the features and use of lever shears**
- **state the uses of circle cutting machines.**

A snip, also called a hand shear ans it is used like a pair of scissors to cut thin, soft metal sheets. Snips are used to cut sheet metal upto 1.2mm thickness.

Types of snips (shears)

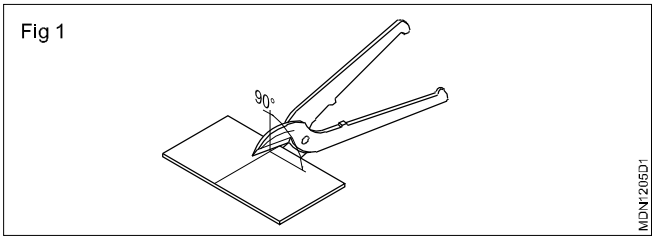
There are several types of snips available for making straight or circular cuts, the most common being straight snips and curved snips.

The choice of shears (snips) depends on the shape and type of the cut required.

Straight snips (Figs 1& 2)

These are used for making straight cuts and large external curves.

Fig 1



Straight snips have thin blades which are only strong on a vertical planes. They are, therefore, only suitable for straight cuts and external curves when surplus waste has to be removed.

While cutting, the blade of the snips should not cover the marking.

Bent snips (Fig. 3)

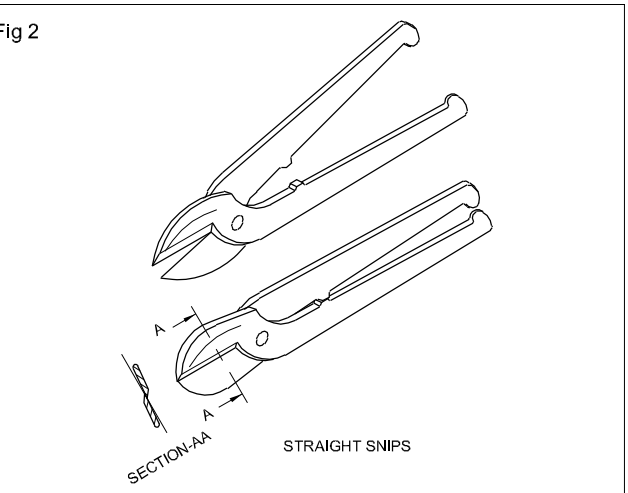
These snips have curved blades for making circular cuts. They are also used for trimming cylindrical or conical work in sheet metal.

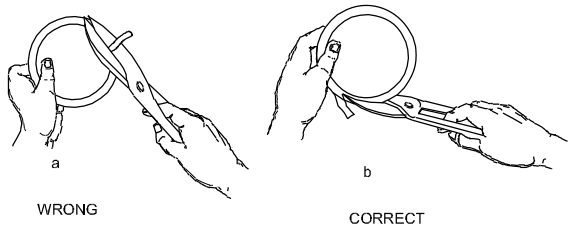
Snips are specified by the overall length and the shape of the blade.

Example

200mm straight snip (Fig.4)

Fig 2





CUTTING OUT A CIRCULAR DISC

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Fig 3

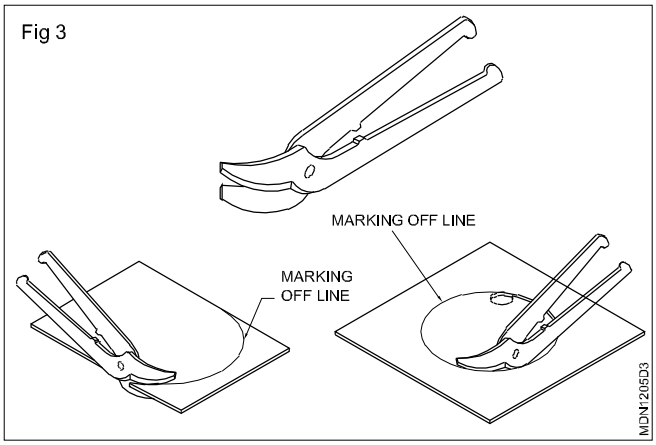

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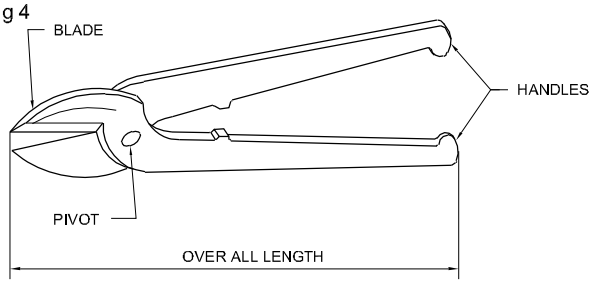
Fig 4



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Lever shears (Fig 5)

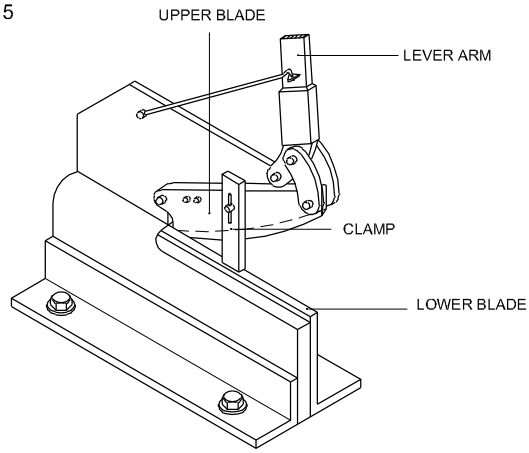
Lever shears are used to cut sheets which cannot be cut with hand shears.

The lever shear possesses a fixed lower blade and a moving upper blade. The sheet being cut is prevented from tilting by a clamping device which can be adjusted to the thickness of the sheet. The knife-edge cutter of the upper blade is curved so that the opening angle at the point of cut remains constant.

Circle cutting and curve cutting machines (Fig 6)

These machines are used to cut circles and curves of the desired shapes. When cutting curves, the sheet must be guided by the hand.

Fig 5



LEVER SHEARS

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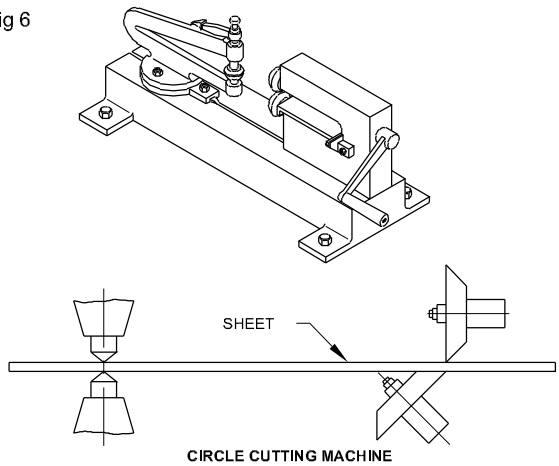
Fig 6



CIRCLE CUTTING MACHINE

MDN1205D6

Wrenches

Objectives : At the end of this lesson you shall be able to

- **name the different wrenches used**
- **state the features of each type of wrenches.**

Types of wrenches

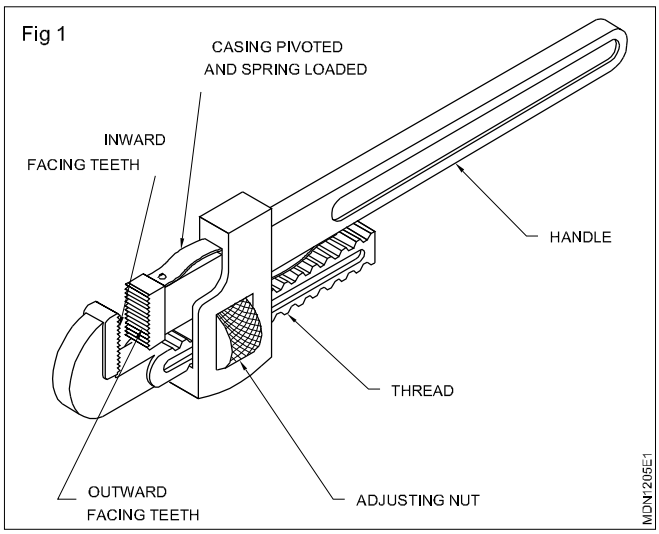
- **Stillson pipe wrench**
- **Footprint pipe wrench**
- **Tension wrench**
- **Hexagon socket wrench**

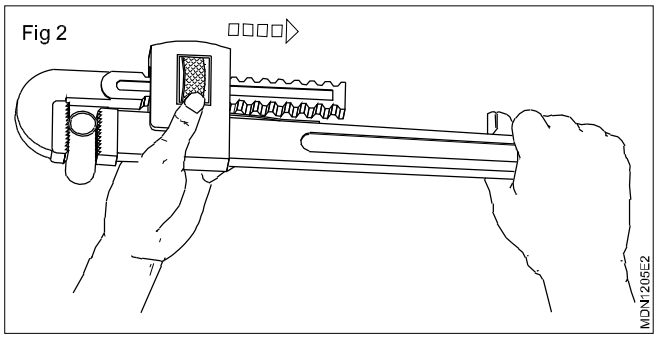
Stillson pipe wrenches (Fig 1 & 2)

These are used for gripping and turning pipes of a wide range of diameters.

The parts and their names are shown in the (Fig 1).

A jaw is fixed to the handle with outward facing teeth. Attached to the handle by a pivot pin is a spring-loaded casing that carries a knurled adjusting nut. This engages with a thread on the adjustable arm of a jaw with inward facing teeth.





Once the jaws are adjusted, the spring loading keeps them in contact with the work, and the toggle action causes the hardened serrations to bite into the work.

The jaws will mark the work. File off any burrs. Never use them on polished or plated surfaces. Never grip hardened materials with this type of wrench as this will damage the serrations.

Footprint pipe wrenches (Fig. 3)

These are used for gripping and turning pipes and round stock, particularly in confined spaces.

Adjust the size by fitting the removable pin in the hole that allows the pipe to be gripped, with the handles a comfortable distance apart. Thrust the jaws fully on to the pipe. Squeeze the handles firmly. Pull on the folded steel handle to turn the pipe. Stop squeezing and slide the jaws back round the pipe, squeeze and pull again.

File off any burrs raised by the jaws on the pipe.

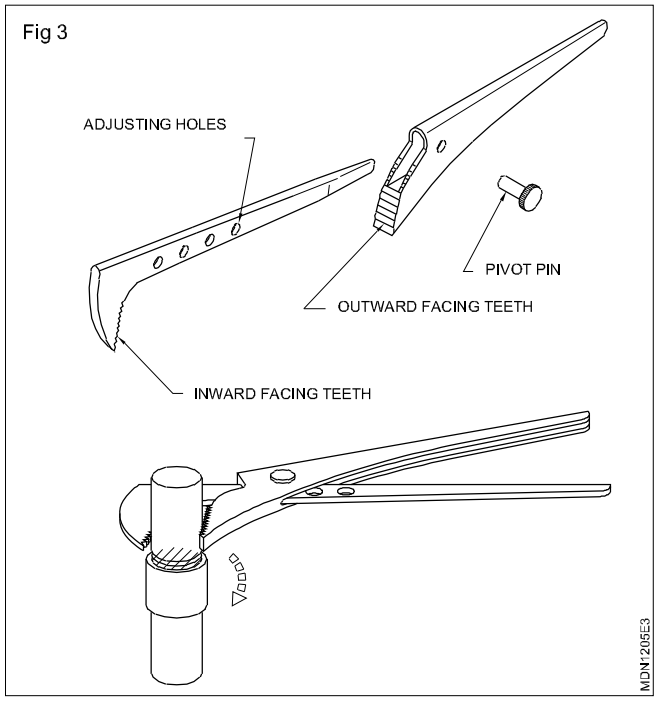
Tension wrench (Fig 4)

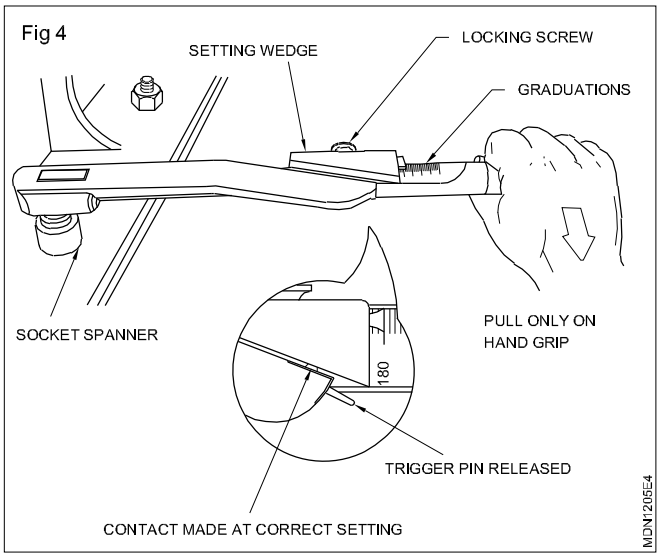
A tension wrench acts as a torque limiting device for turning (rotating) nuts to a predetermined degree of tightness. This avoids breaking the fasteners. It is also essential to avoid warping or springing components held by multiple fasteners that could be unevenly or excessively tightened, cylinder heads of engines, for example.

Some tension wrenches have direct reading indicators that you must watch as you pull the handle to the desired extent. With others, you preset to the desired graduation and pull until you detect a signal which may be an audible click, the release of a trigger pin or an automatic release within the wrench mechanism.

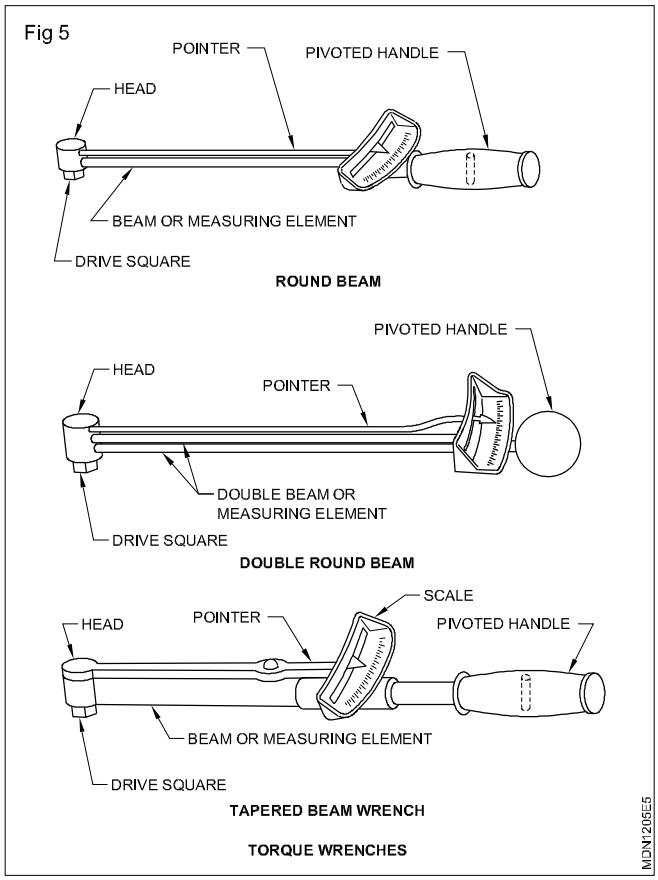
To apply the correct torque with a tension wrench :

- check that the threads of the nut and the bolt are clean and well formed.
- pull slowly with evenly increasing effort on the hand grip of the handle.





Torque wrench (Fig 5)**:** Torque wrench is used to tighten the bolts/nuts at recommended ended torque. The torque wrench will meausre the torque (twisting force) applied to the fastener. E.g. Cylinder head nuts, bearing cap nuts etc. (N.m; Kg m or Ib-ft)



Flaring, flare fittings and testing the joints

Objectives : At the end of this lesson you shall be able to

- **illustrate necessity, types of flaring methods**
- **list the types and applications of flare fittings**
- **pressurise the joint system and test for leaks.**

Flaring necessity: When connecting tubing to fittings, it is common practice to flare the end of the tube and to use fittings designed to grip the flare for a vapour tight seal. Special tools are used for making flares.

Types of flaring : There are two types of flaring

Single thickness flare

Double thickness flare

Single thickness flare : It can be made on smaller size copper tubing (Fig.1)

Double thickness flare : Double thickness flares are recommended for only the larger size tubing 5/16 inch (9mm) OD and over. Such flares are not easily formed on smaller tubing. The double flare makes a stronger joint than a single flare.

The Fig (2 & 3) shows some defects and correctly made flare. This also shows how defective flare made the fitting mismatched.

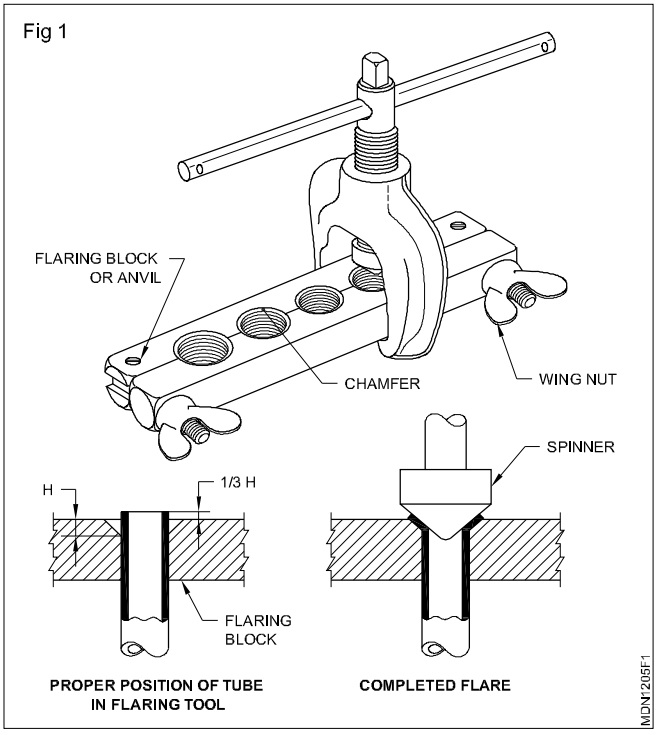
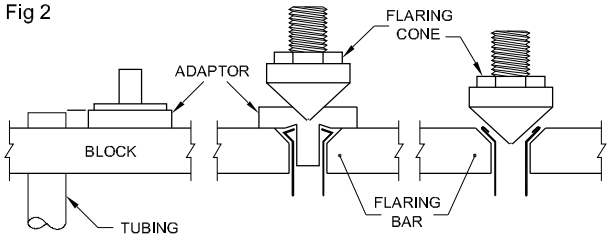


Fig 2



CORRECT PROCEDURE FOR FORMING DOUBLE FLARE

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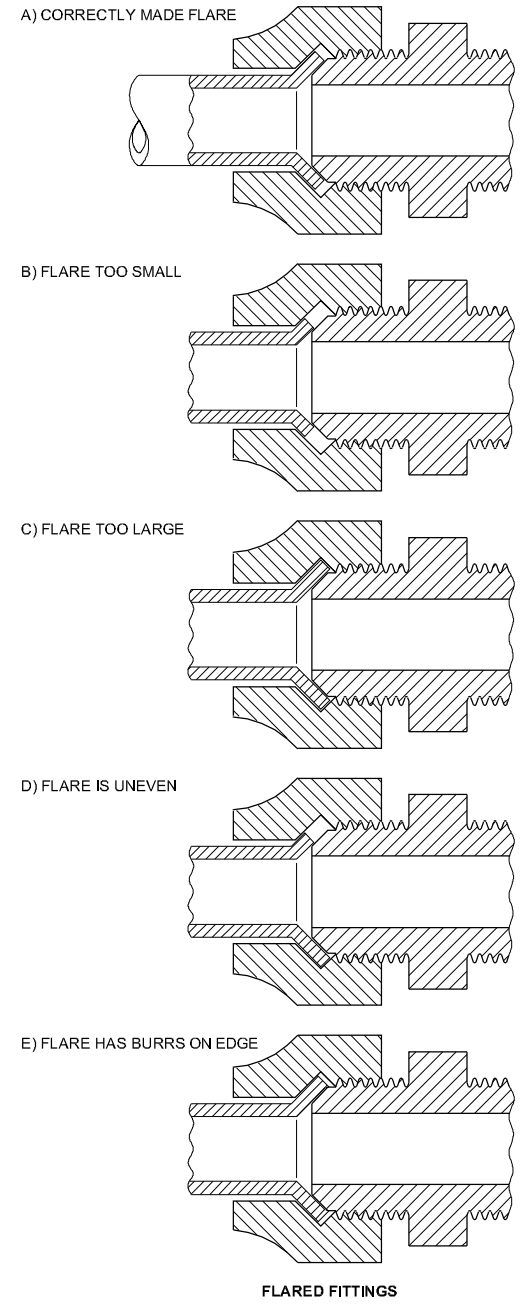
Fig 3



FLARED FITTINGS

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Flared tubing fittings : To attach a fitting to soft copper tubing, a flared type connection is generally used.

The following are some of the more common flared type fittings. (Fig. 4, 5 & 6)

Pressurising the joint on tubing : A flared joint or brazed joint needs to be tested for its firm. If it leaks while working it will put the whole system into problem. Before putting the joint into a system after it is made pressure test must be done.

Air pressure from

Air compressor - 150 PSI

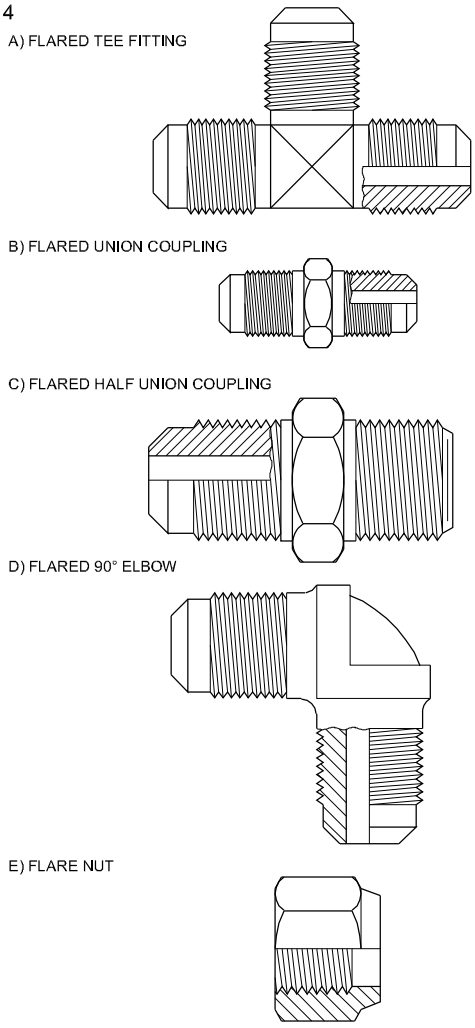
or - 10Kg/cm^2

The gas which is employed can be used for testing.

Leak can be detected with the use of soap solution. There are also other methods for leak detection.

Pressure tests are usually made on the joints above the working pressure.

Fig 4



FLARED TYPE FITTINGS

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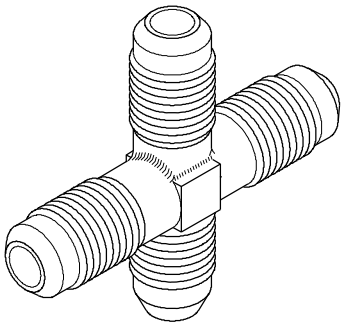
Fig 5



CROSS

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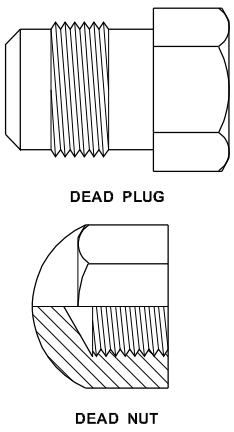
Fig 6



A pipe cutter is more convenient and better than a saw when cutting pipes and metal tubing. (Fig. 7)

The sharpened wheel does the cutting. As the tool turns around the pipe the screw increases the pressure, driving the wheel deeper and deeper through the pipe until it finally cuts rights through. (Fig. 8)

Fig 8

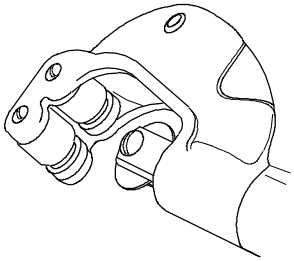
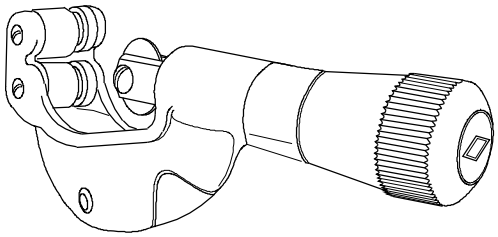


Fig 7



Puller

Objectives : At the end of this lesson you shall be able to
- **state the function of puller**
- **state the types of puller.**

Puller

The puller is a General Workshop tool which is used to remove Gears, bearings pulleys, flanges, bushes.

The puller is made out of steel material, generally with two or three legs and they are adjusted to hold the outside of the gears or bearing sleeves while the central threaded shaft is screwed forward exerting force on the gear/bearing. This enables to remove the bearing without damaging the shaft.

Pullers are classified according to the application and the number of leg.

Another classification is bsed on the power utilised i.e. Mechanical puller and Hydraulic puller.

Two legs puller is generally used for removing the gears. Where as puller with three legs are for removing pulleys. flanges and bearings. It is also called gear puller. Special pullers: These are mainly used for specialised application such as crank shaft bearing removal brake drum, removal pilot bearing removal.

Hydraulic puller : These pullers eliminate time consuming and unsafe hammering, heating or prying. Damage to past is minimised through the use of Hydraulic. pullers.

Safety

To avoid personal injury during system operation,

Always wear proper PPE gear

never use a tool to strike a puller

make sure that items are pulled is well and adequately supported

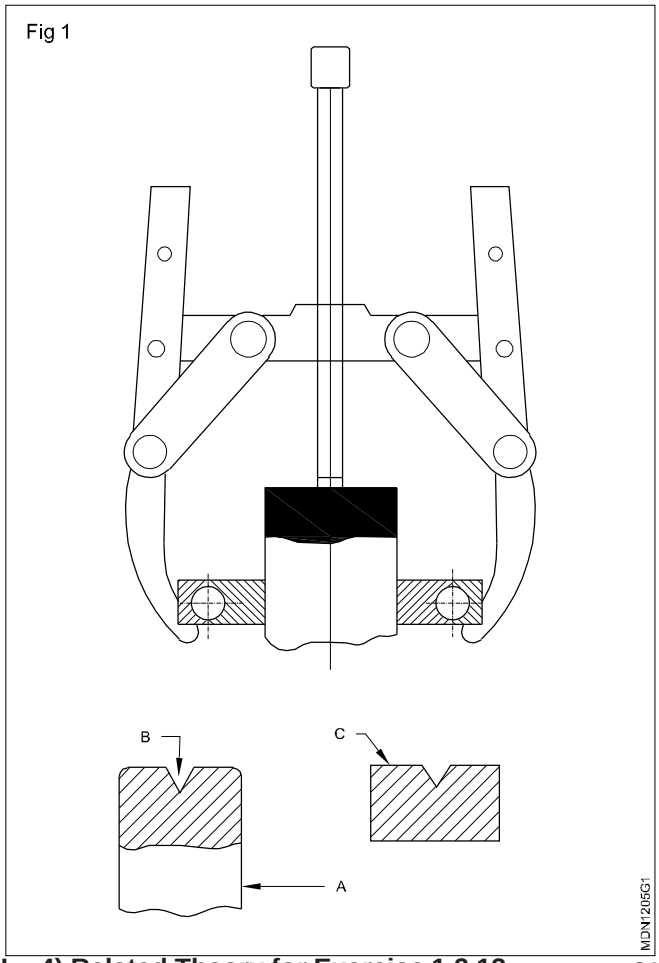
do not apply heat to a puller

before every use lubricate the centre bolt threads, with graphite - based lubricant

use puller only with recommended attachment

do not over load a pulley which may cause to break

Fig 1



Important: Always keep the guide parts of the lifting plate greased.

Hydraulic pullers are derigned to help you extend bearing life in your applications through proper installtion, removal and service.

Hydraulic pulling systems are available with capacity ranging from 4 tons to 30 tons, and are ideal for removing all kinds of shaft filled parts.

Hydraulic pulling system comprises of integrated pump. clyinder, hose, puller with safety-release valve. The pullers have self-contained hydraulic pump and are compact, handy. There are ideal for pulling variety of press-fit parts including bearing, wheels bushings, gears, pulleys.

In Automobiles Hydraulic Puller especially used for memoring Engine Liner from the cylinder block during engine Reconditioning Work.

Mechanical Puller Operation: (Figs 1 & 2)

1 Ensure that the spindle is clean and applied grease before use.

2 The Shaft (A) must have a center hole (B) as shown in the figure. If it does not, use a shaft protector (C) as shown in (fig 1)

3 Tighten strap bolts to hold jaws lightly in place

4 Position the puller that the spindle as shown in fig 2.

5 Tighten the spindle slightly by turning the spindle nut with proper wrench

6 Check that the jaws are fully contacting the part to be pulled.

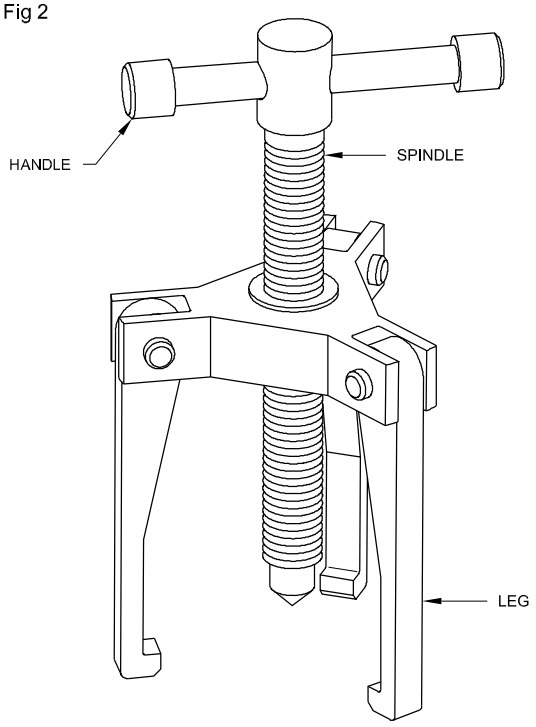
7 Tighten the strap bolts.

8 Apply pulling force by turning the spindle.

Post lock puller operation (Manual pullers)

1 Make sure that all items being pulled are supported by a means other than the puller. NO LOOSE PIECES!!!

Fig 2



2 Before each use, lubricate the center bolt of the puller with a graphite-based lubricant.

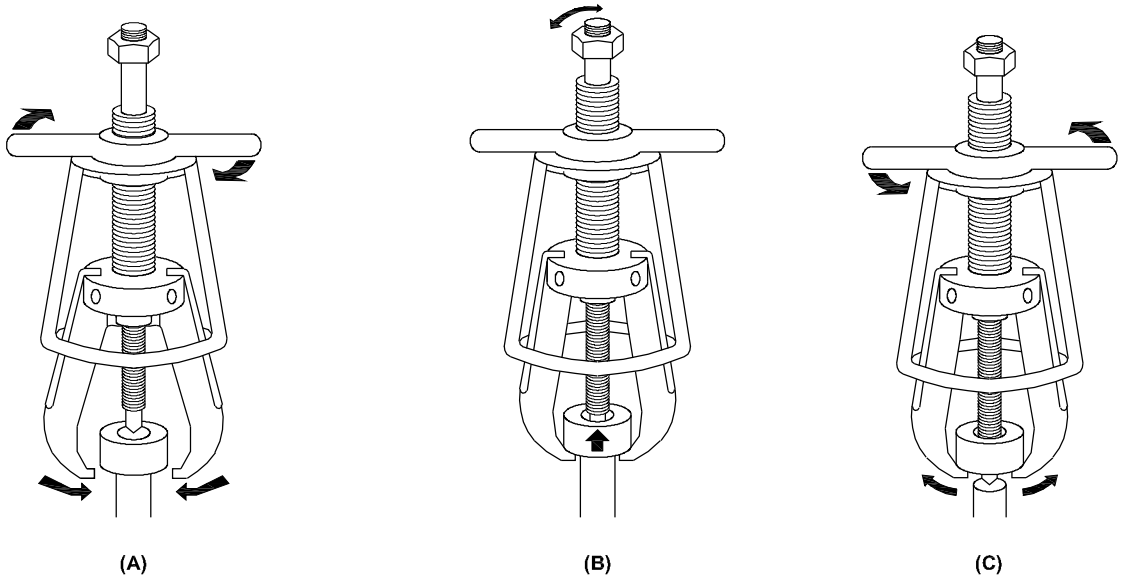
3 To operated the puller, grasp the puller with one hand and and turn the T-handle counter-clockwise with the other hand until the jaw opening is big enough to fit over the component to be pulled

4 Turn the T-Handle clockwise with the other hand until the jaw firmly onto the component. (Fig.3A)

5 Make sure that the center of the puller is aligned with the center of the component to be pulled. Using hand tools only, tighten the center bolt to pull the component off of its shaft. Never exceed the maximum torque ratings of the puller's drive bolt. (Fig.3B)

6 Turn the T-handle counter-clockwise to remove the puller from the component. (Fig.3C)

Fig 3



Hydraulic Puller Operation: (Fig. 4)

1 Make sure that all items being pulled are supported by a means other than the puller. NO LOOSE PIECES!!!

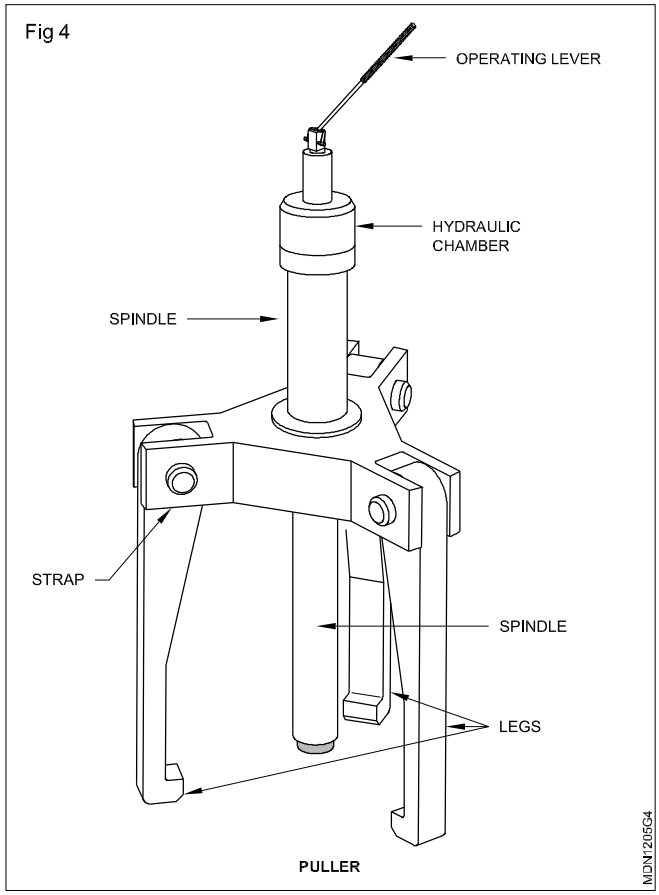
2 Install the cylinder into the puller by threading collar threads clock-wise into the jawhead assembly. Make sure that the puller collar threads are fully engaged in the puller. Attach lift plate to the coupler end of the cylinder. Remove the saddle from the cylinder and insert the ram point into the plunger. Select the ram point that will provide the maximum contact with the shaft.

3 To operate the puller, grasp the puller with one hand and turn the T-handle counter-clockwise with the other hand until the jaw opening is big enough to fit over the component to be pulled.

4 Turn the T-Handle clockwise to tighten the jaw firmly onto the component.

5 Make sure that the puller is square with the component to be pulled. Advance the plunger until the ram point contacts the shaft to insure correct alignment. The center point of the puller must be aligned with the center point of the shaft. Continue to advance the plunger slowly to pull the component off of the shaft. Never try to retighten the T-handle during the pulling operation.

Fig 4



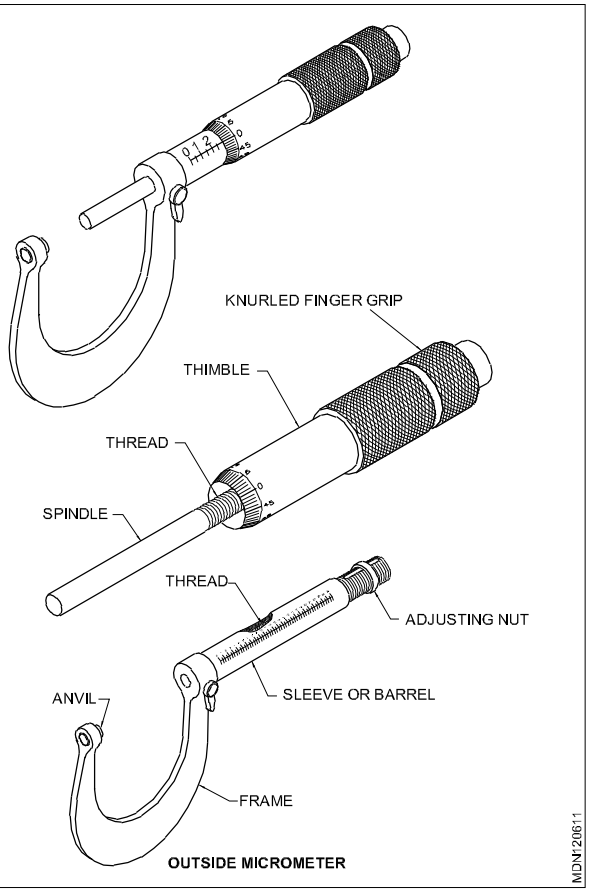
PULLER

Least count calculation, care and use of micrometer

Objectives : At the end of this lesson you shall be able to
- **name the principal parts of an outside micrometer**
- **derive the least count of metric micrometer**
- **determine the reading by using a metric micrometer**
- **solve the reading and give the measurement**
- **state the features of a large micrometers.**

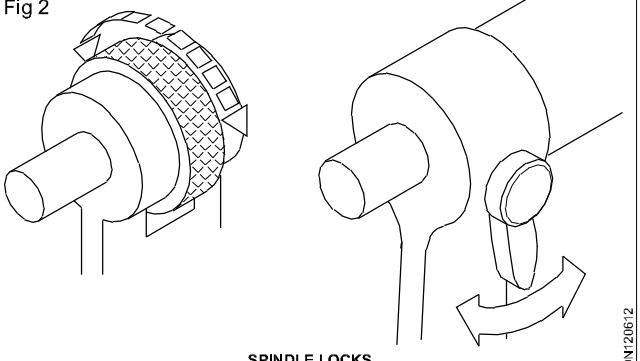
The purpose of a metric micrometer is to read an accuracy of 0.01 mm of an object. It is available in various sizes. However, the measuring range is limited to the length of the threaded spindle.(Fig 1)

Fig 1



OUTSIDE MICROMETER

Fig 2

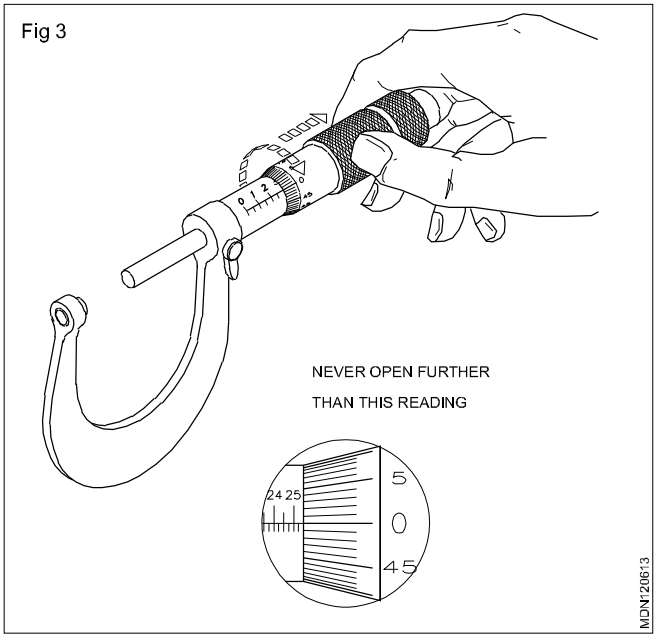


SPINDLE LOCKS

The principal parts of a micrometer are the frame, anvil, spindle and the thread, sleeve or barrel and the thimble, there is a knurled collar or small lever on the frame to lock the spindle in the barrel.(Fig 2) In addition to this, a ratchet stop is provided to the spindle in order to prevent a possible excess pressure on the screw treads.

The sleeve or barrel is marked (Fig 3) with the main scale in full mm and half mm. The thimble bevel end is graduated with the thimble scale. Fifty equal divisions are made on the circumference of the thimble bevel end. Every 5th division of the graduation is indicated with the number. Normally, the spindle face is fitted with a carbide tip to resist the wear. The spindle with the screw is attached to the thimble of the micrometer. The corresponding threaded nut is fitted to the barrel or sleeve of the micrometer. The other measuring face of the micrometer is the anvil, which is normally fitted with a carbide tip to resist the wear.

Fig 3



The range of micrometers are 0-5 mm, 25-50 mm, 50-75, 75-100 mm etc. The spindle can be easily screwed down in the barrel. In order to have the reference point for reading the micrometer, the datum or index line is marked on the sleeve.

When the face of the anvil and the face of the spindle are in contact, the O graduations of the index line and O graduation of the thimble coincide with each other.

The spindle may be withdrawn by rotating the thimble in an anticlockwise direction. The thimble portion is knurled to provide a good grip for holding as well as for rotating the spindle.

Deriving the least count of a metric micrometer

The main scale is graduated in ½ mm. Every 5th mm is shown with the reading. The pitch of the screw thread is accurately maintained to ½ mm.(Fig 4)

Fig 4

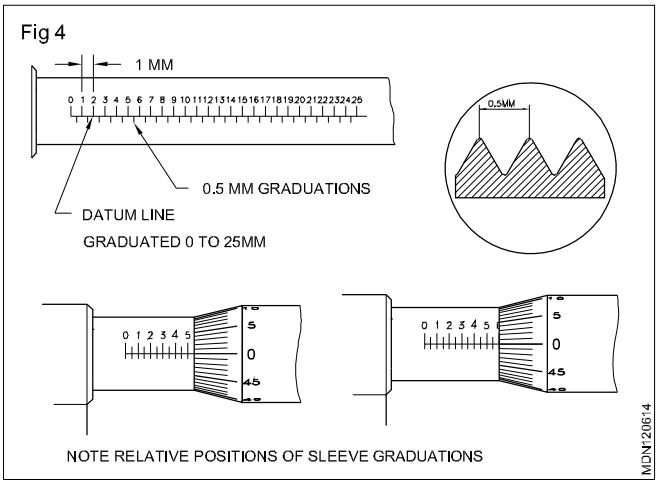
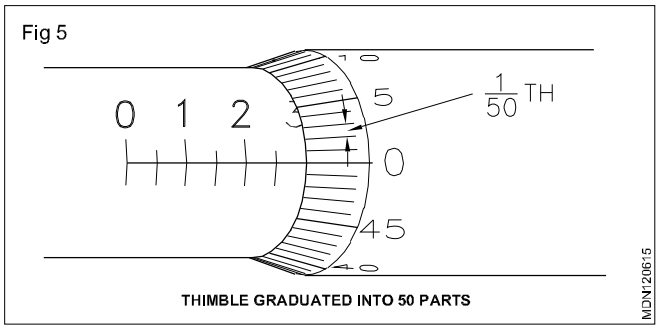


Fig 5



By turning one complete revolution of the thimble in a clockwise or an anticlockwise direction, the spindle moves exactly ½ mm in the forward direction or the reverse direction. As the circumference of the thimble graduated into 50 equal divisions, the advancement of the spindle for each division of the thimble scale is ½ mm - 50 i.e. 1/100 mm or 0.01 mm. Therefore, the least count of a metric micrometer is 1/100 mm or 0.01 mm.(Fig 5)

Determining the reading of a metric micrometer

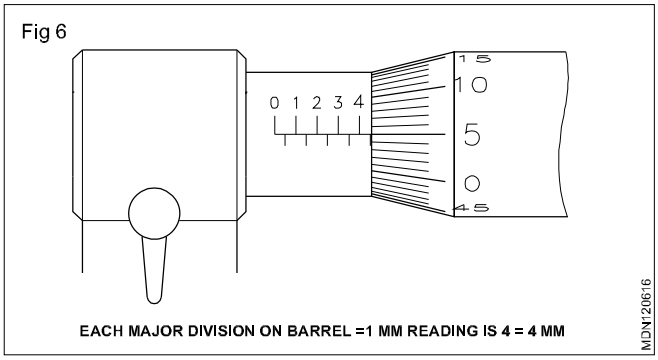
Before using the micrometer for measurement, it is necessary to ascertain that there is no error in the micrometer.

The faces of the anvil spindle must be free from dust.

While reading the micrometer, the spindle must be locked with the reading.

Method of reading

Fig 6



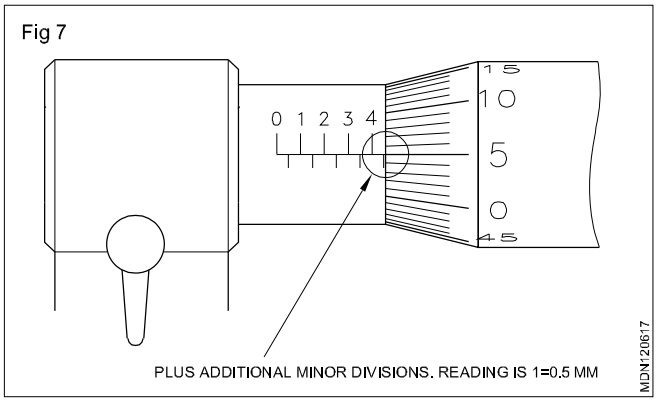
Read on the barrel scale the number of whole millimeters that are completely visible from the bevel edge of the thimble. It reads 4 mm. (Fig 6)

Add to this any half millimeters that are completely visible from the bevel edge of the thimble.

The figure reads ½ = 0.5 mm

Add the thimble reading to the two earlier readings.(Fig 7)

Fig 7

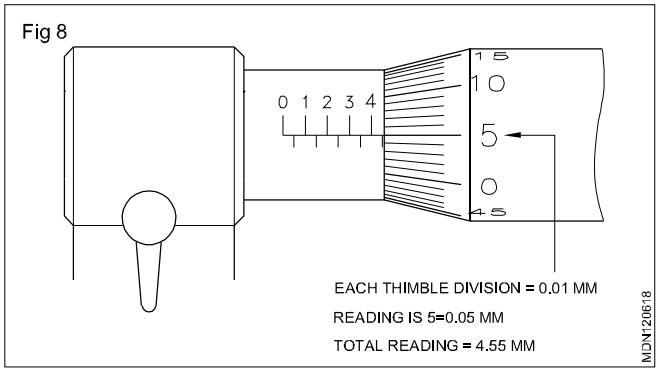


The figure shows the 5th division of the thimble is coinciding with the index line of the sleeve. Therefore the reading of the thimble is 5 8 0.01 mm = 0.05 mm. The total reading of the micrometer.(Fig 8)

a 4.00 mm

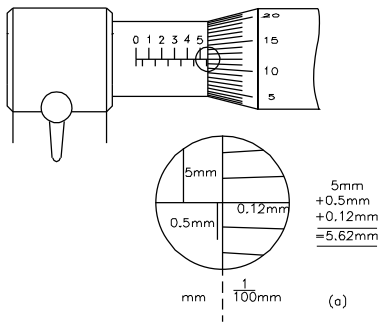
b 0.50 mm
c 0.05 mm
Total reading 4.55 mm

Fig 8

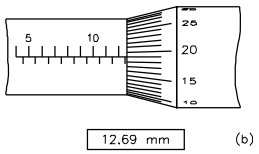


Some examples of metric micrometer readings and their solution.

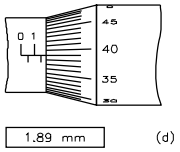
i) 5.00 mm
0.50 mm
0.12 mm
Total 5.62 mm



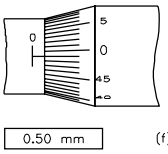
ii) 12.00 mm
0.50 mm
0.19 mm
Total 12.69 mm



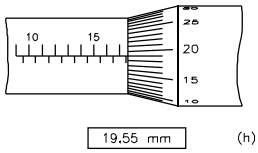
iii) 23.00 mm
0.50 mm
0.49 mm
Total 23.99 mm



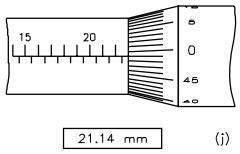
iv) 1.00 mm
0.50 mm
0.39 mm
Total 1.89 mm



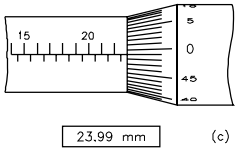
v) 5.00 mm
0.50 mm
0.00 mm
Total 5.50 mm



vi) 0.00 mm
0.50 mm
0.00 mm
Total 0.50 mm



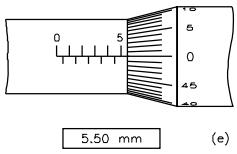
vii) 7.00 mm
0.00 mm
0.22 mm
Total 7.22 mm



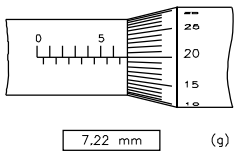
Outside micrometers have limited reading capacity as they are dependent upon the length of the spindle which itself is limited and fixed.

A 0-25 mm capacity outside micrometer can read a maximum dimension of 25 mm. For measuring sizes over and above this, we have to change to the next capacity micrometer 25-50 mm, then 50-75 mm and so on depending on the size of the job. As such, a good number of micrometers will have to be used for finishing jobs of various dimensions. In order to eliminate this problem, a large micrometer is used for measurements.

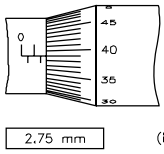
viii) 19.00 mm
0.50 mm
0.05 mm
Total 19.55 mm



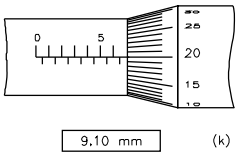
ix) 2.00 mm
0.50 mm
0.25 mm
Total 2.75 mm



x) 21.00 mm
0.00 mm
0.14 mm
Total 21.14 mm

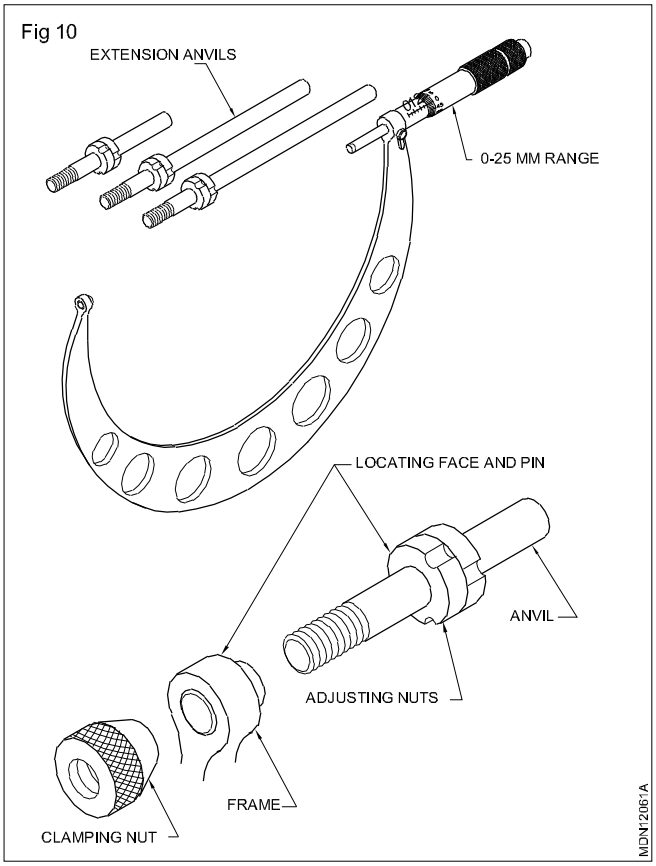


xi) 9.00 mm
0.00 mm
0.10 mm
Total 9.10 mm



Large micrometers (Fig 10)

Fig 10



Skill Information

Precision Measuring Instruments - Outside Metric Micrometer

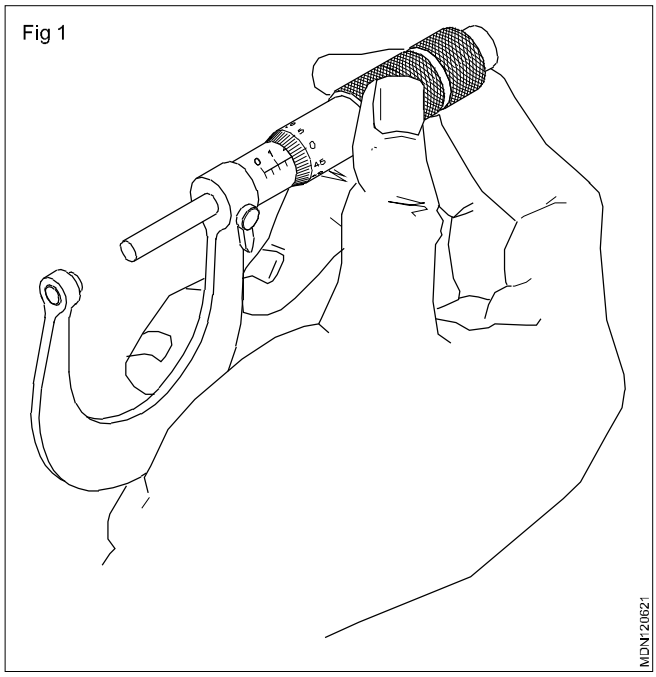
Objectives At the end of this lesson you shall be able to
- **hold the micrometer for measurement**
- **set the micrometer on work for measurement**
- **read the measurement.**

Holding the micrometer for measurement

The micrometer may be held either in one hand or both the hands.

Holding In one hand (Fig 1)

Fig 1



Hold the outside micrometer in your right hand, keeping the graduations on the main scale towards you.

Support the frame on the lower centre of your palm. Use your little or third finger to hold the frame in the palm.

Place the middle finger behind the frame to support it.

Keep the first finger and thumb free to adjust the knurled thimble.

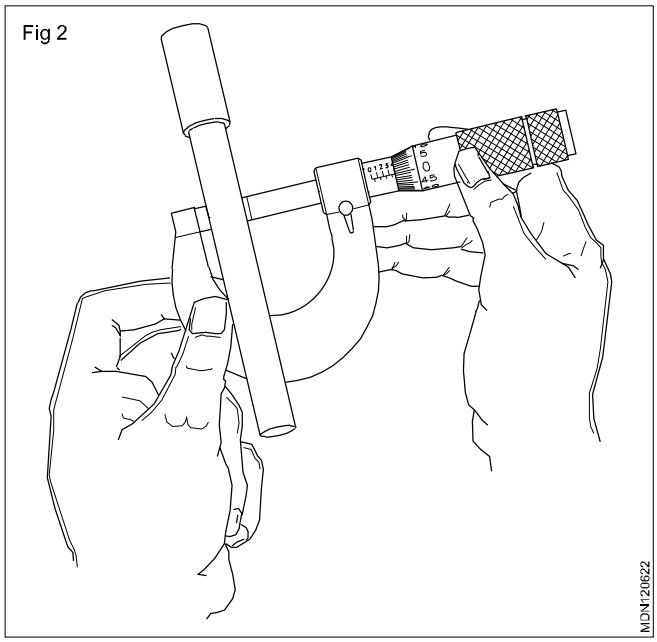
Holding by both the hands (Fig 2)

Sometimes, it may be more convenient to hold the micrometer with both the hands.

Support the frame between the fingers and the thumb of your left hand.

Use the thumb and finger of your right hand to adjust the thimble.

Fig 2



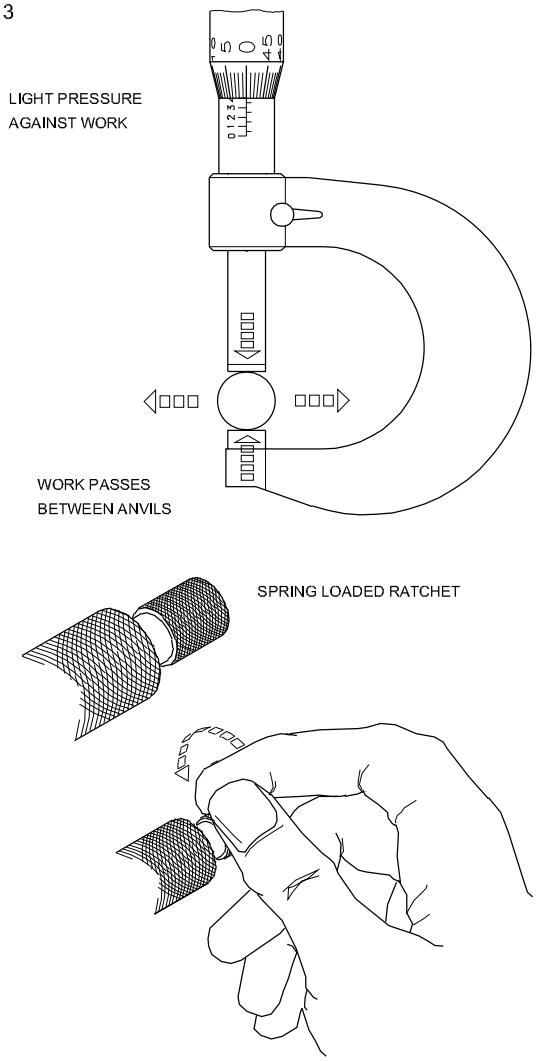
Setting the micrometer on the workplace for measurements (Fig 3**)**

High skills needed for obtaining accurate measurements with the outside micrometer. A wrong setting of the micrometer over the workplace may cause:

- inaccurate reading
- excessive strain on the screw thread
- distortion in the frame.

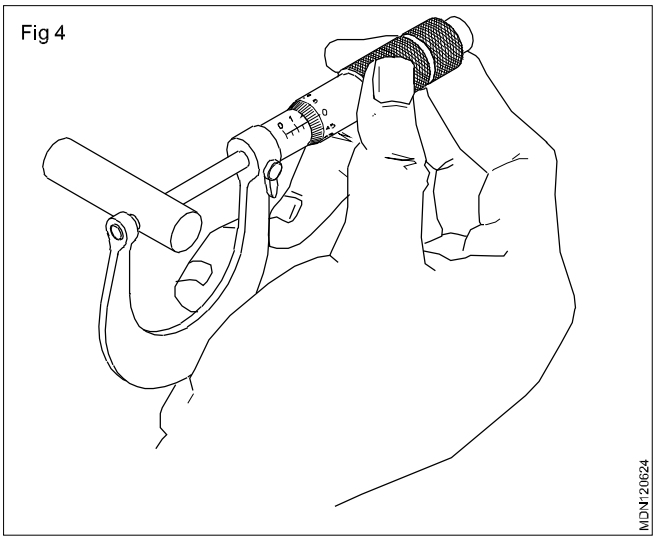
Figure shows the adjustment of the spindle and anvil over workplace. As you adjust the workplace between the spindle and the anvil, you should feel a light pressure or resistance against the workplace surface. Use the spring loaded ratchet stop to ascertain the feel.

Fig 3



While using only one hand: (Fig 4**)**

Fig 4



- Close the anvil and spindle until you feel them just touching the work
- Move the work slightly between the spindle and the anvil or pass the micrometer over the workplace by moving your wrist
- Make further adjustments of the thimble as required until you obtain the right 'feel'
- When satisfied with the feel, remove the fingers from the thimble
- Turn the micrometer towards you
- read the measurement

Method of reading the micrometer 0-25 range (Fig 5)

Look at the reading which has been taken from the workplace.

Read on the barrel scale the number of whole millimeters that are completely visible from the bevel edge of the thimble. Figure 'a' shows 4 divisions = 4 mm.

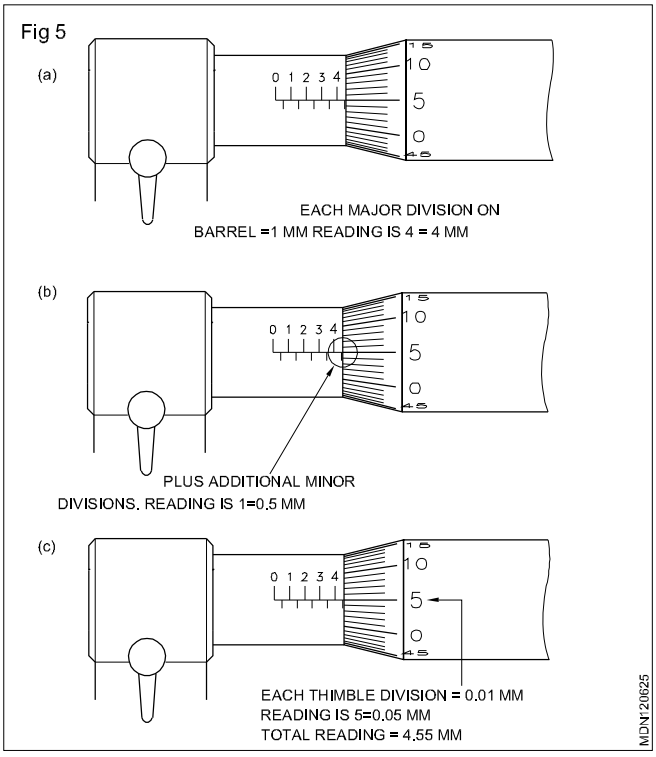
Add any half millimeters that are completely visible from the bevel edge of the thimble.

Figure 'b' shows 1 division = 0.5 mm.

Add the thimble reading to the main scale reading which has already been taken. Figure 'c' shows the 5th division of the thimble scale is coinciding with the index line. So thimble reading = 5 * 0.01 = 0.05 mm.

	4. 00 mm
	0.50 mm
	0.05 mm
Total reading	4.55 mm

Fig 5



Depth micrometer

Objectives: At the end of this lesson you shall be able to

- **name the parts of a depth micrometer**
- **state the constructional features of a depth micrometer**
- **read the depth micrometer measurement.**

Constructional features (Fig 1)

A depth micrometer consists of a stock on which a graduated sleeve is fitted.

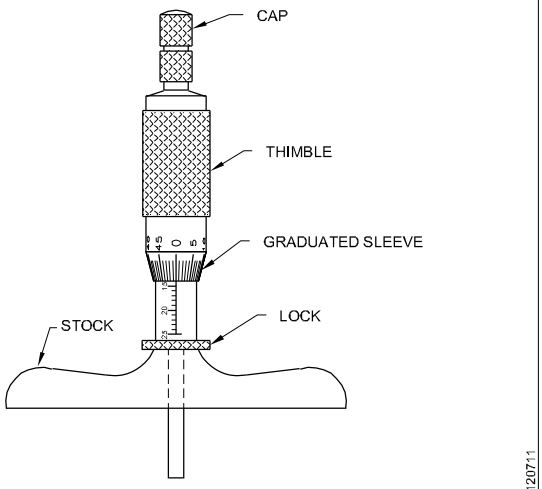
The other end of the sleeve is threaded with 0.5 mm pitch 'V' thread.

A thimble, which is internally threaded to the same pitch and form, mates with the threaded sleeve and slides over it.

The other end of the thimble has an external step machined and threaded to accommodate a thimble cap.

A set of extension rods are generally supplied. On each of them, the range of sizes that can be measured with that rod is engraved as 0-25 mm, 25-50 mm, 50-75 mm, 75-100 mm, 100-125 mm and 125-150 mm.

Fig 1



DEPTH MICROMETER

These extension rods can be inserted inside the thimble and the sleeve.

The extension rod has a collar head which helps the rod to be held firmly. (Fig 2)

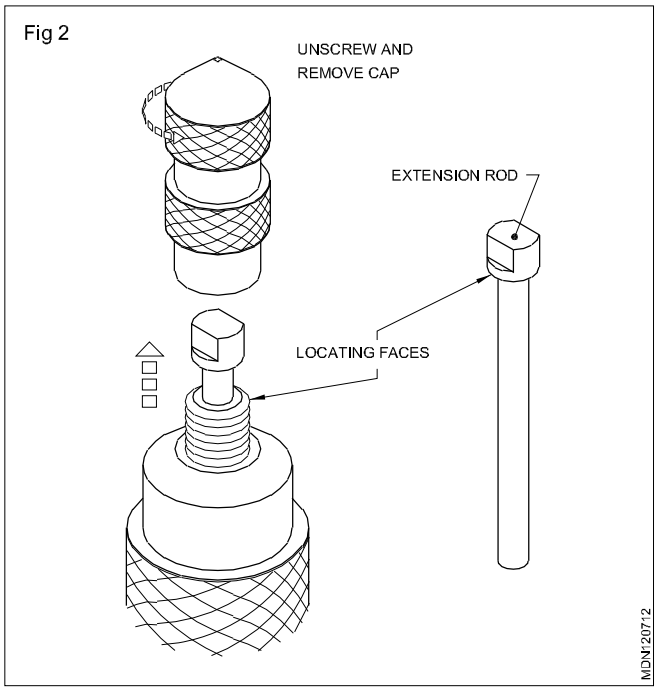
The measuring faces of the stock and the rods are hardened, tempered and ground. The measuring face of the stock is machined perfectly flat.

The extension rods may be removed and replaced according to the size to be measured.

Graduation and least count

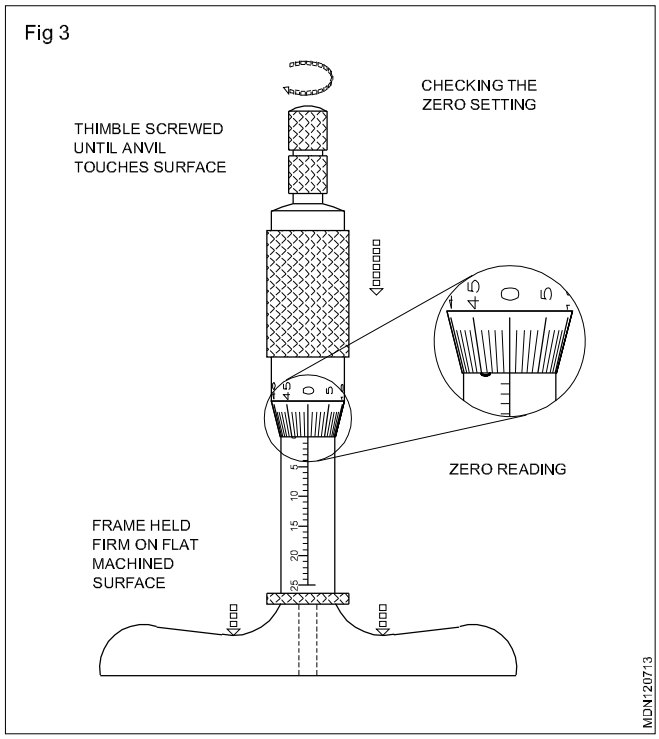
On the sleeve a datum line is marked for a length of 25 mm. This is divided into 25 equal parts graduated. Each

Fig 2



line represents one millimeter. Each fifth line is drawn little longer and numbered. Each line representing 1mm is further subdivided into two equal parts. Hence each subdivision represents 0.5 mm. (Fig 3)

Fig 3

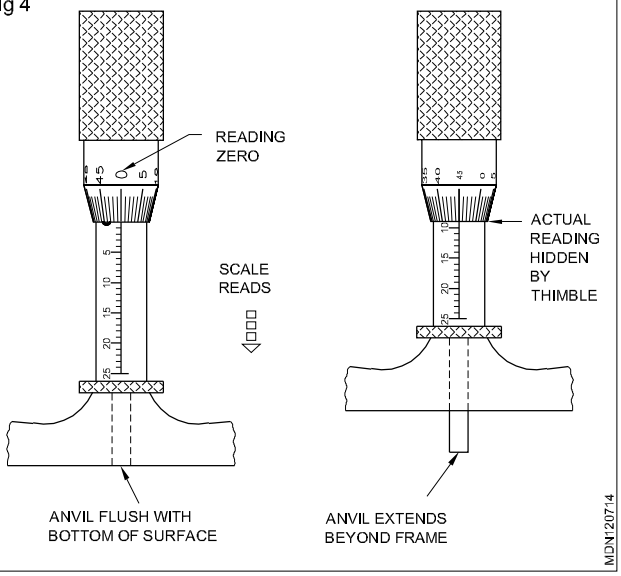


The graduations numbered are in the reverse direction to that marked on an outside micrometer.

The zero graduation of the sleeve is one the top and the 25 mm graduation is near the stock.

The bevel edge of the thimble is also graduated. The circumference is divided into 50 equal parts and every 5th division line is drawn longer and numbered. The numbering is in the reverse direction and increases from 0 to 5, 10, 15, 25, 30, 35, 40, 45 and 50 (0). (Fig 4)

Fig 4



The advancement of the extension rod for one full turn of the thimble is one pitch which is 0.5 mm.

Therefore the advancement of the extension rod for one division movement of the thimble will be equal to 0.5 / 50 = 0.01 mm.

This will be the smallest measurement that can be taken with this instrument, and so this is the accuracy of measurement of this instrument.

Uses of a depth micrometer

Depth micrometers are special micrometers used to measure:

- Depth of holes
- depth of grooves and recesses
- heights of shoulders and projections.

Description least count, calculation, care and use of vernier caliper

Objectives: At the end of this lesson you shall be able to
- **state the principle of vernier**
- **define least count**
- **derive the least count of vernier scales.**

The vernier principle

The basic principle of the vernier is that the smallest unit of size to which a vernier can be read is equal to the difference in the length between the divisions of the two scales.

The magnification on the vernier scale is given by two scales sliding over each other; the eye can detect which divisions on one of them are smaller than those on the other. The eye can detect which of these divisions are in line with each other, and it is this fact which enables us to read a vernier to 0.02 mm accuracy.

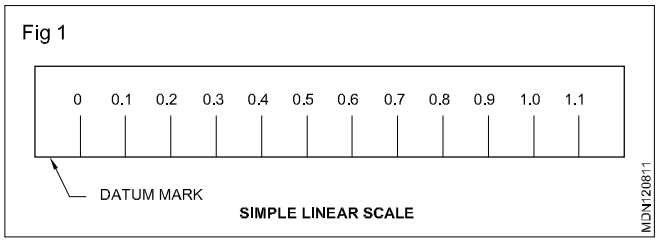


Figure 1 show the vernier principle being used to determine the reading. Figure 1 shows the main scale with the datum line marked.

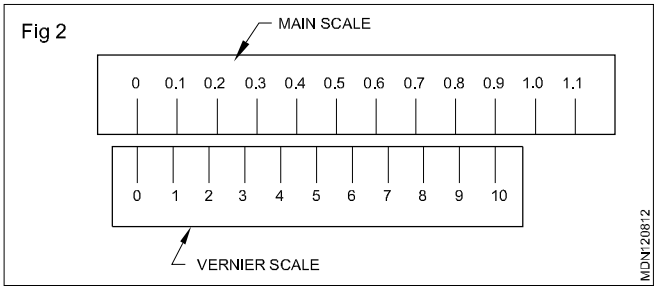


Figure 2 shows the main scale and vernier scale with graduations. The value of 1 main scale is 0.1 unit. In vernier scale 9 such units are taken and divided into 10 equal parts. Hence the value of 1 vernier scale is

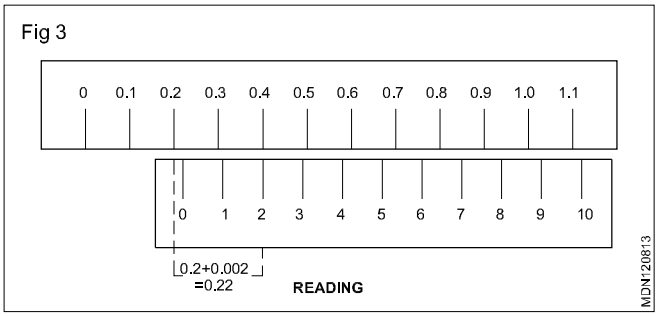
0.9/10=0.09 units

Now, by applying the vernier principle, the smallest unit of size is 1 M.S.D. - 1 V.S.D. (i.e.) 0.1 - 0.09=0.01 unit.

Definition of the least count

The least count is the smallest possible measurement that can be taken with the precision instrument.

Figure 3 shows the method of reading the vernier scale. The zero of the vernier scale is between 0.2 to 0.3 units



on the main scale and number 2 graduation of the vernier scale is coinciding with the 4th division of the main scale. Thus the reading is 0.2 + 2 * 0.01=0.22.

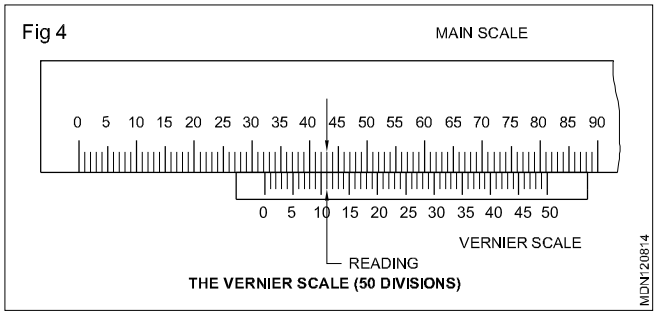
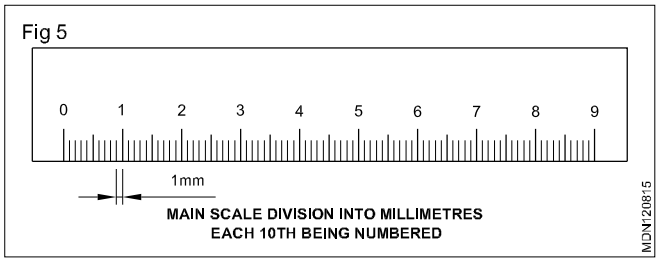
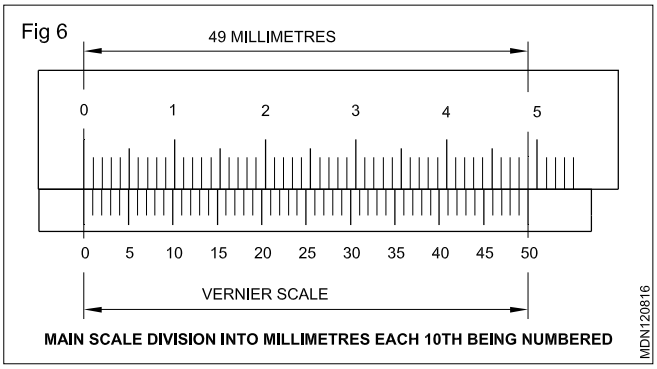


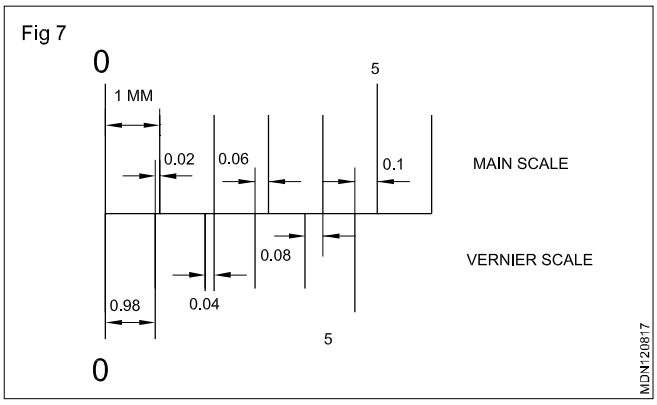
Figure 4 shows a typical 50 division vernier scale as used in modern metric measurements.



The main scale of this instrument is graduated in mm.

The purpose of a vernier 49 such divisions are … divided into 50 equal divisions. So the value of vernier scale division works out to 49/50 mm (Fig 6).





Least count is 1 main scale division - 1 vernier scale division (Fig 7).

which is $1\text{mm} - \frac{49}{50}\text{mm} = \frac{50 - 49}{50} = \frac{1}{50} = 0.02\,\text{mm}$

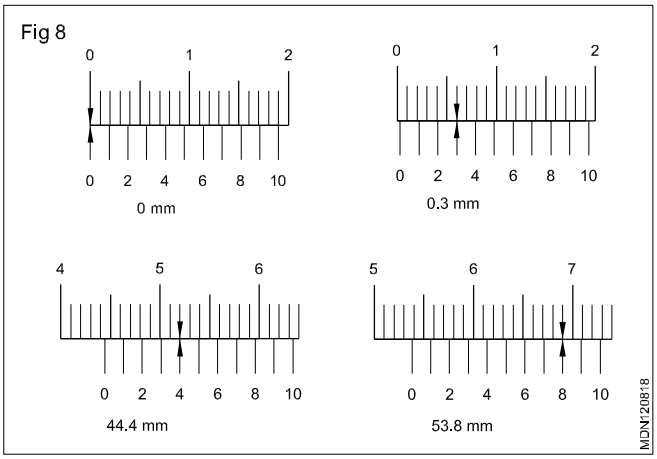
In that case of 150 mm capacity vernier calipers the main callers graduated in ½ mm instead of in 1 mm. For the purpose of the vernier scale 24 such divisions are taken and divided into 25 equal divisions. So the value of 1 vernier scale division is

$$\frac{1}{2} \times \frac{24}{25} = \frac{12}{25}\text{mm}$$

Least count = 1 M.S.D. - 1 V.S.D.

$$\frac{1}{2}\text{mm} - \frac{12}{25}\text{mm} = \frac{25 - 24}{50} = \frac{1}{50} = 0.02\text{mm}$$

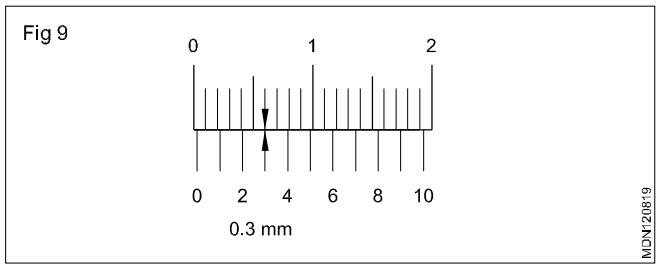
Measurement of reading (Fig 8)



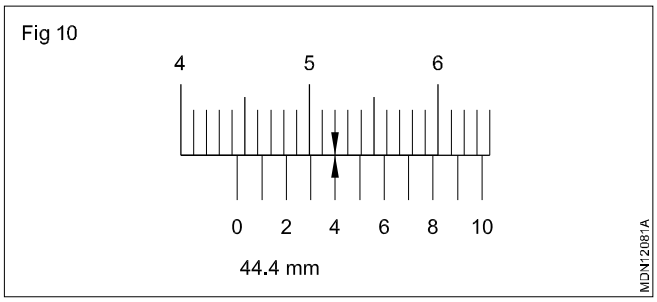
It is 0 mm as 'O' of vernier scale and 'O' of the main scale if that coincide.

Measurement of reading (Fig 9 & 10)

'O' of vernier is to the right of the main scale and lies between 'O' and 1st division of the main scale. The 3rd division of the vernier scale coincides with a division on the main scale.

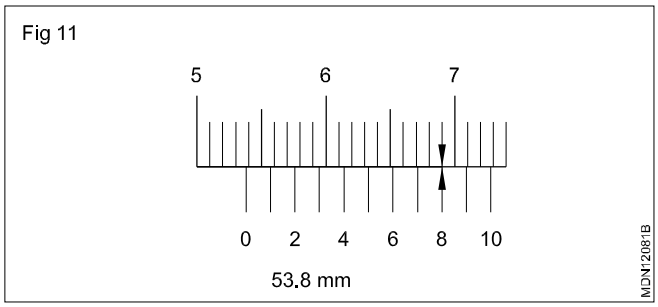


Hence measurement is 0 mm + 3 * 0.1 mm = 0.3 mm.



Measurement of reading (Fig 11)

'O' of the vernier scale lies between the 44th and 45th divisions of the main scale and the 4th division of the vernier scale coincides with a division of the main scale. Hence the measurement is 44 mm + 4 * 0.1 mm = 44.4



Measurement of reading

'O' of the vernier scale lies between the 53rd and 54th divisions on the main scale, and the 8th division of the vernier scale coincides with a division on the main scale. Hence measurement is 53 mm + 8 * 0.1 mm = 53.8 mm.

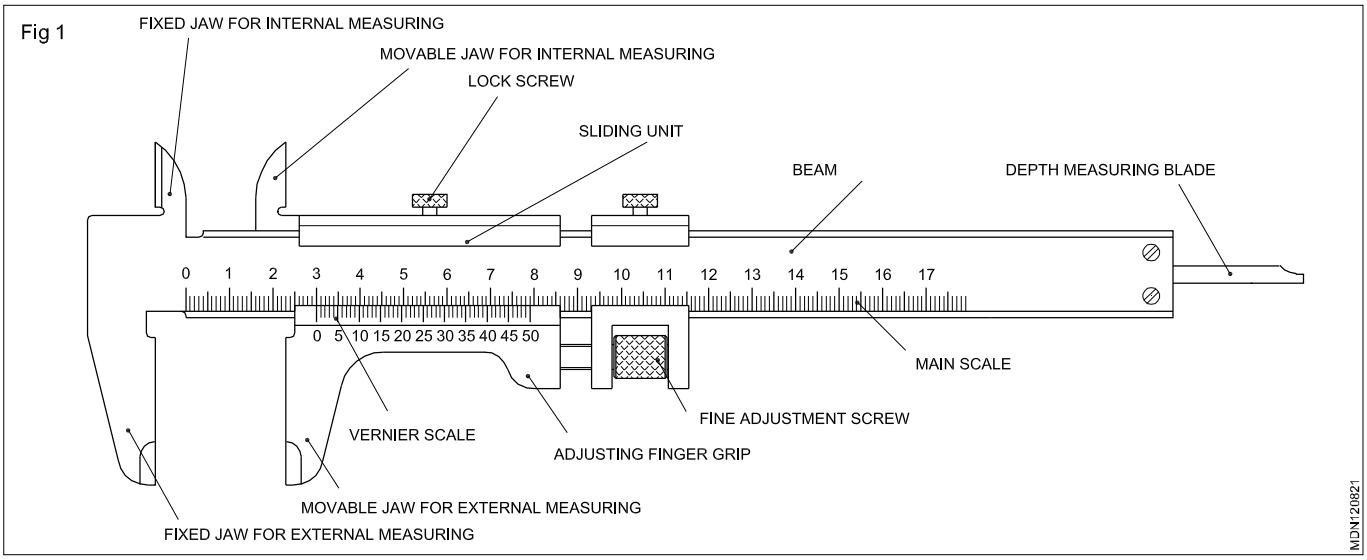
The least count of the vernier caliper used for the above readings is 0.1 mm.

The universal vernier caliper and its application

Objectives: At the end of this lesson you shall be able to
- **list out the parts of a universal caliper**
- **state the constructional features of the universal vernier caliper**
- **state its functional features**
- **list out the points for taking the measurements.**

One of the precision instruments having the principle of vernier applied to it is the universal vernier caliper. It is known as a universal vernier caliper because of its application to take outside, inside and depth measurements. Its accuracy is 0.02 mm.

Fig 1



A universal vernier caliper consists of a:

- Beam
- Fixed jaw for external measurements
- Movable jaw for external measurements
- Movable jaw for internal measurements
- Blade for depth measurement
- Main scale
- Vernier scale
- Fine adjustment screw
- Set of locking screws.

All parts are made out nickel-chromium steel, heat-treated and ground. They are machined to a high accuracy. They are stabilized to avoid distortion due to temperature variations.

Constructional features (Fig 1)

The beam is the main part and the main scale graduations are marked on it. The markings are in millimeters and every tenth line is drawn a little longer and brighter than the other graduations and numbered as 1,2,3 ….

To the left of the beam the fixed jaws for external and internal measurements are fixed as integral parts., The vernier unit slides over the beam.

At the bottom face of the beam a keyway-like groove is machined for its full length, permitting the blade to slide in the groove.

At the bottom right hand end, a unit is fixed serving as a support for the blade when it slides in the groove.

The vernier unit has got the vernier graduations marked on it. The movable jaws for both external and internal measurements are integral with this.

The fixed and movable jaws are knife-edged to have better accuracy during measurement. When the fixed and movable jaws are made to contact each other, the zero of the vernier scale coincides with the zero of the main scale.

At this position in the blade will be in line with the right hand edge of the beam.

When the vernier scale unit slides over the beam, the movable jaws of both the measurements as well as the blade advance to make the reading.

To slide the vernier unit, the thumb lever is pressed and pulled or pushed according to the direction of movement of the vernier unit.

Least count

In the vernier scale illustrated here, 19 mm are divided into 10 equal parts on the vernier scale. The value of 1 vernier scale division will then be

$$\frac{19}{10}=1.9\text{mm}$$

The difference of the two main scale divisions and 1 vernier scale division gives the least count and it is equal to 2*1m -1.9 mm = 0.1 mm.

For better accuracy, a 49 mm space is divided into 50 equal parts on the vernier scale so that one vernier scale division value will be

$$\frac{49}{50}=0.98\,\text{mm}$$

Here the least count will be 1 main scale division - 1 vernier scale divisions = 1 mm-0.98 mm= 0.02 mm.

The application of the universal vernier caliper is taking external, internal and depth measurements is shown in (Fig 2)

Advantages

No need to have separate precision instruments for taking external, internal and depth measurements.

Disadvantages

Accuracy of reading depends on the skill of the operator.

Loses its accuracy by constant usage as slackness in the sliding unit develops.

Cannot be used to measure components having deviations less than +/-0.02 mm.

Possibility of parallax error during noting down the coinciding line may cause the reading of the measurement to be wrong.

To read a measurement

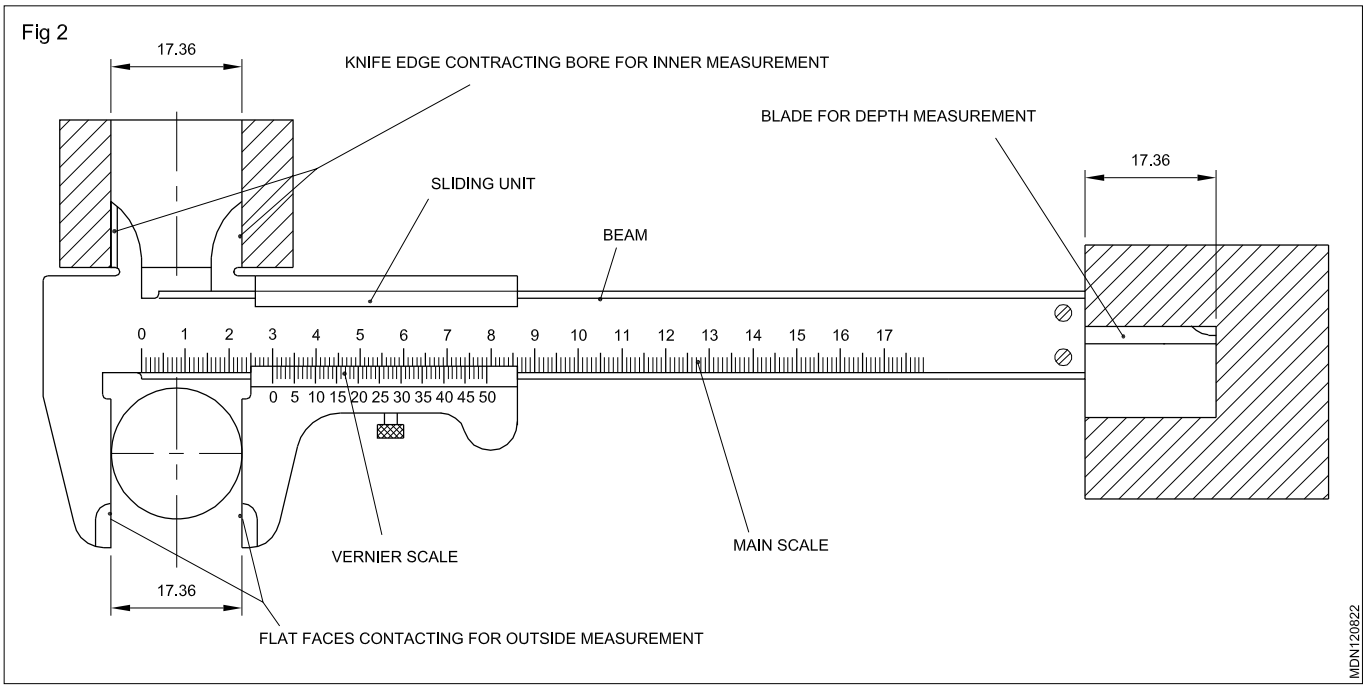
Note the number of graduations on the main scale passed by the zero of the vernier. This gives the full mm.

Note which of the vernier scale division coincides with any one line on the main scale.

Multiply this number with the least count.

Add the multiplied value to the mainscale reading.

Fig 2



Telescope gauge

Objectives: At the end of this lesson you shall be able to
- **name the parts of telescope gauge**
- **Measuring technique how to telescope gauge reading on outside micrometer**

Telescopic Gauge (Fig 1) **:** This is an instrument used for measuring the inside size of slots or holes. It consists of a handle and two plungers, one of which telescopes into the other. Both the plungers are kept under spring tension. In order to lock the plungers in position, a knurled screw at the end of the handle is tightened. If the diameter of a hole is to be measured, the plungers are first compressed and then locked. The plunger end is put into the hole and the end is allowed to expand so that the plungers touch the opposite edges.

Then the plungers are locked in position and taken out of the hole. The diameter is measured with the help of an outside micrometer. The telescopic gauge does not have graduations of its own.

The precaution to be taken in the telescopic gauge in that they should be inserted squarely on to the bore and centralised properly.

Measuring Technique

(a) Compress the fixed and telescopic legs and lock them by locking screw.

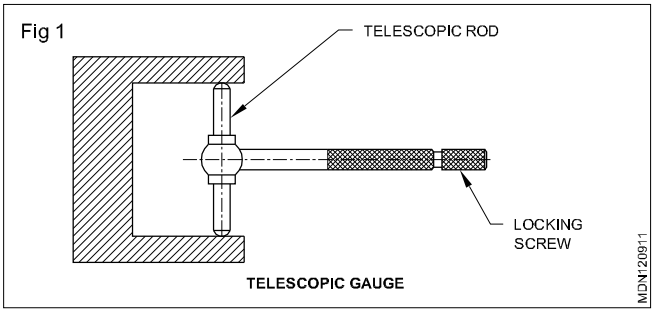
(b) Insert the gauge ends into the hole to be measured.

(c) Unlock the legs by unscrewing the locking screw for expanding the legs to the inner diameter of the hole.

(d) Measure with feel and lock the legs in position.

(e) Transfer the measurement to an outside micrometer for reading.

Fig 1



TELESCOPIC GAUGE

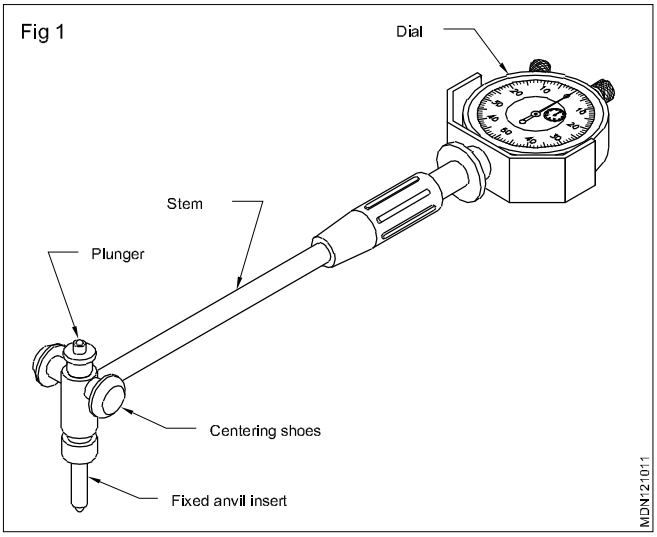
Dial bore gauge

- **name the parts of a bore dial gauge**
- **state the features of a bore dial gauge**
- **read the measurement using a graduated dial.**

This is a precision measuring instrument used for measuring the internal dimensions. The dial bore gauge is normally available as a two-point, self-cantering type

Dial bore gauge (Fig 1) **:**

Fig 1



Stem

This holds all the components together and contains the mechanism for transmitting the plunger motion to the dial.

Fixed anvil/inserts

These anvils are interchangeable. The selection of the anvil is made depending on the diameter of the bore to be measured. For certain types of bore dial gauges, extension rings/washers are provided for extending the range of measurement.

Sliding plunger

This actuates the movement of the dial for reading the measurement.

Centering shoes/spherical supports

Certain types of bore dial gauges are provided with a pair of ground discs. (Fig 2)

This maintains the alignment of the measuring faces in the centre of the bore. For some types, two spherical supports which are spring-loaded are provided.

Dial Indicator (Fig 3)

This has graduations marked on the dial. The graduations has marked in clockwise and anticlockwise directions.

Bore dial gauges are available in various sizes with different measuring ranges. These are interchangeable measuring rods (external rods or combination washers) for measuring different sizes. (Fig 4)

Fig 2

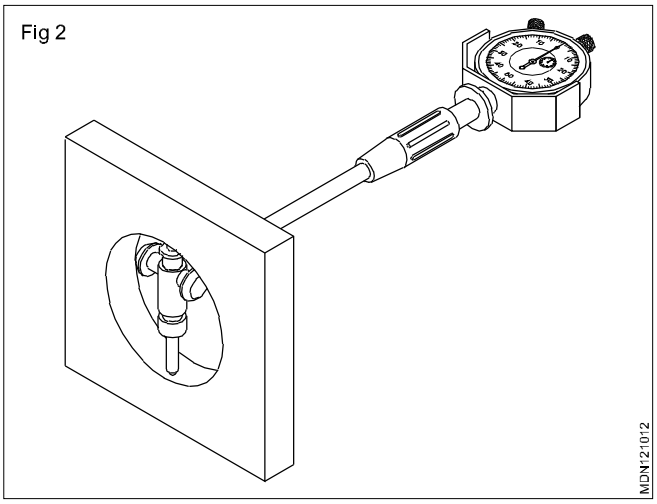


Fig 3

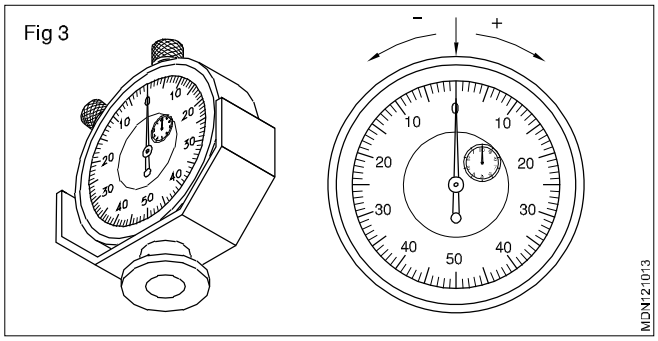
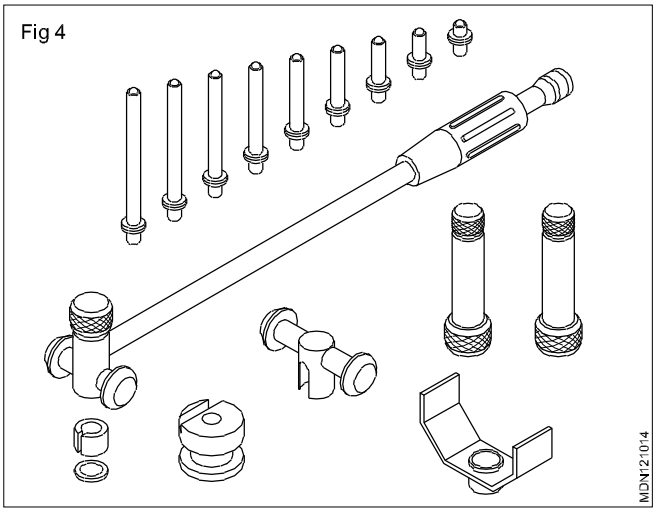


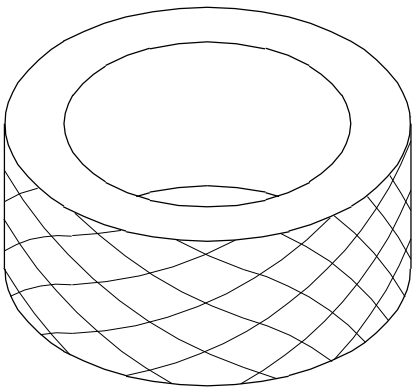
Fig 4



The accuracy of the instrument depends on the type of graduations on the dial. The most frequently used instruments have accuracies of 0.001 mm and 0.01 mm.

The dial gauge should be set to zero before taking measurement. Setting rings are available for zero setting. (Fig 5)

Fig 5



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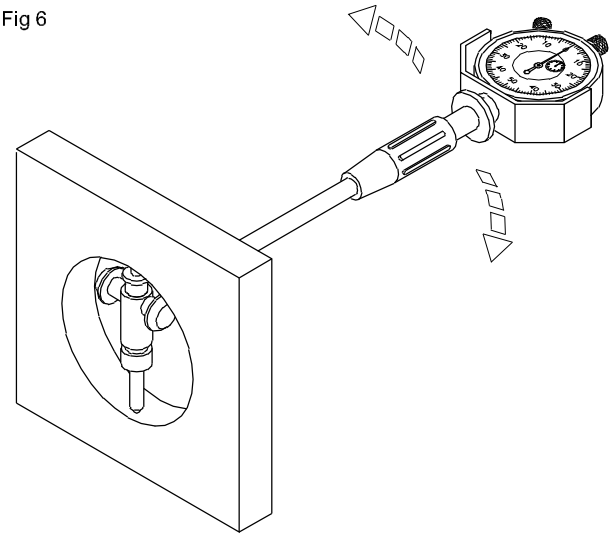
While taking measurements press the spring-loaded end (plunger) as it enters into the setting device or in the bore being measured. Slightly rock and steady the device for keeping the measuring faces in position. (Fig 6)

Fig 6



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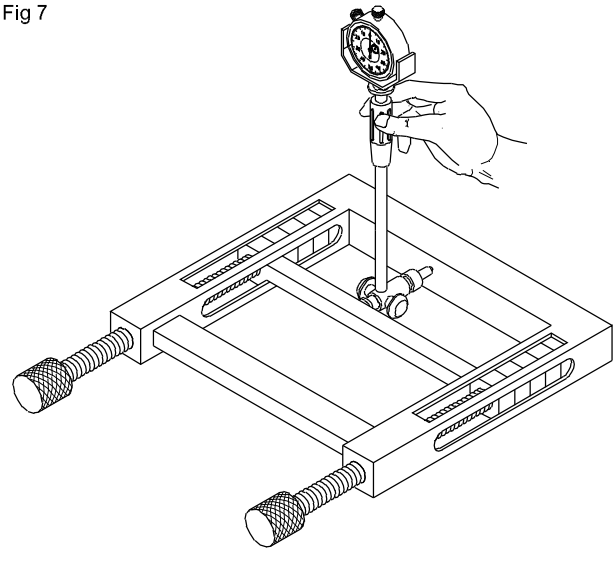
Slip gauges fixed in a setting fixture can also be used for zero setting. (Fig 7)

Fig 7



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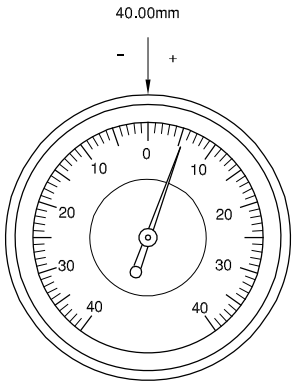
Reading the dial indicator (Fig 8)

When taking the reading, first check the measuring range and the subdivisions of the scale. The indicator in the figure has a range of 0.8 mm and is graduated 0-40 in both directions. Thus the value of each division is 0.01 mm.

The indicator shows positive deviations in the clockwise direction and negative deviations in the anticlockwise direction.

Fig 8



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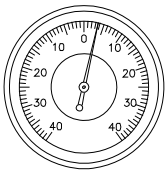
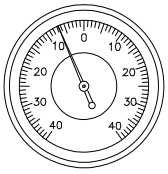
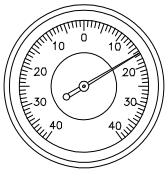
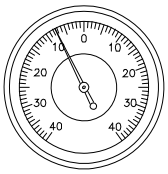
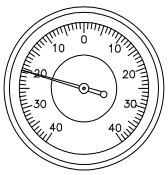
Classroom assignment

Basic measurement		Value measured	
30.0 mm		29.97 - 29.98	☐
		30.02 - 30.03	☐
		30.03 - 30.04	☐
		30.04 - 30.05	☐
23.0 mm		22.92 - 22.93	☐
		22.93 - 22.94	☐
		22.94 - 22.95	☐
		22.96 - 22.97	☐
47.8 mm		47.86 - 47.87	☐
		47.88 - 47.89	☐
		47.92 - 47.93	☐
		47.96 - 47.97	☐
53.0 mm		52.92 - 52.93	☐
		52.93 - 52.94	☐
		53.96 - 53.97	☐
		53.97 - 53.98	☐
65.0 mm		64.75 - 64.76	☐
		64.79 - 64.80	☐
		64.83 - 64.84	☐
		64.87 - 64.88	☐

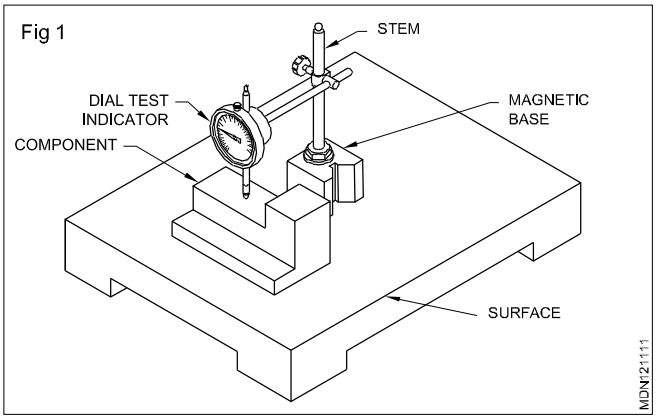
Dial test indicators

Objectives: At the end of this lesson you shall be able to
- **state the principle of a dial test indicator**
- **state the types of dial test indicator**
- **identify the parts of a dial test indicator**
- **state the important features of a dial test indicator**
- **state the functions of a dial test indicator**
- **identify the different types of stands.**
- **state the important of straight edge**

Dial test indicators

Dial test indicators are instruments of high precision, used for comparing and determining the variation in the sizes of a component. These instruments cannot give the direct reading of the sizes like micrometers and vernier calipers. A dial test indicator magnifies small variations in sizes by means of a pointer on a graduated dial. This indirect reading of the deviations gives an accurate picture of the conditions of the parts being tested. (Fig 1)

Fig 1



Principle of working

The magnification of the small movement of the plunger or stylus is converted into a rotary motion of the pointer on a circular scale.

Types

Two types of dial test indicator4s are in use.

They are the

- Plunger type (Fig 2)
- Lever type. (Fig 3,4 & 5)

The plunger type dial test indicator

The external parts and features of a dial test indicator are as shown in the (Fig 2).

Pointer (A)

Rotatable bezel (B)

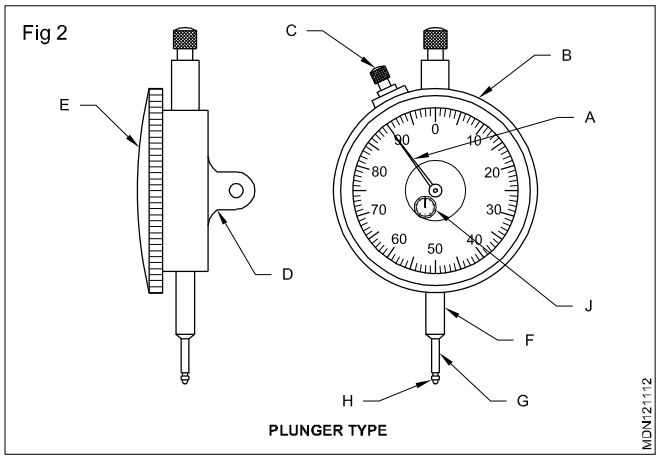
Bezel clamp (C)

Back lug (D)
Transparent dial cover (E)
Stem (F)
Plunger (G)
Anvil (H)

Revolution counter (J)

For converting the linear motion of the plunger, a rack and pinion mechanism is used.

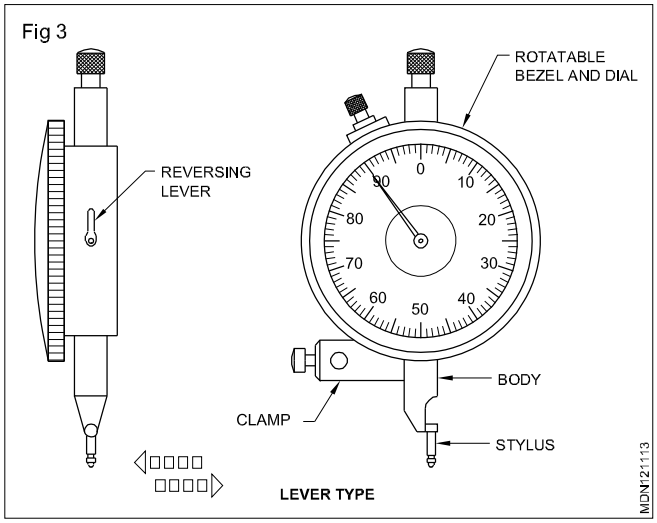
Fig 2



The lever type dial test indicator (Fig 3,4,5)

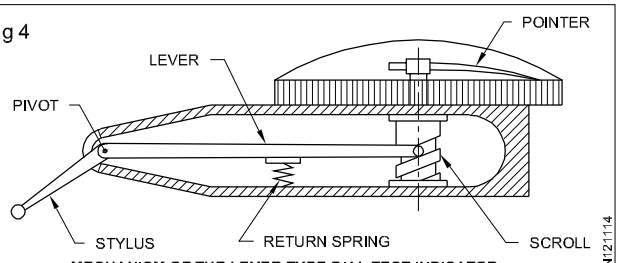
In the case of this type of dial test indicators, the magnification of the movement is obtained by the mechanism of the lever and scroll.

Fig 3



It has a stylus with a ball-type contact, and it has an oscillating movement as against the reciprocating movement in the plunger type indicator.

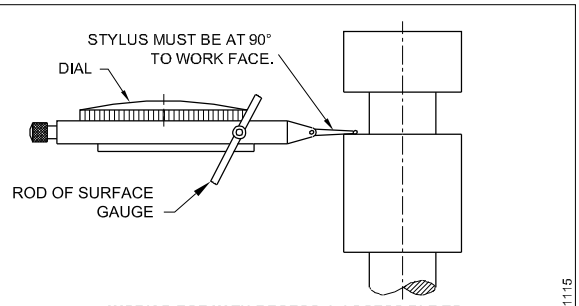
Fig 4



MECHANISM OF THE LEVER TYPE DIAL TEST INDICATOR

This can be conveniently mounted on a surface gauge stand, and can be used in places where the plunger type dial test indicator application is difficult.

Fig 5



WORK PIECE WITH RECESS INACCESSIBLE TO PLUNGER TYPE DIAL INDICATOR

Important features of dial test indicators

An important feature of the dial test indicator is that the dial can be rotated by a ring bezel, enabling the zero to be get in any position.

Many dial test indicators read plus in the clockwise direction from zero, and minus in the anticlockwise direction so as to give plus and minus indications.

Uses

- To compare the dimensions of workpiece against a known standard, eg. Slip gauges.
- To check plane surfaces for parallelism and flatness.
- To check straightness of shafts and bars.
- To check concentricity of holes and shafts.

Indicator stands (Fig 6 & 7)

Dial test indicators are used in conjunction with stands for holding them so that the stand itself may be placed on a datum surface or machine tool.

The different types of stands are:

- Magnetic stand with universal clamp
- Magnetic stand with flexible post
- General purpose holder with cast iron base.

Fig 6

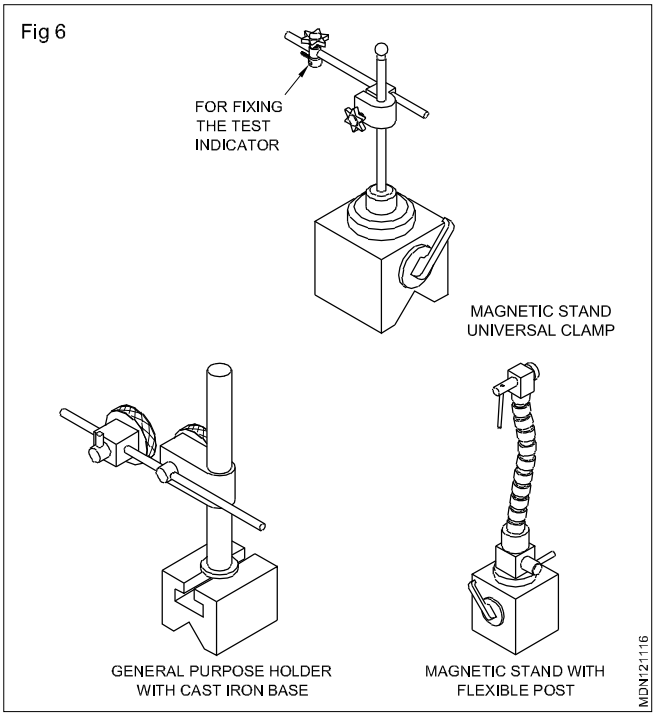
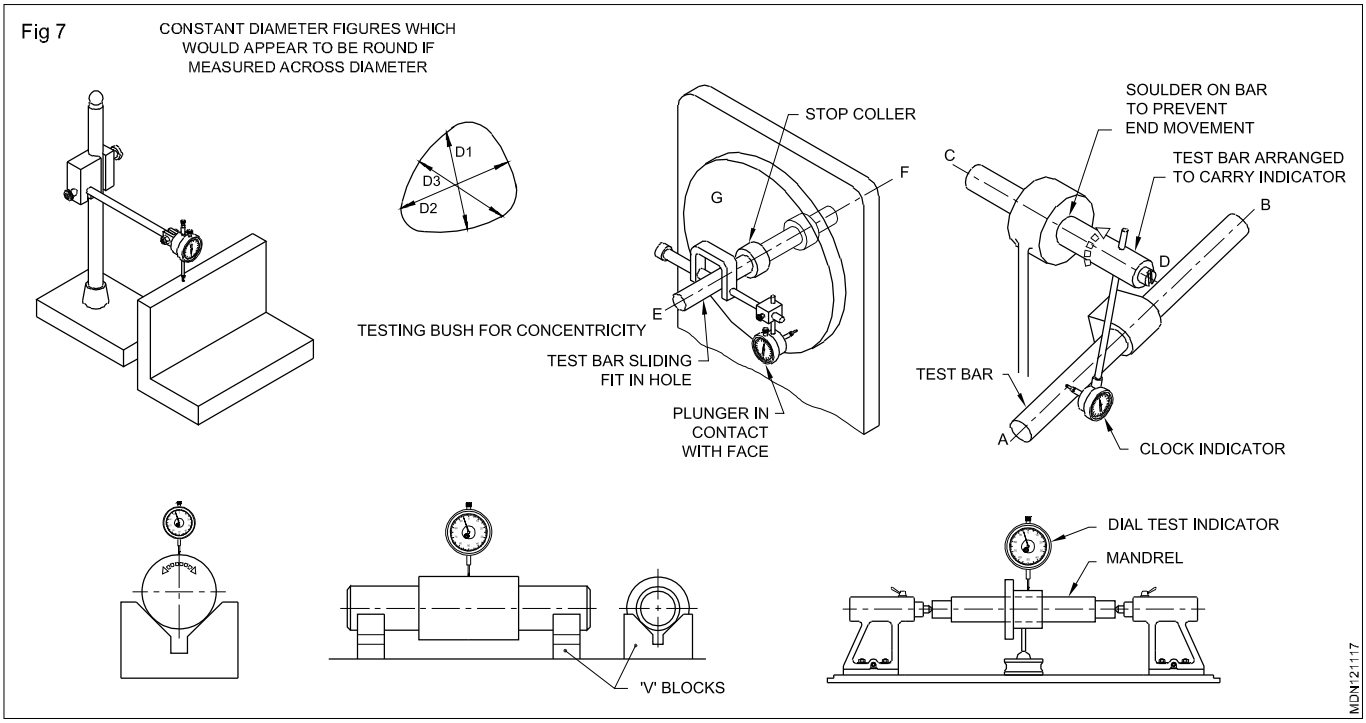


Fig 7



Straight edges

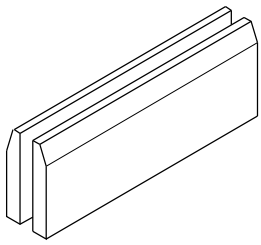
Objectives: At the end of this lesson you shall be able to
- **name the different types of straight**
- **state the straight edge uses edge**
- **state the different method of testing straightness.**

For testing straightness and to use a guide for marking long straight lines. Straight edges made of steel or cast iron are used.

Steel straight edges.

These are usually available up to 2 meters in length and may be rectangular in cross-section or have one edge beveled (Fig 1)

Fig 1



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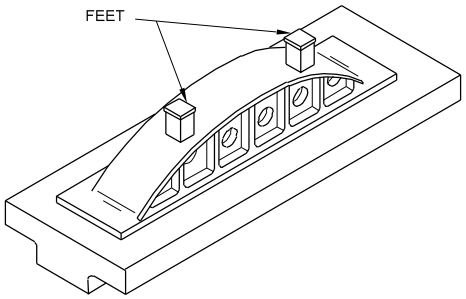
Cast iron straight edges (Fig 2)

These are made from close- grained, grey, cast iron and can be considered as narrow surface plates. They are available up to 3 meters length and are used for testing machine tool sideways, cast iron straight edges have ribs, and bow-shaped tops to prevent distortion. These straight edges are-shaped tops to prevent distortion. These straight edges are provided with feet to prevent distortion under their own weight.

Fig 2



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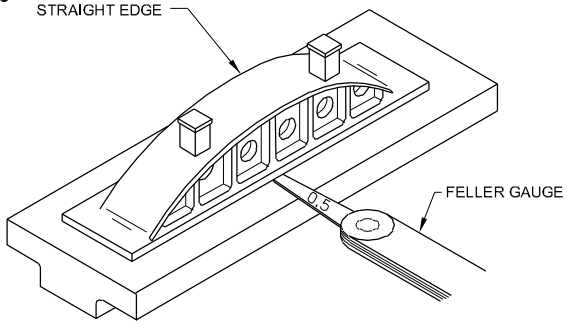
Use of straight edges

Checking with feeler gauges

In certain situations when the gap between the surface and the straight edge is more. a feeler gauge can be used (Fig 3) to determine the extent of deviation.

Fig 3



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USE OF STRAIGHT EDGE -FELLER GAUGE

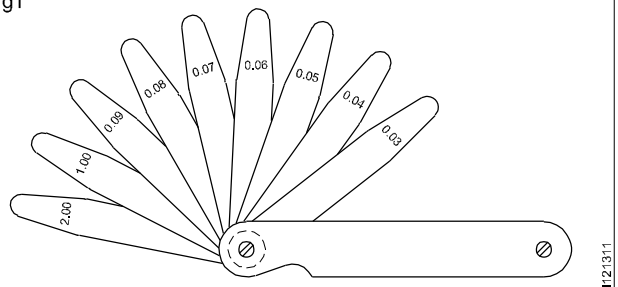
Feeler gauge & uses

Objectives: At the end of this lesson you shall be able to
- **state the constructional features of a feeler gauge**
- **state the method of indicating different ranges of**
- **state the method of setting a feeler gauge**
- **state the different uses of feeler gauges.**

Features

A feeler gauge consists of a number of hardened and tempered steel blades of various thicknesses mounted in a steel case.

Fig1



The thickness of individual leaves is marked on it. (Fig 1)

The sizes of the feeler gauges in a set are carefully chosen in order that a maximum number of dimensions can be formed by building up from a minimum number of leaves.

The dimension being tested is judged to be equal to the thickness of the leaves used. When a slight pull is felt while with drawing them. Accuracy in using these gauges requires a good sense of feel.

B.I.S

The Indian standard establishes four sets of feeler gauges Nos.1,2,3 and 4 which differ by the number of blades in each and by the range of thickness(minimum) is 0.03mm

Example

Set No.4 of Indian standard consists of 13 blades of different thicknesses.

0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.010, 0.015, 0.20, 0.30, 0.040, 0.50.

USES

Feeler gauges are used:

- to check the gap between the mating parts
- to check and set the spark plug gaps and tappet clearance in an engine etc.
- to set the clearance between the fixture (setting block) and the cutter/tool for machining the jobs. (Fig 2,3)
- to check and measure the bearing clearance, and for many other purposes where a specified clearance must be maintained.

Fig 2

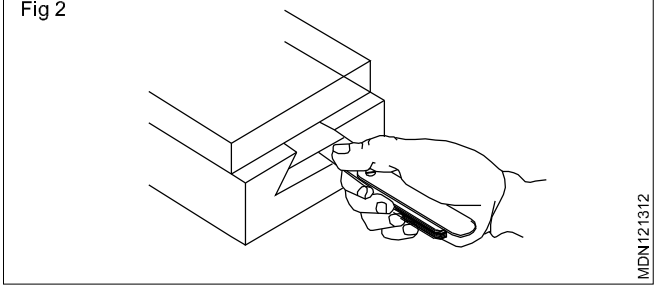
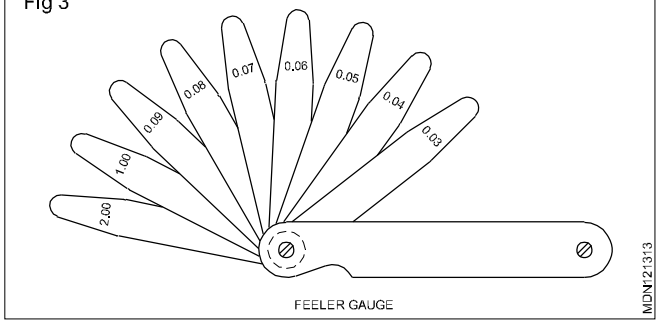


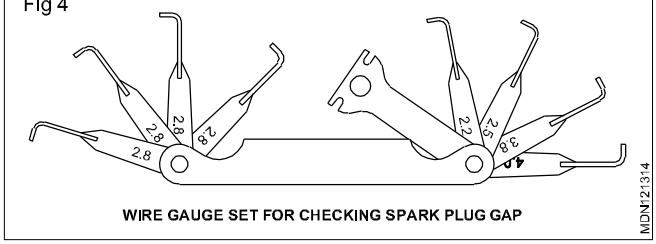
Fig 3



FEELER GAUGE

Wire gauge (Fig 4): The plug wire gauge is a thickness gauges using wires of varying diameter instead of thin flat strips of steel. It is used fir checking spark plug gap.

Fig 4



WIRE GAUGE SET FOR CHECKING SPARK PLUG GAP

Types of feeler gauge.

1 universal master gauge

2 standard feeler gauge

3 ignition and wire gauge

Classification of feeler gauge

- Universal master gauge containing 25 leaves
- Standard feeler gauge containing 10 leaves
- Go and No Go type feeler gauge containing 15 step-grand leaves
- Overhead valve feeler gauge containing 16 offset blades
- Ignition feeler gauge containing 12 leaves
- Piston gauge containing and leaves
- Spark plug wire gauge containing are electrode bender 8 wire gauge

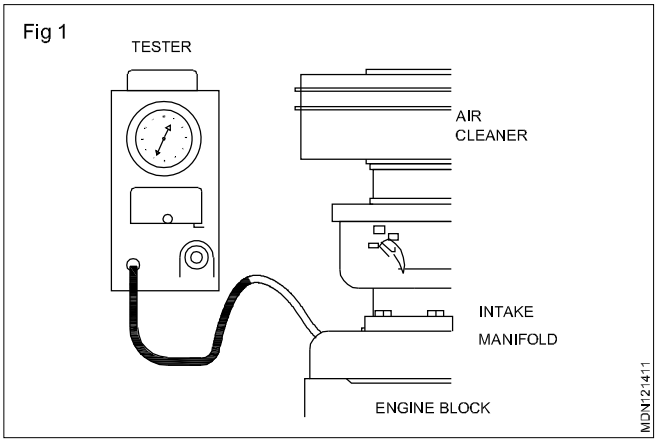
Vacuum gauge

Objectives: At the end of this lesson you shall be able to
- **state the purpose of vacuum gauge**
- **state the vacuum gauge attachment in an engine.**

A vacuum gauge (Fig 1) is a useful diagnostic and time-up tool.

It is used to detect vacuum leaks at idle speed, sticking valves, worn rings, clogged exhaust, incorrect timing and positive crank case ventilation (PCV)

Fig 1



Attaching Vacuum Gauge

At normal operating temperature connect the vacuum gauge to the intake manifold. Some manifolds incorporated a plug that may be removed so that vacuum line adopter may be installed.

- A relative study high vacuum reading indicate an absence vacuum leak in the system (i.e) values and rings are in good sealing.
- Fairly study vacuum reading indicate vacuum leak in the system (i.e) value and rings are not in good sealing.
- Vacuum reading indicate uneven, valve are burned or sticky and damaged piston or blown gasket.

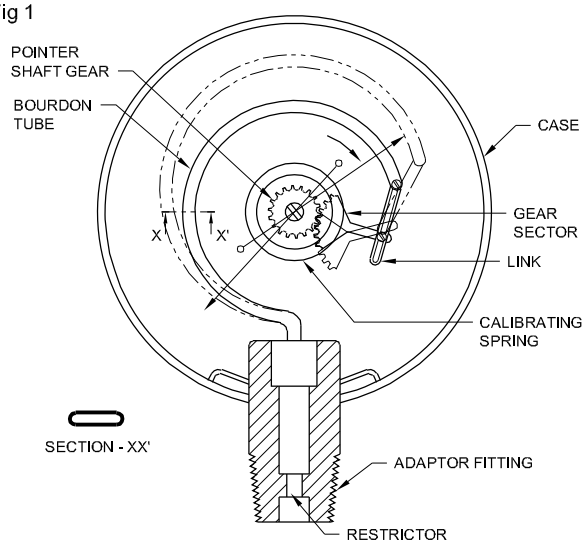
Tyre pressure gauge

Objectives: At the end of this lesson you shall be able to
- **state the construction and features of tyre pressure gauge**
- **use a tyre pressure gauge to check & set tyre pressure.**

Pressure gauge

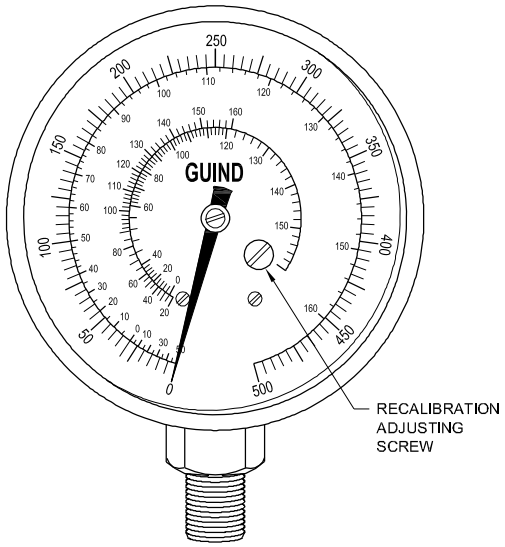
It is used to check the pressure of tyre unit. Bourdon tube pressure gauges (Fig 2) made by stainless steel. A Pressure rise in bourdon tube makes it tend to straighten. This movement will pull on the link which will turn the gear sector counter clockwise. The pointer shaft with then turn clockwise to move needle on a graduated scale to indicate pressure. (Fig 1)

Fig 1



INTERNAL CONSTRUCTION OF PRESSURE GAUGE

Fig 2



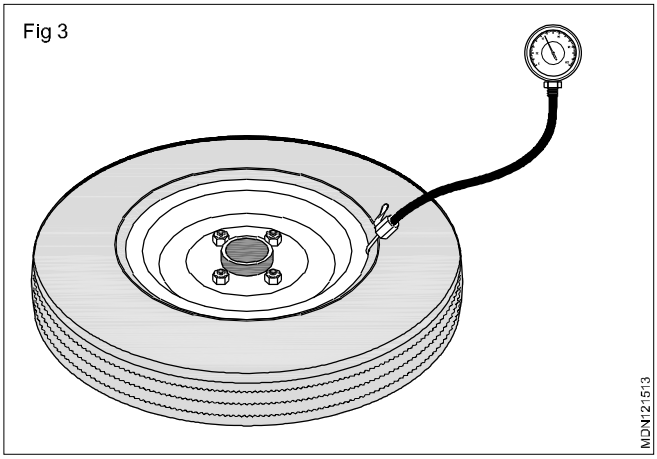
PRESSURE GAUGE

Special features

- Excellent load-cycle stability and shock resistance.
- All stainless steel construction
- Positive pressure ranges 0-200 P.S.I (Fig 3)

The pressure gauge hose has a adapter, which depresses the valve pin of tyre and compressed air get into the tube of the gauge. The pressure is indicated in the dial. Compare the pressure to the recommended pressure by the manufacturer. If it is less, refill the tyre with compressed air by operating the trigger (Fig 3). When the required pressure is shown in the gauge stop filling.

Fig 3



Rivets - types & uses

Objectives : At the end of this lesson you shall be able to
- **state what is riveting**
- **state the uses of a rivet**
- **name the features of a rivet**
- **name the different types of rivets.**

Riveting (Fig. 1)

Riveting is a method of making permanent joints. For riveting, the plates to be joined are drilled or punched The head on the other end is formed after assembling the parts.

The main features of rivets used in self-piercing riveting are:

Shank diameter and rivet length

Shape of rivet head and tail design

Rivet material and hardness

Type of crating/plating

Types of rivets

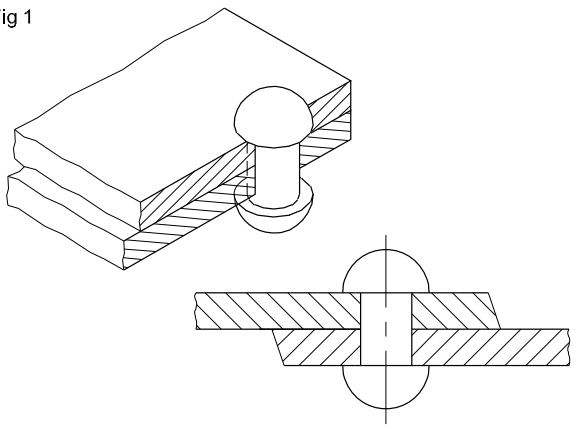
1 solid/round rivets

2 Semi tubular rivets

3 Blind rivets

4 Oscar rivets

Fig 1



5 Drive rivets

6 Flesh rivets

7 Friction-lock rivets

8 Rivet alloys shear strength and driving conditions

9 Self-piercing rivets

Rivet proportions

Objectives : At the end of this lesson you shall be able to
- **determine the hole sizes for different diameters of rivets**
- **choose the rivet diameters according to the thickness of the plates/sheets**
- **calculate the length for different diameter rivets and plate sizes.**

In order to produce efficient and good quality riveted joints the following aspects are important.

The size of the hold drilled for inserting the rivets.

The diameter of the rivet in proportion to the thickness of the plates/sheets to be joined.

The length of the rivet according to the type of the rivet and the thickness of the plates/sheets.

The size of the rivet and hole

The size of the hole to be drilled is according to the diameter of the rivet used.

A formula generally used for determining the diameter of a solid rivet is

D.Min = T

to D.Max = 2T

The actual value used will depend upon the actual joint features and service conditions.

The size of the hole has to be slightly larger than the nominal diameter of the rivet (Table 1)

For hot working, rivets will have holes with more clearance than for cold working.

TABLE 1

Hole diameter for rivets

Rivet nomial dia	2	3	4	5	6	8	10	12	15	15-40
Hole dia	2.2	3.2	4.2	5.3	6.3	8.5	11	13	16.5	Holes largethan the nominal dia by 1.5. to 2.0mm

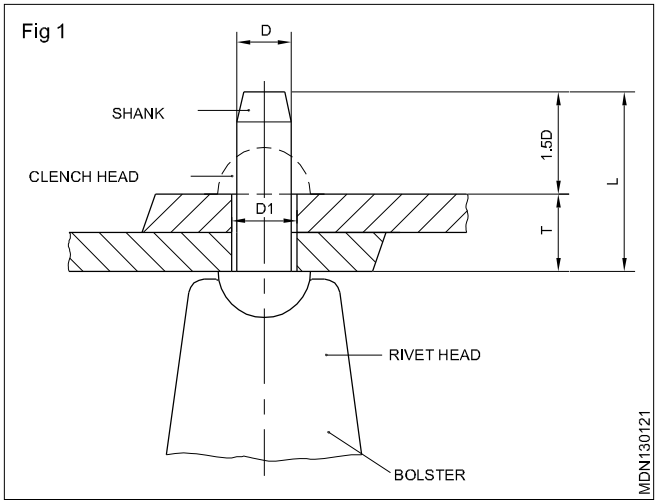
Length of rivets

The length of a rivet is the shank length. This will vary according to the thickness of the plates to be riveted and the type of the rivet head.

A formula generally used in the shop floor is

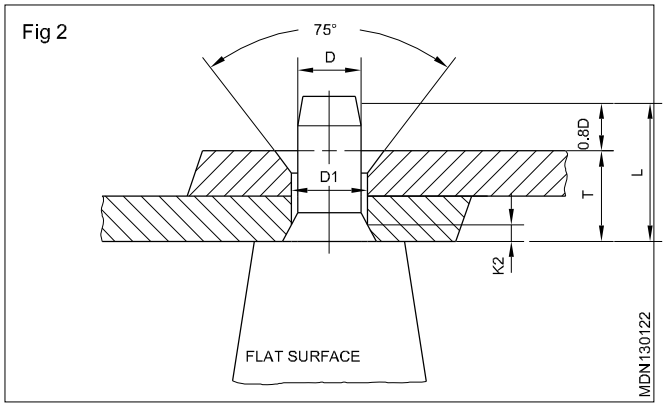
length of snap-head rivets (Fig 1)

L = T + 1.5 D



Length of countersunk head rivets (Fig 2)

L	=	T + 0.6 D
L	=	shank length
T	=	total thickness of the number of plates used
D	=	rivet diameter
D1	=	hole diameter



The rivets are then inserted and closed by force so that they completely fill the hole and form a rigid joint.

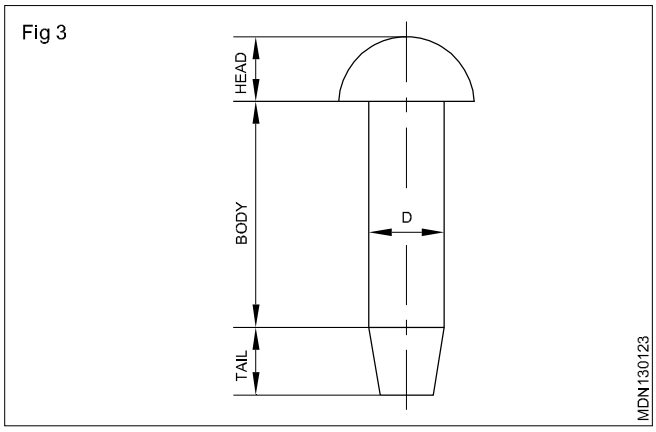
Uses

Rivets are fasteners used for joining metal sheets and plates in fabrication work such as bridges, ships. cranes. structural steel work, boilers, aircraft etc.

Parts (Fig 3)

The following are the parts of a rivet.

Head



Body

Tail

Materials

In riveting, the rivets are secured by deforming the shank to form the head. These are made of ductile materials.

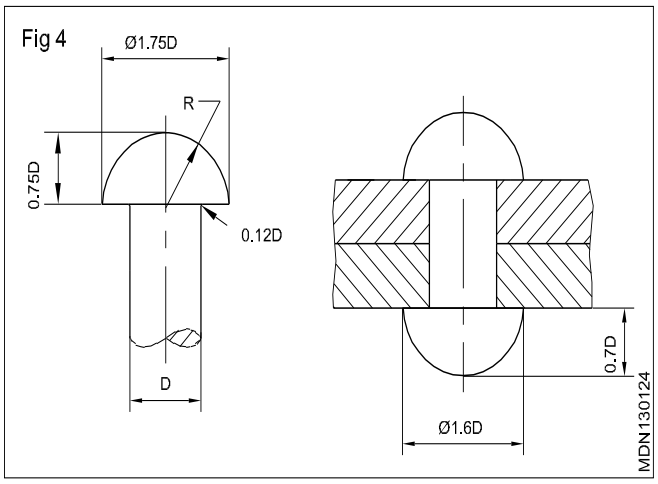
Examples

Low carbon steel, brass, copper and aluminium.

Rivet head-shapes

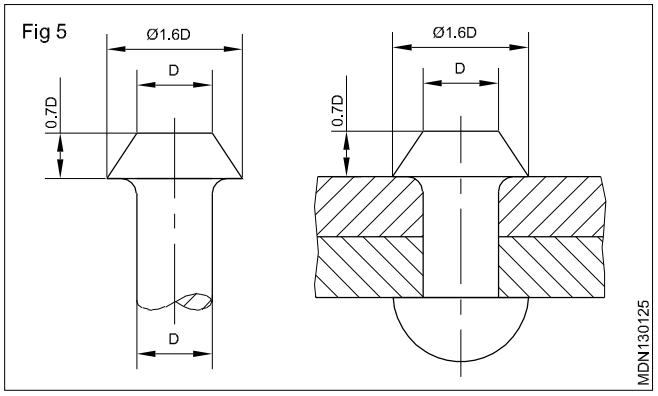
Snap-head (Fig 4)

This rivet is most commonly used for structural works. The opposite end of the rivet is shaped similar to the head.



Pan head (Fig 5)

It is a very strong rivet. The opposite end is usually finished to the snap-head shape. Pan head rivets are used in heavy construction.



Riveted joints

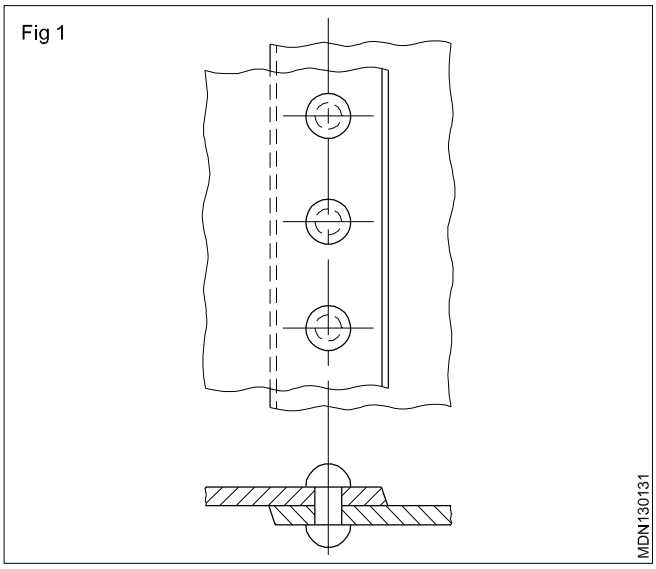
Objectives : At the end of this lesson you shall be able to
- **name the different types of riveted joints**
- **state the features of different types of riveted joints**
- **distinguish between chain riveting and zigzag riveting.**

In construction and fabrication work different types of riveted joints are made.

The commonly used joints are:

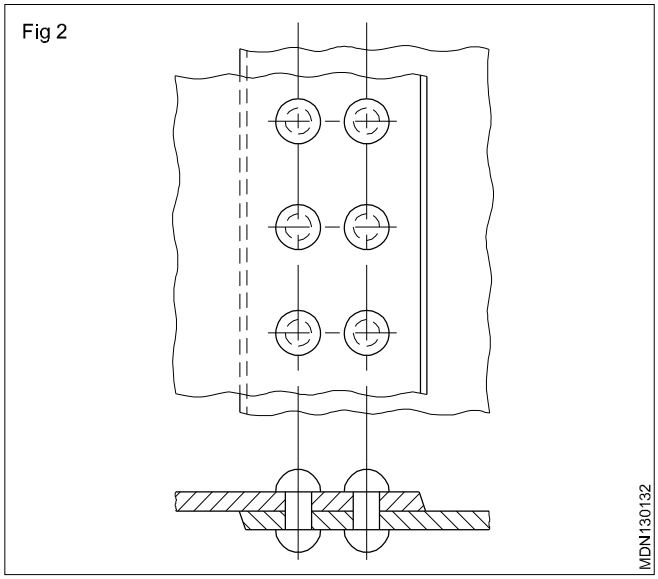
- single riveted lap joint
- double riveted lap joint
- double riveted (zigzag) lap joint
- single strap butt joint
- double strap butt joint

Single riveted lap joint (Fig 1)



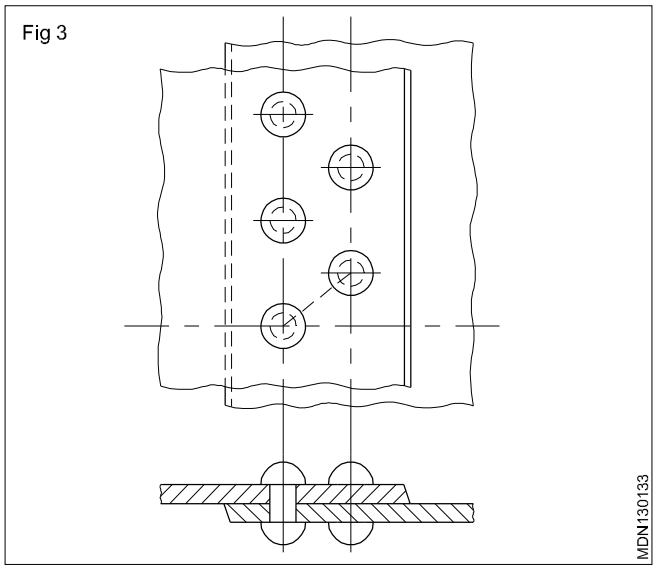
This is the simplest and most commonly used type of joint. This joint is useful for joining both thick and thin plates. In this, the plates to be joined are overlapped at the ends and single row of rivets is placed in the middle of the lap.

Double riveted lap joint (Fig 2)



This type of joint will have two rows of rivets. The overlap is large enough to accommodate two rows of rivets.

Double riveted (Zigzag) lap joint (Fig 3)

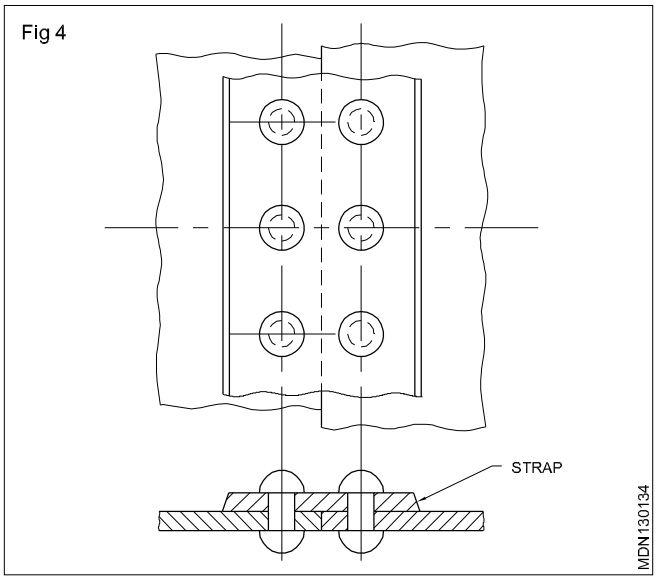


This provides a stronger joint than a single lap joint. The rivets are placed either in a square formation or in a triangular formation. The square formation of rivet placement is called CHAIN riveting. The triangular formation of rivet placement is called zigzag riveting.

Single strap butt joint (Fig 4)

This method is used in situations where the edges of the components are to be joined by riveting.

A separate piece of metal called STRAP is used to hold the edges of the components together.



Double strap butt joint (Figs 5 & 6)

This joint is also used for joining the edges of components together. This is stronger than the single strap butt joint. This joint has two cover plates placed on either side of the components to be assembled.

When a single or double straps are used for riveted butt joints, the arrangement of rivets may be:

- Single riveted, i.e. one row on either side of the butt

double or triple riveted with chain or zigzag formation.

Fig 5

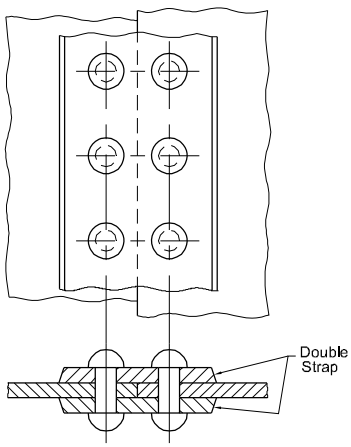
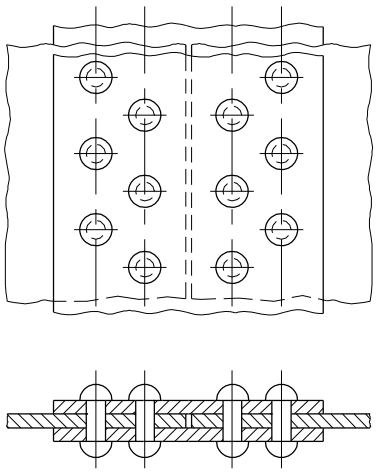


Fig 6



Tools for hand riveting

Objectives : At the end of this lesson you shall be able to
- **name the different tools used for hand riveting**
- **state the uses of different hand riveting tools.**

The following tools are used for making efficient riveted joints.

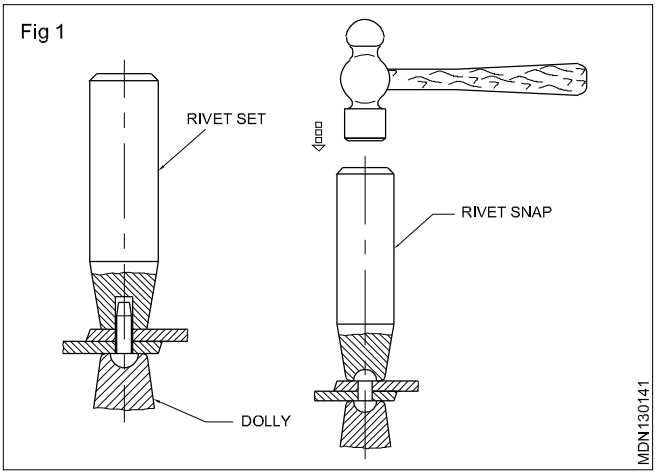
Rivet set (Fig 1)

A rivet set is used for bringing the plates closely together after inserting the rivet in the hole. This is required while riveting thin plates or sheets with small rivets.

Dolly

This is used to support the head of the rivet which is already formed and also to prevent damage to the shape of the rivet head.

Fig 1

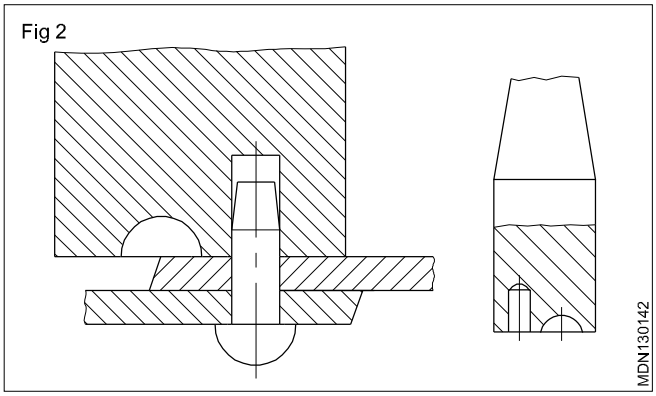


Snap

The rivet snap is used to form the final shape of the rivet during riveting. Snaps are available to match the different shapes of rivet heads.

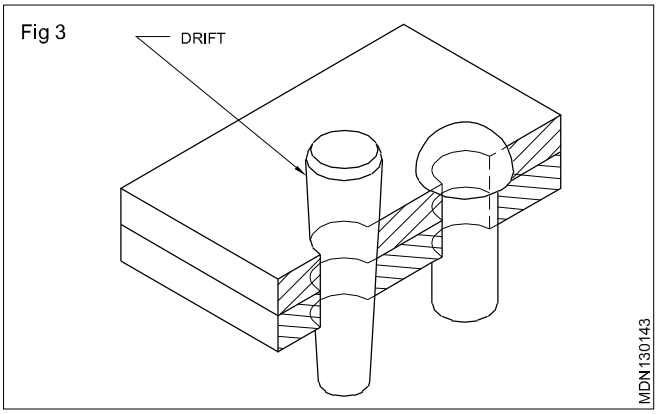
Combined rivet set (Fig 2)

Fig 2



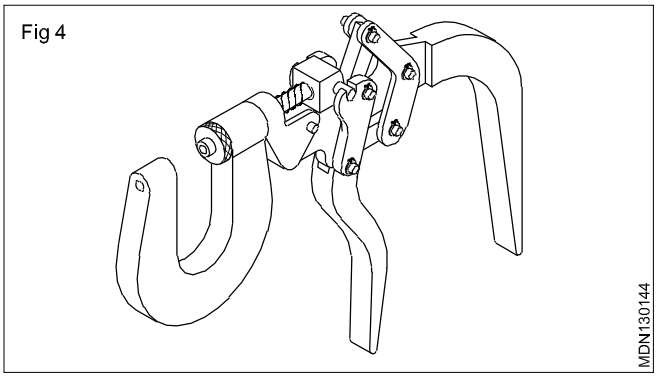
This is a tool which can be used for setting and forming the head.

Drift (Fig 3)



This is used to align the holes to be riveted.

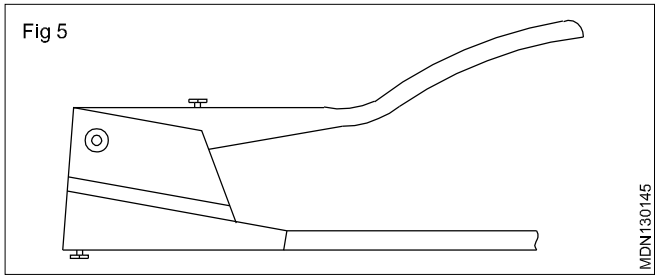
Hand riveter (Fig 4)



This has a lever mechanism which exerts pressure between the jaws when the handle is pressed.

This is useful for riveting copper or aluminium rivets, interchangeable anvils can be provided.

Pop riveter (Fig 5)



This is used for riveting pop rivets by hand. The trigger mechanism squeezes the rivet and separates the mandrel of the rivet. In this method, as the mandrel is being separated from the rivet, the head is formed on the other end.

Spacing of rivets in joints

Objectives : At the end of this lesson you shall be able to
- **determine the distance between the rivet and the edge of the joint.**
- **state the effect on the joints when the rivets are too close or too far from the edge**
- **determine the pitch of rivets in joints**
- **state the effect of too close and too far a pitch of rivets in joints**.

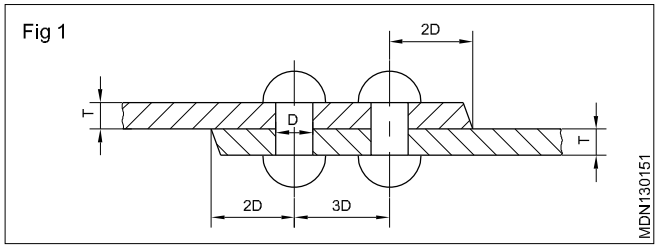
The spacing of the rivet holes depends upon the job. Given below is a general approach in determining this.

Distance from the edge to the centre of the rivet (Fig1)

The space or distance from the edge of the metal to the centre of any rivet should be at least twice the diameter of the rivet.

The purpose of this is to prevent the splitting of the edges. The maximum distance from the edge should not be more than ten times the thickness of the plate.

Too much distance from the edge will lead to GAPING.



Pitch of rivet

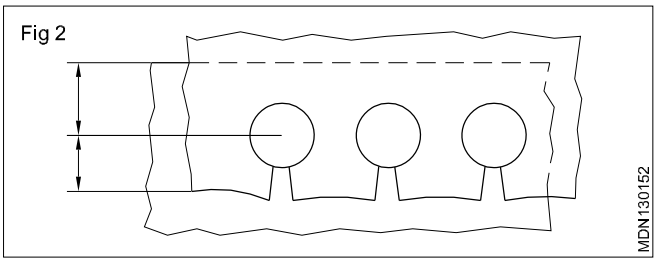
The minimum distance between rivets should be three times the diameter of the rivet (3D)

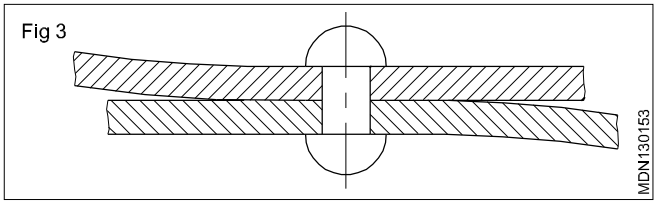
This distance will help to drive the rivets without interference.

Too closely spaced rivets will tear the metal along the centre line of the rivets.(Fig 2)

The maximum distance between the rivets should not exceed twenty four times the thickness of the metal.

Too far a pitch will allow the sheet/plate to bukcle between the rivets. (Fig 3)



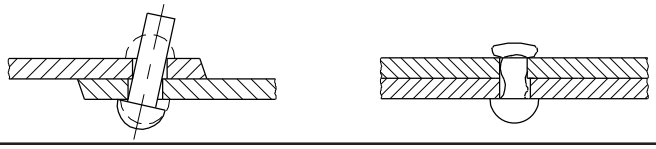
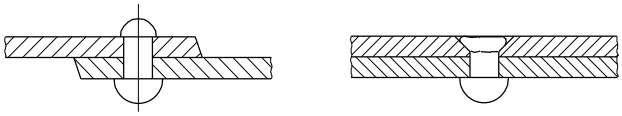
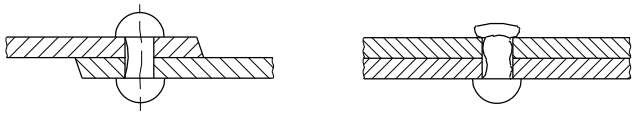
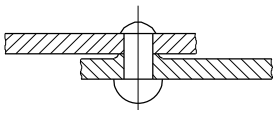
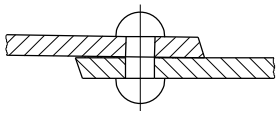
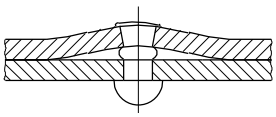
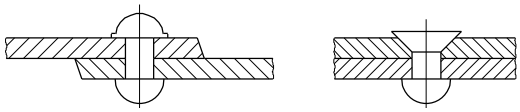
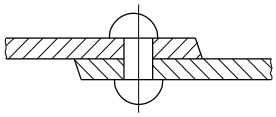


Defects in riveted joints

Objectives : At the end of this lesson you shall be able to
- **relate riveting defects with their causes.**

While making riveted points certain precautions are to be exercised to avoid defects in the joints.

A few common causes and defects and resistant effects in riveting are given below:

Causes of riveting defects	Resultant effect
Holes wrongly aligned	
Rivet too short	
Hole too large	
Burrs in drilling	
Burrs between plates	
Rivet not set correctly	
Rivet length too long	
Head formed out of centre	

Caulking and fullering

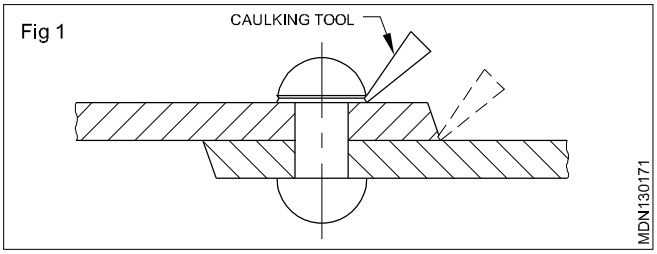
Objectives : At the end of this lesson you shall be able to
- **state the purpose of caulking and fullering**
- **distinguish between caulking and fullering processes.**

In order to provide a leak-proof joint in the construction of fluid containers, caulking and fullering are carried out after riveting.

Caulking (Fig. 1)

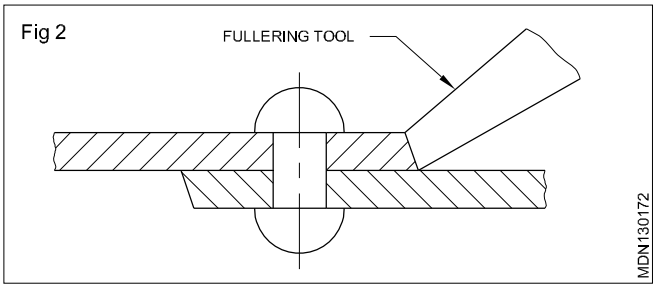
Caulking is an operation of closing down the edges of the plates and heads of the rivets to form a metal-to-metal joint.

Fig 1



The edge of the rivet head is tightly pressed and expanded on the plate by a caulking tool which looks like a flattened cold chisel.

Fullering (Fig. 2)



Fullering is an operation of pressing the whole surface of the edge of the plate. It is done by a fullering tool.

When the caulking tool is about as thick as the plate, it is called a fullering tool.

The whole surface of the edge of the first plate is tightly pressed on the second plate.

A better fluid-tight joint is achived by fullering.

Caulking is done on the edges of the plates as well as on the edges of the rivet heads. But fullering is done on the edges of the plate only. To facilitate caulking and fullering on the plates, the edges of the plates are bevelled about 80° to 85°.

The strength of riveted joints

A riveted joint is only as strong as its weakest part and it must be borne in mind that it may fail in one of the following four ways.

Shearing of the rivet

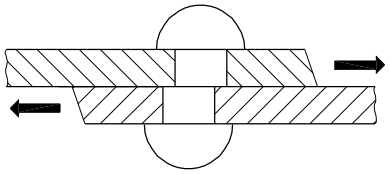
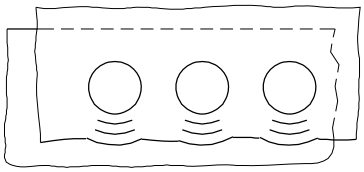
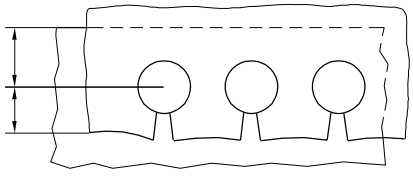
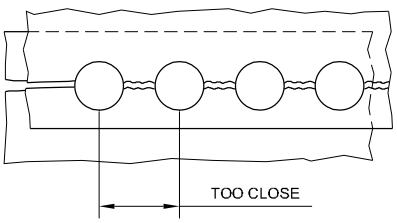
Crushing of the metal

splitting of the metal

Rupture or tearing of the plate

These four undesirable effects are illustrated in the table below:

Table

Riveted Joint	Effects	Causes	Prevention
	Shearing of the rivet	Diameter of the rivet too small compared with the thickness of the plate. The diameter of the rivet must be greater than the thickness of the plate in which it is to be inserted.	Select the correct diameter rivet to suit thickness of the plate.
	Crushing of the metal	Diameter of the rivet too large compared with the thickness of the plate. The rivets when driven tend to bulge and crush the metal in front of them.	Select the correct diameter rivet for the thickness of the metal plate.
	Splitting of the metal	Rivet holes punched or drilled too near the edge of plate. Metal is likely to fail by splitting in front of the rivets.	Drill or punch the rivet at the correct distance from the edge and use the correct lap allowance for the diameter of the rivet.
	Tearing of the plate	Plates weakened by rivete holes being too close together. Plate tend to rupture along the centre line of the rivets	Punch or drill rivet holes at the correct spacing or ‘pitch. In addition remove all burrs from the holes before final assembly.

Special sheet metal rivets and their applications

Objectives : At the end of this lesson you shall be able to
- **state the types and uses of tubular rivets**
- **state the use of `hank' rivet bushes**
- **state the use of speed nuts.**

Tubular rivet (Figs 1, 2 & 3)

The use of the tubular rivet removes much of the skill necessary, and there is no need for the support as with a solid rivet.

Fig 1

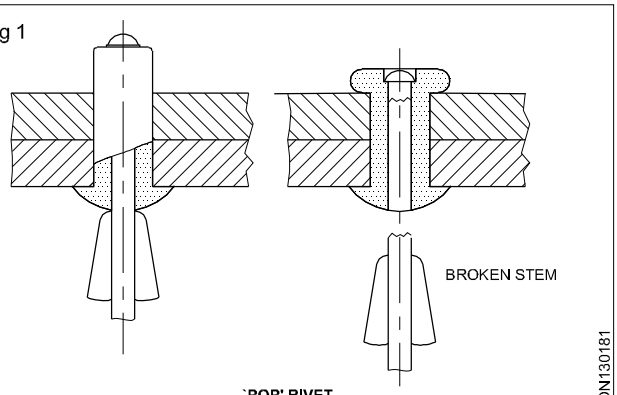


Fig 2

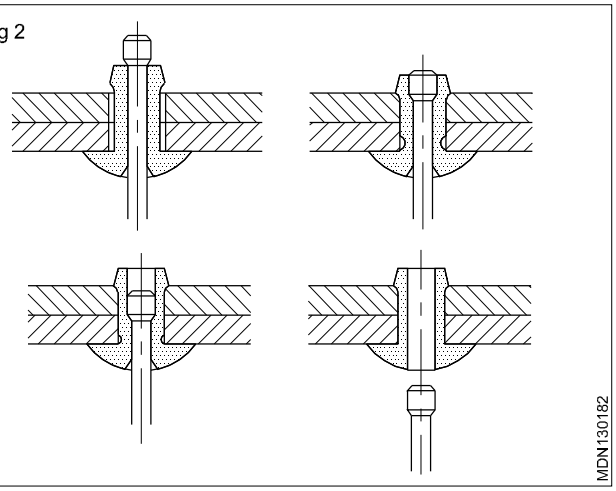
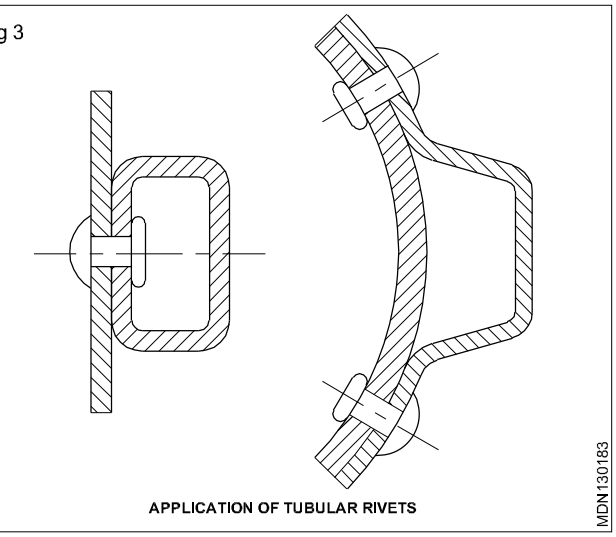


Fig 3



One type of tubular rivet is the `pop rivet'. While it is held by its stem in the riveting `gun', the rivet is pushed into the rivet hole and the gun causes the stem to be pulled back into the gun, while the gun nozzle remains pushed against the flanged head. The stem-head causes the rivet tube to be swaged out thus forming a new head on the far side of the joint, and consequently pulling the plates tightly together. Finally the pulling force on the stem is sufficient to fracture the stem below its head on the stem diameter.

Another type of tubular rivet has a stem-head which breaks off outside the rivet tube after the swaging stage, thus leaving the central hole clear. This is essential where drainage from cavities and hollow sections is necessary.

`Hank' rivet bushes (Figs 4, 5 & 6)

These bushes are a means of providing a thin sheet metal with a deep tapped hole, and diameters and thread form, and they are used in conjuction with the standard set screws where access cannot be gained to fit the standard nuts.

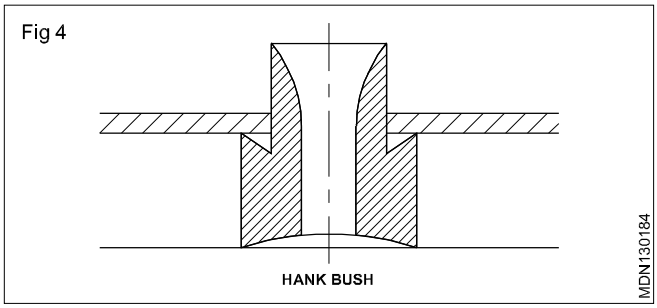
The following steps are required to fit shank bushes.

Position the previously drilled hole in the panel.

Mark the centre punch hole position

Drill a hole of the required size. The hole should be the clearance size of the bush shank.

Fig 4

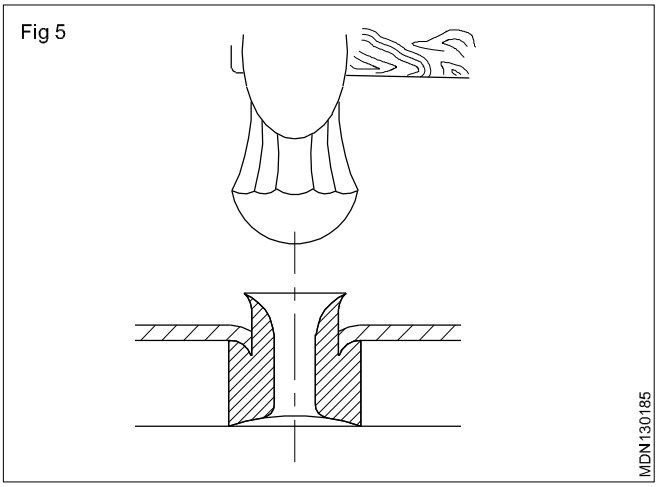


Remove the burrs.

Fit the shank bush from the under the side.

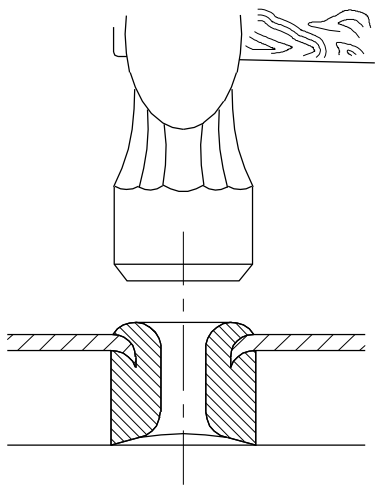
Support for riveting operation.

Fig 5



Using a ball pein hammer, spread the shank of the bush. Strike squarely to ensure the even spread of the shank.

Fig 6



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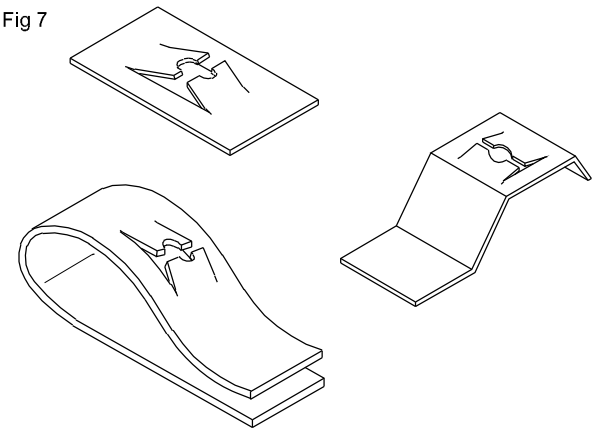
Change to the flat face of the hammer. Strike squarely, flatten the shank.

Speed nut (Fig. 7)

Speed nuts are available in a variety of forms and are made form different materials such as spring steel, stainless steel etc. The speed nut consists of a strip of metal stamped in such a manner that one or more thread engaging portions are pressed upwards from the base to form part of a screw thread.

Fig 7



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Speed nuts are generally used in conjunction with coarse thread or sell-tapping screws. As the screw is tightened, the pressure exerted on the tongues gives a self-locking action.

This is used for lacking and soldering of joining points.

Bolts, studs and nuts

Objectives : At the end of this lesson you shall be able to

- **state the situations in which bolts and nuts are used**
- **state the advantages of using bolts and nuts**
- **name the different types of bolts**
- **state the applications of the different types of bolts**
- **state the situations in which studs are used**
- **state the reason for having different pitches of threads on stud ends.**

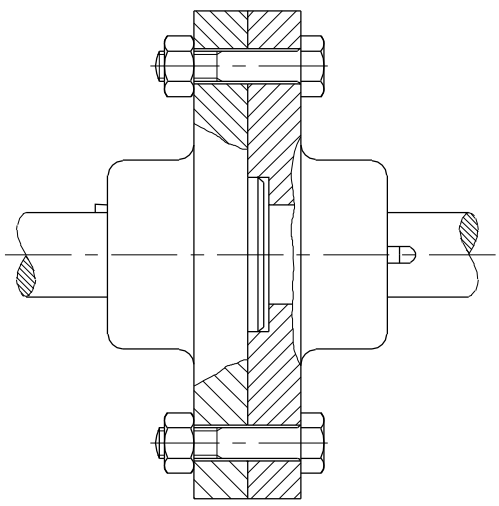
Bolts and nuts (Fig.1)

These are generally used to clamp two parts together.

When bolts and nuts are used, if the thread is stripped, a new bolt and nut can be used. But in the case of a screw directly fitted in the component. When threads are damaged, the component may need extensive repair or replacement.

Depending on the type of application, different types of bolts are used.

Fig 1



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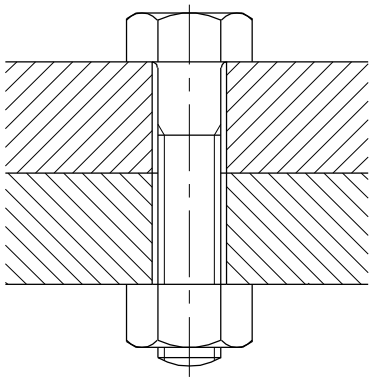
Bolts with clearance hole (Fig.2)

This is the most common type of fastening arrangement using bolts. The size of the hole is slightly larger than the bolt (clearance hole)

Slight misalignment in the matching hole will not affect the assembly.

Fig 2



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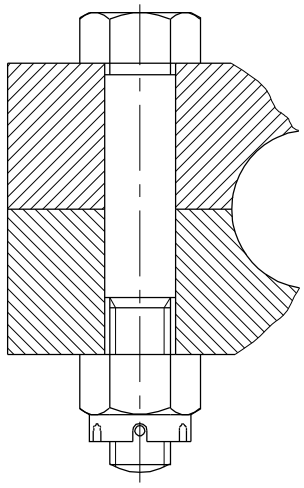
Body fit bolt (Fig.3)

This type of bolt assembly is used when the relative movement between the workpieces has to be prevented. The diameter of the threaded portion is slightly smaller than the shank diameter of the bolt.

Fig 3



BODY FIT BOLT

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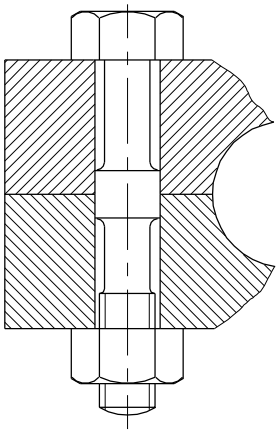
The bolt shank and the hole are accurately machined for achieving perfect mating.

Anti-fatigue bolt (Fig.4)

This type of bolt is used when the assembly is subjected to alternating load conditions continuously. Connection rod big ends in engine assembly are examples of this application.

Fig 4



ANTI-FATIGUE BOLT

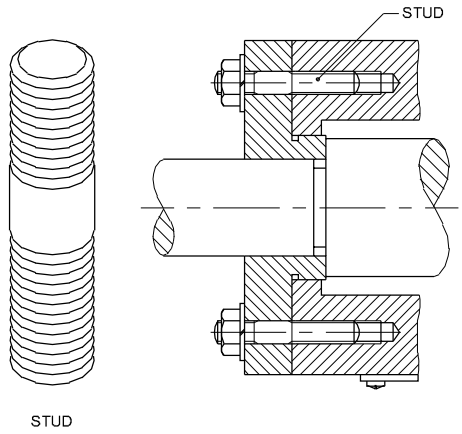
MDN121524

The shank diameter is in contact with the hole in a few places and other portions are relieved to give clearances.

Studs (Fig.5)

Studs are used in assemblies which are to be separated frequently.

Fig 5



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When excesssively tightened, the variation in the thread pitch allows the fine thread or nut end to slip. This prevents damage to the casting.

Designation of bolts as per B.I.S. specifications

Hexagon head bolts shall be designated by name, thread size, nominal length, property class and number of the Indian Standard.

Example

A hexagon head bolt of size M10, nominal length 60mm and property class 4.8 shall be designated as:

Hexagon head bolt M10x60 - 4.8-IS: 1363 (Part 1)

Explanation about property class

The Part of the specification 4.8 indicates the property class (mechanical properties). In this case it is made of steel with minimum tensile strength = 40kgf/mm2 and having a ratio of minimum yield stress to minimum tensile strength = 0.8.

NOTE

Indian standard bolts and screws are made of three product grades - A,B, & C, `A' being precision and the others of lesser grades of accuracy and finish.

While there are many parameters given in the B.I.S. specification, the designation need not cover all the aspects and it actually depends on the functional requirement of the bolt or other threaded fasteners.

For more details on the designation system, refer to IS: 1367, Part XVI 1979.

Locking Devices

Objectives : At the end of this lesson you shall be able to

- **state what is a locking device**
- **name the effect, if proper locking devices are not employed**
- **name the various types of locking devices**
- **state the uses of the commonly used locking devices.**

Locking devices

A locking device is a device used to lock the threaded fasteners to prevent them from loosening. Due to vibration in the moving part, there is a tendency for the threaded fastener to get slack and to slip off. Then the assembled part will get loose and cause damages. Some examples are given below to illustrate the importance of the locking device.

In the case of a micrometer, the lock-nut avoids the Movement of the spindle after taking the reading. In the case of boilers and gas cylinders, locking of the nut avoids the leakage of steam or gas.

In automobiles the lock-nut avoids the loosening of the assembled part.

Classification of lock-nuts

Lock-nuts are classified into two categories.

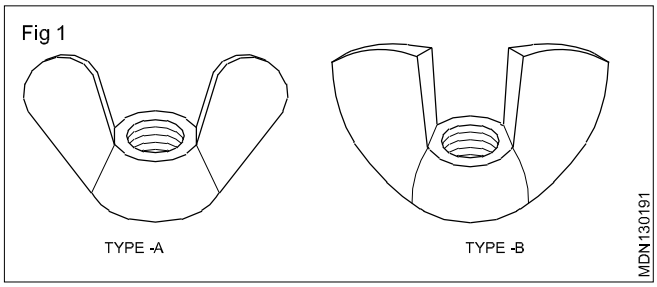
- Positive locking device
- Frictional locking device

These nuts have special provision in the form of slots for fixing split pins for locking the nuts.

Slotted nuts are hexagonal shaped throughout. In the case of castle nuts, the top part of the nut is cylindrical in shape.

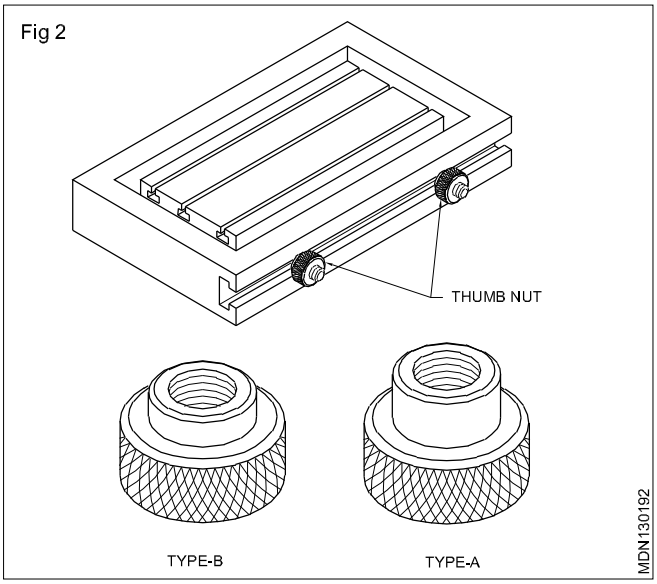
Wing-nuts (Fig. 1)

Wing-nuts are used in light duty assembly which require frequent removal and fixing. These are available as hot forged/cast (Type A) and cold forged (Type B).



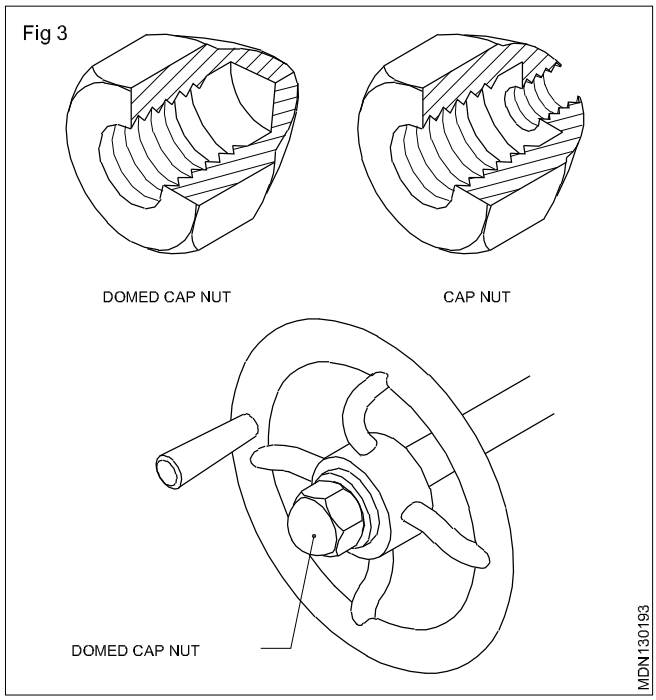
Thumb-nut (Fig. 2)

These are used in places where frequent adjustments are required and mere finger tightening enought. They are available in two types - Types A & Type B.



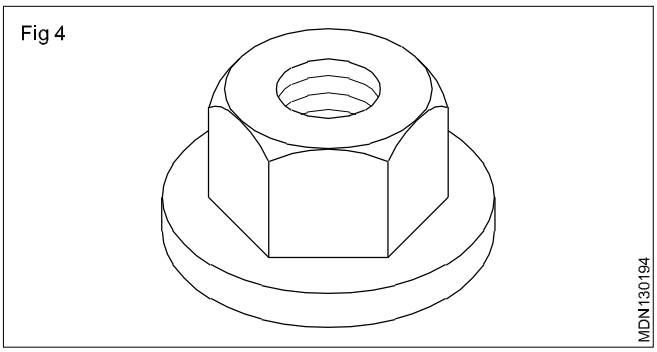
Cap nut (Fig. 3)

These are used to protect the bolt end threads from damages and also as a protector for safe working. They serve to provide a decorative appearance.



Hexagonal nuts with collar (Fig. 4)

These nuts have a machined collar on one end. This provides additional bearing surface in assembly. The collar acts like a washer and is useful where frequent tightening



and loosening is necessary.

Hexagonal weld nuts (Fig. 5)

These are nuts used for welding on the plate work. These nuts have:

- a spigot ring which fits in the hole of the plate
- three projections to provide a uniform contact on the surface, that is to be welded
- a countersunk hole on one end to protect the thread during welding.

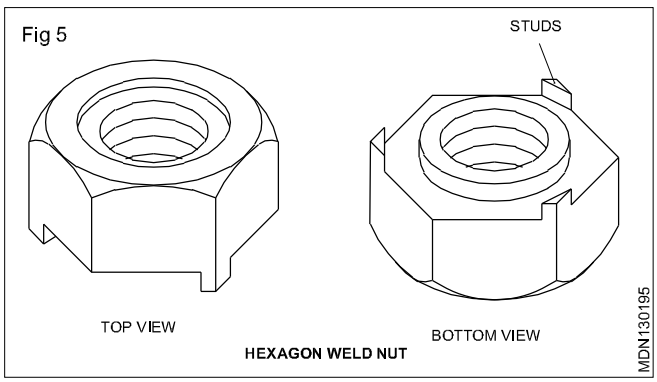
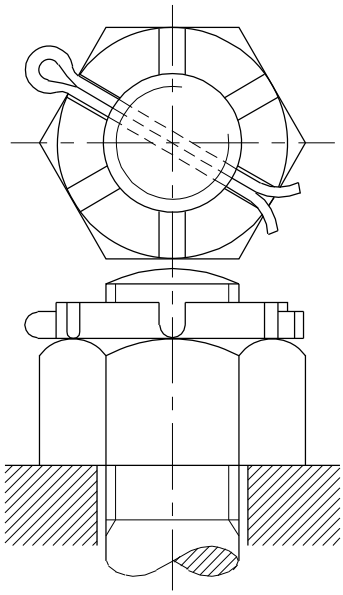


Fig 6



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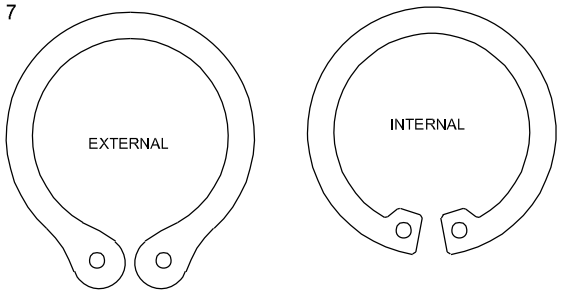
Out. Castle nuts (Fig. 6) are widely used in automobiles and locomotive engines to avoid sudden shock and vibration.

Circlip (Fig. 7)

These are widely used to retain the component on a shaft or in a bore. Seating of these circlips in a slot by using a special type of pliers facilitates rapid assembly and disassembly.

Fig 7



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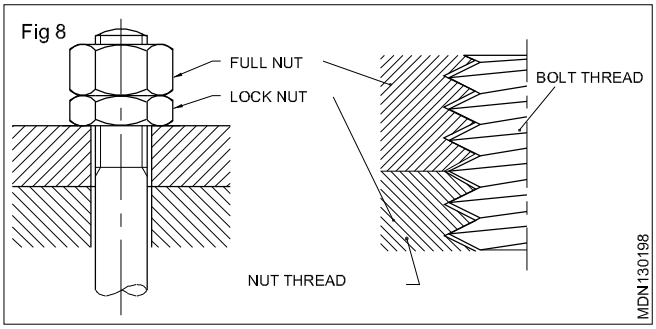
Chuck nut (Fig. 8)

This nut is used along with one ordinary nut as shown in the figure.

Fig 8



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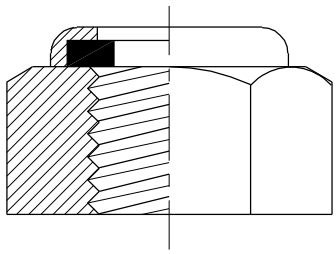
A chuck nut is also called a lock-nut. The two nuts are thus locked or wedged tightly against each other and against the bolt. This will prevent slackening.

Self-locking nut (Fig. 9)

Self-locking nut will have a nylon insert to prevent the loosening of the nut from shock, vibration and temperature.

Fig 9



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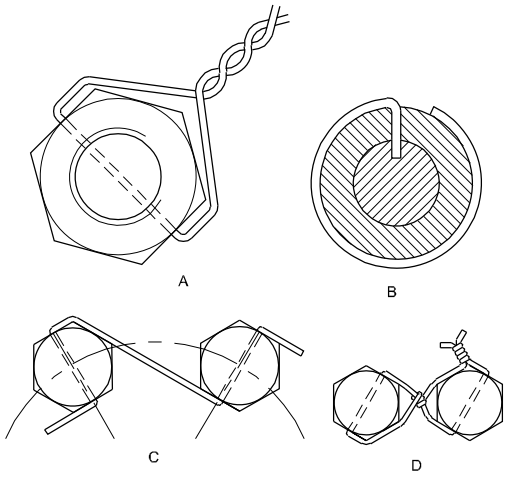
Wire lock (Fig. 10)

Wire locks are used for light engineering works. The wire is passed through the groove.

Nut applied with a sealant

These locking devices are for permanent locking in light works.

Fig 10



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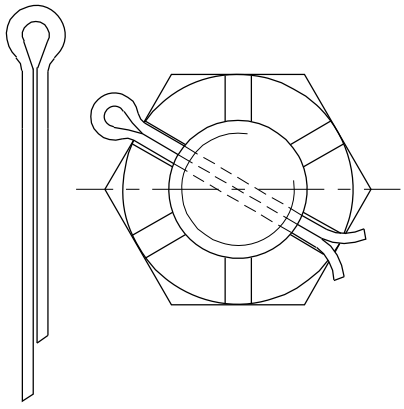
Split pin (Fig. 11)

A split pin is made from a steel wire of semicircular crosssection, bent as shown in the figure. It is inserted in a hole drilled in the bolt so that it exerts pressure on the top face of the nut to prevent it from turning.

Fig 11



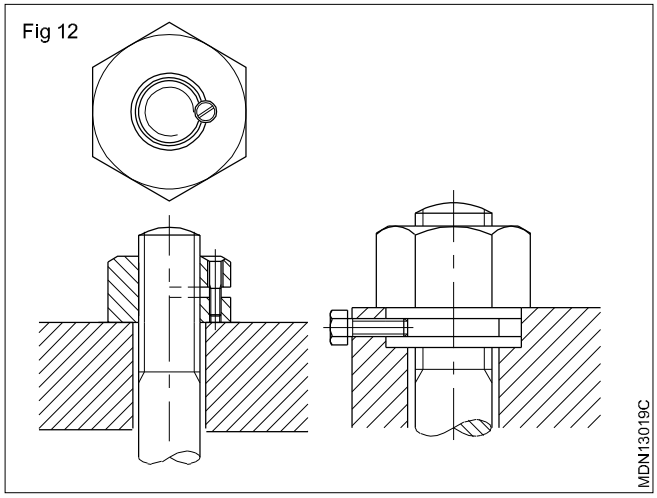
MDN13019B

Sawn nut (Wiles nut)

In this locking device, a slot is cut half way across the nut. A screw is fitted with a clearance hole on the top part and a matching thread on the lower part of the nut. Tightening of the nut provides positive locking for the nut.

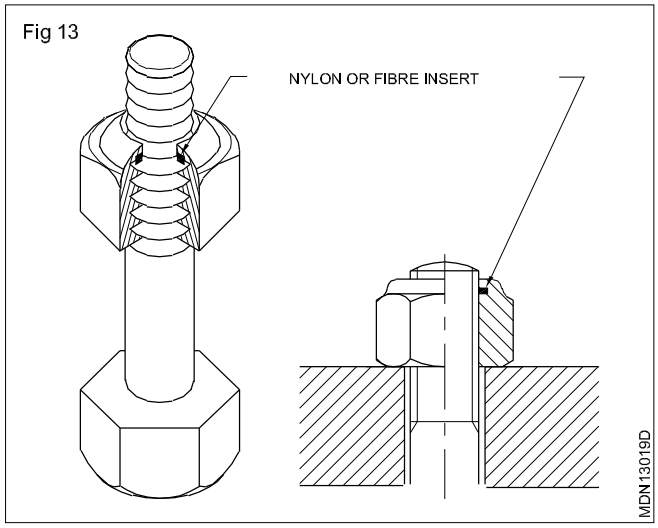
Positive locking device (Fig. 12)

Frictional locking device



Positive locking device(Fig. 13)

In the positive locking device, the locking action is positive. This locking device is difficult to fit and may take more time. But it is very essential to use this type of locking device in critical joints where failure could cause serious accidents.



Eg. Clutches, brakes, controls etc.

The positive locking devices are:

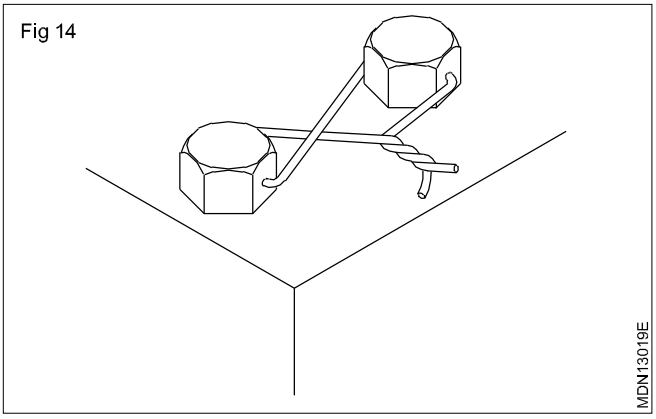
- standard hexagonal nut, cross-drilled and pinned
- standard slotted nut
- standard castle nut
- hexagonal nut and locking plate
- wiring bolt heads.

Frictional locking devices (Fig 14)

These lock nuts are easy to fit and less time consuming.

The frictional locking devices are:

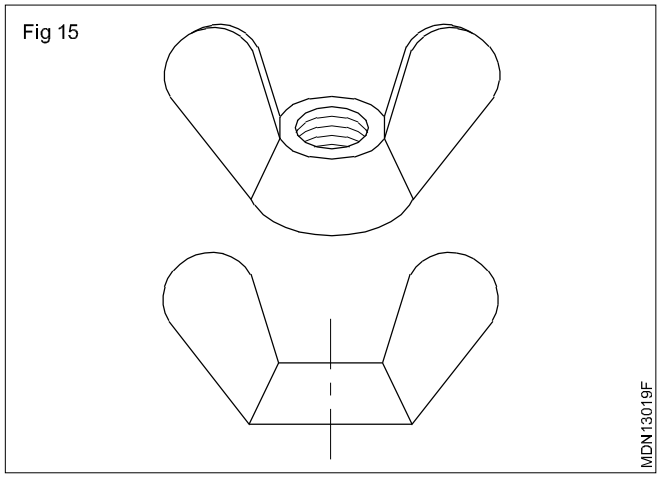
- lock-nut (chuck nut)
- spring washer
- wedge lock bolt
- simmonds lock-nut.



Commonly used locking devices

Wing-nut (Fig. 15)

A wing-nut is used where frequent adjustment or removal is necessary. It can be loosened or tightened rapidly without the need of a wrench. These nuts are manufactured with the same material as is used for the bolts.



Thumb-nut

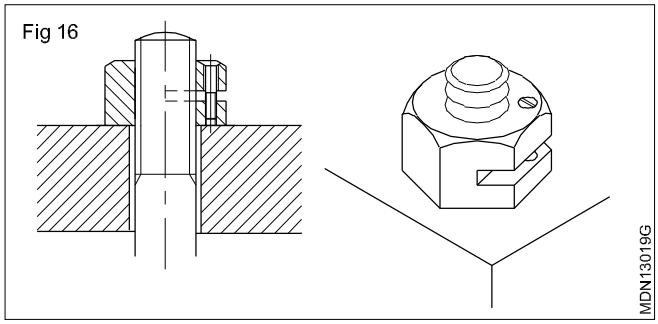
A thumb-nut is used where the movement of the spindle is to be locked, as in a micrometer. Stopping the movement of the spindle is necessary for taking a correct reading.

Locking ring

A locking ring is used in taper nose spindles of lathes to lock the chuck.

Castle nut (Fig. 16)

Slots are cut in a cylindrical collar provided on the top of the nut, thus overcoming the disadvantage of the slotted



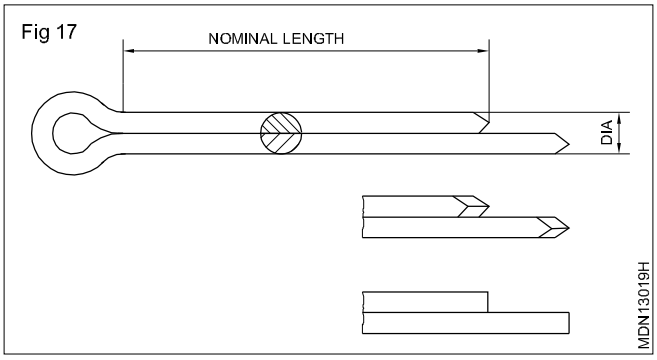
Slotted and castle nut with a split pin

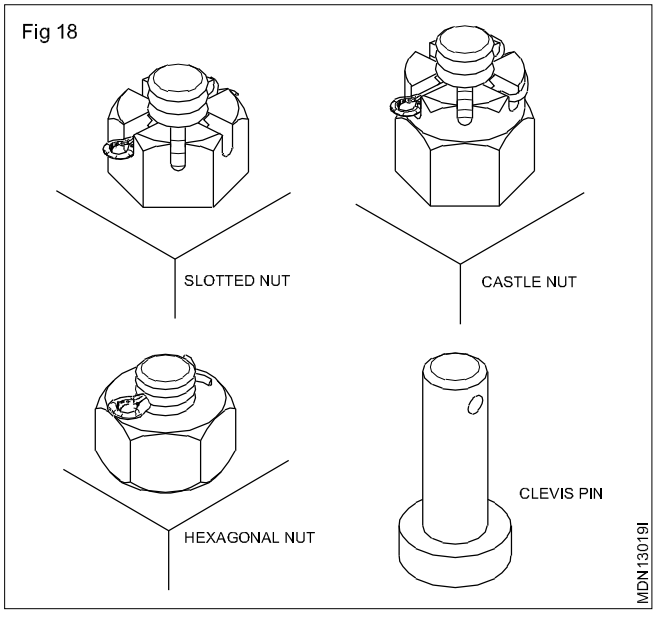
The position of the nut can be locked using the split pin.

Split pins are designated by the nominal size, nominal length, the number of the Indian Standard and the material. (Fig. 17 & 18)

The nominal length is the distance from the underside of the eye to the end of the short leg.

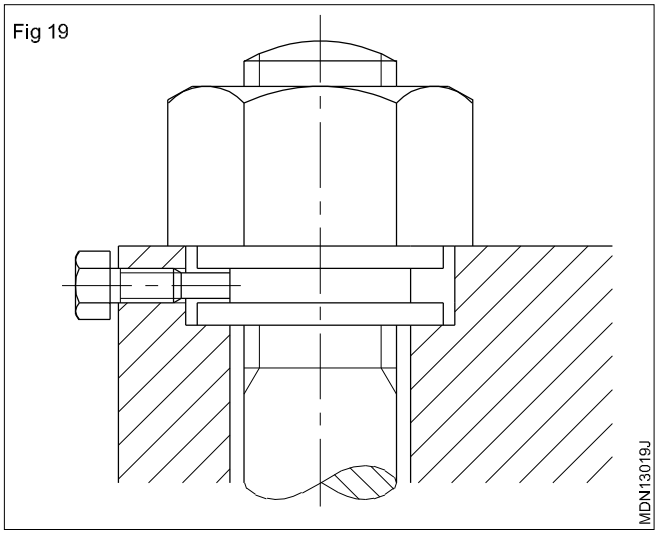
Split pins are used for locking slotted nuts, castle nuts, hexagonal nuts, clevis pins etc. and are used in different ways.





Grooved nut (Penning nut) (Fig. 19)

This is a hexagonal nut with the lower part made cylindrical. On the cylindrical surface there is a recessed groove in which a set screw is used to lock the nut.

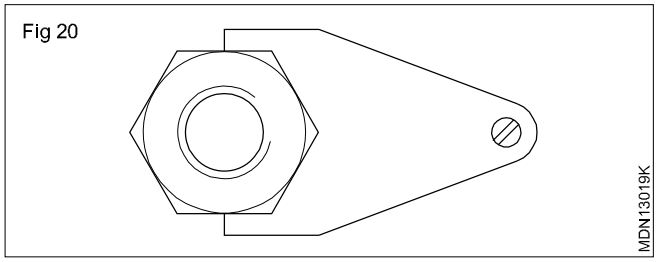


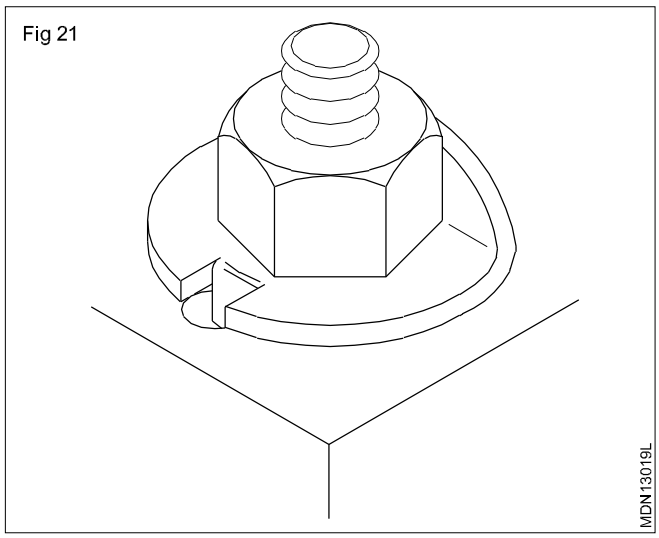
Locking plate (Fig. 20)

For preventing the nut from loosening, locking plates are fixed on the outside of the hexagonal nut.

Lock washers with lug (Fig. 21)

In this arrangement of locking, a hole is drilled for accommodating the lug.





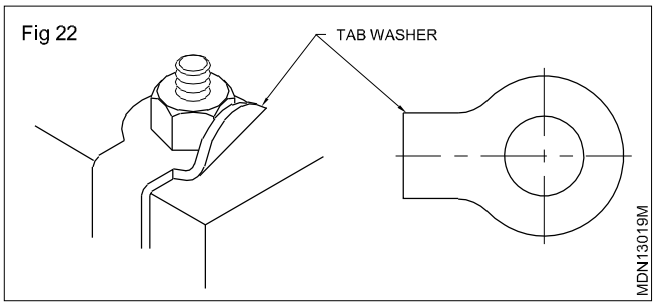
The movement of the nut is prevented by folding the washer against the nut.

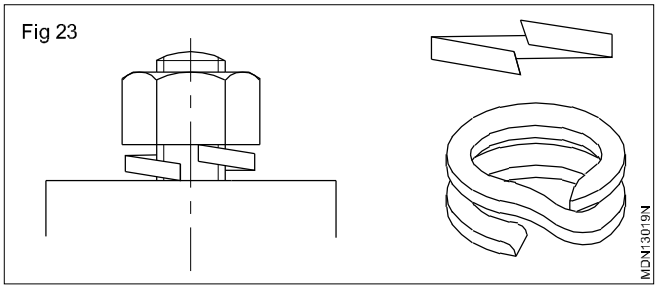
Tab washers (Fig. 22)

Tab washers can be used for locking the nuts which are located near an edge or corner.

Spring washer (Fig. 23)

Spring washers are available with single or double coils. These are placed under a nut in the assembly as washers. The stiff resistance offered by the washer against the surface of the nuts serves to prevent loosening.



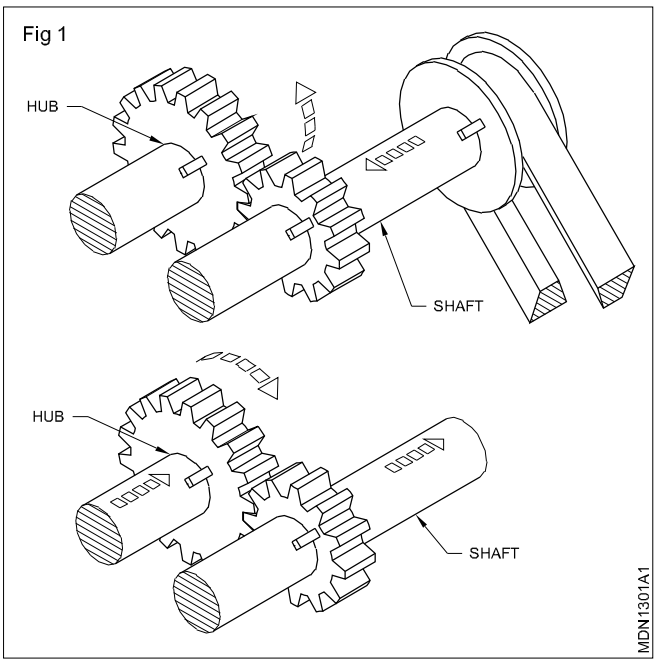


Keys and Splines

Objectives : At the end of this lesson you shall be able to
- **name the different types of keys used in transmission**
- **state the features of each type of keys.**

Keys and splines

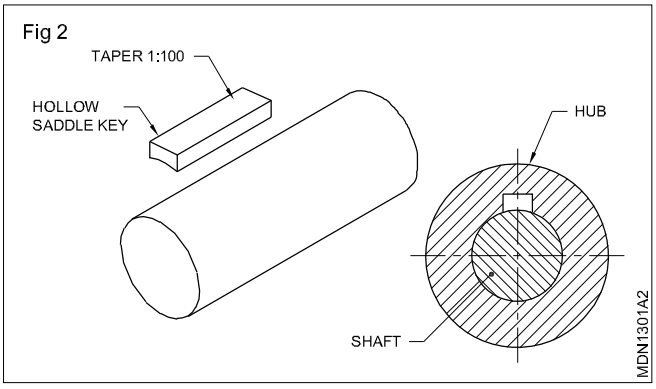
Keys are used for transmitting torque from a rotating shaft to a hub/wheel or from a hub/wheel to the shaft. (Fig.1)



Keys of different types are used depending on the requirements of transmission.

Hollow saddle key

One face of this key has a curvature to match with that of the shaft surface. It has a taper of 1 in 100 and is driven in through the keyway. (Fig.2)

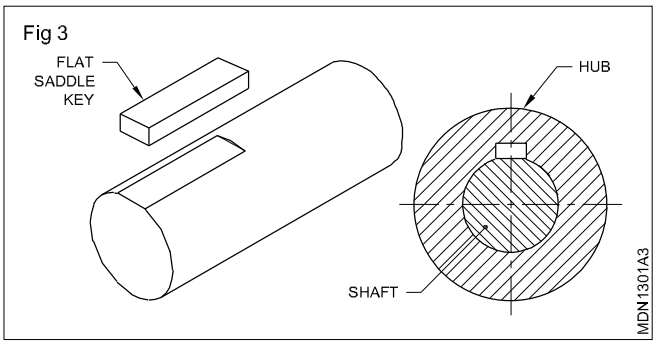


The hub is held on the shaft due to friction. This key is useful only for light duty transmission.

Flat saddle key

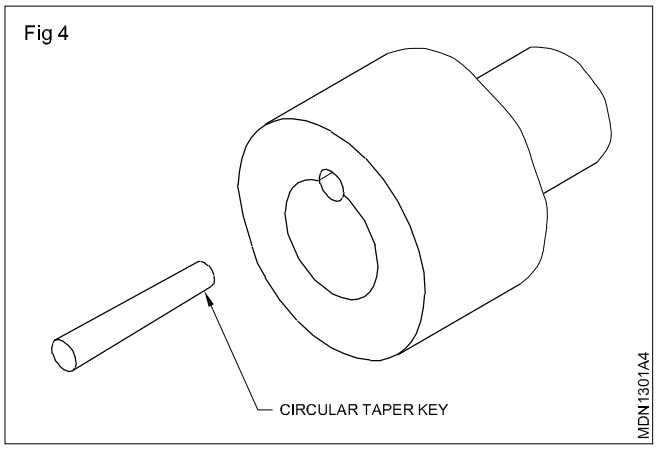
This key has a rectangular cross-section.

For fitting this key in the assembly a flat surface is machined on the shaft. (Fig. 3). The key is placed between the flat surface of the shaft and the keyway on the hub. This is considered to be stronger than the hollow saddle key. This is not suitable for heavy duty transmission.



Circular taper key (Fig 4)

In this case both the shaft and the hub have semicircular keyways cut on them. (Fig.4) The taper key is driven in while assembling. This key is suitable only for light transmission.



Sunk key (Fig 5 & Fig 6)

This key has a rectangular cross-section and its fits into the keyway cut on both the shaft and the hub. Sunk keys are either parallel or tapered. (Figs.5 and 6)

Fig 5

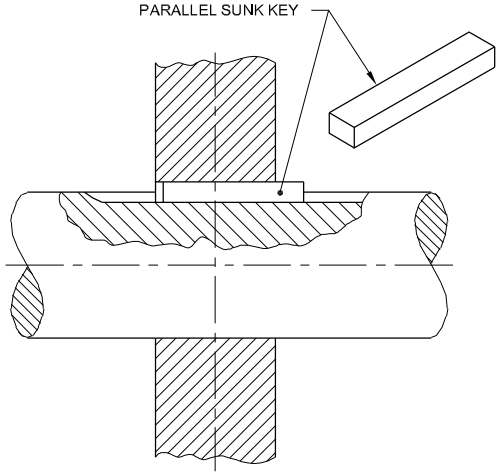
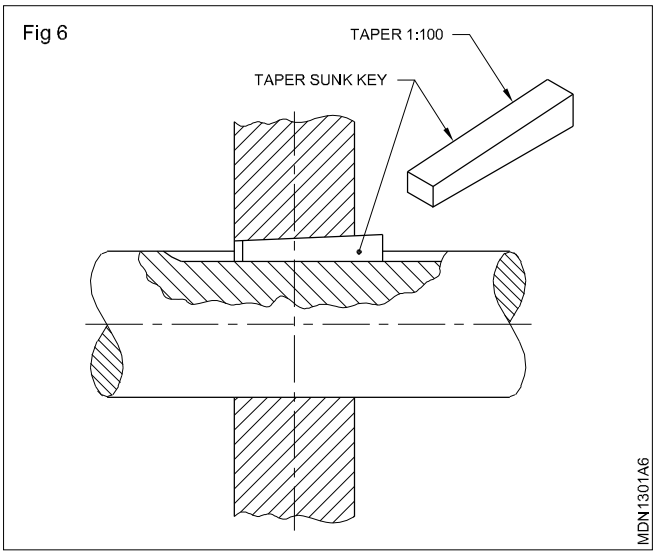


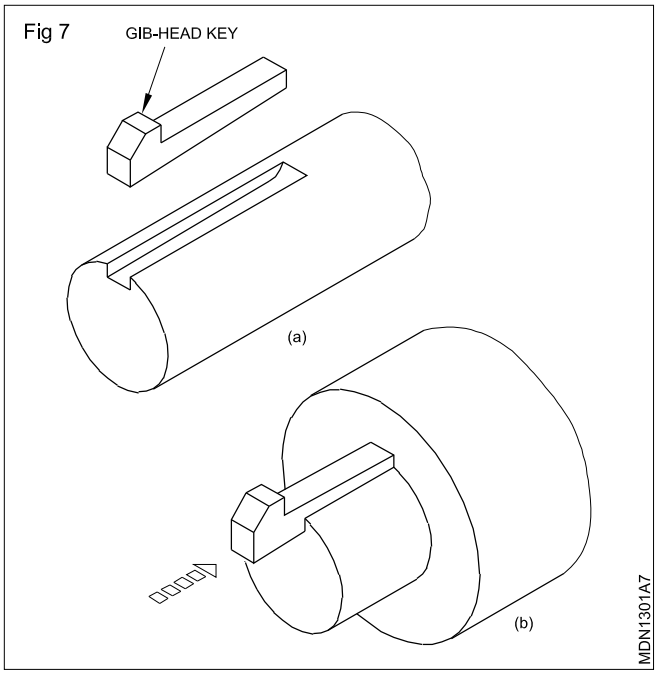
Fig 6



Gib-head key (Fig 7)

This is another type of sunk key. This has a gib-head to assist in fixing and removing the keys. (Figs 7a and b)

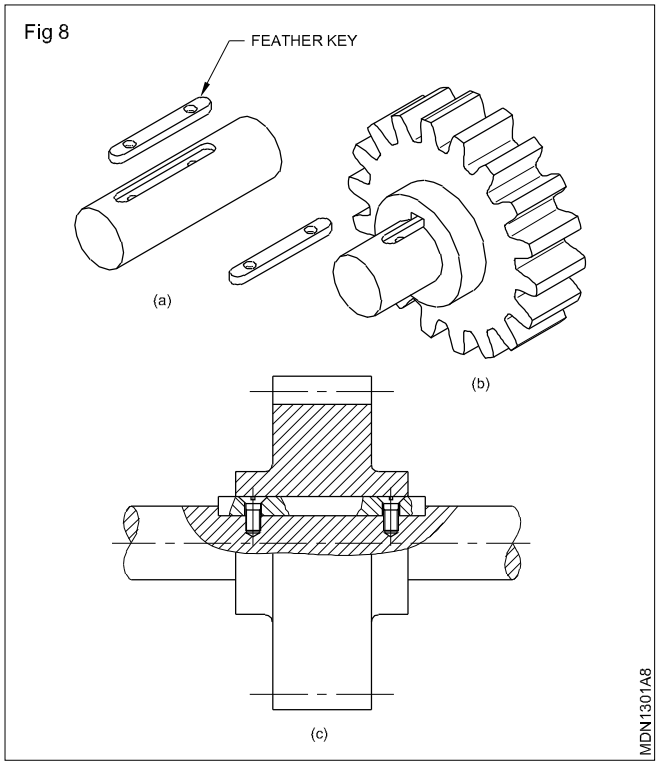
Fig 7



Feather key (Fig 8)

This is a parallel key with rounded ends. This is useful when the hub/pulley has to slide axially on the shaft to some distance. (Figs 8a,b and c) This key may be either tightly fitted in the keyway or screwed in.

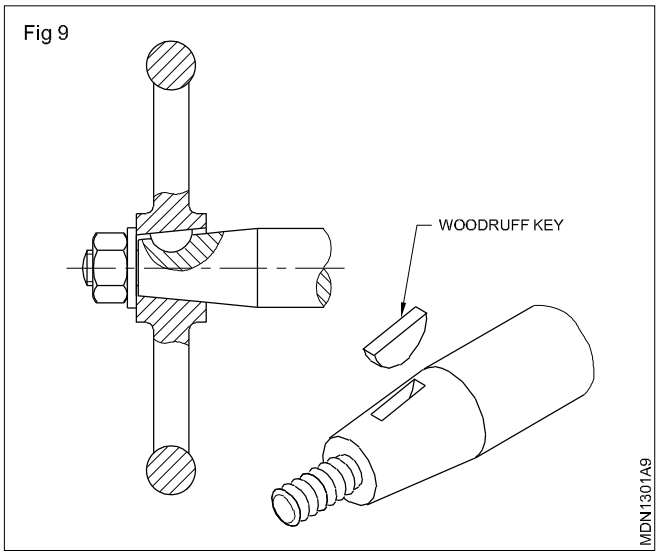
Fig 8



Woodruff key (Fig 9)

This is semicircular key and it fits on to the shaft on which matching recesses are cut. The top portion of the key projects out and fits in the keyway cut on the hub. (Fig.9)

Fig 9



This key is particularly useful on tapered fittings of shafts.

Splined shaft & serrated shaft

Splinded shafts along with splined hubs are used particularly in the motor industry. The splined hub can also slide along the shaft, wherever necessary. (Figs 10a and b)

In certain assemblies, serrated shafts are also used for transmission. (Figs 11a and b)

Fig 10

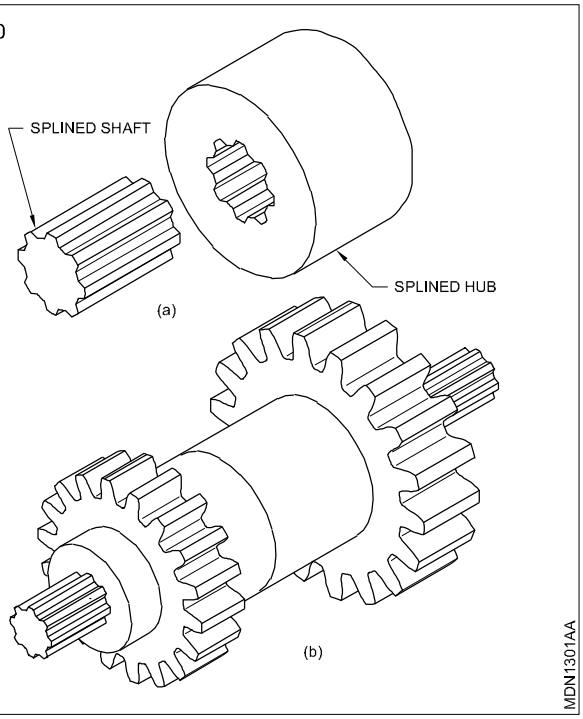
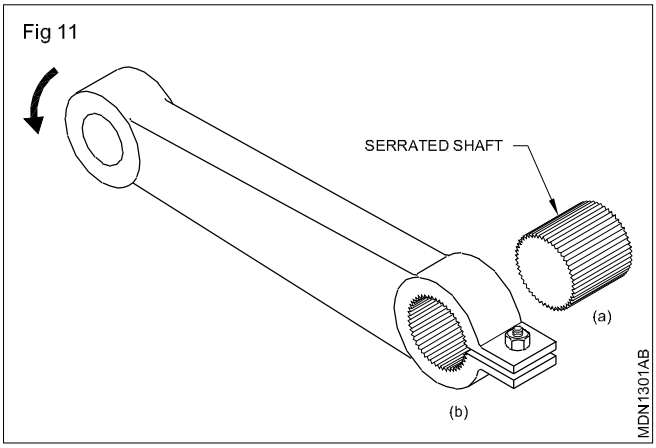


Fig 11



Circlips

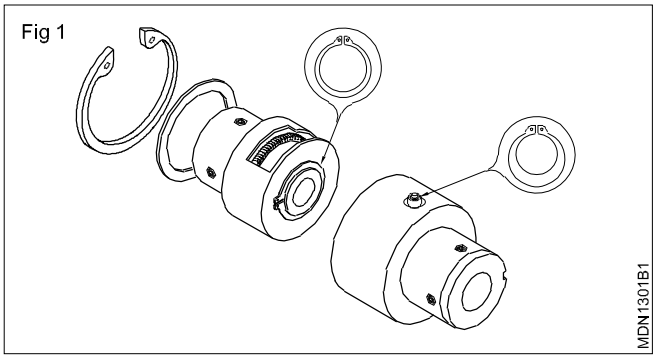
Objectives : At the end of this lesson you shall be able to

- **state the functions of circlips**
- **state the different types of circlips**
- **state the advantages of circlips over other fastening devices**
- **state the material used for circlips.**

Circlips are fastening devices used to provide shoulders for positioning or limiting the movement of parts in an assembly (Fig.1) Circlips are also called `Retaining rings.

The rings are generally made of meterials having good spring properties so that the fastener may be deformed elastically to a considerable degree and still spring back to its original shape. This permits the circlips to spring back into a groove or other recess in a part or they may be seated on a part in a deformed conditiona so that they grip the part by functional means. Circlips are manufactured from spring steel with high tensile and yield strength.

Fig 1



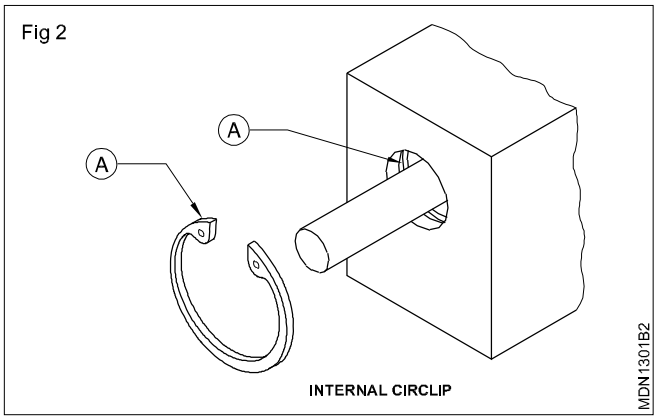
TYPES

There are two types.

Internal circlips (Fig.2)

This type of rings are assembled in holes, bores or housing.

Fig 2



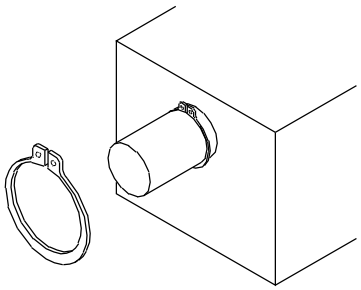
External circlip (Fig.3)

This type of rings are installed on shafts, pins, studs and similar parts.

Both types offer a number of advantages over other types of fasteners.

- Their cost is relatively low when compared with other types of fasteners.
- Their use often results in savings in raw material and simplified machining operations for other parts in the assembly.
- One circlip often can replace two or more parts.
- Assembly toolings developed for circlips usually permit very rapid assembly of the fasteners, even by unskilled workers.

Fig 3



EXTERNAL CIRCLIP

MDN1301B3

Material

Because retaining rings depend for their function largely on their ability to be deformed elastically during assembly and disassembly, the materials must have good spring properties. Circlips are manufactured from spring steel with high tensile and yield strength.

Washers - Types and Uses

Objectives : At the end of this lesson you shall be able to

- **state the purpose of washers**
- **name the types of washers**
- **state the uses of each type of washers**
- **specify the washers as per B.I.S.**

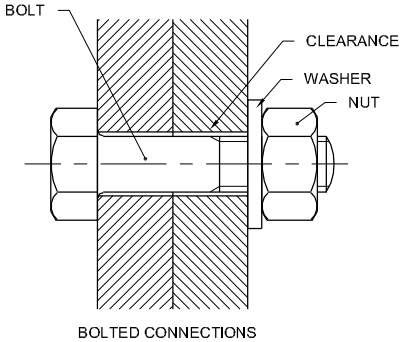
Purpose

It is a common practice to provide washers under the nuts in bolted joints.

Washers help to (Fig 1)

- increse the frictional grip
- prevent loosening of nuts due to vibration
- prevent damage to the work piece and
- distribute force orver a larger area.

Fig 1



BOLTED CONNECTIONS

MDN1301C1

Types of washers

There are different types of washers available. They are

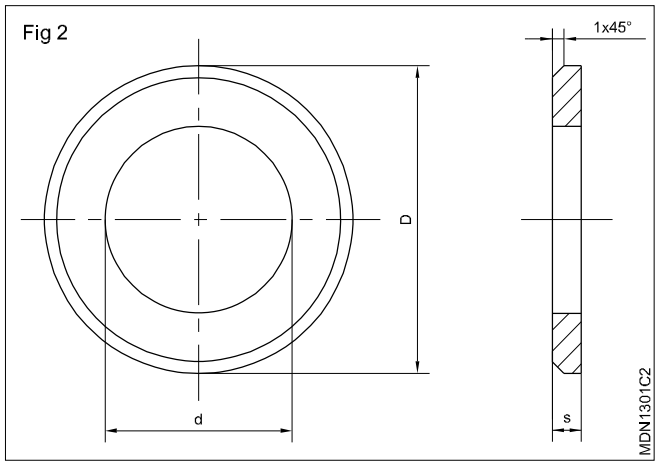
- plain or flat washers
- taper washers
- spring washers
- tab washers
- toothed lock washers.

Plain or flat washers (Fig 2)

These washers are used for bolting assemblies with flat surfaces. The diameter thickness and the bore diameter are proportional to the diameter of the bolt. (I.S. 2016)

Plain washers are available as machined or punched washers.

Fig 2



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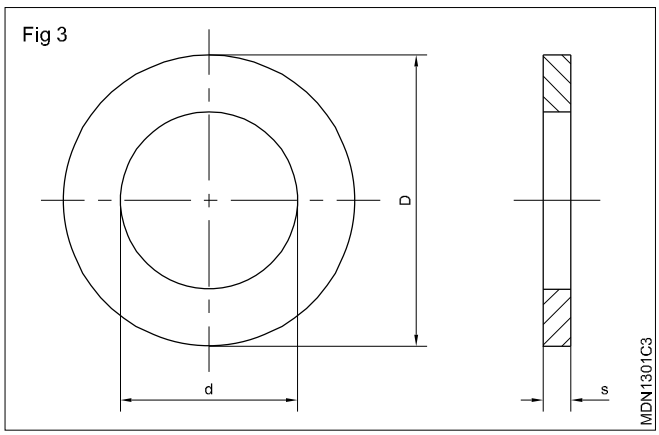
Machined washers (Fig 3)

These washers are used for assemblies using machined components. These washers are available with chamber on one side or on both sides. They are heat treated and ground.

Fig 3



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Punched washers

These do not have chamfers and are commonly used in structural fabrication work.

Tapered washers (Figs 4 & 5)

These are used in structural assemblies with tapered surfaces like the inside of beams, channels etc. These washers help bolt head or nut to seat square to the hole.

Fig 4

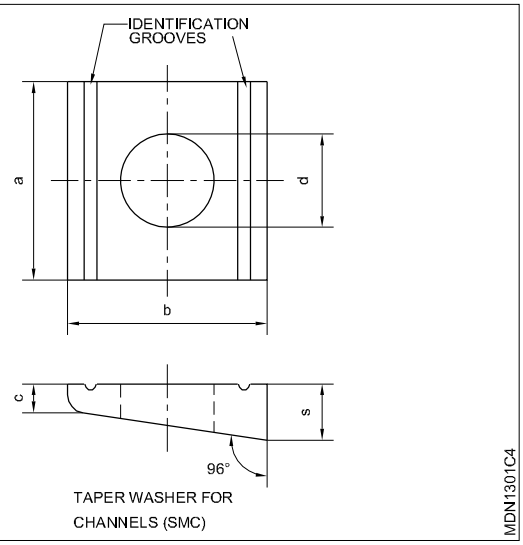
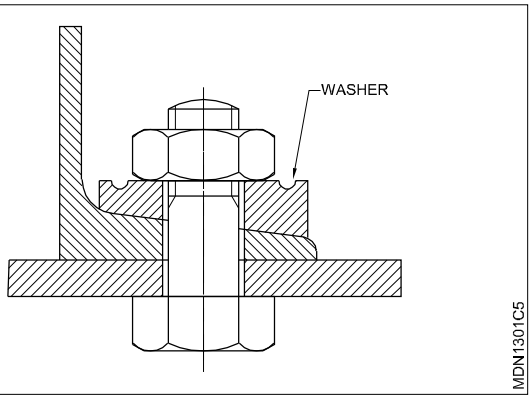


Fig 5



Spring washers (Figs 6 & 7)

Spring washers are used under the nuts to prevent slackening of the nuts due to vibrations. They are made of spring steel, and when compressed they create tension between the bolt and the nut.

Fig 6

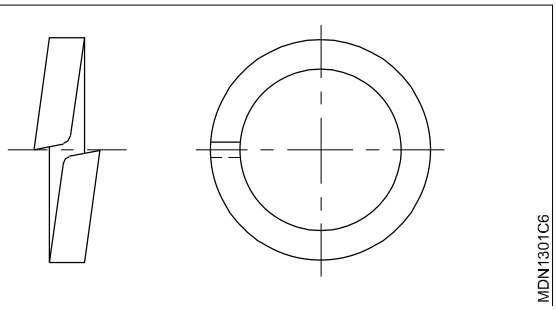
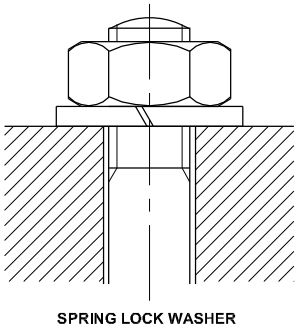


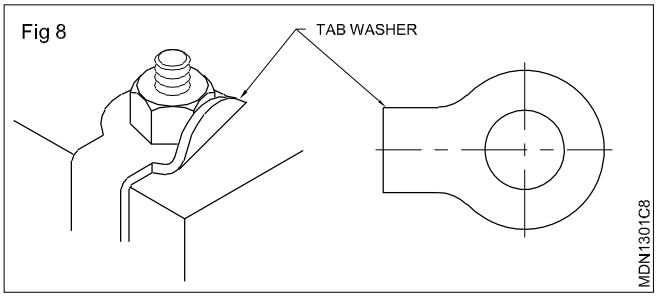
Fig 7



Tab washers (Fig. 8)

These washers are used for locking the nuts.

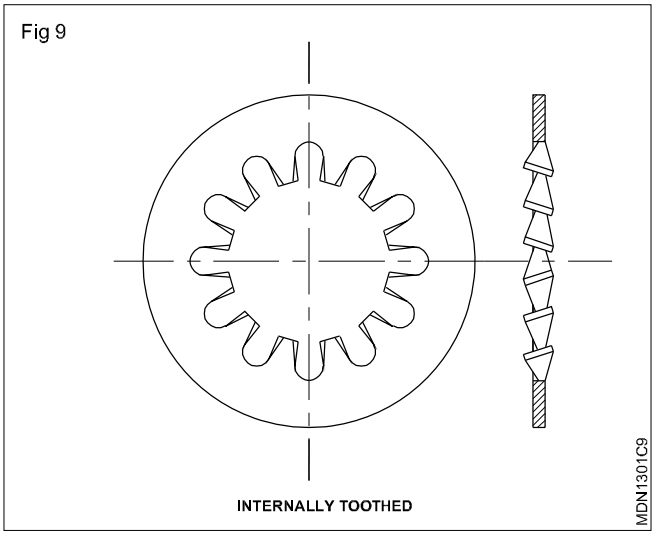
Fig 8



Toothed lock washers (Fig. 9)

These washers have serrations, cut and twisted. When placed between the nut and the assembly, this washer exerts friction on both the contacting surfaces. This prevents the nuts from slackening.

Fig 9



Specifications

The Indian standard Is:2016-1967 designates a washer by name, type size and number of the standard and material.

Example

A machined washer of size 10.5 mm made of brass shall be designated as machined washer 10.5 IS:2016 Brass.

Note

For detailed specification of different types of washers refer to the following IS specifications.

Taper washer	- IS: 5374 and IS: 5372
Tab washer	- IS: 8068
Toothed lock washer	- IS: 5371
Plain washer	- IS: 2016

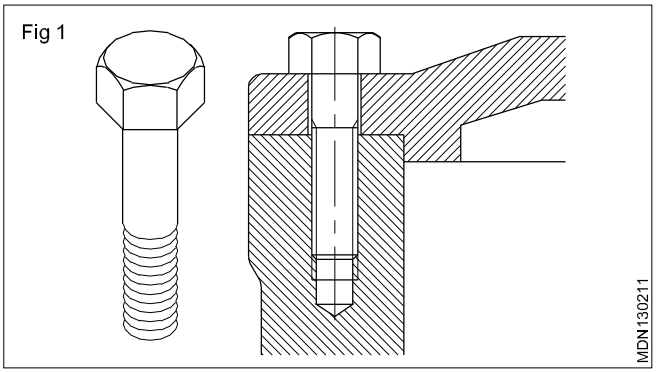
Different types of screws, nuts, studs and bolts.

Objectives : At the end of this lesson you shall be able to

- **name the different types of machine screws used in heavy duty assembly**
- **name the different types of machine screws used in light assembly work**
- **state the uses of different types of machine screws**
- **name the different types of set screws.**

Machine screws are used when a nut cannot be used in the assembly and the component in the assembly has a threaded hole to receive the screws (Fig.1)

Fig 1



Types of machine screws (Heavy duty)

Hexagon head screws

Hexagon socket head cap screws

Square head countersink head screws

These are heavy duty screws.

Hexagon head screws

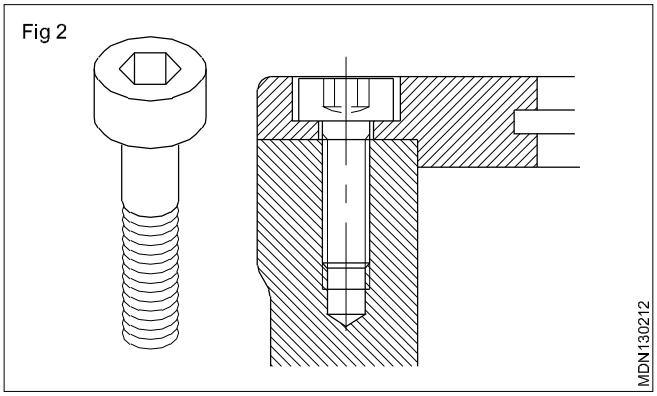
These are used when the projection of the screw head will not be an obstruction in the assembly (Fig.1)

Hexagon socket head cap screws

These are used when the projection of the screw head above the surface is to be avoided. (Fig.2) The Indian Standard specification head socket cap screws cover the range from 1.6 mm to 36mm.

Hexagon head screws and hexagon socket head screws are made of steel. Hexagon head screws used in electrical work are made of brass.

Fig 2



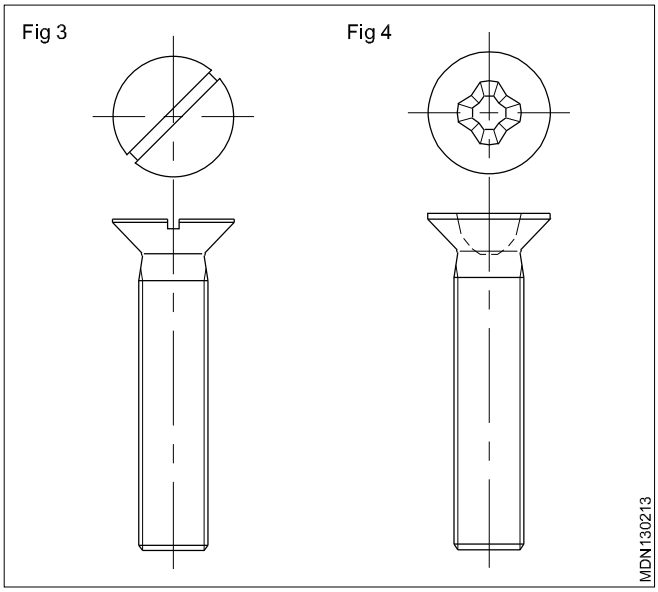
Countersink head screws

There are four types of countersink head screws in common use.

They are:

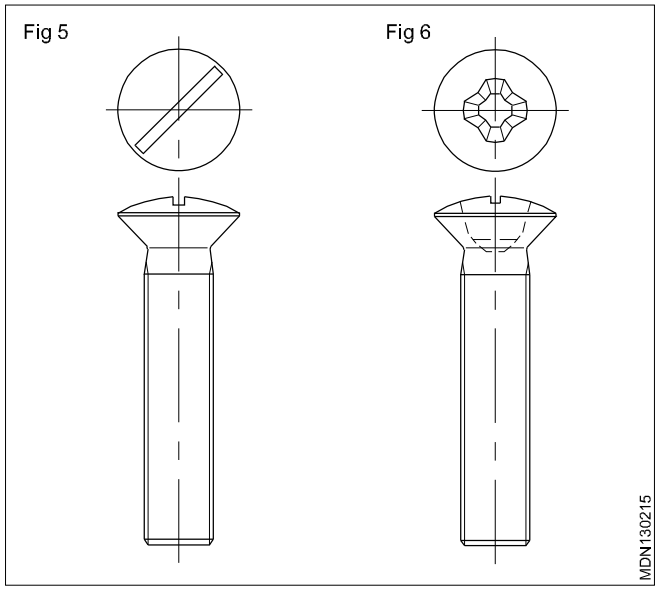
- slotted countersink head screws (Fig.3)
- cross-recessed countersink head screws (Fig 4)

Fig 3 Fig 4



- slotted raised countersink head screws (Fig.5)
- cross recessed, raised countersink head screws. (Fig.6)

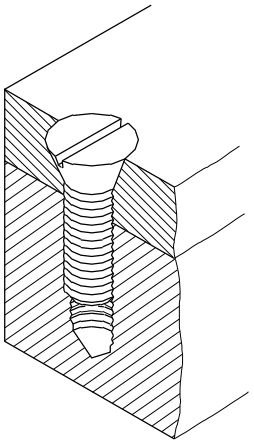
Fig 5 Fig 6



Countersink screws are capable of aligning the matching component correctly with the threaded hole. (Fig.7)

The projection of the screw head above the assembly is also avoided. B.I.S. specification covers the following ranges of countersink head screw sizes in different types.

Fig 7



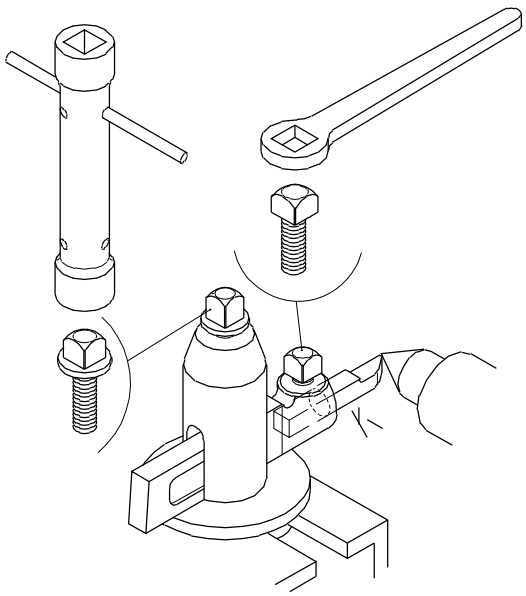
MDN130217

- Slotted countersink head screws M1 - M20
- Cross-recessed countersink head screws M1.6 to M10.
- Slotted raised countersink head screws M1 to M20.
- Cross-recessed raised countersink head screws M1.6 to M10.

Square head screws. (Fig. 8)

Square head screws are used in places where there is frequent removal and refitting of the assembly. These screws are tightened to a higher torque using a wrench. (Fig.8) Square head screws are also available with a collar. In this there is a washer at the base which is an integral part of the head. The purpose of this collar is to protect the work-surface from damages due to constant use of wrenches.

Fig 8



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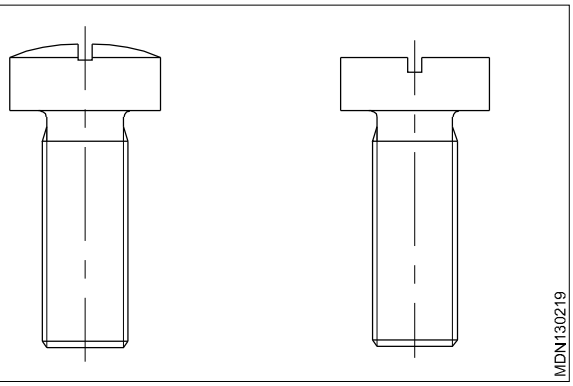
Other types of machine screws used in light assembly work are:

Pan head (Fig 9) ; Cheese head (Fig 10)

Fig 9



MDN130219

Raised cheese head (Fig 11) ; Round head (Fig 12)

Fig 11

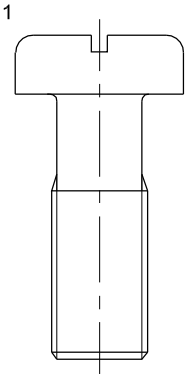
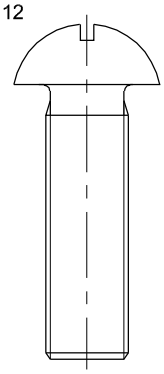


Fig 12



MDN13021B

These screws are also available with slotted head or as cross-recessed.

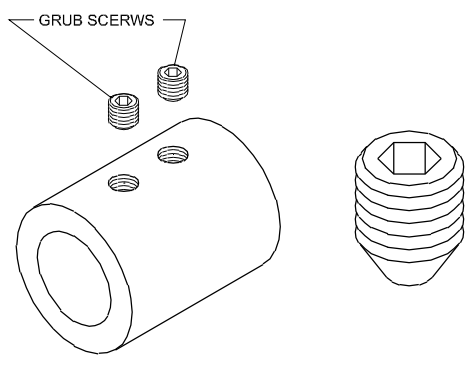
The screws used for light duty are normally available up to 10mm thread diameter.

These screws are made of steel, stainless steel or brass. These screws are either plain finished, zinc-coated or chrome-plated.

Set screws and grub screws

Hexagonal socket set screws (Fig.13)

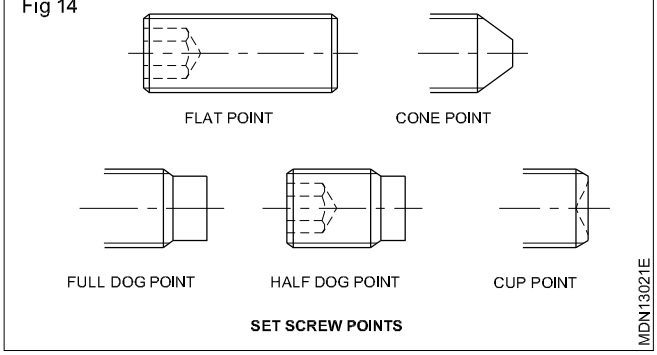
Fig 13



MDN13021D

These are headless socket screws available with different points for various functional requirements. (Fig.14)

Fig 14

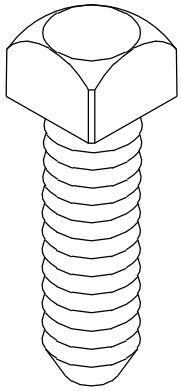


These points either allow to bite into the metal or tighten without damage to the work-surface. They are used to fasten pulleys, collars etc. to the shafts. They are used for higher strength applications where space is limited.

Square set screws (Fig.15)

These set screws have similar applications as hexagon socket set screws but have square heads projecting above the work-surface.

Fig 15

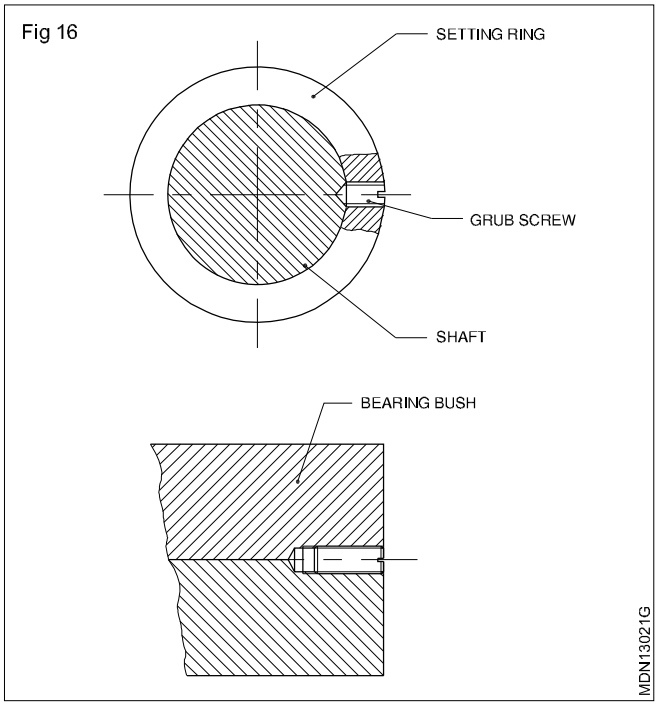


These are useful when the assembly needs frequent disassembly and setting.

Grub screws

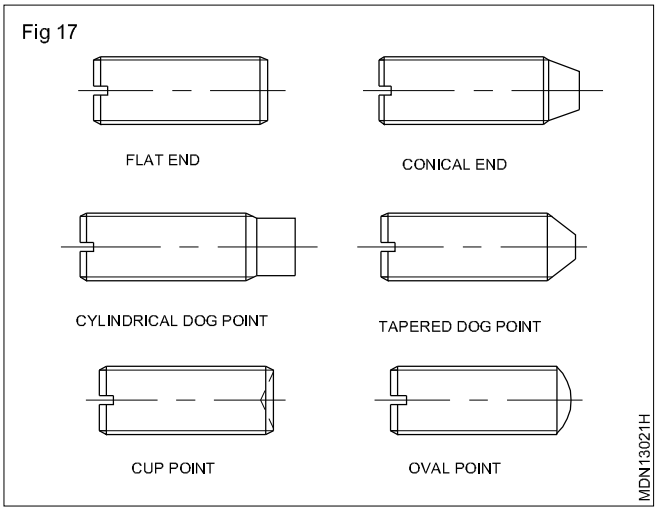
Grubs have similar application as hexagon socket set screws but are used for light holding. (Fig. 16)

Fig 16



Grub screws are also available with different types of points (Fig.17)

Fig 17



Thumb Screws

Objectives : At the end of this lesson you shall be able to
- **state the types of thumb screws**
- **state the uses of thumb screws**
- **designate thumb screws as per B.I.S. specification**.

Thumb screws are used in places where fixing and removal of components are frequent. Tightening and loosening of the assembly is finger tight only.

Types

As per the Indian standard specification IS:3726-1972 there are five types of thumb screws.

Type-A Thumb screws partially threaded (Fig 1)

Type-B Thumb screws fully threaded (Fig 2)

Fig 1

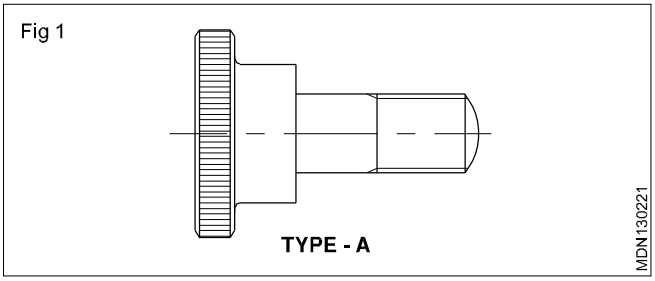
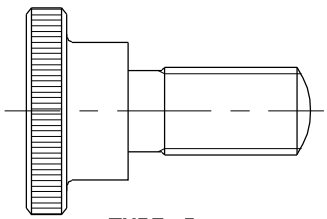


Fig 2



TYPE - B

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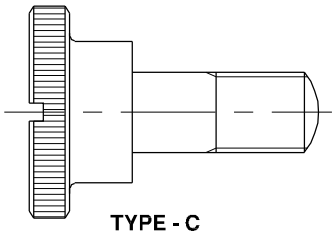
Type-C Slotted thumb screw partially threaded (Fig 3)

Fig 3



TYPE - C

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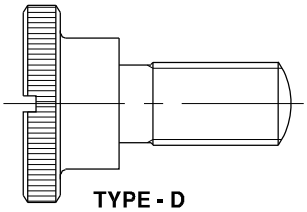
Type-D Slotted thumb screw fully threaded (Fig 4)

Fig 4



TYPE - D

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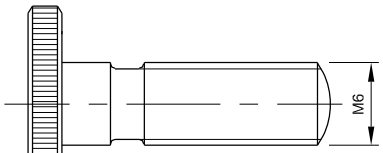
Type-E Flat thumb screws (Fig 5)

Fig 5



TYPE - E

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The type of thumb screw selected depends on the actual requirement in the assembly.

Sizes

Thumbs screws are available in the following sizes as per B.I.S.

M1.6, M2, M2.5, M3, M4, M5, M6, M8 and M10.

Designation of thumb screws

Thumb screws shall be designated by the nomenclature, type, thread size, nominal length, the number of Indian Standard and the symbol for mechanical properties.

Example

A thumb screw of Type `A', size M6, nominal length 12mm and of property class 4.6 shall be designated as:
Thumb screws A M6 x 12 IS: 3726-4.6
When brass or any other non-ferrous metal is used for the manufacture of thumb screws, the word Brass or the name of the non-ferrous metal used will replace the property class number in the designation.

Types of Nuts

Objectives : At the end of this lesson you shall be able to
- **name the common types of nuts**
- **state the features and uses of the common types of nuts.**

Different types of nuts are used depending on the requirement of the assembly.

Hexagonal nuts (Figs 1 & 2)

This is the most commonly used type of nut in structural and machine tool construction.

Hexagonal nuts are available in different thicknesses. Thin nuts are used as lock-nuts.

Fig 1

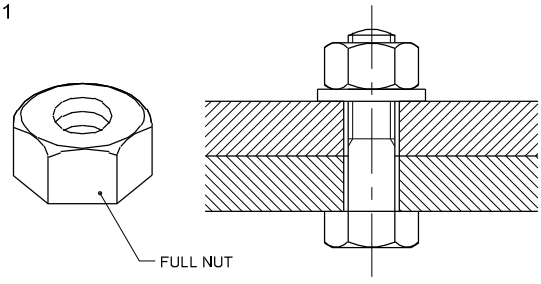

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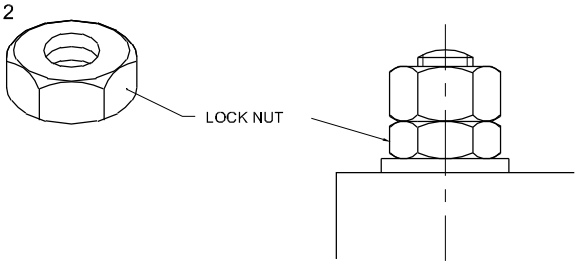
Fig 2



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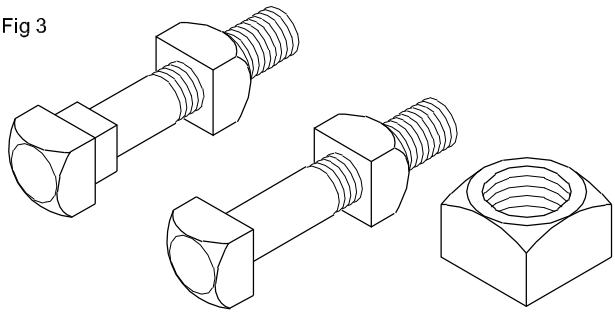
Square nut (Fig. 3)

Fig 3



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Square bolts are provided with square nuts. In bolts for coaches mostly square nuts are used.

Self-locking nuts (Simmonds lock-nut)

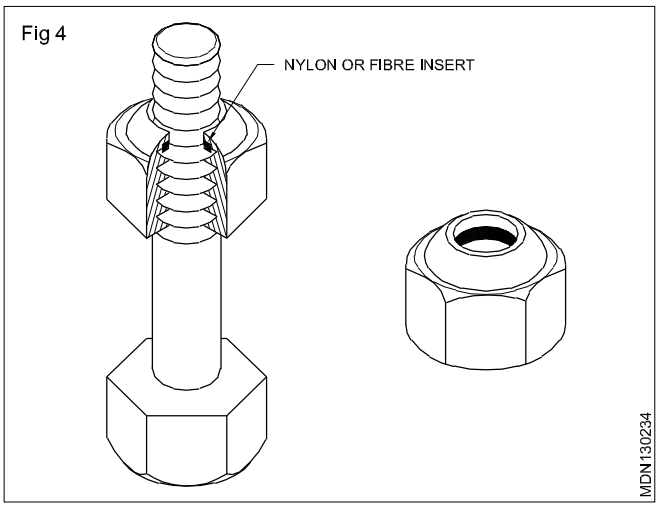
This nut has an internal groove cut in which a fibre or nylon ring is inserted. This ring holds the nut tightly on the bolt and serves as a locking device.

Self-locking nuts are not used with studs.

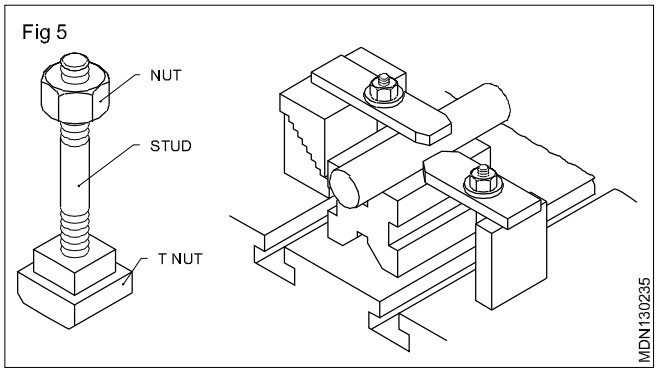
T-nuts.

T-nuts are used along with studs on machine tools for fixing/holding devices or workpieces.

Slotted and castle nuts (Fig. 4)



Round nuts (Fig. 5)



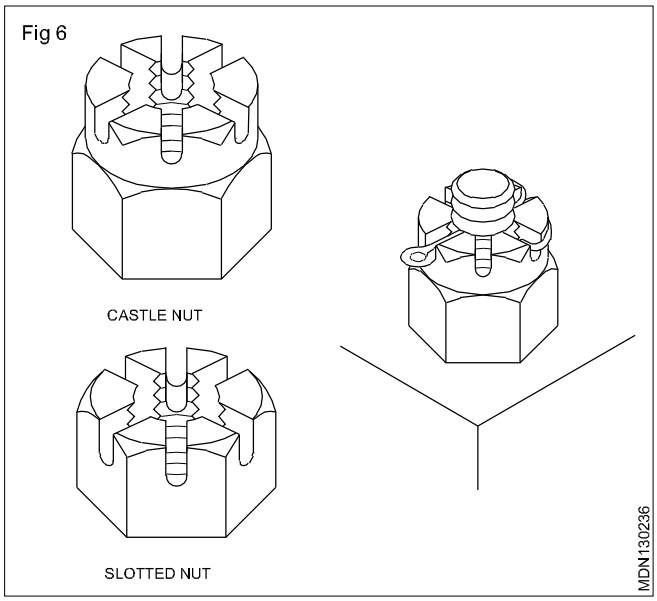
Round nuts of different types are available for special applications.

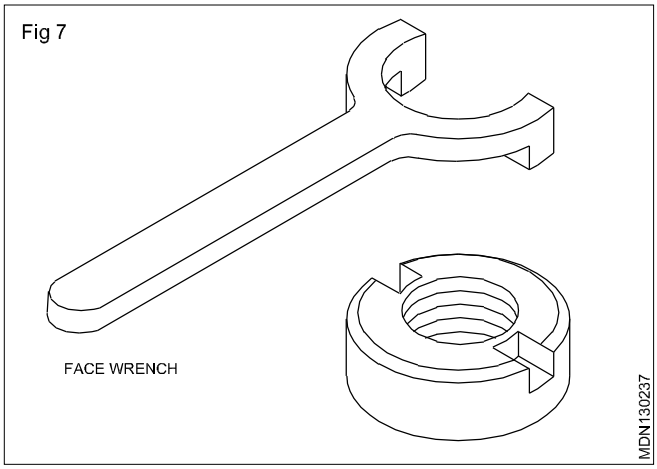
Slotted round nut (Figs 6, 7, 8, 9 & 10)

Slotted round nut for hook wrench.

Round nut with set pin holes on sides

Round nut with holes in the face.





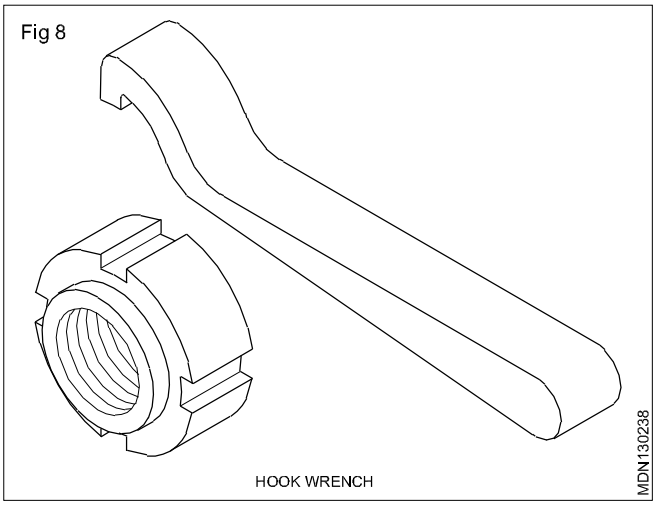
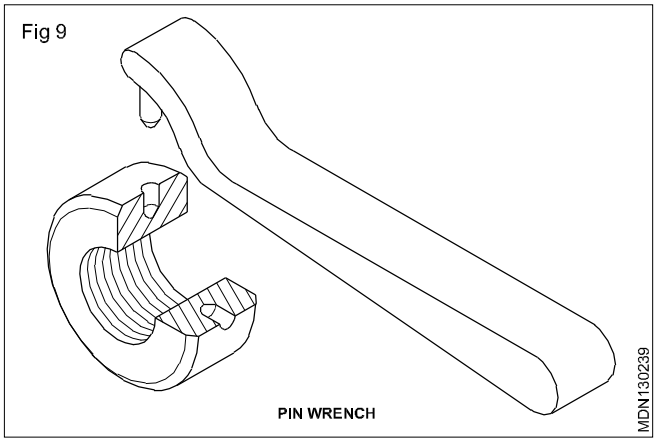


Fig 9



PIN WRENCH

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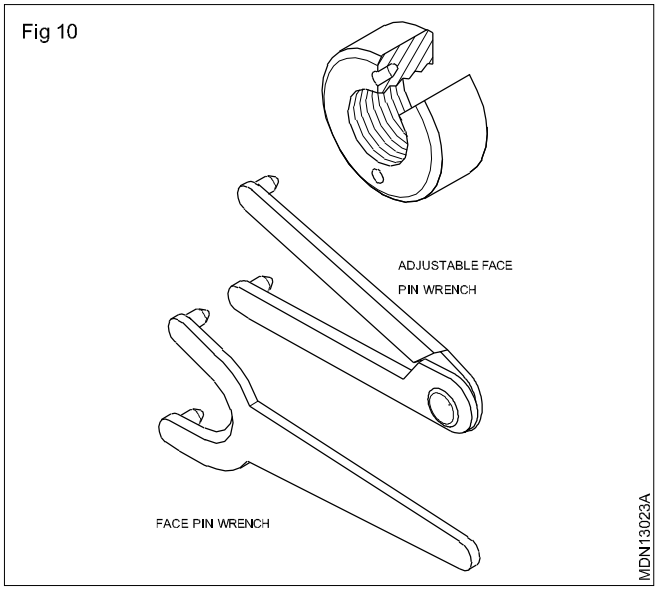
Fig 10



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Methods of removing broken studs

Objectives : At the end of this lesson you shall be able to
- **state the reasons for breakage of studs**
- **state the different methods for removing broken studs.**

The stud is used in the place of a bolt. Where hole cannot be had for the bolt to pass through or to avoid the use of an unnecessarily long bolt. Studs are generally used to fix up cover plates or to connect cylinder covers to engine cylinders.

Reasons for breakage of stud/bolt

Excessive torque is applied while screwing the stud into the hole/tightening the nut.

Threads are corroded excessively.

Matching threads are not of proper formation.

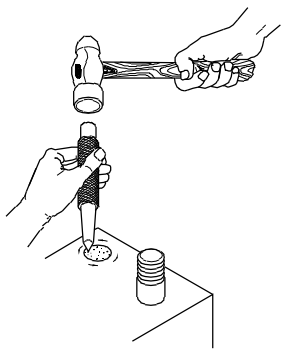
Threads are seized.

Methods of removing broken studs

Prick punch method (Fig 1)

If the stud is broken very near to the surface, drive it in an anticlockwise direction, using a prick punch and hammer to remove it.

Fig 1



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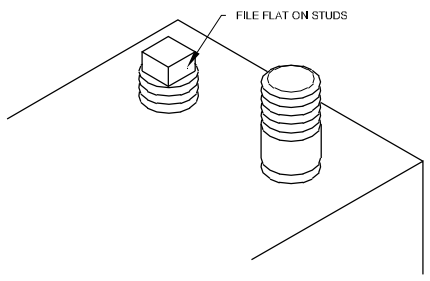
Filling square form (Fig 2)

When the stud is broken a little above the surface, form a square on the projecting portion to suit a standard spanner. Then turn it anticlockwise using a spanner to remove stud.

Fig 2



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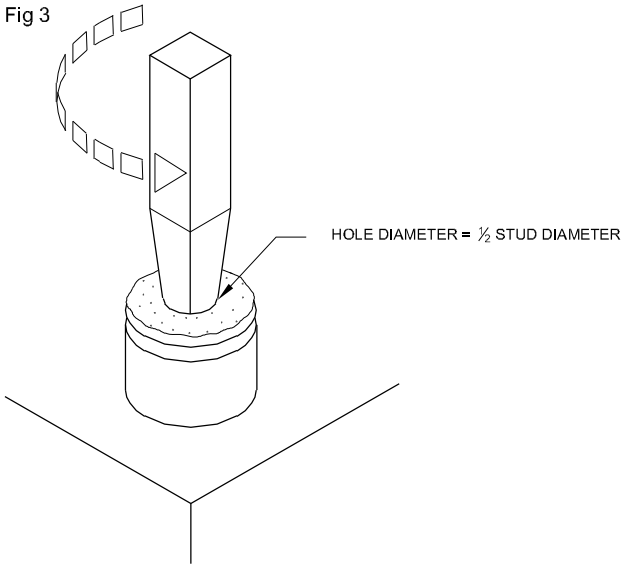
Using square taper punch (Fig 3)

Broken studs can also be removed by drilling a blind hole (hole diameter equal to half of stud diameter) and driving a square taper punch into the hole as shown Fig 3. Turn the punch using a suitable spanner in an anticlockwise direction to unscrew the stud.

Fig 3



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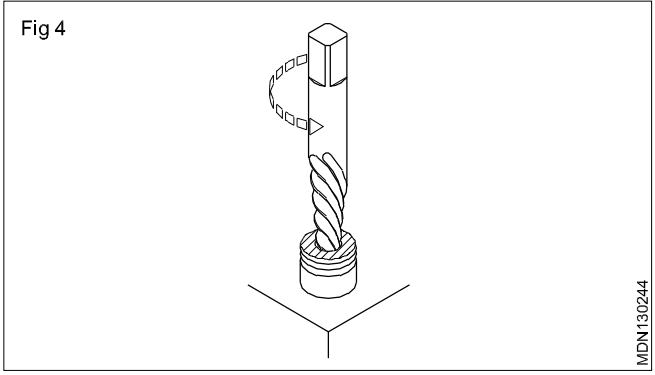
Ezy-out method (Fig 4)

Ezy-out or a stud extractor is a hand tool, some what similar to the form of a taper reamer but it has left hand spiral. It is available in a set of 5 pieces. The recommended drill size is punched on each ezy-out.

Drilling the hole, the recommended ezy-out is set on and turned in an anticlockwise direction by a tap wrench. As it is rotated it penetrates into the hole increasing its grip and in the process the broken stud gets unscrewed.

Fig 4



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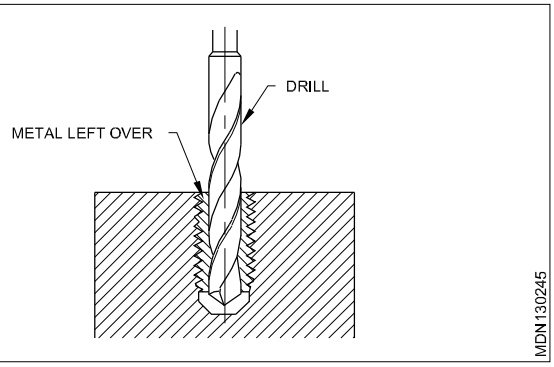
Making drill hole (Fig 5)

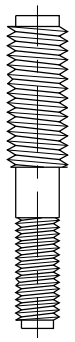
Fig 5



Correctly find out the centre of the broken stud and drill a hole nearly equal to the core diameter of the stud down the centre so that the threads only remain (Fig 5). Remove the thread portion by the point of a scriber in the form of broken chips. Re-tap the drill hole to clear the threads.

If all other methods fail drill a hole equal to the size of the stud size or a little over and tap the hole with an oversize tap. Now a special oversize stud as shown in figure 6 is to be made and fitted in position. (Fig. 6)

Fig 6



Screw pitch gauge

Objectives: At the end of this lesson you shall be able to
- **state the purpose of a screw pitch gauge**
- **state the features of a screw pitch gauge.**

Purpose

A screw pitch gauge is used to determine the pitch of a thread.

It is also used to compare the profile of threads.

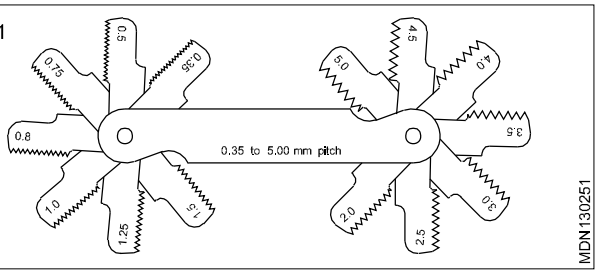
Constructional features

Pitch gauges are available with a number of blades assembled as a set. Each blade is meant for checking a particular standard thread pitch. The blades are made of thin spring steel sheets, and are hardened.

Some screw pitch gauge sets will have blades provided for checking British Standards threats (BSW, BSF etc.) at one end and the Metric Standard at the other end.

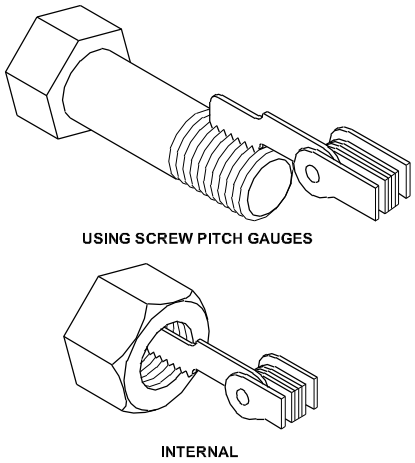
The thread profile on each blade is cut for about 25 mm or 30 m.. The pitch of the blade is stamped on each blade. The standard and range of the pitches are marked on the case. (Fig 1)

Fig 1



For obtaining accurate results while using the screw pitch gauge, the full length of the blade should be placed on the threads. (Fig 2)

Fig 2

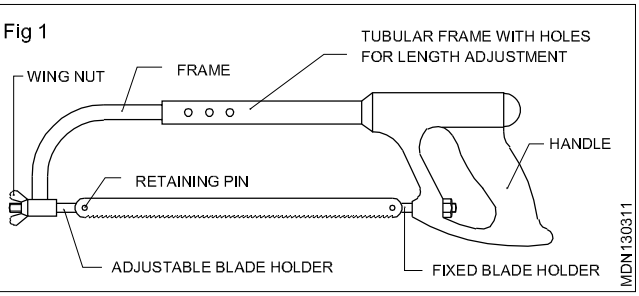


Hacksaw frame and blade

Objectives : At the end of this lesson you shall be able to
- **name the parts of a hacksaw frame**
- **specify hacksaw frames**
- **state the different types of hacksaw frames and their uses.**

The hand hacksaw is used along with a blade to cut metals of different sections. It is also used to cut slots and contours.

Fig 1



The parts are idenfified in the (Fig 1)

Types of hacksaw frames

The two different types of hacksaw frames are solid frame and adjustable frames.

Solid frame

Only a prticular standard length of blade can be fitted to this frame.

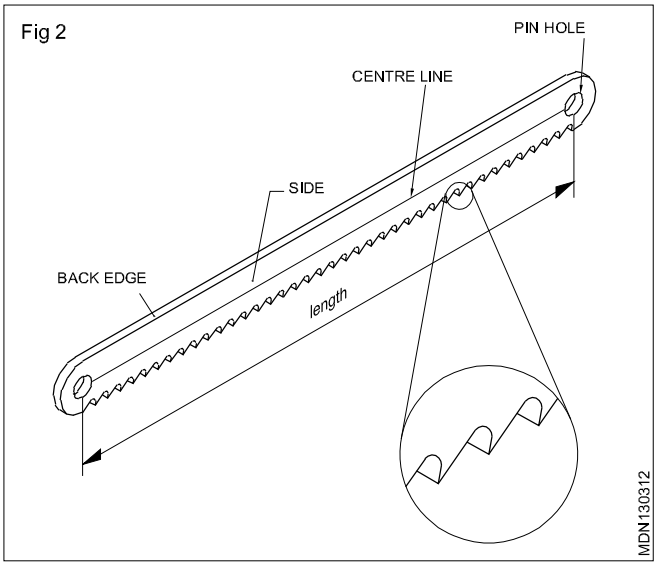
Adjustable frame (Flat type)

Different standard lengths of blades can be fitted to this frame.

Adjustable frame (Tubular type)

This is the most commonly used type. It gives a better grip and control, while sawing.

Fig 2



For proper working. It is necessary to have frames of rigid construction.

Hacksaw blades (Fig. 2)

A hacksaw blade is a thin narrow steel band with teeth and two pin holes at the ends. It is used along with a hacksaw frame. The blade is made of either low alloy steel (LAS) or high speed steel (HSS) and is available in standard lengths of 250 mm and 300 mm.

Types of hacksaw blades

Two types of hacksaw bladws are available - all hard blades and flexible blades.

All hard blades

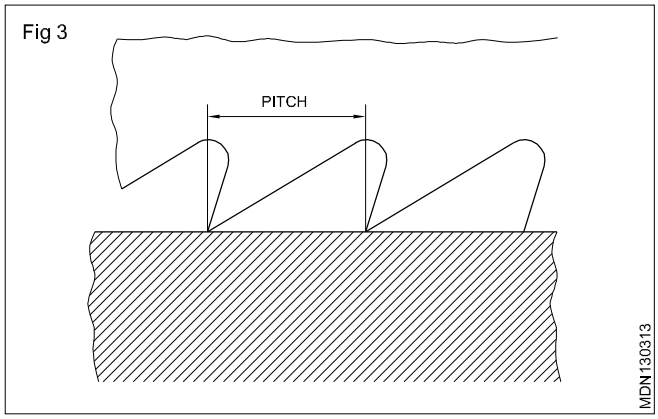
These are hardened to the full width between the pin holes.

Flexible blades

For these types of blades. Only the teeth are hardened. Because of their flexibility, these blades are useful for cutting along curved lines.

Pitch of the blade (Fig. 3)

Fig 3



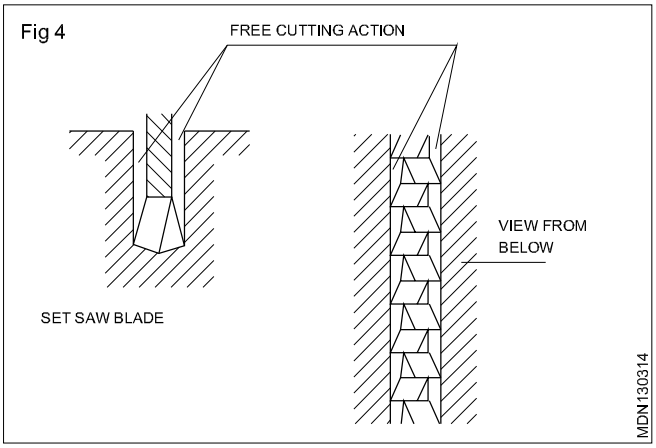
The distance between adjacent teeth is known as the pitch of the blade.

Classification	Pitch
Coarse	1.8 mm
Medium	1.4 mm & 1.0 mm
Fine	0.8 mm

Hacksaw blades are designated according to their length, pitch and type.

To prevent the saw blade binding when penetrating into the material and to allow free movement of the blade, the cut is to be broder than the thickness of the saw blade. This is achieved by the setting the saw teeth. There are two types of saw teeth settings.

Staggered set (Fig. 4)

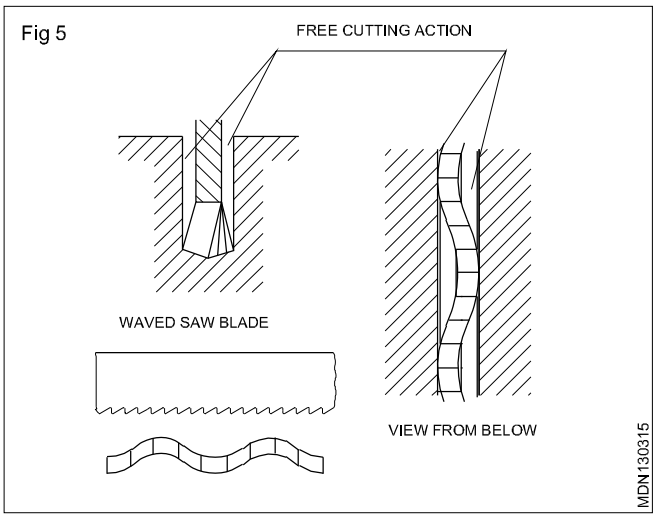


Alternate teeth or groups of teeth are staggered. This arrangement helps for free cutting and provides for good chip clearance.

Wave set (Fig. 5)

In this, the teeth of the blade are arranged in a wave form.

Sets of blades can be classified as follows



Pitch	Type of Set
0.8 mm	Wave -set
1.0 mm	Wave or staggered
Over 1.0 mm	Staggered

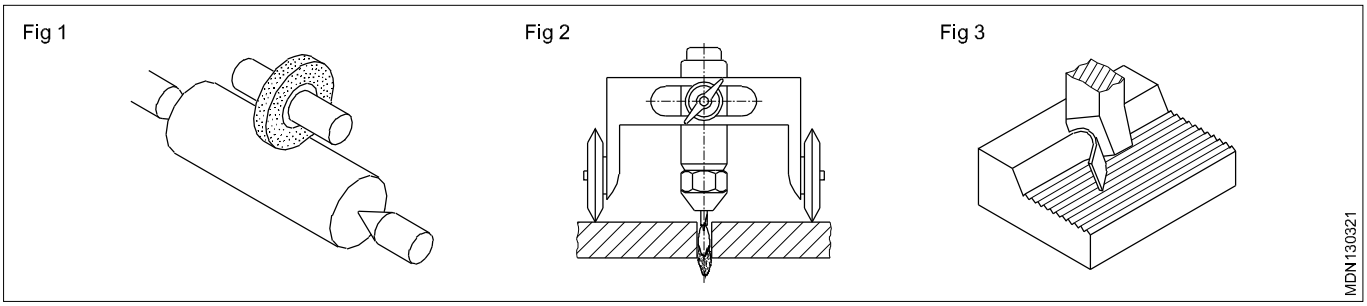
For the best results, the blade with the right pitch should be selected and fitted correctly.

Elements of a file

Objectives: At the end of this lesson you shall be able to
- **name the parts of a file.**

Methods of Material Cutting

The three methods of metal cutting are abrasion (Fig.1). Fusion (Fig 2) and Incision (Fig 3)



Filing is a method for removing excess material from a work pieces by using a file which acts as a cutting tool. (Fig 4) shows how to hold a file. Files are available many shapes and sizes.

Parts of a file (Fig 5)

The parts of a file as can be seen in figure 5, are

Tip or Point

The end opposite to tang

Face or side

The broad part of the file with teeth cut on its surface

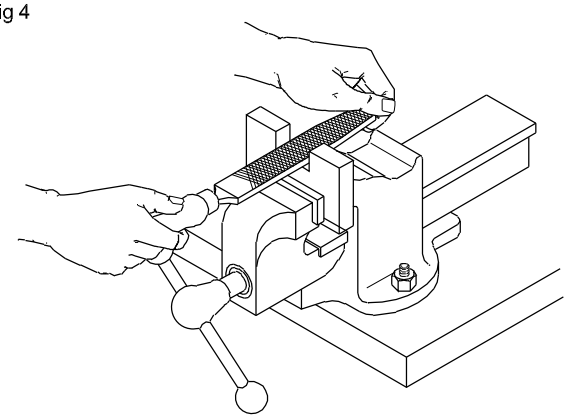
Edge

The thin part of the file with a single row of parallel teeth

Heel

The portion of the broad part without teeth.

Fig 4



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Shoulder

The curved part of the file separating tang from the body

Tang

The narrow and thin part of a file which fits into the handle

Handle

The part fitted to the tang for holding the file

Parts of a file (Fig 5)

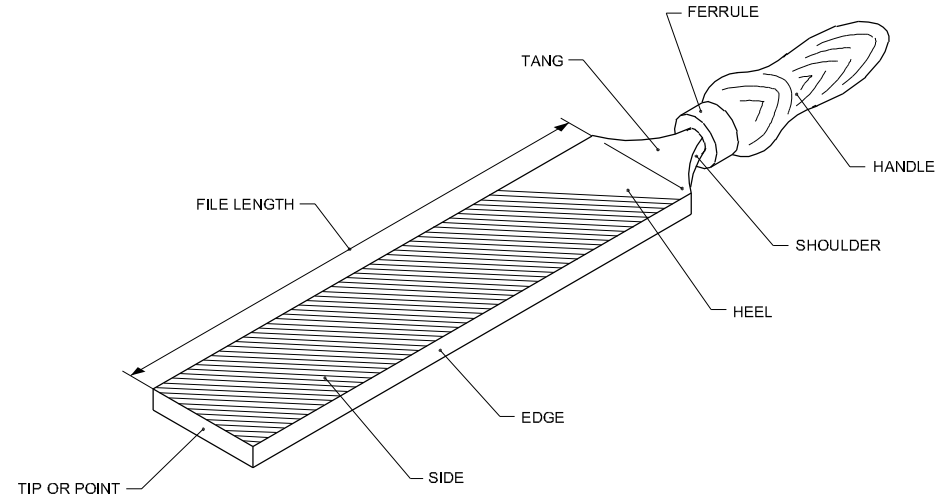
Ferrule

A protective metal ring to prevent cracking of the handle.

Materials

Generally files are made of high carbon or high grade cast steel. The body portion is hardened and tempered. The tang is however not hardended.

Fig 5



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Cut of files

Objectives : At the end of this lesson you shall be able to

- **name the different cuts of files**
- **state the uses of each type of cut.**

The teeth of a file are formed by cuts made on its face. Files have cuts of different types. Files with different cuts have different uses.

Types of cuts

Basically there are four types.

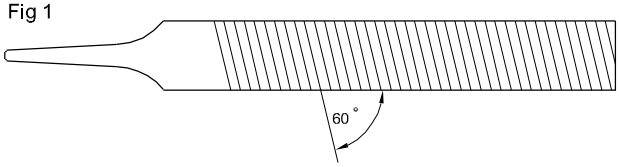
Single cut. Double cut. Rasp cut and curved cut.

Single cut file (Fig. 1)

A single cut file has rows of teeth cut in one direction across its face. The teeth are at an angle of 60^{o} to the centre line. It can chips as wide as the cut of the file. Files with this cut are useful for filing soft metals like brass, aluminium, bronze and copper.

Single cut files do not remove stock as fast as double cut files, but the surface finish obtained is much smoother.

Fig 1



SINGLE CUT FILE

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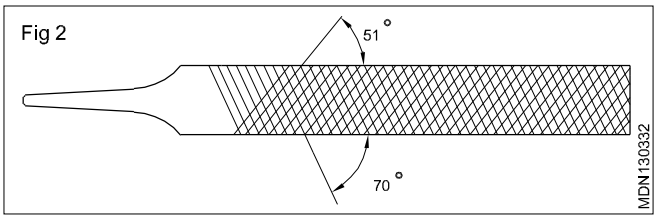
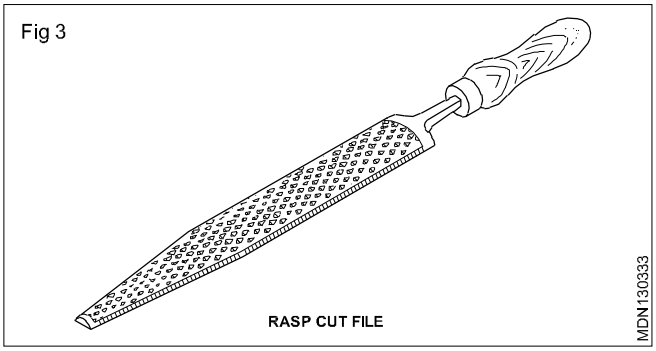
Double cut file (Fig. 2)

A double cut file has two rows of teeth cut diagonal to each other. The first row of teeth is know as OVERCUT and they are cut at an angle of 70^{o}. The other cut, made diagonal to this, is known as UPCUT and is at an angle of 51^{o}. This removes stock faster then the single cut file.

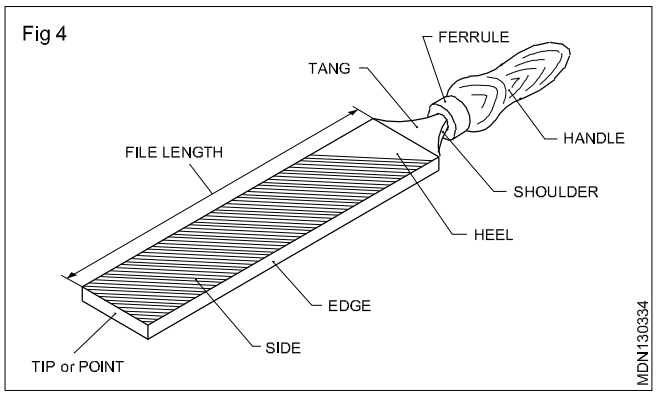


Rasp out file (Fig. 3)



The rasp cut has individual sharp pointed teeth in a line and is useful for filing wood, leather and other soft materials. These files are available only in half round shape.

Curved cut file (Fig. 4)



These files have deeper cutting action and are useful for filing soft materials like - aluminium, tin, copper and plastic. The curved cut files are available only in a flat shape.

The selection of a file with a particular type of cut is based on the material to be filed. Single cut files are used for filing soft materials. But certain special files, for example, those used for sharpening saws are also of single cut.

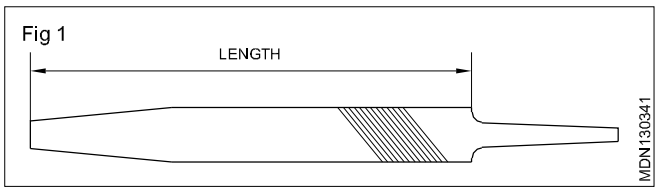
File specifications and grades

Objectives : At the end of this lesson you shall be able to
- **state how files are specified**
- **name the different grades of files**
- **state the application of each grade of file.**

Files are manufactured in different types and grades to meet the various needs.

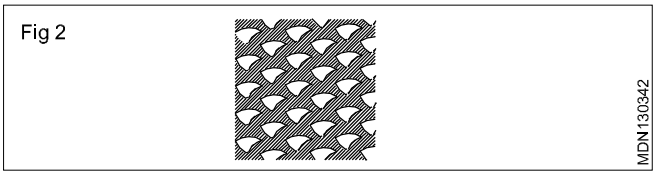
Files are specified according to their length, grade, cut and shape.

Length is the distance from the tip of a file to the heel. (Fig 1)

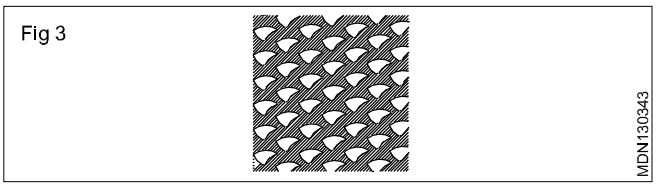


File grades are determined by the spacing of the teeth.

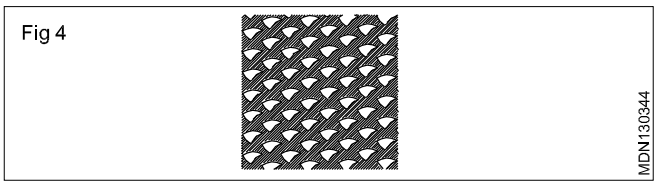
A round file (Fig 2) is used for removing rapidly a larger quantity of metal. It is mostly used for trimming the rough edges of soft metal castings.



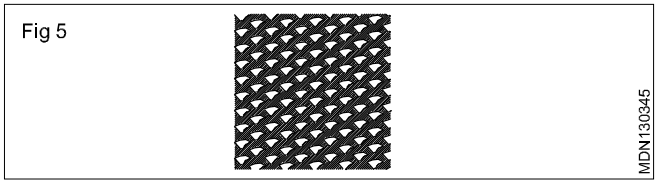
A bastard file (Fig 3) is used in cases where there is a heavy reduction of material.



A second cut file (Fig 4) is used to give a good finish on metals. It is excellent to file hard metals. It is useful for bringing the jobs close to the finishing size.



A smooth file (Fig 5) is used to remove small quantity of material and to give a good finish.



A dead smooth (Fig 6) file is used to bring to accurate size with a high degree of finish.

Fig 6

MDN130346

The most used grades of files are bastard, second cut, smooth and dead smooth. These are the grades recommended by the Bureau of Indian Standars. (BIS)

Different sizes of files with the same grade will have varying sizes of teeth. In longer files, the teeth will be coarser.

File - Applications

Objectives : At the end of this lesson you shall be able to
- **state the features of flat and hand files**
- **state the application of flat and hand files.**

Files are made in different shapes so as to be able to file and finish components to different shapes.

The shape of files is usually specified by their cross section.

The files useful for this exercise are flat files and hand files.

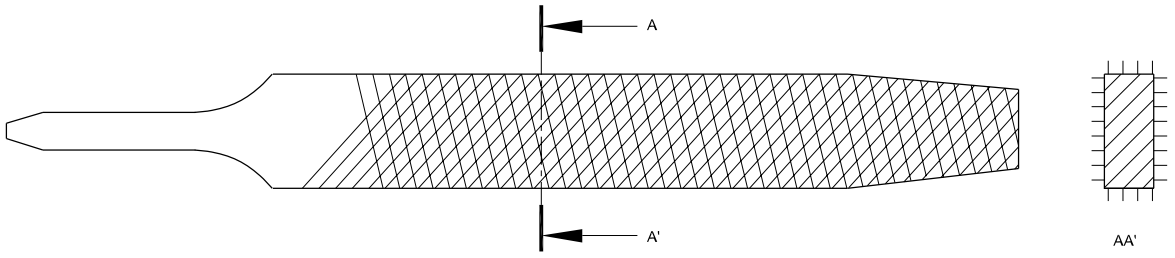
Flat files

These files are of a rectangular cross section. The edges along the width of these files are parallel up to two-thirds of the length, and then they taper towrads the point. The faces are double cut, and the edges single cut. These files are used for general purpose work. They are useful for filling and finishing external and internal surfaces.

Hand files (Fig 1)

These files are similar to the flat files in their cross section. The edges along the width are parallel through the length. The faces are double cut. One edge is single cut whereas the other is safe edge. Because of the safe edge, they are useful for filling surfaces which are at right angles to surfaces already finished.

Fig 1



MDN130351

Shapes of files

Objectives : At the end of this lesson you shall be able to
- **name the different shapes of files**
- **state the uses of Square, Round, Half Round, Triangular and Knife-edge files.**

For filing and finishing different profiles, files of different shapes are used.

The shape of files is stated by its cross section.

Common files of different shapes

Flat file, Hand file, Square file, Round file

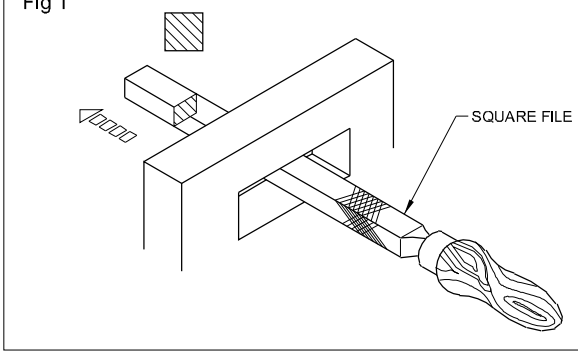
Half found file, Triangular file and Knife-edge file.

(Flat and hand files have already been discussed).

Square File

The square file is square in its cross sectiion. It is used for filling square holes, internal square corners, rectangular opening, keyways and spines. (Fig 1)

Fig 1



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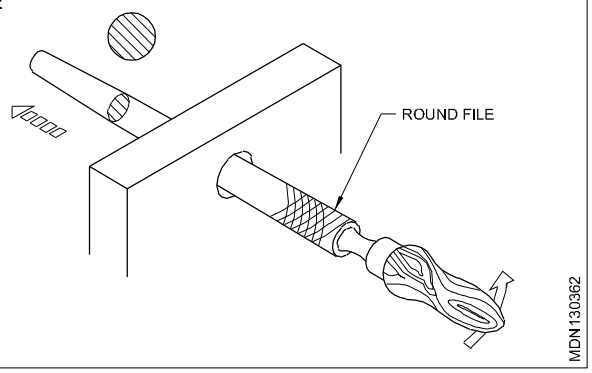
Round file

A round file is circular in its cross section. It is used for enlarging the circular holes and filing profiles with fillets. (Fig 2)

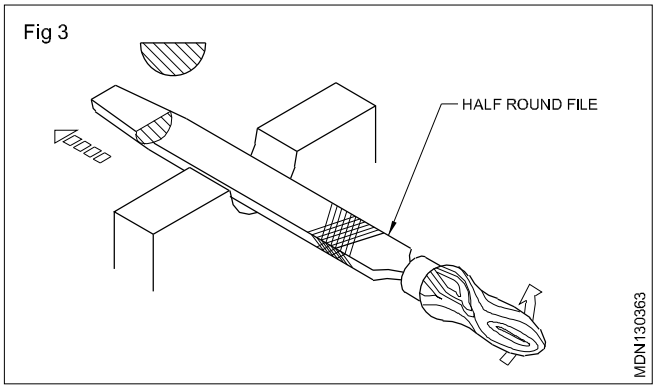
Fig 2



Half round File

A half round file is in the shape of a segment of a circle. It is used for filing internal curved surfaces (Fig 3)

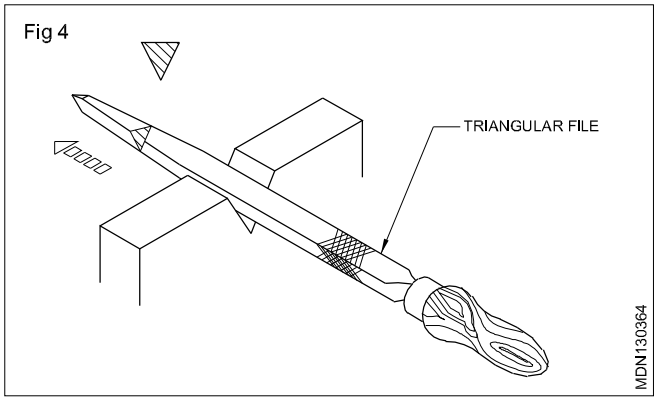
Fig 3



Triangular File

A triangular file is of a triangular cross section. It is used for filing corners and angles which are more than 60^0. (Fig 4)

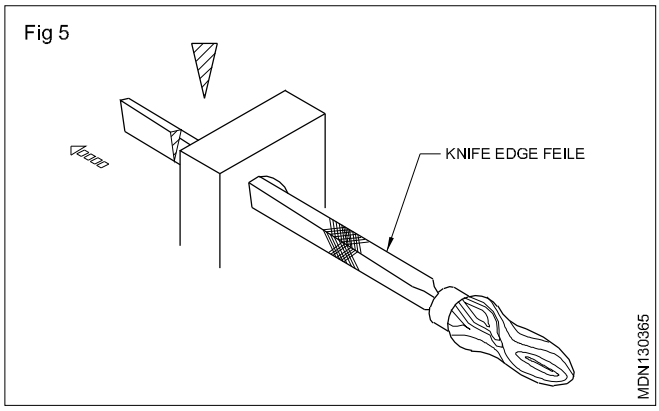
Fig 4



Knife-edge File

A knife-edge file has the cross section of a sharp triangle. It is used for filing narrow grooves and angles above 10^0. (Fig 5)

Fig 5



The above files have one third of their lengths tapered. They are available both in single and double cuts.

Square, round, half-round and triangular-files are available in lengths of 100, 150, 200, 250, 300 and 400 mm. These files are made in bastard, second cut and smooth grades.

Off- hand grinding with bench and pedestal grinders

Objectives : At the end of this lesson you shall be able to
- **state the purposes of off-hand grinding**
- **state the features of bench and pedestal grinders.**

Off-hand grinding is the operation of removing material which does not require great accuracy in size or shape. This is carried out by pressing the workpiece by hand against a grinding wheel.

Off-hand grinding is performed for rough grinding of jobs and resharpening of

scribers, punches, chisels, twist drills

single point cutting tools etc.

Off-hand grinding is performed with a bench or pedestal grinder (Fig 1 and 2)

Bench grinders

Bench grinders are fitted to a bench or table, and are useful for light duty work.

Pedestal grinders

Pedestal grinders are mounted on a base (pedestal), which is fastened to the floor. They are used for heavy duty work.

Fig 1

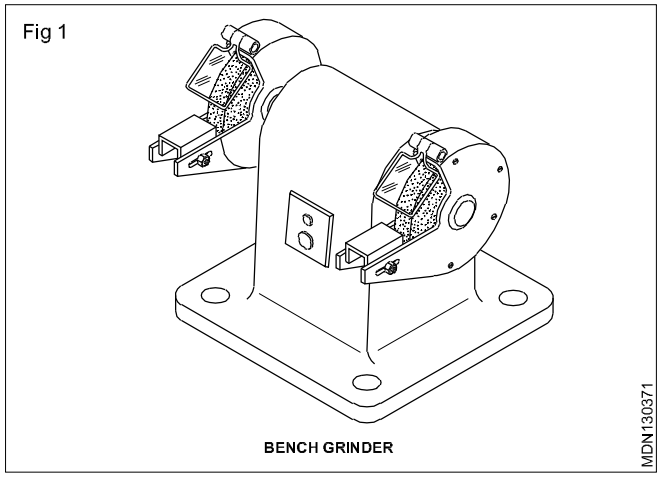
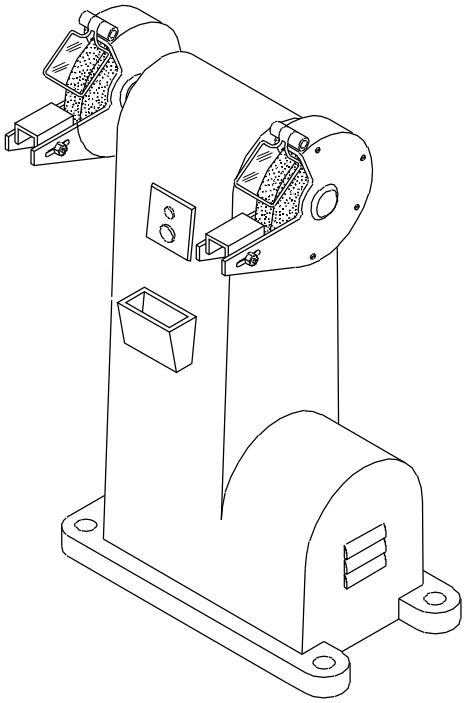


Fig 2



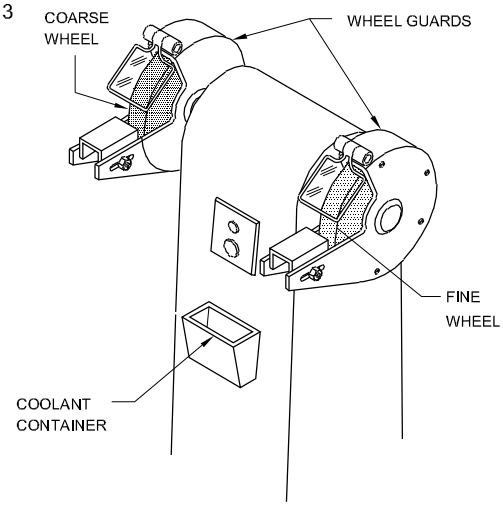
PEDESTAL GRINDER

MDN130372

These grinders consist of an electric motor and two spindles for mounting grinding wheels. On one spindle a coarse-grained wheel is fitted, and on the other, a fine grained wheel. For safety, while working, wheel guards are provided. (Fig 3)

A coolant container is provided for frequent cooling of the work. (Fig 3)

Fig 3



MDN130373

Adjustable work-rests are provided for both wheels to support the work while grinding. These work-rests must be set very close to the wheels. (Fig 4)

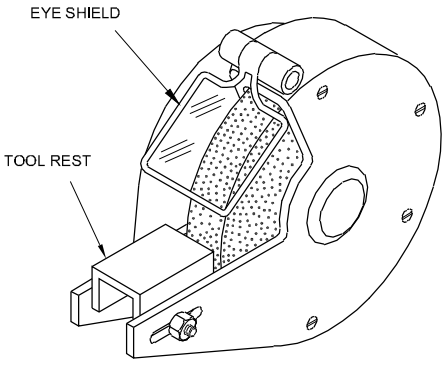
Extra eye-shields are also provided for the protection of the eyes. (Fig 4)

While grinding

Adjust the tool-rest as close to the wheel as possible. The maximum recommended gap is 2 mm. This will help to prevent the work from being caught between the tool-rest and the wheel. (Fig 5)

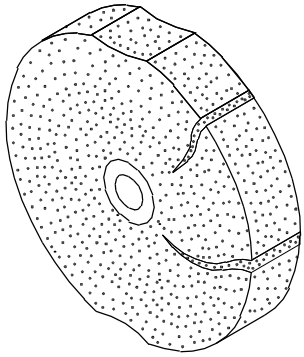
Small jobs should be held with pliers or other suitable tools. (Fig 5)

Fig 4



MDN130374

Fig 5



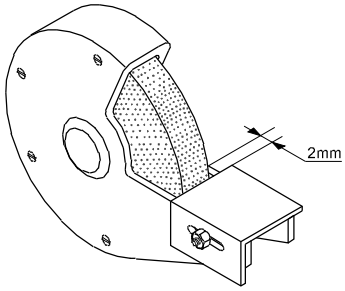
MDN130375

Never hold jobs with cotton waste or similar materials.

Use gloves for your hands while grinding heavy jobs.

Do not grind on the side of the grinding wheels. (Fig 6)

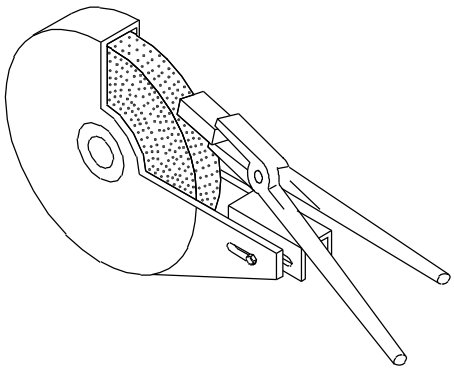
Fig 6



MDN130376

Move the work across the full face of the wheel to prevent uneven wearing of the grinding wheel. (Fig 7)

Fig 7



MDN130377

Safe working on off - hand grinders

Objectives : At the end of this lesson you shall be able to
- **work safety on an off-hand grinder.**

How to work on an off-hand grinder?

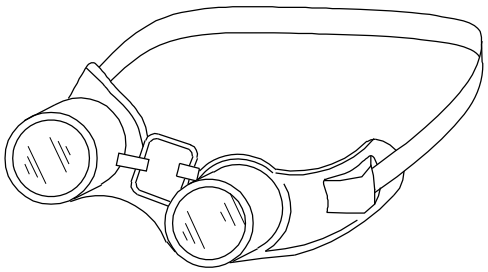
While working on off-hand grinders, it is important to observe the following safety measures.

BEFORE STARTING

Make sure the grinding wheel guards are in place.

Wear safety goggles while grinding. (Fig 1)

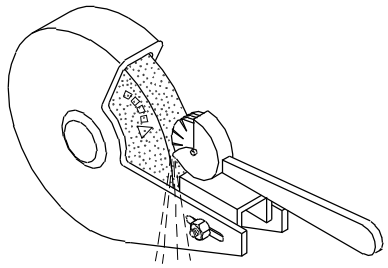
Fig 1



MDN130381

Do not work on grinding wheels which are loaded or glazed. Dress and true wheels whenever necessary. (Fig.2)

Fig 2



MDN130382

If any abnormal sound is noticed, stop the machine. Cracked or improperly balanced wheels are dangerous.

Stand on one side of the machine while starting.

Indian standard system of limits & fits-terminology

Objectives : At the end of this lesson you shall be able to
- **state the terms under the BIS system of limits and fits.**
- **define each term under the BIS system of limits and fits.**

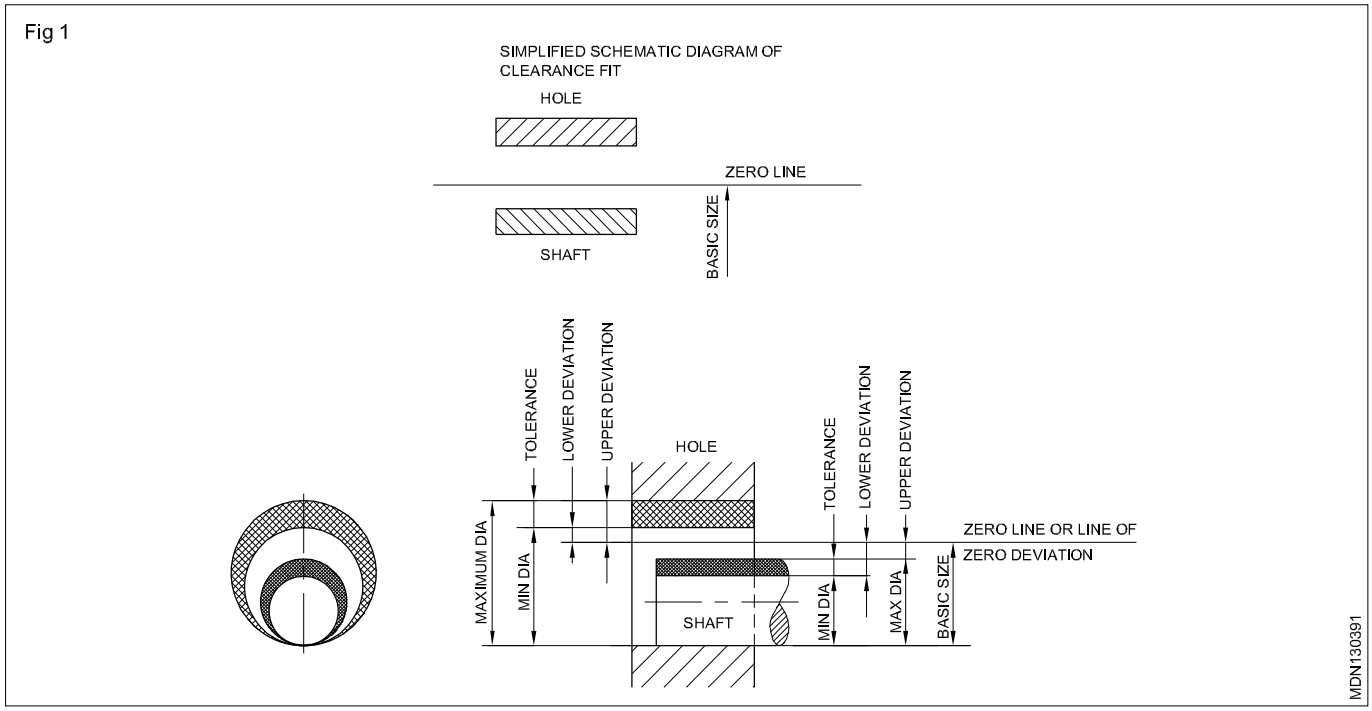
Size

It is a number expressed in a particular unit in the measurement of length.

Basic size

It is the size based on which the dimensional deviations are given. (Fig 1)

Fig 1



Actual size

It is the size of the component by actual measurement after it is manufactured. It should be between the two limits of size if the component is to be accepted.

Limits of size

These are the extreme permissible sizes within which the operator is expected to make the component. (Fig 2) (Maximum and minimum limits)

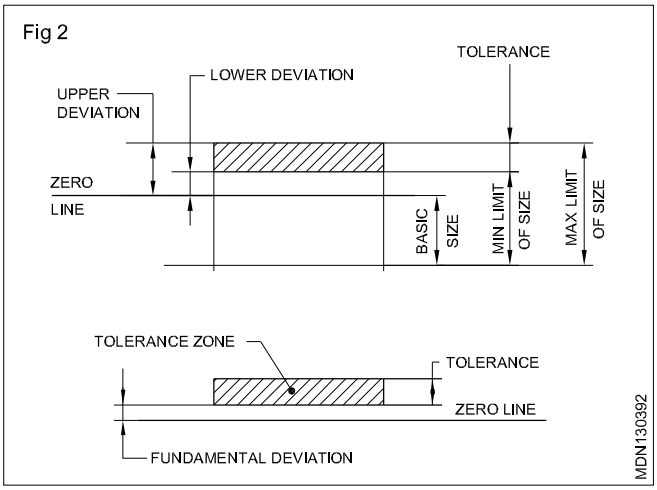
Maximum limit of size

It is the greater of the two limit sizes. (Fig 2) (Table 1)

Minimum limit of size

It is the smaller of the two limits of size. (Fig 2) (Table 1)

Fig 2



Hole

In the BIS system of limits & fits, all internal features of a component including those which are not cylindrical are designated as 'hole'. (Fig 3)

Shaft

In the BIS system of limits & fits, all external features of a component including those which are not cylindrical are designated as shaft. (Fig 3)

Deviation

It is the algebraic difference between a size, to its corresponding basic size. It may be positive, negative or zero. (Fig 2)

Fig 3

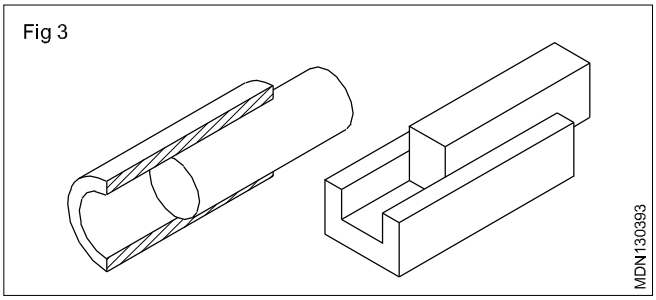


TABLE 1 (Examples)

Sl.No	Size of Component	Upper Deviation	Lower Deviation	Max-Limit of size	Min-Limit of Size
1	+.008 20-.005	+0.008	-0.005	20.008	19.995
2	+.028 20+.007	+0.028	+0.007	20.028	20.007
3	-.012 20-.021	-0.012	-0.021	19.988	19.979

Upper deviation

It is the algebriac difference between the maximum limit of size and its corresponding basic size. (Fig 2) (Table 1)

Lower deviation

It is the algebraic difference between the minimum limit of size and its corresponding basic size (Fig 2) (Table 1)

Upper divation is the deviation which gives the maximum limit of size. Lower deviation is the deviation which gives the minimum limit of size.

Actual deviation

It is the algebraic difference between the actual size and its corresponding basic size (Fig 2)

Tolerance

It is the difference between the maximum limit of size and the minimum limit of size. It is always positive and is expressed only as a number without a sign. (Fig 2)

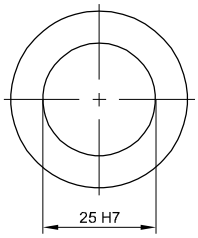
Zero line

In graphical representation of the above terms, the zero line represents the basic size. This line is also called as the line of zero deviation. (Fig 1 and 2)

Fundamental deviation

There are 25 fundamental deviations in the BIS system represented by letter symbols (capital letters for holes and small letters for shafts). i.e for holes - ABCD.....Z excluding I,L,O,Q&W. (Fig 4)

Fig 4



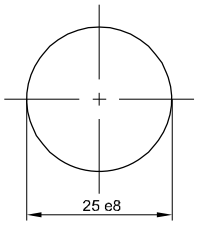
INDICATION FOR HOLES — CAPITAL LETTERS REFER TO HOLES OR INSIDE DIMENSIONS e.g 25 H7

MDN130394

In addition to the above, four sets of letters, JS, ZA, ZB & ZC are included. For fine mechanisms CD, EF and FG are added. (Ref. IS:919 Part II - 1979)

For shafts, the same 25 letter symbols but in small letters are used. (Fig 5)

Fig 5



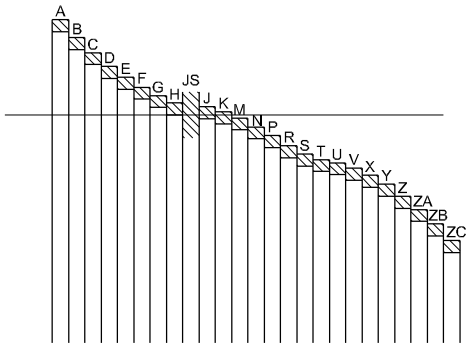
INDICATION FOR SHAFTS

SMALL LETTERS REFER TO SHAFTS OR OUTSIDE DIMENSIONS e.g. 25 e8

MDN130395

The position of tolerance zone with respect to the zero line is shown in figs 6 and 7

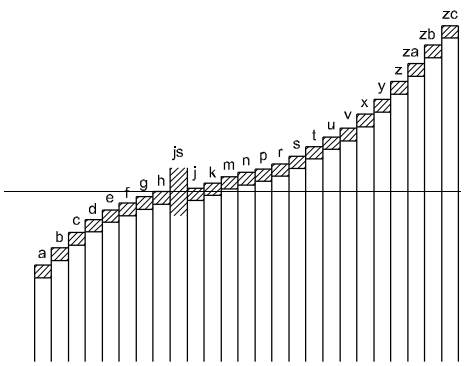
Fig 6



CAPITAL LETTERS INDICATE FUNDAMENTAL DEVIATION OF HOLES

AU1130976

Fig 7

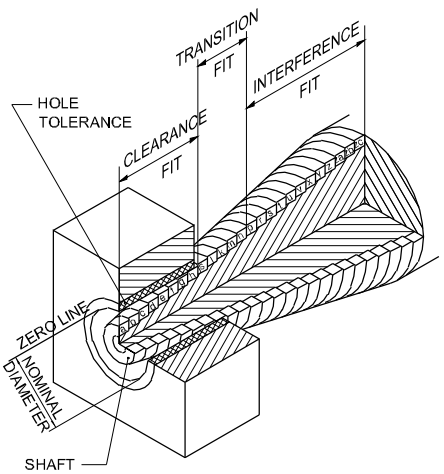


SMALL LETTER INDICATE FUNDAMENTAL DEVIATION OF SHAFTS

MDN130397

The fundamental deviations are for achieving the different classes of fits. (Fig 8 and 9)

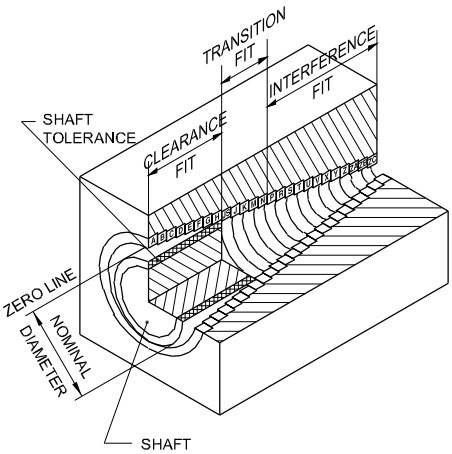
Fig 8



HOLE BASIS SYSTEM

MDN130398

Fig 9



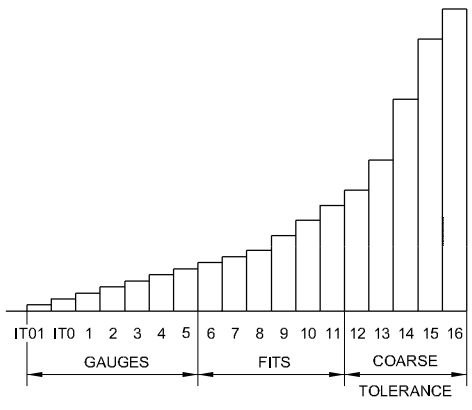
SHAFT BASIS SYSTEM

MDN130399

Fundamental tolerance

This is also called as 'grade of tolerance'. In the Indian Standard System, there are 18 grades of tolerances represented by number symbols, both for hole and shaft, denoted as IT01, IT0, IT1.... to IT16. (Fig 10) A high number gives a large tolerance zone.

Fig 10



MDN13039A

The grade of tolerance refers to the accuracy of manufacture.

In a standard chart, the upper and lower deviations for each combination of fundamental deviation and fundamental tolerance are indicated for sizes ranging upto 500 mm. (Refer to IS 919)

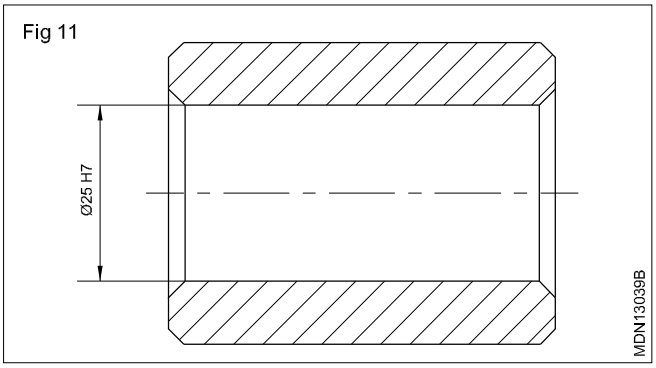
Toleranced size

This includes the basic size, the fundamental deviation and the grade of tolerance.

Example

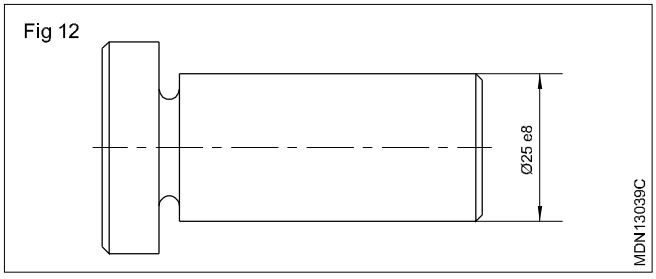
25H7 - toleranced size of a hole whose basic size is 25. The fundamental deviation is represented by the letter symbol H and the grade of tolerance is represented by the number symbol 7. (Fig 11)

Fig 11



25 e8 - is the toleranced size of a shaft whose basic size is 25. The fundamental deviation is represented by the letter symbol e and the grade of tolerance is represented by the number 8. (Fig 12)

Fig 12

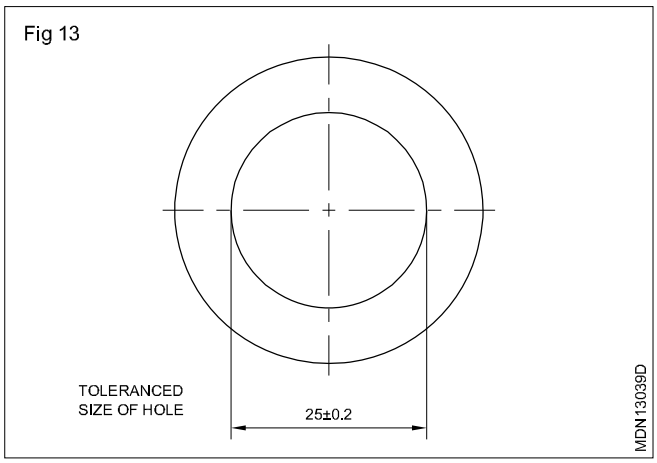


A very wide range of selection can be made by the combination of the 25 fundamental deviations and 18 grades of tolerances.

Example

In fig. 13, a hole is shown as 25 ± 0.2 which means that 25 mm is the basic dimension and ± 0.2 is the deviation.

Fig 13



As pointed out earlier, the permissible variation from the basic dimension is called 'DEVIATION'.

The deviation is mostly given on the drawing with the dimensions.

In the example 25 ± 0.2, ± 0.2 is the deviation of the hole of 25 mm diameter. (Fig 13) This means that the hole is of acceptable size if its dimension is between

25 + 0.2 = 25.2 mm

or 25 - 02 = 24.8 mm.

25.2 mm is known as the maximum limit. (Fig 14)

24.8 mm is known as the minimum limit. (Fig 15)

Fig 14 Fig 15

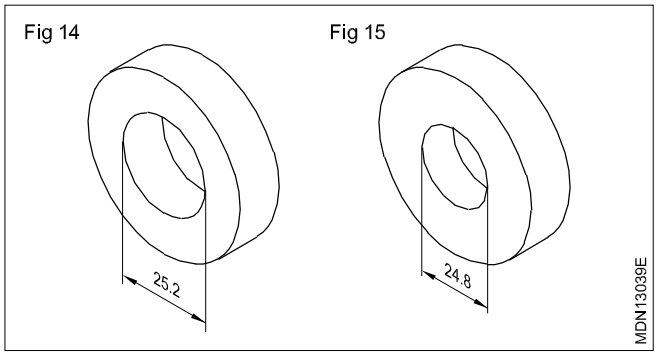
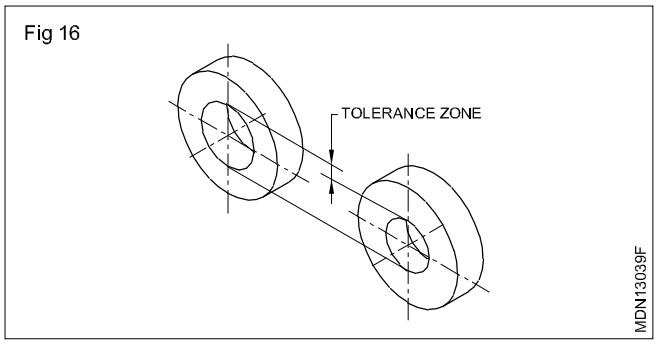


Fig 16

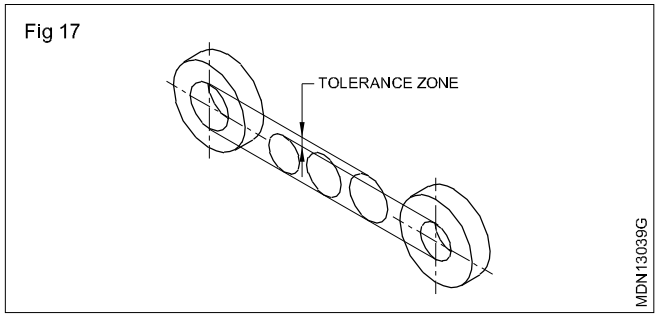


The difference between the maximum and minimum limits is the TOLERANCE. Tolerance here is 0.4 mm. (Fig 16)

All dimensions of the hole within the tolerance zone are of acceptable size as in Fig 17.

As per IS 696, while dimensioning the components as a drawing convention, the deviations are expressed as tolerances.

Fig 17



Fits and their classification as per the indian standard

Objectives : At the end of this lesson you shall be able to
- **define 'Fit' as per the Indian Standard**
- **list out the terms used in limits and fits as per the Indian Standard**
- **state examples for each class of fits**
- **Interpret the graphical representation of different classes of fits.**

Fit

It is the relationship that exists between two mating parts, a hole and a shaft, with respect to their dimensional difference before assembly.

Expression of a fit

A fit is expressed by writing the basic size of the fit first, (the basic size which is common to both the hole and the shaft) followed by the symbol for the hole, and by the symbol for the shaft.

Example

30 H7/g6 or 30 H7 - g6 or 30

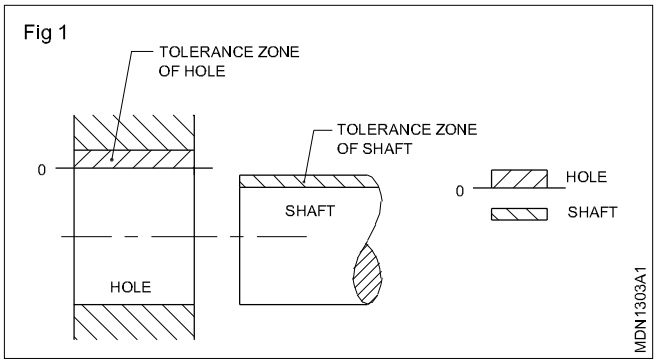
Clearance

In a fit the clearance is the difference between the size of the hole and the size of the shaft which is always positive.

Clearance fit

It is a fit which always provides clearance. Here the tolerance zone of the hole will be above the tolerance zone of the shaft. (Fig 1)

Fig 1



Example 20 H7/g6

With the fit given, we can find the deviations from the chart.

For a hole 20 H7 we find from the table +21mm.

These numbers indicate the deviations in microns.

(1 micrometre = 0.001 mm)

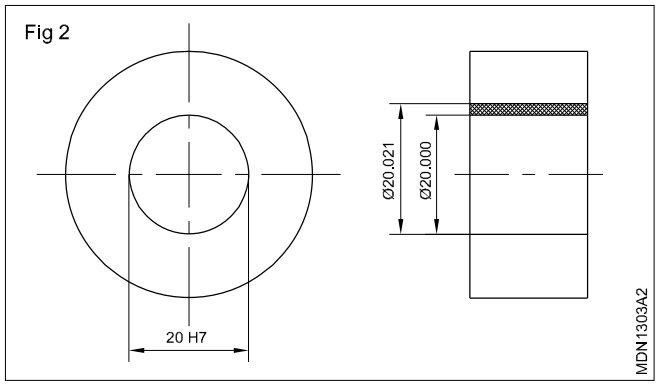
The limits of the hole are 20 = 0.021 = 20.021 mm and

20 + 0 = 20.000 mm. (Fig. 2)

For a shaft 20 g6 we find in the table - 7mm

- 20mm

Fig 2

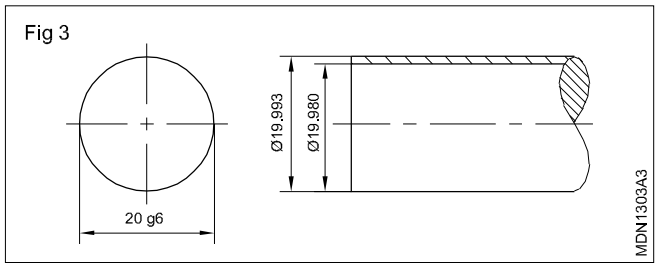


So the limits of the shaft are

20 - 0.007 = 19.992 mm

and 20 - 0.020 = 19.980 mm. (Fig 3)

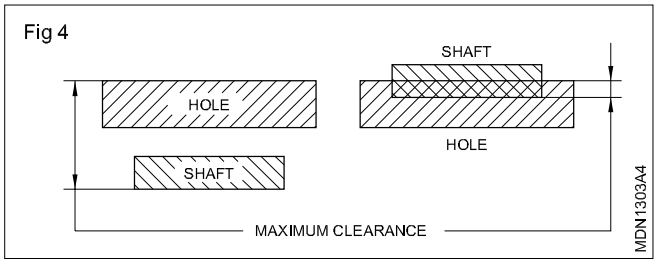
Fig 3



Maximum clearance

In a clearance fit or transition fit, it is the difference between the maximum hole and minimum shaft. (Fig 4)

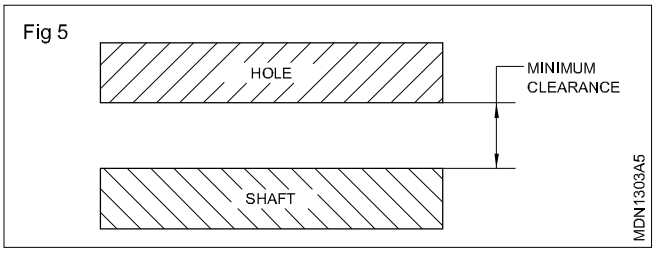
Fig 4



Minimum Clearance

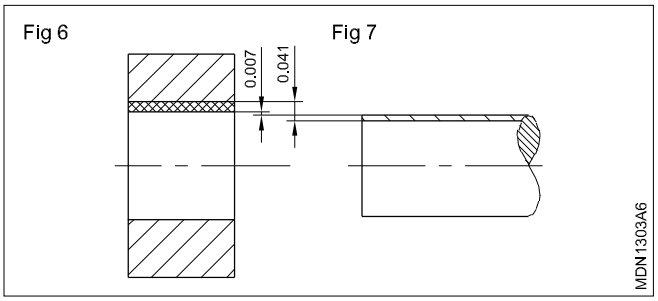
In a clearance fit, it is the difference between the minimum hole and the maximum shaft. (Fig 5)

Fig 5



The minimum clearance is 20.000 - 19.993 = 0.007 mm. (Fig 6)

The maximum clearance is 20.021 - 19.980 = 0.041 mm. (Fig 7)



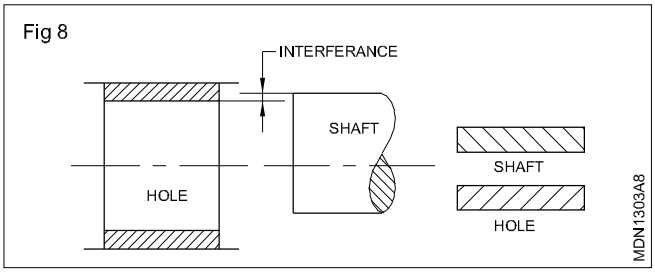
There is always a clearance between the hole and the shaft. This is the clearance fit.

Interference

It is the difference between the size of the hole and the shaft before assembly, and this is negative. In this case, the shaft is always larger than the hole size.

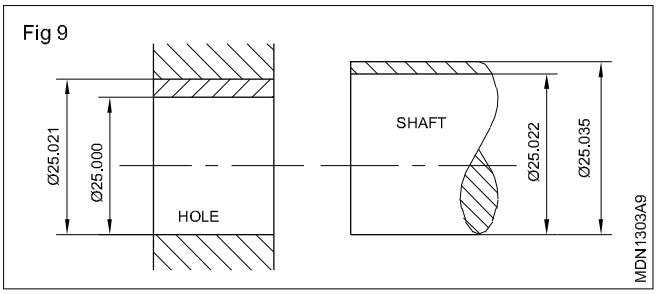
Interference Fit

It is a fit which always provides interference. Here the tolerance zone of the hole will be below the tolerance zone of the shaft. (Fig 8)



Example Fit 25 H7/p6 (Fig 9)

The limits of hole are 25.000 and 25.021 mm and the limits of the shaft 25.022 and 25.035 mm. The shaft is always bigger than the hole. This is an interference fit.



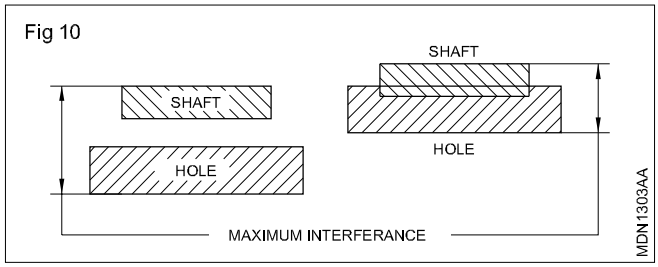
Maximum interference

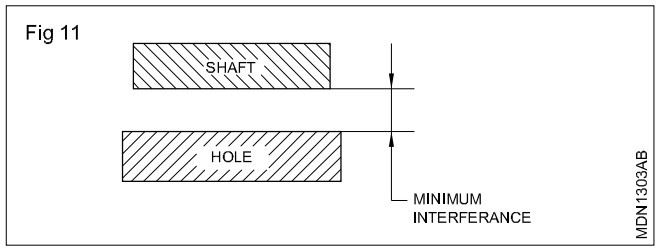
In an interference fit or transition fit, it is the algebraic difference between the minimum hole and the maximum shaft. (Fig 10)

Minimum interference

In an interference fit, it is the algebraic difference between the maximum hole and the minimum shaft. (Fig 11)

In the example (Fig 9)





The maximum interference is = 25.035 - 25.000

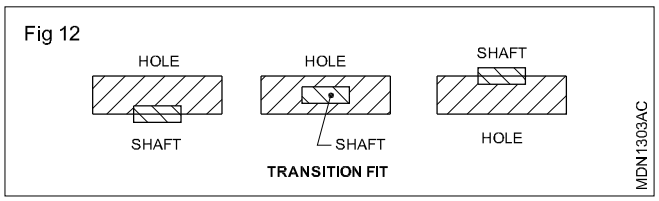
= **0.035**

The minimum interference is = 25. 022 - 25.021

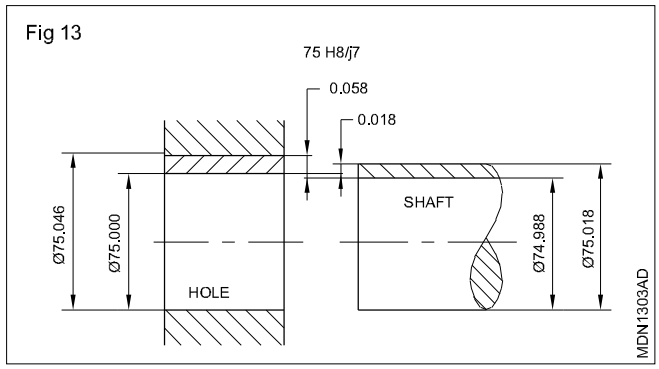
= **0.001**

Transition fit

it is a fit which may sometimes provide clearance, and sometimes interference. When this class of fit is represented graphically, the tolerance zones of the hole and shaft will overlap each other. (Fig 12)



Example Fit 75 H8/j7 (Fig 13)



The limits of the hole are 75.000 and 75.046 mm and those of the shaft are 74.018 and 74.988 mm.

Maximum Clearance = 75.046 - 74.988 = 0.058 mm.

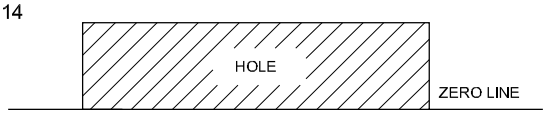
If the hole is 75.000 and the shaft 75.018 mm, the shaft is 0.018 mm, bigger than the hole. This results in interference. This is transition fit because it can result in a clearance fit or an interference fit.

Hole basis system

In a Standard system of limits and fits, where the size of the hole is kept constant and the size of the shaft is varied to get the difference class of fits, then it is known as, the hole basis system.

The fundamental deviation symbol ‘H’ is chosen for the holes, when the hole basis system is followed. This is because the lower deviation of the hole ‘H’ is zero. It is known as ‘basic hole’. (Fig 14)

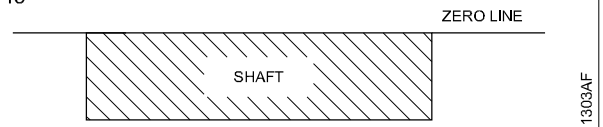
Fig 14



Shaft basis system

In a standard system of limits and fits, where the size of the shaft is kept constant and the variations are given to the hole for obtaining different class of fits, then it is known as shaft basis. The fundamental deviation symbol ‘h’ is chosen for the shaft when the shaft basis is followed. This is because the upper deviation of the shaft ‘h’ is zero. It is known as ‘basis shaft’. (Fig 15)

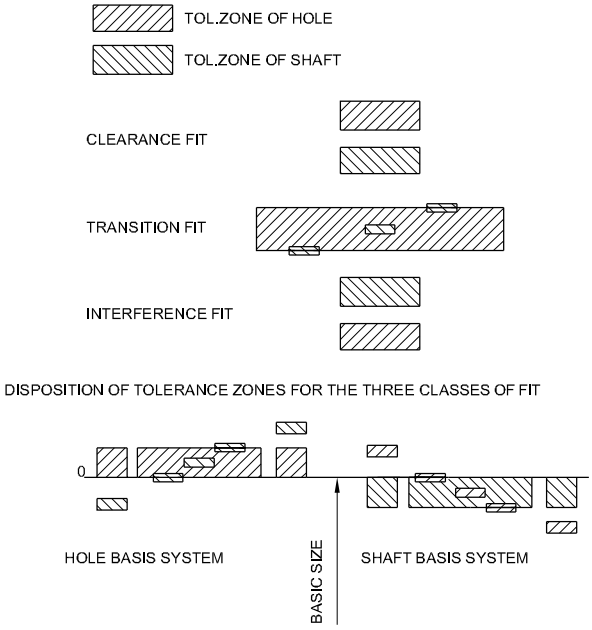
Fig 15



The hole basis systemis followed mostly. This is because, depending upon the class of fit, it will be always easier to alter the size of the shaft because it is external, but it is difficult to do minor alternations to a hole. Moreover the hole can be produced by using standard toolings.

The three classes of fits, both under hole basis and shaft basis, are illustrated in (Fig 16)

Fig 16



EXAMPLES ILLUSTRATING THE HOLE BASIS AND SHAFT BASIS SYSTEM

Soldering

Objectives : At the end of this lesson you shall be able to
- **state the process of soldering**
- **state the method of applicatoin of soldering iron**
- **state the different types of solder and their application**.

There are different methods of joining metallic sheets. Soldering is one of them.

Soldering is the process by which metallic materials are joined with the help of another liquified metal (solder)

The melting point of the solder is lower than that of the materials being joined.

The solder wets the base material without melting it.

Soldering iron (Fig 1)

The soldering iron is used to melt the solder and heat the metal that are to be joined together.

Fig 1

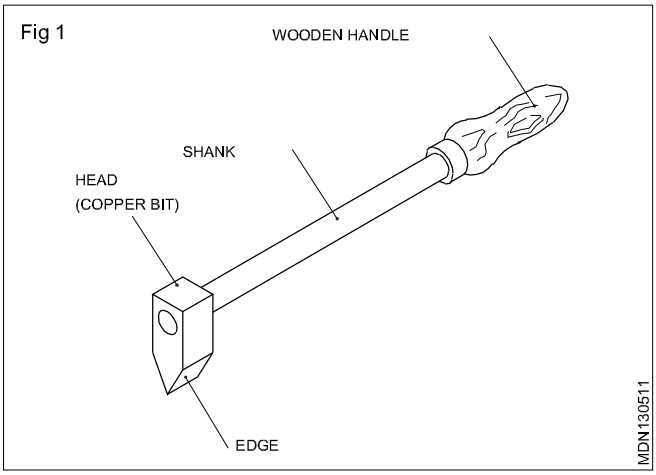


Fig 2

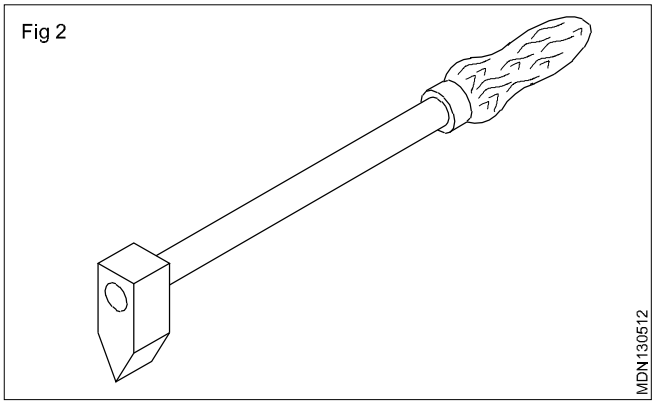


Fig 3

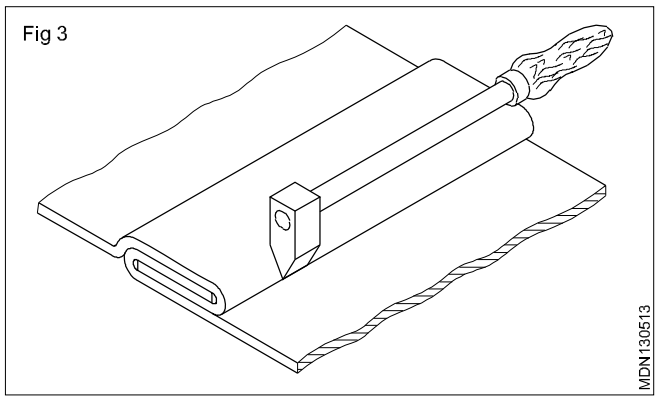
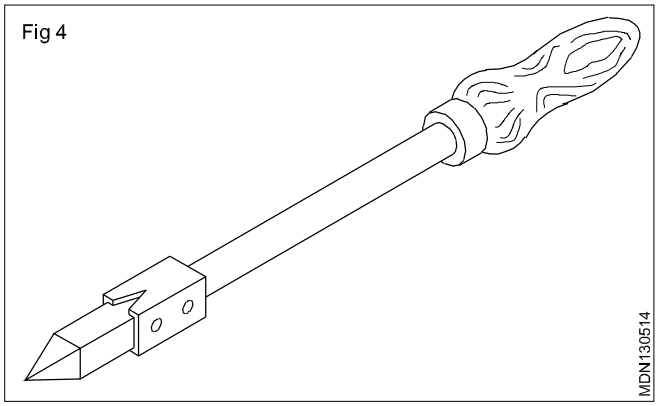


Fig 4



A soldering iron has the following parts.

- Head (copper bit)
- Shank

Fig 5

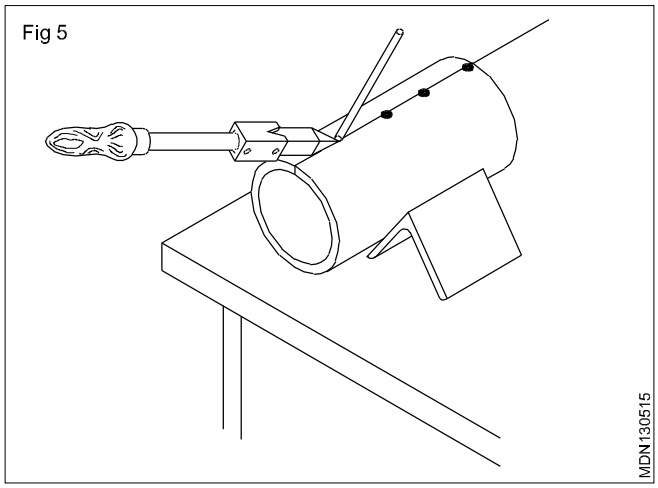
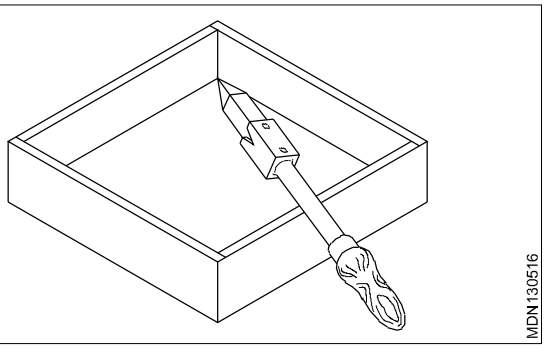


Fig 6



- Wooden handle
- Edge

Shape of head (Fig 1, 2 & 3)

The head of the iron is made of forged copper. This is because copper has a good heat conductivity and has a strong affinity for the solder so that the solder melts easily and sticks to the bit.

The edge is V shaped from two sides of a square. This is called Hatchet type soldering iron

This type is used for straight soldering joints.

The other type is the square pointed soldering iron or a standard workshop pattern soldering iron. For this type the edge is shaped to an angle on four sides to form a pyramid shape.

Metal : The fitter metal is distributed between the closely fitted surfaces of the joint by capillary action' Coalescence is a joining or uniting of materials. (Figs 5 & 6)

Brazewelding : A welding process variation in which a filler metal, having a liquidus above 840°F (450°C) and below the solidus of the base metal, is used. Unlike brazing, in braze welding the filler metal is not distributed in the joint by capillary action.

Brazing has been used for centuries. Blacksmiths, jewelers, armorers and other crafters used the process on large and small articles before recorded history. This joining method has grown steadily both in volume and popularity. It is an important industrial process, as well as jewelry making and repair process. The art of brazing has become more of a science as the knowledge of chemistry, physics and metallurgy has increased.

The usual terms Brazing and Braze welding imply the use of a nonferrous alloy. These nonferrous alloys consist of alloys of copper, tin, zinc, aluminum, beryllium, magnesium, silver, gold and others

Brass is an alloy consisting chiefly of copper and zinc. Bronze is an alloy consisting chiefly of copper and tin. Most rods used in both brazing and braze welding on ferrous metals are brass alloys rather than bronze. The brands which are called bronze usually contain a small percent (about one percent) of tin.

Brazing and braze welding principles: Brazing is an adhesion process in which the metals being joined are heated but not melted; the brazing filler metal melts and flows at temperatures above 840°F (450°C). Adhesion is the molecular attraction exerted between surfaces.

A brazed joint is stronger than a soldered joint because of the strength of the alloys used. In some instances it is as strong as a welded joint. It is used where mechanical strength and leakproof joints are desired. Brazing and braze welding are superior to welding in some applications. since they do not affect the heat treatment of the original metals as much as welding.

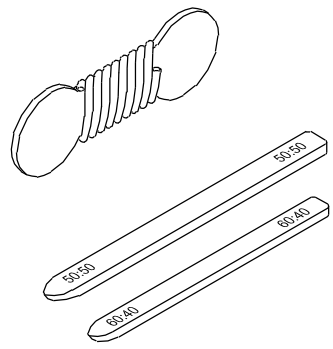
Brazing and braze welding wrap the original metals less and it is possible to joing dissimilar metals. For example. steel tubing may be brazed to cast iron, copper tubing brazed to steel and tool steel brazed to low carbon steel.

Brazing is done on metals which fit together tightly. The metal is drawn into the joint by capillary action (A liquid will be drawn between two tightly fitted surfaces. This drawing action is known as Capillary action). Very thin layers of filler metals are used when brazing. The joints and the material being brazed must be specially designed for the purpose. When brazing, poor fit and alignment result in poor joints and in inefficient use of brazing metal.

In braze welding, joint designs used for oxyfuel gas or arc welding are satisfactory. When braze welding, thick layers of the brazing filler metal is used.

Solders (Fig. 7)

Fig 7



Pure metals or alloys are used for solders

Solders are applied in the form of wires, sticks, ingots, rods, threads, tapes, formed sections, powder and pastes

Types of solders

There are two types of solders

- soft solder
- hard solder

One distinguishes between soft solders whose melting points are below 450°C and hard solders whose melting points are above 450°C.

Soft solders

These are alloys of the metals-tin, lead, antinomy, copper, cadmium and zinc and are used for soldering heavy (thick) and light metals.

Hard solders

These are alloys of copper, tin, silver, zinc, cadmium and phosphorus, and are used for soldering heavy metals.

Brazing

Objectives : At the end of this lesson you shall be able to
- **describe the method of brazing**
- **state advatnages and disadvantages of brazing**
- **difference between soldering and brazing.**

Brazing (Fig. 1): Brazing is a metal joining process which is done at temperature of above 450°C as compared to soldering whihc is done at below 450°C.

Process:

Clean the area of the joint thoroughly by wire brushing, emerying and by chemical solutions for removing oil, grease paints etc.

Flame joints tightly using proper clamping, (Maximum gap permitted between the two joining surfaces is only 0.08mm)

Apply the flux in paste form (for brazing iron and steel a mixture of 75% borax powder with 25% boric acid (liquid form) to form a paste is used). Usually the brazing flux contains chlorides, fluorides, borax, borates, fluroborates, boric acid, wetting agents and water. So suitable flux combination is selected based on metal being used.

Brazing is employed where a ductile joint is required.

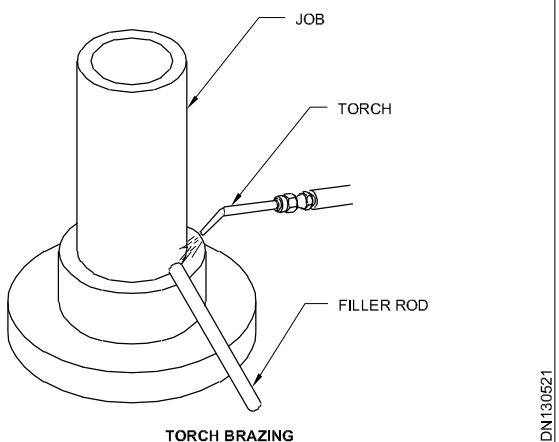
Brazing filler rods/metals melt at temperature from 860°C 950°C and are used to braze iron and its alloys.

Brazing fluxes: Fused borax is the general purpose flux of post metals.

It is applied on the joint in the form of a past made by mixing up with water.

Brazing is to be done at a lower temperature, fluorides of alkali materials are commonly used. These fluxes will remove refractory oxides of aluminium, chromium, silicon and berrylium.

Fig 1



TORCH BRAZING

Torch brazing: The base metal is heated to the required temperature by the application of the oxy-acetylene flame.

Conditions to obtain satisfactory brazed or soldered joint

Wet the base metal

Spread the filler metal and make contact with the joint surfces. The solder will be drawn into the joint by capillary action.

Suggested joint designs for solidering and brazing.

Advantages of brazing

The completed joint requires little or no finishing

The relatively low temperature at which the joint is made minimizes distortion.

There is no flash or weld spatter.

The brazing technique does not require as much skill as the technique for fusion welding

The process can be easily mechanised

The process is economical owing to the above advantages.

Disadvantages of brazing

If the joint is exposed to corrosive media, the filler metal used may not have the required corrosive resisteance.

All the brazing alloys loose strength at an elevated temperature.

The colour of the brazing alloy which ranges from silver white to copper red may not match the base metal very closely.

Brazing and braze welding: Both brazing and braze welding are metal joining processes which are performed at temperatures above 840°F (450°C) as compared to soldering which is performed at temperatures below 840°F (450°C)

The American Welding Society defines these processes as follows:

Brazing - `A group of welding processes which produces coalscence of materials by heating them to a suitable temperature and by using a filler metal having a liquids above 840°F (450°C) and below the solidus of the base.

Gasket

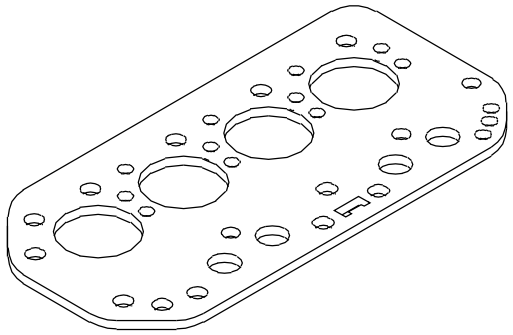
Objectives : At the end of this lesson you shall be able to
- **state the need of gaskets**
- **state the materials of gaskets**

The gasket (Fig. 1) in automobiles has to combat sealing problems caused by high and low temperatures, expansion and contraction, vibration, pressure or vaccum, corrosion and oxidation, inadequate sealing reduces the service life and efficiency of the components.

The seals which are used between two stationary components are called static seats. The most common static seal is gasket. Gaskets are designed to suit particular needs and are manufactured from different materials like copper, aluminium, cork fibre, asbestos, synthetic rubber, paper and various combinations of these materials. In latest In latest semi-liquid is also used as gasket.

Cylinder head gaskets are the most complicated in design and construction because they must withstand extreme pressure, vibration, high temperature and expansion changes. They must seal against compression, oil and coolants. They must resist extrusion, elongation, oxidation and chemicals. The cylinder head gasket consists of a multi-layer of materials with coolant and oil passages.

Fig 1



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Oil seal

Objectives : At the end of this lesson you shall be able to
- **state the use of oil seals**
- **explain differnt types of oil seals**
- **state the material used for oil seals.**

Seals

Seals are sealing parts on static or moving inter faces of machines, devices pipes and tank reservoir seals are used for sealing spaces as different pressure against each other, ie combustion chamber & oilways etc. oil seals have flexible lip that rubs against a shaft or housing to prevent leakage of fluid (grease, oil etc.)

All seal are used to retain or seperate lubricant on fluid

T**ypes of oil seal**

i) Flexible lip

ii) radial lip

iii) rotary shaft seal

configuaration

a) single lip

b) double lip

c) triple lip

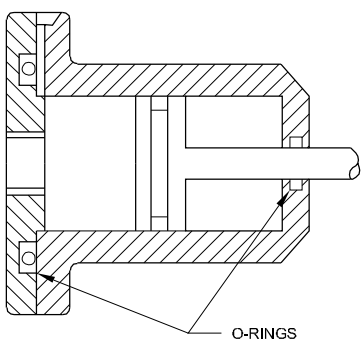
d) Fan lip

Seals capable of sealing two components which move or rotate insulation to each other are called dynamic seals. The most common dynamic seal is called 'O' rings which are moulded to close tolerances in the cross-sectional areas and to the inner and outer diameters.

Bearing Isolator (Fig. 1)

Bearing Isolator are dynamicsed designed to protect bearing from outside containant. The contain potor (rotating) & stater (Stationary) member same bearing Isolator are of labyrinth construction of other use o-rings.

Fig 1



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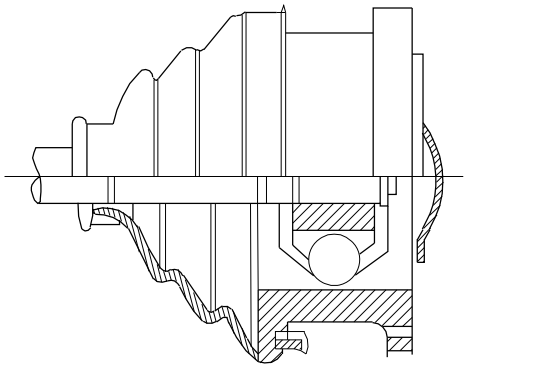
Specifications

Sealing orientation (Fig 2 & 3)

- Rod seals or shaft seals are type of radial seal.
- Radial seal are pressfit into a housing bore with the sealing up contacting the shaft.

Fig 2



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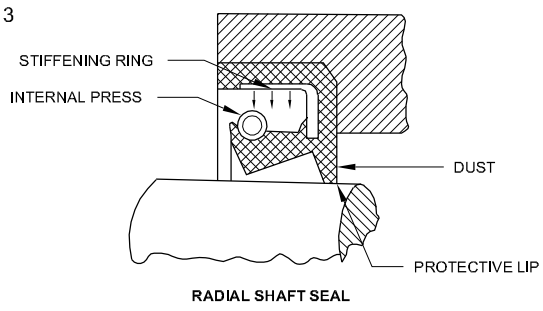
- Piston seals are radial seal. These seals are fit on a shaft with sealing lip contacting the housing bore. V rings are external lip seals.
- Symmetrical seal works equally as a rod or piston seal.
- An axial seal seals axially against a housing or machine component.
- Material - Nylon, Rubber, polythen, PTFE etc.

Fig 3



RADIAL SHAFT SEAL

MDN130623

Sealants:

Type of sealant:

There are three types of sealant used.

1 The Teflon tape

2 Pipe tape

3 Anaerobic resin compound

1 Teflon tape

The purpose of this Teflon tape (whir), no sticking tape is the serve as a lubricant when threaded part of pipe a piping system are being assembles.

2 Pipe tape

This material relies on a solvent carrier and hardware when the solvent evaporator. The resulting seal adheres to all plastic, metal pipes and effective blocks leak paths.

3 Anaerobic resin compound

This sealant is confined within the threads of the metal pipe connection and air in exuded. It maintains the sealing properties even after heat aging, excellent then prelature and solvent remittance.

Key concepts

- Tape does not truly seal, it lubricator.
- Tape can harden and become brittle.
- Anaerobic must be combatable with pipe fitting material.

Sealant selection factors

- Material
- Temperature
- Pressure
- Vibration

Drilling machine (portable type)

Objectives : At the end of this lesson you shall be able to
- **name the different types of portable drilling machines**
- **state their distinctive features and uses.**

Necessity

Portable hand drills of different types are used for certain jobs which cannot be handled on stationary drilling machines.

Types

There are two types of portable drilling machines,

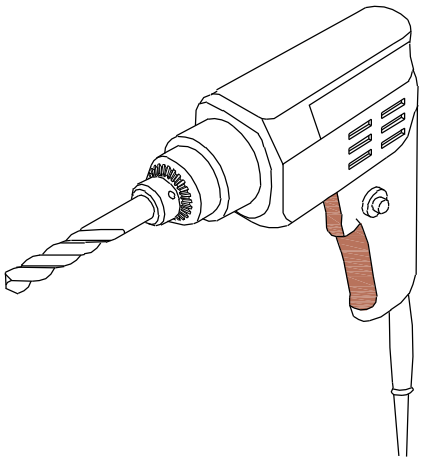
power operated and hand operated.

Power Operated drilling machines

Electric hand drill (light duty) (Fig 1)

These are available in different forms. The electric hand drill has a small electrical motor for driving the drill. On the end of the spindle, a drill chuck is mounted. Electric hand drills used for light duty will have, usually, a single speed.

Fig 1



Electric hand drill (heavy duty) (Figs 2 and 3)

This drill has an additional feature by which the drill speed can be varied through a system of gears. This is particularly useful for drilling larger diameter holes.

Fig 2

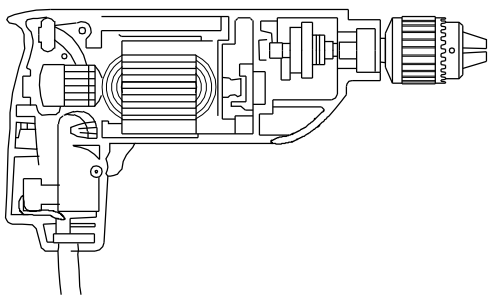
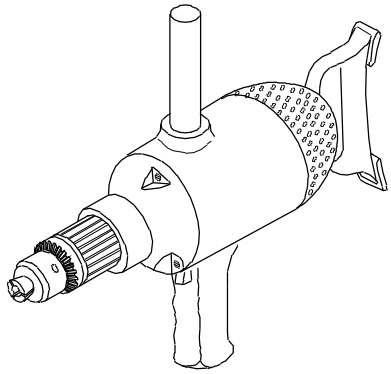


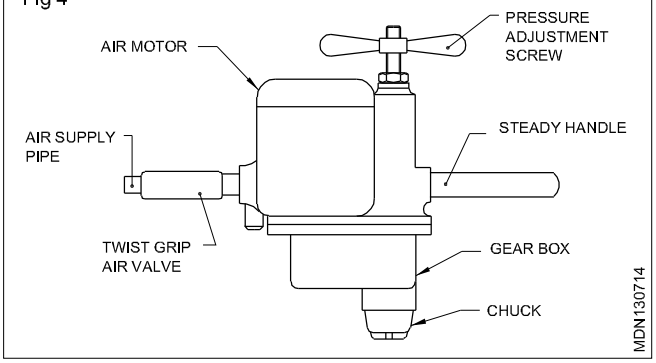
Fig 3



Pneumatic hand drill (Fig 4)

This type of drill is operated by compressed air. An air driven motor is housed in the casing, and a handle is fitted along with an air pipe to operate the drill conveniently.

Fig 4



This drill is used where electrically operated drills are prohibited i.e. explosives factories, petroleum refineries etc.

Hand operated drilling machines

Different types of hand operated drilling machines are shown below. They are used in structural fabrication, sheet metal and carpentry, particularly where electricity or pneumatic supply is not available.

The ratchet drilling machine (Fig 5) is commonly used in structural fabrication. Square head, taper shank drills are used on these machines.

The bevel gear type drilling machine (Fig 6) is used for drilling small diameter holes up to 6mm.

The breast drilling machine (Fig 7) is used for drilling holes of larger diameter as more pressure can be exerted. Drills between 6 mm to 12 mm can be used on these machines.

Fig 5

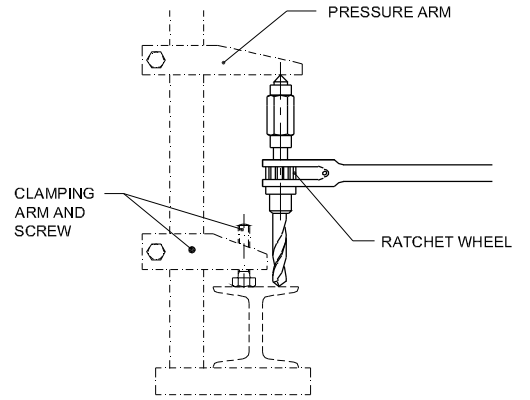


Fig 6

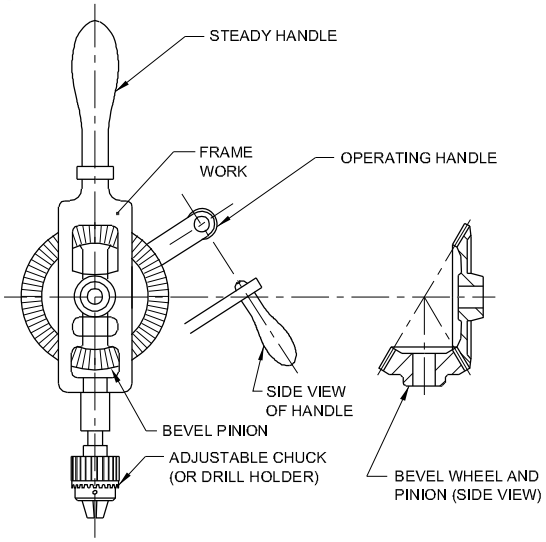
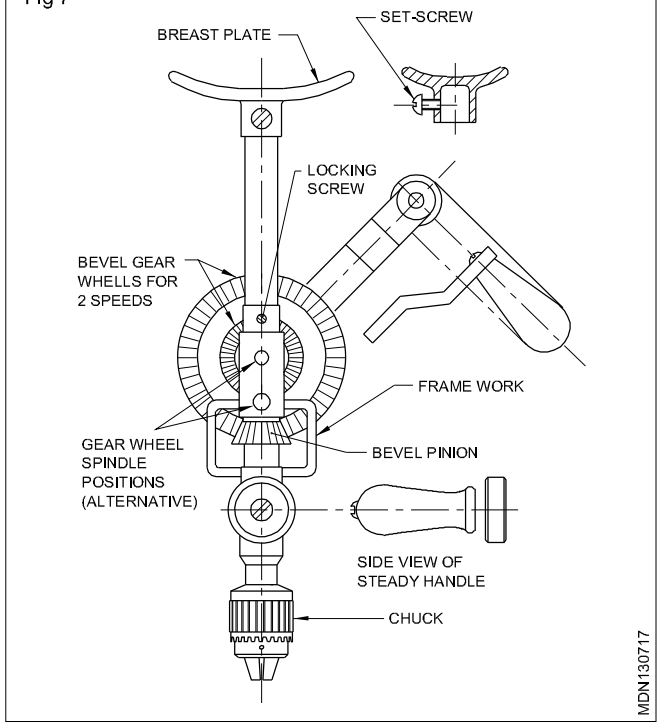


Fig 7



Drilling machines (bench and pillar type)

Objectives : At the end of this lesson you shall be able to

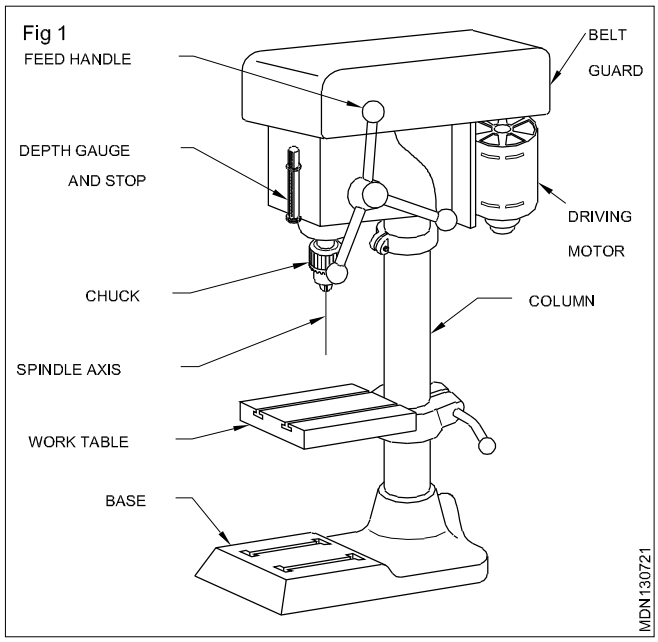
- **name the types of drilling machines**
- **list out the parts of bench type, pillar type and radial drilling machines**
- **compare the features of the bench type, pillar type and radial drilling machines.**

The principal types of drilling machines are :

- the sensitive bench drilling machine
- the pillar drilling machine
- the column drilling machine
- the radial arm drilling machine (radial drilling machine).

(You are not likely to use the column and radial types of drilling machines now. Therefore, only the sensitive and pillar type machines are explained here.)

Fig 1

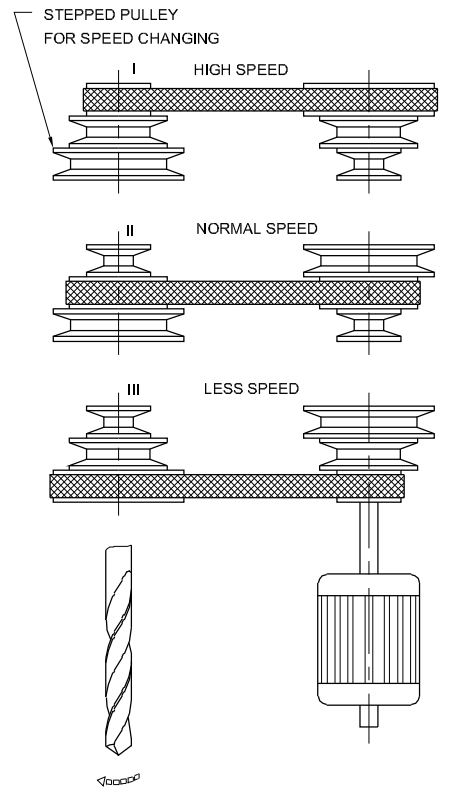


The sensitive bench drilling machine (Fig. 1)

The simplest type of sensitive drilling machines is shown in the figure with its various parts marked. This is used for light duty work.

This machine is capable of drilling holes upto 12.5 mm diameter. The drills are fitted in the chuck or directly in the tapered hole of the machine spindle.

Fig 2

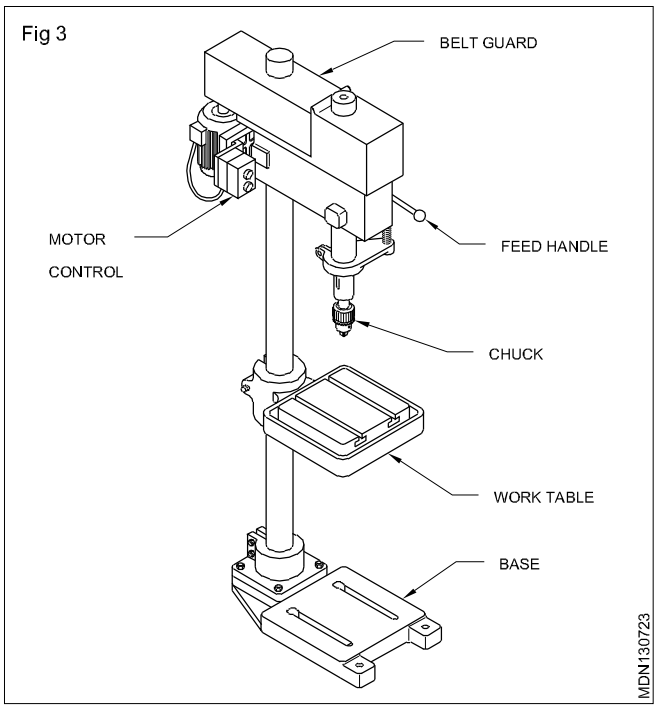


For normal drilling, the work-surface is kept horizontal. If the holes are to be drilled at an angle, the table can be tilted.

Different spindle speeds are achieved by changing the belt position in the stepped pulley. (Fig 2)

The pillar drilling machine (Fig 3)

Fig 3



This is an enlarged version of the sensitive bench drilling machine. These drilling machines are mounded on the floor and driven by more powerful electric motors. They are used for heavy duty work. Pillar drilling mechines are available in different sizes.

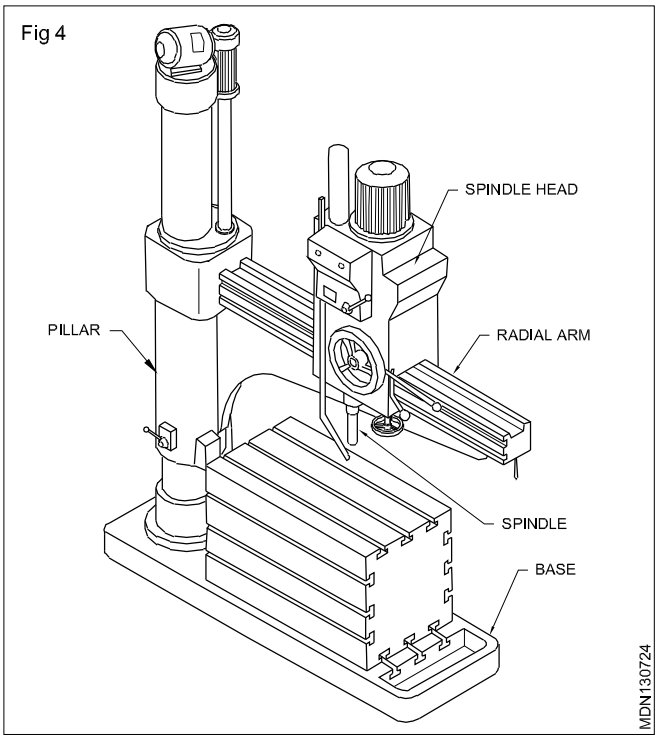
Large machines are provided with a rack and pinion machanism for moving the table for setting the work.

Radial drilling machines (Fig 4)

These are used to drill :
- large diameter holes
- multiple holes in one setting of the work
- heavy and large workpieces.

FEATURES

Fig 4



The radial drilling machine has a radial arm on which the spindle head is mounted.

The spindle head can be moved along the radial arm and can be locked in any position.

The arm is supported by a pillar (column). It can be rotated about with the pillar as centre. Therefore, the drill spindle can cover the entire working surface of the table. The arm can be lifted or lowered.

The motor mounted on the spindle head rotates the spindle.

The variable-speed gearbox provides a large range of r.p.m.

Cutting speed and RPM

Objectives : At the end of this lesson you shall be able to
- **define cutting speed**
- **state the factors for determining the cutting speed**
- **differentiate between cutting speed and r.p.m.**
- **determine r.p.m. spindle speed**
- **select r.pm. for drill sizes from tables.**

For a drill to give satisfactory performance, it must operate at the correct cutting speed and feed.

Cutting speed is the speed at which the cutting edge passes over the material while cutting, and is expressed in metres per minute.

Cutting speed is also sometimes stated as surface speed or peripheral speed.

The selection of the recommended cutting speed for drilling depends on the materials to be drilled, and the tool material.

Tool manufacturers usually provide a table of cutting speeds required for different materials.

The recommended cutting speeds for different materials are given in the table. Based on the cutting speed recommended, the r.p.m. at which a drill has to be driven, is determined.

Calculate r.p.m

$$V = \frac{n \times d \times \prod}{1000} \text{ m/min}$$

$$n = \frac{v \times 1000}{d \times \pi} \text{ r.p.m}$$

n= r.p.m

v= cutting speed in m/min

d= diameter of drill in mm

$\prod$= 3.14

Material being drilled for HSS	Cutting speed (m/min)
Aluminium	70 -100
Brass	35-50
Bronze (Phosphor)	20-35
Cast Iron (grey)	25-40
Copper	35-45
LC/MC steel/ Alloy steel	20-30
Thermosetting plastic (low speed due to abrasive properties)	5-8

Work - holding devices

Objectives : At the end of this lesson you shall be able to
- **state the purpose of work-holding devices**
- **name the devices used for holding work**
- **state the precautions to be observed while using.**

Workpieces to be drilled should be properly held or clamped to prevent them from rotating along with the drill. Improperly secured work is not only a danger to the operator but can also cause inaccurate work, and breakage to the drill. Various devices are used to ensure proper holding.

The machine vice (Fig 1)

Most of the drilling work can be held in a machine vice. Ensure that the drill does not drill through the vice after it has passed through the work. For this purpose, the work can be lifted up and secured on parallel blocks providing a gap between the work and the bottom of the vice.

Workpieces which are not accurate may be supported by wooden pieces.

Clamps and bolts (Fig 2,3,4 & 5)

Drilling machine tables are provided with T-slots for fitting bolt heads. Using clamps and bolts, the workpieces can be held very rigidly. While using this method, the packing should be, as far as possible, of the same height as the work, and the bolt nearer to the work.

There are many types of clamps and it is necessary to determine the clamping method according to the work.

Fig 1

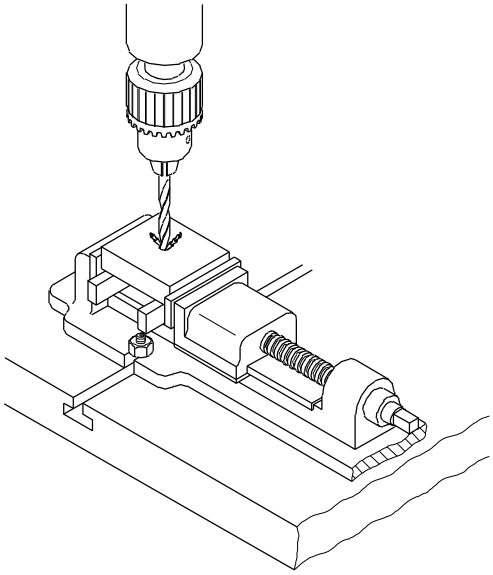


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Fig 2

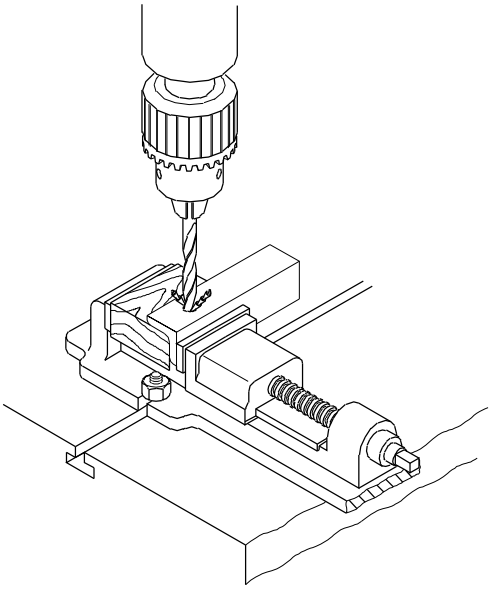

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Fig 3

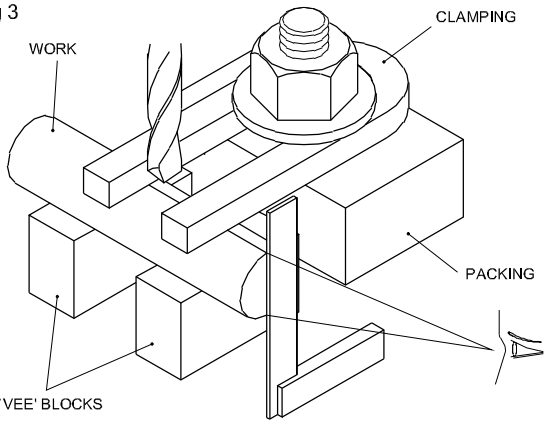

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Fig 4

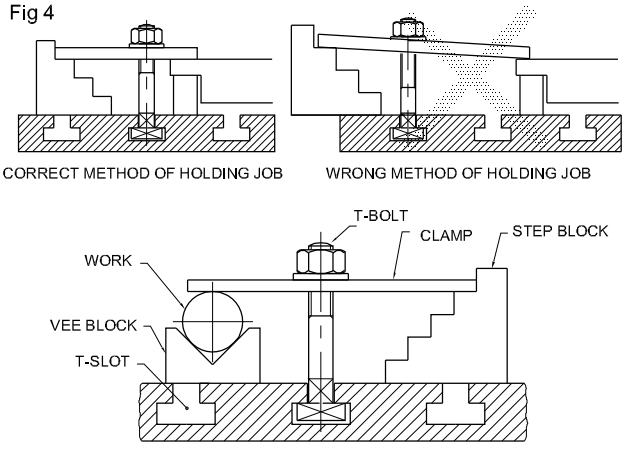

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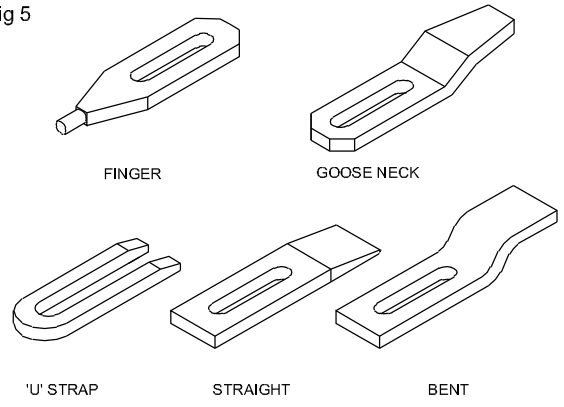
Fig 5



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Drill - holding devices

Objectives : At the end of this lesson you shall be able to

- **name the types of drill-holding devices**
- **state the features of drill chucks**
- **state the functions of drill sleeves**
- **state the function of drift.**

For drilling holes of material, the drills are to be held accurately and rigidly on the machines.

The common drill-holding devices are drill chucks and sleeves and sockets.

Drill Chuck

Straight shank drills are held in drill chucks. For fixing and removing drills, the chucks are provided either with a pinion and key or a knurled ring.

The drill chucks are held on the machine sprindle by means of an arbor fitted or the drill chuck. (Fig 1)

Taper Sleeves and Sockets (Fig 1)

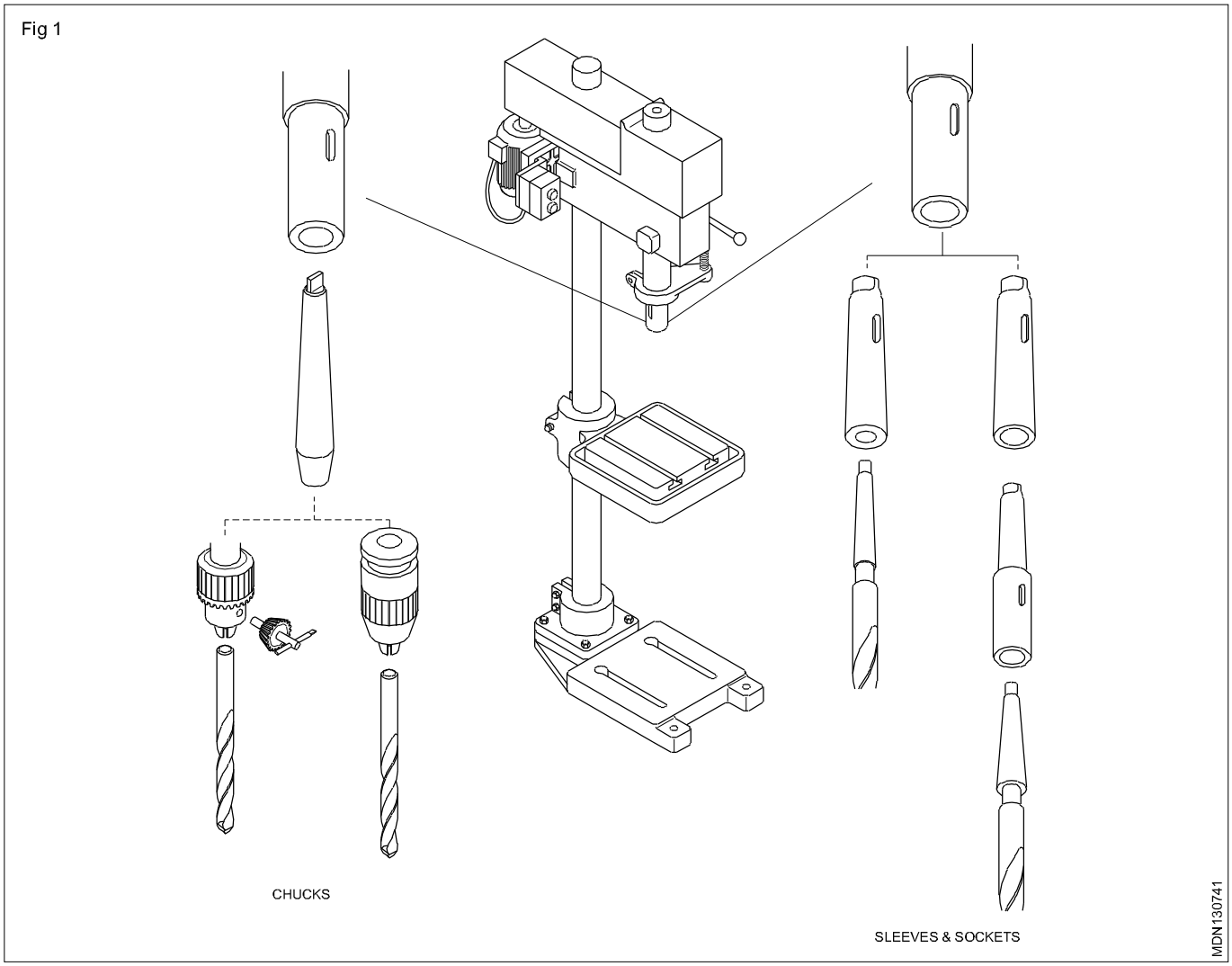
Taper shank drills have a morse taper.

Sleeves and sockets are made with the same taper so that the taper shank of the drill. When engaged, will give a good wedging action. due to this reason morse tapers are called self-holding tapers.

Drills are provided with five different sizes of morse tapers, and are numbered from MT 1 to MT5.

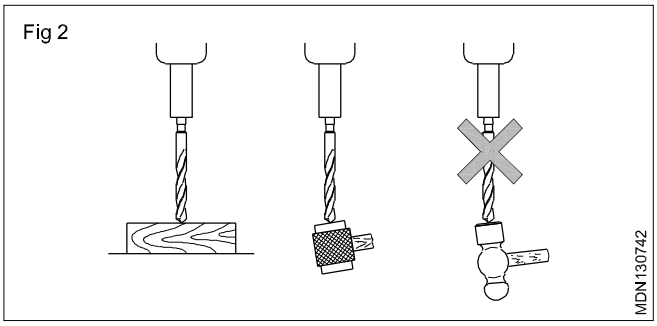
In order to make up the difference in sizes between the shanks of the drills and the type of machine spindles, sleeves of different sizes are used. When the drill taper shank is bigger than the machine spindle,taper sockets are used. (Fig 1)

Fig 1



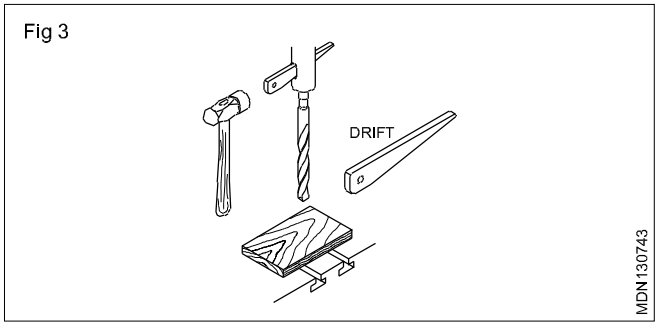
While fixing the drill in a socket or sleeves the tang portion should align in the slot (Fig 2). this will facilitate the removal of drill or sleeve from the machine spindle.

Fig 2



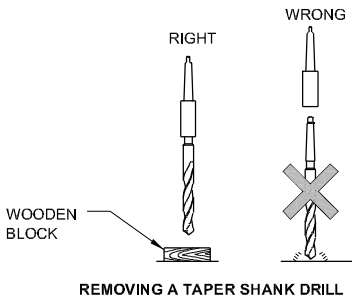
Use a drift remove drills and sockets from the machine spindle. (Fig 3)

Fig 3



While removing the drill from the sockets sleeves, don't allow it to fall on the table or jobs. (Fig 4)

Fig 4



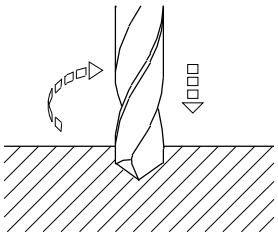
REMOVING A TAPER SHANK DRILL

Drill Bits

Objectives : At the end of this lesson you shall be able to
- **state the functions of drills**
- **name the parts of a drill**
- **state the functions of each part of a drill.**

Drilling is a process of making holes on workpieces. The drill used as a tool. For drilling the drill is rotated with a downward pressure causing the tool to penetrate into the material (Fig 1)

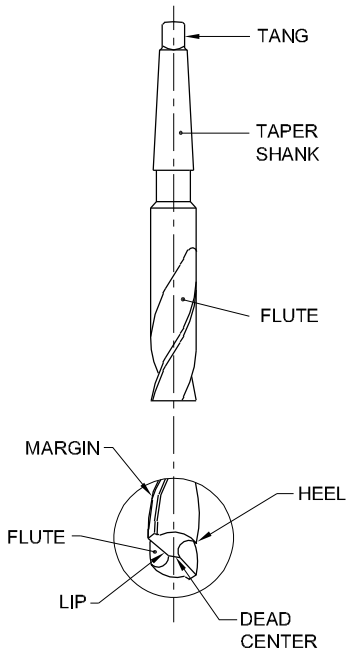
Fig 1



Parts of a Drill (Fig 2)

The Various parts of a drill can be identified from fig. 2

Fig 2



Point

The cone shaped end which does the cutting is called point. It consists of a dead centre, lips or cutting edges and a heel.

Shank

This is the driving end of the drill which is fitted on to the machine. Shanks are of two types.

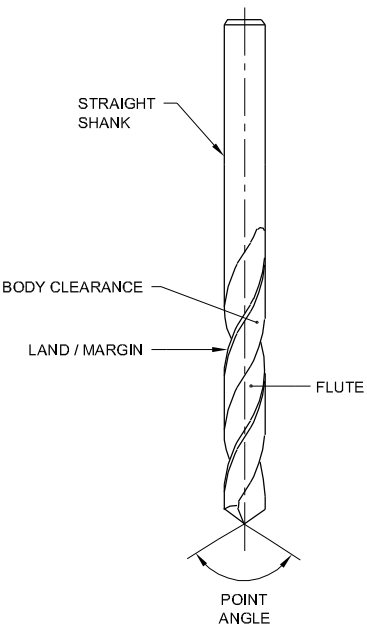
Taper shanks, used for larger diameter drills, and straight shank, used for smaller diameter drills.

Tang

This is a part of the taper shank drill which fits into the slot of the drilling machine spindle.

Body (Fig. 3)

Fig 3



The portion between the point and the shank is called the body of a drill.

The parts of the body are flute, land/margin, body clearance and web.

Flutes

Flutes are the spiral grooves which run to the length of the drill. The flutes help,

- to form the cutting edges
- to curl the chips and alow these to come out
- the coolant to flow to the cutting edge.

Land/Margin

The land/margin is the narrow strip which extends to the entire length of the flutes.

The diameter of the drill a measured across the land margin.

Body Clearance

Body clearance is the part of the body which is reduced in diameter to cut down the function between the drill and the hole being drilled.

Web

Web is the metal column which separates the flutes. It gradually increases in thickness towards the shank.

Drill Angles

Objectives : At the end of this lesson you shall be able to
- **list the various angles of a twist drill**
- **state the functions of each angle**
- **list the tool types for drill as per IS**
- **distinguish the features of different types of drills**
- **designate drills as per ISI recommendations.**

Angles

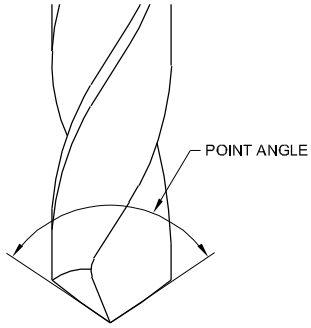
They are different angles for different purposes. They are listed below.

Point Angle, Helix angles,Rake angle, Clearance angle and chisel edge angle.

Point Angle/Cutting Angle

The point angle of a general purpose (standard) drill is 118°.This is the angle between the cutting edges (lips). This angle according to the hardness of the material to be drilled (Fig 1)

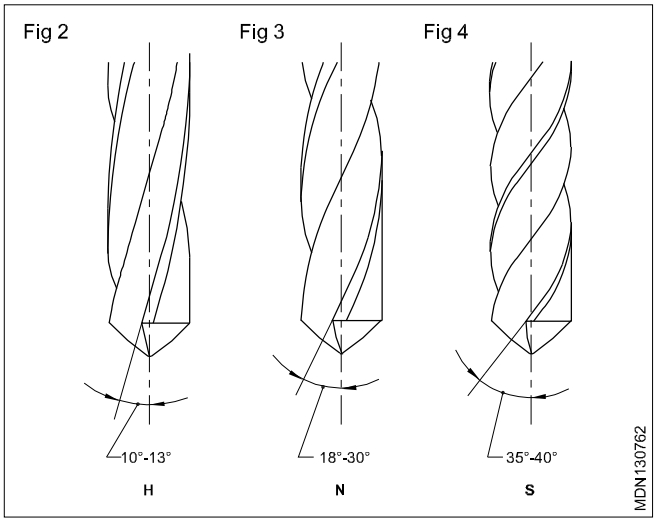
Fig 1



Helix Angle (Figs 2,3 and 4)

Twist drills are made with different helix angles. The helix angle determines the rake angle at the cutting edge of teh twist drill.

Fig 2 Fig 3 Fig 4

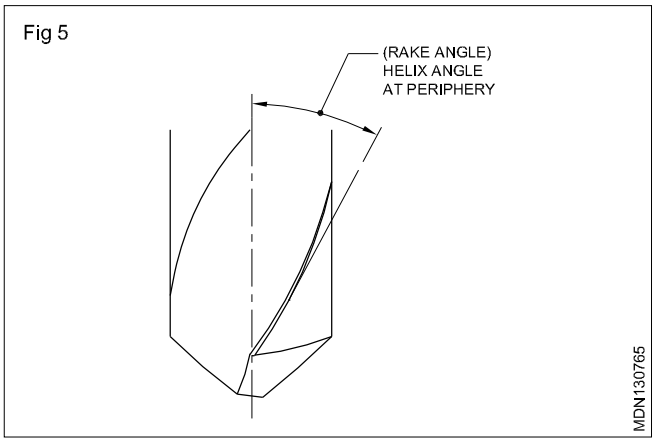


The helix angles vary according to the material being drilled. According to Indian Standards, three types of drills are used for drilling various materials.

- Type N-for normal low carbon steel
- Type H-for hard and tenaceous materials
- Type S- for soft and tough materials.

The type of drill used for general purpose drilling work is Type N.

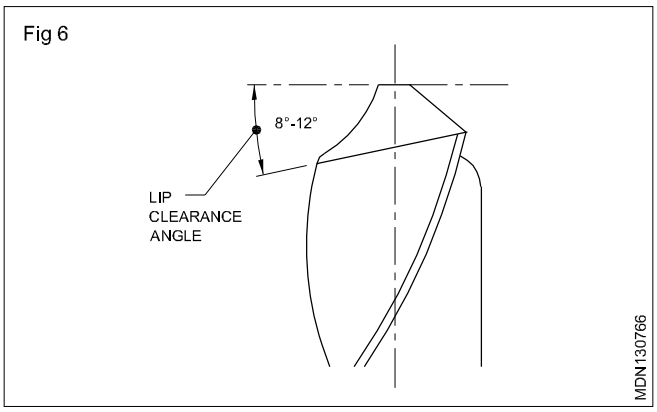
Rake Angle (Fig 5)



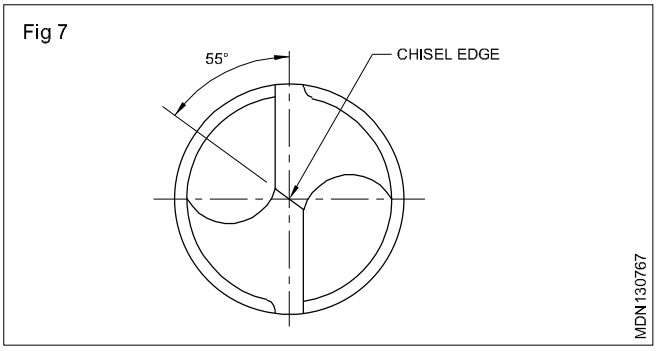
Rake angle is the angle of flute (helix angle)

Clearance Angle (Fig 6)

The clearance angle is to prevent the friction of the tool behind the cutting edge. This will help in the penetration of the cutting edges into the material. If the clearance angle is too much the cutting edges will be weak, and if it is too small the drill will not cut.



Chisel Edge Angle/ Web Angle (Fig 7)

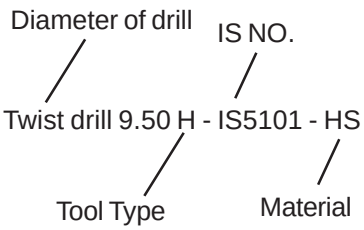


This is the angle between the chisel edge and the cutting lip.

Designation of drills

Twist drills are designated by the

- diameter



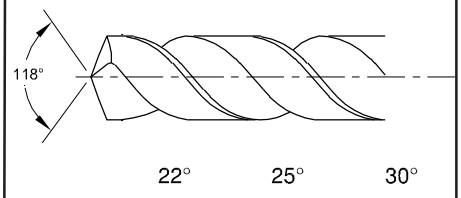
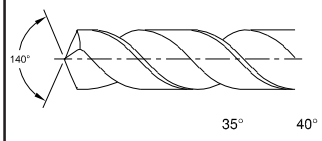
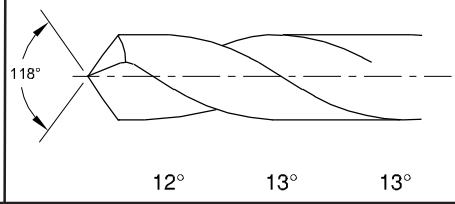
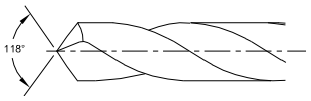
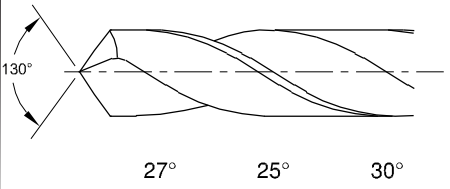
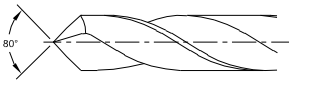
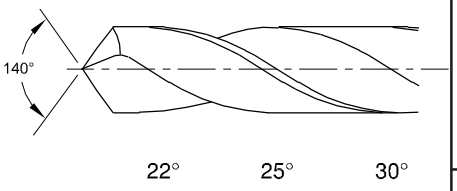
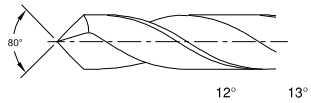
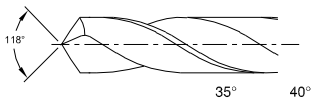
- tool type
- material

Example

A twist drill of 9.50mm dia of tool type “H’ right hand cutting and made from HSS is designated.

If the tool type is not indicated in the designation, it should be taken as type ‘N’ tool.

Drills for different materials

Recommended drills				
Material to be drilled	Point angle	Helix angle d=3.2-5 5-10	Material to be drilled	Point angle Helix angle d=3.5 -5
Steel and cast steel up to 70 kgf/mm^2 strength Gray cst iron Malleable cast iron Brass German silver, nickel			Copper (up to 30 mm drill diameter) Al-alloys, forming curly chips celluloid	
Brass, CuZn 40			Austentic steels	
Steel and cast steel 70.... 120 Kgfmm^2			Moulded plastics (with thickness s>d)	
Stainless steel; Copper (drill diameter) more than 30 mm) Al-alloy, forming short - broken chips			Moulded plastics, with thickness s<d Laminated plastics. hard rubber (ebonite) marble, state, coal	
			Zinc alloys	

Hand taps and dies

Objectives : At the end of this lesson you shall be able to
- **state the uses of threading hand taps**
- **state the features of hand taps**
- **distinguish between different taps in a set**
- **name the different types of tap wrenches**
- **state the uses of different types of wrenches.**

Use of Hand Taps

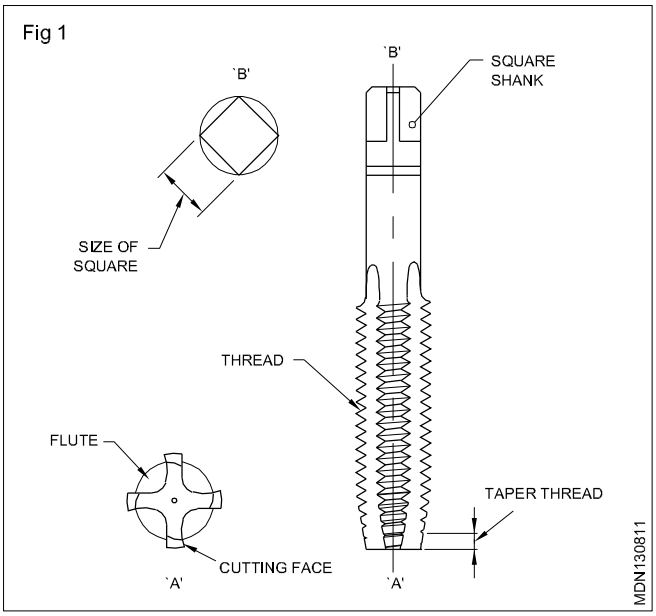
Hand taps are used for internal threading of components.

Features (Fig 1)

They are made from high carbon steel of high speed steel handened and ground

Threads are cut on the surface and are accurately finished.

Fig 1



To form the cutting edges, the flutes are cut across the thread.

For holding and turning the taps while cutting threads the ends of the shanks are squared.

The ends of the taps are chamfered (taper lead) for assisting aligning and starting of the thread.

The size of the taps and the type of the thread are usually marked on the shank.

In certain cases the pitch of the thread will also be marked.

Markings are also made to indicate the type of tap i.e first, second final or plug tap.

Types of Taps in a set

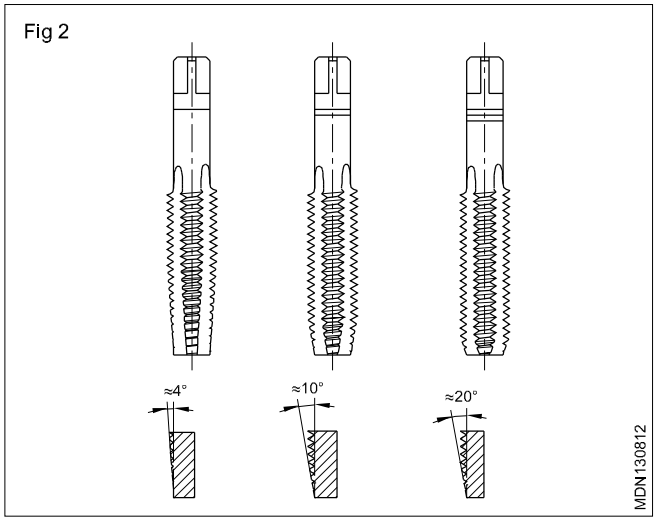
Hand taps for a particular thread are available as a set consisting of three pieces. (Fig 2)

These are

first tap or taper tap

second tap or intermediate tap

Fig 2



plug or bottoming tap

These taps are identical in all features except in the taper lead.

The taper tap is to start the thread. It is possible to form full threads by the taper tap in through holes which are not deep.

The bottoming tap (plug) is used to finish the threads of a blind hole to the correct depth.

for identifying the type of taps quickly - the taps are either numbered as 1,2 and 3 or rings are marked on the shank.

The taper tap has one ring the intermediate tap has two rings and the bottoming tap has three rings (Fig 2)

Tap Wrenches

Tap Wrenches are used to align and drive the hand taps correctly into the hole to be threaded.

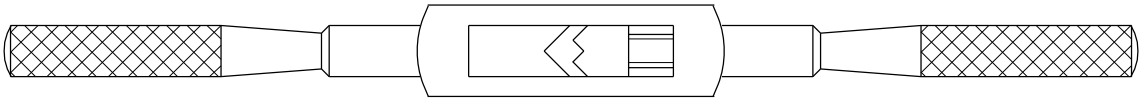
Tap Wrenches are of different types.

Double ended adjustable wrench, T handle tap wrench and solid type tap wrench.

Double ended adjustable tap Wrench or Bar Type Tap Wrench (Fig 3)

This is the most commonly used type of tap wrench. It is available in various sizes. These tap wrenches are more suitable for large diameter taps and can be used in open places where there is no obstruction to turn the tap. It is important to select the correct size of wrench.

Fig 3



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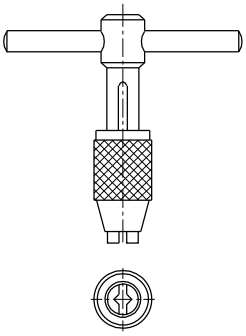
T- Handle Tap Wrench (Fig 4)

These are small adjustable chucks with two jaws and a handle to turn the wrench.

This tap wrench is useful to work in restricted places and is turned with one hand only.

Fig 4



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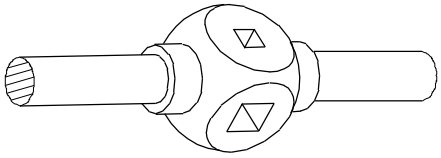
This is not suitable for holding large diameter taps.

Solid Type Tap Wrench (Fig 5)

These Wrenches are not adjustable

They can take only certain sizes of taps. This eliminates the use of wrong length of the tap wrenches and thus prevents damage to the taps.

Fig 5



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Tap drill size

Objectives: At the end of this lesson you shall be able to
- **state what is tap drill size**
- **choose the tap drill sizes for different threads from tables**
- **calculate the tap drill sizes for ISO metric and ISO inch.**

What is a tap drill Size?

Before a tap is used for cutting internal threads, a hole is to be drilled. The diameter of the hole should be such that it should have sufficient material in the hole for the tap to cut the thread.

Tap Drill Sizes for Different Threads

ISO Metric Thread

Tapping drill size

for M10 x 1.5 thread

Minor diameter = Major diameter – 2 x depth

depth of thread = 0.6134 x pitch of a screw

2 depth of thread = 0.6134 x 2 x pitch

=1.226 x 1.5 mm = 1.839 mm

Minor dia (D1)=10 mm – 1.839 mm

=8.161mm or 8.2 mm

This tap drill will produce 100% thread because this is equal to the minor diameter of the thread. For most fastening purposes a 100% formed thread is not required.

A standard nut with 60% thread is strong enough to be tightened until the bolt breaks without stripping the thread. Further it also requires a greater force for turning the tap if a higher percentage formation of thread is required.

Considering this aspect, a more practical approach for determining the tap drill sizes is

Tap drill size = Major diameter – pitch
= 10 mm - 1.5 mm
= 8.5 mm.

Compare this with the table of tap drill sizes for ISO metric threads.

ISO Inch (Unified) threads Formula

$$\text{Tap Drill size} = \text{Major diameter} - \frac{1}{\text{Number of thread per inch}}$$

For calculating the tap drill size for 5/8" UNC thread

Tap drill size = 5/8" – 1/11"
= 0.625" – 0.091"
= 0.534"
The next drill size is 17/32" (0.531 inches)

Compare this with the table of drill sizes for unified inch threads.

What will be the tapping size for the following threads?

(a) M 20
(b) UNC 3/8

Refer to chart for determining the pitches of the thread.

TABLE FOR TAP DRILL SIZES - ISO METRIC

PITCH / NOMINAL DIA	0.25	0.3	0.35	0.4	0.45	0.5	0.6	0.7	0.75	0.8	1	1.25	1.5	1.75		2.5	3	3.5	4	4.5	5	5.55
1	0.85																					
1.1	0.95																					
1.2	0.96																					
1.4		1.10																				
1.6			1.25																			
1.8			1.45																			
2				1.60																		
2.2			2.15		1.75																	
2.5			2.65		2.05																	
3			3.15			2.50																
3.5							2.90															
4						3.50		3.30														
4.5						4.00			3.70													
5						4.50				4.20												
5.5						5.00																
6									5.20		5.00											
7									6.20		6.00											
8									7.20		7.00	6.80										
9									8.20		8.00	7.80										
10									9.20		9.00	8.80	8.50									
11									10.20		10.00		9.50									
12											11.00	10.80	10.50	10.20								
14											13.00	12.80	12.50		12.00							
15											14.00		13.50									
16											15.00		14.50		14.00							
17											16.00		15.50									
18											17.00		16.50		16.00	15.50						
20											19.00		18.50		18.00	17.50						
22											21.00		20.50		20.00	19.50						
24											23.00		22.50		22.00		21.00					
25											24.00		23.50		23.00							
26													24.50									
27											26.00		25.50		25.00		24.00					
28											27.00		26.50		26.00							
30											29.00		28.50		28.00		27.00	26.50				
32													30.50		30.00							
33													31.50		31.00		30.00	29.50				
35													33.50									
36													34.50		34.00		33.00		32.00			
38													36.50									
39													37.50		37.00		36.00		35.00			
40													38.50		38.00		37.00					
42													40.50		40.00		39.00		38.00	37.50		
45													43.50		43.00		42.00		41.00	40.50		
48													46.50		46.00		45.00		44.00		43.00	
50													48.50		48.00		47.00					
52													50.50		50.00		49.00		48.00		47.00	
56																						50.50

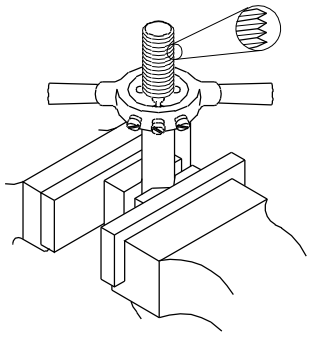
Die and die stock

Objectives: At the end of this lesson you shall be able to
- **name the different types of dies**
- **state the features of each type of die**
- **state the use of each type of die**
- **name the type of diestock for each type of die.**

Uses of Dies

Threading dies are used to cut external threads on cylindrical workpieces. (Fig 1)

Fig 1



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Types of Dies

The following are the different types of dies.

Circular Split Die (Button die)

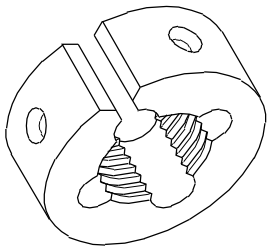
Half Die

Adjustable Screw Plate Die

Circular Split Die/Button Die (Fig 2)

This has a slot cut to permit slight variation in size.

Fig 2



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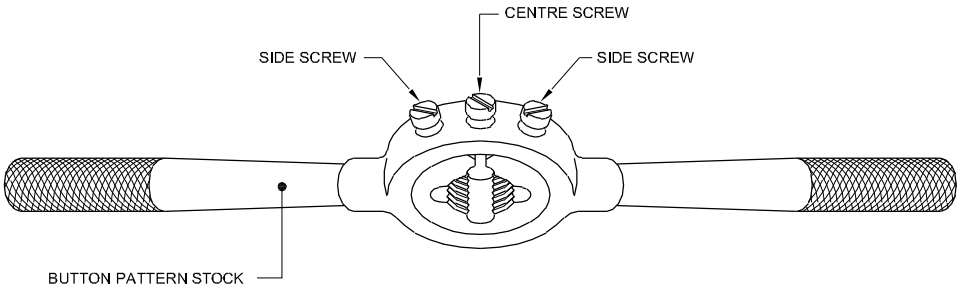
When held in the diestock, variation in the size can be made by using the adjusting screws. This permits increasing or decreasing of the depth of cut. When the side screws are tightened the die will close slightly.(Fig 3)

For adjusting the depth of the cut, the centre screw is advanced and locked in the groove. This type of die stock is called button pattern stock.

Fig 3



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Half Die (Fig 4)

Half dies are stronger in construction.

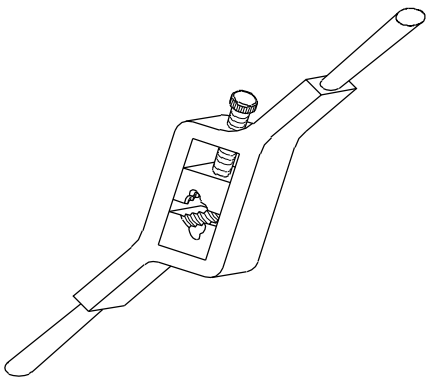
Adjustments can be made easily to increase or decrease the depth of cut.

These dies are available in matching pairs and should be used together.

By adjusting the screw of the diestock, the die pieces can be brought closer together or can be moved apart.

They need a special die holder.

Fig 4



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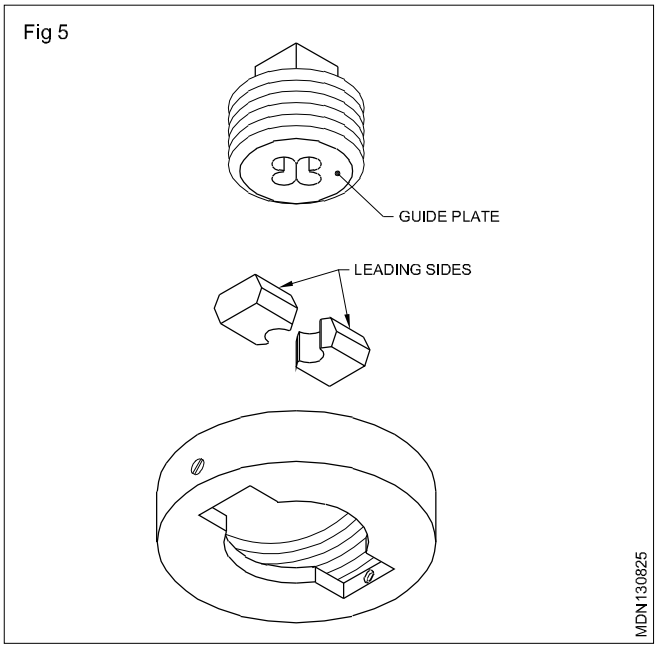
Adjustable Screw Plate Die (Fig 5)

Fig 5



This is another type of a two piece die similar to the half die.

This provides greater adjustment than the split die.

The two die halves are held securely in a collar by means of a threaded plate (guide plate) which also acts as a guide while threading.

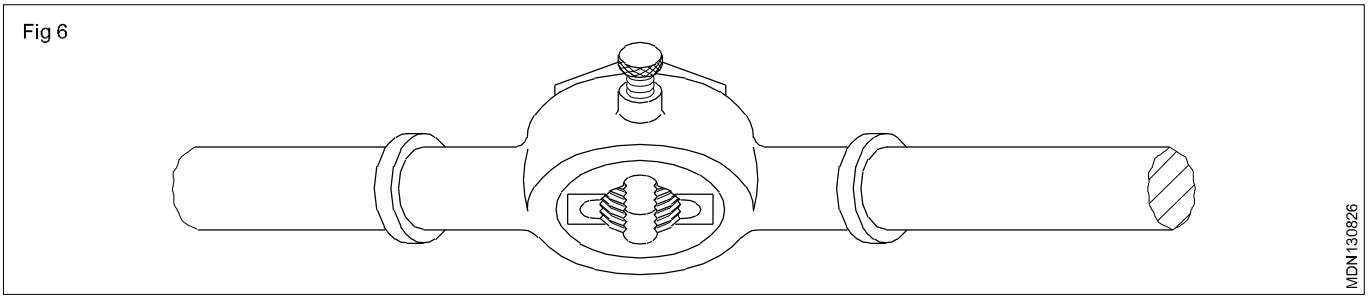
When the guide plate is tightened after placing the die pieces in the collar, the die pieces are correctly located and rigidly held. (Fig 5)

The die pieces can be adjusted, using the adjusting screws on the collar. This type of die stock used is called quick cut diestock. (Fig 6)

The bottom of the die halves is tapered to provide the lead for starting the thread. On one side of each die head, the serial number is stamped.

Both pieces should have the same serial numbers.

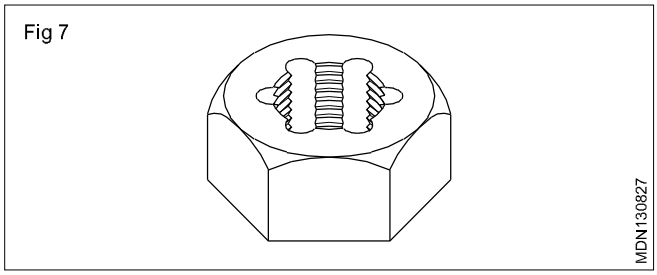
Fig 6



Die Nut (Solid Die) (Fig 7)

The die nut is used for chasing or reconditioning the damaged threads.

Fig 7



The die nut is turned with a spanner.

The die nuts are available for different standards and sizes of threads.

Die nuts are not to be used for cutting new threads.

Hand Reamers

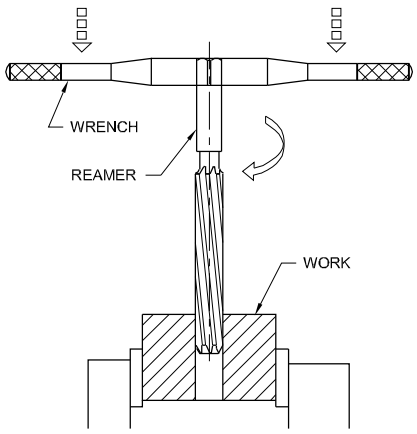
Objectives : At the end of this lesson you shall be able to
- **state the uses of reamers**
- **state the advantages of reaming**
- **distinguish between hand and machine reaming**
- **name the elements of a reamer.**

What is reamer?

A reamer is a multi-point cutting tool used for enlarging and finishing previously drilled holes to accurate sizes. (Fig 1)

Advantages of 'reaming'

Fig 1



Reaming produces high quality surface finish and dimensional accuracy to close limits.

Also small holes which cannot be finished by other processes can be finished.

Classification of reamers

Reamers are classified as hand reamers and machine reamers. (Fig 2 and 3)

Fig 2

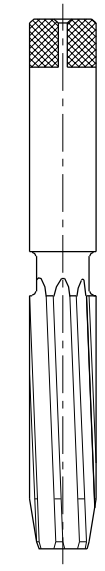
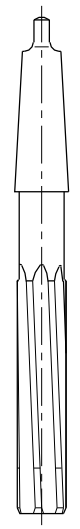


Fig 3



Reaming by using a hand reamer is done manually for which great skill is needed.

Hand reamers have straight sha nks with 'square' at the end for holding with tap wrenches. (Fig 2)

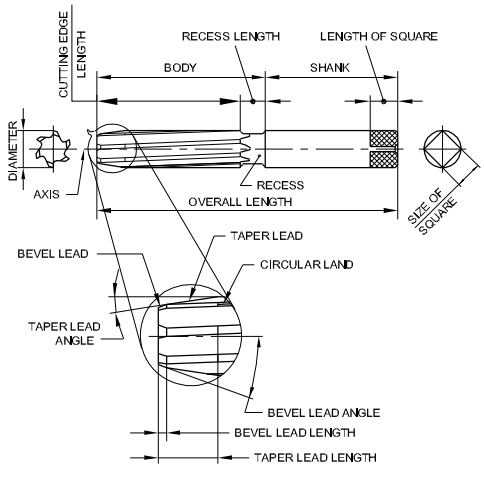
Machine reamers are fitted on spindles of machine tools by means of a floating chuck and are rotated for reaming.

Machine reamers are provided with Morse taper shanks for holding on machine spindles.(Fig 3)

Parts of a hand reamer

The parts of a hand reamer are shown in Fig 4

Fig 4



Hole size for reaming

Objectives : At the end of this lesson you shall be able to
- **determine the hole size for reaming.**

For reaming with a hand or machine reamer the hole drilled should be smaller than the reamer size.

The drilled hole should have sufficient metal for finishing with the reamer. Excessive metal will impose a strain on the cutting edge of the reamer and damage it.

Calculating drill size for reamer

A method generally practised in workshops is by applying the following formula.

Drill size = Reamed size - (undersize+oversize) of drilled hole.

Finished size

Finished size is the diameter of the reamer.

Undersize

Undersize is the recommended reduction in size for different ranges of drill diameter. (see Table)

TABLE -1

Undersizes for reaming

Diameter of ready reamed hole (mm)	Undersizes of rough bored hole (mm)
under 5	0.1...0.2
5....20	0.2...0.3
21....50	0.3....0.5
over 50	0.5....1

Oversize of drilled hole

It is generally considered that a twist drill will make a hole larger than its diameter. The oversize for calculation purposes is taken as 0.05 mm, for all diameters of drills.

For light metals the undersize will be 50% larger.

Example

A hole is to be reamed on mild steel with a 10mm reamer. What will be the diameter of the drill for drilling the hole before reaming?

Drill size = Reamed size - (undersize + oversize) (finished size) = 10mm

Undersize as per table = 0.2 mm

Oversize = 0.05 mm, finished size = 0.05+0.2=0.25mm

Drill size = 10mm-0.25mm

= 9.75mm

Determing the drill hole sizes for the following reamers.

i) 15mm ii) 44mm

iii) 4mm iV) 19mm

Answer

i) ----------

ii) ----------

iii) ----------

iv) ----------

If the reamed hole is undersize, the cause is that the reamer is worn out.

Always inspect the condition of the reamer before commending reaming.

For obtaining good suface finish, use a coolant while reaming. Remove metal chips from the reamer frequently advance the reamer slowly into the work.

DEFECTS IN REAMING - CAUSES AND REMEDIES

Reamer hole undersize

If a worn out reamer is used, it may result in the reamed hole being undersize. Do not use such reamers.

Always inspect the condition of the reamer before using.

Surface finish rough

The causes may be anyone of the following ara combination there of.

- incorrect application
- Swarf accumulated in reamer flutes
- in adequate flow of coolant
- feed rate too fast

While reaming apply a steady and slow feed rate.

Ensure a copious supply of the lubricant.

Do not turn the reamer in the reverse direction.

Lapping

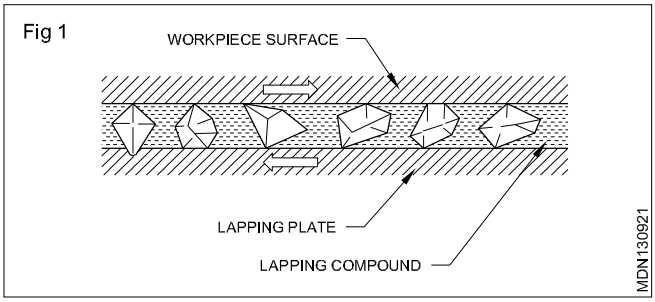
Objectives : At the end of this lesson you shall be able to
- **state the purpose of lapping**
- **state the features of a flat lapping plate**
- **state the use of changing a flat lapping plate**
- **state the method of charging a cast iron plate**

Lapping is a precision finishing operation carried out using line abrasive materials.

Purpose: This process

- improves geometrical accuracy
- refines surface finish
- assists in achieving a high degree of dimensional accuracy.
- improves the quality of fit between the mating components.

Fig 1



Lapping process: in the lapping process small amounts of material are removed by rubbing the work against a lap charged with a lapping compound. (Fig 1)

The lapping compound consists of the abrasive particles. Suspended in a vehicle such as oil, paraffin, grease etc.

The lapping compound which is introduced between the workpiece and the lap chips away the material from the workpiece. Light pressure is applied when both are moved against each other. The lapping can be carried out manually or by machine.

Hand lapping of flat surfaces: Flat surfaces are hand lapped using lapping plates made out of close grained cast iron. (Fig 2) The surface of the plate should be in a true plane for accurate results in lapping.

The lapping plate generally used in tool rooms will have narrow grooves out on its surface both lengthwise and crosswise forming a series of squares.

These grooves are usually about 12mm apart.

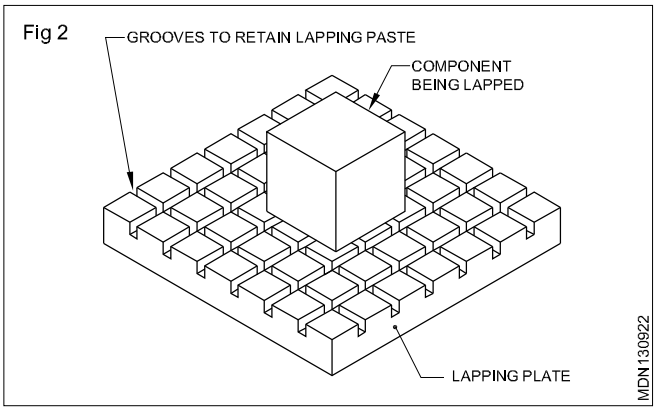
While lapping the lapping compound collects in the serrations and rolls in and out as the work a moved.

Before commencing lapping of the component, The cast iron plate should be CHARGED with abrasive particles.

This is a process by which the abrasive particles are embedded on to the surfaces of the laps which are comparatively softer than the component being lapped.

For charging the cast iron lap apply a thin coating of the abrasive compound over the surface of the lapping plate.

Fig 2



Use a finished hard steel block and press the cutting particles into the lap. While doing so, rubbing should be kept to the minimum. When the entire surface of the lapping plate is charged, the surface will have a uniform grey appearance. If the surface is not fully charged, bright spots will be visible here and there.

Excessive application of the abrasive compound will result in the rolling action of the abrasive between the work and the plate developing in accuracies.

The surface of the flat lap should be finished true by scraping before charging. After charging the plate, wash of all the loose abrasives using kerosene.

Then place the worpiece on the plate and move along and across, covering the entire surface areas of the plate. When carrying out fine lapping, the surface should be kept moist with the help of kerosene.

Wet and dry lapping: Lapping ca be carried out either wet or dry.

In wet lapping there is surplus oil and abrasives on the surface of the lap. As the workpiece which is being lapped is moved on the lap, there is movement of the abrasive particles also.

In the dry method the lap is first charged by rubbing the abrasives on the surface of the lap. The surplus oil and abrasives are then washed off. The abrasives embedded on the surface of the lap will only be remaining. The embedded abrasives act like a fine oilstone when metal pins to be lapped are moved over the surface with light pressure. However, while lapping, the surface being lapped is kept moistened with kerosene or petrol. Surfaces finished by the dry method will have better finish and appearance. Some prefer to do rough lapping by wet method and finish by dry lapping.

Lap Materials and lapping compounds

Objectives : At the end of this lesson you shall be able to
- **name the different types of lap materials**
- **state the qualities of different lap materials**
- **name the different types of abrasive materials used for lapping**
- **distinguished between the application of different lapping abrasives**
- **state the function of lapping vehicles**
- **name the solvents used in lapping.**

The material used for making laps should be softer than the workpiece being lapped. This helps to charge the abrasives on the lap. If the lap is harder than the workpiece, the workpiece will get charged with the abrasives and cut the lap instead of the workpiece being lapped.

Laps are usually made of

- close grained iron
- copper
- brass or lead.

The best material used for making lap is cast iron, but this cannot be used for all applications.

When there is excessive lapping allowance, copper and brass laps are preferred as they can be charged more easily and cut more rapidly than cast iron.

Lead is an in expensive form of lap commonly used for holes. Lead is cast to the required size on steel arbar. These laps can be expanded when they are worn out. Charging the lap is much quicker.

Lapping abrasives:

Abrasives of different types are used for lapping.

The commonly used abrasives are:

- silicon carbide
- aliminium oxide
- boron carbide
- diamond.

Silicon carbide: This is an extremely hand abrasive. Its grit is sharp and brittle. While lapping the sharp cutting edges contiuously break down exposing new cutting edges. Due to this reason this is considered as very ideal for lapping hardened steel and cast iron, particularly where heavy stock removal is required.

Aluminium oxide: Aluminium oxide is sharp but tougher than silicon carbide. Aluminium oxide is used in un-fused and fused forms.

Un-fused alumina(aluminium oxide) removes stock effectively and is capable of obtaining high quality finish.

Fused alumina is used for lapping soft steels and nonferrous metals.

Boron Carbide: This is an expensive abrasive material which is next to diamond in harness. While it has excellent cutting properties, it is used because of the high cost only in special application like dies and gauges.

Diamond: This being the hardest of all materials. It is used for lapping tungsten carbide. Rotary diamond laps are also prepared for accurately finishing very small holes which cannot be ground.

Lapping vehicles: In the preparation of lapping compounds the abrasive particles are suspended in vehicles. This helps to prevent concentration of abrasives on the lapping surfaces and regulates the cutting action and lubricates the surfaces.

The commonly used vehicles are:

- water soluble cutting oils
- vegetable oils
- machine oils
- petroleum jelly or grease
- vehicles with oil or grease base used for lapping ferrous metals.

Metals like copper and its alloys and other non-ferrousmetals are lapped using slouable oil, bentomite etc.

In addition to the vehicles used in making the lapping compound, solvents like water, kerosene, etc are also used at the time of lapping.

Types of sheet metals and their application

Objectives: At the end of this lesson you shall be able to
- **state the types of metals used in sheet metal work**
- **state the uses of the different types of metals.**

In sheet metal work, different types of metal sheets are used. The sheets are specified by standard gauge numbers.

It is very essential to know the different uses and applications of these metal sheets.

Black Iron

The cheapest sheet metal is black iron, which is rolled to the desired thickness. It has a bluish black appearance, and is often referred to as uncoated sheet. Since it is uncoated, it corrodes rapidly.

The use of this metal is limited to articles that are to be painted or enamelled such as tanks, fans, stoves, pipes etc.

Galvanised iron

Zinc-coated iron is known as 'galvanised iron'. This soft iron sheet is popularly known as GI sheet. The zinc coating resists rust, improves the appearance of the metal and permits it to be soldered with greater ease. Because it is coated with zinc, galvanised sheet iron withstands contact with water and exposure to weather.

Articles such as fans, buckets, furnaces, heating ducts, cabinets, gutters etc. are made mainly from GI sheets.

Stainless sheet

This is an alloy of steel with nickel, chromium and other metals. It has good corrosive resistance and can be welded easily. Stainless steel used in a sheet metal shop can be worked as galvanised iron sheets, but is tougher than GI sheets. The cost of stainless steel is very high. Stainless steel is used in dairies, food processing, chemical plants, kitchenware etc.

Copper sheet

Copper sheets are available either as cold-rolled or hot-rolled sheets. Cold-rolled sheets being resistant to corrosion and worked easily are commonly used in sheet metal shops. Copper sheet has better appearance than other metals.

Gutters, expansion joints, roof flashings, hoods, utensils and boiler plates are some of the common examples where copper sheet is used.

Aluminum

Aluminum cannot be used in its pure form, but is mixed with a very small amount of copper, silicon, manganese and iron. It is whitish in colour and is light in weight. It is highly resistant to corrosion and abrasion.

Aluminum is now widely used in the manufacture of articles such as household appliances, refrigerator trays, lighting fixtures, windows, and also in the construction of airplanes and in many electrical and transport industries.

Tinned plate

Tinned plate is sheet iron coated with tin to protect it against rust. This is used for nearly all solder work, as it is the easiest metal to join by soldering. This metal has a very bright silvery appearance and is used in the making of roofs, food containers, dairy equipment, furnace fittings, cans and pans, etc.

Lead

Lead is very soft and heavy. Lead sheets are used for making the highly corrosive acid tanks.

Properties of an auto body sheet metal

Objectives: At the end of this lesson you shall be able to
- **describe the properties of an auto body sheet metal.**

Properties of auto body sheet metal: The sheet metal used in the production of automobile surface panels must contain certain properties of qualities such as plasticity, elasticity and work hardening.

Direct and indirect damages: Damage to the body sheet metal can be classified as either direct or indirect damage.

Direct damage results from the impact of an object stilling the sheet metal. The area of damage is called the point of impact. Direct damage can be in the form of deep scratches, gauges, tears in the metal or in the case of severe impact, crumpled or mangled sheet metal.

The force of the direct damage is transmitted or transferred from the impact area to different parts of the panel thus causing indirect damage in the form of roll buckles, valleys or sharp ridges.

When straightening a panel with direct and indirect damage, the indirect damage should be straightened first.

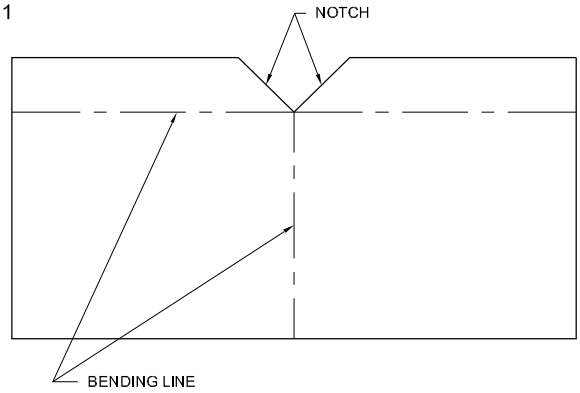
Notches in sheet metal

Objectives : At the end of this lesson you shall be able to
- **state the purpose of notches**
- **name the types of notches**
- **distinguish the features of different notch forms.**

Notches

Notches are the spaces provided for joining the edges when sheet metals are cut form the layout.

Fig 1



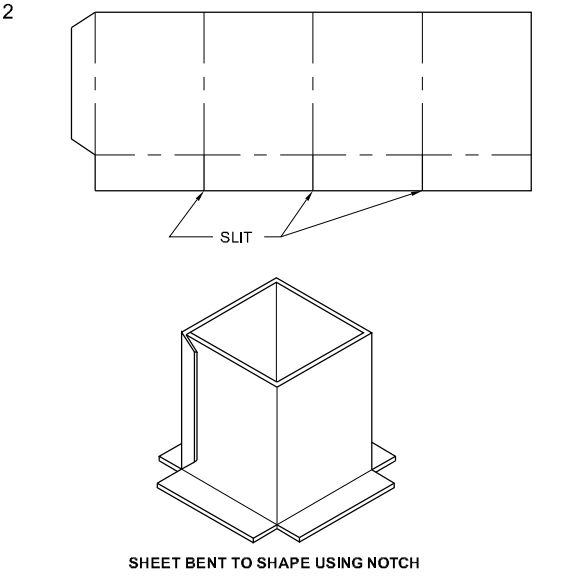
Purpose of notches

Notch helps:
- to prevent surplus material from overlapping and causing a bulge at the seam and edges.
- to allow the work to be formed to the required size and shape.
- to allow the work to assemble better.

Types of notches

Straight notch of slit (Figs 1 & 2)

Fig 2



Straight cuts made in the edge of the sheet where it is to be bent is know as a straight notch.

Square notch (Figs 3, 4 & 5)

A square notch is used for forming a square or rectangular box.

Fig 3

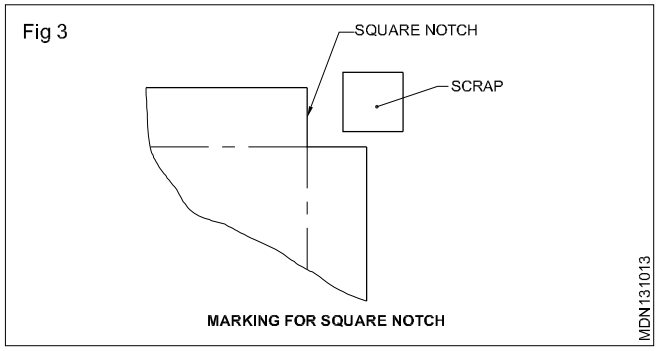


Fig 4

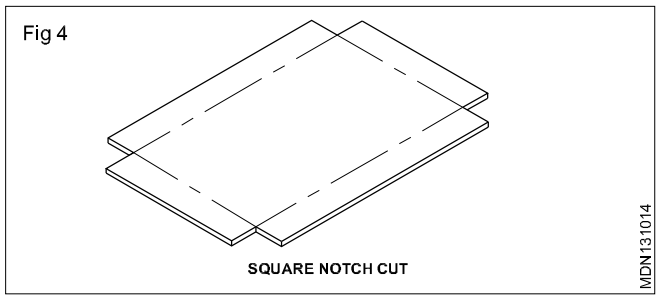
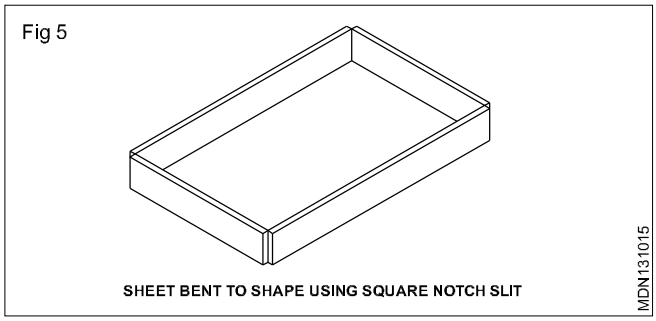


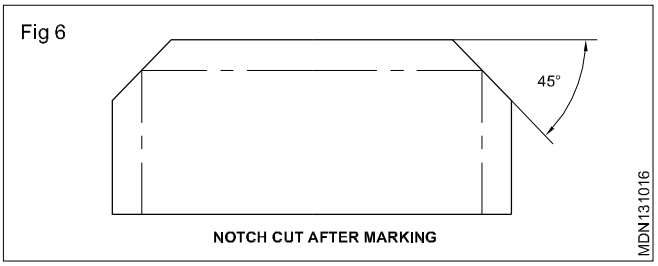
Fig 5



Slant notch (Fig. 6)

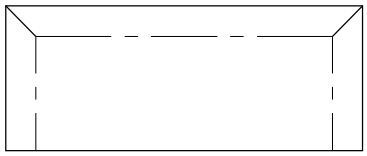
This Notch is cut at an angle of 45° to the corner of the sheet. It is used when a single hem meets at right angles.

Fig 6



'V' Notch (Figs 7 & 8)

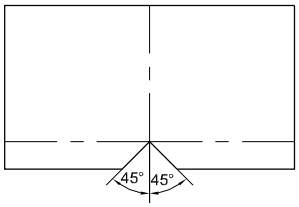
Fig 7



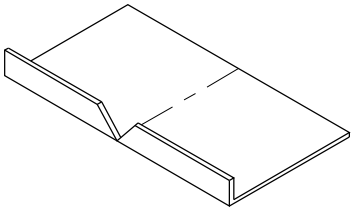
BENT TO SHAPE USING SLANT NOTCH

MDN131017

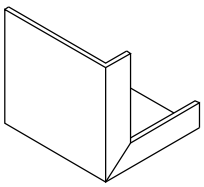
Fig 8



`V' NOTCH MARKED AND OUT



FIRST FOLDING NOTCH



BENT TO SHAPE USING `V' NOTCH

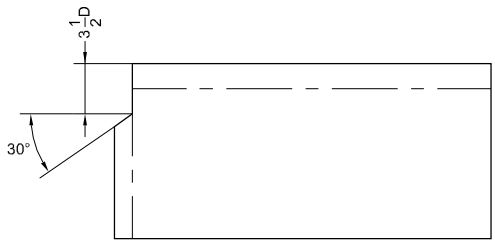
MDN131018

In this notch, both the sides are cut at a 45° angle to the edge of the sheet.

The sides of the notch meet at 90° . This notch is used when making a job with a 90° bend and an inside flange.

Wire notch (Figs 9 & 10)

Fig 9



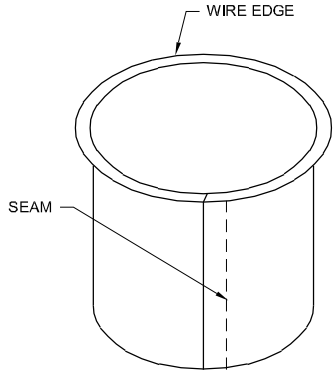
MDN131019

The angle of this notch is usually 30° and the distance from which the notch is started is 3 times the diameter of the wire.

Uses

The wire notch is used on a work which has wired edges. This notch must be provided to prevent the wired edge from overlapping at the seam.

Fig 10



AN EDGE WIRED USING WIRE NOTCHES

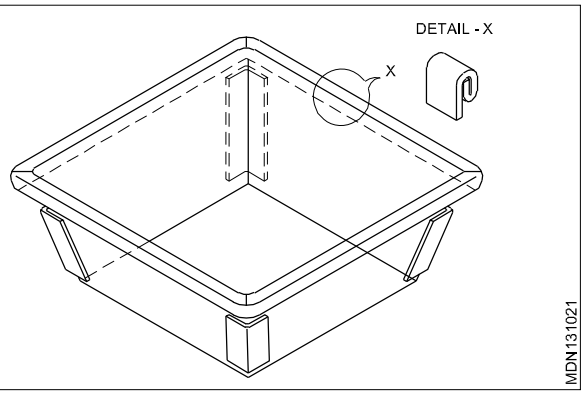
MDN131101A

Edge Stiffening

Objectives : At the end of this lesson you shall be able to
- **state what is a hem**
- **state the types of hems**
- **state the uses of the different types of hems.**

The edges of light gauge sheet metal articles (Fig. 1) are very sharp and unsafe to handle. Safe edges are provided to strengthen the sheet metal and to enhance the appearance of the finished article.

Fig 1



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What is a hem?

A hem is an edge or border made by folding.

It stiffens the sheet of the metal and avoids sharp edges.

Types of hems

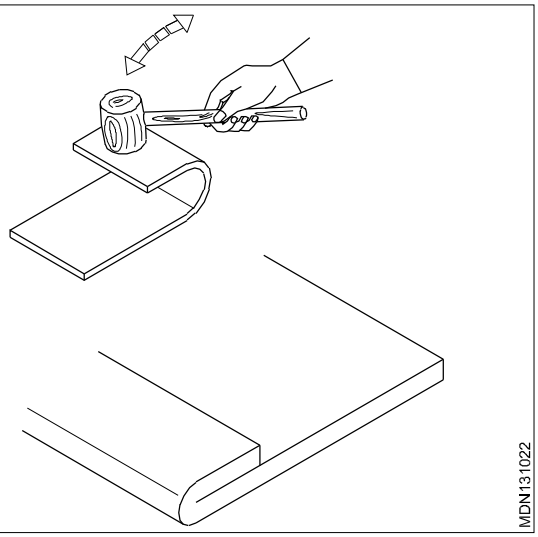
- Single hem
- Double hem
- Wired edge

Single hem (Fig. 2)

A single hem is made by folding the edge of the sheet metal with a single folding.

It makes the edge smooth and stiff and is done while making small articles.

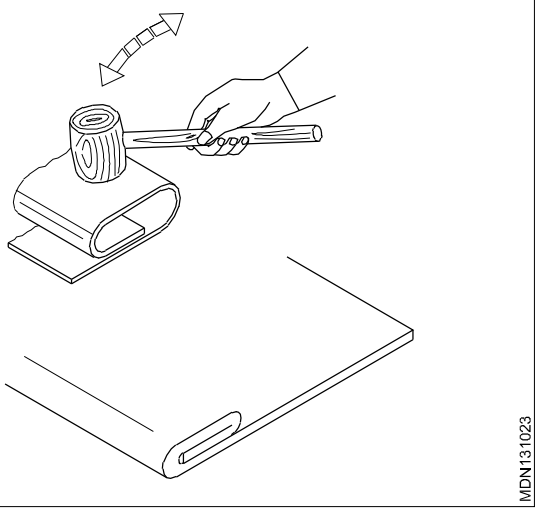
Fig 2



Double hem (Fig. 3)

A double hem is made by folding the edges over twice to make it smooth and this is done normally to strengthen the edges of lengthy articles.

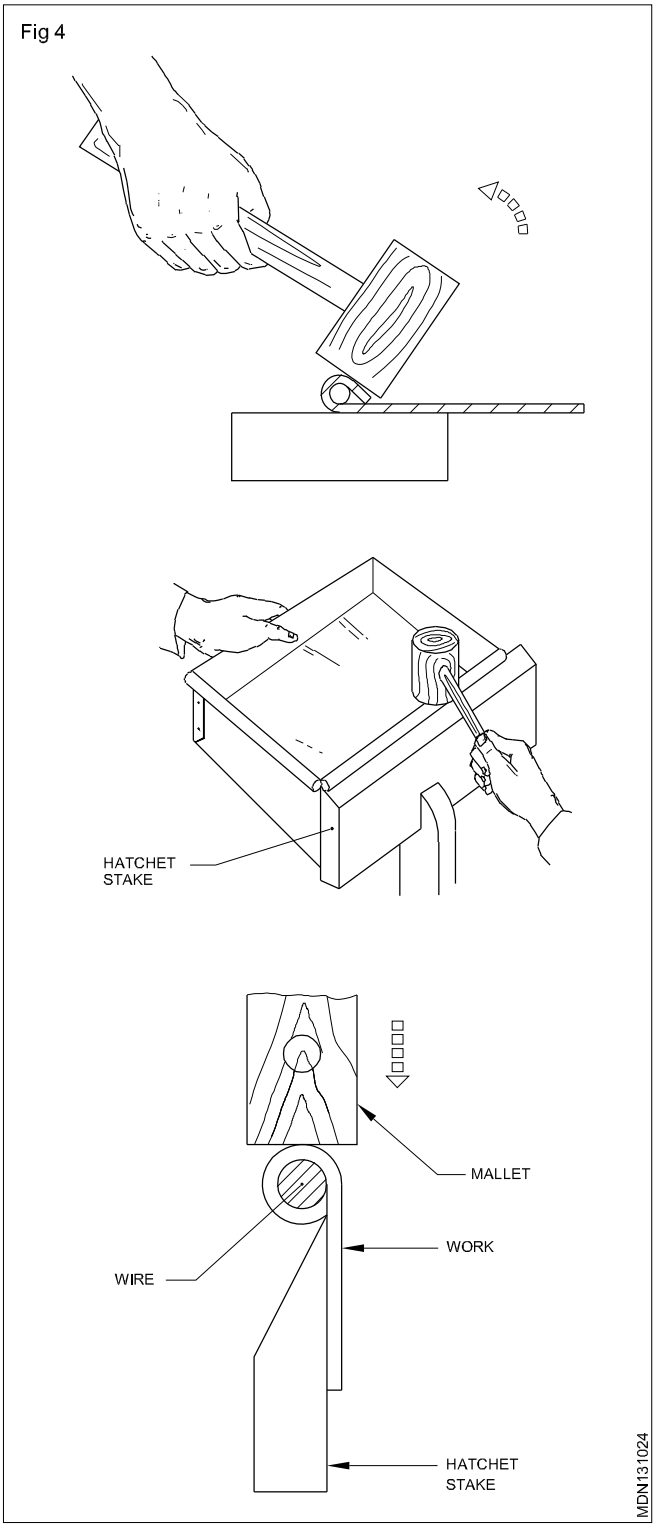
Fig 3



Wired edge (Fig. 4)

The wired edge is done for round and lengthy articles to enhance the appearance and increase the strength. The wired edge is smooth and is very strong.

Fig 4



Sheet Metal Joints

Objectives : At the end of this lesson you shall be able to

- **state what is a seam**
- **state the types of seams**
- **state the uses and application of the different types of seams.**

Sheet metal working incorporates a wide variety of seams

What is a seam?

A seam is a joint made by the fastening of two edges of two pieces of metal together.

Types of seams

Lap seam

The lap seam is the simplest type of seam and can be prepared as a lap joint. This joint is also known as edged

on joint. This joint is used to fit the top and bottom to cylindrical shapes. This joint is finally secured by soldering or brazing.

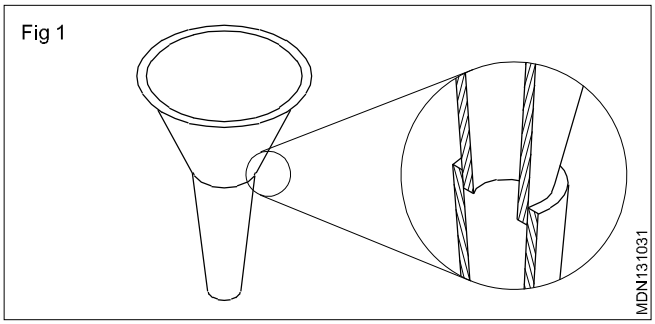
Grooved seam

A grooved seam is used to join two pieces of straight or curved metal of light gauge and then locking them by a groove.

Single seam (Fig. 1

The single seam is used to join a bottom to vertical bodies of various shapes. This joint is called paned-down joint. This joint is also secured by soldering or brazing.

Fig 1



Double seam (Figs 2 & 3)

The double seam is similar to a single seam joint except that its forward edge is bent upward against the body. This joint fulfils the same function as the edged-on and paned-down joints, but it is the strongest of the three.

Fig 2

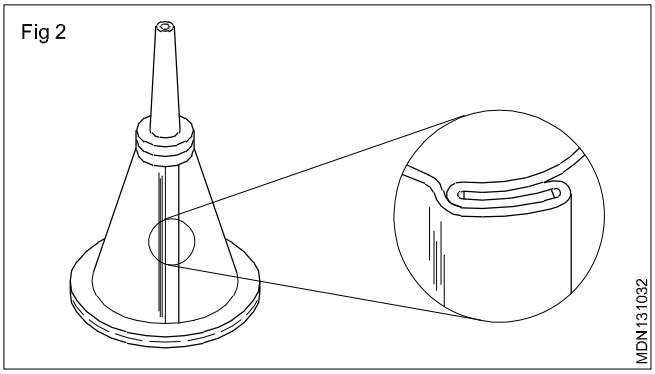
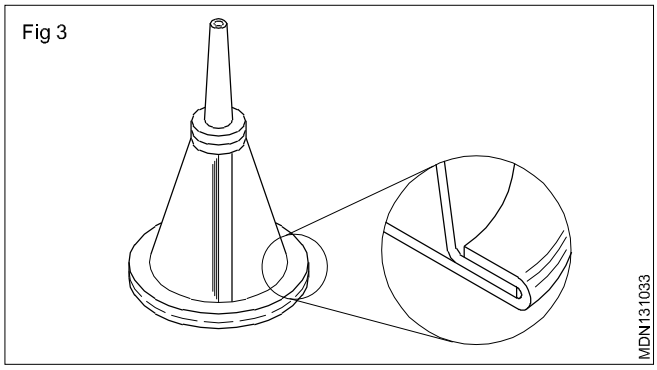


Fig 3



Double grooved seam (Figs 4 & 5)

The double grooved seam (Fig. 5) is similar to the dovetail joint in carpentry and it is used for roofing and paneling joints.

Fig 4

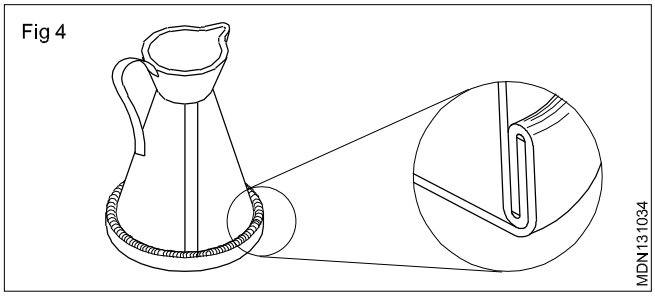
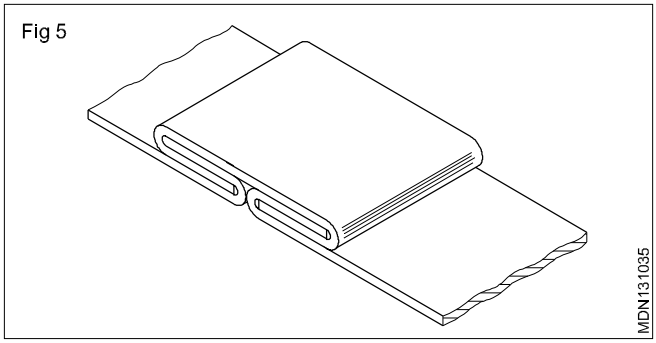


Fig 5



Folding and Joining Allowances

Objectives : At the end of this lesson you shall be able to

- **state the necessity for providing allowances in sheet metal operations.**

When making self-secured joints or seams, it is necessary to make an allowance for the extra material to be added for the preparation of the edges and seams.

The allowance is necessary for maintaining the correct size of the finished product and for improving the strength at joints of all edges.

Allowance is also necessary for avoid cracking or warping, and for obtaining the required finish.

This allowance depends upon the width of the folded edge and the thickness of the metal.

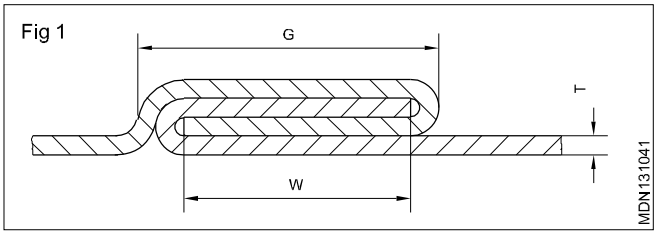
Allowances

In the making of various types of hems and seams, no allowance is necessary for thinner sheets of 0.4 mm or less.

Allowance for grooved joints/seams (Fig. 1)

If we fold over the edges to width W and form the joint, the final completed width of the joint G will be greater than W. It can be seen that the final width of the groove will have a minimum value of W + 3T, where T represents the metal thickness.

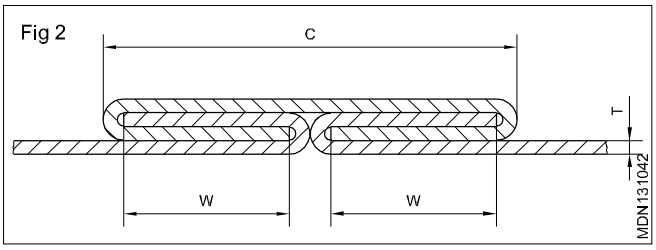
Fig 1



The allowance for a grooved seam is three times the thickness of the sheet.

Allowance for double grooved seam/joint (Fig. 2)

It will be seen from the figure that the width of the capping strip is equivalent to two times the width of the folded edge plus four times the thickness of the metal size.



C = 4W + 4T

The complete allowance for the double grooved seam/joint will be four times the width of the folded edge plus four times the thickness of the metal.

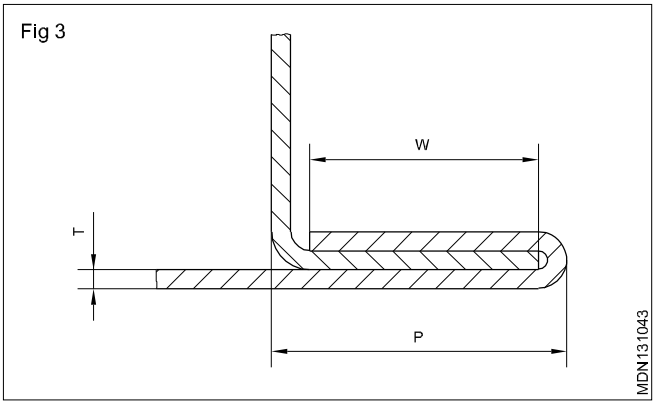
Allowance for paned down and knocked-up joints (Figs 3 & 4)

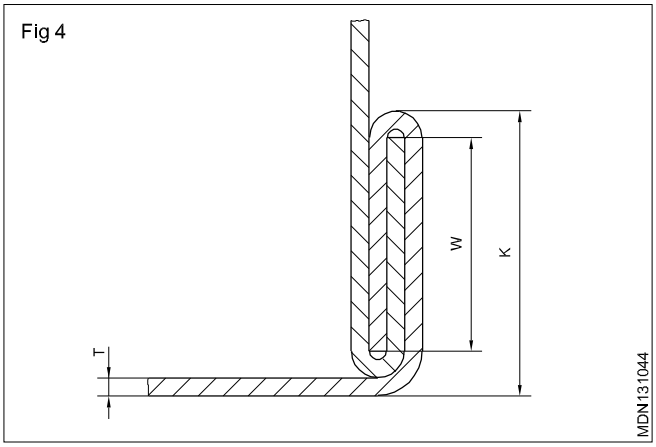
The size of paned down and knocked-up joints is determined by the width of the single folded edge.

'P' represents the size of the paned down joint and 'K' represents the size of the knocked-up joint.

P = 2W + 2T

K = 2W + 3T





Groovers

Objectives : At the end of this lesson you shall be able to
- **state what is a groover**
- **state the sizes of groovers**
- **state the uses and application of groovers.**

Any seam in sheet metal should be locked or closed properly for effective functioning. Otherwise the joint will be a failure.

What is a groover?

A groover is a hand tool used for closing and locking of seams in sheet metal work.

The end of the tool is recessed to fit over the lock making the grooved seams.

Sizes (Figs 1 & 2)

Groovers are available in various sizes viz.3mm, 4mm, 5mm etc.

Generally a groover 1.5 mm wider than the width of the fold is used.

For thicker materials, a groover 3 mm larger than the width of the fold is used.

The width of the groove is stamped on the tool body.

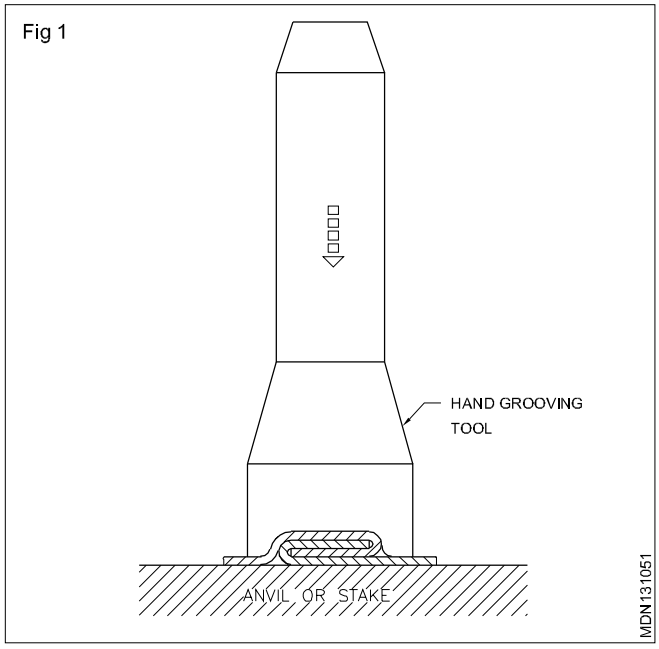
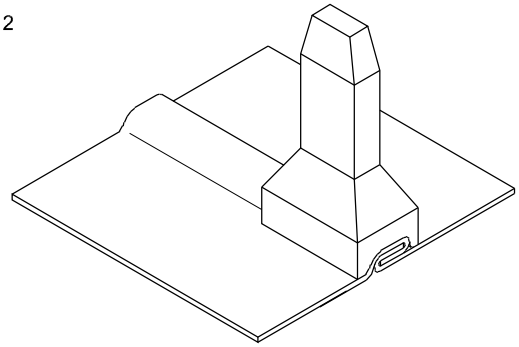


Fig 2



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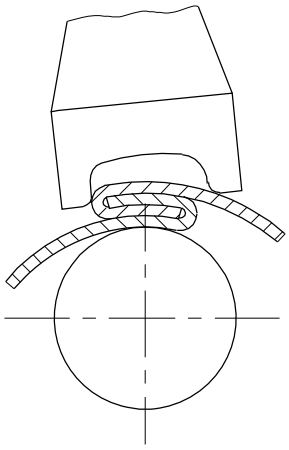
Closing and locking (Figs 3, 4 & 5)

Fig 3



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First the joint is held in position and then it is closed with a mallet.

Then the groover is placed over the closed end of the joint. The groover is positioned at a very slight angle. The edge of the joint acts as a guide to the groover position.

The grooving operations are repeated for the other end of the joint.

The joint is locked working along the joint in stages.

The seam is tightened using a mallet or a light planishing hammer.

Failure to lock the joints in stages with the end of the groover will result in bite marks along the joint.

Using too small groover will mark the metal and prevent locking.

Fig 4

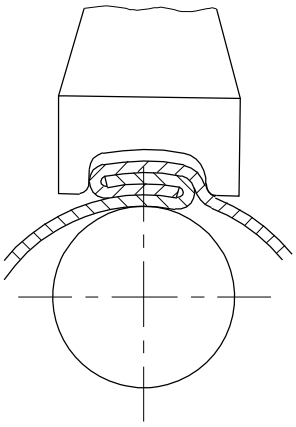

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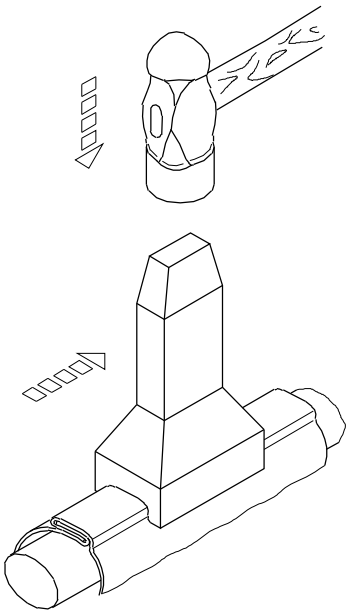
Fig 5



MDN131055

Standard wire gauge

Objectives : At the end of this lesson you shall be able to

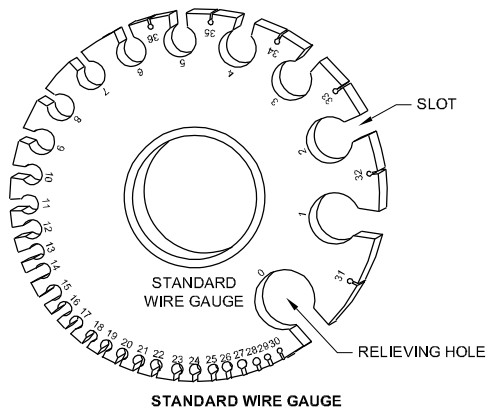
- **state the use of the standard wire gauge**
- **state some important hints in using standard wire gauge**
- **state the metal thickness in mm for the given gauge numbers.**

The job drawing indicates only gauge or thickness of the meet to be used. Before starting the work identify the correct thickness of the sheet. The thickness of the sheet is measured with the help of the standard wire gauge.

The gauge consist of a disc shape smoothened steel metal piece with numerous slots around the outside edge. These slots are of various width and correspond to certain gauge number (Fig.1)

Gauge number is stamped on one side of each slot and on the other side, the decimal part of an inch is stamped to show the thickness of the sheet and the diameter of the wire.

Fig 1



STANDARD WIRE GAUGE

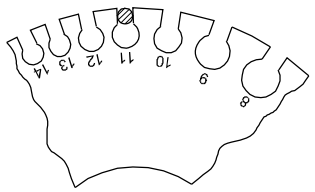
MDN131061

Thickness of the sheet is checked by inserting the edge of the sheet in the appropriate slot of the standard wire gauge.

Wire diameter is checked by inserting the wire only in the slot, and not in the circle (Fig.2)

Higher the SWG gauge number lessen the thickness of the sheet.

Fig 2



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Following is the table showing the thickness in inch and mm corresponding to the gauge No.

Table for G.No.to inches and mm

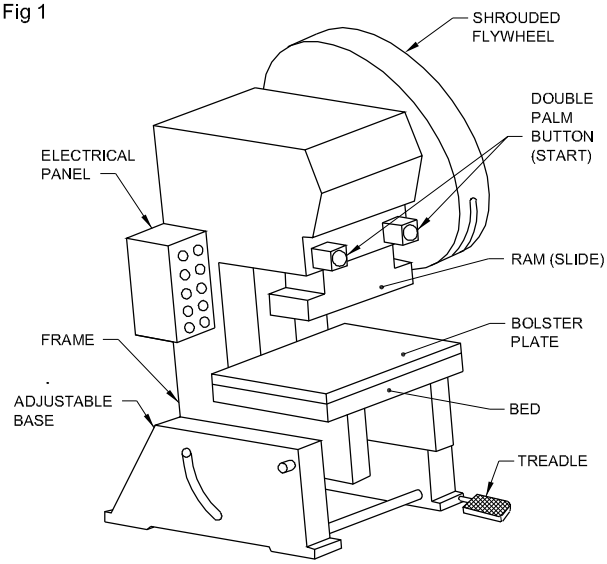
No. of the gauge	Approx. Th. in inch	Approx. Th. in mm	No. of the gauge	Approx. Th in inch	Approx Th. in mm
00	.3437	8.729	18	0.480	1.257
0	.3125	7.937	19	.0418	1.118
1	.2812	7.142	20	0.359	0.996
2	.2656	6.846	21	0.329	.886
3	.2391	5.895	22	.0299	.794
4	.2321	5.895	23	.0269	.707
5	.2092	5.312	24	.0230	.629
6	.1943	4.935	25	.0179	.498
7	.1793	4.770	26	.0179	.498
8	.1644	3.988	27	.0164	.443
9	.1495	3.551	28	.0149	.396
10	.1280	3.175	29	.0135	.353
11	.1196	2.827	30	.0120	.315
12	.1046	2.517	31	.0109	.276
13	.0897	2.240	32	.0101	.256
14	.0747	1.994	33	.0093	.236
15	.0673	1.775	34	.0085	.251
16	.0640	1.587	35	.0073	.185
17	.0538	1.412	36	.0070	.177

Sheet metal shearing, drawing, squeezing .

Objectives : At the end of this lesson you shall be able to
- **state the constructional features of the power press**
- **name the different types of power presses**
- **state and explain the different operations that can be performed on the power press**
- **state the safety precautions while working in the press shop.**

The constructional feature of the power press is almost similar to that of a fly press or hand press. (Fig 1) Except that the ram is driven by power. The power presses may be identified as Mechanical or Hydraulic, according to the type of working mechanism used to transmit power to the ram. In a mechanical press, the rotary motion of the electric motor is converted into a reciprocating motion of the ram by using various mechanical devices. In a hydraulic press, the fluid under high pressure is pumped on one side of the piston and then to the other side in a hydraulic cylinder to drive the reciprocating movement. The power presses are designated according to the power sources, Frame construction, Number of slides in action.

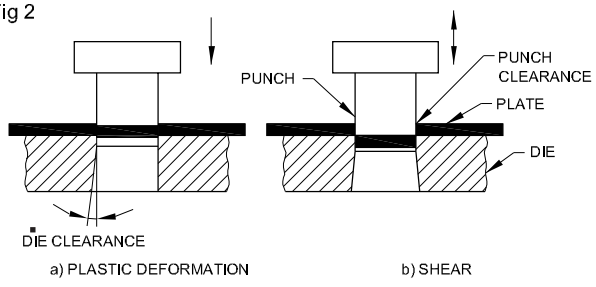
Fig 1



POWER PRESS

Power press operations (Fig 2)**:** The press operations are classified based on the operations performed.

Fig 2

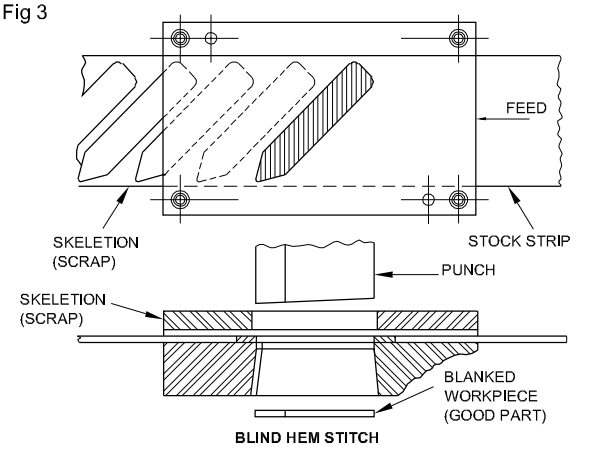


SHEARING OPERATION

Shearing : Shearing is an operation of cutting sheet metal with the help of a punch and die on a power press. The sheet is placed on the die and when the punch descends on the metal, it causes a rupture and forces the metal to be severed and ram the sheet metal. As the clearance between the punch and die is very small it forces the metal to drop down from the die opening.

a) Blanking (Fig 3)**:** Blanking is an operation of producing a flat component from a strip of sheet metal. The metal cutout is the required component and the sheet with the cut on the die is the scrap. In blanking, the size of the blank is governed by the size of the die and the clearance is left on the punch.

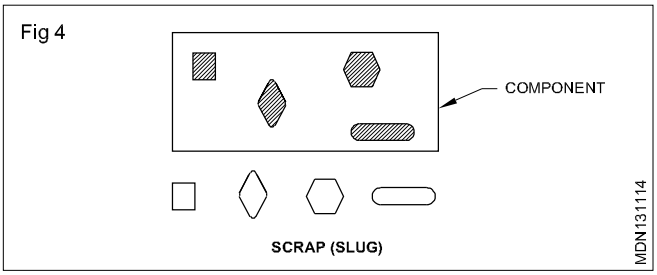
Fig 3



BLIND HEM STITCH

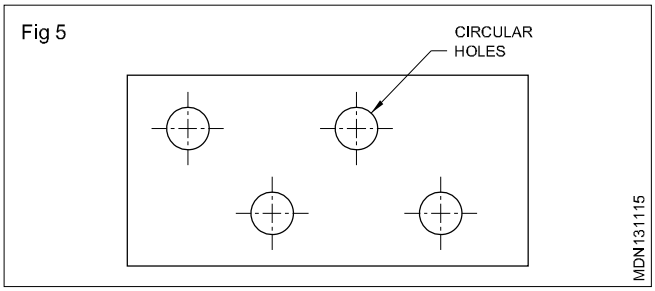
b) Piercing (Fig 4)**:** Piercing is an operation of making a cutout on a component. The cutout can be of any shape. The material punched out which comes out of the die is the scrap and the metal with the cutout which is on the die is the component. The punch governs the size of the cutout and the clearances is provided on the die.

Fig 4



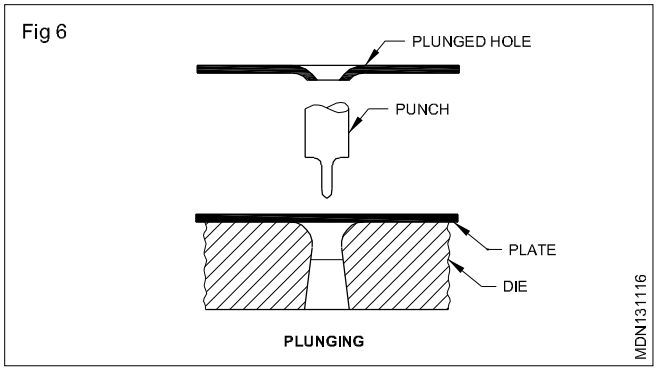
c) Punching (Fig 5)**:** Punching is an operation of punching out circular holes. The difference between punching and piercing is that this cutout made by piercing can be of any shape. But in punching only circular holes are made. The size of the hole is governed by the size of the punch and the clearance is provided on the die. (Fig. 4)

Fig 5



d) Perforating (Fig. 6)**:** Perforating is an operation of punching circular holes in a regular pattern or evenly spaced. Metal this is done by dimpling operation where the metal will be punched and a dimpling tool will be kept at the extreme of the hole and using a hammer the forming will be completed to accommodate the heads of countersunk screws and countersunk rivets.

Fig 6



PLUNGING

Drawing: Drawing is the operation of producing cup shaped articles from flat sheet metal blanks. The blank is placed on the die and while the punch comes down, the pressure pad holds the blank firmly on the die. As the punch further comes down the metal blank is pushed into the die opening and the metal is made to flow down the die plastically to form the sides of the cup. The pressure pad avoids the formation of wrinkles developed while forming. The size of the blank required to draw out a cup can be calculated by the formula given below.

D = O d2 +4dh

Where D = The diameter of the blank

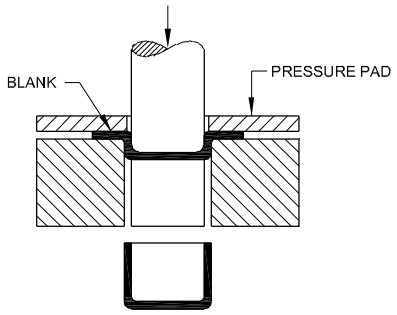
d = The diameter of the cup

h = The height of the cup

a) Cupping (Fig. 7)**:** Cupping is the operation of forming cup shaped articles by drawing operation.

Squeezing: Squeezing operation is the most sever of all cold press operations. More pressure is required to squeeze the metal into the cavity of the die and punch to get the required shape. Hydraulic presses are most suited for this operation.

Fig 7

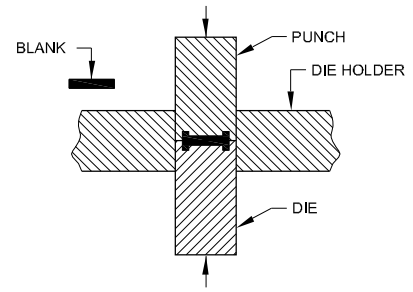


DRAWING OPERATION

b) Coining (Fig. 8)**:** Coining is the operation of producing coins, medals or other ornamental work. The metal having good plasticity and correct size is places into the tool and pressure is applied on the tool form both ends.

Compressive load the metal flows under severe and fills into the cavity of the punch and die. The component gets sharp impression on both sides according to the engravings on the punch and die.

Fig 8

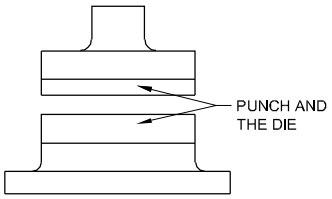


COINING

c) Embossing: Embossing is the operation of forming impressions of figures, letters or designs on sheet metal. The punch or the die or both of them may have the design engraved on them which are formed on the sheet metal by squeezing and with the plastic flow of metal.

Flattening or Planishing (Fig. 9)**:** Flattening or Planishing is the operatioin of straightening the curved or bent sheet metal parts, on a press using a planishing tool.

Fig 9



PLANISHING PUNCH AND DIE SET UP

Bending Sheet Metal

Objectives : At the end of this lesson you shall be able to

- **state what is a bend radius**
- **state the need for a bend radius**
- **state what is a spring back**
- **state the factors governing spring back.**

Bending sheet metal neutral line (Figs 1, 2 & 3)

Fig 1

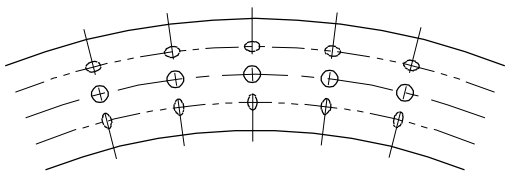


Fig 2

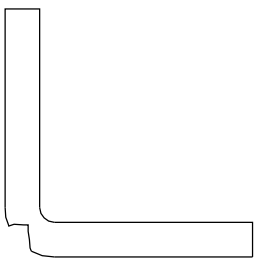
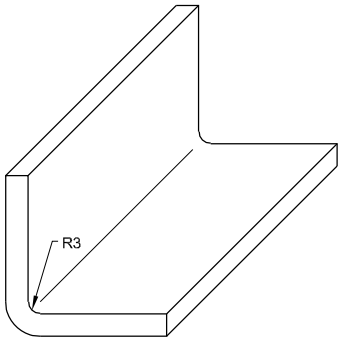


Fig 3



When a sheet metal is bent the plane (or line) Where neither extension nor contracton occurs but only a bend takes place, is called the neutral plane (or line).

While performing a bend, if the inside of the sheet is not rounded, the outside of the sheet will be much pulled. In order to avoid it, the sheet is often bent after providing the radius as shown in the (Fig 3).

The radius of the roundness is called the bend radius.

Least bend radius

The radius of the least roundness with which the sheet can be bent without occurances of a crack in the outside of the bend is called the least bend radius.

The least bend radius varies depending on the :

- material
- thickness
- direction of the plate
- working temperatures. etc.

Table 1 gives the least bend radius generally used.

Where the material is soft and the bend line is at right angle to the rolling direction of the sheet, a small value is used, and where the metal is hard and the bend line is parallel with the rolling direction, a higher value is used.

Table 1

Least bend radius

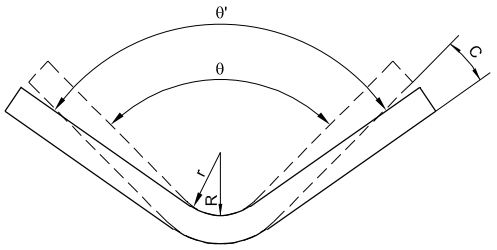
Material	Least bend radius R
Cold rolled steel plate	t x (0 - 0.5)
Semi-hard steel plate	t x (0.3 - 1.5)
(C 0.35 - 0.40%)	
Sheet of copper group	t x (0 - 2.0)
Brass/Aluminium sheet	t x (0 - 1.0)
Soft Aluminium	t x (1.0 - 2.5)
Duralumin	t x (2.0 - 4.0)

Plate thickness

What is spring back (Fig. 4)

When a sheet of steel is bent, if the bending force is removed, a part of the elastic deformation returns to the original state of the material before deformation. This phenomenon is called spring back.

Fig 4



Factors governing spring back

The spring back varies depending on the :

- material
- thikness of the sheet
- system of working
- bend radius
- bending pressure, etc.

It is difficult to calculate the accurate degree of spring back. When the job is actually performed, the sheetis experimentally bent and the pressure adjusted so that an accurate bend angle can be made after allowing for the spring back.

Manual Bending

Objectives : At the end of this lesson you shall be able to
- **state the function of the folding bar**
- **state the method of bending a sheet over the hatchet stake**
- **define a hand seamer and its function**
- **state the method of bending by a fly press.**

Folding bars (Fig 1 & 2)

The sheet metal to be bent is clamped in the folding bar. The folding line coincides with the top of the folding bar. The folding bar clamped in the vice as shown in the figure. While tightening the vice, pull the projecting part of the folding bar towards yourself to prevent the sheet from dropping from the bars, in most cases a wooden or rubber mallet is used for bending at right angles with bending bar.

Fig 1

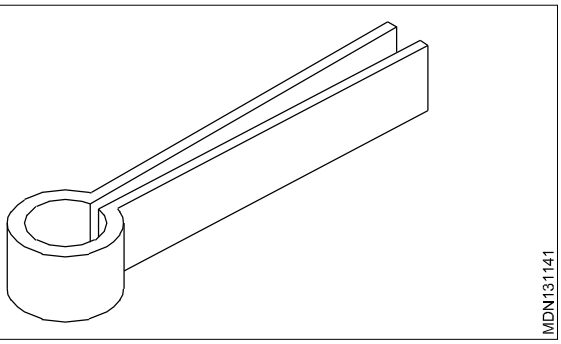
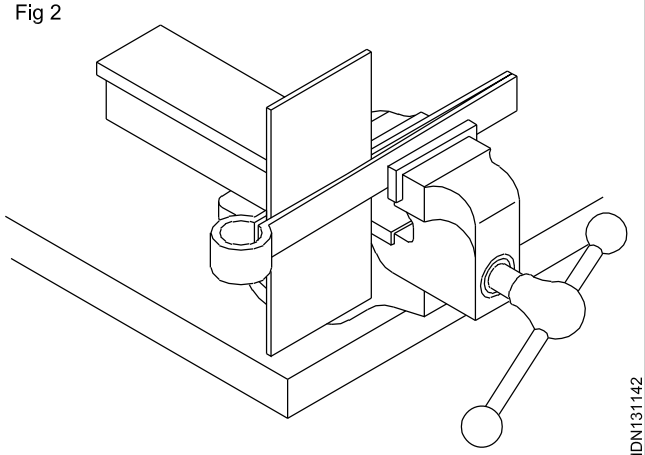


Fig 2



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Bending over hatchet stake (Fig 3 & 4)

The folding line is to coincide with the edge of the stake, and the sheet pressed with both the hands and hammered for the required bend.

Fig 3

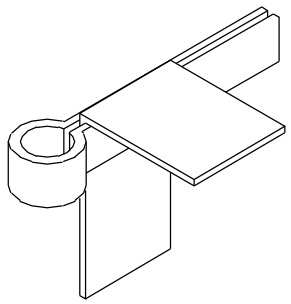

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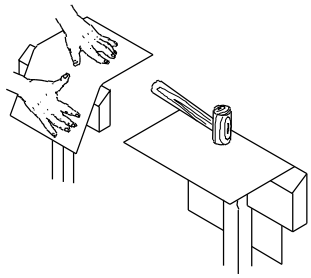
Fig 4



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Another method of bending is shown in the figure. The work is clamped to the edge of the bench by means of a piece of hardwood and two `C' clamps (Fig. 5). Then the projecting parts of the plate can be folded downwards.

If folding bars are not available, two pieces of angle iron (Fig. 6) can be used. The ends are clamped together by means of a `C' clamp.

For bending narrow edges (Fig. 7) on small pieces of sheet, for eg. if seams must be folded, a hand seamer can be used.

Fig 5

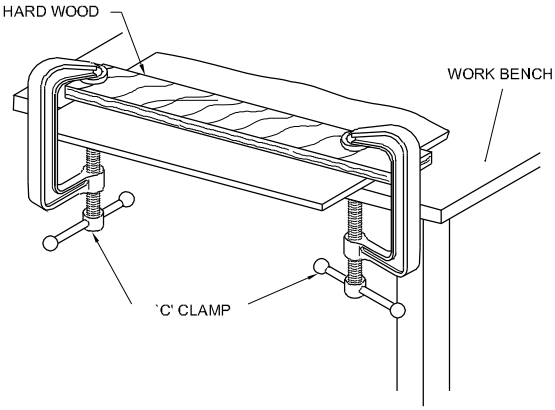

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Fig 6

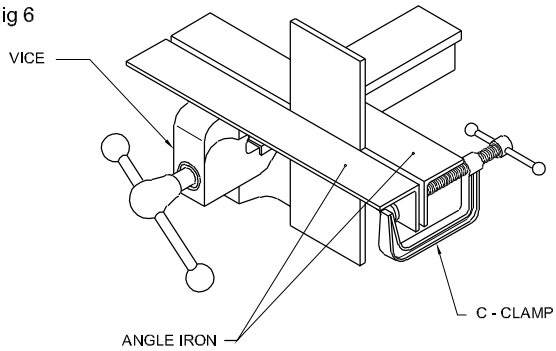

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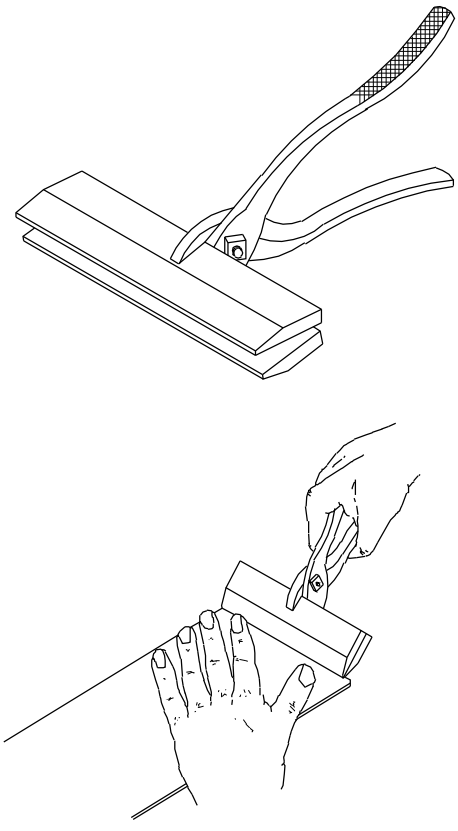
Fig 7



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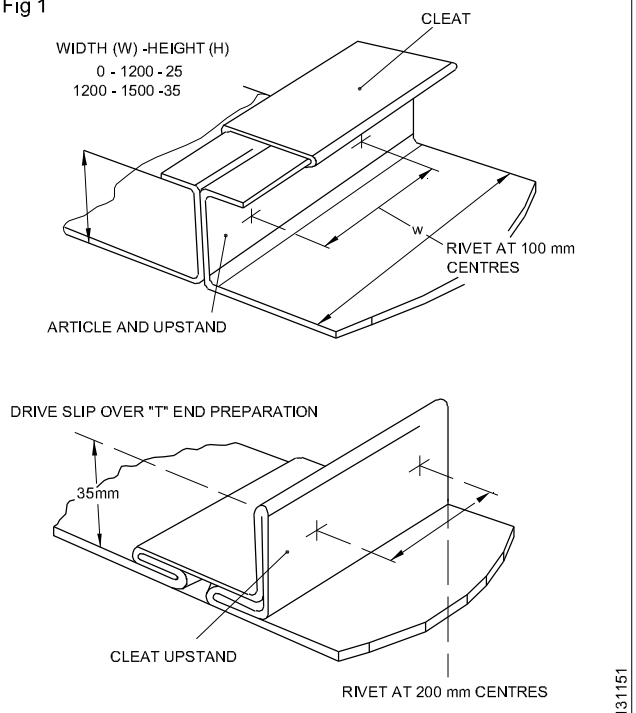
Bending metals to an angle

Objectives : At the end of this lesson you shall be able to
- **state the methods of bending rods and pipes in a bench vice**
- **state the methods of bending rods and pipes with a fixture.**

Bending is a process of shaping materials without cutting.(Fig.1)

Fig 1



Different methods are used for bending rods, sheets and pipes.

Bending on vice

Work is held in the vice and bent with hand force or with a hammer according to the diameter of the rod or the thickness of the sheet. (Fig. 2) A hammering block (Fig 3 and 4) is used to prevent hammer marks and also to direct the force at the correct place.

Fig 2

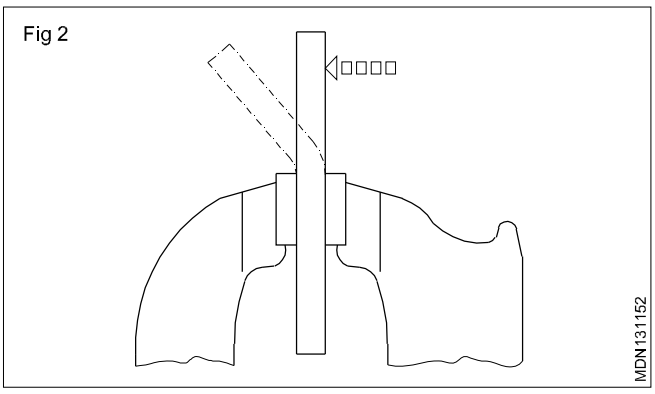


Fig 3

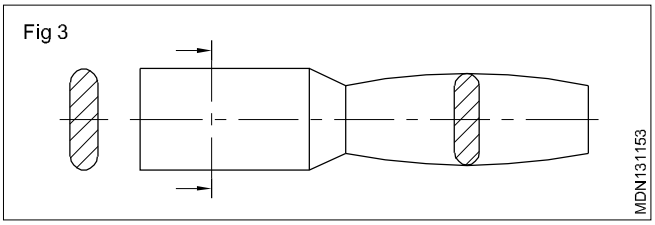
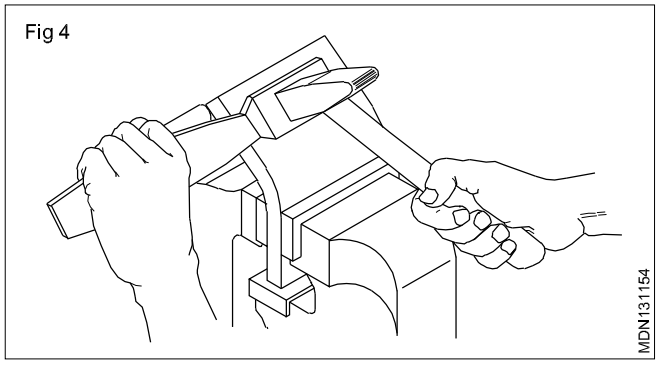


Fig 4



Bending using bending jaw or bending block

To form bends to a required radius on workpieces, bending jaws or bending blocks are used (Figs 5 and 6)

Fig 5

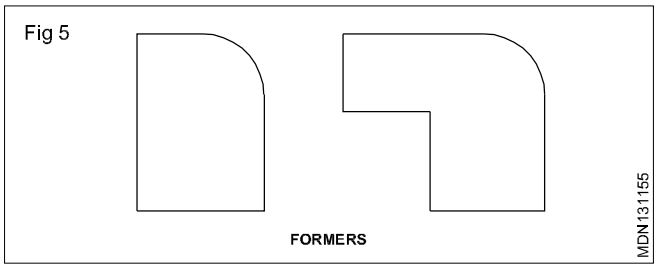
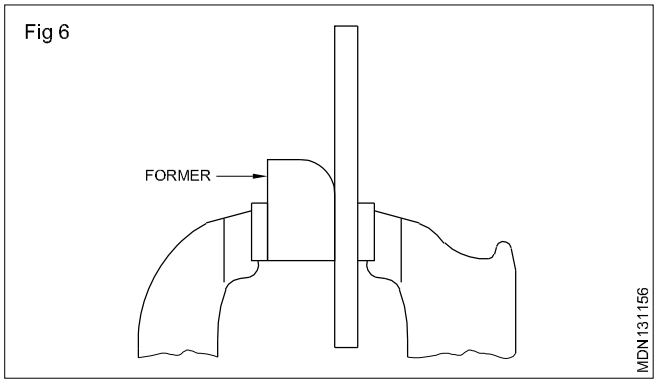
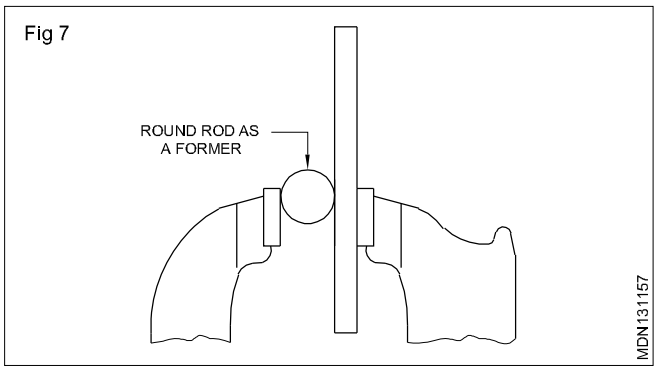


Fig 6



Round rods are also used sometimes for forming radius on sheets or rods (Fig 7)

Fig 7



Bending with fixtures (Figs 8, 9 & 10)

A bending fixture can be prepared and used when a large number of workpieces is required to be bent (Fig 8a and 8b)

Fig 8

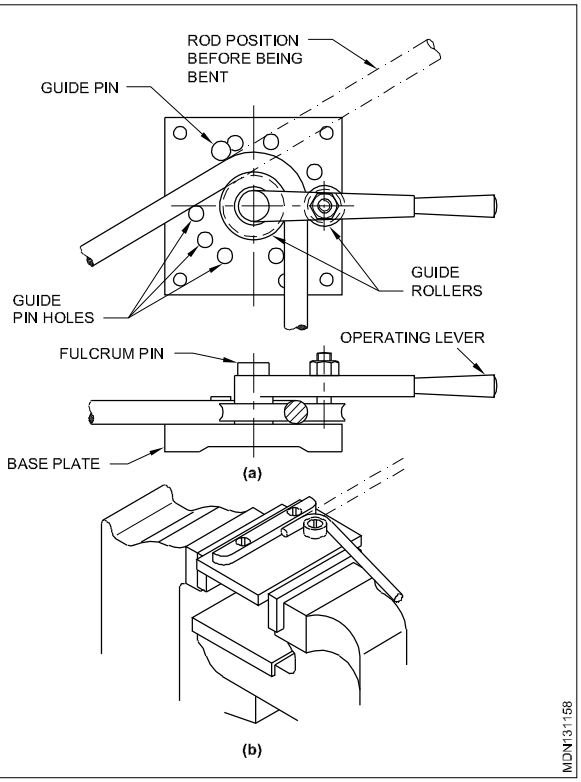
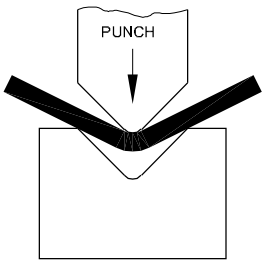


Fig 9



BENDING DIE

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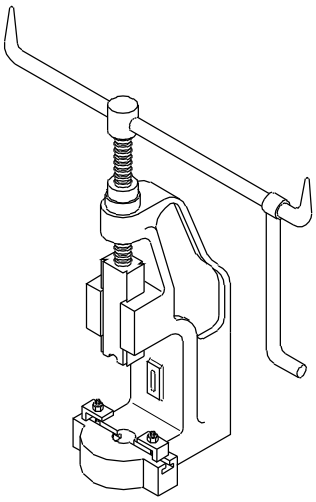
Fig 10



FLY PRESS

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Pipe bending machines

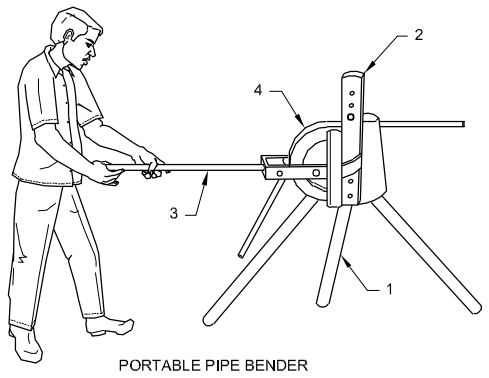
Objectives : At the end of this lesson you shall be able to
- **name the three most common pipe benders**
- **differentiate their constructional features**
- **name the parts of bending machines**
- **state the uses of bending machines.**

There are some situations in plumbing jobs, where it is preferable to bend a pipe rather than use a pipe fitting.

The most common pipe benders are listed here.

Portable hand operated pipe bending (Fig.1)

Fig 1



PORTABLE PIPE BENDER

The portable hand-operated pipe bender consists of the following parts.

1 Tripod stand

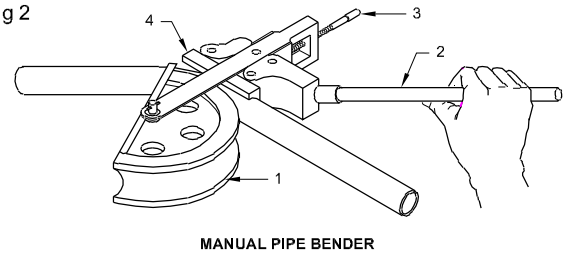
2 Pipe stop lever

3 Handle or lever

4 Inside former

Bench type hand operated pipe bender (Fig 2)

Fig 2



MANUAL PIPE BENDER

This consists of the following parts. It is used for bending galvanized iron and steel pipes.

1 Inner former

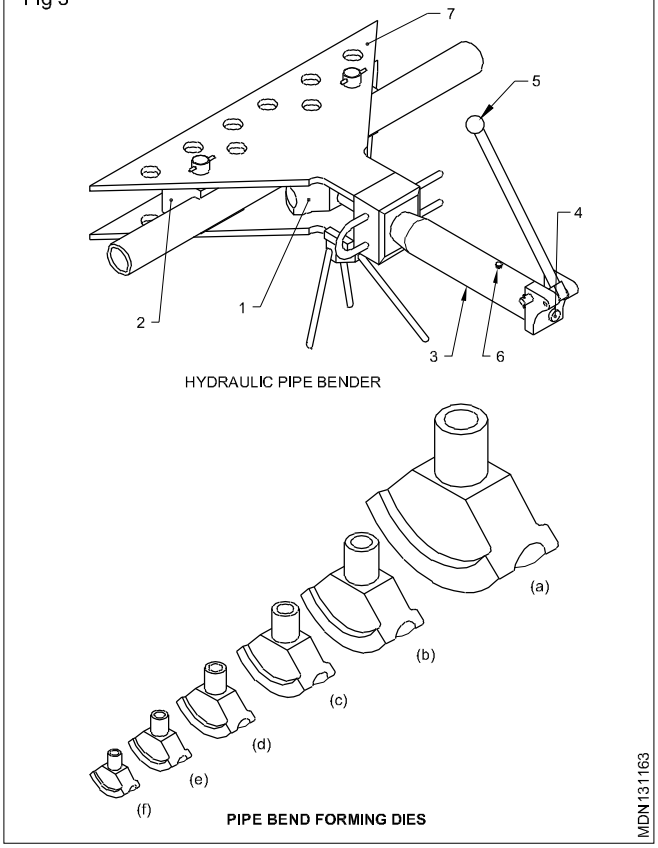
2 Lever or handle

3 Adjusting screw with lock nut

4 Pipe guide

Hydraulic bending machine (Fig 3)

Fig 3



This machine can be used bending G.I. and M.S. pipes without sand filling to any direction.

It consists of the following the parts.

1 Inner former

2 Back former

3 Hydraulic ram

4 Pressure release valve

5 Operating lever

6 Bleed screws

7 Base plate.

Inner formers are interchangeable and are able to bend pipes up to 75 mm diameters (Figs 3a, b, c, d, e & f)

Pipes and pipe fittings

Objectives : At the end of this lesson you shall be able to
- **state the uses of pipes**
- **name the common types of pipes**
- **list the standard pipe fittings and state their uses.**

Various types of pipes and tubes are used for the following purposes.

- Domestic hot and cold water supplies
- Waste water outlets
- High pressure steam supplies.
- Hydraulic oil supplies
- Lubricating oil supplies
- Special fluid and gases for industrial processes.
- Pneumatic systems
- Refrigeration systems
- Fuel oil supplies

The common types of pipes classified according to material are:

- galvanized iron pipes
- mild steel pipes
- C.I. soil pipes
- copper pipes
- aluminum pipes
- brass pipes
- lead pipes
- P.V.C. pipes
- rubber pipes
- plastic pipes
- stoneware pipes

Standard pipe fitting: Pipe fittings' are those fittings that may be attached to pipes in order to:

- change the direction of the pipe
- connect a branch with a main water supply pipe
- connect two or more pipes of different sizes
- close the pipe ends

Standard Pipe Fittings

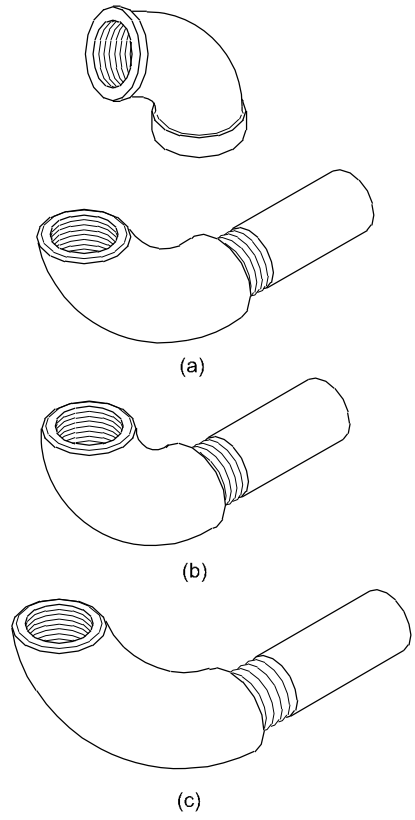
Elbows (Fig 1**):** Elbows and bends provide deviations of 90 and 45o in pipe work systems.

Long radius elbows have a radius equal to 1 1/2 times the bore of the pipe (Fig 1a)

Short radius elbows have a radius equal to the bore of the pipe. (Fig 1b)

The 45° elbows allow pipe deviation of 45° (Fig 1c)

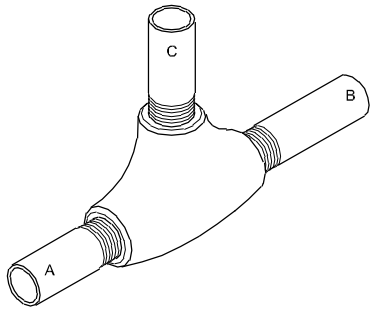
Fig 1



Tee branch: A tee joint helps the pipe line to branch off at 90°. The branches may be equal in diameter or there may be one reducing branch.

Dimensions of a branch are always quoted as A x B x (Fig 2)

Fig 2



Reducing tee branch : Reducers are fitted where a change in pipe diameter is required (Fig 3)

Eccentric reducer : Used mainly in horizontal position (Fig 4)

Fig 3

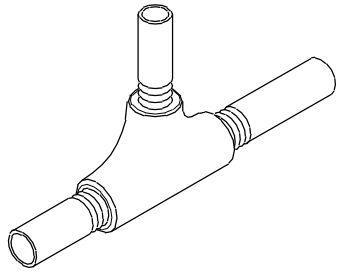


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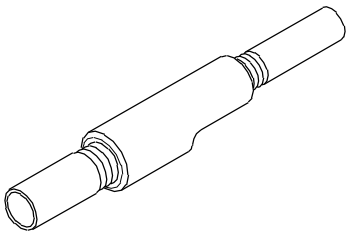
Fig 4



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Concentric reducer : Used mainly in vertical position (Fig5)

Caps: Caps are used for closing the end of a pipe or fitting which has an external thread. (Fig 6)

Plug: A plug is used for closing a pipeline which has an internal thread (Fig 7)

Fig 5

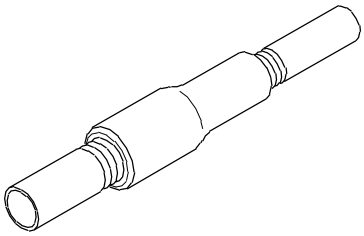

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Fig 6

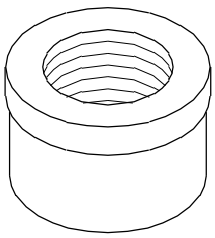

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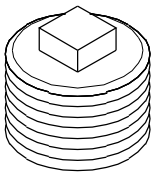
Fig 7



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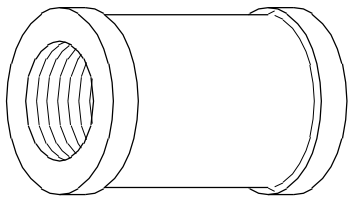
Coupling: (Fig 8) A coupling is used to connect two pipes. Couplings have internal threads at both ends of fit the external threads on pipes.

Fig 8



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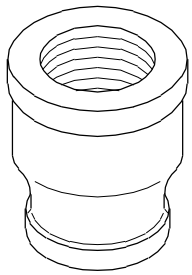
Reducer (Fig 9)**:** A reducer coupling is used to connect two pipes with different diameters.

Fig 9



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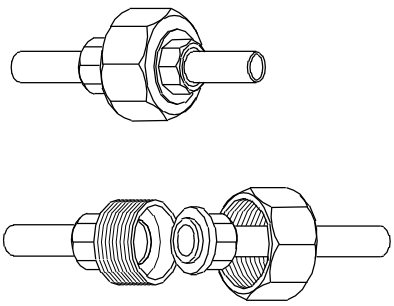
Union : A device used to connect pipes. Unions are inserted in a pipe line to permit connections with little change to the position of the pipe. (Fig10)

When unions are used in pipe lines, it is easy to dismantle and repair.

Pipe nipples (Figs 11, 12, 13 & 14)**:** Pipe nipples are tubular pipe fittings used to connect two or more pipes of different sizes

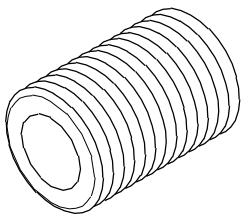
Fig 10



MDN13117A

Close nipple (Fig 11)

Fig 11



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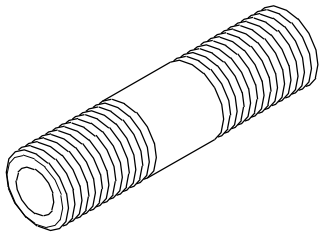
Short nipple (Fig 12)

Fig 12



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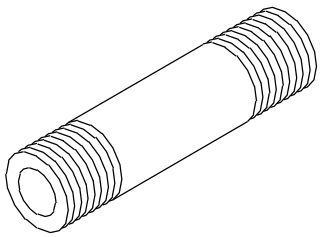
Long nipple (Fig 13)

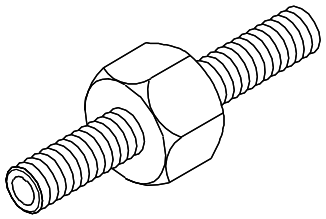
Fig 13



MDN13117D

The hexagonal nut (Fig 14)**:** The hexagonal nut in the centre of the nipple is for tightening with a spanner or wrench (Fig 14)

Fig 14



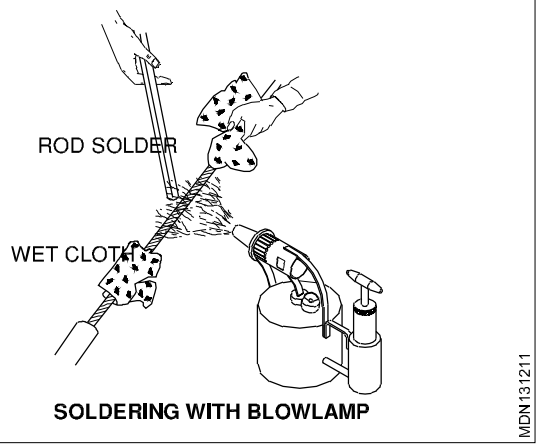
MDN13117E

Blow lamp

Objectives : At the end of this lesson you shall be able to
- **state the constructional feature of blow lamp**
- **name the parts of blow lamp**
- **describe the operation of blow lamp.**

Blow lamp (Fig 1)**:** the kerosene is pressurized to pass through pre-heated tubes, thus becoming vaporised. The kerosene vapour continues through a jet to mix with a air and when ignited directed through a nozzle, producing a forceful flame.

Fig 1



SOLDERING WITH BLOWLAMP

The flame within the housing provides the heat to maintain vaporisation of the kerosene. The free flame at the nozzle outlet is used to heat the soldering bit.

Blow lamp is a portable heating appliance used as a direct source of heat for soldering irons or other parts to be soldered. Fig.1 shows parts of blow lamp.

It has an tank made of brass, filler cap is fitted at its top to fill kerosene. A pressure relief valve is connected to the mouth to switch ON/OFF and control the flame.

Priming trough is provided for filling mentholated spirit for lighting the blow lamp. Set of nozzle is provided to direct the kerosene vapor to produce forceful flame. Burner housing is mounted on support brackets on which soldering iron is placed for heating as shown in figure.

Pump is provided to pressurise the kerosene in the tank.

Flux

Objectives : At the end of this lesson you shall be able to
- **state the criteria for the selection of fluxes**
- **distinguish between corrosive and non-corrosive fluxes**
- **name the different types of flux and their application.**

Fluxes are non-metallic materials which are used at the time of soldering.

Functions of flux

- Flux removes oxides from the soldering surface.
- It prevents corrosion.
- It helps molten solder to flow easily in the required place.
- It promotes the wet surface.

Selection of flux

The following criteria are important for selecting a flux.

- Working temperature of the solder
- soldering process
- materials to be joined

Classes of flux

Flux can be classified into corrosive flux, and non corrosive flux

Corrosive flux in acid form is corrosive and should be washed immediately after the soldering operation is completed.

Non-corrosive flux is in the form of lump, powder, paste or liquid.

DIFFERENT TYPES OF FLUX

Hydrochloric acid

Concentrated hydrochloric acid is a liquid which fumes when it comes into contact with air. After mixing with water, 2 or 3 times the quantity of the acid, it is used as dilute hydrochloric acid.

Hydrochloric acid combines with zinc forming zinc chloride and acts as a flux. So it cannot be used as a flux for sheet metals other than zinc, iron or galvanised sheets.

Zinc chloride

It is mainly used for soldering copper sheets, brass sheets and tin plates.

As it is extremely corrosive, the flux must be perfectly washed off after soldering.

Ammonium chloride

This is the form of powder or lump. It evaporates when heated.

Ammonium chloride is used as a flux for soldering steel.

A solution of a mixture of hydrogen chloride, zinc chloride and ammonium chloride is used as a flux for stainless steel sheets.

Resin

As resin is not very effective for removing oxidation coating, and, as it is not highly corrosive, it is used as flux for copper and brass. Resin melts at about 80° to 100°C.

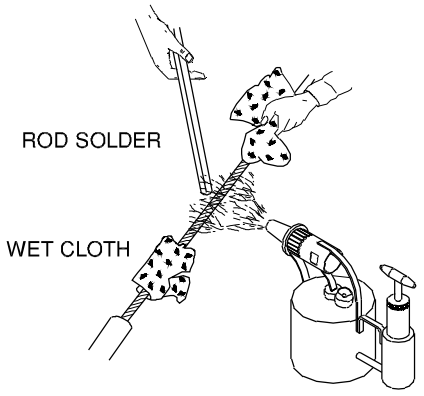
Paste

This is a mixture of Zinc chloride, resin, glycerin and others and is available as a paste.

As it is effective for removing oxidation coating, it is used for soldering small handworks and radio wiring.

Soldering with blowlamp

Fig 1



SOLDERING WITH BLOWLAMP

Soldering with a blowlamp is done when the heat capacity of a soldering iron is not sufficient.

The method, shown in Fig 1, permits rapid heating and is used primarily for larger jobs, such as piping and cable work, vehicle, body repairs and some applications in the building trade.

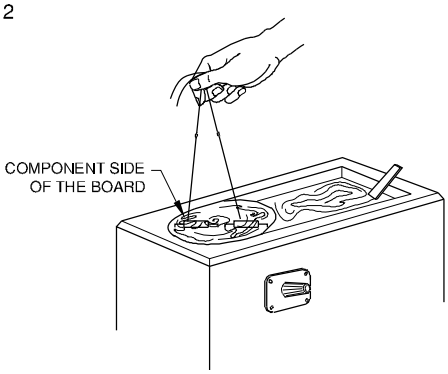
This requires skillful management of the flame.

Dip soldering

This method, shown in Fig 2, is used for bulk production and for tinning work similar to component soldering on printed Circuit Boards (PCB). Components to be soldered or tinned are dipped into a bath of molten solder, which is heated electrically. The solder is kept in motion by an agitator in order to obtain an even temperature and to keep the surface free from oxides. If no agitator is provided, the surface must be protected or skimmed at regular intervals to remove the oxides.

The temperature can be controlled very accurately.

Fig 2

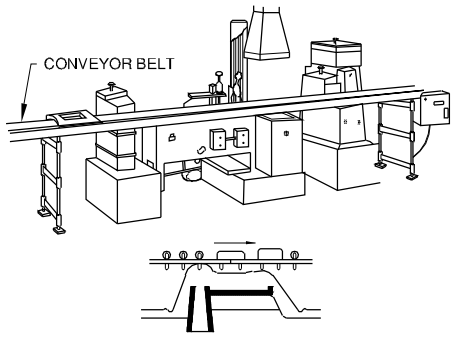


DIP SOLDERING

Machine soldering

The method, shown in Fig 3, is used for quantity production and is based on the principle, when molten solder is set in rapid motion, the oxide film breaks without setting on the surface. The solder comes into direct contact with the components to be soldered.

Fig 3



MACHINE SOLDERING

Soldering machines are of different designs for wave soldering, cascade soldering and jet soldering.

Equipment for machine soldering is expensive and the cost of production is high.

Accurate temperature control can be arranged.

Brazing Techniques

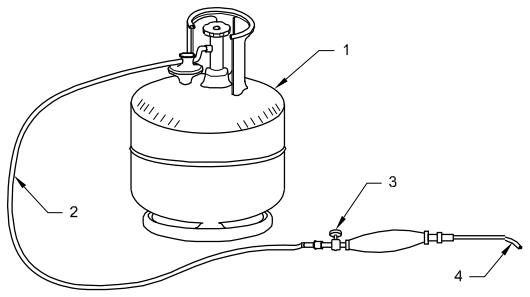
Objectives : At the end of this lesson you shall be able to
- **explain the brazing technique**
- **Study copper to copper pipe brazing swaged joint**
- **Studies braze copper with MS tube**

Brazing techniques

Acetylene torch (Fig 1): (Danger: Acetylene is very inflammable, Do not allow anyone to smoke while you are brazing)

- Connect the torch with a flexible hose to the gas regulating valve of the acetylene cylinder; make sure that all of the connections are tight to prevent gas leakage. Check all connections for leaks with soap water before lighting the torch.

Fig 1



ACETYLENE TORCH

- Open the cylinder valve one turn, only. Open the regulating valve fully. Open the torch control valve just enough to give a flow of gas. Light the escaping gas at the tip of the torch.
- Adjust the torch control valve to get the correct flame. The flame should be blue. It should have a sharp bright cone in the middle with pale outer flame. If the flame is yellow more gas is required. open the control valve.
- The size of the torch tip or nozzle determines the size of the inner cone. use a cone size that gives the required amount of heat.

Propane turbo torch (Fig 2): (Danger: Propane is very inflammable. Do not allow anyone to smoke while you are brazing)

- This gives a smaller outside flame. The tip of the inner cone is much hotter than an acetylene flame of the same size. Always work with a smaller flame than acetylene.
- Connect, adjust and use this torch in the same way as acetylene described above, check all connections for gas leaks with soap water before lighting the torch.
- Follow exactly the instruction supplied with the torch.

1 This is the cylinder that holds the gas for brazing

2 Check the connections for leaks at each end of this hose with soap water.

3 Use the torch control valve to control the gas flow.

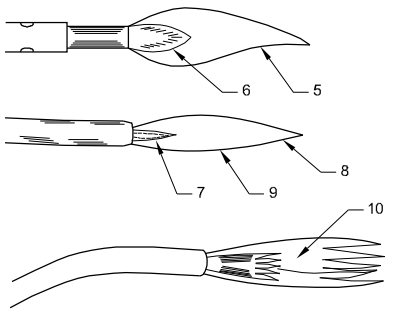
4 Fit a torch tip which gives the correct flame.

5 This is an acetylene flame suitable for pipe brazing

6 The bright cone is the hottest part of the flame work with the tip of the cone.

7 The high bright cone is the hottest part of the flame with the tip of the cone

Fig 2



TURBO TORCH

8 This is an acetylene flame suitable for capillary tube brazing required.

9 The other flame should be pale yellow. If it is yellow,

10 This is a propone turbo torch flame. The end tractions will tell you what size of flame of use.

Kerosene blow lamp

- This gives a larger flame than a propane or acetylene torch.
- When lighting, follow carefully the instructions supplied with the torch. Wherever possible light the blow lamp in an open space for safety.

Silver brazing: One of the best method of connection copper pipes after swaging or by the use of coupling, in a leak proof manner is by silver brazing,. By this method the copper pipes can be connected to the compressor, service valves and the other parts also.

Silver brazing can be easily done if the correct procedure is followed.

Clean the inside and outside of the tube end using sand paper of wire brush. Fit the joint closely and support the joint. Apply flux required for the brazing rod. (Flux is used to prevent chemical action during heating the metal. The flux used for soldering refrigeration fittings is made of alcohol and resin.

There are various silver alloys in the market. The rod used to join copper pipes is called copper to copper brazing rod'. These have 35 to 45 percent silver content. This material melts at 1120°F and flows 1145°F

Precautions: Do not apply the solder at the joint if it is not red hot

Any oxy-acetylene torch is excellent heat source for silver brazing. While using blow lamp the joint is to be heated longer time.

To join copper pipe to steel pipe and any pipe to the compressor dome only oxy acetylene torch can be used. This torch can also used for refrigerator cabinet patch work.

While brazing keep away the flame from rubber plastic parts and insulating materials of the refrigerator or AC.

The pipes joined by brazing can be separated by heating it again.

Flux: Flux is a substance which works as an agent help the solder to flow easily. It cleans the surface and prevents oxidation. Melting point of flux is much less than that of solder.

Various types of flux and their uses are given below.

Ammonium chloride NH_4CI - For soldering cast iron

Hydrochloric acid HCL - For soldering G.I sheets

Zinc chloride $ZnCI_2$ - For soldering mild iron sheets

Tallow - For soldering lead and electrical joints

Resin - For soldering electrical joints

Phosphoric - For soldering stainless steel

Braze a copper tube with swaged joint

Fit two pipes to braze. If it is a loose fit the joint will be weak. Insert the end of one pipe into the swage of the other. Apply a small amount of flux to the surfaces to be joined, with the help of blow torch heat the joint. The brazing rod must be meted by the heat. Complete ring of brazing material can be seen at the end of the swage remove the torch and allow the joint to cool.

Braze copper with ms tube: In most tube and fitting connections are made by either soldering or silver brazing. Soldering joints are used for water pipes and drains. silver brazed joint are used for refrigerant pipes and rubbing.

The best methods of making leak proof connection while providing maximum strength is to silver braze the joints. These joints are very strong and will stand up under the most extreme temperature condition.

An oxyacetylene torch is an excellent heat source for silver brazing. The proper silver brazing temperature will be indicated by the colour of green shade.

Electricity principles

Objectives: At the end of this lesson you shall be able to
- **describe an atom**
- **describe electricity**
- **describe electron flow**
- **describe conductors**
- **describe insulators**
- **describe semlconductors**
- **describe shielding.**

Introduction

Electricity is one of today's most useful sources of energy. Electricity is of utmost necessity in the modern world of sophisticated equipment and machinery.

Electricity in motion is called electric current. Whereas the electricity that does not move is called static electricity.

Examples of Electric current

- Domestic electric supply, industrial electric supply.

Examples of static electricity

Shock received from door knobs of a carpeted room. Attraction of paper of the comb.

Structure of matter

To understand electricity, one must understand the structure of matter. Electricity is related to some of the most basic building blocks of matter that are atoms. All matter is made of these electrical building blocks, and, therefore, all matter is said to be 'electrical'.

Matter is defined as anything that has mass and occupies space. A matter is made of tiny, invisible particles called molecules. A molecule is the smallest particle of a substance that has the properties of the substance. Each molecule can be divided into simpler parts by chemical means. The simplest parts of a molecule are called atoms.

Basically, an atom contains three types of sub-atomic particles that are of relevance to electricity. They are the electrons, protons and neutrons. The protons and neutrons are located in the centre, or nucleus, of the atom, and the electrons travel around the necleus in orbits.

Atomic Structure

The Nucleus

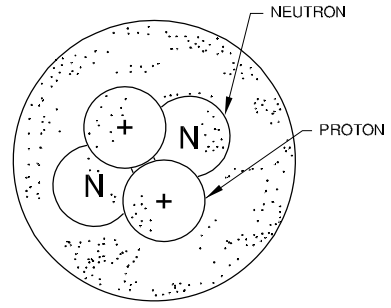
The nucleus is the central part of the atom. It contains the protons and neutrons of an atom as shown in Fig 1

Protons

The proton has a positive electrical charge. (Fig 1) It is almost 1840 times heavier than the electron and it is the permanent part of the nucleus; protons do not take an active part in the flow or transfer of electrical energy.

Electron

Fig 1

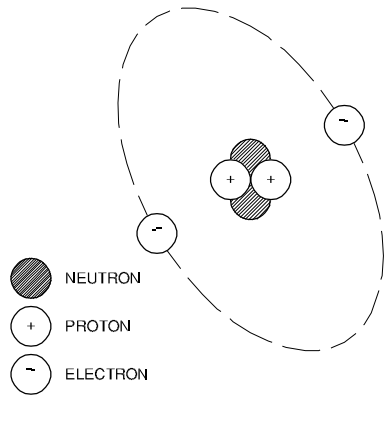


NUCLEUS OF AN ATOM

It is a small particle revolving round the nucleus of an atom as shown in (Fig 2). It has a negative electriccharge. The electron is three times larger in diameter than the proton. In an atom the number of protons is equal to the number of electrons.

Neutron

Fig 2



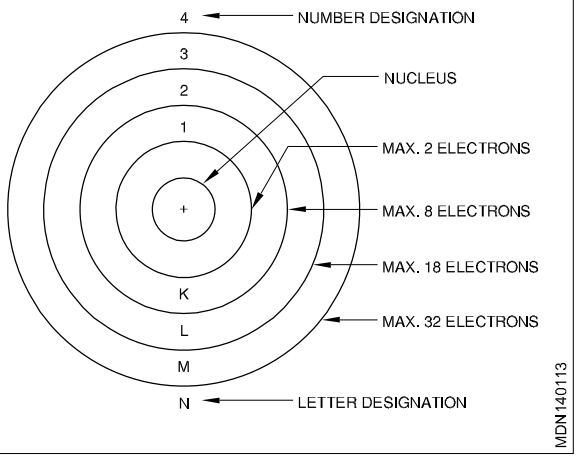
A neutron is actually a particle by itself, and is electrically neutral. Since neurtons are electrically neutral, they are not too important to the electrical nature of atoms.

Energy Shells

In an atom, electrons are aranged in shells around the nucleus. A shell is an orbiting layer or energy level of one or more lectrons. The major sheel layers are identified by numbers of by letters starting with 'K' nearest the nuclues and continuing alphabetically outwards. There is a

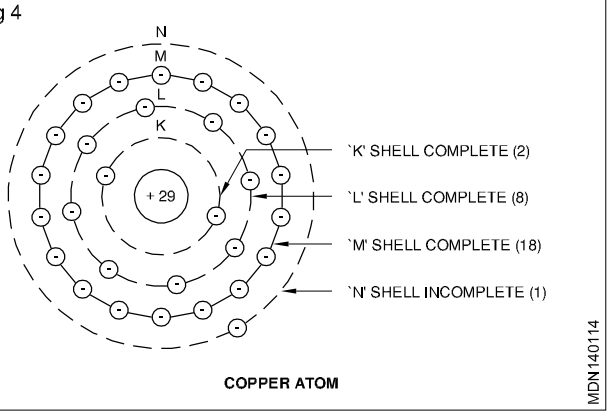
maximum number of electrons that can be contained in each sheel. (Fig 3) illustrates the relationship between the energy shell level and the maximum number of electrons it can contain.

Fig 3



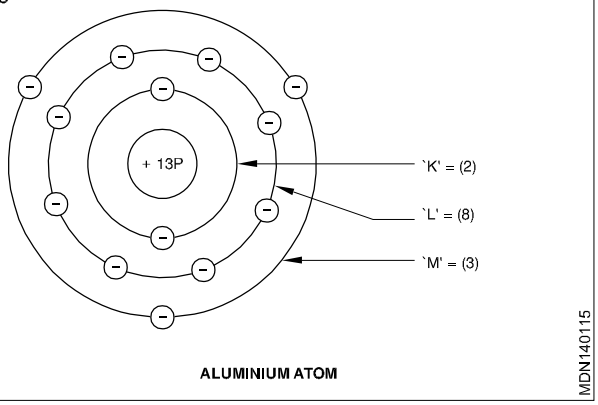
If the total number of electrons for a given atom is known, the placement of electrons in each shell can be easily determined. Each shell layer, beginning with the first, is filled with the maximum number of electrons in sequence. For example, a copper atom which has 29 electrons would have four sheels with a number of electrons in each shell as shown in (Fig 4).

Fig 4



Similarly an aluminium atom which has 13 electrons has 3 shell as shown in (Fig 5).

Fig 5



Electron distribution

The chemical and electrical behaviour of atoms depends on how completely the various shell and sub-shells are filled.

Atoms that are chemically active have one electron more or one less than a completely filled shell. Atoms that have the outer shell exactly filled are chemically inactive. They are called inert elements. All inert elements are gases and do not combine chemically with other elements.

Metals possess the following characteristics

- They are good electric conductors.
- Electrons in the outer shell and sub-shells can move more easily from one atom to another.
- They carry charge through the material.

The outer shell of the atom is called the valence shell and its electrons are called valence electrons. Because of their greater distance from the nucleus, and because of the partial blocking of the electric field by electrons in the inner shells, the atrracting force exerted by nuclues on the valence electrons is less. Therefore, valence electrons can be set free most easily. Whenever a valence electron is removed from its orbit it becomes a free electron. Electricity is commonly defined as the flow of these free electrons through a conductor. Though electrons flow from negative terminal to positive terminal, the conventional current flow is assumed as from positive to negative.

Conductors Insulators and Semicondutors

Conductors

A conductor is a material that has many free electrons permitting electrons to move through it easily. Generally, conductors have incomplete valence shells of one, two or three electrons. Most metals are good conductors.

Some common good conductors are Copper, Aluminium, Zinc, Lead, Tin, Eureka, Nichrome, Silver and Gold.

Insulators

An insulator is a material that has few, if any, free electrons and resists the flow of electrons. Generally, insulators have full valence shells of five, six or seven electrons. Some common insulators are air, glass, rubber, plastic, paper, porcelain, PVC, fibre, mica etc.

Semiconductors

A semiconductor is a material that has some of the characteristics of both the conductor and insulator. Semiconductor have valence shells containing four electrons.

Common examples of pure semiconductor materials are silicon and germanium. Specially treated semiconductors are used to produce modern electronic components such as diodes, transistors and integrated circuit chips.

Earthing and its importance

Objectives : At the end of this lesson you shall be able to
- **describe the necessity of earthing**
- **describe the reasons for system and equipment earthing**.
- **describe shielding**

Necessity of earthing

While working in electrical circuits, the most important consideration for an Electrician is the safety factor - safety not only for himself but also for the consumer who uses the electricity.

Earthing the metal frames/ casing of the electrical equipment is done to ensure that the surface of the equipment under faulty conditions does not hold dangerous potential which may lead to shock hazards. However, earthing the electrical equipment needs further consideration as to ensure that the earth electrode resistance is reasonably low to activate the safety devices like earth circuit leakage breaker, fuses and circuit breakers to open the faulty circuit, and thereby, protect men and material.

Earthing of an electrical installation can be brought under the following three categories.

System earthing

Equipment earthing

Special requirement earthing

System earthing

Earthing associated with current - carrying conductors is normally essential to the safety of the system and it is generally known as system earthing.

System earthing is done at generating stations and substations.

Equipment earthing

This is a permanent and continuous bonding together (i.e. connecting together) of all non-current carrying metal parts of the electrical equipment to the system earthing electrode.

'Equipment earthing' is provided to ensure that the exposed metallic parts in the installation do not become dangerous by attaining a high touch potential under conditions of faults. It is also carry the earth fault currents, till clearance by protective devices, without creating a fire hazard.

Special requirements for earthing

'Static earthing' is provided to prevent building up of static charges, by connections to earth at appropriate locations. Example, operation theatres in hospitals.

'Clean earth' may be needed for some of the computer data processing equipments. These are to be independent of any other earthing in the building.

Earthing is essentially required for the protection of buildings against lightning.

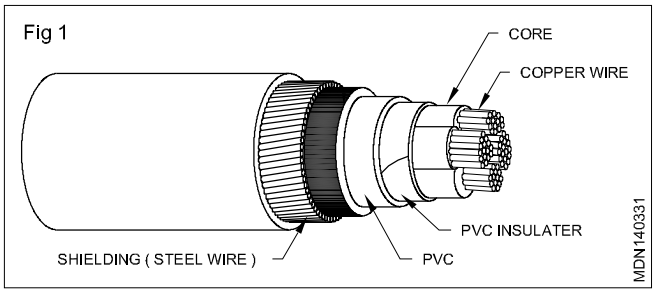
Reasons for earthing

An electric shock is dangerous only when the current flow through the body exceeds beyond certain milliampere value. In general any current flowing through the body beyond 5 milliamperes is considered as dangerous.

Shielding

Shielding is the (Fig 1) protective device layer over the insulated cable.

Fig 1



Uses

- It act as earth/ground for the electrical appliances.
- It protect the cables from moisture entering as well as flexible.
- It also act as mechanical strength as well as flex ible to the cables.
- It protect the cable from all whether condition like water, oil, grease and heat.

Neutron

A neutron is actually a particle by itself, and is electrically neutral. Since neutrons are electrically neutral, they are not too important to the electrical nature of atoms.

Ohm's Law

Objectives: At the end of the lesson you shall be able to
- **describe an atom**
- **describe electricity**
- **describe electron flow**
- **describe conductors**
- **describe insulators**
- **describe semiconductors.**

Electrical terms and definitions EMF and Pd

The force tending to make electrons to move along a conductor is called the potential difference (pd) in the conductor and is expressed in volts. This is also called the electric pressure or voltage.

The voltage developed by a source such as a generator is called as electromotive force. (emf)

When one ampere current flows through one ohm resistance the p.d. across the resistance is said to be one "Volt". Voltmeter is used to measure the voltage of a supply and is connected in parallel to the supply. EMF/Pd is denoted by letter "V".

Current

The flow of electrons is called current. Its unit is ampere. When one volt is applied across a resistance of one ohm the amount of current passess through the resistance is said to be one "Ampere". It is denoted by "A". Smaller units are milliampere and microampere. Ammeter should be connected in series with the load.

Resistance

It is the property of a substance which opposes the flow of electricity. Its unit is ohm. The resistance of a conductor, in which a current of one ampere flows when potential difference of one volt is applied across its terminals, is said to be one ohm.

An ohmmeter is used to measure the resistance of an electric circuit. It is denoted by "Ω" Bigger units are Kilo ohms and Mega ohms.

1 K Ω = 10^3 ohms

1 Mega Ω = 10^6 ohms

Ohmmeter should be connected in parallel with the load and should not be connected when there is a supply.

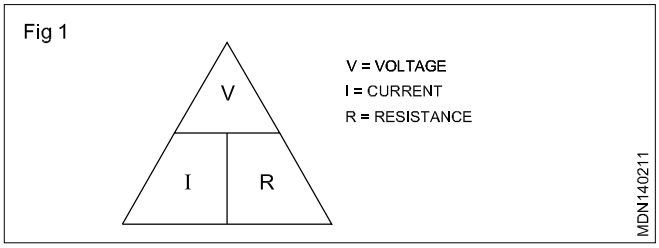
There is a definite relationship between the three electrical quantities of Voltage, Current and Resistance.

Ohm's Law states

`The current is directly proportional to the voltage and inversely proportional to the resistance' when the temperature remains constant.

An aid to remember the Ohm's law relationship is shown in the divided triangle.(Fig 1)

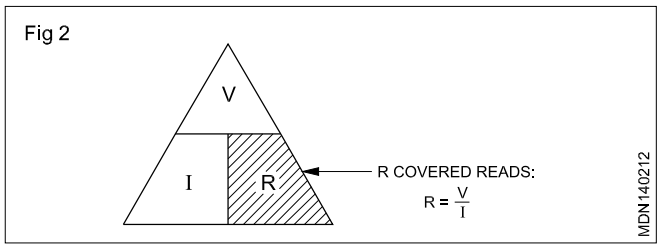
Fig 1



Written as a mathematical expression, Ohm's Law is -

$$\text{Current } (I) = \frac{\text{Voltage } (V)}{\text{Resistance } (R)}$$

Fig 2



$$\text{or } I = \frac{V}{R}$$

Of course, the above equation can be rearranged as:

$$\text{Resistance}(R) = \frac{\text{Voltage } (V)}{\text{Current } (I)}$$

$$\text{or } R = \frac{V}{I}$$ (Refer Fig 2)

Example

How much current(I) flows in the circuit shown in (Fig 3)

Given:

Voltage(V) = 1.5 volts

Resistance(R) = 1 k ohm

= 1000 ohms.

Find:

Current(I)

Known:

$$I = \frac{V}{R}$$

Solution:

$$I = \frac{1.5\ V}{1000\ ohms} = 0.0015\ amp$$

Answer:

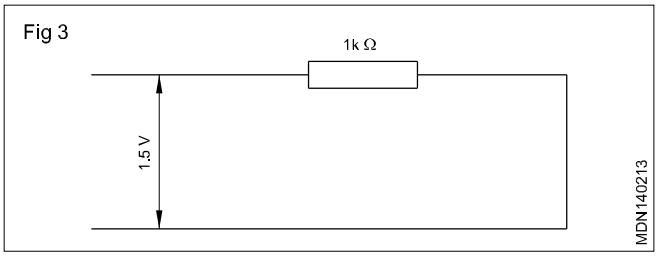
The current in the circuit is 0.0015 A

or

the current in the circuit is 1.5 milliampere (mA).

(1000 milliamps = 1 ampere)

Fig 3



Electrical power (Fig 4)

The rate which work is done in an electric circuit is called electrical power.

When voltage is applied to a circuit, it causes current to flow through it or in other words it causes electrons or charge through it, clearly certain amount of work is being done in moving these electrons in the circuit. This work done in moving the electrons in unit time is called as electrical power, From Fig 4.

V = P.D. across xy in colts,

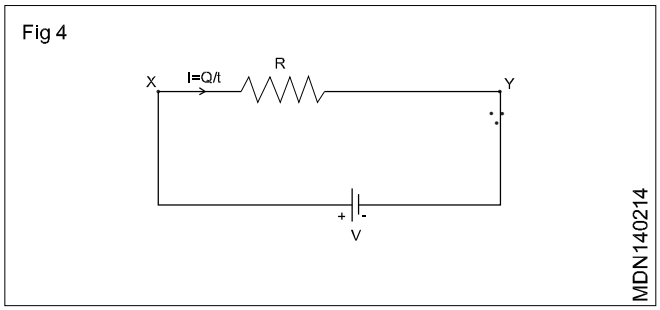
I = Current in amps.

R = resistance between xy in

t = time in sec for which current flows.

The total charge flows in t secs is Q = I X T coulombs

Fig 4



As per earlier definition the P.d, $V = \frac{work}{charge} = \frac{work}{Q}$

$\therefore$ Work = VQ.

= VIt (Q = IT).

$\therefore$ Electrical power $P = \frac{Workdone}{time} = \frac{Vit}{t}$

W = VI joules/secs. (or) watts.

Wattmeter is used to measure the electrical power.

Electrical power in watts = Voltage in volts X current in ampere

The digger units of electric power are kilowatts (KW) and Megawatts (MW).

1 KW = 1000 watts(or) 10^3 watts

1 MW = 1000000 watts (or) 10^6 watts

Electrical Energy: (E)

The total work done in an Electric circuit is called as Electrical Energy.

Electrical Energy = Electrical power X time

= VI X t = VIT

i.e. Electrical power multiplied by the time for which the current flows in the circuit is known as Electrical energy. The meter used to measure electrical energy is energy meter. The symbol for electrical energy is E.

The unit of electrical energy will depend upon the units of electric power and time.

(a) If power is in watts and time is in seconds then the unit of Electrical energy will be watt-sec.

i.e. Electrical energy in watt - secs. = Power in watts Time In secs.

(b) If power is in watts and time is in hours then the unit of Electrical Energy will be watt-hours.

i.e. Electrical energy in watt - hours = power in watts time in hours

(C) If Power is in kilowatts (10 watts (or)1000 watts) and time is in hours then the unit of electrical energy will be kilowatt - hour (Kwh).

i.e. Electrical energy in kwh = power in kilowatt time in hours

In practice the electrical energy is measured in kilowatt-hours (KWh). The electricity bils are made on the basis of total electrical energy consumed by the consumer. 1KWh of electrical energy is called as Board of Trade (B.O.T.) Unit or simply 1 unit. i.e. 1KWh = 1Unit.

Thu when we say a consumer has consumed 75 units of electricity means the electrical energy consumed by the consumer is 75 KWh.

In and Electrical circuit if 100 watts (or) 1Kw of power is supplied for 1 hour then the electrical energy expended is one kilowatt-hour (1KWH) or 1 electrical unit (Or) 1 unit.

1Kwh = 1 Unit	=	power in watts time in sece
	=	Watts, secs (or) joules.
	=	1000 60 60 joules
	=	36 105 joules (or) watt-sec.
1 calorie	=	4. 186 joules (or)
1 kilo calorie	=	4186 joules.
1kwh = calories	=	860009.557
	=	860000 calories = 860 10^3 calories
	=	860 kilo calories.
	∴1 kwh =	860 Kcal.

Identification of AC and DC Meters

AC and DC meters can be identified as follows

1 By the symbol available on the dial / scale.

(a) Direct current

(b) Alternating current

2 By seeing the graduation on the dial / scale

a) If the graduation of dial is uniform throughout, it is a D C meter.

(b) If the graduation of dial is cramped at the beginning and at the end, it is an A.C. meter

3 By seeing the terminals

(a) In the d C meter the terminals are marked with + and– The positive (+) terminal is Red in colour and the negative (–) terminal is Black in colour.

(b) In the A.C. meter there is no marking on the terminals and no difference in colour.

(iii) current :

$I = V / R$

$= P / V$

$= \sqrt{P / R}$

(iv) Voltage :

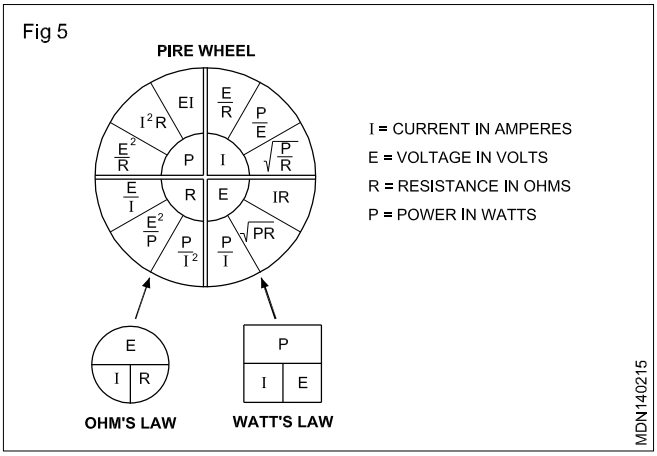
$V = I R$

$= P / I$

$= \sqrt{PR}$

The formulae (or equations) to solve for unkown voltage, current, resistance or power can be obained by combining Ohm's law and Power law. This is shown in (Fig 5).

Fig 5



Basic types of electrical meters

Objectives: At the end of this lesson you shall be able to
- **describe the connection of an ammeter in the circuit**
- **describe resistance symbols used in wiring diagram**
- **state the use of an ammeter**
- **describe the care to be taken of an ammeter**
- **describe the connection of a voltmeter**
- **describe the use of a voltmeter**
- **describe the care to be taken of voltmeters**
- **describe the connection of an ohmmeter**
- **state the use of an ohmmeter**
- **describe the care to be taken of ohmmeters**
- **describe the maintenance of meters**
- **state the simple electric circuit**
- **state the open electric circuit**
- **state the short electric circuit**
- **state the series circuits & parallel circuits**

There are three basic types of meters used to test the electric circuit and accessories. The following meters are used in automobiles.

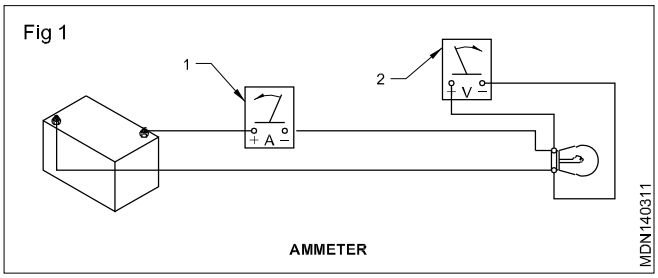
– Ammeter

– Voltmeter

– Ohmmeter

Ammeter (Fig 1)

Fig 1



The ammeter (1) is fitted on the vehicle panel board/ dashboard.

It is connected in series in the circuit as shown in the fig.1.

Uses of ammeter

An ammeter is used to measure the amount of current flowing in the circuit.

This is connected in series with the load.

It is used to indicate the rate at which the battery is being charged or discharged.

Care

Do not connect an ammeter in parallel in the circuit.

Take care of "+" and "-" mark on terminals.

Use DC meter for automobile charging system.

Select and use an ammeter as per the required range.

Voltmeter

A voltmeter (2) is used to measure electrical voltage. It is not fitted permanently on the vehicle but used separately whenever required. It is connected in parallel with the circuit. Use DC voltmeter for automobiles.

Uses of a voltmeter

To measure the voltage at any point of circuit.

To measure the voltage drop in the circuit.

To check the condition of the battery.

Care

Select the voltmeter as per the required range.

Do not connect the voltmeter in series in the circuit.

Ohmmeter (Fig 2)

An ohmmeter (1) is also known as resistance meter.

It is not fitted permanently on the vehicle but is used separately whenever required.

It has its own built-in power source. Hence the device/ circuit being checked with the ohmmeter should be disconnected from the power supply as shown in the figure, to prevent damage to the ohmmeter.

The unit of resistance is an ohm.

Uses of ohmmeter

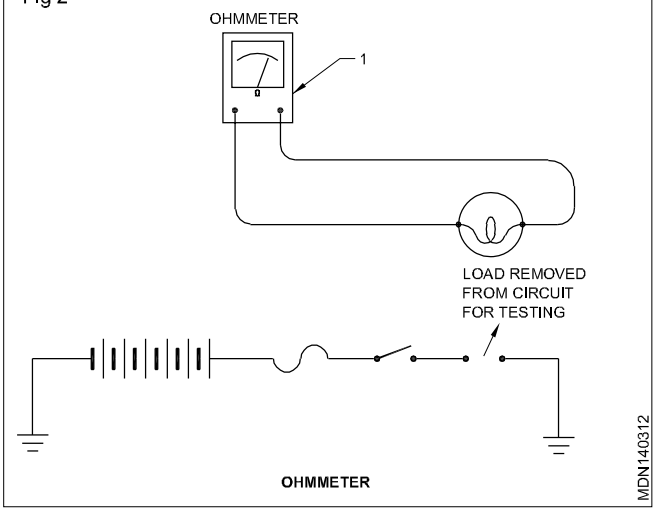
An ohmmeter is used:

– to measure the resistance of any conductor

– to measure the resistance of any load

– to check the continuity of the field coils.

Fig 2



Care

Do not connect an ohmmeter to any part of a live circuit.

Do not connect an ohmmeter across the terminals of a battery.

Maintenance of meters

Handle the meters with care.

Keep the connections tight while the meters are in use.

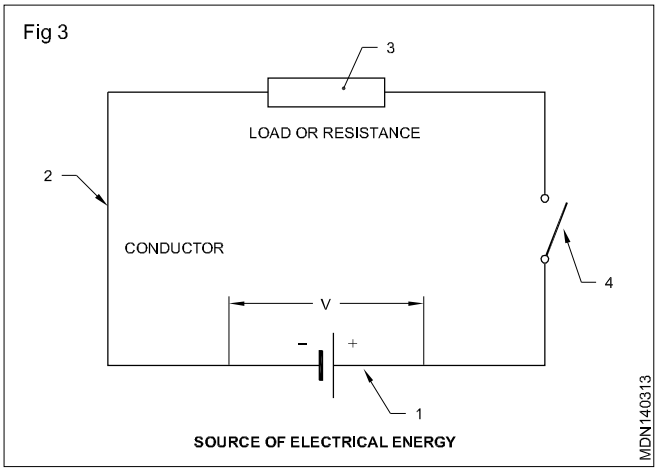
Use the meters within specified loads.

After use, keep the meters in a separate place.

Electrical circuits

Simple electrical circuit (Fig 3)

Fig 3

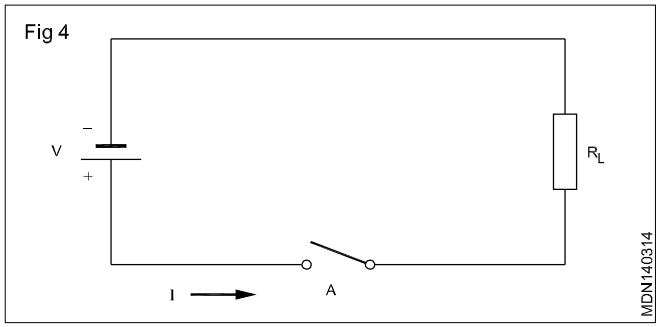


A simple electric circuit is a complete pathway of the current flow from the battery via the switch and load and back to the battery. An electric circuit consists of :

– a voltage source (1)
– connecting wires (conductors) (2)
– a load (lamp or motor) (3)
– switch (4).

Open circuit (Fig 4)**:** In an open circuit, an infinite resistance is provided, most of the time by the open switch (A). Therefore no current can flow.

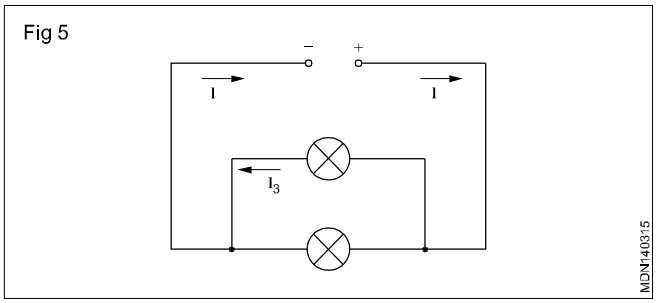
Fig 4



Short circuit : A short circuit will occur when two terminals of the same circuit touch each other. A short circuit may also occur if the insulation between the two cores of the cable are defective. This results in a lower resistance. This causes a large current to flow which can become a hazard.

Parallel circuit (Fig 5)**:** In this circuit two or more loads are connected. Each load is provided with its own path to the source of supply.

Fig 5



Example

A pair of head lights is connected in parallel circuit. When wired in parallel the failure of one bulb will not effect the operation of the other bulb. Each load receives full system voltage.

The formula to calculate resistance in a parallel circuit is:

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

where

I = current
R = resultant resistance
R_1, R_2, R_3 = resistance of each load.

Series circuit : This circuit consists of only one load and one source of supply. It has one continuous path for the flow of current. Hence the current flows through all the load in a sequence in circuit. If any of the parts fails the circuit breaks and the current stops flowing.

$$\text{Resistance}(R) = \frac{\text{Voltage}(V)}{\text{Current}(I)}$$

$$\text{Current}(I) = \frac{\text{Voltage}(V)}{\text{Resistance}(R)}$$

Voltage = Current (I) x Resistance (R)

Types of resistance

Based on the ohmic value of resistance it is grouped as low, medium and high resistance.

Low resistance

Range : 1 Ohm and below.
Uses : Armature winding, ammeter.

Medium resistance

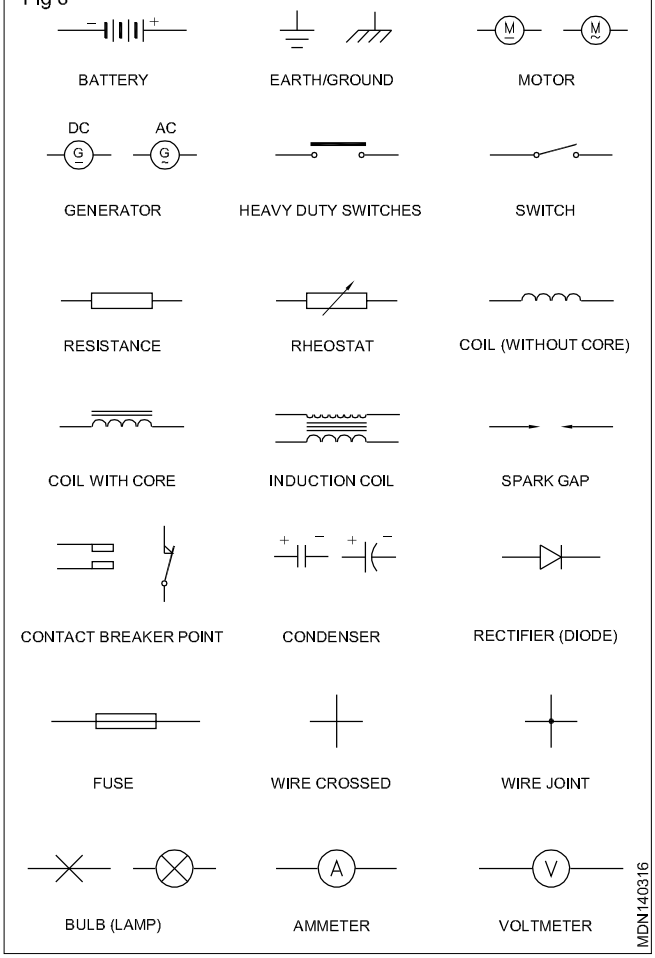
Range : Above 1 Ohm up to 1,00,000 Ohm.
Uses : Bulbs, heaters, relay starters.

High resistance

Range : Above 1,00,000 Ohm (100 k.Ohms).
Use : Lamps.

Electrical symbols used in a wiring diagram (Fig 6)**:** Automotive circuits are generally shown by wiring diagrams. The parts in those diagrams are represented by symbols. Symbols are codes or signs that have been adopted by various automobile manufacturers as a convention.

Fig 6



Multimeter

Objectives: At the end of this lesson you shall be able to

- **state the function of multimeter controls**
- **explain about the dial (scale) of the multimeter**
- **explain about zero adjustment during ohmmeter function**
- **state the function of digital multimeter**
- **state the application of the multimeter**
- **state the precautions to be followed while using a multimeter.**

A multimeter is an instrument in which the functions of an ammeter, voltmeter and ohmmeter are incorporated for measurement of current, voltage and resistance respectively. Some manufacturers call this a VOM meter as this meter is used as volt, ohm and milli ammeter, Multimeters use the basic d' Arsonval (PMMC) movement for all these measurements. This meter has facilities through various switches to change the internal circuit to convert the meter as voltmeter, ammeter or ohmmeter.

There are two major types of multimeters

1 Ordinary multimeters having passive components.

2 Electronic multimeters having active and passive com ponents. An electronic multimeter may be of the analog type or digital type.

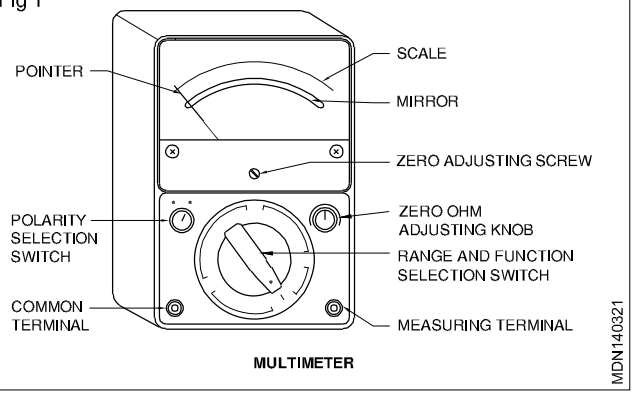
Most of the ordinary multimeters will have a sensitivity of 20k ohms per volt in the voltmeter mode whereas electronic multimeters have internal resistances to the tune of 5 to 10 megohms, irrespective of the selected voltage range.

There are several types of multimeters available in the market, manufactured by various manufactures. Each model differs from the others by the extra facilities available. It is a versatile tool for all automobile. With proper usage and care, it could give service for many years.
Rectifiers are provided inside the meter to convert AC to DC in the AC measurement circuit.

Parts of a multimeter

A standard multimeter consists of these main parts and controls as shown in (Fig 1).

Fig 1

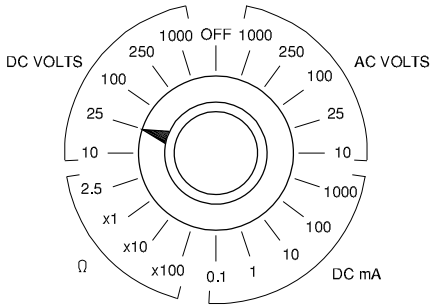


MULTIMETER

Controls

The meter is set to the required current, voltage or resistance range - by means of the range selector switch. in (Fig 2), the switch is set to DC, 25 volts.

Fig 2



FUNCTION AND RANGE SWITCH

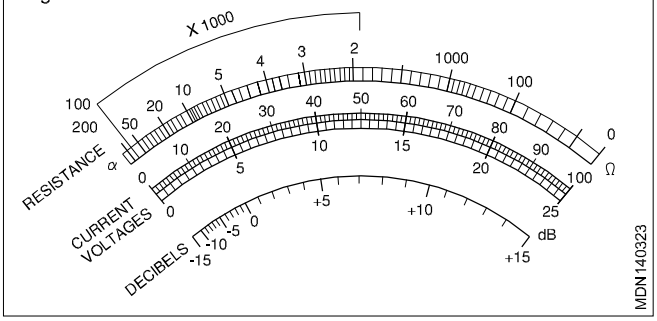
Scale of multimeter

Separate scales are provided for :

- resistance
- voltage and current.

The scale of current and voltage as uniformly graduated (Fig 3)

Fig 3



The scale for resistance measurement is non-linear. That is, the divisions between zero and infinity (α) are not equally spaced. As you move from zero to the left across the scale, the division become closer together.

The scale is usually 'backward', with zero at the right.

Zero adjustment

When the selector switch is in the resistance range and the leads are open, the pointer is at left side of scale, indicating infinite (α) resistance (open circuit). When the leads are shorted, the pointer is at right side of the scale,indicating zero resistance.

The purpose of the zero ohm adjusting knob is to vary the variable resistor and adjust the current so that the pointer is at exactly aero when the leads are shorted. It is used to compensate for changes in the internal battery voltage due to aging.

Multiple range

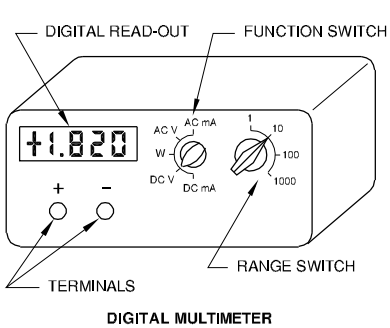
Shunt (parallel) resistors are used to provide multiple ranges so that the meter can measure resistance values from very small to very large values. For each range, a different value of shunt resistance is switched on. The shunt resistance increases for the higher ohm ranges and is always equal to the centre scale reading on any range. These range settings are interpreted differently from those of the ammeter or voltmeter. The reading on the ohmmeter scale is multiplied by the factor indicated by the range setting.

Remember, when a multimeter is set for the ohmmeter function, the multimeter must not be connected to the circuit with the circuit's power is on.

Digital multimeter (DMM)

In a digital multimeter the meter movements is replaced by a digital read - out. (Fig 4) this read-out is similar to that used in electronic calculators. The internal circuitry of the digital multimeter is made up of digital integrated circuits. Like the analog-type multimeter, the digital multimeter has also a front panel switching arrangement. The quantity measured is displayed in the form of a four digit number with a properly placed decimal point. When d quantities are measured, the polarity is identified be means of a + or - sign displayed to the left of the number.

Fig 4



DIGITAL MULTIMETER

Fuse

Objectives: At the end of this lesson you shall be able to
- **state the need of a fuse in the circuit**
- **state the construction of a fuse**
- **list out the types of fuses**
- **describe the working of fuses**
- **describe the circuit with and without a fuse**
- **describe the circuit breakers.**

Introduction

A fuse is a protective device. It is a weakest portion in the electrical circuit.

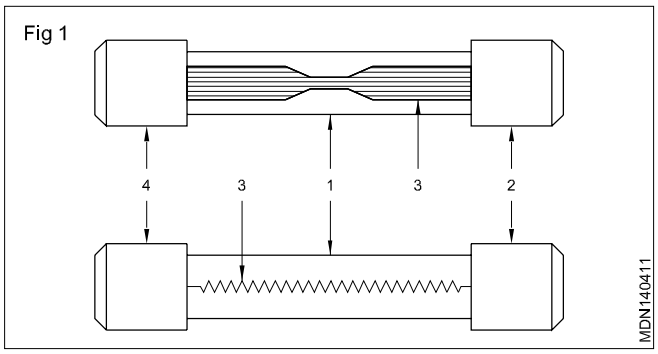
An electric current heats the wire when the current passes through it. The amount of heat depends upon the current and resistance in the wire.

In automobiles, this heating effect is utilized in heaters, bulbs and gauges etc,

The heating effect in the circuit is limited by the fuse. If this limit is not controlled, the circuit of accessories will be overloaded causing severe damage to them.

Purpose of fuse (Fig 1)

Fig 1



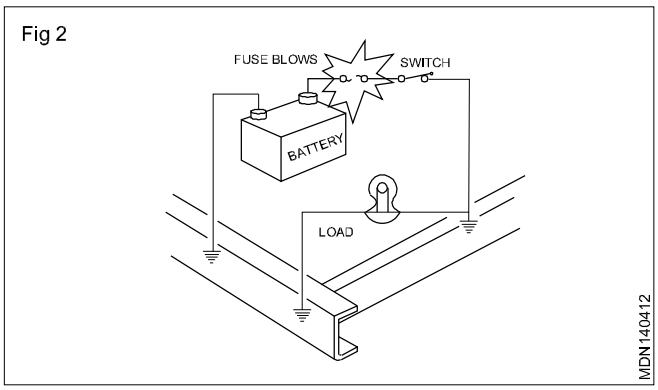
A fuse opens the circuit by blowing out when current (overload) flows in the circuit to prevent severe damage to the accessories.

The flow of excess current in a circuit may be caused by a short circuit.

Construction

Fuse elements are of lead-tin or tin-copper alloy wire in strip of correct amperage for each circuit.

Fig 2



The fuse is assembled in a fuse carrier of glass or ceramic material.

Nowadays fuse elements assembled in glass tubes, called cartridges, are widely used in automobiles.

It consists of a glass tube (1) with metal end caps (2) & (4).

A soft fine wire or strip (3) carries the current from one cap to another (4).

The conductor (3) is designed to carry a specific maximum current.

Working

The current flows through the conductor (3) between two metal caps (2) & (4) and then to the equipment.

If the current value exceeds the limit prescribed on the fuse, the fuse element (3) melts and opens the circuit and prevents the equipment from damage.

Identification of blown fuse

If you look at the burnt fuse and if the element is broken the fuse is burnt due to overloading (Fig 2).

The glass is foggy white or black the fuse is blown out due to short circuit.

Circuits protected with fuse

- Headlight circuit
- Tail - light circuit
- Number -plate circuit
- Panel lamp circuit
- Interior lamp circuit
- Side indicator circuit
- Horn circuit
- Wiper circuit
- Dashboard / panel instruments circuit
- Heater and air conditioner circuit
- Charging circuit
- Radio / Audio / Video circuit

- Cigarette lighter
- Reverse lamp

Circuits without fuse

- Starting circuit
- Ignition circuit
- Fuel pump circuit
- Stop - light circuit
- Oil pressure lamp circuit
- Ignition warning lamp circuit.

Fuse rating and colour

Rating	Colour
3 Amp	Violet
5 Amp	Tan
10 Amp	Red
20 Amp	Yellow
25 Amp	White
30 Amp	Light green

Fusible link and circuit breakers:

Fusible link (Fig 3)

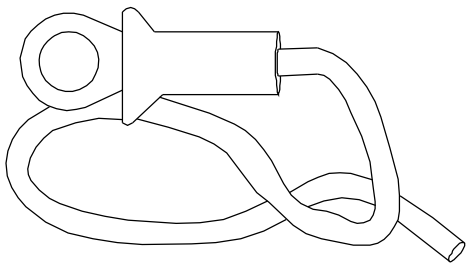
An electrical fusible link is a type of electrical fuse that is constructed simply with a short piece of wire typically four standard wire gauge sizes smaller than the wiring harness that is being protected.

Electrical fusible links are common in high -current automotive applications. The wire in an electrical fusible link is covered with high-temperature fire-resistant insulation to reduce hazards when the wire melts and also encased in special materials that are designed to not catch on fire when exposed to high temperatures.

Fusible links can be found in a variety of places in cars and truck, but they are commonly used in high-amperage applications. Such as starter motors, alternator where load exceeds rated amps.

When this type of fusible link blows, the vehicle will no longer start, but the risks of fire are eliminated.

Fig 3



MDN140413

Circuit Breakers - Automotive

Automotive circuit breakers provide a resettable and reusable alternative over standard fuses for circuit protection, and can altogether replace fuses and fusible links in most applications.

Circuit breakers come in 3 types:

Type 1

This type are auto resettable, and once tripped, will attempt to reset the circuit, as the internal elements of the breaker cool down.

Type 2 (trip and hold)

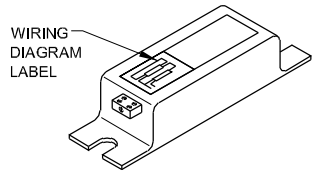
This type are called modified reset, and will remain tripped until the power is removed from the breaker.

Type 3 (circuit breakers)

This type are manual resettable, and require that a button or lever be pushed in order to reset breaker.

Ballast (Choke): The ballast is basically a coil of many turns wound on a laminated iron core (Fig 4). It steps up the supply voltage to start the fluorescent tube conducting. Once the tube is conducting, it regulates the flow of current to the tube cathodes to keep them from burning out.

Fig 4



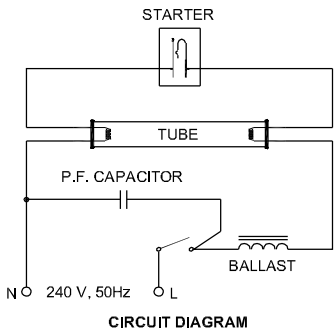
BALLAST

MDN140414

Circuit diagram: The method of connecting the starter, ballast and the tube's electrodes at its either end is shown in Fig 5.

Function of the various parts in a fluorescent light circuit.

Fig 5



CIRCUIT DIAGRAM

MDN140415

Cable colour codes and size

Objectives: At the end of the lesson you shall be able to
- **describe automobile cables**
- **state the needs of colour coding in wiring**
- **state the use of colours in various circuits.**

Description of cables

The cable consists of multi - strand copper conductor covered with good quality PVC insulation.

The current to the various electrical accessories is carried through cables.

The various cables used in wiring are :

- Starting system cable
- General purpose cable
- High tension cable

The specification of the cable refers to the number of stands and diameter of each strand. Eg. 25/012 indicates, the cable consists of 25 strands of 0.012” gauge diameter of each strand.

The size of the cable depends upon the current rating of the accessories connected in that circuit. A thick cable can carry more current and is used in the starting system.

Colour code in cables

In automobiles a number of electric circuits are connnected to the battery which is quite complicated.

The large number of cables are braided into a single har ness assembly.

The automobile manufactures use cables of different colours and usually follow the Lucas colour code system. It consists of basic colours (main colours) and combination of colours to identity individual circuits. (Refer of Fig 1).

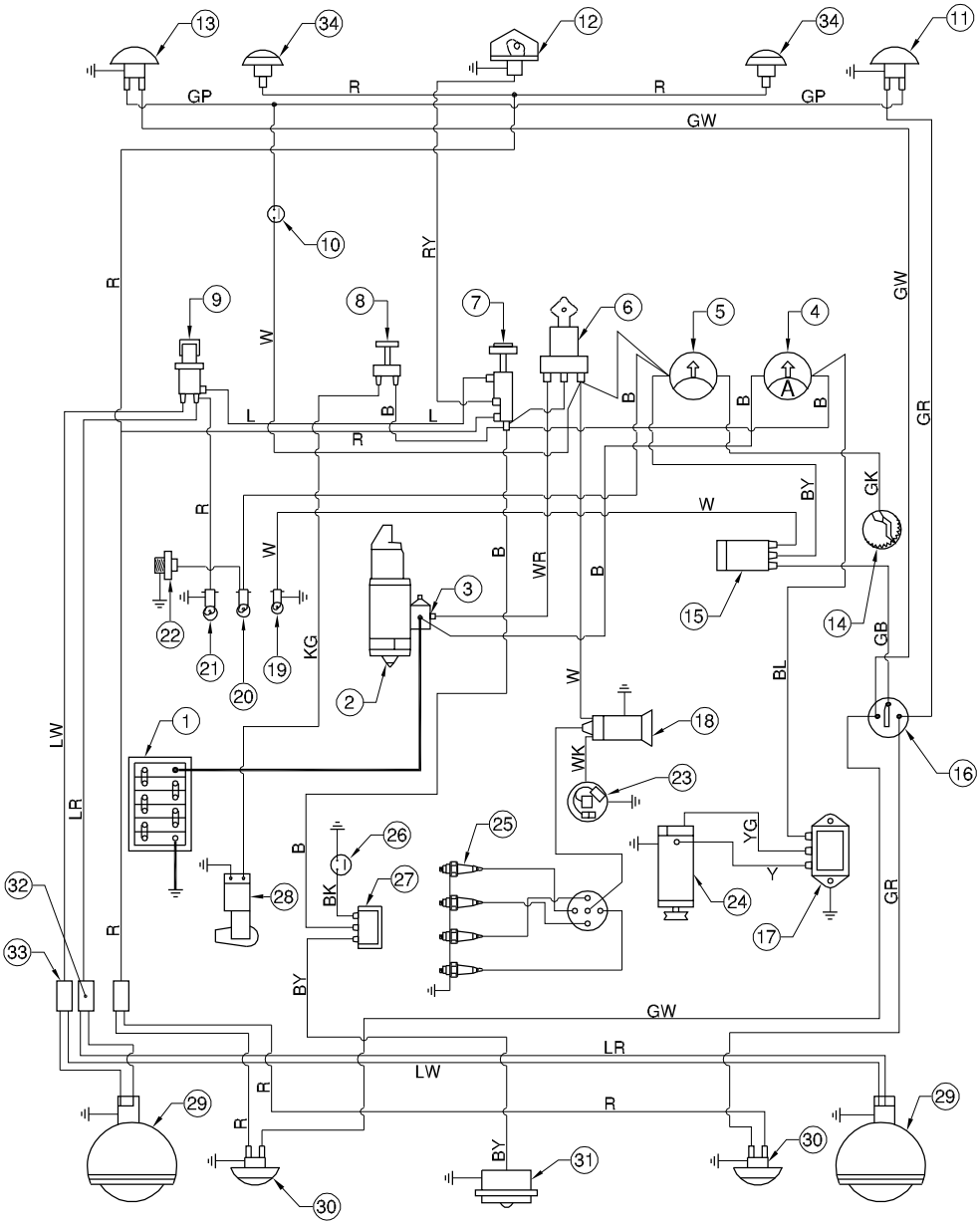
The distinction between wires in a group is done by the use of a coloured bracer on the main colours of the insulator of each wire.

Purpose of colour code

For easy identification of each circuit.

To help to locate the defect easily in a particular circuit and to rectify the same quickly.

Fig 1



NO.	INDEX	NO.	INDEX	COLOUR CODE			
1	BATTERY	18	IGNITION COIL	B	BROWN	GK	GREEN BLACK
2	STARTER MOTOR	19	INDICATOR WARNING LAMP	Y	YELLOW	GP	GREEN PURPLE
3	SOLENOID SWITCH	20	OIL PRESSURE WARNING LAMP	W	WHITE	LR	BLUE RED
4	AMMETER	21	HEAD LIGHT WARNING LAMP	G	GREEN	LW	BLUE WHITE
5	FUEL GUAGE	22	OIL PRESSURE SWITCH	L	BLUE	RG	RED GREEN
6	IGNITION SWITCH	23	DISTRIBUTOR	R	RED	RW	RED WHITE
7	HEADLIGHT SWITCH	24	DYNAMO	K	BLACK	RY	RED YELLOW
8	WIPER SWITCH	25	SPARK PLUG	BL	BROWN BLUE	KG	BLACK GREEN
9	DIM-DIP SWITCH	26	HORN SWITCH	BK	BROWN BLACK		
10	STOP LIGHT SWITCH	27	HORN RELAY	BY	BROWN YELLOW		
11	STOP CUM INDICATOR LAMP	28	WIPER UNIT	BG	BROWN GREEN		
12	NUMBER-PLATE LAMP	29	HEAD LIGHT	YG	YELLOW GREEN		
13	STOP CUM INDICATOR LAMP	30	FRONT PARKING CUM I-LAMP	WR	WHITE RED		
14	FUEL TANK UNIT	31	HORN	WK	WHITE BLACK		
15	FLASHER UNIT	32	DIM SOCKET	GB	GREEN BROWN		
16	INDICATOR SWITCH	33	DIP SOCKET	GW	GREEN WHITE		
17	CONTROL BOX	34	TAIL-LAMP	GR	GREEN RED		

Law of Resistances

Objectives: At the end of this lesson you shall be able to
- **state the Laws of Resistance, compare resistances of different materials**
- **state the formula giving the relationship between the resistance and dimemsions of a conductor**
- **state the effect of temperature on resistance and describe the temperature cofficient of resistance**
- **calculate the resistance of a conductor.**

Laws of resistance (Fig. 1): The resistance R offered by a conductor depends on the following factors.

– The resistance of the conductor varies directly with its length.

– The resistance of the conductor is inversely proportional to its cross-sectional area.

– The resistance of the conductor depends on the material with which it is made of.

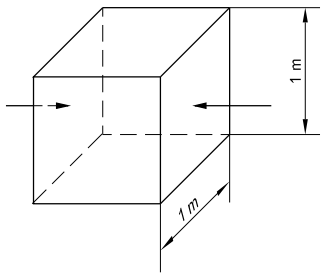
– It also depends on the temperature of the conductor.

Ignoring the last factor for the time being,we can say that

$$R = \frac{PL}{a}$$

where r is a constant depending on the nature of the material of the conductor, and is known as its specific resistance or resistivity.

Fig 1



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If the length is one metre and the area, 'a' = 1 m^2, then R = r.

Hence, specific resistance of a material may be defined as `the resistance between the opposite faces of a metre cube of that material'. (sometimes, the unit cube is taken in centimetre cube of that material).

We have $\rho = \frac{aR}{L}$

In the SI system of units

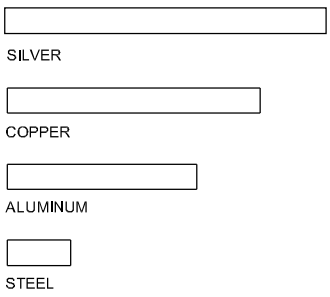
$$\rho = \frac{a \text{ metre}^2 \times R \text{ ohm}}{L \text{ metre}}$$

$$= \frac{aR}{L} \text{ ohm-metre}$$

Hence the unit of specific resistance is ohm metre (Wm).

Comparison of the resistance of different materials: (Fig 2) gives some relative idea of the more important materials as conductors of electricity. All the conductors have the same cross-sectional area and the same amount of resistance. The silver wire is the longest while that of copper is slightly short and that of aluminium is shorter still. The silver wire is more than 5 times longer than the steel wire.

Fig 2



THE CONDUCTANCE OF DIFFERENT MATERIALS

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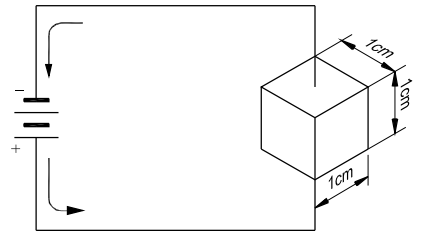
Since different metals have different conductance ratings, they must also have different resistance ratings. The resistance ratings of the different metals can be found by experimenting with a standard piece of each metal in an electric circuit. If you cut a piece of each of the more common metals to a standard size, and then connect the pieces to a battery, one at a time, you would find that different amounts of current would flow. (Fig 3)

Fig 3

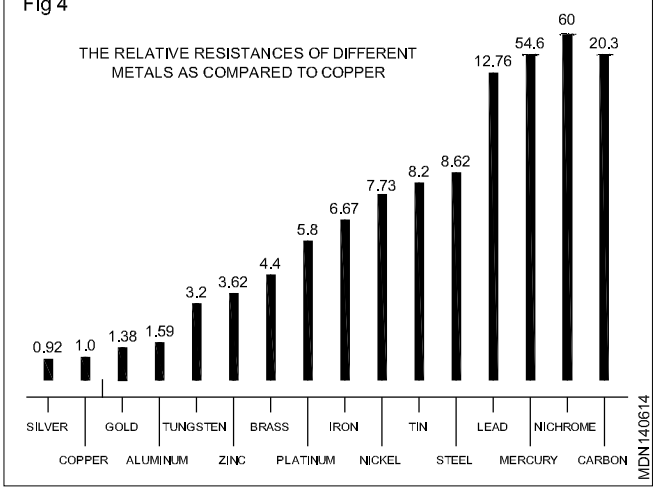


THE MORE RESISTANCE A MATERIAL HAS, THE LESS CURRENT THE MATERIAL WILL CONDUCT. GOOD INSULATORS, SUCH AS GLASS, RUBBER, MICA, POLYSTYRENE, ETC., HAVE CONSIDERABLY MORE THAN A MILLION TIMES THE RESISTANCE OF ANY GOOD CONDUCTOR

MDN140613

The bar graph (Fig 4) shows the resistance of some common metals as compared to copper. Silver is a better conductor than copper because it has less resistance. Nichrome has 60 times more resistance than copper, and copper will conduct 60 times as much current as Nichrome, if they were connected to the same battery, one at a time.

Fig 4



Resistors :

These are the most common passive component used in electronic circuits. A resistor is manufacture with a specific value of ohms resistance. The purpose using a resistor in circuit is either to limit the current to speciifc value or to provide desired voltage drop (IR) The power rating of resistors may be from O.1.W. to hundred of Watts.

Wire - wound resistors

Wire-wound resistors are manufactured by using resistance wire (nickel - chrome alloy called Nichrome) wrapped around an insulating core, such as cerami porcelain bakelite pressed paper etc (Fig 4). The bare wire used in the unit is generally enclosed in insulating material. Wire wound resistors are used for high current application. They are avilable in wattage ratings from one watt to 100 watts or more. The resistance can be less than 1 ohm and go up to several thousand ohms. They are also used where accurate resistance values are required.

One type of Wire-wound resistor is called as fusible resistor enclosed in a porcelain case. The resistance is designed to open the circuit when the current through it exceeds certain limit.

This type of ballast resistor is used in the automobile vechile flasher unit. Due to which the the indicator lamp flash at the regulation of 70-100 times / min.

Resistors and Capacitors

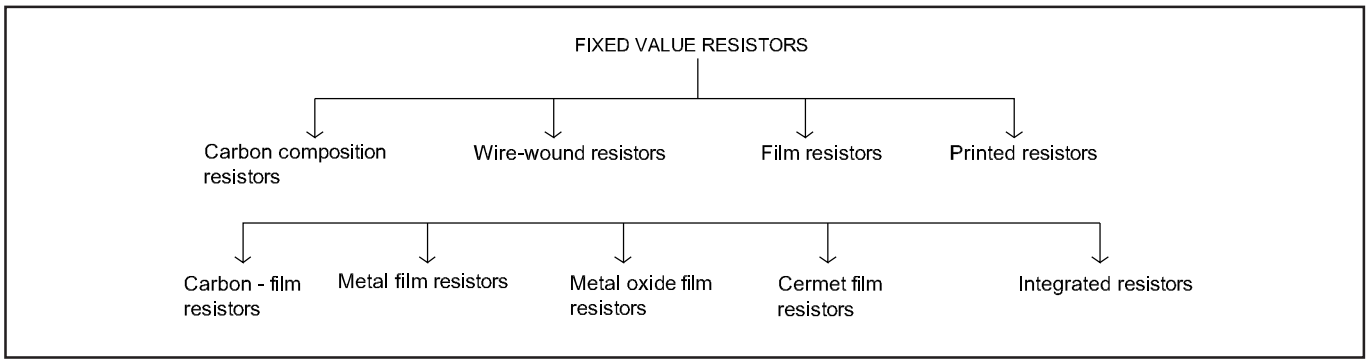
Objectives: At the end of this lesson you shall be able to
- **name the types of resistors**
- **state the meaning of tolerance in resistor**
- **give examples to find the value of a resistor**

Fixed value resistors

Its ohmic value is fixed. This value cannot be changed by the user. Resistors of standard fixed values are manufactured for use in majority of applications.

Fixed resistors are manufactured using different materials and by different methods. Based on the material used and their manufacturing method/process, resistors carry different names.

Fixed value resistors can be classified based on the type of material used and the process of making as follows.

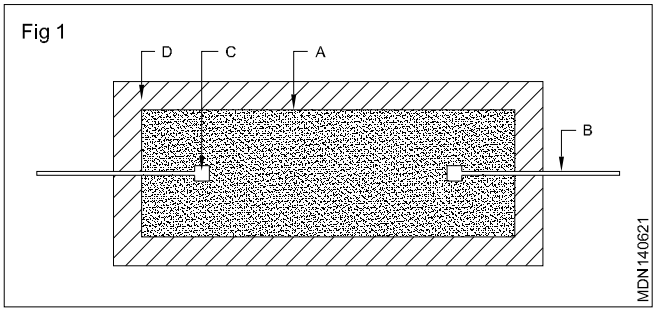


Carbon composition resistors

Construction

These are the simplest and most economical of all other types. Brief constructional detail of the simplest type of carbon composition resistors commonly called carbon resistor is shown in (Fig 1).

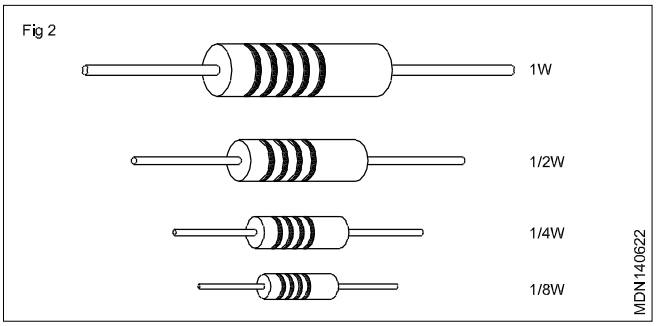
Fig 1



A mixture of finely powdered carbon or graphite(A), filler and binder is made into rods or extruded into desired shapes. Leads(B) made of tinned copper are then attached to the body either by soldering or embedding(C) in the body. A protective layer/tube(D) of phenolic or Bakelite is moulded around the assembly. Finally its resistance value is marked on the body.

Power rating

As already discussed, when current flows through a resistor, heat is generated. The heat generated in a resistor will be proportional to the product of applied voltage (V) across the resistor and the resultant current (I) through the resistor. This product VI is known as *power*. The unit of measurement of power is watts.



The physical size of a resistor should be sufficiently large to dissipate the heat generated. The higher the physical size, the higher is the heat that a resistor can dissipate. This is referred to as the power rating or wattage of resistors. Resistors are manufactured to withstand different power ratings.

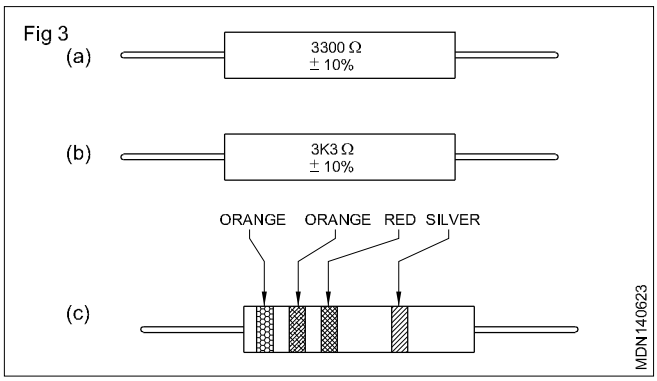
(Fig 2) illustrates comparative physical sizes of different wattage resistors. If the product of V and I exceeds the maximum wattage a resistor can dissipate, the resistor gets charred and loses all its property. For instance, if the applied voltage across a 1 watt resistor is 10 volts resulting in 0.5 Amps of current through the resistor, the power dissipated (VI) by the resistor will be 5 watts. But, the maximum power that can be dissipated by the IW resistor is much less. Therefore, the resistor will get overheated and gets charred due to overheat.

Hence, before using a resistor, in addition to its ohmic value, it is important to choose the correct wattage rating. If in doubt, choose a higher wattage resistor but never on the lower side. The power rating of resistors are generally printed on the body of the resistor.

Resistor values - coding schemes

For using resistors in circuits, depending upon the type of circuit in which it is to be used, a particular type, value and wattage of resistor is to be chosen. Hence before using a resistor in any circuit, it is absolutely necessary to identify the resistor's type, value and power rating.

Selection of a particular type of resistor is possible based on its physical appearance. The resistance value of a resistor will generally be printed on the body of the resistor either directly in ohms as shown in (Fig 3a) or using a typographic code as shown in (Fig 3b) or using a colour code as shown in (Fig 3c).



Colour band coding of resistors

Colour band coding as shown in (Fig 3c) is most commonly used for carbon composition resistors. This is because the physical size of carbon composition resistor is generally small, and hence, printing resistance values directly on the resistor body is difficult. Refer Table 1.

Tolerance

In bulk production/ manufacturing of resistors, it is difficult and expensive to manufacture resistors of particular exact values. Hence the manufacturer indicates a possible variation from the standard value for which it is manufactured. This variation will be specified in percentage tolerance. Tolerance is the range(max -to- min) within which the resistance value of the resistor will exist.

Typographical coding of resistors

In the typographical coding scheme of indicating resistance values, the ohmic value of the resistor is printed on the body of the resistor using an alpha-numeric coding scheme.

Some resistance manufacturers use a coding scheme of their own. In such cases it will be necessary to refer to the manufacturer's guide.

Applications

Carbon composition, fixed value resistors are the most widely used resistors in general purpose electronic circuits such as radio, tape recorder, television etc. More than 50% of the resistors used in electronic industry are carbon resistors.

TABLE 1

Resistor Colour Code

Colour	Significant figures	Multiplier	Tolerance
Silver	-	10^{-2}	± 10%
Gold	-	10^{-1}	± 5%
Black	0	1	-
Brown	1	10	± 1%
Red	2	10^{2}	± 2%
Orange	3	10^{3}	± 3%
Yellow	4	10^{4}	± 4%
Green	5	10^{5}	± 0.5%
Blue	6	10^{6}	-
Violet	7	-	-
Grey	8	-	-
White	9	-	-
(None)	-	-	± 20%

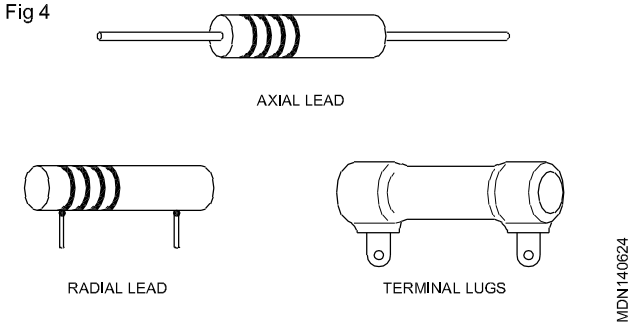
1, 2 and 3: 1st, 2nd and 3rd significant figures ;

M : Multiplier ; T : Tolerance ; T_c : Temperature co-efficient

Types of resistor leads

Resistors are available with different types of lead attachment as shown in Fig 4. This make it easy for the user to mount the resistors in different ways on lug boards, PCBs and other types of circuit boards.

Fig 4



Capacitors

Objectives: At the end of this lesson you shall be able to

- **state and describe a capacitor**
- **state and explain charging of a capacitor**
- **state and explain capacitance and unit of capacitance**
- **state and describe the factors determining the capitance**
- **state and describe the different types of capacitors**
- **explain the defects in capacitors**
- **state and describe the testing of capacitors.**

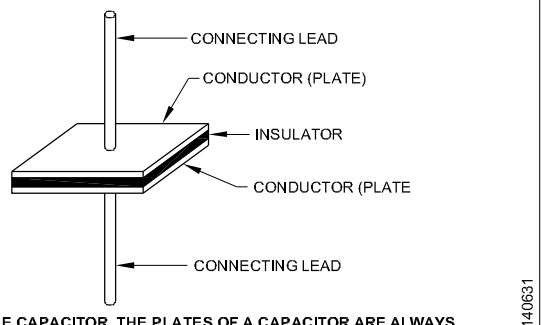
Capacitors

A device designed to posses capacitance is called a capacitor.

Construction

A capacitor is an electrical device consisting of two parallel conductive plates, separated by an insulating material called the dielectric. Connecting leads are attached to the parallel plates. (Fig 1)

Fig 1



SIMPLE CAPACITOR. THE PLATES OF A CAPACITOR ARE ALWAYS INSULATED FROM EACH OTHER

Function

In a capacitor the electric charge is stored in the form of an electrostatic field between the two conductors or plates, due to the ability of dielectric material to distort and store energy while it is charged and keep that charge for a long period or till it is discharged through a resistor or wire. The unit of charge is coulomb and it is denoted by the letter `C'.

How a capacitor stores charge?

In the neutral state, both plates of a capacitor have an equal number of free electrons, as indicated in (Fig 2a). When the capacitor is connected to a voltage source through a resistor, the electrons (negative charge) are removed from plate A, and an equal number are deposited on plate `B'. Plate A becomes positive with respect to plate B as shown in (Fig 2b).

The current enters and leaves the capacitor, but the insulation between the capacitor plates prevents the current from flowing through the capacitor.

As electrons flowing into the negative plate of a capacitor have a polarity opposite to that of the battery supplying the current, the voltage across the capacitor opposes the battery voltage. The total circuit voltage, therefore, consists of two series-opposing voltages.

As the voltage across the capacitor increases, the effective circuit voltage, which is the difference between the battery voltage and the capacitor voltage, decreases. This, in turn, causes a decrease in the circuit current. When the voltage across the capacitor equals the battery voltage, the effective voltage in the circuit is zero, and so the current flow stops. At this point, the capacitor is fully charged, and no further current can flow in the circuit.

Capacitance (Fig 2c)

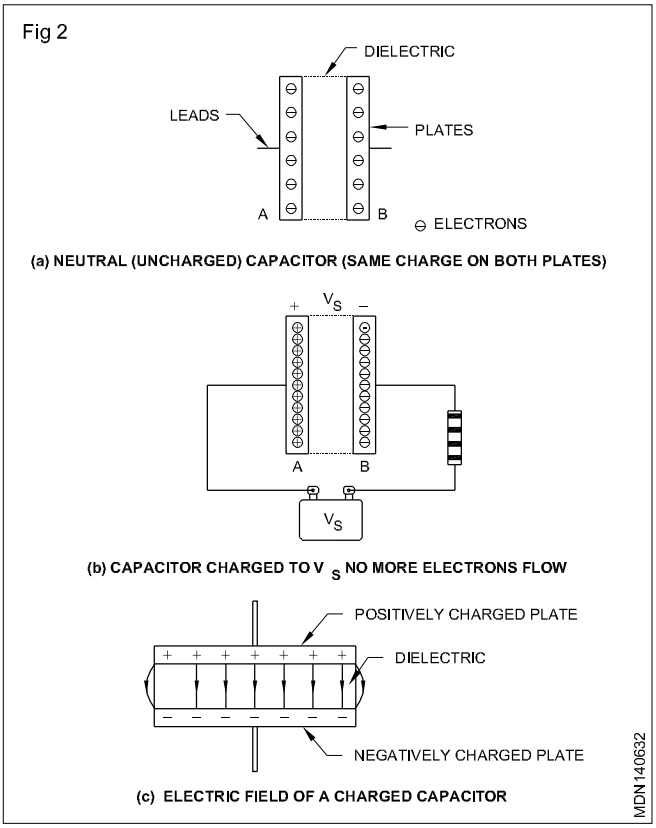
The ability to store energy in the form of electric charge is called capacitance. The symbol used to represent capacitance is C.

Unit of capacitance

The base unit of capacitance is farad. The abbreviation for farad is F. One farad is that amount of capacitance which stores 1 coulomb of charge when the capacitor is charged to 1 V. In other words, a farad is a coulomb per volt (C/V).

A farad is the unit of capacitance (C), and a coulomb is the unit of charge(Q), and a volt is the unit of voltage(V).

Fig 2



Grouping of capacitors

Objectives : At the end of this lesson you shall be able to

- **state the necessity of grouping of capacitors**
- **list the conditions for connecting capacitors in parallel**
- **determine the values of capacitance and voltage in parallel combination**
- **list the conditions for connecting capacitors in series**
- **determine the values of capacitance and voltage in series combination.**

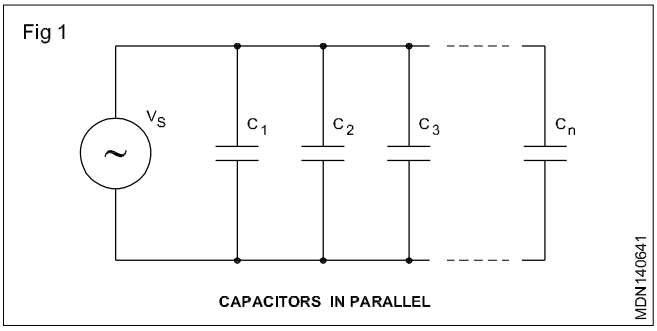
Necessity of grouping of capacitors

In certain instances, we may not be able to get a required value of capacitance and a required voltage rating. In such instances, to get the required capacitances from the available capacitors and to give only the safe voltage across capacitor, the capacitors have to be grouped in different fashions. Such grouping of capacitors is very essential.

Necessity of parallel grouping

Capacitors are connected in parallel to achieve a higher capacitance than what is available in one unit.

Fig 1



Connection of parallel grouping

Parallel grouping of capacitors is shown in (Fig 1) and is analogous to the connection of resistance in parallel or cells in parallel.

Total capacitance

When capacitors are connected in parallel, the total capacitance is the sum of the individual capacitances, because the effective plate area increases. The calculation of total parallel capacitance is analogous to the calculation of total resistance of a series circuit.

By comparing (Fig 2a and 2b), you can understand that connecting capacitors in parallel effectively increases the plate area.

General formula for parallel capacitance

The total capacitance of parallel capacitors is found by adding the individual capacitances.

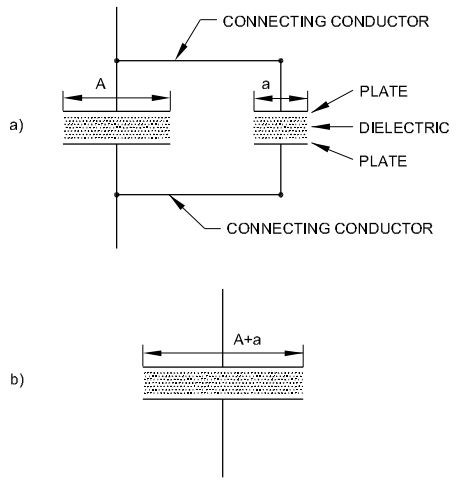
$C_T = C_1 + C_2 + C_3 + ... + C_n$

where C_T is the total capacitance,

C_1, C_2, C_3 etc. are the parallel capacitors.

The voltage applied to a parallel group must not exceed the lowest breakdown voltage for all the capacitors in the parallel group.

Fig 2



CAPACITORS IN PARALLEL. THE EQUIVALENT CAPACITANCE IN (b) IS EQUAL TO THE SUM OF THE CAPACITANCES IN (a).

MDN140642

Example: Suppose three capacitors are connected in parallel, where two have a breakdown voltage of 250 V and one has a breakdown voltage of 200 V, then the maximum voltage that can be applied to the parallel group without damaging any capacitor is 200 volts.

The voltage across each capacitor will be equal to the applied voltage.

Charge stored in parallel grouping

Since the voltage across parallel-grouped capacitors is the same, the larger capacitor stores more charge. If the capacitors are equal in value, they store an equal amount of charge. The charge stored by the capacitors together equals the total charge that was delivered from the source.

$Q_T = Q_1 + Q_2 + Q_3 + ... + Q_n$

where Q_T is the total charge

Q_1, Q_2, Q_3.....etc. are the individual

charges of the capacitors in parallel.

Using the equation Q = CV,

the total charge $Q_T = C_T V_S$

where V_S is the supply voltage.

Again $C_T V_S = C_1 V_S + C_2 V_S + C_3 V_S$

Because all the V_S terms are equal, they can be cancelled.

Therefore, $C_T = C_1 + C_2 + C_3$

Series grouping

Necessity of grouping of capacitors in series

The necessity of grouping capacitors in series is to reduce the total capacitance in the circuit. Another reason is that two or more capacitors in series can withstand a higher potential difference than an individual capacitor. But, the voltage drop across each capacitor depends upon the individual capacitance. If the capacitances are unequal, you must be careful not to exceed the breakdown voltage of any capacitor.

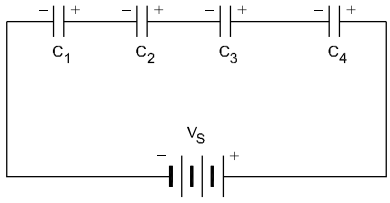
Conditions for series grouping

- If different voltage rating capacitors have to be connected in series, take care to see that the voltage drop across each capacitor is less than its voltage rating.
- Polarity should be maintained in the case of polarised capacitors.

Connection in series grouping

Series grouping of capacitors, as shown in (Fig 3) is analogous to the connection of resistances in series or cells in series.

Fig 3



SERIES CONNECTION OF CAPACITORS

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Total capacitance

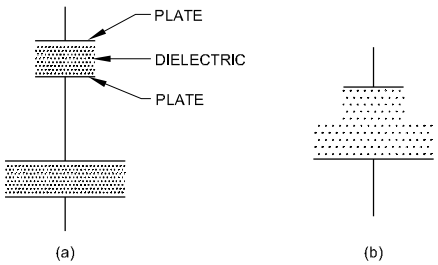
When capacitors are connected in series, the total capacitance is less than the smallest capacitance value, because

- the effective plate separation thickness increases
- and the effective plate area is limited by the smaller plate.

The calcualtion of total series capacitance is analogous to the calculation of total resistance of parallel resistors.

By comparing (Fig 4a and 4b) you can understand that connecting capacitors in series increases the plate separation thickness, and also limits the effective area so as to equal that of the smaller plate capacitor.

Fig 4



THE EQUIVALENT CAPACITANCE IN (b) IS LESS THAN THE LOWER OF THE TWO CAPACITANCES IN (a).

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General formula for series capacitance

The total capacitance of the series capacitors can be calculated by using the formula

$$C_T = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + ... + \frac{1}{C_n}}$$

or

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + ... + \frac{1}{C_n}$$

If there are two capacitors in series

$$C_T = \frac{C_1 C_2}{C_1 + C_2}$$

If there are three capacitors in series

$$C_T = \frac{C_1 C_2 C_3}{(C_1C_2) + (C_2C_3) + (C_3C_1)}$$

If there are `n' equal capacitors in series

$$C_T = \frac{C}{n}$$

Maximum voltage across each capacitor

In series grouping, the division of the applied voltage among the capacitors depends on the individual capacitance value according to the formula

$$V = \frac{Q}{C}$$

The largest value capacitor will have the smallest voltage because of the reciprocal relationship.

Likewise, the smallest capacitance value will have the largest voltage.

The voltage across any individual capacitor in a series connection can be determined using the following formula.

$$V_x = \frac{C_T}{C_x} \times V_s$$

where

V_x - individual voltage of each capacitor

C_x - individual capacitance of each capacitor

V_s - supply voltage.

The potential difference does not divide equally if the capacitances are unequal. If the capacitances are unequal you must be careful not to exceed the breakdown voltage of any capacitor.

Example: Find the voltage across each capacitor in Fig 6.

DC series - parallel - series and parallel combination circuits

Objectives: At the end of this lesson you shall be able to

- **identify the series connection and determine the current in the series circuit**
- **determine the voltage across elements in a series circuit**
- **determine the total voltage in a circuit when the voltage sources are in series**
- **state the uses of a series connection.**

The series circuit

It is possible to connect two incandescent lamps in the way shown in (Fig 1). This connection is called a series connection, in which the same current flows in the two lamps.

Fig 1

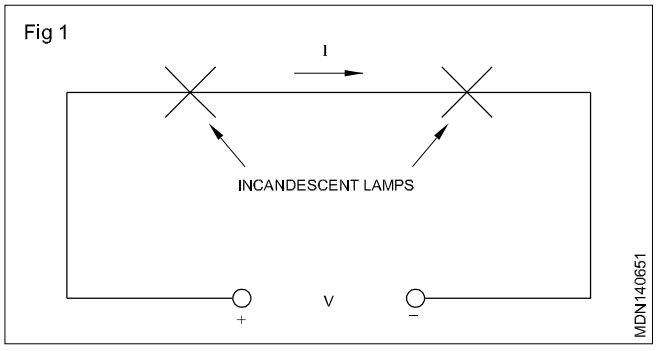
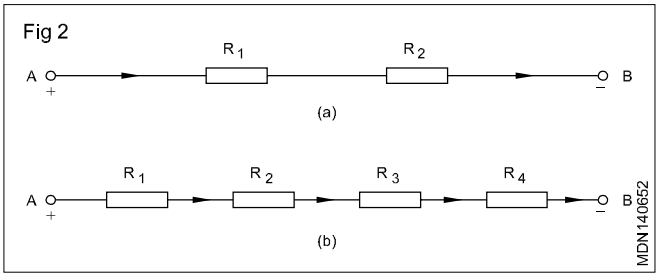


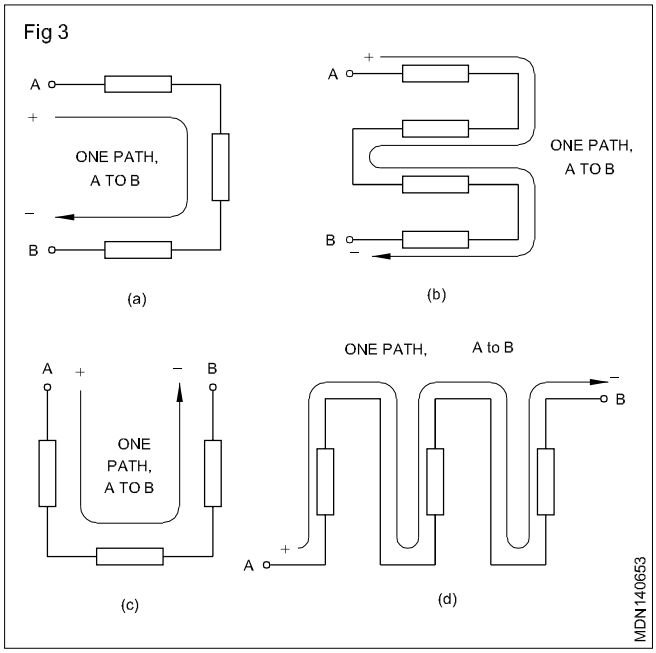
Fig 2



The lamps are replaced by resistors in Fig 2. Fig 2 (a) shows two resistors are connected in series between point A and point B. Fig 2(b) shows four resistors are in series. Of course, there can be any number of resistors in a series connection. Such connection provides only one path for the current to flow.

Identifying series connections

Fig 3



In an actual circuit diagram, a series connection may not always be as easy to identify as those in the figure. For

example, (Fig 3(a), 3(b), 3(c) & 3(d)) shows series resistors drawn in different ways. In all the above circuits we find there is only one path for the current to flow.

Current in series circuits

The current will be the same at any point of the series circuit. This can be verified by measuring the current in any two points of a given circuit as shown in (Fig 4 (a) and 4(b)). The ammeters will show the same reading.

The current relationship in a series circuit is

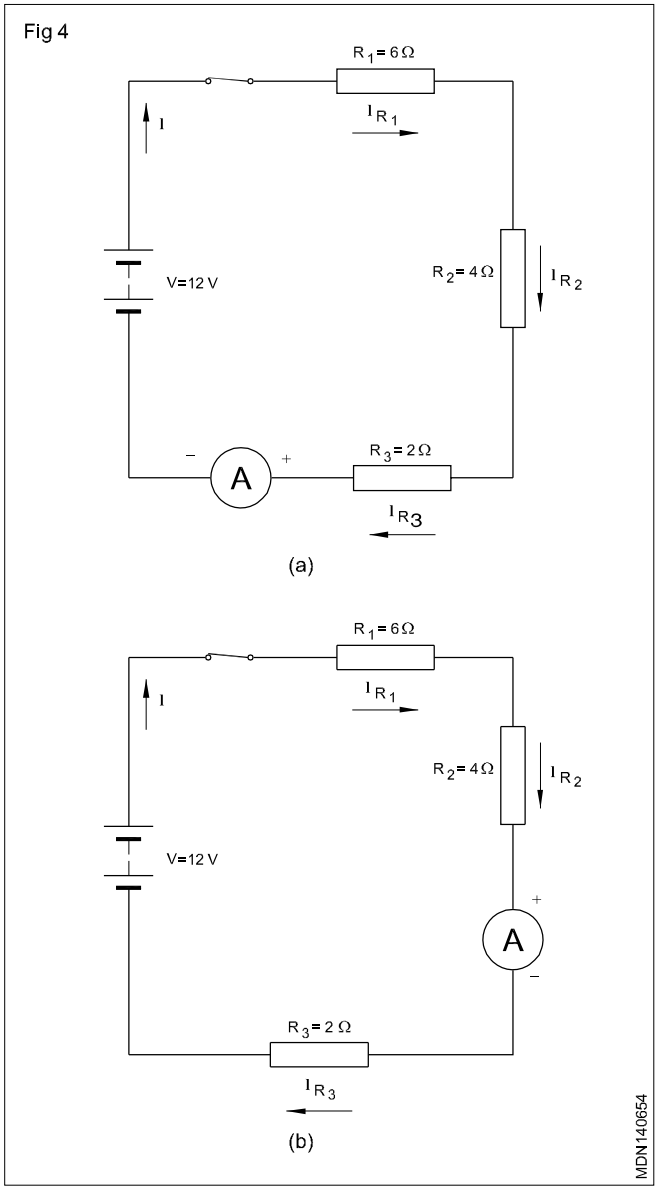
$I = I_{R1} = I_{R2} = I_{R3}$. (Refer Fig 4)

We can conclude that there is only one path for the current to flow in a series circuit. Hence, the current is the same throughout the circuit.

Total resistance in series circuit

You know how to calculate the current in a circuit, by Ohm's law, if resistance and voltage are known. In a circuit consisting of two resistors R_1 and R_2 we know that the resistor R_1 offers some opposition to the current flow. As the same current should flow through R_2 in series it has to overcome the opposition offered by R_2 also.

Fig 4



If there are a number of resistances is series, they all oppose the flow of current through them.

The 2nd characteristic of a DC series circuit could be written as follows.

The total resistance in a series circuit is equal to the sum of the individual resistances around the series circuit. This statement can be written as

$R = R_1 + R_2 + R_3 + ...R_n$

where R is the total resistance

$R_1, R_2, R_3, ...R_n$ are the resistances connected in series.

When a circuit has more than one resistor of the same value in series, the total resistance is $R = r \times N$

where 'r' is the value of each resistor and N is the number of resistors in series.

Voltage in series circuits

In DC circuit voltage divides up across the load resistors, depending upon the value of the resistor so that the sum of the individual load voltages equals the source voltage.

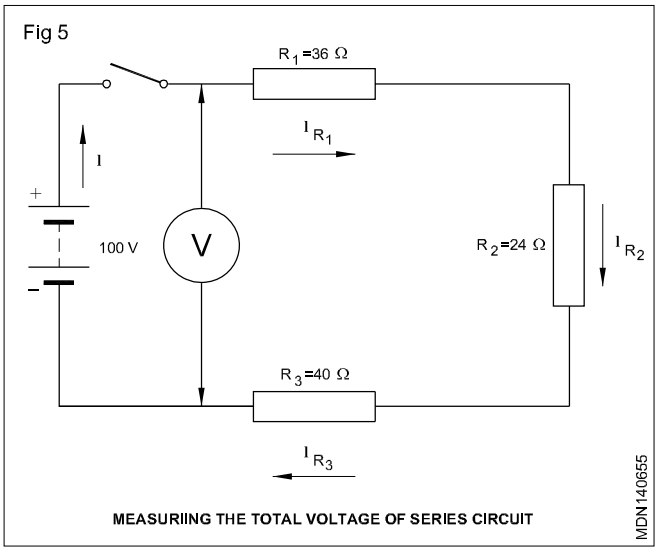
The 3rd characteristic of a DC circuit can be written as follows.

As the source voltage divides/drops across the series resistance depending upon the value of the resistances

$V = V_{R1} + V_{R2} + V_{R3} + ...$

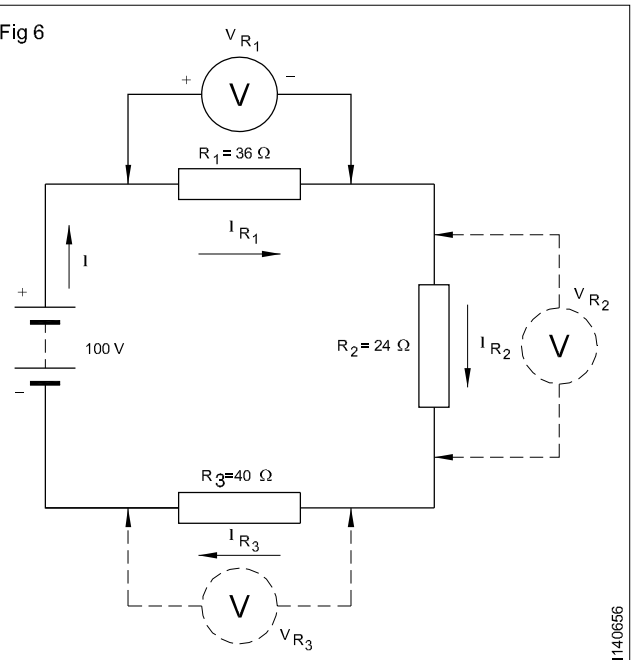
the total voltage of a series circuit must be measured across the voltage source, as shown in (Fig 5).

Fig 5



Voltages across the series resistors could be measured using one voltmeter at different positions as illustrated in (Fig 6).

Fig 6



VOLTAGE DROP IN A SERIES CIRCUIT

When Ohm's law is applied to the complete circuit having an applied voltage V, and total resistance R, we have the current in the circuit as

I = V/R

Application of Ohm's law to DC series circuits

Applying to Ohm's law to the series circuit, the relation between various currents could be stated as below

Potential difference and polarity of I R voltage drops

Objectives: At the end of this lesson you shall be able to

- **state the relation between the emf, potential difference and terminal voltage**
- **define I.R. drop (voltage drop) in a DC series circuit**
- **identify polarity of voltage drops**
- **identify positive and negative grounds**
- **mark the polarity of the voltage drop with respect to ground to determine the terminals of the voltmeter.**

Definitions

Electromotive force (emf)

We have seen in Related Theory of Exercise 1.07, the electromotive force (emf) of a cell is the open circuit voltage, and the potential difference (PD) is the voltage across the cell when it delivers a current. The potential difference is always less than the emf.

Potential difference

PD = emf – voltage drop in the cell

Potential difference can also be called by another term, the terminal voltage, as explained below.

Terminal voltage

It is the voltage available at the terminal of the source of supply. Its symbol is V_T. Its unit is also the volt. It is given by the emf minus the voltage drop in the source of supply,

i.e. V_T = emf – IR

where I is the current and R the resistance of the source.

Voltage drop (IR drop)

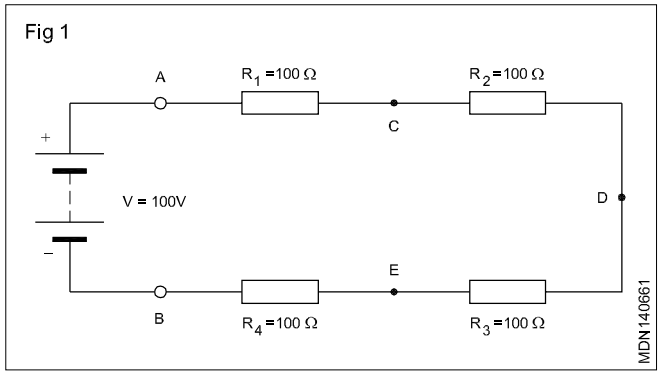
The voltage lost by resistance in a circuit is called the Voltage drop or IR drop.

Example 1

The resistances and applied voltage are known. (Fig 1)

What are the voltage drops across the resistors

Fig 1



The total resistance of the circuit in (Fig 1) would be equal to R_T = 100 + 100 + 100 + 100 = 400 ohms.

The current flowing through the circuit would be

I = (100/400) = 0.25 amps.

But point A has a potential of 100 volts and point B has zero. Somewhere along the circuit between A and B, the 100 volts have been lost.

To find the voltage drop for each resistor is easy. First find the current, which we have calculated as 0.25 amps, then

V_{R1} = 0.25 x 100 = 25 V

V_{R2} = 0.25 x 100 = 25 V

V_{R3} = 0.25 x 100 = 25 V

V_{R4} = 0.25 x 100 = 25 V.

Add up all the voltage drops and they will total 100 volts which is the applied voltage of the circuit.

25 + 25 + 25 + 25 = 100 volts.

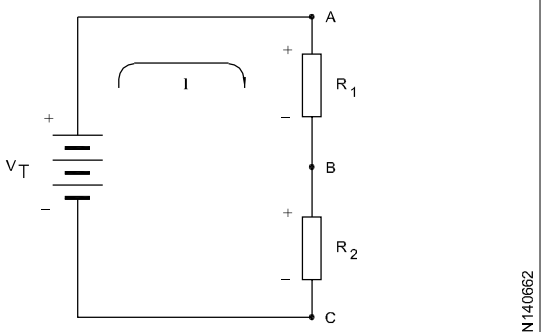
The sum of the voltage drops in a circuit must be equal to the applied voltage.

$V_{Total} = V_{R1} + V_{R2} + V_{R3} + V_{R4}$.

Polarity of voltage drops

When there is a voltage drop across a resistance, one end must be more positive or more negative than the other end. The polarity of the voltage drop is determined by the direction of conventional current. In (Fig 2), the current direction is through R_1 from point A to B.

Fig 2



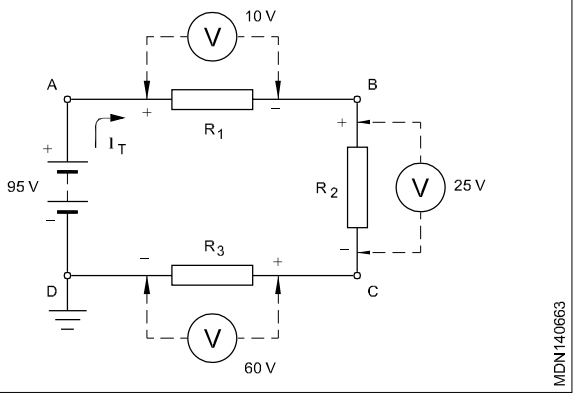
Therefore, the terminal of R_1 connected to point A has a more positive potential than point B. We say that the voltage across R_1 is such that point A is more positive than point B. Similarly the voltage of point B is more positive than point C. Another way to look at polarity between any two points is that the one nearer to the positive terminal of the voltage source is more positive; also, the point nearer to the negative terminal of the applied voltage is more negative. Therefore, point A is more positive than B, while C is more negative than B. (Fig 2)

Example 2

Find the voltage at the points A,B, C and D with respect to ground.

Mark the polarity of voltage drops in the circuit (Fig 3) and find the voltage values at points A, B, C and D with respect to ground.

Fig 3



Trace the complete circuit in the direction of current from the + terminal of the battery to A, A to B, B to C, C to D, and D to the negative terminal. Mark plus (+) where the current enters each resistor and minus (–) where the current leaves each resistor.

The voltage drops indicate (Fig 3) Point A is the nearest point to the positive side of the terminal; so voltage at A with respect to ground is

$V_A = +95$ V.

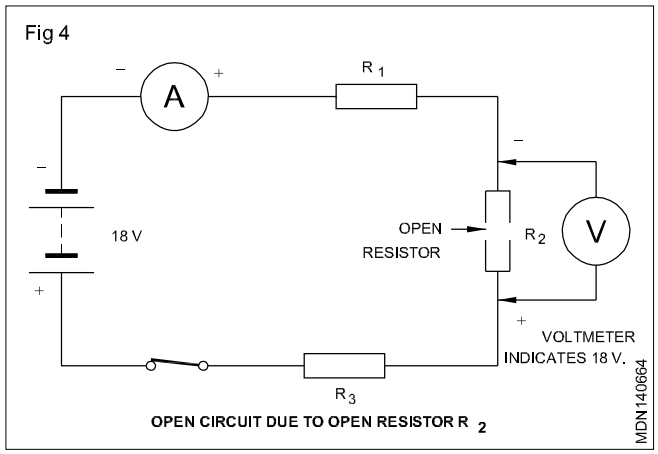
There is a voltage drop of 10 V across R_1; so voltage at B is

$V_B = +85$ V.

An open circuit results whenever a circuit is broken or is incomplete, and there is no continuity in the circuit.

In a series circuit, open circuit means that there is no path for the current, and no current flows through the circuit. Any ammeter in the circuit will indicate no current as shown in (Fig 4).

Fig 4



Causes for open circuit in series circuit

Open circuits, normally, happen due to improper contacts of switches, burnt out fuses, breakage in connection wires and burnt out resistors etc.

Effect of open in series circuit

a No current flows in the circuit.

b No device in the circuit will function.

c Total supply voltage/ source voltage appear across the open.

How can we determine where a break in the circuit has occurred?

Use a voltmeter on a range that can accommodate the supply voltage; connect it across each connecting wire in turn. If one of the wire is open as shown in (Fig 4), the full supply voltage is indicated on the voltmeter. In the absence of a current, there is no voltage drop across any of the resistors. Therefore, the voltmeter must be reading full supply voltage across the open. That is

Voltmeter reading

$= 18\ V - V_{R1} - V_{R2} - V_{R3}$

$= 18\ V - O\ V - O\ V - O\ V = 18\ V.$

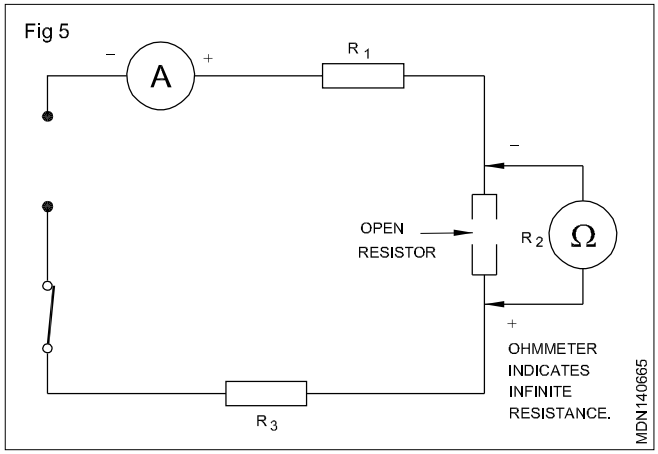
If the circuit was open due to a defective resistor, as shown in (Fig 5) (resistors usually open when they burn out), the voltmeter would indicate 18 V when connected across this resistor, R_2.

Alternatively, the open circuit may be found using an ohmmeter. With the voltage removed, the ohmmeter will show no continuity (infinite resistance), when connected across the broken wire or open resistor. (Fig 5)

Practical application

With the knowledge gained from this lesson:

- locate open and short circuit faults in a series circuit
- repair series-connected decoration bulb sets.

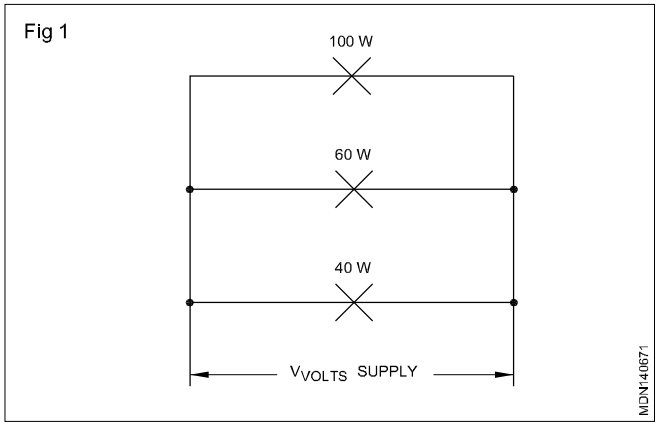


DC parallel circuit

Objectives: At the end of this lesson you shall be able to
- **explain a parallel connection**
- **determine the voltages in a parallel circuit**
- **determine the current in a parallel circuit**
- **determine the total resistances in a parallel circuit**
- **state the application of a parallel circuit.**

Parallel circuit

It is possible to connect three incandescent lamps as shown in (Fig 1). This connection is called parallel connection in which, the same source voltage is applied across all the three lamps.



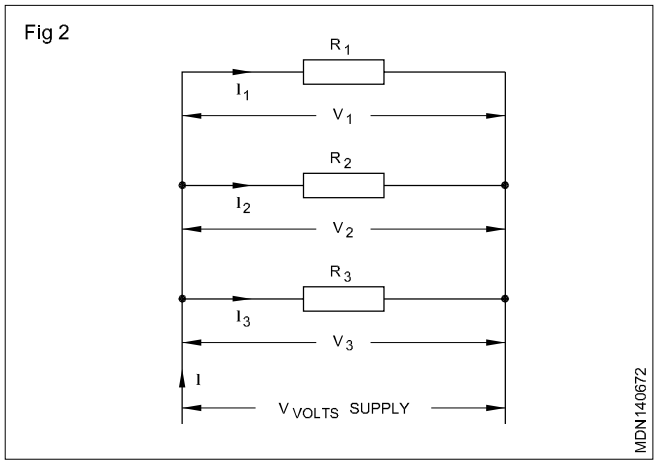
Voltage in parallel circuit

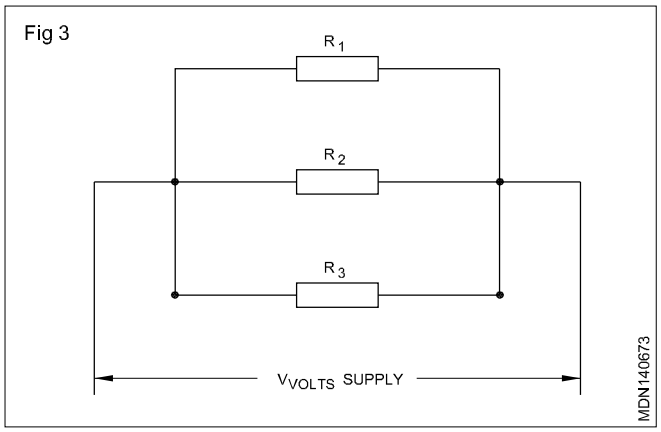
The lamps in (Fig 1) are replaced by resistors in (Fig 2). Again the voltage applied across the resistors is the same and also equal to the supply voltage.

We can conclude that the voltage across the parallel circuit is the same as the supply voltage.

(Fig 2) could also be drawn as shown in (Fig 3).

Mathematically it could be expressed as $V = V_1 = V_2 = V_3$.





Current in parallel circuit

Again referring to (Fig 2) and applying Ohm's law, the individual branch currents in the parallel circuit could be determined.

Current in resistor $R_1 = I_1 =$ = .

Current in resistor $R_2 = I_2 =$ = .

Current in resistor $R_3 = I_3 =$ =

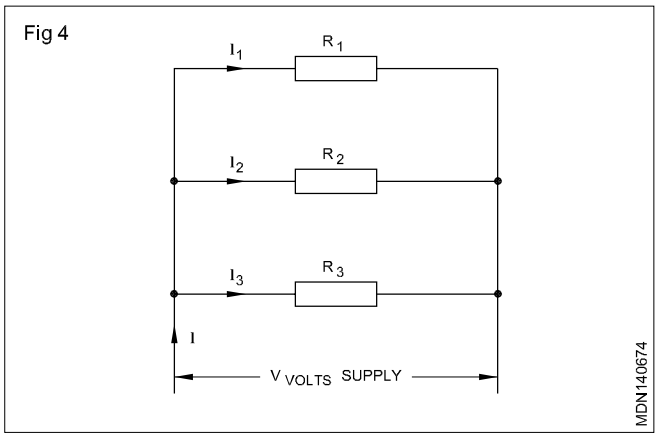
as $V_1 = V_2 = V_3$.

Refer to (Fig 4) in which the branch currents I_1, I_2 and I_3 are shown to flow into resistance branches R_1, R_2 and R_3 respectively.

The total current I in the parallel circuit is the sum of the individual branch currents.
Mathematically it could be expressed as $I = I_1 + I_2 + I_3 + ... I_n$.

Resistance in parallel circuit (Fig 4)

Fig 4



In a parallel circuit, individual branch resistances offer opposition to the current flow though the voltage across the branches will be same.

Let the total resistance in the parallel circuit be R ohms.

By the application of Ohm's law

we can write

$$R = \frac{V}{I} \text{ohms or } I = \frac{V}{R} \text{amps}$$

where

R is the total resistance of the parallel circuit in ohms

V is the applied source voltage in volts, and

I is the total current in the parallel circuit in amperes.

We have also seen

$$I = I_1 + I_2 + I_3$$

or $$R = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_2}$$

As V is the same throughout the equation and dividing the above equation by V, we can write

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_2}$$

The above equation reveals that in a parallel circuit, the reciprocal of the total resistance is equal to the sum of the reciprocals of the individual branch resistances.

Special case: Equal resistances in parallel

Total resistance R, of equal resistors in parallel (Fig 5) is equal to the resistance of one resistor, r divided by the number of resistors, N.

$$R = \frac{r}{N}$$

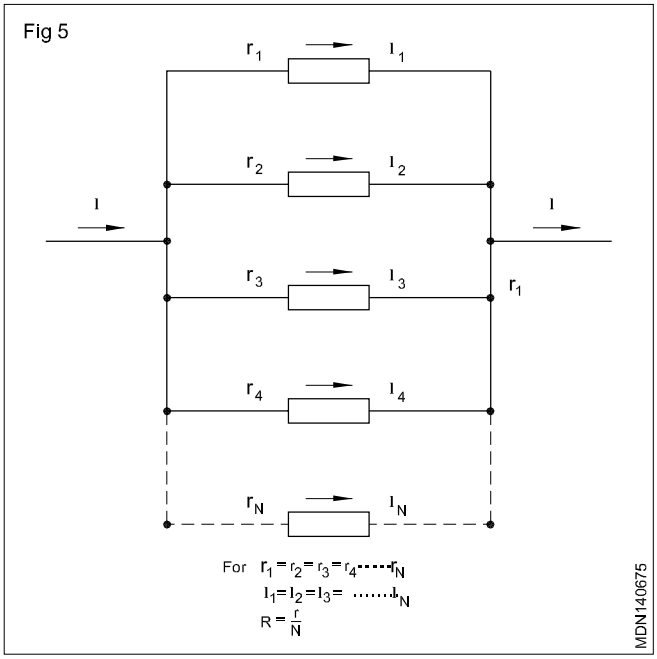
Applications of parallel circuits

An electric system in which section can fail and other sections continue to operate in parallel circuits. As previously mentioned, the electric system used in homes consists of many parallel circuits.

An automobile electric system uses parallel circuits for lights, horn, motor, radio etc. Each of these devices operates independently.

Individual television circuits are quite complex. However, the complex circuits are connected in parallel to the main power source. That is why the audio section of television receivers can still work when the video (picture) is inoperative.

Fig 5



Series parallel combination

Objectives: At the end of this lesson you shall be able to
- **compare the characteristics of series and parallel circuits**
- **solve the series-parallel circuit problems**
- **calculate the current in series-parallel circuits.**

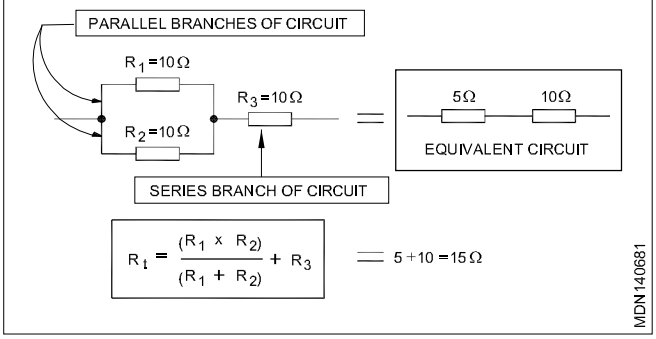
Comparison of characteristics of DC series and parallel ciruits

Series circuit	Parallel circuit
1 The sum of voltage drops across the individual resistances equals the applied voltage.	The applied voltage is the same across each branch.
2 The total resistance is equal to the sum of the individual resistances that make up the circuit. $R_t = R_1+R_2+R_3+...$ etc	The reciprocal of the total resistance equals the sum of the reciprocal of the resistances. The resultant resistance is less than the smallest resistance of the parallel combination.
3 Current is the same in all parts of the circuit.	The current divides in each branch according to the resistance of each branch.
4 Total power is equal to the sum of the power dissipated by the individual resistances.	(Same as series circuit) Total power is equal to the sum of the power dissipated by the individual resistances.

Formation of series parallel circuit

Apart from the series circuit and parallel circuits, the third type of circuit arrangement is the series-parallel circuit. In this circuit, there is at least one resistance connected in series and two connected in parallel. The two basic arrangements of the series-parallel circuit are shown here. In one, resistor R_1 and R_2 are connected in parallel and this parallel connection, in turn, is connected in series with resistance R_3.(Fig 1)

Fig 1

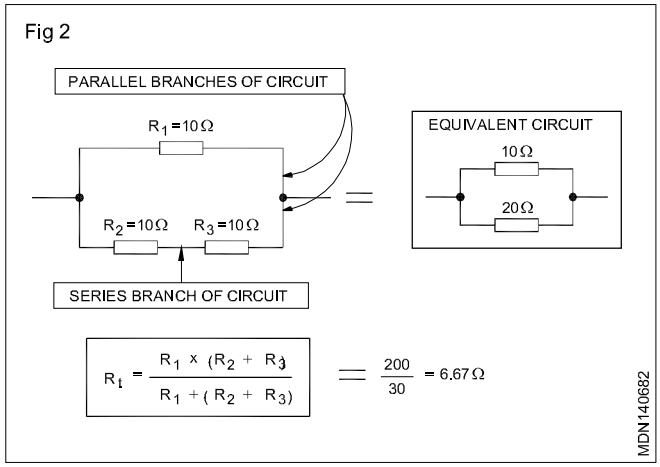


Thus, R_1 and R_2 form the parallel component, and R_3 the series component of a series-parallel circuit. The total resistance of any series-parallel circuit can be found by merely reducing it into a simple series circuit. For example, the parallel portion of R_1 and R_2 can be reduced to an equivalent 5-ohm resistor(two 10-ohm resistors in parallel).

Then it has an equivalent circuit of a 5-ohm resistor in series with the 10-ohm resistor(R_3), giving a total resistance of 15 ohms for the series-parallel combination.

A second basic series-parallel arrangement is shown in (Fig 2) where basically it has two branches of a parallel circuit. However, in one of the branches it has two resistances in series R_2 and R_3. To find the total resistance of this series -parallel circuit, first combine R_2 and R_3 into an equivalent 20-ohm resistance. The total resistance is then 20 ohms in parallel with 10 ohms, or 6.67 ohms.

Fig 2



Combination circuits

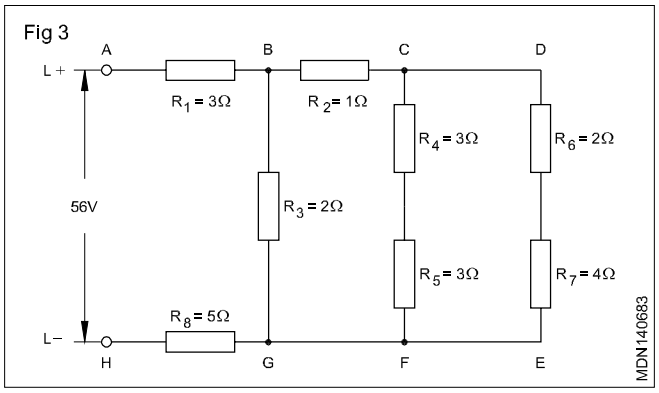
A series-parallel combination appears to be very complex.

However, a simple solution is to break down the circuit into series/or parallel groups, and while solving problems, each may be dealt with individually. Each group may be replaced by one resistance, having the value equal to the sum of all resistances.

Each parallel group may be replaced by one resistance value equivalent to the combined resistance of that group. Equivalent circuits are to be prepared for determining the current, voltage and resistance for each component.

Example

Determine the combined resistance of the circuit shown in (Fig 3).



PROCEDURE

1) Combine R_6 and R_7.

$R_a = R_6 + R_7$

$R_a = 2 + 4$

R_a = 6 ohms.

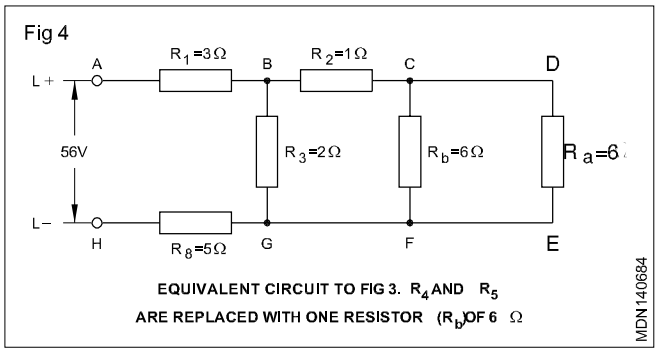
2) Draw an equivalent circuit with resistance Ra. (Fig 4)

3) Combine R_4 and R_5 of Fig 4.

$R_b = R_4 + R_5$

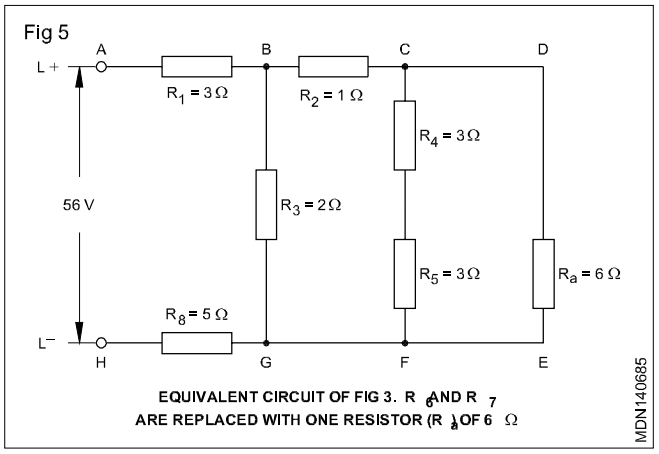
$R_b = 3 + 3$

R_b = 6 ohms.



4) Draw an equivalent circuit as per Figure 5.

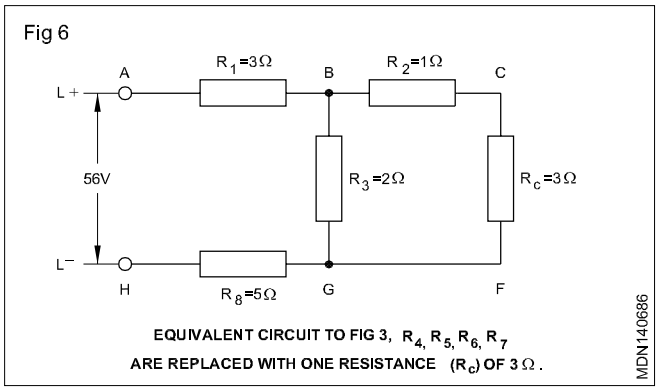
5) Combine R_a and R_b and call the equivalent resistance value as R_C. (Fig 5)



$$\frac{36}{12} R_c = \frac{R_a \times R_b}{R_a + R_b} = \frac{6 \times 6}{6 + 6}$$

$$= \frac{36}{12} \text{ 3 ohms.}$$

6) Draw the equivalent circuit. (Fig 6)

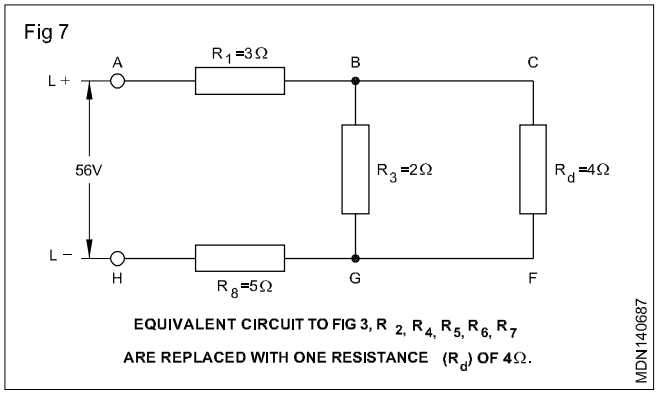


7) Combine R_2 and R_c and call the equivalent resistance R_d.

$R_d = R_2 + R_c$

$R_d = 1 + 3$ R_d = 4 ohms.

8) Draw an equivalent circuit. (Fig 7)



9) Now combine R_3 and R_d and call it R_e

$$R_e = \frac{R_3 \times R_d}{R_3 + R_d} = \frac{2 \times 4}{2 + 4}$$

$$= \frac{8}{6} = \frac{4}{3} = 11/3 \text{ ohms.}$$

10) Draw an equivalent circuit. (Fig 8)

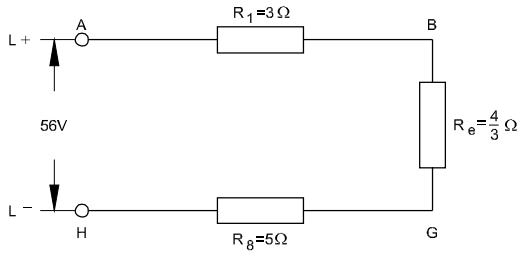
11) Combine R_1, R_e, and R_8.

$R_t = R_1 + R_e + R_8$

$$R_t = 1\frac{1}{3} + 5 + 5$$

$$R_t = 9 = \frac{1}{3} \text{ ohms.}$$

Fig 8



EQUIVALENT CIRCUIT IN FIG 3, R_2, R_3, R_4, R_5, R_6, AND R_7 ARE REPLACED WITH ONE RESISTANCE (R_e) EQUAL TO $\frac{4}{3}$ Ω.

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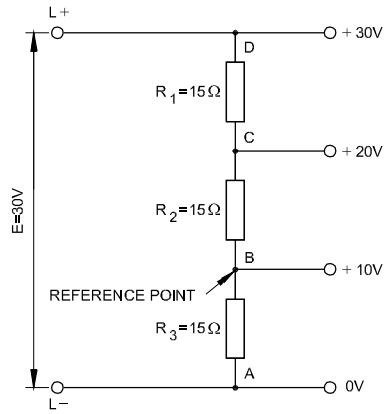
The total combined resistance of the circuit is $9\frac{1}{3}$ ohms.

Application

Series-parallel circuits can be used to form a specific resistance value which is not available in the market and can be used in the voltage divider circuits (Fig 9).

Fig 9



VOLTAGE VALUES ARE GIVEN FOR VOLTAGE DROP TESTS TAKEN ACROSS RESISTORS FROM A TO B (10V), B TO C (+10V) AND B TO D (+20V). NOTE THAT THE CIRCUIT IS GROUNDED AT REFERENCE POINT B.

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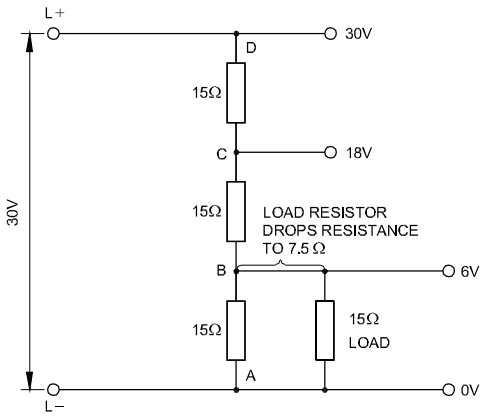
Voltage divider

To have different voltages for different parts of a circuit, construct a voltage divider. In effect, a voltage divider is nothing more than a series-parallel circuit.

A good voltage divider cannot be designed without first looking at the load resistance. Note in (Fig 9) that a voltage divider is made with three 15 ohm resistors to get 10 volts drop across each one.

Fig 10



THREE 15 OHMS RESISTORS AND ONE 15 OHM LOAD RESISTOR SERVE AS A VOLTAGE DIVIDER THAT ROUTES DIFFERENT VOLTAGES TO DIFFERENT PARTS OF THE CIRCUIT.

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However, as soon as another resistor (load) is added as in (Fig 10), there is a further change. The load resistor serves to drop the total resistance of the lower part of the voltage divider. Use this formula for finding the equivalent resistance (R_{eq}) of resistors of equal value in a parallel circuit:

$$R_{eq} = \frac{r}{N}$$

$$R_{eq} = \frac{15}{2} = 7.5 \text{ohms,}$$

The equivalent resistance of these two 15 ohm resistors in the lower part of the voltage divider is 7.5 ohms. What will happen to the current and voltage in the circuit as a result of this resistance change?

Remember that, as resistance goes down, current goes up. Therefore, with the addition of the load resistor, the circuit will now carry higher amperage but the voltage between points A and B as well as A and C changes. It is important, then, when constructing a voltage divider circuit, to watch the resistance values which change both voltage and current values. Study Figure 10 carefully to make sure you understand how a voltage divider works.

Battery

Objectives: At the end of the lesson you shall be able to
- **state the classification of cells**
- **describe the primary cells**
- **describe the secondary cells**
- **describe the construction of a lead acid battery**
- **describe the chemical action during discharging**
- **describe the chemical action during charging**
- **describe the maintenance of a battery**
- **describe the testing of a battery.**

A cell is an electrochemical device consisting of two electrodes and an electrolyte. The chemical reaction between the electrodes and the electrolyte produces a voltage.

Cells are classified as:

– dry cells

– wet cells.

Dry cells : A dry cell has paste or gel electrolyte. It is semi-sealed and could be used in any position.

Wet cells : It consists of two plates and a liquid electrolyte. These cells have vent holes to allow the gases to escape during charging and discharging. The most common wet cell is the lead acid cell; wet cells can be recharged for reuse.

Primary cells : Primary cells are those cells which are not rechargeable. Chemical reaction that occurs during discharge is not reversible. The following types of primary cells are used.

– Voltanic cell

– Carbon zinc cell

– Alkaline cell

– Mercury cell

– Silver oxide cell

– Lithium cell.

Secondary cell (Lead acid battery) : These cells can be recharged by supplying electric current in the reverse direction to that of a discharged battery.

Lead acid battery (Figs 1 & 2)**:** This battery is an electrochemical device for converting electrical energy into chemical energy and vice versa. The main purpose of the battery is to store electrical energy in the form of chemical energy. It provides supply of current for operating various electrical accessories, when the engine is not running. When the engine is running it gets electric supply from the dynamo/alternator. It is also known as accumulator and storage battery.

Fig 1

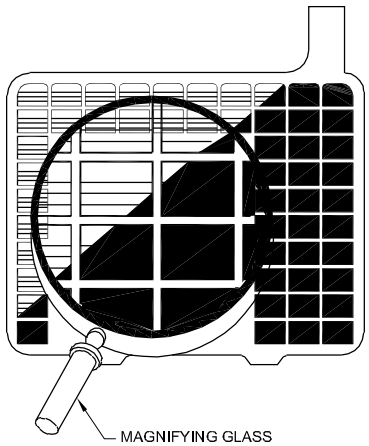
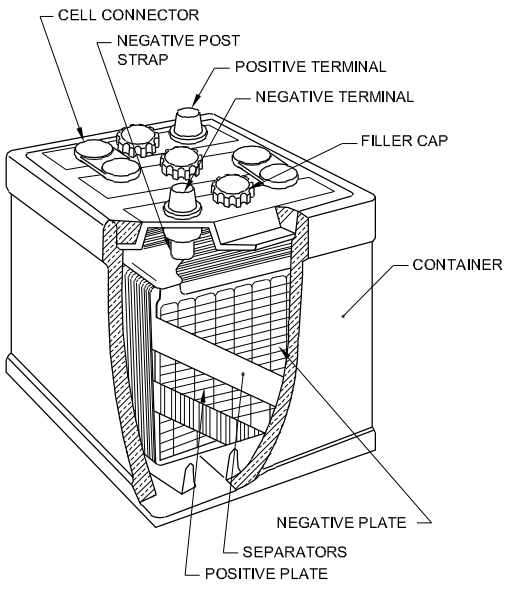


Fig 2



Construction: The automobile battery's plates are rectangular. They are made of lead. Antimony alloy is used to provide them strength.

The group of plates, which are connected to the positive terminal of the cell, consists of grids filled with a paste of lead peroxide. This lead is brown in colour. The group of plates, which are connected to the negative terminal of the cell, consists of grids filled with metalic lead which is spongy in nature. This lead is dull grey in colour.

Each a group of plates is held together by a post strap, to which individual plates are welded. The post strap is extended up to the cell cover to provide battery terminals. The positive and negative plates are arranged alterna-tively, and in between the plates, seperators are used to prevent contact of the positive and negative plates. Separators are made of specially treated wood, hard rubber, resin, integrated fibre or in combination with rubber or mats of glass fibres. The container in which the plates are placed is made of hard rubber which is not affected by the electrolyte. A solution of sulphuric acid and distilled water is added until the level of the liquid in the container is about 1/4" to 3/8" above the top of the plates. A filler cap with air vents is provided to allow gases to escape From battery cells..

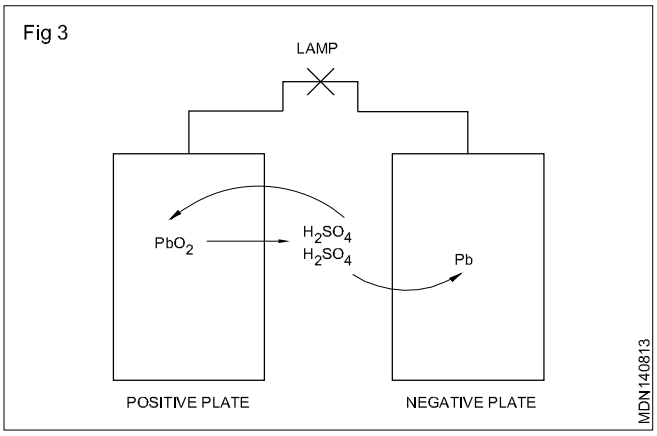
Chemical Reactions

Discharging (Fig 3)**:** During discharging, the sulphuric acid is broken into two parts, hydrogen (H_2) and sulphate (SO_4). The hydrogen is liberated at the lead peroxide plates (PbO_2) reducing them to lead oxide (PbO) which combines with parts of the sulphuric acid to form lead sulphate ($PbSO_4$) and water (H_2O). The SO_4 is liberated at the spongy lead plate (Pb) and combines with them to form lead sulphate ($PbSO_4$). During this process the electrolyte becomes less concentrated due to absorption of the sulphate by the lead plates.

$$PbO_2 + 2H_2SO_4 + Pb \rightleftharpoons PbSO_4 + 2H_2O + PbsO_4$$

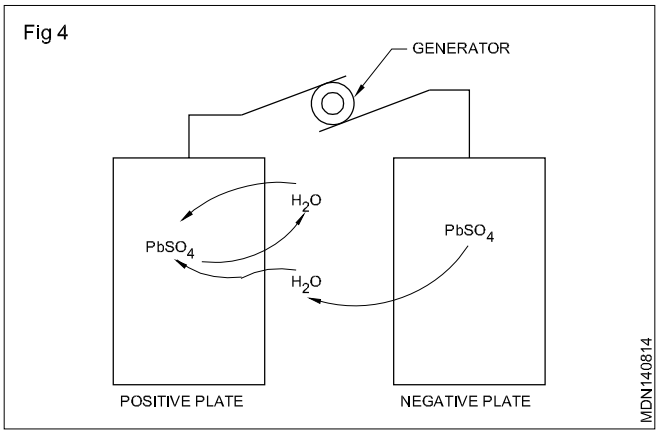
(+ve) (electrolyte) (-ve) (+ve) (water) (-ve)

Fig 3



Charging (Fig 4)

Fig 4



When the battery is charged (Fig 4) by passing current through a dynamo or charger in the opposite direction, the reverse chemical reaction takes place. The lead sulphate on one plate becomes lead peroxide (+ve plate). The lead sulphate on the other plate (-ve plate) becomes spongy lead and the electrolyte becomes more concentrated because of the increased amount of sulphuric acid.

$$PbSO_4 + 2H_2O + PbSO_4 \rightleftharpoons PbO_2 + 2H_2SO4 + Pb$$

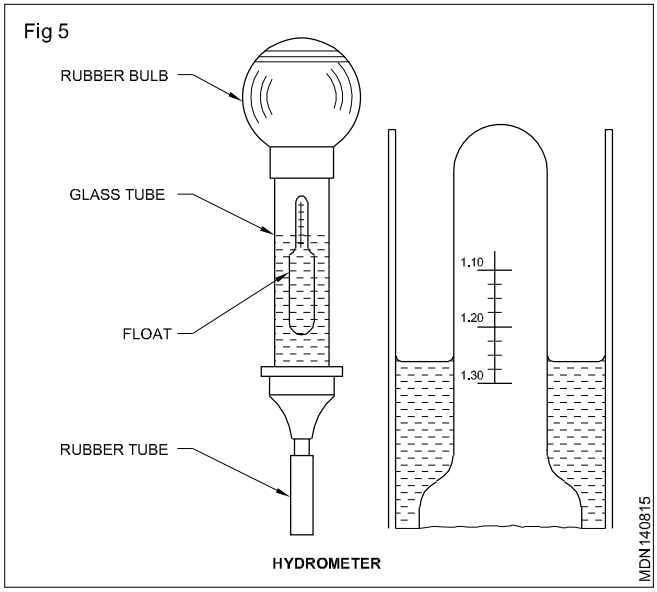
(+ve) (water) (-ve) (+ve) (Electrolyte) (-ve)

Maintenance of battery : Batteries are expensive items to replace. They should be serviced regularly as recommended by the manufacturer. If maintained properly, they can be used for longer periods. The following aspects are to be checked to maintain the battery in good condition.

Check and top up electrolyte level every week. Electrolyte should be 10 mm to 15 mm above the plates.

Check the specific gravity of the battery with a hydrometer.(Fig 5) If the specific gravity falls below 1.180 then add a few drops of sulphuric acid.

Fig 5



Sp. gravity readings and the state of charge of the battery are as follows.

Sl.No.	Specific	State of charge of the battery
1	1.260 - 1.280	Fully charged
2	1.230 - 1.260	3/4 charged
3	1.200 - 1.230	1/2 charged
4	1.170 - 1.200	1/4 charged
5	1.140 - 1.170	About run down
6	1.110 - 1.140	Discharged

Check the voltage across the cell terminals of each cell by using a cell tester. Cell voltage is 2 to 2.3 volts per cell for fully charged condition.

If the voltage of each cell is less than specified, then the battery should be recharged.

While charging do not overcharge the battery.

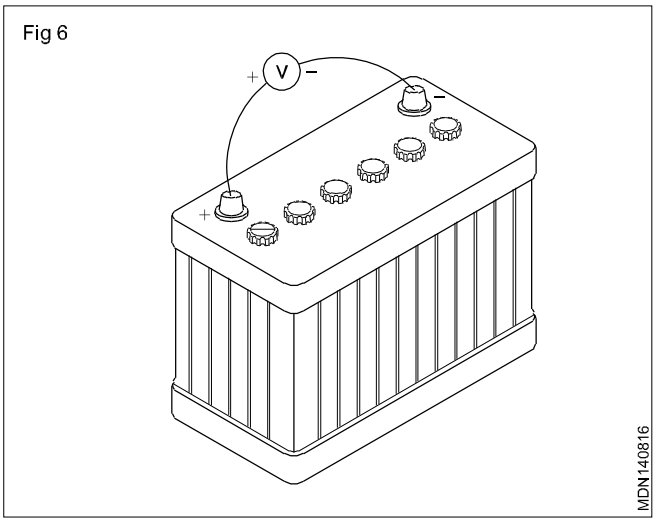
Keep the battery terminals always tight and clean.

To prevent formation of corrosion on the terminals smear petroleum jelly on it.

Voltage check of battery : With the help of a voltmeter the voltage of battery is tested. This will commonly vary from 12-13V

Battery selection (Fig 6)**:** Most cars in current production are equipped with a 12V battery. When a manufacturer installs a battery in a new car that battery is chosen to meet the requirements of that particular car. Prime importance is the battery's ability to crank and start the engine. The current required to crank on engine can range from 150A to over 1000A depending on the size of the engine, the temperature and the viscosity of the oil in the engine. Those factors are all considered in battery selection. The number and type of electrical options installed in the car are also considered.

Fig 6



The lead acid batteries are made for different vehicle application to suit the electrical demands, While the voltage of the battery remains same for all application, the ampere-hour rate changes as per demand.

The following examples reveal the importants of ampere-hour of a battery.

Vehicle type	Battery applicable
2.5 Amps 12V	Two wheeler without starter
7 Amps 12V	Two wheeler with starter motor
35 Amps 12V	800CC - 1000 car petrol
40 - 45 Amps 12V	1300CC Diesel vehicles
60 Amps 12V	2.5 Ltrs LCV
80 Amps 12V	4 Ltrs medium
120 Amps 12V	6 Ltrs Diesel HCV
180 Amps 12V	6 Ltrs Diesel passenger

Battery rating

Ampere-hour rating: The ampere-hour rating provides a measure of how much current a battery at 80^0F (27^0C) will deliver for a fixed period of time without the cell voltage dropping below 1.75V (10.5 total terminal volts). Due to a specified 20 hour time period, this test is sometimes referred to as the "20 hour test". The rating number is determined by multiplying the current delivered by 20. If a battery can deliver 3A for the 20 hour period, it receives a 60 ampere-hour rating. If a battery can deliver 5A for the 20 hour period, it receives a rating of 100 ampere-hour.

CONVENTIONAL BATTERIES

BATTERY CAPACITY (AMPERE HOURS)	DISCHARGE RATE (AMPERES)
36	155
41	145
45	190
53	175
54	225
68	220
77	228

MAINTENANCE-FREE BATTERIES

BATTERY CAPACITY (AMPERE HOURS)	DISCHARGE RATE (AMPERES)
53	200
63	215
68	235

Battery charging: A discharged battery in good condition can be charged and retuned to service.

Many types of battery in use, but all chargers operate on the same principle. They apply an electrical pressure that forces current through the battery to reverse the electro chemical action in the cells.

Charging rates: The amount of charge a battery receives is equal to the rate of charge, in amperes, multiplied by the amount of time, in hours, that the charge is applied. As an example, a battery charged at the rate of 5A for a period of 5 hours would receive a 25 ampere-hour charge. To bring a battery to a fully charged condition.

Initial rate for constant voltage taper rate charger.

To avoid damage, charging rate must be reduced or temporarily halted if:

1 Electrolyte temperature exceeds 125^oF.

2 Violent gassing or spewing of electrolyte occurs.

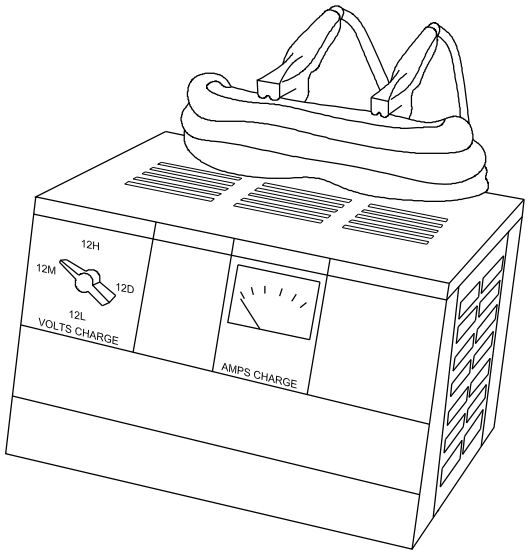
Battery is fully charged when over a two hour period at a low charging rate in amperes all cells are gassing freely and no change in specific gravity occurs. For the most satisfactory charging, the lower charging rates in amperes are recommended.

Full charge specific gravity is 1.260 - 1.280 corrected for temperature with electrolyte level at split ring.

Slow charging (Fig 7)**:** Slow charging consists of charging a battery at a rate of about 5A for a time sufficient to bring the specific gravity of the electrolyte to its highest reading. Slow charging many require from 12 to 24 hours of time. A battery that is sulphated may require even more time. During the charging period, the electrolyte temperature should not exceed 110^0F (43^0C). If the electrolyte temperature rises above 110^0F (43^0C), the charging rate should be decreased.

A conventional battery with vent plugs is considered fully charged when the electrolyte is gassing freely and when no further rise in the specific gravity is noted at intervals of 1 hours. a sealed battery should be slow charged until the green dot appears in the built-in hydrometer. in some instances, a sealed battery must be slightly shaken to allow the green dot to appear.

Fig 7

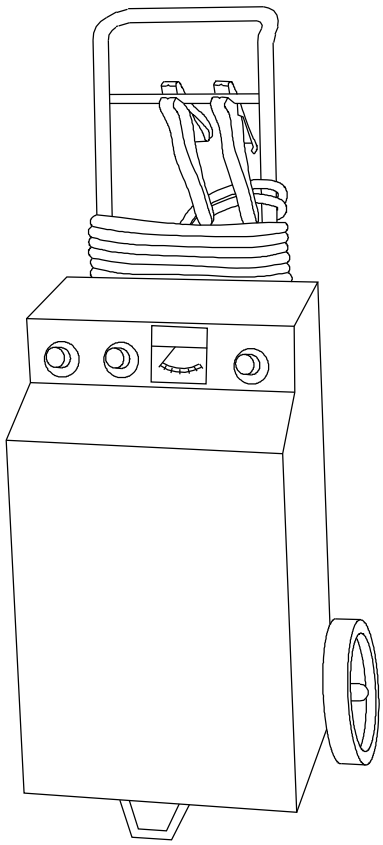


A TYPICAL SLOW CHARGER

Fast charging (Fig 8)**:** Fast charging will not fully recharge a battery, it will restore the charge sufficiently to allow the battery to be used.

Fast charging consists of charging a battery at a rate from 10 to 50A. The exact charging rate depends on the construction of the battery, the condition of the battery and the time available. The temperature of the electrolyte provides an indication of the current charging rate. If the electrolyte temperature rises above 125^0F (65^0C), the charging rate is too high and should be reduced. Since a high charging rate and the resultant high temperature can damage a battery, a battery should be charged at the lowest possible rate.

Fig 8



A TYPICAL FAST CHARGER

Features of sealed maintenance free battery

- No need for checking electrolyte level and tapping throughtout the life.
- Seal construction ensures no leakage of electrolyte from terminal or casing.

Benefits

- Saving of 100 litres of distilled water through out its life time as compared to convention batteries.
- Saving of man power for regular topping up & cleaning corroded terminals as in conventional batteries.
- No damage of flooring by spoilage of batteries acid or water during maintenance.
- No need of separate battery room.
- It indicates the battery current charging rate through inbuilt indictor.

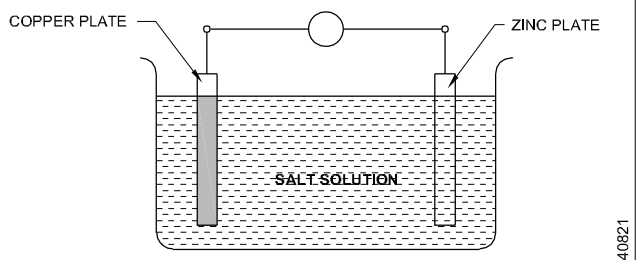
Electricity effects

Objectives: At the end of this lesson you shall be able to
- **state the electro chemical process**
- **state the effect of an electric currents.**
- **state the thermo couple**
- **state the thermo electric energy**
- **state the piezo electric energy.**
- **state the photo voltaia energy.**

Chemical sources (Electro chemical process) (Fig 1)

If two electrically conducting materials (metals) are immersed in salt solutions, an electric charge is produced between the two metals (electrodes, poles). Two examples are given below.

Fig 1



ELECTRICITY GENERATION BY DISSOLVING IN ELECTROLYTES

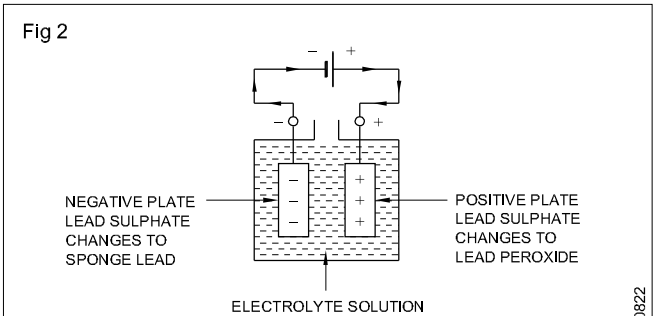
Copper and Zinc in salt solution is one combination

Lead and sulphuric acid is another combination.

This arrangement is known as wet cell and gives direct current. The second combination is used in a Lead Acid Battery for Motor vehicles.

Dynamic electricity (Fig 2)

Fig 2



DURING CHARGING PROCESS

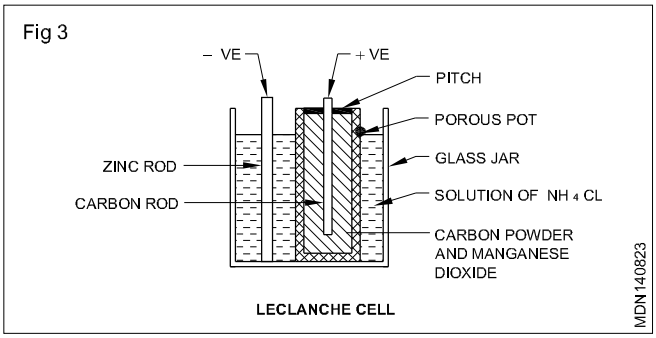
The current is produced by A/C or D/C generators, by conversion of mechanical energy into electrical energy. The generation of electric current is based on the fact when a conductor is moved in a magnetic field an E.M.F is set up in the conductor. When a large number of conductors are moved in a powerful magnetic field, high voltages and current are produced. This is the Principle of Dynamo.

The effect of an electric current

Let us now study effects of an electric current. When an electric current flows through a circuit, its presence could be analysed by its effects. They are stated below.

Chemical effect (Fig 3)

Fig 3



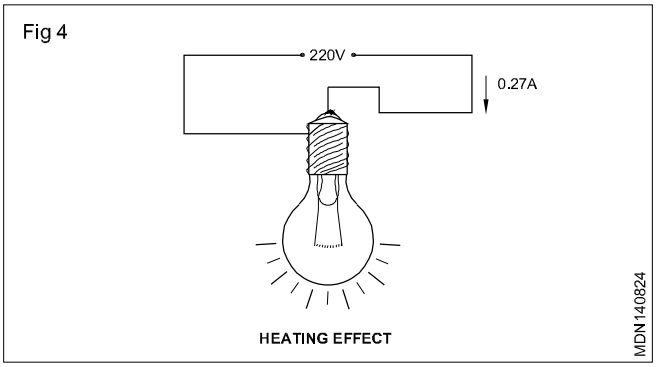
LECLANCHE CELL

When a current is applied to a battery from a battery charger various chemical reactions are produced which enable the electrical energy to be stored in a chemical form.

The process is called charging a battery by electrolysis method (using electric current).

Heating effect (Fig 4)

Fig 4



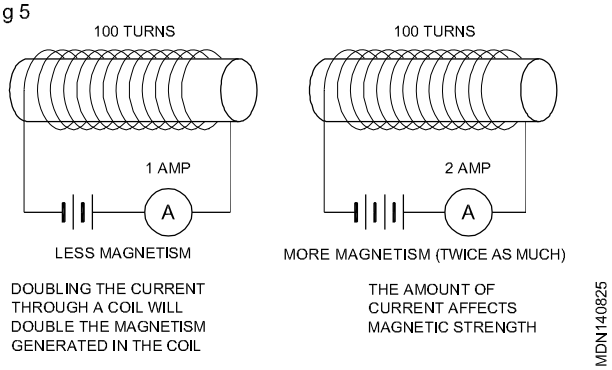
HEATING EFFECT

When a current is applied to a bulb filament (fine wire) it becomes white hot and thus produces light.

Magnetic effect (Fig 5)

- If a soft iron bar is placed in a coil of wire and a current is passed through the wire, the iron bar becomes magnetised. If the current is withdrawn the bar with retain some magnetism depending on the materials.
- If a bar magnetic is moved in a coil of wire, to and fro then Current flow is occurred in the coil of wire. This can be find by connecting a "Galvanometer".The current, will flow only when the bar magnet is moving actually. Because, the turns of coil of wire should cut the lines of force.

Fig 5



Shock effect

If the current flow through Human body, it may give a severe stock or cause even death of the individuals so one must be careful in dealing with electrical current during work.

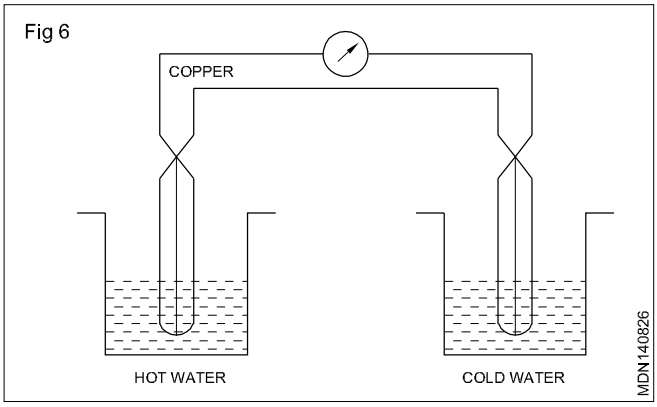
Note :

In motor vehicle trade application, the following effect electric current are widely used

- Chemical effect-for battery.
- Heating effect-Head lamp bulbs for lighting.
- Magnetic effect-Electro magnets in relays and cuts.

Thermocouple (Fig 6)

Fig 6



This is such an arrangment where circuit is closed by wires of different metals. One metal wire is kept at low temperature and the other at high temperature. In this way thermo-electro motive force is created which can be seen by galvanometer. This works on the effect of seebake.

Thermo electric energy

Thermo electric energy is the electrical energy produced by waste heat of an IC engine using seeback effect.

Thermo electric generation can convert waste heat from an engine coolant or exhaust into electricity.

Piezo - electric energy

Piezo electric sensor is a device that uses the piezo electri effect to measure the changes in pressure, acceleration or force, by convertring them to an electrical charge.

Application

It is used to initiate combustion in the IC engine mounted into a holes into the cylnider head.Glow plug is a in-built miniature piezo-electric sensor.

Photo voltaic energy:

Photo volatile (PV) is a term which covers the conversion of light into electricity by using semiconducting materials that exhibit the photovoltaic effect. This effect is seen in combination of two layers of semi conductor materials, one layer of this combination will have it depleted number of electrons.

When sunlight strikes on this layer, it absorbs the photons of sunlight ray and consequently the electrons are excited and jump to the other layer. This phenomenon creates a charge difference between the layer and resulting to a tiny potential difference between them.

The unit of such combination of two layers of semi conductor materials, for producing electric potential deference in sunlight is called solar cell. Silicon is normally used as solar cell. For building cell, silicon material is cut and very thin wafers. Some of these wafers are doped with impurities. Then both doped and undated wafers are and switched together to build solar cell. A metallic strip is reached to two extreme layers to collect current.

A desired number of solar cell are connected together in both parallel and series to form a solar module for producing desired electricity.

The solar cell can also work in cloudy weather as well is moon light but the rate of production of electricity low as and it depends up on intensity of incident light ray.

Fig 1 describes the typical system of solar panels, controller, energy storage, inverter for converting DC into AC and how the system is connected to power grid.

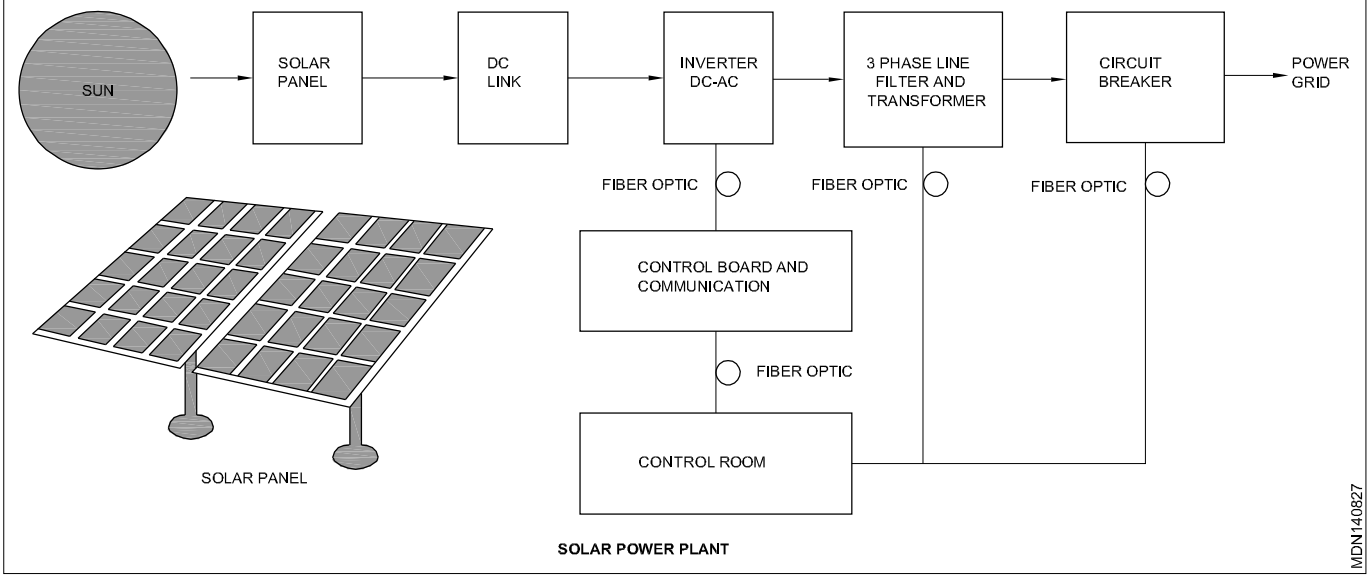
Solar panels installation may be ground, rooftop or wall mounted. The solar panels mount may be fixed a solar tracker to follow the sun across the sky.

Photo voltaic systems have long been used in specialized applications and stand alone and grid-connected PV systems have been in use since the 1990. After hydro and wind powers, PV is the third renewable energy source in term of global capacity. The PV energy covering approximately two percent of global electricity demand. It is an environmentally clean source of energy and it is free and available in adequate quanties in all the parts of world.

Advantages of solar photo voltaic: Solar panels once installed. Its operation generates no pollution and no green house gas emissions it is simple salability in respect of power needs and silicon has large availability in earth

Disadvantages of solar photovoltaic (Fig 7) : The power output is dependent on direct sunlight. That 10-25% is lost, if a tracking system is not used. Dust, clouds and other obstruction in the atmosphere also diminish the power output. Solar photovoltaic power needs to be stored for later use.

Fig 7



SOLAR POWER PLANT

Electromagetic induction, self-induced emf - inductors

Objective: At the end of this lesson you shall be able to

- **state the principle and law of electromagnetic induction.**

Faraday's Law of Electromagnetic induction are also applicable for conductors carrying alternating current.

What are Faraday's Law of Electromagnetic Induction?

Faraday's First Law states that whenever the magnetic flux is linked with a circuit changes, an emf is always induced in

The second Law states that the magnitude of the induced emf is equal to the rate of change of flux linkage.

According induced emf can be produced either by moving the conductor in a stationery magnetic field by changing magnetic flux over a stationery conductor. When conductor moves and produces emf, the emf is called as dynamically induced emf Ex. generators.

When changing flux produces emf the emf is called as statically induced emf as explained below. Ex: Transformer.

Tracing auto electrical components in circuit - Solenoid & relay

Objectives: At the end of the lesson you shall be able to
- **define a realy**
- **classify relays according to the operating force and function**
- **describe the function of current sensing relay & Voltage sensing relay**
- **state the function of solenoid.**

Relay : A realy is a device which opens or closes an auxiliary circuit under predetermined conditions in the main circuit.

Relays are extensively used in electronics, electrical engineering and many other fields.

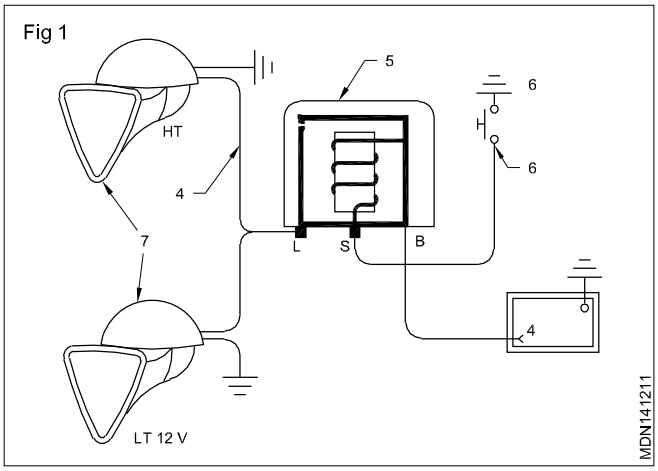
The relays are sensitive to conditions of voltage, current, temperature, frequency or some combination of these conditions.

Relays are also classified according to their main operating force as stated under

- Electromagnetic relays
- Thermal relays

Electromagnetic relay : A relay switch assembly is a combination of movable and fixed low - resistance contacts that open or close a circuit. The fixed contacts are mounted on springs or brackets, which have soem flexibility. The movable contacts are mounted on a spring or a hinged arm that is moved by the electromagnet int he relay as shown in (Fig 1).

Fig 1



The other types of relays coming under this group are as follows.

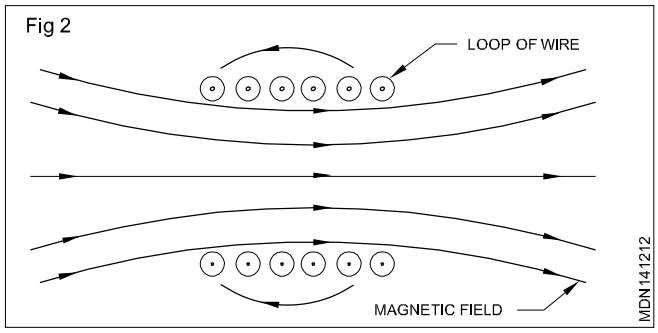
Current sensing relay : A current sensing relay functions whenever the current the coil reaches an uppe limit. The difference between the current specified for pick up (must operate) and non - pick up (must non operate) is usually closely controlled. The difference in current may also be closely controlled for drop out (must release) and non - drop out (must not release).

Voltage sensing relay : A voltage sensing relay is used where a condition of under - voltage or over - voltage may cause a damage to the equipment. For example, these types of relays are used in voltage stabilizers. Either a proportional AC voltage derived from a transformer or a proportional DC derived from a transformer and rectifier is used for this purpose.

Solenoid

Solenoid is a coil wound into a tightly packed to a long thin loop of wire, often wraped arrouned a metalic core, which produces a uniform magnetic field in a volume of space. (Fig. 2)

Fig 2



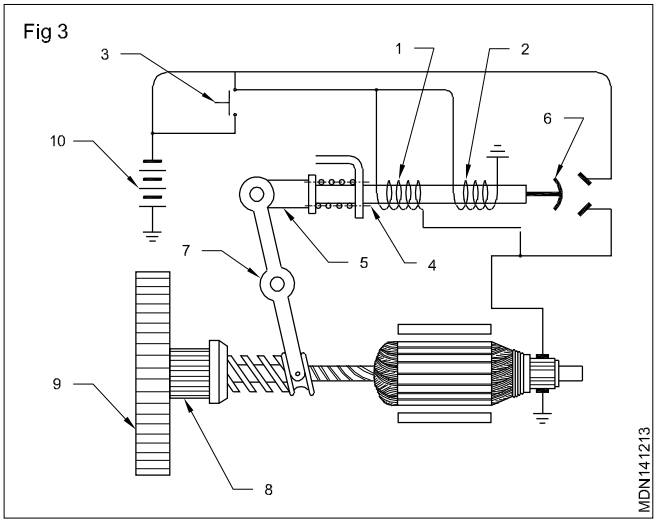
Application

Need for solenoid switch: The solenold switch is a strong electromagnetic switch. It is used to operate the over running clutch drive pinion to engage with the fly wheel ring gear. It also acts as a relay to close the contacts between the bettery and the staring motor.

Construction fo solenoid switch (Fig 3) : In a solenoid there are two windings, a pull-in winding (1) and a hold - in winding (11). The pull - in winding (10) is wound with thick wires (series winding) and the hold - in winding (11) is of thin wires (shunt winding). The pull-in winding (10) is connected to the starter switch (3) in the solenoid.

The hold in winding (2) is connecteed across the switch terminal and ground. The two windings are wound around a hollow core (4). An iron plunger (5) is placed inside the core (4). The other end of the plunger moves a shift lever (7) to engage the pinion (8) with the fly wheel ring gear (9).

Fig 3



Function of solenold switch : When the starter switch (3) is turned, current flows from the battery to the solenoid windings (1) and (2). This energises the windings which pull the plunger (5). The plunger (5) operates are shift lever (7) to engage the pinion (8) on the flywheel ring gear (9). Then it closes the circuit between the battery (10) and the starting motor.

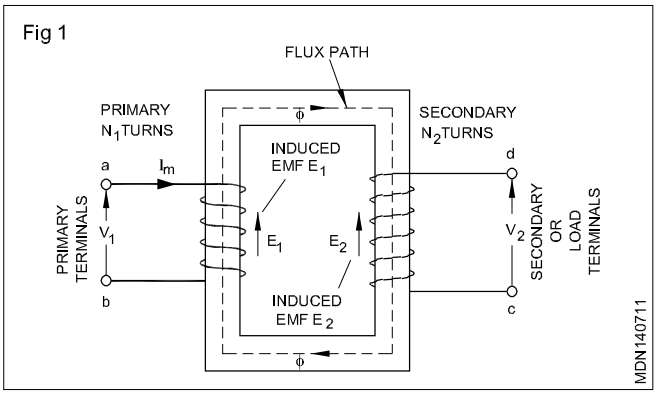
Primary and secondary winding, transformers, stator and rotor coil.

Objectives : At the end of this lesson you shall be able to
- **define the primary and secondary of a transformer**
- **state the constructional features of a power transformer and the function of each part**
- **state the reasons for laminated silicon steel being used as core material.**

Two- winding transformers

A transformer in its simplest form consists of two stationary coils coupled by a mutual magnetic flux (Fig 1). The coils are said to be mutually coupled because they link a common flux.

Fig 1



Laminated steel core transformers are used in power applications. As shown in Fig 1, the current flowing in the coil connected to the AC source is called the primary winding or simply primary. The primary is the input to a transformer. It sets up the flux in the core, which varies periodically both in magnitude and direction. The flux links the second coil, called the secondary winding or simply the secondary.

The flux is changing; therefore, it induces a voltage in the secondary by electromagnetic induction. Thus the primary receives its power from the source while the secondary supplies this power to the load. This action is known as transformer action. There is no electrical connection between these two coils.

Transformers are afficient and reliable devices used mainly to change voltage levels. Transformers are efficient because the rotational losses are absent; so little power is lost when transforming power from one voltage level to another. Typical efficiencies are int he range of 92 to 99%. The higher values apply to the large power transformers. There is no change in frequency of voltage.

Transformer

A transformer is an electrical device that transforms the AC voltage between two circuit through an electromagnetic induction.

A transformer may be used as a safe and efficient voltage convertor to change the AC/DC voltage and its to a higher / lower voltage its ouput without changing the frequency and power.

Types

1. Step up transformer

2. Step down tranformer

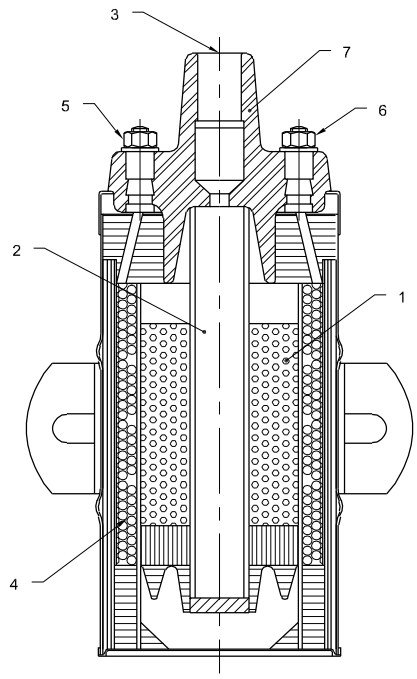
Application

Transformer is used in (1) ignition coil in petorl engine igrition system and battery charger.

Ignition coil (Fig. 2)

It is used to step up low voltage to high voltage to generate sparks. It consists of two windings, one wound over soft iron core. The secondary winding (1) is wound over the core (2). It consists of about 21,000 turns. One end of the winding is connected to the secondary terminal (3) and the other end to the primary winding (4). The primary winding (4) is wound over the secondary winding (1) and consists of about 200-300 turns. The ends are connected to the external terminal (5,6) of coil. The bakelite cap (7) insulates the secondary terminal from the container and primary terminals.

Fig 2



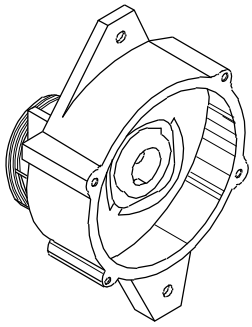
Rotor

Rotor is the moving part of a rotary electric motor, electric generator alternated which rotates because the wire and magnitive field of the motor are arranged so that them to develop about the rotar axis.

Description of parts of an alternator

Drive end frame (Fig 3)

Fig 3



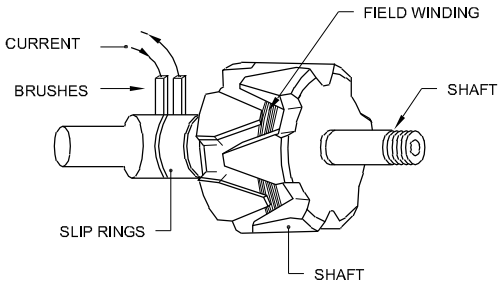
DRIVE END FRAME

The drive end frame supports a pre - lubricated sealed sliprimgs in which the drive end of rotor shaft rotates.

The rotor and its shaft is mounted and encased between drive end frame and slip ring end frame.

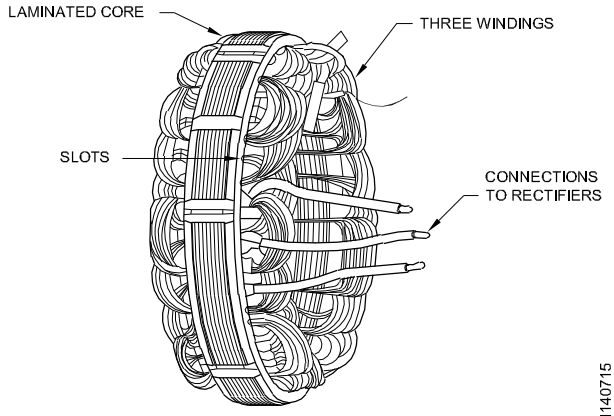
The rotor assembly (Fig 4)

Fig 4



This consists of a steel shaft which carries the driving pulley and cooling fan, a cylindrical iron core, and two stationary part which is held between two end covers. (Fign 5)

Fig 5



STATOR ASSEMBLY

Diodes

Objectives: At the end of the lesson you shall be able to
- **state the meaning of semiconductors**
- **state how P and N materials are formed**
- **state the unique property of a PN junction**
- **list the different classifications of diodes**
- **state the polarity**
- **list a few type numbers/code numbers of diodes.**

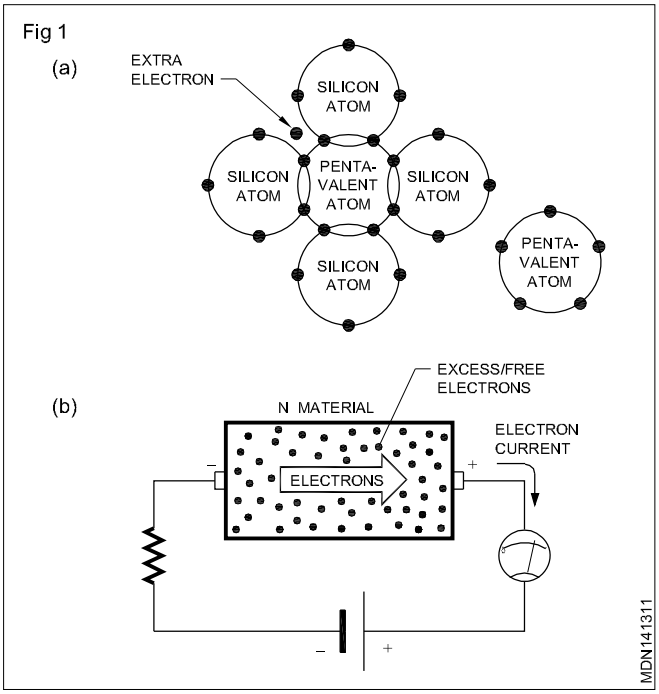
Semiconductors

Semiconductors are materials whose electrical property lies between that of Conductors and Insulators. Because of this fact, these materials are termed as semiconductors. In conductors the valence electrons are always free. In an insulator the valence electrons are always bound. Whereas in a semiconductor the valence electrons are normally bound but can be set free by supplying a small amount of energy. Several electronic devices are made using semiconductor materials. One such device is known as Diode.

1) N-type semiconductors

When a pentavalent material like Arsenic (As) is added to a pure Germanium or pure Silicon crystal, one free electron results per bond as shown in Fig 1a. As every arsenic atom donates one free electron, arsenic is called the *donor impurity.* Since a free electron is available and since the electron is of a Negative charge, the material so formed by mixing is known as **N type material.**

Fig 1



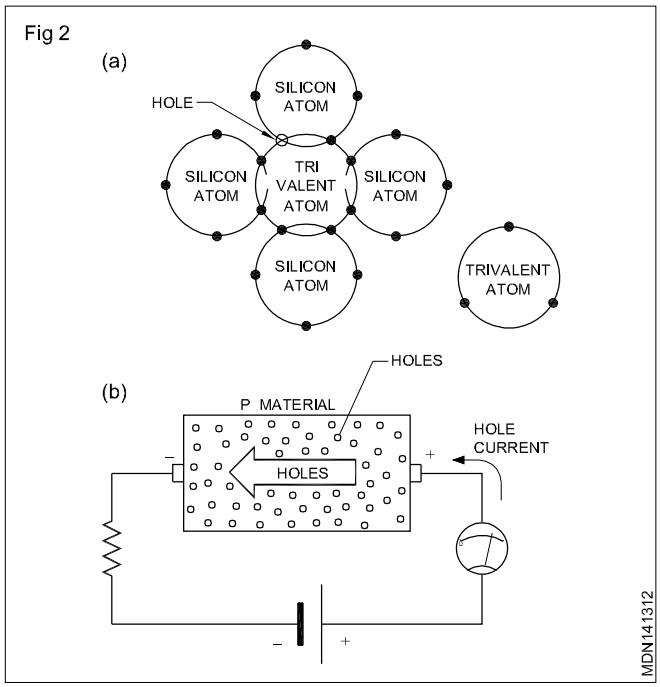
When a N-type material is connected across a battery, as shown in Fig 1b, current flows due to the availability of free electrons. As this current is due to the flow of free electrons, the current is called electron current.

2) P-type semiconductors

When a trivalent material like Gallium(Ga) is added to a pure Germanium or pure Silicon crystal, one vacancy or deficit of electron results per bond as shown in Fig 2a. As every gallium atom creates one *deficit of electron or hole,* the material is ready to accept electrons when supplied. Hence gallium is called *acceptor impurity*. Since vacancy for an electron is available, and as this vacancy is a hole which is of Positive charge, the material so formed is known as **P-type material**.

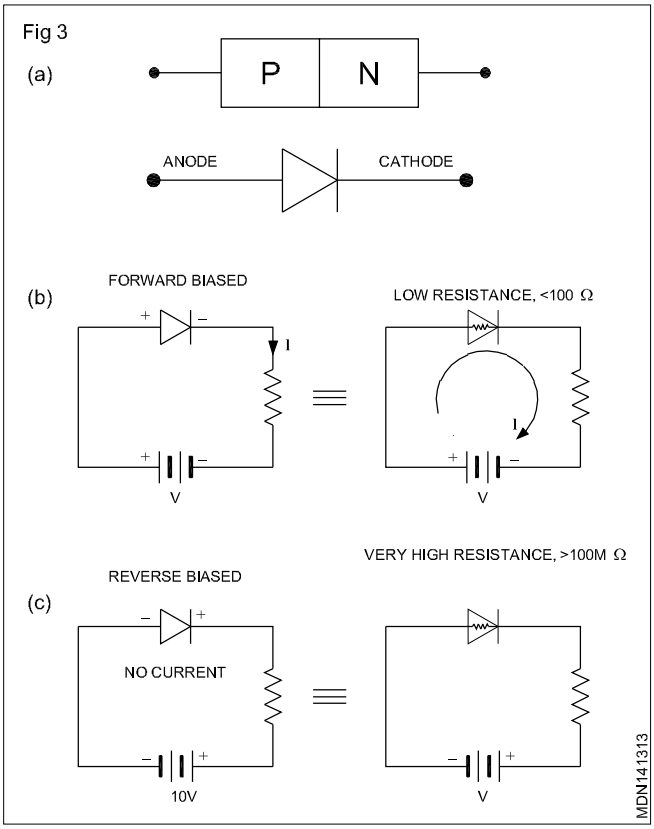
When a P-type material is connected across a battery as shown in Fig 2b, current flows due to the availability of free holes. As this current is due to flow of holes, the current is called *hole current.*

Fig 2



P-N junction

When a P-type and a N-type semiconductors are joined, a contact surface between the two materials called PN-junction is formed. This junction has a unique characteristic. This junction, has the ability to pass current in one direction and stop current flow in the other direction. To make use of this unique property of the PN junction, two



terminals one on the P side and the other on the N side are attached. Such a PN junction with terminals attached is called a **Diode.** The typical symbol of a PN-junction diode is shown in Fig 3a.

Types of diodes

The PN junction diodes discussed so far are commonly referred to as *rectifier diodes.* This is because these diodes are used mostly in the application of rectifying AC to DC.

Classification of Diodes

1 Based on their current carrying capacity/power handling capacity, diodes can be classified as

– **low power diodes**

can handle power of the order of several milliwatts only

– **medium power diodes**

can handle power of the order of several watts only

– **high power diodes**

can handle power of the order of several 100's of watts.

2 Based on their principal application, diodes can be classified as,

– **Signal diodes**

low power diodes used in communication circuits such as radio receivers etc. for signal detection and mixing

– **Switching diodes**

low power diodes used in switching circuits such as digital electronics etc. for fast switching ON/OFF of circuits

– **Rectifier diodes**

medium to high power used in power supplies for electronic circuits for converting AC voltage to DC.

Polarity marking on the diodes

The cathode end of a diode is usually marked by a circular band or by a dot or by plus (+) sign. In some diodes the symbol of the diode, which itself indicates the polarities, is printed on the body of the diode.

Type number or diode code number

Unlike resistors, capacitors or inductors, the diodes do not have any value that can be printed or coded on its body. The other reason for this is, there are almost innumerable types of diodes with varied current handling and other specifications. Hence, instead of printing its specifications on its body, all diodes will have a type number printed on their body. This type number carries a set of specifications which can be found out by referring to a *diode data manual*. Diode data manuals give data of several thousands of diodes from different manufacturers. Some of the popular type numbers of diodes are

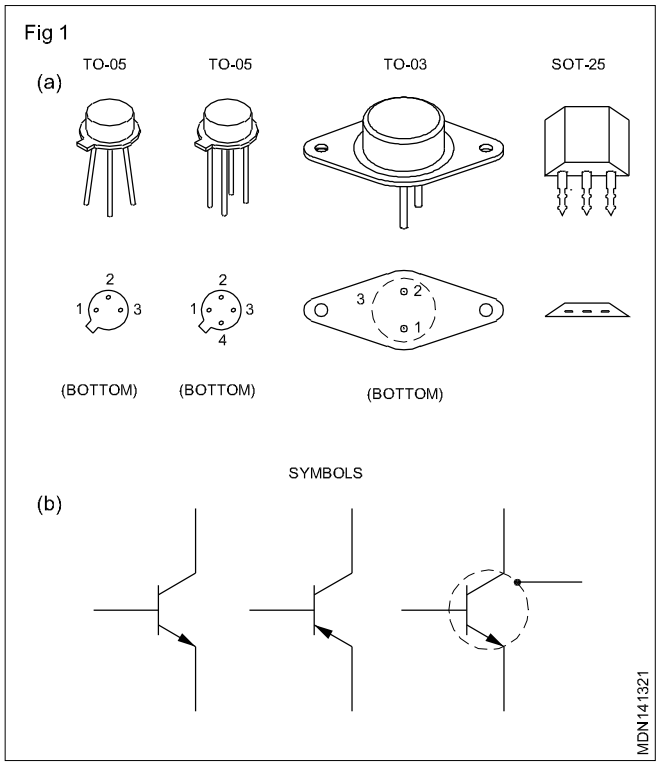
OAxx,	xx - from 70 to 95.	examples: OA79, OA85 etc.,
BYxxx,	xxx- from 100 onwards,	examples: BY127, BY128 etc.
DRxxx,	xxx- from 25 onwards.	examples: DR25, DR150 etc.,
1Nxxxx	examples: 1N917	1N4001, 1N4007 etc.

Transistors and classification

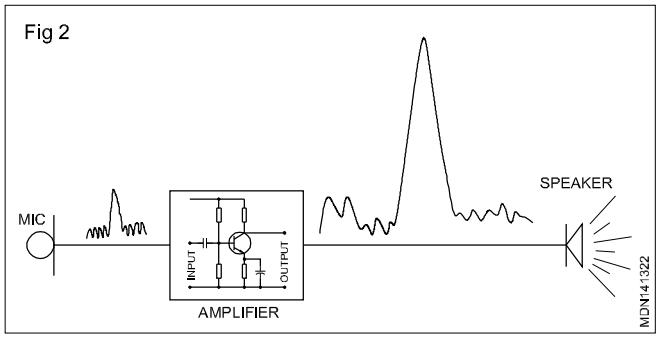
Objectives: At the end of this lesson you shall be able to
- **state the two main uses of transistors**
- **list the advantages of transistors over vacuum tubes**
- **list the important classifications of transistors**
- **state the use of a transistor data book**
- **state the names given to the leads of a transistor**
- **state the functions of the three sections of a transistor**
- **state the uses of putting sleeves to transistor leads**
- **describe the two tests to be conducted on a transistor before using it.**

Introduction to Transistors

Transistors are the semiconductor devices having three or four leads/terminals. Fig 1a shows some typical transistors. Fig 1b shows the symbols used for different types of transistors.

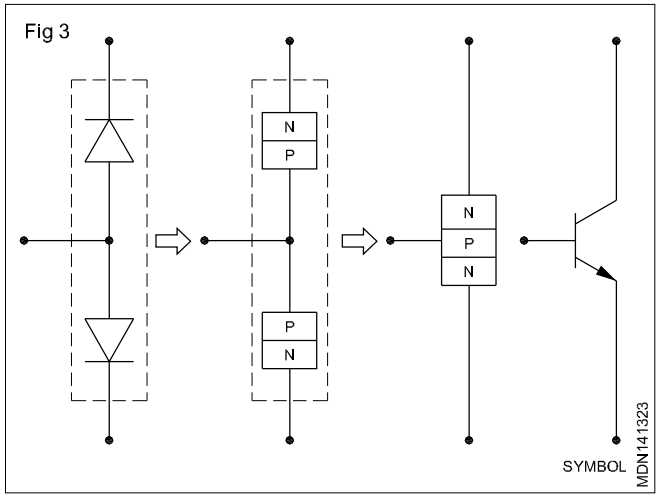


Transistors are mainly used for enlarging or amplifying small electric/electronic signals as shown in Fig 2. The circuit which uses transistors for amplifying is known as a transistor amplifier.

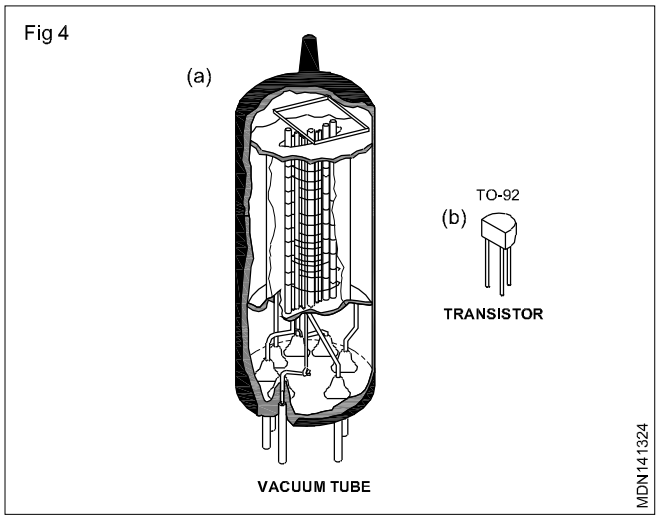


Other important application of transistors is its use as a solid state switch. A solid state switch is nothing but a switch which does not involve any physical ON/OFF contacts for switching.

Transistors can be thought of as two PN junction diodes connected back to back as shown in Fig 3.



Before the transistors were invented (1947), there was vacuum tubes which were used in amplifiers. A typical vacuum tube is shown in Fig 4a.



Compared with the present day transistors the vacuum tubes were big in size , consumed more power, generated lot of unwanted heat and were fragile. Hence vacuum tubes became absolute as soon as transistors came to market.

Transistors were invented by Walter H. Brazil and John Barlow of Bell Telephone Laboratories on 23rd Dec. 1947. Compared to vacuum tubes (also known as valves), transistors have several advantages. Some important advantages are listed below;

– Very small in size (see Fig 4b)
– Light in weight
– Minimum or no power loss in the form of heat
– Low operating voltage
– Rugged in construction.

To satisfy the requirements of different applications, several types of transistors in different types of packaging are available. As in diodes, depending upon the characteristics, transistors are given a type number such as BC 107, 2N 6004 etc., The characteristics data corresponding to these type numbers are given in Transistor data books.

Classification of Transistors

1 Based on the semiconductor used.

– Germanium transistors

– Silicon transistors

Like in diodes, transistors can be made, using any one of the above two important semiconductors. However, most of the transistors are made using silicon. This is because, silicon transistors work better over a wide temperature range (higher thermal stability) compared to germanium transistors.

Transistor data books give information about the semiconductor used in any particular transistor.

2 Based on the way the P and N junctions are organized as shown in Fig 5.

– NPN transistors

– PNP transistors

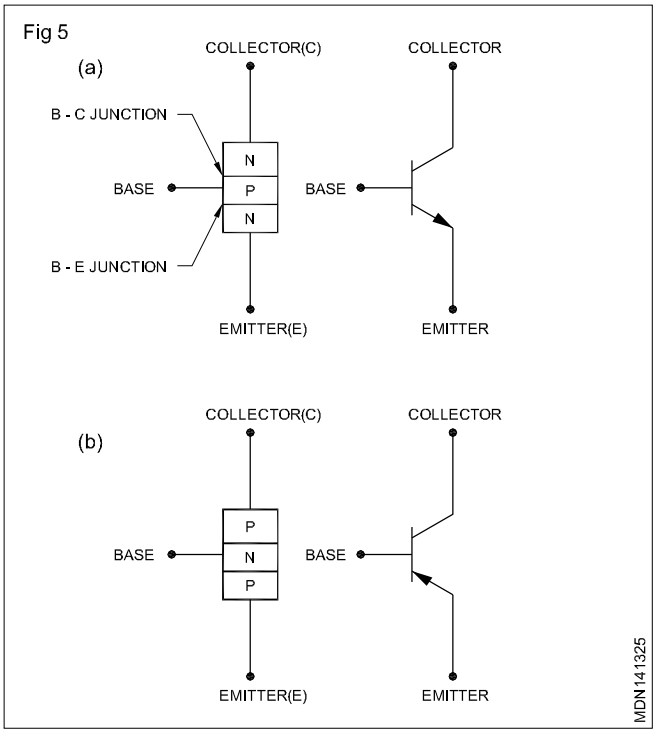
Both NPN and PNP transistors are equally useful in electronic circuits. However, NPN transistors are preferred for the reason that NPN has higher *switching speed* compared to PNP.

Whether a transistor is PNP or NPN can be found with the help of transistor data book.

3 Based on the power handling capacity of transistors as shown in Table below (Fig 6).

Low power transistors, also known as small signal amplifiers, are generally used at the first stage of amplification in which the strength of the signal to be amplified is low. For example, to amplify signals from a microphone, tape head, transducers etc.,

Fig 5



Low power transistors (less than 2 watts)	Medium power transistors (2 to 10 watts)	High power transistors (more than 10 watts)
TO-92	TO-05	TO-03

Fig 6

Medium power and high power transistors, also known as large signal amplifiers are used for achieving medium to high power amplification. For example, signals to be given to loudspeakers etc. High power transistors are usually mounted on metal chassis or on a physically large piece of metal known as heat sink. The function of heat sink is to, take away the heat from the transistor and pass it to air.

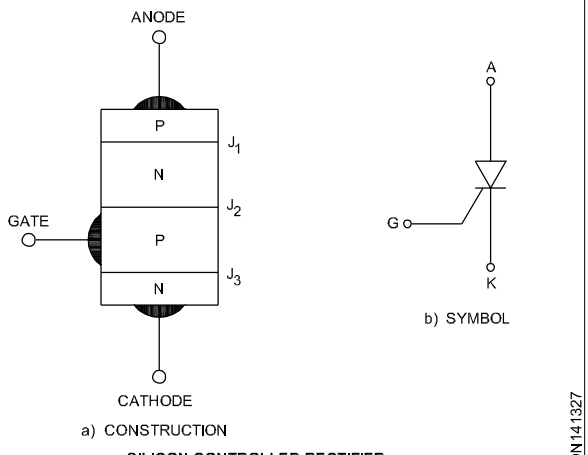
Transistor data books give information about the power handling capacity of different transistors.

Thyristor and the characteristics of SCR

Introduction: Thyristors are four layer device which can be switched 'on' or 'off' electronically to control relatively large amounts of current for motors and other electrical equipments. The Silicon Controlled Rectifier (SCR) and the triac are examples of thyristor. Almost all electronic controls used in modern industries consist of electronic circuits with thyristors.

Working of SCR: The SCR is a four-layer device with three terminals, namely, the anode, the cathode, and the gate. When the anode is made positive with respect to the cathode (Fig 7), junction J_2 is reverse-biased and only the leakage current will flow through the device. The SCR is then said to be in the forward blocking state or off-state. When the anode-to-cathode voltage is increased, the reverse-biased junction J_2 will break down due to the large voltage gradient across the depletion layers. This is the avalanche breakdown. Since the other junctions J_1 and J_3 are forward-biased, there will be free carrier movement across all the three junctions, resulting in a large anode-to-cathode forward current I_F. The voltage drop V_F across the device will be the ohmic drop in the four layers, and the device is then said to be in the conduction state or on-state.

Fig 7



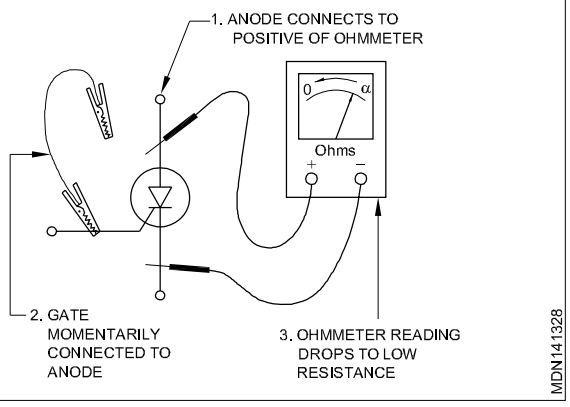
SILICON CONTROLLED RECTIFIER

In the on-state, the current is limited by the external impedance. If the anode-to cathode voltage is now reduced, since the original depletion layer and the reverse-biased junction J_2 no longer exist due to the free movement of the carriers, the device will continue to stay on. When the forward current falls below the level of the holding current I_h, the depletion region will begin to develop around J_2 due to the reduced number of carriers, and the device will go to the blocking state. Similarly, when the SCR is switched on, the resulting forward current has to be more than the latching current I_L. This is necessary for maintaining the required amount of carrier flow across the junctions; otherwise, the device will return to the blocking state as soon as the anode-to-cathode voltage is reduced. The holding current is usually lower than, but very close to the latching current; its magnitude is in the order of a few milliampere(mA). When the cathode is made positive with respect to the anode, junctions J_1 and J_3 are reverse-biased, and a small reverse leakage current will flow through the SCR. This is the reverse blocking state of the device.

Set the multimeter to a low range. Adjust to zero and infinity with the adjustment knob. Connect the SCR as shown in Fig 8. The meter will not indicate any reading. Even the test prods are interchanged because of the junctions. The multimeter shows infinite resistance. Connect the SCR as shown in Fig 8. When the gate is touched momentarily with the anode prods, the meter reads low resistance between 30 and 40 Ohm. When the gate is removed, the meter still continues to read the same value of 30 and 40 Ohm.

This means that the SCR is in good working condition. If the meter does not show any reading, the SCR is faulty. When the gate is given a small forward bias, the gate switching the SCR and the internal resistance of the junction is low, so the current can flow easily from the cathode to the anode. Once the SCR is conducted, even if the gate's forward bias is removed, the SCR anode-to-cathode current will flow through the meter, and the multimeter will continue to read a low resistance, ie 30 to 40 Ohm.

Fig 8

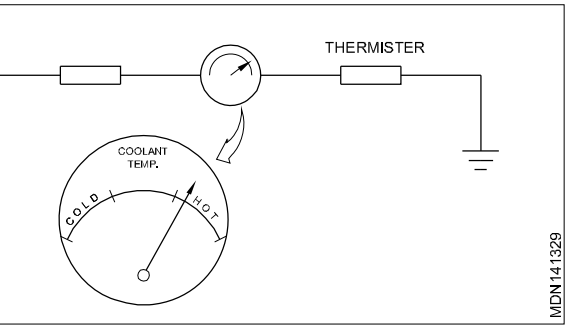


Thermistor: It is also semiconductor device used in most vehicles today. They are named because they are actually a temperature sensitive resistor. It is made of powdered nickel, cobalt, copper, iron and manganese which has been fused together at a higher temperature. The electrical resistance of a thermistor changes greatly with temperature.

Thermistors are used to detect various temperatures or changes in temperature. Their most frequent use involves the measurement of engine coolant temperature, or inlet air temperature.

In the most common type of thermistor, the resistance decreases as the temperature increases. This type is called a negative temperature coefficient (NTC) thermistor. Some thermistors are of the positive temperature coefficient (PTC) type. This means that the resistance of the thermistor increases with temperature. NTC type thermistors are used in automobiles as engine coolant temperature sensors as shown in Fig 9.

Fig 9



Thermistors can also be used to detect the temperature of the air. Many of the computer controlled fuel system in use utilize air temperature as an input. These are easily installed and wired into the computers and will have their resistance changes seen as temperature changes.

Uni-junction transistor (UJT)

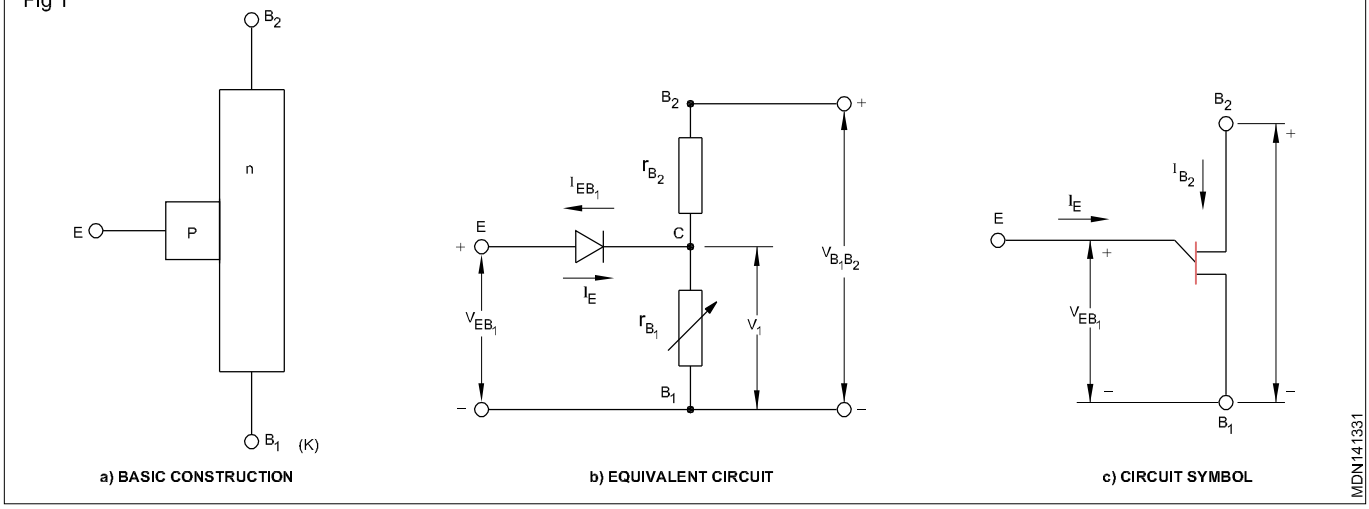
Objectives: At the end of this lesson you shall be able to

- **explain the construction, equivalent circuit and symbol of an UJT**
- **state the application of UJT.**

The Uni-junction transistor (UJT): The uni-junction transistor consists of a bar of lightly doped n-type silicon with small piece of heavily doped P-type material joined to one side at 60% of height from the base as shown in Fig 1a. The end terminals are named as base 1(B_1) or Cathode (K) and base 2(B_2) or anode (A) and the P-type material as emitter (E). The highly doped n-type material has a high resistance and can be represented by two resistor r_{B1} and r_{B2}. The sum of r_{B1} and r_{B2} is designated as R_{BB} (Refer Fig 1b). The emitter (P-type) form a PN junction with the n-type silicon bar and this junction is represented by a diode in the equivalent circuit (Fig 1b). The circuit symbol is shown in Fig 1c.

Application of UJTs: UJTs are employed in a wide variety of circuits involving electronic switching and voltage or current sensing applications.

Fig 1



Field effect Transistors

Objectives : At the end of this lesson you shall be able to

- **explain the difference between bi-polar transistors and field effect transistors**
- **write the basic construction and symbol used.**
- **explain the theory of operation of FETs**
- **explain a typical FET a.c voltage amplifiers.**

Field Effect Transistor (FET)

The main difference between a Bi-polar transistor and a FET is that,

Bi-polar transistor is a current controlled device.

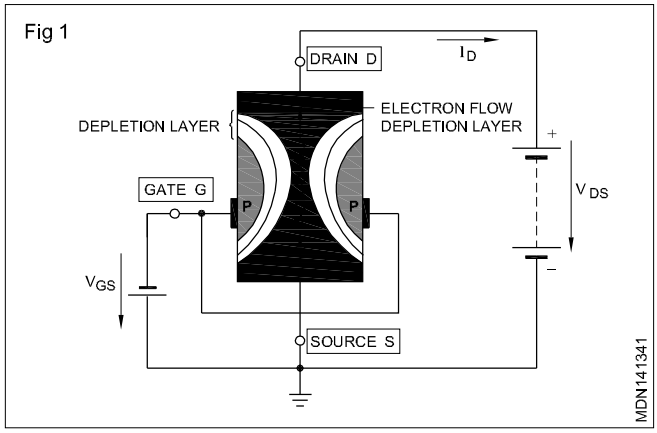
In simple terms it means that the main current in a bi-polar transistor is controlled by the base current.

FET is a voltage controlled device.

This means that the voltage at the gate controls the main current.

In addition to the above, in a bi-polar transistor,the main current always flows through N-doped and P-doped semiconductor materials.Where as in a FET the main current flows either only through the N-doped semiconductor or only through the P-doped semiconductor as shown in Fig 1.

Fig 1



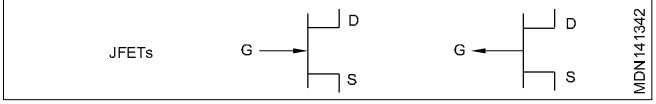
If the main current flow is only through the N-doped material,then such a FET is reffered as a P-channel or P type FET.The current through the P-doped material in the P-type FET is only by Holes.

Unlike in bipolar transistors in which the main current is both by electrons and holes.In contrast in FETs depending on the type(P or N type) the main current in either by electrons and holes and never both.for this reason FETs are also known as Unipolar transistors or unipolar device.

Junctin Field Effect Transistor(JFET)

It is a three terminal device and looks similar to a bi-polar transistor.The standard circuit symbols of N-channel and P-channel type FETs are shown in Fig2.

Fig 2

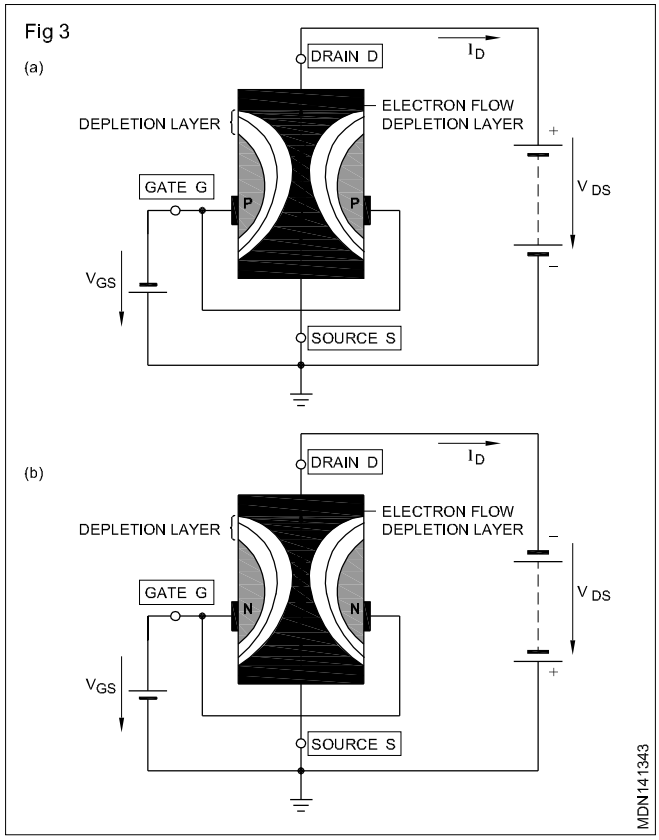


Construction

As shown in Fig 3a, a N-channel JFET has a narrow bar of n-type. To this,two p-type junctions are diffused on opposite sides of its middle part fig 3a.These diffused junctions form two PN diodes or gates.The N-type semiconductor area between these junctions/gates is called the channel. The diffused P regions on opposite sides of the channel are integrally connected and a single lead is brought out which is called gate lead or terminal.Direct electrical connections are made at the two ends of the bar. One of which is called source terminal S and the other terminal,D is called drain-D.

A P-channel FET very similar to the N-channel FET in construction except that it uses P-type bar and two N-type junctions as shown in Fig 3b.

Fig 3



FET notation listed below are essential and worth memorizing.

1 Source terminal: It is the terminal through which majority carriers enter the bar (N or P bar depending upon the type of FET).

2 Drain terminal: It is the terminal through which majority carriers come out of the bar.

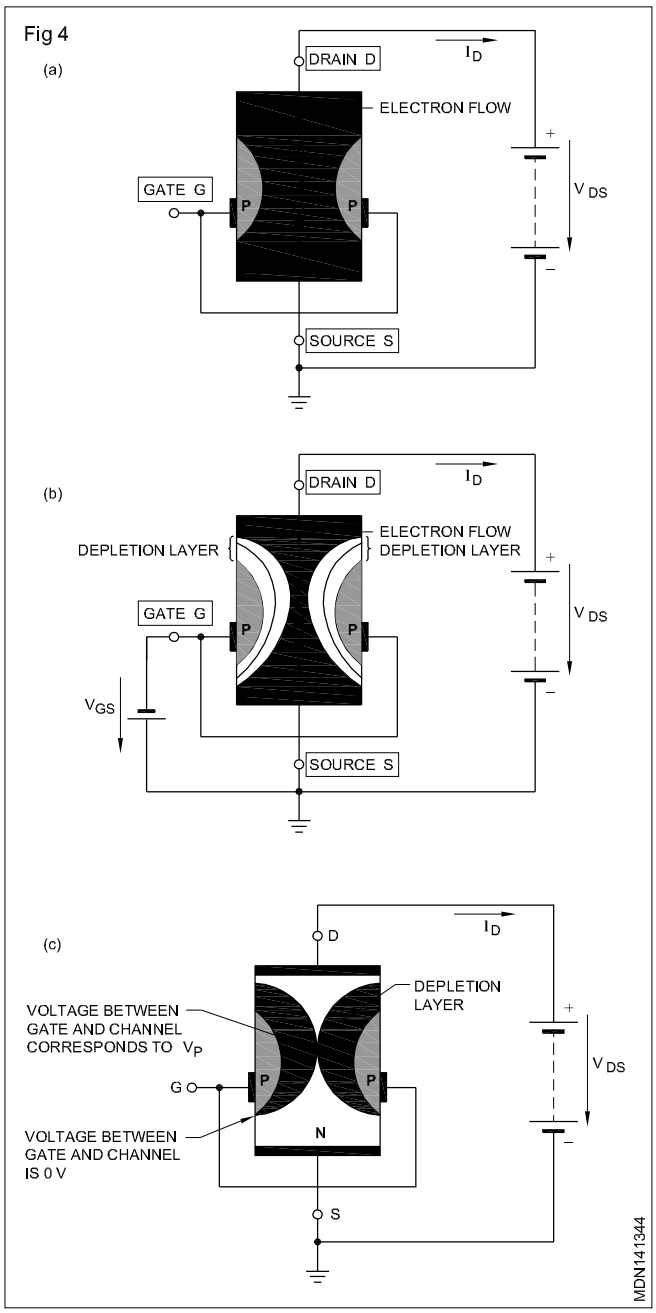
3 Gate terminal: These are two internally connected heavily doped regions which form two P-N junctions.

4 Channel: It is the space between the two gates through which majority carriers pass from source to drain when FET is working (on).

Working of FET

Similar to Bipolar transistors, the working point of adjustment and stabilization are also required for FETs.

Fig 4



Biasing a JFET

The biasing arrangement of JFET is shown in Fig 4. In which the gates are always reverse biased. Therefore the gate current Ig is practically zero.

The current source terminal is always connected to that end of the supply which provides the necessary charge carriers. For instance, in a N-channel JFET source terminal S is connected to the negative of the d.c power supply.And, the positive of the d.c power supply is connected to the drain terminal of the JFET.

Where as in a P channel JFET,Source is connected to the positive end of the power supply and the drain is connected to the negative end of the for the drain to get the holes from the P-channel Where the holes are the charge carriers.

Where as in a N channel JFET, the drain is made positive with respect to source by voltage Vds as shown Fig 4a.When gate to source voltage Vgs is zero, there is no control voltage and maximum electron current flows from source(S)-through the channel-to the drain (D).This electron current from source to drain is referred to as Drain current,Id.

When gate is reverse biased with a negative voltage as shown in Fig 4b,the static field established at the gate causes depletion region to occur in the channel as shown in Fig 4b.

This depletion region decreases the width of the channel causing the drain current to decrease.

If Vgs is made more and more negative, the channel width decreases further resulting in further decreases in drain current. When the negative gate voltage is sufficiently high, the depletion regions meet and block the channel cutting off the flow of drain current as shown in Fig 4c.This voltage at which this effect occurs is referred to as the pinch off voltage, Vp.

Thus, by varying the reverse bias voltage between gate and source (-Vgs),the drain current can be varied between maximum current (with –Vgs=0) and zero current (with –Vgs=pinch off voltage).So,JFET can be reffered as a voltage controlled devices.

P channel JFET operates in the same way as explained above except that bias voltages are reversed and the majority carrier of channel are holes.

Metal oxide field effect transistor (MOSFET)

Objectives: At the end of the lesson you shall be able to
- **state the MOSFET's operation principle and its types**
- **list the special type of MOSFET**
- **explain the features of MOSFET.**

In MOSFETs, control is via an insulating layer instead of a junction (as in JFETS). This insulating layer is generally made of silicon dioxide, from which the very name MOSFET is derived(Metal Oxide Semiconductor). Some times the MOSFETs are also referred to as Insulated-gate FET, for which the abbreviation used are IFET or IGFET.

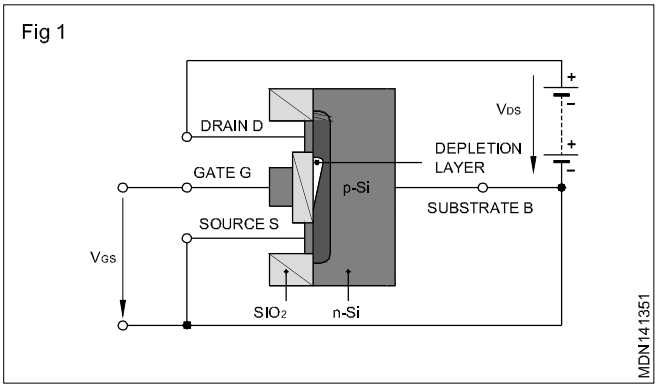
Type of MOSFET

Depletion-type MOSFET

Construction and mode of operation

Fig 1 shows the construction of a depletion MOSFET of the n-channel type.

Fig 1



Here, two highly doped n-zones are diffused into p-doped silicon plate, which is referred to as the substrate, and are provided with junction-free drain and source connections. Between the two zones there is a thin weakly n-doped channel, which produces an electrical connection between the source and drain without an external field-action. This channel is covered by an insulting layer of silicon dioxide (SIO_2), to which a metal electrode is applied as the gate connection.

If a voltage U_{DS} is applied between source and drain, at U_{GS} =)V an electron current flows from the source electrode via the n-channel to the drain electrode. If, however, a negative voltage is applied to control electrode G, the electrons present in the n-channel are forced out of the vicinity of the gate electrode, so that a zone depleted of charge carriers is produced there. This causes a constriction of the n-channel and consequently also a reduction of its conductivity. If the gate voltage becomes more negative, the conductivity of the channel is reduced, as is consequently also the drain current I. Another peculiarity of depletion type MOSFET s is that they can also be controlled with a positive gate-voltage. charge carries are then drawn out of the P- doped substrate into then-channel and its conductivity is increased even further, compared with the conductivity at U_{GS}- OV

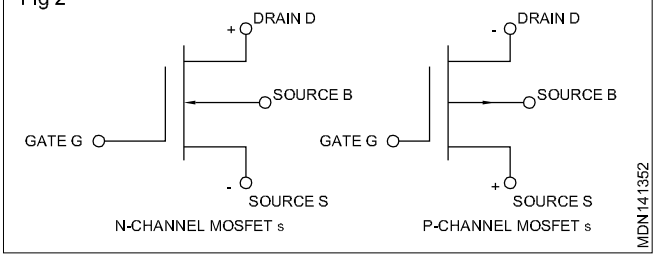
Designations and circuit symbols

The same designations are used for the connections of MOSFETs as they are for JFETs, I,e. source, drain and gate. MOSFETs, however, have another electrode, which is referred to as the substrate connection. Together, which is referred to as the substrate connection, Together with the semiconductor material of the channel, this substrate

forms a P-N junction, which can be used as a second control- electrode. It is then led out of the casing. Like the other electrodes is connected directly to the additional control possibility.

Fig 2 Shows the circuit symbols for depletion- type n-channel MOSFETs and p-channel MOSFETs. For the n-channel type, the arrow points towards the line representing the channel, in the case of the P-Channel type, on the other hand, it points away from the line representing the channel. The continuous line representing the channel indicates that it is depletion-type MOSFET.

Fig 2



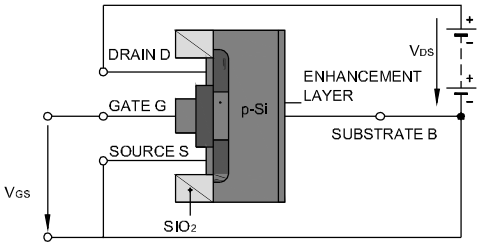
N- Channel MOSFETs are operated with a positive drain-source Voltage. They have a considerably greater practical significance than p-channel MOSFETs, which require a negative drain-source voltage for their operation.

Enhancement-type MOSFET

Construction and mode of operation

Enhancement-type MOSFETs have a similar technological construction to the depletion types. Without the external action of a field. However no conducting channel exists between the drain connection and the source connection, so that at U_{GS}=)V, no drain current can flow, Fig 3. shows the construction of an enhancement-type n-channel MOSFET.

Fig 3

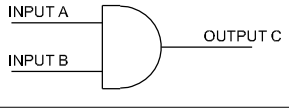


Basic logic gates

Objectives: At the end of this lesson you shall be able to
- **describe the AND, OR, NOT & NAND gate and their applications with simple digital circuits.**

Logic circuits (Fig 1)**:** Digital ICs are made up of many different elements. Most important of these are transistors. This transistor circuits are called logic circuits or digital circuits and are made up of combinations of different types of so-called gates. These gates have the special ability to logically process two or more signals. Thus they are also called logic gates.

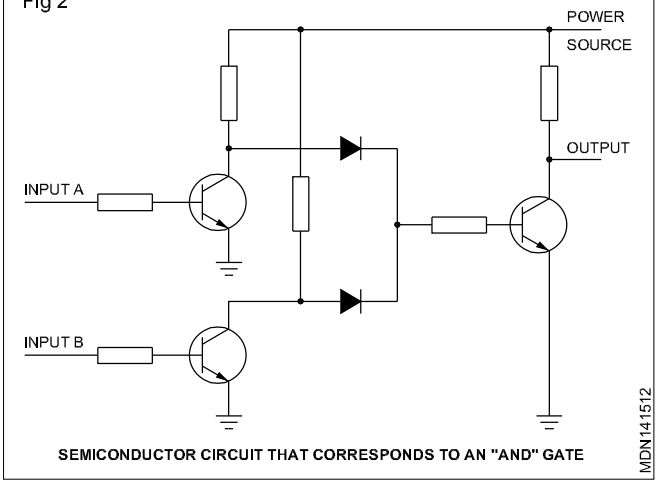
Fig 1



The "AND" Gate:

Logic circuits are usually indicated by a special symbol. Such a circuit, however is actually composed of semiconductor elements as shown in (Fig 2).

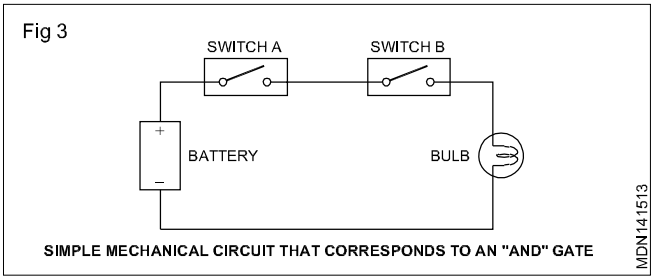
Fig 2



SEMICONDUCTOR CIRCUIT THAT CORRESPONDS TO AN "AND" GATE

To make an AND gate easily understand, a simple mechanical circuit without the use of semiconductors is shown in (Fig 3). In this circuit the switches A and B are equivalent to (C). The light bulb lights only if both switches A and B are closed. If either switch is open, the bulb will (or it both are open), not come on.

Fig 3



SIMPLE MECHANICAL CIRCUIT THAT CORRESPONDS TO AN "AND" GATE

Similarly, in an actual AND gate, there will be an "on" signal (often represented as the number 1) at the output terminal (C) only if there is a voltage at both input terminals (A and B). If either A or B is zero (off) or if both are zero, C will also be zero. These combination can be shown in a truth table.

AND - gate truth table

Inputs		Output
A	**B**	**C**
0	0	0
0	1	0
1	0	0
1	1	1

The "OR" Gate (Fig 4, 5 & 6)

Fig 4 shown the symbol for an "OR" gate, its corresponding semiconductor circuit, and an equivalent mechanical circuit.

Fig 4

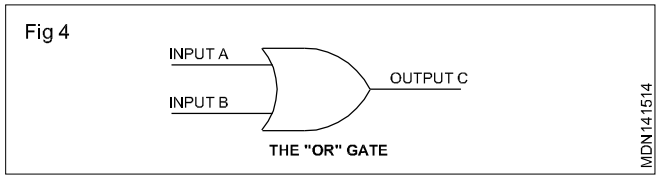


Fig 5

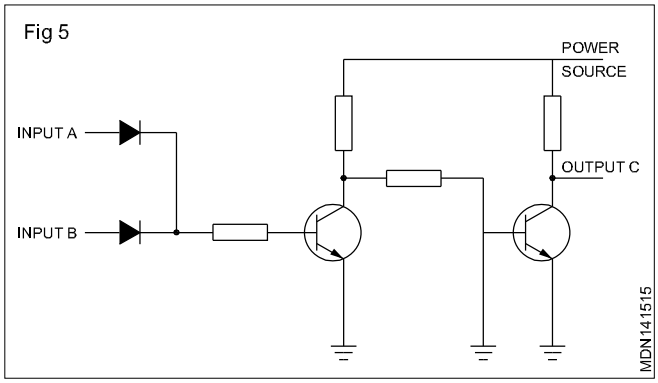
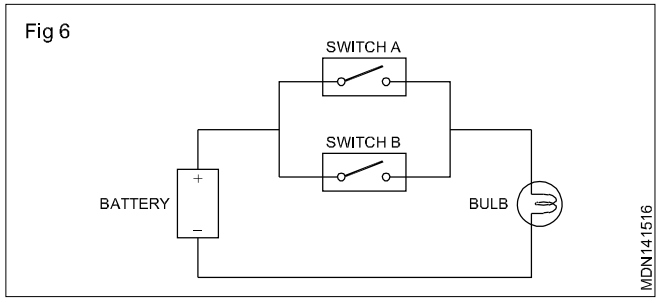


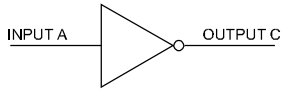
Fig 6



If there is voltage at either input terminal (or if there is a voltage at both inputs) there will be voltage at the output terminal “OR” gate truth table is given.

The symbol for a “NOT” gate is shown in (Fig 7). A corresponding semiconductor circuit and an equivalent mechanical circuit are as shown in (Fig 8).

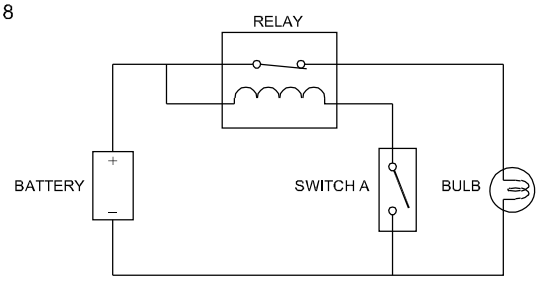
Fig 7



"NOT" GATE

MDN141517

Fig 8



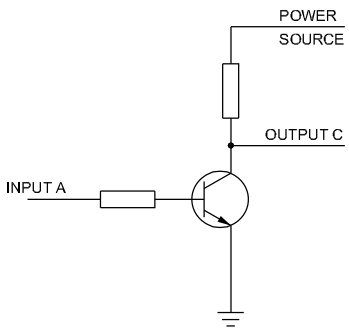
SIMPLE MECHANICAL CIRCUIT THAT CORRESPONDS TO "NOT" GATE

MDN141518

In the mechanical NOT circuit, the light bulb doesnot go on if switch A is closed. When switch A is opened the relay closes and the bulb is turned on.

As can be seen in the truth table, the “NOT” gate inverts the signal so that the output is always the opposite of the input. For this reason it is called as “inverter”. (Fig 9)

Fig 9

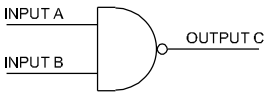


SEMICONDUCTOR CIRCUIT THAT CORRESPONDS TO "NOT" GATE

MDN141519

“NAND” is a combination of “AND” gate and a “NOT” gate as shown in (Fig 10).

Fig 10



"NAND" GATE

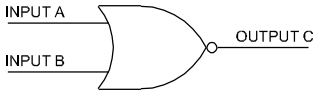
MDN14151A

A zero will appear at the output terminal (C) only if there is a voltage at both input terminals (A and B). If there is a zero at either A or B, an “on” signal (number 1) will appear at C.

This can be observed in Truth Table as shown.

A “NOR” gate is a combination of an “OR” gate and a NOT gate (Fig 11). For this reason, an “on” signal will appear at the output terminal only if there is an “off” signal (zero) at both input terminals. If there is an “on” signal at either A or B, terminal C will zero as shown in the truth table.

Fig 11



"NOR" GATE

MDN14151B

Principles of arc welding brief description classification and applications

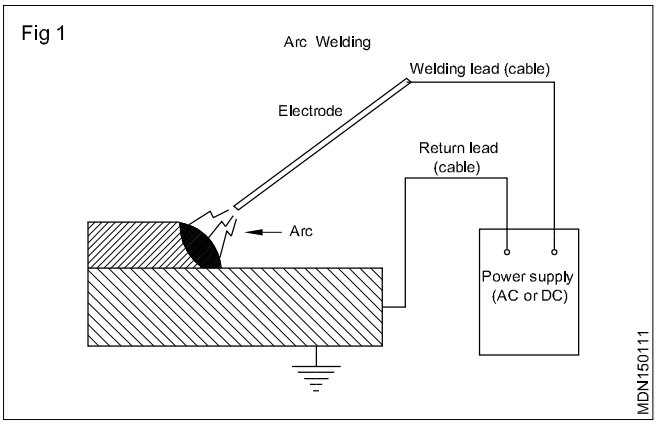
Objectives: At the end of this lesson you shall be able to
- **state the principle of arc welding**
- **state the clasification of arc welding**
- **state the application of arc welding**

Arc welding is a welding process, in which heat is generated by an electric arc struck between an electrode and the work piece.

Electric arc is luminous electrical discharge between two electrodes through ionized gas.

- Power supply (AC or DC)
- Welding electrode
- Welding leads (electric cables) connecting the electrode and work piece to the power supply.
- Electric arc between the electrode and work piece closes the electric circuit. The arc temperature may reach 10000°F (5500°C), which is sufficient for fusion the work piece edges and joining them.

Fig 1



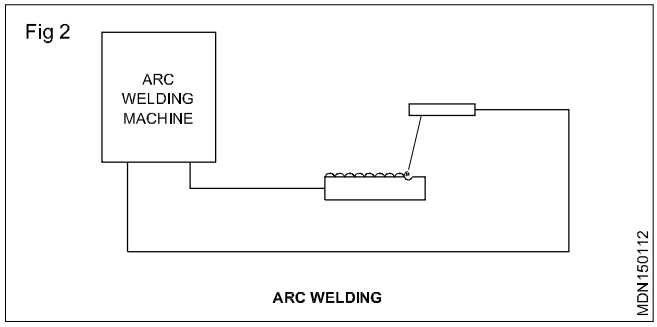
Classification and applications of Arc welding

- Shield metal arc welding
- Carbon arc welding
- Tungsten inert gas arc welding
- Gas metal arc welding
- Atomic Hydrogen are welding
- Submerged arc welding
- Electro slag welding
- Plasma arc welding

Shielded Metal arc welding (Fig 1,2): This is an arc welding process in which the welding heat is obtained from an arc, formed between a metallic (consumable) electrode and welding job.

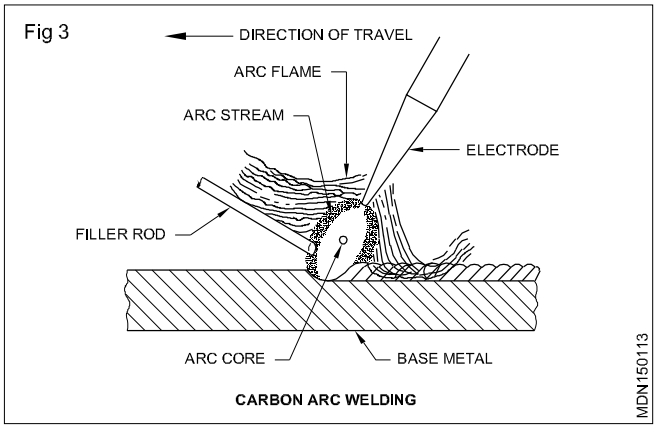
The metal electrode itself melts and acts as a filler metal.

Fig 2



Carbon arc welding (Fig 3): Here the arc is formed between a carbon electrode (non-consumable) and the welding job.

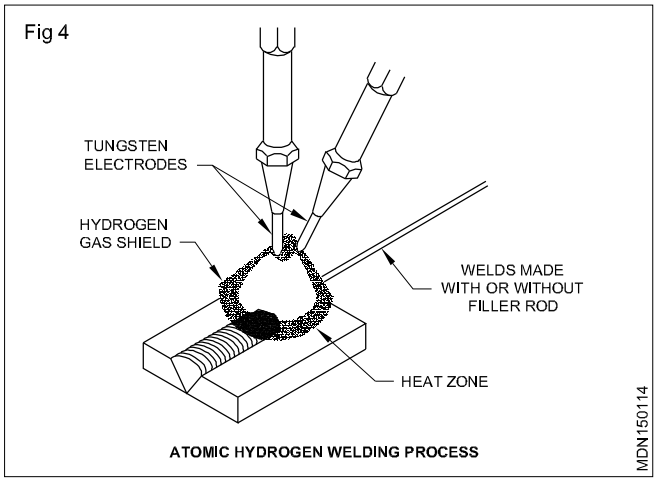
Fig 3



A separate filler rod is used since the carbon electrode is a non-metal and will not melt.

Atomic hydrogen arc welding (Fig 4): In this process the arc is formed between two tungsten electrodes in an atmosphere of hydrogen gas.

Fig 4



The welding job remains out of the welding circuit.

A separate filler rod is used to add the filler metal.

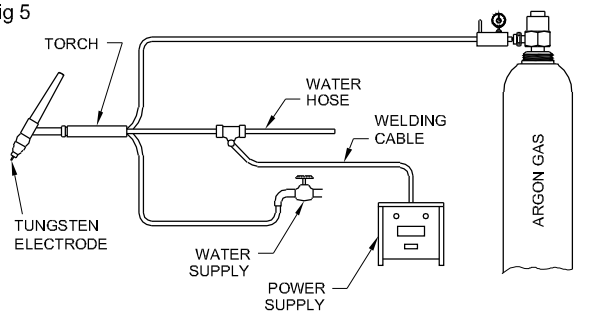
Tungsten inert gas arc welding (TIG) (Fig 5): In this case the arc is formed between the tungsten electrodes (non-consumable) and the welding job in an atmosphere of an inert gas (argon or helium).

A separate filler rod is used to add the filler metal.

This process is also called gas tungsten arc welding (GTAW) process.

Gas metal arc welding (GMAW) or Metal inert gas arc welding (MIG) (Fig 6): In this process the arc is formed between a continuous, automatically fed, metallic consumable electrode and welding job in an atmosphere of inert gas, and hence this is called metal inert gas arc welding (MIG) process.

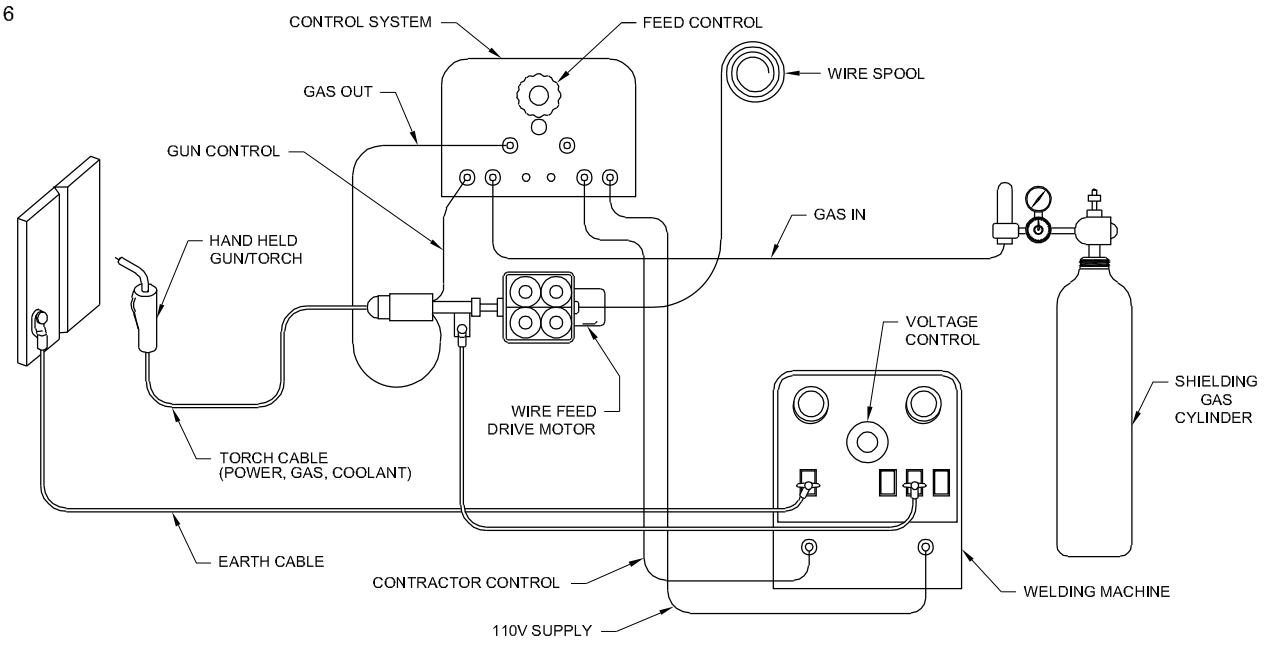
Fig 5



When the inert gas is replaced by carbon dioxide then it is called CO_2 arc welding or metal active gas (MAG) arc welding.

The common name for this process is gas metal arc welding (GMAW).

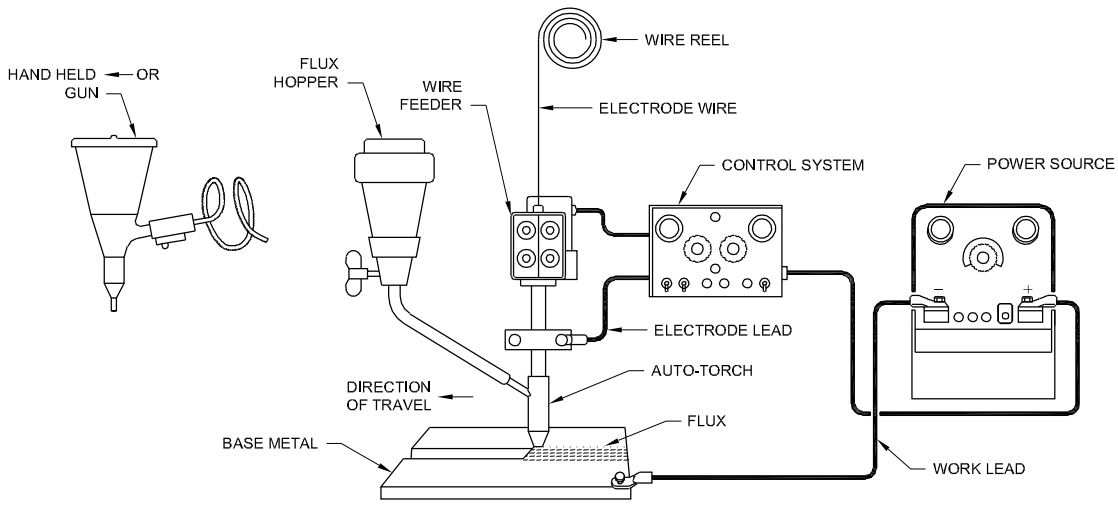
Fig 6



BLOCK DIAGRAM (GMAW/MIG)

Submerged arc welding (Fig 7): Here the arc is formed between a continuous, automatically fed, metallic consumable electrode and the welding job under a heap of powdered/granulated flux.

Fig 7



SUBMERGED ARC WELDING

The arc is totally submerged in the flux (invisible).

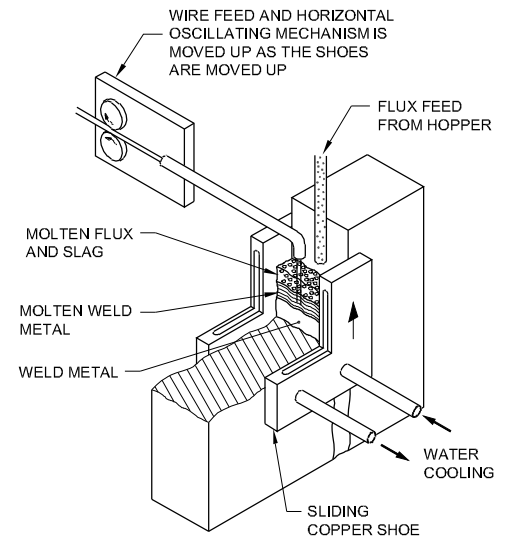
Electro-slag welding (Fig 8): The arc is formed between a continuous, automatically fed, metallic consumable electrode and the welding job under a thick pool of molten flux (slag).

This automatic process requires special equipment and is used only in vertical position for the welding of heavy thick plates.

Plasma arc welding: In this process the arc is formed between a tungsten electrode and the welding job in an atmosphere of plasma-forming gas-nitrogen, hydrogen and argon.

A separate filler rod is used to add the filler metal in the joint, if necessary. But normally no filler rod is used.

Fig 8



Arc-Welding machines

Objectives : At the end of this lesson you shall be able to
- **state the function of arc-welding machines**
- **name the different types of arc-welding machines.**

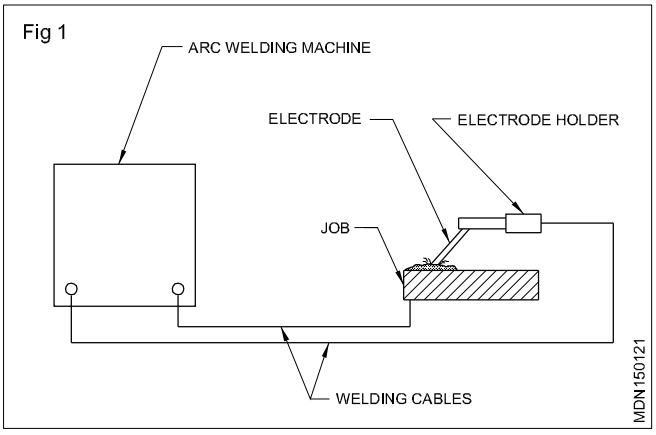
In the arc-welding process, the source of heat is electricity (high ampere low voltage). This heat is supplied by the arc-welding machine which is the power source.

Function (Fig 1)

The equipment is used to

- Provide A.C. or D.C. supply for arc welding
- Change the high voltage of main supply (A.C.) to low voltage, heavy current (A.C. or D.C.) suitable for arc welding
- Control and adjust the required supply of current during arc welding

Fig 1



Power sources (Fig 2)

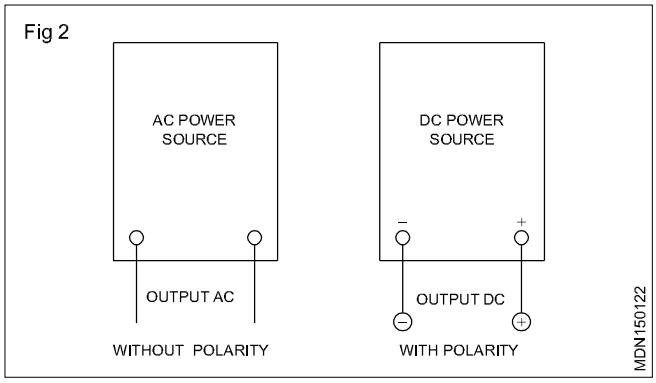
Basically the power sources are
- Alternating current (A.C.) welding machine
- Direct current (D.C.) welding machine.

These may be further classified as

D.C.Machines
- Motor generator set
- Engine generator set
- Rectifier sets.

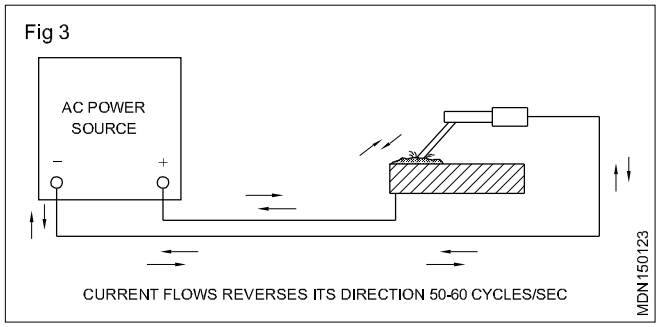
A.C.Machines
- Transformer sets

Fig 2

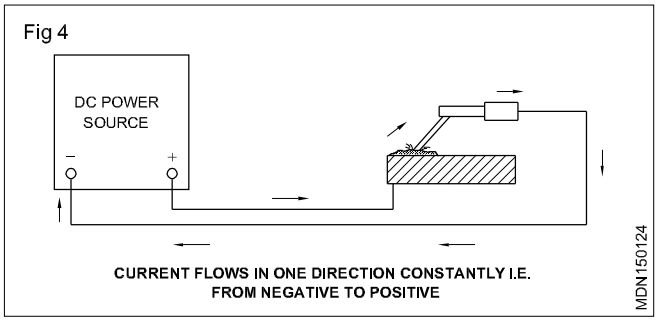


A.C. means Alternating Current. It changes or reverses its direction of flow 50-60 cycles per second. (Fig 3)

Fig 3



D.C. means Direct Current. It flows steadily and constantly in one direction. (Fig 4)

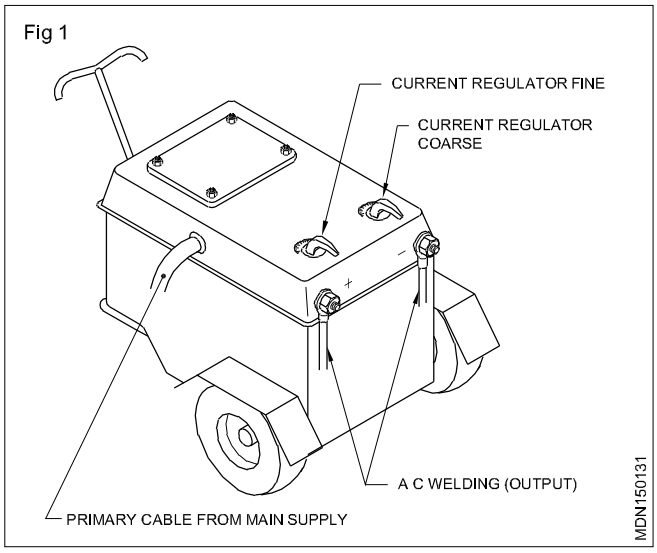


A.C. Arc welding machine

Objectives : At the end of this lesson you shall be able to
- **state the features of A.C. welding transformers**
- **state the advantages and disadvantages of A.C. welding machines.**

A.C. welding transformer

An A.C.welding transformer is a type of A.C. welding machine which converts the A.C. main supply into an A.C. welding supply. (Figs 1 and 2)

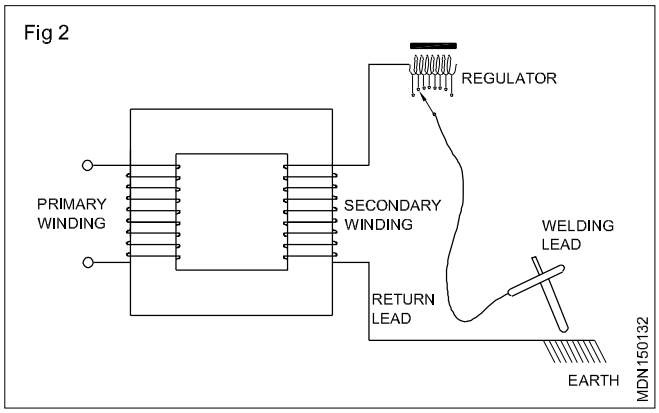


The A.C. main supply has high voltage - low ampere.

The A.C. welding supply has high ampere - low voltage.

It is a STEP-DOWN transformer which reduces the main supply voltage (220 or 440 volts) to the welding supply open circuit voltage (O.C.V.), between 40 and 100 volts.

It increases the main supply low current to the required output welding current in a hundred or thousand amperes.



The A.C. welding machine cannot be operated without the A.C. main supply.

Advantages

- Less initial cost
- Less maintenance cost
- Freedom from arc blow.

Magnetic effect which disturbs the arc is called the arc blow.

Disadvantages

- Not suitable for the welding of non-ferrous metals, light coated and special electrodes.
- The A.C. cannot be used without special safety precautions.

D.C. Arc-welding machines

Objectives : At the end of this lesson you shall be able to
- **state the features of a D.C. welding machine**
- **state its advantages and disadvantages.**

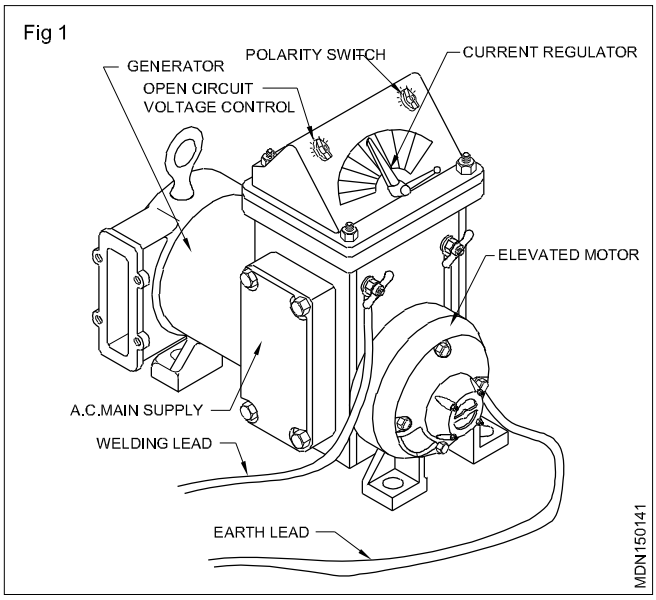
Motor generator set (Fig 1)

It is used to generate D.C. for arc-welding.

The generator is driven by an A.C. or D.C. motor.

Main supply is a must to run the machine.

Fig 1



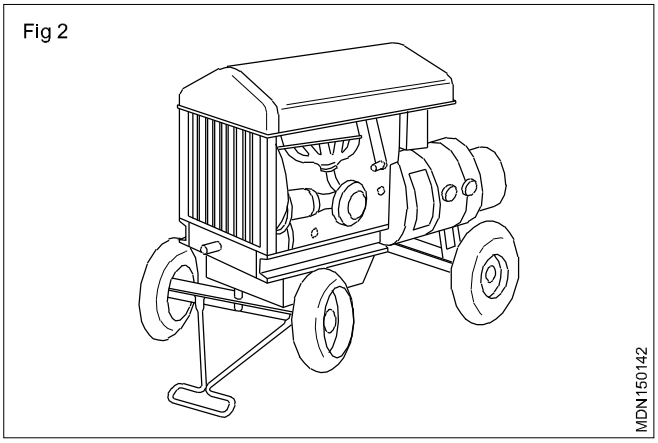
Engine generator set (Fig 2)

Equipment is similar to the motor generator set except that the generator is driven by a pertrol or diesel engine.

Its running and maintenance charges are higher.

It can be used anywhere in field work, away from electric lines.

Fig 2



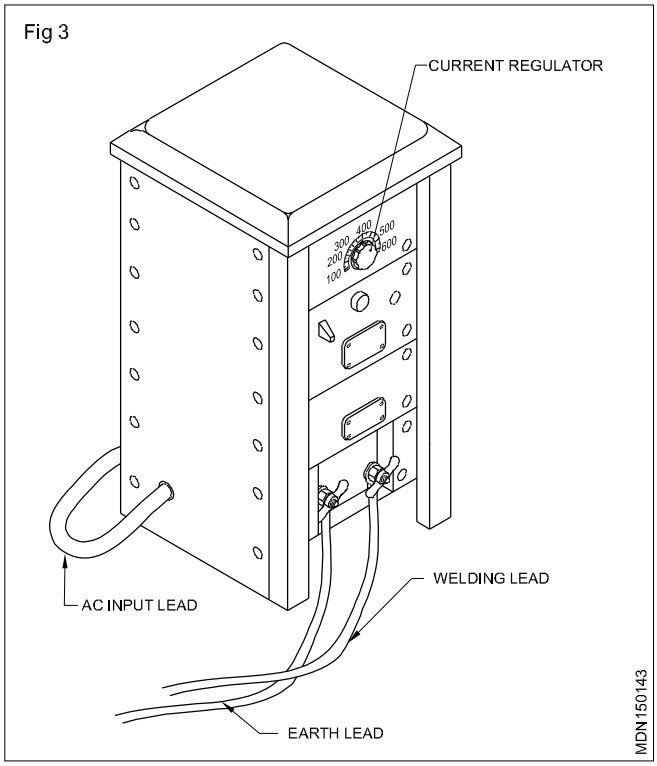
Rectifier set (Fig 3)

It is used to convert A.C. into D.C. welding supply.

Basically it is an A.C. welding transformer. The output of the transformer is connected with a rectifier to change the A.C. into D.C.

It may be designed to supply both A.C. and D.C. currents for welding (called A.C.-D.C. rectifier set).

Fig 3



Advantages

Suitable for welding all ferrous and non-ferrous metals using all types of electrodes

- Better heat distribution in the electrode and job due to polarity in the welding current supplies constant main load and accurate current setting.

It ensures safe working.

Disadvantages

- Initial cost is higher
- Maintenance cost is more
- Arc-blow trouble faced at certain times.

Edge preparation

Objectives: At the end of this lesson you shall be able to
- **state the necessity of edge preparation**
- **describe the edge preparation for butt and fillet welds.**

Necessity of edge preparation: Joints are prepared to weld metals. The preparation of edges are also necessary prior to welding in order to obtain the required strength to the joint. The following factors are to be taken into consideration for the edge preparation.

– The welding process like SMAW, oxy-acetylene welds, Co_2, electro-slag etc.

– The type of metal to be jointed, (i.e.) mild steel, stainless steel, aluminium, cast iron etc.

– The thickness of metal to be joined.

– The type of weld (groove and fillet weld)

– Economic factors

The square butt weld is the most economical to use, since this weld requires no chamferring, provided satisfactory strength is attained. The joints have to be bevelled when the parts to be welded are thick so that the root of the joints have to be made accessible for welding in order to obtain the required strength.

In the interest of economy, bevel butt welds should be selected with minimum root opening and groove angles such that the amount of weld metal to be deposited is the smallest. "J" and "U" butt joints may be used to further minimise weld metal when the savings are sufficient to justify the more difficult and costly chamferring operations. The "J" joint is usually used in fillet welds.

A root gap is recommended since the spacing allows the shrinking weld to draw the plates freely together in the butt joint. Thus, it is possible to reduce weld cracking and minimise distortion and increase penetration, by providing a root gap for some welded joints.

Method of edge preparation: The joining edges may be prepared for welding by any one of the methods mentioned below.

– Flame cutting

– Machine tool cutting

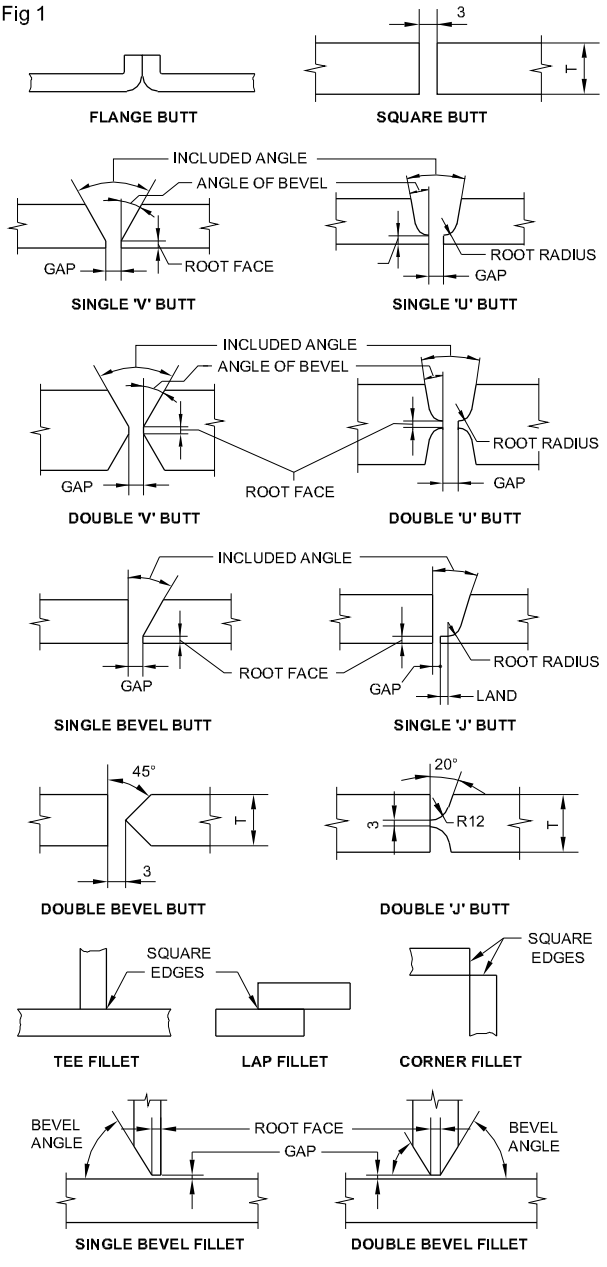
– Machine grinding or hand grinding

– Filing, chipping

TYPES OF EDGE PREPARATION AND SETUP

Different edge preparations generally used in arc welding are shown in (Fig 1).

Fig 1



Tools and equipment used in oxy-acetylene gas welding

Objectives : At the end of this exercise you shall be able to
- **compare the features of oxygen and acetylene regulators**
- **state the features of hose - pipes used in gas welding**
- **distinguish between the hose connections for oxygen and acetylene regulators and blowpipes**
- **state the features of a blowpipe and their functions**
- **state the features of a spark lighter**
- **state the use of a cylinder trolley.**

Gas welding principle

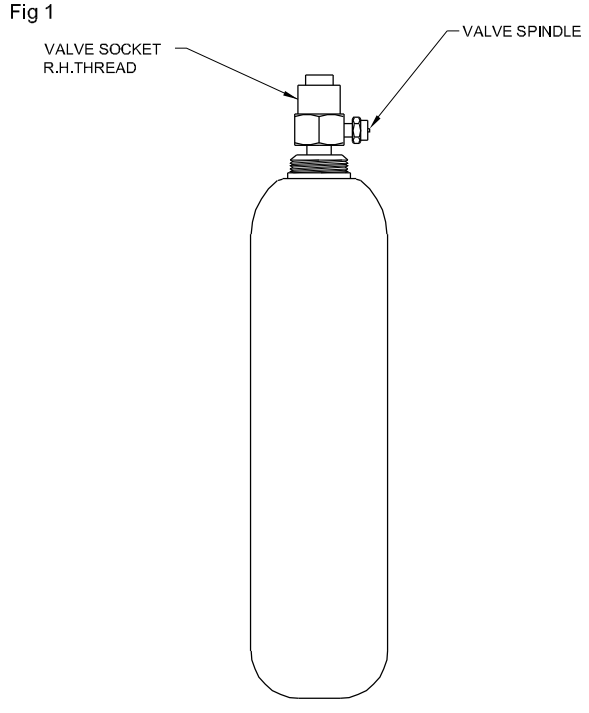
Gas welding is a most important type of welding process. it is done by burning of fuel gases with help of oxygen which form a concentrated flame of high temperature. This flame directly strikes the weld area and melt the weld surface and filler materials. The melted part of welding plates diffused one another and create a weld joint after cooling. This welding method can be used to join most of common metals used in daily life.

Oxy - acetylene gas welding

The essential requirement for a beginner dealing with oxy - acetylene gas welding is to identify the tools and equipment required and know their uses.

Oxygen gas cylinders (Fig. 1)

Fig 1



OXYGEN CYLINDER (COLOUR BLACK)

oxygen gas cylinder is black colour pointed steel bottle and it has a storing capacity of 7m^3 gas.

The valve socket has right hand threads.

The cylinder is used to store oxygen gas with a pressure of 120 to 150 kg/cm^2

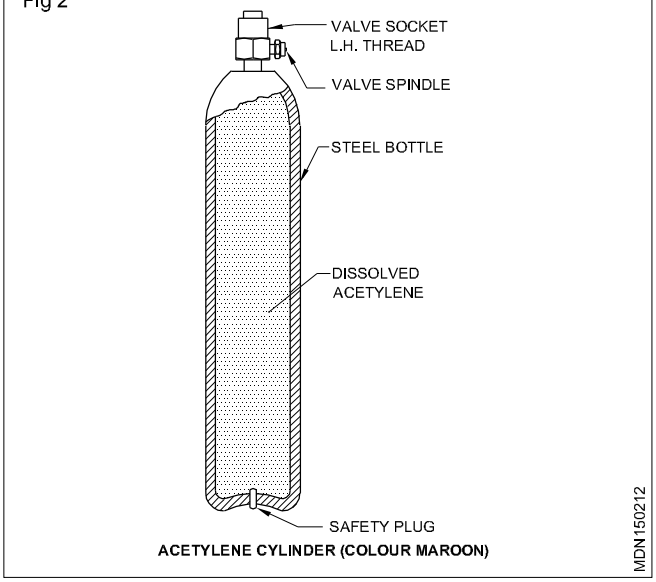
Dissolved acetylene cylinders (Fig. 2)

This is painted maroon and has a storing capacity of 6m^3. The valve socket has left hand threads. It is used to store acetylene gas in a dissolved state with a pressure of 15-16kg/cm^2.

Pressure regulators for oxygen

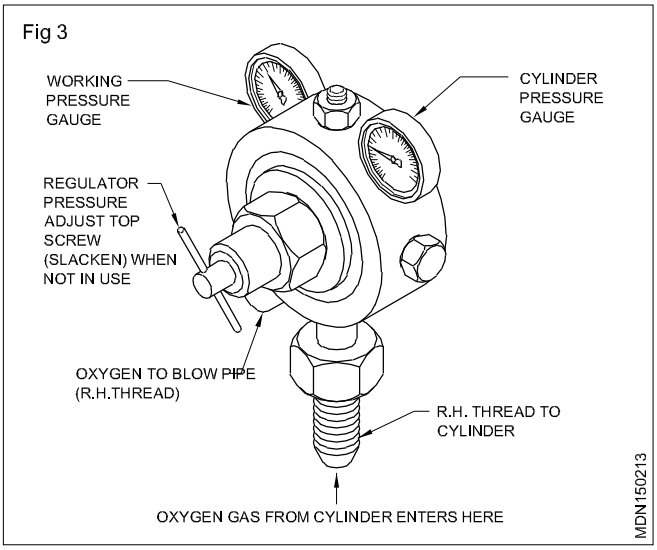
The regulator is used to reduce and control the oxygen cylinder gas pressure to a suitable working pressure and maintain constant rate of gas flow for the blowpipe. The regulator has right hand screws threads. (Fig. 3)

Fig 2



ACETYLENE CYLINDER (COLOUR MAROON)

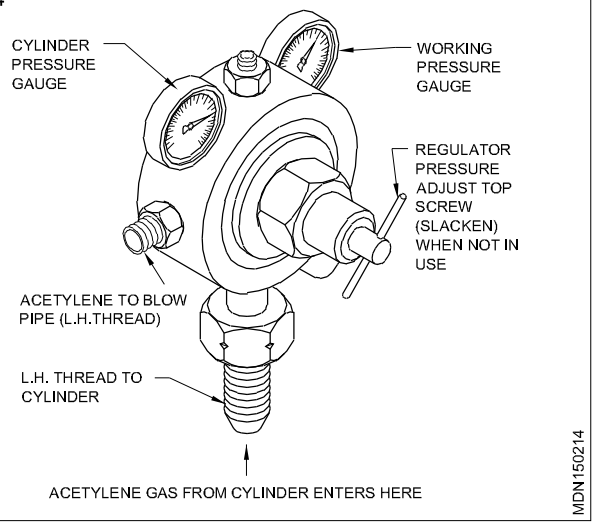
Fig 3



Pressure regulators for acetylene

This is to reduce and control the acetylene cylinder gas pressure to a suitable working pressure at a constant rate of flow for the blowpipe. This regulator has left hand screw threads. (Fig 4)

Fig 4

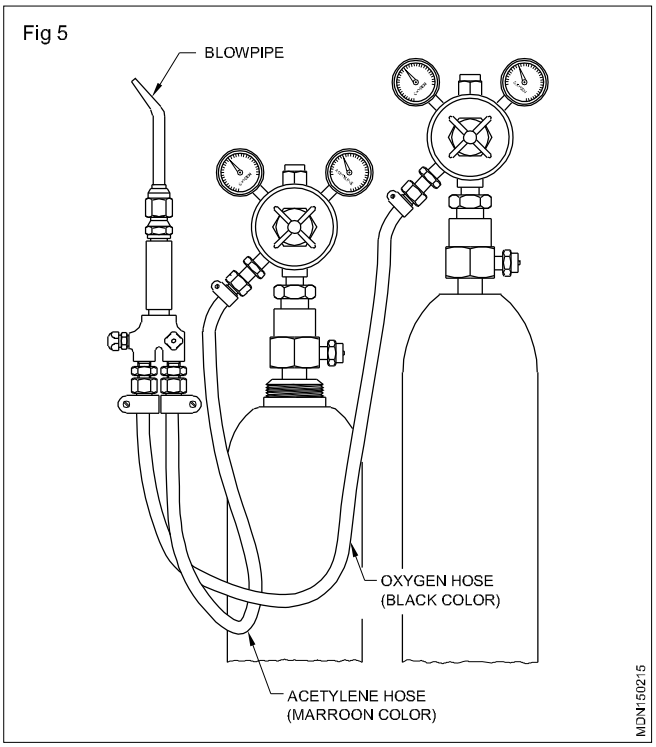


Both oxygen and acetylene regulators have a cylinder pressure gauge to indicate the cylinder gas pressure and a working pressure gauge to indicate the working pressure required for the blowpipe. (Figs 3 & 4)

Rubber hoses

The hose carries the gases from the gas regulators to the blowpipe. The hoses are made of strong canvas rubber and it having good flexibility. The hose pipe for the oxygen line is black in colour while that for the acetylene line is maroon colour. (Fig 5)

Fig 5

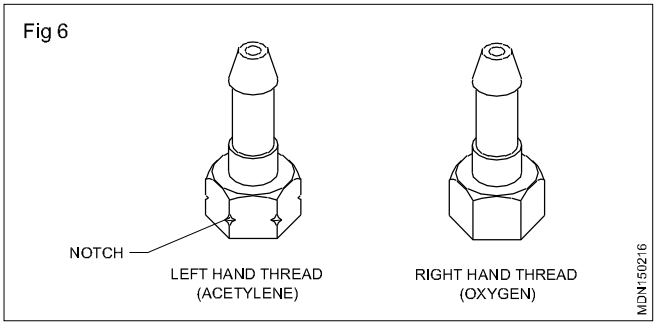


Hose pipe connections for regulators

This is a connecting union used to connect rubber hose pipes with the regulators.

Oxygen connection has right hand threads while the acetylene connection has left hand threads. (Fig 6). The nut used for the acetylene rubber hose connections will have a notch at its corners.

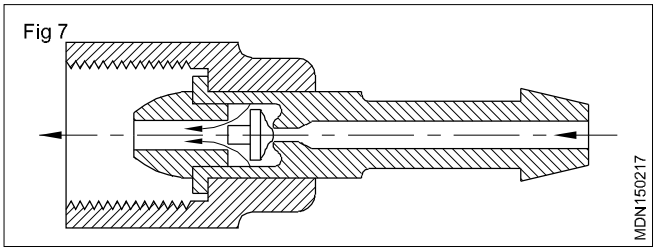
Fig 6



Hose pipe connections for blowpipes

This has the shape of a connecting union and is fitted with a non-return disc to prevent flash-back and backfire during welding. (Fig 7)

Fig 7



It is used to connect the rubber hose pipe with the blowpipe.

The oxygen connection has right hand threads while the acetylene one has left hand threads.

Blowpipe set with nozzle (Fig 8)

This is a device with a handle and inlet connection for acetylene (left hand threads) and oxygen (right hand threads). It has control valves for acetylene and oxygen gas flow, a gas mizing chamber, and a neck - pipe with a nozzle.

Fig 8

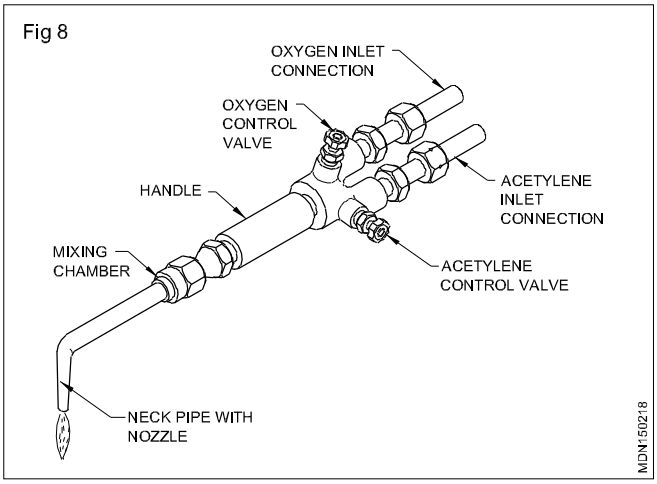
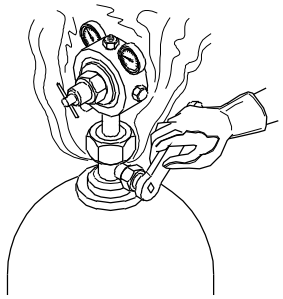


Fig 9



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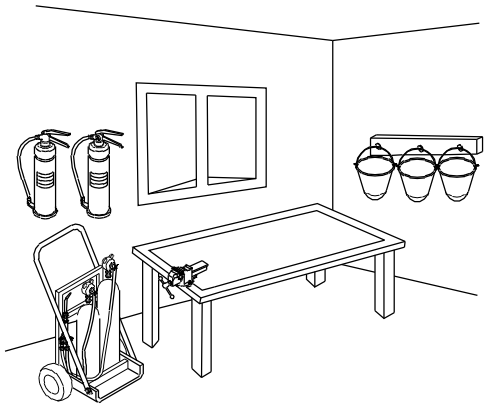
Always keep the working condition handy fire-fighting equipment to put off fires (Fig 10)

Fig 10



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Keep the work area free from any form of fire.

Safety gas cylinders

Do not roll gas cylinders or use them as roller.

Use a trolley to the carry the cylinders.

Close the cylinder valves (Fig 9) when it is not in use or empty.

Keep full and empty cylinders separately.

Always open the cylinder valves slowly, not more than one and a half turn.

Use the correct cylinder keys to open the cylinders.

Do not remove the cylinder keys from the cylinders while welding. It will help to close the cylinders quickly in the case of a back-fire or flash-back.

Always use the cylinders in an upright position for easy handling and safety.

Always check the cylinder valves to clean the valve sockets before attaching regulators. (Fig 11)

Safety for rubber hose pipes (Fig 12)

Inspect the rubber hose pipes periodically and replace the damaged ones.

Do not use old bits of hose pipes / tubes.

Do not replace the hose pipes for acetylene with the ones used for oxygen.

Always use a black hose pipes for oxygen and maroon hosepipes for acetylene.

Fig 11

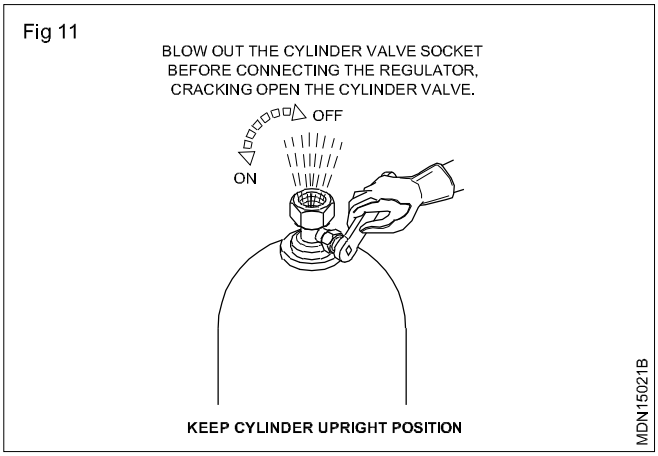

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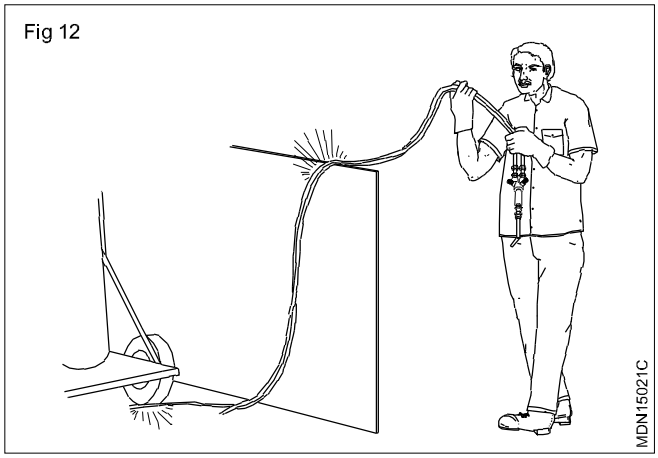
Fig 12



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Safety for regulators (Fig 11)

Prevent hammer blows to the gas cylinders and ensure that water, dust and oil do not settle on the cylinders.

Right hand threaded connection for oxygen and left hand threaded connection for acetylene.

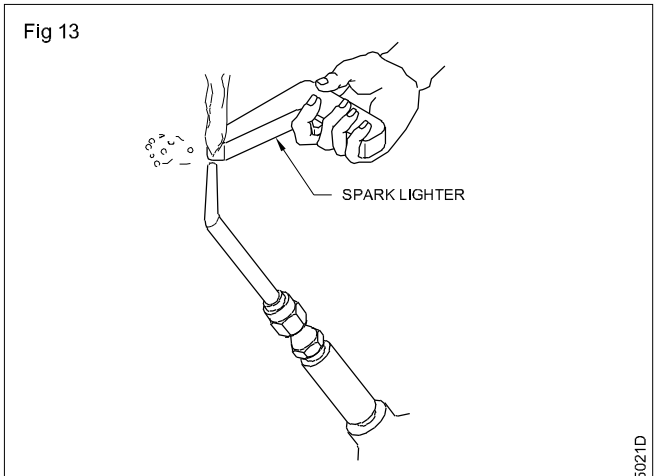
Safety for blowpipes

When a blowpipe is not in use put away from the flame and place the blowpipe in a safe place.

When flame snaps out and backfires, quickly shut off the both valves in blowpipe (oxygen first) then acetylene and their dip in water.

While igniting the flame, point the blowpipe nozzle in a safe direction. (Fig 13)

Fig 13



MDN15021D

While extinguishing the flame, shut off the acetylene valve first and then the oxygen valve to avoid a backfire.

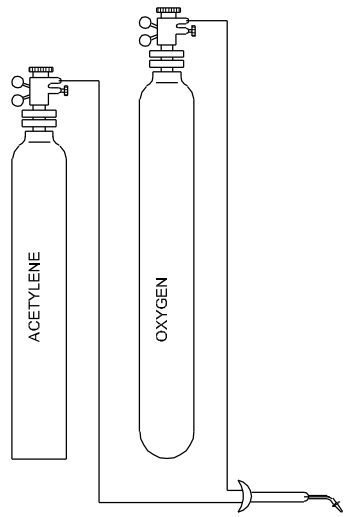
Systems of oxy-acetylene welding

Objectives : At the end of this lesson you shall be able to
- **distinguish between high pressure and low pressure acetylene plants**
- **distinguish the features of low pressure and high pressure blowpipes.**

Oxy-acetylene plants can be either high pressure or low pressure.

A high pressure plant utilizes acetylene under high pressure, upto 1 kg/cm^2. (Fig 1)

Fig 1



HIGH PRESSURE OXY-ACETYLENE PLANT

Dissolved acetylene (acetylene in cylinder) is a commonly used source.

A low pressure plant utilizes acetylene under low pressure (0.017 kg/cm^2) produced by an acetylene generator only. (Fig 2)

High pressure and low pressure plants utilize oxygen gas in compressed high pressure cylinders only.

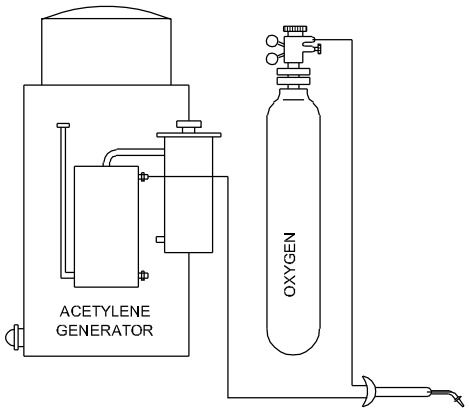
The high or low pressure systems used in oxy-acetylene welding refer only to the acetylene pressure.

Distinguishing features of blowpipes

For low pressure systems, a specially designed injector type blowpipe is required. This can be used for high pressure also. (Fig 3)

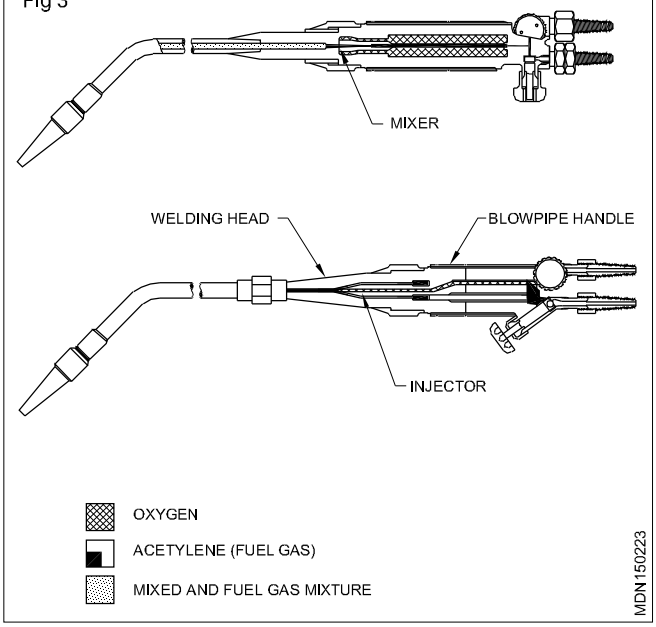
In a high pressure system, a mixer type high pressure blowpipe is used, this is not suitable for the low pressure system. (Fig 3)

Fig 2



LOW PRESSURE OXY-ACETYLENE PLANT

Fig 3

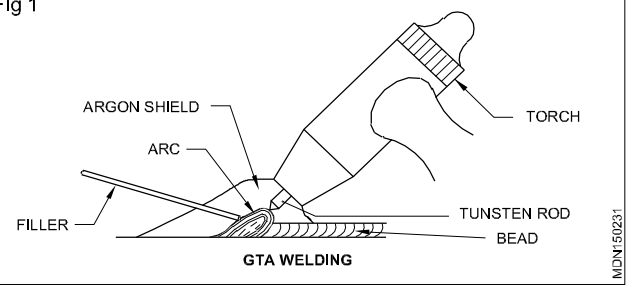


TIG Welding process and equipment

Objectives : At the end of this lesson you shall be able to
- **state the principle of TIG welding process**
- **state the application of TIG welding**
- **identify the TIG welding equipment**
- **name the parts of TIG welding equipment**
- **state the purpose of different parts.**

Introuction to TIG welding: The Gas Tungsten Arc Welding (GTAW) process fuses metals by heating them between a non consumable (does not melt) tungsten electrode and workpiece. The heat is necessary for fusion (mixing or combining of molten metals) and it is provided by an arcing electric current between the tungsten electrode and base metal.

Fig 1

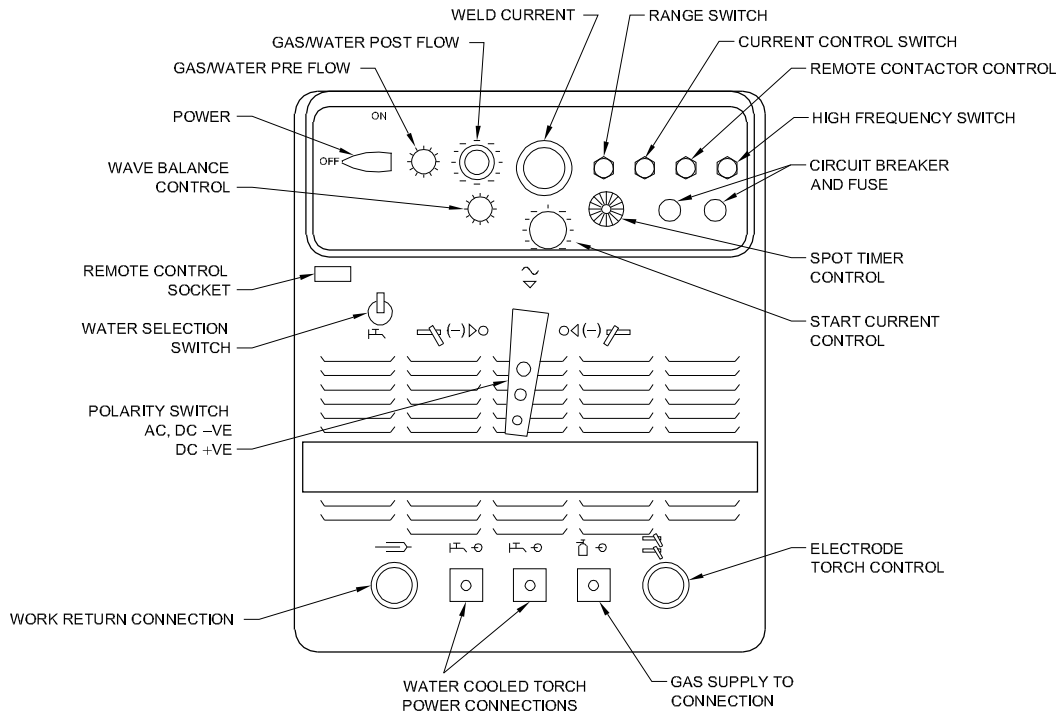


This type of welding is usually done with a single electrode. The tungsten electrode and the weld zone (area being welded) are shielded from the atmosphere (air around it) by an inert gas, such as argon or helium. Filler metal may or may not be used. This process is also called TIG (Tungsten Inert Gas) welding. Gas tungsten arc welding, is particularly used when welding stainless steel, aluminium, titanium and many other non-ferrous metals.

TIG welding equipment

– An AC or DC arc welding machine. (Fig 1 & 2)
– Shielded gas cylinders or facilities to handle liquid gases
– A shielding gas regulator
– A gas flowmeter
– Shielding gas hoses and fittings
– A welding torch (electrode holder)
– Tungsten electrodes
– Welding rods
– A water cooling system with hoses for heavy duty welding operations
– Foot rheostat (switch)
– Arc timers

Fig 2



Torch: There is a variety of torches available varying from light weight air cooled to heavy duty water cooled types. Fig.1 & 3. The main factors to be considered in choosing a torch are:

– Current carrying capacity for the work in hand
– Weight, balanced and accessibility of the torch head to the work in hand.

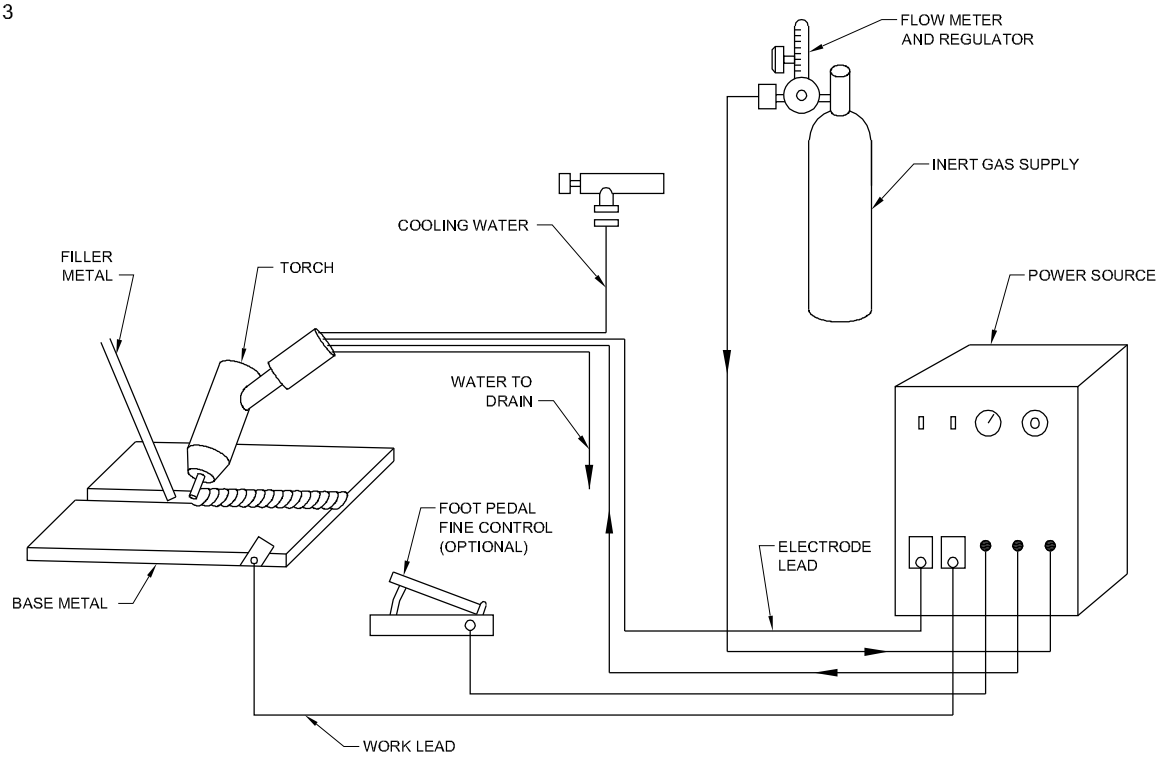
The torch body which a top loading compression-type collet assembly which accommodates electrodes of various diameters. They are securely gripped, yet the collet is easily slackened for removal or reposition of the electrode.

As the thickness of plate to be welded increases, size of torch and electrode diameter must increase to deal with the larger welding currents required.

Gas regulator, flowmeter (Fig 3 & 4): The gas regulator reduces the pressure in the argon cylinder from 175 or 200 bar down to 0-3.5 bar for supply to the torch.

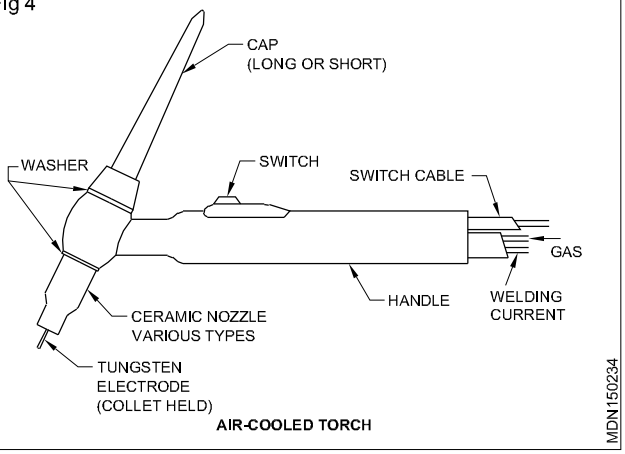
The flowmeter which has a manually operated needle valve, controls the argon flow from 0-600 litres/hour to 0-2100 litres/hour according to type.

Fig 3



A DIAGRAMMATIC DRAWING OF A COMPLETE GAS TUNGSTEN ARC WELDING

Fig 4

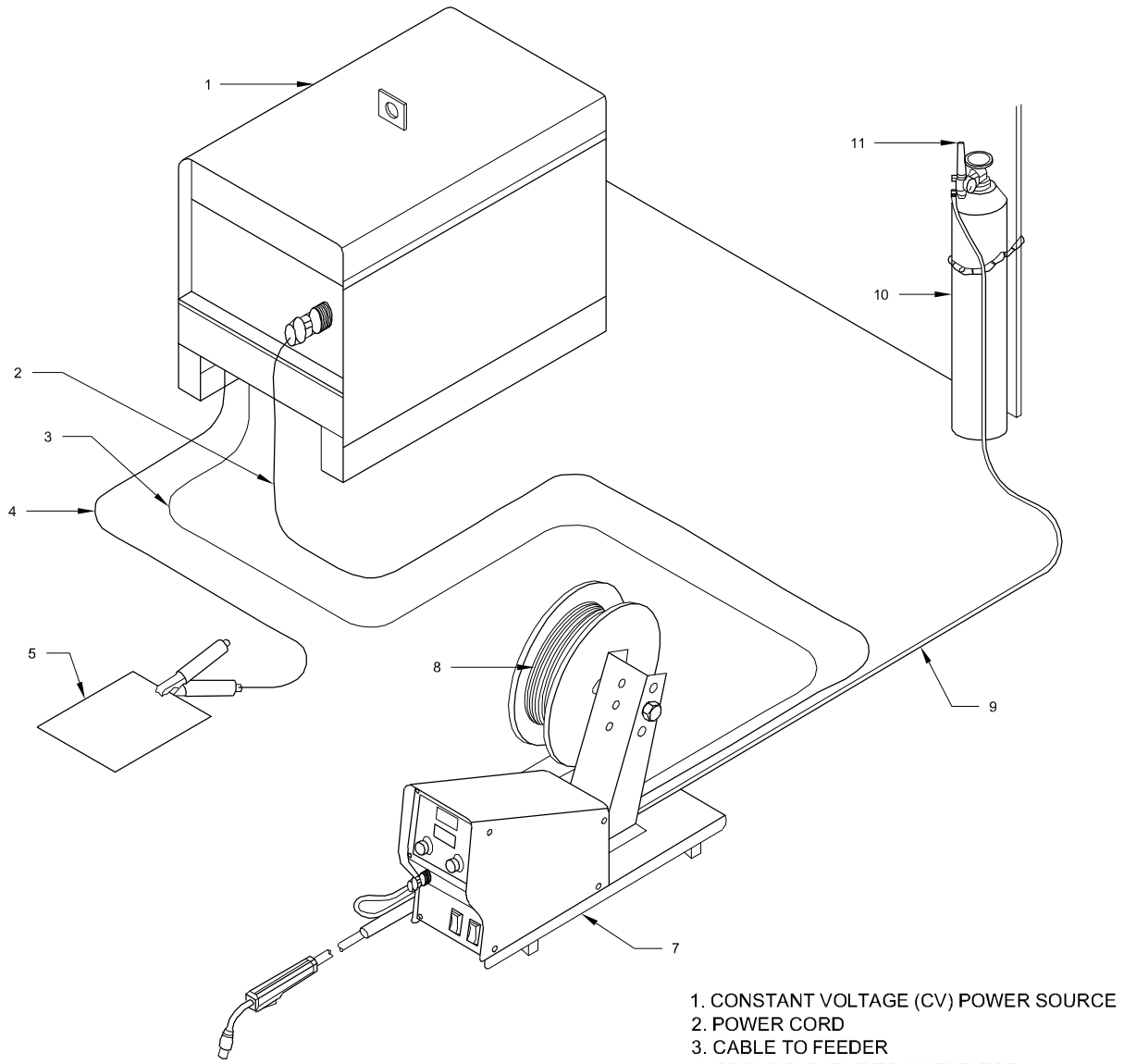


AIR-COOLED TORCH

Basic equipment for a typical gmaw semiautomatic setup (Fig 5).

- Welding Power Source - provides welding power.
- Wire Feeders - controls supply of wire to welding gun.
- Supply of Electrode Wire.
- Welding Gun - delivers electrode wire and shielding gas to the weld puddle.
- Shielding Gas Cylinder - provides a supply of shielding gas to the arc.

Fig 5



1. CONSTANT VOLTAGE (CV) POWER SOURCE
2. POWER CORD
3. CABLE TO FEEDER
4. GROUND CABLE TO WORKPIECE
5. WORKPIECE
6. WELDING TORCH
7. CONSTANT SPEED WIRE FEEDER
8. ELECTRODE WIRE
9. GAS HOSE
10. SHIELDING GAS CYLINDER
11. GAS REGULATOR WITH FLOW METER

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GMAW equipment and accessories

Objectives: At the end of this lesson you shall be able to
- **state the power sources for GMAW**

MIG welding power sources have come a long way from the basic transformer type power source to the highly electronic and sophisticated types we see around today.

Even though the technology of MIG welding has changed, the principles of the MIG power source have, in most cases, not. The MIG power sources use mains power and converts that mains power into CV (constant voltage), DC (direct current) power suitable for the MIG welding process.

MIG welding power sources control voltage – this is done by either voltage stepped switches, wind handles, or electronically. The amperage that the power source produces is controlled by the cross sectional area of the wire electrode and the wire speed, ie the higher the wire speed for each wire size, the higher the amperage the power source will produce.

Because the output of the MIG power source is DC (direct current) the terminals on the front will have + positive and negative on the output side. The principles of electric circuits states that 70% of the heat is always on the positive side.

This means that the lead that is connected to the positive side of the welder, will carry 70% of the total energy (heat) output.

The characteristics volt, ampere curves (A & B) are shown in Fig.1.

Curve A (For SMAW): On the output slope or voltampere curve A, a change from 20 volts to 25 volts will result in a decrease in amperage from 135 amps to 126 amps. With a change of 25 percent in voltage, only a 6.7 percent change occurs in the welding current in curve A. Thus if the welder varies the length of the arc, causing a change in voltage, there will be very little change in the current and the weld quality will be maintained. The current in this machine, even though it varies slightly is considered constant.

This is called drooping characteristic power source. Also called constant current (CC)power source.

This type of power source is used in SMAW & GTAW process.

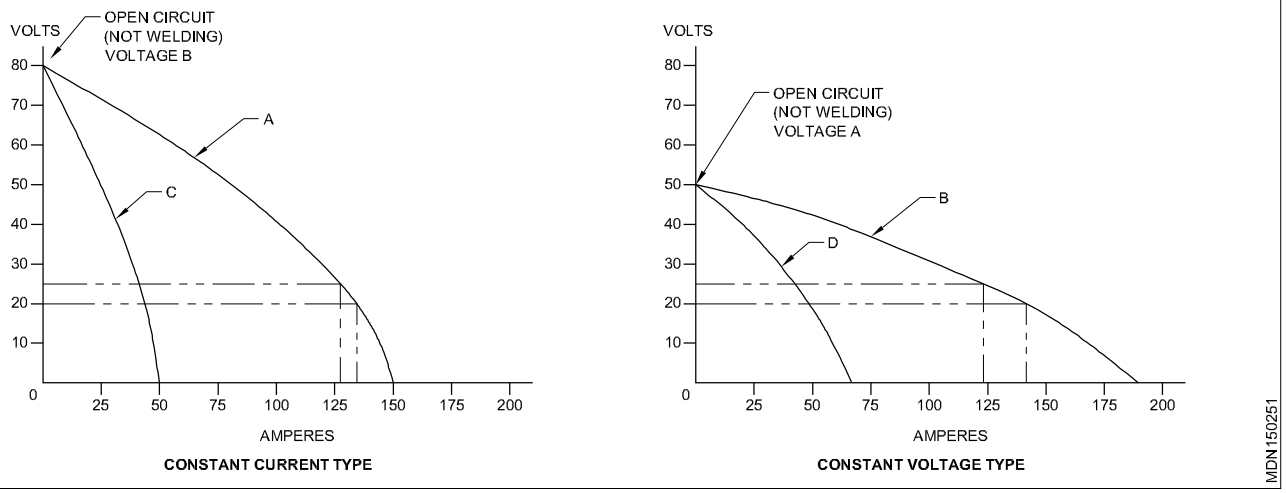
Curve B (For GMAW): The open circuit voltage curve for a setting of 50 volts on the machine is shown as curve B in the Fig.1. The same 20 volt to 25 volt (25 percent) change in the welding voltage will result in a drop in current from 142 amps to 124 amps or 13.3 percent. This slower sloping volt ampere curve output causes a large change in amperage with the same small change in voltage. A welder may wish to have this slower sloping (flatter) volt-ampere output curve.

This is called flat characteristic power source. Also called constant Voltage(CV)power source.

This type of power source is used in **GMAW & SAW** process.

With a flatter output slope the welder can control the molten pool and electrode melt rate by making small changes in the arc length. Control of the molten pool and electrode melt rate are most important when welding in the horizontal, vertical and overhead positions.

Fig 1



GMAW (MIG/MAG) torches

Objectives: At the end of this lesson you shall be able to
- **state the types and functions of torches.**

MIG/MAG Torch Connection

The torch connection is the system in which the MIG torch is connected to the wire feeder. There are various types of MIG torch connections. Different manufacturers can use any one of many systems to connect their torch to the wire feeder.

When ordering a new Torch tell the supplier

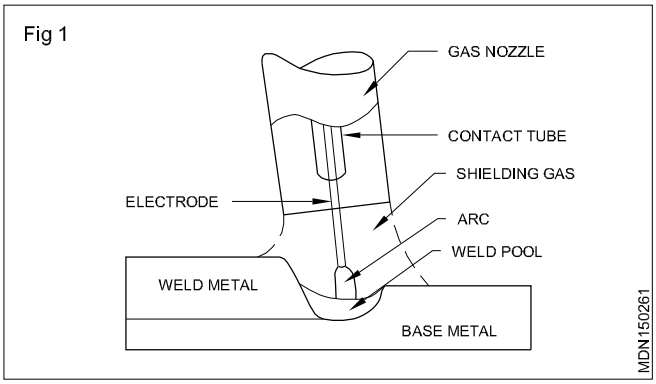
a) the type of torch you need, including amperage rating

b) the type of connection on the feeder so the Torch can be supplied to match the connection

The Torch connection is also the area where the wire electrode, welding current and welding gases are passed onto the welding torch. This means these components should be checked for damage or leaky seals etc, so the connection will do its job correctly.

MIG/MAG Torches

Fig 1



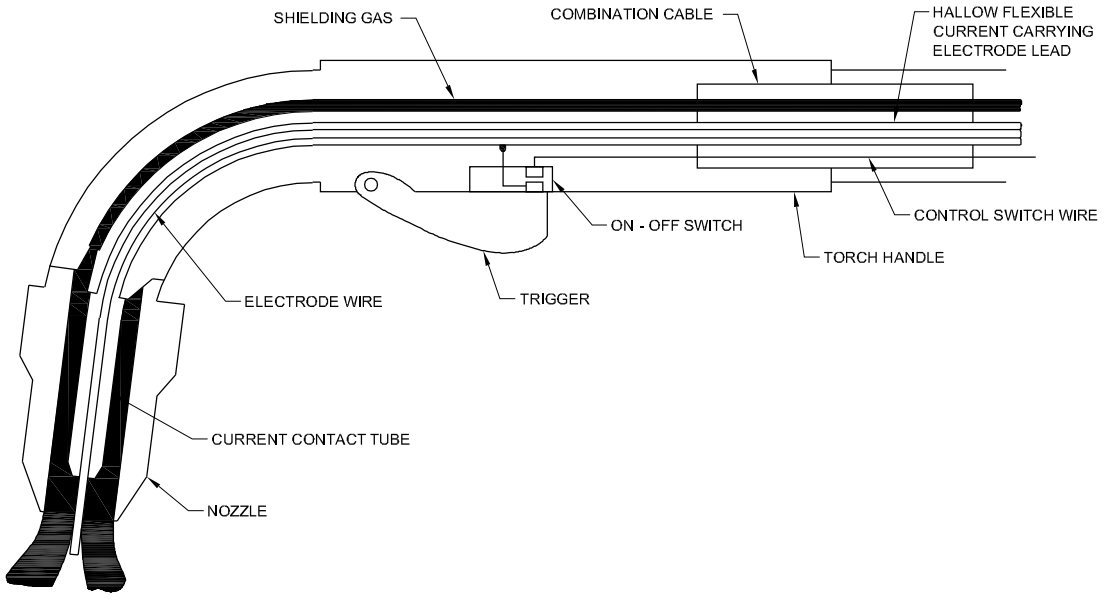
The MIG Torch is connected to the wire feeder, and its job is to deliver the wire electrode, shielding gas and the electrical welding current to the welding area. There are a lot of different shapes and styles of MIG Torch out in the marketplace but they all have things in common. (Fig. 1 & 3).

1 Aircooled (less than 200 Amps) or watercooled (above 200 Amps) (Fig 2)

2 Current rating. The operator must select the correct size Torch. Using a torch that is not sufficiently rated for the machine may result in the Torch overheating. This may result in a poor weld and damage to the Torch . A Torch with an excessive rating will be larger and heavier than the smaller Torch, which could result in discomfort for the operator.

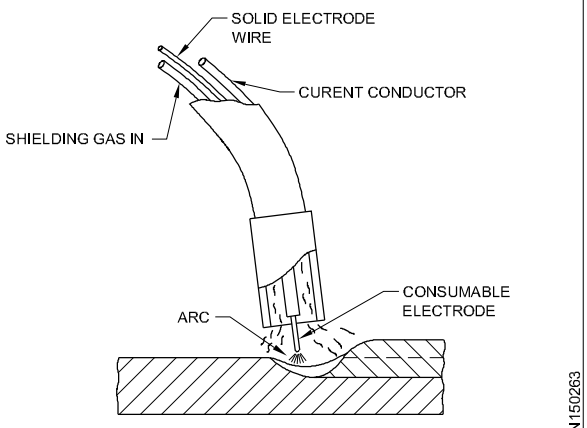
3 They all have parts that will wear out (consumables eg liners, tips, diffuser, nozzle, etc.)

Fig 2



A SCHEMATIC CROSS SECTION OF AN AIR COOLED GAS METAL ARC WELDING TORCH

Fig 3



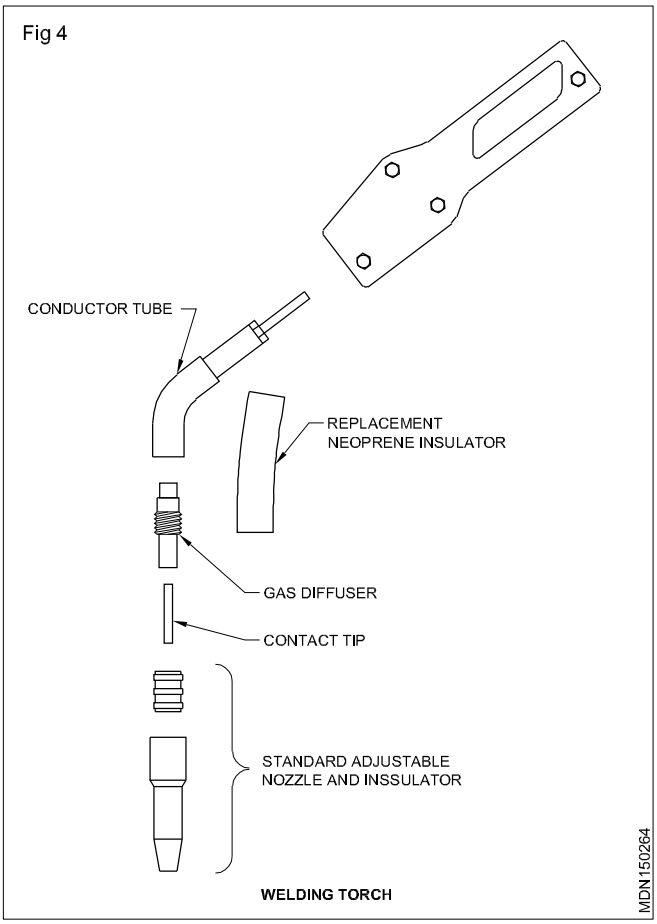
TORCH ASSEMBLY

Let's take a look at each part (Fig 4)

Liner The liner causes the most problems. First, they have a life span that is approximately one to four rolls of MIG wire depending on the quality of the liner and wire. The life of the liner will also be increased if the operator removes and cleans it by soaking in non-corrosive and a non-toxic solvent. Each wire size needs to have the correct wire size liner. Be aware some liners may fit more than one size of wire.

There are also different materials for different types of wire electrode, eg steel or stainless liners for solid wires and Teflon liner for aluminium.

Fig 4



WELDING TORCH

The liner length is most important. In the field it is very common to find even newly fitted liners that have been cut too short. This results in the wire being able to move around behind the welding tip and leading to bad wire feeding. The liner has to be fitted correctly and different MIG Torch will often have a different way of ending up with a liner that is the correct length.

Don't just take out the old liner and cut the new one to the same length. It could end up with an incorrect result. Please refer to MIG Torch manual.

All MIG Torch should be laid out straight ont he floor before trimming the liner, to prevent the new liner being cut too short. Do not cut the liner if the Torch lead is coiled up.

Gas Diffusers The gas diffuser's job is to make sure that the shielding gas is delivered to the shielding nozzle correctly. It is designed to make the gas come out as straight as possible and equally supplied around inside the gas shield nozzle. Diffusers can be made of different materials, eg copper, brass or fibre. Some diffusers will also be the tip holder.

Contact Tip Holder This is the item which holds the welding tip in place. Again, tip holders can be very different in design and are very often unique to that brand of MIG torch.

Contact Tips The Contact tip/tube is the key to good welding. First of all, it is the way that welding amperage is delivered to the welding wire electrode, often with a very high amperage.

Most contact tips are made of copper alloy, the better the alloy the better the tip will pass current to the wire electrode and the less wear the MIG tip will have; also the less the tip will oxidize.

The size is important. The right size contact tip must be selected contact . If the selected tip size is too large the wire electrode will not make a good contact, leading to poor welding performance.

If a contact tip selected is too small, the wire electrode will feed poorly and may even jam in the contact tip.

Nozzle: Guns are available with a straight or curved nozzle. The curved nozzle provides easy access to intricate joints and difficult-to-weld.

Torch angle

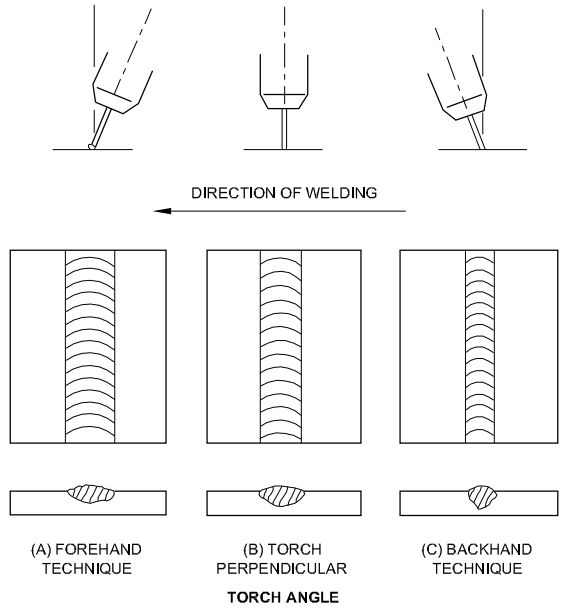
The position of gun and electrode with respect to the joint affects the weld bead shape and penetration rather than arc voltage or travel speed. The gun is usually maintained within 10 - 20º on either side of the vertical. Depending on which way the gun is incline, the technique is referred to as forehead and backhand. The various electrode positions and techniques and their effects are shown in (Fig 5). It is observed that as the electrode is changed from perpendicular to the forehand technique, the weld bead becomes shallower and wider and has less penetration.

Backhand technique gives a more stable arc, less spatter and a narrower, more convex weld bead with deep penetration. Perpendicular technique is used more in automatic welding and avoided in semi-automatic mode because the end of the gas nozzle restricts the operator's view of the weld pool.

Synergic Control

The complexity of setting welding parameters in conventional DC and pulsed GMAW promoted the development of equipment with 'Single-knob' controls known as Synergic control. These systems relied on selection of combinations of present welding (e.g. Wire feed speed/mean current and voltage) by means of a single control.

Fig 5



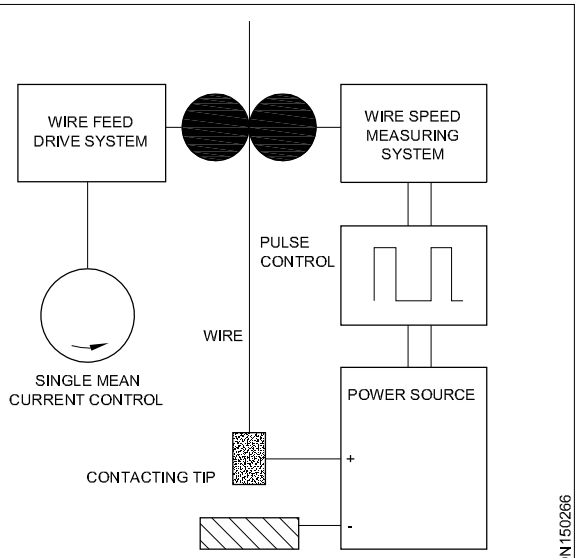
This is possible now because of development of electronic power regulation and micro processor control and programmable equipment which can supply a large number of predetermined welding conditions as well as allowing users to record and retrieve their own customerised parameters.

Although in the pulsed GMAW process the optimum welding parameters can be accurately predetermined, if a change in mean current is required the control settings must be recalculated and a number of the welding parameters reset. This could impose significant practical problems including the possibility of error and resultant deterioration in operating performance. Fortunately it is possible to store both the predetermined parameters and the control equations in the equipment and automatically adjust the output in response to a single input signal. This system is known as Synergic Control (Fig. 6).

Spot welding: This type of resistance welding machine is most commonly used for resistance welding. The material to be joined is placed between two electrodes as shown in (Fig 7a). Pressure is applied after a quick shot of electricity is sent from one electrode through the job to the other electrode.

1 **The frame:** It is the main body of the machine which differs in size and shape for the stationary and portable types.

Fig 6



2 **Force mechanism:** The compressed air cylinder and the pivoted rocker arm gives the necessary high pressure to the lever to which the upper electrode holder is attached.

3 **The electric circuit:** It consists of a step down trans former which provides for the necessary current to flow at the point of weld.

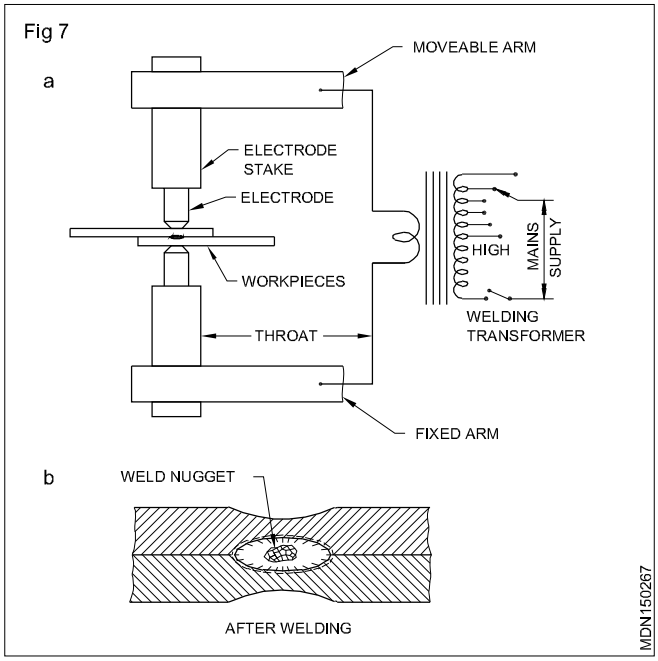
4 **The electrodes:** The electrodes include the mechanism for making and holding contact at the weld area.

5 **The timing controls:** The switches which regulate the value of current, current flow time and contact period time as the timing controls.

6 Water cooling system to circulate cooling water to the electrodes.

This is the additional part consisting of a water reservoir and flow system.

Fig 7



Spot welding is made in three steps.

The first step is when the parts to be joined are clamped between the electrodes. In the second step, a high current is allowed to pass through the clamped members and is raised to the welding temperature. The third step sees the current being cut off and high pressure being applied to the joint and the joint completed. A nugget is formed as shown in (Fig 7b).

A special copper alloy material has been developed for use as electrodes.

Cooling of the electrodes is accomplished by internally circulating water.

Cutting processes - plasma arc cutting

Objectives: At the end of this lesson you shall be able to
- **state the principle of plasma arc cutting**
- **explain the process of variable plasma cutting**
- **state the advantages of plasma cutting.**

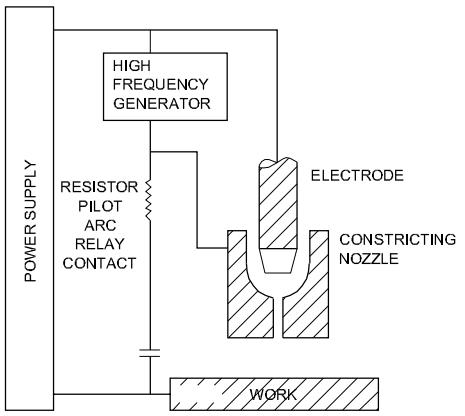
Cutting processes - plasma arc cutting

Plasma arc cutting process, was introduced in the industry in the mid 1950s. The process is used to cut all metals and non-metals. The common oxy-fuel cutting process (based on a chemical process) is suitable for cutting carbon steel and low alloy steel cutting only. Materials such as cpper, aluminium and stainless steels were earlier separated by sawing, drilling or sometimes by power flame cutting. These materials are now cut using a plasma torch, at faster rates and more economically. The Plasma cutting process is basically a thermal cutting process, free of any chemical reaction, that means, without oxidation. In plasma arc cutting an extremely high temperature and high velocity constricted arc is utilized.

Principle of operation

Plasma arc cutting is a process resulting from ionizing a column of gas (argon, nitrogen, helium, air, hydrogen or their mixtures) with extreme heat of an electric arc. The ionized gas along with the arc is forced through a very small nozzle orifice, resulting into a plasma stream of high velocity (speed up to 600 m/sec) and high temperature (up to 20000°K). When this high speed is reached, high temperature plasma stream and electric arc strike the workpiece, and ions in the plasma recombine into gas atoms and liberate a great amount of latent heat. This heat melts the workpiece, vaporizes part of the material and the balance is blasted away in the form of molten metal through the heat (Fig 1).

Fig 1



BASIC PLASMA ARC CUTTING CIRCUITRY

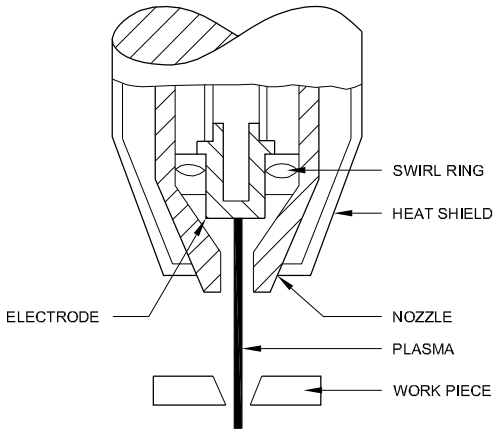
Plasma cutting system (Fig 2,3,4)

Plasma cutting requires a cutting torch, a control unit, a power supply, one or more cutting gases and a supply of clean cooling water (in case water-cooled torch is used).

Equipment is available for both manual and mechanical cutting. A basic plasma arc cutting circuit is shown in Fig 1. It employs direct current straight polarity (DCEN). The nozzle surrounding the electrode is connected to the workpiece (positive) through a current limiting reisitor and a pilot arc relay contact.

The pilot arc between the electrode and nozzle is initiated by a high frequency generator connected between the electrode and nozzle. The orifice gas ionized by the pilot arc is blown through the constricting nozzle orifice and forms a low resistance path to ignite the main transferred arc between the electrode and the workpiece when the ON/OFF switch is closed. The pilot arc relay may be opened automatically when the main arc ignites, to avoid unnecessary heating of the constricting nozzle. The constricting nozzle is of copper and normally water cooled to withstand the high plasma flame temperature (about 20000°K) and to have longer life.

Fig 2

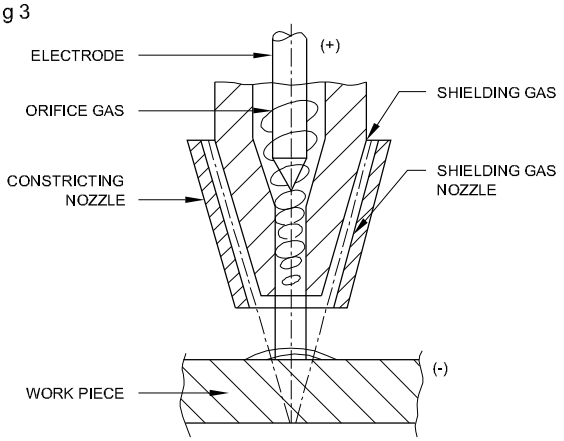


COMPONENTS OF AN AIR-PAC TORCH

In conventional gas plasma cutting, discussed above, the cutting gas can be argon, nitrogen, (argon + hydrogen), or compressed air. For all the cutting gases other than compressed air, the non-consumable electrode material is 2% thoriated tungsten. In air plasma cutting (Fig 2) where dry, clean compressed air is used as the cutting gas, the electrode of hafnium or zirconium. In used because tungsten is rapidly eroded in air. Wet and dirty compressed air reduces the useful life of consumable parts and produces poor quality.

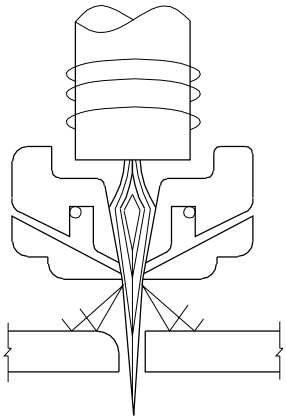
Several process variations are used to improve the cut quality for particular applications. Auxiliary shielding in the form of gas or water is used (Fig 3) to improve the cut quality and to improve the nozzle life. Water injection plasma cutting (Fig 4) uses a symmetrical impinging water jet near the constricting nozzle orifice to further constrict the plasma flame and to increase the nozzle life. Good quality cut with sharp and clear edges with little or no dross is possible in water injection plasma cutting.

Fig 3



DUAL FLOW PLASMA ARC CUTTING

Fig 4



Process variables (Fig 5 & 6)

1 Torch design - constricting nozzle shape and size.

2 Process variation - dual gas flow, water injection, air plasma.

3 Cutting gas type and its flow rate.

4 Distance between nozzle and job.

5 Cutting speed.

6 Plasma cutting current.

7 Power used during cutting.

8 Manual/machine cutting.

9 Material to be cut and its thickness.

10 Quality of cut required - rough or smooth.

11 The bevel angle and round off corner etc.

Advantages of plasma cutting

1 All metals and non-metals can be cut due to the high temperature and high velocity plasma flame.

2 Cuts are of very clear form with little or no dross.

3 High speed piercing is achieved.

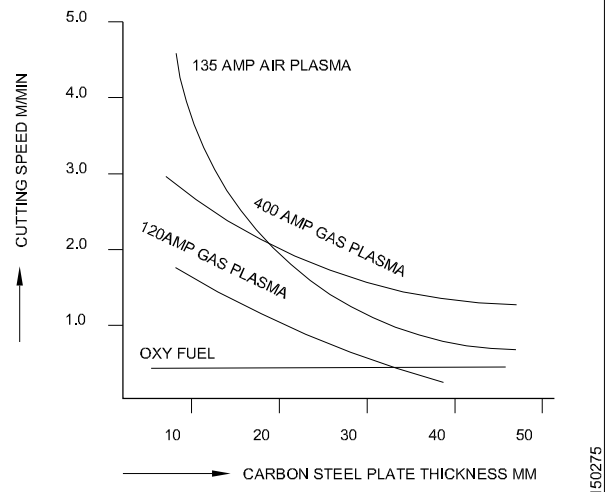
4 Cutting of piled plates is possible, even with different materials.

5 Cutting cost is quite low as compared to other processes, especially for stainless steels.

6 Cutting speed is high.

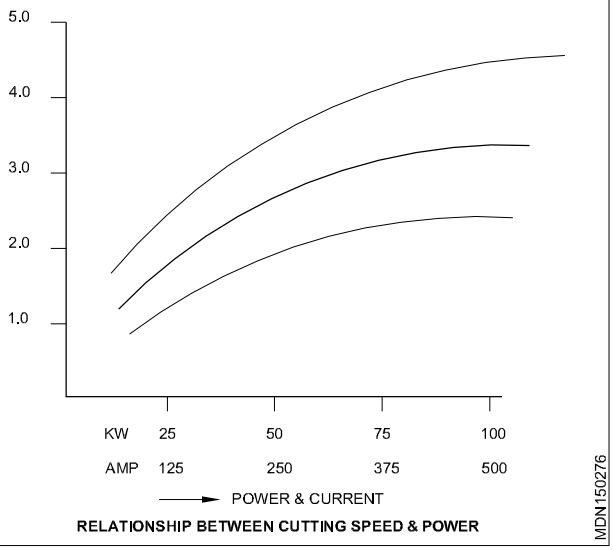
7 Cutting is possible in all positions and locations (underwater also).

Fig 5



COMPARISON OF OXY FUEL AND PLASMA CUTTING PROCESSES

Fig 6



RELATIONSHIP BETWEEN CUTTING SPEED & POWER

Application of plasma cutting

1 Straight and sharp cutting of all metals and non-metals.

2 Cutting of risers and gates for forging and casting.

3 Stack cutting of several sheets of 1.5 to 6 mm thickness.

4 For making holes in thick sheets (by piercing operation).

5 For gouging, rough machining etc.

6 For sizing the scarp.

Safety precautions in plasma cutting

The operator and persons in the vicinity of plasma cutting operation must be protected from:

1 arc radiation and spatter - protect body and eyes

2 metal fumes and gases - use breathing mask, proper ventilation

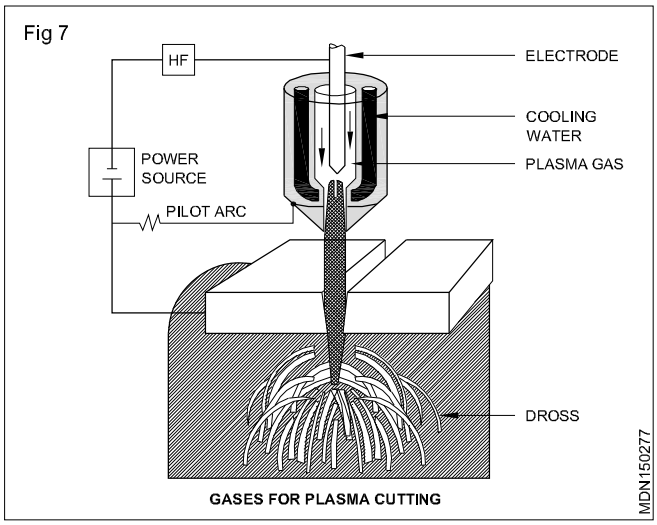
3 noise - up to 115 dB - use ear plugs

4 electrical shocks - high operating voltage (180-400V) and both anode and cathode in torch; input supply is to be switched off before attending to the torch etc.

Gases for Plasma cutting (Fig 7)

- no need to promote oxidation & no preheat
- works by melting and blowing and/or vaporisation
- "gases : air, Ar, N_2, O_2, mix of Ar + H_2, N_2 + H_2
- air plasma promotes oxidation and increased speed but special electrodes need
- shielding gas - optional
- applications : stainless steels, aluminium and thin sheet carbon steel.

Fig 7



GASES FOR PLASMA CUTTING

Heat Treatment

Objectives : At the end of this lesson you shall be able to

- **state the importance of heat treatment**
- **list the stages of heat treatment**
- **state the type of Heat treatment process**
- **explain the process of Annealing, Normalising, Hardening and Tempering**
- **state the importance of case hardening**
- **explain the process of carbursing, Nitriding, Induction hardening and flame hardening.**
- **state the types of heat treatment and surface hardening used for production of automotive components.**

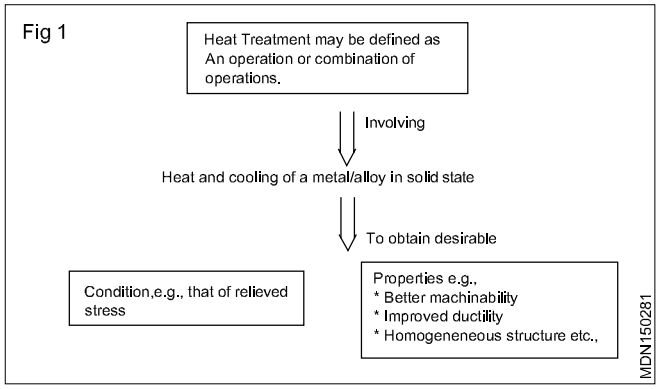
Introduction

The automobile is a typical industrial product that involves a variety of materials and technologies. Beginning with raw metal products leading all the way to final component assembly, various types of heat treatment and surface engineering processes are applied in the manufacture of automotive components.

Heat treatment impart the required strength or hardness properties as dictated by the given component application. Other processes involved in metal processing may include forming, machining as well as quench and tempering, carburizing and hardening and nitriding during production. Surface modification, when properly applied, yields optimum surface properties enhancing corrosion and wear resistance while improving frictional properties.

Definition of Heat Treatment (Fig 1)

Fig 1



Some of the common industrial heat treatment operations are as follows:

a) Annealing

b) Normalising

c) Hardening and Tempering

- Ferrous metals (metals with iron) are annealing, normalizing, hardening, and tempering.
- Nonferrous metals can be annealed, but never tempered, normalized, or case-hardened.

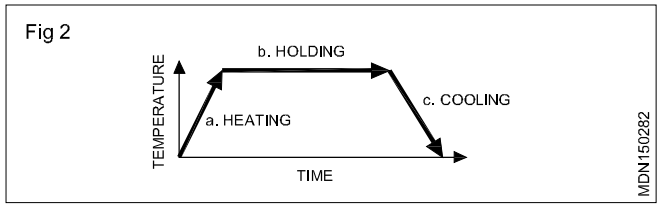
Stages of Heat Treatment (Fig 2)

Stage a : Heating the metal slowly to ensure a uniform temperature.

Stage b : Soaking (Holding) the metal at a given temperature for a given and cooling the metal to room temperature.

State c : Cooling the metal to room temperature.

Fig 2



Annealing

Annealing consists of heating a metal to a specific temperature-based on the carbon content, holding it at that temperature for a set length of time, and then cool it very slowly in the furnace

Full annealing is used to obtain the following properties:

- To relieve the internal stresses and strains developed by various fabrication methods like forgings, castings etc.
- To improving properties of elasticity and ductility
- To reduce hardness

Normalising

Normalising is a type of heat treatment applicable to ferrous metals only. It differs from annealing in that the metal is heated to a higher temperature and then remove from the furnace for air cooling.

Normalising may be employed to

- to remove the internal stresses induced by heat treating, welding, casting, forging, forming, or machining
- Refine the grain and provide homogeneous micro-structure, to improve response to hardening treatment.
- Improve machining characteristics

Hardening

Hardening is a heat treatment process in which steel is heated to an appropriate temperature based on the carbon content of the steel and held at this temperature for sufficient time to allow the steel to obtain a uniform

temperature throughout the section. Then the steel is rapidly cooled through a cooling medium. Water, oil, molten salt or air may be used as a cooling medium depending upon the composition of the steel and the hardness required.

Carbon steels are usually quenched in brine or water, and alloy steels are generally quenched in oil.

Purpose of Hardening

- To increases the hardness and strength of the steel,but makes it less ductile

Tempering :

Tempering consists of heating the steel to a specific temperature generally below its hardening temperature, holding it at that temperature for the required length of time, and **then cooling it, usually instill air.**

Purpose Of Tempering

Steels in its hardened condition, it is often harder than necessary, generally too brittle and too severally strained in the quenching operation. The aim of tempering is:

- To relieve the steel from internal stresses and strains.
- To regulate the hardness and toughness
- To decrease the brittleness and to restore some ductility to induce shock resistance.

Tempering immediately after quenching prevents development of such destructive cracks

Case Hardening

Case hardening produces a hard, wear-resistant surface or case over a strong, tough core. The principal forms of casehardening are carburizing, cyaniding, and nit riding. Only ferrous metals are case-hardened.

Importance of Case Hardening

Case hardening is ideal for parts that require a wear-resistant surface and must be tough enough internally to withstand heavy loading. The steels best suited for case hardening are the low-carbon and low-alloy series.. In case hardening, change the surface of the metal chemically by introducing a high carbide or nitride content. The core remains chemically unaffected. When heat-treated, the high-carbon surface responds to hardening, and the core toughens.

While surface hardening by induction hardening and flame hardening does not change the chemical composition of the material techniques like carburizing. Nitriding and carbonitriding change the surface composition.

Carburising

Carburizing is a case-hardening process by which carbon is added to the surface of low-carbon steel. This results in a carburized steel that has a high-carbon surface and a low-carbon interior.

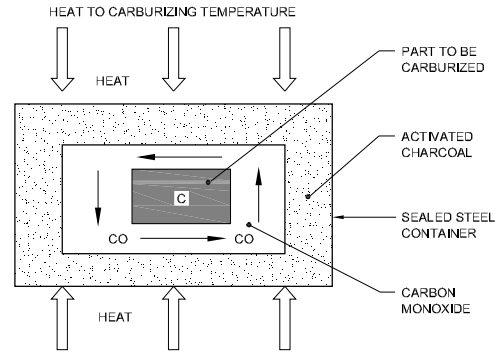
When the carburized steel is heat-treated, the case becomes hardened and the core remains soft and tough.

a) Pack Carburising

Components are placed in a container along with solid carburizing material like charcoal, wood charcoal energized by sodium, potassium and barium carbonate. A lid is fitted to the container made of heat resisting cast iron. The box with the contents is sealed with fire clay and is placed in muffle furnace at 900° - 920° C as shown in (Fig 3) and held for a period of time depending upon the case and held for a period of time depending upon the case depth required (Fig 4).

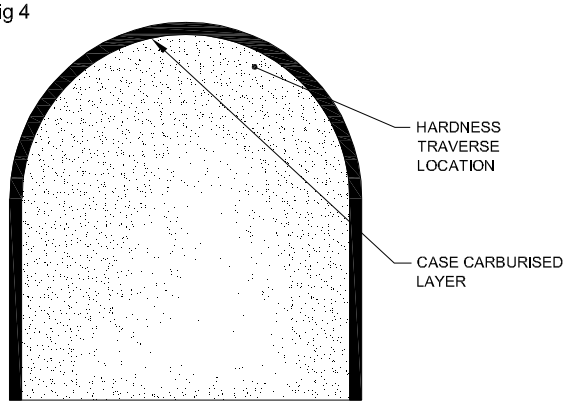
After carburizing the component is hardened by re-heating at 760 - 780° C followed by quenching in water or oil. Thus the case hardening improves surface hardness and the core toughness.

Fig 3



PACK CARBURISING PROCESS

Fig 4



Advantages : It requires no prepared atmosphere and is economical process.

b) Gas Carburising

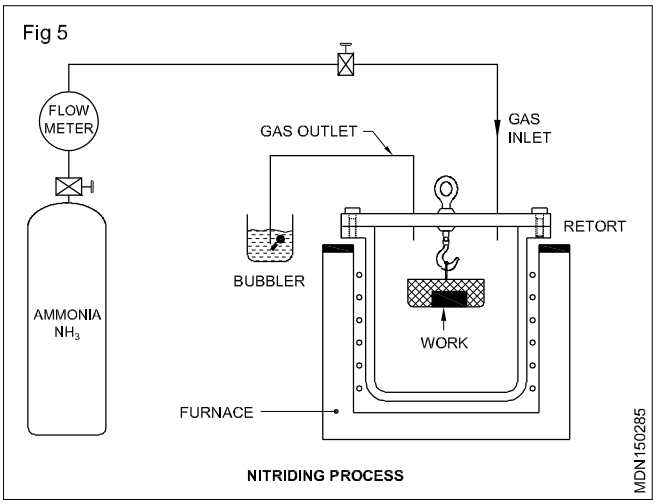
If a suitable carbonaceous furnace atmosphere namely hydro carbon atmosphere or carbon monoxide atmosphere can be provided, the components can be directly loaded in the furnace so as to achieve gas carburizing. The time and temperature can be compared to that of pack carburizing. Hydrocarbon atmosphere decomposes readily at the carburizing temperature at 95°C.

Advantage : It is used to carburise large number of components simultaneously thus saving the heat energy, labour and carburizing compound. Thus it supercedes pack carburizing. It enables quicker handling by direct quenching.

Nitriding (Fig. 5)

Nitriding case-hardening method produces the hardest surface of any of the hardening processes it introduces nitrogen into the surface of steel. Medium carbon steels are generally nitride. It differs from the other methods in that the individual parts have been heat-treated furnace that has an ammonia gas atmosphere as shown in (Fig 5) No quenching is required so there is no worry about warping or other types of distortion. Time of nit riding is long and will be about 70 hours. The case depth is less than 0.5 mm.

Fig 5



NITRIDING PROCESS

This process is used to case harden items, such as gears, cylinder sleeves, camshafts and other engine parts, that need to be wear resistant and operate in high-heat area

Induction Hardening

When high frequency alternating current is passed through the heating coil an electromagnetic field is created around it. It gives rise to eddy currents in the surface of the metal bar centered in the coil.

Thus, the surface of the metal bar gets heated above the critical temperature and subsequently gets hardened during quenching.

This method is employed for very long parts and normally requires a cross sectional area that is uniform along the entire length of the hardened surface.

Flame Hardening

Flame hardening is another procedure that is used to harden the surface of metal parts. When you use an oxy-acetylene flame, a thin layer at the surface of the part is rapidly heated to its critical temperature and then immediately quenched by a combination of a water spray and the cold base metal. This process produces a thin, hardened surface, and at the same time, the internal parts retain their original properties.

Types of Heat Treatment And Surface Hardening Used For Production Of Automotive Components

Types of heat treatment	Typical components
Annealing	Forged blanks for gearing and misc. parts
Normalizing	Reduce hardness for machining
Quench and temper	Fasteners, Rods and Arms
Case hardening : Carburizing	For fatigue and wear resistance Gears and shafts
Induction hardening	Cam shafts, Drive shafts, steering knuckles
Nitriding :	Cam shafts, oil pump gears, valves, Brake pad liner plates, A/T gears

Non - destructive testing methods

Objectives : At the end of this lesson you shall be able to:

- **state the definition of Non-Destructing Testing**
- **list the different type of NDT Methods**
- **explain the principle and process of Liquid penetrant testing Method**
- **state the Advantages and disadvantages of Liquid penetrant testing**
- **explain the principle and process of Magnetic Particle Testing Method**
- **state the Advantages and disadvantages of Magnetic particle Testing Method.**

Importance of Non-Destructive Testing in Automotive Industry

Automobile companies face when accidents happen because of component failures, the stringent quality control requirements expected by organizations or the high number of human lives lost in accidents, the automobile industry has reduced 'cutting' of its components and has transitioned into non-destructive testing for its automotive parts. A malfunction of a component, however small, can have catastrophic consequences. Hence NDT plays an important role in the quality control of a product. It is used during all the stages of manufacturing of a product. It is used to monitor the quality of the.

a) Raw materials which are used in the construction of the product.

b) Fabrication processes which are used to manufacture the product.

c) Finished product before it is put into service.

Definition of NDT

Non-destructive testing (NDT) is the use of physical methods which will test materials, components and assemblies for flaws in their structure without damaging their future usefulness.

Types of NDT methods

The methods of NDT range from the simple to the complicated. Which are commonly used are:

1 Visual or optical inspection

2 Dye penetrant testing

3 Magnetic particle testing

4 Eddy current testing

5 Radiographic testing and

6 Ultrasonic testing.

Liquid Penetrant Testing (Fig. 1)

A liquid penetrant dye is passed through the object to be inspected. By capillary action, the liquid seeps into the defects in the material. A developer is applied to the material which pulls back the penetrant and forms an indication on the surface of the material, which is much easier to see than the crack itself.

This non-destructive testing technique can be used to find the cracks, pores and other surface defects.

Basic Process of LPT

1 **Clean & Dry Component**

Pre clean area, spray on cleaner, wipe off with cloth.

2 **Apply Penetrant**

Spray Penetrant, allow short penetrant time 5-10 min

3 **Remove Excess Penetrant**

Spray cleaner on wiping towel and wipe surface

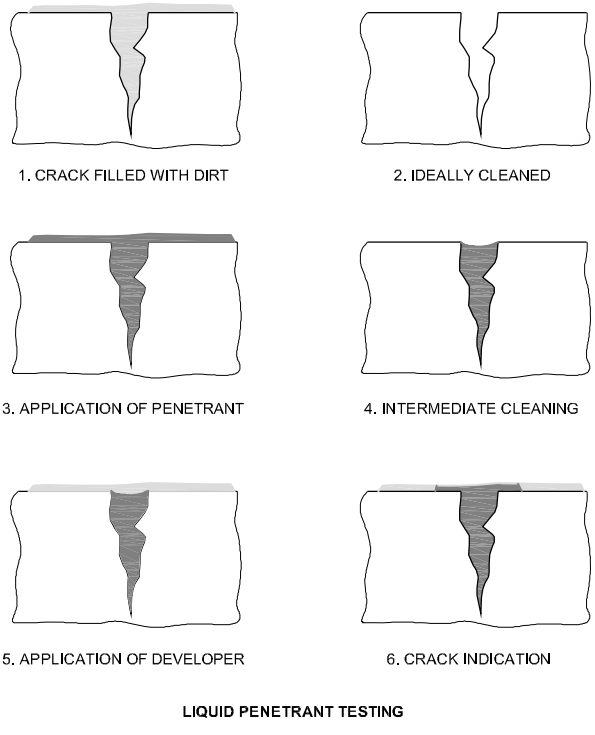
4 **Apply Developer**

Spray on thin uniform film of developer

5 **Visual Inspection**

Inspect defects will show as bright red lines/dot in while developer background as pink colour

Fig 1



Advantages

- Parts with large surface areas can be measured rapidly at a low cost
- Low initial investment cost
- Parts with complex shapes can be inspected

Disadvantages

- Can be applied only on nonporous materials
- Chemicals used could be toxic, and so precautions need to be taken
- Cleaning necessary before and after material is tested by this technique

Magnetic particle testing (MPT) (Figs 2 & 3)

Magnetic particle testing is used for the testing of materials which can be easily magnetized. This method is capable or detecting open to surface and just below the surface flaws.

In this method the test specimen is first magnetized either by using a permanent or an electromagnet yoke or by passing electric current through or around the specimen.

Whenever minute magnetic particles are sprinkled onto the surface of such a specimen, these particles are attracted by these magnetic poles to create a visual indication approximating the size and shape of the flaw.

Basic Process of MPT

(a) Preparation of the inspection surface.

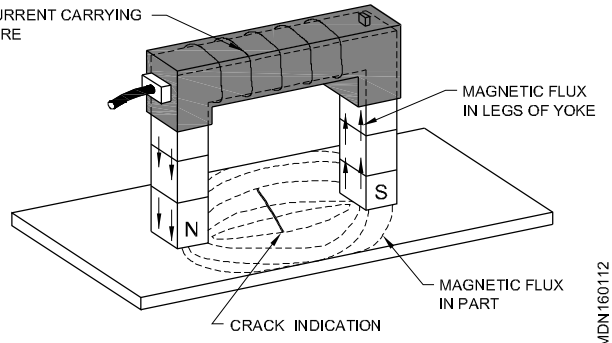
Surface preparation by grinding, machining, Cleaning may be accomplished using detergents, organic solvents, de-scaling solutions, paint removers, sand or grit blasting methods.

(b) Magnetization of the inspection surface.

The method of magnetization shall be done using either electromagnetic yoke or permanent magnet, with pole spacing to be between a minimum of 3 inches (76.2mm) and a maximum of 8 inches (203.2mm).

The Yoke shall be placed in contact with the surface to be examined and energized.

Fig 2

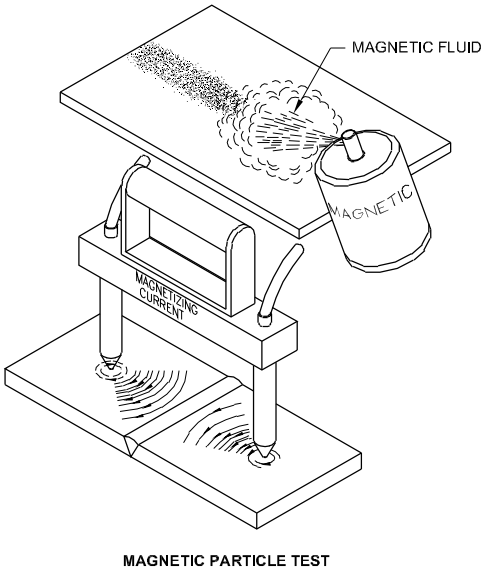


Electromagnetic yoke

(c) Indicating medium selection and application.

While maintaining the magnetic field the magnetic dry particles are applied to the area between the poles.

Fig 3

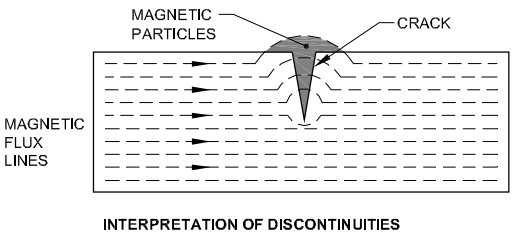


MAGNETIC PARTICLE TEST

(d) Interpretation of discontinuities. (Fig. 4)

In magnetic particle testing an indication could be any magnetically held magnetic particle pattern on the surface of the part being tested.

Fig 4



INTERPRETATION OF DISCONTINUITIES

(e) Demagnetization

Finished parts processed with wet inks should be immediately cleaned and dried to prevent the chances of surface corrosion or wear between moving parts.

(f) Post cleaning

Finished parts processed with wet inks should be immediately cleaned and dried to prevent the chances of surface corrosion or wear between moving parts.

Advantages

- Rapid inspection of large surface areas
- Surface and subsurface flaws can be detected

Disadvantages

- Can only be used for inspection of ferromagnetic materials.
- A relatively smooth surface required for application of this method.
- Non-magnetic materials like paints, coatings etc. affect the sensitivity of this testing technique.

Introduction to the hydraulics and pneumatics

Objectives: At the end of this lesson you shall be able to:

- **define the term fluid power**
- **explain the working principle of pneumatic systems and advantages and disadvantages**
- **explain the working principle of hydraulic systems and advantages and disadvantages.**

Fluid Power Systems

Fluid power is the driving force in most industrial and mobile applications. A bulldozer or excavator used for moving soil where a new project is being built, and a brake used in a car or truck are some examples of where fluid power is used. Fluid power involves the use of a fluid medium, such as air or oil, in a controlled manner, to get some useful work. Two specialized areas cover the scope of the definition of the term 'fluid power'. They are: (1) Pneumatics and (2) Hydraulics. Transmission and control of power by means of air is called pneumatics and transmission and control of power by means of liquid is called hydraulics.

Pneumatic Systems

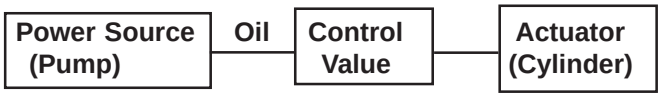
In a pneumatic system, energy in the form of compressed air is transmitted to an actuator, where work is to be done. The basic elements of the system are power source, control valves and actuators, as shown in Figure, Air compressor is used as the power source to increase the pressure of the related air medium to the required level. However, the process of pressure development in the system is quite slow. The slow response of the air compressor in developing sufficient pressure necessitates storage of compressed air in a receiver tank. The energy that is stored in the receiver tank can be transmitted, in a controlled manner, to an actuator to perform some useful work.

Pneumatic Systems

An important advantage of pneumatic systems is that they can produce linear motion quite easily. They can also produce high-speed operation. Speed control can also be achieved easily by using simple flow control valves. However, pneumatic systems are not suitable for providing uniform motion. Operating pressures in pneumatics are generally much lower than that used in hydraulics. Therefore, pneumatic systems are ideal for applications that involve small magnitude of linear forces.

Hydraulic Systems

In a hydraulic system, energy in the form of pressurized liquid (oil) is transmitted to an actuator, where work is to be done. The basic elements of the system are power source, control valves and actuators, as shown in Figure. In the hydraulic power transmission, a pump is used as the power source to create flow and subsequently raise the pressure of an enclosed incompressible oil medium to the required level almost instantaneously. The hydraulic energy can, then, be transmitted through the pressurised oil medium, in a controlled manner, to an actuator to perform some useful work.



Hydraulic Systems

A major advantage of hydraulic systems is that they can easily generate linear motion through the basic actuator, cylinder. Operating pressures in hydraulics are generally much higher than that used in pneumatics. Therefore, high-pressure hydraulic systems are capable of generating large magnitude of forces economically to drive heavy loads. Speed control of an actuator can also be achieved easily by regulating the flow rate of oil to the actuator. Precise control of speed even at low values is another advantage of hydraulic systems.

Extensive use of hydraulics is due to the following facts

- Oil is practically incompressible
- Oil can transmit high forces rapidly and accurately
- Simple step-less control of speed, force or torque
- Have simple over load protection
- Simple, compact and highly reliable

Hydraulic systems are used in the following subsystems in modern Automobiles and related maintenance equipment

- Fuel injection system
- Lubrication system
- Brake system
- Steering system
- Shock absorbers
- Adoptive suspension system
- Automatic transmission system
- Clutch actuating mechanism
- Jack
- Hoist
- Bearing puller etc.

Pascal's law - pressure viscosity

Objectives: At the end of this lesson you shall be able to
- **state the Pascal's Law**
- **understand the concept of force multiplication**
- **state many functions of hydraulic fluids**
- **define the term viscosity.**

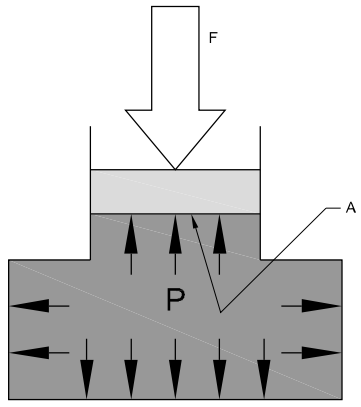
Pascal's law (Blaisé Pascal, 1623-1662)

Pascal's law is the central law for the development of a number of machines, such as hydraulic brakes, hydraulic jacks, etc. The law states that 'pressure exerted on a fluid is transmitted equally in all directions, acting with equal force on equal areas'. The following sections explain how a pressure is developed in a hydraulic system with the application of a force through a pump mechanism and how a force is developed with the application of the pressure through an actuator mechanism.

Hydraulic Pressure

Pressure is the result of the resistance offered to compression when an incompressible oil medium is squeezed by the application of a force. This pressure is transmitted equally throughout the medium in all directions, according to the Pascal's law.

Fig 1



DEVELOPMENT OF PRESSURE

MDN160211

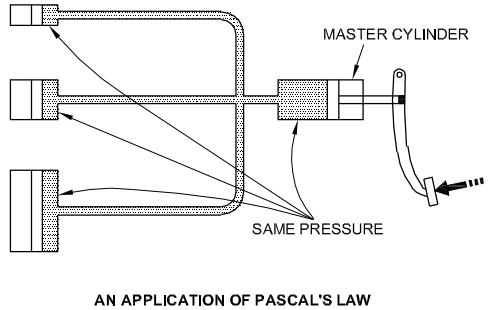
Figure 1 shows a cylinder chamber with a definite volume of oil and a piston. A force (F) is applied to the oil through the piston. When the oil is pushed, its pressure (P) increases in direct proportion to the applied force and inverse proportion to the piston area (A). Pressure can, therefore, be defined as the force acting per unit area. That is,

$$P = \frac{F}{A}$$

A typical Application of Pascal's Law

A feature of hydraulic theory can be seen in the illustration in Figure 2. which demonstrates the pressure in the master cylinder is transmitted equally to all wheel cylinders as per the Pascal's Law.

Fig 2



AN APPLICATION OF PASCAL'S LAW

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Units of Pressure: There are many units of pressure, such as Pascal (Pa), bar, pounds per square inch (psi), Kg/ cm^2, etc., used in industrial world. Some of the most important units of pressure are highlighted below:

1 Pascal = 1 N/m^2

1 bar = 100000 Pa = 10^5 Pa (100 kPa)

1 bar = 14.5 psi

1 bar = 1.02 kgf/cm^2

1 kgf/cm^2 = 0.981 bar

Hydraulic Force

When a pressure (P) is applied onto the area (A) of a cylinder piston, a force (F) is developed. The amount of force developed is equal to the area times the applied pressure. That is,

$$F = P \times A$$

Example 1: What will be the pressure required to lift 75000 N using a hydraulic cylinder with an effective area of 0.0103 m^2?

Force, F = 75000 N

Area, F = 0.0103 m^2

Pressure, P = F/A

= 75000/0.0103 Pa

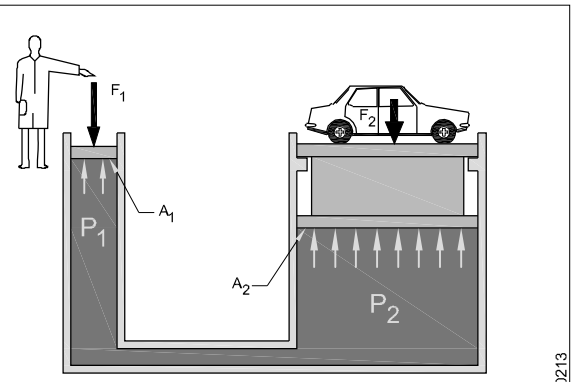
= 7281553 Pa = 72.8 bar

Exercise 1: Calculate the approximate force, a hydraulic cylinder can apply, if it has a diameter of 5.1 cm and is connected to a 200 bar circuit.

Force Multiplication

Figure 3 shows an arrangement of two cylinders with piston areas A_1 and A_2 ($A_2 > A_1$) respectively. These two cylinders are interconnected by a pipeline. Oil is enclosed in the cylinder chambers and in the pipeline. When the plunger piston A_1 is applied with a force F_1, a pressure (say P1) is developed in the oil, which acts equally in all directions through the oil. It means that the same pressure (P1) acts on the ram piston A_2. This causes the development of a force (say F_2). The governing equations for the forces developed in the cylinders are as follows:

Fig 3



ILLUSTRATING THE CONCEPT OF FORCE MULTIPLICATION

$$F_1 = P \times A_1$$

$$F_2 = P \times A_2$$

Therefore,

$$F_2 = F_1 \times (A_2 / A_1)$$

We can see that by controlling the area ratio (A2/ A1) a larger output force can be obtained from a smaller input force. This principle is also used in many hydraulic machines. For example, a hydraulic jack used to lift cars at service stations, brakes in vehicles, etc., use the force multiplier principle for power amplification.

Example 2

To understand the idea of force multiplication, consider Fig 3 where applied force, F1= 25 N, cross sectional area of plunger, A1 = 10 cm2, ram piston area A2 = 100 cm2. What will be the force F2 required to lift the car placed on the ram platform?

Solution:

Pressure P_1 $= F_1 / A_1 = 25/10 = 2.5$ n.cm^2

P_1 $= P_2 = 2.5$ n.cm^2

Therefore, F_2 $= A_2 P_2$

$= 100 \times 2.5$ N

$= 250$ N

Exercises 2: A hydraulic car lift used in a service station has an input pump piston and an output plunger to support a loading platform. The pump piston has a radius of 0.012 m and the loading piston has a radius of 0.15 m. The total weight of the car and the plunger is 25000 N. If the bottom surfaces of the piston and plunger are at the same level, what input force is required to lift the car and output plunger? What pressure produces this force? [Ans: 160 N, 3.536 bar]

Oil Flow

A hydraulic system, with a pump pushing oil continuously through a pipeline, produces a oil flow between any two points in the pipeline as long as there is a pressure differential between these two points.

Flow Rate

Flow rate of oil is a measure of the volume of the oil passing a point per unit of time. It is usually measured in m^3/ s or litre per minute (lpm) or in other units.

Hydraulic Oil

Hydraulic oil is the lifeblood of any hydraulic system. Its primary function is to transmit power from one part of the system to the other part. Apart from this function, it has to lubricate the internal moving parts of system components, seal clearance between the moving parts, and act as a heat transfer medium, as it flows through the system. Oil is usually composed of base stock ad many additives. Mineral-based oils (i.e., petroleum-based oils) are used in a majority of applications. The purpose of using additives in oil is to improve the performance of the oil for a give application. Oil's resistance to flow, expressed in terms of its viscosity, is an important parameter that must be considered.

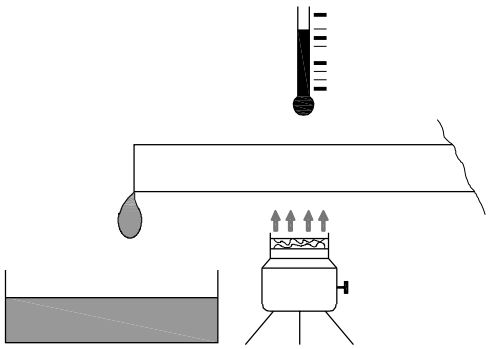
Hydraulic oils are susceptible to the problem of contamination as they are generally used in harsh environments. Presence of particulates, water, air, and their reaction products in hydraulic oils can adversely affect the performance of these systems. Therefore, the most important requirement of any hydraulic system is to maintain its oil medium in a clean state. Hydraulic filters are used to remove solid contaminants in hydraulic oil.

Viscosity (Fig 4)

Viscosity is a measure of a liquid's resistance to flow. Thicker oil has more resistance to flow and possesses a higher viscosity. Viscosity is affected by temperature. Oil viscosity decreases as the temperature of oil increases.

A property, that describes the difficulty with which oil moves under the force of gravity, is called kinematic viscosity. It is measured in terms of stokes.

Fig 4



ILLUSTRATING THE EFFECT OF TEMPERATURE ON VISCOSITY

MDN160214

Stoke (St): This is the CGS unit of kinematic viscosity, equivalent to square centimeter per second (cm^2/s.) The more customary unit of kinematic viscosity is the centistokes (cSt). One cSt is one one-hundredth of a stoke. The relations amongst various units of kinematic viscosity are summarized below:

* 1 stoke = 1 cm^2/s

* 1 cSt = 0.01 Stoke

* 1 cSt = 1 mm^2/s

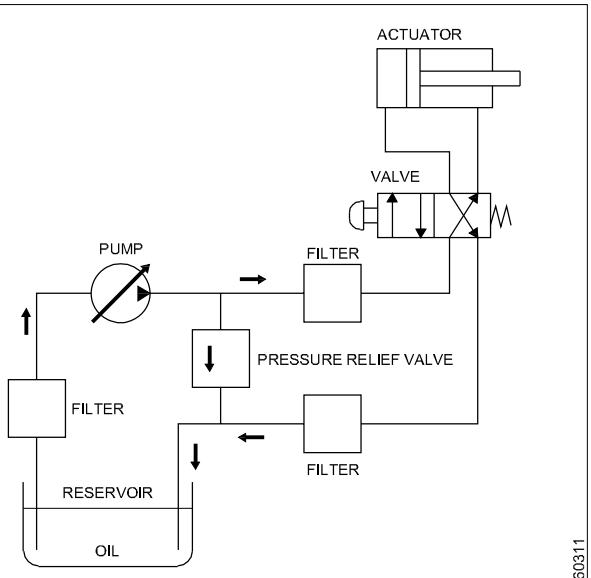
Hydraulics

Objectives: At the end of this lesson you shall be able to:
- **describe the hydraulic system**
- **understand the components of a hydraulic power pack**
- **explain the working of a hydraulic pump.**

Hydraulic System

The hydraulic system is shown in the schematic diagram of Figure 1. The system is a closed system and comprises a power pack, control valves, and actuators. The hydraulic power pack consists of a hydraulic pump coupled to engine, a reservoir filled with oil, and a pressure relief valve (PRV). The pump pushes the oil into the closed system. It develops a high pressure, when the pump flow encounters some opposition. Therefore, the mechanical energy provided by the prime mover of the pump is converted into hydraulic energy. This energy is transmitted to hydraulic actuators through the oil medium. Hydraulic actuators, such as cylinders, are used to convert the hydrostatic energy back to mechanical energy. Hydraulic valves are used to control the direction and the speed of the actuators. The pressure relief valve is used to limit the pressure in the system.

Fig 1



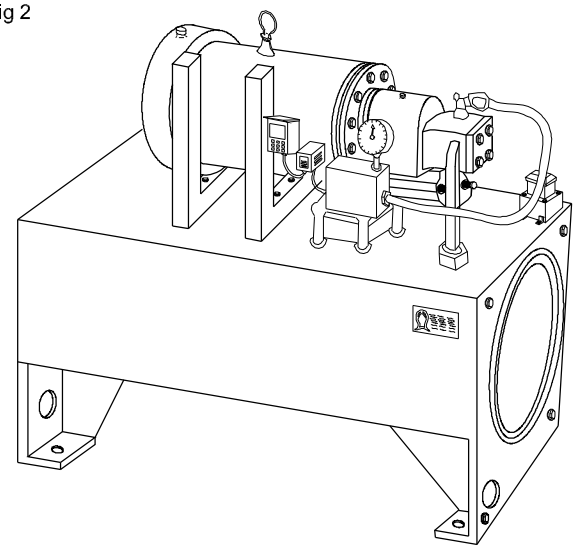
REPRESENTATIONS OF A TYPICAL HYDRAULIC SYSTEM

All system components are interconnected through fluid conductors, such as pipes, tubing and/or hoses, for the leak-free transmission of the hydraulic power. The pressurized oil media must be positively confined in the system, through the use of effective seals, for the efficient utilization of the power. Contaminants should not be allowed to accumulate in the system. Filters are used to remove contaminants in the oil medium.

Reservoir (Fig 2)

A hydraulic power pack, employed in a hydraulic system, transforms the power conveyed by its prime mover into hydraulic power, at pressures and flow rates as required for all system actuators. It is usually a compact and portable assembly that contains components necessary to store and condition a given quantity of oil, and to push a part of the oil into the system. The essential components are reservoir (tank), pump, relief valve, pressure gauge etc. A reservoir is essentially a container that stores a sufficient quantity of oil required for the system. A well-designed reservoir in a hydraulic system allows most of the foreign matter to drop out of the oil and assists in dissipating heat from the oil.

Fig 2

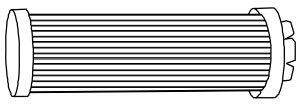


HYDRAULIC POWER PACK

Oil Filter (Fig 3)

Impurities can be introduced into a system as a result of mechanical wear, and external environmental influences. For this reason filters are installed in the hydraulic circuit to remove dirt particles from the hydraulic oil. The reliability of the system also depends on cleanliness of oil.

Fig 3

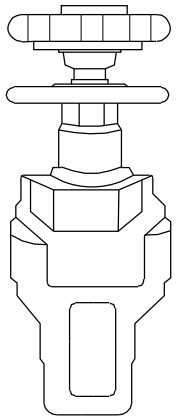


HYDRAULIC FILTER ELEMENT

Pressure Relief Valve (Fig 4)

A pressure relief valve (PRV) is used in a hydraulic system to limit the maximum working pressure of the system to a safe value in order to protect operating personnel against injury and system components against any damage.

Fig 4



PRESSURE RELIEF VALVE

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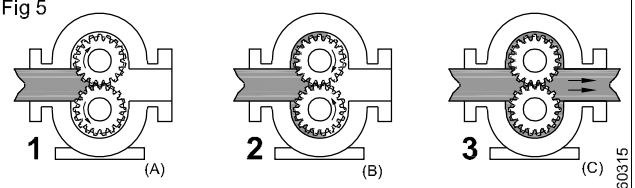
External Gear Pump (Fig 5)

Figure 5 illustrates the operation of an external gear pump with the help of its schematic diagrams in three critical positions. It is basically consists of two close-meshing identical gears, enclosed in a close-fitting housing. Oil chambers are formed in the space enclosed by the gear teeth, pump housing, and side plates. Each of the gears is mounted on a shaft supported on bearings in the end covers. One of the gears - called the drive gear - is coupled to a prime mover through its drive shaft. The second gear is driven, as it meshes with the driver gear.

Fig 5



SCHEMATIC DIAGRAMS ILLUSTRATING THE OPERATION OF AN EXTERNAL GEAR PUMP

MDN160315

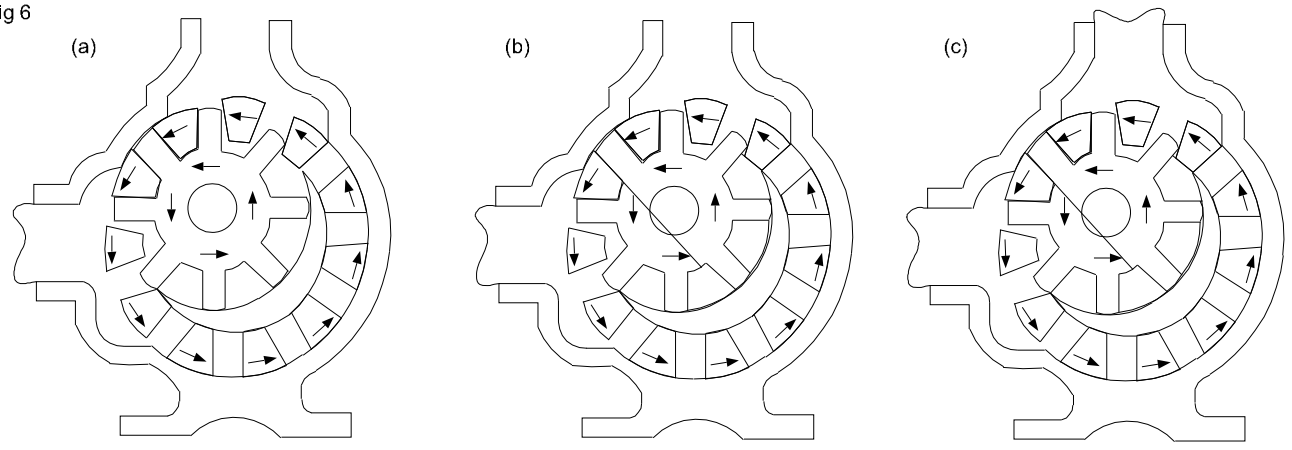
The gears rotate in opposite directions when driven by the prime mover, and mesh at a point in the housing between the inlet and outlet ports. When the gears rotate in the housing, the diverging teeth create an expanding volume at the inlet side of the pump. This creates a partial vacuum at the inlet chamber of the pump, which draws oil into the chamber from the system reservoir (Fig 5a). The oil then travels around the periphery of the rotating gears as two streams (Fig 5b). Since the pump has a positive internal seal against leakage, the oil is positively ejected out of its delivery port (Fig 5c). Therefore, when run by the prime mover, the intermeshing gears displace a fixed volume of oil from the suction side to discharge side in one revolution of the drive shaft and crate a flow.

Internal Gear Pump (Fig 6)

Figure 6 illustrates the operation of an internal gear pump with the help of its schematic diagrams in three critical positions. This pump consists of an outer rotor gear, an inner spur gear, and a crescent-shaped spacer, all enclosed in a housing. The inner gear with less number of teeth operates inside the rotor gear. The gears are set eccentric to each other. The stationary crescent spacer is machined into the space between these gears and separates them. The spacer divides the oil stream, and acts as a seal between the suction and discharge ports.

Any one of the gears can be driven through a shaft supported on bearings. Both the gears rotate in the same direction, when power is applied to the drive shaft. The rotation of gears causes the teeth to un-mesh near the inlet port and consequently a partial vacuum is created at the inlet chamber of the pump, which draws oil into the chamber from the system reservoir (Fig 6a). Oil trapped between the inner and outer gear teeth on both sides of the spacer is carried from the inlet port to the delivery port, as the gears rotate (Fig 6(b & c). Since the pump has a positive internal seal against any leakage, the oil is positively ejected out of the delivery port.

Fig 6



SCHEMATIC DIAGRAM ILLUSTRATING THE OPERATION OF AN INTERNAL GEAR PUMP

MDN160316

Hydraulic actuators, and valves

Objectives: At the end of this lesson you shall be able to
- **explain different types of hydraulic actuators**
- **explain the symbol and working of hydraulic DC valves**
- **explain the symbol and working of non-return valve**
- **explain the symbol and working of an adjustable type throttle valve.**

Hydraulic Actuators

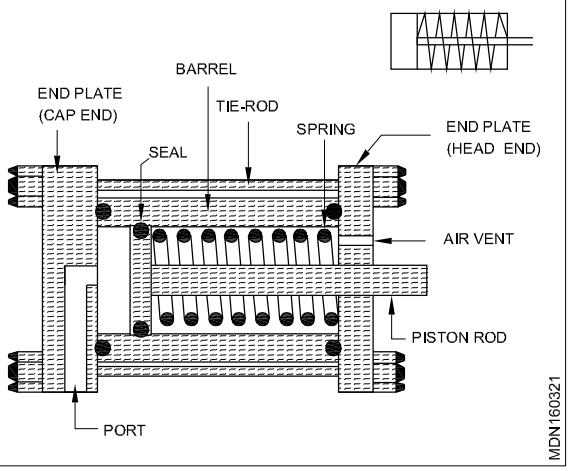
A linear actuator, as used in hydraulic system, converts hydraulic power into a controllable linear force and/or motion.

Single-acting Hydraulic Cylinders

A single-acting cylinder is designed to exert force hydraulically in one direction - either on its extension stroke or on its retraction stroke. It utilizes some other force to complete the motion in the other direction. It can be seen that the single-acting cylinder is capable of performing work only in one direction of its motion and hence the name single-acting cylinder.

The cross-sectional view of a single-acting cylinder is shown in Figure 1. It consists of a barrel, a piston-and-rod assembly, a spring, end-caps, a set of seals, and a port. Oil chamber is formed in the cylinder with the barrel, piston, and the piston-side end-cap. The piston-and-rod assembly is a tight-fit inside the barrel and is biased by the spring. The port is integrated into its cap-end to permit or to relieve the system oil. Application of a hydraulic pressure through the port moves the piston-and-rod assembly in one direction to provide the working stroke. The piston-and-rod assembly moves in the opposite direction, either by a spring force or by gravity, or even by exerting an external force. In a cylinder with a spring-assisted retraction, the spring is designed not to carry any load, but, to retract the piston-and-rod assembly with sufficient speed.

Fig 1

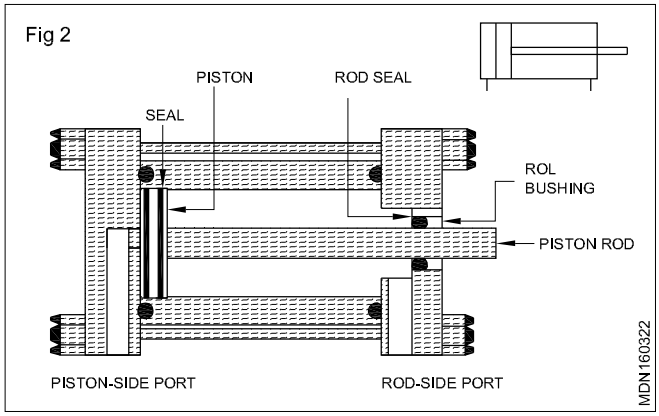


A schematic diagram showing the cross-sectional view of a single-acting cylinder.(Fig 1)

Double-acting Hydraulic Cylinders

Double-acting hydraulic cylinders, like single-acting cylinders, are also linear actuators. A double-acting cylinder can perform work in both directions of its motion, and hence the name double-acting cylinder.

Fig 2



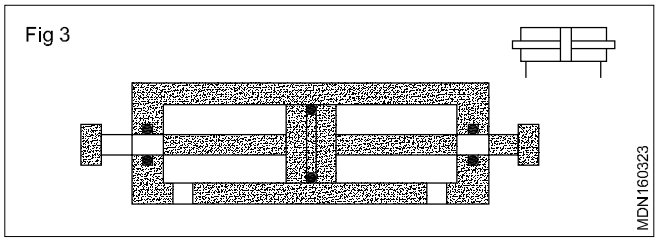
Cross-sectional view of a double-acting cylinder. (Fig 2)

A cross-sectional view of a double-acting hydraulic cylinder is given in Figure 2. It consists of a barrel, a piston-and-rod assembly, end-caps, a set of seals, and two ports. The double-acting cylinder has oil ports on both ends, namely piston-side port and piston-rod-side port. Application of a hydraulic pressure through the piston side port extends the cylinder, provided that the pressure from the piston-rod side is relieved. In the same way, application of a hydraulic pressure through the piston-rod side port retracts the cylinder, provided that the pressure from the piston side is relieved.

Double Rod-end Hydraulic Cylinders

A double rod-end cylinder has piston-rods extending out of the cylinder at both ends, as shown in Fig 3. It has equal areas on both sides of the piston.

Fig 3



A double rod-end hydraulic cylinder.(Fig 3)

2/2-way Directional Control (DC) Hydraulic Valve

Simplified sketches of a 2/2 - DC (way) valve are shown in Fig 4. The valve consists of housing with a sliding spool, a compression spring. The spool is designed to slide in a close-fitting bore of the valve body. The groove between lands on the spool provides leak-free flow paths between the ports. The operation of the valve is explained with the help of the two views of the valve in its normal and actuated positions.

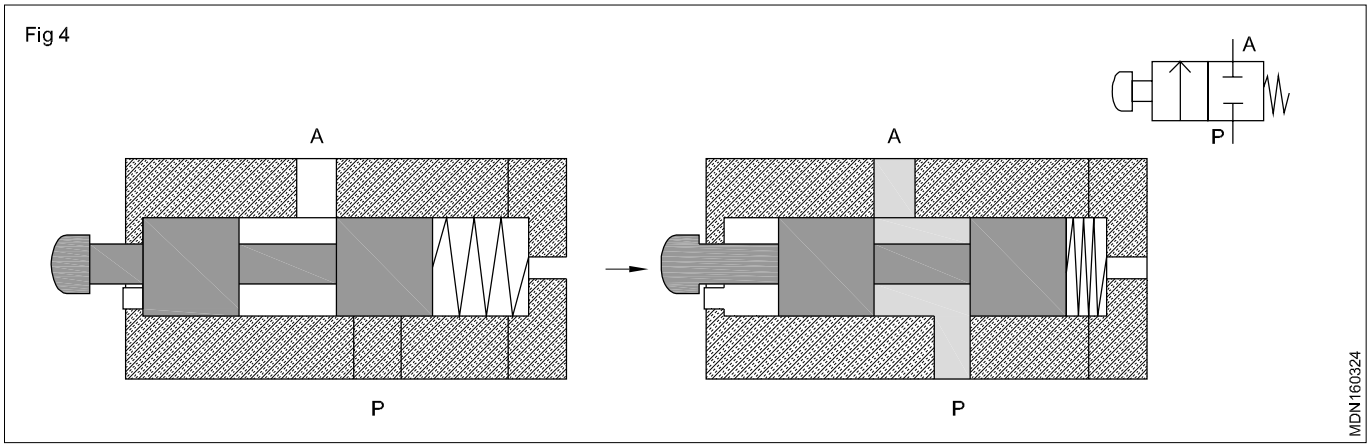


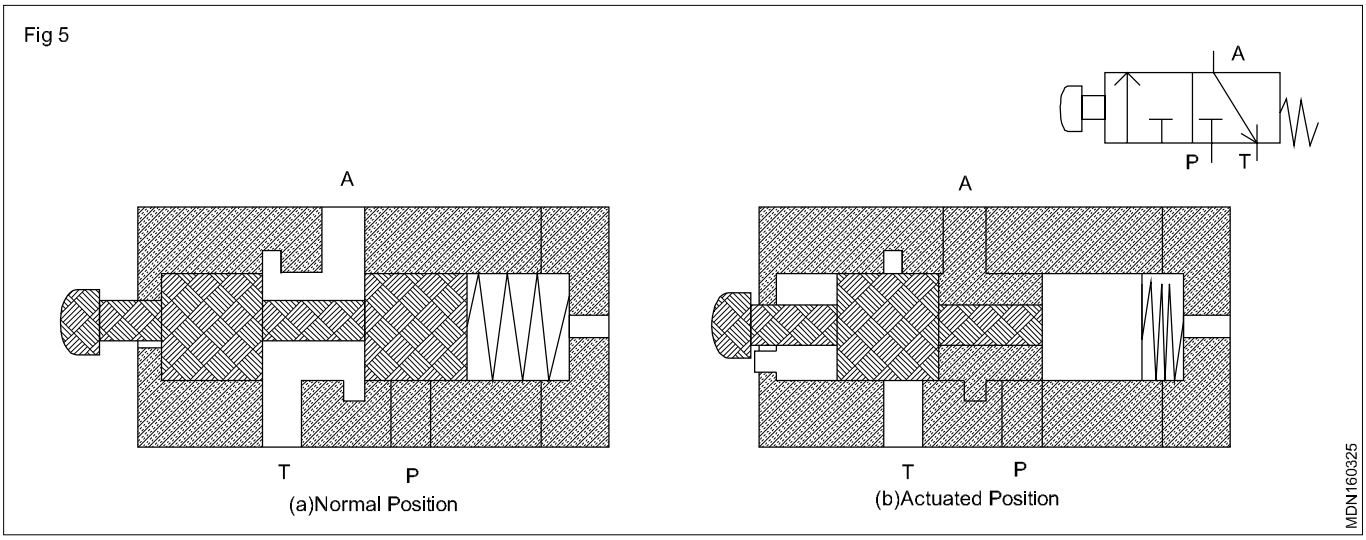
Fig 4 (a) Normal position **Fig 4 (b) Actuated position**

(Fig 4) Cross-sectional views of a 2/2-DC hydraulic valve in its normal and actuated positions.

In the normal position of the valve, as shown in Figure 4(a), both the pressure port P and the working port A are blocked. In the actuated position of the valve, as shown in Figure 4(b), the working port A is open to the pressure port P. Once the actuating force is removed, the compression spring brings the spool back to its normal position.

3/2-Directional Control (DC) Hydraulic Valve

A 3/2-DC (way) valve has three ports and two switching positions. The cross-sectional views of a spool type 3/2-DC valve in its normal position as well as actuated position are shown in the simplified sketches of Figure 5. The pressure port is blocked in the normal position of the valve, as shown in Figure 5(a). In the actuated position of the valve, as shown in Figure 5(b), the working port A is open to the pressure port P and closed to the tank port T. The 3/2-way valves can be used to control single-acting hydraulic cylinders.

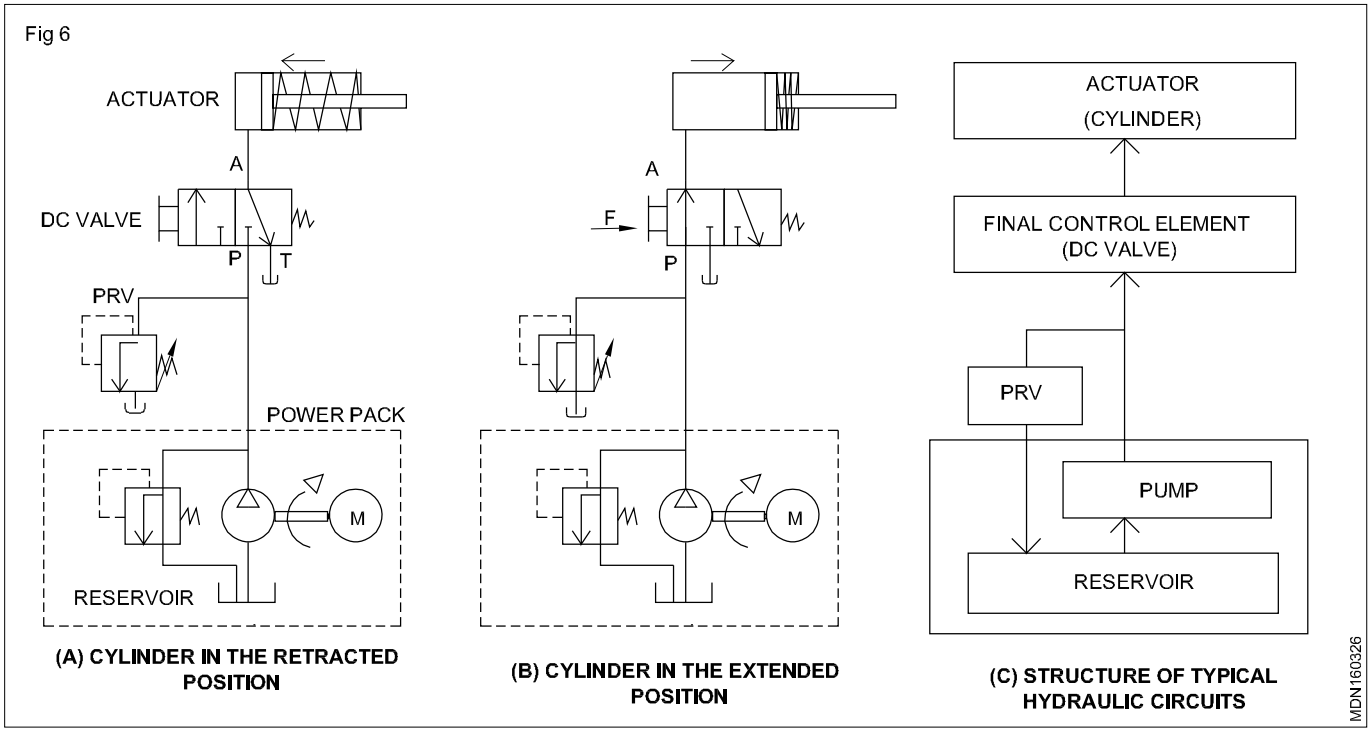


(Fig 5) Cross-sectional views of a spool type 3/2-DC hydraulic valve (NC type) in its normal and actuated positions.

Example 1: A single-acting hydraulic cylinder is to clamp a component when a push-button valve is pressed. As long as the push-button is pressed, the cylinder is to remain in the clamped position. If the push-button is released, the cylinder is to retract to its home position. Develop a hydraulic circuit to implement the control task using a fixed-displacement pump and a 3/2-Dc valve.

Solution

Two positions of the hydraulic circuit, for implementing the control task given in Example 1, in the normal and actuated positions of the DV valve, are shown in Figure 6. The power supply unit consists of a hydraulic pump driven by an electrical motor, a reservoir and an integral pressure relief valve. The pump can be set by using a separate pressure relief valve (PRV), as shown.



(Fig 6) Two positions of the hydraulic circuit for the direct control of a single-acting cylinder, and a typical structure of hydraulic circuits.

The single acting cylinder can be controlled by using a manually actuated 3/2 DC valve as shown in the figure. In the actuated position of the valve, as shown in the Fig 6(b), the valve allows the flow the pump to the cylinder. The cylinder then extends to its forward direction. When system pressure reaches the setting of the relief valve, pump flow is bypassed over the relief valve against the full system pressure. This maximum pressure limiting action of teh relief valve serves to protect the system against over-pressurisation. In the normal position of the 3/2 - DC valve a shown in Fig. 6(a), the valve blocks the flow from the pump to the cylinder. The cylinder then retracts to its home position. A typical structure of hydraulic circuits is given in the block diagram of Fig 6(c).

4/2 Directional control (DC) Hydraulic valve

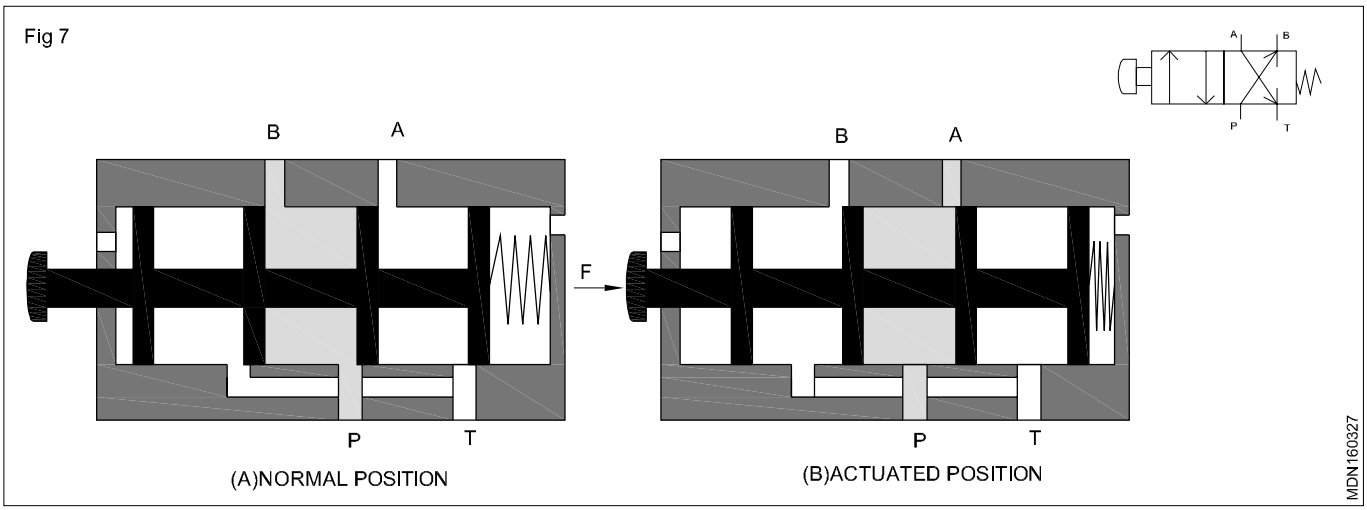
A 4/2 - DC (way) valve has four ports and two switching positions. Simplified cross-sectional views of a manually actuated 4/2 DC valve with spool design, in its normal and actuated positions, are shown in Fig. 7. In the normal position of the valve, as shown in Fig. 7(a), paths from the pressure port P to the working port B and from the working port A to the tank port T are open. When the valve is actuated, paths from the pressure port P to the working port A and from the working port B to the tank port T are open, as shown in Fig. 7(b). This valve can be used as the main valve to drive a double - acting hydraulic cylinder or a bi-directional hydraulic motor.

Example 2 A double -acting hydraulic cylinder is to extend and clamp a work - piece when a push - button valve is pressed. As long as the push - button is actuated, the cylinder is to remain in the clamped position. If the push button is released, the cylinder is to retract. Develop a hydraulic control circuit to implement the control task. A fixed -displacement hydraulic pump is used as the power source.

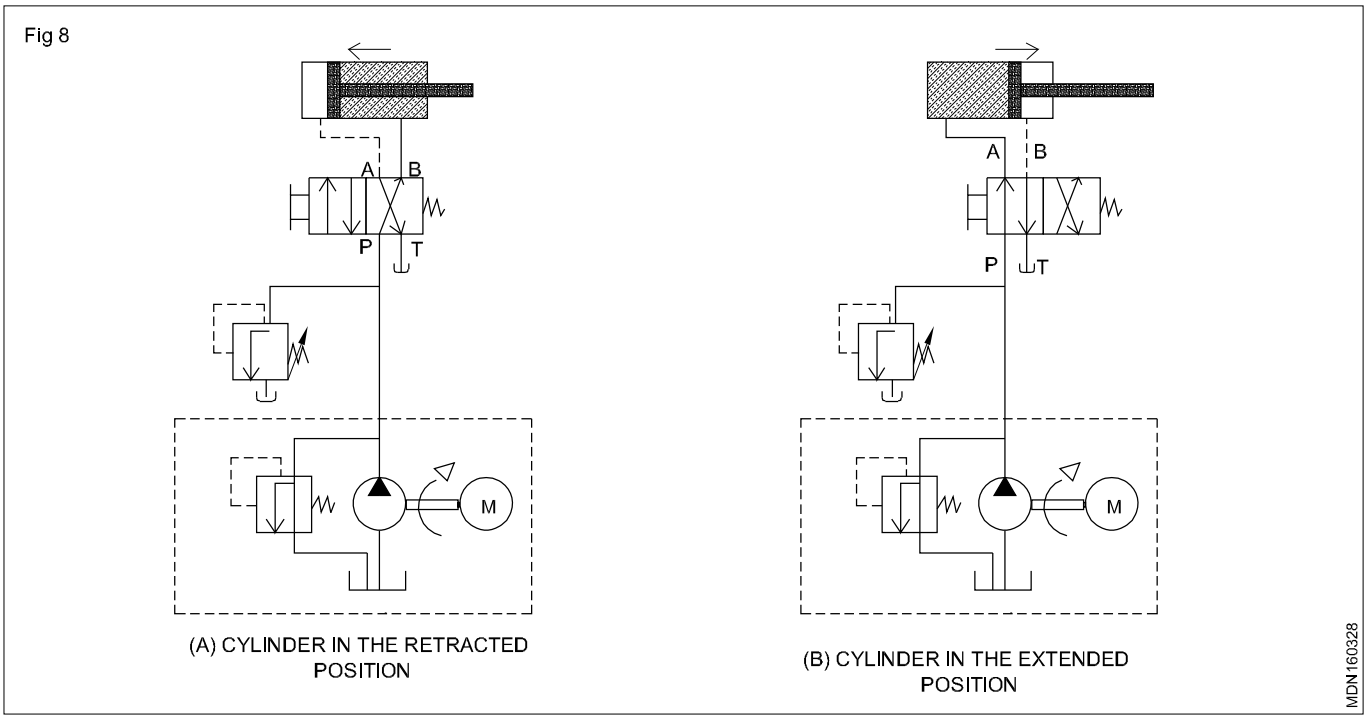
Solution

Two positions of the hydraulic circuit for the control task in Example 2 in the normal and actuated positions of the double -acting hydraulic cylinder are shown in Fig. 8. The double - acting cylinder can be controlled by using a manually-actuated 4/2 DC valve. The power supply unit consists of hydraulic pump driven by an electricla motor, a reservoir, and an integral pressure relief valve. The pump delivers pressurized oil to the circuit with constant displacement.

When the valve is actuate as shown in the Fig. 8(b) the system oil flow is directed to the iston side port of the cylinder, and the cylinder extends in the normal position of the valve as shown in the Fig. 2(a) the oil flow is directed to the piston - rod side port of the cyliner and teh cylinder retracts to its home position. The maximum / operating pressure (say 100 bar) in the system can be set by using a separate pressure relief vave (PRV) as shown .



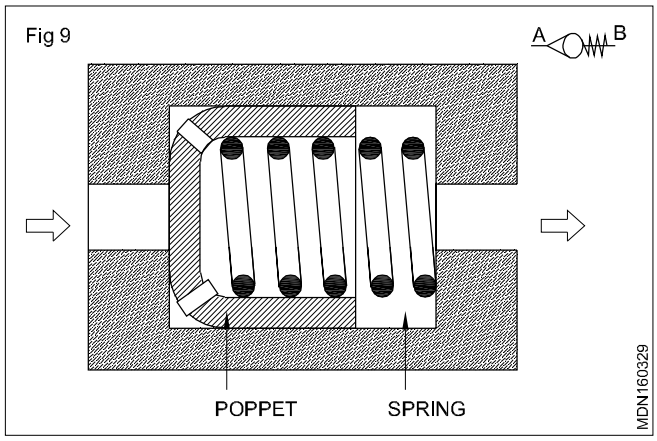
(Fig 7) Cross sectional views of a manually actuated 4/2 DC hydraulic valve in its normal and actuated position



(Fig 8) Two positions of the circuit for the control of a double-acting hydraulic cylinder.

Non-return Hydraulic Valve

A non-return valve (NRV) is the simplest type of directional control valve used in a hydraulic circuit. The value preferentially permits flow through it in one direction and blocks the flow in the reverse direction. The basic NRV is the so-called check valve. A hydraulic check valve consists of a valve body and a spring-biased ball poppet or cone poppet, apart from inlet/outlet ports. The spring holds the poppet against the valve seat. Cross-sectional views of these two types of hydraulic check valves are shown in Fig 9.



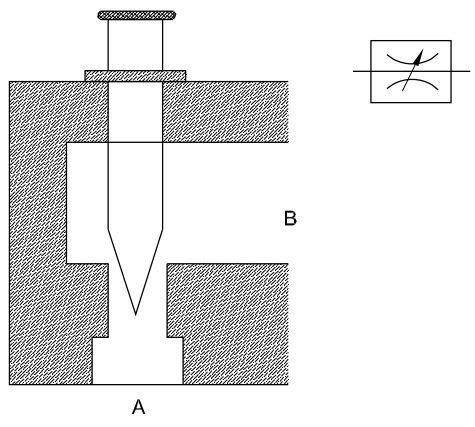
(Fig 9) Cross-sectional views of a check valve.

When the system pressure at the port A is high enough to overcome the spring force, the poppet is pushed off its seat allowing the system oil to flow freely through the valve from the port A the port B with a low-pressure drop across it. The flow through the valve is blocked when the intended flow direction is from the port B to the part A, by poppet reseating.

Flow Control (Throttle) Valve

A throttle valve is a device with a restriction that offers a resistance to the system oil flowing through it. The throttle valve regulates the flow rate of the system oil. According to the type of restriction, throttle valves are of two types. They are: (1) Fixed type and (2) Adjustable type. In a fixed type throttle valve, the restriction is fixed, whereas in an adjustable type throttle valve, the area of the restriction can be varied. These types of throttle valves are further explained in the following sections.

Fig 10



(Fig 10) A cross-sectional view of an adjustable type throttle valve

An adjustable throttle valve consists of an orifice whose cross-section can be controlled by an externally adjustable needle-shaped plunger. Oil flow passing through the controlled cross-section can be regulated precisely by the pointed needle. The cross-sectional view of the adjustable throttle valve is given in Fig 10.

Pneumatic System

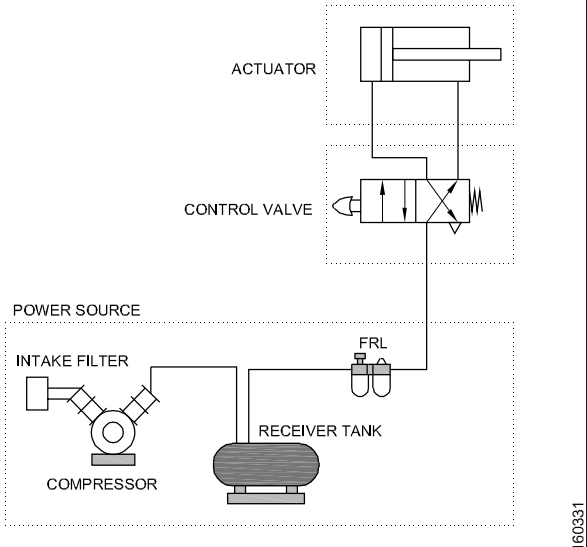
Objectives: At the end of this session you shall be able to:

- **appreciate a typical pneumatic system**
- **understand the working of a reciprocating compressor**
- **explain the functions FRL**
- **explain the working of pneumatic cylinders.**

A Typical Pneumatic System

A basic pneumatic system can be thought of consisting of the following three main blocks: (1) Power source, (2) Control valves and (3) Actuators. A typical pneumatic system with a number of components is depicted in figure 1. The power source includes compressor, receiver tank, FRL etc.

Fig 1



A SIMPLIFIED REPRESENTATION OF A PNEUMATIC SYSTEM

Air compressor

The compressor is the most common industrial energy supply unit that converts mechanical energy into pneumatic energy. The vast of pneumatic systems use air as the operating medium. It is designed to take in air at atmospheric pressure and deliver it into a closed system at a higher pressure, as per Boyle's Law.

Boyle's law

The relation between pressure and volume of a gas is given by Boyle's law. It states that: "At constant temperature, the volume of a given mass of gas is inversely proportional to the absolute pressure." Let V_1 is the volume of a gas at pressure p1. When this gas is compressed to a volume V_2 then the pressure will rise to a value of P_2. Mathematically,

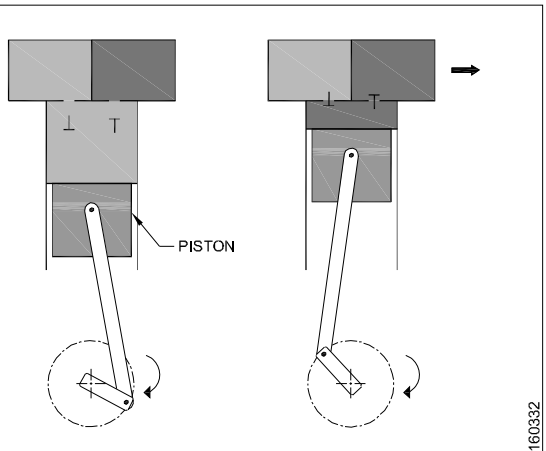
$$P_1V_1 = P_2V_2\ T, \text{Constant}$$

As air is compressed, energy used in this work is dissipated as heat, i.e., the temperature will rise as the air is reduced in volume. This is known as adiabatic compression.

Reciprocating piston compressor

Reciprocating piston compressors are very common and provide a wide range of pressures. Piston compressors are employed where high pressures (4-30 bar) are needed. Figure 2 shows the basic single-cylinder reciprocating compressor. As the piston moves down during the inlet stroke, the inlet valve opens and draws air into the cylinder. During the upward motion of the piston air is compressed and discharged through the opened outlet valve.

Fig 2

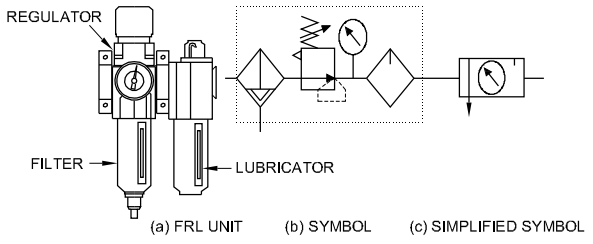


RECIPROCATING COMPRESSOR

FRL or air service unit

Compressed air, which is dry and clean, is the most important requirement for the satisfactory operation of any pneumatic system. As we are aware, compressed air in a pneumatic system is liable to be contaminated to a high degree. It is essential to remove fine dirt particles, to regulate the pressure, and perhaps to introduce a fine mist of oil in the compressed air to aid lubrication. These important functions can be accomplished through auxiliary airline equipment, namely, filter, regulator and lubricator (FRL). A combined FRL unit and detailed and simplified symbols are shown in (Fig 3).

Fig 3



AIR SERVICE UNIT

Pneumatic actuators

Pneumatic actuators are output devices for conversion of energy contained in compressed air to produce linear or rotary motion or apply a force. Linear actuators convert energy of compressed air into straight-line mechanical energy. Single-acting and double-acting cylinders are the two basic types of pneumatic linear actuators.

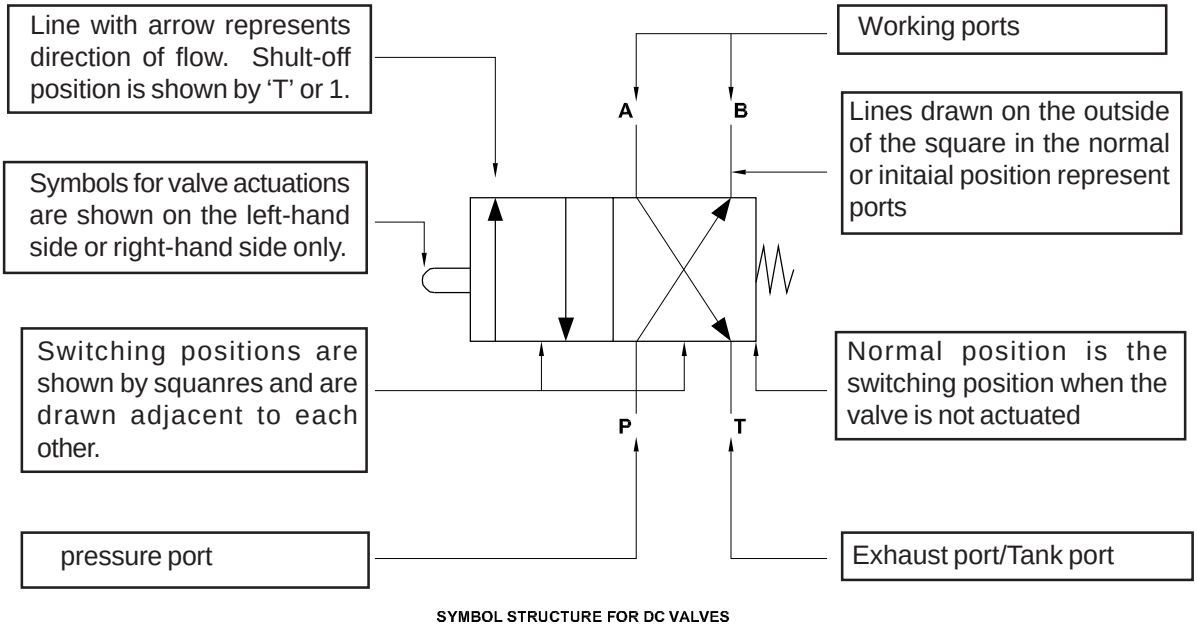
Valves in fluid power systems

In fluid power systems, power is conveyed and controlled through a fluid under pressure within a circuit. Therefore, pneumatic and hydraulic systems require valves to control or regulate the flow of pressurised fluid from power source to various actuators. According to their function, valves in fluid power systems can be divided into the following groups.

- Directional control valves (way-valves) control the direction of fluid flow.
- Non-return valves allow the fluid flow in only one direction and block the flow in the other direction.
- Pressure control valves regulate or limit the fluid pressure or generate a control signal when a set pressure is reached.
- Flow control valves restrict the fluid flow in order to reduce its flow rate.

Graphic representation

A symbol specifies only the function of the valve without indicating the design principle. Apart from that, a symbol also indicates the method of actuation and designations of ports of the concerned valve. Fluid power symbols are standardized and described in ISO 1219. This is a set of basic shapes and rules for the construction of fluid power symbols.



SYMBOL STRUCTURE FOR DC VALVES

Port markings

Ports of pneumatic values are designated using a number system in accordance with ISO 5599. Letter system for pneumatic valves is no longer used. Port markings of hydraulic valves are, however, designated using a letter system. Both systems of port marking are presented in table below.

Table: Port markings of directional control valves

Port	Letter system	Number system	Comment
Pressure port	P	1	Supply port
Working ports	A,B	2,4	4/2 or 5/2 dc valve
Exhaust (tank) ports	R,S(T)	3,5	5/2 dc valve, T for tank
Pilot port	Z,Y	10,12,14	Pilot line

Ports and positions

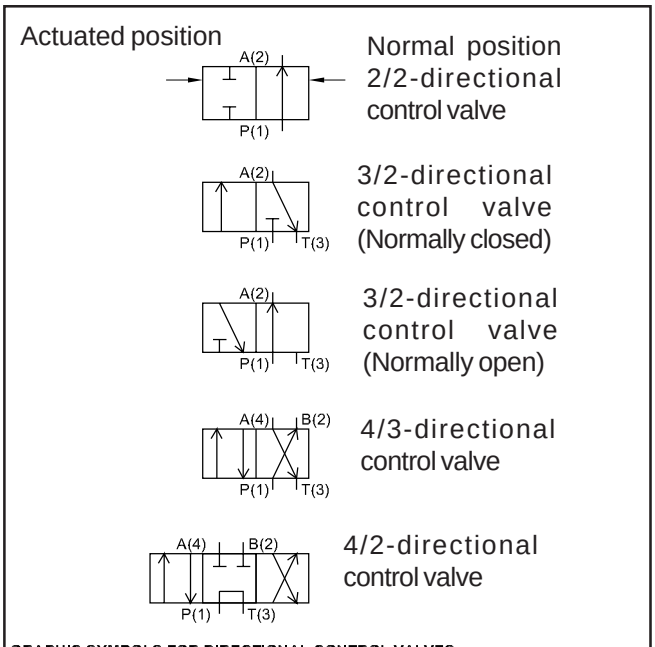
Directional control valves are described by the number of port opening or "ways" which are to be controlled. For example: a 2-way or 3way. Or 4-way valve. A 2-2ay valve is a simple on-off valve used to control power supply through the pressure port and the working port of the valve. A 3-way valve controls air supply through the pressure port, the working port and the exhaust port of the valve. Directional control valves are further described by the number of switching positions available in the valve.

Directional control valves are specified according to the number of controlled connections and number of switching positions. For example, in a 3/2-way valve, there are 3 ports and 2 switching positions. In the case of valves with two switching positions, right-hand square usually represents the normal position and left-hand square represents the actuated position. The lines for pressure, working and exhaust ports are drawn attached to the square that represents the normal (initial) position.

Graphic symbols for dc valves

Graphic symbols serve as an aid to functional identification of components in circuit diagrams of fluid power systems.

A few more examples of valve representation are given in (Fig 4) to make the idea more clear.

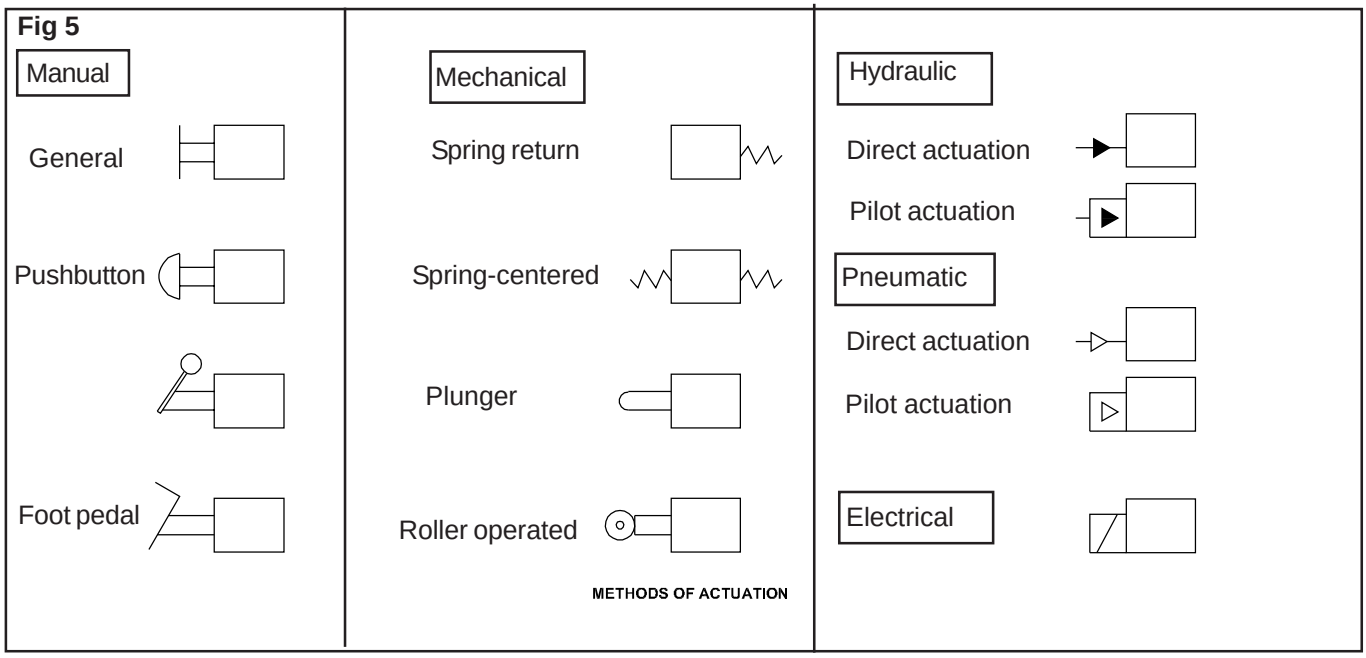


GRAPHIC SYMBOLS FOR DIRECTIONAL CONTROL VALVES

Method of valve actuation

Another important feature of directional control valves is their methods of actuation. These valves can be actuated manually or mechanically or hydraulically or pneumatically or electrically or by an appropriate combination of the above four basic methods. When the controlling spool of a valve is held in one extreme position by the force of its resetting spring, the spool is said to be "spring offset" and when the spool is held in the centre position by the spring, it is said to be "spring-centred". Symbols for methods of valve actuation are presented in (Fig 5)

Fig 5



METHODS OF ACTUATION

Resent trends and developments

Objectives: At the end of this lesson you shall be able to
- **state the history of auto industry**
- **state the leading manufacturers**
- **state the auto mobile industry, new product.**

Auto industry - History, leading manufacturing

In 1887 first car rolled out in the streets of Calcutta the next year there were four cars in the street of Bombay.

1940 Indian company like Hindustan motors and premier started to manufacture car of other firm, the same decade started Mahindra and Mahindra also started utility vehicle.

1980 Hindustan Motors ambassador and premier were challenged by a new entrant, maruti udyog limited.

The alliance between maruti and Suzuki was first joint venture between an Indian company.

2000-2010, almost every major car company establishing manufacturing facilities across different parts of the country.

Chennai, Mumbai, pune, north NCR are majority of Indian car industry

Top and major manufactures in Automobile industry

- Maruti udyog
- General motors' India
- Ford India
- Eicher motors
- Bajaj Auto
- Daewoo motors India
- Hero motors
- Hindustan motors
- Hyundai Motor India.
- Royal Enfield motors
- Telco
- Swaraj mazda
- BMW

The pioneer Mr. J.R.D. Tata's role in setting up the Tata group (ERC).

In India maruti 800, Car launched by SMT, Indira Gandhi - In 1983.

India in the largest three wheeler and two wheeler market in the world and second largest tractor manufacture in the world , fifth largest commercial vehicle manufacture in the world and second largest producer of motorcycle in the world after china.

In Indian some Industries are manufacturing the vehicle parts and assembling.

Example: TATA, Hindustan Motor and ashok leyland etc.

In India some vehicle parts are importing and assembling in the plants

Example: Ford, Hyundai, Audi etc.

Development in automobile industry

Due to the recent developments in electronics and computers lots of changes have come in the automobile also a mini computer named ECM electronic control module takes the control of

Engine control, transmission control, Brake and steering system controls, Safety controls, and infotainments.

More no of sensors and transducers are employed in all systems to send information to their corresponding electronic control units to achieve precise control on all activities.

Due to this precise controls we could achieve,

Fuel efficient engines, clean emission engine, Easy steering, and anti locking brakes, keyless entry, Navigation and smart dash board etc.

Gasoline Direct Injection (GDI)

Fuel is injected directly into the cylinders, not mixed with air in the inlet manifold or inlet ports before being drawn into the cylinders. The advantages of direct injection are that the fuel can be placed in the combustion space in a more controlled manner than the conventional inlet injection system.

Hybrid vehicles

Hybrid vehicle that combines a conventional internal combustion engine with an electric propulsion system (hybrid vehicle drive train). The presence of the electric power train is intended to achieve either better fuel economy than a conventional vehicle or better performance.

Electric vehicle (EV)

India has plans to make a major shift to electric vehicles by 2030.E-commerce companies, Indian car manufactures like Rava Electric Car Company (RECC), and Indian app-based transportation network companies like Ola are working on making electric cars in the near future.

The electric cars available in India are:

Mahindra e2oplus

Mahindra e-Verito.

Tata Tigor Electric

Mahindra e-KUV 100

Tata Tiago Electric.

Fuel cells

The fuel cell as used in space-craft, reverses this reaction combining hydrogen and Oxygen to release electrical energy with pure water as a byproduct.

The attraction of using in an internal combustion engine, is that the fuel cell is very efficient indeed, achieving 45 to 60% efficiency versus petrol engine 15 to 35%.

A danger involved in fuel cell is the hydrogen is an explosive gas that is difficult to store and handle.

Lean burn engines

This engine are designed for Lean-burning, They have higher compression ratios and thus provide better performance, efficient fuel usage and low exhaust hydrocarbon emissions compare with the conventional gasoline engines. Lean mixtures with very high air-fuel ratios can only be achieved by direct injection engines.

Driverless Cars

This is a vehicle that is capable of sensing its environment and navigating without human input.

Driverless cars combine a variety of techniques to perceive their surroundings, including radar, laser light, GPS and computer vision. Advanced control systems interpret sensory information to identify appropriate navigation paths, as well as obstacles and relevant signage.

The potential benefits of driverless cars include reduced mobility costs and infrastructure costs, increased safety, increased mobility, increased customer satisfaction, and reduced crime. And also potentially significant reduction in traffic collisions, resulting injuries and related costs, including less need for insurance.

Waymo is a self-driving technology development company and it is a subsidized by Google.

Alternate fuel.

Bio fuels are also considered a renewable source. Although renewable energy is used mostly to generate electricity, it is often assumed that some form of renewable energy of a percentage is used to create alternative fuels. Research is going on the search of more suitable bio fuel crops and improving the oil yields of these crops, Using the current yields, Vast amount of land and fresh water in needed to produce enough oil to completely replace fossil fuel usage. Alternative fuels, known as non-conventional and advanced fuels, any materials or substances that can be used as fuels, other than conventional feels like; fossil fuels (Petroleum (oil), coal, and natural gas.

Some well-known alternative fuels includes biodiesel, bio alcohol (Methanol, ethanol), vegetable oil, propane and other biomass sources.

Classification of vehicles

Objectives: At the end of this lesson you shall be able to
- **classify the vehicles.**

Classification of vehicles

Based on central motor vehicle act

- Motor cycle
- Invalid carriage
- Three wheelers
- Light motor vehicle
- Medium passenger motor vehicle
- Medium goods vehicle
- Heavy passenger motor vehicle
- Heavy goods vehicle
- Any other motor vehicle of a specified description

Based on wheel

Two wheeler

Three wheelers

Four wheelers

Six wheelers

Multi axles

Based on fuel used

Petrol vehicle

Diesel vehicle

Gas vehicle (CNG & LPG)

Electric vehicle

Based on body

Saloon (BMW,AUDI)

Sedan (Maruti ciaz, ambassador etc)

Hatch back (Alto, i10, santro, Tata Tiago)

Convertible (Jeep, maruti gypsy)

Station wagon (Innova, Ertiga, etc)

Van (Omni, Touristor)

Special purpose (Ambulance, Milk van, etc)

Based on drive

Front engine rear wheel drive (Sumo, Omni, Ambassador, etc) (Fig 1)

Rear engine rear wheel drive (Tata Nano, Bajaj auto, Valvo bus etc) (Fig 2)

Front engine front wheel drive (Alto, Ertiga, santro, Tiago etc) (Fig 4)

Four wheel/ All wheel drive (jeep, Scorpio, Gypsy etc) (Fig 3)

Based on position of engine

Front transverse engine (Example ; Maruti 800)

Front longitudinal engine (Example ; Maruti Omni)

Rear Transverse engine (Example ; Volvo bus)

Based on steering

Conventional manual steering

Power steering hydraulic

Power steering electric

Based on transmission

Manual transmission

Automatic transmission

This is transmission that uses a torque converter, planetary gears set and clutches or bands to shift a vehicle's forward gears automatically.

Automated manual transmission (AMT)

This is an automated manual transmission it employs a mechanical clutch, but the action of the clutch is not controlled by the driver's clutch pedal. Gears shifts done by using automated electronic, pneumatic or hydraulic controls.

Continuously Variable Transmission (CVT)

This transmission has a continuously variable drive ratio and uses belts, pulleys and sensors rather than gears to maintain a steady acceleration curve with no pauses for gear changes. Because of this, a CVT can keep the engine in its optimum power range, thereby increasing efficiency and gas mileage.

Fig 1

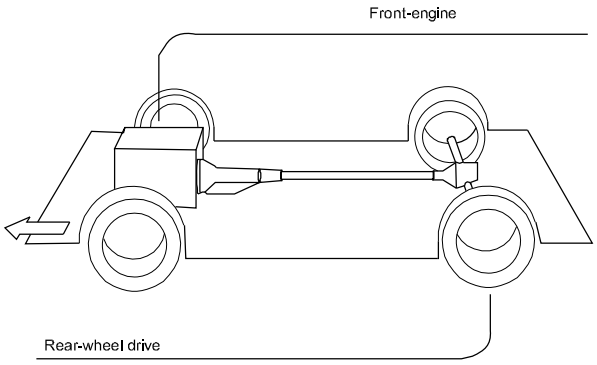


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Fig 2

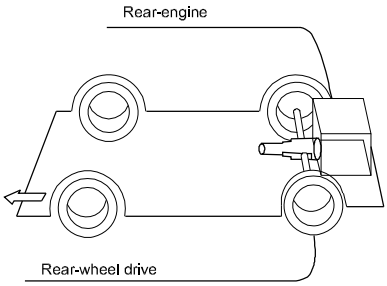

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Fig 3

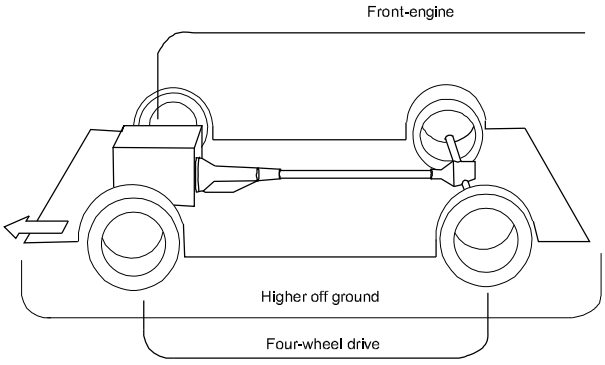

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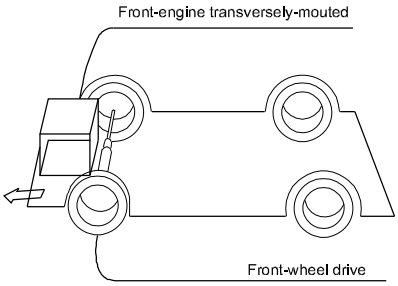
Fig 4



MDN170214

Ministry of road transport & high ways

Objectives: At the end of this lesson you shall be able to
- **state the function of ministry of road transport & highways**
- **state the function of NATRIP**
- **state the function of ARAI**

Ministry of road Transport & Highways

This is an apex organization under the central Government, is entrusted with the task of formulating and administering, in consultation with other central Ministries/Departments, State Governments/ UT Administrations, organisations and individuals, policies for Road transport, National highways and transport research with a view to increasing the mobility and efficiency of the road transport system in the country. The ministry has two wings: Roads wing and Transport wing.

Roads wing

Deals with development and maintenance of National Highway in the country

Main Responsibilities:

- Planning development and maintenance of national Highways in the country
- Extends technical and financial support to state Governments for the development of state roads and the roads of inter-state connectivity and economic importance.
- Evolves standard specifications for roads and bridges in the country.
- Serves as a repository of technical knowledge on roads and bridges.

Transport wing

Deals with matter relating to Road transport

Main Responsibilities:

- Motor vehicle legislation
- Administration of the Motor Vehicles Act, 1988
- Taxation of motor vehicles.
- Compulsory insurance of motor vehicles.
- Administration of the Road transport corporations Act, 1950.
- And promotion of transport co-operatives in the field of motor transport
- Evolves road safety standards in the form of a national policy on road safety and by preparing and implementing the Annual road safety plan.
- Collects, compiles and analyses road accident statistics and takes steps for developing a road safety culture in the country by involving the members of public and organizing various awareness campaigns.
- Provides grants-in-aid to non-governmental Oranisations in accordance with the laid down guidelines.

National automotive testing and R&D infrastructure project (NATRIP)

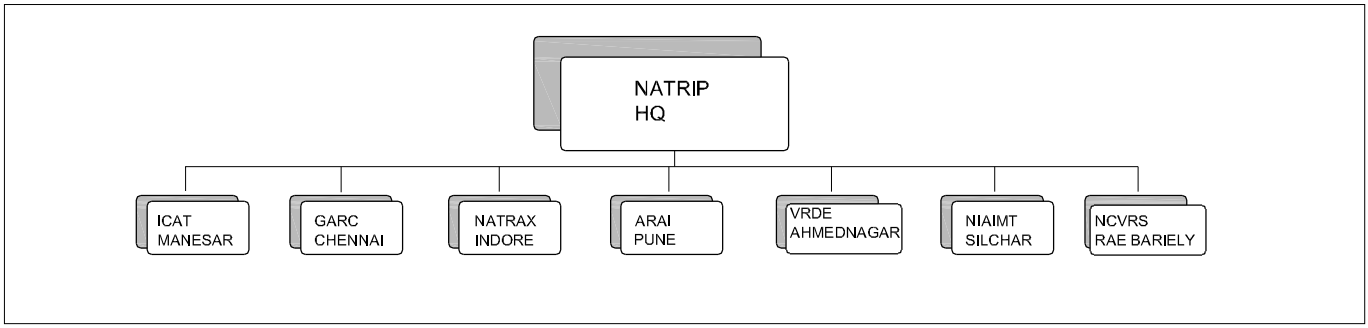
The largest and one of the most significant initiatives in Automotive sector so far, represents a unique joining of hands between the Government of India, a number of state Governments and Indian Automotive industry to create a state of the art testing, Validation and R&D infrastructure in the country.

The project aims at creating core global competencies in Automotive sector in India and facilitate seamless integration of Indian Automotive industry with the world as also to position the country prominently on the global automotive map.

Create state- of - art research and testing infrastructure to drive India into the future of global automotive excellence.

(NATRIP) aims at setting up of seven-of-the-art automotive testing and R&D centers across the country and thereby;

- Creating core global competencies.
- Enhancing competitive skills for product development leading to deepening of manufacturing.
- Synergizing Indias unique capabilities in information technology with the automotive sector.
- Facilitating seamless integration of Indian automotive industry with the world to put India strongly on the global automotive map.



Automotive Research Association of India (ARAI)

The Automotive Research Association of India (ARAI) has been Playing a crucial role in assuring safe, less polluting and more efficient Vehicles. ARAI provides technical Expertise in R & D, testing, certification, homologation and framing of vehicle regulations.

ARAI is research association of the Automotive Industry with Ministry of Heavy Industries and Public Enterprises, Government of India, It works in harmony and complete confidence with it members, customers and the Government of India to offer the finest services, which earned for itself ISO 9001,ISO 14001, OHSAS 18001 and NABL accreditations.

ARAI has a strong base of state-of-the-art technology equipments, laboratory facilities and highly qualified and experienced personnel. With these assets, ARAI has goals, strategies and action plans to achieve fullest customer satisfaction.

These are

to compete in service with excellence

to cover global market

to obtain recognition and accreditation

to build commitment of all personnel

to develop team sprit and sense of belonging amongst all.

Automotive research association of India

ARAI has been providing various services to the Indian Automotive Industry in the areas of design & development and know-how for manufacture & testing of components/ system to national /international standards. ARAI shall strive to achieve international recognition in these areas.

ARAI shall seek the valuable guidance and support from association members, from time to time to achieve growth and stability.

With the globalization of economy and business, ARAI shall enlarge its scope of services to meet the requirements of automotive industries anywhere in the world.

ARAI strongly believes that satisfaction of the customer needs on continuing basis is of prime importance to earn the loyalty of the customers. Therefore, emphasis shall be on meeting and exceeding the customer needs through continuing quality improvement with active participation of employees and also the customer.

Uses of hoists, jacks and stands.

Objectives: At the end of this lesson you shall be able to
- **state the function of vehicle hoists**
- **state the function of engine hoists**
- **sate the function of jacks**
- **state the function of axes stand standt.**

The modern automobile service stations are used the various types of equipments to lift the vehicles. They are as follows.

Single post hydraulic car hoist

Two post car hoist

Four post car hoist

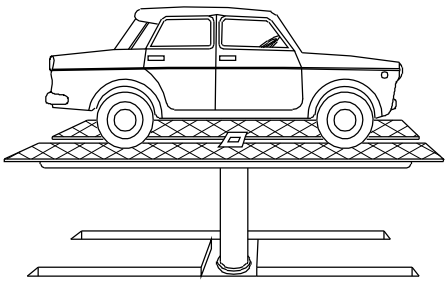
Engine hoist

Jacks

Stands

Single post hydraulic car hoist (Fig1) : It is facilitate the servicing and reaper works conveniently. It is constructed for dependable, trouble free performance and ensuring smooth and safe operation. The post is made of high grade steel. The car hoists are specially designed for resistant to wear and damage during water wash. Single post type is suitable for vehicle up to 6 tones.

Fig 1

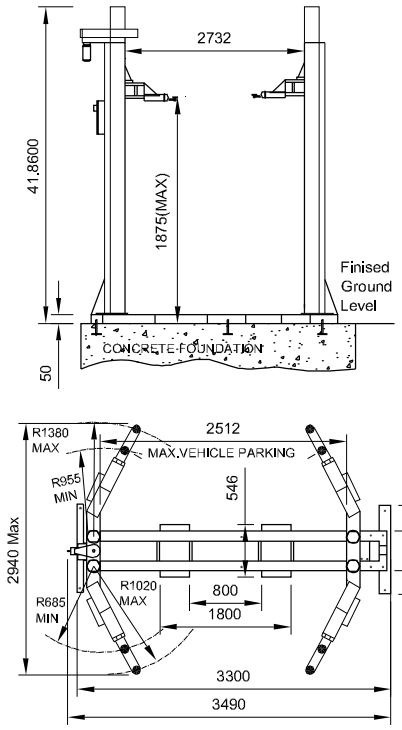


HYDRAULIC CAR HOIST

MDN170411

Two post hoist (Fig 2) **:** It is operated by electro -hydraulic system. it is easy to operate and maintain the double post hoist and safety provision also provided to hold the vehicle. Double post type suitable for vehicle upto 4 tones.

Fig 2

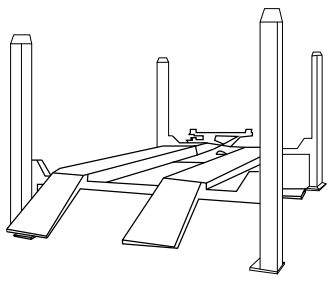


TWO POST HOIST

MDN170412

Four post car hoist (Fig 3) **:** It is operate by electro hydraulically and balancing the lifting vehicle. It is easy to operate and maintain the moving parts. Four post hoists is work as single and double post hoist it is suitable for lift the vehicle light and heavy vehicle.

Fig 3



FOUR POST HOIST

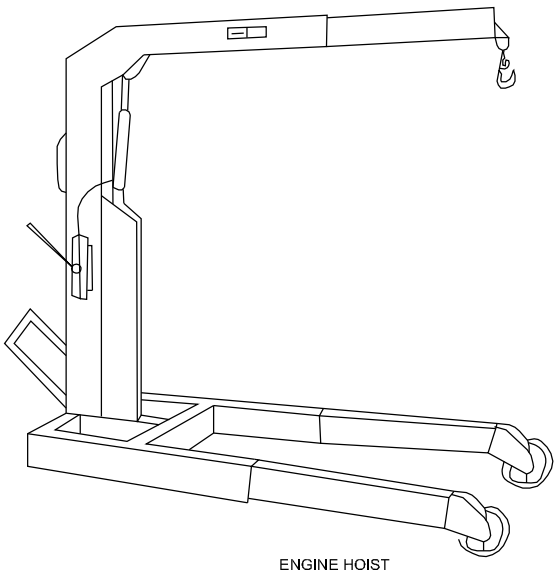
MDN170413

Engine hoist (Fig 4)

The engine hoist helps to lift an engine from a car/truck. The hydraulic pressure converts power to a mechanical advantage and lifts the engine from the car with less effort. When using a block and tackles for lifting an engine, use a lifting plate attached to the intake manifold or use a chain bolted at each end of the block.

so on. They are operated by moving the handle up and down. The other type of portable floor jack is the pneumatic jack which uses compressed air to lift a car or truck. It is mostly used in production side.

Fig 4



ENGINE HOIST

MDN170414

Never work under a car without safety stands or jack stands.

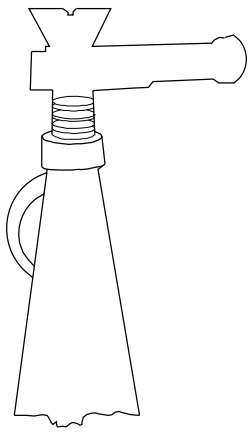
On roads mostly mechanical jacks are used to lift the car/vehicle for small jobs. These jacks work under the principle of screw and nut.

Jacks: It is used to lift the vehicle, which are operated by mechanically and hydraulically, Jack is designed to lift the vehicle and hold the vehicle load during the repair works. Jack is a standard accessory with many vehicles.

Types of jacks

- Light weight screw jack (Fig 5)
- Heavy duty bottle type hydraulic jack (Fig 6)
- Trolley types hydraulic jack (Fig 7)

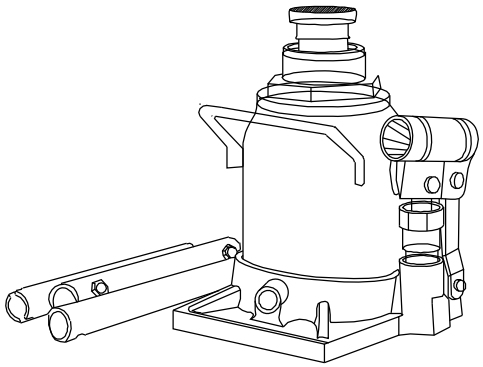
Fig 5



MANUAL TYPE LIFITING JACK

MDN170425

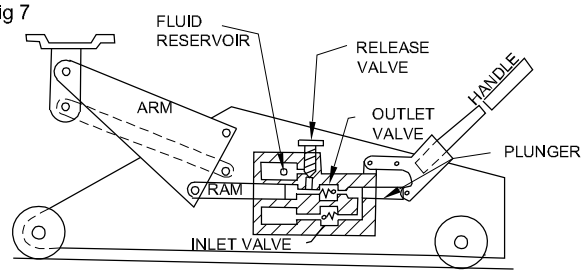
Fig 6



HEAVY DUTY BOTTEL TYPE LIFITING JACK

MDN170416

Fig 7



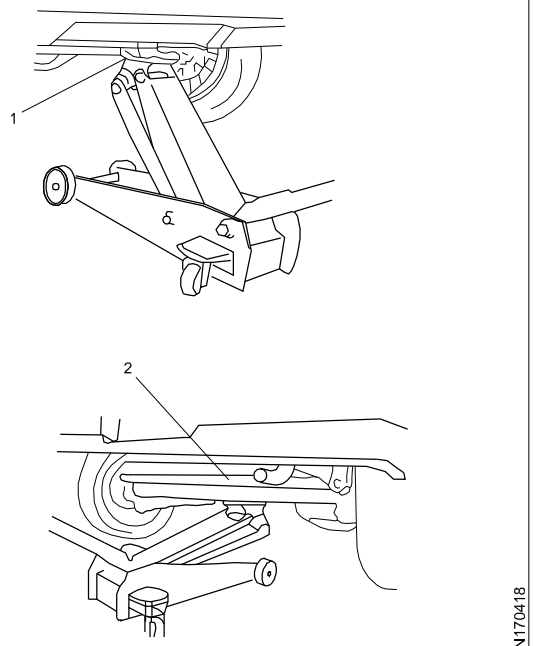
TROLLEY TYPE JACK

MDN170417

In raising front vehicle end off the floor by jacking , be sure to apply jack against front jacking bracket(1) (Fig 1).

In raising rear vehicle end off the floor by jacking, be sure to apply jack against the center portion of rear axle (2) .

Fig 8



FLOOR JACK

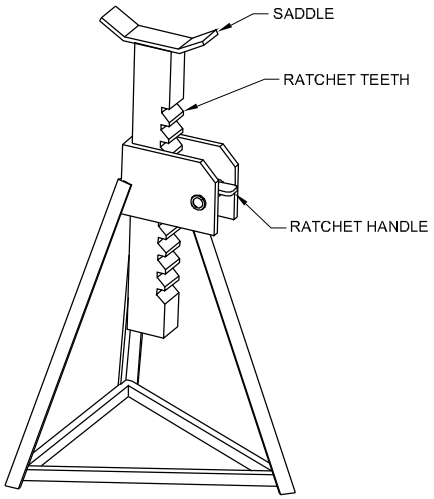
Caution: Never apply jack against suspension parts (i.e., stabilizer, etc.) front bumper or vehicle floor, Otherwise it may get deformed.

Warning: If the vehicle to be jacked up only at the front or rear end, be sure to block the wheels on ground in order to ensure safety.

After the vehicle is jacked up , be sure to support it on stands. It is extremely dangerous to do any work on the vehicle raised on jack alone.

Axle stand (Fig 9)**:** It is always injure safety before starting the work under the lifted vehicle, Jack report is not enough, it could be dangerous. Always use axle stands for safety work. Different size of stands are used depend upon the vehicle load.

Fig 9



TYPICAL ADJUSTABLE JACK STAND

To perform service with either front or rear vehicle end jacked up, be sure to place safety stands (1) under body so that body is securely supported. And the check to ensure that body does not slide on safety stands and the vehicle is held stable for safety's sake.